

CHAPTER NO 2. SOLVING A BIOLOGICAL PROBLEM

Q1: What is science? How does science work?

Ans: Science:

Meaning:

The word science is derived from Latin word “Scientia” meaning knowledge.

Definition:

The knowledge which is based on observation and experiment is called science.

Scientific method:

A systematic method uses to solve a problem with the help of observation, information and experimentation is called scientific method.

Science work:

In science first observation is done and then after observation experiment is conducted to check the reality of the observation.

Q2: What is Biological method? Give its importance.

Ans: Biological method:

Definition:

The scientific method, in which biological problems are solved is termed as biological method.

Importance:

It has played a very important role in biological research from the last 500 years. It has contributed a lot to the progress of biology and up to the current Advancement in all the biological fields such as medicine, ecology and technology etc.

Steps of Biological method:

For solving biological problem, biologists take the following steps.

Step (1): Recognition of biological problem:

Biologists go for adopting biological method when they encounter some biological problem. A biological problem is a question related to living organism. It either asked by someone or comes in biologist mind by himself.

Step (2): Observation and previous research:

After recognizing the biological problem. The biologist makes observation. He also recalls his old observation and also studies previous research on the same problem.

Observation are made with five senses i-e, vision, hearing smell, taste and touch. There are two type of observation.

S/No	Quantitative Observations	Qualitative Observation
1	It deals numbers	It deals with description
2	It can be measured	It can be observed but not measured
3	Length, height, area, temperature, volume, weight, cost etc	Colour, texture, smell, taste etc
4	Examples: The freezing point of water is 0°C and the boiling point is 100°C A liter of water weight 1000 grams and liter of ethanol weighs 789 grams	Examples: The freezing point of water is colder than the boiling point. A liter of water is heavier than a liter of

		ethanol.
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Step (3): Hypothesis:

Hypothesis is an unaltered before experimentation “so tentative explanation of observation is called hypothesis” Biologist reasoning to formulate a hypothesis. Hypothesis consists of two type reasoning

I. Deductive Reasoning (deduce – take away from total):

Deductive Reasoning is the observation from general to specific.

Example:

If all organisms have cells and human is also an organism then conclude that human should have cells.

II. Inductive Reasoning (induct-lead in):

Inductive reasoning is the observation from specific to general.

Example:

We observe cell in Micro-Organisms so we can conclude that all living organism have cell in their body

Characteristic of a good Hypothesis:

- It is based upon observation made by the biologist
- It is a proposed statement to answer the problem.
- It is testable through experiments.
- It should be kept as simple as possible.
- There is always a way to disprove the hypothesis after experimentation.

Step (4): Deduction:

In this step biologist draw deduction from hypothesis deduction is the logical consequences of hypothesis as true and draw out the expected results called deduction. It involves the use of “if” and “then”.

Example:

If all birds have wings then pigeon is a bird

Step (5): Experiment:

The most important thing of biological method is experimentation. Biologist perform experiments on his hypothesis and checks the deductions.

Through experiment he can find that deduction of some hypothesis has come true while others have not. In this way, the hypotheses are proved as true or false hypothesis are rejected while the true ones are accepted.

In science when doing the experiment, it must be a controlled experiment. The scientist must contrast an experimental group with a control group.

For example,

- Experimental group (patients)
- Control group (Healthy person)

Step 6: Conclusion and Reporting:

Biologist collects data from his experiments. He analyze the data statistically to reach some conclusion. He publishes his conclusion in the form of research articles in scientific journals and books. Publishing of result is an essential part of scientific method.

Q3. Describe the steps involved in biological method taking malaria as an example?**Ans: Malaria**

Malaria is a common disease in many countries including Pakistan.

Naming:

The word malaria is the combination of two Italian words:

- “Mala” Mean
- “Area” Mean “air”

Biological problem 1: what is the cause of Malaria**Step 1: Observation:**

- Malarial patient experienced recurring attacks of chills and fevers.
- The disease was more common among people who lived in low marshy area.
- Drinking the water of marshes does not cause malaria.

These observations did not help much for solving the problem i-e “what is the cause of malaria” In 1878 a French physician Laveran examined the blood of a malaria patient under microscope. Five year late, the same microorganisms were observed in the blood of malaria patient and these microorganisms were given the name of “**Plasmodium**”

Step 2: Hypothesis and Deduction:**Hypothesis**

Biologist further build upon the ancient observation and the discovery of Laveran the hypothesis made in this case was,

“Plasmodium is the cause of Malaria”

Deduction:

Biologist does not know whether his hypothesis is true or not, but he accepts it may be true and make deduction. One of deduction from above hypothesis was,

If plasmodium is the cause of malaria, then all malarial patients should have plasmodium in their blood

Step 3: Experiment and Result:**Experiment:**

The next step was to test the deduction through experiments which were designed as, “Blood of 100 malaria patient was examined under microscope. For the purpose of having a control group, the blood of 100 healthy persons was also examined under microscope”

Result:

It was observed that all the malarial patients have plasmodium in their blood; whereas the blood of healthy persons was free from plasmodium.

Step 4: Conclusion

The result was quite convincing and proved that the hypothesis “Plasmodium is the cause of malaria” was true.

Biological problem 2: How is plasmodium transmitted to human beings?**Step 1: Observation:**

Biologist were having following observations

- Malaria is associated with marshes
- Drinking water of marshes does not cause malaria.

From these observations it can be concluded that plasmodium was not in the marsh water. But it must be carried by something that comes to marsh water.

In 1883 a physician A.F.A king listed twenty observation. Some important observation of A.F.A king were:

- People who slept in open places suffered from malaria more than the people who slept indoors.
- Individuals who slept near a smoky fire usually did not get malaria.
- Those people who used mosquito nets suffer less from malaria as compared to those who did not use mosquito nets.

Step 2: Hypothesis:

On the basis of this observation king suggested a hypothesis:

“Mosquitoes transmit plasmodium and so are involved in the spread of malaria

Step 3:

Following deductions were made considering the hypothesis as true:

“If mosquitoes are involved in the spread of malaria then, plasmodium should be present in mosquitoes” OR

“A mosquito can get plasmodium by biting a malarial patient”

Step4: Experiment:

Ronald Ross was British army physician who worked in India 1880s. He performed important experiment to test the above deduction. He allowed a female Culex mosquito to bite sparrows suffering from malaria. Some of the mosquitoes were killed and studied at various times. Ross found that plasmodium multiplied in the wall of the mosquito's stomach and then moved into mosquitoes' salivary glands. He kept some mosquitoes near the blood of mammals or birds for the maturation of the eggs. Ross found that the saliva of the infected mosquito contained plasmodium and in these previously healthy sparrows, he found many plasmodium.

Result:

It was observed that sparrows had plasmodium in their blood.

Step 4: Conclusion:

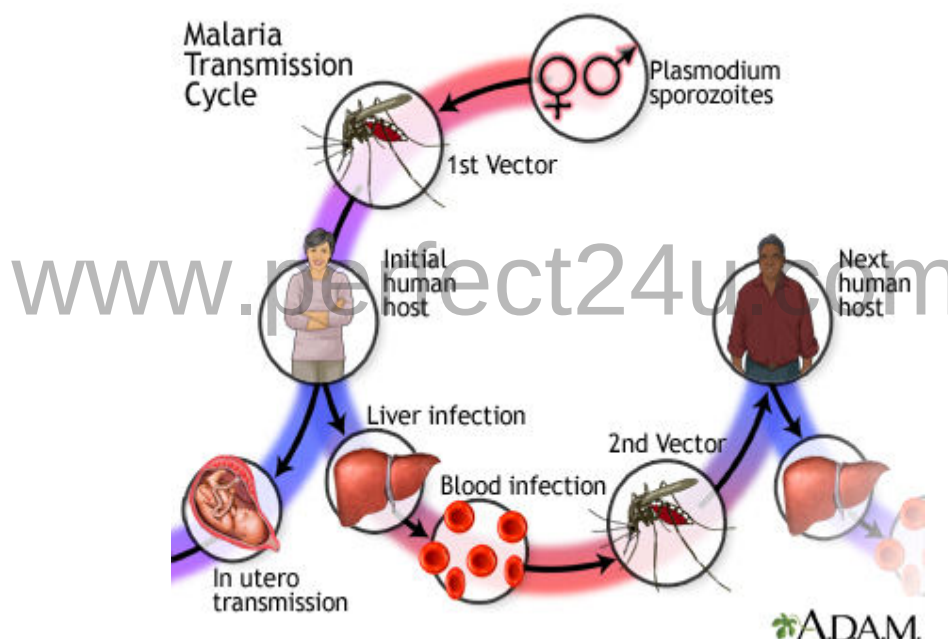
The results were quite convincing and proved that the hypothesis “How plasmodium transmitted to human beings” was true.

Q4: Explain the experiment of malaria on Human?

Ans. In the end hypothesis was tested by direct experimentation on human beings. In 1898 Italian biologists allowed an anopheles mosquito to bite a malarial patient. The mosquito was kept for a few days and then it was allowed to bite a healthy man. This person later got malaria. In this way, it was confirmed that mosquitoes transmit plasmodium and spread malaria.

Transmission of plasmodium:

When a female mosquito pierces the skin with her mouthparts, she injects a small amount of saliva to prevent the blood from clotting in her food canal.



Q5: Write a comprehensive definition of theory, law or principle.

Ans: Theory: -

When more research is carried out on a hypothesis and all the available evidence favours it, then it becomes theory.

Explanation: -

We know that when a hypothesis has been proved by experiments. Scientists keep on trying to do more experiments on it. When a hypothesis is proved by many experiments, scientists develop more hypothesis. If a hypothesis is proved by many experiments, scientists develop more hypotheses from it and test them experimentally. If the new hypotheses are again proved the original hypothesis becomes a theory.

Example: -

- Darwin theory about evolution
- Lamarck theory about evolution

Law or scientific principle: -

When a theory is accepted again and again and become a universal truth is called law. It must be simple, universal and absolute.

Explanation: -

Many biologists take it as a challenge and exert greater efforts to disprove the theory. If a theory survives such doubtful approach and continues to be supported by experimental evidences, it becomes law or principle. A scientific law is a uniform or constant fact of nature.

Example:

Hardy Weinberg principle and Mendel's laws of inheritance.

Q6: Discuss data organization and data Analysis?

Ans: Data organization and data analysis are important steps in the biological method.

Data organization:**Data:**

Data can be defined as

“Data can be defined as

“A piece of information such as name, date or values taken from observation and experimentation”

In order to formulate and then to test the hypotheses scientist collect and organize data through the use of variables and controls, results can be determined.

a. Variable:

Variable are those factors being tested in an experiment and usually compared to a control.

control:

A control is a known measure to which scientist can compare their results. Prior to conducting an experiment, it is very important for a scientist to describe the data collection methods. It ensures the quality of the experiment. Data is organized in different formats like graphics, tables, flow charts, maps and diagrams.

Data analysis:

Data analysis is necessary to prove or disprove hypothesis by experimentation. The methods involved in testing or analyzing the data are also important since an experiment should be repeated by others to ensure the quality of results. Depending on the type of data and the biological problem, this might include application of statistical methods i.e., ratio and proportion.

a.Ratio:

When a relation between two numbers e.g. ‘a’ and ‘b’ is expressed in terms of quotient (a/b), such a relation is the ratio of one number to the other. A ratio may be expressed by putting a division (÷) or Colon (:) mark between the two numbers.

Example:

The ratio between 50 malarial patients and 150 normal persons is 1: 3.

proportion:

Proportion means to join the equal ratios by the sign of equality (=).

Example:

$$a: b = c: d$$

is a proportion between the two ratios. This proportion may also be expressed as

$$a: b::c: d.$$

In every proportion of two ratios have four terms i.e., the first and forth terms are called extremes, the second and third are called means.

So, in the above proportion ‘a’ and ‘d’ are extremes while ‘b’ and ‘c’ are means.

The basic rule used to solve problems through ratio and proportion is that the product of the extremes is equal to the product of means. When three values in a proportion are known, the fourth one (X) can be calculated by using this rule.

Example: -

If a biologist wants to know how many sparrows would be infected with malaria if he allows Culex mosquito to bite 50 sparrows. Previously in one of his findings he already noticed that if allowed Culex mosquito to bite 10 sparrows 6 out of them got malaria.

Rule:

a: b::c: d

Sparrow: -

$$\begin{array}{ccc} 10 & \swarrow & 6 \\ 50 & \searrow & x \\ 10x & = & 50 \times 6 \end{array}$$

Dividing both sides by 10.

$$\frac{\cancel{10}x}{\cancel{10}} = \frac{\cancel{300}^{30}}{\cancel{10}} \\ x = 30$$

It means that 30 out of 50 sparrows will get malaria. Proportions are used to draw the conclusion.

Q7: what is the relationship of biology with Mathematics?

Ans: Mathematics as integral part of science:

Mathematics is used in biology in many fields.

Applied mathematics:

Biological method also involves the use of applied mathematics to solve biological problems. Major biological Problems in which knowledge of mathematics is used include gene finding, protein structure and the modelling of evolution

Bioinformatics:

Bioinformatics refers to the use of algorithms, computational and statistical techniques for the analysis of biological data. Computational biology refers to hypothesis driven investigation of specific biological problem using computer

For Example:

It is used for calculation in Human genome project. This project is used to determine the gene sequence of a particular organization. Mathematics is also used in ecology and evolution.

SHORT QUESTION

B. Give short answers to the following question?

Q1. What is science? How does science work?

Ans. See Q NO 1

Q2. Control group is important for scientific study, How?

Ans. Control group:

It is a group that remains constant throughout the experiment to test a hypothesis. But other variables are compared with it.

Importance:

1. To find more accurate and acceptable result of the experiment.
2. To compare the result with it.
3. To know the effect of treatment.

Q3. What deductions were developed during the study of Malaria?

Ans. Biologist does not know whether his hypothesis is true or not, but he accepts it may be true and make deduction.

- i. "If Plasmodium is the cause of malaria, then all malarial patients should have plasmodium in their blood"
- ii. "if mosquitoes are involved in the spread of malaria then Plasmodium should be present in mosquitoes"
- iii. "A mosquito can get plasmodium by biting a malarial patient"

Q4: How Ronald Ross conducted the experiment to prove that mosquitoes are involved in the spread of malaria?

Ans: Ronald Ross Experiment:

Ronald Ross was a British army physician who worked in India in 1880's. He performed important experiment to test the above deduction. He allowed a female Culex mosquito to bite sparrows suffering from malaria. Some of the mosquito were killed and studied at various times. Ross found that Plasmodium multiplied in the wall of the mosquito's stomach and then moved into mosquitoes salivary glands. He kept some mosquitoes alive and allows them to bite healthy sparrows. Female mosquitoes need the blood of mammals or birds for the maturation of their eggs. Ross found that the saliva of the infected mosquito contained Plasmodium and these entered the sparrow's blood. When he examined the blood of these previously healthy sparrows, he found many Plasmodium's.

Q5: At what stage of the biological method, Hypothesis, is accepted or rejected?

Ans: The stage of biological method, in which hypothesis is accepted or rejected is experiment.

The most basic step of biological method is experimentation. After experimentation the incorrect hypothesis are rejected and the one which proves correct is accepted.

LONG QUESTION

Give Detailed answers to the following Questions.

Q1: Differentiate between inductive reasoning and deductive reasoning?

Ans: See Q No. 2

Q2: Explain how biologists use scientific method to solve the mysteries of addressing the malarial problem?

Ans: See Q No. 3

Q3: Explain that how mathematics can be used to interpret the data obtained through experimentation.

Ans. See Q No. 6(See ratio, proportion and solved example)

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