

# A Challenge of Friction

## Great Sand Dunes National Park Quarter

### Grades Nine through Twelve



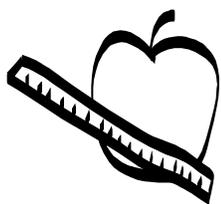
#### OBJECTIVES

Students will investigate and make predictions about friction and surface design. Students will develop persuasive communication skills.



#### MATERIALS

- 1 overhead projector or equivalent technology (optional)
- 1 overhead transparency (or photocopy) of the following:
  - “Great Sand Dunes National Park Quarter” page
  - “Comparison of Dunes” worksheet
- 1 class map of the United States
- 1 topographical map of Colorado
- Copies of the following:
  - “Materials Collection” letter to parents
  - “Sand Observations” worksheet (two pages)
  - “Personal Sand Dune Flags” worksheet
  - “Sand Landcraft Rubric”
- Variety of plastic containers (such as peanut butter jars, milk jugs, juice bottles etc.) with screw-on caps (at least one per group)
- Variety of pebbles 1/2 inch or smaller
- Measuring cups and beakers, 1 set per group of four
- Paper filters and funnels, 1 set per group of four
- Spray bottles, filled with water (1 per group)
- Two 40-pound bags of play sand
- Sandwich size resealable bags, 1 per student
- Dinner size foam or water-resistant plates
- Box of 4 colors of food coloring
- Box of toothpicks
- Glue sticks
- Markers or colored pencils
- Small fan (optional)
- Electric hair dryer (optional)



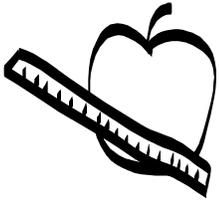
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- Four baking pans
- Text, photos, or videos that give information about the scenery and recreation of Great Sand Dunes National Park, such as:
  - *The National Parks: America’s Best Idea* by Ken Burns
  - *Images of America: Great Sand Dunes National Park* by Mike Butler
  - *Guide to National Parks of the United States, Seventh Edition* by National Geographic
  - *Great Sand Dunes: The Shape of the Wind* by Stephen Trimble
- Fictional text that describes a sandy landscape and/or an imaginative vehicle designed to travel across sand, such as:
  - *A Princess of Mars* by Edgar Rice Burroughs
  - *Around the World in Eighty Days* by Jules Verne
- Web pages that provide information about the properties of sand and geologic interactions, such as:
  - “How Were the Great Sand Dunes Formed?” at [www.nps.gov/grsa/naturescience/sandddunes.htm](http://www.nps.gov/grsa/naturescience/sandddunes.htm)
  - “Creeping Sand” at [www.nasa.gov/audience/forstudents/5-8/features/creepy\\_feature.html](http://www.nasa.gov/audience/forstudents/5-8/features/creepy_feature.html)
  - “Sand on the Move” at [www2.nature.nps.gov/geology/usgsnps/dune/dune.html](http://www2.nature.nps.gov/geology/usgsnps/dune/dune.html)
- Digital camera
- Video and audio recording equipment
- Large tub, such as a plastic baby pool



## PREPARATIONS

- Make an overhead transparency or equivalent of each of the following:
  - “Great Sand Dunes National Park Quarter” page
  - “Comparison of Dunes” worksheet
- Make copies of the following:
  - “Materials Collection” letter to parents (one per student)
  - “Sand Observations” worksheet (page 1, one per group; page 2, one per student)
  - “Personal Sand Dune Flags” worksheet (1 copy per 16 students)
  - “Sand Landcraft Rubric” (one per student)
- One or two weeks before the lesson, send “Materials Collection” letter home with the students.
- For Session 1:
  - Set out spray bottles, measuring cup, beaker, funnel and filters at each station.



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- Provide a large, undisturbed area to dry “Sand Observations” activity.
- Scoop out one-half cup or 130 ml of damp sand from bag of play sand.
- Seal each scoop of sand in a resealable bag.
- Stack bag of sand, toothpick and flag cut-out on a foam plate.
- Prepare recording equipment for student use.
- For Session 2:
  - Prepare four pans, one containing a sample of pebbles from the previous session, another with damp sand from the bag, another with dry sand (leave out overnight to dry), and another with enough water to cover the bottom of the pan.
  - Set out fan and electric hair dryer (optional)
  - Locate photos of sand dunes (see suggestions under “Materials”).
- For Session 3:
  - Locate a passage from a fictional text that describes a vehicle traveling on sand (see suggestions under “Materials”).
  - Fill a large tub, such as a plastic baby pool, with all the remaining sand and shape a 45 degree slope at least 5 inches wide and 12 inches long.
- For Session 4:
  - Provide poster paper, markers or colored pencils
  - Obtain video and audio recording equipment.



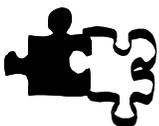
## GROUPINGS

- Whole group
- Small groups
- Pairs
- Individual work



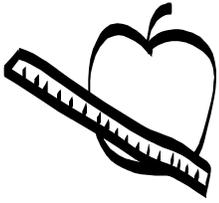
## CLASS TIME

Six 45- to 60-minute sessions, total 4.5 to 6 hours



## CONNECTIONS

- Science
- Language Arts
- Mathematics



# A Challenge of Friction



## NATIONAL STANDARDS/COMMON CORE

- Common Core State Standards (CCSS)
  - Language Arts, Reading and Literature RL.9-10.9: Analyze how an author draws on and transforms source material in a specific work.
  - Language Arts, Writing W.9-10.2: Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
- Next Generation Science Standards (NGSS)
  - Science, HS Forces and Interactions: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during collision.
- National Council for Teachers of Mathematics (NCTM)
  - Mathematics: Use geometric ideas to solve problems in, and gain insights into, other disciplines and other areas of interest such as art and architecture.
  - Mathematics: Analyze properties and determine attributes of two- and three-dimensional objects.
  - Mathematics: Explore relationships (including congruence and similarity) among classes of two- and three-dimensional geometric objects, make and test conjectures about them, and solve problems involving them.



## TERMS AND CONCEPTS

- |            |                   |                   |                |
|------------|-------------------|-------------------|----------------|
| • Quarter  | • Obverse (front) | • Reverse (back)  | • Displacement |
| • Erosion  | • Barchan dune    | • Transverse dune | • Alpine       |
| • Montane  | • Dune field      | • Nonrenewable    | • Scarcity     |
| • Friction |                   |                   |                |



## BACKGROUND KNOWLEDGE

Students should have a basic knowledge of:

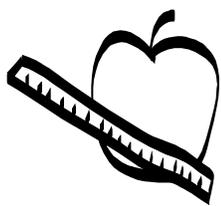
- Rock formation and composition
- Hardness scales, such as Mohs and field



## STEPS

### Session 1

1. Display and examine the “Great Sand Dunes National Park Quarter” page. Locate this site on a class map. Note its position in relation to your school’s location.

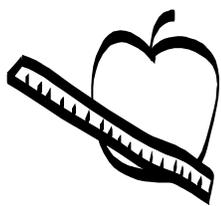


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2. As background information, explain to the students that the United States Mint began to issue the quarters in the America the Beautiful Quarters® Program in 2010. By the time the program ends in 2021, there will be a total of 56 quarter designs. Each design will focus on a different national site—one from each state, territory and the District of Columbia.
3. Tell the students that the back of a coin is called the “reverse” and the front is called the “obverse.” Ask the students to share their ideas about the image on the quarter’s reverse. If necessary, explain that the image shows a father and son playing in the sand next to a creek bed. The distinctive mountains and sand dunes of Great Sand Dunes National Park are featured in the background.
4. Describe the lesson objective to the students: to explore what makes sand so difficult to travel on. Prompt the students to recall definitions or examples of texture, hardness and luster, and review as necessary.
5. Point out the location of materials and the drying and storage area in the classroom.
6. Divide the class into groups of four students. Distribute a copy of page 1 of the “Sand Observations” worksheet to each student and discuss it with the whole class. Have them share the materials they brought and have each group decide on one container and one type of rock to use for their observations. Encourage the different groups to use different types of containers and rocks.
7. Following page 1 of the worksheet under “Making Sand,” have each group appoint one student to each of the actions: record, measure, shake, filter. Tell the students to complete the “Predict Outcomes” question before shaking their containers. Guide teams as necessary through the process described on the worksheet.
8. Host debriefing discussions with each group. Ask the students if there were any surprises or if conclusions could be drawn yet from the data they collected. Ask them how long they think it would take to make a beach full of sand.
9. As the groups finish, have the students pick up one each of the following items: a cut-out sand dune flag, a toothpick, and a plastic resealable bag containing 1/2 cup (or 130 ml.) of damp play sand. Have glue sticks and markers available for the students to assemble the flags on the toothpicks.
10. Review the directions under “Making a Sand Structure” on page 2 of the worksheet. Explain that this is an individual activity.
11. Allow the students to place two drops of food coloring in the sand bag to dampen the sand and distinguish the structures. Have the students seal the bags and knead the color through the sand. Display a sample sand dune with a flag and challenge them to form a dune that will hold up a flag the longest.
12. Show the students where to store their dunes to dry until the next class period. Have the students take photos of their dunes with a digital camera.



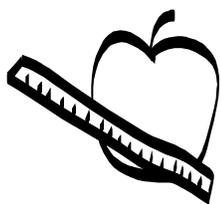
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## Session 2

1. Display and examine the “Great Sand Dunes National Park Quarter” page. Point out to the students that the design represents four geographic formations: alpine tundra, montane forests, dune field and creek field. Point to each feature on the coin image and provide a brief description, including the elevation of the mountains (13,600 feet) and the tallest dune (750 feet).
2. Display the classroom map of Colorado, locating the Sangre de Cristo Mountains and the San Juan Mountains. Orient the students to the topographical map by pointing out the same features discussed on the coin image.
3. Tell the students that you are going to demonstrate the effect of wind on different terrains. Display four pans, one containing rocks, the second damp sand, the third dry sand and the fourth water. Have the students predict what will happen when you direct a small fan at each pan.
4. Explain that the fan represents cold air. Ask the students what effect it would have over a long time. Repeat the process with a hair dryer representing hot air. Lead the students to conclude that different temperatures of wind will affect the dryness of sand and the amount of possible wind erosion.
5. Display and discuss the “Comparison of Dunes” worksheet.
6. Refer back to the map of Colorado and explain that the Great Sand Dunes were formed and are maintained by a unique combination of geologic features. View more detailed descriptions of the properties of sand and of sand geology using Web sites such as those suggested under “Materials.”
7. Using a Think/Pair/Share method, ask the students to determine the three requirements in the formation of sand dunes (ground water from creeks, competing cross winds and sand trapped between mountains). As they discuss, remind the students of the dunes they created during the last session and ask the students which of the three requirements are missing that maintain the Great Sand Dunes.
8. Have small groups of students retrieve their dunes and record their observations to finish page 2 of the “Sand Observations” worksheet. Have the students reconstruct their dunes by adding water and record dune changes with a digital camera.
9. Have the groups follow up on page 1 of the “Sand Observations” worksheet. Have the student assigned to filtering scrape the sand from the filter into a small resealable bag, observe whether the sand settled in the beaker or not and repeat the filtration if warranted.
10. Prepare the class for the next two sessions by reminding them to bring materials listed in the “Materials Collection Note” to build a sand landcraft.



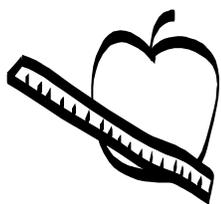
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# A Challenge of Friction

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## Sessions 3 and 4

1. Display the “Great Sand Dunes National Park Quarter” page. Discuss what the class has previously learned and note each fact on a whiteboard or chart paper.
2. Introduce the students to the recreational aspects of the Great Sand Dunes National Park by showing a video or photos (see suggestions under “Materials”). Ask the students to share their impression of the scenery.
3. Conduct an opinion poll: Ask the students to put a hand up if they thought it was easy to make sand from rocks in the classroom demonstration. Ask who thought the classroom could make a bucket of sand in an hour or in a week.
4. Now ask to see the hands of whoever thinks sand is a nonrenewable resource—that we could make more if we needed it. Ask who thinks it would be cost-effective to make sand. Lead the students to conclude that sand, although plentiful, is an example of scarcity.
5. Explain to the students that, in the 1920s, the sand in the Great Sand Dunes National Park was being excavated for making concrete mix and glass. As a result, concerned citizens petitioned for the Great Sand Dunes to be designated a national monument in 1932. In 2004, it became part of the national park system.
6. Explain to the students that many famous scientists and engineers have been inspired by science fiction stories they read as children. Tell the students that you are going to read some science fiction to inspire creativity in their landcraft designs.
7. Read a passage from one or more fictional texts that describes a vehicle traveling on sand (see suggestions under “Materials”). Ask the students what geometric shapes they have seen used in vehicles. Ask the students what features a surfboard, a boat and a snow sled have in common. Ask students what properties water, snow and sand have in common.
8. Distribute a copy of the “Sand Landcraft Design Rubric” to each student and review the directions. Divide the class into groups of four and have the students pick roles as defined on the rubric. Answer any questions.
9. Allow time for the groups to construct, assemble and test their sand landcraft. Have available a large tub with 2 bags of play sand molded to a 45-degree slope for testing. Have the students complete their rubrics.
10. Remind the students to follow up as needed on the previous demonstrations on making sand and sand dunes.
11. Prepare the students for the next step of the lesson by describing the culminating project, a persuasive presentation. Have the students choose a format for their presentations from among a radio or TV commercial or a magazine advertisement.



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## Sessions 5 and 6

1. Display the “Great Sand Dunes National Park Quarter” page. Lead a discussion about the man and child in the foreground. Have the students imagine how an adult and a child might use the sand landcrafts they have designed. Have the students evaluate whether an adult and a child would consider their landcraft a toy or a vehicle. Lead the students to conclude that engineers must adapt designs to fit the needs of the intended audience. Ask the students what features become more important in design when a child is involved. Have the students discuss in their groups how to add features to their design that would be more advantageous for a child.
2. Have students write a description of their landcraft that takes 30 seconds to read.
3. Allow the students to choose whether they will create a digital audio or video presentation or a magazine advertisement. Allow time for them to prepare scripts or create or gather artwork for their print ad.
4. Assist the students with recording their presentations as needed. Provide poster paper, markers and rulers for students creating magazine advertisements.
5. Allow time for the students to present their landcraft to each other and invite other classes to visit.



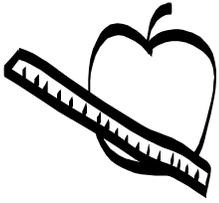
## ASSESSMENTS

- Take anecdotal notes on group teamwork and class fact checking.
- Use the “Sand Observations” worksheet and rubric to assess whether the students have met the lesson objectives.



## ENRICHMENTS/EXTENSIONS

- Use specific types of rocks (shale, quartz, gypsum) for page 1 of “Sand Observations.”
- Have students host a viewing/listening session at Open House or school assembly. Place student work or photographs of work in school gallery or display cases.
- Have students merge commercials into a loop and upload to a school or county Web site.
- Have students research the diverse animal life native to the park and construct a sand landcraft that reflects the motion of the animal.
- Conduct reading study groups using the types of fictional texts suggested under “Materials.”
- Construct an actual prototype of the vehicle to full scale.



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## DIFFERENTIATED LEARNING OPTIONS

- Provide ready-made materials or found objects for students to finish their sand landcrafts.
- Provide written fact sheets and lecture notes for students who have difficulty with synthesis.
- Provide timed guidance for students with attention deficits.
- Adjust assignment deadlines to allow more time for students to fulfill writing or presentation requirements.



Name \_\_\_\_\_

# Materials Collection

Dear Parent or Guardian,

Next week our class will be conducting demonstrations, experiments and engineering projects to understand the properties of sand.

Please help your student locate one or more of the following items. The items are needed by \_\_\_\_\_.

## MAKING SAND

- \_ Plastic container with lid, such as disposable water bottle, plastic (not glass) spice jar, frosting can, coffee can.
- \_ Rocks or pebbles, about 1/2 cup. Nothing valuable or irreplaceable. Rocks from a driveway or stream, river pebbles.

## SAND LANDCRAFT DESIGN

The following materials are allowed. Please ask about using other materials.

- \_ Aluminum foil
- \_ Paper
- \_ 60# cardboard stock
- \_ Corrugated cardboard
- \_ Craft sticks
- \_ Toothpicks
- \_ Bottle caps
- \_ Plastic lids
- \_ Rubber bands
- \_ Balloons
- \_ Cloth
- \_ Duct tape
- \_ Glue, tape as needed.

Thank you very much for your assistance with this project. You are invited to visit the classroom to see the outcome of this experiment. Please call or email me to schedule a visit.

Sincerely,



Name \_\_\_\_\_

# Sand Observations

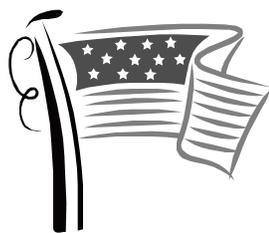
## Page 1

**Directions:** Follow the steps as listed below to make and collect sand samples. The recording student will fill in the blank spaces below to describe the variables in your group's experiment.



### MAKING SAND

Name:	Name:	Name:	Name:
<p><b>Step 1: Record</b> Record observations about the container and rocks in the grid below (numbers 1 through 4). At the end of the experiment, record the results in number 5.</p>	<p><b>Step 2: Measure</b> Pour 50 ml water into clean container with lid. Fill beaker to 100 ml. Add clean rocks until water is displaced to 150 ml mark. Drain water and move rocks to first container.</p>	<p><b>Step 3: Shake</b> Tightly close the lid and shake the container for 5 minutes. After 5 minutes, observe with the team the condition of the water.</p>	<p><b>Step 4: Filter</b> Label a paper filter with your name. Place filter and funnel over a beaker. Carefully pour water and rocks into filter. Spray water to remove all sand from rocks. Remove rocks and set filter and beaker in drying area.</p>
1. Describe and illustrate the container (size, shape)			
2. Describe the rocks (color, shape, size, texture, hardness, luster)			
3. Predict the outcome of shaking			
4. Describe the grains (amount, color, shape, size, texture, hardness, luster)			
5. Compare your results with another team. What conclusions can you make about how much sand is produced from different kinds of rock? Does the shape of the container matter?			



Name \_\_\_\_\_

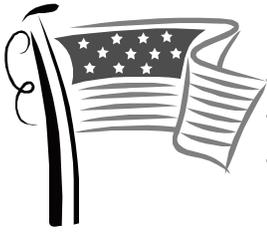
# Sand Observations

## Page 2

**Directions:** Construct a sand dune that will maintain its shape and hold a flag upright. Consider what changes will occur in your dune over time. Draw diagrams of your dune on the left and explain the results in one to two sentences on the right each day of class.

### MAKING A SAND STRUCTURE

Draw a picture of what your dune looks like.	Describe what is happening to your dune.
Day One	
Day Two	
Day Three	
Day Four	
<p>Conclusions: What does a dune need to maintain its shape and height?</p>    	



# Sand Landcraft Rubric

<b>Organizer</b> Maintains all team's materials Name _____	<b>Spokesperson</b> Appears on screen Name _____
<b>Liaison</b> Presents team's needs to teacher Name _____	<b>Timekeeper</b> Motivates team to keep on task Name _____

Category	4	3	2	1	Self	Teacher
<b>Vehicle Design</b>						
<b>Mobility</b>	Moves at least 10 inches on sand path	Moves at least 6 inches on sand path	Moves at least 4 inches on sand path	Moves 2 inches or less on sand path		
<b>Appropriateness of shape and contact surface</b>	Both shape and surface well-matched to terrain	Either shape or contact surface not ideal for terrain	Shape and surface not ideal for sand terrain	Little apparent regard for sand terrain properties		
<b>Originality</b>	Unique, not heavily influenced by other designs	Uses both standard sand vehicle design and original twist	Uses mostly existing sand vehicle design	Device lacks planning or synthesis of elements		
<b>Presentation</b>						
<b>Originality</b>	Matches style to audience in a precise or unique way	Matches style to audience fairly well	Either audience or approach not creative	Effort is uninspired, relies heavily on existing verbiage or ignores audience		
<b>Mechanics</b>	Professional quality.	Clean, neat, suitable to represent high school	3 or 4 revisions necessary	More than 4 instances of carelessness		
<b>Grammar</b>	No errors	No more than two errors	Between 3 and 6 errors	Many errors, understanding is difficult		

**Totals**

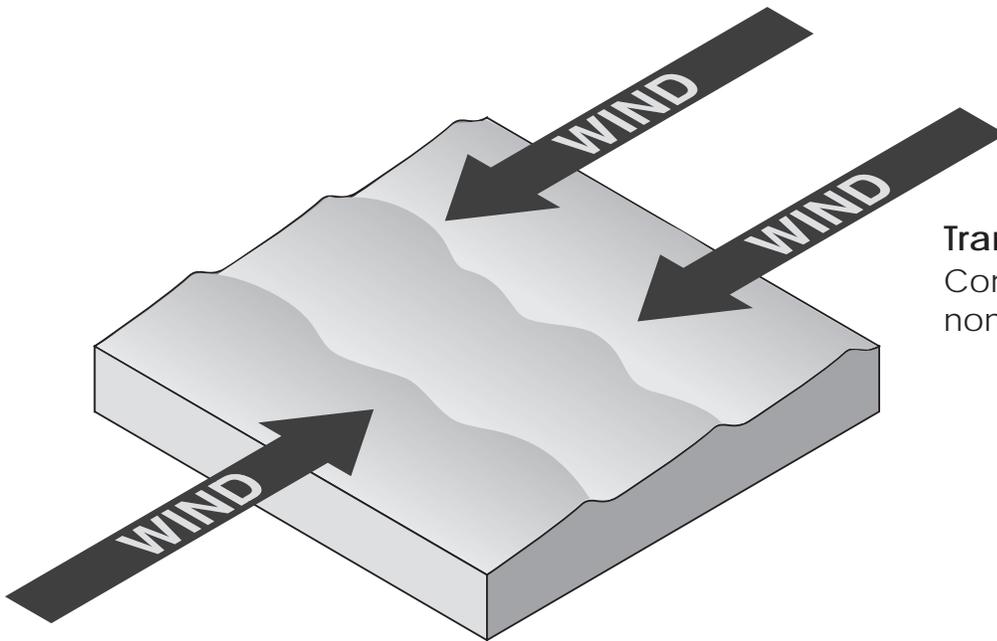
**Student Reflection**

**Teacher Comments**

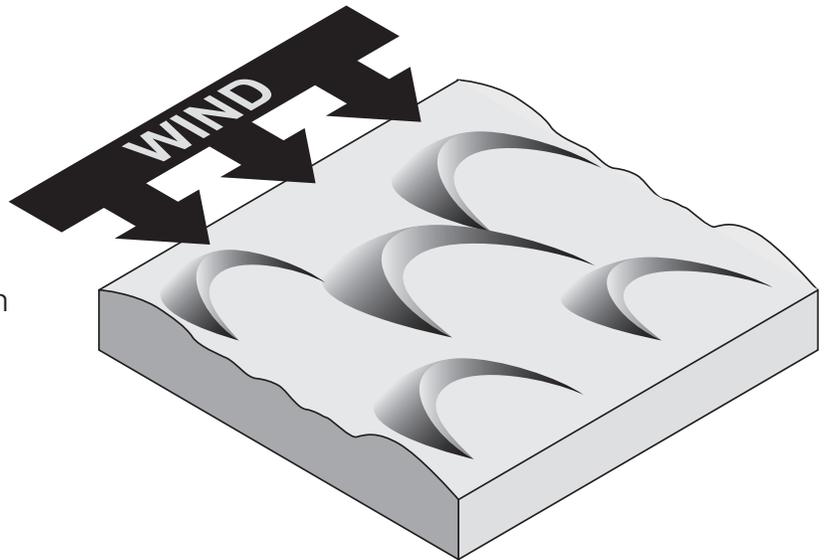


Name \_\_\_\_\_

# Comparison of Dunes

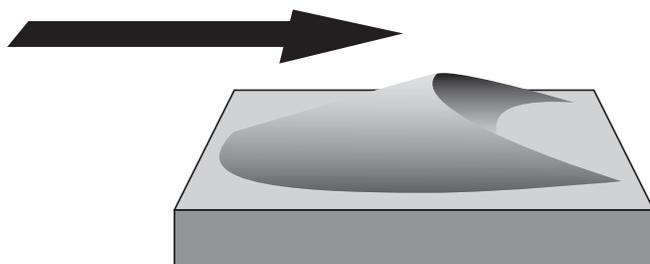


**Transverse dune**  
Competing winds create a non-uniform wavy shape.



## Barchan dunes

Very steady winds from one direction create smaller colonies of crescent-shaped dunes.





# Personal Sand Dune Flags



fold

fold

Name



Name



Name



Name



Name



Name



Name



Name



Name



Name



Name



Name



Name



Name



Name



Name





# Great Sand Dunes National Park Quarter



# The United States of America

