

Section 1

The Active River

Key Concept Water running downhill is the dominant process in shaping the landscape.

What You Will Learn

- Moving water shapes the surface of Earth by the process of erosion.
- The sun is the major source of energy that drives the water cycle.
- Three factors that affect the rate of stream erosion are gradient, discharge, and load.

Why It Matters

Factors that affect how water moves over the surface of Earth influence the shape of Earth's landscape.

Imagine that you fell asleep with your toes dangling in the Colorado River 6 million years ago. Today, you wake up to find that your toes are hanging about 1.6 km (about 1 mi) above the river! The Colorado River carved the Grand Canyon, shown in **Figure 1**, by washing billions of tons of rock and sediment from its riverbed. This process can take millions of years.



Figure 1 The Grand Canyon is located in northwestern Arizona. The canyon formed over millions of years as running water eroded the rock layers.

Rivers: Agents of Erosion

Six million years ago, the area now known as the Grand Canyon was nearly as flat as a pancake. Tectonic uplift raised the land, and water running downhill became the Colorado River. The Colorado River cut down into the rock and formed the Grand Canyon over millions of years through the process of erosion. **Erosion** is the process by which wind, water, ice, and gravity move soil and sediment from one place to another. Rivers, such as the Colorado River, are agents of erosion that shape Earth's landscape. Because of erosion caused by water, the Grand Canyon is now about 1.6 km deep and 446 km long. In this section, you will learn about stream development and river systems. You will also learn about factors that affect the rate of stream erosion.

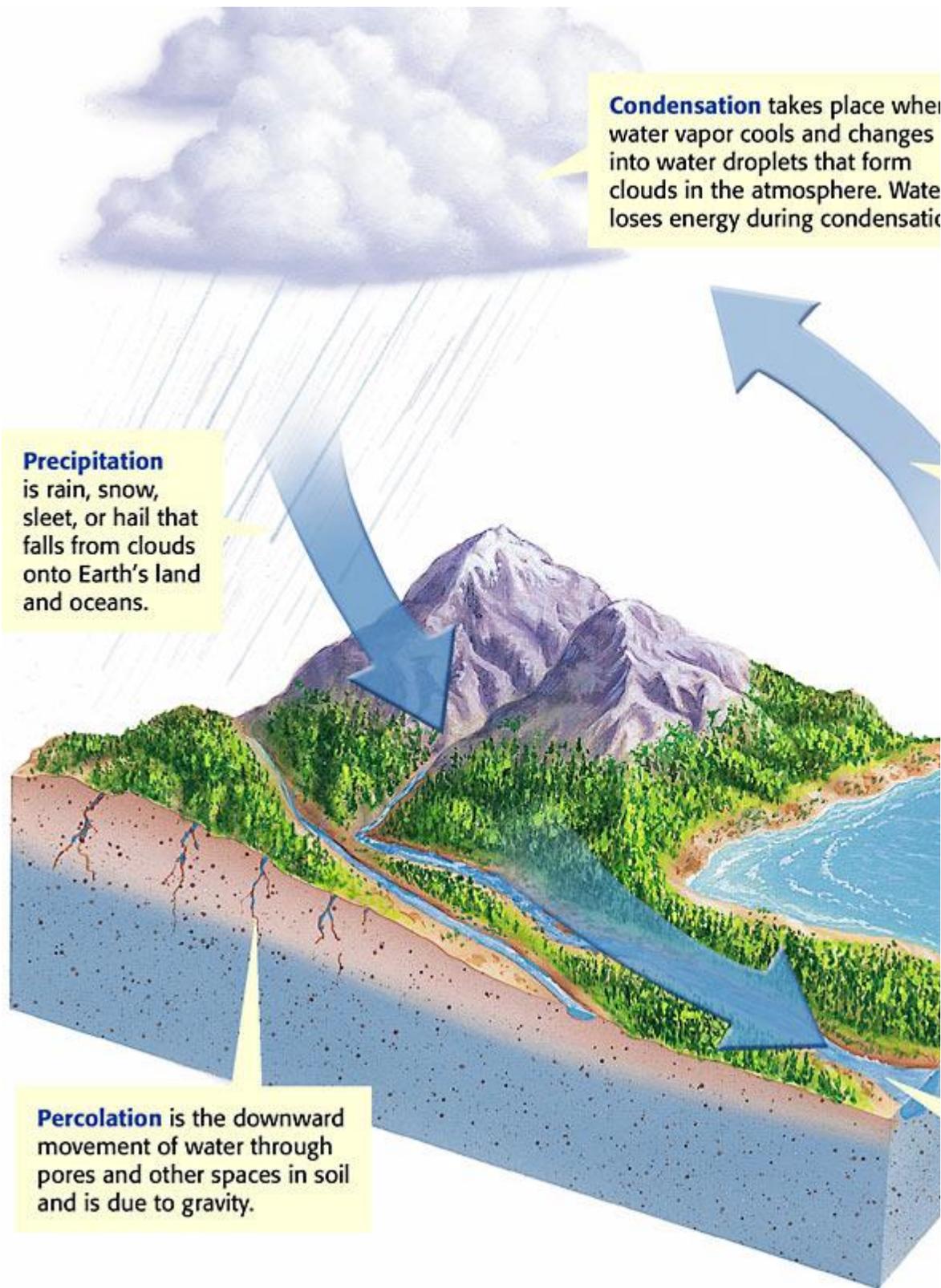
Standards Check What is erosion, and how does it shape Earth's landscape?

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The Water Cycle

Have you ever wondered where the water in rivers comes from? This water is part of the water cycle. The **water cycle**, shown in **Figure 2**, is the continuous movement of water between the atmosphere, the land, and the oceans. The major source of energy that drives the water cycle is the sun.

Figure 2 The Water Cycle



Standards Check Describe the water cycle.



River Systems

The next time you take a shower, notice that individual drops of water join to become small streams. These streams join other small streams and form larger streams. Eventually, all of the water flows down the drain. Every time you shower, you make a model of a river system. A *river system* is a network of streams and rivers that drain an area of its runoff. A stream that flows into a lake or into a larger stream is called a **tributary**.

Standards Check Describe the difference between a tributary and a river system.



Watersheds and Divides

River systems are divided into regions called watersheds. A **watershed** is the area of land that is drained by a river system. Watersheds vary in size. The largest watershed in the United States is the Mississippi River watershed. This watershed has hundreds of tributaries. These tributaries extend from the Rocky Mountains, in the West, to the Appalachian Mountains, in the East. A main stream that drains a large watershed and has many tributaries is called a *river*.

The image in **Figure 3** shows that the Mississippi River watershed covers more than one-third of the United States. Other major watersheds are the Columbia River, the Rio Grande, and the Colorado River watersheds. Watersheds are separated from each other by an area of higher ground called a **divide**.

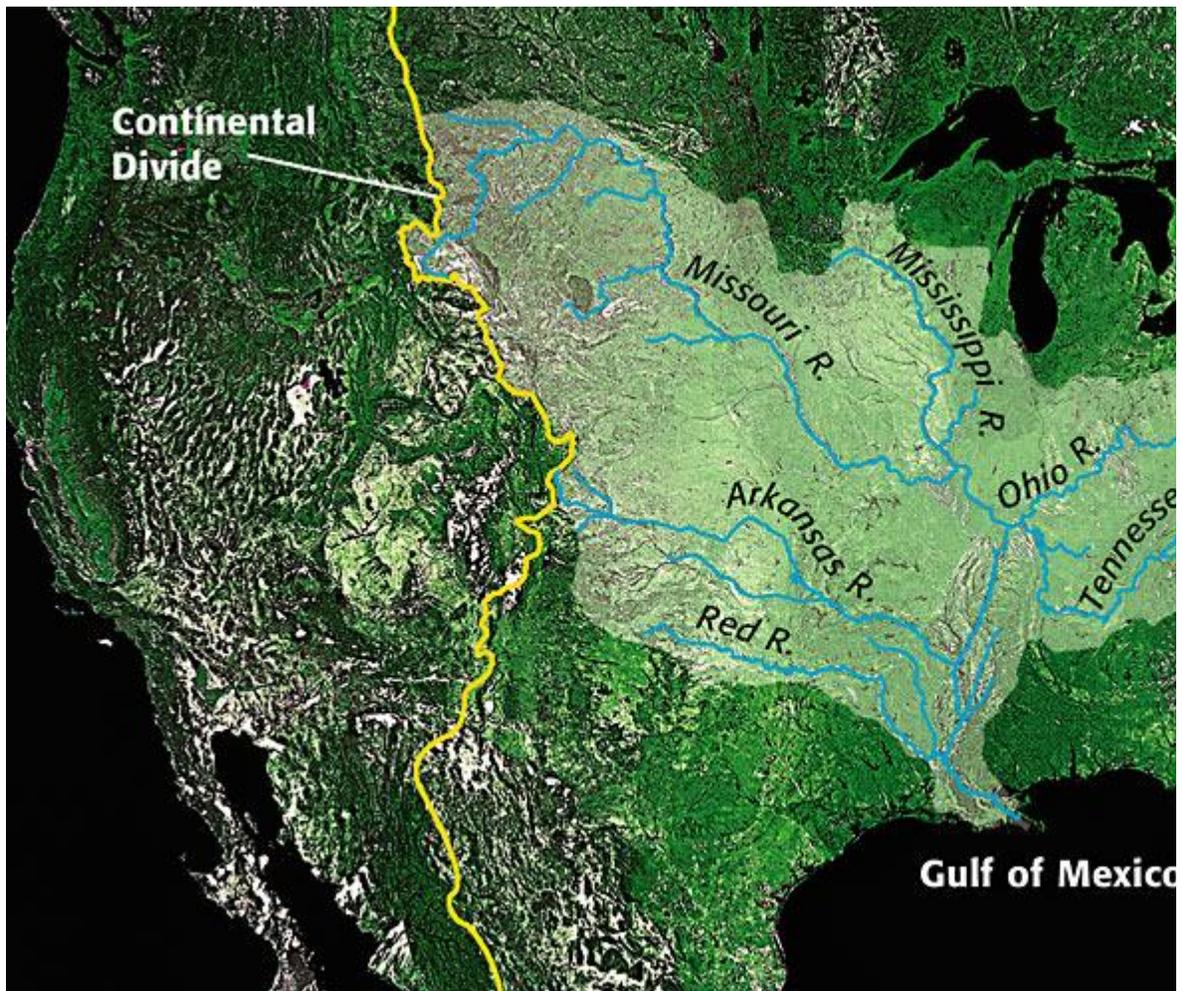


Figure 3 The Continental Divide runs through the Rocky Mountains. It separates the watersheds that flow into the Atlantic Ocean and the Gulf of Mexico from those that flow into the Pacific Ocean. The Mississippi River watershed is shown in light green.

Stream Erosion

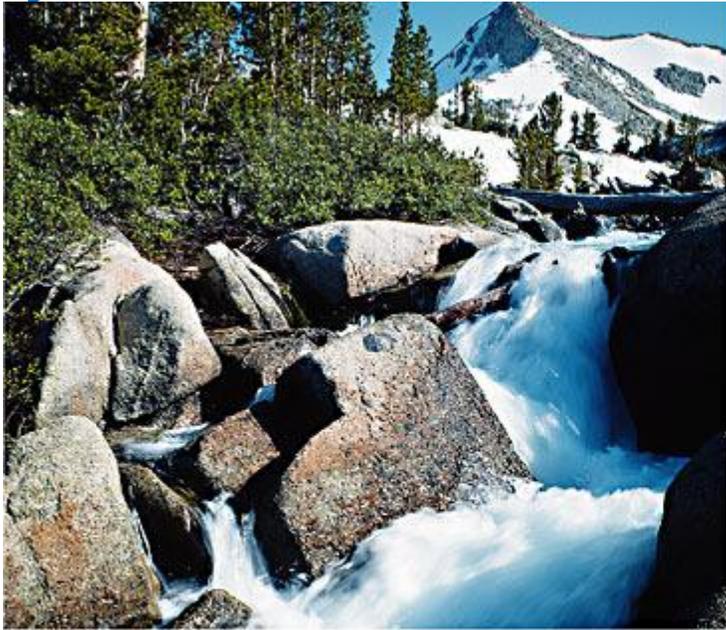
A stream forms as water erodes soil and rock to make a channel. A **channel** is the path that a stream follows. As the stream continues to erode rock and soil, the channel

gets wider and deeper. Over time, tributaries join the main channel. The increased water flow from the tributaries causes the stream to become longer and wider.

Gradient

Figure 4 shows two rivers that have very different gradients. *Gradient* is the measure of the change in elevation over a certain distance. The water in a stream or river that has a high gradient moves very rapidly. This rapid water flow gives the stream or river a lot of energy to erode rock and soil. A river or stream that has a low gradient has less energy for erosion.

Figure 4 California Rivers That Have Different Gradients



This stream in John Muir Wilderness has a high gradient. Therefore, the stream flows swiftly downhill over rocks.

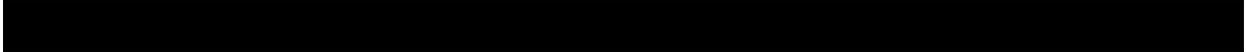


Mad River Slough near Eureka. It flows slowly and has less energy than streams with a high gradient.

Standards Check How does gradient affect the erosion of stream channels?

Discharge

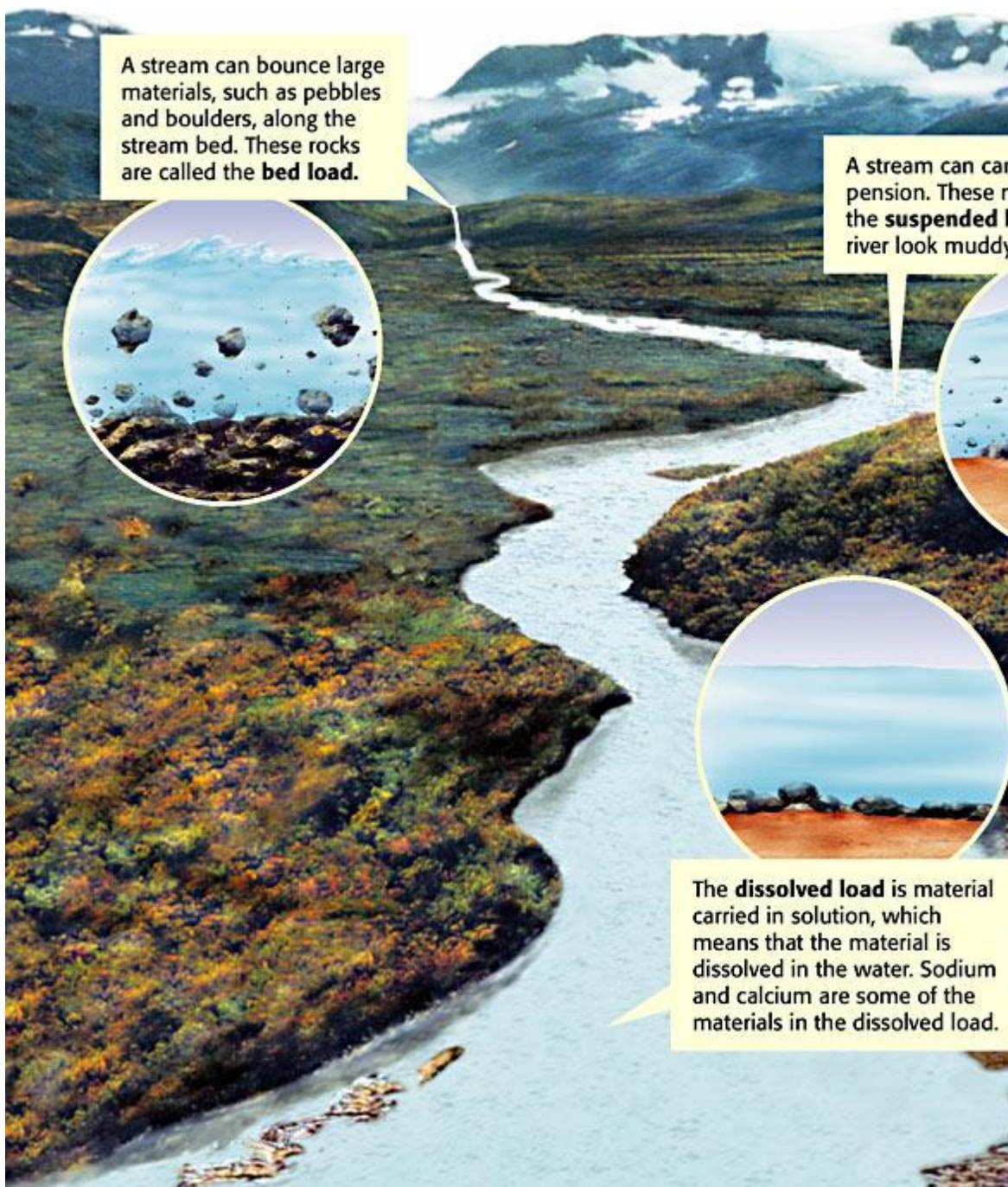
The amount of water that a stream or river carries in a given amount of time is called *discharge*. The discharge of a stream increases when a major storm occurs or when warm weather rapidly melts snow. As the stream's discharge increases, the water's speed and erosive energy increase. The amount of solid material that the stream can carry also increases.



Load

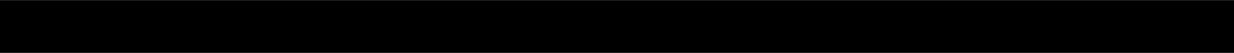
The materials carried by a stream are called the stream's **load**. The three types of load are shown in **Figure 5**. The size of the particles in a stream's load is affected by the stream's speed. Fast-moving streams can carry large particles. Rocks and pebbles bounce and scrape along the bottom and sides of the stream bed. Thus, a stream that has a load of large particles has a high rate of erosion. Streams that move more slowly carry smaller particles and have less erosive energy.

Figure 5 Three Types of Load



Standards Check How does load affect rates of erosion?





Describing Rivers

William Morris Davis was a geomorphologist who studied how rivers shape the landscape. His studies of rivers in the Appalachian Mountains helped him develop a model to describe the stages of river development. In his model, rivers went through a series of stages. Davis described rivers as evolving from a youthful stage to an old-age stage. He thought that all rivers eroded in the same way and at the same rate.

Today, scientists support a model that differs from Davis's model. Because materials erode at different rates, one river may develop more quickly than another river does. Many factors, such as climate, local geology, gradient, and load, influence the development of a river. Scientists no longer use Davis's model to explain river development. But they still use many of his terms to describe a river. These terms describe a river's general features, not a river's actual age.

Youthful Rivers

A youthful river erodes its channel deeper rather than wider. Its channel is narrow and straight. The river tumbles over rocks in rapids and waterfalls. Youthful rivers have very few tributaries. These rivers flow quickly because they have steep gradients. Many youthful rivers have steep gradients because the areas that these rivers drain have been tectonically uplifted. A youthful river in Wyoming is shown in **Figure 6**.



Figure 6 This youthful river is located in Yellowstone National Park in Wyoming. Rapids and falls exist where the river flows over hard, resistant rock.

Standards Check Describe a youthful river.



Mature Rivers

Unlike a youthful river, a mature river erodes its channel wider rather than deeper. The gradient of a mature river is not as steep as that of a youthful river. Therefore, a mature river has fewer falls and rapids. A mature river is fed by many tributaries. Because of its large watershed, a mature river has more discharge than a youthful river does. A mature river is shown in **Figure 7**. Notice that a mature river tends to curve back and forth. These curves or bends in the river's channel are called *meanders*.



Figure 7 A mature river, such as this one in the Amazon basin of Peru, curves back and forth.

Standards Check Describe the difference between youthful rivers and mature rivers in terms of how these rivers erode their channels.

Rejuvenated Rivers

A rejuvenated (ri JOO vuh NAYT ed) river forms where the land has been raised by tectonic activity. When land rises, the river's gradient becomes steeper and the river flows more quickly. This rapid water flow allows the river to cut more deeply into the valley floor. Steplike formations called *terraces* commonly form on both sides of a stream valley because of rejuvenation, as **Figure 8** shows.



Figure 8 The rejuvenated river above is located in Canyonlands National Park in Utah.

Old Rivers

An old river has a low gradient, so it has little erosive energy. Instead of widening and deepening its banks, the river deposits rock and soil in and along its channel. An old river has wide, flat floodplains, or river valleys, and many bends. An old river also has fewer tributaries than a mature river does. An old river has fewer tributaries because its smaller tributaries have joined together. An old river commonly forms an oxbow lake, such as the one shown in **Figure 9**. An oxbow lake forms when the strip of land that separates parts of a meander is eroded. This process shortens the river's length.



Figure 9 This old river is located in New Zealand.

Section Summary

- Rivers shape Earth's landscape through the process of erosion.
- The sun is the major source of energy that drives the water cycle.
- A river system is made up of a network of streams and rivers.
- A watershed is a region that collects runoff water that then becomes part of a river system that drains into a lake or the ocean.
- Gradient affects the speed at which water flows in a stream. The higher the gradient, the faster the water flows. Water that flows rapidly has a lot of energy for eroding soil and rock.
- When a stream's discharge increases, the stream's erosive energy also increases.

- A stream can carry eroded particles as bed load, suspended load, or dissolved load. A stream that has a load of large particles has a high rate of erosion.
- A river can be described as youthful, mature, old, or rejuvenated based on its characteristics.

