How can weathering and erosion be all that? The investigations you have done so far give some clues about these processes.

Remember, in physical weathering, rock breaks down into smaller pieces. The smaller pieces are called sediment. Erosion transports sediment to a basin by water, wind, or ice.

What do sheer cliffs, balancing rocks, massive caves, and giant sand dunes have in common? They result from the processes of weathering and erosion. The same processes form and take away the soils we depend on to grow our food.

Interesting rock formations like arches and pillars in Utah's Bryce Canyon were created by the natural forces of weathering.
Physical Weathering and Round Rocks

Physical weathering occurs when large rocks break into smaller rocks of the same kind. When a rock, like granite, is broken, it may break into small pieces of the minerals that make it up, such as quartz and feldspar. But they are the same minerals that were in the original granite.

The sharp edges and corners of broken rock pieces wear away as they hit other rocks. This reshaping occurs naturally when rocks are hit by windblown sand or rock particles in moving water. The name for this type of physical weathering is abrasion. Abrasion also happens when falling rocks hit other rocks, breaking them apart.

When you observe beach sand or sand in a riverbed, you can see smooth, polished sand grains. Waves and flowing water rolled these sand grains around, causing them to hit each other. You observed sand particles in the stream table bouncing and hitting other grains of sand as they moved along. The water carries rocks that bump off the rough edges on other rocks. The farther the sand grains are carried by water, the smoother they get.

The abrasion, or scraping, of blowing sand helped carve and smooth this sandstone canyon.

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The abrasion, or scraping, of blowing sand helped carve and smooth this sandstone canyon.
The slope of loose rock, or talus, at the base of the cliff is evidence of rock falls. No water is involved when wind transports sediment. The sand grains bang into each other, creating a frosted, dull rounded surface. Beach sand, river sand, and dune sand are all similar in at least one way—the farther the weathered rocks travel and the more they get banged around, the smaller they become.

**Ice Wedging and Rock Falls**

When ice freezes, it expands with great force. You saw what happened when water in a jar froze and expanded. The force shattered the jar! Ice expansion naturally causes physical weathering when water gets into tiny cracks in a rock. At night, temperatures fall, and the water freezes, expands, and presses against the surrounding rock. The crack gets bigger. During the day, as the temperature rises, the water thaws and seeps farther down into the crack. Night comes, and the water freezes again. With repeated freezing and thawing, the crack becomes larger. Eventually, pieces of the rock break off. Ice wedging can break rocks off the side of a cliff. These rock falls make piles of jagged rocks, called talus, at the base of cliffs. These rocks fell because a tiny crack kept growing until the piece broke off. You may have seen the results of ice wedging in your neighborhood. Ice damages concrete sidewalks and curbs, and wedges flakes from bricks. Plant roots also cause weathering, by growing into cracks. The roots expand as the plant grows, breaking the rocks apart. You may have seen tree roots that lifted and broke a sidewalk or even cracked the foundation of a house. Tree roots cause physical weathering when they grow into cracks in a rock. Growing roots can split huge boulders.
Chemical Weathering

Physical weathering is not the only way to break down rocks. Remember how the limestone fizzed when you put a drop of acid on it? During that chemical reaction, acid dissolved a tiny amount of rock. This same process takes place naturally. Tiny amounts of carbon dioxide in the air dissolve in falling raindrops. The solution is a very weak acid called carbonic acid. This acid is too weak to make limestone fizz. But each slightly acidic raindrop dissolves a few molecules of limestone. Over thousands of years, limestone will slowly wear away because of chemical weathering.

Decaying plant material, lichens, and plant roots also produce carbon dioxide and other weak acids. These acids dissolve in rainwater as it moves through soil and into cracks in rock. Limestone caves such as Mammoth Cave in Kentucky formed over millions of years as chemical weathering dissolved limestone. This weathering creates landforms called karst topography. Sinkholes and caves are karst landforms and are found in many areas, including Kentucky and Florida. Dramatic limestone pinnacles found in Asia are also examples of karst topography. Because acids need moisture to form, karst topography is found in humid environments. In dry locations, limestone tends to form steep cliffs, like the Redwall Limestone in the Grand Canyon.

Vast karst landscapes are found in the humid tropics of Southeast Asia. The towers, pinnacles, and cones are caused by chemical weathering.
Weak acids also weather granite, though much more slowly than limestone. Granite is made of several common minerals, mainly quartz, feldspar, and hornblende. Quartz is very resistant to chemical weathering. Feldspar is easier to break down. Acid slowly weathers feldspar into clay particles. Without feldspar to hold the granite together, the quartz crystals fall out and become sand. The toughness of quartz is the reason so much sand is mostly quartz.

Differential Erosion

You saw differential erosion in action in the stream tables that had a layer of clay between two layers of sand. The water easily eroded away the top layer of sand. The clay layer resisted erosion. As long as the clay layer was solid, it protected the bottom layer of sand. This is called differential erosion, because the layers erode at different rates.

This large mushroom rock near Lees Ferry on the Colorado River in Arizona is the result of differential erosion. The soft sandstone and shale that once overlaid this plug of hard volcanic rock have been eroded away.

Warning:

Rock structures of this kind can be hazardous. Be careful around them.

Once hidden below Earth's surface, Devils Tower now looms above the Wyoming prairie. Erosion has worn away the soft sandstone and shale that once overlaid this plug of hard volcanic rock.
Differential erosion happens any time soft rock is eroded away, leaving harder rock behind. Much of the scenery in the Grand Canyon is due to differential erosion. Devils Tower in Wyoming consists of hard rock that was once surrounded by softer rock. Over the past 1 to 2 million years, the softer rock weathered and eroded away. The column of hard rock still stands.

Niagara Falls on the New York–Canada border is another example of differential erosion. The water going over the falls erodes the edge of the thick, soft shale layer under a hard limestone layer. This undercuts the limestone, causing it to give way. The photo above of American Falls, a part of Niagara Falls, shows huge limestone boulders that have fallen. For the past 10,000 years, the falls have moved upstream, eroding the rock at the plunging edge of the fall, at an average rate of about 1 meter (m) a year.

Wind Erosion and Rain Forests

How could erosion in Africa help the Amazon rain forests, all the way across the Atlantic Ocean? Windstorms on the Sahara Desert carry dust high into the atmosphere. High-altitude winds carry the dust west across the Atlantic Ocean. Sometimes it reaches the rain forests of South and Central America. The soil in rain forests is normally poor in nutrients, and the dust from Africa provides many of the nutrients that the rain forest plants need to survive.

The Niagara River tumbles over a hard limestone layer to form a waterfall 50 m high. Millions of gallons of water plunge downward every minute.

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There is also a negative side to all this dust. Some of the dust settles on coral reefs in the sea. The dust carries bacteria and fungi that can kill or weaken the coral. When the dust settles over populated areas, it can trigger asthma and other respiratory diseases. Different places in the world are affected by different dust sources. Dust from China sometimes reaches people living in California!

Weathering and erosion created the Grand Canyon and many spectacular landforms around the world. The spires and hoodoos of Bryce Canyon in Utah, the rugged Badlands in South Dakota, and the rounded Blue Ridge Mountains extending from West Virginia to Pennsylvania are all products of weathering and erosion. Mammoth Cave in Kentucky, the world's longest cave system, was created by weathering and erosion. All these wonders were once solid rock.

Weathering and erosion produce sediments that can form new rocks, create soil, change landforms, and affect air quality. Think about that the next time you feel smooth, rounded sand between your toes at the beach, see a crack in a sidewalk, or eat a carrot!

Dust storms can carry silt and other fine particles long distances, even across the ocean.