NanoLeap

Investigating Static Forces in Nature: The Mystery of the Gecko
Lesson 4: What Do We Learn When We Look More Closely?
Explain/Elaborate

Student Learning Objectives:

- Explain how size, structure, and scale relate to surface features
- Describe the function of compliant surfaces with regard to adhesion
  (What happens when a surface of an object is applied to the surface of another object?)

At a Glance for Teachers:

- Mini-Me Activity (optional)
- Visualization and diagramming of surface of gecko foot at various scales

<u>Note: Some questions in the Student Journal are underlined as formative assessment checkpoints for you to check students' understanding of lesson objectives.</u>

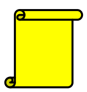
Estimated Time: 45 Minutes

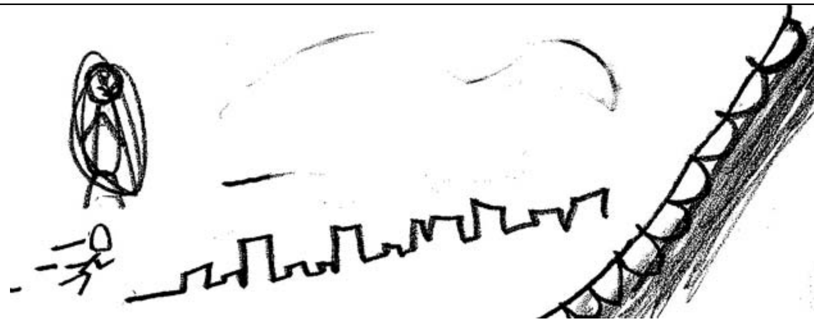
Vocabulary: Adhesive, Compliant, Lamella, Seta, Spatula, Surface Terrain, Topography
Refer to the end of this Teacher Guide for definitions.

Materials

- PowerPoint for Lesson 4
- Student Journals for Lesson 4
- Computer with LCD or overhead projector
- Transparent tape
- Pipe cleaners (for Mini-Me optional activity)
- Measuring tape (for Mini-Me optional activity)
- Modeling clay (for Mini-Me optional activity)

<u>Slide #</u> **Student Journal Page #**	*<u>Teacher Background Information and Pedagogy</u>* **“Teacher Script”**
Slides 1& 2 Student Journal Page: 4–1	***Teacher Background:*** *By definition, an* **adhesive** *is any material that will be useful in holding two objects together solely by surface contact. For an adhesive to achieve extremely close contact with an object, it must have the properties of a liquid, which makes it capable of coming into intimate contact with the surface. In use, an adhesive must be able to resist any applied force that attempts to break the bond formed between it and the object or surface to which it was applied. In other words, it will need the properties of a solid.* *Adapted from Johnston, J. (2003). Pressure sensitive adhesive tapes. Pressure Sensitive Tape Council. Northbrook, Illinois, Page 23.* *1) Provide each student with a piece of transparent tape.* **“Observe the transparent tape on a smooth surface, like a desk. Place the tape on the surface and “rub” out as many of the bubbles as possible. Use a pen to circle the bubbles on the tape. Place the actual tape onto the journal page 4–1 with the bubbles marked.”**
Slide 3 Student Journal Page: 4–1	*2) Based on student observations and this text, ask students questions similar to these below. Solicit from the students their ideas about the properties of the tape. Draw out the properties of solids and liquids and explanations for what makes the tape work.* **“Would you consider the tape stuck to a surface to be an adhesive? Why or why not?”** **“Work in your small groups to describe how transparent tape has the properties of both a liquid and a solid.”**
Slide 4	*3) Ask the students the following:* **“Recall the activity we did with the shoes. What forces exist between each pair of surfaces?”** ○ **“Tape and smooth surface”** ○ **“Shoe and floor”** *Students might say “adhesive force” for the tape and “gravity” for the shoe.* **“Which surface to surface interaction do you think is most similar to a gecko climbing a wall? Explain your answer.”** *Allow students to explain their response.* *4) Note to teacher: For image 4.3, point out that two compliant surfaces would come into even closer contact than one compliant surface with a hard surface.*

Slide 5	5) *The Gecko Up-Close Activity: A gecko can "stick" or adhere to just about any surface from a single toe. Ask the students to make predictions.* **"We are going to be making some close-up observations of the surface of the gecko's foot. Before we take a closer look, predict what you think the surface of the gecko's foot looks like at the nanoscale level."** *Solicit student predictions without comment.* **"Let's take a closer look at the foot of a gecko. Each of the following images takes a progressively closer look at the foot of a gecko."**
Slide 6 Student Journal Pages: 4–2 4–3 4–4 4–5 	*Teacher Background Information: The following description of the anatomy of a gecko's toe is adapted from "The Life of Reptiles Volume I" by Angus Bellairs:* *Each toe pad is covered on its under surface by rows of wide scales called lamellae, which overlap each other at their edges. Each lamella is covered by fine projecting hairs or setae about 100 microns in length. The setae branch and sub-branch several times, the final twigs ending in a pair of minute flattened tips called spatulas. It has been estimated that the total number of setae on all the lemellae of all the toes of the four feet of a gecko is about one million. Each seta carries between 100 and 1,000 spatulas on its branches.* *Optional Hands-On Activity: Use the Mini-Me activity located at the end of this teacher guide (courtesy of the University of Wisconsin, Madison) to provide students with the experience of picturing themselves much smaller than what they are and then sculpting an image that symbolizes their understanding of the invisible world. Once students have built their mini-me, have them proceed to the student journal page 4-2.* *6) Working in pairs, students should respond to the journal prompts and visualize what it would be like to shrink down to these scales and interact with the various structures. Tell them to be creative with their drawings, but also to be as accurate as they can when they "enter" this new world. Provide an example of the first sketch on the board. Students may describe the "view" as appearing like hills and valleys. Below is a sample student drawing depicting the centimeter scale from the field test.*



Optional: You may want to add some discussion about what makes a good scientific drawing.

7) Use the slides at the end of the PowerPoint of this lesson to illustrate a field test student's for each magnification.

As you introduce the four images on this slide, you may wish to use the following descriptions and explanations:

Image (a): "The toes are lined with deep ridges."

Image (b): "At the next higher magnification, one can see that the surface looks like a rug. These yarn-like projections are called "setae." Each seta is 10 times thinner than a single hair on your head. The very end of each seta is frayed into even tinier projections."

Image (c): "At the next higher magnification, one can see that the tiny projections are actually flattened on the end."

Image (d): "These tiny objects are called "spatulas" because of their shape. Each spatula is about 100 nanometers thick. This is the upper limit of the range of what is considered nanoscale science. Nanoscale science is the study of objects in the range of 1–100 nanometers."

"It has been estimated that a gecko has a total of about one million setae on all its feet."

7) Ask the students:

"What is the significance that each seta contains between 100 and 1,000 spatulas?"
Students should conclude that with one million setae, each with 100–1000 spatula, there is a lot of potential for surface contact between the surface and the gecko.

"As the scale decreased, what did you find out about the structure of the gecko's toe?"
As the scale decreased, more and smaller structures became evident in the images.

Slide 7	*8)*	*As a culminating discussion, ask students to respond to the questions in "Making Connections."* **"Let's review briefly your understanding."** **1. "Describe one or two ideas that you learned during this lesson."** **2. "Which range do gecko setae fit into?"** *Micrometer scale* **3. "Which force would make best use of these many points of contact?"** *Adhesive force* **4. "How might the gecko's foot structure help the gecko climb a wall or ceiling?"** *Make sure to talk with the students about the structure of the gecko's foot being compliant with a surface.*
Slide 8	*9)*	*The end of each lesson contains this flow chart that provides an opportunity to show students the "big picture" and where they are in the lesson sequence. The following color code is used:* *Yellow: Past Lessons* *Blue: Current Lesson* *Green: Next Lesson* *White: Future Lessons*

Appendix: NanoLeap Physical Science Vocabulary for Lesson 4

Adhesive
Something that tends to remain in association or attachment

Compliant
1. Soft and able to conform to the surface of another object
2. Yielding to physical pressure

Lamella (Lamellae plural)
Each gecko toe pad is covered on its under surface by rows of wide scales

Seta (Setae plural)
Each gecko lamella is covered by fine projecting hairs or setae about 100 microns in length

Spatula (Spatulas plural)
The setae branch and sub-branch several times; the final twigs end in a pair of minute flattened tips called spatulas

Surface terrain
The physical features of a surface, usually referring to the topography

Topography
1. The physical or natural features of an object and their structural relationships
2. The depths and rises on a surface

MINI-ME

Learning Objectives

To understand the concept of scale
To relate to changes in scale
To learn how to accurately measure length and height

Background:

If the properties of matter are to be truly understood scientists need to be able to change their perspective to understand scale and size. How do we begin to understand a scale we cannot see, a scale that is characterized by less than one hundred millionth of a meter? First we must be able to see ourselves on a very small scale. We must be able to picture ourselves much smaller than what we are and sculpt an image that symbolizes our understanding of the invisible world. Imagine yourself 1/10 of your size, for example if your height is 5 feet your new size would be 6 inches. You will now sculpt a miniature of yourself from clay making sure to keep your height, and the length of your arms and lengths to 1/10 their normal size. You have moved from the meter scale to the centimeter scale. How much more would you need to shrink your sculpture to become the smallest size visible by your eye? (10^{-4}) You would need to shrink another 1000 times smaller than your sculpture. What if you were to shrink to nanosize? You would need to shrink the sculpture 10 million times? You would be the smallest size visible by a special microscope called an electron microscope. Think of the advantage you would have to understand how reactions occur if you could witness them. Now picture the sculpture of yourself as an atom, what would be the normal size of a person? A person would be as tall as the distance across the earth.

Activity

Construction of a Mini Me

Materials:

Pipe cleaners
Measuring Tapes
Crayola Modeling Clay

Procedure:

Each student is given pipe cleaners, a small lump of Crayola modeling clay and a measuring tape. The students should work in pairs and assist each other in measuring their height, and the length of their arm's span. Then each student should take two pipe cleaners and twist them to make the body and legs. Use one more pipe cleaner to make the arms. The length of the body should be 1/10 the student's height and the length of arms of the sculpture should be 1/10 that of the students arm's span. Then the crayola clay should be shaped around the pipe cleaner body and a head should also be fashioned from the clay and slid on the top of the body formed by the pipe cleaners. The sculpture should be allowed to dry and checked for accuracy.

After completing their mini-me have students repeat the process by making a $1/10^{th}$ scale model of their mini-me. This mini-mini-me will now be $1/100^{th}$ of their original size. Ask students how many more times they would need to do this process to make a nanome (7 more times).

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