Name_____ Period _____

Scientific Method Case Study

A Case Study in Science

Perhaps the best way to see how science works is to look at a real case where science has been used to solve a problem and improve human health. We will study malaria, a disease that kills more humans than any other. In 1941, more than 4,000 Americans died of malaria. This disease has been virtually eliminated from the United States as the result of one man's work. His story is a very real example of how science works. His investigations were simple. They involved careful observation and the formulation of clear questions. Finding the cause of malaria is one of the greatest medical advances of all time.

1. This case studies one of the greatest medical discoveries of all times. What is the disease that is being discussed?_____

Observations suggest questions to investigate

In the summer of 1897 an English physician, Ronald Ross, worked in a remote field hospital in Secunderabad, India. Ross set out to find the cause of malaria. Of all tropical diseases, malaria was the greatest killer, taking more than a million lives a year in India alone. No one knew what caused the disease - but most doctors thought it was brought about by poisonous mists or vapors. Working alone, Ross discovered the pattern by which the disease spread.

Ross observed that patients in the field hospital who did not have malaria were more likely to develop the deadly disease in the open wards (those without screens or netting) than in wards with closed windows or screens. Ross wondered why people in open wards were much more likely to get malaria than those in closed wards.

2. In searching for the cause of malaria, what observations did Ross make about the location of patients who developed the disease in the field hospital?

   _____

   _____

Hypothesis: The basis of further investigation

Observing this pattern, Ross suggested an explanation for why people in open wards were much more likely to get malaria. We call such an explanation a hypothesis. A **hypothesis** is a testable explanation for an observation. Ross proposed that mosquitoes in the open wards might be spreading the disease from patients with malaria to patients who did not have the disease. By observing the mosquitoes closely, Ross noted they were *Anopheles*. Using this fact, Ross formulated a hypothesis. Ross's hypothesis was that *Anopheles* mosquitoes were spreading the disease from one patient to another.

3. Ross proposed that _____ mosquitoes were spreading malaria from patients with the disease to patients who did not have the disease.
4. Ross's testable explanation for his observations is called a(n) _____.

Predictions: The framework for testing hypotheses

If Ross's hypothesis was correct, then several consequences could reasonably be expected. We call these expected consequences predictions. A **prediction** is what you expect to happen if a hypothesis is accurate. Ross predicted that *if* the *Anopheles* mosquitoes were spreading malaria (hypotheses), *then* mosquitoes that had bitten malaria patients and sucked up some of their blood should have picked up the parasite *Plasmodium* (prediction), which is always present in the blood of malaria victims. Ross also predicted that parasites should be alive within the mosquito. Somehow the parasites make their way from the mosquito's stomach to its saliva so that the parasites are transferred with the mosquito's saliva to the next person bitten.

5. Based on Ross's hypothesis, several _____ can be made.
6. What is the parasite that causes malaria?_____

Testing under controlled conditions can verify predictions

The controlled test of a hypothesis is called an experiment. Ross did two types of experiments. He looked for living malaria parasites in *Anopheles* mosquitoes that had bitten malaria patients. He carefully dissected the mosquito's stomach and found the live parasites. He then located the mosquito's salivary gland and by careful dissection showed that the parasite spreads throughout an infected mosquito's body and was indeed present in the salivary gland.

If a person is bitten by a malaria-carrying mosquito, that person will receive a dose of the parasite in the saliva left behind by the mosquito. To test this prediction, Ross carried out a control experiment. A **control experiment** is one in which the condition suspected to cause the effect is compared to the same situation without the suspected condition (a control group). Nothing else is changed or altered in any way. In Ross's experiment, the suspected condition was mosquitoes feeding on malaria victims. As a control, Ross checked mosquitoes that had not bitten someone with the disease to see if they also contained the parasites. If they did, then malaria patients could not possibly be the source of the parasites in the mosquitoes, and Ross's prediction must be wrong. Gathering newly hatched mosquitoes, which had not yet fed, he allowed them to feed on malaria-free blood, and then he examined them as adults. Their stomachs and salivary glands lacked the parasite. The control group of mosquitoes did not contain malaria parasites.

7. How is the parasite transferred from the mosquito to the person that is bitten?

   _____

   _____

8. Explain the control experiment Ross conducted.

   _____

   _____

Theories: Explanations for observations

A collection of related hypotheses that have been tested and supported is called a theory. A **theory** is a unifying explanation for a broad range of observations. Theories can have a major impact on science when they tie many accepted and proven hypotheses together into a unified concept. Ross's theory that malaria is transmitted by *Anopheles* mosquitoes carrying it form one person to another was an important milestone in medicine. The idea that combating mosquitoes could prevent malarial epidemics was first put forth in a letter written by Ross to the government of India in 1901. Before the end of that year, American army doctors had eliminated almost all malaria from Havana, Cuba, where malaria had reached an epidemic stage. The success of eliminating the deadly disease in these areas was brought about by the reduction of the mosquito population. There have been few advances in the history of medicine more dramatic than the discovery of the cause of malaria.

9. What is a theory? _____

_____

Science requires continued verification of hypotheses

The essence of science is to reject any hypothesis not supported by observations and the results of control experiments. A new hypothesis is examined very closely to see what it predicts and the predictions are then rigidly tested. If the predictions are not supported, the hypothesis is rejected. If they are confirmed, the hypothesis is subjected to further verification. One very critical aspect of science is that a scientist's work is held up for review by other scientists. The validity of one's hypothesis is questioned by others until similar results are obtained from similar control experiments. This system of checking and rechecking hypotheses ensures that most, if not all, scientific information is factual information.

Hypotheses that do not explain observations are rejected

A scientist works by systematically showing that certain hypotheses are invalid, that is, they are not consistent with the results of experiments. The results of all experiments are used to evaluate alternative hypotheses. An experiment is successful when it shows that one or more of the alternative hypotheses are inconsistent with observations. By conducting experiments, Ross was able to eliminate the hypotheses that mosquitoes *could* transmit the malaria parasite without biting malaria victims. He retained the alternative hypotheses that if mosquitoes did bite malaria victims, then the mosquitoes could not transmit the parasite. Scientific progress is often made the same way a marble statue is, by chipping away the unwanted bits.

10. Science rejects any hypothesis not supported by _____ and the results of _____ experiments.

In each space provided, write the letter of the term or phrase that best completes each statement or best answers each question.

_____ 11. Most typically, the order in which the steps of the scientific method are applied is
   a. observations, predictions, hypothesis, controlled testing, theory, verification
   b. predictions, observations, hypothesis, theory, controlled testing, verification
   c. observations, hypothesis, predictions, controlled testing, theory, verification
   d. observations, hypothesis, predictions, controlled testing, verification, theory

_____ 1 2. A unifying explanation for a broad range of observations is a
a. hypothesis.
b. theory.
c. prediction.
d. control experiment.

_____ 13. A control experiment
a. is one in which a lead scientist controls a group of scientists conducting an experiment.
b. Is always conducted using one large, random sample group.
c. Is one in which the condition suspected to cause the effect is compared to the same situation without the suspected condition.
d. Rarely provides the answer to a question posed by a theory.

_____ 14. A hypothesis that does **not** explain an observation
a. is known as an inaccurate forecast.
b. often predicts a different observation.
c. is rejected.
d. None of the above.

_____ 15. The English physician Ronald Ross wanted to find the cause of malaria. Based on his observations, Dr. Ross suggested that the *Anopheles* mosquito might spread malaria from person to person. This suggestion was a
a. prediction.
b. hypothesis
c. theory.
d. scientific "truth."

_____ 16. Dr. Ross knew that a parasite, *Plasmodium*, was always found in the blood of malaria patients. He thought that if the *Anopheles* mosquitoes were responsible for spreading malaria, then *Plasmodium* would be found in the mosquitoes. This idea was a
a. prediction.
b. hypothesis.
c. theory.
d. scientific "truth."

_____ 17. To test his ideas, Dr. Ross performed an experiment. He looked for *Plasmodium* in the bodies of mosquitoes that had bitten, and some that had not bitten, people with malaria. This type of experiment is known as a
a. hypothesized experiment.
b. concluding experiment.
c. control experiment.
d. theoretical experiment.