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UNIT ONE

BIOTECHNOLOGY

1.1 What is Biotechnology?

Biotechnology is the use of microorganisms to make things that people want, often involving industrial production. **It** is the controlled use of micro-organisms for human benefit.

- Not all types of microorganisms are used in biotechnology.
- Some microorganisms cause disease, others are useful to people—for example, and they play a vital role in decay and recycling of nutrients in the environment
- With the arrival of new technologies such as a **genetic engineering**, microorganisms are becoming more useful all the time.
- The main groups are **bacteria** and **fungi, and viruses** are being more and more for genetic engineering.
- Many of the principles and some of the techniques involved in biotechnology are **ancient, but fast growing.**
- For example, **fermentation**, in which microorganisms are used, has been practiced for thousands of years to produce:
    - Alcoholic drinks like beer, *wine tella* and *tej*
    - Bread and *injera*
    - Cheese and yoghurt

Traditional Approach of Biotechnology involve:

1. Making alcoholic drinks like wine, beer, *tej, tella* and brewing beers,
2. Making bread and *injera*
3. Making cheese and yoghourt.

- One of the most useful microorganisms is **yeast.**
- When yeasts have plenty of oxygen, they respire **aerobically, breaking down sugar to provide energy** for their cells, and producing **water** and **carbon dioxide** as waste products.
- But yeasts are useful because they can also respire **anaerobically.**
- When yeast cells break down sugar in the absence of oxygen, they produce **ethanol** (alcohol) and **carbon dioxide.**
- Aerobic respiration provides **more energy** than anaerobic respiration, allowing yeast cells to grow and reproduce.
- However, once they exist in large numbers, yeast cells can survive for a long time in **low-oxygen conditions**, and will break down all the available sugar to produce **ethanol.**
- The anaerobic respiration of yeast is sometimes referred to as **fermentation (or alcoholic fermentation).**

I. Making Alcoholic drinks

1. Beer production

- In brewery process the grain is first "malted‖ (i. e., soaked in water to germinate).
- During this malting period the enzyme present in the grain converts the **starch to sugar.**
- Then yeasts are added to convert the **sugar to alcohol.**
- The **bitter flavor** of beer is provided by the addition of **hop flowers.**
- In the preparation of "Tella‖ **Gesho** is added to give a bitter flavor for the"Tella‖.

2. **Tej and tela production**

- **Tej** is one of the oldest drinks in Ethiopia—it has been known since at least 400 BC.
- When we make *tej* we need **honey, water** and **gesho leaf** or **gesho stick.**
- **Gesho** gives a bitter edge to the brew, and wild yeasts found on the plant start the fermentation going.
- The yeasts use the honey as a **source of food**. As yeast colonies grow they start to respire **anaerobically,** and this produces **ethanol** and **carbon dioxide**.
- The alcohol content of tej varies from about 6 to 11%.
- **Tej** and **tella** are the most commonly consumed alcoholic drinks in Ethiopia.

3. Wine production

- In contrast, wine making uses natural sugar, found in fruit such as grapes, as the energy source for the yeast.
- We press the fruit and mix the juice with yeast and water.
- We then let the yeast respire anaerobically until most of the sugar has been used up.
- At this stage, we filter the wine to remove the yeast and put it in bottles, where it will remain for some time to mature before it is sold.

Most commercially sold wine is made from grapes, but wine can be made from almost any fruit or vegetable — the yeast does not care where the sugar it uses comes from!

Interestingly, alcohol in large amounts is poisonous to yeast as well as to people. This is why the alcohol content of the wine is rarely more than 14% -- once it gets much higher, it kills all the yeast and stops fermentation.

Wine is made from fermented grapes.

- The **alcohol** in the wine is obtained from the **sugar in the grapes.**
- This conversion of sugar into wine is done by **yeasts** that are naturally occurring on the grapes skin.
- This process does not require oxygen and thus the process is known as **anaerobic fermentation.**
- This process can be summarized in the following equation:

$$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2C_2H_5OH + 2CO_2$$

Remember: yeast can respires aerobically in bread making, but must respire anaerobically to make alcoholic drinks.

II. Food production

1. Making bread and injera

- When yeasts have i**nsufficient** amount of oxygen (i. e., anaerobic condition), they ferment glucose into CO_2 and H_2O with the production of **very little alcohol**.
- This process is used in the making of bread and injera.
- The CO_2 produced helps the dough to become **lighter in weight.**
- This process is called "**leavening**‖, i. e. making the bread **light** and **spongy.**
- When we make *injera,* we grind the *teff* or barley and then add water.
- We mix well and leave the dough at room temperature for about two days.
- Natural yeasts start to grow and respire in the dough. At first the yeast respires **aerobically**, although this may change to anaerobic respiration.
- The yeast produces carbon dioxide, making the mix rise a little and giving it a **tangy flavor.**
- When we cook the mixture, the bubbles of gas expand in the high temperature, giving *injera* its typical texture, which is so good for soaking up the food.
- The yeasts are **killed** during the cooking process.

2. Production of Yoghurt

- Milk goes sour due to the production of a substance called **lactic acid** by the action of bacteria on milk sugar (lactose).
- This make the milk to **curdle** (i. e. some parts of the milk solidify and separate from the liquid part).
- The solids are called **curds** and the liquid part is called **whey (አጓት).**
- **To make yoghurt**, we add a **starter culture** of the right kind of bacteria **to warm milk.**
- Often this starter culture is just a small amount of yoghurt we have already made.
- The mixture needs to be warm so that the bacteria begin to grow, reproduce and ferment.
- As the bacteria break down the lactose in the milk, they produce **lactic acid,** which gives the yoghurt its sharp, tangy taste. This is known as **lactic fermentation**.
- The lactic acid produced by the bacteria causes the milk to **clot** and **solidify into yoghurt.**
- The action of the bacteria also gives the yoghurt a **smooth, thick texture.**
- Once the yoghurt-forming bacteria have worked on the milk, they also help prevent the growth of other bacteria that normally send the milk bad.
- Yoghurt, if it is kept cool, will last almost three weeks before it goes bad.

- Ordinary milk lasts only a few days – and then only if it is kept really cold.
- Once we have made our basic yoghurt, we can mix in flavorings, spices and fruit.

3. Production of Cheese

- Like yoghurt making, cheese making depends on the reactions of **bacteria** with milk changing the texture and taste, and also preserving the milk.
- Cheese making is very successful in preserving milk, and some cheeses can survive for years without decay.
- Around **900 different** types of cheese are made around the world, but the bases of production method is the same for them all.
- Just as yoghurt making, we add a **starter culture** of bacteria to warm milk.
- The difference is in the **type of bacteria** added.
- The bacteria in cheese making also convert lactose to **lactic acid**, but they make **much more lactic acid.**
- As a result, the solid part, (curds) is **much more solid than in yoghurt.**
- **Enzymes** are also added to increase the separation of the milk. These often come from the stomachs of calves or other young animals.
- When it has completely curdled, we can separate the curds from the liquid **whey** (**አጓት**).
- Then we can use the curds for cheese making. The whey is often used in other dishes.
- The curds can be used **fresh**, and can be **seasoned** or **flavored**. This is the basis of ***ayib*** in Ethiopia.
- Alternatively, we can cut and mix the curds with **salt** along with other bacteria or even molds, **before** we press them and leave them to dry out.
- The bacteria and molds added at this stage of the process are very important. They affect the development of the final flavor and texture of the cheese as it **ripens** – a process that may take months or years, depending on the type of cheese being made. This is how the majority of cheeses are made in countries such as the UK and the USA.
- Here in Ethiopia cheese is traditionally made by first making yoghurt from fresh milk, **extracting the butter** by **continuous agitation**, and finally **boiling** the remaining part to make the cheese.

Notice: Assignment: answer review questions (page 6 and 7)

1.2 New Applications of Biotechnology

What is Genetic Engineering (genetic Modification)?

Genetic engineering (genetic modification) involves changing the genetic material (DNA) of an organism.

In this case we take a small piece of a gene from one organism and transfer it to the genetic material (DNA) of a completely different organism.

Genetic engineering (genetic modification) is the process of inserting new genetic information into existing cells in order to modify a specify organism for the purpose of changing its characteristics.

- Modern applications of biotechnology include **genetic engineering**
  1. to change crops and animals;
  2. to produce new medicines; and
  3. to provide new energy sources.
- Among the new applications of biotechnology in the field of agriculture is **genetic engineering.**
- **Genetic engineering** is a technique of changing an organism's genotype by **inserting genes** from other organisms into its DNA.
- By this technique an organism is "programmed‖ to make useful substances and develop **new characters.**
- Some new applications of biotechnology also take place in an industrial setting.
- Many advances in agriculture are the result of one of the important new areas of biotechnology – **genetic engineering** (also known as **genetic modification**).
- Genetic engineering is used to change an organism and give it new characteristics which people want to see. .
- Genetic material (DNA) carries the instructions for a new organism, found in the nucleus of every cell.

- You take small piece of information – a **gene** – from one organism and transfer it to the genetic material (DNA) of a completely different organism.
- So, for example, a gene from one of human cells can be "cut out‖ using enzymes, and transferred to the cell of a bacterium.
- Our gene carries on making a human protein, even though it is now in a bacterium.
- Scientists have found that genes from one organism can be transferred to the cells of another type of animal or plant at an **early stage of their development.**
- As the animal or plant grows, it develops with the **new**, **desired** characteristics from the other organism.

The Technology

- A lot of new biotechnology relies on growing large numbers of micro-organisms on an industrial scale in large vessels, known as fermenters.
- If a lot of micro-organisms are grown together, they can easily use up all the oxygen available and even poison each other with waste products.
- Industrial fermenters usually have a range of features to overcome the problems that stop a culture growing satisfactorily.
- They react to changes, keeping the conditions as stable as possible.
- This, in turn, means we can obtain the maximum yield.

Industrial fermenters usually have:

1. An **oxygen supply** — to provide oxygen for respiration by the micro-organisms
2. A **stirrer** — to keep the micro-organisms in suspension, maintain an even temperature, and make sure oxygen and food are distributed evenly
3. A **water-cooled jacket** – to remove the excess heat produce by the respiring micro-organisms – and rise in temperature is used to heat water, which is constantly removed and replaced with more cold water.
4. **Measuring instruments** – for continuous monitoring of factors such as pH and temperature so that adjustments can be made if necessary. Draw figure 1.8 page 8

Agriculture and Industry

Genetically modified Crops (GM crops)

- **Ideally, genetic modification could lead to better, less expensive and more nutritious food as well as less-harmful manufacturing processes.**
- **Resistance to insects** is just one useful characteristic being engineered into crops.
- Others include **resistance to herbicides**, which are chemicals to destroy weeds, and **resistance to viral infections.**
- Some transgenic plants may soon produce foods that are **resistant to rot and spoilage.**
- Since their introduction in 1996, genetically modified (**GM**) plants, like the **soybeans** have become an important component of our food supply.
- In 2007, GM crops made up to
  1. 92 % of soybeans,
  2. 86% of cotton, and
  3. 80% of corn in the United States.
- One type of modification, which has already proved particularly useful to agriculture, uses bacterial genes that produce a protein known as **Bt toxin.**
- While this toxin is harmless to humans and most other animals, enzymes in the digestive systems of insects convert Bt to a form that kills the insects.
- Plants with Bt gene, then, do not have to be sprayed with pesticides.
- In addition, they produce higher yields of crops'
- And engineers are currently developing GM plants that may produce plastics for the manufacturing industry.

Genetically Modified (GM) Animals

- **GM animals** are also becoming more important to our food supply. For example, about 30% of the milk in U.S. markets comes from cows that have been injected with hormones made by recombinant-DNA techniques to increase milk production.
- **Pigs** can be genetically modified to produce more lean meat or high levels of healthy omega-3-acid.

Health and Medicine

Biotechnology, in its broadest sense, has always been part of **medicine.**

Early physicians extracted substances from plants and animals to cure their patients

- Today, **recombinant DNA** technology is the source of some of the most important exciting advances in the prevention and treatment of disease.
- One interesting development in transgenic technology is **golden rice.**
- This rice contains increased amounts of **vitamin A**, also known as **beta-carotene**—a nutrient that is essential for human health.
- **Provitamin A** deficiency produces serious medical problems, including **infant blindness.**
- There is hope that **provitamin A-rich golden rice** will help prevent these problems.
- Other scientists are developing transgenic plants and animals that produce **human antibodies** to fight disease.
- In the future, transgenic animals may provide us with an ample supply of **our own proteins.**
- Several laboratories have engineered **transgenic sheep** and **pigs** that produce human proteins in their milk, making it easy to collect and refine the products.
- Many of these proteins can be used in disease prevention.
- We genetically engineered bacteria are cultured on a large scale; they can make huge quantities of protein.
- We now use them to make a number of **drugs** and **hormones** used as medicines.
- These genetically engineered bacteria make exactly the protein needed, in exactly the amounts needed, and in a very pure form.
- For example, people with diabetes need supplies of hormone **insulin**.
- This hormone was extract from the pancreas of **pigs** and **cattle**, but it wasn‘t quite the same as human insulin, and the supply was quite variable.
- Both problems have now been solved by the introduction of **genetically engineered bacteria** that can make human insulin.
- Biotechnology also makes it possible to develop **vaccines** more easily.
- A number of **sheep** and **other mammals** have been engineered to produce **life-saving human proteins** in their milk.
- These are much **more complex proteins than those produced by bacteria,** and have the potential to save many lives.
- For example, genetically modified sheep can make special **blood-clotting proteins** in their milk.
- These can be used for people with **hemophilia**, so they are no longer at risk from receiving contaminated blood.

Application of biology in energy production

- Everyone needs fuel of some sort to provide them with energy.
- It might be direct energy such as a **heat** to cook on, or it can be indirect energy – heat being used to make **electricity**, for example.
- The generation of biogas from human and animal waste is becoming increasingly important in both and developing and the developed world. This depends on biotechnology.

Biogas Production

- **Biogas** is a flammable mixture of gases, formed when bacteria break down plant material, or the waste products of animals, in **anaerobic conditions.**
- Biogas is mainly **methane**, but the composition of the mixture varies depending on what it put into the generator and which bacteria are present

The components of biogas

Components	% in the mixture by volume
Methane	50-80
Carbon dioxide	15-45
Water	5
Hydrogen sulphide	0-3
Other gases including hydrogen	0-1

- To produce biogas, you collect dung or plant material, which contains a high level of carbohydrates, and put it into a **biogas generator or digester.**
- Then you add a mixed population of many different types of **bacteria** which are needed to digest the carbohydrate.
- The bacteria you use are similar to those in the **stomachs** of ruminants such as cows or sheep.
- Some of the bacteria break down the **cellulose** in plant cell walls.
- Others break down the sugars formed, to produce **methane** and **other gases.**
- The biogas produced is passed along a **pipe** into your home, where you burn it to produce **heat, light** or **refrigeration**.
- The bacteria involved in biogas production works best at a **temperature of around 30%,** so biogas generators tend to work best in **hot countries**.
- However, the process generates heat (the reactions are **exothermic**).
- This means that if you put some heat energy in at the beginning to start things off, and have your generator well insulated to prevent heat loss, biogas generators will work anywhere.
- The waste material we produce from **sugar factories, sewage farms** and **rubbish tips** all has the potential to act as a starting point for the production of biogas.

More Biofuels

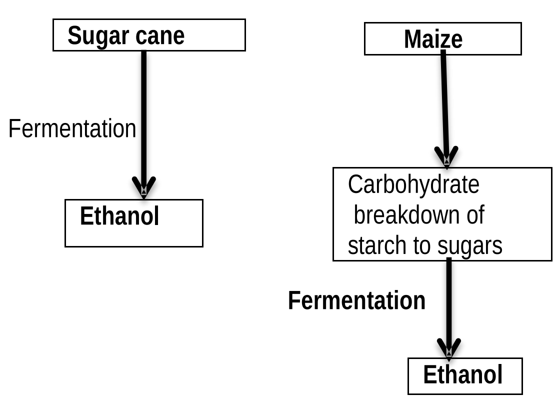
- In countries such as Ethiopia, plants grow quickly. **Sugar cane** grows about 4 – 5 meters in a year, and has a juice which is very high in carbohydrates, particularly, **sucrose.**
- Maize and sweet potatoes also grow fast. We can break down the starch in maize kernels or potato tubers into glucose, using the enzyme **carbohydrase.**
- We can convert the carbohydrates we grow into clean and efficient fuels.

Ethanol based fuels

- If sugar-rich products from cane and maize are fermented anaerobically with yeast, the sugars are broken down incompletely to give ethanol and water.
- You can extract the ethanol from the products of fermentation by **distillation**, and you can then use it in cars and other vehicles as a **fuel.**
- Car engines needs special modification to be able to use pure ethanol as a fuel, but it is not a major job.
- Many cars can run on a mixture of petrol and ethanol without any problems at all.

Advantages and disadvantages of ethanol as a fuel

- Ethanol is efficient, and it does not produce toxic gases when we burn it.
- It is much less polluting than conventional fuels, which produce carbon monoxide and nitrogen oxides.
- In addition you can mix ethanol with conventional petrol to make a fuel known as **gasohol.**
- This increasingly being done and reduces pollution levels considerably, although there is still some pollution from the petrol part of the mix.
- Using ethanol as a fuel is a **carbon-neutral** activity.
- This means there is no overall increase in carbon dioxide in the atmosphere when we burn ethanol.
- The biggest difficulty with using plant-based fuels for our cars is that it takes a **lot of plant material** to produce the ethanol.
- As a result, the use of ethanol as a fuel has largely been limited to countries with **enough space**, and a **suitable climate,** to grow a lot of plant material as quickly as possible.



- Here in Ethiopia, we have that capability. We might develop biogas generators, which can break down the excess glucose into **methane**, another useful fuel.
- Genetically engineered bacteria or enzymes may be able to break down the cellulose in **straw** and **hay** and make it available for yeast to make more ethanol.

Unit Two — Heredity

1. Thread-like structures in the nucleus are called **chromosomes.**
2. The genetic information will be passed from parent to offspring through **chromosome.**
3. **DNA** carries all the instructions needed to make all the proteins in our cells.
4. Chromosomes come in pairs known as **homologous pairs**. So people have **23** pairs, tomatoes have **12** pairs and elephants have **28** pairs of chromosomes.
5. Scientists can photograph the chromosomes in human cells when they are dividing and arrange them in pairs to make a special picture known as a **karyotype.**
6. Human karyotypes show 23 pairs of chromosomes. In 22 of the pairs, both chromosomes are the **same size** and **shape,** regardless of whether you are a boy or a girl. These 22 pairs of chromosomes are known as the **autosomes.**
7. A girl has a pair of two similar X-chromosomes, but a boy has one X-chromosomes and another, much **smaller, Y-chromosome**. These are the sex chromosomes because they determine whether you are male or female.
8. Everyone inherits an X-chromosome from their **mother**. If this joins with the sperm carrying another X-chromosome, you will be a **girl**. If it joins with the sperm carrying a Y-chromosome, you will be a **boy**.
9. X-chromosomes carry information about being **female**, but they also carry information about many other things—like the way your blood clots, and the **formation of your teeth**, **body hair** and **sweat glands.** Y-chromosome mainly carries information about **maleness.**
10. The chromosomes you inherit from your parents carry all the information needed to make a new you. The information is kept in the form of **genes.**

DNA — is a nucleic acid containing the genetic instructions used in the development and functioning of all known living organisms and some viruses.
Homologous chromosomes — are a pair of chromosomes having the same gene sequences, each derived from one parent.
Autosomes — are chromosomes that are not sex chromosomes.
Double helix — is the pair of parallel helices intertwined about a common axis.
Polynucleotide — is long chains of linked nucleotides
Karyotype — is map of the chromosomes in the nucleus of a single cell.
The Human Genome Project — has cost around 3 billion US dollars so far. Scientists have worked about the **3 billion base pairs** that make up human DNA –and have shown that everyone shares around **99.99%** of their DNA. It looks as if human beings have only between **20000 and 25000 genes**, far fewer than scientists originally predicted.

11. Each gene is a small section of a DNA A gene is a unit of hereditary material located on the chromosome.

12. DNA is a long molecule, made up of two strands twisted together to make a spiral known as a double helix.

13. The big DNA molecule is actually made up of smaller molecules (**nucleotides**) joined together.

14. A nucleotide consists of a **phosphate group**, a **sugar**, and a **base.**

15. In DNA there are **four** different bases that appear time after time in different orders, but always paired up in the same way. The bases link the two strands of the DNA molecule together.

16. Genes are made up of **repeating patterns of bases in the DNA**.

17. **Body cells** (also known as **somatic cells**) divide to make new cells. The cell division that takes place in the **normal body cells** and produces identical cells is known as **mitosis.**

18. As a result of mitosis, every body cell has the **same genetic information.**

19. In asexual reproduction, the cells of the offspring are produced by **mitosis** from the cells of their parent. This is why they contain <u>exactly the same genes with no variety.</u>

20. **How does mitosis work?** Before a cell divides, it produces new copies of the homologous pairs of chromosomes in the nucleus.

21. Each chromosome forms **two identical chromatids.** Then the chromatids divide into two identical packages, and the rest of the cytoplasm divides as well to form **two genetically identical daughter cells.**

22. Once the new cells have formed, the <u>chromatids are again</u> referred to as **chromosomes.**

23. The daughter cells each have <u>exactly the same number of chromosomes</u> as the original cell. Cell division has **5 stages**: 1. interphase, 2. prophase, 3. metaphase 4. anaphase and 5. telophase.

24. Most of the time you can't see the chromosome in the nucleus of the cell, even under the microscope. However, when a cell is **splitting in two**, the chromosomes become much **shorte**r and **denser**, and will take up special colors called **stains.** At this stage you can see them under the microscope. The name —chromosome‖ means **colored body** referring to what the chromosome look like when they have taken up the stain.

25. The cells of early animal and plant embryos (known as **stem cells**) are **unspecialized**.

26. Each one of the stem cells <u>becomes any type of cell</u> that is needed.

27. In many animals, the cells become **specialized very early** in life.

28. By the human a human baby is born, most of its cells have become specialized for a particular job, such as liver cells, skin cells and muscle cells. They have differentiated.

29. Some of their genes have been **switched on** and others have been **switched off**. This means that when a <u>muscle cell divides by mitosis, it can only form more muscle cells</u>

30. Liver cells can <u>only produce more liver cells</u>. So in <u>adult animals, cell division is restricted because differentiation has occurred.</u>

31. Some specialized cells can divide by mitosis, but this can be used only to **repair damaged tissue** and **replace** worn-out cells. Each cell can **only produce identical copies of itself.**

Our **red blood** cells have a finite life because they lack their nuclei as they **mature.**
Worn out red blood cells are destroyed, at a rate of around 100 billion per day, by our spleen and liver. Fortunately, mitosis takes place in our bone marrow just as quickly to make the new red blood cells we need.
Our body cells are lost at an amazing rate — 300 million cells die every minute. Fortunately mitosis takes place all the time

to replace them.

32. A cell normally contains a fixed number of chromosomes that usually occur in pair, such a cell is referred to as a **diploid** cell and is symbolized by **2n,** e.g. each human body cell (somatic cell) contains 46 chromosomes i. e. **2n = 46.**

33. **The Cell Cycle —** Cells go through a series of events known as the **cell cycle** as they grow and divide.

34. During the cell cycle, a cell:

- grows,
- prepares for division, and
- divides to form two daughter cells.

Each daughter cell then moves into: 1. a new cell cycle of activity, **2**. Growth and **3**. Division

35. The **Prokaryotic Cell Cycle** — the process of cell division in in prokaryotes is a form of asexual reproduction known as binary fission.

36. Once the chromosome has been replicated, the two DNA molecules attach to different regions of the cell membrane.

37. A network of fibers between them stretches from one side of the cell to the other.

38. The fibers constrict and the cell is pinched inward, dividing the cytoplasm and chromosomes between two newly formed cells.

39. Binary fission results in the production of two genetically identical cells.

40. The **Eukaryotic Cell Cycle** — the eukaryotic cell cycle consists of four phases: G1, S, G2, and M.

41. The **length of each part of the cell cycle** — and the length of the entire cell cycle—varies depending on the type of cell.

42. The life of a cell as one cell division after another separated by an in-between period of growth is called **interphase.**

43. In rapidly dividing tissue and in cancer cells, interphase may only be a **few hours**. In other tissues, or in **adult animal**, interphase **may last for years**.

44. Interphase is divided into three parts: **G**1, **S**, and **G**2.

1. G_1 phase: Cell Growth

- Cells do most of their growing during the G_1-phase.
- In this phase, cells **increase in size** and synthesize **new proteins** and **organelles.**
- The G in G_1 and G_2 stands for "**gap**,‖ but the G_1 and G_2 phases are actually periods of intensive growth and activity.

2. S Phase: DNA Replication

- The G1 phase is followed by the S phase.
- The S stands for synthesis,
- During the S phase, new DNA is synthesized when the chromosomes are replicated.
- The cell at the end of the S phase contains twice as much DNA as it did at the beginning.

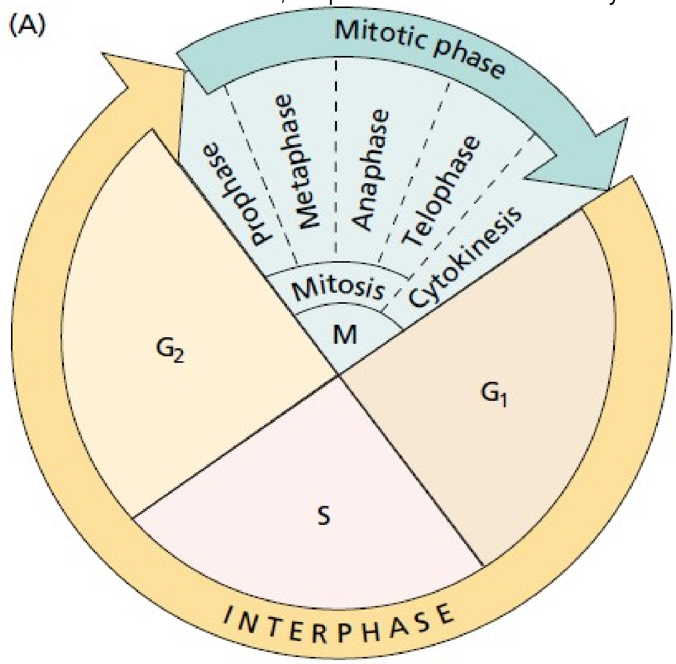
3. G_2 phase: Preparing for Cell Division

- When DNA replication is completed, the cell enters the G2 phase.
- G2 is usually the shortest of the three phases of interphase.
- During the G2 phase, many of the organelles and molecules required for cell division are produced.

- When the events of the G2 phase are completed, the cell is ready to enter the M phase and begin to process of cell division.

4. **M Phase: Cell Division**

- The M phase of cell cycle, which follows interphase, produces **two daughter cells**.
- The M phase takes its name from the process of mitosis.
- During the normal cell cycle, interphase can be quite long.
- In contrast, the process of cell division usually takes place quickly.



45. In eukaryotes, cell division occurs in **two** main stages.

1. The **first stage** of the process, **division of the cell nucleus,** is called **mitosis.**

2. The **second stage**, the division of the cytoplasm, is called **cytokinesis.**

- In many cells, the two stages may overlap, so that cytokinesis begins while mitosis is still taking place.

I. Mitosis

What events occur during each of the four phases of mitosis?

Biologists divide the events of mitosis into four phases:

1, Prophase 2. Metaphase 3. Anaphase 4. telophase

1. **Prophase:**

- The first phase of mitosis, **prophase,** is the **longest** and may take up to half of the total time required to complete mitosis.
- During prophase, the genetic material inside the nucleus **condenses** and the duplicated chromosomes become **visible.**
- Outside the nucleus, a spindle starts to form.
- The duplicated strands of the DNA molecule can be seen to be attached along their length at an area called the **centromere.**
- Each DNA strand in the duplicated chromosome is referred to as a **chromatid**, or **sister chromatid**.
- When the process of mitosis is complete, the chromatids will have separated and been divided the new daughter cells.

- **Spindle fibers** extend from a region called the **centrosome,** where tiny paired structures called **centrioles** are located.
- Plant cells **lack** centrioles, and organize spindles directly from their centrosome regions.
- The centrioles, which were duplicated, during interphase, start to move toward opposite ends, or poles, of the cell.
- As prophase ends,
    - the chromosomes **coil more tightly**,
    - the nucleolus disappears, and
    - the nuclear membrane breaks down.

2. Metaphase

- The second phase of mitosis, **metaphase,** is generally the **shortest.**
- During metaphase, the centromeres of the duplicated chromosomes line up across the center of the cell.
- Spindle fibers connect the centromere of each chromosome to the two poles of the spindle.

3. Anaphase

- The third phase of mitosis, **anaphase**, begins when sister chromatids suddenly **separate** and begin to move apart.
- Once anaphase begins, each sister chromatid is now considered an **individual chromosome.**
- During **anaphase,** the **chromosomes separate** and **move along spindle fibers to opposite ends** of the cell.
- Anaphase comes to an end when this movement stops and the chromosomes are completely separated into two groups.

4. Telophase

- Following anaphase is **telophase,** the fourth and final phase of mitosis.
- During telophase, the chromosomes which were distinct and condensed begin to spread out into a tangle of **chromatin.**
- A nuclear membrane re-forms around each cluster of chromosomes.
- The spindle begins to break apart, and the nucleolus becomes visible in each daughter nucleus.
- Mitosis is complete. However, the process of cell division has one more step to go.

Cytokinesis

- As the result of mitosis, two nuclei—each with a duplicate set of chromosomes—are formed.
- All that remains to complete the M phase of the cycle is cytokinesis, the **division of the cytoplasm** itself.
- Cytokinesis usually occurs at the same time as telophase.
- Cytokinesis completes the process of cell division—it splits one cell into two.
- The process of cytokinesis differs in animal and plant cells.

The **length** of the cell cycle varies considerably. It can take **less than 24 hours**, or it can take **several years**, depending on which cells are involved and at which stage of life. There are many cycles during the years of growth and development, but it **shows down** once **puberty is over in the adult.**

Cytokinesis in Animal Cells

- During cytokinesis in most animal cells, the cell membrane is drawn inward until the **cytoplasm is pinched into two nearly equal parts.**
- Each part contains its own nucleus and cytoplasmic organelles.

Cytokinesis in Plant Cells

- Cytokinesis in plant cells proceeds differently. The cell membrane is not flexible enough to draw inward because of the ridged cell wall that surrounds it.
- Instead, a structure known as the **cell plate** forms halfway between the divided nucleuses.
- The cell plate gradually develops into cell membranes that separate the two daughter cells.
- A cell wall then forms in between the two new membranes, completing the process.

II. Meiosis

- The reproductive organs in humans, as in most animals, are the ovaries and the testes. This is where the sex cells (the gametes) are made. The female gametes, or ova, are made in the ovaries; the male gametes, or sperm, are made in the testes.

- In plants, the sex cells are the pollen and the ovules. The cells in the reproductive organs (also known as germ cells) divide to make sex cells. The cell division that in the reproductive organ cells are and produce gametes is known as meiosis.
- **Meiosis** is special form of cell division where the chromosome number is **reduced by half.**
- When a cell divides to form gametes, the chromosomes are copied so there are **four sets of chromatids.**
- The cell then divides to form two identical daughter cells. These cells then divide again immediately, without the chromatids doubling again, in the second meiotic division.
- These forms of **four gametes**, each with a single set of chromosomes. Therefore, meiosis is the division of the sex cells resulting in daughter cells with half the original number of chromosomes.
- The gametes join together at **fertilization**; the new cell that is formed contains the normal number of **46** chromosomes in humans (**23** chromosomes from our father and **23** chromosomes from our mother).
- **Meiosis** is a process in which the number of chromosomes per cell is cut in half through the separation of homologous chromosomes in a diploid cell (2N).

Once **testis** can produce over 200 million sperm each day by meiosis. As **most boys** and men have two working testes, that gives a total of 400 million sperm produced every 24 hours! Only one sperm is needed to fertilize an egg. However, as each tiny sperm needs to travel 100000 times its own length to reach the ovum, fewer than one in a million over complete the journey — so it is a good thing that plenty are made.

- Meiosis usually involves two distinct divisions, called **meiosis I** and **meiosis II.**
- By the end of meiosis II, the diploid cell becomes **four haploid cells (N).**

Meiosis I

- Just prior to meiosis I, the cell undergoes a round of chromosome replication during **interphase**.
- As in mitosis, each replicated chromosome consists of two **identical chromatids** joined at the center.

1. Prophase I

- After interphase I, the cell begins to divide, and the chromosomes pair up.
- Each chromosome appears in the condensed form with two chromatids.
- Homologous pairs of chromosomes associate with each other.
- In **prophase I** of meiosis, each replicated chromosome **pairs** with its corresponding homologous chromosome.
- This pairing form a structure called a **tetrad**, which contains **four chromatids.**
- As the homologous chromosomes form **tetrads,** they undergo a process called **crossing over.**
- First the chromatids of the homologous chromosomes (**non-sister chromatids**) cross over one another.
- Then, the crossed sections of the non-sister chromatids—which contain **alleles—are exchanged.**
- Crossing-over therefore produces new **combinations of alleles** in a cell.

2. Metaphase I

- As prophase I ends, a spindle forms and attaches to each tetrad.

- During metaphase I of meiosis, paired homologous chromosomes line up across the **center** of the cell.

3. Anaphase I

- As the cell moves into anaphase I, the homologous pairs of chromosomes separate.
- During anaphase I, spindle fibers pull each **homologous** chromosomes pair toward **opposite ends** of the cell.

4. Telophase I and Cytokinesis

- When anaphase I is complete, chromosomes cluster at opposite ends of the cell.
- The nuclear membrane reforms around each cluster of chromosomes. Cytokinesis follows telophase I, forming two new cells.
- Meiosis I results in two cells called daughter cells. However, because each pair of homologous chromosomes was separated, neither daughter cell has the two complete sets of chromosomes that it would have in diploid cell.
- Those two sets have been shuffled and sorted almost like a deck of cards. The tywo cells produced by meiosis I have sets of chromosomes and alleles that are different from each other and from the diploid cell that entered meiosis I.

Meiosis II

- The two daughter cells now enter a second meiotic division (meiosis II).
- Unlike the first division, neither cell goes through a round of chromosome replication before entering meiosis II.

1. Prophase II

- As the cell enter prophase II, their chromosomes—each consisting of **two chromatids**—become **visible.**
- **The chromosomes do not pair to form tetrads, because the homologous pairs were already separated during meiosis I.**

2. Metaphase II, Anaphase II, Telophase II, and Cytokinesis

Metaphase II: During metaphase of meiosis II, chromosomes line up in the center of the each cell.

Anaphase II: As the cell enters anaphase II, the paired chromatids separate.

- The final four phases of meiosis II are similar to those in meiosis I. However, the result is **four haploid daughter cells.** Each of the four daughter cells produced in meiosis II receive two chromosomes. These four daughter cells know contain the haploid number (N) — just two chromosomes each.

Gametes to Zygote

- The haploid cells produced by meiosis II are the **gametes** that are so important to heredity.
- In male animals, these gametes are called **sperm.** In female animals, generally only one of the cells produced by meiosis is involved in reproduction.
- In animals, the female gamete is called an **egg.**
- After it is fertilized, the egg is called a **zygote**.
- The zygote undergoes cell division by mitosis and eventually forms a **new organism.**

Comparing Mitosis and Meiosis

- Mitosis can be a form of asexual reproduction, whereas meiosis is an early step in sexual reproduction.
- There are three other ways in which these two processes will differ.

A, Replication and separation of Gametic Material

- Mitosis and meiosis are both preceded by a complete copying, or replication, of the genetic material of chromosomes.
- However, the next steps differ dramatically.
- In mitosis, when the two sets of gametic material separate, each daughter cell receives one complete set of chromosomes.
- In meiosis, **homologous chromosomes** line up and then move to separate daughter cells.
- As a result, two alleles for each gene are **segregated,** and end up in different cells.
- The sorting and recombination of genes in meiosis result in a **greater variety** of possible gene combinations than could result from mitosis.

B, Changes in Chromosome Number of the original cell.

- Mitosis does not normally change the chromosome number of the original cell.
- This is **not** the case for meiosis, which reduces the chromosome number by **half.**

C, Number of Cell Division

- Mitosis is a **single** cell division, results in the production of **two genetically identical diploid cells,** whereas meiosis requires two rounds of cell division and produces four **genetically different haploid cells.**

The relationship between chromosomes, Genes, alleles, and traits (Characters of the organism)

- In eukaryotes inheritance of characteristics (**trait**) is the result of cellular structures called **chromosomes.**
- A **chromosome** is composed of a molecule of inheritance called **DNA,** enclosed within a protein coat called **histone.**
- There are different sections of DNA molecules called **genes** that determine the characteristics of an organism.
- A **gene** is a region or segment of DNA for a particular character (e.g. blood type, skin color, tongue rolling, sex, etc.).
- A gene may have two or more alternative forms called **alleles.**
- An **allele** is an alternative form of a gene.
- A character (trait) with **similar** alleles in a pair is called **homologous.**
- A character (trait) with **dissimilar** alleles in a pair is called **heterozygous.**
- In each body cell of an organism, chromosomes exist in paired sets.
- In sexually reproducing organisms one set is **parental** (inherited from father), while the other is **maternal** (inherited from mother).
- For example, humans have 46 chromosomes (23 pairs) of which one set (23 is paternal and the other set (23) is maternal.

Gametogenesis

Meiosis occurs as part of a process known as **gametogenesis**, or **gametes formation**. In females this called **oogenesis.** In a baby girl, the first stage of meiosis is completed <u>before she is even born.</u>

The tiny ovaries of a baby girl contain all the ova she will ever have. The second meiotic division <u>begins as the eggs mature in the ovaries during the monthly cycle.</u>

In males, meiosis doesn‘t until puberty, when the testis starts to produce sperm. The production of sperm is called spermatogenesis, and carries on throughout a man‘s life.

Each gamete you produce is slightly different from all the others. The combination of chromosomes will be different. What is more, there is some exchange of genes between the chromosomes during the process of meiosis, which means that no two eggs or sperm are the same. This introduces a lot of variety into a genetic mix of the offspring.

Mendelian Inheritance

Gregor Mendel (1822 – 1884) was the first person to systematically study inheritance and formulate laws about heredity.

- Mendel did several experiments on garden pea plants to study the mechanism of inheritance of characters.
- Mendel chose garden pea plants because of the following advantages observed by him:

1. Naturally they are self-pollinated when required they can be cross pollinated
2. Attain maturity and complete their life cycle within a short period of time, i.e. three months
3. Showed several variable contrasting characters (14 varieties)
4. They are cheap or easily available

- The delivery of characteristics from parent to offspring is called **heredity.**
- The scientific study of heredity is known as **genetics.**
- A **trait** is a specific characteristic, such as seed color or plant height of an individual plant.
- 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.**
- When doing genetic crosses, we call each original pair of plants the **P_1** or **parental**, generation.
- Their offspring are called the **F_1**, or **first filial**, generation (*Filius* and *filia* are the Latin words for "son‖ and"daughter‖).
- In each cross, the nature of the other parent, with regard to each trait, seemed to have disappeared.
- From these results, Mendel drew two conclusions. His first conclusion formed the basis of our current understanding of inheritance.

1. An 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.**
- For example, the two contrasting genes for plant height are tall (TT) and short (tt).
- The different forms of a gene are called **alleles** (a gene has two alleles).

2. **Dominant and Recessive Alleles**. Mendel's second conclusion is the **principle of dominance.**

- This principle 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.**

Mendel's Seven F_1 Crosses on Pea Plants

Traits	Contrasting Traits Dominant and Recessive alleles	Genotype of offspring	Phenotype of offspring
Seed shape	Round (RR) & wrinkled (rr)	all Rr	Round
Seed color	Yellow (YY) & green (yy)	all Yy	Yellow
Seed coat	Gray GG & white (gg)	all Gg	Gray
Pod shape	Inflated (Dd) & constricted (Dd)	all Dd	Smooth
Pod color	Green (GG) & yellow (gg)	all Gg	Green
Flower position	Axial (AA) & terminal (aa)	all Aa	Axial
Plant height	Tall (TT) & short (tt)	all Tt	Tall

Using Punnett Square

Pure tall (TT)l pure short (tt)

F_1= hybrid tall == All F_1 tall (hybrid tall)

	T	T
t	Tt	Tt
t	Tt	Tt

Punnett Square - is a simple table that shows the possible combination of gametes of two parents.

- **Punnett square** uses mathematical probability to predict the **genotype** and **phenotype** combinations in genetic crosses.
- It represents the possible genotypes of the offspring so produced, and the ratio in which they will occur.
- It was named after the English geneticist **Reginald Crundal Punnett**

Mendel's Techniques

1. First, Mendel allowed self-pollination and fertilization of different lines of garden pea plants.
   - He took those lines which produced the same trait (phenotype) generation after generation during self-fertilization.
   - He called these **true breeders** or **pure breeders.**
2. He then crossed pure breeders for seven contrasting characteristics. Pure tall and pure short plants, for example, were crossed.
   - For this, he removed stamens from flowers of the tall plants before maturity.
   - This prevented self-pollination.
3. At flower maturity, he transferred pollen grains from flowers of short plants to the stigma of tall plants.
   - He reciprocated his experiment by removing stamens from short plants and dusting them with pollen grains from tall plants.

1. Mendel grew all seeds from F1 generation and noted the plants at maturity. **All of them were tall**.
   - Mendel called the trait expressed in F_1 as **dominant**, and the one masked, **recessive**.
   - In this case **tallness** is dominant and **shortness** is recessive.
2. The F_1 plants were allowed to **self-pollinate**, and produce seeds.
3. These seeds were collected and planted to produce **F_2, the second filial generation.**

- The second filial generation exhibited nearly 3 dominant to 1 recessive trait in all Mendel's experiments (3:1).
- For example, when hybrid tall, **Tt** is self-pollinated, it result:

1 true-breeding dominant,

2 not-true-breeding dominant and

1 true-breeding recessive.

	T	t
T	TT	Tt
t	Tt	tt

- F_1 x F_1 = F_2 and the genotypic ratio is **1: 2: 1**and phenotypic ratio is **3: 1** and such cross is known as **monohybrid cross** which considers **one trait only.**

- Homologous are characters having identical alleles
- Heterozygous are characters having non identical alleles
- Dominant is the expressed character
- Recessive is the hidden character
- Phenotype is the physical appearance of an organism
- Genotype is the genetic composition of an organism
- Organisms that have two identical alleles for a particular gene—TT or tt (for height) are said to be **homozygous.**
- Organisms that have two different alleles for the same gene—such as Tt—are **heterozygous.**

Segregation

- During gamete formation, the alleles for each gamete carry only one allele for each gene.
- Thus, each F_1 plant produces two kinds of gametes—those with the tall (T) allele and those with the short (t) allele.
- During gamete formation, the alleles for each gene segregate (separate) from each other, so that each gamete carries` only one allele for each gene.
- The alleles are paired up again when gametes fuse during fertilization.
- A **capital letter** represents a dominant and a **small letter** a recessive letter.

Mendel's Laws

1. Mendel's First Law: Segregation

Mendel's First Law: States that only one allele specifying an alternative trait can be carried in a particular gamete, and gametes combine randomly in forming offspring

2. **Mendel's Second Law: Independent assortment**

Mendel's Second Law: States that genes located on different chromosomes are inherited independently of one another.

Mendel's theories of segregation and independent assortment are so well supported by experimental results that they are considered "**laws.**‖

Test Cross

- When an individual expresses the dominant phenotype, its genotype is unknown, it can be either heterozygous (hybrid) or homozygous.
- To determine the genotype, we must perform a test cross.
- An individual of unknown genotype is crossed with an individual having a recessive phenotype because to express the recessive trait, the individual must be heterozygous.

A summary of Mendel's Principles

1. The inheritance of biological characteristics is determined by individual units called **genes**, which are passed from parent to offspring.
2. Where two or more forms (alleles) of the gene for a single trait exist, some alleles may be **dominant** and others may be **recessive.**
3. In sexually reproducing organisms, **each adult has two copies of each gene**—one from each parent. These genes **segregate** from each other when gametes are formed.
4. Alleles for different genes usually **segregate independently** of each other.

Dihybrid Cross

- So far, the experiments of Mendel that we have discussed involved only one trait (**monohybrid**).
- Mendel also made crosses that involved the inheritance patterns of **two traits** in a single mating. This type of cross is termed as a **dihybrid cross.**
- For example: Tall (TT) plants with round seeds X Short plants with wrinkled seeds.
  TTRR x ttrr ⟶ TR x tr

Gamete is formed by taking one allele from each gene, and only one gene type of gamete is formed from homozygous organisms.

F_1—TtRr (all tall and round seeds)

P_2 == Self- fertilization of F_1 == TtRr x TtRr

Gametes-----TR, Tr, tR, tr x TR, Tr, tR, tr

Punnett square showing sixteen offspring produced from dihybrid cross.

Female \ Male	TR	Tr	tR	tr
TR	TTRR	TTRr	TtRR	TtRr
Tr	TTRr	TTrr	TrRr	Ttrr
tR	TtRR	TtRr	TtRR	ttRr
tr	TtRr	Ttrr	ttRr	ttrr

F_1 x F_1 == F_2 (16 offspring are produced)

1) 9 tall round ---------T-R- -------- 3/16
2) 3 tall wrinkled -----T-rr --------- 3/16
3) 3 short round ------- ttR- --------- 3/16
4) 1 short wrinkled ---- ttrr --------- 1/16

Phenotypic ratio === 9: 3: 3: 1
Genotypic ratio =====1: 2: 1: 2: 4: 2: 1:2: 1

Phenotypic classes ===== 4
Genotypic classes ======9

Types of Dominance: 1. Complete dominance 2, Incomplete dominance 3. Codominance

1. **Complete dominance**—is a situation in which one of the alleles in the pair completely masks the other allele, and expresses itself.
   Example; When pure tall (TT) crossed with pure short (tt) all offspring become tall.
2. Incomplete dominance = some alleles are neither dominant nor recessive. Cases in which one allele is not completely dominant over another are called **incomplete dominance.**

- In incomplete dominance, the heterozygous phenotype lies somewhere between the two homozygous phenotypes.
- **For example**: The F1 generation produced by a cross between red-flowered (RR) and white flowered (WW) Mirabilis plants consists of **pink –colored plants (RW).**

3. **Codominance**—The phenotypes produced by both alleles are clearly expressed.

- **For example:** If pure-breeding red cattle are crossed with pure-breeding white cattle, the heterozygote so produced will be **roan (ቡራቡሬ).**
- Another example of codominance is **AB blood type in humans.**

There are three alleles for human blood type: These are I^A, I^B, and I^O.

1. Group A → AA or AO (A is dominant over O)
2. Blood group B → BB or BO (B is dominant over O)
   Blood group AB → AB (example of codominant)

More Human Inheritance

- There are a number of genetic conditions which cause serious health problems and even death.
- Many other combinations have a relatively simple but very noticeable effect. One of these is albinism.
- The high levels of melanin (black pigment) in Ethiopian skin gives a natural protection against UV radiation from the sun but even so it is still sometimes useful to have additional protection from sunscreen.
- People with paler skins are much more likely to suffer severe sun damage.
- **Albinism** is a genetic condition in which no melanin pigment is formed in the cells.

A) How two carriers can produce an albino child?

- Parental genotype → Aa x Aa
- Possible gametes → A and a x A and a
- Possible F1 genotype → 1AA : 2Aa : 1aa
- Possible F1 phenotypes → 3 normal: 1 albino

	A	a
A	AA	Aa
a	Aa	aa

B) How an albino and someone with a normal phenotype but heterozygous might produce an albino child or a normal child?

- Parental genotype → Aa x aa
- Possible gametes → A and a x a and a
- Possible F1 genotypes are → 1AA : 1aa
- Possible F1 phenotypes → 1 normal: 1 albino

	A	a
a	Aa	aa
a	Aa	aa

C) How an albino and a homozygous normal individual would never have an albino child?

- Parental genotype → AA x aa
- Possible gametes → A and A x a and a
- Possible F1 genotypes → All Aa
- Possible F1 phenotypes → all normal

Albinism is particularly noticeable in areas where most people have a high level of melanin in the skin, such as **Africa.**

- The appearance of an albino in a family can appear quite random, but it is the result of hidden recessive alleles.
- For example, in the inherited condition known as albinism the melanin pigment in the skin, hair and eyes does not develop.
- The normal allele for pigment to develop is A and it is dominant.
- The allele for albinism, a, is recessive. Albinism is found throughout the animal kingdom and people are no exception.
- Albino individuals are very vulnerable to sun damage to their skin, so they have a greatly increased risk of developing skin cancer.
- They have to take great care to protect their vulnerable skin from sunlight.
- Their eyes are also very sensitive to light and they often have problems with their vision – but apart from this they lead completely normal lives.
- If people do not understand genetics, the arrival of an albino baby can cause great distress, and in the past, albinos often suffered discrimination as a result of their unusual appearance.
- However, for albinism and indeed any other genetic traits, looking at the family can show exactly how a characteristic has been passed on.

Heredity and Breeding

1. **Selective breeding**

- One way to improve the performance of a crp plant or domestic animal is to select the best possible individuals of that type and use them to build up your stock.
- Selective breeding is used to breed for particular trait.
- You need to select true-breeding plants or animals, so it is important that the history of the organism is known.
- If the characteristic you want to select is recessive, it is easy to be sure that the parents are true breeding.
- If they show the characteristic, they will be homozygotes.
- If the trait you want is dominant, you may need to carry out a test cross using a known homozygous recessive on the parents to make sure they are homozygous.
- For selective breeding to work, it is important to use only the best animals which have the characteristics you want in the breeding program.
- This means that the male and female animals which have the characteristic you want should be allowed to mate, but animals which do not have the characteristic should be castrated or prevented from mating.

2. **Cross-breeding—hybridization**

Hybridization (cross breeding) is crossing dissimilar individuals to bring together the best of both organisms.
Hybrids—the individuals produced by such crosses—are often hardier than either of the parents.

Multiple Alleles

- Many genes exist in several different forms and are therefore said to have multiple alleles.
- A gene with more than two alleles is said to have multiple alleles.
- One of the best-known examples is coat color in rabbits.
- A rabbit's coat color is determined by a single gene that has at least four different alleles.
- The four known alleles display a pattern of simple dominance that can produce four coat colors.
- Many other genes have multiple alleles, including the human genes for blood type.

Polygenic Traits

- Many traits are produced by the **interaction of several genes.**
- Traits controlled by <u>two or more</u> genes are said to be **polygenic traits.**
- *Polygenic* means "many genes.‖ For example, **at least three genes** are involved in making the <u>reddish-brown pigment in the eyes of fruit flies.</u>
- Polygenic traits often show a wide range of phenotypes.
- The variety of **skin color in human** comes about partly because <u>more than **four** different genes</u> probably control this trait.

Genes and the Environment

- Scientific study showed that butterflies hatching in the **shorter days** of springtime had levels of pigment in their wings, making their markings appear **darker** than those hatching in the <u>longer days of summer.</u>
- In other words, the environment in which the butterflies influences the expression of their genes for wing coloration.
- **Environmental conditions** <u>can affect gene expression and influence genetically determined traits.</u>

UNIT 3

Human Biology and Health

I. The Nervous System

- The Nervous System collects information about the body's internal and external environment, processes that information, and responds to it.
- These functions are accomplished by the peripheral nervous system and the central nervous system.
- The **peripheral nervous system**, which consists of nerves and supporting cells, collects information about the body's external and internal environment.
- Peripheral nervous system is composed of **cranial** nerves and **spinal** nerves.
- Cranial nerves arise from the brain (there are 12 pairs of cranial nerves).
- Spinal nerves arise from the spinal cord
- 31 pairs of spinal nerves branch out from the spinal cord, connecting the brain to different parts of the body.
- Certain kinds of information, including many reflexes, are processed directly in the spinal cord.
- A reflex is a quick, automatic response tops a stimulus.
- The way in which you pull your hand back quickly when picked by a pin is an example of a reflex.

3. The **Central Nervous System (CNS)** , which consists of the **brain** and **spinal** cord, processes that information and creates a response that is delivered to the appropriate part of the body through the peripheral nervous system.

Peripheral Nervous system
Gathers information and sends it to he central nervous system

Input ↓

Central Nervous system
Processes the information and forms a response

Output ↓

Peripheral Nervous System
Carries the response of the central nervous system to glands and muscles

Neurons: Nervous system impulses are transmitted by cells called **neurons**.

Types of Neurons: Neurons can be classified into three types according to the direction in which an impulse travels.

1. **Sensory Neurons**: Carry impulses from the sense organs, such as the eyes, the ears, to the spinal cord and brain.

2. **Motor Neurons**: carry impulses from the brain and spinal cord to muscles and glands.

3. **Interneurons (Association neurons):** Process information and determine how an animal responds to stimuli.

- They process information from sensory neurons and then send commands to other interneurons or motor neurons.

- ¬ Determination by interneuron--- E.g. Is the immediate environment too hot, too cold, or just right?
- ¬ The number of interneurons an animal has, and the ways those interneurons process information, determine how flexible and complex an animal's behavior can be.
- ¬ Some invertebrates such, as cnidarians and worms, have very few interneurons.
- ¬ These animals are capable of only simple responses to stimuli. They may swim toward light or toward a chemical stimulus that signals food.
- ¬ Vertebrates have more highly developed nervous systems with larger numbers of interneurons.
- ¬ The brain is made up of many of these interneurons. That is why the behaviors of vertebrates can be more complex than those of most invertebrates.

Structure of Neurons: Although neurons come in many shapes, and sizes, they all have certain features in common.

- The largest part of a typical neuron is its **cell body**, which contains the nucleus and much of the cytoplasm.
- Spreading out from cell body are short, branched extensions called **dendrites.**
- **Dendrites** receive impulses from other neurons and carry impulses to the **cell body.**
- The long fiber that carries impulses away from the cell body of a neuron is the **axon.**
- An axon ends in a series of small swelling called **axon terminals.**
- Neurons may have dozens of dendrites, but usually they have only **one axon.**
- In most animals, axons and dendrites of different neurons are clustered into bundles of fibers called **nerves.**
- Some nerves contain fibers from only a few neurons, but others contain hundreds or even thousands of neurons.
- In some neurons the axon is surrounded by an insulating membrane known as the **myelin sheath.**
- The myelin sheath that surrounds a single, long axon has many gaps, called nodes; where an axon membrane is exposed. As an impulse moves along the axon, it jumps from one node to the next.
- This arrangement causes an impulse to travel faster than it would through an axon without a myelin sheath.

The Nerve Impulse

How does a nerve impulse begin?

- A **nerve** is a bundle of the long neuron fibers known as axons, which are held by connective tissue.
- In a nerve, as in wires of a telephone cable, each axon is insulated from the neighbors by the protective myelin sheath.

How a Neural Impulse is transmitted?

- A resting neuron: a neuron not transmitting an impulse the inner surface of the plasma membrane is negatively charged compared with the interstitial fluid surrounding it.
- The resting neuron is said to be electrically polarized, that is, the inside of the membrane and the interstitial fluid outside are oppositely charged.
- When electrical charges are separated in this way, they have the potential to do work.
- This difference in electric potential between the two sides of the membrane is called the resting potential of the neuron.

What is Responsible for the Resting Potential?

- It results from the presence of a slight excess of negative ions INSIDE the plasma membrane and a slight excess of positive ions inside of the plasma membrane.
- This imbalance in ion distribution is brought about by several factors.
- One of them is the sodium – potassium pump (Na^+ - K^+). As a result of this pump, the cell actively transports Na^+ out of the cell and K^+ into the cell. This pump works against a concentration gradient.
- About **three sodium** ions are pumped out of the neuron for every two potassium pumped in. Thus, more positive ions are pumped out than pumped in.
- Hence, the positive charges result from an excess of sodium ion (Na^+) on the outside of the membrane. Some potassium ions K+) also move to the outside of the membrane. The negative charged molecules like proteins and organic phosphates within the neuron that are too big to diffuse out.
- This difference in charge across the membrane creates a resting potential.

The Action Potential

- In a **depolarized state**, there are more positive ions in the **inside of the neuron** than on the outside.
- The positive ions now on the inside cause the adjacent section of the membrane to **change permeability.**

- In this way the impulse travels down the axon as a wave. The wave of depolarization is called an **action potential** (a state of depolarization).
- This is the actual wave impulse transmission of the wave of a neural impulse.
- After the impulse passes a given spot the original polarity of the resting potential returns.

Neurons are not continuous ‗wires' running about our body. Whenever one neuron ends and another begins there is a gap known as a **synapse**.

- The electrical impulses that travel along our neurons have to cross these synapses, but an electrical impulse cannot leap the gap.
- So when an impulse arrives at the end of a neuron, chemicals are released. These chemical transmitters (**neurotransmitters**) cross the synapse and are picked up by special receptor cells in the end of the next neuron.
- In turn this starts up an electrical impulse, which then travels along our next neuron. This is how impulses pass from one neuron to another over our body.
- Synapses are very important for the **co-ordination** of information in our central nervous system, information that is coming in from many different areas of our body.
- There are special synapses between effector neurons and the muscles they stimulate.
- These are known as **neuromuscular junctions** and they work in the same way as a normal synapse, except the chemical crossing the gap causes the **muscles to contract**.

An **impulse** is a bit like the flow of an electric current through a wire. To see how this occurs, let as examine a neuron at rest.
The Resting Neuron: Neurons, like most cells, have a charge, or an electrical potential, across their cell membrane.

- The inside of a neuron has a voltage of –70 millivolts (mV) compared to the outside.
- This difference, or **resting potential**, is roughly one-twentieth the voltage in a flash light battery.

Where does this potential come from?

- Active transport proteins pump sodium ions (Na^+) out of the cell and potassium ions (K^+) into it.
- Since both ions are positively charged, this alone doesn't produce a potential across the membrane.
- However, ungated potassium channel proteins make it easier for K+ ions than Na+ ions to diffuse back across the membrane.
- Because there is a higher concentration of K+ ions inside the cell as a result of active transport, there is a net movement of positively charged K+ ions out of the cell.
- As a result, the inside becomes negatively charged compared to the outside, producing the resting potential.
- **The Moving Impulse:** A neuron remains in its resting state until it receives a stimulus large enough to start a nerve impulse.
- **An impulse begins when a neuron is stimulated by another neuron or by the environment.**
- Once it begins, the impulse moves quickly down the axon away from the cell body toward the axon terminals.
- In myelinated axons, the impulse moves even more rapidly as it skips from one node to the next.

What actually happens during an impulse?

- The impulse itself is a sudden reversal of the resting potential.
- The neuron cell membrane contains thousands of "gated‖ ion channels.
- At the leading edge of an impulse, gated sodium channels open, allowing positively charged Na+ ions to flow into the cell.
- The inside of the membrane temporarily becomes more positive than the outside, reversing the resting potential.
- This reversal of charges, from more negatively charged to more positively charged, is called a nerve impulse or **action potential.**
- Once the impulse passes, sodium gates close and gated potassium channels open, allowing K+ ions to flow out.
- This restores the resting potential so that the neuron is once again negatively charged on the inside.
- All the while, the sodium-potassium pump keeps working, ensuring that the axon will ready for more action potentials.
- A nerve impulse is self-propagating that is, the flow of ions at the point of the impulse causes sodium channels just ahead of it to open.
- This allows the impulse to move rapidly along the axon

In your own words, summarize what happens across a neurons membrane when it is at rest and during an action potential?

Threshold: Not all stimuli are capable of starting an impulse. The minimum level of a stimulus that is required to cause an impulse in a neuron is called its **threshold.**

- Any stimulus that is weaker than the threshold will not produce an impulse.

- A nerve impulse is an all-or-none response.
- Either the stimulus produces an impulse, or it does not produce an impulse.
- The threshold principle can also be illustrated by using a row of dominoes.
- If you were to gently press the first domino in a row, it might not move at all.
- A slightly harder push might make the domino teeter back and forth but not fall.
- A push strong enough to cause the first domino to fall into the second, and start the whole row falling, is like a threshold stimulus.
- If all action potentials have the same strength, how do we sense if a stimulus, like touch or pain, is strong or weak?
- The brain determines this from the frequency of action potentials.
- A weak stimulus might produce three or four action potentials per second, while a strong one might result in as many as 100 per second. If you accidentally hit your finger with a hammer, those action potentials fire like mad!

Synapse: At the end of the neuron reaches an axon terminal, which may pass the impulse along to another cell.

- A motor neuron, for example, may pass an impulse to a muscle cell, causing the muscle cell to contract.
- The point at which a neuron transfers an impulse to another cell is called a synapse.

A space called synaptic cleft, separates the axon terminal from the adjacent cell.

- The axon terminal at the synapse contains tiny vesicles filled with **neurotransmitters.**

Neurotransmitters are chemicals that transmit the impulse across a synapse to another cell.

- When an impulse arrives at the synapse, neurotransmitters are released from the axon, diffuse across the synaptic cleft and bind to receptors on the membrane of the receiving cell.
- If the stimulation exceeds the cells threshold, a new impulse begins.
- Once they have done their work, the neurotransmitters are released from the receptors on the cell surface.
- They are then broken down by enzymes in the synaptic cleft or taken up and recycled by the axon terminal.

The Central Nervous System (CNS)

The Brain and spinal Cord

- The control center of the central nervous system is the **brain.**
- Each of the major areas of the brain –the **cerebrum**, **cerebellum**, and **brain stem**—are responsible for <u>processing and relaying information.</u>
- Like the central processing unit of the computer, information processing is the brains principal task.
- Most of the neurons that enter and leave the brain do so in a large cluster of neurons and other cells known as the **spinal cord.**
- The **spinal cord** is the main communication link between the brain and the rest of the body.
- **31 pairs** of spinal nerves branch out from the spinal cord, connecting the brain to different parts of the body.
- Certain kinds of information, including many reflexes, are processed directly in the **spinal cord**.
- A **reflex** is a quick, automatic response to a stimulus.
- The way in which you pull your hand back quickly when pricked by a pin is an example of a **reflex**.

1. Cerebrum

- The largest region of the human brain is the cerebrum.
- The **cerebrum** is responsible for the **voluntary**, or **conscious**, activities of the body.
- A deep groove divides the cerebrum into right and left **hemispheres**.
- The hemispheres are connected by a band of tissue called the **corpus callous.**
- Each hemisphere deals mainly with the <u>**opposite sides of the body.**</u>
- **Sensations** from the left side of the body go to the right hemisphere, and those from the right side go to the left hemisphere. Commands to move muscles are delivered in the same way.
- Each hemisphere is divided into regions called **lobes**. The four lobes are named for the skull bones that cover them. Each of these lobes are associated with **different functions**.

Cerebral Cortex

- The cerebrum consists of two layers. The **outer layer of the cerebrum** is called the **cerebral cortex** and consists of densely packed nerve cell bodies known as **gray matter.**
- The cerebral cortex processes in**formation** from the sense organs and **controls body movements.**
- It is also where **thoughts**, **plans**, and **learning abilities** are processed.

- Folds and grooves on the outer surface of the cerebral cortex greatly increase its surface area.

  White matter: The inner layer of the cerebrum is known as **white matter.**
- Its white color comes from bundles of axons with myelin sheaths. These axons may connect different areas of the cerebral cortex, or they may connect the cerebrum to other areas of the brain such as the brain stem.

2. Thalamus and Hypothalamus

The **thalamus** and **hypothalamus** are found between the brain stem and the cerebrum.

- The thalamus receives messages from sensory receptors throughout the body and then relays the information to the proper region of the cerebrum for further processing.
- Just below the thalamus is the hypothalamus.
- The hypothalamus is the control center for recognition and analysis of hunger, thirst, fatigue, anger, and body temperature.
- The hypothalamus also helps to coordinate the nervous and endocrine systems.

4. **Cerebellum**

- The second largest region of the brain is the cerebellum.
- Information about muscle and joint position, as well as other sensory inputs, are sent to the cerebellum.
- Although the commands to move muscles come from the cerebral cortex, sensory information allows the cerebellum to coordinate and **balance** the actions of these muscles.
- This enables the body to move gracefully and efficiently.

5. **Brain Stem**

- The **brain stem** connects the brain and spinal cord. Located just the cerebellum, the brain stem includes 3 regions—the **midbrain**, the **pons,** and the **medulla oblongata.**
- Each of these regions regulates the flow of information between the brain and the rest of the body.
- Some of the body's most important functions—including the **regulation of blood pressure**, **heart rate breathing,** and **swallowing**—are controlled by the **brain stem.**

Brain stem does the work of keeping the body functioning even when you have lost consciousness due to sleep or injury.

Addiction and Brain

How do drugs change the brain and lead to addiction?

- **Synapses** make the brain work by transferring messages from cell to cell, doing the conscious work of thinking and the less conscious work of producing feelings and emotions.
- Nearly every additive substance, including illegal drugs such as heroin, methamphetamine, and cocaine, and legal drugs, such as tobacco and alcohol, affect brain synapses.
- Although the chemistry of each drug is different, they all produce changes in one particular group of synapses.
- These synapses use the neurotransmitter **dopamine** and are associated with the brains pleasure and reward centers.

Dopamine—is neurotransmitter that is associated with the brains pleasure and reward centers.

- When we engage in an activity that brings us pleasure, whether it is eating a tasty snack or being praised by a friend, neurons in the hypothalamus and the limbic system release dopamine.
- **Dopamine** molecules stimulate other neurons across these synapses producing the sensation a pleasure and a feeling of wellbeing.
- **Additive drugs** act on dopamine synapses in a number of ways.
- **Methamphetamine** releases a flood of dopamine, producing an instant "high.‖
- **Cocaine** keeps dopamine in the synaptic region longer, intensifying pleasure and suppressing pain.
- Drugs made from **opium poppies**, like **heroin,** stimulate receptors elsewhere in the brain that lead to dopamine release.
- **Nicotine**, the additive substance in tobacco, and alcohol, also cause increased release of dopamine.
- The brain reacts to excessive dopamine levels by reducing the number of receptors for the neurotransmitter.
- As a result, normal activities no longer produce the sensation of pleasure they once did.
- Addicts feel depressed and sick without their drugs. Because there are fewer receptors, larger amounts of tobacco, alcohol and illegal drugs are required to produce the same high.
- The result is a deeper and deeper spiral of addiction that is difficult to break.

The Peripheral Nervous System (PNS)

How does the central nervous system receive sensory information?

- The peripheral nervous system consists of all the nerves and associated cells that are not part of the brain or spinal cord.
- Cranial nerves go through openings in the skull and stimulate regions of the **head** and **neck.**
- Spinal nerves stimulate the rest of the body. The cell bodies of the spinal and cranial nerves are arranged in clusters called **ganglia.**
- The peripheral nervous system, our link with the outside world consists of two main divisions.

1, Sensory division **2. Motor division**

- The sensory division of the PNS transmits impulses from **sense organs to CNS.**
- The motor division transmits impulses from CNS to the **muscle** and **glands.**
- **Sensory receptors** are cells that transmit information about changes in the environment—both **internal** and **external.** These changes are called **stimuli.**
- Sensory receptors can be categorized by the **type of stimuli** to which they respond.
- When stimulated, sensory receptors transmit impulses to the central nervous system.

Sensory Receptors		
Type	Responds to	Some Location
Chemoreceptors	Chemicals	Mouth, nose blood vessels
Photoreceptors	Light	Eyes
Mechanoreceptors	Touch, pressure, vibrations, & stretch	Skin, hair follicles, ears, ligaments, tendons
Thermo receptors	Temperature changes	Skin, hypothalamus
Pain receptors	Tissue injury	Throughout the body

2. The Motor Division

How do muscles and glands receive commands from the central nervous system?

- The nervous system plays a key role in maintaining homeostasis by coordinating the activities of other systems and organs.
- Once it has gathered and processed sensory information, the nervous system sends commands to the rest of the body.
- The motor division of the PNS transmits impulses from the CNS to muscles or glands.
- These messages are relayed through one of the two divisions, the **somatic nervous system** (SNS) or the **autonomic nervous system (ANS).**

1. Somatic Nervous System (SNS)

- The **Somatic Nervous System** regulates body activities that are under conscious control, such as the movement of the skeletal muscles.
- Most of the time you have control over voluntary muscle movement, but when your body is in danger the central nervous system may take over.

1.1 Voluntary Control

- Every time you lift your finger or wiggle your toes, you are using motor neurons of the somatic nervous system.
- Impulses originating in the brain are carried through the spinal cord where they synapse with the dendrites of the motor neurons.
- The axons from these motor neurons extend from the spinal cord carrying impulses directly to muscles, causing the contractions that produce voluntary movements.

1.2 Reflex Arcs

- Although the somatic nervous system is generally considered to be under conscious control, some actions of the system occur automatically/

- For example if you accidentally step on a tack with your bare foot, your leg may recoil before you are even aware of the pain.
- This rapid response (a **reflex**) is caused by impulses that travel a pathway known as a **reflex arc.**

1. In the above example, sensory receptors react to the sensation of the tack and send an impulse to sensory neurons.

2. Sensory neurons relay the information to the spinal cord.

3. An interneuron in the spinal cord processes the information and forms the a response.
4. A motor neuron carries impulses to its effector, a muscle that it stimulates.

5. The muscle contracts and your leg moves.

- Meanwhile, impulses carrying information about the injury are sent to your brain.
- By the time your brain interprets the pain, however, your leg and foot have already moved.
- The spinal cord **does not** control all reflexes. Many reflexes that involve structures in your **head**, such as **blinking** or **sneezing,** are controlled by the **brain.**

2. Autonomic Nervous System

- The autonomic Nervous System regulates activities that are involuntary, or are not under conscious control.
- The autonomic nervous system consists of two equally important parts, the sympathetic nervous system and parasympathetic nervous system.
- In general, the sympathetic parasympathetic systems have opposite effects on each organ they influence.
- For example, heart beat rate is increased by the sympathetic nervous system but decreased by the parasympathetic nervous system.
- In general, the sympathetic system prepares the body for intense activity.
- Its stimulation causes an increase in blood pressure, the release of energy-rich sugar into the blood, and the shutting down of activities not related to the body's preparation to "fight or flee‖ in response to stress.
- In contrast, the parasympathetic system causes what might be called the "rest and digest‖ response.
- It lowers heart rate and blood pressure, activates digestion, and activates pathways that store food molecules in the tissues of the body.

II. The Sense Organs

1. Touch and Related Senses

How does the body sense touch, temperature and pain?

- Because nearly all regions of the skin are sensitive to touch, your skin can be considered your largest sense organ.
- Different sensory receptors in the body respond to touch, temperature and pain.
- All of these receptors are found in your skin, but some are also found in other areas.

I. Touch

Human skin contains at least **seven types of sensory receptors**, including several that respond to different levels of pressure.

- Stimulation of these receptors creates the sensation of touch. Not all parts of the body are equally sensitive to touch.
- The skin on your fingers, as you might expect, has a much higher density of touch receptors than the skin on your back.

II. Temperature

- **Thermoreceptors** are sensory cells that respond to heat and cold. They are found throughout the skin, and also in the hypothalamus, part of the brain that senses blood temperature.
- Recently, researchers studying the cell membrane proteins that sense heat made an interesting discovery. The chemical substance that make jalapeno peppers taste "hot‖ actually bind to these very same proteins.

III. Pain

- Pain receptors are found throughout the body. Some, especially those in the skin, respond to physical injuries like cutting or tearing.

- Many tissue also have pain receptors that respond to chemicals released during infection or inflammation.
- The brain, interestingly, does not have pain receptors. For this reason, patients have often kept conscious during brain surgery, enabling them to tell surgeons what sensations are produced when parts of the brain are stimulated.

2. Smell and Taste

How are the senses of smell and taste similar?

- Chemical-sensing cells known as **chemoreceptors** in the nose and mouth are responsible for both of these senses.
- Sensations of smell and taste are both the result of impulses sent to brain by **chemoreceptors**
- Your sense of smell is capable of producing thousands of different sensations.
- In fact, much of what we commonly call the "taste‖ of food and drink is actually smell.
- To prove this for yourself, eat a few bites of food while holding your nose. You will discover that much of the taste of food disappears until you release your nose and breathe freely.
- The sense organs that detect taste are the **taste buds**. Most of the taste buds are on the **tongue,** but a few are found at other locations in the mouth.
- Sensory cells in the taste buds respond to **salty, better, sweet,** and **sour** foods.
- Recently, a fifth kind of taste sensation was identified, now called "umami,‖ from Japanese word for savory.
- Umami receptors are strongly stimulated by monosodium glutamate (MSG), a substance often added to Asian foods to enhance their flavor.
- They are also stimulated by meat and cheese, which typically contain the amino acid glutamate.

Hearing and Balance

How do the ears and Brain process sounds and maintain balance?

- The human ear has **two sensory functions,** one of which, of course, is hearing.
- The other function is detecting positional changes associated with movement.
- Mechanoreceptors found in parts of the ear transmit impulses to the brain. The brain translates the impulses into sound and information about balance.

1. Hearing

Sound is nothing more than <u>vibrations moving through the air</u> around us.

- The ears are the sensory organs that can distinguish both the pitch loudness of those vibrations.
- Vibrations enter the ear through the auditory canal and cause the tympanum or eardrum to vibrate**.**
- **Three tiny bones** commonly called the **hammer, anvil,** and **stirrup**, transmit these vibrations to a membrane called the **oval window.**
- Vibrations there create pressure waves in the fluid-filled **cochlea** of the inner ear. The cochlea is lined with tiny hair cells that are pushed back and forth by these pressure waves.
- In response, the hair cells send nerve impulses to the brain, which processes them as **sounds**.

2. Balance

Your ears contain structures that help your central nervous system maintain your **balance,** or **equilibrium**.

- Within the inner ear just above the cochlea are three tiny canals. They are called **semicircular canals** because each forms a half circle.
- The **semicircular canals** and the **two tiny sacs** located behind them monitor the position of your body, especially your **head**, in relation to **gravity**.
- The semicircular canals and the sacs are filled with **fluid** and lined with **hair cells**.
- As the head changes position, the fluid in the canals also changes position. This causes the hair on the hair cells to bend.

- This action, in turn, sends impulses to brain that enables it to determine body motion and position.

The Eye

How do the eye and the brain produce vision?

Vision occurs when photoreceptors in the eyes transmit impulses to the brain, which translates these impulses into images.

Structure of the eye

Light enters the eye through the **cornea**, a tough transparent layer of cells.

- The **cornea** helps to focus the light, which then passes through a chamber filled with a fluid called **aqueous humor.**
- At the back of the chamber is a disk-shaped structure called the **iris.**
- The **iris** is the colored part of the eye. In the middle of the iris is a small opening called the **pupil.**
- Tiny muscles in the iris adjust the size of the pupil to regulate the amount of the light that enters the eye.
- In the **dim light**, the pupil becomes **larger** and more light enters the eye.
- In the **bright light**, the pupil becomes **smaller** and less light enters the eye.
- Just behind the iris is the lens. Small muscle attached to the lens change its shape, helping to adjust the eye's focus to see **near** or **distant** objects clearly.
- Behind the lens is a large chamber filled with a transparent, jellylike fluid called vitreous humor.

How You See

- The lens focuses light onto the **retina**, the inner layer of the eye.
- **Photoreceptors** are arranged in a layer in the retina. The photoreceptors convert light energy into nerve impulses that are carried to the brain through the **optic nerve.**
- There are two types of photoreceptors: rods and cones. **Rods** are extremely sensitive to **light,** but they **do not distinguish different colors**. **They only allow us to see black and white.**
- **Cones** are less sensitive than rods, but they do respond to **different colors, producing color vision.**
- Cons are concentrated in the fovea, the site of sharpest vision.
- The impulses assembled by this complicated layer of interconnected cells leave each eye by way of the optic nerve, which carry the impulses to the appropriate regions of the brain.
- There are no photoreceptors where the optic nerve passes through the back of the eye, producing a black spot in part of each image sent to the brain.
- During the processing of the nerve impulses, the brain fills in the holes of the blind spot with information.
- If the eye merely took photographs, the images would be no more detailed than the blurry images taken by an impressive camera and would be incomplete.
- The images we actually see of the world, however, are much more detailed, and the reason is the sophisticated way in which the brain processes and interprets visual information.

The eye is a complicated sense organ. The **sclera, choroid**, and **retina** are three layers of tissues that form the inner wall of the eye ball.

The Endocrine System

Hormone and Glands

The **endocrine system** is made up of glands that release hormones into the blood. Hormones deliver messages throughout the body.

- **Hormones** act by binding to specific chemical receptors on cell membranes or within cells.
- Cells that have receptors for a particular hormone are called **target cells**. If a cell does not have receptors for a particular hormone, the hormone has no effect on it.
- In general, the body‘s responses to hormones are slower and longer lasting than its responses to nerve impulses.
- It may take several minutes, several hours, or even several days for a hormone to have its full effect on its target cells.
- A nerve impulse on the other hand, may take only a fraction of a second to reach and affect its target cells.
- Many endocrine functions depend on the effects of **two opposing hormones**. For example, the hormone **insulin** prompts the liver to convert blood glucose to glycogen an d store it.
- The hormone **glucagon** prompts the liver to convert glycogen to glucose and release it in the blood.

- The **opposing effects** of insulin and glucagon maintain homeostasis by keeping blood glucose levels within a narrow range.

Glands*: A gland is an organ that produces and releases a substance, or secretion.*

- ***Exocrine glands*** *release their secretions through tube like structures (called ducts) either out of the body or directly into the digestive system.*
- ***Exocrine glands*** *include those that release sweat, tears, and digestive enzymes.*
- ***Endocrine glands*** *usually release their secretions (hormones) directly into the blood, which transports the secretions throughout the body.*
- *Although not usually considered as endocrine glands, other body structures such as* ***bones, fat tissue, the heart,*** *and* ***the small intestine*** *also produce and release* ***hormones.***

Major Endocrine Glands and their hormones' functions

	Gland	Hormone	Function
1	**Hypothalamus**		Control the pituitary gland
2	**Pituitary Glands**		Regulate many of the other endocrine lands and other organs
3	**Parathyroid Glands**	Parathyroid hormone	Regulate the level of calcium in the blood
4	**Thymus**	Thymosin	Stimulate T cell development and proper immune response
5	**Adrenal Glands**		Help the body respond to stress
6	**Pineal Gland**	Melatonin	Involved in rhythmic activities, suchas daily sleep-work cycles
7	**Thyroid**	Thyroxin	Regulates metabolism throughout the body
8	**Pancreas**	Insulin and glucagon	Regulate the level of glucose in the blood
9	**Ovaries**	Estrogen and progesterone	Estrogen for development of female secondary sex characteristics and for the development eggs. Progesterone prepares the uterus for a fertilized egg.
10	**Testes**	Testosterone	Responsible for sperm production and the development of male secondary sex characteristics

The Human Endocrine Glands

The Major glands of the endocrine system include

1. Pituitary gland 3. Adrenal gland 5. Thyroid gland

2. Hypothalamus 4. Pancreas 6. Parathyroid glands 7. Reproductive glands

1. Pituitary Gland

The **pituitary gland** is a bean-size structure that dangles on a slender stalk of tissue at the base of the brain. The pituitary gland is divided into two parts:

1. The anterior pituitary and 2. The posterior pituitary

- The pituitary gland secretes hormones that directly regulate many body functions or control thew actions of other endocrine glands.
- Proper functioning of the pituitary gland is essential. For example, if the gland produces too much growth hormone (GH) during childhood, the body grows too quickly, resulting in a condition called **gigantism.**
- Too little GH during childhood causes pituitary dwarfism, which can be treated with GH produced by genetically engineered bacteria.

2. Hypothalamus

- The **hypothalamus,** which is attached to the posterior pituitary, is the link between the central nervous system and the endocrine system.
- The hypothalamus controls the secretion of the pituitary gland. The activities of the hypothalamus are influenced by the levels of hormones and other substances in the blood and by sensory information collected by other parts of the central nervous system.
- The hypothalamus contains the cell bodies of the neuro-secretory cells whose axons extend into the posterior pituitary.
- **Antidiuretic hormone**, which stimulates the kidney to absorb water, and oxytocin, which stimulate contractions during child birth, are made in the cell bodies of the hypothalamus and stored in the in the axons entering the **posterior pituitary**.
- When the cell bodies are stimulated, axons in the posterior pituitary release these hormones into the blood.
- In contrast, the hypothalamus has indirect control of the anterior pituitary.
- The hypothalamus produces **releasing hormones**, which are secreted into blood vessels leading to the anterior pituitary, which are secreted into blood vessels leading to the **anterior pituitary.**
- The hypothalamus produces a specific releasing hormone that controls the secretion of each anterior pituitary hormone.

Anterior Pituitary Gland Hormones

	Hormone	Action
1	Follicle stimulating Hormone (FSH)	Stimulates production of mature eggs in ovaries and sperm in testes
2	Luteinizing hormone (LH)	Stimulates ovaries and testes; prepares uterus for implantation of fertilized egg
3	Thyroid stimulating hormone (TSH)	Stimulates the synthesis and release of thyroxin from the thyroid gland
4	Adreno-corticotropic hormone (ACTH)	Stimulates release of some hormones from the adrenal cortex
5	Growth hormone (GH)	Stimulates protein synthesis and growth in cells
6	Prolactin	Stimulates milk production
7	Melanocyte-stimulating hormone (MSH)	Stimulates melanocytes in the skin to increase the production of the pigment melanin

3. Adrenal Glands

- The adrenal glands are pyramid-shaped structures that sit on the **top of the kidney.**
- The **outer part** of the adrenal gland is the **adrenal cortex** and **the inner part** is the **adrenal medulla.**
- About **80%** of an adrenal gland is its **adrenal cortex.** The adrenal cortex produces more than two dozen steroid hormones called **corticosteroids.**
- One of these hormones, **aldosterone**, regulates **blood volume** and **pressure.** Its release is stimulated by dehydration, **excessive bleeding, or Na+ deficiency.**
- Another hormone called, **cortisol,** helps control the rate of metabolism of carbohydrates, fats, and proteins. **Cortisol** is released during **physical stress** such as **intense exercise**.
- Hormones released from the adrenal medulla produce the heart-pounding, anxious feeling you get when excited or frightened—commonly known as the "fight or flight‖ response.
- When you are in this sort of stress, impulses from sympathetic nervous system stimulate cells in the adrenal medulla to release large amounts of **epinephrine** (commonly known as adrenaline) and **norepinephrine**. These hormones increase heart rate and blood pressure.
- They also cause air pathways to widen, allowing for an increase in oxygen intake, and stimulate the release of **extra glucose.**
- If your heart rate speeds up and your hands sweat when you take a test, it is your adrenal medulla at work!

4. Pancreas

- The pancreas is both an exocrine and an endocrine gland. As an exocrine gland it releases digestive enzymes that help break down food.
- However, other cells in the pancreas release hormones into the blood.
- The hormone-producing portion of the pancreas consists of clusters of cells.
- These clusters, which resemble islands, are called the **"islets of the Langerhans**,‖ after their discover, German anatomist Paul Langerhans.

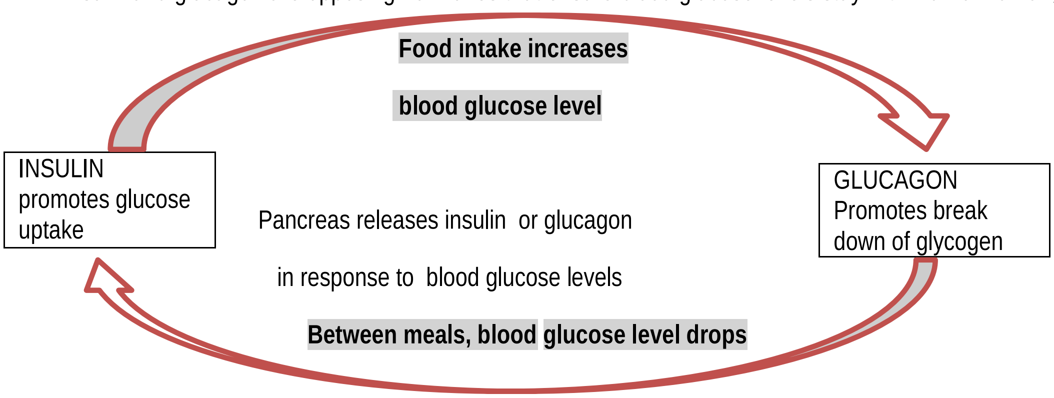
- Each islet contains **beta** cells, which secrete the hormone **insulin**, and **alpha** cells, which secrete the hormone **glucagon.**
- **Insulin** and **glucagon,** produced by the pancreas, help to keep the blood glucose level stable.

Blood Glucose Regulation

- When blood glucose levels rise after a person eats, the pancreas releases **insulin**. Insulin stimulates cells **to take glucose out of the blood**, which prevents the levels of blood glucose from rising too rapidly and ensures that glucose is stored for future.
- Insulin's major target cells are in the l**iver, skeletal muscles,** and **fat tissue.**
- The liver and skeletal muscles store glucose as **glycogen.** In fat tissue, glucose is converted to **lipids**.
- Within one or two hours after a person has eaten, **when the level of glucose drops, glucagon is released** from the pancreas.
- Glucagon stimulates the liver and skeletal muscle cells to break down glycogen and release glucose into the blood. Glucagon also causes fat cells to break down fats so that they can be converted to glucose.
- These actions help raise the blood glucose level back to normal.

Blood glucose control

- Insulin and glucagon are opposing hormones that ensure blood glucose levels stay within a normal range.



Diabetes Mellitus

- When the body fails to produce or properly respond to insulin, a condition known as diabetes mellitus occurs.
- The very high blood glucose levels that result from diabetes can damage almost every system and cell in the body.
- There are two types of diabetes mellitus. Type I diabetes is an autoimmune disorder that usually develops in people before the age of 15.
- The immune system kills beta cells, resulting in little or no secretion of insulin. People in type I diabetes must follow a strict diet and receive daily doses of insulin to keep their blood glucose level under control.
- The second type of diabetes, type II, most commonly develops in people after the age of 40.
- People with type II diabetes produce low to normal amounts of insulin. However, their cells do not properly respond to the hormone **because the interaction of insulin receptors and insulin is inefficient.**
- In its early stages, type II diabetes can often be controlled through diet and exercise.
- Unfortunately, the incidence of type II diabetes is rising rapidly as a result of increasing obesity, especially among young people.

6. Thyroid and Parathyroid

- The **thyroid gland** is located at the base of the neck and wraps around the upper part of the trachea.
- The thyroid gland has a major role in **regulating the body's metabolism**. Recall that metabolism is the sum of all the chemical reactions that occur in the body.
- The thyroid gland produces the hormone **thyroxin**, which increases the metabolic rate of cells throughout the body.
- Under the influence of thyroxin, cells become more active, use more energy, and produce more heat.

- **Iodine** is needed to produce thyroxin. Low levels of thyroxin in iodine-deficient infants produce a condition called **cretinism**, in which neither the skeletal system nor the nervous system develops properly.
- Iodine deficiency usually can be prevented by the addition of small amounts of **iodine** to table salt or other food items.
- If the thyroid produces too much thyroxin, a condition called hyperthyroidism occurs.

Hyperthyroidism results in:

- Nervousness,
- elevated body temperature,
- increased blood pressure, and
- weight loss.

Too little thyroxin causes a condition called **hypothyroidism**.

- Lower body temperature, lack of energy, and weight gain are signs of this condition. A goiter can be a sign of hypothyroidism.
- The thyroid also produces **calcitonin**, a hormone that <u>reduces blood calcium levels.</u>
- **Calcitonin** signals the kidneys to absorb less calcium from filtrate, inhibits calcium's absorption in the small intestine, and promotes calcium's absorption into bones.
- Its opposing hormone is parathyroid hormone, which is released by four parathyroid glands located on the back surface of the thyroid.
- Parathyroid hormone (PTH) increases the calcium levels in the blood by promoting the release of calcium from bone, the reabsorption of calcium in the kidneys, and the uptake of calcium from the digestive system.
- The actions of PTH promote proper nerve and muscle function and proper bone structure.

7. **Reproductive Glands**

The **gonads**—ovaries and testes—are the body's reproductive glands. The gonads serve two important functions:
1. In **females**, ovaries produce eggs and secrete a group of hormones called **estrogens.**

2. In **males**, the testes produce sperm and secrete the hormone **testosterone.**

Reproductive System

What effects do estrogens and testosterone have on female and male?

- At first, male and female human embryos are nearly identical in appearance. Then, during the seventh week of development, the reproductive systems of male and female embryos begin to develop along different lines.
- The male pattern of development is triggered by the production of the testosterone in the gonads of the embryo.
- n female embryos, testosterone is absent and the female reproductive system develops under the influence of estrogens produced in the embryo's gonads.
- Estrogen and testosterone, which have powerful effects on the body, are steroid hormones primarily produced in the gonads.
- In addition to shaping the sexual development of the embryo, these hormones act on cells and tissues to produce many of the physical characteristics associated with males and females.
- In females, the effects of the sex hormones include breast development and a widening of the hips.
- In males, the result in the growth of facial hair, increased muscular development, and deepening of the voice.
- In childhood, the gonads and the adrenal cortex produce low levels of sex hormone that influence development.
- However, neither the testes nor the ovaries can produce active reproductive cells until puberty.
- **Puberty** is a period of rapid growth and sexual maturation during which the reproductive system becomes fully functional.
- The age at which puberty begins varies considerably among individuals.
- It usually occurs between the age of 9 and 15, and, on average, begins about one year earlier in females than in males.
- Puberty actually begins in the brain, when the hypothalamus signals the pituitary to produce two hormones that affect the gonads—follicle stimulating hormone (FSH) and luteinizing hormone (LH).

The Male Reproductive System

The release of LH stimulates cells in the testes to produce **increased amounts of testosterone.**

- Testosterone causes the male physical changes associated with puberty and, together with FSH, stimulates the development of sperm.
- When puberty is complete, the reproductive system is fully functional, meaning that the male can produce and release active sperm.
- Just before birth (or sometimes just after), the primary male reproductive organs, the testes (singular; testis), descend from the abdomen into an external sac called the **scrotum.**
- The testes remain in the scrotum, outside the body cavity, where the temperature is a few degrees lower than the normal temperature of the body (37^{O}C).
- The lower temperature is important for proper sperm development.

Sperm Development

- Within each testis are clusters of hundreds of tiny tubules called **seminiferous tubules** where sperm develop. Recall that a haploid cell contains only a single set of chromosomes.
- After they are produced in the seminiferous tubules, sperm are moved into a tube called the **epididymis**, in which they **mature** and are **stored**.
- From the epididymis, some sperm are moved into a tube called the vas deferens.
- The vas **deferens** extends upward from the scrotum into the abdominal cavity.
- Eventually, the vas deferens merges with the **urethra**, the tube that leads to the outside of the body **through the penis.**
- Glands lining the reproductive tract—including the seminal vesicles, the prostate, and the bulbourethral glands—produce a nutrient-rich fluid called **seminal fluid.**
- The seminal fluid nourishes the sperm and protects them from acidity of the female reproductive tract.
- The combination of semen and seminal fluid is known as **semen.**
- The number of sperm present in even a few drops of semen is astonishing. Between 50 million and 130 million sperm are present in 1 milliliter of semen. That is about **2.5 million sperm per drop**!

Sperm release

- When the male is sexually aroused, the autonomic nervous system prepares the male organs to deliver sperm.
- The penis becomes erect, and sperm are ejected from the penis by the contractions of the smooth muscles lining the glands in the reproductive tract.
- This process is called **ejaculation**. Because ejaculation is regulated by the autonomic nervous system, it is **not completely voluntary.**
- About 2 to 6 millimeters of semen are released in an average ejaculation.
- If the sperm in this semen are released in the reproductive tract of a female, the chances of a single sperm fertilizing an egg, if one is available, are very good.

Sperm Structure

- A mature sperm cell consists of a **head,** which contains a highly condensed **nucleus**; a **midpiece**, which is packed with energy-releasing mitochondria; and a **tail**, or flagellum, which propels the cell forward.
- At the tip of the head is a small cap containing **enzymes** vital to fertilization.

The Female Reproductive System

- The primary reproductive organs of the female are the ovaries.
- As in the males, puberty in females starts when the hypothalamus signals the pituitary gland to release FSH and LH.
- FSH stimulates cells within the o varies to produce increased amounts of estrogens and to start producing egg cells.
- The main function of the female reproductive system is to produce egg cells or ova (singular; ovum). In addition, the system prepares the female's body to **nourish a developing embryo.**
- At puberty, each ovary contains as many as **400, 000 primary follicles**, which are clusters of cells surrounding a single cell.

- The function of a follicle is **to help an egg mature for release into the reproductive tract**, where it may be fertilized by a sperm.
- Despite the huge number of primary follicles, a females ovaries release **only about 400 mature eggs** in her life time.
- In addition to the ovaries, other structures in the female reproductive system include:

1. Fallopian tubes (oviducts), 2. Cervix, and 3. uterus, 4. Vagina

The Menstrual Cycle

- One ovary usually produces and releases one mature ovum every 28 days or so.
- The process of **egg formation** and **release** occurs as part of the menstrual cycle, a regular sequence of events involving the ovaries, the lining of the uterus, and the endocrine system.
- The menstrual cycle is regulated by hormones made by the

1. hypothalamus,
2. pituitary, and
3. ovaries; and it is controlled by internal feedback mechanisms.

- During the menstrual cycle, an egg develops within a follicle and is released from an ovary.
- In addition, the uterus is prepared to receive a fertilized egg.
- If an egg is not fertilized, it is discharged along with the lining of the uterus.
- If an egg is fertilized, embryonic development begins and the menstrual cycle ceases.

The menstrual cycle includes:

1. Follicular phase 3. Luteal phase, and
2. Ovulation 4. Menstruation

1. Follicular phase

- On day 1 of the menstrual cycle, blood estrogen levels are low.
- The hypothalamus reacts to low estrogen levels by producing a releasing hormone that stimulates the anterior pituitary to secrete FSH and LH.
- These two hormones travel to the ovaries, where they cause a follicle to mature.
- Usually, just a single follicle develops, but sometimes two or even three mature during the same cycle.
- As the follicle develops, the cells surrounding the egg enlarge and begin to produce increased amounts of estrogens.
- This causes the estrogen level in the blood to rise dramatically.
- High blood estrogen levels cause the hypothalamus to produce less releasing hormone, and the pituitary releases less LH and FSH.
- Estrogens also cause the lining of the uterus to thicken in preparation for receiving a fertilized egg.
- The development an egg during this phase takes about 12 days.

2. Ovulation

- As the **Follicle grows**, it **releases more and more estrogens.**
- When concentrations of these hormones reach a certain level, the hypothalamus reacts by triggering a burst of LH and FSH from the anterior pituitary.
- The **sudden increase** in these hormones (especially **LH**) causes the follicle to **rapture.** The result is **ovulation**, the release of an egg from the ovary into one of the fallopian tubes.
- When released, the egg is stalled in metaphase of meiosis II and will remain that way unless it is fertilized.
- As the newly released egg is drawn into the fallopian tube, microscopic cilia push the cell through the fluid-filled tube, toward uterus.

3. Luteal Phase

- The luteal phase begins immediately after ovulation. As the egg moves through the Fallopian tube, the cells of the raptured follicle change.
- The follicle turns yellow and is now known as the **corpus luteum,** which means ―**yellow body‖** in Latin.
- The corpus luteum continues to release estrogens but also begins to release another steroid hormone called **progesterone.**

Progesterone also stimulates the growth and development of the blood supply and surrounding tissue in the already-thickened uterine lining.

- The rise in these hormones once again inhibits the production of FSH and LH. Thus, additional follicles do not develop during this cycle.
- Unless fertilization occurs and an embryo starts to develop, the fall of LH levels leads to the **degeneration of the corpus luteum.**
- Estrogen levels fall, the hypothalamus signals the release of FSH and LH from the anterior pituitary, and the follicular phase begins again.

4. Menstruation

- At the start of the new follicular phase, low estrogen levels also cause the lining of the uterus to detach from the uterine wall.
- This tissue, along with blood and the unfertilized egg are discharged through the vagina. This phase of the cycle is called **menstruation.**
- The Latin word for ―month‖ is ***mens*** which is why the reproductive cycle is called the menstrual cycle or monthly cycle.
- Menstruation lasts about three to seven days on average.
- A **new** cycle begins with the first day of menstruation.
- The menstrual cycle continues, on average, until a female is in her late forties to early fifties.
- At this time, the production of estrogens declines, and ovulation and menstruation stop. The permanent stopping of the menstrual cycle is called **menopause.**

Pregnancy

- Of course, the menstrual cycle also ceases if a woman becomes pregnant.
- Before the **first two days** of the luteal phase, immediately following ovulation, the **chances that an egg will be fertilized are the greatest.**
- This is usually from 14 to 18 days after the completion of the last menstrual cycle.
- If a sperm fertilizes an egg, the fertilized egg completes meiosis and immediately undergoes mitosis.
- After several divisions, a ball of cells will form and implant itself in the lining of the uterus.
- Within a few days of implantation, the uterus and the growing embryo will release hormones that keep the corpus luteum functioning for several weeks.
- This allows the lining of the uterus to nourish and protect the developing embryo and prevents the menstrual cycle from starting again.

Fertilization and Development

- The story of human development begins with the **gametes**—sperm produced in the testes and egg cells produced in the ovaries.
- Sperm and egg must meet, so that the two gametes can fuse to form a single cell. With this single cell, the process of development begins.
- The fusion of a sperm and egg cell is called fertilization.

Fertilization

- During sexual intercourse, sperm are released when semen is ejaculated through the penis into the vagina.
- Semen is generally released just **below the cervix**, the opening that connects the vagina to the uterus. Sperm swim actively through the uterus into the Fallopian tubes.
- **Hundreds of millions** of sperm are released during an ejaculation.
- If an egg is present in one of the fallopian tubes, its chances of being fertilized are good.
- The egg is surrounded by a **protective layer** that contains binding sites to which sperm can attach.
- The sperm head then releases **powerful enzymes** that break down the protective layer of the egg.
- The haploid (N) sperm nucleus enters the haploid egg, and chromosomes from sperm and egg are brought together.
- Once the two haploid nuclei fuse, a single diploid (2N) nucleus is formed, containing a single set of chromosomes from each parent cell.
- The fertilized egg is called a **zygote**. At this point the developing human can also be called an **embryo.**

What prevents more than one sperm from fertilizing an egg?

- Early in the twentieth century, cell biologist Ernest Everett Just found the answer.
- The egg cell contains a series of granules just beneath its outer surface.

- When a sperm enters the egg, the egg reacts by releasing the content of these granules outside the cell.
- The material in the granules coats the surface of the egg, forming a barrier that prevents other sperm from attaching to, and entering the egg.

Multiple Embryos

- If two eggs are released during the same menstrual cycle and each is fertilized, **fraternal twins** may result.
- **Fraternal twins** are not identical in appearance and may even be different sexes, because each has been formed by the fusion of a different sperm and different egg cell.
- Sometimes a single zygote splits apart and two **genetically identical** embryos.
- These two embryos are called **identical twins**. Because they result from the same fertilize egg, identical twins are always the same sex.

Implantation

- While still in the Fallopian tube, the zygote begins to undergo mitosis.
- As the embryo grows, a cavity forms in the center, until the embryo becomes a hallow ball of cells known as a **blastocyst.**
- About six or seven days after fertilization, the blastocyst attached to the wall of the uterus and begins to grow into the tissue of the mother.
- This process is known as **implantation.** At this point, cells in the blastocyst begin to **specialize.**
- This specialization process, called **differentiation,** results in the development of the various types of tissues in the body.
- A cluster of cells, known as the **inner cell mass**, develops within the inner cavity of the blastocyst.
- The **body of the embryo** will develop from **these cells,** while the other cells of the blastocyst will differentiate into some of the tissues that **support and protect the embryo.**

Gastrulation

- As development continues, the embryo begins a series of dramatic changes that will produce the key structures and tissue layers of the body.
- Key events in early development include **gastrulation**, which leads to the formation of **nervous** tissue.

Gastrulation is the process of cell migration that results in the formation of **three cell layers** called:

1. Ectoderm 2. Mesoderm and 3. Endoderm

- The **ectoderm** and **endoderm form first**.
- The mesoderm is produced by a process of cell **migration** (during gastrulation, some cells migrate from the ectoderm and form the mesoderm).
- The **ectoderm** will develop into the **skin** and the **nervous system.**
- **Mesoderm** cells differentiate and form many of the body's internal structures, including **bones, muscles, blood cells** and **gonads.**
- **Endoderm** forms the linings of organs in the digestive system, such as:
  1. stomach 2. Intestines 3. respiratory system 4. excretory systems.

Neurulation

- Gastrulation is followed by another important step in development called **neurulation**.
- **Neurulation** is the first step in the development of nervous system.
- Shortly after gastrulation is complete, a block of mesodermal tissue begins to differentiate into the **notochord.**
- Recall that all chordates possess a notochord at some stage of development.
- As the notochord develops, the ectoderm near the notochord thickens and forms the neural plate.
- The raised edges of the neural plate form neural folds and the neural crest.
- The neural folds gradually move together and form the neural tube, from which the **spinal cord** and the **brain** will develop.
- Cells of the neural crest migrate to other locations and become types of nerve cells, and other structures such as the **lower jaw**.

The Placenta

- As the embryo develops, specialize membranes form to protect and nourish the embryo.
- The embryo is surrounded by the amnion, a sac filled with amniotic fluid that cushions and protects the developing embryo.
- Another sac, known as the **chorion**, forms just outside the amnion.
- The chorion makes direct contact with the tissues of the uterus.
- Near the end of the third week of development, small, fingerlike projections called chorionic villi form on the outer surface of the chorion and extend into the uterine lining.
- The chorionic villi and uterine lining form a vital organ called the **placenta.**
- The **placenta** is the connection between the mother and the embryo that acts as the embryos organ of **respiration. nourishment,** and **excretion.**
- Across this thin barrier oxygen and nutrients diffuse from mother's blood to the embryo's blood; carbon dioxide and metabolic wastes diffuse from the embryo's blood to the mother's blood.
- The blood of the mother and that of the embryo flow fast each other, **but they do not mix**.
- The exchange of gases and other substances occurs in the **chorionic villi**.
- The **umbilical cord**, which contains two arteries and one vein, connects the embryo to the placenta.
- After eight weeks of development, the embryo is called a fetus.
- By the end of the three months of development, most of the major organs and tissues of the fetus are fully formed.
- The fetus may begin to move and show signs of **reflexes**. The fetus is about 8 centimeters long and has a mass of about 28 grams.

Later Development

- Although most of the tissues and organs of the embryo have been formed after three months of development, many of them are not yet ready to go to work their own.
- On average, another six months of development takes place before all of these systems are fully prepared for life outside the uterus.

Months 4—6

- During the **fourth, fifth, and sixth months after fertilization,** the tissues of the fetus **become more complex and specialized, and begin to function.**
- The fetal heart becomes large enough so that it can be heard with the stethoscope.
- Bone continues to replace the cartilage that forms the early skeleton.
- A layer of soft hair grows over the skin of the fetus.
- As the fetus increases I size, the mothers abdomen swells to accommodate it. The mother begins to feel the fetus **moving.**

Months 7—9

- During the last three months before birth, the organ system of the fetus mature, and the fetus grows in size and mass.
- The fetus doubles in mass, and the lungs and other organs undergo a series of changes that **prepare them for life outside the uterus.**
- The fetus is now able to **regulate its body temperature.**
- In addition, the central nervous system and lungs complete their development.
- On average, it takes **nine months** for a fetus to develop fully.
- Babies born before eight months of development are called **premature** babies and often have **severe breathing problems** as a result of incomplete lung development.

Child Birth

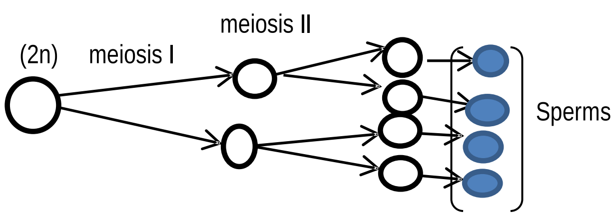
- About nine **months** after fertilization, the fetus is ready for birth.
- A complex set of factors triggers the process; one of these factors is the release of the hormone **oxytocin** from the mother's **posterior pituitary gland.**
- **Oxytocin** affects a group of large involuntary muscles in the uterine wall.
- As these muscles are stimulated, they begin a series of rhythmic contraction collectively known as labor.
- As labor progresses, the contractions become more frequent and more powerful.
- The opening of the cervix expands until it is large enough for the head of the baby to pass through.
- At some point, the amniotic sac breaks, and the fluid it contains rushes out of the vagina.
- Contractions of the uterus force the baby, usually head first, out through the vagina.
- As the baby meets the outside world, he or she may begin to cough or cry, a process that rids the lungs of fluid.
- Breathing starts almost immediately, and the blood supply to the placenta begins to dry up.
- The **umbilical cord** is clamped and cut, having leaving a small piece attached to the baby.

- This piece will soon **dry and fall off**, leaving a scar known as the **navel**—or, its more familiar term, the **belly button**.
- In a final series of uterine contractions, the placenta itself and the now-empty amniotic sac are expelled from the uterus as the **afterbirth.**
- The baby now begins independent existence. Most newborns are remarkably hardy.
- Their systems quickly make the switch to life outside the uterus, supplying their own oxygen, excreting wastes on their own, and maintaining their own body temperatures.
- The interaction of the mother's reproductive and endocrine systems does not end at childbirth.
- Within a few hours after birth, the pituitary hormone prolactin stimulates the production of milk in the breast tissues of the mother.
- The nutrients present in that milk contain everything the baby needs for growth and development during the first few months of life.

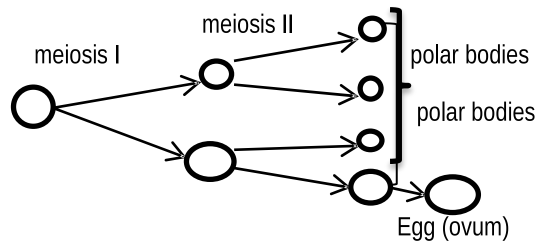
Infant and Maternal Health

- Although the placenta acts as a barrier to many harmful or disease- causing agents, some do pass through this barrier and affect the health of the embryo.
- The virus that causes AIDS can infect the developing fetus, and the virus responsible for rubella (German measles) can cause birth defects. Alcohol can permanently injure.

1. Spermatogenesis



2. Oogenesis



Homeostasis

Homeostasis — maintenance of normal internal conditions in a cell or an organism by means of self-regulating mechanisms. Gk. *Homoios*—like or the same and *stasis*—state.

- Internal environment –is the immediate surroundings of the cells.
- In mammalian tissues cells are surrounded by tiny spaces filled with a fluid called tissue fluid.
- Tissue fluid supplies cells with nutrients, oxygen and mineral ions and removes wastes from them.
- The tissue fluid represents the organism's **internal environment**.
- **Homeostasis** is essential for proper body function to ensure survival of the organism.

Among those factors that need a homeostatic control are controlling

1. Controlling temperature
2. Maintaining water balance, and
3. Regulating blood sugar

1. Temperature regulation

One of the most important factors which animals need to control is the internal or core body temperature.

Heat is a form of energy which is produced in a number of ways including the **sun** and by **artificial heating systems**.

It is also generated by the **chemical reactions** which take place in our own body.

Temperature is a way of <u>measuring hotness or coldness</u> (the effect of heat energy) on a relative scale.

It is vitally important that whenever we go and whatever we do our body temperature is maintained at the temperature (around 370C at which our enzymes work best.

It is not the temperature at the surface of an organism which matters – the skin temperature can vary enormously without causing harm.

It is the temperature deep inside the body, known as the **internal** or **core body temperature**, which must be kept **stable**.

We can get a good measure of our human core body temperature by taking the temperature in the **mouth**, in the **anus** or **on the surface of the eardrum**.

Regulating body temperature is very critical because cells can live and work at optimum body temperature.

With regard to temperature regulation animals can be divided into two groups. These are:

1. **Poikilotherms**
2. **Homeotherms**

1. Poikilotherms

- These animals produce **little** internal heat and have little insulation.
- They rely more on heat derived **from their environment** than metabolic heat in order to raise their body temperature.
- In general, poikilothems are animals whose body temperature increases or decreases as the temperature of their surroundings raise or falls down.
- When the outside temperature is too hot or too cold, most poikilotherms become **inactive.**
- However, some poikilotherms live in temperate regions where the climate becomes extremely cold in the winter and extremely hot in the summer seasons.
- Some poikilotherms that live in cold climates go into a period of deep sleep until the cold season passes. This is what we call **hibernation**.
- On the other hand, there are animals that go into a period of deep sleep until a very hot season passes. This is what we call **aestivation**.
- In both hibernation and aestivation the animals:
    - I. Heart beat slowly
    - II. Blood circulates sluggishly
    - III. Body temperature drops
    - IV. Breathing intervals become very long
    - V. Live on very food or depend on their stored food (fat)

When poikilotherms are cold, they may

- Busk in the sun
- Press their bodies close to a warm surface
- Erect special sails or areas of skin which will allow them to absorb more heat from the sun.

When they are getting too hot, they may

- Move into the shade
- Move into water or mud

1. **Homeotherms** — are animals whose body temperature within certain limits is **independent** of the temperature of their external environment.
    - They rely on a high metabolic rate to generate heat and they have mechanisms to regulate their body temperature at a fairly constant level.
    - One of the advantages of being a homeotherm is that if the body temperature can be kept at around 37^{0}C, for instance in human beings, then enzymes can always work very efficiently, no matter what the outside temperature is.
    - So, metabolic processes can keep going even when the outside is cold or hot. That means, being homeothermic provides constant optimum conditions for the enzyme controlled metabolic processes.

Temperature Regulation in Homeothermic Animals

In homeothermic animals there is a controlling center in their brain that balances heat production in their body against heat loss. This controlling center is called the **hypothalamus.**

Homeothermic animals have additional mechanisms to regulate their body temperature under too hot or too cold conditions.

1. Physiological methods
2. Behavioral methods
3. Morphological methods

- **Physiological methods**
    1. Sweating
    2. Vasodilation
    3. Panting and licking
    4. Vasoconstriction
    5. Piloerection (pulling the hairs upright)
    6. Shivering and metabolic responses
    7. Fat layer under the skin (Subcutaneous fat)
- **Behavioral methods of temperature regulation**
    1. Clothing
    2. Seeking shade or shelter
    3. Taking high calorie food
    4. Hibernation
    5. Aestivation
    6. Wallowing or bathing
    7. Burning fires, central heating, air conditioning, etc.

- In humans control of the temperature relies on the **thermoregulatory center in the brain**.
- This center contains **receptors** which are sensitive to the temperature of the blood flowing through the **brain itself**.
- Extra information comes from the temperature receptors in the skin, which send impulses to the thermoregulatory center giving information about the skin temperature.
- These receptors are so sensitive; they can detect a difference of as little as **0.5⁰C.**
- When the thermoregulatory center detects changes our first responses are conscious—we put more cloths on, or take clothes off, move outside or light a fire.
- But if the core temperature starts to move in one direction, or the other, automatic body responses take over.
- The control of body temperature is an example of a **negative feedback** loop

The feedback control of the body temperature involves the thermoregulatory center in the brain and the skin (*read 3.59 pp.127*).

- **Morphological methods**

- Since most heat loss or gain is from the body surface of an organism, the **surface area** of an animal is an important aspect with regard to temperature regulation.
- The **volume** of an object is the distance within the object through which materials exchanged travel from its surfaces.
- Hence, the **smaller** of an object the greater is its surface area to volume ratio is.
- This means that **smaller animals have greater surface area to volume ratio**.
- As a result they tend to lose heat at a higher rate to their surroundings.
- To replace the lost heat these animals have a higher metabolic rate and as a result the amount of heat they produce per unit of body weight (i. e. Calorie / kg/day) will be higher, and that is why smaller animals eat more food per unit of their body weight than bigger.
- But the amount of total heat (i. e.) heat/body mass) that smaller mammals produce is the **least** one.

Conclusion

- Since **small birds** and **mammals** have higher rate of heat loss they could NOT survive in cold climates because they would lose heat faster than they could produce it, even with a high rate of metabolism.
    - In hot climates, however, the rate of heat loss is NOT as great as their surroundings.
- Large mammals like elephants, rhinoceros, hippopotamus live in the tropics (hot climates) because of the availability of food items in these areas.Since such animals have small surface area to volume ratio they would not lose heat fast enough.

To help them survive in these hot regions and increase their rate of heat loss, the animals have various morphological and behavioral adaptations, like folds of skin, flopy ears, long legs in elephants, etc. which all increase the surface area of the heat loss.

Water Balance and Ionic Control

Water balance is a problem in terrestrial (land) animals. Water balance in such animals is achieved **by balancing the process of water loss and gain.**

This balancing role is done by the **kidneys**. The total amount of water gained and lost by all adult human being per day is equal.

Table: The average daily water intake and loss in an adult human per day

Source	**Water intake**	**Water loss**	**Water loss**
	Amount in cubic centimeter	In terms of	Amount in cubic centimeter
Drinking	1450	Urine	1500
Food	800	Sweat	600
Respiration	350	Lung evaporation (breathing)	400
		Faeces	100
Total	2600 cc		2600 cc

From the above table it is clear that the total amount of water gained (i.e. 2600 cc) is equal to the total amount of water lost which is also 2600 cc.

- The water balance is maintained by the **kidneys**. Kidneys remove any excess water and it leaves the body as **urine**.
- If we are short of we produce very little urine and most water is saved for use in the in the body.
- If we have too much water then our kidneys produce lots of urine to get rid of the excess.
- The ion concentration of the kidneys — particularly **ordinary salt**—is also important.
- We take in mineral ions with our food.
- Some are lost via our skin when we sweat. Again the kidney is most important in keeping an ion balance.
- Excess mineral ions are removed by the kidneys and lost in the urine.
- The balance of water and salts in our body is very important because of the **osmotic impact** on our cells.
- If the balance is wrong so controlling this balance is known as osmoregulation.

Urinary System

The Urinary system of humans consists of:

1. Kidneys 3. Urinary bladder 2. ureters 4. urethra

1. **Kidneys** — are the main excretory organs that excrete nitrogenous and other metabolic wastes in the form of urine. Each kidney is about $10cm^2$, long and shaped like a bean.

2, Ureters — there are two ureters one arising from each kidney.

- **Urine** formed in each kidney passes out into the ureter which carries it to the **urinary bladder.**
- Urine moves in the ureter by the peristaltic waves of its walls.

3, **Urinary bladder** — a large storage sac that collects urine from both kidneys.

- Urine is temporarily stored here until it is released via the urethra.

4. **Urethra** — is a small tube that carries urine at intervals from urinary bladder to the exterior.

- There is a urethral muscular sphincter present at the base of the urethra which consists of a circular band of muscles.
- By the contraction and relaxation of these muscles, the flow of urine into urethra is controlled.
- The sphincter keeps the urethra closed except during voiding of urine.

Homeostasis and the kidney

How do the kidneys remove urea and control the levels of water and ions in our body?

Blood flows into the kidney along the renal artery. The blood is filtered, so fluid containing **water, salt, urea, glucose** and **many other substances** is forced out into the kidney tubules called nephrons.

Then everything the body needs is taken back (reabsorbed), including all of the sugar and the mineral ions needed by the body.

The amount of water absorbed depends on the needs of the body.

The waste products like urea and excess ions and water that are not needed by the body are released as urine.

Each kidney has a very rich blood supply and is made up of millions of tiny microscopic tubules called nephrons.

All the filtering and reabsorption processes take place in the nephron.

- *Our kidneys are very important organs of homeostasis, involved in controlling the loss of water and mineral ions from the body as well as getting rid of urea. Read page 131*
- *Kidneys filter the blood and remove materials which are not needed to form urine.*
- *Nephrons (the kidney tubules) are the units which carry out the work.*
- *Each nephron is 12 – 14 mm long, but only about 10 microns wide, and there are around 1.5 million of them in each kidney.*

Structure of the Mammalian Kidney

I. External Structure

- Mammalian kidneys are located on either side of the back bone of the posterior surface ot the abdominal cavity.
- Left kidney is positioned higher than the right one in man.
- At the anterior end of each kidney is present an adrenal gland.
- On the concave side (depressed) of each kidney, there is median and indentation called the **hilum** from where three tubes:
  - the renal artery
  - the renal vein, and
  - the ureters pass out

II. Internal Structures

1. **Renal cortex**
   - It is the outer most region towards the cortex surface of the kidney
   - It contains the glomeruli of the nephrons
2. **Renal medulla**
   - It is a region just inner to renal cortex
   - It contains renal
     - tubules,
     - collecting ducts and
     - blood vessels present in the form of renal pyramids.

- The conical pyramid mass projects into the **renal pelvis**.
- The urine is drained into the renal pelvis and is passed through minute openings at the apices or papillae of the pyramids.

3. **Renal pelvis**
   Is a large funnel shaped space behind the medulla region
   Urine is collected in the renal pelvis and is passed down to the ureters.
   Each kidney consists of millions of filtering units called nephrons.
   Each nephron originates in the cortex region and extends into the medulla region.

Structure of a Nephron

A **nephron** is the functional unit of a kidney. Each nephron works as an independent unit and produces a miniscule amount of urine.

- Nephrons are where most of the work of the kidney takes place—impurities are filtered out, wastes are collected, and purified blood is returned to circulation.
- Blood purification in the kidneys is complex and involved two distinct processes.
  1. Filtration and
  2. Reabsorption
- The urine collected by various ducts from all the nephrons is finally poured into the renal pelvis.
- Each nephron consists of **5 anatomical regions**.
  1. Bowman‘s Capsule
  2. First coiled (convoluted) tubule
  3. Loop of Henle
  4. Second coiled (convoluted) tubule
  5. Collecting duct

1, Bowman‘s capsule — is the site of the **ultrafiltration** of the blood.

- The blood vessel **leading into** the Bowman‘s capsule is **wider** than the vessel leaving the Bowman‘s capsule, which means the blood in the capillaries is under a **lot of pressure**.
- Several layers of cells—the wall of the blood capillaries and the wall of the Bowman‘s Capsule—act as a filter and the **blood cells** and the **large blood proteins** cannot leave the blood vessels because they are too **big** to fit through the gaps.
- However, water, salt, glucose, urea and many other substances are forced out into the start of the nephron – in fact the concentration of the substances in the liquid in the Bowman‘s Capsule is the same as that in the blood itself. This process is known as **Ultrafiltration** – filtration on a very small scale.

Glomerulus: is the knot of the blood vessels in the Bowman‘s capsule where the pressure builds up so that ultrafiltration occurs.

The volume of the blood leaving the glomerulus is about 15% less than the blood coming in – which is a measure of the liquid which has moved into the Bowman‘s Capsule as a result of ultrafiltration.

2. **First coiled (convoluted) tubule**:
   - The liquid which enters this first tubule is known as the **glomerular filtrate**.
   - The first tubule is where **much of the reabsorption** takes place.
   - All of the glucose is actively taken back into the blood along with around 67% of the sodium ions and around 80% of the water.
   - It has **microvilli** to increase the surface area for absorption.
3. **Loop of Henle** — is where the urine is **concentrated** and **more water is conserved**.
4. **Second coiled (convoluted) tubule** — is the place where the main water balancing is done.
   - If the body is short of water, more is reabsorbed into the blood in this tubule under the influence of the anti-diuretic hormone or ADH.
   - **Diuresis** means passing urine, so anti-diuretic means preventing or reducing urine flow.
   - Also ammonium ions and some drugs (if they have been taken into the body) are secreted from the blood into the tubule to get rid of them.
   - By the end of this second coiled tubule all of the salt which is needed by our body has been reabsorbed, leaving the excess in the filtrate along with most of the urea.
5. **Collecting duct** — is the place where the liquid (essentially **urine**) is collected.
   - It contains about 1% of the original water, with no glucose at all.

- The level of the salt in the urine will depend on the amount of salt in our diet and the water content of the urine.
- There is also a <u>much higher concentration of urea in the urine than in the blood</u> – about 60 times more, in fact.
- But if our body badly needs more water, more may be reabsorbed along the collecting duct - again under the influence of ADH – until the urine passes into the pyramid of the kidney and on into our bladder.

- **Urine** is formed constantly in our kidneys, and it drips down to collect in our bladder.
- The **bladder** is a muscular sac which can hold between <u>600</u> and <u>800 cm^3 urine</u>, although we usually empty it when it contains only <u>150-300 cm3.</u>
- We can control the opening of the bladder to a strong ring of muscle known as a **sphincter** at the entrance to our **urethra**.
- **Urethra** is the tube that leads from the bladder to the outside world. We can open and close this sphincter voluntarily, although it also opens as a reflex action if the bladder is too full – or if we are very frightened!
- When we are young, we have to learn to control our bladder sphincter voluntarily.
- The amount of water lost from the kidney in the urine is controlled by a sensitive feedback mechanism involving the hormone ADH.
- If the water content of the blood is **too low** (so the salt concentration of blood increases) special sense organs known as **osmoreceptors** in our brain detect this.
- They stimulate the pituitary gland at the base the brain to release ADH into the blood. This hormone affects the second coiled tubule making them more permeable so more water is reabsorbed back into the blood.
- This means less water is left in the kidney tubules and so a more concentrated urine is formed.
- At the same time the amount of water in the blood increases and so the concentration of salts in the blood returns to normal.
- If the water content of the blood is too high, the pituitary gland releases much less ADH into blood.
- The kidney then reabsorbs less water back into the blood, producing a large volume of dilute urine.
- Water is effectively lost from the blood and concentration of salts returns to normal.
- This system of osmoregulation is an example of negative feedback. As the water concentration of the blood falls, the level of ADH produced rises. Then as the water concentration of the blood rises again, the level of ADH released falls.
- On an average day our kidneys will produce around 180liter (that is about 50 gallons) of liquid filtered ut of our blood in the glomerulus (glomerular filtrate) – but only about 1.5 liter of urine.
- So more than 99% of the liquid filtered out of our blood is eventually returned to it.
- We can observe the way in which our kidney works to maintain water balance in our own body.
- If we drink a lot water, we will quickly notice that we need to urinate more often, and that we produce large quantities of very pale colored, dilute urine.

Kidneys are vitally important in two aspects of homeostasis, both in

1. **excretion** and
2. **osmoregulation.**

Excretion — getting rid of waste products which could build up in our body and damage our cells—is one of the most aspects of homeostasis

There are **two main metabolic products** which would cause major problems in our body if the levels rise. These are **CO_2** and **urea**.The organs which are involved in getting rid of these metabolic wastes are called **excretory organs.**

Osmoregulation—controls the water and electrolyte balance in the body.

The main excretory organs in our body are our

1. Lungs ------------------ removes CO_2
2. Kidneys, -------------- removes urea and controls salt balance
3. Skin ------------------- removes salt though sweat

Three major parts of the kidney are identified

1. **renal cortex** — outer region
2. **renal medulla —** consists of renal pyramids hat lie on the inner side of the renal cortex
3. **Renal pelvis** — inner most part of the kidney and is a hollow chamber and is the flared end of the ureter inside the kidney.

- The urine formed in the kidney collects in the **renal pelvis** <u>before entering the ureter.</u>
- Microscopically, each kidney is composed of <u>about **one million**</u> tiny tubules called **nephrons.**
- **Nephron—**is the functional unit of kidney.

Our blood passes through our kidneys at the rate of 1200 cm^3 per minute which means all the blood in our body passes through our kidneys and is filtered and balanced approximately once every 5 minutes.

The Liver and Osmoregulation

Liver is the largest individual organ in our body – in fact it makes up around 5% of our body mass.

Our liver cells are very active – they carry out a wide range of functions, many of which help to maintain a constant internal environment. The liver has a very special blood supply.

As well as the usual artery and vein (the hepatic artery and vein) there is another blood vessel which comes to the liver directly from the gut.

This is the hepatic portal vein and it brings the products of digestion to the liver to be dealt with.

A large number of reactions take place in the liver. Many of them are involved in homostasis in one way or another.

The Liver plays a part in all of the following functions:

1. **Control of the sugar levels in the body** (through stored glycogen in the liver itself).
2. **Controlling and balancing the fats** that we eat and the cholesterol levels in our blood.
3. **Protein metabolism**.
    - Our liver breaks down excess amino acids and forms urea.
    - If we eat more carbohydrate or fat than we need in our diet our body simply stores the excess energy as fat.
    - If we eat too much protein, it is not so easy. Our body cannot store the excees amino acids or simply convert protein to fat.
    - Instead the amino acids which make up the protein are broken down in our liver.
    - The amino part of the amino acid molecule is removed and converted into ammonia and then urea in the liver.
    - The rest of the amino acid can be used in cellular respiration or converted to **fat for storage.**
    - The process of removing the amino group from excess amino acids is known as **deamination.**
4. **Breaking down of worn out RBCs** (breaking down of haemoglobin and storing iron).
5. **The formation of bile** which is made in the liver and stored in the gall bladder before it is released into our gut to emulsify fats and help in their digestion.
6. Control of toxin (detoxification).
    - Our liver breaks down most of the poisons we take into our body, including alcohol.
    - This why the liver is so often damaged when people drink heavily.
    - Drinking too much alcohol can cause **cirrhosis of the liver**—the liver tissue is destroyed which can eventually kill us.
    - Heavy drinkers also often develop liver cancer which spreads quickly and can be fatal. .
7. **Temperature control —** Around <u>500 different reactions</u> take place in the liver at any time.

UNIT FOUR
Food Making and Growth in Plants

Sub topics

1. The Leaf 2. Photosynthesis 3. Transport in plants 4. Response in plants

There are four main organs of a flowering plant:

1. Roots 2. Stems 3. Leaves 4. Flowers

Roots

- Anchor the plant to the ground
- Absorb water and minerals from soil
- Root hairs are especially responsible absorption of water and minerals

Stem

- Provides support and transport system for water and minerals to the leaves and flowers.
- It also transports food from the leaves to roots and flowers

Leaves

- Carry on photosynthesis
- Receive water from soil by the way of stem
- Usually they are broad and thin
- This shape of leaves helps to absorb maximum light and diffuse gases (CO_2 and O_2)

Adaptation of a leaf for photosynthesis

- Flat and wide, giving a large surface area to collect light
- Short distance (diameter) for gases to diffuse
- The veins bring water from he soil to the cells
- The waxy cuticle is a water proof layer found on the surface of many leaves to help prevent water loss
- Its lower epidermis contains openings called stomata which are guarded and controlled by guard cells.
- The stomata allow carbon dioxide to diffuse into the leaf and oxygen and water vapor to diffuse out.
- The guard cells open and close to control the entry iof carbon dioxide into the leaf and also to control the loss of of water by transpiration.
- The palisade mesophyll is the main photosynthetic tissue of the plant leaf containing elongated cells with many chloroplasts. However, there are lots of air spaces and a big surface area for gas exchange.
- **Some photosynthesis** takes place in the **spongy mesophyll** but more importantly it is where the carbon dioxide needed for photosynthesis moves into the cells, and oxygen moves out.
- The **water lost** in transpiration evaporates from the cells here (in spongy mesophyll) as well.
- **Vascular bundles** contain the **xylem**, dead tissue which brings water from the soil to the cells of the leaves, and the **phloem**, **living tissue** which carries the products of photosynthesis away from the leaves to all of the cells of the plant.
- Each **chloroplast** contains stacks of membranes and chlorophyll to give an increased surface area for photosynthesis to take place.

Photosynthesis

Photosynthesis --- is a process usually within chloroplasts whereby chlorophyll-containing organelles trap solar energy to reduce carbon dioxide to glucose.

- For photosynthesis to occur successfully, the inorganic molecules **carbon dioxide** and **water** are needed, along with a supply of **light energy** and the means to capture that energy in the form of the green pigment **chlorophyll**.
- **Iodine solution** is reddish brown. In the presence of starch, iodine turns **blue-black.**
- There is a simple procedure to test a leaf successfully for the presence of starch that we can use in many different experiments to investigate photosynthesis.
- During photosynthesis light energy from the sun is absorbed by a green substance called **chlorophyl**l that is found in the chloroplasts of some plant cells.

- The energy that is captured is used to convert CO_2 from the air and H_2O from the soil into a simple sugar, glucose, with O_2 as a **by-product.**

$$H_2O + CO_2 \xrightarrow[\text{light energy}]{\text{chlorophyll}} C_6H_{12}O_6 + O_2$$

- Sugars like glucose are built into
1) **starch** for storage.
2) molecules like **fructose** (fruit sugar) and
3) **sucrose** (a double sugar unit)
4) more complex carbohydrates like **cellulose** to make new plant cell walls.
5) large molecules such as **chlorophyll**, using minerals such as **magnesium** taken up from the soil.
6) Sugars, along with nitrates and other nutrients that the plant takes up from the soil, are used to make **amino acids**.
7) Sugars may be built up into **fats** and **oils (lipids)** for storage in seeds and to make up part of the **cell membranes.**
8) These amino acids are then built up into **proteins** to act as **enzymes** and make up much of the **cytoplasm** of the cells.
9) Some of the glucose produced by photosynthesis is always converted into starch for storage, at least as a first step. This is because glucose is soluble and so could affect the water balance within the plant.

- If the concentrations of the glucose vary in different parts of the plant then osmosis takes place to correct this and this could upset the whole organism.
- Starch is insoluble, which means that it does not dissolve, so it has not effect on the concentration of solutions.
- This means that it can be stored in different places without having any effect on the water balance of the plant.
- Starch is also a very compact molecule, so it takes up relatively little room, and it is easily broken down again into glucose molecules when it is needed by the cells of the plant.
- Because so much starch is produced, we often use it to show us that photosynthesis has taken place in a plant. There are **two** sets of reactions involved in photosynthesis

1. Light-dependent reaction (Light Reaction)
2. Light-independent reaction (Dark Reaction)

1. Light-dependent reaction -- cannot take place unless light is present.

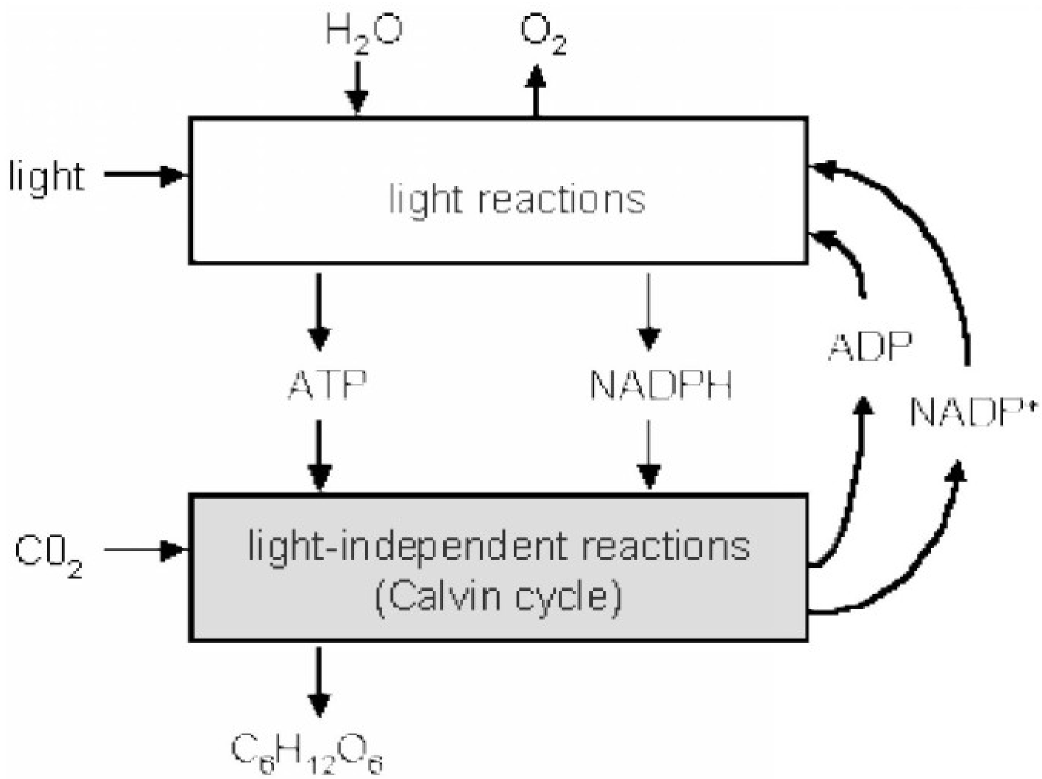
2. Light independent reaction—can take place where light is present or not (dark).

- The light-dependent reactions occur in the thylakoid membrane were the pigments **chlorophyll a** and **b,** plus the **carotenoids**, are located.
- Light can be—1. absorbed (taken up) by a pigment

2. reflected back (given off) by a pigment

3. transmitted (passed through) a pigment.

- **Chlorophyll *a*** appears **blue-green** and **chlorophyll *b*** appears **yellow-green** to us because these are the very colors they **do not absorb** and are instead **reflected to our eyes** or **transmitted through** these pigments.
- For the same reason, the **carotenoids** appear as **various shades** of **yellow** and **orange** to our eyes.
- Light-independent reaction—occurs in the **stroma** of a chloroplast.
- Light-independent reactions are the synthesis reactions, which use the ATP and NADPH formed in the thylakoids to reduce CO_2.



Transport

The transport systems in plants rely heavily on:

1. osmosis 2. diffusion, and 3. active transport

- Trees are obviously supported by their woody trunks. But many plants do not have woody tissue, and so they have no structural support.
- They rely on having cells which are **rigid** and **firm**. These firm cells are maintained by the **movement of water into the cells by osmosis to create turgor.**
- This is one reason why osmosis is so important for plants.
- Osmosis is not vital for keeping the plant cells turgid. It is also very important for **moving water** around within the plant itself.
- Plants take up water through their **roots**. The water in the soil has a **very low concentration of dissolved minerals**. In other words, there is a very **high concentration of water**.
- Water moves into the plant root cells across the cell membrane along a concentration gradient.
- The roots are covered with special cells, which have tiny hair-like extensions called the **root hairs.**
- These root hairs **increase the surface area for osmosis** to take place. Once water has moved into the root hair cells, the cytoplasm of the root hair cells is more dilute than cytoplasm of the surrounding cells.
- Water moves into the neighboring cells by **osmosis**. These cells now have more dilute cytoplasm than the cells next to them, and the water moves on by osmosis until it reaches the xylem and **transpiration stream.**

Active Transport in Plants

- Plants don't just rely on osmosis and diffusion. **Active transport** is also widely used in plants.
- Mineral ions in the soil are usually found in very **dilute** solutions – more dilute than the solution within the plant cells.
- By using active transport plants can absorb these mineral ions, needed for making proteins, and other important chemicals from the soil, even though it is against a concentration gradient.
- Active transport like this involves the use of **energy** produced by respiration in the cells.

A double Transport System

There are two separate transport systems in plants: 1. transport through phloem 2. transport through xylem

Phloem: The phloem is made up of living tissue and it is involved in the transport of organic materials – the nutrients made by photosystem – from the leaves to the rest of the plant.

- **Phloem cells** are thin walled and are regularly replaced when they are worn out. They contain a liquid rich sugar.
- The plant has to use energy to move substances around the phloem, and food substances can move both up and down the plant.
- They are carried to all the areas of the plants including the growing regions where they are needed for making new plant material, and the storage organs, where they are needed to provide a store of food for the winter.

Xylem: The xylem carries water and mineral ions from the soil around the plant.

- The **xylem** tissue is dead and here is no active transport taking place. The movement of the water in the xylem is due to **transpiration** and it is **passive**. This means it uses **no energy** from by the plant. Water only moves up from the roots to the leaves.
- As water evaporates from the surface of the leaves, water is pulled up through the xylem to take its place.
- This constant moving of water molecules through the xylem from the roots to the leaves is known as the **transpiration stream.**
- In **woody plants** like the trees the xylem tissue make up the bulk of the wood, and the phloem is found in a ring just underneath the bark.
- This makes young trees in particular very vulnerable to damage by animals because, if a complete ring of bark is nibbled, transport in the phloem comes to complete halt and the tree will die.
- Sometimes the animals have to be killed to protect the young trees.

Moving Water through the Plant

- As water evaporates from the surface of the leaves, water is pulled up through the xylem to take its place.
- This constant moving of water molecules through the xylem from the roots to the leaves is known as the **transpiration stream.**

What factors move the water upwards?

- There is pressure pushing the water up from the bottom – the root pressure – as water moves in by osmosis.
- In the xylem, two physical forces help the water to move up.

  1. Adhesive forces

  2. Cohesive forces
- **Adhesive forces**: between the water and the walls of the xylem which support the whole column of water, of water, no matter how tall it is.
- **Cohesive forces**: As molecules evaporate away from the surface of the leaf, the following molecules are pulled upwards by cohesive forces between the water molecules.
- In other words, the water molecules tend to stick together and get pulled upwards like a string of beads.
- However, the main pull which moves the water up from roots to the leaves is the almost constant evaporation of water from the leaves.
- When water reaches the xylem in the leaves, there is a reversal of the situation in the roots.
- Now the **solution in the xylem** has a much **higher concentration of water** than the solution in the mesophyll cells in the leaf.
- Water moves out from the xylem into the mesophyll cells and so across the leaf by osmosis.
- When it reaches a mesophyll cell which is surrounded by air, water evaporates from the surface into the air and diffuses out through the stomata along a concentration gradient.

Factors affecting the role of transpiration

- Because the transpiration stream is driven mainly by the evaporation of water from the leaves, anything which affects the rate of evaporation will affect transpiration.
- Conditions which increase the rate of evaporation also increase the rate of transpiration.
- The **higher** the temperature, the **more evaporation** takes place.

- Water evaporates **more rapidly into dry air than into humid air**.
- If the air is moving – it is **windy** – then water-vapor-rich air is always being removed from around the leaf.
- This maintains a good concentration gradient for diffusion and increases evaporation.
- So transpiration is more **rapid in hot, dry and windy** conditions than it is in still or humid conditions.
- Plenty of **light** also speeds up transpiration.
- In good light conditions, lots of photosynthesis takes place and so the stomata are opened to allow plenty of carbon dioxide in.
- When the stomata are open, lots of water can evaporate from the surface of the leaves.

Reducing water loss

- If a plant begins to lose water faster than it is replaced by the roots, it runs the risk of wilting.
- The stomata in the leaves will close to stop this if possible.
- To make sure that water is not lost from the surface of the leaf generally, most leaves have a waxy, waterproof layer, (known as the **cuticle**) to prevent uncontrolled water loss.
- In very hot environments the cuticle may **be very thick** and **shiny.**
- The fact that the stomata are on the underside of the leaf also helps because this means that they are not as exposed to the heat of the sun as they would be on the top of the leaf.

Adaptation of plants to reduce water loss in difficult environments

- Plants manage to grow and survive in many different environments.
- In many plants survival is a real struggle.
- Plants need to **balance opening the stomata to allow photosynthesis** to take place with the loss of water which takes place when the stomata are open.
- Plants which live in very dry areas like Somali, or in areas where there is relatively little water, often have adaptations which help them to balance up their different needs.
- They may have very **thick, waxy cuticles** to reduce any water loss through the overall leaf surface to an absolute minimum.
- Others have developed **very hairy leaves**, which trap a micro-atmosphere around the stomata and reduce water loss.
- Yet other plants have **reduced their leaves** to **very narrow spikes** to reduce the surface area over which water may be lost.
- On some plants the **stomata are sunk into pits**.
- Another way of preventing water loss, which we often see in grasses, is for the **leaves to rolled**, trapping a micro-environment of moist air inside.
- The purpose of all these adaptations is to reduce the loss of water from the leaves by transpiration, so the plant cane photosynthesize and avoid wilting whatever the condition around it.

Adaptation of plants to reduce water loss in difficult environments		
1. Thick, waxy cuticles	*3. Stomata sunken into pits*	5*. Rolled leaves, e.g. Some grasses*
2. Very hairy leaves	*4. Leaves reduced to very narrow spikes*	

- Transpiration has many implications for the way we grow our crops – and the crops we choose to grow.
- If our plants do not get enough water, then they will not be able to transpire and they will wilt.
- This means the cells will not work properly and the crops will not grow as well as they should.
- So, whenever possible we need to **irrigate** our fields and water the plants so that they can transpire fully, which allows them to photosynthesize and grow as much as possible.
- It is not only the **level of sunlight** and the **temperature** which affects transpiration rate in our plants.
- **Wind** also increases the rate of transpiration. If we can grow our crops in relatively **sheltered** places, the rate of water loss will be slower and so our crops are more likely to grow well.
- The final way in which transpiration affects agriculture is in **our choice of crop plants**.
- Some plants are **more resistant** to water loss by transpiration than others.
- By choosing crops which are suited to the conditions where we are growing them, we can improve our yields and make sure that transpiration works for us and does not cause our plants to wilt and fail.

Transpiration affects agriculture due to	
1. Level of sunlight	*3. Wind*
2. Level of temperature	*4. our choice of crop plants*

Response in Plants

Plants achieve their co-ordination and responsiveness through a system called hormones.
Hormones are chemical messengers which are produced in one part of an organism and have an effect elsewhere.
Plant hormones (phytohormones) have several effects on plants. For example, they coordinate:

1. **flowering,**
2. **cell division, and**
3. **cell elongation.**

These are essentially growth processes and plant responses of this type are called growth responses. Since growth is a slow process, most plant responses are slow.

Germination of Seeds

In most flowering plants (angiosperms), growth starts when the seed begins to germinate.
Seeds come in many different sizes and shapes, but the basic structure of seeds always contains certain things.

1. An embryo plant is made up of three main parts
   - **plumule ------------ embryonic shoot**
   - **radicle -------------- embryonic root**
   - **cotyledons ---------- embryonic leaves**
2. **testa** ------------ is the seed coat , which may be thin and papery like the covering on a groundnut or very strong and hard like the shell of a nut.

There are two classes of angiosperms (flowering plants):

1. monocotyledons — flowering plants with one cotyledon—example maize
2. dicotyledons — flowering plants with two cotyledons—example beans and peas

- In monocots the main food store is the endosperm and the embryo remains a very small part of the seed.
- In dicots the endosperm moves food into the cotyledons which become the main food store.
- By the time the seed is mature the endosperm will be disappeared. The embryo with its food-swollen leaves takes up most of the seed. Once the food store has been laid down and the embryo has developed the seed dries out (dehydrates). It loses much of its wet mass and becomes dormant.
- The three conditions for seed germination are: 1. Water 2. Warmth 3. Oxygen
- As the seed absorbs water, the large insoluble food molecules stored in it undergoes changes. They are broken down (hydrolyzed) into soluble food. The main food storage material in seeds is starch, and it is stored either in the cotyledons or in the endosperm. This starch store is converted to sugars by the action of the enzyme diastase. In some seeds fats and oils are stored.
- In these seeds enzymes the enzyme lipase catalyzes the hydrolysis of fats to fatty acids and glycerol.
- Proteolytic enzymes present in the seeds catalyze the hydrolysis of proteins to amino acids.
- A lot of energy is needed during germination. The seed cannot make its own food by photosynthesis while it is underground, so the energy needed comes from the stored food materials.it follows therefore that as a seed germinates its weight decreases as the stored food is used up.The decrease in weight continues until the seedling is capable of photosynthesizing.
- The following is a summary of changes which occur during the germination of a bean seed - a dicot seed.

1. The seed absorbs water through the micropyle (small hole) and swells.

2. The testa (seed coat) bursts and the radicle emerges. The radicle continues to elongate and gives rise to many side roots.

3. As the radicle elongate it pushes the seed out of the ground. The curved part of the radicle which protrudes is called the epicotyl. The seed coat is discarded and the two cotyledons open out and begins to photosynthesize.

4. The plumule emerges from in between the cotyledons and produces the first true leaves. At this stage, the young plant is called a seedling.

Types of germination

1. Epigeal germination (dicot)—the germination of seedlings such as beans whose cotyledons come above the ground

2. Hypogeal germination (monocot) —the germination of seedlings such as maize whose cotyledons remain below the ground. In monocots the cotyledons do not store food. Instead they absorb food from the part of the seed called the endosperm and pass it onto the developing embryo. Thus, in monocots the embryo derives its nourishment from the endosperm. In dicot plants, however, the embryo derives its food from the cotyledons.

- The **embryo** is the part that develops to plumule and radicle.
- The **radicle** is the embryonic root which grows and develops into the root system of the plant.
- The **plumul**e is the embryonic shoot which grows and develops into the shoot system.
- The **stored food** serves as a source of energy during germination.
- The **seed coat** is a tough, hard coat which protects the seed. It has a tiny hole called micropyle.
- In addition to these structures a seed also has a scar left by the stalk of **funiculus** which attaches the seed to the fruit wall. This is called the **hilum.**
- As a seed ripens and matures, the development of the embryo gradually ceases. As a result, the seed enters into a period of rest. This period of rest is called **dormancy.**
- **Dormant seeds** are dry, and so the chemical activity of the living cells is reduced to minimum.
- This reduced chemical activity is just sufficient to maintain life.
- When a seed is exposed to optimum conditions for germination including proper amount of moisture, temperature and oxygen, it will germinate, and the embryo inside the seed will start to grow.
- Thus, germination may be defined as a series of development processes that wake up the dormant embryo.
- When a seed germinates, the embryo uses stored food for energy until its leaves begin to produce food by **photosynthesis.**
- Some seeds have food stored in the cotyledons (seed leaves).
- Seed embryos have regions that develop into definite structures during germination.
- In the axis of the embryo of a seed there are two regions called the **epicotyl** above the ground and the **hypocotyl** (below the ground).
- The hypocotyl is the part of the embryo that gives rise to the **embryonic root** (the radicle).
- The radicle is the part of the embryo to emerge from the seed which then becomes the **primary root.**
- The epicotyl is the part of the embryo that gives rise to a **young leaves** and **apical meristems**.
- The embryonic shoot that develops from the epicotyl is called **plumule**.
- **Germination** is simply the growth of the embryo in a seed into seedling. It transforms the embryo into a self-supporting seedling.
- Before any seed germination, they are usually in a state of dormancy during which time their metabolic activities are minimal.
- This is partly because they are very dry. However, other factors, such as the hard seed coat prevents the entry of water and oxygen. The seed coat also shuts off light. Chemical inhibitors may also lead to dormancy.

Conditions necessary for germination

1. Water --- activates enzymes that hydrolyze stored starch into sugars needed for energy release
2. Suitable temperature --- enzyme activities are temperature controlled. Each enzyme has an optimum temperature.
3. Oxygen --- required for cellular respiration

- In general, the development of an embryo to a seedling during germination represents a shift from a heterotrophic nutrition to an autotrophic one.

What Controls Plant Growth and Development?

- Growth in plants is brought about by: 1. cell division, 2. cell elongation, and 3. cell differentiation.
- Any factor that directly or indirectly affects these processes will influence growth.
- Plant growth as a whole depends on the interaction of the following factors.

1. External factors — such as light, moisture, length of the day, etc.

2. Internal factors — such as chemical messengers called plant hormones

Plant hormones are growth regulators and

- are produced constantly in plants
- are active in very small amounts
- each type of hormone does not act alone, but together with other hormones.
- affect plants in more than one way
- affect different plant organs in different ways
- make unspecialized plant cell (or callus) to be specialized and differentiated tissues and organs of plants.

Examples of plant hormones are

1. auxins (including indole-aceticacid, IAA)

2. gibberellic acid **3. Cytokinin** **4. Ethylene** **5. abscisic acid**

Some of these hormones promote growth, others inhibit it. Some of them will promote growth in one type of plant tissue and inhibit it in others.

1. **Auxin (IAA)** — is the best-known plant hormone and it is involved in general plant growth. It stimulates the elongation of the new plant cells, so they get longer and bigger. It is also involved in apical dominance.

- IAA is made at the tip of the main shoot and as it moves down the stem it slows down the growth of the side shoots. So the main shoot dominates the whole plant. If we cut of the growing tip of a plant it will bush out.
- The side shoots grow quickly once we remove the apical dominance from the auxins produced by the main shoot.
- Auxin also stimulates the growth of roots. If auxin is applied to a cut stem it will stimulate new roots to grow – this will widely used by gardeners and farmers in some parts of the world to help them take successful cuttings.
- The best known function of the auxins is in the response of plants to the world around them. The responses of the plants towards things such as light and gravity are called tropism.

2. Gibberellins — stimulate the growth of plant stems. If we take a dwarf plant and give it IAA, something much will happen. If we give it gibberellins the stems will grow until the plant is a normal size.

- Gibberellins also help seeds to break their dormant period and start to grow. Scientists think they do this by stimulating the production of the enzymes needed to break down the food stores in the seeds.

3. Cytokinins — are hormones that stimulate cell division in plants so they are very important in plant growth.
The balance between auxins and cytokinins in a tissue culture of plant cell decides whether roots or shoots will grow.

4. Ethylene — is a gas at room temperature and it causes fruit to ripen. It also causes fruit and leaves to fall from the plant in some species.

5. Abscisic acid (ABA) — inhibits growth and plays a major role in leaf fall.
It is also involved in geotropism, but it plays a small part compared to IAA.

Tropic Responses (Tropism)

Plants respond to external factors like light, water, gravity, touch, etc. Their responses to such stimuli are observed as changes in the direction of growth of certain parts of plants. Such responses are not active but passive responses.

Such changes in the direction of growth of plants by growth in response to external stimuli are called tropism (tropic movements).

If the tropic movement is towards the stimulus, it is known as positive tropism. If the tropic response is away from the stimulus, it is known as negative tropism.

Types of Tropism

1. Phototropism — plant response to unilateral light (light from one direction).

- When the shoot of a growing plant is exposed to unilateral light, the light will cause redistribution of auxin on the shoot so that a greater amount of the auxin travels down the shaded side.
- As one of the effects of auxin is to cause cell elongation, the cells on the shaded (dark) side of the shoot elongates more than those on the illuminated side. As a result, the shoot bends (grows) towards the unilateral light (see page 174 figure 4.24).
- If the same argument is reached, a root tip is exposed to unilateral light should accumulate less auxin on the illuminated side and the cells on this illuminated region of the root elongate more than those cells on the dark side. As a result the root bends away from light.

3. **Geotropism** — is response of plant parts to gravity involving growth towards or away from it. Similar redistribution of auxin could account for the responses of shoots and roots to gravity.

- If a plant is placed horizontally on the ground, gravity causes redistribution of auxin so that more auxin accumulates on the lower side of the shoot and root. This high concentration of auxin on the lower side of the shoot promotes, growth (cell elongation), hence the shoot bends upwards. This same high concentration of auxin on the lower side of the root inhibits growth, and hence the root tip bends down wards (i. e. positive geotropism).

NB: Roots are more sensitive to auxin than shoots; i. e. the concentration of auxin that causes maximum growth in shoots inhibits the growth of roots and vice versa.

- The response of seedlings to gravity can also be investigated using a piece of apparatus known as a klinostat in a horizontal position (see figure 4.25 page 175) you can make sure that gravity acts equally all over the plant.
- You need other seedlings fixed horizontally but not rotated as a control. After two days you can see clearly the effect of the rotation.
- The root keeps bending towards gravity, and the shoot away from gravity, but because the stimulus is not unilateral, due to the klinostat the movements all cancel out and the plants stay straight.

3. **Hydrotropism** — the tendency of plants to move or grow towards water. Water as a stimulus has a greater influence on root growth than gravity (see activity 4.19 page 175).

Apical Dominance

- Experiments have shown that the auxin which is produced by the shoot inhibits the development of lateral buds into branches.
- This phenomenon is called apical dominance. It is here at the apex of the shoot where sufficient conclusion of auxin is produced to inhibit growth of the lateral buds further down the shoot.
- These lateral buds remain dormant unless the apical bud is removed. If this apical dominance is removed, then more of the lateral buds would develop into side branches.
- This phenomenon of removing apical dominance (removing apical shoots) of plants and thereby promoting growth of lateral branches is called pruning.

Advantage of pruning

1. To keep plants at a desired height to make the picking of leaves flowers, and fruits easier.

2. In case of fruit trees, to get a strong framework of branches capable of supporting heavy loads of fruits or

3. To help in improving the size and quality of fruits

How are tropic responses brought about

- As we can see from our earlier experiments, plants respond to unilateral stimuli.
- Further experiments have allowed scientists to find out more about these responses.

- Maize grains germinate to produce a straight shoot called a coleoptile.
- Coleoptiles are widely used in experiments to investigate the role of hormones in shoot growth.
- It is known that the growth region of a shoot is some distance below the tip.
- This fact suggests that removal of the tip would not affect the growth of the shoot. However, when the tips of the coleoptiles are removed (they are decapitated), they don‘t grow.
- Since we know that the growth a shoot is promoted by auxins, failure of decapitated seedlings to grow suggests that the auxins are probably produced in the tip.
- It has been found out that the growth hormone, auxin, produced in the tip is indole-3-acetic acid (IAA) diffuses from the tip to the growth region to initiate growth.
- In the decapitated seedlings, although the source of IAA production was removed, the seedling grew for a while and then stopped. This is because some IAA had already diffused away from the tip before decapitation. This amount of IAA was responsible for the slight growth.
- The fact that IAA promotes growth in shoots suggests that it is also involved in the response of the shoots to light and gravity.
- A simple experiment such as that in figure 4.25 page 175shows you clearly that the tropic response of a plant to gravity is brought about by growth.
- Shoots lit from one side only also respond by growth – the shaded side grows 175shows you clearly that the tropic response of a plant to gravity is brought about by growth.
- Shoots lit from one side only also respond by growth – the shaded side grows faster than the illuminated side so the shoot bends over towards the light.
- IAA promotes growth so it seems likely that the shaded side of shoots affected by one-sided light had more IAA than the illuminated side.
- Since the growth curvature was influenced by light, it suggests that light is somehow involved in the distribution of IAA in the shoot.
- Experiments have shown that IAA diffuses away from light. When a shoot is illuminated on one side, IAA in that side diffuses towards the dark side of the shoot.
- This causes a build-up of the hormone in the dark side of the shoot.
- Since growth is directly proportional to the amount of IAA, the dark side will grow faster than the illuminated side. This explains the observed growth curvature of shoots shown in the experimental set up in figure 4.26 page 176.
- The upward growth of the shoot and the downward growth of the root, when the bean seedlings were placed horizontally, involve plant hormones.
- In the shoot, the force of gravity causes an accumulation of IAA on the underside of the plumule.
- The build-up of IAA on the underside promoted more growth in that region than the upper portion.
- This differential growth resulted in the stem growing upwards.
- The downward growth of the root is also influenced by IAA, but in the root tip the hormone inhibits growth, rather than stimulating it.
- The force of gravity causes the accumulation of IAA on the underside of the root, resulting in reduced growth in that region.
- The corresponding upper side of the root, which had very little or no IAA, grows faster than the underside.
- This differential growth results in the downward curvature of the roots.
- The different effects of this hormone on root and shoot growth are illustrated in figure 4.28 page 177.

Importance of tropic and nastic responses

- In tropisms, some stimuli to which plants respond positively are the basic requirements for the plant's life.
- Water, for example, is one of the important requirements for photosynthesis.
- This means that when positive hydrotropism occurs, roots come into close contact with water. This makes it possible for them to absorb as much water and mineral salts as possible for the plant.
- In addition to water, plants require light for photosynthesis.
- When a plant responds positively to light its leaves become well exposed to it. This maximizes the amount of light available for photosynthesis.

Review Questions (Unit 4)

1. Which of the following is NOT an external feature of a leaf?
   A. Petiole B. Midrib C. Chloroplast D. Cuticle
2. Which of the following is the tissue where most photosynthesis takes place?
   A. Spongy mesophyll B. Palisade mesophyll C. Epidermis D. Stomata
3. Gases move in and out of a plant through
   A. the cuticle B. the stomata C. the epidermis D. the roots
4. Two gases that plants must exchange are
   A. Oxygen and nitrogen C. carbon dioxide and nitrogen
   B. Oxygen and carbon dioxide D. carbon dioxide and carbon monoxide
5. The plant organ that supports the plant body and carries nutrients between different parts of the plant is the:
   A. Root B. stem C. leaf D. flower
6. Phloem functions primarily in: A. Transport of water C. Growth of the root
   B, Transport of the products of photosynthesis D. Increasing stem width
7. As a growing root pushes through the soil, the delicate apical meristem is protected by
   A. A root cap B. xylem C. bark root hairs
8. Stomata open and close in response to water pressure within
   A. Root cells B. cell walls C. guard cells D. xylem
9. The period during which the embryo is alive but not growing is called
   A. Fertilization B. dormancy D. germination C. vegetative growth
10. Which of the following structures is an internal part of a leaf?
    A. Midrib B. Cuticle C. Petiole D. spongy mesophyll

11. The place where leaf is fixed to a stem is called
    A. Internode B. node C. petiole D. radicle
12. Leaves are usually thin, flattened and have large surface area. These phenomena allow
    A. Light to pass easily B. easier diffusion of gases C. easier food transport D. A and B
13. Plants can reserve food in their
    A. Leaves B. stem C. root D. all of the above
14. Which of the following is NOT required for light independent reaction?
    A. ATP B. NADPH C. Oxygen D. Carbon dioxide
15. Which of the following is the product of light dependent reaction?
    A. ATP B. NADPH C. Hydronium ion D. All of the above
16. Which of the following is NOT the advantage of transpiration in plants?
    A. Movement of synthesized food C. Absorption of water
    B. Water and mineral transport D. Cooling effect
17. The internal factors that affect rate of transpiration are
    A. Water content of the mesophyll cells C. Structure of the leaf
    B. Thickness of the cuticle layer D. All of the above
18. The ringing experimentation a tree trunk shows that
    A. Food is accumulated below the ring C. The tree swells above the ring
    B. The phloem transports water and minerals D. The root obtains the food
19. If the leaves of plants are depicted with Vaseline, the rate of transpiration:
    A. Decreases B. Increases C. Remains constant D. Fluctuates
20. Which of the following decreases the rate of transpiration?
    A. Low temperature B. Low wind C. Low humidity D. A and B
21. In most cases germination does not require
    A. Light B. Water C. Suitable temperature D. Oxygen
22. The plant hormone that is produced at the shoot tip of the plants is
    A. Gibberellins B. Ethylene C. Indole acetic acid D. Indole pyruvic acid
23. If a plant is kept horizontally, its shoot tip
    A. bends downwards B. grows horizontally C. bends upwards D. shows no growth
24. If a shoot of a plant is exposed to unilateral light, its shoot tip
    A. bends away from light C. has less auxin on the light side
    B. shoot grows less on the dark side D. All of the above

25. If a plant is placed in a rotating klinostat, its tip
   A. Continue to grow horizontally   C. Bends upwards
   B. Shows unequal auxin distribution   D. All of the above
26. __________ is a type plant hormone which inhibits cell division, thereby halts growth.
   A. Abscisic acid   B. Indole acetic acid   C. gibberellin   D. Ethylene
27. Which of the following happens during the light reactions of photosynthesis?
   A. Production of glucose   B. Formation of ATP   C. Use of carbon dioxide   D. Use of oxygen
28. The compounds carbon dioxide and water are used in
   A. Cell respiration   B. photosynthesis   C. both A and B   D. Sometimes respiration
29. In green plants, the combining of carbon dioxide and water occurs
   A. in the grana   B. in the cytoplasm   C. in the stroma   D. on the cell membrane
30. Where are carbohydrates made in plants stored? In
   A. Leaves   B. Stems   C. Roots   D. All of the above
31. The job of ___________ is to store nutrients and then transfer them to the growing embryo as the seed germinates.
   A. Plumule   B. radicle   C. cotyledon   D. micropyle
32. The buds near the apex grow more slowly than those near the base of the plant. The reason for this delay is that growth at the lateral buds is inhibited by auxins. This phenomenon is called
   A. Apical meristem   B. apical dominance   C. apical differentiation   D. apical stimulation
33. During photosynthesis, the elements carbon and oxygen come from ______ and _______to form glucose respectively.
   A. Water and carbon dioxide   C. Carbon dioxide and atmosphere
   B. Carbonates and water   D. Carbon dioxide and water
34. In the process of photosynthesis, the use of water is primarily
   A. to serve as hydrogen donor for production of sugar   C. to liberate oxygen for us and animals to inhale
   B. to transport synthesized food within plants   D. to serve as a medium of chemical reactions
35. The technique used to separate different components of chlorophyll molecule is
   A. hydroponic   B. centrifugation   C. chromatography   D. dissection
36. Which one of the following indicates the significance of photosynthesis as a whole?
   A. Maintenance of constancy of atmospheric gases   C. Major source of food for heterotrophs
   B. Providing of materials such as wood, fossil fuel, cloth, etc.   D. All of the above
37. The parts of the leaf that allow a wider surface for sunlight absorption are _____________
   A. blades   B. veins   C. leaf margin   D. petiole
38. Leaves are usually thin, flattened and have larger surface area. These phenomena allow:
   A. Light to pass easily   B. easier diffusion of gases   C. easier food transport   D. A and B
39. The openings on the surfaces of leaves are regulated by the
   A. Cuticles   C. hairs on leaves
   B. Guard cells   D. all epidermal cells on the lower surface
40. Trace the route of carbon dioxide from air to the site where maximum photosynthesis takes place in a typical leaf
   A. Stomata → spongy mesophyll → lower epidermis → palisade layer
   B. Stomata → xylem → spongy layer → palisade layer
   C. Stomata → air space → spongy cells → palisade cells
   D. Stomata → midrib → vein → lamina
41. Which of the following adaptations assist leaves for gaseous exchange
   A. The presence of numerous stomata
   B. The existence of many air spaces between spongy cells
   C. The ability of stomata to be opened and closed   D. all of the above
42. Microscopic examination of peelings from the upper and lower surfaces of a leaf revealed the presence of stomata on the upper epidermis only. It would be correct to assume that the leaf came from
   A. Terrestrial habitat   B. a desert plant   C. a floating water plant   D. all of the above
43. The phase of growth during which unspecialized tissues become specialized to perform particular function is called
   A. Development   B. growth   C. differentiation   d. elongation
44. Which one of the following is true about the function of stoma? Stoma
   A. Allows carbon dioxide to diffuse out the leaf   C. Allows carbon dioxide to diffuse into the leaf
   B. Allows water to diffuse into the leaf   D. Allows oxygen to diffuse into the leaf
45. Which of the following is true about tropism
   A. Root is negative to geotropism   C. Shoot is positive to geotropism
   B. Shoot is positive to phototropism   D. Root is positive to phototropism

46. Light is important for photosynthesis to
    A. Combine carbon, hydrogen, and oxygen to form sugar
    B. Split sugar molecule into carbon, hydrogen, and oxygen
    C. Combine hydrogen and oxygen to form sugar
    D. Split water molecule into hydrogen and oxygen
47. Which of the following layers of a leaf has largest number of chloroplasts?
    A. Palisade mesophyll B. spongy mesophyll C. Upper epidermis D. Lower epidermis
48. Which of the following structures of the root is responsible for the absorption of water from the soil?
    A. Xylem B. Root hair C. Phloem D. Cortex
49. Which of the following plant hormones is correctly paired with its function?
    A. Ethylene _______ inhibits fruit ripening C. Abscisic acid ____ stimulate growth
    B. Cytokinins ______ stimulates cell division D. Gibberellic acid _____ inhibits growth
50. Which of the following is true of germination in monocots?
    A. Leaves emerge from cotyledons C. Radicles push cotyledons above the ground
    B. Cotyledons remain below the ground D. Cotyledons appear above the ground
51. In addition to light and chlorophyll, photosynthesis requires
    A. Water and oxygen C. Water and sugars
    B. Oxygen and carbon dioxide D. Water and carbon dioxide
52. The leaves of a plant appear green because chlorophyll
    A. reflects blue light C. reflects green light
    B. absorbs blue light D. absorbs green light
53. the first process in the light-dependent reactions of photosynthesis is
    A. light absorption B. electron transport C. oxygen production D. ATP formation
54. Which substance from the light-dependent reactions of photosynthesis is a source of energy for the Calvin cycle?
    A. ADP B. NADPH C. H_2O D. pyruvic acid
55. The light-independent reactions of photosynthesis are also known as the
    A. Calvin cycle B. sugar cycle C. carbon cycle D. ATP cycle
56. The principal pigment in plants is
    A. Chlorophyll B. oxygen C. ATP D. NADPH
57. Which of the following is NOT produced in the light-dependent reactions of photosynthesis?
    A. NADPH B. Sugars C. Hydrogen ions D. ATP
58. The color of light that is LEAST useful to a plant during photosynthesis
    A. Red B. blue C. green C. violet
59. Identify the correct statement
    A. The flattened part of leaves is called lamina C. All leaves have petioles
    B. Petioles of leaves contain xylem and phloem D. A and B only
60. In a typical plant, all of the following factors are necessary for photosynthesis EXCEPT
    A. Chlorophyll B. light C. oxygen D. water
61. Which of the following is NOT a characteristic of plants?
    A. Eukaryotic cells B. Cell walls containing chitin C. Multicellular structure D. Chlorophyll
62. Two gases that plants must exchange are
    A. Oxygen and nitrogen C. Carbon dioxide and nitrogen
    B. Oxygen and carbon dioxide D. Carbon dioxide and carbon monoxide
63. Water is carried upward from the roots to every part of a vascular plant by
    A. Cell wall B. Phloem C. Cuticle D. Xylem
64. In angiosperms, the mature seed is surrounded by a structure called a
    A. Cone B. flower C. fruit D. cotyledon
65. Which of the following is a basic requirement of plants?
    A. Sun light B. Carbon dioxide C. Water D. All of the above
66. Which of the following is NOT a characteristic of dicots?
    A. Branched veins B. Taproot C. Parallel veins D. Two cotyledons
67. An etiolated plant is a plant which is
    A. Variegated B. washed by alcohol C. grown in total darkness D. grown in light
68. Phloem functions primarily in
    A. Transport of water C. Transport of products of photosynthesis
    B. Increasing stem width D. Growth of the root

69. As a growing root pushes through the soil, the delicate apical meristem is protected by
    A. a root cap   B. xylem   C. bark   D. root hairs
70. What would happen if all green plant life vanishes from the world?
    A. Global warming would soon occur   C. any form of life would vanish
    B. The concentration of carbon dioxide in the atmosphere would rise   D. All of the above
71. Stomata open and close in response to water pressure within
    A. Root cells   B. Cell walls   C. guard cells   D. xylem
72. The region of the stem from which the leaf springs is called
    A. Node   B. petiole   C. bud   D. midrib
73. Which of the following parts of leaves possesses vascular tissues?
    A. The petiole   B. the midrib   C. the branch veins   A. all
74. Substances that stimulate cell division and cause dormant seeds to sprout are
    A. gibberellins   B. cytokinins   C. auxins   D. phytochromes
75. photoperiod is a measurement of: A. water level   B. gravity   C. day length   D. nutrients
76. Which of the following causes fruit to ripen?
    A. Auxin   B. Cytokinin   C. Ethylene   D. Gibberrelin
77. Which is an example of thigmotropism?
    A. Change in leaf color   B. Climbing vines   C. Blooming   D. Photoperiod
78. The rise of water in a tall plant depends on capillary action and
    A. Osmosis   B. evaporation   C. nutrient transport   D. transpiration pull
79. Attraction between water molecules and other substances is
    A. Adhesion   B. capillary action   C. transpiration   D. cohesion
80. Where in a plant does mitosis produce new cells?
    A. Meristems   B. Chloroplasts   C. Mesophyll   D. tree bark
81. Which is NOT a factor in the movement of water through plants vascular tissues?
    A. Transpiration   B. Capillary action   C. Osmotic pressure   D. Meristems
82. Plants can: A. respire and give out water vapour   C. respire and produce CO_2
    B. photosynthesize and give off oxygen   D. All of the above
83. Which of these is an INCORRECT contrast between monocots (stated first) and dicots (stated second)?
    A. Vascular bundles in a ring—vascular bundles scattered   C. One cotyledon — two cotyledons
    B. Flower parts in threes — flower parts in four or five   D. Leaf veins parallel — net veined
84. Which of these types of cells is most likely to divide?
    A. Epidermis   B. Xylem   C. Meristem   D. Cork cells
85. Root hairs are found in the zone of
    A. apical meristem   B. cell division   C. elongation   D. maturation
86. What happens when a ring of bark is removed from a woody shoot?
    A. Absorption of water stops   C. Uptake of mineral ions will slow down
    B. Movement of food to the roots will be blocked   D. Rate of photosynthesis will slow down
87. Which of these is a correct statement?
    A. Only roots show negative geotropism   C. Only roots show positive geotropism
    B. Only stems show positive geotropism   D. Both roots and stems show positive geotropism
88. In plants growth is brought about by
    A. Cell division only   C. Cell enlargement only
    B. Both cell division and cell elongation   D. Physical factors only
89. Which of the following statements is true?
    A. Growth and development in plants begins only after seedling stage
    B. As plant embryo grows older, growth is restricted to the meristems
    C. Increase in the diameter of a plant is because of apical meristems   D. All of the above
90. The zone of plant roots from where root hairs develop is the zone of
    A. Cell division   B. Elongation   C. Differentiation   D. Root cap
91. Which of the following is NOT part of a plant embryo?
    A. Plumule   B. Radicle   C. Cotyledon   D. Seed
92. An opening on a seed through which water enters for germination is
    A. a hilum   B. a micropyle   C. a testa   D. cotyledon
93. Which part emerges first from a germinating seed during germination?
    A. Plumule   B. Radicle   C. Cotyledon   D. Endosperm

94. The part of the embryo that gives rise to young leaves and shoot is
A. A hypocotyl B. an epicotyl C. cotyledon D. radicle
95. The process of germination is
A. The growth of the embryo of a seed into a seedling
B. Transformation of an embryo into a self-supporting seedling
C. A shift from a seed to a young plant D. All of the above
96. A kind of germination in which the cotyledons of a seed are brought above ground is
A. an epigeal B. a hypogeal C. anaerobic D. aerobic
97. Responses in plants
A. Passive B. active C. are due to growth movements D. A and C
98. As seeds ripen and mature, the development of the embryo gradually stops and the seeds are said to enter into a period of rest called: A. Germination B. hibernation C. dormancy D. an endosperm
99. Which of the following is true?
A. The tip of the root is responsible for the increase in shoot length
B. The tip of the shoot is responsible for the increase in shoot length
C. The tip of the shoot is responsible for the increase in root length
D. The tip of the shoot is responsible for the increase in shoot and root length
100. Experiments using oats have shown that auxin concentration produced maximum growth in the shoot ________
A. inhibits root growth C. results maximum growth in the root too
B. auxin has no effect on root growth D. all except C
101. Which of the following is true about growth hormones on roots and shoots?
A. They have positive effects at lower concentrations
B. The concentration that produces maximum growth in the shoots inhibits in the roots
C. They have positive effects at high concentrations D. Only A and B
102. When a growing seedling is exposed to light on one side, it usually bends. This is due to
A. The intensity of light pushing the plant
B. Unequal growth between the tip of the plant and other parts
C. The darker side of the plant growing faster than the exposed side
D. The exposed side of the plant growing faster than the part of the plant facing dark
103. The instrument used to overcome the effect of gravity in plants growth experiments is called
A. Thermostat B. Potometer C. Klinostat D. Hydrometer
104. If a horizontally placed plant is rotated slowly no geotropic curvature appears. This is because
A. no segment of the plant stays long enough in any one position for growth curvature to occur
B. no growth hormones produced under such conditions to initiate growth curvature
C. plants do not grow while they are rotating D. the plant is terribly confused
105. Which of the following substances is synthesized by plants?
A. Indole –pyruvic acid B. Indole – acetic acid C. Indole – butric acid D. Indole – nitrile
106. Pruning is: A. Used in scientific agriculture C. Used only in primitive agriculture
B. Never used by Ethiopian farmers D. Unscientific practice
107. Which of the following best illustrates the principle of apical dominance?
A. Auxin produced at the tip of the shoot prevents the development of lateral buds
B. The removal of the tip of a growing plant enhance the development of the lateral buds
C. Inhibition of lateral meristem by the apical meristem D. All of the above
108. Suppose a farmer wants to keep his coffee plants short with more side branches, the best that you would advise him to do is: A. to stop watering them B. to spray with auxin
B, to remove the apical shoots D. to spray them with root tone
109. If plant meristems are removed from the tip of shoots and grows on agar medium, the meristem cells divide and produce: A. Apical tissues B a mass of unspecialized cells C. Callus D. B and C
110. Auxins in general cause: A. Cells to become longer C. cells to become larger
B, development of flowers D. all of the above
111. The synthetic auxin 2 – 4D serves as a selective weed killer by
A. Making dicot plants respire faster C. making monocots respire faster
B. Making dicots use up their food reserves D. A and B only
112. Abscission (falling of leaves from plants) is caused by
A. Increased production of auxins by leaves C. Decreased production of auxins by leaves
B. Spraying synthetic by leaves A. B and C

113. The phenomenon by which too much gibberellins causes the stems of plants to become very long and thin, with few branches and pale stem is called

A. etiolation B. blotting C. pruning D. vernalization

114. Which of the following plant growth hormones are considered to be primarily stimulators of cell division?

A. Cytokinins B. Auxins C. Gibberellins D. Ethylene

115. If you come across a fruit growing farmer whose plants do not bear branches, which of the following suggestions would you make so that the farmer obtains more branches?

A. To remove the lateral bud C. To prune the plants
B. To remove the apical bud D. B and C

116. What would be the effect if you collect auxins from the shoots and apply them onto the root?

A. Root growth would increase C. Root growth would be retarded
B. Root growth would not be affected D. Root would be changed into

117. The sheath that covers and protects the tip of the plumule until the young leaves burst through it called

A. Coleoptiles B. Coleorhiza C. Root cap C. Apex

118. In a certain plant seedling that was placed horizontally on a ground, the more auxin is found to accumulate

A. On the part of the root that is away from the ground C. On the shoot of the seedling equally
B. On the part of the shoot that touched the ground D. B and C only

119. Which of the following movements in plants is NOT caused by a differential distribution of auxin?

A. Phototropism B. Geotropism C. Thigmotropism D. Nastic movements

120. The growth movement of plants towards or away from the source of a stimulus is called

A. A reflex B. stimulation C. taxis D. tropism

121. The effect of light duration on plants is known as

A. Reflex B. photoperiodism C. phototropism D. photoreception

122. The two stimuli to which both plants and animals respond are

A. Light and heat B. sound and smell C. heat and touch D. light and touch

123. Flowering in short day plants is

A. Induced by long nights C. induced by short light period
B. Inhibited if light period is interrupted by flashes of light D. all of the above

124. Long-day plants will flower if exposed to

A. 8 hours light and 16 hours dark C. 16 hours light and 8 hours dark
B. 16 hours light and 16 hours dark D. 24 hours of the continuous illumination

125. If a twining stem winds around a support stick, this is

A. Tropism B. nastic movement C. taxis D. mutualism

126. Which of the following terms is given a wrong description?

A. Tropic movements — bending of plant organ in response to a unidirectional stimulus
B. Nastic movement — movement in a non-directional pattern in response to a diffuse stimulus
C. Phototropic movement — growth of pollen tube towards the egg
D. Phototropic movement—bending of plant shoot in response to light

127. Which of the following describes nastic movements?

A. They are due to non-directional stimulus C. They are confined to growing regions only
B. They are due to growing changes D. All of the above

128. Plants growing in moderate shaded areas have a larger leaves. This phenomenon is due to

A. A reduction of photosynthesis than transpiration C. abundant supply of water in the leaves
B. Reduced transpiration rate of the plant D. B and C only

129. Day-neutral plants, which are actually common in the tropics, produce flowers,

A. When nights are shorter than a critical period C. When nights are longer than the critical period
B. Without any reference to light stimulus D. When nights and days are equal in length

130. If a short-day plant is illuminated with a brief flash of light during the night, flowering will be

A. Accelerated B. unaffected C. inhibited D. promoted

131. The indigenous plants in Ethiopia are in general

A. Plants more or less requiring equal day and night length
B. Short-day plants C. long-day plants D. day-neutral plants

132. Plants which flower only when the hours of the light period are shorter than the critical time are best classified as

A. Long-night plants B. Long-day plants C. Short-day plants D. Short-night plants

133. Plants growing in the dark usually have long, thin and weak stem and their leaves are pale yellow. Such plants are known as: A. etiolated plants B. vernalized plants C. a neutral-plants D. none

134. The treatment of plants to cold climates for several weeks to enable them flower is called
A. Vernalization B. etiolation C. blotting D. freezing

135. Tropic movements
A. are due to growth changes
B. are due to unidirectional stimulus
C. are confined to growing regions
D. all are true

136. Which of the following is the correct order of the zones of root tip from the bottom of the root?
A. Zone of cell division—zone of elongation—zone of differentiation
B. Zone of elongation —zone of cell division —zone of differentiation
C. Zone of cell division—zone of differentiation—zone of elongation
D. Zone of differentiation —zone of elongation—zone of cell division

137. The plant growth hormone that causes plants grow abnormally tall is
A. Cytokinins B. IAA C. Gibberellins D. ethylene

138. If a apical bud of a certain shoot is removed, then
A. Auxin production will cease
B. Growth in the apex of the shoot will be inhibited
C. lateral buds near the tip will grow
D. all of the above

139. By pruning plants, one can
A. keep plants at a desired height
B. increase the production abundant flowers
C. make plants develop a strong framework of branches
D. all of the above

140. If a plant that has been growing in the dark is exposed to light
A. The rate of elongation is quickly reduced
B. The rate of elongation is neither reduced nor increased
C. The leaves of the plant becomes green
D. the leaves remain etiolated

141. Light affects the development of plants in its
A. duration B. intensity C. quality D. all of the above

142. If a klinostat holding a seedling is rotated very slowly to the plant where the centrifugal force is less than the pull of gravity
A. the seedling will grow horizontally without bending
B. the usual geotropic curvatures of both the shoot and the root soon appear
C. there will be equal distribution of auxin in the seedling
D. only the root bends towards gravity

143. nastic movement
A. is non-directional
B. is due to diffused stimulus
C. the responses are not determined by the stimuli
D. all of the above

144. During senescence
A. Plants functional capacity increases
B. Metabolic failures increase
C. cellular break down increases
D. B and C only

145. Which of the following comparisons between spongy and palisade cells of leaf is NOT correct?

	Spongy cells		**Palisade cells**
A.	Have chlorophyll	---------------------	Have no chlorophyll
B.	Have more air spaces	----------------	Have less air spaces
C.	Irregular in shape	-----------------------	Elongated in shape
D.	Loosely arranged	-----------------------	Vertically arranged

Answer for Unit 4 [Food Making and Growth in Plants]																							
																						131	A
																						132	C
1	C	14	C	27	B	40	C	53	A	66	C	79	A	92	B	105	B	118	A	133	A
2	B	15	D	28	B	41	D	54	B	67	C	80	A	93	B	106	A	119	D	134	A
3	B	16	A	29	C	42	C	55	A	68	C	81	D	94	B	107	D	120	D	135	D
4	B	17	D	30	D	43	C	56	A	69	A	82	D	95	D	108	B	121	B	136	A
5	B	18	C	31	C	44	C	57	B	70	D	83	A	96	A	109	D	122	C	137	C
6	B	19	D	32	B	45	B	58	C	71	C	84	C	97	D	110	D	123	D	138	D
7	A	20	D	33	D	46	D	59	D	72	A	85	D	98	C	111	D	124	C	139	D
8	C	21	A	34	A	47	A	60	C	73	A	86	B	99	B	112	C	125	A	140	A

9	B	22	C	35	C	48	B	61	B	74	B	87	C	100	A	113	B	126	C	141	D
10	D	23	C	36	D	49	B	62	B	75	C	88	B	101	D	114	A	127	A	142	B
11	B	24	C	37	A	50	B	63	D	76	C	89	B	102	C	115	D	128	D	143	D
12	D	25	A	38	D	51	D	64	C	77	B	90	C	103	C	116	C	129	B	144	D
13	D	26	A	39	B	52	C	65	D	78	D	91	D	104	A	117	A	130	C	145	A

Unit Five

Conservation of Natural Resources

The term resource can refer to any necessity of life, such as water, nutrients, light, food, or space. For plants, resources can include sunlight, water and soil nutrients—all of which are essential to survival. For animals, resources can include nesting space, shelter, types of food and places to feed.

Natural resources are anything natural that are used. They are the components of nature found in the atmosphere, hydrosphere, and the lithosphere. They are useful sources of energy, to support life for survival and prosperity.

Classification of Natural Resources

1, Renewable Natural resources: are resources that can be re-used and replenish or replace themselves in a reasonable time. Renewable resources are mainly living things and their products. Managed carefully, they can be used, reused and replaced. Examples of renewable resources are crop plants, trees, cattle, and chickens.

2, Non-renewable natural resources: are resources that can be used but not replaceable by themselves. They are not living, and when they are used they cannot be replaced. Examples of non-renewable resources are including metals like gold and iron and fossil fuels, like gas, coal, petroleum and minerals.

Even renewable resources can be lost if we do not manage them carefully. Trees can reproduce new trees and forests can last thousands of years — but if all the trees are cut down and used for timber in a very short time the forest will not be able to renew itself and all the species within it will be lost.

Similarly if an animal is hunted until there are no more of that species left (extinction) or its habitat is destroyed so it can no longer feed and breed, then another natural resource will be lost forever when the species becomes **extinct**. It may be lost in a particular area, or it may be lost everywhere in the world, when it is totally extinct.

To protect our natural resources, both here in Ethiopia and around the world, people are becoming more aware of the need for **conservation**.

Conservation — is the wise use, protection and preservation of our natural resources in a sustainable manner.

Conservation and Biodiversity

- **Biodiversity** is the species richness of a given region or place. It shows the number and variety of species in a given area.
- One of the most important things that concerns scientists around the world at the moment is the loss of the biodiversity that is taking place very quickly. This means that renewable resources are disappearing from our countries.
- Tropical regions especially tropical rain forests are known for their highest biodiversity since there are diverse number of plants, animals, and microbial species. Ethiopia is also part of the tropical region and it is famous for its biodiversity.

The importance of conserving biodiversity

1. Food security—to provide food in feeding humans and other animals
2. Health care—to treat and cure diseases as they are used to make medicine
3. Commercial value—to generate income from tourism and sell of their products
4. Aesthetic value—to recreate people by watching their beauty
5. Educational and research value—to acquire knowledge through scientific investigation

6. Sheltering—to be home for animals
7. Protection of water and its preservation to supply water for ecosystem services

The Method of Conserving Biodiversity

- Establishing of natural resources including zoos, parks, and sanctuaries to conserve plant and animal species.
- **Management of ecosystems** — protection and preservation of ecosystems for their sustainable development
- **Restoration of damaged habitats** — maintenance of loss of habitats and their disturbance. It also includes the creation of new habitats.

Conservation of Vegetation

We look at the use of plants in two ways: Direct and indirect uses

1, Direct uses of plants

- Timber and wood are major resources of plants
- Forests provide fuel wood
- Plants are used in extracting essential oils used in soaps, cosmetics, incense, etc.

2, direct uses of plants

- Forests check soil erosion and land degradation
- Forests reduce pollution by absorbing CO_2
- Forests are of great educational and aesthetic values

Vegetation Types in Ethiopia

Ethiopia has a varied topography (landscape). It varies between the high lands and the flat lands (low lands). This has given the country a wide range of habitat. It has also provided the country with diverse forms of plant and animal life. Ethiopia has been divided into the following vegetation types. These are listed in the table below.

Vegetation type		Location	Dominant vegetation
1	Desert and semi-desert scrubland	Afar, Somali, Oromia regions, Sidama and Southern Oromia zones	Euphorbia (qulqual), acacia (grar,commiphora (yekebezaf)&Aloe (eret)
2	Acacia – commiphora (small leaved deciduous woodland)	Ogaden bale(lowland), Hararghei and Sdamo lowlands	Drought-resistant trees and shrubs with small deciduous leaves. eg. Acacia, commiphora (yekebezaf)
3	Low land, semi evergreen forest	Gambella	Semi-deciduous trees and shrubs Emergent trees-certistoka
4	Combretum Terminaria (broad leaved) deciduous woodland	North and South western parts of Ethiopia — Gambella, Gamogafa, Western Tigray, Gondar, Gojam, Wellega and kaffa	Small trees with large deciduous leaves and understory of herb and grasses. The dominant trees include species of Comberatum and Terminalia
5	Ever green scrub	Occurs adjacent to the dry evergreen montane forest on the lower parts	Shrubs, scattered trees eg. *Juniperous Procera*
6	Dry ever green montane forest and grass land complex	In the highlands in the northern and south western plateau of Ethiopia	The common trees include *Juniperus procera*, *Celtis Africana*, *Euphorbia ampliphylla*, *Olea europaea*
7	Moist ever green montane forest	High lands of Arsi, Sidamo, Bale, Hararge	Tall emergent and medium sized trees Endemic herbs and epiphytes
8	Afroalpine and sub-afroalpine vegetation	On the slopes and at the top of highest mountains	Mount Abune Yoseph, Guna massif, MountGuge and Menz
9	Riparian Swamp vegetation	Banks of rivers and shores of inland lakes	Riparian vegetation, Sledges and grasses dominate swamps

Effects of Man on Natural Vegetation

- The great threat to vegetation cover is the **unwise use** of these natural resources by people.
- This includes **deforestation**, **overgrazing**, and **burning** of natural vegetation.

1. Deforestation — is the removal of trees and shrubs from forests for various purposes. Some of these are:

1. Clearing the vegetation **2**. Cutting woods for fuel consumption **3**. Cutting trees for timber production

Deforestation not only will remove the plant cover from the site but also will remove the nutrients in the plants together with it.

2. Overgrazing — Overgrazing due to increased animal population will expose the land surface to serious wind and water erosion.

3. Burning — Fire destroys the softer and more nutritious grasses, whilst seeds of tougher, firer resistant and less nutritious grasses survive.

Endemic plant species of Ethiopia

Ethiopia is a country which is internationally recognized for its rich diversity of plant species.

An **endemic species** is an organism that is only found in a particular area – so we have around 800 endemic plants which grow wild in parts of Ethiopia.They are very important both to Ethiopia and world biodiversity!

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 with up to 800 endemic species. 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 History of Ethiopian Vegetation

The history of our vegetation in Ethiopia has not been recorded in as much detail as we might wish. Unfortunately, as we are blessed with such a rich and diverse vegetation, we have not as a nation conserved that gift until recent years.

But perhaps we are not too late! We have used our resources without thought for future - in each area of the country the available vegetation has often been destroyed. However, now we are looking at the the paaast and making great efforts for the future.

Some Conservation Methods of Vegetation

1. **Reforestation** — tree felling should be matched by tree planting programs. Planting of indigenous plants should be given priority.
2. **Enclosure** — sites with little vegetation will have seeds that remain in the soil. Such areas if protected will regenerate within few years of natural vegetation.
3. **Fire protection** — the deliberate use of fire should be prohibited and people caught in doing so should be penalized.
4. **Awareness creation** — this is the most important part in planning conservation strategies. Both at the national and community level educational programs need to the intensively provided to create awareness.
5. **Use of firewood and charcoal** — should be discouraged. Other sources of energy, such as biogas, have to be provided and costs of electric energy should be reduced.

Wild Life Conservation

Wildlife — refers to animals and plants that live and grow in natural conditions. It refers to both big and small animals and plants.

The use of wild animals:

1. **Ecological balance** — each species plays an important role in balancing the population, maintaining the food chain and natural cycles on the earth. The destruction of a particular species of wild animals which has been regarded as harmful on the basis of a particular incident may prove to be wrong than right in the long run.
2. **Survival value** — the rich diversity of today is a result of natural evolution that has taken since 3.5 years on earth. The species surviving today represent years of evolution and constitute a heritage to the past.
3. **Educational and scientific value** — Wildlife provides valuable information to naturalists and biologists, in understanding the environment, ecology and behavior. These animals are also used to study the effects of pollution.
4. **Recreational value**—Wild animals have aesthetic value. Because of this they serve as the center of attraction.
5. **Economic value**—Wild species of animals not only provide meat but their skin is used as fur. They are also sources of income to tourism.
6. **Genetic value**—Wildlife has a great as a gene bank of nature. It is of great importance in breeding programs in agriculture, animal husbandry, etc.
7. **Medicinal value**—There are so many varieties in the wild whose medicinal importance is not known even today.
8. **Source of food**—In Ethiopia there are about **277** species of mammals, **861** species of birds, **78** species of reptiles, **63** species of amphibians and **101** species of fishes.

- The high species richness creates many diverse ecological zones with many ecological niches for animals to fill.

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.

Wild Animals in Ethiopia

- Most of the wild animals are concentrated in the South Western part of the country mainly in the Omo river basin, and the Gambella region.
- In this part of the country there are large herds of:

1, Eland,	**3**. Lions	**5**. Grant's giraffe	**7**. White eared kob	**9**. Elephant	**12**. Oryx	**14**. Gerenuk
2, Buffalo,	**4**. Ostrich	**6**. Zebra	**8**. Hartebeest	**11**. Wild ass	**13**. Summering's gazelle	**15**.Warthog

– are found in the eastern part of the country. The Bale Mountains are known for Mountain Nyala, Semien fox, Menlik's bush buck and Golden Jackals.

As shown in the table above there are a lot of endemic animals in Ethiopia. These include

1. **Walia ibex** — in the semien mountain
2. **Mountain Nyala** (Dega Agazen) — in the Bale Mountain
3. **Semien fox** (Kei kebero) — in Bale Mountains, Semien Arsi, Wello, gojam and Menze
4. **Gelada baboon** (Chilada zinger) — in Semien Mountains and in Menze (Semien shewa)
5. **Somali wild ass** (Yemeda Ahiya) — in the Afar region
6. **Menlik's bush buck** (Yemeda Dikula) — in Semien Mountain and central high lands
7. **Swayne's Hartebeest** — in Senkelle sanctuary and in Nechsar National park
8. **Thick-billed Raven** (Kura) — in the central high lands

Human effect on Wildlife

- The **deforestation** which has deprived our country of so much plant biodiversity has also caused many species to be pushed to the verge of extinction.
- At the moment our institute of Biodiversity Conservation (the IBC) is warning that at least four mammal species and two bird species are on the brink of extinction as a result of habitat loss.
- These are the Walia ibex (there are only about 514 left), Mountain Nyala, Ethiopian wolves and Grevy's zebras, while the White-winged fluff tail and the Ankober Serin bird are also badly threatened.
- The IBC explains that deforestation is one of the main reasons for the decline in wildlife in our country – when the forests go, so does the wildlife.
- Many animals have been hunted and their numbers greatly reduced. These may be to keep them away from crops or to stop them killing and eating domestic animals, or it may be for report.
- Whenever people settle they change the environment and make it more difficult for wildlife to survive.

Methods of Conservation Wild Animals

The conservation of wild animals is mainly associated with the conservation of soil, water and vegetation.
Wild animal conservation methods include the following:

1. **Controlling hunting** — If there are more wild animals than the habitat would support there will be destruction of the habitat. Then control hunting would be allowed.
   Controlled hunting requires the development hunting rules, these rules, for instance, consider the following points into account:
   - Shooting only a certain number of animals (adults) per given period but not female ones.
   - Endangered or threatened species or young animals should never be considered even for controlled huntingduring the breeding seasons of the animals hunting should not be permitted
2. **Protection of the habitat** — the habitat in which the species should be protected as parks, sanctuaries, etc.
3. **Survey and research** — Survey on the number of species and their habitat and research on the reproductive behaviours of species will provide important information for the conservation of wild animals
4. **Establishing national parks** — Wild reserves and sanctuaries
   I. **National park** — is a conservation area designed to give maximum protection to the largest wild animals
   II. **Wild sanctuary** — is an area that is managed for the protection of particular animal and bird communities
   III. **Wildlife reserves** — are areas set aside for the conservation, management and propagation of wild animals. They are protected and managed habitats. In such reserves, controlled human settlement and activity may be allowed.

Below are listed many of the main National Parks of Ethiopia along with some of the wildlife sanctuaries that have been set up to protect specific species.

National Parks				**Wildlife sanctuaries**	
1	Abjata-Shalla lakes	6	Mago National park	1	Harar Wildlife sanctuary
2	Awash National park	7	Omo National Park	2	Kuni-Muktar Mountain Nyala Sanctuary
3	Bale Mountain National Park	8	Nechsar National Park	3	Senkelle Swaynes Hartebeest Sanctuary
4	Gambella National Park	9	Simien Mountain National Park	**For full understanding** — Please read student text book page 192 — 197	
5	Rift Valley Lakes National Park	10	Yangudi-Rassa National Park		

The Major Problems of National Parks of Ethiopia

1. Lack of awareness by the community
2. Lack of low enforcement
3. Lack of trained technical personnel
4. Absence of land use planning
5. Lack of consultation and participation by the people around the protected areas
6. Lack of realistic and effective resettlement programs for the inhabitants in and around conservation areas

Air

Causes of air pollution

Pollution — is the process by which harmful substances are added to the environment. As human pollutions increase and society becomes more industrialized, pollution has become more of a problem.

- Many of the products of modern technology are toxic and when they find their way into the air and water, they threaten the lives of organisms in the ecosystem, including humans.
- Air pollution results mainly from the burning of fuels such as coal, oil, petrol and wood. It may also be due to natural causes such as volcanic eruptions, forest fires and biological decay which release ammonia into the air.

- Air pollution due to human activities includes exhaust fumes from motor vehicles, chimney fumes from factories where fossil fuels are burnt, and the burning of garbage.
- The pollutant gases released include sulfur dioxide, nitrogen oxide, carbon monoxide and carbon dioxide. In addition, lead and particulate matter can be released into the environment from petrol and diesel used in car, bus and lorry engines. Further changes in the atmosphere then produce secondary pollutants such as **ozone.**
- **Sulfur dioxide** at high concentrations has damaging effects on both plants and animals. In addition, **sufur dioxide** and **nitrogen oxide** react with oxygen and rain water to form **sulfuric acid and nitric acid respectively**, which falls to earth as **acid rain.**
- The death of fish in lakes and rivers in countries such Germany has been attributed to large amounts of acid rain, which dissolves aluminum salts in the soil and washes them into rivers and lakes, leading to concentrations that are **poisonous to fish.**

- **Lead** may be present in the air, water and the food we eat. **Lead poisoning** occurs when lead accumulates in the body over long periods.
- High concentrations of lead in the body may cause cramps, loss of control of the hands and feet and even death. Urban air contains a much higher concentration of lead than rural air.

- The main source of carbon monoxide is motor vehicle and exhaust fumes. Carbon monoxide combines with hemoglobin in the red blood cells to form **carboxyhemoglobin**.
- This reduces the capacity of the blood to transport oxygen round the body which is harmful and may be fatal in high concentrations.

The greenhouse Effect of CO_2 (Global Warming)

- Before widespread industrialization, the concentration of Co_2 in the atmosphere was approximately 260-280 parts per million (ppm).
- As industries grow, use of fossil fuels — coal, oil, and gas has increased greatly. As a result of increased use of fossil fuels, the amount of CO_2 in the atmosphere has increased rapidly.

- In 25 years period starting in 1958, the concentration of CO_2 increased from 315 ppm to more than 340ppm. **Climatologists** have calculated that the actual mean global temperature has increased about 1^oC since 1900, a phenomenon known as **global warming.**
- Scientists have determined the concentration of gases in the atmosphere particularly CO_2 maintains the average temperature on earth about 25%.

- Much of the energy entering the Earth's atmosphere from the sun is reflected back into space as infra-red radiation.
- The CO2 and other gases trap the radiation and keep the earth warm. This is known as a **greenhouse effect.**
- The atmosphere acts like the glass of a big greenhouse surrounding the earth. As the result of greenhouse effect of the gases, nitrous oxide, methane, and chlorofluorocarbons (CFCs), in addition to CO_2, the earth is beginning to warm up.

- In recent studies, it was estimated that the concentration of the CO_2 in the atmosphere would pass 600ppm by 2025.
- If this concentration is reached, it would warm the surface air by between 1.5^OC and 4.5^OC.
- The warming up of the atmospheric air due to the greenhouse effect of CO_2 may also have an effect on climate.
- Most important effect is that the great polar ice caps melt causing sea levels to rise which in turn, would have a disastrous effect such as flooding for low-lying countries.

Ozone Depletion

- Ozone (O_3) is a different form of oxygen gas than o2. The Ozone layer protects key biological molecules especially proteins and nucleic acids from the harmful ultraviolet rays that bombard the earth continuously from the sun. Life on earth may have become possible only when the oxygen layer is sufficiently thick to generate enough ozone to shield the surface of the earth from the destructive UV-rays.

- Every 1% drop in the atmospheric ozone is estimated to lead to a 6% increase in the incidence of skin xcancer. However, the Ozone layer is being damaged by certain chemicals (pollutants) primarily by chlorofluorocarbons (CFCs).
- The destruction of the Ozone layer forms holes. The increase in the loss of the ozone layer is called Ozone depletion.

- The CFCs are used in cooling systems, fire extinguishers and foam containers. They percolate up through the atmosphere and reduce O_3 molecules to O_2.
- Industrial CFCs released into the atmosphere react at very cold temperatures with Ozone converting it to oxygen gas. This has the effect of destroying the earth's Ozone shield and exposing the earths surface to increased levels of harmful UV-radiation.

Composition of atmosphere

The atmosphere is a mixture of several gases. The composition the earth's surface is given below:

- Nitrogen (N2)—78% approximately
- Oxygen (O2)—21% approximately
- Carbon dioxide (CO2)—0.03% approximately
- Hydrogen, Helium, Neon, Crypton,and other gases—0,04% approximately
- The air also contains water vapour, dust particles smoke and salts

Air Pollution

Pollution — is the release of harmful waste into the environment

Pollutant — is the agent that causes pollution. Example-- burning of fossil fuels, industrial smoke, deforestation and chemicals
such as insecticides are the main pollutants.

The Greenhouse Effect (Global Warming)

An excessive use of fossil fuel can change the self-regulating cycle of the carbon.

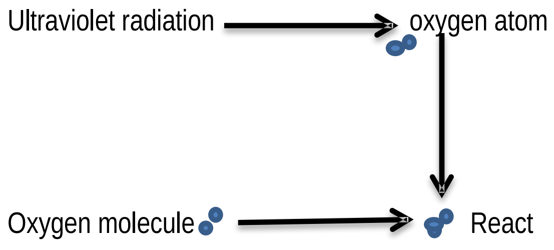
The excessive carbon dioxide traps the infra-red rays which are normally radiated back into the space from the earth's surface.

This trapping leads to the gradual warming of the earth and melting of the polar caps.

Ozone Depletion

- The ozone layer is a layer of gas which protects the earth from the harmful rays of the sun such as the ultraviolet rays.

- The main chemicals that cause the loss of this layer are the so called chlorofluorocarbons (CFCs). These chemicals
- result in the damage of the ozone layer and as a result the layer forms holes.
- The increase in the loss of this layer is called the ozone depletion. Ozone depletion allows more ultraviolet radiations
- to reach the earth. This causes skin cancer, increased global
- warming, etc. The first hole in the ozone layer was discovered in early 1980s is in the **Antartic.**



Ozone is formed in the atmosphere when UV rays strike an oxygen molecule (O2), freezing it (O) to combine with other oxygen molecule (O_2) to create Ozone (O_3). The Ozone produced is then broken apart by the UV-rays, again absorbing UV – light and forming and reforming ozone many times.
The increase in air traffic has led to excessive nitrogen oxides emitted from the jet fuel.
The industrial activities have led to increased carbon dioxide by forming petroleum products
This has disturbed the balance of gases and the ozone layer and is a threat to the earth's atmosphere.

- It is stimulated that CO_2 is responsible for 50% increase in the greenhouse effect.

Review Questions

Unit Five == Conservation of Natural Resources

1. Which of the following statements about renewable resources is TRUE?
   A. They are only found in tropical climates
   B. They can never be depleted
   C. They are replaceable by natural means
   D. They regenerate quickly
2. Which of the following is a nonrenewable resource?
   A. Wind B. Fresh water C. Coal D. Topsoil
3. Which of the following is NOT a direct effect of deforestation?
   A. Decreased productivity of the ecosystem C. Soil erosion
   B. Biological magnification D. Habitat destruction
4. The total variety of organisms in the biosphere is
   A. Biodiversity B. Ecosystem diversity C. Species diversity D. genetic diversity
5. Ozone is made up of
   A. Hydrogen B. Oxygen C. Nitrogen D. Chlorine
6. Ozone depletion in the atmosphere has been caused by
   A. Monoculture B. CFCs C. Suburban sprawl D. Soil erosion
7. In a food chain, concentrations of the harmful substances increase in higher trophic levels in a process is known as
   A. Biological magnification B. Biologica succession C. Genetic drift D. Pesticide resistance
8. The concept of using natural resources at a rate that does not deplete them is called
   A. Conservation B. Successful use C. Sustainable development D. Reforestation
9. A resource that cannot easily be replenished by natural processes is called
   A. Common B. Renewable C. Nonrenewable D. Conserved

10. Whatever human beings use for food, shelter, clothing, etc., directly or indirectly comes from
    A. Plants B. The soil C. Animals D. Natural resources
11. Renewable natural resources are
    A. Present in limited quantities C. Present in unlimited quantities
    B. Replaced even if they are continuously used D. B and C
12. Conserving one of the following means conserving all the others
    A. Wild life B. Vegetation C. Soil D. Water
13. Which of the following natural resources are non-renewable?
    A. Air B. Solar energy C. Oils and minerals D. Animals and plants
14. The highest diversity of living things is registered in
    A. The tropical rain forest B. The temperate rain forest C. the coral reefs D. A and B
15. Biodiversity of a certain country has
    A. Aesthetic value B. Economic value C. Ecological value D. All of the above
16. The wise use of natural resources on a sustainable bases without serious effects to the natural environment is referred to as
    A. Conservation B. Extinction C. Biodiversity D. Utilization
17. Natural resources can be increased by
    A. Transplanting plants from other countries C. Producing more cultivated varieties
    B. Conversion of grass land to crop land D. Recycling of used materials
18. Ozone layer is affected by
    A. Supersonic jet C. Increased use of pesticides
    B. Burning of petroleum D. Increased use of aerosols
19. Increased level of CO2 in the atmosphere is harmful because it
    A. Increases turbidity B. Causes respiratory disorder C. forms smog D. Traps heat
20. Which of the following wildlife conservation methods gives the maximum protection to the largest wild animals?
    A. National parks B. Wildlife reserve areas C. Wildlife sanctuaries D. All of the above
21. 434A wildlife conservation area that is managed for he protection of a particular wild animal and bird communities is referred to as
    A. national park B. sanctuary C. reserve area D. aquarium
22. identify the correct statement from the following
    A. Animal and plant resources are renewable because they reproduce
    B. The greatest diversity of living organisms is found in the tropical rain forests and coral reefs.
    C. If an animal or a plant becomes extinct, then it is regarded as a non-renewable resource
    D. All of the above
23. If an area is covered with vegetation, then
    A. The water coming from the rain fall will be conserved
    B. The force of the rain droplets will be reduced
    C. The soil under the vegetation will be able to hold the available water D. All of the above
24. Which of the following is NOT the rule of controlled hunting?
    A. Killing a certain number of male and female animals per a given period of time
    B. Excluding endangered or young species from being shot
    C. Hunting should not be done on the breeding seasons
    D. None of the above
25. One of the major problems of national parks of Ethiopia is
    A. Lack of awareness by the community
    B. Lack of the participation by the people around the protected area
    C. Lack of trained technical personnel D. All of the above
26. In what way does a land with a cover of natural vegetation influence soil erosion?
    A. By retarding surface water run-of
    B. By trapping soil particles and restrict their movement
    C. By increasing soil aggregation D. All of the above
27. Which of the following is regarded as a direct use of forests?
    A. They control soil erosion C. They reduce pollution by absorbing CO_2
    B. They provide educational and aesthetic values D. All of the above
28. Which of the following helps to reduces wastage of energy?
    A. Planting more fuel wood trees

B. Generating energy from hydroelectric or wind power
C. Using biogas plants D. All of the above

29. Which of the following plants is NOT endemic to Ethiopia?
A. Maize B. Zigba C. Enset D. Teff
30. Which of the following gases results in global warming when accumulated in the atmosphere?
A. Nitrogen B. hydrogen C. Oxygen D. Carbon dioxide
31. Which of the following activities increases the biodiversity of our country?
A. Burning of fossil fuels C. Cultivation of a single crop
B. Cutting of trees D. Replanting trees
32. Air pollution by chlorofluorocarbons (CFCs) has caused
A. Ozone hole B. global cooling C. Volcanic eruption D. Acid rain
33. Natural resources are components of
A. Hydrosphere B. atmosphere C. land D. all of the above
34. Which of the following is a renewable resource?
A. Soil B. Petroleum C. Coal D. Mineral
35. Which of the following measures is NOT recommended for controlling gullies from advancing farther?
A. Planting shrubs and trees across the gully C. Planting grass on the gully
B. Planting contour ploughing across the gully D. Building check dams across the gully
36. A factor the least contributes to soil erosion is
A. The soil eroding forces C. Land erodability
B. Poor land management D. He nutrient status of the soil
37. Overexploitation of natural resources may end up with
A. Sustainability of resources C. richness of resources
B. Destruction of resources D. A and C
38. One negative consequence of large scale deforestation is that it may result in
A. A rise in the atmospheric composition of nitrogen
B. A rise in the atmospheric composition of oxygen
C. A rise in the atmospheric composition of carbon dioxide
D. A reduction in the atmospheric composition of carbon dioxide
39. Which of the following cannot be conserved?
A. Ecosystem B. Energy C. Air pollution D. Living organisms
40. Which of the following would be unwise to adapt as the strategy of conserving Ethiopian wildlife?
A. Selective hunting
B. Selective killing of young animals
C. introducing natural predators to control rising numbers
D. Selective killing of old males
41. The cause of extinction and reduction in the number of wild life can be
A. Uncontrolled hunting C. Use of chemical pesticides
B. Overgrazing by domestic stock D. All of the above
42. Which of the following reduce biodiversity around the world?
A. Climate change B. Deforestation C. human activities D. All of the above
43. Why should we protect semen fox from hunters?
A. It is an endemic C. It has an economic value
B. It has the right to exist in its habitat D. All of the above
44. Which of the following human activities affects vegetation?
A. Appropriate farming B. Reforestation C. Fire D. Over hunting
45. Examples of non-renewable natural resources are
A. Solar energy and water B. Natural gas and petroleum C. Water and wind D. Wind and soil
46. Which of the following human activities affects wild life?
A. Habitat destruction B. Over grazing C. Road construction D. All of the above
47. Acid rain may be caused due to
A. Chlorofluorocarbon B. Carbon monoxide C. Oxides of nitrogen D. Oxides of lead

146. Which of the following isn‘t necessarily an aspect of conservation?
A. The avoidance of pollution of the environment C. The avoidance of unwise destruction of climate
B. To maintain an environment as it is D. None of the above

147. Biodiversity is lowest in

A. the polar region B. the tropical region C. the desert region D. the temperate region

148. conservation of wild life demands

A. national laws to reduce tree felling and poaching C. conservation education
B. Development of nature reserves D. All of the above

149. _________ is caused by an accumulation of large amounts of CO_2 and other gases in the atmosphere.

A. The greenhouse effect B. Skin cancer C. Acid rain D. The ozone hole

150. Atmospheric air must be conserved because

A. It is the source of the gases we breathe in C. It is a source of light
B. It is the source of the gases for photosynthesis D. A and B

151. Three natural resources considered to be renewable but can become non-renewable if not properly managed are

A. Coal, petroleum and minerals C. water in lakes, oil and coal
B. Wind, solar energy and precipitation D. Underground water, forests and wild life

152. Which of the following is NOT major reason for the destruction of tropical forests?

A. Over hunting C. Uncontrolled deforestation
B. Firewood gathering D. Lumbering

153. The ever increasing global warming may cause

A. Regulation of climate B. Melting of the polar ice cap C. Volcano D. A and B

154. _______ is a pollutant that decreases the oxygen supply to our tissues by combining with hemoglobin?

A. Nitrogen oxide B. Sulfur oxide C. Carbon monoxide D. Ozone

155. A good method to discourage use of firewood and charcoal is

A. Providing other sources of energy
B. Penalizing fire wood collectors and charcoal sellers
C. Controlling grazing D. Fire protecting

156. Which of the following methods of wild animals‘ conservation is most effective?

A. Reducing over hunting B. educating people C. reducing over grazing D. National reserves

157. Which of the following is NOT endemic to Ethiopia?

A. *Walia ibex* B. *Semien fox* C. *Wild Ass* D. Giraffe

158. Reforestation is useful to conserve

A. Wild life B. Air C. Water D. all of the above

159. Among the following environmental problems, human kind is least responsible

A. Deforestation in forest ecosystem C. Nutrient depletion
B. Overgrazing by domestic animals in grass land D. wind erosion in desert

160. Which of the following helps to restore biodiversity?

A. Ecosystem management B. Rehabilitation of habitats C. Hunting and poaching D. A and B

161. All of the following contributes to air pollution EXCEPT

A. Exhaust of cars B. Household wastes C. Solar energy D. Agrochemicals

162. Which of the following national parks in Ethiopia Walia Ibex is found?

A. Semien mountains B. Bale mountains C. Nechsar D. Awash

163. Which of the following would you say resulted in the greatest harm to the resources to the earth?

A. Human's lack of concern for the environment
B. Soil erosion by the wind and water
C. Human attempt to alter some plants through genetic engineering D. Forest fires

164. All of the following are inexhaustible EXCEPT

A. Wind B. Gold C. Solar energy D. Precipitation

165. Global warming is associated with

A. Ozone depletion B. increased carbon dioxide C. Natural disasters D. all of the above

166. As compared to the previous time, the current biodiversity situation in Ethiopia is

A. Increasing B. decreasing C. constant D. unknown

167. An accumulation of large amounts of CO_2 and other gases in the atmosphere causes

A. Fossil fuel combustion B. Acid rain C. The greenhouse effect D. skin cancer

168. Which of the following are true about air pollution?

A. It is highest in rural areas C. it is lowest in urban areas
B. It affects all living organisms D. All of the above

169. Burning of fossil fuels has released large amounts of __________ into atmosphere

A. Carbon monoxide B. carbon dioxide C. molecular oxygen D. acid rain

170. What do you call a measure of wealth of species in a given place?
   A. Biodiversity B. Ecosystem C. Environment D. Biomass
171. Biodiversity refers to
   A. Identifying and scientifically describing species of living things
   B. Sustainable use and protection of natural resources
   C. The variety of living things on the planet earth
   D. All the natural resources we have on the planet earth
172. Which of the following is used to conserve wild life?
   A. Setting national parks and sanctuaries C. Shifting their habitats and niches
   B. Allowing poaching for economical use D. Mixing wild life with the domestic species
173. Which of the following activities causes global warming?
   A. Reducing the number of livestock C. Reducing the amount of rice farmers
   B. Burning of fossil fuels D. Afforestation of the habitat
174. Which of the following describes renewable resources?
   A. They are mainly living things and their products
   B. They can be replaced but unable to be reused
   C. They can be used but are unable to be replaced
   D. They are mainly non-living and replaced
175. Ethiopia has various types of vegetation. This mainly due to
   A. Varied altitude and rain fall distribution C. Tropical climate
   B. Nearness to the equator D. Location and lakes
176. Which of the following is a non-renewable resources?
   A. Egg B. Teff C. Sweet potato D. Oil
177. Which of the following is NOT an example how humans can affect natural vegetation?
   A. Classification B. Deforestation C. Burning D. Farming
178. Which of the following methods is NOT an effective way of conserving wildlife?
   A. Setting up national parks C. Intensive farming
   B. Controlling hunting D. Restoring lost habitat

ANSWER FOR THE REVIEW QUESTIONS (Unit 5)

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