Objectives

- **Explain** how surface water can move weathered materials.
- **Explain** how a stream carries its load.
- **Describe** how a floodplain develops.

Vocabulary

- runoff
- watershed
- divide
- solution
- suspension
- bed load
- discharge
- flood
- floodplain

Surface Water Movement

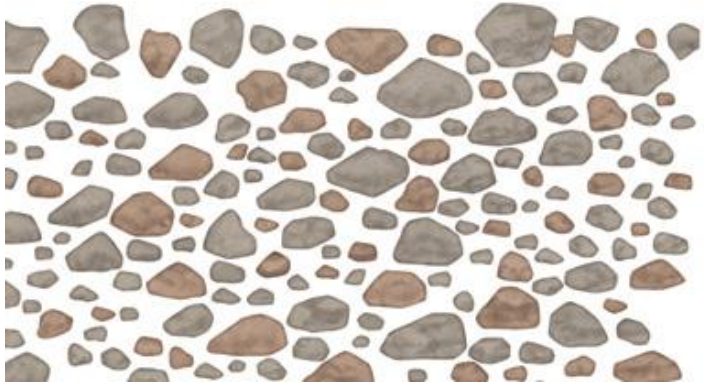
- Earth's water supply is recycled in a continuous process called the water cycle.
- Water molecules move continuously through the water cycle following many pathways.
- The mechanics of the water cycle help to explain the reasons for variations in the amount of water that is available throughout the world.
- The overall process is one of repeated evaporation and condensation powered by the Sun's energy.

Runoff

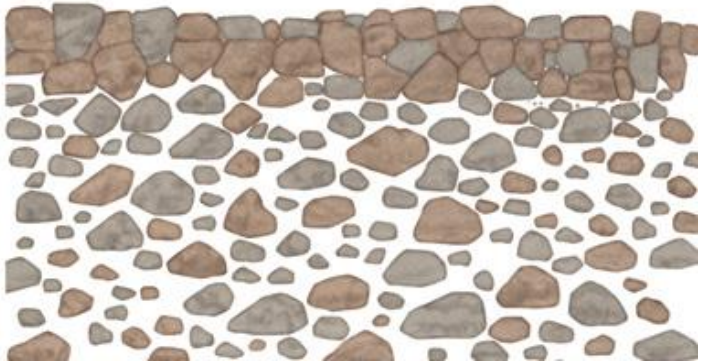
- Once water reaches Earth's surface as precipitation, it can evaporate into the atmosphere, soak into the ground, or flow down slopes on Earth's surface.
- **Runoff** is water flowing downslope along Earth's surface.
- Runoff may reach a stream, river, or lake, may evaporate or accumulate and eventually seep into the ground.
- Water that seeps into Earth's surface becomes groundwater.

Runoff

- For water to enter the ground, there must be large enough pores or spaces in the ground's surface materials to accommodate the water's volume.



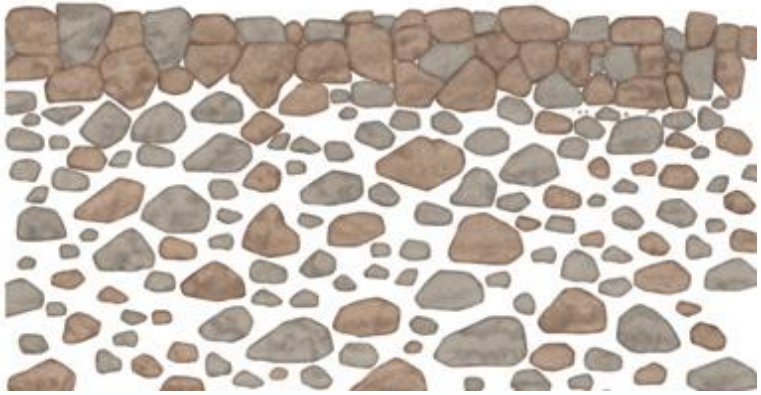
- If the pores already contain water or the soil has few pores, the newly fallen precipitation will accumulate on the surface or run downhill.



Runoff

Vegetation

- Soils that contain grasses or other vegetation allow more water to enter the ground than do soils with no vegetation.
- In such areas, soil particles clump together and form dense aggregates with few pores or spaces between them.
- The force of falling rain may then push the soil clumps together, thereby closing pores and allowing less water to enter.



Runoff

Rates of Precipitation

- Light, gentle precipitation infiltrates the dry ground.
- During heavy precipitation, water falls too quickly to soak into the ground and becomes runoff.
- Thus, a gentle, long-lasting rainfall is more beneficial to plants and causes less erosion by runoff than a torrential downpour.

Runoff

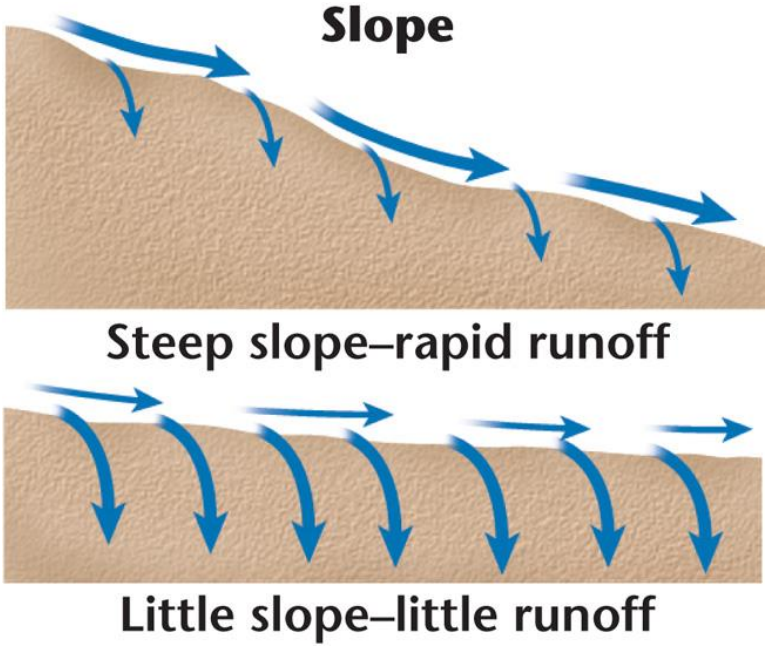
Soil Compaction

- Humus creates pores in the soil, thereby increasing a soil's ability to retain water.
- Soil with a high percentage of coarse particles has relatively large pores between its particles that allow water to enter and pass through the soil quickly.
- Soil with a high percentage of fine particles clumps together and has few or no spaces between the particles.
- Small pores restrict both the amount of water that can enter the ground and the ease of movement of water through the soil.

Runoff

Slope

- Water from precipitation falling on slopes flows to areas of lower elevation.
- The steeper the slope, the faster the water flows.
- There is also greater potential for erosion on steep slopes.
- In areas with steep slopes, little water seeps into the ground before it runs off.



Stream Systems

- Some surface water flows in thin sheets and eventually collects in small channels.
- A stream is a channel with permanent water flow.
- All streams flow downslope to lower elevations.
- Tributaries are streams that flow into other streams, increasing the size of the stream it is joining.
- A large stream is called a river, and all its tributaries make up a stream, or river system.
- Small streams are called brooks and creeks.

Watersheds and Divides

- A **watershed**, or drainage basin, is all of the land area whose water drains into a stream system.
- A **divide** is a high land area that separates one watershed from another.
- Each tributary in a stream system has its own watershed and divides, but they are all part of the larger stream system to which the tributary belongs.

Watersheds and Divides

Stream Load

- A stream's load includes all the materials that the water in a stream carries.
- A stream load includes the living components of water, such as animals and plants, and the nonliving components, including sediments and dissolved gases.
- A stream carries its load in solution, suspension, or as bed load.

Stream Load

Solution

- Material is carried in **solution** after it becomes dissolved in a stream's water.
- Groundwater adds most of the dissolved load to stream water, while runoff adds only a very small amount.
- The amount of dissolved material that water carries is often expressed in parts per million, or ppm.
- The total concentration of materials in solution in streams averages 115–120 ppm.
- Measuring the amount of material in solution helps scientists monitor water quality.

Stream Load

Table 9-1 Concentrations of Some Dissolved Materials in River Water and Seawater

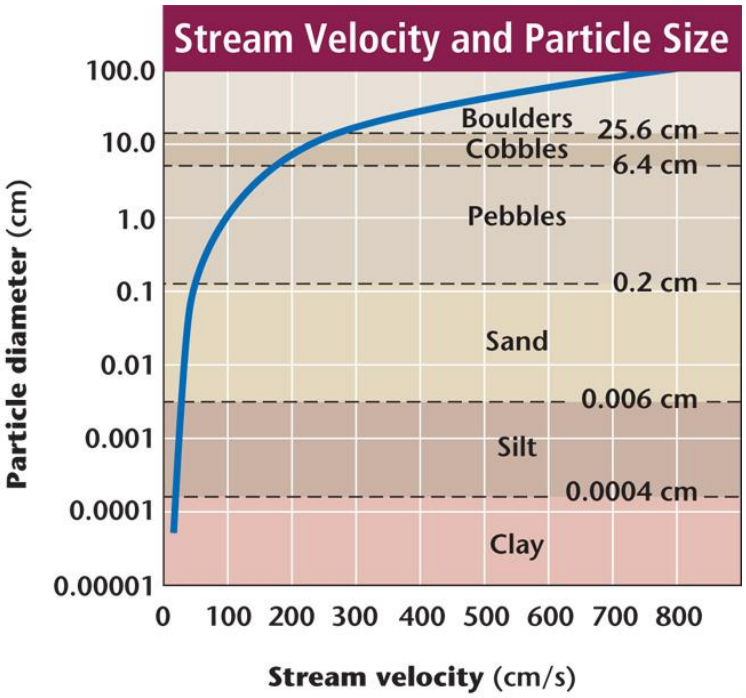
Materials	Concentration (ppm)			
	Amazon River	Mississippi River	World Average (est.)	Average Seawater
Silica (SiO_2)	7.0	6.7	13.0	6.4
Calcium (Ca)	4.3	42.0	15.0	400.0
Sodium (Na)	1.8	25.0	6.3	10 500.0
Potassium (K)	—	2.9	2.3	380.0
Magnesium (Mg)	1.1	12.0	4.1	1350.0
Chloride (Cl)	1.9	30.0	7.8	19 000.0
Fluoride (F)	0.2	0.2	—	1.3
Sulfate (SO_4)	3.0	56.0	11.0	2700.0
Bicarbonate (HCO_3)	19.0	132.0	58.0	142.0
Nitrate (NO_3)	0.1	2.4	1.0	0.5

Source: J. D. Hem, *Study and Interpretation of the Chemical Characteristics of Natural Water,* U.S. Geological Survey Water-Supply Paper 1473, 1970, pp. 11, 12, and 50.

Stream Load

Suspension

- All particles small enough to be held up by the turbulence of a stream's moving water are carried in **suspension**.
  - Particles, such as silt, clay, and sand, that are carried in suspension are part of a stream's suspended load.
  - The amount of material in suspension varies with the volume and velocity of the stream water.



Stream Load

Bed Load

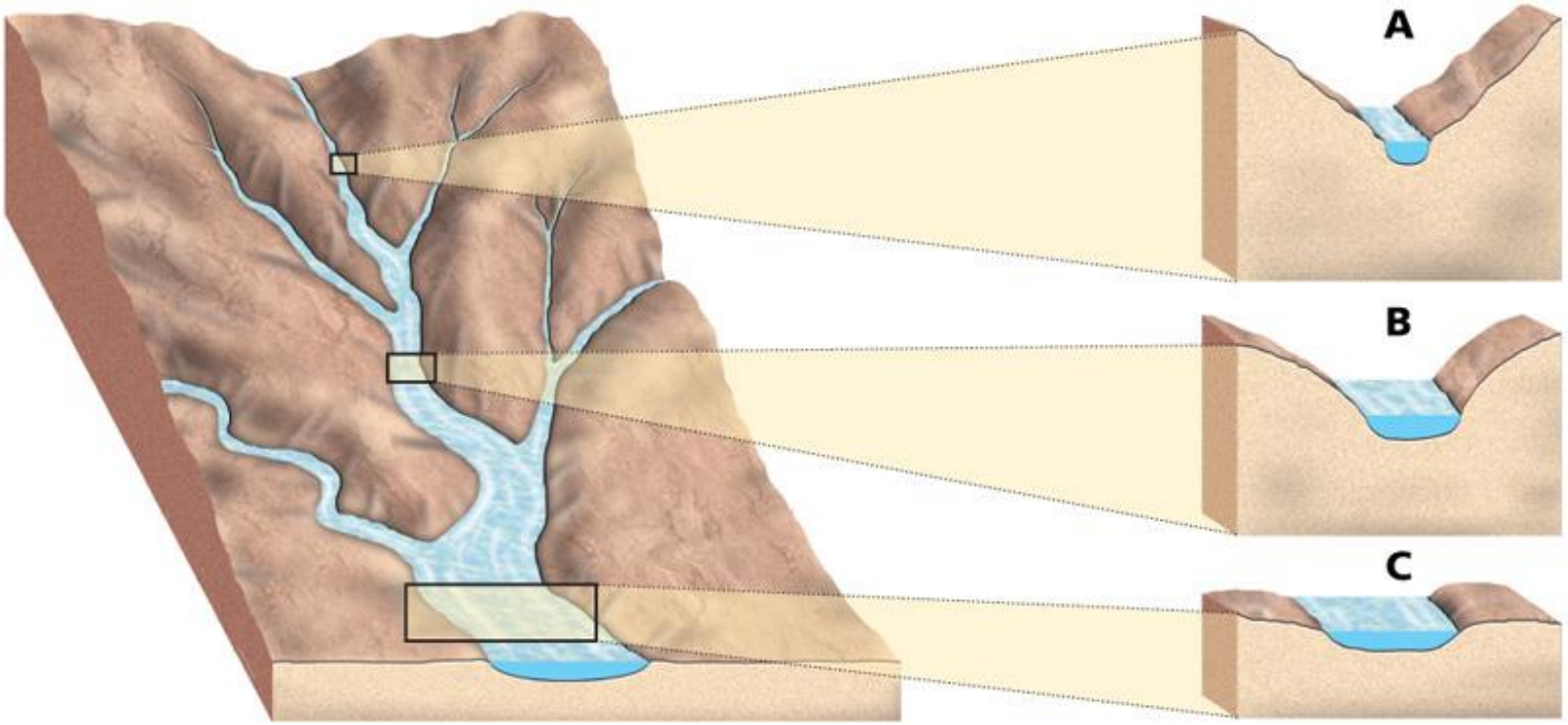
- A stream's **bed load** consists of sand, pebbles, and cobbles that the stream's water can roll or push along the bed of the stream.
  - Abrasion occurs as the particles grind against one another or against the solid rock of the streambed.
  - This action contributes to the physical weathering of the stream's bottom and sides and the bed load itself.

https://upload.wikimedia.org/wikipedia/commons/9/91/Agigawa_mountain_stream_03.jpg

Stream Velocity and Carrying Capacity

- A stream's carrying capacity is its ability to transport material.
- Carrying capacity depends on both the velocity and the amount of water moving in the stream.
- A stream's water moves more quickly where there is less friction and greater slope.
- The total volume of moving water also affects a stream's carrying capacity.

Stream Velocity and Carrying Capacity



Stream Velocity and Carrying Capacity

- **Discharge** is the measure of the volume of stream water that flows over a particular location within a given period of time, commonly expressed in cubic meters per second (m^3/s).
- The following formula is used to calculate the discharge of a stream:

$$\underset{(m^3/s)}{\text{discharge}} = \underset{(m)}{\text{width}} \times \underset{(m)}{\text{depth}} \times \underset{(m/s)}{\text{velocity}}$$

Stream Velocity and Carrying Capacity

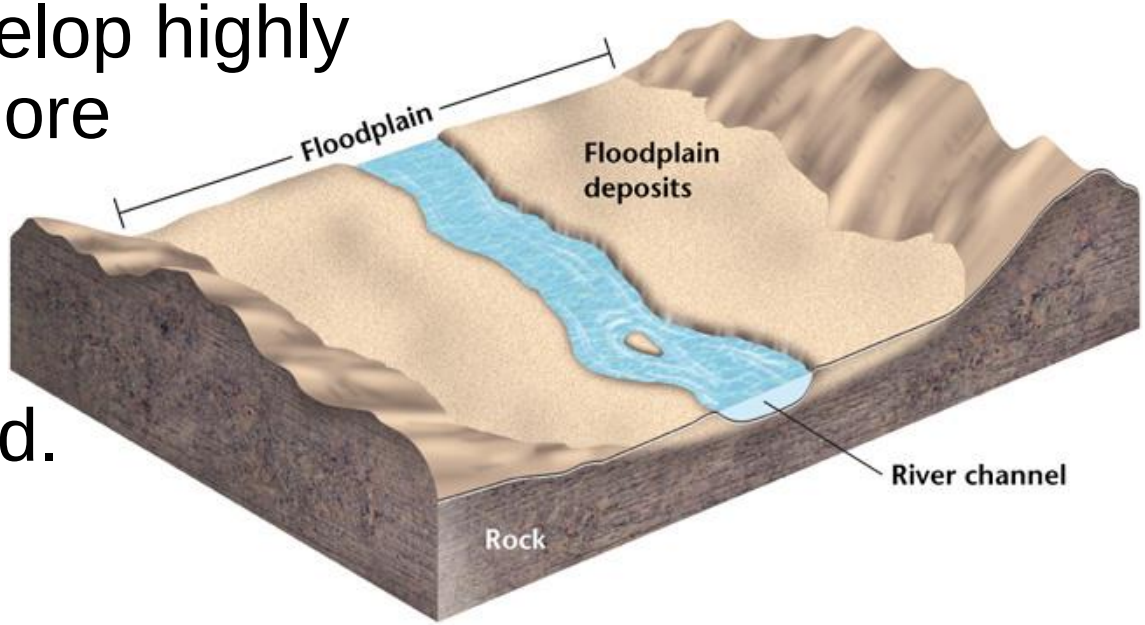
- As a stream's discharge increases, the stream's carrying capacity increases as well.
- A stream's ability to erode the land over which it passes is heightened when water velocity and volume increase.
- A streambed can widen and deepen, thereby increasing the stream slope and further adding to the stream's carrying capacity.

Floodplains

- A **flood** occurs when more water pours into a stream than the banks of the stream channel can hold causing water to spill onto the adjacent land.
- A stream's **floodplain** is the broad, flat area that extends out from a stream's bank and is covered by excess water during times of flooding.

Floodplains

- As floodwater recedes and its volume and speed decrease, the water drops its sediment load onto the stream's floodplain.
- Floodplains develop highly fertile soils as more sediment is deposited with each subsequent flood.



https://upload.wikimedia.org/wikipedia/commons/8/88/Cuckmere_River_Flood_Plain_-_geograph.org.uk_-_670462.jpg

Floods

- Flood stage is the level at which a stream overflows its banks and the crest of the stream is the maximum height.
- Because it takes time for runoff to collect in streams, the water continues to rise and may reach its crest days after precipitation ends.

http://media.mlive.com/grandrapidspress/photo/2013/05/-ce7e17524c72f01a.JPG

Floods

- Flooding may occur over localized, small areas or across large regions.
  - An upstream flood is the flooding of a small area.
  - Sudden rainstorms that drop large amounts of rain within a short period of time cause upstream floods.
  - Downstream floods result from heavy accumulations of excess water from large regional drainage systems.
  - Downstream floods occur during or after long-lasting, intense storms or spring thaws of large snowpacks.

Flood Monitoring and Warning Systems

- Government agencies including the National Weather Service and The U.S. Geological Survey (USGS) monitor potential flood conditions.
- The USGS has established gauging stations on approximately 4400 streams in the United States.
- Flood warnings and emergency plans often allow people to safely evacuate an area in advance of a flood.

Section Assessment

1. Match the following terms with their definitions.

_B_ watershed

_A_ suspension

_D_ bed load

_C_ discharge

A. particles that are carried in the turbulence of a stream's moving water

B. all of the land area whose water drains into a stream system

C. a measure of the volume of stream water that flows over a particular location within a given period of time.

D. sand, pebbles, or cobbles that a stream's water can roll or push along the bed of the stream

Section Assessment

2. What is the difference between an upstream flood and a downstream flood?

An upstream flood is a flood that occurs over a relatively small area. A downstream flood is a large flood over a wide area. Downstream floods result from excess water from large regional drainage system. Upstream floods result from locally heavy rains or other local events.

Section Assessment

3. Identify whether the following statements are true or false.

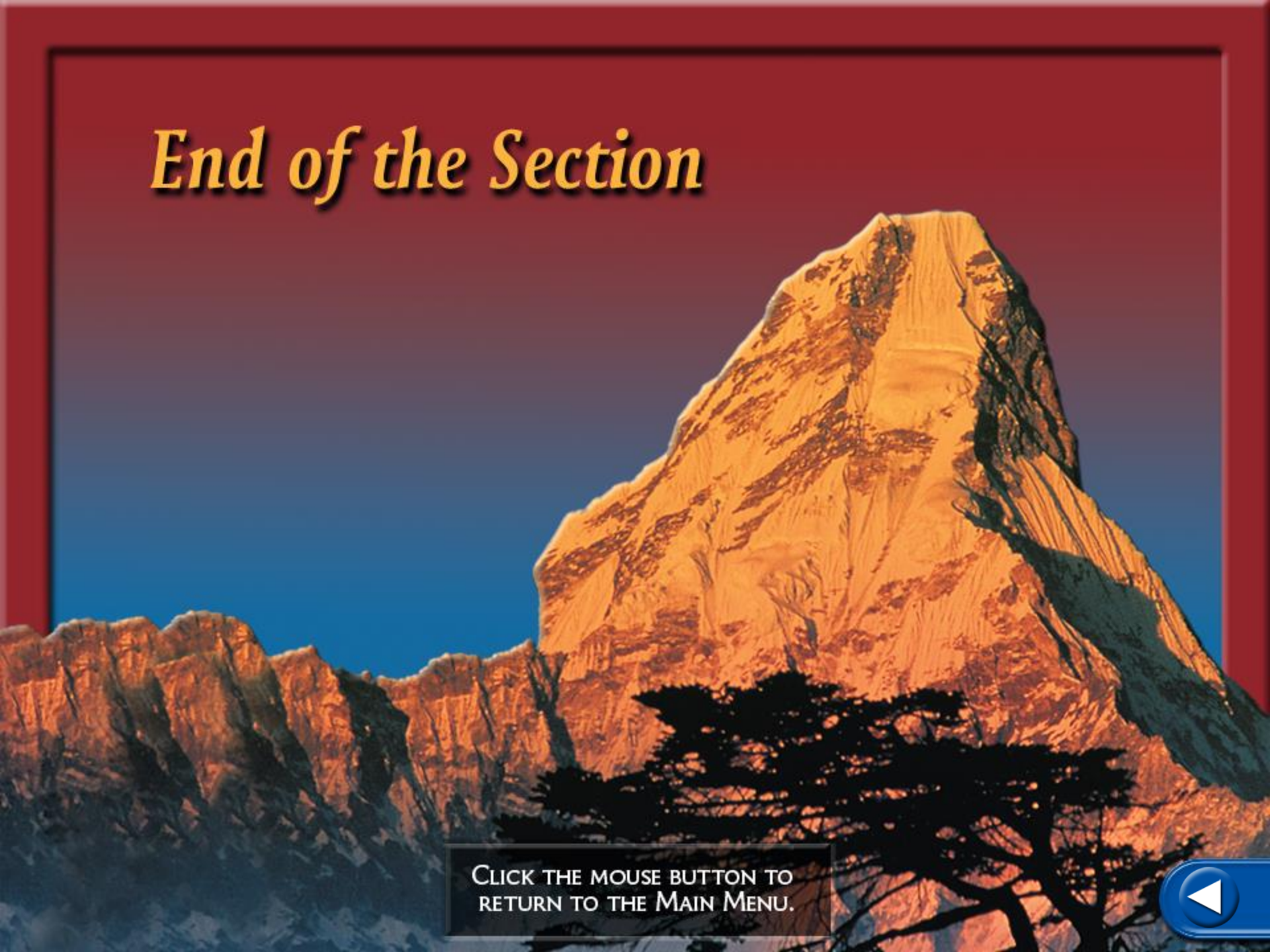
true More rainfall is usually absorbed by slow steady rain compared to a downpour.

false Bare ground will absorb more water than ground covered with vegetation.

false The average stream have a dissolved material level of 1,200 ppm.

true Floodplain deposits are usually very fertile.

End of the Section



Click the mouse button to return to the Main Menu.

Objectives

- **Describe** some of the physical features of stream development.
- **Explain** the process of rejuvenation in stream development.

Vocabulary

- – stream channel
- – stream bank
- – meander
- – delta
- – rejuvenation

Moving Water Carves a Path

- The first condition necessary for stream formation is an adequate supply of water.
- The region where water first accumulates to supply a stream is called the headwaters.
- It is common for a stream's headwaters to be high in the mountains.

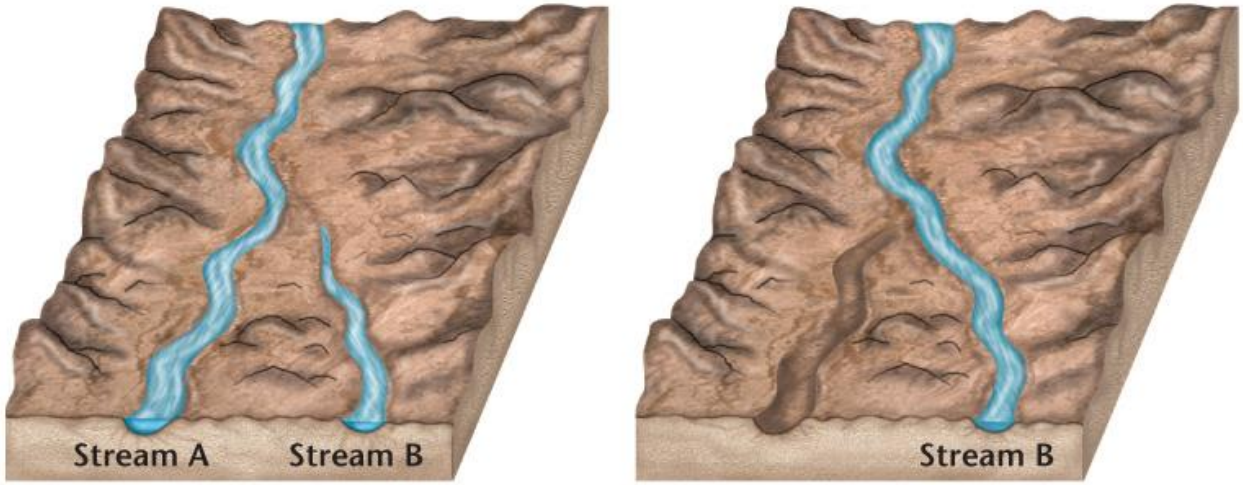
A **stream channel** forms as the moving water carves a narrow pathway into the sediment or rock.

Moving Water Carves a Path

- **Stream banks**, the ground bordering the stream on each side, hold the moving water within the confines of the stream channel.
- Headward erosion is the process by which small streams erode away the rock or soil at the head of the stream.

Moving Water Carves a Path

- Sometimes, a stream erodes its way through the high area separating two drainage basins, joins another stream, and then draws away its water.
- This process is called stream capture, or stream piracy.



Formation of Stream Valleys

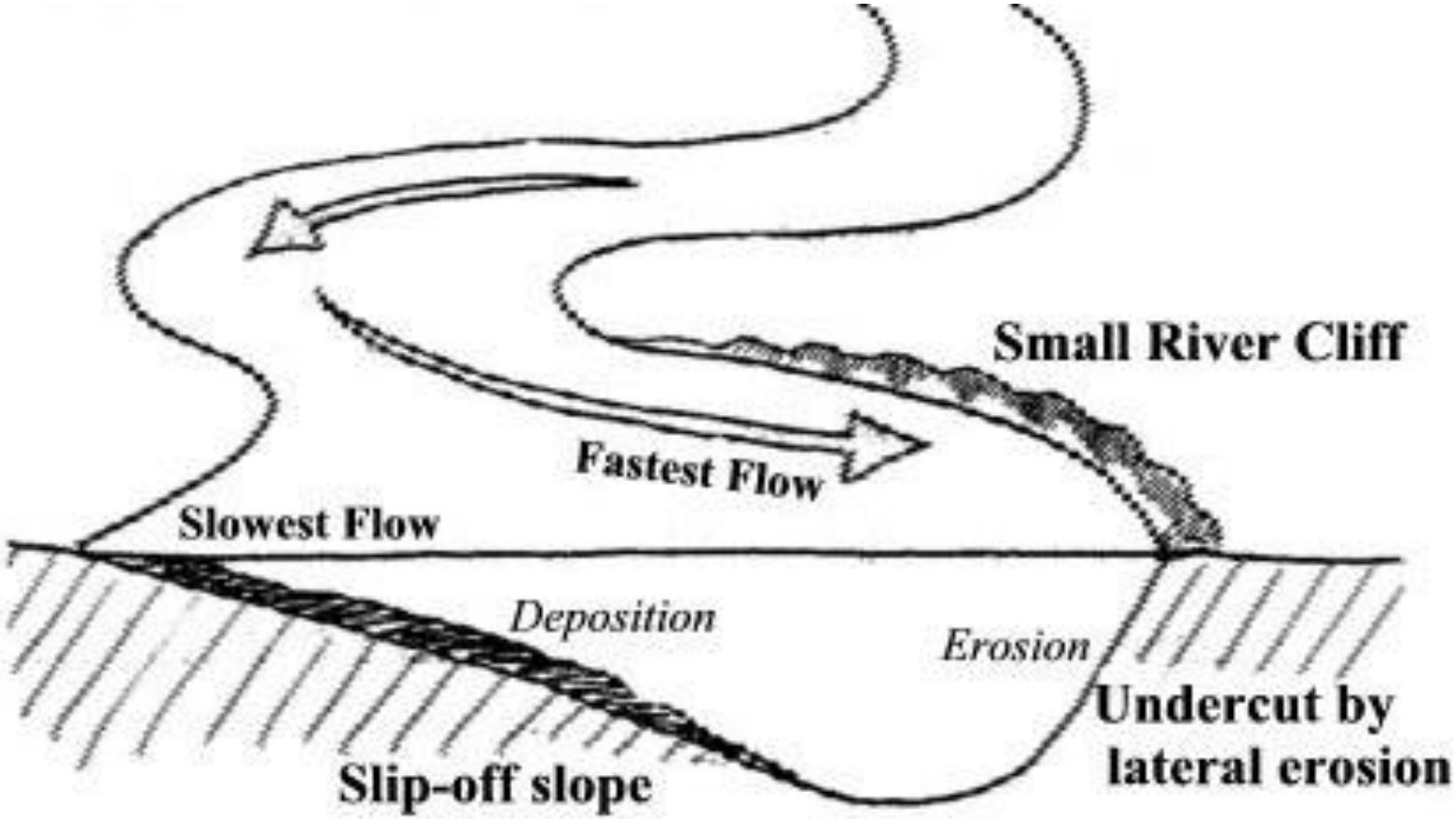
- As a stream actively erodes its path through the sediment or rock, a V-shaped channel develops.
- V-shaped channels have steep sides and sometimes form canyons or gorges.
- A stream continues to erode until it reaches its base level, the elevation at which it enters another stream or body of water.
- Over time, a V-shaped valley will be eroded into a broader valley that has gentle slopes.

Meandering Streams

- A stream's slope, or gradient, decreases as it nears its base level, and as a result the channel gets wider.
- The decrease in gradient causes water to build up within the stream channel.
- Sometimes, the water begins to erode the sides of the channel in such a way that the overall path of the stream starts to bend or wind.

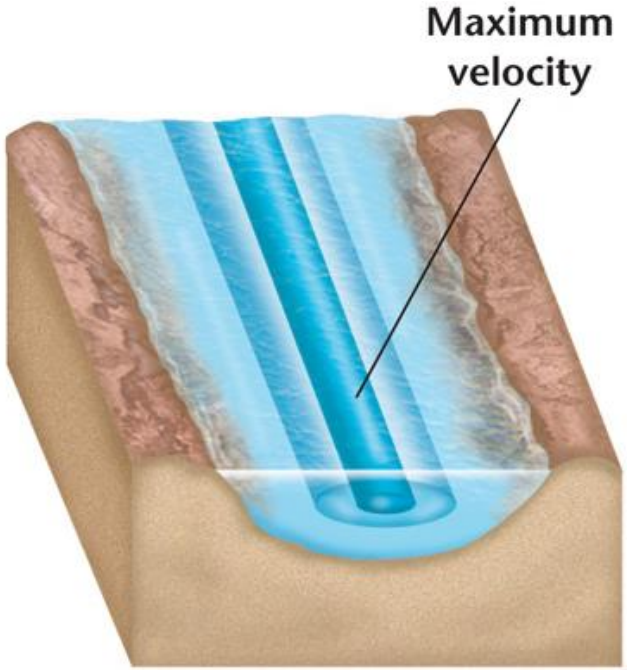
A **meander** is a bend or curve in a stream channel caused by moving water.

Meander Diagram (copy)



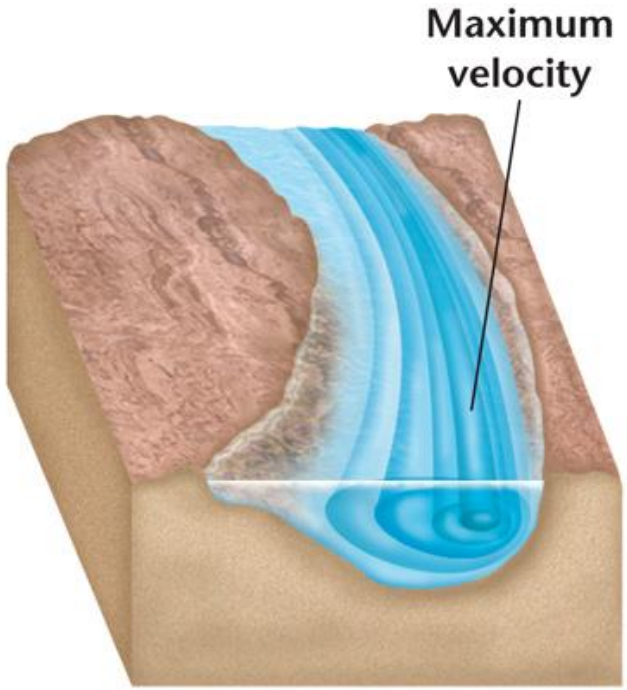
Meandering Streams

- Water in the straight parts of a stream flows at different velocities, depending on the location of the water in the channel.
  - In a straight length of a stream, water in the center of the channel is flowing at the maximum velocity.
  - Water along the bottom and sides of the channel flows more slowly because it experiences friction as it moves against the land.



Meandering Streams

- The water moving along the outside of a meander moves the fastest causing erosion.
  - The water that flows along this outside part of the curve continues to erode away the sides of the streambed, thus making the meander larger.
  - Along the inside of the meander, the water moves more slowly and deposition is dominant.



Meandering Streams

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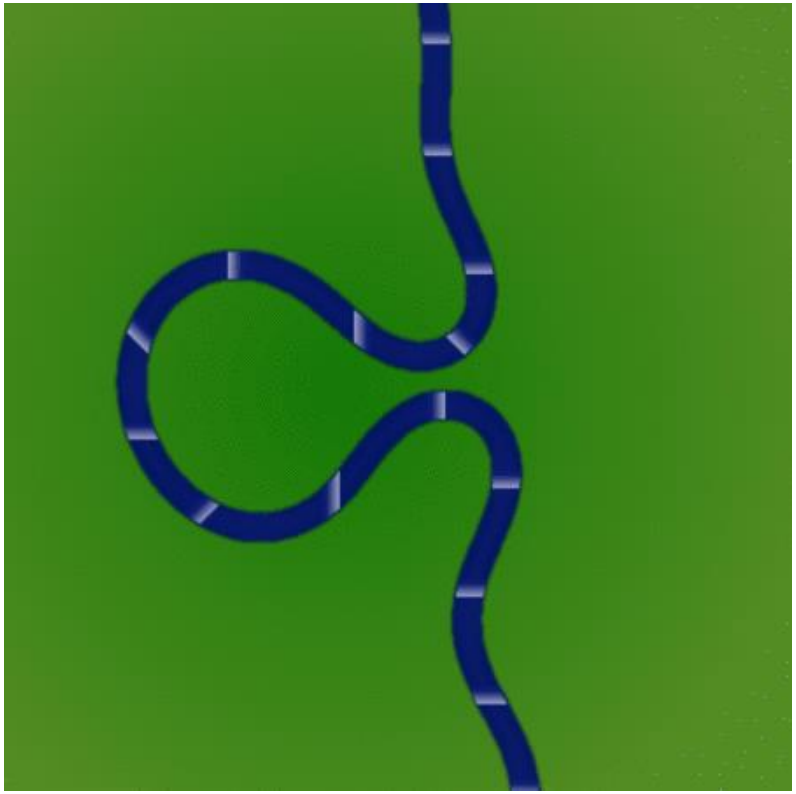
Oxbow Lake



https://upload.wikimedia.org/wikipedia/commons/8/84/OxbowAnimation.gif

http://awwatersheds.org/cms/assets/oxbow-lake.jpg

Meandering Streams

- It is common for a stream to cut off a meander and once again flow along a straighter path.
- A cut off meander is called an oxbow lake, which eventually dries up.
- As a stream approaches its ultimate end point, the ocean, the streambed's gradient flattens out and its channel becomes very wide.
- The mouth is the area of the stream that leads into the ocean or another large body of water.

Deposition of Sediments

- When a stream's velocity decreases, its sediment load settles to the bottom.
- In dry regions, a stream's gradient may suddenly decrease causing the stream to drop its sediment as a fan-shaped deposit called an *alluvial fan*.
- Alluvial fans are sloping fan-shaped depositional features formed at the bases of slopes and composed mostly of sand and gravel.

Alluvial Fan

Deposition of Sediments

- Streams also lose velocity and the ability to carry sediment when they join larger bodies of quiet water.

A **delta** is the triangular deposit, usually consisting of silt and clay particles, that forms where a stream enters a large body of water.

Rejuvenation

- Downcutting, or the wearing away of the streambed, stops when the stream reaches its base level.
- If the land over which the stream is flowing uplifts or if the base level lowers, the stream undergoes rejuvenation.
- During **rejuvenation**, a stream actively resumes the process of downcutting toward its base level.
- If rejuvenation occurs in an area where there are meanders, deep sided canyons are formed.

Section Assessment

1. Match the following terms with their definitions.

A	stream channel
C	meander
D	delta
B	rejuvenation

A. a pathway that is carved into sediment or rock by moving water

B. when a stream actively resumes the process of downcutting after a geological event

C. a bend of curve in a stream channel caused by moving water

D. the triangular deposit that forms where a stream enters a large body of water

Section Assessment

2. Why does a delta form?

As the water of a stream enters a larger body of water, its velocity rapidly decreases. This causes the water to drop its load. Sediment buildup can block the original channel causing smaller distributary streams to form to carry the water through the delta.

Section Assessment

3. Identify whether the following statements are true or false.

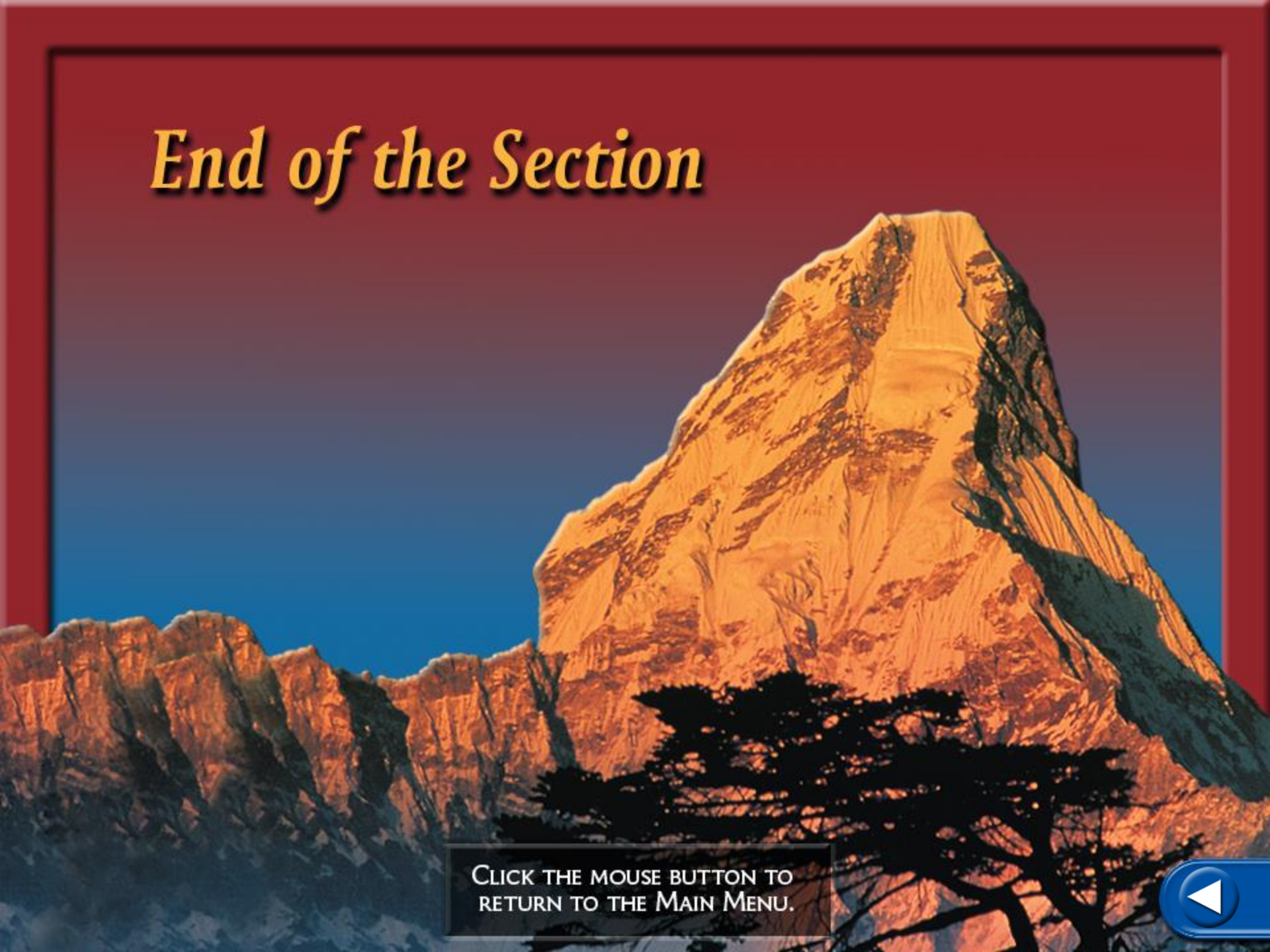
false The maximum velocity of water in a meander is on the inside of the meander curve.

true A stream will actively erode its stream bed until it reaches its base level.

true Without uplift or the base level lowering, rejuvenation will not occur.

false Floods are caused when stream banks give way.

End of the Section



Click the mouse button to return to the Main Menu.

Objectives

- **Explain** the formation of freshwater lakes and wetlands.
- **Describe** the process of eutrophication.
- **Recognize** the effects of human activity on lake development.

Vocabulary

– lake

– eutrophication

– wetland

Lakes and Freshwater Wetlands

- A **lake** is a depression in the surface materials of a landscape that collects and holds water.
- Lakes accumulate water from streams and runoff that flow into them, local precipitation, springs, and other sources.
- Most lakes have outlets from which water flows to rivers and to the ocean.
- Reservoirs are lakes made for the primary purpose of storing water for a community's use.

Types of Lakes

- Natural lakes form in different ways in surface depressions and in low areas.
  - Oxbow lakes form when streams cut off meanders and leave isolated channels of water.
  - Lakes can form when stream flow becomes blocked by sediment from landslides.
  - Some lakes are remnants of prehistoric lakes that have receded to lower-lying areas.
  - Moraine-dammed lakes formed when glacial moraines dammed depressions gouged out by glaciers.

Origins of Lakes

- Natural lakes form in different ways in surface depressions and in low areas.
  - Cirque and Kettle lakes are formed by glaciers.
  - Sinkhole Lakes (Cenotes)

http://www.arctic.uoguelph.ca/cpe/environments/inland_water/lakes/kettle.jpg

http://trudelsknapsack.com/Photos/Adventure%20Pages/Stein%20Blowdown/Day%202/91-Cirque_Lake2.jpg

http://www.floridasportsman.com/files/2012/06/09bass03.jpg

Lakes Undergo Change

- A depression that receives more water than it loses to evaporation or use by humans will exist as a lake for a long period of time.
- Lakes are temporary water-holding areas.
- Over hundreds of thousands of years, lakes usually fill in with sediment and become part of a new landscape.

Lakes Undergo Change

Eutrophication

- The amount of dissolved oxygen helps determine the quality of lake water and its ability to support life.
- **Eutrophication** is the process by which lakes become rich in nutrients from the surrounding watershed, thereby resulting in a change in the kinds of organisms in the lake.
- Eutrophication can be sped up with the addition of nutrients, such as fertilizers, that contain nitrogen and phosphorus.

Lakes Undergo Change

Freshwater Wetlands

- A **wetland** is a land area that is covered with water for a large part of the year.
- Wetlands include environments commonly known as bogs, marshes, and swamps.
  - Bogs receive their water from precipitation and their waterlogged soil tends to be rich in Sphagnum, also called peat moss.
  - Freshwater marshes frequently form along the mouths of streams and in areas with extensive deltas.
  - The constant supply of water allows for the lush growth of marsh grasses.

Lakes Undergo Change

Freshwater Wetlands

- Swamps are low-lying areas often located near streams.
- Swamps may develop from marshes that have filled in sufficiently to support the growth of shrubs and trees.
- Swamps that existed 250 million years ago developed into present-day coal reserves.

Lakes Undergo Change

Freshwater Wetlands

- Wetlands serve as a filtering system that traps pollutants, sediments, and pathogenic bacteria contained in water sources.
- Wetlands also provide vital habitats for migratory waterbirds and homes for an abundance of other wildlife.
- From the late 1700s to the mid 1980s, the continental United States lost 50 percent of its wetlands.

Section Assessment

1. What is eutrophication?

Eutrophication is the process by which lakes become rich in nutrients from the surrounding watershed, thereby resulting in a change in the kinds of organisms in the lake.

Section Assessment

2. Why are lakes “temporary” water-holding areas?

Lakes are temporary water holding areas because over hundreds of thousands of years , they usually fill in with sediment and become part of a new landscape.

Section Assessment

3. Identify whether the following statements are true or false.

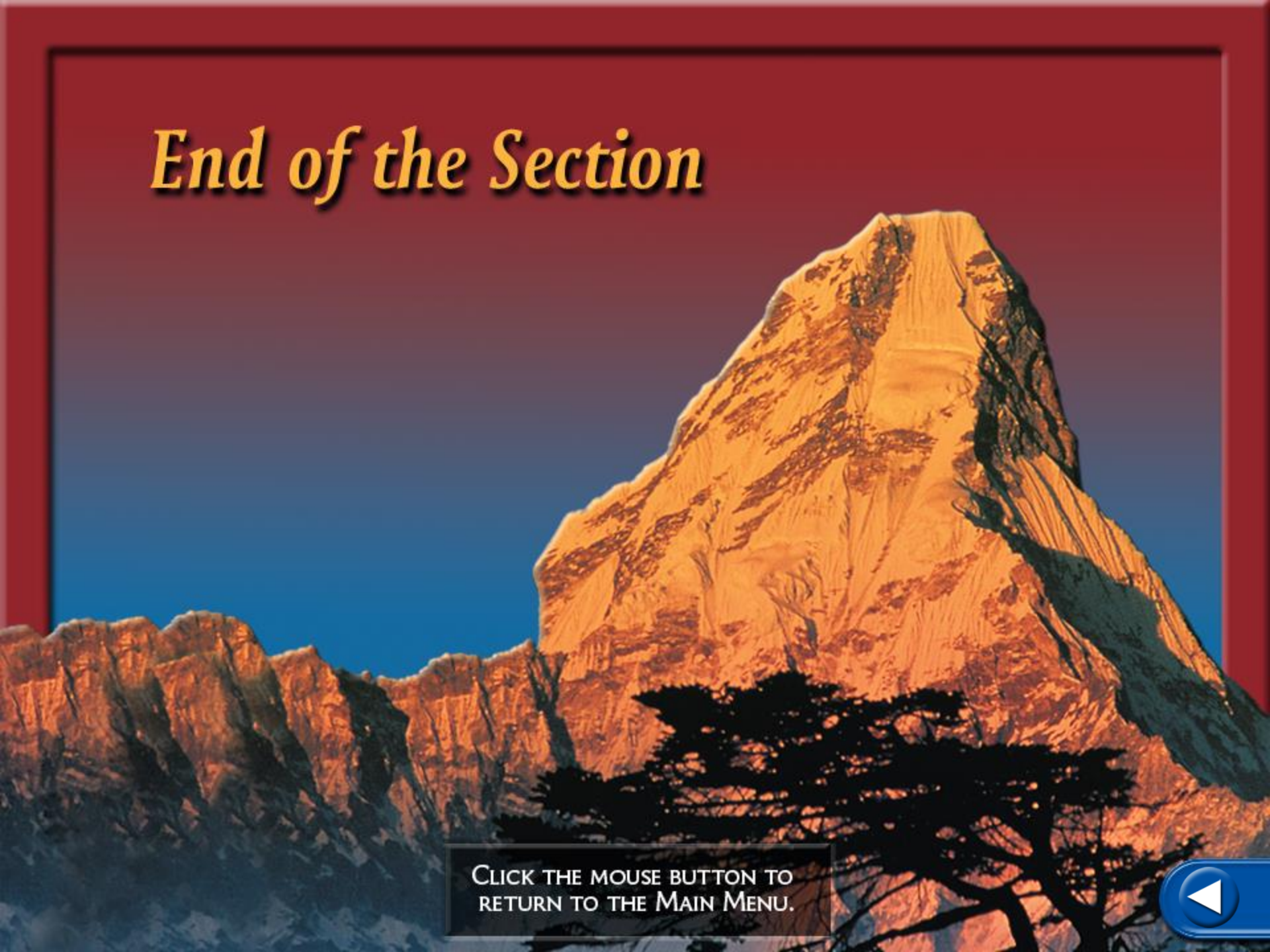
false Oxbow lakes are remnants of prehistoric lakes that have receded.

false Lakes cannot be located high in mountains.

true The dissolved oxygen level is a good indicator of the quality of a lake's water.

true Swamps that existed 250 million years ago developed into present-day coal reserves.

End of the Section



Click the mouse button to return to the Main Menu.

Study Guide

Section 9.1 Main Ideas

- Water on Earth may follow a variety of pathways as it is recycled through the processes of evaporation and condensation.
- Infiltration of water into the ground depends on the number of open pores or spaces in Earth materials and on the presence of unsaturated pores in the ground.
- All the land area that drains into a stream system is the system's watershed, or drainage basin. Elevated land areas called divides separate one watershed from another.

Section 9.1 Main Ideas

- A stream's load is all the material the stream carries, including material in solution, in suspension, and as bed load.
- A floodplain is a broad, flat area that extends out from a stream's bank during times of flooding.
- Flooding occurs in small, localized areas as upstream floods or in large, downstream floods. Damage from flooding can be devastating.

Section 9.2 Main Ideas

- Water from precipitation gathers in gullies at a stream's source area, or headwaters. The stream's water flows in channels confined by the stream's banks.
- Alluvial fans and deltas form when stream velocity decreases and sediment is deposited. Alluvial fans are fan shaped, and they form where water flows down steep slopes onto flat plains. Deltas are triangular, and they form when streams enter large, relatively quiet bodies of water.

Section 9.3 Main Ideas

- Lakes form in a variety of ways when depressions on land fill with water. Lakes may be natural or human-made.
- Eutrophication occurs in a lake when nutrients from fertilizers, detergents, or sewage are added.
- Wetlands are low-lying areas that are periodically saturated with water and support specific plant species. Wetlands include bogs, marshes, and swamps.

Multiple Choice

1. What is the source of the energy that drives the water cycle?

a. evaporation

b. transpiration

c. the Sun

d. the oceans

The *Sun* is the source of energy that heats the oceans and land surface causing evaporation. The Sun also fuels photosynthesis which causes transpiration.

Multiple Choice

2. What river has the largest watershed in the United States?

a. Arkansas River

b. Mississippi River

c. Ohio River

d. Missouri River

The watersheds of the Arkansas, Ohio, and Missouri rivers are all part of the Mississippi River watershed.

Multiple Choice

3. Floods that cover small areas are known as ___.

a. upstream floods

b. downstream floods

c. minor floods

d. major floods

Downstream floods involve large areas. *Major* and *minor* refer to the severity of the flood, not the size of the area size that is affected.

Multiple Choice

4. Where is water flow the slowest in a meander?

a. outside

b. center

c. inside

d. equal in all areas

Water has the highest velocity on the outside of a meander. It is there that erosion of a cutbank occurs. Deposition occurs on the inside of the meander as the water slows down.

Multiple Choice

5. A wetland that is not stream-fed and receives its water from precipitation is called a _____.

a. swamp

b. marsh

c. delta

d. bog

Bogs tend to be rich in peat moss which is burned as fuel in some parts of the world.

Short Answer

6. How does stream capture, or stream piracy occur?

Sometimes, a stream erodes its way through the high area separating two drainage basins, joins the other stream, and then draws away its water.

Short Answer

7. What has to occur for a stream to begin the process of rejuvenation?

The land over which the stream flows either has to be uplifted or the base level must be lowered.

True or False

8. Identify whether the following statements are true or false.

true Loose soil absorbs water more efficiently than packed soil.

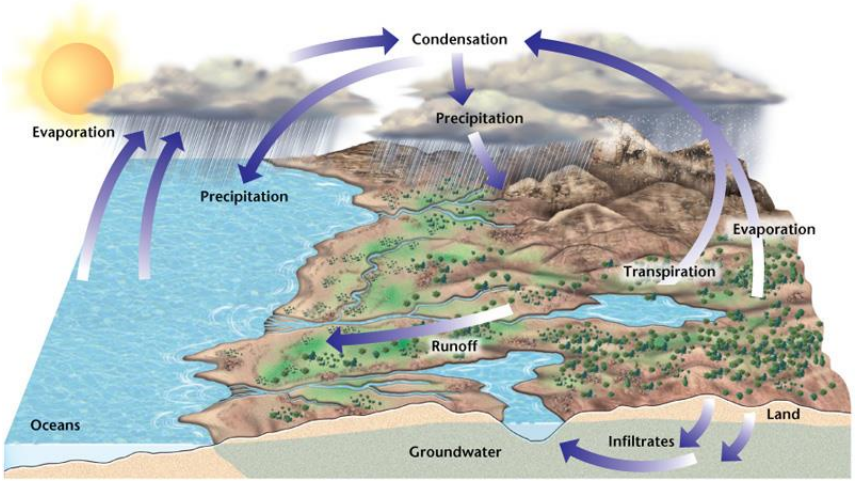
false Clay will be deposited before silt when stream water slows down.

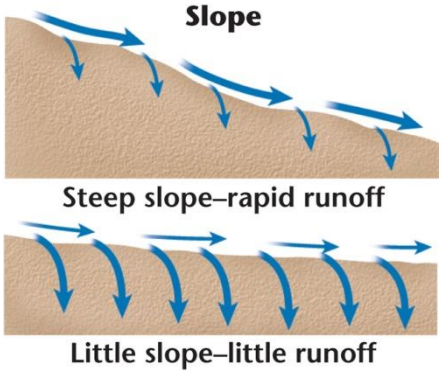
false The Mississippi River has the highest discharge rate in the world.

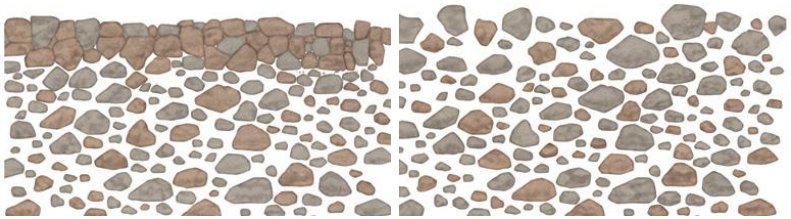
true The Grand Canyon is a V-shaped channel.

true Eutrophication causes dissolved oxygen levels to decrease.

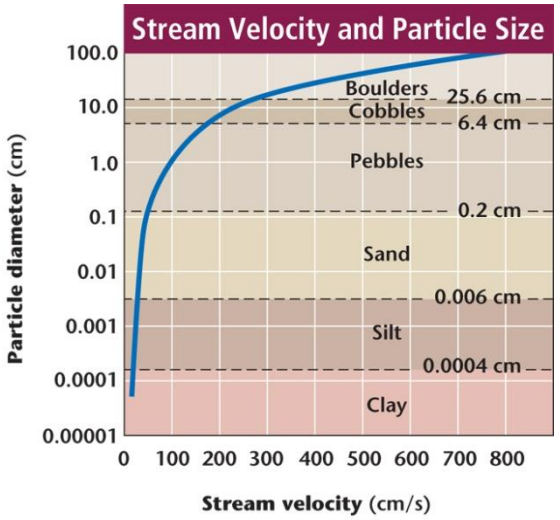
Chapter 9 Images

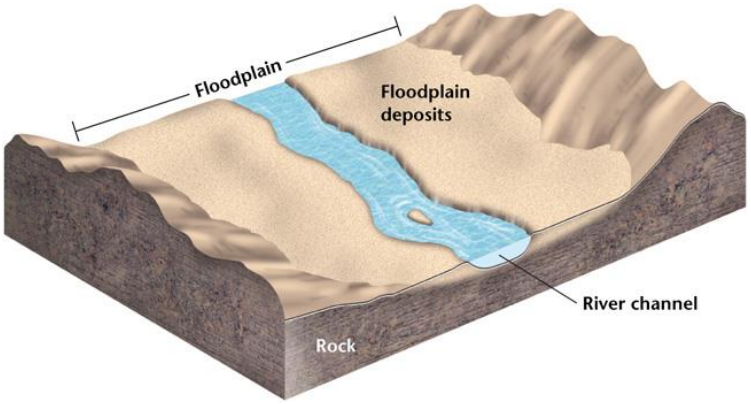


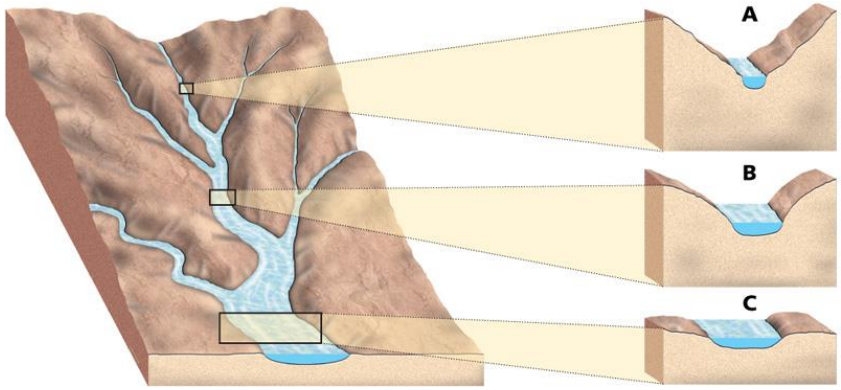


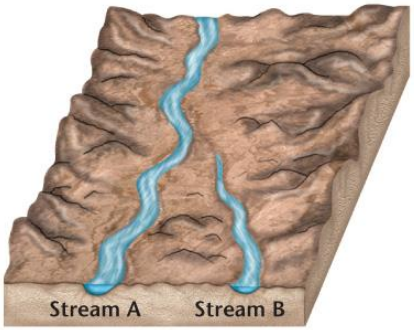


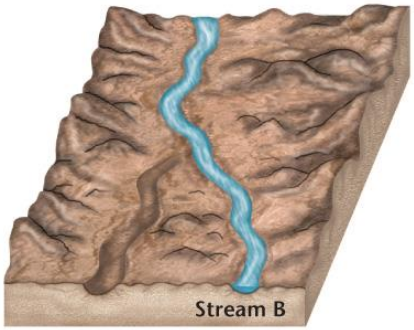
Chapter 9 Images



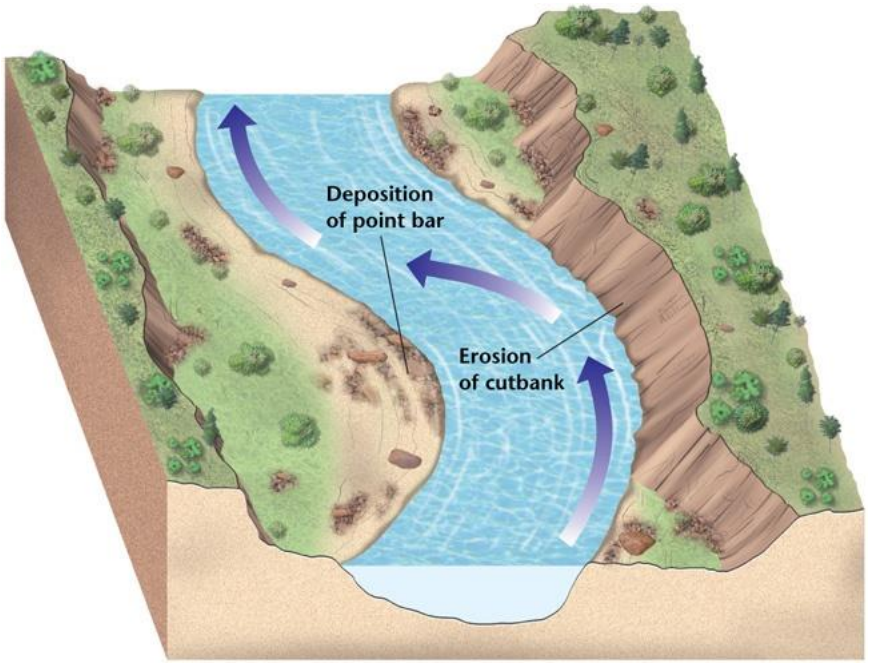


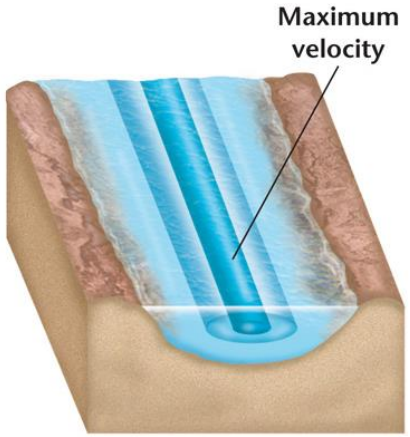


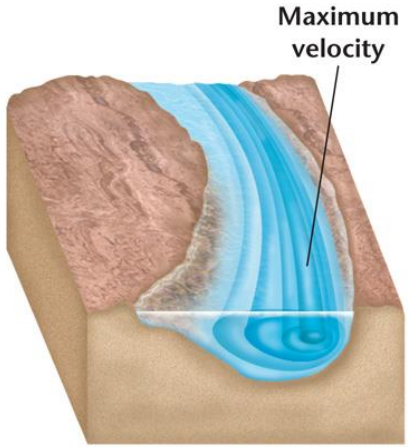




Chapter 9 Images







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