

COURSE GUIDE

BIO 107 INTRODUCTORY PRACTICAL BIOLOGY I

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INTRODUCTION

Introductory Practical Biology I is a one-semester, 2 Unit course. It is compulsory for all B.Sc. students. Biology programme. It will also be suitable as an elective course for any student in the Faculty of Science who wishes to learn about Biology and Environmental Science. The course will equip learners with fundamental laboratory skills and practical competency in recordkeeping, microscopy and specimen handling, and safe lab practice. It covers laboratory organisation and safety practices, the use and maintenance of biological equipment, the principles and operation of the microscope, the preparation and drawing of biological specimens, and the collection and preservation of animal and plant materials.

This course is entirely practical and designed to complement theoretical concepts taught in general biology courses.

COURSE COMPETENCIES

This course aims to introduce students to the fundamental practical skills and techniques used in biological investigations.

By the end of the course, students should be able to perform simple biological experiments safely, record and interpret their observations accurately, and appreciate the practical basis of biological concepts learned in theory.

COURSE OBJECTIVES

The specific objectives of the course:

- Identify and categorise the various types of laboratory hazards and describe appropriate safety measures
- Apply basic laboratory rules and first aid procedures in cases of common laboratory accidents.
- Identify and operate common laboratory equipment, such as the autoclave, centrifuge, hot air oven, and microscope.
- Draw accurate biological diagrams and apply standard conventions of labelling, magnification, and proportion.
- Procure and preserve animal and plant materials ethically and effectively for biological study.
- Demonstrate correct procedures for killing, mounting, and displaying insect specimens.

WORKING THROUGH THIS COURSE

To complete this course, you are required to read each study unit, read the textbooks and other materials provided.

Reading the reference materials can also be very helpful. Each unit has a self-assessment exercise which you are advised to attempt.

There will be hands-on practical sessions at designated laboratories across the nation, followed by a final examination at the end of the course. The course should take you about 8 weeks to complete.

This course guide provides you with all the course components, how to study, and how to allocate your time to each unit so you can finish on time and successfully. This course material will help students with their lab work.

COURSE STRUCTURE

This course is divided into three (3) modules, each containing several units:

Module 1 Laboratory Safety and Practices

- Unit 1 Common Laboratory Hazards
- Unit 2 Laboratory Hazard Precautions and First Aid
- Unit 3 What Practical Biology Involves
- Unit 4 Laboratory Organisation
- Unit 5 Handling Common Laboratory Equipment

Module 2 Microscopy and Measurement

- Unit 1 Introduction to Microscopy
- Unit 2 Practical Use of the Microscope
- Unit 3 Microscope Maintenance and Care

Module 3 Biological Diagrams and Sample Procurement

- Unit 1 Drawing Biological Diagrams
- Unit 2 Procuring Animal Material for Laboratory Work
- Unit 3 Procuring Plant Materials
- Unit 4 Killing, Mounting, and Display of Insect Specimens

REFERENCES AND FURTHER READINGS

You will be required to read the recommended references and textbooks provided for each unit of the course.

PRESENTATION SCHEDULE

A timetable has been prepared for the early and timely completion of this. Avoid falling behind the scheduled time.

ASSESSMENT

You would be required to submit your practical reports and drawings for assessment purposes, and to take an e-examination at the end of the course. Review the exercises or activities in the unit by applying the information and knowledge you acquired during the course. The practical reports submitted for assessment will account for 70% of your final assessment, and the e-examination for 30% of your final score in the course.

HOW TO GET THE MOST FROM THE COURSE

The course comes with a list of recommended textbooks. These textbooks are supplements to the course materials so that you can read more. Therefore, it is advisable that you acquire some of these textbooks and read them to broaden your understanding.

Course Information

Ice Breaker

Mr Stephen E. Omada is a lecturer in the Department of Biological Sciences at the Faculty of Sciences, National Open University of Nigeria.

His research interests cover industrial biotechnology, fermentation technology and bioreactor design, water treatment, and fermentative production of renewable biofuels.

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MODULE 1 LABORATORY SAFETY AND PRACTICES

Module Introduction

The biology laboratory is an essential part of scientific learning, discovery, and innovation. However, laboratories also present a wide range of hazards that can lead to accidents and injuries if not properly managed. This module introduces students to essential laboratory safety principles, types of hazards, precautions, and basic first aid procedures. It also covers laboratory organisation and handling of common biological equipment. By the end of this module, students will have developed the fundamental skills required to work safely and effectively in a biological laboratory.

This module is broken into the following units:

- Unit 1 Common Laboratory Hazards
- Unit 2 Laboratory Hazard Precautions and First Aid
- Unit 3 What Practical Biology Involves
- Unit 4 Laboratory Organisation
- Unit 5 Handling Common Laboratory Equipment

Unit 1 Common Laboratory Hazards

Unit Structure

- 1.1 Introduction
- 1.2 Learning outcomes
- 1.3 Laboratory hazards
 - 1.3.1 Categories of laboratory hazards
 - 1.3.2 Sources of laboratory hazards
- 1.4 Summary
- 1.5 References/Further Reading/Web Resources
- 1.6 Possible Answers to Self-Assessment Questions



1.1 Introduction

Welcome to your first practical stepping stone in biology! Have you ever wondered why science laboratories look so different from standard classrooms? It is because they are active hubs of discovery where dangerous chemicals, high-energy devices, and microscopic life-forms interact daily.

In this unit, we will explore the foundational baseline of laboratory safety. We will unpack what constitutes a hazard, break them down into distinct

groupings, and pinpoint where they hide in our everyday operations. Mastering this unit establishes the baseline protection you need to conduct meaningful, safe, and incident-free experimental research throughout this course.



1.2 Learning Outcomes

By the end of this unit, you will be able to:

- identify and categorise laboratory hazards into at least four groups;
- state at least four sources of each group of hazards; and
- design a proactive safety checklist mapping how specific physical hazards manifest during biological experimentation.



1.3 Laboratory Hazards

A laboratory hazard is anything that has the potential to cause damage in the laboratory. A laboratory poses potential hazards due to the presence of dangerous chemicals, corrosive liquids, poisonous substances, and toxic gases.

Common hazards include exposure to toxic chemicals, cuts from glassware or sharps, infections from microbes, slips and falls due to spills or poor housekeeping, electrical shock from damaged equipment, and injuries from improper lifting. To mitigate these risks, it is crucial to follow safety protocols, use appropriate personal protective equipment, and maintain a clean and organised workspace.

Let us think about what just happened: Using the hazard definitions you read in section 1.3.1, identify **two distinct categories of hazards** that Tobi faced, and name the exact **source** that caused each danger.

1.3.1 Categories of laboratory hazards

The hazards that can be encountered in the laboratory can be classified into 3 major categories:

- **Chemical hazards;** handling toxic substances can cause irritation and carcinogenicity. Common chemical hazards in the lab include explosives, compressed gases, flammables, oxidisers, toxic materials, and corrosives.
- **Biological hazards;** biological hazards include hazards from working with small animals or body fluids, working with blood-borne pathogens, working with biological agents, such as viruses,

fungi and bacteria, and exposure to genetically modified organisms.

- **Physical hazards;** physical hazards include exposure to noise, heat or burns from hot equipment (thermal hazards), cuts from broken glassware and sharps, electric shocks or fire from damaged or faulty electrical equipment, slips, trips, and falls due to spills, cluttered walkways, or uneven surfaces, etc.

Other categories include;

- **Mechanical and ergonomic hazards;** injuries from repetitive motions or poor posture, working in confined spaces, and improper handling of equipment.
- **Radiation:** exposure to radioactive materials or lasers.
- **Allergy hazards:** A common allergy hazard in the lab is latex allergy, as many of the materials used in a laboratory are made of latex.
- **Safety hazards;** safety hazards include unbalanced centrifuges, danger when handling hot sterilised items and electric hazards, such as shock, explosions, blasts and electrocutions.

Note: Always identify potential hazards before starting any laboratory activity.

Most laboratories display hazard symbols to improve safety by alerting personnel to risks, guiding safe handling and emergency procedures, and ensuring compliance with regulations. These symbols communicate hazards, including chemical, biological, physical, and radiation risks, and indicate the location of safety equipment, such as eyewash stations.

Laboratory hazard symbols, often standardised by systems such as the Globally Harmonised System (GHS), provide quick visual warnings of potential dangers. They are crucial for safety in labs, hospitals, and industrial workplaces.

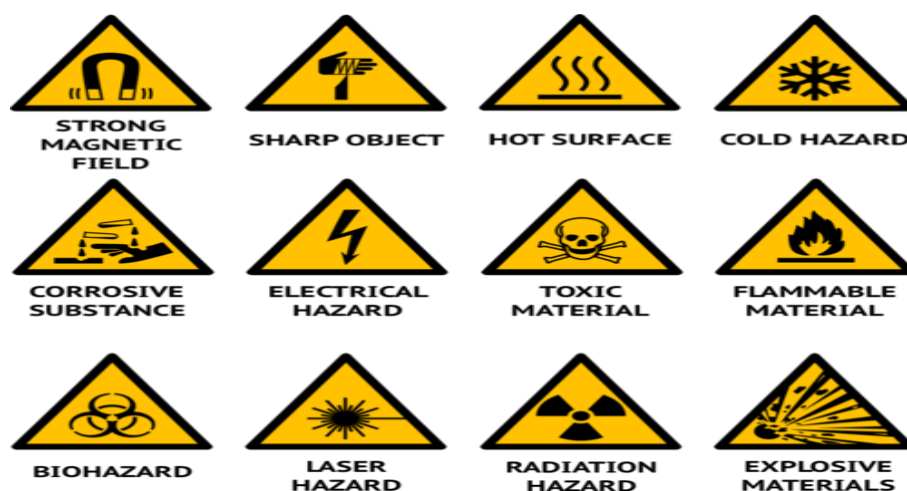


Fig 1: Some laboratory hazard symbols

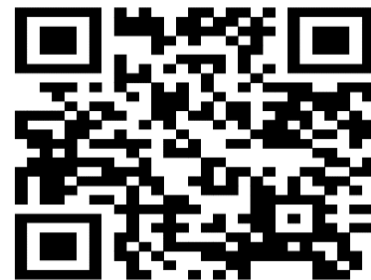
1.3.2 Sources of Laboratory Hazards

Each category has specific sources:

- **Physical hazards:** Glass breakage, hot plates, autoclaves, gas burners.
- **Chemical hazards:** Improper labelling, storage, or mixing of chemicals.
- **Biological hazards:** Contaminated specimens, microbial cultures, and waste materials.
- **Mechanical/Ergonomic hazards:** Misuse of centrifuges, pipettes, or incorrect workstation design.
- Scenario:

Imagine it is your first week in the university biology laboratory. A 100-level student named Tobi is running late for his practical session. Panicking, he rushes into the lab and accidentally bumps his elbow against an unorganised workbench.

A clear glass beaker sitting on the edge instantly falls and shatters on the floor, splashing a clear, odourless liquid all over his bare hands. Assuming the puddle is just plain water left behind by a previous practical group, Tobi decides not to waste time wearing his laboratory gloves. He reaches down with a tissue paper to wipe it up. Within a minute, his skin begins to experience an intense, painful burning sensation.



Click this link: <https://youtu.be/PP9dYoN8pTk> and watch the video, or scan the QR code.

Self-Assessment Questions

Which of the following contains four core categories of laboratory hazards encountered in a biology practical session?

- Chemical, Biological, Physical, and Mechanical/Ergonomic hazards
- Corrosive, Flammable, Exploding, and Toxic hazards
- Bacterial, Viral, Fungal, and Parasitic hazards
- Thermal, Sharp, Slippery, and Electrical hazards

An uncalibrated, high-speed centrifuge with an unbalanced rotor and a poorly arranged computer workstation are examples of sources belonging to which hazard category? A) Physical hazards

- B) Mechanical and Ergonomic hazards
- C) Chemical hazards
- D) Biological hazards

Which of the following pairs correctly matches a laboratory hazard category with its common operational source?

- A) Chemical hazard — Expired petri-dish microbial cultures
- B) Biological hazard — Mixing incompatible concentrated acids
- C) Physical hazard — Cracked boiling flasks and uncalibrated hot Plates
- D) Mechanical hazard — Bypassing a chemical fume hood



1.4 Summary

In this introductory unit, we explored what defines a laboratory hazard. We learned that biological laboratory hazards can be classified into chemical, biological, physical, mechanical, and unique allergen/radiation streams. Furthermore, we found that these threats stem from specific sources, such as unlabelled chemicals, raw biological specimens, or broken glassware. Recognising these vulnerabilities helps you prevent accidents and maintain a safe, professional approach to scientific inquiry.



1.5 References/Further Readings/Web Sources

Raven, P. H., Johnson, G. B., Mason, K. A., Losos, J. B., & Duncan, T. (2022). *Biology* (13th international student ed.). McGraw-Hill Education.

Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Orr, R. B. (2020). *Campbell Biology* (12th ed.). Pearson Education.

Open-Access ODL Web Resource: Occupational Safety and Health Administration (OSHA).

Laboratory Safety Guidance Standards. Available open-access at: <https://www.osha.gov/publications/laboratory-safety>



1.6 Possible Answers to Self-Assessment Questions

1. **A**
2. **B**
3. **C**

Unit 2 Laboratory Hazard Precautions and First Aid

Unit Structure

- 2.1 Introduction
- 2.2 Learning outcomes
- 2.3 Laboratory safety
 - 2.3.1 Laboratory hazard precautions
 - 2.3.2 First aid treatment
 - 2.3.3 First aid treatment for some common laboratory accidents
- 2.4 Summary
- 2.5 References/Further Readings/Web Resources
- 2.6 Possible Answers to Self-Assessment Questions



2.1 Introduction

In Unit 1, we explored how to identify and classify the various threats in a biological laboratory, including chemical burns, sharp objects, and biohazards. But knowing where the dangers are is only half the battle. How do we build an active shield against these risks? And what happens if someone makes a mistake and an accident occurs?

This unit is designed to equip you with practical safety habits and foundational first-aid skills. By learning to use personal protective equipment, follow chemical protocols, and respond quickly and precisely in emergencies, you become a proactive asset in the scientific workspace. Let us look at how you can keep yourself and your fellow students safe.

Prevention is better than a cure. People working in the laboratory are exposed to potential hazards. Laboratory hazard precautions and first-aid knowledge are vital for reducing accidents and managing emergencies when they occur. Risks can be minimised by eliminating dangerous situations when possible, establishing clean, safe work habits, taking proper precautions at all times, and maintaining awareness of good safety practices. Safety is an important aspect of any biological laboratory.



2.2 Learning Outcomes

By the end of this unit, you will be able to:

- explain different laboratory hazard precautions;
- categorise at least six first aid treatments for common laboratory accidents; and
- differentiate between the immediate first aid protocols.



2.3 Laboratory safety

Every biological laboratory must have a formal safety program to ensure a safe and healthy working environment. Safety should be the code of practice, and it involves discipline in handling and containing hazardous materials in a laboratory.

It is the responsibility of laboratory workers to ensure and maintain adequate standards, policies, procedures, and good work practices to achieve a healthy working environment.

A safe lab, in addition to protecting laboratory workers, also helps to protect the environment and the public from exposure to hazardous materials.

Identify **two distinct safety precaution violations** that Amina committed, and state the immediate danger caused by her actions.

2.3.1 Laboratory hazard precautions

To stay safe in the laboratory, researchers and students should take precautions and be aware of common laboratory accidents and the first aid associated with them. Awareness of these accidents and knowledge of first aid can protect workers and students in the laboratory. Basic safety precautions in the lab include;

- **Personal Protective Equipment (PPE):** Always wear protective clothing such as lab coats, safety goggles, and appropriate gloves. Choose gloves based on the specific chemicals or pathogens you are handling. Also, wear closed-toe shoes, long pants, and tie back long hair. Remove gloves and lab coats before leaving the lab area.
- **Chemical safety:** Work in a well-ventilated area or fume hood when using volatile chemicals. Never taste or smell chemicals directly; use your hand to waft fumes towards you if needed. When diluting concentrated acids, always add acid to water, never the other way around. Properly label all solutions and dispose of all chemical and biological waste appropriately.
- **Handling materials:** Never pipette by mouth. Handle all sharps, including needles and broken glass, with care. Use a spatula for chemicals and a broom and dustpan for broken glass. Transport large containers with two hands.
- **General lab practice:** Do not eat, drink, or store food in the lab. Wash your hands thoroughly with soap and water before and after

working in the lab, and especially after removing gloves. Report all injuries and spills to your lab supervisor immediately. Know the locations of emergency exits and all safety equipment, including eyewash stations, safety showers, fire extinguishers, and first-aid kits. Avoid working alone in the laboratory and always keep your workspace clean and organised.

Scenario:

During an introductory practical session, Amina needs to dilute a concentrated sulfuric acid sample for her biology experiment. She feels hot in her laboratory coat, so she unbuttons it and pulls her safety goggles up onto her forehead to see more clearly.

Hurrying to finish her work before the cleanup bell rings, Amina grabs a beaker of plain water and quickly pours it straight into the container of concentrated acid. Instantly, the mixture releases an intense hiss and boils violently. A collection of hot, acidic liquid drops sprays out of the flask, splashing across her unbuttoned lab coat and landing directly onto her unprotected face.

2.3.1 First Aid Treatment

First aid is the immediate assistance or care given to a person with a minor or serious illness or injury to preserve life, prevent the condition from worsening, or promote recovery until medical services arrive. Even when all safety precautions are in place, accidents can still happen. This requires a well-stocked first-aid kit for laboratory settings.

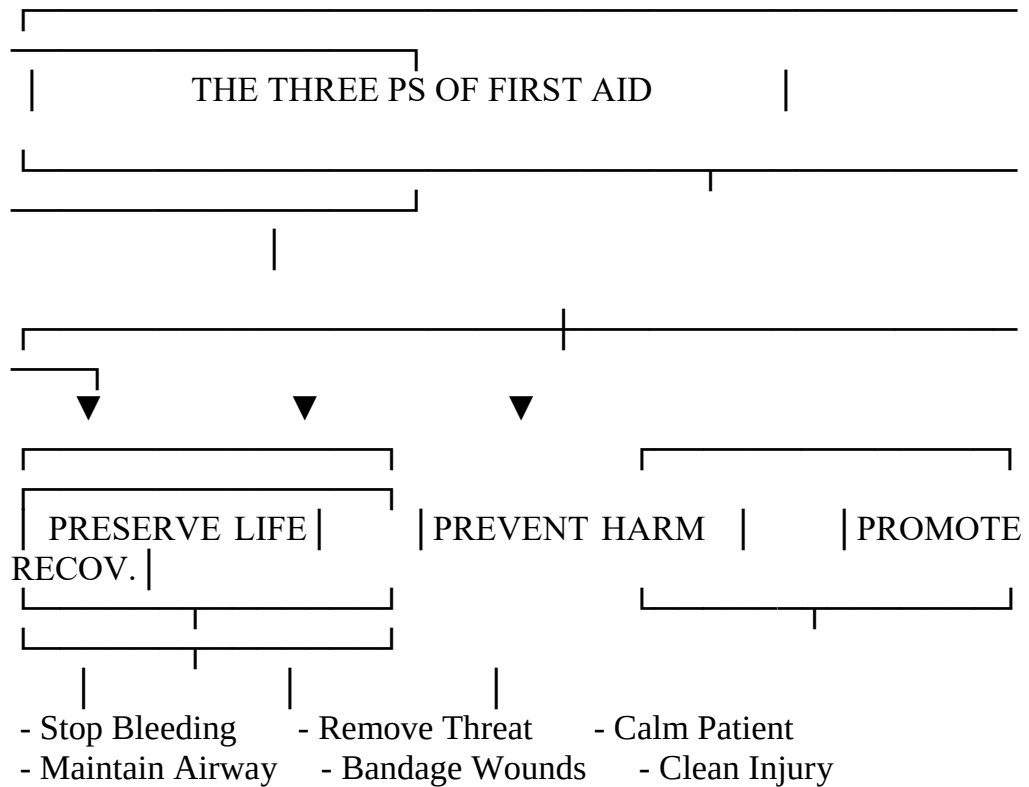
From the definition given, the key aims of first aid can be summarised with the acronym of the three Ps;

- **Preserve life:** the overriding aim of all medical care, which includes first aid, is to save lives and minimise the threat of death. First aid done correctly should help reduce a patient's pain and calm them during the evaluation and treatment process.
- **Prevent further harm:** prevention of further harm includes addressing both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed from becoming dangerous.
- **Promote recovery:** first aid also involves trying to start the recovery process from the illness or injury, and in some cases, might involve completing a treatment, such as in the case of applying a plaster to a small wound.

2.3.2 First aid treatment for some common laboratory accidents

First aid is the immediate care given to an injured or ill person before professional medical help arrives. Even with excellent precautions, accidents can still happen, which is why a fully stocked first-aid kit must be available in every lab.

The primary aims of first aid can be easily memorised using the acronym of **The Three Ps**:



1. **Preserve Life:** The absolute priority of all medical care. This involves keeping the casualty breathing and stopping life-threatening conditions like severe bleeding to minimise the risk of death.
2. **Prevent Further Harm:** This involves addressing external dangers—such as pulling a victim away from a live electrical wire or a toxic smoke zone—and applying stabilisers (like applying pressure to a cut) to prevent an injury from worsening.
3. **Promote Recovery:** This involves starting the healing process, such as soothing a minor burn with cool water or applying a sterile adhesive bandage to a clean wound.

2.3.3 First Aid Treatment for Common Laboratory Accidents

If an accident occurs, you must remain calm and execute these specific medical interventions immediately:

1. Cuts or wounds

Laboratories rely on glass pipettes, beakers, and other containers, and if these pieces of glassware break, they can lead to cuts, ranging from minor to major.

For minor cuts:

- Apply pressure to the wound with sterile gauze.
- Wash the area with soap and water.
- Apply a sterile bandage.

For a more serious cut (major cuts):

- Have the person sit down and raise the bleeding part while adding pressure.
- Continue to add pressure while transporting them to an urgent care or emergency room. If the bleeding is severe or the person feels faint or lightheaded, then contact a physician.

2. Burns

Burns are one of the more common injuries in the laboratory. Not only are chemical burns serious and common, but heat burns occur as well.

To treat heat burns:

- Run cool water over the area for 5 – 10 minutes.
- If minor (first degree or less), apply burn cream and a sterile bandage.
- If more serious (the burn is large), or the victim appears to be in shock, call for medical attention immediately.

To treat chemical burns (either acid or alkaline):

- Remove contaminated clothing and rinse the area with large amounts of cool, running water for 15 minutes and seek medical treatment.
- Call for medical attention if the victim appears faint, dizzy, or if the area is large.

3. Eye injuries

If dust, liquid or a chemical makes contact with the eye area, follow these steps:

- Flush with tepid, running water for at least 15 minutes before seeking medical treatment.
- Make sure the victim turns their head from side to side and allows water to run across both eyes.
- If dust or solid material is in the eye, cover or close the eye, and avoid rubbing hands over the eye while you seek medical treatment.

4. Shock

People who are suffering from any severe injury (for example, a bad burn or major loss of blood) may be in a state of shock. A person in shock is usually pale and faint. The person may be sweating, with cold, moist skin and a weak, rapid pulse. Place the victim face up in a horizontal position, with the feet raised about 12 inches. Loosen any tightly fitting clothing and keep him/her warm.

5. Poisons

Many chemicals are poisonous to varying degrees. Any chemical taken into the mouth should be spit out, and the mouth rinsed thoroughly with water. Note the name of the chemical and notify the physician immediately.

6. Chemical (acid or base) spilt on the skin

Flush the skin with water first, then, for an acid spill, neutralise with baking soda; for a base spill, neutralise with boric acid. Then, take the victim to the physician.

7. Clothing or hair on fire

A person whose clothing or hair catches fire will often run around hysterically, in an unsuccessful effort to escape. This only provides the fire with more oxygen, making it burn faster. It is the responsibility of the closest person to bring the fire blanket to the victim as quickly as possible and suffocate the fire by wrapping the victim in the blanket. Notify the physician immediately.

8. Inhalation of smoke or chemical fumes

All experiments that give off smoke or noxious gases should be conducted in a well-ventilated fume hood. This will reduce accidents of this kind. If smoke or chemical fumes are present in the laboratory, all persons, even those who do not feel ill, should leave the laboratory immediately. Ensure that all doors to the laboratory are closed after the last person has left. Since smoke rises, stay low while evacuating a smoke-filled room. Notify the physician immediately. Thoroughly ventilate the room before going back to work.

9. Electric shock

Turn off the power source before touching the victim, or use a non-conductive object to separate the victim from the source, then seek medical help immediately. If the person is unresponsive, check for breathing and begin CPR if necessary. Cover any burns with a sterile, non-adhesive dressing and monitor for signs of shock.



Click this link: https://youtu.be/qE4BNMsIZ_Y and watch the video, or scan the QR code.

Self-Assessment Exercise

1. During her biology practical, Amina suffered a chemical splash to her face and coat. Which two distinct PPE safety violations directly exposed her to this danger?
 - A) She wore the wrong type of gloves and forgot to wash her hands.
 - B) She unbuttoned her laboratory coat and pulled her safety goggles up onto her forehead.
 - C) She left her long hair unbraided and wore open-toe shoes.
 - D) She worked alone in the laboratory and did not use a fume hood.
2. What immediate physical reaction occurs if a student incorrectly pours plain water straight into a container of concentrated sulfuric acid?
 - A) The mixture completely solidifies and neutralises into baking soda.
 - B) The mixture releases an intense hiss, boils violently, and sprays hot, acidic droplets.
 - C) The mixture creates an electrical charge that triggers a severe shock.
 - D) The mixture safely dissolves without any thermal reaction.
3. A laboratory worker is severely injured and bleeding. According to the "Three Ps" of first aid, which objective takes absolute priority over all other care?
 - A) *Promote Recovery* by cleaning the injury and applying a plaster.
 - B) *Prevent Further Harm* by filling out an accident report for the supervisor.

- C) *Preserve Life* by stopping life-threatening conditions like severe bleeding to minimise the risk of death.
 - D) *Maintain Organisation* by cleaning the surrounding workspace first.
4. If a hazardous chemical spills directly onto a researcher's skin and clothing, what is the required first aid treatment before seeking medical attention?
- A) Apply burn cream immediately over the clothing and wrap the area tightly.
 - B) Wait 15 minutes to see if a rash develops, then wash it with soap.
 - C) Neutralise it with boric acid first, then run warm water over it for 2 minutes.
 - D) Remove contaminated clothing and rinse the area with large amounts of cool, running water for 15 minutes.



2.4 Summary

This unit focused on transitioning from hazard awareness to active physical safety. We explored essential protective procedures, unpacked the "Three Ps" framework of first aid (preserve life, prevent further harm, promote recovery), and walked through the exact tactical responses for emergencies such as chemical burns, cuts, eye contact, and electrical shocks. Developing these safe operational habits ensures you protect yourself and maintain a secure, professional scientific environment.



2.5 References/Further Readings/Web Resources

Raven, P. H., et al. (2022). *Biology* (13th international student ed.).

Urry, L. A., et al. (2020). *Campbell Biology* (12th ed.). Pearson.

Campbell, N. A., et al. (2020). *Biology: A global approach* (12th ed.). Pearson.



2.6 Possible Answers to Self-Assessment Questions

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

Unit 3 What Practical Biology Involves

Unit Structure

- 3.1 Introduction
- 3.2 Learning outcomes
- 3.3 Importance of practical biology
 - 3.3.1 Hints for a successful practical
 - 3.3.2 Practical biology – involvement
 - 3.3.2.1 Field study
 - 3.3.2.2 Collection of specimens
 - 3.3.2.3 Preparing Specimens for Laboratory Studies
 - 3.3.2.4 Preservation and storage
 - 3.3.2.5 Making sections and slides
 - 3.3.2.6 Study of specimens in the laboratory
 - 3.3.3 Biological drawings
 - 3.3.4 Views and magnification
 - 3.3.5 Labelling
 - 3.3.6 Experimentation
- 3.4 Summary
- 3.5 References/Further Reading/Web Resources
- 3.6 Possible Answers to Self-Assessment Questions



3.1 Introduction

Practical biology is the cornerstone of the life sciences, shifting your learning experience from passive, theoretical memorisation to active scientific discovery. This unit bridges the gap between conceptual text definitions and real-world execution. By engaging in hands-on processes—such as field exploration, micro-sectioning, slide preparation, structural visualisation, and precision documentation—you will develop the physical and analytical skills necessary to work confidently in any modern laboratory environment.

Understanding relationships and patterns existing among living things allows biologists and other scientists to approach ecological and medical problems in a logical, orderly manner. This unit unpacks the foundational protocols that govern biological exploration.



3.2 Learning Outcomes

By the end of this unit, you will be able to:

- list at least five important aspects of practical biology;
- explain five hints for a successful practical;
- state at least five requirements for conducting a successful practical biology exercise;
- describe five requirements for good biological drawings; and
- structure a systematic scientific laboratory report using the standard six-step experimentation protocol.



3.3 Importance of Practical Biology

Biology is the study of living things. Living things perform various activities, which biologists study as organisms perform them. It is likely that if you see the organism you are studying physically and even in its natural location, you will remember and understand better than when you are taught only theoretically. Many facts about living things are continually discovered in laboratories and practical studies; most of these are uncovered as biologists physically study organisms. The large-scale destruction of natural flora and fauna upsets the natural interdependence among living organisms. These facts are very evident in practical biological studies. Some of these interferences, which also have serious effects on man, can be better understood when the studies involve practical work. It is therefore important that practicals, as part of the study of biology, should go hand in hand with theory. Once relationships and patterns existing among living things have been understood, biologists and other scientists can approach the problems in a logical and orderly manner.

Throughout history, man has been challenged by the mysteries of his body and the world around him. They wanted to know the causes of diseases and how to fight them; how life is produced and maintained, and many other things. These are the knowledge that practical biology, as part of biology, will make available to us.

The importance of practical biology can be summarised as follows:

- Reinforces theoretical knowledge.
- Develops observation and analytical skills.
- Encourages scientific curiosity and problem-solving.
- Provides hands-on experience with biological tools and materials.
- Helps students appreciate living systems and biodiversity.

Scenario: Imagine you are packing your personal kit for tomorrow's biology laboratory session. You need to prepare your tools for rendering an exact technical replication of a plant cell section.

3.3.1 Hints for a Successful Practical

Even though these points look simple and commonplace, they will help you to succeed in your practical work. First, let us list here what you require to do a successful practical work. Without these, you will experience difficulties in your practical work.

Requirements

You should get these things for yourself; they are essential for practical purposes:

- Sharp pencils (H.B type).
- Sharpener to re-sharpen when necessary.
- Sharp pen knife, razor-blade or scalpel.
- Dissecting pins.
- A flat piece of thick cardboard about 1 10cm sq.
- Hand lens.
- Pair of foolscaps.
- Watch glasses of various sizes.
- A small ruler.
- Microscopes and slides should be available to you at the study centre. Ask your tutor for these.
- Laboratory coat, hand gloves, nose masks, etc.

Pencils: It is necessary to specifically mention that unless your pencils are always sharp, your drawing will not be good. In an examination, you sharpen two or more pencils beforehand so that you don't lose time re-sharpening.

Observations: You should always observe your specimens closely and very carefully. Look out for all details, size, texture, adaptive features, etc. Some examiners even count the number of parts of the specimen you are supplied with. So, you must draw exactly what you are given and label all diagrams clearly.

You must follow all the techniques for drawing in biology. They have been spelt out in the section on biological drawings.

Following Instructions: In practical biology, you must follow instructions that you are given to the letter. Sometimes, even for laboratory safety reasons, it is imperative. When conducting experiments, your results may be incorrect if you do not follow the given instructions. Seek advice from your tutor when you are not sure of what to do in the laboratory. This is safer and more important. You save your time as well by doing so.

Which type of pencil should you ensure is perfectly sharpened and ready in your toolkit to fulfil standard biological drawing rules?

- A) A soft coloured pencil
- B) An HB graphite pencil
- C) A heavy charcoal pencil

3.3.2 Practical biology – involvements

We will now consider six aspects of practical biology. Practical biology is part of the study of biology. Ideally, it should go alongside the theory for better understanding. Practical biology involves at least six things.

3.3.2.1 Field study

Sometimes, Biologists choose to learn about organisms in their natural habitats. In such places, you can see how they live, how they relate to other organisms, and how they impact their environment. A lot of what is done in ecology is based on field studies.

However, as a biology student, you could take a field trip to observe where such organisms live, then collect them and bring them to the laboratory for further study.

Class activity

If you leave the room you are in now, you will surely find plants and animals within a radius of about 100 meters. Look closely to understand and describe where you find what. In the table below, put in the required information.

Serial/No.

Name of Organism(s) (optional)

Describe organism

Where found

Describe location

The items in the table can become your specimen(s). This takes us to the next level of involvement in practical biological work.

3.3.2.2 Collection of Specimens

In the activity above, you may need tins or clean, empty specimen bottles to put your specimen in. Let us imagine what you could have found. We could name them as follows:

Rats, leaves, seeds, fruits, flowers, flies, fish, birds, lizards, snakes, toads, frogs, butterflies, mosquitoes, grasshoppers, ants, snails, scorpion ants, worms, etc.

If you want to “catch” or collect these specimens, you will agree that the method of collection will vary with the type of organism and in which state (condition) you want to have it and the kind of study you intend to carry out on it. If you desire to study how the toad breathes, you will have to devise means of collecting it without killing it. If you wish to study the structure of the skeleton in the snake, you must consider how you can “catch” the snake safely because of its nature, its land-fragile skeleton. If, however, you wish to collect different types of butterflies to study the difference in their designs and colours, you will have to devise or use an instrument to reach them as they fly. A net used for collecting butterflies may differ from one that must necessarily be used for collecting fish from a pond.

Therefore, various methods of specimen collection are used depending on the type of study, the organism, its habitat, and its life habits. Sometimes, when the biologist has to collect his specimens, he may seek the help of a laboratory assistant who is specially trained to do so, as well as to perform many other tasks in the laboratory.

3.3.2.3 Preparing Specimens for Laboratory Studies

When you have collected your specimens, you may find it necessary to bring them into the laboratory so you can take time to study them. Often, you want to keep them for as long as necessary to conduct sufficient studies. For this reason, you need to know how best to keep or preserve the specimens. The same methods may not apply to all types of specimens. For example, bones will not be stored the same way as worms. The laboratory technologists may handle the details. It is, however, important for you to know that some storage and preservation may be necessary.

3.3.2.4 Preservation and Storage

Apart from preservation and storage, you might also need to prepare the specimen for the desired study. For example, if you want to study the structure of a section through the root of a plant, you need a microscope

to view the details of the sections. Besides, you need to make a slide. In Module 2, you will learn about making slides.

3.3.2.5 Making Sections and Slides

When you have to study the internal structures of (some parts of) some organisms, you have to make sections.

These sections are described by the way they are made. A transverse section across a root, for example, is cut with a sharp blade or penknife across the root. However, a longitudinal section is cut along the length of the root. These two sections, for example, will show different perspectives of the same structure.

Sections are most useful for biological studies when cut very thin, so that cells can be easily made visible with a hand lens or a microscope.

You will need several practices to make good sections. So, when you try and you do not get the whole section sufficiently thin, do not worry, try again, you will soon be an expert. You may have to apply stains on sections to make them visible. Your course tutor will direct you on this matter. Remember that sections are best viewed with a magnifying glass and a microscope. They may need to be mounted on slides and stored properly for viewing under the microscope.

3.3.2.6 Study of Specimens in the Laboratory

Identification is the first step when you bring your specimens into the laboratory. Here, you look out for characteristic features. In an examination or identification exercise, you state the features you have observed before concluding by naming the specimen. In other words, you are to give reasons first before saying what it is. You will look out for details in the external features. As you do this, you note the parts and their functions. You will look out for differences and similarities, and why these exist. If the object of study is small, you may need to use a hand lens or a microscope.

3.3.3 Biological drawings

Usually, practical work includes drawings because it is a way to document what you did in the laboratory. When you have studied the details of an organism, be it the external or internal structures, you want to make a diagrammatic report of what you saw. It becomes very important for the biology student to be able to make such a diagram.

Sometimes, you are specifically told what to do and draw. It is very important to follow instructions and do exactly what you are told. You must also ensure that you understand the instructions you are given. You are advised not to behave like those who choose to do what they like; they do not follow instructions that are given for practical reasons. They do not even draw what they have seen in their practical work. They choose to draw from memory, and such drawings may not be exactly what they have been given in the practical exercise, thinking examiners will not be able to tell when they are not complying with instructions. But this is not true.

Examiners are quick to spot it, and they can interpret it as dishonesty on the part of the students, who often have to lose marks for this. Your drawings should not be too small or too big.

Your drawings can be between a third and half a foolscap page. While drawing, you are also expected to study the specimen and note its proportions. For example, where the length of the mango is about twice its width, your drawing must also reflect these proportions. You are expected to record all curves. You are not expected to shade in biological drawings. Your pencil must be sharp. Most times, you have to re-sharpen your pencil as you draw. The lines of your diagram must be thin and continuous. You should not allow the lines to go wavy or woolly. Drawing diagrams with wavy lines is often a problem with beginners. If you find yourself doing this in your practice, do not worry. With time, you'll get used to drawing neat single lines. Fig. 1A shows you an egg drawn with wavy and woolly lines. Fig. 1B shows a clean, clear drawing of the egg. Can you spot the woolly and wavy portions in the drawing in 1A?

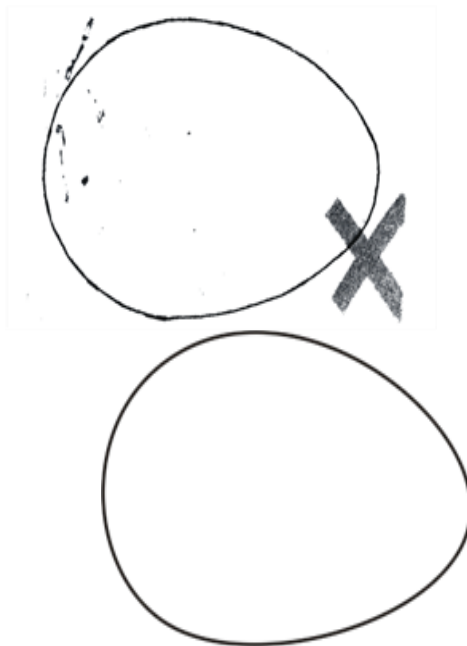


Fig. 1A: A poorly drawn diagram of an egg with woolly lines

Fig. 1B: A neat diagram of an egg

3.3.4 Views and magnification

When you draw, you are expected to give some basic information about your specimen. You want to say how large the specimen you are presenting is relative to your drawing. For example, if you have drawn an egg and its size is exactly as it is physically, you will express this size as 'x1'. If, however, you have drawn a bone, and you have made your drawing half the actual size, you will express this by 'x1/2' or 'x.5'. Suppose, however, you have drawn a bean seed that is five times bigger than it actually is; you will express this by 'x5'.

You are also expected to say what aspect or view of the organism you are drawing. Here, the term 'views' refers to the organism's natural state. For example, you naturally see a dog standing on its legs. If you have placed the dog on its back and drawn it as you see it lying back down, the view you are seeing is the ventral view of the dog. If you draw the dog from the front, i.e., as you see it facing you, you have an anterior view. Fig. 2 shows other perspectives of organisms that you could have.

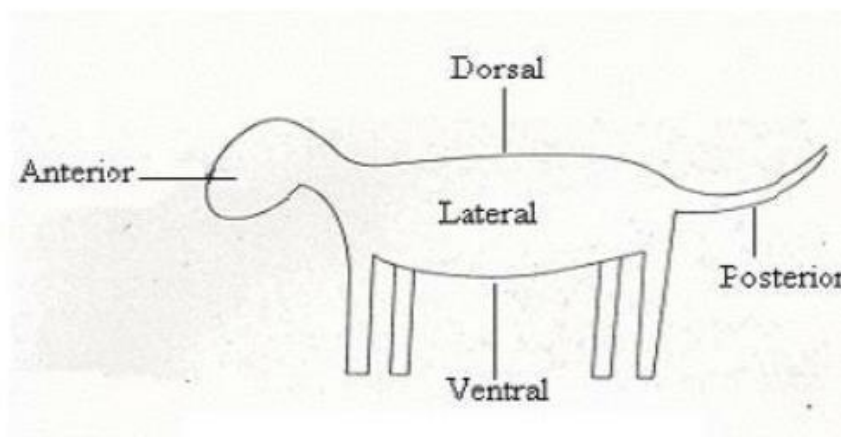


Fig. 2: Aspects of a specimen

Sometimes, you draw what you see as you cut through your specimen to reveal internal structures. You call these sections. For example, given a mango fruit, you may have to draw a longitudinal section through the mango fruit. This is a section you make by cutting the fruit from top to bottom along its natural length.

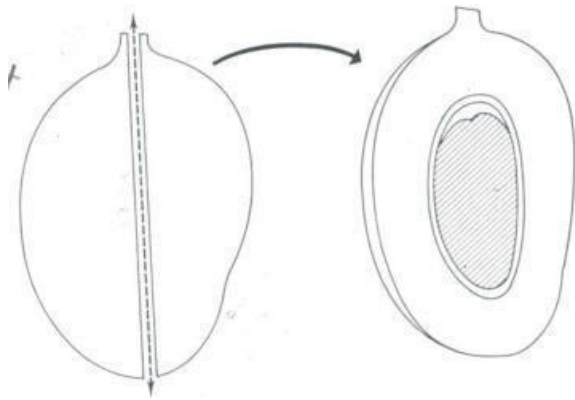


Fig. 3: Longitudinal section of a mango fruit (x1)

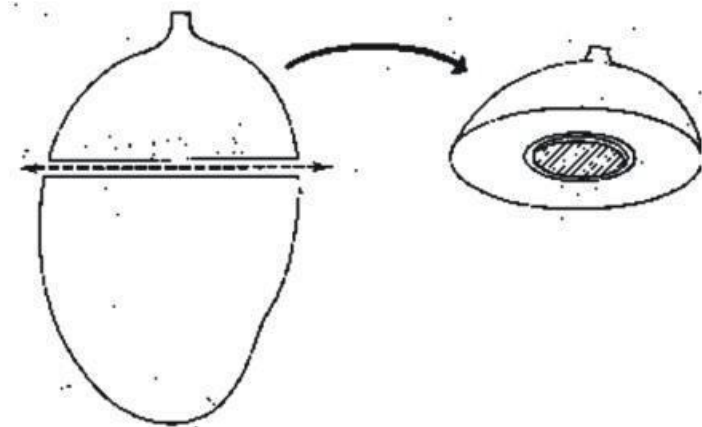


Fig. 4: Transverse section of a mango fruit (x1)

3.3.5 Labelling

An important aspect of biological drawings is the labelling lines, which indicate what you are labelling. In biological drawings, these labelling lines are called guidelines. The correct way to draw a guideline is to draw it horizontally (i.e. running parallel to the top and bottom edges of your drawing paper). You should never allow them to cross each other.

They should be ruled and not freely drawn with the hand. The guideline could be drawn on either side of the drawing, if necessary, but you should not allow the lines to cross each other or the drawing itself. The shorter the guidelines, the better they are. You should write the labels with a pencil. You should not put an arrow at the head of the guidelines, as in biology, arrows indicate the direction of movement. Fig. 5 shows the correct way to label a biological drawing.

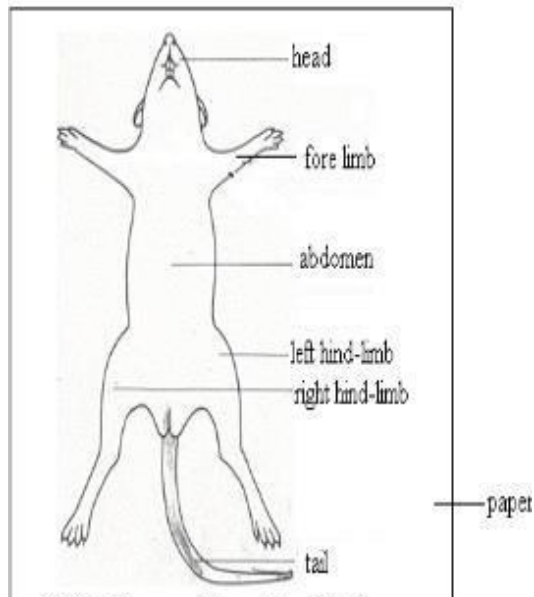


Fig. 5: Properly labelled diagram of a rat

You must always put a heading for all diagrams. It is written above or below the diagram. The heading contains three vital elements:

1. The identity of what you have drawn, e.g., a diagram of the head of a guinea pig.
2. The magnification or size.
3. The view of the organism which you have drawn.

3.3.6 Experimentations

You have to perform certain experiments in a biology practical. Scientists conduct experiments to discover facts or confirm them. You may have carried out experiments to demonstrate some enzyme actions and to show that processes (e.g., respiration and transpiration) are taking place. You may also want to demonstrate certain confirmed happenings in organisms. For example, you know that roots grow downwards, not upwards, or that plants grow towards the light source, or the impact of auxins on growth. You may also have to determine the amount of water in a soil sample, the amount of humus, or differences in capillarity between two types of soil. You can continue to name other experiments you may have to carry out. The important issue here is that your practical work in biology can also involve doing experiments.

You are expected to report your experiment systematically. The items of your report should include the following in the order;

1. Date of experiment.
2. Purpose of experiment (e.g. Experiment to test for starch).
3. Materials: List all the materials used (e.g. a piece of raw potato, iodine, Petri-dish, etc.).

4. Procedure: Describe what you did, e.g. place the piece of potato in the Petri dish. Add two to three drops of iodine. etc. Sometimes you might want to create a diagram of the procedure's steps. This is where there are various setups on the same experiment. You will either number progressively or use an arrow to indicate direction.
5. Result: A blue-black colour appeared on the potatoes.
6. Conclusion: Shows that starch is present (if necessary).

Self-Assessment Exercise

1. Which type of pencil should you ensure is perfectly sharpened and ready in your toolkit to fulfil standard biological drawing rules?
 - A) A soft coloured pencil
 - B) An HB graphite pencil
 - C) A heavy charcoal pencil
 - D) A non-erasable ink pen
2. When executing a standard biological diagram, which line technique must a student use to avoid losing marks for a "poorly drawn" or dishonest representation?
 - A) Thick lines with heavy artistic shading to show depth
 - B) Wavy, woolly lines drawn freehand from textbook memory
 - C) Thin, clean, and continuous single lines reflecting exact specimen proportions
 - D) Coloured dashed lines to separate different tissue layers
3. A student wants to study the internal structures of a plant root from two different perspectives. What is the difference between a transverse section and a longitudinal section?
 - A) A transverse section is cut across the root, while a longitudinal section is cut along its length.
 - B) A transverse section is cut along the length, while a longitudinal section is cut across the root.
 - C) A transverse section requires a microscope, while a longitudinal section only requires a hand lens.
 - D) A transverse section preserves the root, while a longitudinal section destroys it completely.
4. According to standard biological drawing rules, how should labelling lines (guidelines) be properly drawn on a diagram?
 - A) Freely drawn by hand with an arrow pointing at the structure
 - B) Ruled horizontally without crossing each other, and without arrowheads
 - C) Placed diagonally crossing over the specimen lines to save space
 - D) Drawn in ink with double-headed arrows to show directions of movement



3.4 Summary

Practical biology shifts your education from theoretical memorisation to active scientific discovery. Success in this field relies on sharp observation, precise following of instructions, and careful use of tools. This unit covered the baseline tool requirements, field collection techniques, tissue sectioning methods, and structural documentation standards. Mastering these skills ensures that your illustrations, magnification calculations, and lab reports meet professional scientific standards.



3.5 References/Further Readings/Web Resources

Weyers, J., et al. (2021). *Practical skills in biology* (7th ed.). Pearson.

Campbell, N. A., et al. (2020). *Biology: A global approach* (12th ed.). Pearson.



3.6 Possible Answers to Self-Assessment Questions

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

Unit 4 Laboratory Organisation

Unit Structure

- 4.1 Introduction
- 4.2 Learning outcomes
- 4.3 General laboratory organisation
 - 4.3.1 Physical space and layout
 - 4.3.2 Processes and procedures
 - 4.3.3 Inventory and equipment
- 4.4 Displaying general instructions for laboratory use
- 4.5 To label specimens, slides and reagents
- 4.6 Summary
- 4.7 References/Further Reading/Web Resources
- 4.8 Possible Answers to Self-Assessment Questions



4.1 Introduction

Have you ever walked into a workspace that made you feel instantly focused and energised? Or, conversely, struggled to work in a chaotic room where you couldn't find a single tool?

A well-organised laboratory does wonders. It elevates your mood, supercharges your enthusiasm, and simplifies cleaning and maintenance. It is where real science comes alive! Unfortunately, laboratory orders are often neglected and treated as afterthoughts.

Remember Chidi's "dilution disaster"? His accident happened because he rushed through an unorganised workspace. When a laboratory lacks a system, hazards multiply.

Lab organisation is a collective activity that relies on everyone who uses the space. While global "Dos and Don'ts" define basic operations, each laboratory is unique and reflects the care of its users. Let's explore how to transform any lab into a safe, inspiring environment for discovery.



4.2 Learning Outcomes

By the end of this unit, you will be able to:

- **identify** at least ten essential equipment pieces, infrastructure assets, and safety installations available in a standard biology laboratory;

- **design** a laboratory safety directive poster that correctly groups and prioritises housekeeping, operational, and emergency;
- explain how items are stored and displayed in the laboratory; and
- **formulate** technically accurate, compliant labels for biological specimens, histological micro-slides, and chemical reagents using standardised scientific terminology.



4.3 General Laboratory Organisation

General laboratory organisation involves the systematic arrangement of physical space, equipment, and personnel to ensure safety, efficiency, and accuracy. Important aspects include creating distinct zones for different activities, implementing a clear labelling system, establishing standardised procedures (SOPs), and maintaining a well-organised inventory and storage system. Effective organisation also requires a defined management structure, roles, and quality assurance procedures.

Key areas to be considered in laboratory organisation include: Workbenches and storage cabinets; Shelves for glassware and reagents; Safety equipment (fire extinguishers, eyewash stations); Fume cupboards and sinks; etc. The 3 key aspects of general laboratory organisation are;

4.3.1 Physical Space and Layout

- **Zoning:** Designate separate areas for specific activities like sample reception, sample preparation, analysis, waste disposal, and washing.
- **Workstations:** Organise the lab into workstations for different tasks or protocols, keeping all necessary supplies and tools together.
- **Safety Infrastructure:** Ensure proper ventilation, lighting, and temperature control. Have adequate washing facilities and a designated area for safety equipment and waste.
- **Storage:** Provide sufficient storage for chemicals, equipment, and records. Organise chemicals by type and ensure proper storage conditions, such as in a climate-controlled area.

4.3.2 Processes and Procedures

- **Standard Operating Procedures (SOPs):** Develop and maintain clear, up-to-date, and easily accessible SOPs for all processes to ensure consistency and quality.

- **Quality Management:** Implement a quality management system that includes regular training, monitoring, and a mechanism for continuous improvement.
- **Workflow:** Optimise the workflow to minimise turnaround time and reduce errors.

Scenario: A student enters a university biology laboratory carrying a damp soil sample collected from a local wetland. To save time before a microscopy session, the student sets the raw sample bag directly on the analytical balance benchtop in the Instrument Analysis Zone.

4.3.3 Inventory and Equipment

- 1 **Labelling:** Implement a comprehensive and consistent labelling system for all reagents, chemicals, and equipment. Labels should include name, date, and concentration of reagent. Slides should be marked with the specimen name and preparation date. Specimens should be displayed in jars with descriptive tags.
- 2 **Inventory management:** Maintain an up-to-date inventory of all supplies and equipment to track usage and reorder needs.
- 3 **Equipment maintenance:** Regularly check and remove old or unnecessary equipment to keep the workspace clear.

Which principle of spatial zoning did the student violate, and what risk does this action introduce to the laboratory?

4.4 Displaying General Instructions for Laboratory Use

Materials Required

You require the following materials to write and display general instructions for laboratory use.

- Coloured chart paper
- Scissors
- Coloured pens
- Adhesive tape

Procedure

Display instructions/rules are very important for housekeeping, convenience, ease, and, above all, the safety of a lab. Preparing a display is partly a creative exercise, as it requires some artistic ability. A display should be conspicuous, legible, neat, and attractive.

Class Activity

Here are some general laboratory safety guidelines. Choose any 7 instructions that you consider more important than the rest for the display.

Cut a chart paper of an appropriate size, write the instructions neatly using a colour pen that can highlight them, and try to make it attractive without losing its purpose. When it is ready, display it at an appropriate place, using the adhesive tape.

- Keep the laboratory scrupulously clean and free of unnecessary things.
- While entering the lab, place all books, notebooks and purses in the designated areas and not on the working benches.
- Do not eat, drink or smoke in the laboratory.
- Do not make a noise in the laboratory.
- Do not wear shorts or loose clothes in the laboratory.
- Always wear a laboratory coat.
- Do not perform unauthorised experiments.
- Do not use equipment without reading the instructions or being instructed to do so.
- Report all spills and accidents to your instructor immediately.
- Never leave heat sources unattended.
- Keep containers of alcohol, acetone, and other inflammable liquids away from flame.
- Leave the laboratory clean and organised for the next batch of students.
- Wash your hands with powdered soap before leaving the laboratory.
- Upon completion of laboratory exercises, place all discarded materials in the disposal area designated by the technologist/instructor.
- Do not allow any liquid to come into contact with electrical cords. Handle electrical connectors with dry hands. Do not attempt to disconnect electrical equipment that cracks, snaps, or smokes.
- Wash skin immediately and thoroughly if exposed to chemicals or microorganisms.
- Never pipette by mouth. Use mechanical pipetting devices.
- Wear disposable gloves whenever necessary.
- Use a bandage on cuts or scrapes before attending the laboratory.
- Do not taste the chemicals
- Do not lick the labels.
- Decontaminate work surfaces after any spill of potentially dangerous chemicals/micro-organisms
- Wear safety glasses, gloves or other protective devices whenever and wherever necessary.
- Turn off gas, electricity and water before leaving the laboratory.

Scenario: A student labels a beaker of solution "Acid" with a pen on a piece of masking tape, without listing the date, concentration, or chemical name.

4.5 To Label Specimens, Slides and Reagents

Specimens Labels

Biology laboratories have collections of various plants and animals. After the collection, such specimens must be appropriately and attractively labelled. Likewise, certain slides of tissues, organs or micro-organisms prepared by a teacher or student may be essential or valuable for permanent record. These need to be appropriately labelled for proper identification.

Specimen labels should therefore carry the following essential information:

- Common name of organism
- Kingdom - Plantae
- Phylum - Angiospermae
- Class - Angiosperms
- Order – Monocotyledoneae
- Family - Poaceae
- Genus - *Zea*
- Species – *Zea mays*
- Place from where it was collected (optional)
- Name of the collector, date.

Labels for Slides

They should carry the following information:

- The name of the organism - if the whole organism is mounted, then the slide can be marked WM = whole amount or E = entire. Examples: *Paramecium* WM, frog Blastula WM.
- The part of the organism used, e.g. liver, root. Examples: liver of a frog, onion root.
- The type of preparation, e.g. smear, squash. Examples: human blood /smear.
- Type of section e.g. TS = transverse section; VS = vertical section; LS = longitudinal section. Examples: TS of kidney, VS of phloem.
- Other specifications, e.g. type of cell division (mitosis, meiosis), stage of cell division (prophase/metaphase), sporulation. The following information is desirable but not essential.
- Stain(s) used e.g. H.E = Haematoxylin Eosin.
- If the slide is prepared in-house, then it should be dated and installed.

It is common to use two labels, one on each end. Self-adhesive or gummed slide labels pre-printed with lines are available from laboratory suppliers. Alternatively, use ordinary self-adhesive or gummed labels. You will find it easier to write the label before you stick it on the slide. Remember: if

the label is gummed (rather than self-adhesive), you must not lick it; instead, use a wet sponge.

Critique this student's labelling approach against proper reagent labelling rules. What specific details are missing?

Class Activity

Prepare at least one label and stick it to a slide.

Sample Label

- Onion root tip, squash
- Mitosis, prophase
- Vinita Sharma, 20th October, 1999

Labels for Reagents

We also need to label routinely prepared stock solutions, stains and culture media for identification. These should carry the following information:

- Name of the Chemical(s)
- Concentration (Percentage/molarity)
- Aqueous/any other solvent
- Date
- Initial

Sample Label

5% CuSO₄ (aqueous)
Lalit, 15/3/2000

Self-Assessment Exercise

1. A laboratory technologist wants to minimise errors, optimise workflows, and limit cross-contamination by defining distinct areas for sample reception, sample preparation, analysis, waste disposal, and washing. Which primary aspect of physical space organisation does this workflow plan follow?

- A) Inventory Management
- B) Zoning
- C) Equipment Maintenance
- D) Standard Operating Procedures (SOPs)

Question: Why is it essential for a laboratory management team to develop and maintain clear, up-to-date, and easily accessible Standard Operating Procedures (SOPs)?

- A) To ensure consistency and quality across all analytical processes and workflows.
- B) To design creative and artistic guidelines on colored chart paper.
- C) To systematically eliminate the need for regular chemical tracking and inventory reviews.

- D) To replace physical safety infrastructures like ventilation and eyewash stations.

Question: According to the listed laboratory safety guidelines, which precaution must be taken when managing volatile or flammable liquids such as alcohol and acetone?

- A) They must be licked to verify proper labelling concentration before application.
B) They must be handled on open workbenches directly next to active heat sources.
C) They must be kept in unlabelled containers to optimise spatial layout efficiency.
D) They must be kept completely away from open flames.

Question: A student is preparing a permanent biological record of a paramecium sample, mounting the whole organism on a glass slide. According to proper slide labelling protocols, how should this specimen volume be marked?

- A) TS
B) VS
C) WM
D) LS



4.6 Summary

Proper laboratory organisation is essential for maintaining safety, efficiency, and accuracy in scientific education. By dividing workspaces into distinct functional zones, laboratories can prevent cross-contamination and extend the lifespan of sensitive equipment. Clear, highly visible safety signs help prevent accidents, while standardised labelling protocols for specimens, slides, and reagents ensure accurate tracking and reliable experimental data. Mastering these management principles is crucial for safely and successfully operating any life sciences facility.



4.7 References/Further Readings/Web Resources

Weyers, J., et al. (2021). *Practical skills in biology* (7th ed.). Pearson.

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Cappuccino, J.S. & Sherman, N., *Microbiology: A Laboratory Manual*, 5th edition, Benjamin/Cummings Science Publishing.



4.8 Possible Answers to Self-Assessment Questions

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

Unit 5 Handling Common Laboratory Equipment

Unit Structure

- 5.1 Introduction
- 5.2 Learning outcomes
- 5.3 Autoclave
- 5.4 Hot air oven
- 5..5 Incubator
- 5.6 Centrifuge
- 5.7 Laminar air flow
- 5.8 Microtome
- 5.9 Dissecting kit
- 5.10 Summary
- 5.11 References/Further Reading/Web Resources
- 5.12 Possible Answers to Self-Assessment Questions



5.1 Introduction

Welcome to Unit 5. In Unit 4, you studied the spatial layout, zoning laws, and administrative standards required to organise a biology laboratory. However, a properly organised floor plan is only effective if you know how to safely operate the equipment inside it. Every biological laboratory is equipped with specialised tools designed for measurement, observation, separation, and sterilisation.

This unit provides hands-on, practical guidance for operating the foundational instruments you will use throughout your academic and professional career. You will study thermal sterilisation systems (such as autoclaves and hot-air ovens), microenvironmental culture chambers, high-velocity centrifuges, clean benches, and precision anatomical tools. Learning the proper operational procedures, safety boundaries, and mechanical limitations of these devices is essential for generating reliable experimental data and preventing workplace accidents.



5.2 Learning Outcomes

By the end of this unit, you should be able to:

- demonstrate the use of a pressure cooker and autoclave for sterilisation;
- operate the hot air oven and water bath;
- handle the centrifuge and laminar flow system; and
- demonstrate the use of microtome knives and dissecting kits.



5.3 Autoclave

An autoclave is a pressure chamber that uses steam to sterilise equipment and materials by killing microorganisms and spores through high temperature and pressure. In medical, dental, and laboratory settings, it is essential to ensure that items such as instruments, glassware, and waste are decontaminated and made safe for use or disposal. Common cycles run at temperatures around 121°C and 15 psi for 15–30 minutes.

Procedure

The following steps are to be followed when using an autoclave:

- Pour a sufficient amount of water into the autoclave.
- Set the safety valves, put the materials/items to be sterilised in the container and load it inside the autoclave.
- Open the steam outlet to pass it out.
- Lock the door by tightening the bolts diagonally.
- Set the autoclave pressure.
- Place the autoclave on the heat source, ensuring that the heat is on maximum.
- See that air is expelled from within the body of the autoclave, and a continuous stream of steam comes out from the steam outlet. Now shut the steam outlet.
- Allow the autoclave to come to the required pressure and adjust the amount of heat so that the needed pressure is maintained, and then time it.
- Let the materials remain at a necessary pressure for a definite time. Later, cut the heat source and allow the autoclave to cool.
- Open the steam outlet when the needle reaches zero in the pressure gauge.
- Before opening the door of the autoclave and taking out materials/items which were sterilised, let the autoclave cool down for a considerable time.

Precautions

- Do not open the valve before zero is reached because the boiling liquid will dampen the cotton wool plugs, and there will be a chance of contamination by bacteria which may enter through the moisture film up to the medium.
- Do not open the valve when a vacuum has developed within because the air will rush suddenly inside the autoclave and will carry loose-fitting plugs into the autoclave.
- Do not allow the vacuum to remain for a long time because it will take out moisture from the medium kept inside the autoclave for sterilisation.

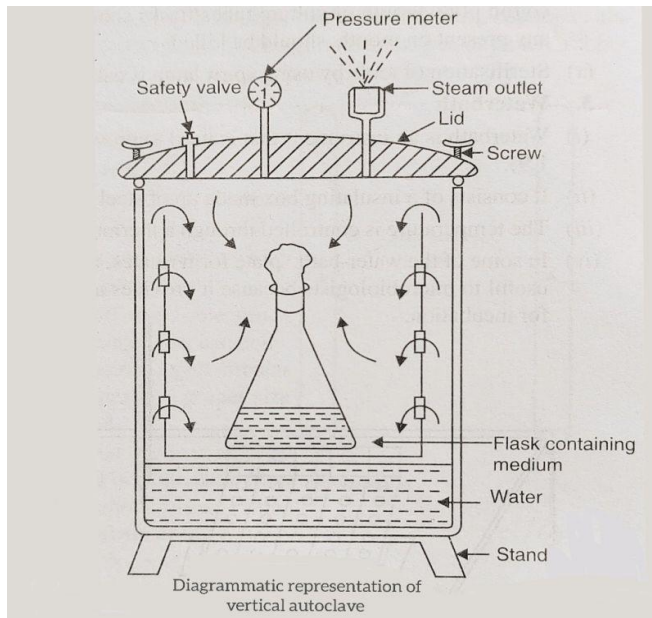


Fig. 1: Diagrammatic representation of an autoclave

5.4 Hot Air Oven

A hot air oven is an electrical device that uses dry, high-temperature air to sterilise equipment and materials such as glassware, powders, and metal instruments. It works by conduction, where heat is transferred to the items' surfaces and then into the centre, and uses high temperatures for extended periods to kill microorganisms and spores. There are two main types: forced-air ovens, which use a fan for uniform heat distribution, and static-air ovens, which rely on a heating coil at the bottom.

Procedure

- Sterilise only dry Petri-dishes singly or together in a metal can (petri dish canister). If a canister is not available, wrap the Petri dishes in aluminium foil. Do not remove the sterile Petri dishes from the can or unwrap them if they are not ready to be used.
- Flasks and tubes should be dried and plugged with cotton wool before sterilisation. The tube should be placed in iron, steel, or heat-resistant glassware, e.g., an enamel tray, test tube stands, or a beaker.
- Pipettes should be plugged with cotton wool at the mouth end after air drying and placed in an oven in a closed metal cylinder.
- Do not exceed the prescribed temperature.
- Do not overload. These may prevent air circulation, and the glassware may not be properly sterilised.
- Allow the temperature to rise to 160 °C and continue sterilisation at this temperature for one hour.

- Do not open the door of the oven immediately after the sterilisation because the glass may develop cracks due to a sudden fall in temperature.
- Use a towel to remove the glassware from the oven.

Identify three operational mistakes this student made. What will be the outcome of this sterilisation attempt?

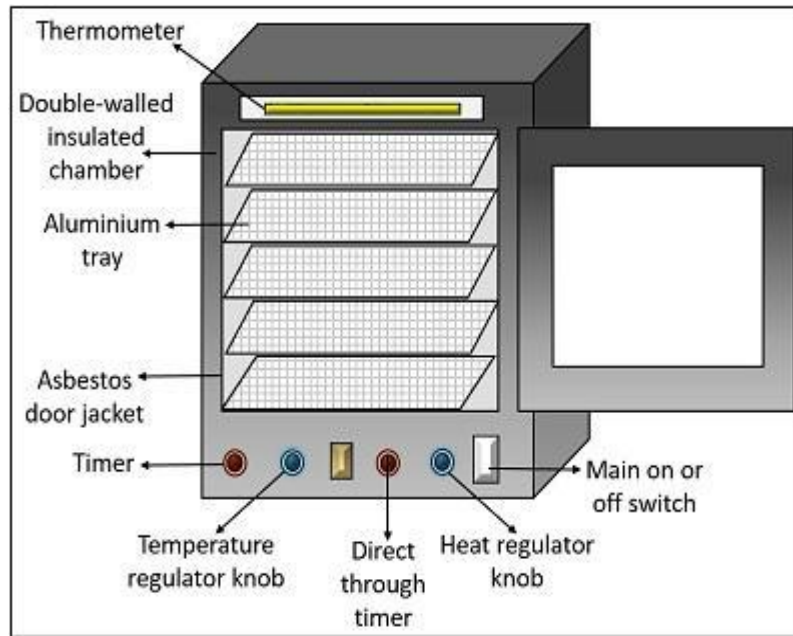


Fig. 2: Diagrammatic representation of a hot air oven

Scenario: A student wants to clean and prepare twenty glass Petri dishes for an upcoming microbial genetics experiment. They wash the dishes thoroughly, leave them damp, pack them tightly into a static-air laboratory oven, and set the temperature to 121°C for 15 minutes.

5.5 Incubator

An incubator is a device used to grow and maintain biological cultures, such as cells, bacteria, or viruses. It regulates key environmental factors, such as temperature, humidity, and gas levels (CO_2 and O_2), to create optimal conditions for growth or to preserve samples.

Incubators are essential tools in fields like cell biology, microbiology, and molecular biology. Its construction and operation are essentially the same as those of a hot-air oven, except that the operating temperature range in an incubator is lower, between room temperature and 50°C .

Incubators, hot-air ovens, and water baths require accurate temperature control. A thermostatic system maintains the required temperature in such an apparatus.

5.6 Centrifuge

A centrifuge is an important piece of equipment in a biology laboratory. A centrifuge is a device used to separate components of a mixture based on density by spinning samples at high speeds. Common uses include separating cells and bacteria, purifying viruses, isolating organelles, and preparing DNA, RNA, and proteins. The principle is that a spinning force, or centrifugal force, pushes denser components to the bottom of the tube, leaving lighter components in the supernatant.

How It Works

- A liquid sample is placed in a tube and put into a centrifuge.
- The tube is spun at a controlled high speed, creating centrifugal force.
- This force pushes the components with higher density to the bottom of the tube, forming a sediment or pellet.
- The remaining liquid, which contains less dense components, is called the supernatant and can be carefully decanted (poured off).

Precautions During Centrifugation

- Tubes must be put in pairs to balance.
- Be sure that rubber cushions are in position at the bottom of the bucket before inserting the tubes.
- Be sure that cotton wool plugs, if used, are not forced down during centrifugation.
- Make sure that the metal buckets are properly sealed on the ring and are free to swing.
- Secure the lid properly.
- Bring the rheostat to zero before starting. Gradually increase the speed until it reaches the required rpm (revolutions per minute).
- After centrifugation, switch off the meter and then bring the rheostat to the zero position, allowing it to come to a stop. Do not apply the hand to slow down the speed of the rotor.
- Take care to lubricate periodically.

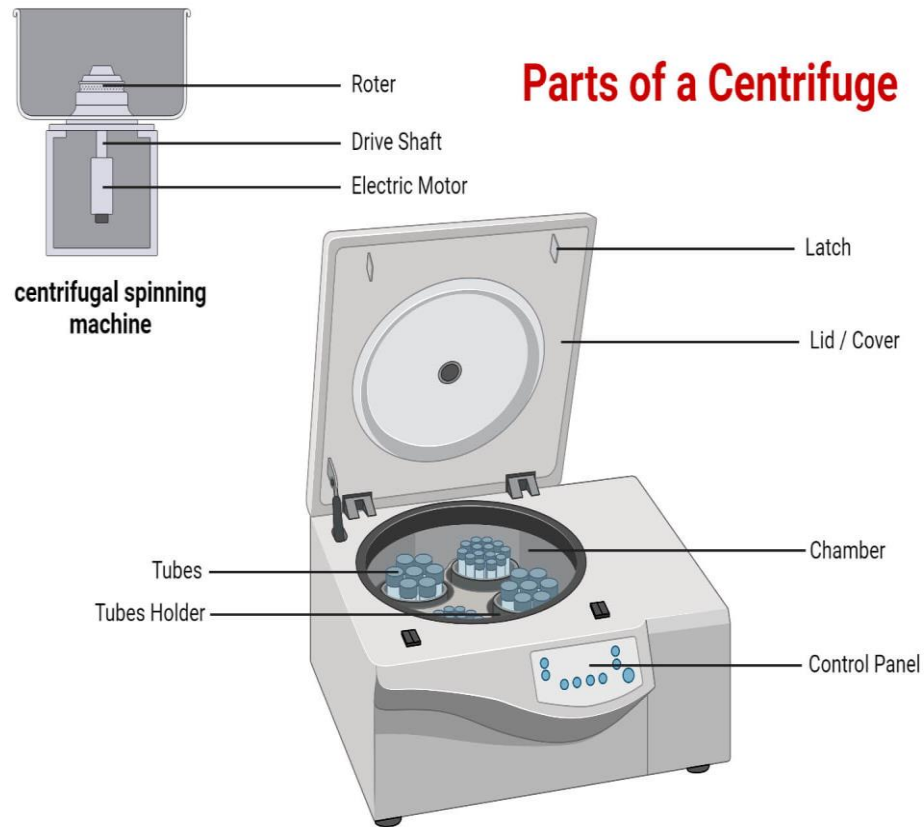


Fig. 3: Diagrammatic representation of a centrifuge

5.7 Laminar Air Flow

Laminar air flow refers to a system that creates a sterile, contaminant-free workspace for sensitive work by providing a unidirectional, steady stream of HEPA-filtered air. This technique is critical for preventing contamination of microbial cultures and samples during processes such as cell culture, sub-culturing, assays, and sterile preparations. The system uses filters that trap airborne particles, such as dust, bacteria, and viruses, ensuring the work area remains clean.

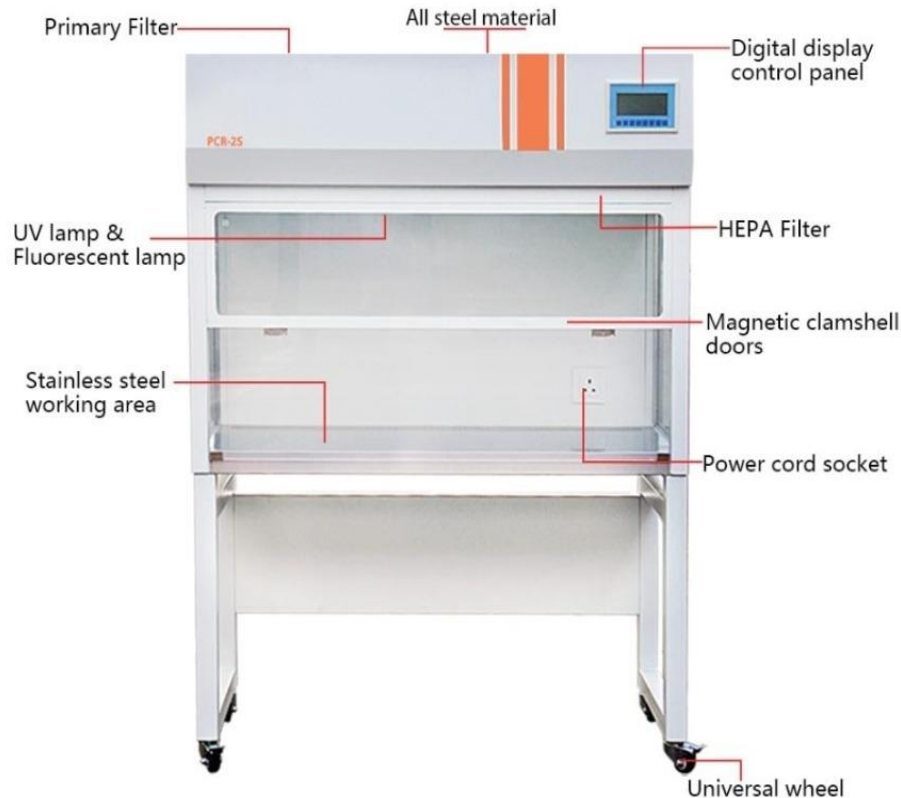


Fig. 4: Image of a laminar air flow

5.8 Microtome

A microtome is a specialised cutting instrument used to slice very thin sections of material for microscopic examination. These sections, called samples or specimens, are prepared for viewing under a microscope and are essential in fields like biology, medicine, and materials science. Microtomes are precision tools that produce uniform slices using a sharp blade. Various types exist, including rotary, sliding, and vibrating microtomes, each suited to different applications and materials.

What a Microtome Does

- **Cuts thin sections:** Its primary function is to cut extremely thin slices, or sections, of a material, which can be organic tissue or inorganic samples.
- **Enables microscopic analysis:** The thin sections allow scientists to observe the structure of the material in detail with a microscope, whether it's a light or electron microscope.
- **Supports histological studies:** In medicine and biology, microtomes are critical for preparing tissue specimens for histological analysis and staining.
- **Produces uniform slices:** The instrument is designed for accuracy and repeatability, ensuring that the sections are consistent in thickness.

How It Works

The material to be cut is typically embedded in a block of wax or other support material. The microtome's blade, often made of steel, glass, or diamond, is positioned to cut the block. A mechanism, such as a rotary flywheel, advances the block against the blade to slice it. The thickness of the section is controlled by the instrument's settings, with some modern microtomes capable of creating sections as thin as 0.5 micrometres.

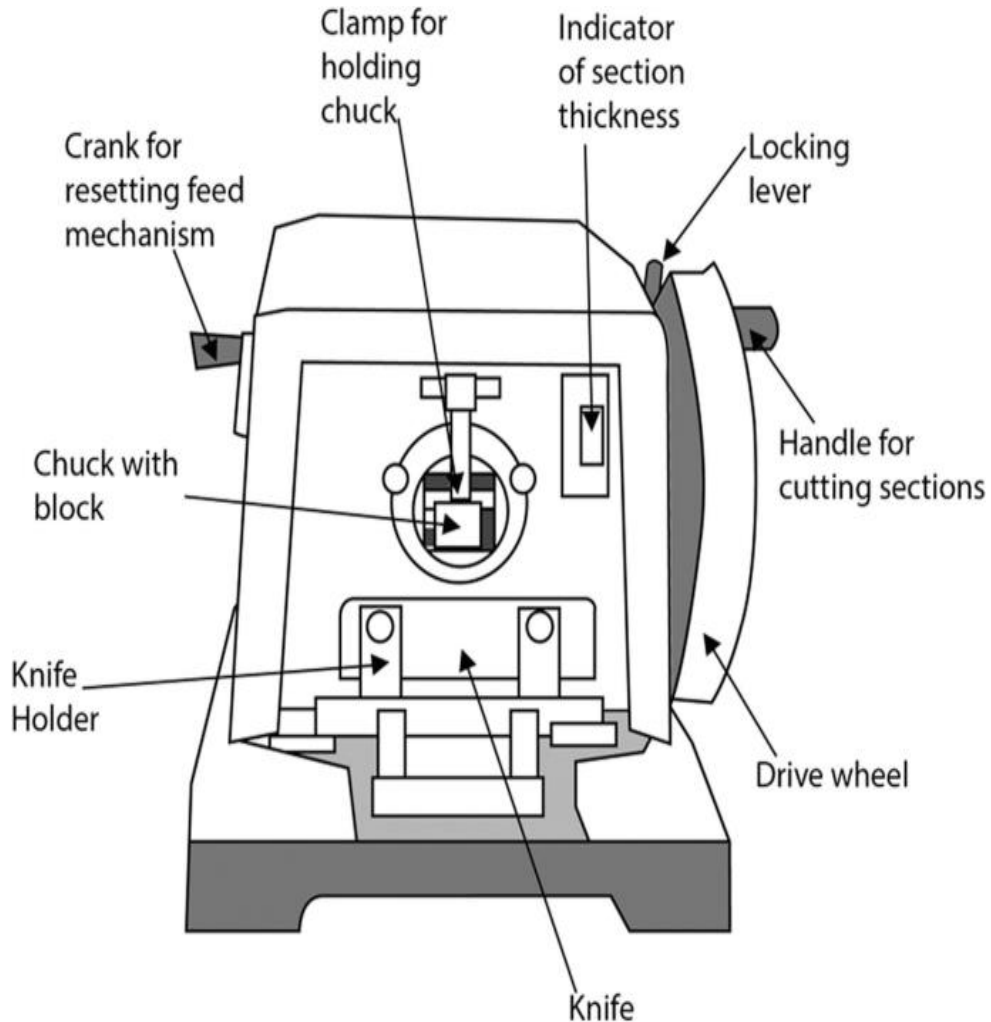


Fig. 5: Diagrammatic representation of a microtome

5.9 Dissecting Kits

A dissecting kit is a collection of specialised tools used for the precise separation and examination of biological specimens in educational, research, and medical settings. These kits typically include essential instruments like scalpels, scissors, forceps, and probes, all designed to facilitate the study of anatomy.

A standard dissecting kit contains several instruments, often made of surgical-grade stainless steel, each serving a specific function;

Table 1: Dissecting instruments and their functions

Instrument	Function
Scalpel	A small, extremely sharp blade used for making precise initial incisions into solid tissues.
Dissecting Scissors	Used for cutting through muscle, connective tissue, and sometimes small bones. Some have a blunt end to help prevent accidental damage to the underlying delicate structures.
Forceps	Act like tweezers, used for grasping, pulling back, and holding small pieces of tissue or organs in place, acting as an extra set of "hands".
Dissecting Needles	Fine-pointed tools are used to manipulate, separate, and tease apart delicate tissues in small areas without tearing them.
Blunt Probe	A rounded metal tool used to move organs or explore structures without cutting or puncturing them.

Dissecting Pins

Used to pin back skin flaps or hold specimens in a dissection tray, keeping the work area clear and the specimen stable.



Magnifying Glass

A convex lens is sometimes included to provide a magnified view of the specimen's intricate details.



Fig. 62: A dissecting kit containing various dissecting instruments

Usage and Safety

Dissection is a hands-on method for learning about the internal structures of plants and animals, as well as human cadavers in medical school. It is crucial to follow laboratory safety guidelines when using a dissecting kit:

- Always wear appropriate personal protective equipment, including safety goggles, gloves, and a lab coat.
- Ensure the work area is properly ventilated, as specimens are often stored in chemical preservatives like formaldehyde.
- Sterilise all instruments before the procedure.
- Dispose of used blades and other hazardous materials properly in designated containers.

Dissecting kits are available in various configurations, from basic student sets to advanced professional kits, and can be purchased from scientific supply companies and online retailers. Dissection in the lab must be carried out in dissecting trays.

Self-Assessment Questions

1. Before closing the steam outlet valve to build pressure inside an autoclave, what operational condition must be met to ensure proper sterilisation?
 - A) The internal temperature must match a hot air oven at 160°C .
 - B) A vacuum must be allowed to form for at least 30 minutes.
 - C) Cold air must be completely expelled, indicated by a continuous stream of pure steam escaping the valve.
 - D) The pressure gauge must register exactly 0 psi before sealing the lid.
2. A technician needs to sterilise a batch of glass pipettes in a closed metal cylinder using a forced-air hot-air oven. What are the correct temperature and duration parameters required for this process?
 - A) 121°C at 15 psi for 15 minutes
 - B) 160°C at ambient pressure for 1 hour
 - C) 50°C with controlled CO_2 for 24 hours
 - D) 100°C with running water for 30 minutes
3. What will occur if a student runs a benchtop laboratory centrifuge with an unbalanced rotor configuration?
 - A) The supernatant will mix evenly with the pellet.
 - B) The motor will spin faster due to reduced load resistance.
 - C) The sample tubes will crack under high vacuum pressure.
 - D) Severe vibration will develop, causing structural damage to the rotor and a serious safety hazard.
4. Which tool within a standard surgical-grade stainless steel dissecting kit should be selected to track the path of a blood vessel or shift an organ without tearing or puncturing the tissue?
 - A) Scalpel
 - B) Dissecting needle
 - C) Blunt probe
 - D) Direct pins



5.10 Summary

A modern biology laboratory contains a wide range of specialised tools designed for specific tasks. Sterilisation requires choosing the right method: steam autoclaves (121°C at 15 psi) are ideal for heat-stable liquids and agar media, while dry-heat hot air ovens (160°C) are reserved for sturdy glassware and metal tools. Biological incubators focus on supporting life rather than destroying it, using precise low temperatures (typically 37°C) and humidity controls to grow cultures.

When separating fluid mixtures, centrifuges rely on powerful centrifugal force to isolate components by density, which requires loading tubes in perfectly balanced pairs. Finally, specialised work requires high-precision systems: laminar flow hoods use HEPA filters to maintain sterile workspaces, microtomes slice embedded tissues into ultra-thin sections, and surgical dissecting kits provide specialised tools for studying anatomy safely and accurately.



5.11 References/Further Readings/Web Resources

Weyers, J., et al. (2021). *Practical skills in biology* (7th ed.). Pearson.

Campbell, N. A., et al. (2020). *Biology: A global approach* (12th ed.). Pearson.

Cappuccino, J.S. and Sherman, N., (n.d) *Microbiology: A Laboratory Manual*, 5th edition, Benjamin/Cummings Science Publishing.



5.12 Possible Answers to Self-Assessment Questions

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

End of Module 1: Laboratory Safety and Practices

MODULE 2 MICROSCOPY AND MEASUREMENT

Module Introduction

Microscopy sits at the absolute heart of biological investigation. The microscope is the primary tool that allows biologists to observe cells, tissues, and microorganisms that are completely invisible to the naked eye. This module introduces you to the core principles, mechanical structures, and everyday operations of the microscope—the single most important instrument in biological sciences.

Throughout this module, you will explore different types of microscopes, study their structural parts and functions, master practical calibration and viewing techniques, and learn how to take highly accurate microscopic measurements.

Unit 1	Introduction to Microscopy
Unit 2	Practical Use of the Microscope
Unit 3	Microscope Maintenance and Care

Unit Introduction to Microscopy

Unit Structure

- 1.1 Introduction
- 1.2 Learning outcomes
- 1.3 What is a microscope?
- 1.4 Types of microscopes
- 1.5 Basic principles of microscopy
- 1.6 Parts of the microscope and their functions
- 1.7 Summary
- 1.8 References/Further Reading/Web Resources
- 1.9 Possible Answers to Self-Assessment Questions



1.1 Introduction

Have you ever wondered how we discovered that our bodies are made up of trillions of tiny, working blocks called cells? Or how a doctor can look at a single drop of blood and identify the exact microbe causing an infection?

The invention of the microscope completely revolutionised biological science by revealing the cellular basis of life. Before this instrument was developed, the rich world of microorganisms remained entirely hidden from human sight. This unit explores the history, underlying physical

principles, different design types, and mechanical parts of the microscope. Mastering these concepts will provide you with the essential foundation for successful practical laboratory work throughout your biological career.



1.2 Learning Outcomes

By the end of this unit, you will be able to:

- explain the basic principles of microscopy;
- identify and explain the functions of at least eight parts of a microscope; and
- differentiate between types of microscopes.



1.3 What is a Microscope?

A microscope is an optical instrument that magnifies small objects so they can be observed in detail. Microscopes are powerful tools that allow us to explore the microscopic world, revealing intricate details invisible to the naked eye. The microscope is a fundamental tool for biologists. This instrument has been perfected over the past 300 years. It has, within limits, allowed the invisible to become visible.

Microscopy, therefore, is the science of using microscopes to view objects that the unaided eye cannot see. Microscopy is used by scientists and health care professionals for many purposes, including diagnosing infectious diseases, identifying microorganisms in environmental samples (including food and water), and determining the effects of pathogenic (disease-causing) microbes on human cells.

1.4 Types of Microscopes

1. **Simple Microscope** – Uses a single lens to magnify small objects.
2. **Compound Microscope** – Uses two or more lenses (objective and eyepiece) to achieve higher magnification. It is common in student labs.
3. **Stereo or Dissecting Microscope** – Used for viewing larger, less detailed specimens in three dimensions (3D).
4. **Electron Microscope** – Uses beams of electrons rather than light to produce highly magnified images, e.g., Transmission and

Scanning Electron Microscopes. Transmission Electron Microscope (TEM) creates a high-resolution image of the internal structure of a sample by passing an electron beam through a thin section, while Scanning Electron Microscope (SEM) produces an image by scanning the surface of a specimen with a beam of electrons, allowing you to see its topography.

Scenario: A student is examining a slide of human cheek cells under a microscope using a $15\times$ wide-field ocular lens paired with a $100\times$ oil-immersion objective lens.

1.5 Basic Principles of Microscopy

1. **Magnification** – Making an object appear larger.

In a compound microscope, enlargement or magnification of a specimen is the function of a two-lens system: the **ocular lens** found in the eyepiece, and the **objective lens** situated in a revolving nose-piece. These lenses are separated by the body tube. The objective lens is closer to the specimen. It magnifies it, projecting a real image into the focal plane, where the ocular lens further magnifies it to produce the final image.

The most commonly used microscopes are equipped with a revolving nosepiece containing four objective lenses with different magnifications. When these are combined with the ocular lens magnification, the total linear magnification of the specimen is obtained. For example, a 10x eyepiece and a 40x objective lens create a total magnification of 400x ($10 \times 40 = 400$).

2. **Resolution** – The ability to distinguish two closely spaced points as separate entities.

It is a measure of image clarity and is the true indicator of a microscope's performance. A higher resolution means finer detail can be seen. The resolution is limited by the wavelength of light used and the numerical aperture of the objective lens.

Although magnification is important, a common and critical misconception is that higher magnification automatically yields a better image. However, magnification without sufficient resolution is known as “empty magnification.” The image becomes larger but blurrier, revealing no additional detail. The factor that truly governs the level of detail a microscope can capture is its resolution, which is fundamentally determined by a property of the objective lens called numerical aperture.

3. **Contrast** – The difference in light intensity (brightness) or colour, between specimen and background.

Many biological specimens are transparent and absorb very little light; they require specialised techniques to create sufficient contrast for viewing.

4. **Illumination** – Proper lighting to enhance image clarity.
The light source illuminates the specimen. The light passes through or reflects off the specimen, then is collected and focused by the objective lens. The brightness and path of the light are controlled by components such as the diaphragm, which regulates the diameter of the light beam. Effective illumination is required for efficient magnification and resolving power. Since the intensity of daylight is uncontrollable, a tungsten lamp is the most commonly used light source in microscopy. The light passes through the condenser located beneath the stage. The condenser contains two lenses that are required to achieve the maximum numerical aperture. The condenser's height can be adjusted with the condenser knob. Always keep the condenser close to the stage, especially when using the oil-immersion objective. A rule of thumb is that as the lens magnification increases, the distance between the objective lens and the slide (the working distance) decreases, while the objective lens's numerical aperture increases.

What is the total linear magnification of the cheek cells?

- A) $115\times$
- B) $150\times$
- C) $1,500\times$
- D) $15,000\times$

1.7 Parts of a Compound Microscope and Their Functions

Table 1: Parts of a Compound Microscope and Their Functions

Part

Function

--	--

Eyepiece (ocular lens)

Magnifies the image formed by the objective lens.

--

Objective lenses

Provide various magnifications (e.g., $\times 4$, $\times 10$, $\times 40$, $\times 100$).

Stage

Platform where the slide is placed.

Condenser

Focuses light onto the specimen.

Diaphragm

Regulates light intensity.

Mirror or Light source

Provides illumination.

Coarse adjustment knob

Bring the object into general focus.

Fine adjustment knob

Brings the object into sharp focus.

Arm and base

Provide support and stability.

Note: Always carry the microscope with two hands — one on the arm and the other supporting the base.

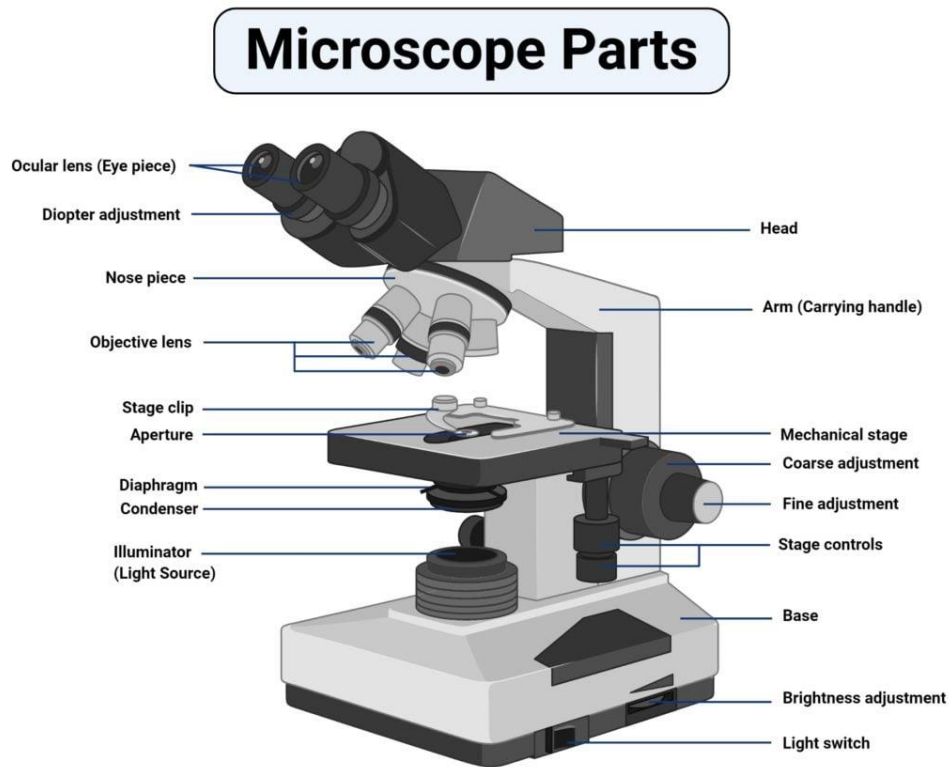


Figure: Parts of a microscope, Image Copyright © Sagar Aryal, www.microbenotes.com

Fig. 1: Parts of a microscope



Click on this link: <https://youtu.be/IU68wmkekR0>, and watch the video or scan the QR code.

Self-Assessment Exercise

1. A scientist wants to observe the detailed, three-dimensional surface topography of a pathogenic bacterium. Which microscope would be best suited for this task?
 - A) Transmission Electron Microscope (TEM)
 - B) Scanning Electron Microscope (SEM)
 - C) Compound Light Microscope
 - D) Stereo Dissecting Microscope
2. What occurs when a user continuously increases the magnification of a microscope without a corresponding increase in its numerical aperture or resolution?
 - A) Increased working distance
 - B) Higher structural contrast
 - C) Empty magnification
 - D) Improved image clarity
3. As a student switches from a $10\times$ objective lens to a $40\times$ objective lens, what happens to the working distance and the numerical aperture?
 - A) Working distance increases, and numerical aperture increases.
 - B) Working distance decreases, and numerical aperture decreases.
 - C) Working distance increases, and numerical aperture decreases.
 - D) Working distance decreases, and numerical aperture increases.
4. Which component of the compound microscope is situated directly beneath the stage and houses two lenses designed to maximise the light beam's numerical aperture?
 - A) The diaphragm
 - B) The body tube
 - C) The condenser
 - D) The revolving nosepiece

**1.7 Summary**

Microscopy is an essential skill for exploring biology at the cellular level. This unit covered the foundational tools of the discipline, tracing the development of the microscope from simple single-lens tools to modern designs. You studied light-based compound systems and electron-beam instruments (TEM and SEM), learning how each is used for distinct imaging tasks.

You also explored the physical principles that govern image quality—magnification, resolution, contrast, and sub-stage illumination. Finally, you studied the physical anatomy of the compound microscope, learning how its optical elements and mechanical adjustment knobs work together to help you safely find a sharp focus.



1.8 References/Further Readings/Web Resources

Campbell, N. A., et al. (2020). *Biology: A global approach* (12th ed.). Pearson.

Weyers, J., et al. (2021). *Practical skills in biology* (7th ed.). Pearson.

<https://youtu.be/d4FNueODr5c> - Introduction to the Microscope.



1.9 Possible Answers to Self-Assessment Exercise

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

Unit 2 Practical use of the Microscope

Unit Structure

- 2.1 Introduction
- 2.2 Learning outcomes
- 2.3 Setting up the microscope
- 2.4 Proper handling and carrying
- 2.5 Specimen preparation
 - 2.5.1 General steps in specimen preparation
 - 2.5.2 Techniques for specimen preparation
- 2.6 Basic microscopy techniques
- 2.7 Observation and image interpretation
 - 2.7.1 Key principles
 - 2.7.2 Steps for Observation and Image Interpretation
- 2.8 Summary
- 2.9 References/Further Reading/Web Resources
- 2.10 Possible Answers to Self-Assessment Exercises



2.1 Introduction

Now that you understand the basic components and physics of a microscope from Unit 1, it is time to focus on how to use it in a real laboratory environment. Knowing the names of the parts is only the first step; the real skill lies in learning how to configure, adjust, and maintain the instrument to reveal the hidden secrets of biological samples.

This unit provides a step-by-step guide to setting up your workspace, handling the microscope safely, preparing your own slides, and recording your findings using proper biological techniques. Mastering these steps ensures you can gather clear, reliable data while keeping your equipment safe from damage.



2.2 Learning Outcomes

By the end of this unit, you should be able to:

- demonstrate the proper handling and carrying of the microscope;
- prepare specimens for microscopic examination;
- explain basic microscopy techniques; and
- observe and interpret microscopic images correctly.



2.3 Setting up the Microscope

To set up a microscope, place it on a stable, flat surface, plug it in, and turn on the light. Rotate the lowest power objective lens into position, place a prepared slide on the stage, and secure it with the clips. Then, with your eye to the eyepiece (or eyepieces, if the microscope is binocular), use the coarse and fine focus knobs to bring the specimen into sharp focus, starting with the coarse knob to bring the objective close to the slide, then using the fine knob for final adjustments. Move to the next-highest power objective (do not skip the individual objectives) and use only the fine focus to achieve perfect focus for your eyes. If you need further magnification again, move to the next-highest power objective and use only the fine focus to bring your image into perfect focus for your eyes. Do not use the 100x objective (if you have one) without proper guidance. It must be used with immersion oil.

2.4 Proper Handling and Carrying

1. Always carry your microscope with two hands, one firmly grasping the arm of the microscope and the other supporting the base.
2. Set the microscope on a flat, solid support and in a position where it will not easily be knocked off. Coil the cord to avoid tripping over it.
3. Never force the adjustments. All adjustments should work freely and easily. Never allow an objective lens to jam into or even to touch the slide or cover slip. Never focus downward with the coarse adjustment while you are looking through the microscope. Always incline your head to the side with eyes parallel to the slide, so that the downward movement can be arrested before the objective touches the slide.
4. Lenses must be clean for resolution. If the lenses become dirty, only wipe them gently with lens paper and cleaning solution. Never use your finger, handkerchief, paper towels or spit to clean the lenses. Never leave a slide on the microscope when it is not in use.
5. Cover the microscope when not in use.
6. Never attempt to carry two microscopes at one time.

7. On completion of the laboratory exercise, return the microscope to its cabinet in its original condition. Clean all lenses with dry, clean lens paper. If needed, you can use a drop or two of methanol to help clean the lens. Use xylol to remove oil from the stage only. Place the low-power objective in position and bring the stage and objectives close together. Centre the mechanical stage. Coil the electric wire around the cord hanger. Carry the microscope to its position in the cabinet, as previously described.

2.5 Specimen Preparation

Specimen preparation is the process of treating a sample for accurate and reliable observation or testing, and it can involve techniques like fixation, dehydration, sectioning, staining, and mounting. The specific steps depend on the type of specimen and the intended analysis (such as microscopy or materials testing). Proper preparation is critical to prevent artefacts (artificial structures or errors in a sample that do not represent the living organism or tissue but are instead the result of the techniques used to prepare or observe it) or structural damage.

2.5.1 General steps in specimen preparation

- **Collection and labelling:** The specimen is collected and labelled correctly to ensure proper identification throughout the process.
- **Fixation:** The specimen is treated to preserve its structure and prevent degradation. For microscopic analysis, this might involve immersion in a fixative like formaldehyde or glutaraldehyde.
- **Dehydration:** Water is removed from the specimen and replaced with other substances to allow for embedding or other processes. This often involves washing the specimen in a graded series of alcohol.
- **Sectioning:** The specimen is cut into very thin slices, which is essential for microscopy. This is done with a specialised instrument called a microtome.
- **Embedding and mounting:** The thin sections are placed on a slide or grid for viewing. For example, paraffin sections are embedded in wax, while electron microscopy samples are often placed on a copper grid.
- **Staining:** To enhance contrast and highlight specific structures, stains are applied. This is particularly important for specimens like bacteria and tissue, which may lack natural colour.

2.5.2 Techniques for specimen preparation

1. **Wet Mount:** A wet mount is a laboratory technique for viewing living specimens and fluids (such as a vaginal discharge sample, saliva or urine) under a microscope by placing them in a drop of liquid (water or saline) on a glass slide and covering it with a coverslip. This method is useful for observing organisms in motion, like bacteria, yeast, and other microorganisms, which can help diagnose infections or other conditions.
2. **Smear Preparation:** Smear preparation involves spreading a sample of microorganisms on a glass slide, letting it air dry, and then heat-fixing it to adhere the cells to the slide for staining. This is a crucial first step in procedures like bacterial staining to ensure proper visualisation and analysis under a microscope. The specific steps differ slightly depending on whether the culture is in liquid (broth) or on a solid medium (from a plate).
3. **Staining:** Staining refers to the process of applying a dye or pigment to something to colour it or enhance visibility. In biology, it's a technique used to increase the contrast of microscopic samples for easier observation, such as distinguishing between different types of bacteria using the Gram stain method. The different staining methods used, depending on the specimen and purpose, are: Gram staining, simple staining and differential staining.

Scenario: You are preparing a wet mount of pond water to look for moving amoebae. When you look through the eyepiece, you see several large, perfectly round shapes with thick, dark black borders. These structures lack internal organelles and do not change shape.

2.6 Basic Microscopy Techniques

A fundamental light microscopy technique requires preparing a sample on a slide, placing it on the microscope's stage, and then using the coarse and fine focus knobs to bring the specimen into view, starting with the lowest-power objective and increasing magnification as needed.

Techniques;

- **Preparation:** prepare the specimen to be viewed using the relevant technique (2.5.2 above).
- **Placement:** secure the slide on the stage with the clips and position the specimen over the light source.
- **Focusing:** Turn on the light and rotate the revolving nosepiece to the lowest power objective lens (e.g., 4X or 5X). Always begin

observation with low power before switching to higher magnifications. Look through the eyepiece and use the coarse focus knob to move the stage up until the specimen is visible, then use the fine focus knob to sharpen the image. Adjust the diaphragm to control the light intensity.

- **Increasing magnification:** Rotate the revolving nosepiece to a higher power objective. Use the fine focus knob to re-focus the image. You should not need to use the coarse focus at higher magnifications, and avoid moving the slide too quickly at high power.

What are these structures, and how did they get on your slide?

- They are target bacteria caused by using too much methylene blue stain.
- They are air bubbles (artefacts) caused by dropping the coverslip straight down too quickly.
- They are living protozoans in the resting cyst stage of their life cycle.
- They are wax contaminants that transferred over from a microtome cutting blade.

2.7 Observation and Image Interpretation

In biology practical, observation and image interpretation require students to carefully examine specimens (live, preserved, or presented as images/micrographs) and accurately record their features through labelled biological drawings and descriptive notes.

2.7.1 Key Principles

- **Accuracy over artistic skill:** Biological drawings prioritise clear, scientifically accurate representation of observed features, not artistic flair. Shading and colours are generally avoided.
- **Focus on the specimen:** Draw only what is visible, not what you expect to see from a textbook or prior knowledge.
- **Objectivity:** Observations should be objective and factual. Avoid personal pronouns or subjective descriptions.
- **Proper technique:** Use a well-sharpened HB pencil, draw clear, continuous lines, and use a ruler for straight, non-crossing label lines.

2.7.2 Steps for Observation and Image Interpretation

1. **Careful Observation:** Closely examine the specimen or image. Use a hand lens or microscope (starting on low power, then switching to high power) if required to identify specific details.

2. **Identification:** Identify the main subject and its key features. For specimens, this might involve classifying its kingdom or division, e.g., identifying a specimen as a plant or an animal tissue.
3. **Drawing:** Title: Provide an appropriate title, such as "Transverse section of a leaf".

Size and Proportion: Draw a large, clear diagram that is proportionally accurate, showing the correct relative sizes of different parts.

Details: Depict only well-defined structures and a representative number of repetitive features.

4. **Labelling:**
Use a ruler for straight, horizontal label lines that touch the part being labelled.

Write labels in front of the guideline and ensure correct spelling. Include as many labels as necessary to highlight important structures.

5. **Magnification/Scale:** Note the magnification used for microscopic images (eyepiece power $\times$ objective power) or provide an estimation of the scale for larger specimens.
6. **Documentation:** Record all findings in a structured format in your lab manual or record book. Differentiate between observations (what you see) and interpretations (conclusions based on biological knowledge).

True or False?

When drawing a plant cell under a microscope, a student should use soft pencil shading to show that the central vacuole looks darker than the surrounding cytoplasm.

Self-Assessment Exercise

1. Why must you look at a microscope from the side (at eye level with the stage) when rolling the stage upward using the coarse adjustment knob?
 - A) To check if the light source is bright enough.
 - B) To align the condenser with the stage clips.
 - C) To ensure the objective lens does not crash into the slide or cover slip.
 - D) To easily read the magnification values on the revolving nosepiece.
2. What specialised instrument is used to slice a fixed and embedded biological specimen into very thin sections for microscopy?
 - A) A centrifuge
 - B) A microtome
 - C) A desiccator
 - D) A chemical fixative
3. A student is looking at a specimen under a high-power objective lens and wants to sharpen the image. Which of the following actions violates safe handling rules?
 - A) Turning the diaphragm to alter light intensity.
 - B) Adjusting the image clarity using the fine focus knob.
 - C) Adjusting the image clarity using the coarse focus knob.
 - D) Moving the slide slowly to view a different field of view.
4. Which chemical is explicitly designated for removing oil from the microscope stage only upon completing laboratory exercises?
 - A) Methanol
 - B) Formaldehyde
 - C) Glutaraldehyde
 - D) Xylol

**2.8 Summary**

Operating a microscope effectively requires combining mechanical safety habits with proper specimen preparation. This unit reviewed the step-by-step process for setting up a microscope, from low-power positioning to fine-focus adjustments. You studied the workflows for creating temporary wet mounts to examine living cells and for making heat-fixed smears for simple and differential staining procedures. Finally, you learned the professional guidelines for documenting your work through objective notes and accurate, unshaded biological drawings.



2.9 References/Further Readings/Web Resources

Weyers, J., et al. (2021). *Practical skills in biology* (7th ed.). Pearson.

<https://www.youtube.com/watch?v=SUo2fHZaZCU> – Basic Microscope Setup and Use.



2.10 Possible Answers to Self-Assessment Exercise

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

Unit 3 Microscope Maintenance and Care

Unit Structure

- 3.1 Introduction
- 3.2 Learning outcomes
- 3.3 Routine cleaning and maintenance
- 3.4 Storage of microscopes
 - 3.4.1 Daily storage
 - 3.4.2 Long-term storage
- 3.5 Troubleshooting common problems
- 3.6 Summary
- 3.7 References/Further Reading/Web Resources
- 3.8 Possible Answers to Self-Assessment Exercise



3.1 Introduction

Microscopes are delicate and expensive instruments that require careful handling and regular maintenance. This unit provides guidelines for cleaning, storing, and troubleshooting common microscope problems.



3.2 Learning Outcomes

By the end of this unit, you will be able to:

- highlight procedures for cleaning and maintaining microscopes
- explain ways to store microscopes properly
- identify common problems in microscopes and their solutions.



3.3 Routine Cleaning and Maintenance

Routine microscope maintenance includes daily cleaning with compressed air and a microfiber cloth, weekly cleaning of lenses with a special solution and lens paper and post-use cleaning of oil-immersion objectives with lens paper and a solvent. Remove dust from the stage and base regularly. Wipe the body with a soft, dry cloth after each use. Always cover the microscope when not in use and refer to the user manual for specific instructions.

3.4 Storage of Microscopes

To store a microscope, cover it with a dust cover and place it in a cool, dry, and clean location away from direct sunlight and chemical fumes. For long-term storage, it is best to clean the lenses, remove any oil immersion, and store them in a cabinet or dedicated box with a desiccant if humidity is a concern.

3.4.1 Daily storage

- Cover the microscope: Always use the dust cover to protect it from dust and dirt.
- Turn off the light: Ensure the light source is turned off.
- Lower the stage: Move the stage to its lowest position and place the lowest power (scanning) objective lens in place.
- Store in a dry, clean place: Place it in a clean, dry area that is free from vibration and away from direct sunlight.
- Unplug the power: If possible, unplug the microscope from the power outlet.

3.4.2 Long-term storage

- Clean thoroughly: Before long-term storage, perform a thorough cleaning, especially of the lenses.
- Remove immersion oil: Clean off any immersion oil from the objective lenses with a delicate task wipe.
- Store in a controlled environment: Store the microscope in a dry environment, ideally in a storage cabinet.
- Use a desiccant: If the environment is humid, store the microscope in a waterproof container with a drying agent to prevent moisture damage.
- Keep it away from fumes: Do not store the microscope near corrosive chemical fumes or solutions that could leak.

3.5 Troubleshooting Common Microscope Problems

Problem

Possible Cause

Solution

--

Image not clear

Dirty lens or slide

Clean lenses and slide.

--

Uneven illumination
Misaligned mirror or condenser
Adjust the light source.

Difficulty focusing
Slide upside down or the wrong objective
Reorient the slide and use the correct lens.

Mechanical stiffness
Lack of lubrication
Apply a small amount of grease to moving parts.

Self-Assessment Exercise

1. After using an oil immersion objective lens, what is the proper protocol to prevent damage?
 - A) Wipe it down with a dry microfiber cloth and lower the stage.
 - B) Clean it immediately using lens paper and a solvent.
 - C) Leave the oil on the lens until the weekly deep-cleaning cycle.
 - D) Spray it with compressed air to remove the excess oil.

2. When preparing a microscope for daily storage, how should the stage and objective lenses be positioned?
 - A) Stage at its highest position; highest power objective in place.
 - B) Stage at its lowest position; highest power objective in place.
 - C) Stage at its highest position; lowest power (scanning) objective in place.
 - D) Stage at its lowest position; lowest power (scanning) objective in place.

3. If you are experiencing humidity issues during long-term microscope storage, what preventative measures should be taken?
 - A) Apply a generous layer of mechanical grease to the lenses.
 - B) Store the microscope near chemical fumes to dry the air.
 - C) Place the microscope in a waterproof container with a desiccant.
 - D) Leave the microscope light source turned on to generate heat

4. A student notices that the view through the eyepiece has uneven illumination. According to the troubleshooting guide, what is the most likely cause?
- A) The slide is placed upside down.
 - B) The moving parts lack lubrication.
 - C) The mirror or condenser is misaligned.
 - D) The objective lens is dirty.



3.6 Summary

Routine care and maintenance ensure a long lifespan and optimal performance of microscopes. Immediate attention to faults prevents costly repairs and ensures reliability.



3.7 References/Further Readings/Web Resources

<https://www.youtube.com/watch?v=eJeEjS2aYPo> – Care and Handling of Microscopes.

<https://www.youtube.com/watch?v=E5sh31EmdGc> – Prepping Your Microscope to be Put Away.

Weyers, J., et al. (2021). *Practical skills in biology* (7th ed.). Pearson.



3.8 Possible Answers to Self-Assessment Exercise

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

MODULE 3 BIOLOGICAL DIAGRAMS AND SAMPLE PROCUREMENT

Module Introduction

Biological illustration and specimen collection are fundamental aspects of practical biology. Accurate diagrams help communicate scientific observations, while proper collection and preparation of biological materials ensure meaningful laboratory exercises. In this module, you will learn how to draw accurate biological diagrams, procure both animal and plant materials for laboratory work, and properly kill, mount, and display specimens. These skills are vital for biological studies, taxonomy, and research.

Unit 1	Drawing Biological Diagrams
Unit 2	Procuring Animal Material for Laboratory Work
Unit 3	Procuring Plant Materials
Unit 4	Killing, Mounting, and Display of Insect Specimens

Unit 1 Drawing Biological Diagrams

Unit Structure

- 1.1 Introduction
- 1.2 Learning outcomes
- 1.3 Fundamentals of biological diagrams
 - 1.3.1 Key rules for biological drawings
 - 1.3.2 Types of biological diagrams
- 1.4 Scale and magnification
 - 1.4.1 Calculating the scale/magnification of a drawing
- 1.5 Summary
- 1.6 References/Further Reading/Web Resources
- 1.7 Possible Answers to Self-Assessment Exercises



1.1 Introduction

In biology, sketches and diagrams are used to record observations of organisms and their structures. A good biological drawing is clear, proportionate, and correctly labelled. This unit will teach you the basic rules and techniques for accurately drawing biological specimens.



1.2 Learning Outcomes

By the end of this unit, you will be able to:

- create accurate and informative biological diagrams using appropriate techniques;
- represent the relative sizes of different biological structures and components correctly;
- add clear and concise labels to diagrams; and
- mention the different types of biological diagrams.



1.3 Fundamentals of Biological Diagrams

A biological diagram is a simple, accurate line representation of an observed specimen. The aim is not artistic beauty but scientific accuracy. To draw biological diagrams, use a sharp pencil to create large, clear, and accurate 2D drawings on unlined paper, avoiding shading and using continuous lines. Label structures with straight lines drawn with a ruler, ensuring they do not cross and are aligned neatly, preferably on one side of the page. Always include an underlined title, the magnification (especially for microscopic views), and state the source or type of section (e.g., T/S or L/S).

1.3.1 Key Rules for Biological Drawings

- Draw with a sharp pencil (HB or 2H).
- Use clean, unlined paper.
- Avoid shading — use clear, single lines.
- Place labels horizontally using a ruler. Label all key structures and do not use arrowheads.
- Include title and magnification. The title should state the specimen you are drawing. Write the title either above or below your drawing.
- Draw only what is seen under the microscope — not what is imagined.
- Keep it large: Draw the diagram to be large and proportionate, occupying at least half of the space provided.
- Stay 2D: Drawings should be two-dimensional; use stippling (dots) for darker areas instead of shading.
- Draw what you see: The drawing should be an accurate representation, not an idealised version. Use firm, continuous lines, and avoid sketching or cross-hatching.
- No colour: Do not use colour in your diagrams.
- Consider detail: If a specific part is very small, you can draw a larger, separate diagram of it.

Why is shading or using colour prohibited in standard biological drawings, and what technique should you use instead to indicate darker or denser regions?

1.3.3 Types of Biological Diagrams

There are various types of biological diagrams, depending on the level of detail or view. They include;

1. **Cell drawings:** Show the structures of a single cell, often under a microscope.
2. **Tissue drawings:** Illustrate the location and extent of different tissues in an organ or whole organism.
3. **Body plan drawings:** Provide a lifelike representation of a whole organism or dissected parts.
4. **Whole mount (w.m.):** A diagram of an entire organism or object, viewed whole.
5. **Section drawings:** Show internal structures after a cut is made.

Two types of section drawings are cross-section and longitudinal section. Cross-section (x.s. or t.s.): a cut across the body at a right angle, while longitudinal section (l.s.): a cut along the length of the body.

6. **Ventral view:** Shows the under or lower surface.
7. **Dorsal view:** Shows the upper or back surface.

1.4 Scale and Magnification

Scale, or magnification, is how much larger or smaller the drawing is compared to the actual specimen. It is useful to indicate the scale/magnification of a drawing, particularly for large specimens drawn without the aid of a microscope. The actual size of a plant or leaf, for example, it may be impossible to judge simply from a drawing. For drawings made using microscopes, if the actual scale or magnification is not given, it may be useful to indicate whether a low or high-power lens was used, preferably the actual magnification achieved by the combined eyepiece and objective lens, usually just below the title.

1.4.1 Calculating the scale/magnification of a drawing

- (a) **For specimens drawn without the aid of a microscope**
- Measure between two appropriate points of the **drawing** (e.g. total length or width).
 - Measure between the same two points of the **specimen**.
 - Divide measurement 1 by measurement 2. The formula is given below;

$$\text{magnification} = \frac{\text{length of drawing}}{\text{length of specimen}}$$

Show your working when calculating the magnification. Don't forget to check the units, make sure they are the same (cm or mm) before you divide. *The degree of accuracy for your calculated value should not be more accurate than your measured values.* For example, if the length of the drawing measured is 10.0cm and the length of the specimen is 6.0cm, the magnification should be written as "x1.7" (to 1dp), not "x1.67".

(b) For specimens drawn with the aid of a microscope

When using the microscope for your drawing, you multiply the magnification of the eyepiece by that of the objective lens. The formula is expressed below;

magnification

= magnification of eyepiece X magnification of objective lens

For example, if the eyepiece magnification is x10 and the objective lens magnification is x40, the combined magnification would be x400. An example of a biological diagram is shown below.

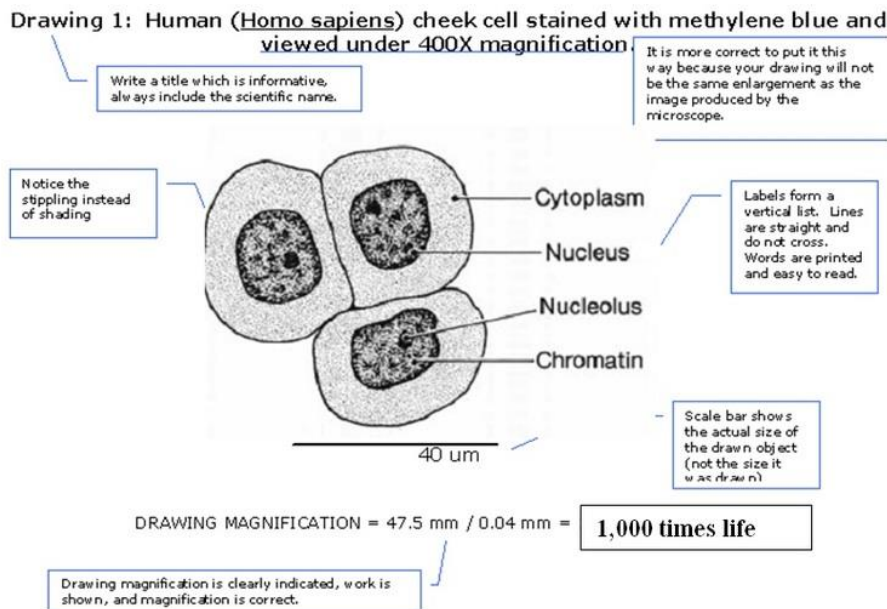


Fig. 3: A biological drawing of a human cheek cell viewed under a microscope

Another example is shown below;

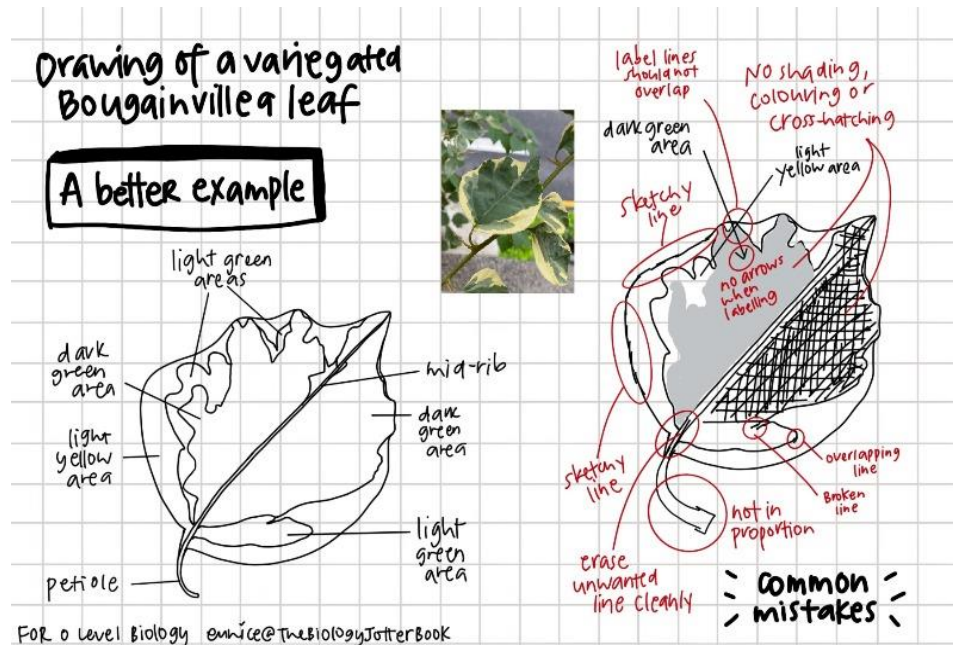


Fig. 2: Biological drawings of a leaf. The drawing on the left is an example of a good biological drawing, while the drawing on the right is an example of a bad biological drawing with common mistakes highlighted in red.

Self-Assessment Exercise

1. When drawing a biological diagram, which of the following practices is considered correct according to scientific standards?
 - A. Using a blend of crayons or colored pencils to match the specimen's appearance.
 - B. Utilising artistic cross-hatching and shading to show depth and three-dimensionality.
 - C. Using a sharp HB or 2H pencil to make large, clear, 2D line drawings on unlined paper.
 - D. Drawing an idealised version of what the textbook describes rather than what is observed.
2. How should labelling lines be drawn and positioned on a standard biological diagram?
 - A. Freehand, crossing over each other, ending with clear arrowheads.
 - B. Horizontally using a ruler, ensuring lines do not cross and do not use arrowheads.
 - C. Diagonally, aligned neatly on both sides of the page using arrowheads.
 - D. Curved around the structures to avoid touching other structural components.

3. A student measures the length of their drawing of a leaf specimen to be 10.0 cm. The actual leaf specimen measures 6.0 cm. Following the correct rule for the degree of accuracy, how should the calculated magnification be written?
 - A. x1.67
 - B. x1.7
 - C. x0.6
 - D. x1.666...
4. Which type of biological diagram illustrates internal structures exposed specifically by making a cut across the specimen's body at a right angle?
 - A. Longitudinal section (l.s.)
 - B. Whole mount (w.m.)
 - C. Cross-section (x.s. or t.s.)
 - D. Dorsal view



1.6 Summary

A good biological drawing demonstrates observation skill, accuracy, and neatness. Following proper drawing conventions ensures effective scientific communication.



1.7 References/Further Readings/Web Resources

Campbell, N. A., et al. (2020). *Biology: A global approach* (12th ed.). Pearson. [URL:

<https://www.pearson.com/store/p/biology-a-global-approach/P200000005431>] (*Added Web Resource*)

Raven, P. H., et al. (2022). *Biology* (13th international student ed.). McGraw-Hill. [URL:

<https://www.mheducation.com/highered/product/biology-raven>] (*Added Web Resource*)

Urry, L. A., et al. (2020). *Campbell Biology* (12th ed.). Pearson. [URL: <https://www.pearson.com/store/p/campbell-biology/P200000006151>] (*Added Web Resource*)



1.8 Possible Answers to Self-Assessment Exercises

1. C
2. B
3. B
4. C

Unit 2 Procuring Animal Material for Laboratory Work

Unit Structure

- 2.1 Introduction
- 2.2 Learning outcomes
- 2.3 Procuring animal material
 - 2.3.1 Placing orders for specimens
 - 2.3.2 Collection of live animals from nature
- 2.4 Collection of aquatic invertebrates
- 2.5 Collection of terrestrial animals
- 2.6 Summary
- 2.7 References/Further Reading/Web Resources
- 2.8 Possible Answers to Self-Assessment Exercises



2.1 Introduction

In the previous unit, you learned about the laboratory environment and its importance in biological investigations. In this unit, you will explore how animal materials required for laboratory practicals are obtained in an ethical, safe, and scientifically acceptable manner.

Animal specimens are essential resources for studying anatomy, physiology, morphology, taxonomy, and other branches of biology. As a laboratory technician or biology educator, you need to understand the appropriate methods of procuring these materials, whether through authorised suppliers or by collecting them from their natural habitats. You must also be familiar with the equipment, techniques, and ethical principles that guide specimen collection and handling.



2.2 Learning Outcomes

By the end of this unit, you will be able to:

- describe methods of procuring animal materials for laboratory work;
- explain how to place orders for laboratory specimens;
- identify techniques for collecting aquatic and terrestrial animals;
- apply safe and ethical practices during specimen collection and handling.



2.3 Procuring Animal Material

Animal specimens can be obtained through:

- **Placing orders for specimens from authorised dealers or suppliers**, ensuring ethical and legal compliance.
- **Collection from nature**, such as ponds, rivers, or fields.

2.3.1 Placing Orders for Specimens

Some specimens are to be procured from the market. For that, you have to first invite quotations in sealed and marked envelopes for the materials to be purchased. The purchase committee at your institution will review all quotations and decide which dealer to purchase the specimens and/or live animals from. You would normally expect the purchase order to be awarded to the lowest bidder. In some cases, you may realise that the company's stock is not the best, even though it is cheap. Some companies may fail to meet the deadline, and you are forced to look to those that can perform. However, this must have been after they had really failed.

For this activity, two letters are to be written from your institution for inviting quotations and the second for placing the order. The letters are signed by the Head of the institution or the person designated by the Head. Given below are examples of these letters. The first letter is an example of the format used for inviting quotations from the dealer, and the second is an example of a letter for placing the order. There may be variations in the formats used across institutions.

Example 1: Letter to Invite Quotation

Tel No..... Fax No.....

The Director,
Jos Study Centre,
National Open University,
Coordinating Office,
Jos.

M/s Vinay Chemicals,
4, Ipaja Road
Lagos.

Ref: EI/quotation/1999-2000

Dear Sir,

Quotations are invited for the supply of the specimens/apparatus/equipment as per the enclosed list, quoting the price/discount (%) on the catalogue prices and the make of the apparatus/equipment.

It is requested that the following should be carefully observed in every detail while submitting quotations, as they may not be considered.

Quotations should be sent under sealed cover addressed to the Manager, Jos Study Centre, National Open University, Coordinating Office, Jos to reach him not later than _____

The subject "Quotations for apparatus" should be written prominently on the envelope.

Quotations should be for the supply of articles F.O.R Manager, Study Centre, National Open University, Coordinating Office, Jos.

Kindly quote the price/discount (%) you will give on the listed price.

Thanking you,

Yours sincerely,
Name

Example 2: Letter for Placing Order

Tel. No..... Fax. No.....

The Director,
Jos Study Centre,
National Open University,
Coordinating Office,
Jos.

M/s Vinay Chemicals,
4, Ipaja Road,
Lagos.

Ref: El/quotation/1999-2000/

Dear Sir,

Regarding your quotation no, you are requested to kindly supply the following immediately.

S/N
Items
Number

1

2

3

4

Bill may be sent in duplicate to the undersigned for payment.

Yours sincerely.

Name

In procuring specimens generally, it is important to;

- Specify the **type, number, and size** of specimens required.
- Order from **registered biological suppliers**.
- Ensure that transport conditions maintain specimen integrity.

2.3.2 Collection of Live Animals from Nature

Live animals are generally collected from aquatic and land areas. For the collection, visit a nearby aquatic body (e.g., a pond) and a land area (e.g., a park/Field) with your course tutor and other students in your group. In collecting live animals;

- Use **nets, traps, or jars** for capturing small animals.
- Handle all specimens carefully to avoid injury.
- Identify and label specimens immediately after collection.

2.4 Collection of Aquatic Invertebrates

Sources of aquatic invertebrates can include ponds, lakes, and rivers for freshwater animals, and ocean coasts for marine animals. However, in this section, as an example, we will study the collection of animals from ponds.

Materials Required

Nylon nets (Fine weave for small animals and coarse weave for large animals), large clean jars or buckets, shallow white pans or papers

Method

- Take a clean bucket or a jar and fill it up to about half with the pond water from which you are going to collect the samples.
- With a trowel, scoop a little amount of mud from the wet edge of the pond and put it in the bucket or jar containing pond water.
- Also put one or two small submerged branches of aquatic plants in the bucket or jar.
- Take a suitable net and sweep through the water in the pond. You have to sweep more than once (see fig. 6.1 for different types of nets).
- Take out the net. You will see the specimens trapped in the net. Transfer the specimen into the bucket or the jar.
- Take some extra pond mud, submerged branches or aquatic plants along with some pond water and carry them to the laboratory for subsequent use, if needed.
- In the laboratory, transfer the live specimens into shallow white pans or place them on a large sheet of paper and spread them out for study.

Note;

- Use **plankton nets** for microscopic organisms.
- Collect snails, worms, or insects using sieves or dipping jars.
- Store aquatic samples in water from the same habitat to prevent osmotic shock.

2.5 Collection of Terrestrial Animals

Terrestrial insects are found in gardens, especially during flowering seasons, in fields, and, of course, indoors. Annelids can be easily collected from soils with organic matter, especially at night and after a rain, when they come to the soil surface. In the dry season, earthworms are not readily available, so they are preserved and used whenever available.

Example 1: Collection of Earthworms

Sources;

Rich garden soils, lawns, and agricultural fields, especially after a rainy day or night.

Material Required;

A bucket, flashlight torch (for night collection), and blunt-end forceps.

Method:

Visit the collection site. Put some moist soil in the bucket. Pick up the worms with the blunt-end forceps and put them in the bucket. Use a flashlight or torch if the collection is to be done at night. Take the worms to the laboratory.

Example 2: Collection of Insects

There are several methods of collecting insects, but in this section, you will collect terrestrial insects using three methods:

- a) net
- b) light trap, and
- c) aspiration

(a) Sweep Net Method

This method is suitable for collecting many insects.

Materials Required

Insect-collecting net and Killing jar

Steps

1. Go to the garden/field and identify the insects to be collected.
2. Approach the specimen(s) very quietly. You should try to avoid overtly chasing the insects, as this would alert them and make them fly/run away.
3. Sweep the net through the herbage over the specimen(s). You might have to sweep more than once.
4. When the insect(s) are trapped in the net, twist the net or your wrist so that the net is closed and the specimen is not able to escape.
5. Transfer the collected insects into the killing jar.

(b) Light Trap Method

In this method, the collector is not required to be present. It is mainly used for nocturnal insects such as moths, midges, some beetles, and winged termites.

Materials Required

- Light sources such as an electric bulb (200 W) or a lantern lamp.
- Large shallow container such as a basin or saucepan
- White paper sheet
- Killing jar

Method

1. Select an area where insects are abundant
2. Hang the light source with the help of a hook
3. Put the white paper as a lining in the shallow container and set the container below the light sources so that the electric lamp is shining in the middle of the container. (In the absence of an electric light, keep a lantern lamp in the middle of the container)
4. Soon, the insects will be attracted by the light and fall into the container. (In case the shallow basin saucepan is not available, you can keep a collecting jar fitted with a cone made of white sheet under the light source, as shown in the figure. 2. The most efficient light source for insect- trapping is a mercury vapour lamp)
5. Transfer the collected insects into the killing jar.

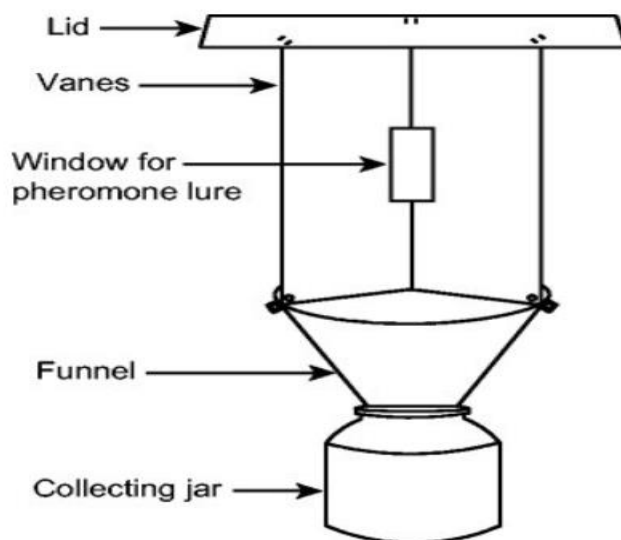


Fig. 1: Light trap for insect collection

(c) Aspirator

An aspirator is a simple suction device used to collect small insects such as mosquitoes, thrips, and sandflies.

Materials Required

- A transparent vial made of glass or plastic (transparent plastic is preferably used).
- Rubber stopper with two holes
- Two glass tubes, each with a bend, and a rubber tube
- Small piece of muslin cloth

Method

- Insert the two glass tubes (intake and suction tube) through the two holes in the stopper.
- At one end of one glass tube, attach a rubber tube. Cover the other end of this tube by tying a piece of muslin cloth. This tube acts as a suction tube. The other tube is the intake tube.
- To the open end of the vial, fix the rubber stopper (with inserted tubes). The stopper should be tightly fixed in the vial. The end of the suction tube that is covered by muslin cloth should be inside the vial. The aspirator is now ready for use.
- Place the aspirator with the outer end of its intake tube facing the insect(s) and suck through the rubber tube. The suction creates a partial vacuum in the vial, thereby drawing the insect through the intake tube. The muslin cloth tied at the inner end of the suction tube will prevent insects from entering the tube.
- Plug the outer end of the intake tube to prevent the escape of the insects caught in the vial, and then transfer the collected insects into the killing jar.

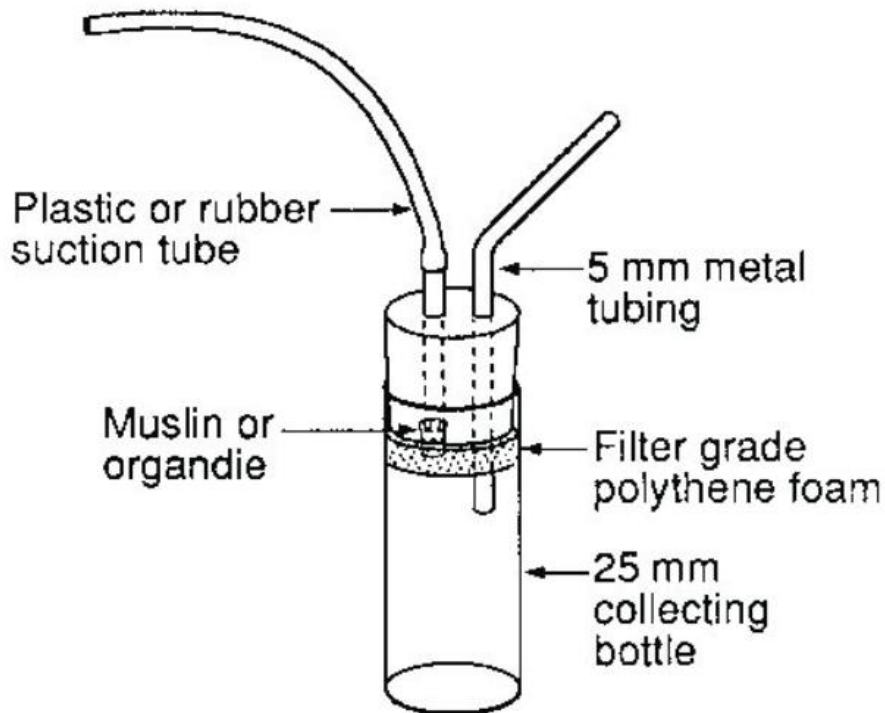


Fig. 2: Standard Aspirator

Note:

- Search under leaves, stones, or decaying logs.
- Keep specimens in ventilated containers with suitable food or substrate.

Ethical Note: Always collect responsibly — avoid harming ecosystems or protected species.

Self-Assessment Exercise

1. Animal specimens should preferably be obtained from:
 - A. Hunters
 - B. Registered biological suppliers
 - C. Street vendors
 - D. Fishermen
2. Which instrument is used to collect small insects?
 - A. Bucket
 - B. Aspirator
 - C. Knife
 - D. Spoon

3. Which method is commonly used to collect nocturnal insects?
 - A. Sweep net
 - B. Hand picking
 - C. Light trap
 - D. Digging
4. Why should aquatic specimens be kept in water from their habitat?
 - A. To increase their size
 - B. To prevent stress and damage
 - C. To reduce transport cost
 - D. To improve colour



2.6 Summary

In this unit, you learned different methods of procuring animal materials for laboratory work. You also studied how to collect aquatic and terrestrial animals safely, place specimen orders, and observe ethical and safety practices during collection and handling. Animal materials can be procured from dealers or collected in the field. Once they have been acquired, they must either be killed and preserved for studying or kept alive in suitable conditions for the same purpose of being studied. Proper handling, labelling, and ethical practices are essential for successful laboratory use.



2.7 References/Further Readings/Web Resources

Raven, P. H., et al . (2022). *Biology* (13th international student ed.).

Urry, L. A., et al. (2020). *Campbell Biology* (12th ed.). Pearson.

Campbell, N. A., et al. (2020). *Biology: A global approach* (12th ed.). Pearson.



2.8 Possible Answers to Self-Assessment Exercise

1. B
2. B
3. C
4. B

Unit 3 Procuring Plant Materials

Unit Structure

- 3.1 Introduction
- 3.2 Learning outcomes
- 3.3 Growing materials for squash preparation
- 3.4 Collection of plants
- 3.5 Collection of lower plants
 - 3.5.1 Collection of Algae
 - 3.5.2 Collection of Bryophytes
 - 3.5.3 Collection of Pteridophytes
 - 3.5.4 Collection of Gymnosperms
- 3.6 Herbarium preparation
- 3.7 Summary
- 3.8 References/Further Reading/Web Resources



3.1 Introduction

Welcome to this unit.

In this unit, you will learn how to collect, preserve, and prepare plant materials for laboratory work. You will also study how to collect plants from different groups and prepare herbarium specimens for identification and future reference. Study the unit carefully and complete the self-assessment exercise to test your understanding.



3.2 Learning Outcomes

By the end of this unit, you will be able to:

- describe how to grow plant materials for squash preparation;
- explain the methods of collecting different plant groups;
- identify procedures for preserving plant specimens;
- prepare and label herbarium specimens correctly; and
- apply good practices in collecting and preserving plant materials.



3.3 Growing Materials for Squash Preparation

The primary material used for a squash preparation practical in biology is typically the root tip of an onion or garlic bulb. These materials are used because the cells in the root tip's meristem region are actively undergoing mitosis (cell division), making the different stages of the process easy to observe under a microscope.

Materials Required

- Onion or garlic bulbs
- A beaker, jar, or a suitable container (a 50-mL beaker also works well)
- Water
- Scalpel

Procedure

- **Preparation:** Select a healthy onion or garlic bulb. Gently rub the base to remove any old, withered roots.
- **Setup:** Suspend the bulb over a container of water so that only the base (where the roots will grow) is consistently touching the water, or is just immersed. Toothpicks can be inserted into the sides of the bulb to help it balance on the rim of the container.
- **Growing Conditions:** Place the container in a suitable location at room temperature, away from direct sunlight. Change the water daily or twice daily to ensure oxygenation and prevent microbial growth.
- **Harvesting:** Roots will typically grow to a usable length (about 2-3 cm) within 3 to 5 days. The best time to cut the observation tips is around midday or early afternoon, as mitotic activity is often highest then.
- **Fixation:** Once grown, cut off about 1-2 cm of the root tips and place them immediately into a fixative solution (commonly a 3:1 mixture of absolute ethanol and glacial acetic acid, known as Farmer's fluid) to kill and preserve the cells.

3.4 Collection of Plants

- You should remember one important thing about collection: Do not pick plants haphazardly. Choose only those plants whose flowers are large and whose organs are easily seen.
- If possible, collect complete plants with roots, stems, leaves, flowers and fruits (sometimes they are necessary for recognising species of some families such as Cruciferae, Umbelliferae, Compositae, revised name Asteraceae).
- The underground parts (root, bulbs, rhizomes) are often interesting. Try to collect them. If the plant is large, take just a branch with leaves, flowers, and fruits.
- Use a sharp knife or pruning shears to collect specimens.
- Avoid collecting wet specimens — they rot easily.

3.5 Collection of Lower Plants

Collecting plant material is a simple job, but one should take great care with the collected plants or their parts so they are preserved without any

damage. The plants may be collected in vases, polythene bags, or bottles. You will need a pair of secateurs for cutting hard material, a sharp knife for cutting soft parts, a pick for digging out underground parts like roots and rhizomes, and a scalpel and forceps for separating plants that grow attached to the bark of trees and rocks.

The stems and roots are cut into pieces about 3 cm long with a sharp razor or knife, so that the tissues at the cut ends do not macerate. Bryophytes are freed from soil particles and debris before being stored in a preservative. The smaller leaves can be preserved as is, and the larger ones can be cut into pieces and then preserved.

We will now discuss the collection of algae, bryophytes, pteridophytes and gymnosperms specimens one by one.

3.5.1 Collection of Algae

Sources: The algae occur widely in nature on soil surfaces and below it, on the bark of trees, in fresh water, sea water, and a variety of other habitats.

Collection from Bark of Trees

- i. In case of bark algae, pick up the algae patches from the tree trunk with the help of an iron spatula.
- ii. Sterilise the spatula by swirling it in spirit and then flaming it.
- iii. Store various samples collected in separate sterilised bottles after fixing and labelling them in their respective shelves.

Collection from Fresh Water

- i. Collect the fresh water algae at the spot in sterilised specimen tubes containing some habitat water.
- ii. Never fill the container more than a quarter so that the quantity of oxygen present in the water may be sufficient for respiration.
- iii. Fix the material, label them and keep them in their respective shelves.

Collection from Sea Water

- i. In Nigeria, the southern coast is best for marine algae collection during low tides, as during this period, these are mostly in their reproductive stages.
- ii. Collect marine algae in large bottles.
- iii. Fix them, label them and keep them in their respective shelves.

3.5.2 Collection of Bryophytes

Normally, bryophytes occur in nature attached to wet soil, rocks, bark of living and dead trees, wood and humus rich in organic substances.

Procedure

- Scrape the bryophytes from the place of occurrence with the help of a sharp scalpel or knife and keep them in polythene bags, within which they remain alive for several days.
- Keep these bags loosely tied and in a damp condition in the laboratory.
- Wash the soil-growing species with ordinary water to remove soil particles and dirt attached to the plant.
- Keep the bags under illumination at 0°C - 5°C to keep the plant alive for a longer duration.
- Fix the material, label and keep it in the cupboard.

3.5.3 Collection of Pteridophytes

Pteridophytes, also known as vascular cryptogams, are spore-producing vascular plants. They possess the vascular tissues, xylem and phloem. They grow in variable habitats. Most pteridophytes are terrestrial and thrive in moist, shady conditions, while others are found growing in xeric conditions. A few are epiphytes, and some are found in aquatic habitats.

Procedure

- Collect the pteridophytes from natural habitats in the mature spore-producing stage.
- Collect the plants with or without strobili or mature sporophyll in polythene bags loosely tied at the mouth.
- If the material is large, cut it into pieces, fix, label and keep it in a cupboard.

3.5.4 Collection of Gymnosperms

Gymnosperms belong to seed plants, but the seeds are naked, with a very conspicuous and independent sporophyte that is the main plant, and a very reduced gametophyte dependent on the sporophyte. They have xeric characteristics also.

Procedure

- Collect the root, stem, leaves, male and female gametophytes of the plant.
- Cut the material into small pieces of 3cm, fix them, label them and keep them in a cupboard.
- You can collect the dry fruits and cones of gymnosperms and preserve them as such.

3.6 Herbarium Preparation

A herbarium is a place where plant specimens are kept, often in a dry state, for biological studies. Some plants are also grown in a botanical garden or specially maintained in a greenhouse for this purpose. The herbarium curator makes and maintains a herbarium.

To create a herbarium, collect representative and healthy specimens, including flowers and fruits if possible. Specimens should be pressed flat and dried quickly to preserve features, and details such as location, date, and habitat should be recorded for each specimen. Finally, the dried plant is mounted on a sheet and labelled with all the collected data.

Collection and preparation of plants for a herbarium

- **Specimen selection:** Choose healthy, complete plants. For larger plants, collect a branch with leaves, flowers, and fruits to show diagnostic features. A separate collection later in the year may be necessary to get fruits.
- **Documentation:** Immediately upon collection, record critical information in a field log, such as the collection number, date, and exact location. Note characteristics that may be lost during drying, such as flower colour, scent, and growth habit.
- **Pressing:** Within minutes of collecting, press the specimens flat between layers of newspaper. Spread the plant parts to avoid overlap and maximise visibility. Place a newspaper between the specimens and add a cardboard sheet to facilitate airflow.
- **Drying:** Place the stack in a plant press, tightening it firmly to prevent shrinkage. Change the drying papers daily until the specimens are completely dry. For faster results, use a dryer with bottom heat and steady airflow.
- **Pest control:** After drying, professional herbaria may place specimens in a cryogenic freezer at -80 °C for 2 – 3 days to kill any pests or eggs.

Mounting and labelling

- **Mounting:** Once thoroughly dried and free of pests, mount the specimen onto acid-free herbarium paper. Secure the plant with adhesive strips, or use thread for thicker parts.
- **Labelling:** Create a label with the scientific name, collection number, location, date, habitat description, and other relevant data. Affix this label to the lower right-hand corner of the mounting paper.
- **Arrangement:** Store the completed herbarium sheets in cabinets, organised systematically by plant family and geographic origin.

Self-Assessment Exercise

1. Why are the root tips of onion or garlic bulbs specifically chosen as the primary material for a squash preparation practical?
 - A) They contain large amounts of chlorophyll needed for staining.
 - B) The cells in the root tip's meristem region are actively undergoing mitosis.
 - C) They are highly resistant to rotting and do not require fixation.
 - D) They lack vascular tissues like xylem and phloem, making them easier to crush.
2. According to the squash preparation procedure, when is the best time of day to cut and harvest the grown root tips for observation, and why?
 - A) Early morning, because the roots are completely free of dirt particles.
 - B) Late evening, because the absence of sunlight prevents cell damage.
 - C) Around midday or early afternoon, because mitotic activity is often highest then.
 - D) Exactly at midnight, because cells are in a dormant state.
3. When collecting fresh water algae on-site, what specific precaution must be taken regarding the specimen container?
 - A) Fill the container to the brim with spirit to preserve the colours.
 - B) Never fill the container more than a quarter full so that there is sufficient oxygen for respiration.
 - C) Keep the container tightly sealed and buried in wet soil to maintain cold temperatures.
 - D) Use an unsterilized iron spatula to stir the water continuously before sealing
4. The text describes pteridophytes as vascular cryptogams. What internal feature differentiates them from bryophytes during collection?
 - A) They possess specialised naked seed cones.
 - B) They lack underground parts like roots and rhizomes.
 - C) They possess the vascular tissues xylem and phloem.
 - D) They do not produce spores and grow only in xeric conditions.



3.7 Summary

In this unit, you learned how to grow plant materials for squash preparation and collect different groups of plants, including algae, bryophytes, pteridophytes, and gymnosperms. You also learned the procedures for preserving plant specimens and preparing herbarium sheets for laboratory study and identification.



3.8 References/Further Reading/Web Resources

Raven, P. H., et al. (2022). *Biology* (13th international student ed.).

Urry, L. A., et al. (2020). *Campbell Biology* (12th ed.). Pearson.

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3.9 Possible Answers to Self-Assessment Questions

1. B
2. C
3. B
4. C

Unit 4 Killing, Mounting, and Display of Insect Specimens

Unit Structure

- 4.1 Introduction
- 4.2 Learning outcomes
- 4.3 Killing insect specimens
- 4.4 Relaxing and softening
- 4.5 Mounting
 - 4.5.1 Direct Mounting
 - 4.5.2 Point Mounting
 - 4.5.3 Spreading
- 4.6 Display and labelling
- 4.7 Preservation
 - 4.7.1 Preservation of animal material
 - 4.7.2 Preservation of animal specimens
 - 4.7.3 Preservation of live animals
- 4.8 Summary
- 4.9 References/Further Reading/Web Resources
- 4.10 Possible Answers to Self-Assessment Exercises



4.1 Introduction

Insects are among the most diverse organisms studied in biology. Proper killing, mounting, and display of insects allow their morphological features to be studied and preserved for teaching or research.



4.2 Learning Outcomes

By the end of this unit, you will be able to:

- explain the procedures for killing and preserving insect specimens;
- demonstrate the correct methods for mounting and displaying insects;
- identify external features of selected insects; and
- recognise differences between male and female specimens.



4.3 Killing of Insect Specimens

Insect specimens can be killed using a **kill jar** with a chemical like ethyl acetate, by **freezing** them, or by immersing them in **liquid preservatives** like alcohol. A kill jar is portable and works quickly, while freezing is simple but requires care to avoid damage upon thawing. Preserving in liquid alcohol is another option, particularly for longer-term preservation.

For killing using a kill jar, the insects are transferred into a bottle (kill jar) containing a killing agent. Various killing agents, such as chloroform, ether, tetrachloroethane, etc., can be used, but the safest and most efficient agent is ethyl acetate.

Materials Required

An empty glass bottle with an air-tight lid (you can take a jam or Horlicks bottle), Ethyl acetate, Cotton wool, Blotting paper, Forceps.

Steps

1. Soak a wad of cotton in ethyl acetate. You must hold this cotton wad with forceps, not with your hands.
2. Place the soaked cotton at the bottom of the bottle and cover it with a piece of blotting paper. Blotting paper is used to prevent direct contact between the specimens and the chemical, as it can wet the specimens and spoil them. However, you can pour a few drops of the killing agent over the blotting paper to make the bottle more effective. (Instead of cotton wool, plaster of Paris can also be used.
3. Transfer the insects into the bottle. Close the bottle tightly. Remove the insects within 20 minutes; otherwise, they will de-colourise and become unduly hardened. Do not overcrowd the bottle with insects. Overcrowding a bottle with tough and fragile insects, or with large and small insects, may cause damage to them. You should, therefore, use separate killing bottles for separate types and sizes of insects.
4. Label the killing bottle as 'poison' and keep it away from the reach of others. The bottles that are no longer able to kill should be buried or burned.

Important considerations

- **Handle carefully:** To avoid damage, use forceps or a paintbrush and immobilise the insect by squeezing its thorax immediately after capture.
- **Labelling:** Properly label all containers, and remove specimens from kill jars promptly to prevent damage.

- **Rehydration:** Insects killed with ethyl acetate may become brittle over time. They can be rehydrated if needed by placing them in a moist chamber for a day or two before mounting.
- **Safety:** When using kill jars, adult supervision is recommended. Avoid breathing the fumes, and label the jar clearly with its contents.

Why must a piece of blotting paper be placed over the soaked cotton wad inside a killing jar?

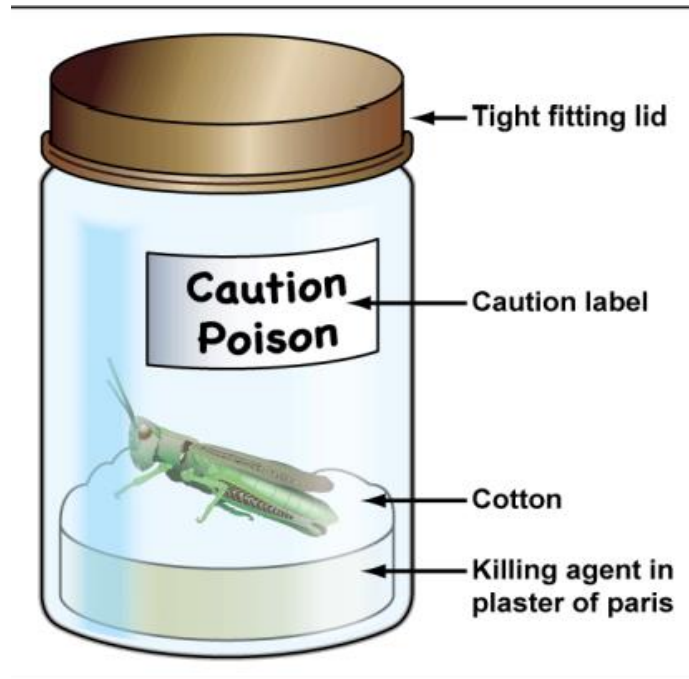


Fig. 4: Killing jar

4.4 Relaxing and Softening

To relax and soften insect specimens, place them in an airtight container with a moist environment, such as damp paper towels or sand, for several hours to a couple of days. For a faster method, especially with hard-bodied insects like beetles, soak them in a hot water bath for about 5-10 minutes until they are pliable enough to pin without breaking. Adding a drop of detergent to the hot water can help with softening beetles.

Procedure

- **Create the chamber (Relaxing box):** Use an airtight container (like a jar or plastic box) with a lid and place a few inches of moist sand, sawdust, or damp paper towels at the bottom.
- **Add an anti-fungal agent:** For sand or sawdust, add a few drops of carbolic acid or a mixture of equal parts rubbing alcohol and water to prevent Mold. Place a sheet of blotting paper on the inside

of the lid to absorb moisture that might otherwise condense and drip onto the specimen.

- **Place specimens:** Put the dried specimens in a petri dish or on top of a plastic lid, and place them inside the container so they are not directly in contact with the moisture.
- **Seal and wait:** Seal the container and leave it for 12 hours to a couple of days, depending on the size and dryness of the insect.
- **Check for pliability:** Periodically check if the insect's parts are soft and flexible enough to pin without breaking. A prolonged period in the relaxation box will cause damage and discolouration to the insects.

4.5 Mounting

You should mount the insects immediately after killing them. If left in the killing bottle for too long, the insects become dry and stiff, making them difficult to pin. Under such circumstances, insects must first be relaxed as described above (4.4).

After being killed, insects are pinned with the help of entomological pins on the pinning board. These pins are made of steel and do not rust. Such pins are available in a variety of sizes and thicknesses. You can also prepare entomological pins with sewing needles and coloured beads. Take thin sewing needles, heat the eye of the needle over a spirit lamp flame, and insert the heated end into a coloured bead.

The bead forms the needle's head. You can make many such entomological pins. Now you know that mounting means pinning the killed insect. Mounting can be done by any one of the methods given below;

4.5.1 Direct Mounting

As you have read earlier, mount the insects immediately after their death. Direct mounting is carried out using the following steps:

1. The entomological pin is pushed through the thorax region of the insect. However, the exact point in the body of the insect through which the pin should pass differs in the different groups of insects. You can seek the help of your course tutor in identifying that point in the insects you have collected.
2. Insert the pin vertically through the body, or slope it so that the front part of the body is raised very slightly.

3. Push the specimen up in the pin until its back is about 1^{1/2}cm away from the top. This distance helps keep the pin from contacting the insect's back.
4. Mount these pinned insects on the board or on a pinning block. Take care to mount the insects uniformly so that specimens can be examined and compared easily.

4.5.2 Point Mounting

This method is especially used for mounting small and dried insects.

Steps:

1. Take a stiff card paper and cut triangles from it. For a smaller insect, the triangle can be 6 mm long, 2 mm wide at the base, and 0.5 mm wide at the apex (tip). However, the triangle's size varies depending on the insect's size.
2. Attach the dried specimens to the apical tip of the triangle with the help of a quick-drying adhesive like Quick-Fix. The best places on the insect body for adhesion can be at the sides of the thorax below the wings, the margin of the tergum and above or between the bases of the legs.
3. Insert the entomological pin in the broader end of the triangle and pin this triangle with the mounted insect on the display board.

4.5.3 Spreading

To display the head, abdomen, wings and legs, you have to spread the freshly killed insects on the spreading board. In freshly killed insects, the internal organs are soft enough to allow the pin in, and the appendages are pliable. The pin is pushed through the thorax region. A spreading board is available in the market, but it can also be made locally. A simple method is to cut a groove in a thick sheet of cork or thermocol for the insect's body.

Steps:

1. The insect is placed in such a way that the body and thorax of the insect rest in the groove of the board.
2. One end of a narrow strip of setting paper is pinned at the front end on each side of the insect body.
3. The fore wings on the back are drawn forward and each pinned on either side with a fine pin inserted behind one of the strong veins in the wings.
4. The hind wings are also spread like this and pinned.

5. When the wings are correctly placed, the paper strips can be taken over the wings, and their other end is pinned on the back of the insect body, so that both the wings are held by paper strips and setting pins.
6. The antennae are also spread symmetrically and pinned under the narrow strip.
7. Legs (appendages) are also spread and pinned on both sides under the strips. Care should be taken that while spreading, the joints and the shape of the appendages remain intact.
8. If the abdomen is inclined to fall into the groove, it can be supported by crossed pins placed beneath it.



Fig. 2: Spreading a butterfly on the spreading board

After pinning and spreading, the specimens are dried for a few weeks in the open or in drying chambers and stored.

4.6 Display and Labelling

Once the specimens are collected and spread, they should be given permanent labels. Proper mounting, spreading, and display are necessary for taxonomic studies, such as the identification and study of insect external morphology. These labels should be small and made of white card. Labels should include;

- Scientific name
- Common name
- Date and place of collection
- Collector's name

The ink used for writing should be permanent and not run or smear when in contact with any liquid.

4.7 Preservation

The spread board, along with the labelled spread insects, should be displayed in wooden insect boxes with glass tops. The mounted insects should also be stored in closed boxes. You must keep naphthalene balls or camphor in the storage or display boxes used for insect specimens to deter pests. If these precautions are not taken, the specimen insects can spoil or be eaten by other insects/small animals. Keep display boxes in dry, well-ventilated areas.

Insect specimens can be preserved either by pinning dry specimens or by placing soft-bodied insects in a liquid preservative, such as 70-85% isopropyl alcohol or ethanol. For pinning, use proper insect pins and mount the insect through the thorax, while smaller specimens can be glued to a triangular card point and then pinned. Soft-bodied insects, such as larvae or termites, should be placed in vials of alcohol, with a label written in pencil inside each vial, as alcohol will dissolve ink.

4.7.1 Preservation of Animal Material

Once you have purchased the animals from dealers or collected them yourself, you might end up with surplus material. In such a situation, you will need to preserve these animals for future use. In this section, you will study the way to preserve certain animals that are normally used in the school or college laboratories.

4.7.2 Preservation of Animal Specimen

Material Required

- Animal specimens
- 10% formalin
- Glass jars with lids
- Big containers with lids

Steps

1. All museum specimens are stored in 40% formalin in glass jars or containers with lids.
2. Earthworms, scoliodon, rat and pigeon head, mystus, prawns, Sepia, Pila Crab, etc., are also stored in 10% formalin in the containers.
3. For Pila Crab, you need to make a hole in the shell before keeping it in the formalin so that formalin enters the mantle cavity and the internal tissues are preserved.
4. Use different containers for different types of animals, e.g., all earthworms in one container, scoliodons in another container and so on.

All these preserved animals can stay fresh for 3-4 years.

4.7.3 Preservation of Live Animals

Live animals cannot be preserved for long. The methods for keeping animals alive differ for different animals and are as follows;

- Leeches are kept in glass containers filled with fresh water. Water should be changed daily or every other day. The water used should be clean and free of dirt.
- Cockroaches are kept in a plastic or metal jar that has many small holes so that air is available for their respiration. To feed the insects, small pieces of paper are placed in the jar. It is advisable to put fresh paper pieces in every day.
- Rats are kept in rat cages. For feeding, they need to be given bread pieces. If the rats are to be kept for a longer period, i.e., a few days, they should be kept in separate cages; otherwise, they will hurt each other and die. Before dissection, the rats are killed with chloroform and treated with disinfectants such as phenyl and Dettol solution.
- Frogs are kept in a sink that is covered with a wooden or plastic plank, with a few holes. A water tap should be adjusted to allow water to fall into the sink drop by drop only. This keeps the frogs' skin moist for respiration. (In some institutions, a cemented tank that has water and certain aquatic plants is built. The tank's cover has large holes for air circulation. The frogs are kept in this tank. Here they live and breed. Within the tank area, a few cemented elevations of different heights and flat top surfaces are also made. So, when the frogs need to be out of the water, they can jump and sit on these elevations.



Click this link: <https://youtu.be/XgBEAgGdq1w> and watch the video, or scan the QR code.

Self-Assessment Exercise

1. **When preparing a field insect-killing jar with ethyl acetate, a student places a layer of blotting paper directly over the cotton wad soaked in the chemical. What is the precise functional purpose of this blotting paper barrier?**
 - A) To accelerate the rate of tissue discolouration and hardening.
 - B) To prevent direct liquid contact from wetting the specimens and spoiling their taxonomic features.
 - C) To generate a negative pressure vacuum that shifts the insect's abdomen.
 - D) To serve as an alternative to carbolic acid for fungal prevention.
2. What is the maximum recommended duration for leaving captured insects inside an ethyl acetate killing jar, and what occurs if this timeframe is exceeded?
 - A) 5 to 10 minutes; the appendages will absorb too much water and dissolve.
 - B) 20 minutes; the specimens will discolour and become unduly hardened.
 - C) 12 hours; the specimens will grow mould due to the missing carbolic acid.
 - D) 2 days; the insects will revert to their natural, alive state.
3. When performing direct mounting on medium-to-large insects, how far down the shaft of the entomological pin must the specimen be positioned relative to the top of the pin head?
 - A) 0.5 mm
 - B) 2.0 mm
 - C) 6 mm
 - D) 1.5 cm
4. A laboratory technologist is preserving soft-bodied insect larvae inside a glass vial filled with an alcohol preservative solution. Which labelling rule must be followed to prevent data erasure?
 - A) The label must be written in permanent ink and placed on the outside of the box.
 - B) The label must be written in pencil and placed *inside* the vial, because alcohol dissolves standard ink.
 - C) The label must be licked thoroughly before being gummed to the interior glass wall.
 - D) The label must include the order name *Monocotyledoneae* written exclusively with a coloured pen.



4.8 Summary

The killing, mounting, and display of insects require precision, patience, and care. Well-prepared specimens are essential for taxonomic and anatomical studies.



4.9 References/Further Reading/Web Sources

Raven, P. H. et al. (2022). *Biology* (13th international student ed.)

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4.10 Possible Answers to Self-Assessment Exercise

1. B
2. B
3. D
4. B