13.9

Major Ocean Currents

As you have seen, oceans are particularly important in weather dynamics. One reason is that they occupy so much of Earth's surface. To find another reason, look at a world map: there is little land mass at the equator, but if you circle the globe at, say, 45° north, there is considerable land mass. So there is a vast volume of water at the equator, where the radiation from the Sun is direct. One way in which all this direct energy absorbed by the oceans is spread around the world is by ocean currents.

You might expect countries such as Norway and Iceland, which are as far north as Canada's Arctic region, to have very cold winters. However, their Atlantic harbours remain ice-free all winter because of the Gulf Stream, an Atlantic Ocean current that transports warm water all the way from the Gulf of Mexico, near the equator, to the North Atlantic region. **Figure 1** shows the Gulf Stream and several other major ocean currents in the world. The warm ocean currents act like "conveyer belts," transporting energy (stored in the water) from warmer parts of the world to colder parts. The cold ocean currents from the North Atlantic and Pacific Oceans and the Antarctic circumpolar current flow toward the equator. These cold waters become warmer as they circulate through the equatorial regions of the world's oceans.

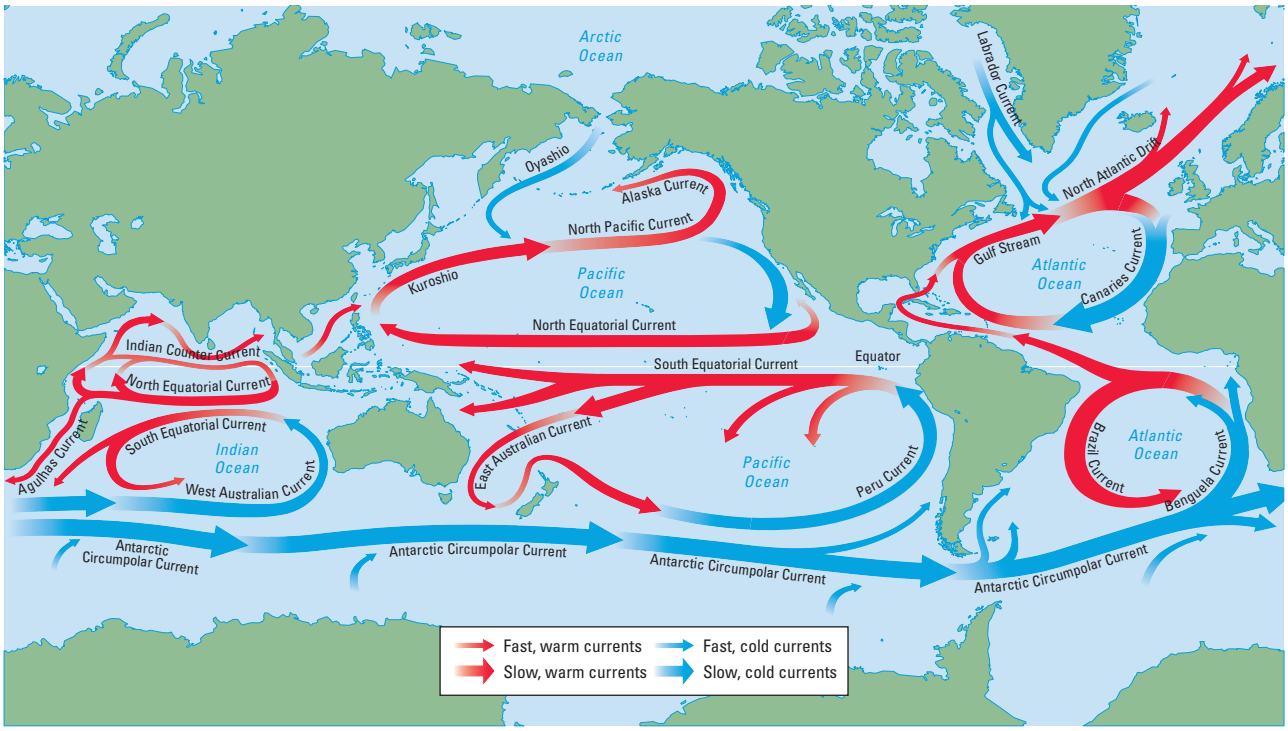

Figure 1

The major warm and cold ocean currents in the world. Compare the directions of the ocean currents with the directions of the major winds in Figure 2 in Section 13.6.

Causes of Ocean Currents

As you study the map of ocean currents in **Figure 1**, you will begin to notice certain patterns. Each of these patterns can be explained by considering convection currents, winds across the oceans, the influence of Earth's rotation, the shapes of the continents, the heat capacity of water, and the amount of salt in the oceans.

Warm water tends to travel from the equator toward the North or South Pole, and cold water tends to travel in the opposite direction. Solar energy strikes the oceans at the equator directly and therefore more intensely, heating the water and starting convection currents. As the warm, less dense water moves away from the equator, it is replaced by cooler, denser water, as shown in **Figure 2**. The convection currents are also influenced by the prevailing winds blowing at the surface and the twisting caused by the Coriolis effect.

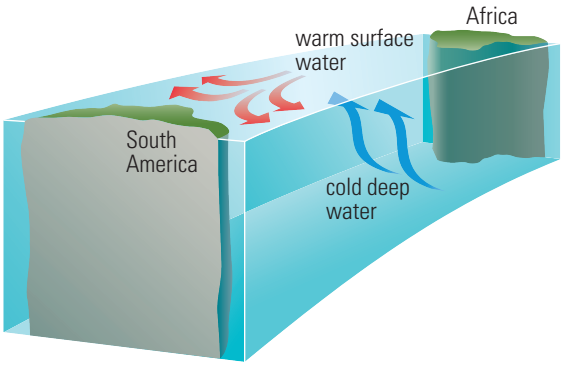

Figure 2

Ocean water near the equator absorbs the direct, intense solar energy. Since warm water is less dense than cold water, the warm water moves northward or southward at the surface, and is replaced by cold water from below, starting a convection current.

Close to a continent, ocean currents are forced to travel along its edge, just like water in a river changes direction if it hits a rock or steep shoreline. Because of Earth's eastward rotation, ocean currents on the west sides of the oceans tend to be narrow and fast moving, travelling at about 6.5 km/h. Currents on the east sides tend to be wider and slower, travelling at about 1.1 km/h. Only one ocean current, the Antarctic Circumpolar Current, travels all the way around the world, with no continents in the way.

The oceans act as huge heat sinks because water has a high capacity to store heat. As water absorbs solar energy, it takes a long time to heat up. However, once it is warm, the water takes a long time to cool down again. These properties have an important effect on both world climate and local weather.

The salt in the water also affects ocean currents. For example, as the warm Gulf Stream flows northward, water evaporates, leaving increasingly saltier water. The saltier water is more dense, so it sinks, creating deep-water currents, and is replaced by warm, less dense water.

Effects of Ocean Currents

The Gulf Stream warming the coasts of Norway and Iceland is just one example of the effect of ocean currents. You will understand all the ocean current effects if you recognize the relationship between air temperature and its ability to hold moisture: the warmer a body of air, the greater its ability to hold moisture.

The ocean current that reaches Peru in western South America is cold, so the air above it is dry. Therefore, the coast of Peru is cool and dry, which helps to create a desert called the Atacama Desert beside the Pacific Ocean. (You have already seen how winds help create the dry conditions.) According to **Figure 1**, in what other coastal regions in the world could cold ocean currents help produce similar dry effects?

Along the western side of the huge Pacific Ocean, the warm waters evaporate, form clouds, and produce large quantities of precipitation. Which current causes a similar effect in Brazil, which has a large portion of Earth's rain forests?

Did You Know?

Currents that go through narrow channels travel much faster than other currents. The strongest currents in the world are the Nakwakto Rapids, Slingsby Channel, British Columbia, where the current can flow as fast as 30 km/h.

Ocean currents are responsible for coastal regions being cooler in summer and warmer in winter than regions several kilometres inland. Large bodies of water and their currents moderate the climate. For example, the average early-morning January temperature in Ottawa, Ontario, is 30°C lower than the average early-morning July temperature. But in St. John's, on the east coast of Newfoundland, that difference is only 18°C. And Ottawa is farther south than St. John's! Newfoundland is warmer in winter because of the warm, moist air brought northward by the Gulf Stream.

The high heat capacity of water is one factor that causes seasonal changes to lag behind the daylight hour changes; that is, in the Northern Hemisphere the most daylight hours occur on June 21, yet the hottest months are June, July, and August rather than May, June, and July. This occurs partly because water takes a long time to warm up after the winter. Another factor that contributes to this lag is the flow of energy: in July the energy input in the Northern Hemisphere is greater than the energy output.

A similar lag occurs in winter when the fewest daylight hours occur on December 21, yet the coldest months are December, January, and February, rather than November, December, and January.

Ocean currents also affect the pressure of the air above them. For example, air above warm ocean currents becomes warmer and less dense, forming low-pressure systems. You will learn later how these systems influence weather.

Challenge

1 How could you use record low and high temperatures and other statistics for your region to make your forecasts more interesting?

2 Where will your imaginary community be located? For what conditions will it be designed?

Understanding Concepts

1. Use **Figure 1** as a reference to answer these questions:

(a) In what way are the ocean currents in the Southern Hemisphere "mirror images" of those in the Northern Hemisphere?

(b) Name three fast-moving surface currents and three slow-moving currents.

(c) On which side of Australia (east or west) would you expect to find deserts? rain forests? Explain why. Use a map of Australia to check your answer.

(d) In what other regions of the world would you expect to find deserts? Why?

2. The text states that ocean currents act as "conveyer belts" of energy. Explain what this means.

3. Explain why the name "Antarctic Circumpolar Current" is appropriate.

4. A student who lives on the south coast of New Zealand places a message in a bottle, seals the bottle, and throws it into the coastal waters. About four years later, another student finds the same bottle floating in the ocean on the coast of Iceland. Describe how this is possible. Include the names of the ocean currents as well as the continents that the bottle passed on its route to Iceland.

5. Why is it impossible to have an Arctic Circumpolar Current?

6. The Namib Desert is on the west coast of southern Africa. Explain how this region can be dry, even though it is on the Atlantic Ocean.

7. Explain why the coldest months of the year in the Northern Hemisphere are December, January, and February, even though the fewest daylight hours occur in December.

Making Connections

8. When big ships enter a harbour or channel that is unfamiliar to the captain, a local navigator comes onboard to help. What are some possible hazards the visiting captain may not know about?

Exploring

9. (I) (J) Research how "eddies" form when warm and cold ocean currents meet. Why do fishing fleets like to track these slow-moving locations?

10. In the 1947 *Kon-Tiki* Expedition, six adventurers sailed a raft across the Pacific Ocean. Report on how currents and winds helped the sailors on their journey. Do you think the expedition accomplished its objectives?