Chapter 4
Moving Mountains, Shifting Sands

Earth's surface is constantly changing, and has been since the begining of time. Most changes occur slowly and are hard to observe, such as sea level rise, moving sand dunes, or changes in the amount of sand on riverbanks and beaches. Other changes occur quickly such as landslides, earthquakes, floods, and tsunamis. Most natural changes occur during extreme events when powerful forces such as large waves pound the coast, but some changes are related to human actions. Some important human changes occur inland, often at a great distance from the ocean—such as the damming of rivers. Inland changes can directly affect coastal erosion, beach sand, and life in the ocean's intertidal habitats.

Elements that shape the land are:

- Precipitation: provides the water that transports sediment off the continent. The water in rivers and streams carries sand to make beaches and carves deep gullies through steep rock canyons.
- Gravity: drives (provides the energy for) the flow in streams, and generates large volumes of material for the streams to carry off the land.
- Wind: erodes rock and soil surfaces and transports material. Wind powers ocean waves and currents that shape the coast.
- Tectonics: the forces that move plates, cause volcanic eruptions and earthquakes, elevate the continental land masses thereby providing the potential energy for gravity to act on water, rocks and soil. Tectonics push rocks up, and gravity and water wear them down.

New words

sea level rise; gravity; coastal erosion; rock weathering; sediment; deposit; tectonics

Sand on our beaches comes from rocks that make up Earth's continental crust. Water, wind, chemicals, and temperature changes break down (*weather*) these rocks to coarse gravel and then individual mineral grains. Quartz grains, abundant in these rocks, resist chemical and physical breakdown, and as a result California's beach sands are dominated by quartz grains. Every grain of sand starts as a piece of a bigger rock close to or far away from the beach where it ends up. Rivers and streams carry sand to the ocean; the sand is constantly in motion. Though rivers and streams come from many miles inland they have a big influence on our coast.

California Coastal Commission Area of Critical Concern: Coastal Processes

Relevant California Science Content Standards, Grade 4: Earth Sciences 4. a,b; 5. a, c

Sandy beaches protect the backshore areas and sea cliffs from wave erosion. Ocean waves must first remove or erode the beach before they can attack the cliff. So, the more beach sand there is and the wider a beach is, the less wave erosion of the cliffs. Remove the beach or reduce its width or size, and the cliffs can erode more quickly.

Grade 4 Activities

In these hands-on, interactive activities, students learn about how beaches and coastal cliffs are formed, how flowing water reshapes the land by removing material from one place and depositing it in another, and about coastal erosion.

Activity Goals

Activity 4.1. Moving Mountains to the Sea

Students will:

1. Identify sand and rocks to describe where beach sand comes from and how it is transported to the beach.
2. Know that flowing water, wind, and waves cause erosion, which is the gradual wearing away of objects.
3. Describe how sand is transported great distances by streams, rivers, and longshore currents.
4. Understand how humans have changed natural processes of beach formation and cliff erosion.

Activity 4.2. No Ordinary Sandy Beach

Students will:

1. Develop the skill of close observation.
2. Describe where sand comes from, and how it becomes beach sand.
3. Understand the processes of rock weathering, transport, and deposition.
4. Investigate sand samples to identify their properties and collect clues to their origins.

Activity 4.3. Beach in a Pan

Students will:

1. Create a model of a beach and conduct experiments on the effect of waves.
2. Design an experiment to test the effect of winter storms, coastal development, the construction of a breakwater or jetty, presence of a submarine canyon, or damming of a river.
3. Discover the natural and human impacts on beach formation.

Beaches can be changed when dams are built on rivers. Dams and other flood control structures on rivers and streams trap the sediment (sand, gravel, etc.) that would otherwise be washed into the ocean. The sediment that normally is carried to the ocean and becomes the beach accumulates behind dams on the bottoms of reservoirs, resulting in less sand on the beaches. Less sand on the beaches can result in more erosion of the sea cliffs. Another human activity that may increase sea cliff erosion is construction of buildings, roads, or storm drains on eroding cliffs, causing increased runoff down the cliff face.

Natural forces such as waves also influence the shapes of our beaches and cliffs. Sea cliffs clearly show the erosion potential of waves. Cliffs are formed naturally by the action of waves striking the coastline, an action that breaks down and removes rock from the cliff face. This erosion keeps the cliff face steep and results in a slow landward retreat of that cliff. The presence of a steep sea cliff, by itself, is testimony to erosion at its base by storm waves. The broken down rock fragments created by the wave erosion may become part of the beach. Some sea cliffs, such as those of the Big Sur Coast, are composed of harder rock such as granite and do not erode as easily.

These activities introduce students to the processes of beach formation and the natural and human influenced changes that happen to sandy beaches along our coast.

Grade 4 Activity

Science skills

- Observing
- Gathering and analyzing information
- Predicting
- Experimenting
- Communicating

Concepts

- Rocks on the continent are weathered by water, wind, and chemicals, breaking them into smaller pieces.
- These smaller pieces are transported by rivers and streams to the ocean and become pebble or sand beaches.
- Gravity is an important part of the process of transportation; the rocks, gravel, and sand are carried by the water down slope.
- Waves and currents move sand onto the beach and just offshore, forming beaches that change with seasons.

California Science Content Standards

Earth Sciences

5. Waves, wind, water and ice shape and reshape Earth's land surface. As a basis for understanding this concept, students will know:

5.a. Some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

5.c. Moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in other places (weathering, transport, and deposition).

Activity 4.1
Moving Mountains to the Sea

What is sand? Where do beaches come from, and where do they go? Here today, gone tomorrow, you'll never take beaches for granted again.

Background

California's sandy beaches attract millions of visitors each year, and also serve important functions such as buffering cliffs from waves. Without its wide sandy beaches, California would look very different. What is sand made of, and from where does all of our sand come?

In general, sand comes from weathering of continental granitic and sedimentary rocks (the most common sources), weathering of oceanic volcanic rocks (basalts), and skeletal remains and shells of organisms (carbonates). The sand on our beaches is made up of the rocks and soil of California. These rocks and soils *weather* (break down by chemical or physical action), primarily by the chemical and physical action of water. Broken up rock fragments (boulders, cobbles, gravel, sand, silt, and clay) are carried off the continent by water flowing in rivers and streams. The coarser grains are *deposited* (set down) in the ocean at the mouths of the rivers, where the ocean waves and currents take up where the rivers left off. Waves pick up the coarser *sediment* (formed by the broken-up rock fragments) and move it along the coastline. The finer grains, silt and clay, are carried offshore and moved great distances by currents before they settle to the sea floor.

This activity is divided into two sections; *The Layered Jar* is a hands-on activity that shows how rocks, gravel, and sand separate out into layers in water; and *Sandy's Journey to the Sea* is a reading/writing activity that follows the science concepts learned in the hands-on activity.

California English-Language Arts Content Standards

1.1. Read narrative and expository text aloud with grade-appropriate fluency and accuracy and with appropriate pacing, intonation, and expression. *(Applies to 4.1b if story is read aloud by students.)*

California History-Social Science Content Standards

4.1.4. Identify the locations of the Pacific Ocean, rivers, valleys, and mountain passes and explain their effects on the growth of towns.

Objectives

- Students will be able to describe where beach sand comes from and how it is transported to the beach.
- Students will know that flowing water, wind, and waves cause erosion, the gradual wearing away of objects.
- Students will describe how wind, waves, and currents transport sand great distances.

Time to complete

1 hour 15 minutes

Mode of instruction

Students create a layered jar for small group observation and discussion. They then read a story about a rock and its travels to the sea, followed by a whole class discussion. Students write travelogue letters or draw a picture postcard story about the rock's travels.

Materials

Layered Jar activity

One jar for each group of 4-6 students; students share rock and sand:

1. One-half quart or similar size clear, heavy glass jar with tight lid
2. One gallon bucket of pebbles (1/2 to 1 inch diameter)
3. One gallon bucket of gravel (1/4 to 1/2 inch diameter)
4. One gallon bucket of coarse sand
5. One gallon bucket of garden soil
6. Scooper (plastic scoopers from liquid laundry detergent work)

Reading activity

1. Photocopy of "Sandy's Journey to the Sea," one for each student
2. Blank lined paper, one for each student

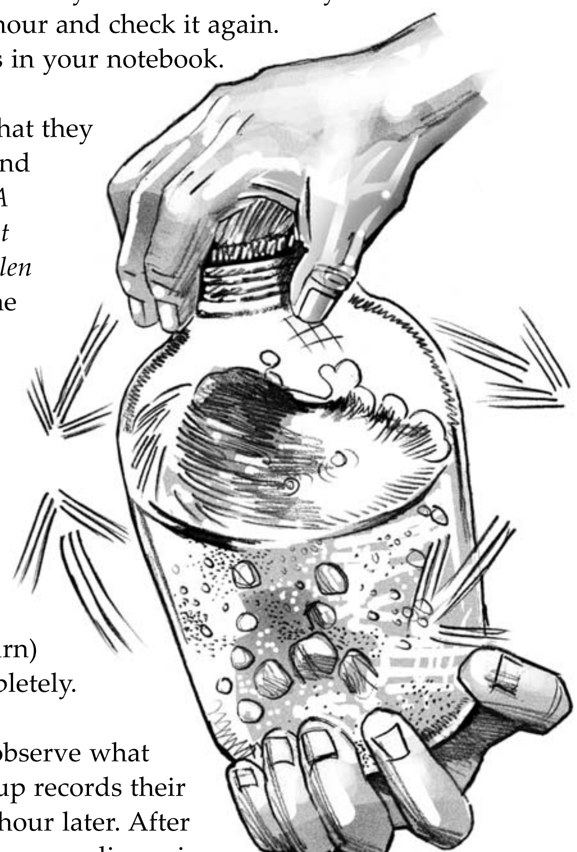
Activity 4.1a
The Layered Jar

(Adapted from: Crack, Crumble, and Carry, in The Layered Jar. *Naturescope Geology: The Active Earth.* National Wildlife Federation. Learning Triangle Press, 1997. Reproduced with permission of the McGraw-Hill Companies.)

1. Divide class into groups of 4-6 students, depending on number of jars you have collected. One jar per group.

2. Write the following instructions on the board, or print them out so students may follow the instructions as though they were conducting an experiment.

    1. Place one scoop of gravel in the jar.
    2. Place one scoop of pebbles in the jar.
    3. Place one scoop of sand in the jar.
    4. Place one scoop of soil in the jar.
    5. Fill the jar with water.
    6. Screw the cover tightly onto the jar.
    7. Shake jar GENTLY, enough to mix the materials but not so hard that the jar breaks. Turn the jar upside down and right side up three to four times, slowly. (The speed at which it mixes will not affect the final mixing result.)
    8. Set the jar down and write in your notebook what you observe inside the jar. Wait one hour and check it again.
    9. Write your observations in your notebook.



3. Begin by asking students what they think happens to river rocks and sand during big rainstorms. (*A jumble of river rocks and sand get carried downstream by rain-swollen rivers.*) What happens when the pulse of water in the river is over and things calm down? The jar is a model of what happens in a river during a storm.

Predict: What will happen when we shake the jar? Write predictions on board. Have students shake jars (all members of the group get a turn) until contents are jostled completely.

4. Students set jar down and observe what happens right away. Each group records their observations. Check again an hour later. After the second observation, lead a group discussion. Which material settled to the bottom first? Why? (*When a fast-flowing river carrying pebbles, sand, and soil begins to slow down, the heavier materials settle to the bottom first because of gravity.*) Which material settled last? Why? (*Lighter materials such as sand and silt require less force to be carried in water column, settle last, and are carried furthest downstream.)*

Preparation

Teach this as a small group activity, followed by a whole group discussion and individual reading/writing/illustration assignment.

Outline

One week before class:

1. Gather materials. One jar for every four to six students.

Day before class:

1. Photocopy "Sandy's Journey to the Sea," one for each student. **Optional**: you may read the story aloud to the students. In this case, do not photocopy the story.
2. Assemble jar and rock buckets in an area that can get dirty (outside the classroom may work best).

During class:

1. Divide class into groups of 4-6 students. Demonstrate how to make the layered jar. After jar activity is completed, lead whole class discussion on results.
2. Read the story aloud, OR hand out photocopies of story for students to read silently for 15 minutes. Lead classroom discussion. Students complete writing or illustration activity.

5. **Predict**: Based on students' observations, what do they predict a river mouth will look like after a storm? (*Lots more sand and silt in water.)* River flood plains and deltas are rich areas where much sediment has been deposited to create vast fertile growing areas, such as California's Central Coast (Salinas Valley) and the upper reaches of the San Francisco Bay/Delta (Sacramento and San Joaquin Valleys). Locate these deltas and fertile regions on a map of California and deltas all over the world. (*Egypt/Nile, London/Thames, China/Yangtze, Louisiana/Mississippi*). Why have people chosen to settle in these areas? (*Historically, humans have settled in rich river valleys and deltas initially because of the availablity and diversity of plants for food, then later farming opportunities because of the rich soil and availability of water.)*

Activity 4.1b
Sandy's Journey to the Sea Reading Activity

1. Students now have an idea of what happens to rocks and sand in water. To extend this knowledge, they will take an imaginary trip from the mountains to the sea that begins in the Sierra Nevada. On a map of California, have students locate the Sierra Nevada range, and identify some rivers that Sandy might travel on her long trip to the sea.

2. Hand out one copy of the story to each student or read the story to the students. Allow about 15-20 minutes.

3. After the students have read the story, lead a whole class discussion. Here are some sample questions: How did Sandy leave her original mountaintop home? *(The crack widened due to erosion; water from rain and snow carried her away.)* During the winter storm, Sandy became smaller and smaller until she was just a tiny sand grain. What caused this? *(Winter storm run-off carried her into the ocean where she was ground up against other rocks by waves.)* Sandy kept moving throughout the story. What forces moved her? *(Water: down the river and longshore ocean currents. Gravity: water flows downhill. Wind: waves and sand blowing across the beach.)* Waves in the winter are different from summer waves. How are they different? *(Winter waves are bigger and stronger and can move lots of sand quickly. Summer waves are smaller and gentler, and move the lighter sand easily but not the larger gravel and cobbles, which are under the sand and just offshore in the summer.)* How might a summer beach look different from a winter beach? *(The dry summer beaches are wider, gradually sloped, have more sand, and the sand is finer. Winter beaches are narrower, more steeply sloped, have exposed rock, gravel, or cobbles because the sand has been washed off the beaches by large storm waves.)*

4. Explain to students they will pretend they are Sandy, and are writing a letter "home." They describe their travels to those left behind. Home could be the mountain off of which she chipped, the lodgepole pine tree nearby, the river she lived near that eventually carried her downstream, etc. Students will write two complete paragraphs in a personal letter style. Students may read their letters to the class. Students may also make an illustration to accompany the letter; encourage students to include objects that Sandy would "see" (Sierra mountains/rock, tree; river/smaller rocks; beach/kelp, etc.).

Results and reflection

Student groups may create a postcard storybook.

1. Divide the class into groups of six.
2. Hand out to each student a blank 4" x 6" index card. Each of the cards will be a scene from Sandy's journey. Distribute a seventh card to each group to be a title card.
3. Review the six parts of the story with the class.
4. Pass out crayons, markers, or colored pencils to each group.
5. Assign each of the six students in each group a part of the story to illustrate Sandy on her journey and write a postcard home. Be sure they include Sandy in each picture. Students may write a couple of sentences on the back of the card as though it were a postcard, for example, "Dear Mom, Here I am, tossed on and off a sandy beach."
6. When the first person in the group finishes their card, they may write the title card that says "Sandy's Journey to the Sea."
7. Have students make a postcard storybook. Line all seven postcards in a row sequentially. Tape the short edges together, alternating the tape on the front and back to open and close like an accordion.

Conclusions

Sand on California's beaches begins as rocks in nearby or distant mountains. Storm swollen rivers carry rock particles downstream, tumbling and weathering them into even smaller pieces. By the time they reach the ocean, they are usually broken into sand-sized grains which are carried by waves and longshore currents along the coast.

Extensions and applications

1. Hold a classroom discussion on what would have happened to Sandy if she were in a river that was dammed for flood control or hydroelectricity. Would she make it to the sea? Where would she have ended up? What happens to dams if they stop many, many "Sandys" from going further downstream?
2. Locate on the map the larger rivers that are dammed. What might the beaches look like that are downriver from these dams?
3. Photocopy a small map of California. Students mark the locations of the major river deltas, research the timeline of the founding of nearby towns, and their commercial activities (farming, fishing, etc.).

Adapted from

Crack, Crumble, and Carry, from The Layered Jar. *Naturescope Geology: The Active Earth.* National Wildlife Federation. Learning Triangle Press, 1997. Reproduced with permission of the McGraw-Hill Companies.

Sandy's Journey to the Sea. Story written by Dr. Stephanie Kaza and reprinted from the Marine Activities, Resources & Education (MARE) *Teacher's Guide To The Sandy Beach*, copyright by The Regents of the University of California, and used with permission. The MARE series includes 11 teacher's guides and handbooks for preschool through eighth grade, available from: LHS MARE, Lawrence Hall of Science, University of California, Berkeley, CA 94720-5200. (510) 642-5008. For more information, visit their web site: *www.lhs.berkeley.edu/mare*

Sandy's Journey to the Sea

By Stephanie Kaza

Part 1: The High Mountains in Winter

High in the mountains, the rivers and creeks had begun to freeze over for winter. Golden aspen leaves fluttered down along the banks, leaving the white-barked trees empty against the blue sky. Already the craggy granite peaks of the High Sierra were deep in snow. On a ledge by a gnarled lodgepole pine was a small rock named Sandy. Smooth on one side, rough on the other, the rock was about the size of your thumbnail. It had broken off from a big mountain boulder and been caught in a crack for a very long time. Year after year, the small rock watched the seasons go by. But lately as the pine tree grew, Sandy noticed that the crack was getting wider and wider. She did not seem to be quite so stuck in her place anymore. She rattled a tiny bit and wondered if she would be there forever.

Part 2. The River Journey in Spring

One fine spring day, when the sun was out and beaming its hot rays onto the snow, a trickle of water crept underneath Sandy. It tickled a little bit and Sandy smiled in the warm air. As the day grew hotter, the little trickle turned into a rushing stream. Much to Sandy's surprise, she was lifted up out of her familiar crack and carried off over the edge of the granite.

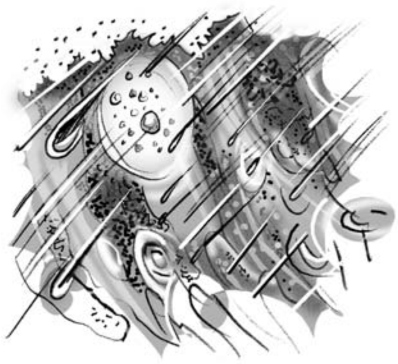
Crash, bang! She tumbled down a roaring waterfall. In two seconds Sandy landed at the bottom in a deep pool, a little dazed. She barely caught her breath and was whooshed away down the racing river. She jumped and bumped through the raging rapids, sliding out of the high mountains to the foothills below.

Part 3: Oceanside Rest in Summer and Fall

After quite some time and many miles, Sandy settled out on a flat spot perched on a riverbank not far from the sea. She had drifted by leopard lilies in spring and dragonflies in summer. During the dry months of fall the river had shrunk to a narrow creek, leaving Sandy high and dry. After such an exciting journey, she though she might just stay there awhile and rest. She hardly remembered her old crack, for she had been so many places since then.

As the season turned to winter, Sandy felt chilly in the cold night air. With all the wear and tear of going down the river, she was a little worn down. But she didn't mind, for the sky was brilliant with beautiful stars of many colors. One especially quiet night she gazed for hours at the silver dazzling full moon. In the early morning dawn she could barely hear the ocean's roar.

Part 4: The Winter Storm



Boom, crack! Just six hours later, the ocean was suddenly at her feet! It was high tide and winter storm waves were rolling in fast and hard, one right after the other. The rain pounded against the wild ocean. Before she knew it, Sandy was washed out to sea in a great churning of stones and sand. She barely caught one last look at her resting place, now so rocky and bare of sand.

Sloshing and grinding, the rocks crashed into each other in the open sea. Bit by bit, pieces broke off from Sandy until only a small sand grain was left. For days and days, Sandy tumbled around in the huge ocean, dancing on roller coaster waves and sinking in the silky blackness.

Part 5. The Kelp Wrack in Spring

After a month of gray skies and rain, the storm cleared. Sandy washed back up on the beach with may other sand grains. She herself was stuck to a big stalk of brown kelp. The waves carried her high above the tideline next to a driftwood log. She wondered if it might be her old friend the lodgepole pine.

As the sun grew hot, the kelp began to grow slimy and start to rot. Sandy was quite stuck in place, but at least she had many visitors. Flies and crabs nibbled at the kelp, gulls and shorebirds wandered by. It seemed there was always a party going on the kelp wrack. Out in the ocean, other sand grains waited underwater on sand bars for their time to join the party.

Part 6: The Summer Beach

As the days grew long and spring changed to summer, the beach once again grew wide and deep with sand. The kelp dried up and Sandy fell off onto the beach. People and dogs came by and scuffled the sand. Sandy hitched a ride on someone's toe and found herself at the edge of the ocean again. The waves were gentle now and spaced farther apart. At high tide she was scooped up in a quiet rocking motion and carried into the longshore current. Here Sandy drifted, pushed along the ocean, heading south with not much to do except go with the flow.

By the end of the summer, Sandy had traveled far from the kelp wrack beach. Now she was near a small coastal town by a large point of land. The nearshore current caught her up and pushed her on shore right next to a child building a sand castle. Scoop! The shovel picked her up and she landed at the bottom of the bucket. Splat! The bucket dumped her onto the top of the castle. She felt the child's warm hands patting her into a beautiful shape. Oh, how lovely! She could feel the child smiling, and she was glad to be there—at least for a while.

Grade 4 Activity

Science skills
- Observing
- Inferring
- Predicting
- Deducing

Concepts
- Observable characteristics of sand grains can provide clues to the origin of the sand.

California Science Content Standards
Earth Sciences
4. The properties of rocks and minerals reflect the processes that formed them. As a basis for understanding this concept, students will know:
4.a. How to differentiate among igneous, sedimentary, and metamorphic rocks by referring to their properties and method of formation (the rock cycle).
4.b. Know to identify common rock-forming minerals and ore minerals by using a table of diagnostic properties.
5. Waves, wind, water and ice shape and reshape Earth's land surface. As a basis for understanding this concept, students will know:
5.a. Some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
5.c. Moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in other places (weathering, transport, and deposition).

Activity 4.2
No Ordinary Sandy Beach

From mighty mountains come rivers of sand. Be a sand scientist in your own sand lab and see if you can trace sand to its origin.

Background

This activity builds on the knowledge students have gained from Activity 4.1b, *Sandy's Journey to the Sea*. Beaches come from rocks that have been weathered and transported by water to the ocean. Now we will determine exactly where sand samples have originated. What do we have to go on? We have maps and sand, a short list but a powerful combination when approached with an investigative perspective!

This activity is divided into two sections; *Sand Match Up* hones students' descriptive skills, and *A Chip Off the Old Block* is where students try to match the sand to rocks from which they came. The two activities can be carried out either sequentially in one day or over a two-day period. The *Sand Match Up* activity requires advance time for students to collect sand samples. **Begin collecting sand early in the year, over vacations.**

For Activity 4.2a, Sand Match Up: Make a Sand Sampler

This activity requires planning ahead. If your students begin collecting sand early in the school year before holidays, they can collect samples on their vacations or have their parents or friends collect samples on their travels.

Collect empty film canisters (obtainable from film processing businesses) and stick masking tape on canister for labeling. Hand out canisters and blank 3" x 5" card to each student. Students collect a sample of sand and place in film canister (one sample per canister). Samples can be found near a lake, stream, ocean, beach, wetland, river; any body of water will likely have some sand. Students put their name and collection date on canister label, but NOT the origin. Students put collection information on the 3" x 5" card: where the sample was taken (location and specific spot), date, person who took the sample, any other characteristics of the area (i.e. rushing river, calm lagoon, windy beach, steep beach with big waves, etc.). **Make a master list of where the samples came from, using a special code that is meaningful to you, but not to students!**

Make a sand "sampler" for each group of six students by pouring a small quantity of six different sand samples into separate plastic cups. Use different types of sand for each group so that the groups have different combinations of sands, with some sand samples the same, but not all six. Label the plastic cups with your special code.

Prepare a reference sand slide or petri dish:
To prepare the reference sand slides or containers:
a. Mix water with white glue that dries clear so the resulting mixture is thin.
b. Smear the thinned glue in the middle of the slide or container
c. Sprinkle the sand samples on the glue. NOTE: use just a little sand, so edges of the individual sand grains can be observed.
d. Label the location of collection using a small piece of masking tape on one side of the microscope slide or container.
e. The completed, labeled slides or sand containers serve as a "checking station" for students.

California History-Social Science Content Standards

4.1.1. Explain and use the coordinate grid system of latitude and longitude to determine the absolute locations of places in California and on Earth. (Ext. #3)

Objectives

Students will:

- Develop the skill of close observation.
- Describe where sand comes from, and how it becomes beach sand.
- Define the processes of rock weathering, transport, and deposition.
- Investigate sand samples to identify their properties and collect clues to their origins.

Time to complete

One hour for each activity (two hours total)

Mode of instruction

Over time and outside the class, students collect samples for the sand lab. Teacher prepares sand sampler. Groups examine samples and write observations, then compare observations with other groups. A whole class discussion on observable characteristics of sand is followed by students completing a worksheet on origins of sand samples.

Materials

1. Empty film canisters for sand samples (one per student)
2. 3" x 5" cards
3. Dissecting microscope (if available, one per group) and slides
4. Small, clear Petri dishes (for use with microscope)
5. Small plastic cups (one for each sand sample)
6. Hand lens (preferably one for each student)
7. Overhead transparency of map of local areas where sand was collected
8. "What's My Sand?" worksheet
9. "Sand Lab Data Sheet" worksheet
10. Dropper bottles of vinegar and salt water, one bottle per small group (Ext. 1b)
11. Magnets, one per group of six students (Ext. 2)
12. U.S. or world wall map (Ext. 3)
13. Overhead projector

Activity 4.2a
Sand Match Up (honing descriptive skills)

1. **Ask:** What do you know about sand? Are all sands the same? What are some of the differences? How do scientists describe the different types of sand? Write on board what students know about sand. They will now investigate different types and sources of sands.

2. Divide students into working groups of six and distribute a sand sampler (containing six samples) to each group.

3. Distribute a hand lens to each student with the instruction to examine one of the sand samples carefully and describe the sand in one paragraph on a 3"x 5" card or piece of paper.

4. Direct each group to put their sand samples and description cards in the middle of their work station and shuffle them.

5. Have each group rotate to a different set of sand samples and description cards. The group challenge is to match each of the six sand samples with the correct description card.

6. Students return to original stations to see if the cards were matched correctly by the other students.

7. Lead a whole class discussion of sand matching successes and challenges. List observable characteristics of sand on the board (grain size, color, texture).

Activity 4.2b
A Chip Off the Old Block (matching sand to rocks)

1. Explain that observable, physical characteristics of sand provide some clues to its origin. Ask students for their ideas about the ways sand is created and what observable characteristics might result.

2. Distribute worksheets "Sand Lab Data Sheet" and "What's My Sand?" to each student, and discuss the physical appearance of the different sands listed (mineral, volcanic, or shell sand). List on the board the different characteristics of each sand type.

3. Each student closely observes her or his sand sample and completes the chart on the "Sand Lab Data Sheet," recording observations and inferences for her sample. For the second to last question on the worksheet, display the list of locations where the sand samples were collected and ask students to guess where their samples were collected.

4. Display reference sand slides or containers labeled with location of collection and have students check their guesses by comparing their samples with sand in containers or on slides. Allow time to observe a variety of samples for comparison; dissecting microscopes help.

Preparation

This activity takes some time to prepare but is well worth the effort. Get a head start—collect samples early in the school year.

Outline

Before Class

1. Students collect sand samples.
2. Make master list of sample locations.
3. Prepare reference slides or dishes.
4. Photocopy "What's My Sand" and "Sand Lab Data Sheet," one for each student.
5. Make overhead transparencies of Sand Types master and a map of local areas where most sand was likely collected.
6. Create sand sampler stations for groups of 6.

During Class

1. Students make observations at their original station.
2. Groups rotate to next station. Match up cards with samples.
3. Groups rotate back to original station and determine if the visiting group matched up samples correctly.
4. Classroom discussion on observable characteristics of sand.
5. Students complete "Sand Lab Data Sheet."
6. Students check reference slides to see if they correctly determined the source of their sand sample.

Results and reflection

1. How many students were able to successfully identify the source of the sand? What observations did they make to identify the source? (*Characteristics such as smoothness/roughness, color, size, shape of individual grains.*)
2. How do students think the sand ended up where it did? (*Some samples may have been transported from other sites by truck, such as sand in playground sand boxes, or from a construction site, while most other sands were transported by water.*) What observations support their hypotheses?
3. How would this activity be different if you were in a classroom in Hawaii? On a coral reef? (*Sands from the same source, either volcanic or shells*)
4. Why would some beaches have coarse sand or gravel, and others have fine sand, even though these beaches may not be far from each other? (*Coarse sand is an indication of "younger" sand or higher wave energy, recently eroded from parent rock and found near origin. Fine sand is long eroded from parent rock and far from its origin; wave energy creates finer sand. The angle of the beach to the waves may affect the size of the sand particles.)*

Conclusions

Moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in others. Close observation of sand yields clues to the origin and type of rock from which it came. Small details can yield large bits of information.

Extensions and applications

1. Does the sand come from rocks or bits of shell, or both? A simple acid test using vinegar (an acid) will identify shell pieces in sand samples: shells are made of calcium carbonate which will "fizz" as they react with vinegar. Students may place a few drops of vinegar on a sand sample to see if it contains shell pieces, then guess the origin of the sand (rock or shell).
2. The rate at which shells dissolve are affected by alkalinity (pH). Conduct this experiment as a class.

   Prepare two containers:

   a. In one container, place broken shells with salt water.
   b. In the second container, place broken shells with vinegar (acid).
   c. Students predict what will happen to the shells in each container. Observe the shells after several hours, after one week? Two?
   d. Repeat the above experiment with beach sand.
3. Magnetic Attraction: Place a pinch of sand on a sheet of paper, then move a magnet under the paper. If some of the grains are attracted by the magnet, they are likely to be the mineral magnetite (iron oxide). Magnetite grains are black or very dark gray.
4. Find Your Sand: Students mark the sand collection sites on a map, creating a wall chart noting the latitude and longitude of the locations, along with the type of sand found there. Each student will be responsible for mapping at least one collection site and for noting his or her explanation of why a certain type of sand is found there.

Adapted from

No Ordinary Sandy Beach, from For SEA Institute of Marine Science. P.O. Box 188, Indianola, WA 93842. *www.forsea.org*

Additional References

www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SANDHP.htm

Sand Lab Data Sheet

What characteristics of sand apply to your sample?

1. Is your sand ABIOTIC or BIOTIC?
ABIOTIC SAND:

- Is not made from shells, coral, or parts of living things.
- Is often made from eroded continental rock, such as granite.
- Usually contains a lot of clear quartz grains. Quartz is harder than other minerals, so it remains after other grains have worn away.
- Often includes dark mineral grains which may be biotite, magnetite, amphibole, or pyroxene.
- Might be volcanic sand: material from eruptions that cooled, hardened, then shattered or eroded into sand-size particles which are often black or shiny.

BIOTIC SAND:

- Is made from parts of living things: pieces of shell, coral, sea urchin spines.
- Is found on beaches in tropical areas where coral grows.
- Often shows pink or white colors.

2. Is your sand "OLD" or "YOUNG"?
"OLD SAND":

- Was long ago eroded from its parent rock, and is often far from its origin.
- Is well sorted, with all of its grains generally the same size.
- Has no skeletal remains that are easily identified.
- Is smooth, with no sharp edges on the grains, often rounded.
- If it is continental sand, it will be mainly quartz, other (softer) grains will have worn away: the sand will look mostly clear or glassy.

"YOUNG SAND":

- Is more recently eroded from its parent rock, so it is often found near its origin.
- Contains grains that are not well sorted, with many sizes present in one sample. (However, even "young" beach sand is well sorted; in general, river sand would be less well sorted.)
- Would still show skeletal remains.
- Contains angular or sharp grains that are rough, not rounded.
- If it is continental sand, it will have other minerals present along with the quartz grains, unless the parent rock is sandstone.

Note: there are always exceptions to these "rules!"

My sand is:

1. (Circle one) Mostly mineral sand   Mostly volcanic sand   Mostly shell sand

2. (Circle one) Near to origin (young sand)   Far from origin (old sand)

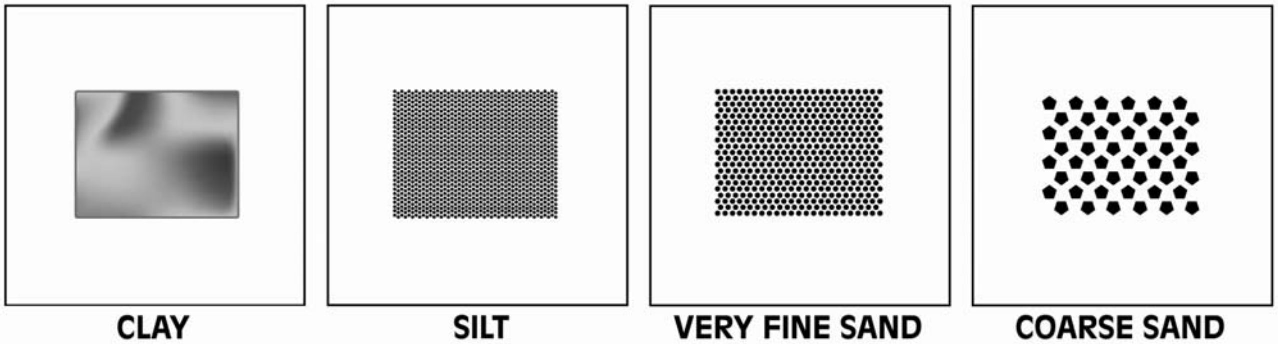
3. Physical appearance____

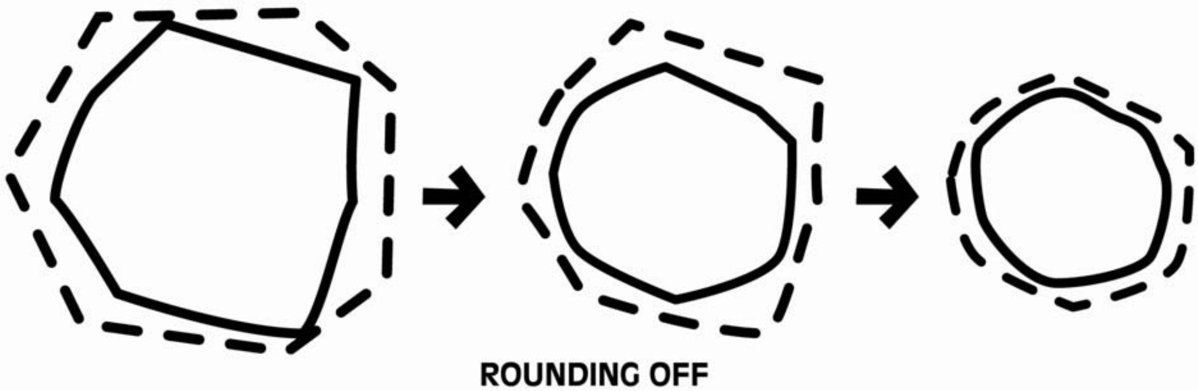
4. Observations ____

5. I think this sand sample was collected from ________________________
   (Check the list of locations where sand samples were collected.)

6. What did you successfully infer ("figure out") about your sand sample?

What's My Sand?





Sand: Take a Closer Look

We can learn a lot by looking closely at sand. By carefully examining the composition, size, rounding, and sorting of sand we can infer how far it has traveled, and from where and what type of rocks it came. Scientists classify sand according to two characteristics, grain size and texture.

Grain Size
Whether a material is gravel, sand, silt, or clay depends on the size of the individual grain: Gravel is material greater than 2 mm, including pebbles (4 - 64 mm) and granules (2 - 4 mm). Sand is material between 2 mm and 0.06 mm, and is divided into very coarse, coarse, medium, fine, or very fine sand. Very fine sand is the smallest grain size you can still see with the naked eye. Silt is finer than sand, but still feels gritty. Clay is the finest material of all, like flour, and forms a sticky ball when wet.

Texture
Whether a material has been transported a great or short distance can be seen by its texture; very coarse material indicates a short distance. The three guides used to understand the texture of sediment are size, rounding, and sorting. As rocks move in water, they knock and rub against other rocks, which "rounds-off" their sharp edges and corners. A well-rounded sand grain likely traveled a great distance from its original source area, while a sharply angled grain has probably not been transported very far. Rounding is also related to the size of the grains—boulders round more quickly than sand grains because they strike each other with greater force. Wind or water sorts rocks and sand; as they work they separate by size. The heavier, larger rocks settle to the bottom, while the lighter sand remains on top, kept constantly in motion by wind or water.

Grade 4 Activity

Science skills

- Observing
- Predicting
- Experimenting

Concepts

- Shape and composition of beaches result from interactions of many factors, including angle and orientation of the beach, size and frequency of the waves, and size and composition of the substrate.
- Seasonal changes, coastal development, and the presence of dams upstream can impact the intertidal.

California Science Content Standards

Earth Sciences

5. Waves, wind, water, and ice shape and reshape Earth's land surface. As a basis for understanding this concept, students will know:

5.a. Some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

5.c. Moving water erodes landforms, reshaping the land by taking it away from some places and depositing as pebbles, sand, silt, and mud in other places (weathering, transport, and deposition).

California Mathematics Content Standards

Measurement and Geometry

3.5. Know the definitions of a right angle, an acute angle, and an obtuse angle. Understand that 90°, 180°, 270°, and 360° are associated, respectively, with 1/4, 1/2, 3/4, and full turns.

California English-Language Arts Content Standards

Listening and Speaking

1.1. Ask thoughtful questions and respond to relevant questions with appropriate elaboration in oral settings.

1.2. Summarize major ideas and supporting evidence presented in spoken messages and formal presentations.

Activity 4.3
Beach in a Pan

Build a model of a beach and explore the forces that shape it. Is it a good idea to build a house on the sand or a beach cliff? Find out!

Background

As anyone who has spent a windy day at the beach getting sandblasted can tell you, beaches and dunes are dynamic systems. Sand is constantly in motion; it moves down the coast, up and down the beach face, and inland into dune fields. Wind and waves are natural forces that move sand from nearshore to onshore and back again, while California's longshore currents silently move the sand underwater.

With each wave the beach is changed. The force of the waves moves sand onshore during the summer, and offshore during the winter. Gentle summer waves bring sand from underwater sandbars just offshore to replenish the beaches. Stormy winter waves wash away beach sand that has built up over the summer and deposit the sand in the nearshore, creating underwater bars.

For the most part, the shape of the coastline determines the shape of the beach. Straight beaches are commonly found along low sandy coasts, such as much of southern California and the Monterey Bay. Pocket beaches and crescent shaped beaches are found along coastlines dominated by cliffs, such as the Big Sur coast and northern California. Variables that affect beach shape include the shape and relief (mountains or lowlands) of the coast, the resistance of the coastal materials to erosion, and the angle of approach of the waves.

Erosion is a natural process caused by weathering and wave action on the continent. Beaches protect ocean cliffs from erosion. Ocean waves must first remove or erode the beach before they can attack the cliff. Many sea cliffs are formed by the action of waves striking the coastline, a process that breaks down and removes rock from the cliff face. This erosion keeps the cliff face steep and results in a slow retreat of that cliff. The broken-down rock fragments become part of the beach. Some rock types, such as granite found along the Big Sur coast, are harder and more resistant to erosion.

The more beach sand and the wider the beach, the less cliff erosion will occur. Reduce the beach's width or size, and the potential for cliff erosion increases dramatically. Along with natural forces that shape our beaches are the unnatural forces created by humans. Coastal development, harbors, jetties, cliff armoring, and dams on rivers affect the shape and size of many of California's beaches.

Objectives

Students will:

- Create a model of a beach and conduct experiments with waves.
- Design an experiment to test the effect of natural and human created disturbances to beaches.
- Discover natural and human created impacts on beach formation.

Time to complete

1.5 hours

Mode of instruction

Students watch a video, then use models of a beach to test different variables.

Materials

1. Video available to borrow—*Beach: A River of Sand* (order in advance: *www.coastforyou.org*, 800-Coast-4u*)*
2. Two paint roller pans or rectangular baking pans for each group
3. A 3"x5" wave maker for each group (plastic or wood works best, but cardboard or an index card will work)
4. Sand: at least two different samples of different grain size. Two or more cups of sand per model, depending upon the size of the pan.
5. Gravel or small rocks
6. Larger rocks, about 2" in diameter
7. Water (three or more cups per model depending upon the size of the pan)
8. Sponges
9. Paper hole punches (colored papers)
10. Plasticene clay
11. Popsicle sticks or similar material
12. Copies of "Beach in a Pan" worksheet (one per student)

Preparation

1. Two-three weeks in advance: order video from Coastal Commission.
2. Gather one set of materials for each group of four students, or create two demonstration models (two models, groups take turns). Allow 30 min. for each group.The activity will take place over the course of 2-3 days.

Outline

Before class

1. Gather materials, photocopy worksheet.
2. Make two demonstration models.
3. Set up materials for students.

During class

1. Watch video.
2. Discuss factors that shape beaches.
3. Demonstrate beach model.
4. Hand out model materials, worksheet.

Activity

1. Begin the lesson by reviewing what students know about the sand that moves along our coast. Where does it come from, where does it go, and how does it affect our lives?

2. Hand out "Beach in a Pan" worksheet. Show video *Beach: A River of Sand* (order in advance from the Coastal Commission).

3. After the video, lead a whole class discussion. Topics may include:
   a. What are factors that might influence the shape of a beach?
   b. Why would you find different kinds of plants, algae, and animals on a rocky shore than at a sandy beach?
   c. What kind of beach would stay the same (have the most stability) over time? What maintains that stability? What events change it?
   d. In California, which direction does the longshore current run?

4. Divide students into groups of four to set up beach models and record their results on the back of worksheet. Alternatively, create two demonstration models for student groups to take turns conducting experiments.

Results and reflection

1. Each group of students presents their experimental findings to class. Discuss what they decided was more important in shaping their beaches: the slope of the beach, the size, frequency or angle of the waves, materials that make up the beach, or some other variable.
2. If you wanted to build a house with an ocean view, where would you build it? Have students write a one paragraph description of how they could get an ocean view without having to worry about the cliff eroding under their house, or a wave crashing through a window.

Conclusions

Sand is constantly in motion. Water, waves, and wind are physical forces that move sand. Beaches are shaped seasonally by waves; coastline orientation and rock type also play a role in the long-term shape of a beach. Coastal erosion is a natural phenomenon, one we must learn to live with. Humans can affect beach formation by constructing jetties, harbors, and cliff armoring. Potential changes to beaches should be thoroughly investigated before structures are built, as public beaches may be adversely affected.

Extensions and applications

Nothing beats a field trip to the beach! Visit the beach in winter and the same beach in late spring. In most cases, the class will see two very different beaches. Conducting a beach profile is an excellent way to visualize the changes a beach goes through over the year (See Activity 6.1). Check a tide table before you go.

Adapted from

Beach in a Pan. ©Monterey Bay Aquarium Foundation, 2000. This activity was developed by educators at the Monterey Bay Aquarium. For information about aquarium activities, exhibits, and classes, visit *www.montereybayaquarium.org* or call (831) 648-4800.

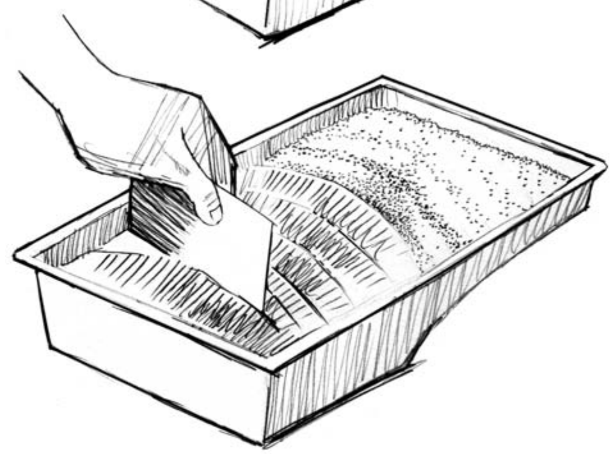
Additional references: *A Natural History of the Monterey Bay National Marine Sanctuary*, Monterey Bay Aquarium, 1997.

Beach in a Pan

LOOK: Watch the video *Beach: River of Sand*. While watching, pay careful attention to the material on the beach where the waves break, the size of the waves, and how often the waves hit the beach.

MAKE A MODEL OF THE BEACH:

1. Pour the sand into the shallow end of the paint pan.
2. Shape the sand to form a flat rectangle filling the shallowest section of the pan.
3. Slowly pour the water into the deep end of the pan.
4. Using the plastic or wood "wave maker" practice making waves in the pan. The goal is to make waves of a consistent height and frequency.
5. Once you have "mastered" wave making, reshape the sand in your pan as it was in step 2.
6. Sketch a profile (side-view) of the sand in your pan.
7. SLOWLY make waves which sweep up onto the sand. Keep making waves until over half of the sand is washed from the sand pile and extends down the slope toward the deep end of the pan.
8. Sketch a second profile of the way the sand looks in your pan now.
9. Compare your beach profiles with those of other students in your group.



GUESS: Discuss with your group the differences and similarities of the various beach profiles? Why do you think there are so many variations? What causes beaches to have different shapes? Do beaches change over time? Which is more important: the angle of the beach, the size and frequency of the waves, the angle at which the waves hit the beach, or the materials that make up the beach?

TEST: Using the materials provided by your teacher, make a second beach model to test your ideas. Your second model has to be exactly the same as your first model except for ONLY ONE characteristic, the "experimental variable." You may want to experiment with angle of the beach, the size, frequency or angle of the waves, the materials that make up the beach, or some other idea of your own (see "Experimental Variables" box).

TELL: Share and compare your findings with others in your group.

LOOK AGAIN: Use your models to predict, then test, the effect of one of the following on a beach: winter storms, coastal development, the construction of a harbor or jetty, presence of submarine canyon, damming of a river. Draw an illustration of your results.

Experimental Variables

- slope of the beach (increase elevation of the beach by placing a book under the sand end of pan)
- angle that the waves hit the beach (i.e., at a right angle or at acute angles such as 60° or 45°)
- size and frequency of the waves (make wave maker go faster or slower, vigorous or gentle)
- wind (blow on the waves)
- dune plants (add toothpicks or small grass-like plants)
- structures such as jetties (popsicle stick) or beach armor (a small pile of rocks)
- cliffs (make cliffs of plasticene clay)
- detritus or oil (colored paper spread on water)