HIGHER SECONDARY - SECOND YEAR
BOTANY PRACTICALS

INTRODUCTION

Laboratory is a place where ideas and concepts can be tested through experiments. Laboratory investigations in biology increase the reasoning abilities, brings scientific attitude in a learner and also helps in acquisition of skills of scientific processes. Hence, a biology student too, is obliged to attend practical in laboratory with utmost sincerity, honesty and inquisitiveness. The practical work includes

- ❖ Study of permanent slides
- ❖ Microscopic preparation of slides
- ❖ Study of preserved and fresh specimens
- ❖ Section, cutting and mounting
- ❖ Analysing the problem and solving it
- ❖ Physiological experiments, etc.

GENERAL INSTRUCTIONS

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

VMNJ53

1. Laboratory record book
2. Dissection box
3. Laboratory manual
4. A laboratory coat or apron
5. A hand towel
6. Drawing pencil (HB) and pencil eraser to record various experiments and to draw diagrams
7. Any item more as per the instructions of the teacher

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. Maintain a complete silence and working atmosphere in the laboratory. Record keeping is most important in practical. Diagrams should be correctly drawn and well labelled. Always get the signature of the teacher in the practical note book on each day after the practical class.

However, it is important that every student of Botany / Biology may pay proper attention to the practical work and should try to acquire basic laboratory skills and develop a keen sense of observation and acquire a sound training in the reporting of the work done.

If the material suggested for a particular experiment is not available, a suitable alternate material may be used.

BOTANY PRACTICALS

MODEL QUESTION

I.	Identify the given slide 'A' and give any two reasons. Draw a neat, labelled diagram.
II.	Identify the given fresh / preserved specimen 'B" and give any two reasons.
III.	Identify the given model / photograph / picture 'C' and give any two reasons.
IV.	Analyse the given ecological / genetic problem 'D'. Solve/Construct it by giving appropriate reasons.
V.	Write the aim, procedure, observation and inference of the given experiment 'E'
VI.	Identify the economically important plant / plant product 'F'. Mention its Botanical name, useful part and their uses.

MARKS ALLOTMENT-PRACTICAL EXAMINATION

I.	A	Identification – 1 , Reason (any two) – 1 , Diagram and Labelling – 1	3
II.	B	Identification – 1, Reason (any two) – 1	2
III.	C	Identification – 1, Reason (any two) – 1	2
IV.	D	Identification – 1 , Solve/ Construct– 1, Reason/ Observation and Inference/ Answer – 1	3
V.	E	Aim – 1, Procedure – 1, Table (Observation, Inference) – 1	3
VI.	F	Identification – ½ Botanical name – ½ , Useful part – ½, use – ½.	2

Total 15 marks

Record 3 marks

Skill 2 marks

Maximum marks 20 marks

QUESTION No- I (A) - Preparation and Demonstration of Slides	
Note: Teacher has to prepare a temporary slide using fresh specimen for demonstration. (During examination permanent slides can be used if temporary slide preparation is not possible).	
Exercise 1	T.S. of Mature anther
Exercise 2	L.S. of an Angiospermic ovule
Exercise 3	T.S. of *Nerium* leaf
QUESTION No- II (B) - Fresh or preserved specimens	
Exercise 4	Natural methods of vegetative propagation in plants - Rhizome, Sucker, Epiphyllous buds.
Exercise 5	Adaptations of flowers for pollination by different agents – Wind, Insects.
Exercise 6	Structure of Dicotyledonous seed – Gram (*Cicer*).
Exercise 7	Dispersal of seeds by various agents – Wind, Water, Animal.
Exercise 8	Ecological adaptations of plants - Hydrophytic, Xerophytic, Halophytic and Epiphytic.
QUESTION No- III (C)- Models / Photographs / Charts	
Exercise 9	Types of ovules – Anatropous, Orthotropous, Campylotropous
Exercise 10	Picture of a vector (pBR 322)
Exercise 11	Plant tissue culture – Callus with plantlets
Exercise 12	Types of ecological pyramids – Number, Biomass, Energy
QUESTION No- IV (D) - Problems – Genetics and Ecology	
Exercise 13	To verify Mendel's Monohybrid cross
Exercise 14	Analysis of seed sample to study Mendelian Dihybrid Ratio
Exercise 15	Flow of energy and Ten percent law
Exercise 16	Determination of population density and percentage frequency of different plant species of given area by Quadrat method
Exercise 17	Chromosomal aberration – Deletion, Duplication, Inversion
Exercise 18	Genetic / Linkage maps
QUESTION No- V (E) - Experiments	
Exercise 19	Dissect and display the Pollinia of *Calotropis*
Exercise 20	Study of pollen germination on a slide
Exercise 21	Study of pH of different types of soils
Exercise 22	Water holding capacity of garden soil and road side soil
Exercise 23	Isolation of DNA from plant material
QUESTION No- VI (F) -Economic importance of plants	
Exercise 24	Economically important plants and their uses Wheat, Black pepper, Cotton, Keezhanelli, Green gram, Banana
Exercise 25	Economically important plant products and their uses:Sesame / Gingelly oil, Rubber, Aval (Flaked rice), Rose water, Henna powder,Aloe gel

BOTANY PRACTICALS

I - Preparation and Demonstration of Slides

Note: Teacher has to prepare a temporary slide using fresh specimen for demonstration. (During examination permanent slides can be used if temporary slide preparation is not possible)

Exercise 1: T.S of Anther

Aim: To study and identify the given slide – T.S of Anther

Principle: Androecium is made up of stamens. Each stamen possesses an anther and a filament. Anther bears pollen grains which represent the male gametophyte.

Requirements: Anther of *Datura metel*, glycerine, safranin, slide, cover slip, blade, brush, needle to prepare temporary slides, permanent slide of T.S. of mature anther and compound microscope.

Collect buds and opened flowers of *Datura metel*. Dissect the stamens, separate the anthers and take thin sections and observe the structure under the microscope. Record the various stages of anther from your observation.

Diagnostic Features

- A mature anther is bilobed (dithecous) and the two lobes are joined by a connective.
- Each anther lobe has two pollen chambers in which pollen grains are produced.
- A microsporangium or pollen sac is surrounded by four wall layers. They are epidermis , endothecium, middle layers and tapetum.
- Centre of the microsporangium (pollen sac) is filled with haploid pollen grains.

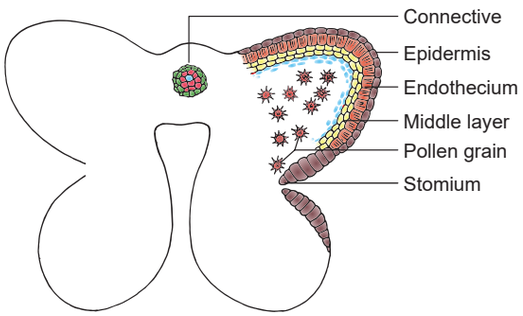

Figure 1: Pollen grain stage of anther

Exercise 2: L.S of an Angiospermic ovule.

Aim: To study and identify the L.S. of an Angiospermic Ovule.

Principle: In female reproductive part of a flower, the basal swollen part is ovary. The ovules are present inside the ovary, later they develops to seed.

Requirement: Permanent slide of L.S. of Ovule, microscope

Diagnostic Features

- Ovule or megasporangium is protected by one / two coverings called integuments.
- The stalk of the ovule is called funicle.
- The point of attachment of funicle to the body of the ovule is known as hilum.
- The body of the ovule is made up of a central mass of parenchymatous tissue called nucellus.
- The integuments form a pore called micropyle and the region opposite to the micropyle is called as chalaza.
- The nucellus has a large, oval, sac like structure towards the micropylar end called embryo sac.
- A mature ovule, has 8 nuclei in its embryo sac.

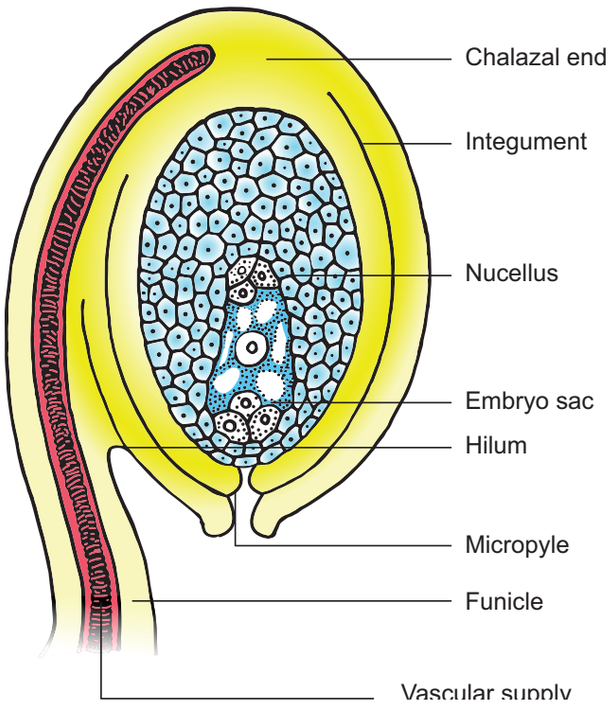

Figure 2: L.S of ovule

Exercise 3: T.S. of *Nerium* Leaf

Aim: To observe and understand the xerophytic adaptations found in *Nerium* leaves for living in dry or xeric habitat.

Principle: The plants which are living in dry or xeric condition are known as Xerophytes.

Requirements: *Nerium* leaf, few pieces of carrot / pith / styrofoam, blade, brush, needle, compound microscope, glycerine, coverslip, wash glass, microslide, saffranin solution, petri dish, etc.

Start cutting transverse sections of *Nerium* leaf placing it in between a piece of carrot. Select the thinnest section of the material with the help of a delicate brush. Take a clean watch glass with water, transfer thin sections of the material. Put a few drops of safranin stain in the watch glass with water. Leave it for 3-5 minutes. Drain off stain and wash with water if necessary. Put the thinnest section in the centre of the slide. Put a drop of glycerine over the material. Cover it with a coverslip with the help of needle. Observe it under a compound microscope.

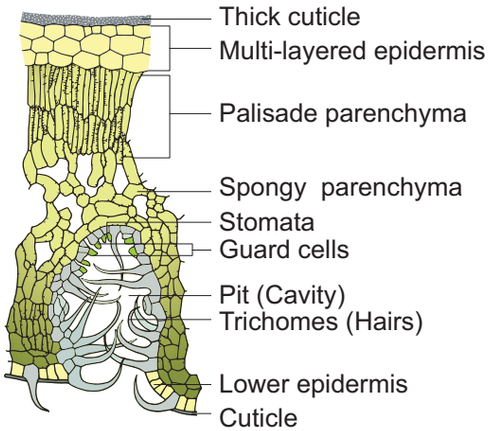

Figure 3: T.S. of Nerium leaf

Diagnostic Features

- Presence of multilayered epidermis with thick cuticle.
- Sunken stomata are present only in the lower epidermis.
- Mesophyll is well differentiated into palisade and spongy parenchyma.
- Mechanical tissues are well developed.

II - Fresh or Preserved Specimens

Exercise 4: Natural methods of Vegetative Propagation in Plants

Aim: To study and identify the types of natural methods of vegetative propagation in plants.

Principle: Natural vegetative reproduction is a form of asexual reproduction in which vegetative bud grows and develops into a new plant.

Requirements: Fresh / preserved specimens of *Zingiber*, *Chrysanthemum*, *Bryophullum*.

Ask the students to visit the nearest vegetable market and classify the vegetable into root, stem or leaf based on their utility and identify how many of them can be propagated through vegetative methods.

4 A. Vegetative Propagation by underground stem – Rhizome

Diagnostic Features

- Ginger is a underground stem which is called as Rhizome.
- Rhizomes are horizontal and swollen due to the storage of food materials.
- The terminal buds turn upwards to produce the aerial flowering shoot and the lateral buds grow out to form new rhizomes.

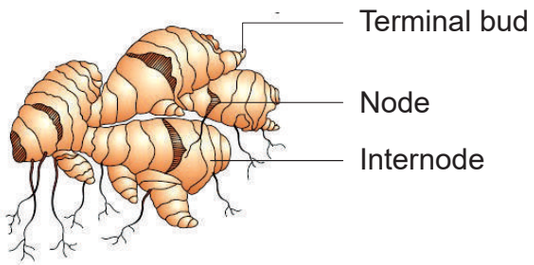

Figure 4a: Rhizome – Ginger

4 B. Vegetative Propagation by sub-aerial stem – Sucker

Diagnostic Features

- The suckers of *Chrysanthemum* are used for propagating plants.
- Suckers grows horizontally under the soil and then emerge out obliquely from the soil and give rise to a new plant or leafy shoot.
- The sucker has nodes and internodes. In the nodal region, it bears axillary buds above and adventitious roots below.

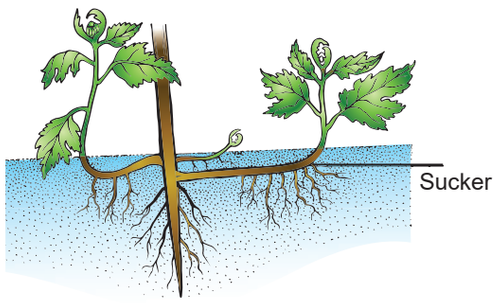

Figure 4b: Sucker - *Chrysanthemum*

4 C. Vegetative Propagation by epiphyllous buds - *Bryophyllum*

Diagnostic Features

- In *Bryophyllum*, adventitious buds arise on the leaf margins. These are called epiphyllous buds.
- When the leaves fall off the epiphyllous buds develop roots into the soil and becomes independent plants.

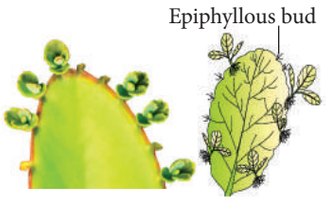

Figure 4a: *Bryophyllum* leaf

Exercise 5: Adaptations of flowers for pollination by different agents.

Aim: To study the adaptations in flowers for pollination by different agents (wind and insects)

Principle: The process of transfer of pollen grains from the anther to stigma of a flower is called **pollination**.

Requirements: Fresh flowers of maize or any other cereal / gram, any insect pollination flowers like *Salvia*, *Calotropis, Ocimum* and Asteraceae flowers.

Place the given flower on a slide and observe it with the help of hand lens. Note down the adaptations of the flowers meant for pollination by the external agents.

5 A. Wind Pollinated Flowers - Anemophily

Diagnostic Features

- The flowers are small, inconspicuous, colourless, odourless and nectarless.
- Anthers and stigmas are commonly exerted.
- Pollen grains are light, small, powdery and produced in large numbers.
- The stigmas are large, sometimes feathery and branched adapted to catch the pollens.

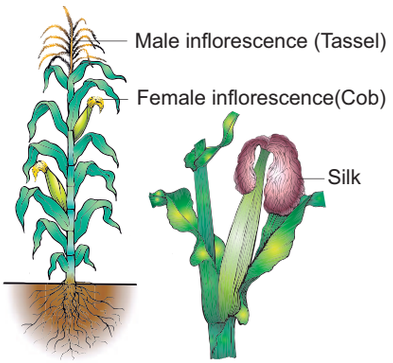

Figure 5a: Maize

5 B. Insect Pollinated Flowers - Entemophily

Diagnostic Features

- The flowers are showy, brightly coloured and scented.
- The flowers produce nectar or edible pollen.
- Anthers and stigmas are commonly inserted.
- Stigmas are usually unbranched and flat or lobed.

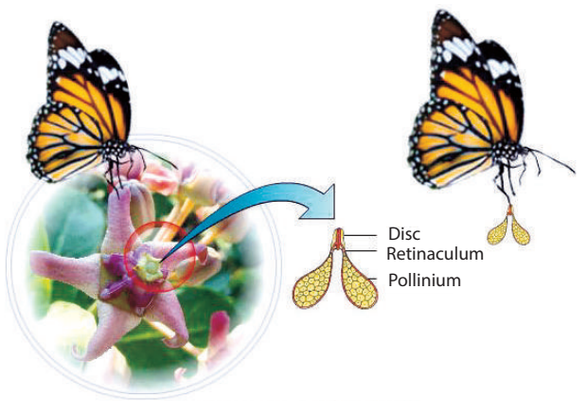

Figure 5b: *Calotropis*

Exercise 6: Dicot seed

Aim: To study and identify the Dicot seed

Principle: The fertilized ovule is called seed and possesses an embryo, endosperm and a protective coat. Seeds may be endospermous or non endospermous.

Requirements: Chick pea, bowl, water

Soak the seeds of chick pea or gram in water for 2 – 3 hours. Drain the water and place the seeds in a moist cotton cloth for 2 – 3 days. Observe for germination. Select some sprouted seeds, observe under a dissection microscope and record the parts.

Diagnostic Features

- Seeds of gram have two cotyledons and an embryonal axis.
- Each seed is covered by two seed coats (a) Testa – outer coat and (b) Tegmen – inner coat.
- The embryonal axis consists of radicle and plumule.
- The portion of the embryonal axis above the level of cotyledons is called epicotyl. It terminates into the plumule.
- The portion of the embryonal axis below the level of cotyledons is called hypocotyl. It terminates into the radicle or root tip.

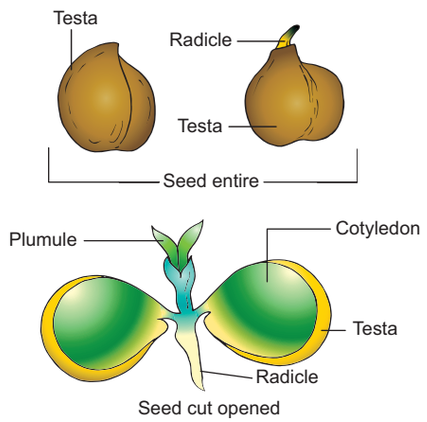

Figure 6: Dicot seed – Gram (*Cicer*)

Exercise 7: Dispersal of seeds by various agents

Aim: To study and understand the agents that help in the dispersal of fruits and seeds.

Principle: The dissemination of seeds and fruits to various distances from the parent plant is called seed and fruit dispersal . It takes place with the help of ecological factors such as wind, water and animals.

Requirements: Fruits of *Tridax*, Coconut and *Achyranthes*, knife, forceps, petridish, hand-lens etc.

7 A. Dispersal by wind – Anemochory (Example: *Tridax*)

Diagnostic Features

- Fruits are light so that wind may carry them away.
- Fruits are minute, very small and with inflated covering.
- Fruits have feathery appendages (pappus) which greatly increase their buoyancy to disperse in high altitudes.

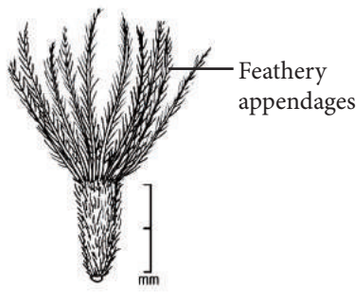

Figure 7a: Fruit of Tridax

7 B. Dispersal by water – Hydrochory (Example: Coconut)

Diagnostic Features

- Fruits have outer coats that are modified to enable them to float.
- The mesocarp of coconut is fibrous, which is easily carried away by water currents.

Figure 7b: Coconut

7 C. Dispersal by animals –Zoochory (Example: *Achyranthes*)

Diagnostic Features

- Fruits are provided with hooks, spines, bristles, stiff hairs, etc. on their outer coat.
- The sharp pointed fruits of *Achyranthes* stick to the hairs of the animals and clothes and get carried away from one place to another.

Figure 7c: *Achyranthes*

Exercise 8: Ecological adaptations of plants found in hydrophytic, xerophytic, halophytic and epiphytic conditions.

Aim: To study plants found in different habitats and comment upon their adaptations.

Principle: The modifications in the structure of organisms to survive successfully in an environment are called adaptations of organisms. Observe different plants existing under various ecological habitats. The corresponding adaptations of plants and their interaction with the environment can be better understood.

Requirements: Fresh or preserved specimens of *Eichhornia*, *Opuntia*, *Avicennia* and *Vanda*.

8 A. Adaptations of Hydrophytes - *Eichhornia* (Water hyacinth)

Eichhornia is a free floating hydrophyte that grows in ponds, lakes and water bodies containing fresh water.

Diagnostic Features

- Root system is poorly developed.
- Root pockets are present.
- The petioles become swollen and spongy, providing buoyancy.
- Cortex is well developed with numerous air chambers. It helps in buoyancy and rapid gaseous exchange.
- Mechanical tissues are generally absent.

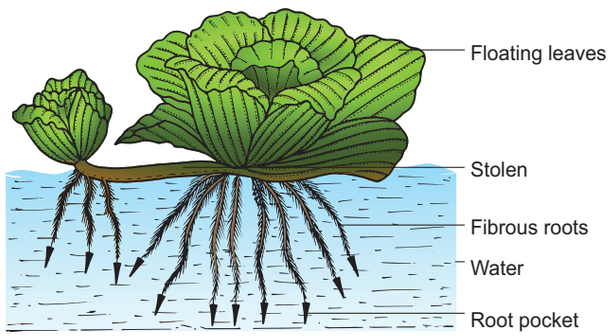

Figure 8a: Free floating hydrophyte – *Eichhornia*

8 B. Adaptations of Xerophytes - *Opuntia*

Opuntia is a succulent or drought resisting xerophyte, which grows wild in arid areas.

Diagnostic Features

- The stem is flattened, green, thick and fleshly called phylloclade
- Mucilage is present which helps to retain the water.
- Leaves are modified into spines

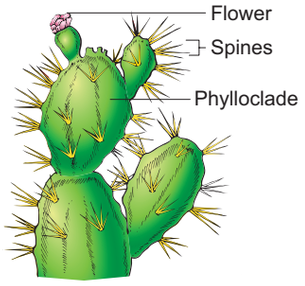

Figure 8a: Succulent xerophyte - *Opuntia*

8 C. Adaptation of Halophytes – Pneumatophores of *Avicennia*

Avicennia is a plant which grows and survives in saline environment like salty lakes and sea shores (mangrove vegetation).

Diagnostic Features

- A special kind of negatively geotropic root called pneumatophores (respiratory roots) are present.
- The leaves excrete salts through the salt glands.

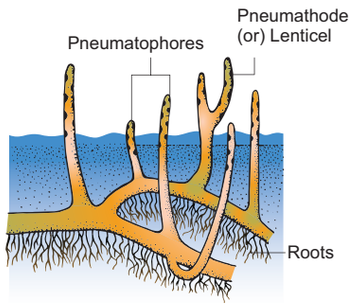

Figure 8c: Pneumatophores of *Avicennia*

8 D. Adaptation of Epiphytes – *Vanda*

Vanda is an epiphytic plant that grows perched on other plants (supporting plants). They use supporting plants only as shelter and not for water or food supply.

Diagnostic Features

- Root system is extensively developed. These roots are of two types (1) clinging roots and (2) aerial roots.
- The clinging roots fix epiphytes firmly on the surface of the supporting plant.
- Aerial roots are green coloured, hang downwardly and absorbs moisture from the atomosphere with the help of spongy tissue called velamen.

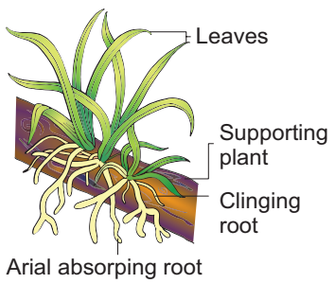

Figure 8d: Epiphytic roots of *Vanda*

III - Models / Photographs / Pictures

Exercise 9: Types of ovules

Aim: To recognize different types of ovules in flowering plants

Principle: To identify ovules based on the orientation, form and position of the micropyle with respect to funicle and chalaza

Requirements: Models / Photographs/ Pictures of different types of ovules.

9 A. Anatropous Ovule

Diagnostic Features

- The body of the ovule becomes completely inverted so that micropyle lies close to the funicle.
- Micropyle and chalaza lie on the same straight line. Example: Asteraceae.

Figure 8a: Anatropous ovule

9 B. Orthotropous Ovule

Diagnostic Features

- In this type of ovule, the micropyle is at the distal end.
- The ovule is erect or straight so that the funicle, chalaza and micropyle lie on the same vertical line. Example: Piperaceae and Polygonaceae.

Figure 8b: Orthotropous ovule

9 C. Campylotropous Ovule

Diagnostic Features

- In this type, the body of the ovule at the micropylar end is curved and more or less bean shaped.
- The embryosac is slightly curved.
- The funicle, micropyle and chalaza are adjacent to one another with the micropyle oriented towards the placenta. Example: Leguminosae.

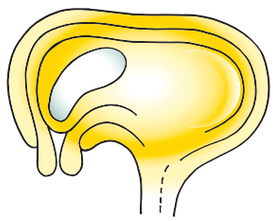

Figure 8c: Campylotropous ovule

Exercise 10: E.coli cloning vector (pBR 322)

Aim: To study and identify the features of cloning vector – pBR 322

Principle: Vectors are used as carriers to deliver the desired foreign DNA into a host cell.

Requirements: Models/ Photographs / Pictures of E.coli Cloning vector pBR 322.

Diagnostic Features

- pBR 322 plasmid is a reconstructed plasmid containing 4361 base pairs and most widely used as cloning vector.
- In pBR, p denotes plasmid and B and R respectively the notes of scientists Boliver and Rodriguez who developed the plasmid. The number 322 is the number of plasmids developed from their laboratory.
- It contains two different antibiotic resistance genes and recognition site for several restriction enzymes (Hind III, Eco R I, Bam H I, Sal I, Pvu II, Pst I, Cla I), Ori and antibiotic resistance genes (amp^R and tet^R). Rop codes for the proteins involved in the replication of the plasmid.

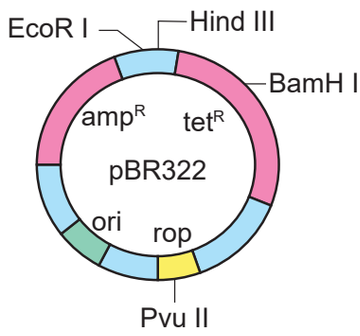

Figure 10: E-coli cloning vector (pBR 322)

Exercise 11: Plant tissue culture – Callus with plantlets

Aim: To study and identify the Callus with plantlets.

Principle: Growing the plant cells, tissues and organs in an artificial, synthetic medium under controlled conditions is called plant tissue culture. The technique of cloning plant is easier than animals because plant cells are simple in structure and most plant cells shows totipotency (i.e) ability to regenerate from cells.

Requirements: Model / Photograph / Picture of callus with plantlets.

Diagnostic Features

- The callus is an unorganized mass of undifferentiated tissue.
- The mechanism of callus formation is that auxin induce cell elongation and cytokinin induces cell division as a result of which masses of cells are formed.
- Roots and shoots are differentiated from the callus.

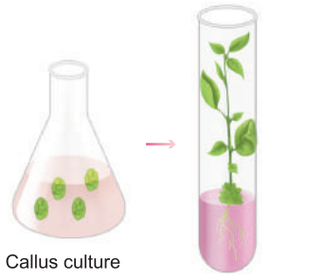

Figure 11: Callus with plantlets

Exercise 12: Types of ecological pyramid

Aim: To study and identify the different types of ecological pyramids

Principle: The relationship between different trophic levels in an ecosystem when shown diagrammatically appear as 'ecological pyramids'. In these ecological pyramids, the successive tiers represent successive trophic levels towards the apex. The base of the pyramid is of producers, the next one above it is of herbivores and the top tiers are of carnivores. The top most or apex represents the tertiary or top level consumers.

Requirements: Models / Photographs / Pictures of different types of ecological pyramid.

12 A. Pyramid of numbers

Diagnostic Features

- The number of organism that are present in successive trophic levels of an ecosystem is shown in the pyramid of numbers of a grassland ecosystem.
- There is a gradual decrease in the number of organisms in each trophic level from producers to primary consumers, then to secondary consumer, and finally to tertiary consumers.
- Therefore, pyramid of number in grassland ecosystem is always upright.

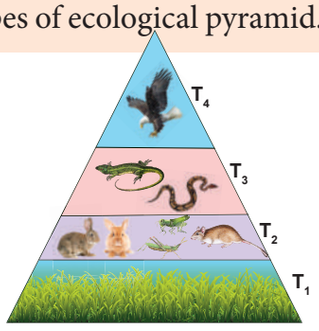

Figure 12 a: Pyramid of numbers in grassland ecosystem

T_1 - Producers | T_2 - Herbivores | T_3 - Secondary consumers | T_4 - Tertiary consumers

12 B. Pyramid of biomass

Diagnostic Features

- Pyramid of biomass represents the total biomass or standing crop (dry weight) of organisms in each trophic level at a particular time.
- In aquatic ecosystem, the bottom of the pyramid is occupied by the producers, which comprises very small organisms (algae and phytoplanktons) possessing the least biomass and so the value gradually increases towards the tip of the pyramid.
- Therefore, here the pyramid of biomass is always inverted in shape.

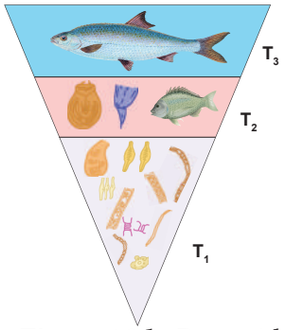

Figure 12 b: Pyramid of biomass in aquatic ecosystem

T_1 - Producers | T_2 - Herbivores | T_3 - Secondary consumers |

12 C. Pyramid of energy

Diagnostic Features

- Pyramid of energy represents the number of joules transferred from one trophic level to next.
- The bottom of the pyramid of energy is occupied by the producers. There is a gradual decrease in energy transfer at successive trophic levels from producers to the upper levels.
- Therefore pyramid of energy is always upright.

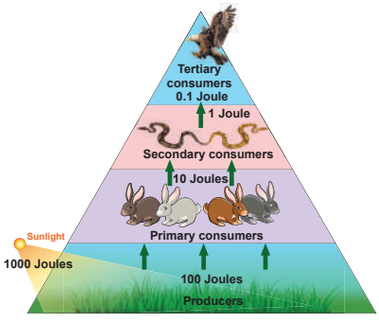

Figure 12 c: Pyramid of Energy

IV - Solving the Problems

Exercise 13: To verify Mendel's Monohybrid cross

NOTE: Student have to work in pairs to perform this experiment and record the data in the observation and record note book with the help of the teacher.

Need not consider this Monohybrid cross experiment for Board Practical Examination.

Aim:

To verify Mendel's Monohybrid cross.

Principle:

When two pure lines with contrasting traits of a particular character (phenotype) are crossed to produce the next generation (F_1 generation), all the members of the progeny are of only one phenotype, i.e. of one of the two parents. The phenotype that appears is called dominant and the one that does not appear is called recessive. When the F_1 plants are selfed, the progeny i.e. the F_2 generation, is in the ratio of 3 dominant : 1 recessive (¾ : ¼ of 75% : 25%). This reappearance of the recessive phenotype in F_2 generation, verifies Mendel's Monohybrid cross.

Requirements:

64 yellow and 64 green plastic beads, all of exactly same shape and size (when beads are not available, pea seeds may be painted and used). Plastic beakers, petri dish and a napkin / hand towel.

Procedure

Make the student to work in pairs to perform the experiment. Follow the steps in given sequence.

1. Put 64 yellow beads in one beaker and 64 green beads in the other to represent male and female gametes respectively. Let the yellow bead be indicated by 'Y' and the green bead by 'y'
2. Take a bead from each container and place them together (it represents fertilization) on the hand towel spread before you on the table.
3. Just like the previous step, continue to pick beads and arrange them in pairs. Thus 64 pairs of beads are obtained representing the 64 heterozygous F_1 progeny.
4. Put 32 F_1 progeny in one petridish and the remaining 32 in another petridish (representing the F_1 males and females).
5. To obtain the F_2 generation, the student should withdraw one bead from one beaker labelled male and one from the other beaker labelled female keeping his / her eyes closed (to ensure randomness) and put them together on the hand towel spread over the table. Continue this process till all the beads are paired. Thus 64 offsprings of F_2 progeny are obtained.
6. Note the genotype (YY or Yy or yy) of each pair and their possible phenotype.
7. Pool all the data and calculate the genotypic and phenotypic ratios.

Observation:

Record the result in the following table:

Generation	Total Number of individuals	Genotypes			Phenotype(s)
		YY	Yy	yy	
F_1					
	Total				
F_2					
	Total				

Phenotypic ratio : in F_1 _____

in F_2 _____

Genotypic ratio : in F_1 _____

in F_2 _____

Inference:

The results are so because when the F_1 individuals are crossed together to raise the F_2 generation, each F_1 individual produces two types of gametes: 50% having dominant allele and the remaining 50% having recessive allele. These gametes undergo random fusion during fertilization to produce the F_2 generation. According to simple probability of mixing of opposite sex gametes, offsprings of three genotypes are likely to appear as follows:

Among these, proportion of dominant phenotype would be YY + Yy = yellow and recessive phenotype yy = green, which occur in 3 : 1 or 75% : 25% ratio.

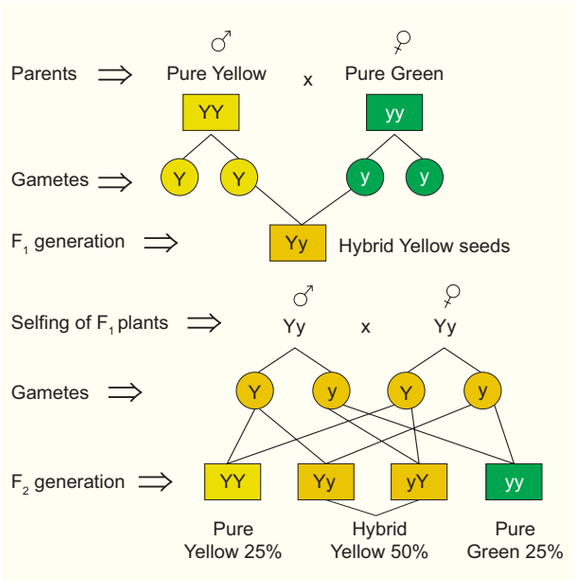

Figure 13 : Monohybrid cross

This ratio of 3 :1 in the F_2 suggests that the hybrids or heterozygotes of F_1 generation have two contrasting factors or alleles of dominant and recessive type. These factors, though remain together for a long time, do not contaminate or mix with each other. They separate or segregate at the time of gamete formation so that a gamete carries only one factor, either dominat or recessive.

Precautions:

1. Take a sufficiently large number of seeds for analysis to minimise the error.
2. Observe the contrasting form of trait carefully.

Exercise 14: Analysis of seed sample to study Mendelian dihybrid ratio

Aim:

To analyse seed sample of pea for Mendelian dihybrid ratio of 9 : 3 : 3 : 1.

Principle:

In a dihyrbid cross, the segregation of one gene pair is independent of the segregation of the other pair. It means that when the factors (genes) for different characters inherited from parents do not remain linked in the offsprings, but their distribution in the gametes and in the progeny of subsequent generations is independent of each other.

Requirement:

Plastic beakers, Pea seed samples or plastic beads, tray, petri dishes, notebook, pencil / pen.

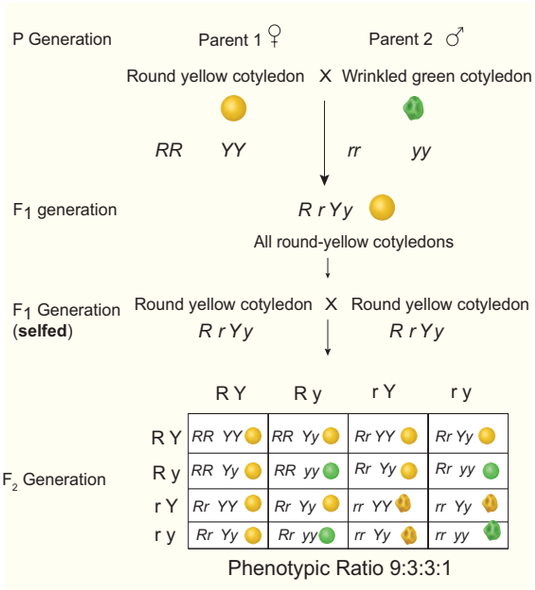

Figure 14 : Dihybrid cross

Teachers should select the Pea seed or plastic beads which represents the four types of traits such as yellow round, yellow wrinkled, green round and green wrinkled in the ratio of 9:3:3:1

Procedure:

1. Take a lot of about 160 Pea seeds or plastic beads in a tray.
2. Separate out yellow round, yellow wrinkled, green round and green wrinkled and put them in separate petridishes.
3. Note down the number of seeds in each plate and find out their approximate ratio.

Observation:

Present your finding in the form of a table.

Total Number of seeds observed	No. of yellow round seeds	No. of yellow wrinkled seeds	No. of green round seeds	No. of green wrinkled seeds	Approximate ratio
160	90	30	30	10	9 : 3:3:1

Inference:

The ratio of yellow round : yellow wrinkled : Green round : green wrinkled is approximately 9 : 3 : 3 : 1 which is exactly the same as obtained by Mendel for a dihybrid cross. This indicates that the contrasting genes for seed colour and seed shape show an independent assortment in the population of pea seeds.

Exercise 15: Flow of energy and Ten percent law

Aim:

To understand the unidirectional flow of energy in an ecosystem and transfer of energy follows the 10% law.

Principle:

The student studies about flow of energy and that only about 10% of energy is made available to the next trophic level. Large amount of energy about 90% is lost at each trophic level in a food chain.

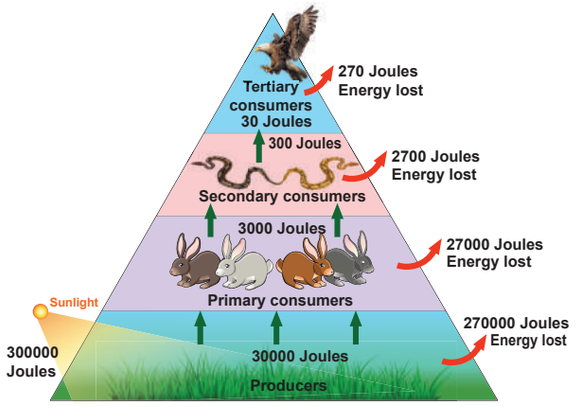

Figure 15: Ten percent law

Requirements:

Problems to be given to students based on different examples with alternating food chain and amount of energy.

> The teacher must train the student by giving them various kinds of food chain with different values.

Problem

Analyse the food chain given below and find out the amount of energy received by the organism in third trophic level.

Sun

↓ Grass receives 30,000. J of energy from sun

Grass ⟶ Rabbit ⟶ Snake ⟶ Eagle

Given: The amount of energy in the producers, i.e. grass = 30,000 J.

Solution:

Grass	⟶	Rabbit	⟶	Snake	⟶	Eagle
T_1		T_2		T_3		T_4
Producer		Primary Consumer		Secondary Consumer		Tertiary Consumer

T_1 – Grass (Producer) = 30,000 J of energy

T_2 – Rabbit (Primary Consumer) = ?

T_3 – Snake (Secondary Consumer) = ?

According to the ten percent law, during the transfer of energy, only about 10% of the energy flows from each trophic level to the next lower trophic level. So 10% of energy from T_1 gets transferred to T_2

So T_2 - Rabbit (primary consumer) receives $30000 \times \frac{10}{100} = 3000$ J

Similarly, 10% of energy from T_2 gets transferred to T_3

So T_3 – Snake (Secondary consumer) receives $3000 \times \frac{10}{100} = 300$ J

Answer:

1. The third tropic level T_3 – (Snake) receives 300 J of energy.

Exercise 16: Determination of Population density and Percentage frequency by Quadrat method.

NOTE: Teachers can take the students to open space and teach them how to construct plot/ quadrats and to record the number of individuals of each plant species occurring in the quadrat. The percentage frequency should be calculated and entered in the practical observation and record note book. Examiner need not consider this experiment for Board Practical Examinations.

Aim:

To study population density and percentage frequency of different plant species of a given area by quadrat method.

Principle:

The number of individuals in a population never remains constant. It may increase or decrease due to many factors like birth rate, death rate, migration, etc. The number of individuals of a species presents per unit area or space of a given time is called population density. The population density and percentage frequency of different plant species can be determined by laying quadrats / segments of suitable size and recording of the number of individuals of each species occurring in the quadrat.

Requirements:

Metre scale, string or cord, hammer, nails, paper, pencil, etc.

Procedure:

1. In the selected site of study, hammer the nails firmly in the soil without damaging the vegetation.
2. Fix four nails to make a square plot.
3. Tie each end of the nails using a thread, to make 1 m X 1 m plot.
4. If the number of plants in the plot is large, the plot can be divided into quadrats.
5. Count the number of individuals of a species "A" present in the first quadrat and record the data in the table.
6. Similarly count the individuals of the species "A" in other quadrats respectively and record the data in the table.
7. Count the number of individuals of a species "B" present in the all quadrats and record the data in the table.
8. Repeat the same procedure for other species and record the data in the table.

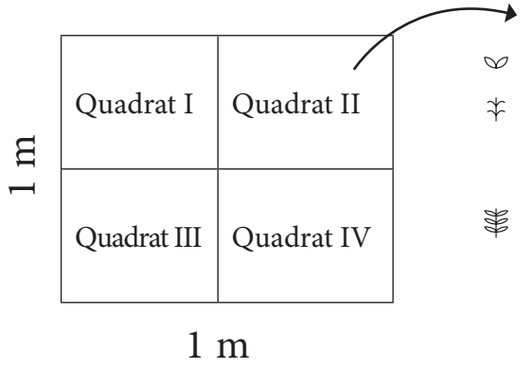

Figure: A plot

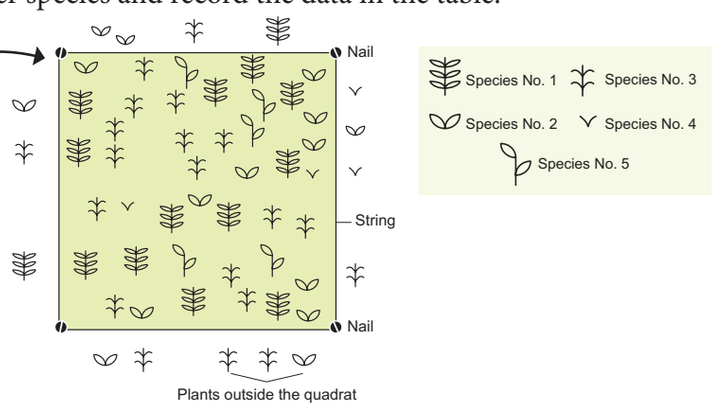

Figure 16: Occurrance of plant species in a quadrat

$$\text{Population Density} = \frac{\text{Total number of individuals in all the quadrats studied}}{\text{Total number of quadrats studied}}$$

$$\text{Percentage frequency} = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of quadrats studied}} \text{ X } 100$$

Observation and Inference:

Different plant species, their population density and percentage frequency occurring in a given area.

S. No.	Plant species	No. of individuals per quadrat				Total number of individuals in all the quadrats studied (N)	Total number of quadrats in which each species occurred (A)	Total Number of quadrats studied (B)	Population Density (N/B)	Frequency percentage (A/B) x 100
		I	II	III	IV					
1										
2										
3										
4										
5										

Precautions:

1. The measurement of quadrat should be accurate.
2. The string or cord used should not be very thick.

Exercise 17: Chromosomal aberrations – Deletion, Duplication and Inversion

Problem:

Given below is the representation of a kind of chromosomal aberration such as deletion, duplication and inversion. Identify and give reasons for identification. Also mentions its significance.

Aim:

To understand the abnormality in the chromosomal structure in an organism.

Principle:

To study about the chromosomal aberration which can occur due to ionizing radiations or chemicals. On the basis of breaks and reunions in the chromosomal segment different types of aberrations can be recognized.

Requirements:

Copper wire, Alphabets marked (A to H) yellow colour beads denotes gene, and red colour bead without alphabet denote centromere. Using this materials make different kinds of chromosomal segments with specific gene sequence, that can be given to the students and asked to analyse the aberration involved in it.

Procedure:

1. Make a normal chromosome model using copper wire and yellow beads and place it on the table. In the model chromosome with gene sequence A to H, along with centromere (red bead).
2. For Deletion - Give yellow colour beads without one or more marked alphabets A to H (The lack

of any one or more beads denotes deletion type of chromosomal aberration).

3. For Duplication – Give yellow colour beads with addition of one or more marked alphabets A to H (The repetition of one or more beads denotes duplication type of chromosomal aberration).
4. For Inversion – Give yellow colour beads which marked alphabets from A to H as in normal chromosome. (There is no addition or deletion of beads (A to H) given, so the students can construct the inverted segment of the chromosome using the given beads).

Based on the type of beads given the student has to identify and construct the relevant chromosomal aberration.

17 A. Chromosomal Aberration – Deletion

Reasons:

1. The deletion of the chromosomal segement A and D. (Refer figure 17a)
2. When there is a loss of a segment of the genetic material in a chromosome it is called deletion.

Significance:

Most of the deletions lead to death of an organism.

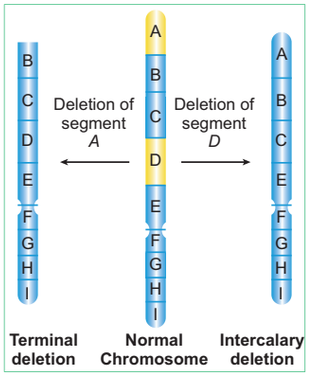

Figure: 17 a: Deletion

17 B. Chromosomal Aberration - Duplication

Reasons:

1. When a segment of a chromosome is present more than once in a chromosome, then it is called duplication (Tandem duplication)
2. The order of the genes in a chromosome is A, B, C, D, E, F, G, H and I. Due to aberration, the genes B and C are duplicated and the sequence of genes becomes A, B, C, B, C, D, E, F, G, H and I. (Refer figure 17b)

Significance:

Some duplications are useful in the evolution of the organism.

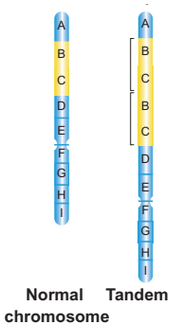

Figure 17 b: Duplication

17 C. Chromosomal Aberration - Inversion

Problem:

Given below is the representation of a kind of chromosomal aberration. Identify it giving reasons for your identification. Also mentions its significance.

Identification:

The given genetic problem is identified as inversion type of chromosomal aberration.

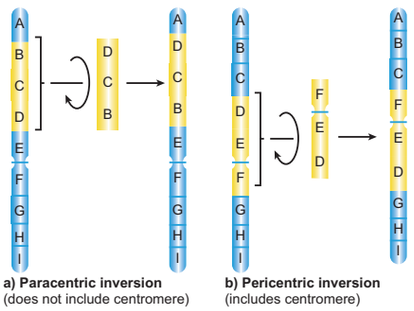

Figure: 17 c: Inversion

Reasons:

1. When the order of genes in a chromosomal segment is reversed due to rotation by an angle of 180°, it is called inversion.
2. The order of genes in a chromosome is A, B, C, D, E, F, G, H and I. Due to aberration, the sequence of genes become A, D, C, B, E, F, G, H and I (Refer figure 17c)

Significance:

Sometimes inversion is responsible for evolution of the organism.

NOTE: Likewise the teacher can give different types of chromosomal aberrations with various gene sequence to students for practise. The external examiner can also use the same technique by giving different gene sequence.

Exercise 18: Genetic / linkage maps

Aim:

To understand the frequency of recombination between the gene pairs on the same chromosome.

Principle:

To analyse the relative distance between the various genes and map their position in the chromosome, which is called genetic or linkage maps.

Requirements:

Different kinds of linkage / genetic maps can be constructed by giving the students the relative distance between the linked genes of a chromosome. A diagrammatic representation can be drawn showing the location and arrangement of genes and their relative distance between them.

Solve the Problem

Problem: There are three linked genes A, B and C in a chromosome. Percentage of crossing over (recombination frequency) between A and B is 20, B and C is 28 and A and C is 8. What is the sequence of genes on the linkage map?

Given: Percentage of crossing over between the 3 linked genes A – B = 20%, B – C = 28% and A – C = 8%.

Solution

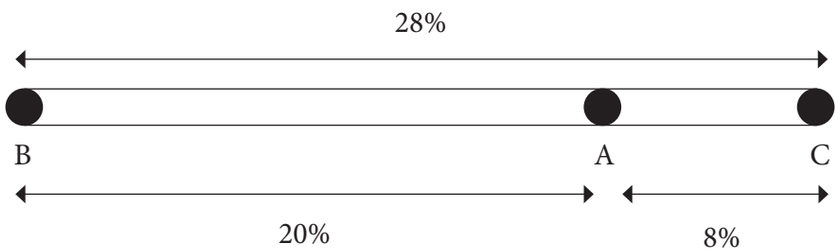

Figure 18: Linkage Map

Reasons:

1. The frequency of crossing over is directly proportional to the relative distance of the genes on the chromosomes.
2. More crossing over = More distance between two genes and
   Less crossing over = Less distance between the two genes.

In the above problem, the sequence of the genes on the linkage map is B, A, C

NOTE: Teachers can give different crossing over percentage between its linked genes in a chromosome and make the students construct the linkage maps. The external examiner can also do the same for the Board Practical Examinations.

IV - Experiments

Exercise 19: To dissect and display the pollinia of *Calotropis*

Aim:

To dissect and observe the structure of pollinia and understand the mechanism of pollination in *Calotropis* flowers. (Translator Mechanism)

Principle:

In *Calotropis* the pollen in each anther lobe of a stamen unites into a mass, forming a pollinium.

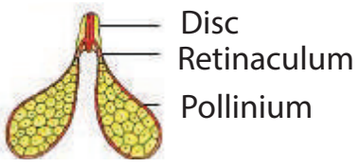

Figure 19: Pollinia of *Calotropis*

Requirements:

Flowers of *Calotropis*, dissection needle, dissection microscope ,slide, blade, glycerine, coverslip, scissors.

Procedure:

Take a mature flower of *Calotropis*. Observe the parts of the flower and remove the calyx and corolla with the help of scissors. Identify the pentangular stigmatic disc. Insert the needle at the angles of the stigma where the pollinia are adhered. Dissect it and place the pollinia on a clean slide. Mount it in glycerine and place a coverslip on it. Observe the pollinia under the dissection microscope and record your observation.

Observation:

The stamens of *Calotropis* produce pollinium. Two pollinia are found attached to a glandular adhesive disc called corpusculum by a thread like structure called retinaculum. The whole structure looks like inverted letter 'Y' and is called translator. The sticky disc gets attached with the legs of pollinator (bees or butterflies) and is carried to the stigma of another flower, thus ensuring pollination.

Inference:

The structure of pollinia of *Calotropis* is well suited to achieve pollination.

Exercise 20: Study of Pollen germination on a slide

NOTE: Pollen germination can be studied by dusting some pollens from common flowers like *Crotalaria*, *Hibiscus*, *Pisum*, etc. on a glass slide containing a drop of 10% sugar solution or tender coconut water or any nutrient medium.

Observe the slide after about 10 – 15 minutes under the low power of compound microscope. You will be able to observe the pollen tubes coming out of the pollen grains.

Aim:

To study the pollen germination on a slide.

Requirements:

Fresh seasonal flowers, cavity slide, cover slip, compound microscope, sucrose, boric acid, distilled water, beakers, etc.

Procedure:

1. Prepare a nutrient solution by dissolving 1 gm. of sucrose / 1 gm. of boric acid in 100 ml. of distilled water.
2. Take a clean cavity slide and put a few drops of nutrient solution in the cavity of the slide.
3. Dust a few pollen grains from the stamen of a mature flower on it.
4. View the slide in the microscope after 5 minutes and then observe it regularly for about half an hour.

Observation:

In nutrient medium, the pollen grains germinate. The tube cell enlarges and comes out of the pollen grain through one of the germ pores to form a pollen tube. The tube nucleus descends to the tip of the pollen tube. The generative cell also passes into it. It soon divides into two male gametes.

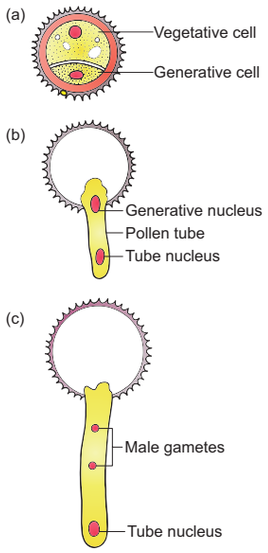

Figure 20: Pollen germination

Inference: Different stages of germinating pollens are observed. Some pollens are in their initial stage of germination while others have quite long pollen tube containing tube nucleus and two male gametes.

Precautions:

1. Flowers should be freshly plucked.
2. Use clean cavity slide to observe the pollen grains.
3. The slides should not be disturbed, otherwise position of pollen grains will get changed.

Exercise 21: Study of pH of different types of soil

Some nutrients become toxic in higher concentration. Therefore pH of the soil is an important chemical property of the soil. Plants thrive well in neutral or slightly acidic soils. The pH of the soil determines the types of soil organisms and also controls the solubility of different nutrients. The pH of soil ranges from 0 - 14.

a. pH level 7 - Neutral soil

b. pH level below 7 - Acidic soil

c. pH level above 7 -Alkaline soil

d. Optimum pH for plant growth ranges from 5.5 to 7.

Most plants thrive best in neutral pH. Slight acidity favours tree growth and forms forests. Slight alkalinity is favourable for grasses and legume crops.

Aim:

To study pH of different types of soil.

Requirements:

Soil samples (from two different sites such as crop soil, garden soil, roadside soil, pond soil, river bank soil), test tubes, funnel, filter papers, pH papers of different range, distilled water, beaker.

Procedure:

Dissolve one tablespoon or 1 gram of soil from each soil sample in 100 ml of distilled water in separate beakers. Stir the solutions well and keep aside for half an hour to settle down the suspended particles. Filter off each solution separately in different test tubes. Dip a small piece of broad range pH paper on each of the solution. Match the colour of the pH paper with the colour scale given on the pH paper booklet. This gives an approximate pH.

Observation:

Record the pH of different soil samples in the observation table.

S. No.	Soil sample	pH Value
1		
2		
3		

Figure 21: Study of pH of different types of soil

Inference:

Thus the pH value of different soil samples required for plant growth can be determined.

Precautions:

1. Wash the glassware thoroughly and get it dried before the experiment.
2. Dry the pH papers before comparing the colour with the colour scale.
3. Match the colour carefully and determine pH accurately.

Exercise 22: Water holding capacity of garden soil and roadside soil

The maximum amount of water retained by soil per unit of its dry weight after the gravitational flow has ceased is called water holding capacity or field capacity of the soil. The water holding capacity varies in different type of soils and depends upon the types of soil particles and porocity of the soil. Sandy soils have poor water holding capacity then the loam and clay soils.

Aim:

To study the water holding capacity of garden soil and roadside soil.

Requirements:

Garden soil, roadside soil, measuring cylinders, funnels, filter papers, beakers, balance, etc.

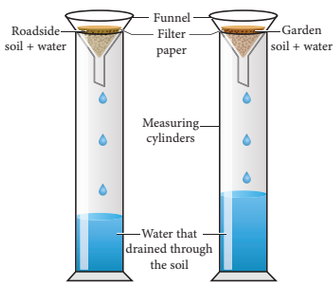

Figure 22: Water holding capacity of soil

Procedure:

Take two funnels and line them with filter paper. Lable them A and B. Place them on measuring cylinders. Take 100 gm dried sample each of the garden soil and roadside soil. Put the garden soil in funnel A and roadside soil in funnel B. Pour 100 ml of water in each funnel. Record the volume of filtered out water in the measuring cylinder when the dripping of water stops from the funnel.

Observation:

Record the observation in the table as follows:

S. No.	Soil types	Weight of soil (X)	Volume of water poured (Y)	Volume of water collected in measuring cylinder (Z)	Volume of water retained by the soil (Y – Z)	Water holding capacity of the soil in percentage (Y – Z) / X × 100
1	Garden soil					
2	Roadside soil					

Inference:

Garden soil has a high water holding capacity than the roadside soil, because roadside soil has larger quantities of sand and silt.

Precautions:

1. Weighing of soil samples should be done accurately.
2. Pour water slowly and gently on the soil in the funnel
3. Record the volume of collected water in the measuring cylinders carefully.

Exercise 23: Isolation of DNA from plant materials

DNA is one of the nucleic acids found in living systems. DNA acts as the genetic material in most of the organisms.

Principle: Recombinant DNA technology has allowed breeders to introduce foreign DNA in other organisms including bacteria, yeast, plants and animals. Such organisms are called Genetically Modified Organisms (GMOs). Thus rDNA technology involves isolation of DNA from a variety of sources and formation of new combination of DNA.

Aim: To isolate DNA from available plant materials such as spinach leaves, fresh green pea seeds, green papaya, etc.

Requirements: Plant materials, mortar and pestle, beakers, test tubes, ethanol, etc.

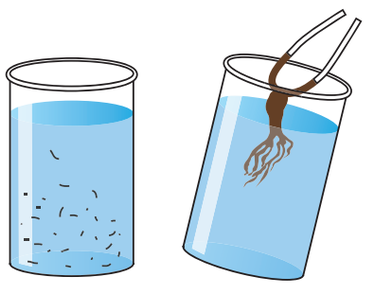

Figure 22: Isolation of DNA

Procedure: Take a small amount of plant material and grind it in a mortar with a little amount of water and sodium chloride. Make it into a solution and filter it. To this filterate, add liquid soap solution or any detergent solution and mix it with a glass rod. Then tilt the test tube and add chilled ethanol and leave it aside in the stand. After half-an-hour we can observe the precipitated DNA as fine threads. DNA that separates can be removed by spooling

Observation: DNA appears as white precipitate of very fine threads on the spool.

Inference: Thus DNA can be isolated from the plant cell nucleus by this technique.

Precautions:

1. All the glasswares must be thoroughly cleaned and dried.
2. The chemicals used for the experiments must be of standard quality.
3. If ordinary ethanol is used, the time duration for obtaining precipitated DNA may extend further.

VI - Economic Importance of Plants

Exercise 24: Economically important plants

S.No	Identification (Plant name)	Botanical Name	Useful parts	Uses
1	Wheat	*Triticum aestivum*	Whole grain	1. Wheat flour is suitable to make bread and bakery products. 2. Malted wheat is a major raw material for producing alcoholic beverages and nutritive drinks.
2	Black pepper	*Piper nigrum*	Seeds	1. It is used as an aromatic stimulant for enhancing salivary and gastric secretion. 2. Pepper also enhances the bio-absorption of medicine.
3	Cotton	*Gossypium barbadense*	Seed coat fibres	1. It is mainly used in the manufacturing of various textile, hosiery products, toys and is also used in hospitals. 2. Cotton fibres are used in stuffing pillows and cushions.
4	Keezhanelli	*Phyllanthus amarus*	Entire shoot system	Extract of the plant is generally used for the treatment of jaundice
5	Green gram	*Vigna radiata*	Seeds	1. Roasted, cooked or sprouted seeds are edible. 2. Fried, dehulled and broken or whole green gram is used as a popular snack and breakfast dish.
6	Banana	*Musa* x *paradisiaca*	Fruit	1. The banana fruit contains potassium and essential vitamins which can be eaten raw or cooked. 2. The fruit can be processed into flour and can be fermented for the production of beverages such as banana juice, vinegar, beer and vine.

Exercise 25: Economically important plant products

S. no	Identification (Product name)	Botanical Name	Useful parts	Uses
1.	Sesame/ Gingelly oil	*Sesamum indicum*	Seeds	1. Sesame oil is mostly used for culinary purposes. 2. Lower grades are used in manufacture of soaps, in paint industries, as a lubricant and as an illuminant.
2.	Rubber	*Hevea brasiliensis*	Latex	1. Rubber is used in the manufacture of footwear, wire and cable insulations, rain coat, sports goods, erasers, adhesives, rubber bands, household and hospital goods and shock absorbers. 2. Concentrated latex is used for making gloves and balloons. 3. Foamed latex is used in the manufacture of cushions, pillows and life-belts.
3.	Flaked Rice (Aval)	*Oryza sativa*	Seeds	1. Flaked rice (aval) is used as breakfast cereal or as snacks.
4.	Rose Water	*Rosa* x *damascena*	Petals	1. Rose water (panneer) is used in confectionaries, syrups and soft drinks. 2. In India, rose water is much used in eye lotions and eye washes.
5.	Henna Powder	*Lawsonia inermis*	Leaves	1. An orange dye "henna" obtained from leaves and young shoots is used to dye skin, hair and fingernails. 2. It is also used for colouring leather, tails of horses and hair.
6.	Aloe Gel	*Aloe vera*	Leaves	1. Aloe gel is used as skin tonic. 2. Because of its cooling effect and moisturizing characteristics, it is used in the preparation of creams, lotions, shampoos, shaving creams and allied products. 3. It is used in gerontological applications for rejuvenation of ageing skin.