Introduction

Laboratory is a place where ideas and concepts can be tested through experiments. Biology, like any other discipline of science, is based on experimental work and therefore practical forms an integral part of learning. Biology laboratory provides a unique learning environment where learners inculcate scientific temper, develop relevant skills and get exposed to realms of techniques and methodologies of scientific investigations. Laboratory investigations in Biology increase the reasoning abilities, bring scientific attitude in a learner and also help in acquisition of skills of scientific processes. Also, observation of nature and the living organisms found in it is no less important for the understanding of many aspects of the subject especially the diversity of the living organisms, their systematic study, their relationships among themselves and with the environment. Knowledge in the field of Biology can be acquired or constructed only on the basis of correct observations and experimentally verifiable processes.

Biology laboratory thus provides the learners an environment where the process of learning is facilitated by hands-on experiments. Biology is a unique discipline in the sense that it does not merely deal with the study of morphology, anatomy, physiology and reproduction of the living organisms, rather, understanding of the subject requires understanding of a number of interdisciplinary areas and approaches. On one hand, a biologist needs to be sufficiently skilled in handling the enormous diversity of the living organisms, be it plants, animals, fungi or even microscopic bacteria, while on the other hand, a biologist should be able to understand the biochemical, molecular, physiological, behavioural, genetic and many other phenomena pertaining to the living organisms. The study of intricate relationship of different types of organisms among themselves and also with its environment is an important concern of a biologist. Thus, experiments and exercises in Biology train a learner about skills of observations, manipulation of the organisms for the study of internal details, biochemical as well as molecular composition and processes, investigation of the abiotic environment and even analysis of phenomena like inheritance and evolution.

As far as the study of the living organism is concerned, correctness of the method is very important. Such a study may be very simple, e.g., study of habit, habitat and external features of the plants or animals, or, it may involve certain manipulations like dissection and section cutting of the parts of the organisms to study the minute details. Very often observation and study of the magnified image of the minute parts under a microscope provides a better insight about the features of the organisms. However, microscopic study involves certain specific skills depending on type of the organisms/ tissues/cells to be studied. It involves specific preparations (peeling, section

cutting, fixation, staining, dehydration, mounting, etc.) so that microscopic examination reveals the expected details. As histological and cytological observations give us only static pictures of the continuous processes, analysis of biochemical, physiological and ecological aspects need certain other kinds of skills such as preparation of chemicals and reagents, designing and performing an experiment, observation and recording of data and ultimately interpretation and drawing conclusions. While performing experiments, honesty in recording of data and its correct presentation is very important as it is not only useful in the logical interpretation but also helps in the identification of errors.

In order to perform experiments successfully, a learner needs to go to the Biology laboratory well prepared. This includes the following:

1. Laboratory Record Book: For maintaining all the information including recording of data and its interpretation.
2. Dissection Box: A dissection box is required in the Biology laboratory for various purposes like handling and manipulation of living materials, performing experiments, preparation of slide, etc. A dissection box should contain scissors (two pairs, one small with fine tip and one larger), scalpels (one small and one medium sized), forceps (two, one small with sharp fine tips and the other medium sized with blunt tips), dissecting needles (two), razor, hand lens, dropper, fine brush, etc.
3. Laboratory Manual
4. A Laboratory Coat or Apron
5. A Hand Towel

While in the laboratory a student should be very careful and methodical. One should listen carefully to the instructions given by the teacher/ instructor before performing an experiment. In the biology laboratory a student has to handle a number of sharp objects and hence necessary precaution and care should always be taken while handling objects like scissors, forceps, needles, scalpel, razor, etc. It is also very important to follow the safety instructions mentioned on the instruments and/or on the label of the reagent/chemical. Students should also be aware about the use of the First-aid Box so that in case of any accident or injury the preliminary aid can be provided to the affected person.

While describing the experiment students are expected to follow a pattern in which the aim of the experiment, its principle, list of the materials to be used, procedure, observation table (if required), inference and discussion should be given. Necessary precautions to be taken should also be mentioned appropriately in the procedure or at the end. There are a few experiments in which field visit is essentially required. For this all the necessary preparations (materials, equipments, reagents and chemicals)

should be made in advance. Drawing of illustrations is also an important component of the practical in Biology. Students are expected to follow certain fundamental rules while drawing the illustrations so that it reflects your observations correctly.

- Make your illustrations using pencil only and always use white drawing sheet. Illustration should be in the centre of the page.
- Drawing of an object (plant, animal or experimental set-up) should be proportionate in size.
- Draw your illustrations keeping the object before you.
- Drawing must be clear with simple outlines.
- Appropriately label your drawing. Parts of the drawing should be indicated by straight horizontal line or arrow. Two lines or arrow should never cross each other. As far as possible, labelling should be done on the right side of the drawing. An appropriate legend or heading of the drawing should also be given below it.

About the Manual

The main objective of the manual is to introduce the students of higher secondary stage to the fascinating world of plants, animals and microbes and their complex biological phenomena. The manual covers a complete description of the experiments and exercises. The suggested experiments cover almost all the units/topics including those on diversity in living world, plant, animal and human physiology, genetics, bio-technology and human welfare and environment. A standard format has been used to describe each experiment which includes

- **Aim**: It gives a brief title of the experiment under investigation.
- **Principle**: It is a very brief introduction of the experiment under investigation and explains the biological phenomenon involved. It gives brief but comprehensive ideas about the design of the experiment and explains the significance of the phenomenon being studied.
- **Materials required**: This includes the names of plants/animals to be used as 'samples', the type of apparatus, the type and quantity of glasswares required, reagents, chemicals and solutions needed, their concentration and other specifications, method of preparations of solutions and reagents. If a particular material/chemical/glassware is not available, sufficient alternatives have been suggested.
- **Procedure**: This section includes full details of experimental procedure explained stepwise, including special precautions necessary to be taken while the experiment is being conducted. Drawings of the samples, apparatus and the experimental setup, wherever found necessary, have been included to facilitate the students to perform the experiment as accurately as possible.

- **Observation and Results**: This section deals with the recording of all observations made during the experiment. Students are advised to consider the entire data. Data can be represented in the form of tables, graphs and histograms wherever possible. Use of units in which various quantities are measured has been indicated in the manual.
- **Discussion**: Included in this heading is a statement of the conclusions drawn from the experimental results and compared thesis (wherever possible) with any comparable data from other sources. The relevance of the conclusions drawn from the experimental results to the various processes under investigation and to the life of plant, animal and microbes has been prompted out.
- **Precaution**: This section contains all the necessary precautions to be taken during experimentation to obtain results free of errors. However, attempts have been made to mention required precautions along with the procedure also.

A great emphasis has been laid on a student getting valid results and interpreting them. It is essential that the teacher should properly explain each experiment so that inexperienced students will be able to obtain accurate results within a reasonable time. Teachers are also expected to help students in identifying errors and mistakes committed during experiments and ways for correcting them. It is possible that some of the students may undoubtedly be capable of doing more sophisticated work than that represented in the manual. But introductory course of this sort has been designed to help all students for some useful and joyful experience by conducting the experiments of their own. The manual also aims that students and teachers not be discouraged by either incomplete experiments or experiments which yield apparently meaningless results.

With the objectives of inculcating scientific temper among learners and providing them an opportunity to undertake independent scientific investigation, Investigatory Project Work has been included as an integral part of the practical curriculum of Class XII. Such investigatory projects are expected to provide thrill in the learning process. It is also expected to serve the real purpose of practicals, i.e., developing an ability to hypothesise and design experiments to address certain problems, to make observations methodically and to draw conclusions out of the experimental data. A comprehensive idea about undertaking investigatory project has been given in the book with a list of a few problems on which investigatory project work can be undertaken. However, the list is only suggestive and considering the wider scope students can undertake any kind of investigatory project work depending on their region, its climatic condition, availability of resources, etc.

Exercise 1

Aim: To study the reproductive parts of commonly available flowers

Principle: The male reproductive parts of a flower are the stamens collectively called androecium and the female reproductive parts are the carpels/pistils collectively called gynoecium. The individual units of stamen consist of a filament, which supports the anther lobes. Gynoecium consists of stigma, style and ovary. Many variations are found in different characteristics of both the stamens and carpels. We shall try to study these variations in the reproductive parts of flowers in the exercise.

Requirement: Commonly available flowers, needles, forceps, razor/scalpel blade, brush, slides, cover slip, watch glass, magnifying lens, dissecting microscope, compound microscope, etc.

Procedure

(i) Familiarise with the terms to describe the reproductive parts of flowers given in annexures of Exercise No. 11 of Laboratory Manual: Biology (Class XI) and at the end of this experiment.

(ii) Observe the flower with the naked eye, hand lens or under a dissecting microscope. Study their reproductive parts and count the number of stamens and record their cohesive and adhesive features.

(iii) Cut L.S. of the flower and place it on a slide to observe the following characters:

  (a) Placement of anthers

  (b) Position of the ovary: epigynous/perigynous/hypogynous.

(iv) Mount one stamen on a slide and study the following characters:

  (a) Attachment of filament to anther

  (b) Dehiscence pattern of the anther lobes for discharge of pollen.

(v) Cut T.S. of anther lobe to observe the number of pollen sacs.

(vi) Mount the pistil on a slide and study style, stigma and ovary. Record the number of stigma and nature of pistil.

(vii) Cut T.S. of ovary, mount it on a slide and observe

  (a) Number of locules in the ovary

(b) Type of placentation

(c) Number of ovules per locule

(viii) Draw labelled figures of your preparation and observations.

Questions

1. Name the most common type of placentation observed.
2. What is the most common type of dehisence pattern in anthers?
3. Name a few unisexual flower-bearing plants studied by you.
4. "Flower is a modified shoot." Justify the statement based on your observation.

Annexure 1

Description of reproductive parts of flowers

Androecium

Number of stamens	The number of stamens may vary from a few to many in different flowers
Cohesion (Fig. 1.1 a–e)	Stamens may be free or united. If united they can be of the following type: (i) ***Syngenesious***: Filaments free and anthers united, e.g., Sunflower. (ii) ***Synandrous***: Stamens fused all through their length, e.g., *Cucurbita* (iii) ***Adelphous***: Anthers remain free and filaments are united. Adelphous condition can be (a) Monoadelphous—United to form 1 bundle, e.g., China rose (b) Diadelphous—United to form 2 bundles, e.g., Pea (c) Polyadelphous—United into more than two bundles, e.g., Lemon
Adhesion (Fig. 1.2)	Fusion of stamens with other parts of the flower (i) ***Epipetalous***: Stamens fused with petals, e.g., Sunflower, Datura (ii) ***Epiphyllous***: Stamens fused with perianth, e.g., Lily
Attachment of filament to anther (Fig.1.3 a–d)	(i) ***Basifixed***: Filament attached to the base of anther, e.g., Mustard (ii) ***Adnate***: Filament attached along the whole length of anther, e.g., Michelia, Magnolia (iii) ***Dorsifixed***: Filament attached to the back of anther, e.g., Passion flower (iv) ***Versatile***: Anther lobes attached with filament in the middle portion with both ends free, e.g., Gramineae family
Dehiscence pattern (Fig. 1.4 a,b)	(i) ***Porous***: Pollens released through pores, e.g., Brinjal, Potato (ii) ***Longitudinal***: Pollens released through the longitudinal slit of another lobes, e.g., China rose, Cotton

Gynoecium

Number of stamens	**The number of stamens may vary from a few to many in different flowers**
Position of ovary (Fig. 1.5 a–d)	(i) ***Epigynous***: Position of ovary inferior to other floral parts, e.g., Mustard, China rose (ii) ***Perigynous***: Other floral parts are attached around the ovary, e.g., Apple, Guava (iii) ***Hypogynous***: Position of ovary superior to other floral parts, e.g., Sunflower
Cohesion (Fig. 1.6 a–c)	If number of carpels is more than one, they may be (i) ***Apocarpous***: Carpels are free. Each carpel has its own style and stigma, e.g., Rose (ii) ***Syncarpous***: Carpels are united, e.g., Lady's finger, Tomato
Number of locules in ovary	Vary from one to many (i) ***Unilocular***: One locule, e.g., Rose, Pea (ii) ***Bilocular***: Two locules, e.g., Datura (iii) ***Multilocular***: Many locules, e.g., Lady's finger, China rose
Placentation (Fig. 1.7 a–e)	(i) ***Marginal***: The placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge, e.g., Pea (ii) ***Axile***: The ovary is partitioned into several chambers or locules and the placentae are borne along the septa of the ovary, e.g., Tomato, China rose (iii) ***Parietal***: The ovules develop on the inner wall of the ovary or on peripheral part. Ovary unilocular but in some cases becomes two chambered due to formation of a false septum, e.g., Mustard (iv) ***Free central***: Ovules are borne on the central axis and septa are absent, e.g., Carnation, Chilly (v) ***Basal***: Placenta develops at the base of the ovary, e.g. ,Sunflower.

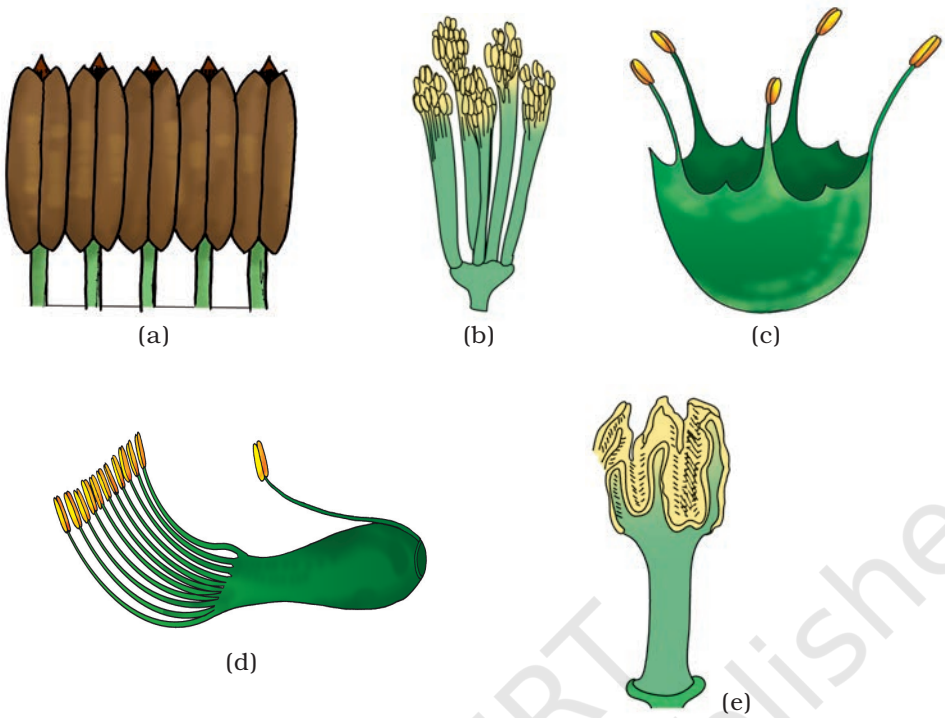


Fig.1.1 Cohesion of stamens: (a) Syngenesious (b) Synandrous (c) Monoadelphous (d) diadelphous (e) Polyadelphous

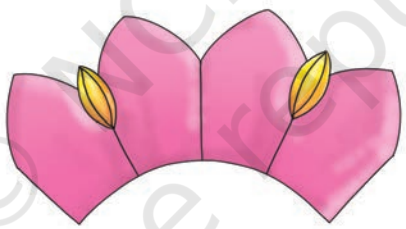


Fig.1.2 Adhesion of Stamens: Epipetalous/Epiphyllous

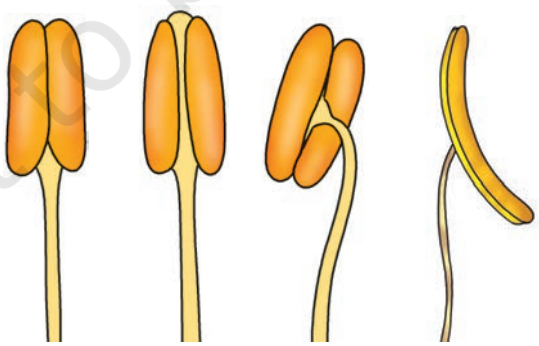
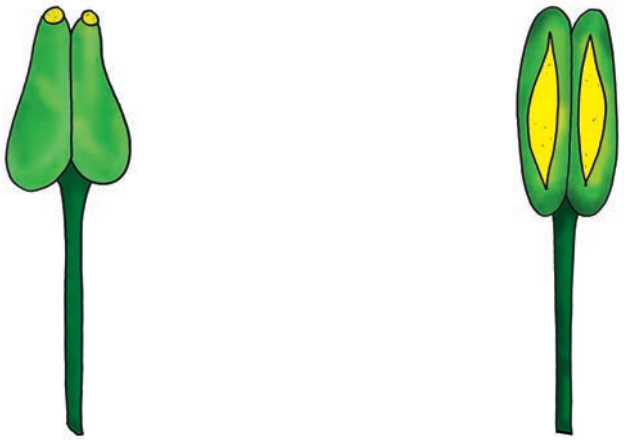


Fig.1.3 Attachment of filament to anther: (a) Basifixed (b) Adnate (c) Dorsifixed (d) Versatile

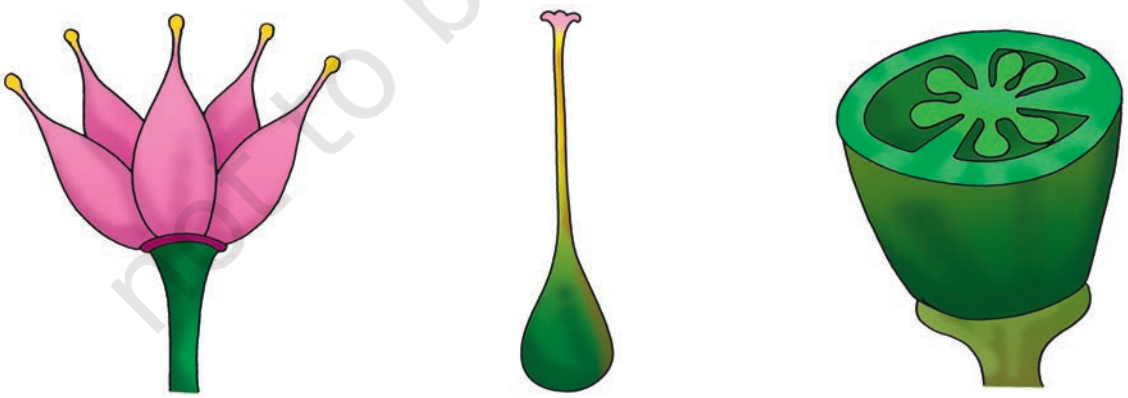


(a) (b)

Fig.1.4 Dehiscence pattern of anther: (a) Porous (b) Longitudinal

(a) (b) (c) (d)

Fig.1.5 Position of ovary: (a) Epigynous (b–c) Perigynous (d) Hypogynous



(a) (b) (c)

Fig.1.6 Cohesion of carpels: (a) Apocarpous (b–c) Syncarpous

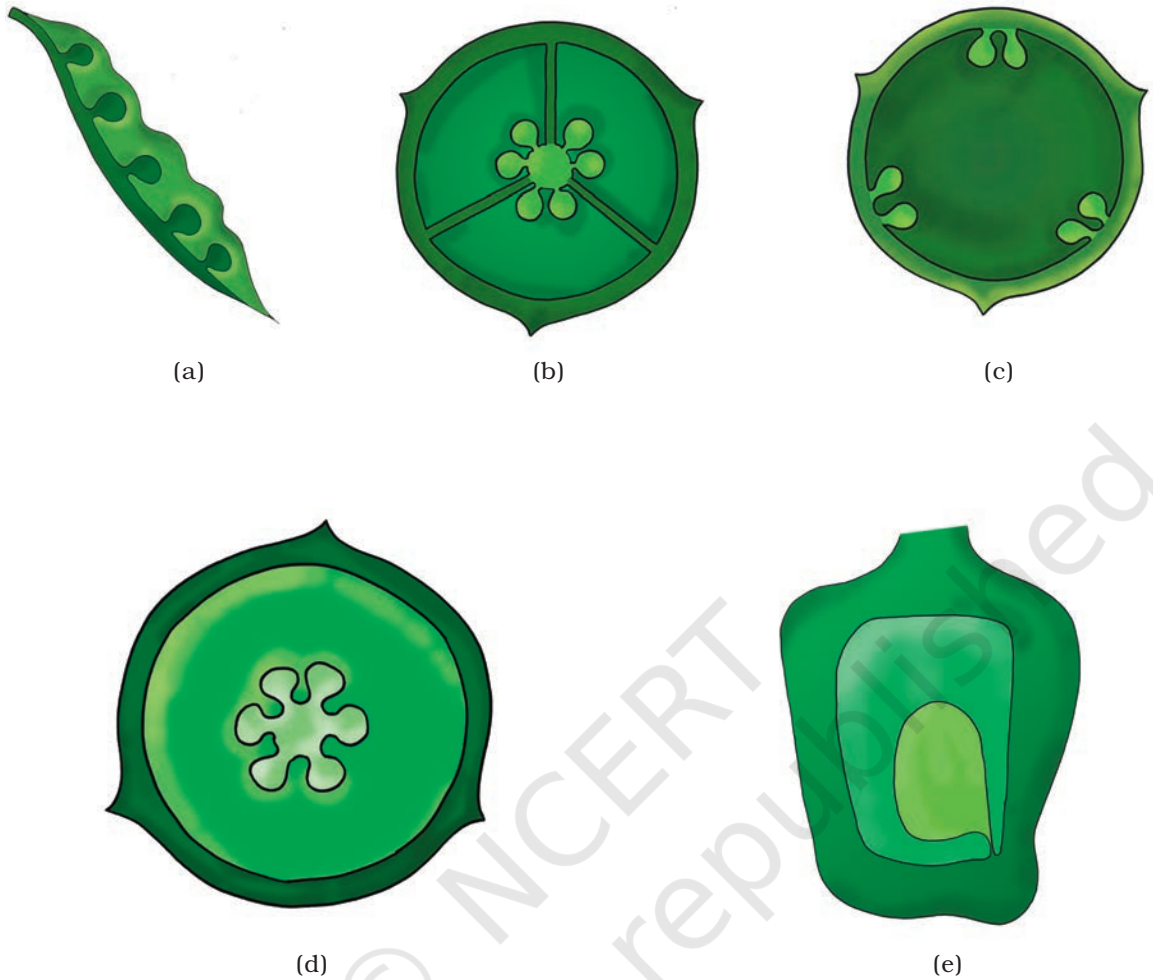


Fig.1.7 Placentation: (a) Marginal (b) Axile (c) Parietal (d) Free central (e) Basal