Chapter 3: Changing Climates

Practice, page 369

1. It was these collisions that caused the final upthrusts of the rock formations that would become the Rocky Mountains and their foothills. As this rock and the plate around it were pushed higher, the Bearspaw Sea would have started to drain.

2. The ammonite fossils are indicators of the fact that Alberta spent much of its ancient past under tropical seas. The source of ammonite is the Bearspaw Sea. The fine sediment at the bottom of that sea formed the sedimentary rock that encases these fossils.

Practice, page 371

3. Mowing a lawn does not kill the grass because grass grows from the base, not from the tips. Other plants, including most house plants, grow from the tips. Removing too many leaves from the stem could kill a plant because it may not be able to generate new growth from the base.

4. The African savanna is a current landscape that meets this same description.

3.1 Questions, page 374

Knowledge

1. The largest rock moved a great distance by a glacier in Alberta is located near Okotoks. This rock—which originated in the Rocky Mountains—must have hitched a ride on a flowing glacier during the last glaciation. The very cold climate that would have allowed a glacier to move this rock is different from the climate that exists there now.

2. This chart shows similarities and differences between the traditional Blackfoot explanation for Big Rock and the scientific explanation for Big Rock.

	Traditional Blackfoot Explanation	Scientific Explanation
Similarities	Big Rock is not of local origin. It travelled a long distance before it came to rest at its present location.	
Differences	The rock's origin is from what is now Waterton Lakes National Park. It moved under its own power.	The rock's origin is close to where Jasper is now. Big Rock was carried to Okotoks by advancing glaciers.

3. Ice flows like water, only much more slowly. In both cases, surface rock can be transported great distances by that flow. One difference is that flowing water typically moves the rock in smaller pieces than a glacier does.

4. The Cretaceous Extinction marked the beginning of the Cenozoic Era. A dramatic cooling of the global climate is believed to have caused this extinction. Several large meteorite impacts near the end of the Cretaceous Period may have added to the cooling trend.

5. Cypress Hills has an undisturbed rock column that serves as a record of the last 65 million years. The sedimentary rock strata that make up the column contains many fossils from the Cenozoic Era.

6. The Tertiary Period and the Quaternary Period make up the Cenozoic Era.

7. More than 97% of the Cenozoic Era is made up of the Tertiary Period.

8. The mountain-building was caused by a collision between the North American Crustal Plate and another tectonic plate carrying continental crust that was subducted under the North American Plate.

9. Before the Rocky Mountains were covered by glaciers, they were more rounded. One of their main features was V-shaped valleys.

10. During the Tertiary Period, the North American Tectonic Plate slowly migrated north to a colder climate.

11. Small, flying dinosaurs and mammals took over.

12. Big dinosaurs became extinct. Some small, feathered dinosaurs survived and are believed to be the ancestors of modern birds.

13. During the Tertiary Period, many new species of mammals originated. These included big-brained primates, large grazers, and carnivorous predators.

14. The climate was becoming colder and drier. The root systems of grasses allowed them to survive cold, dry periods. The spread of ruminants and other grazers favoured grasses—which grow from the base—over plants that grow from the tips.

Applying Concepts

15. For much of Alberta's history, it must have been submerged by a marine environment. This explains the source of calcium carbonate present in limestone-rich soils.

Practice, page 380

5. The event that marked the end of the Pleistocene Epoch was the retreat of the continental ice sheets. In North America, the event was the retreat of the Laurentide Ice Sheet.

6. Three examples of landforms that show evidence of extensive glaciation in Alberta's past are

   - the teardrop-shaped hills—called drumlins—that can be found at Morley Flats outside of Cochrane
   - the small hills—called kames—that formed at Peerless Lake in northern Alberta
   - the Athabasca Dunes found in northeastern Alberta

3.2 Questions, page 381

Knowledge

1. **a.** The Quaternary Period—1.7 million years ago to the present—is made up of the Pleistocene Epoch and the Holocene Epoch.

   b. The Pleistocene Epoch began 1.7 million years ago when ice caps began to form. It ended 10 000 years ago as the continental ice sheets began to retreat.

   c. The Holocene Epoch began 10 000 years ago at the end of the Wisconsin Ice Age. It has not yet ended.

2. $\frac{1\,700\,000\text{ a} - 10\,000\text{ a}}{1\,700\,000\text{ a}} \times 100\% = 99.4\%$

About 99.4% of the Quaternary Period is taken up by the Pleistocene Epoch.

3. The climate during the Pleistocene Epoch was cold with repeated glaciations.

4. The animals living in Alberta during the Pleistocene Epoch were large and, in some cases, very woolly mammals.

5. **a.** A continental ice sheet is a large mass of ice that covers much of a continent. It forms when annual snowfall exceeds annual melting.

b. A mountain glacier is a mass of ice that forms in mountainous areas due to high snowfalls at high altitudes.

6. Ice cores contain tiny bubbles of atmospheric gases from the past. By analyzing the oxygen-18 to oxygen-16 ratios in annual layers, scientists can chart changes in the average temperature over hundreds of thousands of years.

7. Over the past 160 000 years, Earth's temperature has fluctuated. Most of the time the temperature has been far below what it is today, corresponding to major glaciations. The last one ended 10 000 years ago.

8. Methods of tracking Earth's average temperature are noted in this chart.

	Deep-Sea Sediment Cores	Ice Cores
Compare	• Both use the ratio of oxygen-18 to oxygen-16 stored in chronological layers to determine the temperature. • Both rely on relationships between the ratio of oxygen-18 to oxygen-16 and average temperatures that are established through present observations.	
Contrast	• Oxygen is stored as calcium carbonate from the shells of microscopic marine organisms, such as *Foraminifera*. • These cores can be used to study climate from more than 70 million years ago.	• Oxygen is stored in annual layers of ice. • The deepest ice core only reaches back 420 000 years.

9. Mountain glaciers and ice sheets around the world have been melting over the past century—especially in the last few decades—due to a global-warming trend. Many scientists believe that this warming trend is caused by human activities, such as the burning of fossil fuels that release the greenhouse gas known as carbon dioxide.

Applying Concepts

10. **a.** This is a teardrop-shaped hill called a drumlin. Drumlins form as an advancing ice sheet plucks up till and deposits it in a characteristic teardrop shape.

b. The direction of ice flow is from the rounded end of the drumlin to the pointed end.

11. The bowl is called a cirque. It is carved out by a mountain glacier.

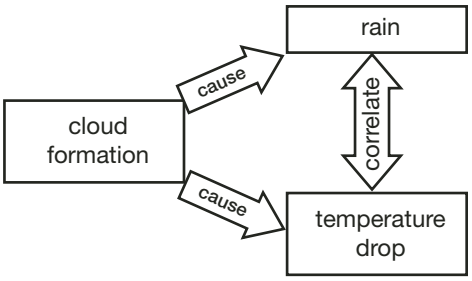
Practice, page 384

This next group of questions introduces some key terms. It also not only helps you draw connections between the concepts represented by these terms but also asks you to begin to explore the relationship between cause and probability. These are complex and abstract ideas, but they may help you plot a course through the stormy waters of climate-change theory.

7. Cause indicates a chain of events where one leads to the next, so that the nature of the first event determines the outcome of the subsequent event. Correlation may be coincidence or causation. If the events are only correlative, changing one of them will not affect the other. It is also possible that both events are outcomes of the same unknown cause.

8. Decreases in temperature do not cause rain. Rain and temperature decreases are both the outcomes of cloud formation, which is increased by warm weather and a whole host of other variables. During the summer, solar energy during the day evaporates water, which then condenses to form clouds. When the water droplets that make up the clouds reach a critical size, they return to the ground in the form of rain. Clouds in the summer have a cooling effect because they block out the Sun's radiation.

9. Rain and temperature are correlates because they are outcomes of the same cause: cloud formation.



10. Your response could be similar to the following.

I can predict rain and a drop in temperature by observing dark clouds on the horizon that are heading my way. I can make this prediction using my knowledge of what causes rain (clouds). I can predict a drop in temperature to accompany the rain because they are correlates. My level of certainty depends on how big and dark the clouds are and how far away they are. If the clouds are really far away, there is a greater probability they might change direction before they reach me. I require more knowledge of the present state of the system—such as wind velocity and variability—to be more certain, and I need to know whether it is already raining.

11. The elements are

- knowledge of the system's causal relationships and correlating variable, and, for example, what causes rain
- knowledge of the present state of the system, for example, the position and velocity of nearby clouds

Practice, page 387

12. This chart summarizes possible causes of glaciation and their effects.

Possible Causes of Glaciation	Effects on Earth's Atmosphere	Effects on Earth's Lithosphere	Effects on Earth's Hydrosphere	Effects on Solar Radiation Received on Earth's Surface
Plate Tectonics		Plate tectonics is all about the crustal plates moving, so this is primarily an effect on the lithosphere.	Over geological time, changes in the positions of the continental crust will have significant impacts on the boundaries of oceans and ocean currents.	Geologists suspect that when the plates of continental crust move to the poles, continental ice sheets can form that increase the amount of solar radiation reflected into space.
Global Conveyor	The high heat capacity of water means that the global conveyor will move enough heat over time so that the atmospheric temperature will be dramatically affected.	As was the case for the atmosphere, the global conveyor has a huge impact on the climate of Earth's land masses.	The global conveyor is clearly about ocean currents, so this is primarily a hydrospheric effect.	

Volcanic Activity	The most significant effect of large volcanic eruptions is the soot, ash, and dust thrown high into the atmosphere.		The blanket of volcanic ash that circles the globe reduces the amount of solar radiation that can be received at Earth's surface.
Milankovitch Cycles			Variations in Earth's orbit around the Sun have a direct effect on the amount of solar energy received on Earth's surface.
Variations in the Sun's Energy Output			If less energy leaves the Sun, then less energy can be received on Earth's surface.

13. Plate tectonics and the global conveyor show the greatest degree of interconnectedness because they have overlapping effects on the lithosphere and the hydrosphere.

3.3 Questions, page 389

Knowledge

1. Brief descriptions follow in the table.

Time Frame	Description of Average Temperature Fluctuations	Theory of Cause	Description of Theory
Earth's Entire History	• long warm periods (millions of years), each punctuated with periods of repeated glaciations • occurred in Precambrian, Ordovician, Carboniferous, Jurassic, and Pleistocene	Plate Tectonics	• continents moving to polar regions allowed formation ice sheets • changes to ocean-circulation patterns prevented heat transfer to polar regions
		Volcanic Activity	• release of volcanic emissions into atmosphere prevented Sun's energy from reaching Earth in short term • in long term, release of carbon dioxide can increase greenhouse effect
Pleistocene and Holocene	• repeated glaciations every 80 000 to 120 000 years	Milankovitch Cycles	• periodic changes orbit shape, axial tilt, axial wobble match timing of repeated glaciations
		Natural Carbon Dioxide Fluctuations	• correlation between atmospheric carbon dioxide and average global temperature

Little Ice Age	• unusually cold period during medieval times	Variations in Solar Intensity	• decrease in number of sunspots corresponding to decrease in solar energy output may have caused lower temperatures
Last 100 Years	• fluctuations but mainly upward trend	Enhanced Greenhouse Effect	• at least in part caused by human emissions of greenhouse gases—carbon dioxide and methane

2. The *Holocene Epoch* began with the melting of the Laurentide Ice Sheet about 10 000 years ago. It continues to the present day.

3. Conditions affecting certainty in predictions include a knowledge of the current variables in a system and an understanding of how the system works. There is still much to learn about the present state of the global climate system and how all of the components work together. The system is so complex that these two conditions will never be fully satisfied.

4. The major theme is change. This is a change in landscape, climate, and life forms.

Applying Concepts

5. This table shows one possible interpretation of the connections between science, technology, and society.