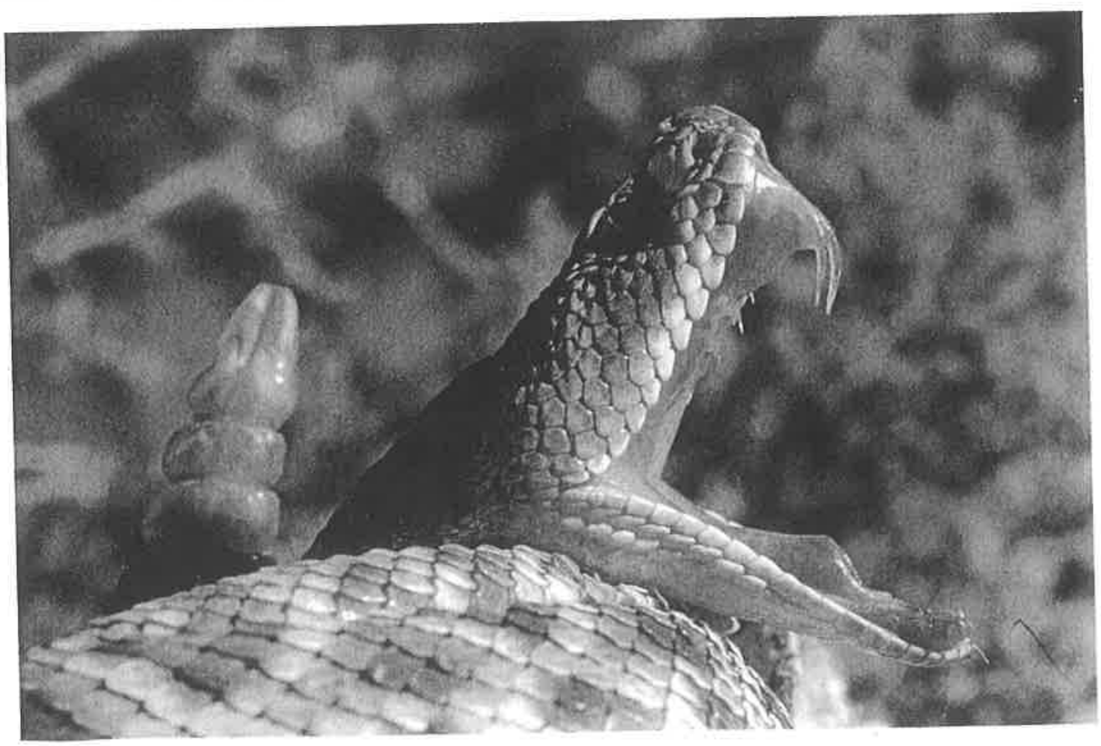
1-1 What Is Science?

The universe around you and inside of you is really a collection of countless mysteries. It is the job of scientists to solve those mysteries. And, like any good detective, a scientist uses special methods to find truths about nature.

These truths are called facts. An example of a fact is that the earth is populated with millions of different kinds of living things. But science is more than a list of facts. Jules Henri Poincaré, a famous nineteenth-century French scientist, put it this way: "Science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house."

So scientists go further than simply discovering facts. Scientists try to use facts to solve larger mysteries of nature. In this sense, you might think of facts as clues to scientific mysteries. An example of one of these larger mysteries is how the relatively few and simple organisms of three billion years ago gave rise to the many complex organisms that inhabit the earth today.

Figure 1-1 *It is a fact that this red diamondback rattlesnake injects poison into its prey. It is a hypothesis that the rattler locates its injured victim by following the smell of its own venom.*



Scientific Methods

To uncover scientific facts and solve scientific mysteries, scientists can use any one of a number of **scientific methods.** There are various basic steps in these methods. But these steps need not be followed in any particular order, although some orders make more sense than others. Sometimes the order in which a scientist tries to solve a mystery depends on the nature of the mystery. The basic parts of any scientific method are the following:

- Stating the problem
- Gathering information
- Suggesting an answer for the problem
- Performing an experiment to see whether the suggested answer makes sense
- Recording and analyzing the results of experiments or other observations
- Stating conclusions

The following example shows how a scientific method was used to solve an actual problem. As you will see, the basic steps of a scientific method often overlap.

Activity

Similarity and Diversity in Living Things

An ability to observe things around you can help you gain information about your world. Take a walk through your neighborhood and look at the different forms of plant and animal life, such as trees, shrubs, flowers, insects, birds, and fish. As you observe each organism, try to answer the following questions: How is that particular organism similar to other organisms? How is it different?

Take a notebook and a pencil with you to record your answers to these questions. You may wish to include drawings.

Stating the Problem

Most people know enough to walk the other way if they should run into a rattlesnake. However, if you could safely observe a rattler, you would discover a rather curious kind of behavior.

With fangs flashing and body arching, the deadly rattler strikes. The snake's fangs quickly inject poisonous venom into its victim. Then, in a surprise move, the rattler allows the wounded animal to run away! But the rattlesnake will not miss its intended meal. After waiting for its poison to take effect, the rattler follows the trail of the injured animal.

Although the rattler cannot see well, somehow it manages to find its victim on the dense, dark, forest floor. Clearly, something leads the snake to its prey. What invisible trail does the snake follow in tracking down its bitten prey? This is a *problem* that scientists recently tried to solve.

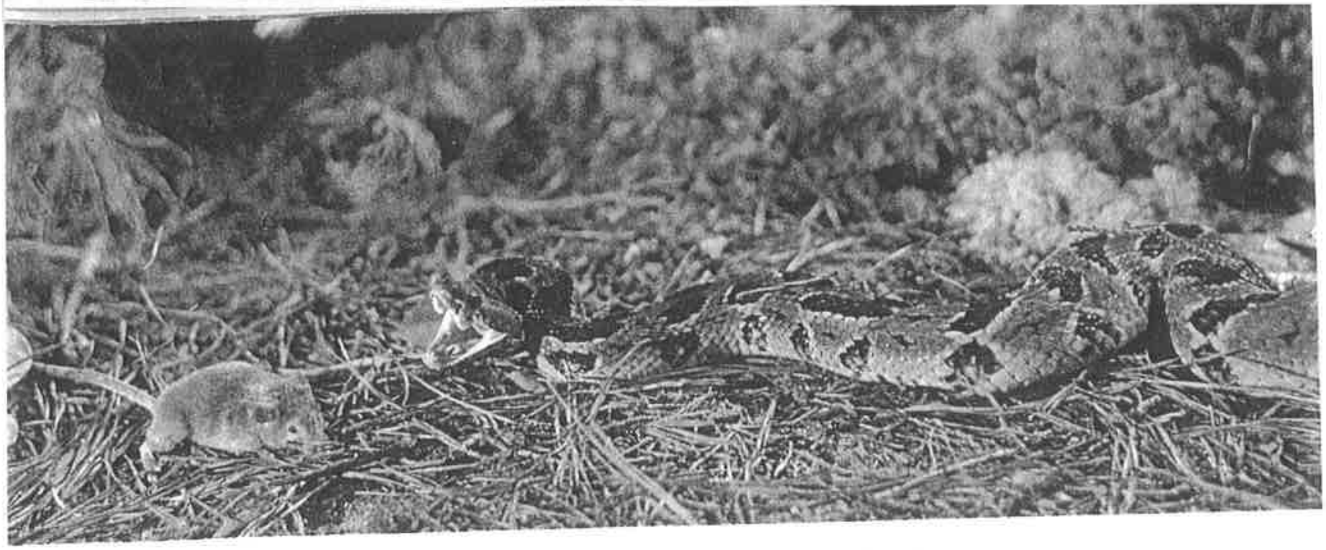


Figure 1-2 *The rattler does not have an especially keen sense of sight. Its pit organs detect the body heat given off by this field mouse.*

Gathering Information on the Problem

The first step in solving a scientific problem is to find out or review everything important related to it. For example, the scientists trying to solve the rattlesnake mystery knew that a rattlesnake's eyes are only sensitive to visible light. However, they also knew that a pair of organs located under the animal's eyes detects invisible light in the form of heat. These heat-sensing pits pick up signals from warmblooded animals. The signals help the snake to locate its intended prey. But the heat-sensing pits cannot help the snake find a wounded victim that has run many meters away. Some other process must be responsible for that.

The scientists knew that a rattler's tongue "smells" certain odors in the air. The rattler's tongue picks up these odors on an outward flick. The odors enter the snake's mouth on an inward flick. The scientists also knew that the sight or smell of an unbitten animal did not trigger the rattler's tracking action. Using all this information, the scientists were able to suggest a solution to the problem.

Activity

Theories and Laws

Scientists sometimes use observations and experiments to develop a theory. A theory is a broad scientific explanation for things that happen in nature. If the theory is tested and confirmed, it may become a law.

Using books and reference materials in the library, find out about a theory in life science that became a law.

Forming a Hypothesis

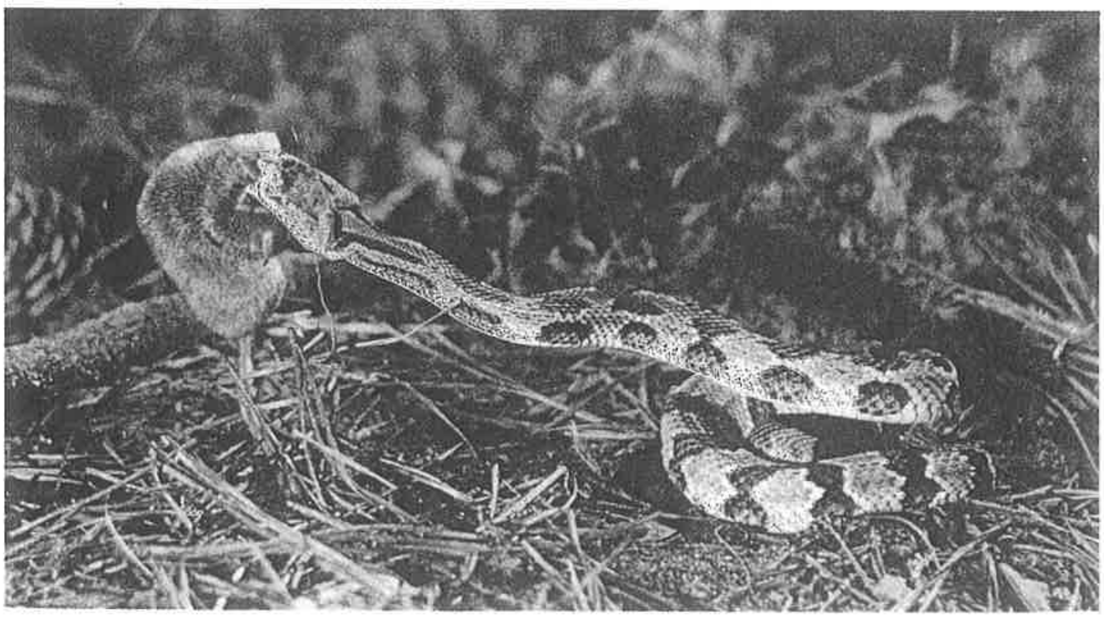
A suggested solution is called a **hypothesis** (high-PAH-thuh-sis). A hypothesis is almost always formed after the information related to the problem is carefully studied. But sometimes a hypothesis is the result of creative thinking that often involves bold, original guesses about the problem. In this regard, forming a hypothesis is like good detective work, which involves not only logic, but hunches, intuition, and the taking of chances.

To the problem, "What invisible trail does a rattler follow in tracking down its prey?" the scientists suggested a hypothesis. The scientists suggested that *after the snake wounds its victim, the snake follows the smell of its own venom to locate the animal.*

Experimenting

The scientists next had to test their hypothesis by performing certain activities and recording the results. These activities are called *experiments.* Whenever scientists test a hypothesis using an experiment, they must make sure that the results of the experiment clearly support or do not support the hypothesis. That is, they must make sure that one, and only one, factor affects the results of the experiment. The factor being tested in an experiment is called the **variable.** In any experiment, only one variable is tested at a time. Otherwise it would not be clear which variable had caused the results of the experiment.

Figure 1-3 *Sinking its fangs into its victim, the rattler injects the mouse with deadly poison.*



In the rattlesnake experiments, the scientists tested whether the snake's venom formed an invisible trail that the snake followed. The venom was the variable, or single factor, that the scientists wanted to test. The scientists performed the experiment to test this variable.

First, the scientists dragged a dead mouse that had been struck and poisoned by a rattlesnake along a curving path on the bottom of the snake's empty cage. When the snake was placed in its cage, its tongue flicked rapidly, its head moved slowly from side to side, and it followed the exact trail the scientists had laid out. The results seemed clear, but the scientists had one more experiment to perform.

To be sure it was the scent of the venom and no other odor that the snake followed, the scientists ran a **control** experiment. A control experiment is run in exactly the same way as the experiment with the variable, but the variable is left out. So the scientists dragged an unbitten dead mouse along a path in the cage. The experiment was exactly the same, except this mouse had not been poisoned. This time the snake seemed disinterested. Its tongue flicked very slowly and it did not follow the path.

Recording and Analyzing Data

The rattlesnake experiments were repeated many times, and the scientists carefully recorded the **data** from the experiments. Data include observations such as measurements.

Stating a Conclusion

After analyzing the recorded data, the scientists *concluded* that the scent of venom was the only factor that could cause a rattlesnake to follow its bitten victim. Rattlesnake venom is made up of many different substances. Exactly which ones are responsible for the snake's behavior are as yet unknown. As is often the case in science, a solution to one mystery brings to light another mystery. Using scientific methods similar to those described here, scientists hope to follow a path that leads to the solution to this new mystery.

Activity

Early Scientists

The science of biology owes a great deal to the work of many early scientists. Using books and reference materials in the library, look up the following names.

Anton van Leeuwenhoek

Robert Hooke

Leonardo da Vinci

Gerty Radnitz Cori

Write a brief report about the scientists, including information about the contribution of each.

SCIENTIFIC METHOD

Part I- from: A Voyage of Adventure page 14-18

Directions: Read pages 14-18 and answer the following questions.

1. In your own words explain what is meant by the quotation, "Science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house."

2. What do scientists do?

3. List the steps of the scientific method. Must they always be followed in this order?

4. What is the problem, concerning rattlesnakes, that scientists are trying to solve? Before reading any further, suggest one or more hypothesis or guesses as to how the snake accomplishes this.

5. What information about rattlesnakes did scientists gather to help them answer this mystery?

6. What types of thinking are involved when making hypothesis? What hypothesis did scientists come up with in this case?

7. What are experiments? What is their purpose?

8. What is a variable?

9. Why is only one variable tested at a time?

10. What was the variable in the rattlesnake problem? Describe how the experiment was conducted.

11. Why did scientists drag an unbitten mouse along a path in the snake's cage? What is this part of the experiment called?

12. What is data?

13. Why is it important to run an experiment more than once?

14. What did the scientists conclude in this experiment?

15. Did this experiment solve all the scientist's questions?