Unit 02

# SOLVING A BIOLOGICAL PROBLEM

**Q.1. Define biological method. Explain its various steps involved in this method.**

**Ans. Biological Method:-**

**Definition**

Any organized and systematic method which is used to resolve a specific biological problem is called biological method of study.

Or

"The scientific method in which biological problems are solved is called biological method."

**Importance:**

Biological method has contributed to the advancements in medicine, ecology, technology etc. Biological method also ensures the quality of data for public use.

**Different steps of solving a Biological Problem**

In order to resolve a specific biological problem, biologist takes following steps;

(i) Recognition of biological problem
(ii) Observations
(iii) Hypothesis formulation
(iv) Deductions
(v) Experimentations
(vi) Summarization of results (create tables, graphics etc.)
(vii) Reporting the results.

**(i) Recognition of Biological Problem**

The first step in biological method is to determine a biological problem. A biological problem is a query about living organisms that is either asked by someone or comes in biologist's mind by himself.

**(ii) Observations**

Observations are made with five senses of vision, hearing, smell, taste and touch.

**Types of observations**

Observations may be qualitative or quantitative.

**Comparison of Quantitative and qualitative observations.**

Quantitative observations are considered more accurate than qualitative observations because the former are invariable and measureable and can be recorded in terms of numbers.

**Explanation**

**(a) Qualitative Observations**

**Definition**

Qualitative observations are less accurate, variable and can't be measured. These represent the quality of substance e.g., beauty, intelligence etc.

- The freezing point of water is colder than the boiling point.
- A liter of water is heavier than a liter of ethanol.

**(b) Quantitative Observations**

**Definition**

These represent quantity which can be measured in term of numbers and are measurable and invariable.

- The freezing point of water is $0^{o}C$ and the boiling point is $100^{o}C$.
- A liter of water weighs 1000 grams and a liter of ethanol weighs 789 grams.

**(iii)Formulation of Hypothesis**

**Definition**

Any suitable proposition that might be true is hypothesis.

**OR**

The tentative explanation of observations is called a hypothesis.

**Characteristics of hypothesis**

(a) It should be a general statement.
(b) It should be a tentative idea.
(c) It should agree with available observations.
(d) It should be kept as simple as possible.
(e) It should be testable and potentially falsifiable.

**iv) Deductions**

**Definition**

It is a logical conclusion drawn from hypothesis.

The deductions are tested through experiments.

Testing one deduction and finding it correct does not mean the hypothesis is correct but the validity of hypothesis is more supported if many deductions confirm the hypothesis.

**v) Experiments**

Experiments are designed to test the deduction. Biologists perform experiments to see hypotheses are true or not. For this purpose, experimental and control groups are formed.

**Experimental group**

The group of those who are affected in some way and we do not know the real cause e.g., a group of malarial patients.

**Control Group**

It is the group of unaffected people i.e. group of healthy persons in case of malaria.

**vi) Summarization of Results**

The biologist gathers actual and quantitative data from the experiments. To draw conclusions, the biologist also uses statistical analysis.

**vii) Reporting the Results**

Publishing of results in scientific journals and books is an essential part of the scientific method. It allows other people to verify the results or apply the knowledge to solve other problems.

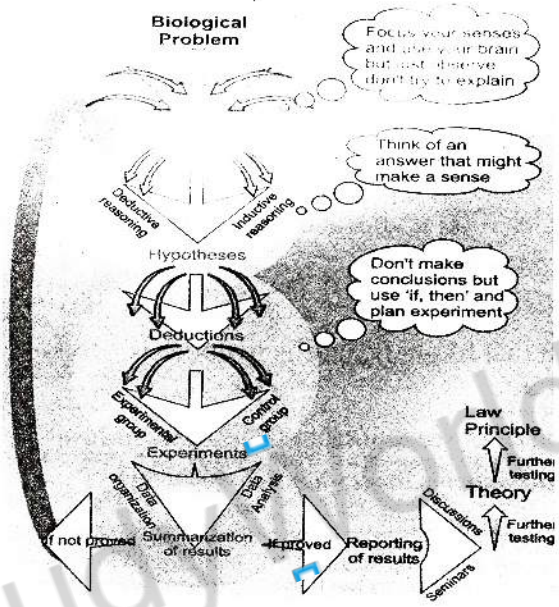


**Figure 2.1: biological method**

**Q.2. Explain biological method with an example of malaria.**

**Ans. Observations about Malaria**

**(1) Disease of chills and fever**

In ancient times, physicians were familiar with this disease. They described it as a disease of chills and fever with recurring attacks. They observed that the disease was more common among people living in low marshy areas.

**(2) Association of malaria with marshy places**

It was thought that the stagnant water of marshes poisoned the air and as a result of breathing in this "bad air", people got malaria. This belief lead to the name of disease "Malaria".

**(3) Meaning of malaria**

A combination of two Italian words. "The Italian word for "bad" is mala and "air" is aria".

**(4) Marshes and Malaria**

Some volunteers drank the stagnant water from the marshes. They did not develop malaria.

**(5) Treatment of malaria by using cinchona bark**

In 17th century, many plants from America were sent back to Europe to be used as medicines. The bark of a tree known as quina-quina was very suitable for curing fevers.

Some dishonest merchants began to substitute the bark of another tree; "cinchona" which closely resembled quina-quina. This dishonesty proved much valuable for mankind.

Cinchona bark was found to be excellent for treating malaria. Cinchona bark contains quinine that is effective in treating the disease.

**(6) Work of Laveran**

In 1878, a French army physician Lavern began to search for the cause of malaria. He took a small amount of blood from a malarial patient and examined it under microscope. He noticed some tiny living creatures. The organism was given a name "Plasmodium".

**(7) Four major observations about malaria**

1. Malaria and marshy areas have some relation.
2. Quinine is an effective drug for treating malaria.
3. Drinking the water of marshes does not cause malaria.
4. Plasmodium is seen in the blood of malarial patients.

## Hypothesis

The hypothesis made regarding malaria was "Plasmodium is the cause of malaria".

**Deduction**

Following deduction is drawn from the above mentioned hypothesis. "If the Plasmodium is the cause of malaria then all persons ill with malaria should have Plasmodium in their blood".

**Experiments**

The next step was to test the deduction through experiments which were designed as:

**(i) Experimental Group**

Blood of 100 malarial patients was examined under microscope.

**(ii) Control Group**

Blood of 100 healthy persons was also examined under microscope.

**Results**

The results of the experiments showed that almost all malarial patients had Plasmodium in their blood while 7 out of 100 healthy persons had plasmodium in their blood. Now we know that Plasmodium in the blood of healthy people was in incubation period i.e. the period between the entry of Parasite in host and appearance of symptoms. The results were quite convincing and proved that the hypothesis "Plasmodium is the cause of malaria" was true.

**Q.3. How Plasmodium gets into human body?**

**Ans.**

It was the next biological problem. The biologists want to learn how plasmodium gets into the blood of man

**(i) Observations .**

Biologists had following observations:

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

These observations show that plasmodium was not present in the marsh water. But it must be carried by something. That thing comes to marsh water.

**(ii) Work of A.F.A.King** **(Lahore board 2012 G I)**

**In 1883, a physician A.F.A. King listed 20 observations some important observations of king were:**

**(iii)Observations of A.F.A King**

- ❖ People who slept outdoors were more likely to get malaria than those who slept indoors.
- ❖ People who slept under fine nets were less likely to get malaria than those who did not use such nets
- ❖ An individual who slept near smoky fire usually did not get malaria.

**(iv)King's Hypothesis**

"Mosquitoes are involved in the spread of malaria".

**(v) Deductions**

Following deductions were made considering the hypothesis as true i.e; If mosquitoes are involved in the spread of malaria then;

**Deduction 1**

"Plasmodium should be present in mosquitoes".

**Deduction 2**

"A mosquito can get plasmodium by biting a malarial patient."

**(vi) Experiments of Ronald Ross** **(Lahore board 2012 G I)**

**Introduction**

In order to test the above deductions, Ronald Ross, a British army physician working in India in 1880's, performed important experiments.

**Experiment No. 1**

Ross allowed a female Anopheles mosquito to bite a malarial patient. He killed the mosquito some days later and found plasmodium multiplying in mosquito's stomach.

The next logical experiment was to allow an infected mosquito to bite a healthy person. If the hypothesis was true, the healthy person would have got malaria but scientists avoid using human beings for experiments.

**Experiment No. 2**

Ross used sparrows and redesigned his experiments. He allowed a female culex mosquito to bite on the sparrows suffering from malaria. Some of the mosquitoes were killed and studied at various times. In each mosquito, Ross found that plasmodium multiplied in the wall of mosquito's stomach and then moved into the mosquito's salivary glands.

**`Experiment No. 3**

Ross kept some mosquitoes alive in the second experiment and allowed them to bite healthy sparrows. Ross found that 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 in it.

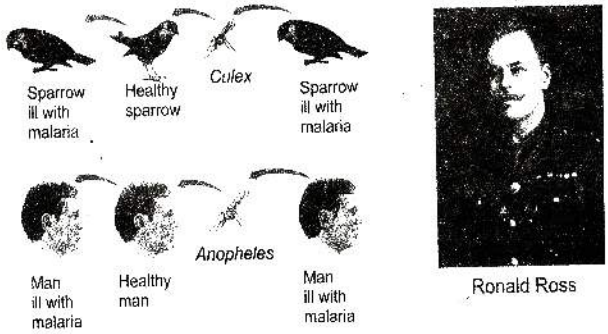


**Figure 2.2: Malaria in sparrow and man is transmitted by Culex and Anopheles mosquitoes respectively**

**Conclusion**

Ross concluded that similar relationship is found in mosquito and plasmodium.

**(vii) Experiments on Man**

In the end, the hypothesis that "mosquitoes transmit plasmodium and so are involved in the spread of malaria" was tested by direct experimentation on human beings. In 1898, some 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 became ill with malaria. In this way, it was confirmed that mosquitoes transmit plasmodium and so are involved in the spread of malaria.

**(viii) Theory:** **(Lahore board 2012 G II)**

The hypothesis that stand the test of time (often tested and never rejected) is called theory. A theory is supported by a great deal of evidence.

**(ix) Law and Principle:** **(Lahore board 2012 G II)**

If a theory survives a doubtful approach and continues to be supported by experimental evidence, it becomes a law or principle. A scientific law is a uniform or constant fact of nature. It is an irrefutable theory. The examples of biological laws are Hardy Weinberg law and Mendel's law of inheritance.

**Q.4. Explain the importance of data organization and data analysis in biological method.**

**Ans. Data Organization and Data Analysis**

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

**Data**

Data can be defined as a single piece of information such as names, dates or values made from observations and experimentations.

## Data Organization

In order to formulate and then to test the hypotheses, scientists collect and organize data. Prior to conducting an experiment, it is important for a scientist to describe the collection methods because it ensures the quality of experiments. Data is organized in different formats like graphics, tables, flow charts, maps and diagrams.

**Data Analysis**

Data analysis is necessary to prove or disprove a hypothesis by experimentation. It is done through the application of statistical methods.

**Application of Statistical Methods**

Depending on the type of data and the biological problem this might include application of statistical methods i.e.

(i) Ratio (ii) Proportion

**(i) Ratio**

**Definition:** When a relation between two numbers e.g. 'a' and 'b' is expressed in terms of quotient (a/b), it is called the ratio of one number two other.

**Representation of Ratio**

A ratio may be expressed by putting a division (÷) or colon (:) mark between two numbers.

**Example**

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

**(ii) Proportion**

**Definition**

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

**Representation of Proportion**

a : b = c : d or a : b :: c : d

**Example**

A biologist can calculate how many birds would get malaria, when he allowed infected mosquitoes to bite 100 healthy sparrows. In one experiment he noted that when he allowed mosquitoes to bite 20 sparrows, 14 out of them got malaria. By using proportion rule:-

X : 100 :: 14 : 20

$$\frac{X}{100} = \frac{14}{20} \Rightarrow X \times 20 = 14 \times 100$$

$$\Rightarrow X = \frac{100}{20} \times 14 \Rightarrow X = 70.$$

It means 70 out of 100 sparrows would get malaria.

**Statistics**

Statistics are thus a means of summarizing data through the calculation of a mean value. This step is very important as it transforms raw data into information which can be used to summarize and report the results.

**Q.5. Mathematics as an integral part of scientific process. Explain briefly.**

**Ans.** Biological method also involves the use of applied mathematics to solve biological problems. Major biological problem in which knowledge of mathematics is used including gene finding, protein structure and protein-protein interaction.

**Bioinformatics**

Bioinformatics refer to the use of computational and statistical techniques for the analysis of Biological problem.

## Multiple Choice Questions

1. Which one of the following is correct sequence in biological method?
   (a) Observations, Hypothesis, Law, Theory
   (b) Hypothesis, Observations, Deduction, Experimentation
   (c) Observations, Hypothesis, Deduction, Experimentation
   (d) Law, Theory, Deduction, Observations
2. Which one of these is not a characteristic of a hypothesis?
   (a) Must be consistent with all available data
   (b) Must be testable
   (c) Must be correct
   (d) Must make predictions
3. At which point, is a biologist most likely to use reasoning?
   (a) While taking observations
   (b) During hypothesis formulation
   (c) During data organization
   (d) None of the above.
4. A hypothesis must be testable to be scientifically valid. Being testable means that:
   (a) Some observations could prove that hypothesis is incorrect
   (b) Only a controlled experiment can indicate whether the hypothesis is correct or incorrect
   (c) The hypothesis is proven wrong
   (d) The opposite of hypothesis is tested and proven wrong
5. What would be the best experimental design for testing a hypothesis that bean plants require sodium?
   (a) Measure the amount of sodium in a few bean plants
   (b) Grow bean plants with and without sodium
   (c) Look for sodium in leaf tissues
   (d) Analyze root contents for sodium
6. A gardener sees a large snake nearby. He knows generally snakes sting, so

the gardener ran away. The gardener did which of the following?
(a) Used reasoning
(b) Used observation
(c) Constructed a theory
(d) Tested a hypothesis

**7.** A scientific theory has which of the following properties?
(a) It agrees with the available evidence
(b) It cannot be rejected
(c) It has been absolutely proven
(d) It does not need to be altered in the light of new evidences

**8.** Experimentation is only a step of the scientific process but it is very important step because it always:
(a) Gives the biologist a correct result
(b) Allows rejection of some alternative hypothesis
(c) Ensures that hypothesis can be confirmed with certainty
(d) Give scientists a chance to work in the laboratory

**9.** You are testing a hypothesis; "students learn more if they drink tea before sitting for study". Your 20 experimental students drink tea before study;
You test their learning by giving question. Your 20 students of the control group should have all experimental conditions identical to the experimental group EXCEPT that;
(a) They should take tea
(b) They should take tea before as well as during study
(c) They should not take tea before studying
(d) They should not sit for studying

**10.** When A.F.A King did work on Malaria?
(a) 1880 (b) 1881
(c) 1882 (d) 1883

**11.** The scientist who observed Plasmodium first time in human blood is:
(a) Aristotle (b) Bu-Ali-Sina
(c) Laveran (d) None of these

**12.** Which mosquito spread malaria in birds.
(a) Anopheles (b) Culex
(c) Anopheles & Culex
(d) None of these

**13.** Five senses are involved in:
(a) Hypothesis (b) Observations
(c) Deduction (d) Experiment

**14.** Logical consequence of hypothesis is:
(a) Experiment (b) Deduction
(c) Observation (d) theory

**15.** Which is the quantitative observation
(a) colour (b) smell
(c) beauty (d) height

**16.** Which of the followings is the symptom of malaria?
(a) Chills (b) Fevers
(c) Recurring attacks (d) All

**17.** Quinine is obtained from:
(a) quina - quina (b) Deodar
(c) Cinchona (d) shisham

**18.** Bark of quina – quina was imported from:
(a) Europe (b) America
(c) Spain (d) India

19. Plasmodium was first seen by:
(a) Ross (b) A.F.A.King
(c) Laveran (d) None

20. Plasmodium was named by:
(a) Ross (b) A.F.A.King
(c) Laveran (d) None

21. Who performed experiments on sparrow?
(a) Ross (b) A.F.A.King
(c) Laveran (d) None

22. No of steps of biological method are:
(a) Seven (b) Six
(c) Two (d) Eight
**(Lahore board 2011 G II)**

23. A scientific law is an irrefutable:
(a) observation (b) Theory
(c) Principle (d) None of these
**(Lahore board 2011 G I)**

| Answers | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | c | 3. | b | 5. | b | 7. | c | 9. | c | 11. | c |
| 2. | b | 4. | b | 6. | a | 8. | c | 10. | d | 12. | b |
| 13. | b | 14. | b | 15. | d | 16. | d | 17. | c | 18. | b |
| 19. | c | 20. | c | 21. | a | 22 | a | 23 | b | | |

## Short Questions

**Q1. What is Bioinformatics?**

**Ans.** Bioinformatics refers to the use of computational and statistical techniques for the analysis of biological data.

**Q2. Define Biological Method.** **(Lahore board 2012 G II)**

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

**Q3. Define Biological Problems.**

**Ans.** The question which is related to living things are called biological problem that is either asked by someone or comes in biologist's mind by himself.

**Q4. What is the difference between control group and experimental group?**

**Ans.** Control group is the group of people who are unaffected. For example the group of healthy persons will be called a control group.

Group of those persons who are affected with some disease and we do not know the real cause e.g. Group of malarial patients.

**Q5. Define Deduction.** **(Lahore board 2012 G II)**

**Ans.** The logical conclusion drawn from hypothesis is called deduction e.g., the deduction made about malaria from hypothesis was "If plasmodium is the cause of malaria then all persons ill with malaria should have plasmodium in their blood."

**Q6. Define Experiments and describe its types.**

**Ans.** Experiments are designed to test the deduction. For this purpose, experimental and control groups are formed. Two groups are always made in experimentation:

(i) Control group (ii) Experimental group

**Experimental Group:**

The group of those persons who are affected in some way and we do not know the real cause e.g. persons suffering from any disease.

**Control Group:**

It is the group of unaffected people i.e. group of healthy persons.

**Q7. Define Hypothesis.** **(Lahore board 2011 G I)**

**Ans.** The tentative explanation of the observation is called a hypothesis e.g., hypothesis made about malaria was "Plasmodium is the cause of malaria".

**Q8. Differentiate between Law and Theory.**

**Ans. Law**

If a theory survives doubtful approach and continues to be supported by experimental evidence, it becomes a law.

**Theory**

The hypothesis that stands the test of time (often tested and never rejected) is called theory. A theory is supported by a great deal of evidence.

**Q9. Define observations. What are their types?**

**Ans.** Observations are made with five senses of vision, hearing, smell, taste and touch.

**Types of observations**

Observations may be both qualitative and quantitative.

**Quantitative Observations**

Quantitative observations are considered more accurate than qualitative ones because these are invariable and measureable and can be recorded in terms of numbers.

**Qualitative Observations**

Qualitative observations are less accurate, variable and cannot be measured e.g., beauty, intelligence.

**Q10. What is the association of anopheles mosquito with humans?**

**Ans.** It is a female mosquito which transfers plasmodium from one person to another and it plays an important role in spreading the malaria in humans

**Q11. Why Cinchona bark is important in biologist's mind for treating malaria?**

**Ans.** Cinchona is a plant and the biologists get Quinine from the bark of cinchona.

**Q12. What is Plasmodium?**

**Ans.** Plasmodium is a microscopic parasitic protozoan which causes malaria. It completes its sexual phase of life cycle in mosquitoes and asexual phase in the body of human.

**Q13. What do you know about Quina Quina?**

**Ans.** This is a plant which is found in America. Initially, the bark of Quina Quina was used in the treatment of fever.

**Q14. What is incubation period?**

**Ans.** The period in between the entry of plasmodium parasite in human body and appearance of symptoms of malaria is called incubation period.

**Q15. What are the characteristics of a good hypothesis?** **(Lahore board 2011-12 G I)**

**Ans.** 1. It should be a general statement.

2. It should be a tentative idea.
3. It should agree with available observations.
4. It should be kept as simple as possible.
5. It should be testable and potentially falsifiable.

**Q16. Why welts appear after biting mosquito?**

**Ans.** The welts that appear after mosquito bites is not a reaction to the wound but an allergic reaction to the saliva. In most cases, the itching sensation and swelling subside within several hours.

**Q17. Write major observations about malaria.**

**Ans.** 1. Malaria and marshy areas have some relation.
2. Quinine is an effective drug for treating malaria.
3. Drinking water of marshes does not cause malaria.
4. Plasmodium is seen in the blood of malarial patients.

**Q18. Define Science.**

**Ans.** Science is the systematized knowledge derived from observations and experiments.

**Q19. What are the observations of A.F.A. King?**

**Ans.**

1. People who slept outdoors were more likely to get malaria than those who slept indoors.
2. People who slept under fine nets were less likely to get malaria than those who did not use such nets.
3. People who slept near a smoky fire usually did not get malaria.