Section 3

Long-Term Changes in Climate

Reading Preview

Key Concepts

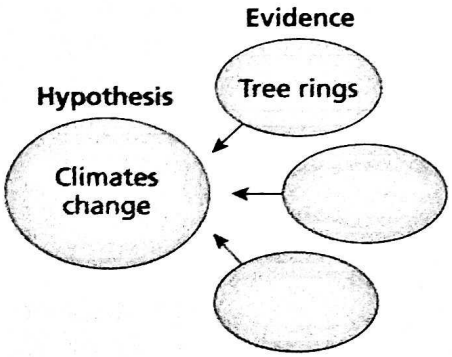
- What principle do scientists follow in studying ancient climates?
- What changes occur on Earth's surface during an ice age?
- What factors can cause climate change?

Key Terms

- ice age
- sunspot

Target Reading Skill

Identifying Supporting Evidence As you read, identify the evidence that is used to show that climates change. Write the evidence in a graphic organizer like the one below.



Lab zone **Discover Activity**

What Story Can Tree Rings Tell?

1. Look at the photo of tree rings in Figure 18. Tree rings are the layers of new wood that form each year as a tree grows.
2. Look closely at the tree rings. Note whether they are all the same thickness.
3. What weather conditions might cause a tree to form thicker or thinner tree rings?

Think It Over

Inferring How could you use tree rings to tell you about weather in the past?

One of the greatest Native American cultures in the American Southwest was the Ancestral Pueblos. These farming people built great pueblos, or "apartment houses," of stone and sun-baked clay, with hundreds of rooms, as shown in Figure 17. By about the year 1000, the Ancestral Pueblos were flourishing. Evidence from tree rings indicates that several periods of intense drought then occurred. These droughts may have contributed to a breakdown in their society. By the late 1200s, they had abandoned the pueblos and moved to other areas.

Although weather varies from day to day, climates usually change more slowly. But climates do change, both in small areas and throughout the world. Although climate change is usually slow, its consequences are great.

FIGURE 17
Ancient Pueblo Dwellings The Ancestral Pueblos lived in these buildings, now in Mesa Verde National Park in southwestern Colorado, about 1,000 years ago.

Studying Climate Change

Climate changes have affected many regions in addition to the Southwest. For example, Greenland today is mostly covered by an ice cap. But 80 million years ago, Greenland had a warm, moist climate. Fossils of magnolias and palm trees found in Greenland provide evidence for this climate change. Today magnolia and palm trees grow only in warm, moist climates. Scientists assume that the ancestors of these trees required similar conditions. **In studying ancient climates, scientists follow an important principle: If plants or animals today need certain conditions to live, then similar plants and animals in the past also required those conditions.**

Pollen One source of information about ancient climates is pollen records. Each type of plant has a particular type of pollen. The bottoms of some lakes are covered with thick layers of mud and plant material, including pollen that fell to the bottom of the lake over thousands of years. Scientists can drill down into these layers and bring up cores to examine. By looking at the pollen present in each layer, scientists can tell what types of plants lived in the area. From pollen data, scientists can infer that an ancient climate was similar to the climate where the same plants grow today.

Tree Rings Tree rings can also be used to learn about ancient climates. Every summer, a tree grows a new layer of wood just under its bark. These layers form rings, as shown in Figure 18. In cool climates, the amount the tree grows—the thickness of a ring—depends on the length of the warm growing season. In dry climates, the thickness of each ring depends on the amount of rainfall. Scientists study the pattern of thick or thin tree rings. From these data they can see whether previous years were warm or cool, wet or dry.

Reading Checkpoint **What are two ways scientists study ancient climates?**

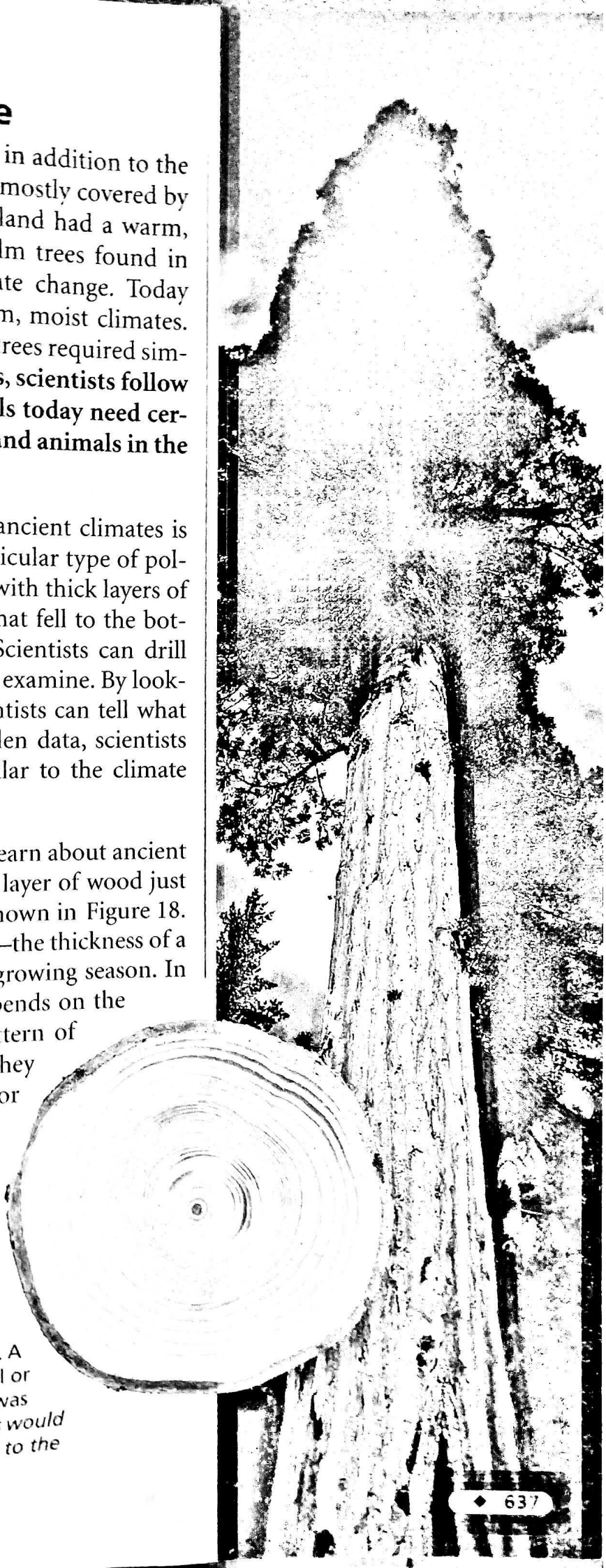


FIGURE 18
Evidence of Climate Change
The width of tree rings provides information on temperature and rainfall. A thin ring indicates that the year was cool or dry. A thick ring indicates that the year was warm or wet. **Inferring** *Which tree rings would provide information about climate close to the time that the tree was cut down?*

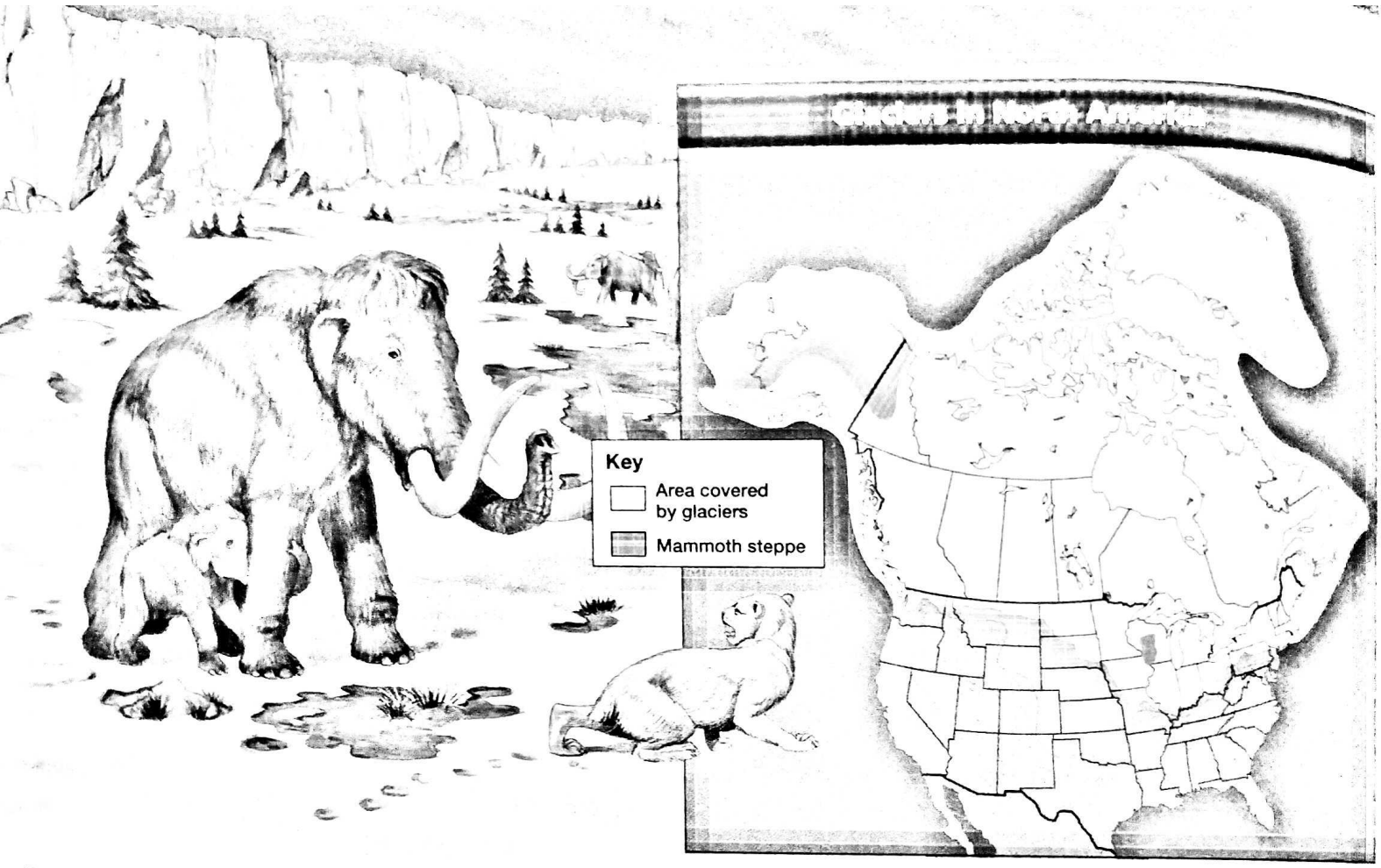


FIGURE 19
The Last Ice Age
The map shows the parts of North America that were covered by glaciers 18,000 years ago. On the steppe near the glaciers lived many mammals that are now extinct, including woolly mammoths.

Ice Ages

Throughout Earth's history, climates have gradually changed. Over millions of years, warm periods have alternated with cold periods known as **ice ages,** or glacial episodes. **During each ice age, huge sheets of ice called glaciers covered large parts of Earth's surface.**

Glaciers transform the landscape by carving giant grooves in solid rock, depositing enormous piles of sediment, and moving huge boulders hundreds of kilometers. From this evidence and from fossils, scientists have concluded that in the past two million years there have been many major ice ages. Each one lasted 100,000 years or longer. Long, warmer periods occurred between the ice ages. Some scientists think that we are now in a warm period between ice ages.

The last ice age ended only about 10,500 years ago. Ice sheets covered much of northern Europe and North America, reaching as far south as present-day Iowa and Nebraska, as shown in Figure 19. In some places, the ice was more than 3 kilometers thick. So much water was frozen in the ice sheets that the average sea level was much lower than it is today. When the ice sheets melted, the rising oceans flooded coastal areas. Inland, the Great Lakes formed.

Reading Checkpoint **Why were the oceans lower during the ice ages than they are now?**

Causes of Climate Change

Why do climates change? **Possible explanations for major climate changes include variations in the position of Earth relative to the sun, changes in the sun's energy output, major volcanic eruptions, and the movement of the continents.**

Earth's Position As Earth revolves around the sun, the time of year when Earth is closest to the sun shifts from January to July and back again over a period of about 23,000 years. The angle at which Earth's axis tilts and the shape of Earth's orbit around the sun also change slightly over long periods of time. The combined effects of these changes may be the main cause of ice ages.

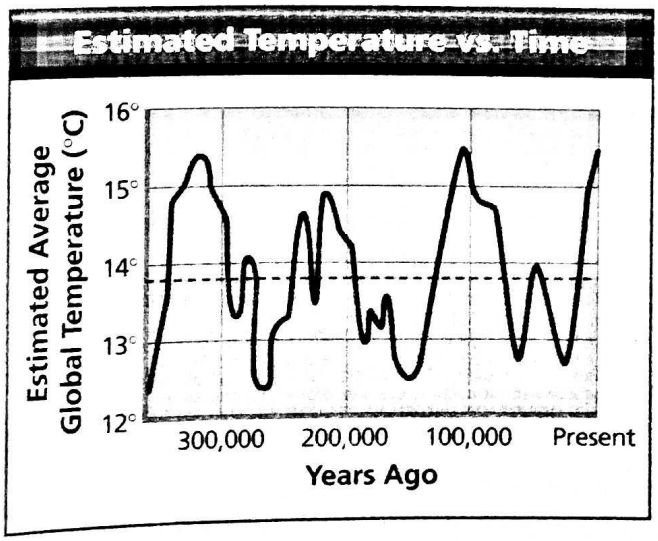
Solar Energy Short-term changes in climate have been linked to changes in the number of **sunspots**—dark, cooler regions on the surface of the sun. Sunspots increase and decrease in fairly regular 11-year cycles. Satellite measurements have shown that the amount of energy the sun produces increases slightly when there are more sunspots. This may cause Earth's temperature to warm.

Volcanic Activity Major volcanic eruptions release huge quantities of gases and ash into the atmosphere. These materials can stay in the upper atmosphere for months or years. Scientists think that the gases and ash filter out some of the incoming solar radiation, and may lower temperatures.

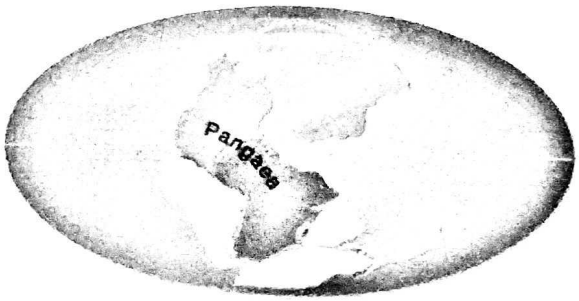
Math Analyzing Data

Ice Ages and Temperature

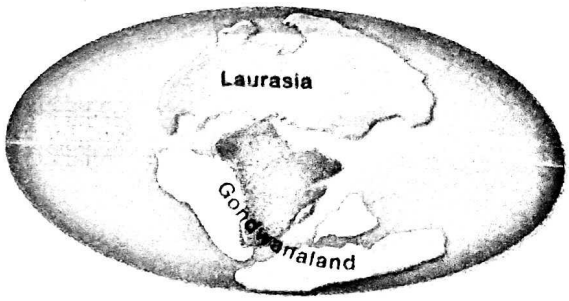
The graph shows the estimated average worldwide temperature over the last 350,000 years. During this time, cold glacial periods (blue) alternated with warmer interglacial periods (pink).



1. **Reading Graphs** What does the *x*-axis of the graph represent? What does the *y*-axis represent?
2. **Interpreting Data** What pattern do you see in these data? How would you explain this pattern?
3. **Predicting** Based on the pattern over the last 400,000 years, predict how global temperature will change in the future.



225 Million Years Ago



180—200 Million Years Ago

FIGURE 20
Moving Continents
The continents have moved over millions of years.
Interpreting Maps *Which present-day continents broke away from Gondwanaland? Which broke away from Laurasia?*

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Movement of Continents The continents have not always been located where they are now. About 225 million years ago, most of the land on Earth was part of a single continent called Pangaea (pan JEE uh), as Figure 20 shows. At that time, most continents were far from their present positions. Continents that are now in the polar zones were once near the equator. This movement explains how tropical plants such as magnolias and palm trees could once have grown in Greenland.

The movements of continents over time changed the locations of land and sea. These changes affected the global patterns of winds and ocean currents, which in turn slowly changed climates. And as the continents continue to move, climates will continue to change.

Reading Checkpoint **What was Pangaea?**

Section 2 Assessment

Target Reading Skill

Identifying Supporting Evidence Refer to your graphic organizer about the hypothesis that climate changes as you answer Question 1 below.

Reviewing Key Concepts

1. **a. Reviewing** What principle do scientists follow in studying ancient climates?
   b. Describing What types of evidence do scientists gather to study changes in climate?
   c. Inferring Suppose that you are a scientist studying tree rings in a cross-section of an ancient tree. What could several narrow tree rings in a row tell you about the climate when those rings were formed?
2. **a. Defining** What is a glacier?
   b. Explaining What occurs during an ice age?
   c. Comparing and Contrasting Compare the climate today with it during an ice age.
3. **a. Listing** What are four factors that could be responsible for changing Earth's climate?
   b. Summarizing Select one of the four factors that could cause climate change and summarize how it may cause the climate to change.

Writing in Science

Procedure for Data Collection Suppose that you are a scientist who wants to use pollen data from a lake bed to learn about ancient climates. Write the steps for the procedure that you would follow to collect and analyze your data.