Sticky Secrets:

Unveiling the Gecko's Defiance of Gravity

Grades 6-8

Pet: **Gecko**	**Class:** **6-8**

Brief Overview: This lesson delves into the fascinating science behind how geckos cling to walls and ceilings, seemingly defying gravity. Students will explore the role of intermolecular forces and friction, then unleash their creativity to design their own gravity-defying invention. For the 3-5 version of this lesson, please see: [Sticky Secrets (Grades 3-5)]	**Lesson Breakdown** **Lesson 1:**Unmasking the Gecko's Grip **Lesson 2:**Testing Gecko Grip with Plastic Wrap **Lesson 3:** Defying Gravity: The Invention Challenge
Essential Question How do geckos use the secrets of science to overcome gravity and stick to seemingly impossible surfaces?	

Subjects ☑ Science ☑ ELA ☑ Math ☑ STEM ☐ Art ☐ Other	**Stem Connections** **Science:** adaptations **Technology:** measuring force **Engineering:** invention challenge **Math:** calculating area

Performance Expectations/ Standards
NGSS Alignment:
MS-LS4-2: Apply scientific principles to construct an explanation for the prevalence of particular characteristics in a population as a result of environmental selection.
MS-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
ETS1.A: Defining and Delimiting Engineering Problems: Define the criteria and constraints of a multi-faceted engineering problem.
ETS1.B: Developing Possible Solutions: Generate and compare multiple possible solutions to a problem based on how well those solutions meet the criteria and constraints of the problem.

CCSS Math Alignment:
7.RP.A.2.b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships**.**
7.NS.A.3 Solve real-world and mathematical problems involving the four operations with rational numbers.
8.MP.2: Reason abstractly and quantitatively.
CCSS ELA Alignment:
RI.7.6: Analyze the relationship between a graphic and its text**.**
W.7.7: Conduct short research projects that answer a question**.**
SL.8.5: Integrate information from diverse sources when constructing arguments.

I CAN statements
- explain how intermolecular forces and friction help geckos stick to walls.
- design and create an invention that utilizes these forces to defy gravity in a specific way.
- communicate the scientific principles behind my invention through written and oral presentations.

Materials
- Sticky Secrets Student Worksheet
- Clear plastic wrap (large enough for group experiments)
- Various textured objects:
    - Smooth, flat surface (mirror, glass sheet, tile)
    - Rough, textured surface (sandpaper, fabric with bumpy texture)
    - Smooth, curved surface (plastic bottle, bowl)
- Variety of additional textures (optional: cork, leather, metal sheet)
- Markers or pens
- Rulers
- Stopwatch
- Spring scales

- Scales
- Weights
- Building materials - cardboard, tubes, tape, scissors, glue, saran wrap, aluminum foil, yarn, string
- [Discovering the Marvels of Gecko Feet]
- [Unleashing the Power of Gecko Adhesion]

Teacher Background

Beyond Van der Waals: Electrostatic Forces Take Center Stage in Gecko Adhesion
For decades, the remarkable ability of geckos to defy gravity, clinging to even the smoothest surfaces, has been attributed to van der Waals forces, weak attractive interactions between molecules. However, recent research reveals a hidden player in this sticky saga: electrostatic forces. This article delves into this groundbreaking discovery, shedding light on the surprising contribution of charged particles to gecko adhesion.

The microscopic marvel behind gecko grip lies in their feet, covered in thousands of tiny hairs called setae. These setae, in turn, are adorned with even smaller spatulae, creating an immense surface area for interaction. Traditionally, scientists believed that van der Waals forces arising from the slight dipoles in these structures provided the adhesive power. However, new studies employing sophisticated techniques like surface charge mapping and triboelectric nanogenerators paint a more nuanced picture.

The key revelation lies in the dynamic nature of gecko-surface contact. As the setae touch a material, friction induces the transfer of electrons, creating opposite charges on the gecko foot and the surface. This results in an attractive electrostatic force, adding a significant boost to the adhesion. The researchers quantified this contribution, demonstrating that electrostatic forces can account for up to 30% of the total sticking power on certain surfaces, particularly those prone to charge transfer like Teflon.

This discovery rewrites the textbook understanding of gecko adhesion. It highlights the complex interplay of various forces, with electrostatic forces stepping up as key players in specific scenarios. The findings have far-reaching implications for biomimetic research, inspiring innovative adhesives and gripping technologies inspired by the humble gecko.

The implications extend beyond engineering. The research sheds light on the intricate adaptations animals employ to thrive in their ecosystems. Geckos inhabiting diverse environments may utilize different combinations of van der Waals and electrostatic forces for optimal adhesion on specific surfaces, like tree bark or smooth rocks. Understanding these adaptations allows us to better appreciate the evolutionary marvels shaping the natural world.

In conclusion, the discovery of electrostatic forces as significant contributors to gecko adhesion unlocks a new chapter in our understanding of this captivating phenomenon. It expands our knowledge of animal adaptations, pushes the boundaries of biomimetic technology, and reminds us that nature holds secrets yet to be unraveled, waiting to inspire awe and scientific breakthroughs.

Lesson 1: Understanding the Gecko's Grip

Time	Materials	Activity
10 mins		Show students videos of geckos scaling walls and ceilings or spend time observing your classroom gecko. Ask the students how they think these tiny creatures achieve this seemingly impossible feat. How does this adaptation help the gecko survive in its natural environment?
15 mins	Discovering the Marvels of Gecko Feet	Explain the concept of attractive and repulsive forces between molecules, introducing terms like van der Waals forces and friction.
20 mins	Hand lenses	Use diagrams or models to showcase the unique structure of gecko feet, highlighting the thousands of tiny hairs (setae) covered in microscopic spatulae. If a classroom gecko is available, have the students observe the setae with hand lenses.

Lesson 2: Testing Gecko Grip with Plastic Wrap

Time	Materials	Activity
15 mins	Clear plastic wrap (large enough for group experiments)	Divide students into small groups of 3-4 members. Assign each group a distinct set of textured objects for testing. Remind them of the adhesive properties of the gecko feet that were discussed in the previous lesson.

	Various textured objects: (see materials list) Sticky Secrets Student Worksheet	Students will be recording their observations in their Student Worksheet. Stick it On: Ask them to place the plastic wrap on each surface, smoothing it out gently. Observe and record observations how easily or firmly it adheres to each texture. Encourage students to use descriptive terms like "sticky," "slippery," or "grabbed." in their observations
15 mins	Rulers Spring scales Sticky Secrets Student Worksheet	Surface Area Matters: Introduce the concept of surface area and its impact on adhesion. Show diagrams or real-life examples of how a larger surface area provides more points of contact and potentially stronger adhesion. Think of sticky notes versus a full sheet of paper, or wet paint adhering better to a rough wall than a smooth one. Briefly review how to calculate area (length x width) Ask students to compare the gripping ability of the plastic wrap on larger and smaller areas of the same texture. Divide the same textured object (sandpaper, cloth, etc.) into two sections of different sizes. Have students mark the outline of each area on the plastic wrap before sticking it to the object. This allows them to visualize and compare the actual surface area in direct contact with the textured surface. The Sticky Tug-of-War: Ask students to gently pull the plastic wrap from each area of the same texture, starting with the smaller one. Qualitative Observation: Encourage them to observe and compare the ease or difficulty of removal, noting any differences in resistance. Quantitative Comparison: After the tug-of-war, repeat the experiment and record the force required to remove the plastic wrap from each area using a spring scale.
5 mins	Sticky Secrets Student Worksheet Stopwatch	**Timing the Grip:** Have the students use a stopwatch to measure the time it takes for the plastic wrap to detach from each surface.
5 mins		Have each group share their observations and findings with the class. Compare and contrast the results from different textured surfaces. Discuss how these findings relate to the actual functioning of gecko feet, highlighting the role of setae and intermolecular forces.

Lesson 3: Defying Gravity: The Invention Challenge		
Time	**Materials**	**Activity**
15 mins	Sticky Secrets Student Worksheet Unleashing the Power of Gecko Adhesion	Present the challenge: Create an invention that can stick to vertical surfaces and hold a specific weight (teacher determined) using only the principles of intermolecular forces and friction. Share the presentation: Unleashing the Power of Gecko Adhesion Brainstorming and Sketching: Students brainstorm ideas in their groups, sketching rough designs and discussing potential materials and construction methods. Encourage them to consider scaling and the weight bearing capacity of their inventions
20 mins	Sticky Secrets Student Worksheet scales,weights,cardboard, tape, paper towel tubes, and string	Allocate time for students to build their inventions, guiding them to test and refine their designs based on results. Use clear criteria for testing, such as the weight held and duration of adhesion.
10 mins		Gallery Walk and Presentations: Each group presents their invention to the class, explaining the scientific principles behind its design and showcasing its performance in the tests. Encourage questions and peer feedback.

Differentiation

For students who need additional support:

- Provide pre-built models or templates for younger students or those needing additional support
- Accommodate different learning styles by allowing students to present their inventions through models, drawings, or multimedia presentations.

For students who need additional challenges:

- Area Challenge: Divide the class into teams and provide them with various textured objects in different sizes. Have them predict which object/area will hold

the most weight using the plastic wrap (ensure weights are appropriate and safe for students to handle). Let each team test their predictions and determine the "stickiest surface" based on the maximum weight their chosen area can hold. Encourage discussion about factors like texture, surface area, and potential reasons for unexpected results.

Assessment				
Category	**4 Points (Exemplary)**	**3 Points (Proficient)**	**2 Points (Developing)**	**1 Point (Emerging)**
Understanding of Electrostatic Forces:	Explains clearly how electron transfer and electrostatic forces contribute to gecko adhesion, using accurate terminology. Discusses the role of surface properties and triboelectric charging.	Provides a good explanation of electrostatic forces and their role in gecko adhesion, but may lack detail or use some inaccurate terminology.	Explanation of electrostatic forces is vague or inaccurate. Focuses primarily on van der Waals forces or misses the role of charge transfer.	Lacks understanding of electrostatic forces. Explanation is irrelevant or absent.
Design Creativity and Functionality:	Design demonstrates significant creativity and effectively utilizes features that maximize electrostatic forces (e.g., rough surfaces, materials prone to charge transfer). Functions well, adhering securely to various surfaces.	Design shows some creativity and includes elements that could enhance electrostatic adhesion. Functionality is adequate, but may not work consistently on all surfaces.	Design lacks creativity and misses opportunities to utilize electrostatic forces. Functionality is limited or unreliable.	Design is unoriginal and lacks features related to electrostatic adhesion. Functionality is poor or nonexistent.

Scientific Justification and Explanation:	Clearly explains how design choices and materials relate to enhancing electrostatic adhesion, citing scientific principles and evidence. Provides well-reasoned justifications for the design's functionality.	Provides some explanation for design choices and their connection to electrostatic forces, but may lack detail or accuracy. Justification for functionality is partially unclear.	Explanation for design choices and their connection to electrostatic forces is vague or inaccurate. Justification for functionality is missing or unconvincing.	Design choices and their connection to electrostatic forces are absent or nonsensical. Explanation for functionality is irrelevant or absent.
Presentation and Communication:	Presentation is clear, engaging, and visually appealing. Effectively communicates design features and their scientific basis to the audience. Uses appropriate terminology and explains concepts in an understandable way.	Presentation is mostly clear and engaging, but may lack some details or visual clarity. Communication of design features and scientific basis is adequate, but may use some inaccurate terminology or complex language.	Presentation is unclear or disorganized. Communication of design features and scientific basis is difficult to understand, with inaccurate terminology or overly complex language.	Presentation is ineffective or absent. Communication of design features and scientific basis is missing or incomprehensible.

Extension

- Have students write fictional stories or scripts featuring characters with gecko-like abilities, focusing on the scientific principles behind their sticky hands.
- Research other animals with similar adaptations, like spiders or tree frogs, and compare their gripping mechanisms.
- Explore the ethical and potential dangers of biomimicry in advanced technology
- Organize a "Geckolympics" where students compete with their inventions in various weight bearing and surface adhesion challenges