BIOLOGY

PRACTICAL MANUAL

Classes XI & XII

Department of School Education
Ministry of Education and Skills Development
Thimphu

Published by
Department of School Education (DSE)
Ministry of Education and Skills Development (MoESD, Thimphu

Provisional edition 2016
First edition 2020

Acknowledgments

The Department of Curriculum and Professional Development (DCPD), MoE, Thimphu extends earnest gratitude to all the teachers and science professionals for the dedicated contribution towards the production of this practical book. Our sincere thanks also goes to all the schools and agencies for unfeigned cooperation and support, without which the participation of the teachers and professionals would not have been possible. At the same time, DCPD also wishes to acknowledge the valuable contributions made by the teachers and professionals in reviewing the provisional edition and bringing out the first edition of the book.

The DCPD sincerely acknowledges the retrieval and use of ideas and illustrations, either in part or whole, from numerous websites and other forms of sources, and the REC reaffirms that these resources are purely for educational purposes.

Reprint 2023

ISBN: 978-99936-0-427-3

Cover photo courtesy : www. canstockphoto.com

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Foreword

The Teaching and Learning of Science has been given the highest priority. Science as a subject and the course that guides the way of living of an individual is crucial in building a scientifically literate and science elite professionals much needed for a developing country, Bhutan. It envisages that our young children develop quantum of scientific knowledge through meaningful hands-on engagement in the fundamental of scientific processes to foster skills and attitude and empower learners with abilities to justify their actions and take part in debate related to social, cultural and environmental issues. Towards this, the Science Curriculum at the Royal Education launched the science curriculum reform 2008 and concludes with the publication of the Practical Science textbooks in Chemistry, Biology and Physics for classes XI and XII in 2016.

Though the educational inspiration and •insights are drawn from the concepts of 21st Century Learning Framework, the curricular approaches and delivery is largely guided by the principles and values of Gross National Happiness (GNH). The 21st Century Leaning and Innovative skills is founded on the premise of developing critical thinking, collaboration, communication, and creativity skills in learners. This mandates a shift from the existing teacher-centered to a learner-centered constructive approach to teaching and learning. The constructivist approach emphasises on cooperative learning and project based learning using Information, Communication and Technology (ICT) as tools to learning Science through understanding.

The development of these practical science textbooks is inspired by the ideology that science curriculum is not merely to focus on content, but emphasis is also on the scientific processes of questioning, hypothesizing, observing, investigating, recording and communicating. Therefore, Science teaching is not to impart knowledge, rather it is to inspire •1eamers to inquire and probe into the scientific ideas and the world around them. At the same time make learners daring to attempt to try out new possibilities, which may culminate to addition of new knowledge in the field of science at the national and global levels.

The Royal Education Council is optimistic that because these textbooks are designed based on the new breed of curriculum orientations with emphasis on learning by doing, learners enjoy the learning through active engagement and in-depth exploration of scientific concepts and phenomena. The Science curriculum materials present suggestive contents and practices of science only ensuring that both teachers and learners explore further beyond the classroom and school boundaries to embrace the contemporary ways of thinking and doing science.

Wishing both teachers and learners an insightful and enriching engagement in science teaching and learning processes!

(Kesang Choden Dorji)
DIRECTOR
Royal Education Council

Introduction

According to the Bhutanese science curriculum framework (Department of Curriculum Research and Development-DCRD, 2012), one of the goals for science education is "To develop and apply the skills of inquiry, investigation, problem-solving, logical reasoning and communication". Towards this, scientific inquiry is crucial. Scientific inquiry is the primary process by which scientific knowledge is gained. It involves the practice of basic skills of questioning, hypothesizing, investigation and experiment, observation, classification, drawing conclusion, and communication. This process engages learners in identification and control of variables, generation of procedures, planning strategies for testing hypotheses and answering questions, collecting and interpreting data to draw conclusion founded on the scientific concepts and ideas.

There is a substantial amount of research evidences supporting constructivism (Fosnot, 1996) and cooperative learning (Educational Resources Information Centre) in science education to equip learners with the 21st Century Learning and Innovative skills. The 21st Century Learning and Innovative skills is founded on the premise of developing critical thinking, collaboration, communication, and creativity skills in learners. These skills fundamental to Life and Career skills are to enhance the academic performance in learners and prepare them to be productive citizens guided by the GNH values, without compromise as globally competitive individuals. This mandates a shift from the existing teacher-centered to a learner-centered constructive approach to teaching and learning (Moursund, 2004). The constructivist approach emphasises on cooperative learning and project based learning using Information, Communication and Technology (ICT) as tools to learning science through understanding.

Biology is a branch of science that deals with the study of life forms and their physiological processes to answer numerous questions of existence of life forms on the Earth. The study of Biology engages learners in observation of life forms and processes; compare and contrast life forms; experiment the physiological processes; and communicate their ideas in different forms. The practical and project works are means to Biology learning. They provide learners with opportunities to question, observe, sample, experience and experiment with scientific phenomena in their search for knowledge. They are the effective means for comprehension, understanding, and application of biological knowledge.

This handbook is designed to reinforce learners to validate the theoretical knowledge based on the practical probes. Therefore, the book has two sections, Section I and Section II. The Section I, fundamentals of practical in science briefly outlines the purpose of Biology practical, general scientific skills, and assessment in Biology practical. It is developed with all the necessary information for conducting the experiments. It discusses on the laboratory skills, general procedures, equipment and their uses, chemicals, safety measure, etc. It is incorporated with a motive to provide a general overview of laboratory management and other necessary skills to conduct a practical successfully. Section II is divided into two parts, Part A comprises of experiments identified for class 11 science students. It includes some investigative type of experiment developed in relation to the theory learnt in Biology classes. Similarly, Part B contains experiments relevant for class 12 science students. Many experiments are designed to facilitate learners to explore beyond the scope of the syllabus.

The exercises given at the end of each experiment provoke critical thinking; facilitate learners to generalise scientific ideas and concepts inductively and deductively, and enable them to relate these experiences to their immediate environment and lives.

Science, Technology, Engineering and Mathematics Division,

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SECTION I

FUNDAMENTALS OF BIOLOGY PRACTICAL WORKS

1. Purpose of Practical Works in Science

1.1. Rationale

Educational paradigm for most of the twentieth century was governed by the philosophy of indoctrinating the young into the logic of the present. This world-view had to evolve when mass exodus of technology, a product of science, infused every strata of society. Scientific technology, society and scientific literacy therefore gained prominence becoming a popular slogan for science education reform movement. School science, therefore, was carefully realigned to reflect the intellectual and cultural traditions that characterise the practice of contemporary science. It is of utmost importance that students develop an understanding of what science is, what science is not, what science can and cannot do, and how science contributes to culture (National Research Council - NRC, 1996).

The goals of school science that underlie the Science Curriculum Framework (DCRD, 2013) and the National Education Framework (REC, 2012) are to educate students who are able to:

1. understand scientific concepts and acquire skills appropriate to their level of learning and for their lives as citizens, or as future science professionals.
2. develop their skills of inquiry in order to carry out investigations and experiments.
3. transfer the skills of inquiry to be active and critical citizens.
4. develop the ability to use information critically from a wide range of sources to answer scientific questions, address misconceptions and issues in society and in life.
5. apply knowledge and understanding of science to solve key problems of science and for the conservation of environment, including adopting the principles of refuse, reduce, recycle and reuse.
6. develop their abilities for meeting the scientific and technological needs and aspirations of the country and day-to-day life.
7. develop a sense of ethics and responsibility by understanding that the knowledge of science has not only contributed positively to the human development, but also has harmful effect both on environment and human life.
8. share the skills learnt in science in order to develop effective scientific communication skills in learners and in the society.

9. acquire qualities of commitment, self-confidence, curiosity, creativity, integrity and adaptability.
10. develop a sense of honesty and the importance of their contribution to their family, community and country, and understand the value of working together as a team.

In essence, Science Education encompasses "Scientific Content" and "Scientific Process". The content ascribes the quantum of scientific knowledge critical in understanding about living and non-living things around, while the scientific process elicits the variety of skills that facilitate learners to understand "the nature of the scientific knowledge" and "how science works". The later part is critical in facilitating learners develop the ability of constructing their understanding about the world around them culminating to making individuals lifelong learners and endowed with scientific temper and competencies. On this premise, practical work in all discipline of science classes is pivotal in science teaching and learning processes in Bhutan.

1.2. What is Biology Practical Work?

Millar (2009) describes a practical activity as any science teaching and learning activity, which involves students in working individually or in small groups, in observing or manipulating objects and conditions to develop Biological knowledge and understanding. Practical work is viewed by majority of science teachers as an essential and integral part of science education.

1.2.1. Components of Practical Works

The practical work is considered as the means and ends and embeds numerous types of scientific activities, which can be categorised into two main groups as described by Woodley (2009), as follows:

1. Core Activities: These include hands-on activities such as different investigations, laboratory techniques and procedures, as well as fieldwork. These types of activities can help enhance the development of students' practical laboratory skills, as well as helping them to understand the key scientific concepts and phenomena.
2. Directly Related Activities: These are closely connected to the above core activities, and include content based practical demonstrations performed by the teacher, planning and designing scientific investigations, and analysis of data by students.

Biology is a practical science that intends to discover or attempts to answer numerous questions about different life forms, their interaction with abiotic world, and about the physiological processes responsible to sustenance of life on the Earth. Appropriate Biology experiments are important for enhancing learning, clarifying and consolidating the theory. Practical activities allow students to apply and extend their knowledge and understanding of Biology in a new investigative situation, which can stimulate interest in learning and facilitate greater retention. Practical work gives learners an understanding of how Biological knowledge is generated by experiment and observation. From the smallest of organisms to the largest, at a molecular level through to the study of populations and their interactions with a changing world, the inherent variability associated with the practical study of life processes and biological material requires specific teaching of appropriate mathematical, statistical and modeling skills. It is important to support and provide high quality practical work in Biology because it:

1. illustrates the beauty and complexity of the living world.
2. promotes understanding of how to extract information from complex living systems.
3. provides experience of analyzing and evaluating variable data.
4. highlights and promotes discussion on ethical issues.
5. gives learners the skills to tackle global challenges.

As per the national science curriculum, through the study of life processes, learners understand the Biology of humans and the Biology of other living things, and recognise the diversity and interdependence of life. Learners also understand the impact of humans on their environment and how they can live more sustainably with their environment. The study of life processes helps learners understand how to maintain good health and hygiene for better living and life.

2. Aims and Objectives of Practical Work

Learning by doing is fundamental to science education. Practical work is one of the means that helps student to develop their understanding of science, appreciate that science is evidence driven and acquire hands-on skills that are essential to development of quantum of scientific knowledge and understanding, and empower learners as scientifically literate citizens to lead productive lives and contribute to nation building.

2.1. Objectives of Practical Work

The practical work as defined by Science Community Representing Education (2009) is "a hands-on learning experience which prompts thinking about the world in which we live". Therefore, the objectives of doing practical in science classes are to facilitate learners to be able to:

1. create new knowledge and understanding through the process of inquiry.
2. apply scientific knowledge and critical thinking to identify, define and analyse problems, create solutions, evaluate opinions, innovate and improve current practices.
3. design and conduct investigations.
4. disseminate new knowledge and engage in debate around the scientific ideas and issues.
5. recognise and value communication as a tool for negotiating and creating new understanding, interacting with others and further learning.
6. present and interpret data using graph, tables, diagrams and symbols.
7. develop manipulative skills in arranging and handling the apparatus and instruments and taking readings on them.
8. work independently and sustainably embedding the personal qualities of openness, curiosity and a desire to meet new challenges.
9. hold personal values and beliefs consistent with his or her roles as responsible member of the society.
10. demonstrate an understanding of significance and scope of ethical principles with commitment to apply these principles while making decisions.
11. appreciate the importance of sustainability and the impact of science on the economic, environment and socio-cultural context

12. demonstrate empathy and sensitivity towards others situation, feelings and motivation.
13. demonstrate an understanding of various skills that can be applied to various situations.
14. use manipulative skills to conduct practical and conceptualise learning with respect to various domains of learning.
15. apply basic skills in day to day learning and life situations.
16. demonstrate the use of scientific skills to generate ideas by incorporating the research and investigation as an integral part of science learning process.

2.2. Learning Outcomes

Students are engaged in the series of learning experiences during the Biology practical as outlined in the Science Curriculum Framework (DCRD, 2013), culminating to the following learning outcomes.

2.2.1. How Science Works

By the end of Key stage 5 (Class XII), learners should be able to:

1. use theories and models to develop scientific explanations.
2. demonstrate that theories and models can help explain some ideas in science, but that they also have their limitations.
3. recognise how the scientific community validates new knowledge generated in research through processes such as peer review and conferences and that these processes help to ensure scientific integrity.
4. state some benefits and risks of the applications of science, and evaluate the implications of these benefits and risks in the society.
5. describe the ways in which science informs decision making at the national level in Bhutan and across the world.

2.2.2. Investigation and Experimentation

By the end of Key stage 5 (Class XII), learners should be able to:

1. Designing and Planning:
   (a) identify an appropriate question for investigation using their own knowledge from the Key Stage 5 or from their daily life experiences.

(b) describe, where necessary, how to use controls and explain why appropriate control experiments should be established for the investigation being undertaken.

(c) distinguish between the terms accuracy and reliability.

(d) describe the methods used in their investigation or experiment to obtain accurate and reliable data.

(e) plan an investigation or experiment that takes account of any safety and environmental issues involved, and state any ethical considerations that occur because of the treatment of living organisms.

2. Obtaining and Communicating Evidence

(a) use apparatus and chemicals with due regard for safety of themselves, others and the environment and the well-being of living organisms.

(b) carry out the experimental work systematically with a high level of accuracy.

(c) use a wide range of appropriate ways to present the findings of the investigation including the use of tables, line graphs, pie charts, histograms, writing, labeled drawings and diagrams.

(d) interpret key trends and patterns in the data collected and communicate these in an appropriate form.

3. Concluding and Evaluating

(a) draw valid conclusions using the scientific knowledge.

(b) apply simple statistical tests and, where appropriate, assign confidence limits to experimental results.

(c) assess the reliability and precision of experimental data and the conclusions drawn from them.

(d) evaluate the techniques used in the experimental activity, recognising their limitations.

(e) discuss any improvements and adjustments to the plans and methods.

3. Scientific Skills

Learning science entails learners' engagement in the complexities of scientific processes of questioning, hypothesizing, investigating and drawing conclusion. This calls for possession and practice of different types of skills. In broader context, the scientific skills consist of the following categories.

3.1. Manipulative Skills

Manipulative skills in scientific investigation or practical work are the students' ability to conduct an experiment correctly and safely other than writing or reporting about it. They are psychomotor skills that enable students to use and handle instruments, substances, and specimen in a manner that befits a scientific temperament and safety standards. They play an important role in science education and are mastered only through 'hands-on' practical works. Evidences suggesting the possession of manipulative skills for practical works include the following:

1. Comprehend the theory and objectives of the experiment.
2. Conceive the procedure to perform the experiment.
3. Set-up the apparatus in proper order.
4. Check the suitability of the equipment, apparatus, and tool regarding their working and functioning.
5. Know the limitations of measuring device and find its least count, error, etc.
6. Handle the apparatus carefully and cautiously to avoid any damage to the instrument, as well as causing any personal harm.
7. Perform the experiment systematically.
8. Make precise observations.
9. Make proper substitution of data in formula by using appropriate units (SI).
10. Calculate the result accurately and express the same with appropriate significant figures justified by high degree of accuracy of the instrument.
11. Interpret the results, verify principles and draw conclusions.
12. Improvise simple apparatus for further investigations by selecting appropriate equipment, apparatus, tools and materials.

3.2. Science Process Skills

The skills and practices used by scientists in gathering precision data and deducing relevant conclusion based on authentic data are called scientific process skills. They are a set of broadly transferable abilities, appropriate to different science disciplines reflective of a scientist's behavior.

The Framework for the development of Next Generation Science Standards (NGSS) underpins scientific process skills as practices to emphasise the engagement in scientific investigation not only require the skills, but also the knowledge that is specific to each practice. The Framework presents the following rationale to highlight the importance of process skills.

Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world.

Any education that focuses predominantly on the detailed products of scientific labor- the facts of science- without developing an understanding of how those facts were established or that ignores the many important applications of science in the world misrepresents science (NRC, 2012. pp. 42 -43).

The standard practices of scientific investigation and experimentation are dependent upon tacit assumptions regarding their precision. These prerequisite skills to accurately experiment, with a certain acceptable margin of error, can be grouped as basic and integrated science process skills.

3.2.1. Basic Process Skills

1. Observation: Observation is the most fundamental science process skills. A person's ability to make good and reliable observation by engaging different sense organs is essential for the development of other scientific process skills. Some of the best practices to make good observations in Biology practical work are as follows:
   (a) Read about appropriate instruments to be used in an experiment.
   (b) Follow the correct sequence while making observations.
   (c) Take observations carefully in a systematic manner.
   (d) Minimise errors in measurement by repeating the test.

2. Classifying: The ability to group, order, and sort objects and phenomena into categories based on properties and varying complexities of criteria. The following competency indicators indicate a good classification system:
   (a) Use common characteristics of objects and events to classify them.
   (b) Group objects and events based on their similarities and differences.
   (c) Use classification systems to categories objects and phenomena.
3. Measuring and Using Numbers: Measuring is an important method of observation. The statement of a measurement contains two parts, a numerical value or a number that tells us how much or how many, and an accepted terminology of the unit that tells us how much of what. Classifying without a numerical value makes it a qualitative observation, while the use of a number and its corresponding unit makes it a quantitative observation.
4. Inferring: Inferring refers to drawing conclusion based on the gathered data or information. Past experiences play a crucial role in making reliable inferences. The accuracy in inferring improves with experience and repetition of the test.
5. Predicting: It is the ability or a skill to state the outcome of a future event based on a series of evidences, which have similar pattern. To make a good prediction of an event, a series of similar observations must be made. For example, predicting the height of a plant in two weeks' time based on a graph of its growth during the previous month.
6. Communicating: Communicating skills refer to the ability to use accurate words or graphic symbols to describe an action, object, or an event. It comprises two sub-skills, which are directly related to biology practical works.

   Drawing skills: Drawing are generally used to describe an experimental set up pictorically, which otherwise is a lengthy descriptions of apparatus and their setups. It is essential for students to be able to draw diagrams, observation tables and graphs wherever necessary to replace lengthy descriptions and present a set of data in a comprehensive visual format.
   (a) Make schematic diagram of the apparatus and specimen.
   (b) Label different parts with appropriate lines and arrows.
   (c) Depict the direction of force, tension, current, ray of light, etc., by suitable lines and arrows.
   (d) Plot the graphs correctly and neatly by choosing appropriate scale and using appropriate scale.

Reporting skills: The accuracy of a scientific conclusion drawn from a set of authentic data is dependent on its generalization and reliability. Generalization refers to applicability of the conclusions to other settings, and the reliability refers to the accuracy of the processes involved in arriving to the conclusion. Reporting skills allow others to test the conclusions by conducting similar experiments. Follow the following scheme:

(a) Make a proper presentation of aim, apparatus, formula used, principle, observation table, calculations and result for the experiment.

(b) Support the presentation with labelled diagram.

(c) Record observations systematically and with appropriate units in a tabular form wherever required.

(d) Present the calculations or results for a given experiment along with proper units.

(e) State limitations of the apparatus or devices.

(f) Summarise the findings to reject or accept a hypothesis.

(g) Interpret recorded data, observations or graphs to draw conclusion. (h) Explore the scope of further investigation in the work performed.

3.2.2. Integrated Science Process Skills

Integrating the different forms of basic science process skills enables a person to make sense of a scientific enterprise. The development of integrated skills occurs gradually as students are sufficiently exposed to experiments, or deliberately taught by teachers as a learning objective. These are prerequisites to independently design experiments and derive conclusions. The following section provides a brief description of these skills:

1. Space-time Relationships: Space form a coordinate system of coexisting objects and states of matter. It means that the objects are juxtaposed to one another, alongside, beside, beneath, above, within, behind, in front, etc., and have certain quantitative relationships. Time is also a form of coordination of objects and states of matter in their succession. Every state is a consecutive link in a process and has quantitative relation with other states. A correct understanding of the relationship between space and time is required to appreciate the universal form of existence of matter, referred to as the coordinate system.

2. Defining Operationally: It is the skill required to state the correct procedure to measure variable in an experiment. The competency indicators of defining operationally are to state the definition of object or phenomena in terms of:
   (a) what the object is doing or what is occurring in the phenomena.
   (b) observable characteristics of the objects or the phenomena.
3. Identifying and Controlling Variables: The process skills required to identify and control the variables that can affect an expected outcome are called identifying and controlling variables. It helps in understanding the importance of both dependent and independent variables for a process.
4. Formulating Hypothesis: It is the ability to develop an assumption on the expected outcome of an experiment based on limited evidence as a starting point for further investigation. Similarly, it allows a person to generate a theory based on empirical evidences.
5. Experimenting: Experiment is the use of all the basic and integrated science process skills. A person with this skill is able to design and conduct scientific investigation independently to either formulate a new or validate the existing theory.
6. Interpreting Data: This integrated process skill is essential for a student to be able to organise data in a way that makes sense and draw relevant evidence based conclusion. Logical and mathematical reasoning skills are a prerequisite for interpreting data.

4. Safety in Laboratory

In the science laboratories, students handle equipment and chemicals of different nature. Chemicals can be hazardous, poisonous, and corrosive and can pose health risk, or may injure themselves. In order to minimise or prevent the health risk and accident in the laboratory, safety is a necessary precaution. Adoption of set of laboratory rules is one of the ways. Once students know the need to behave safely, accidents can be prevented.

Some of the factors affecting the level of risk in school laboratories are:

1. Use of laboratory facilities: All the facilities in the laboratory should be properly utilised under the strict supervision of the teacher or laboratory assistant. This can avoid misuse of facilitates, injuries and risk to oneself and others.
2. Clothing and hair: Improper clothing and untied long hairs can increase the risk of fire accident in the laboratory. Therefore, always be in proper attire and tie long hairs while doing experiments.
3. Handling of substances and apparatus: Careless handling of corrosive substances, hazardous chemicals, glass wares, sharp apparatus and hot materials can put you at risk. It is always advisable to handle such materials with extra care.
4. Movement: Avoid unnecessary movement inside the laboratory to minimise disturbance and chances of accident.
5. Housekeeping and proper maintenance: Laboratory should be kept neat and clean. Always clean work station and other equipment used before leaving the laboratory. Practice safe disposal of waste. It avoids chemical contaminations and other hazards.

4.1. Safety Rules

These are set of safety rules that students need to follow to prevent laboratory accidents.

1. The students should clearly understand the instruction of experiment they are to perform in the laboratory.
2. The instruments, glassware and any other equipment should be kept clean in proper places before and after its use.

3. The microscope and other delicate instruments should be handled gently and properly, and should be at least five inches from the edge of the table to avoid knocking off it accidentally.
4. Dispose broken glassware in a separate bin.
5. Whenever working with sharp instruments such as blade or scalpel etc., be careful not to cut or puncture your skin.
6. Avoid inhaling, tasting or applying stains or chemicals, as they may be harmful.
7. Do not eat in the laboratory to avoid infection.
8. Safety glasses should be worn while handling the chemicals.
9. Avoid wearing ornaments in the laboratory.
10. Hair must be tied up properly.
11. Laboratory coats must be worn while working in the laboratory.
12. Avoid swallowing chemicals, as it may be toxic.
13. The mouth of the test tube should be facing away from you while heating the substances.

4.2. Safety Signs and Symbols

Safety signs are very informative and they can be displayed on walls, doors, etc. There are four categories of signs:

1. Warning signs
2. Mandatory signs
3. Safe condition signs
4. Prohibition signs

4.2.1. Warning Signs

Warning signs are very informative and help reduce laboratory related accidents. These are usually labelled on the container of chemicals to indicate the nature of its contents. These signs must be displayed wherever appropriate to remind anyone in the laboratory regarding the possible hazards.

Poisonous

Most chemicals marked by this symbol are fairly dangerous if ingested or inhaled and many of these are dangerous even on contact

Biohazard

These are living organisms that may cause infection

Corrosive

Most chemicals marked by this symbol will destroy or damage another substance with which it comes in contact.

Oxidiser

Oxidising chemicals are materials that spontaneously evolve oxygen at room temperature or with slight heating, or that promote combustion.

Explosive

Most chemicals marked by this symbol are subjected to explosion when exposed to fire, flame or sparks.

Irritant or Harmful

This symbol covers a wide range of hazards - with precautions such as avoid contact with the skin, do not breathe, etc

Radiation

These substances are radioactive. Radiation can damage cells and cause cancer

Flammable

Most chemicals marked by this symbol are volatile, flammable and pyrophoric materials

Environmental hazard

Most chemicals marked by this symbol are environmental hazardous and if disposed into streams and rivers, these may affect marine life

Dangerous when wet

Most chemicals marked by this symbol are subjected to react fairly violently with water

Stow away from foodstuffs

Most chemicals marked by this symbol should not come in contact with foodstuffs

Non flammable gas

Most chemicals marked by this symbol are nonflammable in open air

Figure 4.1. Safety warning signs.

4.2.2. Mandatory Signs

The mandatory signs inform students of the specific course of actions that they need to do as precautionary measures while performing experiments in the laboratory or outside. The common signs are:

Figure 4.2. Common mandatory signs.

4.2.3. Safe condition Signs

They are the signposts about the condition, direction of the place or label of safety facilities in the science laboratories or in the public places.

Figure 4.3. Safe Conditions signs.

4.2.4. Prohibition Signs

These signs informs the certain behaviour is prohibited in the premises for the safety of oneself and the others.

Figure 4.4. Prohibition signs.

4.3. Safety Equipment

To protect you from potential hazards, personal protective equipment must be worn at all times while in the laboratory. The common protective equipment are:

4.3.1. Safety Goggles or Spectacles

Protective safety goggles/spectacles, or face shields must be worn in all circumstances when there is recognised risk of damage or injury to eyes. Failure to do so will be regarded as negligence. Eye protection should always be worn when heating chemicals, handling corrosive or irritants such as acids, alkalis, formalin, chloroform etc.

4.3.2. Protective Clothing

Wear suitable protective clothing and gloves while working in the laboratory when:

1. washing apparatus (especially if contaminated with chemicals or microorganisms).
2. handling dangerous chemicals.
3. handling chemicals known to sensitise the skin and cause allergy.
4. handling hot apparatus.

4.4. First Aid in the Laboratory

The main purpose of first aid is to make the person feel secure and comfortable during any accident in the laboratory. It is also to prevent deterioration of patient's condition. The following treatments or measures are recommended as first aid in case of injuries.

4.4.1. Fire

In case of fire accident, the following measures can be practiced:

1. Pour water carefully, except when sodium, potassium, oil or spirit is on fire or fire caused due to electricity.
2. Use large quantity of sand if sodium, etc., is on fire.
3. Use a mixture of sand and sodium bicarbonate or fire extinguisher if oil or spirit is on fire.

4. When any liquid or flask is on fire, cover the mouth of the vessel with a damp cloth.
5. In case a cloth of a person catches fire, lay the person on the floor, keeping burning parts of clothes upwards and cover with a fire blanket. Never throw water on the person; it may cause serious injury on the body.

4.4.2. Fainting

It may be caused by fatigue,sitting or standing for a long time in a hot or stuffy atmosphere or due to inhalation of gases. Carry out the following to the person who has fainted:

1. Loosen clothing at the neck, chest and waist.
2. Lay the patient down in comfortable place or let her/him sit down and lower the head between the knees.
3. Do not flush water on the face as this can lead to choking.
4. On recovery, give some water to drink.

4.4.3. Cuts and Bleeding

A sharp, pointed or broken instrument may cause bleeding. The wound with slight bleeding usually stops on its own or is controlled by local pressure. Try the following steps to control bleeding:

1. Place the bleeding part at rest.
2. If the wound is dirty, wash and gently clean it with clean water.
3. Raise the injured part and support it in position.
4. Apply a dressing with a pad and bandage firmly on the position.

For wounds with severe bleeding, stop the bleeding and get medical help immediately.

4.4.4. Burns

Burns are caused by fire, electricity, contact with a hot object, corrosive chemicals (acids, alkalis, etc.) and friction. The best way to treat burns is by immersing the burnt part under slow running water until the pain stops. In case of severe burns get medical help immediately.

Do not:

1. Apply lotions, ointments, etc.
2. Prick blisters or touch the burned area to prevent infection.

4.4.5. Eye Injuries

Whenever there is eye injury, try the following:

1. Prevent the patient from rubbing the eye.
2. If chemical or solid particles has got into the eyes then wash with plenty of water by using a clean wash bottle. For any eye injury get medical help immediately.

4.4.6. Poisoning by Strong Acid

1. If acid gets into the mouth, first spit it out and wash with water repeatedly. Then drink plenty of water to dilute the acid. Refer the patient to the hospital.
2. If alkali gets into the mouth, first spit it out and wash the mouth with water for several times. Then drink plenty of water followed by lemon juice or orange juice.

4.4.7. Electric Shock

Whenever a person gets an electric shock, switch off the mains supply immediately. Drag the person away using dry clothes or other insulating materials to protect oneself. Make the person lie down with feet raised slightly and keep her/him warm. For mild shock, a person may be given a water to drink.

4.4.8. Poisoning by Toxic Gases

If a person has inhaled poisonous gases like chlorine or bromine, keep him/her in fresh (open) air for sometime and take him/her to the hospital.

4.5. First Aid Box

The content in first aid box contains the following items.

1. One pair of blunt-ended scissors
2. Assorted bandages
3. Adhesive plaster and dressings
4. Sterilised cotton wool

5. Sterilised gauze
6. Mild antiseptic solution
7. Safety pins
8. Small forceps
9. Eye bath (clean wash bottle)
10. Anti-septic cream

4.6. Disposal

Different kinds of waste are produced in the laboratory. Some of them may be harmful to human health and the environment. It is advisable to segregate these wastes appropriately and dispose them off safely.

4.6.1. Chemical Wastes

Disposal with large quantities of water and disposal through the laboratory drainage system may be used for small amounts of acid, alkalis and solutions containing small amounts of metals. However, greater quantity of chemicals must be disposed off in landfills.

4.6.2. Organic Wastes

Organic waste should be collected in labeled bottles for disposal. It should never be flushed down the laboratory sink. However, very small amounts may be disposed by burning.

4.6.3. Biological Wastes

Potentially infectious material, for example, blood, and urine, bacteriological and fungal cultures must not leave the laboratory unless they are treated in the autoclave. The remains of non-infectious materials and dissected animals should be placed in sealed plastic bags and incinerated. The safest method of disposing biological waste is by incineration.

4.6.4. Plastic, Glass, and Sharp Wastes

Non-infectious or non-contaminated glass and sharp waste should be placed in metal bins and may be disposed with domestic waste to landfill sites.

4.6.5. Disposable and Ordinary Syringes

1. Disposable syringe should not be obtained second hand from any source as they cannot be sterilised.
2. Syringes used for nutrient solutions may promote the growth of micro- organisms and therefore, should be incinerated after use.
3. The teacher should ensure that no syringes are taken out from the laboratory.
4. Excessive pressure on the syringe with needle may cause the needle to blow off either striking another student with the needle or spraying the liquid from it on oneself or others.
5. Used disposable syringes and needles should be disposed properly.

4.7. Ethical Issues

Whenever students are involved as subjects of experiments, alienation or emotional insecurity may arise. Therefore, the following guidelines are suggested:

1. Students should not be forced to take part in such experiments.
2. If parents, guardians or doctors have objections on their wards taking part in experiments for fear of health effects, students should be refrained from activities that have health risk.
3. Experiments must not be carried out in which physical, chemical or biological means such as drug or electrical stimulation, are used to study the mental state of the subject.

5. Laboratory Techniques and Skills

The laboratory technique is the use of standard pieces of laboratory equipment essential in many experiments, as well as how to perform basic laboratory functions as deemed scientifically appropriate and safe. Reading a meniscus, cleaning glassware, making solution of required strength, operating microscopes, etc., students need to exhibit the know-how of these equipment.

5.1. Practical Work Record Book

Maintaining proper record is very important for any experimental process as it provides a collection of data that can be used as future references, and also to evaluate accuracy of different experiments. The following points should be considered in maintaining proper practical record.

1. Record should be neat and up to date.
2. Diagrams should be accurate, drawn and labeled correctly using straight lines.
3. Date should be written for each practical.
4. Proper sequence and format should be followed while recording observations.
5. Always start recording the new practical on a fresh page.

The purposes of any scientific investigation are to construct and propose new knowledge claims and validate those claims based on empirically obtained evidence, including evidence gathered by others or through experimentation. Therefore, it is crucial to communicate the procedures of investigation to others in detail using appropriate scientific language, so that they can conduct similar investigations to validate the new knowledge claims. The proposed theory is then either accepted or rejected based on scientific, logical, or mathematical reasoning using empirical data. The details of an investigation, the data obtained, result analysis procedure, and the conclusions drawn are communicated, through publications, in a standard format which consists of all the above essential components as follows:

I. Title of the Experiment

This section should contain the name of the experiment and the date the experiment was conducted.

II. Aim of the Experiment

The aim of the experiment consists of one or two sentences indicating the goal(s) of the practical work.

III. Theory/Principle/Law

This section includes explanation, a brief description, or statement of a specific phenomenon regarding the experiment. However, this section would appear only if the experiments are based on the spirit of quantitative inquiry/theory testing/ deductive by nature.

IV. Question

In this section, the students(s) should dive to know more about or inquire about the situation that needs to be changed or addressed.

V. Hypothesis

In this section, the student(s) should include his/her own hypothesis of what is the expected outcome of the experiment. Students (s) should explain, in one or two sentences, why s/he thinks the stated hypothesis is correct.

VI. Variable

This section requires the student(s) to recognise the variables underlying in the experiment. Students should identify independent variables, dependent variables, and controlled or constant variables.

VII. Material or Apparatus Required

This section should contain the list of all the materials in a set, including the numbers of devices, to conduct the practical individually or in a group.

VIII. Procedure

This is one of the most important sections in the laboratory report. The procedure to be followed to conduct the practical should be written in the chronological order.

IX. Data and Observation Table

Typically, an observation table is drawn before the experiment where you record all the data. Always be cautious that the observed values are not the final data to be entered into the observation table. The data should be the corrected reading, with all the errors and least count of the instrument accounted for. These data which will be used for all the computations. There may be cases where two or more than two observation tables are required. Irrespective of the number of observation tables required, they should be labelled and contain appropriate units.

In case of observing and recording the models and specimens, locate the salient or significant characteristics to classify them such as the kind of body covering hairs, feathers, scales, etc.; appendage number, arrangement and other structural

characteristics, and note the observations. Draw the diagram(s) of the specimens, label their parts.

X. Data Analysis

This is the most important section of the report which emphasise on the thought process that make the data meaningful. In school practical work, data analysis consists of two essential components: graphs and calculations.

- **Graph**

  Plotting a graph is not data analysis, but a way of representing a lot of data in a very limited space. A graph allows the experimenter to analyse the data in many ways.

- **Calculation**

  This section shows a sample of all the calculations that you have done. It is a list of all the equations used to compute data in the experiment.

XI. Result

It consists of all the findings of the experiment.

XII. Conclusion/Verification of Hypothesis

In this section, the entire results of the experiment is generalised into general theory, law or phenomenon.

5.2. Plotting a Graph

Graph is a two dimensional drawing which represents relationship of two quantities in visual form. There are different types of graphs but all the graphs consist of components of x-axis and y-axis to represent the variables with values.

1. Axis: Axes are the lines perpendicular to each other. The vertical line is known as y-axis and the horizontal is called x-axis. The intersection point on the axes is called origin of the graph, usually represented by the ordered pair (0, 0), but it may have other ordered pair according to the reading. This origin divides each of these axes into two halves (four quadrants), a positive and a negative semi axis.
2. Plotting of variables: Out of the two variables, one is independent and the other is dependent variables. Independent variables do not change or vary with other variables and should be taken along the x-axis as well as should be the first set of data in a data table. Dependent variables vary according to the value of the independent variables; hence, it should be taken along the y-axis.

3. Choosing of scale: From the data, calculate the range of each variable by subtracting minimum reading from the maximum reading, then divide the range and the number of squares on the axis. Round the answer to a number that is easy to count by such as 1, 2, 5, 10, 20, etc. The scale chosen for both the axes may be different, but it should be easily subdivided for the divisions on the graph paper. Axes should be marked at regular intervals according to the chosen scale and should cover more than half of the area of graph.
4. Plotting the points: Plot each ordered pair on the graph with a small dot and encircle it with a small circle or with a cross (x).
5. Plotting of graph line or curve: Join all the points with a thin and sharp straight line with the help of ruler for line graph and for curve, draw perfect curve with free hand.
6. Line of best fit: It is a straight line that passes through either maximum number of points or closer to maximum number of points, on the either sides of the line. They can either be straight lined, or a smooth curve. The Figure 6.1 is example of the graph with the best fit line and curve.
7. Extrapolations and interpolations: If required to extrapolate (extend the graph, along the same slope, above or below measured data), use dotted line. It is used to predict the value of the dependent variable for an independent variable that is outside the range of our data. Interpolation is used to predict the value of the dependent variable for an independent variable that is in the midst of our data. Interpolation and extrapolations are shown in Figure 6.2. Interpolation is preferred because we have a greater likelihood of obtaining a valid estimate. When we use extrapolation, we make the assumption that our observed trend continues for values outside the range we used.
8. Calculating slope: The steps for calculating the slope of graph are given below.
   (a) Mark two points on the line, as far apart as possible.
   (b) Connect the two points with one horizontal line and one vertical line to form a triangle.
   (c) Measure the run - how far the line has gone to the right on the horizontal line.
   (d) Measure the rise - how far the line has gone up (or down) on the vertical line.
   (e) Divide the rise by the run to get the slope.

A line or curve of best fit comes close to as many points as possible without necessarily passing through all of them. The points not included is the outlier.

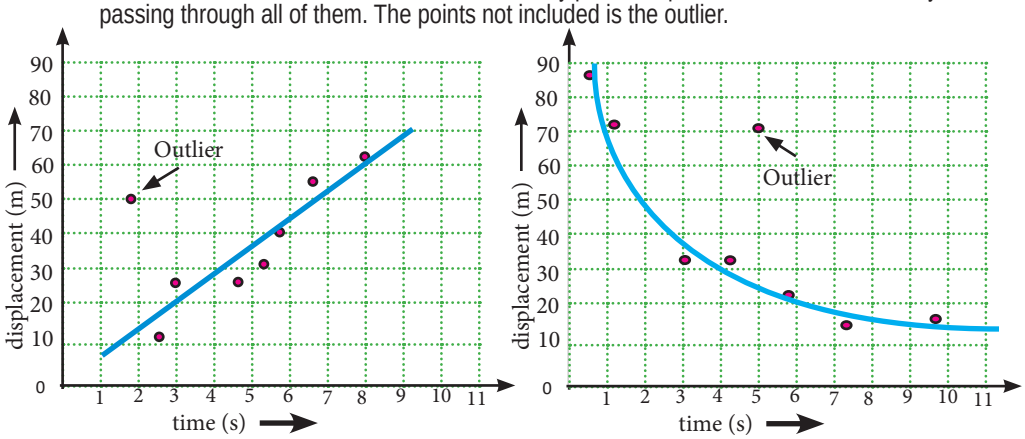


Figure 5.1. A line and curve of best fit.

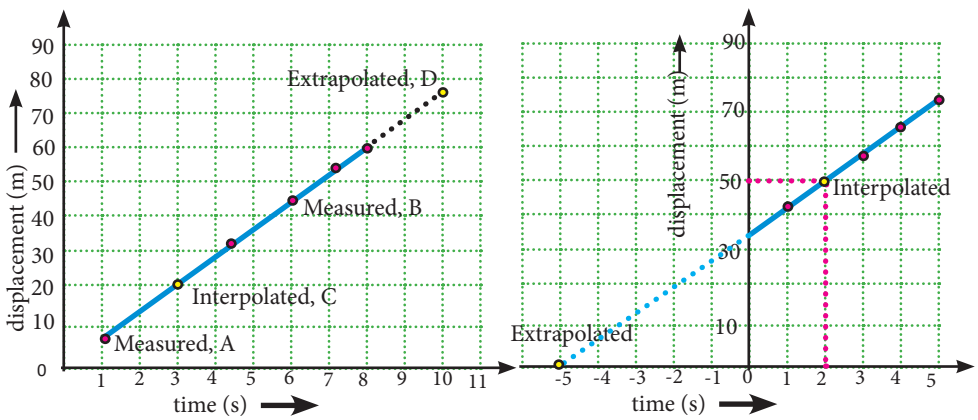


Figure 5.2. Extrapolation and Interpolation.

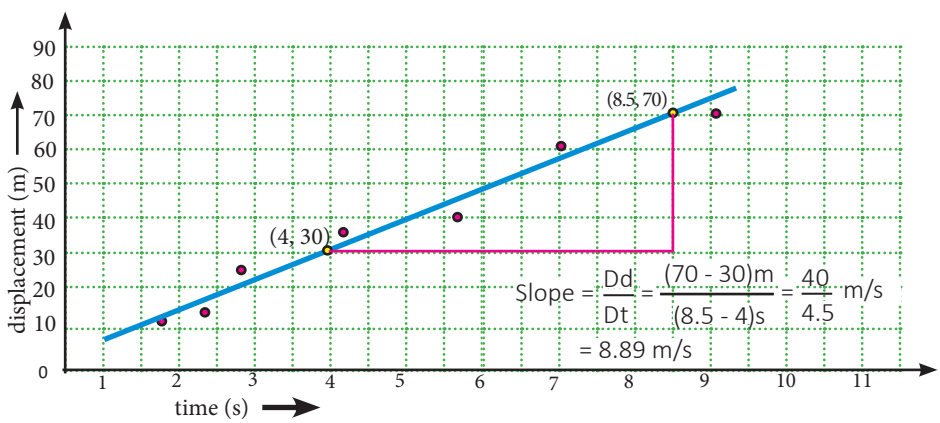


Figure 5.3. Slope.

5.3. Measurement in Biology

5.3.1 Measurement Error(s)

Error is the difference between the actual value of a quantity and the value obtained by a measurement. Repeating the measurement will reduce the random error but not the systematic error.

Accuracy: Accuracy in measurement is how close measured values are to the actual value or true value on multiple observations.

Precision: Precision in measurement is how close the measured values are to each other.

5.3.2 Classification of Error(s)

Errors can be broadly classified into two categories namely, systematic error and random error.

1. Systematic error: Systematic errors are those errors which tend to shift all measurements in a systematic way so their mean value is displaced. This may be due to incorrect calibration of equipment, consistently improper use of equipment or failure to properly account for some effect.
2. Random errors: Random errors are those errors which fluctuate from one measurement to the next. They yield results distributed about the mean value. They can occur due to various reasons.
    - They may occur due to lack of sensitivity. For a sufficiently small change, an instrument may not be able to respond to it or to indicate it or the observer may not be able to discern it.
    - They may occur due to noise. There may be extraneous disturbances which cannot be taken into account.
    - They may be due to imprecise definition.

    Random errors displace measurements in an arbitrary direction whereas systematic errors displace measurements in a single direction. Some systematic error can be substantially eliminated (or properly taken into account). Random errors are unavoidable and must be lived with.
3. Absolute error: The absolute error is the difference between the actual and the measured value.
4. Relative error: Relative error is the absolute error divided by the actual measurement.

$$\text{Relative error} = \frac{\text{Absolute error}}{\text{Actual value}}$$

5. Percentage error: The percentage error is the relative error shown in terms of percentage.

5.3.3 Significant Figures and Rounding Off

(a) Significant Figures

Significant figures of a measurement are the digits reliably known plus one last digit that is uncertain.

Following points should be kept in mind while determining the significant figures of a measurement:

i. All the non-zero digits are significant figures.

ii. The number of significant figures in a number is equal to the number of digits counted from the first non-zero digit on the left to last digit on the right. For instance, in a number 12.6 there are three significant figures.

iii. All zeros occurring between two non-zero digits are significant figures. In a number 10003, there are 5 significant figures.

iv. All zeros lying in between a decimal point and the first non-zero digit on its right side are not significant. A number 0.000345 has 3 significant figures.

v. All zeros appearing on the right side of a decimal point are significant. A number 12.000 has 5 significant figures.

vi. Where there is no decimal, final zeros are not significant. A number 3340000 has 3 significant figures.

vii. The last digit in significant figures of a number is its uncertain digit. In a number 45.6, 6 is uncertain digit.

(a) Rounding off to the Required Number of Significant Figures

The following are the rules to be followed for rounding off:

i. If a digit to be dropped is less than 5, then the digit immediately preceding it remain unchanged. For example, if the result 134.627 m is rounded off to 4 significant figures, then the digits 2 and 7 are dropped and the result is 134.6 m.

ii. If the digit to be dropped is more than 5, then the digit immediately preceding it is raised by one. For example, if the result 12.376 m is to be rounded off to 4 significant figures, then digit 6 is dropped, the preceding digit 7 is raised by one and the result is 12.38 m.

iii. If the digit to be dropped is 5, then preceding digit is made even by:

a. increasing it by one, if it is odd.

b. keeping it unchanged, if it is even.

For example, if the result 3.75 m is rounded off to two significant figures, the result is 3.8 m and if the measurement is 3.85 m, the result is 3.8 m.

The accuracy of the measurement depends upon the number of significant figures. Greater the number of significant figures, greater is the accuracy of the measurement.

5.3.4. Measurement of Length

The length of an object is measured with a metre scale that contains 100 divisions in centimetre (cm). A centimetre is further divided into ten divisions called millimetre (mm). The following methods are used to minimise errors in measurement using a metre scale.

1. Place the object horizontally against the metre scale in such a way that one end of the object coincides with any calibration on the scale other than zero.
2. While taking the reading, the eye must be horizontal or perpendicular to the marking and not at an angle.
3. Sometimes, it may happen that the other end does not coincide with any of the markings exactly. In such cases, correct measurements are obtained by noting the marking near to the end of the object.
4. The correct length is obtained by subtracting the two values corresponding to the two coinciding calibrations.

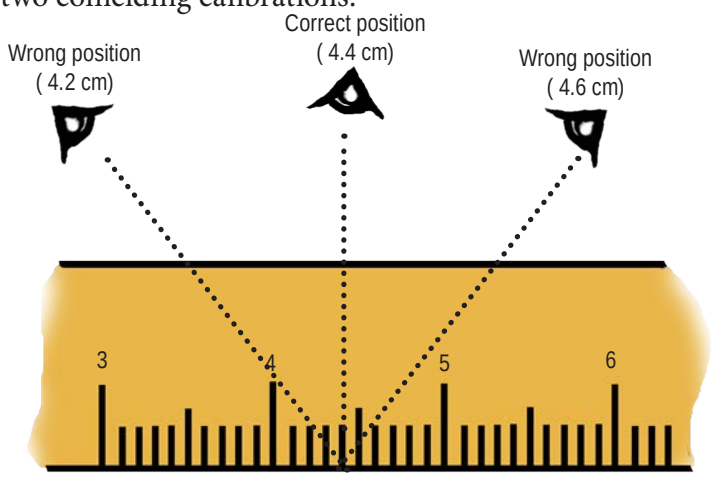


Figure 5.4. Position of eye while measuring.

5.3.5. Measurement of Volume

The most common instrument used in laboratory to measure volume of liquid is the measuring cylinder. Measuring cylinder has graduated scale marked on the cylinder. It is used to determine the volume of irregular shaped objects by displacement method. There are various types of measuring cylinders such as 150 mL, 100 mL, 50 mL, etc. based on their capacities.

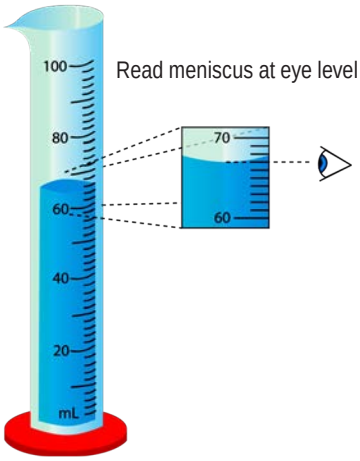


Figure 5.5. Volume measurement.

The volume of the liquid is measured by pouring it into the measuring cylinder. In case of water and other liquid which form concave meniscus, the lower meniscus is used to record the volume of the liquid; while, upper meniscus is recorded for the liquids that form convex meniscus such as in mercury. Reading must be observed by placing the eye horizontal to the meniscus.

5.3.6. Measurement of Mass and Weight

A digital balance is a measuring device used to measure the mass of an object or substances. It is more compact, durable, and precise than other kinds of balances which often wear out and give different readings over time. Digital balance requires a power source. It is generally accurate and consistent even when used over extended periods of time. A digital balance may be used for different purposes ranging from the measurement of ingredients in the kitchen to the precise measurement of substances in a laboratory. A picture of a digital balance is shown in Figure 6.6 (a).

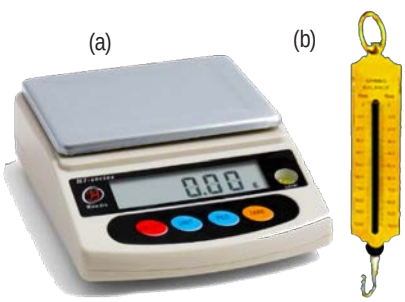


Figure 5.6. (a) Digital balance (b) spring balance.

Spring balance is an instrument used to measure the weight of an object. It works upon the principle of Hooke's law, which states that load applied is directly proportional to the length of the spring stretched by the load.

5.3.7. Measurement of Temperature

1. Laboratory Thermometer

It is used to measure the temperature of substances with high level of accuracy, and it is designed to hold mercury or coloured alcohol in a graduated tube, which either expands or contracts as the temperature changes. The temperature of the body is read where the liquid column coincides with a calibrated scale on the tube or frame of the thermometer. The general laboratory thermometer has the graduation ranging from -20°C to 110°C.

Clinical thermometer is used to measure human body temperature. It has a constriction in the capillary tube above the bulb to prevent the downward movement of the liquid once it has reached its maximum temperature. This helps to continue to indicate the maximum temperature until the liquid reaches to its original position by shaking the thermometer.

Figure 5.7. Clinical thermometer and laboratory thermometer.

Relation of temperature in degree Celsius and Fahrenheit scale

There are different temperature scales used to record the temperature of the patients. Our normal body temperature is 37°C or 98.6°F respectively. The relation between temperature in Celsius scale and Fahrenheit scale is:

$$C = \frac{5}{9}(F - 32)$$

$$\text{or } F = \frac{9}{5}C + 32$$

5.3.8. Measurement of pH

1. pH Test Strips

These are paper strips that show the colour depending on the pH of the substance. To test the pH, place strips in the solution until they are sufficiently covered. Shake off any excess liquid and wait for 15 seconds. The changed colour of the strip is then compared to the colour chart to determine the pH.

2. pH Meter

It is a device used for measuring the pH, which is either the concentration or the

activity of hydrogen ions of an aqueous solution. It usually has a glass electrode plus a calomel reference electrode, or a combination electrode. The pH meters are usually used to measure the pH of liquids and semi-solid substances. The pH meters of various types and quality can be used for soil measurements in agriculture, water quality for water supply systems, swimming pools, etc.

Figure 5.8. pH metre.

5.4. Chemicals and Reagents

5.4.1. Fixatives and Preservatives

Fixatives are chemicals that are used to preserve and stabilise biological materials before microscopy or other examination. Fixatives are applied to so that there is minimal disturbance to the cells and the specimen obtained is not distorted. Some of the commonly used fixatives and preservatives are given in the following Table 5.1.

Table 5.1 Fixatives and Preservatives

Sl No	Name	Composition	Uses
1	Formalin-Aceto-Alcohol (FAA)	Ethanol (95 mL) Glacial Acetic Acid (5 mL) Formaldehyde (5 mL)	Fixing and preserving agent for plant and animal tissues.
2	Formalin	Formaldehyde (40 mL) Water (60 mL)	Preservation of animal specimen.
3	Carnoy's fluid	Absolute alcohol (60 mL) Glacial Acetic acid (10 mL) Chloroform (30 mL)	Quick fixation and study of chromosomes.
4	Ethanol	Absolute ethyl alcohol (70 mL) Water (30 mL)	Preservations of plant and animal specimen.
5	Bouin's fluid	Picric Acid (75 mL) Formalin (25 mL) Glacial Acetic Acid (5 mL)	Preservation of tissue specimen

Sl No	Name	Composition	Uses
6	Formal-Picric-trichlor Acetic Acid	Trichlor acetic acid (0.5 mL) Formalin (15 mL) Alcoholic picric acid (85 mL)	Preservation.

5.4.2. Stains

Stains are dyes or coloring materials which are used to give specific colour to various plants and animal tissues to make their microscopic study easier. Different stains are used for different organelles. Some of the commonly used stains are provided in Table 5.2:

Table 5.2 Some of the Commonly Used Stains

Sl No	Stain	Composition	Purpose
1	Methylene blue	It contains 0.3 gm methylene blue stain with 30 mL of 95% ethanol and 100 mL of distilled water.	For preparation of temporary slides of plant and animal tissues; cytoplasm stains blue and nucleus dark blue.
2	Eosin	Aqueous solution contains 1gm eosin in 100 mL of distilled water.	For staining animal tissues.
3	Crystal violet	It contains 14 gm crystal violet dye dissolved in 100 mL of 95% ethanol.	For staining bacteria and protozoans.
4	Leishman's stain	It contains 15 gm Leishman's powder dissolved in 100 mL of methyl alcohol.	For staining blood cells; RBC stain pink, nucleus of WBC stains blue and platelets stain purple.
5	Acetocarmine	It contains 45 mL glacial acetic acid with 55 mL distilled water and 2 gm carmine powder.	To stain chromosomes;
6	Safranin	It contains 2.5% safranin solution dissolved in 100 mL of 90% alcohol.	To stain lignified, cutinized (dead) tissues; nucleus stains dark red, cytoplasm stains light red.
7	Basic Fuchsin	It contains 8 gm of basic Fuchsin dissolved in 100 mL ethyl alcohol.	To stain DNA and chromosomes.
8	Borax Carmine	It contains 4 gm borax powder, 3 gm carmine powder, 100 mL distilled water, 100 mL ethyl alcohol.	To stain tissues.

Sl No	Stain	Composition	Purpose
9	Haematoxylin	It contains 4 gm of haematoxylin, 25 mL of ethyl alcohol, 400 mL of ammonium alum, 100 mL of meturahyl alcohol, 10 mL of glycerine.	To stain nucleus.
10	Iodine solution	It contains 1 gm of iodine crystals and 2 gm of potassium iodide in 300 mL of distilled water.	To stain starch; starch turns blue- black.

5.4.3. Reagents and Solutions

Reagents are the substances that are added to verify the presence of a chemical, more specifically to check the occurrence of reaction, or to bring about reaction in an experiment or chemical test.

Reagent solutions are homogenous mixtures of two or more substances. Concentration of any component in a solution may be expressed in terms of weight, volume or moles.

1. Molar Solution

It is 1 mole of a substance dissolved in 1 litre of solution.

$$\text{Molarity} = \frac{\text{number of moles of substance}}{\text{volume of solution in litres}}$$

2. Normal Solution

A normal solution contains one gram equivalent weight of a compound in one litre of solution.

$$\text{Normality} = \frac{\text{number of gram equivalent weight}}{\text{volume of solution in litres}}$$

Some of the reagents and solutions that need to be prepared to perform experiments are given in Table 5.3.

Table 5.3 Preparation of Reagents

Sl No	Reagent	Preparation
1	Acid water	Dissolve 2 drops of concentrated HCl in 100 mL distilled water.
2	Lime water	Dissolve 75 g of calcium oxide in 1 litre of water and filter the solution obtained. The filtrate is the limewater.
3	Starch solution	Make a paste of 1 gm starch in 5 mL of distilled water. Boil 95 mL distilled water and add starch paste to it. Stir and store.
4	Dil. HCl acid	Mix one part of concentrated HCl in 5 parts of distilled water.
5	Dil. sulphuric acid	Mix one part of concentrated sulphuric acid in 4 parts of distilled water.
6	Dil. Nitric Acid	Mix 1 part of conc. Nitric acid in 4 parts of distilled water.
7	Benedict's Solution	Take 17.3 gm Sodium Citrate and 10gm anhydrous sodium carbonate in 90 mL water. Filter the solution. Dissolve 17 gm copper sulphate in 10 mL water and add it to the solution prepared and mix them well.
8	Millon's Reagent	Dissolve 50 gm of mercury in 100 mL of nitric acid and add 300 mL of distilled water.
9	Biuret reagent	Dissolve 95 mL of 3% copper sulphate solution in 1L of 10% potassium hydroxide solution.
10	Fehling's Solution A	Dissolve 6 gm copper sulphate in 500 mL distilled water.
11	Fehling's Solution B	Dissolve 175 gm potassium hydroxide and 173 gm potassium sodium tartrate in 500 mL water.
12	Ringer's Solution (Isotonic Salt Solution)	Take 0.24 g NaCl or KCl, 0.24 g of $CaCl_2$ and 0.1 g of $NaHCO_3$ in a beaker and dissolve them in 1L of distilled water.
13	Glycerine	Add 250 mL glycerine to 250 mL of distilled water.

3. Preparation of Normal Saline

Normal saline is a mixture of salt and water. It is called normal because its salt concentration is similar to tears, blood and other body fluid. To prepare 0.9% saline solution, dissolve 0.9 gm of NaCl in 100 mL of distilled water. For animal tissues, 0.9 % saline solution is used.

6. Equipment and Apparatus and their Uses

The Biology practical is one of the ways of teaching and learning the subject and involves the use of both basic and complex equipment and apparatuses in doing experiments and project works. Some of the basic equipment include microscopes, test tubes, beakers, and Bunsen burners, soil testing kits, Ganong photometer, dissecting set, and computers. These equipment are necessary for visualizing cells and organelles, as well as preparing samples of cells or fluids for testing or visualization, dissecting specimens, or observe the physiological processes in living things.

6.1. Compound Microscope

Students in Biology class use microscopes of differing powers to observe organisms and samples more closely. They are high-powered and sensitive pieces of equipment that can make even the smallest parts of a single cell seem clear. Depending on the size and purpose of the study, different types of microscopes

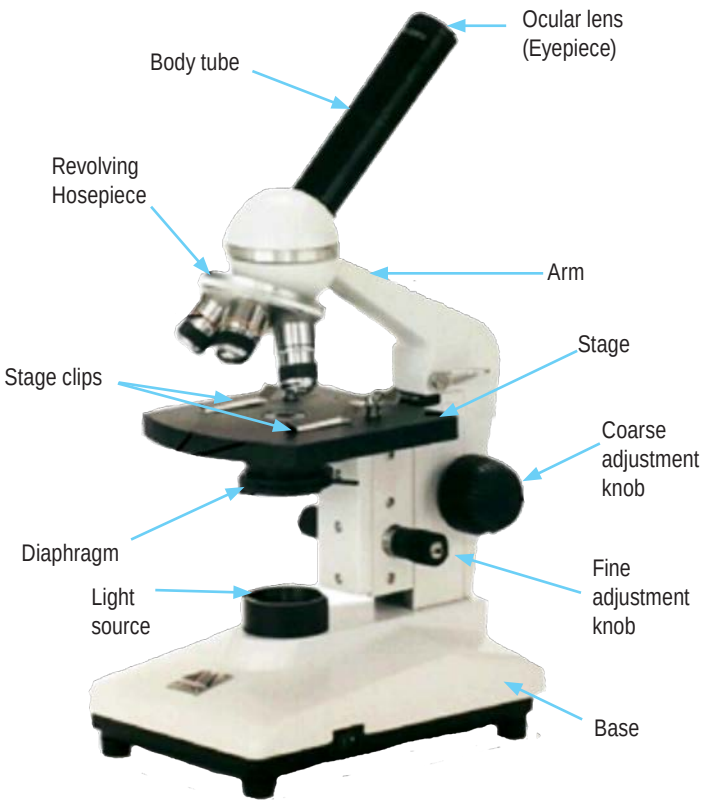


Figure 6.1. Compound microscope.

are used. For instance, instead of using beams of light to illuminate the specimen, an electron microscope that works on the beams of electrons is used.
A compound microscope has the following parts and functions:

i. Eyepiece (ocular lens): It is a lens to increase the magnification of the object, and the power of magnification of a lens is denoted by X; for example, the normal power is 10X.

ii. Body tube: Holds eyepiece and objectives lenses at proper working distance from each other.

iii. Arm: Supports body tube and adjustment screws.

iv. Nosepiece: Holds the objective lenses and allows the interchange of lenses to different magnifications, i.e. 10X, 45X and 100X.

v. Coarse adjustment screw: Moves body tube or the stage up and down to the correct the distance of objective lens from the specimen to obtain a magnified image of the object.

vi. Fine adjustment screw: Helps in fine tuning the focus by moving the body tube or stage up and down gently.

vii. Objective lens: Receives the light coming from the object.

viii. Stage: Holds the slide over the aperture that admits light from the mirror.

ix. Stage clips: Hold the specimen slide firmly in place.

x. Diaphragm: Regulates the amount of light passing through the specimen.

xi. Mirror: Reflects light upwards through the diaphragm.

xii. Inclination joint: Permits tilting of the body tube for convenient observations.

xiii. Base: Supports and holds the microscope firm on the substrate.

Handling of compound microscope involves the following steps.

Step 1. Adjust the mirror in different angles so that sufficient light is reflected towards the specimen.

Step 2. Place the slide on the stage ensuring the specimen lies over the stage aperture and clip it.

Step 3. Regulate the amount of light entering the microscope by adjusting the diaphragm.

Step 4. Adjust the coarse adjustment screw to get a clear focus of the specimen and fine-tune it with the fine adjustment screw using the lowest magnification objective lens.

Step 5. To obtain image of higher magnification, rotate the nosepiece to bring the high magnification objective lens in position above the specimen.

Step 6. Upon the completion of the experiment, rotate the nosepiece so that the objective lens is not over the stage aperture.

Step 7. When the microscope is not in use, keep it covered.

6.2. Dissecting Microscope

A dissecting microscope consists of a single biconvex lens mounted on a horizontal foldable arm. The foldable arm is mounted on a vertical limb and can be moved up and down.

The dissecting microscope has a glass stage for placing the slide or object to be studied. This microscope is used for viewing those objects for which high magnification is not required. It is also used for dissecting the small specimen. The lenses of magnifying powers 5X, 10X or 20X are used.

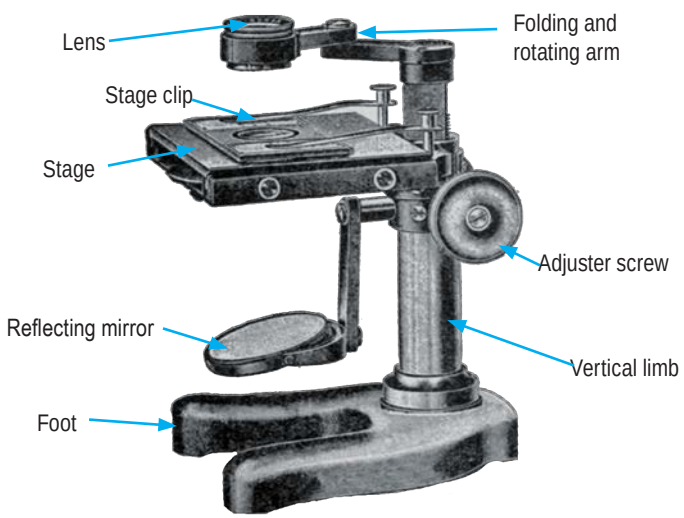


Figure 6.2. Dissecting microscope.

The following steps are useful to handle the dissecting microscope.

Step 1. Adjust the mirror so that the light is reflected towards the specimen.

Step 2. Place the slide on the stage and clip it.

Step 3. Adjust the adjustment screw to get a clear focus of the specimen.

Step 4. When microscope is not in use, keep it covered.

6.3. Glass Tubes and Rods

Glass apparatuses of different shapes and sizes are necessary for various experiments in Biology. However, many of them must be customised construction. The following techniques help students to construct some of them.

1. Cutting a Delivery Tube

Step 1. Hold the glass tube or glass rod on a soft flat surface.

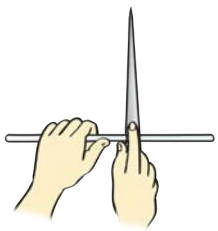


Figure 6.3. Make a scratch using a triangular file.

Step 2. Using a file make straight scratch at the place of the measured length and scratch around the glass tube with minimum force or pressure.

Step 3. Hold the tube with both hands between the thumbs and the first fingers in such a way that the thumbs lie adjacent to the scratch.

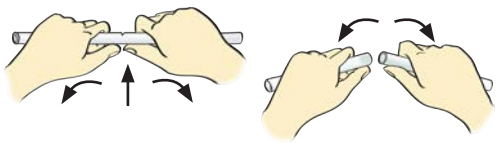


Figure 6.4. Cutting glass-tube and rod (step 3 & 4).

Step 4. To break the tube at the marked place, apply an outward force on the tube with thumbs.

Step 5. If the tube doesn't break, repeat the steps 1 to 4.

2. Bending a Delivery Tube

Step 1. Hold the tube in horizontal position.

Figure 6.5. Bending glass-tube in non-luminous flame.

Step 2. Place the portion tube to be bent in the non-luminous flame and keep on rotating gently till it softens.

Step 3. Remove it from the flame and bend it as a desired shape.

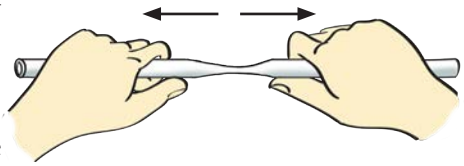


Figure 6.6. Making jet tube.

3. Making a Dropper or Jet Tube

Step 1. Heat the glass tube at the middle in non-luminous flame.

Step 2. Rotate the tube gently to ensure even heating.

Step 3. When the tube softens take out the hot tube from the flame. Do not touch the hot section with the bare hands.

Step 4. Slowly pull apart the two ends of the tube till a narrow tube of required diameter as shown in figure 7.6 is obtained.

Step 5. Hold the tube in the same position till it cools down and stiffens.

Step 6. Place the cooled tube on top of the soft surface and cut into desired length.

4. Boring Hole in the Cork

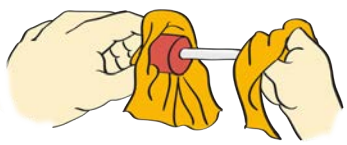


Figure 6.7. Boring hole using a cork borer.

Step 1. Select the cork borer whose diameter is slightly less than that of the glass tube to be fitted into the cork.

Step 2. Soften the cork by dipping in water for sometimes and gently rolling it under your shoe.

Step 3. Mark the position of the hole on both sides of the cork in the middle for a single hole. In case of double holes, mark the position of holes on each side of the cork, which are parallel and vertical. They should not be too near to the center nor be too near to the periphery.

Step 4. Dip the sharp end of cork borer in water and place the wet borer vertically on the position of the mark with your right hand.

Step 5. Drive the cork borer half way into the cork. Then pull out the cork borer and remove the cork pieces from inside the borer with the help of a probe.

Step 6. Turn the cork upside down and bore hole through the mark from the opposite side.

5. Fitting Delivery Tube in the Bored Cork

Step 1. Dip the delivery tube in water and hold it partly wrapped in cloth with right hand.

Step 2. Hold the cork with your left hand.

Step 3. Insert the delivery tube into the hole with a gentle twist.

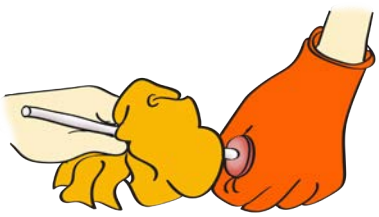


Figure 6.8. Inserting delivery tube in the bored cork.

PRECAUTION

Do not push the delivery tube forcefully, it may break and cause accidents. The hole should be slightly narrower than the tube to be inserted..

The other equipment used for various experiment are given in the Table 6.1:

Table 6.1 List of laboratory equipment

Name of the Equipment	Use	Equipment
Glass Slides	Preparing temporary or permanent mounts.	
Cover slips	For covering the specimen placed on the glass slide.	
Conical flask	For storage and heating.	

Name of the Equipment	Use	Equipment
Petri dish	Culturing microorganisms, temporary storage of specimen.	
Beaker	Preparation, measurement and storage of solutions.	
Spirit lamp	For heating.	
Funnel	Filtration of solutions.	
Bunsen burner	Heating and sterilization.	
Boiling tube	Heating of solution.	
Safety filler/ dropper	Transferring liquid in small quantities.	

Name of the Equipment	Use	Equipment
Wash bottle	For cleansing purposes.	
Test tubes	Observing reactions and indirect heating of substances.	
Watch glass	Staining of specimen and temporary storage of substances.	
Mortar and pestle	Crushing solid materials.	
Stop clock	Recording time.	
Water bath	Heating substance in a constant temperature over time, or indirect boiling.	
Blender	Blending and homogenization.	

Name of the Equipment	Use	Equipment
Filter paper	Filtration	
Hess Sampler	Collection of small aquatic organisms.	
Hot air oven	Drying and heating at a constant temperature over time.	
Sieve	Separating solid mixtures based on their sizes.	
Cork borer	Boring holes in corks	

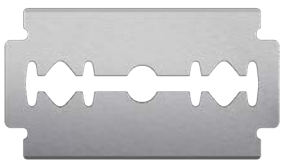
6.4. Students' Requirements

The following is a list of materials required for practical purpose:

1. Practical record book
2. Lab manual or practical textbook
3. Pencil
4. Pencil sharpener
5. Eraser
6. Ruler
7. Dissection box containing equipments as listed in Table 6.2.

Table 6.2 List of equipments in a Dissection Box

Name of the Instrument	Use	Image of the Instrument
Scissors	Cutting	
Forceps	Picking small materials.	
Needle	Teasing and mounting specimen on the slide.	
Scalpels	Cutting and obtaining a specific part from a large specimen.	
Brush	Handling soft specimens like pollen grains from the anther to the slide.	

Name of the Instrument	Use	Image of the Instrument
Dropper	Transferring liquid in small quantities.	
Spatula	Used for lifting, spreading and flipping.	
Blow pipe	Inflate hollow organs and ducts.	
Razor	Cutting.	
Hand lens	Observing smaller specimen.	
Pin	To hold the specimen in place.	

7. Practical Works on Flower

7.1. Flower

A flower is a reproductive shoot having arranged whorls on the receptacle as per the basic plan of a flower. The four whorls are calyx, corolla, androecium and gynoecium. Amongst the four whorls, the outer two (calyx and corolla) are called non-essential whorls while the inner two, androecium and gynoecium, are called essential whorls. In some cases, petals and sepals are not differentiated and such whorl is called perianth and its components are called tepals.

Each component of calyx is called sepals, petals for corolla, stamens for androecium,

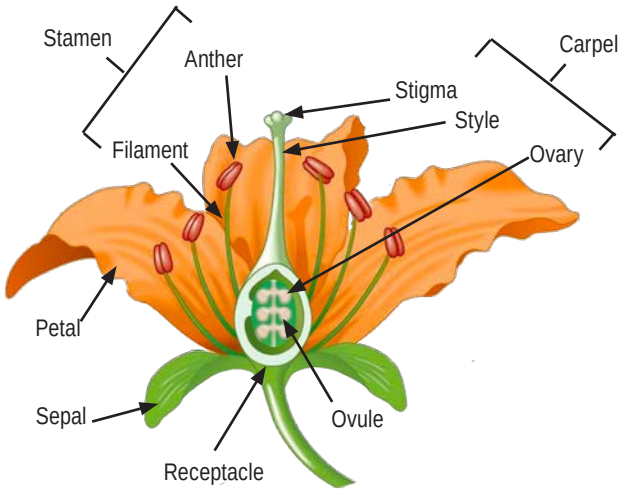


Figure 7.1. LS of flower.

and pistil or carpels for gynoecium. Stamens (microsporophylls) are composed of anther and filaments. An anther bears pollen sacs (microsporangium) that produce pollen grains (microspores). Carpels (megasporophylls) are made up of stigma, style and ovary. Ovary possesses ovule having an embryo sac, female gametophyte or megaspore.

7.2. Semi-technical Terms for Describing a Flower

1. Complete and Incomplete Flower
   (a) Complete: Flower having all the four whorls.
   (b) Incomplete: Flower having any one of the four whorls missing.

2. Sexuality of Flower

   (a) Bisexual/perfect/hermaphrodite: Flower having both the male and female whorls.

   (b) Unisexual/imperfect: Flower having only one of the sexual organs.

   (c) Staminate: Flower having only stamens.

   (d) Pistillate: Flower having only pistils or carpels.

   (e) Neutral: Flower not having either male or female organs.

   (f) Monoecius: Plant having both staminate and pistillate flowers.

   (g) Diecious: Staminate and pistillate flowers are borne on different plants.

   (h) Polygamous: Plant having both unisexual and bisexual flowers.

3. Relative Insertion of Different Whorls on Thalamus

   (a) Hypogynous: All the other whorls are inserted below the ovary, or ovary is superior as in China rose (Hibiscus rosa sinesis).

   (b) Perigynous: All the four whorls are inserted in a cup shaped furrow in the thalamus as in peach (Prunus persica).

   (c) Epigynous: Thalamus surrounds the ovary completely and other whorls are inserted above the ovary or ovary is inferior as in apple (Malus pumila).

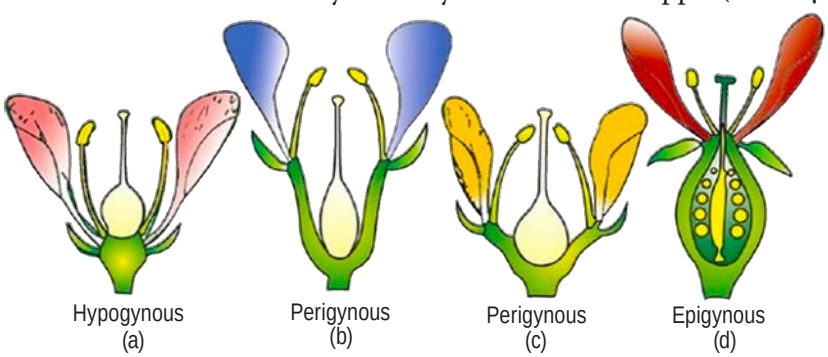


Figure 7.2. Relative insertion of floral whorls.

4. Symmetry

   (a) Actinomorphic/regular/symmetrical: It can be cut into two equal halves through many planes as in China rose (Hibiscus rosa sinesis).

   (b) Zygomorphic/bilaterally symmetrical: It can be cut into two equal halves through one plane only as in pea (Pisum sativum).

(c) Asymmetrical/irregular: It cannot be cut into two halves as in Valerian (Valeriana officinalis).

5. Aestivation

The arrangement of sepals and petals in the respective whorls is called aestivation and it is of five types.

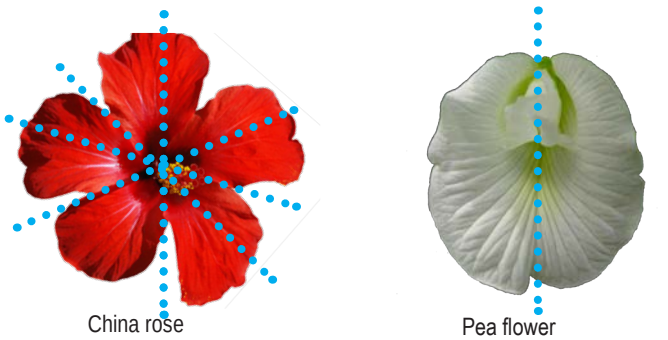


Figure 7.3. Symmetry of flower.

(a) Valvate: All the members are arranged in circular manner with their ends free, or fused with each other but not overlapping. Example, mustard (Brassica campestris).

(b) Twisted: The entire members overlap each other and one margin of a member is covered by the next one. Each member has an interior margin and an exterior margin. Example, china rose (Hibiscus rosa sinesis).

(c) Imbricate: One member is outside and one is inside while the rest three members have an exterior and an interior margin each. Example,

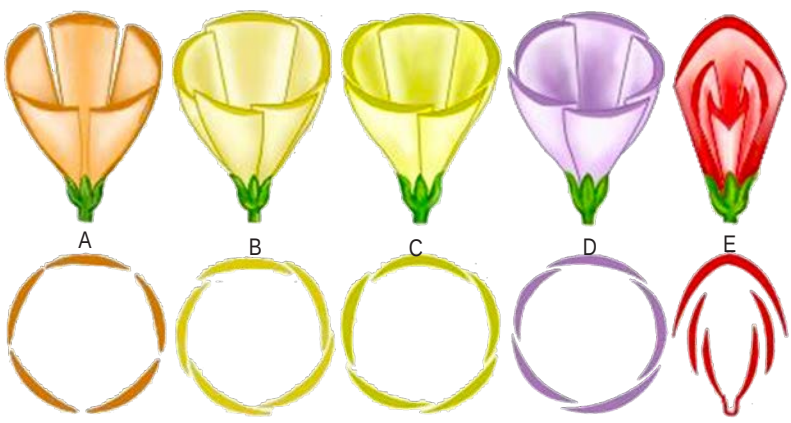


Figure 7.4. Types of aestivation (A. valvate, B. twisted, C. imbricate, D. quincuncial, E. vexillary).

sappanwood (Caesalpinia sapan).

(d) Quincuncial: Out of the five members, one is completely internal, other two are completely external, and the fourth is partially internal and the last is partially external. Example, squash (Cucurbita maxima).

(e) Vexillary: The largest (standard) overlaps two (wing) petals, which further overlap the last two (keel) petals. Example, sweet pea (Lathyrus odoratus). (Figure 8.4 c)

6. Shapes of Corolla

(a) Cruciform: It has four petals having claw (base) and limb (tips). Limbs are arranged in a form of a cross. Example, mustard (Brassica campestris).

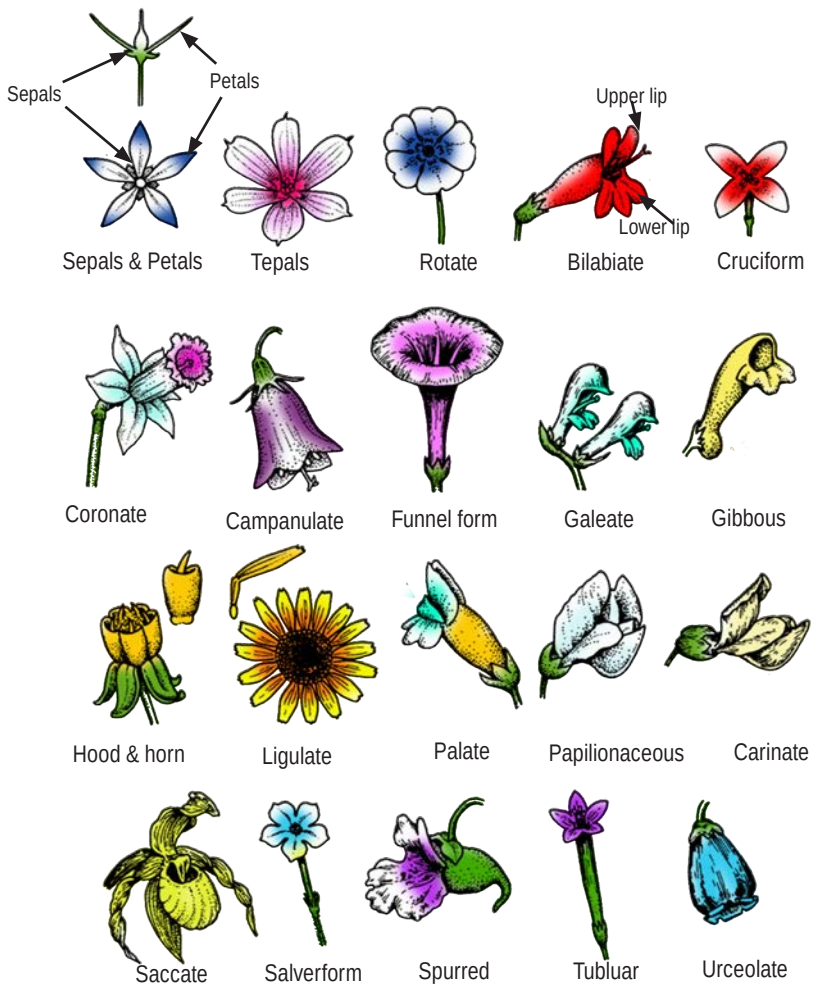


Figure 7.5. Shapes of corolla.

(b) Papilionaceous: There are five petals, out of which, posterior petals (standard/vexillum) overlap two lateral petals (wings/alae). They overlap two innermost fused petals (keel/carina). Example, sweet pea (Lathyrus odoratus).

(c) Campanulate: The petals are fused to form a bell-like structure. Example, gooseberry (Ribes grossularia).

(d) Tubular: The petals are fused to form a tube-like corolla. Example, disc florets of sunflower (Helianthus anus).

(e) Rotate: It has fused petals and is circular and flat. Example, periwinkle (Vinca minor).

(f) Ligulate: The corolla forms a narrow tube below and is flattened at the top. Example, disc floret of sunflower (Helianthus anus).

(g) Urceolate: It is urn-shaped, broader base, hollow with a contracted opening on the top. Example, pink water lily (Nymphea pubescens).

(h) Bilabiate: The petals are divided to form two upper and lower lips. Example, salvia (Salvia officinalis).

(i) Caryophyllaceous: There are five petals having long claws and shorter limbs. The limbs are placed at right angles to the claws. Example, sweet william (Dianthus barbatus).

(j) Rosaceous: Petals are not differentiated into claws and limbs and they spread outwards. Example, silky rose (Rosa sericea).

(k) Infundibuliform: The corolla is funnel-shaped. It widens up as it passes from the base to the tip. Example, petunia (Petunia hybrida).

(l) Personate: A bilabiate in which upper petals are curved closing the flower. Example, snapdragon (Antirrhinum majus).

7. Types of Androecium

Stamens are fused in different ways as follows:

(a) Monadelphous: Stamens are fused by their filaments into one group with free anthers. Example, china rose.

(b) Diadelphous: Stamens are fused by the filaments into two bundles with free anthers. Example, sweet pea.

(c) Polyadelphous: The stamens are joined by the filaments to form many groups with free anthers. Example, cotton (Bombax ceiba).

(d) Syngenesious: The stamens are joined by their anthers to form a cylinder with free filaments. Example, sunflower.

(e) Synandrous: All the stamens are joined (both by anther and filaments) through the entire length. Example, pumpkin (Cucurbita pepo).

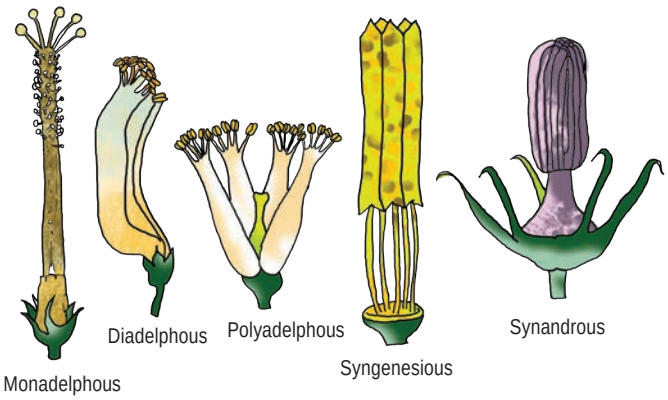


Figure 7.6. Cohesion of stamens.

8. Relative Lengths of the Stamens

(a) Didynamous: Androecium has four stamens, out of which two are short while the other two are long.

(b) Tetradynamous: Androecium has six stamens, out of which inner four are long and outer two are short.

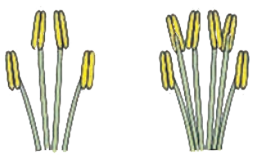


Figure 7.7. (a) Didynamous and (b) tetradynamous.

9. Placentation

It is the arrangement of ovules in the chambers of the ovary. It may be of the following types:

(a) Marginal: It occurs in unilocular ovary where the ovules are arranged along the ventral suture. Example, sweet pea.

(b) Axile: Ovary is multilocular, syncarpous and the placenta develops from the central axis. Example, china rose.

(c) Parietal: Ovary is multicarpellary, syncarpous but one chambered and the placenta arises from the inner wall of the ovary. Example, poppy (Papaver somniferum).

(d) Free-central: Ovary is multicarpellary, syncarpous but one-chambered and placenta develops from the central axis. Example, dianthus.

(e) Basal: The ovary is monocarpellary with one locule and the placenta develops at the base of the ovary. Example, sunflower.

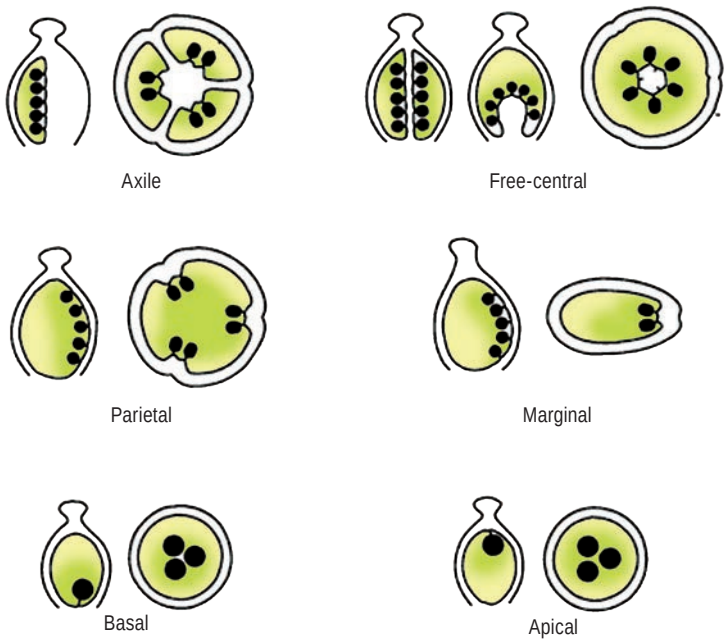


Figure 7.8. Placentation in ovaries.

(f) Superficial: Ovary is polycarpellary, syncarpous with many locules and the placenta develops all around the inner surface of the partition walls. Example, Nymphea gigantean.

(g) Apical: One or more ovules are attached at the top of the ovary. The ovary is unilocular. Example, wheat.

10. Inflorescence

A flower is called solitary when single, and is called inflorescence when there are a cluster of them together. Inflorescence can be racemose, cymose and special types.

i. Racemose or an indeterminate:

In an indeterminate inflorescence, there is no true terminal flower and the stem usually has a rudimentary end. In many cases the last true flower formed by the terminal bud (sub-terminal flower) straightens up, appearing to be a terminal flower. Flowers are arranged in acropetal succession (i.e. youngest at the top). It can be of following types:

1. Raceme: The main axis is elongated and flowers are borne laterally. Flowers are stalked and are present in acropetal succession. Example, mustard.

2. Panicle: The primary axis is divided into secondary axis on which flowers are borne. The flowers are pedicellate and appear in acropetal succession and it is a compound raceme. Example, blume (Melia sambucina).
3. Spike: The main axis is elongated. However, the flowers are sessile and arranged in acropetal succession. Example, Southern amaranth (Amaranthus australis).
4. Catkin: A spike with a long and pendulous axis bearing unisexual flowers. Example, white mulberry (Morus alba L.).
5. Spadix: A spike with a long, thick and fleshy axis. Male flowers occupy the upper areas while the female flowers cover the lower portion. Lower portion forms tube-like structure. Example, banana (Musa velutina).
6. Corymb: Main axis is relatively shortened and pedicels elongated. The lower flowers have longer pedicels than the upper ones due to which they appear together. Example, corainder (Coriandrum sativum).
7. Umbel: Primary axis is shortened and pedicels of equal length arise from the same node. Pedicels are of same length and nodes may sometimes have a whorl of bracts (involucre). Example, onion.
8. Head or Capitulum: A compound inflorescence where all the flowers are borne on a single receptacle and appear like a single flower. Example, sunflower.

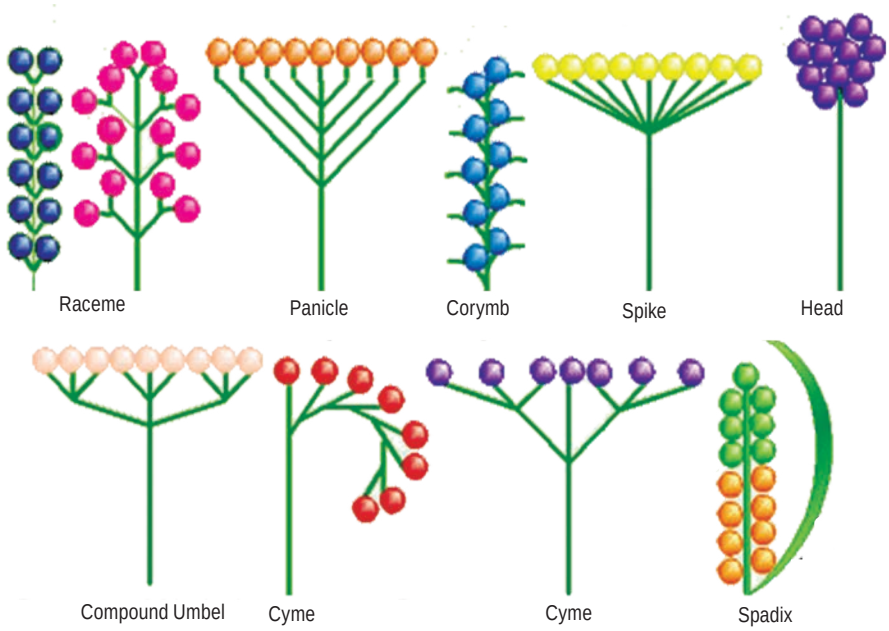


Figure 7.9. Inflorescences.

ii. Cymose Inflorescence or Determinate:

The primary axis bears a flower on the terminal end and lateral buds form branches bearing flowers. The flowers in lateral branches are arranged in basipetal succession. It is of the following types:

1. Uniparous (monochasial) cyme: The main axis ends with a flower and the axis bears a lateral branch bearing a flower. From the lateral branch other smaller branches bearing flowers appear. It is of two types:
2. Helicoid cyme: The lateral branches bearing flowers are produced successively on the same sides. Example, black nightshade (Solanum nigrum).

   Scorpicoid cyme: The lateral branches bearing flowers are formed on opposite sides alternatively forming a zig-zag structure. Example, Heliotrope.
3. Biparous (bichasial) cyme: The primary axis bearing flower produces two lateral branches that bear flowers and produce smaller lateral branches. Example, jasmine.
4. Multiparous (multichasial) cyme: The main axis bearing flower produces multiple branches that behave like the primary axis. Example, calotropis.

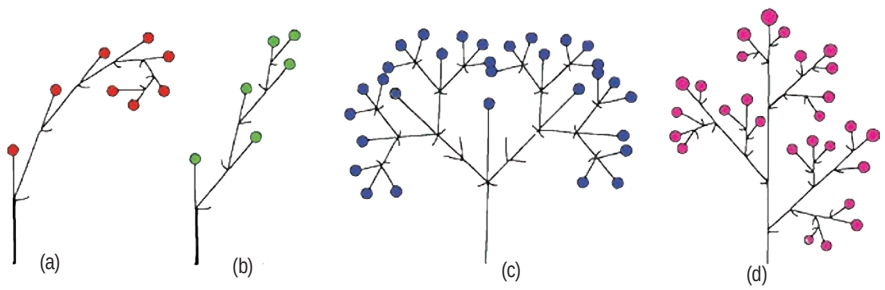


Figure 7.10. Types of cymose inflorescence- (a) helicoid, (b) scorpicoid, (c) bichasial, and (d) multichasial.

iii. Special Types of Inflorescences:

1. Verticillaster: It is a condensed type of cymose inflorescence having a cluster of sessile or short pedicellate flowers. Node contains bracts bearing a cluster of flowers opposite to each other. Example, red dead nettle (Laminum purpureum).
2. Cyathium: It is a modified cymose inflorescence but appears like a single flower. A large single female flower is present at the center surrounded by smaller male flowers. Example, sun spurge (Euphorbia helioscopia).

3. Hypanthodium: Thalamus is modified to form cup-shaped structure enclosing entire inflorescence. The flowers are small, sessile and unisexual. Example, peepal (Ficus religiosa).

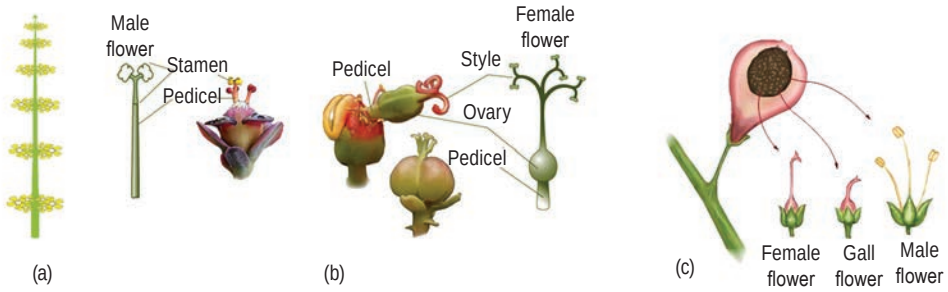


Figure 7.11. Special types of inflorescences- (a) verticillaster, (b) cyathium, and (c) hypanthodium.

7.3. Guidelines to Describe a Flower (step-wise guide)

Flower should be described in the following sequence:

1. Inflorescence
   (a) Arrangement on stem or branch: Solitary / clusters (inflorescence).
   (b) If solitary: Terminal or axillary to the branch or stem.
   (c) If inflorescence: Racemose / cymose / special.
2. Flower
   (a) Bracts: Bracteate / ebracteate.
   (b) Stalk: Sessile / pedicellate.
   (c) Presence or absence of floral whorls: Complete / incomplete.
   (d) Symmetry: Actinomorphic / zygomorphic / asymmetrical.
   (e) Presence of reproductive organs: Hermaphrodite / if unisexual then Pistillate / staminate.
   (f) Number of members in floral whorls: Dimerous (two) / trimerous (three) / tetramerous (four) / pentamerous (five).
   (g) Insertion of floral whorls: Hypogynous / epigynous /perigynous.

(h) Any other special feature should be mentioned

3. Epicalyx (if present)
   (a) Number of episepals
   (b) Cohesion of episepals: Free / fused.
   (c) Aestivation: Valvate / twisted / imbricate / quincuncial / vexillary.
   (d) Colour: Green / others.
   (e) Any other special feature (if present).
4. Calyx
   (a) Number of sepals
   (b) Cohesion of sepals: Polysepalous / gamosepalous.
   (c) Aestivation: Valvate / twisted / imbricate / quincuncial / vexillary.
   (d) Colour: Any other special feature (if present).
5. Perianth (if present)
   (a) Number of tepals
   (b) Cohesion of tepals: Polytepalous / gamtepalous.
   (c) Aestivation: Valvate/twisted / imbricate / quinquncial / vexillary.
   (d) Colour: Sepaloid (like sepals) / petaloid (like petals).
   (e) Any other special feature (if present).
6. Corolla
   (a) Number of petals
   (b) Cohesion of sepals: Polypetalous / gamopetalous.
   (c) Aestivation: Valvate / twisted / imbricate / quinquncial / vexillary.
   (d) Shape: Cruciform / caryophyllaceous / rosaceous / campanulate / tubular / infundibuliform / rotate / papilionaceous / bilabiate/personate / ligulate.
   (e) Colour
   (f) Any other special feature (if present).
7. Androecium

(a) Number of stamens: Fixed or indefinite.

(b) Cohesion of stamens: Polyandrous / synandrous; if fused, whether monadelphous / diadelphous / polyadelphous / syngenesious / synandrous.

(c) Adhesion of stamens: Epipetalous / epitepalous / gynandrous.

(d) Length of filaments: Whether equal or not, if not, then didynamous / tetradynamous.

(e) Insertion: inserted / exserted.

(f) Attachment of filament to anther: Adnate / basifixed / dorsifixed / versatile.

(g) Number of theca: Monothecous / dithecous.

(h) Dehiscence of anther: Extrose / introse.

(i) Any other special feature if present

8. Gynoecium

(a) Number of carpels: Monocarpellary / bicarpellary / tricarpellary / pentacarpellary / multicarpellary.

(b) Cohesion of carpels: Apocarpous / syncarpous.

(c) Position of ovary: Superior / inferior / semi-inferior.

(d) Number of locules in the ovary: Unilocular / bilocular / trilocular / tetralocular / pentalocular / multilocular.

(e) Number of ovules in each locule

(f) Placentation: Marginal / axile / parietal / central / basal / superficial.

(g) Style: Number and length.

(h) Stigma: Capitate / plumose / discoid / dumb-bell / bifid / sticky.

(i) Any other special feature if present

7.4. Guidelines for Recording Floral Diagram

A floral diagram is a schematic representation of floral parts, their number, arrangement with respect to the mother axis. It provides a floral plan as viewed in a transverse section of a flower. Drawing of a flower can be done in the following way:

Step 1. Hold the flower in such a way that the bract is on your side and the

mother axis is in the opposite direction.

Step 2. Make a big circle. Represent mother axis by placing a big dot over the circle.

Step 3. Draw a bract (if present) at the base of the circle.

Step 4. Represent floral whorls in concentric circles starting with calyx (outermost), corolla, androecium (innermost) and cross-section of

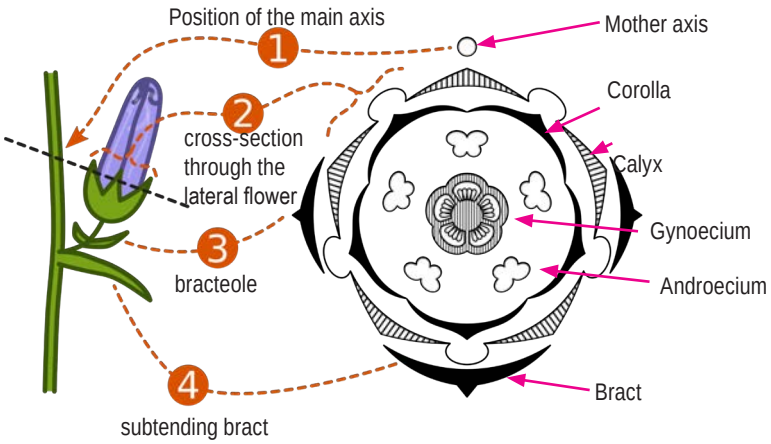


Figure 7.12. Floral diagram.

ovary is drawn in the center to represent gynoecium.

Step 5. Represnt sepals, petals and perianth by arcs.

Step 6. If perianth is present, the arcs should be different depending on petaloid or sepaloid.

Step 7. Note whether a sepal is opposite to mother axis or not. Once first sepal is marked continue with the other sepals in relation to the previous sepal. Number, size and aestivation should be drawn very carefully.

Step 8. While drawing the petals, check if the floral whorls lay alternate or opposite of the sepals. Aestivation should be observed and drawn properly.

Step 9. If calyx is gamosepalous and corolla is gamopetalous join the floral leaves.

Step 10. While drawing androecium, count the number of stamens and draw them inner to the corolla lobes. If the anthers are extrose, they should face petals and if introse, they should face gynoecium. If stamens are

monadelphous, then join all the stamens and, if diadelphous represent as they appear. They should be connected to petals if they are epipetalous.

Step 11. Gynoecium is represented by drawing a cross-section of the ovary in the center and it should clearly indicate the number of carpels, apo- or syncarpous.

7.5. Guidelines for Writing Floral Formula

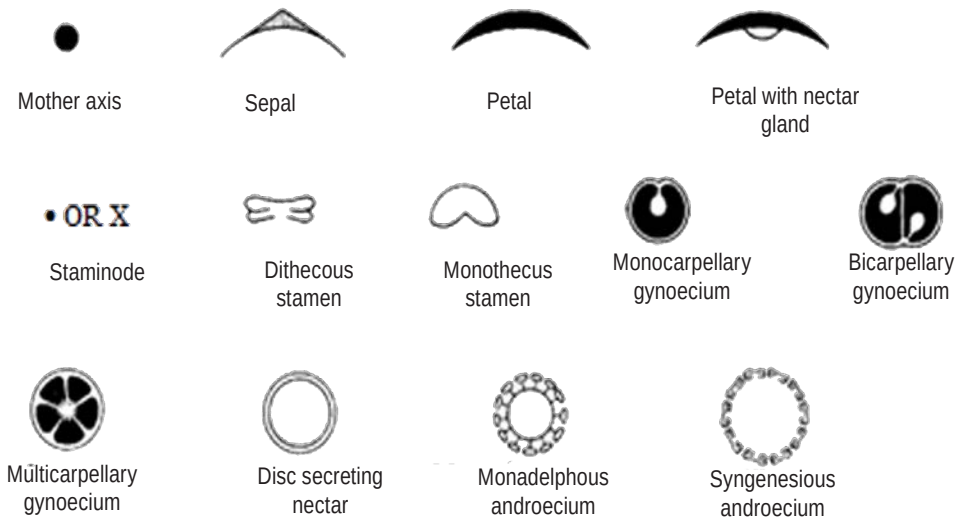


Figure 7.13. Symbols used for drawing floral diagram.

A floral formula is a coded representation of flower that enables us to draw the floral structures. A floral formula needs to be written in the following sequence:

1. Bracteate or ebracteate
2. Bracteolate or ebracteolate
3. Symmetry
4. Sexuality
5. Epicalyx and its type if present
6. Calyx
7. Corolla
8. Androecium
9. Gynoecium

Table 7.1 Symbols Used for Writing Floral Formula

Br.	Bracteate	**C**	Corolla-free (polypetalous)
Brl.	Bracteolate	**(C)**	Corolla-united (gamopetalous)
Ebr.	Ebracteate	**Cx**	Corolla-cruciform
Bbrl.	Ebracteolate	**P**	Perianth
♂	Male	**A**	Androecium-free
♀	Female	**(A)**	Androecium-united
☿	Bisexual	P A	Epiphyllous
⊕	Actinomorphic	C A	Epipetalous
↾ or %	Zygomorphic	**G**	Gynoecium-free
Ep	Epicalyx	**(G)**	Gynoecium-united
K	Calyx-free (polysepalous)	$\underline{G}$	Superior ovary
(K)	Calyx-united (gamosepalous)	$\overline{G}$	Inferior ovary
		G A	Gynostagium

**Specifications of all the whorls should be mentioned based on the information given in the Table 7.1.

Ebr ⊕ ♂ Epi $_{5\text{-}7}$ K $_{(5)}$ C $_{5}$ A $_{(\alpha)}$ G $_{(5)}$ (Hibiscus rosa sinesis)

7.6. Drawing LS of Flower

Following steps to draw the L.S of flower:

Step 1. Remove a flower from the twig.

Step 2. With a sharp blade cut the flower lengthwise along the median plane into two equal halves. This is called longitudinal section (L.S.) or vertical section (V.S.).

Step 3. Place the two halves in a watch glass / petri dish and study the relative position of different floral whorls.

Step 4. Draw a labeled diagram of L.S. of flower.

8. Temporary Slides Preparation

A temporary slide is used in laboratories to view mounts under a microscope. Since we cannot view the specimen as a whole, so as to observe under a microscope, and to make observations easier, we prepare slide. Simple process includes the following:

8.1. Cutting Sections of Plant Materials

For microscopic examination of specimens and tissues, they must be sectioned, smeared or squashed and made thin enough to allow light to pass through them so as to make the observation clear.

8.1.1. Free Hand Sections

Rigid specimens like stems, roots, rhizome, etc. can be cut free hand. The suggested procedure for free hand section cutting is as follows:

Step 1. Dip the razor in water.

Step 2. Hold the specimen by the thumb and index finger of the dominant hand.

Step 3. Hold a razor by the thumb and finger of the other hand.

Step 4. Cut sections holding the razor at right angles to the axis of the specimen.

Step 5. Transfer the sections into a watch glass containing water by using thin brush.

Step 6. Select the thinnest section having no damage.

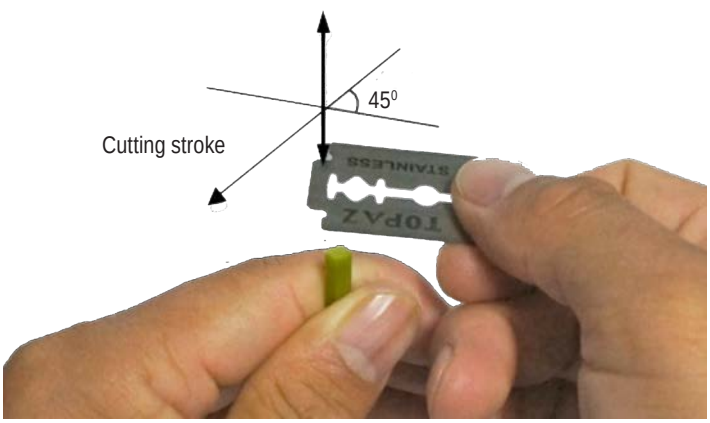


Figure 8.1. Section cutting (free hand).

8.1.2. Using Pith or Cork

It is difficult to cut soft materials like leaves, soft stems etc. by using the free hand. In such cases, the materials have to be held in a support formed by pith or cork. The pith can be rectangular block of potato tuber, radish or bottle cork. The sections can be cut by the following procedure:

Step 1. Make a slit on the pith.

Step 2. Insert the specimen in the slit of the pith.

Step 3. Cut the pith along with the specimen using a sharp razor blade.

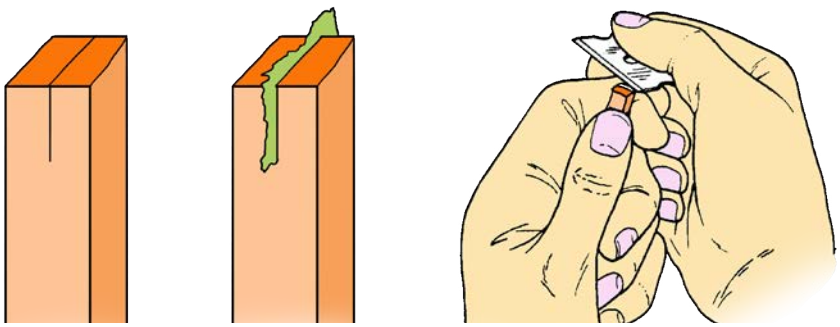


Figure 8.2. Section cutting using pith.

8.2. Types of Sections

Transverse section: When a section is cut at right angle to the long axis of the specimen.

Longitudinal section: When a section is cut parallel to the long axis of the specimen.

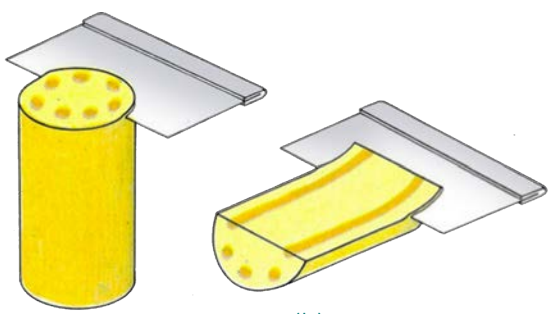


Figure 8.3. (a) Transverse section and (b) longitudinal section.

8.3. Squashing (blending)

Materials like root tip, which are too soft to be sectioned or too rigid to allow smearing, are squashed before staining and mounting. Tissues are squashed to separate the cells so that individual cell can be seen more clearly.

8.4. Staining

Different cells and tissues can be studied under microscope only if their refractive indexes are different. Therefore, staining is a must to make different parts look more obvious. Most of the stains are colored dyes of organic matter and are soluble in water or alcohol or in both. Depending upon the number of stains used, permanent staining can be called single staining or double staining. There are two main types of stains in use.

Temporary stains: Temporary stains fade away with passage of time, or the stain damages the stained tissues / components, example, methylene blue, Sudan IV, Iodine, etc.

Permanent stains: Permanent stains retain their colors for years, example, light green, hematoxylin, safranin, fast green, etc.

8.5. Mounting

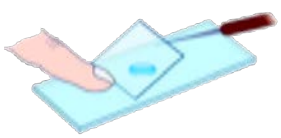


Figure 8.4. Mounting a specimen.

The stained specimen has to be mounted on suitable mounting medium. It has to be covered by cover slip in order to prevent dust and germs entering into the specimen. Follow the following steps to mount a specimen.

1. Add one or two drops of mounting medium in the centre of a clean slide.
2. Place the stained specimen in the mounting medium with the help of a fine brush.
3. Gently lower the cover slip on top of the specimen and the medium by means of a mounting needle.
4. If excess of mounting medium has been dropped on the slide, clean it with tissue paper or blotting paper before mounting the specimen.

8.6. Labeling

Paste the label on the left side of the slide. Label should contain the name of the division or generic name, specific name, name of its part, section's plane and your name.

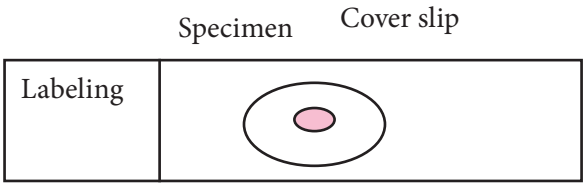


Figure 8.5. Labelling a mount.

8.7. Sealing the Slide

Temporary slide can be kept for a few days by sealing the cover slip with substances like nail polish, Canada balsam, melted wax, etc. Excessive amount of sealing agent can be scraped off with a blade.

PART A

SECTION II

Experiments for Class XI

EXPERIMENT 1

Effect of Concentration of Solution on Water Potential

Aim: To determine the effect of concentration of solution on water potential.

Theory:

Water potential is the difference of potential energy between a solution and pure water. Water potential of pure water is zero and is considered to be the highest. Therefore, all solutions have water potential less than pure water. The value of water potential decreases and becomes negative with the increase in concentration of a solution. As a result, the water moves from the area of high water potential to the area of low water potential until the water potential becomes equal.

Question:

(i) Does the concentration of solution affect the water potential?

(ii) How does the concentration of solution affect the water potential?

Hypothesis: Formulate your own hypothesis.

Variable: Identify the following:

Independent variable
Dependent variable
Controlled variable

Material required:

Specimen	Apparatus	Chemical
Potato tuber	Test tube (4 No), Cork borer (1 No), ruler (1 No), filter paper (1 No), measuring cylinder (1 No), and blotting paper (2 No)	Sucrose/salt solution and distilled water

Procedure:

Step 1. Prepare 2 M sucrose stock solution.

Step 2. Prepare sucrose solutions of 0.4 M, 0.8 M and 1.2 M from the stock solution.

Step 3. Take four test tubes and label them as A, B, C and D.

Step 4. Take 5 mL of water in test tube A, and same volume of 0.4 M, 0.8 M and 1.2 M solutions into test tube B, C and D respectively.

Step 5. Make four potato cylinders of same length using a cork borer.

Step 6. Blot out excess water from the potato cylinders and place each into the respective tube.

Step 7. Keep the set-up undisturbed for about an hour.

Step 8. Remove the potato cylinder from each test tube and blot out excess solution.

Step 9. Measure the length of the potato cylinders and record in Table 1.1.

Step 10. Plot a graph that illustrates the change in length against the concentration of solution in a spreadsheet or graph paper.

Observation:

Table 1.1 Change in the Length of Potato Cylinders

Solution	Initial Length (cm)	Final Length (cm)	Change in Length (cm)
Distilled water (0.0 M)			
0.4 M			
0.8 M			
1.2 M			

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. What could be other variables one can choose to determine water potential?
2. What would happen to the water potential of a potato if it is allowed to dehydrate? Explain.
3. In the field of medicine, the organs or tissues to be transplanted are customarily stored in normal saline solution. Why?

2 EXPERIMENT

Test for Carbohydrate, Protein and Fat

Aim: To detect the presence of carbohydrate, protein and fat in a given food sample.

Question: Which type of biomolecule is present in the given food sample?

Material required:

Specimen	Apparatus	Chemical
Food sample	Test tube (3 No), test-tube holder (1 No), test-tube rack (1 No), funnel (1 No), beaker (1 No), filter paper (1 No), paper (1 No), burner (1 No), dropper (1 No), water bath (1 No), and mortar and pestle (1 Set)	Iodine, conc. NaOH, dil. HCl, and conc. HNO_3

Procedure:

Step 1. Prepare a test solution of the given food sample.

Step 2. Add 3-4 drops of Iodine solution to 2 mL of test solution. Heat the solution and record your observation (Iodine test).

Step 3. Add 5 drops of conc. HNO_3 to 2 mL of test solution. Add 4-5 drops of conc. NaOH to the mixture and record your observation (Xanthoproteic test).

STAY SAFE

Acids are corrosive in nature.
Handle with care.

Step 4. Take the given sample in a test tube and add some water to it (Emulsion test).

Observation:

Table 2.1 Test for Biomolecules

Test	Observation	Inference
Iodine Test		
Xanthoproteic Test		
Emulsion Test		

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. Why is iodine a suitable reagent to detect the presence of starch?
2. How is this experiment relevant in our daily lives?

EXPERIMENT 3

Effect of Light Intensity on the Rate of Transpiration

Experiment 3a

Aim: To study the effect of light intensity on the rate of transpiration.

Theory:

Transpiration is the loss of water in the form of vapour from the aerial parts of the plant. The amount of water loss due to transpiration depends on various factors like temperature, light intensity, wind velocity, humidity, and plant surface area.

Question:

i. Does the light intensity affect the rate of transpiration?

ii. How does light intensity affect the rate of transpiration?

Hypothesis: Formulate your own hypothesis.

Variable: Identify the following:

Independent variable
Dependent variable
Controlled variable

Material required:

Specimen	Apparatus	Chemical
Twig of any herbaceous plant	Ganong's potometer (1 No), stop watch (1 No), cork (1 No), and cork borer (1 No).	Petroleum jelly and water

Procedure:

Step 1. Fill the Ganong's potometer with water through the water reservoir.

Step 2. Insert the twig of a freshly cut herbaceous plant in the vertical arm through the hole of the cork.

Step 3. Apply petroleum jelly at the point of insertion of the twig to make it air tight.

Step 4. Introduce the air bubble in the graduated tube.

PRECAUTION

The end of the graduated tube should be dipped in water.

Step 5. Record the initial postion of the air bubble in Table 3.1 and keep the set-up in sunlight for 10 min. Record the final position of the air bubble.

Step 6. Repeat the process in step 5 by keeping the set-up in shade and dark place.

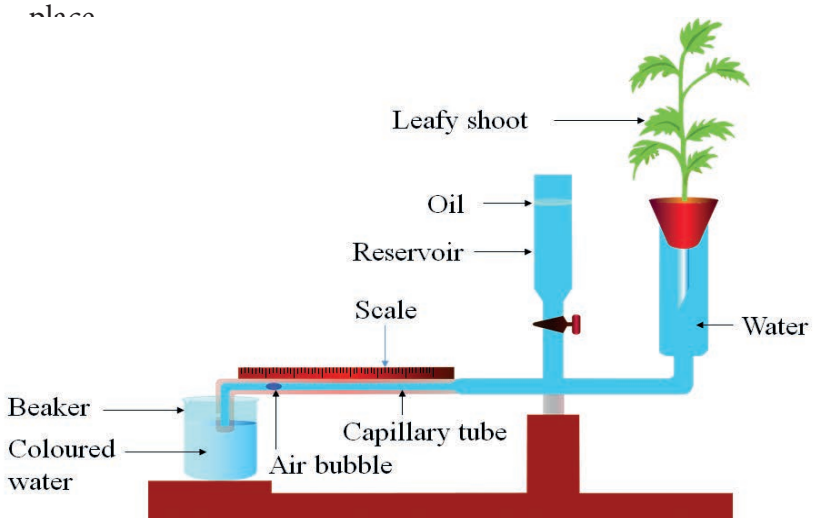


Figure 3.1. Ganong's potometer.

Observation:

Table 3.1 Rate of Transpiration in Different Condition

Condition	Time (min)	Initial Position of the Air Bubble	Final Position of the Air Bubble	Distance Travelled by the Air Bubble (Final Position- Initial Position)	Rate of Transpiration (Distance Travelled by the Air Bubble/ Time)
Sunlight	10				

Shade	10				
Dark	10				

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Experiment 3b

Design and carry out the experiment to determine the effect of wind velocity on the rate of transpiration.

Question:

1. What would be the result of the experiment if the surrounding temperature is increased?
2. How would you calculate the amount of water lost through the transpiration in the above experiment?
3. List down some of the limitations of the above experimental set-up.

4 EXPERIMENT

Study of Water Quality through EPT Index

Aim: To determine the quality of water through Ephemeroptera, Plecoptera, and Trichoptera (EPT) index.

Question: What is the quality of water collected from the sampling sites?

Theory:

The water quality can be determined by using biological, chemical and physical indicators. The chemical and physical indicators include the test for pH, dissolved oxygen, temperature and turbidity. The biological indicators include organisms present in a water body such as crustaceans, molluscs, worms and larvae of mayfly, stonefly, caddisfly and beetles.

EPT index is one of the biological methods to ascertain the water quality. It is computed based on the relative abundance of three pollution-sensitive macroinvertebrates (ephemeroptera, plecoptera and Trichoptera) against one pollution-resistant species (diptera). EPT index is determined by the mathematical expression:

$$\text{EPT index} = \Sigma \frac{E+P+T}{\text{No. of D}}$$

E= Number of Ephemeroptera P=Number of Plecoptera

T= Number of Trichoptera D=Number of Diptera

Generally, the EPT Index is based on the premise that high-quality waters usually have the greatest species richness. Many aquatic insect species are intolerant of pollutants and will not be found in polluted waters. The greater the pollution, the lower the species richness expected, as only a few species are pollutant tolerant. The quality of water is inferred by comparing EPT index with the qualifiers of the EPT rating chart. In the common praxis, the EPT rating chart varies depending on the eco-regions or simply tailor-made based on the sampling site, i.e. rivers, streams, or ponds. Table 4.1 shows one of the EPT rating charts used to infer the quality of water in the streams.

Table 4.1 EPT Rating Chart

EPT Index	Water Quality
>22	Excellent
17-22	Good
11-16	Fair
<11	Poor

Table 4.2 Features of Macroinvertebrates

Sl No	Order	Description	Picture
1	Ephemeroptera (Common Mayfly)	The common Mayflies are up to 2.54 cm in length. These are usually black but may be green, brown or gray with three distinct fuzzy or threadlike tails. They have varying tolerance to pollution, but are usually found to inhabit cleaner water bodies.	
2	Plecoptera (Common Stonefly)	The Common Stoneflies measure less than 2.54 cm in length. They have two wings, two sets of branched gills located between the undersides of the body, and may be yellow or brown body. They are intolerant to low levels of dissolved oxygen and therefore, prefer cold and swift moving streams.	
3	Trichoptera (Caddisfly)	The Caddisflies resemble a caterpillar with a soft, worm-like body bearing a hard covering on the head. They are usually green but may be yellow or brown. They exhibit large range of tolerance to pollution.	

4	Diptera (Diptera)	Midges have worm-like body with a distinct head and paired prolegs below their heads and towards the end of the abdomen. Usually the abdomen is red or green, and appears deeply segmented. They have a pair of large compound eyes that are well separated. The antennae are long and visibly curved. Their presence is often an indicator of polluted water.	

Material required:

Apparatus
Hess sampler/sieve (1 No), litmus paper (3 No), white pan (3 No), thermometer (1 No), beaker (4 No), glove (1 pair), tray (1 No), pH meter (1 No)

Procedure:

Step 1. Choose three suitable sampling sites in a river/stream.
Step 2. Using Hess sampler/sieve, collect macroinvertebrates from one of the sampling sites.
Step 3. Transfer the macroinvertebrate samples into a white pan containing water.
Step 4. Sort out the macroinvertebrates referring Table 4.1 and transfer them into the beakers.
Step 5. Count the macroinvertebrates and record in Table 4.3.
Step 6. Repeat process in steps 2-6 for other remaining sites.

STAY SAFE

Be careful of slippery surface

Observation:

Table 4.3 EPT Index

Macroinvertebrates	Number		
	Site I	Site II	Site III
Ephemeroptera			
Plecoptera			
Trichoptera			

Diptera			
EPT Index			

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. Why are samples collected from three different spots?
2. How can we apply the result of this experiment in our daily lives?
3. Explore if other organisms can be used as indicators in determining the water quality.
4. Using the data and results from your experiment, determine if the water is safe for drinking and other domestic uses.

5 EXPERIMENT

Deoxyribonucleic Acid (DNA) in Plant Tissue

Aim: To verify the presence of DNA in plant tissue.

Theory:

DNA is a macromolecule present in the living tissues containing negative charge. Once DNA is removed from the cell content, it will break down into smaller fragments as it comes in contact with water. When salt is added, the sodium ions combine with the negative charges of DNA forming a temporary attraction, thereby preventing breakdown of DNA. Upon adding ice cold ethanol, DNA precipitates and long fibres of DNA can be spooled out.

Question: Does the plant tissue contain DNA?

Material required:

Specimen	Apparatus Chemicals	Chemicals
Onion/ spinach/ carrot	Cutting board (1 No), blender (1 No), knife (1 No), water bath (1 No), beaker (2 No), filter paper (1 No), funnel (1 No), test tube (1 No), glass rod (1 No), stop-watch (1 No), thermometer (1 No), and tablespoon (1 No)	Common salt, liquid detergent, ice water, and 95 % ethanol

Procedure:

Step 1. Cut the plant specimen into small pieces and blend them.

Step 2. Add one-half tablespoon of common salt and two tablespoons of detergent (solution) to form the mixture.

Step 3. Add some distilled water to the mixture and stir thoroughly with a glass rod.

Step 4. Transfer the mixture into a beaker and keep it in the water bath at 60^0 C for about 15 min.

Step 5. Cool the beaker in the ice water.

Step 6. Filter the mixture into a test tube.

Step 7. Pour 10 mL of ice cold ethanol down the wall of the test tube containing the filtrate.

Step 8. Leave the test tube undisturbed for 2 to 3 min and observe the changes.

Step 9. Gently twirl the glass rod into the solution and spool out the substance.

Observation:

Record your observation.

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. What is the purpose of heating the homogenate mixture?
2. What are the roles of sodium chloride (salt) and detergent in the experiment?
3. Why is ice-cold 95% ethanol added to the experimental content?
4. How would the result differ if salt is not used in the experiment?

6 EXPERIMENT

Vital Capacity of Lungs in Relation to Height

Experiment 6a

Aim: To determine the vital capacity of lungs in relation to height.

Theory: Vital capacity is the maximum volume of air that can be expired after a maximum inspiration. It is about 4500 mL in male and 3000 mL in female. It is influenced by gender, height, weight, age of the person, etc.

Question: Does the vital capacity of lungs depend on the height of the person?

Hypothesis: Formulate you own hypothesis.

Variable: Identify the following:

Independent variable

Dependent variable

Controlled variable

Material required:

Apparatus
Round balloon (1 No), measuring tape (1 No), and metre ruler (1 No)

Procedure:

Step 1. Stretch the balloon several times to make it loose.

Step 2. Inhale as much air as you can and then exhale forcibly into the balloon.

Step 3. Close the mouth of the balloon, measure its diameter and record in Table 6.1.

Step 4. Repeat step 2 and 3 for three times and record the observation in Table 6.1. Find the average diameter and the corresponding volume.

Step 5. Measure your height and record it in Table 6.1.

Step 6. Calculate the volume of the balloon which is the actual vital capacity of the lungs.

$$\text{Volume} = \frac{4}{3}\pi r^3$$

r = radius of the balloon

$\pi = 3.14$

Step 7. Measure and record the height and vital capacity of your classmates into two categories as male and female.

Step 8. Plot a graph of height against vital capacity for both male and female separately.

Observation:

Table 6.1 Vital Capacity of Lungs in Relation to the Height

Sl No	Actual Vital Capacity		Height [cm]
	Diameter of Balloon [cm]	Volume [mL]	
1			
2			
3			
Average			

Result:

Write the result from the graphs.

Conclusion:

Draw a conclusion based on the result.

Experiment 6b

Design and carry out experiment to determine vital capacity in relation to weight.

Question:

1. Vital capacity of the lungs is influenced by the height of a person. How?
2. Explain how vital capacity of the lungs change with the age?
3. How would you improve the vital capacity of your lungs? Mention some health tips.

7

EXPERIMENT

Effect of Temperature on Enzyme Action

Experiment 7a

Aim: To study the effect of temperature on enzyme action.

Theory:

Enzyme is a biocatalyst which regulates various biochemical reactions. It increases the rate of reaction by minimizing the level of activation energy. The rate of enzyme reaction is influenced by several factors such as temperature, pH, substrate concentration, etc.

Question:

(i) Does the temperature affect enzyme action?

(ii) How does the temperature affect enzyme action?

Hypothesis: Formulate your own hypothesis.

Variable: Identify the following:

Independent variable

Dependent variable

Controlled variable

Material required:

Specimen	Apparatus	Chemical
Potato cubes of 1 cm^3	Test tube (3 No), test tube rack (1 No), cork (3 No), beaker (1 No), dropper (1 No), water bath (1 No), thermometer (1 No), and ruler (1 No)	Hydrogen peroxide (H^2O^2)

Procedure:

Step 1. Peel off the potato skin and cut it into small cubes of equal volume (1 cm^3).

Step 2. Place a potato cube each into three test tubes and label them as A, B, and C.

Step 3. Maintain the temperture of test tube A, B and C at 0^0 C, 37^0 C and 60^0 C respectively for 10 min.

STAY SAFE

Hydrogen peroxide (H_2O_2) is corrosive.

Step 4. Add 5 mL of H_2O_2 in each test tube and cover the mouth of the test tubes using cork stopper. Observe the set-up for 2 min.

Step 5. Measure the height of the froth column formed and record in Table 7.1.

Step 6. Plot a graph that illustrate the height of froth column against temperature.

Observation:

Table 7.1 Height of the Froth Column at Different Temperature

Temperature (^{0}C)	Height of the Froth Column (cm)
0	
37	
60	

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Experiment 7b

Design and carry out an experiment to show the effect of pH on the enzyme action.

Question:

1. What would happen to the enzyme activity if the temperature is decreased after reaching the maximum point? Explain.
2. Why does the shelf-life of vegetables increase when stored in the refrigerator? Explain.
3. List some application of enzymes in industries.

8

EXPERIMENT

Identification of Permanent Slides

Aim: To identify the permanent slide based on the anatomical features.

Question: What are the anatomical features that help in the identification of the permanent slide?

Material required:

Permanent Slide	Apparatus
TS of mammalian pancreas (1 No), Permanent slides of Stages of mitosis and meiosis.	Compound microscope (1 No)

Procedure:

Step 1. Observe the given permanent slide using compound microscope.

Step 2. Draw a labelled diagram of the specimen.

Observation:

List all the observable features of the specimen.

Result:

Identify the permanent slide based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. Study any other permanent slides and write their features..

9 EXPERIMENT

Study of Human Organs Using 3D Models

Aim: To study the parts of the human organ using 3D model.

Question: What are the parts of the human organ and their functions?

Material required:

3D Model of Human Organ
Human heart (1 No), human eye (1 No), pituitary gland, and human brain.

Procedure:

Step 1. Study the given 3D model.

Step 2. Draw a labelled diagram of the organ.

Step 3. State the functions of parts of the organ.

Observation:

List all the parts of the organ.

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. How will the study of models help us understand the structures of human organs?

10 EXPERIMENT

Study of Plant and Animal Specimens

Aim: To classify the plant and animal specimen into kingdom, phylum/division and class.

Question: To which kingdom, phylum/division and class does the given specimen belong?

Material required:

Specimen
Mushroom (1 No), amoeba (1 No), leech (1 No), prawn (1 No), algae (1 No), liverwort (1 No), fern (1 No), pine (1 No), china rose (1 No), roundworm (1 No), honeybee (1 No), snail (1 No), and starfish (1 No), rat (1 No).

Procedure:

Step 1. Observe the given specimen.

Step 2. Draw a labelled diagram of the specimen.

Step 3. List the features of the given specimen.

STAY SAFE

The preservative in the specimen jar is highly toxic.

Observation:

List all the features of the specimen.

Result:

Taxon	Name
Kingdom	
Phylum/division	
Class	

Conclusion:

Draw a conclusion based on the result.

Question:

1. Observe some plants in your locality and classify them into kingdom, phylum and class.
2. Write the scientific importance of categorising plants and animals into different class.

PART B

SECTION II

Experiments for Class XII

1 EXPERIMENT

Identification of Family through Floral Characteristics

Experiment 1a

Aim: To identify the family of the given flower specimen through floral characteristics.

Question: What is family of the given flower specimen?

Material required:

Specimen	Apparatus
Flower specimen: a) *Hibiscus* spp., *Alcea* spp., *Gossypium* spp., or any other related flowers. b) *Petunia* spp., *Solanum* spp., *Datura* spp., or any other related flowers. c) *Pisum* spp., *Lens* spp., *Lathyrus* spp., or any other related flowers. d) *Sinapis* spp., *Brassica* spp., *Raphanus* spp., or any other related flowers.	Dissecting microscope (1 No), forceps (1 No), razor blade (1 No), needle (1 No), glass slide (1 No), blotting paper (3 No), brush (1 No), and hand lens (1 No).

Procedure:

Step 1. Study the floral characteristics of the given specimen and record your observation in Table 1.1.

STAY SAFE

Handle razor blade, forceps and needle with care.

Step 2. Draw a diagram of:

i. LS of flower.

ii. TS of ovary.

iii. Calyx, corolla, androecium and gynoecium.

Step 3. Draw the floral diagram of the specimen.

Step 4. Write the floral formula of the specimen.

Observation:

Table 1.1 Characteristics of the Flower Specimens

Flower	
Epicalyx	Present ☐ Absent ☐
Perianth	Present ☐ Absent ☐
Bract	Bracteate ☐ Ebracteate ☐
Stalk	Sessile ☐ Pedicellate ☐
Number of Whorl	Complete ☐ Incomplete ☐
Sexuaity	Unisexual ☐ Pistillate ☐ Staminate ☐ Bisexual ☐ Neutral ☐
Insertion of whorl	Epigynous ☐ Hypogynous ☐ Perigynous ☐
Symmetry	Actinomorphic ☐ Zygomorphic ☐ Asymmetrical ☐
Member in each whrol	Dimerous ☐ Trimerous ☐ Tetramerous ☐ Pentamerous ☐ Anyother (specify).... ☐
Calyx	
Colour of sepal	
Number of sepal	1 ☐ 2 ☐ 3 ☐ 4 ☐ More than 5 ☐
Cohesion if sepal	Gamosepalous ☐ Polysepalous ☐
Aestivation of sepal	Valvate ☐ Twisted ☐ Imbricate ☐ Vexillary ☐ Quincuncial ☐
Corolla	
Colour of petal	
Number of petal	1 ☐ 2 ☐ 3 ☐ 4 ☐ More than 5 ☐
Cohesion of petal	Gamotepalous ☐ Polypetalous ☐
Aestivation of petal	Valvate ☐ Twisted ☐ Imbricate ☐ Vexillary ☐ Quincuncial ☐
Androecium	
Number of stamen	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ More than 5 ☐
Group of stamen	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ More than 5 ☐ Free ☐
Cohesion of stamen	Monadelphous ☐ Diadelphous ☐ Polyadelphous ☐ Synandrous ☐ Syngenesious ☐ Polyandrous ☐

Attachment of filament to anther	Adnate ☐ Basifixed ☐ Dorsifixed ☐ Versatile ☐
Number of anther lobe	Monothecous ☐ Dithecous ☐
Relative length of stamen	Equal ☐ Unequal ☐ Didynamous ☐ Tetradynamous ☐
Dehiscence of anther	Introse ☐ Extrose ☐ Longitudinal ☐
Adnate to petal	Yes ☐ No ☐

Gynoecium

Number of carpel	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ More than 5 ☐
Cohesion of carpel	Syncarpous ☐ Apocarpous ☐
Position of ovary	Inferor ☐ Semi-inferior ☐ Superior ☐
Number of locule	Unilocular ☐ Bilocular ☐ Trilocular ☐ Tetralocular ☐ Pentalocular ☐ More than 5 ☐
Number of ovule per locule	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ More than 5 ☐
Placentation	Marginal ☐ Axile ☐ Basal ☐ Superficial ☐ Central ☐ Parietal ☐
Nature of stigma	Discoid ☐ Plumose ☐ Capitate ☐ Dumb-bell ☐ Bifid ☐ Sticky ☐
Adnate to petal	Yes ☐ No ☐
Other special characters	

Result:

Table 1.2 Unique Features of the Flower Specimens

Floral Whorl	Unique Feature
Calyx	
Corolla	
Androecium	
Gynoecium	

Conclusion:

Draw a conclusion based on the result.

Experiment 1b

Study the floral characteristics of any two flowers available in your locality and identify their family.

Question:

1. With floral characteristics, can one predict the type of pollination that can occur in a flower? Explain.
2. What does the variation in the floral characteristics amongst flowers indicate?
3. What is the scientific importance of classifying flowers into different family?

EXPERIMENT 2

Effect of Glucose Concentration on Respiration

Experiment 2a

Aim: To determine the effect of glucose concentration on the rate of cellular respiration.

Theory:

Cellular respiration is a metabolic pathway that occurs in all living cells. It involves breaking down of glucose to release energy by transferring electrons through series of enzymatic reaction. Cellular respiration occurs in three phases, namely glycolysis, Krebs cycle, and electron transport chain.

The rate of respiration is affected by temperature, substrate concentration (e.g., glucose), oxygen level, pH, and enzyme concentration. The increase in the substrate concentration, for instance, increase the rate of respiration. However, the rate of respiration remains constant at certain point in time even when the substrate concentration is increased further.

Question:

1. Does the concentration of glucose affect the rate of respiration?
2. How does the concentration of glucose affect the rate of respiration?

Hypothesis: Formulate your own hypothesis

Variable: Identify the following:

Independent variable
Dependent variable
Controlled variable

Material Required:

Material	Apparatus	Chemical
Yeast	Test tube in two sizes (that the small test tube must be able to fit inside large test tube) (12 No), measuring cylinder (1 No), ruler (1 No), Test tube rack (1 No), Stop watch	Glucose and water

Procedure:

Step 1. Prepare glucose solutions of 15%, 30% ,45%, 60% and 75% concentration. Add the solutions into 5 small test tube and label them as B, C, D, E, and F.

Step 2. Take 10 mL of water in a test tube and label it as A. Keep this test tube as the control set-up.

Step 3. Add 5 g of yeast in all the test tubes and gently shake the mixtures approximately for 20 seconds.

Step 4. Take 6 larger test tubes and place each of them over the smaller test tubes that contain mixtures.

Step 5. Then invert the small test tubes along with large test tubes as shown in figure 2.1.

Step 6. Measure the level of the air space formed in the small test tubes using ruler.

Step 7. Measure the air space formed after 20 minutes and record in the table 2.1.

Step 8. Plot a graph to show the rate of respiration against the concentration of glucose using MS software or a graph paper.

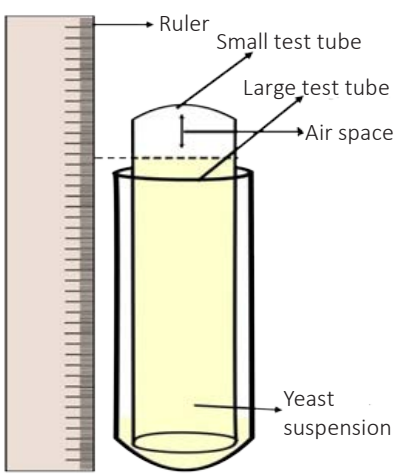


Figure 2.1 Initial experimental set up

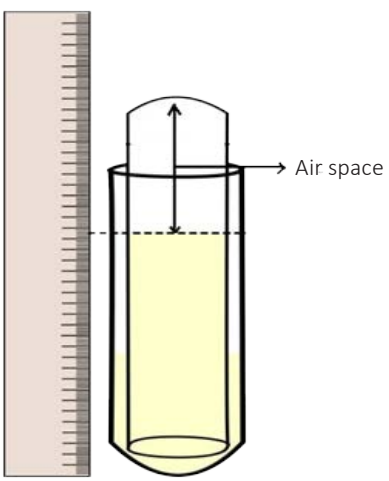


Figure 2.2 Experimental set up after X minutes

Observation:

Table 2.1. Length of Air Space in the Test Tubes

Test Tube	Glucose concentration (%)	Length of air space(cm) in the small test tubes after 20 minutes
A	0	
B	15	
C	30	
D	45	
E	60	
F	75	

Result:

Write result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Experiment 2b

Design and carry out an experiment to determine the effect of temperature on cellular respiration.

Question:

1. How is the concentration of glucose related to the rate of cellular respiration?
2. How would the temperature affect the rate of cellular respiration?
3. Why does the rate of cellular respiration decrease after certain point in time when the temperature is increased further?

3 EXPERIMENT

Effect of Carbon dioxide Concentration on the Rate of Photosynthesis

Experiment 3a

Aim: To study the effect of carbon dioxide concentration on the rate of photosynthesis.

Theory:

The external factors such as light intensity, carbon dioxide concentration and temperature affect the rate of photosynthesis. In a given situation, one of these factors become a limiting factor and control the rate of photosynthesis. For instance, the rate of photosynthesis increases with the increase in concentration of carbon dioxide as long as other factors are in adequate supply.

Question:

1. Does the concentration of carbon dioxide affect the rate of photosynthesis?
2. How does the carbon dioxide concentration affect the rate of photosynthesis?

Hypothesis: Formulate your own hypothesis.

Variable: Identify the following:

Independent variable

Dependent variable

Controlled variable

Material Required:

Specimen	Apparatus	Chemical
Aquatic plant	Wilmott's bubbler (1 No), water, petroleum jelly, stop watch (1 No), and digital balance (1 No)	$NaHCO_3$/ Na_2CO_3/ $KHCO_3$

Procedure:

Step 1. Take an aquatic plant and set up the experiment as shown in Figure 3.1

Step 2. Keep the set-up near the light source and count the number of bubbles evolved in a specified time. Record the observation in Table 3. 1.

Step 3. Add 5 g of $NaHCO_3$ into the flask and record the number of bubbles evolved in a specified time. Record the observation in Table 3.1.

Step 4. Add 10 g and 15 g of $NaHCO_3$ into the flask and record the number of bubbles evolved respectively. Record the observations in Table 3.1.

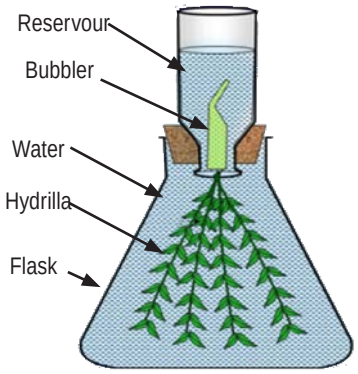


Figure 3.1. Wilmott's bubbler.

Step 5. Plot the graph showing number of bubbles evolved against the amount of $NaHCO_3$ using spreadsheet or graph paper.

Observation:

Table 3.1 Number of Oxygen Bubbles Evolved in Different Concentrations of $NaHCO_3$

Sl No	Quantity of $NaHCO_3$ (g)	Number of Bubble Evolved in 15 Min
1	0	
2	5	
3	10	
4	15	

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion from the result.

Experiment 3b

Explore and carry out leaf disc experiment to study the effect of light intensity on the rate of photosynthesis.

Question:

1. How would the result differ if a xerophytic plant is used instead of aquatic plant in the experiment?
2. What would happen to the rate of photosynthesis if the concentration of CO_2 keeps increasing?
3. Does photosynthesis help in the containment of global warming? Explain.

4 EXPERIMENT

Urine Analysis

Aim: To investigate the presence of sugar and protein in urine.

Theory:

Urine is slightly acidic in nature (pH 6.5 – 7). It is pale yellow in colour due to the presence of urobilin or urochrome. It contains water (95%), urea (9.3 g/l), chloride (1.87 g/l), sodium (1.17 g/l), potassium (0.750 g/l), creatinine (0.670 g/l) with traces of uric acid, and ions such as calcium, magnesium, bicarbonate, and phosphate.

The normal volume of urine produced is 1.5 -1.8 litres per day. However, the volume and the chemical composition vary with dietary intake and pathological condition of the body. Urine might also differ based on the activities carried out by a person. Urine shows higher levels of proteins (albumin), glucose, ketones and haemoglobin under abnormal conditions and their detection leads to diagnosis of different pathological conditions of kidneys.

Question:

Does your urine contain sugar and protein?

Material required:

Specimen	Apparatus	Chemical
Fresh urine	Bunsen burner, pH metre, red litmus paper, test-tubes, microscope,conical flask, cork, water bath, tripod stand, dropper, and digital weighing machine.	Sodium carbonate solution, Benedict's solution and glucose

Procedure:

Step 1. Collect about 50 ml of urine sample.

Step 2. Take 5mL of urine sample in the test tube and add 5mL of Benedict's solution. Place the test tube in the water bath(50-600C) for 3 minutes and observe the colour change.

Step 3. Take 5mL of urine sample in the test tube and add 1gram of Glucose. Further add 5mL of Benedict's solution to it and mix it thoroughly. Place the test tube in water bath(50-600C) for 3 minutes and observe the colour change.

Step 4. Take 5 mL of urine sample in a test tube and add sodium carbonate solution to it till the pH reaches 9.0. Then boil the content and test the solution with the red litmus paper and record the observation.

Observation:

Table 4.1 Chemical Content of the Urine

Test for constituents	Observation	Inference
Reducing sugar		
Reducing sugar after adding glucose		
Ammonia		

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. Why is urine test important?
2. What does the presence of sugar and protein represent?

5

EXPERIMENT

Effect of Enzyme Concentration on Digestion

Aim: To study the effect of enzyme concentration on digestion.

Theory:

Chemical digestion in our body is regulated by enzymes. The carbohydrates, fats, and proteins that we consume are all digested by enzymes. For instance, carbohydrates are digested by salivary and pancreatic amylase, while proteins are digested by proteases.

However, the working of enzymes is regulated by temperature, pH, substrate concentration, and enzyme concentration. Take, for example, the increase in enzyme concentration increases the rate of digestion while the decrease in enzyme concentration decreases the rate of digestion.

Question:

1. Does enzyme concentration affect the rate of digestion?
2. How does enzyme concentration affect the rate of digestion?

Hypothesis: Formulate your own hypothesis.

Variable: Identify the following:

Independent variable

Dependent variable

Controlled variable

Material Required:

Specimen	Chemical
Test-tube, test tube rack, test tube holder, droppers, water bath	Starch, Benedict's reagent, iodine solution, industrial amylase or saliva.

Procedure:

Step 1. Take five test tubes and label them from 1 to 5. Add 4 mL of 1 % starch in the first four test tubes. Add 4 mL of amylase solution in the fifth test tube.

Step 2. Place all the test tubes in the water bath at 37°C for 5 minutes.

Step 3. Remove the test tubes from the water bath. Keep test tube 1 as your control set-up.

Step 4. Add 3, 6, and 9 drops of warmed amylase solution into test tube 2, 3, and 4 respectively. Shake the test tubes gently and put them back in the water bath at 37°C for sometime to warm the mixture.

Step 5. Remove the test tubes from the water bath and add 3 mL of Benedict's reagent to each test tube.

Step 6. Place all the test tubes into the water bath for 3-4 minutes and observe the changes as shown in the figure 5.1. below.

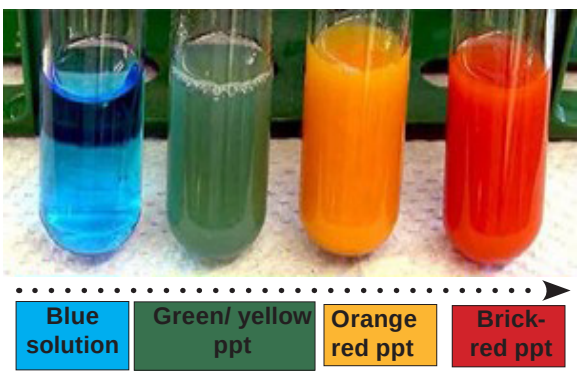


Figure 5.1 Color Change

Observation:

Table 5.1 *Effect of Enzyme Concentration on Digestion*

Test-tube	No. of drops (amylase)	Observation	Inference
1			
2			
3			
4			
5			

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. How would be the result of the experiment if temperature is not kept constant?
2. How would enzyme act if the substrate concentration is changed, while the enzyme concentration is kept constant?
3. Can enzyme supplements be beneficial for individuals with digestive disorders?

6

EXPERIMENT

Study of Plant Population Density

Aim: To study population density of plants using quadrat sampling method.

Question:

How does the number of individuals determine the population density of a species?

Materials required:

Apparatus
Twin thread (1 No), hammer (1 No), and nail (4 No)

Procedure:

Step 1. Select the study site randomly.

Step 2. Make a quadrat using nail(s) and thread. Ensure that the quadrate is 1 m X 1 m by dimension.

Step 3. Count the number of X, Y, Z, or other species present in the quadrat. Record the data in Table 6.1.

Step 4. Make six more quadrats in the study site.

Step 5. Count the number of X, Y, Z, or other species present in the quadrates. Record the data in Table 6.1.

Step 6. Calculate population density of each species using an mathematical expression:

Population Density (D) =Total number of individual species in all the quadrates (S) / Total number of quadrates (Q).

Observation:

Table 6.1 Population Density in Relation to the Number of Individual Species

Species	Number of Individuals in the Quadrat							Total Number of Individuals (S)	Total Number of Quadrats Studied (Q)	Population Density (D) = S/Q
	I	II	III	IV	V	VI	VII			
X										
Y										
Z										

Result:

Write the result based on observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. How does the number of individual species determine the population density of the species?
2. Do you think quadrat method is a suitable method for determining animal population density? Explain.
3. What are some of the precautions one must take while using quadrate sampling method?
4. Why should the sampling site be selected randomly?

EXPERIMENT 7

Anatomical Features of Monocot and Dicot Root

Aim: To study the anatomical features of monocot and dicot root.

Question:

What are the anatomical features of monocot and dicot root?

Materials required:

Specimen	Apparatus	Chemical
dicot root (1 No), and monocot root (1 No)	Microscope (1 No), razor blade (1 No), forceps (1 No), watch glass (1 No), brush (1 No), dropper (1 No), glass slide (1 No.), cover slip (1 No), needle (1 No), and blotting paper (1 No)	Safranin and glycerine.

Procedure:

Step 1. Prepare the temporary slide of TS of the monocot and dicot root specimen.

Step 2. Observe the slide under the microscope.

Step 3. Draw the labelled cellular diagram of the anatomical features of monocot and dicot roots.

Step 4. Record your observation in Table 7.1.

STAY SAFE

Handle razor blade with care.

Observation:

Table 7.1 Anatomical Features of Dicot and Monocot Roots

Anatomical Feature	Dicot Root	Monocot Root
Epidermis		
Cortex		
Vascular bundle		
Pith		

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

8

EXPERIMENT

Anatomical Features of Monocot and Dicot Stem

Aim: To study the anatomical features of monocot and dicot stem.

Question:

What are the anatomical features of monocot and dicot stem?

Materials required:

Specimen	Apparatus	Chemical
dicot stem (1 No), and monocot stem (1 No)	Microscope (1 No), razor blade (1 No), forceps (1 No), watch glass (1 No), brush (1 No), dropper (1 No), glass slide (1 No.), cover slip (1 No), needle (1 No), and blotting paper (1 No)	Safranin and glycerine.

Procedure:

Step 1. Prepare the temporary slide of TS of the monocot and dicot stem specimen.

Step 2. Observe the slide under the microscope.

Step 3. Draw the labelled cellular diagram of the anatomical features of monocot and dicot stems.

Step 4. Record your observation in Table 8.1.

STAY SAFE

Handle razor blade with care.

Table 8.1 Anatomical Features of Dicot and Monocot Stems

Anatomical Feature	Dicot Stem	Monocot Stem
Epidermis		
Hypodermis		
General cortex		
Pericycle		
Medullary rays		
Vascular bundles		
Pith		

Result:

Write the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. How would your observations differ if methylene blue is used in place of safranin?
2. Suggest other ways of distinguishing monocot from dicot plants besides their anatomical features.
3. What is scientific importance of studying anatomical features of angiosperms?

9

EXPERIMENT

Identification of Permanent Slides

Aim: To identify the permanent slide based on the anatomical features.

Question:

How unique features in plant and animal cells and tissues help in identifying unknown permanent slides?

Material required:

Permanent slide	Apparatus
TS of mammalian pancreas (1 No), striated muscle (1 No), prokaryotic cell (1 No), eukaryotic cell (1 No) and TS of monocot and dicot leaves.	Compound Microscope (1 No).

Procedure:

Step 1. Observe the given permanent slide under the microscope.

Step 2. Draw a labelled diagram of the specimen.

Observation:

List all the features of the specimen.

Result:

Write the result based on the observation..

Conclusion:

Draw a conclusion based on the result.

Question:

1. Describe how you would set up microscope to examine the given permanent slides under high power.
2. Study and identify any other permanent slides based on the anatomical features.

10 EXPERIMENT

Study of Human Organs

Aim: To study the parts of human organ using 3D model.

Question:

What are the parts of human organ and their functions?

Material required:

Model
Human kidney (1 No), Nephron (1 No), Neuron (1 No), Bones (1 No)

Procedure:

Step 1. Study the given 3D model of human organ.

Step 2. Draw a labelled diagram of the organ.

Step 3. State the function of parts of the organ.

Observation:

Write down all the features of the model.

Result:

Write down the result based on the observation.

Conclusion:

Draw a conclusion based on the result.

Question:

1. Study any other model and identify their parts.
2. Draw a labelled diagram and state the function of each part.

ANNEXURE A

Apparatus

Sl No	Name	Sl No	Name
1	Dissecting microscope	35	Gloves
2	Compound microscope	36	Tray
3	Forceps	37	Cotton roll
4	Razor	38	Balloon
5	Needle	39	Bathroom scale
6	Glass slide	40	Measuring tape
7	Blotting paper	41	Ruler
8	Camel brush	42	Petri dish
9	Hand lens	43	Watch glass
10	Test tube	44	Cover slips
11	Funnel	45	Masking tape
12	Beaker	46	Chopping board
13	Filter paper	47	Blender
14	Bunsen burner	48	Knife
15	Droppers,	49	Table spoon
16	water bath	50	Wilmott's bubbler
17	Test tube holder.	51	Cork borer
18	Digital pH metre,	52	Scalpel
19	Litmus paper,	53	Ganong’s potometer
20	Conical flask	54	Hess sampler
21	Cork	55	pH strips
22	Tripod stand,	56	Scissors
23	Digital weighing machine	57	Boiling tube
24	Thermometer	58	Hammer
25	Stop clock	59	Nail
26	Measuring cylinder	60	Twin thread
27	Glass rod		
28	Sieve		
29	Oven		
30	Spatula		
31	Tongs		
32	Clay crucible with perforated bottom		
33	Mortar and pestle		
34	Polythene bag		

Chemicals

Sl No	Name
1	Benedict's solution
2	Fehling's solution A and B
3	Seliwanoff's solution
4	Iodine
5	NaOH
8	Biuret reagent
9	Sudan III solution
10	NaHCO3
10	Glucose
11	Ethyl alcohol
12	Safranin
13	Glycerine
14	Petroleum jelly
15	Detergent
16	Sucrose/cane sugar
17	Distilled water
18	Methylene blue
19	Liquid paraffin
20	Hydrogen peroxide
21	NaCl

Permanent slides

Sl No	Name
1	T.S. of Mammalian pancreas
2	T.S of mammalian ovary
3	T.S of mammalian testis
4	T.S. of spinal cord
5	Striated muscle

3D models

Sl No	Name
1	Mammalian heart
2	Human eye
3	Human ear
4	Human brain
5	Human digestive system
6	Phases of mitosis

Plant and animal specimens

Sl No	Name	Sl No	Name
1	Rhizopus	8	Roundworm
2	Agaricus	9	Leech
3	Liverwort	10	Prawn
4	Fern	11	Honey bee
5	Pine	12	Snail
6	Amoeba	13	Star fish
7	Liver fluke		

ANNEXURE B

Assessment in Science Practical Works

Educational assessment is the process of documenting, usually in measurable terms, outcomes of knowledge, skills, attitudes and beliefs of the learners. This includes the processes of gathering and interpreting information about the progress of their learning. In order for the assessment to be valuable to individuals and organizations, the assessment must be accurate and objective. The learners should be well informed about what will be assessed and how it will be assessed. This makes the teacher's expectations clear to the learners to set appropriate learning outcomes. The teachers can play an important role in the learners' achievement by effectively monitoring their learning and giving them constructive feedback on how they can improve, and provide the necessary scaffolding for the needy learners as identified through the reliable assessment techniques and tools.

Purpose of Assessment

One of the first things to consider when planning for assessment is its purpose. Who will use the results? For what will they use them? Assessment is used to:

1. inform and guide teaching and learning: A good classroom assessment plan gathers evidence of student learning that informs teachers' instructional decisions. It provides teachers with information about what students know and can do. To plan effective instruction, teachers also need to know what the student misunderstands and where the misconceptions lie. In addition to helping teachers formulate the next teaching steps, a good classroom assessment plan provides a road map for students. Students should, at all times, have access to the assessment so they can use it to inform and guide their learning.
2. help students set learning goals: Students need frequent opportunities to reflect on where their learning is at and what needs to be done to achieve their learning goals. When students are actively involved in assessing their own next learning steps and creating goals to accomplish them, they make major advances in directing their learning, and what they understand about themselves as learners.
3. assign report card grades: Grades provide parents, employers, other schools, governments, post-secondary institutions and others with summary information about student learning.
4. motivate students: Research (Davies 2004; Stiggins et al. 2004) has shown

that students will be motivated and confident learners when they experience progress and achievement, rather than the failure and defeat associated with being compared to peers that are more successful. The achievements and performances of the learners in science are assessed on three domains (Work scientifically, scientific knowledge and scientific values and attitudes).

Areas of Assessment

Assessment in science involves detailed process of measuring students' achievement in terms of knowledge, skills, and attitude. The progress of learning is inferred through analysis of information collected.

The achievements and performances of the learners in Biology are assessed on the following three domains:

Scientific Knowledge

Advanced knowledge and understanding of living things with the environment, anatomy and physiology of living things, health and hygiene. The qualitative studies on genetics, microbiology and biotechnology from the perspective of the relevance and contribution to the existing body of knowledge in biology and human lives are crucial at this key stage.

Working Scientifically

Advanced, logical and abstract thinking; exploration, experimentation and investigation, and comprehension of complex situation, including exploration of how technological advancement are related to the scientific ideas that underpins them. Compare, contrast, synthesise, question and critique the different sources of information, and communicate their ideas clearly and precisely in a variety of ways, including the use of ICT.

Scientific Values and Attitudes

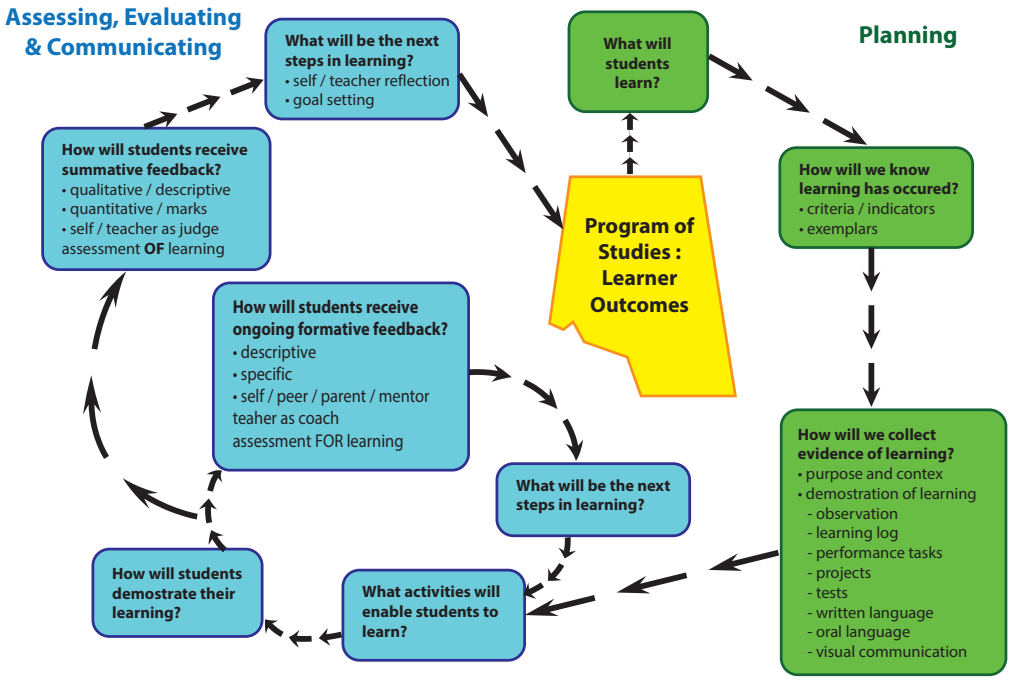
Consider the power and limitations of science in addressing social, industrial, ethical and environmental issues, and how different groups in the community and beyond may have different views about the role of science. They make informed judgments on statements and debates that have a scientific basis, and use their learning in science for planning positive action for their own welfare as well as of others in their community and the environment.

Assessment Process

Effective classroom assessment in Science may entail the following processes:

1. Addresses specific outcomes in the program of studies
2. Shares intended outcomes and assessment criteria with students prior to the assessment activity
3. Assesses before, during and after instruction
4. Employs a variety of assessment strategies to provide evidence of student learning
5. Provides frequent and descriptive feedback to students
6. Ensures students can describe their progress and achievement and articulate what comes next in their learning
7. Informs teachers and provides insight that can be used to modify instruction.

Assessing Student Learning in Classroom



Tools for Assessment of Science Practical Works

In order to assess the learners' performance objectively and provide empirical evidences, the following suggested tools are widely used in the assessment processes.

Observation Checklist

Observing students as they solve problems, model skills to others, think aloud during a sequence of activities, or interact with peers in different learning situations provide insight into their learning and growth. The teacher finds out under what conditions success is most likely, what individual students do when they encounter difficulty, how interaction with others affects their learning and concentration, and what students need to learn next. Observations may be informal or highly structured, and incidental or scheduled over different periods of time in different learning contexts.

Observation checklists allow teachers to record information quickly about how students perform in relation to specific outcomes from the program of studies. Observation checklists, written in a yes or no format can be used to assist in observing student performance relative to specific criteria. They may be directed toward observations of an individual or group. These tools can also include spaces for brief comments, which provide additional information not captured in the checklist.

Before you use an observation checklist, ensure students understand what information will be gathered and how it will be used. Ensure checklists are dated to provide a record of observations over a period of time.

Tips for using observation checklist:

1. Determine specific outcomes to observe and assess.
2. Decide what to look for. Write down criteria or evidences that indicate the student is demonstrating the outcome.
3. Ensure students know and understand what the criteria are.
4. Target observations by selecting four to five students per class for one or two specific outcomes to observe.
5. Develop a data gathering system, such as a clipboard for anecdotal notes, a checklist or rubric, or a video or audio recorder.
6. Collect observations over a number of classes during a reporting period and

look for patterns of performance.

7. Date all observations.
8. Share observations with students, both individually and in a group. Make the observations specific and describe how this demonstrates or promotes thinking and learning.
9. Use the information gathered from observation to enhance or modify future instruction.

Rating Scale

Rating Scales allow teachers to indicate the degree or frequency of the behaviours, skills and strategies displayed by the learner. Rating scales state the criteria and provide three or four response selections to describe the quality or frequency of student work.

Teachers can use rating scales to record observations which the students can use as self-assessment tools. Teaching students to use descriptive words, such as always, usually, sometimes and never helps them pinpoint specific strengths and needs. Rating scales also give students information for setting goals and improving performance. In a rating scale, the descriptive word is more important than the related number. The more precise and descriptive the words for each scale point, the more reliable is the tool. Effective rating scales use descriptors with clearly understood measures, such as frequency. Scales that rely on subjective descriptors of quality, such as fair, good or excellent are less effective because the single adjective does not contain enough information on what criteria are indicated at each of these points on the scale.

Rubrics

Rubrics are a set of criteria used to evaluate student's performance. They consist of a fixed measurement scale and detailed description of the characteristics for each level of performance. These descriptions focus on the quality of the product or performance and not the quantity; e.g., not number of paragraphs, examples to support an idea, spelling errors. Rubrics are commonly used to evaluate student performance with the intention of including the result in a grade for reporting purposes. Rubrics can increase the consistency and reliability of scoring. They may be used to assess individuals or groups performances..

Rubrics are increasingly recognised as a way to effectively assess student learning and communicate expectations directly, clearly and concisely to students.

The rubrics describe stages in the development and growth of knowledge, understandings and skills. To be most effective, rubrics should allow students to see the progression of mastery in the development of understandings and skills.

Rubrics are constructed with input from students whenever possible. A good start is to define what quality work looks like based on the learning outcomes. Examples of achievement need to be used to demonstrate to students what an excellent or acceptable performance is. This provides a collection of quality work for students to use as reference points. Once the standard is established, it is easy to define what exemplary levels and less-than-satisfactory levels of performance look like. The best rubrics have three to five descriptive levels to allow for discrimination in the evaluation of the product or task. Rubrics may be used for summative purposes to gauge marks by assigning a score to each of the various levels. Begin by developing criteria to describe the acceptable level. Then use Bloom's taxonomy to identify differentiating criteria as you move up the scale. The criteria should not go beyond the original performance task, but reflect higher order thinking skills that students could demonstrate within the parameters of the initial task.

While developing the scoring criteria and quality levels of a rubric, consider the following guidelines:

1. Level 4 is the Standard of excellence level. Descriptions should indicate that all aspects of work exceed grade level expectations and show exemplary performance or understanding. This level is a "Wow!"
2. Level 3 is the Approaching standard of excellence level. Descriptions should indicate some aspects of work that exceed grade level expectations and demonstrate solid performance or understanding. This level is a "Yes!"
3. Level 2 is the Meets acceptable standard. This level should indicate minimal competencies acceptable to meet grade level expectations. Performance and understanding are emerging or developing but there are some errors and mastery is not thorough. This level is a "On the right track, but …"
4. Level 1 Does not yet meet acceptable standard. This level indicates what is not adequate for grade level expectations and indicates that the student has serious errors, omissions or misconceptions. This level is a "No, but …" The teacher needs to make decisions about appropriate intervention to help the student improve.

After a rubric has been created, students can use it to guide their learning. Criteria described in a rubric serve to focus student reflection on their work and facilitate

the setting of learning goals for a particular performance assessment. Through self-assessment or peer-assessment by using rubrics, students can assess the quality of work completed to date and guide them in planning steps in learning.

The following tables provides the format for recording and assessment of students' performances in the biology practical classes.

Format to Record Biology Practical Assessment

Name	Performance Criteria						Total scores (24)
	Question (4)	Variables (4)	Manipulative skills (4)	Data Analysis (4)	Conclusions (4)	Communication (4)	
Sonam							
Wangmo							
Dorji							

Rubric to Assess Biology Practical

Performance Criteria	Performance Rating (Score)			
	4	3	2	1
Question	Clear, testable, relates to aim and shows the variables	Stated but one of the qualifiers is missing	Stated but two qualifiers are missing	Stated but three qualifiers are missing
Hypothesis	Relevant, testable, specific and predicts relationship between variables	Stated but one of the qualifiers is missing	Stated but two qualifiers are missing	Stated but three qualifiers are missing
Variables	Independent, dependent and controlled variables are correctly spelled out	One variable is missing or misattributed to other variable	Two variables are missing or misattributed to other variables	Three variables are misattributed to other variables
Manipulative Skill	Uses appropriate method and obtains relevant and sufficient data	Uses appropriate method, obtains relevant but insufficient data	Uses appropriate method but obtains irrelevant and insufficient data	Uses inappropriate method, and obtains irrelevant and insufficient data
Data analysis	Appropriate mathematical procedures and graphic representation with clear interpretation	Appropriate mathematical procedures and graphic representation but no clarity in interpretation	Appropriate mathematical procedures but lacks graphic representation and clarity in interpretation	Inappropriate mathematical procedures and lack graphic representation and clear interpretation

Performance Criteria	Performance Rating (Score)			
	4	3	2	1
Conclusion	Relates to hypothesis, shows scientific facts and explains the phenomena, and links to a new context	Relates to hypothesis, shows scientific facts and explains the phenomena	Relates to hypothesis and shows scientific facts	Relates to hypothesis only
Communication	The record is relevant and evidence-based	The record is relevant but lacks evidence	The record lacks both the relevancy and evidence	The record is incomplete

Note.

1. For the prescribed list of experiments, one may come across the research question spelled out beforehand. Therefore, teachers are advised to assess all the phases of inquiry cycle, except the research question. More so, if the experiments are organised in the manner of qualitative inquiry/inductive approach/theory development, the same do not entail to test hypothesis as well as identify the variables. Therefore, in such instance, teachers are advised to forgo with the assessment of hypothesis and variables. As a result, the total score many not necessarily be same with the one featured in Table 4.1.

2. If the experiments demand students to design and carry out independently, then teachers are expected to base the assessment on all the phases of inquiry. However, if the experiments are to be devised and carried out based on the principles of qualitative inquiry/ inductive approach /theory development, teachers are advised to forgo with the assessment of hypothesis and variable criteria.

   Therefore, the total score many not necessarily be same with total score spelled out in table 4.1.

Anecdotal Notes

Anecdotal notes are used to record specific observations of individual student behaviours, skills and attitudes as they relate to the outcomes in their learning. Such notes provide cumulative information on student learning and direction for further instruction. Anecdotal notes are often written as results of ongoing observations during the lessons but may also be written in response to a product or performance the student has completed. They are brief, objective and focused on specific outcomes. Notes taken during or immediately after activity are generally the most accurate. Anecdotal notes for a particular student can be periodically shared with the student or be shared upon the student's request. They can also be shared with students and parents at parent–teacher–student conferences.

1. The purposes of anecdotal notes are to:

   (a) provide information regarding a student's development over a period of time.

   (b) provide ongoing records about individual instructional needs.

   (c) capture observations of significant behaviours or skills that might otherwise be lost.

(d) provide ongoing documentation of learning that may be shared with students, parents and teachers.

2. Tips for establishing and maintaining anecdotal notes:

(a) Keep a binder with a separate page for each student. Record observations using a clipboard and sticky notes. Write the date and the student's name on each sticky note. Following the note taking, place individual sticky notes on the page reserved for that student in the binder.

(b) Keep a binder with dividers for each student and blank pages to write notes. The pages may be divided into three columns: Date, Observation and Action Plan.

(c) Keep a class list in the front of the binder and check off each student's name as anecdotal notes are added to their section of the binder. This provides a quick reference of the students you have observed and how frequently you have observed them.

(d) Keep notes brief and focused (usually no more than a few sentences or phrases).

(e) Note the context and any comments or questions for follow-up.

(f) Keep comments objective. Make specific comments about student strengths, especially after several observations have been recorded and a pattern has been observed.

(g) Record as the observations are being made, or as soon after as possible, so recollections will be accurate.

(h) Record comments regularly, if possible.

(i) Record at different times and during different activities to develop a balanced profile of student's learning.

(j) Review records frequently to ensure that notes are being made on each student regularly and summarise information related to trends in students' learning.

(k) Share anecdotal notes with students and parents formally and informally.

Scheme of Assessment

The Biology practical works of learners are assessed through the following schemes of assessment:

Continuous Formative Assessment (CFA)

Formative assessment is used to provide feedback to teachers and learners, so that teaching and learning can be improved through provision of regular feedback and remedial learning opportunities for the learners when needed. It also enables the teachers to understand what teaching methods and materials work best.

CFA facilitates teachers to diagnose the learning needs of learners and recognise individual differences in learning. Through the constructive feedback provided, learners are able to understand their strengths and weaknesses. It also empowers them to be self-reflective learners who monitor and evaluate their own progress.

CFA should happen daily throughout the teaching-learning processes of the academic year. It is NOT graded, its purpose is to give continuous feedbacks to the learners. The tools identified for CFA are checklists and anecdotal records.

The suggested techniques for CFA for the three domains are:

1. work scientifically: Class work, observations, immediate interaction with the students, etc.
2. scientific knowledge: Question and answer, homework, class work, etc.
3. scientific values and attitudes: Observations of students' conduct guided by scientific and social values.

Continuous Summative Assessment (CSA)

Continuous Summative Assessment is another form of continuous assessment. It helps in determining the learner's performance and the effectiveness of instructions. The feedback from this assessment helps students improve learning, and guides teachers to incorporate varied teaching strategies and resources to ensure quality teaching and learning in the science classes. It empowers learners to be self-reflective learners who monitor and evaluate their own progress.

In CSA, the learner's performances and achievement are graded. This ensures active participations of learners in the teaching-learning processes. The main tools for CSA are rubrics, and paper pencil tests.

The suggested techniques for CSA for the three domains are:

1. work scientifically: Project work, science journal and scrapbook, and practical works.
2. scientific knowledge: Home work, and class tests.

3. scientific values and attitudes: Observation of the learners' conduct in the classroom guided by scientific and social values.

Summative Assessment (SA)

Summative assessment (SA) is conducted at the end of the first term and at the end of the year to determine the level of learning outcomes achieved by the learners. The information gathered is used by the teachers to grade learners for promotion and to report to parents and other stakeholders.

The identified techniques for SA are term examinations - first term and annual examinations. The questions for the term examinations should cover all the three domains of science learning objectives using the principles of Bloom's taxonomy

Assessment Matrix

The assessment types, techniques and tools of assessment, frequency and weighting for each assessment type and domains are summarised in the assessment matrix given below.

Assessment Matrix for Class XI and XII

Assessment Matrix								
Types of assessment	**CFA**			**CSA**			**SA**	
Definition	It is a continuous process of assessing student's problems and learning needs and to identify the remedial measures to improve student's learning. It also enables teachers to understand what teaching methods and materials work best.			It is a continuous process of grading student's performances and achievements. Teachers provide feedbacks for improvement. It also enables teachers to understand what teaching methods and materials work best.			Assesses student's cumulative performances and achievements at the end of each term.	
Domains	Scientific knowledge (SK)	Working scientifically (WS)	Scientific values and attitudes (SV)	Scientific knowledge (SK)	Working scientifically (WS)	Scientific values and attitudes (SV)	SK, WS & SV	SK, WS & SV
Techniques	Quiz & debate,class presentation, homework, class work, immediate interaction with students.	Immediate interaction with students, class work, home work, experiments, exhibition, case studies	Observation of student's conduct, in group work, field trip, excursion, etc.	Class Test	Practical work	Project Work.	Term exam.	Term exam
Assessment Tools	Q&A, checklist and anecdotal records.	Checklist and anecdotal records.	Checklist and anecdotal records.	Paper pencil test	Rubrics (Practical work)	Rubrics (Project work)	Paper pencil test	Paper pencil test

Assessment Matrix						
Types of assessment	**CFA**	**CSA**			**SA**	
Frequency interval (when &how)	Checklists and anecdotal records must be maintained for each topic throughout the academic year.	Monthly	Twice in each term	Project Work – One PW for Cl 11 & 12 but the work is assessed in parts in each year.	Once in a term.	Once in a year.
Format in Progress Report		SK	WS	SV	Mid-Term	Annual Exam
		T1= 2.5 T2= 2.5	T1=15 T2= 15	T1= 2.5 T2= 2.5	T1=20	T2=40
NB:	Same mode of assessment will be followed in Mid Term and Trial examinations for Class 12. The mark for the Project Work of Class 12 is the sum total of Cl 11 and 12, which is out of 10 (5+5). The Cl 12 Practical Examination (20) is assessed externally.					

ANNEXURE C

Sample Question Paper

BIOLOGY PRACTICAL WORKS Paper -2

Three hours and a quarter

(The first 15 minutes of the examination are for reading the paper only) Candidates will NOT be allowed to write or start working on the apparatus during this time).

ALL ANSWERS MUST BE WRITTEN IN THE ANSWER BOOKLET.

Read the questions carefully and follow the given instructions.

Marks are given for clear record of observations actually made and correct significant figures and units wherever applicable.

Candidates are advised to write practical work laboratory report for Question 1.

Candidates are advised to write the observation report as demanded by the procedure for Question 2.

All workings, including rough work, should be done on the same sheet as, and adjacent to, the rest of the answer.

The intended marks for questions or parts of questions are given in brackets [ ].

Question 1

(a) Theory: Light intensity is one of the abiotic factors which influence the rate of transpiration. The rate of transpiration increase with the increase of light intensity.

To test the above theory, design and carry out an experiment to determine the effect of light intensity on the rate of transpiration. You are expected to provide information on the following components: [6 Marks]

- Research question
- Hypothesis
- Dependent, independent, and controlled variable
- Material required
- Procedure
- Observation (with diagram, table, or any list of finding)
- Calculation (if needed)
- Result
- Conclusion

(b) You are provided with compound microscope and specimen A. [4 Marks]

(i) Identify the given specimen A by focusing it under the compound microscope.

(ii) Show your set-up to the visiting examiner.

(iii) Draw the diagram of the specimen and labell the parts.

(iv) Write two points to support your identification

Question 2.

(a) Identify the family of flower specimen D-1 and D-2. [5 Marks]

(i) Observe specimen D-1. Describe its symmetry.

(ii) Take specimen D-1. Describe the characteristics of sepals and petals using semi-technical terms.

(iii) Dissect the specimen D-1 to observe the following characteristics.

1. Sexuality
2. Insertion point of floral whorls
3. Complete or incomplete

(iv) Examine the androecium carefully and answer the following:

1. Number of stamen (on the basis of cohesion)
2. Cohesion of stamen
3. Anther lobe
4. Attachment of anther to the filament
5. Draw a neat labelled diagram of androecium

(v) Examine specimen D-2. Display floral parts and show it to the visiting examiner.

(vi) Compare specimen D-1 and D-2 based on the observation:

Feature of Floral Whorl	D-1	D-2
Cohesion of sepals		
Aestivation of corolla		
Position of ovary		
Length of stamens		
Placentation		

(vii) Write the floral formula for the specimen D-1.

(viii) Draw a floral diagram for the specimen D-1.

(ix) Identify the family of specimen D-2. Give two reasons for your identification.

(b) Theory: When a cell is placed in the hypertonic solution, it lose the water into the surrounding solution by a process called exosmosis or plasmolysis. As a result, the cell lose its turgor pressure and induce change in its protoplasmic content. The plasmolysed condition of a cell can be reversed by placing it into the hypotonic solution:

Conduct an experiment to determine the effect of concentration of solution on plant cell as per the instructions provided below. You are required to provide information wherever required [5 Marks]

i. Question: How does the concentration of solution affect the protoplasmic content of the plant cell?

ii. Hypothesis:……..

iii. Variables:

1. Independent variable……

2. Dependent variable……..

3. Controlled variable……..

iv. Materials Required:

Few fleshy leaves of an onion bulb, compound microscope (1 No), forceps (1 No), glass slide (2 No), coverslip (2 No), needle (1 No), dropper (2 No) and blotting paper (1 No), petri dish (2 No), brush (1 No), safranin, water, and sugar.

v. Procedure:

1. Cut about 1 cm^2 of a fleshy leaf of an onion bulb, remove its epidermal layer (peel) from the concave side and place it in water.

2. Stain the peel with safranin.

3. Mount it on a slide with water, observe it under the microscope and record your observation.

4. Draw the water out from the slide with blotting paper.

5. Add 2-3 drops of sugar/salt solution to the slide and keep it undisturbed for about 5 min.

6. Observe under the microscope.

7. Add few drops of water to the same slide and keep it undisturbed for about 10 min.

8. Observe under the microscope.

vi. Observations: Record your observation in the table given below:

Mount	Observation
In water	
In salt/sugar solution	
After adding water	

vii. Questions:

1. Write the result based on the observation.
2. How does the concentration of solution affect the protoplasmic content of plant cell? Explan.
3. How would the result differ if an animal cell is used in place of plant cell?
4. How is the scientific principle of this experiment similar to the salting of fish and pickle?

Note. The aspects of question paper are subjected to change. Therefore, please take note of the following:

1. *At times, you may be asked to (a) test or develop theory based on the prescribed elements- structured inquiry, (b) test or develop theory by designing your own procedures and other necessary elements based on the prescribed aim, question, and materials-guided inquiry, or (c) design and carry out the experiment based on the materials provided-open inquiry.*
2. *The number of questions and sub-questions may vary.*
3. *Marks allotted for each question and sub-question may also change.*
4. *It is not necessary to repeat the similar experiment every year.*