chapter 1 The Study of Life

section 3 Methods of Science

Before You Read

Suppose you want to identify a bird that visits the feeder in your yard. On the lines below, describe some methods you might use to identify the bird. Then read the section to learn the methods scientists use to gather information and answer questions.

MAIN Idea

Biologists use specific methods when conducting research.

What You'll Learn

- the difference between an observation and an inference
- how a control, an independent variable, and a dependent variable differ

Read to Learn

Ask a Question

Scientific inquiry begins with observation. **Observation** is a direct method of gathering information in an orderly way. It often involves recording information. For example, if you want to identify a bird, you observe it. You note how it behaves and what it eats. You might draw or photograph it.

Scientific inquiry involves asking questions and using information from reliable sources. By combining information from other sources with your observations of the bird, you could start making logical conclusions. This process is called making **inferences**, or inferring. For example, if you saw a photo of a bird that was similar to your bird, you might infer that your bird was related to the bird in the photo.

Biologists work in many settings. They work in the field. They work in laboratories, universities, and museums. No matter where they work, all biologists use similar methods to gather information and to answer questions. These methods are an organized series of events called **scientific methods**. Throughout the process, biologists continue to observe and make inferences.

Study Coach

Make an Outline Make an outline of the information you learn in this section. Start with the headings. Include the boldface terms.

Think it Over

1. **Explain** how inferences relate to observation.

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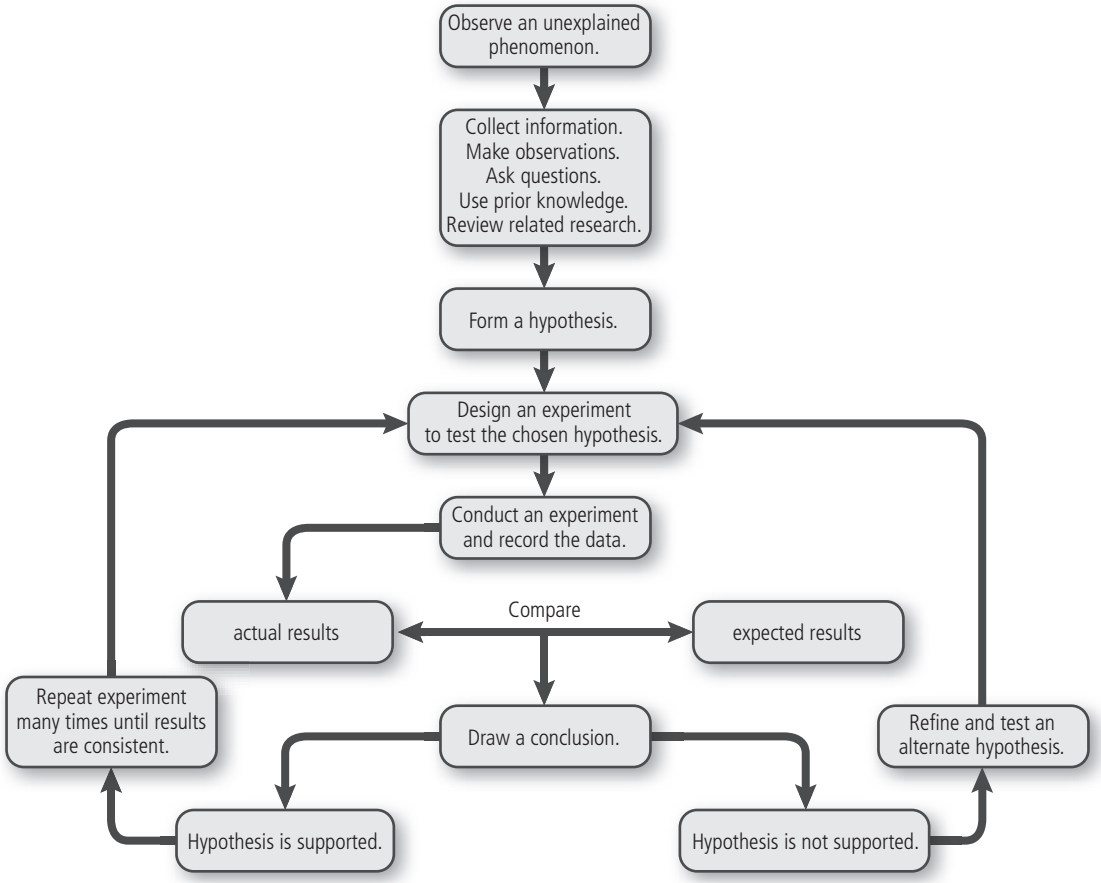

Picture This

2. Sequence After a researcher draws a conclusion, what does he or she do next, whether or not the hypothesis is supported? (Circle your answer.)

a. draw another conclusion
b. conduct another experiment
c. compare results again

Reading Check

3. Explain the purpose of an experiment.

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Form a Hypothesis

The figure below shows the sequence of events in scientific methods. Scientists use the information they gather from observation and other sources to form a hypothesis. A **hypothesis** (hi PAH thuh sus) is a testable explanation of a situation. When enough data from many investigations support a hypothesis, the scientific community accepts the explanation as valid. If the data do not support a hypothesis, the hypothesis is revised and investigated further.

Sometimes scientists make unexpected discoveries. Serendipity is the occurrence of accidental or unexpected, but fortunate, results. For example, penicillin was discovered while a scientist was investigating something else.

Collect the Data

Scientists test a hypothesis through experiments. An **experiment** is an investigation done in a controlled setting that tests the hypothesis.

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What is the purpose of a control group?

Experiments have an experimental group and a control group. The **experimental group** is the group exposed to the factor being tested. For example, suppose scientists wanted to test the effects of a vitamin supplement on energy level. The experimental group would receive the vitamin. The **control group** is the group used for comparison. This group would not receive the vitamin.

How do scientists design an experiment?

In a controlled experiment, scientists change only one factor at a time. The factor that is changed in an experiment is called the **independent variable**. It is the tested factor, and it might affect the outcome of the experiment. A **dependent variable** is something that results from or depends on changes to the independent variable. In our example, the vitamin is the independent variable and energy level is the dependent variable. A **constant** in an experiment remains fixed, while the independent and dependent variables change.

What two kinds of data do scientists collect?

Information gained from observations is called **data**. Data in the form of numbers is called quantitative data. Quantitative data might measure time, temperature, length, mass, area, volume, density, or other factors. Qualitative data are descriptions of what the observer senses. Everyone senses things differently. As a result, qualitative data can vary from one observer to another.

What system of measurement is used?

Scientists use the **metric system** which uses units with divisions that are powers of ten. In 1960, a system of unit standards of the metric system was established called the International System of Units, or **SI**. In biology, the SI units you will use most often are meter (length), gram (mass), liter (volume), and second (time).

Analyze the Data

After biologists collect data from experiments, they interpret the data and look for patterns. They compare their results to expected results to see if the data support their hypothesis. If not, they revise the hypothesis and retest. Even when the data support the hypothesis, the experiment must be repeated many more times. Consistent results from repeated trials give strength to the hypothesis as a valid explanation for the tested phenomenon.

Think it Over

4. Apply Suppose a biologist designed an experiment to study the effect of water pollution on the reproductive rate of salmon. What is the dependent variable in this experiment?

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Reading Check

5. Classify "The average high temperature here in March is 22°C." Is this information qualitative data or quantitative data?

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Why do biologists use tables and graphs?

Biologists often display data in tables and graphs to make patterns easier to detect. The data about the mass of an anole, a type of lizard, are listed in the table below. The data are plotted on the graph. Note the regular pattern in the graph. The mass increases over a three-day period and then levels off for three days. Then it increases again.

Picture This

6. Predict what the mass of the anole will be at 21 days.

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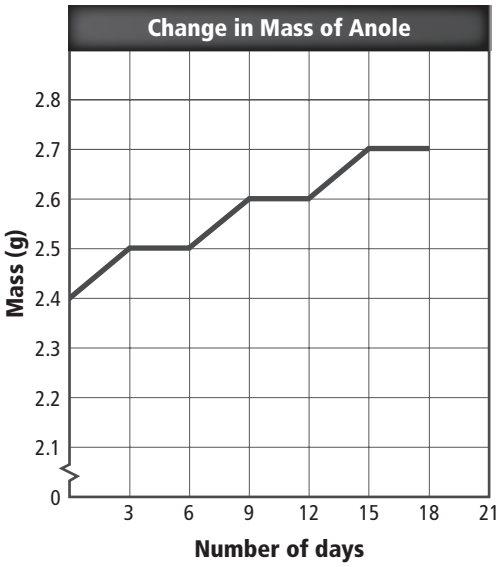
Change in Mass of Anole	
Date	**Mass (g)**
April 11	2.4
April 14	2.5
April 17	2.5
April 20	2.6
April 23	2.6
April 26	2.7
April 29	2.7



Report Conclusions

Scientists write a report of their experiments for peer review. Other scientists in the same field examine the methods, analysis, and conclusions in the report. If the reviewers agree that the report has value, then the report is published in a scientific journal.

Student Scientific Inquiry

As you study biology, you might have opportunities to do your own investigations. If so, develop a research plan based on the scientific methods described in this chapter. Ask meaningful questions. Form hypotheses. Collect data by conducting careful experiments. Analyze the data. Draw conclusions and report them.

During biology labs, warning statements and safety symbols will alert you to possible hazards. A safety symbol is a logo designed to alert you about a specific danger. Refer to the safety symbols chart at the front of the textbook before beginning any field or lab activity. Learn where safety equipment is located in the classroom. You are responsible for performing your investigations safely at all times.

Reading Check

7. Explain the purpose of a safety symbol.

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