Investigatory Project Work

Investigations are more open-ended than practical exercises involving a search to understand the unknown and begins with a question or a hypothesis. You are not instructed exactly what to do, but are given only general guidance. These give you more opportunity to plan your work. For example, you might investigate what traits you and your classmates inherit from your parents and forefathers (both maternal and paternal).

Projects are even more open-ended than investigations. These are practical investigations carried out by an individual or a group of students. Projects are largely your own initiative. It also requires evaluation of your findings, redefining ideas and designing further investigations. This may lead to evidence that enables answering the question posed at the outset. Some of these projects would take about few hours to complete. Other may take few weeks. Some are laboratory based, others involve fieldwork. Many could be carried out at home.

Investigatory projects are part of obligatory assignment involving purely experimental procedures so that you report on, duplicate, or adapt something that someone else has already discovered. It may involve some other form of investigation also. For example, you may undertake to investigate the richness and patterns of biodiversity (flora and fauna) in your school campus and prepare a mural of it or to investigate the effects of physical fitness on your pulse rate.

Choosing an Investigatory Project

You may be guided by your teacher for your choice of topic. The more original or new the project is, the better it would be. But it must be realistic in terms of the time available and at a level attained in the higher secondary biology.

You must review the available literature to find out what type of work has been done. This will help you to reject some of the alternatives, and possibly cause you to modify others. It may also be the source of new ideas.

By doing these investigatory projects you will gain experience of research besides providing opportunity for learning skills such as photography, electronics, etc.

Identifying the Objectives of the Project

Having identified a possible project, you should be able to identify and list the tentative objectives you hope to attain by completing that investigation. For example,

¨ Suppose your project involves studying the biodiversity of birds in your district/state, examine the data in the light of some questions (say, how do the birds in Rajasthan differ from those in Assam or Bihar?) your investigation might attempt to answer.

¨ Suppose your project involves investigating leaf mosaics revealing the complexity of the growth correlations that lead to efficient light interception, suggest also the factors that might affect this type of study.

Keep the aim of your project simple. Investigate only one factor at a time and never allow yourself to be side-tracked. Remember that time may be too short for follow-up and any fascinating secondary aspects that you may come across.

Designing Projects

Having established the objectives of your chosen project, you must have an experimental design. This will allow you to collect the data you need in a scientific way to test the hypothesis. For example, if your project involves investigating the hypothesis that stale milk contains more bacteria than fresh milk, devise the procedure you would adopt to carry out your investigation.

Planning Investigations

Having decided your topic for scientific investigation, you should give careful thought to the plan of your investigation in some detail. These may include

¨ What hypothesis can you make?

¨ How can you ensure that the experimental tests and measurement you carry out are accurate and reliable?

¨ What controls do you need?

• How many variables are you investigating? Correctly identify key variables as independent and dependent.

¨ Are your variables discrete or continuous?

¨ Identify appropriate control variable for fair test.

¨ How many repeat observations or samples will you require?

¨ What instruments/equipment or techniques will you use to obtain relevant information? Identify suitable materials and equipment to be used.

¨ If your investigation requires the use of a questionnaire, design and standardise before implementation.

¨ Is your intended procedure safe and ethically permitted, i.e., taking care of the distress or suffering of living organisms and damage to the environment?

¨ How will you collect your data?

¨ How do you plan to analyse your results? Would you employ statistical or other methods? Are scale range, interval, number of values chosen are adequate and reasonable ?

Executing the Project

Following planning, a brief description of the expected procedures has to be approved in advance by the teacher. Having decided what controls you need to use, list the components of your experiment and decide what quantities of substances to use, how to set the experiment. You should also decide what type of readings or measurements you are going to make, how often and how many. Note the source of error, if any, that you come across.

¨ Handle instruments and equipments appropriately to give accuracy.

¨ Repeat measurement.

¨ Keep proper controls and the variables constant.

Reporting/Writing of Project

A format, such as given below, can be followed.

 (i) **Title of the investigatory project**: Write the title of the project, for example, 'Inheritance pattern of eye colour'.

 (ii) **Objectives**: Express as clearly as possible the effect of one variable that the experiment is designed to investigate.

 (iii) **Materials needed**: This might be just a list, or a diagram if a particular piece of apparatus was used.

 (iv) **Method**: Describe the procedure stepwise including the precautions taken, if any.

 (v) **Result**: A suitable chart or table for recording and organising your readings or measurements should be made out before you start the experiment.

 (vi) **Analysis and interpretation**: Observation data are factual, and may not be as expected by you.

 (vii) **Discussion**: Discuss briefly the implication of your results and suggest extensions of any kind that can be undertaken.

 (viii) **Conclusion**: In view of the results obtained and related work done on the topic of the project, write conclusion briefly.

 (ix) **References**: Any work related to the project which you have come across through books/articles or any other source should be written as reference, for example: Michael Michalco (2001), *Cracking Creativity*, Berkeley, Ten Speed Press.

This write up is meant to train the students in scientific methods. In other words, it accentuates the spirit of enquiry and investigation in young minds.

The operational aspects of doing a project include choosing a hypothesis or problem to be investigated, collecting data in a designed manner, analysing the data in a scientific way, drawing conclusions which are justified and discussing the results in the light of known knowledge and bringing out its importance. Finally it includes the scientific way of communicating the findings.

While your discovery during the investigatory project may not merit a Nobel Prize it may help you discover something, a fact or relationship that was unknown to you and that was not recorded in any book available to you. Scientists refer to this as an independent discovery. Your investigation will certainly give a sample of the thrill of discovery.

Following are pages on procedural guideline about a few suggestive investigatory project work.

1. Investigating the pH of a water sample

Background information

Monitoring the physico-chemical properties of water is of vital importance. Normal maximum permissible limit of pH for our life and health is 6.5–8.5.

Abnormal levels of pH and their consequences are given below:
pH 3 to 5 is too acidic for most organisms to survive, when the pH of water falls below 4.5 most of the fishes die, leaving only a small number of acid-tolerant insects such as water boatman and whirligig. These insects (beetles) can survive and multiply even at pH 3.5. Similarly, pH>8.5 is too basic for most organisms to survive.

Materials needed

¨   Universal indicator test paper (broad range, narrow range PH 2–11)

¨   Water sample

2. Investigating the biochemical (also called biological oxygen demand [BOD]) of a water sample as pollution indicator.

Background information

A dissolved oxygen (DO) test measures the current status of oxygen in a water body. This is a useful starting point.

However, DO content can vary considerably from day-to-day as affected by many factors like temperature, wind velocity, eutrophication, pollution, etc. The unpolluted water is characteristically rich in DO and low in BOD.

Higher the BOD, lower would be DO. Conversely, the polluted water has high values of BOD. Water for drinking should have a BOD less than 1. Typical BOD value for raw sewage run from 200–400 mg of oxygen/litre. The maximum

permissible limit of BOD followed by Central Pollution Control Board (India) for national water quality monitoring purposes is less than or equal to 3mg/L.

For example, in a study the prevalence of some organisms were done at two different sites in a water body. The result can be tabulated on the basis of following facts:

A = Abundant; R = Rare; X = Very few

Concentration	Indicator organism	Site 1	Site 2
Organisms in order of tendency to disappear as degree of pollution increases	Red sledge worm (Tubifex worm)	A	A
	Larvae of midge (Chironomus)	R	A
	Blood Worm	X	X
	Leech (Hirudinea)	X	X
	Water louse, water skaters (Asellus)	X	X
	Fresh water shrimp (Gammarus)	X	X
	Water boatman	X	X
	Diving beetle (Dytiscus)	X	X
	Caddisfly larva (Ochrotricha)	X	X
	Damselfly larva (Lestes)	X	X
	Stonyfly nymph (Isoperla)	X	X
	Mayfly nymph (Stenonema)	X	X
	Snail (Lymnaea)	none	X
	Clams (Corbicula)	none	X
	Fungi	X	X
	Bacteria (anaerobic)	X	X
	Utricularia	X	X
	Chara	X	X
	Water fern (Salvinia)	X	X
	Water velvet (Azolla)	X	X
	Water meal (Wolffia)	X	X
	Lesser duckweed (Lemna minor)	X	X
	Greater duckweed (Spirodela)	X	X
	Diatom	X	X

3. Population density of plants

(i) Identify any 5 weeds from your locality.

(ii) Collect information about them from various sources. Focus on their economic importance especially their medicinal importance (collect samples for herbarium preparation).

(iii) Study their distribution in different localities by quadrat method.

(iv) Register their data and draw comparisons of their distribution by histograms.

(v) Try to analyse the differences in distribution and density.

(vi) Correlate their presence with their habitat/adaptability.

4. To make an inventory of local tree, shrub and herb

Informations can be listed in following categories:

(i) Avenue trees

(ii) Wind Breakers

(iii) Road dividers

(iv) Sound barriers

(v) Medicinal and other uses

5. Agrochemicals and their effects

The project may be carried out in a survey mode with a questionnaire prepared with the help of the teacher to cover the following aspects.

(i) List of pesticides used, amount used/hectare or acre, periodicity of spray, name of the crop plant grown, recommended dose and the dose employed, known effects on pest, whether the chemical pesticide is biodegradable or not, alternate ecofriendly biocides.

(ii) List of fertilisers used, cost incurred/acre/year, recommended dosage/ time of use and the dosage used, known effects on fertility of soil, any decrease in crop productivity, use of ecofriendly biofertilisers (VAM fungi, leaf mold, green manure, dung, etc.).

6. Ecological role of some animals observed in a local area

Record the various plant species growing in the area under study—trees, shrubs, annual/perennial herbs, etc.

Note the season when flower/seed is formed.

Note the various types of insects, birds, reptiles, amphibians, mammals, etc., and record their role as a/an

(i) Herbivore

(ii) Pollinator

(iii) Agent in seed dispersal

(iv) Prey

(v) Predator

(vi) Vectors for transmission of diseases

(vii) Any other

7. Study the effect of a local industry on environment

(i) Select an industry of your choice.

(ii) Note the source of energy used, product formed, raw materials used (locally available or imported) mode of transport used to move the final product.

(iii) Possible types of pollutants released by the industry (air/water/soil).

(iv) Measures undertaken by the management to comply with the standard set by Central Pollution Control Board (CPCB), PCBs, etc.

(v) Awareness about ISO 2000.

(vi) Impact assessment carried out or not.

8. Study of the effect of chemicals and pollutants on the Mitotic Index of the mitotically dividing onion root tip cells

This study may include

(i) Growing of onion root tip cells in the solution of pollutant/chemical and also in normal water as control.

(ii) Preparation and observation of slide for the study of mitotic index both in experimental and control set-ups.

(iii) Analysis of the effect of pollutant/chemical by comparing the data of mitotic index between experimental and control variable.

9. Study of the genetic markers in the human population

In this investigation a few selected inherited traits can be investigated in the family members of a small population in the locality. The compilation and analysis of data will provide an about prevalence of trait in the said population.

10. Inventory of weeds in aquatic bodies/agricultural fields

11. Inventory of birds in your locality, their ecological role as scavangers, pollinators, etc.

12. Impact of local industry on the environment and the remedial measures taken by the industry

The guidelines and a brief outline of a few projects have been given with a purpose to design and perform such investigation. Students and teachers can think and design investigatory projects based on almost all concepts about which experimental protocol have been given in the manual. However, a small list of suggestive projects are also given below. Please note that these are only suggestive and it is expected that students and teachers will take up many more types of investigatory projects depending on the specificity of their area, need and problems.

Investigatory Project **1**

Aim: To study the effect of pH on seed germination

Principle: pH is one of the most important factors that controls the composition of flora and fauna in different terrestrial and aquatic ecosystems. pH of soils is essentially controlled by the amount and type of various minerals and also by the quality and quantity of humus (dead, decaying organic matter) present in it.

Seed germination is controlled by pH of the germinating medium. Seeds of different species prefer a specific range of pH for maximum germination. pH not only controls the germination of seeds but also growth and development, reproduction and various other metabolic activities, of the plant.

Objectives: After completing the project, the students will be able to
1. Plan out an experiment and understand the use of appropriate chemicals, apparatus and equipment, and learn the preparation of solutions.
2. Understand research methodology.
3. Generate, analyse and interpret the data and draw conclusions.
4. Conceive and choose other different themes related to pH and plant growth.

Materials required:
1. 125 seeds each of sunflower, mustard, green moong, alfa alfa, fenugreek and barley (selection of seeds of different species may be made as per their availability)
2. Phosphate buffers
3. Distilled water
4. Petridishes of 7.5 cm diameter (15 pairs)
5. Blotting papers cut into circular discs to the size of petridishes

Procedure

(i) Prepare a range of pH buffers using Na_2HPO_4 and KH_2PO_4.

(ii) Wash the seeds with water and blot them dry.

(iii) Select an appropriate place in the laboratory where there is sufficient light. Arrange petridishes in three horizontal lines, with 5 dishes in each line. Arrange petridishes horizontally in three rows A, B and C with seven dishes in each row.

(iv) Place one blotting paper disc in each petridish.

(v) Wet the blotting papers with small quantities of buffer solution of 4.0 pH for petridish No. 1, 5.0 pH for petridish No. 2 and so on till all the blotting papers in petridishes No. 1–5 in row 'A' are wet with appropriate buffer solution.

(vi) Repeat the process for rows B and C also.

(vii) Spread selected seeds in each of the five petridishes in such a way that each petridish contains 25 seeds in row 'A'.

(viii) Repeat the process for rows B and C using two other types of seeds.

(ix) Cover the petridishes and record your observation after every 24 hours for 7 days. Tabulate your results as given.

Observation

Observe the emergence of radicle as an indicator of germination and record in the table. Calculate the percentage of germination every day.

Table: Percentage of .... seed germination

pH	No and % of seed germination							Total % of seed germination		
	1	2	3	4	5	6	7	A	B	C
4										
5										
6										
7										
8										

Use the data of the table for graphic presentation.

Inferences and conclusion

The inferences and conclusion may be drawn on the basis of observations and the points given below

- Find out at what pH range seeds of different species had maximum % of germination.
- Find out at what pH seeds failed to germinate or showed minimum % of germination.
- Is there any general pattern of seed germination with regard to pH ranges?
- What are the common features exhibited by the various types of seeds under varied pH ranges? For example, did all the type of seeds show maximum germination in acidic range or alkaline range or did pH preference varied between acidic and alkaline ranges?
- Did you observe any relationship among time period, seed germination and pH range?

Investigatory Project 2

Aim: Quantitative analysis of phytoplankton in a water body

Principle: The species composition and the density of the phytoplanktons determine the productivity status of a water body. Phytoplanktons are the principal producers in a water body. Based on the density of phytoplanktons, the water bodies are classified into non-productive or **oligotrophic** and highly productive or **eutrophic**. Oligotrophic water bodies support only a few species, whereas eutrophic water bodies support large number of species. Further, the species composition of the phytoplanktons indicates the status of health of the water body. Through phytoplankton assays, limnologists make an estimate of degree of pollution in the water body. High density of cyanophycean algae, diatoms, volvocales, etc., are the indicators of high degree of pollution. It should be noted that density and the species composition of phytoplanktons exhibit diurnal, seasonal and annual fluctuations. It therefore becomes important to monitor water bodies at regular intervals for drawing specific conclusions related to their ecology.

It is in this context, the procedure for phytoplankton analysis on qualitative (species composition) and quantitative estimation (density/unit area) is suggested for students who want to enter into fascinating realms of aquatic ecology.

Objectives: After completing the project, the students will be able to
1. Plan out an experiment.
2. Identify and quantify phytoplanktonic forms present in an aquatic ecosystem.
3. Interpret the data and draw conclusions.
4. Recognise the indicator species of pollution.

Requirements: Plankton net with plankton bucket, graduated plastic bucket (15 L), slides, cover slips, compound microscope, watch glasses, dropper, and 5% F.A.A (Formaldehyde Acetic acid, Alcohol)

Procedure

(i) Plankton net resembles the butterfly net in several aspects. Plankton net, however, is prepared from bolting silk cloth which is readily available at shops dealing in scientific equipments and chemicals. Procure about one metre of bolting silk cloth of 40 mesh size and stich out of it a 40 cm

long cone with a diameter of about 20 cm at the mouth and a diameter of 3–4 cm at the other end (both the sides open). Fasten to the mouth of the cone a circular iron ring (with handle) of about 20 cm diameter with the help of twine thread. Fasten a small steel bucket (plankton bucket) or glass specimen tube of 50 ml capacity at the lower end.

(ii)   Visit a nearby pond, pool or river bank carrying along with you the plankton net fitted with the plankton bucket, graduated plastic bucket and 5–10 ml of F.A.A.

(iii) Since this is a group activity, ask your friend to hold the plankton net firmly a few centimetres above the water surface.

(iv)   Immerse and fill the plastic bucket with water completely upto 15–litre – graduated mark and filter the water through the plankton net. Repeat the process several times (say10 times).

(v)   At the end calculate the quantity of water in litres (X) filtered by multiplying the amount of water in one bucket and number of buckets of water filtered.

(vii) During this process of filtering, the planktons are collected in plankton bucket. Only the water free of planktons escapes through the mesh of the net.

Splash a few buckets of water against the net from outside taking care that no water enters into the cone from the mouth. This will wash all the planktons sticking against the inside wall of the net into the plankton bucket.

Detach the plankton bucket from the net and add a few drops (1–2 ml) of 5% F.A.A. to the plankton concentrate. Transfer the concentrate collected into a suitable specimen tube and cork it. Note the volume of the concentrate (Y).

In the laboratory

1.   With the help of 1 ml pipette, draw 1 ml of concentrate and transfer it dropwise into the watch glass. Count the total number of drops that make 1 ml of concentrate (A).

2.   Transfer one drop of plankton concentrate from the watch glass on a clean slide. Cover it with square shaped cover slip. (For convenience divide the area of the cover slip into parts with the help of lines drawn by Indian ink).

Observation

Observe the slide under microscope and count the number of total organisms (B) by moving the slide from one corner of the cover slip to another horizontally as well as vertically till the entire sample under the cover slip is completed. With the help of following calculations find out the total number of different organisms per litre of water.

$$\text{Unit cells/L} = \text{Unit/L} = \frac{1000 \times (ABY)}{X}$$

Where A = number of drops in 1ml concentrate

B = number of organisms counted in 1 drop of concentrate

X = total amount of water filtered

Y = total volume of concentrate after filtration

Note: Another alternate method is the use of haemocytometer to calculate the density of organisms under the guidance of teacher.

Inferences and conclusion

Find out the density and composition of organisms in different water samples (polluted/non-polluted).

Note the common organisms in both the water samples and those specific to each sample.