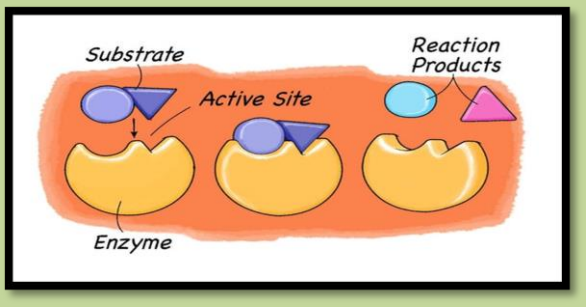
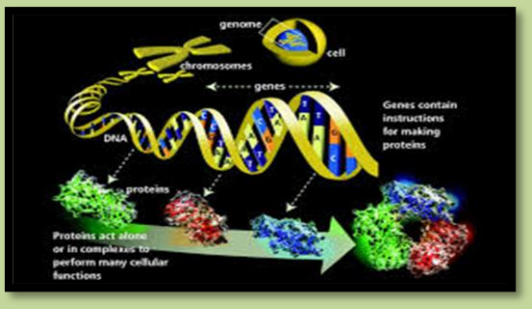
Virtual Study

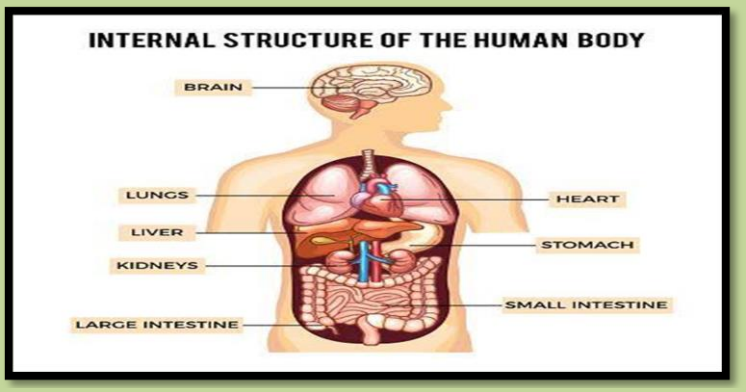
Learn, Connect, Succeed

Biology

Grade 11







Prepared by: Virtual Study

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UNIT ONE

BIOLOGY AND TECHNOLOGY

1.1 LEARNING FROM NATURE

What is imitation?

- Nature is the physical, natural and material world of life that exists without human intervention. It includes landscape sceneries, water and forest ecosystems, weather, organisms, geology, celestial bodies and inanimate objects, etc. Organisms have well-adapted structures and that make them survive on their immediate environment.
- Nature provides us with doable structures and forms which can be developed as functional and applicable mechanisms for various technological systems. Scientists and engineers learn from nature through imitation of physical structures, shapes, materials and functional mechanisms of natural facts.
- The better their understanding the diverse nature of biological materials, the better their ability to develop technologies. Using imitation of nature, they can sketch the biological structures, design functional mechanisms and tune into more efficient technologies at macro (large) and nano (very small) scales through imitation.

❖ **What are the technologies imitated from nature?**

- The design and adaptation of many technologies we utilize today imitated natural working systems. Many technologies have been imitating birds, bats, termites, spiders, bees, ants and parts of human body since timeless. The successful design of technologies from robotics to material sciences was through imitating nature
- Nature inspires scientists and engineers and serves as a reliable source of knowledge, ideas and concepts from which technologies can be developed. Buildings were made through the imitation of the mound architecture of termites that have chimneys, constant temperature and humidity.

❖ **Examples of technology that imitates nature:**

- Swallow nests have inspired the house building design.
- Weaving technologies have been developed by studying the formation of spider webs.
- Buildings have been made through the imitation of the mound architecture of termites.

- These buildings mimic termite mound architecture that has chimneys with constant temperature and humidity.

Figure.1 Nature imitated technologies and architectures

- An example is The East gate Center in Harare
- The first heavy aircraft technology was designed by imitating birds. Aircraft engineers designed aircraft wings and their flight techniques by imitating the wings of birds and bats
- Engineers imitating human eyes made the technology of photograph camera.
- The movement of bio-robots was designed from the movement of kangaroo.
- .Injection needle technology was copied from mosquito **proboscis**
- The sensors of electrical devices were imitations of biological neurons.
- A cutting saw was imitated from the nature of the sharp teeth of animals.
- Synthetic bulletproof vests are imitations of the spin silks of spiders.
- Ceramics are an imitation of the nature of crack-resistant shellfish exoskeleton.
- A robotic arm was imitated from an elephant trunk

1.2 BIOLOGY AND TECHNOLOGY

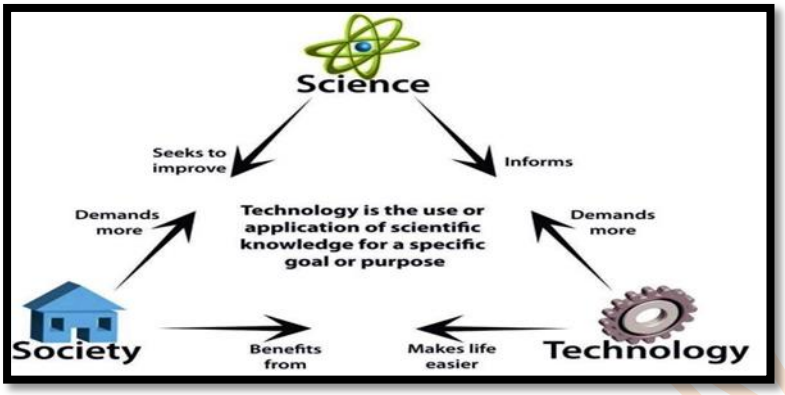


Figure.2 Biology and Technology

- Biology is the study of life: the structures, functions, growth, origins, evolution and distribution of living organisms.
- Technology is the application of scientific knowledge, skills, methods and processes for the production of devices and tools for scientific investigations.
- The blend of biology and technology forms biotechnology, which is a technology that utilizes biological systems to develop useful products**.**
- Biotechnology is the integration of natural and engineering sciences to achieve the application of organisms, cells, parts and molecular analogues for products and services. Examples: people use yeasts to produce bread and beer.

1.2.1 The benefits of biology to technology

- There are many benefits of biology to technology. Biology is a source of materials that enable us to imitate, design, adapt and develop modern technologies and solve complex human problems. The diversity of nature stimulates the development of new technologies. Scientists and engineers imitate nature to innovate, problem solve and expand their scientific understanding.
- **Here are just a few examples of the benefits of biology to technology:**

1. **Medicinal plants:** Many biochemical substances in plants have been used to develop medicines. Scientists have imitated nature to develop artificial versions of these biochemical substances.
2. **Gene engineering and biosynthetic materials**: Scientists have imitated the nature of human, animal and plant genes.

3. The uses of imitating genes include gene engineering to cure genetic conditions and the creation of biosynthetic materials to repair damaged body tissues.
4. **Building design:** Engineers have imitated the mound architecture of termites in the design of buildings with chimneys which have a constant temperature and humidity.
5. **Bullet train design:** The noses (front) of bullet trains have been designed by engineers imitating the shape of the beaks of kingfishers when they dive into water.

1.2.2 Uses of technology in biology

- The uses of technology in biology are the ways in which technological tools can be applied to solve various human problems. It is the practical application of biotechnological instruments (products) in providing required human services and investigations of new biological questions.
- **Biological studies that use technological tools include:**

1. **Biochemical** studies are helpful to investigate information on carbohydrates, proteins, lipids and nucleic acids.
2. **Biomedical** studies deal with providing detailed of information on the chemical components of medicinal plants.
3. **Biophysical** studies are the science of using physical devices to gather biological information at all scales of biological organization (molecular, organismic, and populations).
4. **Environmental** studies are a multidisciplinary system dealing with the interactions of humans with the environment.
5. **Bioinformatics** is a scientific discipline involving computer technology to collect, store, analyze, and disseminate biological data and information (DNA and amino acid sequences).
6. **Biogeographical information** is the study of the distribution of species along with geographic ecosystems through geological periods.

- **The following are examples of technological devices:**
  - A **digital thermometer** is an instrument used for measuring body temperatures.
  - A **pregnancy urine test** is a tool that checks if a woman is pregnant or not by detecting the amount of the hormone Human Chorionic Gonadotropin (HCG), produced in the placenta around six to ten days after **fertilization** in either the urine (pee) or blood. The test result in one line is a **control line** showing negative (no pregnancy) and the other line (two lines) confirms the existence pregnancy.

- **The diabetic blood test** is a tool to measure the level of blood sugar taking sample blood from figure tip
- An **HIV test** is a detector to identify infections with the virus or not.
- **Microscopes** used to magnify objects (
- **Computer Information Technology Scanning (CITS)** is a device used for investigating information on diseases or cancerous areas of the human body.
- **Computed Tomography scan (CT scan)** is a sophisticated x-ray technology used to take many X-ray pictures of the body, used to detect and screen for variety of diseases and conditions.
- **Positron Emission Tomography (PET scan)** is an imaging technology device used to check for diseases or information in areas with cancer in the human body. It uses a special dye containing radioactive tracers that is swallowed, inhaled, or injected into an arm vein conditionally. It visualizes and measures changes in metabolic processes and physiological activities like blood flow, chemical composition, and absorption
- **Geographical Position System (GPS**) is a device used to collect biogeographical information (biological data) on landscape mapping, plants, animals, and human movements
- **Handheld Body fat calculator** device used to measure body fat

1.3 IMPACTS OF BIOLOGY AND TECHNOLOGY ON SOCIETY AND THE NATURAL WORLD

- The impacts of biology and technology refer to factors that pose positive or negative effects on the society and the natural world. The advancements of biological information and technological devices can highly influence or control the societal and natural world.

1.3.1 Impacts of biology on the society and the natural world

- The impact of biology refers to the effects arising from the advancement of biological knowledge and innovations.

Examples:

- ✓ Ensuring food security as a result of an increase in productivity
- ✓ Medicine and disease treatments have resulted in improved health and longevity.
- ✓ Achieving better supply of energy and clean water.
- ✓ An increase in industrial production due to microbial action

- ✓ Creating antibiotics to treat bacterial infections
- ✓ Technological devices made from biological materials by biological information advancements to provide services that influence, treat, and control the society and the natural world negatively or positively.
- ✓ Biological weapon production and use destroy the natural world.
- ✓ Practicing a predetermined limit to have only boys (XY males) and avoid (XX females) of child sex chromosomes affects the society and the natural world will lead to the loss of females

1.3.2 Impacts of technology on the society and the natural world

- Technology is part of everyone's life. Technological products and their applications in various fields of study have solved societal problems and had significant societal and environmental impacts. However, industrialization and subsequent technological advancements have resulted in the misuse and destruction of our natural environment. These technologies have damaged our world in two main ways through pollution and the depletion of natural resources.

Examples:

- Industrial emissions and effluents pollute clean air and drinking water.
- 2. Biochemical agents, pesticides, and fertilizers cause toxicity and biohazards.

1.4 ETHICAL ISSUES IN BIOLOGY

- Ethical issues in biology are those issues that arise concerning the rightness or wrongness of using biological discoveries for the health and wellbeing of humans. Ethical issues in biology deal with a variety of concerns related to biotechnology, medicine, and the environment including, the rightness or wrongness of using biotechnological information, products, or devices on human health and lifestyles and livelihood systems.

1.4.1 Ethical treatment of plants and animals during biological studies

- Ethical treatment of plants and animals during biological studies is the process of subjecting animals and plants to various experiments and rigorous tests.

Ethical treatment of plants

- Plants are primary producers and feeders for all living organisms. Trees are living organisms that properly function in decentralized forms without any centralized order-providing unit (brain). Subjecting plant species to severe life-treating conditions leads to a total disappearance of plant

species. collecting seeds, berries, roots, leaves, bark or flowers for personal uses, medicaments, and other purposes (tooth brushing) affect the survival of the plant species and the community that depends on the plants

Unethical treatment of plants:

- Testing seeds or berries through destructive rays
- Cutting tree terminals for experiments
- Consumption of all seeds and fruits without conservation
- Unplanned cutting of trees or deforestation
- Burning forests and seedlings for farmlands
- Restructuring the shapes of trees for aesthetic appeal
- Care for plants is an ethical treatment and important for saving the jeopardized species and conserve for our common future. It is ethical to plant trees and it is a national responsibility.

Ethical treatment of animals in experiments

- In biological studies, researchers use animals to gain scientific understanding of the world. The ethical treatment of animals is a moral question of whether it is acceptable to harm animals for scientific research. Animals are sentient creatures that have a nervous system, feel painful feelings, emotional stress, and have interests and values. Given this, it is unethical to harm animals during experiments or rigorous testing.
- Unethical treatments of animals in research include approaches which expose animals to rigorous experiment that may injure or cause pain to animals.
- Researchers must reduce impacts of unethical treatments of animals through the three **Rs** principles described below (Reduction, Refinement, and Replacement).

A. **Reduction** aims to minimize the number of animals used in experiments by improving experimental techniques and sharing information with others.

B. **Refinement** is cleansing experiments in a way that enables to reduce suffering of animals using less invasive techniques, better medical care, and better living conditions

C. **Replacement** is substituting experiments on animals with alternative techniques using cell cultures instead of whole animals, biosynthesis, and computer simulated models.

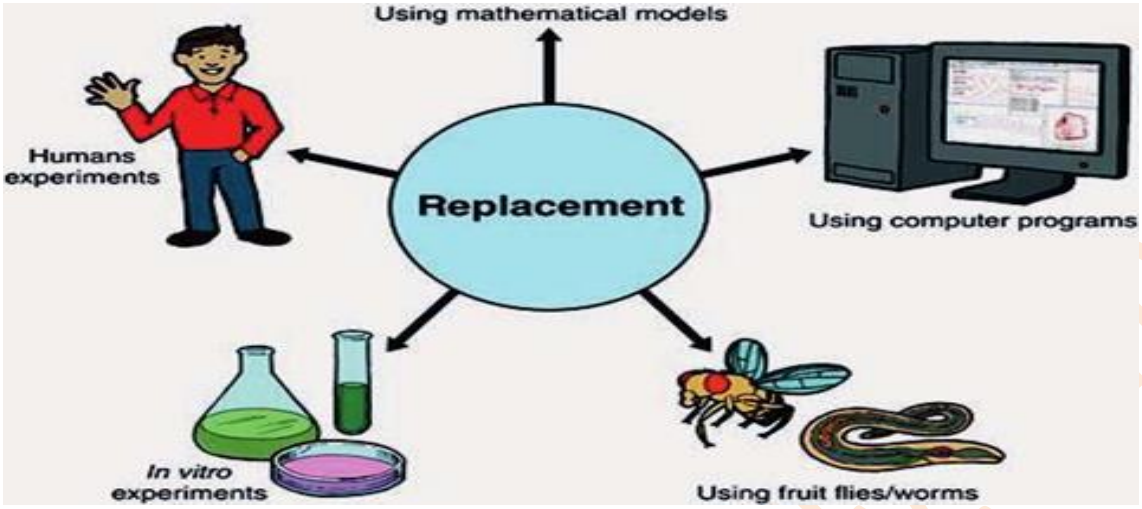


Figure3: Unethical treatments of animals

UNIT ONE SUMMARY

- Human beings learn powerful lessons from nature like the technologies of flight, submarine, bullet train, flipper and other engineering and architectures.
- Biology is a natural science studying living organisms from the simplest to the most complex ones. Technology is the sum of techniques, skills, methods and processes used in the production of goods or services to accomplish objectives.
- Biology is dependent on technology in terms of using devices likewise; technology is dependent on biology in terms of identifying scientific information and imitating biotechnological devices from nature.
- Biology and technology are tightly blended and form **biotechnology,** which is useful in designing various devices and engineering systems to solve complex human problems.
- Biotechnology is the use of biology to develop new products, methods and organisms intended to improve human health and society.
- Biotechnological devices are tools used to solve day-to-day biological tasks and support the discovery of more information in the course of biological studies.
- The benefits of biology to technology are biological information on biological systems helpful to derive technological systems, working mechanisms and related products.
- The impacts of biology and technology on society and the natural world are positive and negative influences of using biologically derived technologies.

- Uses of technology in biology deal with technical applications in the biological study process to investigate biological information.
- Ethical issues in biology are concerned with respecting the values for all life forms; particularly the determining the right or wrong values that may affect human rights to equality to live freely and natural.
- Ethical issues in biology deal with questions related to unethicality, immorality, illegality, inequality, injustice, and disrespectful acts to the values and rights of someone. It also includes the commercialization and commodification of human organs; assisted reproduction techniques; and manipulation of basic biological organ systems.

Unit one review questions

Part I. True or false items

Instructions: Write "true" if the statement is correct and "false" if it is not correct.

1. Humans started house building from swallows.
2. Blending of biology and technology make biotechnology.
3. The East Gate Center building in Harare is designed by imitating termite's mound.
4. Nature is a reliable source of knowledgeable ideas.
5. Modern technological instruments have learnt from nature by imitation.
6. Animals are sentient creatures with the capacity to feel pain.
7. Care for plants is unethical treatment of plant species.
8. Replacing experimental animals with the use of biosynthetic tissues is an ethical treatment of research animals

Part II. Multiple-choice Test Items

Instructions: Choose the correct answer from the given alternatives.

1. Biotechnology is a technology that utilizes ____ to develop different products.

A. Biotech C. A and B

B. Biological systems D. All

2. The system of manufacturing biological elements is _____.

A. Synthetic biology C. Environmental biology

B. Plant biology D. Animal biology

3.The device used to collect geographical data or information is _____.

A. CIT scans C. Microscope

B. GPS D. X-ray

4. The sum of techniques, skills and processes used in the production or delivery of services is

A. Biology C. Technology

B. Biochemistry D. Genetic engineering

5. The influences of biological and technological products against on society and nature are

A. Benefits of biology and technology

B. The advantages of biology and technology

C. Development of biology and technology

D. Impacts of biology and technology

6. An instrument used to measure human body temperature is _____.

A. Microscope C. Barometer

B. Thermometer D. CT scan

7. What are industrial wastes?

A. Effluents C. Air pol ution

B. House wastes D. Vehicle wastes

8. Soil fertilizers can cause _____.

A. Toxicity B) C. A and B

B. Biohazards D. All

9. Designing technologies from the nature is through

A. Sketching C. Drawing

B. Imitation D. Photographing

10. Plants have

A. Centralized function systems C. Decentralized function systems

B. Brain led functional systems D. All system units are not functioning

Part III. Essay questions

Direction: Write a short answer to each question

1. Explain what and how humans learn from nature.

2. Describe the importance of biological systems to design technologies.

3. What are the ethical issues of biology?

Answer Key to review questions

I. True or False items

1	2	3	4	5	6	7	8
T	T	T	T	T	T	T	F

II. Multiple-choice questions

1	B	3	B	5	D	7	A	9	B
2	A	4	C	6	B	8	D	10	C

III. Short answer:

Part III. Essay questions

Direction: Write a short answer to each question

1. Explain what and how humans learn from nature?

- **Answer:** By using imitation of nature, they can sketch the biological structures, design functional mechanisms and tune into more efficient technologies at macro (large) and nano (very small) scales through imitation.

2. Describe the importance of biological systems to design technologies.

- **Answer:** The use of biological system to design technology is in designing various devices and engineering systems and to solve complex human problems.

3. What are the ethical issues of biology?

Answer: Ethical issues in biology are

- Respecting the values for all life forms by determining the right or wrong values
- Posting questions related to unethicality, immorality, illegality, inequality, injustice, and disrespectful acts to the values and rights of someone.

UNIT TWO

ANIMALS

2.1. CHARACTERISTICS OF ANIMALS

- They may be domestic animals, wild animals, or animals in zoos and sanctuaries. There are diverse groups of animals in the world. In previous grades, you have learned about the types of cells (prokaryotes and eukaryotes) and the characteristics of animals and plants. This unit provides you with a review of the characteristics of animals and details of reproduction in some sampled animals.
- Animals are eukaryotic, multicellular, heterotrophic, and sensitive to stimuli; and they reproduce, protect themselves, move, respire, excrete, grow, and have different body symmetries. Although animals have such common characteristics, they also have characteristics that distinguish one group from another.
- Animals can be categorized into two major groups based on the presence or absence of a backbone: vertebrates and invertebrates. Vertebrates are further classified into homoeothermic (warm-blooded) animals that include mammals and birds, and poikilothermic (cold-blooded) animals that include fish, reptiles, and amphibians. Invertebrates are also classified into porifera, platyhelminthes, cnidarian, arthropoda, Annelida, echinidermata, and mollusca. Arthropods are again classified into crustacea, spiders, insects and many legs.

2.2. INVERTEBRATES AND VERTEBRATES

2.2.1 Invertebrate Animals

- Invertebrates are animals that do not have a backbone or vertebral column. This group of animals is the most diverse group of animals in the world. They are found almost everywhere, from the hottest deserts and the deepest seabeds to the darkest caves and the highest mountains.
- Invertebrate animals lack a rigid internal skeletal system. Many invertebrates are soft-bodied. However, some of them have an external skeleton called an exoskeleton, usual y made of chitin, which protects their soft inner bodies. Invertebrates are cold-blooded, and hence, do not regulate

their body temperature. This group includes earthworms, insects, spiders, snails, sponges, jellyfish, lobsters, crabs, sea stars, and squid.

2.2.2 Vertebrate Animals

- Vertebrates are the most advanced groups in the animal kingdom. They are a highly advanced group of animals. These groups of animals possess a well-defined internal skeleton system with cartilage and a backbone or vertebral column separated into an axial skeleton (skul, vertebrae, ribs and sternum) and appendicular skeleton (girdles and appendages). The skull and vertebrae protect the highly developed brain and the nerve cord respectively.
- Vertebrates have more complex and specialized organ systems such as the circulatory systems, respiratory systems, nervous systems, and excretory systems. The circulatory system is a closed circulatory system with a ventral heart having 2-4 chambers and a median dorsal artery. The respiratory system consists of either gills or lungs. They have a centralized nervous system with a brain and sensory organs (eyes, ears, nostrils).
- The excretory system of vertebrates consists of paired kidneys. They have bilateral y symmetrical. This group includes mammals, birds, fish, reptiles, and amphibians. Vertebrates such as fish, reptiles, and amphibians are cold-blooded animals; whereas birds and mammals are warm-blooded animals (see homeostasis in the next section). All vertebrates are chordates, but not all chordates are vertebrates.

2.3 REPRODUCTION IN ANIMALS

- Reproduction is one of the common characteristics of animals that enable them to ensure the continuity of their species. Thus, reproduction is the process by which living organisms duplicate themselves. There are two types of reproduction in animals. These are **asexual reproduction** and **sexual reproduction.** Although the majority of animals undergo sexual reproduction and have similar forms of development, a few groups of animals also undergo asexual reproduction.

2.3.1. Asexual reproduction in animals

- Asexual reproduction is a type of reproduction that involves a single individual and does not require the fusion of gametes from two parents. Asexual reproduction in animals is more common among invertebrates than in vertebrates. Budding and fragmentation are the most common forms of asexual reproduction especially in aquatic animals. The other form of asexual reproduction in

animals is parthenogenesis. In this type of reproduction, unfertilized eggs develop into new offspring as in some insects and vertebrates.

2.3.2 Sexual reproduction in animals

- In previous grades, you learned that sexual reproduction is a type of reproduction that involves two individual parents and requires the fusion of gametes from two parents (male and female). It produces offspring that have genetic material from both parents. The parents are diploid organisms with a complete set of chromosomes (2n).
- Sexual reproduction involves different male and female reproductive structures with different functions. One of the most important functions is the production of haploid cells called gametes (n) for the transmission of genetic information from parents to offspring. In sexual reproduction, males produce sperm and haploid cells (n) in the testes where sperm cells are stored in the epididymis until ejaculation. On the other hand, females produce an ovum or egg haploid cell (n) that matures in the ovary and the fusion of sperm cells with female gametes produces a zygote through the process of fertilization. There are two types of fertilization: external and internal. In the next section, we shall see the similarities and differences between external and internal fertilization.
- In animals that use internal fertilization, the eggs are released from the ovary into the uterine tubes for fertilization, but eggs are released into the aqueous environment in animals that use external fertilization. The fertilization of an egg by sperm produces a single-celled diploid fertilized egg called a zygote (2n), which develops into an embryo and then into an individual organism.
- After fertilization, a series of developmental stages occur in embryonic development. The first stage is cleavage, which involves a series of mitotic cell divisions of the fertilized egg (zygote). This cell division results in an eight-celled structure. The second stage is another cell division and rearrangement of cells into hollow structures called blastulae. Then, the blastula undergoes further cell division and rearrangement with the process called gastrulation.
- The process of gastrulation produces a gastrula that has different cell layers called “germ layers”. By the process of organogenesis, these germ layers later develop into different tissue types, organs, and organ systems. Organogenesis is the formation of organs during embryonic development. The embryo eventual y develops into an adult with all tissue types, organs, and organ systems.
- The next section deals with sexual reproduction in some sampled animals of insects from invertebrate animals and frogs, crocodiles, birds and rats from vertebrate animals

2.3.3 Reproduction in insects (complete and incomplete metamorphosis)

- Insects that constitute the most diverse groups of animals are the largest class of the phylum Arthropoda (the animal phylum). They have segmented bodies, jointed legs, and external skeletons (exoskeletons). Insects include flies, grasshoppers, lice, butterflies, bees, and beetles, to mention some of them. They undergo sexual reproduction and have their own life cycle.
- During sexual reproduction, eggs are usually fertilized internal y. However, some insects undergo parthenogenesis, a process in which an individual develops from unfertilized eggs. In sexual reproduction, the male produces sperm and fertilizes the egg produced by the female during mating.
- After fertilization, the female insect lays eggs and hatches them after completing their development. After hatching, insects undergo a series of major changes in body structure as they develop. This series of changes is called metamorphosis.
- Chemical substances in the insects control the process of metamorphosis. There are two types of metamorphosis: complete metamorphosis and incomplete metamorphosis. Complete metamorphosis has four stages whereas in complete metamorphosis has three stages. For instance, in honeybees, the four stages of complete metamorphosis are **egg, larva, pupa,** and **adult** and in grasshoppers, the three stages of incomplete metamorphosis are **egg, nymph,** and **adult.**
- 2.3.4 Reproduction in Frog
- The common frog (Rana temoraria) is the most common in Europe. The grass frog genus Ptychadena goulenger is found throughout sub-Saharan Africa, including Ethiopia. Frogs such as Ptychadena harennaand, Leptopelis ragazziare found in the Bale Mountains and Shoa forests, Ethiopia. Frogs undergo sexual reproduction and have male and female reproductive structures.
- Unlike birds, frogs do not produce amniotic eggs. Rather, they are usually covered in a jelly-like substance. They must lay their eggs in water to protect them from drying out. Frogs have external fertilization. However, internal fertilization also occurs in a few species of frogs. Unlike internal fertilization, in external fertilization, the female releases eggs from her body into the water and the male releases his sperm to fertilize the eggs. Usually, frogs lay a large number of eggs in the same place at the same time. In a process called metamorphosis, after the fertilization of an egg by sperm, frogs go through a larval stage that is very different from the adult form. The fertilized eggs develop into a larval stage called a tadpole.

2.3.5 Reproduction in Crocodiles

- Crocodilians are large semi-aquatic reptiles that live in different parts of the world. Crocodiles reproduce sexual y involving both male and female parents.
- The mating season for crocodiles usually begins in July or August and mating takes place under water. During mating, the sperm fertilizes the egg and develops in the female. They have internal fertilization. They lay their eggs and bury them in sand or deposit them in mound vegetation. The number of eggs a crocodile deposits varies from 10 to 100, which generally depends on the type of species. Unlike frogs, crocodiles have hard, leathery eggs that enable them to protect their young.

2.3.6 Reproduction in Birds

- Similar to other animals, reproduction in birds is one of the key processes that enable birds to produce new individuals and perpetuate their species. Birds reproduce sexually and have internal fertilization. Most bird species are monogamous but there are also polygamous species. Monogamous is usually a mating system between a single adult male and a single adult female for entire breeding seasons, whereas polygamous is a mating system with several partners during a single breeding season.
- Unlike other animals, male birds do not have external genital organs whereas females have a single ovary. Reproduction in birds starts by the joining of an egg or ovum with a sperm cell in the oviduct. The ovum is produced in the ovary and travel down through the oviduct for fertilization to occur. The oviduct consists of the infundibulum, magnum, isthmus, uterus, and vagina.

Table1 Parts of oviduct and functions

Parts of the oviduct	Nature and Functions
Infundibulum	• A funnel-shaped upper portion of the oviduct • Its purpose is to search out and engulf the yolk, causing it to enter the ovi
Magnum	• It is the longest part of the oviduct • Secretion of albumen: nearly all the egg white is deposited in the magnum
Isthmus	• It is the relatively short portion of the oviduct • Formation of shell membrane-inner and outer shell membranes

	• The glands of the isthmus produce sulfur-containing amino acids that are important for shell membrane formation
Uterus	• Developing an egg takes a longer period of time. • Formation of egg shell -shell is formed over shell membranes
Vagina	• The final section of the oviduct is the vagina, which is separated by a sphi presents in between the uterus and the vagina • During oviposition, relaxation of the muscles allows the egg to leav uterus, and it is almost immediately laid through the cloaca.

- Both male and female birds have a structure called the cloaca. During mating, the male brings its sperm to the female cloaca, and the sperm from the male cloaca fertilizes the egg. The fertilized egg travels down to the uterus, forming a layer of albumen around it, which is followed by the shell membranes in the uterus. Then, the hard-shelled egg develops within the female with a fluid-filled amnion, a thin membrane forming a closed sac around the embryo.
- Birds lay eggs after the egg completes its development. The number of eggs a bird lays varies from a few to more than 10, depending on its species. For example, penguins and albatrosses lay few eggs, but chickens and ducks can lay more than 10 eggs. The egg of a bird has different parts. The major parts of the egg of a bird are the yolk, the chalaza, the albumen, the membranes, air sac and the shell.
- **Incubation:** incubation or brooding is the process of keeping eggs warm with body heat, while the embryos inside continue to develop after birds lay their eggs. In most cases, the female parent incubates the eggs, although males sometimes participate. When a breeding season approaches, the female will develop a brood patch to help transfer heat effectively. This brood patch has an area of skin with densely packed blood vessels that produces more heat and facilitates heat transmission to the egg. The brood patch will disappear at the end of the breeding season. Birds rotate their eggs periodically to ensure an even distribution of warmth. This helps the embryo to finish its development inside the egg.
- **Hatching:** After incubation, the embryo completes its development and hatching occurs. During hatching, the chick develops a tooth-like structure at the beak's tip to break the eggshell.

Moreover, the chick also communicates with its parents a day or two before hatching, with parents with some vocal sounds. The chick then starts to use the hard tip of its bill, a tooth-like structure called an egg tooth, to break out of the egg, and the young lose the egg tooth after hatching.

- **Parental Care in Birds:** One of the methods bird use to protect their young is by building nests. Birds make nests in areas that are hidden in order to avoid predators. Some birds do not use nests. They simply lay their eggs on bare cliffs. Birds that make nests in an open area have camouflaged eggs.
- While the parental care of offspring lies on one or both parents, the length and type of parental care varies widely amongst different species of birds. In some species, parental care ends at hatching. Accordingly, the newly hatched chick digs itself out of the nest mound without any parental help and can take care of itself right away. Other species care for their young for an extended time.

2.3.7 Reproduction in rat

- Rat (genus Rattus) is the name general y applied to numerous members of several rodent families. The black rat (Rattus rattus) and the brown rat (Rattus norvegicus) are among the most common types of rats species. They live virtually everywhere that human populations have settled; the black rats is predominantly live in warmer climates, and the brown rats are dominantly found in the temperate regions. Giant Mole rat (Tachyoryctes macrocephalus), also known as the giant root rat, is endemic to Ethiopia where it is confined to high altitude shrub and grasslands in the Afro-alpine habitat such as the Bale Mountains.
- Reproduction in rats is representative of mammalian sexual reproduction. The male reproductive structure of a rat consists testes (singular testis), scrotum seminiferous tubules, epididymis, vasdeferens and penis with bacula. Similarly, the female reproductive structure of a rat consists of two ovaries, oviducts, uterine horns and vagina with vulva. Like in other mammals, fertilization of the egg occurs inside the female, and the fertilized zygotes develop in the mother during a gestation period known as pregnancy.
- **Pregnancy and Development:** The average pregnancy time or gestation period of a rat varies depending on the species. The gestation period for a brown rat is 22 to 24 days, whereas the gestation period for black rats is usually 22 days and the gestation period for giant mole rats is 37-49 days. After fertilization, each zygote divides and forms a hollow ball of cells that further

develops into a blastocyst called a blastula. The blastulas travel down the oviducts, implant in the uterine horns, and begin to differentiate into embryonic tissue and extra-embryonic tissue.

- The umbilical cord, a complex system of connecting blood vessels nourishes the embryo from the mother. The placenta transports oxygen from the mother to the embryo and removes waste from the embryo's environment, and the amniotic sac protects the embryo during pregnancy.
- Gradually, the embryo forms a neural plate, which later develops into brain and spinal cord, the arm and leg buds become visible, the nervous system pathways develop and the rat gives birth to hairless, deaf with sealed eyelids offspring.
- Rats normally give birth from 7 to 12 offspring per litter on average, but the number is fewer than this for giant mole rats. The mother feeds milk and, after 45 days, the young rats are fully weaned and are actively foraging and feeding. The age of sexual maturity also vary depending on species. In brown-black rats, the age of sexual maturity is 3–4 months old. Giant mole rats become reproductively mature when they are 4-6 months old.
- **Parental care in rats**: Parental care in mammals is often critical for the survival and development of the offspring. Rats build nests to rear their young, called pups or kittens. The pups stay in the nest built by their mother until they are weaned. The female rats care pups regardless of which their true mothers are. If a mother dies, the other females will take over nursing her pups. Male rats do not participate in the parental care.

2.4 THE ECONOMIC IMPORTANCE OF ANIMALS (INSECTS)

- Insects have plenty of economic importance in the world. Most insects are harmful to us simply because they are pests, but they have very important benefits for human beings and the ecosystem.
- Insects are the most diverse animals in the world. They have both positive and negative impacts on our economy, our lives, and the ecosystem. While there are many harmful pests, there are also beneficial insects. The following section provides some descriptions of the beneficial, or useful and harmful aspects of insects in agriculture, food, industry, health, and medicine.

2.4.1 Beneficial aspects of insects

- **Agriculture**

- One of the major activities of agriculture is crop production. Regarding this, insects provide services to agriculture through pollination and regulation of pests.
- Pollinators: insect pollinators are flower-visiting insects that forage on flowering plants to obtain plant-provided food (nectar, pollen). They have the potential to transfer male gametes (contained in pollen) to the female gametes, resulting in pollination.
- Pollination by insects is an essential activity for the reproduction of the majority of the world's flowering plants, including numerous cultivated plant species. Many plants depend on pollination for seed and fruit production. For instance, an estimated 35% of crop production yielded in the world is a result of insect pollination. This has huge economic value in the world as well as in the country.
- Pest regulation: Insect predators and parasitoids that attack and feed on other insects, particularly on insect pests of plants are used in pest control. This type pest regulation is known as a natural biological control, which destroys harmful insects that infect both animals and plants.
- This natural biological control plays an important role in limiting potential pest populations. Important insects in pest regulation include mantis, lady beetles, ground beetles, rove beetles, flower bugs, lacewings and hover flies.
- For example, Stagmomantis insects, species of mantis feed on grasshoppers and caterpillars that damage crops. Chilomenes, a ladybird beetle, feed on aphids that damage cotton plants and destroys scale worms that are pests of orange and lemon trees respectively. Epicauta, a blister beetle, eat up masses of the eggs of locust.
- Insects also play a great role in feeding on unwanted weeds, creating channels for smaller organism's water, air, and roots to travel through to improve soil aeration. Their activities can enhance the nutrient cycle and physical properties of the soil, such as soil structure and tilt, and decomposers can help in the biochemical cycling of nutrients.
    - **Food**
- Many species of insects are being used as a food for people in many countries. Evidence suggests that edible insects have potential to become a valuable protein source for addressing the global food demand. They are widely recognized as a sustainable source of animal protein. There are over 1,462 recorded species of edible insects in the world.

- Most insects are consumed in Asia and Central America. Usually crickets, grasshoppers, beetle and moth larvae and termites are eaten there. Being rich source of protein, grasshoppers have been eaten in many parts of the world. Moreover, insects are important sources of food for many vertebrates, including birds, amphibians, reptiles, fish and mammals. One of the many ways to address food and feed security for the over increasingly growing world population is through insect farming. Insects are everywhere and they reproduce quickly, and they have high growth and feed conversion rates and a low environmental footprint over their entire life cycle. They are nutritious, with high protein, fat and mineral contents and can be reared easily.
    - **Industry**
- One of the benefits of insect related to industries is their role in commercial products. Insects are being used to produce different materials at home and in industries. The following are some of the examples.
- Production of Honey and Bee Wax: Honey and wax production are considered some of the commercial benefits of insects. For example, the honeybees (Apis meliffera L.) produce millions of tons of honey and wax every year around the world.
- Production of Silk: The other commercially beneficial insects are silk worms (Bombyx moriand other silk worms). Silkworms produce silk fibers, which are woven into the delicate, smooth material used for luxurious textiles and for different purposes in the textile industry.
- Production of shellac: shellac is a resin secreted by Lac insects. Among the many species of lac insects, Laccifer lacca, is the commercial y cultured lac insect. Shellac is still in use as dyes, inks, polishes, sealing waxes, and as stiffening agents in the fabrication of felt hats. It is an animal originated commercial resin.
- Production of Cochineal: Cochineal pigment is extracted from scale insects such as Dacylopius coccus. The cochineal pigment was important for the intensity and permanency of colors in painting. The cochineal pigment is still giving the colors in foods, beverages, cosmetics (lipsticks) and art product.
- Production of Tannic Acid: Tannic acid is a chemical compound used in dyeing goods made of leather in leather industries, for tanning and in manufacturing some inks. Tiny wasps in the family Cynipidae secrete some chemical and in response to this, the tree produces gall tissues that contain tannic acid.

- **Health and medicine**

- Some insects have medicinal value in treating different human and animal diseases. Since ancient times, insects and insect-derived products have been used as medicinal agents in many parts of the world. . For instance, honey is applied to treat burns, chronic and post- surgical wounds. Bee and ant venom are used to treat joints pain. Recent research confirms that bee products promote healthy immune systems, improve circulation and decrease inflammation.
- Blister beetles secrete cantharidan, which acts as a powerful protein blocker in the human body and is effective in treating severe viral infections because it prevents the reproduction of some viral cells. Researchers subsequently discovered that cantharidan reacts with genetic material of hostile cells, and therefore may be useful in the treatment of cancerous tumors most resistant to radiation and chemotherapy. Several African cultures use poultices made from ground grasshoppers as pain relievers, especial y for migraines.

2.4.2 Harmful aspects of insects

- Although most insects are beneficial, they can also be harmful to humans and animals. Some insects are pests of plants, fruits, and grains in a store. They feed on several parts of green plants and crops, such as leaves, stems, buds, flowers, fruits, and seeds on fields and in stores at home thereby damaging crops and reducing production.
- These insects include locusts, caterpillars, bugs, hoppers, aphids etc. Locusts are among the most destructive of all insect pests. Countries have faced threats of swarms of desert locusts. Consequently, regional and international organizations have started to monitor desert locust populations and launch control measures when necessary.
- Locusts are particularly destructive in hot and dry regions when there is a sudden increase in their numbers. The prevalence of food shortage has further forced them to migrate. They migrate in huge swarms, for several kilometers away devouring virtual y every green plant in their path. Some insects are also regarded as serious pests for stored cereal grains.
- The most common insect pests of stored cereal grains are: Rice Weevil (Sitophilus oryzae); Lesser Grain Borer (Rhyzopertha dominica); Rust Red Flour Beetle: (Tribolium spp.); Sawtooth Grain Beetle: (Oryzaephilus surinamensis); Flat Grain Beetle: (Cryptolestes spp.)
- Moreover, several insects serve as vectors for transmitting diseases from one organism to another or serve as intermediate hosts for several pathogens and transfer disease from one to another. For

example, Anopheles mosquitoes transfer malarial parasites,"Plasmodium,"from one person to another. Culex mosquitos spread filariasis and transmit filarial worms from infected to healthy people. The tsetse fly, Trypanosoma gambiense, also spreads the African sleeping sickness to the human population. The housefly (Musca domestica) spreads food and water-borne diseases to human populations.

2.5 ANIMAL BEHAVIOR

- Animals have different behaviors and behavioral patterns for survival and reproduction. Animal behavior means all the ways in which animals interact with other organisms and the physical environment. It includes the movements of animals, interaction of animals within and with the environment and learning about their environment.

2.5.1 Types of Animal Behavior

- Animals have different behaviors and behavioral patterns. Animal behavior can be categorized into two main types: innate or inherent behavior and learned or acquired behavior.

Innate or inherent behavior

- Innate or inherent behavior is an inborn behavior that is determined by genes and independent of experience and specific to a species. There are three types of innate or inherent behavior, and these are instinctive, reflexive, and orientative. The following examples are instinctive behaviours in animals.
- Web making in spiders
- Nest-building in birds
- Swimming with dolphins and other aquatic species.
- Opening of mouth in chicks of many bird species when their mother returns to the nest.
- Honeybees dance when they return to the hive after finding a source of food.
- The following examples are reflex behaviours in animals.

- A simple reflex action is a sudden, involuntary response to stimuli. For example, when you touch a sharp or hot object, you pull your hand away rapidly without even thinking about the action. You blink when something gets too close to your eye and you close your eyes when dust gets into them. These are simple reflex actions. During a reflex action, messages about pain do not travel all the way to and from the brain. Instead, they travel only as far as the spinal cord, and the spinal cord responds to the messages by giving orders to the muscles. This allows you to respond to pain more quickly.

The following examples are orientation behaviours in animals.

- **Taxis** are directed in relation to a given stimulus. It is the orientation of an animal (directed either towards or away) in response to the source of stimulus. If the orientation is towards the stimulus it is called as positive taxis, and if it is away from the stimulus, it is known as negative taxis. Example: The movement of cockroaches away from the source of light.

- **What is the difference between Phototaxis, Chemotaxis, Thigmotaxis and Geotaxis?**

- **Kinesis** is undirected, random movement. Kinesis is a type of locomotory behavior in relation to the source of stimulus. The animal responds to the variation in the intensity of the stimulus and not the source or direction of the stimulus. Example: The movement of woodlice in relation to the temperature around them.

Learned or acquired behavior

- Learned or acquired behavior is not inherited and not determined by genes. It is the type of animal behavior acquired during the lifetime of an individual. Learned behavior allows an individual organism to adapt to changes in the environment that are modified by previous experiences. Examples of simple learned behaviors include habituation, classical conditioning, operant conditioning, sensitization, latent and insight learning.
- **Habituation** is a simple form of learning in which an animal stops responding to a stimulus, or cue, after a period of repeated exposure. This is a form of non-associative learning, in which the stimulus is not linked with any punishment or reward. For example, you were reading a book when someone turned on the television in the same room. At first, the sound of the television might have

been annoying. After a while, you may no longer have it noticed. Accordingly, it means that you have become accustomed to the sound.

- **Classical conditioning** is a result of associative learning in which a response already associated with one stimulus is associated with a second stimulus to which it had no previous connection. Classical conditioning was discovered by Ivan P. Pavlov, a Russian physiologist. There are three stages of classical conditioning.
- **Stage 1:** Before conditioning. This stage states that an unconditioned stimulus (UCS) produces an unconditioned response (UCR) in an individual, which means that a stimulus in the environment has produced a behavior or response which is unlearned (i.e., unconditioned), and therefore it is a natural response which has not been taught. In this case, no new behavior has been learned yet.
- **Stage 2:** During conditioning. During this stage, a stimulus that produces no response is associated with the unconditioned stimulus, due to what it is known as a conditioned stimulus (CS). For learning to take place, the UCS must be associated with CS on a number of occasions, or trials at this stage. .
- **Stage 3**: After conditioning, this conditioning happens once the conditioned stimulus (CS) has been associated with the unconditioned stimulus (UCS) to create a new conditioned response.
- **Operant conditioning** is a result of associative learning in which a bit different from classical conditioning because it does not rely on an existing stimulus-response pair. Instead, whenever an organism performs a behavior or an intermediate step on the way to the complete behavior, the organism is given a reward or a punishment. It was discovered by B.F. Skinner. Based on the theory of operant conditioning, behavior will likely be repeated when the organism is reinforced (rewarded), and behavior will occur less frequently when it is punished. Skinner identified three types of responses or operant behavior.
- **Neutral operants** are responses from the environment that neither increase nor decrease the probability of a behavior being repeated.
- **Reinforces** are responses from the environment that increase the probability of a behavior being repeated are called rein forcers. Reinforcers can be either positive or negative.
- **Punishers** are responses from the environment that decrease the likelihood of a behavior being repeated are called punishers. Punishment weakens behavior.

- **Insight learning** is learning which is based on past experience and reasoning and is a hallmark of the human behavior. Humans have used insight learning to solve problems ranging from starting a fire to traveling to the moon.
- **Sensitization,** also referred to as reverse tolerance, is a non-associative learning process in which repeated administration of a stimulus results in the progressive amplification of a response. It occurs when a stimulus is presented above the tolerance threshold. For example, repetition of a painful stimulus may make one more sensitive to a loud noise.

2.5.2 Patterns of Behavior

- There are different behavioral patterns in animals. Although the behavioral patterns are different due to the diversity of species, there are also common patterns of behavior exhibited by many species. Examples of behavioral patterns in animals include behavioral cycles, reproductive behavior, social behavior, competition, territory and communication.
- **Behavioral cycles** are behavioral pattern in which animals respond to periodic changes in the environment. It can be daily or seasonal cycles. For example, seasonal migration (movement) and Circadian rhythms (sleep and wake).
- Seasonal migration refers to the movement of various species of birds, insects, and mammals from one habitat to another during different times of the year because of seasonal fluctuations in factors such as the availability of food, sunlight, temperature, and breeding difficulty. An example is the migration of various whale and bird species from their summer habitats in the Arctic or Antarctic to the tropical waters near the equator and warmer latitudes, respectively
- Circadian rhythms, also referred as biological clocks, are 24-hour cycles that are part of the body's internal clock, running in the background to carry out essential functions and processes. One of the most important and well-known circadian rhythms is the sleep-wake cycle.
- **Reproductive behavior:** it is a behavioral pattern of animals to meet the needs of reproduction. It the coordination of the timing and patterning of reproductive activity. Reproductive behavior is vital fo locating and selecting suitable mates, producing offspring, and rearing them successful y to independence. For example, courtship that involves sounds visual displays or chemicals and paradise dance.
- **Social behaviour**: it is the behavioral pattern of animals commonly observed in that live in groups. Insects such as ants, termites, bees, exhibit some of the most well developed social behavior and

wasps are social behaviors. One benefit of social behavior for these insects is that different individuals perform better in certain activities or division of labor as workers and soldiers. Other examples of social behaviour are observed in elephants, penguins, human beings and other primates.

- **Competition**: it is a behavioral pattern of animals observed during competition such as for resources. Example of the competition includes the competition between animals for space, territory, water, mates and food. Competition occurs naturally between living organisms that coexist in the same environment. There are two basic types of competition: intraspecific and interspecific.
- **Territoriality**: it is abehavioral pattern that involves protecting spaces by an animal from others. The territories of animals contain all of the resources and conditions they need to survive. Many animals defend their area by using display behavior instead of fighting. The behavior gives signals for other animals to stay away.
- Displaying behavior is generally safer and uses less energy than fighting. For example, Male dogs and lions use pheromones in their urine to mark their territory. It means that they are signaling other dogs or lions to stay out of their yard. Male gorillas use display behavior to defend their territory by pounding on their chests and thumping the ground with their hands, robin by displays his red breast to warn other robins to stay away.
- **Communication behaviour**: it is a behavioural patter vital for the interaction of animals. Animals can communicate with the aid of sight, sound, tactile (with body touch), and chemical cues (they produce special chemicals called pheromones**)**. For example, birds sing and frogs croak to communicate with each other. Ants communicate with chemicals called **pheromones** to mark trails to food sources so other ants can find them.

2.6 HOMEOSTASIS IN ANIMALS

- Animals are directly affected by the environmental situations. A change in these situations may negatively affect the physiological functions of their bodies. Hence, they need to have a controlling mechanism for these factors in order to maintain stability in their body. Despite environmental changes, most animals maintain almost constant internal body conditions through homeostasis.
- Homeostasis is the self-regulatory process by which animals maintain stable internal conditions in their bodies regardless of external condition. Homeostasis helps animals to maintain equilibrium in

the internal conditions of their bodies or cells at a set point (normal conditions). Animal body systems constantly adjust to internal and external changes in order to maintain this normal condition.

- A change in the internal or external environment (stimulus) is detected by receptors in the animals' bodies, which sends information to a control center (the brain). As a result, the body system responds to the stimulus and by returning the value back or toward the set point. Generally, homeostasis involves four components: stimulus, receptor, control center, and effector.
- **Stimulus:** is a change in the environment that forces the organism to response. It can be a change in body condition, such as an increase or decrease in body temperature, glucose, or water.
- **Receptor:** It detects the change in the environment or body condition and send signal to control center to counteract it, returning the internal condition to the normal. For example, thermo receptors (the end of sensory neurons).
- **Control center**: This receives messages from receptors and sends commands to the effector to counteract the change. The hypothalamus, a region of the brain, is a control center for homeostasis.
- **Effector:** It acts on the stimulus based on the command control center, counteracting the change and returning the internal body condition to normal. Organs or tissues such as the kidney, liver, or heart are effectors. For example, if the animal's body becomes too warm and the blood glucose rises, adjustments are made to cool the animal and lower the blood glucose level, respectively, by effector organs. This enables animals to function in the changing external and internal conditions that surround them.

2.6.1 Thermoregulation

- Thermoregulation is the process of maintaining the internal body temperature constant. Many organisms use behaviour, physiology, and morphology to keep their body temperatures within optimal level. Based on temperature regulation, animals can be divided into two groups:
- **Poikilothermic animals**: These are animals that have a body temperature that is the same as their environment where their temperature varies with the environmental temperature are called poikilothermic animals..
- **Homoeothermic animals**: Animals that keep their body temperature constant in the face of changing environmental temperatures.

A. Poikilothermic Animals

- Poikilothermic animals, also known as ectothermic animals, lack internal control over their body temperature. The body temperature of these organisms is general y similar to the temperature of the environment. However, individual organisms may burrow themselves into the ground on a hot day or rest in the sunlight on a cold day to keep their bodies temperature slightly below or above the environmental temperature. Some poikilothermic animals seek cooler areas during the hottest time of the day or may climb onto rocks to capture heat during the coldest time of the day. Some animals swim in water to cool their body. Some also use burrows to keep their bodies warm and still others such as bees use group activity or stay in a hive to survive in cold seasons.

B. Homoeothermic Animals

- Homoeothermic or endothermic animals are those animals that can generate internal heat to maintain a constant internal body temperature. Their cellular processes operate optimally even when the environment is cold and loses heat when the environment is hot. They use morphological, physiological and behavioral methods of temperature regulation. Homoeothermic animals can retain heat in a variety of ways when the environment is cold. Some of the ways of insulation used to conserve the body heat in these animals include fur, fat and feathers. For example, the arctic fox uses its fluffy tail as extra insulation when it curls up to sleep in cold weather. Homoeothermic animals also use vasoconstriction in response to the coldest environment.
- Vasoconstrictionis the narrowing of blood vessels to the skin by the contraction of their smooth muscles to reduce blood flow in the peripheral blood vessels and retain heat.
- Shivering is another way of maintaining body temperature in cold. Shivering is caused by involuntary contractions of your muscles. Muscle contractions require energy from respiration that releases heat to warm the body.
- Homoeothermic animals can loss heat in a variety of ways when the environment is hot. Some of the ways of losing heat in response to the hottest environment include vasodilation which is the opening up of arterioles to the skin through the relaxation of their smooth muscles and by bringing more blood and heat to the body surface to loss heat and thereby cool their body through radiation and evaporation.

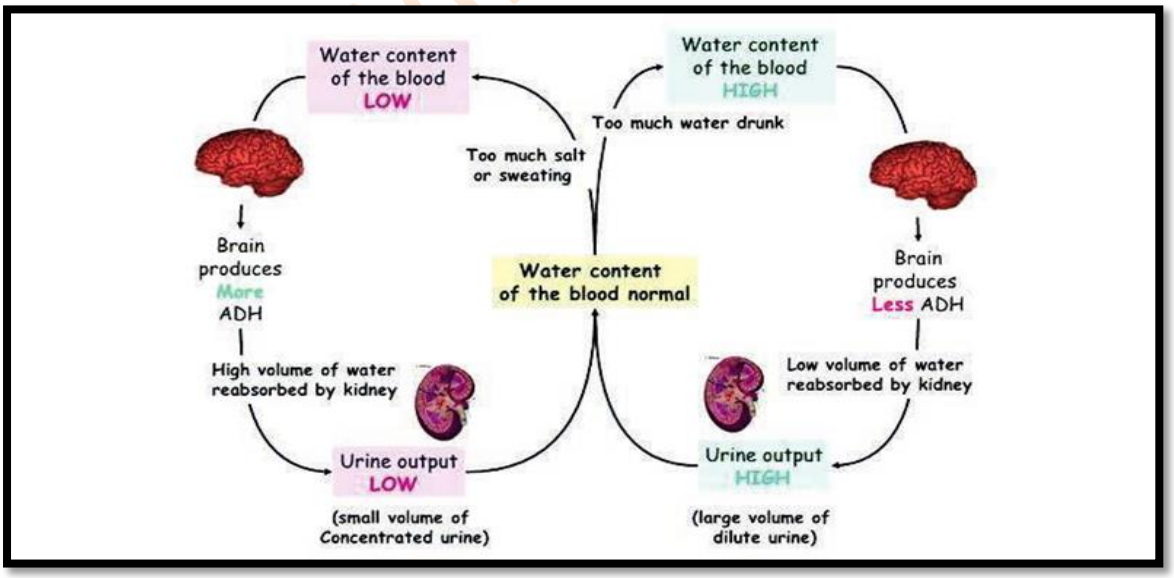
- Vasodilation is the widening of blood vessels at the skin surface to increase heat loss through the surface of the skin. Sweating is another way of maintaining body temperature during a hot season. Sweat, which is produced by the sweat glands travels up the sweat duct and out of the sweat pore onto the skin surface.
- The processes of coordination occur in the part of the brain called hypothalamus. When the temperature of the environment changes (decreases or increases), signals are sent to the brain to alert the hypothalamus. The hypothalamus then responds by activating the process of vasodilation, vasoconstriction, shivering and sweating to maintain the body temperature constant.
- In controlling the body temperature, there are four mechanism of heat exchange between an animal and its environment. These are radiation, evaporation, convection and conduction.
- The body structure of animals also helps to maintain their body temperature. For instance, large ears in hot areas help to lose heat and cool their body, whereas small ears and fur in cold areas help to minimize heat loss and keep their body warm. The size of the animals also affects regulation of body temperature. As animals grow in size, their inside volume increases and the outside surface area decreases. This affects the surface-area-to-volume ratio or the surface-to-volume ratio of animals, which consequently affects heat loss.
- For example, since the size of an elephant is high, the surface area to volume ratio becomes smaller than the surface area to volume ratio of a rabbit. The greater the surface area-to-volume ratio an animal has, the more heat loss it will have, and the smaller the surface area- to- volume ratio an animal has the less heat loss it will have. The smaller the animal, the higher the surface area-to-volume ratio it will have, so it will have the higher heat loss.
- Example: a rabbit. On the other hand, the larger the animal, the smaller the surface area-to-Animals also maintain their body temperature by searching out cold or hot habitats that allow them to alter its rate of heat loss or gain, making nests or digging burrows, huddling with conspecifics, and in human like wearing clothes or turning on an air conditioner as human do.

2.6.2 Osmoregulation

- Osmoregulation is a process that regulates the osmotic pressure of fluids and electrolytic balance in organisms to maintain homeostasis. About 60% of the human body is composed of fluids. Approximately 2/3 of our body's water content is in our intracellular fluids and the remaining 1/3

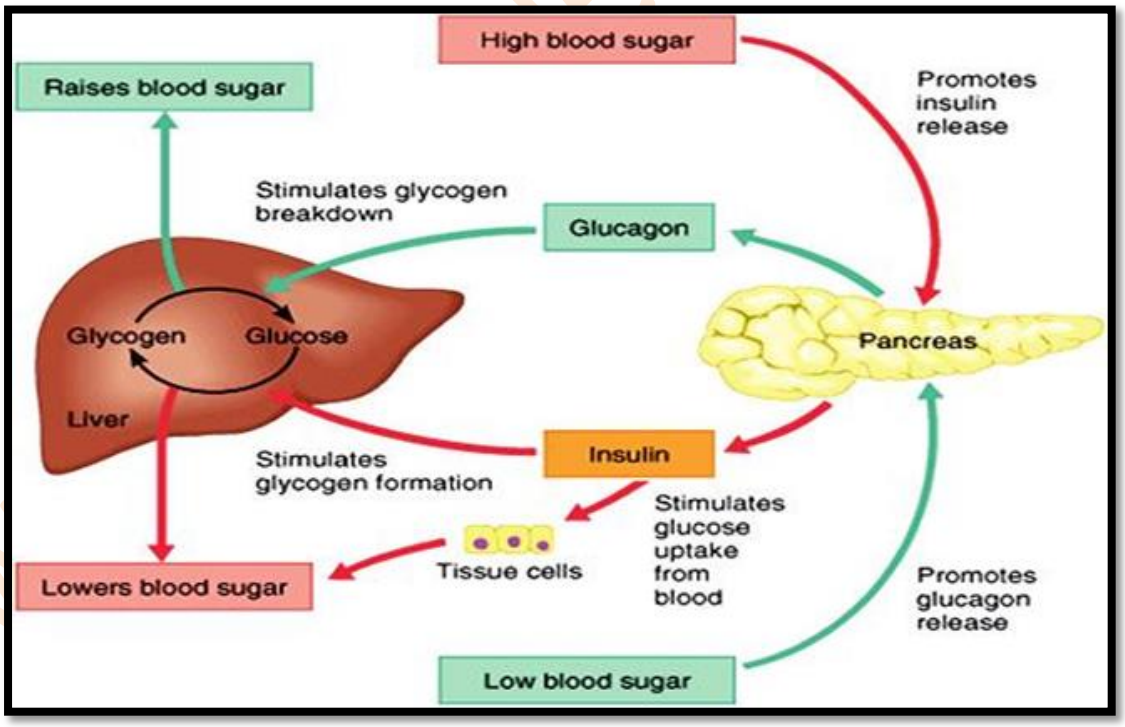
forms our extracellular fluid. Extracellular fluid consists of the fluid between cells (interstitial fluid) and the blood plasma.

- A disruption in the osmotic pressure can result in an imbalance in the movement of water between them and hence alter the concentration of their electrolytes. Hence, osmoregulation is important to balance osmotic pressure of fluids and electrolytes. In humans and other animals, this process is brought about by osmoreceptors, which can detect changes in osmotic pressure. Humans and most other warm-blooded organisms have osmoreceptors in the hypothalamus, part of the brain and in the kidneys. There are two major types of osmoregulation:
- **Osmoconformers**: organisms that try to match the osmolarity of their body with their surroundings are called osmoconformers. In other words, these organisms maintain the same osmotic pressure inside the body as outside water. Examples are invertebrates like starfish, jellyfish and lobsters.
- **Osmoregulators**: organisms that actively regulate their osmotic pressure, independent of the surrounding environment are called osmoregulators. Examples are many vertebrates, including humans. The kidney is the main organ responsible for osmoregulation in humans. When the water level in the body is high, the kidney releases a large amount of hypotonic urine. When the water level is low, it retains water and produces a low amount of hypertonic urine. Thus, the kidneys maintain the electrolytic balance of the body. The hypothalamus of the brain and Antidiuretic hormone (ADH) secreted from pituitary gland controls osmoregulation.



2.6.3 Blood Sugar Regulation

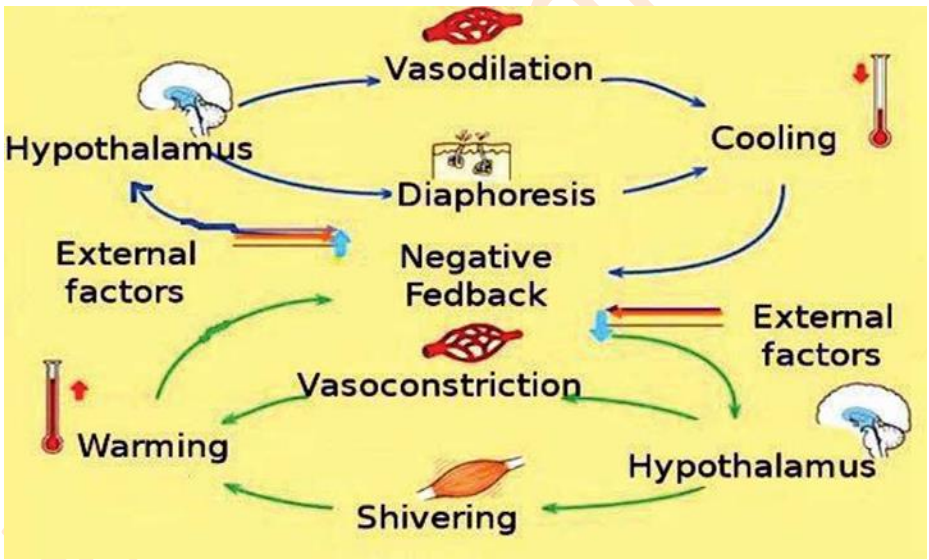
- Glucose is the main source of energy for the normal functioning of our body systems including the brain. The body requires volumes of glucose in order to generate energy during respiration. Hence, the body regulates the availability of glucose in our body to maintain its concentration at constant level in order to supply energy continuously. Two hormones produced from pancreas are responsible for controlling the concentration of glucose in the blood. These are **insulin** and **glucagon**.
- When blood glucose level is high and the glucagon level is low, more insulin is released by the pancreas into the liver. Insulin promotes the conversion of glucose into glycogen so that the excess glucose can be stored for a later use in the liver.
- When blood glucose level is low and glucagon level is high, more glucagon is released by pancreas into the liver. Glucagon promotes the conversion of glycogen into glucose so that the lack of glucose can be compensated for by the new supply of glucose.
- Glycogen is stored in the liver and converted in to glucose when the glucose level decreases.



2.6.4 Control of homeostasis

- When there is any change in the environment, an animal must make an adjustment to balance the situation. To do this, animals have feedback mechanisms for the stimulus (change in the environment). A feedback mechanism is a physiological regulation system to return the body to its normal internal state. In the feedback mechanism, the receptor senses the change in the environment (stimulus) and sends a signal to the control center (the brain) which in turn generates a response that is signaled to an effector in muscles to contract or relax or glands to secrete hormones.
- There are two types of feedback mechanisms. To maintain homeostasis, animals types of feedback mechanisms: Negative and positive feedback.
- **Negative feedback** occurs when a change in a variable triggers a response that reverses the initial change. In other words, negative feedback occurs when the activation of one component results in the deactivation of another.
- **Positive feedback** occurs when a change in a variable triggers a response that causes more change in the same direction. Unlike negative feedback, positive feedback occurs when the activation of one component causes the activation of another.
    - **Negative and positive feedback mechanisms**
- Negative feedback mechanism is a homeostatic process that reverses the direction of the stimulus or any deviation from the normal. This means that if the level is too high from the normal, the body brings it down, and if the level is too low from the normal, the body lifts it up. In contrast to negative feedback mechanism, positive feedback mechanism accelerates a change in the body's physiological condition rather than reversing it. The positive feedback takes you further away from homeostasis while the negative feedback brings you back to it.
- A negative feedback system has three basic components. These are sensor (receptor), control center and effector**.** The sensor (receptor) monitors the physiological value not to deviate from the normal (receives stimulus) and reports to the control center if there is any deviation. The control center compares the value of the deviation from the normal and activates the effector if there is any deviation. An effector causes a change to reverse the situation and returns the value to the normal set point.

- There are numerous examples of negative feedback mechanisms that aid in maintaining a constant internal body condition. One of the examples in humans is the feedback mechanism in temperature regulation. This mechanism works by promoting either heat loss or heat gain. For instance, when the sensor (receptor) receives a stimulus that indicates an increased body temperature from the normal range, it sends its message to the brain's temperature regulation center, where the control center stimulates a cluster of brain cells. Then, the control center causes vasodilatation so that the more blood flows to the surface of the skin al owing the heat to radiate into the environment, activate sweat glands to increase their output through diaphoresis (excessive sweating) to remove heat through evaporation across the skin surface into the surrounding environment.
- The reverse occurs when the body temperature drops from the normal range. It means that vasoconstriction and deactivation of sweat glands occurs. However, if heat loss is severe, the brain (control center) causes skeletal muscles to contract and produce shivering to release heat while using up ATP for muscles contraction. As soon as your body has cooled off, negative feedback halts the signaling process to stop the process of sweating. In the opposite process, a **positive feedback loop** would continue to cause the body to sweat even though it was no longer hot.



2.7 RENOWNED ZOOLOGISTS IN ETHIOPIA

- Zoology is the study of animals in relation to their evolution, anatomy, physiology, behavior, habitats and health. Many zoologists from various Ethiopian universities have studied animals found though the country. Some researchers have invested their time and energy in studying

animals in Ethiopia throughout their lives. This has a great contribution not only to the development of zoological science but also for the economic development of the country. Such researchers are patriots for their country because, as indicated in the general curriculum framework stipulates, "Patriotism is not only in showing love to the country and defending it in times of difficulties but also in exhibiting the diligence to successfully carry out a wide-range of duties and tasks which epitomize hard work".

UNIT TWO SUMMARY

- Animals are diverse groups of organisms in the world. They have their own characteristics related to reproduction, cellular organization, mode of nutrition and energy generation.
- There are two major groups of animals: invertebrates and vertebrate animals.Invertebrates are animals that do not have a backbone/vertebral column whereas vertebrate animals possess a well-defined internal skeleton system with cartilage and a backbone/vertebral column.
- While the majority of animals undergo sexual reproduction, a few groups of animals undergo asexual reproduction.
- Asexual reproduction is a type of reproduction that involves a single individual, which is more common among invertebrates than vertebrates.
- Sexual reproduction is a type of reproduction that involves two individual parents to produce offspring by having genetic materials from both parents through fertilization. Insects undergo sexual reproduction and a series of major changes undergone in their body structure called metamorphosis:
- Complete metamorphosis and incomplete metamorphosis. Frogs undergo external fertilization and develop through metamorphosis. Birds undergo internal fertilizations and lay eggs with external hard cover in nest or ground where they hatch after incubation. Reproduction in rats involves internal fertilization and the development of embryo is inside the female rat. Insects have plenty of economic importance in agriculture and food production health and medicine. Insect are important organisms for commercial products such as honey, wax, dyes and silk production and have medicinal value in treating different human and animal diseases. Animals have different behaviours that can be grouped into innate or inherent behavior and learned or acquired behavior.
- Animals also have different behavioral patterns such as behavioral cycles, reproductive behavior, social behavior, competition, territory and communication.

- Homeostasis is a self-regulatory process by which animals maintain stable internal conditions in their body.
- Thermoregulation is the process of maintaining the internal body temperature constant. Homoeothermic animals maintain a constant body temperature regardless of differing environmental temperatures, whereas poikilothermic animals have a body temperature that is the same as their environment, and thus, their temperature varies with the environmental temperature.
- Osmoregulation is the process of controlling the amount of water and electrolytes by the help of osmoreceptors in order to retain homeostasis. The kidney plays an important role in the process of osmoregulation in humans by producing large amount of urine when there is excess water and small amount of urine when the amount of water in our body is low.
- Our body needs continuous supply of energy. The major source of energy for normal functioning of our body is glucose. Insulin and glucagon are the two hormones produced from pancreas to regulate glucose level. Insulin decreases the glucose level and glucagon increases the glucose level to maintain sugar balance in our body.
- Homeostasis is maintained by negative feedback mechanisms that control the internal body change by reversing the direction of the stimulus. The feedback mechanisms involve the receptor that senses the change in the environment (stimulus), the control center (the brain) that generates a response and an effector in muscles that contract o relax or glands to secrete hormones to respond to the stimuli.

Unit two review questions

I. Multiple-choice questions

Directions: Choose the correct answer for each questions

1. Which of the following is not a characteristic of animals?

A. Autotrophs C. Multicellular

B. Reproduce D. Heterotrophs

2. In the body organization patter of an animal, if the left and right sides of the body are mirror images of each other, it is called:

A. Radial symmetry C. Bilateral symmetry

B. Asymmetry D. All of the above

3. Which of the following developmental processes develop into germ layers?

A. Cleavage C. Gastrula

B. Blastula D. A and B

4. Which one of the following is a common characteristic of all vertebrates?

A. The division of the body into a head, neck, trunk and tail

B. Their bodies are covered with an exoskeleton

C. The possession of two pairs of functional appendages

D. The presence of a well-developed skull.

5. Why is sexual reproduction useful?

A. It completes in a very short period of time

B. It results in the rapid production of many offspring

C. It increases genetic diversity, allowing organisms to survive in an unpredictable environment

D. It needs less energy and leads to genetic variation in the offspring

6. The phenomenon by which a female gamete develops into a new organism without fertilization is called_____.

A. Syngamy C. Gametogenesis

B. Parthenogenesis D. Embryogenesis

7. Metamorphosis of insects is regulated through hormone

A .Pheromone C. Ecdysone

B. Thyroxine D. All of the above

8. Animals that have external fertilization produce a large number of gametes. What is the reason?

A. They are small in size and want to produce more offspring.

B. To increase chance of fertilization in water.

C. Sufficient food is available in water to feed offspring.

D. Water promotes production of large number of gametes

9. Which mating system involves a male mating with multiple females during a reproductive? season?

A. Androgeny C. Polygamy

B. Monogamy D. Polygyny

10. The site of fertilization in the chicken is

A. Uterus C. Infundibulum

B. Magnum D. Ovary

11. Which of the following is called the resting and inactive stage in the insect life cycle?

A. The egg stage C. The pupa stage

B. The larva stage D. The adult stage

12. Insects are considered to be beneficial because they/are

A. Effective pollinators

B. Sources of useful products and potential protein

C. Biological control agents D. All of above

13. When laying eggs, a female insect returns to her larval host plant, even though she has not fed upon this plant during her adult life. This is an example of:

A. Conditioning C. Instrumental learning

B. Habituation D. A and C

14. Behavior patterns that change drastically over the lifetime of an insect are probably:

A. Learned C. Afferent

B. Innate D. None of the above

15. A certain insect usual y becomes active each day at dusk. If kept in the dark all day, it will still become active around sunset even though it cannot see the sun. This behavior is an example of:

A. Transverse orientation C. Diurnal behavior

B.A circadian rhythm D. Exogenous entrainment

16. Given these terms related to negative feedback: 1. control center, 2. effector, 3. receptor, 4. response,

5. Stimulus, arrange the terms in the correct order as they operate to maintain homeostasis.

A. 1, 2, 3, 4, 5 C. 3, 2, 1, 5, 4

B. 2, 3, 5, 1, 4 D. 5, 3, 1, 2,

17. The mechanism of regulation of solutes and the loss and gain of water in human is known as

A. Homeostasis C. Osmoregulation

B. Thermoregulation D. Poikilotherms

18. What does glucagon promote in the liver?

A. Hydrolysis of glycogen C. Glycogen production

B. Hydrolysis of glucose D. Release of insulin

19. What is the reason why smaller mammals have higher metabolic rates?

A. Higher SA: V ratios C. Lower Lifespans

B. Lower SA: V ratios D. More Frequent Exposure to Predators

20. What happens when blood sugar levels become too high?

A. Insulin is secreted, causing the conversion of glucose to glycogen

B. Glucagon is secreted, causing the conversion of glucose to glycogen

C. Insulin is secreted, causing the conversion of glycogen to glucose

D. All of the above

21. Why do the hairs on our skin sometimes stand up when we are cold?

A. to know when we are frightened

B. to trap air under them in order to keep us warmer

C. to release air order to cool us down

D. to trap air under them to keep us cooler

22. What happens if the core body temperature is too high?

A. the blood vessels supplying the capillaries constrict

B. the body decreases sweating

C. the blood vessels supplying the capillaries dilate

D. the body shivers to produce heat

23. When an animal is placed in a hot environment, it loses heat through sweating whereas when to cold environment, it increases muscular activity to produce more heat. The animal in this thought is:

A. Homeothermic C. Ectothermic

B. Poikilothermic D. None of these

24. An increase in blood sugar level causes the pancreas to release of the hormone insulin; insulin lowers blood sugar level, restoring the body to its original blood glucose level by converting glucose to glycogen. This is an example of

A. Positive feedback C. Homeostatic imbalance

B. Negative feedback D. None of these

Part II: Short answer item

Direction: Write a short answer to each question

1. How does reproduction differ in rats, birds and crocodilians?

2. What is the difference between vertebrates and invertebrates?

3. What is the difference between poikilothermic and homoeothermic animals?

4. Explain why mammals living in the tropics as compared to similar species living in the Polar regions have generally large protruding structures?

5. How surface area to volume ratio is related with temperature regulation and metabolism

Answer key for review questions

I. Multiple Choice Question

1	2	3	4	5	6	7	8	9	10
A	**C**	**C**	**D**	**C**	**B**	**C**	**B**	**C**	**C**
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	**D**	**B**	**A**	**B**	**D**	**C**	**A**	**A**	**A**
21	**22**	**23**	**24**						
B	**C**	**A**	**B**						

II. Short answer:

- How does reproduction differ in rats, birds and crocodilians?

- **Answer: Reproduction in rats** involves internal fertilization sexually and the development of embryo is inside the female rat and the fertilized zygotes develop in the mother during a gestation period known as pregnancy and give birth from 7 to 12 offspring per litter on average. The mother feeds milk and, after 45 days, the young rats are fully weaned and are actively foraging and feeding.

- **Reproduction in birds** also involves by mating, the male brings its sperm to the female cloaca, and the sperm from the male cloaca fertilizes the egg. The fertilized egg travels down to the uterus, forming a layer of albumen around it, which is followed by the shell membranes in the uterus. Then, the hard-shelled egg develops within the female with a fluid-filled amnion, a thin membrane forming a closed sac around the embryo.

- **Crocodiles reproduce** sexually involving both male and female parents. During July and August mating takes place under water and sperm fertilizes the egg and develops in the female. They have also internal fertilization. They lay their eggs and bury them in sand or deposit them in mound vegetation. The number of eggs a crocodile deposits varies from 10 to 100, which generally depends on the type of species.

➢ What is the difference between vertebrates and invertebrates?

Answer:

No	Characteristics	Invertebrates	Vertebrates
1	Backbone	Do not possess a backbone or an internal skeleton	Possess a backbone and an internal skeleton.
2	Exoskeleton	Have an exoskeleton	. Do not possess an exoskeleton.
3	Size	Body size varies, but most are generally smaller than vertebrates.	are comparatively larger than invertebrates
4	Circulatory system	Nearly all invertebrates possess an open circulatory system	All vertebrates have closed circulatory systems
5	Eye	The majority of invertebrates have compound eyes.	Vertebrates do not have compound eyes.
6	Body symmetry	Have radial or bilateral body symmetry	All vertebrates have bilateral body symmetry
7	Nervous system	Presence of a simple and unorganized nervous system	Presence of complex and highly specialized organ systems with specific functions

8	Mode of nutrition	Mode of nutrition includes Autotrophic, Parasitic, and Heterotrophic	The mode of nutrition is usually heterotrophic

- What is the difference between poikilothermic and homoeothermic animals?

Answer: Vertebrate animals are classified into homoeothermic (warm-blooded) animals that include mammals and birds, and poikilothermic (cold-blooded) animals that include fish, reptiles, and amphibians.

- Explain why mammals living in the tropics as compared to similar species living in the Polar Regions have generally large protruding structures?

- **Answer:** Morphological method of temperature regulation involves the morphological adaptation of organisms. It is a structural change to adapt to very hot and cold habitats. For instance, the Fennec fox lives in the desert and has large ears (morphology) as a structural adaptation that allows heat to be radiated from the body. This structural adaptation helps the fox to cool it down

- **5. How surface area to volume ratio is related with temperature regulation and metabolism.**

Answer: The surface area-to-volume ratio is the relationship between the volume of an organism and the surface area of that organism. The surface area is the external layer of an organism. The volume of a cell refers to the total amount of space in that organism. The ratio refers to the amount of surface area per unit volume of an organism. The surface area that an organism has is important because body heat can be either lost to or gained from the external environment via the body's surface. The larger the surface area of an organism has, the greater the potential rate of heat loss or gain it will have. The smaller the animal is, the larger the surface area-to-volume ratio it will have. Therefore, a small animal such as a shrew has a greater potential for losing heat from its body because of its relatively large surface area to volume ratio.

UNIT THREE

ENZYMES

3.1. WHAT ARE ENZYMES?

- Enzymes are protein molecules that act as biological catalysts (biocatalysts) and accelerate rate of chemical reactions by lowering activation energy. Activation energy is the minimum amount of energy required for the reactant to be converted to products. All enzymes are **proteins** made up of chains of amino acids linked together by **peptide** bonds.
- All cells contain different enzymes depending on the type of the living cell, which engage in tremendous biochemical activity called metabolism. Metabolism is the process of chemical and physical changes, including the breakdown (catabolism) and synthesis (anabolism) of molecules. The metabolic processes in the cells require enzymes to catalyze many biochemical reaction types at a rates fast enough to sustain life. Enzymes act upon molecules (substrates), convert them into products of different molecules, and remain unchanged.

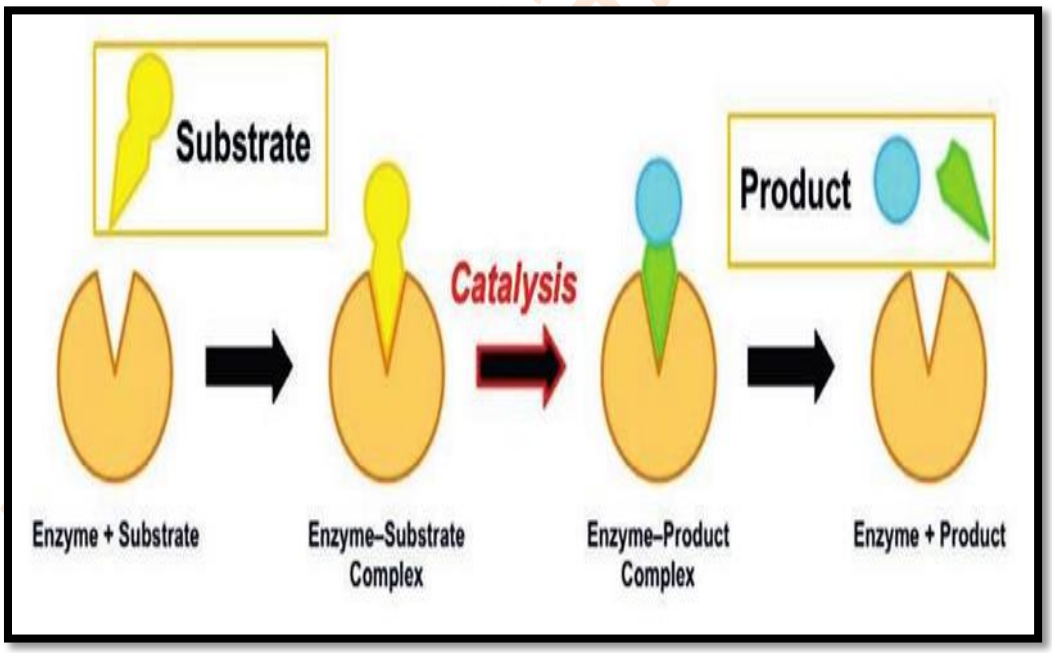


Figure. Enzymatic reaction

3.2 PROPERTIES AND FUNCTIONS OF ENZYMES

➢ Enzyme properties are reactions demonstrated through physical and chemical properties.

3.2.1 General properties of an enzyme

- The general properties of enzymes are the nature of both their physical and chemical properties. Enzymes accelerate the reaction rates. They neither affect the nature of products formed nor undergo any changes by the reaction catalyzed.

A. The physical properties of enzymes

- The physical properties of enzymes include denaturation, solubility, colloids, biocatalysts, precipitation, molecular weight, and enzyme activity.
- **Denaturation** is the process of breaking the intra and inter-molecular non-covalent bonds that distort the shape and active site of the enzymes. Enzymes are denatured by high heat (above 40^{o}C), alternation in the pH (too low or too high), heavy metals and high salt concentrations, solvents and other reagents.
- **Solubility** is the property of enzymes that allow them to be dissolved in water, salt (NaCl), diluted glycerol and alcohol causing denaturation.
- **The colloidal** nature of enzyme is the tendency of having little or no dialysis cross the semipermeable membrane due to the large size or high molecular weight.
- **The biocatalyst property** is the activity of enzymes in which very small quantities or a small amount of enzyme is enough to convert a large quantity of substrate and remain unchanged after the reaction.
- **Enzyme precipitation** is the separation of enzymes for analysis using different aqueous or ethanol solvents.
- **Molecular weights** of enzymes are large protein biomolecules that hold polypeptide chains of various amino acid sequences in enzymes having a high molecular weight.
- **Enzymatic activity** is the general catalytic properties of an enzyme. It depends on factors such as temperature, pH, and enzyme concentration and substrate concentration. Enzymes show the highest activity at optimum temperature and pH that a low concentration of enzymes and substrates slows down the enzymatic reaction.
- **B. Chemical properties of enzymes**

- Enzyme chemical properties are sensitivity, regulations, and specificity, catalysis and reversibility reactions.
- **Heat** and **PH Sensitivity** is an enzymatic reaction to heat (temperatures) and pH (acidity and basicity) activated at optimum levels.
- **Regulation** is the process of controlling the activity of enzymes by activator and inhibitor molecules.
- **Catalysis is the process** of the acceleration of a chemical reaction by a catalyst. Enzymes are biological catalysts that possess high catalytic efficiency. They can transform about 100-10,000 substrates per second. The reactions catalyzed by the enzymes show a 103-108times faster reaction rate in comparison to the non-catalyzed reactions.
- **Reversibility** is the ability of enzymatic biomolecules to catalyze various metabolic (anabolic and catabolic) reactions. It is the reaction to synthesize (build up new molecules or products) and decompose (breaks down different products) in which enzymatic reactions catalyze biochemical reactions in both forward and reverse directions.
- **Enzyme specificity is** a property of the enzyme that describes how restrictive the enzyme is in its choice of substrate. A completely specific enzyme would have only one substrate.
- **Specificity of enzymes**:
- **Bond specificity** is a relative specificity of enzymes, which indicates that enzymes are specific for a bond.
- **Group specificity** is a structural specificity of enzymes, which describes that enzymes are specific for a group.
- **Substrate specificity** is the feature of enzymatic activity where an enzyme acts only on a particular substrate.
- **Optical specificity** is when enzymes act on the substrate optical configuration.
- **Co-factor specificity** is the enzymatic specificity to the substrate and co-factors.

3.2.2 The function of enzymes

- Enzymes help speed up chemical reactions in the human body. They are essential for respiration, digesting food, the liver, muscle, and nerve function. Each cell in the human body contains thousands of enzymes that provide help in facilitating chemical reactions within each cell. The **turn**

over number of molecules is the number of **substrates** converted by one enzyme molecule per second at saturated (fully occupied) active sites.

- Enzyme acting on a substrate to produce product releasing enzyme for further use through steps 1-(Figure).

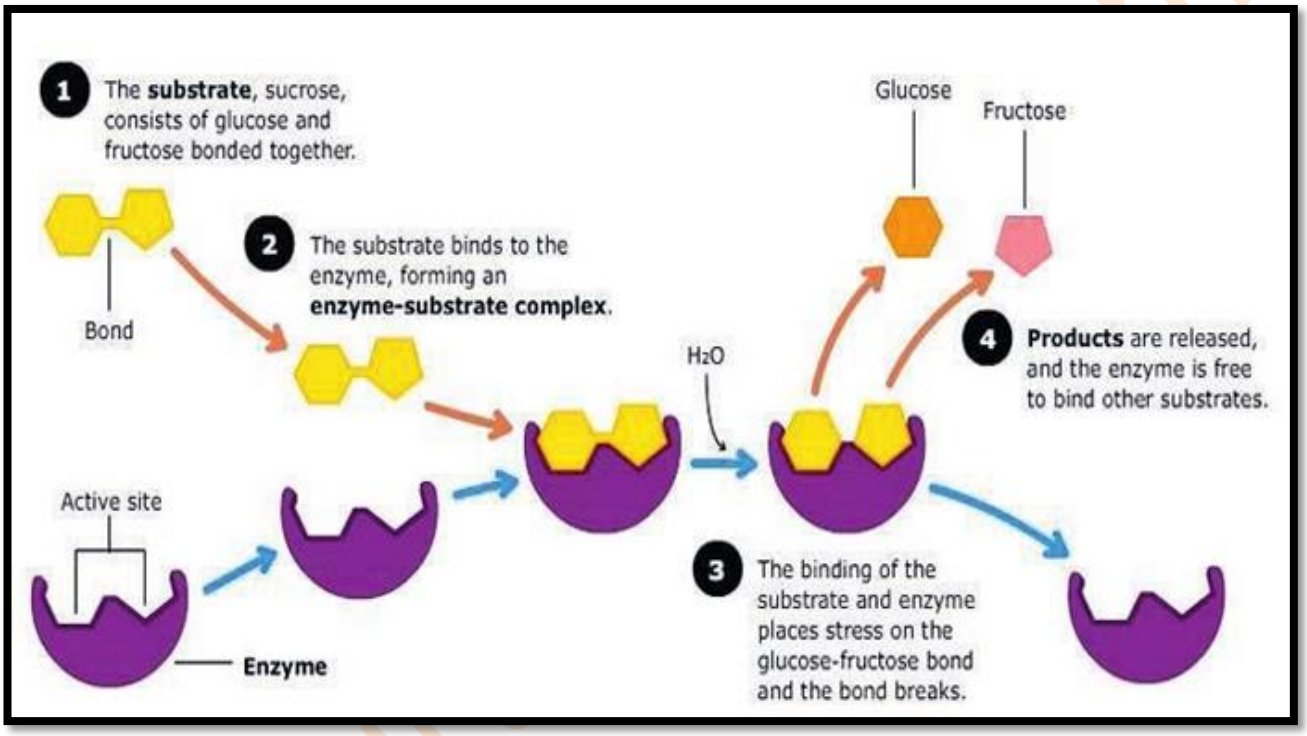


Figure: Enzyme functions

- Enzymes are markers of the states of various diseases like myocardial infraction, jaundice, pancreatitis, cancer and neurodegenerative disorders etc. Each enzyme has an **active site** with a unique shape that speeds up metabolism or chemical reactions in our bodies and builds substances in all living things.

Examples of enzymes:

- **Sucrase** breaks down a sugar cal ed sucrose.
- **Lactase** breaks down lactose, a kind of sugar found in milk products.
- **Carbohydrase** breaks down carbohydrates into sugars.

- **Lipase** breaks down fats into fatty acids.
- **Protease** breaks down protein into amino acids
- Enzymes perform their function by lowering a reaction's **activation energy**. Activation energy is the energy required to start a reaction. The lower the activation energy, the faster a reaction happens.

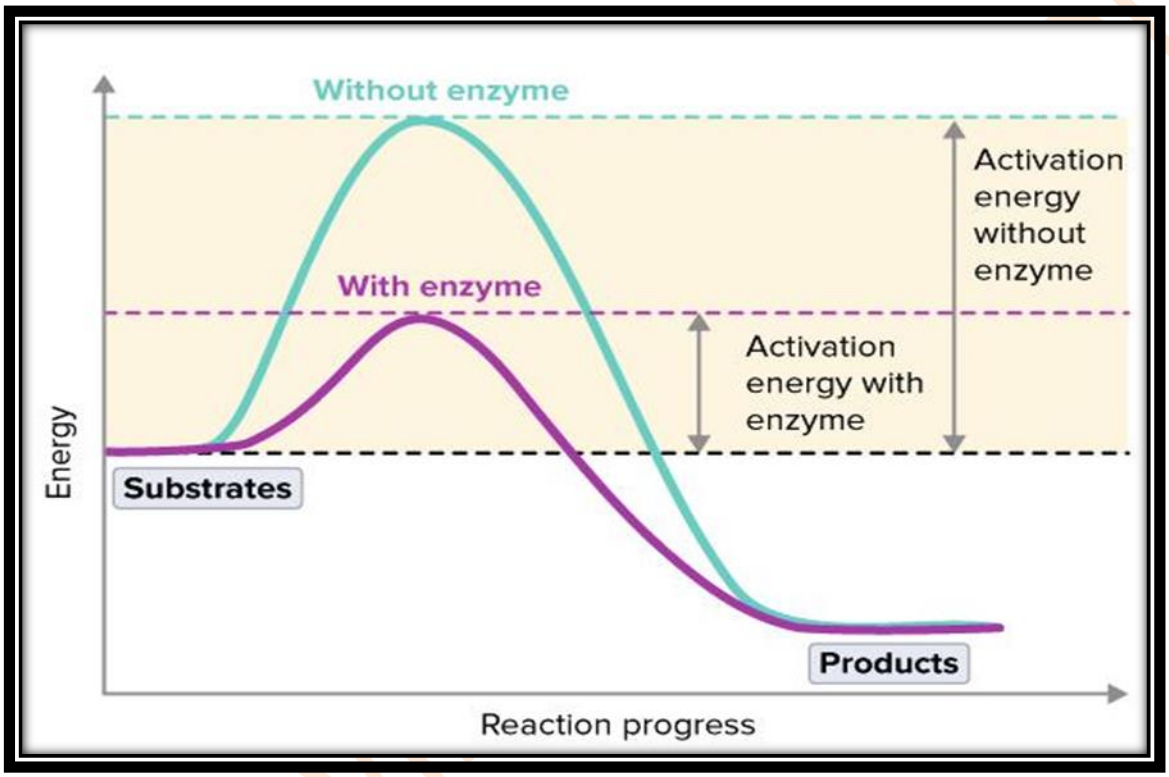


Figure**:** Enzymatic reactions between glucose and oxygen

Table1 some of enzymes in the body and their functions

Enzyme	Function
Lipases	Split fats found in the blood, gastric juices, pancreatic secretions, intestinal juices, adipose (fatty) tissues and participate in digestions
Amylase	Amylase exists in saliva and helps in changing starches into sugars.
Maltase	Maltase exists in foods such as potatoes, pasta and beer and saliva break sugar maltose into glucose.
Trypsin	Found in the small intestine, breaks proteins down into amino acids.

Lactase	Found in the small intestine, breaks lactose, the sugar in milk, into glucos galactose.
Helicase	Unwinds DNA
DNA Polymerase	An enzyme responsible for forming new copies of DNA in the form of nucleic acids molecules
Acetyl cholinesterase	Breaks down the neurotransmitter acetylcholine in nerves and muscles

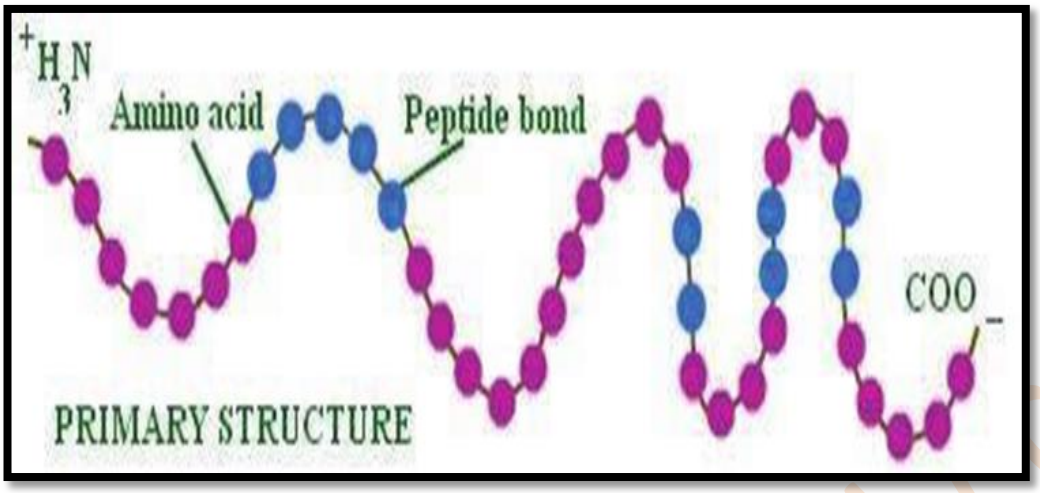
3.3 PROTEIN STRUCTURES

- Enzymes are proteins. Proteins have different structures. Protein structure is a polymer of amino acids joined by peptide bonds with three-dimensional arrangements of atoms in amino acid chain molecules. The protein complex macromolecules have four structural levels:

- Primary structure
- Secondary structure
- Tertiary structure
- Quaternary structure

1. The primary structure of proteins

- The primary structure of proteins makes up amino acid sequences based on the side-chain substituents that differ by the chemical, physical, and structural properties. It is the sequence of amino acids linked together to form a polypeptide chain through peptide bonds created during the protein biosynthesis process.
- Proteins with fewer than 50 sequences are **peptides,** and proteins with longer than 50 sequences of amino acids are **polypeptides**. Humans require 20 amino acids out of which 10 amino acids are synthesized in the human body, and the rest 10 amino acids are obtained from diets. Cells use 20 different standards of **L-α-amino acids** containing basic amino acids and acidic carboxyl groups for protein construction.



2. The secondary structure of proteins

- The secondary structure of a protein is a folded structure formed within a polypeptide due to interactions between atoms of the backbone based on hydrogen bonding and containing **α-helix** and **ß-sheet** types of strands.

2.1 The α – Helix

- The**α-helix** is a right-handed coiled strand and the side-chain substituents of amino acid groups extend to the outside and form hydrogen bonds with oxygen (C=O) in the strand with the hydrogen of each (N-H) group of four amino acids to make the structure stable. The α–Helix structure is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right-handed screw with the NH group of each amino acid residue hydrogen-bonded to the CO of the adjacent turn of the helix.

2.2 β–pleated sheets

- The hydrogen bonding in the ß-sheet is between the inter-strands and intra-strands in which the sheet conformation of the ß-sheet consists of pairs of strands lying side-by-side. All peptide chains stretch out to nearly maximum extension, laid side by side and held together by intermolecular hydrogen bonds forming pleated folds of drapery

3. The tertiary structure of proteins

- The tertiary protein structure is the three-dimensional shape of protein molecules that bend and twist to achieve the maximum stability or the lowest energy state. It is fashioned by many stabilizing forces due to the bonding interactions between the side-chain groups of amino acids.

4. The quaternary structure of proteins

- A protein quaternary structure is the arrangement of multiple folded protein subunits in a multi-subunit complex. It is the association of several protein chains or subunits into closely packed arrangements with their own primary, secondary, or tertiary structures and held together by the hydrogen bonds.

3.4 ENZYME SUBSTRATE MODELS

➢ Enzyme substrate models are models for enzyme substrate interaction describing that the shapes of the active site and the substrate complement to fit into the binding **active site** perfectly.

3.4.1 Enzyme-substrate binding models

➢ There are two different of enzyme-substrate binding models: the lock and key model and the induced fit model.

1. Enzyme lock and key model

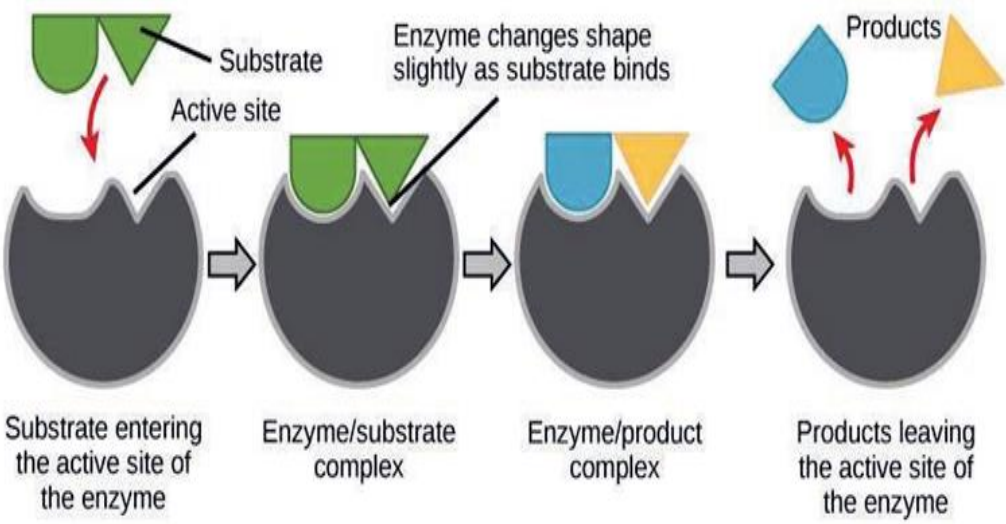
➢ The lock and key model is when enzyme activities fill -in with a substrate to interact through **non-covalent** interactions. The model explains on how the enzymes must bind to substrates before they catalyze a chemical reaction. Once the reaction progresses to the transition state and forms products, the **active site** will not be able to accommodate changes

2. Enzyme induced fit model

➢ An enzyme induced fit model is the active site of an enzyme that elicits responses to the binding substrate by inducing the substrate to take up transition even when the **active site** is not perfect to perform the required product.

➢ Enzymes change shapes by induced fit upon substrate binding to form enzyme substrate complexes. The amino acid side chains that make up the active site mold into the precise positions enable the enzyme to perform its catalytic functions.

- The concept of induced fit states that when a substrate binds to an enzyme, it brings about a change in the shape of the enzyme, which either enhances or suppresses the activity of the enzyme. Upon binding, the inducing process enables to elicit required energy for the reaction to move by putting the active site under strain and making the transition stable.



3.4.2 Enzymatic transition state

- An enzymatic transition state is the reaction rates of elementary chemical reactions and assumes chemical equilibrium between reactants and activated transitions.
- It describes how the chemical reactions are taking place qualitatively in the activated enzyme-substrate complex of absolute reaction rates. The reactive state of substrate binding catalysis is corresponding to the maximum reaction activated and its state of transition

3.5 ENZYME REGULATION

- Enzyme regulation is a control system for enzymatic activities in which enzymes are turned "on" or "off" depending on the organisms need.
- It is adapting enzymatic activities by other molecules or metabolic cells to either increase or decrease the activities.

- A regulatory enzyme is the one in a biochemical pathway through which it responds to the presence of certain other biomolecules and regulates the pathway activity. It requires an extra activation process to pass through some modifications and functions.
- Regulatory enzymes are of two types, allosteric enzymes and covalently modulated enzymes.

1. **Allosteric enzymes**

- Allosteric enzymes are enzymes that have additional binding sites for effector molecules other than the active site that cause conformational changes, leading to changes of catalytic properties. Allosteric enzymes contain two binding sites called **active site/catalytic site** and **allosteric site/regulatory site** for binding effectors and substrates respectively.
- Effectors are small molecules (inhibitor or activator) modulating the enzyme activity and function through reversible non-covalent binding of a regulatory metabolite in the allosteric site or non-active site. Effectors lead to conformational changes in a concrete part of the enzyme that affect the overall conformation of the active site, causing modifications in the activity of the reaction.

2. Genetic and covalent modification

- The genetic and covalent modification modifies the protein surface and facilitates intracellular delivery. Genetic modification of enzymes is to improve the properties of enzymes and gain active and inactive forms. Covalent modulated enzymes are active and inactive forms of the enzymes altered due to covalent modification of structures catalyzed by other enzymes.
- Covalent modifications are enzyme-catalyzed alterations of synthesized proteins by the addition or removal of chemical groups. Modifications can target a single type of amino acid or multiple amino acids and will change the chemical properties of the site. Enzyme regulation occurs by the addition or elimination of some molecules attaching to the enzyme protein.

  Example:

- **Phosphorylation** is the addition of phosphate groups to proteins. It is the most frequent regulatory modification mechanism in our cells.

3. Enzyme inhibition

- Enzyme inhibition is a decrease in enzyme activity by enzyme inhibitors. Enzyme inhibitors are molecule that binds to an enzyme and blocks its activity. There are two types. These are reversible inhibitors and irreversible inhibitors.

  - **Irreversible inhibitor:** is a substance that permanently blocks the action of an enzyme.
  - **Reversible inhibitor**: inactivates an enzyme through noncovalent easily reversed interactions.

- Reversible inhibitors can be competitive and uncompetitive.

1. **Competitive inhibitor**s a molecule that blocks the binding of the substrate to the active site.
2. **Noncompetitive inhibitor** binds to the enzyme already bound the substrate and decreases the efficacy of the enzyme.
3. **Uncompetitive inhibitor** binds only to the enzyme substrate complex, but not to the free enzyme. It occurs in reactions with two or more substrates or products and slows enzyme reactions by binding the substrate to each other.

3.6 TYPES OF ENZYMES

- Enzymes that catalyze chemical reactions can be classified into various types. Enzyme types are based on how enzymes that bind specific molecules together to form new molecules and

3.6.1 Enzyme structural classification

- The structural classification of enzymes deals with the separation of an enzyme into **simple proteins** (**active**) and conjugated proteins **(holoenzymes).** Then, the conjugated protein part (holoenzyme) is divided into the non-protein part **(cofactor)** and the protein part **(apoenzyme: inactive)** groups. Finally, the non-protein part (cofactor) separates into the firmly attached metal ion **(prosthetic group)** and the loosely attached vitamin B complex **(coenzyme)** groups.

3.6.2 Basic classification of enzymes

- Enzymes are composed of six classes based on what and how they react, the types of reactions they catalyzed, and the end suffix "**-ase**". The followings are basic classes of enzymes.

- **1. Oxidoreductases** are a class of enzyme that catalyzes oxido-reduction reactions. It catalyzes the transfer of electrons from one molecule (oxidant) to other molecule (reductant) reactions in the following pattern: **A**– **+ B** → **A + B**– where A is the oxidant and B is the reductant.

  2. Transferase is an enzyme that transfers functional groups like methyl from one donor molecule to acceptor molecule.

- **3. Hydrolases** are enzymes that catalyze the hydrolysis of various bonds.

- **4. Lyases** are enzymes that cleave bonds by other means rather than hydrolysis or oxidation in which two or more substrates are involved in one reaction.

- **5. Isomerases** are a general class of enzymes that convert molecules from one isomer to another isomer.

- 6. **Ligases** are enzymes that catalyze the joining of two molecules with concomitant hydrolysis of the di-phosphate bond in ATP.

3.7 FACTORS AFFECTING ENZYME ACTION

- Enzymes work best within specific temperature and pH ranges and at optimal conditions (the condition under which particular enzyme is most active), an increase or decrease in the conditions of these factors affects the functions of enzymes. There are varieties of factors that affect the activity of enzymes: temperature, pH, inhibitors, activators, radiation, water, enzyme, substrate, and end-product concentrations.

3.7.1 Description on factors affecting enzymatic actions

- **Temperature:** while all enzymes work best within the specific ranges of optimum temperatures, low or high temperature causes an enzyme to lose its activity and ability to bind a substrate and denatured. Once enzymes denatured, they cannot be denatured.

  PH: enzymes function at optimum pH (the potential of hydrogen ions) that ranges from too low (strong acid) to too high (too alkaline) pH. Such extreme temperatures cause an enzyme to lose its ability to bind into a substrate.

  Substrate concentrations: enzymes require a maximum limit of substrate concentration to bind.

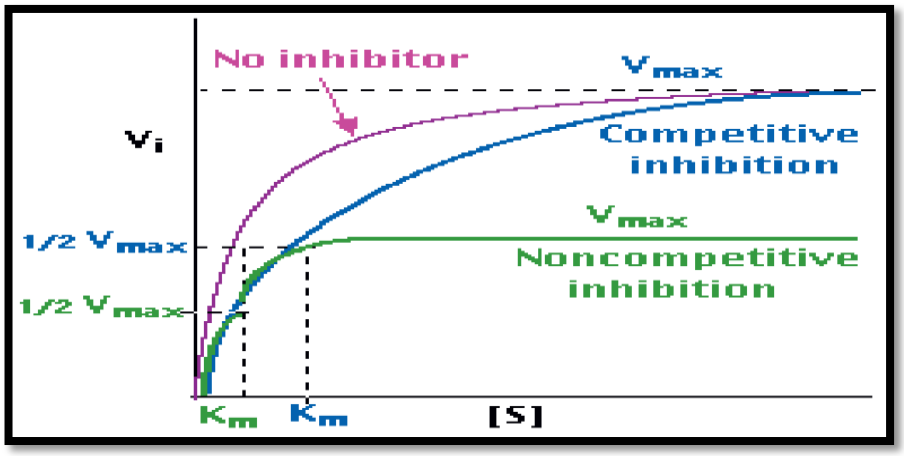
Radiation damages enzyme activities by reducing in enzymatic efficiency and creating disorders in the macromolecules.

Water: affects the performance of enzymes' activity beyond its optimum level.

- **End product (Feedback) inhibition** is a cellular control mechanism in that the end products inhibit enzyme's activity. In feedback inhibition, the end products bind to the allosteric site of the enzyme and change the structure of the active site. This prevents the enzyme to perform its activity. Due to feedback inhibition, a cell is able to know whether the amount of a product is enough for its subsistence or not.
- **Example:** The drug Tipranivir used to treat HIV blocks the activity of a viral genome enzyme to make more copies as a reversible inhibitor.

3.8 ENZYME KINETICS

- Enzyme kinetics describes the rates of chemical reactions that are catalyzed by enzymes and the binding affinities of substrates, inhibitors and the maximal catalytic rates achieved.
- Enzyme kinetics explains that enzymes speed up reactions by lowering the activation energy of the reactants and turning them into products. Hence, the concentration of enzyme and substrates determines the rate of the reactions or production volumes per unit time.
- One of the most known models of **enzyme kinetics** is the **Michaelis-Menten** formula that takes a form of **equation** describing the rate of enzymatic reaction by relating the reaction rate, rate of formation of product to the concentration of substrate. The model explains the relationship between the rate of an enzyme-catalyzed reaction [V1], the concentration of substrate [S] and two constants, Vmax and Km with the following equation.
- Where: **V1** = the initial velocity/rate reaction **Vmax** = the maximal velocity/maximum rate of reaction
- **[S]** = the substrate concentration **KM** = substrate concentration at half-maximal velocity (Michaelis constant).



3.9 APPLICATION OF ENZYMES IN INDUSTRIES AND THEIR BENEFITS

- Application of enzymes is the use of enzymatic biochemical reactions for chemical conversion process that are driving forces of great change for productivity of various industries. Enzyme protein catalytic activity is efficient enough (100s to 1000s) of times higher than that of inorganic catalyst.

3.9.1 Uses of enzyme application

- The applications of enzymes are widely used in food, feed, textile, papermaking, leather and detergents, pharmaceutical and other industrial productions.

Examples:

- Enzymes break down larger complex molecules into simpler molecules in our body where they can be used to fuel our digestive systems and cellular respirations.
- Most enzymes used for food industry were extracted from the internal organs of animals and plants, but now most enzymes are obtained by microbial fermentation.
- Enzymes cause billions of chemical reactions to happen at lightning speed inside the cells of our body.
- Enzymes improve the utilization of feed rate of starch, protein, and minerals and degrade the anti-nutritional factors in animal feed, prevent animal indigestion and improve feed digestibility.

- In the pharmaceutical industry, enzymes are used in drugs, antibiotics, household products to speed up chemical reactions and synthesis.

- Enzymes are powerful tools in sustaining a clean environment in several ways.
- Washing powders are enzymes used to break down protein, starch and fat stains on clothes
- Table 3.3 the applications and functions of enzymes

3.10 MALTING IN ETHIOPIAN TRADITION

- Malting (sprouting) is a widely applied traditional technology. It is the process of steeping, germinating and drying grain to convert it into malt. Malting is the limited controlled germination of grains in moist air, which results in the mobilization of amylases, proteases and other enzymes that hydrolyze and modify the grain components and its structure.

3.10.1 Steps of modern malting

- There are three steps to modern malting, steeping, germinating and kilning, and these will be discussed in this section.

1. Steeping

- Steeping is the process of cleaning the grain kernels and bringing it to life with water and oxygen by immersing it in the water and air for a specified time period. The water activates natural y the existing enzymes in grains and stimulates the production of enzymes in which water temperature and aeration are vital for producing high quality malt. Although the process can vary depending on the grain type and size, malting occurs over a period of 24–48 hours.

- The **steeping** will be complete when the barley has reached a sufficient moisture level to allow a uniform breakdown of starches and proteins. So starch and protein hydrolyzing enzymes are activated during steeping

2. Germinating

- Germinating is to continue the process with the growth and modification of the grain. Rootlets emerge from the kernel to the outside of the grain and within the outer husk and a shoot or acrospires grows.

- Modification is the breakdown of protein and carbohydrates, resulting in the opening up of the seeds' starch reserves within four to six days as Green Malt. The control of temperature and moisture levels with regulated airflow and the uniformity of water spray enables achieve a high quality and consistent germination process. Malting is partly an art and partly a science that can be gauged in the degree of modification with the eyes, sense of smell and hands.

3. Kilning (Heating)

- Kilning is the heating treatment of germinated grain to dry the green malt and prevent from further germination. If germination continued, the kernel would keep growing and the growing plant would use all of the starch reserves needed by the brewer. Removing moisture from the germinated grain is initially for **withering**. Additional drying further reduces the moisture content and prepares the malt for flavor and color development.

- The kilning process achieves enzymatic activity and friability, a wide ranges of malt colors and flavors and distinctive ales and lagers.

3.10.2 Why is malting for?

- Malting aims to convert or modify the physical structure of the barley grain and allow synthesis or activation of a series of enzymes to produce malt for uses in the subsequent purposes (brewing, distilling or food production).

- Barley is the most common cereal used for the production of malt because of its high starch-to-protein ratio and adhering husk that contribute to the economic yield, ease of processing and production.

- Barley malting in Ethiopia is practiced for the production of traditional beer (Tella) and uses as in ingredient in porridge making or drinks.

- The most common enzymes used in the malting process are **beta-glucanase**, **alpha-amylase, protease** (breaks down proteins) and **beta-amylase**.

- The main purpose of malting is to produce enzymes such as the**α-amylase** and **β-amylase** useful for modifying and converting grains' **starches** into simple sugar (monosaccharide), complex sugar

(disaccharides) and malt sugar (maltose) and higher sugars called **maltodextrines.** Then after, the yeast uses these monosaccharides to produce alcohol by alcoholic fermentation.

3.10.3 Traditional malting for local alcohol production

- Traditional malting is the process of sprouting barley grains for the production of enzymes (α-amylase and β-amylase**)** to process fermentation drinks such as Tella.
- The steps of traditional malting process include:
  - Soaking barley grains (steeping)
  - Germinating (sprouting)
  - Kilning (Heating) the malt
  - The most commonly used grains for malting are barley, maize, millet, sorghum and the like. However, barley is the most preferable grain to produce local drinks in local malting.
  - The main purpose of malt production is to produce alcoholic beverages drinks for consumptions and income generation to support the livelihood of the people. Malting requires raw materials like barley for fermentation of alcoholic drinks like Tella.
  - People in Ethiopia produce local drinks like Booka, Cheka, Keribo, Korefe, Shameta, Borde and Teji in different occasions (holidays, wedding ceremonies, and celebrations).

3.11 RENOWNED BIOCHEMISTS IN ETHIOPIA

- A biochemist is a scientist who studies the chemical processes transformations in living organisms including DNA, proteins and cell parts. A biochemist also conducts research on how certain chemical reactions happen in cells, tissues and organisms and record the effects of products in food additive and medicines.
- The study of biochemistry deals with all aspects of the immune systems, expressions of genes, isolation, analysis and synthesis of products.
- It also concerned with studying mutations that leads to cancers, scientific procedures used to manage and monitor laboratory works.

- Biochemists also conduct research in the field of agriculture, in the interactions between herbicides with plants. They also examine the relationships between or among compounds that determine the ability to inhibit growth and evaluate the toxicological effects.

UNIT THREE SUMMARY

- Enzymes are protein biochemical catalysts that speed up chemical reactions to keep up metabolisms without affecting the products and the nature of the catalyst itself. An enzyme is a substance that acts as a catalyst in living organisms, regulating the rate at chemical reactions and proceeds unaffected in the process.

- Enzyme **active site** increase reaction rates by lowering energy activations. However, some enzyme reactions convert substrates to products in mil ions of times faster speeds. In contrast, enzymes are inactive, destroyed or denatured at very low and higher temperature and PH.

- Enzyme substrate complex is a temporary molecule formed in perfect contact of enzymes with binding substrate **active sites** to converts into products. Substrate concentrations, enzyme concentrations and inhibitors are also factors affecting the properties enzymes.

- Many enzymes require cofactors (coenzyme) to become complex holoenzyme with apoenzyme before exerting catalytic activities (apoenzyme + coenzyme = holoenzyme). **Cofactors** are non-protein molecules that make enzymes active on binding to none-proteins. Enzymes require dietary minerals, vitamins and cofactors to function, make products that act as the substrate for the nextside-product and remove wastes from cells. The entire active complex of an enzyme is a **holoenzyme**made up of apoenzyme (protein portions), coenzyme (cofactor) and prosthetic groups of metal-ion activators.

- Most enzymes are proteins and not all proteins are enzymes whereby the non-protein parts attached to the protein as apoenzyme (cofactors). Molecules that increase the activity of enzymes are **activators** and molecules that decrease the activity of enzymes are **inhibitors**. Both **activators** and **inhibitors** of enzymes are molecules that turn up or down the activity of enzymes by binding with molecules of enzymes. Regulatory enzymes exist at high concentrations and their activity increases or decreases depending on changes in substrate **concentrations**.

Unit three review questions

Part I. True or false items

Instructions: write true if the statement is correct and false if the statement is not correct.

1. Enzymes are biocatalyst proteins.
2. The rate of enzymatic reaction increases with increased rate of substrate concentration.
3. Inhibitor is a molecule that reduces the rate of enzyme-catalyzed reactions.
4. If you drop H2O2on slice of boiled potato, enzymatic reactions are very active.
5. The suffix "ase" indicates that a molecule is an enzyme.
6. All enzymes are protein molecules, but not all proteins are enzymes.
7. Our saliva contains an enzyme amylase.
8. Enzymes can react beyond the optimum pH.
9. Activators are molecules that increase the activity of enzymes.
10. Enzymes are drugs in the pharmaceutical industry.

Part II. Multiple-choice test Items

Instructions: Choose the correct answer from the given alternatives.

1. What is the optimum temperature of enzyme activity in human body?

A.5 - 30 ºC C. 25 - 45

B.35 - 75 ºC D. 37 ºC

2. What is the first discovered enzyme?

A. Lactase C. Diastase

B. Ligases D. Hydrolase

3. An enzyme acts best at a particular pH called

A. Catalytic pH C. Optimum pH

B. Abnormal pH D. None

4. The two enzyme specificity models are

A. Lock and Key C. A and B

B. Induced fit model D. All

5. Which of the following statement is incorrect?

A. Enzymes are protein in nature C. Enzymes are thermo-labile

B. Enzymes is colloidal in nature D. Enzymes are inorganic catalyst

6. What is enzyme kinetics?

A. The rate of reaction C. Acidic reactions

B. Base reactions D. Heat reaction

7. What is the molecular weight of enzymes?

A. Large protein biomolecules C. A and B

B. 200 to 300 peptide bonds D. all

8. Enzymes that have additional binding sites

A. Allosteric enzymes C. Transition state

B. Enzyme rates D. None

9. Enzyme activity is dependent on

A. The folding of a proteins C. Sensitivity to the pH and salt concentration

B. Sensitivity to the temperature D. All

10. What is the formula for the rate enzyme kinetic mechanism?

A. S⇄ ES ⇄ ES* ⇄ EP ⇄ E + P B. S + ES⇄ ES* ⇄ EP ⇄ E + P C. S⇄ ES ⇄ ES ⇄ EP ⇄ E + P D. S ⇄ ES ⇄ ES*⇄ EP⇄ P

11. The three steps of malting are

A. Germinating, Steeping and Kilning C. Steeping, Germinating and Kilning

B. Kilning, Germinating and Steeping D. None of the steps is correct

12. An enzyme that carries and transfers methyl groups from one compound donor

(Cofactor) to another compound (acceptor) is

A. Transferase C. Isomerases

B. Lyases D. Translocases

Part III. Short answers

Instruction: give short answer for the following questions

1. What are the five types of enzymes and their applications (uses).

2. How does the function of the active site of an enzyme differ from that of an allosteric site?

Answer Key to review questions

I. True or False items

1	2	3	4	5	6	7	8	9	10
T	T	T	F	T	F	F	F	T	T

II. Multiple-choice questions

1	D	3	C	5	D	7	D	9	D	11	C
2	C	4	D	6	A	8	A	10	A	12	A

III. Short answer:

1. What are the six types of enzymes and their applications (uses)?

Answer:

No	Types of Enzymes	Applications
1	Oxidoreductases	Transfer of electrons from one molecule (oxidant) to other molecule (reductant)
2	Transferase	The transfer's functional groups like methyl from one donor molecule to acceptor molecule.
3	Hydrolases	An enzyme that catalyze the hydrolysis of various bonds.
4	Lyases	enzymes that cleave bonds by other means rather than hydrolysis or oxidation in which two or more substrates are involved in one reaction
5	Isomerases	class of enzymes that convert molecules from one isomer to another isomer
6	Ligases	Catalyze the joining of two molecules with concomitant hydrolysis of the di-phosphate bond in ATP.

2. How does the function of the active site of an enzyme differ from that of an allosteric site?

Answer :

- **A**ctive sites are the part of an enzyme that used for the binding of substrate whereas allosteric sites are also other parts of an enzyme for binding other competitive substrates.

UNIT FOUR

GENETICS

4.1. THE GENETIC MATERIALS

- The branch of biology concerned with the study of the genetic materials of organisms and how traits are passed from one generation to the next generation through genes is called **genetics**. The genetic material of an organism refers to material that carries genetic information and passes it from one generation to the next generation to perpetuate life. The genetic material in almost all organisms is DNA. RNA is also a genetic material in some viruses like HIV, COVID-19.

- DNA (deoxyribonucleic acid) is the hereditary material in humans and other organisms. It exists in a double helix formed by base pairs attached to a sugar-phosphate backbone. RNA (ribonucleic acid) serves as the genetic codes in some viruses. It is involved in protein synthesis in cells.

4.2. THE STRUCTURE AND FUNCTION OF DNA AND RNA

- Both DNA and RNA have their own structures and important role in determining the characteristics of organisms.

4.2.1. The Structure and function of DNA

The structure of DNA

- The structure of DNA is a ladder-like double helix twisted into a spiral shape, in which the sugar and phosphate groups form the two vertical ladder and the nitrogenous bases form the ladder's rungs (Figure 4.3). It consists of two long chains of chemicals called polynucleotide that twist around each other to form a double helix. Nucleotides are the basic building blocks of a DNA molecule. Each nucleotide is composed of a sugar, phosphate group and a nitrogenous base. There are four types of nitrogenous bases. These are: **Adenine (A)**, **Thymine (T)**, **Guanine (G)** and **Cytosine (C).**

- The nitrogen bases belong to the two large chemical families called purine and pyramidine. The A and G are purines and the C and T are pyrimidines. A pairs with T and C pairs with G to form

units called base pairs. Each base is also attached to a sugar molecule and a phosphate molecule to form a nucleotide, the building blocks of the DNA called nucleotide.

- In the DNA structure, the sugar (Deoxyribose) and phosphate form the backbone of the DNA molecule and the nitrogenous bases form hydrogen bonds between the two strands (backbone), to form a ladder-like structure. Each strand of DNA shows polarity (two ends are different). The one is referred as 5' end and the other is 3' end. The two strands of DNA run in opposite directions. The strands are helically twisted where each strand forms a right-handed coil. James Watson and Francis Crick discovered the double helix structure of a DNA molecule.

Genes and chromosomes

- Sections of the DNA structure that contain the set of instructions that determine the characteristics of an organism are called genes. Genes are the basic structural and functional units of inheritance in nature. Genes pass from parents to offspring during both sexual and asexual reproduction through cell division.

- Genes are located on chromosomes. Chromosomes are threadlike structures made of a protein called histone and DNA molecule. Each chromosome may contain hundreds to thousands of genes that are arranged linearly along the length of each chromosome (like beads on a string), with each gene having its own unique position on to chromosomes called locus / loci (plural).

- Chromosomes exist in pair in diploid organisms in which one chromosome is always inherited from the mother and the other from the father. For example a human cell contains 46 chromosomes which exist in 23 pairs of chromosomes.

The Function of DNA

- The function of DNA is to store all of the genetic information that an organism needs to grow, develop, reproduce, control the cell and survive. While DNA determines the characteristics of an organism, it is also responsible for carrying and transmitting the hereditary materials or the genetic instructions from parents to the offspring. The transmission of this information from the mother to daughter cells occurs through the process of DNA replication during cell division.

4.2.2 DNA replication

- DNA replication is the process by which DNA makes a copy of itself during cell division. DNA has a unique property of replication or production of carbon copies.

- This is essential for transfer of genetic information from one cell to its daughters and from one generation to the next. DNA gives rise to RNAs through the process of transcription. DNA replication is a **semiconservative**, which means that each strand in the DNA double helix acts as a template for the synthesis of a new, complementary strand.

- In other words, the two original DNA strands separate during replication; each strand then serves as a template for a new DNA strand. Each newly synthesized double helix is a combination of one old and one new DNA strand. DNA replication involves the following enzymes.

Table 1: Enzymes and their functions

No	Enzyme	Function
1	DNA Helicases	It binds to the double stranded DNA and stimulates the separation of the two strands
2	DNA polymerase	It adds new nucleotides to a growing strand of DNA, and links together, or polymerizes, DNA bases in the correct sequence using the template DNA strand
3	RNA primase	It synthesizes RNA primers complementary to the DNA Strand
4	DNA ligase	links two fragments of DNA by forming a phosphodiester bond
5	Topoisomerase	It prevents super coiling at the region ahead of the replication for

- **Replication fork:** A structure that forms within the long helical DNA during DNA replication is called replication fork. It is the point formed due to unwinding and separations of two strands appear like Y–shaped fork is called replicating fork.

- **Leading strand**: the strand of new DNA, which is synthesized in the same direction as the growing replication fork.

- **Lagging strand**- The strand of new DNA whose direction of synthesis is opposite to the direction on the growing replication fork. There are three stages in DNA replication. These are:

- **Stage one** - the DNA helix structure is unwound and unzipped, hydrogen bonds between bases, which are holding the two strands together break and the double helix structure of the DNA molecule separate in to two strands.
- **Stage two** - The two separated strands will act as templates for making the new strands of DNA.
- DNA polymerase will add the free DNA nucleotides using complementary base pairing (A-T and C-G). One of the strands is synthesized in the same direction as the growing replication fork (leading strand). DNA polymerase adds nucleotides to the deoxyribose (3') ended strand in a 5' to 3' direction. The other strand synthesizes opposite to the direction of the growing replication fork (lagging strand).
- **Stage three**- The two new strands twist to form a double helix. Each is identical to the original strand.

4.2.2 The structure and function of RNA

The structure of RNA

- RNA has single strand structure. RNA contains the sugar ribose, phosphates, and the nitrogenous bases adenine
- (A), guanine (G), cytosine (C) and uracil (U) which replaces thymine in DNA. There are three most well-known types of RNA in all organisms. These are messenger RNA (mRNA), transfer RNA (tRNA) and ribosomal RNA (rRNA). All types of RNAs are formed on DNA strands by transcription process.

The function of RNA

- RNA is the most important molecule in all lives. RNA is involved in a variety of functions within the cell and is found in all living organisms. RNA functions in protein synthesis and used as a storage of genetic information in some viruses. RNA facilitates the translation of the DNA into different proteins required by organisms. For example, it serves as a messenger in conveying instructions between the DNA and the ribosome during proteins synthesis.

4.3 THE PROCESS OF CELL DIVISION

- Think about how the growth of your body, the healing of a wound on your body and the reproduction of organisms are possible. Growth and reproduction of organisms are possible because of cell division. The information stored in the DNA transfers from one cell to another cell and from generation to generation through cell division. DNA replicates during cell division.

4.3.1 Cell Division

- Cell division that helps an organism to live and substitute its generation is an important event in the body of an organism. In cell division, each cell divides to make two cells and these two cells then divide to make four cells, and so on. The process that repeats in this way is called the cell cycle.

- The cell cycle is an ordered series of events that involve cell growth and cell division to produce new daughter cells. Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth. The replication and division of DNA produces two identical daughter cells. The cell cycle has two major phases: interphase and mitotic phase (M phase).

I. The Interphase

- Interphase is the period of preparation for a cell to divide and start the cell cycle. During interphase, the cell undergoes normal growth processes, gathers nutrients and energy and prepares for the cell division. The parent cell also makes a copy of its DNA to share equally between the two daughter cells. The three stages of interphase are called G1(first gap stage), S (synthesis stage), and G2(second gap stage).

The G1 Phase (First Gap)

- G1 phase (first gap) is the first stage of interphase in which the cell is quite active at the biochemical level. At G1phase, the cell accumulates the building blocks of chromosomal DNA and the associated proteins as well as sufficient energy reserves to complete the task of replicating each chromosome in the nucleus. The **G0** phase (resting phase), is a phase in which the cell is neither dividing nor preparing to divide but performs regulatory and basic cellular functions.

The S Phase (Synthesis of DNA)

- The S phase is a stage in which DNA replication proceeds to form identical pairs of DNA molecules (sister chromatids) that are firmly attached to the centromeric region. In this phase, the centrosome duplicates and centrcoles develops to help organize cell division.

G2 Phase (Second Gap)

- The G2 phase is a stage in which, the cell replenishes its energy stores that exhausted during DNA replication at S-phase and synthesizes proteins necessary for chromosome manipulation. In this phase, some cell organelles duplicate and the cytoskeleton disintegrates to provide resources for the mitotic phase. The cell performs the final preparations for the mitotic phase to enter the first stage of mitosis. After completing the interphase, the cell undergoes either mitotic or meiotic cell divisions.

I. Mitosis

- Mitosis is a basic process for life. Mitosis is the division of somatic cells. Somatic cells make up most of your body's tissues and organs, including skin, muscles, lungs, gut, and hair cells. Mitosis undergoes multistep processes during which a cell duplicates all of its contents, including its chromosomes and organelles, which the duplicated chromosomes are aligned, separated, and moved into respective poles then, two new identical daughter cells produced. The first phase of the mitotic phase is called karyokinesis (the nuclear division) and the second phase is called cytokinesis (the physical separation of the cytoplasmic components into the two daughter cells).

1. Prophase

- Prophase is the first step in mitotic cell division in which the nuclear envelope starts to dissociate into small vesicles where chromosomes become more condensed, discrete, and visible through compound microscope and centrosomes move to opposite poles. While mitotic spindle microtubules also extend between the centrosomes, sister chromatids begin to coil more tightly to develop a kinetochore in the centromeric region.

- The kinetochore attracts and binds mitotic spindle microtubules that extend from the centrosomes and the sister chromatids face the opposite poles. Moreover, organelles such as the Golgi complex or Golgi apparatus, and endoplasmic reticulum fragment disperse toward the periphery of the cell.

At the end, the sister chromatids will be attached via their kinetochores to microtubules from opposing poles.

2. Metaphase

- Metaphase is the second step in the mitosis process. All the chromosomes are aligned at the metaphase plate or the equatorial plane, which is at the middle of the cell between the two poles of the cell. The sister chromatids are still tightly attached to each other by cohesion proteins.

3. Anaphase

- Anaphase is the third step in which the sister chromatids separate at the centromere and are pulled rapidly toward the centrosome to which its microtubule is attached. The connection between the sister chromatids breaks down and the microtubules pull the chromosomes toward opposite poles

4. **Telophase**

- Telophase is the fourth step in which the chromosomes reach the opposite poles and begin to decondense (unravel). The mitotic spindles are depolymerized, the nuclear envelopes form around the chromosomes and nucleosomes appear within the nuclear area.

- **Cytokinesis** is the final phenomenon in which division of cell is completed by the physical separation of the cytoplasmic components resulting in two genetically identical daughter cells

II. Meiosis

- Meiosis is another fundamental process for life. Meiosis is the division that produces sex cells (gametes). It has two phases, meiosis I and Meiosis II, each with their own process. During Meiosis I, a cell duplicates all of its contents and divides into two daughter cells whereas it divides into four different daughter cells with haploid number of chromosomes in Meiosis II. Meiosis reduces the number of chromosome by half and produces genetic variation through a process of crossing over and independent assortment, whereas the cells are dividing. Meiosis cell division has eight stages (four stages for each meiosis).

A. **Meiosis** I

- In diploid organisms, chromosome exists in pairs each members of the pair are called homologous chromosomes. In meiosis I, homologous chromosomes are separated into two cells consisting of two chromatids (chromosome pair) in each daughter cell. Meiosis I is also called reduction division. Why?

1. Prophase –I

- Prophase I is the first step in part one of the meiosis stage in which chromosomes replicate to form two **sister chromatids.** In this step**,** nuclear envelope also disintegrates, the chromosomes begin to condense and **spindle fibers** appear. **Spindle fibers** are important for the successful division of chromosomes in that they are attached to the chromosomes at **centromeres.**

- A diploid cell contains two copies of every chromosome, one derived from male gamete and the other from the female gamete. These pairs of chromosomes are called **homologous chromosomes. Sister chromatids** are the two chromatids of a replicated chromosome that are connected by the centromere.

- **A non-sister chromatid** is one of the two chromatids of two homologous chromosomes. Non-sister chromatids of homologous chromosomes form chiasmata to exchange genetic material during prophase I of meiosis I. In this phase, homologous chromosomes pair each other and **crossing over** takes place. During crossing over, homologous chromosomes exchange small parts to each other so that one chromosome contains parts of male and female DNA. This results in an increase in **genetic variation**

2. Metaphase I

- Metaphase I is the second step in part one of the meiosis stage in which the pairs of chromosome align next to each other along the center (equator) of the cell. When the pairs of chromosomes line up randomly, they align themselves on either side of the equator**.** The meiotic spindles extend from centrioles at opposites poles of the cell and attach to one chromosome of each pair.

3. **Anaphase I**

- Anaphase I is the third step in part one of meiosis in which the pair of chromosomes are then pulled apart by the meiotic spindle. Each of the homologous chromosomes get pulled towards opposite

poles of the cell as the spindle fibres retract. This equal y divides the DNA between the two cells to be formed.

4. **Telophase I**

- **Telophase I** is the fourth step in part one of meiosis in which the chromosomes complete their move to the opposite poles of the cell. During this step, the spindle fibres disappear, the full set of chromosomes gather together, the nuclear envelope reforms and a membrane forms around each set of chromosomes.

- **Cytokinesis** is the final phenomenon of Meiosis I in which the single cell pinches in the middle to form two separate daughter cells each containing a half set of the parent chromosomes within a nucleus.

Meiosis II

1. Prophase II

- Prophase II is the first step in part two of meiosis in which the chromosomes condense again into visible X-shaped structures in each of the two daughter cells. In this step, the membrane around the nucleus in each daughter cell dissolves away releasing chromosomes, the centrioles duplicate and the meiotic spindle forms again. This stage is similar to prophase in meiosis I.

2. Metaphase II

- Metaphase II is the second step in part two of meiosis. Unlike metaphase I where chromosomes line up in homologous pairs, sister chromatid line up end-to-end in a single line along the equator of the cell. Meiotic spindle fibers from the centrioles at opposite poles attach to each of the sister chromatids.

3. Anaphase II

- Anaphase II is the third step in part two of meiosis in which sister chromatids are pulled to opposite poles of the equator due to the action of the meiotic spindle. The separated chromatids are now individual chromosomes.

4. Telophase II

- Telophase II is the fourth step in part two of meiosis in which chromosomes complete their move to the opposite poles of the cell, a membrane forms around each set of chromosomes.

- **Cytokinesis** is a phenomenon in which the cytoplasm and the cell divide producing 4 non-identical haploid daughter cells.

4.4 PROTEIN SYNTHESIS

- Proteins are organic compound made of amino acids joined together by peptide bonds. There are essential for the maintenance of structural attributes and the functioning of all living cells and viruses. There are 20 different natural ly occurring amino acids but each protein is different in structure and function due to the sequence in which these amino acids are arranged. Protein synthesis is the stepwise process of the production of different types of proteins from amino acids.

- It involves **DNA**, **RNA** (mRNA, tRNA and rRNA), **amino acids,** various **enzymes** and **ribosome. DNA** stores genetic information used to produce different proteins. **Messenger RNA (mRNA)** transcribes genetic information from DNA in the nucleus with the help of enzyme RNA polymerase. **Transfer RNA** (tRNA) brings amino acids from the cytoplasm to the ribosome and it translates the message within the nucleotide sequence of mRNA to a specific amino acid sequence. **Ribosomal RNA (rRNA)** is a molecule in cell s that forms part of the ribosome that helps translate the information in messenger RNA (mRNA) into protein.

- **Ribosomes** are cytoplasmic organelle that translates the mRNA template into a polypeptide chain. The process of protein synthesis involves the conversation of instructions in DNA into a functional product (proteins) through **transcription** and **translation**. Reverse transcription is a process in which a DNA molecule is synthesized from an RNA template. These all process of biological information flow is called central dogma.

Transcription

- Transcription is the synthesis of mRNA molecules within the cell nucleus with the code for a protein copied from the genetic information contained in the DNA. In other words, transcription produces an exact copy of a section of DNA known as messenger RNA (mRNA). It carries

complementary genetic code copied from DNA during transcription, in the form of triplets of nucleotides called **codons**.

- A codon is a sequence of three nucleotides and four nitrogenous bases on an mRNA strand derived from the DNA that encodes a specific amino acid. Each codon specifies a particular amino acid. For example, amino acid tryptophan is coded by a codon TAG, alanine by GCA, GCC, glycine by GGA, AGG, etc for each 20 amino acids. There are only 20 naturally existing amino acids but the number of possible amino acids combination is 43 = 64 triplets. Out of the 64 codons, three are stop codons, which stop the process of protein synthesis (UAG, UAA, and UGA) and one of the codons is an initiator codon or **start codons** that initiates protein synthesis (AUG).

Translation

- Translation is the synthesis of protein from the building blocks of protein /amino acids/ based on the genetic information instructed on mRNA with the help of rRNA, tRNA and enzymes. Transfer RNA (tRNA) carries a specific amino acid from cytoplasm. This tRNA contains an **anticodon** which is three nucleotides long that is complementary to the three nucleotides long genetic codon on the mRNA.

- The anticodon on tRNA enables to recognize the codon of mRNA through complementary base pairing. For example, the genetic codon GUG (guanine-uracine- guanine) specifies particular amino acid valine. By binding its anticodon (CAC) that is complementary with mRNA codon /GUG/, the tRNA acts as an adapter, bringing the specific amino acid based on base complementarily.

- The complementary bases on the codon and anticodon held together by hydrogen bonds to from peptides bond in growing protein chain. The ribosome guides the tRNA to bind to the mRNA if it is carrying an amino acid.

During Translation:

  - mRNA carries the information from DNA align on the ribosome in the cytoplasm
  - The ribosomes attach on to mRNA and let the tRNA loaded with specific amino acid to enter

- tRNA with anti-codon brings amino acids from the cytoplasm to the ribosomes
- The anti-codon of tRNA pairs with the codon of mRNA on the ribosome
- The information in messenger RNA (mRNA) translated into protein with the help of rRNA
- A polypeptide chain of amino acids will then form a protein.

4.5 MENDELIAN INHERITANCE

- There is great variation among all organisms. There is also similarity among organisms. An Austrian monk Gregor Mendel first explained the way in which characteristics of organisms are passed from one generation to the next generation. He studied how traits and characteristics were transferred from one generation to the next and discovered the principles of heredity in the middle of the 19th century.
- Gregor Mendel performed thousands of crosses with garden peas (Pisum sativum) at his monastery. After eight years of tedious experiments with these plants, he discovered two foundational principles of inheritance and established different terminologies used in genetics, such as **factors** (later **genes, alleles**), dominant, recessive, genotype, homozygous, heterozygous, phenotype, etc.
- The principles of Mendelian inheritance, or Mendel's principles of heredity, are the law of segregation and the law of independent assortment.
- Mendelian inheritance refers to the patterns of inheritance of traits or transmission of traits, controlled by a single gene with two alternative alleles, from parent to offspring. In other words Mendelian inheritance is a set of principles discovered by Gregor Mendel regarding the transmission of genetic characters from parent to offspring.

4.5.1 Mendelian crosses

- Gregor Mendel is the father of genetics, conducted experiments on pea plants (Pisum sativum) by cultivating them, crossing them with each other, and observing the pattern of inheritance in different stages of generation. Mendel studied seven pairs of different characters of pea plants with contrasting traits that exist in two forms. Traits in the first row are dominant traits and traits in the second row are recessive traits.

- In order to determine the mechanism of inheritance of these seven pairs of contrasting traits/characteristics from parents to offspring, Mendel conducted different types of crosses such as monohybrid crosses, dihybrid crosses and test crosses.

4.5.2 Monohybrid crosses

- A monohybrid cross is a cross between two parents to study the inheritance of a single character from each parent. Mendel performed seven types of monohybrid crosses, each involving contrasting traits for different characteristics.
- Mendel first conducted a self-cross, that is, tall with tall, dwarf with dwarf, violet with violet, etc., to verify the purity of plants in which a tall plant produces only tall offspring in successive crosses, and a dwarf plant produces only dwarf plants. He did the same self-cross for all the traits (14 traits). He found that the seven pea plant characteristics were consistent in generation after generation of self-fertilization, and they were considered pure lines/true lines. Then, he began his experiments using purebred lines for contrasting characters.
- He cross-pollinated two pure lines for contrasting characters and the resultant offspring were called the F1 generation (also called the first filial generation). In this generation, one of the traits was always seen in the offspring but not the other one.
- The F1 generations were then self-pollinated which gave rise to the F2 generation (also called the second filial generation). In this generation, both traits were observed. Mendel counted the number of second-generation (F2) progeny with dominant or recessive traits and found a 3:1 ratio of dominant to recessive traits. This means when the F1 generation self-crossed, he observed that three of the offspring out of four were phenotypically the same whereas one was different. He called the characters that appear in the F1 generation **dominant** traits and those that appear for the first time in the F2 generation **recessive** traits.
- He used **capital letters** to denote the dominant allele of a gene and **small letters** for recessive alleles of a gene. His cross can be easily shown through a Punnett Square.
- A **Punnett square** is a chart used to determine the expected ratios of the possible genotypes and phenotype in the offspring of two parents (probabilities). This is because it is drawn to predict all the possible outcomes of all the possible random fertilization events and their expected frequencies.
- The following example shows the monohybrid cross for tall plants with homozygous dominant genotype (TT) and dwarf/short plants with homozygous recessive genotype (tt) using the

Punnett square. The first column and row show parental generation. The second column and row show the gametes of the two plants. The box shows the first hybrid generation or F1 generation with genotype (Tt). All offspring (F1) are Tt, possessing the dominant tall gene (T) and the recessive short gene (t). The phenotype of the F1 generation is tall and the genotype is heterozygote dominant.

	Parents Tall plant (TT)	
Short Plant (tt)	T	T
t	Tt	Tt
t	Tt	Tt

- F1- First hybrid generation
- All tall (phenotype)
- All Tt (Genotype
- Mendel self-crossed the F1- first hybrid generation (heterozygote dominant genotype (Tt)) and obtained both tall and short plants. The box shows the second filial generation or F2 generation with genotypes TT, Tt, Tt and tt, with a genotypic ratio of 1:2:1 and a phenotypic ratio 3:1. This implies that Mendel observed that 3/4th of the offspring possess at least one copy of the dominant tall gene, whereas 1/4th of the offspring possess two copies of the short gene. In other words, the phenotype of the F2 generation is 3 tall and 1 short and the genotype is 1 TT, 2 Tt and 1 tt.

	Parents Tall plant (Tt)	
Tall Plant (Tt)	T	T
T	TT	Tt
T	Tt	Tt

- F2 second filial generation
- Phenotypic ration : (3 tall :1short)
- Genotypic ratio : (1TT: 2Tt: 1tt)

- In this way, Mendel followed the inheritance of all the seven pair of contrasting traits and found that the paired pea traits were either dominant or recessive, as shown below. He identified round (RR), yellow (YY), inflated (II), green (GG), purple (PP), axial (AA) and tall (TT) as dominant trait and wrinkled (rr), green (yy), constricted (ii), yellow (gg), white (pp), terminal (aa) and short (tt) as recessive trait.

- **Mendel drew the following conclusions**:
- Each parent in his F1 generation starts with two hereditary "factors." One factor is dominant and the other is recessive.
- The factors separate in the parent. Only one factor from each parent is contributed to the offspring.
- Each offspring inherits one factor from each parent. If the dominant factor is present, it will be expressed even if the recessive factor is also present. The recessive factor will be expressed if only recessive factors are present.

4.5.3 Dihybrid Cross

- A dihybrid cross is a cross between two traits of individuals at a time. It is a cross between two entities of two different traits such as round seed shape-yellow pod color and wrinkled seed shape-green pod color. The cross between round-yellow seed (RRYY) and wrinkled-green seed (rryy) resulted in all round yellow seeds (RrYy). This is the F1 generation. The outcome of the cross between F1 generations (RrYy x RrYy) resulted in round-yellow, wrinkled-yellow, wrinkled-green and round-green, as follow.

F1 Generation	Male gametes			
Female gamete	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYy	RrYy	rrYY	rrYy
Ry	RrYy	Rryy	rrYy	rryy

- F2 generation
- Phenotype

- Round Yellow = 9
- Round green = 3
- Wrinkled Yellow = 3
- Wrinkled green = 1
- 9:3:3:1 phenotypic ration
- Genotype : 1:2:2:4:1:2:1:2:
- From monohybrid and dihybrid crosses, Mendel discovered the two foundational laws of inheritance.
- These are the **laws of segregation** and the **law of independent assortment**.

The Law of segregation

- The Law of segregation is the first Mendel's law of heredity discovered from a monohybrid cross. It states that a diploid organism passes alleles for a trait randomly to its offspring, whereby the offspring receives one allele from each parent. In essence, the law states that copies of genes randomly separate or segregate during meiosis so that each gamete receives only one allele.
- Gregor Mendel crossed various pure lines of garden peas and observed that traits are inherited as alternate states of independent units of inheritance or genes (factors), and that these units come in pairs. Each unit of inheritance can have alternate states (alleles) that segregate at meiosis, during which each gamete receives only one al ele. This is called the law of segregation.
- The physical basis of Mendel's law of segregation is the first division of meiosis in which the homologous chromosomes with their different versions of each gene are segregated into daughter nuclei. As chromosomes separate into different gametes during meiosis, the two different alleles for a particular gene also segregate so that each gamete acquires one of the two alleles as chromosomes separate into different gametes during meiosis.

The Law of Independent Assortment

- The Law of independent assortment is the second Mendel's law of heredity which states that genes do not influence each other with regard to the sorting of alleles into gametes. This indicates that every possible combination of alleles for every gene is equal y likely to occur.
- According to this law, the separate genes for separate traits are passed independently of one another from parents to the offspring. The Law of independent assortment occurs in metaphase I of meiosis when pairs of chromosomes randomly align next at the center.
- For example, in the dihybrid cross with characteristics of seed color and seed texture for two pea plants, the one that has yellow, round seeds (YYRR) and another that has green, wrinkled seeds (yyrr) alleles sort into gametes independently and every possible combination of alleles for every gene is equally likely to occur.
- The genotype of the F1 generation of all offspring is YyRr. In the F2 generation, according to the law of independent assortment, a gamete in which an r al ele sorted would be equally likely to contain either a Y allele or a y allele.
- Here the chances of formation of gametes with the R allele and the r allele are 50:50. The chances of formation of gametes with the Y allele and the y allele are also 50:50. Thus, each gamete should have either R or r and Y or y.
- The Law of Independent Assortment states that the segregation of R and r is independent of the segregation of Y and y. Hence, four equal y likely gametes (YR, Yr, yR, and yr) can be formed when the YyRr heterozygote is self-crossed (see also the previous dihybrid cross}.

4.5.4 Test Crosses

- Another cross that was introduced by Gregor Mendel is a testcross. Knowing the genotypes of an individual is usually an important part of a genetic experiment. A test cross is How did Mendel determined the unknown genotype of a trait?
- A test cross used to determine the unknown genotype of an organism by crossing with a known homozygous recessive genotype. For example, when we cross a known parent of a homozygous recessive with an unknown parent and if the dominant trait is observed in all progenies, the unknown genotype is homozygous dominant. In contrast, when we cross a known homozygous recessive and an unknown genotype of parent and if the recessive trait is

manifested in any of their progenies, it means that the unknown genotype is heterozygous dominant.

- For example, if you have a pea plant with a purple flower it might be either a homozygote (PP) or a heterozygote (Pp). You can cross a purple flower to a white flower plant, because you know the genotype of a white flower plant is homozygous recessive (pp). If the phenotypic ratio in the F1 generation were all plants with purple flowers, the unknown genotype of the parent would be homozygous (PP). If the phenotypic ratio in the F1 generation were 1:1, the unknown genotype of the parent would be heterozygouse (Pp).
- In addition, Gregor Mendel introduced a backcross which is a cross between the F1 individual and either of the two parents. In a back cross, the F1 hybrid is crossed back with any of the parents, either recessive/or dominant.

4.6 SEX DETERMINATION

- During fertilization of egg by sperm, a zygote is produced and developed into either male or female. Sex refers to a set of biological attributes that are usual y categorized as female or male in organisms. Sex determination in organism is remarkably diverse. In some organisms, sex of both male and female resides within the same individual (hermaphroditic species), whereas other organisms have separate male and female sexes (dioecious) or may be haplodiploidy in which males develop from unfertilized eggs and are haploid, and females develop from fertilized eggs and are diploid.
- The sex of human beings and other mammalian is determined genetically by sex chromosomes. **Sex chromosome**: Either of a pair of chromosomes that determine whether an individual is male or female is designated by X and Y. In humans, out of 23 pairs of chromosomes, one pair is sex chromosomes and 22 pairs are autosomal chromosomes. Individuals having two X chromosomes (XX), are female, whereas individuals having one X chromosome and one Y chromosome (XY) are male.
- During meiosis, the sex chromosome pair of male XY and female XX separates. While male passes on an X or a Y to separate gametes, one-half of the gametes (sperm) contain the X chromosome and the other half gametes contain the Y chromosome. Female has two X chromosomes and passes on X chromosomes to egg cell. The eggs fertilized by X-bearing

sperm become females (XX), whereas those fertilized by Y-bearing sperm become males (XY).

- The process of sex determination begins after fertilization, a process where male and female gametes fuse to form a zygote, or a single-celled, fertilized egg. The following figure shows the separation of sex chromosomes during gamete formation by meiosis cell division and gamete combinations during fertilization for determining the sex of the offspring.

4.7 NON-MENDELIAN INHERITANCE

- Think about what you have learned from the theory of Mendelian inheritance, the mechanism of transmission of genetic material from parents to offspring. After Mendel revealed the results of his experiments with pea plants, other researchers also investigated the mechanism of inheritance and found that the dominance of some traits could not always hold true. Accordingly, several different patterns of inheritance have been revealed. The non-Mendelian Inheritance is a form of genetic Inheritance that is not in accordance with Mendel's law. Therefore, Non-Mendelian genetics are, therefore, any inheritance patterns that don't follow one or more laws of the Mendelian genetics.

- Gregor Mendel explained that gene might exist indifferent forms (alleles) that are either dominant or recessive. However, there are other conditions in which alleles show different dominance relationships (e.g. Co-dominance and Incomplete dominance) and modes of inheritance (Gene linkage and multipleallelism). These are examples of non-Mendelian inheritance.

4.7.1 Co-dominance, Incomplete dominance and Multiple alleles

Co-dominance

- Co-dominance is a condition in which both alleles are expressed equally rather than a dominant allele taking complete control over a recessive allele. This means that when an organism has two different alleles (heterozygote), it will express both alleles at the same time. Coat color is an example of co-dominance in short-horned cattle. The following example shows the cross between red and white cattle that produce ratio 1 red: 2 roans: 1 white coat color because of co-dominance. Heterozygous individuals (RW) show roan coat color as both the alleles express themselves equally.

Incomplete dominance

- Similar to co-dominance, in incomplete dominance, Mendel's principle of dominance is not applicable. In incomplete dominance, the mixes of genetic traits that produce an intermediate phenotype result in heterozygotes in terms of physical traits. The pink rose is a great example in which the white and red varieties of rose are hybridized resulting pink rose offspring. Example – Phenotype = whit rose; genotype = WW; phenotype = red rose; genotype = rr , F1 = all pink no one is dominant, either white or red F2 = 1 white, 2 pink, 1 red = 1:2:1

Multiple alleles

- Gregor Mendel suggested that each gene would have pair of factors (alleles), which are inherited from two parents (one from each parent). However, some genes exist in more than two alleles. In addition to co-dominance, the ABO blood group system in humans is an example of traits with multiple alleles because it exists in three allelic forms: **A**, **B**, and **O**. ABO blood group system is the classification of human blood based on the presence or absence of the antigens A and B on the surface of the red blood cells. As a result, people may have type A, B, O, or AB blood. This blood type classification refers to which of the certain proteins called antigens are found on the red blood cells.

- The A and B blood types are also co-dominant. Thus, if two people with AA and BB blood type alleles have children, every single child (male or female) from this couple would be heterozygotes (AB) with AB blood type.

- During blood transfusion, it is very important to determine the antigens and antibodies present in each of the ABO blood types. If someone has blood type A, this means that the person's red blood cells have the A antigen and the blood plasma contains anti-B antibodies.

- If this person were to receive a transfusion of type B or type AB blood, both of which have the B antigen, his/her anti-B antibodies would attack the transfused red blood cells. No antigen is associated with the O allele, so people with the OO genotype (type O blood) have no antigens for ABO blood types in their blood.

4.7.2 Rh factor inheritance in humans and its medical importance

- The Rh factor inheritance is the inheritance of a blood group other than the ABO blood group. The Rh factor is inherited independently of the ABO blood types. There are two different alleles for the

Rh factor known as Rh+ with dominant Rhesus D antigen and Rh- , without antigen. People who are Rh+/Rh+ or Rh+/Rh- genotype possess the Rh (D) antigen and are called Rh positive. People who are Rh-/Rh- do not possess the antigen are called Rh negative. Just like the ABO alleles, each biological parent transmits one of their two Rh alleles to their child.

4.7.3 Sex-linked inheritance in humans

- Sex in human is determined by two sex chromosomes. Females have two copies of the X chromosome (XX), whereas males have one copy of the X chromosome and one copy of the Y chromosome (XY). Because males have only one X chromosome, genes that are on the chromosome are expressed because there is no similar gene on the corresponding Y chromosome that masks them. Hence, men are far more likely to get sex-linked genetic diseases than women are.

- Men also have their own special Y chromosome that women do not possess. Hence, any gene on the X chromosome of male will be expressed regardless of whether it is dominant or recessive. Hemophilia is an example of sex-linked genetic diseases in humans. This gene is carried on the X chromosome and can only be passed on to males through their mother.

4.7.4 Environmental effects on phenotype

- Various organisms live in different environmental conditions, ranging from the hottest to the coldest areas, from watery to dry areas and from areas with ample food to those where there is a scarcity of food. The environment can affect the phenotype of these organisms.
- A phenocopy is an environmental y induced phenotype of an individual, which is identical to the phenotype of another individual determined by genotype. In other words, the phenocopy induced by the environmental conditions mimics the phenotype produced by a gene. Most of the time phenocopies can result from exposure to radiation, chemicals poisons, temperature shocks etc.
- An example of phenocopy due to temperature variation is observed in Himalayan rabbits. Himalayan rabbits have a white colored coat along with a black tail, nose, and ears when raised in moderate temperatures. However, they also show black coloration of their coats when raised in cold temperatures, resembling the genetically black rabbits.

4.8 HUMAN PEDIGREE ANALYSIS AND ITS IMPORTANCE

- In various plant and animal species, scientists study the inheritance of phenotypes, or traits, using carefully controlled mating experiments called crosses.
- However, it is practical y and ethical y difficult to cross human beings. Therefore, researchers analyze pedigrees, or family trees, to understand how human traits and diseases are inherited. A pedigree can show the transfer of some genetically determined disease from one person to another in a family.
- Specifically, it can show whether a trait is an autosomal dominant, autosomal recessive or X-linked trait. Pedigrees show relationships and identify individuals with a given trait from the history of a family.

Pedigree analysis

- A typical pedigree that consists of squares and circles which represents males and females, respectively. Rows show generations with the oldest generation at the top row and with each subsequent generation on separate rows. A horizontal line connecting two parents is called a "marriage line". A vertical line connects children to couples. Pedigree analysis can provide information about trait inheritance by examining the presence and absence of a trait throughout the history of a family. Pedigrees can give important clues about the risk of disease inheritance and propagation. In general analyzing pedigrees can reveal the following:

  - Whether a trait is dominant or recessive
  - The type of chromosome, autosomal or sex, a trait is linked to
  - The genotypes of family members, and
  - The probabilities of phenotypes in the future generations.

4.9 GENETIC DISORDERS

- A genetic disorder is a disease that is caused by a change, or mutation, in an individual's DNA. Mutation is a change in the DNA sequence of an organism due to either errors that occur during DNA replication or environmental factors**.** Parents pass genes on to their children, and some of these genes may contain genetic disorders. Some genetic disorders

are carried by a dominant allele, whereas others are carried by a recessive allele. Genetic disorders can be grouped into three main categories.

- Diabetes, cancer, Down syndrome, Turner syndrome, hemophilia, cystic fibrosis, and albinism are some of the commonly known genetic disorders, which can be further categorized as autosomal dominant, autosomal recessive, x-linked, chromosomal and multifactorial disorders in human being.

4.9.1 Single-gene disorders

- Single gene disorders are caused by defects in **one particular gene** due to changes or mutations that occur in the DNA. These disorders are known as **monogenetic disorders**.
- There are many well-known single-gene disorders. The pattern of inheritance depends on whether they are controlled by genes on autosomes or by genes on sex chromosomes. The three major patterns of Mendelian inheritance for genetic disorders and diseases are autosomal dominant, autosomal recessive, and X-linked.

A. **Autosomal dominant**

- Autosomal-dominant disorders are expressed in the heterozygous condition. Autosomal - dominant disorders are controlled by genes on one of human autosomes (22 pairs of non sex chromosomes) that do not differ between males and females. Therefore, autosomal- dominant disorders are inherited in the same way regardless of the sex of the parent or offspring.
- **Huntington's disease** is a well-known example of an autosomal dominant single-gene disease. Individuals with a single defective gene will have Huntington's disease later in life by a progressive neurodegenerative disorder.

B. **Autosomal recessive**

- Autosomal-recessive disorders are expressed in homozygous conditions. An autosomal recessive disorder will most commonly occur when both parents carry the trait and the offspring receives the defected gene from each parent. Cystic fibrosis and Albinism are autosomal recessive disorders controlled by a single autosomal gene with two alleles. Although both parents are the carriers off the trait, they are unaffected. A child with cystic fibrosis or albinism has inherited a defective gene from each parent.

C. **X-linked disorders**

- Sex-linked inheritances are control ed by genes on the sex chromosomes. Females have two X-chromosomes that have two alleles (XX) for any X-linked disorder. Therefore, they must inherit two copies of the recessive allele to express an X-linked recessive disorder, i.e. XhXh for hemophilia as indicated above. This explains why X-linked recessive disorders are less common in females than in males. Hemophilia, the blood-clotting disorder, is an example of a recessive X-linked disorder that is characterized by the blood's inability to clot normally.

4.9.2 Chromosome disorders

- Chromosome disorders are disorders resulting from changes in the number or structure of chromosomes. Because chromosomes are the carriers of the genetic material, abnormalities in the chromosome number or structure can result in disease. Chromosomal abnormalities typically occur due to errors during cell division.
- Down syndrome or trisomy 21(2n+1), is an example of the most commonly known genetic disorder that occurs when a person has three copies of chromosome 21, which results from an extra chromosome 21 (trisomy 21: three copies of chromosome 21). The most common types of chromosomal disorders occur due to the following.

- **Aneuploidy**: wrong number of chromosomes (2n-1, 2n-2, 2n+1, 2n+2, search the type of disorder for each).

- **Deletion:** a part of a chromosome is missing.

- **Inversion**: occurs when there are two breaks on a chromosome and the segment between the breakpoints flips around and reinserts back into the chromosome**;**

- **Translocation**: is a rearrangement of a chromosomal segment from one location to another.

4.9.3 Multifactorial disorders

- Multifactorial disorders are complex disorders caused by changes in the combination of multiple genes, complex interaction with environmental and lifestyle factors such as smoking, drinking alcohol, eating an unhealthful diet, not getting enough sleep and living in an area that has high levels of air pollution. Examples of multifactorial inheritance include diabetes and cancer.

4.10 GENETIC TESTING AND COUNSELING

- Genetic disorders have their own treatments. To treat these disorders, genetic testing is important to identify the type of the disorder.
- Genetic counseling is also important because diseases caused by genetic disorders are complicated and may have different psychological and social impacts. There are different diseases that are caused by genetic disorders. Such as diabetes, cancer, Down syndrome, Turner syndrome, hemophilia, cystic fibrosis, Huntington's disease, muscular dystrophy, epilepsy and albinism are the most common ones.
- Genetic testing examines the genetic material and tells an individual about the likelihood and risk of passing genetic disorders on to children. It identifies the likelihood of parents who pass a genetic disease or disorder to their children. Genetic testing examines if there are any change in our DNA that can inform us the well-being of our health of us and our family. For instance, a woman may have diagnostic tests as part of her pregnancy checkups and scans to find out if her baby has a genetic disorder or not. Amniocentesis and chorionic villus sampling are examples of diagnostic tests to be taken during pregnancy.
- Genetic counseling is the process of checking a family with regard to the medical history and medical records, ordering genetic tests, evaluating the results of these tests and recording, and helping parents understand and reach decisions about what to do next. It helps to make informed decisions about genetic testing. It gives information about how genetic disorders might affect one's family in order to increase understanding of genetic disorders that are inherited in the family. Genetic counselors can help people in identifying and interpreting the risks of an inherited disorder, explaining inheritance patterns and suggesting genetic testing.

4.11 GENE THERAPY

- It is important here to recal that the genetic disorders discussed above which are caused by a change on the DNA of an organism can be transmitted from generation to generation and other types of disease affect human beings. There are different mechanisms by which we treat these disorders. One of these treatment mechanisms is called gene therapy. Gene therapy is the technique that introduces genes into the existing cells to modify a person's genes to prevent or cure a wide range of diseases (Figure 37). The promising development in using gene therapy ttreat a brain tumor that

develops from rapidly dividing cancer cells, which are caused by some defective or mutated gene is an example for this therapy.

- There are two different types of gene therapy depending on the types of cells are treated. These are:
- **Somatic gene therapy** refers to transferring a section of DNA to somatic cells and the effects will not be passed onto the patient's children.
- **Germ line gene therapy** refers to transferring a section of DNA to sex cells and the effects will be passed onto the patient's children and subsequent generations.
- Gene therapy can be done through different mechanisms, such as by replacing a disease-causing gene with a healthy copy of the gene, inactivating a disease-causing gene that is not functioning properly and introducing a new or modified gene into the body to help treat the disease. To do this, there are different types of gene therapy products. It includes plasmid DNA, viral vectors, bacterial vectors, human gene editing technology and patient-derived cellular gene therapy products. These are used to introduce curative genes into the patient and edit the infected genes.

- **Plasmid DNA uses** DNA molecules to carry curative genes into human cells.
- **A viral vector uses** modified viruses as vectors (vehicles) to carry curative genes into human cells.
- **Bacterial vectors** use modified bacteria as vectors (vehicles) to carry curative genes into human tissues.
- **Human gene editing technology** is used to disrupt harmful genes or to repair mutated genes.
- **Patient-derived cellular gene therapy products use** cells removed from the patient genetically modified and then returned them to the patient.
- Although gene therapy is a promising treatment option for a number of diseases, there are challenges. Some of the challenges are related to delivering the gene to the right place and switching it on, avoiding the immune response, making sure the new gene does not disrupt the function of other genes and the cost of gene therapy.

4.12 BREEDING

- Farmers and agricultural experts have used in your area to select varieties of animals and plants based on some desired characteristics, and the ways they breed to have such desired characteristics

in the future. Breeding that involves male and female to produce off spring is sexual reproduction in animals or plants. Breeding is also the application of genetic principles in animal husbandry, agriculture, and horticulture to improve desirable qualities. Breeding can occur through selective breeding/artificial selection or natural selection.

- **Selective breeding** is the selection of individual animals or plants that show the most desirable characteristics for the next generation in the breeding program. It is a scientific process of animals and plants to select and develop particular phenotypic traits (characteristics) by choosing which typically animal or plant males and females will sexual y reproduce and have offspring together. Selective breeding utilizes the natural variations in traits that exist among members of any population.

- **Plant breeding** is the science of changing the traits of plants in order to produce desired characteristics. It has been used to improve the quality of nutrition in products for humans and animals. The goals of plant breeding are to produce crop varieties that boast unique and superior traits for a variety of agricultural applications. The most frequently addressed traits are those related to biotic and abiotic stress tolerance (resistance against drought, high temperature, salinity, flooding, and insect pest infestation). Plant breeding is also applied to improve grain or biomass yield, end-use quality characteristics such as taste or the concentrations of specific biological molecules (proteins, sugars, lipids, vitamins, fibers) and ease of processing (harvesting, milling, baking, malting, blending, etc).

- Plant breeding can be carried out through many different techniques ranging from simply selecting plants with desirable characteristics for propagation, to utilizing methods that make use of knowledge of genetics and chromosomes, to more complex molecular techniques. Some of them are mass selection, pure line selection and bulk selection.

- **Mass selection method:** In mass selection, a large number of plants of similar phenotype are selected and their seeds are mixed together to constitute the new variety. Mass selection is the simplest form of plant breeding that was practiced in agriculture by early humans.

- **Pure line selection:** In this method, a large number of plants are selected from self- pollinated crops and are harvested individually by which individual plant progenies from them are evaluated and best progeny is released as pure line variety

- **Bulk method**: In this, F2 and the subsequent generations are harvested in mass or as bulk to rise the next generation. At the end, individual plants are selected and evaluated.

- **Animal breeding** consists of choosing the desired quality characteristics, selecting the breeding stock, and determining the breeding system. Humans have selectively bred plants and animals for thousands of years. Selective breeding involves choosing parents with particular characteristics to breed with each other to produce offspring with more desirable characteristics. The two types of selective breeding/artificial selection are:

- **Inbreeding**: is inbreeding is the process of producing offspring through mating genetically similar organisms. After many generations of inbreeding, the offspring will be almost genetically identical and will produce identical offspring. When this happens, an organism is described as inbred or purebred. Pure breeds are animals with homogeneous appearance, behavior and other characteristics. Purebred breeding aims to establish and maintain stable traits that the animal can pass on to the next generation that could help to develop superior qualities. The negative consequence of inbreeding is that it makes the expression of undesired recessive traits in the family more likely.

- **Crossbreeding**: is the process of producing offspring through mating two purebred individuals that come from different breeds, varieties, or even species. Crossbreeding involves breeding two unrelated individuals. For instance, crossbreeding of the local breeds with exotic sires. Crossbreeding is incompatible with the conservation of indigenous breeds. Examples of selective breeding of sheep with long tails, with long horn sheep and wheat and Borena cattle and Camel breeds in Ethiopia.

- Ethiopians have practiced breeding of animals and plants for the past many years and are still practicing selective breeding of seeds, fruits, cattle, goats and sheep. The following section deals with the indigenous knowledge used by Ethiopians in breeding animals and plants.

4.12.1 Indigenous knowledge of Ethiopian farmers

- Ethiopia is home for a large and diverse livestock and crop resources and favorable production environments. According to the Central Statistics Agency, CSA, 2020a, Ethiopia has the largest livestock population in Africa, with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels and 49 million chickens in 2020. Ethiopia is one of the richest genetic resource centres in the world in terms of crop diversity. Crop plants such as coffee, safflower, tef, noug, anchote, enset, wheat, barley, sorghum, peas, linseed, castor, finger mil et, lentil and oats are widely produced in Ethiopia.

- Production of crops and livestock accounts for the largest share of the economic contribution of the agricultural sector in Ethiopia. Five major cereals (teff, wheat, maize, sorghum, and barley) are the core of Ethiopia's agriculture and food economy. Ethiopia's crop agriculture and livestock production are complex, involving substantial variation in crops grown and livestock reared across the country's different regions and ecologies. Livestock rearing of sheep and goats and different crops in Ethiopia has been practiced under the traditionally extensive systems with indigenous knowledge preserved among farmers for many years.

- People in the community have their own accumulated knowledge about natural phenomena or events, challenges such as diseases and their effects on agriculture practices and living systems in their environment. They have their own indigenous knowledge and practices on how to combat environmental changes, diseases and plant and animal reproduction. They have indigenous knowledge on the selection of desired characteristics, breeding and management practices on their agricultural activities. For example, indigenous knowledge in selecting the desired quality based on growth rate, body size, resistance to disease and other environmental conditions.

4.13 BIOINFORMATICS INTRODUCTION

- In the era of information technology or the digital world, there is a need to find new ways of studying biology. Bioinformatics that considers the digital world into account is one of the modern ways of studying biology. Bioinformatics is a modern, growing hybrid field that links biology, computer science, and information technology to support the storage, organization, and retrieval of biological data

- It is the design, constructions and use of software tools to generate, store, interpret and analyze data and information related to biology.
- Bioinformatics provides tools to comprehensively analyze and save large amounts of biological data that would be impossible to investigate without informatics-based approaches. Bioinformatics has also become useful to improve the diagnosis and detection of diseases, to promote vaccine development by screening databases for pathogen genomes, and to increase our understanding of evolutionary processes through the analysis of nucleotide/protein sequence mutations.
- The field of bioinformatics incorporates three main areas: 1) genomics, 2) proteomics, and 3) systems biology. Genomics includes DNA sequence data, whereas proteomics deals with the function, shapes, interactions, and abundance of proteins. Systems biology that examines the extensive role of protein and DNA interactions on the function of cells, tissues, and organs, as a whole is the most recent and complex branch in the field of bioinformatics. Systems biology can describe the pathway of enzymes and their various metabolites by using computer data models. It can illustrate brain function by using computer images.

UNIT FOUR SUMMARY

- The genetic material of an organism is DNA that carries genetic information and passes it on from one generation to the next generation to perpetuate life. The genetic material in viruses is RNA. DNA is ladder like double helix material twisted into a spiral shape and composed of nucleotides made of a sugar, phosphate group and four types of nitrogenous bases Adenine (A), Thymine (T), Guanine (G) and Cytosine (C). RNA is a single strand composed of nucleotides made of sugar ribose, phosphates, and the nitrogenous bases adenine (A), guanine (G), cytosine (C) and uracil (U).In base pairing rules, 'A' pairs with 'T' and 'C' pairs with 'G' in DNA and 'A' with 'U' in RNA. The function of DNA is to store all of the genetic information that determines the characteristics of an organism, whereas the function of RNA is to synthesize protein and it is used as storage of genetic information in some viruses. DNA has an ability to copy itself by the process of replication.
- Cell division has made the growth and transfer of the information stored in the DNA from one cell to another cell and from generation to generation possible. There are two types of cell divisions:

mitosis and meiosis. Mitosis is the division of somatic cells to produce two new, identical daughter cells at the end of series of steps. Meiosis is the division of sex cells. It occurs in two phases: meiosis I and Meiosis II and at the end produces four different daughter cells with haploid number of chromosomes due to crossing over or genetic recombination and reduction of chromosome numbers.

- Protein synthesis is the process of making proteins from amino acids through the process of Transcription and Translation. The process involves **DNA, RNA** (mRNA, tRNA and rRNA), amino acids, various **enzymes** and ribosome. During transcription, mRNA read instruction from DNA used to produce polypeptides during translation.
- Gregor Mendel, the Austrian monk, explained the mechanism of transfer of trait from one generation to the next generation and sometimes not and the principles of heredity. The pattern of inheritance of traits, which are controlled by a single gene with two alleles from parent to their offspring, is called Mendelian inheritance.
- Mendel conducted monohybride cross and dyhibrid crosses, and explained the two foundational principles of inheritance: The law of segregation, and the law of independent assortment. Gregor Mendel conducted a Monohybrid cross between homozygous dominant genotype and homozygous recessive genotype plants, which resulted in all heterozygote dominant genotype (F1generation and crossed F1 with F1 and resulted F2generation with phenotypic ratio 3:1 and genotypic ratio 1:2:1 for all traits he studied.
- A test cross is used to determine the unknown genotype of a dominant phenotype by crossing unknown genotype (dominant phenotype) with known homozygous recessive genotype. The law of segregation states that copies of genes randomly separate or segregate during meiosis so that each gamete receives only one allele. On the other hand, the law of independent assortment states that separate genes for separate traits are passed on independently of one another from parents to the offspring.
- In humans and other mammals, sex is determined by sex chromosomes that determine whether an individual is male or female, designated by X and Y. Individuals having two X chromosomes (XX),

homozygous for X, are females; individuals having one X chromosome and one Y chromosome (XY), heterozygous, are males.

- The types of inheritance such as co-dominance, incomplete dominance, gene linkage and multiple alleles are called non-Mendelian Inheritance. When both alleles are expressed equally rather than a dominant allele taking complete control over a recessive allele, it is called co-dominance, whereas when an intermediate phenotype results in heterozygote, it is called incomplete dominance. Sex-linked is a trait influenced by genes located on the sex chromosomes, mainly X chromosome because an X chromosome is large and contains many more genes than the smaller Y chromosome. The phenotype of an organism can also be determined by environmental factors. An example is phenocopy, an environmentally induced phenotype of an individual.

- A pedigree shows how a gene that passes on from one generation to the next generation in a family determines the characteristics or genetically determined diseases in humans. It can also show whether a trait is an autosomal dominant, autosomal recessive or X-linked trait.

- A genetic disorder is a disease that is caused by a change or mutation in the body cells of an individual's DNA that passes on from parents to their children. It can be single gene disorders (autosomal dominant, autosomal recessive, x-linked), chromosomal or multifactorial disorders, which indicate that genetic testing and counseling is important.

- Genetic testing examines the presence of disorders on genetic materials and tells an individual about the likelihood and risk of passing genetic disorders on to their children, whereas genetic counseling involves checking the medical history and records of a family to order to conduct genetic tests. Then, it evaluates the results of these tests with regard to the genetic disorder to help parents understand and reach decisions about what to do next about the disorder.

- Gene therapy is the technique of the introduction of genes into the existing cells to modify a person's genes to prevent or cure a wide range of diseases through somatic gene therapy or Germ-line gene therapy

- Breeding is a scientific practice of sexual reproduction and the application of genetic principles that involve male and female to produce offspring in animals or plants. It involves crossbreeding and inbreeding.
- Local communities have accumulated knowledge about their environment and their practices particularly in agriculture by which the main activity for the majority of the people is to sustain their life. People in the community have their own indigenous knowledge and practices in selective breeding and on how to combat environmental changes, diseases, plant and animal reproductions.
- The development of technology has resulted in new science called bioinformatics, which is an information technology that uses software tools to support the storage, generation, organization, and retrieval of biological data, interpretation and analysis of biological information and data.

Unit four review questions

I. Multiple-choice questions

Direction: Choose the correct answer from among the given alternatives.

1. The primary function of DNA and RNA are _____ and _____ respectively.

A. Storing information, making proteins

B. Making proteins, storing information

C. Making nucleotides, storing energy.

D. Storing energy, making nucleotides

2. If one of the DNA strand has the nucleotide sequence of 5'-CGA TTG CTA-3', what would be the nucleotide sequence of on the second strand?

A. 5'-GCU AAC GAA-3' C. 5'-GTT AGC GAT-3'

B.3'-GCT AAC GAT-5' D. 3'-CAA TCG GTC-5'

3. During which step of cell division does crossing over occur?

A. Prophase II **C**. Prophase I

B. Metaphase I D. Metaphase II

4. Assume that a homozygous black color (BB) is crossed with a homozygous white color (bb).

What is the probability that an offspring will have black color?

A.25 percent **C.** 100 percent

B.50 percent D. 75 percent

5. Assuming that both parent plants in the diagram below are homozygous. Why would all of the f1 generation have yellow phenotypes? It is because:

A. The f1 genotypes are homozygous

B. Yellow is dominant over green

C. Both parents passed on yellow alleles

D. Yellow is recessive for the trait

6. Pea plants were particularly well suited for use in Mendel's breeding experiments for all of the following reasons except that:

A. Peas show easily observed variations in a number of characters

B. It is possible to completely control mating between different pea plants.

C. Peas have an unusually long generation time.

D. Many of the observable characters that vary in pea plants are controlled by single genes

7. Which parental genotypes could possibly have all four blood groups expressed in their offspring?

A. I^Bi and ii C. I^AI^B and ii

B.I^AI^A and I^Ai **D.** I^Ai and I^Bi

8. Why are X-linked traits more common in males than in females?

A. All alleles on the X chromosome are dominant.

B. All alleles on the Y chromosome are recessive.

C.A recessive allele on the X chromosome will always produce the trait in a male.

D. Any allele on the Y chromosome will be codominant with the matching allele on the X chromosome

9. Hemophilia is an X-linked recessive disorder in humans. A hemophiliac man and a non-hemophiliac woman who has hemophilic son. What is their chance of having hemophilic daughter?

A.75% **B.**0% C.50% D.25%

10. Assuming that equal ratio, if a mating has already produced 3 girls, what is the probability that the next 3 children will be boys..

A.1 C. 1/8

B. ½ D. 3

11. Two true-breeding stocks of pea plants are crossed. One parent has red, axial flowers and the other has white, terminal flowers; all F1 individuals have red, axial flowers. If 1,000 F2 offspring resulted from the cross, approximately how many of them would you expect to have red, terminal flowers? (Assume independent assortment).

A.65 C. 750

B.B. 190 D. 250

12. Protein synthesis includes which of the following two processes?

A. Replication and transcription C. Transcription and translation

B. Replication and cell division D. Replication and translation

13. If a portion of a messenger RNA molecule contains the base sequence A-A-U, the corresponding transfer RNA base sequence is

A.A-A-U C. T-T-C

B. G-G-T D. U-U-A

14. What is the role of tRNA during translation?

A. Carry amino acids to the mRNA for correct placement into the protein chain

B. bond to open the DNA strand to carry the code for protein synthesis out of the nucleus

C. Carry ribosomes to the site of protein synthesis

D. Break a party mRNA and send it back to the nucleus so that it can be reused

15. In a species of rabbits, there are several alleles that control for coat color. The allele B results in a brown coat color. The allele b results in a beige coat color. The two alleles are co-dominant. What phenotype is a rabbit likely to display with the genotype Bb?

A. All beige coat C. Brown coat with beige patches

B. All brown coat D. All white coats

16. Which of the following events occurs during the metaphase of mitosis?

A. The nuclear membrane reforms around the chromosomes.

B. Chromosomes move to the middle of the cell, attached to microtubules.

C. Chromosomes begin to segregate and the enzyme separate cleaves the centromere

D. The chromosomes condense and the centrosomes move to opposite sides of the cell.

17. If a plant with genotype AaBb is self-fertilized, the probability of getting AABB genotype will be

(A and B are not linked)

A. 1/2 C. 1/8

B. 1/4 D. 1/16

18. A form of vitamin D-resistant rickets, known as hypophosphatemia, is inherited as an X-linked dominant trait. If a male with hypophosphatemia marries a normal female?

A. All of their sons would inherit the disease

B. All of their daughters would inherit the disease

C. About 50% of their sons would inherit the disease

D. About 50% of their daughters would inherit the disease

19. Which of the following is the most likely explanation for a high rate of crossing-over between two genes?

A. The two genes are far apart on the same chromosome.

B. The two genes are both located near the centromere.

C. The two genes are sex-linked.

D. The two genes code for the same protein.

20. In the pedigree below, squares represent males and circles represent females. Individuals who express a particular trait are represented by shaded figures. Which of the following patterns of inheritance best explains the transmission of the trait?

A. Sex-linked dominant C. Autosomal recessive

B. Sex-linked recessive D. Autosomal dominant

21. Which of the following is not an aspect of animal breeding?

A. Improve desirable qualities of breed's C. Making diseased organisms

B. Increasing the yield D. making disease resistance breeds

22. What is the basic genetic effect of inbreeding?

A. Increased homozygosity C. Increased heterozygosity

B. Decreased homozygosity D. No effect on heterozygosity

23. The desired varieties of economically useful crops are raised by

A. Vernalization C. Mutation

B. Hybridization D. Natural selection

24. A plant breeder wants to develop a disease resistant variety. What should he do first?

A. Hybridization C. Selection

B. Mutation D. Production of crop

25. Which of the following type of animals breeding is used to develop a pure line in any animal?

A. Inbreeding C. Crossbreeding

B. Outcrossing D. Hybridization

26. Which method of crop improvement can be practiced by a farmer, if he is in experienced?

A. clonal selection C. pure line selection

B. mass selection D. hybridization

27. Which of the following marriage is not good for the offspring?

A. Rh-women and Rh + man C. Rh+ women Rh- man

B. Rh-woman Rh- man D Rh+ women Rh+ man

II. Short answer

Direction: Write a short answer for each questions

1. What is the difference between law of segregation and law of independent assortment? Give example.

2. If a pea plant with axial flower cross-pollinated with a plant with terminal flower, what would be the genotypic and phenotypic ratio of F1 and F2 generations? Show the cross using punnett square.

3. To identify the genotype of yellow-seeded pea plants as either homozygous dominant (YY) or heterozygous (Yy), you could do a test cross with plants of which genotype? Draw the Punnett square that illustrates the test cross.

4. What fraction of the offspring of the cross AaBb X AaBb would show the dominant phenotypes for both genes?

5. Three babies are born in the hospital on the same day. Baby X has type B blood; Baby Y has type AB blood; Baby Z has type O blood. Use the information in the following table to determine which baby belongs to which couple. (Assume that all individuals are homozygous dominant for the gene.)

Couple	Father	Blood type	Mother	Blood type
I	Mr. 1	B	Ms. 1	AB
II	Mr. 2	A	Ms. 2	A
III	Mr. 3	O	Ms. 3	B

Answer key for review questions

I. Multiple Choice Question

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

III. Answer of short answer part

1. What is the difference between law of segregation and law of independent assortment? Give example.

Answer:

- **Law of segregation** states that a diploid organism passes alleles for a trait randomly to its offspring, whereby the offspring receives one allele from each parent. In essence, the law states that copies of genes randomly separate or segregate during meiosis so that each gamete receives only one allele.

- For example, As chromosomes separate into different gametes during meiosis, the two different alleles for a particular gene also segregate so that each gamete acquires one of the two alleles as chromosomes separate into different gametes during meiosis.
- **Law of independent assortment** states that genes do not influence each other with regard to the sorting of alleles into gametes. This indicates that every possible combination of alleles for every gene is equally likely to occur.
- For example, in the dihybrid cross with characteristics of seed color and seed texture for two pea plants, the one that has yellow, round seeds (YYRR) and another that has green, wrinkled seeds (yyrr) alleles sort into gametes independently and every possible combination of alleles for every gene is equally likely to occur.

2. If a pea plant with axial flower cross-pollinated with a plant with terminal flower, what would be the genotypic and phenotypic ratio of F1 and F2 generations? Show the cross using punnett square.

Answer

Parental type		**Axial flower (AA)**	
Terminal flower (aa)		Gametes	
		A	A
Gametes	a	Aa	Aa
	a	Aa	Aa

- F1- First hybrid generation
- All tall (phenotype)
- All Aa (Genotype
- Mendel self-crossed the F1- first hybrid generation (heterozygote dominant genotype (Aa)) and obtained both axial and terminal flower. The box shows the second filial generation or F2 generation with genotypes AA, Aa, Aa and aa, with a genotypic ratio of 1:2:1 and a phenotypic ratio 3:1. This implies that Mendel observed that $3/4^{th}$ of the offspring possess at least one copy of the dominant tall gene, whereas $1/4^{th}$ of the offspring possess two copies of the short gene. In other words, the phenotype of the F2 generation is 3 axial and 1terminal and the genotype is 1 AA, 2 Aa and 1 aa.

Parental type		Hybiid flower (Aa)	
Hybiid flower(Aa)		Gametes	
		A	a
Gametes	A	AA	Aa
	a	Aa	aa

- F2 second filial generation
- Phenotypic ration : (3 axial :1 terminal)
- Genotypic ratio : (1AA: 2Aa: 1aa)

3. To identify the genotype of yellow-seeded pea plants as either homozygous dominant (YY) or heterozygous (Yy), you could do a test cross with plants of which genotype? Draw the Punnett square that illustrates the test cross.

- **Answer:** You can cross yellow-seeded (YY) pea plants to a green seeded (yy) plant, because you know the genotype of green seeded homozygous recessive (yy).
- If the phenotypic ratio in the F1 generation were all yellow seeded plants, the unknown genotype of the parent would be homozygous (YY).

x	**y**	**y**
Y	Yy	Yy
Y	Yy	Yy

- If the phenotypic ratio in the F1 generation were 1:1, the unknown genotype of the parent would be heterozygouse (Yy).

X	**y**	**y**
Y	Yy	yy
Y	Yy	yy

3. What fraction of the offspring of the cross AaBb X AaBb would show the dominant phenotypes for both genes?

Answer

AABBXaabb →ABx ab →AaBb x AaBb→ AB, Ab,aB,ab x AB,Ab,aB,ab

X	AB	Ab	aB	ab
AB	**AABB**	**AABb**	**AaBB**	**AaBb**
Ab	**AABb**	**AAbb**	**AaBb**	**Aabb**
aB	**AaBB**	**AaBb**	**aaBB**	**aaBb**
ab	**AaBb**	**Aabb**	**aaBb**	**aabb**

- **AABB, AABb,AABb,AaBb,AaBb,AaBb,AaBb,AaBB,AaBB**
- **aaBB,aaBb,aaBb**
- **Aabb,Aabb,AAbb**
- **aabb** **Phenotypic ratio: 9:3:3:1**

5. Three babies are born in the hospital on the same day. Baby X has type B blood; Baby Y has type AB blood; Baby Z has type O blood. Use the information in the following table to determine which baby belongs to which couple. (Assume that all individuals are homozygous dominant for the gene.)

Couple	**Father**	**Blood type**	**Mother**	**Blood type**
I	Mr. 1	B	Ms. 1	AB
II	Mr. 2	A	Ms. 2	A

Answer:

Couple	Parents		Children	
	Phenotype	Genotype	Phenotype	Genotype
I	BxAB	I^AI^A or I^Ai x I^AI^B	A, AB, B	I^AI^A, I^AI^i, I^Bi, I^AI^B
II	AxA	I^AI^A or I^Ai x I^AI^A or I^Ai	A,O	I^AI^A, I^AI^i, ii
III	OxB	ii x I^BI^B or I^Bi	O,B	ii, I^Bi

UNIT FIVE

THE HUMAN BODY SYSTEMS

- The human body is a biological machine made of body systems and groups of organs that work together to produce and sustain life. The human organ systems include the integumentary system, skeletal system, muscular system, lymphatic system, respiratory system, digestive system, nervous system, endocrine system, cardiovascular system, urinary system and reproductive systems. However, in this unit, we shall discuss only the musculoskeletal and reproductive systems.

5.1. HUMAN MUSCULOSKELETAL SYSTEMS

- The human musculoskeletal systems are organ systems that give humans the ability to move. Muscles and skeletal systems are musculoskeletal systems that provide the human body with shapes and forms and protect the vital organs of musculoskeletal systems. Musculoskeletal systems bind organs together, support stability, allow bodily movements and produce blood cells for the body (bone marrow) and stores minerals.
- Musculoskeletal system is a body structure made up of bones of the skeletons, muscles, cartilages, tendons, ligaments, joints and connective tissues. Musculoskeletal system is a body structure made up of bones of the skeleton, muscles, cartilage, tendons, ligaments, joints, and connective tissues.

- The human musculoskeletal system comprises:
  - **Muscles** keep bones in place and enable movements.
  - **Joints and cartilages** connect bones to bones and prevent them from rubbing against each other.
  - **Tendons** connect muscles to bones.
  - **Connective tissues**: internal skeletal system parts favoring positions and movements
  - **Ligaments** are fibrous connective tissues that attach bone to bone.

5.1.1. Types of muscles

- The human muscular systems include about 700 muscles that make up half of the human body weight and are responsible for the movement of the human body. Human muscles are discrete organs made of skeletal muscle tissues, blood vessels, tendons and nerves found attached to the bones of the skeletal system.
    - The human body is composed of three types of muscles:
    - Cardiac muscles
    - Skeletal muscles
    - Smooth muscles

1. The Cardiac muscles

- The cardiac muscle (heart muscle) forms a thick middle layer between the outer layer of the heart wall (pericardium), and the inner layer (endocardium) with blood supplied to circulate via the coronary circulation.
- The cardiac muscle is an involuntary striated muscle composed of tissues of the wall of the heart called **myocardium.** Individual cardiac muscle cells are joined together by intercalated discs and are encased by collagen fibers to form the extracellular matrix.

2. The Skeletal Muscle

- The skeletal muscles arranged in opposing systems around joints are attached to bones and are composed of 30 to 40% of total body mass (Figure 5.3). They allow the body to perform a wide range of movements and functions such as voluntary controlled systems on works. The skeletal muscle fibers innervated by a single motor axon are called a **motor unit.**

3. The Smooth Muscles

- The smooth muscles are involuntary, non-striated and unconsciously controlled muscles that control the flow of substances within the lumens. The Smooth muscles are muscles found in the walls of hollow organs: the stomach, intestine, bladder, uterus and walls of passageways of the blood and lymph vessels, respiratory tracts, urinary and reproductive systems, in the eyes and

the ciliary muscles. The smooth muscle cells of the skins are the erector of pili causing hair to stand erect in response to cold, heat or fear.

5.1.2. Mechanism of actions of skeletal muscles

- Mechanisms of action of muscles are the process of activations of muscle cells to generate tension or contract for movements. Skeletal muscles are bundles of muscle fibers with single large cells formed by the fusion of many individual cells during development. Most of the cytoplasm consists of myofibrils of cylindrical bundles of two types of filaments of thick filaments of myosin and thin filaments of actin where each is each organized as a chain of contractile unit called sarcomeres.
- Actin and myosin are both proteins found in every type of muscle tissue where the thick myosin filaments and thin actin filaments work together to generate muscle contractions and movement. Myosin is a type of molecular motor that converts chemical energy released from ATP into mechanical energy used to pull the actin filaments along causing muscle fibers to contract and generate.
- Actin filaments, together with myosin are responsible for many types of cell movements. The most noticeable form of movement is muscle contraction, which has provided the model for understanding actin-myosin interactions and the motor activity of myosin molecules.

What are mechanisms of action?

- Troponin is a complex system of three regulatory proteins integral to muscle contraction in skeletal muscles. In a relaxed muscle, tropomyosin blocks the attachment site for the myosin cross bridge preventing contraction. The binding of myosin to actin causes cross bridge formation and contraction of the muscle.

Mechanism of actions in muscles:

- **Muscle activation:** the motor nerve stimulates an action potential (impulse) to pass down a neuron to the neuromuscular junction and stimulates the sarcoplasmic reticulum to release calcium into the muscle cell.

- **Muscle contraction:** Calcium floods into the muscle cells bound with troponin allowing **actin** and **myosin** to bind, in which the actin and myosin cross bridges bind and contract, using ATP as energy that all cells use to fuel activity.

1. **Recharging:** ATP is re-synthesized (re-manufactured), allowing actin and myosin to maintain a strong binding state.

- **Relaxation:** relaxation occurs when stimulation of the nerve stops and pumps Calcium back into the sarcoplasmic reticulum breaking the link between actin and myosin. Actin and myosin return to unbound state causing the muscle to relax, but relaxation failure occurs if ATP is no longer available. In natural movements, the activity of locomotors and muscle contractions is multifaceted to produce changes in length and tension in a time-varying manner. Muscle contraction occurs when the two-inter-digitizing filaments, the thin actin and the thick myosin filaments, slide pass each other.

There are three types of muscle contractions:

- **Isometric**: does not change the length
- **Concentric**: shortening the muscle
- **Eccentric**: lengthening the muscle fibers

5.1.3. The human axial and appendicular skeletons

- The human skeletal system is a complex structure with two distinct divisions composed of fused and individual bones supported by ligaments, tendons, muscles, and cartilage. Humans are born with over 300 bones, but many of the bones fuse between birth and the end of maturity and remain with the average number of 206 bones in an adult skeleton. Bones have three different layers made from three different kinds of cells. The general structure of bones is a combination of a protein called collagen and a molecule called calcium phosphate that weave together to form a strong and lightweight structure.

- **Bones are composed of four types of cells. These are:**
- **Osteoblasts** involve in new bone formation.
- **Osteocytes** are mature bone cells that help to mature bones of newborns.

- **Osteoclasts** break down bones and help them to form into correct shapes.
- **Osteoprogenitor** are important in repair of fracture.
- **Based on their shapes, there are five different types of bones in the human body:**
- **Long bones** have long and thin shapes.
- **Short bones** have squat and cubed shapes.
- **Flat bones** have flattened and broad surfaces.
- **Irregular bones** have shapes that do not conform to the above three types.
- **Sesamoid bones** are small, flat bones and are shaped similarly to a sesame seed

Table.1 General classifications of bones

Types of bones	Names and parts
Long bones	Femur and tibia (bones longer than wide)
Short bones	Carpus (bone of wrists)
Flat bones	Cranium (skull), ilium (pelvis), sternum, and ribs
Irregular bones	Vertebrae, sacrum, coccyx, temporal, mandible, palatine, nasal,
Sesamoid bones	Small sesame seed-like bones that are embedded in the muscles

- **Functions of bones:**

1. **Support body and helping move:** bones hold up body **stability**, keep from collapsing to the ground, movement and body posture.

2. **Protecting the internal organs:** bones keep organs to be safe from hard impacts, punctures, and other forms of injury (ribs protect the heart and lungs, and the skull protects the brain).

3. **Producing blood cells:** certain types of bones make platelets, red blood cells, and white blood cells inside bones.

4. **Storing and releasing fat:** certain bones store fat and release when body needs energy.

5. **Storing and releasing minerals:** bones store necessary minerals when the levels are too high in the blood and release minerals when the body needs them (calcium, phosphorus, and vitamin D).

1. The axial skeleton

- The axial skeleton is the one that consists of the skull, trunk, and pelvis bones of the medial core of the body. The skull is composed of the cranium bones fitting together at joints (sutures) and the facial bones forming the lower front part, consisting of the eye, the ear, the nose, and the mouth cavities. Axial skeleton includes the jaw, or mandible, the upper jaw, or maxilla, the zygomatic, or cheekbone, and the nasal bone. The rib cage (thoracic cage) forms the thorax (chest) portion of the body and consists of 12 pairs of ribs with costal cartilage and the sternum.

Table.2 Parts of the axial skeleton parts

Parts of the axial skeleton	**Number of bones**	**Functions**
Skull (Cranium 8+Facial 14)	22	It holds and protects the brain
Ossicles (both ears, 3+3)	6	Auditory
Hyoid (neck)	1	Holds the head
Thoracic (rib cage)	24	It protects the heart and lungs.
Thorax (sternum)	1	Bind and handle the abdomen
Vertebral column	26	Holds up human body
Total bones	**80**	

2. The appendicular skeleton

- An appendicular skeleton is the portion of the skeleton that consists of 126 bones out of a total of 206 bones and supporting appendages. It includes skeletal elements, limbs, shoulder-supporting girdle, pectoral, pelvic girdle, and joined appendages. An appendicular skeleton is involved in the

locomotion of lower limbs and manipulation of objects in the upper limbs. It also consists of six major regions (Table 5.3).

Table 3 Parts of the appendicular skeleton

Appendicular skeleton parts	Number of bones
Shoulder girdles	4
Pelvis	2
Arms and forearms	6
Thighs and legs	8
Hands	54
Feet and ankles	52
Sum	126

- Total number of bones in the human body = axial + appendicular = 80 + 126 = 206

5.1.4. Joints

- Joints are the parts of the body where two or more bones meet with binding tissues and allow the body to produce movements.

5.1.4.1 Types of joints

- **The ball and socket joint:** the rounded head of one bone sits in the cup of another bone to permit movement in all directions (shoulder and hip joints).
- **Hinge joints:** like a door, a joint that opens and closes in one direction along one plane only (elbow and knee joints).
- **Condyloid joints:** joints that do not rotate but allow movements (finger and jaw).
- **Pivot joints** are rotary or trochoid joints in which one bone swivels in a ring (ulna, radius, and neck).
- **Gliding joints:** a plane joint that allows only limited movement by slipping smooth surfaces over one another (wrist joint).

6. Saddle joint: enables movement back and forth, side to side, and cannot rotate (thumb base).

1. Construct the human musculoskeletal system from local y available materials.

2. Robotic system

3. Label each part using scientific terms and count the bones.

4. Define the following terms and present them to the class.

- The muscular system
- The skeletal system
- The functions of the musculoskeletal system

5.2 THE REPRODUCTIVE SYSTEM

- The human reproductive system is the functional male and female reproductive organ systems. The function of the human reproductive system is to produce and deposit sperms in males and egg cells in females. Internal fertilization by sexual intercourse occurs when the male inserts his penis into a female's vagina and ejaculates sperm that pass through the cervix into the uterus and the fallopian tubes for the fertilization of the ovum (egg).

5.2.1. Human reproductive system (Male and Female)

The male reproductive systems

- The male reproductive system contains the external genital organs (penis, testes, and the scrotum) and internal parts (prostate gland, vas deferens, and urethra) that work together to produce **sperm (male gametes)**, **male sex hormones,** and other components of the semen.

1. The penis

- The penis is the male copulatory organ. The penis contains soft, spongy tissue as well as muscles, fibrous tissue, veins, arteries, and the urethra. These allow the penis to perform its functions. It has urinary and sexual functions. The sexual function of the penis can be described as two stages: erection and ejaculation. An erection is the stiffening of the penis caused by sexual arousal and/or physical stimulation. It is also normal for erections to occur during sleep and upon waking. An erection occurs when there is an increased flow of blood into the corpus cavernosa and corpus spongiosum.

- During an erection,arteries supplying the erectile tissues wil dilate (widen), causing the penis to engorge (fill) with blood. The engorgement compresses the veins through which blood usually exits the penis. This "traps" the blood and helps sustain the erection.

2. Urethra

- The urethra is a tube that connects the urinary bladder to the urinary meatus for the removal of urine from the body. In males, the urethra allows for the passage of urine from the bladder to the outside of the body (urination) and is also responsible for the expulsion of sperm during ejaculation.

3. The scrotum

- The scrotum is a sack of thick skin that protects the testes and controls the temperature of the testes for suitable sperm creation. It contains seminal vesicles, vas deferens, testicles (testes), and prostate gland that constitute all the remaining components of the male reproductive system.

4. Testes

- **Testes** are oval pair bodies found in the scrotum with two primary functions: Production of **testosterone** or male sex hormones and **sperm** (spermatogenesis).

Table.4 summary of male reproductive structures and their function

Structure	Function
testes	• produce sperm cells • produce the hormone testosterone
seminiferous tubules	• produce immature sperm cells
epididymis	• matures and stores sperm cells in coiled tubules
vas deferens	• Carries sperm from the epididymis to its junction with the urethra
seminal vesicle	secretes fructose into the semen, which

	provides energy for the sperm
prostate gland	secretes an alkaline buffer into the semen to protect the sperm from the acidic environment of the vagina
Cowper's gland	• secretes mucus-rich fluids into the semen that may protect the sperm from acids in the urethra
urethra	• carries semen during ejaculation • carries urine from the bladder to the exterior of the body
penis	• deposits sperm into the vagina during ejaculation • contains the urethra

The Female Reproductive Systems

- The female reproductive system includes the ovaries, fallopian tubes, uterus, vagina, accessory glands, and external genital organs. Its functions include producing gametes called eggs, secreting sex hormones (such as estrogen), providing a site for fertilization, gestating a fetus if fertilization occurs, and giving birth to a baby.

- **The External reproductive organs include**:

- **Labia majora**: The labia majora (large lips) enclose and protect the other external reproductive organs.
- During puberty, hair growth occurs on the skin of the labia majora, which also contain sweat and oil-secreting glands.
- **Labia minora**: The labia minora (small lips) can have a variety of sizes and shapes. They lie just inside the labia majora, and surround the openings to the vagina (the canal that joins the lower part of the

uterus to the outside of the body) and urethra (the tube that carries urine from the bladder to the outside of the body). This skin is very delicate and can become easily irritated and swollen.

- **Bartholin's glands**: These glands are located next to the vaginal opening on each side and produce a fluid (mucus) secretion.

- **Clitoris**: The two labia minora meet at the clitoris, a small, sensitive protrusion that is comparable to the penis in males. The clitoris is covered by a fold of skin, called the prepuce, which is similar to the foreskin at the end of the penis. Like the penis, the clitoris is very sensitive to stimulation and can become erect.

- **The internal reproductive organs include:**

- **Vagina**: The vagina is a canal that joins the cervix (the lower part of the uterus) to the outside of the body. It is also known as the birth canal.

- **Uterus (womb):** The uterus is a hollow, pear-shaped organ that is the home to a developing fetus. The uterus is divided into two parts: the cervix, which is the lower part that opens into the vagina; and the main body of the uterus, called the corpus. The corpus can easily expand to hold a developing baby. A canal through the cervix allows sperm to enter and menstrual blood to exit.

- **Ovaries**: The ovaries are small, oval- shaped glands that are located on either side of the uterus. The ovaries produce eggs and hormones.

- **Fallopian tubes**: These are narrow tubes that are attached to the upper part of the uterus and serve as pathways for the ova (egg cells) to travel from the ovaries to the uterus.

- Fertilization of an egg by sperm normally occurs in the fallopian tubes. The fertilized egg then moves to the uterus, where it implants into the uterine lining.

Table.5 Summary of female reproductive structures and their function

Structure	Function
Ovaries	Produce the hormones estrogen and progesterone Site of ova (egg cell) development and ovulation
Fallopian	carry the ovum from the ovary to the uterus

tubes (oviducts)	usually the site of fertilization
Fimbria	sweep the ovum into the oviduct following ovulation
Uterus (womb)	pear-shaped organ in which the embryo and fetus develop involved in menstruation
Cervix	separates the vagina from the uterus holds the fetus in place during pregnancy dilates during birth to allow the fetus to leave the uterus
Vagina	extends from the cervix to the external environment provides a passageway for sperm and menstrual flow functions as the birth canal

5.2.2 Gametogenesis

- Gametogenesis is the process where of formation and development of specialized generative cells, gametes (oocytes/sperm), from bi-potential primordial germ cells. Gametogenesis is a process where a haploid daughter cell (n) is formed from a diploid mother cell (2n) through meiosis. This process is called spermatogenesis in male that produces spermatozoa and oogenesis in female that produces ova.

Spermatogenesis

- Spermatogenesis is the process by which haploid (n) spermatozoa develop from germ cells in the seminiferous tubules of the testis. Male gamete production starts at puberty and takes place in the testis. The testes also produce the male hormone called androgen (testicular hormone). Germinal epithelium lines the seminiferous tubules. The majorities of cells here are cuboidal and called primordial germ cells or PGCs. These immature male germ cells undergo successive mitotic and meiotic divisions to produce sperms.
- The diploid primordial germ cells are present in the lining of the seminiferous tubules of testis. Some cells which are tall and somatic are called sertoli cells. They help in the nourishment of the developing sperms and are also called nurse cells.

- At sexual maturity, the undifferentiated primordial germ cells or PGCs of seminiferous tubules divide several times by mitosis to produce large number of sperm mother cells or spermatogonia.
- Spermatogonia are diploid and possess 46 chromosomes. They then go through mitotic division and generate primary spermatocytes which undergo meiosis to form two haploid cells known as secondary spermatocytes. Each secondary spermatocyte has 23 chromosomes.
- Second meiotic division occurs in secondary spermatocytes, resulting in production of four equal and haploid spermatids. The spermatids are transformed into spermatozoa (sperm) by the process of spermiogenesis. These develop into mature spermatozoa, also known as sperm cells. Maturation of the sperm cells takes place in the epididymis where it is secreted in the form of semen during puberty.

Oogenesis

- Oogenesis is the development of female egg cells found in the outermost layers of the ovaries germ cell oogonium and ends with one to two million cells in the embryogenesis. It undergoes the primary oocyte development that begins with meiotic division. Oogenesis arrests division as it develops in the follicle and gives rise to a haploid (n) cell oocyte of a smaller polar body called **oogenesis**.

Phases of the menstrual cycle

- The menstrual cycle is the process of discharge of blood and other things through the vagina of a woman every month from puberty to menopause excluding pregnancy. It is a natural periodical process that brings changes in the female reproductive system which is responsible for the pregnancy.
- It includes changes that occur in the ovary and the uterine walls simultaneously as a result of changes in the level of hormones in the blood.
- Two significant events occur within the female reproductive organs: the first is the release of a single ovum from one of the ovaries and, the second is that the uterine endothelium is prepared for the plantation of a fertilized ovum.
- If the ovum is not fertilized, the lining is released which results in menstruation. Menstruation occurs when the uterine lining sheds, resulting in blood that exits the body via the vagina. The duration of the cycles averages about 28 days. However, the period that might differ in different

women can range from 20 days to 45 days. The difference in the duration is associated with decreased fertility. Events of the menstrual cycles are phases of follicular, ovulation, luteal and menstruation. Phases (events) of menstrual cycles are:

- **The follicular phase:** is the event when the anterior pituitary produces and secret estrogens called follicles stimulated hormones (FSH) that inhibit the secretion of **negative feedback** to prevent the growth of other follicles.
- **The ovulation phase:** an event when ovulation takes place in the midway through the cycle (days 12-14) and estrogen stimulates the anterior pituitary to secret luteinizing hormones (LH) as **positive feedbacks** to surge the release of an egg (secondary oocyte) as ovulation.
- **The Luteal phase:** rupture follicle develops into a slowly degenerating corpus luteum to secret high levels of **progesterone** and lower levels of **estrogen**. Both estrogen and progesterone act on the uterus to thicken the endometrial lining in preparation for pregnancy and inhibit the secretion of FSH and LH to prevent any follicle from developing.
- **The Menstruation phase:** in the menstrual cycle, if fertilization occurs, the embryo develops, implants in the endometrium and release hormones to sustain the corpus luteum. If fertilization fails, the corpus luteum degenerates, estrogen and progesterone levels drop and forms corpus albinos after two weeks. The endometrium is not maintained longer and its layer is eliminated from the body as **menstrual blood** or period

- **Feedbacks to menstrual cycle**:
  - Estrogen hormone promotes the secretion of the ovulation of the menstrual cycle. During days 12–14, estrogen provides positive feedbacks to the hypothalamus and pituitary gland to accelerate the production of estrogen leading to ovulation.
  - Progesterone involves in the menstrual cycle and promotes gestation or the carrying of a fetus to maintain the endometrium of the uterus. The uterus walls dilation continue by contracting and stretching until the birth of a baby.

Table 6 Menstrual cycle

Phases	Days	Events
Menstrual	1- 4	Menstruation occurs

phase		
Follicular Phase	5-13	Follicles matures and endometrium develops
Ovulation phase	14	Ovary releases an egg
Luteal Phase	15-28	Follicle becomes the corpus luteum and endometrium prepares for an egg

5.2.2 Positive and negative feedbacks to control the menstrual cycle

- A feedback mechanism is a physiological regulation system in the body that works to return the body to its normal internal state, commonly known as homeostasis. The "**positive feedback"** is the process in which the end products of an action cause more of that action to occur in a feedback loop. In a menstrual cycle, it is a period (days 12–14) during when estrogen stimulates the hypothalamus of the brain to release Gonadotropin Releasing Hormones (GnRH) that stimulates the anterior **pituitary** gland to secrete **Luteinizing Hormones (LH)**and **Follicle Stimulating Hormones (FSH).**
- Hormones are chemicals that coordinate different body functions by carrying messages through our blood to organs, muscles and other tissues.

1. Luteinizing Hormone (LH)

- LH is a gonadotrophic hormone for regulating the function of the testes in men and ovaries in women

- **In men**, it stimulates cells in the testes to produce testosterone to support sperm production.
- **In women**, it carries out different roles in the two halves of the menstrual cycle. In weeks one to two of the cycle, the hormone stimulates the ovarian follicles to produce the female sex hormone estradiol.
- Around day 14 of the cycle, a surge in LH levels causes the ovarian follicle to rupture and release a mature oocyte (egg) from the ovary called ovulation. For the remainder of the cycle (weeks three to four), the remnants of the ovarian follicle form **acorpus luteum** to produce progesterone required to

support the early stages of pregnancy. The rise of the levels LH is a negative feedback and too much LH is an indicator of infertility.

2. Follicle Stimulating Hormone (FSH)

- FSH is a hormone that plays a role in sexual development, reproduction and affects ovaries and testicles. Women are born with all the eggs and the ovarian reserve consists of one to two million eggs at birth of which around 400,000 eggs reach puberty, 400 eggs mature and ovulate throughout our reproductive years. The brain releases the hormone at the beginning of each cycle to stimulate ovaries to grow follicles and eggs for ovulation. The progesterone maintains the uterine lining or thickness of the uterus wall and lesser it for happening pregnancy.
- The rise in FSH stimulates the growth of the follicle in the ovary, produces the increasing amounts of estradiol and reduces the release of gonadotrophin hormone as **negative feedback**. During each menstrual cycle, is a rise in FSH secretion in the first half of the cycle (fol icular phase) stimulates follicular growth in the ovary leading to ovulation. The ruptured follicle forms a **corpus luteum**that produces high levels of progesterone (luteal phase) and at the end of the cycle, the **corpus luteum** breaks down, progesterone production decreases and the next menstrual cycle begins as follicle stimulating hormone levels start to rise again.
- In **negative feedbacks,** the mechanism of biochemical pathway turns off, the egg fails of fertilization, the corpus luteum dies, **progesterone levels drop** and the uterine lining breaks down and the woman is having a period or menstruation. The positive feedback leads to ovulation and the negative feedback leads to menstruation

5.2.3 Fertilization and pregnancy

1. Fertilization

- Fertilization is the union of human egg and sperm cells in the ampulla of the fallopian tube to produce a **zygote.** The process of fertilization occurs when 23 sets of chromosomes from a spermatozoon and 23 sets of chromosomes from an egg cell fuse together. The fertilized egg (zygote) divides repeatedly as it moves down the fallopian tubeto the uterus. About six days after fertilization, the embryo attaches to the lining of the uterus, usually near the top. This process is called **implantation** and it is completed within nine or ten days.

2. Pregnancy

- Pregnancy or gestation period is the period in which the fetus develops inside a woman's womb or uterus. Pregnancy lasts about 40 weeks (280 days) to delivery counted from the last menstrual period. A pregnancy with more than one fetus at a time is called a multiple pregnancy (twin or triplet).
- **The followings are signs and symptoms of pregnancy:**
  - Missed periods, tender breasts and morning sickness (nausea, vomiting)
  - Hunger and frequent urination
  - Pregnancy test confirms pregnancy

5.2.4 Mechanism of action of contraceptives

- Contraception refers to the intentional process of preventing pregnancy through the use of various hormonal drugs, devices, sexual practices, chemicals, and surgical procedures. People use contraception for a range of reasons such as to plan family size, reduce pregnancy- related risk, reduce teenage pregnancies, have healthy babies, prevent sexually transmitted diseases like HIV/AIDS, and to balance the population growth with economic growth.
- Based on their mechanisms of action, contraceptives can be categorized as **barrier or non-barrier** contraceptives.
- **Barrier mechanism of contraceptives**: Devices that provide a physical barrier between the sperm and the egg. Examples include the male condom, female condom, diaphragm, and cervical cap. **Condoms (male and female)** are the only contraceptive methods that helps prevent sexually transmitted infections (STIs).
- **Diaphragm** is a small and soft silicon dome placed inside the vagina to stop sperm from entering the uterus where it forms a physical barrier between the man's sperm and the woman's egg like a condom.
- **Non-barrier contraceptives:** Types of contraceptive methods such as chemical barriers or spermicides, oral contraceptive pills, intrauterine devices (IUD), hormonal implants, hormone injections, post pill and contraceptive ring.

- **Chemical barriers or spermicides** are sperm-killing substances, available as foams, creams, gels, films or suppositories, which are often used in female contraception in conjunction with mechanical barriers and other devices.
- **Oral contraceptive pills** are combined hormonal pills with oestrogen and progesterone. Oral contraceptive pill (COC) is a type of birth control that is designed to be taken orally by women. The pill contains two important hormones: progesterone and estrogen. The pill prevents the ovaries from releasing an egg each month (ovulation). It also thickens the mucus in the neck of the womb, so it is harder for sperm to penetrate the womb and reach an egg. It thins the lining of the womb, so there is less chance of a fertilized egg implanting into the womb and being able to grow.
- Progesterone-only pill**s** (POP) prevent pregnancy by thickening the mucus in the cervix to stop sperm reaching an egg. The progesterone-only pills can also stop ovulation. The progesterone-only pills need to be taken every day to work.
- **The copper-coated intrauterine device (IUD)** is a small T-shaped device made from material that contains (coated) progesterone hormone or plastic and copper. The IUD fitted inside a woman's uterus by trained healthcare providers does not allow the sperm to fertilize the egg and prevent pregnancy. It may also make it harder for a fertilized egg to implant in the uterus as it thickens the cervical mucus and thins the uterine lining.
- **Contraceptive implant** is a small flexible plastic rod placed under the skin in your upper arm by a doctor or a nurse and lasts for three years releasing the hormone progesterone into the bloodstream to prevent pregnancy
- **Contraceptive injection** contains a synthetic version of the hormone progesterone DEPO Provera, which is a well -known brand name formed roxyprogesterone acetate, a contraceptive injection. It prevents the body from producing its own hormones and releasing eggs from the ovaries.
  However, an estimated 6% of people using Depo-Provera will get pregnant
- **Post pill** is a hormonal oral contraceptive tablet used as an emergency contraceptive to prevent pregnancy within 72 hours. It contains the hormone levonorgestrel, a progestin that prevents ovulation, block fertilization or keep a fertilized egg from implanting in the uterus. Post pill is an emergency oral contraceptive pill (ECP) used to prevent pregnancy after unprotected sex
- **Contraceptive ring (vaginal ring)** releases a continuous dose of the hormones estrogen and progesterone into the bloodstream to prevent pregnancy.

- **Sterilization:** is a permanent method of contraception, suitable for people who are sure they never want children or do not want any more children. Sterilization procedures for women **tubal ligation**. The procedure for men is called **vasectomy**. Tubal ligation prevents an egg from traveling from the ovaries through the fallopian tubes and blocks sperm from traveling up the fallopian tubes to the egg. Vasectomy blocks or cuts each vas deferens tube, keeping sperm out of your semen. Sperm cells stay in the testicles and are absorbed by the body. Starting about 3 months after a vasectomy, the semen won't contain any sperm, so it can't cause pregnancy.

Table 6 Summary of contraceptives

Methods	Failure rate	Mode of action	Advantage	Disadvantage
Oral Contraceptives	0.3-5	Inhibit ovulation; may affect endometrium and cervical mucus and prevent implantation	Highly effective and regulate menstrual cycle	Minor discomfort in some women, should not be used by women over age 35 who smoke
Injectable contraceptives Depo-Provera	About 1	Inhibit ovulation	Effective and long-lasting	Irregular menstrual bleeding, fertility may not return for six to 12 months after contraceptive is discontinued

Intrauterine device (IUD)	1-1	Stimulates inflammatory responses and prevent implantation	Provides continuous protection, highly effective for several years	Cramps, increased menstrual flow and risks of pelvic inflammatory diseases and infertility; not recommended for women who have not had a child
Spermicides, foams, jellies and creams	3-20	Chemically kill sperm	No known side effects; can be used with a condom or diaphragm to improve efficacy	Messy, must be applied before intercourse
Diaphragm Contraceptives	3-14	Mechanically blocks entrance to cervix	No side effects	Must be inserted prior to intercourse and left in place for several hours afterward
Condom	2.6-14	Mechanically prevent	No side effects; some protection	Slightly deceased

		sperm from entering vagina	from STIs and HIV	sensation for male and could break (torn)
Sterilization Tubal ligation	0.04	Prevent ovum from leaving uterine tube	Most reliable method	Requires surgery and considers permanent
Vasectomy	0.15	Prevent sperm from leaving vas deferens	Most reliable method	Requires surgery and considers permanent

5.2.5 Causes of infertility in humans

- Infertility is the inability of a person to reproduce by a natural way. Female infertility is the inability to get pregnant (conceive) after unprotected sex. Male infertility refers low sperm production, abnormal sperm function, or blockages that prevent the delivery of sperm and consequently protect the ejaculation of adequate healthy sperm cells.

Causes of infertility in women

- Females are fertile for a natural fertility period before and during ovulation whereas they are infertile for the rest of the menstrual cycle. The cause of female infertility is ovulatory problems manifested by the sparse or absent menstrual periods

Causes of infertility in females:

- **Thyroid problems:** it prevents ovulation by making both overactive and underactive.
- **Pelvic surgery complications** include fallopian tube damage and scarring, as well as cut ovaries

- **Cervical mucus problems**: harder mucus does not let sperms to swim into vagina.
- **Fibroids:** non-cancerous growths in or around the womb affect fertility.
- **Endometriosis:** growths in the womb lining the endometrium block the ovaries.
- **Pelvic inflammatory diseases** cause infections of the upper female genital tract.
- **Sterilization** is a choice not to have any more children.
- **Medicines and drugs**: their uses and misuses have side effects that cause infertility.

Examples:

1. Drugs like marijuana, cocaine, and heavy cannabis use tobacco.
2. Medicines such as blood pressure medications, anti-depressants, and anti-psychotics.
3. Misuses of drugs and alcoholic drinks

Infertility in men

- Male infertility is the production of low, abnormal, and dysfunctional sperm and blockages that prevent the adequate delivery of sperm. Chronic health problems, illnesses, injuries, inherited disorders, hormonal imbalances, dilated veins around the testicle, or a condition that blocks the passage of sperm and contribute to male infertility.

Symptoms of male infertility:

1. Immotile sperms facing harder to swim to the egg
2. Discomfort, pain and swelling or a lump in the testicle area
3. Surgery of the groin, testicle, prostate, penis, or scrotum
4. Lower sperm count (fewer than 15 million sperm per milliliter of semen or a total sperm count of less than 39 million per ejaculate).

Risk factors linked to male infertility:

- Smoking tobacco, using alcohol, and drugs

- Being overweight and exposed to toxins
- Having repeated past or present STD infections
- Overheating and trauma to the testicles

5.2.6 The major sexually transmitted infections (STIs) in Ethiopia

- Sexual y transmitted Infections are communicable diseases primarily transmitted through sexual contact from a sick person to a healthy person.

Types of sexually transmitted infections and preventions

- More than 20 types of sexually transmitted infections or diseases spread through unprotected sexual intercourses.
- The major causative agents or pathogens are bacteria, viruses, and parasites.

Bacterial infections diseases

A. Bacterial Vaginosis

- Bacterial vaginosis is a type of vaginal inflammation caused by the overgrowth of bacteria naturally found in the vagina. Bacterial vaginosis increases the risk of developing a post-surgical infection and causes infections of the uterus, fallopian tubes, and infertility.
- **Causative agent:** bacterial vaginosis
- Means of transmission: sexual contacts
- **Symptoms: v**aginal discharge (thin, gray, white or green), foul-smelling or fishy vaginal odor, vaginal itching and burning during urination.
- **Prevention/treatment**: protective sexual contact and medical treatments
- The prevalence of Bacterial Vaginosis in Ethiopia ranges from 2.8–19.4%.

B. Chlamydia

- Chlamydia is a common sexually transmitted infection (STI) that's caused by bacteria called Chlamydia trachomatis (C. trachomatis). Chlamydia infections spread through sexual contact, when vaginal fluid or semen containing the bacteria that causes chlamydia travels from one person to another.

C. Syphilis

- Syphilis is a life-threatening disease that affects the brain, nervous system, eyes, heart, and several other organs and develops through four stages of symptoms (Table 5.7).

Table 7 Stages of syphilis development

Stages	Timing	Symptoms
Primary	3-4 weeks after exposure	Formation of non-itchy and painless chancers on genital skin and mucosa.
Secondary	4-8 weeks after the appearance of a primary chancer.	Rash on hands and soles of feet
.Latent	Early (< 1 year) after infection. Late (>1 year) after infection	No symptoms (asymptomatic
Tertiary/late	1-10 years after infection.	Gummatous lesions, cardiovascular syphilis, late neurological complications

- Causative agent: Treponema pallidum
- Means of transmission: sexual contacts
- **Symptoms:** form sores around the genitals, anus, rectum or mouth tend to last 3-6 weeks, appearing as a non-itchy rash of rough, brownish or red spots on the palms of the hands, soles of the feet, lesions in the mucous membranes, the mouth, vagina or anus. Swollen lymph nodes, hair loss, headache, weight loss, muscle fatigue, fever that appear around 21 days after infection.
- **Prevention/treatment:** protective sexual contact and medical treatments

D. Gonorrhea

- Gonorrhea is an infectious disease of the bacterium Neisseria gonorrhea. It is highly contagious and can lead to life-threatening complications if not well treated. Its transmission is through touches of an infected area of the body, thrives in warm, moist parts of the body (vagina, penis, mouth,rectum and eye). It spreads during sexual contact.
- **Causative agent:** the bacterium Neisseria gonorrhea
- **Means of transmission:** spreads by sexual contacts

- **Symptoms**: painful urination and abnormal discharge from the penis or vagina. Men may experience testicular pain and women may experience pain in the lower stomach. In some cases, gonorrhea has no symptoms.
- **Prevention/treatment**: protective sexual contact and medical treatments

E. Chancroid

- Chancroid is a curable sexual y transmitted disease caused by the infection of bacterial species. Haemophilus ducreyi. Chancroid is a highly contagious, painful necrotizing genital ulcer accompanied by inguinal lymphadenopathy.

Viral infections diseases

A. Genital herpes

- Genital herpes is a sexually transmitted infection caused by two types of the herpes simplex virus (HSV). These are HSV-1 and HSV-2. **Human Simplex Virus 1 (HSV-1)** is a virus that affects the mouth and spreads through saliva or a herpes-related sore around the mouth. **Human Simplex Virus 2 (HSV-2)** affects the genital, anal, and mouth and is transmitted through sexual intercourse.

B. Genital warts

Genital warts are sexual y transmitted infections caused by the human papil omavirus (HPV). They can cause pain, discomfort, and itching. The human papillomavirus (HPV) is a group of viruses that affect the skin, mucous membranes, throat, cervix, anus, and mouth. It increases the risk of cervical and throat cancer and spreads through sex.

C. Molluscum contagiosum

- Molluscum contagiosum is a contagious viral skin infection caused by a poxvirus called Molluscum contagiosum virus that affects both adults and children.
- **Causative agent:** Molluscum contagiosum virus
- **Means of transmission:** by skin to skin contacts
- **Symptoms:** a small round bumps and indents on skin disappearing soon

- **Prevention/treatment**: protective self-hygiene

D. Human Immunodeficiency Virus (HIV)

- **Human Immunodeficiency Virus (HIV)** is a virus that attacks the human immune system cell s that fights against the body infections. HIV makes a person vulnerable to other infections and diseases. Without treatment, HIV infection advances in stages, getting worse over time gradually destroys the immune system and eventual y causes acquired immunodeficiency syndrome (AIDS).
- Human Immunodeficiency Virus **(HIV)** belongs to a class of viruses known as **retroviruses.** It attacks a specific type of immune system cell called CD4 helper cells or T cells and Ribosome, Golgi apparatus and endoplasmic reticulum organelles. HIV weakens the body, makes the body harder to fight off infections and destroys.

There are three stages of HIV infection:

1. **Acute HIV infection** is the earliest stage from 2 to 4 weeks after infection and people show flu-like symptoms, such as fever, headache, and rash. At this stage, HIV multiplies rapidly and spreads throughout the body. The virus attacks and destroys the infection- fighting CD4 cells (CD4 T lymphocytes) of the immune system.
2. **Chronic HIV infection** is the second stage from 1 to 7 years. It is also called **asymptomatic.** HIV infection or **clinical latency** at which HIV continues to multiply in the body and usually advances to AIDS.
3. **AIDS** is the final stage from 10 years and above. This is the most severe stage of HIV infection in which HIV severely damages the immune system and the body cannot fight off opportunistic infections such as tuberculosis and tumors, and the number of **CD4** cells decreases. People at AIDS stage have a CD4 count of fewer than **200 cells /mm3**. Without treatment, people with AIDS typically survive about 3 years. The healthy immune system's **CD4** counts are between **500** and**1600 E. Hepatitis B**

- Hepatitis B is a viral infection that attacks the liver and causes both acute and chronic liver diseases. Once a person is infected with Hepatitis B, the virus remains in the semen, blood and other bodily fluids. People with acute **hepatitis B** develop liver cancer diseases **cirrhosis** and hepatocellular **carcinoma** that causes liver failure leading to death. Vaccines prevent hepatitis B disease effectively and make safe. The World Health Organization (WHO) estimated that about

296 million people were living with chronic **hepatitis B** infections in 2019 with 1.5 million new infections each year and **820 000** deaths from **cirrhosis** and **hepatocellular carcinoma** (liver cancer).

- Causative agent: viruses
- Means of transmission:
- Sexual contact with infected persons
- Uses of non-sterile injections
- Puncturing the skin with sharp objects infected with virus
- Blood and bodily fluids
- **Symptoms:** yellowing of the skin and eyes (jaundice), dark urine, extreme fatigue, nausea, vomiting and abdominal pain
- **Prevention/treatment**: protective sexual contact and safe from any contact of bodily fluids or contaminations

Parasites

- Among parasites, trichomoniasis and pubic lice are the most prevalent causative agents of sexually transmitted infections.

A.Crabs (Pubic lice)

- **Crabs** are pubic lice attaching to pubic hair and sometimes affect the hair in the armpits, moustache, beard, eyelashes or eyebrows. Pubic lice spread during close physical and sexual contact and are transmitted via shared towels or bed linen.

B. Trichomoniasis

Trichomoniasis is a common sexual y transmitted infection caused by the parasite Trichomonas vaginalis

- **Causative agent:** Trichomonas vaginalis
- Means of transmission: sexual contact

- **Symptoms:** in women (a large amount of a thin, often foul-smelling discharge from the vagina — which might be clear, white, gray, yellow or green; genital redness, burning and itching; pain with urination or sex; discomfort over the lower stomach area). In men (itching or irritation inside the penis, burning with urination or after ejaculation, discharge from the penis).

- **Prevention/treatment**: protective sexual contact and medical treatments

C. Scabies

- Scabies are contagious skin diseases that develop due to a mite (Figure 5.39). Scabies spreads from person to person through direct skin-to-skin contact. It can also be spread by using clothing, sheets, towels or furniture that has touched an infected person's skin. Scabies is considered as STI because it often spreads during sex.

5.2.8. Epidemiology of STIs in Ethiopia

- **E**pidemiology is the study of the transmission causation, outbreak, surveillance, monitoring of a disease and the application of this study to the control and treatment of the disease. Epidemiology of STIs is the systematic study of sexually transmitted infections, identify and understand the causes, symptoms and ways of transmission. Even though there is little information on the incidence and prevalence of STIs in Ethiopia, the problem of STIs is generally believed to be similar to that of other developing countries. About 1.4 million people are infected with STIs every day. In Ethiopia, the highest reported rates of STIs are found among 15–24-year olds.

5.2.8.1Risks of STIs epidemic in Ethiopia

Risks of STIs epidemic include:

- Anyone who is sexually active risks some degree of exposure to an STD or STI. Factors that may increase that risk include:

- **Having unprotected sex**. Having sex with an infected partner who isn't wearing a latex condom significantly increases the risk of getting an STI. Improper or inconsistent use of condoms can also increase risk.

- **Having sexual contact with multiple partners**. The more people you have sexual contact with, the greater your risk.

- **Having a history of STIs**. Having one STI makes it much easier for another STI to take hold.
- **Being forced to engage in sexual activity**. Dealing with rape or assault is difficult, but it's important to see a doctor as soon as possible to receive screening, treatment and emotional support.
- **Misuse of alcohol or use of recreational drugs**. Substance misuse can inhibit your judgment, making you more willing to participate in risky behaviors.
- **Injecting drugs**. Needle sharing spreads many serious infections, including HIV, hepatitis B and hepatitis C.
- **Being young**. Half the new STIs occur in people between the ages of 15 and 24.

5.3 HARMFUL TRADITIONAL PRACTICES

5.3.1 Harmful traditional practices

- Harmful traditional practices that affect the physical and mental health of individuals are actions against the rights of people. Both men and women have the right to live free from harm, oppression, discrimination and violence (harmful practices).In Ethiopia, the currently recorded harmful traditional practices has accounted for about 20 of which 50% deals with **mutilation** of skins and related parts, whereas the female genital mutilation (FGM) alone has accounted for 73% of the practices.

Harmful traditional practices affect reproductive health

- **Early marriage** is forcing underage girls to get married based on cultural norms to perpetuate poverty. It has a wide-ranging impact on girls, causing them to drop out of school, become pregnant, and face long-term health risks.
- **Kidnapping or is abduction** to make the girl a wife unwillingly.
- **Gender-based violence,** or any form of **unwanted sexual contact** (sexual abuse or harassment), or even violence within a relative or marriage.
- **Female Genital Mutilation (FGM)** is one of the harmful traditional practices that involve the partial or total removal of external female genital organs.

5.4 FAMILY PLANNING

- Family planning is the ability to anticipate and attain a desired number of children, the spacing and timing of births, and the materials of individuals and couples to establish a family. Family planning deals with issues related to marital situation, career considerations, financial position and the number of children and a choice of a woman wishing to have or no children. Family planning is concerned with ensuring the resources required for raising the children, time, social, financial, and environmental conditions.

5.4.1 Risks related to the lack of family planning

- The risk of maternal health means that a mother requires care during pregnancy, childbirth, and the postpartum period.
- Both early and late motherhood have increased the risk that teenagers could face a higher risk of life complications and deaths.
- When mothers suffer from illness, get sick or have health problems, the whole family could be threatened
- Complications of pregnancy and childbirth leads to abortions, disability and lower incidence of deaths.

5.4.2 Family planning actions

The family calendar includes:

- Prevention of unwanted pregnancy
- Safe family from STIs, counseling plans and fertility management
- Adequate resources for couples to prevent unwanted pregnancy
- Waiting at least 6 months after a miscarriage or abortion
- Adoption as another option used to build a family.
- Birth control and assisted reproductive technology
- Adjustment of the family plan calendar to the natural menstrual cycle

5.4.3 Family planning services

- Pregnancy testing and counseling
- Pregnancy- achieving services (preconception health)
- Basic counseling on infertility
- Counseling on sexually transmitted diseases
- Breast and pelvic examinations
- Breast and cervical cancer screening

5.5 EFFECTS OF ALCOHOL USE, CHEWING KHAT, CANNABIS AND OTHER DRUG USES ON STIS TRANSMISSION AND UNWANTED PREGNANCY

5.5.1 The effects of alcohol uses

- Heavily alcohol use affects the lifestyles of humans. The normal blood alcohol limit for euphoria is 0.1%, but the increase in alcohol intake damages many parts of the human body functions. Alcohol use has the following negative effects:
- Too much intake of alcohol causes acute effects on parts of our bodies. For example, a higher concentration of blood alcohol (0.25 to 0.30%) causes sleepiness and confusion.
- Prolonged excessive alcohol intake increases dementia **(**poor nutritional status).
- Alcohol damages the brain (vitamin deficiencies) and the liver (causing cirrhosis).
- Heavy alcohol drinking cases a J-shaped legs, colorectal and colon cancer, violence, traffic accidents and death.
- Gulping up more alcohol causes a coma and death.
- Alcoholic drinks cause 6.2% of males' and 1.1% of females' deaths globally.
- Alcohol drinking is associated with risky sex and transmission of HIV.

5.5.2 Effects of chewing Khat

- Khat is shrubs by plant (Catha edulis) that people chew its leaves as a recreational stimulant and a psychoactive drug. It has become a popular chewable cosmopolitan leaf among users living in Ethiopia and widespread in the Horn and Eastern Africa, Europe, and North America. In Eastern Ethiopia, it is chewed by nearly 30% of adolescent girls and over 70% of adolescent boys. There are about twenty million people worldwide who chew Khat leaves. When khat is chewed, it stimulates the central nervous systems of human beings because the leaves of Khat contain a stimulant drug called **cathinone.** Chewing Khat leaves has the following negative effects:

1. Hypertension, stomatitis, esophagitis, gastritis, and constipation.

2. Acute coronary syndrome (coronary artery spasm) and myocardial infarction

3. Metabolic disorders, diabetes mellitus, hepatitis, and liver cirrhosis.

4. Impotency or loss of sexual drive in libido among aphrodesia (male users)

Table 8 Effects of using Khat leaves

Khat leaves	Effects of chewing
Immediate term	Alertness, Arousal, Concentration, Confidence, Constipation Euphoria, Friendliness, Hyperactivity, Increased blood pressure, Increased heart rate, Insomnia, Psychosis, suppressed appetite, Talkativeness, thought disorder, Verbosity etc.
Long term	Depression, infrequent hallucinations, impaired inhibition, increased risk of myocardial infarction (heart attack), Psychosis in extreme cases in the genetically predisposed and oral cancer leading to death in indeterminate terms

5.5.3 Effects of drug uses

- Drugs are biochemical components mostly extracted from some plant species. Some drugs intermittently affect the body and the brain whereas some drugs have long-lasting consequences and permanent health hazards.

1. Marijuana

- Marijuana is a drug prepared from dried leaves and flowers of a plant called Marijuana plant (Cannabis sativa), which is stronger than any other form with high potency strains known as sinsemilla or **hashish** and extracts. Marijuana harms the brain, breathing system, heart, child development, and muscular system coordination.

2. Cocaine

- Cocaine is an addictive stimulant drug made from the leaves of the coca plant. Erythroxylum cocanative to South America. Cocaine harms the cardiovascular system, breathing system, gastrointestinal system, and nervous system.

3. Heroin

- Heroin is a very addictive drug made from morphine, a psychoactive (mind-altering) substance taken from the resin of the seedpod of the **opium poppy.** Similarly, heroin has also negative effects on our health.

4. Inhalants

- Inhalants are chemicals that can be found in ordinary household or workplace products that people inhale on purpose to get in high mood. In fact, chemicals found in the products can change the way the brain works and cause other problems in the body.

Generally, drugs have the following side effects

- Increasing the risk of illness and infection
- Heart conditions range from abnormal heart rates to heart attacks, collapsed veins, and blood vessel infections from injected drugs.
- Nausea and abdominal pain lead to changes in appetite and weight loss.
- Increased strain on the liver that puts the person at risk of significant liver damage or liver failure.
- Seizures, stroke, mental confusion, and brain damage are all possibilities.
- Problems associated with memory, attention, and decision-making, which make daily living more difficult People suffering from drug and alcohol addiction have a higher risk of unintentional injuries, accidents, and domestic violence incidents. The high prevalence of HIV infections, syphilis, and genital

ulcer is due to unprotected sex fueled by the use of crack cocaine. Sexual y active adolescents are at a high risk of contracting sexually transmitted infections, including HIV.

UNIT FIVE SUMMARY

- The human skeletal system consists of 206 various types of bones, cartilage, joints, ligaments, tendons and connective tissues. The primary functions of the skeletal systems are locomotion, support to the body and the protection of internal organs (brain, heart and lungs). Bones that store minerals (calcium (99%), iron, magnesium and phosphorus are responsible for the production of red blood cells, platelets and most white blood cells.

- The functions of the muscular systems are movements, joint stabilization and heat protection, maintenance of posture and facilitation of blood circulation. The skeletal muscles connected to the bones and work hand-in-hand with the skeletal system to control voluntary movements such as walking and running. Smooth muscles (stomach, intestines, bladder and uterus) are involuntary muscles that are responsible for the contraction of hollow muscles. The cardiac muscle is an involuntary muscle found only in the heart and facilitates the circulation of blood by pumping to the major arteries and out into the body via the circulatory systems. The human reproductive system dealing with both male and female reproduction systems includes gametogenesis (gamete formation) fertility and infertility.

- The male reproductive system discusses the male reproductive organs including the penis, urethra, testes that make sperm and produce the hormone testosterone. The female reproduction system is the body parts including vagina, cervix, ovary, uterus, the menstruation cycles and both positive and negative feedbacks. In relation to reproduction, the unit briefs the mechanisms of uses contraceptives, sexual y transmitted infections (STI) and diseases, causative agents, treatment or preventions.

- Family planning is an access to ensure safe human right. It is central to gender equality and women's empowerment and a key factor in reducing poverty. In developing regions, about 218 million women are suffering from lack of using safe and effective family planning methods for reasons ranging from the lack of access to information or services to the lack of support from their partners or communities.

- Family planning is the ability of individuals and couples to anticipate and attain their lifestyles with family formation and to have children or not. Family planning is a very important action that anticipates

the futurity of the young generation on how to sustain all living forms and family formation with pertinent necessities to work and live successfully.

- Alcohol interferes with the brain's communication pathways and affects the way the brain works. It changes mood and behavior and makes harder to think clearly and move with coordination. Drinking over a long time damages the heart and causes cardiomyopathy (stretching and dropping of heart muscle), arrhythmias(irregular heart beat), stroke and high blood pressure. Heavy drinking takes a toll on the liver and leads to a variety of problems and liver inflammations including steatosis or fatty liver, alcoholic hepatitis, fibrosis and cirrhosis. Alcohol causes the pancreas to produce toxic substances that can eventually lead to pancreatitis, a dangerous inflammation and swelling of the blood vessels in the pancreas that prevents proper digestion.

- Cathinone is illegal in some countries since it has stimulant effect when chewed as drug class similar to the leaves of the coca plant used for making cocaine. Uses of Khat increase respiration, tends to elevate blood pressure, heart arrhythmias and dilated pupils. A regular use of Khat can also cause tooth decay, gum disease, ulcers and constipation. Drug use can cause short and long-term serious health hazards effects possibly irreversible**.** Drugs affect mainly the central nervous systems and cause flatness, depression and exhaustion and hallucinogens or distorting the sense of reality.

Unit five review questions

Part I. True or false Items

Instructions: write true if the statement is correct and false if not.

1. Musculoskeletal system composes of only skeletons.
2. Muscular system comprises of cardiac, skeletal and smooth muscles.
3. The three types of muscle contractions are concentric, isometric and centric muscle fibers.
4. The source of blood cells is bone marrows.
5. Joints are binding tissues connecting individual bones to allow movements.
6. The saddle joints are in between the carpal and metacarpal.
7. Bones compose of Yellow and Red marrow.
8. The skull protects the human brain.

9. The rib cages protect the lung.

10. The skull is made of the cranium bones.

Part II. Multiple-choice Test Items if the statement is not correct.

Instructions: choose the correct answer from the given alternatives

1. What mineral makes bones strong?

A. Oxygen C. Calcium

B. Iron D. Zinc

2. What are the two bones in the lower arm?

A. Radius and ulna C. Femur and humerus

B. Tibia and Fibula D. Mandible

3. The purpose of white blood cells is to

C. Carry oxygen C. Speed up digestion

D.Protect against infection D. All

4. Which of the followings is a hinge joint?

A. Shoulder C. Knee

B. Hip D. None

5. What is a fibrous connective tissue that attaches bone to bone?

A.Cartilage C. Ligament

B.Tendon D. Rib

6. Which one is the hip joint?

A. Hinge joint C. A and B

B. Ball and Socket joint D. All

7. Muscles attached to bones by

A.Cartilage C. Ligament

B.Tendon D. Tissues

8. One of the following is not a part of the male reproductive system.

A. Penis C. Uterus

B. Testes D. Scrotum

9. Which of the following is not a part of the female reproductive system?

A.Ovary C. Sperm duct

B.Vagina D. All

10. What are the male sex cells?

A. Sperm cells C. Scrotum

B. Sperm ducts D. Vagina

11. The male sex cells made in

A. Testes C. Penis

B. Sperm ducts D. Ovary

12. The female sex cell is

A.Cilia C. Cervix

B.Egg cells D. Sperm cells

13. How long does the menstrual cycle take?

A.5 days C. 28 days

B.14 days D. 30 days

14. The character of an ovulation is

A. The release of a mature egg cell

B. The loss of the lining of the uterus

C. The joining of male sex cell and female sex cells

D. Fertilization

15. What is substance that passes through the placenta to the baby?

A. Oxygen C. Blood

B. Carbon dioxide D. Food

16. How long is gestation in humans?

A. 28 days C. 9 years

B. 40 weeks D. 11 Years

17. Which changes due to happen during puberty to boys and girls?

A. Hips widen C. Underarm hair grows

B. Facial hair grows D. Sperm production

18. STIs are most common in ___age groups.

A. Young and adults of ages 18- 35 C. People of ages 60 and older

B. People of ages 36 – 45 D. All

19. The overall number of cases of STIs is:

A. Rising C. Constant

B. Falling D. All

20. As far as a person has no symptoms of STI, he/she

A. Cannot pass on STI C. A and B

B. Don't have STI D. None

21. Which of the following is a cause for STIs in women?

A. Pelvic inflammatory disease C. Ectopic pregnancy

B. Higher risk for cervical cancer D. Al of the above

22. Which of the fol owing sexually transmitted infection (STI) is caused by bacteria?

A. Gonorrhea C. A and B

B. Syphilis D. All

23. One of the symptoms of genital herpes is

A. Burning in the genital area C. A and B

B. Painful blisters in the genital area D. None of the above

24. Which one of the human organs untreated syphilis affects?

A. Heart C. Liver

B. Brain D. A and B

25. Which of the followings is another type of STIs?

A. Chancroid C. Molluscum contagiosum

B. Scabies D. All of the above

26. It is one of the protective measures to lower the risk of getting an STI:

A. Use of male condoms

B. Eliminating multiple sex partners

C. Delay with having sexual relations as long as possible

D. Al of the above

27. Which of the listed contraceptives requires prescriptions?

A. Birth control pil C. Diaphragm

B. Contraceptive patch D. All of the above

28. What do male condoms offer that other forms of birth control do not?

A. Least chance of failure C. Cheapest to use

B. Best protection against STIs D. All

29. Besides the condom, which one is another barrier method of birth control?

A. Diaphragm C. Withdrawal

B. IUD D. All

30. Which type of intrauterine device (IUD) is available?

A. Copper C. Hormonal

B. Titanium D. A and C

31. Which one is a possible side effect of birth control pil s?

A. Nausea C. Headaches

B. Irregular bleeding D. All

32. How long is the vaginal ring left in place?

A. Months C. 3 Weeks

B. 2 Weeks D. 1 week

33. Which of the methods is a natural family planning?

A. Basal temperature C. Tracking the menstrual cycle on a calendar

B. Tracking changes in cervical mucus D. All

34. Which of the methods of sterilization is permanent?

A. Tubal sterilization C. A and B

B. Vasectomy D. No

35. One of the FGM commonly practiced in Ethiopia is _____.

A. Circumcision C. Infibulations

B. Excision D. Clitoridectomy

36. How can you solve the problem of underage marriage of girls?

A. Awareness creation C. Education

B. Law D. All

37. Gulping up more alcohol causes

A.Toxicities C. Does not affect

B.Coma and death D. All

38. Chewing Khat causes

A. Hypertension, stomatitis, esophagitis, gastritis and constipation

B. Acute coronary syndrome and myocardial infarction

C. Metabolic disorders, Impotency, Diabetes mellitus, Hepatitis and Liver cirrhosis

D. All of the above

39. What types of drugs causing health hazards do you know?

A. Marijuana C. Heroin

B. Cocaine D. All

40. What are the health hazards of using drugs?

A. Abnormal heart attacks and increased liver damage or failure

B. Weight loss and lung disease, stroke, confusion and brain damage

C. Lung disease, seizures, stroke, mental confusion and brain damage D. All

Answer key for review questions

I. True or False items

1	2	3	4	5	6	7	8	9	10
F	T	T	F	T	T	T	T	T	T

II. Multiple Choice Questions

1	2	3	4	5	6	7	8	9	10
C	A	B	C	C	B	B	C	C	D
11	12	13	14	15	16	17	18	19	20
A	B	A	A	C	B	C	A	A	C
21	22	23	24	25	26	27	28	29	30
D	D	C	D	D	D	D	D	D	A
31	32	33	34	35	36	37	38	39	40
D	C	D	B	A	D	B	D	D	D

UNIT SIX

POPULATION AND NATURAL RESOURCES

6.1 POPULATION ECOLOGY

- The earth is home to diverse groups of organisms that are classified into different ecological organizations. Ecology is the study of the interaction between those diverse groups of organisms and the physical environment. The levels of ecological organization include individual, population, community, ecosystem, biome and biosphere.

- A population is a group of interacting individuals of the same species with common characteristics living and interbreeding within a given area. The study of populations involves examining how individuals in a particular population interact with each other and how the population as a whole interacts with its environment. The branch of biology that deals with this concept is called **ecology.**

- **Population ecology** is the study of the processes of interaction and changes that affect the distribution and abundance of populations in the environment. In studying population ecology, scientists use statistical measures (demographic parameters**)** to help them investigate how populations respond to changes in their environments. The next section deals with population size, density, dispersal, and population growth in brief.

6.1.1 Population size, density and dispersal

Population size

- Population size is the total number of individuals present in a particular habitat where it is designated by the capital letter "N". For instance, a population of rats might consist of 1000 individual rats or many more. In studying populations, locating and counting each individual is

very difficult. Scientists use sampling technique and count individuals in the sample area and infer the total population to estimate the larger population in that particular habitat.

- They use one or more samples from the population and use these samples to make inferences about the population as a whole. Different sampling methods can be used to determine the size and density of a population of organisms. For example, the **quadrat** for plant species and **mark- recapture** methods for animals are commonly used. In studying the human population, a population census is conducted once every 10 years at least.

Studying populations using the Quadrat method

- This method is used to study immobile organisms such as plants and small, slow-moving organisms. A quadrat is a square made from sticks and string or by using a wood, plastic, or metal square and placed on the ground to count organisms in each square.
- After setting up quadrats, we count the number of individuals within the boundaries of each quadrat. Many quadrats are located randomly throughout the habitat at several locations, to make sure that the recorded numbers are representative for the overall habitat. Then, counted numbers from each quadrat can be used to estimate the population size and population density within the entire habitat using the following formula. ?????????????
- **Example:** A student wanted to know how many plants there were in a $50m^2$ field and threw many quadrats to cover $10m^2$ and counted 50 plants. The student used the equation above to calculate the estimated number of plants in the whole field ($50\ m^2$).

Given A = 50 m2; a = 10 m2; n = 50 plants

Populations Estimation by Mark-recapture method

This method is used to determine the population size of animals that move from one place to another. The procedure for this method is:

- Capture a sample of animals, mark them with tags, bands, paint, or other body markings, and release them back into the environment, al owing them to join with the rest of the population.
- Capture a sample of animals that includes both marked and unmarked individuals.
- Estimate how many individuals there are in the total population using the ratio of marked to unmarked individuals.
- Example- Let us assume that researchers captured 60 birds, marked and released them back into the forest. After some time, they came back and captured another 100 birds. Of the birds that were captured for the second time, they found that 20 were already marked and 80 were unmarked.
  - Using this data, they can estimate population size as follows:
  - Given: M = 60; n = 100; X = 20
  - Population size has an effect on the survival of the population. Over a long period, genetic variation is more easily sustained in large populations than in small populations. Moreover, a large population has an advantage over a small population in surviving due to adaption in natural selection and changes in the physical environment, diseases, predators, and competitors.

Studying the human population

- The human population can be studied using a census. A census is a systematic collection of information from all units or individuals in the population, or a complete enumeration of the members of a given population. It involves the official counting of a population in the territory of a country and the collection of information on selected demographic and socio economic characteristics of the population in terms of age, sex, ethnic group, religion, marital status, household size and structure, occupation, economic activity status, etc.
- The traditional approach to a population census consists of the registration of all individuals and their details using paper questionnaires during a field operation that normal y lasts a few days or weeks. Data obtained from the population census can be used to calculate measures of

population size, density, age, sex, birth rate, death rate, fertility rate, life expectancy, population growth rate (r), etc.

- There are two methods of conducting a census. These are:

1. **De Facto Method of Census:** in which the government fixes one date for conducting the census throughout the country, it is usual y done on a full-moon night because it is presumed that all households are present at their residences during that time.

2. **2. De Jure Method of Census: the** government fixes the enumeration period of two or three weeks. The enumerators collect information from households by visiting them frequently to fill in the required information. Persons residing temporarily at a place are not counted, whereas only persons residing permanently at a place are counted in it.

Population density

- A more complete description of a population's size includes the population density. Population density is the number of individuals within a specific area or volume, i.e., population size divided by the total land area. It is the measurement of the size of a population as a percentage of the total land area occupied by the people. For example, the number of people per 10 square kilometers is a population density. Similar to all properties of a population, density is a dynamic characteristic that changes over time as individuals are added to or removed from the population. For instance, birth and immigration can increase a population's density, whereas death and emigration can decrease it.

Population dispersal

- Species dispersal patterns refer to how the individuals in a population are distributed in space at a given time. There are three dispersal patterns of species. These are:

1. **Uniform dispersion**: individuals of a population are spaced more or less evenly.

2. **Random dispersion**: individuals are distributed randomly, without a predictable pattern.

3. **Clumped dispersion**- individuals are clustered in groups.

- The dispersal pattern of individuals in a population provides more information about how they interact with each other and with their environment than a simple density measurement.

Population growth

- Population growth is the increase in the number of humans on Earth. The global human population as well as population of Ethiopia has been increasing rapidly, and has continued to struggle for energy, food, water, and medical care availability. There are two ways of describing population growth. These are logistic growth and exponential growth.

6.1.2 Exponential and logistic growth in populations

- The population size changes overtime. Accordingly, population ecology studies the changes that happen to groups of organisms and how those changes affect their constant interactions with their environment. Population growth rate is the percentage rate of change within a specified number of individuals in a population. It is the average annual rate of change of population size during a specified period. It measures how fast the size of the population is changing.

- Scientists use different methods and models to describe changes that occur in a population there by predict future changes. The two models are:

- Exponential growth model describes populations increase in numbers without any limits to their growth.

- Logistic growth model describes populations' increases in number in the presence of limits, and due to an increase in number.

Exponential growth model

- Exponential growth model represents the growth of a population without environmental constraints in which the population size (N) increases exponentially. In other words, it shows the growth of a population in an ideal environment with unlimited resources to use. The population growth graph of this model shows a J-shaped curve

- In determining population growth, it is important to consider the death and birth of the organism. Thus, growth rate is determined by subtracting the death rate (D) from the birth rate (B). The death rate refers to the number of organisms that die during an interval, whereas the birth rate refers to the number of organisms that are born during the same interval.
- Considering death and birth rate as single factor (r), growth rate can be expressed in a simple equation as: Where dN/dT = growth rate of the population in a given instance, d = change, N = population size, t = time and r = the per capita (per individual) rate of increase, that is, how quickly the population grows per individual in the population (r = B – D). It is the intrinsic rate of natural increase. The value "r" can be positive, negative, or zero, i.e., the population growth rate (dN/dt) is proportional to r. $r > 0$: increase $r = 0$: no change , $r < 0$: decrease
- When r is zero, it indicates that the population's size is unchanging. This condition is known as "zero population growth." The equation above is very general, which we can make it more specific to describe the two different kinds of growth models:
- **Exponential growth model** is used when the per capita rate of increase (r) takes the same positive value regardless of the population size.
- **Logistic growth model** is used when the per capita rate of increase (r) decreases as the population increases towards a maximum limit.
- For any positive, constant r, exponential growth is often represented by an r of rmax. Rmax is the maximum per capita rate of increase for a particular species under ideal conditions, where it varies from species to species. Hence, a further refinement of the formula is given below:
- $dN/dt = rN$, $\Delta N = r\,Ni$, $Nf = Ni + \Delta N$

Logistic growth model

- Population growth can be affected by the availability of resources. Exponential growth is difficult to sustain over a long period for any population because resources are limited in nature. Therefore, exponential growth cannot express this condition. Hence, there is a necessity for

another type of growth model. Accordingly, to express the reality of limited resources, population ecologists developed another growth model called the **logistic growth** model.

- In the logistic growth model, the population growth levels off from exponential growth due to limited resources, resulting in S-shaped curve graph models of population growth instead of J-shaped curve growth rate. The maximum population size that the available resources in an environment can sustain/support is called carrying capacity (K). When the size of the population reaches its carrying capacity, population growth levels off. Hence, the equation for the logistic model is: Where K represents carrying capacity.

dN/dt= **ΔN = r Ni (K-N/K),Nf= Ni + ΔN**

6.1.3 Demographic structure

- Population size and density describe a population at one particular point in time, whereas demography describes the dynamics of a population. Demographic parameters that scientists use include population size, crude death rate, population growth rate, population density, infant mortality rate, fertility rate, crude birth rate, migration, and life expectancy.

- **Crude birth rate** is the number of live births per 1000 people in a year.
- **Crude death rate** is the yearly annual number of deaths per 1,000 people.
- **Infant mortality rates** refer to the annual number of deaths of children aged less than a year old per 1000 of those born alive.
- **Life expectancy** is a measure that interests many people. It refers to the number of years that a human being can live in relation to the current mortality rates.
- **Fertility rate** is a measure of the number of children born.
- **Mortality rate** is a measure of the number of people who die.
- **Migration** means the movement of people from one area to another area
- **Immigration**- movement of people into an area to take up permanent residence

- **Emigration** refers to the movement of people out of an area to another place of permanent residence.

- In demography, age and sex are the most commonly studied elements of population composition. It is the number of individuals in terms of sex and age in the population. The age-sex structure is an important factor that influences population growth. This is because younger people are more likely to reproduce, whereas older people have higher rates of dying. The age and sex data of individuals in a population are often compared over time using population pyramids.

Population pyramid

- Population pyramid is a graphical representation of the age and sex composition of a specific population. In other words, the population pyramid represents the age-sex structure of a population and states the complex social narrative of a population through its shape. Demographers use these simple graphs to evaluate the extent of development for a given population in a country and to make predictions about the types of services that population will need, such as schools, hospitals, homes, etc. A population pyramid is popularly known as an "age pyramid" or "age and sex pyramid." There are three types of population pyramids.

- **Expansive population pyramids** are used to describe populations that are young and growing. The pyramid' shape has a broad base and a narrow top. Expansive population pyramids show the presence of a larger percentage of the population in the younger age group. Populations with this shape usual y have high fertility rates with lower life expectancies. Many third world countries have expansive population pyramids.

- **Constrictive population pyramids** are used to describe populations that are elderly and shrinking. Constrictive pyramids have smaller percentages of people in the younger age group. Countries with higher levels of economic development have constrictive population pyramids because access to quality education and health care is available to a large portion of the population.

- **Stationary population pyramids** are used to describe populations that are not growing. They show an almost equal proportion of the population in each age group in that it tapers off at the top. There is not a decrease or increase in population; it is stable. Developed countries, where birth rates are low and overall quality of life is high, have a stationary population pyramid.

- **Population pyramids in Ethiopia:** According to a report by the Ethiopian Public Health Association in 2014, the population of Ethiopia grew substantially in the years it was 42.6 million in 1984, 53.5 million in 1994, 73.5 million in 2007 and 83.7 million in 2012 and is currently estimated to be more than 110 million. Moreover, the 2007 national population census indicated that Ethiopia has a younger population, with 45 percent of its population under the age of 15 years and only 4.8 percent of its population aged 60 years or older. Women between the ages of 15 and 49 account for 23% of the total population.

Survivorship Curves

- **A survivorship curve** is a graph of the number of individuals surviving at each age interval versus time. There are three types of survivorship curves.

- **Type I:** Organisms produce relatively few offspring and provide a lot of care to the offspring, increasing the likelihood of their survival. As a result, most of the offspring survive to adulthood, so they can reproduce.

- While mortality is low in the early and middle years, it occurs mostly in older individuals. This pattern is typical of humans and most mammals.

- **Type II**: Organisms produce moderate numbers of offspring and provide some parental care. The death /mortality rate is relatively constant throughout the entire life span, and mortality is equal y likely to occur at any age in the life span. An example of this pattern of survivorship curve occurs in some birds.

- **Type III**: organisms produce many offspring but provide them with little or no care. As a result, relatively few offspring survive to adulthood. Mortality is highest at early ages, but it is lower at

later ages. This pattern is a typical example of plants, invertebrates, and many species of fish because very few of these organisms survive their younger years.

6.1.4 Population regulation

- **There are two resistances to population growth**.
  - **Density-dependent factors** refer to the density of the population at a given time that affects its growth rate.
  - **Density-independent factors** are factors that influence the growth rate of the population regardless of its population density.

A. Density-dependent factors

- Density-dependent factors are living (biotic) factors that affect a population. They include predation, competition (interspecific and intraspecific), accumulation of waste, and diseases. Usually, the denser a population is, the greater its mortality rate will be. For example, during intraspecific and interspecific competition, the reproductive rates of individuals will usually be lower, reducing the growth rate of their population. In addition, low prey density increases the mortality of its predators because they have more difficulty ensuring their food source. The diseases in the area regulate population growth. For instance, unlike in a sparsely packed population, communicable diseases spread quickly and increase mortality in a dense population.

B. Density-independent factors

- Density-independent factors are non-living (abiotic) factors that regulate the population growth rate regardless of population density. Other density-independent factors include weather, natural disasters, and pollution. An individual may be killed in a catastrophic earthquake regardless of the number of individuals present in that area. This indicates that the chances of survival of the organisms are the same whether the population density is high or low.

6.2 NATURAL RESOURCES

- The earth is full of resources that are important for human beings to live on. Natural resources are the abundant resources available on the earth that are used to support life and meet people's needs. Nature provides us with the basic needs for our survival, such as food, shelter, clothes, etc. Natural resources refer to any natural substances or materials that are available naturally in the environment and that are used by human beings.

- They include oil, coal, natural gas, metals, stone, air, sunlight, soil, water, animals, birds, fish, and plants. Natural resources are used to make food, fuel, our clothes, cars, televisions, computers, and refrigerators, which provide us with heat, light, and power. Natural resources can be classified in various ways as renewable and non-renewable, or inexhaustible and exhaustible, respectively.

6.2.1 Renewable

- Renewable natural resources are resources that can be replaced after utilization. Resources that cannot be exhausted even after continuous utilization are termed renewable resources. Examples of renewable resources include sunlight, air, trees, water, wind, tidal energy, solar and wind energy, biomass energy, and hydropower. They are available continuously and their quantity is not noticeably affected by human consumption. However, renewable resources do not have a rapid recovery rate and are susceptible to depletion if they are overused. They can also be depleted if not properly managed or conserved.

6.2.2 Non-renewable

- Non-renewable natural resources are those resources that are found in the environment but do not naturally replenish at the same speed at which they are used up to meet the growing demands. These resources may take mil ions of years to form and replenish. A resource is considered non-renewable when its rate of consumption exceeds its rate of recovery. Examples of non-renewable natural resources are minerals, fossil fuels, coal, and natural gas.

6.3 CONSERVATION OF NATURAL RESOURCES IN ETHIOPIA

- Most of the natural resources are limited. In other words, these natural resources will eventually run out, and consequently, the amount resources to provide people, need especially in areas where population size is increasing at a higher rate, will be limited. There is a need to use existing resources wisely so that they will be available for the next generation. Therefore, conservation of natural resources is crucial. Natural resources are resources that exist in nature. These include soil, water, air, plants, animals, and energy. Some of them are found in a limited amount, which can be used only for a few years. Therefore, wise use and substitution of such natural resources is crucial to passing them on to the next generation. However, due to the growing population, rapid industrialization, and urbanization, the demand for natural resources is rapidly increasing and they are excessively being used. This leads to the depletion of natural resources.

- Conservation is the care, protection, and wise use of natural resources so that the resources can be used for future generations. It is also the preservation, management, or restoration of natural environments and the ecological communities habituated to human beings. Conservation aims to manage human use of natural resources for the current public benefit and sustainable social and economic utilization. Ethiopia has a wide range of natural resources such as plants, animals, water, and soil. Its topography and diverse climatic conditions have contributed to the existence of such natural resources. However, natural resources are facing problems unless appropriate conservation mechanisms are designed and implemented to keep them and pass them on to the next generations. The next section deals with natural resources including, wildlife, plants, soil, and water.

6.3.1 Wildlife in Ethiopia

- **Wildlife in Ethiopia:** has huge wildlife resource potential that has national and global importance. Wildlife refers to living things that live in the natural environment and are not yet domesticated. This section focuses on one of the categories of wildlife, animals.

- **Importance:** Wildlife resources have different benefits in that they are used to maintain natural ecological processes, store genetic material for the future, secure wildlife tourism, and contribute to the national economy, and manufacture goods.

- **Causes of loss and decline**: Loss and decline of wildlife is caused by different natural and human activities in Ethiopia. Natural disasters such as earthquakes, floods, droughts, tornadoes and wild fire are the major causes of loss and decline of wild life. Human activities such as expansion of agricultural activities, development activities, deforestation, poaching, illegal wildlife trade, habitat change, climate change, overexploitation, and pollution have also contributed to the loss and decline of wildlife in Ethiopia. How?

- **Conservation mechanisms**: due to the gradual loss and decline of wild life, we found it very crucial to design and implement wildlife conservation mechanisms. Wildlife conservation is the practice of protecting wildlife and their habitats. Wildlife conservation in Ethiopia has been practiced based on wildlife conservation areas. For this purpose, Ethiopia has established 24 national parks, 2 wild sanctuaries, 6 wild life reserves, 5 community conservation areas and more than 10 controlled hunting areas, as shown in the table below (Table 6.1). The table shows the wildlife conservation areas, regional states in which they are located, year of establishment and area in hectares of each national park, wild sanctuary, wild life reserve, community conservation area and controlled hunting area.

6.3.2 Plants in Ethiopia

- Similar to animals, the topography and diverse climatic conditions of Ethiopia have enabled various plant species to survive. Plant species in Ethiopia are diverse and have a rich endemic element. Therefore, Ethiopia is considered a center for crop genetic diversity. The following figure shows examples of plants in Ethiopia. Similar to the threatening fate of animals, the loss and decline of plant species is a big problem in Ethiopia.

- **Cause of loss and decline of plant species:** Plant species are being lost and declined due to natural and manmade activities. The natural disasters mentioned so far for the loss and decline

of wildlife can be the major causes of the loss and decline of plant species. Human activities such as deforestation, climate change, invasive species, overexploitation, pollution and land degradation are some of the problems endangering plant species in Ethiopia.

- **Conservation mechanisms:** conservation mechanisms for plant species in Ethiopia include indigenous and modern practices.
- **Indigenous practices:** Indigenous or cultural practices refer to the long-standing traditions and ways of life of specific communities or localities. Some of the traditional systems used for plant conservation rely on taboos or forbidden practices for using or consuming some plant species; domestication; reserves; selective harvesting; sacred groves, etc. Sacred places and places of worship, such as the compounds of churches and mosques, graveyards, and monasteries, have been important sites and are considered reserved areas that have contributed to the protection of indigenous plants.
- The traditional practices for preserving the genetic resources of indigenous vegetables are regarded as important conservation practices. The traditional farming systems and the traditional agroforestry systems practices have been able to maintain a rich genetic diversity of vegetables and other crops as the people who have used them have developed sophisticated mechanisms of selection, transfer, exchange, and conservation.
- **Modern practices:** practices used to establish botanical gardens, control invasive species, recover, restore, and preserve genes in a bank are some of the examples of modern practices. Preservation of seeds in the Ethiopian national gene bank is another conservation mechanism for plants.

6.3.3 Soil and water in Ethiopia

- Ethiopia has large soil and water resources. The wide range of climate, topography, parent material, and land use in Ethiopia has resulted in the formation of various soil types in different parts of the country. Similarly, it has resulted in the distribution of different surface and groundwater resources in quantity and quality. The country's water resources provide the

country with a large potential for hydropower generation, irrigation, and fishing. The best example is the Grand Ethiopian Renaissance Dam (GERD), which has been built on the Abay (Nile) River and can generate hydropower

- Water resource potential in Ethiopia includes lakes, river basins, and ground water. However, soil erosion and the decline in water quantity and quality have been the major problems that have affected the agricultural production, the environment, and health of human beings and other animals in Ethiopia.
- **Causes of soil erosion and the decline in water quantity and quality**: the major causes of these problems are human activities such as deforestation, poor land husbandry practices, and wastes emitted from industries and homes. Hence, conservation of soil and water is mandatory.
- **Conservation mechanisms**: soil and water conservation measures involve both **mechanical** and **biological measures**.
- **Mechanical measures**: The major mechanical measures include constructing bunds, terraces, diversion ditches, check dams, micro-basins, and hillside terraces.
- **Biological measures**: The biological measures include enclosing degraded land from human and animal interferences; tree seedling production; planting of tree seedlings on farmlands (agro-forestry); afforestation; and tree plantations around homesteads. The Green Legacy initiative that was launched in June of 2019 with the vision of building a green and climate resilient Ethiopia is a good example of efforts made by the Ethiopian people to reduce environmental problems such as soil erosion and loss of water.

6.4 IMPACT OF TRAFFIC ACCIDENT ON WILD AND DOMESTIC ANIMALS

Studies show that road traffic accidents have become a huge global public health and development problem, killing and injuring many people and destroying properties every year.

Developing countries, including Ethiopia, have accounted for a large number of global road traffic deaths. In addition to the loss of a human being, car accidents have also been the major cause of death for both wild and domestic animals. Even those animals that live in the conservation areas and outside are affected by car accidents while crossing highways near the reserved areas.

- Studies in the field of road ecology suggest that car accidents are the major cause of reductions in wildlife populations. This holds true in Ethiopia, where many animals are killed every year due to car accidents. For instance, a study conducted in 2017 by Addisu Asefa and his colleagues in Geralle National Park indicated that 29% of the wildlife mortality was due to car accidents.

- Imagine how this mortality would be high in other national parks and other wider areas where there are a number of crossing roads. Some of the methods to reduce traffic accidents on both wildlife and domestic animals include designing structures that allow safe passage for animals and wildlife, constructing underpasses to promote habitat connectivity and encourage natural movements, and considering natural wildlife habitats when roads are constructed and deriving slowly.

6.5 IMPACT OF HUMAN ACTIVITIES ON THE ENVIRONMENT

- We, human beings, are an integral part of the environment where we depend on it for different aspects. We obtain all the materials needed for survival and development from the environment we live in. However, in an attempt to lead a standard life, we are exploiting the environment through destructive practices that have far-reaching side effects on the entire ecosystem and our lives. This has an effect on not only the present generation but also on the future generation.

- Human beings perform different activities to live in this word, from small activities at home to larger mechanized activities in the industrialized world. Though these activities have benefits for human beings in developing their economy and improving their living conditions, they have

a negative impact on the environment, which in turn affects sustainable development and the health of human beings.

- **The following is a list of the major activities that affect the environment.**
  - Burning of coal, natural gas
  - Using refrigerants and coolants
  - Applying pesticides
  - Waste incineration and waste disposal
  - Using various volatile chemicals
  - Agricultural activities
  - Industrial and other sewage discharges
  - Construction of infrastructure and transportation
  - Urban development
  - Mining activities

- Because of such human activities, the environment is now experiencing environmental pollution, climate change, and global warming, acid rain, and ozone layer depletion, loss of biodiversity, toxic bioaccumulation, and resource depletion that affect all living things in the environment.

6.5.1 Environmental pollution

- Environmental pollution is the contamination of the components of the environment that adversely affect the normal environmental processes. It is also the addition of any substances and forms of energy to the environment at a rate faster than they can be dispersed, diluted, decomposed, recycled, or stored in some harmless form.

- **Causes of environmental pollution:** Environmental pollution can be caused to some extent by natural events such as forest fires and active volcanoes, but mainly by human activities. Rapid human population growth and industrialization have aggravated pollution, which has become a universal problem.

- **Types of environmental pollution:** The major types of pollution are air pollution, water pollution, land pollution, noise pollution, and light pollution. Pollution of all kinds can have negative effects on the environment and wildlife that in turn have impacts on the health and wellbeing of human beings.

6.6 AIR POLLUTION AND ITS EFFECTS

- Air pollution is the contamination of the air in the atmosphere by harmful gases, dust, and smoke that affect plants, animals, and humans drastically.

- **Causes of air pollution:** Air pollution is caused by air pollutants being added into the environment at rates that exceed the natural capacity of the environment to dissipate and dilute or absorb them. The major air pollutants are carbon monoxide, nitrogen dioxide, ozone, lead, sulfur dioxide, smog and particles. These pollutants are released from human activities such as transportation, industrial activities, the burning of coal and natural gas, the use of refrigerants and the use of various volatile chemicals.

- **Effects of air pollution:** Air pollution is the leading environmental health risk and a major cause of environmental degradation in the world. It is the major cause of the depletion of the ozone layer and of many other harmful environmental effects. It causes respiratory and cardiovascular disorders in human beings, changes the pH levels of the soil, causes acidic rain and infects plants and other forms of vegetation, thereby making the food we eat harmful and toxic.

6.7 WATER POLLUTION AND ITS EFFECT

- Water is essential for living things. Water pollution is the contamination of water bodies. It interferes with the beneficial use of water. For instance, the presence of an excessive number of toxins in water bodies causes pollution of water.

- **Causes of water pollution:** The major causes of water pollution are usual y human activities. Many pollutants into water are released from human activities such as factories, industrial agricultural wastes, sewage, transportation of oil, use of chemical fertilizers and insecticides, herbicides, pathogenic microorganisms, and Water hyacinth (Emboch)

- **Effects of water pollution:** Water pollution is the major cause of the depletion of fish populations, the destruction of biodiversity, and waterborne diseases that lead to death.

6.8 CLIMATE CHANGE

- Climate is the usual weather of a place that can vary for different seasons. Climate change is a change in the usual patterns of weather. This could be a change in the amount of rain, temperature, etc., for a month or season. Thus, climate change can affect living organisms in the environment.

- **Cause of climate change:** Global climate changes naturally over time scales due to the natural variations from internal fluctuations such as exchange of energy, water and carbon between the atmosphere, oceans, land and ice, and from external influences such as variations in the energy received from the sun and the effects of volcanic eruptions.

- Human activities can also change the climate by changing the natural components of the environment. Human activities, particularly the combustion of fossil fuels, are altering the climate system. It has increased the levels of carbon dioxide and other greenhouse gases in the atmosphere. Many of these greenhouse gases occur natural y, but human activities are increasing the concentrations of some of them in the atmosphere, in particular carbon dioxide (CO2), methane, nitrous oxide, and fluorinated gases.

- **Effects:** Greenhouse gases have far-ranging environmental and health effects. They have a greenhouse effect that causes **global warming**. They act like the glass in a greenhouse, trapping the heat of the sun and preventing it from returning into space, resulting in global warming. These heat-trapping gases can be thought of as a blanket wrapped around the earth to prevent it from turning back. This results in an increase in the temperature of the earth's atmosphere, the ocean, and land surface.

6.9 GLOBAL WARMING

- Climate change results in global warming. Global warming is an average rapid rise in the earth's temperature. The major causes of global warming are greenhouse gases released from human activities such as burning fossil fuels and industries.

- **Effects of global warming:** Global warming has an effect on living things. Some of the effects include flooding, melting of ice caps, rising oceans, loss of species, health problems. Some of the consequences of an increase in the earth's temperature include drought, rising sea levels, extinctions of species, heavy rainfall and flooding, high heat stress and health risk, poverty and displacement. The following figure shows some of the effects of global warming such as forest burning, deforestation, draught and flooding and meting of ice.

6.9.1 Ozone layer depletion

- One of the major problems caused by air pollution is the depletion of the ozone layer. Ozone (O_3) is made of three oxygen atoms. While oxygen is important for the life of organisms, ozone is a toxic gas. However, ozone plays a critical function in the various ambient layers of the atmosphere. The atmosphere has four layers. These are the troposphere, stratosphere, mesosphere, and thermosphere.

- Ozone is found in the stratosphere of the atmosphere. The sun releases UV rays onto the earth, where the rays harm animals by causing skin cancer in humans. The ozone layer protects the earth from these harmful radiations (UV rays). It absorbs the radiation from the sun, thereby

preventing it from entering the earth's atmosphere. However, this protective layer has been eroding due to the various factors resulting in ozone depletion (ozone hole).

- **Cause of ozone depletion:** The major cause of ozone layer depletion is the release of CFCs (chlorofluorocarbons), which are used in refrigerators and fire extinguishers, hydro fluorocarbons (HCFCs), and halons. CFCs cause chemical reactions that break down ozone molecules, reducing the ozone's ultraviolet radiation-absorbing capacity. Chlorine reacts with ozone and forms oxygen (O_2) and chlorine monoxide (ClO).

$$Cl + O_3 \rightarrow ClO + O_2$$

- When the molecule of chlorine monoxide (ClO) meets with another molecule of oxygen (O), it breaks up, releasing chlorine (Cl), which can react with another molecule of ozone (O_3), creating the catalytic cycle of chlorine.

$$ClO + O \rightarrow Cl + O_2$$

Effects of ozone layer depletion

- Ozone layer depletion exposes to UV rays that can lead to:
  - Skin cancer and cataracts and weaken the immune system response.
  - Ageing of the skin, making one look much older than he/she actual y is.
  - Cause respiratory diseases such as chest pain, difficulty in breathing, or even throat irritation.
  - Ozone layer depletion also affects other living beings, such as terrestrial and aquatic animals and plants.
  - It also increases the formation of ground-level ozone (smog)

6.10 ACID RAIN

- Acid rain is rain with more acidic content (lower pH value) than natural rain.

- **Causes of Acid rain.** It is caused by high concentrations of acid-forming pollutants that dissolve in freshly condensed water vapor in the atmosphere. The major causes of acid rain are the burning of fossil fuels, electric power-generating facilities, industrial processes, exhausts emitted from the internal combustion engines that serve as sources of sulfur dioxide and nitrogen oxides, etc.

- The burning of fossil fuels (coal or oil) for energy contains sulfur and nitrogen, which combine with oxygen to form sulfur dioxide (SO_2), and nitrogen dioxide, which contribute to the acidity of rain. Sulfur dioxide and nitrogen oxides enter into the atmosphere and react with water to form solutions of sulfuric acid (H_2SO_4), and nitric acid (HNO_3) respectively. The reactions are shown as follows:

  $2SO_2\,(g) + O_2\,(g) + 2H_2O\,(l) \rightarrow 2H_2SO_4\,(aq)$

  $4NO_2\,(g) + O_2\,(g) + 2H_2O\,(l) \rightarrow 4HNO_3\,(aq)$

- Moreover, carbon dioxide (CO_2) in the atmosphere makes rain slightly acidic. This is because carbon dioxide and water combine to form carbonic acid, commonly known as carbonated water.

- **Effects of acid rain:** Acid rain causes great damage to plants, soil, and water that in turn affects many living organisms that depend on these resources for their survival. Acid rain can harm plants by damaging the outer leaf surfaces by stripping away the waxy protective coating from the plant leaves, resulting in the leaching of nutrients such as calcium, magnesium, and potassium out of leaf tissue and drying.

- Acid rain can keep seeds from germinating and degrade the available nutrients in the soil so that plants do not use them. It dissolves aluminum in the soil, which stops the growth of plants. It also dissolves other minerals in the soil quickly, allowing nutrients to be released and leached away.

- Soil microorganisms, aquatic animals such as fish and amphibians can also be affected by acid rain. It also affects human beings by reducing the quality of the water people use for drinking and cleaning and can cause acute toxicity or chronic health problems due to dissolved trace metals.

- Corrosion of water pipes, which further results in leaching of heavy metals such as iron, lead, and copper into drinking water, can also be caused by acid rain. It also damages the buildings and monuments made up of stones and metals.

6.11 LOSS OF BIODIVERSITY

- Biodiversity refers to the variety of life on earth in terms of genes, species, individual organisms within a given species, and biological communities from an ecosystem to the global biosphere. The loss of biodiversity is a decrease in biodiversity with regard to the number genes, species, and biological communities in the world.

- **Causes of loss of biodiversity:** Over the last many years, the rapid growth of the human population has caused rapid ecosystem change and massive loss of biodiversity across the world. The loss of biodiversity is mainly related to the permanent ecological changes in the ecosystems, landscapes, and the global biosphere because of the exponential growth and demands of the human population. The major causes of the loss of biodiversity are:

- **Loss of habitat and degradation.** The fragmentation, destruction, and transformation of the existing natural habitat reduce or eliminate the food resources and living space for most species. This results in the loss of biodiversity, even in the elimination of those species that cannot migrate.

- **Overexploitation:** Activities connected with capturing and harvesting of animals or other organisms beyond the capacity for surviving populations without leaving enough to replace their losses result in biodiversity loss.

- **Pollution**: Human activities influence the natural environment, resulting in pollution of the environment and this cause's biodiversity loss thereby creating health problems for the exposed organisms, killing organisms or creating reproductive problems that threaten the species' survival.

- **Climate change:** Heating of the earth's surface affects biodiversity because it endangers all the species, especially those species that are adapted to the cold due to latitude or altitude.

- **Invasive species:** The introduction of new species/non-native species to the country that significantly modify or disrupt the ecosystems they colonize may out compete native species for food and habitat, which triggers population declines in the native species.

- **Effects of biodiversity loss:** The loss of biodiversity is increasingly threatening the earth's ability to provide humans with things such as food, water, fertile soils, and protection from pests and disease. Biodiversity is critical to maintaining the ecosystem. The decline of biodiversity lowers an ecosystem's productivity and lowers the quality of the ecosystem's services.

- Loss of biodiversity affects the economic systems and human society. Humans rely on various plants, animals, and other organisms for food, building materials, and medicines, and their availability as commodities is important to many cultures. The loss of biodiversity among these critical natural resources threatens the global food security and the development of new pharmaceuticals to deal with future diseases. The mainstream and traditional medicines can be derived from the chemicals in rare plants and animals, and thus lost species represent will loss opportunities to treat and cure.

6.12 TOXIC BIOACCUMULATION

- Bioaccumulation is an increase in the concentration or accumulation of chemicals in living organisms' body tissues. Persistent bio accumulative toxic substances (PBTs) are chemicals that do not degrade easily in the environment. PBTs are typically accumulated in fatty tissues and are slowly metabolized, often increasing in concentration within the food chain.

- **Sources of toxic bio-accumulates:** The major bio-accumulates are organic compounds and metals. They include synthetic chemicals that contain halogen atoms (particularly fluorine, chlorine, or bromine), DDT, and metals, such as lead and mercury.

  The process of bioaccumulation occurs as follows:

  1. Plants absorb small amounts of toxic substances, often pesticides or pollutants.

  2. These plants are eaten by primary consumers in low concentrations.

  3. The toxin cannot be excreted, so when the primary consumers are eaten by secondary consumers, the toxin is absorbed by secondary consumers.

  4. This repeats as secondary consumers are eaten by higher-level consumers.

  5. At each trophic level of the food chain, the toxins remain in the tissues of the animals, so the concentration of toxins becomes the most concentrated in the body tissues of the animals at the top of the food chain.

- **Effects of toxic bio-accumulates**: Unlike many chemicals in the environment, bio-accumulates are not degraded by sunlight, destroyed through reactions with other environmental substances, or metabolized by naturally occurring bacteria. They are also resistant to the metabolic reactions in people or wildlife. Humans, domestic animals, and wildlife are more likely to be exposed to these chemicals in the environment.

- Bio-accumulative chemicals can have a variety of toxic properties, resulting in a diverse array of adverse health effects such as mutagenic damage to DNA, cancer, neurological toxicity, reproductive toxicity, developmental toxicity, and immune system damage.

- Lead contamination of air, soil, or drinking water can ultimately result in significant exposures in fetuses, infants, and children, resulting in impaired brain development. When mercury is

consumed by fish with plankton, it passes through the food chain and damages the nervous systems and the reproductive systems of mammals, including humans.

- For examples, DDT affects the population of birds of prey at the top of food chains, which are badly affected because it makes the shells of their eggs very thin, causing them to break easily when the birds try to incubate them.

6.13 RESOURCE DEPLETION

- Resource depletion occurs when the consumption of natural resources becomes faster than they can recover and become scarce. Natural resources have been depleted primarily because of human activities (recal natural resources and human activities that affect the environment from the previous sections). Due to the increasing global population, natural resource depletion is also increasing.

❖ The **major causes** of the depletion of natural resources are:

1. **Overpopulation.** The consistent increase in the overall global population has been a critical factor in accelerating the depletion of natural resources because of the need for resources and conditions necessary to sustain it.

2. **Poor farming practices**: Poor irrigation practices, poor soil management practices, and the use of heavy machinery and farming equipment result in resource depletion. For instance, destroying the soil structure makes it unsuitable for plant growth. Moreover, excessive use of pesticides, fungicides, and herbicides kills important soil microorganisms that are essential in replenishing nutrients in the soil.

3. **Overconsumption of natural resources**- industrial revolution saw large-scale mineral and oil exploration, and the practice has been gradually growing, leading to more and more natural oil and mineral depletion. Moreover, together with the advancements in technology, development, and research in the contemporary era; exploitation of minerals has become easier and humans

are digging deeper to access different ores. The increased exploitation of different minerals has resulted in a production decline.

4. **Industrial and Technological Development:** Industrialization and technological advancement have resulted in the release of toxins and chemical by-products that have affected natural resources and the demand for natural resources, and these have increased the rate of natural resource depletion.

6.14 INDIGENOUS CONSERVATION PRACTICES IN ETHIOPIA

- **Indigenous peoples** have strong social and cultural values, orderly social control and cohesive social systems rooted in their indigenous knowledge of the universe in general, and their locals in particular. Indigenous knowledge is a body of knowledge built over generations by a group of local people living in a particular environment. Ethiopia has a known indigenous culture, tradition, religion, and knowledge. The people of Ethiopia have indigenous knowledge about natural phenomena, natural resources, and their environment. For instance, they have indigenous knowledge of natural phenomena such as astronomy, the proper use of natural resources, including the conservation and the prediction of seasonal conditions such as rainy season, drought season, weather conditions, productivity of the season, etc. This indigenous knowledge was developed through the critical observation of the sun, moon, and stars; behavior of animals; winds; and the level of temperatures.

- The indigenous knowledge they have developed has helped them to have their own calendar, predict the weather conditions, treat different types of diseases, produce crops to sustain their lives, protect their environment and conserve natural resources. Peoples in Ethiopia have developed indigenous knowledge in a wide range of fields of conservation of natural resources, such as the conservation of soil, water, crop seeds (selection and preservation), forest, medicinal plants, animals, etc. For example, the well-known and internationally recognized indigenous soil and water conservation practice of the Konso People, southwestern Ethiopia (practiced for

more than 400 years) and this practice, which was registered by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a world heritage, can be mentioned. The most commonly used soil and water indigenous conservation practices among the Konso people are making terraces, contour ploughing, crop rotation, mixed cropping, surface mulching, and agro forestry.

- **Making Terraces:** Terraces are structures or buildings built mainly in hil y areas to intercept run off water to reduce soil erosion and for soil and water conservation. The Konso Cultural Landscape is characterized by extensive dry stone terraces. The terraces retain the soil from erosion, collect maximum water and discharge the excess, and create terrace saddles that are used for agriculture.

- Contour Ploughing - Contour ploughing is the act of farming on a hill to reduce runoff of water and prevent soil erosion.

- Crop Rotation: Crop rotation is planting different crops sequentially on the same plots of land to improve soil fertility and reduce the effects of pests and weeds. Farmers know this, which is similar to the scientific method used to improve soil fertility that can be achieved by alternating high residue-producing crops with low residue-producing crops.

- **Mixed Cropping**: Mixed cropping is the growth of two or more species on the same field at the same. The great majority of the cases are a mix of maize and groundnuts. This shows that most of the farmers have an awareness of the potential to maintain soil fertility and to be cost-effective by using their indigenous knowledge of mixed cropping.

- Surface Mulching: Surface mulching is applying a layer of materials to the surface of the soil for conservation of soil moisture to improve the fertility of the soil and reduce weed growth. Most farmers use surface mulch on their fields by using crop residue and branches.

- Agro-forestry: the use of agro-forestry for soil conservation is the most widely practiced activity in different areas. It is very common to see different types of small and big trees inside and just

outside the farm land of Konso The best example is Moringa stenopetala (locally also called Moringa).Thus, it seems that in addition to the role of trees for indigenous soil conservation practices in agro-forestry form, they also have a strong attachment to the cultural practices of society. These indigenous conservation practices are also observed among peoples in different parts of Ethiopia.

- Moreover, there are also areas protected from any intervention by the community for conservation purposes. For example, the Guassa community conservation area of Menz in Ethiopia's central highlands, which was practiced for over 400 years, can be mentioned. The area was governed under a communal management system known as Qero. The Qero system requires the closure of the Guassa area from any use by the community for about three to five years. The opening of the area for use depends on the growth and recovery of the grass, community requirements for resources, the success of the local crop harvest, and on the frequency of drought in the Guassa area. The community elects headmen who determine when to open the area, for how long local people can harvest thatch grass, graze their livestock, and close it again.

UNIT SIX SUMMARY

- Population is group of individuals that live in an area. Ecology is the study of the interaction between living things and their environment. Hence, population ecology is the study of the interaction between populations and the environment and the changes that affect the distribution and abundance of populations in the environment. Population ecology studies populations in terms of population size, growth rate, density, age structure, birth rates, death rates, and dispersal.

- Population size is the total number of individuals present in a particular habitat, whereas population density is the number of individuals per specific area or volume. Since it is difficult to locate and count all individuals in a population, a sampling technique is used to determine whether individuals in the sample are counted and used to infer the total population in an area.

The quadrat and marker capture methods are commonly used in population studies. Individuals in an area show dispersal patterns, which refer to the distribution of individuals in space at a given time. They may have uniform dispersion, random dispersion, or clumped dispersion.

- The world's human population, including the population of Ethiopia, has been growing faster and faster from time to time. This has resulted in various adverse effects in the transformation of a considerable portion of natural ecosystems in order to accommodate and supply this population growth. The magnitude of its impact on the environment depends on the following factors: human population size, resource use, waste production, environmental degradation, and technological developments.

- Models are used to study population ecology to describe the changes that occur in a population, thereby predicting future changes. The exponential growth model describes populations increasing in numbers without any limits to their growth, and the logistic growth model describes populations increasing in number using limits due to an increase in number. The population growth graph of the exponential growth model shows a J -shaped curve, whereas the logistic growth model shows an S-shaped curve graph because of the carrying capacity by which population growth levels off. There are two causes, density-dependent factors (due to an increase in population density) and density-independent factors (regardless of population density).

- Demography is the study of population changes over time and focuses on population size, population density, fecundity (birth rates), fertility, mortality (death rates), marriage, migration, age, and sex. Demographers use population pyramids to represent the age-sex structure of a population and states the complex social narrative of a population through their shape. A population pyramid is a graphical representation of the age and sex composition of a specific population.

- Natural resources are substances or materials that exist naturally in the environment and are used for different purposes. They include oil, coal, natural gas, metals, stone, air, sunlight, soil,

water, animals, birds, fish, and plants. These can be grouped as renewable (can be replaced after utilization) and nonrenewable natural resources (do not naturally replenish).As a result of an increase in the population, natural resources are depleting excessively. Hence, conservation is very important. Conservation is the preservation, management, protection, and wise use of natural resources. Ethiopians have indigenous and modern ways of conserving natural resources such as wild life, plants, soil, etc. The day-to-day activities of human beings have several negative impacts on the environment. One of the impacts is climate change due to the combustion of fossil fuels. This activity has increased the levels of greenhouse gases such as carbon dioxide, methane, and nitrous oxide in the atmosphere. Greenhouse gases trap the sun's heat and prevent it from returning into space, resulting in global warming which has caused an increase in the temperature of the earth's atmosphere, the ocean, and land surface. This has resulted in the rise of sea levels, extinctions of species and loss of habitat, heavy rainfall and flooding, high heat stress and health risk.

- The other effect of human activities is environmental pollution. Environmental pollution is the contamination of the components of the environment. This pollution has different impacts on the natural world. Some of the impacts that adversely affect human beings and other living things are global warming, acid rain, ozone depletion, loss of biodiversity, and bioaccumulation in the environment. The local people are aware of the degradation and depletion of natural resources. They have accumulated their own indigenous knowledge to conserve natural resources. People in Ethiopia have developed indigenous knowledge in the conservation of natural resources such as soil, water, crop seeds (selection and preservation) forest, medicinal plants, animals, etc. The practice of the Konso people in Ethiopia can be taken as exemplary indigenous knowledge used for the conservation of natural resources.

Unit six review questions

I. Multiple choice questions Direction: Choose the correct answer for each question.

1. Which one of the following best describes population Ecology?

A. the dynamics of individuals B. groups of individuals C. how populations grows D. how populations change over time and through space

2. Assume that using the mark-recapture technique a student captured 100 birds and mark them. One week later the student captured 100 individuals and find that 40 are marked. The population of bird is

A. Decreasing B. 250 individuals C. 40 individuals D. 160 individuals

3. The dispersion pattern of the individuals in the diagram on the right is

A. Random B. Clumped C. Uniform D. A and B

4. Density-dependent regulation may occur due to all of the following except:

A. Food limitation B. Territorial behavior C. Air pollution D. predation

5. Carbon dioxide is important in our atmosphere because it is required for photosynthesis and traps some heat, keeping the Earth warm. However, human produced carbon dioxide is a problem because it:

A. Increases carbon dioxide concentration in the oceans B. Leads to higher global warming C. Causes toxic bioaccumulation D. Causes uncontrolled photosynthesis.

6. Which one of the following natural resource is renewable? A. Coal B. Natural gas C. Solar D. Uranium

7. Which will most likely result in a negative growth rate in the human population?

A. The death rate is higher than the birth rate. B. The birth rate is higher than the death rate C. Improved economic conditions. D. Improvements in sanitation.

8. Which one of the following is the main purpose of planting different types of crops on the same land throughout the year? A. It prevents insects from destroying crops. B. It allows for

more genetic variation in plants. C. It helps to preserve the quality of the soil. D. It serves to preserve quality of water

9. Which of the following is measure by child-woman ratio? A. Population growth B. Fertility C. Migration D. Mortality

10. Which of the following cannot be drawn from the population pyramid of a country? A. Total population size B. Population growth rate C. Age distribution of population D. Birth and death rate

11. A bird release many eggs each time they reproduce. The majority of these offspring are eaten before they hatch. However, birds can live for many years. This is an example of A. Type I survivorship curve C. Type III survivorship curve B. Type II survivorship curve D. All of the above

12. Chief air pollutant which is likely to deplete ozone layer is A. Sulfur dioxide B. Carbon dioxide C. Nitrogen oxides and Fluorocarbons D. Carbon monoxide

13. Most abundant water pollutant is A. Detergents B. Pesticides C. Industrial wastes D. Ammonia.

14. An environmental factor such as storms and extreme heat or cold that affects population are: A. density- dependent factor B. density- independent factor C. population density D. dispersion

15. Which one of the following is not true about the logistic model of population growth? A. The graph of the model is J shaped. B. The model shows a restricted growth rate C. The logistic model considers the environment's carrying capacity. D. The graph of the model is S shaped

16. What is likely to be true of a population with an age structure that is pyramid shaped? A. It is expected to grow slowly in the future. B. It is expected to decline in population size over time. C. It has potential for rapid population growth in the future. D. This age structure is characteristic of zero population growth.

17. At what year is the census carried? A. Every 5 years B. Every 7 years C. Every 1 year D. Every 10 years

18.80 individuals are born per year in a population, and the mid-year population is 5000. What is the birth rate of that area? A. 20 B. 16 C. 4 D. 2

19. The 20 individuals are dying per year in a population, and the mid-year population is 7000. What is the death rate of that area? A. 13 B. 30 C. 2.8 D. 29

Image??

20. Which of the following is the most likely explanation for the differences in the population pyramids? A. Region A has a higher dependency ratio than Region B. B. Region B has a higher population density than Region A. C. Region A has a higher childhood mortality rate than Region B. D. Region B has a higher total fertility rate than Region A.

21. Based on information presented in the population pyramids, it is reasonable to infer that, compared with governments in Region A, governments in Region B will be devoting a greater proportion of state spending over the next decade to which of the following needs? A. communication infrastructure B. school construction C. health care D. highway development

22. Which one of the following is said to be the most important cause or reason for the extinction of animals and plants? A. Loss of habitat and fragmentation B. Over-exploitation of specie C. Invasion of alien species D. Co-extinctions

23. In which approach do we protect and conserve the animals that need urgent measures to save it from extinction?

A. In-situ conservation B. On-site conservation C. Ex-situ conservation D. No conservation

24. On what does the harmful effect of pollution depend on?

A. The concentration of pollutants and the organism

B. The concentration, duration of exposure to pollutants and the organism

C. The concentration of pollutants and duration of exposure

D. The organism only

25. What happens when phosphorus, nitrates, and detergents in water lead to acceleration in the growth of algae? A. Extinction B. Eutrophication C. Increase in the number of fishes D. Increase in the number of aquatic plants

26. What happens to the concentration of DDT in each trophic level? A. Decrease B. Remains unchanged C. Increases D. Becomes zero

27. Which gases are commonly known as greenhouse gases? A. Carbon dioxide B. Nitrogen C. Chlorine D. Oxygen

II. Short answers Direction:

Write a short answer for the following questions.

1. What is greenhouse effect? How it causes global warming. What is the effect on living things?

2. What is the difference between logistic and exponential growth? What conditions support exponential population growth?

3. One of the causes of biodiversity loss is invasive species. Mention invasive species in Ethiopia and describe how they cause loss of biodiversity.

4. How does the age-sex structure of a population influence growth?

5. Explain what can be learned about a population from its population pyramid

6. The 100 individuals are born per year in a population, and the mid-year population is 5000. What is the birth rate?

7. Describe the difference between population density and distribution. Why organisms aren't always distributed evenly throughout their habitat?

Answer key for review questions

I. Multiple Choice Question

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

II. Answer short answers:

1. What is greenhouse effect? How it causes global warming. What is the effect on living things?

- **Answer :**
  - Greenhouse gases have far-ranging environmental and health effects. They have a greenhouse effect that causes **global warming**. They act like the glass in a greenhouse, trapping the heat of the sun and preventing it from returning into space, resulting in global warming. These heat-trapping gases can be thought of as a blanket wrapped around the earth to prevent it from turning back. This results in an increase in the temperature of the earth's atmosphere, the ocean, and land surface.
  - Some of the effects include flooding, melting of ice caps, rising oceans, loss of species, health problems.
  - An increase in the earth's temperature include drought, rising sea levels, extinctions of species, heavy rainfall and flooding, high heat stress and health risk, poverty and displacement.

2. What is the difference between logistic and exponential growth? What conditions support exponential population growth?

- **Answer :**

- Exponential growth model describes populations increase in numbers without any limits to their growth.
- Logistic growth model describes populations' increases in number in the presence of limits, and due to an increase in number.

3. One of the causes of biodiversity loss is invasive species. Mention invasive species in Ethiopia and describe how they cause loss of biodiversity.

Answer :

- The introduction of new species/non-native species to the country that significantly modify or disrupt the ecosystems they colonize may out compete native species for food and habitat, which triggers population declines in the native species.

4. How does the age-sex structure of a population influence growth?

Answer :

- In demography, age and sex are the most commonly studied elements of population composition. It is the number of individuals in terms of sex and age in the population. The age-sex structure is an important factor that influences population growth. This is because younger people are more likely to reproduce, whereas older people have higher rates of dying. The age and sex data of individuals in a population are often compared over time using population pyramids.

5. Explain what can be learned about a population from its population pyramid

Answer :

- Population pyramid is a graphical representation of the age and sex composition of a specific population. In other words, the population pyramid represents the age-sex structure of a population and states the complex social narrative of a population through its shape. Demographers use these simple graphs to evaluate the extent of development for a given population in a country and to make predictions about the types of services that population will

need, such as schools, hospitals, homes, etc. A population pyramid is popularly known as an "age pyramid" or "age and sex pyramid." There are three types of population pyramids.

6. The 100 individuals are born per year in a population, and the mid-year population is 5000. What is the birth rate?
    - **Answer:** As per the formula, Natality = Number of deaths per year / Mid−year population x 1000 = 100/5000x 1000 = 20. The birth rate of the given area is 20 per year.
7. Describe the difference between population density and distribution. Why organisms aren't always distributed evenly throughout their habitat?

Answer :

- Population density is the number of individuals within a specific area or volume, i.e., population size divided by the total land area.
- Species dispersal patterns refer to how the individuals in a population are distributed in space at a given time.
- Because organisms also distributed randomly and clumped each other.