OROMIA EDUCATION BUREAU

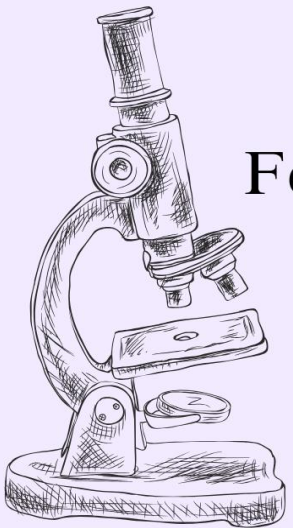
ASTU SPECIAL SCHOOL

BIOLOGY

HIGH SCHOOL MODULE

Writer: Fikre Belete(MSc)

Reviewers: Alemneh Mideksa(MSc)
Jeylan Aman (PhD)



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Email: fikirebelete@gmail.com

PREFACE

Welcome to the ***Comprehensive Biology High School Module*** for Grades 9-12, designed to align with the new curriculum and provide an engaging, in-depth exploration of biology. This module covers key topics through six main themes: Cell Biology, Genetics and Heredity, Evolution and Natural Selection, Human Biology and Physiology, Ecology and Environmental Science, Biotechnology, and Biology, Technology, Society, and Environment (BTSE). Each theme offers a thorough understanding of the subject matter, providing clear explanations, real-world examples, and interactive learning opportunities. Students will find helpful illustrations, key terms, and multiple-choice questions for practice throughout the material, enabling them to test their knowledge and prepare for exams. With an emphasis on critical thinking, practical understanding, and updated curriculum integration, this resource aims to deepen students' comprehension of biological concepts, foster scientific curiosity, and equip them with the skills necessary for both academic success and real-world application.

Acknowledgements

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THEME 1: BIOLOGY, TECHNOLOGY, SOCIETY, AND ENVIRONMENT

Biology, Technology, Society, and Environment (BTSE)

The **BTSE framework** highlights the interconnected relationship between biological sciences, technological advancements, societal development, and environmental sustainability. The **BTSE framework** explores the dynamic relationship between biology, technology, society, and the environment. These four domains are deeply interconnected, influencing and shaping one another in various ways. **Biology** is the study of living organisms, providing essential knowledge about life processes, ecosystems, and biodiversity. **Technology** applies scientific principles to develop innovations that enhance healthcare, agriculture, and industry. **Society** benefits from biological and technological advancements, improving quality of life and economic growth. However, these developments also impact the **environment**, which includes all natural systems that sustain life. Balancing progress with sustainability is essential to ensure that technological and biological advancements support human well-being while preserving the natural world. Understanding these connections helps in making informed decisions for a better future.

1.1. Introduction to Biology

What is biology?

Biology is the foundation of life sciences, providing insights into the structure, function, and interactions of living organisms. However, its significance extends beyond mere observation of nature. Biology is deeply intertwined with technological advancements, societal progress, and environmental sustainability. The study of biology has led to innovations in medicine, agriculture, and industry, improving human life while also raising ethical and ecological concerns.

The integration of biology with technology, often termed **biotechnology**, has enabled scientific breakthroughs such as genetic engineering, cloning, and artificial intelligence-driven diagnostics. These advancements have revolutionized fields like medicine, where vaccines and gene therapy have saved millions of lives. In agriculture, genetically modified organisms (GMOs) have enhanced crop yields and food security. However, these developments come with ethical dilemmas, including genetic privacy, bioethics, and environmental sustainability.

As we navigate the modern world, understanding the impact of biology on society is crucial. Ethical considerations in biological research, the responsible use of biotechnology, and the balance between technological progress and environmental conservation are essential

discussions. This section explores the interplay between biology, technology, and society, helping us make informed decisions about scientific advancements and their impact on the world.

Branches of Biology:

Table 1. Summary about some branches of biology

Branch of Biology	Description
Botany	Study of plants, including their structure, growth, and reproduction.
Zoology	Study of animals, including their classification, behavior, and physiology.
Microbiology	Study of microscopic organisms like bacteria, viruses, fungi, and protists.
Genetics	Study of heredity and variation in organisms, including DNA and gene functions.
Ecology	Study of interactions between organisms and their environment.
Anatomy	Study of the structure and organization of living organisms.
Physiology	Study of the functions and mechanisms in living organisms.
Biotechnology	Use of living organisms or biological systems in technology and industry.
Molecular Biology	Study of biological processes at the molecular level, including DNA, RNA, and proteins.
Evolutionary Biology	Study of the origin, evolution, and diversity of life.
Immunology	Study of the immune system and how organisms defend against diseases.
Neuroscience	Study of the nervous system, including the brain and spinal cord.
Marine Biology	Study of marine organisms and their ecosystems.
Parasitology	Study of parasites and their interactions with hosts.
Astrobiology	Study of life in the universe, including the possibility of extraterrestrial life.

1.2. Scientific Methods in Biology

Definition of scientific method

- The scientific method is the process of objectively establishing facts through testing and experimentation (Fig 1). The basic process involves making an observation, forming hypothesis, making prediction conducting an experiment and finally analyzing the results.
- It is a powerful method to solve new scientific problems.

Steps of scientific method

I. **Observation**: Entirely view of the material world, made directly through the sensory systems mainly vision, hearing, taste smell and touch.

II. **Identifying the problem/Question:** State the problem as a specific question.

III. **Gathering information (**Qualitative and quantitative data)

IV. **Develop hypothesis :** Inductive and deductive reasoning

V. **Testing hypothesis /experimentation**

VI. **Observing and recording results:** results are recorded carefully and systematically organized in the form of data tables, charts and graphs.

VII. **Analysis and interpretation of data**

VIII. **Drawing conclusion**

IX. **Evaluation:** for valid conclusion

X. **Reporting and publishing of results**

What is a hypothesis?

- It is an **educated guess** based on observations and your knowledge of the topic

1.2.1. The Scientific Experiment

Scientific experiment usually has three kinds of Experimental variable:

1. **Independent variable (IV)**:
   - The variable that an experimenter changes to see if the performance of the dependent variable.
   - Event under experimentation or testing
   - It is controlled by the scientist
2. **Dependent Variable (DV)**
   - Something that might be affected by the change in the independent variable. What is observed, what is **measured**
   - the dependent variable changes depending on the independent variable. This is measured by the scientist to prove or disprove their hypothesis.
   - Is the variable that scientist changes to see if it changes when the independent variable is changed.
   - The **data** collected during the investigation "the **numbers**"
   - Example: how tall the plant grew (Fig 2).

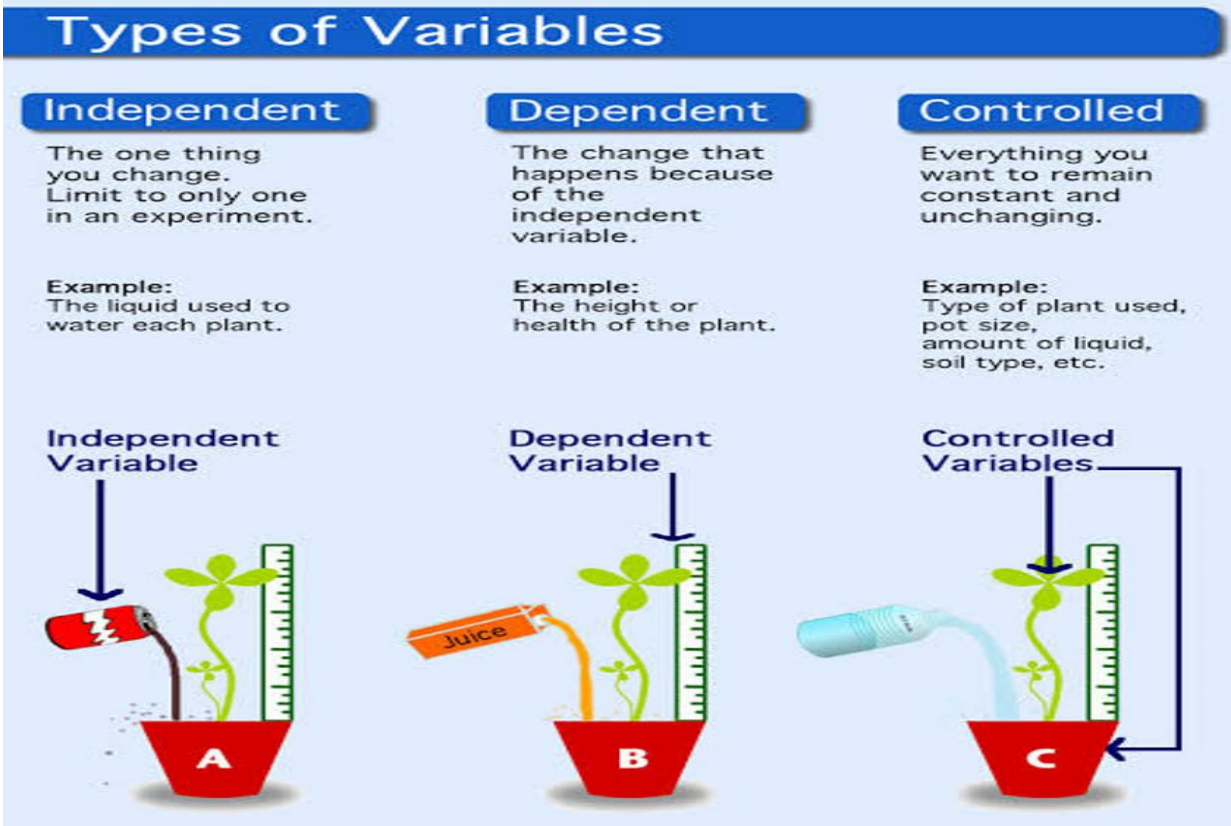


Figure 2. Examples of experimental variables

Example 1. Students of different ages were given a jigsaw puzzle to put together. The scientist wanted to see if the students' ages affected how long it took to put the puzzle together.

Independent Variable (**IV**)**:**

Ages of the students. Different ages were tested by the scientist

Dependent Variable (DV):

The **time** it took to put the puzzle together. The time was observed and measured by the scientist

Example 2. If I put 3 spider plants in different locations, then the plant in the sunlight will grow taller in a one-week period than the plants in the closet and basement.

Independent variable: location of the plants

Dependent Variable: height of plants

3. **Controlled Variable:** a variable that is not changed. Affect the outcomes of an experiment
   - ❖ Also called **constants** variable. Used for a "**fair** test". Everything in the experiment except for the IV should be kept constant. Example: In a medical science, the group of people who don't get the medicine are the control group
4. **Confounding variable**: a factor that can't be controlled which may influence the result of the experiment.

Summary

Biology is the scientific study of life and living organisms. It encompasses a wide range of disciplines, from molecular biology to ecology, focusing on the structure, function, growth, evolution, distribution, and taxonomy of organisms. By exploring biological principles and mechanisms, biologists seek to understand the complexities of life at various levels, from molecules and cells to organisms and ecosystems. Biology plays a crucial role in advancing knowledge about genetics, physiology, behavior, and the interconnectedness of life on Earth. It collects evidence through a method of science which is a systematic approach used to acquire knowledge and understanding of the natural world by using different biological tools. It involves several key steps like observation, hypothesis, prediction, experimentation, analysis, conclusion and communication. In a method of science, scientific experiments are essential for testing hypotheses, advancing knowledge, and providing evidence-based understandings into natural phenomena and processes. It contributes to the development of theories and understanding in various scientific disciplines. In scientific experimentation, understanding and carefully managing variables (like independent variable, dependent variable and controlled variables) are crucial for producing reliable and valid results, allowing researchers to draw accurate conclusions about cause-and-effect relationships between variables.

EXAMPLES OF REVIEW EXERCISE

1. Which of the following is the best definition of biology?
   A. The study of living organisms and their interactions with the environment
   B. The study of the physical structure of Earth
   C. The study of chemical reactions in laboratories
   D. The study of non-living objects and their movement

Explanation: Biology is the branch of science that studies **living organisms**, their **structures, functions, and interactions** with their surroundings. The other options refer to different scientific fields (geology, chemistry, and physics).

2. **Which characteristic of life is demonstrated when a plant bends toward sunlight?**
   A. Growth and development
   B. Response to stimuli
   C. Reproduction
   D. Homeostasis

Explanation: Organisms respond to environmental **stimuli**—such as light, temperature, and touch. A plant bending toward sunlight is an example of a **response to stimuli** (phototropism).

3. Which of the following correctly compares prokaryotic and eukaryotic cells?
   A. Prokaryotic cells have a nucleus, while eukaryotic cells do not
   B. Both prokaryotic and eukaryotic cells contain DNA
   C. Eukaryotic cells lack membrane-bound organelles, while prokaryotic cells have them
   D. Prokaryotic cells are usually multicellular, while eukaryotic cells are unicellular

Explanation: Both prokaryotic and eukaryotic cells contain DNA, but only **eukaryotic cells** have a nucleus and membrane-bound organelles. Prokaryotic cells (bacteria and archaea) lack a nucleus and are usually unicellular.

4. A scientist claims that viruses are living organisms. Which of the following observations would best support this claim?
   A. Viruses reproduce by infecting host cells
   B. Viruses are made of proteins and genetic material
   C. Viruses do not grow or respond to stimuli on their own
   D. Viruses can be crystallized and stored indefinitely

Explanation: Viruses do not meet all the characteristics of life independently, but they can reproduce though only inside a host cell. This is the strongest argument for considering them as living organisms. However, their inability to grow or maintain homeostasis weakens the claim.

5. If you were to design an experiment to test whether an unknown specimen is a living organism, which of the following would be the best approach?
   A. Observe whether the specimen moves on its own
   B. Place the specimen in a sealed container and check if it consumes oxygen or releases carbon dioxide
   C. Compare the specimen to known living and non-living objects under a microscope
   D. Expose the specimen to different temperatures and record changes in appearance

Explanation: Living organisms perform **cellular respiration**, which involves consuming oxygen or producing carbon dioxide. Measuring this process is a strong indicator of life.

6. Which branch of biology focuses on the study of microscopic organisms such as bacteria and viruses?
   A. Botany
   B. Zoology
   C. Microbiology
   D. Ecology

Explanation: Microbiology is the study of microscopic organisms, including bacteria, viruses, fungi, and protists.

7. How is genetics different from molecular biology?
   A. Genetics focuses on inheritance, while molecular biology studies biological processes at the molecular level.
   B. Genetics studies only plants, while molecular biology studies animals
   C. Genetics studies disease-causing organisms, while molecular biology studies healthy cells
   D. Genetics and molecular biology are the same field with no differences

8. **Explanation:** Genetics deals with heredity and variation in organisms, focusing on DNA inheritance. Molecular biology, on the other hand, studies biological processes such as DNA replication, protein synthesis, and cell function at a molecular level.

9. A scientist studying how different environmental factors affect plant growth is working in which branch of biology**?**
   A. Ecology
   B. Microbiology

C. Genetics
D. Immunology

Explanation: Ecology examines the relationships between organisms and their environment. Studying how plants respond to environmental factors like sunlight, water, and soil conditions falls under this field.

10. Which of the following statements correctly compares anatomy and physiology?
    A. Anatomy studies the structure of organisms, while physiology studies how their parts function
    B. Physiology focuses only on human bodies, while anatomy includes all organisms
    C. Anatomy is related to chemistry, while physiology is related to physics
    D. Physiology is the study of genetic inheritance, while anatomy is the study of evolution

Explanation: Anatomy focuses on the **structure** of organisms (e.g., organs, bones, tissues), while **physiology** studies how these structures **function** (e.g., how the heart pumps blood).

11. A scientist claims that biotechnology is the most impactful branch of biology in modern medicine. Which argument best supports this claim?
    A. Biotechnology allows for genetic engineering, leading to advances in disease treatment and drug development
    B. Biotechnology focuses only on plants and agriculture
    C. Biotechnology is an ancient science that does not contribute to modern advancements
    D. Biotechnology studies the immune system and how it defends against diseases

Explanation: Biotechnology has revolutionized modern medicine through **genetic engineering, cloning, and pharmaceutical advancements**. It plays a crucial role in creating vaccines, gene therapy, and synthetic biology.

12. If you wanted to study the impact of pollution on marine ecosystems, which two branches of biology would be most relevant?
    A. Marine biology and ecology
    B. Genetics and microbiology
    C. Botany and anatomy
    D. Zoology and immunology

Explanation: Marine biology focuses on ocean life, while **ecology** studies **how organisms interact with their environment**, making both relevant for studying pollution's effects on marine ecosystems.

13. Which of the following is the correct definition of an independent variable in a scientific experiment?
    A. The variable that is measured as a result of the experiment
    B. The variable that is intentionally changed by the experimenter
    C. The variable that remains constant throughout the experiment
    D. The variable that depends on the control group

Explanation: An **independent variable** is the factor that is deliberately changed by the researcher to observe its effect. The **dependent variable** is what is measured in response to the independent variable. The **control variables** remain constant to ensure a fair test.

14. In an experiment testing the effect of sunlight on plant growth, which of the following is the dependent variable?
    A. Type of plant used
    B. Amount of sunlight given
    C. The growth of the plant
    D. The type of soil used

Explanation: The **dependent variable** is what is measured in the experiment. In this case, plant growth (height or biomass) depends on the amount of sunlight. The **independent variable** is the amount of sunlight given. The type of plant and soil are controlled variables.

15. A scientist wants to test how different soil types affect the germination of seeds. What is the best way to control extraneous variables?
    A. Use different types of seeds for each soil type
    B. Keep the amount of water, light, and temperature the same for all samples
    C. Change multiple variables at once to see a stronger effect
    D. Measure the height of plants instead of seed germination

Explanation: To ensure a **fair experiment**, all factors except the independent variable (soil type) should be kept constant. Changing multiple variables (Option C) makes it difficult to determine which factor affects germination. Using different seeds (Option A) introduces an additional variable.

16. A student conducted an experiment to test the effect of fertilizer on plant growth. They measured plant height over four weeks. Which of the following would be a potential source of error in their experiment?
    A. Using the same type of fertilizer for all plants
    B. Measuring plant height with the same ruler each time
    C. Watering some plants more than others
    D. Keeping all plants in the same location with equal sunlight

Explanation: For a controlled experiment, **only one variable should change** (the type of fertilizer). Unequal watering introduces another factor that can affect plant growth, making results unreliable. Using the same ruler and keeping plants in the same location help maintain accuracy.

17. A researcher concludes that increasing temperature speeds up enzyme activity based on one experiment. What should they do before making a final conclusion?
    A. Repeat the experiment multiple times to confirm the results
    B. Change the independent variable to see if the result is different
    C. Assume the conclusion is correct and publish the results
    D. Ignore other factors that might affect enzyme activity

Explanation: Replication is essential in scientific research to ensure results are valid and not due to chance. Changing the independent variable without confirming results does not validate the first experiment.

18. If you wanted to test how different concentrations of salt affect freshwater fish survival, what would be the best experimental design?
    A. Keep all fish in pure freshwater and observe their behavior
    B. Use different fish species in each group to see varied results
    C. Set up multiple tanks with increasing salt concentrations and monitor fish survival over time
    D. Add the same amount of salt to all tanks and record the fish's eating habits

Explanation: A well-designed experiment should have **different levels of the independent variable** (salt concentration) while keeping other factors constant.

19. A scientist wants to study how a newly discovered virus affects the human immune system. Which branch of biology is most relevant to this research?
    A. Ecology
    B. Immunology
    C. Botany
    D. Evolutionary Biology

Explanation: Immunology focuses on the **immune system** and how organisms defend against diseases. Since the research involves a virus affecting the immune response, immunology is the most relevant field.

20. If you were designing an experiment to study how bacteria develop resistance to antibiotics, which branch of biology would be most useful, and what method would you use?
    A. Microbiology: Grow bacteria in different antibiotic concentrations and observe resistance patterns
    B. Zoology: Study how animals respond to antibiotics
    C. Anatomy: Compare the structures of different bacteria under a microscope
    D. Botany: Examine how plants produce natural antibiotics

Explanation: Microbiology is the correct field because it focuses on microorganisms, including **bacteria**. To study antibiotic resistance, a useful method would be to grow bacteria under **different antibiotic concentrations** and observe how they adapt or survive over time. Zoology

SELF TEST EXERCISE ONE

Choose the correct answer from the given four alternatives

1. Which of the following is a branch of biology that focuses on the study of genes and heredity?
   A. Ecology
   B. Genetics
   C. Anatomy
   D. Paleontology
2. What is the primary goal of the scientific method in biological experiments?
   A. To prove theories
   B. To find solutions to complex problems
   C. To observe, hypothesize, experiment, and conclude in a reasonable manner
   D. To create complex hypotheses without testing
3. If a biologist wants to test the effect of light on plant growth, which of the following steps should come first in the scientific method?
   A. Form a conclusion based on data
   B. Analyze the results
   C. Develop a hypothesis
   D. Test the hypothesis with an experiment
4. Which of the following observations in an experiment would be considered qualitative data?
   A. The temperature of water is 30°C
   B. The plant grows 5 cm every week
   C. The flower is red in color
   D. The mass of the fruit is 10 grams
5. How would a biologist combine information from the fields of genetics, ecology, and physiology to understand the impact of climate change on an animal species?
   A. By studying the behavior of the species in isolation
   B. By researching the physiology and genetic makeup of the species in different ecosystems
   C. By analyzing how the species has adapted over time to its habitat
   D. By observing the species' population in a controlled lab setting
6. Which of the following would be the most effective method to evaluate the reliability of an experiment on the effect of a new drug on cell growth?
   A. Peer review of the experimental design and results
   B. Relying only on personal observation of the effects
   C. Comparing the results to a theoretical model without testing
   D. Ignoring control groups and testing only one variable
7. Which branch of biology focuses on the study of interactions between organisms and their environment?
   A. Genetics
   B. Ecology
   C. Physiology
   D. Biochemistry
8. Why is it important to have a control group in a biological experiment?
   A. To ensure the experiment is conducted under normal conditions
   B. To compare the experimental group's results with those under normal conditions
   C. To randomly select subjects for the experiment
   D. To prove that the hypothesis is correct

9. In an experiment on the effects of different fertilizers on plant growth, which of the following is the independent variable?
   A. The type of plant used
   B. The amount of sunlight the plants receive
   C. The type of fertilizer used
   D. The height of the plants
10. Which of the following statements would be most appropriate when analyzing the results of an experiment on bacterial growth?
   A. The results show that all bacteria grew, so the hypothesis is correct
   B. The results indicate that bacteria grow best in 37°C, supporting the hypothesis that bacteria prefer body temperature
   C. The experiment was a failure because not all bacteria died
   D. The experiment shows no change in bacterial growth, meaning the hypothesis was invalid
11. If a biologist wanted to combine evolutionary biology and molecular biology to create a new theory, which of the following methods would be most appropriate?
   A. Collect genetic samples from various species and analyze the molecular changes that have occurred over time.
   B. Observe how species adapt to their environment without considering their genetic makeup.
   C. Focus on the physical traits of animals and ignore their genetic inheritance.
   D. Compare the molecular structure of plants and animals in a controlled lab environment
12. When evaluating a scientific experiment, which of the following should be considered to determine the experiment's reliability?
   A. The experiment's sample size and controls
   B. The experimenter's opinions on the results
   C. The number of published papers on the topic
   D. The theoretical framework without considering the data
13. Which branch of biology focuses on the use of technology to manipulate biological systems for human benefit?
   A. Ecology B. Biotechnology C. Genetics D. Microbiology
14. How has biotechnology impacted modern medicine?
   A. It has helped develop gene therapies and personalized medicine
   B. It has reduced the need for medical advancements
   C. It only applies to agricultural improvements, not medicine
   D. It focuses only on the discovery of new bacteria
15. A scientist is developing genetically modified crops that are resistant to pests. This research falls under which area of biology?
   A. Ecology B. Biotechnology C. Anatomy D. Taxonomy

ANSWER TO SELF TEST ONE

1.B	4.C	7.B	10.B	13.B
2.C	5.B	8.B	11.A	14.A
3.C	6.A	9.C	12.A	15.B

1.3. Biology and Technology

Learning competencies: At the end of this unit, learners will be able to:

- ♣ Adapt technologies from nature
- ♣ Illustrate the impact of Biology and technology on society and the natural world
- ♣ Indicate the benefits of Biology to Technology and Vice versa
- ♣ Recognize Ethical issues in Biology

Biology and technology are deeply interconnected, with each influencing the development of the other. Understanding biological processes has led to groundbreaking technological advancements, while technology enhances our ability to study and manipulate biological systems. Technology enhances biological research by enabling precise data collection, analysis, and experimentation. Advanced tools like microscopes, DNA sequencing, and artificial intelligence help scientists study life processes, diagnose diseases, and develop medical treatments.

✓ Biology and technology are interdependent fields. Biological discoveries drive technological advancements, while technology improves our ability to explore and manipulate biological systems. Innovations such as biotechnology, genetic engineering, and medical devices illustrate this relationship.

✓ Biology has inspired technological advancements in medicine (Development of vaccines, antibiotics, and genetic engineering), agriculture (GMOs, pest-resistant crops, and sustainable farming). It also provided **Environmental Solutions** like Biodegradable materials, wastewater treatment, and biofuels.

1.3.1. Learning from Nature

Nature has inspired countless innovations, leading to advancements in technology and improving human life. By studying biological systems, scientists develop new materials, devices, and processes that benefit society. They learned from nature through Imitation which is the act of copying or mimicking something. It involves replicating behaviors, actions, or characteristics observed in others. In **science and technology**, imitation plays a crucial role in fields like **biomimicry**, where engineers and researchers design innovations inspired by nature, such as airplane wings modeled after birds or Velcro inspired by burdock plant hooks.

Examples of Nature-Inspired Technologies and Architectures

1. Technologies Inspired by Nature (Biomimicry)

✓ Velcro – Inspired by burdock plant hooks.

- ✓ Bullet Train Design – Modeled after the kingfisher's beak for reduced noise and improved aerodynamics.
- ✓ Drone Flight – Based on insect and bird flight mechanics.
- ✓ Self-Cleaning Surfaces – Inspired by the lotus leaf's water-repellent properties.
- ✓ Artificial Skin & Bandages – Modeled after gecko skin and its adhesive properties.
- ✓ Robotic Arms & Grippers – Designed based on octopus tentacles and elephant trunks.
- ✓ Shark Skin-Inspired Material – Used for antibacterial surfaces and swimwear to reduce drag.
- ✓ Spider Silk-Inspired Fibers – Developed for lightweight and ultra-strong materials.
- ✓ Beetle-Inspired Water Collection System – Mimicking the Namib Desert beetle's ability to harvest water from the air.
- ✓ Energy-Efficient Buildings – Based on termite mounds' natural ventilation systems.

2. Architectures Inspired by Nature (Biophilic Design & Biomimicry)

- ✓ The Eden Project (UK) – Inspired by natural geodesic structures found in nature.
- ✓ The Lotus Temple (India) – Modeled after the lotus flower.
- ✓ The Bird's Nest Stadium (China) – Designed to resemble a woven bird's nest.
- ✓ The Gherkin (UK) – Mimicking the ventilation system of sea sponges.
- ✓ The Eastgate Centre (Zimbabwe) – Designed with passive cooling, inspired by termite mounds.
- ✓ The Milwaukee Art Museum (USA) – Features a moving wing-like structure similar to bird wings.
- ✓ The Singapore Gardens by the Bay Supertrees – Inspired by natural tree functions like photosynthesis and water collection.
- ✓ Beijing National Aquatics Center ("Water Cube") – Patterned after soap bubbles and natural cellular structures.
- ✓ **Falling water (USA)** – Designed to blend seamlessly with the surrounding waterfall and landscape.
- ✓ **Sagrada Família (Spain)** – Inspired by natural tree canopies for structural support and aesthetics.

1.3.2 Use of Technology in Biology

Modern technology has revolutionized biological research through advanced imaging, genetic sequencing, artificial intelligence, and biotechnology, allowing scientists to make precise discoveries and applications.

1.4. The Impact of Biology and Technology on Society and the Natural World

Advancements in biology and technology have transformed healthcare, agriculture, and industry, improving quality of life. However, they also pose environmental challenges, such as pollution and loss of biodiversity, necessitating responsible use.

1.5. Ethical Issues in Biology

Biological research raises ethical concerns, particularly regarding genetic modifications, cloning, and conservation. Balancing scientific progress with moral responsibility is essential.

1.5.1. Ethical Treatment of Plants and Animals During Biological Studies

Ethical research practices require humane treatment of animals, sustainable use of plants, and minimizing harm during experiments. Regulations and ethical guidelines ensure responsible scientific study while respecting life.

What are examples of Unethical treatment of plants?

- Destruction of Rare or Endangered Species
- Testing **toxic chemicals, herbicides, or pollutants** on plants without proper containment, leading to soil or water contamination.
- Genetically modifying plants without **considering potential risks** such as crossbreeding with native species, ecological imbalance, or unintended consequences.
- Collecting plants from **protected areas or indigenous lands** without permission, violating conservation laws and disrespecting local communities.
- Growing or destroying excessive amounts of plants for research without a valid scientific purpose or proper use of resources.
- Using plants traditionally cultivated by indigenous communities without acknowledgment or benefit-sharing.

What are examples of unethical treatment of animal in scientific research?

- ✓ Performing painful procedures without proper anesthesia
- ✓ Repeating experiments without scientific justification, leading to avoidable suffering.
- ✓ Keeping animals in overcrowded, unsanitary, or stressful environments.

- ✓ Conducting experiments on animals when non-animal methods (e.g., computer models, cell cultures) are available.
- ✓ Creating genetically modified animals that suffer severe health issues
- ✓ Exposing animals to extreme fear, isolation, or prolonged stress without justification.
- ✓ Failing to treat sick or injured animals properly.
- ✓ Keeping animals in painful or distressing conditions for extended periods without clear scientific benefit.
- ✓ The ethical treatment of animals' questions whether harming them for research is acceptable. As sentient beings with nervous systems, they experience pain, stress, and have their own interests and values. Scientist uses the **Three Rs (Reduction, Refinement, and Replacement)** are ethical principles designed to minimize the impact of research on animals while ensuring scientific integrity.

1. **Reduction:** Minimizing the number of animals used in experiments while obtaining reliable results.
   - ➢ Using statistical methods to design experiments that **require fewer animals**.
   - ➢ Sharing data and findings to **prevent unnecessary duplication** of experiments.
   - ➢ Using advanced technology (e.g., computer models, in-vitro studies) to **reduce reliance on live animals**.
2. **Refinement**: Improving procedures to minimize animal suffering and enhance welfare.
   - ➢ Providing better housing, nutrition, and veterinary care.
   - ➢ Using non-invasive techniques whenever possible.
   - ➢ Ensuring proper anesthesia and pain management.
   - ➢ Training researchers in humane handling and ethical practices.
3. Replacement: Finding alternatives to animal use whenever possible.
   - ➢ Using cell cultures, and computer simulations instead of live animals.
   - ➢ Conducting human-based studies (e.g., volunteer testing, epidemiological research).

EXAMPLES OF REVIEW EXERCISE

1. The design of airplanes with streamlined shapes is inspired by which of the following?
   A. The wings of birds
   B. The fins of fish
   C. The shells of mollusks
   D. The legs of insects
   - Explanation: The streamlined shapes of airplanes are inspired by the wings of birds, which have evolved to be aerodynamic, allowing for efficient flight with minimal drag. This inspiration helps to reduce air resistance and improve the performance and fuel efficiency of aircraft.
2. Which natural source influenced the design of a new drone technology for better stability and maneuverability?
   A. Birds
   B. Fish fins
   C. Dragonflies
   D. Bats
   - Explanation: Dragonflies are known for their impressive aerial abilities, including precise control and agile movements, which have inspired engineers to create drones with enhanced stability and maneuverability
3. Which natural source influenced the design of cutting saws with improved precision and efficiency?
   A. Shark teeth
   B. Porcupine quills
   C. Beehive cells
   D. Eagle talons
   - Explanation: Shark teeth have a unique, serrated design that allows for efficient cutting, which has inspired the development of cutting tools like saws. Their tooth-like structures help reduce friction and improve cutting precision, making them an effective model for improving the performance of man-made cutting tools
4. Which natural phenomenon inspired the development of techniques for preserving live vaccines?
   A. Freezing of Arctic organisms
   B. Tardigrades' resistance to radiation
   C. Hibernation in mammals
   D. Photosynthesis in plants
   - Explanation: Tardigrades, also known as water bears, are microscopic organisms that can survive extreme conditions, including radiation, dehydration, and freezing. Their unique

ability to preserve themselves in such harsh environments has inspired techniques for preserving live vaccines by enhancing their resilience.

5. Which of the following is a common ethical concern in biological research?
   A. The development of new food crops
   B. The use of animals in experiments without proper care
   C. The discovery of new species
   D. The study of ecosystems in remote areas
   - Explanation: The use of animals in experiments without proper care. One of the most common ethical concerns in biological research is the use of animals in experiments, particularly when they are not provided with proper care or when the experiments cause unnecessary suffering. Ethical guidelines, such as the "3Rs" (Replacement, Reduction, and Refinement), aim to ensure humane treatment of animals in research.
6. What is one ethical issue related to the use of medications?
   A. Their ability to cure all diseases
   B. Ensuring equal access to medicines for all people
   C. Making medicines out of renewable resources
   D. The creation of new diseases through medication
   - Explanation: One of the major ethical issues related to medicaments (medications) is ensuring that all people, regardless of their socio-economic status, have access to life-saving treatments. This includes addressing issues such as affordability, availability, and distribution, particularly in low-income or rural areas.
7. When conducting biological research, respecting ethical issues typically involves:
   - ✓ Conducting experiments with minimal environmental harm
   - ✓ Allowing any type of experimentation on living organisms
   - ✓ Disregarding informed consent from participants
   - ✓ Maximizing profit from discoveries regardless of consequences
   - **Explanation:** Respecting ethical issues in biological research involves conducting experiments in a responsible manner, minimizing harm to the environment, animals, and people. This also includes adhering to guidelines for humane treatment, ensuring informed consent, and considering the broader impacts of the research.
8. A major ethical issue in the production and distribution of medicaments (medications) is:
   A. The creation of over-the-counter drugs for minor illnesses

B. Ensuring that medications are tested for effectiveness and safety while being affordable and accessible to all populations
C. The promotion of a single medication as a universal cure
D. The elimination of all regulations on drug sales

- **Explanation:** A major ethical issue in the production and distribution of medications is ensuring that drugs are both effective and safe while also being accessible and affordable for all people, regardless of their socio-economic status. This addresses concerns about fairness, access, and the well-being of populations worldwide

9. What is the primary goal of the "Refinement" principle in the Three Rs when conducting animal research?
   A. To replace animals with in vitro models entirely
   B. To ensure that animal research is conducted in natural habitats
   C. To minimize the pain, suffering, or distress experienced by animals
   D. To increase the number of animals used in studies for accuracy

- **Explanation: Refinement** focuses on improving research techniques to reduce any negative impact on animals. This can include modifying experimental procedures, improving living conditions, using less invasive methods, and providing pain relief, all with the aim of reducing harm and distress to the animals involved in research.

10. Which of the following correctly matches the biological study with its primary focus or purpose?
    A. Biochemical studies focus on analyzing the interactions between humans and their environment.
    B. Biomedical studies provide information about the chemical components of medicinal plants.
    C. Biophysical studies focus on the biochemical structure of carbohydrates, proteins, lipids, and nucleic acids.
    D. Bioinformatics is the study of the distribution of species across geographic ecosystems.

- **Explanation:** Biomedical studies focus on understanding how biological systems work, especially in relation to health and disease. Part of this includes investigating the properties of medicinal plants and their components for potential therapeutic use.

SELF TEST EXERCISE TWO

Choose the correct answer from the give four alternatives given below

1. The design of self-cleaning surfaces in modern architecture and technology is inspired by which natural feature
    A. The waxy coating on leaves of the lotus plant
    B. The exoskeletons of certain arthropods
2. The texture of bird feathersThe skin of a sharkThe development of advanced underwater adhesives that function in wet conditions was inspired by which of the following?
    A. The sticky pads of a gecko
    B. The barnacle's ability to attach to rocks
    C. The suction cups of an octopus
    D. The resin of tree sap
3. What natural structure inspired the design of hexagonal structures in technology?
    A. Honeycombs
    B. Coral reefs
    C. Tree bark
    D. Spider webs
4. Which natural source influenced the design of a new drone technology for better stability and maneuverability?
    A. Birds
    B. Fish fins
    C. Dragonflies
    D. Bats
5. Which natural source influenced the design of cutting saws with improved precision and efficiency?

    A. Shark teeth B. Porcupine quills C. Beehive cells D. Eagle talons
6. A government is considering the use of genetically modified organisms to address food shortages. Which argument supports this decision?
    A. GMOs can increase crop yield and resistance to pests, helping to feed a growing population
    B. GMOs are completely unnatural and should never be used in agriculture
    C. GMOs reduce the need for scientific advancements in food production
    D. GMOs only benefit large corporations and have no advantages for society
7. Which of the following is a positive impact of biological innovations on society?
    A. The development of genetically modified organisms (GMOs) for better food security
    B. The increased use of fossil fuels to power industries
    C. The production of biological weapons for defense purposes
    D. The destruction of habitats due to urbanization

8. The discovery of antibiotics has had which of the following effects on society?
    A. Increased rates of bacterial infections
    B. Improved health and longevity by treating bacterial infections
    C. Reduced access to healthcare in rural areas
    D. Encouraged the use of harmful chemicals in food production
9. Which of the following is a positive impact of biotechnology on society?
    A. The development of genetically modified organisms (GMOs) for improved food production
    B. Increased pollution due to the use of synthetic chemicals in biotech processes
    C. Reduction in biodiversity due to the dependence on monoculture farming practices.
    D. Deterioration of soil quality due to intensive agricultural practices
10. The rapid advancement of biotechnology has raised concerns about:
    A. The potential for medical breakthroughs and longer life expectancy
    B. Ethical implications and potential misuse, such as cloning and genetic manipulation
    C. The development of more sustainable agricultural systems
    D. The improvement of biodiversity through careful genetic conservation
11. A negative impact of technological advancements in the field of medicine includes:
    A. Improved healthcare accessibility for remote areas
    B. Increased use of medical equipment reducing the need for invasive surgeries
    C. Ethical concerns regarding genetic modifications and cloning
    D. Enhanced vaccine development and distribution to prevent diseases
12. One of the negative environmental impacts of technological innovations in industry is:
    A. Development of renewable energy sources
    B. Increased greenhouse gas emissions contributing to climate change
    C. Development of sustainable agricultural practices
    D. Decrease in electronic waste due to improved recycling technologies
13. The advancement of biological research and technology has led to:
    A. The prevention of diseases such as malaria through vaccines and genetic therapies
    B. The creation of more efficient farming practices with reduced environmental impact
    C. Ethical concerns surrounding gene editing and its long-term consequences
    D. Improvements in air and water quality through bioremediation
14. Which of the following is a direct impact of biology on human health?
    A. Development of vaccines
    B. Creation of new programming languages
    C. Discovery of new planets
    D. Advancements in artificial intelligence
15. How does deforestation, influenced by human activities, impact biodiversity?
    A. It increases biodiversity by creating new habitats
    B. It decreases biodiversity by destroying ecosystems
    C. It has no effect on biodiversity
    D. It causes animals to evolve faster

16. A company is planning to introduce genetically modified (GM) crops. Which of the following is a potential benefit of this decision?
    A. Increased crop yield and pest resistance
    B. Reduced food supply for humans
    C. Higher risk of immediate species extinction
    D. Reduced oxygen levels in the atmosphere
17. Which of the following is an ethical concern regarding genetic modification of organisms?
    A. Increased biodiversity
    B. Potential harm to non-target species
    C. Decreased food production
    D. Discovery of new plant species
18. A researcher is studying the effects of a new drug on mice. What ethical principle should guide this study?
    A. Maximize harm to the animals for reliable results
    B. Ensure proper pain relief and minimize suffering
    C. Use as many animals as possible to get clear results
    D. Keep the animals in isolation for the entire study
19. What is a potential long-term societal effect of choosing to selectively reproduce only male children (XY) in a society?
    A. Increased male population and loss of gender diversity
    B. Improved societal stability through gender balance
    C. Reduced population growth due to decreased fertility
    D. A stronger social structure with equal representation of both genders
20. How has industrialization and the growth of technology contributed to environmental destruction?
    A. By improving agricultural practices that protect the environment
    B. By increasing the use of renewable energy sources
    C. By causing the depletion of natural resources and increasing pollution
    D. By promoting environmental conservation efforts globally

ANSWER KEY FOR SELF TEST EXERCISE TWO

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

1.6. APPLICATION OF BIOLOGY

Learning Competencies

- Describe conservation of natural resources
- Explain the application of biological knowledge in different areas in their environment
- Describe food and nutrition security
- Explain conscious citizen and global citizen
- Describe biotechnology and genetic engineering
- Explain the role of biotechnology to secure the food of the society
- Explain some of the traditional uses of biotechnology
- Explain the role of microorganisms in making food and drink
- Describe the application biotechnology in agriculture, environment, industry and Medicine
- Explain what genetically modified organisms means
- Describe the benefits of creating transgenic crops
- Explain the process and importance of gene therapy
- Explain the modern application of biotechnology

1.6.1. Application of biology in conservation of natural resources

What are natural resources? It is any resources that (actual and potential) supplied by nature and benefit life.

Types of Natural resource

a. Renewable Natural resources:

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

b. Non-renewable natural resources:

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

Biological knowledge is applied in conserving Natural resources

What is conservation?

- ➢ **Conservation** is the act of protecting Earth's natural resources for current and future generations.
- ➢ It is the careful maintenance and wise use of natural resources to prevent them from disappearing.

- Conservation is the protection and preservation of our natural environment, so that non-renewable resources are used sparingly and renewable resources are managed so that they can last for the foreseeable future.
- By protecting and conserving natural resources we help to ensure that they are available for use not only today, but in the future as well
- One of the most effective ways of conserving biodiversity is to protect large areas of habitat. Biodiversity maintains the balance in an ecosystem, produces genetic variety, makes places look good with a mixture of different species rather than a monoculture and helps reduce the spread of disease.

1.6.2. Application of biological knowledge in improving food and nutrition security

- **Food security**: exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life
- ✓ It refers to the causes and effects of food availability.
- Low food security refers to "Reports of reduced quality, variety, or desirability of diet.
- **Nutritional security:** is about a community's access to essential nutrients, not just calories.
- ✓ It refers to food availability, caring capacity, health services, environmental conditions, food intake, health status and, ultimately, nutritional status
- Both food security and nutrition security go in tandem.
- Nutrition security is overarching and contains food security within it.

What are the effects of food insecurity?

Poverty	Poor public Policy	Food waste
unemployment	Climate change	Gender inequality
inconsistent access to enough and healthy food	Poor nutrition	Forced Migration and Hunger
War & conflict	Economy	Malnutrition

Which biological application is important for maintaining food security?

- Bio pesticide, Bio fortification, Bioremediation, Bio fertilizer…

Biotechnological application:

- increase crop yields through introducing high-yielding varieties resistant to biotic and abiotic stresses;
- increasing crop productivity, diversifying crops, enhancing nutritional value of food, reducing environmental impacts of agricultural production
- Increase the nutritional values of foods (Biofortification)

- Increase Herbicide resistant crops
- Produce pest resistant crops and reduce pest– associated losses
- Used in the production of cloned plants and animals

Examples of biofortified food items released by Ethiopia

- Maize – fortified by Vitamin A and protein
- Rice – zinc and vitamin A. Sweet potato – vitamin A
- Pearl millet and Bean – fortified by zinc and Iron.
- Oat – Zinc

1.6.3.Application of biological knowledge in biotechnology

Biotechnology: Is the application of technologies that uses living organism or products of organism for the development of products that benefit human beings.

- ✓ It uses recombinant DNA technologies or Genetic engineering. Genetic engineering is a process that uses laboratory-based technologies to alter the DNA makeup of an organism which is called GMO or transgenic organism.
- ✓ Biotechnology has a wide range of applications across various fields. Some common applications of biotechnology include:

A. Medicine and healthcare: wellbeing and health of human

- ✓ Biotechnology is used in the development of new drugs and therapies, including the production of recombinant proteins and monoclonal antibodies.
- ✓ It is also used in gene therapy, where genetic material is introduced into a patient's cells to treat genetic disorders
- ✓ Human drugs such as
  - ➢ Insulin for diabetics which regulate blood sugar growth hormone for individuals with dwarfism.
  - ➢ Tissue plasminogen activator for heart attack victims.
  - ➢ Dissolve blood clotting.
  - ➢ Antibiotics; Complex organic compound produced by bacteria and fungi.
  - ➢ Antibiotics are a substance that treat infections by killing, or inhibiting the growth of microorganism

- It is mainly used to treat bacterial infection on the body
- It is administered orally, topically or by injection
- It is produced by culturing microorganism and using genetic engineering
- It is not a fermentation product, but secondary metabolic products
- Most antibiotic we use come from Bacteria and fungi live in soil
- The most prolific source of antibiotics in use today is Actinomycetes. Example: Erthromycin, Tetracyclin, Vancomycin, Streptomycin are synthesized from actinomycetes species.
    - Antibiotics attack bacteria in different ways like
        - ✓ Disrupt cell wall synthesis
        - ✓ Block protein synthesis
        - ✓ Block synthesis of DNA
        - ✓ Inhibit bacterial growth
- Antibiotics that slow the growth rate by stopping their reproduction is called Bacteriostatic
- Antibiotic that kills bacteria is called bactericidal
- Antibiotic don't damage human cell, because of the absence of cell wall, but may have side effect
- Animal drugs like growth hormone, produced by fermentation of transgenic bacteria that bovine somatotropin or received targeted gene from human, cow or pig, porcine somatotropin and Hormones regulate milk production, increase growth rate

B. Agriculture

- Biotechnology is used in crop improvement through genetic engineering where genes from one organism are transferred to another to enhance traits such as pest resistance, drought tolerance, and nutritional content (Bio fortification)
- Bio fortification is the process of breeding staple crops to have higher levels of essential
- nutrients either through selective breeding or genetic modifications
- It is also used in the production of genetically modified organisms (GMOs) for increased crop yield and reduced pesticide use.

C. Environmental application

- Biotechnology is used in environmental cleanup and waste management. For example, bioremediation uses microorganisms to break down pollutants in soil and water.

- Biotechnology is also used in the production of biofuels, such as ethanol and biodiesel, as a renewable and sustainable alternative to fossil fuel.

D. Industrial application

- ✓ Biotechnology is used in various industrial processes, such as the production of enzymes for laundry detergents, food processing, and bio-based materials.
- ✓ It is also used in the development of bioplastics, which are biodegradable and environmentally friendly alternatives to traditional plastics

E. Forensic science application

- ✓ Biotechnology is used in forensic science for DNA analysis and identification.
- ✓ It is used in criminal investigations, paternity testing, and identifying human remains

F. Application in food production and beverage industry

- ✓ Biotechnology is used in the production of fermented foods and beverages, such as cheese, yogurt, beer, and wine.
- ✓ It is also used in the development of food additives, flavorings, and nutritional supplements these are just a few examples of the many applications of biotechnology. As technology advances, the potential for biotechnology to contribute to various fields continues to grow.

Application in biotechnology can be:

A. Traditional application of biotechnology

1. **Beer production** (Alcoholic fermentation)

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

<u>To make beer</u>

- Cereal grains (usually barley) are malted (partially germinated) to increase the concentration of starch-digesting enzymes that provide the sugar for fermentation.
- Malted grain is crushed and mixed with hot water (about 65^0_C), producing mash. After a few hours, a liquid extract called wort is separated from the mix. Hops (flower cones from the hop

plant) are added to the wort for flavoring, and the mixture is boiled to stop enzyme action and precipitate proteins.

- A strain of Saccharomyces is added and Fermentation produces ethyl alcohol, carbon dioxide, and other substances, including amyl and isoamyl alcohols and acetic and butyric acids, which add to the flavor of the beer. After fermentation, the yeast is removed, and the beer is filtered, pasteurized, and bottled.

2. Tej and Tella production (Alcoholic fermentation)

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

3. Wine and spirit production

Wine is made from fermented grapes.

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

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

- Most wine is made from juice extracted from grapes, although it can be made from any fruit and even from nuts or dandelion blossoms.
- Juice is treated with sulfur dioxide to kill any wild yeasts that may already be present.
- Sugar and a strain of Saccharomyces are then added, and fermentation proceeds. Although ethyl alcohol is the main product of fermentation, other products similar to those in beer add to the flavor of the wine.
- In both beer and wine, the particular characteristics of the juice and the yeast strain determine the flavor of the final product. When fermentation is completed, liquid wine is siphoned to

separate it from yeast sediment and, if necessary, cleared with agents such as charcoal to remove suspended particles. Finally, it is bottled and aged in a cool place.

- Spirits are made from the fermentation of a variety of foods, including malted barley, rye, gin, corn wine or fruit juice, potatoes and molasses
- After fermentation, distilling separates alcohol and other volatile substances that impart flavor from the solid and nonvolatile substances. Because of distillation, the alcohol content of spirits ranges from 40 to 50% much higher than the typical 12% for wine and 6% for beer.

4. Food production

a. Making bread and injera

- ✓ When yeasts have insufficient amount of oxygen (i. e., anaerobic condition), they ferment glucose into CO_2 and H_2O with the production of very little alcohol.
- ✓ This process is used in the making of bread and injera
- ✓ The CO_2 produced helps the dough to become lighter in weight.
- ✓ This process is called "leavening" i. e. making the bread light and spongy.
- ✓ When we make injera, we grind the teff or barley and then add water.
- ✓ We mix well and leave the dough at room temperature for about two days.
- ✓ Natural yeasts start to grow and respire in the dough. At first the yeast respires aerobically, although this may change to anaerobic respiration.
- ✓ The yeast produces carbon dioxide, making the mix rise a little and giving it a tangy flavor.

Three roles of microbes in bread making

Microorganisms accomplish three functions in bread making:

A. leavening the flour-based dough,

- ✓ achieved primarily through the release of gas to produce a porous and spongy product

e.g. *Saccharomyces cerevisiae*

- ✓ Bread texture come from kneading, which incorporates air into the dough, and from microbial enzymes, which break down flour proteins (gluten) and give the dough elasticity.

B. **Imparting flavor and odor**

- ✓ volatile organic acids and alcohols that impart delicate flavors and aromas
- ✓ Yeasts and bacteria can also impart unique flavors, depending upon the culture mixture and baking techniques used.

- ✓ The pungent flavor of rye bread, for example, comes in part from starter cultures of lactic acid bacteria such as Lactobacillus plantarum, L. brevis, L. bulgaricus, Leuconostoc mesenteroides, and Streptococcus thermophilus.
- ✓ Sourdough bread gets its unique tang from Lactobacillus sanfrancisc

C. **Conditioning the dough** to make it workable.

Besides carbon dioxide production, bread fermentation generates other volatile organic acids and alcohols that impart delicate flavors and aromas

5. Production of Yoghurt

- ✓ Milk goes sour due to the production of a substance called lactic acid by the action of bacteria on milk sugar (lactose).
- ✓ This makes the milk to curdle (i. e. some parts of the milk solidify and separate from the liquid part).
- ✓ The solids are called curds and the liquid part is called whey
- ✓ To make yoghurt, we add a starter culture of the right kind of bacteria to warm milk.
- ✓ Often this starter culture is just a small amount of yoghurt we have already made.
- ✓ The mixture needs to be warm so that the bacteria begin to grow, reproduce and ferment.
- ✓ As the bacteria break down the lactose in the milk, they produce lactic acid, which gives the yoghurt its sharp, tangy taste. This is known as lactic fermentation.
- ✓ The lactic acid produced by the bacteria causes the milk to clot and solidify into yoghurt. The action of the bacteria also gives the yoghurt a smooth, thick texture.
- ✓ Yoghurt, if it is kept cool, will last almost three weeks before it goes bad. Ordinary milk lasts only a few days – and then only if it is kept really cold.
- ✓ Once we have made our basic yoghurt, we can mix in flavorings, spices and fruit.

6. Production of Cheese

- ➢ Like yoghurt making, cheese making depends on the reactions of bacteria with milk changing the texture and taste, and also preserving the milk.
- ➢ Around 900 different types of cheese are made around the world, but the bases of production method is the same for them all.
- ➢ The bacteria in cheese making convert lactose to lactic acid, but they make much more lactic acid when compared to that of yoghurt.
- ➢ As a result, the solid part, (curds) is much more solid than in yoghurt.

- Enzymes are also added to increase the separation of the milk. These often come from the stomachs of calves or other young animals.
- When it has completely curdled, we can separate the curds from the liquid whey.
- Here in Ethiopia cheese is traditionally made by first making yoghurt from fresh milk, extracting the butter by continuous agitation, and finally boiling the remaining part to make cheese.

B. Modern application of biotechnology

- ✓ Genetic engineering or recombinant DNA technology
- ✓ Gene therapy. Gene cloning, DNA finger printing
- ✓ Biogas production, energy production, Bio fortification
- ✓ Tissue culture

1. Genetic engineering

- ✓ is the process of transferring DNA from one organism into another that results in a genetic modification; the production of a transgenic organism.
- ✓ Genetic engineering is being used in the production of pharmaceuticals, gene therapy, and the development of transgenic plants and animals.
- ✓ Is process of modifying genome of organism or making GMO organism

The purpose of modification of the genome of an organism is:

- ✓ To make them more suitable
- ✓ To increase yields, resistance to pest, disease, herbs etc...
- ✓ To obtain novel products (used in pharmaceuticals, gene therapy

2. Tissue culture/micropropagation:

- ✓ Plants can be propagated quickly and in large quantity by tissue culture technique. Tissue culture, a method of biological research in which fragments of tissue from an animal or plant are transferred to an artificial environment in which they can continue to survive and function.
- ✓ It is important biotechnology for developing countries for the production of disease-free, high quality planting material and the rapid production of many uniform plants.

Food processing and production

- Biological knowledge is used in increasing of food productivity using Microorganism.

Example of food produced using microorganism

i. Single cell protein – from wastes like molasses

ii. Pruteen - produced by the mass culture of the bacterium *Methlophils methylotrophus which* is used for animal feed.

iii. Mycoprotein – Made from fungus called *Fusarium venenatum which is meat substitute for human*

iv. Spirulina: -viable alternative to green plants as a primary nutrient source

v. Vitamin C: - the first vitamin to be produced through fermentation by bacteria

vi. Vitamin B12 - from fermentation of propionic bacteria

vii. **Fermented Meat**

- ✓ Lactobacillus plantarium and pediococcus cerevisiae add flavor by fermenting meat such as salami, sumer sausage.
- ✓ Heterolactic acid fermentation helps preserve the meat and gives a tangy flavor
- ✓ Aspergillus and Penicillium are fungi that helps to produce flavor

viii. **Dairy Products**:

- ✓ Buttermilk is made by adding Streptococcus *cremoris to* Skim milk and fermented until consistency, flavor and acidity reached
- ✓ Yoghurt is made by adding Streptococcus thermophilus and lactobacillus bulgaricus to the milk.
- ✓ Acidophilus milk is made by adding Lactobacillus acidophilus to sterile milk.
- ✓ Bulgarian milk is made by L.bulgaricus

1.6.4.Promise of biotechnology

Application of biotechnology is ongoing effort that have potential t: Goals are

- ❖ cures for genetic diseases.
- ❖ treatments for degenerative diseases, such as Parkinson's disease and Alzheimer's disease
- ❖ establishing biologically controlled industrial processes to
- ❖ manufacture more biological products in the same way as insulin
- ❖ is now manufactured
- ❖ producing drugs that are 'tailor-made' to suit an individual's needs
- ❖ genetically modifying plants to meet a specific need; for example:
    - ▪ plants that can produce a good yield of a crop in dry conditions

- plants that produce their own insecticide will not need to be sprayed with chemical insecticides

❖ cloning of productive animals and plants

❖ production of monoclonal antibodies that can deliver a drug to only those cells that need treatment (for example, cancer cells)

❖ using stem cells to repair damaged organs and, ultimately, to grow whole new organs from just a few of a person's stem cells

EXAMPLES OF REVIEW EXERCISE

1. Which of the following statement is considered as the importance of application of biotechnology for a society? It is used to:
   A. reduce the use of natural resources
   B. reduces genetic diversity
   C. produces adequate food
   D. increase pest associated losses

❖ **Explanation:** Biotechnology is applied in different sector like medicine, agriculture, Energy, industry and etc... it offers ways to transform foods, treat water, develop sustainable materials, and design vaccines, among many other examples. Like improving food quality, quantity, and processing. Producing Bio-fertilizers and bio-pesticides, which contain living microorganisms that help in promoting growth by increasing the supply or availability of primary nutrients.

2.Which one of the following statements is no correct about renewable energy?
   A. Sources of renewable energy are natural
   B. The wind is a source of renewable energy
   C. Coal is a source of renewable energy
   D. Renewable sources can be refilled easily

❖ **Explanation**: Sources of renewable energy are natural and hence can be easily refilled. Solar energy, tidal energy and wind energy are examples of renewable energy. Solar energy can be obtained from the sun. Coal is a non-renewable energy source as it cannot be replenished easily and takes millions of years to form.

3. The fossil fuels, coal and petroleum are the examples of _____ natural resources.
   A. Renewable
   B. Vanished
   C. Inexhaustible
   D. Exhaustible

Explanation: Coal and petroleum are examples of exhaustible natural resources. **Exhaustible:** It refers to those natural resources which are present in finite quantity. They cannot be readily replaced by natural means as compared to their consumption. These resources are not eco-friendly i.e., they cause pollution. Example: coal and petroleum. **Inexhaustible:** It refers to those natural resources which are present in infinite/unlimited quantity in nature and will not deplete throughout the existence of Earth. These resources are eco-friendly. Example: wind, solar energy/Sunlight etc

4. Which of the following statements are correct regarding non-renewable resources?
   A. They take millions of years to form
   B. They do not have any negative impact on the environment
   C. Hydro energy is an example of a non-renewable resource
   D. They are non-replenishable in nature

❖ **Explanation**: Non-renewable resources are limited in supply and cannot be used sustainably. There are four major types of nonrenewable resources: oil, natural gas, coal, and nuclear energy. Oil, natural gas, and coal are collectively called fossil fuels. They are non-replenishable in nature. Non-renewable resources take millions of years for their formation. For example, coal, petroleum, and natural gas. They are non-replenishable in nature. The use of such resources also pollutes and damages the environment.

5. Which of the following statement about is correct about renewable natural resources? They
   A. Are exhaustible resources that are replaced at the same speed as that are used up
   B. Never lost no matter how much we use them
   C. Are mainly living things and their products
   D. Are finite resources that are replaced and recycled

❖ **Explanation**: Renewable natural resources are: resources that are Capable of being produced indefinitely. It will not be used as there will always be more available. They are mainly living things and their products. The main sources of renewable resources are sun, wind, water, the earth's heat.

6. Which of the following statements are correct regarding non-renewable resources?
   A. They take millions of years to form.
   B. They do not have any negative impact on the environment.
   C. They are non-replenishable in nature.
   D. Hydro energy is an example of a non-renewable resource.

❖ **Explanation**: Non-renewable resources are non-replenishable in nature. Non-renewable resources take millions of years for their formation. For example, coal, petroleum, and natural gas. They are non-replenishable in nature. The use of such resources also pollutes and damages the environment

7. Which of the following is not renewable natural resource?
   A. Geothermal energy
   B. Fossil Fuel energy
   C. Bioenergy
   D. Tidal energy

❖ **Explanation**: Fossil fuel is not renewable, while the rest are renewable source of energy

8. Which one of the following is the potential natural resource found in Ethiopia?

A. Gold
B. Coffee
C. Walia Ibex
D. Mango

❖ **Explanation** The difference between actual and potential resources lies in whether these resources can be used in the present or not. Actual resources are those whose quantity is known and which are now in use. Potential resources are those that already exist in a specific area but are useful in the future. The total amount of a potential resource may be unknown while an actual resource's exact supply is known. Coal, water, fossil fuels, mines and petrol are examples of actual Resources. Solar energy, Wind power Mineral Oil and Uranium is an example of Potential resources.

9. Which one of the following biological knowledge areas provides a cost-effective, long-term, and sustainable strategy for combating hidden hunger?
   A. Bioremediation
   B. Bio fortification
   C. Bio degradation
   D. Bio accumulation

❖ **Explanation:** Bio fortification is a strategy for increasing micronutrient levels in food groups through the use of modern biotechnology techniques or traditional plant breeding and agronomic practices.

10. Golden rice is a bio fortified crop that contain
   D. Vitamin C
   E. Vitamin D
   F. Calcium
   G. Vitamin A

❖ **Explanation**: Golden Rice is a form of GMO Plants that contain Beta-carotene which is the precursor of Vitamin A. It is produced to combat Vitamin A deficiency.

11. Which of the following biological application is prohibited? The use of
   A. Biosensor
   B. Biological warfare
   C. DNA profile
   D. Biofuel

❖ **Explanation**: Using microorganism or biological toxins to kill or incapacitate humans, animals or plants as an act of war. This is strongly prohibited as it is easily used by terrorist groups or individuals may acquire the technologies and expertise to use these destructive agent

11. Which of the following species of fungi is used to ferment alcoholic drink?
   A. Saccharomyces
   B. Actinomyces
   C. Streptomyces
   D. Lactobacillus

Explanation: Strains of Saccharomyces are the fermenters for all alcoholic beverages.

12. Which one of the following bacterial species is extensively used in producing biopesticide?
   A. *Agrobacterium tumafeciens*
   B. *Thiobacillus ferrooxidan*
   C. *Beauveria bassiana*
   D. *Bacillus thuringiensis*

❖ **Explanation**: Bacillus thuringiensis is widely used in modern-day biology as insecticide.

13. Which of the following discipline of biotechnology have potential application in waste water analysis?
   A. Biosensor
   B. Bioinformatics

C. Biopesticide D. Bioremediation

- **Explanation**: Biosensor can be dipped into water to provide a near instant result of a water quality parameter such as the presence of bacteria, viruses, algae, or pollutants. Biosensors have potential applications in monitoring drinking water supply systems, wastewater systems and raw water in catchments for early detection of water quality issues.

14. Activated sludge method of waste water treatment is differ from trickling filter method. Because in activated sludge method,
    A. Water contains high number of organic matters
    B. Sludge is not produced because of Complete decomposition of organic matter
    C. More microbes that contain mixed microbial sludge is added to degrade organic matter
    D. Organic matters are allowed to be degraded at bed of stone under aerobic respiration

- **Explanation:** in activated sludge method, large quantities of air are bubbled through wastewaters that contain dissolved organic substances in open aeration tanks. Bacteria and other types of micro-organisms present in the system need oxygen to live, grow, and multiply in order to consume the dissolved organic "food" or pollutants in the waste. After several hours in a large holding tank, the water is separated from the sludge of bacteria and discharged from the system.

15. How does the production of wine from grapes differ from the production of wine from other fruits?
    A. It requires a different type of yeast.
    B. It does not involve fermentation.
    C. The specific characteristics of the grape juice contribute to the unique flavor of the wine.
    D. Distillation is always necessary for grape wine.

- **Explanation:** The specific characteristics of the grape juice contribute to the unique flavor of the wine. The production of wine from grapes differs from the production of wine from other fruits primarily because of the unique chemical composition of grape juice. Grapes have a specific balance of sugars, acids, and other compounds (such as phenols) that give wine its characteristic flavors and aromas. This balance is key to the wine's quality and is not typically found in the same proportions in other fruits.

16. Which of the following field of biotechnology is widely acceptable field of forensic science?
    A. Bioremediation C. Bio mining
    B. Biohydrometallurgy D. Bioinformatic

- **Explanation:** Bioinformatics is a scientific discipline involving computer technology to collect, store, analyze, and disseminate biological data and information (DNA and amino acid sequences). bioinformatics is applied in different fields like forensic science, environment, medical sectors and others. Forensic Investigation is impartial valuable computation for DNA recognition with the help of bioinformatics.

17. Which of the following is the best method of treating domestic biodegradable solid waste?
    A. Incineration C. Composting
    B. Land filling D. Dumping into river

- **Explanation**: Composting is an aerobic microbial driven process that converts solid organic waste into a usable product and safely returned to the environment.

18. Which of the following statement is correct about application of microbes in food production?
    A. Mycoprotein is the product obtained from *Fusarium venenatum*
    B. Pruteen is Single cell protein used by human as primary nutrient.
    C. Antibiotics is largely extracted from Saccharomyces species
    D. Actinomycetes are the most important fungi used in beer production

Explanation:

- **Pruteen** is produced by the mass culture of the bacterium *Methlophils methylotrophus* which is used for animal feed.
- **Actinomycetes** are the most important fungi used in antibiotic production
- **Spirulina:** -viable alternative to green plants as a primary nutrient source

19. Glyphosate is the most widely used:
    A. Biopesticide
    B. bioherbicide
    C. bioinsecticide
    D. fungicide

- **Explanation**: Glyphosate is one of the most widely used herbicides with applications in agriculture, forestry, industrial weed control, lawn, garden, and aquatic environments. Sites with the largest glyphosate use include soybeans, field corn, pasture and hay

20. What is the primary environmental concern associated with landfill decomposition?
    A. Methane gas production
    B. Increased soil fertility
    C. Enhanced groundwater recharge
    D. Reduced waste volume

Explanation: The primary environmental concern associated with landfill decomposition is the production of **methane gas**. As organic waste decomposes in landfills, particularly in anaerobic (low-oxygen) conditions, it produces methane (CH_4), a potent greenhouse gas that contributes to global warming. Methane is about **25 times more effective** at trapping heat in the atmosphere than carbon dioxide (CO_2) over a 100-year period.

21. Which of the following bacteria is commonly used as a biopesticide for controlling a wide variety of vegetable and field crops?
    A. *Pseudomonas fluorescens*
    B. *Bacillus thuringiensis*
    C. *Bacillus popilliae*
    D. *Beauveria bassiana*

Explanation*: Bacillus thuringiensis* is widely used as a biopesticide on various crops, fruits, trees, and ornamentals due to its safety for humans and effectiveness against insects.

22. What is the primary insect pest that *Bacillus popilliae* targets in agricultural applications?
    A. Aphids
    B. Japanese beetle larvae
    C. Colorado potato beetle
    D. Black cutworm

Explanation: *Bacillus popilliae* is specifically used to target and control Japanese beetle larvae, which are a common pest in many crops.

23. Which fungus is used to control the Colorado potato beetle?
    A. *Verticillium lecanii*
    B. *Metarhizium anisopliae*
    C. *Beauveria bassiana*
    D. *Entomophthora spp*

Explanation*: Beauveria bassiana* is used for controlling the Colorado potato beetle, a major pest in potato crops.

24. Which of the following viruses is used as a biopesticide and does not replicate in warm-blooded animals?
    A. Cytoplasmic polyhedrosis virus (CPV)
    B. Bacillus thuringiensis virus (BTV)
    C. Herpesvirus
    D. Influenza virus

Explanation: CPV is one of the viruses used in biopesticides, and it does not replicate in warm-blooded animals, making it safe for humans and animals. **Cytoplasmic polyhedrosis virus (CPV)** is used as a biopesticide for controlling certain insect pests. CPV is one of the viruses that does not replicate in warm-blooded animals, which makes it safe for human and animal health. It primarily infects insects, which makes it an ideal candidate for use in pest control without posing a risk to humans or other mammals.

25. What is the primary mode of infection for fungal biopesticides like *Beauveria bassiana* and *Metarhizium anisopliae*?
    A. By ingestion through insect feeding
    B. By direct injection into the insect's bloodstream
    C. Through the insect's cuticle
    D. Through the insect’s respiratory system

Explanation: Fungal biopesticides infect insects primarily through the insect’s cuticle, entering the body and causing disease.

26. Which genus of fungi is used to control aphids in greenhouse and field environments?
    A. *Beauveria bassiana*
    B. *Metarhizium anisopliae*
    C. *Verticillium lecanii*

*Entomophthora spp***Explanation***: Verticillium lecanii* is associated with controlling aphids, a common pest in both greenhouse and field environments.

27. Why is the Ti plasmid a useful tool in genetic engineering?
    A. It can be used to insert foreign genes into plant cells.
    B. It is very easy to manipulate in the laboratory.
    C. It is naturally present in many plant species.
    D. It can be used to create herbicide-resistant plants.

Explanation: The Ti (tumor-inducing) plasmid is a circular DNA molecule found in *Agrobacterium tumefaciens*, a bacterium that causes crown gall disease in plants. The Ti plasmid can transfer a segment of its DNA (known as T-DNA) into the plant's genome. This property makes it a powerful tool in genetic engineering, allowing scientists to introduce foreign genes into plant cells, which is essential for developing genetically modified plants.

28. How does distillation contribute to the production of spirits?
    A. It increases the sugar content of the fermented product.
    B. It separates alcohol from other substances in the fermented product.
    C. It kills harmful bacteria in the fermented product.

D. It adds flavor to the final spirit.

Explanation: It separates alcohol from other substances in the fermented product. Distillation is the process used to separate alcohol from the fermented liquid. It works by heating the fermented mixture to vaporize the alcohol, which has a lower boiling point than water. The vapor is then condensed back into liquid form, effectively concentrating the alcohol and separating it from other substances in the fermented product (such as water, sugars, and other compounds). This process results in the production of spirits with higher alcohol content.

SELF TEST EXERCISE THREE

CHOOSE THE CORRECT ANSWER FROM THE GIVEN FOUR ALTERNATIVES

1.Which of the following is not the key role of biology in creating Conscious citizens? Developing Innovative bio-based technologies that

A. Consume more resources
B. Enhances nutritional quality of crops
C. Reduces uses of chemical pesticides
D. Reduces production of wastes

2. Which of the following statement is correct about the importance of conservation? It

A. Preserves best quality seeds only
B. Preserves genetic diversity
C. Develops more resistant crop varieties
D. enhances monoculture of crops Variety

3. Which of the following byproduct is a primary metabolite?

A. Antibiotic B. Steroid C. Ethanol D. Pigments

4. Biotechnology is applied in producing inactivated vaccine from

A. Dead version of pathogenic microorganisms
B. Living microorganism cultured in laboratory
C. Toxic product of bacteria
D. Weakened microorganism

5. Gel-electrophoresis is the process of

A. Making multiple copies of gene using PCR machine
B. Separating DNA fragments based on their molecular size
C. Extraction of DNA from sample that contain genetic material
D. Cutting and transferring DNA fragment in to membrane

6. Which of the following is not the purpose of waste water treatment?

A. Preservation of water quality of natural water resources
B. Inactivation of pathogenic microbes
C. Increasing BOD value of water
D. Reduction of nutrients to reduce pollution of surface water

7. Which application of biology is a promising technology that can help humans to cope with the environmental challenges caused by pollution and waste?

A. Biofortification
B. Biofuel
C. Bioremediation
D. Biomining

8. Which of the following is not the purpose of producing transgenic crop?

A. Developing Crops that are less resistant to abiotic stress
B. Produce pest resistant crops

C. Increasing biofortified crops
D. Increasing products that benefits human beings

9. Which of the following microorganism are commonly used to produce enzyme used in industry?
   A. Aspergillus and Bacillus
   B. Clostridium and Penicillium
   C. Actinomycetes and Saccharomyces
   D. Mycobacterium and Streptomyces
10. Which one of the following is not the use of biotechnology in bioinformatics?
   A. Analyzing and interpreting biological data
   B. Investigating criminal scenes
   C. Bio remediation of polluted sites
   D. Studying genomics and proteins
11. Which of the following is an example of secondary metabolite?
   A. Protein B. Carbohydrate C. Vitamins *D. Steroids*
12. Which of the following scientific tool is not used in forensic science?
   A. DNA Sequencer
   B. Fume Hood
   C. Thermal cycler
   D. *Plastic pipettes*
13. Which of the following is not the new application of biotechnology?
   A. Cell therapies B. Cell culture C. *Brewing* D. Gene cloning
14. Ethiopia has a great agricultural potential because of
   A. Diverse climate
   B. Small labor pool
   C. Low precipitation
   D. adequate supply of irrigation
15. Crops engineered for glyphosate are resistant to
   A. Fungi B. Insect C. Bacteria D. Herbicide
16. Bt cotton variety that was developed by the introduction of toxin gene of Bacillus thuringiensis (Bt) is resistant to:
   A. Insect pest
   B. Fungal infection
   C. Insect predators
   D. viral disease
17. Which of the following biological agents are possibly used as a biological warfare?
   A. *Bacillus thuringensis*
   B. *Bacillus anthracic*
   C. *Bacillus popilliae*
   D. *Agrobacterium tumefaciens*
18. Biochemical Oxygen Demand (BOD) may not be a good index for pollution for water bodies receiving effluents from:
   A. Domestic Sewage
   B. Sugar industry
   C. Dairy industry
   D. Petroleum Industry
19. Which of the following is put into anaerobic sludge digester for further sewage treatment?
   A. Floating debris
   B. Activated sludge
   C. Effluents for further sewage treatment
   D. Primary Sludge
20. Which of the following organism is used in fermentation process of Bread?
   A. *Lactobacillus bulgaricus*
   B. *Saccharomyces cerevisiae*
   C. *Aspergillus flavus*
   D. *Streptococcus thermophile*
21. Which of the following in sewage treatment removes suspended solids?
   A. Secondary treatment
   B. Primary treatment
   C. Sludge treatment
   D. Tertiary treatment

22. Which of the following is not correctly matched for the product produced by them?
    A. *Fusarium venenatum* → *Spirulina*
    B. *Actinomycete Streptomyces* → Antibiotics
    C. *Saccharomyces cerevisiae* →Ethanol
    D. *Penicillium notatum* →Acetic acid
23. The domestic sewage in Adama cities:
    A. Has a high BOD as it contains both aerobic and anaerobic bacteria
    B. Is processed by aerobic and then anaerobic bacteria in the secondary treatment in sewage treatment tank
    C. When treated in sewage treatment tank does not really require aerobic the aerobic aeration step as the sewage contain adequate oxygen
    D. Has very high amounts of suspended solids and dissolved salt
24. Ethanol is commercially produced by the action of a particular species called
    A. Clostridium
    B. Saccharomyces
    C. Aspergillus
    D. Actinomycetes
25. Which of the following biotechnological product is not used to detect clinical pathogens?
    A. Bioinformatics
    B. Biosensor
    C. Polymerase chain reaction
    D. Biohydrometallurgy
26. Thiobacillus ferrooxidan is extensively used to:
    A. Extract metals from rocks through leaching
    B. Used to make insecticide
    C. Used to remove pollutant from the soil
    D. Used to as vector in genetic engineering
27. What are the two most common types of biofuels in use today?
    A. Biodiesel and Ethanol
    B. Gasoline and Petroleum
    C. Biogas and Petroleum
    D. Coal fuel and Gasoline
28. Which of the following application of biotechnology is best to detect bacteria and viruses in waste water?
    A. Biological oxygen Demand
    B. Chemical Oxygen Demand
    C. Biosensor based method
    D. Total Organic Carbon
29. If the COD value is higher than BOD value, it indicates that the waste water contains
    A. Many biodegradable organic wastes
    B. Many organic matters not degradable by microorganism
    C. Less amount of pollutant in waste water
    D. High amount of oxygen in waste water
30. Which of the following process is the best method to treat organic solid waste?
    A. Incineration
    B. Landfill
    C. Composting
    D. Recycling
31. Which of the following is NOT involved in the production of beer?
    A. Malting of grains
    B. Fermentation by Saccharomyces
    C. Distillation of the fermented product
    D. Addition of hops for flavor

32. What is the primary purpose of malting barley in beer production?
    A. To increase the alcohol content
    B. To improve the color of the beer
    C. To increase the concentration of starch-digesting enzymes
    D. To enhance the bitterness of the beer
33. Which of the following is a key difference between beer and wine production?
    A. The type of microorganisms used
    B. The source of the initial sugars
    C. The need for distillation
    D. The presence of hops
34. What is the role of sulfur dioxide in wine production?
    A. To enhance the sweetness of the wine
    B. To kill any wild yeasts present
    C. To improve the color of the wine
    D. To increase the alcohol content
35. What is the primary advantage of using biopesticides over traditional chemical pesticides?
    A. They are generally less harmful to the environment and non-target organisms.
    B. They are always more effective at controlling pests.
    C. They are cheaper to produce.
    D. They have no side effects.
36. What is the role of the T-DNA region in the Ti plasmid?
    A. It contains genes that are essential for the plasmid to replicate.
    B. It contains genes that are transferred from the bacterium to the plant cell.
    C. It contains genes that confer antibiotic resistance to the bacterium.
    D. It contains genes that allow the bacterium to attach to the plant cell.
37. What are the primary factors that determine the flavor of beer?
    A. The type of hops used only
    B. The characteristics of the yeast strain and the initial juice
    C. The temperature during fermentation only
    D. The type of container used for aging

ANSWER KEY FOR SELF TEST EXERCISE 3.

1. A	7. B	13. C	19. B	41
2. B	8.A	14.A	20.C	26.A
3. D	9.A	15.B	21.B	27.A
4. A	10.C	16.A	22.C	28.C
5. B	11.D	17.C	23.B	29.B
6. C	12. B	18.D	24.C	30.C

THEME 2: LIVING THINGS

2.1. Classification

Learning Competencies

- ♣ Explain the need for classification.
- ♣ Describe the system of binomial nomenclature developed by Linnaeus.
- ♣ Explain how organisms are given scientific names.
- ♣ Write scientific names properly and give examples.
- ♣ Classify some common plants and animals, including humans, using their scientific names

Introduction

Life on Earth is incredibly diverse, with millions of species ranging from microscopic bacteria to towering trees and complex animals. Despite this diversity, all living organisms share fundamental characteristics, such as the ability to grow, reproduce, and respond to their environment. Understanding this diversity requires a classification system that organizes life into hierarchical groups based on similarities and evolutionary relationships.

The science of taxonomy, first developed by **Carl Linnaeus**, provides a systematic way to categorize organisms using binomial nomenclature, a universal method of naming species. Organisms are grouped into five major kingdoms—Monera, Protista, Fungi, Plantae, and Animalia—based on structural and functional characteristics. Each kingdom contains unique life forms adapted to different environments, illustrating the complexity and interconnectedness of life.

Principles of classification

- ➢ The process of classifying living organisms is known as taxonomy. It is the law governing to classify this diversity by studying, identifying, naming them to put into group called **taxa**.
- ➢ **This approach helps** to:

i. Simplify classification and study of living things.
ii. Try to understand how life originated.
iii. To create an internationally accepted way of referring to a particular living thing.
iv. To avoid confusion created by different languages

Classification System

- Taxonomy began with the work of Aristotle, a philosopher who lived in Ancient Greece from 384–322 BC. He called humans 'rational animals'
- The modern system of classification was developed by Carl Linnaeus
- He developed the binomial system of nomenclature.
- The modern system of classification contains five taxa

Kingdom → phylum (or for plants, division) → Class → Order → Family → Genus → Species

There are rules for writing names in binomial approach

1. The first name is the name of the genus to which the organism belongs written in capital letter.
2. The second name is the name of a species to which the organism belongs is written with a small letter.
3. The two names are underlined when handwritten or in italics when printed.

2.2. The five kingdoms system

There are five kingdoms of Organisms:

a. Kingdom Monera
b. Kingdom Protista
c. Kingdom Fungi
d. Kingdom Plantae
e. Kingdom Animalia

Kingdom Monera

- all are unicellular prokaryotes and microscopic organism
- Include archaea and eubacteria
- Many are heterotrophic, some are photosynthetic
- Example: *Cyanobacteria, Mycobacterium tuberculosis, Haemophilus ducrey*

Kingdom Plantae

- Plants are photosynthetic multi-cellular organisms with differentiated organs into true root and shoot systems
- plants have vascular systems called Xylem and phloem
- There are 4 divisions of Plants

i. Bryophytes: Mosses and liver wort)

- Called the simplest land plant that have no true leave, root and stem
- Are non-vascular plants that have rhizoid simple root like structure

ii. Pteridophyte (Filicinophyta) Called ferns

- They have ***true leaves, stems*** *and* ***roots.***
- Stems have **rhizomes**, which grow horizontally below the surface of the soil.
- ***contain vascular tissue***
- Have spore-forming bodies on the underside of the **fronds** called **sori**

iii. Gymnospermae (Coniferophyta)

- Are **seed-bearing plants** called **spermatophytes**.
- Known as the conifers or 'naked seeded (***not enclosed in fruits***) Plants'.
- They are often cultivated for timber dominant vegetation in cold and mountainous regions.
- They have small ***needle-shaped leaves*** with ***thick with a waxy cuticle*** that reduces water loss and minimizes damage by excess heat or cold.
- Are **evergreen** with reproductive structures are found in ***cone*** e.g. include juniper, yew Pine trees, spruces

iv. Angiospermae

- Are **seed-bearing plants** called **spermatophytes and** are the biggest group of land plants.
- They have Seeds enclosed in a fruit.
- The have Well-developed **xylem** and **phloem** tissue.
- Contain two classes (Monocot and Dicot)

a. Monocots

The main characteristics of the monocotyledons include:

- ✓ monocots are the cereal plants that form the **staple source of diet**
- ✓ The embryo has a single seed leaf (cotyledon).
- ✓ Leaves are generally long and thin with parallel veins.
- ✓ The stem contains scattered vascular bundles.
- ✓ In general, monocots do not reach great sizes (palms are the exception to this).
- ✓ They are often wind pollinated.
- ✓ E.g. include grasses, orchids and maize, teff

b. Dicotyledons

- ✓ ***Dicotyledons*** are flowering plants.
- ✓ They make up most of the trees including many vegetables plants

The main characteristics of the dicotyledons are:

- The embryo has two seed leaves (cotyledons).
- The leaves are relatively broad and have a network of veins.
- The stem contains a ring of vascular tissue.
- Some dicots reach great sizes.
- They are often insects pollinated.
- E.g. include sunflowers, peas, roses and beans, *Jacaranda*, *Eucalyptus*, *Cassia* and mangos

Kingdom Animalia

- Is kingdom of heterotrophic multicellular animals
- Are locomotive organisms with nervous systems so they are sensitive to their surroundings?
- The main phyla include:

Phylum Porifera = sponges

- are the simplest invertebrates that are called hollow filter feeders
- are an evolutionary dead ended animals

Phylum Coelenterate = cindaria

- Are marine creatures that have ring of stinging cell on their **tentacles** for poisoning or immobilizing prey.
- **Only one opening, the mouth**, and their bodies have **radial symmetry**.

Phyla Platyhelminthes = Flat worm

- Show relatively high level of organization.
- They possess a front end where the mouth, major sense organs sited.
- They have flattened bodies with a mouth but no anus.
- They are hermaphrodites

Example: Tape worm, Liver fluke

Phylum Nematoda = round worm

- are thought to be the numerous animals in the world.
- They have narrow, thread-like bodies, which are pointed at both ends and bilaterally symmetrical.
- Their bodies are not segmented and are round in cross-section

Phylum Annelida

- Have regular segments with structures and organs repeated along the body.
- They have a closed blood circulatory system

- They are hermaphrodites, with male and female reproductive organs and they have bristle like structures called chaetae to help them move.
- Common example is earth worm that increase fertility of soil

Phylum Mollusca = Soft bodied animal

- an invertebrate animal with a soft unsegmented body protected by a shell
- Include the most intelligent of the invertebrate species
- E.g. Octopi and Squid have well developed brains

Phylum Echinodermata =

- Are Spiny-skinned and radially symmetrical marine invertebrates
- Move around using **tube feet**.
- The adults have five arms, but the larval stages do not.
- Examples include *Asteris*, the common starfish, sea urchin and sea cucumber known as a sea apple.

Phylum Arthropoda = joint footed animals

- Are animals with segmented bodies, jointed limbs with a well-developed nervous system and complete gut.
- It is divided into a number of classes according to number of limbs antennae and number of body parts. The classes include insecta, crustacea, arachnida, diplopoda and chilopoda.

Class insect

- They have a body divided into three body parts; head, thorax and abdomen.
- They have three pairs of jointed legs on the thorax along with one or two pairs of wings.
- On their head they have a pair of antennae and one pair of compound eyes.
- They include **flies, butterflies** and **moths, beetles, wasps** and **bees** and many other common groups.

Class crustacea

- are mainly aquatic vary in size from very small to quite large
- The body is made up of **two parts** – a **cephalothorax** (head fused with thorax) and **abdomen**.
- Their body is protected by a tough covering called a **carapace**.
- They have **more than four pairs** of jointed legs, **two pairs** of antennae and **simple** eyes

Class Arachnida: are spiders mainly terrestrial although some are aquatic.

- have **two** body parts – a **cephalothorax** (fused head and thorax) and the **abdomen** with **no antennae**.
- They have **eight legs** in four pairs.
- Arachnids have simple eyes but often up to eight of them.. Examples of arachnids include **spiders, ticks, scorpions** and **mites**.

Class Chilopoda: Are centipedes' arthropods having the trunk composed of numerous somite each bearing one pair of legs

Class Diplopoda: Are millipede arthropods having the body composed of numerous double somite each with two pairs of legs.

Phylum Chordata = vertebrates

- Are creatures characterized by a notochord, hollow nerve chord and gill slits
- The term chordata is derived from the term **notochord which** is flexible rod-like structure, made of cartilage that provides support to the body.
- They have gill slits during early stages of development that are later replaced by lungs and gills.

They are divided into five classes:

1. Class Pisces = fishes.

- They are aquatic except the **mudskipper** and **lung fish**, which can spend short periods breathing in air.
- They have **streamlined bodies** with scales on their skin.
- They use **gills** for gaseous exchange and have fins for swimming.
- They are **ectothermic** – they rely on heat from their environment to regulate their body temperature

2. Class Amphibia

- The first vertebrates to colonize the earth.
- Are creatures that spend part of their lives in water and part of it on land
- They have simple sac-like lungs and smooth, moist skin, which is also used as a respiratory surface.
- The class includes frogs, toads, newts and salamanders
- They need **water** for successful reproduction as **fertilization is external** and the larval form (tadpole) is aquatic.

- Are **ectothermic** – they rely on heat from their environment to regulate their body temperature.

3. Class Reptilia

- **Reptiles** are cold-blooded, usually egg-laying, vertebrates that have dry skin with scales
- their gas exchange takes place exclusively in the lungs.
- Reproduce by internal fertilization and they lay **eggs** on
- Colonized many dry and hot environments. Dominant group of animals for million years
- The gill slits are seen only in **embryonic development**
- **have no external ears** and are **ectothermic**
- Examples include **snakes, crocodiles** and **lizards**

4. Class Aves

- These are the birds having **feathers** over most of their body, and **scales** on their legs.
- Their forelimbs are adapted to fly as **wings** which attached to **sternum**
- Their jaws are tooth-less and are covered by a **horny beak**.
- Reproduce by internal fertilization using well-developed eggs with a **hard shell**
- have **light skeletons**, which makes it easier for them to fly.
- are **endothermi**c

5. Class Mammalia

- **Mammals** are creatures who produce milk for their young, have a high internal body temperature and regulate their own body temperature.
- They have hair on the skin and external ears.
- Mammals are classified according to the way their young are produced.
- There are **three** sub classes of mammals:

a. **Egg-laying mammals** – **lay eggs**

b. **Marsupials** – produce **immature young**, which are nourished by **milk** in the **pouch**

c. **Higher mammals** – produce **fully developed young**, which are nourished by **milk** from the **mammary glands.** Bats are flying mammals

SELF TEST EXERCISE FOUR

Choose the correct answer from the given four alternatives

1. Which one of the following characteristics of an organism is more sophisticated way of grouping an organism into species level? By
   A. Using pentadactyl limb pattern C. Looking at morphology of an organism
   B. Comparing genome sequence D. Using dichotomous keys
2. Binomial system of nomenclature for organism was developed by
   A. Carl Linnaeus B. Aristotle C. Wittaker D. Charles Darwin
3. The book written by Carl Linnaeus was entitled as
   A. The system of nature C. Philosophy of Zoologies
   B. The ladder of life D. The nature of life
4. Which of the following is correctly paired with its scientific name?
   A. House fly – *Felis domesticus* C. Lion – *Panthera leo*
   B. Wolf – *Canis familiaris* D. Bean – Zea mays
5. Which of the following is the correct naming (language) of scholars?
   A. Keyih wukariya B. *Red jackal* C. *Musca Domestica* D. *Canis simensis*
6. Which of the following organism is correctly grouped under their classes
   A. Fishes – Aves C. Elephant – Mammalia
   B. Human – primates D. Birds – Pisces
7. The maximum nutritional diversity is found in the group
   A. Fungi B. Animalia C. Plantae D. Monera
8. Methanogen belongs to:
   A. Eubacteria B. Dinoflagellates C. Archaebacteria D. Moulds
9. Archaebacteria differ from eubacteria in
   A. Cell wall structure C. Cell shape
   B. Mode of nutrition D. Mode of reproduction
10. Which of the following are likely to be present in seed sea vent?
    A. Cyanobacteria B. Saprophytic fungi C. Archaebacteria D. Eubacteria
11. In Prokaryotic, a cellular component that resemble eukaryotic cell is:
    A. Plasma membrane B. Ribosomes C. Nucleus D. Cell wall
12. In the five-kingdom system classification, Chlamydomonas and chlorella have been included in
    A. Protista B. Algae C. Plantae D. Monera
13. Which groups of Protista causes bioluminescence in the oceans when they produce greenish light?
    A. Dinoflagellates B. Trypanosoma C. Mycorrhizae D. Chlamydomonas

14. Which one of the following is the characteristic of all members of monera? All
    A. Carries photosynthesis C. are eukaryotic organism

B. Are single celled organism D. are decomposers

15. Which of the following kingdom is correctly matched with its examples?
    A. Protista – Bacteria C. Protista – *Plasmodium vivax*
    B. Fungi – Blue green algae D. Monera – *Entameba histolyca*
16. Which of the following options holds only the classes of vertebrates?
    A. Amphibians, Arthropoda, Reptilia, Aves and Mammalia
    B. Pisces, Amphibian, Echinodermata, Aves and Mammalia
    C. Amphibia, Annelida, Reptilia, Aves and Mammalia
    D. Pisces, Amphibian, Reptilia, Aves and Mammalia
17. What is the importance of classification? To
    A. give Latin/Greek names to organism C. assign local names to organism
    B. make education more complex D. bring order out of chaos
18. Which of the following organism is an example of Kingdom Monera?
    A. Fern B. Bacterium C. Fungus D. Algae
19. In kingdom animalia, which phylum poisons its prey by tentacles that contain stinging cells?
    A. Annelida B. Coelenterata C. Nematoda D. Porifera
20. Mosses are grouped under division bryophyte because they
    A. Have flat and broad leaves
    B. Aare ever green and photosynthesize all year round
    C. Lack true root system and vascular tissues
    D. Have true leaves, stems and roots
21. Which of the following taxonomic categories of organisms is in the correct sequences?
    A. Phylum → Family→ class→genus→order→species
    B. Phylum → order →Family →Class→ genus →species
    C. Phylum →class →Family→ order →genus→ species
    D. Phylum → Class → Order → Family →Genus →species
22. Which of the following is true about kingdom animalia?
    A. They have cell wall C. They are immobile
    B. They are autotrophs D. They have nervous system
23. What major problems did the scientific naming of organisms solve?
    A. Showed the mechanism how new species arise from the existing ones
    B. Provided understanding among scientists of different countries
    C. Designed the hierarchy of the different groups of living things
    D. Showed the way how living thing organisms originated on this planet
24. Which of the following organisms is vertebrate animal?
    A. Lizard B. Ascaris C. Earthworm D. Snails

25. This item is based on the following structure of plants

    I. Seed II. Flower III. Vascular tissue IV. Cone

    The structures that perfectly fit to the division Gymnospermae are

A. I, III, IV B. I, II, III C. I, II, IV D. II, III, IV

26. A biology student went to field to collect animals and grouped them into vertebrates. He collected the following organisms. 1. Squids 2. Earthworm 3. Frog 4. Butterfly 5. Shark 6. Shrimp. Which of the above organisms did he grouped vertebrates?
    A. 4 and 6 B. 1 and 5 C. 3 and 5 D. 2 and 3
27. Which of the following divisions of Kingdom plantae is correctly matched with its example?
    A. Gymnospermae – true flowering plants C. Pteridophyte -- ferns
    B. Bryophyta – Conifers D. Angiospermae – mosses and liverworts
28. Which of the following groups of plants possess roots?
    A. Ferns B. Lichen C. Mosses D. Liverworts
29. Which of the following scientific name is correctly written?
    A. *Eragrostis teff* B. Musca domestica C. Homo *sapiens* D. *canis Familiaris*
30. In which kingdom would you classify the archaea and nitrogen fixing organisms, if the five-kingdom system of classification is used?
    A. Plantae B. Fungi C. Protista D. Monera
31. Which of the following is not grouped in Protista?
    A. Mucor B. *Gardia lambillae* C. *Entameba histolyca* D. Diatom
32. Which of the following is correctly matched with its phylum?
    A. Mushroom→ Basidiomycot C. Teff → Gymnospermophya
    B. Honey bee → Arthropoda D. Mango → Mangifera
33. Representative of Gymnospermae are
    A. Ferns B. Conifers C. Mosses D. Liverworts
34. Which of the following phyla of kingdom animalia contains evolutionary dead organisms?
    A. Coelentrata B. Nematoda C. Annelid D. Porifera
35. The most intelligent groups of all invertebrate are found in the phylum
    A. Nematoda B. Annelida C. Mollusca D. Arthropoda
36. The smallest/simplest land plant are:
    A. Pteridophyes B. Bryophytes C. Angiospermae D. Filicinophyta
37. Which one of the following is the characteristic of Bryophytes? The
    A. absence of vascular tissues C. Presence of well-developed roots, stem and leaves
    B. presence of reproductive structure in cone D. presence of xylem and phloem
38. Which of the following is correctly paired with its examples
    A. Mollusca → segmented worms C. Annelida → soft bodied animals
    B. Nematoda → roundworms D. Arthropoda → spiny skinned animals

39. All are invertebrates except
    B. Flat worm B. Cidaria C. Coelentrates D. Chordates
40. The most numerous animals in the world
    A. Round worms B. Flatworms C.Mollusca D. Chilopoda

41. As chaetae is to phylum Annelida, tube feet is to
    A. Echinodermata B. Arthropoda C. Diplopoda D. Centipedes
42. Which of the following is not correctly matched with its features?
    A. Porifera – are hollow filter feeders and an evolutionary dead ended invertebrates
    B. Coelenterata – contain stinging tentacle to immobilize prey and predator
    C. Platyheminthes – are hermaphrodite with mouth but not anus
    D. Mollusca – segmented worm with organ repeated along the body
43. Which of the following organisms are representative examples of Echinodermata?
    A. Sea urchin, starfish and Sea apple C. Sea anemones, Hydra and jelly fish
    B. Octopuses, squids, slugs and snails D. Crustacea, arachnida and diplopoda
44. All are the characteristic of monocots except
    A. Leaves contain long and thin parallel vein C. They are often wind pollinated
    B. Contain scattered vascular bundles D. Contain ring of vascular tissues
45. Which of the following is not true about amphibians? They are
    A. The first vertebrates to colonize the land
    B. Have smooth, moist skin used as a respiratory surface
    C. Ectothermic animals that rely on ambient temperature
    D. Are animals with dry scale and uses lungs for gaseous exchange
46. Teleosts and elasmobranchs are the two subclasses of:
    A. Aves B. Pisces C. Reptiles D. Amphibians
47. This item is based on the following features of Class Chilopoda (Centipide and Millipides).

Centipedes	Millipedes
have flattened bodies	Cylindrical bodies
1	2
Less segment	More segment
3	4
Have one pairs of limbs per segment	Have two pairs of limbs per segment

    Which of the following feature is correctly matched with its features for 1, 2, 3 and 4 respectively?
    A. Bright colored, Dull-colored, Carnivores and Herbivores
    B. Dull-colored, brightly colored, Herbivores and carnivores
    C. Have claws for biting plant, have poisonous claws, Herbivores and carnivores
    D. Herbivores, carnivores, have poisonous claws and Have claws for biting plant
48. In which of the following group do blue green algae grouped?
    A. Bryophytes B. Prokaryotes C. Protista D. Fungi
49. An important criterion for modern day classification is:
    A. Resemblances in morphology C. Breeding habits
    B. Anatomical and physiological traits D. Presence or absence of notochord
50. Which of the following organism are found in extreme saline condition?
    A. Eubacteria B. Mycobacteria C. Cyanobacteria D. Archaebacteria

51. Viruses have:
   A. DNA enclosed in a protein
   B. Single chromosome
   C. Prokaryotic nucleus
   D. both RNA and DNA

52. Which of the following is not correct about viruses?
   A. All are parasites
   B. They have different structure and shape
   C. They have ability to synthesis nucleic acid and proteins
   D. Antibiotics have no effect on them

53. Which of the following is not correctly paired with its function?
   A. Saprophytes – decomposition of dead organic material
   B. Parasites – Living on living plant or animal
   C. Lichens – Symbiotic association of plant and algae
   D. Mycorrhiza – symbiotic association of fungi with plant roots

54. Which of the following is wrong about fungi?
   A. They are eukaryotic
   B. They are heterotrophic
   C. All fungi possess cellulose cell wall
   D. they are both unicellular and multicellular

55. The cell wall of most fungi is composed of:
   A. Cellulose B. Chitin C. Peptidoglycan D. Poly saccharide

56. Single celled eukaryotes are included in Kingdom
   A. Protista B. Fungi C. Monera D. Archaea

57. Which of the following organism lack membrane organelle?
   A. Streptococcus B. Chlamydomonas C. Plasmodium D. Saccharomyces

58. Lichens are organism produced by intimate association of
   A. Algae and plant
   B. Algae and bacteria
   C. Fungus and algae
   D. Fungus and Plant

59. Which of the following statement about viruses is correct?
   A. Viruses possess their own metabolic system
   B. Viruses are obligate parasites
   C. All viruses contain both RNA and DNA
   D. Nucleic acid of viruses is known as capsid

60. Which of the following organism often used as indicator of pollution and sensitive to SO_2
   A. Lichens B. fungi C. Mosses D. Mushrooms

61. Which of the following groups are decomposers of plant
   A. Monera and Fungi
   B. Protista and animalia
   C. Fungi and plants
   D. animalia and monera

62. Which one of the following is correctly paired with feature?
   A. Nematoda → Animal with radial body symmetry
   B. Arthropoda → soft bodied animals
   C. Mollusca → spiny skinned animals
   D. Sponges → hollow filter feeder animals

63. Which of the following is not correctly paired with its best examples?
    A. Arthropod →Spider and Shrimp C. Coelenterate → Hydra and jelly fish
    B. Mollusca →Octopi and squid D. Chordate→earth worm and flat worm
64. Which one of the following is not the characteristic feature of kingdom Fungi? They are:
    A. Multicellular B. Saprophytic C. Prokaryotic D. Eukaryotic
65. Which one of the following scientific names is correctly written?
    A. Tapeworms, Nemathelminthes, Liver flukes
    B. Musca Domestica, *Homo Erectus, Zea* mays, Annelid worm
    C. Fasciola hepatica, H. sapiens, Zea mays
    D. lumbricus terrestris, Archatina fulica, Pinus radiate
66. Which of the following organism is not the class of phylum arthropods?
    A. Arachnida B. Crustacean C. Reptilia D. Diplopoda
67. Which of the following is not the feature of organism grouped in kingdom Monera?
    A. Multicellular B. Prokaryotic C. Unicellular D. Microscopic
68. Which one of the following is example egg laying mammals?
    A. Duck-billed platypus B. Oposum C. Human C. Bats
69. Which of the following is not correctly paired with its classes?
    A. Millipedes → Diplopoda C. Boney fishe →Teleosti
    B. Centipedes →Chilopoda D. Shrimps → Insecta
70. Who was the father of taxonomy?
    A. Aristotle B. Wittaker C. Linnaeus D. Darwin
71. One of the following is not the contribution of Carlos Linnaeus?
    A. He discovered new plant species and published on his book entitled '' The system of Nature''
    B. He tried to group animal based on similarities such as animal that live on land and in water
    C. He was the first person to propose an orderly system for classifying organism
    D. He was known with the binomial system of classifying organism with the first name genus followed by species
72. As we go from species to kingdom in a taxonomic hierarchy, the number of common characteristics
    A. will decrease B. will increase C. remain same D. may increase or decrease
73. In a taxonomic hierarchy, the number of common characters will increase as we go from
    A. Species to kingdom C. Kingdom to species
    B. Order to class D. Genus from species
74. The most representative example of bryophytes is/are:
    A. Sponges and Hydra C. Mosses and liverworts
    B. Conifers and Ferns D. Monocots and dicots
75. Which of the following feature is not representing division Pteridophyta?
    A. They have true leaves, roots and stems
    B. they are non-vascular plant species

C. They produce spore forming fronds under fronds
D. they have simple root like structure called rhizoid

76. The largest and most diverse of all phyla in the animal kingdom is the Phyla
A. Arthropoda B. Mollusca C. Annelida D. chordate

77. Which of the following is organism is grouped into class Arachnida?
A. Spider, Scorpions, ticks and mites
B. Water flea, Lobsters, Crabs and Woodlice
C. Wasps, Bees, Cockroach and Butterfly
D. Millipedes, Centipedes, Tilapia and Catfish

78. Which of the following mammals are not marsupial?
A. Opossum B. Kangaroo C. Monkeys D. Koala bear

79. Which classes of vertebrata has scaly skin on the legs, lays eggs and can regulates its own body temperature?
A. Birds B. Reptiles C. Mammals D. Fishes

80. The biomass is maximum in a
A. Forest ecosystem C. Grass ecosystem
B. Marine ecosystem D. Lake ecosystem

81. Which of the following organism have the highest biomass?
A. Producers B. Herbivores C. Carnivores D. Decomposers

82. Which of the following is a biotic component of ecosystem?
A. Sunlight B. Rainfall C. Oxygen D. Disease

83. Which of the following organism occupies the first trophic level in any food chain?
A. Carnivores B. Herbivores C. Producers D. Decomposers

84. Which of the following is not true about Terrestrial food chain?
A. Decomposers are the last stage of food chain
B. Primary consumers are also called herbivores
C. Biomass increase as we move up from lower trophic
D. Energy decrease as we move up the trophic level

85. What do we call animal that feeds partly or wholly on the bodies of dead animals?
A. Scavengers B. Decomposer C. Producers D. Chemotrophs

86. Bacteria that convert atmospheric nitrogen to nitrate in the soil is
A. Putrefying bacteria C. Denitrifying bacteria
B. Nitrogen fixing bacteria D. Nitrifying bacteria

87. In carbon cycle the process that removes carbon dioxide from the atmosphere is
A. Respiration B. Fossilization C. Photosynthesis D. Decomposition

88. Which of following feature is physical adaptation means of animals in hot climate? The presence of;
A. thin fur coat C. thick fur coat
B. blubber under skin D. Small surface area to volume ratio

89. Which one of following not true about adaptation?
    A. In hot climate the rate of photosynthesis is very high
    B. Animal in cold climate contain large surface area to volume ratio to increase heat loss
    C. Succulent plants have fleshy stem and leaves
    D. Desert animals have large surface area to volume ratio to loss heat

90. A biologist is classifying a newly discovered animal species. The species has a segmented body, an exoskeleton, and jointed appendages. Based on these characteristics, which phylum within Kingdom Animalia does it most likely belong to, and why?

A. Mollusca, because it includes animals with hard protective structures.

B. Arthropoda, because it has segmented bodies and jointed appendages.

C. Annelida, because it has a segmented body structure.

D. Chordata, because it exhibits bilateral symmetry.

ANSWER KEY TO EXERCISE NINE ON CLASSIFICATION

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

2.3. ANIMAL

Learning Competencies

- Describe the characteristics of animals
- Differentiate between vertebrates and invertebrates
- Compare and contrast reproduction in vertebrates. Industry, health, and medicine
- Explain animal behavior balance
- Evaluate the economic importance of animals (insects) in agriculture, food,
- Discuss the types and patterns of animal behavior
- Discuss homeostasis in animals: thermoregulation, osmoregulation and chemo regulation

2.3.1. Characteristics of animals

- Animals are **multicellular, eukaryotic organisms** that are typically **heterotrophic** (relying on other organisms for food). They exhibit **mobility** at some stage of their life cycle and have specialized **nervous systems** to respond to stimuli. Most animals also have **symmetry** (bilateral or radial) and **reproduce sexually**, though some can reproduce asexually.

Common Characteristics of Animals:

- **Animals are Eukaryotic:** meaning their cells have a **nucleus** and other membrane-bound organelles. This allows for more complex and organized cellular functions. **Example:** Human cells, as well as the cells of other animals, have **membrane-bound nuclei** and organelles like **mitochondria** and **ribosomes**.
- Animals can have different types of body symmetry like **Bilateral symmetry:** e.g. humans, butterflies). **Radial symmetry:** e.g. starfish, jellyfish. **Asymmetry:** Some animals, like sponges, do not have any symmetry.
- Most animals reproduce sexually, involving the combination of **sperm** and **egg** cells. Some animals can also reproduce asexually through processes like **budding** or **fission**.
- Animals are **multicellular**, meaning they are made up of more than one cell. This allows for specialized functions and structures (e.g., tissues, organs). **Example:** Animals like **humans** and **elephants** are composed of trillions of specialized cells that work together to perform different functions.
- Animals are **heterotrophs**, meaning they cannot produce their own food

- Animals require oxygen for **respiration**, which is the process of extracting energy from food.
- Animals can respond to environmental stimuli through **sensitivity**. They have **nervous systems** that allow them to react to light, temperature, touch, and other factors.
- Animals undergo **growth** through **cell division** and **cell differentiation**. Most animals grow to a certain size and then stop growing after reaching maturity.

Invertebrate and vertebrate animals

Differentiate between vertebrates and invertebrates

Vertebrates are animals that have a **backbone** or **vertebral column**, which provides structural support and protects the spinal cord. Vertebrates include groups like **mammals, birds, reptiles, amphibians, and fish**.

Invertebrates, on the other hand, are animals that **lack a backbone**. They make up about 95% of animal species and include groups such as **insects, mollusks, arachnids, and crustaceans**. Invertebrates typically have an **exoskeleton** for protection.

Table 2. Difference between vertebrates and invertebrate animals

Characteristic	Vertebrates	Invertebrates
Presence of Backbone	Have a **backbone** (vertebral column)	**Lack a backbone**
Examples	Mammals, Birds, Fish, Amphibians, Reptiles	Insects, Mollusks, Arachnids, Crustaceans, Sponges
Body Structure	Typically have an **internal skeleton** made of bone or cartilage	Have an **external skeleton** (exoskeleton) or no skeleton
Size	Usually **larger** in size	Usually **smaller** in size
Nervous System	Well-developed **central nervous system** with a brain and spinal cord	Simpler **nervous systems**, often with ganglia or no brain
Circulatory System	**Closed circulatory system** (blood contained in vessels)	**Open circulatory system** (blood flows freely through body cavity)
Reproduction	**Sexual reproduction** with internal or external fertilization	Mostly **sexual**, but some reproduce asexually (e.g., budding)
Respiratory System	**Lungs or gills** for respiration	**Gills, tracheae, or diffusion** for respiration
Complexity of Organs	Have complex **organs** and systems (digestive, circulatory, respiratory)	Have simpler organs or none at all (e.g., invertebrates like sponges)

Reproduction in vertebrates

In vertebrates, reproduction is primarily sexual, involving internal or external fertilization.

- Internal fertilization occurs in most mammals, reptiles, and birds, where fertilization happens inside the female's body.
- External fertilization is common in amphibians and fish, where eggs and sperm meet outside the body, usually in water.
- Reproduction in Animals can be divided into two main types: sexual reproduction and asexual reproduction.
- Sexual Reproduction: involves the combination of genetic material from two parents. It typically involves gametes (sperm and egg cells) that fuse during fertilization to form a zygote. It Can be internal or external. Development:
  - ✓ Oviparous: Animals lay eggs that develop outside the body (e.g., birds, reptiles).
  - ✓ Viviparous: Animals give live birth after the embryo develops inside the female (e.g., mammals).
  - ✓ Ovoviviparous: Eggs develop inside the female's body, but there is no direct nourishment from the mother (e.g., some reptiles).
- Asexual Reproduction: involves a single parent, and offspring are genetically identical to the parent. It is typically used by simpler animals and can be much faster than sexual reproduction.
- No need for gametes: One parent can produce offspring on its own. Offspring are genetically identical to the parent and called clone!
- Types of Asexual Reproduction:
  - ✓ Budding: A small outgrowth forms on the parent, eventually detaching to form a new organism (e.g., hydra, sponges).
  - ✓ Fission: The parent organism splits into two or more parts, each capable of developing into a new organism (e.g., bacteria, flatworms).
  - ✓ Fragmentation: A piece of the parent breaks off and grows into a new individual (e.g., starfish).
  - ✓ Parthenogenesis: Female organisms produce offspring without fertilization by a male (e.g., some insects, reptiles).

Table 3. Comparison of Sexual and Asexual Reproduction

Feature	Asexual Reproduction	Sexual Reproduction
Number of Parents	One parent	Two parents (male and female)
Genetic Variation	Offspring are genetically identical to the parent (clones)	Offspring are genetically diverse
Speed of Reproduction	Fast (no need for mates or fertilization)	Slower (requires finding a mate, fertilization, etc.)
Types of Organisms Produced	Identical copies of the parent organism	Unique offspring with mixed traits from both parents
Examples	Hydra (budding), starfish (fragmentation)	Humans, animals, birds, reptiles

Q1. Why is Internal Fertilization More Advantageous for Land Animals as Compared to Aquatic Animals? Because: internal fertilization:

- ensures that embryos are **protected inside the female's body** and can develop without the risk of desiccation.
- enables more **controlled conditions** for the development of the embryo (e.g., regulated temperature, nutrients, and protection).
- reduces the risk of **egg predation**.

Q2. What major features are associated with internal fertilization in animals?

- **Protection of Gametes**: Sperm and eggs meet within the female's body, often in specialized organs like the uterus (mammals) or oviducts (reptiles, birds).
- **Formation of a Zygote**: Fertilization produces a zygote, which develops into an embryo inside the female.
- **Parental Care:** Many species with internal fertilization provide nurturing care to their young after fertilization (e.g., humans, mammals).
- **Sexual Dimorphism:** In many species, males and females exhibit physical differences (e.g., size, coloration) related to mating.
- **Longer Gestation or Incubation**: Offspring development occurs within the mother's body (live birth or egg-laying with protection), requiring longer time periods for development.

Q3. Define Zygote, Cleavage, Blastula, and Gastrula

- **Zygote--** A fertilized egg formed by the fusion of sperm and egg; the first stage of development.
- **Cleavage:** The series of cell divisions that occur immediately after fertilization, leading to a multicellular embryo.
- **Blastula:** The stage after cleavage where the embryo forms a hollow ball of cells, marking the early stages of development.

- **Gastrula:** The stage where the blastula folds inwards to form three germ layers (ectoderm, mesoderm, and endoderm), marking the beginning of organ development.

Q4. How Tissues, Organs, and Organ Systems Develop from Germ Layers

- **Ectoderm**: Forms the outer layer of the body and gives rise to the skin, nervous system, and sensory organs (e.g., brain, spinal cord).
- **Mesoderm:** Forms the middle layer and develops into the muscles, bones, circulatory system, and reproductive organs (e.g., heart, kidneys).
- **Endoderm:** Forms the inner layer and develops into the digestive system, liver, pancreas, and other internal organs (e.g., lungs, intestines).

The stages of embryonic development in animals

The **stages of embryonic development in animals** follow a well-defined sequence, where a single fertilized egg (zygote) undergoes a series of changes to form a complex organism. These are:

Fertilization → Cleavage → Morula → Blastula → Gastrulation → Neurulation → Organogenesis

1. **Fertilization**: Formation of the zygote.
2. **Cleavage**: Rapid division of the zygote into smaller cells.
3. **Morula**: Solid ball of cells.
4. **Blastula**: Hollow ball of cells with a blastocoel.
5. **Gastrulation**: Formation of the three germ layers (ectoderm, mesoderm, endoderm).
6. **Neurulation**: Formation of the neural tube.
7. **Organogenesis**: Development of organs and tissues.
8. **Fetal Development**: Growth and maturation of organs before birth.

Reproduction in Insects: Complete and Incomplete Metamorphosis

- Insects have two main types of metamorphosis, **complete** and **incomplete**, which describe their development from egg to adult.

A. Complete Metamorphosis

- ✓ This process allows the larva and adult to occupy different habitats or niches, reducing competition for resources.
- ✓ Egg → Larva → Pupa → Adult
- ✓ Examples: Butterflies, flies, beetles

B. Incomplete Metamorphosis

- ✓ The process in which Nymphs can begin feeding and growing immediately after hatching, with fewer dramatic changes than in complete metamorphosis.

- ✓ Egg → Nymph → Adult
- ✓ Examples: Grasshoppers, cockroaches, dragonflies

Reproductive Structures of Male and Female Honeybees and Their Functions

- **Ovary:** The queen has well-developed ovaries that produce eggs. The ovaries are the primary reproductive organs, responsible for egg production. Worker bees have small, undeveloped ovaries. In normal circumstances, these ovaries are not used because the queen's presence suppresses their development.
- **Spermatheca:** A storage organ where the queen stores sperm received during her mating flight. This sperm is used to fertilize eggs throughout her lifetime.
- **Testes:** The testes produce sperm used for mating with the queen. Drones have large testes relative to their body size.
- **Endophallus:** The reproductive organ that is used during mating. It delivers sperm to the queen during copulation. Drones typically die after mating.

Reproduction in Frogs:

- Frog reproduction involves several key steps, including external fertilization, and typically occurs during the mating season in spring or early summer.
- In frogs with **external fertilization**, the female releases her eggs into the water, and the male releases sperm over the eggs to fertilize them.
- The **jelly-like substance** around the eggs is crucial for protecting the eggs, providing nutrients, and ensuring that the eggs stay in place until they are fertilized and begin developing into tadpoles

Reproduction in Crocodile

- Crocodiles begin their mating season in **July or August**, and mating occurs **underwater**. During this process, the male fertilizes the female's eggs internally.
- they have internal fertilization. After fertilization, the female lays her **eggs** and **buries them** in sand or deposits them in **mound vegetation**. Unlike frogs, crocodiles lay **hard, leathery eggs** that provide better protection for the developing young.

Q1. Can all of the crocodile eggs be hatched and survive?

- **No**, not all eggs may hatch or survive. Several factors, such as **predation**, **temperature fluctuations**, and **environmental conditions** can affect egg survival. Additionally, **not all eggs are fertilized**, and some may fail to hatch due to genetic or developmental issues.

Q2. What advancements or adaptations do crocodiles' reproductive systems have over frogs?

- Crocodiles have internal fertilization, whereas frogs typically use external fertilization. This allows for greater control over the fertilization process.
- Crocodile eggs are hard and leathery, offering better protection against environmental factors and predators compared to the soft, jelly-like eggs of frogs.
- Female crocodiles show more parental care, protecting and sometimes assisting their young, while frogs typically do not care for their offspring after they hatch.

Reproduction in Birds:

Q1. How Does the Male Transfer Sperm to the Female?

- Birds engage in internal fertilization through a unique process where the male transfers sperm to the female during a cloacal kiss. After fertilization, eggs are laid, incubated, and eventually hatch into chicks.
- Birds have unique reproductive systems compared to other animals. Key features include the **absence of external genital organs** in males and the presence of a **single ovary** in females.
- The female bird produces an **ovum** (egg) in her **ovary**.
- The egg travels down the **oviduct**, a tube-like structure where fertilization occurs. The oviduct is made up of different parts like:
  - **Infundibulum**: The first part of the oviduct where the **egg is captured** after being released from the ovary. Fertilization happens here if sperm is present.
  - **Magnum**: The section where the **egg white (albumin)** is added around the egg.
  - **Isthmus**: This part adds the **membranes** to the egg.
  - **Uterus**: Here, the **shell** is formed around the egg, which provides protection to the developing embryo.
  - **Vagina**: The final section where the egg is passed out of the female's body once it is fully formed.

2.3.2. Economic Importance of Insects:

Insects play a significant role in various economic sectors. Some of their important contributions include:

- Many insects, especially **bees**, **butterflies**, and **moths**, are crucial pollinators for a wide variety of crops. **Pollination** by insects contributes to the production of fruits, vegetables, and seeds, which are essential for food production and agriculture.
- Some insects, such as **ladybugs** and **lacewings**, help control pests by feeding on harmful insects, thus acting as **natural pest controllers**. This reduces the need for chemical pesticides, saving costs and protecting the environment.
- Insects like **Honeybees** are important for honey and beeswax production used in various products.

- The **silkworm** (Bombyx mori) is used in the production of **silk**, which is a highly valuable material in the textile industry.
- In some cultures, insects such as **crickets**, **grasshoppers**, and **mealworms** are consumed as a source of protein, making them an important food resource. **Edible insects** are gaining attention globally as an alternative protein source due to their high nutritional value.
- They are also used in **Decomposition and Waste Recycling**: like **beetles**, **termites**, and **flies** play vital roles in the decomposition of organic matter, recycling nutrients back into the ecosystem.
- Certain insects contribute to **pharmaceutical** industries. For example, **insect-derived compounds** are used in medicines, and **antimicrobial peptides** from insects are being researched for medical applications.
- Some insects, such as **cochineal** (which produces carmine dye), are used in the production of dyes and pigments for textiles and cosmetics. Others contribute to leather production.
- Insects are used in **cosmetics**, **biological research**, and **fertilizers**, providing a wide range of products for industries

Insects and Their Uses in Industry:

- **Bees (Honeybees)**: are vital for producing honey and **Beeswax**: Used in cosmetics, candles, and pharmaceuticals. Are also Crucial for agricultural crops such as fruits, vegetables, and flowers.
- **Silkworms (Bombyx mori)**: Silkworms produce silk, a highly valued material used in the textile industry for making clothing, fabrics, and upholstery.
- **Cochineal insects** produce **carmine**, a red dye used in cosmetics, textiles, and food
- **Termites** play a significant role in breaking down wood and organic matter, helping in nutrient recycling in ecosystems.
- **Ladybugs** are used in organic farming as natural predators of aphids and other crop-damaging insects, reducing the need for chemical pesticides.
- Crickets are being explored as a sustainable source of protein for human consumption in various food products, including cricket flour. Crickets are used in animal feed for pets, fish, and livestock.
- Some beetle species, such as **tanner beetles**, are used in the production of **leather** through their ability to break down animal hides.
- Mosquitoes are used in **disease transmission research**, particularly for studying **malaria**
- lac insect produces **shellac**, a resin used in coatings, varnishes, and as a food glaze.
- Dragonflies are natural predators of mosquitoes and other small flying insects, aiding in pest control for crops and human habitats.

Examples of Review Exercise

1. Which of the following insects is known for its role in pollination, benefiting agriculture?
   A. Dragonflies B. Honeybees C. Mosquitoes D. Ants
   - Explanation: Honeybees are crucial pollinators, aiding the pollination of many crops, which increases agricultural productivity.
2. How do insects like bees contribute to the economy?
   A. By providing raw materials for clothing
   B. Through their role in pollination of crops
   C. By consuming harmful pests in agriculture
   D. Through the production of honey
   - **Explanation**: Bees contribute to the economy by pollinating crops, which enhances agricultural yields and supports the production of fruits, vegetables, and other plants.
3. Which of the following is an economic benefit of using insects in pest control?
   A. Reduced need for chemical pesticides C. Decreased crop yield
   B. Increased use of synthetic fertilizers D. Increased damage to crops
   - **Explanation**: Insects like ladybugs, spiders, and predatory beetles are used as natural pest control agents, which reduces the need for harmful chemical pesticides, benefiting both the environment and agriculture.
4. A farmer introduces ladybugs into a tomato farm to control aphid populations. What economic advantage is the farmer likely to experience?
   A. Increased labor costs C. Reduced pesticide uses and lower costs
   B. Increased crop damage D. Higher water usage
   - **Explanation**: By using ladybugs, which are natural predators of aphids, the farmer can reduce the need for expensive and harmful chemical pesticides, leading to lower operational costs.
5. In a region dependent on honey production, a decrease in the honeybee population could have which of the following economic consequences?
   A. Increased honey supply
   B. Increased pollination of crops
   C. Lower crop yields and reduced agricultural productivity
   D. Decreased demand for pollination services
   Explanation: Honeybees are vital for pollination. A decline in their population would result in lower crop yields, affecting both food supply and agricultural profits.
6. Which of the following insects has both an economic benefit (through pollination) and a potential economic risk (by damaging crops)?
   A. Dragonflies B. Bees C. Mosquitoes D. Termites
   - **Explanation**: Bees provide significant economic benefits through pollination, which boosts agricultural productivity. However, they can also pose a risk if they spread diseases or cause damage to certain crops, making their role both beneficial and potentially harmful.

7. What could be the potential economic consequence of using non-native insects for pest control in agriculture?
   A. Decreased crop yield
   B. Lower pest control costs
   C. Disruption of local ecosystems
   D. Increased biodiversity
   - **Explanation**: The introduction of non-native insects may disrupt local ecosystems and lead to unintended consequences, such as damage to crops or competition with native species.
8. Why is it more sustainable for farmers to use biological pest control (like introducing predatory insects) rather than chemical pesticides?
   A. Biological control is less effective than chemicals
   B. Biological control can damage the environment
   C. Biological control is more cost-effective and environmentally friendly
   D. Biological control is faster and requires less monitoring
   - **Explanation**: Biological control using insects such as ladybugs or predatory beetles is cost-effective in the long run and environmentally sustainable, as it reduces the need for harmful chemical pesticides that can damage ecosystems.
9. Considering the role of insects in food production, what could be a long-term consequence of reducing insect populations globally?

A. Increased demand for synthetic fertilizers
B. Decreased biodiversity of plants and animals
C. Higher food prices due to reduced crop yields
D. Increased crop diseases due to less pollination

   - **Explanation**: A decrease in insect populations, especially pollinators like bees, could reduce crop yields, which would lead to lower food supply and higher food prices globally.
10. If you were an agricultural policy maker, how would you encourage farmers to adopt more sustainable insect-based pest control methods?
    A. By increasing subsidies for chemical pesticides
    B. By providing training on the benefits of natural pest control and offering incentives for using insect predators
    C. By promoting the use of monoculture farming techniques
    D. By discouraging the use of organic farming practices.
    - **Explanation**: Encouraging sustainable practices like biological pest control can help reduce dependence on chemicals, promote biodiversity, and support long-term agricultural productivity. Offering training and financial incentives can make it more accessible for farmers

3. Animal Behavior:

Learning Competencies:

- Classify the types of animal behaviors (innate, learned).
- Describe the patterns of behavior.

- **Animal behavior** refers to the way animals respond to stimuli in their environment, which can involve actions such as movement, communication, mating, feeding, and social interactions.

Types of animal behavior

A. Innate Behaviors:

- are inborn or instinctive meaning they are determined by genes
- They are typically uniform, predictable, and occur without prior experience
- Are three types (reflective, Orientative (Taxis and Kinesis) and Instinctive.
- **Examples:** Reflexes (like a baby sucking), Migration in birds or fish and Nest building in some animals

B. Learned Behaviors:

- develop from an animal's experience or interaction with its environment.
- Are not inherited and not determined by genes
- They can be modified over time based on new experiences.
- Is acquired during an individual's life time
- Allows organism to adapt to changing environment
- **Examples:** Habituation (getting used to a constant stimulus)
- Conditioning (like Pavlov's dogs)
- Imprinting (young animals bonding to their parent)

Types of Learned Behavior in Animals:

Table 4. Types of learned behavior and its description

Type of Learned Behavior	**Description**	**Example**
Habituation	The process of becoming accustomed to a stimulus after repeated exposure, leading to a decrease in response.	A dog no longer reacts to the sound of a doorbell after repeated ringing.
Classical Conditioning	A type of learning where a neutral stimulus becomes associated with a response after repeated pairings with a stimulus that naturally evokes the response.	Pavlov's dogs salivating to the sound of a bell after being conditioned to associate it with food.
Operant Conditioning	Learning through rewards and punishments. Behaviors are modified by their consequences.	A rat learning to press a lever to receive food.
Imprinting	A form of learning where young animals form attachments to objects or organisms shortly after birth or hatching, typically in a sensitive period.	Ducklings following the first moving object they see, often their mother.
Observational Learning	Learning by observing and imitating the behavior of others.	A chimpanzee learning to use tools by watching others.
Insight Learning	A form of problem-solving that involves sudden realization of a solution without trial and error.	A monkey stacking boxes to reach a banana hanging out of its reach.
Latent Learning	Learning that occurs without immediate reinforcement or obvious demonstration of learning, but becomes apparent when there is a reason to use the knowledge.	A rat learning the layout of a maze even without rewards, but later using that knowledge to navigate it.

Patterns of Behavior in Animals:

1. Fixed Action Patterns (FAPs):
   - Inherited, instinctual behaviors that follow a sequence and are triggered by specific stimuli.
   - Example: A goose rolling an egg back into its nest, even if the egg is removed mid-action.
2. Migration:
   - Seasonal long-distance movement of animals to find food or reproduce.
   - Example: Monarch butterflies migrating to warmer climates.
3. Courtship Behaviors:
   - Mating rituals or displays used to attract mates.
   - Example: Peacocks fanning their tail feathers.
4. Social Behaviors:
   - Interactions between animals within a group, such as cooperation, communication, and hierarchy.

- Example: Wolves hunting in packs.

2.3.5.Homeostasis in animals

Learning competencies:

- Define homeostasis
- Differentiate poikilotherms from homeotherms with examples
- Discuss the physiological and behavioral methods of temperature, water, and sugar regulation in animal

Homeostasis is the process by which living organisms maintain a stable internal environment despite changes in the external environment. It involves regulating variables such as temperature, pH, and the concentration of nutrients and waste products to ensure optimal functioning.

Homeotherms

- Homeotherms, also known as endotherms, are organisms that maintain a constant body temperature regardless of external environmental conditions.
- They use metabolic processes to generate heat and regulate their internal temperature.
- **Examples**: Humans, birds like sparrows, and mammals like dogs.

Poikilotherms

- Poikilotherms, also called ectotherms, are organisms whose internal body temperature fluctuates with the external environment.
- Examples include reptiles, amphibians, and fish. These animals rely on external heat sources to regulate their body temperature.
- These animals do not generate enough internal heat to maintain a constant body temperature.

Osmoregulation

- Osmoregulation is the process by which organisms regulate the balance of water and solutes (like salts) in their bodies to maintain proper cellular function.
- **Example**: Freshwater fish actively absorb salt and excrete large amounts of dilute urine to maintain water balance, while saltwater fish do the opposite by excreting concentrated urine and actively expelling salts.

Sugar Regulation

- Sugar regulation refers to the process by which animals maintain appropriate levels of glucose in the bloodstream. This is controlled by hormones like insulin and glucagon. When blood sugar is too high, insulin helps cells absorb glucose; when it is too low, glucagon stimulates the release of glucose from stored glycogen in the liver.
- **Example**: Humans regulate blood sugar levels through insulin and glucagon, ensuring that cells have a constant supply of glucose for energy.

Mechanisms of Controlling Homeostasis

- Homeostasis is controlled through feedback mechanisms, which include **negative feedback** (which reduces the output or activity to bring the system back to a set point) and **positive feedback** (which amplifies the output to complete a process). For example, temperature regulation through sweating and shivering is controlled by negative feedback, while the process of blood clotting is an example of positive feedback.

Physiological Methods of Thermoregulation

- Physiological methods involve internal mechanisms to regulate temperature. Some common methods include:

- **Sweating**: Evaporation of sweat cools the body (humans).
- **Shivering**: Muscle contractions generate heat to raise body temperature (humans).
- **Vasodilation/Vasoconstriction**: Blood vessels expand or contract to regulate heat loss (mammals).
- **Insulating layers**: Fat or fur traps heat (bears).

Behavioral Methods of Thermoregulation

Behavioral methods involve actions the organism takes to adjust its body temperature. Examples include:

- **Basking**: Reptiles like lizards bask in the sun to absorb heat and increase their body temperature.
- **Burrowing or Seeking Shade**: Animals may seek cooler environments or burrow underground to escape heat.
- **Migration**: Some animals, like birds, migrate to warmer or cooler climates to maintain ideal body temperature.

Thermoregulation and Surface Area to Volume Ratio:

- Thermoregulation refers to the mechanisms that organisms use to maintain their internal temperature. One key factor in thermoregulation is the **surface area to volume ratio** (SA:V ratio), which plays a significant role in heat exchange with the environment.
- The **surface area** of an organism determines how much heat it can gain or lose from its surroundings. A larger surface area allows more heat to be exchanged with the environment.
- A larger volume means more heat is produced by metabolic activities inside the body.
- **Small animals** or organisms with a **high SA:V ratio** (e.g., small mammals, birds) lose heat quickly because they have more surface area relative to their volume. This means they need to generate more internal heat to maintain body temperature.
- **Small animals** typically need to have **higher metabolic rates** (e.g., by shivering or increasing food intake) to maintain warmth.
- **Large animals** or organisms with a **low SA:V ratio** (e.g., elephants, whales) have less surface area compared to their volume, meaning they lose heat more slowly. This makes it easier for them to retain heat, especially in cold environments.
- **Large animals** do not need to generate as much internal heat as smaller animals, and their larger body mass helps insulate and retain heat.

- **Endothermic animals (homeotherms)** like birds and mammals have adaptations to manage their surface area-to-volume ratio to help with thermoregulation. For instance:
    - **Small animals** might have thick fur or fat layers to reduce heat loss.
    - **Large animals** might have adaptations like large ears or sweat glands to release excess heat when needed.
- **Large animals** in cold climates (e.g., polar bears) often have specialized body shapes or behaviors to minimize heat loss. For example, they have a thick layer of fat and fur to insulate their bodies and prevent heat loss despite having a relatively low SA:V ratio.
- In summary, **smaller animals** with a higher SA:V ratio lose heat quickly and must produce more internal heat to survive, while larger animals with a lower SA:V ratio retain heat more effectively, requiring fewer adjustments to maintain their body temperature.

Negative and Positive Feedback in Homeostasis:

a. Negative feedback

- **Negative feedback** is a process that **counteracts** or **reduces** a change in a controlled variable, helping to bring the system back to its set point (ideal state).
- When a variable deviates from its optimal range, negative feedback mechanisms activate to reverse the change and restore balance.
- **Example** of negative feedback mechanism
- **Body temperature regulation** in humans: e.g: Sweating and Vasodilation, Shivering and Vasoconstriction.
- **Blood glucose regulation**: When blood sugar levels rise after eating, the pancreas releases insulin to help cells absorb glucose and lower the blood sugar level. Conversely, when blood sugar levels drop too low, the pancreas releases glucagon to increase blood sugar.
- **Blood pressure regulation**: If blood pressure rises too high, baroreceptors in blood vessels detect this and trigger a response to decrease heart rate and dilate blood vessels, lowering the blood pressure.

b. Positive Feedback:

- Positive feedback is a process that **amplifies** or **increases** a change in a controlled variable, pushing the system away from its set point, often until a specific event or goal is reached.
- In positive feedback, a change in a system triggers a response that **intensifies** the initial change, leading to an escalating effect.
- Positive feedback is typically used in processes that need to be completed rapidly. Examples are:
    - **Childbirth**: Oxytocin stimulates stronger uterine contractions, which push the baby further into the birth canal. The more the baby's head presses against the cervix, the more oxytocin is released, intensifying the contractions until the baby is born.

- **Blood clotting**: When blood vessels are injured, platelets begin to stick to the site of injury and release chemicals that attract more platelets. This cascade effect amplifies until a blood clot form to stop bleeding.

Key Differences:

Negative Feedback: Reduces or counteracts a change, stabilizing the system (e.g., temperature regulation, blood glucose regulation). Negative feedback is the most common mechanism for maintaining homeostasis, as it helps organisms return to a stable state.

Positive Feedback: Amplifies a change, pushing the system further from the set point, often completing a specific event or process (e.g., childbirth, blood clotting).

Positive feedback, is less common, used for processes that require rapid or complete changes, such as childbirth or blood clotting.

EXAMPLES OF REVIEW EXERCISE

1. What is the method of fertilization in most species of frogs**?**
   A. External fertilization
   B. Internal fertilization
   C. Parthenogenesis
   D. Budding
   - **Explanation**: Most frogs undergo external fertilization, where the female lays her eggs in water, and the male fertilizes them externally by releasing sperm onto the eggs.
2. Which of the following is a characteristic of insect reproduction?
   A. External fertilization in all species
   B. Parthenogenesis in some species
   C. Only asexual reproduction
   D. Internal fertilization in all species
   - **Explanation**: Insects reproduce both sexually and asexually. Some species can reproduce asexually via parthenogenesis, where females produce offspring without fertilization.
3. Why do most frogs lay their eggs in water for external fertilization?
   A. To keep the eggs from drying out
   B. To provide food for the developing embryos
   C. To help the eggs stay warm
   D. To avoid predation
   - **Explanation**: Frogs lay their eggs in water to prevent them from drying out, as they lack the protective hard shell that land animals' eggs have.
4. A female bird lays eggs after internal fertilization. What must occur for fertilization to happen?
   A. The sperm must fertilize the egg outside the body.
   B. The egg must be laid before fertilization.
   C. The sperm must enter the female's body to fertilize the egg inside.
   D. The egg must hatch before fertilization.
   - **Explanation**: In birds, internal fertilization occurs when the sperm from the male enters the female's body and fertilizes the egg inside before it is laid.
5. Which of the following describes a major difference between reproduction in frogs and birds?
   A. Frogs undergo external fertilization, while birds undergo internal fertilization.

B. Birds have external fertilization, while frogs use internal fertilization.
C. Frogs lay eggs on land, while birds lay eggs in water.
D. Birds undergo parthenogenesis, while frogs reproduce sexually.

- **Explanation**: Frogs generally have external fertilization, where the male fertilizes the eggs outside the female's body, while birds use internal fertilization, where sperm fertilizes the egg inside the female's body.

6. In insects, what is the purpose of the male's sperm transfer to the female during mating?

A. To produce asexual offspring
B. To fertilize the eggs and create offspring
C. To nourish the female's reproductive system
D. To protect the eggs from predators

- **Explanation**: Insects typically engage in sexual reproduction where the male transfers sperm to fertilize the female's eggs, resulting in offspring.

7. Why is internal fertilization advantageous for land-dwelling animals like birds and reptiles?
   A. It protects eggs from water predators.
   B. It allows for more eggs to be fertilized.
   C. It ensures eggs do not dry out in the environment.
   D. It allows fertilization to occur outside the body.

- **Explanation**: Internal fertilization helps land-dwelling animals protect their eggs from desiccation (drying out), which could occur if fertilization were external and the eggs were laid in an open, dry environment.

8. Why do many insects, such as bees, use parthenogenesis as a form of reproduction?
   A. It allows for rapid population growth.
   B. It creates genetic diversity among offspring.
   C. It increases the likelihood of survival in harsh environments.
   D. It helps to produce both male and female offspring.

   Explanation: Parthenogenesis allows females to reproduce without the need for fertilization by a male, leading to the rapid production of offspring, especially in favorable conditions.

9. Imagine you are studying a new species of frog. You notice that they lay their eggs on land rather than in water. What can you infer about their reproductive strategy?
   A. They likely have internal fertilization.
   B. They may have evolved a mechanism to prevent egg desiccation.
   C. They reproduce through parthenogenesis.
   D. They are aquatic and lay eggs in water.

   Explanation: If frogs lay their eggs on land, they must have evolved a protective mechanism (like a leathery or hard egg shell) to prevent the eggs from drying out, ensuring successful development in a terrestrial environment.

10. Which of the following is an example of negative feedback in humans?
    A. Increased sweating in response to a rise in body temperature.
    B. The release of oxytocin during childbirth to intensify contractions.
    C. Increased blood clotting at the site of an injury.
    D. The release of adrenaline in response to stress.

- **Explanation:** Negative feedback mechanisms act to counteract or reduce changes. Sweating in response to a rise in body temperature helps to cool the body, bringing the temperature back to normal.

11. How does the pancreas regulate blood sugar levels in humans?
    A. By producing insulin to increase blood sugar levels after eating.
    B. By producing insulin to decrease blood sugar levels when they are high.
    C. By producing glucagon to increase blood sugar levels when they are low.
    D. By both insulin and glucagon, depending on the type of meal consumed.
    - **Explanation:** The pancreas releases insulin to help cells absorb glucose and lower blood sugar levels after eating, thus maintaining homeostasis.

    A. During a hot day, a person's body temperature rises above normal. Which of the following actions represents a physiological method of thermoregulation? Sweating to release heat from the body.
    B. Seeking shade to avoid sunlight
    C. Drinking water to stay hydrated.
    D. Shivering to generate heat.
    - **Explanation:** Sweating is a physiological response that helps cool the body by releasing heat through the evaporation of sweat, which is a key method of thermoregulation.

12. Which of the following feedback mechanisms helps maintain blood sugar levels in the body after a meal?
    C. Positive feedback, which increases blood sugar levels.
    D. Negative feedback, which reduces blood sugar levels.
    E. Positive feedback, which amplifies the release of insulin.
    F. Negative feedback, which increases blood sugar levels.
    - **Explanation:** Negative feedback reduces the effects of blood sugar increase by releasing insulin, which allows cells to absorb glucose and lower blood sugar to normal levels.

13. You are studying a group of animals in a cold environment. Which of the following adaptations would you expect to observe in these animals to maintain homeostasis?
    A. A large surface area to volume ratio to help generate heat.
    B. A thick layer of fat or fur for insulation to conserve heat.
    C. Increased shivering in response to high body temperature.
    D. Increased metabolic rate to produce more heat but with minimal insulation.
    - **Explanation:** Animals in cold environments typically have adaptations like thick layers of fat or fur to prevent heat loss and conserve body temperature, supporting thermoregulation.

14. Which of the following is the most appropriate method for regulating body temperature in a small mammal living in a cold climate?
    A. Decreasing body size to reduce the surface area for heat loss.
    B. Increasing activity levels to produce more heat through metabolism.
    C. Seeking warmer areas during the day to increase body temperature.
    D. Increasing surface area to volume ratio to release heat.

- **Explanation**: Small mammals in cold climates may increase their metabolic rate (e.g., through shivering or active foraging) to generate more heat to maintain a stable internal temperature.

15. Which of the following is an example of negative feedback in thermoregulation?
    A. Sweating to cool down the body when temperature rises.
    B. The release of oxytocin to intensify uterine contractions during childbirth.
    C. Increased blood clotting to seal a wound.
    D. Increased heart rate during exercise to increase oxygen supply.
    - **Explanation:** Negative feedback mechanisms act to reduce or reverse changes. Sweating cools the body down when the temperature rises, helping to restore normal temperature.
16. Which of the following describes the role of insulin in blood sugar regulation?
    A. It increases blood sugar levels when they are too low.
    B. It decreases blood sugar levels when they are too high.
    C. It increases metabolic rate to lower blood sugar.
    D. It inhibits glucose absorption by cells.
    - **Explanation:** Insulin helps lower blood sugar by promoting the uptake of glucose by cells, reducing excess blood sugar and restoring normal levels.
17. Which of the following is an example of positive feedback in the body?
    A. Sweating to cool down the body during exercise.
    B. Release of insulin to reduce blood sugar levels.
    C. Release of oxytocin to increase uterine contractions during childbirth.
    D. Constriction of blood vessels to conserve heat.
    - **Explanation:** Positive feedback amplifies a response. During childbirth, oxytocin release increases the intensity of contractions until the baby is delivered.
18. You are studying a group of animals in a warm climate. Which of the following adaptations would you expect to see in these animals to prevent overheating?
    A. A thick layer of fat or fur for insulation.
    B. Increased surface area to volume ratio to release excess heat.
    C. Increased metabolic rate to generate heat.
    D. Behaviorally seeking warmth during the night.
    - **Explanation:** Animals in warm climates tend to have a larger surface area relative to their volume to help release excess heat and avoid overheating.
19. Which of the following is the most effective negative feedback response for regulating high blood pressure?
    A. Increased heart rate to increase blood flow.
    B. Release of adrenaline to constrict blood vessels.
    C. Vasodilation and decreased heart rate to lower blood pressure.
    D. Increased thirst to retain water and raise blood pressure.

- **Explanation:** Negative feedback works to reduce changes. In response to high blood pressure, the body triggers vasodilation (widening of blood vessels) and a decrease in heart rate to lower blood pressure to normal levels.

20. A researcher is studying the foraging behavior of two bird species. One species searches for food individually, while the other forages in groups. Which of the following is the most valid conclusion about the advantages of group foraging?
    A. Group foraging is always more efficient because it reduces competition among individuals.
    B. Group foraging increases the likelihood of finding food but may lead to competition within the group.
    C. Solitary foraging is superior because it eliminates the risk of food theft.
    D. There is no advantage to group foraging, as all animals forage with equal success.

Explanation: Group foraging increases the likelihood of finding food but may lead to competition within the group. Group foraging is a common strategy in animal behavior, especially in social species. It provides several advantages and drawbacks: Advantages of Group Foraging is that more individuals searching increases the chances of locating food sources. Being in a group reduces the likelihood of an individual being attacked. Animals can learn from each other about food sources and foraging techniques.

SELF TEST EXERCISE

21. Which of the following is the main function of positive feedback in biological systems?
    A. To reverse changes in the body and maintain equilibrium.
    B. To enhance or amplify a change to complete a process.
    C. To maintain blood sugar levels within a narrow range.
    D. To maintain a constant body temperature.
22. Which of the following would most likely occur if an animal's body temperature is too high?
    A. The body will increase metabolic rate to generate more heat.
    B. The body will use positive feedback to intensify heat production.
    C. The body will initiate sweating and vasodilation to release excess heat.
    D. The body will lower metabolic rate to conserve heat.
23. Which of the following is an example of an innate behavior in animals?
    A. A dog learning to fetch a ball
    B. A bird migrating for the winter
    C. A dolphin learning tricks in a circus
    D. A rat pressing a lever for food
24. What is the primary difference between innate and learned behavior?
    A. Innate behavior is learned over time, while learned behavior is instinctual.
    B. Innate behavior is influenced by genetics, while learned behavior is shaped by experience.
    C. Learned behavior is harder to change than innate behavior.
    D. Innate behavior can be changed through observation.
25. Which of the following best explains classical conditioning in animal behavior?

A. Animals learn to associate a behavior with a reward.
B. Animals observe and imitate behaviors of others.
C. Animals respond to a neutral stimulus after it is repeatedly paired with another stimulus.
D. Animals learn to solve problems without trial and error.

26. A bird learns to associate the sound of a bell with being fed. After several trials, it starts to salivate when the bell rings, even without food present. This is an example of:
A. Operant conditioning
B. Classical conditioning
C. Imprinting
D. Insight learning

27. In a study, a monkey learns to stack boxes to reach a banana. This behavior best demonstrates which type of learning?
A. Latent learning
B. Observational learning
C. Insight learning
D. Classical conditioning

28. Which of the following scenarios is an example of operant conditioning in animals?
A. A dog sits on command because it receives a treat.
B. A duckling follows its mother after hatching.
C. A rat learns to navigate a maze without any reward.
D. A bear hibernates during the winter based on seasonal changes.

29. A rabbit no longer reacts to the sound of thunder after hearing it frequently. This is an example of:
A. Classical conditioning
B. Observational learning
C. Habituation
D. Imprinting

30. Which type of learning would be most effective for a lion to learn to hunt prey?
A. Insight learning
B. Classical conditioning
C. Operant conditioning
D. Observational learning

31. Why is imprinting critical for the survival of young animals, such as ducklings?
A. It helps them learn important survival skills through observation.
B. It ensures that they recognize their mother and can follow her to safety.
C. It strengthens their ability to learn problem-solving behaviors.
D. It enables them to communicate with other members of their species.

32. Imagine you are studying a new species of bird. You observe that they are instinctively following a specific path during migration. Which type of behavior does this demonstrate?
A. Learned behavior
B. Social behavior
C. Innate behavior
D. Imprinting

33. Which of the following patterns of behavior is most likely to occur in animals that exhibit territoriality?
A. Increased cooperation among individuals
B. Aggressive defense of an area against intruders
C. Migration to new areas each year
D. Formation of large social groups with shared resources

34. What is the main characteristic of the reproductive process in birds?

A. External fertilization
B. Internal fertilization
C. Parthenogenesis
D. Budding

36. What pattern of behavior would you expect to find in animals that engage in cooperative hunting?
    A. Individuals hunt alone and do not share their catch
    B. Group members coordinate their actions to capture prey
    C. Group members fight over the food after a hunt
    D. Prey animals display defensive behaviors in groups
37. Which of the following would be the most advantageous behavior for an animal in a harsh, resource-limited environment?
    A. A behavior that involves large social groups and shared resources
    B. A behavior that involves migration to different climates
    C. A behavior that involves territoriality and defending scarce resources
    D. A behavior that involves abandoning the environment when resources are low
38. Why is the behavior of altruism (self-sacrifice for the benefit of others) generally more likely in kin-based groups rather than in random groups?
    A. It increases the chances of survival for genetically related individuals
    B. It decreases competition within a population
    C. It ensures that the altruist receives a reward in return
    D. It helps individuals from different species cooperate
39. If you were studying a new species of bird that uses complex songs for communication, how would you hypothesize that song variation could be related to mating success?
    A. Males with more complex songs are likely to attract more mates because the song indicates health and genetic fitness.
    B. Males with fewer songs will have more offspring because the energy spent on song is diverted to reproduction.
    C. Song variation has no effect on mating success and is purely for territory defense.
    D. Female preference for song variation is random and unrelated to reproductive success.
40. Imagine you are studying an animal that migrates long distances. How could you test whether the migration pattern is learned or instinctual?
    A. Track the animal’s migration route over several generations to determine if it is genetically programmed.
    B. Train the animals to migrate in a controlled environment to see if they can follow new routes.
    C. Observe the animal's behavior during migration and compare it to other species to see if it is unique.
    D. Analyze the environmental cues that trigger migration and correlate them with the animals' behavior.
41. How would you expect a predator-prey relationship to influence the behavior of prey animals in a new environment where predators are absent?
    A. Prey will behave more aggressively towards each other.
    B. Prey will display more relaxed behavior and possibly increase reproduction.

C. Prey will migrate to areas with more predators.
D. Prey will become more fearful and avoid certain environments.

42. If you observe an animal species engaging in mimicry (looking like another dangerous species) as a survival strategy, what type of behavior is this and why does it provide an advantage?
A. Cooperative behavior; it helps the species form alliances with others.
B. Aggressive behavior; it helps the species defend its territory.
C. Protective behavior; it helps the species avoid predation by tricking predators.
D. Reproductive behavior; it helps the species attract mates.

43. Which of the following is an example of a pattern of behavior that animals use to obtain food?
A. Territorial behavior
B. Courtship display
C. Foraging behavior
D. Sleeping patterns

44. Which behavior in some insects helps them to contribute to ecosystem balance by breaking down organic matter?
A. Mating behavior
B. Foraging behavior
C. Decomposing behavior
D. Hibernation

45. During a cold day, a person's body temperature drops below normal. Which of the following is a negative feedback response to maintain thermoregulation?
A. Shivering to generate heat.
B. Increased sweating to release heat.
C. Vasodilation to release excess heat.
D. Increasing metabolic rate to cool down.

2.3. Microorganisms

Learning competencies: At the end of this lesson the student will be able to:

- ♣ Define microorganisms
- ♣ Describe characteristics of bacteria, fungi, protozoa and viruses
- ♣ Classify bacteria based on their common characteristics
- ♣ Explain the reproduction mechanisms of microorganisms
- ♣ Discuss the roles of bacteria in the ecosystem, industry, medicine, and genetic engineering with examples
- ♣ Explain the food, medicine, ecosystem, and industrial roles of fungi
- ♣ Appreciate the contribution of bacteria and fungi in the preparation of cultural foods and drinks in Ethiopia
- ♣ Discuss the economic importance of protozoa
- ♣ Discuss common viral diseases and their preventive mechanisms
- ♣ Discuss the biology of common disease-causing bacteria, fungi, protozoa (malaria, amoeba, giardia), and viruses in Ethiopia

What is microorganism?

- ➢ Microorganisms are all single-celled microscopic organisms

1. Example of cellular microorganism and their respective example
    i. Archaean – methanogens and halophiles
    ii. Bacteria – E. coli, Clostridium, Leprae…
    iii. Protista – Giardia, algae, Slime molds, Amoeba
    iv. Fungi – yeast, Molds, albican, candida, athlete's foot.
2. Examples of acellular microorganism
    i. Viruses – microbes composed of protein and nucleic acid e.g HIV, Rabies, Covid, Common cold
    ii. Viroid – composed of DNA, subviral particles that consist of a small single stranded RNA without a protein shell.
    iii. Prion – abnormal protein that causes diseases in host cell

Features of microorganism

- Microbes are ubiquitous/omnipresent in their distribution.
- Microorganisms are the oldest forms of life).
- Microorganism causes diseases, they have killed more people than have ever been killed in war. However, without certain microorganisms, life could not exist as they produce O_2 and N_2, drugs and vaccines through genetic engineering
- They are important in nutrient production and energy flow, production of foods, decomposition (bioremediation)
- They affect every aspect of our life
- They cause disease but they are vital in recycling nutrient in ecosystem, agriculture, and industry

2.3.1. Types of microorganisms

- Organism are grouped into three domain Bacteria, Archaea and Eukarya

Eubacteria

What characteristics are common to all bacteria?

The following are the general characteristics of bacteria.

- Bacteria are prokaryotes, which are single-celled organisms with a simple internal structure that lacks a nucleus, and contains DNA that either float freely in a twisted, thread-like mass called the **nucleoid/Genophore** or in separate, circular pieces called plasmids. They are omnipresent.
- The cell bears a thick rigid cell wall outside the plasma membrane (because of this characteristic, they are kept in plant kingdom).
- They have great variation in the mode of nutrition i.e. may be autotrophic and heterotrophic. In heterotrophic mode of nutrition, they may be parasite saprophyte or symbiotic in nature.
- With the exception of few photosynthetic bacteria that have a special type of chlorophyll called bacterio-chlorophyll, they lack true chlorophyll.
- Unlike the cell wall of plants, which is made up of cellulose, the cell wall of bacteria is made up of mucopeptide/peptidoglycan = complex structure
- They lack mitochondria, Golgi apparatus, plastid and endoplasmic reticulum.
- They lack basic protein histone in their DNA
- Ribosomes are of 70s type.
- At some places, the plasma membrane invigilates in folds to form mesosomes
- All the enzymes required for respiration are found in the cell membrane.
- Both DNA and RNA are available in the bacterial cell. DNA is in the form of single circular chromosome (therefore the ce.il is haploid)
- **Vegetative reproduction** generally takes place by binary fission, cyst, budding and gonidia.
- **Asexual reproduction** occurs through conidia, motile spores and endospore
- True sexual reproduction is absent in bacteria but there are examples of genetic recombination which may be of following types. **conjugation, transduction and transformation**

What is the difference between eukaryotes and prokaryotes?

- Both prokaryotes and eukaryotes contain nucleic acids, proteins, lipids and carbohydrates.
- They use the same kinds of chemical reactions to metabolize food, build proteins, and store energy.
- The structure of cell walls and membranes, and the absence of organelles (specialized cellular structures that have specific functions) primarily distinguish prokaryotes from eukaryotes

The chief distinguishing characteristics of prokaryotes as follows:

I. Typically, their DNA is not enclosed within a membrane and is usually a singular, circularly arranged chromosome. exceptionally, Gemma obscuring lobus has a double membrane around its nucleus.
II. Their DNA is not associated with histones other proteins are associated with the DNA.
III. They generally lack organelles, other membrane enclosed organelles such as nuclei, mitochondria, and chloroplasts.
IV. Their cell walls almost always contain the complex polysaccharide peptidoglycan.
V. They usually divide by binary fission, where DNA is copied, and the cell splits into two cells.

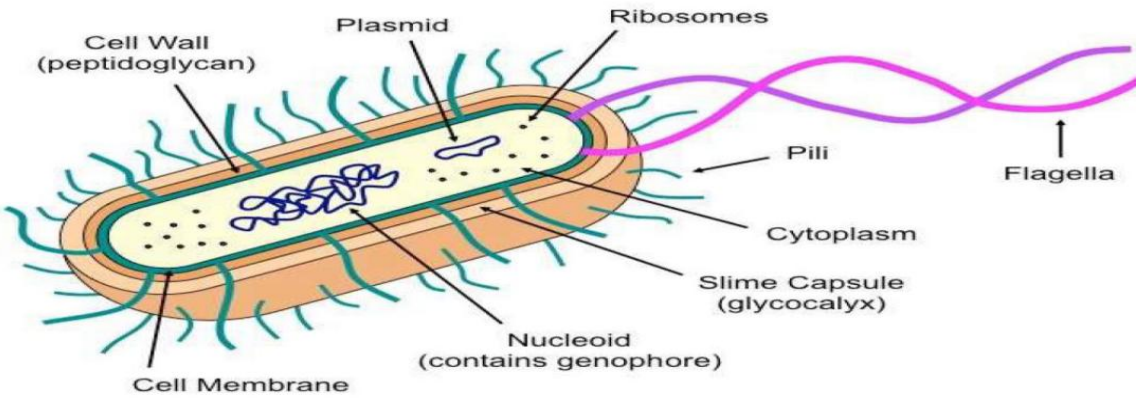


Figure 2.3. Major features of a prokaryotic cell, Bacteria. Source: BioNinja)

Figure 1. Main feature of prokaryotic cell, Bacteria

Eukaryotes have the following distinguishing characteristics:

I. Their DNA is found in the cell's nucleus, which is separated from the cytoplasm by a nuclear membrane, and the DNA is found in multiple chromosomes
II. Their DNA is consistently associated with chromosomal proteins called histones and with non-histones.
III. They have a number of membrane-enclosed organelles including mitochondria, endoplasmic reticulum, Golgi complex, lysosomes, and sometimes chloroplasts.
IV. Their cell walls (if there is any) are chemically simple.
V. Cell division usually involves mitosis, in which chromosomes replicate

Classification of bacteria based on their Shapes

✓ Based on their shapes, bacterial cells can be grouped into the following main shapes:

A. Cocci (singular, coccus) – spherical bacteria
B. Bacilli (singular, bacillus) – rod-shaped bacteria
C. Spirochaetes – spiral or corkscrew-shaped bacteria
D. Comma -shaped – Vibrio cholerae

Classification of bacteria based on Cell wall composition

What is the purpose of gram staining?

✓ It is the laboratory test technique used to diagnosis the presence of the bacterial infection quickly as gram negative or gram positive

Gram-positive bacteria

- Gram-positive bacteria have a distinctive purple appearance when observed under a light microscope following Gram staining. they retain the purple crystal violet stain in the thick peptidoglycan layer of the cell wall.
- Their cell wall contain:
    - ✓ Peptidoglycan—outer
    - ✓ Teichoic acid
    - ✓ Lipoteichoic acid
- They lack outer membrane
- They have narrow periplasmic space
- Lipid and Lipoprotein content is low
- They produce exotoxin
- Examples of Gram-positive bacteria include all staphylococci, all streptococci and some listeria species.

Gram-negative Bacteria

- They lose the crystal violet stain and take the color of the red counterstain in Gram's staining. They have a cell wall composed of a thin layer of peptidoglycan and outer membrane
- Chemical composition of cell wall are:
    - Lipopolysaccharide – outer
    - Lipoprotein
    - Peptidoglycan
- They have extensive periplasmic space
- They produce endotoxin

Examples of Gram-negative bacteria are:

E. coli, Pseudomonas, Klebsiella, Salmonella

Classification of bacteria based on their mode of nutrition

Photolithoautotrophs

I. **Photolithoautotrophs**: an organism that uses light energy and an inorganic electron donor (H_2O, H_2, H_2S and CO_2) as its carbon source

II. **Photoheterotrophic:** organism that uses light for energy, but cannot use carbon dioxide as their sole source of carbon.
   - ✓ Example: Purple sulfur bacteria, green sulfur bacteria and helicobacter

III. **Photo organoheterotrophs**: organism that use light energy, and uses organic compound from the environment to satisfy their carbon requirement, they are inhabitant of polluted lake. Their electron and carbon source is organic CPD.
   - ✓ E.g., Green and Purple non-sulfur bacteria – utilizes organic cpd as an electron donor

IV. **Chemolithoautotrophy**: organism that harvest energy from inorganic chemicals. They use carbon from carbon dioxide and inorganic electron donor.
   - ✓ They oxidize reduced inorganic compounds such as iron, nitrogen, or sulfur to derive both energy and electron for biosynthesis
   - ✓ Bacteria utilize the oxidation and reduction of chemical compound as primary energy.

- ✓ E.g. Nitrosomonas: Oxidize ammonia to nitrite

V. **Chemolithoheterotrophs**: organism that utilize **inorganic electron** sources such as sulfur, Hydrogen gas, Sulfide, Nitrite, Ammonia

- ✓ They use reduced inorganic substance as electron source
- ✓ They donate electron directly to electron transport chain to make ATP
- ✓ They derive their cellular carbon from carbon dioxide
- ✓ E.g. *Sulfur oxidizing bacteria -- Beggiata*,
- ✓ Thiobacillus thioxidans uses thiosulfate and sulfide as source of energy to produce sulfuric acid:

VI. **Chemo organoheterotrophs:** organism that utilize **organic electron and carbon** sources such as carbohydrate, lipid and proteins

- ✓ They use reduced organic compounds as source of energy (they extract electron from it)
- ✓ They regenerate NADH from oxidation of reduced NADH which are then used to donate electron to electron transport system
- ✓ e.g. Most non-photosynthetic microbes including most pathogen, E.coli, fungi and Protista, Decomposers: obtain carbon and electron from dead matters

Reproduction In Bacteria

Asexual reproduction

- ➢ Bacteria reproduce asexually by splitting one cell into two equal halves in a process called **binary fission.**
- ➢ Asexual reproduction includes: Budding, Fragmentation and Binary fission
- ➢ **Budding:** the bud develops from the end of the cell, enlarge and become daughter cell and gets separated.
- ➢ **Fragmentation:** the process by which the organisms split into two or more fragments to become new individual. e.g. *Cyanobacteria, Neisseria Gonorrhoeae*
- ➢ **Binary fission:** the most common method of reproduction in Archaea, bacteria and fungi.

Sexual reproduction in bacteria

Bacteria exchange genetic material through the following ways

I. **Conjugation**: is a form of sexual reproduction in bacteria through contact by using F-pilus located on plasmid called fertility plasmid

- ✓ During this, DNA is directly transferred from one prokaryote to another by means of a conjugation pilus
- ✓ F^- Cell: Plamid lacking fertility plasmid
    - During conjugation, the F factor is transmitted from **F+ cell** into Recipient cell F^-Cell
- ✓ **F^+ Cells:** donor of fertility plasmid
    - It Produces sex pilus
    - Sex pilus develop into Conjugation bridge
    - Posses' fertility plasmid which is separated from bacterial chromosome
    - The genes encode enzymes essential for transferring DNA

II. **Transformation**: Bacterium takes up extracellular Donor DNA. From the environment

III. **Transduction:** Donor DNA packaged in a bacteriophage infects the recipients bacterium

- In Conjugation: the donor bacterium transfers DNA to the recipient by mating.
- Cells containing the F plasmid, capable of forming an F pilus, are called F+ cells or donor cells, and those lacking an F plasmid are called F− cells or recipient cells

Common Bacterial Disease

1. **Pertussis (**Whooping cough)
   - ✓ A very contagious respiratory illness caused by bacteria called *Bordetella pertussis*
   - ✓ The disease is only found in human that affects upper respiratory tract
   - ✓ Transmitted through air
2. **Meningitis:** caused by *Neisseria meningtidis and S.pneumoniae*
   - ✓ leads inflammation of membrane of brain and spinal cord, upper respiratory tract infection and invade meninges
   - ✓ spread/vector is air. Bacteria Neisseria species are Gm (-) diplococcus and *S.pneumoniae are Gm(+) diplococcus*
3. **Tuberculosis:** Caused by Mycobacterium tuberculosis
   - ✓ Most often affect lungs, bones
   - ✓ Transmitted through air and causes symptoms like persistent cough, weight loss, fatigue, and night sweat
   - ✓ Tested/Differentiated by using Acid-Fast staining that indicates presence of Mycobacterium in sputum or blood sample
4. **Syphilis:** Caused by *Treponema pallidum*
   - ✓ Are spirochete and Brain, Skin, hearts and blood vessels, Bones are affected
   - ✓ Transmitted through sexual contact
5. **Tetanus:** Caused by *Clostridium tetani*
   - ✓ Are Gm + spore forming anaerobic rod bacteria
   - ✓ Affects Nerves at synapses. Transmitted from soil that contain spores
6. **Leprosy:** also called Hansen's disease Caused by *Mycobacterium Leprae*
   - ✓ Affects skin, bone, peripheral nerves and lining of nose
   - ✓ Transmitted through contacts
7. **Diphtheria:** caused by caused by *Corynebacterium diphtheriae*
   - ✓ Spread through droplet infection and affects respiratory systems
   - ✓ Prevented through vaccination
8. **Chancroid**: Caused by *Haemophilus ducreyi*
   - ✓ Characterized by painful genital ulcers and swollen lymph nodes in the groin area
   - ✓ Transmitted through sexual contact
9. **Gonorrhea:** Caused by Neisseria gonorrhoeae
   - ✓ causes painful urination, abnormal discharge and pelvic pain in women
10. **Anthracis:** serious infectious disease Caused by bacillus anthracis.
    - ✓ Primarily affect animal and transmitted to human

11. Shigellosis: caused by a group of bacteria called Shigella.

- ✓ Affect intestine and spread through fecal-oral route (contaminated food and water

12. Pneumonia – caused by bacteria like Streptococcus pneumoniae

- ✓ Leads to inflammation of the lung, with symptoms like; cough, chest pain, fever, and difficulty in breathing

EXAMPLES OF REVIWE EXERCISE

1. Bacilli bacteria are:

A. Rounded shaped
B. Rod shaped
C. Spiral shaped
D. Comma shaped

Explanation: Bacteria are classified into three main shapes based on their shapes

- ✓ Spherical shaped bacteria -- are coccus/cocci
- ✓ Rod-shaped bacteria – are bacilli/bacillus
- ✓ Spiral shaped bacteria – are spirochaete that corkscrew shape

2. Bacteria which get their food from dead organic matter are called
   A. Parasitic bacteria
   B. Symbiotic bacteria
   C. Saprophytic bacteria
   D. Autotrophic bacteria

Explanation: Saprophytes are organisms that feed on dead or decaying matter. Bacteria and Fungi which get their food from dead organic matter are called saprophytic.

3. Which of the following disease are all caused by bacteria?
   A. Chicken pox, Polio, measles and Hepatitis
   B. Mumps, Rabies, Pneumonia and Tobacco mosaic disease
   C. Cholera, Typhoid, Tuberculosis and salmonella
   D. Malaria, amoebiasis, Chagas disease and Leishmaniasis

Explanation: Chicken pox, Polio, measles and Hepatitis, mumps, rabies and Tobacco mosaic disease are viral disease. While Malaria, amoebiasis, Giardiasis, Chagas disease, Leishmaniasis, sleeping sickness and Toxoplasmosis are protozoan disease.

4. Which of the following is not a method reproduction in bacteria?

C. Mitosis
D. Budding
E. Fragmentation
F. Binary fission

Explanation: Bacteria reproduce asexually by Budding, Fragmentation and Binary fission. The most common reproduction in bacteria is binary fission. Bacteria also reproduce by conjugation using fertility plasmid which resemble sexual reproductions. Bacteria cant reproduce mitotically.

5. The genetic material of prokaryotic organism contains
   A. Both DNA and histones
   B. DNA but not histones
   C. Histone but not DNA
   D. no DNA and no histone

Explanation: genetic material of bacteria is made from DNA. Which is circular and not associated with histone proteins.

Archaea

Characteristic of archaea

Like bacteria, Archaean's are

- ✓ They are unicellular, microscopic and lack membrane bounded organelles

Unique feature of Archaea

- ✓ They lack peptidoglycan in their cell wall
- ✓ Their cell membrane lipids have branched hydrocarbon chains
- ✓ The initial amino acid in their polypeptide chain is coded by the AUG start codon (Methionine as in eukaryotes)
- ✓ Many are found in extreme environment (abundant in hostile environment
- ✓ E.g. Methanogen. Thermophile, Halophile

Where are archaea bacteria found?

- ➢ Archaeans are inhabitants of some of the most extreme environments on the planet. Some live near hydrothermal in the deep sea at temperatures well over 100 degree Celsius

Importance of archaea

Because of their tolerance to high temperatures, they have been exploited for a wide variety of commercial uses.

a. They are the source of enzymes that are usually added to detergents in order to help it maintain its activity even at higher temperature and PH.
b. Some enzymes from archaea also used to convert cornstarch into the fiber dextrin.
c. Some Archaea also bear the potential for bioremediation or help in cleaning contaminated sites.
d. The thermophilic Archaea, Thermus aquaticus, is an essential part of the development of molecular biology as a science. As a result, Archean has become the source of the enzyme harnessed as the basis for the amplification of the DNA in a technique called Polymerase Chain Reaction (PCR)

Physical factors that affecting microbial growths

3. Temperature: includes three groups

- ✓ Cold temperature → Bacteria that reproduce at optimum temp 15 degree are called Psychrophiles: and Psychrotrophs uses 25 degrees
- ✓ Warm temperature: Bacteria that need Optimum temp near 37 ^{o}c is called thermophiles.

- ✓ Hot temperature- bacteria that uses temperature with optimum of 60 ^{o}c and 95 ^{o}c are called thermophiles and Hyperthermophiles respectively.

4. Oxygen requirement:
   - ✓ Microbes not using oxygen (Anaerobes)
   - ✓ Aerotolerant → microbes tolerating oxygen
   - ✓ Obligate anaerobes → Microbes sensitive to Oxygen are
   - ✓ Microbes using oxygen(aerobic) can be:
   - ✓ Obligate aerobes →microbes requiring oxygen
   - ✓ Microaerotrophiles →Microbes requiring reduced oxygen
   - ✓ Facultative aerobes → microbes growing with without oxygen
5. **PH:** Microbes growing below PH of 6 are termed as: acidophiles
6. **Osmotic conditions**
   - ✓ **Halotolerant** →Microbes tolerating NaCl
   - ✓ **Non-halophiles** → microbes not tolerating NaCl
   - ✓ **Halophiles** → microbes requiring about 15% Nacl
   - ✓ **Extreme halophiles** → microbes requiring NaCl at 15-30%

Fungi

What are the general Characteristics of Fungi?

- ✓ All are eukaryotic and possess membrane-bound nuclei and organelles
- ✓ Most are filamentous. Are composed of individual microscopic filaments called hyphae, which exhibit apical growth and which branch to form a network of hyphae called a mycelium.
- ✓ Some fungi have septate hyphae while some have nonseptate hyphae (Coenocytic hyphae): Septate hyphae have distinct cellular compartments separated by the walls called septae. Coenolytic hyphae lack septa and content of the hyphae move freely.
- ✓ Some are unicellular e.g. yeasts. and many are multicellular
- ✓ Protoplasm of a hypha or cell is surrounded by a rigid wall
- ✓ Are composed primarily of chitin and glucans, although the walls of some species contain cellulose.
- ✓ Many reproduce both sexually and asexually by producing spore
- ✓ Their nuclei are typically haploid and hyphal compartments are often multinucleate
- ✓ All are achlorophyllous
- ✓ All are chemoheterotrophic (chemo-organotrophic).

Economic Importance of Fungi

- ✓ They exist as saprobes and are agents of biodegradation and biodeterioration
- ✓ They recycle nutrients in ecosystem
- ✓ responsible for the majority of plant diseases and several diseases of animals
- ✓ used in industrial fermentation processes e.g. Protein, Alcohol, Fat and Glucose solution from fungi like Fusarium and Molds

- ✓ used in the commercial production of many biochemical
- ✓ Cultured commercially to provide us with a direct source of food e.g. Basidiomycetes
- ✓ Beneficial in agriculture, horticulture and forestry.
- ✓ Fungi are useful tools for studying complex eukaryotic events, such as cancer and aging within a simple cell

Ecology of Fungi

- ➢ *SAPROTROPHIC fungi utilize dead organic materials as sources of nutrients*
- ➢ Many are mutualistic. They establish complex mycorrhizal associations with the roots of plant
- ➢ Lichens are a symbiotic relationship between a fungus and a photosynthetic organism

Classification of Fungi

The current classification of Kingdom fungi into five phyla based on their mode of reproduction and molecular Data: these are: -

A. **Chytridiomycota**: (Chytrids) is the simplest and most primitive true fungi.
   - ➢ The only class in this phylum is Chytridiomycetes
   - ➢ Most of them are unicellular while few are Multicellular
   - ➢ They have rhizoids with no true mycelium
   - ➢ Live in aquatic habitat, some in gut land animals
   - ➢ Asexually produce zoospore which is motile
   - ➢ Sexually produces Flagellated diploid or haploid gametes in sporangium in male and female. eg. Allomyces and water molds

B. **Glomeromycota** – E.g. Mycorrhizal fungi called fruit bodies
   - ➢ Monophyletic group of soil-borne fungi
   - ➢ They are the most important microorganism on the earth
   - ➢ They form intimate obligate symbionts and form mycorrhizal associations with nearly 80% land plants
   - ➢ They are believed to have been crucial in the initial colonization of the terrestrial
   - ➢ They are the oldest multicellular and reproduce asexually through glomerospores and Blastospore

C. **Zygomycota:** are called conjugated fungi and Sporangial fungi
   - ➢ Reproduce asexually by producing **Sporangiospore** (Non-motile spore or asexual spore)
   - ➢ Asexual spore develops in sporangium on tip of hyphae
   - ➢ They are Terrestrial and most are saprobes
   - ➢ They also reproduce sexually when environmental condition become Unfavorable by creating **Zygospore** - sexual spore and share genetic content through conjugate. This is why they are termed as conjugated fungi. Sexual spore called **Zygospores** can remain dormant in adverse environment
   - ➢ Are mainly multicellular, Mycelia of continuous hyphae with many haploid nuclei
   - ➢ Include familiar bread molds. sporangial fungi.
   - ➢ E.g. Rhizopus and mucor, Stolonifer, Black bread molds

D. **Ascomycota:** are also called **Sac fungi**
   - Ascospore producing fungi: non motile spore
   - Unicellular and multicellular with septate mycelia
   - Asexual reproduction, is common by budding (Conidiospores)
   - Sexual reproduction involves the formation of an ascus(sac) on specialized hyphae
   - They inhabit terrestrial, on fruit other organic material
   - E.g., Saccharomyces cerevisiae, Aspergillus and penicillium

E. Basidomycota: are called club fungi. Basidia producing fungi.
   - Are multicellular, uninucleate mycelia,
   - Asexual reproduction is absent and sexually produces **basidiospore** that are borne on club shaped structures at the tips of the hyphae.
   - E.g., Rust and smuts are important plant pathogenic fungi and Mushroom

Reproduction in Fungi

Asexual reproduction in fungi

- **Sporulation**: the process of spore formation in fungi
- Fungi reproduce asexually by (P**roducing spore, Budding, Fragmentation)**
- Many asexual spores develop within sacs (vessel) called Sporangia (Sporangium)
- Spores are called **Sporangiospores**
- Some fungi produce spore asexually on supportive structure called **Conidiophores** (special spore producing hyphae)
- Conidiophores can be arranged singly on hyphae or grouped in special asexual fruiting bodies
- They are unprotected dust like spores called conidia (Conidium = dust)
- They are extremely light and blown by winds easily
- In others spore may form by fragmentation of the hyphae yielding **arthrospores**

(Arthro = joint). Egg. Athlete's foot Multiply in this manner

- Many yeasts reproduce asexually by budding, Cell become swollen and new cell called **Blastospore** develop. (Blasto = bud)
- **Blastospore** is an asexual fungal spore produced by budding.

Sexual reproduction fungi

- Many fungi produce spores by sexual reproduction
- The process of sexual reproduction in fungi is unique. Ex. Nuclear membrane remain intact, diploid chromosome are pulled apart by spindle fiber with in intact nucleus
- It involves three sequential stages: Plasmogamy, Karyogamy and meiosis
- **Plasmogamy**: fusion of two protoplast = two haploid nuclei in the same cell
- **Karyogamy:** Fusion of two haploid nuclei and forming diploid nuclei containing two sets of chromosomes from each parent and zygote is formed.
- Fusion cell represents heterokaryon (different nucleus)
- **Meiosis:** Restores haploid number of chromosomes which produces gametes

Harmful aspect of fungi

- Fungi are the major cause of plant diseases. Over 5000 species attack economically valuable crops, It also causes disease in animal and human
- Molds can cause deterioration of fabrics, leather, electrical insulation and other manufactured goods
- Some fungi also cause mycotoxicosis ingestion of toxin:
  a. **Aflatoxin:** Is mycotoxin produced by *Aspergillus flavus* and *A. parasiticus. It contaminates grains, Cereals, Peanuts, sweet potatoes, corns, Rice and animal feed. They can be carcinogenic*
  b. **Ergotism*:*** *caused by Claviceps purpurea an ascomycete producing powerful toxins. Found on grain products like rye bread*
  c. **Mushroom poisoning (mycetism):** Mycotoxin that affect human body
- Superficial Fungal infections: Affects outer most areas of the human body (Hair, fingernails, Toenails, epidermis). The type of fungi that affect these are ; Trichophyton, Epidermophyton, Microsporum

Major forms of dermatophytosis are:

- ✓ **Tinea Corporis or Ringworm**: caused by Microsporum canis and Trichophyton mentagrophyes: affect hairless skin
- ✓ **Tinea pedis** (Athlete's foot) : T. rubrum.. affects lower legs
- ✓ **Tinea Capitis**: T.tonsurans. Affects scalp, eyebrows and eyelashes
- ✓ **Tinea Barbae**: T.rubrum and T.mentagrophytes: Beard ringworm
- ✓ **Tinea unguium** (Onychomycosis): Affect nails

Candidiasis caused by *Candida albicans*:

- ✓ Sign and symptom are itching, burning pains, Cheesy discharge
- ✓ Transmitted sexually

Aspergillosis: by *A.fumigatus*

- ✓ Symptoms are Bloody cough, chest pain, Wheezing, shortness of breath
- ✓ Transmitted through air borne

Thrush: Caused *Candida albicans*

- ✓ White flecks on mucous membrane is the main sign of thrush
- ✓ It is prevented by practicing good oral hygiene and limiting sugar intake

Which are common in food spoilage?

- ✓ Yeast, Rhizopus stolonifer (Black bread molds) Penicillium, and aspergillus

Examples of diseases caused by fungi

What are the main human diseases caused by fungi?

- ➢ Black Piedra of hair, Ringworm, Aspergillosis Coccidioidomycosis
- ➢ Histoplasmosis, Blastomycosis, Pneumocystis pneumonia

EXAMPLES OF EXERCISE

Choose the correct answer from the given four alternatives

1. From the following ways of transmission, how ringworm cannot be spread to different people?

A. Hugging an infected person
C. Seeing an infected person
B. Shaking hands with an infected person
D. Sharing the comb of an infected person

Explanation: Ringworm cannot be spread by just seeing the infected person. Direct skin-to-skin contact is necessary for the transmission of this disease. The common sources of infection are soil and towels, clothes, combs, etc. of infected persons.

2. Which of the following fungus is responsible for Athlete's foot?

A. *Trichophyton rubrum*
C. *Epidermophyton floccosum*
B. *Trichophyton mentagrophytes*
D. *Epidermophyton cruris*

Explanation: *Trichophyton rubrum* is responsible for causing the Athlete's foot. *Trichophyton mentagrophytes* cause the ringworm of body and beard. *Epidermophyton floccosum* and *Epidermophyton cruris* cause Tinea cruris or Jock Itch.

3. Which of the following fungi does not cause Tinea capitis?

A. *Trichophyton tonsurans*
C. *Microsporum andoninii*
B. *Trichophyton violaceum*
D. *Trichophyton rubrum*

Explanation: *Trichophyton tonsurans, Trichophyton violaceum* and *Microsporum andoninii* are responsible for causing ringworm of the scalp (Tinea capitis). *Trichophyton rubrum* causes Athlete's foot or Tinea pedis.

4. Which of the following ringworm is also called Tinea barbae?

A. Ringworm of Scalp
C. Ringworm of Body
B. Ringworm of Beard
D. Ringworm of Groin

Explanation: Tinea barbae is also called as ringworm of beard. Ringworms of Scalp, Body and Groin are called as Tinea capitis, Tinea corporis and Tinea cruris.

Protozoa

Characteristics of protozoa

- They are eukaryotic and unicellular microorganisms that lack cell wall.
- They are may be free living or parasitic and Aerobic.

- Mostly microscopic and their Locomotion is by **pseudopodia, flagella, cilia**, and direct cell movements; and some are **sessile.**
- Nutrition of all types: **autotrophic heterotrophic, saprozoic**
- Aquatic or terrestrial habitat; free-living or symbiotic mode of life
- Reproduction asexually by **fission, Multiple fission (schizogony) budding, and cysts** and sexually by **conjugation or by syngamy.**

Common diseases caused by protozoa causative agents

- Malaria- Plasmodium
- African trypanosomiasis – Trypanosoma brucei
- Amoebiasis – Entamoeba histolytica
- Giardiasis – Giardia lamblia
- chagas disease – Trypanosoma *cruzi*
- leishmaniosis – Leishmania donovani
- Toxoplasmosis -- Toxoplasma gondii

Viruses

Characteristics of Viruses

- Are obligate intracellular particles seen only with electron microscope
- Genome is either DNA or RNA covered by capsid, which is single stranded or double stranded but not both
- They infect host cell and replicate; they lack chemical machinery
- Have an inner core of nucleic acid is covered by protein coat called **envelope**
- They cannot be grown on artificial cell free media
- Viruses are inert outside their host cell and they are filterable agents
- Viruses **do not** have cellular organization, are acellular
- They lack an enzyme for protein and nucleic acid synthesis
- They are unaffected by antibiotics
- They do not fulfil the characteristic of life and they infect all cellular life forms

Basic structure of viruses

- **Core** – the genome material (DNA/RNA) Single stranded or double stranded
- **Capsid –** a protective coat of protein surrounding the core
- **Nucleocapsid** – the combined structure formed by the core and capsid
- **Envelope** – a few viruses such as the HIV and influenza, have an additional lipoprotein layer around the capsid derived from the cell surface membrane of the host cell
- **Capsomeres** – Capsids are often built up of identical repeating subunits called capsomeres
- Some Viruses contain enzymes like **Lysozyme** which makes small hole in bacterial cell that allows viral nucleic acid to get in. e.g. Bacteriophage

- E.g. Retroviruses are RNA that replicate inside host cell as DNA intermediate. These viruses possess an RNA dependent DNA polymerase called reverse transcriptase
- The particle of a virus is called a **virion.**
- All virions contain at least two components **Capsid and DNA/RNA**

Classification of virus based on Viral Symmetry

- Structure of capsid give the symmetry to the virus.
- Virus particle may be either helical, icosahedral or spherical, complex in symmetry

I. Helical symmetry

- Helical structure provides flexibility of the filaments

e.g. Tobacco mosaic virus

Figure 2.14. Tobacco mosaic virus .Source: BioNinja)

II. Icosahedral Symmetry (spherical)

- A type of polyhedron with 20 equilateral triangular faces and 12 vertices.

E.g. Papovavirus, picornavirus, adenovirus, Toga virus, etc

Figure 2.15. Adenovirus .Source: BioNinja)

III. Complex Symmetry

- E.g. Bacteriophages: a virus that uses a bacterium to replicate its genetic information

Figure 2.16. Bacteriophages.Source: BioNinja)

Viral Replication

- Viruses hijacks the host cell metabolism and produces copies of itself
- They often destroy the host cell when new virions assembled and released

To produce new virions, Viruses like bacteriophage go through the following five steps of replication cycle.

- **Adsorption → Penetration → Synthesis → Maturation → Release**

I. **Adsorption:** attachment of viruses to host cell
II. **Penetration:** the entry of virions (genomes) into the host cell
III. **Synthesis:** the synthesis of new nucleic acid, capsid, proteins, enzymes using host cell machine
IV. **Maturation:** the assembly of newly synthesized viral components into complete virions
V. **Release:** the departure of new virions from host cells by killing (lysis), lysogenic (released continually without killing host cell)

Replication of HIV

- HIV is type of retrovirus that inserts a copy of its RNA genome into the DNA of a host cell where it invades and changes the genome of that cell. The major steps in the HIV replication cycle are: **binding and fusion→ reverse transcription → integration → transcription → assembly →budding**

Two strategies of viral replication

Phages exhibit two different types of life cycle

a. Lytic cycle

- Also known as **virulent cycle/phage**
- The DNA of the virus does not integrate into the host DNA
- Host DNA hydrolyzed and there is no prophage stage
- Replication of virus takes place independently from the host DNA replication and occur with in short period of time
- Symptoms of viral replication are evident
- Genetic recombination in the host bacterium not allowed
- The cellular mechanism of the host cell is totally undertaken by the viral genome
- Cycle result in the lysis of host bacteria, releasing of progeny virions
- Enzyme called lysozyme breaks down cell wall allowing viruses to escape.
- The phage like T4 is virulent and lyse and destroy bacteria they infect.
- The Cycle involves: Attachments →Penetration → Replication →Assembly→ Release

b. **Lysogenic cycle**:

- Infection with every phage does not result in lysis of the host cells
- The DNA of the virus integrate into host cell DNA
- Host DNA not Hydrolyzed
- There is prophage stage
- Replication of viral DNA along with host DNA replication and takes long time
- Symptoms of viral replication are not evident
- Genetic recombination in the host bacterium allowed

- The cellular mechanism of the host cell is somewhat disturbed by the viral genome
- Some phages like temperate integrates into the genome of bacterial chromosomes without causing any lysis of the bacteria.
- The integrated phage nucleic acid is also called prophage.
- Prophage behaves like a segment of host the host chromosomes and multiplies synchronously with it. This is called lysogeny
- The bacterium that carries a prophage within its genome is called lysogenic or temperate phage

Classification of virus based on their genetic material

- **Retroviruses** that can converts its genetic information from RNA into DNA after it has infected a host E. g. HIV (Human Immunodeficiency Virus): Virus that attacks the body's immune system
- **DNA Virus**: store genetic information in the form of DNA
- **RNA Viruses**: Store genetic information in the form of RNA

Importance of viruses for human beings

Viruses serve as: Phage typing of bacteria, Anti-tumor agent, Pesticides, Gene vectors for protein production and Gene vectors for treatment of genetic diseases

What feature of viruses could be used to characterize them as life forms?

- They show multiplication (only inside the host cell).
- They have genetic material i.e., DNA/RNA.
- They can direct protein synthesis though they use host machinery
- They show mutation.
- They can be transmitted from the diseased host to the healthy ones or possess the ability to infect.
- They react to heat, chemicals, radiation, and shows irritability, a character of only living organisms.
- They possess genetic continuity and have definite races/strains.
- Similarity between nucleoproteins of viruses with the protein and nucleic acid of living organisms.

What make viruses more similar to lifeless molecules?

- They can be crystallized and they behave as inert chemicals outside the host cell.
- A cell wall or cell membrane of any type is absent in viruses
- They lack any energy producing enzyme system mean they do not show functional autonomy. They do not move, grow, respire or excrete or they do not show any sign of metabolism except reproduction.

Common viral disease in Ethiopia

✓ AIDS, Common cold, Ebola, Genital herpes, Influenza, Coronavirus disease (COVID-19), Mumps, measles, Rabies, Polio, Chicken Pox

EXAMPLES OF REVIEW EXERCISE

Choose the correct answer from the given alternative for the following question

1. Viruses are: A. acellular B. Noncellular C. Unicellular D. Cellular

Explanation: Viruses are acellular, non-cellular entities. They are microscopic organism. They are neither unicellular, multicellular or prokaryotic. They can replicate only in host cell.

2. All viruses are: A. Parasitic B. Free living C. Saprophytic D. Symbiotic

Explanation: Viruses are **obligate intracellular parasites**, meaning they cannot reproduce on their own and must invade a host cell to replicate and propagate. They depend entirely on the machinery of a host cell to carry out their functions, making them parasitic in nature.

3. The protein coat that encloses the nucleic acid in virus is called

A. Glycoprotein
C. Capsomere
B. Capsid
D. Lysosome

✓ **Explanation**: Capsid is a protective coat of protein surrounding the core (genetic material RNA or DNA).

4. What components make up a virus?

A. A protein shell and nucleic acid
C. Nucleic acid and cell membrane
B. A protein shell and mitochondria
D. Nucleic acid, cell wall, and cell membrane

Explanation: A protein shell and nucleic acid. Viruses consist of two main components:

✓ **A protein shell (capsid)** that protects the viral genome.

✓ **Nucleic acid**, which can be either DNA or RNA, carrying the genetic instructions for replication. Viruses do not have mitochondria, cell membranes, or cell walls like living cells. They rely on host cells to reproduce.

5. Which statement is true about capsomeres?

A. They are individual units of the capsid
B. They are viral proteins for replication

C. They are units of nucleic acid in viruses
D. They are the polymers of nucleic acid

✓ **Explanation**: **Capsomeres** are the repeating protein subunits that make up the **capsid**, the protein shell surrounding the viral genome. These subunits assemble to form the structure of the capsid, which protects the viral nucleic acid. Capsomeres are individual units of the capsid.

6. Which virus has complex symmetry?
   A. T4 bacteriophage
   B. Adenovirus
   C. Influenza virus
   D. Papilloma viruses

   ✓ **Explanation**: T4 bacteriophage. Examples of **helical symmetry** are tobacco mosaic virus,
   ✓ Icosahedral structures like papovavirus, picornavirus, adenovirus, Toga virus. **Complex virus** includes pox virus, Bacteriophage, Vaccinia virus

7. Which of the following is a helical virus?
   A. Tobacco Mosaic Virus)
   B. Herpesvirus
   C. T4 bacteriophage
   D. Poxvirus

   ✓ **Explanation**: The **Tobacco Mosaic Virus (TMV)** is a helical virus, meaning its viral genome is wrapped around a helical protein coat. It is one of the most well-known examples of a helical virus.

8. What are bacteriophages that cause bacterial cell lysis called?
   A. Viroid
   B. Lysogenic phages
   C. Virulent phages
   D. Temperate phages

   Explanation: Virulent phages are bacteriophages that cause bacterial cell lysis (destruction of the bacterial cell). These phages follow the lytic cycle, where they infect a bacterium, replicate inside it, and eventually cause the bacterium to burst, releasing new phage particles.

9. What is the term for the viral genome inserted into bacterial DNA?
   A. Lysogeny
   B. Prophage
   C. Lytic cycle
   D. Virulent phage

   ✓ **Explanation**: A **prophage** is the viral genome that has been inserted into the bacterial DNA. This typically happens during the lysogenic cycle, where the phage DNA integrates into the host bacterium's genome and can remain dormant until triggered to enter the lytic cycle.

10. Which of the following viral diseases is caused by a retrovirus and can lead to the suppression of the immune system?

A. Smallpox
B. HIV/AIDS
C. Rabies
D. Chickenpox

✓ **Explanation**: Human Immunodeficiency Virus (**HIV**) is a retrovirus that attacks and weakens the immune system by infecting CD4+ T cells. Over time, this can lead to **AIDS** (acquired immunodeficiency syndrome), making the body vulnerable to opportunistic infections. Retroviruses are characterized by having RNA as their genome and using reverse transcriptase to convert their RNA into DNA within the host cell.

11. Which of the following diseases does not spread by fomite transmission?

A. AIDS B. Common cold C. Ringworm D. Influenza

✓ **Explanation:** Fomite transmission refers to the transmission of infectious diseases by objects. Common cold, Ringworm and influenza are object borne diseases meaning that the transmission of these diseases takes place by the pathogens left on the objects.

12. What is the primary reason viruses needing an appropriate host cell for replication?

A. They lack the metabolic capacity to produce energy outside a host cell.
B. They cannot form protective protein coats without a host cell.
C. They require the host's immune system to activate replication.
D. They need a host cell to synthesize their own genetic material independently.

✓ **Explanation:** They lack the metabolic capacity to produce energy outside a host cell. Viruses do not have the machinery for energy production or metabolism and rely entirely on the host cell's machinery to provide energy and the building blocks necessary for replication. Viruses are unable to produce energy or carry out metabolic processes on their own. They lack the necessary cellular machinery to generate ATP, synthesize proteins, or replicate their genetic material independently. To replicate, viruses must hijack the host cell's machinery and energy resources. This is why an appropriate host cell is essential for viral replication.

13. Which of the following correctly compares the lytic and lysogenic cycles of viral replication?

A. The lytic cycle results in the destruction of the host cell, while the lysogenic cycle integrates the viral genome into the host's genome without immediate host cell death.
B. The lysogenic cycle is faster than the lytic cycle in terms of viral replication, and it always results in the death of the host cell.
C. In both cycles, the viral genome integrates into the host DNA and then activates immediately to produce new virus particles.

D. The lytic cycle involves the viral genome integrating into the host's genome, while the lysogenic cycle involves immediate viral replication and cell destruction.

Explanation: The lytic cycle results in the destruction of the host cell, while the lysogenic cycle integrates the viral genome into the host's genome without immediate host cell death.

Lytic cycle: The virus infects the host cell, replicates its genome, assembles new virions, and eventually causes the host cell to lyse (break open), releasing new viruses.

Lysogenic cycle: The viral genome integrates into the host cell's genome and remains dormant (in the form of a **provirus**) until it is activated, at which point the virus enters the lytic cycle and begins replicating, potentially causing cell destruction later.

2.4.2. Normal Microbiota/Flora

- Is the population of microbe routinely found growing on the body of healthy individuals
- They can be resident biota – extended period or Transient microbiota – temporary occupants

Importance of normal microbiota

- ✓ Norma microbiotas are soldiers of the body, they compute for the space and food with the pathogenic microorganisms and they produce different metabolites that the pathogenic microorganisms could not tolerate
- ✓ The most significant importance of normal flora is protection against pathogen! They exclude pathogens by:
- ✓ Covering binding sites/attachment site: Provides first line of defense against microbial pathogen
- ✓ Consuming available nutrients that pathogens use
- ✓ Producing toxic to other bacteria.
- ✓ Play role in toxin degradation
- ✓ Assist in digestion, they also produce small quantities of Vitamin K used in blood clotting, bone health, protect certain forms of cancer and heart disease
- ✓ Stimulate adaptive immune system: contribute to maturation of immunity
- ✓ Maintenance of structural integrity of the gut mucosal barrier

When they are suppressed, pathogen can colonize and causes disease. e.g. *Clostridium difficile* that causes diarrhea and colitis.

2.4.3. The Germ Theory of Disease

- ✓ Louis Pasteur and Robert Koch were the first to establish the germ theory of disease.
- ✓ The theory was proposed by L.pasteur and Proved By R.Koch.
- ✓ It was the work of the Louis Pasteur in the later part of the 19th century which resulted in the widespread acceptance of the germ theory of disease.

- ✓ L. Pasteur dentified the micro-organisms that caused a number of diseases in people and animals, including anthrax, rabies and diphtheria.
- ✓ He also found ways of weakening or killing the microbes and made vaccines against the diseases.
- ✓ His work showed everyone that infectious diseases are caused by micro-organisms.
- ✓ Koch used an experment that proved diseases are caused by microorganism
- ✓ He used mice as an experimental animal
- ✓ E.g. he discovered that the anthrax bacteria could be grown in nutrient fluids outside the host
- ✓ He also identified the causative agent of tuberculosis

He formulated a set of regorious Criteria known as Koch's postulates for definitively linking a specific microorgansim to a specific disease.

The theory states that 'contagious or communicable diseases are caused by germs which are transmitted from person to person by contact or by contaminated drinking water or other foods''

Koch's postulates state the following

I. *The disease-causing organism must always be present in animals suffering from the disease but not in healthy animals.*
II. *The organism must be cultivated in a pure culture away from the animal body.*
III. *The isolated organism must cause the disease when inoculated into healthy susceptible animals.*
IV. *The organism must be isolated from the newly infected animals and cultured again in the laboratory where it should then be seen to be the same as the original organism*

Modes of Disease transmission

There are four main routes for the transmission of pathogens:

- ✓ Disease transmitted by contact
- ✓ Direct contacts: many skin infections, such as athlete's foot, ring worms ...
- ✓ Sexual contact: candidiasis, syphilis, gonorrhea, chancroid…

I. Disease Transmitted by Droplet

- ✓ many are respiratory diseases affecting the airways of the lungs
- ✓ transmitted by droplet when infected person cough, sneeze, talk

e.g. Common cold, Flu, Pneumonia, TB…

II. Disease Transmitted by drinking contaminated water (Water-borne)

- ✓ They often infect regions of the gut

E.g. Cholera, Typhoid fever., Legionnaire's disease, Amoeba, Giardia

III. Disease Transmitted by eating contaminated food (Food-borne)

- Most Food posisoning bacteria.they initially inect a region of gut

E.g. Salmonellosis, Shigellosis, Botulinism, Listerosis, Typhoid fever…

V. Disease Transmitted by vectors

- Spread through insect, animals

E.g. Malaria – Anopheles mosquito and Sleeping sichness- Tsetse fly

2.4.3. Uses of Microorganism

- Microbiology has made great advances in understanding the role of microorganism in health, food, agriculture, medicine, energy, clean up the environment.
- Microbes involve in recycling of essential element in the ecosystem

The role of Microorganism in Agriculture

- ✓ The role of microbes in agricullture is indispensable. E.g.
- ✓ Microbes helps in decomposition(ammonification, humus formation, Composting)
- ✓ Nitrogen fixation
- ✓ Phosphate solubilization
- ✓ Potassium Mobilization
- ✓ Antagonism towards pests

Microbes are primarly responsible in converting essential elements of life in the form they need. E.g. Nitrogen in the form of nitrate. Bacteria andd fungi convert carbon in organic matter to CO_2 that is used by plants and algae.

Microbes are used in producing Bt Crops, GR crops by serving as vector

The role of Microorganism in Sewage Treatment

- Anaerobic microbes reduces the volume of sludge and produce methane gas which is used alternative energy source
- They reduces energy consumed to treat waste water
- Microbes also removes Phosphorus from waste water

The role of bacteria in Bioremediation

- Bioremediation: is a natural process that relies on microbes or their products to degrade contaminants
- Microbes involves in biodegeradation and biotransformation (Solubilization of insoluble nutrients) and Toxic to less toxic
- Microbes suppress soil born pathogens
- Recycle and increase availability of plant nutrients,
- Degradation of toxicants including pesticide and heavy metal

The role of bacteria in Carbon cycle

- Fundamental aspect of carbon cycle is carbon fixation,the defining characteristic of primary producers.
- Oxygen supply in the ecosystem influence carbon cycle.
- Many organsim uses sugar,amino acids and Protein as energy source. Amount of Oxygen used determine type of degradable organic matter and type of carbon containing gases formed.
- When organic matter is degraded aerobically, a great deal of CO2 is produced
- In anaerobic enviroments, CO2 is used by methanogens. These archaea obtain energy by oxidizing hydrogen gas, using CO2 as terminal electron acceptor, generating methaneCH4.
- Methane in atomesphere is oxidized by ultraviolet light and chemical ions, forming carbon monoxide and carbon dioxide
- Methylotrophs can use methane as an energy source, oxidizing it to produce CO2.

The role of bacteria in Nitrogen Cycle

- Root nodules are found on the roots of plants, primarily legumes, which form a symbiosis with nitrogen-fixing bacteria (Rhizobia).
- Under Nitrogen limiting conditions, capable plants form a symbiotic relation with a host-specific strain of bacteria known as rhizobia.
- Nitrogen fixation in the nodule is very oxygen sensitive

Table 1. Key processes and Prokaryotes in the Nitrogen Cycle

Processes	Example of Organisms
Nitrification ($NH4^+ \rightarrow NO_3^-$)	
($NH4^+ \rightarrow NO_2^-$)	Nitrosomonas
($NO_2^- \rightarrow NO_3^-$)	Nitrobacter
Denitrification ($NO_3^- \rightarrow N_2$	Pseudomonas, Bacillus, Paracoccus
Free living, aerobic	Azotobacter, Cyanobacteria
Anaerobic	Clostridium, Purple, and Green phototrophic bacteria, Methano bacterium (Archaea)
Symbiotic	Rhizobium, Brady rhizobium, Frankia
Ammonification (Organic -N $\rightarrow NH_4^+$)	Many organisms can do this, Decomposers
Anammox ($NO_2^- + NH_3 \rightarrow 2N_2$)	Brocadia

The role of bacteria in sulfur cycles

- Sulfur is found in fewer types of organic molecules than nitrogen.

Table 2. Key processes and Prokaryotes in sulfur cycle

Processes	Example of Organisms
Sulfide/Sulfur Oxidation ($H2S \rightarrow S^{O} \rightarrow SO_4^{2-}$)	
Aerobic	Sulfur chemolithotrophs (*Thiobacillus, Beggiata*)
Anaerobic	Purple and green phototrophic bacteria and chemolithotrophs
Sulfate reduction (Anaerobic) $SO_4^{2-} \rightarrow H_2S$	*Desulfovibrio, Desulfobacter*, Archaen
Sulfur reduction (Anaerobic) $So \rightarrow H_2S$	*Desulfuromonas*, Many Hyperthermophilic Archaea
Sulfur disproportionation	($S_2O_3 \rightarrow H_2S + SO_4^{2-}$ by *Desulfovibrio*
Organic sulfur cpd oxidation or reduction	$CH_3SH \rightarrow CO_2 + H_2S$ By many organism
Desulfurylation(Organic – $S \rightarrow H_2S$	Many organism can do this

The Phosphorus Cycle

- Phosphorus occurs in soil as both organic and inorganic forms.
- The relative amounts of each form of Phosphorus vary greatly among soils

e.g. P in a clay textured soil being up to ten times greater in a sandy soil.

- Organic P in soils is high and held very tightly which is not available for plant uptake until, decomposed by mineralization process carried out by microbes.
- The rate of P release is affected by factors such as:

- Soil moisture
- Composition of organic material'
- Oxygen concentration and PH

- Inorganic P in soils. the concentration of inorganic P or orthophosphates in the soil solution at any given time is very small. It exists mostly as aluminum, Iron or Calcium compound.

Key process in phosphorus cycle

Adsorption: a process in which phosphorous present in soil solution is bound to surface of soil particles.

Desorption: is the process of releasing ions or molecules from solid into solution.

Immobilization: is the process by which inorganic phosphorus forms are converted to organic and are absorbed into the living cells of soil microbes.

Dissolution: is a form of weathering when the phosphate minerals

Culturing microorganisms

- Many micro-organisms can be grown in the laboratory and seen in colony by using nutrient medium (Agar or Broth).
- Nutrient medium contains: Carbohydrate, Mineral ions such as K, Na, Fe, Proteins, Vitamins and water.
- Agar is a substance which dissolves in hot water and sets to form a jelly. It is the ideal solid medium contained in a Petri dishes
- Broth is the other way to provide nutrients for growing micro-organisms in a culture flask. It is a liquid medium contained in a test tube.

The immune system

- is the system in the body which protects us against invading microorganisms and foreign proteins. Our white blood cells (WBC) defend us against infective microorganisms (Pathogen).
- Like other cells, Pathogens contain antigen and white blood cells (lymphocytes) produce antibodies to disable the pathogen.
- Other white blood cells (the phagocytes) then engulf and digest the disabled pathogens.

Types of Immunity

A. **Artificial immunity**

- Artificial active immunity – is the result of vaccination/immunization with antigen. Weakened, dead or partial pathogen is injected into the body and the body produces antibodies against that pathogen for later use. Ex. Polio, Hepatitis B, Small pox. Etc.
- Artificial passive immunity – injection of vaccine that contain antibodies from another person
- e.g. Tetanus shot and Rabies. Passive immunity provides immediate but short-lived protection.

B. **Natural immunity**

- Natural active immunity: is immunity acquired from exposure to the disease organism through infection with the actual disease and develop imunity.
- Natural passive immunity – in breast milk (in particular the colostrum of the first few days).
- It occurs naturally, when maternal antibodies are transferred to the fetus through placenta or from breast milk to the gut of the infant.

EXAMPLES OF REVIEW EXERCISES QUESTION

Choose the correct answer from the given four alternatives

1. Which of the following is an example of artificial passive immunity?
   A. Antibodies acquired from an immune serum medicine
   B. Antibodies transmitted from mother to baby
   C. Antibodies made after getting vaccination
   D. Antibodies made after exposure to an infection

Explanation

- Natural active immunity: Antibodies made after exposure to an infection
- Artificial active immunity: Antibodies made after getting vaccination
- Natural passive immunity: Antibodies transmitted from mother to baby
- Artificial passive immunity: Antibodies acquired from an immune serum medicine

2. Which of the following is correct about herd immunity? It is
   A. Is immunity that is developed naturally without artificial vaccination
   B. protection offered to everyone in a community by high vaccination rate
   C. Immunity that causes reinfection in vaccinated community
   D. Immunity that is developed when all population in a community is vaccinated

Explanation: Herd immunity is developed when enough people immunized against a given disease like Covid-19. It is difficult for the disease to gain a position in the community. It offers protection to those who are unable to receive vaccination

3. Which of the following statement is correct about Koch's postulate?
   A. The cultured microbes should not cause disease when introduced to a healthy organism
   B. Microorganism that causes diseases must be identified from the healthy individual.
   C. The microorganism should be isolated from experimental host and are identical to the original type.
   D. All microbes that cause disease are cultured in artificial medium.

   Explanation: In Koch's postulates, Microbes must be identified only in the diseased individual and not in healthy one. It is possible to extract and culture microbes in the medium. This cultured microbe could also cause disease when introduced into healthy host. This microbe is identical with the original microbes.
4. It has been said that bacteria are essential for the existence of life on earth. Which of the following would be the essential function performed by bacteria?
   A. Directly provide food for humans
   B. Control insect populations
   C. Decompose organic matter and recycle element
   D. Produce human growth hormone

   Explanation: microbes are essential in producing food, medicine, biofuels …. Without microbes like bacteria essential element like O2, C, N, H, P, S, are locked in organic molecules and others forms. Bacteria makes them available for all life on our planet. Bacteria serve as decomposer of organic molecules and recycle nutrients in the ecosystem.

4. 2.4.5. Controlling Microorganisms

I. Sterilization is the process by which surface or medium is freed of all living organism either in the vegetative or spore state. This material is said to be sterile!

- An object cannot be slightly sterile or almost sterile: it is either sterile or not sterile.
- Sterilization is by physical agents like Heat a few chemicals called sterilant
- Chemical agents that kill pathogenic microorganisms are termed as a germicide
- Germicide can be used on inanimate or nonliving material or on living tissues
- Germicide may not ordinarily kill resistant microbial cells (Spore)
- Any physical or chemical agents that kills ''Germs'' is said to have germicidal properties

Sterilization can be by:

A. **Physical methods:** Boiling, Autoclaving, Pasteurization, Incineration, Ultra-High temperature and Dry heat sterilization
B. **Chemical method:** Disinfectant and antiseptic

a. Disinfectants are agents that destroys vegetative pathogens and their products like toxin that causes infection but not bacterial endospores

- Disinfectants are only applied only on inanimate objects, because they can be toxic to human or other tissues when used in higher concentration.
- Disinfection removes harmful microorganism and their toxin from material

Example of Disinfectants are:

a. Applying a solution of 5% bleach to examining table
b. Boiling food utensils used by a sick person
c. Immersing thermometers in an isopropyl alcohol solution between uses

b. Antiseptics: are Chemical agents applied directly to the exposed body surface e.g. Skin, Wound, and surgical incision

Examples of Antiseptics includes

a. Preparing the skin before surgical incisions with iodine compound
b. Swabbing an open root canal with hydrogen peroxide
c. Ordinary hand washing with a germicidal soap.

II. Sanitization: is any cleansing technique that mechanically removes microbes to reduces the level of contaminants (along with food debris).

- Performed by Soap or detergents. This may not completely free of microbes. but considered safe for normal use
- Air sanitization with ultraviolet Lamps reduces airborne microbes in hospital rooms,laboratory installation..

III. Preservation: a general term for measures taken to prevent microbe caused spoilage of susceptible products like pharmaceuticals and foods

IV. Decontamination: removal or count reduction of microorganisms contaminating an object.

- The objective of antiseptic measures and technique is to prevent microbial contamination of material or wounds
- In antiseptic measures, chemical agents are used to fight pathogens in or on living tissues

Physical method of Sterilization and Disinfectants

- Heat is a simple, cheap and effective
- Application of heat var according to specific pathogens like as follows:

I. Pasteurization: antimicrobial treatment used for food in liquid forms like milk.

- Low temperature pasteurization at 65 ^{O}c for 30 Minutes or at 71 ^{O}C for 15 seconds
- High temperature pasteurization: brief seconds of exposure to 80-85 ^{O}C in continuous operation
- Uperization: heating to 150 ^{O}C for 2.5 seconds in a pressurized container using steam injection

Disinfection

- Application of temp. below what would be required for sterilization.
- Boiling medical instruments, needles, syringes does not constitute sterilization! Because many spores are not killed

II. Dry heat sterilization includes sterilization by:

a. Flamming: sterilization of inoculating loop, forceps on Bunsen burner flame

b. Incineration: an excellent method for safely destroying infective materials by burning them to ashes. Used in hospital, research labs used for complete destruction of infective material like syringes, needles, culture and pathology samples. Fast and effective for most hospital waste, except metal and heat resistant glass.

c. Hot air oven: Sterilization by hot-air oven requires exposure to 160-180 ^{o}C for 2hrs and 30 minutes which ensure destruction of spore through heating of objects

- Dry heat sterilization is used to sterilize scientific equipment which are less sensitive to high temp.e.g. Glass ware, Gause, dressing etc…by using temp of 171 ^{o}C for an hour or 160 ^{o}C for two hours.

III. Moist heat sterilization

Autoclaves charged with saturated, pressurized steam are used for this purpose:

- 121 ^{0}C, 15 minutes, one of atmosphere of pressure (a total = 202kPa)
- 134 ^{0}C, 3 minutes, two atmospheres of pressure (total = 303 kPa)

IV. Intermittent Sterilization

- Heat-labile substance like serum, sugar, egg cannot withstand the high temp of the autoclave can be sterilized by a process of intermittent sterilization or tyndallization
- **Tyndallization** is carried out over a period of 3 days and requires a chamber to hold the materials and a reservoir for boiling water 100^{0}C for 20 minutes for each of three consecutive days.

Bacterial Isolation techniques

- Microbes can be isolated from food, soil, air, water.
- It can be separated on artificial media by serial dilution method.
- Each of the isolates are purified on new media and experimented for morphological characteristic-like shape, Gm nature motility and arrangement of cells
- Enzymatic activities were tested to characterize
- Finally, molecular techniques are used for further identification:

Individual microbes are separated from each other by:

Pour plating – a technique used to count microorganism in liquid sample

Streak plating – is the most commonly used isolation method on solid agar medium

Spread plating – on solid agar medium with a glass spreader

What is the purpose of serial dilution in biology lab?

- **It is used to estimate the number of colonies bacteria or viruses of unknown sample by counting the number of colonies cultured from serial dilution.**

SELF TEST **REVIEW EXERCISE**

CHOOSE THE BEST ANSWER FROM THE GIVEN FOUR ALTERNATIVES

1. Which of the following disease is not transmitted by animal vector?
   A. Elephantiasis C. Leishmaniasis
   B. Trypanosomiasis D. Trichomoniasis
2. Which of the following fungal species is responsible for the production of aflatoxin?
   A. *Aspergillus fumigatus* C. *Aspergillus flavus*
   B. *Claviceps purpurea* D. *Tinea unguium*
3. Which of the following is asexual and sexual method of reproduction in ciliated protozoan respectively?
   A. Transverse fission and conjugation
   B. longitudinal cell division and binary fission
   C. Conjugation and Budding
   D. Multiple fission and Cyst formation
4. Which of the following genera of fungi is not responsible for causing ringworms?
   A. Trichophyton C. Fusarium
   B. Microsporum D. Epidermophyton
5. Which of the following microbes are not parasitic?
   A. Ringworm B. Tapeworm C. Round worm D. Plasmodium
6. Which of the following is not the ways in which protozoan obtain food?
   A. Ingestion B. Absorption C. Phagocytosis D. Exocytosis
7. Which of the following is the feature of all organism in kingdom Monera? They are all. A. Multicellular B. Unicellular C. Autotrophic D. Parasitic
8. Which of the following is not the structure of prokaryotic cell?
   A. Ribosome B. Slime capsule C. Nucleoid D. Nucleolus
9. The main constituent of a Gram-positive cell wall is
   A. Peptidoglycan B. Glycocalyx C. Flagellae D. Fimbriae

B. Which of the following is classified as cell envelope in prokaryotic organism?
   A. Capsomere C. Cell membrane
   B. Cell inclusion D. Appendage

C. Which of the following statement about bacterial structure is not correct?
   A. The flagella allow substances in and out of the bacteria
   B. Plasmid is a piece of extra chromosomal DNA
   C. Bacteria are best measured in micrometer
   D. Bacterial are omnipresent organism

5. The Iodine used in gram staining serve as
   A. Mordant B. Cofactor C. Decolorizer D. Fixer
6. Which of the following is acellular?
   A. Archaea B. Viroid C. Yeast D. Bacteria
7. Which of the following eukaryotic cellular organelle resemble bacteria?

A. Lysosome B. Ribosome C. Mitochondria D. Plastids

8. which of the following prokaryotic structure is not correctly paired with its function?
   A. Mesosome → site where large DNA molecules is condensed
   B. Flagellum → specialized appendage that provides motility
   C. Glycocalyx → coating layer that provide adhesive and receptor function
   D. Pilus → hollow appendage used in transfer of DNA to another cell
9. Which of the following is Not the distinct feature of prokaryotes?
   A. they lack membrane enclosed genetic material
   B. their cell is chemically simple
   C. the lack histone associated protein
   D. they often reproduce by binary fission
10. Which of the following is not true about the cell wall of gram-positive bacteria?
   A. Cell wall comprises of many layers
   B. The cell wall is thicker than the associated gram-negative bacteria
   C. Cell wall comprises of teichoic acids
   D. Cell wall consist thin layer of peptidoglycan
11. An organism that uses methane as carbon source to derive energy is termed as:
   A. Chemolithoautotrophy C. photoheterotrophic
   B. Photoautotrophs D. Photolithoautotrophs
12. Chemo organoheterotrophs are organism that:
   A. harvests energy from inorganic chemical
   B. use reduced organic compounds as source of energy
   C. oxidize reduced inorganic compounds to derive both energy and electron for biosynthesis
   D. obtain energy from sunlight and fix carbon dioxide
13. If a disease is transmitted from a non-human animal to a human, it is termed as:
   A. Hereditary disease C. Infectious disease
   B. Zoonotic disease D. Non-infectious disease
14. Which of the following disease cannot transmitted through droplet contact?
   A. Influenza B. Common cold C. AIDS D. Ebola
15. Which of the following is a bacterial disease?
   A. Leprosy B. Amoebiasis C. Measles D. Thrush
16. Which of the following diseases are all an example of fungal disease?
   A. Shigellosis, Aspergillosis, Salmonellosis, Listeriosis, Syphilis
   B. Histoplasmosis, Pneumocystis pneumonia, Coccidioidomycosis
   C. Leishmaniasis, Toxoplasmosis, trypanosomiasis, Chagas disease
   D. Chicken pox, Mumps, Pneumonia, Influenza, Yellow fever
17. Which of the following is the clinical feature of malaria?
   A. Skin ulcer, visceral diseases C. Fever, shivering and pain in the joints
   B. Blindness and mental retardation D. Myocarditis, edema and nasal discharge
18. All are bacteria that fix nitrogen **except?**

A. Rhizobium B. Azotobacter C. Cyanobacteria D. Pseudomonas

19. Nitrites are oxidized to nitrates by a microorganism called
    A. Nitroso coccus C. Nitrobacter
    B. Azotobacter D. Nitrosomonas
20. Bacteria which Strictly need oxygen for growth are called
    A. Obligate aerobes C. Obligate anaerobes
    B. Facultative aerobes D. Microaerophilic bacteria
21. Bacteria reproduce vegetatively by
    A. Binary Fission only Conjugation C. Transformation and Transduction
    B. Fragmentation and budding only D. Fission, Fragmentation and Budding
22. Binary fission in bacteria involves all except
    A. Spindle fiber formation C. Cytokinesis
    B. DNA replication D. Cell elongation
23. The transfer of genetic material from one bacterium to another via virus is termed as
    A. Transformation C. Conjugation
    B. Transduction D. Transfection
24. The uptake of antibiotic resistance gene from the surroundings by a bacterium is termed as
    A. Recombination C. Conjugation
    B. Transduction D. Transformation
25. Which of the following organism is not abundant in hostile environment?
    A. Methanogen B. Thermophile C. Halophile D. Lactobacillus
26. Bacteria that reproduce at optimum temp 15 degree is termed as
    A. Thermophiles C. Psychrophiles
    B. Halophiles D. Hyperthermophiles
27. The scientific discipline devoted to fungi is called
    A. Mycology B. Ethology C. Phycology D. Mycoses
28. Unlike eubacteria, Archaebacteria
    A. Lack Plasmid in their genetic material
    B. are non-pathogens
    C. Contain ether linkage on the plasma membrane
    D. have both intron and exons
29. Which of the following is not correct about the feature of fungi? All fungi are
    A. Eukaryotic C. Chemoheterotrophic
    B. Achlorophyllous D. Multicellular
30. Mycorrhizal fungi are grouped into phylum
    A. Glomeromycota C. Zygomycota
    B. Ascomycota D. Basidiomycota

31. Which of the following fungal species is commonly used in fermentation of food products?
    A. Saccharomyces cerevisiae C. Ascomycetes
    B. fusarium notatum D. Aspergillus flavus
32. The cell wall of fungi contains
    A. Cellulose, Peptidoglycan and Glycan
    B. Glycogen, Glucose and Murin
    C. Murin, lipopolysaccharide and pectin
    D. Chitin, Glucan, and glycoprotein
33. A motile asexual spore that uses a flagellum for locomotion in water bodies is
    A. Zoospore C. Arthrospores
    B. Ascospore D. Basidiospore
34. Which of the following pairs of spores are an example of sexual spore?
    A. Ascospore and Basidiospore C. Conidiospore and Blastospore
    B. Zoospore and Sporangiospore D. Arthrospore and Chlamydospore
35. A symbiotic association between a fungus and plant is
    A. Mycorrhiza C. Lichens
    B. Mushroom D. Cyanobacterium
36. The causative agent of Thrush or Candidiasis is
    A. Asperigillus fumigatus C. *Candida albican*
    B. Microsporum D. Claviceps purpurea
37. Which one of the following forms of sexual reproduction is exhibited by protista?
    A. Fission B. Budding C. Schizogony D. Syngamy
38. Which of the following diseases is not correctly paired with its symptoms?
    A. Thrush – white flecks on mucous membrane
    B. Aspergillosis – Bloody cough and shortness of breath
    C. Candidiasis – bloody diarrheal fluid
    D. Dermatophytosis – Blister-like lesions
39. Which of the following is not correctly matched with organism and site it infects?
    A. Ringworm – skin C. Cholera – intestine
    B. Pneumonia – lungs D. Athlete's foot – sex organ
40. Unlike fungi, protozoan lack

A. True nucleus B. Cell wall C. Chlorophyll D. Mitochondria

41. Fungi that obtain nutrients from dead organic matter are termed as

A. Photo autotrophic C. Saprophytic

B. Parasitic D. Symbiotic

42. Which of the following protozoan parasites reproduce almost asexually in their life cycle?

A. Ciliated Protozoa C. Flagellated protozoa

B. Sporozoan D. Amoeboid

43. Which of the following is not the a sexually transmitted disease?

A. Trichomoniasis C. Acquired Immune Deficiency Disease

B. Encephalitis D. Syphilis

44. Which of the following disease is usually spread through water?

A. Pneumonia C. Giardiasis

B. Salmonellosis D. Candidiasis

45. DNA Virus is differed from RNA, because DNA

A. Are mostly single stranded C. Mutate frequently

B. Replicate in the nucleus D. replicate in the cytoplasm

46. The first step in the viral replication is

A. Maturation C. Adsorption

B. Penetration D. Replication

47. The most contagious disease among the following is

A. Pneumonia C. AIDS

B. Ringworm D. Leishmaniasis

48. Bacteriophages are

A. Obligate extracellular parasite that infect virus

B. Facultative intracellular parasite that infects eukaryotes

C. Obligate intracellular parasite that infect prokaryotes

D. Retroviruses that can convert their RNA to DNA

49. Which of the following disease is caused by protozoan?

A. Shigellosis C. Babesiosis

B. Blastomycosis D. Botulisms

50. Common cold differs from pneumonia in that:

A. Pneumonia is a communicable disease whereas the common cold is a nutritional deficiency disease
B. Pneumonia can be prevented by a live attenuated bacterial vaccine whereas the common cold has no effective vaccine
C. Pneumonia is caused by a virus while the common cold is caused by caused by the bacterium *haemphilus influenzae*
D. Pneumonia pathogen infects alveoli whereas the common cold affects nose and respiratory passage but not the lungs

51. Which of the following disease cannot be prevented by vaccination?
A. Measles C. Whooping cough
B. Common cold D. Chicken pox

52. Which of the following viral structure is not found in all viruses?
A. Capsid B. Nucleic acid C. Nucleocapsid D. Envelope

53. Which of the following virus contain Helical Symmetry?
A. Tobacco mosaic virus C. Bacteriophage
B. Adenovirus D. Herpes simplex virus

54. When compared with lytic cycle, the lysogenic cycle of viruses
A. Takes shorter time C. There is no prophage stage
B. Host DNA is hydrolyzed D. There is prophage stage

55. When organic matter is degraded aerobically, a great deal of
A. Carbon dioxide is produced C. Methane is produced
B. Oxygen is produced D. Carbon dioxide is removed

56. Which of the following process decrease the availability of phosphate in the soil?
A. Desorption C. Dissolution
B. Mineralization D. Immobilization

57. Sterilization is
A. the process by which surface is freed of all living organism either in the vegetative or spore state
B. cleansing technique that mechanically removes microbes to reduces the level of contaminants
C. the removal or count reduction of microorganisms contaminating an object

D. the process taken to prevent microbe caused spoilage of susceptible products like foods

58. Which of the following technique of sterilization is used to sterilize scientific equipment which are less sensitive to high temperature?

A. Dry heat sterilization C. High temperature pasteurization

B. Intermittent sterilization D. Disinfection

59. Dry heat sterilization includes all except?

A. Tyndallization C. Flamming

B. Incineration D. Hot air oven

60. Flagella in bacteria enable them to:

A. Reproduce C. locomote

B. Thrive in nutrient agar D. Adhere to tissue surface

61. A slippery outer covering in some bacteria that protects them from phagocytosis by host cells is

A. capsule B. cell wall C. flagellum D. peptidoglycan

62. A bacterial cell wall does all of the following **except**

A. gives shape and rigidity to the cell

B. is the site of action for some antibiotics

C. is associated with some symptoms of disease

D. protects the cell from phagocytosis

63. Differences between eukaryotic and prokaryotic cells include all of the following **except**

A. Eukaryotic cells have mitochondria

B. Prokaryotic cells have more complex cell walls

C. Eukaryotic cells have cilia and flagella with complex structure

D. Prokaryotic cells have no genetic material

64. The bacterial envelope includes all of the following structures except

A. capsule C. cell wall C. cell membrane D. endospore

65. Most human pathogens prefer temperatures near that of the human body. They are called:

A. psychrophiles C. thermophiles

B. mesophiles D. halophiles

66. The optimum temperature for an organism is the one at which

A. it grows with the shortest generation time

B. it has the longest time between cell divisions

C. it is near one extreme of its range of tolerated temperatures

D. its enzymes begin to denature

67. In the process of nitrogen cycle, the role of denitrifying bacteria is to

A. Fix atmospheric nitrogen to nitrite

B. Converts nitrate back to nitrogen gas

C. Break down nitrogen in dead bodies to ammonia

D. Convert ammonia to nitrate

68. The main way that AIDS is transmitted is:

A. From an infected mother to her unborn child

B. By using infected blood products

C. Through drug users sharing infected needles

D. Through hetero sexual intercourse

69. All are the ways of reducing the transmission of AIDS except:

A. restricting the number of sexual partners a person has

B. male circumcision

C. not sharing infected needles

D. Female circumcision

70. Which of the following is not a reason for developing a vaccine against HIV/AIDS?

A. it would make individual people immune to AIDS

B. it would help to create a 'herd immunity', protecting people who were not immunized for some reason

C. to produce a cure for people already infected with AIDS

D. it would reduce the spread of HIV/AIDS within communities and across the world

71. Anti-retroviral drugs are drugs that:

A. give someone immunity against AIDS

B. break the life cycle of HIV within a cell

C. stop the transmission of AIDS from person to person

D. prevent other illnesses from developing in someone with AIDS

72. The main distinctive feature of eukaryotic cells:

A. The presence of plasma membrane

B. The absence of membrane bounded organelle

C. The presence of well-defined nucleus

D. The ability to synthesis protein

73. Which of the following organism are found in extreme saline condition?

A. Eubacteria C. Mycobacteria

B. Cyanobacteria D. Archaebacteria

74. Methanogen belongs to:

A. Eubacteria B. Dinoflagellates C. Archaebacteria D. Molds

75. Archaebacteria differ from eubacteria in

A. Cell wall structure C. Cell shape

B. Mode of nutrition D. Mode of reproduction

76. Which of the following are likely to be present in sea vent?

A. Cyanobacteria C. Saprophytic fungi

B. Archaebacteria D. Eubacteria

77. In Prokaryotic, a cellular component that resemble eukaryotic cell is:

A. Plasma membrane B. Ribosomes C. Nucleus D. Cell wall

78. In the light of recent classification of living organisms into three domains of life (Bacteria, Archaea and eukaryote), which one of the following statements is true about archaea?

A. Archaea completely differ from both prokaryotes and eukaryotes

B. Archaea completely differ from prokaryotes

C. Archaea resemble eukaryote in all respects

D. Archaea have some new features that are absent in other prokaryotes and eukaryotes

79. Which of the statement is correct about bacterial transduction?

A. Transfer of some genes from one bacterium to another bacteria through viruses

B. Transfer of genes from one bacterium to another by means of conjugation

C. Bacteria obtained its DNA directly from mother cell

D. Bacteria obtained DNA from other source

80. Organisms which obtain energy by the oxidation of reduced inorganic compounds are called

A. Photoautotrophs C. Saprophytic

B. Chemoautotrophs D. Heterotrophs

81. Difference in gram positive and gram-negative bacteria is due to

A. Cell wall B. Ribosome C. Cell membrane D. Cytoplasm

82. The main role of bacteria in the carbon cycle involves

A. Photosynthesis C. digestion of organic Compound

B. Assimilation of nitrates D. Chemosynthesis

83. Azotobacter is an example of:

A. Pathogenic bacteria C. Symbiotic nitrogen fixer

B. Decomposers D. non-symbiotic Nitrogen fixer

84. Which of the following is not correct about bacteria and eukaryotes?

A. Eukaryotes generally are larger than bacteria

B. Bacteria lack internal compartmentalization

C. Both types of organisms reproduce by mitosis

D. Bacteria are fundamentally single-celled

85. Which of the following is unique feature to Archaea? The

A. Presence of cell wall made from peptidoglycan

B. Presence of cell membrane with no lipid and branched hydrocarbon

C. Abundancy in hostile environment

D. Presence of membrane bounded organelles

86. The following table compares gram negative and gram positive

Characteristic	Gram positive	Gram negative
Peptidoglycan layer	W	Thin
Cell wall composition	Lipoteichoic acid	X
Outer membrane	Y	Present
Retained color	purple crystal	Z

In the above table, W, X, Y and Z can be represented respectively by

A. thick peptidoglycan, present, Crystal violet

B. Thin, teichoic acid, present, purple

C. Thick, Lipoprotein, Absent, counter stain

D. Thick, lipopolysaccharide, present, colorless

87. Which of the following is not found in eubacteria?

A. Nucleoid, plasmid, Ribosome C. Nucleolus, Cellulose, mitochondria

B. Cell wall, Glycocalyx, Chromosome D. Endospore, inclusion, Capsule

88. All bacteria contain

A. Nucleoid B. Endospore C. Capsule D. Pili

89. Spirochaetes are

A. Spherical shaped bacteria C. Corkscrew shaped bacteria

B. Rod-shaped bacteria D. Comma shaped bacteria

90. Which of the following bacterial structure is correctly matched with its function?

A. Flagellum -- maintains the shape of the bacterial cell

B. Pilus -- Adhesion site and means of reproduction

C. Glycocalyx -- specialized appendage that provide locomotion

D. Plasmid -- prevents the cell from bursting during osmosis

91. This item is based on the following steps of gram staining techniques

i. Applying crystal violet
ii. Rapid decolorization
iii. Adding a mordant
iv. Counterstaining
v. Fixation with heat

Which of the following is the correct sequence of staining techniques in gram staining?

A. II, IV, II, I, III C. V, I, III, II, IV

B. B. V, I, II, III, IV D. V, IV, III, II, I

92. Which of the following is the similarities between prokaryotes and eukaryotes?

A. The presence of cytoplasm surrounded by a membrane and cell wall

B. The presence of enclosed genetic material in a nuclear membrane

C. Their ability to involve in nitrogen fixation and denitrification

D. The presence of histone, plastids, lysosome and endoplasmic reticulum

93. The chemical secreted by the lipopolysaccharide portion of some gram-negative bacteria

A. Endotoxin B. Porin protein C. peptidoglycan D. Exotoxin

94. Archaea that inhabit very salty environment is termed as

A. Cryophiles B. Halophiles C. Psychrophiles D. Thermophile

95. Which of the following is sentence is correct about physical factors that control growth of microbes?

A. Obligate aerobic organism can grow under an anaerobic condition

B. Microbes growing with or without oxygen are called facultative microbes

C. Psychrotrophs are microbes that are growing in an extreme high temperature

D. Microbes not using oxygen and sensitive to oxygen are facultative anaerobes

96. Which of the following statement about bacterial mode of nutrition is correct?

A. Chemoheterotrophic bacteria use organic compound as source of energy, electron and carbons

B. Chemo-lithoheterotrophic bacteria extract electrons from reduced organic compounds

C. Photoautotrophs uses light energy and organic carbon as source of carbon

D. Photo organoheterotrophs are bacteria that are nearly all pathogenic

97. Swap of genetic material from the environment into bacteria is termed as

A. Transformation C. Conjugation

B. Transduction D. Transcription

98. The first step in the process of binary fission?

A. Cell wall invagination C. Cytokinesis

B. Cell elongation D. Cross wall formation

99. Chytridiomycota are:

A. Zoospore producing fungi C. Basidiospore producing fungi

B. Mycorrhizal fungi D. Ascospore producing fungi

100. Which of the following is statement about fungi is correct?

A. All fungi contain Coenocytic hyphae C. All fungi are achlorophyllous

B. All fungi are acellular D. All fungal cell contains diploid nuclei

101. Which of the following causes ringworm of beard?

A. Tinea barbae B. Tinea pedis C. Tinea Capitis D. Tinea unguium

102. What do we call a form of poisoning from ingesting grains typically rye, wheat and barley infected by fungus called Claviceps purpurea?

A. Botulism B. Ergotism C. Aflatoxins D. Mycetism

103. Which of the following disease is not transmitted by sexual contact?

A. Candidiasis B. Giardiasis C. Trichomoniasis D. Taeniasis

104. Which of the following statement is true about Chagas Disease? It is

A. African disease C. Caused by parasitic Leishmania

B. A bacterial infection D. Caused parasitic *Trypanosoma cruzi*

105. Which of the following is not the characteristic feature of fungi?

A. Saprophytic B. Autotrophic C. Parasitic D. Symbiotic

106. Which of the following is not an example asexual reproduction in fungi?

A. Conidiospores B. Sporangiospore C. Blastospore D. Basidiospore

107. Which of the following statement is correct about the use of viruses? They are used for

A. Decomposition of dead matter C. treat bacterial infection

B. Detecting mineral in the layers of ores D. anti-tumor agents

108. Which one of the following is true about the feature of viruses?

A. Viruses can be grown on artificial cell free media C. Viruses are inert and filterable agent

B. Viruses are organism that are affected antibiotic D. viruses are cellular parasite of cell

109. Which of the following is the correct sequence of bacteriophage reproductive cycle?

A. Penetration → Attachments → Replication →Assembly → Release

B. Attachments → Replication → Penetration →Assembly → Release

C. Replication → Assembly → Release → Attachments → Penetration

D. Attachments →Penetration→ Replication →Assembly→ Release

110. The following table compare protozoa and fungi. Which of the following is the correct comparison?

	Protozoa	Fungi
A	They are prokaryotic organism	They are eukaryotic organism
B	They lack cell wall	They have cell wall
C	Are all multicellular	Are all multicellular
D	they lack membrane bounded organelle	They consist membrane bounded organelle

111. Which of the following disease is correctly paired with its preventive method?

A. Syphilis – taking vaccination C. Tuberculosis – avoiding overcrowding

B. Malaria -- cooking meat D. Cholera – using bed net

112. Which of the following type of asexual reproduction is not correctly paired with its example of protozoa?

A. plasmodium – Multiple fission C. Paramecium –Transverse binary fission

B. Amoeba – Binary fission D. Bacteria – Longitudinal binary fission

113. Which of the following bacteria convert nitrogen in dead bodies to Ammonia?

A. Denitrifying bacteria B. Putrefying bacteria C. Nitrifying bacteria D. Nitrogen fixing bacteria

114. Which of the following viral disease is not correctly paired with its sign and symptoms?

A. Mumps -- Swollen and painful parotid glands

B. Measles -- Cough, nasal discharge and eye redness

C. Rabies -- Tingling, paralysis and hydrophobia

D. Polio -- Sneezing, sore throat and stuffy nose

115. Which of the following is correct about replication of virulent bacteriophage?

A. Is the life cycle that release viruses without killing the hosts cell

B. Is the life cycle that integrates the viral DNA with host cell DNA

C. Is lysogenic cycle that produces temperate phages that multiplies synchronously with host chromosome

D. Is the phage that undergoes the lytic cycle to produces new phage particles within bacterial cell

116. Plant and animals use nitrogen in the form of :

A. Nitrite B. Nitrate C. Ammonium ion D. Atmospheric Nitrogen

117. Which of the following process do not add carbon dioxide to the atmosphere?

A. Photosynthesis B. Decomposition C. Respiration D. Assimilation

118. How do antiseptics are used to destroy pathogens? By

A. Applying them on cut skin or wound C. Dry heat application in special oven

B. Applying them on inanimate objects D. Taking them into the body

119. The genus of bacteria that involves in Sulphur oxidation and increase the availability of sulphate in the soil?

A. Thiobacillus B. Desulfovibrio C. Pseudomonas D. Cyanobacteria

120. Which of the following is not correct about the contribution of Rober Koch?

A. He proved that all microorganism can causes disease

B. He discovered causative agent of anthracis and tuberculosis

C. He proved diseases are caused by microorganism

D. He stated the germ theory of disease

121. Which of the following diseases can be caused by more than types of agents?

A. Botulism B. Cholera C. Gastroenteritis D. Tuberculosis

ANSWER KEY TO EXERCISE ELEVEN ON MICROORGANISM

1. D	16.B	31.D	46.D	61.D	76.D	91. C	106. A	121.D
2. C	17.D	32.D	47.B	62.A	77.C	92.C	107.C	122.D
3.A	18.A	33.C	48.C	63.D	78.B	93.C	108.A	123.B
4.C	19.B	34.A	49.C	64.A	79.C	94.C	109.B	124.A
5. A	20.B	35.B	50.B	65.A	80.D	95.A	110.B	125.A
6.D	21.C	36. D	51.C	66.A	81.C	96.C	111.D	126.A
7.B	22.B	37. A	52.B	67.C	82.A	97.B	112.B	127.A
8.D	23.B	38.C	53. C	68.A	83.B	98.C	113.D	
9.A	24.C	39.D	54. C	69.C	84.A	99.A	114.D	
10.C	25.D	40.A	55. C	70.D	85.D	100.A	115.C	
11.A	26.C	41.A	56. C	71.D	86.A	101.B	116.D	
12.A	27.A	42.C	57. D	72.B	87.B	102.B	117.B	
13.B	28.D	43.C	58. B	73.B	88.A	103.A	118.C	
14.A	29.A	44.D	59. D	74.A	89.C	104.A	119.D	
15.A	30.B	45.C	60. A	75.D	90.D	105.B	120.B	

THEME 3: CELL BIOLOGY

1.7. The Microscope

Learning Competencies: At the end of the topic students will be able to:

- ♣ Name different types of microscopes
- ♣ Distinguish between the magnification and resolution of a microscope.
- ♣ State the functions of different types of microscopes.
- ♣ Explain the purpose of staining cells.
- ♣ Compare the way materials are prepared for the electron microscope and the light microscope.

Microscope is an instrument used for magnifying and resolving specimens. Each type of microscope has its strengths and is chosen based on the specific requirements of the study, including the level of magnification needed, the type of specimen being observed, and the information desired from the images or data collected. Microscopes are essential tools in biology for observing and studying microscopic organisms, cells, tissues, and structures. There are several types of microscopes, each with its own specific uses and capabilities:

A. **Light Microscope (LM):**
- ❖ Also known as an optical microscope.
- ❖ Uses visible light and lenses to magnify specimens.
- ❖ Can magnify up to about 2000 times.
- ❖ Suitable for observing living organisms and stained or unstained cells and tissues.
- ❖ limit of resolution for optical microscopes is approximately 200nm (0.2micrometer) (1 nm = 1 × 10–9 m).
- ❖ Do not show detail structure of the cell
- ❖ Resolving power is limited by the wave length of light
- ❖ Have very low magnification: unto 10 times and low resolution
- ❖ Requires thin stained specimen for clear vision
- ❖ Show dead and living cell
- ❖ Not need vacuum
- ❖ The human eye can resolve down to about 0.1mm.

B. **Compound Microscope:**
- ❖ A type of light microscope that uses multiple lenses to achieve high magnification.
- ❖ Typically used in biological research and education.
- ❖ Allows observation of cells, tissues, and small organisms.

C. **Electron Microscope (EM):**
- ❖ Uses electron beams instead of light to achieve much higher magnification and resolution. Resolves about 1000 X

- than light microscope
- It uses electromagnetic instead of glass lenses.
- Due to short wavelength of electrons, it produces a very high-resolution image up to 2,000,000 times and revealing ultrastructural details of cells, viruses, and molecules.
- Resolves specimen up to 0.2nm apart
- Show detail structure of the cell of Only dead and need vacuum
- Samples are fixed, stained and sliced very thinly in a similar way to the preparation of samples for the light microscope but the materials and stains used are very different
- Includes:
  - ✓ **Transmission Electron Microscope (TEM):** Are the first types to be developed. Allows detailed internal structures of cells and tissues to be observed. Have greater resolving power compared to SEM. Its imaging is based on transmitted electrons. It produces 2-D image. It produces information about morphology only. Need a very thin sample.
  - ✓ **Scanning Electron Microscope (SEM):** Provides detailed surface images of specimens. It produces a 3-D image. Its imaging is based on emitted and scattered electrons. A thicker sample can be processed. It can resolve objects as close as 20nm. Comparatively lower magnification

Limitation of electron microscope

- ✓ Highly expensive and complex system
- ✓ Need of vacuum of system
- ✓ TEM requires very thin specimen
- ✓ Images are in black and white

D. Dissecting microscope

- A microscope that uses lights reflected from the surface of specimen to produce an image of low magnification
- It is primarily used during dissecting and viewing dissected specimens
- Can view 3-D objects

E. **Phase Contrast Microscope:**

- Enhances the contrast of transparent and colorless specimens without staining.
- Useful for observing living cells, including bacteria and protists, in their natural state.

F. **Fluorescence Microscope:**

- Uses ultraviolet light to excite fluorescent dyes within a specimen.
- Produces fluorescence (visible light) that reveals specific structures or molecules within cells.
- Enables visualization of cellular structures, proteins, and genetic material.

G. **Confocal Microscope:**

- Uses a laser beam to scan multiple layers of a specimen.
- Produces a 3-dimensional image by reconstructing the scanned layers.
- Provides detailed images of cells and tissues, useful in biomedical research.

H. Dark field microscope

- ❖ Uses only the light scattered by the specimen for producing a bright image with darkfield around the specimen.
- ❖ Produces a higher resolution and better contrast than a bright field microscope.
- ❖ There is no need to stain the specimen
- ❖ Used in microbiology to observe motility and spirochetes and thin bacteria
- ❖ Used to study internal organelles

I. **Scanning Probe Microscope (SPM):**

- ❖ Uses a physical probe to scan the surface of a specimen.
- ❖ Includes types such as Atomic Force Microscope (AFM) and Scanning Tunneling Microscope (STM).
- ❖ Used to study surfaces at the atomic and molecular levels.

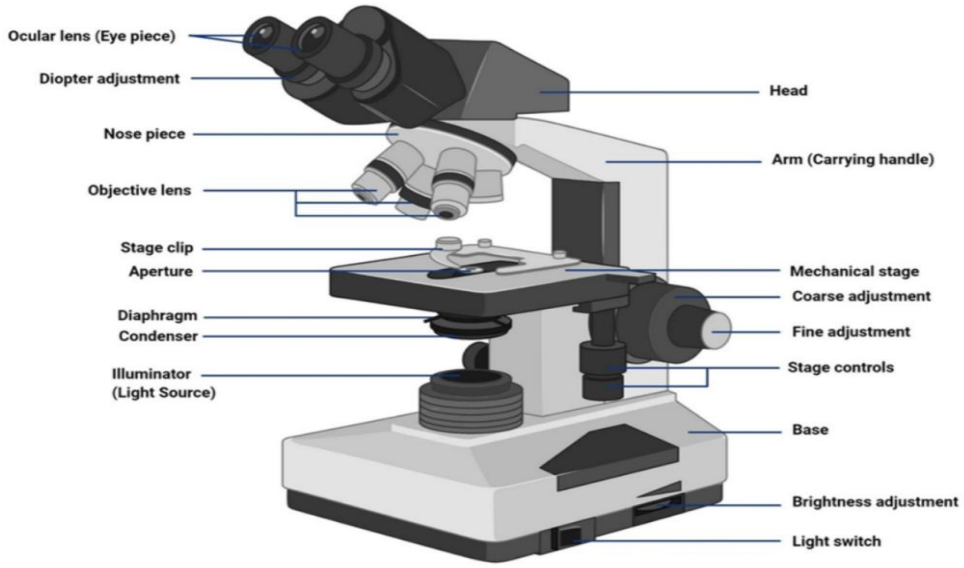


Figure 2. Structure of compound microscope

What is the purpose of staining cell?

- ➢ To enhance visualization of the cell or components of cell under microscope
- ➢ To study the stage of cell division
- ➢ To differentiate between live and dead cells in a sample
- ➢ to determine cell shape, size and arrangement

Example of stain and cell it stains

- ✦ Iodine – plant cell

- ✦ Methylene blue—animal cell
- ✦ Hematoxylin and Acetocarmine – animal and plant cell

EXAMPLE OF REVIEW EXERCISE

Choose the correct answer from the given alternatives

1. Which of the following part of the microscope is correctly matched with its function?
   A. Diaphragm -- used to magnifies the image for the viewer
   B. Base -- platform where the slide with the specimen is place
   C. Nosepieces -- allows the user to switch between different objective lens
   D. Eyepiece -- used for focusing clear image under microscope

   Explanation: Parts of microscope and its function

   Base – support the microscope

   Arm - used to carry microscope

   Stage clips – used to hold slide on the stage

   Eyepiece – magnify the image for the viewer

   Nosepiece – used to switch between different objective lenses

   Coarse adjustment knob – used for focusing the image under low-power = general focusing

   Fine adjustment – smaller knob used for focusing image with the medium and high-power objectives = fine focusing

   Diaphragm – controls the amount of light that passes through the specimen

2. Which part of the microscope should you hold when lifting or moving the microscope?
   A. Eyepiece and body tube C. The base and stage
   B. Arm and base D. Objectives and Diaphragm

   Explanation: Base and Arm is used to carry microscope

3. When using the high-power objective, what adjustment should not be used?
   A. Coarse adjustment knob C. Fine-adjustment knob
   B. Ocular lens adjustment D. Stage clip adjustment

Explanation: Never, ever use the coarse adjustment with the high-power objective. This could break the lens. Therefore, use the fine focus knob to increase the resolution your specimen. It can bring the image to higher clarity.

4. Which of the following is the advantage of electron microscope?
   A. All the specimens are examined in a vacuum
   B. They are kept in a separate room
   C. They rely on a constant source of electricity
   D. gives us much higher magnification and resolution.

   Explanation: the main advantage of electron microscope is that its magnification and resolution power which allowed biologist to study detail of cells structure and how they work.

5. Which of the following is not an advantage of the light microscope?
   A. It is relatively cheap
   B. It can be used anywhere without electricity.
   C. Its resolving power is limited by the wavelength of light.
   D. It is relatively light so can be carried out into the field for research.

Explanation: disadvantage of light microscopes is

- Their resolving power is limited by the wavelength of light. This limits their power of magnification.
- Also, we can't usually magnify living cells as much as we can dead tissue, which limits what we can learn from living cells.

Assignment

Q1. List ten steps /procedures used to focus specimen under light microscope

Q2. Describe the proper care of the microscope

3.2. The cell

Learning Objectives

- state the cell theory.
- list the structure of cells and describe their function.
- Explain the difference between prokaryotic and eukaryotic cells

- Label diagrams and compare plant and animal cells.
- Describe the composition and arrangement of lipids and proteins in the membrane.
- Compare the Davson –Danielli and fluid mosaic models.
- Explain the role of glycoprotein and other components in the cell membrane.

  What is cell?

  Cells: - are the basic structural and functional units of all living organisms.

The history of cell

- ✓ The cell was first discovered by Robert Hooke in 1665, which can be found to be described in his book Micrographia. In this book, he gave 60 observations in detail of various objects under a course, compound microscope. One observation was from very thin slices of bottle cork.

The History of Cell Biology Timeline

Below is a timeline of some of the key events in the development of cell theory and cell biology.

1595 – Jansen is credited with the first compound microscope.
1655 – Hooke described 'cells' in cork.
1674 – Leeuwenhoek discovered protozoa. He saw bacteria some nine years later.
1833 – Brown described the cell nucleus in cells of the orchid.
1838 – Schleiden and Schwann proposed cell theory.
1858 – Rudolf Virchow expounds his famous conclusion: *omnis cellula e cellula*, that is, cells develop only from existing cells (cells come from preexisting cells).
1857 – Kolliker described mitochondria.
1879 – Flemming described chromosome behavior during mitosis.
1883 – Germ cells are haploid, chromosome theory of heredity.
1898 – Golgi described the Golgi apparatus.
1938 – Behrens used differential centrifugation to separate nuclei from cytoplasm.
1939 – Siemens produced the first commercial transmission electron microscope.
1952 – Gey and coworkers established a continuous human cell line.

1955 – Eagle systematically defined the nutritional needs of animal cells in culture.

1981 – Transgenic mice and fruit flies are produced. Mouse embryonic stem cell line established.

1998 – Mice are cloned from somatic cells.

5. 3.2.1. Cell Theory

The cell theory, which describes the fundamental unit of life as the cell, has evolved through several key discoveries and contributions over time. Here is a brief history of the development of cell theory:

1. **Robert Hooke (1665):**
   - ✓ Robert Hooke, an English scientist, used a primitive compound microscope to examine thin slices of cork.
   - ✓ He coined the term "cell" when he observed small box-like structures and likened them to the cells (Latin: cella) of a monastery.
2. **Anton van Leeuwenhoek (1674-1723):**
   - ✓ Anton van Leeuwenhoek, a Dutch scientist, improved the microscope and made detailed observations of single-celled microorganisms, which he called "animalcules."
   - ✓ His discoveries challenged the notion that organisms could be too small to see and laid the foundation for microbiology.
3. **Matthias Schleiden (1838):**
   - ✓ Matthias Schleiden, a German botanist, observed that all plants are composed of cells.
   - ✓ He proposed that the cell is the basic unit of plant structure and development.
4. **Theodor Schwann (1839):**
   - ✓ Theodor Schwann, a German physiologist, extended Schleiden's work to animals.
   - ✓ Schwann concluded that animals, like plants, are composed of cells.
   - ✓ Together with Schleiden, he formulated the first two tenets of cell theory.
5. **Rudolf Virchow (1855):**
   - ✓ Rudolf Virchow, a German pathologist, proposed the third tenet of cell theory: that cells arise only from pre-existing cells (omnis cellulae cellula).
   - ✓ Virchow emphasized cellular reproduction as a fundamental process in living organisms.

These foundational contributions by Hooke, Leeuwenhoek, Schleiden, Schwann, and Virchow established the principles of cell theory:

- ✓ All living organisms are composed of one or more cells.
- ✓ The cell is the basic structural and functional unit of life.
- ✓ Cells arise from pre-existing cells through cell division.

Cell theory revolutionized biology by providing a unifying framework to understand the organization, behavior, and diversity of living organisms. Subsequent advancements in microscopy, biochemistry, and genetics have further refined our understanding of cells and their role in life processes.

The Cell Theory was first given by M.J Schleiden and Theodor Schwann in 1839. It states that all the living beings whether plants or animals are composed of cells that are from pre-existing cells. However, they failed to explain how new cells are formed.

Modern Cell theory

- ➢ all known living things are made up of cells
- ➢ the cell is a structural and functional unit of all living things
- ➢ All cells come from pre-existing cells by division (there is no spontaneous generation of cells)
- ➢ cells contain hereditary information which is passed from cell to cell during cell division
- ➢ all cells have basically the same chemical composition
- ➢ all energy flow (the metabolism and biochemistry of life) occurs within cells

3.2.2. Types of Cells

Prokaryotic Cells:

- ➢ Typically, smaller and simpler in structure.
- ➢ They lack membrane-bound organelles and a defined nucleus. They may have some internal structures like ribosomes, but these are not enclosed within membranes.
- ➢ Their genetic material (DNA) is located in the nucleoid region, not enclosed within a nuclear membrane.
- ➢ Have a single, circular chromosome. They may also contain plasmids, which are small, circular DNA molecules.
- ➢ They reproduce through binary fission, a form of asexual reproduction where the cell divides into two identical daughter cells.

Eukaryotic Cells:

- They are either single celled or multicellular, larger and more complex.
- They have membrane-bound organelles such as mitochondria, endoplasmic reticulum, Golgi apparatus, and a well-defined nucleus that houses the genetic material (DNA) within a nuclear envelope.
- Have a distinct nucleus enclosed by a double membrane (nuclear envelope) that separates the DNA from the cytoplasm.
- They have multiple linear chromosomes composed of DNA and associated proteins (histones).
- The genetic material is organized into chromosomes within the nucleus.
- They reproduce through mitosis (for somatic cells) or meiosis (for gametes), processes involving nuclear division and subsequent cytokinesis.

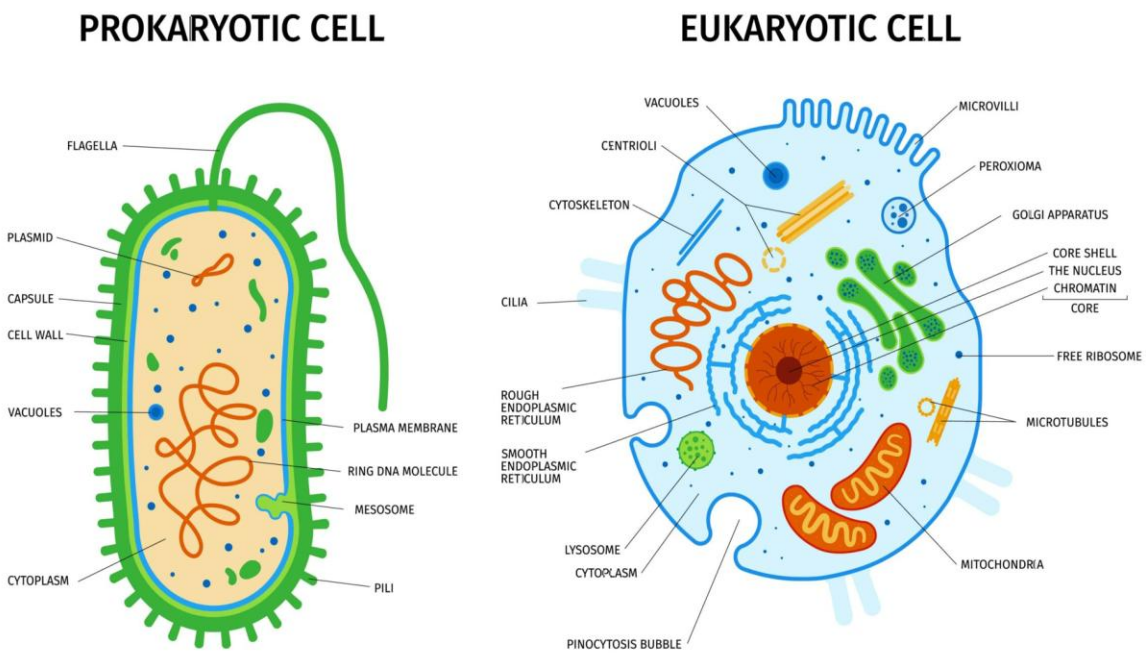


Figure 3. General structure of prokaryotic and eukaryotic cell

Parts of the cell and its function

Plasma membrane

- ✓ It is a living layer of the cell that act as selectively permeable membrane
- ✓ Controlling what enters and leaves the cell; the plasma membrane moves substances in and out of the cell by: simple diffusion, facilitated diffusion, osmosis, active transport, endocytosis, exocytosis

- ✓ Also serve as cell signaling; various molecules in the membrane allow the cell to be recognized by hormones and the immune system (in animals) and (in plants) growth regulator substances, such an auxin.
- ✓ The plasma membrane clearly has a vital role in isolating the cell from its environment, whilst allowing necessary exchanges with that environment.

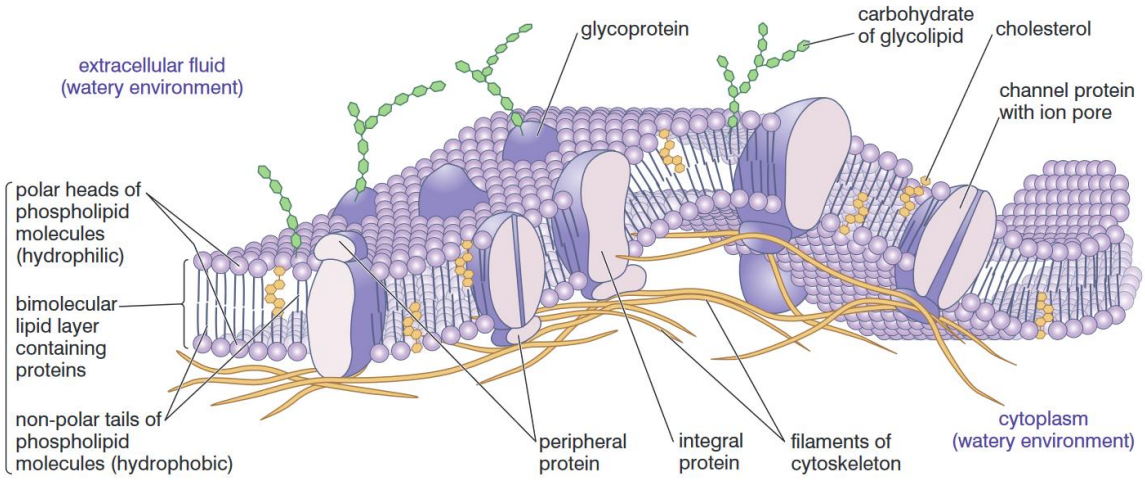


Figure 4. The component of the current cell membrane

Integral proteins: also known as intrinsic proteins and trans-membrane proteins that span the membrane. These proteins play an important role in moving substances across the membrane. The main types of these transport proteins are: C**hannel proteins** – these proteins have a channel through them along which a specific ion can pass; there are different channel proteins for different ions. **Carrier proteins** – these proteins that move larger molecules through the membrane by facilitated diffusion or active transport; the ones involved in active transport are often referred to as pumps.

Peripheral proteins are proteins that span only one layer (or sometimes less) of the membrane. Serve as enzymes, others anchor integral proteins to the cytoskeleton.

Glycoproteins and glycolipids – protein and lipid molecules that have carbohydrate chains attached to them and often serve as signals to other cells. They also act as receptor sites for hormones and drugs. The carbohydrate component of each can be cell-specific and so allow identification of the cell by the immune system.

Cholesterol: reduces the fluidity of the membrane.

Mitochondria

- ✓ organelles that contain oxidative metabolism enzymes for transferring the energy within macromolecules to ATP
- ✓ also called the Power house of the cell where cellular respiration takes place
- ✓ it is found in all types of eukaryotic cells
- ✓ it is surrounded by 2 membranes: smooth outer membrane and folded inner membrane with layers called **cristae and matrix** is within the inner membrane
- ✓ **Inter-membrane** space is located between the two membranes
- ✓ It contains their own DNA

Microbodies

- ➢ membrane bound vesicles
- ➢ contain enzymes
- ➢ Is not part of the endomembrane system
- ➢ **glyoxysomes** in plants contain enzymes for converting fats to carbohydrates
- ➢ **Peroxisomes** contain oxidative enzymes and catalase

Vacuoles

- ✓ Is a membrane-bound structures with various functions depending on the cell type
- ✓ Used for keeping the cells rigid to support the plant.
- ✓ It is filled with cell sap that maintain pressure against cell wall

Table 5. summary of some organelles and their function

Cellular organelle	Function
Nucleus	controls all the activities of the cell
Chloroplast	Site of photosynthesis
Ribosome	Site of protein synthesis
Cytoplasm	A liquid gel where most of the chemical reactions take place
Endoplasmic reticulum	links the nucleus with the cell membrane
Rough endoplasmic reticulum	responsible in transporting proteins
Smooth endoplasmic reticulum	serves in lipids synthesis
Golgi apparatus	responsible in modifying proteins brought by ER, Packages proteins for export from cell; forms secretory vesicles
Lysosome	Digest worn-out organelles and cell debris; play role in cell death
Nucleolus	Site of genes for rRNA synthesis Assembles ribosomes
Plastids	Stores pigments. Non-living layer that maintains the shape of plant and bacterial cell

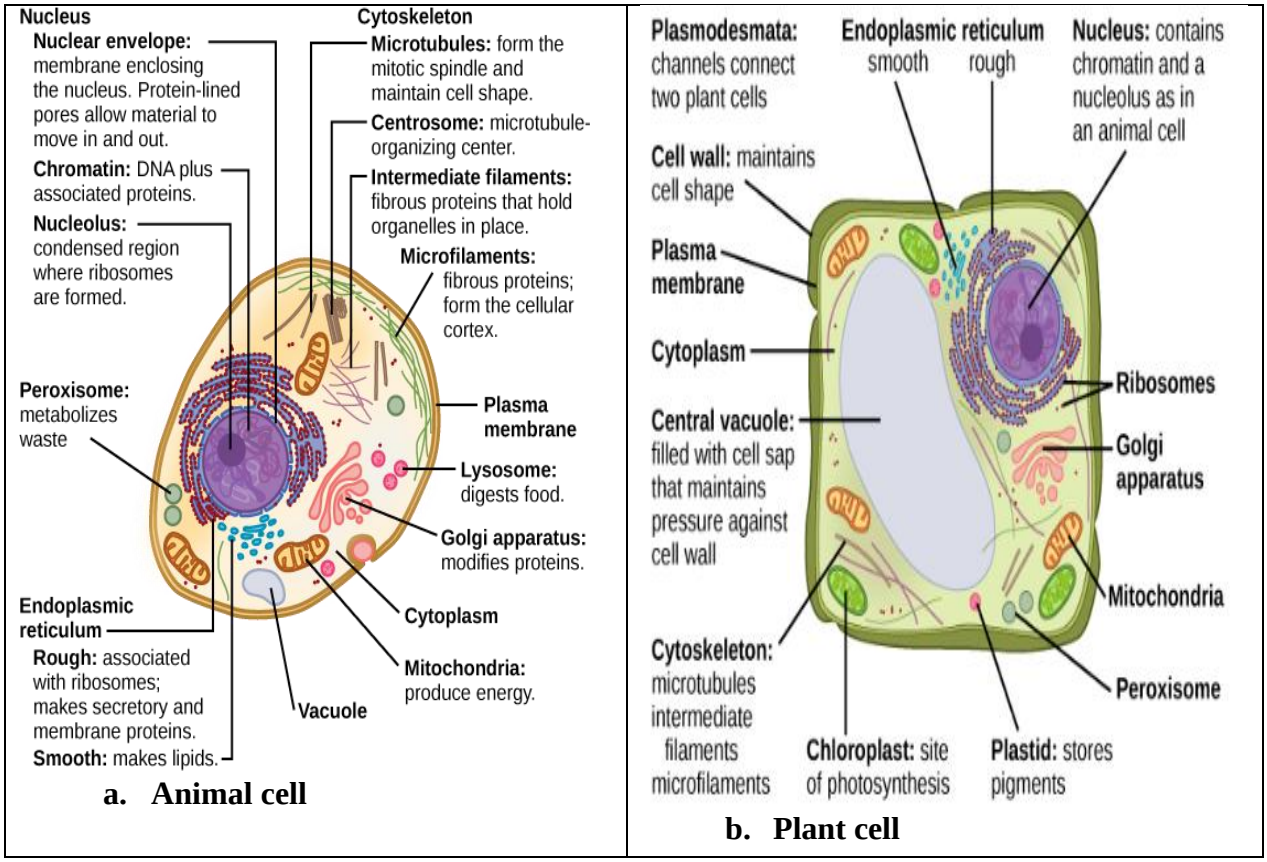


Figure 5. Structure of animal and plant cell

Summary

Microscopes are essential tools in biology for observing and studying microscopic organisms, cells, tissues, and structures. The specimens are stained to enhance visualization of the cell or components of cell under microscope. Cells are the basic structural and functional units of all living organisms. Several biologists involved in the development of the concept of cell. For instance, the contributions of Hooke, Leeuwenhoek, Schleiden, Schwann, and Virchow was crucial since they established the principles of cell theory: Modern cell theory also includes the ideas that: cells contain hereditary information which is passed from cell to cell during cell division. All cells have basically the same chemical composition. All energy flow (the metabolism and biochemistry of life) occurs within cells. There are two basic type of cell such as: prokaryotic and eukaryotic cell. prokaryotic cells are simpler in structure, lack membrane-bound organelles and a nucleus, and are generally smaller than eukaryotic cells. Eukaryotic

cells are more complex, contain membrane-bound organelles including a nucleus, and are larger in size. Endosymbiont theory states that modern' eukaryotic cell was formed when several of the more primitive prokaryotic cells 'got together'. Cell consists different component with specific function. For instance, nucleus controls all the activities of the cell, chloroplast act as site of photosynthesis. Cell membrane act as partially permeable membrane.

SELF TEST ACTIVITY

1. Describe how molecules across the plasma membrane
2. List the main difference between plant and animal cell
3. List organelles that contain membrane and lack membrane

EXAMPLE OF REVIEW EXERCISE

1. Which of the following is not correct about Anton van Leeuwenhoek?
   A. He observed the first dead cell from the bark of tree
   B. He observed bacteria from his teeth with his microscope
   C. He coined small organism that move on the water bodies as animalcules
   D. His microscope magnifies relatively over 300X

E**xplanation:** Anton van Leeuwenhoek observed moving protoctistans in a drop of water and He calls the moving organisms 'animalcules. He also sees bacteria (from his teeth), which he also calls 'tiny animalcules'.

2. The surface area to volume ratio of a cell is important because it is a measure of:
   A. How efficiently the cell releases energy in respiration
   B. How efficient the cell is in conserving energy
   C. How efficient the cell is in obtaining the oxygen it needs for respiration
   D. How efficiently the cell uses the energy it releases in respiration

Explanation: the volume determines how much activity there is in a cell. A large cell will have more processes and the amount of energy released in respiration is determined largely by volume. The amount of oxygen that can be delivered into the cell is decided largely by how much 'surface' there is. Therefore, large SA/V ratio mean that the surface will be able to supply the oxygen demand of the cell.

3. Students in a biology laboratory were asked to view certain cells microscopically and measure the size of a single cell. They were given a compound microscope with an eyepiece of 15X magnification and an objective lens of 10X magnification. The eyepiece has a scale with a least count of 10 μm. When the students focused the cells under the given microscope, they found that one cell measured 60 divisions on the eyepiece scale. What is the approximate size of that cell?

   A. 0.47 μm B. 2.8 μm C. 4.0 μm D. 24 μm

   Explanation: The eyepiece has a scale with the count of 10μm, that is 1 ocular division = 10μm. Under the microscope, one cell measures 60 divisions. Hence, the size of the cell under a microscope will be 60 x 10 = 600 μm. Compound microscope is having an eyepiece of 15X magnification and an objective lens of 10X magnification. Hence, compound microscope is having magnification of 15 x 10 = 150 times. Hence, the original size of the cell will be 600/150 = 4 μm

4. If the cell size increase

   A. Surface area of the cell decrease
   B. Volume of the cell increase faster than its surface area
   C. The ratio of surface area to volume increase
   D. The surface area of the cell double faster than volume of the cell

Explanation: As cell increase in size, the volume increases faster than the surface area and SA/V ratio decrease. The size of the cell is measured with the size of cube

SA= l X h Volume = S^3

5. Why is surface area to volume ratio important for all cells?

   A. A cell must be small enough to absorb small molecules and atoms
   B. If a cell has too small a surface area, the surface to volume ratio will be too large
   C. If a cell has too large a surface area to volume ratio, the plasma membrane is not sufficient to deal with the increased amount of cytoplasm
   D. Surface area to volume ratios is only important for small cells, like bacteria

   Explanation: Surface area refers to the space on the external surface of a structure, while volume is the amount of space inside the structure. For a cell, the plasma membrane represents the surface area and the cytoplasm represents the volume. If a cell has too large a surface area to volume ratio, the plasma membrane is not sufficient to deal with the increased...

6. If the size of a cell doubles what will be the surface area to volume ratio?

   A. 8 to 4 B. 4 to 8 C. 16 to 4 D. 16 to 8

Explanation: The size of a cell depends on many factors, one of the most important of which is the surface area to volume ratio. This ratio changes drastically depending on cell type. Generally, the size of a cell doubling will result in a higher ratio of volume to surface area, meaning the correct answer is 4 to 8.

7. Consider a prokaryotic cell of a certain size (cell A). Assume the cell is cube shaped. If you doubled the dimensions of the sides of the cell to produce Cell B, which of the following statements would be true?
   A. The membrane surface area to volume ratio of Cell A would be approximately half that of Cell B.
   B. The membrane surface area to volume ratio of Cell A would be approximately one quarter that of Cell B.
   C. The membrane surface area to volume ratio of Cell A would be approximately twice that of Cell B.
   D. The membrane surface area to volume ratio of Cell A would be approximately four times that of Cell B.

   Explanation: Biological systems (such as a cell) prefer to have large surface area to volume ratios (SA: V) as this creates the most efficient unit. Such SA: V are achieved with small units. Here, transport and membrane exchange is most rapid.
8. Centrifugation is not employed in which of the following processes?
   A. To squeeze out water from wet clothes
   B. For blood and urine tests
   C. To separate butter from cream
   D. Different pigments from an extract of flower petals

      Explanation: Chromatography is used to separate distinct pigments from a floral extract in a fine manner.
9. In centrifugation, which of the following force is not used?

   A. Electrostatic force B. Gravitational force C**.** Centripetal force D. Centrifugal force

   Explanation: A centrifuge separates substances by rotating at high speeds, employing the strength of centripetal force and the apparent centrifugal force. Since a centrifuge works by using the principle of sedimentation therefore it works under the influence of gravitational force that separates substances according to their density.

SELF TEST EXERCISE THREE

Choose the best answer from the given four alternatives

1. Which of the following statement is true about the cell theory?
   A. All living organism are composed of many cells
   B. Living organism need food to get energy
   C. The cell is the basic unit of life
   D. Living organism have similar characteristics
2. Which of the following cellular principle was contributed by Rudolf Virchow?
   A. The cell is the basic unit of all structures.
   B. All cells arise only from pre-existing cell
   C. Tissues are composed of similar cells.
   D. All organisms consist of one or more cells
3. The first compound microscope was made in 1595 by the Dutch scientist
   A. Zaccharias Jansen C. Antoni van Leeuwenhoek
   B. Robert Hooke D. Rene Dutrochet
4. Centrifugation involves:
   A. Letting a mixture separate out using gravity
   B. Spinning the mixture at a very high speed
   C. Using different boiling points to separate the components
   D. Using a filter paper or a sieve to separate the components
5. Cell fractionation is used for separation of
   A. Liquids C. Cellular components
   B. Cell membranes D. Macromolecules
6. Cell vacuole contains
   A. Water C. cytoplasm
   B. dissolved substances D. water and metabolic wastes
7. Which of the following cell organelles provides turgidity and rigidity to the cell?
   A. Smooth Endoplasmic Reticulum
   B. Golgi bodies
   C. Vacuole
   D. Rough Endoplasmic Reticulum
8. Which of the following cell organelles is not associated with the synthesis of comparatively complex molecules from simpler molecules?
   A. Chloroplast B. Lysosome C. Endoplasmic Reticulum D. Golgi body
9. The function of centriole is_____.

A. DNA synthesis
B. Spindle formation
C. Reproduction
D. Respiration

10. This item is based on the table given below

Cell organelle	Function
Nucleolus	I
II	Synthesis and transport of protein and fat
III	Synthesis and secretion of enzymes and hormones
Ribosome	Iv
V	Intracellular digestion

Which of the following show the correct description of I, II, III, IV and V respectively?

A. (i) Produces ribosomes (ii) Endoplasmic reticulum (iii) Golgi bodies (iv) Protein synthesis (v) Lysosomes
B. (i) Protein synthesis (ii) Endoplasmic reticulum (iii) Golgi bodies (iv) Produces ribosomes (v)Lysosomes
C. (i)Protein synthesis (ii) Endoplasmic reticulum (iii)Lysosomes (iv) Produces ribosomes(v)Golgi bodies
D. (i)Protein synthesis (ii)Lysosomes (iii)Endoplasmic reticulum (iv) Produces ribosomes (v)Golgi bodies

11. Which of the following cellular organelles have no membrane
A. ribosome, chloroplast, endoplasmic reticulum, Golgi body
B. Centrioles, ribosomes, nucleolus and centrosome
C. Plastids, Peroxisome, cell and cell membrane
D. Nucleus. mitochondria, chloroplast

12. Which of the following is correctly paired with its function?
A. Mitochondria -- Controls entry and exit of substances from cell
B. Ribosomes -- Modifies structure of protein molecule
C. Cell membrane -- Gives cell support and rigidity
D. Smooth endoplasmic reticulum – main site for lipid biosynthesis

13. Bacterial cell wall and plant cell wall are
A. Similar in function and composition
B. Different in function and composition
C. Similar in function but different in composition
D. Similar in composition but different in function

14. Which of the following is not true about Rene Dutrochet? He
A. Explained the passage of solvents through semi permeable membrane
B. Recognized the need of chlorophyll in the process of photosynthesis

C. Is known for his disproving the theory of spontaneous generation

D. Showed that gas exchange in plants was through stomata on the surface of leaves

15. Which of the following organelles does not have membrane?

A. Chloroplast B. Ribosome C. Nucleus D. Mitochondria

16. Which of the following organelles does not contain RNA?

A. Plasmalemma B. Nucleolus C. Ribosome D. mRNA

17. The first cell theory stated by Schleiden and Schwann was not completely accurate because it held that:

A. all living things are made of cells C. the cell is the basic unit of living things

B. the cell retains a dual existence D. cells form by cell-free formation

18. Which of the following is the smallest relative to others?

A. Muscle cell B. Egg cell C. Ribosome D. Mitochondria

19. All single celled organism is belonging to domains of

A. Fungi and Algae C. Bacteria and Archaea

B. Protista and Plantae D. Plants and Animalia

20. The cell wall of prokaryotic cell is composed of

A. Cellulose B. Peptidoglycan C. Chitin D. Exoskeleton

21. If eight cells fit across the field of view with two mm, what is the size of each cell in micrometer?

A. 0.25-meter B. 2500 micrometer C. 250 micrometer D. 25 mm

22. Suppose you want to measure the SA/V ratio of the cell in a cube with linear dimension of 4 cm, what is the surface area to volume ratio of this cell?

A. 4: 1 B. 3: 1 C. 1.5: 1 D. 2: 1

23. Suppose you were asked to view certain cells microscopically and measure the size of a single cell. You were given a compound microscope with an eyepiece of 20X magnification and an objective lens of 10X magnification. The eye piece has a scale of 10 μm. When you focused the cells under the given microscope, you found that one cell measured 60 divisions on the eyepiece scale. What is the approximate size of that cell?

A. 0.57 μm B. 8 μm C. 3.0 μm D. 24 μm

24. Which one of the following statements is not correct about prokaryotic cells?

A. They do not have membrane bound organelles

B. Their genetic material is called a nucleoid

C. They do not have a well-defined nucleus

D. Their outermost layer is called plasma membrane

25. Four divisions on the scale of an eyepiece graticule correspond to 16 small divisions on the stage micrometer. Each small division on the stage micrometer = 10 μm. 4 cells fit across 40 divisions of the eyepiece graticule. The length of each cell is:

A. 10 μm B. 40 μm C. 40 mm D. 10 mm

26. Cube A has a side measuring 3 mm. Cube B has a side measuring 12 mm. The surface-area-to-volume ratio of cube A. when compared to cube B is:
    A. two times bigger C. two times smaller
    B. four times smaller D. four times bigger

27. DNA in prokaryotic cell
    A. linear and bound with proteins C. circular and not bound with proteins
    B. linear and not bound with proteins D. circular and bound with proteins

28. Endosymbiont theory is the theory of;
    A. the origin of eukaryotic cells C. the relationship between fungi and bacteria
    B. The origin of life on earth D. the origin of prokaryotic cell

29. The word 'cell' was first coined by Robert Hooke when he examined:
    A. Living cells in cork tissue C. dead cells in skin
    B. Dead cells in cork tissue D. living cells in skin

30. Sedimentation principle is involved in
    A. Chromatography B. Crystallization C. Centrifugation D. Sublimation

ANSWER KEY FOR SELF PRACTICE EXERCISE TWO ON UNIT TWO

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

3.4. ENZYMES

3.4.1. What are enzymes?

- ✓ Enzymes are **biological catalysts**, typically proteins, that accelerate chemical reactions in living organisms. They lower the **activation energy** required for a reaction.
- ✓ **Activation energy** is the **minimum energy** required to initiate a chemical reaction. It is the energy needed to break bonds in the reactants so that new bonds can form to create the products of the reaction.
- ✓ Enzymes speed up reactions by lowering the **activation energy** the energy required to break bonds and start a reaction. Enzymes achieve this by: putting stress on certain bonds, making them easier to break. Enzyme active sites often create acidic or basic conditions that is more conducive to the reaction. Enzyme helps bring the substrate molecules into close proximity and in the correct orientation for the reaction to occur.
- ✓ Enzymes are not consumed in the reaction, meaning they can be reused multiple times. They often require cofactors (inorganic ions) or coenzymes (organic molecules, like vitamins) to function properly. Enzymes are specialized proteins that bind to specific substrates and facilitate biochemical reactions by stabilizing the transition state, lowering activation energy, and being recycled after each reaction.

Properties and functions of enzymes

Physical Properties of Enzymes:

- ✓ **Size and Molecular Weight**: Enzymes are large, macromolecular proteins, with molecular weights ranging from a few thousand to millions of Daltons.
- ✓ **Shape and Structure:** Enzymes have a three-dimensional structure critical for their specificity and function, with an active site where substrates bind.
- ✓ **Solubility:** Most enzymes are water-soluble,
- ✓ **Thermal Sensitivity**: Enzymes have an optimal temperature range, and their activity decreases with temperature extremes.
- ✓ **Denaturation**: Enzymes lose their structure and function when exposed to extreme temperature or pH.

- ✓ **PH Sensitivity:** Enzymes have an optimal pH range, and changes in pH can affect their activity.
- ✓ **Stability**: Enzyme stability can vary depending on environmental factors like temperature, pH, and the presence of inhibitors.
- ✓ **Binding Affinity**: Enzymes vary in their affinity for substrates, which affects the efficiency of the enzyme-substrate interaction.
- ✓ **Isoenzymes:** Different forms of an enzyme that catalyze the same reaction but may differ in physical properties, helping to regulate enzyme activity.
- ✓ **Colloidal nature:** refers to a state of matter in which one substance is dispersed throughout another in the form of fine particles or droplets. These particles do not settle out due to gravity and are stable in suspension, and they exhibit characteristics such as the **Tyndall effect** (scattering of light). Enzymes in solution are **stable** colloids under optimal conditions
- ✓ **Biocatalysts**: Enzymes speed up biochemical reactions without being consumed.
- ✓ **Precipitation**: Enzymes can be precipitated using salts, solvents, or temperature changes.
- ✓ **Enzyme Activity**: Their efficiency depends on factors like temperature, pH, and substrate concentration.

Chemical Properties of Enzymes:

- ➢ **Active Site Specificity:** Enzymes have a specific active site that allows them to recognize and bind to particular substrates through chemical interactions.
- ➢ **Catalytic Mechanism:** Enzymes accelerate reactions by stabilizing the transition state and lowering activation energy, using mechanisms like acid-base catalysis, covalent catalysis, and metal ion involvement.
- ➢ **pH and Ionic Sensitivity**: The chemical properties of enzymes, including their ionizable amino acid residues, make them sensitive to changes in pH, which can affect enzyme activity.
- ➢ **Cofactors and Coenzymes:** Many enzymes require cofactors or coenzymes (metal ions or organic molecules) for proper function and catalysis.
- ➢ **Inhibition:** Enzyme activity can be regulated by inhibitors that either compete with substrates or bind to other sites on the enzyme.
- ➢ **Thermal Sensitivity:** Enzymes are sensitive to temperature changes, and excessive heat can lead to denaturation.
- ➢ **Redox Activity:** Some enzymes catalyze redox reactions, transferring electrons between molecules.

Functions of Enzymes:

- Catalysis of Biochemical Reactions by lowering the activation energy required for the reaction to occur. This enables metabolic processes to take place rapidly and efficiently at the
- Enzymes play a central role in metabolism which is both catabolic reactions (breaking down large molecules to release energy) and anabolic reactions (synthesizing complex molecules, requiring energy).
- Enzymes help regulate various cellular processes by controlling the rates of reactions. Enzyme activity can be regulated through mechanisms such as:
- Allosteric regulation: Where molecules bind to a site other than the active site (allosteric site) to enhance or inhibit enzyme activity.
- Feedback inhibition: In which the end product of a metabolic pathway inhibits the activity of an enzyme earlier in the pathway, preventing overproduction of the product.
- Covalent modification: Chemical changes to the enzyme (such as phosphorylation) that activate or deactivate the enzyme.
- Thet also involve in detoxification and waste removal:
- Enzymes are key components of signal transduction pathways, which are essential for cells to respond to changes in their environment.
- Enzymes such as DNA polymerase are essential for DNA replication, ensuring that genetic material is copied accurately during cell division. Other enzymes, like ligase and nucleases, help repair DNA damage and maintain genetic integrity.
- Digestive enzymes break down macromolecules (like proteins, fats, and carbohydrates) into smaller molecules that can be absorbed by the body.

3.4.2. Protein structure

- Proteins are complex molecules made up of amino acid chains. They are essential for numerous biological functions, from catalyzing metabolic reactions (enzymes) to providing structural support, transport, and immune defense.
- Protein structure is described at **four levels**: **primary**, **secondary**, **tertiary**, and **quaternary**.

Primary Structure:

- refers to the linear sequence of amino acids in the polypeptide chain, connected by peptide bonds.
- is simply the linear sequence of amino acids, and it determines the protein's folding pattern.

Secondary Structure

- refers to local folding patterns within the polypeptide chain, stabilized by hydrogen bonds between the backbone atoms (not the side chains). Exist in two structures:
- **Alpha helices** (α-helices): In this structure, the polypeptide chain coils into a right-handed spiral. The hydrogen bonds form between the backbone amide hydrogen and carbonyl oxygen, creating the helical shape. Example: The helical structure of keratin in hair and nails.

Beta sheets (β-sheets): These structures occur when the polypeptide chain folds back on itself in a zigzag or pleated shape. Hydrogen bonds form between carbonyl oxygen atoms of one part of the chain and amide hydrogen atoms of another part. Example: The fibrous protein silk produced by spiders has extensive β-sheet structures.

Secondary structures can be parallel (chains running in the same direction) or antiparallel (chains running in opposite directions).

The secondary structure represents regions of the protein that form stable, repeating structures due to hydrogen bonding.

Tertiary Structure

- is the overall three-dimensional shape of the entire polypeptide chain. It results from interactions between the side chains (R groups) of the amino acids. These interactions include:
  - **Hydrophobic interactions:** Non-polar amino acid side chains tend to cluster together in the interior of the protein to avoid contact with water.
  - **Hydrogen bonds:** Weak bonds between polar side chains or between side chains and backbone atoms.
  - **Ionic bonds (salt bridges**): Electrostatic interactions between positively and negatively charged side chains.
  - **Disulfide bridges:** Covalent bonds formed between two cysteine residues through their sulfur atoms. These are strong bonds that help stabilize the protein's structure.
  - Van der Waals interactions: Weak attractions between atoms that are in close proximity.

Therefore, tertiary structure determines the protein's functional conformation which is the specific shape required to interact with its substrates or other molecules.

Quaternary Structure

- refers to the assembly of multiple polypeptide chains (subunits) into a functional protein.
- These subunits can be identical or different, and their interactions are held together by the same forces that stabilize tertiary structure (hydrogen bonds, hydrophobic interactions, ionic bonds, etc.). Hemoglobin and DNA polymerase
- Quaternary structure can involve both non-covalent interactions (hydrophobic, hydrogen bonds, ionic) and covalent interactions (such as disulfide bonds).

3.4.3. Enzyme-substrate models (lock-and-key, induced fit)

There are two primary models that explain enzyme-substrate binding:

a. Lock and Key Model

- was proposed by **Emil Fischer** in 1894 and suggests that the enzyme and substrate fit together like a key fitting into a lock.
- In this model, enzyme has a **rigid, complementary shape** that exactly matches the shape of the substrate.
- the enzyme's active site does not undergo significant conformational change upon substrate binding.

- The interaction is highly specific, and the enzyme's shape is already perfectly suited to the substrate's shape. The enzyme has a **pre-formed active site** that matches the substrate

b. Induced Fit Model

- was proposed by **Daniel Koshland** in 1958.
- It suggests that the enzyme's active site is not a rigid structure but rather a flexible site that **undergoes conformational changes** when the substrate binds.
- In this model, the enzyme's active site is not a perfect fit for the substrate before binding.
- The substrate binding induces a change in the enzyme's structure, making the enzyme-substrate interaction more stable and increasing the efficiency of the reaction.

Enzymatic transition state

- **Enzymatic transition state** is a high-energy, unstable intermediate that occurs during the transformation of substrates into products in a chemical reaction.
  - Enzymes stabilize this state, lowering the activation energy required for the reaction.
- the **transition state** refers to the point where the substrate has partially undergone chemical changes but has not yet been fully converted into the product.
- Enzymes play a crucial role in stabilizing this transition state to lower the activation energy of the reaction and speed up the process.
- It describes how the chemical reactions are taking place qualitatively in the activated enzyme-substrate complex of absolute reaction rates.

Example: Enzymatic Reaction of Sucrase on Sucrose
Reaction:

$$\text{Sucrose} + H_2O \xrightarrow{\text{Sucrase}} \text{Glucose} + \text{Fructose}$$

Transition State Formation:
Substrate Binding: Sucrose binds to the active site of sucrase.
Transition State Formation: The enzyme weakens the glycosidic bond, creating an unstable high-energy intermediate.
Product Formation: The bond breaks, leading to the formation of glucose and fructose.
Product Release: The products are released, and the enzyme is free for another reaction cycle.
The enzyme reduces the activation energy by stabilizing the transition state, allowing the reaction to proceed faster.

3.5. Enzyme regulation

Enzyme regulation refers to the control of enzyme activity to maintain metabolic balance. It ensures that reactions occur at the right time and rate. Key mechanisms include:

- ✓ **Allosteric Regulation**: Molecules bind to an enzyme at a site other than the active site, altering its activity.

- ✓ **Feedback Inhibition**: The end product of a pathway inhibits an earlier enzyme, preventing excess production.
- ✓ **Covalent Modification**: Enzymes are activated or deactivated by chemical changes, such as phosphorylation.
- ✓ **Enzyme inhibition** is the decrease in enzyme activity due to the binding of inhibitors. Inhibitors prevent substrate conversion into products.

Types of Inhibition:

- ✓ **Irreversible Inhibition**: Permanently inactivates the enzyme by forming strong covalent bonds.
- ✓ **Reversible Inhibition**: Temporarily inactivates the enzyme through weak, non-covalent interactions and can be reversed.
- ✓ **Competitive Inhibition**: The inhibitor competes with the substrate for the active site.
- ✓ **Uncompetitive Inhibition**: The inhibitor binds only to the enzyme-substrate complex, preventing product formation.

3.6. Types of enzymes

Learning competencies

- Describe action of apoenzyme and cofactors and list their example
- Explain the six main Classes of enzyme and their function
- List some enzymes and their application area

Based on the type of reaction they catalysis:

1. **Oxidoreductases:** Catalyze oxidation-reduction reactions by transferring electrons or hydrogen atoms between substrates.
2. **Transferases:** Transfer functional groups (such as methyl, acyl, or phosphate groups) between molecules.
3. **Hydrolases:** Catalyze the hydrolysis (breakdown) of bonds by adding water molecules.
4. **Lyases:** Remove groups from substrates without hydrolysis, or add groups to double bonds.
5. **Isomerases:** Catalyze the rearrangement of atoms within a molecule to form isomers.
6. **Ligases (or synthetases):** Join two molecules together using energy from ATP hydrolysis.

B. **Classification by Substrate Specificity:**

- ✓ Enzymes are often named based on their substrate specificity. For example, lipases act on lipids, proteases on proteins, and amylases on starch.

C. **Classification of enzyme by Structure**

- ✓ **Cofactor Requirement:**

Apoenzyme:

- ✓ The apoenzyme refers to the protein component of an enzyme that alone lacks catalytic activity. It is an inactive protein that need cofactor to be active
- ✓ It provides the structural framework and active site where the catalytic reaction takes place

- ✓ Example: Many apoenzymes are inactive until they bind to a specific cofactor or coenzyme.

Cofactor: is a non-protein chemical compound or metal ion that is required for the catalytic activity of certain enzymes. Cofactors assist in enzyme-substrate binding, facilitate catalysis, and stabilize reaction intermediates.

- ✓ **Types of cofactors**
  - ✓ **Inorganic Cofactors:** Such as metal ions that bind directly to the enzyme. They bind loosely to enzyme and provide catalytic activity e.g. Zn and Cu ion for carbonic anhydrase and Cytochrome oxidase respectively
  - ✓ **Organic Cofactors (Coenzymes):** These are small molecules derived from vitamins or synthesized within cells, and they often participate in enzyme reactions by donating or accepting chemical groups. They bind tightly e.g. Niacin and Riboflavin in NAD and FAD(Fig14).

Holoenzyme: is the complete, catalytically active form of an enzyme consisting of both the apoenzyme and its cofactor. The binding of the cofactor to the apoenzyme results in the formation of the holoenzyme.

- ✓ **Example:** Examples include the enzyme alcohol dehydrogenase, which requires the cofactor NAD+ (nicotinamide adenine dinucleotide) to catalyze the oxidation of alcohols.

3.7. Factors affecting enzyme action

- ✓ Enzyme denaturation can be caused by various factors, including temperature, pH, salt concentration, organic solvents, heavy metals, radiation, and mechanical stress.

Temperature

- ✓ Enzyme activity increases with temperature up to an optimal level, beyond which the enzyme denatures and loses function.
- ✓ Maintain the optimal temperature for each enzyme (usually 37°C for human enzymes).

PH

- ✓ Enzymes function best within a specific pH range; extreme pH levels can denature them.
- ✓ Too acidic or too alkaline conditions alter enzyme structure, reducing their ability to bind substrates.

Substrate Concentration

- ✓ Higher substrate concentration increases reaction rate until saturation, where all enzyme active sites are occupied.

Enzyme Concentration

- ✓ Increasing enzyme concentration speeds up reactions, provided there is enough substrate.

Inhibitors

- ✓ Competitive inhibitors slow reactions by blocking active sites, while noncompetitive inhibitors reduce enzyme activity by binding elsewhere.
- ✓ Avoid inhibitors unless used for regulation or drug action.

Cofactors and Coenzymes

- ✓ Some enzymes require cofactors (metal ions) or coenzymes (organic molecules like vitamins) to function properly.
- ✓ Ensure adequate availability of necessary cofactors or coenzymes.
- ✓ **Radiation**: Exposure to **radiation** damages enzyme structure, decreasing efficiency and disrupting macromolecules.
- ✓ **Water**: The presence of **water** influences enzyme activity, and deviations from optimal hydration levels can impair function.
- ✓ **Feedback Inhibition**: A **cellular control mechanism** where the end product binds to an enzyme's allosteric site, altering its shape and preventing further activity, helping regulate product levels

Lab activity 1: Testing Enzyme Sensitivity to Heat in Potato Slices

Objective:

Test the sensitivity of enzymes to heat by observing their activity in raw and boiled potato slices when exposed to hydrogen peroxide.

Materials:

- Hydrogen Peroxide (H_2O_2)
- Potatoes
- Knife
- Cooking utensils

Procedure:

1. Take two slices of potatoes.
2. Boil one slice of potato thoroughly and leave the other slice raw.
3. Drop hydrogen peroxide on both the boiled and raw potato slices.
4. Observe and compare the enzyme reactions of both potato slices.

Assessment:

1. Identify the differences in enzyme reactions between the boiled and raw potato slices.
2. Determine in which of the potato slices the enzymes have been denatured.
3. Evaluate whether high temperature affects enzyme activity.

Based on the experiment above answer the following question

1. You are conducting an experiment to test enzyme sensitivity to heat in potato slices. You are using hydrogen peroxide as the substrate to observe enzyme activity. Which material is essential to test the enzyme activity in this experiment?

   A. Water
   B. Hydrogen Peroxide (H_2O_2)
   C. Salt
   D. Acetic acid

   Explanation: Hydrogen peroxide is the substrate used in the experiment to test enzyme activity in the potato slices. The enzymes in the potato break down hydrogen peroxide, releasing oxygen and causing bubbling.

2. In the experiment, one potato slice is boiled, and the other is left raw. What is the purpose of boiling one of the potato slices?

A. To make the potato easier to cut
B. To observe the effect of heat on enzyme activity
C. To enhance enzyme activity
D. To remove the potato skin

Explanation: The purpose of boiling the potato slice is to observe how heat impacts enzyme activity, specifically whether high temperature denatures the enzymes and reduces their activity.

3. After adding hydrogen peroxide to both the boiled and raw potato slices, which of the following would indicate that the enzyme is active in the raw potato slice?
   A. No bubbling or visible change
   B. Bubbling or foaming
   C. Immediate color change
   D. Dissolving of the potato slice

Explanation: The enzyme activity in the raw potato slice causes the breakdown of hydrogen peroxide, resulting in the production of oxygen gas, which forms visible bubbles or foam. This indicates active enzyme function.

4. Based on the results from the experiment, what do you expect to happen when hydrogen peroxide is added to the boiled potato slice compared to the raw one?
   A. The boiled potato slice will show more bubbling than the raw slice.
   B. The boiled potato slice will show less or no bubbling compared to the raw slice.
   C. Both potato slices will show the same amount of bubbling.
   D. The raw potato slice will dissolve, while the boiled slice will remain intact.

Explanation: Boiling the potato slice likely denatures the enzymes, disrupting their ability to break down hydrogen peroxide. As a result, there will be little to no bubbling or enzyme activity in the boiled potato slice.

5. Based on your observations, what can you conclude about the effect of high temperature on enzyme activity in this experiment?
   A. High temperature increases enzyme activity.
   B. High temperature does not affect enzyme activity.
   C. High temperature denatures enzymes, reducing or halting enzyme activity.
   D. High temperature has no effect on enzyme reactions.

Explanation: The boiling of the potato slice likely caused the enzymes to denature, reducing or halting their ability to catalyze the breakdown of hydrogen peroxide. This explains the reduced or absent bubbling in the boiled slice.

6. If you wanted to extend this experiment to test how different temperatures affect enzyme activity in potatoes, what would be an appropriate modification to your procedure?
   A. Use different concentrations of hydrogen peroxide.
   B. Use different types of potatoes.
   C. Boil the potatoes for varying lengths of time.
   D. Perform the test at different temperature levels, such as freezing, room temperature, and boiling.

Explanation: To explore the effects of temperature on enzyme activity more thoroughly, you would test the enzyme activity at a range of temperatures (e.g., freezing, room temperature, and boiling) to observe how temperature influences enzyme function at various levels

Lab activity 2: Investigating the Effect of Inhibitors on Enzyme Activity

Objective: To investigate the effect of **competitive** and **non-competitive inhibitors** on enzyme activity by examining how they influence the rate of reaction and the resulting graph.

Materials:

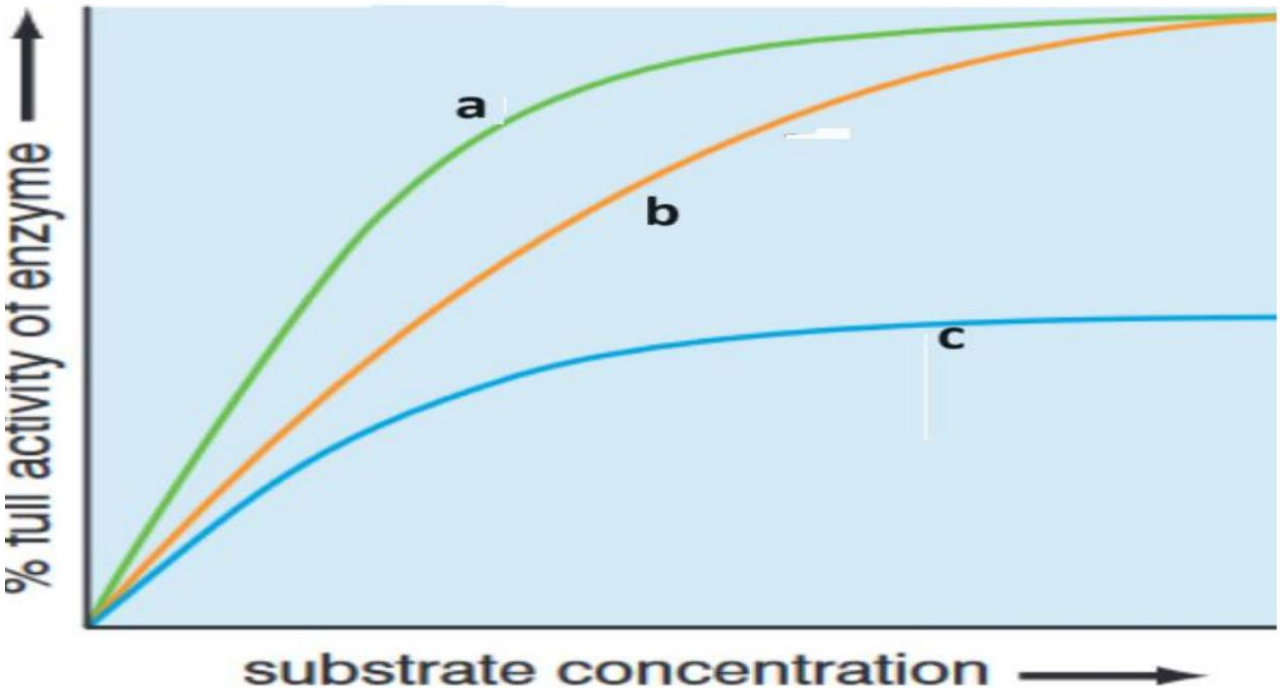
- Enzyme solution, Substrate solution, Competitive inhibitor solution (e.g., methotrexate for enzymes involved in folate metabolism) and Non-competitive inhibitor solution (e.g., cyanide for enzymes involved in cellular respiration)
- Spectrophotometer or colorimeter (optional for measuring reaction rate)

Procedure:

- Prepare enzyme and substrate solutions.
- Set up two experimental groups: one with a **competitive inhibitor** and the other with a **non-competitive inhibitor**.
- Add the appropriate inhibitor to each reaction mixture.
- Measure the reaction rate under each condition by recording changes in product formation or substrate consumption over time.
- Analyze the resulting data and graph the reaction rate versus substrate concentration for each condition.

Assessment:

- Investigate how the **competitive** and **non-competitive inhibitors** affect enzyme activity.
- Analyze the shape of the graph for reaction rate versus substrate concentration in the presence and absence of each type of inhibitor.
- **Based on the experiment above answer the following multiple-choice question**



1 Which of the following represents the correct interpretation of the graph for letter a, b and c respectively?
   A. Competitive inhibitor, no inhibitors and non-competitive inhibitors
   B. Noncompetitive inhibitor, competitive inhibitor and no inhibitors
   C. No inhibitors, competitive inhibitors and non-competitive inhibitors
   D. No inhibitors, non-competitive inhibitors and competitive inhibitors

2 What is the primary difference between **competitive** and **non-competitive inhibitors** in enzyme activity?
   A. Competitive inhibitors bind to the enzyme's active site, while non-competitive inhibitors bind to a different site.
   B. Competitive inhibitors bind to the enzyme's allosteric site, while non-competitive inhibitors bind to the active site.
   C. Competitive inhibitors increase enzyme activity, while non-competitive inhibitors decrease it.
   D. Competitive inhibitors do not affect the reaction rate, while non-competitive inhibitors increase it.

Explanation: Competitive inhibitors compete with the substrate for binding at the enzyme's active site, while non-competitive inhibitors bind at an allosteric site, changing the enzyme's shape and reducing its activity.

3 What happens to the reaction rate when a **competitive inhibitor** is added to the enzyme-substrate reaction?

A. The reaction rate decreases at all substrate concentrations.
B. The reaction rate increases, and the enzyme becomes more efficient.
C. The reaction rate decreases, but increasing substrate concentration can overcome the effect.
D. The reaction rate is unaffected by substrate concentration.

Explanation: Competitive inhibitors reduce the reaction rate by binding to the enzyme's active site, but their effect can be overcome by increasing the substrate concentration, which outcompetes the inhibitor for the active site.

4 If you were graphing the reaction rate versus substrate concentration for a reaction with a **competitive inhibitor**, what would you expect the graph to look like compared to the control (no inhibitor)?

A. The graph for the inhibitor will show a steeper slope and reach Vmax faster.
B. The graph for the inhibitor will show a higher Vmax but a lower initial rate.
C. The graph for the inhibitor will show a lower Vmax but the same initial rate.
D. The graph for the inhibitor will show the same Vmax but a higher initial rate.

Explanation: In the presence of a competitive inhibitor, Vmax (maximum reaction rate) will eventually be lower because it requires higher substrate concentration to reach that rate. However, the initial rate at low substrate concentrations can be the same as the control.

5 What would you observe on a graph of reaction rate versus substrate concentration when a **non-competitive inhibitor** is present?

A. The graph will show a higher Vmax but the same Km.
B. The graph will show a lower Vmax and the same Km.
C. The graph will show the same Vmax but a higher Km.
D. The graph will show a higher Vmax and a lower Km.

Explanation: Non-competitive inhibitors reduce the Vmax because they decrease the enzyme's effectiveness, but they do not affect Km since they do not compete with the substrate for the active site.

6 Given the data on enzyme activity with competitive and non-competitive inhibitors, how would you determine which type of inhibitor is affecting the enzyme?

A. Compare the Vmax values: A reduction in Vmax without a change in Km suggests a non-competitive inhibitor.
B. Compare the Km values: A change in Km without a reduction in Vmax suggests a competitive inhibitor.
C. Both inhibitors will show the same effects on both Vmax and Km.
D) Measure the reaction rate at the same substrate concentration for both inhibitors; the one showing a lower rate is the competitive inhibitor.
Explanation: Competitive inhibitors increase Km (reduce enzyme affinity for the substrate), while non-competitive inhibitors do not affect Km but reduce Vmax.

7 If you wanted to design an experiment to distinguish between **competitive** and **non-competitive inhibitors** based on their effect on reaction rates, what key factor would you manipulate?

A. Vary the temperature and measure enzyme activity at different temperatures.

B. Change the concentration of inhibitors and measure the reaction rate at varying substrate concentrations.
C. Use different enzymes and measure their activity without any inhibitors.
D. Measure the pH and assess the effect on reaction rates.

Explanation: By varying inhibitor concentrations and measuring enzyme activity at different substrate concentrations, you can distinguish the effects of competitive and non-competitive inhibitors. Competitive inhibitors can be overcome by increasing substrate concentration, whereas non-competitive inhibitors cannot.

Lab activity 3. Enzyme Reaction Rates Investigation

Objective: Test the enzyme reactions in beef liver, potato, and carrot by comparing their reaction rates when exposed to hydrogen peroxide.

Materials:

Beef liver	Carrot	Hydrogen Peroxide (H_2O_2)
Potato	3 Test tubes	Knife

Procedure:

- Label the test tubes as A for beef liver, B for potato, and C for carrot.
- Chop the beef liver, potato, and carrot into small pieces and place the chopped samples into the respective test tubes (A for beef liver, B for potato, C for carrot).
- Add about 2 ml of hydrogen peroxide to each test tube equally.
- Observe and measure the height of bubbles (oxygen production) and the speed (reaction time) for each test tube.
- Record the reaction rates and compare them across the three test tubes.

Assessment Questions:

- What were the reaction rates in test tubes A, B, and C?
- Which of the reactions was the fastest?

Why was the reaction in test tube A (beef liver) the highest?**Based on the experiment above answer the following question**

8 In the experiment, which of the following materials was used in test tube A?

A. Carrot
B. Beef Liver
C. Potato
D. Hydrogen Peroxide

Explanation: Test tube A was labeled for beef liver, as stated in the procedure.

9 What is the purpose of adding hydrogen peroxide (H_2O_2) to each test tube in this experiment?

A. To measure the pH of the sample
B. To observe the enzyme activity by breaking down hydrogen peroxide into oxygen and water
C. To cool down the reaction rate
D. To increase the viscosity of the reaction mixture

Explanation: Hydrogen peroxide is broken down by enzymes in the beef liver, potato, and carrot, releasing oxygen, which can be measured to gauge enzyme activity.

10 In this experiment, if test tube A (beef liver) produces the highest number of bubbles compared to test tubes B (potato) and C (carrot), which of the following can be concluded?
   A. Beef liver contains more active enzymes than potato or carrot.
   B. Potato contains more active enzymes than beef liver and carrot.
   C. Carrot contains more active enzymes than beef liver and potato.
   D. All three samples contain equal amounts of enzyme activity.

Explanation: The height of the bubbles indicates enzyme activity. If test tube A produces the most bubbles, it suggests that the beef liver has the most active enzymes breaking down the hydrogen peroxide.

11 Based on the height of the bubbles and reaction speed, what might be a reason for the slower reaction in test tube B (potato) compared to test tube A (beef liver)?
   A. Potato contains a higher concentration of enzymes.
   B. The enzyme in beef liver is more efficient at breaking down hydrogen peroxide.
   C. Potato enzymes are less sensitive to hydrogen peroxide.
   D. Carrot enzymes are more active than potato enzymes.

Explanation: Beef liver typically contains more catalase (the enzyme responsible for breaking down hydrogen peroxide) than potato, leading to a faster reaction rate in test tube A.

12 Given the experimental results where test tube A (beef liver) shows the highest reaction rate, what can you infer about the enzymes in beef liver compared to those in potato and carrot?
   A. Enzymes in beef liver are less efficient than in potato or carrot.
   B. Enzymes in beef liver have a higher substrate affinity or activity than in potato or carrot.
   C. Enzymes in beef liver require lower temperatures to function.
   D. Enzymes in beef liver do not interact with hydrogen peroxide.

Explanation: The higher enzyme activity in beef liver suggests that its enzymes (specifically catalase) are more efficient at breaking down hydrogen peroxide, leading to more oxygen production (bubbles).

13 How could you modify this experiment to further investigate the enzyme activity in potato and carrot?
   A. Change the concentration of hydrogen peroxide in each test tube.
   B. Increase the temperature of the reaction mixtures.
   C. Use larger chunks of beef liver to reduce the surface area.
   D. Add a different enzyme to each test tube to compare their effects.

Explanation: By varying the concentration of hydrogen peroxide, you can test the effect of substrate concentration on enzyme activity and determine the optimal concentration for each enzyme in potato, carrot, and beef liver.

Enzyme kinetics

- **Enzyme kinetics** studies the rate of enzyme-catalyzed reactions and how factors like substrate concentration, enzyme concentration, and inhibitors affect it.
- The **rate of an enzyme-catalyzed reaction** is determined by measuring the formation of the product or the consumption of the substrate over time
- Follows the **Michaelis-Menten equation**, which describes the relationship between **substrate concentration** and **reaction rate**.
- **Vmax**: Maximum reaction rate when all enzyme active sites are occupied.
- **Km (Michaelis constant)**: The substrate concentration at which the reaction rate is half of **Vmax**, indicating enzyme affinity.
- Enzyme kinetics helps in **drug design, metabolic regulation, and industrial enzyme application**
- The model explains the relationship between the rate of an enzyme-catalyzed reaction [V1], the concentration of substrate [S] and two constants, Vmax and K m with the following equation

$$V_1 = \frac{V_{max}[S]}{\{K_m + [S]\}}$$

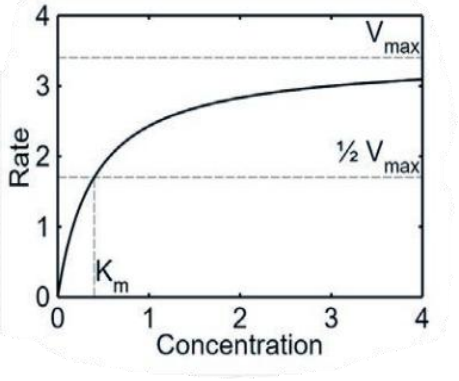
Where:

$\mathbf{V_1}$ = the initial velocity/rate reaction

$\mathbf{V_{max}}$ = the maximal velocity/maximum rate of reaction

[S] = the substrate concentration

$\mathbf{K_M}$ = substrate concentration at half-maximal velocity (Michaelis constant).



Application of enzymes

Application of Enzymes in Industries and Their Benefits

- ✓ The use of enzymes in industrial processes offers numerous benefits, such as energy savings, environmental sustainability, and cost efficiency.
- ✓ Enzymes are used in several industrial sectors to enhance processes, improve product quality, and reduce the environmental impact of chemical processes.

Table 6. areas where enzymes are mainly applied

Industry	Enzyme Application	Benefits
Food and Beverages	- Brewing (amylases, proteases, lipases)	- Faster fermentation, better flavor and texture
	- Cheese production (rennet, lipases)	- Consistency in production, improved yield
	- Baking (amylases, lipases)	- Improved dough handling, better texture, reduced cost
Textiles	- Stone-washing (cellulase)	- Softer fabric, reduced use of harmful chemicals
	- Fabric finishing (pectinase, amylase)	- Enhanced quality, lower water and energy consumption
Detergents	- Laundry and dishwashing (proteases, lipases, amylases)	- Better stain removal, energy savings at lower temps
Paper and Pulp	- Paper bleaching (laccase, xylanase)	- Reduced chlorine use, improved environmental footprint
Pharmaceuticals	- Drug production (lipase, proteases, amylase)	- Increased production efficiency, lower costs
Biofuels	- Bioethanol production (amylases, cellulases, hemicellulases)	- Higher yield, reduced environmental impact
Cosmetics	- Skin care products (lipases, proteases, amylases)	- Improved texture and consistency, natural ingredients
Animal Feed	- Digestive aid in animal feed (phytase, cellulase)	- Enhanced nutrient absorption, reduced feed costs

The what and why of malting for local alcoholic drinks production

What is withering in malting

- **Withering** is one of the key steps in the malting process that follows **steeping** and precedes **germination**.
- It involves the gradual removal of excess moisture from the soaked barley (or other grains), allowing the grain to **prepare for germination** while controlling its moisture content.

The purpose of Withering in Malting:

- to prevent excessive use of stored energy in the barley (mainly in the form of starches)
- Withering slows down or halts the rapid germination that could otherwise occur too early.

Importance of Withering in Malting:

- Ensures Optimal Germination
- Prevents Spoilage
- Improves Malt Quality

The **kilning** process in malting is crucial for several reasons, including the development of **enzymatic activity**, **friability**, and the creation of a wide range of **malt colors**, **flavors**, and the distinctive qualities of **ales** and **lagers**.

- Kilning is the stage where **color** and **flavor** are developed in the malt
  Develops **friability**, which is necessary for efficient milling.
- **Kilning stops** the germination process by **drying** the malted barley.
- Determines the **color** and **flavor** of the malt, influencing the final taste and appearance of the beer.
- **Friability r**efers to the **ease** with which the malted barley can be crushed or milled into a fine powder (grist). This is important because a **friable malt**:
  - ✓ **Improves Milling Efficiency:** Friability ensures that the malt can be easily broken down into smaller pieces during the milling process, which helps expose more surface area for enzymatic action during **mashing**.
  - ✓ **Affects Wort Extract Yield:** The more friable the malt, the more efficiently the enzymes will break down starches into fermentable sugars, which contributes to a higher wort extract (the amount of fermentable material in the wort) during mashing.
  - ✓ **Malt Texture:** Kilning at the appropriate temperatures ensures that the barley develops the right **structure** to create malt that is neither too brittle nor too tough. If too much moisture is retained, the grain will be too soft and can become sticky, affecting the milling process.

EXAMPLES OF REVIEW EXERCISE ON ENZYME

1. Which of the following describes enzyme kinetics?
   A. The study of enzyme structure
   B. The study of the rate of enzyme-catalyzed reaction
   C. The inhibition of enzymes by drugs
   D. The role of enzymes in digestion

Explanation: Enzyme kinetics is specifically concerned with understanding the rates at which enzyme-catalyzed reactions occur, and how factors such as substrate concentration and inhibitors affect those rates. The other options do not describe the core concept of enzyme kinetics.

2. An enzyme has a Km of 2 mM and a Vmax of 50 μmol/min. What happens if the substrate concentration is increased from 1 mM to 2 mM?
   A. The reaction rate decreases
   B. The reaction rate remains unchanged
   C. The reaction rate increases
   D. The enzyme becomes inactive

Explanation: Km is a key parameter in the Michaelis-Menten model that represents the substrate concentration needed for the enzyme to reach half of its maximum reaction rate (Vmax). This gives an idea of the enzyme's affinity for the substrate. A low Km means high affinity, while a high Km means low affinity.

3. Why is enzyme kinetics important in drug design?
    A. It helps determine the molecular weight of enzymes
    B. It explains why all enzymes are proteins
    C. It allows the prediction of how inhibitors affect enzyme activity
    D. It shows that enzymes are not reusable

    - **Explanation:** A competitive inhibitor competes with the substrate for the enzyme's active site, which increases the Km (higher substrate concentration is needed to achieve half of the maximum reaction rate). However, the Vmax remains the same because the reaction rate can still reach maximum levels once enough substrate is present to outcompete the inhibitor.

4. If you were designing an enzyme to work efficiently at low temperatures, which factor would you modify?
    A. Increase the enzyme's Km
    B. Modify the enzyme's active site for better substrate binding at low energy states
    C. Increase the enzyme's denaturation temperature
    D. Remove all cofactors

    Explanation: To optimize an enzyme for low-temperature activity, its active site needs to be adapted to facilitate efficient substrate binding even at lower energy states. This may involve altering the enzyme's structure to make it more flexible or enhance its ability to interact with substrates at cooler temperatures. The other options are less relevant to the specific need for low-temperature efficiency

5. Which of the following statements about enzymes is most accurate?
    A. Enzymes can work effectively at any temperature or pH, as long as there is sufficient substrate concentration.
    B. Enzymes exhibit a "lock-and-key" model of substrate binding, where the enzyme's active site has a fixed shape that perfectly matches the substrate.
    C. Enzyme activity is highly dependent on the presence of specific cofactors or coenzymes, which may be inorganic ions or organic molecules required for the enzyme's function.
    D. Enzymes always increase the rate of a chemical reaction by directly providing energy to the substrate, making the reaction energetically favorable.

Explanation: is correct because many enzymes require cofactors (often metal ions) or coenzymes (organic molecules, such as vitamins) to function properly. These are crucial for the enzyme's catalytic activity

SELF TEST EXERCISE ON ENZYMES

1. How does an increase in temperature typically affect enzyme activity?
   A. It always increases enzyme activity.
   B. It can increase enzyme activity up to an optimal temperature, after which the activity decreases.
   C. It decreases enzyme activity consistently.
   D. Temperature has no effect on enzyme activity.
2. What happens to an enzyme if the pH is too high or too low compared to its optimal pH?
   A. The enzyme becomes more efficient.
   B. The enzyme activity remains unaffected.
   C. The enzyme may denature and lose its ability to function.
   D. The enzyme changes shape and becomes more active.
3. What is the effect of a competitive inhibitor on enzyme activity?
   A. It binds to the active site, preventing the substrate from binding.
   B. It increases the rate of reaction by binding to the enzyme.
   C. It binds to a site other than the active site, changing the enzyme's shape.
   D. It has no effect on enzyme activity.
4. How does enzyme concentration influence enzyme activity?
   A. Increasing enzyme concentration increases the reaction rate until all substrates are used up.
   B. Enzyme concentration has no effect on the reaction rate.
   C. Increasing enzyme concentration decreases the reaction rate.
   D. Enzyme concentration decreases the activity of enzymes.
5. What is a non-competitive inhibitor’s effect on enzyme activity?
   A. It competes with the substrate for the active site.
   B. It binds to the active site, preventing the substrate from binding.
   C. It binds to a site other than the active site, causing the enzyme to change shape and reducing its activity.
   D. It accelerates the reaction rate by increasing substrate binding.
6. Which of the following can increase the rate of an enzyme-catalyzed reaction?
   A. Decreasing enzyme concentration
   B. Increasing the concentration of the product
   C. Increasing substrate concentration up to a certain point
   D. Decreasing pH to a level lower than the enzyme’s optimal range
7. Which of the following best describes the relationship between enzyme activity and temperature?
   A. Enzyme activity always increases with temperature.
   B. Enzyme activity is not affected by temperature.
   C. Enzyme activity increases with temperature until an optimal point, after which it declines due to denaturation.
   D. Enzyme activity decreases as temperature decreases but never reaches zero.

8. Which factor does NOT typically affect enzyme-catalyzed reactions?
    A. Ionic strength of the environment
    B. The concentration of the substrate and enzyme
    C. The presence of coenzymes or cofactors
    D. The wavelength of light used during the reaction
9. Which of the following best describes the Lock and Key Model of enzyme action?
    A. The enzyme's active site undergoes a conformational change when the substrate binds.
    B. The enzyme has a rigid active site that fits exactly with the substrate.
    C. The enzyme's active site is flexible and adapts to fit the substrate.
    D. The substrate changes shape to fit the enzyme's active site.
10. According to the Induced Fit Model, what happens when the substrate binds to the enzyme's active site?
    A. The enzyme and substrate fit together perfectly without any changes.
    B. The active site of the enzyme undergoes a slight change to fit the substrate.
    C. The substrate remains unchanged, and the enzyme's active site remains rigid.
    D. The substrate binds at multiple sites on the enzyme.
11. In the Lock and Key Model, the enzyme's active site:
    A. Is flexible and adjusts to accommodate the substrate.
    B. Has a rigid, specific shape that matches only one substrate.
    C. Undergoes major changes when the substrate binds.
    D. Is adapted to catalyze multiple types of reactions.
12. The Lock and Key Model of enzyme action can be compared to:
    A. A hand fitting into a glove
    B. A lock opening with a key of any shape.
    C. A key that changes shape to fit any lock.
    D. A hand changing its shape to fit any glove.
13. Which of the following is a feature of the Induced Fit Model?
    A. The enzyme's active site is rigid and does not change shape.
    B. The enzyme’s active site changes slightly to accommodate the substrate.
    C. The substrate is always complementary to the enzyme's active site.
    D. The enzyme’s active site only fits a specific substrate without any modification.
14. In the Lock and Key Model, the enzyme is described as a:
    A. Dynamic molecule that changes shape during substrate binding.
    B. Rigid structure that only fits a specific substrate.
    C. Molecule that adapts to fit any substrate.
    D. Fluid structure that adjusts according to the substrate.
15. Which of the following is true about the Induced Fit Model of enzyme action?
    A. It assumes a perfect, unchanging fit between the enzyme and the substrate.
    B. It suggests the enzyme is already shaped to fit the substrate before interaction.
    C. It proposes that the enzyme changes shape slightly when the substrate binds.

D. It ignores the shape of the enzyme's active site.

16. Which of the following models best explains how enzymes lower activation energy?
    A. Lock and Key Model, by providing a fixed pathway for reactions.
    B. Induced Fit Model, by stabilizing the transition state of the reaction.
    C. Both models are equally effective at explaining activation energy reduction.
    D. Neither model explains the reduction of activation energy.
17. Which of the following statements is NOT associated with the Lock and Key Model?
    A. The enzyme's active site and substrate have complementary shapes.
    B. The active site is rigid and does not undergo changes upon binding with the substrate.
    C. The enzyme’s active site is flexible and adapts to fit the substrate.
    D. The substrate binds precisely to the enzyme’s active site, like a key fitting into a lock.
18. What does the Michaelis-Menten constant (Km) represent in enzyme kinetics?
    A. The maximum reaction rate
    B. The substrate concentration at which the reaction rate is half of Vmax
    C. The number of enzyme molecules present
    D. The total amount of product formed
19. Which of the following enzymes is primarily responsible for breaking down starches into fermentable sugars during the malting process?
    A. Amylase
    B. Protease
    C. Lipase
    D. Cellulase
20. The activity of which enzyme is crucial in the production of maltose, the primary fermentable sugar, during malting
    A. Alpha-amylase
    B. Beta-amylase
    C. Protease
    D. Glucanase
21. What is the role of beta-glucanase in the malting process?
    A. It helps break down starches into simpler sugars.
    B. It breaks down beta-glucans, making the mash more fluid and easier to process.
    C. It converts proteins into amino acids.
    D. It helps in the synthesis of maltose from glucose.
22. Amylase activity in malt is essential for converting starch into sugar. Which form of amylase is primarily responsible for the initial breakdown of starch into dextrins during the early stages of malting?
    A. Alpha-amylase
    B. Beta-amylase
    C. Glucanase
    D. Maltase

23. How does alpha-amylase contribute to the production of fermentable sugars during the mashing process?
    A. It breaks down maltose into glucose.
    B. It cleaves the amylose and amylopectin starches into dextrins and oligosaccharides.
    C. It converts starch directly into glucose.
    D. It hydrolyzes proteins into amino acids.
24. Which enzyme is primarily responsible for the final conversion of dextrins into fermentable sugars such as maltose during malting?
    A. Alpha-amylase
    B. Glucanase
    C. Maltase
    D. Beta-amylase
25. The activity of which enzyme decreases as the malt reaches the kilning stage, and why is this significant for the final beer product?
    A. Maltase: it is needed to break down residual sugars into glucose for fermentation.
    B. Beta-amylase; it helps to produce fermentable sugars but is denatured by heat during kilning.
    C. Amylase: it is required for protein degradation but is inactivated during kilning.
    D. Glucanase: it degrades starch but is not important after kilning.
26. How does the temperature during malting influence the activity of enzymes such as alpha-amylase and beta-amylase?
    A. High temperatures accelerate enzyme activity but only for short periods.
    B. Both enzymes are heat-sensitive and are inactivated at temperatures above 50°C.
    C. Alpha-amylase is more active at lower temperatures, while beta-amylase works best at higher temperatures.
    D. The temperature does not affect enzyme activity during malting.
27. What would likely happen if there were insufficient protease activity during the malting process?
    A. There would be an excess of starch left in the malt.
    B. The beer would lack sufficient amino acids for fermentation, leading to poor yeast growth and fermentation.
    C. The malt would not produce any fermentable sugars.
    D. The malt would become overly bitter due to excessive breakdown of phenolic compounds.
28. In the context of malt enzyme activity, which of the following would be a limiting factor that could reduce fermentation efficiency in brewing?
    A. Too much protease activity breaking down amino acids into non-fermentable compounds.
    B. Insufficient amylase activity resulting in incomplete starch conversion.
    C. Excessive beta-glucanase activity making the mash too watery.
    D. Too much glucoamylase activity breaking down sugars too quickly.
29. Which of the following is NOT a key factor in optimizing enzyme activity during malting?
    A. Temperature control during germination and kilning

B. pH balance in the mashing process
C. Oxygen availability during germination
D. The size of the grains used for malting

ANSWER KEY FOR SELF TEST

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

SELF TEST EXERCISE

Choose the best answer from the given four alternatives

1. Which of the following is not true about enzyme?
   G. Enzyme specificity requires specific functional groups on the enzyme and substrate
   H. Enzymes forms complexes with substrates and products
   I. Enzymes affect the rate of reaction without changing themselves
   J. Enzymes undergoes structural modification during a reaction
2. All of the following statements are correct about enzymes, except
   A. All enzymes are proteins in nature C. Enzymes are specific for one reaction
   B. Enzymes get damaged at low temperature D. They occur in living cells
3. Enzymes are specific because:
   A. They have different shaped active site C. they are globular proteins
   B. they are affected by temperature and PH D. they may have cofactors
4. Which of the following does not act as a cofactor to an enzyme?
   B. Niacin B. Copper ions C. Pepsin D. Riboflavin
5. Which of the following is not the main class of enzyme?
   A. Oxidoreductases B. Ligases C. Kinase D. Transferase
6. Which statement about enzymes is true?
   A. Enzymes enable a greater total amount of product to form
   B. Enzymes alter the rate of reaction
   C. Enzymes increase the activation energy required for a reaction to take place

D. Enzymes alter the position of the reaction equilibrium

7. Which of the following is NOT a reason why enzymes are often used in industrial processes?
   A. they allow reactions to be carried out at lower temperatures
   B. they reduce heating costs
   C. more energy is used and so more carbon dioxide is produced during the process
   D. less energy is used and so less carbon dioxide is produced during the processes
8. An environmental benefit of using enzymes in industrial processes is that it can:
   A. reduce use of paper in packaging the product
   B. reduce carbon dioxide emissions
   C. increase purity of the product
   D. Reduce the costs involved
9. Enzymes speed up biological reactions by:
   A. reducing the kinetic energy of the reacting molecules
   B. reducing the activation energy of the reaction
   C. increasing activation energy of the reaction
   D. increasing the kinetic energy of the reacting molecules
10. Which of the following statements about a lock and key model of enzyme action are not true?
   A. the substrate and the active site bind b/c they have shapes that together like a key fit in a lock
   B. the substrate and the active site have complementary 3-D shapes
   C. nothing can interfere with the way the substrate and the active site bind together
   D. high temperatures stop enzymes working as they denature the protein and change the shape of the active site
11. The induced fit model of enzyme action suggests that, when enzyme and substrate bind, there is a conformational change in:
   A. the substrate
   B. both substrate and active site
   C. the active site
   D. neither substrate nor active site
12. An apoenzyme is:
   A. a protein with enzymic activity
   B. a non-protein with enzymic activity
   C. a non-protein with no enzymic activity
   D. a protein with no enzymic activity
13. A coenzyme is:
   A. an organic molecule that binds tightly with the apoenzyme
   B. an organic molecule that binds loosely with the apoenzyme
   C. an inorganic molecule that binds loosely with the apoenzyme

D. an inorganic molecule that binds tightly with the apoenzyme

14. Mineral ions needed for enzyme activity:

A. bind tightly with the apoenzyme C. bind loosely with the coenzyme

B. bind loosely with the apoenzyme D. bind tightly with the coenzyme

15. Enzymes differ from inorganic catalysts in that enzyme;

A. are working at high temperature C. are not being used up in the chemical reaction

B. are protein in nature D. are working at high PH

16. Which of the following statements about enzymes is not correct?

A. Enzymes do not alter the overall change in free energy for a reaction.

B. Enzymes are proteins whose 3-D shape is key to their functions.

C. Enzymes speed up reactions by increasing activation energy.

D. Enzymes are highly specific for reactions.

17. What is activation energy mean?

A. The energy input needed to start a chemical reaction is.

B. The maximum amount of energy produced by enzyme catalyzed reaction

C. The minimum amount of energy produced by enzyme catalyzed reaction

D. the optimum amount of energy used produced and used by the reaction

18. Many coenzymes are derived from:

A. Vitamins B. Hormones C. Lipids D. Proteins

19. The enzymes are substances which

A. Are broken into simpler substances during digestion

B. Are made by the combination of carbohydrates

C. Break complex food molecules into simpler food molecules

D. Break complex substances and they themselves undergo dissociation reactions

20. According to the induced fit model of enzyme action, reacting molecules enter a transition state in which:

A. reacting molecules assume a complementary shape

B. apoenzyme and cofactor assume a complementary shape

C. bonds in reacting molecules are put under tension

D. bonds in the apoenzyme and coenzyme are put under tension

21. Which one is not a cofactor?

A. Co-enzyme C. Apoenzyme

B. Prosthetic group D. Metal ions

22. The optimum temperature of an enzyme is the temperature at which:

A. there is no denaturation

B. the maximum number of enzymes–substrate complexes are formed

C. the maximum number of collisions between enzyme and substrate

D. the particles have the most kinetic energy

23. All are correct about non-competitive enzyme inhibitor. except

A. does not compete for the active site

B. binds with the allosteric site

C. binds with the active site of the enzyme

D. is not affected by the substrate concentration

24. If the ratio of non-competitive inhibitor molecules to substrate molecules is 3:7, the enzyme controlling the reaction will be:

A. 70% inhibited C. 30% activated

B. 30% inhibited D. three-sevenths activated

25. End-product inhibition of a metabolic pathway occurs when:

A. the last product of the pathway inhibits the enzyme controlling the first reaction

B. the last product of the pathway inhibits the enzyme controlling the last reaction

C. the first product of the pathway inhibits the enzyme controlling the last reaction

D. the last product of the pathway inhibits the enzyme controlling the first reaction

26. If substrate concentration is kept permanently high and the enzyme concentration is gradually increased, the rate of activity of the enzyme will:

A. increase C. Increase and then decrease

B. increase and then level off D. Stay the same

27. Which of the following is false regarding the factors affecting enzymatic activity or its inhibition

A. Product formed during a reaction can inhibit enzyme activity.

B. Competitive factors can act as inhibitors.

C. Change in the active site can inhibit the action of enzymes.

D. Increase in temperature beyond optimum generally increases the rate of enzymatic activity.

28. Which of the following factors cannot affect the enzymatic activity?

B. Change in temperature C. Change in pH

C. Change in substrate concentration D. Binding of specific chemical to enzyme

29. Irreversible inhibitors

A. form covalent bonds to the enzyme C. dissociate from enzyme easily

B. Can be removed from enzyme active site D. Do not alter enzyme permanently

30. During a biochemical reaction, an enzyme

A. Becomes part of the product C. Broken down into amino acids

B. Remains unchanged D. Reacts with fatty acids

31. Which of the following element is essential for carbonic anhydrases for uptake of carbon during photosynthesis?

A. Copper ion B. Zinc ion C. Sodium ion D. Calcium ion

32. Consider the following statements about enzymes.

I. Most enzymes are protein in nature

II. The specificity of an enzyme is due to its tertiary structure and the active site present in it.

III. Prosthetic group is loosely bound to the apoenzyme part of the enzyme.

IV. Prosthetic group and apoenzyme are enzymatically inactive when separated from each other.

A. I, II and III are correct C. I, III and IV are correct

B. I, II and IV are correct D. II, III and IV are correct

33. Which statement about enzymes is not correct?

A. Enzymes are in organic. C. Enzymes can catalyze any reaction.

B. Enzymes are catalysts D. Protease is an enzymes

34. Which of the following statements is not correct regarding the effects of pH on enzyme catalyzed reactions?

A. Direction of the reaction is influenced by [H+].

B. Ionization state of dissociating groups on the enzyme is modified.

C. Ionization state of the substrate is modified.

D. Optimum PH can cause denaturation of enzyme

35. All of the following statements are correct except

A. Enzymes are made from proteins

B. One enzyme can facilitate the reaction of many different substrates.

C. Enzymes sometimes use induced fits to break apart their substrates

D. Enzymes are not required for spontaneous reactions.

36. Enzyme denaturation is caused by:

A. Increase in substrate concentration C. Enzyme concentration

B. Highest temperature and PH D. High concentration of inhibitors

37. Mineral ions needed for enzyme activity:

A. bind tightly with the apoenzyme C. bind loosely with the apoenzyme

B. bind loosely with the coenzyme D. bind tightly with the coenzyme

38. How do heavy metal ions reduce the reaction rate of enzymes? By:

A. inducing mutations that disrupt the functioning of the enzyme

B. raising the temperature above the optimum level for the enzymes

C. dropping the PH well below the optimum level for the enzyme

D. destroying the 3-Dimensional shape of the enzyme

39. Which of the following industries can reduce more CO2 emission by shifting to the use of enzymes in the manufacturing process?

A. Bread making C. Cheese making

B. Leather making D. Manufacturing cosmetics

40. Which of the following statements is incorrect with respect to an enzyme's ability to catalyze a reaction?

A. An enzyme binds reactants such that they are positioned correctly and can attain their transition-state configuration

B. An enzyme provides a reaction surface and a hydrophilic environment for the reaction to takes place

C. An enzyme allows the reaction to go through a more stable transition state than would normally be the case

D. An enzyme can weaken bonds in reactants through the binding process

41. How do enzymes lower the activation of substrate molecules according to the induced -fit model?

A. Increasing the kinetic energy and probability of collision

B. Forming strongly bonded enzyme – substrate complex

C. By creating a tension in the bonds of the substate molecules

D. Providing an extra energy for the conversion of reactants into a product

42. Which of the following can reverse an enzyme inhibition that is caused by an allosteric inhibitor?

A. Adding more substrate C. Adding more end products

B. Depleting the end products D. Depleting the substate

43. Significant changes in PH that can affect an enzyme molecule include:

A. Building strong ionic bonds leading to stabilization of enxymes

B. Changing the color and palatability of the food items

C. Altering the charges on some substrates making it different to bind to enzymes

D. Increasing the boiling temperature of the substrate

44. Which one of the following enzymes is used as washing powdwer?

A. Cellulase B. Biochymosin C. Pectinase D. Lipase

45. What happens when the substrate molecule binds to the active site of an enzyme?

A. They form a stable intermediate substance

B. The substrate and the enzyme will bond permanently.

C. The chemical bonds of the substrate distorted.

D. The amino acids in the active site become un reactive

46. Which of the following enzymes requires copper ions for its catalytic activity

A. Nicotinamide adenine dinucleotide C. Alcohol dehydrogenase

B. Cytochrome oxidase D. Flavin adenine dinucleotide

47. An enzyme which is designed as E.C. 2.7.1.2 can be grouped to which class of enzyme?

A. Ligase B. Oxidoreductase C. Transferase D. Isomerase

48. Which of the following statements best describes an induced fit-model?

A. An active site alters shape such that it is ready to accept a substrate

B. A substrate adopts the correct binding conformation before entering an active site

C. An active site alters the shape of the substrate such that it can adopt the necessary active conformation for binding

D. A substrate binds to an active site and alters the shape of the active site

49. Which one of the following conditions is least likely to denature an enzyme?

A. A high temperature C. Heavy metal ions

B. A low temperature D. AN extreme PH

50. Cyclooxygenase -2 is an enzyme that catalyzes the conversion of arachidonic acid to prostaglandins, which promote pain and fever in our body. The pain killer ibuprofen, act as non-competitive inhibitor of cyclooxygenase-2, reduces the production of prostaglandins. What would happens if the concentration of the ibuprofen increased?

A. Production of prostaglandin is increased
B. Pain of the body is decreased
C. Substrate affinity of cyclooxygenase -2 is higher.
D. Concentration of arachidonic acid is decreased.

51. Which of the following vitamins is used as a component of cofactor?

A. Riboflavin B. Thiamine C. Retinol D. Ascorbic acid

ANSWER KEY FOR SELF PRACTICE EXERCISE SEVEN ON ENZYME

1. B	11.C	21.C	31.A	41.C
2.B	12.D	22.B	32.B	42.B
3.A	13.A	23.C	33.A	43.C
4.C	14.B	24.B	34.D	44.D
5.C	15.B	25.A	35.B	45.C
6.B	16.C	26.D	36.B	46.B
7.C	17.A	27.D	37.B	47.C
8.B	18.A	28.B	38.D	48.D
9.B	19.C	29.A	39.C	49.B
10.C	20.C	30.B	40.B	50.B 51. A

3.7 Energy Transformation

Learning Competencies

- ♣ Explain the process of dark and light reaction of photosynthesis.
- ♣ Describe the external and internal structure of a leaf.
- ♣ Describe the different chlorophyll pigments involved in the absorption of light energy.
- ♣ Analyze an absorption spectrum of the chlorophyll pigments from the graph.
- ♣ Explain the roles of grana and stroma in the process of photosynthesis.
- ♣ Describe cyclic and non-cyclic photophosphorylation.
- ♣ Show absorption spectra of chlorophyll a and chlorophyll b using graph.
- ♣ Explain the process of Calvin cycle.
- ♣ Compare cyclic and non-cyclic photophosphorylation.
- ♣ Differentiate between C3, C4 plants, and CAM Plants.
- ♣ Justify the reason why the rate of photorespiration is less in C4 plants as compared to C3 plants.
- ♣ Summarize the process of photosynthesis using chemical equation.
- ♣ Conduct an experiment to show the release of energy during photosynthesis.
- ♣ Conduct an experiment to show the presence of starch in green leaves.
- ♣ Explain the significances of photosynthesis.

Introduction

Energy transformation is a fundamental process in living organisms, enabling them to carry out essential functions for survival. Two key biological processes, photosynthesis and cellular respiration, play a vital role in converting energy from one form to another to support life.

Photosynthesis is the process by which plants, algae, and some bacteria convert light energy from the sun into chemical energy in the form of glucose (a type of sugar). This process occurs in the chloroplasts of plant cells, where light energy is absorbed by chlorophyll pigments and used to drive the conversion of carbon dioxide and water into glucose and oxygen. The energy captured during photosynthesis is stored in the chemical bonds of glucose, which can later be used by the plant or other organisms that consume it.

On the other hand, cellular respiration is the process by which living organisms break down glucose and other organic molecules to release stored energy. This occurs in the cells' mitochondria, where glucose is converted into ATP (adenosine triphosphate), the primary energy currency of the cell. Oxygen is required for this process, and it produces carbon dioxide and water as byproducts. Cellular

respiration is essential for all living organisms because it provides the energy needed for cellular activities like growth, repair, and reproduction. Both are part of the biological cycle that connects energy flow through ecosystems. Photosynthesis captures and stores solar energy, while cellular respiration releases it, allowing organisms to perform the necessary functions for life. This cycle is crucial for sustaining life on Earth and maintaining ecological balance.

What is metabolism on a cellular level?

Cellular metabolism is the set of chemical reactions that occur in living organisms in order to maintain life. Cellular metabolism involves complex sequences of controlled biochemical reactions called metabolic pathways. These processes allow organisms to grow and reproduce, maintain their structures, and respond to environmental changes.

3.7.1Photosynthesis

Adaptations of a leaf for photosynthesis

- The leaf is flat and wide, giving a large surface area to collect light and short distances for gases to diffuse. The veins bring water from the soil to the cells.
- The waxy cuticle is a waterproof layer found on the surface of many leaves to help prevent water loss.
- The palisade mesophyll is the main photosynthetic tissue of the plant.
- ✓ Contain many chloroplasts – spread out through the cytoplasm of the cell when light levels are high but which cluster at the top of the cell when light levels are low.
- ✓ Are near the upper surface of the leaf where they receive more sunlight
- ✓ allows maximum photosynthesis
- The spongy mesophyll has fewer cells with fewer chloroplasts.
- ✓ Contain lots of air spaces and a big surface area for gas exchange.
- ✓ Some photosynthesis takes place here but more importantly it is where the carbon dioxide needed for photosynthesis moves into the cells, and the oxygen moves out.
- ✓ The water lost in transpiration evaporates from the cells here as well.
- The lower epidermis has openings known as stomata which allow carbon dioxide to diffuse into the leaf and oxygen and water vapor to diffuse out.
- The guard cells open and close to control the entry of carbon dioxide into the leaf and also to control the loss of water by transpiration
- The vascular bundles contain the
- ✓ Xylem: dead tissue Transport water from the soil to the cells of the leaves
- ✓ Phloem: living tissue which carries the products of photosynthesis away from the leaves to all of the cells of the plant.

SITE OF PHOTOSYNTHESIS

- In plants, photosynthesis takes place in chloroplasts, which contain the chlorophyll.

- Chloroplasts are surrounded by a double membrane and contain a third inner membrane, called the thylakoid membrane, which forms long folds within the organelle
- Light reaction of photosynthesis takes place grana
- Dark reaction/ Calvin cycle takes in stroma of chloroplast.

Photosynthetic pigments

- ❖ Photosynthetic cell contain Different pigments respond to different wavelengths of visible light.
- ❖ They maximize absorption efficiency of different wavelength of light and increase effectiveness of photosynthesis
- ❖ there are three basic classes of pigments.

i. Chlorophylls are greenish pigments which contain a porphyrin ring.

Chlorophyll a - is a green pigment found in all plants, algae, and cyanobacteria

- ➢ absorbs violet- blue and reddish orange-red wavelengths

Chlorophyll b – pigment occur only in "green algae" and in plants.

- ➢ absorbs mostly blue and yellow light.

Chlorophyll c -- found only in the photosynthetic members of the Chromista and dinoflagellate. Primarily pigment seen in marine algae. Chromista is unicellular or multicellular eukaryotic species such as algae, diatoms and fungi like organisms.

ii. Carotenoids are pigment that exhibit red, orange, or yellow, purple color and they include the familiar compound carotene, which gives carrots their color.

- ➢ Carotenoids cannot transfer sunlight energy directly to the photosynthetic pathway and are called accessory pigments.
- ➢ Are ubiquitous and essential pigments in photosynthesis.
- ➢ They absorb in the blue-green region
- ➢ are the most widely distributed pigment in nature and present in photosynthetic bacteria, some species of archaea, fungi, algae, plants and animals.

iii. Fucoxanthin is a Xanthophyll found in chloroplast of the brown algae as well as the diatoms.

iv. Phycobilin are water-soluble pigments, and are, therefore, found in the cytoplasm, or in the stroma of the chloroplast. They occur only in Cyanobacteria and Rhodophyta.

Light-dependent and light-independent reactions

Light dependent reaction

- ➢ convert solar energy to chemical energy.
- ➢ Water is split, providing a source of electrons and protons (hydrogen ions, H+) and giving off O_2 as a by-product
- ➢ Energy from photolysis drives a transfer of the electrons and hydrogen ions from water to an acceptor called NADP+
- ➢ Light reaction uses solar energy to reduce NADP + to NADPH by adding a pair of electrons along with an H
- ➢ ATP is also generated by Cyclic and non-cyclic photophosphorylation in stroma.

a. Non cyclic photophosphorylation

- Source of electron is water and involve both PSI and PSII.
- Produce O2, ATP and NADPH
- Last electron acceptor is NADP+.

b. Cyclic photophosphorylation

- Source of electron PSI
- Produce only ATP
- Last electron acceptor is PSI

Dark reaction/Light independent reaction

- Called Calvin cycle since discovered by Melvin Calvin in 1957.
- Is the process that plant and algae turn CO2 from the air into sugar
- The energy-poor CO_2 is fixed to energy-rich carbohydrates using the energy-rich compound, ATP, and the assimilatory power, NADPH2 of light reaction.
- Contain three main phases: Carbon fixation, reduction and regeneration phase.
- In the Calvin cycle, 12NADPH2 and 18 ATPs are required to fix 6CO2 molecules into one hexose sugar molecule

C3 plants: C3 photosynthesis

- Plant that produces the first stable product called Phosphoglycerate (PGA).
- Are approximately 95% of plants on the earth are C3 plants.
- Some of the C3 plant examples are wheat, rye, oats, and orchard grass

C4 plants: C4 photosynthesis

- Are plants like maize, sorghum, and sugarcane, the first product of carbon dioxide fixation is the four-carbon compound oxaloacetic acid.

The basic C4 cycle consists of four stages

I. Fixation of CO2 by the carboxylation of phosphoenol-pyruvate (PEP) in the mesophyll cells to form a C4 acid.
II. Transport of the C4 acids to the bundle sheath cells
III. Decarboxylation of the C4 acids within the bundle sheath cells and generation of CO2, which is then reduced to carbohydrate via the Calvin cycle.
IV. Transport of the C3 acid (pyruvate or alanine) that is formed by the decarboxylation step back to the mesophyll cell and regeneration of the CO2 acceptor phosphoenolpyruvate.

CAM (crassulacean acid metabolism) Plants: -

- The CAM mechanism enables plants to improve water use efficiency. In CAM plants, formation of the C4 acids is both temporally and spatially separated.

What is photorespiration?

- Photorespiration is a process which involves oxidation of organic compounds in plants by oxygen in the presence of light.
- It releases carbon from organic compounds in the form of CO2 but does not produce ATP.
- It is defined as CO_2 concentration at which rate of uptake will be equal to the rate of photosynthetic respiratory CO_2 released.

- Photorespiration is common in C3 plants but highly reduced in C4 plants, and absent in CAM plants.

EXAMPLES OF REVIEW EXERCISE ON PHOTOSYNTHESIS

1. What are the chlorophyll pigments responsible for absorption of light spectra?
   - ✓ **Chlorophyll a:** The primary pigment involved in photosynthesis. Absorbs primarily red and blue-violet light.
   - ✓ **Chlorophyll b:** A secondary pigment that assists chlorophyll a in light absorption. Absorbs primarily blue and orange light.
   - ✓ **Carotenoids:** Accessory pigments that absorb light in the blue-green region of the spectrum. They also protect chlorophyll from photooxidation.
2. Compare cyclic and non-cyclic photophosphorylation
   - ✓ **Cyclic Photophosphorylation:**
     - Involves only Photosystem I.
     - Electrons cycle back to Photosystem I.
     - Primarily produces ATP.
   - ✓ **Non-Cyclic Photophosphorylation:**
     - Involves both Photosystem I and II.
     - Electrons flow from Photosystem II to Photosystem I and are ultimately accepted by NADP+ to form NADPH.
     - Produces both ATP and NADPH.
3. What are the products of the light reacttions subsequently used by the Calvin cycle?
   - ✓ **ATP:** Provides energy for the carbon fixation reactions.
   - ✓ **NADPH:** Provides reducing power for the reduction of carbon dioxide.
4. Where do the enzymatic reactions of the Calvin cycle take place?
   - ✓ The Calvin cycle takes place in the **stroma** of the chloroplast.
5. Compare the mechanism of carbon fixation C3 and C4 plants.
   - ✓ **C3 Plants:**
     - Initial carbon fixation product is a 3-carbon compound (3-phosphoglycerate).
     - Stomata open during the day, leading to potential water loss.
     - More susceptible to photorespiration.
   - ✓ **C4 Plants:**
     - Initial carbon fixation product is a 4-carbon compound (oxaloacetate).
     - Minimize photorespiration by spatially separating carbon fixation and the Calvin cycle.
     - More efficient in hot, dry environments.

3.7.2. Cellular Respiration

At the end of this lesson, the student will be able to:

- ♣ define cellular respiration
- ♣ Describe the process of glycolysis.
- ♣ List the products formed at the end of glycolysis.
- ♣ Describe the structure of mitochondria.
- ♣ Explain how energy is harvested in aerobic respiration.
- ♣ Describe the different stages of aerobic respiration.
- ♣ Compare and contrast aerobic and anaerobic respiration.
- ♣ Write the chemical equation of aerobic respiration.
- ♣ State the products of alcoholic fermentation by yeast.
- ♣ Show the mechanism electron transport system in mitochondria.
- ♣ explain the difference between substrate-level phosphorylation and oxidative phosphorylation

What is cellular respiration?

- Cellular respiration is the process by which biological fuels are oxidized in the presence of an inorganic electron acceptor such as oxygen to produce large amounts of energy, to drive the bulk production of adenosine triphosphate.

What is the difference between Photosynthesis and Respiration

3.2.1.The site/place of cellular respiration

- Cellular respiration takes place in the cytoplasm and mitochondria of each cell of the body.
- Glycolysis occurs inside the cytoplasm, whereas the TCA cycle occurs inside the matrix of the mitochondria. On the other hand, oxidative phosphorylation occurs on the inner mitochondrial membrane, with protons diffusing across the membrane and is later pumped back into the matrix.
- Cellular respiration is used to generate usable ATP energy in order to support many other reactions in the body. ATP is particularly important for energetically unfavorable reactions that would otherwise not occur without an energy input.

Stages of cellular respiration

I. GLYCOLYSIS

- Glycolysis occurs in the cytosol of the cell in anaerobic condition
- It is a common pathway of both aerobic and anaerobic respiration
- Begin by breaking glucose into two molecules of a three-carbon compound called pyruvate
- When oxygen is in short supply, mitochondrial reoxidation of NADH formed from NAD+ during glycolysis is impaired, and NADH is re-oxidized by reducing pyruvate to lactate, so permitting glycolysis to proceed.
- It is a ten (10) step process that consist three phases

a. Energy investment phase (Glucose → → Fructose-1,6-bisphosphate)
b. Cleavage phase: Breaks Fructose-1,6-bisphosphate into two molecules of glyceraldehyde -3-phosphate.
c. Energy liberation phase: produces 4 ATP or net 2ATP, 2NADH and 2 Pyruvate per glucose molecule

II. Pyruvate oxidation (Link Reaction)

- Also called pyruvate decarboxylation
- Occur mitochondrial
- Link cytoplasmic product with mitochondria
- Pyruvate is oxidized to acetyl coA
- The process produces 2NADH and 2CO2
- Acetyl Co enter into Citric acid cycle by reacting with oxaloacetate in Kreb cycle.

a. Kreb cycle

- Occur in matrix of mitochondrial
- It begins when acetyl-CoA combines with a four-carbon molecule called OAA.
- Citric acid undergoes series reaction which store energy into ATP, NADH, FADH.
- It also releases CO2 and Final step regenerate OAA.
- Two turn of pyruvate produces 6NADH, 2FADH, 2ATP, 2CO2.

b. Oxidative phosphorylation

- ATP is formed because of transfer of electrons from NADH or FADH2 to O_2 by a series of electron carriers
- is the major source of ATP in aerobic organisms in mitochondria
- this stage generates 26 out of the 30 molecules of ATP that are formed when glucose is completely oxidized to CO2 and H2O.
- It involves three steps: oxidation-reduction, generation of proton and synthesis of ATP.

Table 7. Comparison between photosynthesis and Respiration

Photosynthesis	Respiration
➢ Anabolic process ➢ Requires the presence of light ➢ Uses CO_2 and H_2O ➢ Reduction occurs ➢ Photolysis of water ➢ Produces $C_6H_{12}O_6$ and O_2 ➢ Occurs in cells that contain chlorophyll ➢ Occurs in chloroplasts ➢ NADPH+ is formed ➢ Thylakoid membrane is the location for electron transport system ➢ ATP production is by means of photophosphorylation	➢ Catabolic process ➢ Does not require the presence of light. ➢ Uses $C_6H_{12}O_6$ and O_2 ➢ Oxidation occurs ➢ Formation of water ➢ Produces CO_2 and H_2O ➢ Occurs in all metabolically active cells. ➢ Occurs in cytoplasm and mitochondria. ➢ NADH+ is formed. ➢ Inner mitochondrial matrix is the location for electron transport. ➢ ATP production is by means of substrate level and oxidative phosphorylation

EXERCISES FORTEEN (SELF PRACTICE QUESTIONS)

CHOOSE THE BEST ANWSER FROM THE GIVEN ALTERNATIVES

1. Which of the following is not true about cellular respiration?
   A. Cellular respiration occurs in plasma membrane in prokaryotic cell
   B. Cellular respiration is an exergonic pathway that release energy from glucose
   C. Cellular respiration occurs in cell's cytoplasm and mitochondria
   D. Cellular respiration in plant cell occur in storm of chloroplast
2. If the cell size increase

A. Surface area of the cell decrease
B. The ratio of surface area to volume ratio increase
C. Volume of the cell increase faster than its surface area
D. The surface area of the cell double faster than volume of the cell

3. Which pathway for aerobic cellular respiration is located in the cytoplasm of the cell?
   A. Krebs cycle C. electron transport system
   B. Calvin cycle D. Glycolysis
4. The conversion of lactate to glucose in the liver cell uses
   A. 38 ATP B. 4 ATP C. 6 ATP 2 ATP
5. Which of the following statements is NOT correct regarding aerobic cellular respiration?
   A. Cells are able to utilize all the energy from glucose when released in one burst
   B. Cells would lose too much energy as heat if they used glucose directly for individual reactions
   C. Gradual glucose breakdown releases energy slowly
   D. Gradual glucose breakdown allows for the simultaneous buildup of many ATP molecules
6. Which of the following pathways does NOT occur in aerobic cellular respiration
   A. Glycolysis C. Krebs cycle
   B. electron transport system D. Calvin cycle
7. The carriers for the electron transport system are located
   A. within the cytoplasm of a cell C. within the matrix of mitochondria
   B. on the cristae of mitochondria D. within the stroma of chloroplasts
8. Which of the following statements is NOT correct about glycolysis?
   A. Glycolysis begins with glucose and ends with four pyruvate molecules
   B. Glycolysis takes place within the cytoplasm
   C. Glycolysis uses two ATP but forms four ATP, resulting in a net gain of two ATP molecules
   D. During glycolysis, two NADH are produced as substrate oxidation occurs
9. Which of the following statements about the link reaction is NOT correct?
   A. It occurs in the matrix of mitochondria.
   B. Two oxygen molecules are given off from glucose
   C. Two pyruvate molecules become two acetyl-CoA molecules
   D. Two NADH molecules are formed from the reaction.
10. Which of the following series of enzymatic reactions begins and ends with citrate?
    A. Krebs cycle C. electron transport system
    B. transition reaction D. glycolysis
11. Which molecule will combine with the four-carbon oxaloacetate in the Krebs cycle to form the six-carbon citrate?
    A. lactic acid B. NADH C. acetyl-CoA D. FADH
12. Based on chemiosmosis, hydrogen ions accumulate in the _____ of the mitochondrion to create a large electrochemical gradient for aerobic cellular respiration.

A. Inter-membrane space C. intra-membrane space
B. Cristae of mitochondria D. matrix of mitochondria

13. What molecule will form when hydrogen ions flow down the electrochemical gradient through ATP synthase complexes in mitochondria?
A. Water B. ATP C. ADP D. carbon dioxide

14. Which of the following overall equations represents aerobic cellular respiration?
A. $C_6H_{12}O_6 \rightarrow$ 2 pyruvate + 2 ATP
B. $6\ CO_2 + 6\ H_2O$ + Energy $\rightarrow C_6H_{12}O_6 + 6\ O_2$
C. $C_6H_{12}O_6 + 6O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ + Energy
D. $C_6H_{12}O_6 \rightarrow$2 lactate + 2 ATP

15. If ten FADH2 molecules are produced in the Krebs cycle, how many total ATP molecules will be formed as those hydrogen's are transmitted to the electron transport system?
A. 40 B. 20 C. 30 D. 10

16. Which of the following pathways and reactions will result in the production of the most ATP molecules during aerobic cellular respiration of one glucose molecule?
A. Glycolysis C. chemiosmosis
B. Krebs cycle D. Fermentation

17. Which of the following statements is NOT correct when amino acids undergo catabolism?
A. The carbon skeleton of amino acids is produced in the liver.
B. During deamination of an amino acid, the carboxyl group is removed.
C. The amino group becomes ammonia.
D. Ammonia enters the urea cycle and becomes part of urea.

18. Which of the following molecules is the most efficient form of stored energy?
A. proteins C. monosaccharaides
B. glycerol D. Fats

19. Which of the following overall equations represents fermentation that occurs in yeast cells?
A. $C_6H_{12}O_6 \rightarrow$ 2 Pyruvate + 2 ATP
B. $6\ CO_2 + 6\ H_2O$ + energy $\rightarrow C_6H_{12}O_6 + 6\ O_2$
C. $C_6H_{12}O_6 \rightarrow$ 2 lactate + 2 ATP
D. $C_6H_{12}O_6 \rightarrow$ 2 alcohol + 2 CO_2 + 2 ATP

20. _____ is a series of enzymatic reactions by which glucose is incompletely metabolized to lactate or carbon dioxide and alcohol.
A. The electron transport system C. The Krebs cycles
B. Aerobic cellular respiration D. Fermentation

21. When oxygen is NOT available to an animal cell, which of the following statements is correct?
A. Only the electron transport system remains operative.
B. More hydrogen gas is produced because oxygen, the final acceptor, is not present
C. The cells production of ATP molecules is cut in half
D. Glycolysis still occurs during fermentation because NADH2 passes its hydrogen atoms to pyruvate.

22. Which of the following statements is NOT correct about fermentation in animal cells?
    A. It can provide a rapid burst of ATP when there is limited oxygen supply.
    B. In our bodies, muscle cells more than other cells are adapted to carry on fermentation.
    C. Pyruvate can build up in muscles, changing the pH and causing the muscles to fatigue.
    D. Only animal cells can carry out fermentation.
23. In the electron transport system present in the inner mitochondrial membrane, complexes I and IV are respectively?
    A. FADH2 and NADH dehydrogenase
    B. Cytochrome complex and NADH dehydrogenase
    C. NADH dehydrogenase and cytochrome oxidase complex
    D. NADH dehydrogenase and ATP synthase
24. The usefulness of fermentation as a means of deriving energy is limited because
    A. it cannot generate enough ATP
    B. it produces too much $NADH_2$
    C. the end products are toxic to the producer
    D. it uses more energy than it produces
25. Oxidative phosphorylation is the production of?
    A. NADH in respiration C. ATP in respiration
    B. NADPH in photosynthesis D. ATP in photosynthesis
26. Before pyruvate enters the Krebs cycle, the connecting link between Krebs cycle and glycolysis is changed to
    A. PEP B. Acetyl CoA C. Oxaloacetate D. Citrate
27. Which of the following is not a commercial use for anaerobic respiration?
    A. production of biogas from human waste C. beer making
    B. yoghurt production D. bread making
28. This energy molecule used in fueling the chemical reactions inside of your body is composed of ___.
    A. meats, fruits, and vegetables
    B. an adenosine molecule connected to 2 phosphate groups
    C. an adenosine molecule connected to 3 phosphate groups
    D. amino acids linked together in polypeptides
29. Aerobic respiration is carried out in the ____, and leads to the production of _____.
    A. absence of oxygen, 2 ATP molecules C. absence of oxygen, 36 ATP molecules
    B. presence of oxygen, 2 ATP molecules D. presence of oxygen, 36 ATP molecules
30. What is Not produced at the end of alcoholic fermentation?
    A. Ethanol B. Carbon dioxide C. ATP D. Pyruvate
31. Which of the following is not true about cellular respiration?
    A. Cellular respiration occurs in plasma membrane in prokaryotic cell
    B. Cellular respiration is an exergonic pathway that release energy from glucose

C. Cellular respiration occurs in cell's cytoplasm and mitochondria
D. Cellular respiration in plant cell occur in stroma of chloroplast

32. Which of the following statements is NOT correct regarding aerobic cellular respiration?
    A. Cells are able to utilize all the energy from glucose when released in one burst
    B. Cells would lose too much energy as heat if they used glucose directly for individual reactions
    C. Gradual glucose breakdown releases energy slowly
    D. Gradual glucose breakdown allows for the simultaneous buildup of many ATP molecules
33. The carriers for the electron transport system are located
    A. within the cytoplasm of a cell C. Within the matrix of mitochondria
    B. on the cristae of mitochondria D. within the stroma of chloroplasts
34. Which of the following statements about aerobic cellular respiration in the human body is NOT correct?
    A. Glucose and oxygen are delivered to the cells by the bloodstream
    B. ATP remains in the cytoplasm as a source of energy for the cell to do work
    C. In mitochondria, glucose is broken down to carbon dioxide and water as ATP is produced
    D. Carbon dioxide and water are removed from the cells by the bloodstream
35. Which of the following statements is NOT correct about glycolysis?
    A. Glycolysis begins with glucose and ends with four pyruvate molecules
    B. Glycolysis takes place within the cytoplasm
    C. Glycolysis uses two ATP but forms four ATP, resulting in a net gain of two ATP molecules
    D. During glycolysis, two NADH are produced as substrate oxidation occurs
36. Which of the following statements about the link reaction is NOT correct?
    A. It occurs in the matrix of mitochondria.
    B. Two oxygen molecules are given off from glucose
    C. Two pyruvate molecules become two acetyl-CoA molecules
    D. Two NADH molecules are formed from the reaction
37. Which of the following series of enzymatic reactions begins and ends with citrate?
    A. Krebs cycle C. electron transport system
    B. transition reaction D. glycolysis
38. Which one of the following is not the component of ATP molecule?
    A. Ribose sugar C. Adenosine
    B. Phosphate group D. Hexose sugar
39. Which of the following is correct about coupled reaction in the cell?
    A. The two reaction releases energy at the same time
    B. The first reaction must be exothermic and the second reaction is endothermic
    C. The first reaction must be anabolic and the second reaction is catabolic

D. The first reaction must be endothermic and the second reaction is exothermic

40. Which of the following stage of cellular respiration is the common pathway of both prokaryotic and eukaryotic organism?

A. Pyruvate oxidation C. Glycolysis

B. Citric acid cycle D. Oxidative phosphorylation

41. Cellular respiration takes place in

A. Mitochondria and stroma of the cell

B. Cytoplasm and mitochondria of the cell

C. Thylakoid membrane and plasma membrane

D. Peroxisome and mitochondria

42. Which of the following process takes place in the inner mitochondrial membrane?

A. Glycolysis C. TCA cycle

B. Pyruvate oxidation D. Oxidative phosphorylation

43. Which of the following statement about cellular respiration is not correct?

A. The CO_2 we exhale is produced by pyruvate oxidation and Krebs cycle

B. The oxidation and reduction reaction are usually coupled

C. Glycolysis occurs only in the absence of oxygen

D. NAD+ and FAD+ capture high energy electron from redox reaction

44. Respirometer measures the amount of

A. ATP used by the cell C. Oxygen up taken by the cell

B. Carbon dioxide used in photosynthesis D. Water used by cell in respiration

45. Which of the following process does not occur during link reaction?

A. Dehydrogenation C. Decarboxylation

B. Phosphorylation D. Pyruvate oxidation

46. Which of the following is the product of pyruvate oxidation?

A. 2pyruvate, 2 NADH, 2acetyl coA C. 2Oxaloacetate, 2 Citrate, 2 CO_2

B. 2 acetyl-coA, 2 NADH, 2H+, and 2CO_2 D. Coenzyme A, CO_2, ATP, NADH

47. NADH and FADH deposit their electron in the

A. Glycolysis C. Electron transport

B. Pyruvate oxidation D. Krebs cycle

48. Which of the following statement is correct about electron transport and oxidative phosphorylation?

A. Electron carrier molecules are embedded in matrix of mitochondria

B. Chemiosmosis is due to Proton diffusion from matrix to intermembrane space

C. ATP is produced as a result of the transfer of electron from NADH or FADH to oxygen

D. Water is the final electron acceptor of aerobic respiration

49. Which one of the following organic molecules is serve as the source of phosphate and store free ATP in its phosphate bonds?

A. Creatine phosphate C. Phosphoglycerate

B. Glucose -6- phosphate D. Phosphoenolpyruvate

50. Which of the following statements is not correct about glycolysis?

A. Cleavage phase produces fructose -1,6-bisphosphate

B. The first phase of glycolysis involves phosphorylation of glucose

C. Energy investment phases consumes two ATP molecules

D. Energy liberation phases produces 4 four ATP, two Pyruvate and two NADH

51. Which of the following comparison between photosynthesis and respiration?

A. Photosynthesis is uses glucose and oxygen while respiration produces only oxygen

B. Respiration produces water while photosynthesis photolysis water

C. Both respiration and photosynthesis take place in the chloroplast of green plants

D. Photosynthesis produces NADH+ while respiration generates NADPH+

52. Which one of the following is not the component of ATP molecule?

A. Ribose sugar B. Adenosine C. Phosphate group D. Hexose sugar

53. Which of the following is correct about coupled reaction in the cell?

A. The two reaction releases energy at the same time

B. The first reaction must be exothermic and the second reaction is endothermic

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54. Which of the following is following stage of cellular respiration is the common pathway of both prokaryotic and eukaryotic organism?

A. Pyruvate oxidation C. Glycolysis

B. Citric acid cycle D. Oxidative phosphorylation

55. Cellular respiration takes place in

A. Mitochondria and stroma of the cell

B. Cytoplasm and mitochondria of the cell

C. Thylakoid membrane and plasma membrane

D. Peroxisome and mitochondria

56. Which of the following process takes place in the inner mitochondrial membrane?

A. Glycolysis C. TCA cycle

B. Pyruvate oxidation D. Oxidative phosphorylation

57. What is the ultimate electron acceptor in aerobic respiration?

A. Oxygen B. Water C. NADH D. ATP

58. Which of the following statement about cellular respiration is not correct?

A. The CO_2 we exhale is produced by pyruvate oxidation and Krebs cycle

B. The oxidation and reduction reaction are usually coupled

C. Glycolysis occurs only in the absence of oxygen

D. NAD+ and FAD+ capture high energy electron from redox reaction

59. **Which of the following statements is true regarding photorespiration?**
   A. Photorespiration enhances the efficiency of photosynthesis by producing more ATP.
   B. Photorespiration occurs when the enzyme Rubisco fixes oxygen instead of carbon dioxide.
   C. Photorespiration is more common in C4 plants than in C3 plants.
   D. Photorespiration reduces the production of oxygen in plant cells.
60. **Which of the following best describes the advantage of C4 plants over C3 plants in hot, dry environments?**
   A. C4 plants can store more water, reducing water loss during transpiration.
   B. C4 plants use less energy to fix carbon compared to C3 plants.
   C. C4 plants avoid photorespiration by spatially separating carbon fixation from the Calvin cycle.
   D. C4 plants do not require sunlight for carbon fixation.

ANSWER KEY FOR EXERCISE FORTEEN SELF PRACTICE QUESTION ON CELLULAR RESPIRATION

1. D	16.C	31.D	46.B
2.C	17.B	32.A	47.C
3. D	18.D	33.B	48.C
4. D	19.D	34.B	49.A
5. A	20.D	35.A	50.A
6. D	21.D	36.B	51.B
7. B	22.D	37.A	52.D
8. A	23.B	38.D	53.B
9.B	24.C	39.B	54.C
10.A	25.C	40.C	55.D
11.C	26.B	41.B	56.D
12.B	27.A	42.D	57.A
13.B	28.C	43.C	58.C
14.C	29.A	44.C	59.B
15.B	30.D	45.B	60.C

3.2.2.Stages of respiration

Aerobic respiration is divided into main stages: Glycolysis, Citric acid cycle, and Electron transport chain

i. **Glycolysis:** Occurs in the cytoplasm. Glucose is broken down into pyruvate, producing a small amount of ATP. It is the common pathway of both aerobic and anaerobic respiration.

The net reaction of glycolysis is:

$$Glucose + 2ADP + 2NAD^{+} + 2Pi \longrightarrow 2Pyruvate + 2ATP + 2NADH + 2H^{+} + 2H_2O$$

ii. Pyruvate oxidation (Link reaction)

- ✓ Pyruvate undergoes several changes to become acetyl Coenzyme A. Involve three steps

✓ 1st carboxyl group is removed from pyruvate, releasing a molecule of carbon dioxide into the surrounding medium.

✓ 2nd The hydroxyethyl group is oxidized to an acetyl group, and the electrons are picked up by NAD+, forming NADH

✓ 3rd The enzyme-bound acetyl group is transferred to CoA, producing a molecule of acetyl CoA

Net reaction of link reaction is:

2pyruvate + 2NAD+ + 2 CoA --> 2 acetyl-CoA + 2NADH + 2H+ + 2CO2.

iii. **Krebs Cycle (Citric Acid Cycle):**

✓ Occurs in the mitochondrial matrix. Pyruvate is further oxidized, releasing CO_2 and generating NADH and FADH2.

✓ begins when acetyl-CoA combines with a four-carbon molecule called OAA (oxaloacetate)

Net reaction:

$$\mathbf{3NAD+ + FAD + GDP + Pi + acetyl\text{-}CoA + 2\ H_2O \rightarrow 3NADH + FADH_2 + GTP + 2CO_2 + 4H^+}$$

iv. **Oxidative Phosphorylation:**

✓ Occurs in the inner mitochondrial membrane of eukaryotic cells. NADH and FADH2 donate electrons to the electron transport chain, creating a proton gradient that drives ATP synthesis.

✓ It is responsible for producing the majority of ATP generated during aerobic respiration.

✓ Oxidative phosphorylation involves two main processes:(ETC and chemiosmosis)

2. **Electron Transport Chain (ETC)**: A series of protein complexes embedded in the inner mitochondrial membrane.

✓ **NADH and FADH2**: donate electrons to the electron transport chain.

✓ The energy released during electron transport along the ETC is used to pump protons (H+) across the inner mitochondrial membrane and accumulated in intermembrane space, creating a **proton gradient** (also called a proton-motive force).

✓ The intermembrane space becomes more acidic (higher concentration of protons), and the matrix becomes more basic (lower concentration of protons).

✓ This creates a proton gradient, which drives ATP synthesis by the enzyme ATP synthase.

✓ **Chemiosmosis**: The process of ATP synthesis powered by a proton gradient.

✓ **Three key sites** within the ETC contribute the energy needed for ATP synthesis:

A. **Site I:** Between FMN and Coenzyme Q in Complex I
B. **Site II:** Between cytochrome b and cytochrome c1 in Complex III
C. **Site III:** Between cytochrome a and cytochrome a3 in Complex IV

✓ At the end of the electron transport chain, electrons are transferred to oxygen, which combines with protons to form water. This is crucial because it ensures the continuation of the electron flow and prevents the backup of electrons in the chain.

- ✓ **ATP Yield**: Each NADH can produce approximately 2.5 ATP, while each FADH2 produces around 1.5 ATP through oxidative phosphorylation.
- ✓ **Oxidative Phosphorylation** is responsible for generating **26 out of the 30-38 ATP** produced from the complete oxidation of one glucose molecule (depending on the cell type and conditions).

3.3. Fermentation (alcoholic and lactic acid)

- **Fermentation** is an **anaerobic process** where cells break down glucose to produce energy without oxygen. It occurs in two main types:

A. **Alcoholic Fermentation**

- Performed by yeast and some bacteria.
- Converts glucose into ethanol (alcohol), carbon dioxide (CO_2), and ATP.
- Used in bread-making, brewing, and wine production.
- Equation: Glucose → Ethanol + CO_2 + Energy (ATP)

B. Lactic Acid Fermentation

- Occurs in muscle cells and some bacteria.
- Converts glucose into lactic acid and ATP.
- Happens during intense exercise when oxygen is low.
- Used in making yogurt and cheese.
- Equation: Glucose → Lactic Acid + Energy (ATP)

3.4. Energy from non-carbohydrate sources

- When carbohydrates are unavailable, the body derives energy from fats and proteins through alternative metabolic pathways:

I. Fats (Lipids) as an Energy Source

- Lipids are broken down into glycerol and fatty acids.
- Fatty acids undergo β-oxidation to produce acetyl-CoA, which enters the Krebs cycle for ATP production.
- Used during fasting, prolonged exercise, and low-carb diets.

II. Proteins as an Energy Source

- Proteins are broken down into amino acids through proteolysis.
- Deamination removes the amino group, and the remaining carbon skeleton enters metabolic pathways (Krebs cycle) for energy.
- Used when carbohydrate and fat stores are depleted, such as in starvation.

EXAMPLES OF REVIEW EXERCISE ON CELLULAR RESPIRATION

1. Distinguish between anabolic and metabolic pathways.

- **Anabolic Pathways:**
  - ✓ Build complex molecules from simpler ones.
  - ✓ Require energy input (usually in the form of ATP).
  - ✓ Examples: Protein synthesis, photosynthesis, glycogen synthesis.
- **Catabolic Pathways:**
  - ✓ Break down complex molecules into simpler ones.
  - ✓ Release energy (often stored as ATP).
  - ✓ Examples: Cellular respiration, glycolysis, digestion.

2. Describe the process of cellular respiration. Cellular respiration is a series of metabolic processes that break down glucose to produce energy (ATP).
   - Occurs in three main stages:

     Glycolysis: Occurs in the cytoplasm. Glucose is broken down into pyruvate, producing a small amount of ATP.

     Krebs cycle (Citric Acid Cycle): Occurs in the mitochondrial matrix. Pyruvate is further oxidized, releasing CO2 and generating NADH and FADH2.

     Oxidative Phosphorylation: Occurs in the inner mitochondrial membrane. NADH and FADH2 donate electrons to the electron transport chain, creating a proton gradient that drives ATP synthesis.
3. Justify why oxidation of glucose involving mitochondrion is more efficient.
   - **Mitochondrial oxidation is more efficient than other forms of glucose breakdown** because it utilizes oxygen as the final electron acceptor in the electron transport chain. This allows for complete oxidation of glucose, maximizing ATP production.
   - In contrast, anaerobic processes like fermentation produce less ATP because they rely on less efficient electron acceptors.
4. During a race how can your muscles cells produce ATP if oxygen deficiency occurs?
   - When oxygen is limited, muscle cells switch to **anaerobic respiration (fermentation)**.
   - **Lactic acid fermentation** is the primary pathway.
   - Glucose is converted to pyruvate, and then to lactate, generating a small amount of ATP.
   - Lactate buildup can cause muscle fatigue and soreness.
5. How many ATP molecules are directly produced in the citric acid cycle from one molecule of glucose?

   A. 2 ATP
   C. 6 ATP
   B. 4 ATP
   D. 38 ATP

Explanation: Each glucose molecule produces two pyruvate molecules, leading to two turns of the citric acid cycle. Each turn generates 1 ATP (via substrate-level phosphorylation), so a total of 2 ATP molecules are produced per glucose molecule.

6. What happens to lactic acid that accumulates during anaerobic respiration in muscle cells?
   A. It is converted into glucose through gluconeogenesis.
   B. It is broken down to produce more ATP.
   C. It is converted into ethanol and carbon dioxide.

D. It is transported to the liver to be converted back to glucose.
Explanation: Lactic acid that accumulates in muscle cells is transported to the liver, where it is converted back to glucose through a process called the Cori cycle. This process helps to clear lactic acid from muscles and restores glucose levels.

7. In alcohol fermentation, what is the first step that occurs after pyruvate is produced from glycolysis?
   A. Pyruvate is converted into lactic acid.
   B. Pyruvate is decarboxylated to form acetaldehyde.
   C. Acetaldehyde is reduced to form ethanol.
   D. Oxygen is used to convert pyruvate into carbon dioxide and water.

   Explanation: In alcohol fermentation, the first step involves the decarboxylation of pyruvate, where carbon dioxide is released, forming acetaldehyde.
8. Why is it difficult to lose fat, even though it contains more energy than carbohydrates?
   A. Fat cells cannot be broken down for energy.
   B. The body must work harder to break down fat because of its high energy content.
   C. Carbohydrates are used first for energy, making it harder to use fat.
   D. Fat metabolism produces more ATP, so less effort is needed.

   Explanation: Since fat contains more kilojoules of energy per gram than carbohydrates, the body needs to exert more effort to metabolize fat and use it as a fuel source, making fat loss a more challenging process.
9. What is the role of NADH in alcohol fermentation?
   A. NADH provides the electrons needed to convert acetaldehyde into ethanol.
   B. NADH is used to produce ATP in the electron transport chain.
   C. NADH is oxidized to form NAD+ during the reduction of acetaldehyde.
   D. NADH is required to convert glucose into pyruvate.

   Explanation: In alcohol fermentation, NADH is oxidized to NAD+ during the conversion of acetaldehyde to ethanol. This regeneration of NAD+ is crucial for allowing glycolysis to continue and produce ATP.
10. What must happen to proteins before they can be used for energy?
    A. They are broken down into glucose molecules
    B. Their amino acids are converted into intermediates of glycolysis and the citric acid cycle.
    C. They are stored as fat.
    D. They are directly converted into ATP through oxidative phosphorylation.

    Explanation: Before proteins can be used as fuel, their amino acids must first be converted into intermediates that can enter glycolysis or the citric acid cycle.
11. How are fats broken down to produce energy?
    A. Fats are converted into glucose, which enters glycolysis.
    B. Glycerol is converted into glyceraldehyde 3-phosphate and fatty acids are broken down into two-carbon fragments through beta oxidation.
    C. Fats are directly converted into ATP.

D. Fatty acids are converted into acetyl CoA without undergoing beta oxidation.
Explanation: Fats are broken down into glycerol and fatty acids. The glycerol is converted into an intermediate of glycolysis, while fatty acids undergo beta oxidation to generate two-carbon fragments that enter the citric acid cycle

12. The electrochemical potential difference across the inner mitochondrial membrane is caused by:
    A. The accumulation of negatively charged ions outside the membrane.
    B. The accumulation of positively charged hydrogen ions in the mitochondrial matrix.
    C. The accumulation of positively charged hydrogen ions in the intermembrane space.
    D. The accumulation of electrons in the inner mitochondrial membrane.
    Explanation: The electrochemical gradient is created by the accumulation of protons (H+) in the intermembrane space, resulting in both an electrical and chemical potential difference.

SELF TEST EXERCISE ON ENERGY TRANSFORMATION

Choose the correct answer from the given alternatives

1. Which of the following is an example of a coupled reaction in cellular metabolism?
   A. The breakdown of glucose during glycolysis coupled with the production of ATP.
   B. The electron transport chain coupled with the formation of glucose.
   C. The breakdown of fatty acids coupled with the synthesis of starch.
   D. The reduction of NADP+ to NADPH in the Calvin cycle coupled with the production of oxygen.
2. Which of the following pairs of reactions is most commonly coupled in cellular metabolism?
   A. ATP hydrolysis and the transport of ions across a membrane
   B. Glycolysis and the citric acid cycle
   C. Oxygen consumption and glucose synthesis
   D. Fatty acid oxidation and amino acid synthesis
3. In the reaction below, which of the following best describes the process occurring?
   $C_4H_6O_5 + NAD^+ \rightarrow C_4H_4O_5 + NADH + H^+$
   A. Oxidation of $C_4H_6O_5$ and reduction of NAD^+
   B. Reduction of $C_4H_6O_5$ and oxidation of NAD^+
   C. Hydration of $C_4H_6O_5$ and reduction of NAD^+
   D. Decarboxylation of $C_4H_6O_5$ oxidation of NAD^+
4. Which of the following represents the net reaction of the link reaction (pyruvate decarboxylation)?
   A. 2 Pyruvate + 2 NAD^+ + 2 CoA → 2 Acetyl-CoA + 2 NADH + 2 CO_2
   B. 2 Pyruvate + 2 NADH + 2 CoA → 2 Acetyl-CoA + 2 NAD^+ + 2 CO_2
   C. 2 Pyruvate + 2 NAD^+ + 2 ATP → 2 Acetyl-CoA + 2 NADH + 2 CO_2
   D. 2 Pyruvate + 2 NAD^+ + 2 CoA → 2 Acetyl-CoA + 2 NADH + 2 H_2O
5. In an experiment to demonstrate the production of oxygen during photosynthesis, a local pond weed (aquatic plant) is placed in a beaker of water, with an inverted funnel placed over the plant.

A test tube filled with water is inverted over the stem of the funnel. The setup is placed in sunlight. After some time, the student observes the following:

A. The water level in the test tube rises.
B. The water level in the test tube remains unchanged.
C. The water level in the test tube falls.
D. The water in the test tube turns cloudy.

6. In an experiment to test for the presence of chlorophyll in leaves, the following steps are carried out:

    1. A green leaf is boiled in water for a few minutes.
    2. The leaf is then placed in an iodine solution.
    3. The leaf is observed for a color change.

   What is the purpose of boiling the leaf in water during this experiment?

   A. To remove the chlorophyll from the leaf.
   B. To kill the leaf and soften its cell walls, making it easier to test.
   C. To increase the solubility of the iodine in the leaf cells.
   D. To break down the starch in the leaf before testing for it.

7. What would you expect to happen to the rate of CO_2 production in yeast fermentation when the temperature is increased from 0°C to 37°C?

   A. The rate of CO_2 production will remain constant.
   B. The rate of CO_2 production will decrease.
   C. The rate of CO_2 production will increase and then level off.
   D. The rate of CO_2 production will increase as temperature rises, peaking at 37°C

8. At which temperature would you expect yeast fermentation to be **least effective** in producing CO_2, and why?

   A. 0°C, because low temperatures slow down enzyme activity.
   B. 22°C, because yeast is most effective at temperatures near room temperature.
   C. 37°C, because enzymes are denatured at this temperature.
   D. 70°C, because enzymes are denatured and cell activity is impaired.

9. In an experiment with four different temperature conditions (0°C, 22°C, 37°C, and 70°C), you observe that the CO_2 production at 0°C and 70°C is significantly lower than at 22°C and 37°C. What can you infer from this data?

   A. Yeast metabolism is equally efficient at both 22°C and 70°C.
   B. Yeast fermentation is most efficient at lower temperatures.
   C. The rate of CO_2 production is highest at moderate temperatures, with low rates at extreme temperatures.
   D. Yeast fermentation is inhibited by both very low and very high temperatures.

10. Which of the following best describes what happens during the anaerobic pathway of cellular respiration?

    A. Oxygen is used to fully oxidize glucose into carbon dioxide and water.
    B. Glucose is partially broken down to produce ATP, and lactic acid or ethanol is produced.

C. ATP is generated only through oxidative phosphorylation in the mitochondria.
D. No ATP is produced, and glucose remains unchanged.

11. Which of the following are the typical products of anaerobic fermentation in muscle cells of animals?
A. Lactic acid and 2 ATP
B. Ethanol and carbon dioxide
C. Water and 2 ATP
D. Glucose and oxygen

12. What is the role of NAD+ in the anaerobic pathway?
A. It is used to produce oxygen for the electron transport chain.
B. It is regenerated during fermentation, allowing glycolysis to continue.
C. It is converted into ATP during anaerobic respiration.
D. It is produced from the breakdown of glucose

13. What happens to lactic acid that accumulates during anaerobic respiration in muscle cells?
A. It is converted into glucose through gluconeogenesis.
B. It is broken down to produce more ATP.
C. It is converted into ethanol and carbon dioxide.
D. It is transported to the liver to be converted back to glucose

14. How do the processes of **cellular respiration** and **photosynthesis** help maintain the balance of **CO_2** and **O_2** in the atmosphere?
A. **Cellular respiration** releases CO_2 and consumes O_2, while **photosynthesis** absorbs CO_2 and releases O_2, maintaining a balance between the two gases.
B. **Cellular respiration** and **photosynthesis** both release CO_2 and O_2, but in different proportions, leading to a net increase of O_2 in the atmosphere.
C. **Cellular respiration** produces O_2, which is then consumed by **photosynthesis** to create energy, helping maintain a balance in the atmosphere.
D. **Cellular respiration** consumes CO_2 and produces O_2, while **photosynthesis** consumes O_2 and releases CO_2, helping to balance the two gases.

15. The primary function of the Calvin cycle is to:
A. Convert light energy into chemical energy (ATP and NADPH).
B. Split water molecules to release oxygen.
C. Fix carbon dioxide from the atmosphere into organic molecules.
D. Transport electrons through a series of protein complexes.

16. Which of the following best describes the relationship between the light-dependent reactions and the Calvin cycle?
A. The Calvin cycle provides the energy for the light-dependent reactions.
B. The light-dependent reactions provide the energy and reducing power for the Calvin cycle.
C. The two processes are independent of each other.
D. The light-dependent reactions occur only at night, while the Calvin cycle occurs only during the day.

17. Which of the following observations would provide the strongest evidence that substrate concentration limits the rate of yeast fermentation?
    A. Increasing the sugar concentration leads to a steady increase in CO2 production.
    B. Increasing the sugar concentration initially increases CO2 production, but then plateaus.
    C. Decreasing the sugar concentration always decreases CO2 production.
    D. CO2 production remains constant regardless of sugar concentration.
18. In an experiment investigating the effect of temperature on the rate of fermentation, which of the following should be the **independent variable**?
    A. The type of yeast used
    B. The volume of CO_2 produced
    C. The temperature of the water bath
    D. The concentration of glucose in the solution
19. When investigating the effect of different substrates (different sugars) on the rate of fermentation, which of the following would be the **dependent variable**?
    A. The temperature of the water bath
    B. The type of sugar used (glucose, fructose, sucrose)
    C. The volume of gas collected in the syringe
    D. The concentration of the sugar solution
20. In an experiment where you vary the concentration of glucose (substrate) to investigate its effect on the rate of fermentation, which of the following should be **controlled** to ensure valid results?
    A. The type of yeast used
    B. The rate at which gas is collected
    C. The water bath temperature
    D. The volume of CO_2 produced
21. After conducting an experiment on the effect of substrate concentration on yeast fermentation, the data shows a steady increase in CO_2 production with increasing glucose concentration, but the CO_2 production plateaus at high glucose concentrations. What can be inferred from this data?
    A. Yeast fermentation rate is directly proportional to glucose concentration
    B. Yeast enzymes become saturated at high glucose concentrations
    C. CO_2 production decreases at high glucose concentrations
    D. The temperature used was too high for the yeast to function properly
22. In an experiment to study the photosynthetic pigments in a plant leaf, the following procedure is used: A small sample of plant extract is applied to a chromatography paper. And the paper is placed in a solvent, and the pigments are allowed to separate. What is the primary purpose of using paper chromatography in this experiment?
    A. To separate and identify the different photosynthetic pigments based on their solubility.
    B. To measure the rate of photosynthesis in the plant leaf.
    C. To increase the concentration of pigments in the leaf.
    D. To test the plant's ability to absorb light.

23. Which of the following best explains how the electron transport chain (ETC) and ATP synthesis are coupled in oxidative phosphorylation?
    A. The ETC directly produces ATP by transferring electrons to ADP.
    B. ATP is produced by a proton gradient created by the ETC, which drives ATP synthase.
    C. The ETC uses ATP directly to pump protons across the mitochondrial membrane.
    D. ATP and NADH are synthesized in the same reaction within the ETC.
24. Which of the following substances is NOT formed when glucose is fermented by yeasts?
    A. Alcohol B. ATP C. Lactic acid D. Carbon dioxide
25. Which of the following is the adaptation by C4 plants that helps them to avoid photorespiration?
    A. Harvesting of carbon dioxide at night C. Storing carbon dioxide in the vacuole
    B. Using separate cell for light and dark reactions D. keeping the stomata closed during the day
26. What is the first stable product formed during dark reaction of photosynthesis?
    A. Malic acid B. Phosphoglyceric acid C. Oxaloacetic acid D. Citric acid
27. Identify the correct statement about the role of NAD and FAD during aerobic respiration. They
    A. Oxidizes intermediate products of cellular respiration
    B. are electron carriers that pump proton into inner membrane space
    C. are terminal electron acceptors of electron transport chain
    D. carry hydrogen atoms that will be split into proton and electron
28. The main advantage of C4 photosynthesis to prevent:
    A. Transpiration B. Photorespiration C. Photosynthesis D. Transduction
29. What happen during electron transport chain? Protons
    A. Diffuse down concentration gradient to reduce NAD
    B. Build up in the Inter-membrane space than matrix
    C. Diffuse against concentration gradient through ATP synthesis
    D. Build up in the matrix than the Inter-membrane space
30. One of the following groups of plants carry out light dependent and light independent reaction of photosynthesis in separate cells of the leaf?
    A. C-4 plants B. Temperate plant C. C-3 plants D. CAM
31. Which of the following is supplied to the Calvin Cycle by the light reactions of photosynthesis
    A. CO_2 and ATP B. ATP and NADPH C. ATP and NADH D. H_2O and ATP
32. A green plant is kept in a brightly lighted area for 48 hours. What will most likely occur if the light intensity is then reduced slightly during the next 48 hours?
    A. The rate at which nitrogen is used by the plant will increase
    B. Photosynthesis will stop completely
    C. The rate at which oxygen is released from the plant will decrease
    D. Glucose production inside each plant cell will increase.
33. Plants that follow CAM photosynthesis pathway carryout the two stages of photosynthesis at different times. Which of the following products are formed during the night?
    A. ATP and NADPH C. CO_2 and sugar
    B. Malate and sugar D. Oxaloacetate and malate

34. During conversion of pyruvic acid into acetyl CoA, pyruvic acid is
    A. Reduced B. Oxidised C. Isomerised D. Condensed
35. Krebs cycle takes place in the :
    A. Mitochondrial matrix C. Lysosome
    B. Cytoplasm D. Cistae of mitochondria
36. Which of the following is not an intermediate of Krebs cycle?
    A. Acetyl CoA B. Citric acidC. Succinic acid D. Lactic acid
37. Which of the following is true for Krebs cycle?
    A. Isocitrate → Fumrate → α ketoglutarate C. α Ketoglutarate → Oxalosuccinate → Isocitrate
    B. Oxalosuccinate → Isocitrate → α ketoglutarate D. Isocitrate→ α ketoglutarate → Succinate
38. Which of the following is produced during Krebs cycle?
    A. Citric acid B. Lactic acid C. Acetyl coAD. Acetic acid
39. How many ATP molecules are produced in Krebs cycle through substrate level phosphorylation?
    A. 36 B. 38 C. 24 D. 2
40. Substrate level phosphorylation in TCA occurs when
    A. Succinic acid changes to fumaric acid C. Fumaric acid changes to malic acid
    B. Succinyl CoA changes to succinic acid D. Oxalosuccinic acid changes to α−ketoglutaric acid
41. The inner membrane of mitochondria is permeable to:
    A. Glucose B. Fructose C. Sucrose D. ATP
42. Which of the following enzymes are more abundant in the inner membrane of mitochondria?
    A. Reduced NAD Dehydrogenase C. Pyruvate Kinase
    B. ATP Synthase D. Succinate dehydrogenase
43. Ammonia is the end product of
    A. Glucose breakdown C. Protein metabolism
    B. Fatty acid metabolism D. Breakdown of Glycerol
44. Why is the regeneration of NAD+ important in the alcohol fermentation process?
    A. It allows the electron transport chain to produce more ATP.
    B. It enables glycolysis to continue and produce ATP in the absence of oxygen.
    C. It ensures the complete breakdown of glucose into carbon dioxide.
    D. It maintains high levels of NADH, which is used in oxidative phosphorylation.
45. Why are fats considered excellent fuels for long-term energy storage?
    A. Fats contain more oxygen than carbohydrates, making them more efficient.
    B. Fats can be broken down quickly to produce large amounts of ATP.
    C. Fats store more kilojoules of energy per gram than carbohydrates.
    D. Fats are easier to metabolize than carbohydrates.

EXERCISE TWELVE (SELF PRACTICE QUESTION)

CHOOSE THE BEST ANSWER FROM THE GIVEN ALTERNATIVES

1. What are the products of the light reactions?

A. Hydrogen and sugar
B. Sugar and oxygen
C. Carbon dioxide and sugar
D. Oxygen and hydrogen

2. The first event in the process of photosynthesis is;

A. Fixation of carbon dioxide
B. Production of ATP and NADPH
C. Excitation of electron from chlorophyll
D. Splitting of water molecules

3. In the process of photosynthesis, what is the role of chlorophyll? It:

A. Produces light and oxygen
B. Absorb light and photolysis
C. Absorb carbon dioxide
D. Absorb water and carbon dioxide

4. In photochemical reaction there is an (a) :

A. Reduction of water
B. Oxidation of water
C. Oxidation of carbon dioxide
D. reduction of oxygen

5. Which of the following structure of a leaf is not correctly matched with its function?
   A. Stomata – allows plants to absorb water and oxygen from the environment
   B. Upper epidermis -- prevent water loss by transpiration
   C. Lower epidermis -- consist large surface area that facilitate gas exchange
   D. Waxy cuticle -- water proof layer on the upper surface of leaf.
6. Which one of the following statements is correct?
   A. Lower epidermis consists special cell for controlling gas exchange in the leaf
   B. Glucose and oxygen are the two main reactant of photosynthesis
   C. The waste product of light independent reaction in plant are ATP and NADPH
   D. Stomata is opened if the water moves into the guard cell by osmosis
7. Suppose you want to test a leaf for starch, why you put the leaf in hot ethanol? To:
   A. Kill the cell wall of the leaf
   B. dissolve chlorophyll out of the leaf
   C. Remove starch from the leaf
   D. remove waxy cuticle from the leaf
8. For what purpose do plants take up water? for:
   A. Photosynthesis and respiration
   B. Photosynthesis only
   C. Transpiration and photosynthesis
   D. Transpiration and carbon fixation
9. What is the function of Potometer? It measures amount of:
   A. Water taken up by plants
   B. Oxygen used by plant
   C. Carbon dioxide used by plants
   D. stomata in the leaf
10. The use of radioactive tracer element is to:
    A. Show the importance of water in photosynthesis
    B. Detect the presence of chlorophyll in the leaf.
    C. Absorb carbon dioxide from the environment
    D. Show the presence of starch in the leaves
11. The best storage organic compound in plant is _____.
    A. Cellulose B. Starch C. Glucose D. Lipid
12. Suppose you want to carry out an experiment on how plant photosynthesis, which one of the following is not deprived to do an experiment?
    A. Water B. Light C. Carbon dioxide D. Chlorophyll

13. Variegated leaf is used to show the importance of
    A. Starch B. Carbon dioxide C. Chlorophyll D. Light
14. Which one of the following is true about the function of xylem tissue? It:
    A. Transport sugar to the site needed by active transport
    B. Carries organic nutrients in all direction
    C. Carries inorganic nutrients only upwards
    D. Replaced regularly and carries water from the leaves down ward
15. The external coat of seed is called
    A. Cotyledon B. Embry C. Testa D. Endosperm
16. Which of the following condition are necessary for seed germination?
    A. Light, carbon dioxide and water C. Oxygen, water and temperature
    B. Chlorophyll, light and carbon dioxide D. Oxygen, glucose and light
17. Which one of the following statements is true?
    A. If plant lack light, they convert glucose to starch and use as source of energy
    B. Starch is osmotically inert and allows plant to survive difficult condition
    C. Transpiration is avoidable consequence of photosynthesis
    D. Photosynthesis release both carbon dioxide and oxygen
18. Which of the following are two major limiting factors of photosynthesis?
    A. Carbon dioxide concentration and temperature
    B. Sugar and oxygen concentration
    C. Oxygen concentration and temperature
    D. Carbon dioxide and oxygen concentration
19. Transpiration is the process of:
    A. losing water from the leaves of plant in the form of vapour
    B. fixing carbon dioxide with water to form glucose
    C. maintaining constant internal environment of plant
    D. transporting food from the leave to the storage organ
20. Which one of the following is a method of conserving wildlife?
    A. Introducing alien species that outcompete native species
    B. Restoring degraded area with native plant species and enhancing protection
    C. Fragmentation of habitat and removing unwanted species from an area
    D. Interbreeding wildlife with domestic animals
21. The purpose of practicing monoculture is to:
    A. Reduces spread of disease and pests in cropland
    B. Increase fertility of soil and reduces soil erosion
    C. Increase biodiversity in an area and to make it more attractive
    D. Increase productivity of single crops by covering large area
22. This item is based on the following statements.
    I. Plant roots are negatively geotropic and positively phototropic
    II. Plant shoots are positively phototropic and negatively hydrotropic

III. Plant shoots are negatively gravitropic and negatively hydrotropic

IV. Plant roots are negatively phototropic and positively geotropic

Which of the above statement is/are true?

A. I, III and IV
C. II and III
B. III Only
D. II, III and IV

23. Tomato plants grow and coil around a supporting stick. This type of response is called

A. Thermo tropism
C. Thigmotropism
B. Phototropism
D. Chemotropism

24. Which of the following is correctly paired with its function?

A. Indole Acetic Acid $\rightarrow$ dormancy breaking plant hormone
B. Ethelene$\rightarrow$ Speed up the ripening of fruit and leaves to grow old
C. Abscisic Acid $\rightarrow$ causes the leaves to drop and stomata to close
D. Gibberellin $\rightarrow$ Promote cell division and keep vegetables fresh longer

25. If the amount of Abscisic acid is greater than gibberellin, what will happen?

A. Leaves begin to fall from the trees
B. Adventitious root begins to develop
C. Green leaves and flowers begin to regrow
D. Seeds start germination

26. Ethiopia has rich and varied vegetation. This is due to what?

A. The availability intact forest covers in the country?
B. The presence several protected areas
C. The presence of great elevation range and diverse ecosystem
D. The availability of various wild life in our national parks

27. Which of the following pairs of plant is an example of C3 plants?

A. Sugar cane and Maize
C. Sorghum and Grasses
B. Peanut and Sugar beet
D. Pineapple and Cacti

28. Which of the following is a limiting factor in C4 photosynthesis?

A. High light intensity
C. Low carbon dioxide concentration
B. High temperature
D. Low water concentration

29. Which one of the following factors does not affect photosynthesis?

A. Water B. Temperature C. CO_2 D. Stomata

30. Plants uses cyclic photophosphorylation to:

A. Generate additional ATP required to power the Calvin Cycle
B. Produce more oxygen for respiration
C. Move electrons through Photosystem II and Photosystem I
D. catalyze the breakdown of glucose

31. During photosynthesis

A. light reactions produce sugar, while the Calvin cycle produces O2.
B. light reactions produce NADPH and ATP, while the Calvin cycle produces sugar.
C. light reactions photo phosphorylates ADP, while the Calvin cycle produces ATP.

D. the Calvin cycle produces both sugar and O2

32. In bundle sheath cell of C4 plants, the source of Carbon dioxide is
    A. Oxaloacetate C. Pyruvate
    B. Malate D. Phosphoenolpyruvate
33. The process that causes oxidation of carbon is called
    A. Cellular respiration C. Photorespiration
    B. Phosphorylation D. Photophosphorylation
34. In the light reaction during photosynthesis, which best explains why water is oxidized?
    A. It supplies proton to P 700 in PS I C. It is the terminal electron acceptor
    B. It replaces electrons in electron acceptors in PS II D. It is a source of energy
35. Light is absorbed by Photosystem I and used to energize electrons. To which of the following are these high energy electrons most directly passed?
    A. RUBP C. Photosystem II
    B. NADP+ D. the electron transport chain
36. Which of the following substance produced during photorespiration waste energy in C_3 plant?
    A. Pyruvate B. Phosphoglycerate C. Glycerate D. Malate
37. For fixation of two molecule of carbon dioxide, the energy required in the form of ATP and NADPH are
    A. 6 ATP and 4 NADPH C. 3ATP and 2 NADPH
    B. 18 ATP and 12 NADPH D. 2 ATP and 1 NADPH
38. How does photorespiration reduce the efficiency of photosynthesis?
    A. By preventing the formation of carbon dioxide molecules.
    B. By preventing the formation 3-phosphoglycerate molecules
    C. By enhancing the formation of oxygen molecules.
    D. By enhancing the formation of RuBP carboxylase molecules
39. Sugar produced by C4 plants are stored in
    A. Bundle sheath cell C. Mesophyll cell
    B. Guard cell D. Palisade cell
40. Which of the following is correct about chlorophyll?
    A. Chlorophyll a absorbs wavelength of green and Yellow
    B. Both chlorophyll a and b absorb green light
    C. Chlorophyll a and b absorbs light of wavelength between 500 and 600 nm.
    D. Chlorophyll c is found only in photosynthetic chromistans and dinoflagellates
41. An instrument that measures the relative amount of light of different wavelength is termed as
    A. Spectrophotometer C. Potometer
    B. Photometer D. Sigma manometer
42. Photosynthesis is the process by which green plants prepare their food in the presence of
    A. Sunlight, water, chlorophyll and carbon dioxide
    B. Glucose, water, chlorophyll and carbon dioxide.
    C. 0xygen, water, chlorophyll and glucose

D. sunlight, oxygen, carbon dioxide and nitrogen

43. Which of the following pair of the wave length of light is more useful in photosynthesis?
    A. Green and Yellow
    B. Orange and red
    C. Blue and Red
    D. Blue and green
44. Which of the following wavelength of light is not absorbed by photosynthetic pigment?
    A. 400-45Onm
    B. 600 – 700nm
    C. 480 – 550 nm
    D. 680 – 700 nm
45. What is the source of proton with in chloroplast?
    A. Chlorophyll B. Water C. ATP D. RUBP
46. Which of the following class of pigment is called accessory pigment?
    A. Chlorophyll a
    B. Carotenoids
    C. Chlorophyll b
    D. Chlorophyll c
47. Photosynthetic pigment that is found in stroma and only exist in cyanobacteria and red algae is called
    A. Porphyrin ring
    B. Carotene
    C. Phycobilin
    D. Fucoxanthin
48. Light reaction of photosynthesis does not produce
    A. Oxygen
    B. Sugar
    C. NADPH
    D. ATP
49. The main difference between non-cyclic and cyclic photophosphorylation is that cyclic photophosphorylation uses
    A. Electron from photosystem II and produce ATP and NAPDH
    B. More water and produces more oxygen
    C. Electron from photosystem I and produces only ATP
    D. Electron from water to produce only NADPH
50. What is the use of paper chromatography? It is used to detect presence of
    A. Water in stroma of chloroplast
    B. Starch in green plants
    C. Photosynthetic pigment in green plant
    D. Carbon dioxide in the leaf
51. What is the end product of light independent reaction of photosynthesis?
    A. Glucose
    B. Water
    C. Oxygen
    D. NADPH
52. Which of the following is true about chemiosmosis in chloroplast? It is
    A. The process of pumping proton from stroma to thylakoid membrane
    B. Accumulation of proton (H+) inside the intermembrane space of chloroplast
    C. Diffusion of proton down conc. Gradient from lumen to stroma
    D. Movement of proton against concentration gradient from stroma to grana
53. Which of the following is not the component of the first electron transport chain of chloroplast?
    A. Plastocyanin
    B. Ferredoxin
    C. Cytochrome complex
    D. Plastoquinone

54. The source of proton in the reduction reaction of 3–PGA to G3P is
    A. ATP
    B. Oxygen
    C. NADPH
    D. RUBP
55. Light dependent photosynthesis is the process that
    A. Takes place in stroma of chloroplast and generate glucose
    B. Produces reduced electron carrier and organic energy molecule
    C. Reduces inorganic carbon to carbohydrate
    D. Is called biochemical phase of photosynthesis
56. To generate a molecule of glyceraldehyde -3-phosphate how many molecules of CO_2, ATP and NADPH are invested in Calvin cycle?
    A. $3CO_2$, 9 ATP and 6 NADPH
    B. 12 CO_2, 30 ATP and 18 NADPH
    C. 6 CO_2, 18ATP and 12 NADPH
    D. 2 CO_2, 6 ATP and 9 NADPH
57. What is the first stable product of photorespiration?
    A. Phosphoenolpyruvate
    B. Glycolate
    C. Pyruvate
    D. Oxaloacetate
58. Which of the following statement is correct about Photorespiration?
    A. Photorespiration is a process in which oxygen is added to RUBP in chloroplast
    B. Photorespiration is the process that fix carbon dioxide to organic compound
    C. Photorespiration is the process that uses phosphoglycerate as a respiratory substrate
    D. Photorespiration is a carbon reduction cycle that produce more ATP in chloroplast
59. What is the carbon dioxide acceptor in C_4 plants?
    A. Oxaloacetate
    B. Phosphoenolpyruvate
    C. Malate
    D. RUBP
60. Which of the following enzyme fix carbon dioxide in mesophyll cell of C4 plant?
    A. Rubisco
    B. PEP carboxylase
    C. Malate dehydrogenase
    D. Malic enzyme
61. Which of the following is not an example of C_3 Plants?
    A. Rye
    B. Wheat
    C. Sorghum
    D. Oats
62. Which of the following organic molecule is stored in vacuole of CAM Plant?
    A. Oxaloacetate
    B. Pyruvate
    C. Malate
    D. Phosphoenolpyruvate
63. Crassulacean acid metabolism in a plant is a mechanism that enable plants to
    A. improves water use efficiency
    B. to increase photorespiration
    C. open stomata during the dry and hot days
    D. accumulate CO2 in mesophyll cell
64. In an experiment of testing a leaf for starch, why we immerse/dip a leaf into a hot water? To:
    A. Activate enzyme that digest starch in the leaf
    B. Dissolve out most of the chlorophyll
    C. Makes the leaf more permeable to iodine solution
    D. Makes the leaf impermeable to iodine solution

65. Which one of the following organic molecules is serve as the source of phosphate and store free ATP in its phosphate bonds?
    A. Creatine phosphate
    B. Phosphoglycerate
    C. Glucose -6- phosphate
    D. Phosphoenolpyruvate
66. Which of the following statements is not correct about glycolysis?
    A. Cleavage phase produces fructose -1,6-bisphosphate
    B. The first phase of glycolysis involves phosphorylation of glucose
    C. Energy investment phases consume two ATP molecules
    D. Energy liberation phases produce 4 four ATP, two Pyruvate and two NADH
67. Which of the following comparison between photosynthesis and respiration?
    A. Photosynthesis is uses glucose and oxygen while respiration produces only oxygen
    B. Respiration produces water while photosynthesis photolysis water
    C. Both respiration and photosynthesis take place in the chloroplast of green plants
    D. Photosynthesis produces NADH+ while respiration generates NADPH+

ANSWER KEY TO EXERCISE TWELVE ON HOTOSYNTHESIS

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

THEME 4: HEREDITY AND EVOLUTION

4.1. Genetics

Learning competencies

- Define the genetic materials (chromosomes, DNA, RNA)
- Discuss the structures and functions of DNA and RNA.
- Elaborate on the mechanism of protein synthesis in organisms
- Discuss the detailed process of cell division (meiosis/mitosis) and the cell cycle.
- Compare and contrast Mendelian and non-Mendelian inheritances
- Define the terms genes, allele, phenotype, genotype, homologous, heterozygous, dominant, recessive, probability, monohybrid, test cross, Punnet square, genetic disorders
- Design a test-cross to identify homogeneity and heterogeneity of unknown genotypes
- Describe Genetic disorders, Genetic testing and counseling, and Gene therapy
- Explain the principles of selection and combination for the breeding of plants and animals
- Investigate how Ethiopian farmers select and breed quality seeds, cattle, goats, sheep, etc.
- Define Bioinformatics

Describe Terms in Genetics:

- ✓ **Genetics** is the study of heredity and variation in organisms.
- ✓ Key terms include **gene** (a segment of DNA that codes for proteins), **allele** (variant form of a gene), **genotype** (genetic makeup), and **phenotype** (observable traits).

Table 8. The difference between DNA and RNA

Aspect	DNA	RNA
Structure	Double-stranded helix.	Single-stranded molecule.
Sugar	Deoxyribose.	Ribose.

Aspect	DNA	RNA
Function	Stores and transmits genetic information.	Carries out protein synthesis (transcription and translation).
Base Pairing	Adenine pairs with Thymine, Cytosine with Guanine.	Adenine pairs with Uracil, Cytosine with Guanine.
Location	Found in the nucleus and mitochondria.	Found in the nucleus and cytoplasm.

Describe Cell Division:

Cell division is the process by which a cell divides to form new cells. It occurs in two main types: **mitosis** (for growth and asexual reproduction, resulting in two identical cells) and **meiosis** (for gamete production, resulting in four genetically unique cells with half the chromosome number).

Chromosome: along thread like structure in the nucleus of every cell

- Made from DNA and histone protein
- mean '**colored body'** in the nucleus that stained when cell divide
- Store large number of proteins

Karyotype: Map of chromosome in the nucleus of a single cell Photograph

Homologous chromosome: are a pair of chromosomes each derived from one parent and carries the same gene sequence. They have the same size, shape and pattern of gene sequence. Exapmle: The human genome consist of 22 pairs of homologous chromosome and 1 pair of non-homologous chromosomes or sex chromosomes.

Types of chromosomes

I. **Sex chromosome:** determine sex of an individual

- In Humans and most other mammals have two sex chromosomes, X and Y, that in combination determine the sex of an individual
- Human Female have 'XX' While Male have "Xy' sex chromosome

II. **Autosome:** chromosome that are not sex chromosome

- Are 22 pairs of chromosome/44 chromosomes
- Control almost everything about the way you look, your body work i.e: used to create every cell, enzyme, tissue, bone, and organ within the body except sex

4.2. Cell Division (Mitosis and Meiosis)

- Is a process that enables an organism to grow, repair or reproduce

Cell division consist three stages: **Interphase, Mitosis and Cytokinesis**

Types of Cell division

A. Mitosis:

- Mitosis is a process of nuclear division in eukaryotic cells
- takes place in the normal body cells (somatic cells)
- produces two identical daughter cells (clones). As a result of mitosis,
- Everybody cell has the same genetic information.
- Before a cell divides by mitosis: It duplicate new homologous pair of chromosome – interphase, Chromatids undergoes karyokinesis – mitosis and Cytokinesis – division of cytoplasm.

Mitosis is a continuous process that follow sequence of stages

Interphase —prophase—metaphase—anaphase—telophase

ii. Interphase

- is also called resting stage but physiologically most active
- The DNA in the cell is replicated in preparation for cell division it is the phase of replication

i. Prophase

- The chromosomes condense (Shorten and become thicker) into X- shaped structures that can be easily seen under a microscope as a long thin thread
- The chromosomes are now referred to as pairs of chromatids (sister chromatids) which are joined at a centromere

ii. Metaphase

- The chromosomes line up neatly end-to-end along the center (equator) of the cell.
- The centrioles are now at opposite poles of the cell with the mitotic spindle fibers extending

iii. Anaphase

- sister chromatids separate and move to the opposite poles of the spindles and spindle fibers attached to kinetochores shorten and pull chromatids towards the poles.

iv. Telophase

- spindle fibers disintegrate
- Two new nuclei formed at the poles of the cell
- Each new cell has a copy of each chromosome from the parents
- The two new cells separate by cytokinesis
- nuclear envelopes form around both groups of chromosomes

Cell cycle

- is a series of events that takes place in a cell to bring growth and divides. involves three phases: i. interphase ii. Mitosis iii. Cytokinesis
- A long period of non-division interphase (G1, S and G2 Phase). Is when cells get bigger, increase their mass, carry out normal cell activities and replicate their DNA ready for the next division.
- A period of active cell division is when mitosis takes place the number of cells increases.
- Ctyokinesis – the last stage of cell division
- During Gap 1: cell is metabolically active, cell grows in size, and organelles replicated
- During Synthesis(S) replication of DNA and synthesis of proteins associated with DNA
- During Gap 2: synthesis of proteins associated with mitosis

Summary of Main Differences:

Phase	Main Activity
G0	Cells are not dividing.
G1	Cell grows, carries out normal functions.
S	DNA is copied, doubling chromosomes.
G2	Cell grows, checks DNA for errors.
M	The cell divides into two daughter cells.

B. MEIOSIS

- Special type of cell division that takes place in the reproductive organ/ Germ cell
- Occurs in specialized cell (Sex cells) in gamete producing organs (Ovaries, Tests and anthers).
- Is reduction division (Diploid to haploid)

- Produce four daughter cell that are different from parents
- Daughter cell contain half number of chromosomes
- Occur only in eukaryotic cell and it is not cyclic

Meiosis consists two phases: Meisosi I and Meiosis II

Both produce two daughter cells from each parent cell and Daughter cells are not identical

What is the function of meiosis?

- It restores the number of chromosomes between generation
- Introduce genetic diversity in the species/offspring due to crossing over in prophase I that cause exchange of gene between chromosome

Explain Functions of DNA and RNA:

- **DNA** (deoxyribonucleic acid) stores genetic information and directs the synthesis of proteins. **RNA** (ribonucleic acid) transcribes the information from DNA and assists in protein synthesis. RNA includes mRNA (messenger RNA), tRNA (transfer RNA), and rRNA (ribosomal RNA).

4.3. DNA Replication

- DNA replication is the process by which a cell makes an exact copy of its DNA before cell division.
- It ensures genetic information is accurately transmitted to the next generation of cells. It is essential for cell growth, repair, and reproduction. It follows semi conservative model of replication.
- **Main Enzymes Involved in DNA replication are:**
  - ✓ **Helicase:** Unwinds the double helix, separating the two DNA strands.
  - ✓ **DNA Polymerase:** Adds new nucleotides to the growing DNA strand, using the original strand as a template.
  - ✓ **Primase:** Synthesizes RNA primers to provide a starting point for DNA polymerase.
  - ✓ **Ligase:** Joins the Okazaki fragments on the lagging strand.
  - ✓ **Topoisomerase** is an enzyme that prevents DNA from becoming overly twisted during processes like replication and transcription. Prevents DNA twisting and breakage by reducing torsional strain.

Table 9. Comparison of Okazaki Fragments and the Lagging Strand

Feature	Okazaki Fragments	Lagging Strand
Definition	Short DNA fragments synthesized on the lagging strand during replication.	The strand of DNA that is synthesized discontinuously in the 3' to 5' direction.
Direction of Synthesis	Synthesized in the 5' to 3' direction, but opposite to the direction of the replication fork.	Synthesized in the 3' to 5' direction (relative to the template strand), which requires multiple RNA primers.
Enzyme Involved	DNA polymerase III synthesizes the fragments.	DNA polymerase synthesizes the lagging strand in short fragments.
Replication Process	The DNA is synthesized in short fragments, which are later joined together.	The strand is synthesized discontinuously in small fragments (Okazaki fragments) due to the directionality of DNA polymerase.
Fragment Joining	Okazaki fragments are joined by DNA ligase after RNA primers are removed.	The lagging strand is formed by linking Okazaki fragments, ensuring a continuous strand after ligation.
Template Strand	Occurs on the lagging strand template, which is oriented 3' to 5'.	The lagging strand is the template strand that is copied discontinuously.
Speed of Synthesis	Slower due to discontinuous synthesis.	Slower than the leading strand due to the discontinuous nature of synthesis.

Why the leading strand is able to replicate continuously but the lagging strand isn't?

- ✓ The **leading strand** is able to replicate continuously, while the **lagging strand** is not, due to the directionality of DNA synthesis and the way DNA polymerase works.
- ✓ DNA polymerase can only synthesize DNA in the **5' to 3' direction**, meaning it can only add nucleotides to the 3' end of the growing strand.
- ✓ The **leading strand** is oriented in the **3' to 5'** direction, which means DNA polymerase can continuously move in the same direction as the replication fork (which unwinds the DNA).

4.4. Protein synthesis

Protein synthesis is the biological process by which cells produce proteins, essential for structure and function. It occurs in two main stages:

Transcription (DNA → mRNA)

- ✓ Takes place in the nucleus.

- ✓ The enzyme **RNA polymerase** binds to a specific section of DNA and unzips it.
- ✓ A complementary **messenger RNA (mRNA)** strand is synthesized using the DNA template.
- ✓ Once complete, the mRNA strand leaves the nucleus and moves to the cytoplasm.

2. Translation (mRNA → Protein)

- ✓ Occurs at the ribosome in the cytoplasm.
- ✓ The **ribosome** reads the mRNA sequence in groups of three nucleotides (codons).
- ✓ **Transfer RNA (tRNA)** molecules bring the corresponding amino acids to the ribosome.
- ✓ The ribosome links amino acids together, forming a **polypeptide chain** (protein).
- ✓ The completed protein folds into its functional shape.

4.5. Mendelian inheritances

- ✓ Technique that Gregor Mendel used by considering a single trait at a time
- ✓ Who is Gregor Mendel? ‘’Father of modern Genetics
- ✓ Characteristics that are inherited through different forms of a single gene are examples of monohybrid inheritance.

Principles of Inheritance and Variations

Inheritance is the transfer of genes from parents to the offsprings. The principles of inheritance and variation were explained by Gregor Mendel in his experiments on a pea plant. **Mendelian inheritance** follows Gregor Mendel's laws (dominant/recessive traits, segregation, independent assortment). He stated three laws of inheritance on the basis of his observations with the pea plant:

- ➢ **Law of Segregation:** Alleles segregate randomly during gamete formation, with each gamete receiving one allele.
- ➢ Law of Dominance:
- ➢ Law of Independent Assortment

Before Mendel carried his experiment called cross breeding, He undergoes true breeding.

Characteristics of true breeding

- ✓ It undergoes self-pollination.
- ✓ It depicts stability in the inheritance for several generations.
- ✓ Provide gametes with similar traits, hence used as parents for artificial fertilization
- ✓ Homozygous recessive plants are used to identify the genotype through a test cross

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

Mendel's Second Law: Independent assortment

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

Monohybrid Cross:

- A **monohybrid cross** is a genetic cross between two organisms that are heterozygous for one specific trait. It involves the study of inheritance of a single trait, where only one gene is considered.
- In a monohybrid cross, we look at how alleles (variants of a gene) are inherited by offspring. Each parent contributes one allele for the gene in question, and the offspring inherit one allele from each parent.
  - A **monohybrid cross** involves one trait

Example Exercise

1. what is the genotypic ratio of offspring from a monohybrid cross between two heterozygous parents (Yy × Yy)?

A. 1 YY: 1 Y
B. 1 Yy : 1 yy
C. 1 YY : 2 Yy : 1 yy
D. 3 YY : 1 Yy

Explanation: The Punnett square for this cross results in the genotypic ratio of 1 YY : 2 Yy : 1 yy, where "Y" is the dominant allele for yellow seed color, and "y" is the recessive allele for green seed color.

2. In a monohybrid cross, if the offspring exhibit a 3:1 phenotypic ratio, what can you conclude about the parental genotypes?

A. Both parents are homozygous dominant.
B. Both parents are homozygous recessive.
C. Both parents are heterozygous.
D. One parent is homozygous dominant, and the other is homozygous recessive.

Explanation: The 3:1 phenotypic ratio typically results when both parents are heterozygous (Yy × Yy), where the dominant trait (yellow seeds) is expressed more frequently in the offspring.

Dihybrid Cross:

- **Dihybrid cross** involves two traits..

3. If you cross two pea plants that are both heterozygous for two traits (RrYy × RrYy), what is the expected phenotypic ratio of the offspring?

A. 9:3:3:1
B. 3:1
C. 1:1
D. 2:2:2:2

Explanation: The dihybrid cross (RrYy × RrYy) follows the law of independent assortment, and the expected phenotypic ratio is 9:3:3:1. The traits assort independently, leading to this ratio: 9

showing both dominant traits (round, yellow), 3 showing round, green, 3 showing wrinkled, yellow, and 1 showing both recessive traits (wrinkled, green).\

4. In a dihybrid cross, what does a 9:3:3:1 phenotypic ratio indicate about the relationship between the two traits?
   A. The two traits are linked and do not assort independently.
   B. The two traits are unrelated and do not exhibit independent assortment.
   C. The two traits assort independently.
   D. The two traits are both recessive.

Explanation: The 9:3:3:1 phenotypic ratio in a dihybrid cross occurs when the two traits (e.g., seed shape and color) assort independently, as described by Gregor Mendel's second law of independent assortment.

5. Why might a dihybrid cross produce a ratio other than 9:3:3:1?
   A. The traits are linked and do not follow independent assortment.
   B. The genes are not located on different chromosomes.
   C. One or both of the genes are dominant.
   D. The organisms used in the cross are homozygous for both traits.

Explanation: If two traits are linked (located close together on the same chromosome), they do not assort independently, and the expected 9:3:3:1 phenotypic ratio may not occur. Instead, different ratios would be observed due to genetic linkage.

6. A plant with the genotype AaBb is crossed with a plant with the genotype aabb. What are the possible genotypes of the offspring?
   A. AABb, Aabb, aaBb, aabb
   B. AaBb, Aabb, aaBb, aabb
   C. AaBb, AABb, aaBb
   D. AaBB, AAbb, aabb

Explanation: A cross between AaBb and aabb produces four possible combinations: AaBb, Aabb, aaBb, and aabb, representing the assortment of alleles from both genes for seed shape and color.

Test Cross

- When an individual expresses the dominant phenotype, its genotype is unknown, it can be either heterozygous (hybrid) or homozygous.
- To determine the genotype, we must perform a test cross.

- ❖ An individual of unknown genotype is crossed with an individual having a recessive phenotype because to express the recessive trait, the individual must be heterozygous.

A summary of Mendel's Principles

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

SELF-PRACTICE EXERCISE TEN

Choose the correct answer from the given four alternatives

1. In genetics, crossing over is the
   A. Exchange of the genetic material C. Deletion of chromosomes
   B. Linkage of chromosomes D. Inversion of chromosome
2. In Certain kind of plants, the allele for red color has an effect that is incompletely dominant over the effect of the white color allele. If a cross between two plants produced 18 Red, 32 Pink and 15 white plants, what are the phenotypes of the parents? Both parents are
   A. Red B. white C. Pink D. Red and Pink
3. In genetics, the term test cross means
   A. The crossing of F1 individual with homozygous recessive
   B. Crossing an F1 individual with either of the two parents
   C. Crossing F1 individual with another F1 individual
   D. Crossing F1 individual with that of F2
4. Hybrid vigour is the result of
   A. Complete dominance C. Incomplete dominance
   B. Over dominance D. Codominance
5. Which of the following statements is a definition of a recessive allele?
   A. An allele that controls the development of a characteristic even when it is only present on one of your chromosomes.

B. An allele that controls the development of characteristics alongside another different allele that is also expressed in the phenotype.

C. An allele that only controls the development of a characteristic if it is present on both chromosomes.

D. An allele that only occurs on the sex chromosomes

6. What is the relationship among DNA, a gene, and a chromosome?

A. A chromosome contains hundreds of genes, which are portions of DNA.

B. A chromosome contains hundreds of genes, which are portions of protein.

C. A gene contains hundreds of chromosomes, which are portions of protein.

D. A gene is composed of DNA, but there is no relationship to a chromosome.

7. Chromosomes are made up of:

A. RNA and DNA B. Protein C. DNA and histone D. Amino acid

8. How many chromosome pairs would you expect to find in a normal human body cell?

A. 23 B. 50 C. 84 D. 46

9. Which combination of chromosomes would result in a female grasshopper?

A. XY B. XXX C. XX D. YY

10. After cross-fertilization of true-breeding tall and dwarf plants, the F1 generation was self-fertilized. The resulting pea plants have genotype in the ratio

A. 1:2:1 (homozygous tall: heterozygous tall: dwarf) C. 3:1 (tall: dwarf)

B. 1:2:1 (heterozygous tall: homozygous tall: dwarf) D. 3:1 (dwarf: tall)

11. Which of the following characteristics of pea plants was not used by Mendel in his experiments?

A. seed colour B. seed shape C. pod length D. flower position

12. Mendel took _____ contrasting characteristics of pea plants.

A. eight B. Seven C. six D. five

13. If both genotype and phenotype show the same ratio of 1:2:1 in the F2 generation, then it shows

A. incomplete dominance in monohybrid crosses C. dihybrid cross

B. complete dominance in monohybrid crosses D. Multiple allelism

14. Test cross determines

A. whether two traits are linked or not

B. the genotype of F2 plant

C. whether the two species will breed successfully or not

D. types of alleles in a gene

15. Genotype of dominant plant can be determined by

A. Pedigree analysis ` C. Monohybrid cross

B. Dihybrid cross D. Test cross

16. An allele that is fully expressed is referred to as

A. dominant. B. homologous. C. recessive. D. heterozygous.

17. Test cross is a

A. cross between two recessive homozygotes

B. cross between dominant homozygote and heterozygote

C. cross between two F1 hybrids

D. cross between an F1 hybrid and recessive homozygote

18. The genes for the seven characters chosen by Mendel are located on

A. Four chromosomes C. six chromosomes

B. Five chromosomes D. seven chromosomes

19. Which of the following statement about Mendel is correct?

A. His discoveries concerning genetic inheritance were generally accepted by the scientific community at his time

B. He discovered linkage

C. He believed that the genetic traits of parents will usually blend in their children

D. His principles about genetics apply usually to plants and animals.

20. Which of the following conditions is inherited?

A. Cancer B. Albinism C. Anaemia D. HIV/AID

21. Which of the following is NOT true about crossbreeding?

A. The offspring immediately form a new breed of animal or plant.

B. The offspring are the F1 generation.

C. The offspring do not breed true.

D. The offspring may combine the best traits of both breeds

22. Which of the following is a current rather than a possible future use of biotechnology?

A. producing tailor-made drugs to suit individual needs

B. using stem cells to grow a new heart for someone who needs a transplant

C. monoclonal antibodies used in pregnancy tests and to diagnose diseases

D. producing cures for genetic diseases

23. How many different genotypes and phenotypes are produced in the F2 generation of a dihybrid cross performed by Mendel considering that the parents are true breeding for round, yellow seeds and wrinkled, green seeds?

A. 4 Phenotype and 9 genotypes C. 9 phenotype and 4 genotype

B. 4 Genotype and 9 phenotypes D. 4 phenotype and 16 Genotype

24. In multiple allelism, multiple alleles are present:

A. On non-sister chromatids C. On different chromosomes

B. At different loci on the same chromosome D. At the same locus of the chromosome

25. Which of the following helps in cell division?

A. Centrosome B. Ribosome C. Plasma membrane D. Lysosome

4.6. Sex determination

✓ Sex determination is the biological mechanism that determines the sex of an organism.

Types of Sex Determination:

i. **XX/XY System (Most mammals including humans):**
   - ✓ **In Humans**: Males have one X and one Y chromosome (XY), while females have two X chromosomes (XX). The **Y chromosome** carries the **SRY gene** (Sex-determining Region Y), which triggers the development of male characteristics.

iii. **XX/XO System (Some insects like grasshoppers):**
   - ✓ **Males**: Only have one X chromosome (XO), where O represents the absence of a second sex chromosome. **Females**: Have two X chromosomes (XX)..

iv. **ZW/ZZ System (Birds, some reptiles, and fish):**
   - ✓ **Males**: Have two Z chromosomes (ZZ).
   - ✓ **Females**: Have one Z and one W chromosome (ZW).

v. **Haplodiploidy (Bees, ants, and some wasps):** Males are haploid and females are diploid.
   - ✓ **Females**: Develop from fertilized eggs (diploid, with two sets of chromosomes).
   - ✓ **Males**: Develop from unfertilized eggs (haploid, with one set of chromosomes).

vi. **Environmental Sex Determination (Some reptiles, fish, and amphibians):**
   - ✓ For example, in certain reptiles (like some turtles and crocodiles), higher temperatures during incubation lead to the production of females, while lower temperatures lead to males.

Difference Between Hermaphroditism and Haplodiploidy:

Characteristic	Hermaphroditism	Haplodiploidy
Definition	A condition where an organism has both male and female reproductive organs.	A system of sex determination in which females are diploid (two sets of chromosomes) and males are haploid (one set of chromosomes).
Presence of Reproductive Organs	Organisms can produce both eggs and sperm, often self-fertilizing or mating with other hermaphrodites.	Males are haploid and develop from unfertilized eggs, while females are diploid and develop from fertilized eggs.
Examples	Earthworms, snails, some fish, and certain plants.	Bees, ants, wasps, and other hymenopterans.
Sex Determination	Hermaphrodites are not determined by the number of chromosomes but by the presence of both sexual organs.	The sex of the offspring is determined by fertilization: fertilized eggs produce females (diploid), and unfertilized eggs produce males (haploid).

4.7. Non-Mendelian inheritance

Learning competencies

- Define non-Mendelian inheritance.
- Differentiate between incomplete dominance. dominance
- Describe ABO blood groups. dominance, and codominace
- Explain inheritance of blood group.
- Describe blood transfusion.
- Explain Rh blood group and inheritance
- Describe sex-linked inheritance
- Mention environmental factors that affect the phenotype of organisms.

Non-Mendelian Inheritance:

- **Inheritance Pattern:** Includes patterns that do not follow simple dominant-recessive relationships.
- **Genes Involved:** Involves multiple genes or alleles with more complex interactions.
- **Examples of Traits:** Traits are often influenced by multiple genes or environmental factors, such as human height, skin color, or blood type.

- **Law of Segregation:** May not follow the Law of Segregation due to interactions like incomplete dominance or codominance.
- **Allelic Interaction:** Can involve incomplete dominance (e.g., red + white = pink flowers) or codominance (e.g., AB blood type).
- **Offspring Genotypes:** More difficult to predict with simple Punnett squares due to complex inheritance.
- **Examples:** Incomplete dominance and codominance in traits like flower color or blood type

Difference Between Incomplete Dominance and Other Types of Inheritance:

Incomplete dominance is a type of inheritance where the phenotype of the offspring is a blending of the two parental traits, rather than one trait being completely dominant over the other. In this case, neither allele is completely dominant or recessive.

Table 10. Difference Between Incomplete Dominance and Other Types of Inheritance**:**

Inheritance Type	Dominance Relationship	Phenotype of Heterozygote	Example
Incomplete Dominance	Neither allele is completely dominant.	The phenotype is an intermediate or blended form between both alleles.	**Red (RR) × White (WW) → Pink (RW)** (e.g., Snapdragon flowers)
Complete Dominance	One allele is completely dominant over the other.	The dominant allele's phenotype is expressed, overriding the recessive allele.	**Red (RR) × White (rr) → Red (Rr)** (e.g., Mendel's pea plants)
Codominance	Both alleles are fully expressed in the phenotype.	Both alleles contribute equally to the phenotype without blending.	**AB blood type**: A (IAIA or IAi) and B (IBIB or IBi) alleles are expressed equally in the heterozygote (AB)

Incomplete Dominance:

- The heterozygous offspring will show a **blended** phenotype, intermediate between the two parent phenotypes.
- The heterozygous phenotype is a **mixture** of the two parental traits (e.g., a pink flower from a red and white flower).

- The **genotypic and phenotypic ratios** of a monohybrid cross are the same (1:2:1) — 1 homozygous dominant, 2 heterozygous (blended phenotype), 1 homozygous recessive.
- Neither allele is completely dominant, so the traits mix rather than being expressed equally.
- Example: In snapdragon flowers, crossing a red-flowered (RR) plant with a white-flowered (WW) plant produces pink-flowered (RW) offspring.

Complete Dominance:

- The heterozygote will show the phenotype of the **dominant** allele, completely masking the effect of the recessive allele.
- The offspring will show the dominant trait if it inherits the dominant allele (e.g., a red flower if the dominant red allele is present).
- The **genotypic ratio** is 1:2:1, but the **phenotypic ratio** is 3:1 (3 dominant phenotype, 1 recessive phenotype).

Codominance:

- Both alleles are **fully expressed**, and neither allele is dominant over the other.
- Both traits are visible and expressed simultaneously (e.g., a person with AB blood type has both A and B antigens expressed).
- The **phenotypic ratio** is the same as the **genotypic ratio** (1:2:1), where both alleles contribute equally to the phenotype.

Gene Linkage

- Gene linkage occurs when genes are located close together on the same chromosome, causing them to be inherited together instead of assorting independently.
- This violates Mendel's Law of Independent Assortment and reduces genetic recombination.
- Example: In Drosophila (fruit flies), genes for body color and wing shape are linked, meaning they are more likely to be passed together unless crossing-over occurs.

Multiple Alleles (ABO Blood Group Inheritance)

- Some traits are controlled by more than two alleles, increasing genetic variation.
- The ABO blood group system is controlled by three alleles:
  - I^A (A antigen)
  - I^B (B antigen)
  - I^O (no antigen, recessive)
- I^A and I^B are co-dominant, meaning a person with I^AI^B genotype has both A and B antigens, resulting in AB blood type.
- This system determines blood compatibility and inheritance patterns.

6. 4.7.1. Rh factor inheritance in humans and its medical importance

- ✓ The Rh factor is a protein found on red blood cells, controlled by the Rh (D) gene.
- ✓ Dominant inheritance: Rh-positive (Rh^+) is dominant over Rh-negative (Rh^-).
- ✓ Genotypes: Rh^+Rh^+ → Rh-positive, Rh^+Rh^- → Rh-positive and Rh^-Rh^- → Rh-negative

- ✓ Medical Importance: Blood Transfusions: Rh-negative individuals cannot safely receive Rh-positive blood, as their immune system may attack Rh^+ cells. Hemolytic Disease of the Newborn: Occurs when an Rh-negative mother carries an Rh-positive fetus. The mother's immune system may produce anti-Rh antibodies that attack the baby's red blood cells in later pregnancies. This disease is prevented by Anti D Vaccine

1. How is Rh blood group inheritance different from ABO blood group inheritance?
    A. Rh is inherited through codominance, while ABO is inherited through incomplete dominance.
    B. Rh inheritance is determined by a single gene, while ABO involves two genes.
    C. Rh inheritance does not involve multiple alleles, whereas ABO blood group does
    D. Rh inheritance follows sex-linked inheritance patterns.

Explanation: The Rh factor is determined by a single gene with two alleles (Rh+ and Rh-), while the ABO blood group is controlled by multiple alleles (IA, IB, and i).

7. 4.7.2. Sex-linked inheritance in humans (Autosomal inheritance)

Sex-Linked Inheritance

- ✓ Involves genes located on the X or Y chromosomes.
- ✓ X-linked traits are more common in males because they have only one X chromosome (XY), while females (XX) can be carriers.
- ✓ Examples:
    - Hemophilia – A blood clotting disorder.
    - Color blindness – Inability to distinguish certain colors.
    - Duchenne muscular dystrophy – A genetic muscle-wasting disorder.

Autosomal Inheritance

- ✓ Involves genes on the non-sex chromosomes (autosomes, pairs 1-22) of human chromosomes
- ✓ Can be dominant or recessive:
- ✓ Autosomal Dominant: Only one affected allele is needed (e.g., Huntington's disease).
- ✓ Autosomal Recessive: Two copies of the affected allele are needed (e.g., Cystic fibrosis, Sickle cell anemia).

Environmental effects on phenotype

- ✓ A phenotype can be altered by environmental factors, even if the genetic makeup remains unchanged.
- ✓ External factors like temperature, diet, chemicals, or stress can affect gene expression.
- ✓ Phenocopy: occurs when an environmental factor induces a trait that mimics a genetic condition. Example: Himalayan Rabbits: Their fur color depends on temperature.
- ✓ At warmer temperatures (above 30°C), the fur remains white.
- ✓ At cooler temperatures (below 20°C), black pigment develops on the ears, nose, feet, and tail due to enzyme activation.

Human Pedigree analysis and its importance

- ✓ A pedigree is a family tree diagram that traces the inheritance of genetic traits or disorders across generations.
- ✓ It helps determine dominant, recessive, autosomal, or sex-linked inheritance patterns.
- ✓ It Identifies genetic disorders (e.g., hemophilia, cystic fibrosis).
- ✓ It Predicts inheritance risks for family planning.
- ✓ supports medical diagnosis and treatment by understanding genetic predispositions.
- ✓ Supports genetic counseling to help individuals make informed health decisions.

Genetic disorders

- ✓ Genetic disorders are conditions caused by abnormalities in an individual's DNA, which can affect one or more genes or chromosomes. They can be inherited or occur due to mutations.

Types of Genetic Disorders:

- ✓ Monogenic (Single-Gene) Disorders: Caused by mutations in a single gene. Examples: Cystic fibrosis, sickle cell anemia, Huntington's disease.
- ✓ Chromosomal Disorders: Result from changes in the number or structure of chromosomes. Examples: Down syndrome (Trisomy 21), Turner syndrome (Monosomy X).
- ✓ Multifactorial Disorders: Caused by a combination of multiple genes and environmental factors. Examples: Heart disease, diabetes, cleft lip/palate.

Autosomal Dominant: One copy of the mutated gene is enough to cause the disorder (e.g., **Huntington's disease**).
Autosomal Recessive: Two copies of the mutated gene are needed (e.g., **Cystic fibrosis**).
X-linked: Mutations in genes on the X chromosome (e.g., **Hemophilia**).

Genetic testing and counseling

Genetic Testing:

- ✓ Genetic testing helps identify mutations in an individual's DNA.
- ✓ involves analyzing a person's **DNA** to identify **genetic mutations** or **chromosomal abnormalities** associated with certain diseases or conditions.
- ✓ It confirms a suspected genetic condition.
- ✓ Identify individuals carrying a gene for a recessive disorder.
- ✓ Assess the fetus for genetic conditions (e.g., amniocentesis, chorionic villus sampling).
- ✓ Detect genetic disorders early in life (e.g., phenylketonuria).
- ✓ Identify risk for future health problems (e.g., Huntington's disease).

Genetic Counseling

- ✓ Genetic counseling provides guidance on inheritance patterns.
- ✓ is a service that provides information and guidance about genetic conditions, inheritance patterns, and genetic testing.
- ✓ A genetic counselor helps individuals and families understand:

Gene therapy

Learning competencies

- ✓ Define gene therapy
- ✓ Mention the types of gene therapy
- ✓ Explain the types of gene therapy

Define Gene Therapy: Gene therapy is a medical treatment that involves modifying or replacing a person's genes to treat or prevent disease. It aims to correct or replace defective genes with healthy ones or to introduce new genes into the body to fight diseases, particularly genetic disorders.

Types of Gene Therapy:

A. **Germline Gene Therapy:**
   Involves altering the genes in the germ cells (sex cell) so that the changes are passed on to future generations.

B. **Somatic Gene Therapy**:
   Involves modifying the genes in somatic (body) cells, which affects only the individual being treated and is not passed on to offspring. It is used for conditions such as genetic disorders, cancer, and viral infections.

Gene therapy is done through different mechanism used to introduce curative genes into the patient and edit the infected genes. These are:

Plasmid DNA: uses DNA molecules to carry curative genes into human cells.

Viral vectors: 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

4.8. Breeding

Learning Competencies

- ♣ Define breeding
- ♣ Explain breeding in animals and plants
- ♣ Mention breeding mechanisms
- ♣ Identify indigenous knowledge used in breeding
- ♣ Explain indigenous selection and hybridization mechanisms used by local peoples

What is Breeding

- ✓ Breeding is the process of mating selected animals or plants to produce specific qualities or characteristics in offspring. The goal of breeding is to enhance desired traits such as disease resistance, size, color, yield, or other qualities in the progeny.
- ✓ Breeding can occur through selective breeding/artificial selection or natural selection

Selective breeding:

Breeding in Animals and Plants:

- ✓ **Animal Breeding:** Involves mating specific animals to achieve certain desirable traits. It includes methods like artificial insemination and controlled mating systems to ensure the best genetic outcomes.
- ✓ **Plant Breeding:** Involves selecting plants with desirable traits and cross-pollinating them to produce offspring with better qualities, like higher yield or resistance to pests and diseases. Methods include hybridization, genetic modification, and traditional selective breeding.
- ✓ 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. It 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 raise the next generation. At the end, individual plants are selected and evaluated

Breeding Mechanisms:

Breeding mechanisms refer to the methods used to select and mate individuals in a controlled manner to produce offspring with specific traits. Some mechanisms include:

- ✓ **Selective Breeding:** Choosing animals or plants with specific traits to mate.
- ✓ **Hybridization:** Crossbreeding individuals from different breeds or species to produce offspring with improved traits. It is the process of producing offspring through mating two purebred individuals that come from different breeds, varieties, or even species. It involves breeding two unrelated individuals. For instance, crossbreeding of the local breeds with exotic sires. Crossbreeding is incompatible with the conservation of indigenous breeds.
- ✓ **Inbreeding:** Breeding individuals that are closely related to preserve certain characteristics. After many generations of inbreeding, the offspring will be almost genetically identical and will produce identical offspring and an organism is described as inbred or purebred.

Indigenous knowledge of Ethiopian farmers in selection and combination of plants and animals

Identify Indigenous Knowledge Used in Breeding:

- ✓ Indigenous knowledge in breeding refers to the traditional methods and practices developed by local communities to select and breed plants and animals. This knowledge has been passed down through generations and is used to improve local crop varieties and livestock breeds.

Explain Indigenous Selection and Hybridization Mechanisms Used by Local Peoples:

- ✓ **Indigenous Selection:** Local farmers or breeders may select animals or plants based on traits that are important to them, such as disease resistance or high yield. They rely on experience and observation to select the best individuals for breeding.
- ✓ **Indigenous Hybridization:** This involves crossbreeding different varieties or species to combine beneficial traits. Local people often use this method to improve the resilience of crops or livestock in specific environmental conditions.

4.9. Bioinformatics introduction

Learning competencies

- ♣ Define bioinformatics
- ♣ Describe the role of bioinformatics in biology

Bioinformatics is the application of computational techniques and tools to collect, analyze, and interpret biological data, especially genetic and genomic data. **Bioinformatics** plays a critical role in understanding complex biological systems and aiding in various fields such as drug development, disease research, and personalized medicine.

Role of Bioinformatics in Biology

Bioinformatics has become an indispensable tool in modern biology, enabling researchers to analyze vast amounts of biological data that would otherwise be impossible to handle manually. It is used:

- ✓ to assemble and analyze the sequence of DNA, providing insights into genetic variations, gene function, and evolutionary relationships.
- ✓ As proteomic tool to predict protein structures from genetic sequences.
- ✓ To analyze how genes are expressed in different conditions, revealing insights into disease mechanisms, responses to treatment, and development.
- ✓ Analysis genetic sequences from different species to study their evolutionary relationships.
- ✓ As Systems biology, integrate biological data to model complex biological systems and interactions, enhancing the understanding of cellular and organismal behavior.

EXAMPLE OF REVIEW EXERCISE ON GENETIC

1. A colour blind man marries a daughter of colour blind father, then in the offsprings
   A. All daughters are colour blind
   B. No daughter is colour blind
   C. Half sons are colour blind
   D. All sons are colour blind

   ❖ **Explanation:** Colour blindness is a X-linked recessive disorder. Father transmit its X chromosome to the daughters so the colour blind father will inherit its affected X chromosome to the daughter. Hence, the genotype of carrier female will be (XcX) and that of colour blind man will be (XcY). The carrier female and colour blind man will inherit the disease to 50% sons and 50% daughters. Correct answer is option C.
   Parent generation: "XcX" x "XcY"
2. What are the chances of colour blind daughters and sons being born in a marriage of normal man marrying a normal woman whose father was colour blind?
   A. All sons are normal and all daughters are colour blind.
   B. Both the sons and daughters are phenotypically normal.
   C. 50% sons are colour blind and all daughters are phenotypically normal.

D. All the sons are colour blind and all daughters are normal.

- **Explanation:** Colour blindness is a X-linked recessive disorder. Father transmits its X chromosome to the daughters so the colour blind father will inherit its affected X chromosome to the daughter. Hence, the genotype of carrier female will be (XcX) and that of normal man will be (XY). The carrier female for colour blindness will inherit the disease to 50% son only. The daughters received their normal copy of X-chromosome from the normal father and will be phenotypically normal. Correct answer is option E.
  Parent generation: "XcX" x "XY"

3. A normal vision female whose father is colour-blind marries a normal vision male. What would be the probability of her sons and daughters to be color blind?
   A. 50% sons colour blind and 50% daughter normal
   B. 50% sons colour blind and all daughters with phenotypically normal vision
   C. 50% sons colour blind and 50% daughter colour blind
   D. All sons normal and 50% colour blind daughter

- **Explanation:** Since the father of the woman is colour blind, the woman would be a carrier of the trait. If she marries a normal vision man, then by the method of punnet square, we can say that half of the boys will be colour blind, half boys will have normal vision and half of the girl will be carriers and another half would not have the colour-blind gene. However, all girls will be phenotypically normal. So, 50% sons colour blind and 50% daughter normal

4. A diseased man marries a normal woman. The couple has 3 daughters and 5 sons. The daughters are diseased while the sons are normal. The gene of the disease is
   A. Sex-linked dominant
   B. Sex-linked recessive
   C. Autosomal character
   D. Sex-limited character

- **Explanation:** Genes for sex-linked dominant traits are located on the sex chromosomes. They are expressed even when they are present in the heterozygous condition. It is more common in females. In the given case, the father is deceased. It means father carries the X-chromosome which has the gene for the disease. So, a father can transfer X-chromosomes only to daughter. So, the sex-linked dominant trait will only affect the daughter. The trait can appear in the progeny which are heterozygous. Examples of diseases caused by sex-linked dominant genes are hypophosphatemic rickets, oral-facial-digital syndrome type I and fragile X syndrome.

5. Mendel selected pea plant for his experiments because of the following reasons, except
   A. Garden pea has distinct, easily detectable contrasting characters
   B. The pea plant is self-pollinating in nature because pea flower is bisexual
   C. The plant reproduces well and grows to maturity in a single season
   D. Cross pollination could not be done artificially

- **Explanation:** Cross pollination could not be done artificially. Mendel selected pea plants for his experiments due to their easily detectable, contrasting characters. These are bisexual plants and grow to maturity in a single season only. In these plants, cross-pollination can also be done artificially.

6. What is gene therapy?
    A. medical treatment that involves modifying a person's environment
    B. procedure that modifies or replaces defective genes to treat diseases
    C. A surgery to correct physical injuries
    D. A therapy that prevents the birth of babies with genetic disorders
    - ❖ **Explanation:** Gene therapy involves modifying or replacing defective genes to treat or prevent diseases, particularly genetic disorders.
7. Which of the following is true about somatic gene therapy?
    A. It involves modifying the genes in germ cells
    B. The changes affect only the individual and are not passed to future generations
    C. It is passed down to future generations
    D. It only alters the genes of the offspring
    - ❖ **Explanation:** Somatic gene therapy targets somatic (body) cells and the genetic changes do not affect future generations.
8. If a child receives gene therapy for cystic fibrosis, which type of gene therapy is being used?
    A. Germline gene therapy
    B. Somatic gene therapy
    C. Both germline and somatic gene therapy
    D. None of the above

❖ **Explanation:** Somatic gene therapy is used to treat genetic disorders like cystic fibrosis in an individual without affecting their offspring.

9. How do germline and somatic gene therapy differ in terms of inheritance?
    A. Germline gene therapy alters genes in somatic cells, while somatic gene therapy alters germ cells
    B. Germline gene therapy is passed to future generations, while somatic gene therapy is not
    C. Both therapies affect future generations equally
    D. Both therapies do not affect the individual being treated

❖ **Explanation:** Germline gene therapy affects germ cells and can be passed to future generations, whereas somatic gene therapy only affects the treated individual.

10. Why is germline gene therapy controversial and not yet approved for clinical use in humans?
    A. It is too expensive
    B. It involves altering the genetic makeup of offspring, which raises ethical concerns
    C. It only affects somatic cells
    D. It has been proven to be ineffective

❖ **Explanation:** Germline gene therapy raises ethical concerns because it changes the genetic makeup of offspring, potentially impacting future generations without their consent.

11. If you were to design a breeding program to improve local livestock, which of the following would you consider using?
    A. Rely solely on hybridization from unrelated species
    B. Combine modern genetic engineering with traditional selective breeding
    C. Use only inbreeding without considering genetic diversity
    D. Avoid any form of hybridization or selection

❖ **Explanation:** A successful breeding program would benefit from both modern and traditional techniques, ensuring the best traits while maintaining genetic diversity.

12. What is the main purpose of using selective breeding in animal and plant breeding?
    A. To introduce new species into the environment
    B. To eliminate unwanted traits and increase desirable traits
    C. To increase genetic variation in a population
    D. To create hybrids between different species

❖ **Explanation:** Selective breeding aims to pass down specific desirable traits while minimizing undesirable ones, creating a more consistent and productive population.

13. What is the key difference between inbreeding and hybridization in breeding?
    A. Inbreeding involves breeding unrelated individuals, while hybridization involves breeding related individuals.
    B. Inbreeding focuses on increasing genetic diversity, while hybridization results in genetic uniformity.
    C. Inbreeding involves breeding closely related individuals, while hybridization involves crossing individuals from different breeds or species.
    D. Inbreeding and hybridization are the same process.

❖ **Explanation:** Inbreeding can increase the likelihood of passing on genetic defects, whereas hybridization is used to combine beneficial traits from different breeds or species.

14. In a breeding program for crops, which of the following would be a common reason for using hybridization?
    A. To increase the size and yield of crops by combining traits from two different varieties
    B. To preserve the genetic uniformity of crops
    C. To breed crops for increased resistance to specific pests or diseases within the same species
    D. To select for the lowest yielding crops for market

❖ **Explanation:** Hybridization is often used to combine the strengths of two varieties, such as higher yield or increased disease resistance, leading to improved crop productivity.

15. How does the use of indigenous knowledge in breeding help improve the success of local farming systems?
    A. By allowing for large-scale, industrial farming techniques
    B. By adapting crops and livestock to specific environmental conditions and cultural preferences
    C. By creating a globalized approach to farming that ignores local conditions
    D. By promoting monoculture and reducing biodiversity

❖ **Explanation:** Indigenous knowledge ensures that breeding methods are well-suited to the local environment and the community's needs, preserving biodiversity and sustainability.

16. Which of the following is a disadvantage of inbreeding in breeding programs?
    A. It often results in increased genetic diversity.
    B. It may lead to the expression of harmful recessive traits.

C. It improves adaptability to various environmental conditions.
D. It guarantees all offspring will be genetically unique.

❖ **Explanation:** Inbreeding can increase the likelihood of recessive genetic disorders because it concentrates genetic defects in the offspring.

17. If you were to develop a breeding program for cattle that maximizes milk production while maintaining disease resistance, which two breeding techniques would you consider?
    A. Only inbreeding to ensure high milk production
    B. Hybridization and selective breeding to enhance desirable traits
    C. Hybridization to create genetic uniformity
    D. Selective breeding and genetic engineering to alter the species

❖ **Explanation:** A combination of hybridization and selective breeding allows for the integration of desirable traits from different breeds, enhancing milk production and disease resistance.

18. What is the main focus of bioinformatics?
    A. Physical therapy for biological organisms
    B. Using computational tools to analyze biological data
    C. Research on human psychology
    D. Study of plant biology

❖ **Explanation:** Bioinformatics primarily focuses on using computational methods to analyze large biological datasets, such as genomic data.

19. Which of the following best describes the role of bioinformatics in the study of genomics?
    A. It helps in the creation of physical maps of genes.
    B. It helps identify and analyze gene sequences using computer tools.
    C. It allows scientists to breed organisms with desired traits.
    D. It promotes the use of laboratory techniques like PCR.

Explanation: Bioinformatics is crucial in genomics, as it provides the computational power to analyze complex gene sequences and understand their functions.

20. What is the main advantage of using bioinformatics tools in phylogenetic analysis?
    A. They allow scientists to predict the weather.
    B. They can compute evolutionary relationships based on genetic data.
    C. They help design better fertilizers for crops.
    D. They are used to treat genetic diseases in humans.

Explanation: Bioinformatics tools allow the analysis of genetic data from different species to determine their evolutionary relationships, helping to construct phylogenetic trees.

21. Which of the following is a major benefit of integrating bioinformatics with systems biology?
    A. It simplifies the process of breeding animals for agriculture.
    B. It helps create large gene databases for personal health records.
    C. It allows for the modeling of complex biological systems and interactions.
    D. It assists in producing more nutritious crops through genetic engineering.

Explanation: Systems biology uses bioinformatics tools to integrate various types of biological data, creating models to understand complex interactions within biological systems.

22. Imagine you are tasked with developing a bioinformatics tool to help identify potential drug targets for a new disease. Which combination of data sources would be most useful for designing your tool?
    A. Gene expression data and protein structure data
    B. Animal behavior studies and molecular dynamics simulations
    C. Population growth data and soil sample
    D. Meteorological data and nutrient profiles of plants

Explanation: For identifying drug targets, bioinformatics tools need to integrate gene expression data (to find genes involved in disease) and protein structure data (to identify suitable drug targets).

4.10. EVOLUTION

Learning Competencies

- Define evolution
- Analyze different views about the origin of life and evaluate from a scientific
- explanations point of view.
- Compare Lamarck Vs. Darwinian theory
- Describe scientific evidence that supports that modern living things have evolved from a common ancestor.
- Explain major causes of evolution that lead to variation in organisms.
- Define natural selection and describe its type
- Explain how comparative anatomy embryology, fossil records, and biochemistry provide evidence for evolution
- Outline human evolution and explain significancy of Ardi and Lucy
- Define mutation and examine the different types of mutations with examples
- Explain genetic drift

What is evolution?

- Evolution is a change in genetic composition of a population over successive generations, which may be caused by meiosis, hybridization, natural selection or mutation.

8. 4.11.1 . THEORIES ABOUT THE ORIGIN OF LIFE

There are several theories about the origin of life

SPECIAL CREATIONISM

- Special creationism explained that the formation of life on earth may have been taken place due to supernatural or divine forces
- It mainly focuses on spiritual matters which cannot be seen, touched or measured effectively by their very nature.

There was different version of special creationism theory

Young Earth creationism

- This form of creationism today suggests that the Earth is only a few thousand years old.
- Young Earth creationists often believe that the Earth was created in six 24-hour days. While they agree that the Earth is round and moves around the sun, they all interpret geology in light of Noah's flood.

Old Earth creationism

- There are several types of creationism that consider Old Earth. They vary in different aspects of how they explain the age of the Earth while still holding to the story found in Genesis.
- Those who believe in Old Earth creationism accept the evidence that the Earth is very old but still maintain that all life was created by God.

Day-age and gap creationism

- Both are similar in that each interprets the beginnings of the creation story as actually having taken much longer than six Earth days.
- Gap creation discusses a large gap between the formation of the Earth and the creation of all animals and humans.
- The gap could be millions or billions of years. This gets around the scientific evidence that the Earth is several billion years old without having to believe in the process of evolution itself.
- Day-age creationism is similar to the Gap creation in terms of the length of time but talks about each of the six 'days' as really meaning a billion years or so of geologic time, where the 'days' are just symbolic.

Progressive creationism

- This type of creationism accepts the Big Bang as the origin of the Universe. It accepts the fossil record of a series of creations for all organisms catalogued. However, it does not accept these as part of a continuing process by which each is seen as a unique creation. In this theory, modern species are not seen as being genetically related to ancient ones.

Theistic evolution/Evolutionary creationism

- This view of evolution maintains that God 'invented' evolution and takes some form of an active part in the ongoing process of evolution.
- It also invokes the role of God in areas not discussed by science, including the creation of the human soul.
- Theistic evolution is promoted by the Pope of the Catholic Church and is also espoused by most mainline Protestants.

Intelligent design

- This is the newest version of creationism and maintains that God's handiwork can be seen in all creation if one knows where to look.
- Advocates of intelligent design offer sophisticated arguments, often based on cell biology and mathematics at the expense of giving the impression of the complex scientific arguments and creating equal stature with mainstream scientific thought.
- These arguments attack different parts of the evolutionary theory with the idea that if one part of the evolutionary theory can be found to be incorrect, then it follows a premise that all theories of evolution must be incorrect.
- The term intelligent design is used to mask the theory as if it's a form of creationism cloaked in scientific-sounding ideas

Spontaneous generation (abiogenesis)

- Spontaneous generation is a hypothetical process by which living organisms develop from nonliving matter.

Example: mice from corn, flies from bovine manure, maggots from rotting meat, and fish from the mud of previously dry lakes

- The theory could not experimentally prove how living organisms developed from a nonliving matter. Supported by: Aristotle
- Disproved by:

i. Francesco Redi, an Italian scientist, designed a scientific experiment to test the spontaneous creation of maggots by placing fresh meat in jars
ii. Johon Needham boiled mutton broth and then tightly stoppered the flasks. Eventually many of the flasks became cloudy and contained microorganisms. He thought organic matter contained a vital force that could confer the properties of life on nonliving matter
iii. Lazzaro Spallanzani improved on Needham's experimental design by first sealing glass flasks that contained water and seed. He used *"swan-neck*" flask and disproved this theory finally.
iv. Pasteur's set of experiments irrefutably disproved the theory of spontaneous generation and also articulated "*Omne vivum ex vivo"* ("Life only comes from life")

- These two scientists showed that both macro-organisms (Redi) and micro-organisms (Pasteur) could only arise from pre-existing organisms, disproving the theory of spontaneous generation. But what about the first ever cell? Unless we believe that life is eternal, with no beginning and no end, there had to be a first cell. It could not have come from a pre-existing cell because it was the first.

Eternity theory

- Claims that the Universe has always existed and that there has always been life in the Universe
- In this theory of life, there is no beginning and no end to life on Earth and so life neither needs special creation nor does it need to be generated from non-living matter.
- However, evidence support the formation of the earth before the existence of life on the earth.
- Supporters of this theory believe that life is an inherent property of the Universe and it has always existed as has the Universe.

Cosmozoan theory, Panspermia or Spore broth theory

- Claims that life on Earth originally came from elsewhere in the Universe (possibly from another planet).
- This theory assumes that life was present in the form of resistant spores and appeared on earth from another planet.
- However, no mechanism has been revealed about the transfer of spores from another planet or whether these spores could survive the journey in space.
- It states the absence of life forms on any planet except on the earth, but no detail was provided about the spores, its origin and mechanism of crossing interplanetary space and reaching the earth.
- This theory was proposed by Richter (1865). According to this theory, 'protoplasm' reached the earth in the form of spores or germs or other simple particles from some unknown part of the universe with the cosmic dust, which subsequently evolved into various forms of life.
- In the nineteenth century, Hermann Richter put forward the idea that life has always existed in the Universe where it has propagated itself from one place to another by means of 'cozmozoa' (germs of the cosmos).
- In this theory, life has existed and will exist for all eternity across the Universe, and so there is no need for an explanation of its origin.
- Two other eminent scientists of the time – Lord Kelvin and Herman von Helmholtz – also took the same view.
- Helmholz (1884) speculated that 'protoplasm' in some form reached the earth from falling meteorites.
- In 1908, the Swedish physical chemist Svante Arrhenius put forward a new version of the cosmozoan theory, and gave it the name panspermia.
- Arrhenius' contribution was a new theory of the mechanism by which life could have been transported between planets; he proposed that bacterial spores were propelled through an inter-planetary space by radiation pressure.
- The previous versions of the theory had assumed that the means of transport was meteorites or by comets. However, the very high temperatures that meteorites create on entering the Earth's atmosphere seemed to rule this out.

- In Arrhenius' version of the theory, spores reaching the Earth (possibly attached to grains of interstellar dust) could fall slowly to the ground without being subjected to high temperatures due to air friction.

Biochemical origin (abiogenesis)

- Biochemical theory suggests that life on Earth originated as a result of a number of biochemical reactions producing organic molecules which associated to form cells.
- This theory was supported by considerable experimental evidence
- However, purines (adenine and guanine) were not synthesized under the same conditions as pyrimidines (thymine, uracil and cytosine).
- This is quite a serious problem for the theory.
- Proposed by:
- Aleksandr Oparin, a Russian biologist who first put forward his ideas in 1924, and
- John Haldane an English biologist independently put forward almost identical ideas in 1929
- Both believed that organic molecules could be formed from abiogenic materials in the presence of an external energy source such as ultraviolet radiation and that the primitive atmosphere was reducing (having very low amounts of free oxygen and contained ammonia and water vapour, among other gases
- They proposed that common gases in the early Earth atmosphere combined to form simple organic chemicals, and these in turn combined to form more complex molecules. later forms life character!!
- Later Miller had apparently approved the Oparin-Haldane model.
- In 1953, Stanley Miller conducted his spark-discharge renown experiment. In this investigation, he passed electric sparks repeatedly through a mixture of gases that were thought to represent the primitive atmosphere of the Earth.
- These gases were methane (CH_4), ammonia (NH_3), water (H_2O) and hydrogen (H_2).
- When he analyzed the liquid in the water trap, he found that it contained a number of simple organic molecules, out of which hydrogen cyanide (HCN) was one of them. He found larger variety and more complex organic molecules were formed including:

A. amino acids – essential to form proteins
B. pentose sugars – needed to form nucleic acids
C. hexose sugars – needed for respiration and to form starch and cellulose
D. hydrogen cyanide – starting point to synthesize nitrogenous bases.

4.11. Theories of evolution

Lamarckism (Theory of transformation)

- He proposed 'the theory of inheritance of acquired characters' in 1809.
- Is the theory that claimed that organisms passed on to subsequent generations traits acquired during their lifetime

Postulate of Lamarck

a. New Needs:

b. Use and disuse of organs

c. Inheritance of acquired characters d. Speciation

- Lamarck did believe that evolutionary change takes place gradually of evolution and constantly.

Significance of Lamarckism

i. It was first comprehensive theory of biological evolution

ii. It nicely explains the existence of vestigial organs in animals due to their continuous disuse. Vestigial organs are organs that are a part of the organism that are no longer in use. That can be used to determine the relatedness of different species. For example, the bone structures of the front flippers of a whale contain bones of limbs that exist in mammals such as cows.

iii. It explains the development of strong jaw muscles and claws in the carnivores due to their continued extra use.

iv. It stimulated other biologists to look for the mechanism of organic mechanism

Criticism of Lamarckism

August Weismann, a German biologist proposed the 'Theory of continuity of germplasm' in 1892. This theory states that a multicellular organism is formed of 2 types of cells;

A. germ cells (have genes for inheritable characters to the offspring)

B. somatic cells (which have genes of particular organ during one's life time only). Environment affects only somatic cells. As a link between the generations is through germ cells and somatic cells are not transmitted to the next generation, the acquired characters must be lost with the death of an organism, so these should have no role in evolution.

Pavlov, a Russian physiologist, trained mice to come for food on hearing a bell. He reported that this training is not inherited and was necessary in each generation.

Kellogg and Bell experiment – they fed larva of silk moths on reduced quantity of mulberry leaves. They found decrease in size of larva in the next two generations even though these fed normally.

Darwinism (Theory of natural selection)

- Proposed by Charles Darwin (1809-1882 A.D.)
- He went on a voyage on H.M.S Beagle and explored the Galapagos Islands and other islands. He was highly influenced by essay entitled '*On the Tendency of varieties on Depart Indefinitely from the original type''* by Alfred Russell Wallace and '*'Principle of geology*'' written by Charles Lyell.

Basic postulates of Darwinism

- ✓ Geometric increase: All species tend to produce more offspring than can possibly survive
- ✓ Struggle for existence: there is an everlasting competition between organisms at all levels of life.

- ✓ Variation under nature: No two individuals of a species are exactly similar and they have some differences. Variations give rise to new characters and heredity passes them on to the next generation
- ✓ Natural selection or survival of the fittest: due to struggle for existence and useful heritable variations, only those individuals survive which show high selective value and in the course of time they develop various adaptive modifications to suit the changed conditions of life
- ✓ Origin of species: In the course of long periods of time the best fitted and suitable individuals survived and adjust to the nature. Later become new species

Evidence in favor of Darwinism

- ✓ Close parallelism between natural selection and artificial selection.
- ✓ The remarkable cases of resemblance e.g. Mimicry and protective coloration.
- ✓ Replacement of earlier giant dinosaurs by small sized carnivorous reptiles due to scarcity of food, space and global cooling.
- ✓ Pedigree of horse and other animals also support Darwinism.
- ✓ Correlation between position of nectars in flower and length of proboscis of pollinating insect which can be developed only gradually

Evidences against Darwinism

A. Inheritance of vestigial organs.
B. Inheritance of over-specialized organs.
C. He didn't explain the cause of variations and the mode of transmission of variations.
D. It doesn't include the transitional stages which have no fossil record.
E. Darwin did not differentiate between somatic and germinal variations.
F. It doesn't explain the evolution of terrestrial animals from aquatic animals.

Neo-Darwinism theory

- ➢ Is a revised version of Darwin's theory of evolution by means of natural selection.
- ➢ This theory, combines Darwin's original theory, genetic theory and theories about animal behavior.
- ➢ It incorporates the laws of Mendelian genetics and emphasizes the role of natural selection as the main force of evolutionary change.
- ➢ Explains that new species evolved if the all the allele/gene in a population (gene pool of the population) changed.

Postulates of Neo-Darwinism are:

- ✓ Genetic variability.
- ✓ Natural selection
- ✓ Reproductive isolation

A. Genetic variability – variability is an opposing force to heredity. In other words, it forms the raw material for evolution. There exist various sources of genetic variability.

- ➢ Chromosomal aberrations: Morphological changes in chromosomes without affecting their number. These are the four types of chromosomal aberrations namely;
- Deletion → loss of gene block from chromosome,
- Duplication → presence of some genes more than once,
- Translocation →transfer of gene block from one chromosome to other,
- Inversion → rotation of intercalary gene block through 180 degrees.
- ➢ Numerical chromosomal changes - Can be Euploidy – gain or loss of one or more genome. It may be Haploidy or polyploidy, Aneuploidy- gain or loss of one or two chromosomes. It may be hypoploidy.

Gene Mutations- invisible changes in the chemical nature of the gene. These include point mutation, gross mutations, deletion, addition, and substitution.

Recombination of genes- new combination of genes are formed due to crossing over, chance arrangement of the bivalents during metaphase and chance fusion of gametes.

Hybridization- the interbreeding of two different individuals to produce hybrids. It introduces genes from one species to the gene pool of other species.

Mutagens- physical and chemical agents used to induce mutations artificially, chemical mutagens- such as base analogues, methylating agents, acridine dyes etc. and physical mutagens such as temperature, x-rays, uv-rays etc.

Genetic Drift- a change in the gene frequency of small breeding population due to bottle neck and founder effect.

Immigration - introduces many genes in the existing gene pool by cross breeding between the native individuals and immigrants

B. Natural selection

- ➢ Natural selection does not operate on survival of the fittest. It operates through differential reproduction and comparative reproductive success.
- ➢ Differential Reproduction - members which are better adapted to the environment reproduce at a high rate and produce more offspring than the members which are less adapted. Due to sexual communication, there is free flow of genes and genetic variability that spread from individuals to deme then to population and finally to most of the members of species. So, natural selection causes progressive changes in the gene frequency. Frequency of more adaptive genes increases and that of less adapted gene decreases.

C. Reproductive Isolation

- Reproductive Isolation- the inability of living organisms to interbreed. It maintains distinctiveness of characters among species.
- Mechanical isolation occurs due to the difference in the morphology of genitalia or reproductive organs.
- Geographical Isolation- due to physical factors such as sea, mountain, deserts etc.
- Spatial isolation - individuals are isolated by long distances. Ecological or habitat isolation - due to differences in their habitat. Temporal Isolation - due to difference in the breeding periods in different seasons of the year.
- Ethological or Behavioral isolation- due to behavioral differences between individuals of different species during courtship.
- Genetic Isolation – the inter specific sterility of species due to the accumulation of independent gene mutations for structural and functional characters.
- Physiological Isolation- due to functional incompatibility in their mating or in the production, fertilization and survival of the gametes.

4.12. The evidence for evolution

Comparative anatomy

- Comparative anatomy is one of the strongest forms of evidence for evolution.
- It looks at the structural similarities of organisms and uses these similarities to determine their possible evolutionary relationships

It looks at homology and analogy

Homologous Structure

- Homologous structures are structures with the same basic anatomy and a common evolutionary origin but having a different function
- It assumes that organisms with similar anatomical features are closely related evolutionarily, and that they probably share a common ancestor. This structure is called homologous structures.
- Example forelimb of mammals and pentadactyl limb. When examined closely, the forelimbs of humans, whales, cats and bats are all very similar in structure.

Analogous structures

- Structures having the same function but different anatomy and different evolutionary origin.
- they cannot indicate that two species share a common ancestor

e.g. the wings of a bat, bird and mosquito

Comparative Embryology

- studies the way in which the embryos of vertebrates develop before they hatch or born. This development shows similarities which supports a common ancestry

Paleontology

- the study of fossils is known as paleontology.

- Fossils are formed when certain remains of organisms or plants get embedded in the soil or water and are preserved for many hundreds of years
  - ✓ It can be the remains of dead animals or plantsBones
  - ✓ teeth
  - ✓ skin impressions
  - ✓ hair
  - ✓ trilobite or an ammonite
  - ✓ an impression of an animal or plant

I. Something that was made by the animal while it was living and that it has hardened into stone since then; these are called trace fossils and include:

✓ Footprints, burrows, coprolite

Dating fossils

Fossil age can be determined using two ways;

a. Relative dating: Use strata / layers of the rock

- Stratigraphy: Layer of the rock. the oldest strata and the oldest fossils are found in the lowest layers and more recent rocks and fossils in the layers above them nearest to the surface.

b. Absolute dating: which determines the number of years that have elapsed since an event occurred. Uses radiometric dating

- Radiometric dating: Uses half-life of radioactive substances
- Half-life: the time needed for half the atoms of a radioactive substance to decay. After two half-lives, three quarters of the atoms will have decayed
- Radiocarbon dating: Radioactive carbon atoms (C14) decay into non-radioactive nitrogen atoms (N).

✓ Half-life carbon is 5730 years

✓ Measures fossil older up to 60,000 years

e.g.: At 22,920 Years old, only 6.25 % of C14 remain unchanged:

- Potassium–argon dating: Radioactive potassium atoms (K40) decay into argon atoms (A40).

✓ Half-life if K is 1.3 million years

✓ Used to measure fossil of million years

Comparative biochemistry

- The best evidence that supports evolutionary
- Uses analysis of Biochemical molecules like DNA, Proteins like Haemoglobin.
- Species that are closely related are believed to have the most similar DNA and proteins; those that are distantly related are assumed to share fewer similarities. For example, a comparison of DNA sequences shows that 98% of our DNA is the same as chimpanzees which confirms that chimpanzees are the closest relatives of humans

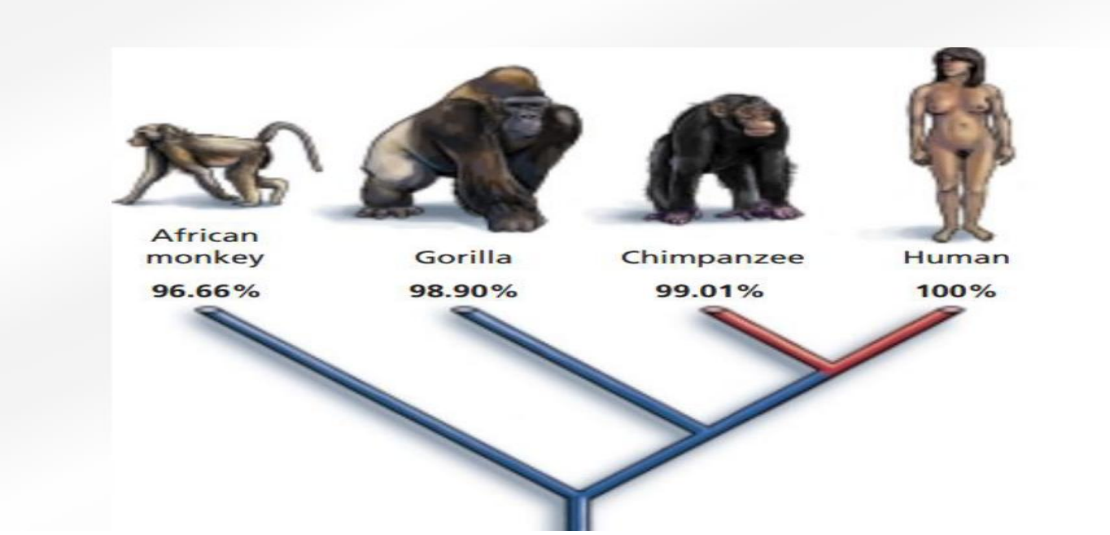


Figure 6. A phylogenetic (evolutionary) tree of some animals based on differences in DNA

4.13. Natural selection

Minimum learning competency

- Define natural selection
- Describe the types of natural selection with examples
- Apply the theory of natural selection in their day-to-day life (survival of the fittest)
- Appreciate the struggle among organisms for survival

What is Natural Selection

- Natural selection is the 'driving force' behind evolution. It is the process that brings about changes (over time) in populations that can, eventually, lead to different populations of the same species to become different species.
- Those members of a species which are best adapted to their environment will survive and reproduce in greater numbers than others that are less well adapted.
- natural selection is a key force for ADAPTATION

An example of a modern example of natural selection in action is Antibiotic resistance of pathogenic bacteria that developed due to over use of antibiotics and genetic mutation.

Types of natural selection

- Directional selection: shifts the curve in one direction, changing the average value off the character.
- Stabilizing selection: reduces variation about the mean and increases homozygosity
- Disruptive selection: Trims off intermediate phenotypes, results in two or more phenotype

Pattern of evolution

- Due to different selection pressure/Factor such as environment and predation pressures can have different effects on the ways in which species exposed to evolve.
- There are three main types of evolution: divergent, convergent, and parallel evolution

Divergent evolution

- Is the he evolutionary pattern in which two species gradually become increasingly different.
- Is a process of developing two or more species from a common ancestor.
- Is the process of macroevolution that creates more diversity of species in the biosphere.
- often occurs when closely related species diversify to new habitats.
- Largely responsible for the creation of the current diversity of life on earth from the first living cells.
- On a smaller scale, it is responsible for the evolution of humans and apes from a common primate ancestor.
- It produces important changes within individuals for their survival within a changing environment
- Adaptive radiation of Darwin Finches and Homologous structure are an example of Divergent evolution

Convergent evolution

- Convergent evolution takes place when species of different ancestry begin to share analogous traits because of a shared environment or other selection pressure.
- Is the development of similar structures within different species that live in the same environment.
- The species do not share a common ancestor.
- For example, whales and fish have some similar characteristics since both had to evolve methods of moving through the same medium: water.
- The wings of bats and the wings of insects are evolved from completely different original structures.

Parallel evolution

- Parallel evolution occurs when two species evolve independently of each other, maintaining the same level of similarity.
- Parallel evolution usually occurs between unrelated species that do not occupy the same or similar niches in a given habitat.

Speciation

- Speciation is the formation of new species in evolution.
- Natural selection provides a mechanism by which new populations of a species can arise.
- Those two new populations can be considered as distinct species, if they are unable to produce fertile offspring.

Types of speciation

- The two main ways Speciation

a. Allopatric speciation b. Sympatric speciation

Both allopatric and sympatric speciation involves isolating mechanisms that prevent different populations from interbreeding for a period of time.

a. Allopatric speciation

- occurs when a population from an existing species becomes geographically isolated and the isolated population develops into a new species
- involves physical separation like mountain, lake or rivers …
- The cause of speciation is first geographic isolation which leads to reproductive isolation and speciation.
- The speed of evolution of new species is slow.
- It is common in nature
- Major differentiation mechanism is natural selection
- Allopatric speciation involves one population.

Example: Darwin's finches Squirrels in the Grand Canyon.
Spiny anteater in different continent

b. Sympatric speciation

- Speciation that occurs when one or two groups of the same species live in the same geographical area, but they evolve differently until they can no longer interbreed and are considered different species.
- The cause of speciation: is indistinct/unknown factors could be attributed to be main reason behind sympatric speciation.
- The Speed of the emergence of new species is fast with autopolyploid and slow with allopolyploids.
- The populations are not geographically separated.
- It is Common in plants
- Major differentiation is polyploidy.
- Sympatric speciation involves two or more populations.

Some examples include: Cultivated wheat Corn Tobacco African tilapia
What is polyploidy and why is it important in plant evolution?

- occurs when an organism has more than two sets of homologous chromosomes
- Some human liver cells have 92 chromosomes per cell they are tetraploid and have four sets of chromosomes per cell
- Tetraploid: a tetraploid organism has four sets of homologous chromosomes
- It has been important in plant evolution because it allowed infertile hybrids to become fertile.

Reproductive Isolation

Reproductive isolating mechanisms fall into two major categories:

A. **Prezygotic reproductive barriers**

- act before fertilization to prevent individuals of different species or populations from mating.
- this mechanism affects the ability of two species to combine gametes and form a zygote. Examples are :
- Ecological (or habitat) isolation): A difference in habitat preference can separate two populations in the same geographic area.
- Temporal isolation: Two species that share a habitat will not mate if they are active at different times of day/years.
- Behavioral isolation: Behavioral differences may prevent two closely related species from mating.
- Mechanical isolation: Any change in the shape of the gamete-delivering or receiving structures may prevent groups from interbreeding.
- Gametic isolation: If a sperm cannot fertilize an egg cell, then no reproduction will occur.

B. **Postzygotic reproductive barriers**

- act after fertilization to prevent the development of viable offspring, or to reduce the offsprings' fertility. It includes:
- Hybrid inviability: A hybrid embryo may die before reaching reproductive maturity, typically because the genes of its parents are incompatible.
- Hybrid breakdown: Some species produce hybrid offspring that are fertile. When the hybrids reproduce, however, their offspring may have abnormalities that reduce their fitness.

Human evolution

Learning competency

- Outline human evolution
- State the role of paleontological discoveries in Ethiopia in explaining human (Ardi and Lucy) evolution

Who are we and where have we come from

- We are not evolved from monkey, apes, or chimpanzee.
- We are Homo sapiens and we are the latest of several humans to live on the planet.
- We have two features in particular that distinguish us from other primates. These are:
- ✓ A very large brain
- ✓ Bipedalism

How brain size changed during human evolution?

Genus: a group of closely related species

Hominin: any member of the genus Homo. This includes modern humans (*Homo sapiens*), neanderthals and *Homo erectus*.

Hominid: a group of species that includes all the species belonging to the genus Homo along with other species such as *Ardipithecus ramidus* and *Australopithecus afarensis.*

- As early humans faced new environmental challenges and evolved with bigger bodies, they evolved larger and more complex brains.
- Large, complex brains can process and store a lot of information. That was a big advantage to the early humans who faced with unfamiliar habitats in their social interactions.
- Over the course of human evolution, brain size tripled (500 to 1500cm^3).
- The modern human brain is the largest and most complex of any living primate.
- The brain has increased in size as a proportion of body mass. Species of Australopithecus have a brain that is between 0.7% and 1.0% of their body mass, whereas modern humans have a brain size between 1.8% and 2.3% of their body mass.
- The brain of Homo sapiens uses 25% of the resting energy requirement, compared with 8% in the great apes.

A larger brain allows humans to:

- ✓ run faster and in a more upright posture
- ✓ plan in advance to avoid attack
- ✓ develop and use tools and weapons

- Brain size increases slowly from 6–2 million years ago
  - During this time period, the early humans began to walk upright and make simple tools.
  - Brain size increased, but only slightly.
- Brain and body size increase: from 2 million–800,000 years ago
  - During this time period, the early humans spread around the globe, encountering many new environments in different continents.
  - These challenges, along with an increase in body size, led to an increase in brain size.
- Brain size increases rapidly: from 800,000 – 200,000 years ago.
- The human brain size evolved most rapidly during a time of dramatic climate change.
- Larger, more complex brains enabled early humans of this time to interact with each other and with their surroundings in new and different ways. As the environment became more unpredictable, bigger brains helped our ancestors to survive.

The emergence of Homo sapiens

- The relationships among *Australopithecus*, K. platyops, *Paranthropus*, and the direct ancestors of Homo are unknown.
- Because of its early date and geographic location, A. anamnesis may be the common ancestor of *A. afarensis*, A. garhi, K. platyops, and perhaps the Laetoli Pliocene hominins of eastern Africa, *A. bahrelghazali* of central Africa, and A. africanus of southern Africa. *A.* afarensis in turn may be ancestral to *P. aethiopicus*, which begot *P. boisei* in eastern Africa and *P. robustus* in southern Africa.

Mutation

- A mutation is any spontaneous change in the genetic material of an organism.
- It is random, rare, spontaneous change in the genome of an organism.
- occur quite randomly during DNA replication.
- If the agent that caused the mutation cannot be identified then it is known as a spontaneous mutation.
- If the mutation can be identified then it is called an induced mutation.
- Mutation can be **point mutation and chromosomal mutation**

Point mutation

- The changes involving only a single base/nucleotide in DNA are called point mutations.
- Effect of point mutation:
- ✓ Silent mutation: mutated codon codes for the same amino acid
- ✓ Missense mutation: mutated codon codes for a d/t amino acid with variable effect
- ✓ Nonsense mutation: mutated codon is a premature stop codon, with serious effect.
- The different types point mutations are:

a. Substitution b. Addition c. deletions

- They are accidents that mistakenly occur when DNA is replicating.
- Mutations are rare events, which are quite surprising when you consider that each cell contains 6 × 109 (six billion) base pairs that might mutate! This means that each new cell will have, on average 120 mutations.
- These mistakes are detected and repaired, and because, 95% of our DNA is non-coding, so most mutations are unlikely to affect coding genes.
- The rate of mutation can be increased by a number of factors (mutagens) including:
- ✓ Carcinogenic chemicals, like, those in tobacco smoke
- ✓ High-energy radiation, like: ultraviolet radiation, X-rays.
- ✓ Nuclear radiation and certain chemical substances

What are the consequences of gene mutations?

- The consequence depends on which cell and which gene it occurs
- Mutations that occur in a normal body cell (a non-sex cell) may/will
- ✓ Be completely harmless.
- ✓ Damage the cell
- ✓ kill the cell
- ✓ make the cell cancerous, which might kill the person.
- mutation occurs in a sex cell or a cell that will divide to give rise to a sex cell, then it may be passed on to the next generation.
- Mutation that occurs on genes that regulate cell division can causes cancer
- Example: Protooncogene and Tumur suppressor gene

Chromosomal mutation

- Involving a long segment of DNA.

- Occurs when there is any change in the arrangement or structure of the chromosomes.
- Chromosomal mutation occurs most often during meiosis at crossing over in prophase I.
- There are several different mutation types that result in a change in the structure of a chromosome such as duplication, deletion, inversion and translocation.
- They are much bigger events than point mutations and usually result in the death of a cell. They may also affect the whole organism

Types of Chromosomal Mutations

a. Chromosomal Mutations I: Involve the processes of

- Inversion (paracentric and pericentric inversion).
- Deletion (terminal, interstitial, micro deletion)
- Duplication/amplification called partial trisomy.
- Translocation (Reciprocal translocation occurs when pieces of chromosomes "swap" places. Robertsonian translocation occurs when a segment of a chromosome is attached to another chromosome, causing an elongation of it.
- Example: The translocation of chromosome 21 onto the 14th chromosome causes downy syndrome

b. Chromosomal Mutations II called heteroploidy

- Involves aneuploidy and polyploidy
- Aneuploidy: This mutation either causes the loss or addition of a chromosome by the contortion of the chromosome set.
- Nondisjunction during meiosis or mitosis usually results in this mutation.
- Polyploidy: causes the creation of two sets of genomes within an organism. It is not usually common naturally however; it can be observed in some plants.
- It usually causes effects like giantism and the reduction of fertility

Examples of A chromosomal disorders list can be seen below:

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

Genetic Drift

- Allele frequencies can change due to chance alone. This is called genetic drift.
- Drift is a binomial sampling error of the gene pool. In other words, the alleles that form the next generation's gene pool are a sample of the alleles from the current generation.
- When a population is sampled, the frequency of alleles differs slightly due to chance alone.
- Alleles can increase or decrease in frequency due to drift. The average expected change in allele frequency is zero since increasing or decreasing in frequency is equally probable.
- A small percentage of alleles may continually change the frequency in a single direction for several generations just as flipping a fair coin may, on occasion, result in a string of heads or tails.
- A very few new mutant alleles can drift to fixation in this manner.

- Genetic drift is change due to "sampling error" in selecting the alleles for the next generation from the gene pool of the current generation.

Hardy–Weinberg Equilibrium

- ❖ The equilibrium was named mathematician Godfrey H. Hardy and physician Wilhelm Weinberg.
- ❖ They independently developed two simple equations that represent the relationship between allele frequencies and genotype frequencies

i. The first equation represents the frequencies of both alleles in the population: $p + q = 1$

ii. The second equation is used to calculate genotype frequencies by using allele frequencies: $p2 + 2pq + q2 = 1$

- ❖ At Hardy–Weinberg Equilibrium, Allele Frequencies Do Not Change.
- ❖ The equation is used to study population genetics (analysis allele frequency and genotypes frequency)
- ❖ It is a situation in which allele frequencies and genotype frequencies do not change from one generation to the next.

The equilibrium occurs only in populations that meet the following assumptions:

I. Natural selection does not occur
II. Mutations do not occur, so no new alleles arise;
III. The population is infinitely large, or at least large enough to eliminate random changes in allele frequencies
IV. Individuals mate at random
V. Individuals do not migrate into or out of the population (no gene flow)

Two examples of genetic drifts are

A. The genetic bottleneck effects

- ❖ Is an extreme example of genetic drift that happens when the size of a population is severely reduced. Events like natural disasters (earthquakes, floods, fires) can decimate a population, killing most individuals and leaving behind a small, random assortment of survivors.

B. The founder effects

- ❖ The founder effect is another extreme example of genetic drift that occurs when a small group of individuals breaks off from a larger population to establish a colony.
- ❖ The founding individuals may not represent the full genetic diversity of the original population.
- ❖ Occur by colonization, not by catastrophes.

EXAMPLES OF REVIEW EXERCISE

Choose the best alternative from the given four alternatives for the following questions

2. According to Oparin, which of the following gas was not present in primitive atmosphere of the earth?

A. Methane B. Hydrogen C. Oxygen D. Water

Clue: According to Oparin, the primitive atmosphere was reducing because its atoms were most numerous and most reactive. There was no free oxygen, because of vast iron the earth that absorb and there were large quantities of H_2, N_2, Water vapor, CO_2, CH_4, NH_3 were present.

3. In Australia, marsupials and placental mammals have evolved to share many similar characteristics. This type of evolution may be referred to as
   A. Convergent evolution C. Adaptive radiation
   B. Divergent evolution D. Cyclical evolution

Clue: In Australia, Marsupials and placental mammals have evolved to share similar characteristics which is referred to as convergent evolution.

4. Through careful observation, Charles Darwin came to understand that:
   A. populations of plants and animals in nature most often consist of individuals that are clones of each other
   B. those individuals whose variation gives them an advantage in staying alive long enough to reproduce are more likely to pass their traits on to the next generation
   C. populations of a species that become isolated from others by adapting to different environmental niches quickly become extinct
   D. population tend to reproduce offspring that could potentially survive.

   Clue: If an individual has a trait that allows it to get more food or to avoid being killed by predators or illness, it will have a greater chance of reproducing. As a result, more of the next generation will inherit the genes for the advantageous traits

5. The theory of evolution by natural selection was independently developed by:
   A. Charles Lyell and Charles Darwin C. Charles Darwin and Alfred Wallace
   B. Erasmus Darwin and Lamarck D. Charles Lyell and James Hutton

Clue: While Charles Darwin developed the theory first during the 1830`s, he did not rush it into print. When Wallace came up with the same idea on his own during the late 1850`s, Darwin quickly wrote and published the theory in his book "ON THE ORIGIN OF SPECIES"

6. In species, the weight of new born ranges from 2 to 5 Kg. 96% of the new born with an average weight between 3 to 3.5Kg. survive where as 99% of the infants born with weight 2 to 2.5 Kg or 4.5 to 5 Kg die. Which type of selection process is taking place.
   A. Directional selection C. Stabilizing selection
   B. Disruptive selection D. Non-selection

Clue: Stabilizing selection is a type of natural selection in which the population mean stabilizes on a particular non-extreme trait value. The data shows that most of the newborn having average weight between 3 to 3.5Kg survive and babies with less and more weight have low survival rate.

7. The similarities of bone structure in the forelimbs of many vertebrates is an example of
   A. Homology C. Analogous
   B. Adaptive radiation D. Convergent evolution

Clue: Bird and Bat wings are analogous as forelimb is homologous. In different vertebrates, bone of forelimbs are similar but their forelimbs are similar are adapted in different way as their adaptation, show homology.

8. Analogous structures are a result of

A. Divergent evolution C. Convergent evolution
B. Common ancestor D. Stabilizing selections

Clue: Analogous structure is those that have the same function, but not share common ancestor. Convergent evolution favors the same type of structure in different ancestors. Example flying insects, birds, and bats same all evolved the capacity of flight independently. All four serve the same function. The wing is a classic example of convergent evolution.

9. Variation in gene frequencies within populations can occur by chance rather than by natural selection. This is termed as:

A. Genetic drift C. Gene flow
B. Random mating D. Gene mutation

Clue: Genetic drift is variation in gene frequencies with in gene population can occur by chance rather than natural selection, the change in allele frequency is different in new sample of population that they become a different species. The original drifted population becomes founders and the effect is called founder effect.

10. Evolution of different species in a given area starting from a point and spreading to other geographical area is called:

A. Adaptive radiation C. Divergent evolution
B. Natural selection D. Migration

Clue: the process of evolution of different species in a given area of geographical area is called adaptive radiation

11. Which of the following is most important for speciation?

A. Seasonal isolation C. Reproductive isolation
B. Behavioral isolation D. Geographical isolation

Clue: Seasonal isolation refers to the difference in seasons of breeding that can isolate two varieties. Behavioral isolation like courtship prevents mating. Mechanical isolation refers to the difference in position, size, and structure of animal genetilia which prevent reproductive contact and bring about isolation. Reproductive isolation is the prevention between the population of two different species.

12. Genetic drift operates only in:

A. Smaller population C. Single Individual
B. Larger population D. Microscopic organism

Clue: Genetic drift can operate only in smaller population where its fluctuation can be observed in the proportion of allele distribution in the presence of external disturbance. It is the random change in allele frequency in a gene pool.

13. What is the half-life of Carbon? It is bout

A. 10,000 years B. 5700 Years C. 1.3 million years D. 60,000years

Clue: in about 5730 years half of Carbon 14 is converted to non -radioactive nitrogen 14. Carbon dating is used to date fossil aged about 60000 years.

14. Which pf the following hominid has the smallest brain size?

A. Homo neanderthalensis
B. Homo habilis
A. Homo erectus
B. Homo sapiens

Clue: the cranial capacity of Homo neanderthalensis = 1400cc, Homo habilis = 400cc, Homo erectus = 900cc, Homo sapiens = 1600cc.

15. A population will not exist in hardy Weinberg equilibrium if:

A. There are no mutations
B. There is no migration
C. The population is large
D. Individuals mate selectively

Clue: the theory states that in the absence of disturbance, on the level of genetic structure, a population existence will not continue. Thus, mating should be in a random way.

1. Natural selection where more individual acquires specific character value led to

A. Stabilizing change
B. Disruptive change
C. Random change
D. Directional change

Clue: Natural selection led to stabilization if more individual acquires mean character value and if more individual acquire value other than the mean character value, it led to directional change.

SELF TEST EXERCISE

Choose the best answer from the given alternative

1. Birth mass in humans is an example of which of the following selections?

A. Disruptive selection
B. Stabilizing selection
C. Directional selection
D. Diversifying selection

2. Supporter of eternity theory believe that: -

A. Life has reached the earth from other meteorites in the form of highly resistant spore.
B. Life have been evolved as a result of biochemical reactions
C. Life is an inherent property of the universe where it has always existed
D. God invented evolution take some form of active part in the ongoing process of evolution.

3. Which of the following is correct about Vestigial organ? They are organ that are

A. reduced and has function
B. well-developed and non-functional
C. well-developed and functional
D. reduced and non-functional

4. Which of the following is a part of Lamarckism?

A. Over reproduction
B. Inheritance of acquired character
C. Competition for survival
D. Natural selection

5. Which of the following concepts was NOT part of Darwin's theory of evolution?

A. Natural selection
B. Inheritance of acquired characteristics
C. Common descent
D. Gradualism

6. The replacement of glutamic acid by valine at a specific position in the beta chains of hemoglobin leads to sickle cell anemia. This change represents which of the following mutational events?

A. DNA base-pair substitution C. DNA base-pair deletion
B. DNA base-pair addition D. chromosomal deletion

7. Nonsense mutation is one that
A. change an amino acid from to another C. delete segments of DNA
B. Adds an additional codon to an RNA D. Create premature stop codon

8. What is the possible cause for the formation of allopatric speciation
A. Seasonal Isolation C. Geographical Isolation
B. Temporal Isolation D. Behavioral isolation

9. Human species with the largest brain is
A. *H*. neandartalis C. *H.sapiens*
B. *H. erectus* D. *H.habilis*

10. Which one of the following is our closest living relative among the apes?
A. Gibbon B. Gorilla C. Chimpanzee D. Orangutan

11. What is the term used to describe the process by which new species arise?
A. Adaptation C. Speciation
B. Divergence D. Convergence

12. What is the term used to describe the process by which two or more species evolve in response to each other?
A. Coevolution C. Parallel evolution
B. Convergent evolution D. Divergent evolution

13. The half-life of carbon-14 is about 5730 years. At 22920 years, what percentage of the atom would be decayed?
A. 87.5 % B. 50% C. 75% D. 93.5%

14. Which of the following principles is NOT part of Darwin's theory of evolution by natural selection?
A. Evolution is a gradual process that occurs over long periods of time.
B. Mutations are the ultimate source of genetic variation
C. More individuals are born than will survive
D. Individuals that possess the most favorable variations have the best chance of reproducing.

15. Albinism (aa) is due to a homozygous recessive condition for melanin pigment. If the frequency of the allele for this condition is 0.06, which of the following is closest to the frequency of the dominant allele in this population? (Assume Hardy-Weinberg equilibrium).
A. 0.04 B. 0.36 C. 0.94 D. 0.16

16. What is the process by which organisms change over time as a result of changes in heritable behavioral traits called?
A. Adaptation C. Natural selection
B. Evolution D. Mutation

17. Which of the following is NOT a component of the Theory of Evolution by Natural Selection?
A. competition for food and space C. variation among species

B. inheritance of acquired characteristics D. survival and reproduction

18. What did Darwin observe on the Galápagos Islands that contributed to his theory of evolution?

A. Different species of finches C. different species of plants

B. different fossil of human species D. Ancient fossils

19. Any variation that can help an organism survive in its environment is called:

A. Adaptation C. characteristic

B. Competition D. vestigial structure

20. Which of the following best describes the idea of "survival of the fittest"?

A. The most physically fit individuals survive

B. The keenest individuals survive

C. The individuals best adapted to their environment survive

D. The most aggressive individuals survive

21. Convergent evolution occurs when the same characteristic…

A. causes independent groups to become extinct.

B. evolves independently in different groups.

C. evolves multiple times in related groups.

D. has identical DNA.

22. The gene pool includes

A. all of the fitness within a population.

B. all of the individuals within a population.

C. all of the mutations within a population.

D. all of the alleles of genes within a population.

23. Charles Darwin's theory of evolution by natural selection explains all of the following EXCEPT

A. How an ecosystem decays over time.

B. How inherited traits are passed from parent to offspring.

C. How the DNA of a population can change over time.

D. How evolution takes place in the natural world

24. A virus killed most of the seals in the North Sea (e.g., dropped the population from 8000 to 800). In an effort to help preserve the species, scientists caught 20 seals and used them to start a new population in the northwest Pacific Ocean. Which of the following factors would most likely have the least impact in this new population?

A. Founder effect C. Random mating

B. Genetic drift D. Bottleneck effect

25. Which of the following aspect of theory was believed by both Lamarck and Darwins?

A. New species arise over time

B. New features acquired during life time of an individual are passed to the offspring.

C. Organism didn't die out in extinction, but changed into other species

D. The natural variation present in an organism are heritable.

26. Which one of the following processes could not be the source of genetic variability in an existing population?

A. Mutagens B. Emigration C. Chromosomal aberration D. Genetic drift

27. Suppose two organisms unable to reproduce due to difference in breeding period in different season of the year. This type of reproductive isolation is termed as:

A. Ecological isolation C. Physiological function

B. Temporal isolation D. Spatial isolation

28. Which of the following theory made impossible the inheritance of acquired characteristic and supported the natural selection?

A. Neo-Darwinism theory C. Germ-plasm theory

B. Lamarckism theory D. spontaneous generation theory

29. The ratio of Carbon 14 to carbon 12 in living things is about 1 to 1 trillion. if the half-life of carbon 14 is 5730 years, what is the ratio of C14 to C12 after at the second half life?

A. 2 to 2 trillion B. 0.5 to 1 trillion C. 1 to 2 trillion D. 1 to 4 trillion

30. What is the cause of allopatric speciation? It is caused by

A. Polyploidy C. Behavioral isolation

B. Geographical isolation D. Aneuploidy

31. Which one of the following animals is distantly related to human?

A. Gorilla B. Rhesus monkey C. Gibbon D. Chimpanzee

32. Which hominin was considered as the first wise-man?

A. Homo habilis B. Homo sapiens C. Homo Neanderthal D. Homo erectus

33. Chromosomal mutation occurs mostly during meiosis at crossing over in

A. Metaphase I B. Prophase II C. Anaphase I D. Prophase I

34. Darwin proposed that the mechanism behind evolutionary change was

A. Heterozygosity C. Genetic drift

B. Inheritance of acquired traits D. Natural selection

35. In a population of Pea plants, the frequency of the dominant allele for round seed is 0.8. what is the frequency of the recessive wrinkled seed allele?

A. 0.04 B. 0.64 C. 0.32 D. 0.16

36. The differences in cricket calls among sympatric species of crickets are examples of

A. habitat isolation C. behavioral isolation

B. temporal isolation D. geographic isolation

37. The occurrence of large or small beak sizes among seed crackers in the absence of medium-sized beaks is an example of

A. directional selection C. stabilizing selection

B. disruptive selection D. Neutral selection

38. What is the significance of the discovery *Ardipithecus ramidus*? The fossil exposed that

A. the common ancestor of humans and chimpanzees could not have resembled a chimpanzee

B. large brain evolved before bipedalism

C. the common ancestor of modern humans and chimpanzees resemble chimpanzee

D. she was 4.4 million years older than *Australopithecus afarensis*

39. A decrease in genetic variation caused by a drastic reduction in population size is called

A. a Founder effect C. Hardy-Weinberg effect.

B. bottleneck effect D. adaptive effect.

40. In the Hardy-Weinberg equation, the term 2pq represents the frequency of the:

A. dominant homozygotes C. heterozygotes

B. Recessive allele D. recessive homozygotes

41. The many species of Galapagos Finches are adapted to eat different foods. This is the result of

A. Gene pool C. Genetic Drift

B. Survival of the fittest D. Adaptive radiation

42. Which of the following is true about Genus? It is: -

A. a group of closely related family C. a group of closely classes

B. a group of closely related species D. a group of closely related order

43. Which of the following is true about the extinct common ancestor of human and other primates?

A. The extinct common ancestor of human and chimpanzee lived 5 million years ago

B. The extinct common ancestor of chimpanzee and Bonobo lived 3 million years ago

C. The extinct common ancestor of orangutan, chimpanzee and human lived 8 million years ago

D. The extinct common ancestor of Gorilla and Orangutan lived 6 million years ago

44. Radioactive carbon (C14) dating is suitable to measure the age of fossils up to: -

A. 60 000 years old C. 100,000 years old

B. 1.3 million Years old D. 5730 years old

45. If the amount of C-14 relative to C-12 in a sample is one-quarter of that in living organisms at present, what is the age of the fossil at 5,730 half-life years?

A. 11,460 years B. 17,190 years C. 22,920 years D. 50,000 years

46. Adaptive radiation refers to

A. Migration of members of a species to different geographical areas

B. Power of adaptation in an individual to a variety of environments

C. Adaptations due to geographical isolation

D. Evolution of different species from a common ancestor

47. According to Lamarck, the organs which are used more are:

A. Better developed D. Completely lost

B. Less developed C. Remain the same

48. According to evidence of Neo-Darwinism theory, the ultimate source of genetic variability is:

A. Mutation B. Migration C. Genetic drift D. Random mating

49. Which of the following concepts was NOT part of Darwin's theory of evolution?

A. Inheritance of acquired characteristics C. Gradualism

B. Natural selection D. Common descent

50. Which of the following genera of hominid is the oldest/evolved first?

A. Ardipithecus B. Sahelantropus C. Austraopithecus D. Homo

51. Which chromosomal mutation is termed as partial trisomy?

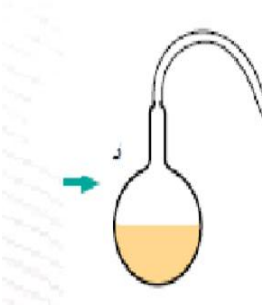
A. Deletion B. Duplication C. Translocation D. Inversion

52. At Hardy-Weinberg Equilibrium allele frequency do not change under all of the following condition except?

A. If there is no natural selection C. If there is no gene flow

B. If there is no random mating D. If there is no Mutations

53. This item is based on the diagram below.



Why did Pasteur bend the neck at curve?

A. To make the flask air tight

B. To trap dust & microbes

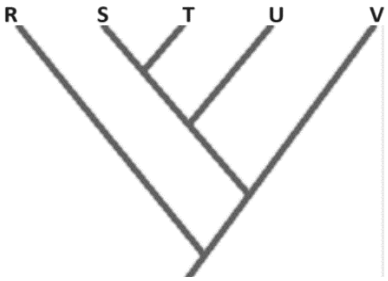
C. To enable the steam – easily comes out

D. To make dust and microbes pan in and out

54. When the human and other primate DNA compared, human's DNA are found distantly related to

A. Rhesus monkey B. Chimpanzees C. House mouse D. Gibbon

55. This item is based on the phylogenetic tree given below



Based on the phylogeny shown above we can conclude that **species "S"** is most distantly related to species

A. Species V C. Species T

B. Species U D. Species R

56. Structures that are derived from the same body part in a common ancestor but may have different appearances and functions are called

A. analogous structures C. homologous structures.

B. embryonic structures D. homozygous structures.

57. The fins of fish and whales are examples of structures that resemble each other and have similar function, but are the result of parallel evolution in separate lineages. These structures are called

A. analogous structures C. vestigial structures.

B. homologous structures D. embryonic structures.

58. Which of the following is the direct ancestor of Homo sapiens?

A. Australopithecus C. Homo erectus

B. Neanderthals D. Homo sapiens fossils

59. A bell-shaped curve in a variable indicates which kind selection?

A. Stabilizing selection C. Divergent selection

B. Unidirectional selection D. Disruptive selection

60. Which one of the following statements are not true about Charles Darwin?

A. Darwin observed variation within the finches of the Golapagos Islands

B. Darwin proposed natural selection as the mechanism for species change over time.

C. Darwin used DNA evidence to support the process of Natural selection.

D. Darwin wrote the book Origin of Species by Natural Selection

ANSWER KEY FOR EXERCISE FIFTEEN ON EVOLUTIN

1.B	7.D	13.D	19.A	25.A	31.B	37.B	43.B	49.B	55.C
2.C	8.C	14.B	20.C	26.B	32.C	38.A	44.A	50.B	56.B
3.D	9.C	15.C	21.B	27.B	33.D	39.B	45.C	51.B	57. B
4.B	10.C	16.C	22.D	28.C	34.D	40.C	46.D	52.B	58.B
5.B	11.C	17.B	23.C	29.D	35.A	41.D	47.D	53.B	59.A
6.A	12.B	18.A	24.A	30.B	36.C	42.B	48.A	54.C	60.C

THEME 5: Human biology

5.1. Digestive system

At the end of this section, you will be able to:

- Label a diagram of the human digestive system.
- Describe the functions of the structures of the human digestive system.
- Define enzymes and describe their role in the process of digestion.
- Describe the structure of the teeth and explain their importance.
- Describe the processes of digestion in the mouth, stomach and small intestine.
- Demonstrate that starch digestion begins in the mouth using saliva and bread.
- Explain how the products of digestion are absorbed and assimilated by the body.

Introduction

The digestive system is crucial for nutrient intake and waste elimination, supporting overall health and functioning of the body. Maintaining a balanced diet, adequate hydration, and regular physical activity promotes optimal digestive health.

- ❖ Digestive system consists of a system of tubes and associated glands.
- ❖ It extends from the mouth to the anus opening to the exterior at both ends.
- ❖ The wall of the tube is made up mainly of involuntary muscles.
- ❖ It consists of the following parts:

Mouth→ Pharynx→ Esophagus → Stomach → Small intestine → Large intestine → Rectum and Anus

The associated glands are:

1. Liver 2. Pancreas 3. Salivary glands

Role of salivary gland in digestive system

- Salivary gland makes saliva that moisten food so we can swallow it more easily.
- It also has an enzyme called amylase that makes it easier for the stomach to break down starches in food.

Digestion in mouth

- ❖ Both physical and chemical digestion takes place in mouth
- ❖ Salivary gland secretes saliva, the liquid that keeps our mouth moist and makes it easier to swallow food
- ❖ Saliva contains enzyme like ptyalin (salivary amylase) mucus and water.
- ❖ Saliva coated chunk of chewed food is called Bolus

Parts of tooth

Enamel: -is the top outer surface of the teeth and non-living.

- ✓ It is the strongest substance made by the human body

Dentine: - is still very hard (but not as enamel) similar to bone.

- ✓ It occupies the bulk of the teeth and supplied with oxygen and nutrients from the pulp cavity.
- ✓ It is relatively soft and contains living cells.

Pulp cavity: - is found in the center of the tooth.

- ✓ It contains living cells and nerves.

Cement: - is used to set (fix) the tooth into the jaw bone.

- ✓ It keeps the teeth firmly in place but at the same time allows certain amount of flexibility during chewing.

Digestion in the stomach

- ✓ Lining of stomach secrete gastric juice that contain
- ✓ **Protease (pepsin**): is an enzyme that catalyzes the breakdown of proteins into peptone.
- ✓ **Rennin**: solidifies milk proteins (casein). It is usually found in young mammals
- ✓ **Hydrochloric acid (HCl**): Provides suitable medium for the enzymes in the stomach and Kill bacteria, Inhibit the action of ptyalin
- ✓ **Mucu**s: protects the muscle walls from being digested by the proteases and attacked by the acid.

Digestion in the small intestine

- ❖ The duodenum cannot make its own enzyme but supplied by the pancreas Called pancreatic juice that consist enzymes like lipase, maltase, trypsin etc.…
- ❖ The liver produces bile which neutralizes the acid from the stomach and emulsifies the fats.
- ❖ In small intestine: Trypsin: converts peptones into peptides, Erepsin: converts peptides into amino acids and lipase: converts lipids into fatty acids and glycerol.

- Jejunum is the middle part of the small intestine where digestion takes place and
- ileum is the lower part of the small intestine where digestion is completed and soluble products are absorbed into the blood stream. The ileum is therefore both digestive and absorptive part of the small intestine

- ✓ Adaptation of Small intestine to allow the diffusion of digested food. It contains villi that increase surface area and rich blood supply that carries away digested food. Glucose, amino acids, minerals salts and vitamins being smaller in size go directly into the blood. The fatty acids and glycerol, being larger in size, move initially into the lacteals, which are part of the lymph vessels.

In the large intestine there is no digestion but

- ✓ Water is absorbed back into the blood
- ✓ Semi-solid faeces are formed.

Summary of Digestive system

The digestive system is responsible for breaking down food into nutrients that the body can absorb and use for energy, growth, and repair. The key components and functions of digestive system are as follow.

- ✓ **Mouth and Salivary Glands:** Begins the process of digestion by chewing food and mixing it with saliva, which contains enzymes that start breaking down carbohydrates.
- ✓ **Esophagus:** Acts as a conduit to move chewed food (bolus) from the mouth to the stomach through muscular contractions (peristalsis).
- ✓ **Stomach:** Stores and mixes food with gastric juices (hydrochloric acid and enzymes) to break down proteins and kill bacteria. It also regulates the release of partially digested food (chyme) into the small intestine.
- ✓ **Small Intestine:** Primary site of nutrient absorption. Enzymes from the pancreas and bile from the liver further break down food. Villi and microvilli on the intestinal walls increase surface area for absorption.
- ✓ **Large Intestine (Colon):** Absorbs water and electrolytes from indigestible food residues, forming feces. Houses beneficial bacteria that aid in fermentation and produce certain vitamins (like vitamin K).
- ✓ **Rectum and Anus:** Store feces until they are expelled through the anus during defecation.

Key Points:

- **Digestive Juices:** Enzymes and acids break down food into simpler forms that can be absorbed.
- **Peristalsis:** Wave-like muscle contractions move food through the digestive tract.
- **Absorption:** Nutrients (carbohydrates, proteins, fats, vitamins, minerals, water) are absorbed into the bloodstream or lymphatic system for distribution throughout the body.

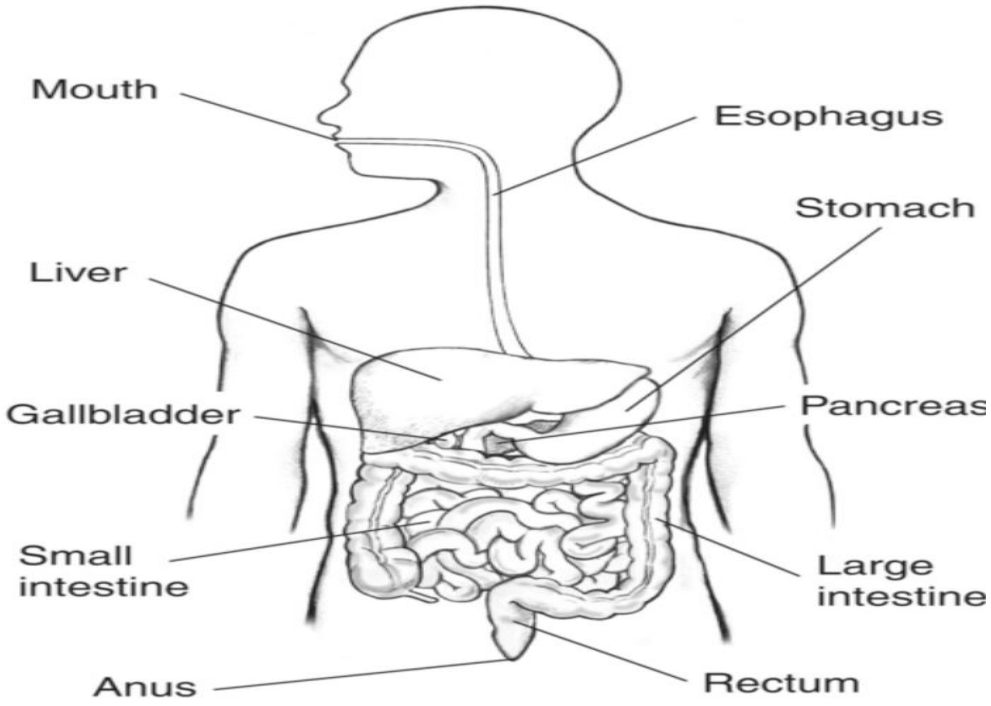


Figure 7. Human digestive system

Self-Test

Q. What is the role of liver in digestion?

Q. What is the role of pancreas in digestion?

Example of Review Exercise

1. Which of the following is not correctly paired with digestive a digestive organ and their enzymes?
   A. Duodenum – pancreatic lipase C. Mouth – salivary amylase
   B. Large intestine – protease D. Ileum – maltase
   Explanation: there is no digestion in large intestine since digestion is completed in small intestine
2. Which of the following is the function of bile in digestive systema?
   A. It is used to digest carbohydrate in small intestine
   B. It emulsifies fat into glycerol and fatty acid
   C. It increases acidity in stomach
   D. It is used to mix chewed food with saliva in stomach
   Explanation: Bile is a fluid produced by liver and used to neutralize acid from stomach and break down lipid.
3. Which one of the following organs is not the accessory organ of digestive system?
   A. Kidney B. Liver C. Pancreas D. Tongue

Explanation: Accessary organs aid the process of digestion. Liver produces bile, pancreas secrete pancreatic juices that contain digestive enzymes act in small intestine. Tongue and Teeth involve in physical digestion.

4. Which of the following pairs of food components in humans reaches the stomach totally undigested?
   A. Starch and fat C. Starch and cellulose
   B. Fat and cellulose D. Protein and starch

Explanation: Digestion of carbohydrate start in mouth. Digestion of protein start in stomach. Digestion of Fat start in small intestine. Cellulose is indigestible organic molecule in human gut.

SELF TEST EXERCISE

Choose the correct answer from the given four alternatives

1. A baby boy aged two years is admitted to play school and passes through a dental check-up. The dentist observed that the boy had twenty teeth. Which teeth were absent?
   A. Canine C. Pre-Molars
   B. Molars D. Incisors
2. Two babies are eating together on a dining table. One of them suddenly starts coughing while swallowing some food. This coughing would have been due to improper movement of:
   A. Epiglottis C. Tongue
   B. Neck D. Diaphragm
3. Which of the following organ produce digestive enzyme and hormone?
   A. Pancreas C. Stomach
   B. Liver D. Spleen
5. If salivary amylase is lacking in the saliva, which of the following events in the mouth cavity will be affected?
   A. Proteins breaking down into amino acids
   B. Starch breaking down into sugars
   C. Fats breaking down into fatty acids and glycerol
   D. Absorption of vitamins
6. The pancreatic amylase acts on starch and converts it to ___
   A. Peptides C. glycerol
   B. fatty acids D. maltose
7. Which one of the following is true site of action of enzyme?
   A. Lipase break down fat into glycerol and fatty acid in stomach
   B. Pepsin digest protein to amino acid in small intestine
   C. Erepsin convert peptone and peptide to amino acid in small intestine
   D. Pancreatic amylase convert starch to glucose in large intestine
8. Which of the following enzyme will not function properly if gastric gland is blocked by a certain inhibitor?
   A. Trypsin B. Pepsin

C. Amylase D. Sucrase

9. Hydrolytic enzymes that act in low PH are:
   A. Hydrolases C. Proteases
   B. Carbohydrase D. Lipase
10. Most of the fat digestion occur in
   A. Stomach C. Small intestine
   B. Duodenum D. Rectum
11. Digestion of protein start in _____ and ends in _____ respectively
   A. Stomach and rectum C. Duodenum and Rectum
   B. Mouth and Duodenum D. Stomach and Ileum
12. Emulsification of fat is the role of
   A. Intestinal juice C. Pancreatic Juice
   B. Bile salts D. Gastric juices
13. Fructose and glucose are absorbed into blood through microvilli of intestine by the process called
   A. Active transport C. Simple diffusion
   B. Facilitated diffusion D. Endocytosis
14. Absorption of fatty acid and glycerol takes place on
   A. Wall of stomach C. Lacteal
   B. Colon D. Micro villi
15. A Young infant may be feeding entirely on mother's milk which is white in color but the stool which the infant passes out is quite yellowish. What is this yellow color due to?
   A. Bile pigment passed through bile juice
   B. Intestinal juice
   C. Pancreatic Juice poured into duodenum
   D. Undigested milk protein casein
16. Cells lining the wall of the stomach secrete gastric juice containing:
   A. Pepsin B. Rennin C. Hydrochloric acid D. Trypsin

5.2. The respiratory system

At the end of this section, you will be able to

- Describe the structure and functions of the human respiratory system.
- Explain the process of gas exchange
- Compare the composition of inhaled and exhaled air.
- List the factors which affect breathing
- List the methods of maintaining the hygiene of breathing

Respiratory system in human

The respiratory system is responsible for the exchange of gases between the body and the environment, ensuring oxygen enters the body for cellular functions while removing carbon dioxide as a waste product. Key components and functions of the respiratory system include:

1. **Nose and Mouth:**
   - ✓ **Function:** Air enters through the nose and mouth, where it is filtered, warmed, and humidified before reaching the lungs.
2. **Trachea (Windpipe):**
   - ✓ **Function:** The trachea carries air from the nose and mouth to the lungs. It is lined with cilia and mucus that trap particles and move them upward towards the throat for removal.
3. **Lungs:**
   - ✓ **Function:** Paired organs where gas exchange occurs. The lungs are divided into lobes and contain millions of tiny air sacs called alveoli, where oxygen from inhaled air passes into the bloodstream and carbon dioxide is removed from the blood into the lungs to be exhaled.
4. **Diaphragm and Respiratory Muscles:**
   - ✓ **Function:** The diaphragm and intercostal muscles expand and contract the chest cavity during breathing. Contraction of the diaphragm increases the volume of the lungs, lowering air pressure and causing inhalation. Relaxation of these muscles leads to exhalation.
5. **Gas Exchange:**
   - ✓ **Function:** In the alveoli, oxygen diffuses into the bloodstream across thin capillary walls and binds to hemoglobin in red blood cells for transport to tissues. Simultaneously, carbon dioxide diffuses from the blood into the alveoli to be exhaled.
6. **Regulation of Breathing:**
   - ✓ **Function:** Breathing rate and depth are controlled by the respiratory center in the brainstem, which responds to levels of oxygen, carbon dioxide, and pH in the blood to maintain homeostasis.
7. **Respiratory System Health:**
   - ✓ **Function:** The respiratory system defends against pathogens and irritants through mechanisms like coughing, sneezing, and the production of mucus. Smoking, pollution, and respiratory diseases can impair its function

We carry on breathing – on average about 14 times a minute – until the day we die.

How is air brought into our lungs?

- ✓ By intercostal muscle and Diaphragm

When we breathe in:

- ❖ Our ribs move up and out
- ❖ The muscles of the diaphragm contract so that it flattens from its normal domed shape.
- ❖ External intercostal muscle contract pulling ribs out and up
- ❖ The intercostal muscles between the ribs contract, pulling them upwards and outwards
- ❖ The pressure inside the chest is lower than the pressure of the air outside

When we breathe out:

- ❖ the intercostal and diaphragm muscles relax
- ❖ the ribs drop and the diaphragm domes up
- ❖ internal intercostal muscle contract and pulling ribs down and in
- ❖ The volume of the thorax is decreased

- ❖ So, the pressure inside the chest increases

In alveoli gas exchange is efficient because it provides

- ✓ a very large surface area
- ✓ moist surface.
- ✓ rich blood supply through capillaries
- ✓ short diffusion distances

Composition of inhaled and exhaled air

Atmospheric air is composed primarily of nitrogen, oxygen, and argon, along with trace amounts of other gases.

1. **Nitrogen (N_2):** Approximately about 80% by volume
   - ✓ Nitrogen is the most abundant gas in the Earth's atmosphere. It is inert and non-reactive under normal conditions.
2. **Oxygen (O_2):** Approximately 21% by volume
   - ✓ Oxygen is essential for respiration in most living organisms. It supports combustion and oxidation reactions.
3. **Argon (Ar):** Approximately 0.93% by volume
   - ✓ Argon is a noble gas and chemically inert. It is commonly used in various industrial applications.
4. **Carbon Dioxide (CO_2):** Approximately 0.04% by volume
   - ✓ Carbon dioxide is a trace gas essential for photosynthesis in plants. Its concentration has been increasing due to human activities such as burning fossil fuels and deforestation.
5. **Other Trace Gases:**
   - ✓ Neon (Ne), helium (He), methane (CH4), krypton (Kr), hydrogen (H2), and xenon (Xe) are present in very small amounts, contributing to less than 1% of the total atmospheric composition.

Table 11. Composition of inhaled and exhaled air.

Atmospheric gas	Air breathed in	Air breathed out
Nitrogen	**About 80%**	**About 80%**
Oxygen	**21%**	**16%**
Carbon dioxide	**0.04%**	**4%**

Importance of Atmospheric Composition:

- ✓ **Respiration:** Oxygen is crucial for aerobic respiration in animals and many microbes.
- ✓ **Photosynthesis:** Plants use carbon dioxide and sunlight to produce oxygen and carbohydrates through photosynthesis.
- ✓ **Greenhouse Effect:** Certain gases like carbon dioxide, methane, and water vapor trap heat in the atmosphere, contributing to Earth's temperature regulation (greenhouse effect).
- ✓ **Weather and Climate:** Atmospheric composition influences weather patterns, atmospheric circulation, and climate.

Tidal volume: the amount of air breathed in during normal quite breathing at rest. we take about 500 cm3 of air in and out each time we breathe this is only about 15% of our possible maximum.

Vital capacity of your lungs: is the absolute maximum amount of air we can take into or breathe out of our lungs. If we need more oxygen for any reason, we have two ways of getting more air into our body.

- ✓ Breathing faster and breathing more deeply

Breathing fails because of:

- ✓ an accident, drowning or a heart attack.

When breathing stop on casualty, mouth-to-mouth resuscitation is used

Steps of this artificial respiration are as follow

i. Call for help loudly.
ii. Check to see if the casualty is conscious
iii. Open the airway.
iv. Check for breathing
v. Use a clean piece of cloth over the mouth and do mouth-to-mouth resuscitation
vi. Remove your lips and let the chest fall naturally.
vii. Repeat these steps at about 12 breaths per minute – a steady rate

Summary on respiratory system

The respiratory system is essential for delivering oxygen to tissues for cellular respiration and removing carbon dioxide from the body. Its efficient function supports overall health, energy production, and the body's ability to respond to changing environmental conditions. It consists Nose (Nostril) → Nasal passages → pharynx → Glottis → Larynx → Trachea → Brochi → Bronchioles → Alveol

Examples of Review Exercise

1. Which of the following chemical is used to know the presence of carbon dioxide in exhaled air?
   A. Lime water C. Thermometer
   B. Blue cobalt chloride D. White anhydrous copper (II) Sulphate

   Explanation: Calcium hydroxide is the chemical name for lime water. It reacts with carbon dioxide in the exhaled air to form calcium carbonate and which is insoluble in water and forms a milky white precipitate.
2. In which part of the respiratory system, gaseous exchange takes place?
   A. Alveoli B. Capillaries C. Trachea D. Pharynx

   Explanation: Alveoli is air sac where gas exchange takes place.it consist moist, large surface area that allow diffusion of gases in and out. Capillaries are site of exchange of material between blood and tissue cells. Trachea is a tube that allows passage of inspired and expired air into and out of the lung. Pharynx common passage for food and air and serves both respiratory and digestive function.
3. Which of the following disease is not the most common respiratory disease?
   A. Emphysema C. Asma

B. Chronic obstructive disease D. Atherosclerosis

Explanation: Asma, COPD, Influenza, Tuberculosis, Lung cancer, Pneumonia, are an example of respiratory disease. Atherosclerosis a disease caused dee to the deposition of metabolic products in the joints.

4. Which of the following correctly outlines the movement of oxygen from the atmosphere into the body?
   A. Atmosphere → trachea→ alveoli →capillaries →blood stream→ bronchi→ bronchioles
   B. Atmosphere→ trachea→ bronchi → bronchioles → alveoli → capillaries →bloodstream
   C. Atmosphere →alveoli → trachea → bronchi →bronchioles →capillaries → bloodstream
   D. Atmosphere → trachea →bronchi → bronchioles → bloodstream → alveoli →capillaries

   Explanation: The correct path of air is Atmosphere Nostril, Pharynx, Trachea, Bronchi, Bronchioles and Alveoli.

5. The air we exhale is a mixture of gases. Which of the following gases in the mixture is the highest in percentage?
   A. Carbon dioxide B. Nitrogen C. Oxygen D. Methane

   Explanation: Inhaled and exhaled air contain about 78% of nitrogen. While exhaled air contain 16% of Oxygen and 4% of carbon dioxide. Oxygen is the second most abundant gas at about 21% in atmosphere.

SELF TEST EXERCISE ON RESPIRATORY SYSTEM

Choose the correct answer from the given four alternatives

1. An alveolus has a large surface area relative to its volume. Which of the following best describes the advantage of this? A large surface area:
   A. allows the temperature to be regulated more easily.
   B. allows more diffusion to occur.
   C. prevents the entry of microbes or pathogens.
   D. provides more space for the enzyme-controlled reactions to take place
2. Which of the following is correctly paired with its function?
   A. Trachea→ Tubes that allows the passage of food and air
   B. Diaphragm → sheet of muscle that separate the thorax and abdomen
   C. Bronchioles → main branches of the lungs where gas exchange takes place
   D. Cartilage → complete ring of muscle that reduces the stretch of esophagus during swallowing
3. The Ventilation movement of the lung in human is governed by
   A. Trachea and ribcage
   B. Diaphragm and intercostal muscle
   C. Abdomen and thorax
   D. Bronchus and alveoli
4. Which of the following respiratory movement is not occur during inhalation?
   A. Contraction of external intercostal muscle
   B. decrease of air pressure in the lung

C. Contraction of diaphragm muscle
D. Internal intercostal muscle contact

5. The transport of oxygen and carbon dioxide by the blood happen with the help of
   A. WBC and Plasma
   B. RBC and Plasma
   C. WBC and platelet
   D. RBC and WBC
6. Which of the following is true about the structure of the human respiratory system?
   A. Alveoli is thin-walled air sac with extensive network of capillaries for gaseous exchange
   B. Trachea is a long tube supported by complete cartilaginous rings that prevent collapse during inspiration
   C. Pleural membrane is smooth rubbery material that reduces friction cushions joints
   D. Diaphragm is ring of muscle that allows air to move down into the stomach through esophagus
7. Which one of the following covers the opening of trachea during swallowing?
   A. Larynx
   B. Epiglottis
   C. Pharynx
   D. Cartilage
8. Which of the following is not true about the lung?
   A. Epiglottis covers larynx to prevent passage of food and fluid from entering into the lung
   B. Pharynx is the common passage for both food and air and site where mouth and nasal cavity join
   C. The wall of trachea secretes mucus that removes dusts and bacteria towards the lung
   D. Cartilage is a C-shaped muscle on the wall of trachea that facilitate swallowing of bolus in esophagus
9. Which of the following pairs of the structure of the lung is not supported by the ring of cartilage?
   A. Alveolus and Bronchus
   B. Trachea and Bronchi
   C. Bronchioles and Bronchus
   D. Alveoli and Trachea
10. Which one of the following would occur when an athlete run a 100 meters race?
    A. More oxygen is taken to produce more ATP during the race
    B. The body uses more energy and oxygen dept develop
    C. Breathing rate is increased to supply sufficient oxygen for aerobic respiration
    D. Muscle cell uses aerobic respiration to produce more ATP
11. Which of the following is not correctly paired with its function in experiment to detect the presence of substance in exhaled air?
    A. Calcium Hydroxide – detect the presence of water
    B. Lime water change to cloudy due to the presence carbon dioxide
    C. Blue cobalt chloride paper turns pink in the presence of carbon dioxide
    D. White anhydrous copper (II)sulphate turn to blue in the presence of oxygen
12. Which of the following is correct about tidal volume? It is

A. The maximum amount of air you breath during exercise
B. The minimum amount of air you breath you breath out
C. The amount of air your lung holds at resting state
D. The maximum amount of air breathed in and out

13. Breathing rate can be increased by all except?
A. Excess body weight C. Height above sea level
B. Increase in the level of carbon dioxide in the air D. taking depressant

14. The exchange of gases in the alveoli of the lung takes place by
A. Osmosis C. Facilitated diffusion
B. active transport D. simple diffusion

15. At high altitude the red blood cell in human blood will
A. Increase in number C. Increase in size
B. Decrease in number D. Decrease in size

16. Which of the following is true about ventilation of the lung?
A. Exhalation occurs due to external intercostal muscles
B. Air pressure in the lung is lower than atmospheric pressure during inhalation
C. Inhalation occur when atmospheric pressure id less than intrapulmonary pressure
D. Breathing out is initiated due to contraction of diaphragm

17. Which one of the following is a possibility for most of us with regards to breathing, by making a conscious effort?
A. One can consciously breathe in and breathe out by moving the diaphragm alone, without moving the ribs at all
B. The lungs can be made fully empty by forcefully breathing out all air from them
C. One can breathe out air totally without oxygen.
D. One can breathe out air through the Eustachian tube by closing both the nose and the mouth

18. The amount of air taken in or expelled during normal breathing is about
A. 500 cm^3 B. 1500 cm^3 C. 2000cm^3 D. 8000cm^3

19. Chronic respiratory disorder caused by cigarette smoking is
A. Stroke C. heart attack
B. Emphysema D. Cancer

20. Which of the following is not a respiratory disease?
A. Thrombosis C. Asthma
B. Pneumonia D. Arthritis

21. Which of the following option correctly represents the lung conditions in asthma and emphysema respectively?
A. Inflammation of bronchioles/bronchi and decrease respiratory surface
B. Increased number of bronchioles and increased respiratory surface
C. increased respiratory surface and Inflammation of bronchioles
D. Decreased respiratory surface and Inflammation of bronchioles

22. Chronic obstructive pulmonary disease mostly is caused by
A. Excessive consumption of alcohol B. Smoking and air pollution

C. Carbon monoxide D. Consuming large amount of Caffeine

23. Respiratory center which controls inhalation and exhalation is located in
    A. Cerebrum C. Medulla oblongata
    B. Spinal cord D. Cerebellum
24. Suppose a person goes to high altitude and experiences altitude sickness like heavy breathing and heart palpitation. It is due to:
    A. Increase in atmospheric oxygen C. Decrease atmospheric pressure
    B. Increase in atmospheric pressure D. Decrease in carbon dioxide
25. Plasma is the liquid component of blood that transport all **except**
    A. Carbon dioxide B. Oxygen C. Urea D. glucose
26. Which of the following is not the part of the respiratory response to exercise?
    A. Breathing faster C. Producing more oxygen
    B. Breathing deeper D. Producing more carbon dioxide
27. When you stop breathing, which of the following gas changes in the blood would first lead to the urge to breath?
    A. decreasing of Carbon dioxide
    B. Increasing of Oxygen concentration
    C. Increasing of O_2 and decreasing of CO_2
    D. Increasing of Carbon dioxide concentration
28. Suppose you are untrained person and found causality stop breathing due to drowning and mouth-to-mouth resuscitation should be taken. What should be your first step to save him/her?
    A. Opening the airway C. call for help loudly
    B. Checking for breathing D. Tilting the head back
29. The walls of the alveoli and the capillaries are very thin. Why is this the advantage?
    A. It provides a small surface area for reactions to occur.
    B. It provides a short diffusion pathway for gas exchange.
    C. It allows alveoli to expand and contract easily.
    D. It prevents blood from clotting in the capillaries

30. Which of the following is the correct path of air from outside into the lungs though?
    A. Nasal cavity→ larynx→ pharynx →trachea → bronchi →alveoli
    B. Nasal cavity→ larynx →pharynx → trachea →bronchioles→ alveoli
    C. Nasal cavity → pharynx→larynx→trachea → bronchioles→bronchi→alveoli
    D. Nasal cavity→pharynx→larynx→trachea→ bronchi→ bronchioles→alveoli

ANSWER KEY FOR SELF PRACTICE EXERCISE FIVE ON RESPIRATORY SYSTEM

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

5.3. Circulatory system

At the end of this section, you will be able to:

- Explain how oxygen and nutrients are transported in the blood. Indicate the structures of the heart on a diagram.
- Explain the functions of the structures of the heart.
- List the three types of blood vessels.
- Explain the functions of the blood vessels.
- Name the components of the blood.
- List the four blood groups.
- Explain the causes and prevention of anemia and hypertension.

Introduction

Simple organisms rely on diffusion for exchange of nutrient and gases. Higher organisms like Human beings are made up of trillion of cells, most of them a very long way from a direct source of food or oxygen, so a more complex transport system is required to supply the needs of the body cells and remove the waste material they produce.

Circulatory System: Delivers nutrients, oxygen, and hormones to cells and tissues. It Facilitates the exchange of oxygen and carbon dioxide between the blood and tissues. It also distributes heat throughout the body to maintain optimal temperature. It carries immune cells and antibodies to fight infections and remove pathogens. The circulatory system works with other systems (respiratory, digestive, urinary) to maintain overall balance (homeostasis) in the body's internal environment.

The human transport system (blood circulation system) has three elements,

I. the pipes (blood vessels)
II. the pump (the heart)
III. the medium (the blood).

William Harvey, correctly explaining the circulation of the blood for the first time.

Double circulation

a. **Pulmonary circulation:** Carries deoxygenated blood from the right side of the heart to the lungs, where it is oxygenated, and then returns it to the left side of the heart. During this process:

- ✓ Deoxygenated blood from the body returns to the right atrium of the heart through the superior and inferior vena cava.
- ✓ Blood moves from the right atrium to the right ventricle through the tricuspid valve.
- ✓ The right ventricle pumps the deoxygenated blood into the pulmonary arteries via the pulmonary valve
- ✓ Blood travels to the lungs, where it releases carbon dioxide and picks up oxygen through the alveoli

Importance of pulmonary circulation

- ✓ It ensures that blood is oxygenated in the lungs before it is pumped to the rest of the body.

b. Systemic circulation: Carries oxygenated blood from the left side of the heart to the rest of the body, delivering oxygen to tissues and organs, and then returns deoxygenated blood to the right side of the heart. Its pathway is as follow:

- ✓ Oxygenated blood returns from the lungs to the left atrium of the heart through the pulmonary veins
- ✓ Blood moves from the left atrium to the left ventricle through the mitral (bicuspid) valve.
- ✓ The left ventricle pumps oxygenated blood into the aorta via the aortic valve
- ✓ Blood is distributed to the body's tissues and organs, delivering oxygen and nutrients and picking up carbon dioxide and other waste products

Importance of Systemic circulation

- ✓ The systemic circulation ensures that oxygen-rich blood is delivered to all parts of the body, supporting cellular metabolism and function.

Significance of Double Circulation

1. **Efficient Oxygen Delivery:**

- ✓ By separating oxygenated and deoxygenated blood, double circulation allows for more efficient oxygen delivery to tissues.
- ✓ Oxygenated blood is pumped at high pressure, ensuring it reaches distant tissues effectively.

2. **Enhanced Metabolic Support:**

- ✓ Tissues receive a constant supply of oxygen-rich blood, which is crucial for high metabolic rates seen in mammals and birds.
- ✓ Supports endothermy (regulation of body temperature) in these organisms.

3. **Waste Removal:**

- ✓ Efficiently removes carbon dioxide and other metabolic wastes from tissues.

The blood vessels

- ✓ we have three main types of blood vessels, arteries, veins and capillaries

A. Arteries

- ✓ carry blood away from the heart usually oxygenated blood except pulmonary arteries: that carry deoxygenated blood
- ✓ umbilical artery, which carries blood away from a fetus into the placenta

- ✓ Carry blood under high pressure due to the force generated by the heart's contractions (systole).
- ✓ Arteries have thick, muscular walls that are elastic and capable of withstanding high pressure as they carry oxygen-rich blood away from the heart to the body.
- ✓ have a pulse
- ✓ Distribute oxygenated blood to tissues and organs throughout the body, ensuring they receive essential nutrients and oxygen for cellular function

B. Veins

- ✓ carry blood towards the heart usually deoxygenated **except** pulmonary vein and umbilical vein
- ✓ Veins have thinner walls compared to arteries and contain valves to prevent backflow of blood. They carry oxygen-depleted blood back to the heart.
- ✓ Carry blood under lower pressure and rely on muscle contractions and one-way valves to force blood toward the heart.
- ✓ They do not have a pulse but have valves that prevent back flow of blood
- ✓ Return deoxygenated blood, along with waste products like carbon dioxide, back to the heart for reoxygenation and recirculation

C. Capillaries

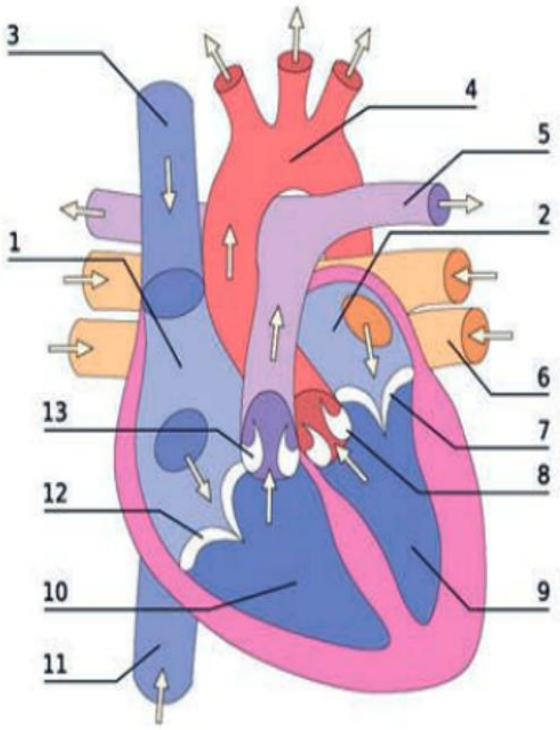
- ➢ are thin-walled, very narrow, blood vessels that are found between the arteries and the veins. They are the site of the exchange of substances within the body.

The human heart

Heart is a vital organ acts as a muscular pump that continuously circulates blood throughout the body. It is made up of cardiac muscle. It consists of four chambers: two atria (upper chambers) and two ventricles (lower chambers)(Fig,12)

- ➢ **Right Atrium and Ventricle:** Receive deoxygenated blood from the body and pump it to the lungs via the pulmonary arteries.
- ➢ **Left Atrium and Ventricle:** Receive oxygenated blood from the lungs and pump it to the rest of the body via the aorta

Structure of human heart



Self-Test

Q. Write the name of heart structure labelled in fig 12.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____

Figure 12. Structure of human heart

- The path flow of blood is as follow:

(Right Atrium→ Left Ventricle→ Lung → Right Atrium → Left Ventricle → Body → back to Right Atrium)

- Contain three valves: produce sound when surging blood

A normal blood pressure is 120 mmHg/80 mmHg – usually quoted as 120 over 80 or 120/80. Systole/diastole

- Diastole is when the heart muscles relax and filled with blood.
- Systole is when the heart muscles contract and force the blood out of the heart.

The blood

- Blood is a complex mixture of cells and liquid that carries a huge range of substances around the body. It is a fluid connective tissue that carries nutrients, oxygen, carbon dioxide, hormones, and waste products throughout the body. It consists of a liquid called the plasma, which carries red blood cells, white blood cells and platelets.
- Plasma is a pale-yellow liquid that transports all the blood cells but also a number of other things. Like CO2, Urea, digested product, mineral etc. Plasma (liquid portion), red blood cells (carry oxygen), white blood cells (immune response), and platelets (blood clotting).

Blood cells

i. **Red Blood Cells**: carrying oxygen around your body

- ❖ have a unique shape – they form biconcave discs
- ❖ allow them to have large surface area to volume ratio for oxygen to be transported
- ❖ they have thin surface membrane (short diffusion distance) for ease of diffusion.

ii. White blood cell:

- ❖ they are much bigger than the red cells and there are fewer of them.
- ❖ have a nucleus and form part of the body's defense system against microbes.

Some white blood cells are:

- ✓ The lymphocytes: form antibodies against microbes whilst others.
- ✓ The phagocytes: engulf invading bacteria.

iii. Platelets

- ❖ are small fragments of cells and they are very important in helping your blood to clot at the site of a wound.

Human blood group

Table 12. types of blood group and antigen and antibodies it consists

Blood group	Antigen on RBCs	Antibody in the plasma
Blood group A	A	b
Blood group B	B	a
Blood group AB	AB	none
Blood group O	None	ab

Short summary of circulatory system

The circulatory system, is responsible for transporting blood, nutrients, oxygen, carbon dioxide, and hormones throughout the body. It consists of the heart, blood vessels, and blood. There is double circulation. **Pulmonary Circulation:** Carries blood between the heart and lungs for oxygenation and removal of carbon dioxide. **Systemic Circulation:** Supplies oxygen-rich blood to the body and returns oxygen-depleted blood to the heart. **Heart** acts as a muscular pump that continuously circulates blood throughout the body. It consists of four chambers: two atria and two ventricles. **Arteries:** Carry oxygen-rich blood away from the heart to the body tissues. **Veins**: Return oxygen-depleted blood back to the heart. **Capillaries:** Tiny blood vessels where gas exchange occurs between the blood and tissues. Blood is a complex mixture of cells and liquid that carries a huge range of substances like nutrients, oxygen, carbon dioxide, hormones, and waste products around the body. The circulatory system plays a vital role in maintaining the body's overall function by transporting essential substances, regulating temperature, supporting immune responses, and ensuring efficient gas exchange. Its proper function is essential for overall health and well-being.

Examples of Review Exercise

1. Systemic circulation is the circulation between:

A. Body and lungs C. Lung and heart

B. Lung and stomach D. Heart and body

Explanation: systemic circulation: is carrying blood all around the rest of the body and back again (between the heart and the rest of the body).

2. Which of the following is true about blood vessels
   A. Umbilical artery carries oxygenated blood towards the fetus through placenta
   B. Pulmonary artery carries deoxygenated blood away from heart to the lung
   C. Coronary artery transport deoxygenated blood the lungs
   D. Umbilical vein carries oxygenated blood towards the placenta from the foetus

Explanation: the only artery that carries deoxygenated bloods are pulmonary artery and umbilical artery. Veins carry deoxygenated blood except pulmonary vein and umbilical vein.

3. Which of the following blood group is correctly paired with its antigen presented its surface?
   A. Blood group 'AB' - no antigen C. Blood Group 'O'—antigen a and b
   B. Blood group 'A' – antigen b D. Blood group B – antigen b

Explanation:

Blood group 'A' has antigen A and antibodies 'b'
Blood group B has antigen B and antibodies 'a'.
Blood group AB has both antigen a and b and lack antibodies
Blood Group 'O' has no antigen and contain both antibodies (a and b).

4. Bicuspid valve prevents back flow of blood from
   A. Right atrium to Right ventricle C. Wall of aorta and pulmonary artery
   B. Left ventricles to Left auricles D. Right ventricles to Left ventricles

Explanation: Valve are found on the wall of the heart and allows blood to flow in one direction. There are three types of valves.

I. Tricuspid – between Right atrium and right ventricle
II. Bicuspid -- between Right and Left ventricle
III. Semi-lunar valve – on the wall of Pulmonary artery and aorta

5. Blood is pumped long distance by
   A. Left ventricles
   B. Right atrium
   C. Left auricles
   D. Right Ventricles

Explanation: the wall of the left side of the heart is thicker than the right-hand side which allows the heart to pump blood long distance.

EXERCISE SIX (SELF PRACTICE QUESTION)

1. The transport of oxygen and carbon dioxide by the blood happen with the help of
   A. WBC and Plasma C. RBC and Plasma
   B. WBC and platelet D. RBC and WBC
2. Which of the following is an ethical to increase red blood count to avoid oxygen debt during competition?
   A. Having hormonal injection C. Training at high altitude
   B. Blood doping D. Blood transfusion
3. Which of the following is true about white blood cell? It
   A. Is smaller than red blood cell C. lacks of it causes anemia
   B. Is bigger and fewer than red blood cell D. Lacks nucleus
4. Beta blocker is a drug used to treat
   A. HIV/AIDS B. Hypertension C. Diabetes D. Goiter
5. Mature RBCs lack nucleus. This enables it
   A. To reproduce and diffuse easily
   B. allows it to metabolize easily
   C. Allow internal structure to have enough haemoglobin to carry oxygen
   D. Allow the structure to move inside the blood vessel easily
6. What is the name of blood cells whose reduction in number can cause clotting disorder and leading to excessive loss of blood from the body?
   A. Erythrocytes B. Leukocytes C. Neutrophils D. Thrombocytes
7. A person with blood group AB is considered to be the universal recipient, because he has
   A. Both A and B antigen on RBC but no antibodies in plasma
   B. Both A and B antibodies in the plasma
   C. No antigen on RBC and no antibody in the plasma
   D. Both A and B antigens in the plasma but no antibodies
8. A certain road accident patient with unknown blood group needs immediate blood transfusion, his one doctor friend at once offers his blood group. What was the blood group of the doctor?
   A. Blood group B C. Blood group AB
   B. Blood group O D. Blood group A
9. Which of the following event could not happen if you move to high altitude about 3500 meter above sea level?
   A. Increase in Heart beat C. Increase count of RBC
   B. Increase number of Capillaries D. Increase oxygen concentration
10. If both antigens are present but no antibody the blood group of an individual would be
    A. Blood group B C. Blood group A
    B. Blood group O D. Blood group AB
11. What one is correct about blood group O?
    A. No antigens but both a and b antibodies in plasma
    B. antigen A and antibodies b present

C. Antigen and antibodies are absent
D. A and B antigens and a and b antibodies are present

12. Which of the following is not correct about WBC?
A. Lack nucleus C. in deficiency causes cancer
B. made in thymus D. Squeeze through blood capillaries

13. Life span of White Blood Cell is approximately
A. Between two to three months C. More than four months
B. Less than twenty days D. between one and two months

14. Vitamin K is essential for
A. Change of prothrombin to thrombin C. Change of fibrinogen to fibrin
B. Synthesis of prothrombin D. formation of thromboplastin

15. Which of the following component of blood is responsible for producing antibodies?
A. Lymphocytes C. Thrombocytes
B. Erythrocytes D. Phagocytes

16. Transporting oxygen is the role of
A. Red blood cell B. White Blood Cell C. Platelets D. Lymph

17. Compared to blood our lymph has
A. More WBCs and no RBC C. Plasma without proteins
B. More RBCs and less WBC D. No plasma

18. The lymph serves to
A. Returns the interstitial fluid to the blood
B. Transport CO_2 to the lungs
C. Returns the WBCs and RBCs to the lymph nodes
D. Transport O2 to the brain

19. The heart sound ‘dub’ is produced when
A. Mitral valve is closed
B. Bicuspid valve is opened
C. Semilunar valve at the base of each aorta gets closed
D. Tricuspid valve is opened

20. Which of the following is not correctly paired with its function?
A. Hepatic portal vein – receives deoxygenated blood from intestine to the liver
B. Hepatic artery – deliver oxygenated blood to the liver
C. Coronary artery – Carries oxygenated blood to the lungs
D. Mesenteric artery -- provide oxygenated blood the intestine

21. Hepatic portal vein drains blood to liver from
A. Stomach B. intestine C. kidney D. Heart

22. Blood pressure in the pulmonary artery is
A. More than that in the pulmonary vein C. Less than that in the vena cava
B. Same as that in the aorta D. More than that in the hepatic artery

23. Which blood vessel would carry largest amount of urea?

A. Hepatic vein C. Renal vein
B. Hepatic portal vein D. pulmonary vein

24. Arteries are best defined as the blood vessel which
A. Supply oxygenated blood to the different organs
B. Carry blood away from the heart to different organs
C. Break up into capillaries which re-unite to form a vein
D. Carry blood from one visceral organ to another visceral organ

25. Pulmonary artery is differed from pulmonary vein in that pulmonary artery has
A. Thick wall B. Thin walls C. Pulses D. Oxygenated blood

26. Which of the following blood vessel does not carries oxygenated blood.
A. Pulmonary vein C. Pulmonary artery
B. Hepatic artery D. Renal artery

27. An adult human with average health has diastolic and systolic pressure as:
A. 120mmHg and 80 mmHg C. 140 mmHg and 90 mmHg
B. 80 mmHg and 120 mmHg D. 60 mmHg and 110 mmHg

28. Systolic pressure is the pressure formed by
A. Relaxation of the muscles of the hearts C. Contraction of lungs
B. Contraction of the muscles of the heart D. relaxation of lungs

29. The right side of the heart is separated from the left side by
A. Valves B. Septum C. Cardiac muscle D. lumen

30. Circulation between the heart and the lung is called
A. Coronary circulation C. Pulmonary circulation
B. Systemic circulation D. single circulation

31. The two chambers of human heart that contain deoxygenated blood are
A. Right auricle and Left ventricles C. Left atria and Left ventricles
B. Right atria and Right ventricle D. Left atrium and aorta

32. What is the cause of the back flow of blood into atria from the ventricles? It could be the damage of the
A. Pulmonary vein B. Aorta C. Valves D. Pulmonary arteries

33. The capillaries are blood vessel that have thin wall and large surface area since their function is
A. To return blood to the heart C. Transport oxygenated blood
B. Transport of deoxygenated blood D. exchange of substance

34. This item is based on the function of blood cell given in the table below

Blood components	Function of blood cell components
W	Transport of oxygen
X	Fight against diseases
Y	Causes blood clotting
Z	Carries glucose

The four blood components were placed in W, X, Y and Z were

A. Plasma, Red blood cell, Platelets, white blood cell
B. Red blood cell, white blood cell, Platelets, Plasma
C. White blood cell, Plasma, platelets and red blood cell
D. Red blood cell, plasma, white blood cell and platelets

35. Which of the following is not a disease of circulatory system?

A. Hypertension B. Leukemia C. Hemophilia D. arthritis

36. Cardiac muscle contract continuously without fatigue because it contains many

A. Nucleus C. Mitochondria
B. Golgi complex D. Smooth endoplasmic reticulum

37. In which of the following aspect a vein differs from an artery?

A. Having valves to control flow of blood C. Having muscular wall
B. Having narrow lumen D. Having pigmented wall to give dark look

38. Arteries differ from veins in all, except

A. Absence of valves C. Type of blood they carry
B. Presence of smooth muscles in its wall D. Diameter of lumen

39. Which of the following blood disease is heritable?

✓ Leukemia B. Hemophilia C. Hypertension D. Cancer

ANSWER KEY FOR SELF PRACTICE EXERCISE SIX ON CIRCULATORY SYSTEM

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

5.4. Nervous system

Learning Competency

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

Body Coordination

- ➢ There are two main forms of coordination in animals as a whole. These are nervous and hormonal (Endocrine system)

  Difference between Nervous system and Hormonal system

Nervous system	Hormonal system
➢ Electrical messages travel along neurons. ➢ Chemical messages travel across synapses ➢ Messages travel fast ➢ Messages usually have rapid effect. ➢ Usually a short-lived response. ➢ Nerve impulse affects individual cells, e.g., muscle cells, so have a very localized effect.	➢ Messages transported slightly more slowly in the blood minutes rather than milliseconds. ➢ Only chemical messages involved ➢ Often take longer to have an effect ➢ Effect often widespread in the body – affect any organ or tissue with the correct receptors. ➢ Effects often long lasting.

- ➢ Nervous system is responsible for the reception and processing of sensory information from both the external and internal environments.
- ➢ The nervous system has two major divisions.
- ➢ CNS: includes: Brain and spinal cord
- ➢ PNS: includes cranial nerves, spinal nerves, sensory nerves, motor nerves and mixed nerves

  There are four requirements that are necessary for a nervous response to occur: sensory receptors to detect a stimulus (skin, eye, ear); a system for impulse transmission (neurons); the capacity to interpret and analyze impulses (brain, spinal cord); and an effector (muscle, gland) to carry out the response

9. Types of nervous system

Central Nervous System

Brain

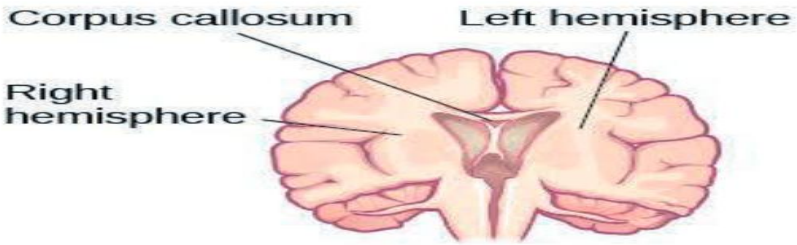
- ✦ Is delicate tissue protected by skull/ cranium
- ✦ Contain 12 pairs of cranial nerves that emerges from brain
- ✦ Three protective and nourishing membranes, the meninges
- ➢ Dura mater -- closest to the bone of the skull and is a double layer of tough, fibrous, connective tissue

- Arachnoid -- is a delicate serous membrane. Contain CSF.
- Pia mater -- is a delicate connective tissue layer that clings tightly to the brain.
- The brain “floats” in a special cushioning fluid, the cerebrospinal fluid (CSF).
- Grey matter of brain is primarily made up of neuron cell bodies and dendrites and Unmyelinated axon
- Grey matter is the outer region of brain.
- White matter of the brain is found in inner region and consist consists of bundled axons (Myelinated axon)
- White matter is serves as signaling between neurons functions in learning, feeling emotions, processing sensory information, and generating commands.

Brain consists three main regions.

1. **Cerebrum**: called Telencephalon

- is the largest portion of the brain in humans
- Consist right and left hemispheres.
- It performs higher mental functions and fine control of movement.
- The two hemispheres are connected by a thick band of neural fibers known as the corpus callosum that consists of about 200 million axons.
- The corpus callosum allows the two hemispheres to communicate with each other and allows for information being processed on one side to be shared with the other side of the brain.



(a) Front View

2. **Cerebellum:**

- Separated from brain stem by the fourth ventricle.
- It is the largest part of the hindbrain.
- The cerebellum receives sensory input from the eyes, ears, joints, and muscles about the present position of body parts
- cerebellum maintains posture and balance.
- It also ensures that all of the muscles work together to produce smooth, coordinated voluntary movements.
- The cerebellum assists the learning of new motor skills such as playing the piano or hitting a baseball.
- New evidence indicates that the cerebellum is important in judging the passage of time.

3. **Brainstem (Medulla):**

- Consists the medulla oblongata, pons, and midbrain
- Act as a relay station for tracts passing between the cerebrum and the spinal cord or cerebellum
- Has reflex centers for visual, auditory, and tactile responses.

Hypothalamus:

- the center for homeostatic control of the internal environment.
- It receives signals about the state of the body and regulates thirst, appetite, and body temperature
- Controls sex drive and is an endocrine gland

Thalamus

- is superior to the hypothalamus and inferior to the cerebrum.
- Are concerned with sensation.

The spinal cord

- The spinal cord runs out from the brain down the body.
- It is encased and protected by the vertebrae making up the spine.
- In human beings, there are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal.
- Grey matter areas in the brain and spinal cord that consist of unmyelinated nerve cells
- It involves reflecting its role in linking the CNS to sensory and motor neurons of the PNS
- White matter areas of the brain and spinal cord composed mainly of long-range myelinated axons

Types of Peripheral nervous system

Somatic nervous system

- ✓ is responsible for carrying out sensory and motor information to and from the central nervous system.
- ✓ is responsible for transmitting sensory information as well as for voluntary movement.

Sensory nerves - carry sensory information into brain and spinal cord

Somatic sensory nerves – signal from skin, skeletal muscle, Joints, special senses

Visceral sensory nerves – signal from body organs like digestive system

Motor nerves (Efferent) - carry motor information from CNS to effectors.

Somatic motor nerves – signal to skeletal muscle and voluntary.

Autonomic motor nerves – signal to smooth muscle, cardiac muscle, gland and is involuntary

- ✓ Contain two main division

Sympathetic division – fight or flights

- ✓ prepares the body to expend energy to respond to environmental threats.

Parasympathetic division – rest and digest

Autonomic Nervous System

- ✓ Is responsible for regulating involuntary body functions, such as blood flow, heartbeat, digestion, and breathing.
- ✓ controls aspects of the body that are usually not under voluntary control.
- ✓ Allows these functions to take place without the need to consciously think about what is happening

Neurons and their functions

- ➢ The nervous system is composed of only two principal types of cells - neurons and supporting cells (glial cells).
- ✓ Neurons are the basic structural and functional units of the nervous system.
- ✓ Conduct electrochemical impulses, Release chemical regulators.
- ✓ Perceives sensory stimuli, learning, memory, and the control of muscles and glands.
- ✓ Supporting cells aid the functions of neurons and are about five times more abundant than neurons.
- ✓ In the CNS, supporting cells are collectively called neuroglia, or simply glial cells (from the Middle Greek glia = glue).
- ✓ Neuroglia serves as supporting cells, providing support and nourishment to the neurons.
- ✓ All neurons consist of: a cell body, dendrites, and an axon.

Cell body (Soma)

- ✓ Contains nucleus that carries genetic information.
- ✓ maintains the neuron's structure.
- ✓ provides energy to drive activities

Axon

- ✓ Carry impulse away from cell bodies
- ✓ The most distinctive feature of all nerve cells
- ✓ Many axons are insulated with a fatty substance called myelin sheath.
- ✓ Axon membrane changes its permeability to sodium ions to create an electrical impulse.
- ✓ It receives signals from sensory receptors or other neurons. Incoming signals from dendrites can result in nerve signals that are then conducted by an axon.

Dendrite

- ✓ receive signals from sensory receptors or other neurons towards cell bodies.

Myelin sheath:

- ✓ Myelin is a fatty substance used to protect the neuron and to electrically insulate it,
- ✓ It is also used in speeding up impulse transmission.
- ✓ The axons of peripheral nerves and long or large axons are covered by a myelin sheath.

Schwann cells

- ✓ Cell in that make myelin sheath
- ✓ Within the peripheral nervous system Schwann cells wrapped in layers around the neuron form the myelin sheath.

Nodes of Ranvier

- ✓ The gaps where there is no myelin sheath
- ✓ Some nerve fibers are unmyelinated, and this makes nerve impulse transmission significantly slower.
- ➢ Most of the neuron cell bodies are located inside the central nervous system and form the grey matter
- ➢ The Cell bodies that are located in the peripheral nervous system are called ganglia.

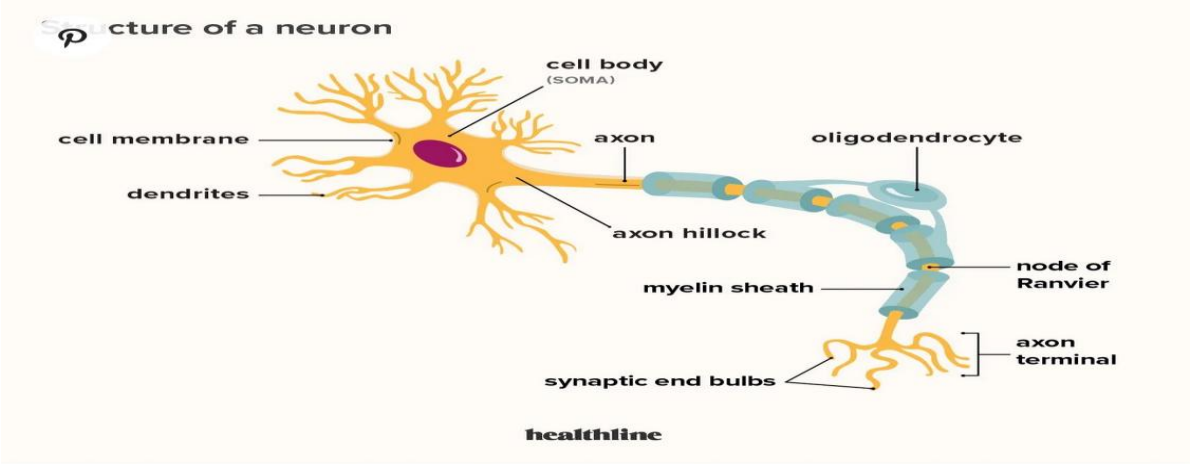


Figure 8. the structure of nerve cell

Mixed nerves - sciatic nerves in the legs

Nerve and nerve tract

- ➢ nerve tract refers to groups of neurons within the central nervous system
- ➢ nerve is a group of neurons (bundles of neurons) with blood vessels and connective tissue
- ➢ All the neurons in a nerve tract are concerned with either sensory or motor activity. These tracts are often referred to as white matter; the myelin sheaths of the neurons give them a white color.

Table 13. the main difference between a nerve and a neuron

Neuron	Nerve
➢ is an individual specialized cell.	➢ is a group of neurons
➢ conducts electrochemical signaling or nerve impulses.	➢ transmits information to the various parts of the body
➢ are found in the brain, spinal cord and the peripheral nerves	➢ Are found in the peripheral nervous system.
➢ Constitutes four parts (soma, nucleus, dendrite tree and axons)	➢ Constitutes different types of axons, with each nerve covered by three layers (endoneurium, perineurium and epineurium

The Nerve Impulse and transmission

- The nervous system relies on nerve impulses travelling along a neuron. The wave of positive charge inside the axon when the neuron is stimulated is known as the action potential.

Resting Potential

- When an axon is resting, its membrane is polarized; that is, the outside is positive compared to the inside (which is negative).
- When the axon is not conducting an impulse, the voltmeter records a membrane potential equal to about -65 mV (millivolts), indicating that the inside of the neuron is more negative than the outside this change is called **Polarization.**

Threshold potential: the voltage at which depolarization of a cell leads to generation of an action potential.

Hyperpolarization: increasing neuronal membrane potential to more than its usual resting potential (making it harder to induce the cell to produce an action potential)

Refractory period: a brief period following the generation of an action potential, during which a neuron is hard to re-excite

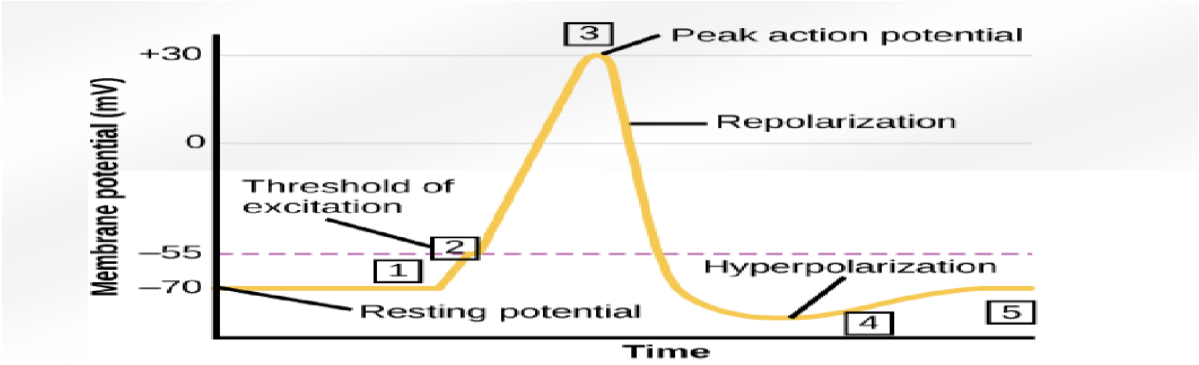


Figure 9. Conduction of action potential

Synapse

- Synapse the junction between two neurons (axon-to-dendrite) or between a neuron and a muscle.
- There are special synapses between effector neurons and the muscles they stimulate called neuromuscular junctions and they work in the same way as a normal synapse, except the chemical crossing in which the gap causes the muscles to contract.
- The axon terminal of the presynaptic neuron, which conducts its action potentials toward the synapse, ends in a slight swelling, the synaptic knob.
- The synaptic knob contains synaptic vesicles, which store a specific chemical messenger, a neurotransmitter that has been synthesized and packaged by the presynaptic neuron.
- Postsynaptic neuron, whose action potentials are propagated away from the synapse.
- The space between the presynaptic and postsynaptic neurons is called the synaptic cleft.

- Synaptic transmission: the process by which the impulse in the presynaptic neuron signals the postsynaptic cell.

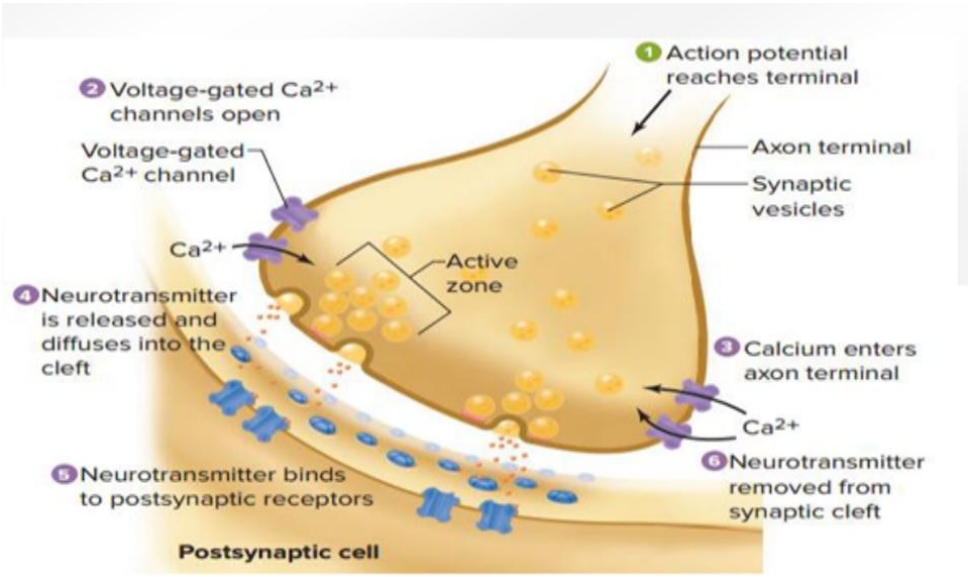


Figure 10. Signal transmission through a synapse

Neurotransmitters

- Neurotransmitters are often referred to as the body's chemical messengers.
- The first neurotransmitter to be discovered was a small molecule called acetylcholine.
- Acetylcholine (ACh) is an abundant neurotransmitter in the human body.
- It plays a major role in the peripheral nervous system, where it is released by motor neurons and neurons of the autonomic nervous system.
- It also plays an important role in the central nervous system in maintaining cognitive function.
- Glutamate is the primary excitatory transmitter in the central nervous system.
- Gama-aminobutyric acid (GABA) and glycine are major inhibitory transmitter which is mainly found in the spinal cord.
- Noradrenaline (norepinephrine) is another monoamine, and is the primary neurotransmitter in the sympathetic nervous system where it works on the activity of various organs in the body to control blood pressure, heart rate, liver function and many other functions.

Reflexes

- ✓ A reflex action is a sudden, automatic and uncontrolled response of parts of the body or the whole body to the external stimuli.

- ✓ Help us to avoid danger or damage
- ✓ It involves three types of neurons affector, relay and effector neurons
- ✓ The response involves neural path called reflex arc.
- ✓ Involves: Receptors, Sensory neuron, Central nervous system (inter neuron) and effector
- ✓ The neuron enters the spinal cord through the dorsal root
- ✓ Dorsal root- root at the back of the spinal cord
- ✓ Ventral root- root at the front of the spinal cord

Drug abuse and its effect on nervous system

How do drugs change the brain and lead to addiction?

- ❖ Drug abuse can profoundly impact the nervous system, disrupting normal neurotransmission and altering brain function. Substances like opioids, stimulants, and depressants can hijack neural pathways, leading to addiction, tolerance, and withdrawal symptoms. Prolonged drug use can cause structural and chemical changes in the brain, affecting memory, decision-making, and emotional regulation. Overall, drug abuse can have long-term consequences on neurological health, impairing cognitive abilities and increasing susceptibility to mental health disorders.
- ❖ Synapses make the brain work by transferring messages from cell to cell, doing the conscious work of thinking and the less conscious work of producing feelings and emotions
- ❖ Nearly every additive substance, including illegal drugs such as heroin, methamphetamine, and cocaine, and legal drugs, such as tobacco and alcohol, affect brain synapses. Drugs such as lysergic acid diethylamide (LSD), ecstasy, cocaine and heroin are illegal but rarely used in Ethiopia. These synapses use the neurotransmitter dopamine and are associated with the brains pleasure and reward centers.
- ❖ Dopamine--is neurotransmitter that is associated with the brains pleasure and reward centers.
- ❖ When we engage in an activity that brings us pleasure, whether it is eating a tasty snack or being praised by a friend, neurons in the hypothalamus and the limbic system release dopamine.
- ❖ Dopamine molecules stimulate other neurons across these synapses producing the sensation a pleasure and a feeling of wellbeing.
  - ❖ Additive drugs act on dopamine synapses in a number of ways.
  - ❖ Methamphetamine releases a flood of dopamine, producing an instant ‟high’’.

- ❖ Cocaine keeps dopamine in the synaptic region longer intensifying pleasure and suppressing pain.
- ❖ Drugs made from opium poppies, like heroin, stimulate receptors elsewhere in the brain that led to dopamine release.
- ❖ Nicotine, the additive substance in tobacco, and alcohol, also cause increased release of dopamine.
- ❖ The brain reacts to excessive dopamine levels by reducing the number of receptors for the neurotransmitter.
- ❖ As a result, normal activities no longer produce the sensation of pleasure they once did.
- ❖ Addicts feel depressed and sick without their drugs. Because there are fewer receptors, larger amounts of tobacco, alcohol and illegal drugs are required to produce the same high.
- ❖ The result is a deeper and deeper spiral of addiction that is difficult to break.

Types of illegal drugs and their effects:

1. **Opioids**:
    - **Effects**: Opioids such as heroin, fentanyl, and oxycodone bind to opioid receptors in the brain, leading to pain relief, euphoria, and drowsiness. They can also cause respiratory depression, nausea, and constipation. Long-term use can lead to physical dependence and addiction.
2. **Stimulants** (e.g., cocaine, methamphetamine):
    - **Effects**: Stimulants increase dopamine and norepinephrine levels in the brain, leading to increased alertness, energy, and euphoria. They can also cause increased heart rate, elevated blood pressure, and decreased appetite. Long-term use can result in paranoia, aggression, and severe dental problems (in the case of methamphetamine).
3. **Depressants** (e.g., benzodiazepines, barbiturates):
    - **Effects**: Depressants slow down the central nervous system, inducing relaxation, sedation, and reduced anxiety. They can also impair coordination, memory, and judgment. Overdose can lead to respiratory depression and death.
4. **Hallucinogens** (e.g., LSD, psilocybin mushrooms):
    - **Effects**: Hallucinogens alter perception, thoughts, and feelings. They can cause visual and auditory hallucinations, intense emotional experiences, and altered sense

of time and space. Some hallucinogens can lead to paranoia, panic attacks, and psychosis.

5. **Cannabis**:
    - **Effects**: Cannabis (marijuana, hashish) affects mood and cognition by interacting with cannabinoid receptors in the brain. It can induce relaxation, euphoria, altered sensory perception, and increased appetite. Long-term use may impair memory and cognition.
6. **Club drugs** (e.g., MDMA/ecstasy, ketamine, GHB):
    - **Effects**: These drugs are commonly used at parties or clubs and can induce euphoria, increased energy, and heightened sensory perception. MDMA/ecstasy, for example, increases serotonin levels, leading to feelings of empathy and emotional closeness. However, they can also cause dehydration, hyperthermia, and, in some cases, seizures or cardiac arrest

Exercise

1. Which of the following is not the part of peripheral nervous system?

A. Cranial nerve C. Spinal nerves

B. Spinal cord D. Mixed nerve

2. Which one of the following is not the function Sympathetic Nervous System?

A. Constriction of peripheral arteries C. Dilation of pupil

B. Contraction in the wall of urinary Bladder D. Stimulate ingestion

3. Which of the following is illegal drug is used common in Ethiopia?

A. Cocaine B. Heroin C. Cannabis D. Ecstasy

4. Addictive drug found in Khat edulis is called

A. Cathine B. Nicotine C. Cocaine D. Opiate

5. Which of the following statements best describes the effects of chronic alcohol consumption and chewing chat on health?

A. Chronic alcohol consumption primarily affects the cardiovascular system leading to increased risk of heart disease.

B. Chewing chat is associated with increased risk of oral cancers due to its high content of tobacco and areca nut.

C. Alcohol consumption and chewing chat (gutka) have minimal impact on mental health and cognitive function.

D. Both chronic alcohol consumption and chewing chat (gutka) improve overall oral hygiene and reduce the risk of dental problems.

6. Which of the following statements best describes the impact of chronic drug abuse on the nervous system?

A. Chronic drug abuse primarily affects the peripheral nervous system, causing numbness and tingling in extremities

B. Drugs like opioids and stimulants alter neurotransmission in the brain, leading to addiction and affecting cognitive functions

C. Drug abuse has minimal long-term effects on the nervous system if the drugs are discontinued promptly.

D. The nervous system adapts quickly to chronic drug use, restoring normal function once drugs are stopped.

5.5. Endocrine gland

Learning Competencies

- ♣ Define glands and hormones
- ♣ Compare endocrine and exocrine glands
- ♣ Identify the location and function of principal endocrine glands, including pituitary thyroid, parathyroid, adrenal, and pancreas
- ♣ Explain the function of glands and hormones

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

Exocrine glands: release their secretions through tube called ducts either out of the body or directly into the digestive system.

✓ Exocrine glands include those that release sweat, tears, Milk, sebum, and digestive enzymes.

Endocrine Glands

✓ A diverse collection of cell, tissues and organs including specialized endocrine glands that produces and secrete hormones that regulate physiological process

✓ Is made up of glands that make hormones.

✓ The hormones influence almost every cell, organ, function of our bodies.

Examples of endocrine glands are: Hypothalamus, Pituitary gland, thyroid gland, Parathyroid gland, Thymus gland, Pineal gland, Pancreas and Gonads (Ovaries and Testes)

a. Hypothalamus

- Connects nervous system and hormonal system.
- Control pituitary glands
- Most hypothalamic hormones that target cells of the anterior pituitary are releasing hormones, which encourage
- secretion of hormones
- It also makes inhibiting hormones that slow secretion of anterior pituitary hormone

b. Pituitary gland

- It is called master gland
- involved in the co-ordination between the nervous and hormonal systems of control.
- It is divided into anterior lobe (adenohypophysis) and posterior lobe (neurohypophysis).

Anterior pituitary gland

- Three times larger than posterior lobe
- Secrete produces six major hormones: whose secretion is regulated by the hypothalamus.

II. Growth hormone (GH)
III. Adrenocorticotropic hormone (ACTH)
IV. Thyroid-stimulating hormone (TSH)
V. Prolactin
VI. Luteinizing hormone (LH)
VII. Follicle-stimulating hormone (FSH

- These hormones control of metabolic functions throughout the body.
- FSH, LH, TSH, ACTH are hormone that have only tropic effect.
- Prolactin and, MSH are hormone that have only non-tropic effect.
- Growth hormone have both tropic and non-tropic hormone.

Growth hormone (Somatotrophin)

- Growth hormone is produced by the somatotropic cells of the anterior lobe and called somatotropin.

- The hormone is an anabolic or tissue-building hormone that has metabolic and growth-inducing functions.
- promotes growth of the entire body by affecting protein formation, cell multiplication, and cell differentiation.
- Growth hormone is responsible for the mobilization of fat in the body by increasing the levels of fatty acids.
- It also affects the glycogen breakdown and the release of glucose into the blood
- These proteins influence cell division and differentiation in organs like the liver, skeletal muscle, bones and connective tissues.
- The quantity is greatest during childhood and adolescence.
- If too little GH is produced during childhood, the individual has pituitary dwarfism, small stature occurs
- If too much GH is secreted, gigantism may result. May also promoting an illness called diabetes mellitus.
- On occasion, GH is overproduced in the adult and a condition called acromegaly (large face, chin, nose...) will be caused.
- The secretion of growth hormone by the anterior pituitary is regulated by two hypothalamic hormones; growth hormone-releasing hormone and growth hormone-inhibiting hormone.

Adrenocorticotropin (corticotropin):

- controls the secretion of some of the adrenocortical hormones, which affect metabolism of glucose, proteins, and fats.
- Adrenocorticotropic hormone or ACTH is secreted by the anterior pituitary that regulates the release of adrenocortical hormones by the adrenal gland.
- The hormone is secreted by the corticotropic cells in the form of a prohormone or precursor molecule.
- The most important function of the hormone is the activation of the adrenal cortex for the release of glucocorticoids.
- The release of ACTH is regulated by the hypothalamic corticotrophin-releasing hormone. The hormone is released in a daily rhythm where the levels are highest in the morning and decrease during the night.

Thyroid-stimulating hormone(thyrotropin):

- controls the secretion rate of thyroxine and triiodothyronine by the thyroid gland, and these hormones control the rates of most intracellular chemical reactions in the body.
- Thyroid-stimulating hormone is a hormone that stimulates the development of the thyroid gland and the secretion of thyroid hormones.
- The hormone is a tropic hormone and is also called thyrotropin.
- Like in the case of growth hormone, the activity and secretion of the thyroid-stimulating hormone are influenced by the thyrotropin-releasing hormone from the hypothalamus.
- Besides, the growth hormone-inhibiting hormone of the hypothalamus also affects the activity of this hormone.
- The release of the regulatory hormone, in turn, is controlled by the levels of thyroid hormones in the blood.

Prolactin

- stimulates milk production in a woman's breasts after she gives birth.
- The hormone is also produced in males, but its role in males is not yet understood.
- The release of prolactin, unlike other pituitary hormones, is regulated by prolactin-inhibiting hormone, also known as dopamine.

Gonadotropin

- ✓ The gonadotropin hormone secreted by the anterior pituitary includes two important hormones; luteinizing hormone and follicle-stimulating hormone.
- ✓ Gonadotropins are released in very small quantities before puberty; however, the concentration of these hormones in the blood increases at puberty.
- ✓ At puberty, the gonadotropic cells of the anterior pituitary mature to increase the level of gonadotropin in the blood.
- ✓ Both of these hormones are essential for the stimulation of gonads in males and females

Follicle stimulating hormone

- Stimulates production of mature eggs in ovaries and sperm in testes
- is responsible for the production of gametes, whereas the luteinizing hormone (LH) controls the production of gonadal hormones.
- The function of FSH and LH in females is extended to the regulation of the ovarian cycle and the release of ovarian hormones.
- FSH (follicle stimulating hormone) stimulates the development of a follicle in the ovary, and within the follicle the egg matures and ripens.
- FSH stimulates the ovaries to produce hormones, particularly oestrogen.
- As the oestrogen levels rise, the production of FSH by the pituitary gradually falls. This, in turn, means the oestrogen levels fall.
- The rise in oestrogen levels has the opposite effect on the levels of the other pituitary hormone, LH.
- As estrogen rises, the production of LH goes up.
- When the LH reaches its peak in the middle of the menstrual cycle, it stimulates the release of a ripe egg from the ovary.
- Progesterone maintains the thickened lining of the uterus and stimulates the growth of blood vessels in the lining to prepare for a pregnancy.
- Further, if a fertilized ovum arrives in the uterus, progesterone helps to maintain the pregnancy. By the end of the cycle, when the menstrual bleeding is about to start, all of the hormones are at a low ebb.
- The hormones produced by the ovaries are the steroids estrogen and progesterone.

Estrogen:

- ✓ promotes the maturation of the ovum in the ovarian follicle
- ✓ stimulates the growth of blood vessels in the endometrium (lining) of the uterus in preparation for a possible fertilized egg.
- ✓ Estrogen targets uterine lining, hypothalamus, pituitary gland and other tissues
- ✓ Estrogen regulates menstrual cycle and maintain secondary sex character in female

Progesterone

- ✓ Hormone secreted from corpus luteum (Ovarian follicle) after release of ovum.
- ✓ Stimulated by LH

- ✓ promotes the storage of glycogen and the further growth of blood vessels in the endometrium, which thus becomes a potential placenta. The secretory cells of the mammary glands also develop under the influence of progesterone.
- ✓ Progesterone regulates menstrual cycle and prepare body for pregnancy

Luteinizing hormone

- ➢ Stimulates ovaries and testes; prepares uterus for implantation of fertilized egg.
- ➢ In males, LH also stimulates the testes to produce the male sex hormone, testosterone.
- ➢ LH (luteinising hormone) stimulates the release of an egg from the ovary in the middle of the menstrual cycle and also affects the ovary so that it produces another hormone (progesterone) to keep the uterus lining in place. Produced by the ovaries, oestrogen stimulates the lining of the uterus to build up in preparation for pregnancy.

Testes:

- ✓ It contains leydig's cells that secrete testosterone to develop male secondary sexual characteristics.
- ✓ Promote sperm development and maintain secondary sex character in males
- ✓ Hormone target sperm producing cells, hypothalamus, pituitary gland …

Posterior pituitary gland

- ➢ Stores and releases hormones when needed that are actually produced by the hypothalamus. Produces two hormones (vasopressin and Oxytocin)

a. Antidiuretic hormone (vasopressin)

- ✓ Controls the rate of water excretion into the urine
- ✓ Control the concentration of water in the body fluids by decreasing sweating and causing vasoconstriction.
- ✓ Increase water reabsorption in distal convoluted tubules and regulates urine formation.
- ✓ Alcohol inhibits its secretions
- ✓ The hormone is responsible for maintaining water balance and prevents dehydration and water overload in the body.
- ✓ The hormone is secreted by the hypothalamus under the influence of osmoreceptors that monitors the level of solute in the blood.
- ✓ When the levels of solute increase in the blood, the osmoreceptors transmit excitatory signals to the hypothalamus to release ADH.

- ✓ ADH targets the convoluted tubules and collecting the ducts of the nephrons in the kidney, causing them to reabsorb water and release more solute into the urine.

b. Oxytocin

- ✓ helps express milk from the glands of the breast to the nipples during suckling.
- ✓ The primary function of oxytocin is to stimulate uterine contractions during childbirth.
- ✓ The number of oxytocin receptors on the uterine wall increases at the end of pregnancy which causes the smooth muscles of the uterine wall to be sensitive.
- ✓ Besides, oxytocin is also called the milk ejection hormone in women producing milk in response to prolactin.
- ✓ Suckling of nipples causes a reflex-induced release of oxytocin that targets the specialized myoepithelial cells of the mammary glands.
- ✓ Oxytocin is produced in the hypothalamus as neurotransmitter
- ✓ During labor or childbirth, both natural and synthetic oxytocin drugs are administered in order to hasten the process.

C. Thyroid gland

- ✓ Thyroid follicles utilize iodine and synthesize thyroglobulin (TGB) to be stored in the colloids.
- ✓ TGB is converted into two hormones: Triiodothyronine (T3) and Thyroxine (T4) to promote normal metabolism.
- ✓ Hypo secretion causes hypothyroidism (goiter, cretinism and myxedema).
- ✓ Goiter is prevented by addition of iodine to table salt.
- ✓ hyper secretion causes hyperthyroidism that result in Graves' disease.
- ✓ Thyroid gland also secretes Calcitonin to lower blood calcium and phosphate levels and regulate digestive (inhibit secretion of insulin).
- ✓ Its lower Ca level in blood not in bone
- ✓ It causes bone cell to pull more Ca from blood and increase Ca excretion by the kidney.
- ✓ Calcitonin stimulates the bone to absorb more phosphate.

D. Parathyroid gland

- ✓ Have the size of a grain of rice.
- ✓ release parathyroid hormone (PTH) which controls the calcium levels in the blood stream.

- ✓ Controls the calcium levels in the blood stream. Other areas of the body, especially the bones, kidneys and small intestine, respond to PTH by increasing the calcium levels in the blood.
- ✓ When Ca level in the blood is high, thyroid gland produces calcitonin increase Ca excretion by kidney.
- ✓ If the Ca level in the blood is low, PTH stimulate the release of Ca store in bone and kidney for reabsorption from filtrate and promote activation of Vitamin D
- ✓ PTH decrease phosphate level in the blood by inhibiting reabsorption in the kidney tube.
- ✓ It indirectly acts in small intestines; it increases the production of Vitamin D metabolite that increase rate at which Ca is absorbed.
- ✓ Hypo secretion causes tetany, and hyper secretion causes osteitis fibrosa cystica (Inflammation of bone).

E. Adrenal glands

- ❖ Is called Suprarenal glands, located on the top of both kidneys.
- ❖ Adrenal glands are composed of two parts.
- ❖ The cortex and the medulla

I. **Adrenal cortex**

- ❖ is the outer portion of the adrenal gland
- ❖ produce more than 60 different steroid hormones
- ❖ divided into 3 regions

a. Zona glomerulosa:

- ✓ the outermost layer and the main site for the production of mineralocorticoids, mainly aldosterone
- ✓ Mineralocorticoids are largely responsible for the long- term regulation of blood pressure
- ✓ Aldosterone exerts its effects on the distal convoluted tubule collecting duct of the kidney where it causes increased reabsorption of sodium and increased excretion of both potassium and hydrogen ions
- ✓ Aldosterone act on sweat gland to reduce the amount of sodium lost in sweat.

b. Zona Fasciculata

- ✓ Is the layer between glomerulosa and reticularis
- ✓ This layer is responsible for producing glucocorticoids, such as 11-deoxycorticosterone, corticosterone and cortisol in humans.
- ✓ Cortisol enhances the activity of other hormones including glucagon and catecholamines.

c. Zona reticularis

- ✓ is the innermost cortical layer,
- ✓ it produces androgens, mainly dehydroepiandrosterone DHEA sulfate (DHEA-S), and androstenedione (the precursor to testosterone) in humans.

What is the function of the zona glomerulosa, zona fasciculata and the zona reticularis?

- The outer region is the zona glomerulosa, which produces mineralocorticoids such as aldosterone; the next region is the zona fasciculata, which produces glucocorticoids such as cortisol; the inner region is the zona reticularis, which produces androgens.

Adrenal Medulla:

- This is the inner portion of the adrenal gland.
- It is made of modified nerve tissue that is under direct regulation of sympathetic nerves of the autonomic nervous system.
- Contains glandular cells called chromaffin cells which secrete Epinephrine (adrenaline) and Norepinephrine (noradrenaline).

Adrenaline: hormone produced by your adrenal glands.

- ✓ It is the hormone of 'fight or flight'.
- ✓ Affects different organs
- ✓ Increases heart rate and force of contraction
- ✓ Dilates bronchioles
- ✓ Decreases peristalsis
- ✓ Increases conversion of glycogen to glucose in the liver
- ✓ Causes vasodilation in skeletal muscles
- ✓ Causes vasoconstriction in skin and viscera
- ✓ increases use of fats for energy
- ✓ Increases the rate of cell respiration

Norepinephrine: hormone that Causes vasoconstriction in skin, viscera, and skeletal muscles

- ✓ Main site of storage and release neuron of sympathetic nervous system.

What is the function of the adrenaline?

- Key actions of adrenaline include increasing the heart rate, increasing blood pressure, expanding the air passages of the lungs, enlarging the pupil in the eye (see picture 1), decreasing the sensitivity to pain, improve vision, hearing and other senses, slowing digestion, redistributing blood to the muscles

What is the difference between adrenaline and cortisol?

- Adrenaline makes the heart beat faster, causes blood pressure to go up and gives you more energy. Cortisol, the primary stress hormone, increases sugar, also called glucose, in the bloodstream, enhances the brain's use of glucose and increases the availability of substances in the body that repair tissues.

F. Pancreas

- ✓ is a gland that produces digestive enzymes and manufactures hormones, including insulin and glucagon.
- ✓ is a small pink organ found below the stomach.
- ✓ It is both exocrine and endocrine in physiology.
- ✓ 99% of its mass is composed of cells called acini which secrete digestive enzymes which make it exocrine gland

- ✓ 1% of its mass is of cells called islets of Langerhans secrete hormones to regulate blood glucose level.
- ✓ alpha cells (α cells) secrete glucagon to raise blood glucose level,
- ✓ beta cells (β cells) secrete insulin to lower blood glucose level. Hypo secretion causes diabetes mellitus and hyper secretion causes hyperinsulinism.
- ✓ Delta cells (δ cells) secrete somatostatin or growth hormone inhibiting hormone (GHIH) which helps regulate carbohydrate metabolism by inhibiting the secretion of glucagon.

What is the function of Insulin and Glucagon

Insulin

- ✓ Is Hormone reducing the blood glucose levels by:
  - i. It increases conversion of glucose into glycogen and deposition of it in liver and muscles.
  - ii. It increases the rate of oxidation of glucose in the tissues.
  - iii. It increases the rate of conversion of glucose into fat and facilitates its storage in adipose tissue.
  - iv. It also regulates the rate at which amino acids are catabolized into water and CO2.

What is the difference of Type I and II?

Diabetes Mellitus

- ❖ When the body fails to produce or properly respond to insulin, a condition known as diabetes mellitus occurs.
- ❖ The very high blood glucose levels that result from diabetes can damage almost every system and cell in the body.

There are two types of diabetes mellitus.

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

Glucagon:

- ✓ is a hormone that raises the blood glucose level.
- ✓ stimulates the breakdown of glycogen stored in the liver;

- ✓ activates hepatic gluconeogenesis (the creation of glucose from substrates such as amino acids);
- ✓ has a minor effect enhancing triglyceride breakdown in adipose tissue – providing fatty acid fuel for most cells, and thus conserving glucose for the brain and neurons.

G. Pineal gland

- ❖ Pineal gland is pine cone shaped located deep in the cerebrum.
- ❖ It secrets melatonin to regulate circadian rhythms which are necessary to keep track of day or night cycles, sleep/wake rhythm, menstrual and ovarian cycles.

H. Thymus gland

- ❖ A thymus gland is a diminishing gland (over time) located between the lungs.
- ❖ It secretes a group of hormones, such as thymosin, to affect the production and maturation of lymphocytes in body defenses.

Homeostasis in the human body

Learning objectives

- Define homeostasis
- Explain the regulatory mechanisms of body temperature, sugar level water balance
- Discuss the structures and functions of the human kidney

The structure and function of the human kidney

- ❖ The kidneys are a pair of bean-shaped organs
- ❖ They are important organ with many functions including producing hormones, absorbing minerals, and filtering blood and producing urine.
- ❖ Internally, the kidney has three regions: an outer cortex, a medulla and renal pelvis
- ❖ The renal cortex contains the nephrons, which is the functional unit of the kidney.

Structure of nephron

a. Bowman's capsule

- ➢ is the site of the ultrafiltration of the blood.
- ➢ Contain Glomerulus

b. Glomerulus

- ➢ the knot of blood vessels where pressure builds up and ultrafiltration occur
- ➢ The glomerulus forces small solutes out of the blood by pressure
- ➢ Several layer of cell filter blood
- ➢ Large protein like RBC and platelets do not pass over the membrane
- ➢ Glomerular filtrate contains water, amino acid, glucose, urea and other substance.
- ➢ The volume of the blood leaving the glomerulus is about 15% less than the blood coming in which is a measure of the liquid which has moved into the capsule.

c. First coiled (convoluted) tubule:

- ➢ Is where much of the reabsorption takes place.

- All of the glucose is actively taken back into the blood along with around 67% of the sodium ions and around 80% of the water.
- It reabsorbs ions, water, and nutrients from the filtrate into the interstitial fluid, and actively transports toxins and drugs from the interstitial fluid into the filtrate
- It also adjusts blood pH by selectively secreting ammonia (NH_3) into the filtrate, where it reacts with H^+ to form NH_4^+.
- The more acidic the filtrate, the more ammonia is secreted.

d. Loop of Henlé:

- is part of a kidney where the urine is concentrated and more water is conserved
- In descend limb, water is also reabsorbed. The descending loop of Henle is lined with cells containing aquaporins that allow water to pass from the filtrate into the interstitial fluid.
- In its ascending limb, Na ion is reabsorbed from the filtrate. In the thin part of the ascending loop of Henle, Na^+ and Cl^- ions diffuse into the interstitial fluid. In the thick part, these same ions are actively transported into the interstitial fluid. Because salt but not water is lost, the filtrate becomes more dilute as it travels up the limb(Fig.15).

e. Second coiled (convoluted) tubule:

- is part of a kidney where the main water balancing is done.
- If the body is short of water, more is reabsorbed into the blood in this tubule under the influence of the anti-diuretic hormone or ADH.
- Ammonium ions and some drugs are secreted from the blood
- By the end of this second coiled tubule all of the salt which is needed by your
- In the distal convoluted tubule, K^+ and H^+ ions are selectively secreted into the filtrate, while Na^+, Cl^-, and HCO_3^- ions are reabsorbed to maintain pH and electrolyte balance in the blood.

f. Collecting duct:

- is also part of a kidney where the liquid (essentially urine) is collected.
- The collecting duct reabsorbs solutes and water from the filtrate, forming dilute urine.
- It contains about 1% of the original water, with no glucose at all.
- There is much higher concentration of urea (about 60 times more) concentrated urine than urea in the blood.
- Bladder holds between 600 and 800 cm3 urine
- On an average day the kidneys will produce around 180 l of glomerular filtrate and only 1.5 liter is urine

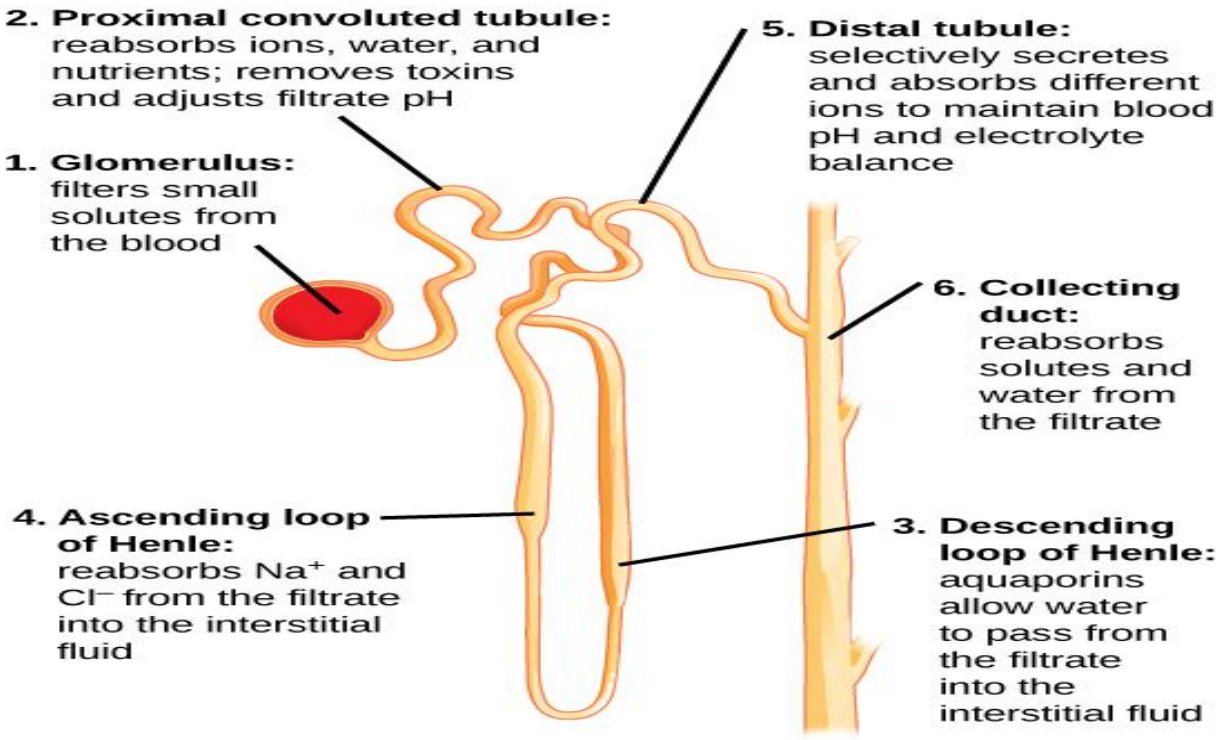


Figure 11. Structure of nephron

Q1. What is the difference between central chemoreceptor and Peripheral chemoreceptor

Q2. What is the role of Aortic body and Carotid body in chemo regulation?

REVIEW EXERCISE FIFTEEN (SELF PRACTICE QUESTION)

Choose the best answer for the following question

1. Which of the following is not correctly describe nervous system and hormonal system?

	Nervous system	**Hormonal system**
A.	Message travel rapidly	Message travel slowly
B.	**Effects are often long lasting**	**Effects are often short lasting**
C.	Have very localized effect.	Effect often widespread in the body
D.	Have Usually a short-lived response	Often take longer to have an effect.

2. Which one of the following types of nerves is correctly paired with its role?
   A. Visceral sensory neurons- signals from skin and special sense organs
   B. Somatic motor neurons – signals from to skeletal muscle
   C. Somatic sensory neuron – signals to involuntary muscles
   D. Autonomic motor neuron – signals to smooth muscles
3. Receiving sensory input is the role of:
   A. Efferent neuron B. Afferent neuron C. motor nerves D. Relay neuron
4. Which of the following the main function of neuroglia? It
   A. Conduct electrochemical impulse along neuron C. Respond to chemical and physical stimuli

B. Provide nutrition to the neuron D. Send, receive neurotransmitter

5. Which of the following is not the component of all nerve cell?
   A. Cell body B. Axon C. Dendrite D. Mylein sheath
6. Cell bodies formed in peripheral nervous system are called
   A. Soma B. Ganglia C. Telodendria D. Schwann Cell
7. The grey matter of the Central nervous system contains all except
   A. Synapses B. Axon C. Cell bodies C. Relay neuron
8. Which of the following nerves does not provide sensory function?
   A. Autonomic nerves B. Olfactory nerves C. Optic nerves D. Sciatic nerves
9. The most distinctive feature of all nerve cell is
   A. Myelin sheath B. Dendrite C. Cell bodies D. Axon
10. This item is based on the comparison between sensory neuron and motor neuron in the table below

R.no	**Sensory neuron**	**Motor neuron**
1	Integrate information in CNS	Send information to CNS
2	Allow CNS to comminate with sense organs	Allow CNS to communicate with muscle and organs
3	Have typically long dendrite and short axon	Have typically short dendrite and long axon
4	Carry messages to the sensory receptors	Carry message from the sensory receptor

Which of the above comparison is correct?
   A. 1 and 3 B. 2 and 3 C. 1 and 4 D. 2 and 4

11. Which of the following is the correct sequence of neural path?
   A. Sense organ → afferent neurons → central nervous system → efferent neurons → muscles
   B. Central nervous system → efferent neurons → muscles → sense organ → afferent neurons
   C. Sense organ → afferent neurons → central nervous system → efferent neurons → muscles
   D. Muscles →afferent neurons → central nervous system → efferent neurons → Sense organ
12. Which of the following is the role of node of Ranvier? It is
   A. Used to maintain neuron structure C. Allow rapid conduction of nerve impulses
   B. Slow the conduction of nerve impulses D. Synthesis myelin sheath that covers neuron
13. Which of the following component of the nerve cell is correctly paired with its function?
   A. Axon terminal — converts chemical signal to electrical signal
   B. Node of Ranvier – an insulating layer made from fatty substance
   C. Presynaptic neuron—transmit signal toward a synapse
   D. Dendrite – synthesize incoming information from cell bodies
14. Which of the following is not correct about cerebrum?
   A. It processes motor and sensory information
   B. It is protective in function to physical injury
   C. It is divided into left and right hemisphere
   D. It is the largest part of the brain
15. Neuron differ from other cells because,

A. it contains nucleus and mitochondria C. communicate through chemical
B. transmits electrical impulse D. regenerate through mitosis

16. What is a reflex arc? It is the
A. Receptor of a reflex C. Neural path of a reflex
B. Effector of a reflex D. Return point a reflex

17. Which of the following nerves provide purely sensory function?
A. Mixed nerves B. Optic nerves C. Sciatic nerves D. Peripheral nerve

18. This item is based on the component of nervous system,

I. Transmission by effector neuron
II. Integration by interneuron
III. Action by effector
IV. Transmission by afferent neuron
V. Reception by sensory receptors
VI. Stimulus

Which is a correct order for the flow of impulse?

A. V, VI, I, III, IV, II
B. IV, V, IV, II, I, III
C. II, III, I, VI, V, IV

19. Which of the following is not the component of reflex arc?
A. Sensory neuron B. Spinal cord C. Brain D. Motor neuron

20. If the inside of neuron potential is about -65mv, it is said to be
A. Action potential C. Refractory period
B. Resting potential D. threshold potential

21. Effector organ includes
A. Brain and Spinal cord C. Gland and Muscle
B. Affecter and motor neuron D. Nerve tract and Glial cell

22. Afferent nerve fibers carry impulses from
A. Effector organ to CNS C. CNS to receptors
B. Receptor to CNS D. CNS to muscl

23. Coordinator between nervous system and Hormonal System is
A. Thalamus B. Hypothalamus C. Cerebrum D. Medulla

24. Which of the following is not the component of fore brain?
A. Cerebrum B. Olfactory lobe C. Cerebellum D. Hypothalamus

25. Which of the following is not correctly matched with its function?
A. Thalamus – center for homeostasis C. Medulla – reflex center
B. Hypothalamus – regulate thirst and appetite D. Cerebellum – maintain posture

10. The region of human brain concerned with touch, vision and hearing is
A. Brain stem B. Cerebellum C. Hypothalamus D. Cerebrum

11. Which part of the following is correct about the grey matter of brain?
A. Primarily made from myelinated neuron
B. It is located in the inner region of brain
C. It Contains bundles of axon
D. It is home to neuron cell bodies and synapses

12. Which part of the brain serve as major coordinating center for sensory and motor signaling?

A. Hypothalamus B. Thalamus C. Medulla D. Cerebellum

13. Brain stem consists
    A. Midbrain, Pon, Medulla oblongata
    B. Cerebrum, Cerebellum and Medulla
    C. Spinal cord, Cerebrum, Cerebellum and Medulla
    D. Thalamus, Hypothalamus and Cerebral cortex
14. Central Nervous system is mostly made of
    A. Motor neuron and sensory neurons C. Association neuro/interneuron
    B. Sensory neuron and association neuron D. Motor neuron and association neurons
15. Hind brain consists of all except
    A. Cerebellum B. Medulla oblongata C. Pons D. Cerebrum
16. Most of the 12 cranial nerves are emerged from
    A. Cerebrum B. spinal cord C. Pituitary gland D. Hind brain
17. Which part of the brain is responsible for a reflex movement?
    A. Fore brain B. Brain stem C. Cerebrum D. Right cerebral hemisphere
18. Which of the following is an important function of spinal cord?
    A. Blood pumping C. Respiratory control
    B. Control of reflex action D. Balancing posture
19. A stage of recovery that occurs in after a neuron has fired an action potential?
    A. Resting potential C. threshold potential
    B. Refractory period D. Graded potential
20. When a membrane potential become more positive or less negative compared to outside it is termed as
    A. Hypo polarization B. Depolarization C. Repolarization D. Hyperpolarization
21. If the axon membrane become more negative than the resting state, it is called
    A. Hyperpolarized B. Repolarized C. Action potential D. Depolarized
22. What happens if the axon is stimulated? Formation of
    A. Positive charge inside the axon C. Negative charge in both side of the axon
    B. Positive charge outside of the axon D. Negative charge inside the axon
23. Threshold potential is the voltage at which
    A. Depolarization of a cell leads to the generation an action potential
    B. Neuron is hard to re-excite
    C. Repolarization of cell lead to generation of action potential
    D. Maximum fall of neuron potential due to efflux of K^+
24. During depolarization
    A. Sodium ion move out C. Sodium ion in
    B. Potassium ion in D. Sodium-potassium channel gate closed
25. During repolarization,
    A. Both sodium and Potassium gated are closed
    B. Sodium channels are closed and potassium channel are opened

C. Sodium moves inwards faster than potassium ion
D. Neuron become more permeable to Na+ than K+

26. What causes a neuron at rest be slightly negative compared to the surrounding fluid? The movement of:
A. Sodium ion out of the cell C. K+ out of the cell
B. Chlorine ions out of the cell D. K+ ions into the cell

27. The most abundant intracellular cation is
A. Protons(H+) B. Sodium (Na+) C. Potassium(K+) D. Calcium (Ca++)

28. When neuron is in resting state, the axon membrane is
A. Comparatively more permeable to Na+ ions and nearly impermeable to K+ ions
B. Equally permeable to both Na+ and K+ ions
C. Impermeable to both Na+ and K+ ions
D. Comparatively more permeable to K+ ions and nearly impermeable to Na+ ions

29. Repolarization of neuron occurs due to
A. Influx of Na+ B. Influx of K+ C. Efflux of Na+ D. Efflux of K+

30. During Hyperpolarization, the inside of the axon membrane is
A. More positive B. Less negative C. More negative D. Neutral

31. Which of the following is the correct path of action potential?
A. Stimulus → Repolarization → action potential →depolarization →hyperpolarization →Resting potential
B. Resting potential →action potential → Repolarization →depolarization →hyperpolarization →Stimulus
C. Resting potential →Stimulus →depolarization →action potential → Repolarization →hyperpolarization
D. hyperpolarization →Stimulus → Repolarization →depolarization → Resting potential →action potential

32. The most abundant neurotransmitter in the human body is
1. Acetylcholine B. Serotonin C. Noradrenaline D. Dopamine
2. Receptor sites for neurotransmitters are present on
3. Tip of axon terminal C. Pre-synaptic membrane
4. Post- synaptic membrane D. Membrane of synaptic vesicles

33. Which of the following is the effect of excitatory neurotransmitter?
A. Promote the generation of action potential
B. Decrease generation of action potential
C. Block the chemical message from being passed along
D. Provide the calming effect for brain

34. Which of the following is the function of postsynaptic neuron?
A. Secrete neurotransmitters like Acetylcholine and serotonin
B. Conduct action potential towards the synapse

C. Propagate action potential away from the synapse
D. Inhibit generation of action potential

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C. Propagate action potential away from the synapse
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36. White matter of spinal cord contains
A. Glial cells and myelinated axon C. Glial cell and unmyelinated axon
B. Motor neuron and Inter neuron D. Sensory neuron and relay neuron

37. Grey matter in the center of the spinal cord consists:
A. Interneuron, cell bodies of sensory neuron
B. Synapses and cell bodies of afferent neuron
C. Relay neuron and cell bodies of motor neuron, and dendrite
D. Nerve fibers and myelinated region of relay neuron

38. In human beings, there are
A. 31 pairs of spinal nerves C. 32 Pairs of spinal nerves
B. 33 pairs of cranial nerves: D. 12 pairs of spinal nerves

39. Which of the following statement is incorrect?
A. The sensory neuron enters the spinal cord through the dorsal root
B. The effector neuron leaves the spinal cord through the ventral root
C. Relay neuron is located in grey matter of spinal cord
D. Reflex action involves Secrete neurotransmitters like Acetylcholine and serotonin

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A. 31 pairs of spinal nerves C. 33 pairs of cranial nerves:
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55. Which of the following statement is incorrect?

A. The sensory neuron enters the spinal cord through the dorsal root
B. The effector neuron leaves the spinal cord through the ventral root
C. Relay neuron is located in grey matter of spinal cord
D. Reflex action involves voluntary reaction to stimuli

40. Which of the following is an example of conditioned reflex?
A. Withdrawal of hand on touching a hot surface C. Sneezing during cold
B. Salivation in Dog on seeing meat D. Running indoor on arrival of rain

41. Assume you wanted to demonstrate a simple reflex action using the knee jerk reflex. You asked a friend to sit with one leg crossed over the other. Which of the following indicates the correct demonstration?
A. Bending up your friend's leg followed by downward movement of the leg
B. Hitting your friend below the knee cap followed by a sudden upward movement
C. Pulling down your friend's leg that is followed by down ward movement
D. Hitting your friend on the toes followed by sudden upward movement of the leg.

42. Ivan Pavlov conducted experiments on
A. Simple reflex B. Conditioned reflex C. Reflex arc D. Autonomic reflex

43. Which of the following is an unconditioned reflex arc?
A. Knee Jerk C. Playing cercus
B. Joining with Out looking D. Reading and Writing

44. Which of the following is the correct sequence of vertebrae in from top to down?
A. Cervical → thoracic → lumbar→ Sacral
B. thoracic → Cervical → lumbar→ Sacral
C. Sacral → lumbar→ Cervical → thoracic
D. lumbar→ thoracic →Cervical → Sacral

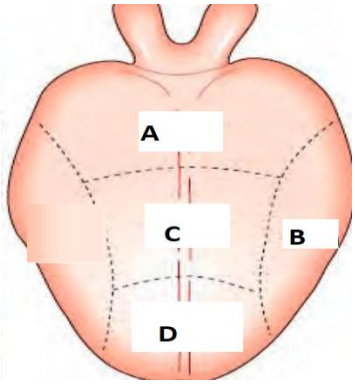
45. Which of the following is not the part of peripheral nervous system?
A. Cranial nerve B. Spinal nerves C. Spinal cord D. Mixed nerve

46. Which of the following pairs of the regions of spinal cord is more sensitive to injury?
A. Thoracic and Sacral C. Sacral and Coccyx
B. Cervical and Lumbar D. Cervical and Lumbar

47. A person entering an empty room suddenly finds a snake right Infront on opening the door, which one of the following is likely to happen in this neuro-hormonal control system?
A. Sympathetic nervous system is activated releasing epinephrin and norepinephrine from adrenal medulla
B. Neurotransmitters diffuse rapidly across the cleft and transmit a nerve impulse
C. Hypothalamus activates the parasympathetic division of brain
D. Sympathetic nervous system is activated releasing epinephrin and norepinephrine from adrenal cortex

48. Which of the following is an example of the action of the autonomous nervous system?
A. Swallowing of food B. Pupillary reflex C. Peristalsis of the intestine D. Knee jerk response

49. Which one of the following is not the function Sympathetic Nervous System?
    C. Dilation of pupil C. Constriction of peripheral arteries
    D. Contraction in the wall of urinary Bladder D. stimulate digestion
50. Which of the following is illegal drug is commonly used in Ethiopia?
    A. Cocaine B. Heroin C. Cannabis D. Ecstasy
51. Which of the following statement describes the harmful effect of alcohol use disorder? It
    A. Improve the living system of the entire community
    B. Helps to make good decision throughout life
    C. Exposes the user to sexually transmitted disease
    D. Increases the concentration and attention of users
52. Addictive drug found in Khat edulis is called
    1. Cathine B. Nicotine C. Cocaine D. Opiate
53. Which of the following is not the function of human skin?
    A. Breathing B. Excretion C. Sensation D. Water proofing
54. Which of the following is the correct sequence of skin layer inwards?
    A. Dermis, Hypodermis, Epidermis C. Epidermis, Dermis, Hypodermis
    B. Hypodermis, Dermis, Epidermis D. Dermis, Epidermis, Hypodermis
55. The abundant cell in epidermis is called
    A. Langerhans cell B. Keratinocytes C. Melanocytes D. Collagen
56. Which of the following cell in skin layers is correctly matched with its function?
    A. Melanocyte – secrete pigment of skin color
    B. Keratinocytes – serves as excretory organ
    C. Langerhans cell -- prevents entry of pathogen
    D. Tactile corpuscle – senses touch stimulus
57. Which of the following is correct about skin?
    A. Epidermis creates our skin tone C. Dermis is made of fat and connective tissues
    B. Epidermis consists blood vessel and sweat gland D. Dermis contain dead cell
58. Which of the following is the function of dermis of skin? It
    A. Contains blood vessels and sweat glands
    B. Forms a water proof around the body tissue
    C. Protects the entry of pathogens into the body
    D. Acts as protection against heat loss
59. This item is based on the following diagram of human tongue?



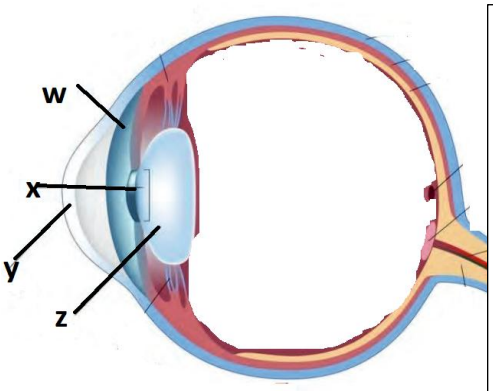
Letter 'A' and 'B' respectively represents the main taste site for

A. Bitter and Sour
B. Sweat and Salt
C. Sour and Sweat
D. Umami and Bitter

60. Which of the following is not the external structure of the human eye?
A. Conjuctiva B. sclera C. Retina D. Pupil

61. Which of the following structure of human eye is not correctly matched with its function?
A. Iris → membrane responsible to control amount of light
B. Pupil → aperture in the center of eyes changed in response to light
C. Choroid → allows light to enter and focused on retina
D. Cornea → refract light along with lens

62. This item is based on the given anatomy of human eyes.



What is the name of parts of human eye represented by letter 'W, X, Y and Z are respectively are in the diagram?

A. Cornea, Iris, lens and Pupil
B. Iris, Lens, cornea and pupil
C. Cornea, pupil, Lens and Iris
D. Iris, pupil, Cornea, Lens

63. The inner back surface of the eye is
A. Cornea B. Retina C. Iris D. Pupil

64. The transparent lens in the human eye is held in its place by
A. Ligaments attached to the ciliary body C. Smooth muscle attached the iris
B. Ligaments attached to the iris D. Smooth muscles attached to the ciliary body

65. Blind spot is place were
A. More rods than cones are found C. Light enter the eyes
B. Only cones occur D. Optic nerves leaves the eye ball

66. A flexible disc that helps to focus light on the retina of the eye is called
A. Fovea B. Iris C. Lens D. Choroid

67. Light rays entering the eye is controlled by
A. Pupil B. Iris C. Lens D. Cornea

68. This item is based on the table given below that describe the structure and function of human eye

Structure of human Eye	Function
R	Alter the size of pupil
T	Sensitive pigmented layer of eye
U	Nourish retina
V	White visible portion and support internal structure

Which of the following structure of human eye labelled by (R, T, U, and V) correctly with its function in the table above?

A. Cornea, Iris, lens, pupil
B. Pupil, Retina, Choroid, Sclera
C. Lens, Fovea, Blindspot, cornea
D. Iris, Lens, Sclera, Choroid

69. Short sightedness in human can be corrected by wearing

A. Convex lens B. Concave lens C. Cylindrical D. Diverging lens

70. The most sensitive part of retina is called

A. Optic disc B. Macula lutea C. Fovea centralis D. Ciliary muscle

71. How is long sight corrected? By

A. Removing ciliary muscle
B. Using convex lens
C. Using concave lens
D. Wearing solar glass

72. Which of the following is not the correct of the outer ear?

A. Ear canal B. Auricle C. Tympanum D. Eustachian tube

73. Why Children who play the spinning round and round fast, feel dizzy when they stop?

A. The sensory hairs vibrate highly in response to movement of their body
B. The fluid in their semicircular canals keeps on moving after they stop
C. The optic nerves report the children are still moving
D. The otoliths round in the same direction with the head

74. In mammalian eye. The “Fovea” is the center of the visual field, were

A. Only rods are present
B. More rods than cones are found
C. High density of cones occur, but has no rods
D. The optic nerves leave the eye

75. What is the function of Eustachian tube?

A. Control respiration and secretion of saliva
B. Equalize air pressure on either side of tympanum membrane
C. Control body temperature and urge for eating and drinking
D. Consist auditory nerves and send impulse to the temporal lobe

76. How are hormones able to find their target cells/glands?

A. The cell /glands contain receptor cells specific to the hormone
B. The glands and the cells are located near to each other
C. The hormone and the cells are made up identical molecules
D. The hormones are taken to the targeted organ by carrier molecules

77. Which of the following statements are not true?

A. Endocrine glands are ductless and they secrete hormones.

B. Hormones have long lasting effects on the target cells
C. Endocrine glands are always present near their target cells
D. Hormones bind to specific receptors present on the cells

78. Which of the following endocrine gland is correctly paired with its function?
A. Pituitary gland → Secrete corticoid steroid hormone
B. Pineal gland → Produce thyroxin hormone
C. Thyroid gland → produce growth hormone
D. Adrenal gland → secrete aldosterone hormone

79. Which one of the following statements is correct?
A. Endocrine glands regulate neural activity, but not vice versa
B. Neuron regulate endocrine activity, but not vice versa
C. Endocrine glands regulate neural activity and nervous system regulate endocrine glands
D. Neither hormones control neural activity nor the neurons control endocrine activity

80. Secretion of thyroxine hormone requires
A. Iron B. Iodine C. Calcium D. Potassium

81. Which of the following character is caused by hypersecretion of thyroxine?
A. Cretinism B. Myxedema C. Grave disease D. Goiter

82. Which of the following hormone is responsible for hypoglycemia?
A. Thyroxine B. Melatonin C. Insulin D. Glucagon

83. The level of which of the following is reduced after menopauses?
A. Aldosterone B. Estrogen C. Insulin D. Parathyroid hormone

84. Temporary gland that secretes hormone in the presence of fertilization and later disintegrate leading to menstruation in the absence of pregnancy
A. Corpus luteum B. Fallopian tube C. Uterus D. thymus gland

85. Goiter (Grave disease) occur due to
A. Excess production of glucagon hormone C. malfunction of pancreas
B. Excess secretion of adrenaline hormone D. excess amount thyroxin hormone

86. Which of the following gland is an example of endocrine gland?
A. Adrenal gland B. Mammary glandC. Pancreatic glands D. Sweat glands

87. Which one of the following is not the function of antidiuretic hormone?
A. Increases water reabsorption by the kidney C. Causes vasoconstriction
B. Decrease sweating D. Promotes release of milk from mammary gland

88. Which of the is an example of negative feedback loop mechanism in human?
A. Secretion of tears after falling of sand particles into the eye
B. Salivation of mouth at the sight of delicious food
C. Secretion of sweat glands and constriction of skin blood vessels when it is too hot
D. Constriction of skin blood vessels and contraction of skeletal muscles when it is too cold

89. Which one of the following hormones is not produced by anterior pituitary glands?
A. Growth hormone B. Corticotropin C. Prolactin D. Oxytocin

90. Which one of the following hormones is not involved in sugar metabolism?

A. Thyroxine B. Insulin C. Aldosterone D. Glucagon

91. Gonadotrophic hormone is secreted by
A. Hypothalamus gland B. Pituitary gland C. thyroid gland D. Adrenal cortex

92. Which of the following gland is not correctly paired by hormone it secretes?
A. Thymus gland →thymosin C. Parathyroid gland → aldosterone
B. Adrenal medulla → epinephrin D. Pineal gland → melatonin

93. Diabetes is due to deficiency of:
A. Enzyme B. Iodine C. Mineral D. Hormone

94. Fight-or-flight reactions cause activation of
A. Parathyroid gland to increase metabolic rate
B. Kidney and increase frequency of urination
C. Adrenal medulla to increase secretion of epinephrine
D. Pancreas to reduce sugar level in the blood

95. How are hormones able to find their target cell?
A. The cells contain receptors cell specific to the hormones
B. The glands and the cells are located near to each other
C. The hormones and the cells are made up of identical materials
D. The hormones are taken to the cells by carrier molecules

96. Which of the following endocrine gland is called master gland?
A. Thyroid gland B. Pituitary gland C. Mammary gland C. Pineal gland

97. A patient exhibited symptoms of weight loss, sweating, irritability and the doctor suspected an endocrine malfunction that can be related to the
A. Thyroid gland B. Gonad C. Pancreas D. Adrenal gland

98. Secretions of endocrine glands require receptors on cell membrane to be picked by their targets while exocrine secretions do not. This is because
A. Exocrine glands are controlled by the nervous system
B. Endocrine glands produce protein-based hormones
C. Exocrine glands secrete hormone directly to the blood stream
D. Endocrine glands are ductless

99. Progesterone is
A. an enzyme for digesting proteins.
B. a hormone to initiate uterine contraction.
C. a hormone that triggers production of egg
D. a hormone concerned with the maintenance of pregnancy

100. Which of the following hormone cause dilation of blood vessels, increased oxygen and glucose consumption?
A. Glucagon B. Adrenaline C. Insulin D. Antidiuretic hormone

101. Menstrual cycle is regulated by all except
A. FSH B. Estrogen C. Progesterone D. testosterone

102. he major response of testosterone is: It

A. Promotes sperm development
B. Maintain secondary sexual character in female
C. Prepare body for pregnancy
D. Regulate menstrual cycle

103. Wich of the following organ do not serve as an excretory organ in your body?

A. Skin B. Lung C. Kidney D. Heart

104. A pine cone shaped gland located deep in the cerebrum is

A. Thalamus gland
B. Pineal gland
C. Hypothalamus
D. Pituitary gland

105. Which of the following hormone is not the hormone of adrenal gland?

A. Epinephrine B. Aldosterone C. Cortisone D. thyroxine

106. Which of the following statement about pancreas is not correct?

A. Pancreas is both exocrine and endocrine glands
B. Islets of Langerhans cell secretes digestive enzymes into small intestine
C. Alpha cell secretes glucagon to raise blood glucose level
D. Beta cell secretes insulin to lower blood sugar

107. Which of the following hormone is not correctly matched with its function?

A. Prolactin -- stimulates the production of milk
B. Vasopressin – Increase water reabsorption in nephron
C. Aldosterone – increase reabsorption of sodium ion in the kidney
D. Thymosin – increase activities in nocturnal and diurnal animal

108. Pituitary dwarfism is caused by

A. Excessive secretion of prolactin
B. Low secretion of growth hormone
C. High amount of thyroxin
D. Absent of corticotrophin

109. Melatonin is the hormone responsible for

A. Synchronizing circadian rhythms
B. Stimulates break down of sugar
C. Vasodilation in skeletal muscle
D. providing skin color

110. Which of the following is the basic function of the liver? It

A. Controls the water level of the body
B. Removes mineral ions from the body
C. Removes urine from the body
D. Controls the sugar level of the body

111. Thyroid gland produces hormone that

A. Regulate the body's metabolic rate, growth and development
B. Control the calcium level in the blood stream
C. Control body temperature in the higher animals
D. Regulate water content of human body cell

112. Which one of the following is not the response to increase in core body temperature?

A. Dilation of blood capillaries under skin
B. Production of more sweat
C. Decrease in blood flow under skin
D. increase in blood flow through the capillaries

113. The principal nitrogenous excretory compound in humans is synthesized

A. In kidney butt eliminated mostly through liver
B. In kidneys as well as eliminated by kidney

C. In liver and also eliminated the same through bile
D. In the liver, but eliminated mostly through kidney

114. Which one of the following is not a part of a renal pyramid?
A. Convoluted tubules C. Collecting ducts
B. Loop of Henle D. Peritubular capillaries

115. Which of the four parts mentioned below does not constitute a part of a single uriniferous tubule?
A. Distal convoluted tubule C. Bowman's capsule
B. Collecting duct D. Loop of Henle

116. On average day the kidney will produces
A. 180 Liter of urine C. 1.5 Liter of urine
B. 1.5 glomerular filtrates D. 15O liter of urine

117. Proximal and distal convoluted tubules are parts of:
A. Nephron B. Seminiferous tubules C. Oviduct D. Vas deferens

118. Which of the following statement is correct?
A. The descending limb of loop of Henle is impermeable to water
B. The ascending limb of loop of Henle is permeable to water
C. The descending limb of Henle is permeable to electrolytes
D. The descending limb of loop of Henle is permeable to water

119. The part of nephron involved in active reabsorption of sodium is
A. Distal convoluted tubule C. Bowman's capsule
B. Proximal convoluted tubule D. Descending limb of Henle's loop

120. Removal of proximal convoluted tubule from the nephron will result in:
A. No change in quality and quantity of urine C. no urine formation
B. More dilute urine D. More concentrated urine

121. The maximum number of electrolytes (67%) and water (80%) is reabsorbed in which of part of the nephron?
A. Loop of Henle C. First coiled tubules
B. Second coiled tubules D. Collecting duct

122. Which of the following statements in regards to excretion by the human kidney is correct?
A. Descending limb of loop of Henle is impermeable to water
B. Distal convoluted tubule is incapable of reabsorbing HCO_3^-
C. Nearly 99 % of glomerular filtrate is reabsorbed by the renal tubules
D. Ascending limb of loop of Henle is impermeable to electrolytes

123. Glucose is taken back from glomerular filtrate through
A. Active transport B. Osmosis C. Passive transport D. Diffusion

124. Under normal condition which one is completely reabsorbed in the real tubule?
A. Urea B. Uric acid C. Salts D. Glucose

140.Reabsorption of useful substances from glomerular filtrate occur in
A. Collecting duct C. Loop of Henle

B. Proximal convoluted tubule D. Distal convoluted tubules

141.Concentration of urine depends up on which organ?

A. Bowman's capsule C. Length of Henle's loop

B. Proximal Tubules D. Networks capillaries arising from glomerulus

142.Which of the following would help in prevention of diuresis?

A. More water reabsorption due to under secretion of ADH

B. Reabsorption of Na+ and water from renal tubules due to aldosterone

C. Atrial natriuretic factor causes vasoconstriction

D. Decrease in secretion of renin

143.Which of the following causes an increase in sodium reabsorption in the distal convoluted tubule?

A. Increase in aldosterone level C. Decrease in aldosterone level

B. Increase in antidiuretic hormone level D. decrease in antidiuretic hormone level

144. If excess water passes out from the tissues without being restored by the Kidneys, the cells would

A. Burst open and die C. Takes water from the placenta

B. Not be affected at all D. Shrivel and die

145.Which of the following statement is correct when the water content of the blood is too high?

A. The brain produces more thyroxine stimulating hormone

B. The brain produces more anti diuretic hormone

C. The brain produces less amount of anti-diuretic hormone

D. The kidney reabsorbs more amount of water and produce concentrated urine

146.Which of the following is true about osmoregulation?

A. Insulin promotes hydrolysis of glycogen

B. Glucagon promotes hydrolysis of glycogen

C. Insulin stimulates the hydrolysis of glycogen

D. Glucagon stimulates the uptake of glucose by the body

147.Which of these conditions indicates positive feedback has occurred?

A. Blood pressure decreases greatly; blood flow to the heart is inadequate, and blood pressure decreases.

B. Hot temperatures increase your body temperature above normal: you sweat

C. Cold temperature decreases your body temperature below normal; you shiver

D. Blood pressure decreases; as a result, your heart rate increases

148.Human urine is usually acidic because

A. Potassium and sodium exchange generates acidity

B. Hydrogen ions are actively secreted into the filtrate

C. The sodium transporters exchange one hydrogen ion for each sodium ion in peritubular capillaries

D. Excreted plasma proteins are acidic

149.Which of the following is the correct path taken by urine in our body?

A. kidney → ureter → urethra → bladder C. kidney → bladder → urethra → ureter

B. kidney → ureter → bladder → urethra D. bladder → kidney → ureter → urethra

150.which of the following is not the function of insulin?

A. Increases conversion of glucose into glycogen

B. Increases the rate pf oxidation of glucose in the tissues

C. Regulates rate of amino acid catabolism

D. Increase the conversion of glycogen to glucose

ANSWER KEY FOR EXERCISE FIFTEEN ON HUMAN BODY SYSTEM

1.B	16.C	31.D	46.C	61.C	76.C	91.B	106.C	121.D	136.C
2.D	17.B	32.D	47.C	62.B	77.C	92.A	107.B	122.B	137.C
3.B	18.B	33.B	48.A	63.A	78.D	93.C	108.C	123.D	138.A
4.B	19.C	34.B	49.B	64.C	79.B	94.D	109.D	124.B	139.D
5.D	20.B	35.B	50.A	65.D	80.A	95.C	110.B	125.D	140.B
6.B	21.C	36.B	51.C	66.C	81.D	96.B	111.A	126.A	141.C
7.B	22.B	37.A	52.A	67.C	82.C	97.C	112.B	127.C	142.A
8.A	23.B	38.A	53.C	68.A	83.A	98.C	113.A	128.D	143.A
9.D	24.C	39.A	54.A	69.A	84.B	99.B	114.D	129.D	144.A
10.B	25.A	40.C	55.D	70.C	85.B	100.A	115.D	130.B	145.C
11.A	26.D	41.B	56.B	71.B	86.C	101.D	116.B	131.C	146.B
12.C	27.D	42.C	57.B	72.B	87.B	102.A	117.D	132.A	147.A
13.C	28.B	43.C	58.B	73.A	88.D	103.D	118.A	133.B	148.B
14.B	29.A	44.D	59.A	74.D	89.B	104.D	119.D	134.B	149.B
15.B	30.C	45.D	60.A	75.A	90.C	105.D	120.B	135.D	150.D

5.6. Human Musculoskeletal System

Learning competencies

- ♣ Explain the musculoskeletal systems
- ♣ List the muscle and skeletal systems the function musculoskeletal systems

What are the main components of the musculoskeletal system?

The musculoskeletal system consists of:

a. **Bones**: Provide structure, protection, and support for the body.
b. **Muscles**: Facilitate movement by contracting and relaxing.
c. **Joints**: Allow movement between bones.
d. **Ligaments**: Connect bones to other bones and provide stability.
e. **Tendons**: Connect muscles to bones and transmit the force from muscle contraction.
f. **Cartilage**: Provides cushioning and reduces friction in joints.

What are the functions of the musculoskeletal system?

The musculoskeletal system has several important functions:

- ✓ **Movement**: Muscles contract and pull on bones, allowing the body to move.
- ✓ **Support**: The bones provide a rigid framework that supports the body's structure.
- ✓ **Protection**: Bones protect vital organs (e.g., the skull protects the brain, ribs protect the heart and lungs).
- ✓ **Mineral Storage**: Bones store minerals like calcium and phosphorus.
- ✓ **Blood Cell Production**: Bone marrow produces red blood cells, white blood cells, and platelets.
- ✓ **Thermoregulation**: Muscles help maintain body temperature through shivering.
- ✓ **Stability**: Joints, ligaments, and muscles work together to stabilize the body and prevent injury.

How do the skeletal and muscular systems work together to enable movement?

- ✓ Bones: Act as levers for movement.
- ✓ Muscles: Attach to bones via tendons and contract to move the bones at the joints.
- ✓ Joints: Provide flexibility and allow movement between bones.
- ✓ Ligaments: Stabilize the joints, allowing for controlled movement.

What is the role of cartilage in the musculoskeletal system?

- ✓ Cushions joints, preventing bones from rubbing directly against each other.
- ✓ Provides flexibility and smooth movement in the joints (e.g., in the knee and elbow).
- ✓ Acts as a shock absorber to prevent damage to bones during movement.

How do ligaments and tendons differ in function?

- ✓ **Ligaments**: Connect bones to bones, providing stability to joints and limiting excessive movement.

- ✓ **Tendons:** Connect muscles to bones, transmitting the force generated by muscles to move the bones.

Types of Muscle

The human body has three main types of muscles, each with distinct functions and structures (Fig.8).

These muscles are essential for movement, posture, and other bodily functions. These are

I. Skeletal Muscle

- ✓ Skeletal muscles are bundles of muscle fibers with single large cells formed by the fusion of many individual cells during development
- ✓ Are Striated and multinucleated.
- ✓ Responsible for voluntary movements of the body, such as walking, running, and lifting.
- ✓ Skeletal muscles are attached to bones by tendons and help in posture and balance.
- ✓ Its fibers are innervated by a single motor axon are called a motor unit.
- ✓ **Example**: Biceps, quadriceps, hamstrings.

II. Cardiac Muscle

- ✓ Striated, involuntary control, single nucleus per cell, connected by intercalated discs.
- ✓ Found only in the heart, cardiac muscle is responsible for the involuntary contraction of the heart to pump blood throughout the body. **Example**: Heart muscle (myocardium).

III. Smooth Muscle

- ✓ Non-striated (smooth appearance), involuntary control, single nucleus per cell.
- ✓ Smooth muscle controls involuntary movements in various organs and structures like the digestive tract, blood vessels, and the bladder.
- ✓ It helps to move food through the digestive system, regulate blood flow, and expel waste.

Example: Walls of blood vessels, stomach, intestines, bladder.

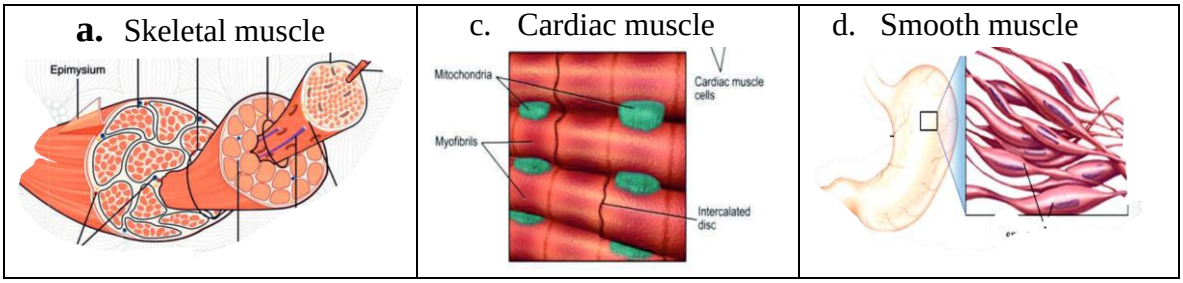


Figure 12. Types of musculoskeletal system in human

EXAMPLES OF REVIEW EXERCISE

1. Which of the following is NOT part of the musculoskeletal system?

A. Bones
C. Ligaments
B. Muscles
D. Heart

❖ **Explanation:** The heart is part of the circulatory system, not the musculoskeletal system.

2. If a person has a joint injury, which part of the musculoskeletal system is most likely affected?
   A. Muscle fibers
   C. Ligament or cartilage
   B. Bone structure
   D. Tendons

❖ **Explanation:** Joint injuries often involve damage to ligaments or cartilage, which connect and cushion joints.

3. Which of the following is a major function of bones in the musculoskeletal system?
   A. Producing red blood cells
   C. Producing insulin
   B. Regulating blood pressure
   D. Absorbing nutrients

❖ **Explanation:** Bones, specifically bone marrow, produce red blood cells, which is one of their major functions.

4. How do skeletal muscles help in movement?
   A. By contracting to pull on bones, causing movement at joints
   B. By secreting hormones that trigger joint movement
   C. By forming a rigid structure that prevents movement
   D. By relaxing and reducing bone length

❖ **Explanation:** Skeletal muscles contract and pull-on bones, creating movement at the joints.

5. If a person has a fractured femur, which part of the musculoskeletal system will most directly be affected?
   A. Heart
   C. Femur bone
   B. Femoral muscle
   D. Nervous system

❖ **Explanation:** A fractured femur directly affects the femur bone in the skeletal system.

6. If a person has a weak musculoskeletal system due to aging, what is the most likely outcome?
   A. Reduced bone density and muscle strength, leading to difficulty in movement
   B. Increase in flexibility and joint movement
   C. Strengthened bones and ligaments
   D. Enhanced muscle coordination

❖ **Explanation:** As people age, bones can lose density, and muscles weaken, leading to difficulty moving and increased risk of fractures.

Mechanism of actions of skeletal muscles

The **mechanism of action of skeletal muscles** involves the process by which muscles contract to produce movement.

- A motor neuron sends an electrical signal (action potential) to a muscle fiber at the **neuromuscular junction**. The neurotransmitter **acetylcholine** is released from the neuron and binds to receptors on the muscle cell membrane (sarcolemma), initiating an action potential in the muscle.
- The action potential travels down the **T-tubules**, which are extensions of the muscle cell membrane, to the **sarcoplasmic reticulum (SR)**, an organelle that stores calcium. The action potential causes the SR to release calcium ions (Ca^{2+}) into the cytoplasm of the muscle cell.

- Calcium ions bind to **troponin**, a protein attached to the **actin filaments**. This binding causes a conformational change in **tropomyosin**, another protein that blocks the active sites on actin. With the active sites exposed, the **myosin heads** (part of the thick filaments) bind to actin, forming **cross-bridges**.
- Once the myosin heads are attached to actin, they pivot and pull the actin filaments toward the center of the sarcomere, a process called the **power stroke**. This sliding of actin and myosin filaments shortens the muscle fiber, causing contraction.
- After the signal stops, calcium ions are pumped back into the SR. Without calcium, troponin and tropomyosin block the actin's active sites, preventing further cross-bridge formation. The muscle relaxes, and the actin and myosin filaments slide back to their resting positions.

Three types of muscle contraction

- **Isometric Contraction**: The muscle generates force without changing its length (e.g., holding a plank position).
- **Concentric Contraction**: The muscle shortens as it contracts, generating force to move a load (e.g., lifting a weight).
- **Eccentric Contraction**: The muscle lengthens while still generating force, often when controlling the lowering of a load (e.g., slowly lowering a weight after lifting).

The human axial and appendicular skeletons

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 four different types of bones in the human body:

i. Long bones have long and thin shapes.
ii. Short bones have squat and cubed shapes.
iii. Flat bones have flattened and broad surfaces.
iv. Irregular bones have shapes that do not conform to the above three types.
v. Sesamoid bones are small, flat bones and are shaped similarly to a sesame seed

Types of joints

1. **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).
2. **Hinge joints:** like a door, a joints that opens and closes in one direction along one plane only (elbow and knee joints).
3. **Condyloid joints**: joints that do not rotate but allow movements (finger and jaw).
4. **Pivot joints** are rotary or trochoid joints in which one bone swivels in a ring (ulna, radius, and neck).

5. **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)

The **human skeleton** is divided into two main parts:

A. **Axial Skeleton**:
- Comprises the bones that form the central axis of the body, providing support and protection.
- Includes the **skull**, **vertebral column** (spine), **rib cage**, and **sternum**.
- Protects vital organs such as the brain, heart, and lungs.

B. **Appendicular Skeleton**:
- Consists of the bones of the **limbs** and the **girdles** (shoulder and pelvic girdles) that attach limbs to the axial skeleton.
- Includes the **arms**, **legs**, **pelvic bones**, and **shoulder blades**.
- Facilitates movement and provides support for locomotion and manipulation of objects.

5.7. The reproductive system

Learning competencies

- Describe female and male reproductive systems
- Explain gametogenesis
- Explain menstrual cycle and list types contraceptive mechanisms and uses
- Describe infertilities in males and Females
- Explain the spread, prevention or treatments methods of STIS/ HIV

Structures and Functions of the Male and Female Reproductive Systems

Male Reproductive System:

- ✓ Composed of the testes, epididymis, vas deferens, prostate gland, seminal vesicles, and penis.
- ✓ The testes produce s**perm** and **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 and carries urine from the bladder to the exterior of the body

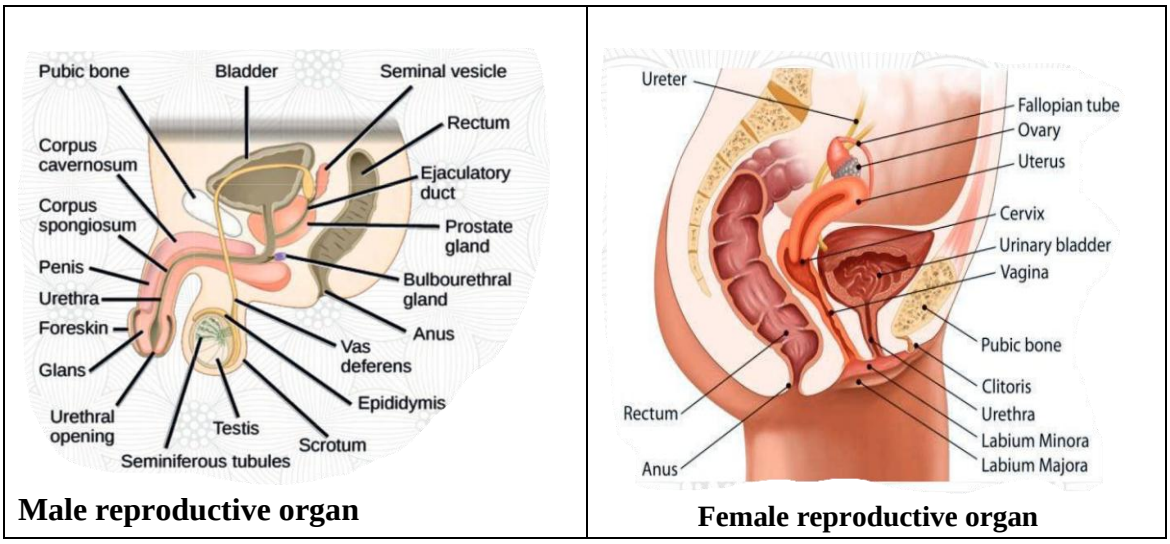


Figure 13. Reproductive structure of male and Female

The **female reproductive system** consists of internal and external structures that facilitate reproduction.

1. **Ovaries**: Produce eggs (ova) and hormones like estrogen and progesterone.
2. **Fallopian Tubes**: Transport eggs from the ovaries to the uterus. Fertilization typically occurs here.
3. **Uterus**: A muscular organ where a fertilized egg implants and develops into a fetus during pregnancy.
4. **Cervix**: The lower part of the uterus that opens into the vagina, allowing passage of menstrual blood, sperm, and during childbirth, the baby.
5. **Vagina**: A muscular canal that serves as the passage for menstrual flow, sexual intercourse, and childbirth.

Phases of the menstrual cycle

The menstrual cycle consists of four phases, typically lasting about 28 days:

1. Menstrual Phase: The shedding of the uterine lining (endometrium), resulting in menstrual bleeding. This phase lasts 3-7 days.
2. Follicular Phase: Begins after menstruation, where follicle-stimulating hormone (FSH) promotes the growth of follicles in the ovaries. One follicle becomes dominant, and the ovaries produce estrogen, thickening the uterine lining in preparation for pregnancy.
3. Ovulation: Triggered by a surge in luteinizing hormone (LH), the mature egg is released from the dominant follicle and travels down the fallopian tube, ready for fertilization.
4. Luteal Phase: After ovulation, the ruptured follicle becomes the corpus luteum, which secretes progesterone to maintain the uterine lining. If pregnancy does not occur, the corpus luteum breaks down, and hormone levels drop, leading to the start of a new cycle

Mechanism of action of contraceptives

- Contraceptives can be categorized based on their **mechanism of action** into **barrier** and **non-barrier** methods:

1. Barrier Contraceptives

- These methods **physically block sperm** from reaching the egg, preventing fertilization.
- **Male Condoms** – Prevent sperm from entering the vagina.
- **Female Condoms** – Act as a barrier inside the vagina.
- **Diaphragms & Cervical Caps** – Cover the cervix to block sperm entry.
- **Spermicides** – Chemicals that kill sperm or immobilize them.

2. Non-Barrier Contraceptives

- These methods work by **hormonal or physiological changes** that prevent ovulation, fertilization, or implantation.
- **Hormonal Methods (Pills, Patches, Implants, Injections)** – Suppress ovulation, thicken cervical mucus, and thin the uterine lining.
- **Intrauterine Devices (IUDs)**
- **Hormonal IUDs** – Release **progestin** to prevent ovulation and implantation.
- **Copper IUDs** – Create a hostile environment for sperm.
- **Emergency Contraceptives (Morning-After Pill, Copper IUD)** – Delay ovulation or prevent implantation.
- **Sterilization (Tubal Ligation, Vasectomy)** – Permanently blocks egg or sperm transport.

Causes of Infertility in Humans

Male Infertility

- ✓ Low sperm count or poor sperm quality due to factors like:
- ✓ Varicocele (enlarged veins in the scrotum).
- ✓ Hormonal imbalances.
- ✓ Genetic disorders (e.g., Klinefelter syndrome).
- ✓ Infections (e.g., mumps, sexually transmitted infections).
- ✓ Lifestyle factors (e.g., smoking, alcohol, stress, obesity, drug use).
- ✓ Obstructions (e.g., blocked vas deferens).

Female Infertility

- ✓ Ovulatory disorders: Problems with ovulation, like Polycystic Ovary Syndrome (PCOS).
- ✓ Fallopian tube blockages due to infections or endometriosis (growths in the womb lining the endometrium block the ovaries)

- ✓ Uterine problems (e.g., fibroids-non cancerous growth in or around the womb and scarring).
- ✓ Hormonal imbalances affecting egg production.
- ✓ Thyroid problems
- ✓ Age: Fertility declines with age, particularly after 35.
- ✓ Lifestyle factors (e.g., Medicine, drugs, smoking, stress, excessive weight, poor diet).
- ✓ Cervical mucus problems: harder mucus does not let sperms to swim into vagina.

The major sexually transmitted infections (STIs) in Ethiopia

The major causative agents or pathogens, are bacteria, viruses, and parasites.

Bacterial infection disease: bacterial vaginosis, Chlamydia, Syphilis, Gonorrhea, Chancroid

Viral infections diseases: Genital herpes (Human Simplex Virus 1 and HSV2), Genital warts caused by the human papillomavirus (HPV), Molluscum contagiosum, HIV, Hepatitis B.

Parasitic disease: trichomoniasis, pubic lice (Crabs), Scabie

EXAMPLES OF REVIEW EXERCISE

1. Which of the following describes the role of negative feedback in the menstrual cycle?
   A. It prevents the release of eggs during the luteal phase.
   B. It helps maintain stable levels of estrogen and progesterone during the cycle.
   C. It triggers the release of the egg from the ovary.
   D. It increases the secretion of luteinizing hormone (LH) during ovulation.

Explanation: Negative feedback helps maintain hormonal balance by regulating the levels of estrogen and progesterone to avoid excessive secretion.

2. What hormone prevents menstruation during pregnancy?
   A. Estrogen
   B. Progesterone
   C. Luteinizing hormone (LH)
   D. Follicle-stimulating hormone (FSH)

   Explanation: Progesterone is produced during pregnancy to maintain the uterine lining and prevent menstruation from occurring.

2. Which of the following is the role of FSH in the menstrual cycle?
   A. It stimulates ovulation.
   B. It helps in the maturation of follicles in the ovaries.

C. It promotes the thickening of the uterine lining.

D. It triggers the release of progesterone.

Explanation: FSH (Follicle-Stimulating Hormone) stimulates the growth and maturation of ovarian follicles, which produce eggs.

3. How does an increase in LH lead to ovulation?
   A. It promotes the thickening of the endometrium.
   B. It triggers the release of the mature egg from the ovary.
   C. It suppresses the secretion of estrogen.
   D. It maintains the uterine lining throughout pregnancy.

Explanation: A surge in LH triggers ovulation, causing the mature egg to be released from the follicle in the ovary.

4. Which of the following is the correct order of phases in the menstrual cycle?
   A. Follicular phase, Ovulation, Luteal phase, Menstrual phase
   B. Ovulation, Luteal phase, Menstrual phase, Follicular phase
   C. Luteal phase, Menstrual phase, Follicular phase, Ovulation
   D. Menstrual phase, Follicular phase, Ovulation, Luteal phase

Explanation: The correct order of the menstrual cycle phases is: Menstrual phase, Follicular phase, Ovulation, Luteal phase.

5. Which of the following best defines menarche?
   A. The cessation of menstrual periods in women.
   B. The first occurrence of menstruation in a female's life.
   C. The end of ovulation in females.
   D. The age at which women experience menopause.

Explanation: Menarche is the term for a female's first menstrual period, marking the start of reproductive capability.

6. What is the primary difference between menarche and menopause?
   A. Menarche is when a woman stops menstruating, and menopause is when menstruation begins.
   B. Menarche marks the first menstruation, while menopause marks the end of menstruation.
   C. Menarche and menopause both occur at the same time in a woman’s life.

D. Menarche happens after menopause, marking the return of menstruation.

Explanation: Menarche is the first menstrual period, and menopause is the natural cessation of menstruation and fertility in women, typically occurring later in life.

7. What is the function of the ovaries in the female reproductive system?

A. To produce sperm
B. To produce eggs and hormones
C. To house the fetus during pregnancy
D. To transport eggs to the uterus

8. Which structure is responsible for carrying sperm from the testes to the urethra in males?

A. Urethra
B. Seminal vesicle
C. Vas deferens
D. Epididymis

Explanation: The vas deferens is the tube that carries sperm from the testes to the urethra.

9. In which part of the female reproductive system does fertilization most commonly occur?

A. Ovaries
B. Uterus
C. Fallopian tubes
D. Cervix

Explanation: Fertilization usually takes place in the fallopian tubes when sperm meets an egg.

10. If the male reproductive system is unable to produce sperm, which part of the system would likely be malfunctioning?

A. Vas deferens
B. Seminal vesicles
C. Testes
D. Prostate gland

Explanation: The testes are responsible for producing sperm. A malfunction in the testes could prevent sperm production.

11. Why is it important to get tested regularly for STIs?

A. To prevent the spread of infections and ensure early treatment
B. To increase the number of sexual partners
C. To avoid using contraceptives
D. To prevent pregnancy

Explanation: Regular testing helps detect STIs early, which can prevent complications and transmission to others.

12. A couple wants to reduce their risk of contracting HIV. What is the best course of action?

A. Practice unprotected sex with multiple partners
B. Limit sexual activity to a single partner and use condoms consistently
C. Use recreational drugs while engaging in sexual activity
D. Have sex only when neither partner feels ill

Explanation: Limiting sexual partners and consistently using condoms are key strategies in reducing the risk of HIV transmission.

13. How do hormonal contraceptives like birth control pills prevent pregnancy?

A. By blocking the sperm from entering the uterus

B. By altering hormone levels to prevent ovulation

C. By increasing the number of eggs released by the ovaries

D. By killing sperm

Explanation: Hormonal contraceptives prevent ovulation, making it impossible for the egg to be fertilized.

14. A couple chooses the withdrawal method (coitus interruptus) for family planning. What is a potential risk of this method?

A. High risk of pregnancy

B. High cost and difficulty in use

C. Risk of STI transmission

D. Unreliable for long-term use

Explanation: The withdrawal method is considered unreliable, with a high risk of pregnancy due to pre-ejaculatory fluid and timing issues.

13. If a woman forgets to take her birth control pill for a few days, what is the most likely outcome?

A. Increased risk of pregnancy

B. Increased effectiveness of the pill

C. Immediate protection from pregnancy

D. No effect on the pill's efficacy

Explanation: Missing birth control pills increases the risk of pregnancy because hormone levels may not be maintained effectively.

14. How does cannabis use affect the reproductive system?

A. Enhances fertility in both males and females

B. Can reduce sperm count and disrupt menstrual cycles

C. Improves hormone levels

D. Has no effect on the reproductive system

Explanation: Cannabis can disrupt reproductive health by lowering sperm count in males and affecting menstrual cycles in females.

15. What is the primary function of the female uterus?

A. To produce eggs

B. To house and nourish a developing fetus

C. To secrete hormones

D. To transport eggs from the ovaries

Explanation: The uterus is where a fertilized egg implants and develops into a fetus during pregnancy.

16. Which of the following is a method to prevent the transmission of HIV?

A. Regular physical exercise
C. Eating a healthy diet
B. Use of condoms during sexual activity
D. Reducing alcohol consumption

Explanation: Condoms provide a barrier that reduces the risk of HIV transmission during sexual activity.

17. If a person is at high risk for HIV, which of the following would be recommended?

A. Getting tested for HIV regularly
C. Not using any form of contraception
B. Avoiding sexual activity altogether
D. Avoiding health check-up

Explanation: Regular testing helps detect HIV early, which can help in prevention and management.

18. Which of the following is a temporary contraceptive method?

A. Vasectomy
C. Tubal ligation
B. Intrauterine device (IUD)
D. Birth control pills

Explanation: Birth control pills are a reversible, temporary contraceptive method.

19. Which of the following is a consequence of chronic alcohol use on the musculoskeletal system?

A. Increased muscle strength
C. Improved coordination
B. Reduced bone density
D. Increased joint flexibility

Explanation: Chronic alcohol use can lead to a reduction in bone density, making bones more fragile.

SELF TEST EXERCISE ON HUMAN BODY SYSTEM

Choose the correct answer for the following questions

1. Why is the left ventricle of the heart thicker than the right ventricle?
   A. It pumps blood to the lungs at a higher pressure
   B. It pumps blood to the entire body, requiring more force
   C. It pumps blood only to the brain and arms
   D. It stores blood before sending it to the body
2. How do the structural differences between the small intestine and the large intestine reflect their respective functions?

A. The large intestine has more villi than the small intestine for increased absorption
B. The small intestine has a larger surface area due to villi for nutrient absorption
C. The small intestine is longer than the large intestine because it stores waste
D. The large intestine has digestive enzymes while the small intestine absorbs water

3. If you were to design an experiment to observe how neurons transmit electrical signals, which method would be most appropriate?
   A. Measure the rate of blood flow in the brain during a task
   B. Observe changes in muscle contractions after nerve stimulation
   C. Track the firing patterns of neurons using electrodes
   D. Compare levels of neurotransmitters in different brain regions
4. A community program advocates for safe sex practices, including condom use. What is the expected outcome of this program?
   A. Increased HIV transmission rate
   B. Decrease in unwanted pregnancies
   C. Decrease in the spread of STIs
   D. No change in sexual behaviors
5. How does the structure of the femur support its function in the body?
   A. The femur is made up of a flexible material to absorb shock
   B. The femur is hollow inside to reduce weight while maintaining strength
   C. The femur is rigid to allow for movement at the hip and knee joints
   D. The femur has multiple layers to protect the body from injury
6. Which of the following scenarios best illustrates the role of the musculoskeletal system?
   A. A person runs, and their legs move due to muscle contractions and joint movement
   B. A person breathes due to lung expansion and contraction
   C. A person digests food with the help of enzymes
   D. A person senses hot objects with their skin
7. Why is it important for the endocrine system to use hormones to communicate with distant organs, rather than relying only on the nervous system?
   A. Hormones can travel more quickly than electrical impulses in the nervous system
   B. Hormones enable the body to respond to stimuli without direct nerve connections
   C. Hormones allow long-term regulation, while nerves only control short-term responses
   D. Hormones are faster and more precise in reaching their target organs
8. If you were studying how sperm cells affect fertilization, which of the following would be the most effective approach to investigate the process?

A. Observe sperm cells under a microscope to note their motility

B. Inject sperm into an egg cell and observe fertilization under controlled conditions

C. Compare the structure of sperm cells from different species

D. Measure the size of sperm cells in various environmental conditions

9. A woman who uses khat regularly may experience menstrual irregularities. What is a possible reason for this?
   A. Khat stimulates hormonal balance
   B. Khat interferes with normal hormone production
   C. Khat improves reproductive health
   D. Khat has no effect on the menstrual cycle
10. What could be the consequence of a blockage in the coronary arteries?

    A. The heart will pump less blood to the lungs

    B. The heart will pump more blood to the brain

    C. The heart muscle may be deprived of oxygen, leading to a heart attack

    D. The heart will increase its output to compensate for the blockage

11. What is the role of bile in the digestive system, and how does its structure aid in its function?

    A. Bile neutralizes stomach acid, preventing damage to the small intestine

    B. Bile emulsifies fats, increasing surface area for digestion by enzymes

    C. Bile helps in the absorption of carbohydrates from the small intestine

    D. Bile provides enzymes that break down proteins in the stomach

12. To investigate how the brain processes sensory information, which part of the nervous system should be the focus of your experiment?

    A. The spinal cord, as it relays signals between the brain and the body

    B. The sensory organs, as they detect environmental stimuli

    C. The cerebrum, as it processes sensory input and integrates it with motor responses

    D. The autonomic nervous system, as it regulates unconscious bodily functions

13. What is the advantage of having a flexible ribcage instead of a rigid one?

    A. It allows the ribcage to expand during breathing

    B. It makes the ribs less prone to breakage in case of injury

    C. It allows the heart to pump more blood to the lungs

    D. It provides better support for muscle movement

14. How does the structure of red blood cells relate to their function in oxygen transport?

    A. The biconcave shape increases surface area for efficient oxygen diffusion

B. The spherical shape allows red blood cells to carry more hemoglobin

C. The large nucleus in red blood cells enables them to process oxygen more efficiently

D. The absence of a nucleus allows more room for oxygen but decreases flexibility

15. Why do digestive enzymes function best at specific pH levels?

A. The enzymes denature at temperatures that are too high or low

B. The enzymes change shape to fit their substrates more effectively at certain pH levels

C. The body maintains a neutral pH in the digestive tract to ensure enzyme function

D. The enzymes work best when they are not affected by acid or alkaline conditions

16. To study how neurotransmitters affect mood and behavior, which of the following would be the most appropriate experimental setup?

A. Monitor hormone levels during different stages of the menstrual cycle

B. Inject a subject with different neurotransmitters and observe their behavior

C. Observe a subject's reactions to external stimuli without any chemical interference

D. Compare the effects of diet on mood changes in individuals

17. If an individual tests positive for HIV, which of the following is the most important step to take?

A. Discontinue safe sex practices

B. Seek medical advice and begin antiretroviral therapy

C. Stop using condoms altogether

D. Ignore the diagnosis and continue normal activities

18. How do bones and muscles work together to facilitate movement?

A. Bones act as levers, while muscles provide the force to move them

B. Bones provide the energy for muscles to contract

C. Muscles act as levers, while bones provide the force for movement

D. Muscles and bones do not interact in movement

19. Why is feedback regulation important in the endocrine system?

A. It ensures that hormone levels remain balanced within the body

B. It allows the body to increase hormone levels uncontrollably

C. It helps enzymes in the endocrine system break down excess hormones

D. It prevents the release of all hormones during stressful situations

20. Why is the production of progesterone crucial for maintaining pregnancy?

A. It stimulates the release of eggs from the ovaries.
B. It promotes the shedding of the uterine lining.
C. It prevents the uterus from contracting and supports fetal development.
D. It decreases the release of luteinizing hormone (LH).

21. What is the role of the hypothalamus in regulating the reproductive system?
A. It releases hormones that directly stimulate gamete production in the ovaries and testes
B. It synthesizes sperm and eggs for reproduction
C. It monitors the levels of estrogen and testosterone in the bloodstream
D. It controls the release of hormones from the pituitary gland that regulate reproduction

22. To study the effects of exercise on heart rate, which experimental setup would be most useful?
A. Measure the heart rate of participants at rest and after various levels of exercise
B. Observe the changes in blood pressure without exercise intervention
C. Study the relationship between exercise and body temperature
D. Measure the heart rate of individuals under conditions of extreme stress

23. Why is the villi in the small intestine essential for nutrient absorption?
A. Villi increase surface area for the absorption of nutrients
B. Villi contain digestive enzymes that break down proteins and fats
C. Villi produce hormones that regulate digestion
D. Villi remove toxins from the body during digestion

24. How does the process of synaptic transmission contribute to communication between neurons?
A. It allows electrical signals to jump across the synaptic gap to the next neuron
B. It releases neurotransmitters into the synaptic gap to pass signals between neurons
C. It generates electrical impulses that travel through the axons
D. It is responsible for the regeneration of damaged neurons

25. To investigate how exercise affects bone density, which experiment would you design?
A. Measure the increase in bone mineral content of individuals before and after a consistent exercise regimen
B. Monitor the activity of osteoblasts in bone marrow during exercise
C. Compare the levels of calcium in the blood before and after exercise
D. Study the flexibility of bones in response to different exercise types

26. Which of the following is a permanent method of contraception?

A. Birth control pills
B. Condom use
C. Tubal ligation
D. Intrauterine device (IUD)

27. How does cannabis use affect the male reproductive system?
A. Increases sperm count
B. Increases testosterone levels
C. Reduces sperm count and motility
D. Has no effect on sperm production

28. How do tendons contribute to the musculoskeletal system?
A. They store energy for muscle contraction
B. They connect muscles to bones
C. They produce red blood cells
D. They act as lubricants for joints

29. During which phase is the uterine lining thickening in preparation for a possible pregnancy?
A. Follicular phase
B. Ovulation phase
C. Luteal phase
D. Menstrual phase

30. How does positive feedback contribute to the release of an egg during ovulation?
A. It stimulates the release of FSH to inhibit egg release.
B. It causes a surge in LH, which triggers ovulation.
C. It decreases estrogen levels to promote uterine lining thickening.
D. It prevents FSH secretion during ovulation.

Answer key for Self-test exercise

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

THEME 6. Ecology, Environment, and Climate change

6.1. Ecological interaction

Learning Competencies

- Define ecology
- Define environment
- Define ecosystem and list its biotic and abiotic components
- Explain food relationship (food chain and web) in diagram
- Explain pyramids of biomass using diagrams.
- Explain pyramids of energy using diagrams.
- Define climate change
- Explore the key scientific concepts of climate change.
- Analyze the causes of climate change and how human activities affect the climate.
- Discuss the effects of climate change on living things

Introduction

Ecological interactions are relationships between organisms in an ecosystem that shape population dynamics, species distribution, and biodiversity. These interactions include competition, predation, mutualism, commensalism, parasitism, and amensalism, and can be positive, negative, or neutral. Understanding these interactions is crucial for ecosystem management and conservation. They help scientists understand species coexistence, energy flow, and the effects of disturbances. Examples include competition for resources, mutualism like bees and flowers, and parasitism like ticks on mammals.

Ecology is the branch of biology that studies how organisms interact with their environment and other organism. The environment refers to the surroundings in which organisms live, including both living (biotic) and non-living (abiotic) elements. An ecosystem is a complex network where organisms interact with each other and their physical surroundings, with biotic components (plants, animals,

microorganisms) and abiotic components (water, soil, air, temperature, sunlight) forming the foundation of ecological processes.

Food relationships in ecosystems are illustrated through food chains and food webs, showing how energy flows from producers to consumers and decomposers, typically represented in diagrams. The pyramids of biomass and energy are graphical tools that demonstrate the distribution of biomass and energy across trophic levels, with energy decreasing as it moves up the pyramid.

The concept of climate change is introduced as a long-term alteration of temperature and typical weather patterns. The key scientific principles of climate change explore the Earth's atmosphere, greenhouse gases, and global warming. The causes of climate change are analyzed, emphasizing human activities such as fossil fuel burning, deforestation, and industrial emissions, which contribute significantly to the rise in global temperatures. Finally, the effects of climate change on living organisms are explored, showing its impact on biodiversity, species migration, ecosystems, agriculture, and human health, underlining the urgent need for mitigation and adaptation strategies.

An important focus for ecologists is to improve the understanding of how biodiversity affects ecological function. Ecologists seek to explain:

- ✓ Life processes, interactions, and adaptations
- ✓ The movement of materials and energy through living communities
- ✓ The successional development of ecosystems
- ✓ The abundance and distribution of organisms and biodiversity in the context of the environment.

What is environment?

- ✓ Is the circumstance, objects or condition by which one is surrounded.
- ✓ Is the complex of physical, chemical and biotic factors such as climate, soil, and living things that act up on an organism or an ecological community and ultimately determine its form and survival.

Levels of ecological organization (from smallest to largest):

Species→ Population → community → ecosystem → biomes →Biosphere

Species – group of similar organisms that breed and produce fertile offspring.

Population – group of individuals that belong to the same species and live in the same area.

Community – different populations living together in a defined area.

Ecosystem – all the organisms that live in a place together with their physical environment.

Biome – group of ecosystems that share similar climates and typical organisms.

Biosphere – all life on Earth and all parts of Earth in which life exists

6.2. Ecosystem

- ✓ An **ecosystem** is a dynamic community of living organisms (plants, animals, microorganisms) interacting with each other and their physical environment (air, water, soil, climate) in a specific area. It involves both biotic (living) and abiotic (non-living) components that interact and influence the functioning of the ecosystem.

Abiotic components

The abiotic components or factors are the non-living elements of an ecosystem. The climate and weather produce several important abiotic components. They include:

- ❖ The amount of sunlight and the amount of rainfall and Temperature
- ❖ Type of soil and rocks, the drainage of the soil and the pH (acidity).
- ❖ The levels of oxygen dissolved in aquatic ecosystem are an important abiotic factor as many animals cannot survive in low oxygen concentrations.
- ❖ The level of wind is also an important abiotic component of an ecosystem – too much wind can make life very difficult for living organisms.

Biotic components

The biotic components are the living organisms within an ecosystem which affect the ability of an organism to survive there. Examples are:

- ❖ The number of predators in an ecosystem is one biotic component that has a big effect on the numbers of other organisms in the area.
- ❖ The amount of food available is another important biotic
- ❖ Biotic components of an ecosystem also include the numbers of parasites and diseases.
- ❖ The final biotic component which has a big effect on ecosystems is competition. There can be:
    - ✓ **Interspecific competition** is competition between different species all trying to get the same food

- ✓ **Intraspecific competition** is competition between members of the same species for the best mate, the best nest site or the most sunlight

Food relationships

- ✓ The way in which living things are linked to each other and to plants can be described by looking at food chains.

Food chains

- ❖ The first stage of the chain involves converting light energy from the sun into stored chemical energy in plants by photosynthesis. This is always done by plants which are known as **producers**. Then all of the animals that eat plants or other animals are known as **consumers.**
- ❖ **Heterotrophs** – organism that cannot make their own food; acquire energy from other organisms by ingesting them.
- ❖ **Consumers** – organisms that rely on other organisms for energy and nutrients.
- ❖ **Carnivores** – kill and eat other animals.
- ❖ **Scavengers** – consume the carcasses of dead animals.
- ❖ **Decomposers** – chemically break down organic matter (bacteria and fungi
- ❖ **Herbivores** – eat plants.
- ❖ **Omnivores** – diets include both plant and animal matter.
- ❖ **Detritivores** – feed on detritus (small pieces of decaying matter) by grinding them into smaller pieces (earthworms and snails are examples). Often digest the decomposers living on the detritus.

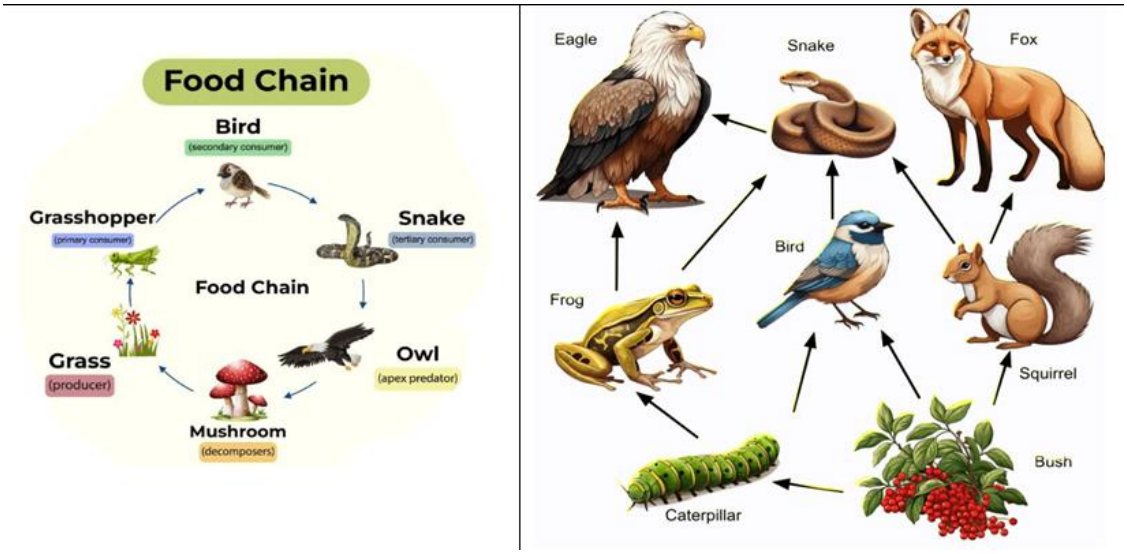


Figure 14. food chain and food web

Food Web

- ❖ Is the totality of interacting food chains in an ecological community.
- ❖ Food chains are very simple, but in real life things are much more complex. Grass is eaten by insects, by rodents and by many large herbivores. Antelope may be prey for lions, leopards or hyenas. This is an example of food webs
- ✓ **Biomass** is a term that describes all the organic material produced by living organisms. It all comes originally from plants as they photosynthesize at the beginning of all food chains
- ✓ biomass is then passed on through a food chain or web into the animals which eat the plants and then on into the animals which eat other animals. However long the food chain, the original source of all the energy and hence the biomass involved is the sun. When you look at a food chain, there are usually more producers than primary consumers, and more primary consumers than secondary consumers. This can be shown as a **pyramid of numbers.**
- ✓ In food relationship, there is pyramid of number, biomass and energy

Pyramid of numbers

- ✓ It does not accurately reflect what is happening.
- ✓ Mostly decrease from producer to the last trophic level

Pyramid of biomass

- ✓ Is the mass of living material in an animal or plant
- ✓ It is always decreasing in up right because: the whole organism at one stage is not eaten by the stage above. When an herbivore eats a plant, it turns some of the plant material into new herbivore. large amount of plant biomass supports a smaller amount of herbivore biomass which in turn supports an even smaller amount of carnivore biomass. This is why tropic level not exceed five stages.

Pyramid of energy

- ✓ represents the energy in the producers and how much of that energy is passed on at each stage along the food chain.
- ✓ Is known as a trophic or ecological pyramid, is **a graphical representation of the energy found within the trophic levels of an ecosystem**.
- ✓ The bottom and largest level of the pyramid is the producers and contains the largest amount of energy.
- ✓ pyramids of energy are very difficult to measure so practically we usually use biomass
- ✓ On average only 10 percent of energy available at one trophic level is passed on to the next.

6.3. Population and natural resources

Population ecology

Population Ecology is the study of how populations of organisms interact with their environment and how factors influence population size and structure over time.

1. **Population**: A population refers to a group of individuals of the same species that live in a specific area and can interbreed.
    - **Population Size**: The total number of individuals in a population.
    - **Population Density**: The number of individuals per unit area or volume.
2. **Population Study Mechanisms**: This includes understanding the mechanisms that affect the growth, survival, and reproduction of individuals in a population, such as environmental factors, food availability, predation, and disease.

3. **Carrying Capacity**: The maximum population size that the environment can support indefinitely without degrading the habitat. It is determined by resources available (food, water, shelter) and other limiting factors.
4. **Exponential vs. Logistic Growth**:
    - **Exponential Growth** occurs when resources are unlimited, leading to a rapid increase in population size. The growth curve forms a J-shape.
    - **Logistic Growth** occurs when resources become limited, and the population growth slows and stabilizes around the carrying capacity, forming an S-shaped curve.
5. **Population Growth Models**:
    - **Exponential Model**: Represents unrestricted growth, where the population grows exponentially with no limit.
    - **Logistic Model**: Represents growth with a carrying capacity where growth rate slows down as resources become limited.
6. **Regulating Population Growth**: Populations are regulated by various factors, both biotic and abiotic. Strategies such as migration, predation, disease, and resource availability regulate population size.
    - **Density-dependent Regulation**: Factors that influence population growth depending on population density, such as competition, predation, and disease. The greater the population, the stronger the effect of these factors.
    - **Density-independent Regulation**: Factors that affect population growth regardless of its density, such as natural disasters (e.g., floods, fires, droughts).
7. **Effects of Population Growth on Living Conditions**: Rapid population growth can strain resources, lead to habitat destruction, increase competition, and cause environmental degradation. Conversely, slow or controlled population growth can lead to better living conditions, more resources per individual, and environmental sustainability.

Summary

- ✓ **Exponential Growth of population**: Describes the rapid increase in a population size when resources are abundant, typically under ideal conditions. It follows a J-shaped curve, where the population grows at a constant rate over time (e.g., bacteria in a controlled lab environment) and **Logistic Growth**: Accounts for environmental limits and the carrying

capacity of an ecosystem. It follows an S-shaped curve where population growth slows as the population size approaches the carrying capacity, balancing out as resources become limited (e.g., herbivores in a forest).

- ✓ Population growth can be regulated by **biotic factors** (like competition, predation, and disease) and **abiotic factors** (such as temperature and availability of resources). Communities also regulate growth through **social or ecological structures**, like territoriality or cooperative behaviors, that limit overpopulation.
- ✓ **Natural Resources**: These are raw materials from nature used by humans, such as water, minerals, air, soil, forests, and wildlife. They can be renewable (e.g., sunlight, wind, forests) or non-renewable (e.g., fossil fuels, minerals). **Conservation**: The responsible management of natural resources to prevent depletion or degradation, ensuring their availability for future generations. Conservation practices include habitat protection, sustainable use, and restoration of ecosystems.
- ✓ Human activities, such as deforestation, industrialization, urbanization, pollution, and overhunting, can lead to habitat destruction, species extinction, climate change, and the loss of biodiversity. These activities disrupt the natural balance and threaten ecosystems' ability to sustain populations.
- ✓ Indigenous practices, such as **sacred groves** or traditional agricultural practices that maintain biodiversity, are vital for the conservation of natural resources. In Ethiopia, many local communities have developed sustainable land use practices rooted in cultural traditions, helping to preserve ecosystems and biodiversity.

6.4. Climate Change: Causes and effects

- ❖ Climate change is a systematic change in the long-term state of the atmosphere over multiple decades or longer. The change is especially due to an increase in the average atmospheric temperature

Causes of climate change

Natural causes

- ❖ Volcanic eruption, Fluctuation in solar radiation, Tectonic shift
- ❖ High temperature and precipitation

Human Causes

- ❖ Anthropogenic activities (Burning of fossil fuel, deforestation, farming, livestock, transportation, electricity, industry…

What are greenhouse gases?

- ❖ A gas that absorbs and emit radiant energy with in the thermal infrared range, causing the greenhouse effect.
- ❖ Primary greenhouse gases are: water vapor, CO2, CH4, N2O, HFCs. PFCs, SF6, Ozone. These act like blanket.
- ❖ They are climate active pollutant.
- ❖ Carbon dioxide (CO2) is the GHG responsible for greatest amount of warming to date.
- ❖ It absorbs less heat per molecule than methane or nitrous oxide, but it's more abundant and stays in the atmosphere much longer.
- ❖ Increase in atmospheric carbon dioxide are responsible for about two-thirds of the total energy imbalance that is causing the earth's temperature to rise.
- ❖ Major greenhouse gases include carbon dioxide, methane, nitrous oxide, and various synthetic chemicals.

- **Carbon dioxide** is widely reported as the most important anthropogenic greenhouse gas because it currently accounts for the greatest portion of the warming associated with human activities. Carbon dioxide occurs naturally as part of the global carbon cycle, but human activities have increased atmospheric loadings through combustion of fossil fuels and other emissions sources. Natural sinks that remove carbon dioxide from the atmosphere (e.g., oceans, plants) help regulate carbon dioxide concentrations, but human activities can disturb these processes (e.g., deforestation) or enhance them.
- **Methane** comes from many sources, including human activities such as coal mining, natural gas production and distribution, waste decomposition in landfills, and digestive processes in livestock and agriculture. Natural sources of methane include wetlands and termite mounds.
- **Nitrous oxide** is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.
- **Various synthetic chemicals**, such as hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and other synthetic gases, are released as a result of commercial, industrial, or household uses.

- Each greenhouse gas has a different ability to absorb heat in the atmosphere, due to differences in the amount and type of energy that it absorbs, and a different **"lifetime**," or time that it remains in the atmosphere.
- For example, it would take thousands of molecules of carbon dioxide to equal the warming effect of a single molecule of sulfur hexafluoride—the most potent greenhouse gases.

Lifetime of Greenhouse Chemicals

✓ Methane has an atmospheric lifetime of 12 to 15 years. The methane is degraded to water and CO^2 by chemical reactions in the atmosphere. Nitrous oxide has an atmospheric lifetime of 120 years, while CFC-12 has an atmospheric lifetime of 100 years.

Which of the following pollutants has the maximum residence time in atmosphere?

✓ As an example, methane has a residence time in the atmosphere of about 10 years, compared with **nitrous oxide**, which stays for about 150 years. An example of secondary effect is CFCs, which although they are powerful greenhouse gases are only expected to give a small net contribution to the greenhouse effect.

✓ **Carbon dioxide** is the greenhouse gas that stays in the atmosphere the longest. Scientists believe that the lifetime of this gas typically lasts in the atmosphere for up to thousands of years

✓ the build-up of carbon dioxide gas in the atmosphere from human activities seems to be adding to this greenhouse effect and causing global warming.

Global warming:

Global warming: Global warming is the long-term warming of the planet's overall temperature

Global dimming: Global dimming is **a phenomenon which produces forces that act opposite to global warming in nature**. Global dimming reduces the amount of sun's rays reaching the earth's atmosphere causing a drop of temperatures around the globe.

Effects of climate change

Climate change destabilizes the earth's temperature equilibrium causing global warming that posed effect on human and environment!

The direct consequences of man-made climate change.

✓ rising maximum temperatures

- ✓ rising sea levels
- ✓ higher ocean temperatures
- ✓ an increase in heavy precipitation and
- ✓ shrinking of glaciers
- ✓ thawing of permafrost

The indirect consequences of climate change

- ✓ an increase in hunger and water crises, especially in developing countries
- ✓ health risks due to the rising air temperatures and heat waves
- ✓ economic crisis (Decrease in crop productivity, loss of animal)
- ✓ increasing spread of pests and pathogens
- ✓ loss of biodiversity due to limited adaptability of flora and fauna
- ✓ Increase in desertification
- ✓ Increase in forest disturbance (Decrease in tree composition)
- ✓ ocean acidification due to increased HCO3 concentrations in the water as a consequence of increased CO_2 concentrations.

Climate change and natural disasters

- ❖ Climate change intensified the frequency of natural disaster that occur following long drought.
- ❖ In our planet we always had Earthquakes, hurricanes (Cyclone), droughts and wildfires, high winds and flooding.

Earthquakes: is the shifting of tectonic plates under the earth's crust causes earthquakes, which are responsible for mass destruction

Tsunamis: are a series of enormous ocean waves caused by earthquakes, underwater landslides, or volcanic eruptions.

Cyclones: are tropical storms, caused by atmospheric disturbances around a low-pressure area. Cyclones are accompanied by strong winds, moving at a speed of sixty-two Kmph or more.

Mitigation Measure

- Climate change mitigation means the practices of avoiding and reducing emissions of heat-trapping greenhouse gases into the atmosphere to prevent the planet from warming to more extreme temperature.

- It means **reducing the flow of heat-trapping greenhouse gases into the atmosphere**.
- This involves cutting greenhouse gases from main sources such as power plants, factories, cars, and farms.
- Forests, oceans, and soil also absorb and store these gases, and are an important part of the solution

Example of ways of mitigating climate change

- Use renewable energy.
- Electrify your home and transportation.
- Conserve energy.
- Conserve water.
- Change your transportation.
- Help conserve and restore forests.
- Practice climate-friendly gardening.

The Paris Agreement works on a five- year cycle of increasingly ambitious climate action carried out by countries. Every five years, each country is expected to submit an updated national climate action plan - known as Nationally Determined Contribution, or NDC.

6.3. International conventions

- ❖ Climate change is a long-term, global problem that require stable but flexible policy implementation over time. Various international conventions have continuously evolved to address the increasingly complex and changing environmental priorities of the world.
- ❖ In 1988, IPCC (Intergovernmental panel on climate change) was held and all members agreed that greenhouse gas are increasing in the atmosphere because of human activities.
- ❖ This report led to establishment of UNFCCC (United Nation Framework Convention on Climate Change) in 1992 which was signed by 154 states.
- ❖ The objective of this international treaty is:
- ✓ To prevent dangerous man-made interference with the global climate system.
- ❖ In 1994, UNFCCC enter into force.
- ❖ The United Nation Climate Change Conference are yearly conference held in the Framework of the UNFCCC Since 1995.
- ❖ In 1995, the first UNFCCC conference of parties (COP1) was held in Berlin and called Berlin mandate.

- At the COP1, the signatories agree to meet annually to maintain control over global warming and see the need to reduce emission of polluting gases.
- In December, 1997, Kyoto protocol was adopted: in Japan to establish legally binding obligation for developed countries to reduce their greenhouse gas emissions.
- It took eight years for participating countries to ratify the Kyoto Protocol.
- Russia ratified Kyoto protocol in 2004.
- Kyoto Protocol is an international agreement that called for industrialized nations to reduce their greenhouse gas emissions significantly.
- Other accords, like the Doha Amendment and the Paris Climate Agreement, have also tried to curb the global-warming crisis.

Example: the Paris agreement goal is to keep the rise in mean global temperature to well below 2 °C above pre-industrial levels and preferably limit the increase to 1.5 °C. It also aims to help countries adapt to climate change effects, and mobilize enough finance.

- The protocol called for reducing the emissions of Six greenhouse gases in 41 countries plus the European Union. Industrialized countries would be legally obliged to cut their greenhouse gas emissions 5% on 1990 levels by 2008-2012 first commitment period.
- Developing countries – including China, India, Brazil and South Africa would face no restriction on their emissions but were encouraged to adopt policies to promote greener growth.
- Kyoto also offered a range of market mechanisms that could help rich countries offset emissions by investing in low carbon projects in poorer parts of the world.
- Since 2005, the "Conference of the Parties Serving as the Meeting of Parties to the Kyoto Protocol" (CMP) accepted parties that are not parties to the Protocol to join to the Convention, but to participate in the Protocol-related meetings as observers.
- Since 2011, the meetings have also been used to negotiate the Paris Agreement as part of the Durban platform activities until its conclusion in 2015, which created a general path towards climate action.
- In 2009 in Copenhagen (COP15), for the first time it was decided that each country would propose a national contribution (INDC, Intended Nationally Determined Contributions).
- All the 195 UNFCCC countries pledged to reduce their greenhouse gas emissions by 2025-2030.
- it aimed “to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty” and contained three key provisions:

i. Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C.
ii. Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production.
iii. Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

International and national practices of Implementation of conventions

- Ethiopia's policy response to climate change has progressively evolved since the ratification of the UNFCCC in 1994.
- Ethiopia launched the National Adaptation Plan of Action in 2007
- Ethiopian Program of Adaptation on Climate Change and Nationally Appropriate Mitigation Actions in 2010.
- Ethiopia endorsed a Climate Resilient Green Economy (CRGE) strategy in 2011.
- The Green Legacy Initiative (GLI) launched in 2019 targeted to plant 20 billion seedling
- Great Ethiopian Renaissance Dam (GERD) is the best example to build green economy and overcome the effect of climate change.

EXAMPLES OF REVIEW EXERCISE

1. Which of the following best defines carrying capacity in population ecology?
   A. The maximum rate of reproduction of a population
   B. The number of individuals an environment can sustainably support
   C. The rate at which a population increases over time
   D. The average age of individuals in a population

Explanation: Carrying capacity refers to the maximum number of individuals that an environment can support without depleting resources.

2. If a population of rabbits in an isolated ecosystem grows exponentially, which factor is likely to eventually limit its growth?
   A. Continuous supply of food
   B. Genetic mutation
   C. Limited space and resources
   D. Abundant sunlight

Explanation: Eventually, exponential growth is constrained by the carrying capacity, which is influenced by limited resources such as food and space.

3. Which of the following human activities most directly contributes to global warming?

   A. Afforestation
   B. Burning of fossil fuels
   C. Use of renewable energy sources
   D. Recycling

Explanation: The burning of fossil fuels releases greenhouse gases such as CO_2, which contribute to global warming.

4. What is the primary goal of the **Kyoto Protocol**?

   A. To reduce the emission of greenhouse gases
   B. To promote global trade
   C. To protect marine biodiversity
   D. To control deforestation

Explanation: The Kyoto Protocol was an international agreement aimed at reducing greenhouse gas emissions to mitigate climate change.

5. To mitigate the effects of climate change, a country decides to implement a national policy that promotes **renewable energy sources**. What is the most likely result of this decision?

   A. Increased reliance on fossil fuels
   B. Reduction in greenhouse gas emissions
   C. Increased deforestation
   D. Rising global temperatures

Explanation: Switching to renewable energy reduces reliance on fossil fuels, thus lowering emissions of greenhouse gases responsible for climate change.

6. What is the most significant long-term consequence of **climate change** on biodiversity?

   A. Expansion of desert areas
   B. Habitat destruction and species extinction
   C. Increased agricultural productivity
   D. Enhanced food chain stability

Explanation: Climate change alters habitats, leading to the loss of species and overall biodiversity.

7. Which of the following is an example of a country that did not meet its greenhouse gas emission reduction targets under the **Kyoto Protocol**?

   A. Germany
   B. United States
   C. Ethiopia
   D. Australia

Explanation: The United States withdrew from the Kyoto Protocol and did not meet its greenhouse gas emission reduction targets.

5. The **Kyoto Protocol** was replaced by the **Paris Agreement**. What major difference exists between the two?

   A. The Paris Agreement does not legally bind countries to reduce emissions.

B. The Paris Agreement mandates stricter emission reductions for developed countries only.

C. The Kyoto Protocol includes only emissions from fossil fuel usage.

D. The Paris Agreement requires a reduction in deforestation rates.

Explanation: Unlike the Kyoto Protocol, the Paris Agreement aims to limit global temperature rise but does not legally bind countries to emission reduction targets.

8. In a food chain, which of the following organisms would typically be considered a **secondary consumer**?

A. A herbivore

B. A producer

C. A carnivore that feeds on herbivores

D. A decomposer

Explanation: A secondary consumer feeds on primary consumers (herbivores), making it a carnivore in this context.

9. Which of the following processes is most critical for the **cycling of nitrogen** in an ecosystem?

A. Photosynthesis

B. Nitrogen fixation

C. Evaporation

D. Precipitation

Explanation: Nitrogen fixation is the process where nitrogen gas is converted into usable forms for plants by bacteria, which is critical for nitrogen cycling in ecosystems

10. If a pesticide kills primary producers in an ecosystem, what is the most likely effect on the food chain?

A. Primary consumers will thrive due to increased food availability.

B. Secondary and tertiary consumers will experience a food shortage.

C. The ecosystem will become more balanced.

D. Decomposers will find more organic material to break down.

Explanation: The death of primary producers reduces the food supply for herbivores, which in turn impacts the entire food chain.

11. Which of the following is true about **decomposers** in an ecosystem?

A. They are primary consumers that feed on producers

B. They break down dead organisms, returning nutrients to the environment

C. They convert sunlight into chemical energy

D. They are the top predators in the food chain

Explanation: Decomposers recycle nutrients by breaking down dead organic matter, which is essential for nutrient cycling in ecosystems.

12. Which process in the **carbon cycle** involves the conversion of atmospheric CO_2 into organic compounds by plants?

A. Respiration
C. Photosynthesis
B. Decomposition
D. Combustion

Explanation: During photosynthesis, plants convert atmospheric CO_2 into organic compounds, storing carbon in their tissues.

13. Which of the following best explains the role of **bacteria** in the nitrogen cycle?

A. Bacteria convert nitrogen gas into a form usable by plants.
B. Bacteria recycle organic matter into nitrogen gas.
C. Bacteria convert nitrogen into ammonia only during droughts.
D. Bacteria remove nitrogen from the atmosphere and store it in the soil.

Explanation: Nitrogen-fixing bacteria convert atmospheric nitrogen (N_2) into ammonia or nitrates, which plants can use for growth.

14. What action can individuals take to contribute to **energy conservation** in their daily lives?

A. Reducing the use of non-renewable resources
B. Increasing the use of fossil fuels for electricity
C. Installing energy-efficient appliances and using public transportation
D. Consuming more disposable products

15. Designing a **sustainable city** requires careful planning. Which of the following strategies would **maximize resource conservation** in urban development?

A. Increasing the use of fossil fuels for transportation
B. Implementing renewable energy sources and green buildings
C. Expanding urban areas with no consideration for natural habitats
D. Encouraging deforestation for new housing projects

16. Which of the following is a **density-dependent factor** affecting population growth?

A. Temperature
C. Competition for resources
B. Natural disasters
D. Floods

17. Which of the following strategies is most effective in mitigating the effects of **climate change**?

A. Increasing fossil fuel consumption
C. Decreasing the use of renewable energy sources
B. Planting trees to absorb CO_2
D. Reducing forest conservation efforts

18. What would likely happen to an ecosystem if all primary consumers were removed from the food chain?

A. Secondary and tertiary consumers would become extinct.

B. Decomposers would increase in population.

C. The producers would thrive with no herbivores.

D. The balance of the ecosystem would be disrupted, and secondary consumers would starve.

Explanation: The removal of primary consumers disrupts the food chain, depriving secondary consumers of food.

19. How does **decomposition** contribute to the cycling of nutrients in an ecosystem?

A. It adds organic matter to the soil, enriching it with nutrients.

B. It traps carbon in plants for long periods.

C. It releases oxygen into the atmosphere.

D. It stores nitrogen in the atmosphere for plant use.

Explanation: Decomposition breaks down dead organic material, releasing nutrients like nitrogen, phosphorus, and carbon back into the soil.

20. Which of the following strategies is most effective in reducing the environmental impact of resource extraction?

A. Increasing deforestation to clear land for agriculture

B. Promoting sustainable agricultural practices

C. Expanding mining operations to meet growing demand

D. Reducing the use of renewable energy sources

Explanation: Sustainable agricultural practices, like crop rotation and organic farming, help conserve soil, water, and biodiversity, reducing environmental degradation.

21. Which of the following **human activities** most contributes to **soil degradation**?

A. Crop rotation and agroforestry

B. Overgrazing and deforestation

C. Water conservation practices

D. Planting native vegetation

Explanation: Overgrazing and deforestation lead to soil erosion, loss of soil fertility, and desertification, which significantly degrade soil quality.

22. Which of the following is an example of **conserving water resources** in agriculture?

A. Increasing irrigation without considering local water supply

B. Using rainwater harvesting systems and drip irrigation

C. Growing water-intensive crops in dry areas

D. Dumping industrial waste into water bodies

Explanation: Rainwater harvesting and drip irrigation conserve water by reducing wastage and using water more efficiently for crops.

23. Which of the following is a **critical component** for the **restoration of a degraded ecosystem**?

A. Expanding mining activities in the region

B. Introducing invasive species to combat pests

C. Planting native vegetation and controlling pollution

D. Building urban infrastructures without considering ecosystem health

Explanation: Restoring native vegetation and controlling pollution helps re-establish ecosystem balance, improve soil fertility, and restore biodiversity.

24. Which of the following policies would most likely **reduce** the rate of **biodiversity loss**?

A. Expanding logging in protected forests

B. Enforcing stricter regulations on wildlife trade and habitat destruction

C. Encouraging urbanization in biodiversity hotspots

D. Increasing the use of harmful pesticides and herbicides

Explanation: Stricter regulations prevent over-exploitation of wildlife and destruction of habitats, which are major factors in biodiversity loss.

25. Which of the following best describes the **role of conservation** in maintaining **ecosystem services**?

A. Depleting natural resources to ensure economic growth

B. Preserving natural areas to maintain clean air, water, and biodiversity

C. Expanding urban areas without concern for natural ecosystems

D. Removing all natural predators to increase the population of certain species

Explanation: Conservation preserves ecosystems, which are crucial for providing services like clean water, air, and habitat for wildlife.

26. Which of the following is the **most significant threat** to **marine biodiversity**?

A. Overfishing and habitat destruction

B. Increased tourism in coastal areas

C. Reducing carbon emissions from ships

D. Use of sustainable fishing practices

Explanation: Overfishing depletes fish populations, and habitat destruction, like coral reef damage, threatens marine biodiversity and ecosystem health.

27. Which of the following best describes **sustainable forestry practices**?

A. Cutting down all trees in an area for immediate profit

B. Selectively cutting trees and planting new ones to maintain forest health

C. Ignoring the effects of deforestation on local wildlife

D. Expanding logging without replanting trees

Explanation: Sustainable forestry involves responsible tree harvesting, ensuring the forest can regenerate and continue providing ecosystem services.

28. What are the gases called that become trapped in the earth's atmosphere and are heating the planet?

A. Humidity
C. Greenhouse gases
B. Precipitation
D. Nitrates

Explanation Accumulation of Greenhouse gases in the atmosphere absorbs and emit radiant energy. It causes the greenhouse effect.

29. An international agreement that aimed to manage and reduce carbon dioxide emission and greenhouse gases is

A. Paris Accord
C. Kyoto protocol
B. Marrakesh accord
D. Copenhagen agreement

Explanation: Kyoto protocol is an international agreement that aimed to manage and reduce carbon dioxide emission and greenhouse gases and set emission target for developed countries.

30. What did countries agree to in the famous "Paris Agreement" in 2015?

A. To keep global temperature, rise below 2°C and pursue a path to limit warming to 1.5°C.
B. To stop countries from dumping rubbish in the ocean
C. To transition to all electric cars by 2050
D. To plant 1 million trees in deforested areas

Explanation: In Paris agreement, countries agree to keep global temperature, rise below 2°C and pursue a path to limit warming to 1.5°C. it covers climate change mitigation, adaptation and finance

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SELF TEST EXERCISE

1. Ecology is the study of the interaction of living organisms
   A. with each other and their habitat
   B. and their communities.
   C. with each other and their physical environment
   D. and the food they eat.
2. Ecological models are useful for all **except**
   A. making predictions about future ecological changes.
   B. testing predictions about future ecological changes.
   C. evaluating proposed solutions to environmental problems.
   D. Making population prone to certain infection
3. The physical location of an ecosystem in which a given species lives is called a
   A. Habitat B. Niche C. Trophic level D. Biotic factor
4. Which of the following is not an abiotic component of an ecosystem?
   A. Sunlight C. Food
   B. Rainfall D. wind
5. Which of the following would be a biotic factor in an ecosystem?
   A. Bacteria C. Temperature
   B. Soil D. Rainfall
6. Which of the following is not a biotic component of an ecosystem?
   A. Predators B. rocks C. parasites D. diseases
7. Which of these are not competed for by plants?
   A. Light B. Minerals C. Warmth D. Water
8. Abiotic factors affect an ecosystem and include all of these except the
   A. Quantity and quality of water C. Nitrogen-fixing bacteria
   B. amount of light available D. quantity of minerals
9. A snake that eats a frog that has eaten an insect that fed on a plant is a
   A. First-level producer C. Second-level producer
   B. first-level consumer D. Third-level consumer
10. Most of the energy available to a consumer trophic level is used by organisms for
   A. transfer to the next trophic level.
   B. Respiration, movement, and reproduction.
   C. Producing inorganic chemical compounds.
   D. Performing photosynthesis
11. Which type of pyramid shows the amount of living tissue at each trophic level in an ecosystem?
   A. A numbers pyramid C. A biomass pyramid
   B. an energy pyramid D. a food pyramid
12. Matter can recycle through the biosphere because
   A. Matter is passed out of the body as waste.

B. Matter is assembled into chemical compounds.
C. Biological systems do not use up matter, they transform it.
D. Biological systems use only carbon, oxygen, hydrogen, and nitrogen.

13. The movements of energy and nutrients through living systems are different because
A. Energy flows in one direction and nutrients recycle.
B. Energy is limited in the biosphere and nutrients are always available.
C. Nutrients flow in one direction and energy recycles.
D. Energy forms chemical compounds and nutrients are lost as heat.

14. Which of the following is NOT recycled between organisms and the environment in an ecosystem?
A. Energy
B. Carbon
C. Nitrogen
D. Phosphorus

15. What is the term that refers to all parts of the earth where living things are found?
A. Population
B. Ecosystem
C. Biosphere
D. Environment

16. What is the important role played by microorganisms such as bacteria and fungi in the ecosystem?
A. Antibiotic production
B. Recycling of nutrients
C. Forming organic substances
D. Supplying energy to the ecosystem

17. Which of the following is an ecosystem?
A. All the organisms in a given area
B. A Tropical Rainforest
C. The African continent
D. The non-living components of an environment

18. Which one of the following concepts contains all the others?
A. Species B. Genus C. Population D. Community

19. Which one of the following processes has a decreasing effect on the concentration of atmospheric carbon dioxide?
A. Cellular respiration
B. decomposition of dead organisms
C. combustion of fossil fuels
D. photosynthesis

20. How does the amount of energy available at one level of an energy pyramid compare to the amount of energy available at the next level up?
A. It is 10 times smaller
B. It is 10 times greater
C. It is the same
D. It is 90 times smaller

21. What does an energy pyramid show?
A. The different food groups and the daily requirement
B. The amount of energy that moves from one feeding level to another in a food web
C. Many overlapping foods chains
D. A series of events by which one organism eats another

22. If producers receive 1,000 kcal of energy from the sun, what would the tertiary consumers in that energy pyramid receive?
A. 10kcal B. 100,000 Kcal C. 100Kcal D. 1Kcal

23. How many times more energy is available at the producer level than at the secondary consumer level?
A. 10 times B. 1000 times C. 100 times D. 100,000 times

24. Which level(s) in the energy pyramid contain consumers? Trophic level:
A. Levels 2, 3, and 4
B. Bottom only
C. Level 2 and 3 only
D. Top only

25. The increase in the average temperature of the earth's atmosphere is referred to by scientists as…
A. Global heating
B. Global cooling
C. Global dimming
D. Core temperature change

26. Which greenhouse gases is generated by decomposition of waste?
A. Methane
B. Water vapor
C. Chlorofluorocarbon
D. Carbon dioxide

27. Greenhouse gases that deplete ozone layer is
A. SF_6 B. CH_4 C. CFCs D. N_2O

28. Too many greenhouse gasses in the atmosphere may block heat from escaping into space and trap too much heat next to the Earth's surface causing: _____.
A. another ice age
B. global warming
C. earthquakes
D. volcanic eruptions

29. Which of following that might happen because of global warming is:
A. melting polar ice caps
B. more reflected sunlight off the ice pack
C. lower sea levels
D. Flourishing of biodiversity

30. Human being makes greenhouse gases of our own by all **except:**
A. burning fossil fuels
B. burning forests
C. with large-scale agriculture
D. using electricity cars

31. what do we call, the layer that keeps us "not too hot in the summer" and "not too cold in the winter."?
A. Greenhouse effect
B. seasonal effect
C. ocean effect
D. lake effect

32. An international agreement that aimed to manage and reduce emission of greenhouse gases is
A. Paris Protocol
B. Doha agreement
C. Koyoto protocol
D. Rio summit

33. Which one of the following is the main source of the greenhouse gases that are concentrating in the atmosphere of the earth?
A. Burning of fossil fuels
B. Photosynthesis by aquatic plants
C. Plants growing in greenhouses
D. Respiration by animals and plants

33. Which component of soil fertility is improved when farmers grow legumes in crop rotation?
A. Phosphorus B. Nitrogen

C. Sulfur
D. Carbon

34. Why is biodiversity important?
    A. It stabilizes ecosystems
    B. It reduces natural selection
    C. It prevents competition among specie
    D. It stops evolution
35. What is the main objective of United Nations Framework Convention on Climate Change (UNFCCC) is
    A. To enforce developing countries to restrict their emission rate
    B. Enforce developed countries to ratify the protocol adopted in 1997.
    C. To prevent dangerous man-made interference with the global climate system
    D. To support green Legacy Initiative in developing countries
36. Which of the following is correct about Kyoto protocol? It is an agreement
    A. that covers climate change mitigation, adaptation and finance.
    B. held by only developed countries to help developing countries.
    C. called for industrialized nations to reduce their greenhouse gas emissions significantly
    D. enforced developing countries to eradicate poverty through education
37. Which of the following best explains why toxic bioaccumulation poses a greater risk to apex predators in an ecosystem?
    A. They consume a larger variety of prey, leading to increased toxin diversity.
    B. They have slower metabolic rates, which prevent toxin breakdown.
    C. They accumulate toxins from multiple trophic levels, leading to higher concentrations.
    D. They rely on primary producers, which contain the highest toxin levels.
38. A scientist is assessing the long-term effects of mercury bioaccumulation in a freshwater ecosystem. Which of the following would be the most effective method to evaluate its impact?
    A. Measuring mercury levels in water samples only.
    B. Monitoring mercury concentrations in fish tissue across multiple trophic levels.
    C. Conducting short-term toxicity tests on aquatic plants.
    D. Surveying human populations that consume fish.
39. You are designing a policy to reduce the impact of toxic bioaccumulation in marine food chains. Which strategy would be the most effective?
    A. Banning all fishing activities in contaminated waters.
    B. Reducing industrial discharge of persistent organic pollutants (POPs).
    C. Encouraging increased fish consumption to dilute toxin effects.
    D. Removing apex predators to prevent toxin accumulation.
40. A government is considering two strategies to reduce the impact of acid rain: (1) regulating sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions from industries, or (2) increasing the

use of alkaline substances like limestone in affected ecosystems. Which approach is more effective in addressing the root cause of acid rain, and why?

A. Strategy 1, because it prevents acid rain formation by reducing pollutant emissions.
B. Strategy 2, because it neutralizes the effects of acid rain without requiring industrial changes.
C. Both strategies are equally effective, as they address different aspects of the problem.
D. Neither strategy is effective, as acid rain is a natural phenomenon.