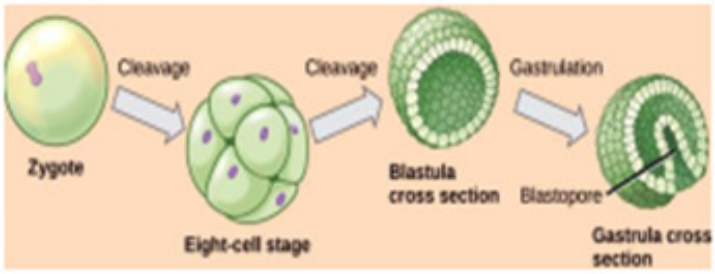
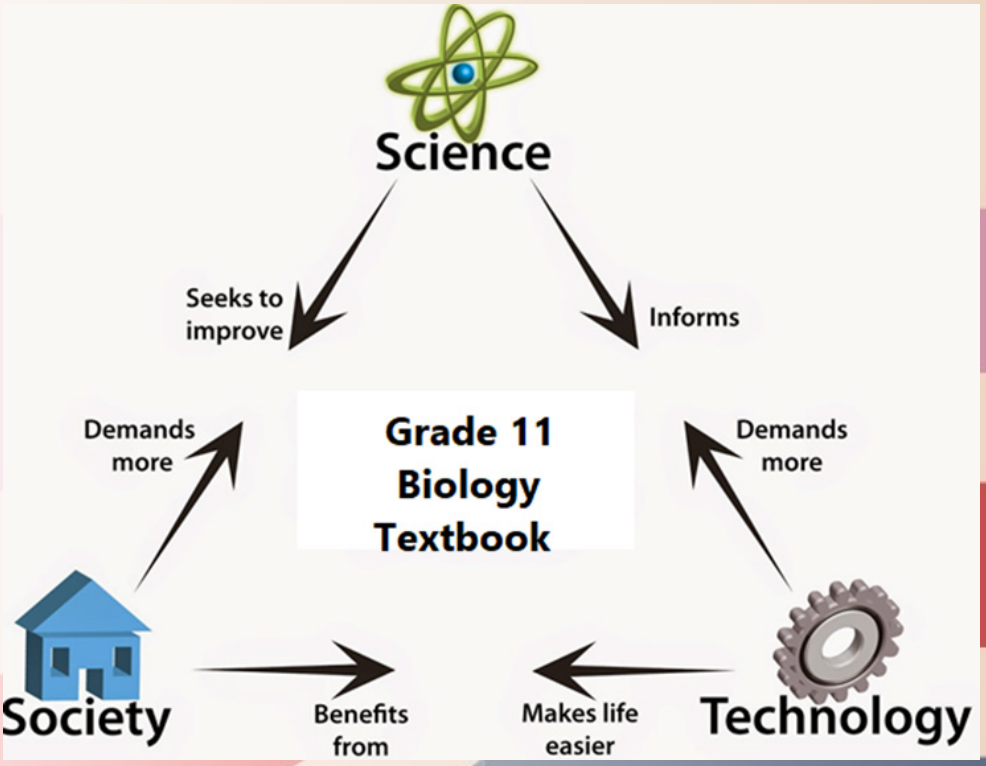
Biology

Grade 11

DISTANCE MODULE I




Science
Seeks to improve
Informs
Demands more
Grade 11 Biology Textbook
Demands more
Society
Benefits from
Makes life easier
Technology

BIOLOGY GRADE 11 DISTANCE MODULE I FDRE, MOE

Biology

Distance Module One

Grade 11 Biology

Biology, Technology, Animals and Enzymes

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TABLE OF CONTENTS

Module Introduction

Dear learner,

Welcome to module 1. In this module, you will study biology, technology, animals and enzymes. Hence, the module is designed to consist of three units that deal with biology and technology, animals and enzymes.

Unit one deals with the contribution of biology to the development of technology and technology to biology and ethical issues. It also deals with biotechnology that explores how we can learn from nature through imitation in general and how technologies can be designed from biological systems in particular.

This unit provides you a fascinating idea into the interplay between biology and technology and their impacts on the society and the natural world. It also clarifies the benefits of biology to technology and the uses of technology in biology in detail.

The unit also includes ethical issues of biology focusing on the merits and difficulties of applying biotechnological products on the life and styles of humans and conducting researches on animals and plants.

In unit two, you will study the general characteristics of animals, reproduction in animals, economic importance of insects, animal behavior and homeostasis in animals. It focuses on reproduction of representative animals such as insects, frog, crocodile, birds and rat. The unit also deals with the two types of animal behavior such as innate and learned behavior in detail. It also deals with how animals control their internal body condition such as temperature, water and glucose through the process of homeostasis.

In unit three, you will learn about enzymes, their characteristic, their functions and application in industries and in our day to day life. The unit enhances your understanding of malting process and how local alcoholic drink production is practiced. It also familiarizes with you the educational experiences of some renowned biochemists in Ethiopia.

Dear learner, self-learning, activities and self-assessments that help you to engage in learning by doing are incorporated in each unit. It also brings pleasure setting unit review questions, feedbacks, checklists and answer keys. Therefore, you are highly expected to cover all portions through self-studies using available resources within a semester and successfully complete the module.

To this end, as the learning resource material is national property, we recommend you to use it wisely, carefully and properly.

Icons or graphic symbols

In this module, you will find the following icons or graphic symbols throughout the module and the interpretation is given below.

 This indicates that there is an overview of the unit and what the unit is all about.

 This signals that there is an in-text question to answer or think about in the text.

 This indicates that you need to take note of or to remember an important point.

 This shows that there is an activity for you to do

 This signals that there is a self-test for you to do

√ This signals that there is a checklist

 This indicates that there is a written assignment

 This indicates that there is a key to the answers for the self-tests.

General Objectives

Dear learner,

This module contains three units. After the successful completion of studying the units, you will be able to:

- Adapt technologies from nature
- Indicate the benefits of Biology to Technology and Vice versa
- Illustrate the impact of Biology and technology on society and the natural world
- Recognize Ethical issues in Biology
- Describe the characteristics of animals.
- Differentiate between vertebrates and invertebrates
- Compare and contrast reproduction in vertebrates.
- Evaluate the economic importance of animals (insects) in agriculture, food, industry, health, and medicine
- Explain animal behavior
- Discuss the types and patterns of animal behavior
- Discuss homeostasis in animals: thermoregulation, osmoregulation and sugar balance
- Appreciate the work of a renowned zoologist in Ethiopia or in your locality
- Explain enzymes, properties of enzymes, factors affecting their activities, functions, mechanisms of action, regulation, their industrial applications and kinetics
- Demonstrate proteins and their structures

Learning strategies

Dear learner,

While learning/studying this module, you can use different types of learning strategies that can be categorized into the cognitive strategies, metacognitive strategies, and resource management strategies illustrated below.

- Cognitive strategies include rehearsal, elaboration, and organization.
  - Rehearsal strategies help you to remember concepts in the module using repetition that includes: repeating the material aloud, copying the material, taking selective notes and underlining the most important parts of the material.
  - Elaboration help you to build an internal connection between what is being learned and previous knowledge through paraphrasing, summarizing, creating analogies, generative note-taking, and question answering.
  - Organization helps you to organize and build connections with the information received in the learning environment through selecting the main idea, outlining, networking and diagramming the information.
- The metacognitive strategies help you to plan your strategies for learning, to monitor your present learning, and to evaluate your knowledge at the end.
  - Planning helps you to set goals, skim the material, and generate questions to learn.
  - Monitoring help you to check yourself for comprehension of knowledge or skills through self-testing, attention-focus, and employing test-taking tactics
  - Evaluating helps to assess yourself through reviewing, or test-taking.

- Resource management helps you schedule the course to obtain the best results through setting a specific time of studying and selecting appropriate resource to support your learning.

Assessment Methods

Dear learner,

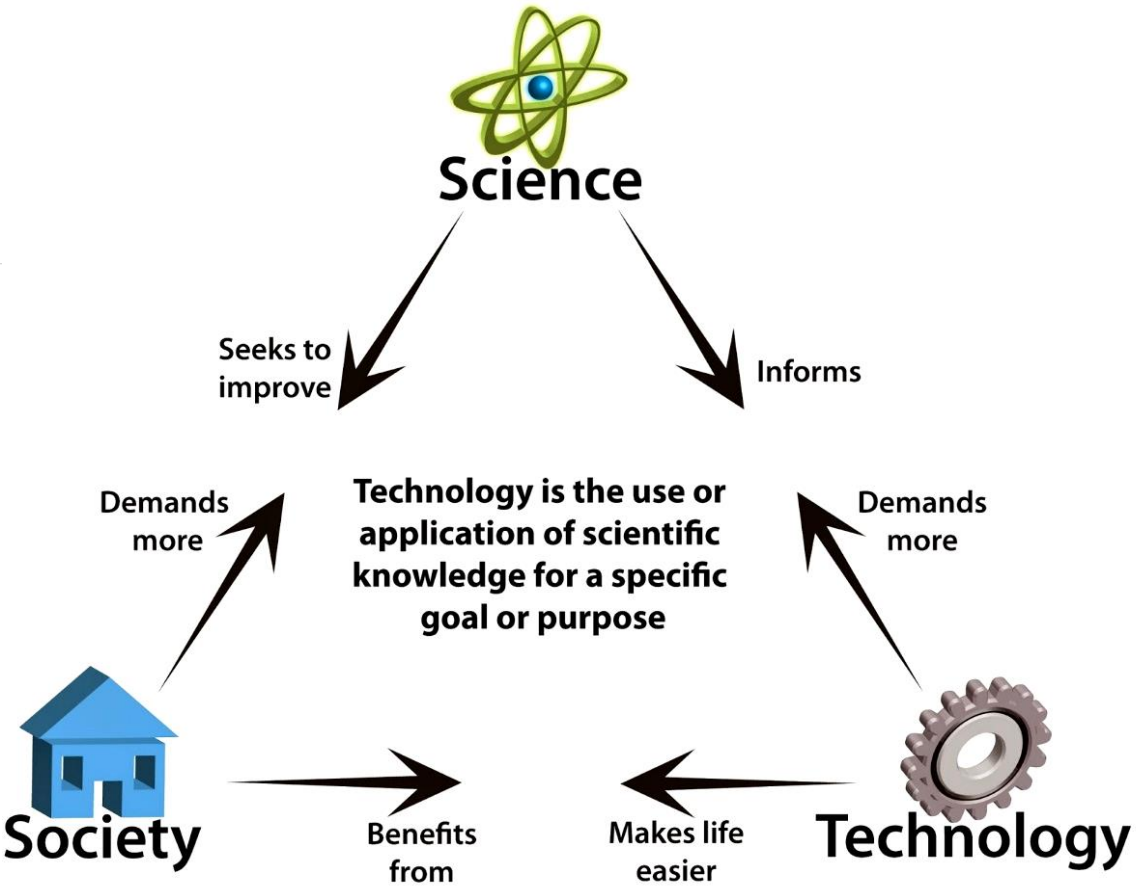
Assessment is a key component of the teaching-learning process by which you can check your learning against the stated outcomes/competencies. Hence, you are expected to use different types of assessment strategies throughout the lesson. You can assess your own learning at the beginning of the lesson (diagnostic assessment), during self-learning/studying process (formative assessment), and at the end of the self-learning/studying process of a unit or a semester (summative assessment).

Particularly, you can use one or more of the following assessment methods while you are learning/studying the module to check if you have learned successfully or not:

1. while learning/studying each section of the module, you are provided with different activities, and hence, you are encouraged to do all activities
2. After each section in the module, there is a self-test exercise and check list to which you should respond. While you are attempting the self-test exercises, do not rush to look at the answers provided at the end of the unit. Answer the questions first, then refer the answer keys
3. You must complete laboratory activities in your tutorial center, which will aid your module study with practical activities and answer questions following your practical activity.
4. There are end of unit assessment questions, and you are also expected to answer all the questions.

5. You will have "Assessment for submission" section at the end of the module. You are required to complete all the questions for an assignment and submit to your tutor at tutorial center.
6. Final examination: Following the successful completion of the module, you will take a final examination at your tutorial center.

Unit One: Biology and Technology



Introduction

Welcome to the first unit of module one that is composed of four sections designated as: 1) Learning from nature, 2) Biology and technology, 3) Impacts of biology and technology on the society and the natural World and 4) Ethical issues in biology.

Dear learner, each section contains different learning lessons and various activities, which you are expected to cover within seven hours of self-learning.

The main objective of unit one is to provide you with insightful ideas on how people learn from nature and design technologies or products imitating the nature. It also deals with the concept of biology and technology its interplay and integration to form biotechnology.

The unit also discusses the positive and negative impacts of biology and technology on the society and the natural world.

The last section presents the ethical issues in biology that addresses the questions of unethicality and ethicality or the merit of using biotechnological products on human life styles and lives and considering ethics of conducting research on animals and plants.

Dear learner, you are expected to study each section, lesson and related activities independently.

Unit one Learning outcomes

Dear learner, after the successful completion of unit one, you will be able to:

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

Contents

Study time: seven (7) hours

Learning strategies

Dear learner, remember that you will need to follow the strategic learning steps suggested below and attempt all the activities on your own.

1. Section 1.1 discusses learning from **nature** using imitation and how technologies mimicked nature to improve the lives of human beings. Look at the pictures in relation to the modern technologies imitated and find the similarities. **Examples**: flying birds and flight technologies
2. Section 1.2 deals with biology and technology and the blended form **biotechnology**. Imagine the importance of biology for technology and the uses of technology in biology. Think whether biology is benefiting from technology or technology is benefiting from biology and take notes.
3. Section 1.3 is about the impacts of biology and technology on the society and the natural world. Think and writes a summary note on both impacts.
4. Section 1.4 is about ethical issues in biology. This section focuses on the treatment of plants and animals during biological studies. Think of the ethical and unethical questions that arise in the course of doing research.

Section 1.1: Learning from nature

Dear learner, in section 1.1 you will learn on how and what to learn from the nature through imitations.

Learning competencies

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

- Learn technologies from nature
- Design devices from biological structural mechanisms
- Recognize devices copied from biological nature

Self-questioning 

Before starting this section, ask yourself the following question:

'What do I know about learning from nature and what do I want to learn from this section?'

Dear learner, what is nature? If your answer for this question is as indicated below, you are right. Nature is the physical, natural and material world that exists without human intervention. Nature includes landscape sceneries, water and forest ecosystems, weather, organisms, geology, celestial bodies and inanimate objects etc.

Have you ever visited a forest around you? If yes, what did you see?

Nature is the source of doable structures and forms, which can be developed into functional and applicable mechanisms for various technological systems.

How do humans learn from nature?

Dear learner, can you answer this question? If yes that is good, if not, here it is. Humans learn from nature through **imitation** of the physical structures, shapes, materials, biological systems and functional mechanisms. **Imitation** of nature enhances to sketch and design and tune into more efficient technologies at macro (large) and nano (very small) scales. The successful design of technologies from robotics to material sciences was by imitating nature.

☞ Nature inspires and serves as reliable sources of ideas, concepts and knowledge to design technologies. Many technologies have been made imitating birds, bats, termites, spiders, bees, ants and parts of human body since timeless. Dear learner, the better you understand the diverse forms of nature and biological systems, the better you grasp ideas and develop technologies.

Look at figure 1.1, observe the nature inspired products with pertinent examples (shown by both side arrows) and learn more on how technologies could be imitated from nature.

Examples:

1. Insects and robots
2. Bee wax and building block
3. Bird nest and Beijing National stadium
4. Cucumber fruit and Gherkin tower London

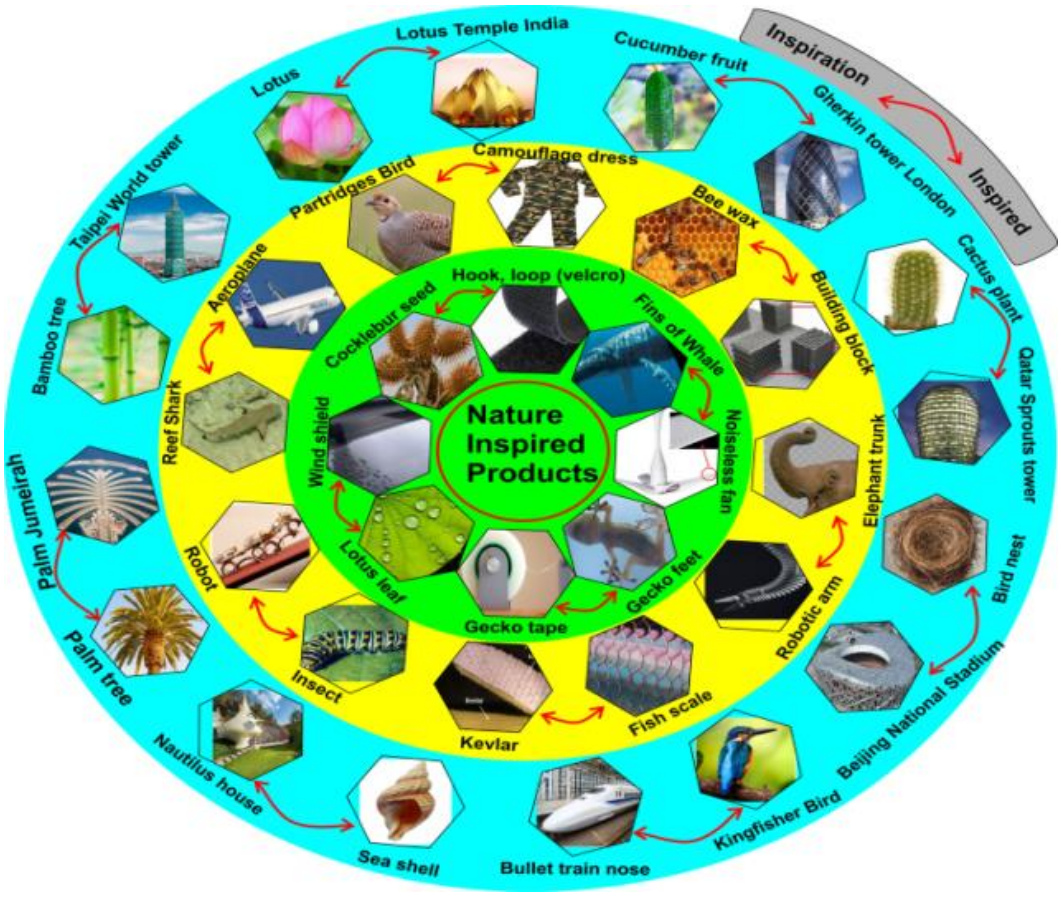


Figure 1.1 Nature imitated technologies and architectures

☞ Look at the following comparative statement of the natural biological systems and technologies serving humans carefully.

1. The art of weaving technologies and silk of spiders
2. Heavy aircraft technology and birds.
3. Aircraft wings flight techniques and wings of birds and bats
4. Photograph camera and human eyes
5. The movement of bio-robots and locomotive nature of kangaroo
6. The sensors of electrical devices and shapes of biological neurons
7. A cutting saw and the sharp teeth of animals
8. Synthetic bulletproof vests and the spin silks of spiders.
9. Ceramics and the nature of crack-resistant shellfish materials.

Examples with pictures:

1. The East gate Center of Harare building was imitated from the architecture termites' mound (See Figure 1.2).

Figure 1.2 Mound (left) and East Gate Building (right)

2. The Injection Syringe head technology was imitated from mosquitoes' Proboscis (Figure 1.3).

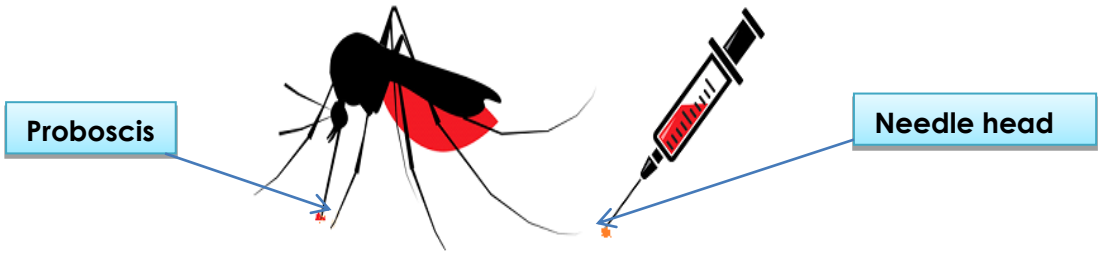


Figure 1.3 Injection syringe head imitated from a mosquito's proboscis

3. Robotic arms were imitated from the motion and gripping ability of elephant trunks (See Figure 1.4).

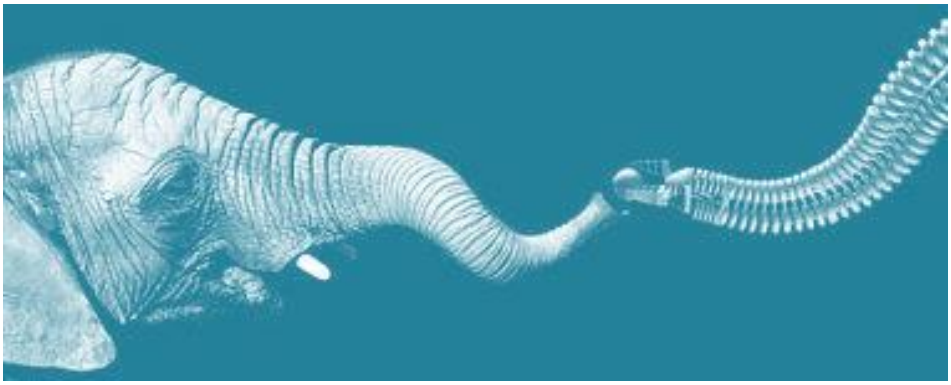


Figure 1.4 Robotic arms imitated from an elephant trunk

Activity 1.1: Imitating technologies from nature

Objective: learning from nature

Procedure

Study figure1.1; find natural sources from which technologies were imitated and fill-in the following table (1.1) as shown in the first row.

Table 1.1 Nature imitated technologies

No	Natural sources	Imitated technologies
1	Bird nest	Beijing National Stadium
2		
3		
4		
5		
6		
7		
8		
9		
10		

Activity 1.2: human hand model construction by imitation

Objective: learning by imitation

Procedure

- Design a human left hand model with jointed fingers and paint.
- Connect each finger with threads and enable them to function.
- Employ the hand model for catching up or dropping objects.
- Compare your model with the natural human hand functions.
- Think of other technologies that you can imitate from nature.

Activity 1.3: finding sources from which technologies imitated

Objective: Identifying natural sources for listed technologies

Procedure

Identify the natural sources for listed technologies and fill-in table 1.2

Table 1.2 Fill-in the natural sources of listed technologies

No	Technologies	Natural sources
1	Hexagonal structures	
2	A brand new drone design	
3	Techniques for preserving live vaccines	
4	Powerful repellent spray inspired	
5	Cutting saw	

🛠 Section 1.1 Self-test exercises

Multiple choices

1. Which of the following is the earliest example of imitation that scientists used as inspiration for human flight?

   A. waves C. Birds

   B. Wind D. Airplane

2. What is biomimicry in biology? It is

   A. studying the biodiversity of the ecosystems

   B. imitating nature to solve human problems

   C. applying genetics to create new species

   D. studying the genetic basis of plants

Short answer

1. How can we learn from it?
2. Define the term *imitation*.
3. List three sources with imitated technologies.

☑ Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can explain technologies imitated from nature ----------☐
2. I can define natural sources for imitating technologies ----------☐

Dear learner, if you have successfully completed section 1.1, you can now proceed to section 1.2 that provides you with scientific ideas and information on how biology and technology interplay and produce new skills and service providing equipment.

Section 1.2: Biology and Technology

Learning competencies

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

- Define the relationship between biology and technology
- Explain the benefits of biology to technology
- Describe the use of technology in biology
- Describe the use of technology in biology

Self-Questioning

Before starting this section, ask yourself the following question:

"What do I know about the role of biology in technology and technology in biology, and what do I want to learn from this section?"

Dear learner, biology is the study of the dynamics of life. It studies the origins, evolutions, structures, functions, growth and distribution of living organisms.

☞ **Biotechnology** is technology that utilizes biological systems, living organisms or parts of this to develop or create different products.

It means a technology that uses biological systems to develop useful products by integrating the natural and engineering sciences to achieve application of organisms, cells, parts and molecular analogues for human services.

Examples: The use of yeasts to produce bread, beer and wine.

1.2.1: The benefits of biology to technology

Dear learner, biological systems are the sources to imitate, design, adapt and develop modern technologies or products and solve complex human problems.

☞ Humans imitate technologies from the diversity of biological systems or, scientifically understand its nature and use to design technological products, innovate and solve human problems.

Examples of biological sources:

1. **Medicinal plants:** modern medicines are made by imitating the natural biochemical substances of medicinal plants.
2. **The genes:** biosynthetic materials (biological) are produced by imitating the nature of human, animal and plant tissues (cells) through the process of gene engineering to repair damaged parts.
3. In designing bullet train, its nose (front) imitated from the shape of the beaks of kingfishers diving into water (Figure 1.5).

Figure 1.5 Bullet train front and beak of a kingfisher bird

Subsection 1.2.2: Uses of technology in biology

Dear learner, Ca you explain the uses of technologies in biology?

The uses of technology in biology describe the application of technological tools to solve various biological problems. It is the practical uses of biotechnological instruments (products) for investigating new biological information and providing human services.

Dear learner, to recap what have learnt so far, study and exercise the following examples.

Examples:

1. A **digital thermometer** is an instrument used to measure body temperatures (Figure 1.6).
2. A **pregnancy urine test** is a tool that checks if a woman is pregnant or not by detecting the amount of the hormone **Human Chorionic Gonadotropin (HCG**) produced in the placenta around six to ten days after **fertilization** in either the urine (pee) or blood. The test result in one line is a **control line** showing **negative** (no pregnancy) and the other line (two lines) confirms the existence **pregnancy** (Figure 1.7).

Figure 1.6 Digital Thermometers **Figure 1.7 Pregnancy urine test**

3. **The diabetic blood test** is a tool to meter the level of blood sugar appears on the finger picker in number (Figure 1.8).
4. An **HIV test** is a detector to identify infections with the virus or not (Figure 1.9).

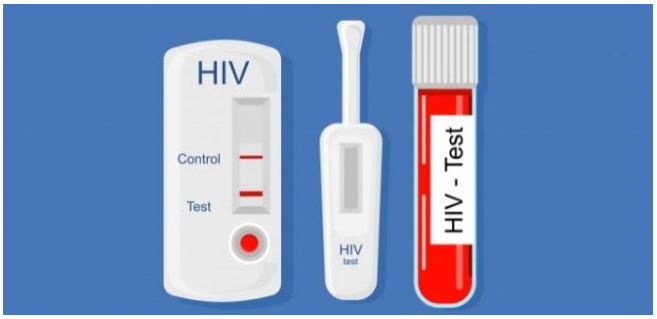


Figure 1.8 Diabetic test kit **Figure 1.9 HIV Test Kit**

5. **Microscopes** are used to magnify objects (Figure 1.10).

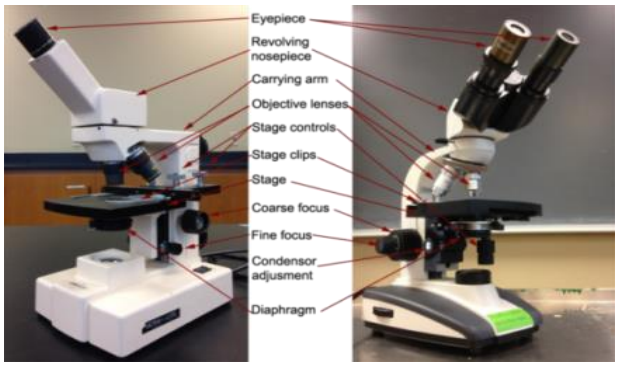


Figure 1.10 Microscope and its parts

6. **Computer Information Technology Scanning** (**CIT**S) is a device for providing information on diseases or cancerous areas of the human body.

7. **Computed Tomography Scan** (CT scan) is a sophisticated x-ray technology used to take many X-ray pictures of the body and detect and screen a variety of diseases and conditions (Figure 1.11).

Figure 1.11 CT scan

8. **Positron Emission Tomography (PET scan)** is an imaging technology device used to check for diseases or obtain information in areas with cancer in the human body. It uses a special dye containing radioactive tracer that is swallowed, inhaled or injected into an arm vein conditionally. PET scan visualizes and measures changes in metabolic processes and physiological activities (blood flow, chemical composition and absorption (Figure 1.12).

Figure 1.12 PET scan

9. **Geographical Position System** (**GPS**) is a device used to collect biogeographical information (biological data) on landscape information, mapping, plants, animals and human movements (Figure 1.13).

10. Handled body fat calculator is used to measure the amount of body fat (Figure 1.14).

Figure 1.13 GPS Figure

1.14 Handheld Body fat calculators

Activity 1.4: Uses of technological equipment

Objective: Measuring body temperature using a thermometer

Procedure

1. Measure and record the body temperature of three individuals and find the differences.
2. Visit a nearby health center and learn on how use pregnancy, diabetic and HIV tests.

Section 1. 2 Self-testing exercises

Multiple choices

1. Which one of the following is a product of Biotechnology?

A. Skin C. Plants

B. Vaccine D. Bacteria

2. The front side of the bullet train is imitated from the shape of the

A. beaks of kingfishers C. Leg of kingfishers

B. wing of kingfishers D. all of the above

Short answer

1. What did you do with thermometer?
2. Explain your experiences on how to use the pregnancy, diabetic and HIV tests tools.
3. List all other tools you have used so far.
4. What is technology?
5. Why is microscope biotechnological equipment?
6. What is a pregnancy urine test and how do we use it?

Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can explain biology and technology----------☐
2. I can describe the benefits of biology to technology and vice - versa----------☐
3. I can describe the use of technology in biology----------☐

Dear learner, it is hoped that you have successfully completed section 1.2 before you proceed to section 1.3 that discusses impacts of biology and technology on the society and the nature.

This section also brings you important ideas on how biotechnological products either negatively or positively affect the life styles of humans.

Section 1.3: Impacts of biology and technology on the society and the natural world

Learning Competencies

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

- Describe the impacts of biology and technology on society and nature
- Explain the relationships between biology and technology.
- Determine the negative and positive impacts of biology and technology on the society and nature.

Dear learner, it is hoped that you have successfully completed section 1.2 before you proceed to section 1.3 that discusses impacts of biology and technology on the society and the nature. This section also brings you important ideas on how biotechnological products either negatively or positively affect the life styles of humans

 **Self-Questioning** 

Dear learner, before starting this section, ask yourself this question

'What do I know about the impacts of biology and technology, and what do I want to learn from this section?'

Impacts of biology and technology are factors that pose positive or negative effects on the society and the natural world. It is how the advancements of biological information and the uses of technological devices influence, control or determine societal and the natural world aspects.

1.3.1: Impacts of biology on the society and the natural world

Impacts of biology on the society and the natural world arise from the advancement of biological knowledge and productions of tools or equipment for uses in various areas services.

The application of tools in different services causes either positive or negative impacts or influences.

Examples of positive impacts:

1. Application of biological knowledge to increase food productivity ensures food security.
2. The knowledge of medicaments and disease treatments has improved health care and longevity (positive).
3. Advancing in understanding biological sciences enhanced in achieving better supply of energy and clean water (positive).
4. The knowledge of microbial action led to the increase in industrial production.

There are also negative impacts.

1. Biological weapon production and uses destroys the natural world
2. Predetermining sex to have boys (XY males) or (XX females) of child sex chromosomes affects the society and the natural world by the loss of females or males

1.3.2: Impacts of technology on the society and the natural world

Applications of technological products for solving problems in various fields of societal and environmental situation have either negative or positive influences.

☞ Industrialization and subsequent technological advancements have resulted in the misuse and destruction of our natural environment and damaged the natural world.

Examples:

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

Activity 1.5: Learning from professionals

Objective: learn through visit

Procedure

Find a nearby health and agricultural professionals and learn

1. The impacts of biology on the society and the natural world.
2. The impacts of technology on the society and the natural world.
3. The positive and negative effects of technology and biology.

🛠 Section 1.3 Self-test exercises

1. Explain impacts of biology and technology on society and the natural world
2. Describe the relationships between biology and technology.

☑ **Checklist**

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can describe the impacts of biology and technology on the society and nature ----------☐
2. I can explain the relationships between biology and technology --☐
3. I can determine the negative and positive impacts of biology and technology on the society and nature ----------☐

Dear learner, now you have successfully completed section 1.3 and ready to proceed to section 1.4 that deals with Ethical issues of biology. This section addresses questions related to the ethicality and unethicality of researching animals and plants particularly focusing on a human being.

Section 1.4 Ethical issues in Biology

Learning competencies

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

- Define ethical issues in biology
- Explain ethical issues in medicaments
- Recognize ethical issues in biology

Self-Questioning

Dear learner, before starting this section, you will need to ask yourself the following question:

"What do I know about ethics in biological studies and what do I want to learn from this section?"

Dear learner, think of the dilemmas of rightness or wrongness issues of biology

Ethical issues in biology are concerns arising from the rightness or wrongness of using biological discoveries on the health and wellbeing of humans.

Ethical issues of biology also deal with a variety of questions related to uses of biotechnological tools, medicine and the environment.

☞ Ethical issues of biology includes the rightness or wrongness of using biotechnological information, products or devices on human health lifestyles and livelihood systems and the ethical treatments of plants and animals during biological studies.

1.4.1: Ethical treatment of plants and animals

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

1.4.1.1: Ethical treatment of plants

Plants are the primary producers for all living organisms (consumers) and function in **decentralized** forms or without any centralized order-providing unit like a **brain** from which humans can learn numberless ideas.

Dear learner, have you ever sat under the shadow of a tree for breath; if so, what was your feeling?

Subjecting plants to severe life-treating conditions and rigorous tests could lead to a total disappearance of species. Collecting seeds, berries, roots, leaves, cutting trees, bark or flowers for personal uses, medicaments and other purposes can affect the survival of species and the community that depends on them.

☞ Trees can give shadow even for an axe-man

Planting trees is depositing national fund and addressing ethical issues of the civilized society.

Examples:

- Testing seeds or berries using destructive rays.
- Cutting tree terminals or pricking seedlings for experiments.
- Consumption of all seeds and fruits without conservation.
- Unplanned cutting of trees, burning forests or deforestation.
- Restructuring the shapes of trees for personal interest and aesthetics.

Activity 1.6: Learning from foresters

Objective: Learning through visit

Procedure

Discuss the following issues with plant science professionals:

1. Unethical treatments of plants being practiced by human beings.
2. Respecting the physical and biological materials of plants.
3. Unethical uses of seeds, leaves, roots, twigs or barks of plant species.

Self-test exercises

1. What is the difference between ethical and unethical issue in plants?
2. How do the organ systems of plants function?

1.4.1.2: Ethical treatment of animals

Ethical treatment of animals is concerned with the life of animals in the process of subjecting to rigorous tests and experiments. Animals are sentient creatures that possess nervous systems and painful feelings, emotional stress and shocking values.

An unethical treatment of animals in researches is approaches exposing animals to rigorous experimental test that affect, deform or threaten the life of animals.

☞Biological studies of animals must avoid unethical treatments and reduce the suffering of research animals using the three "**R**" principles called **Reduction**, **Refinement** and **Replacement**.

1. **Reduction** is to minimize the number of animals used in experiments by improving experimental techniques and sharing information with other researchers.

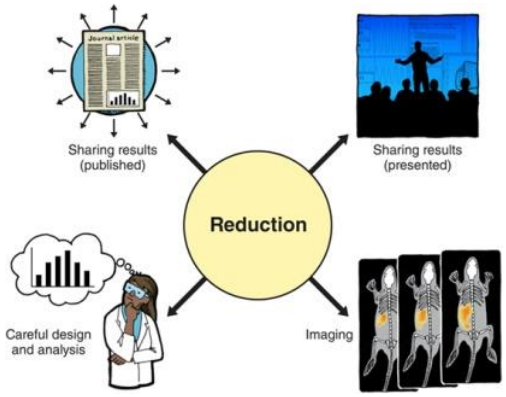


Figure 1.15 Reduction of experiment animals

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

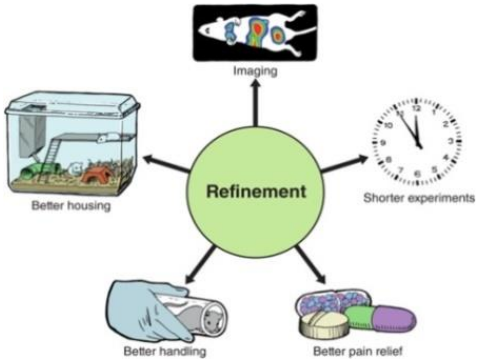


Figure 1.16 Refinement principles of experiment in animals

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

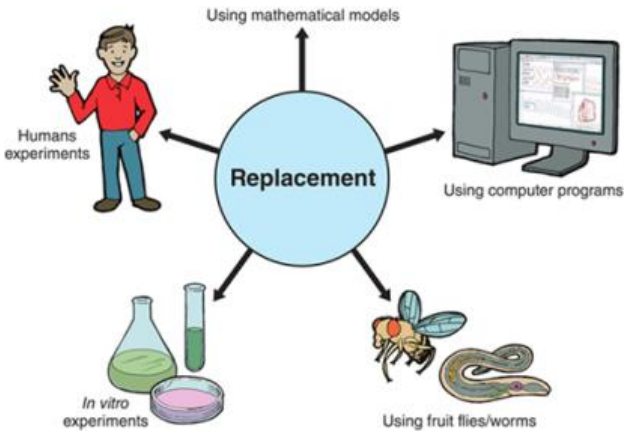


Figure 1.17 Replacement principles of experiment in animals

Activity 1.7: Learning from zoologists

Objective: Learning through visit

Procedure

Discuss the following issues with animal science professionals:

1. Conservation of animals as sentient creatures.
2. Reduction of suffering of animals in research.
3. Habitat, species and ecosystem balance.

Section 1.4 self-assessment questions

1. What are ethical issues in biology?
2. What is a decentralized form of organ systems in plants?
3. What are the three "Rs" in conducting research on animals?

Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can define ethical issues in biology ----------☐
2. I can explain ethical issues in medicaments ----------☐
3. I recognize ethical issues in biology----------☐

Resources

1. www.bioethical.issues.com

Unit one summary

- Learning from nature is a unique educational process to develop skills and acquire knowledge. Learning from nature is an access to nature to provide with health and well-being. Imitation or biomimetic is emulation of the models, systems and technologies using the elements of nature for solving complex human problems. Biology is the study of life science and technology is the sum total of techniques, skills, methods and processes used in the production of goods or services to accomplish objectives.
- Biology and technology are blended to form biotechnology in which technology is based on biology that harnesses cellular and bimolecular processes to develop technologies. Impacts of biology and technology on the society and the natural world deal with the positive and negative effects of technologies imitated from biological systems.
- Ethical issues in biology is the subject concerned with respecting values of all life forms, particularly considering the question of human rights to live naturally, freely and equally. It deals with questions related to ethicality, unethicality, immorality, illegality, inequality, injustice and disrespectful acts to the values of humans.
- The ethicality also worried about commercialization and commodification of human organs, assisted reproduction techniques and manipulation of basic biological organ systems. The ethics of researches and experiments on plants and animals or any parts is considered with respect to ethicality of their right to exist or live freely in the free natural world.

Unit one: Self-exercises

General instructions

Dear learner, conduct self-studies and answer all activities, self-test exercises, review questions and check your responses against the answer Keys provided.

Part I. True or False questions

Instructions: write "True" if the statement is correct and "False if the statement is NOT correct.

1. Humans did not imitate robot from insects.
2. Biotechnology helps to enhance human health
3. Injection Syringe was imitated from mosquitoes' Proboscis.
4. Nature is a reliable source of knowledge and ideas.
5. Modern technological instruments have learnt from nature.
6. Animals are sentient creatures that have the capacity to feel pain.
7. Plants have do not have brains and have decentralized form of organ systems.
8. Reduction to minimize the number of animals used in experiments is an ethical treatment.

Part II. Multiple-choice questions

Instructions: Choose the correct answer among the alternatives given and write the letter of your choice on the space provided.

1. A technology that utilizes Biological systems to develop different products.
   A. Engineering technology
   B. Biology
   C. Biotechnology
   D. A and B
2. A study of how naturally occurring compounds produced in a cell is
   A. Environmental biology
   B. Plant biology
   C. Synthetic biology
   D. Animal biology
3. An imaging technological device used to check for diseases in the human body.

A. PET scan C. Microscope

B. CIT scan D. X-ray

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

A. Biology C. Technology

B. Biochemistry D. Genetic engineering

5. Which one of the following is the negative impact of biological advancement?

A. Production of biological weapons

B. Ensuring food security

C. Production of medicines

D. All of the above

6. A tool used to meter the level of blood sugar is _____.

A. Microscope B, Meter C. The diabetic test D. CT scan

7. Which of the followings are industrial wastes?

A. Vehicle wastes C. Air pollutions

B. House wastes D. Effluents

8. Which one of the following is the effect of soil fertilizers?

A. Toxicity C. Eutrophication

B. Biohazards D. All

9. It is possible to design technologies from nature through

A. Sketching C. Drawing

B. Imitation D. Photographing

10. Animals have all of the following except_____

A. Centralized function systems C. Decentralized function systems

B. Brain led functional systems D. A and B

III. Short Answer questions

Instructions: give short answer for the following questions on your work book.

1. **List five natural sources from which the following technologies were imitated.**

1.1 Camera

1.2 Airplane

1.3 Housing technology

1.4 Lotus temple of India

1.5 Beijing national stadium

2. List five technological tools that serve in biological systems.

2.1 _____

2.3 _____

1.3 _____

1.4 _____

2.5 _____

IV. Essay questions

1. Explain the interconnection between biology and technology. Support your argument with examples from the local context.
2. Suggest a method/technique that enables us to make industrial wastes important resource for our agricultural activities?
3. Discuss the impact of soil fertilizer on agricultural production in your local area.

🗝 1.7 Feedback to unit one self-assessment activities

Dear learner,

Read the feedback and check against your answers in order to identify to what extent you have achieved so far.

🛠 Feedback to section 1.1 Self-test exercises

Multiple choices

1. C 2. B

Short answer

1. How can we learn from it?

Nature is collectively the phenomena of the physical world including plants, animals, the landscape and other features and products of the earth. We learn from the nature through imitation.

2. Define the term imitation.

Imitation is the action of using someone or something as a model. It is mimicking (copying) the natural biological systems.

3. Find sources from which technologies were imitated.

Biological sources	Imitated technologies
Beehive comb	Hexagonal structures
Bombardier beetle	A brand new drone design
Water bear masking	Techniques for preserving live vaccines
Maple seed flight	Powerful repellent spray inspired
Animal teeth	Cutting saw

Feedback to section 1.2 self-test exercises

Multiple choices

1. D 2. A

Short answer

1. What is technology?

Technology is the application of scientific knowledge to the practical aims of human life.

2. What is the role of biotechnology?

Biotechnology is concerned with the exploitation or processing of biological agents (living or dead) or their components (cells, tissues) or constituents (enzymes, proteins, toxins) with the application of scientific engineering principles to generate useful products or services to enhance human welfare.

3. What is a pregnancy urine test and how do we use it?

A pregnancy urine test is used to detect the amount of the hormone: *Human Chorionic Gonadotropin (HCG),* produced in the placenta around six to ten days after **fertilization** in the urine (pee). When a second line is seen next to the control line conform a positive result showing that the woman is pregnant and if it remains as a single line, it confirms that it is negative or the woman is not pregnant.

Feedback to section 1.3 self-test exercises

1. **Explain impacts of biology and technology on the society and nature.**
   - The positive impact of technology on the environment is **the development of environmental technology** like the renewable energy or clean energy, smart technology to save the energy consumption, electric vehicles to limit carbon emissions and carbon dioxide removal.
   - Technology is drastically changing our means of communication, the way we work, our housing, clothes and food, our methods of transportation and even the length and quality of life or changes in moral values and basic philosophies of mankind.

2. **Describe the relationships between biology and technology.**

   The relationship is the integration of natural engineering and sciences. Technological advances are inspired by biological systems to develop a method to tackle biological problems.

   Example

   Synthetic biology is the application of biology, technology and engineering to facilitate and accelerate design, manufacture and/or modify genetic materials in living organisms.

Feedback to section 1.4 self-test exercises

1. **What are ethical issues in biology?**

   Ethical issues in biology are concerns arising from the rightness or wrongness of using biological discoveries on the health and wellbeing of humans.

2. **What is a decentralized form organ systems in plants?**

   The plant organ systems function without a central order providing or brain as a decentralized form.

3. **What are the three "Rs" in conducting research on animals?**

The three "**R**" are principles of **Reduction**, **Refinement** and **Replacement** set to reduce or alleviate the suffering of animals during researches.

🗝 1.8 Answer Keys to unit one self-exercise review questions

Dear learner, look at the answer keys to unit one review questions and check them against your answer to identify to what extent you have achieved so far.

I. True or False questions

No	Answer	No	Answer	No	Answer	No	Answer
1	True	3	False	5	True	7	True
2	True	4	True	6	True	8	True

II. Multiple choice questions

No	Answer	No	Answer	No	Answer	No	Answer	No	Answer
1	C	3	A	5	A	7	D	9	B
2	C	4	C	6	C	8	D	10	C

III. Short answer questions

Dear learner, the open ended question can have more than one answer. Think over and search for more answers and do not limit your ability to learn just taking only the above given feedback.

1. List five sources from which listed technologies imitated.

1.1 Camera

1.2 Airplane

1.3 Housing technology

1.4 Lotus temple of India

1.5 Beijing national stadium

2. List five technologies that serve in biological systems

1.1 Thermometer

1.2 Microscope

1.3 Pregnancy urine test kit

1.4 GPS

1.5 CIT Scan

IV. Essay questions

1. **Explain the interconnection between biology and technology.**

   The combined application of biology and technology is called biotechnology. It is a technology based on biology that connects cellular and bimolecular processes to develop technologies and products that help to improve our lives and the health of our planet. Humans have used biological processes of microorganisms for more than 6000 years to make useful food products (bread and cheese) and to preserve dairy products.

   Examples: Breads, local drinks etc.

2. **Suggest a method/technique to make industrial wastes important resource for our agricultural activities?**
   - Bio-wastes such as rice husks, cereal wastes, potato, onion, mango or fruit peels and coffee wastes enrich soil fertility and improve productivities.
   - Industrial wastes such as sugarcane molasses are used as fertilizers and other purposes.
   - Agro-industrial wastes used for manufacturing of biofuels, enzymes, vitamins, antioxidants, animal feed, antibiotics and other chemicals through solid state fermentation.
3. **Discuss the impact of soil fertilizer on agricultural production in your local area with examples.**

   The overuse of chemical fertilizer can lead to soil **acidification** and **soil crust** that reduce the content of organic matter, humus content and beneficial species, stunting plant growth, altering the pH of the soil, growing pests and even leading to the release of greenhouse gases.

Assignments (10%)

Dear learner,

The following are the end of unit one assignments. Attempt all the questions and submit them to the tutorial center during tutorial time.

Name _____

Id No. _____

Region/city_____ **Zone** _____

Tutorial center_____

Instruction: answer each of the following questions

1. **There are several benefits of biotechnological products.**
   1.1 List ten popular biotechnological instruments used in Ethiopia.
2. **Many farmers around the world use agricultural biotechnology.**
   2.1 What are the reasons for using agricultural biotechnology?
   2.2 How does biotechnology help to feed the world?
3. **What are bioethical issues?**
   3.1 List at least five ethical issues in biology.
   3.2 Describe ethical issues in conducting research on plants and animals.

Unit Introduction

Dear learner,

We hope you have successfully completed studying the first unit which was about biology, technology and society. In this unit, you are going to learn about animals. Animals are one of the largest groups of organisms in the world. Studying animals is very important from different perspectives. For example, it is important to improve the health and well-being of human beings and animals, to increase the productivity of farm and other animals, to preserve, protect and manage animal species and understand the life processes of animal species.

Although animals are diverse, they also have common characteristics. This unit provides you with a review of the characteristics of animals and details of reproduction, economic importance, behaviour and homeostasis in animals. Finally, this unit will highlight the education and life experience of some Ethiopian zoologists who have notably contributed in the field of zoology. We, therefore, designed the unit that consists of seven sections providing you with comprehensive explanations about animals. The time required to study this module is 17 hours

I hope you will enjoy learning these interesting and important topics about animals.

Unit learning outcomes

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

- Describe the characteristics of animals.
- Differentiate between vertebrates and invertebrates
- Compare and contrast reproduction in vertebrates.
- Evaluate the economic importance of animals (insects) in agriculture, food, industry, health, and medicine
- Explain animal behavior
- Discuss the types and patterns of animal behavior
- Discuss homeostasis in animals: thermoregulation, osmoregulation and sugar balance
- Appreciate the work of a renowned zoologist in Ethiopia or in your locality

Content

3.2.4: Reproduction in Birds

3.2.5: Reproduction in rat

Section 4: The economic importance of animals (Insects)

4.1: Beneficial insects

4.2: Harmful insects

Section 5: Animal Behavior

5.1: Types of Animal Behavior

5.2: Patterns of Behavior

Section 6: Homeostasis in animals

6.1: Thermoregulation

6.2: Osmoregulation

6.3: Blood Sugar Regulation

6.4: Control of Homeostasis

Section 7: Renowned Zoologists in Ethiopia

Unit Learning Strategies

Dear learner, to effectively learn this unit, you will need to use the following strategies.

1. Observe your surroundings and read about animals and reflect on their common characteristics, and differentiate them into vertebrates and invertebrates.
2. Gather information on the reproduction of rats, birds, frogs and crocodiles, and summarize the information obtained on the reproduction mechanisms of each animal.
3. Study and compare complete and incomplete metamorphoses in insects (with examples) by drawing and labeling diagrams.
4. Study about insects and mention the advantages and disadvantages of insects in agriculture, food, industry, health, and medicine.

5. Brainstorm on animal behavior and types of animal behavior.
6. Study about animal behavior and describe the behavior of at least one animal that is commonly known in your locality, and let you decide whether that behavior is innate or learned.
7. Read books and explain the different patterns of animal behaviors (e.g. courtship)

8. Read books about the different mechanisms of animal body condition regulation (e.g., heat regulation in a dog), and definehomeostasis
9. Read this unit and search from a library or the internet about poikilothermic and homeothermic animals (taking representative examples of each); the physiologicaladaptation of homeotherms and write a summary of each.

The Required Study Time- 25 hours

Section 1: Characteristics of animals

Dear learner,

Think about all the animals in your environment. They may be domestic animals, wild animals, or animals in zoos and in sanctuaries. There are diverse groups of animals with different characteristics in the world. This section provides you with a review of the major characteristics of animals in relation to cell type and organization, reproduction, nutrition, growth, response to environment, etc with examples.

Learning Competencies

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

- List the characteristics of animals
- Explain the common characteristics of animals

Self-Questioning 

Dear learner,

Before starting this section, ask yourself the following question.

"What Characteristics of animals do I know. and what do I want to learn from this section?"

Well, some of the characteristics of animals include: eukaryote, multicellular, heterotrophs, sensitive to stimuli. They can reproduce, protect themselves, move, respire, excrete, grow, and have different body symmetries.

Can you explain the above characteristics of animals?

We hope that you can! Explanations of some of these characteristics are presented below and others are given as an activity for you later in this section.

- **Eukaryotic:** animals are organisms that have cells with membrane-bounded organelles such as the nucleus, mitochondria, and Golgi bodies.
- **Multicellularity:** Animals are multicellular organisms composed of more than one cell. This enables animals to have cellular specialization and division of labor that makes cells more efficient in performing life processes.
- **Growth**: Animals grow until they reach adulthood. Their skeletons, muscles, and body systems grow over time. They can permanently increase their size or mass by increasing the number or size of their cells.

- **Reproduction**: Animals reproduce through sexual and asexual reproduction systems to perpetuate their generations. Some invertebrates reproduce by asexual reproduction through budding or fission, which involves one individual. Most animals reproduce by sexual reproduction, which involves two individuals (male and female).
- **Body symmetry**: The most primitive animals have asymmetrical body structures (no body axis and no plane of symmetry, e.g., sponges) but most animals have bilaterally symmetrical body structures. While there are also some animals with radially symmetrical body structures, some of them do not have symmetry (See Figure 2.1).

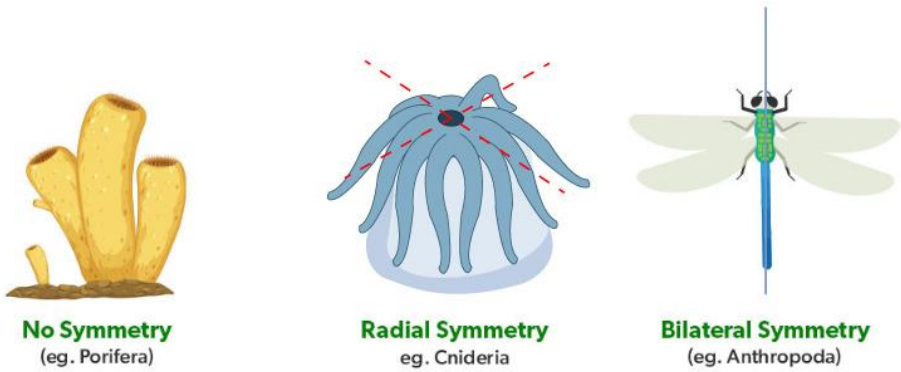


Figure 2.1. Body symmetry in animals

Inquiry activity 1.1 Studying the characteristics of animals

Direction: Dear learner, Describe the following characteristics of animals referring from nearby school library and the internet or consulting with a teacher teaching in a nearby school using the table below.

Characteristics	**Description**
Sensitive to Stimuli	
Protect themselves	
Excrete	
Respiration	
Nutrition	

Based on the presence or absence of a backbone, animals can be categorized into two major groups. These are vertebrates and invertebrates. Vertebrates are further classified into homeothermic (warm-blooded) animals that include mammals and birds, and poikilothermic (cold-blooded) animals that include fish, reptiles, and amphibians.

Dear learner, what is the differenc between homeothermic (warm-blooded) animals and poikilothermic (cold-blooded)? Can you answer? If nor do not worry, here is the definition and you will learn details in the last section of this unit.

☞ Homeothermic (warm-blooded) animals are animals that can keep their body temperature though temperature in their surroundings varies. Whereas, Poikilothermic (cold-blooded) are animals that cannot keep their body temperature and their body temperature varies depending on their

surroundings.

Invertebrates are also classified into porifera, platyhelminthes, cnidaria, arthropoda, Annelida, echinidermata, and mollusca. Arthropods are again classified into crustacea, spiders, insects, and many-legs as shown below (Figure 2.1).

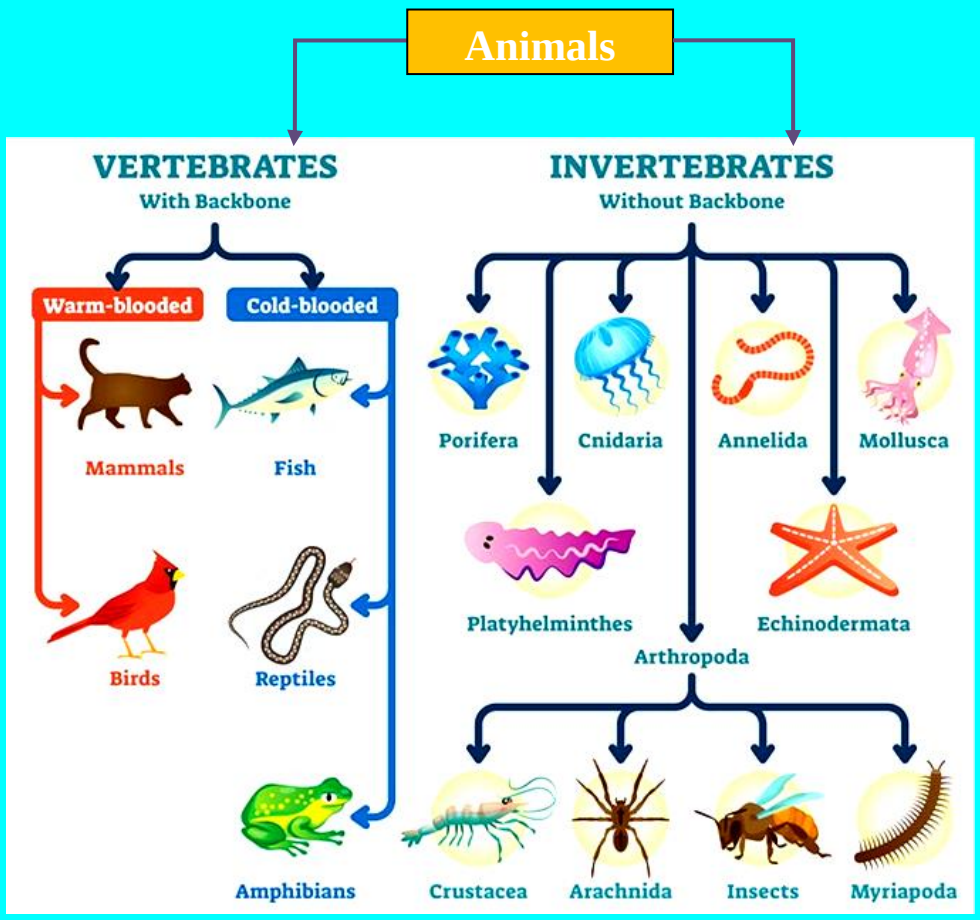


Figure 2.1 Classifications of animals

It is difficult to discuss all of these groups in detail in this unit. Therefore, we will focus on the general characteristics and reproductive cycles of the two major groups, invertebrates and vertebrates, using some examples from mammals, birds, reptiles, amphibians and insects.

🛠 Section 1 self- test exercise 1.1

I. Multiple-choice questions

Instructions: Choose the correct answer among the alternatives given for each of the following questions.

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

A. Autotrophs C. Multicellular

B. Reproduce D. Heterotrophs

2. In the body organization pattern of an animal, the body doesn't have any specific pattern of arrangement it is called:

A. Radial symmetry C. Asymmetry

B. Bilateral symmetry D. All of the above

A. Short Answer

Instructions: give short answer for the following questions on your work book.

1. What are heterotrophic organisms?
2. How do you explain the difference between eukaryotes and prokaryotes?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can list the characteristics of animals ---------- ☐
2. I can explain the common characteristics of animals ---------- ☐

Section 2: Invertebrates and Vertebrates

Dear learner, in section one, you have learned about some common characteristics of animals. However, you have also learned that they have characteristics that distinguish one group from another. Therefore, based on the presence or absence of a backbone, animals can be categorized into two major groups. These are vertebrates and invertebrates animals.

This section is aimed at discussing the major characteristics that distinguish the two major groups of animals: invertebrates and vertebrate animals using some examples.

Learning Competencies

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

- List the main characteristics of invertebrates and vertebrates.
- Compare invertebrates with vertebrates' characteristics.

Self-questioning 

Dear learner, before starting this section, ask yourself the following question.

"What do I know about vertebrates and invertebrates, and what do I want to learn from this section?"

Well, the following subsections will give you brief descriptions about the two groups of animals.

2.1: Invertebrate Animals

Dear learner, if you tried to answer the above question in such a way that invertebrates are animals that do not have backbone or vertebral column, you are correct. These groups of animals are the most diverse groups of animals in the world. They are found almost everywhere ranging from the hottest deserts and the deepest sea beds to the darkest caves and the highest mountains.

Moreover, if you tried to describe invertebrates as they are animals that lack rigid internal skeletal system, you did it very well. While many invertebrates are soft-bodied, some of them have an external skeleton called an exoskeleton,

usually made of chitin, which protects their soft inner bodies. Invertebrates are cold-blooded, and hence, do not regulate their body temperature. This group includes earthworms, insects, spiders, snails, sponges, jellyfish, lobsters, crabs, sea stars, and squid.

2.2: Vertebrate Animals

How do vertebrates differ from invertebrates?

Dear learner, having the description of invertebrates in mind, thinks of vertebrates. If you are thinking and describing vertebrates as the most advanced groups in the animal kingdom, having highly diverse group of animals and possessing a well-defined internal skeleton system with cartilage and a backbone or vertebral column separated into an axial skeleton (skull, vertebrae, ribs and sternum) and appendicular skeleton (girdles and appendages), definitely, your are cleaver.

☞ The skull and vertebrae protect the highly developed brain and the nerve cord respectively.

Vertebrates have more complex and specialized organ systems such as the circulatory systems, respiratory systems, nervous systems and excretory systems.

The circulatory system is a closed system with a ventral heart having 2-4 chambers and a median dorsal artery. The respiratory system consists of either gills or lungs. They have a centralized nervous system with a brain and sensory organs (eyes, ears, nostrils). The excretory systems of vertebrates consist of paired kidneys. They have bilaterally symmetrical. This group includes mammals, birds, fish, reptiles, and amphibians. Vertebrates such as fish, reptiles, and amphibians are cold-blooded animals, whereas birds and mammals are warm-blooded animals.

Inquiry activity 2.1 Studying invertebrates and vertebrate

Observe your surroundings and identify invertebrate and vertebrate animals. Then list their common and unique characteristics and compare them using the following features in the table.

Features	Invertebrates	Vertebrates
Backbone		
Exoskeleton		
Body symmetry		
Circulatory system		
Nervous system		

🛠 Section 2 self- test exercise 2.1

I. Multiple-choice questions

Instructions: Choose the correct answer among the alternatives given for each of the following questions.

1. Which of the following is characteristic of vertebrates?
   A. They are cold blooded
   B. They have open circulatory system
   C. They have bilaterally symmetrical body
   D. They have asymmetrical body
2. Which one of the following is not true about Invertebrate animals? They have:
   A. Vertebral column
   B. Exoskeleton
   C. Closed circulatory system
   D. A and C

Short Answer

Instructions: Give short answer/s for the following questions

2. What is the difference between vertebrates and invertebrates?
3. Explain circulatory and nervous systems in vertebrates and invertebrates

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can list the main characteristics of invertebrates and vertebrates. ------☐
2. I can compare invertebrates with vertebrates' characteristics.----------☐

Section 3: Reproduction in Animals

Dear learner, did you remember the characteristics of sexual reproduction in grade 9 unit 5? If yes, well done, if not, do not worry, in this section you will have brief explanation of reproduction of animals. In section two, you have learned that reproduction is one of the major characteristics of animals. Reproduction enables animals to ensure the continuity of their species. Thus, reproduction is the process by which living organisms replicate themselves.

☞There are two types of reproduction in animals. These are **asexual reproduction** and **sexual reproduction.**

Dear learner, think of the difference between these two types of reproduction. Although the majority of animals undergo sexual reproduction and have similar forms of development, a few groups of animals also undergo asexual reproduction. This section provides you insights into asexual reproduction and details of sexual reproduction with examples. The sexual reproduction section focuses on reproduction in insects, frogs, crocodiles, birds and rats.

Learning Competencies

After successful completion this section, you will be able to:

- Examine reproduction in invertebrate and vertebrate animals.
- Discuss complete and incomplete metamorphosis.

- Describe how rats, birds, frogs, and crocodiles reproduce.
- Compare and contrast reproduction in rats, birds, frogs, and crocodiles.

Self-Questioning 

Dear learner, Before starting this section, ask yourself this question: "What do I know about reproduction in animals, and what do I want to learn from this section?"

Well, the following subsections will give you brief descriptions about the reproduction in animals.

3.1: Asexual reproduction in animals

What is asexual reproduction?

Have you answered the question? Well, asexual reproduction is a type of reproduction in which it involves a single individual to bear a new offspring, and hence, it does not require the fusion of gametes from two parents. Asexual reproduction in animals is more common among invertebrates than vertebrates.

☞ Budding and fragmentation are the most common forms of asexual reproduction especially in aquatic animals. The other form of asexual reproduction in animals is parthenogenesis. In this type of reproduction, unfertilized eggs develop into new offspring as in some insects and vertebrates.

3.2: Sexual reproduction in animals

What is sexual reproduction?

Have you answered the question? If so, well done, if not here it is. Sexual reproduction is a type of reproduction in which it involves two individual parents to bear a new offspring, and hence, it requires the fusion of gametes from two parents (male and female). It produces offspring that have genetic material from both parents. Parents in sexual reproduction are diploid organisms with a complete set of chromosomes (2n).

Where are gametes produced?

Sexual reproduction involves different male and female reproductive structures (ovary and testicles) that have different functions. One of the most important functions of ovary and testicles is to produce haploid cells called gametes (n) which are responsible for the transmission of genetic information from parents to offspring during reproduction.

In sexual reproduction, males produce sperm, haploid cells (n), in the testes and the sperm cells are stored in the epididymis until ejaculation. On the other hand, females produce an ovum or egg haploid cell (n) that matures in the ovary. The fusion of sperm cells with female gametes produces a zygote through the process called fertilization. There are two types of fertilization: external and internal.

What is the difference between external and internal fertilization?

In animals that use internal fertilization, eggs are released from the ovary into the uterine tubes for fertilization, but in animals that use external fertilization, eggs are released into the aqueous environment.

The fertilization of an egg by sperm produces a single-celled diploid fertilized egg called a zygote (2n), which develops into an embryo and then into an

individual organism. The general animal life cycle in sexual reproduction is shown below (See Figure 2.2).

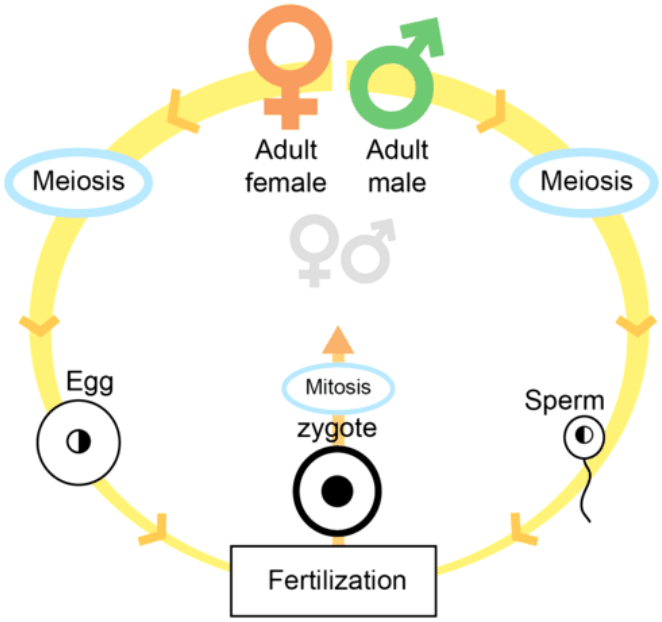


Figure 2.2. Sexual reproduction and the life cycle of animals

How the zygote develops into an adult?

Dear learner, have you answered the question? Well, after fertilization, a series of developmental stages occur in embryonic development (See Figure 2.3). The first stage is cleavage, which involves a series of mitotic cell divisions of the fertilized egg (zygote). This cell division results in an eight-celled structure. The second stage is another cell division and rearrangement of cells into hollow structures called blastulae. Then, the blastula undergoes further cell division and rearrangement with the process called gastrulation.

The process of gastrulation produces a gastrula that has different cell layers called "germ layers". By the process of organogenesis, these germ layers later develop into different tissue types, organs and organ systems. Organogenesis is the formation of organs during embryonic development. The embryo eventually develops into an adult with the formation of all tissue types, organs, and organ systems.

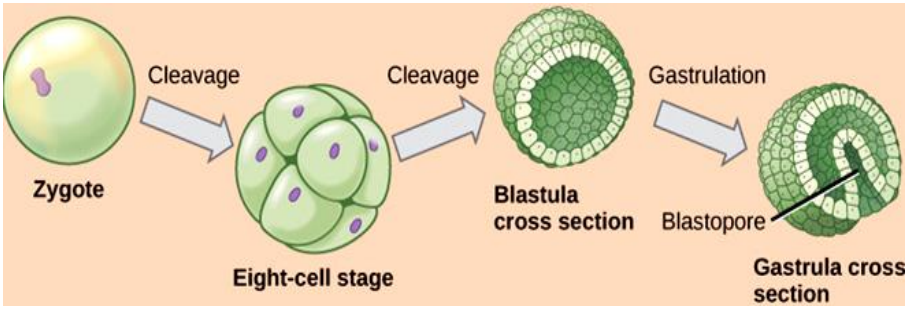


Figure 2.3. Embryonic development

Dear learner, in the above section (section 3.2), you have learned about the meaning of sexual reproduction in general. In the next section, you will specifically learn about sexual reproduction in insects, frogs, crocodiles, birds and rats.

3.2.1: Reproduction in insects (complete and incomplete metamorphosis)

Dear learner, we hope that you are familiar with insects because you can easily observe them in your environment. Insects that constitute the most diverse groups of animals are the largest class of the phylum Arthropoda (the animal phylum). They have segmented bodies, jointed legs and external skeletons (exoskeletons). To mention some of them, insects include flies, grasshoppers, lice, butterflies, bees, and beetles.

☞ Dear learner, how do insects reproduce? Have you answered this question? That is good. Insects undergo sexual reproduction and have their own life cycles. For sexual reproduction to occur, male and female insects have their own reproductive structures.

The following figure shows an example of the male and female reproductive structure of a honeybee (See Figure 2.4 below).

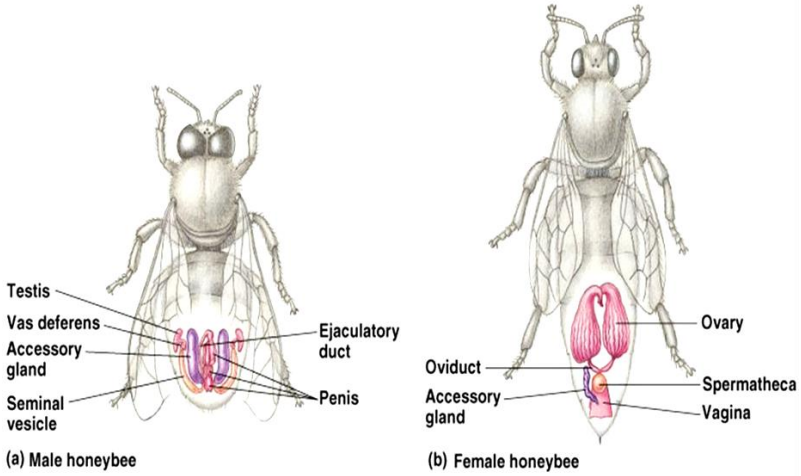


Figure 2.4 Reproductive structures of a honeybee

During sexual reproduction in insects, eggs are usually fertilized internally. However, some insects undergo a process in which an individual develops from unfertilized eggs, and this process is called parthenogenesis.

☞ In sexual reproduction, the male produces sperm and fertilizes the egg produced by the female during mating. After fertilization, the female insect lays eggs and hatches them after completing their development.

What is the difference between complete and incomplete metamorphosis?

After hatching, insects undergo a series of major changes in their body structures as they develop. This series of changes is called metamorphosis.

☞ There are two types of metamorphosis: complete metamorphosis and incomplete metamorphosis (See Figures 2.5 and 2.6 below). Complete metamorphosis has four stages, whereas in complete metamorphosis has three stages.

Dear learner, can you mention these stages? If so, that is nice. The four stages of complete metamorphosis in honeybees, for instance, are **egg, larva, pupa,** and **adult** and the three stages of incomplete metamorphosis in grasshoppers are **egg, nymph,** and **adult.**

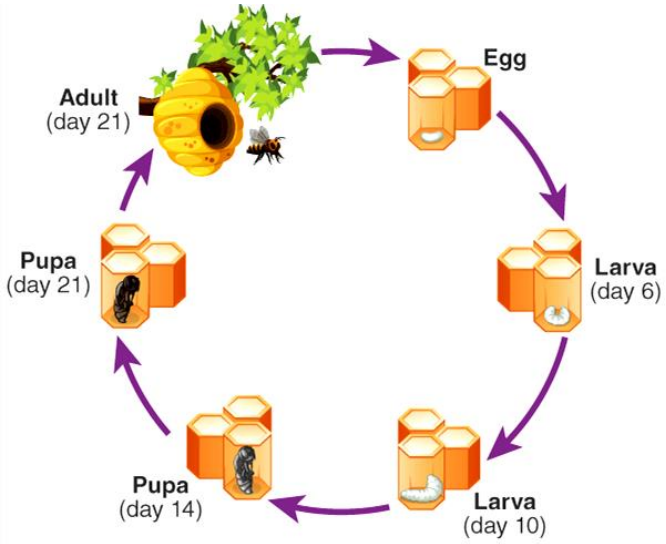


Figure 2.5 Complete metamorphosis in honeybees

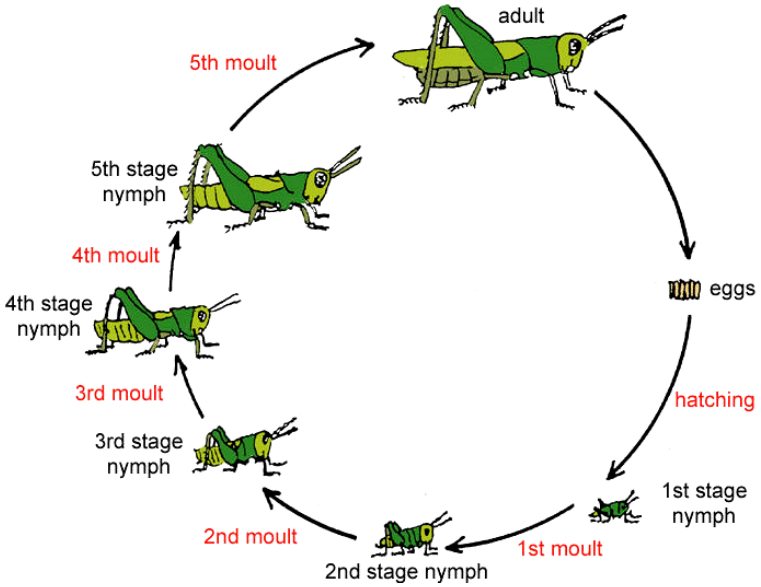


Figure. 2.6 Incomplete metamorphosis in grasshoppers

Inquiry activity 3.1 Studying asexual and sexual reproduction

By using supplementary materials or searching information on the internet:

1. Explain the following forms of asexual reproduction: budding, fragmentation, parthenogenesis with specific examples
2. Why internal fertilization is more advantageous for land animals as compared to aquatic animals?
3. How tissues, organs and organ systems develop from germ layers, discuss and present it during tutorial class.

3.2.2: Reproduction in Frog

Dear learner, it is hoped that you are familiar with frogs. Well, the frog *Rana temoraria* is the most common in Europe. The grass frog *Ptychadena boulenger* is found throughout the sub-Saharan Africa including Ethiopia. Frogs such as *Ptychadena harenna* and *Leptopelis ragazzi* are found in the Bale Mountains and Shoa forests, in Ethiopia.

☞ Frogs undergo sexual reproduction and have male and female reproductive structures.

The following figure shows the male and female reproductive structures in frogs (See Figure 2.7).

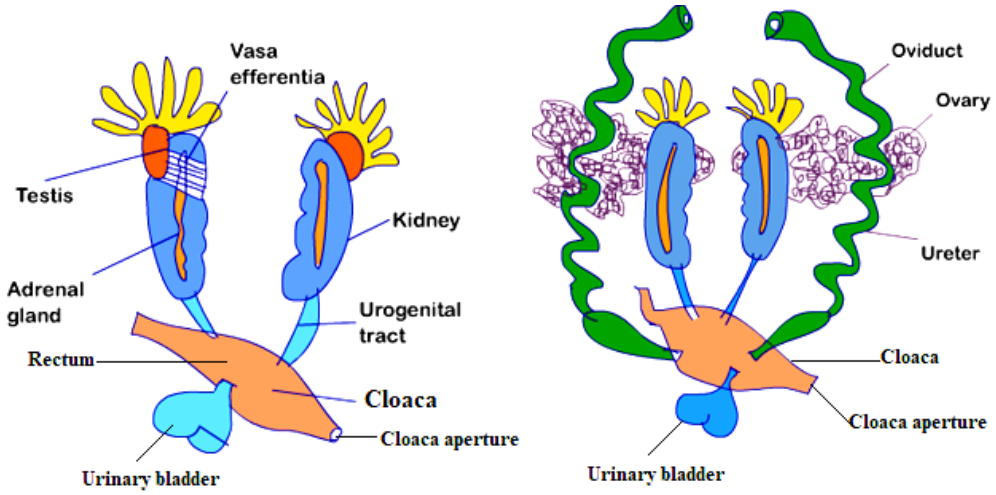


Figure2.7 male (left) and female (right) reproductive structure in frog

Unlike birds, frogs do not produce amniotic eggs. Rather, they are usually covered in a jelly-like substance (Figure 2.8). They must lay their eggs in water to protect them from drying out.

What is the function of the jelly-like substance in frogs?

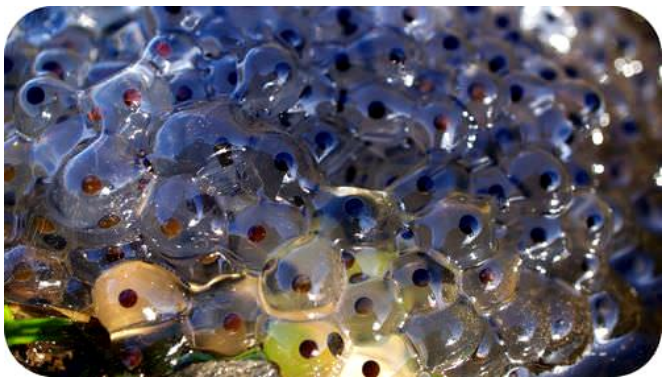


Figure 2.8 Frog Eggs surrounded by "jelly**."**

Dear learner, do you know the type of fertilization in frogs? Very good, frogs have external fertilization. However, internal fertilization also occurs in a few species of frogs. Unlike internal fertilization, in external fertilization, the female releases eggs from her body into the water and the male releases his sperm to fertilize the eggs. Usually, frogs lay a large number of eggs in the same place at the same time. Do you know why? This is to increase the chance of fertilization because they have external fertilization.

In a process called metamorphosis, after the fertilization of an egg by sperm, frogs go through a larval stage that is very different from the adult form. The fertilized eggs develop into a larval stage called a tadpole that is different from the adult frog (See Figure 2.9).

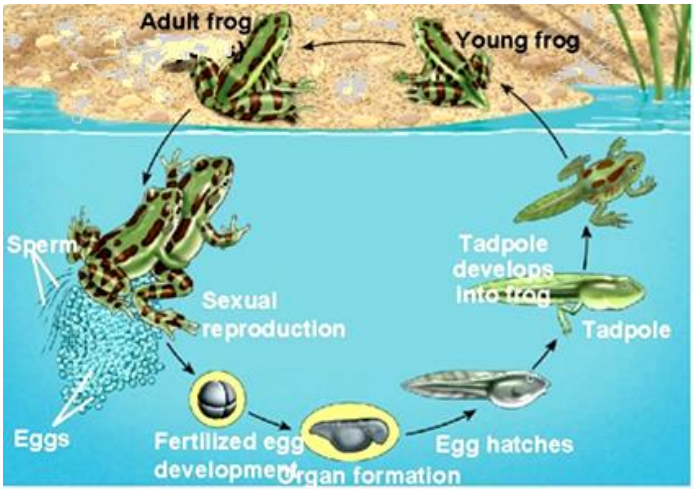


Figure 2.9. The life cycle of a frog

Inquiry activity 3.2 Examining reproduction in frog

Based on the above information and searching from internet, answer the following questions:

1. What is the drawback of external fertilization in frog? How they resolve this problem
2. What is the benefit of laying large number of eggs?

3.2.3: Reproduction in Crocodiles

Dear learner, have you seen a crocodile? We hope! Can you list the characteristics of crocodiles such as snake or lizard? Well, crocodilians are large semi-aquatic reptiles that live in different parts of the world. Crocodiles reproduce sexually involving both male and female parents.

The mating season for crocodiles usually begins in July or August and mating takes place under water. During mating, the sperm fertilizes the egg and

develops in the female. They have internal fertilization. They lay their eggs and bury them in sand or deposit them in mound vegetation.

☞The number of eggs a crocodile deposits varies from 10 to 100, which generally depends on the type of species (See Figure 2.11 below). Unlike frogs, crocodiles have hard, leathery eggs that enable them to protect their young.

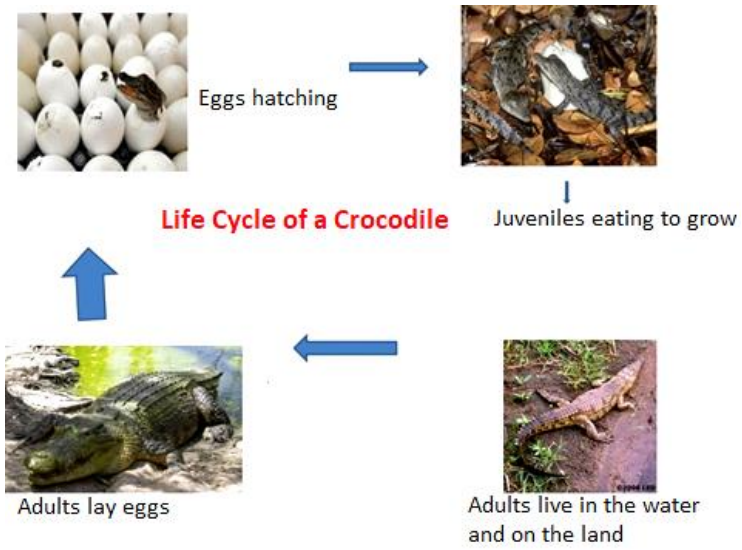


Figure 2.11. The life cycle of a crocodile

3.2.4: Reproduction in Birds

Dear learner, we hope that you are familiar with birds. If you're wondering to know about reproduction in birds, you probably know that chickens that are one of the groups of birds reproduce through laying eggs. Similar to other animals, reproduction in birds is one of the key processes that enable birds to produce new individuals and perpetuate their species.

☞Birds reproduce sexually and have internal fertilization.

The male and female reproductive structures of birds are shown below (See Figure 2.12).

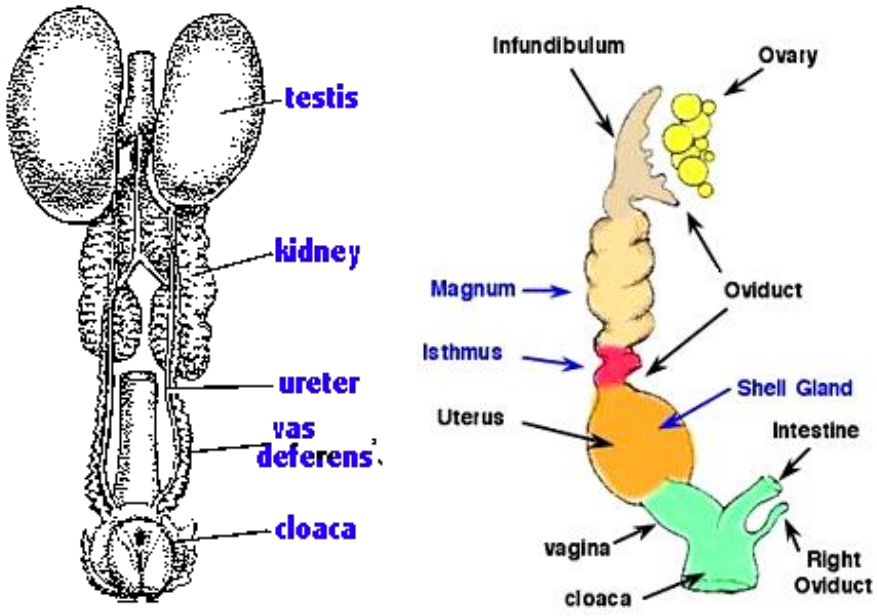


Figure 2.12. The reproductive structures of Male and female birds

Unlike other animals, male birds do not have external genital organs, whereas females have a single ovary.

How does the male transfer the sperm to the female for fertilization to occur?

Both male and female birds have a structure called the cloaca. During mating, the male brings its sperm to the female cloaca to fertilize the egg.

Reproduction in birds starts when an egg or ovum joins with a sperm cell in the oviduct. The ovum which is produced in the ovary travels down through the oviduct for fertilization to occur. The oviduct consists of the infundibulum, magnum, isthmus, uterus, and vagina (See Table 1 below).

Table 2.1 Parts of an oviduct and their functions

Parts of the oviduct	**Nature and Functions**
Infundibulum	• A funnel-shaped upper portion of the oviduct • Its purpose is to search out and engulf the yolk, causing it to enter the oviduct.
Magnum	• It is the longest part of the oviduct. • Its purpose is to secret albumen: nearly all the egg white is deposited in the magnum.
Isthmus	• It is the relatively short portion of the oviduct • Formation of shell membrane inner and outer shell membranes • The glands of the isthmus produce sulfur-containing amino acids that are important for shell membrane formation.
Uterus	• The development of an egg takes a longer period of time. • An eggshell is formed over shell membranes in the uterus.
Vagina	• The final section of the oviduct is the vagina, which is separated by a sphincter located between the uterus and the vagina • During oviposition, relaxation of the muscles allows the egg to leave the uterus where it is almost immediately laid through the cloaca.

The fertilized egg travels down to the uterus, forming a layer of albumen around it, which is followed by the shell membranes in the uterus (See Figure 2.13 below). Then, the hard-shelled egg develops inside the female with a fluid-filled amnion, a thin membrane that forms a closed sac around the embryo.

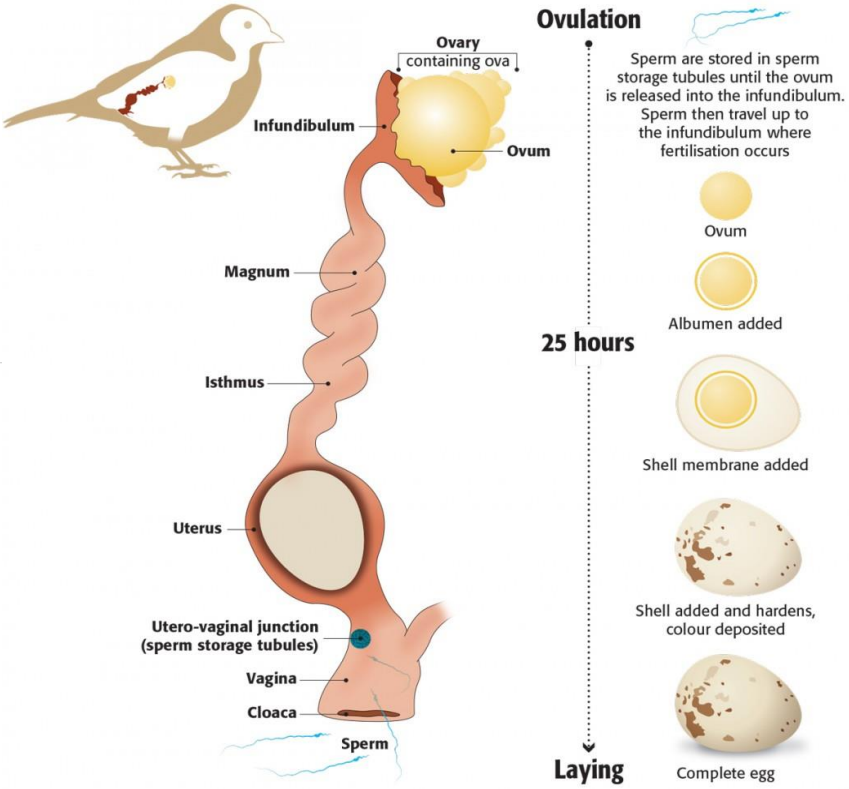


Figure 2.13. The structure of the oviduct and egg development in bird reproduction

Birds lay eggs after the egg completes its development. Depending on its species, the number of eggs a bird lays varies from a few to more than 10. For example, penguins and albatrosses lay few eggs, but chickens and ducks can lay more than 10 eggs. The egg of a bird has different parts. The four major parts of the egg of a bird are the yolk, the albumen, the membranes, and the shell (See Figure 2.14 below).

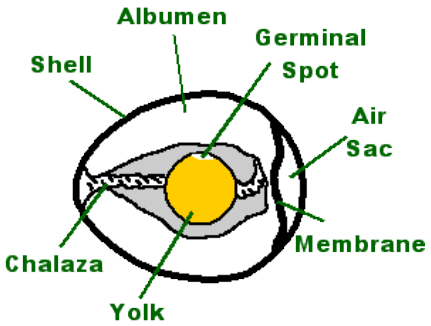


Figure 2.14 The egg structure of a bird

Inquiry activity 3.3 examining chicken egg

1. Find a chicken egg and examine its structures, and compare with the figure given above.

3.2.5: Reproduction in rat

Dear learner, It is hoped that you are familiar with rats. They live everywhere that human populations have settled in. Rat (genus *Rattus*) is the name generally applied to numerous members of several rodent families. The black rat (*Rattus rattus*) and the brown rat (*Rattus norvegicus*) are among the most common types of rats species. The black rats predominantly live in warmer climates, and the brown rats are dominantly found in the temperate regions. Giant Mole rat (*Tachyoryctes macrocephalus*), also known as the giant root rat, is endemic to Ethiopia where it is confined to high altitude shrub and grasslands in the Afro-alpine habitat such as the Bale Mountains.

Do you know reproduction in rats is a representative of mammalian sexual reproduction? If your answer is yes, you are right.

☞The male reproductive structure of a rat consists of testes (singular testis), scrotum seminiferous tubules, epididymis, vasdeferens and penis with bacula. Similarly, the female reproductive structure of a rat consists of two ovaries, oviducts, uterine horns and vagina with vulva.

The following figures show the female reproductive structure (Figure 15a) and the female reproductive structure (Figure 15b)of a rat.

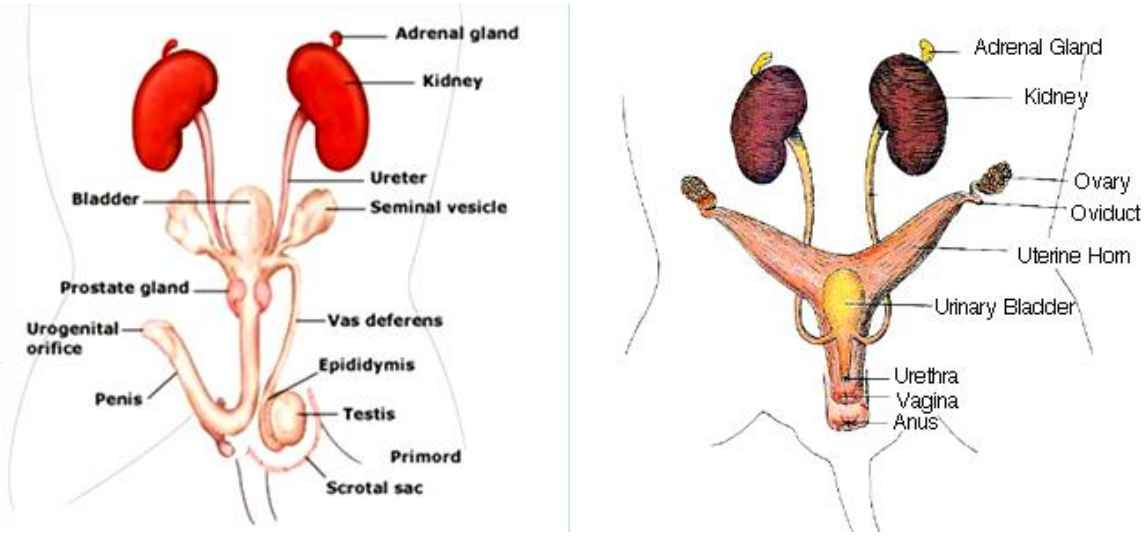


Figure.2.15. Reproductive system in rat, male (left) and female (right)

Similar to other mammals, fertilization of an egg occurs inside the female, and the fertilized zygotes develop in the mother during a gestation period known as pregnancy.

What is gestation period?

Pregnancy and Development: Depending on the species, the average pregnancy time or gestation period of a rat varies. The gestation period for a brown rat is 22 to 24 days, whereas the gestation period for black rats is usually 22 days and the gestation period for giant mole rats is 37-49 days.

☞ After fertilization, each zygote begins to divide and form a hollow ball of cells that further develops into a blastocyst called a blastula. The blastulas travel down the oviducts, implant in the uterine horns, and begin to differentiate into embryonic tissue and extra-embryonic tissue.

The embryo is nourished from the mother through a complex system of connecting blood vessels called the umbilical cord. The placenta transports oxygen from the mother to the embryo and removes waste from the

embryo's environment, whereas the amniotic sac protects the embryo during pregnancy.

Gradually, the embryo forms a neural plate, which later develops into brain and spinal cord. Then, the arm and leg buds become visible, the nervous system pathways develop and the rat gives birth to hairless, deaf with sealed eyelids offspring (See Figure 2.16 below).

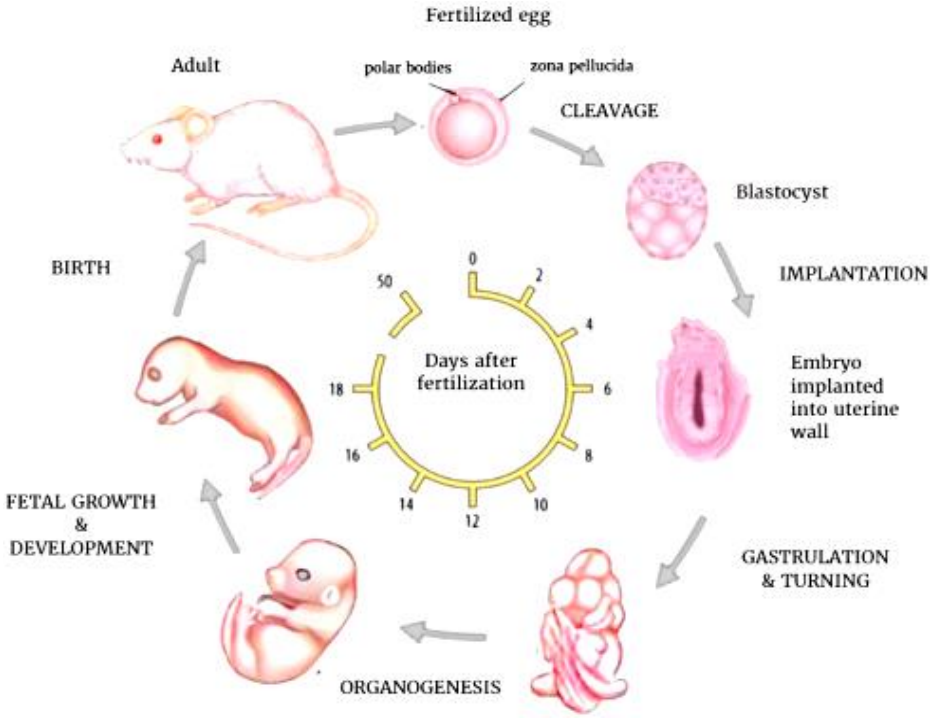


Figure 2.16. Pregnancy and development in rat

How many offspring can a rat produce at once?

Drear learner, have you seen a rat with her offspring and have you ever counted them? That is good, rats normally give birth from 7 to 12 offspring per litter on average (See Figure 2.20), but the number is fewer than this for giant mole rats. The mother feeds milk and after 45 days, the young rats are fully weaned and actively start foraging and feeding.

The age of sexual maturity also vary depending on species. In brown-black rats, the age of sexual maturity is 3–4 months old. Giant mole rats become reproductively mature when they are 4-6 months old.

Parental care in rats: Parental care in mammals is often critical for the survival and development of the offspring. Rats build nests to rear their young called pups or kittens. The pups stay in the nest built by their mother until they are weaned. Female rats care pups regardless of which their true mothers are. If a mother dies, the other females will take over nursing her pups. Male rats do not participate in the parental care.

Figure 2.17 Parental care in rat

Inquiry activity 3.4

Dear learner, search from a library, the internet or other sources to answer the following questions.

1. What is the significant difference between monogamous and polygamous species in birds?
2. Why do you think are eggs laid in so many different colors?
3. What are camouflaged eggs? How does this help to protect the eggs?
4. What advancement did you notice from frogs to rats in reproduction, for instance, in terms of reproductive structure, fertilization and development, etc.

🛠 Section 3 self- test exercise 3.1

I. Multiple-choice questions

Instructions: Choose the correct answer among the alternatives given for each of the following questions.

1. Which one of the following is the correct order of complete metamorphosis in insects?
   A. egg, larva, pupa, and adult
   B. pupa, egg, larva, and adult
   C. egg, larva, adult and pupa
   D. adult, egg, larva and pupa
2. Which one of the following parts of oviduct is involved in the formation of inner and outer shell membranes in bird reproduction?
   A. Infundibulum
   B. Isthmus
   C. Magnum
   D. Uterus
3. Implantation of fertilized egg and storing of sperm in rats occurs in ___and ____respectively.
   A. Oviduct and epididymis
   B. Uterine horn and vas deference
   C. Ovary and vasdeferens
   D. Uterine horn and epididymis
4. The phenomenon by which a female gamete develops into a new organism without fertilization is called_____.
   A. Syngamy C. Gametogenesis
   B. Parthenogenesis D. Embryogenesis
5. Which mating system involves a female mating with multiple males during a reproductive season in birds?
   A. Polyandry C. Polygamy
   B. Monogamy D. Polygyny

II. Short Answer Items

Instructions: give short answer/s for the following questions

1. Elaborate the difference between internal and external fertilization? Which one is advantageous and why?
2. Explain organogenesis with examples?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can examine reproduction in invertebrate and vertebrate animals-------☐
2. I can discuss complete and incomplete metamorphosis ----------☐
3. I can describe how rats, birds, frogs, and crocodiles reproduce ----------☐
4. I can compare and contrast reproduction in rats, birds, frogs, and crocodiles----------☐

Section 4: The economic importance of animals (Insects)

Dear learner, you may think that most insects are harmful to a human being simply because they are pests. Do you know the use insects in your area? Insects have plenty of economic importance in the world. However, they have also very important benefits for human beings and the ecosystem. Insects are the most diverse animals in the world. They have both positive and negative impacts on our economy, our lives, and the ecosystem. While there are many harmful pests, there are also many beneficial insects.

This section provides you some descriptions of the beneficial, or useful and harmful aspects of insects in agriculture, food, industry, health, and medicine.

Learning Competencies

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

- Describe the economic importance of insects in agriculture and food production
- Explain the economic importance of insects to industry
- Explain the economic importance of insects in health and medicine

Self-Questioning 

Dear learner, before starting this section, ask yourself the following question.

"What do I know about the beneficial and harmful aspects of insects and what do I want to learn from this section?"

4.1: Beneficial insects

A. Agriculture

What are the benefits of insects in agriculture from your local experience?

One of the major activities of agriculture is crop production.

Regarding this, beneficial insects provide useful services to agriculture through pollinating plants and eliminating pests.

Pollination: is a process of transferring pollen grains from male flower parts to female flower parts. Insect pollinators are flower-visiting insects that forage on flowering plants to obtain plant-provided food (nectar, pollen). They have the potential to transfer male gametes (contained in the pollen) to the female gametes, resulting in pollination. Pollination by insects is an essential activity for the reproduction of the majority of the world's flowering plants, including numerous cultivated plant species. Many plants depend on

pollination for seed and fruit production. For instance, an estimated 35% of crop production yielded in the world is a result of insect pollination. This has huge economic value in the world as well as in each country.

Pest regulation: Insect predators and parasitoids that attack and feed on other insects, particularly on insect pests of plants are used in pest control. This type of pest regulation is known as a natural biological control, which destroys harmful insects that infect both animals and plants. Natural biological control plays an important role in limiting potential pest populations.

Important insects such as mantis, lady beetles, ground beetles, rove beetles, flower bugs, lacewings and hover flies are used in pest regulation. For example, Stagmomantis insects, species of mantis feed on grasshoppers and caterpillars that damage crops. Chilomenes, a ladybird beetle, feed on aphids that damage cotton plants and destroy scale worms that are pests of orange and lemon trees respectively. Epicauta, a blister beetle, eat up masses of the eggs of locusts (See Figure 2.18).

Figure 2.18: *Stagmomantis(left),* ***Cheilomenes*** *sulfurea(middle), Epicauta,* Blister beetle(right)

B. Food

Do you think that insects serve as a source of food for human beings?

Yes, many species of insects are used as a food for people in many countries. Evidence suggests that edible insects have the potential to become a

valuable protein source for addressing the global food demand. They are widely recognized as a sustainable source of animal protein.

☞There are over 1,462 recorded species of edible insects in the world. Most insects are consumed in Asia and Central America where crickets, grasshoppers, beetle and moth larvae and termites are usually eaten. Moreover, insects are important sources of food for many vertebrates, including birds, amphibians, reptiles, fish and mammals.

As grasshoppers are considered rich source of protein, they have been eaten in many parts of the world. Therefore, insect farming is recommended as one of the many ways to address food and feed security for the over increasingly growing world population. Insects are everywhere and they reproduce quickly. Although they have high growth and feed conversion rates, they have a low environmental footprint over their entire life cycle. They are nutritious, with high protein, fat and mineral contents and can be reared easily.

What do you think of using insects as a food in Ethiopia, particularly in your community?

C. Industry

What is the role of beneficial insects in industry?

☞Dear learner,, can you mention roles of insects in industry? If you attempt the question, it is appreciated. If not, the following paragraphs provide you with some of their roles. One of the uses of beneficial insects related to industries is their role in providing sources of commercially important products. Insects are being used to produce different materials at home and in industries.

The following are some of the examples of the role of beneficial insects in industry.

Production of Honey and Bee Wax: Honey and wax production are considered some of the commercial benefits of insects. For example, the honeybees (*Apis meliffera* L.) produce millions of tons of honey and wax every year around the world.

Production of Silk: The other commercially beneficial insects are silk worms *(Bombyx mori* and other silk worms). Silkworms produce silk fibers, which are woven into the delicate, smooth material used for luxurious textiles and for different purposes in the textile industry (See Figure 2.19 below).

Figure 2.19 Silkworm (Left) Silk threads (Right)

Production of shellac: shellac is a resin secreted by Lac insects. Among the many species of lac insects, *Laccifer lacca*, is the commercially cultured lac insect. Shellac is still in use as dyes, inks, polishes, sealing waxes, and as stiffening agents in the fabrication of felt hats. It is an animal originated commercial resin.

Production of Cochineal: Cochineal pigment is extracted from scale insects such as *Dacylopius coccus*. The cochineal pigment was important for the intensity and permanency of colors in painting. The cochineal pigment provides colors in foods, beverages, cosmetics (lipsticks) and art product.

Production of Tannic Acid: Tannic acid is a chemical compound used in dyeing goods made of leather in the leather industries for tanning and in

manufacturing some inks. Tiny wasps in the family Cynipidae secrete some chemical and in response to this, the tree produces gall tissues that contain tannic acid.

D. Health and medicine

What is the role of insects in medicine?

There are different types of diseases that affect both human beings and animals. Can you mention any insect used to treat diseases? Some insects have medicinal value in treating different human and animal diseases. Since ancient times, insects and insect-derived products have been used as medicinal agents in many parts of the world. . For instance, honey has been applied to treat burns, chronic and post- surgical wounds. Bee and ant venom have been used to treat joints pain. Recent research confirms that bee products promote healthy immune systems, improve circulation and decrease inflammation

Blister beetles secrete cantharidan, which acts as a powerful protein blocker in the human body and is effective in treating severe viral infections because it prevents the reproduction of some viral cells. Researchers have consistently discovered that cantharidan reacts with genetic material of hostile cells. Accordingly, they have suggested that it may be useful in the treatment of cancerous tumors most resistant to radiation and chemotherapy. Several African cultures use poultices made from ground grasshoppers as pain relievers, especially for migraines.

Inquiry activity 4.1 Investigation

1. Visit agricultural institutions, industries, health institutions and medical centres in your surroundings, and collect evidence about the practical applications of beneficial insects and examples of harmful insects.

2. Is there silkworm in your area? Investigate the production of silk fiber in Ethiopia. How are silk fibers produced from silkworm?
3. In your community, what insects have medicinal value? Ask the elders in your community and come up with lists of insects or products of insects used to treat different types of human and animal diseases.

4.2: Harmful insects

What are the harmful insects in your locality?

Dear learner, although most insects are beneficial, they can also be harmful to humans and animals. Some insects are pests of plants, fruits, and grains in a store. They feed on several parts of green plants and crops, such as leaves, stems, buds, flowers, fruits, and seeds on fields and in stores at home thereby damage crops and reduce production. These insects include locusts, caterpillars, bugs, hoppers, aphids etc.

Locusts are among the most destructive of all insect pests. Countries have faced threats of swarms of desert locusts. Consequently, regional and international organizations have started to monitor desert locust populations and launch control measures when necessary. Locusts are particularly destructive in hot and dry regions where their numbers suddenly increase. The prevalence of food shortage has further forced them to migrate. They migrate in huge swarms for several kilometers away devouring virtually every green plant in their path.

Some insects are also regarded as serious pests for stored cereal grains. The most common insect pests of stored cereal grains are: Rice Weevil (Sitophilus oryzae); Lesser Grain Borer (Rhyzopertha dominica); Rust Red Flour Beetle:

(Tribolium spp.); Sawtooth Grain Beetle: (Oryzaephilussurinamensis); Flat Grain Beetle: (Cryptolestes spp.)

Figure 2.20 Crops destroyed by desert locusts (left) and other insects (middle and right)

Moreover, several insects serve as vectors for transmitting diseases from one organism to another or serve as intermediate hosts for several pathogens, which later transfer disease from one to another. For example, Anopheles mosquitoes transfer malarial parasites, "*Plasmodium,*" from one person to another. Culex mosquitos spread filariasis and transmit filarial worms from infected to healthy people. The tsetse fly, *Trypanosoma gambiense,* also spreads the African sleeping sickness to the human population. The housefly (Musca *domestica*) spreads food and water-borne diseases to human populations.

Figure 2.21 Anopheles mosquitoes (left) Culex mosquitoes (middle) Tsetse fly (right)

Inquiry activity 4.2

Have you observed desert locust destroying crops in different parts of our country? What modern, biological and traditional methods, do you think, can be used to control insects that damage crops? Consult any agricultural professionals in your area and calculate the loss of productivity of crops because of locust damage (if it appeared in your area).

Section 4 self- test exercise 4.1

I. Multiple-choice questions

Instructions: Choose the correct answer among the alternatives given for each of the following questions.

1. Which one of the following feeds on eggs of locust?
   A. Stagmomantis insects
   B. Chilomenes insects
   C. Epicauta insects
   D. A and B
2. Which one of the following pigment is extracted from scale insects such as Dacylopius coccus?
   A. Shellac
   B. Cochineal
   C. Tannic acid
   D. Wax
3. Which one of the following spreads the African sleeping sickness to the human population?
   A. Tsetse fly
   B. Culex mosquitos
   C. Laccifer lacca

D. The housefly

4. Insects are considered to be beneficial because they are _____.
   A. Effective pollinators
   B. Sources of useful products and potential protein
   C. Biological control agents
   D. All of above

II. Short Answer Items

Instructions: Give short answer/s for the following questions

1. What is the importance of insects in industry?
2. What is the role of insects in crop production? Can you recall any local experiences from local practices?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can describe the economic importance of insects in agriculture and food production ----------☐
2. I can explain the economic importance of insects to industry----------☐
3. I can explain the economic importance of insects in health and medicine ----------☐

Section 5: Animal Behavior

Dear learner, observe animals in your area. Animals have different behaviours and behavioral patterns for survival and reproduction. Animal behavior means all the ways in which animals interact with other organisms and the physical environment. It includes the movements of animals, interaction of animals within and with the environment and learning about their environment. This section provides you explanations on the

types of animal behaviour and patterns in animal behaviour.

Learning Competencies

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

At the end of this section, you will be able to:

- Define animal behavior
- Describe the differences between innate and learned animal behaviors.
- Identify patterns of behavior in animals

Self-Questioning

Dear learner, Before starting this section, ask yourself this question:

"What do I know about animal behavior, and what do I want to learn from this section?"

5.1: Types of Animal Behavior

What are the different types of animal behavior?

Dear learner, In the previous sections, you have learned about the major characteristics of animals, the economic importance of beneficial insects and reproduction in animals. In this section, you will learn about the behaviours of animals. They have different behaviors and behavioral patterns.

Animal behavior can be categorized into two main types: innate or inherent behavior and learned or acquired behavior.

Innate or inherent behavior

What is Innate or inherent behaviour?

Dear learner, You will need to answer this question. If not, do not worry, the following paragraphs will explain to you in detail. Innate or inherent behavior is an inborn behavior that is determined by genes and independent of experience and specific to a species.

There are three types of innate

or inherent behavior, and these are instinctive, reflexive, and orientative.

Can you mention examples of these types inherent behaviour?

Examples of **instinctive** behaviours include the following:

- Web making in spiders
- Nest-building in birds
- Swimming of dolphins and other aquatic species.
- Opening of mouth in chicks of many bird species when their mother returns to the nest.
- Honeybees dancing when they return to the hive after finding a source of food.

Examples of **reflex** behaviours:

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

Examples of **orientation** behaviours:

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

locomotory behavior in relation to the source of the stimulus. The animal responds to the variation in the intensity of the stimulus and not to the source or direction of the stimulus.

Example: The movement of woodlice in relation to the temperature around them.

Learned or acquired behavior

Learned or acquired behavior is not inherited and determined by genes. It is the type of animal behavior acquired during the lifetime of an individual. Learned behavior allows an individual organism to adapt to changes in the environment that are modified by previous experiences.

☞ Examples of types of learned behaviors include: habituation, classical conditioning, operant conditioning, sensitization, latent and insight learning (See Figure 2.26).

Can you explain the above types of learned behaviour?

If you are able to explain that is good if not read the following explanations.

Habituation is a simple form of learning in which an animal stops responding to a stimulus, or cue, after a period of repeated exposure. This is a form of non-associative learning, in which the stimulus is not linked with any punishment or reward. For example, you were reading a book when someone turned on the television in the same room. At first, the sound of the television might have been annoying. After a while, you may no longer have it noticed. Accordingly, it means that you have become accustomed to the sound.

Classical conditioning is a result of associative learning in which a response already associated with one stimulus is associated with the second stimulus to which it had no previous connection. Classical conditioning was discovered by Ivan P. Pavlov, a Russian physiologist.

☞There are three stages of classical conditioning.

Stage 1: Before conditioning. This stage states that an unconditioned stimulus (UCS) produces an unconditioned response (UCR) in an individual, which means that a stimulus in the environment has produced a behavior or response which is unlearned (i.e., unconditioned), and therefore, it is a natural response which has not been taught. In this case, no new behavior has been learned yet.

Stage 2: During conditioning. During this stage, a stimulus that produces no response is associated with the unconditioned stimulus due to what it is known as a conditioned stimulus (CS). For learning to take place, the UCS must be associated with CS on a number of occasions or trials at this stage. .

Stage 3: After conditioning: This conditioning happens once the conditioned stimulus (CS) has been associated with the unconditioned stimulus (UCS) to create a new conditioned response.

Operant conditioning is a result of associative learning in which a bit different from classical conditioning because it does not rely on an existing stimulus-response pair. Instead, whenever an organism performs a behavior or an intermediate step on the way to the complete behavior, the organism is given a reward or a punishment. It was discovered by B.F. Skinner. Based on the theory of operant conditioning, behavior will likely be repeated when the organism is reinforced (rewarded), and behavior will occur less frequently when it is punished.

Can you mention types of responses/operant behaviour?

Skinner identified three types of responses or operant behavior.

- **Neutral operants** are responses from the environment that neither increase nor decrease the probability of a behavior being repeated.

- **Reinforcers** are responses from the environment that increase the probability of a behavior being repeated. Reinforcers can be either positive or negative.
- **Punishers** are responses from the environment that decrease the likelihood of a behavior being repeated. Punishment weakens behavior.

Insight learning is learning which is based on past experience and reasoning and is a hallmark of the human behavior. Humans have used insight learning to solve problems ranging from starting a fire to traveling to the moon.

Sensitization, also referred to as reverse tolerance, is a non-associative learning process in which repeated administration of a stimulus results in the progressive amplification of a response. It occurs when a stimulus is presented above the tolerance threshold. For example, repetition of a painful stimulus may make one more sensitive to a loud noise.

Inquiry activity 5.1 Examining animal behaviour

Dear learner, Based on the above note:

1. Observe animals in your area critically. What type of behavior do they show? Classify them into innate or acquired animal behaviors.
2. Label the following figures as habituation, classical conditioning, operant conditioning, insight learning, and sensitization on your own work book.

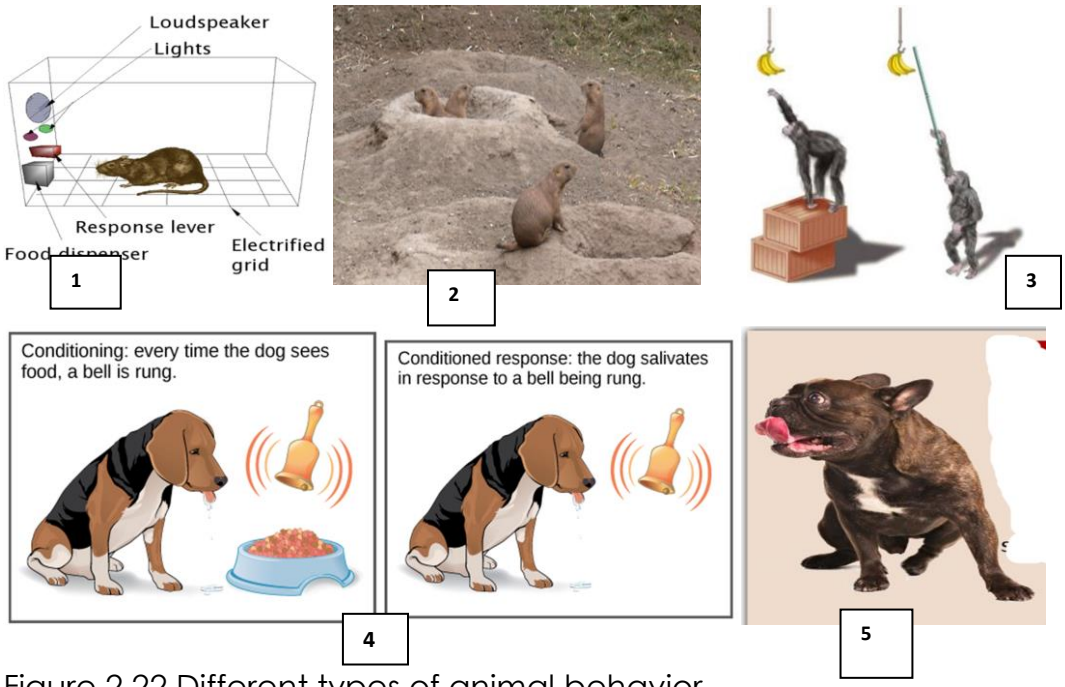


Figure 2.22 Different types of animal behavior

2: Patterns of Behavior

What are the behavioral patterns of animals?

There are different behavioral patterns in animals. Although the behavioral patterns are different due to the diversity of species, there are also common patterns of behavior exhibited by many species.

Examples of common behavioral patterns in animals include behavioral cycles, reproductive behavior, social behavior, competition, territory and communication.

Can you explain the behavioural patterns of these animals?

If you can't, do not worry! Make yourself ready to learn from the brief descriptions and illustrations with some figures below about the behavioral patterns of these animals.

Behavioral cycles are behavioral patterns in which animals respond to periodic changes in the environment. It can be daily or seasonal cycles. Example*s for behavioral cycles include* seasonal migration (movement) and Circadian rhythms (sleep and wake).

Seasonal migration refers to the movement of various species of birds, insects, and mammals from one habitat to another during different times of the year. Seasonal migration occurs because of seasonal fluctuations in factors such as the availability of food, sunlight, temperature, and breeding difficulty. A typical example is the migration of various whale and bird species from their summer habitats in the Arctic or Antarctic to the tropical waters near the equator and warmer latitudes, respectively.

Figure 2.24: A Courtship in Pigeons

☞Circadian rhythms, also referred as biological clocks, are 24-hour cycles that are part of the body's internal clock, running in the background to carry out essential functions and processes.

One of the most important and well-known example for circadian rhythms is the sleep-wake cycle.

Figure 2.23: Circadian rhythms

Reproductive Behavior: it is a behavioral pattern of animals to meet the needs of their reproduction. It is the coordination of the timing and patterning of reproductive activity. Reproductive behavior is vital for locating and selecting suitable mates, producing offspring, and rearing them successfully to independence. For example, courtship that involves sounds visual displays or chemicals and paradise dance.

Social behavior: it is the behavioral pattern of animals commonly observed in those animals that live in groups. Some of the most well developed social behavior is exhibited by insects such as ants, termites, bees, and wasps are social behaviors.

☞One benefit of social behavior for these insects is that different individuals perform better in certain activities or in the division of labor as workers and soldiers.

Other examples of social behaviour are observed in elephants, penguins, human beings and other primates.

Figure 2.25 Elephants pay homage to dead relatives

Competition: it is a behavioral pattern of animals observed during competition such as competing for resources. Example of competition includes the competition between animals for space, territory, water, mates and food. Competition occurs naturally between living organisms that coexist in the same environment. There are two basic types of competition: intraspecific and interspecific.

Territoriality: A behavioral pattern involves protecting spaces by an animal from others. The territories of animals contain all of the resources and conditions they need to survive. Many animals defend their area by displaying behavior instead of fighting. The behavior gives signals for other animals to stay away. Displaying behavior is generally safer because it uses less energy than fighting. Male dogs and lions use pheromones in their urine to mark their territory. It means that they are signaling other dogs or lions to stay out of their yard. Male gorillas use display behavior to defend their territory by pounding on their chests and thumping the ground with their hands, robin by displays his red breast to warn other robins to stay away.

Figure 2.26: Lion keeping territory

How do animals communicate with each other?

Communication behaviour: it is a behavioural pattern that is vital for the interaction of animals. Animals can communicate with the aid of sight, sound, tactile (with body touch), and using chemical cues (they produce special chemicals called pheromones**)**. For example, birds sing and frogs croak to communicate with each other. Ants communicate with each other using chemicals called **pheromones,** marking trails to food sources, so other ants can find them. Male dogs and lions use pheromones in their urine to mark their territory. It means

that they are signaling other dogs or lions to stay out of their yard.

Figure 2.27: Communication in ants

Inquiry activity 5.2 Studying behavioral patterns

1. Observe animals in your surrounding critically and identify the behavioral patterns they display such as behavioral cycles, reproductive behavior, social behavior, competition, territory and communication with examples and present to your classmates.
2. Let us say that you usually go to bed and sleep at 3:00 o'clock local time at night, and wake up at 12:00 o'clock local time in the morning. If you unfortunately sleep at 6:00 o'clock local time at night one day, what do you feel the next day? Why?

🛠 Section 5 self- test exercise 5.1

1. Multiple-choice questions

Instructions: Choose the correct answer among the alternatives given for each of the following questions.

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

A. Learned C. Afferent

B. Innate D. None of the above

2. Worker ants remember landmarks around their nest entrance and use these signals as a guide when returning home. This behavior is an example of:

   A. Conditioning C. Habituation

   B. Imprinting D. Instrumental learning

3. Which one of the following is an orientative innate behaviour?
   A. Swimming of dolphins and other aquatic species
   B. The movement of cockroaches away from the source of light
   C. pulling your hand away rapidly as soon as you touch a sharp or hot object
   D. Nest-building in birds
4. A non-associative learning process in which repeated administration of a stimulus results in the progressive amplification of a response is _
   A. Insight learning
   B. Habituation
   C. Sensitization
   D. *A and B*
5. A certain insect usually becomes active each day at dusk. If kept in the dark all day, it will still become active around sunset even though it cannot see the sun. This behavior is an example of:
   A. A circadian rhythm C. Diurnal behavior
   B. Transverse orientation D. All of the above

II. Short Answer Items

Instructions: Give short answer/s for the following questions

1. What is the difference between classical and operant conditioning?
2. Explain social and communication behavior of animals with different examples other than those given in this module.

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can define animal behavior ----------☐
2. I can describe the differences between innate and learned animal behaviors ----------☐
3. I can identify patterns of behavior in animals ----------☐

Section 6: Homeostasis in animals

Dear learner, do you think that the environmental conditions affect the normal physiological functioning of human beings and other animals ? Yes, Human beings and other animals are directly affected by environmental situations. A change in these situations may negatively affect the physiological functions of their bodies. Hence, they need to have a controlling mechanism for these factors in order to maintain stability in their body. Despite environmental changes, most animals maintain almost constant internal body conditions through homeostasis. This section provides you with mechanisms animals use to control their internal body conditions constant with respect to varied environmental conditions.

Learning Competencies

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

- Define homeostasis, homeotherms, poikilotherms, and thermoregulation.
- Describe thermoregulation in homeothermic animals with examples.
- Explain thermoregulation in poikilothermic animals with examples.

- Explain osmoregulation and sugar regulation.
- Discuss the mechanisms of controlling homeostasis.
- Explain the physiological methods of thermoregulation with examples.
- Discuss the behavioral methods of thermoregulation with examples.
- Explain the behavioral methods of thermoregulation with examples
- Appreciate mechanism of maintaining homeostasis

Self-Questioning

Dear learner, Before starting this section, ask you self this question:

"What do I know about homeostasis and what do I want to learn from this section?

Dear learner, after reflecting on these questions, you will read the following sections to learn more about homeostasis.

What is homeostasis?

What do you feel during a cold day and a hot day? How do you respond to the cold or hot temperature? Why? Why do you feel thirsty?

Homeostasis is the self-regulatory process by which animals maintain stable internal conditions in their regardless of external condition. Homeostasis helps animals to maintain equilibrium in the internal conditions of their bodies or cells at a set point (normal conditions). Animal body systems constantly adjust to the internal and external changes in order to maintain this normal condition. A change in the internal or external environment (stimulus) is detected by receptors in the animals' bodies. These receptors send information to a control center (the brain). As a result, the body system responds to the stimulus by returning the value back or toward the set point.

☞Generally, homeostasis involves four components: stimulus, receptor, control center, and effector.

- **Stimulus:** is a change in the environment that forces the organism to response. It can be a change in the body condition, such as an increase or decrease in body temperature, glucose, or water.
- **Receptor:** It detects the change and alerts the proper control center to counteract it or return the internal condition to the normal. For example, thermoreceptors (the end of sensory neurons)
- **Control center**: This receives messages from receptors and sends commands to the effector to counteract the change. The hypothalamus, a region of the brain, is a control center for homeostasis.
- **Effector:** It acts on the stimulus based on the command control center. It counteracts the change and returns the internal body condition to normal. Organs or tissues such as the kidney, liver, or heart are effectors.

For example, if the animal's body becomes too warm and the blood glucose rises, adjustments are made to cool the animal and lower the blood glucose level, respectively, by effector organs. This enables animals to function in the changing external and internal conditions that surround them in the environment.

6.1: Thermoregulation

What is thermoregulation?

Thermoregulation is the process of maintaining the internal body temperature constant. Many organisms use behaviour, physiology, and morphology to keep their body temperatures within an optimal level.

☞Based on temperature regulation, animals can be divided into two groups:

1. **Poikilothermic animals**: These are animals that have body temperature that is the same as

their environment, where their temperature varies with the environmental temperature.

2. **Homeothermic animals**: Animals that keep their body temperature constant in the face of the changing environmental temperatures.

Dear learner, explain these two groups of animals. Try it, if you are not able to do, learn more from the following subsections.

1. Poikilothermic Animals

Poikilothermic animals, also known as ectothermic animals, lack internal control over their body temperature.The body temperature of these organisms is generally similar to the temperature of the environment. However, individual organisms may burrow themselves into the ground on a hot day or rest in the sunlight on a cold day to keep their bodies temperature slightly below or above the environmental temperature. Some poikilothermic animals seek cooler areas during the hottest time of the day or may climb onto rocks to capture heat during the coldest time of the day. Some animals swim in water to cool their body. Some also use burrows to keep their bodies warm (See Figure 2.28 below), and still others such as bees use group activity or stay in a hive to survive in cold seasons.

Figure 2.28 Temperature regulation in poikilotherms

2. Homeothermic Animals

Homeothermic or endothermic animals are those animals that can generate internal heat to maintain constant internal body temperature.

Their cellular processes operate optimally even when the environment is cold and loses heat when the environment is hot.

What are the ways of regulating body temperature during cold and hot weather?

Homeothermic or endothermic animals use morphological, physiological and behavioral methods of temperature regulation.

Dear learner, from your practical experience, what do you do when the environment is cold and hot? Try to answer the above questions and read the following sections to learn in detail.

Homeothermic animals can retain heat in a variety of ways when the environment is cold. Some of the ways of insulation used to conserve the body heat in these animals include fur, fat and feathers, vasoconstriction and shivering. For example, the arctic fox curls up its fluffy tail as extra insulation when it sleeps in cold weather (See Figure 2.29).

Figure 2.29 Temperature regulation during cold weather by puffing up feathers in birds (left), raising hair in human (middle) and fur in fox (right)

☞Vasoconstriction is the narrowing of blood vessels to the skin by the contraction of their smooth muscles to reduce blood flow in the peripheral blood vessels and retain heat in response to the coldest environment.

Shivering is another way of maintaining body temperature in cold. Shivering is caused by involuntary contractions of your muscles. Muscle contractions require energy from respiration that releases heat to warm the body.

Homeothermic animals can loss heat in a variety of ways when the environment is hot. Some of the ways of losing heat in response to the hottest environment include vasodilation and sweating.

☞Vasodilation which is the opening up of arterioles to the skin through the relaxation of their smooth muscles and by bringing more blood and heat to the body surface to loss heat and thereby cool their body through radiation and evaporation. Vasodilation is the widening of blood vessels at the skin surface to increase heat loss through the surface of the skin.

Sweating is another way of maintaining body temperature during a hot season. Sweat, which is produced by the sweat glands travels up the sweat duct and out of the sweat pore onto the skin surface.

The processes of coordination occur in the part of the brain called hypothalamus. When the temperature of the environment changes (decreases or increases), signals are sent to the brain to alert the hypothalamus. The hypothalamus then responds by activating the process of vasodilation, vasoconstriction, shivering and sweating to maintain the body temperature constant (See Figure 2.30).

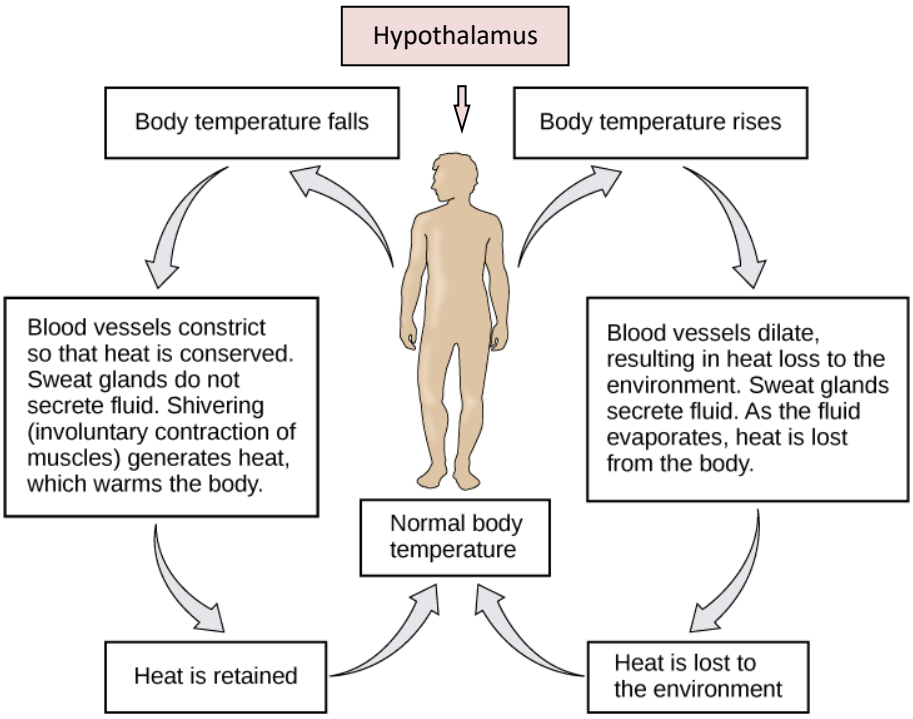
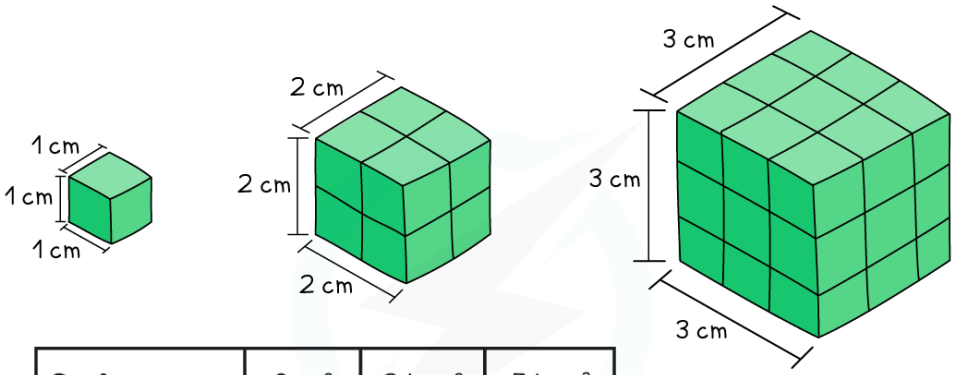


Figure 2.30. The body temperature regulation

The body structure of animals also helps to maintain their body temperature. For instance, large ears of animals help to lose heat and cool their body in hot areas, whereas small ears of animals and fur help them to minimize heat loss and keep their body warm in cold areas. The size of the animals also affects regulation of body temperature.

☞ As animals grow in size, their inside volume increases and the outside surface area decreases. This affects the surface-area-to-volume ratio or the surface-to-volume ratio of animals, which consequently affects heat loss.

Look the following example (See Figure 2.31)



Surface area	6 cm²	24 cm²	54 cm²
Volume	1 cm³	8 cm³	27 cm³
Surface area: volume	6:1	3:1	2:1

Figure 2.31 As size increases, the surface area: volume ratio decreases

How does the surface area: volume ratio affect temperature regulation?

Dear learner, imagine the sizes of different animals in your area where some are small and some others are large and explain the relationship between their size and temperature regulation. The larger the size of an animal, the smaller the surface area to volume ratio it will have. For example, since the size of an elephant is high, the surface area to volume ratio becomes smaller than the surface area to volume ratio of a rabbit.

☞ The greater the surface area-to-volume ratio an animal has, the more heat loss it will have, and the smaller the surface area- to- volume ratio an animal has the less heat loss it will have. The smaller the animal, the higher the surface area-to-volume ratio it will have, so it will have the higher heat loss. Example: a rabbit. On the other hand, the larger the animal, the smaller the surface area-to-volume ratio it will have, so it will have the lower the heat loss. Example an elephant.

Animals also maintain their body temperature by searching out cold

or hot habitats that allow them to alter its rate of heat loss or gain. For example, they maintain their body temperature by making nests or digging burrows, huddling with conspecifics. Human beings regulate their body temperature by wearing clothes or turning on an air conditioner.

Inquiry activity 6.1

Investigating thermoregulation

Search from the library or the internet and answer the following questions.

1. What is the reason for the fact that larger animals lose less amount of heat than smaller ones?
2. What do you think the reason for people living in desert/semi desert regions commonly drink hot tea/drinks and wear different clothing styles in low and high land areas?

6.2: Osmoregulation

What is osmoregulation?

Dear learner, imagine what happens to our body when there is too much water and ion intake and loos? There is a need to balance. Osmoregulation is a process that regulates the osmotic pressure of fluids and electrolytic balance in organisms to maintain homeostasis.

About 60% of the human body is composed of fluids. Approximately 2/3 of our body's water content is in our intracellular fluids and the remaining 1/3 forms our extracellular fluid. Extracellular fluid consists of the fluid between cells (interstitial fluid) and the blood plasma.

A disruption in the osmotic pressure can result in an imbalance in the movement of water between them, and hence, alter the concentration of their electrolytes. Hence, osmoregulation is important to balance osmotic pressure of fluids and electrolytes.

How does osmoregulation occur?

In humans and other animals, this process is brought about by osmoreceptors, which can detect changes in osmotic pressure. Humans and most other warm-blooded organisms have osmoreceptors in the hypothalamus part of the brain and in the kidneys.

There are two major types of osmoregulation:

Osmoconformers: organisms that try to match the osmolarity of their body with their surroundings are called osmoconformers. In other words, these organisms maintain the same osmotic pressure inside the body as the outside water. Examples are invertebrates such as starfish, jellyfish and lobsters.

Osmoregulators: organisms that actively regulate their osmotic pressure, independent of the surrounding environment are called osmoregulators. Examples are many vertebrates, including human beings.

The kidney is the main organ responsible for osmoregulation in humans. When the water level in the body is high, the kidney releases a large amount of hypotonic urine. When the water level is low, it retains water and produces a low amount of hypertonic urine. Thus, the kidneys maintain the electrolytic balance of the body. The hypothalamus of the brain and Antidiuretic hormone (ADH) secreted from the pituitary gland controls osmoregulation (See Figure 2.32 below).

Why does your urine become sometimes yellow and sometimes not?

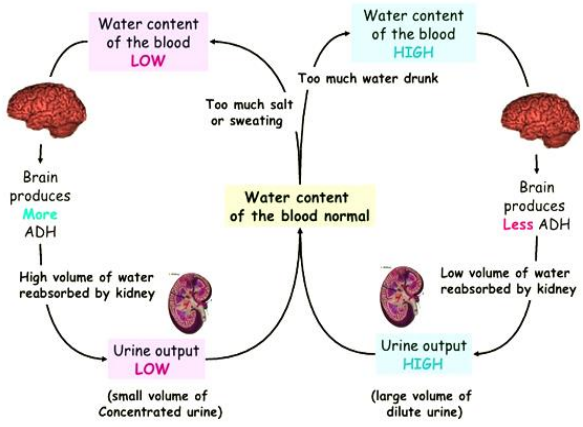


Figure 2.32 Osmoregulation in human

6.3: Blood Sugar Regulation

Glucose is the main source of energy for the normal functioning of our body systems including the

brain. The body requires volumes of glucose in order to generate energy during respiration. Hence, the body regulates the availability of glucose in our body to maintain its concentration at constant level in order to supply energy continuously.

How does the body regulate the glucose level?

Two hormones produced from pancreas are responsible for controlling the concentration of glucose in the blood. These are **insulin** and **glucagon**.

- When the blood glucose level is high and the glucagon level is low, more insulin is released by pancreas into the liver. Insulin promotes the conversion of glucose into glycogen so that the excess glucose can be stored for a later use in the liver.
- When blood glucose level is low and glucagon level is high, more glucagon is released by pancreas into the liver. Glucagon promotes the conversion of glycogen into glucose so that the lack of glucose can be compensated for by the new supply of glucose.

Glycogen is stored in the liver and converted into glucose when the glucose level decreases. The effects of insulin and glucagon on the functions of the liver are as follows (See Figure 2.33 below):

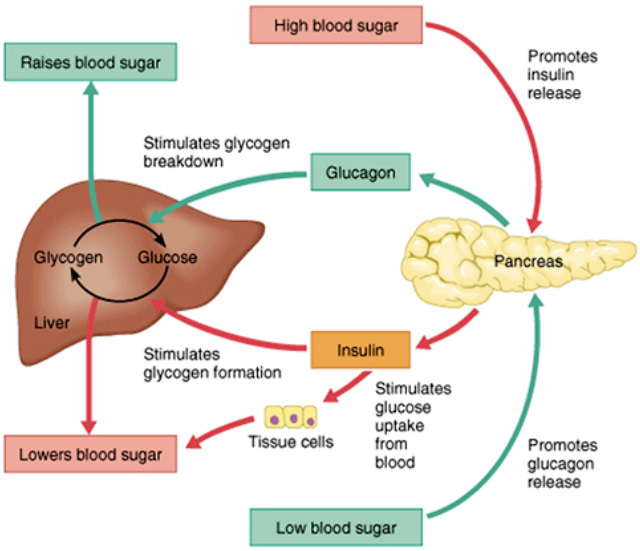


Figure 2.33 Blood glucose level Regulation

Inquiry activity 6.2 Investigation

Dear learner what will happen if:

- Salt and water balance is not maintained in our body.
- The concentration level of glucose in the blood is not maintained. Have you ever heard about diabetic patients? What is the cause?

6.4: Control of Homeostasis

How do negative and positive feedback control homeostasis?

When there is any change in the environment, an animal must make an adjustment to balance the situation. To do this, animals have feedback mechanisms for the stimulus (change in the environment). A feedback mechanism is a physiological regulation system to return the body to its normal internal state. In the feedback mechanism, the receptor senses the change in the environment (stimulus) and sends a signal to the control center (the brain) which in turn generates a response that is signalled to an effector in muscles to contract or relax or to glands to secrete hormones. There are two types of feedback mechanisms.

☞ To maintain homeostasis, animals use two types of feedback mechanisms: Negative and positive feedback.

Negative and Positive Feedback Mechanisms

How do negative and positive feedback work?

Negative feedback occurs when a change in a variable triggers a response that reverses the initial change. In other words, negative feedback occurs when the activation of one component results in the deactivation of another. Positive feedback occurs when a change in a variable triggers a response that causes more change in the same direction. Unlike negative feedback, positive

feedback occurs when the activation of one component causes the activation of another.

☞ Negative feedback mechanism is a homeostatic process that reverses the direction of the stimulus or any deviation from the normal. This means that if the level is too high from the normal, the body brings it down, and if the level is too low from the normal, the body lifts it up. In contrast to negative feedback mechanism, positive feedback mechanism accelerates a change in the body's physiological condition rather than reversing it.

The positive feedback takes you further away from homeostasis whereas the negative feedback brings you back to it.

A negative feedback system has three basic components. These are sensor (receptor), control center and effector. The sensor (receptor) monitors the physiological value not to deviate from the normal (receives stimulus) and reports to the control center if there is any deviation. The control center compares the value of the deviation from the normal and activates the effector if there is any deviation. An effector causes a change to reverse the situation and returns the value to the normal set point (See Figure 2.34).

There are numerous examples of negative feedback mechanisms that help maintain a constant internal body condition. One of the examples in human beings is the feedback mechanism in temperature regulation. This mechanism works by promoting either heat loss or heat gain. For instance, when the sensor (receptor) receives a stimulus that indicates an increased body temperature from the normal range, it sends its message to the brain's temperature regulation center where the control center stimulates a cluster of brain cells.

Then, the control center causes vasodilatation so that the more blood flows to the surface of the skin. Vasodilatation allows the heat to radiate into the environment, activate sweat glands to increase

their output through diaphoresis (excessive sweating) to remove heat through evaporation across the skin surface into the surrounding environment.

The reverse occurs when the body temperature drops from the normal range. It means that vasoconstriction and deactivation of sweat glands occurs. However, if heat loss is severe, the brain (control center) causes skeletal muscles to contract using up ATP and produce shivering to release heat.

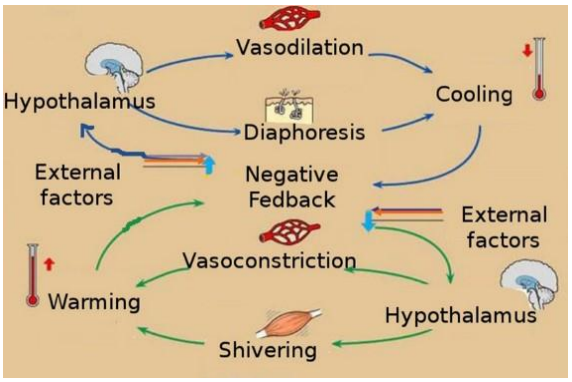


Fig.2.34. Negative feedback mechanism of thermoregulation

In the above example, as soon as your body has cooled off, negative feedback halts the signaling process to stop the process of sweating. In the opposite process, a **positive feedback loop** would continue to cause the body to sweat even though it was no longer hot.

Inquiry activity 6.3 Examining feed mechanisms

Investigate the feedback mechanism in blood glucose level regulation and osmoregulation from nearby library or the internet sources and report your findings to your tutor.

🛠 Section 6 self- test exercise

I. Multiple-choice questions

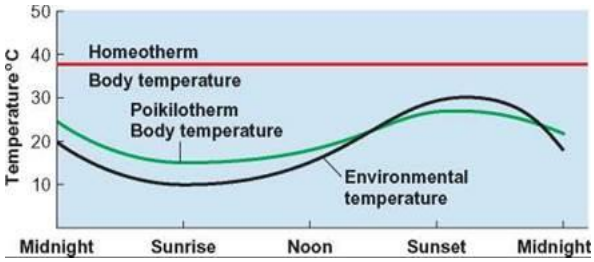
Instructions: Choose the correct answer among the alternatives given for each of the following questions.

1. The mechanism of regulation of solutes and the loss and gain of water in human beings is known as _____.
   A. Homeostasis C. Osmoregulation
   B. Thermoregulation D. Poikilotherms
2. Why do the hairs on our skin sometimes stand up when the weather is cold?
   A. to know when we are frightened
   B. to trap air under them in order to keep us warmer
   C. to release air order to cool us down
   D. to trap air under them to keep us cooler
3. What does glucagon promote in the liver?
   A. Hydrolysis of glycogen C. Glycogen production
   B. Hydrolysis of glucose D. Release of insulin
4. An increase in blood sugar level causes pancreas to release of the hormone insulin; insulin lowers the blood sugar level, restoring the body to its original blood glucose level by converting glucose to glycogen. This is an example of
   A. Positive feedback C. Homeostatic imbalance
   B. Negative feedback D. None of these
5. Which one of the following is not an advantage of homeothermy?
   A. high energy intake requirement
   B. animals can inhabit cold climates
   C. animals can exploit nocturnal niches
   D. physiological activity can be independent of ambient temperature

II. Short Answer Items

Instructions: Give short answer/s for the following questions

The following figure shows the difference in temperature regulation in animals. Can you interpret the graph?



How vasodilation, vasoconstriction and sweating help to maintain the normal level of the body temperature?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can define homeostasis and thermoregulation ----------☐
2. I can differentiate between homeotherms and poikilotherms ----------☐
3. I can describe thermoregulation in homeothermic animals with examples-☐
   can explain thermoregulation in poikilothermic animals with examples------☐
4. I can explain osmoregulation and sugar regulation ----------☐
5. I can discuss the mechanisms of controlling homeostasis ----------☐
6. I can explain the physiological methods of thermoregulation with examples
   ----------☐
7. I can discuss the behavioral methods of thermoregulation with examples--☐
8. D I can explain the behavioral methods of thermoregulation with examples☐
9. I can appreciate mechanism of maintaining homeostasis----------☐

Section 7: Renowned Zoologists in Ethiopia

Think of highly educated people in your area. They may be specialized in different field of studies such as medicine, agriculture, economics, engineering, biology, physics, mathematics, chemistry, etc. and contributing for the development of the nation by conducting research in their area of specialization. Zoology that deals with animals is one field of study in biology. This section introduces you the contribution of zoologists for the development of zoological science.

Learning Competencies

After successful completion of this section, you will be able to

- Mention renowned zoologists in Ethiopia
- Describe the work of these scientists

Zoology is the study of animals in relation to their evolution, anatomy, physiology, behaviour, habitats and health. Many zoologists from various Ethiopian universities have studied animals found throughout the country. Some researchers have invested their time and energy in studying animals in Ethiopia throughout their lives. This has a great contribution not only to the development of zoological science but also for the economic development of the country.

Such researchers are patriots for their country because, as the general curriculum framework stipulates, "Patriotism is not only in showing love to the country and defending it in times of difficulties but also in exhibiting the diligence to successfully carry out a wide-range of duties and tasks which epitomize hard work" (p.20).

Inquiry activity 7.1

Do you know any renowned Ethiopian zoologists who grew up or came from your home town/village or from any other place in your area? Describe the works of these professors and the lessons you learned from them. Reflect on what you could learn from their work.

🛠 Section 7 self- test exercise 7.1

1. What is the contribution of zoologists to the development of a country?
2. Do you have any interest to be a zoologist? Why?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can mention renowned zoologists in Ethiopia ----------☐
2. I can describe the work of these scientists ----------☐

Unit Summery

Animals are diverse groups of organisms in the world. They have their own characteristics related to reproduction, cellular organization, mode of nutrition and energy generation. Animals can respond to environmental stimuli by increasing body size, moving from place to place and protecting themselves from enemies. There are two major groups of animals: invertebrates and vertebrate animals. Invertebrates are animals that do not have a backbone/vertebral column, whereas vertebrate animals possess a well-defined internal skeleton system with cartilage and a backbone/vertebral column.

While the majority of animals undergo sexual reproduction, a few groups of animals undergo asexual reproduction. Asexual reproduction is a type of reproduction that involves a single individual, which is more common among invertebrates than vertebrates. Sexual reproduction is a type of reproduction that involves two individual parents to produce offspring by having genetic materials from both parents through fertilization.

Insects undergo sexual reproduction in which a series of major changes undergo in their body structure called metamorphosis: Complete metamorphosis and incomplete metamorphosis.

Reproduction in rats involves internal fertilization and the development of embryo is inside the female rat. Frogs undergo external fertilization and develop through metamorphosis. Birds undergo internal fertilizations and lay eggs with external hard cover in nest or ground where they hatch after incubation.

Insects have plenty of economic importance in agriculture and food production, health and medicine. Insect are important organisms for commercial products such as honey, wax, dyes and silk production and have medicinal value in treating different human and animal diseases.

Animals have different behaviours that can be grouped into innate or inherent behavior and learned or acquired behavior. Animals also have different behavioral patterns such as behavioral cycles, reproductive behavior, social behavior, competition, territory and communication.

Homeostasis is a self-regulatory process by which animals maintain stable internal conditions in their body. Thermoregulation is the process of maintaining the internal body temperature constant. Homeothermic animals maintain a constant body temperature regardless of differing environmental temperatures, whereas poikilothermic animals have a body temperature that is the same as their environment, and thus, their temperature varies with the environmental temperature.

Osmoregulation is the process of controlling the amount of water and electrolytes by the help of osmoreceptors in order to retain homeostasis. The kidney plays an important role in the process of osmoregulation in humans by producing large amount of urine when there is excess water and producing small amount of urine when the amount of water in our body is low.

Our body needs continuous supply of energy. The major source of energy for normal functioning of our body is glucose. Insulin and glucagon are the two hormones produced from pancreas to regulate sugar level. Insulin decreases the glucose level and glucagon increases the glucose level to maintain the sugar balance in our body.

Homeostasis is maintained by negative feedback mechanisms that control the internal body change by reversing the direction of the stimulus. The feedback mechanisms involve the receptor that senses the change in the environment (stimulus), the control center (the brain) that generates a response and an effector in muscles that contract or relax or glands to secrete hormones to respond to the stimuli.

End of unit Self-Assessment

I. True false items

Instructions: Write true if the statement is correct or false if the statement is NOT correct

1. Invertebrates are warm-blooded and regulate their body temperature.
2. The function of magnum in bird reproduction is to secret albumen in which the egg white is deposited.
3. The contribution of insect pollination agricultural activities is insignificant for crop production.
4. Ectothermic animals use vasoconstriction in response to the coldest environment to control their body temperature.
5. The smaller the animal, the higher the surface area-to-volume ratio and the higher the heat loss.
6. Insulin promotes the conversion of glycogen into glucose so that the excess glucose can be stored for a later use in the liver.
7. The major immediate source of energy for normal functioning of our body is starch.

II. Multiple-Choice Questions

Instructions: Read the following items and choose the correct answer among the alternatives given.

1. Which one of the following is a common characteristic of all vertebrates?
   A. The division of the body into a head, neck, trunk and tail
   B. The presence of a well-developed skull.
   C. Their bodies are covered with an exoskeleton
   D. The possession of two pairs of functional appendages
2. Why is sexual reproduction useful?
   A. It completes in a very short period of time

B. It results in the rapid production of many offspring
C. It needs less energy and leads to genetic variation in the offspring
D. It increases genetic diversity, allowing organisms to survive in an unpredictable environment

3. Metamorphosis of insects is regulated through hormone_____.

A. Pheromone C. Ecdysone
B. Thyroxine D. All of the above

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

A. They are small in size and want to produce more offspring.
B. To increase chance of fertilization in water.
C. Sufficient food is available in water to feed the offspring.
D. Water promotes production of large number of gametes

5. Animals move from a less desirable location to a more desirable location by means of

A. Biological clock C. Kinesis and taxis
B. Courtship display D. All of the above

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

A. Conditioning C. Instrumental learning
B. Habituation D. A and C

7. The daily cycle of activity that occurs over a 24-hour period of time is called _____.

A. Stimulus response C. Taxis behavior
B. Kinesis behavior D. Circadian rhythm

8. Given these terms related to negative feedback: 1. control center, 2. effector, 3. receptor, 4. response, 5. stimulus, arrange the terms in the correct order as they operate to maintain homeostasis.

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

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

   A. Higher SA:V ratios
   B. Lower SA:V ratios
   C. Lower Lifespan
   D. More Frequent Exposure to Predators

10. What happens when blood sugar levels become too high?
    A. Glucagon is secreted, causing the conversion of glucose to glycogen
    B. Insulin is secreted, causing the conversion of glycogen to glucose
    C. Insulin is secreted, causing the conversion of glucose to glycogen
    D. All of the above
11. What happens if the core body temperature is too high?
    A. the blood vessels supplying the capillaries constrict
    B. the blood vessels supplying the capillaries dilate
    C. the body decreases sweating
    D. the body shivers to produce heat
12. What would **NOT** happen if the core body temperature was too low?
    A. shivering would release energy by muscle contraction
    B. sweat would cool the body as it evaporated
    C. there would be a reduced blood flow through the skin capillaries
    D. A and B

Fill in the blank

Instructions: Fill the following blank spaces with appropriate answers

1. A skeleton like structure that is made of chitin in invertebrates is called- _____.
2. The processes of coordination occur in the part of the brain called _____.
3. A hollow ball of cells formed after fertilization is called a _____.
4. _____ is a chemical compound used in dyeing goods made of leather in the leather industries
5. _____ is undirected, random movement animals in relation to the source of the stimulus.
6. Ants communicate with each other using chemicals called _____.
7. _____ is component of homeostasis that acts on the stimulus based on the command control center to return the internal body condition to normal.
8. Organisms that try to match the osmolarity of their body with their surroundings are called _____.

Assignment

Dear learner, Do the following assignments and submit them during your tutorial session.

Name _____

Id No. _____

Region/city_____ **Zone** _____

Tutorial center _____

Instruction: answer each of the following questions and give examples

1. Explain incubation, *hatching and parental care in birds reproduction.*
2. *Elaborate the four mechanism of heat exchange (radiation, evaporation, convection and conduction) between an animal and its environment and their role in controlling the body temperature*
3. Explain how shivering, hibernation and aestivation help to maintain the normal level of the body temperature.
4. Report the economic importance of insects in your area.
5. What happens to a person whose pancreas doesn't make enough insulin or his body doesn't use it properly?

🗝 Feedback to activities

Inquiry activity 1.1

Characteristics	Description
Sensitive to Stimuli	They detect and respond to environmental stimuli such as small changes in light, sound, touch, taste, smell, temperature,
Protect themselves	Animals protect themselves from different types of damage caused by other organisms or natural phenomena using defense mechanisms such as production of venom; the development of sharp spines on their bodies; mimicry; camouflage; and armor (wearing protective gear) to protect themselves from dangerous animals and environmental conditions.
Excrete	Animals excrete different unwanted materials from their bodies. Through the process of excretion, animals get rid of carbon dioxide, water, toxic materials, waste products of metabolism, and excess substances from their body.
Respiration	Animals need energy, which is obtained from cellular respiration. Respiration is the process of releasing energy from the food inside the cells of the body.
Nutrition	Animals are **heterotrophs.** They cannot manufacture their own food by carbon fixation, and therefore, derive their nutrition from other sources of organic carbon, mainly from plants or animal matters.

Inquiry activity 2.1

Features	Invertebrates	Vertebrates
Backbone	Do not possess a backbone or an internal skeleton	Possess a backbone and an internal skeleton.
Exoskeleton	Have an exoskeleton.	Do not possess an exoskeleton.
Body symmetry	Have radial or bilateral body symmetry.	All vertebrates have bilateral body symmetry.
Circulatory system	Nearly all invertebrates possess an open circulatory system.	All vertebrates have closed circulatory systems.
Nervous system	Presence of a simple and unorganized nervous system.	Presence of complex and highly specialized organ systems with specific functions.

Inquiry activity 3.1

1. Budding-budding is a form of asexual reproduction in which small growth on the surface of the parent breaks off and forms two individual. Example corals and hydras
2. Fragmentation- Fragmentation is a form of asexual reproduction in which the body of an organism breaks into two or more fragments that develop into a new individual through regeneration. Example sponges, and starfish
3. Parthenogenesis is a form of asexual reproduction in which an embryo develops from an unfertilized egg. Example insects, wasps, and bees
4. Internal fertilization is more advantageous for land animals as compared to aquatic animals because it helps to protect the fertilized egg from dehydration on land. The embryo is isolated within the female, which limits

predation on the young. Internal fertilization also enhances the fertilization of eggs by a specific male. The survival rate is higher for internal fertilization

5. There are three germ layers of a gastrula from which tissue, organs, and organ system are developed. The threegerm layers of the gastrula are the ectoderm, mesoderm, and endoderm. The process in which the germ layers give rise to the different organ systems is called organogenesis. The **ectoderm,** which is the outer germ layer, gives rise to the nervous and integumentary systems like the epidermis and other tissue. The **mesoderm** or the middle germ layer gives rise to the muscular system as well as the different connective tissue in the body. The **endoderm** or the inner germ layer gives rise to the digestive system and other many internal organs and organ systems.

Inquiry activity 3.2

- The disadvantage of external fertilization in frogs is that some of the eggs may die before fertilization and they overcome this by laying a large number of eggs.

Inquiry activity 3.4

1. Monogamous occurs when one female mates with a single male. Polygamous consists of a mating system in which a female or a male mates with two or more members of the opposite sex.
2. To protect eggs from enemies
3. Camouflaged eggs are with different coloration for defense or tactic use to disguise their appearance by blending in with their surroundings.

Inquiry activity 5.1

1. Operant conditioning
2. Habituation in prairie dogs
3. Insight learning Kholer's Experiment, Chimpanzee
4. Operant conditioning
5. Sensitization

Inquiry activity 6.1

1. Related with size of the volume and body surface.
2. To regulate their body temperature.

Inquiry activity 6.2

1. See osmoregulation

2. We feel confused and have difficulty concentrating, experience hypoglycaemia which can cause excess sweating, disturbed sleep, and feeling tired and confused upon waking. Diabetes is a problem with your body that causes blood sugar (also called blood glucose) levels to rise higher than normal. This is also called hyperglycemia.

Inquiry activity 6.3

If the blood glucose level is too low, the pancreas releases the hormone glucagon. This travels to the liver in the blood and causes the break-down of glycogen into glucose. The glucose enters the blood stream and glucose levels increase back to normal.

If water level is too low, the kidney tubules become less permeable to water. This means less water is reabsorbed into the bloodstream and a larger volume of dilute urine will be produced. These types of control are an example of the negative feedback mechanism.

🗝 Answer Key for Self-test Exercises

Self- test exercise 1.1

Part I. Multiple-choice questions

1. A 2. C

Part II. Short Answer

1. See Inquiry activity 1.1, nutrition
2. It is based on presence and absence of nucleus and organelles

Self- test exercise 2.1

Part I. Multiple-choice questions

1. C 2. D

Self- test exercise 3.1

Part I. Multiple-choice questions

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

Part II. Short Answer

1. Internal fertilization occurs when the sperm fertilizes the egg inside the female. External fertilization is a type of reproduction in which the sperm of a male creature fertilizes the egg of a female organism outside the female's body. Internal fertilization is advantageous because the probability of successful fertilization is increased.
2. Organogenesis is the process of formation of organs from three germ layers. See inquiry activity 3.1 question 5.

Self- test exercise 4.1

Part I. Multiple-choice questions

1. C 2. B 3. A 4. D

Self- test exercise 5.1

Part I. Multiple-choice questions

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

Self- test exercise6.1

Part I. Multiple-choice questions

1. C 2. B 3. A 4. B 5. D

Part II. Short Answer

1. The strait red line shows that Homeotherms have constant body temperature while the environmental temperature (green line) fluctuates. On the other hand, the dark line shows poikilotherms body

temperature fluctuation as environmental temperature fluctuates during midnight, sunrise noon and sunset.

2. **Vasoconstriction** involves the narrowing of blood vessels at the skin surface to reduce heat loss through the surface of the skin during cold.

   Shivering- is caused by involuntary contractions of your muscles that require energy from respiration which releases heat. This heat is used to warm the body up.

   Vasodilation involves the widening of blood vessels at the skin's surface to increase heat loss through the surface of the skin during hot.

   Sweat- is produced by sweat glands and travels up the sweat duct and out of the sweat pore onto the skin surface which evaporates, taking excess body heat from the body to cool it down.

🗝 Answer Key for End of unit Self-assessment

Part I. True false

1. False 2. True 3. False 4. False 5. True 6. False 7. False

Part II. Multiple-Choice questions

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

Part III. Fill in the blank

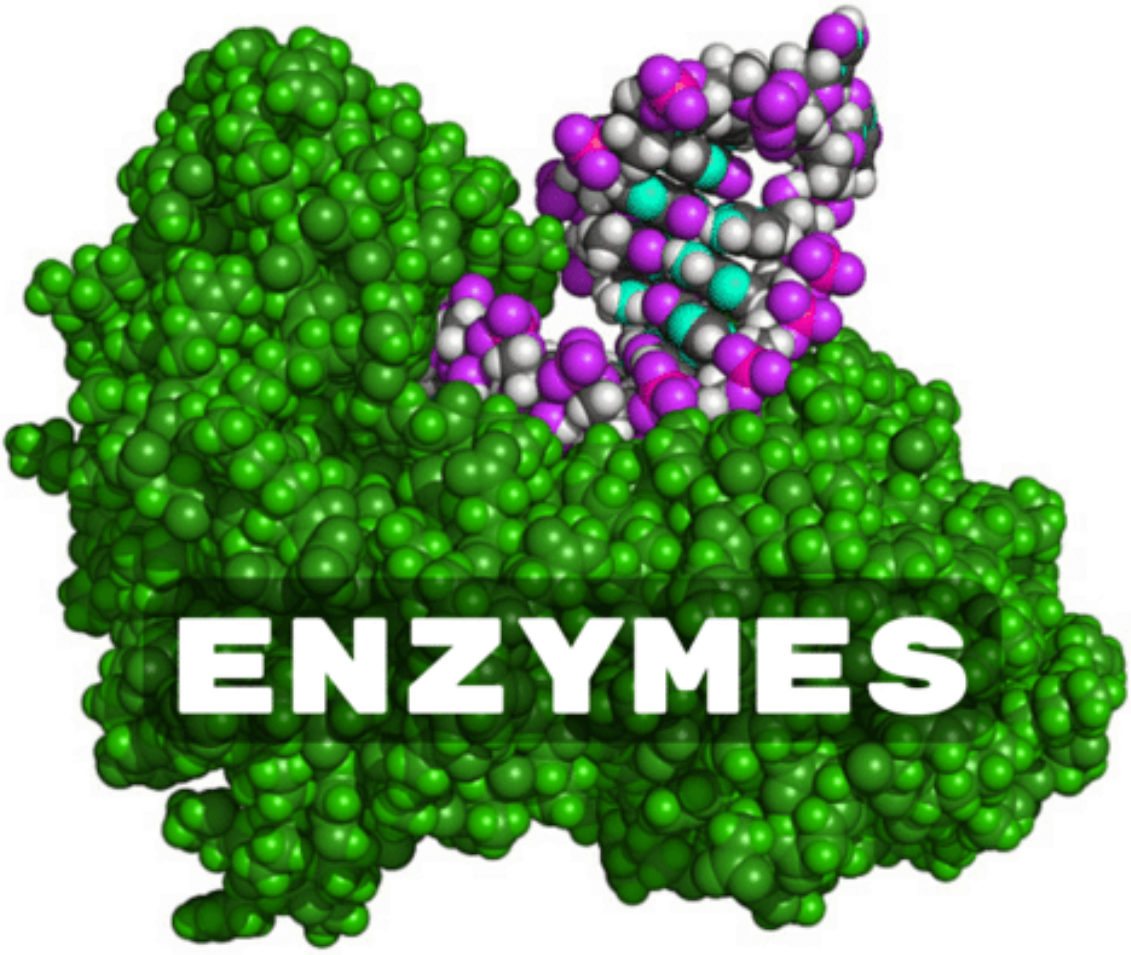
1. Exoskeleton 2. Hypothalamus 3. Blastula 4. Tannic acid
5. Kinesis 6. Pheromones 7. Effectors 8. Osmoconformers.

References

1. grade 11 biology text book and teachers guide
2. Simon, E., Dickey, J. & Reece, J. (2013). Essential biology with physiology (4th ed.). Philadelphia: Pearson Education Inc. ISBN.

3. Postlethwait, J.H. and Hopson, J.L. (2006). Modern Biology. Holt, Rinhart and Winson, United States of America.
4. Raven, P.H. and Jonson, G.B (2011). Biology. 9th ed. McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York.
5. Sylvia S. Mader (2001). Biology. 7th ed. Mc Graw-Hill
6. Taylor, D.J., Stout , G.W. Green, N.P.O. and Soper R. (2008). Biological Science, Cambridge University Press,
7. Daly, H.V., Doyen, T.J. and Purcal (1998). Introduction to Insect Biology and Diversity.
8. Pechenik, J. (2004). Biology of the Invertebrates. (5th ed.) McGraw-Hill.
9. Prentice Hall. Prasad, S. N. (1991). A Text book of Vertebrate Zoology. (13th ed.) Wiley Eastern Limited, New Dehli.
10. Google, YouTube, science websites

Unit Three: Enzymes



Introduction

Welcome to unit three that presents lessons on Enzymes containing 11 sections (contents). The unit begins with providing the definition of enzymes by briefing about enzymatic functions and properties. The unit also describes protein structures displaying all four levels. It discusses the enzyme substrate models and its function, enzyme regulation and about the types of enzymes. The unit explains about factors affecting enzymatic activities including studies about enzyme kinetics. It also describes about applications of enzymes in different industrial products and other sectors including about the practical uses of traditional malting in Ethiopia. In this unit, the works and research of renowned Biochemist in Ethiopia will also be discussed in detail

Dear learner, enzymes act as catalysts for various reactions, hormones act as messengers that trigger various functions in the body and vitamins act as coenzymes to activate several enzymes required for the reaction.

Learning Strategies

Dear learner, you will need to follow the strategic learning steps suggested, conduct self-studies and do all activities and assignments on your own.

1. Identify the properties of enzymes, proteins and protein structures and answer questions on your own.
2. Study about enzyme-substrate models and draw the models in your exercise book with different colours for enzyme, substrate and product using locally available materials.
3. Search for sources (Internet and other sources) and find information on how to regulate enzyme activities, types of enzymes, factors affecting enzyme activities and enzyme kinetics in addition to your module.
4. Conduct simple experiments on how temperature, pH, enzyme substrate concentrations affect enzymatic activities.

5. Read about the applications of enzymes in industry, food, agriculture, medicine, environment with information from websites etc.
6. Discuss the malting process with knowledgeable individuals and apply in the preparation of local drinks and compare the response with scientific explanations of biochemists.

Unit Learning Outcomes

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

- Explain enzymes, properties of enzymes, factors affecting their activities, functions, mechanisms of action, regulation, their industrial applications and kinetics
- Demonstrate proteins and their structures

Contents

Section 3.9Applications of enzymes

3.9.1Application of enzymes in industries and their benefits

3.10Practical uses of traditional malting in Ethiopia

3.10.1Steps of modern malting

3.10.2 Why is malting for?

3.10.3 Traditional malting for local alcohol production

Section 3.11Renowned Biochemist in Ethiopia

Unit three study time: twenty (20) hours

Dear learner, it is hoped that you have completed unit two of this module one successfully before you start this unit. If so, now you can proceed to unit three which is about Enzymes.

Section 3.1: What are Enzymes?

Dear learner, this section will provide you with basic scientific information on enzymes.

Learning competencies

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

- Define enzymes and activation energy
- Explain how enzymes work
- Describe the catalysis reaction of enzymes, activities and substrates

Self-questioning 

Dear learner,

Before starting this section, ask yourself the following question.

"What do I know about enzymes, their properties and functions, and what do I want to learn from this section?"

Enzymes are mainly proteins made up of chains of amino acids linked together by peptide bonds of various molecular weights.

Enzymes compose of protein molecules that act as biological catalysts (biocatalysts) and accelerate the rate of chemical reactions by lowering **activation energy**. It is the minimum amount of energy required for the reactants to convert the products.

☞ All cells contain different enzymes depending on the type of the living cell and engage in tremendous biochemical activity called metabolism. It is the process of chemical and physical changes including the breakdown (catabolism) and synthesis (anabolism) of molecules.

The metabolic processes in the cells require enzymes to catalyse different biochemical reaction types at rates fast enough to sustain life. Enzymes act upon molecules (substrate), convert into products of different molecules and remain unchanged (Figure 3.1).

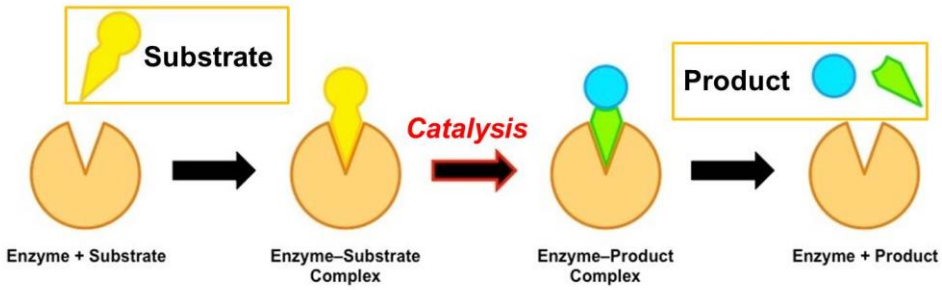


Figure 3.1 Enzymatic reactions

☞ Dear learner, ask someone about the process of local drinks preparation (Tella) by fermentation and relate enzymes reaction.

Activity 3.1: Enzyme experimental activities

Objective: investigating the enzyme Amylase in saliva

Materials: white bread

Procedure

- Take a piece of bread and chew in your mouth slowly.

- Notice the changing flavor of the mush in your mouth.
- Realize that the mush in your mouth slowly tastes sweeter.

Control experiment:

1. Mix some pieces of bread in a glass of water and wait for five minutes
2. Taste the mush (water + bread) and compare with flavor of mush of bread and saliva you chewed in your mouth.
3. Identify the difference of the tastes and take notes

Self-test exercises on 3.1 activity

- What do you recognize from the changes in the mush?
- How did the saliva convert starch into simple sugar molecules?
- Where did the enzyme amylase come from?
- How do you conclude this activity?

Section 3.1 Self-test exercises

1. What are enzymes?
2. What are enzyme active site and substrates?
3. What is the difference between enzymes and hormones?
4. What are coenzymes?
5. Are all enzymes proteins?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can define enzymes and activation energy ----------☐

2. I can explain how enzymes work ----------☐
3. I can describe the catalysts reaction of enzymes, activities and substrates -
---------☐

Dear learner, in order to proceed to section 1.2, you have to complete section 1.1 successfully. When you begin self-study on section 1.2, it provides you with the idea of enzyme properties (physical and chemical) and functions.

Section 3.2: Properties and functions of enzymes

Learning competencies

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

- Identify the properties of enzymes
- Explain the action of each property
- Describe the functions properties

Self-questioning 

Dear learner,

Before starting this section, ask yourself the following question.

"What do I know about enzyme properties and functions and what I want to learn from this section?"

What are enzyme properties?

Enzyme properties are reactions demonstrated through physical and chemical properties.

3.2.1: General properties of an enzyme

The general properties of enzymes are the nature of both their physical and chemical properties. Enzymes **accelerate** the reaction rates and neither affects the nature of products formed nor undergoes any changes by the reaction catalyzed.

3.2.2: The physical properties of enzymes

The physical properties of enzymes include denaturation, solubility, colloids, biocatalysts, precipitation, molecular weight and enzyme activity (Figure 3.2).

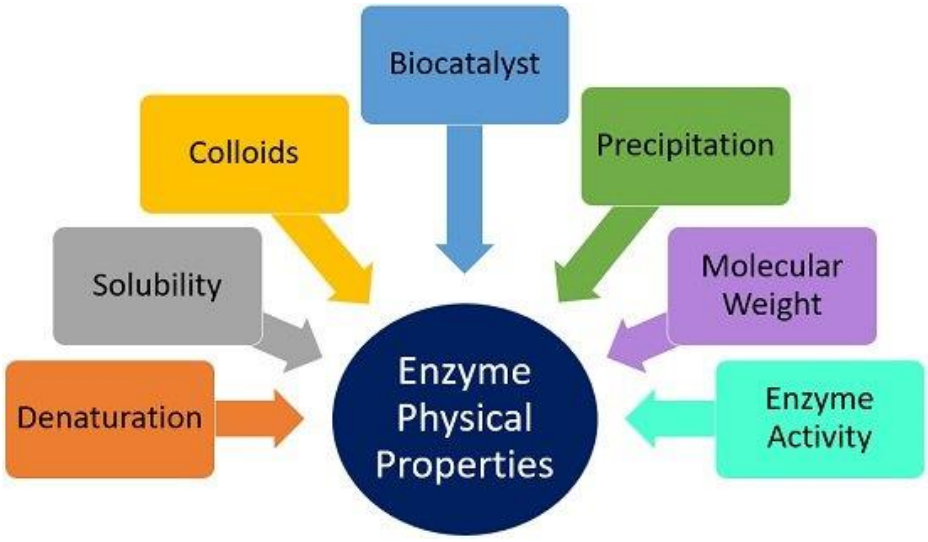


Figure 3.2 Physical properties of Enzymes

Denaturation is the process of breaking the intra and inter-molecular non-covalent bonds and distorts the shapes and active site of enzymes. Enzymes are **denatured** by high **heat** (above 40°C), changes in the **pH** (too low or too high), **heavy metals** and high **salt** concentrations, **solvents** and other reagents.

Solubility is the property of enzymes that allow to be dissolved in water, salt (NaCl), dilute glycerol and alcohol causing denaturation.

The colloidal nature of enzyme is the tendency of having **little** or no **dialysis** across the semipermeable membrane due to the large size or high molecular weight.

The biocatalyst property is the activity of enzymes in which very small quantities or a small amount of enzyme is enough to convert a large quantity of substrate that remains unchanged after the reaction.

Enzyme precipitation is the separation of enzymes for analysis using different aqueous or ethanol solvents.

Molecular weights of enzymes are large protein biomolecules (200 to 300 peptide bonds) that hold polypeptide chains of various amino acid sequences having a high molecular weight in enzymes.

Enzymatic activity is the general catalytic properties of an enzyme that depends on factors such as temperature, pH and enzyme concentration and substrate concentration. A low concentration of enzymes and substrates slows down the enzymatic reactions.

3.2.3: Chemical properties of enzymes

Enzyme chemical properties are **sensitivity, regulations and specificity, catalysis** and **reversibility** reactions (Figure 3.3).

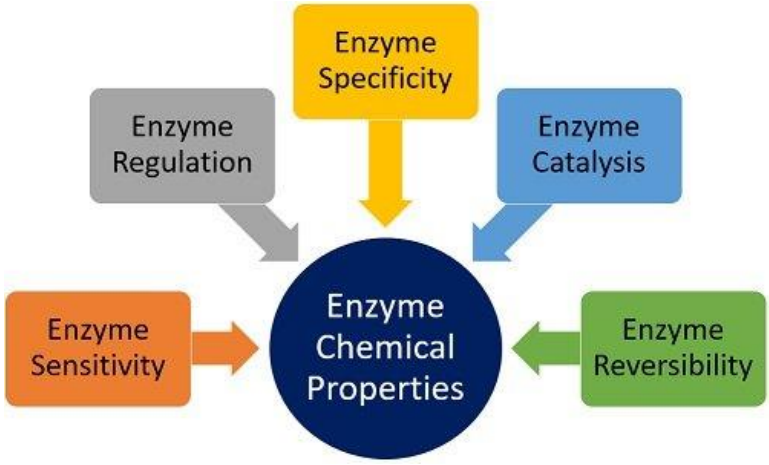


Figure 3.3 Chemical properties of enzymes

Heat and **pH Sensitivity** is an enzymatic reaction to heat (temperatures) and pH (acidity and basicity) activated at the optimum bodily temperature of **37** °C and pH 6 to 9 **nearly neutral** (**7.2)** levels.

Regulation is the function of the **activator** and **inhibitor** molecules.

Catalysis is the process of the **acceleration** of a chemical reaction. Reactions catalyzed by enzymes show a 10^3-10^8 times faster reaction rate in comparison to the non-catalyzed reactions.

Reversibility is the reaction to synthesize (build up new molecules or products) and decompose (breaks down different products) in which enzymatic reactions catalyze biochemical reactions in both forward and reverse directions. It is the ability of enzymatic biomolecules to catalyze various metabolic (anabolic and catabolic) reactions.

What is enzyme specificity?

Enzyme **specificity** is a property of enzyme that describes how restrictive the enzyme is in its choice of substrate.

☞ Enzyme Specificity includes:

- **Bond specificity:** a relative specificity of enzymes indicating enzymes are specific for a bond.
- **Group specificity:** a structural specificity of enzymes showing that enzymes are specific for a group.
- **Substrate specificity:** the feature of enzymatic activity by which an enzyme acts only on a particular substrate.
- **Optical specificity:** shows that enzymes act on optical configuration of the substrate.
- **Co-factor specificity:** the enzymatic specificity to the substrate and co-factors.

Activity 3.2: properties of enzymes

Objective: self-testing on the properties of enzymes

Procedure

Self-test exercises on 3.2 activities

1. What are the major properties of enzymes?
2. What does catalytic property mean?
3. What is the property specificity of enzyme?
4. What does reversibility of enzyme mean?

5. How do you describe the enzyme property of pH sensitivity?
6. How are enzymes sensitive to heat?

3.2.4: The function of enzymes

Enzymes are essential to speed up chemical reactions, respiration, digestion and function of the liver, muscle, nerves and each cell in the human body.

Examples:

- Enzymes help to provide healthcare and check for injuries and diseases.
- In our blood, too much or too little of certain enzymes cause health problems.
- There are thousand types of enzymes and each has only one activity in the body.
- Each enzyme that speeds up metabolism or chemical reactions in our body and builds up substances in all living things has an **active site** and a unique shape.
- Enzymes function when the substrate and active site fit together in the right conditions and do not work unless they change their shapes to fit with the substrates.

Examples:

- **Sucrase** breaks down a sugar called sucrose.
- **Lactase** breaks down lactose, a kind of sugar found in milk products.
- **Carbohydrase** breaks down carbohydrates into sugars.
- **Lipase** breaks down fats into fatty acids.
- **Protease** breaks down proteins into amino acids.

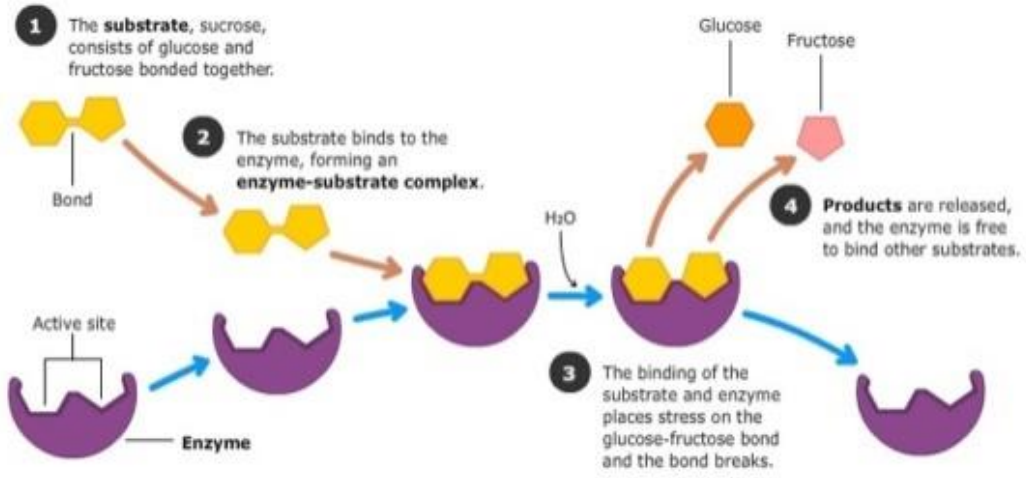


Figure 3.4 Enzyme functions

Dear learner, as shown above in (Figure 3.4, enzymes act on a substrate and release products for further uses through the steps (1, 2, 3 and 4). Enzymes perform their functions by lowering a reaction's activation energy or the energy required to start a reaction (Figure 3.5).

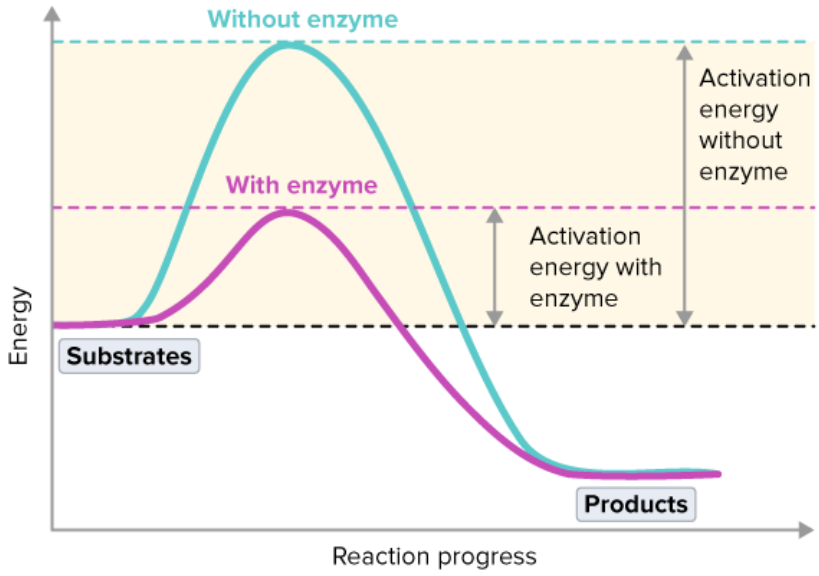


Figure 3.5 Enzymatic reactions between glucose and oxygen

Table 3.1 Enzymes and functions

Enzymes	Functions
Lipases	Split fats found in the blood, gastric juices, pancreatic secretions, intestinal juices, adipose (fatty) tissues and involved in digestions.
Amylase	Amylase that is found in saliva helps in changing starches into sugars.
Maltase	Maltase that is found in foods such as potatoes, pasta and beer and saliva breaks the sugar maltose into glucose.
Trypsin	Trypsin that is found in the small intestine breaks proteins down into amino acids.
Lactase	**Lactase** that is found in the small intestine, breaks lactose, the sugar in milk, into glucose and galactose.
Helicase	Unravels DNA
DNA Polymerase	Synthesizes DNA from deoxyribonucleotides
Acetyl cholinesterase	Breaks down the neurotransmitter acetylcholine in nerves and muscles

Activity 3.3: experiment on the reaction of enzymes

Objective: identifying enzymatic reactions

Materials: knife, Potatoes and Hydrogen peroxide **(H_2P_2)**

Procedure

- Cut the potatoes into two half slices.
- Drop hydrogen peroxide on one half of the potato slice and leave the other half potato slice for control.
- Observe if a bubbling starts from both slices or not as a result of enzymatic reactions and think off why?

Self-test exercises on activities 3.3

4. Why did the potato slice with H_2P_2 drop bubbles?
5. How did the metabolic decomposition take place?
6. Identify the enzyme, the substrate and the product.

Section 3.2 self-test exercises

Multiple choices

1. Which one of the following is the nature of an enzyme? They are

   A. Vitamin C. Carbohydrate

   B. Lipid D. Protein

2. Which of the following enzyme involved in hydrolysis of fat

   A. Maltase B. Lactase C. Lipase D. Amylase

3. All of the following are the physical properties of enzymes except

   A. Enzymes are soluble c enzymes are biocatalyst

   B. Enzymes are specific D. Enzymes are colloidal

4. The function of Trypsin is _____

   A. Digest protein C. unravels DNA

   B. Digest starch D. Synthesizes DNA

Short answer

1. What are the functions of enzymes?
2. Describe enzymatic sensitivities.
3. How do enzymes function in our body?

Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

3. I can identify the properties of enzymes ---------- ☐
4. I can explain the action of each property ---------- ☐
5. I can describe the functions properties ---------- ☐

Dear learner, you have now completed section 1.2 successfully before you proceed to section 1.3 under which you learn about protein structure levels and bonds that form the structures.

Section 3.3: Protein structures

Learning Competencies

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

- Explain the structure of proteins.
- Determine the protein's primary, secondary, and tertiary structures.
- List the levels of protein function

Self-questioning

Dear learner,

Before starting this section, ask yourself the following question:

"What do I know about protein structure and what do I want to learn from this section?"

What are proteins?

A protein structure is a polymer of amino acids joined by peptide bonds with three-dimensional arrangements of atoms in amino acid chain molecules.

Dear learner, complex protein macromolecules have four structural levels:

1. Primary structure
2. Secondary structure
3. Tertiary structure
4. Quaternary structure

1. Primary structure of proteins

The primary structure is the sequence of amino acids linked together to form a polypeptide chain bonds created during the protein biosynthesis process (Figure 3.6). It is the simplest level of protein structure forming simple sequences of amino acids in polypeptides.

Our body requires about **20** different amino acids to grow and function properly of which nine are essential and can make nonessential amino acids, but gained from diets.

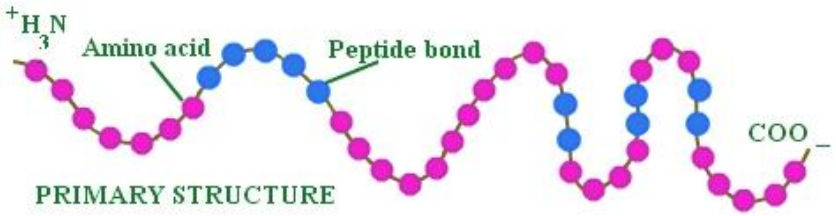


Figure 3.6 The Primary structures of proteins

2. Secondary structure of proteins

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

.

2.1 The a – Helix

The ***a-helix*** is a right-handed coiled strand and the side-chain substituents of amino acid groups. These groups extend to the outside and form hydrogen bonds with oxygen (C=O) in the strand with the hydrogen of each (N-H) group of four amino acids to make the structure stable.

The a–Helix structure is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds. The polypeptide chain twists into a right-handed screw with the NH group of each amino acid residue and the hydrogen-bonded to the CO of the adjacent turn of the helix.

2.2 β–pleated sheets

The hydrogen bonding in the ***ß-sheet*** *is* the bond between the inter-strands and intra-strands in which the sheet conformation of the *ß-sheet* consists of pairs of strands lying side-by-side. All peptide chains stretch out to nearly maximum extension, laid side by side and held together by intermolecular hydrogen bonds forming pleated folds of drapery (Figure 3.7).

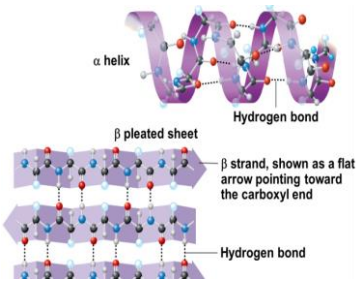


Figure 3.7 Secondary structures of proteins

3. Tertiary structure of proteins

The tertiary protein structure is the three-dimensional shape of protein molecules that bend and twist to achieve the maximum stability or the lowest energy state. It is fashioned by many stabilizing forces due to the bonding interactions between the side-chain groups of amino acids (Figure 3.8).

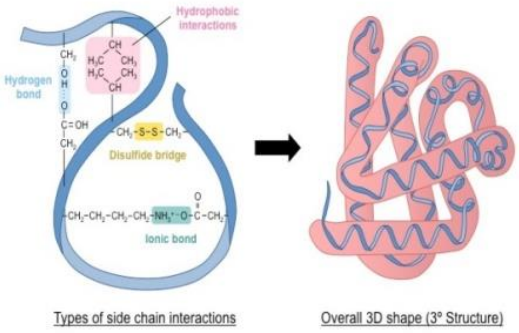


Figure 3.8 Tertiary structures of proteins

4. Quaternary structure of proteins

The quaternary structure of proteins is the arrangement of multiple folded protein subunits in a multi-subunits complex.

It is the association of several protein chains or subunits into closely packed arrangements with their own primary, secondary, or tertiary structures held together by the hydrogen bonds (Figure 3.9).

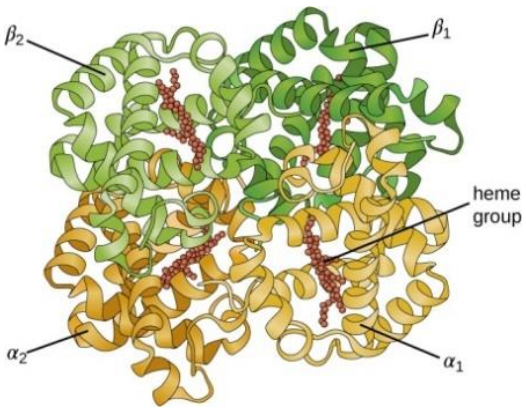


Figure 3.9 Quaternary structures of Proteins

Table 3.2 Summary on protein structures

Proteins levels	Structures
Primary	The basic linear sequence level of amino acids comprise one polypeptide chain
Secondary	The next level up of proteins with folding regions into the specific structural patterns within one polypeptide chain
Tertiary	The next level up is the three-dimensional arrangement of all the amino acids in a single polypeptide chain.
Quaternary	All polypeptide chains are held together by a specific spatial arrangement and interactions.

Activity 3.4: Show the differences of protein structures by drawing

Objective: Learning through drawing protein structures

Procedure

1. Draw a diagram for the primary, secondary, tertiary and quaternary protein structures and label each part.

Self-test exercises on 3.4 activity

1. Describe the difference each level of proteins structure
2. Identify the subunits of each protein structure
3. How are protein subunits held together?

Section 3.3 Self-test exercises

Multiple choices

1. Which of the following statements is NOT true about proteins?
   A. Proteins are made up of amino acids.
   B. Proteins are essential for the development of skin, teeth and bones.
   C. Proteins are major source of energy for the cell
   D. Protein is the only nutrient that can build, repair and maintain body tissues.

2. Tertiary structure is maintained by

A. Peptide bond
B. Hydrophobic bond
C. Di-sulfide- bond
D. All of the above

3. The primary structure of protein represents

A. Linear sequences of amino acids joined by peptide bond
B. 3-dimentional structure of amino acids joined by sulfide bond
C. Helical structure of protein joined by hydrogen bond
D. None of the above

Short answer

1. What are protein structures and the differences among the levels?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can explain the structure of proteins ----------☐
2. I can describe the primary, secondary and tertiary protein structural levels ----------☐
3. I can list the levels of protein structures ----------☐

Dear learner, you have to finish section 3.3 of this unit successfully before proceeding to section 3.4 that provides you with basic information and adequate ideas on enzyme substrate models on how the **Lock** and **key** and **induced fit models** function.

Section 3.4: Enzyme substrate models

Learning Competencies

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

- Identify enzyme substrate models
- Explain the active site of enzymes
- Describe each substrate model

Self-questioning 

Dear learner,

Before starting this section, ask yourself the following question.

"What do I know about models of enzyme actions and what do I want to learn from this section?"

How do enzyme substrate models fit?

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

3.4.1 Enzyme substrate binding models

Dear learners, enzyme substrate binding models include:

1. **Lock** and **key enzyme substrate model**
2. **Induced fit enzyme substrate model**

1. The Lock and Key enzyme substrate Model

The lock and key enzyme substrate model is the **active site** of an enzyme that precisely **fits** a specific substrate to interact through **non-covalent** interactions. It describes on how the enzymes bind to substrates before they catalyze a chemical reaction. Once the reaction progresses to the transition state and forms products, the **active site** will not be able to accommodate changes (Figure 3.10).

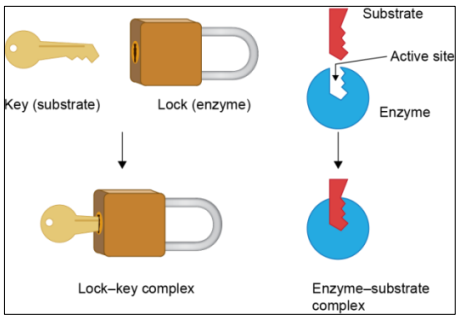


Figure 3.10 Lock and Key model

2. Induced fit enzyme substrate model

An **induced fit** enzyme substrate model explains on how the active site of an enzyme **elicits** responses to the binding substrate to take up transition even when the **active site** is not perfect to perform required products. The amino acid **side chains** making up the active site mold precise into the positions and enable the enzyme to perform its catalytic functions.

☞ The concept **induced fit** is when a substrate binds to an enzyme and brings a change in the shape of the enzyme, which either enhances or suppresses its activity.

Upon binding, the enzyme change shapes by the **induced fit** upon substrate and bind to form enzyme substrate complexes and enables to produce required energy for the reaction to move by putting the active site under strain and making the transition stable (Figure 3.12).

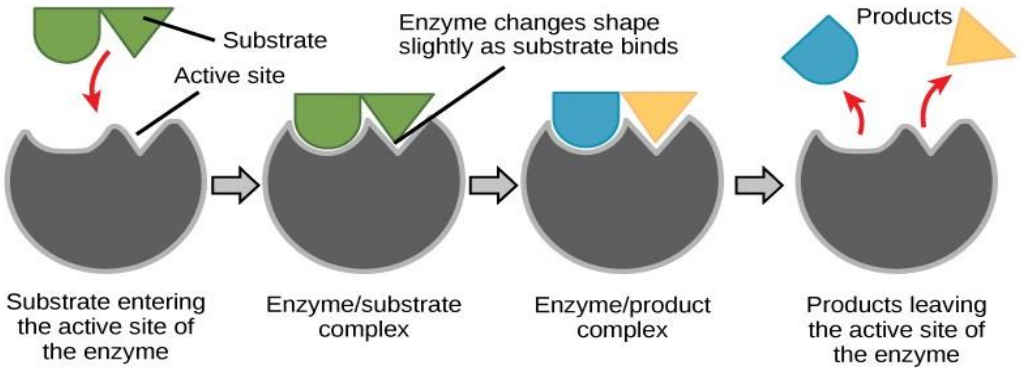


Figure 3.11 Induced fit enzyme model

3.4.2: Enzymatic transition state

An enzymatic transition state is the **chemical reactions** taking place qualitatively in the activated enzyme-substrate complex of absolute reaction rates. It is a state of chemical equilibriums between reactants as a mode of activated transitions in the reaction rates of elementary chemicals. The reactive state of substrate binding catalysis corresponds to the maximum reaction activated and its state of transition (Figure 3.13).

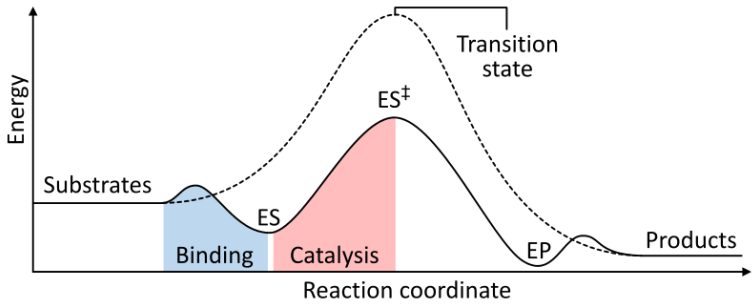


Figure 3.12 Enzymatic transitional states

Activity 3.5: practical activities

Objective: Drawing enzyme substrate models

Procedure

- Draw the shapes of the enzyme substrate models called "**Lock** and **Key**" and "**Induced Fit**" in large, post and learn from.
- What other examples of enzyme substrate models do you know?

🛠 Section 3.4 self-test exercises

Multiple choice

1. After the formation of which complex that a product is formed?

A. EI B. ES C. EP D. None of the above

2. In Which of the following model, enzyme is considered as flexible?

A. Lock and key B. Induced fit model C. A and B D. None of the above

3. The shapes of the enzyme substrate to fit into the binding perfectly is called_____

A. Active substrate B. Inhibitor C. Active site D. Protein structure

Short answer

1. What are the Lock and Key and Induced Fit models?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find tem difficult to answer correctly, go back and read the previous section again.

1. I can Identify enzyme substrate models ----------☐
2. I can explain the active site of enzymes ----------☐
3. I can describe each substrate model ----------☐

Section 3.5: Enzyme regulation

Dear learner, be sure that you have completed section 3.4 perfectly before proceeding to section 3.5.

Section 3.5 engages you in learning **enzyme regulation**, a control of the rate of a reaction catalyzed by an enzyme by some effector (inhibitors or activators) or by alteration of some condition (pH or ionic strength).

Learning Competencies

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

- Explain enzyme regulation
- Distinguish activator and inhibitor enzymes
- Describe substrate and bonding reactions

Self-questioning 

Dear learner,

Before starting this section, ask yourself the following question.

"What do I know about types of enzymes and how their action is regulated and I want to learn from this section?

How can I regulate enzymes?

Enzyme regulation is the **control** of the rate of reactions catalyzed by an enzyme. It is the quantity of enzyme controlled by post-translation and transcription. A regulatory enzyme is the one in a **biochemical pathway** through which it responds to the presence of other **biomolecules** and regulates the pathway activity. Both **Regulation** and **activation** of catalyzing enzymes is to control the **speed** of the whole reaction to obtain the amount of product required at any time, which requires an extra activation process to pass through some modifications and functions.

The three major types of regulatory process of enzymes are:

1. Allosteric enzymes
2. Genetic and covalent modification
3. Enzyme inhibition

1. Allosteric enzymes

Allosteric enzymes are enzymes that have additional binding sites for effector molecules than the active site and cause conformational changes. They contain **two** binding sites called **effectors** and **substrates.**

Effectors are small molecules (inhibitor or activator) modulating the enzyme activity and function through reversible non-covalent binding of a regulatory metabolite leading to conformational changes in a concrete part of the enzyme.

Substrate is a molecule up on which an enzyme acts.

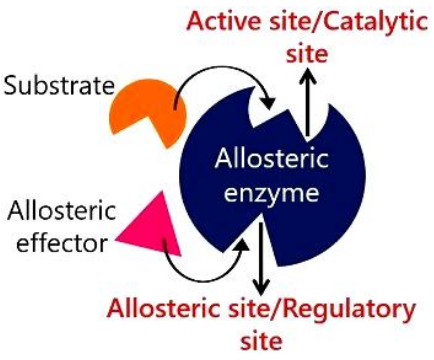


Figure 3.13 Allosteric enzyme

2. Genetic and Covalent Modification

Genetic and covalent modification of the protein surface and facilitate intracellular delivery for improving the properties of enzymes and transit into active or inactive forms.

Covalent modifications are enzyme-catalyzed alterations of synthesized proteins by the addition or removal of chemical groups.

Modifications can target a single type of amino acid or multiple amino acids and will change the chemical properties of the site. It is a mode of enzyme regulation by the **addition** or **elimination** of some molecules attached to the enzyme protein.

Examples:

Phosphorylation is the **addition** of phosphate groups to proteins as the most frequent regulatory modification mechanism in our cells (Figure 3.13).

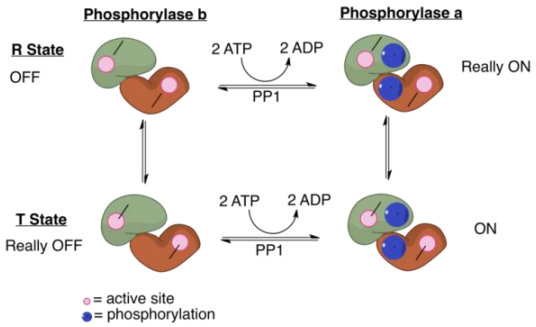


Figure 3.13 Enzyme phosphorylation

3. Enzyme inhibition

Enzyme inhibition is a decrease in enzyme activity. Enzyme **inhibitor** is a molecule that binds to an enzyme and blocks its activity.

☞ An inhibitor has two groups termed as **irreversible** and **reversible inhibitors**.

3.1 **Irreversible** inhibitor is a substance that permanently blocks the action of an enzyme.

3.2 **Reversible** inhibitor inactivates an enzyme through non-covalent easily reversed interactions and includes three subgroups called competitive, uncompetitive and noncompetitive inhibitions.

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

The following (Figure 3.14) shows enzyme inhibition and its types.

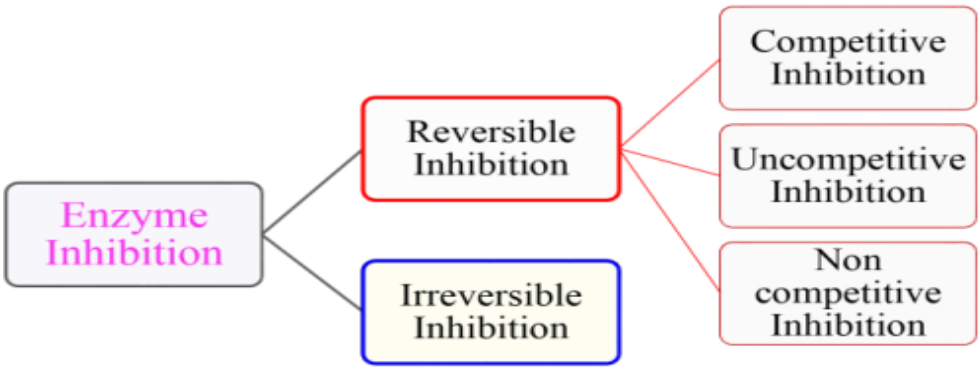


Figure 3.14 Enzyme inhibition

Activity 3.6: Enzyme regulation activities

Search example of reversible and irreversible enzyme inhibition from library and explain how the inhibiter acts.

Self-test exercises on 3.6 activity

1. What are enzyme effectors?
2. What is an enzyme substrate?
3. What are enzyme activators?
4. What are binding and blocking molecules?
5. What are enzyme inhibitors?

Section 3.5 self-test exercises

Multiple choices

1. Enzymes that are involved in the control and regulation of biological process are

   A. allosteric enzymes C. inhibitors
   B. regulators D. Activators

2. Allosteric enzymes are

   A. smaller than simple enzymes
   B. larger than simple enzymes
   C. smaller than simple enzymes but not complex

D. larger and more complex than simple enzyme

3. Blocking of enzyme action by binding on its active sites is called

A. feedback inhibition C. competitive inhibition

B. allosteric inhibition D. non-competitive inhibition

Short answer

1. What is enzyme regulation?
2. What are allosteric enzymes?
3. What is enzymatic inhibition?
4. Explain competitive and noncompetitive inhibitions
5. What is the difference between reversible and irreversible inhibition?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again'

1. I can explain enzyme regulation ----------☐
2. I can distinguish activator and inhibitor enzymes ----------☐
3. I can describe substrate and bonding reactions ----------☐

Dear learner, now you have completed section 3.5 successfully before you continue to section 3.6. Section 3.6 engages you in learning enzyme regulation or a control of the rate of a reaction catalyzed by an enzyme using some effector (inhibitors or activators) or by alteration of some condition (pH or ionic strength).

Section 3.6: Types of enzymes

Learning competencies

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

- List types enzymes
- Describe the function of each type of enzyme
- Define activities of each type of enzyme

Self-questioning 

Dear learner,

Before starting this section, ask yourself the following question.

what different types of enzymes do I know and what I want to learn from this section?

Enzymes are of several types. Dear learner, do you know how do you classify enzymes? Well, the type of enzyme is determined based on how they **bind** specific molecules together to form new molecules and break specific molecules apart into separate molecules. An enzyme has both structural and basic classifications types.

3.6.1: Enzyme structural classification

The structural classification of enzymes deals with the separation of an enzyme into **simple proteins** (active) and **conjugated proteins** (**holoenzyme).** The **conjugated protein** part (holoenzyme) is divided into the **non-protein** part **(cofactor)** and the protein part **(apoenzyme-inactive)** groups.

The non-protein part (cofactor) also separates into the firmly attached metal ion **(prosthetic group)** and the loosely attached **vitamin B complex (coenzyme)** groups (Figure 3.15).

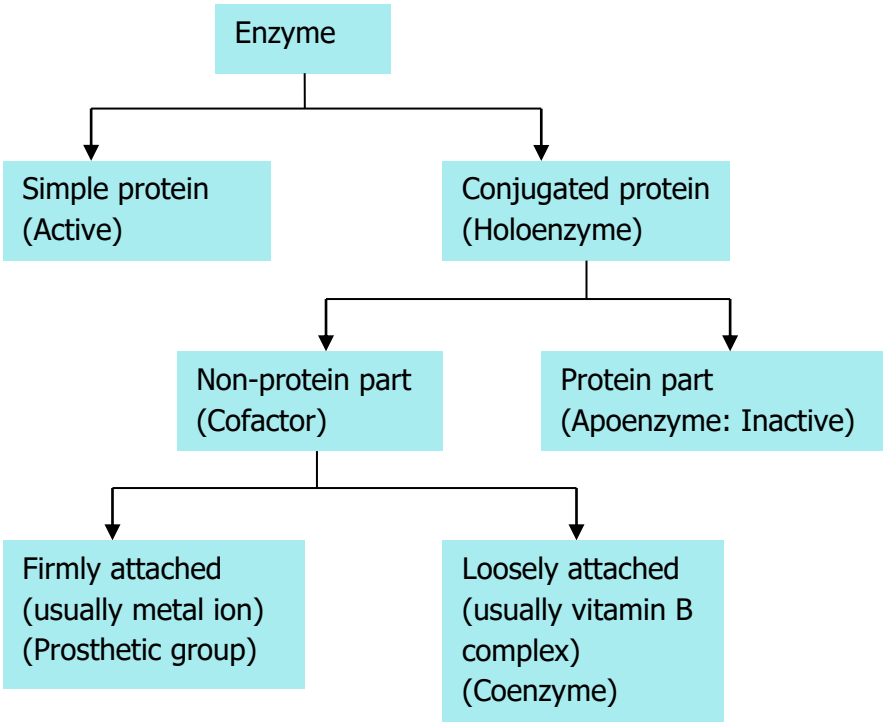


Figure 3.15 The Structural classifications of enzymes

3.6.2: Basic classification of enzymes

Enzymes are divided into **six classes** bearing the ending suffix "-**ase**" based on **what** and **how** they react and catalyze.

The basic classes of enzymes:

1. **Oxidoreductase** is a class of enzyme that catalyzes oxide-reduction reactions. It catalyzes the transfer of electrons from one molecule (oxidant) to other molecule (reductant) reactions in the pattern: **$A^- + B \rightarrow A + B^-$** where A is the oxidant and B is the reductant.

2. **Transferase** is an enzyme that transfers methyl groups and others from one compound donor as a cofactor to another compound (acceptor) carry and transfers.

3. **Hydrolase** is enzyme that catalyzes the hydrolysis of various bonds.

4. **Lyases** are enzymes that cleave bonds by oxidation in which two or more substrates are involved in one reaction.
5. **Isomerases** are a general class of enzymes that convert molecules from one isomer to another isomer.
6. **Ligases** are enzymes that catalyze the joining of two molecules with concomitant hydrolysis of the di-phosphate bond in **ATP.**

Activity 3.7: Tests for enzyme reactions

Objective: Testing enzymatic reactions in apples or bananas

Materials: a banana fruit and a knife

Procedure

- Peel out a banana and cut it into two slices
- Cover one half of the slice of banana by plastic sheet promptly
- Wait until it turns into brownish color pigmentations

Control experiment

1. Observe color changes of covered and exposed banana slices
2. The exposed banana slice changes color into brownish and the covered banana slices remains unchanged.

Self-testing exercises on activity 3.7

1. What was the cause of the enzymatic browning?
2. What is enzyme catalyzing?
3. What is the name of the enzyme found in bananas or apples?

Section 3.6 self-test exercises

Multiple choices

1. All digestive enzymes are classified under which of the following category?

A. Transferase C. Hydrolase

B. Oxidoreductase D. All of the above

2. Which one of the following enzyme and substrate is mismatched

A. Proteases → Carbohydrates C. Trypsin → Protein

B. Lipases → Lipids D. All are correctly matched

Short answer

1. List the six classes of enzymes
2. What is structural classification of enzymes?

☑Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can list the types of enzymes
2. I can describe the function of each type of enzyme ----------☐
3. I can define the activities of each type of enzyme ----------☐
4. I can list the basic and structural classification of enzymes ---------☐

Dear learner, you have now completed section 3.6 of this unit successfully. In section 3.7, you will learn about factors affecting enzyme actions and sensitivity to changes in many physiochemical factors (pH, temperature, substrate concentration and the like).

Section 3.7: Factors that affect enzyme action

Learning Competencies

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

- List factors affecting enzyme actions
- Describe how each factor affects enzyme action
- Discuss on how to normalize the factors

Self-questioning

Dear learner,

Before starting this section, ask yourself the following question.

"What do I know about factors that affect enzyme actions, enzyme kinetics, enzyme application, and what do I want to learn from this section?"

Enzymes work best within specific ranges of **temperature** and **pH** or at optimal conditions, but an increase or decrease in the conditions affects the functions of enzymes.

Factors affecting the activity of enzymes include **temperature, water, pH, substrate concentration, enzyme concentrations, inhibitors, end-products, Factivators and radiations**

The following figure (Figure 3.16) shows the factors that affect enzyme activity.

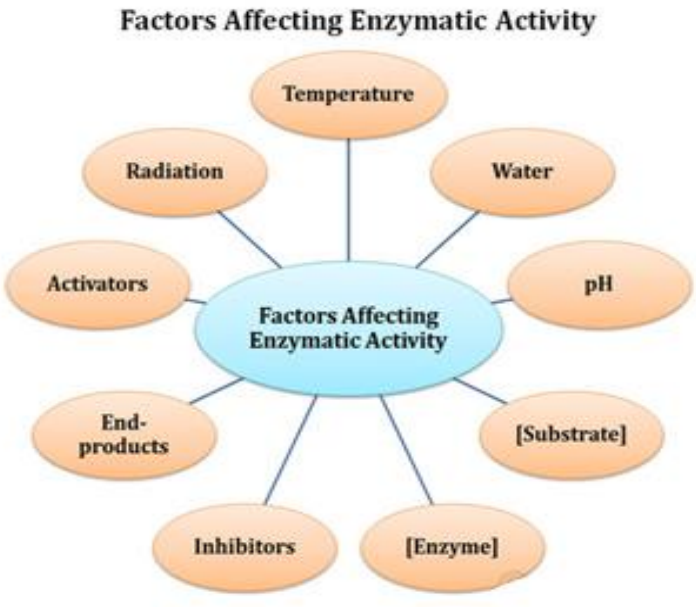


Figure 3.16 Factors affecting enzymes' activities

3.7.1: Factors affecting enzymatic actions

Factors affecting enzymatic activities:

1. **Temperature:** all enzymes work best within the specific ranges of optimum temperatures; low or high temperature causes an enzyme to lose its activity and ability to bind into a substrate and denatured. It means, once enzymes denatured, they cannot be renatured.

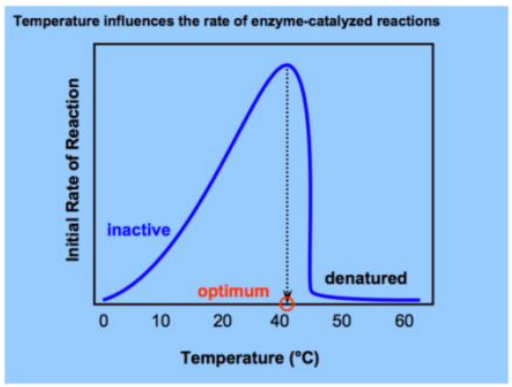


Figure 3.17 Enzyme reactions to temperature

2. **Optimum pH:** enzymes function at optimum pH; too low (strong acidic) or too high (too alkaline) affects enzyme activities.

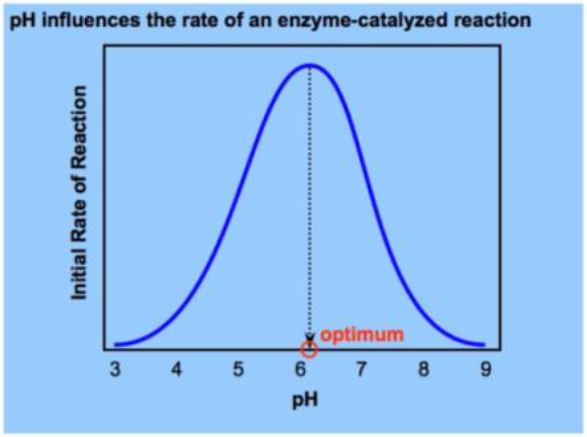


Figure 3.18 Enzyme reactions to pH

3. **Substrate concentrations:** enzymes require a maximum limit of substrate concentration to bind.
4. **Radiation:** damages enzyme activities by reducing its efficiency and creating disorders in the macromolecules.
5. **Water:** affects the performance of enzymes' activity beyond its optimum level.

6. **Product (feedback inhibition):** is a cellular control mechanism. A cell is able to identify the adequacy of a product for its subsistence or not that a lack of product causes feedback inhibition.

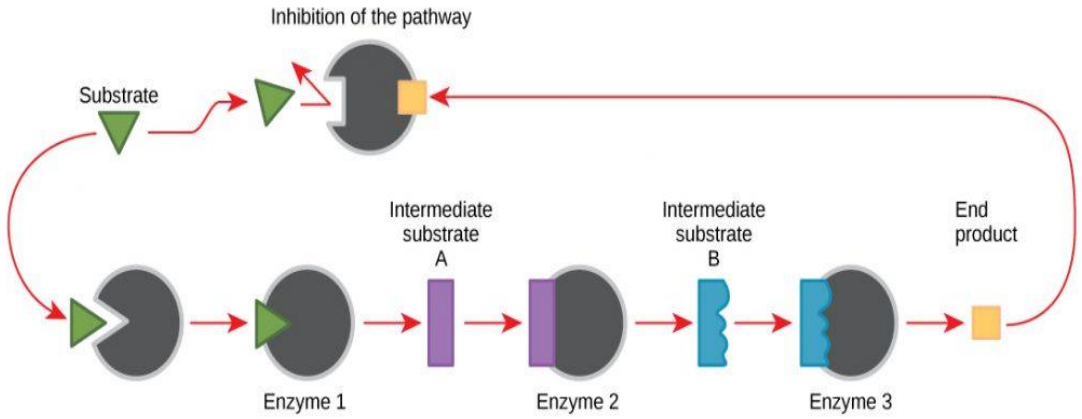


Figure 3.19 Feedback inhibition

Activity 3.8: tests for enzyme sensitivity

Objective: test for enzyme sensitivity to heat and pH

Materials: Hydrogen peroxide, potatoes, knives and cooking utensils

Procedure

1. Boil hard one piece, freeze the other piece at -10 C° and leave the third piece of potatoes.
2. Cut all three pieces of potatoes into two slices and drop hydrogen peroxide on the boiled, freeze and raw potato slices.
3. Observe and compare the reactions of enzymes of each potato slice.

Section 3.7 Self-test exercises

Multiple choices

1. The pH level where the enzyme is most active is known as_____ pH.

A. Standard B. Equilibrium C. Optimum D. Neutral

2. All are factors affecting the activity of Enzymes

A. Substrate Concentration C. pressure

B. Temperature D. pH

Short answer

1. List all the factors that affected the enzymatic reactions?
2. What makes the differences among enzymatic reactions?

☑ Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can list factors affecting enzyme actions ----------☐
2. I can describe how factors affect enzyme action ----------☐
3. I can explain how to normalize the factors ----------☐

Dear learner, now you have completed section 3.7 successfully and ready to proceed to section 3.8 that briefs you about Enzyme **kinetics**. It is about the rates of enzyme-catalyzed chemical reactions.

Section 3.8: Enzyme kinetics

Learning Competencies

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

- Explain enzyme kinetics
- Describe the steps enzyme kinetic
- How enzyme kinetics works?

Self-questioning 

Dear learner,

Before starting this section, ask yourself the following question:

what do I know about enzyme kinetics and what I want to learn from this section?

How do you measure the rates of enzyme kinetics reactions?

Enzyme kinetics is the study of the rates of enzyme-catalyzed chemical reactions, binding affinities of substrates, inhibitors and the maximal catalytic rates achieved.

Enzyme kinetics is the **motion** and speed of reactions gained by lowering the activation energy of the substrate (reactants) and turning into products. The concentration of enzymes and substrates determines the rate of the reactions or production volumes per unit time.

In short, enzyme kinetics mechanism has **formula** set from patterns of Enzyme (E), a protein molecule that reacts to a substrate (S) and produce an enzyme substrate complex (ES*), which is transformed into an enzyme product complex (EP) and a product (P) via the transition state (ES).

Enzyme kinetics mechanism formula: E + S ⇄ ES ⇄ ES* ⇄ EP ⇄ E + P

Where:

E = Enzyme

S = Substrate

ES = Enzyme substrate combined

ES*= Enzyme substrate complexes

EP= Enzyme product,

E+P =Enzyme and substrate separation

⇄ = both side reactions

Dear learner, the most known model of enzyme kinetics is the formula that takes a form of equation called **Michaelis-Menten** model that explains the rate of enzymatic reaction with the reaction rate and rate of formation of product to the concentration of substrate.

The model explains the relationship between the rate of an **enzyme-catalyzed reaction** [V_1], the **concentration of substrate** [S] and **two constants**, V_{max} and K_m which written in the form equation.

Michaelis-Menten model equation:

$$v_1 = \frac{V_{max}[S]}{\{K_m + [S]\}}$$

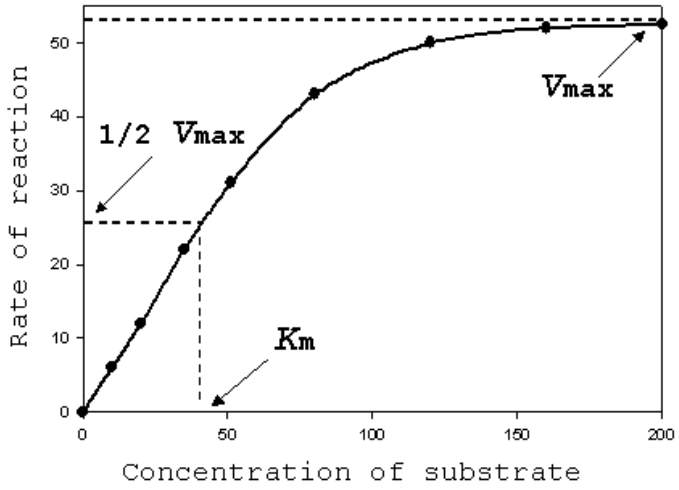
Where:

V_1 = the initial velocity (rate reactions)

V_{max} = the maximal velocity (maximum rate of **reactions**)

[S] = the substrate **concentration**

K_M = substrate concentration at **half-maximal velocity** (Michaelis constant).



Graph 1 Michaelis-Menten model equation

The study of enzyme kinetics revealed the:

1. Catalytic mechanism of enzymes,
2. Roles of enzymes in metabolism,
3. Enzyme controlling mechanisms and

Activity 3.9: Experiment on enzyme reaction rates (during tutorial)

Objective: Test for rates (speeds) of enzyme reactions

Materials: Beef liver, carrot, potato, three test tubes, H_2O_2 and knife

Procedure

1. Chop the beef liver, carrot and potato into small pieces and put into three test tubes.
2. Label the test tubes as "A" for beef liver, "B" for carrot and "C" for potato chops.
3. Add an equal amount of hydrogen peroxide to each test tube "A", "B" and "C" containing chops.
4. Observe the rate of enzymatic reactions in each test tube and measure the height of the reaction of each test tube.

Self-testing exercises on activity 3.9

1. What were the reaction rates in test tubes A, B, and C?
2. Which of the reaction were the highest and the fastest?
3. Why was the reaction in "A" the highest?

Section 3.8 Self-test exercises

- What is an enzyme kinetics?
- The term kinetics is a motion and how do you relate it to enzymes?
- Is the rate of enzymatic reaction measurable and if yes, how?

Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can explain enzyme kinetics ---------- ☐
2. I can describe the steps enzyme kinetics ---------- ☐
3. I can explain how enzyme kinetics works ---------- ☐

Dear learner, now you have successfully completed section 3.8 before you move to section 3.9 that provides you with insightful explanation on application of enzymes. It explains the uses of enzymes in producing a variety of food products, beverages processing, animal nutrition, textile industries, household goods, biofuels and other fuels for automobiles, cleaning products and in energy generation plants.

Section 3.9: The Application of enzymes

Learning competencies

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

- Explain applications of enzymes
- List areas of enzyme applications
- Identify and discuss locally applied enzymes

Self-questioning

Dear learner,

Before starting this section, ask yourself the following question.

what applications of enzymes do I know and what I want to learn from this section?

Application of enzymes is the use of enzymatic biochemical reactions for chemical conversion process that are driving forces of great change for productivity of various industries.

3.9.1 Application of enzymes in industries and their benefits

Dear learner, the application of enzymes is the wide use of enzymes in food, feed, textile, papermaking, leather and detergents, pharmaceutical and other industrial productions.

Examples:

1. Enzymes break down larger complex molecules into simpler molecules in our body where they to fuel our digestive systems and cellular respirations.
2. Most enzymes used for food industry from the internal organs of animals and plants, but now most enzymes are obtained by microbial fermentation.
3. Enzymes cause billions of chemical reactions to happen at lightning speed inside the cells of our body.
4. Enzymes improve the utilization of feed rate of starch, protein and minerals and degrade the anti-nutritional factors in animal feed, prevent animal indigestion and improve feed digestibility.
5. Enzymes used in the pharmaceutical industry, drugs, antibiotics, household products to speed up chemical reactions and synthesis.
6. Enzymes are powerful tools in sustaining a clean environment in several ways.
7. Washing powders are enzymes used to break down protein, starch and fat stains on clothes.

Table 3.4 the applications and functions of enzymes

Enzymes	Applications	Uses (Functions)
Arginase	Soil fertilizer	Responsible for recycling the nature of urea
Cellulases	Biofuel industry	Breakdown cellulose into sugars and ferment to produce cellulosic ethanol
Ligninase	Biofuel industry	Pre-treatment of biomass for biofuel production
Protease, Amylase, Lipase	Biological detergent	Protease removes protein, amylase removes starch, and lipase removes fat or oil stains from laundry and dishware
Mannanase	Biological detergent	Remove food stains from the common food additive guar gum
Betaglucanase	Brewing industry	Improve beer filtration
Papain	Culinary uses	Tenderize meat for cooking
Rennin	Dairy industry	It hydrolyses protein in the manufacture of cheese
Trypsin	Food processing	Manufacture hypo-allergenic baby foods
Cellulases, Pectinase	Food processing	Clarify fruit juices.
Nuclease, DNA Ligase, Polymerase	Molecular biology	Uses restriction digestion and polymerase chain reaction to create recombinant DNA

Activity 3.10: fill-in the blank space

Enzymes	Application	Uses
	Fertilizer	
	Biofuel industry	
	Biological detergent	
	Detergent(removes foods strains)	
	Culinary uses	
	Removes protein strains	

Section 3.9 self-testing exercises

Multiple choice

1. In which of the following industries do we use Enzymes?

   A. Paper B. Food C. Brewing D. All

2. Which of the following enzyme is involved in the manufacture of cheese?

   A. Rennin B. Papain C. Lipase D. protease

Short answer

a. What does application of enzyme mean?

b. Where do we apply enzymes?

c. What are the benefits of enzymatic applications in different sectors?

☑ Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

1. I can explain applications of enzymes ----------☐
2. I can list areas of enzyme applications ---------- ☐
3. I can identify and discuss locally applied enzymes ---------☐

Dear learner, now you have completely finished section 3.9 and ready to proceed to section 3.10 that presents about the traditional malting process, purposes and uses.

Section 3.10: The Practice and use of traditional malting in Ethiopia

Learning competencies

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

- Explain the what and why of malting for alcohol drinks
- List some of the locally prepared types of malting
- Define the nature and function of malting for alcoholic production

Self-questioning

Dear learner,

Before starting this section, ask yourself the following question.

Ask someone about the process and reasons of malting.

what practices of malting do I know in Ethiopia and what I want to learn from this section?

Malting is the process of sprouting grains widely applied traditional technology. Malting is limited or controlled germination of grains in moist air to mobilize enzymes like amylases, proteases and others that hydrolyze and modify the grain components and its structure.

3.10.1 Steps of modern malting

Dear learner, there are three steps of modern malting process:

Step1: Steeping

Steeping is the process of cleaning the grain kernels and bringing it to life with water and oxygen by immersing it in the water and air for a specified time. Steeping is hydrolysing enzymes of the barley seed to become sufficiently moist to allow a uniform breakdown of starches and proteins.

The water activates enzymes in grains and stimulates to produce new enzymes in which water, temperature and aeration are vital for producing high quality malt.

Step2: Germinating

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

Modification is the breakdown of protein and carbohydrates, resulting in the opening up of the seeds' starch reserves within four to six days as **Green Malt**. The control of temperature and moisture levels with regulated airflow and the uniformity of water spray enable to achieve a high quality and consistent germination process.

Malting is partly an art and partly a science gauged in the degree of modification with the eyes, sense of smell and hands.

Step3: Kilning (heating)

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

The gentle drying to keep enzymatic activity and friability with wide ranges of malt colours, flavours, distinctive ales and lagers.

3.10.2 Why is malting for?

The main purpose of malting is to produce **α-amylase** and **β-amylase** enzymes that are useful for modifying and converting **starches** of grains into simple **sugar** (monosaccharide), complex sugar (disaccharides), malt sugar (maltose) and higher sugars or **maltodextrines.** It is also for converting or modifying the physical structure of the barley grain through synthesis or activation of a series of enzymes to produce malt for uses in brewing, distilling or food production.

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

3.10.3 Traditional malting for local alcohol production

Traditional malting is the process of sprouting barley grains for the production of enzymes (α-amylase and β-amylase) to process fermentation drinks such as Tella. It is also to produce alcoholic and beverage drinks for consumptions and income generation to support the livelihood of the people.

The most commonly used grains for malting are barley, maize, millet, sorghum and the like. However, barley is the most preferable grains to produce malt using similar steps of the modern malt.

The steps of traditional malting process include:

1. **Soaking barley grains in water:** steeping
2. **Germinating:** sprouting
3. **Heating (kilning):** drying by sunlight the malt

Barley malting in Ethiopia is one of the traditional practices for the production of traditional beer (Tella) and other drinks (Figure 3.21).

Figure 3.21 Malted barley

Activity 3.11: Malting practices

Materials: barley grains and water

Procedure

1. Make a malt of barley grains
2. Write the steps and the time take for malting

Self-testing exercises on activity 3.11

1. What happened to the barley seeds?
2. How did you halt the malt from further sprouting?
3. Do people in your area use malting to produce local drinks

Section 3.10 self-test exercises

1. What are the raw materials for malting?
2. What enzymes are used in malting?
3. Why do people make malts?

Checklist

Put a tick mark (✓) against the following tasks that you can perform. If you find them difficult to answer correctly, go back and read the previous section again.

2. I can explain applications of enzymes
3. I can list areas of enzyme applications
4. I can identify and discuss locally applied enzymes

Dear earner, now you have completed section 3.10 and ready to continue the last section 3.11that introduces about a renowned biochemist with the objective to inform you their functions and roles.

Section 3.11: Renowned Biochemists in Ethiopia

Learning competencies

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

- Explain what a biochemist is
- Describe the work of a biochemist
- List renowned Ethiopian biochemists

Dear learner, a biochemist is a scientist who studies the chemical processes and transformations in living organisms including DNA, proteins and cell parts. He/she also conducts research on how certain chemical reactions happen in cells, tissues and organisms and record the effects of products in food additive and medicines.

Biochemistry studies the immune systems, expressions of genes and isolation, analysis and synthesis of the products.

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

Activity 3.12: self-study

Objective: learning through studying about renowned exemplars

Procedure

1. List any renowned biochemists you know with pertinent biography.
2. Discuss the roles of biochemists in research and take notes.

☸Unit three summary

- Enzymes are biocatalysts that speed up chemical reactions to speed up metabolism rates without affecting the products and itself. An enzyme is a substance acting as a catalyst in living organisms, regulates the rate of chemical reactions and remains unaffected in the process. Enzyme **active site** enables to bind and increases the reaction rates by lowering **energy activations.**
- Some the enzyme reactions convert substrates into products in millions of times of faster speeds. Enzymes are inactive, destroyed or denatured beyond the optimum temperatures and PH (acidity and alkaline).
- Molecules that increase the activity of enzymes are **activators** and molecules that decrease the activity of enzymes are **inhibitors**.
- Both enzyme activators and inhibitors are molecules turning the activities of enzymes up and down by binding with molecules of other enzyme.

- Enzymes require dietary minerals and vitamins to function properly for the next side-product and remove wastes from cells. Many enzymes require cofactors (coenzyme) to become complex holoenzyme with apoenzyme before exerting catalytic activities.

Unit three review questions

Part I. True or False questions

Instructions: Write "True" if the statement is correct and "False" if the statement is NOT correct.

1. Enzymes act as an inorganic catalyst in the cell.
2. The rate of enzymatic reaction increases with an increase in temperature.
3. Competitive inhibitor activates the rate of enzyme-catalyzed reactions.

4. If you drop H_2O_2 on chopped beef liver, enzymatic reactions will be very active.
5. A molecule named with suffix "ase" is called an enzyme.
6. All enzymes are protein molecules, but all proteins are not enzymes.
7. Our saliva contains an enzyme ligase.
8. Enzymes can react beyond the optimum temprature.
9. Cofactors are molecules that decrease the activity of enzymes.
10. Enzymes are not used in the pharmaceutical industry.

Part II. Multiple-choice questions

Instructions: Choose the correct answer among the alternatives, and write the letter of your choice in your exercise book.

1. Which of the following statement best describes an enzyme?
   A. They speeds up reactions in cells, being used up in the process
   B. They are lipids that speeds up reactions in cells, being used up in the process
   C. Carbohydrate that functions as a biological catalyst
   D. A protein that functions as a biological catalyst
2. K_m of an enzyme is the substrate concentration at

   A. $1/2V_{max}$ B. V_{max} C. $1/4V_{max}$ D. $2V_{max}$
3. Which one of the following is a feature of all catalysts?
   A. They are made from protein
   B. They are broken down in the reaction
   C. They are not changed by the reaction
   D. They are altered by the rate of the reaction
4. Which one is NOT an enzyme specificity model?

   A. Lock and Key B. Michaelis-Menten Kinetics

   C. Induced fit model D. All are specificity models
5. Which of the following statement is correct?

   A. Enzymes are protein in nature

   B. Enzymes are thermo-labile

   C. Enzymes is colloidal in nature

   D. All of the above
6. Blocking of enzyme action by blocking its active sites is

   A. competitive inhibition

B. feedback inhibition

C. allosteric inhibition

D. non-competitive inhibition

7. What is the molecular weight of enzymes?

A. Large protein biomolecules B. A and B

C. 200 to 300 peptide bonds D. All

8. Enzymes that have additional binding sites are called

A. Allosteric enzymes B. Transition state

C. Enzyme rates D. None

9. Enzyme activity is dependent on

A. The folding of a proteins

B. Its sensitivity to the pH and salt concentration

C. Its sensitivity to temperature

D. All of the above

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

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

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

11. The three steps of malting are

A. Germinating, Steeping and Kilning

B. Steeping, Germinating and Kilning

C. Kilning, Germinating and Steeping

D. None of the steps is correct

12. An enzyme that that convert molecules from one isomer to another isomer is

A. Transferase B. Isomerases

C. Lyases D. Translocases

Part III. Short answers

Instruction: Give short answer for the following question

1. What are the five types of enzymes and their applications?

Assignment

Dear learner, Do the following assignments and submit them during your tutorial session.

Name _____

Id No. _____

Region/city_____ **Zone** _____

Tutorial center_____

Instruction: answer each of the following questions and give examples

1. What is the difference between enzymes and hormones?
2. Are enzymes living things?
3. What is the active site of enzymes?
4. What will happen to our body if some enzymes are missing?
5. What will happen to body enzymes, if our body temperature rises beyond $37\ ^0C$?
6. What are the relationships between homeostasis and enzyme functions?
7. How does enzyme kinetics work in our body in relation to medicaments?
8. Which of the followings matter more in enzyme functions (size, volume and shape)?
9. If you buy ripen bananas with droplet of brownish pigments, what is the cause of all these mosaic banana colors?
10. If you buy ripen bananas with droplet of brownish pigments, what is the cause of all these mosaic banana colors?

3.14 Feedback to unit three self-test exercises

Dear learner, here are feedback to unit three self-testing exercises to check that to what extent you have achieved so far.

Section 3.1 Self-test exercises

Short answer

1. **What are enzymes?**
   - Enzymes are biological catalysts proteins that speed up the rate of specific chemical reactions, remain undestroyed during reactions.
2. **What are enzyme active site and substrates?**
   - Enzymes bind substrates at key locations called active sites in their structures and a substrate is a molecule that reacts with n enzymes.
3. **What is the difference between enzymes and hormones?**
   Enzymes are biocatalysts and hormones are messengers.
4. **What are coenzymes?**
   Coenzymes are vitamins.
5. **Are all enzymes proteins?**
   No, all enzymes are not proteins

Section 3.2 Self-test exercises

Multiple choices

1. D 2. C 3. B 4. D

Short answer

1. **What are the functions of enzymes?**
   - Enzymes are proteins that help speed up metabolism or the chemical reactions in our bodies.
2. **Describe enzymatic sensitivities.**
   Enzymes are sensitive to pH and temperatures. Sensitivity means enzymes function at optimum pH and temperature.
3. **How do enzymes function in our body?**

Enzymes are proteins that help speed up metabolism (catabolism and anabolism) or the chemical reactions in our bodies.

Section 3.3 Self-test exercises

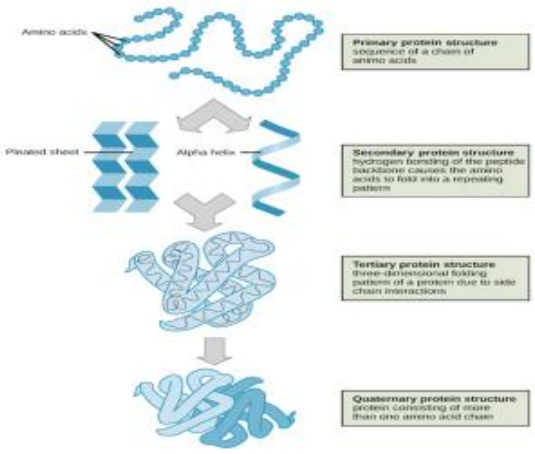
Multiple choices

1. C 2. D 3. A

Short answer

2. What are protein structures and the differences among the structural levels?

The four levels of protein structure are **primary, secondary, tertiary, and quaternary**. It is helpful to understand the nature and function of each level of protein structure in order to fully understand how a protein works.



Section 3.4 Self-test exercises

Multiple choices

1. B 2. B

Short answer

1. What are the Lock and Key and Induced Fit models?

- The lock and key model states are the active sites of an enzyme that precisely fits a specific substrate. The induced fit model is the active site of an enzyme that undergoes a conformational change when binding a substrate to improve the fit.

Section 3.5 Self-test exercises

Multiple choices

1. A 2. D 3. C

Short answer

1. **What is enzyme regulation?**
   - Enzymes are regulated by other molecules that either increase or reduce their activity. Molecules that increase the activity of an enzyme are called activators while molecules that decrease the activity of an enzyme are called inhibitors.

2. **What are allosteric enzymes?**
   - An allosteric enzyme is an enzyme that contains a region to which small, regulatory molecules (effectors) bind in addition to and separate from the substrate binding site and thereby affects the catalytic activity.
3. **Describe covalent modification**
   - Covalent modifications are enzyme-catalyzed alterations of synthesized proteins and include the addition or removal of chemical groups.
4. **What is enzymatic inhibition?**
   - Enzyme inhibitors are molecules that interact with enzymes in some way and reduce the rate of an enzyme-catalyzed reaction or prevent enzymes to work in a normal manner.

5. What are competitive and noncompetitive inhibitions?

- The main difference between competitive and noncompetitive inhibition is that competitive inhibition is the binding of the inhibitor to the active site of the enzyme whereas noncompetitive inhibition is the binding of the inhibitor to the enzyme at a point other than the active site.

6. What is the difference between reversible and irreversible inhibition?

- An irreversible inhibitor inactivates an enzyme by bonding covalently to a particular group at the active site. A reversible inhibitor inactivates an enzyme through non-covalent, reversible interactions. A reversible

inhibitor inactivates an enzyme through non-covalent, easily reversed, interactions.

Section 3.6 Self-test exercises

1. **List the six classes of enzymes.**

Six classes of enzymes are: 1) Oxidoreductases, 2) Transferases, 3) Hydrolases, 4) Lyases, 5) Isomerases and 6) Ligases

2. What is the structural classification of enzyme?

The structural classification of enzymes deals with the separation of an enzyme into simple proteins (active) and conjugated proteins (**holoenzyme).** The conjugated protein part (holoenzyme) is divided into the non-protein part **(cofactor)** and the protein part **(apoenzyme: inactive)** groups.

Section 3.7 Self-test exercises

Multiple choices

1. C. 2. C

Short answer

1. List factors that affect enzymatic reactions?

- Factors affecting the rate at which enzymatic reactions are temperature, pH, enzyme concentration, substrate concentration and the presence of any inhibitors or activators. Do you know any more?

2. What makes differences in enzymatic reactions?

- The difference of enzymatic reaction is based on the active site, factors and sensitivity.

Section 3.8 self-test exercises

1. What is an enzyme kinetics?

- Enzyme kinetics is the study of the rates of enzyme-catalyzed chemical reactions. In enzyme kinetics, the reaction rate is measured and the effects of varying the conditions of the reaction are investigated.

3. The term kinetics means motion and how do you relate it to enzymes?

- By the reaction of catalyzing speeds.

Section 3.9 self-test exercises

1.What does application of enzyme mean?

- It is the practical uses of enzymes.

2. Where do we apply enzymes?

- Enzymes work in all living organisms, industries, manufactures, factories etc.

Section 3.10 self-test exercises

1. What enzymes are used in malting?

- The four most common enzymes used in the malting process are beta-glucanase, alpha-amylase, protease and beta-amylase.

2. Why do people make malts?

- Malts are used in drinks as a fermenting agent and flavoring.

3. **What are the raw materials for malting?**

- Barely and water

Feedbacks to unit thee experimental activities

1. Activity 3.1: Investigating the enzyme Amylase in saliva

1.1 What did you recognize from the changes in the mush?

- The mush was converted into sweets slowly.

1.2 How does the saliva convert starch into simple sugar molecules?

- It coverts starch into **maltose** by **amylase** and into simple **sugar molecules** by the digestive enzyme.

1.3 Where did the enzyme amylase come from?

- It comes from saliva produced in the salivary glands.

1.4 How do you conclude the activity?

- The enzymes amylase converts starch into simple sugar molecules.

2. Activity 3.2: properties of enzymes

2.1 What are the major properties of enzymes?

- Enzymes have both physical and chemical properties and behave as Colloids or as substances of high molecular weight. Enzymes are made up of chains of amino acids linked together by peptide bonds.

2.2 What does the catalytic property mean?

- Catalytic property refers to the biochemical reaction of enzymes

2.3 What is the property specificity of enzyme?

- The ability of an enzyme to select a specific substrate from a range of chemically similar compounds.

2.4. How do you identify if enzymes are pH sensitive?

- Changing the pH of its surroundings will also change the shape of the active site of an enzyme.

2.5 How do you identify if enzymes are heat sensitive?

- Enzymes work at optimal temperature around human body temperature (37.5 å) in human cells.

3. Activity 3.3: experiment on the reaction of enzymes

3.1 What caused the bubbling in the potato slices?

- When hydrogen per oxide dropped on potato slices

3.2 How does metabolic decomposition take place?

- Enzyme catalase causes reactions

3.3 Which one are enzyme, substrate and product in the experiment?

- Enzyme = catalase
- Substrate = hydrogen per oxide
- Product = water and oxygen

4. Activity 3.4: protein structures

4.1 What are the subunits of protein structures?

- A protein subunit is a polypeptide chain or single protein molecule that assembles or co-assembles with others to form a protein complex.

4.2 How do protein subunits hold together?

- The subunits are held together by hydrogen bonds and van der Waals forces (*a distance-dependent interaction between atoms or molecules*) between nonpolar side chains.

4.3 What are enzyme active sites?

- It is the part of the enzyme where the substrate binds.

4.4 What are binding and blocking of molecules?

- Molecular binding is an attractive interaction between two molecules that results in a stable association in which the molecules are in close proximity to each other. Blocking molecules inhibit the binding sites.

5. Activity 3.7: Tests for enzyme reactions

5.1 What gives the brownish color?

- Melanin

5.2 What enzyme is catalyzing?

- Phenols and the enzyme **phenolase** are found in the cells of the apple,

5.3 What is the name of the enzyme found in apples?

- Phenolase

6. Activity 3.9: Experiment on enzyme reaction rates

6.1 What were the reaction rates in test tubes A, B, and C?

Test tube A = Beef liver contains high calories and reacts very high

Test tube B = potatoes contain relatively more calories and show high

Test tube C = Carrot has certain amount showing lower reactions

6.2 Which of the reaction was the fastest?

- Beef liver

6.3 Why was the reaction in A the highest?

- Beef liver contains the highest calories

🗝 3.15: Answer keys to unit three self-assessment questions

Dear learner, here are your answer keys to unit three review question to check up to what extents you have achieved correct answers.

I. Answer keys to true or false questions

No	Answer	No	Answer	No	Answer	No	Answer	No	Answer
1	False	3	False	5	True	7	False	9	False
2	True	4	True	6	True	8	False	10	True

II. Answer keys to multiple choice questions

No	Answer	No	Answer	No	Answer	No	Answer
1	D	4	B	7	D	10	C
2	A	5	D	8	A	11	A
3	C	6	A	9	D	12	B

III. Answer keys to Short answers

1. What are the five types of enzymes and their applications?

- Refer to your module and other materials.

References

Grade 11 biology textbook, teachers guide and syllabus.

Fundamentals of Biology I (Lumen): https://LibreTexts.org

Sexual Reproduction in Animals and Plants, Hitoshi Sawada, Naokazu Inoue, Megumi Iwano *Editors (*2014), New York.

Website reading materials

www.enzymes.com

www.ebzyme.substrate.ecom

www.enzyme.properties.com

www.enzyme.protein.structure.level.come

www.enzyme.application.com