Chapter 6

6.2 The Work of Streams

Reading Focus

Section Objectives

6.6 Explain how streams erode their channels and transport sediments.
6.7 Explain how stream deposition occurs.
6.8 Identify the two general types of stream valleys.
6.9 Predict the causes of floods and describe major flood control measures.
6.10 Explain the relationship between streams and drainage basins.

Reading Focus

Build Vocabulary

Paraphrase Ask students to write the vocabulary terms on a sheet of paper. Instruct students to write a definition, in their own words, for each term as they encounter the term while going through the chapter. After writing their own definition, encourage students to write the term in a complete sentence.

Reading Strategy

Answers will vary. Sample answer: What I Expect to Learn—how erosion happens and what features it can form What I Learned—streams erode by lifting loose particles and by abrasion meanders

Instruct

Erosion

Build Reading Literacy

Refer to p. 334D in Chapter 12, which provides guidelines for outlining.

Outline Have students outline the section, leaving room for notes. Then have students scan through each heading and find the main idea. Allow students to refer to their outlines when answering the questions in Section 6.2 Assessment. Logical, Verbal

Key Concepts

- How do streams erode their channels and transport sediment?
- How does stream deposition occur?
- What are the two types of stream valleys?
- What causes floods, and what are the major flood control measures?
- What is the relationship between a stream and a drainage basin?

Vocabulary

- bed load
- capacity
- alluvium
- delta
- natural levee
- floodplain
- flood
- drainage basin
- divide

Reading Strategy

Monitoring Your Understanding Preview the Key Concepts, topic headings, vocabulary, and figures in this section. List two things you expect to learn about each. After reading, state what you learned about each item you listed.

<table>
<thead>
<tr>
<th>What I Expect to Learn</th>
<th>What I Learned</th>
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Streams are Earth’s most important agents of erosion. They can downcut or erode their channels. They can also transport enormous amounts of sediment. Most of the sediment a stream carries comes from weathering. Weathering produces huge amounts of material that are delivered to the stream by sheet flow, mass movements, and groundwater. Eventually, streams drop much of this material to create many different depositional features.

Erosion

Streams generally erode their channels lifting loose particles by abrasion, grinding, and by dissolving soluble material. When the flow of water is turbulent enough, it can dislodge loose particles from the channel and lift them into the moving water. In this manner, the force of running water rapidly erodes some streambeds and banks. The stronger the current is, the more erosional power it has and the more effectively the water will pick up particles.

Sand and gravel carried in a stream can erode solid rock channels like sandpaper grinds down wood. Moreover, pebbles caught in swirling stream currents can act like cutting tools and bore circular “potholes” into the channel floor.

What are three ways that streams erode their channels?
Sediment Transport

Streams transport sediment in three ways.
1. in solution (dissolved load)
2. in suspension (suspended load)
3. scooting or rolling along the bottom (bed load)

Dissolved Load Most of the dissolved load enters streams through groundwater. Some of this load also enters by dissolving rock along the stream’s course. The amount of material the stream carries in solution changes depending on climate and the geologic setting. Usually the dissolved load is expressed as parts of dissolved material per million parts of water (parts per million, or ppm). Some rivers may have a dissolved load of 1000 ppm or more. However, the average figure for the world’s rivers is estimated at 115 to 120 ppm. Streams supply almost 4 billion metric tons of dissolved substances to the oceans each year.

Suspended Load Most streams carry the largest part of their load in suspension. The visible cloud of sediment suspended in the water is the most obvious portion of a stream’s load. Streams usually carry only sand, silt, and clay this way. However, streams also transport larger particles during a flood because water velocity increases. The total amount of material a stream carries in suspension increases dramatically during floods, as shown in Figure 8.

Bed Load Bed load is that part of a stream’s load of solid material that is made up of sediment too large to be carried in suspension. These larger, coarser particles move along the bottom, or bed, of the stream channel. The suspended and dissolved loads are always moving. But the bed load moves only when the force of the water is great enough to move the larger particles. The grinding action of the bed load is very important in eroding the stream channel.

Competence and Capacity The ability of streams to carry a load is determined by two factors: the stream’s competence and its capacity. Competence of a stream measures the largest particles it can transport. A stream’s competence increases with its velocity. In fact, the competence of a stream increases four times when the velocity doubles.

The capacity of a stream is the maximum load it can carry. Capacity is directly related to a stream’s discharge. The greater the volume of water in a stream is, the greater its capacity is for carrying sediment.

Sediment Transport

Integrate Chemistry

Solutions and Suspensions Streams transport sediment in solution and in suspension. In chemistry, a solution is a homogeneous mixture of dissolved substances. A suspension is a heterogeneous mixture that separates into layers over time. Ask students to write a paragraph explaining how streams are both solutions and suspensions. (Streams are composed, in part, of groundwater that contains dissolved substances, and in this way streams are solutions. Streams also transport fine sand, silt, and clay that are not dissolved, but rather suspended in moving water. In this way, streams are suspensions.)

Build Science Skills

Using Models Some students will have difficulty comprehending the tiny scale of one part per million. To help build number sense and awareness of how small a part per million is, ask students to imagine they have a budget of one million dollars, and have them think of the cost of their lunch in terms of parts per million. A four-dollar lunch would be equal to 4 ppm. This represents only a tiny fraction of their total budget.

Customize for English Language Learners

Students who are learning English can benefit from real-life examples that relate to science content. Encourage students to think of actual flooding events that may have occurred in your area or that they have heard about on the news. Have them discuss the type of damage done by the flood and some of the amazing pictures of rescues and houses floating downstream. Encourage students to share their knowledge and examples with the class.

Answer to . . .

Figure 8 Dissolved load might account for the muddiness of the river.

Streams erode their channels lifting loose particles by abrasion, grinding, and by dissolving soluble material.
Deposition

Whenever a stream slows down, the situation reverses. As a stream’s velocity decreases, its competence decreases and sediment begins to drop out, largest particles first. Each particle size has a critical settling velocity. Deposition occurs as streamflow drops below the critical settling velocity of a certain particle size. The sediment in that category begins to settle out. Stream transport separates solid particles of various sizes, large to small. This process is called sorting. It explains why particles of similar size are deposited together.

The sorted material deposited by a stream is called alluvium. Many different depositional features are made of alluvium. Some occur within stream channels. Some occur on the valley floor next to the channel. And others occur at the mouth of a stream.

Deltas When a stream enters the relatively still waters of an ocean or lake, its velocity drops. As a result, the stream deposits sediment and forms a delta. A delta is an accumulation of sediment formed where a stream enters a lake or ocean. As a delta grows outward, the stream’s gradient lessens and the water slows down. The channel becomes choked with sediment settling out of the slow-moving water. As a result, the river changes direction as it seeks a shorter route to base level. The main channel often divides into several smaller channels called distributaries as shown in sub-delta 7 in Figure 9. These shifting channels act in the opposite way of tributaries.

Mississippi Delta Region

Figure 9
Movement This map shows the growth of the Mississippi River delta over the past 5,000 to 6,000 years. As you can see, the river has built a series of sub-deltas, one after the other. The numbers indicate the order in which they were deposited.

Locating In which overall direction has the Mississippi River built its delta over the past few thousand years?

Locating How has the growth of the delta changed the location of the mouth of the Mississippi River in relation to New Orleans?

Deposition

Facts and Figures

The city of New Orleans, Louisiana, is built on a delta at the mouth of the Mississippi River. As is expected, the water table in this area is very high due to the fact that the delta is built right into the ocean. This high water table leaves New Orleans with a troubling problem—how do they bury their dead? Early settlers were forced to bury their dead in shallow graves due to the high water table. If they dug down only a few feet, the grave filled with water and caused the casket to float.

Finally, settlers adopted another method of burial. They built above-ground vaults. Today many of the cemeteries in New Orleans have tombs arranged in a street-like fashion. In fact, the cemeteries are often referred to as “cities of the dead.”
Rather than carrying water into the main channel like tributaries, distributaries carry water away. After many shifts of the channel, a delta may grow into a triangular shape, like the Greek letter delta (Δ). However, not all deltas have this idealized shape. Differences in the shapes of shorelines and variations in the strength of waves and currents result in different shapes of deltas.

**Natural Levees** Some rivers occupy valleys with broad, flat floors. Successive floods over many years can build natural levees along them. A natural levee is a landform that parallels some streams. They form when a stream overflows its banks. When it overflows, its velocity rapidly decreases and leaves coarse sediment deposits in strips that border the channel. As the water spreads out over the valley, less sediment is deposited. This uneven distribution of material produces the gentle slope of the natural levee.

**Stream Valleys**

**Narrow Valleys** The Yellowstone River, shown in Figure 10, is an excellent example of a narrow valley. A narrow V-shaped valley shows that the stream's primary work has been downcutting toward base level. Rapids and waterfalls are the most prominent features of a narrow valley. Both rapids and waterfalls occur where the stream profile drops rapidly. The variations in the erosion of the underlying bedrock cause these rapid drops.

**Wide Valleys** Once a stream has cut its channel closer to base level, downward erosion becomes less dominant. More of the stream's energy is directed from side to side. The result is a widening of the valley as the river cuts away first at one bank and then at the other.

The side-to-side cutting of a stream eventually produces a flat valley floor, or floodplain. A floodplain is appropriately named because during a flood the river overflows its banks and floods the plain.

Streams that flow on floodplains move in meanders. Once a bend in a channel begins to form, it grows larger. Most of the erosion occurs on the outside of the meander—often called the cut bank—where velocity and turbulence are greatest. Much of the debris the stream removes at the cut bank moves downstream where it is deposited as point bars. Point bars form in zones of decreased velocity on the insides of meanders. In this way, meanders move side to side by eroding the outside of bends and depositing on the inside.

![Figure 10 The Yellowstone River is an example of a V-shaped valley. The rapids and waterfall show that the river is vigorously downcutting the channel.](image)

**Integrate Language Arts**

**Prefixes** Remind students that a tributary is a stream that empties into another stream (p. 162). The text provides a contextual definition of distributary, but tell students that even without this context, they could deduce that a distributary is the opposite of a tributary by knowing the prefix dis- means, among other things, “opposite of.” Encourage students to make a list of common word parts as they read. Have them look up each one in a dictionary. Doing so will help them with new vocabulary and verbal portions of standardized tests.

**Build Science Skills**

**Designing Experiments** Divide students into groups and ask them to model a delta using a sloped paint tray (the type used with rollers), sand, and a constant supply of water (such as from a hose or faucet). (First, dampen the sand. Then distribute the sand evenly in a thin layer over the sloped part of the tray. Supply a gentle but constant flow of water to the top of the slope, and observe the channel the water makes in the sand. Next, observe how some sand is eroded and transported to the mouth of the channel, where it settles into the pool of water at the flat part of the tray.)

**Kinesthetic, Visual**
Erosion is more effective on the downstream side of a meander because of the slope of the channel. The bends gradually travel down the valley. Sometimes the downstream movement of a meander slows when it reaches a more resistant portion of the floodplain. This resistance allows the next meander upstream to overtake it, as shown in Figure 11. Gradually the neck of land between the meanders is narrowed. Eventually the river may erode through the narrow neck of land to the next loop. The new, shorter channel segment is called a cutoff and, because of its shape, the abandoned bend is called an oxbow lake. Such a situation is shown in the bottom portion of Figure 6 on page 163.

Floods and Flood Control

A flood occurs when the discharge of a stream becomes so great that it exceeds the capacity of its channel and overflows its banks. Floods are the most common and most destructive of all natural geologic hazards. Most floods are caused by rapid spring snow melt or storms that bring heavy rains over a large region. Heavy rains caused the devastating floods in the upper Mississippi River Valley during the summer of 1993, as shown in Figure 12.

Unlike far-reaching regional floods, flash floods are more limited in extent. However, flash floods occur with little warning, and they can be deadly as walls of water sweep through river valleys. Several factors...
influence flash floods: rainfall intensity and duration, surface conditions, and topography. As you have learned, many urban areas are susceptible to flash floods. Mountainous areas are also susceptible because steep slopes can send runoff into narrow canyons.

Human interference with the stream system can worsen or even cause floods. A prime example is the failure of a dam or an artificial levee. These structures are designed to contain floods of a certain size. If that size is exceeded, water can then spill over or break through a dam or levee and rush downstream causing a disastrous flood.

There are several flood control strategies. **Measures to control flooding include artificial levees, flood control dams, and placing limits on floodplain development.**

**Artificial Levees** Artificial levees are earthen mounds built on the banks of a river. These levees increase the volume of water a channel can hold. When levees confine a river during periods of high water, the river often deposits material in its channel as the discharge diminishes. This discharge is sediment that would have been dropped on the floodplain. Because the stream cannot deposit material outside of its channel the bottom of the channel is gradually built up. When the channel is built up, it takes less water to overflow the levee. As a result, people may have to raise the height of the levee periodically to protect the floodplain behind it. Moreover, many artificial levees are not built to withstand periods of extreme flooding. For example, there were many levee failures in the Midwest during the summer of 1993 when the upper Mississippi experienced record flooding.

**Flood-Control Dam** Flood-control dams store floodwater and then let it out slowly. Since the 1920s, thousands of dams have been built on nearly every major river in the United States. Many dams have other non-flood related functions, such as providing water for irrigation and for hydroelectric power generation.

Although dams may reduce flooding and provide other benefits, building dams has consequences. For example, dams trap sediment. Deltas and floodplains downstream can erode because silt no longer replenishes them during floods. Built up sediment behind a dam means the volume of the stored water will gradually diminish. This build-up reduces the effectiveness of the dam for flood control. Large dams also cause ecological damage to river environments.

**Limiting Development** Today many scientists and engineers advocate sound floodplain management instead of building structures. That often means preserving floodplains in their natural state. Minimizing development on floodplains allows them to absorb floodwaters with little harm to homes and businesses.

Q Sometimes a major flood is described as a “100-year flood. What does that mean?

A The phrase “100-year flood” is misleading because it makes people believe that such an event happens only once every 100 years. In truth, a huge flood can happen any year. The phrase “100-year flood” is really a statistical designation. It indicates that there is a 1-in-100 chance that a flood this size will happen during any year. Perhaps a better term would be the “1-in-100 chance flood.”
Section 6.2 (continued)

Drainage Basins

Use Visuals

Figure 13 Point out the Mississippi River drainage basin. Ask: Do other drainage basins exist within this one? (Yes, every stream, regardless of size, has its own drainage basin. A larger river, such as the Mississippi, will have a drainage basin that includes those of all of its tributaries.) Where is the divide that is commonly called the Continental Divide? (This is the western portion of the Mississippi River drainage basin that runs through the Rocky Mountains.)

Use Community Resources

Drainage Basins Invite a hydrologist to speak to the class about a drainage basin in your area. Have students trace out the drainage basin of a local stream or river and discuss their findings with the scientist.

Interpersonal

3 ASSESS

Evaluate Understanding

To assess students’ knowledge of section content, have them create a visual showing a narrow and a wide stream valley.

Reteach

Have students make a chart summarizing the differences between erosion and deposition.

Writing in Science

Student paragraphs should describe accurately researched floods and their causes and effects.

Section 6.2 Assessment

1. Streams erode their channels by lifting loose particles by abrasion, grinding, and by dissolving soluble material.
2. Floods occur when the discharge of a stream exceeds the capacity of the channel. Most floods are caused by rapid spring snow melt and storms.
3. A drainage basin is the land area that contributes water to a stream.
4. Streams transport sediment in solution, in suspension, and by rolling along the bottom.
5. Urban development can decrease the effectiveness of floodplains by replacing water-absorbing vegetation with concrete and asphalt and increasing flooding.
6. Sample answer: Deltas are formed as accumulating sediment is deposited where a stream or river enters a lake or ocean.

Descriptive Paragraph

Use library sources or the Internet to research the causes of a recent major flood. Write a paragraph that tells the name of the flood, when it happened, where it happened, and the conditions that led to the flood itself.

Critical Thinking

5. Analyzing Concepts How does urban development interfere with the natural function of floodplains?