

# SciGirls Investigate Physical Science Fun!



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# Physical Science Fun

The physical sciences are a fundamental part of the STEM (science, technology, engineering, and math) curriculum. The activities in this book emphasize key process skills necessary for success in all STEM fields. Girls can practice observing, questioning, problem solving, planning an investigation, and analyzing results.

These activities are based on the Emmy-Award winning national PBS Kids television series **SciGirls**, which features groups of middle-school girls modeling girl-friendly approaches to inquiry-based STEM investigations.

These activities all follow the inquiry process (found on page 2); incorporate the **SciGirls Seven** Strategies for engaging girls in STEM (outlined on page 3); connect to **SciGirls** videos and mentors from the show; and align to national standards.

The activities can be used alone, but we encourage you to enhance your girls' experience by showing the videos to incorporate SciGirls as role models and mentors. Then your girls can take these activities to the next level by logging onto the **SciGirls** website [pbskidsgo.org/scigirls](http://pbskidsgo.org/scigirls), to create their own profiles and share their investigations with our online community.

We encourage you to inspire your girls using the **SciGirls Seven**, making personal connections between the girls' lives and the activities in this book. Look to this material for ideas. But remember that your girls can be the best source of information to help make their learning authentic.

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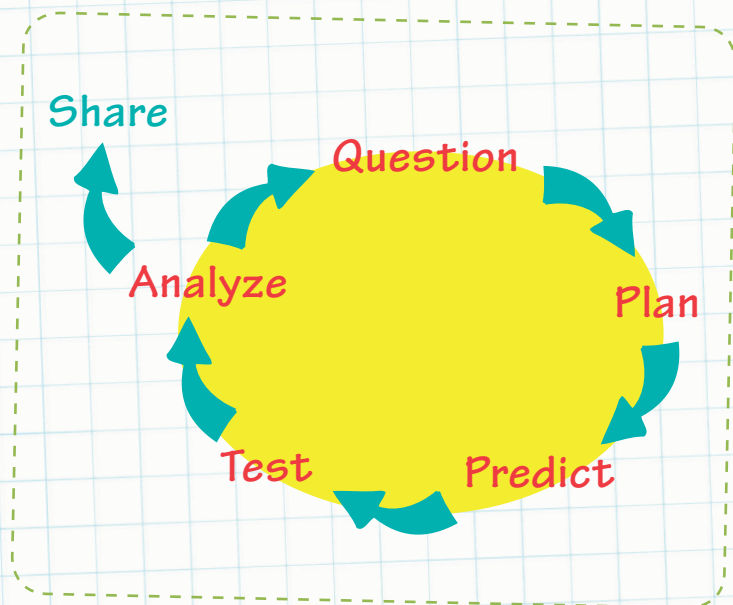




# SciGirls Want to Know

## Scientific Inquiry Process

Here is the **SciGirls'** scientific inquiry process, the same steps all scientists use when tackling a new problem. Encourage your girls to follow these steps as they approach each **SciGirls Challenge**.



**Question** The **SciGirls Challenge** lays out the initial question for investigation, but girls might come up with new questions as they work their way through the process. Steer them away from questions that have simple yes/no answers toward ones they can answer through their own investigations.

**Plan** Research ideas by consulting experts, reviewing books, browsing the Internet, and then brainstorming with others. Each group should choose one idea and plan an investigation that tests one variable at a time, includes multiple trials, and has a clear way to measure results.

**Predict** This important step is sometimes forgotten. Ask girls what they think will happen before diving in. It's OK to disagree. Different predictions make the experiment more interesting and discussing predictions can improve critical thinking skills.

**Test** Let the experimentation begin! Be sure to encourage girls to write down every observation and result in their science journals.

**Analyze** After each test, analyze the data. A failed test can still lead to important results—and new ideas. Encourage girls to make calculations, organize their data in a table or chart, and discuss. This evaluation sometimes raises new questions and starts the entire process over again.

**Share** Encourage girls to be creative when making charts, graphs, or models to share their results. Have them use these visual aids to tell an effective story. Allow time for feedback and discussion, which could open new doors for future investigations.

Throughout this guide, the projector points you to videos on the companion DVD. Or you can watch online at [scigirlsconnect.org](http://scigirlsconnect.org)



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# The SciGirls Seven

## Strategies for Engaging Girls in STEM

The **SciGirls** approach is rooted in research on how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and these have become **SciGirls'** foundation—aka the **SciGirls Seven**. All the activities in this booklet were created with the **SciGirls Seven** in mind and incorporate as many strategies as possible. We even mark the use of select strategies within each activity. (Look for superscript numbers and refer back to this page.) For additional information, please see our introductory booklet, *SciGirls Seven: How to Engage Girls in STEM*, which includes tips for implementing these strategies. You can download it for free at [scigirlsconnect.org](http://scigirlsconnect.org).

1. Girls benefit from collaboration, especially when they can participate and communicate fairly.
2. Girls are motivated by projects they find personally relevant and meaningful.
3. Girls enjoy hands-on, open-ended projects and investigations.
4. Girls are motivated when they can approach projects in their own way, applying their creativity, unique talents, and preferred learning styles.
5. Girls' confidence and performance improves in response to specific, positive feedback on things they can control—such as effort, strategies, and behaviors.
6. Girls gain confidence and trust in their own reasoning when encouraged to think critically.
7. Girls benefit from relationships with role models and mentors.



## Activity 1

# No-Slip Grip

### PREDICT THE AMOUNT OF FRICTION DIFFERENT SURFACES WILL CREATE.

Friction is a force that resists motion when two objects are in contact. If you look closely at the microscopic surfaces of all objects, there are tiny bumps and ridges. When you try to slide one object over another using just a small amount of force, the object won't move since those tiny bumps and ridges catch onto another. This is called static friction. If you apply a little more force, the object will "break free" and slide, although you still need to apply force to keep the object in motion.

#### SMART START:

##### ★ Low Friction Surfaces

wax paper, tabletop (not wooden), linoleum flooring, ice (fill a cookie sheet with water and freeze overnight)

##### ★ Medium Friction Surfaces

felt fabric, rubber car mat, corduroy fabric

##### ★ High Friction Surfaces

sandpaper (24, 30, or 36 grit), rubber stair tread (available at hardware stores), vinyl upholstery fabric

Here's how:

**1. Introduce friction.** Discuss the concept of friction. Have groups brainstorm times they've noticed the effects of friction.<sup>2</sup> (Examples might

### You'll Need:

- ♦ 2 feet minimum of surfaces for testing stations (See Smart Start.)
- ♦ weights (sand, rocks, etc.) to evenly fill each shoebox  $\frac{1}{3}$  full
- ♦ optional: scale

#### For each small group

- ♦ 1 shoebox
- ♦ 1 craft stick or wooden skewer
- ♦ 1 sturdy rubber band
- ♦ paper and pencil
- ♦ masking tape
- ♦ 1 measuring tape or yardstick



include rubbing hands together, walking on ice, or wearing shoes with good traction.) When is friction useful in nature? (Animals that climb trees or walk on ice or snow are great examples.)

#### 2. Predict. Introduce the **SciGirls Challenge**:

How does a surface affect how much force is required to move an object? Ask girls to look at the various testing stations and predict whether the surfaces will create more or less static friction.

Watch girls test different materials on the *SciGirls Investigate* DVD. (Select **Mother Nature's Shoes: Test Materials.**)



**3. Prepare a weighted shoebox.** This will be the object the girls will try to move over various surfaces. Divide girls into groups of two or three.<sup>1</sup>

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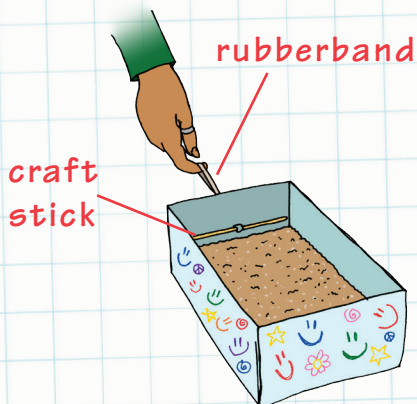
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<sup>1-7</sup> See **SciGirls Seven** strategies on page 3.



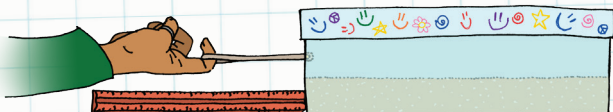
# No-Slip Grip continued

Give each group an empty shoebox, a craft stick, and a sturdy rubber band. Have the girls make a hole in the narrow end of the box. Loop the rubber band around the craft stick, place the stick in the shoebox, and pull the other end of the rubber band through the hole so that the craft stick is pulled tight against the inside of the shoebox. (See below.) Then fill the shoebox roughly  $\frac{1}{3}$  with the weights provided (sand, rocks, etc.). Tape the lid on and decorate.



**POINTER:** If you want to compare data across groups, you will need a scale to make sure each group's box weighs the same amount.

**4. Collect data.** Have each group rotate through the testing stations and start by placing their shoebox on the testing surface. Ask each group to measure and record the initial length of the unstretched rubber band. (See below.)



Have a girl use one finger to slowly pull the rubber band straight away from the box, until the box moves. Record the maximum length of the stretched rubber band at the moment the box starts to move. The girls should repeat this procedure three times on each type of surface.

**POINTER:** Girls should take turns testing surfaces. It helps if one girl pulls the rubber band while the others take measurements and record them.

Rubber bands may snap when testing surfaces that produce a lot of static friction. Be careful.

**5. Analyze data.** Subtract the initial length of the rubber band from the maximum length of the rubber band for each surface and record. Find the average of the three attempts for each of the surfaces. (See table on following page.)





# No-Slip Grip continued

## Force Needed to Move Shoebox

Material	Maximum length		Initial length		Change in length	Average change in length
sandpaper	26 cm	-	10 cm	=	16 cm	15.3 cm
	25 cm	-	10 cm	=	15 cm	
	25 cm	-	10 cm	=	15 cm	
wax paper	13 cm	-	10 cm	=	3 cm	3 cm
	14 cm	-	10 cm	=	4 cm	
	12 cm	-	10 cm	=	2 cm	
rubber car mat	19 cm	-	10 cm	=	9 cm	9.3 cm
	20 cm	-	10 cm	=	10 cm	
	19 cm	-	10 cm	=	9 cm	

**6. Share.** Ask girls to compare the averages and share their findings with the larger group. Does more stretch mean that there is more or less static friction between the surface and the box? What characteristics of each surface might impact your experiment? <sup>6</sup>

**7. Extension.** Try testing surfaces you find outside (sidewalk, concrete, grass, etc.) or testing the same surfaces with the girls' shoes to see if the results are similar.

Watch Cindy discuss the difficulties of prototyping on the *SciGirls Investigate* DVD. (Select Mother Nature's Shoes: Mentor Moment.) <sup>7</sup>



## Mentor Moment

Cindy Gilbert is a biologist who combines her love

of nature with sustainable design at the Minneapolis College of Art and Design. She sees the two fields, biology and design, as bound together by the theme of change. Trained in the field of biomimicry (creating new technologies based on the study of nature), Cindy believes designers hold the key to changing the world for the better.

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<sup>1-7</sup> See **SciGirls Seven** strategies on page 3.



## Activity 2

# Insulation Station

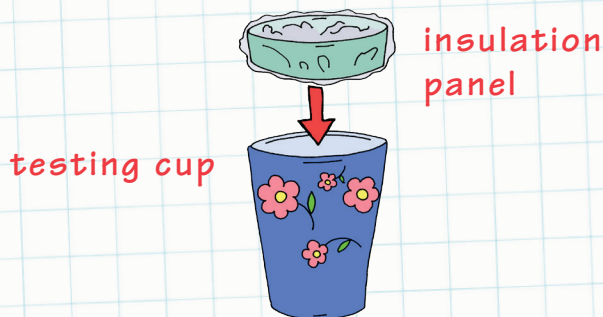
### DETERMINE THE BEST INSULATION TO KEEP ICE CUBES FROM MELTING

Insulation in the home is used for different purposes in different parts of the country. In warmer climates, insulation keeps the cool air in and the hot air out; in cooler climates it has the opposite effect. The purpose of insulation is to slow down the conduction of heat from one side of a wall to the other.

#### SMART START:

- ★ Prepare one paper cup testing station to display as an example. Create a panel of insulation by cutting off the top (approximately 3 cm) of a paper cup and filling with one of the test materials. Use the plastic wrap to cover and keep the material in place and secure with tape. Place the "insulation panel" inside the top of a second whole cup (testing cup). Once the group has seen this sample, remove the test material and use this testing station as the control with no insulation.

- ★ Fill a large pitcher with water and allow it to reach room temperature.



### You'll Need:

- ◆ large pitcher
- ◆ water
- ◆ several insulating materials (shredded paper, bubble wrap, cardboard, packing peanuts, sponges, cotton balls, small scraps of fabric)

#### For each small group

- ◆ 2 ice cubes
- ◆ 1 graduated cylinder (50 mL or larger)
- ◆ plastic wrap
- ◆ 2 large paper cups
- ◆ scissors
- ◆ ruler
- ◆ tape (masking or clear)
- ◆ paper and pencil
- ◆ 1 incandescent lightbulb, 120 watt
- ◆ 1 work light with clamp (or desk lamp capable of holding a 120 watt bulb)
- ◆ 1 stopwatch or clock



#### Here's how:

**1. Question.** Divide the girls into small groups,<sup>1</sup> and introduce the idea of insulation. Have them brainstorm different materials that might provide good insulation for different needs<sup>2</sup> (housing, clothing, food storage, etc.). Deliver the **SciGirls Challenge:** How can you keep ice cubes in a cup from melting?

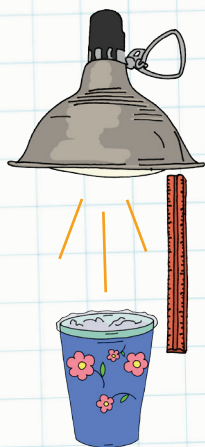
**2. Design the experiment.** Show your example paper cup testing station and ask your girls to choose one material to test. Explain to the girls



# Insulation Station continued

that they'll put water and ice cubes inside the cup to create a temperature difference, then cover the ice water with their insulation panels. Encourage girls to think about the different factors that may affect the outcomes of their experiment.<sup>3</sup>

- ★ **Number** of layers of insulation
- ★ **Thickness** of the insulation panel cut from the paper cup
- ★ **Placement** of the lamp above the cup



To see how the SciGirls test different insulating materials, watch the *SciGirls Investigate* DVD. (Select Insulation Station: Insulation Testing.)



**3. Test.** Prepare and label the test cup with the type of material used. Have the girls pour 50 mL of room temperature water into the testing cup and add two ice cubes. Now, place the cup a set distance away from the lamp, turn the lamp on, and let it sit for 20 minutes. (See example above.)

**4. Analyze.** When the time is up, have the girls remove the insulation and any remaining ice

cubes, and then use the graduated cylinder to measure the amount of water in each cup. Ask girls to record their measurements and subtract the initial volume (50 mL) from the final volume.

**5. Share.** Have groups come together and share their results. Which insulation worked the best? What evidence supports your conclusion? <sup>6</sup> How do you think good insulation would affect a home? Bad insulation?

Watch the SciGirls learn about a solar house on the *SciGirls Investigate* DVD. (Select Insulation Station: Mentor Moment.)<sup>7</sup>



## Mentor Moment

Shengyin Xu is an institutional sustainability specialist who evaluates energy, water, waste, and resource use for the Minnesota Historical Society. She identifies ways to reduce consumption and cost. Also an architect, she worked on the design of an energy-efficient, solar-powered house for the University of Minnesota in the 2009 Solar Decathlon.



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<sup>1-7</sup> See **SciGirls Seven** strategies on page 3.



## Activity 3

# House Warming

### DESIGN A HOME FOR THE CLIMATE WHERE YOU LIVE.

Today, some house builders are using passive solar design to increase energy efficiency. The key is to use the sun's heat to warm a house in the winter, and to avoid the sun's heat in the summer to keep the house cool. In this activity, girls will test paperboard models of different building designs to discover how the design affects the amount of heat that enters the house.

**SMART START:** Set up each lamp at the testing stations (ideally one testing station per small group). The girls' houses should be approximately 8 inches from the bulb; you may need to clamp lights to tables or chairs to achieve this. Be sure to use 120 watt incandescent bulbs. Less powerful bulbs do not put out enough heat.

#### Here's how:

**1. Introduce passive solar heat.** Ask girls about their experience when the sun comes in a window. When do they want sun? When do they not want it?<sup>2</sup> Present the **SciGirls Challenge:** How does the design of a home affect the amount of solar heat that gets in?

**2. Brainstorm.** Ask girls to brainstorm all the variables that could increase or decrease the sun's effect on the internal temperature of a house<sup>6</sup>

### You'll Need:

#### For testing stations

- ◆ 1 120 watt incandescent lightbulb
- ◆ 1 work light with clamp (or desk lamp capable of holding a 120 watt bulb)
- ◆ 1 stopwatch

#### For each small group

- ◆ paperboard (e.g., cereal box, shoebox, tissue box)
- ◆ scissors
- ◆ ruler
- ◆ masking tape
- ◆ 1 thermometer
- ◆ markers
- ◆ paper and pencil
- ◆ optional: plastic wrap for windows



(house shape, house size, window size, window placement relative to the sun).

**3. Choose your variable.** As a large group, decide which variable to test (e.g., window size).

Then, divide girls into small groups<sup>1</sup> and assign each group one version of the variable to test (e.g., small window, medium-sized window, large window).

**4. Design and build.** Have each group sketch a house design, including measurements, and then draw the pieces to be cut on a piece of paperboard. Cut out the pieces, and then tape



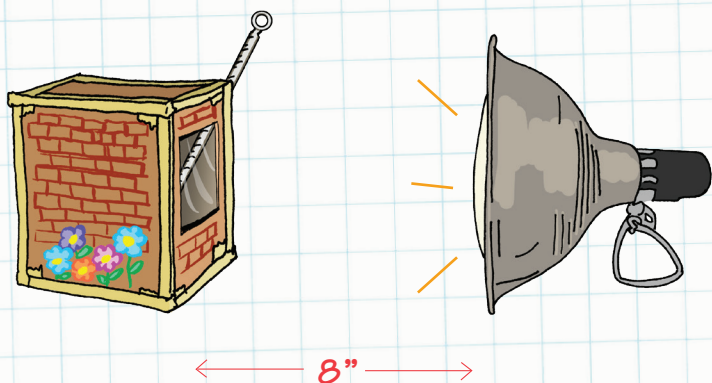
# House Warming continued

the house together, leaving a space to insert the thermometer. Allow time for groups to decorate their houses,<sup>4</sup> but make sure that decorations don't interfere with the variable being tested.



**POINTER:** If girls are struggling to build their house, start by proposing the following challenge. Give one piece of paper, tape and a pair of scissors. Ask them to design and build a self-supporting cube with these materials.

To see how the SciGirls tested their shanty prototype watch the *SciGirls Investigate* DVD. (Select *Insulation Station: Prototype testing*.)



**5. Collect data.** Have the girls secure the thermometer to their house with the end near the center, placing it so it can be read easily. The girls should record the initial temperature, then place the house about 8 inches from the bulb, as shown in the illustration. For the

experiment, the girls will turn on the lamp and record the temperature every minute for 5 minutes. Then they'll turn off the lamp and again record the temperature every minute for 5 minutes.

The lightbulbs will be hot when they have been on for a while.

**6. Analyze results.** Ask the girls, How hot did your house get? How cold? What is the difference between the hottest and coldest temperatures?

**7. Share.** Have groups come together and share their results. Which version of the variables tested was the best design for the climate where you live? What about other areas of the country? What other variables would you test?<sup>6</sup>



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<sup>1-7</sup> See **SciGirls Seven** strategies on page 3.



## Activity 4

# Super Sleuths

### COLLECT, OBSERVE, AND CLASSIFY EVIDENCE TO IDENTIFY THE MOST LIKELY SUSPECT.

No matter how much someone tries to clean up after committing a crime, he or she will leave something behind and take something away from the scene. This idea is known as Locard's Exchange Principle and is why small amounts of material, known as trace evidence, is collected at a crime scene. In this activity, girls will collect trace evidence (glitter) and explore some of its class (or group) characteristics, such as color, size, shape, and light reflection.

#### SMART START:

Set up four to six stations, each containing a shallow dish with a small sample of glitter. Label one station as the crime scene, and the rest with suspects' names. Make sure that one of the suspect glitter samples matches the crime scene glitter!

#### Here's how:

**1. Identify the problem.** A crime has been committed! Glitter was collected as unknown trace evidence at the scene of the crime. After questioning, glitter samples were found on several suspects.<sup>2</sup> Deliver the **SciGirls Challenge**: Collect, observe and classify the trace evidence to identify the most likely suspect.

**2. Collect evidence.** Ask girls how they might

### You'll Need:

- ◆ 4-6 shallow containers (one for each suspect and the unknown glitter evidence)
- ◆ 3-5 different types of glitter (Purchase the same color glitter in different shapes and sizes from a local craft store. SciGirls recommends Tulip Fashion Glitter in silver fine jewel, silver fine hologram and silver medium hologram and Creatology Glitter in sterling and silver.)

#### For each small group

- ◆ 3 magnifying glasses
- ◆ lamp or other bright light source
- ◆ 1 pair of tweezers
- ◆ 1 pad of sticky notes
- ◆ paper and pencil
- ◆ 4-6 notecards (3 in x 5 in, unlined)
- ◆ 4-6 paper envelopes (one for each type of glitter)
- ◆ transparent tape
- ◆ 1 single hole punch
- ◆ light microscope (optional)



collect glitter evidence from each suspect using the materials provided.<sup>3</sup> Have each group<sup>1</sup> move through the stations collecting glitter and placing the evidence in a labeled envelope. (One way is to use a sticky note, placing the sticky area on the glitter to pick it up.)

To see how SciGirls collect evidence, watch the *SciGirls Investigate DVD*. (Select Super Sleuths: Collect Evidence.)





# Super Sleuths continued

**3. Prepare slides.** Punch a hole in an index card and place a piece of tape on the back of the hole. If the girls used sticky notes to collect evidence, press the glitter end onto the tape and gently pull the sticky note off. Some of the glitter will remain on the tape. Repeat a few times if necessary. Then seal with another piece of clear tape and label.



**4. Observe and collect data.** Determine which glitter sample has the same class characteristics as the unknown sample. Examine the known and unknown glitter samples with a magnifying glass, noting color, shape, size and any other distinguishing features of the glitter. Girls should record their observations in a table.



**POINTER:** Make sure the work area is brightly lit, since one of the characteristics of glitter is how it reflects light. It helps to place a sheet of white paper behind the slide if girls are having trouble seeing it. If you have one available, use a microscope to make comparisons.

Watch SciGirls analyze evidence on the *SciGirls Investigate* DVD. (Select **Super Sleuths: Analyze.**)



**5. Draw conclusions.** Each small group should come to conclusions about which known glitter is consistent with the unknown glitter. Make sure the girls support their observations and conclusions with solid evidence.<sup>6</sup>

**6. Share.** Have each small group share their findings. Ask the girls if their investigation indicates that the suspect is guilty. Why or why not? What other evidence would they need to be certain?

## Mentor Moment

Sarah Walbridge-Jones is a forensic scientist who analyzes trace evidence (hair, soil, fibers, paint flecks, etc.) to help solve crimes. Working in a lab, she uses high-tech instruments such as scanning electron microscopes to examine these small particles.

Sarah also likes to share her knowledge of forensics as a professor and guest lecturer at colleges around Minnesota.



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<sup>1-7</sup> See **SciGirls Seven** strategies on page 3.



## Activity 5

# Print Hints

### DETERMINE HOW A "SUSPECT'S" PRINT WAS MADE.

Investigators collect shoe prints from a crime scene to make comparisons with patterns on the sole of a suspect's shoe. Shoe prints can also help determine the entrance or exit point at a crime scene, the direction of travel, or how the suspect was moving (running, limping, etc.). In other fields, trackers and biologists use animal footprints to learn where an animal has been to determine patterns of behavior.

#### SMART START:

For each small group, fill a container halfway with slightly damp (not overly saturated) sand. Make sure groups have access to extra water in case the sand starts to dry out. Keep towels nearby for wiping sand off hands.

**POINTER:** The sand needs to be damp to see the impressions. Remind girls to smooth out the sand with the ruler each time so there is a clear area for the next impression!

#### Here's how:

**1. Observe.** Break into small groups.<sup>1</sup> Have each girl start the activity by pressing their thumb into the sand to make a simple impression. What shape is it? What characteristics differentiate the front and the back? Have girls sketch a diagram of the print and label distinct areas.

### You'll Need:

- ♦ sand
- ♦ 1 large tarp covered with a layer of sand, a sand volleyball court, or natural sandy area (optional)

#### For each small group

- ♦ 1 sturdy plastic container (at least 3 in. deep)
- ♦ 1 ruler or tape measure
- ♦ water
- ♦ 1 magnifying glass
- ♦ 1 towel for wiping off hands and feet
- ♦ paper and pencils



Remind the girls not to throw sand. It can easily cause injuries if it gets in the eyes.



**2. Collect data.** Ask the girls to brainstorm additional ways to make distinct impressions (e.g., press hard, press lightly, or press and turn), then create them in the sand.<sup>3</sup> The girls should draw diagrams of each and note any differences from earlier prints.<sup>6</sup>

**3. Share.** Discuss some of the patterns the groups found while looking at the impressions. What are some unique characteristics that helped distinguish the prints?

**4. Mystery prints.** Have each group set up a mock mystery crime scene and create a set of



# Print Hints continued

thumbprints in the sand.<sup>4</sup> Deliver the **SciGirls Challenge**: Based on what you learned during your observations, can you determine how each suspect's thumbprint was made? Allow girls to rotate and examine each group's mystery crime scene. Then ask girls to share their results.

**5. Continue exploring.** Have girls make different shoe prints on a large sandy area. They might try running, walking, stomping, skipping, tiptoeing, and walking with a twist. Look for patterns and discuss. Then smooth the area and have groups take turns creating and analyzing a crime scene with shoe prints.

Be sure the girls keep their shoes on to avoid injury from sharp materials.



Watch Lindsey and the SciGirls process a crime scene on the *SciGirls Investigate* DVD. (Select Super Sleuths: Mentor Moment.)<sup>7</sup>



## Mentor Moment

Lindsey Garfield received a bachelor's degree in biology and immediately began her career in forensics. She is a crime scene investigator for the Minnesota Bureau of Criminal Apprehension, documenting and collecting physical evidence that helps explain what may have happened during the crime. Lindsey often testifies in court as an expert witness.



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## Standards Correlation

The activities in this book align to national education standards including: Standards for Technological Literacy, Next Generation Science Standards and the Common Core Standards for Mathematics. To download the complete and most current alignments, please visit [scigirlsconnect.org](http://scigirlsconnect.org).

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<sup>1-7</sup> See **SciGirls Seven** strategies on page 3.



# Every girl can be a SciGirl!



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