Sea Grant Virginia

WILLIAM & MARY VIMS VIRGINIA INSTITUTE OF MARINE SCIENCE MARINE ADVISORY SERVICES

❖ NEW VIEWS ON SAND ❖

How to "see the world in a grain of SAND..."
and
Study SCIENCE by hitting the beach… or the WEB.



Sand images by L. Kenny, http://www.vernalpool.org/treefrog/sand/sandposter.htm

There is something about sand that seems to spark the interest of students. For decades, educators have found creative ways to use sand as a tool for teaching earth science and ocean processes, as well as geography. Sand-based labs lend themselves to inquiry learning using a material that is both familiar and exotic. Numerous lab exercises and curricula exist that can address the National Science Education Standards, Ocean Literacy Essential Principles, and earth science Standards of Learning in some states.

This allure is not limited to the classroom. Scientists, teachers, hobbyists, even artists belong to a global community that collects, studies, photographs and trades sand. You no longer need a basement full of sandbags in order to set up a productive sand lab! Comparing and contrasting neighborhood samples with sand from across nation and around the world is possible thanks to web-based virtual collections and enthusiastic sand collectors and traders. By tapping into students' personal experiences, as well as these international resources, teachers can assemble hands-on and virtual samples for classroom use.

The activities outlined here represent a small sampling of the possible hands-on lab stations and web-based searches educators can use in the classroom. Using both real and virtual sands, you can illustrate: sand classification by size and shape; diverse origins and compositions of sand grains; rock cycle processes of erosion, weathering and deposition; coastal processes like the effects of wave action on sand size, movement and beach development; the importance of sand and beaches to marine life and people.

You can examine sands by eye, under the microscope and on the web to investigate: Where sands are found (more places than you think); the different colors, compositions, sizes and shapes of sand; the age and travels of sand and its illustration of the rock cycle; the movement of sand by water; and more. This handout contains suggested exercises, ideas for substituting virtual sand collections for rock-hard ones, articulations with selected learning science learning standards, recommended sand-oriented curricula (hardcopy and web-based) and virtual sand collections, as well as a bibliography of background references.

WHAT CAN WE TEACH USING SAND?

❖**geology** **geography** **physical processes** **chemistry** ✶**biology & more**

Use sand samples from many sources to illustrate basic concepts or processes in earth and marine science, and to practice research skills. Sand can help us demonstrate:

- ✯Regional, national and international geography – Where in the world are sands? Sands are found on beaches and in dunes, rivers, lakes and rock formations all over the world. Look for similarities and differences in location, compare and contrast geology, climate and other factors.
- ✯Geology – The composition and geological origins of sands can tell stories of continental drift and tectonic processes, the rock cycle, weathering and erosion, principles of uniformitarianism and stratigraphy, paleontology, even the location of ancient seas & sea level changes.
- ✯Physical – Sand is affected by processes of water, wind and marine erosion; grains are moved and sorted by wave and wind energy, carried by river and ocean currents and by wind.
- ✯Chemistry – Chemical profiles of minerals (mineralogy), their solubility and other reactions with the environment; and what has happened to sand grains during chemical weathering can help us understand environments of the present and past.
- ✯Biology – Some sand grains are actually marine life remains, from present day or ancient forms of aquatic life. Beaches can reveal the diversity, abundance and ecology of organisms that dwell in water.
- ✯Human uses of sand – From industry to art, and the impacts of human activities on beaches dunes.
- ✯And, much MORE

Notes to educators:

✦ Sand samples: Obtain sands from your local area; ask fellow teachers, students, family and friends to collect a tablespoon of sand on their travels. These can serve as your core collection. You can also purchase sand samples from earth science educational suppliers, or from on-line sand collection associations. Build your collection further by trading samples, your students can get involved here with your supervision (and parental permission, as needed).

✦ Web-based variation: Use virtual collections to augment your classroom sand collection. Using your core collection as reference material, have students frame hypotheses about virtual samples that look similar or different. At the end of this handout is a list of virtual samples that can serve as "Demonstration Sands" to illustrate sand composition, size, color, weathering and more.

✦ **Some basic generalizations apply to exercises in this lab:**

- **Calcium carbonate composition indicates biological origins of sand grains.**
- **Degree of sand grain roundness indicates greater weathering, a function of age or distance traveled; composition influences the rate of weathering.**
- **Sand grain size is positively related to energy of water movement, the larger the grains the stronger the wave movement needed to move them.**

Who studies Sand?

Are there sand experts? Yes! There are earth scientists, oceanographers, and biologists who make a serious study of sand. Geologists that specialize in sand are called *arenologists*. Physical and geological oceanographers may study the way sands and coastlines move. Biologists could be looking at the marine life that contribute to sand, or at sand as a habitat for life forms. There are also amateurs that study sand as a hobby, they are called *arenophiles* (from the Latin) or *psammophiles* (from the Greek). Both professionals and hobbyists have contributed to the wonderful sand resources now available on the web.

WHERE IN THE WORLD IS SAND?

Sands are found all over the world

Where rocks and reef are found, where streams or wind or waves carve them – sands are formed. You can find sand: above water and underwater; on beaches; at the base of cliffs and even single rocks; in streams and lakes; in deserts & dunes.

Sands can inform us

The geology, geography, even biology of an area can be reflected in the sand that accumulates there. Some sands look alike, some are very different! Take a look at the variety!

MATCH SAND SAMPLES WITH LOCATIONS ON A MAP

Where does sand come from? Use a map, atlas or Google Earth to find the locations.

SAND IS FOUND IN MORE PLACES THAN SEASHORES… Including on the web

Sands are found in many different kinds of places

We think of sands as coming from beaches along the seashore. But sands can come from rivers, lakes, dunes, rock formations, even human activities.

Sand on the Web – Virtual Sand Collections

Fascinating virtual sand collections are found on the web. A global community of scientists, teachers, hobbyists and artists collect, study and photograph sand.

TRY OUT A VIRTUAL SAND COLLECTION

Visit one of these virtual sand collections on the web:

- http://www.scienceart.nl/Frames/HOMEpage.htm.
- www.vernalpool.org/treefrog/sand/sandposter.htm
- www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SANDHP.htm
- http://www.jaster.20m.com/index.html

WHERE ELSE ARE SANDS FOUND?

Find a sample that is from a river, lake, dune, or another seashore. Search a virtual sand collection to find a sample from each kind of location.

RESEARCHING SAND LOCALES VIA GOOGLE EARTH

Using maps and atlases to find sand sample locations is a great way to learn how to read maps and other graphical presentations of physical geography or geology. Google Earth adds another dimension to the search.

USE GOOGLE EARTH TO LOCATE THE COLLECTION SITES FOR SAND SAMPLES.

Example 1: In Modderman's virtual sand collection, find Talafofo Bay and Agaña Bay in Guam (Western Pacific). Based on what you have learned about sand origins, can you speculate on the two major geological contributors to island building processes in Guam? Find Guam, Northern Marianas Islands, on Google Earth; look on the east coast for Talafofo Bay and the west coast for Agaña Bay.

Example 2: Based on volcanic sands found in on-line virtual collections, use Google Earth to locate areas of past and present volcanic activity. In Modderman's collection, look for: Stromboli, Italy; Kalapana, Hawai'i; Martinique Island, Caribbean; Glacier Lagoon, Iceland; Java, Indonesia; Galapagos Islands, among many others.

SANDS IN COLOR

Sands come in a spectrum of colors

We usually think of sand as being white or gray. But, sands can also be black, red, pink, purple, green and other colors.

Sand colors can tell us about:

Mineral composition, and the geology, geography, even biology of an area. Take a look at the variety!

HOW MANY COLORS OF SAND DO YOU FIND?

Find sands of different colors. Looking more closely, can you tell if all the grains are the same color? Use a map, atlas or Google Earth to find the where a few of these sand samples have come from.

SANDS FROM THE LAND, SANDS FROM THE SEA

Sands from the Land: Terrigenous sands

Terrigenous sands come from the rocks that build our earth. They have been carved from the mountains by streams, or broken from shorelines by waves. Many terrigenous sands come from weathered granite and contain clear quartz, as well as other minerals that are light or dark colored. Sands from volcanoes are often glassy and black, but may include grains that are olive green or brick red.

Since many "sands from the land" are made of silica-based minerals, they show no reaction to vinegar (5% acetic acid).

Sands from the Sea: Biogenous sands

Biogenous sands come from skeletal fragments of marine plants and animals that live along the shorelines of islands or continents, and even in open waters. Waves coming ashore may carry pieces of coral, stony seaweed, seashell and other sea creatures, depositing them on the beach. Where the ocean once covered land masses, sedimentary deposits may contain biogenous components there, as well.

Marine life skeletons are made of calcium carbonate (limestone). "Sands from the sea" dissolve in vinegar, producing small bubbles of carbon dioxide gas.

TEST SANDS FROM THE LAND & SANDS FROM THE SEA

Put **just a small pinch of sand** from test sand samples into separate petri dishes. Flood each sample with vinegar and watch for a few minutes. You may want to use a magnifying glass to observe more closely.

What happened?

Terrigenous sand grains may float, but they won't bubble – No reaction.
Biogenous sand grains bubble or fizz! They may even move around, propelled by the bubbles.

Optional: CALIBRATE THE TEST METHOD

Use the vinegar to test the reaction of parent sources of these kinds of sands:

What happens to a piece of granite rock, a source of many terrigenous sands?
What happens to a piece of coral or shell, components of many biogenous sands?

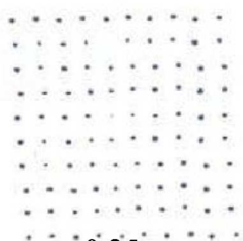
SAND BY SIZES

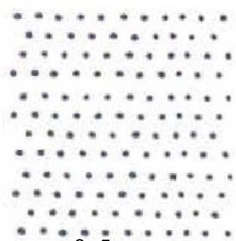
Sand is amazingly variable in its composition, color and where it can be found. But, the definition of sand is based on its size.

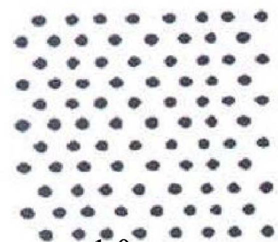
<u>Sand is defined as</u>: Small, loose grains of mineral, rock, or other naturally occurring material, with **<u>grain sizes between 1/16 mm and 2 mm</u>**.

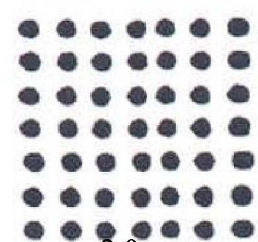
Beaches and other sand deposits can be classified by the size of the sand grains they contain:

- **<u>Sand</u>** includes particles from 0.06 millimeters (mm) to 2.0 mm.

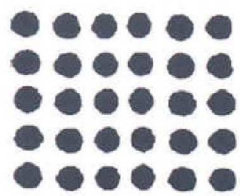

0.25 mm

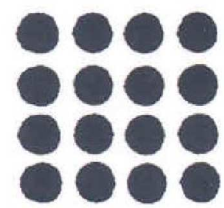

0.5 mm

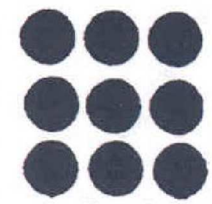

1.0 mm


2.0 mm

- **<u>Gravel</u>** includes particles from 2.0 mm to 64 mm (2.5 inches).


3.0 mm


5.0 mm


7.0 mm

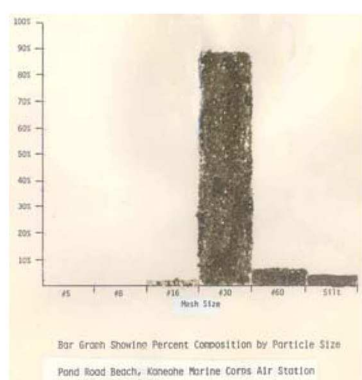
Size examples from NJMSC.

- **<u>Cobbles</u>** are 6.4 to 25.6 centimeters (cm) across (2.5 to 10.1 inches)
- **<u>Boulders</u>** are over 25.6 cm (10.1 inches)

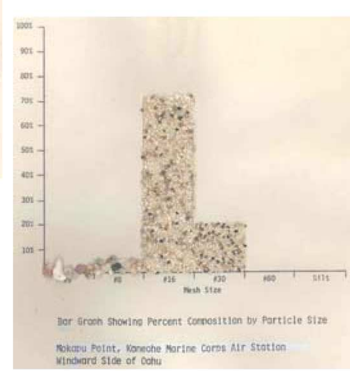
A beach may contain sand grains of different sizes

SORT A SAND SAMPLE INTO DIFFERENT SIZES USING A SET OF GRADED SIEVES.

How much sand is in each size range may reflect conditions on the shore. A sample dominated by small sand grains suggests quiet water conditions, course gravel indicates stronger water movement. You can make a graph of the amount of sand in each size range of your sample.



For these bar graphs of sand grain size distribution, students glued in grains from each size range. Examples courtesy of K.McDermid.



Characterizing Sediment Grain Size Distribution

Sediment Size Distribution:

Sediment grain sizes can by characterized by sifting a sample through a set of graded sieves, separating the particles into specific size ranges. Grain size can imply much about the conditions in the area and about the sample itself. For example, a sample dominated by fine particles suggests quiet water conditions, course gravel indicates stronger water movement.

You can see differences from one sampling site to another. But, you can also observe differences within a single location. On a beach, for example: in the lower beach area, where waves break and roll, larger gravels accumulate; higher on the beach, the weakened wave wash carries only the finer sand particles up the slope. And, changes in particle sizes emerge with the seasons if there differences in wave energy from winter to summer.

Marine sediments are characterized according to the following scale:

Size (mm)	Particle Type
> 4 mm	Pebble, cobble, boulder
4-2	gravel
2-1	Very coarse sand
1-1/2	Coarse sand
1/2-1/4	Medium sand
1/4-1/8	Fine sand
1/8-1/16	Very fine sand
1/16-1/256	Silt
<1/256	Clay


VA Sea Grant MEP photo

Sediment sieves come in sets with fixed mesh sizes that bracket the standard particle types. The mesh sizes below are typical for characterizing marine sediments:

Top #5 mesh = gravel = 4mm
2nd #10 mesh = fine gravel = 2mm
3rd #60 mesh = coarse sand = 0.250 mm
4th #230 mesh = fine sand = 0.063mm
Bottom pan = silt & clay

Arrange the sieves with the largest screen size (#5) on top, decreasing screen sizes in order below to the closed bottom container. Measure a sand sample by volume or weight. Place the sample into the top sieve, cover and shake the entire set with a back-and-forth motion. The particles should separate into their respective sizes. (For wet samples, the addition of water may be needed to facilitate the separation of particles.)

Separate the sieves and re-measure the sand in each. Then convert to percentage by dividing the total mass into the mass retained at each screen size.

[To separate silt from clay particles: Transfer the contents of the bottom pan to a beaker of water, stir and allow to settle for 30 minutes. The finer clay particles will remain suspended in the water. Pour off the clay suspension into another container and allow remaining water to evaporate, then collect the clay and measure. The silt, which remains at the bottom of the beaker, can be measured after allowing water to evaporate.]

With your particle size data you can construct a histogram, or bar diagram, of sand-size distribution for your sample: with sand-size frequency (as percentage of total sample weight or volume) on the Y-axis; and particle size class on the X-axis. You can glue a pinch of sand into each bar to provide a more visual demonstration of the size.

SIFTING SANDS: SEDIMENT SIEVES & SETTLING COLUMNS

SEDIMENT/SAND SIEVES

You can order these from earth science education suppliers or geological/soil science equipment catalogs. Metal sieves (brass or stainless steel) are highly durable and very precise, but can cost hundreds of dollars, depending on the number of sieves in the set. Plastic sieves cost between ~$60-$80, depending on the number of sieves (4 or 6) and durability of the plastic. They come in standard mesh sizes. **OR…**

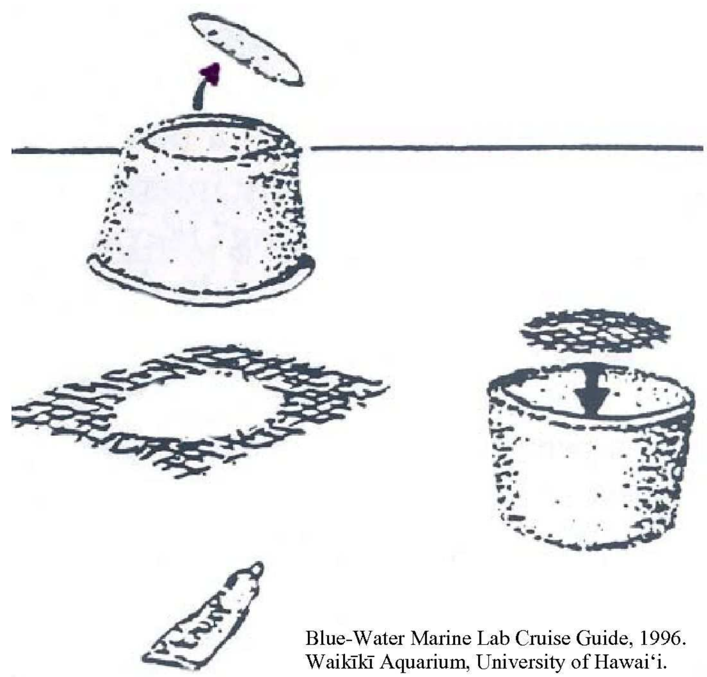
Make your own sieves using plastic cereal bowls, storage tubs or other plastic containers (Cool Whip, etc.) that are between 6-8 inches in diameter. Use containers that are the same size so they can nest inside one another. Four containers are needed for the set described here: large, medium and small mesh, and a solid bottom pan.

Purchase 1/2-inch and 1/4-inch hardware cloth (also called wire mesh) and metal window screen with mesh size of ~1/8-inch.

➤Cut a large circular opening in the bottom of each container, leaving a 1/4-inch ledge around the perimeter.

➤Cut one circle of each mesh to fit into the bottoms of your 3 plastic containers. Make sure your mesh circles overlap completely with the ledge you've left around the perimeter of the bottom.

➤Using aquarium silicon sealant, put a bead of sealant on the ledge you've left on the inside of the bowl. Press the wire mesh firmly down into it. Allow the sealant to cure as indicated on the package. Note: If the screen pops out later, you need to remove all the old sealant before you re-glue the mesh into the bowl.



Blue-Water Marine Lab Cruise Guide, 1996.
Waikīkī Aquarium, University of Hawai'i.

DETERMINING SETTLING TIME

A more indirect way to characterize particle size of a sample is by settling time. Sediment particles are stirred and transported by water. Larger and/or heavier particles tend to settle out first and the finer matter, such as clay particles, stay in suspension longer.

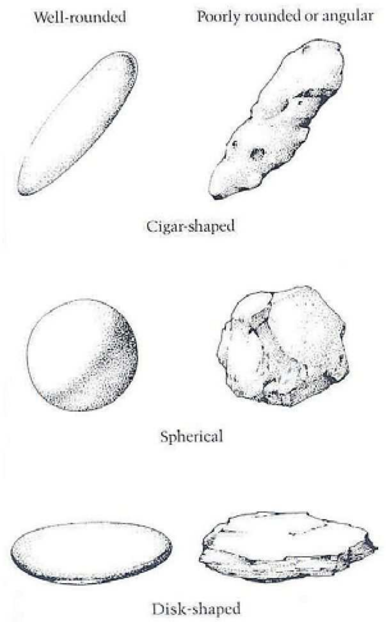
A **settling column** is used to measure settling time and rate. Take a 100 ml volume of the sediment sample and pour it into a 250 ml graduated cylinder. Add water to the 250 ml line, firmly cover the open end and mix thoroughly by turning end over end. Set the column on a level surface and allow the sediments to gradually settle. Record the amount of sediment accumulating on the bottom at regular intervals until the water column is clear (or nearly so).

The total time it takes for the water to clear is the settling time. Graph the sediment accumulating over time to get a rough idea of average settling rate. Larger particles tend to settle faster, the finest take the longest time. If you have several different particle sizes, what does the accumulated sediment on the bottom look like? Is it an even mixture of sizes or does it appear layered? Measure or draw the layers and the sizes of the grains in each

SANDS BY SHAPE

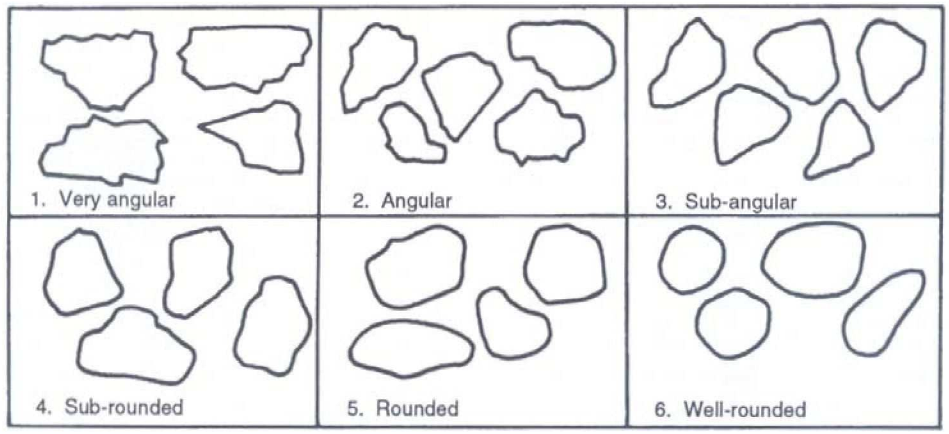
Sands come in different shapes and can be rough (angular) or smooth.
These features can reflect their origin, age and travels.

Sand shapes range from almost spherical to disc-shaped and oblong.



From: Siever,1988.

Angular sands have many sharp edges. As they are worn and smoothed by erosion, they become more rounded



From: Klemm et al, 1990.

LOOK AT SAND SAMPLES USING A HAND LENS OR MICROSCOPE.

Can you find examples of different sand grain shapes?
Can you see different degrees of roundness?

SANDS IN MOTION, SANDS AT REST

Where rivers flow or waves surge, sand moves:

The stronger the water movement, the larger the sand grains that are carried and/or kept in suspension.

Where rivers run swiftly or waves are STRONG,

they can carry larger or heavier grains and build beaches of boulders or gravel. The finer materials keep on moving, you won't find them here!

Where rivers are slow or waves are weak,

they carry only small or light grains. As water movement weakens, even the smallest sands are dropped, contributing to deposits of fine sand.

WHAT HAPPENS TO SAND WHEN WAVES HIT THE BEACH?

Does sand grain size matter? Creating a few waves may help you evaluate this. Oceanographers and coastal engineers use wave tanks 100 to 350 feet long to model waves and how they affect coastlines. You can make a miniature wave tank, a "Beach in a Bottle." Observe what happens to the larger and smaller sand grains inside when you create waves by rocking the bottle as described in the instructions.

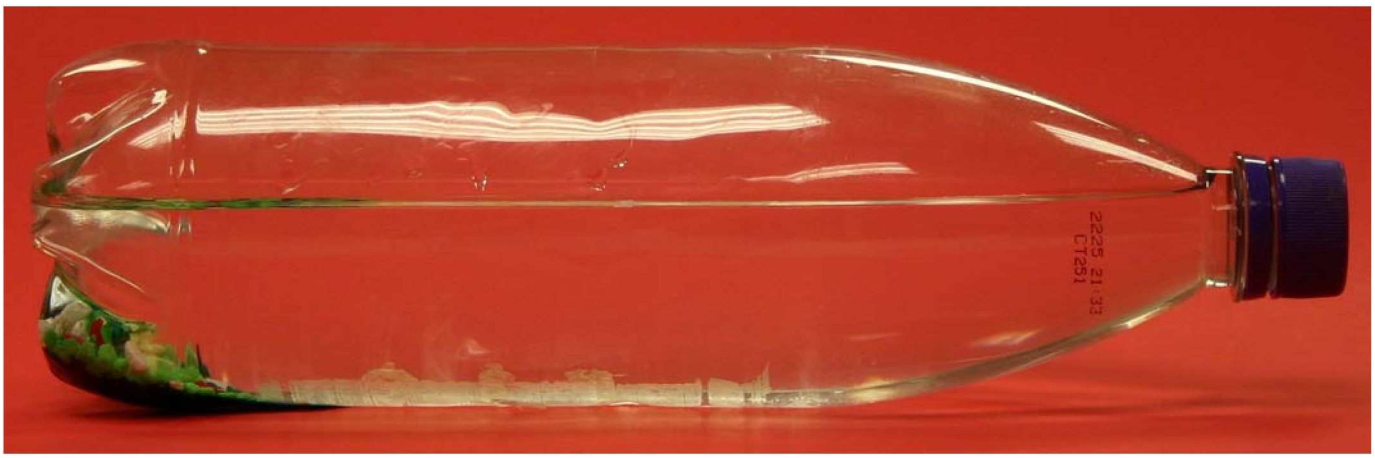
BEACH IN A BOTTLE: Miniature Wave Tank

Supplies:
Clear plastic soda or juice bottle with straight sides: 12, 16, 24 or 32 oz.
~1 Tablespoon coarse aquarium gravel
~1 teaspoon fine sand

Assembly:
1) Fill your clear plastic bottle just over half full (not more than ¾ full)

2) Add ~1 TBS of coarse aquarium gravel & ~1 tsp of fine sand and cap the bottle. Let the bottle sit until the gravel is saturated with water.

3) Make waves in your bottle: Hold the bottle on its side and let the gravel and sand settle to the bottom. Rock the bottle: left side up, then right side up, etc.
*With very gentle rocking, what happens to the coarse and fine sand grains?
*With more energetic rocking, does the behavior of coarse and fine grains change?



WHAT HAPPENS TO SAND WHEN WAVES HIT THE BEACH?

The stronger the water movement, the larger the sand grains that are carried and/or kept in suspension. So sand grain size matters!

Where waves are *gentle*,
they carry only small or light grains. As water movement weakens, even the smallest sands are dropped, contributing to beaches of fine sand.

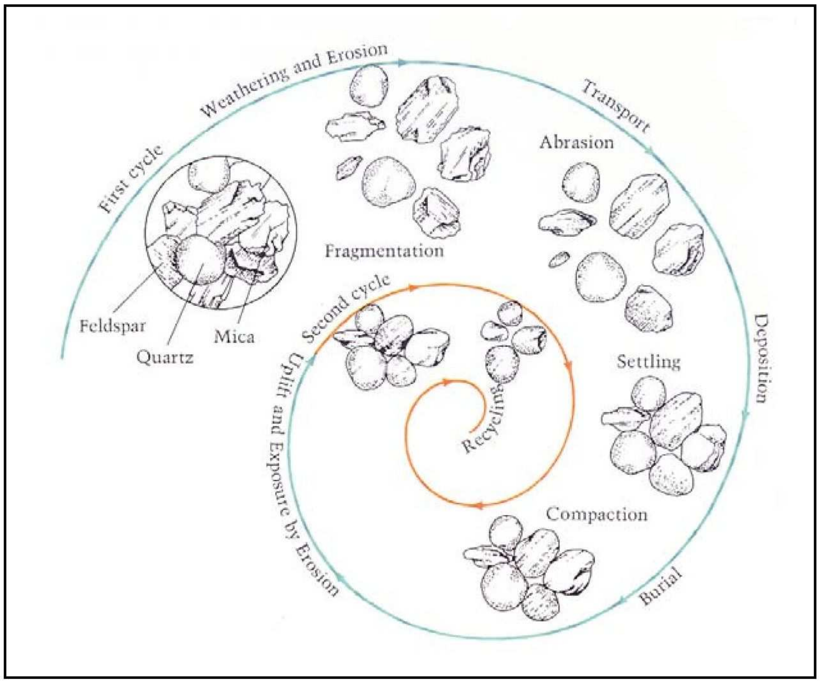
Where waves are STRONG,
they can carry larger or heavier grains and build beaches of boulders or gravel. The finer materials keep on moving.

So, when you rock your bottle gently:
•Only the fine sand moves up into the water (is suspended) and the gravel stays on the bottom.
On a beach, gentle waves allow the most sand to accumulate forming a wider, flatter beach including lots of smaller grains.

When you rock your bottle with more energy:
•Both the fine sand and some of the gravel will be suspended.
On a beach, strong waves can move sediment away, eroding the shore and leaving a narrower, steeper beach of mostly large grains.

MOVING THROUGH THE ROCK CYCLE

Sand grains can illustrate the rock cycle; they may pass through several cycles after their initial formation.



Sand grain life cycle from:
Sand by R. Siever, 1988.
Scientific American Library,
W.H. Freemen & Company, Publishers.

SAND AGES: ARE SANDS YOUNG OR MATURE?

How quickly sands "age," or weather, depends on many factors including their: mineral composition, location, climate and other environmental factors that affect the processes of weathering and erosion.

Sands grow rounded with age:

Angular grains with sharp edges may indicate that the sand is young, recently broken from its parent source. There has not been enough time for water, wind, or waves to wear the grains smooth or dissolve away less resistant minerals. Very old grains have been recycled – buried and eroded again. These oldest grains are made of only the most resistant minerals and often look etched or frosted.

Some grains age faster than others:

What the sand grains are made of can affect how fast they "age." Soft minerals like limestone (which makes up marine life skeletons) wear down rapidly. Very hard minerals like quartz or garnet from continental rocks take a long time to round.

SAND TRAVELS: ARE SANDS FROM NEAR OR FAR?

Grains that are angular:

may indicate the sand is from a source (parent rock) near by. Sands that haven't traveled very far usually aren't as worn by water, wind, or waves.

Grains that are smooth:

may indicate the sand is from a source far away. As sand grains are carried long distances from their source, they dissolve or are worn down, becoming smoother.

SEEING THE WORLD IN A GRAIN OF SAND… STORIES OF EARTH'S GEOLOGY

The processes of earth geology are reflected in sands. Sands have stories to tell!

Finding similar sands in different locations suggests that some of the geology of those regions is similar. The results may surprise you.

White quartz (silica) beaches indicate a granite source. Granite forms when magma cools underground and slowly enough for individual mineral crystals to form. Since granite makes up the massive core of earth's continents, you'll find quartz beaches on many coasts.

Volcanic sands form where eruptions of lava reach the surface and cool quickly. Volcanoes can occur along continent edges where plates of the earth's crust collide, or at "hot spots" where magma punches through the crust. Many volcanic sands are black and shiny, but they may also be red (ash) or greenish (olivine)

Purple sands indicate garnet, a silica mineral produced when older continental rocks are subjected to great pressure and heat. This process, called metamorphosis, occurs when rocks are squeezed or smashed together as continents bang into one another over the course of geological time.

Stories of Earth's Geology: Continents of Granite

GRANITE SANDS – WHITE & GRAY

Granite rocks include of several different minerals, but quartz – made of silicon dioxide is the most durable to erosion. Quartz is often clear.

Depending on the degree of weathering, granite sand may also include light-colored grains of the mineral feldspar or darker grains of hornblende, mica or magnetite.

Where you find quartz sands, there must be some continental rocks somewhere. Even some tropical beaches have a granite source; not all tropical islands are made of coral.

- Have a look at granite sands.
- Look at a world map, atlas or Google Earth, where else would you expect to find granite sands? Find some samples using on-line/virtual sand collections.

Stories of Earth's Geology: Volcanoes

VOLCANIC SANDS – BLACK, RED, GREEN

What if you compare sand from the Kalapana fire shore on the Big Island of Hawai'i with sand from the Yellowstone River, Wyoming. They look alike and they have a similar composition and origin. Geology holds the key…

Both are from lavas derived from hot spot volcanoes! A plume of magma from the Earth's mantle pokes through the crust, creating assembly-line volcanoes as the crust moves with the tectonic plate over the hot spot. On a map or Google Earth, you can find evidence of this volcanic activity in both Hawai'i and North America… Hint: look to the NW or W of the sands' current location.

- Take a look at volcanic sands. They come in black, red and green.
- Look at a world map, atlas or Google Earth, where else would you expect to find volcanic sands? Find some samples using on-line/virtual sand collections.

Stories of Earth's Geology: Tectonic Forces

PURPLE SANDS – GARNETS & TECTONIC FORCES

Garnet is created by the metamorphosis (a process involving heat and pressure) of older continental rocks. So, what could the geology of the Adirondack Mountains of New England and the Namibian Desert of SW Africa have in common?

- Have a look at garnet sands.
- Look at a world map, atlas or Google Earth. Can you predict where garnet sands might occur? What other information do you need? Find some samples using on-line/virtual sand collections.

What Else Can You Do With Sand?

COLLECT IT… Use small sample bag, just a tablespoon will do! Be sure to include a label with collection site and date. Thoroughly dry the sample by baking it in the oven on very low heat in the oven. You can collect in your neighborhood or on your travels. Students, friends and family may also be willing collect for you. Be aware that in some international travel, you must declare soil/sand samples.

You can also obtain sand specimens by trading with other teachers in NSTA, NMEA and other professional organizations. The International Society of Sand Collectors encourages trading among its members. For information, see the list of Selected References.

Or, use a virtual collection. Several websites offer excellent images of diverse sands from around the world. For a list, see the Selected References. You could assemble images of sands similar to the samples used for stations in this lesson.

SIFT IT… You can purchase student sediment sieve sets from earth science education or geological supply catalogs. Or, make your own inexpensive set of sieves using plastic cereal bowls or other storage containers, hardware cloth (wire screen) and silicon sealer. Generate sand size distribution data and graph it. For more detailed outlines of how to analyze and graph sand size distribution, see the reference list for *The Fluid Earth* by Klemm and the *Texas High School Coastal Monitoring Program* website by Hepner & Gibeaut.

SORT IT… Sort sand by its composition. Is it derived from land-based minerals or made of the shells and other skeletal remains of sea life? With practice you can tell individual sand grains apart! Several guides are available with instructions for detailed examination and analysis of sand, and for creating reference displays of representative grain types. The *Fluid Earth* by Klemm, et al contains an excellent outline, other keys to grain origins can be found on-line (see the reference list).

EXAMINE IT WITH A MICROSCOPE… Under the dissecting microscope, sand takes on another dimension! Greater magnification also makes it easier to identify the origins or composition of individual grains. Put a 1" square of white label tape at one end of the slide and record the collection site. Put a few drops of glue on the other end of the slide and spread into an even, thin layer of glue across the surface. Take just a pinch of sand and sprinkle it evenly into the glue. **Less sand is better**, you don't want it too thick. If sand grains are particularly large or heavy, you may need to use a bit more glue. Several references in the list describe this activity.

TRADE IT

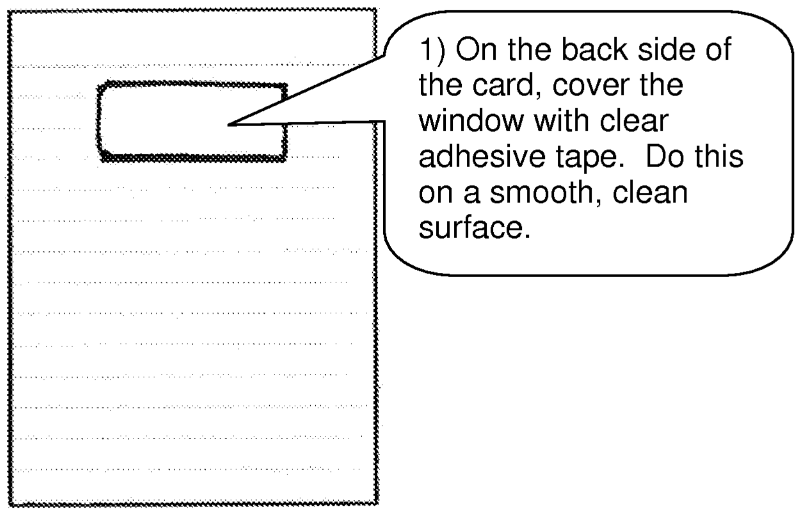
UC San Diego's Parker Program offers a sand trading card design and information on trading that is appropriate for elementary and middle school students. See an adaptation below. For older students, reference the websites of the International Sand Collectors' Society, Treefrog Educational and selected others.

MAKE A SAND COLLECTION CARD

Start your own sand collection! Use snack or mini-size storage bags, just a tablespoon of sand will do! Be sure to include a label with collection site and date. Thoroughly dry your samples by baking them in the oven on very low heat. You can collect in your neighborhood or on your travels. Friends and family may also be willing collect for you. Be aware that in some international travel, you must declare soil/sand samples.

You can also obtain sand specimens by trading with other collectors and professional organizations. The International Society of Sand Collectors encourages trading among its members. See the reference list.

You can make your own sand sample cards for examination and collecting.
Note: This design is based on UC San Diego's Parker Program



Make Sand Collecting Cards

- Cut a 3x5" index card in half to make smaller cards ~3 x 2 ½ inches.
- Fold the smaller card in half (to 3 x 1 ¼ ") and cut out a square ~½ x ¾" along the center line, within ½" of the top of the card. This will be the "window" for your sand sample

.

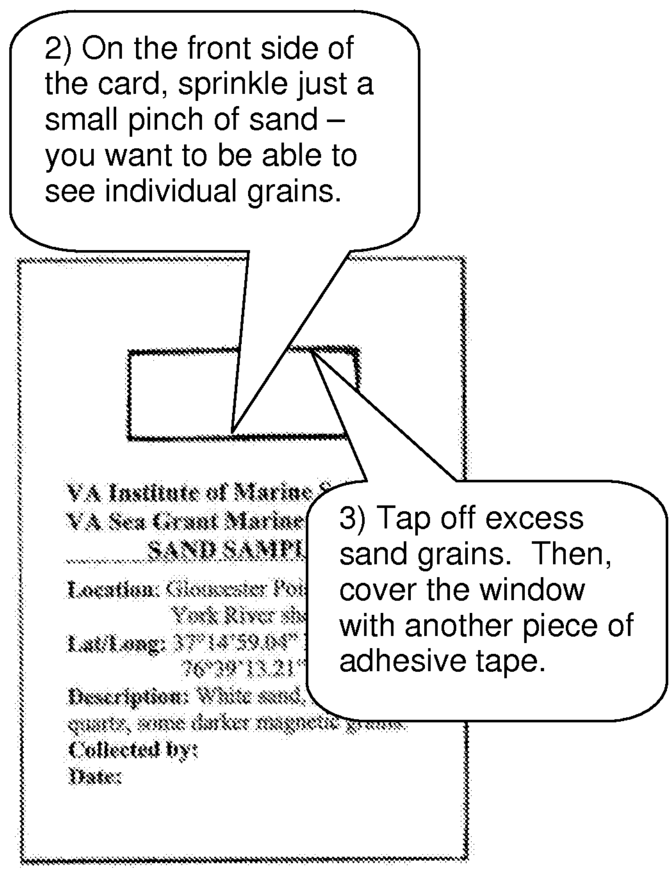
Prepare Your Sand Sample

1) Take a sand collection card and turn it over so the blank side is facing up. Be sure the card is on a smooth, clean surface so things don't stick to the tape.

   Then, put a piece of clear adhesive tape over the "window" in the card. Be sure the whole window is covered by tape. The sticky tape will hold the sand grains in place.

2) Turn the card over so the printed side is facing up. Take a small pinch of sand from the tray and sprinkle it evenly over the sticky side of the tape. The less sand you use the better – you want to see individual grains.

3) Tap off the excess sand grains and put tape on the front side of the card, to seal the sand into the window.



Now you can use a magnifying class or low-power microscope to examine the sand grains in your sample more closely.

Build a collection of sands from all the beaches you visit! All it takes is a pinch of sand.

Sand Labs & SOLs

Using sand as a teaching tool can address several concepts that articulate into the Ocean Literacy Essential Principles, as well as National Science Education Standards and selected state Standards of Learning in Earth Science (examples from Virginia are presented here).

Major concepts that can be addressed using sand:

◆**Sands and other ocean sediments have diverse origins and compositions that reveal geological processes, coastal processes and biological processes.**
Coastal and ocean sediments are derived from minerals and rocks whose origins may be abiotic or biotic, from land sources, marine sources, biological sources. Sediments are part of the rock cycle (formation, erosion, deposition) and are affected by physical and chemical processes on land and in the sea. Sand deposits on beach, dune, seafloor) reveal geological processes, coastal processes, biological processes.

◆**Sands reflect processes of change**
Sands are subject to forces of change that occur on predictable & unpredictable scales, e.g. river flow, tides, currents, seasonal waves and storms, marine erosion, life cycles of plants & animals.

◆**Biological communities affect sands and sands affect biological communities**
Ocean sediments determine the distribution of some forms of ocean life and ocean life forms contribute to and affect the sediments. Living organisms have different tolerances to or survival adaptations for abiotic factors, including: temperature, salinity, dissolved oxygen & other water quality parameters, water movement, exposure to air, seafloor composition. As the physical factors change along the coast, you will see different species and life styles. Human activities also change beaches, sands and the communities that they support.

◆**Scientists in many disciplines collect and report data from coastal and oceanic environments, including data about sands.**
The study of sand is interdisciplinary, marine geologists, physical and chemical oceanographers, as well as biologists study sand origins, movements and what they reveal about geological and biological processes. These scientists use diverse methods and instruments to gather and analyze data. They present their findings using many forms of media.

Kinds of sand-related classroom activities:

✓**Field activities** = Collect sediment samples from different study sites; map dunes or beaches; describe sediment characteristics in relationship to point of origin (near or far from parent source); coastal landforms, beach slope, exposure and wave energy; conduct size distribution analysis, generating data for graphing exercises.

✓**Lab activities** = Compare/contrast sand samples of many locations, origins & compositions; organize data into tables, graphs, prepare reports using written, oral or other communication media.

✓**Computer activities** = Survey virtual sand collections on the web; use Google.earth or other mapping resources to identify sand sample sources; use remote sensing systems to monitor stream flow, coastal currents, impacts of coastal weather events, waves.

✓**Class outreach activities** = correspond with sand collectors to exchange samples; community service stream or shoreline clean-up.

Ocean Literacy Essential Principles related to sand studies

OL 1g: Rivers transport sediments from watersheds to estuaries & the ocean
OL 2c: Erosion of earth materials occurs in coastal areas; wind, waves, currents move sediments
OL 2d: Sand consists of bits of animal, plant rock/mineral…
OL 5e: Ocean is 3-D, habitats exist from surface through water column, into the sediments
OL 5f: Ocean habitats are defined by environmental factors, ocean life is patchy
OL 5h: Tides, waves & predation cause vertical zonation patterns
OL 6c: The ocean is a source of inspiration, recreation, discovery.
OL 6f: Coastal regions are susceptible to natural hazards
OL 6g: Everyone is responsible for caring for the ocean, managing ocean resources
OL 7b: Inquiry and study are required to better understand ocean systems & processes
OL 7d: New technologies, sensors & tools
OL 7f: Ocean exploration is interdisciplinary

Related National Science Education Standards

A: Science as inquiry: understanding about and abilities necessary to do scientific inquiry
B: Physical science: properties of materials, position and motion of objects
C: Life science: organisms and environments, diversity and adaptations
D: Earth science: properties of earth materials, earth's history, geochemical cycles
F: Science in social perspectives: natural hazards, natural resources, environmental quality; nature of science: science as a human endeavor; using science in local challenges

Examples of related VA State Essential Understandings in Earth Science

ES 1: Student plans and conducts investigations, including calculating volume, mass, etc. utilizing appropriate tools; constructing and interpreting diagrams, maps, charts graphs, tables and profiles

ES 2: Student demonstrates scientific reasoning and logic, including applying scientific process to earth science, making predictions using data and analysis, use data to test hypotheses

ES 3: Student investigates and understands how to read and interpret maps, globes, models, charts and imagery, including making measurements, identifying landforms.

ES 6: Student investigates and understands the rock cycle; identifies common rock types based on mineral composition origin, transformation

ES 7: Student investigates and understands difference between renewable and nonrenewable resources found in Virginia, how to make informed judgments related to their use, recognizes environmental cost and benefits.

ES 8: Student investigates and understands geological processes, how they are evidenced in physiographic provinces of Virginia, including volcanism, metamorphism, weathering, erosion, deposition and sedimentation

ES 10: Student investigates and understands aspects of history and evolution of the earth and life can be inferred by studying rocks and fossils, including many VA marine fossils that indicate that large areas of the state have been covered by the ocean.

ES 11: Student investigates and understands that oceans are complex interactive physical, chemical and biological systems and are subject to long- and short-term variations, including the environmental and geological implications of these variations; the economic and public policy issues concerning the ocean and coastal zone.

SELECTED REFERENCES:
SAND STUDIES CURRICULA & BACKGROUND

Sand Lesson Plans: Teaching Geology, Geography, Ocean Processes

Blanchard, Pamela. 2000. Secrets of Sand. A Sea Scope Aquatic Activity from Louisanna State University. This document outlines several activities for grades 6-8, using sand to practice observation and measurement skills. http://www.lamer.lsu.edu/classroom/seascope/folios/sand_folio.pdf

Carlson-Pickering, Jane. 1997. http://www.chariho.k12.ri.us/curriculum/MISmart/ocean/sands.htm
This site has it all! An interactive web site for students in grades 3-12, it is part of an ongoing project initiated by the Chariho Regional School District's *M.I.Smart!*..Program (Multiple Intelligences Program) located in South County, Rhode Island. Includes lesson plans, references, photogallery.

Davenport, J., A. Frankel, C. Parry. 2003. Waves, Wetlands, and Watersheds. California Coastal Commission Science Activity Guide. California Coastal Commission. www.coastal.ca.gov/publiced/waves/waves1.html

Doyle, C. l992. Using sand for more than beaches. NJEA Review, Nov: 38-39.

e-Notes.com. http://science.enotes.com/earth-science/sand. This page, from a site designed for teachers, provides definitions and some properties and descriptions of sand.

Hepner, T. & T.Gibeaut. 2006. Texas High School Coastal Monitoring Program. This excellent site includes background information, field procedures, and detailed instructions for sand analysis and coastal processes affecting beaches. http://coastal.beg.utexas.edu/thscmp/activities.htm

Keener-Chavis, P and Sautter R. 2000. Of Sand and Sea: Teachings From the Southeastern Shoreline. Charleston: S.C. Sea Grant Consortium.

Klemm, B. et al. 1990. Sand (Focus 7-12). In: The Fluid Earth, Hawaiian Marine Science Studies Program, Curriculum Research & Development Group, College of Education, Univ. of Hawaii, Honolulu, HI. Pp. 139-153. This is a classic in sand studies, describes exercises investigating sand composition, size, roundness and other properties. Detailed instructions.

McLaren, J.P. l986. Beach basics for the classroom. Current vol. 7 (2): 20-21.

Millette, J., T. Hopen & Rich Brown. 1996. Collecting and examining beach sand: getting started. Microscopy Today 96 (5): 18-20.

Moffat, B. l988. Sand. The Skimmer (Mississippi Sea Grant Program), Vol. 5(1): 4pp.

New Jersey Marine Sciences Consortium. The Science of Sand. Activity booklet. www.njmsc.org/Education/Lesson_Plans/Sand_Lab_Booklet.pdf

Parker Outreach Program, UC San Diego. Excellent Power Point about sand formation, using CA examples & accompanying instructions for making simple sand trading cards. Geared to middle, upper elementary. Scroll down the page to the Sand entries (note: slow to load). http://earthguide.ucsd.edu/parkerprogram/parker.html

Strang, C., C. Halversen & K.Hosoume. l996. On Sandy Shores, Teacher's Guide. GEMS, Lawrence Hall of Science, Univ. of California at Berkeley, Berkeley, CA 94720. (510) 642-7771. (Focus: Grades 2-4).

Surf Rider Foundation. 2000-2002. Beachology Curriculum Series, includes: User's Guide; Unit 1, Beach Explorers; Unit 2, Studies in Sand; and Unit 3, Sand Travels. Downloadable versions available at www.surfrider.org/whatwedo3a_beachology.asp

Vanderwoort, F. l989. Sands-on learning. The Science Teacher, April 1989: 52-55

Virtual Sand Collections

Carlson-Pickering, Jane. 1997. Sands of the World curriculum website. Sand photo gallery at: http://www.chariho.k12.ri.us/curriculum/MISmart/ocean/pixindex.html

Douglass, Dave. 2005 Sand. A site by a scientist at Pasadena City College, a how to look at sands guide, geography using sand, and other features, advice on collecting and trading. http://www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SANDHP.htm

International Society of Sand Collectors. http://www.sandcollectors.org/Picture_Gallex.html Join an eclectic group of collectors (called psammophiles), find basic facts about sand, order a sand kit and more. Site features a gallery by one of the pioneers of sand microphotography.

Jaster, Andrew. 2001. http://www.jaster.20m.com/index.html Virtual Sandbox Museum of World Sands. Images of sands from around the world, sand facts, join a sand trading network.

Kenny, Leo. Playing in the Sands. The beautiful sand poster by Treefrog Education is also presented on-line with annotations about the sand samples. http://www.vernalpool.org/treefrog/sand/sandposter.htm

Microbus. 2007. Sand analysis. A site by a microscopy professional, includes descriptions of selected sand images, where they came from and what processes shaped them. http://www.microscope- microscope.org/applications/sand/microscopic-sand.htm

Modderman, Loes. http://www.scienceart.nl/Frames/HOMEpage.htm. This site by a Dutch artist and sand collector features microscopic views of sands from many locations. Using a map graphic, the sand images are arranged according to geographical location. Among the largest sites!

Lagendijk, Carla. SAND...a world on its own. This site by a Netherlands author, describes some geological processes affecting sands and uses images from Loes Modderman. http://www.microscopy-uk.org.uk/mag/indexmag.html?http://www.microscopy-uk.org.uk/mag/artjun01/clsand.html

Popular Books on Sands

Greenberg, Gary. 2008. A Grain of Sand: Nature's Secret Wonder. Voyageur Press.
Neal, W., O. Pilkey, J. Kelly. 2007. Atlantic Coast Beaches, A Guide to Ripples, Dunes, and Other Natural Features of the Seashore. Mountain Press Publishing Company, Missoula, MT.
Welland, Michael. 2009. Sand: The Never-Ending Story. University of California Press.

Textbooks: Geology, Coastal Processes, Marine Life & Ecology of Beaches

Duxbury, A.C., A. Duxbury & K. Sverdrup. 2005. Fundamentals of Oceanography, 5th Edition. McGraw Hill.
Morrissey, J. and J.L. Sumich. 2009. Introduction to the Biology of Marine Life, 9th Edition. Jones & Bartlett Publishers, Boston.
Nybakken, J.W. & M. Berness. 2004. Marine Biology: An Ecological Approach. Harper & Row.
Siever, R. 1988. Sand. Scientific American Library. W.H. Freeman & Company.

Other Sand Science:

Amato, I. l991. The sound of one dune booming. Science, Vol. 254, Nov. 15: 938.
Appenzeller, T. l991. Reading history from a single grain of rock. Science, Vol. 254, Dec. 13: 1588-1590.
Burch, B. 1996. Sediments, sands, and sand-formers of the Hawaiian Islands. HI Shell News, Vol. XLIV (3-4): 8-9.
Burton, R. 1973. Tuneful sands of Eigg. Sea Frontiers, Vo. 19 (2), Mar/April:110-113
Elliott, R. 1993. Paradise of form & color. Earth, Vol. 2(1), Jan: 65-69.
Gore, R. l986. Anastasia and the reefs of sand. Sea Frontiers, Vol. 32 (3). May/June 1986: 204-211.
Gorton, E. 2006. Sands of Time: samples from Artic sea floor may rock global climate theories. http://www.jmu.edu/news/madisonscholar/StJohn.shtml
Liou, J., S. Maruyama & W Ernst. 1997. Seeing a mountain in a grain of garnet. Science, Vol. 276, April 4: 48-49.
Mack, W. & E. Leistikow. 1996. Sands of the world. Scientific American, August l996: 62-67.
Michel, H.B. 1986. The mystery of the pink sand. Sea Frontiers, Vol. 32 (6), Nov/Dec: 404-408.
Millette, J., T. Hopen & Rich Brown. 1996. Collecting and examining beach sand: getting started. Microscopy Today 96 (5): 18-20.
Moberly, R. Jr., L.D.Baver Jr., and A. Morrison. l965. Source and variation of Hawaiian littoral sand. In: A Natural History of the Hawaiian Islands, Selected Readings, E.A. Kay (editor). University of Hawaii Press.
Monastersky, R. Fingerprints in the sand. Science News, Vol. 138, Dec. 22 & 29: 392-394.
Nori, F., P. Sholta & M. Bretz. 1997. Booming sand. Scientific American, Vol. 277 (3), Nov: 84-89.
Peterson, I. l992. Trickling grains, sandpiles, and avalanches. Science News, Vol. 142, Oct. 10: 231.
Peterson, I. l997. Dry sand, wet sand. Digging into the physics of sandpiles and sand castles. Science News, Vol. 152, Sept. 20: 186-197.
Raloff., J. l991. Why fountains thunder and dunes boom. Science News, Vol. Nov. 30: 367.
Wanless, H.R. & L.P. Tedesco. 1988. Sand biographies. Sea Frontiers, Vol. 34 (4): 224-230.
Wittig-Harby, B. l990. Ka'u – Green sand and ancient history. Spirit of Aloha, Nov. 1990: 16-19.

Sand Trading Sites: In addition to the sites listed above

Arenophile.com. International meeting point for sand collectors. This is a European site, presented in several languages. Trading sand is a major objective of the site. http://www.arenophile.com/
Robinson, Sue. Suebob's International Sand Collecting Page. This collector offers to trade sand samples and also includes images of the samples in her collection. http://www.suebob.net/sand.html
Science Museum of Minnesota. Features a "Collector's Corner" where you can trade natural objects including sand. http://www.smm.org/visit/collectorscorner/what/

For younger readers:

Berkes, Marianne. 2002. Seashells by the Seashore. Dawn Publications
Dauphin Island Sea Lab, adapted from Parks Canada/Prince Edward Island National Park. No date. Mr. Sand and his friends.
Jauck, Andrea & Larry Points. 1997. Assateague, Island of the Wild Ponies. Sierra Press, Mariposa, CA.
Kirkland, Jane. 2007. Take a Beach Walk. Stillwater Publishing, Lionville, PA
Points, Larry & Andrea Jauck. 1997. Ribbons of Sand, Exploring Atlantic Beaches. Sierra Press, Mariposa, CA.
Points, Larry & Andrea Jauck. 2000. Barrier Islands are for the Birds. Sierra Press, Mariposa, CA.
Prager, Ellen J. 2000. Sand. Jump into Science with National Geographic, National Geographic Society.
Strang, C. 2007. Shoreline Scientist. Seeds of Science/Roots of Reading. Delta Educational, Nashua, NH.
Strang, C. 2007. Gary's Sand Journal. Seeds of Science/Roots of Reading. Delta Educational, Nashua, NH.

5/10 C.Hopper Brill

Examples of Demonstration Sands

from Selected Virtual Sand Collections*

***Kenny, Leo.** Playing in the Sands. The beautiful sand poster by Treefrog Education is also presented on-line with annotations about some sand samples. http://www.vernalpool.org/treefrog/sand/sandposter.htm

***Modderman, Loes**. http://www.scienceart.nl/Frames/HOMEpage.htm. This site by a Dutch artist and sand collector features microscopic views of sands from many locations. Using a map graphic, the sand images are arranged according to geographical location.

WHERE IN THE WORLD ARE SANDS? RESEARCH SAND LOCALES VIA GOOGLE EARTH Images: from Modderman	
Example 1: Talafofo Bay, Eastern Guam Agaña Bay, Western Guam	**Example 2:** Stromboli, Italy Kalapana, Hawai‘i Martinique Island, Caribbean Glacier Lagoon, E. Iceland Java, Indonesia Rapida Beach, Galapagos Islands

SANDS IN COLOR

See color samplers by Modderman, assembled for Arizona, France, Hawaii, Iceland, New Zealand and Turkey and other locations. At: www.scienceart.nl/Frames/HOMEpage.htm

SANDS FROM THE LAND, SANDS FROM THE SEA	
Terrigenous Sands	**Biogenous Sands**
Cape Cod, MA – Modderman	Espaniola, Galapagos – Kenny
Dingle Bay, Ireland – Modderman	Galway, Ireland – Modderman
Cocoa Beach, FL - Kenny	W.Australia – Modderman
Ipanema Beach, Brazil - Modderman	Red Sea, Egypt – Modderman
China Beach, Vietman – Modderman	Kahaluu, O‘ahu – Modderman
Brighton Beach, England – Modderman	Kalimantan, Brunei – Modderman
Victoria, Austrlia – Modderman	Okinawa, Ryuiku Isl. – Modderman
Point Reyes, CA – Kenny	Pink Sand, Bermuda – Kenny
Lake Michigan, MI – Modderman	Miami, FL – Modderman
Aquitaine, France – Modderman	Acadia Nat. Park, ME – Kenny
Channai Beach, India – Modderman	Donegal, Ireland – Kenny
Oland Island, Sweden – Modderman	Sunset Beach, O‘ahu – Modderman

SAND WEATHERING: AGE AND TRAVEL

Example 1: Young grains, Penobscot River, ME – Kenny
More mature sand grains, Acadia Nat.Park Beach, ME – Kenny

Example 2: Sand showing little weathering, Falmouth, MA – Kenny
Mature sand, showing weathering and rounding, Dauphin Island, AL – Kenny

Example 3: Newly formed lava sands, Kalapana, Big Island, Hawai‘i - Modderman
Lava sands from 1801 flow, Kona Village, Big Island, Hawai‘i - Kenny

STORIES OF EARTH'S GEOLOGY

Continents of Granite	Volcanic Activity	Metamorphic Processes
Quartz sands	**Volcanic sands**	**Garnet sands**
Cape Cod, MA - Modderman	El Calderon, NM – Modderman	Plum Island, MA - Kenny
Cocoa Beach, FL – Kenny	Martinique, Caribbean - Modderman	Coeur d'Alene, ID – Modderman
Mohave Desert, CA – Kenny	Costa Rica – Modderman	Ile de Groix, France – Modderman
Dingle Bay, Ireland – Modderman	Rapida Beach, Galapagos – Modderman	Namib Desert, Namibia – Modderman
Aquitaine, France, Modderman	Santa Rosalia, Baja – Modderman	Kayakumari, India – Modderman
Oland Island, Sweden – Modderman	Stromboli, Italy - Modderman	
Ipanema Beach, Brazil – Modderman	Thassos Island, Greece - Modderman	
Valpariso, Chile – Modderman	Cape Verde Islands – Modderman	
Victoria, Australia – Modderman	Glacier Lagoon, Iceland - Modderman	
Lake Langano, Ethiopia – Modderman	South Point, Big Island - Kenny	
Whitsand Bay, S. Africa – Modderman	Wainapanapa, Maui – Modderman	
Kyoung Po De, Korea - Modderman	Hana, Maui – Modderman	
	Samas, Java – Modderman	
	Honshu, Japan – Modderman	
	Comoro Islands - Modderman	

LIFE CYCLE OF THE HAWAIIAN ISLANDS: Volcanic & Biotic Island Building Processes

Images: from Modderman, with the exception of South Point, Big Island, by Kenny.

youngest island

Big Island of Hawai'i
- Kalapana, newly formed lava sand
- South Point, olivine sands from lava
- Volcanic & reef grains

Island of Maui
- Wainapanapa, worn lava sand
- Hana Beach, grains of red ash
- Kamaole Beach, reef sands

Island of O'ahu
- Hanauma Bay, olivine from ash
- Makaha Beach, worn reef sand
- Kahaluu, reef sands

Island of Kaua'i
- Hanapepe, reef sand discolored by red clay
- Polihali State Park, Barking Sands Beach, worn reef sand

oldest island