SANDS OF TIME

FOR THE TEACHER
Discipline
Earth Science

Themes
Evolution, Diversity

Key Concept
The size, color, shape and makeup of sand grains are clues about their origin and evolution, and the type of beach from which they came.

Synopsis
Students, in small groups perform several tests to compare the size, color, shape and source material of several sand samples to determine their origins and the type of beach from which they came.

Science Process Skills
observing, comparing, inferring

Social Skill
Checking For Understanding

Vocabulary
erosion, biogenic, abiogenic

MATERIALS
INTO
- pictures of sandy beaches from various parts of the world
- large shallow sand table or tub filled with sand
  (note: you can purchase bags of sand from a building supply company.)
- Anticipatory Chart
- funnels, spoons, sieves, cups, feathers, shells, rocks, litter for sand exploration; pictures or patterns and water for sand sculpure (OPTIONAL)
- Sand Display: large piece of construction paper with a small amount of sand from each sample glued to it. Label each sample with the location from which it came. (OPTIONAL)

THROUGH

- at least six different sand samples. You don't need much of each sample. Divide up the samples into labeled ziplock sandwich bags or film containers so that each student can have a mini-sample.
- (note: If you don't have your own samples, sand kits can be ordered from The Math/Science Nucleus, 3710 Yale Way, Fremont, CA 94538, (510) 490-MATH)
- a small container of rock powder and one of shell powder for each group
- a SANDS OF TIME Worksheet for each student
- 1 "slide" per student: 3"X5" or 5"X7" index card
- several bottles of white glue
- Station 1: 3 hammers, 3 old rugs or heavy cloths, several soft rocks (shale, sandstone) and seashells, 3 magnifiers, Station 1 directions
- Station 2: six hand lenses or magnifiers (a dissecting microscope makes the activity particularly dramatic, but is not necessary), Station 2 directions
- Station 3: six hand lenses or magnifiers, and if available, a dissecting microscope, six magnets in baggies, labeled rocks and minerals kit (also available from the Math/Science Nucleus), seashells, Station 3 directions
- Station 4: eye dropper, diluted acid (pool acid diluted to 10% works well), one small vial of rock powder and one of shell powder, several small paper plates or bowls, Station 4 directions
- Station 5: posted world map, several other maps, globes and atlases, post-it labels, Station 5 directions
- Alternative Station: several grades of sand paper, three magnifiers, one 5"X7" index card per student, 3 small dishes of very watery white glue, 3 small paint brushes, two small scraps of soft wood per student, Alternative Station directions

INTRODUCTION

Nearly all solid materials in the world, both living and non-living, will eventually be eroded into sand. Rocks, shells, corals, bones, wood, metals and glass are all worn down over time by wind, waves, rivers, earthquakes and other forces into smaller and smaller particles. The story of a grain of sand can be the story of the evolution of the crust of the earth. Thousands or millions of years may pass as a sand grain transforms and travels from a mountaintop to a sandy beach and finally into a submarine canyon where it again might be compressed into rock and uplifted into a mountain. It is no wonder that sand, whether found on a beach, in a child's sandbox or in Native American sand paintings, is often associated with spirituality and feelings of drifting, shifting, timelessness or eternity.

Sandy beaches and dunes can be found in many different types of areas from mainland and island coastlines to lakes, ponds, rivers, and even deserts. The sand on every beach has its own unique history. Detailed observations and some good detective work, however, can often allow us to make some reasonable hypotheses about what the source material of the sand was, what

type of beach it came from, and how old it is. Sand from the remains of plants or animals is referred to as "biogenic," while sand from non-living sources is called "abiogenic." A closer look at sand, through a hand lense or dissecting microscope also reveals the striking beauty and distinctiveness of individual grains.

Some sand is produced right at the shore where waves crash on rocks, headlands and reefs. For example, black, green or red sand beaches in Hawaii and The Galapagos Islands are found directly next to or on top of lava flows of the same color. White sand beaches in Florida and on Caribbean islands are primarily made of eroded coral reefs. Parrot fish, which eat coral polyps, grind up the corals with their sharp teeth, and can excrete up to 100 pounds of coral sand per year. Pink sand might be full of coralline algae fragments. Other sand comes from far inland. Mountains are weathered by freezing, wind, rain and streams, and their fragments are carried down streams and rivers to the seashore. Quartz, a glasslike mineral, is often the most common component of these transported sands. Quartz is the most common mineral on earth. Many light colored sand beaches contain large amounts of quartz. Sand on islands is particularly fascinating. Islands are like miniature continents, and so the origins of individual sand samples are sometimes easier to discern than those from the mainland. Because many islands are actually volcanoes, island sand often reflects each of the different types of lava which have emerged over time. On The Galapagos, nearly every island has its own distinctive color of sand from red to black to white to pink to green.

Sediments are classified by particle size, from mud to gravel. Particles are generally called sand when they are between .06-2mm. Where particles are deposited depends on the size of the grains and the speed of the water carrying them. In fast moving river or ocean water only the largest, heaviest grains settle out. On wave impacted outer coast beaches, only large grains or even gravel will be found. The smaller the particle, the slower the water must be moving for it to settle out. Mud grains are only found inside protected bays or far offshore on the deep ocean bottom.

On a normal coastal beach, no individual sand grain stays in the same place for long. Each wave picks up thousands of grains and deposits them somewhere else. If a prevailing wind causes waves to strike the coast from the same angle, sand can be slowly transported great distances along the coast. The finest grains of sand can become airborne in the wind, and are often deposited high up on the beach in the dunes. Dune sand is usually noticeably lighter than beach sand. There are seasonal migrations of sand, too. Large winter waves often drag sand offshore leaving behind only the heaviest cobbles underneath. Smaller, rolling summer waves then re-deposit sand back on top of the cobbles.

Sandy beaches surround the edges of nearly every coastline, but each is unique, and tells a different story about the history of its continent or island. Sandy beaches are a shared resource, and are firmly embedded in the psyches of people from many cultures.

INTO THE ACTIVITIES

Sand Collecting

Several weeks or months in advance, alert students and parents (and your friends) to be on the lookout for samples of sand. On trips to coasts, islands, lakes, rivers or deserts, or even to playgrounds, have students collect small bags of sand. Label each sample with: where and when it was collected, and who collected it. Does anyone have a friend in another state or country that can send an exotic sample? Can your class establish penpals at another MARE school to exchange sand with? Try to collect samples from islands--and remember that islands can be any places which are isolated, including mountain tops, desert lakes, etc. Discuss each sample as it arrives.

Sand Exploration

Set up your sand table, and encourage students to explore it individually or in small groups. Put out pictures, water, funnels, sieves, spoons, cups, etc. Encourage students to look closely, run it through their fingers, make sand sculptures, and look for evidence of life. Put out paper and pens for students to write descriptions or illustrate sand related images. Every day or so, add a new item to your mini-beach: a shell, feather, rock or piece of litter. Post your Sand Display, and invite students to look with magnifiers at some different types of sand.

Partner Parade

1. When did you last visit a sandy beach? Where was it?
2. What do you think of when you hear the word "sand?"
3. What do you like about sand? What don't you like about it?
4. Describe all the different places you might find sand.
5. What color is sand?
6. Where do you think sand comes from? What is it made of?

Anticipatory Chart

1. Have students sit down with their final Tea Party partner and create a chart on paper divided in half lengthwise. At the top of one column, write "What we already know about sand?" At the top of the other, "What we want to find out about sand?"
2. Give each pair a few pictures of different beaches to prompt their discussion and to help them fill out their chart. Each pair can swap pictures with another pair and discuss again.

3. Lead a class discussion and record the group's ideas on a class chart poster. Refer back to it throughout the activity.

PORTFOLIO ASSESSMENT
Drawings and writings from Sand Exploration
Anticipatory Charts
Observation of Checking For Understanding, especially in Anticipatory Chart work

THROUGH
THE ACTIVITIES

1. Arrange materials into stations.

2. Read aloud to students and discuss the story, "The Sights Sand Has Seen."

3. Have students work together in cooperative groups of six. Provide six small sand samples, some rock powder and some shell powder to each group. Also, pass out the SANDS OF TIME worksheets, index cards and white glue. Two or more students in different groups should end up with sand from the same sample. Have each group first compare their six samples. How are they similar? How are they different?

4. Discuss with students the different things that sand can be made of (rocks, shells, bones, coral, glass, etc.), how sand is made (erosion, waves crashing, freezing, animals dying, etc.), and how it arrives at the beach from mountains or from the ocean (by streams, rivers, wind, ocean currents, etc.). Tell students that if they are sharp, observant scientists, they may be able to piece together a story about the history of their sand. Every grain of sand in their samples has an evolutionary story like Sandy's.

5. Have each student choose one of the samples in their group to work with. Now make a "sand slide" on an index card. Each student draws three circles the size of a quarter along the upper edge of the card. Put a very small dab of white glue in the middle of each circle and smear it with a finger. Sprinkle a little rock powder in the left circle and label it "rock powder--abiogenic", a little shell powder in the right circle and label it "shell powder--biogenic", and a little of the sand sample in the middle circle and label it with the place it was collected from. Students should also, write their name on the card.

6. Tell students that their group will rotate through each of the stations. They will take their sand card, the bag of sand it came from, and their worksheets with them to each station. At each they will find directions for their exploration. They will collect as much information about their sand as possible in order to make hypotheses about its source materials, its evolution, how it got to the beach, how old it is, and what the beach looked like where it is from.

CAUTION: AN ADULT SHOULD DIRECTLY SUPERVISE STATION 4: THE ACID TEST.

7. After each group has been to all stations, provide a few moments for group members to compare their results. What are the similarities and differences among all of their samples.

8. Now have students rearrange into Expert Groups made up of only students with the same type of sand. Groups can be as small as two students. Have them compare their results. If they have data which does not agree, then they should go back to a station and perform the tasks again.

9. How much can they infer about the evolution of their sand? Write the following questions on the board for Expert Groups to consider: Is it very old? What is it made of? Was it created at the beach or transported to a beach from far away? What did the beach look like? Did it have huge waves or no waves? What types of people and animals would have visited this beach? How were the rocks in the sand formed--by volcanoes, sedimentation? How might it have traveled from the beach to your classroom? The groups may need to do some additional library research to answer these questions.

10. Have each Expert Group make up a short story describing the journey of its sand, similar to "The Sights Sand Has Seen." Once the story has been outlined, each member of the group takes a portion of the story to write about. Each person can then write a "postcard" to the class or someone in their family as if they were the the sand grain writing from a stopping place along their journey through time. Postcards can be made on 5"X7" cards with writing on one side and illustrations on the other.

11. Have each student record five distinguishing observations (with words or drawings) about their sand on a card or piece of paper. Collect all of the observations, shuffle them, and pass one out to each student. Make sure that no one has their own. Now each student must match the observations to the correct sand sample. Discuss which types of observations were helpful and which were not.

PORTFOLIO ASSESSMENT

Observation of Checking For Understanding
Observation of ability to conduct stations correctly and safely
Post Card Stories--individual cards, and ability of group to assemble and articulate the cards into a complete story about the evolution of the sand
Written student observations about their sand (from step 11)

BEYOND
THE ACTIVITIES

1. Have students continue to collect sand samples. Find a ***MARE*** class in another region with which you can establish pen pals, and send each other sand samples. Create a sand exhibit, with descriptions of each sample.

2. Take a field trip to a sandy place. Can students determine if the sand has a source which is close by or far away? What evidence can they find about its origin and evolution?

3. Have Expert Groups use their post card stories to develop a skit about their sand, and perform it for the class or other classes.

4. Have Expert Groups research further their sand sample and the region of the world it came from. They can use library books about rocks and minerals to determine how their sand was actually formed. Is it metamorphic, igneous or sedimentary? Are there volcanoes near their beach? What people live near their beach? After doing research, have groups re-write their postcard stories to improve the accuracy, or write research papers about their sand.

5. Keep a sand journal for one month. Log the date, time and place everytime you see sand. How did it get there. Is it being used by people, animals or plants?

THE SIGHTS THAT SAND HAS SEEN

Deep in the middle of winter, the storms blow cold on the top of the high peaks of the Sierra Nevada mountains. Here the jagged granite rocks are covered deep in snow and ice for half of the year. Inside one small crack next to a lodgepole pine tree was wedged a small rock named Sandy, about the size of your thumbnail. It had broken off from a big mountain boulder and had been there for a very long time, watching the seasons go by and enjoying the scenery. But lately, as the pine tree grew, Sandy noticed that the crack was getting wider and she did not seem to be quite so stuck in her place any more. She rattled about a tiny bit and wondered if she would be there forever.

One fine spring day, when the sun was out and beaming its hot rays onto the snow, a trickle of water crept underneath Sandy's underside. It tickled a little bit and Sandy smiled. As the day grew hotter, the little trickle turned to a rushing stream and much to Sandy's surprise, she was lifted up out of her familiar crack and carried off over the edge of the granite and into a roaring waterfall. Crash, bang! Sandy landed at the bottom of the waterfall in a deep pool, a little dazed. She barely caught her breath and was whooshed away on down the racing river. As the melting snow poured into the river, Sandy was carried fast and furiously out of the high mountains down to the valley below.

All through that summer and fall, Sandy traveled down the river, stopping in pools and taking in the sights. Finally, Sandy settled out on a flat spot, perched on the side of the river not far from the sea. She noticed that some of her sharp edges had worn away in the rushing river and now she had one side which was smooth and almost shiny. After such an exciting journey, she thought she might stay there for awhile and rest. She hardly remembered her old crack for she was completely dazzled by the silver beauty of the full moon which was just beginning to rise over the horizon. In the early morning hours, the ocean's roar sounded very far away.

But six hours later as the moon was directly overhead, the ocean was suddenly at her feet! High tide! And winter storm waves were rolling in fast and hard. The rain was pounding down and the ocean was wild and loud. Before she knew it, Sandy was washed out to sea in a great tumble of stones and sand. The bumping and grinding of all the rocks together broke off bits and pieces from her until only a small sand grain was left. Sandy tumbled around in the huge ocean, dancing and spinning on the rollercoaster waves, surrounded by the vast Pacific Ocean.

After a few weeks of black skies and rain, the storms cleared and spring came and Sandy sloshed back up on the beach, stuck to a big stalk of kelp which had been ripped loose in the storm. She was pushed high above the

tideline, out of the reach of the waves. As the sun grew hot, the kelp began to feel sticky and start to rot. Sandy was quite stuck, but at least she had many visitors. The kelp wrack attracted flies, beach hoppers, worms and crabs, as well as many gulls and shorebirds. There was always a party going on at the kelp wrack.

As spring changed to summer, the kelp dried up and Sandy fell off onto the beach. People and dogs came by and scuffled the sand so one day she found herself at the edge of the ocean again. The waves were gentle now, and at high tide, she was scooped up in a quiet, rocking motion and carried into the longshore current. Each day at high tide the ocean picked her up and carried her south to a new beach where she was left at low tide. Sandy saw a lot of new beaches this way. Sandy drifted, pushed along by the ocean and the tides all summer, heading south with not much to do except go with the flow.

By the end of the fall, Sandy had traveled quite a few miles from the kelp wrack beach. Now she was near a small coastal town around the bend of a large point of land. The nearshore current caught her up and pushed her on shore right next to a child who was building a sandcastle. Scoop! The shovel picked her up and she landed at the bottom to the bucket. Splat! The bucket dumped her onto the top of the castle. And then she felt the child's warm hands pushing her around to make a beautiful shape. Oh! How lovely! She could feel the child smiling, and she was glad to be there -- at least, for awhile.

Student Directions For Each Station:

STATION 1: EROSION

Erosion is a hard hitting force in nature. Wind, rain, freezing, crashing waves and strong currents are constantly breaking and eroding rocks, animals and plants into sand. Work with a partner to erode some rock and some shell into sand:

1. First, take a rock and look at it closely. Now, place it between two layers of cloth. You can each pound the rock three times hard with a hammer. Before looking at the results, make some predictions about what you will find.

2. Repeat the same procedure with a shell.

3. Compare the results you and your partner got with those of the rest of your group. Discuss any differences or similarities.

4. Now answer the following SANDS OF TIME questions:

SANDS OF TIME QUESTIONS

1. Look at your newly formed sand under a magnifier. Find the drawing below which is closest in shape to the shell sand, and label it "Shell." Find the drawing below which is closest in shape to the rock sand, and label it "Rock."
verysub-sub-well
angularangularroundedrounded

2. Which grains ended up being more angular, the rock or the shell?

3. Which was easier to erode into sand: rock or shell?

4. Usually, "new sand" which has been recently eroded is very angular, while "old sand" appears to be worn and rounded. Do your results agree with this theory?

5. Does the sand sample on your slide look like it has rock fragments or shell fragments or both in it? Is it mostly made up of one or the other?

6. List some natural forces which might have caused the erosion of your sand.

STATION 2: SIZE & SHAPE

SIZE

The size of your sand grains is an important clue which can help you to describe the amount of energy on the beach which your sand came from. If the beach has large waves crashing or strong currents (high energy), the small grains are picked up and carried away, leaving behind only large grains. The small grains are carried along until they settle out on a beach where the water is moving very slowly (low energy). The highest energy beaches often have the largest sand grains, while the lowest energy beaches often have the finest sand grains.

Now answer the following SIZE questions:

1. Measure the size of the sand grains in your sample by comparing the grains on your slide to the dot sizes below. With a pencil, lightly shade in the portions of the diagram which represent the smallest and the largest grains in your sample.

2. Do you think your sand came from a high energy or a low energy beach? Is it more likely that human visitors to your beach would come to surf or to snorkel?

SHAPE

How many birthdays do you think your sand has had? The shape of the grains might tell you how long it has been since they broke off of a rock, shell or bone. Very well-rounded grains have been worn smooth by the forces of erosion for hundreds or thousands of years. Sharply pointed or angular grains may have broken off its source material quite recently.

Now answer the following SHAPE questions:

1. Look at the sand on your slide through a magnifier or microscope. Draw several examples of the exact shapes of grains in your sand sample.

2. Compare your grains to those below. Circle the shape(s) below which is most like yours.

verysub-sub-well

angularangularroundedrounded

3. Do you think your sand is very old or very new?

4. Discuss all of your answers for STATION 2: SIZE AND SHAPE with your group. Which sand came from the highest energy beach? Which came from the lowest energy beach?

5. Which sand is the newest? Which sand is the oldest?

6. Does everyone in your group understand all of the answers?
YES NO

STATION 3: WHAT'S IN MY SAND

COLOR

The color of your sand can give you some clues about its origin. Sand made up mostly of shells or corals will be very white. Nearly all shells, no matter what color they are will bleach in the sun and eventually turn white. Dark colored black, brown or red sand is often ground up lava from a nearby volcano, especially on islands. Quartz is a common glasslike mineral which is often transported by rivers from mountains to the beach. It can be whitish or rose colored. Pink sand might be made up of millions of ground up sea urchin spines. There are only a few minerals which are magnetic. If any of your sand is attracted to a magnet, you will know that one of those minerals is present. They are generally very dark colored.

Use the Rock and Mineral Kit to do some detective work on your sand sample. Now answer the following WHAT'S IN MY SAND questions:

1. Overall, what color is your sand? Is it generally light or dark?

2. Arrange all the sands in your group from lightest to darkest. Where is the lightest from? Where is the darkest from?

Where is yours in the sequence?

3. Look closely at your sand with a magnifier. List all the colors you see.

4. Compare individual sand grains to the samples in the Rocks and Minerals Kit, and to the shells. List some minerals you think are in your sand.

5. What other things can you find in your sand?

O glass	O wood
O plants	O plastic
O shells	O other things like...

6 Take a magnet in a plastic bag and drag it through your bag of sand. Are any sand grains in your sample attracted to the magnet? If so, what colors are they?

7. Using the Rock and Mineral Kit, can you tell what your magnetic minerals are?

STATION 4: THE ACID TEST

Was your sand ever alive? Many types of sand have bits of shells, corals or bones in them. Shells, corals and bones are made up of calcium carbonate, and so will bubble and fizz when they touch acid. The more fizzing, the more "biogenic" material must be in your sand. Some beaches are completely biogenic, some are completely abiogenic--that is, entirely made up of non-living materials such as minerals. Most, however, are a combination of both.

Now follow the directions and answer the following THE ACID TESTquestions, but ***CAUTION: THE ACID YOU WILL BE USING IS DANGEROUS. BE CAREFUL NOT TO LET IT SPLASH OR TO TOUCH YOUR EYES, SKIN OR CLOTHES!***

1. Place a pinch of rock powder on a plate. Put one or two small drops of acid on the rock powder. What happens to the rock powder when it touches the acid? Does it have any shells or bones in it, or is it made up of only minerals?

2. Repeat the experiment with a pinch of shell powder. What happens to the shell powder when it touches the acid?

3. Repeat the experiment with a pinch of sand from your sample. What happens to your sand sample when it touches the acid? Is it made up of mostly shells, corals and bones, or mostly of minerals?

STATION 5: WHERE IS THAT?

Sand is found all over the world. Your sand sample is labeled with the name of the place from which it was collected. Do you know where that place is?

1. Look on a map, globe or in an atlas to find where your sand is from.

2. Write your name and the name of your sand sample on a post-it. Now stick it on the wall map in the correct location.

Answer the following WHERE IS THAT? questions:

1. What country is your sand from?

2. What language is spoken in that country?

3. Write two other things you know about that country.

ALTERNATIVE STATION: SAND PAPER

Look closely at two or three different types of sand paper using a magnifier. The shiny yellowish grains on most sand papers are often bits of garnets. Garnets are almost as hard as diamonds and can be used to sand down many things.

- What are some of the different uses of sand paper?
- Look at the grains on each type of sand paper. Are they shiny or dull? What colors are they? Are there garnets?
- Which type of sand would be best for sanding wood? for sanding metal?

Now, make your own sand paper. Paint watery glue on a card and sprinkle fine sand on half of it and coarse sand on the other half.

- Which will work best for sanding wood? After your glue is dry sand one wood scrap with half of your sand paper, and another scrap with the other half.
- Look at both scraps closely. Which is smoothest? Do the results match your predictions?
- How well did the sand paper hold up? Which will last the longest?