SHORT FILMS ABOUT CHEMISTRY

UNDER THE SKIN

IN THE CLASSROOM

IDEAS FOR CLASSROOM LESSON PLAN

UNDER THE SKIN

CLASSROOM LESSON

Lesson Preparation

- Prepare a monitor, internet access to the short film UNDER THE SKIN.
- Prepare copies of *Student Handouts* for distribution.
- Assemble materials for *Material Strength Lab* activity.

Key Words + Phrases

Scientific method, hypothesis, experiment, analyze, conductivity, monomer, polymer, molecule, mimic, physical properties, degrade, biodegradable, investigate, characteristics, sensor, conductive, biodegradable, molecular, amorphous, rigid, elongate, hydrogen bond

Requirements

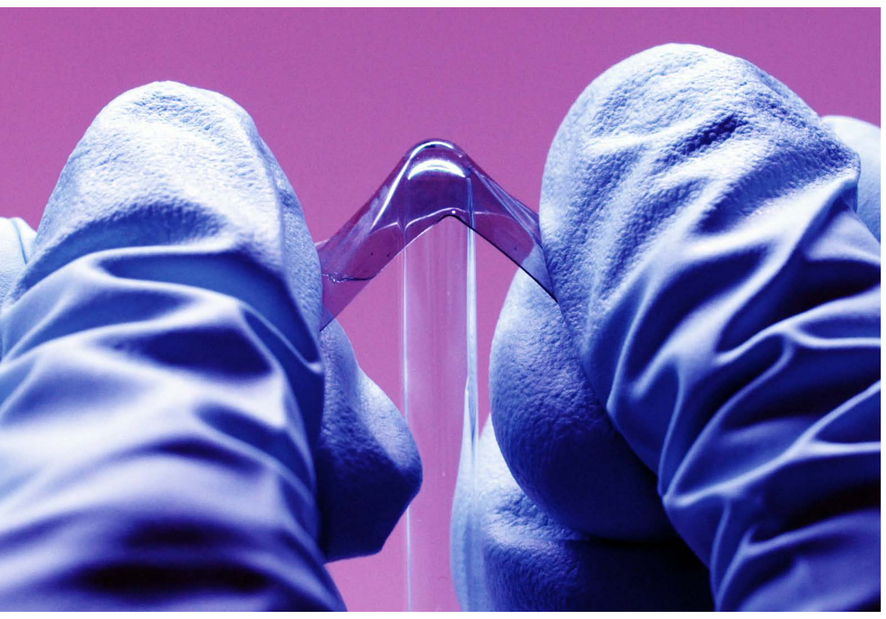
TIME 2 class periods

CLASSROOM MATERIALS

- Whiteboard and markers, chalkboard and chalk, or chart paper and markers
- Monitor/ projector, computer with internet access, or downloaded file of the short documentary, UNDER THE SKIN
- Notebook paper
- *Student Handouts*

LAB MATERIALS

- Basic crafting materials, such as: pompoms, yarn, string, popsicle sticks, stickers, clay, playdoh, beads, foam, straws, paper clips, glue
- Basic measuring tools, such as: rulers, weights, calipers, balances, measuring tape, graduated cylinders, springs, scales, etc.



TECHNIQUES + SKILLS

Vocabulary building, reading comprehension, large group discussion, small group work, working in pairs, problem solving, critical and analytical thinking, supporting ideas with examples, comparing and contrasting information sources, scientific investigation, research and analysis, research skills, listening skills, expository, creative, and responsive writing.

Standards Alignments

HS-PS1-2
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3
Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS2-6
Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

HS-ETS1-1 Engineering Design
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 Engineering Design
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

CCSS.ELA-LITERACY.W.11-12.2
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.

CCSS.ELA-LITERACY.RH.9-10.2
Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text.

CCSS.ELA-LITERACY.RH.11-12.7
Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

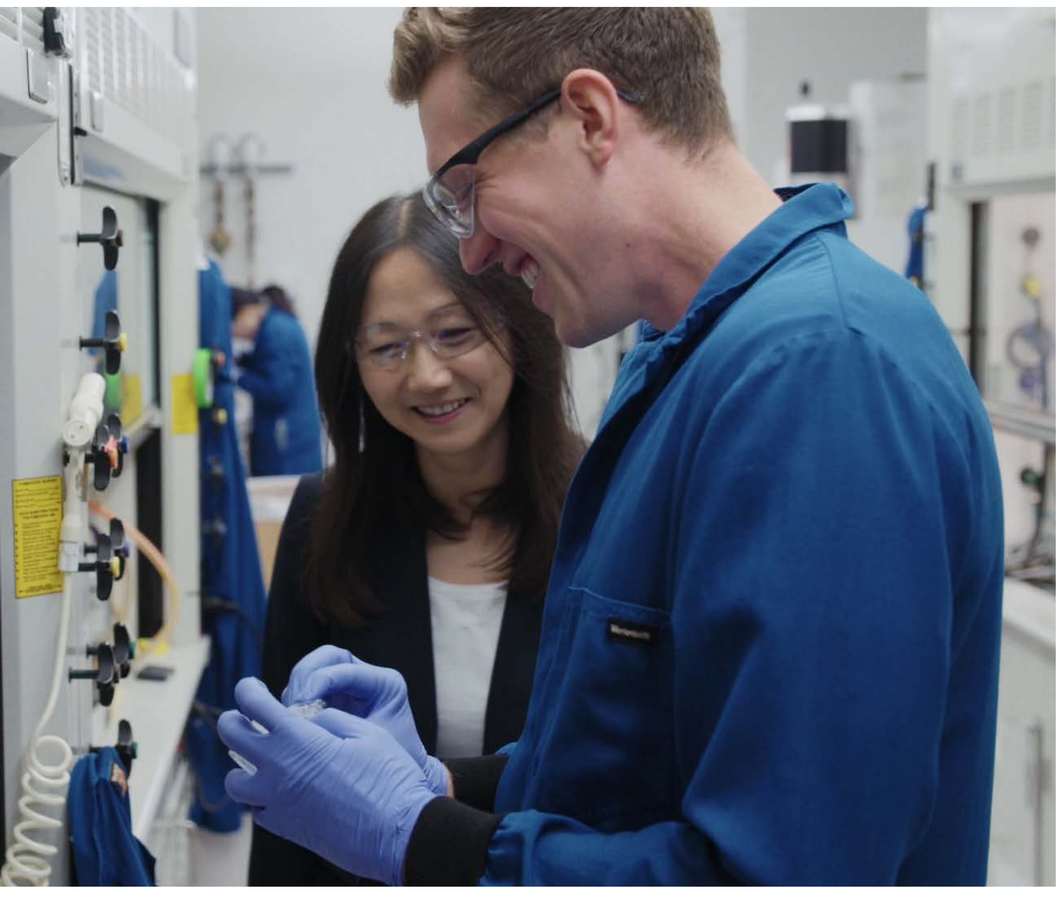
CCSS.ELA-LITERACY.SL.11-12.1.C
Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.

DAY 1

1 Write the following phrase on the board or a piece of chart paper:

EXCITING PROBLEM

2 Give the class 5 minutes to free write on this phrase. What do these words mean? Are they mutually exclusive? Is there such thing as an "exciting problem?" What does this mean in the context of science? What sorts of scientific opportunities can emerge if one sees a problem as "exciting?"



3 Allow 5-10 minutes for the class to share their thoughts. In particular, encourage the class discussion to explore how perspective or attitude can turn a problem into an opportunity, and how this relates to the scientific method.

4 Break the class into small groups of 3-5 students. Distribute *Student Handout: Robot Challenge* to each group. Instruct them to read the scenario on their handout carefully and silently.

5 Allow 15 minutes for the class to work in small groups to complete all the questions on the handout. Then, conduct a short, whole-group discussion, using some or all of the following questions as a guide:

- What are the capabilities or properties that your group decided were the most important? Why are these important for a robot to have?
- What scientific problem or challenge would you need to solve or overcome in order to build your robot?
- What characteristics make your robot "lifelike?"

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DAY 1 (cont.)

- Which of your group's challenges do you think would be the hardest to overcome? Why?
- During your small group conversation, what did the members of your group agree upon? What were your points of disagreement?
- What sciences (i.e., physics, biology, chemistry, computer science, earth science) would you need to use in order to build your robot? Be specific in your explanations!

6 Ask the class for a definition of the term "molecule." Conduct a short discussion with the class about molecules:

- Give an example of a molecule. What properties does that molecule have?
- Give an example of how different molecules have different properties.
- How could scientists use molecular chemistry as part of their experimentation to develop a lifelike robot? Think about this question in the context of materials, and the properties of various materials (plastics, metals, liquids, etc.).

7 Tell the class they will remain in their small groups to conduct a lab experiment to build and measure the properties of a material. Explain that in a real-world scenario, scientists who wish to develop and build robots conduct similar experiments.

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DAY 1 (cont.)

8 Distribute the following to each group:

- A selection of basic crafting materials (pompoms, yarn, string, popsicle sticks, stickers, clay, playdoh, beads, foam, straws, paper clips, glue, etc.)
- A selection of measuring tools (rulers, weights, calipers, balances, measuring tape, graduated cylinders, springs, scales, etc.)
- A copy of *Student Handout: Material Strength Lab* to each student in the group

9 Explain that each crafting material represents a particular "molecule." Give the students a minute or two to investigate their "molecules." Encourage them to touch them, pick them up, compare them in size, weight, texture, etc.

10 Allow 15 minutes for students to test the properties of each individual crafting "molecule." Encourage the groups to use testing equipment such as weights to hang from things, set on things, rulers or calipers to measure length before/after testing, springs to measure tensile strength, scales and balances to measure weight and mass, etc. Testing should be done in groups, but each student should record their findings individually on their own handout.

11 After groups have had adequate time to test their crafting "molecules" and record their findings, conduct a short, whole-group discussion about their experience

- What did they expect to find out?
- What did they discover that surprised them?
- What is the nature of each material as an element/compound/pure substance?

12 For homework, instruct students to review the data they collected in class and develop 3 different plans to combine several components together to make new materials. Their plans must be written out, with full justifications. For example, "Glue a pompom to a popsicle stick to combine the tensile strength of a popsicle stick with the squeezability of the pompom. This hypothetically produces a material that shares these properties." Explain that they will be using these plans with their lab groups in class the following day.

DAY 2

1 Divide the class into their groups from the previous class. Explain that they will be concluding their lab experiment on material strength.

2 Allow 5-10 minutes for students to share their homework (plans for combining components) and come to a consensus on which 2 or 3 plans they want to construct as a group.

3 Allow 10-15 minutes for groups to construct their new materials.

Note: Students who wish to diverge from their original plan should possibly revise their plan at teachers' discretion.

4 Once groups have constructed their new materials, instruct them to analyze the strength of the new material, using the same methods as they did in the previous class. Groups should record their findings on their *Student Handouts*.

Note: If their charts are full from the previous day's experiments, you may distribute another copy of the handout to each student, or, alternatively, instruct them to continue the chart on the back of their paper.

5 Once lab groups have constructed and tested their compound "molecules," ask them to compare their results to the individual component parts. Allow 5 minutes for students to revise the plans they wrote out for homework, based on their findings, adding a description of their new material and their success in synthesizing a material that had the properties they were hoping for.

Note: Timing might be a consideration if glue was used to construct molecules, as it might need time to dry.

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DAY 2 (cont.)

6 Conduct a short debrief as a whole class. Discuss how the process worked, what they found difficult about the process, how successful they were in measuring and building, what caused delays, how their findings differed from their expectations, etc.

7 Instruct the class to turn their attention to the front of the room. They will now be watching a very short video about a team of scientists working together to solve an exciting scientific problem.

8 Before starting the film, distribute *Student Handout: Viewing Guide*. Walk through the instructions, and tell students to complete this chart as they watch the film.

9 Play the film, UNDER THE SKIN (total running time: 7:54).

10 After viewing, conduct a short, whole group discussion about the film. Use some or all of the following questions as a guide:

- How can science turn science fiction into reality? What examples can you think of, where science is bringing science fiction to life?
- Why do you think there is a need to have touch sensors in robots?
- Why is it important to test inventions in "real life" scenarios?
- According to the scientists in the film, what are some of the most important characteristics of human skin?
- Why is it hard to create a material that is both flexible and conductive to electricity?
- What is a monomer? What is a polymer?
- What did you learn about molecules from this film?

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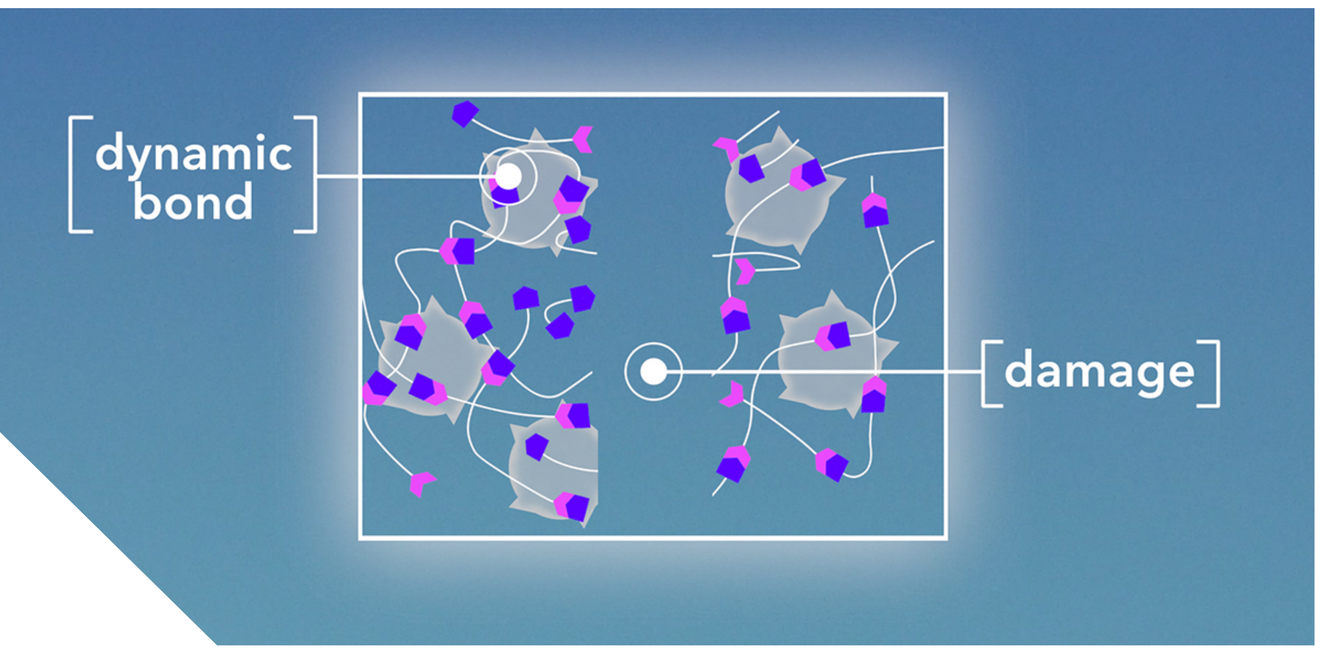
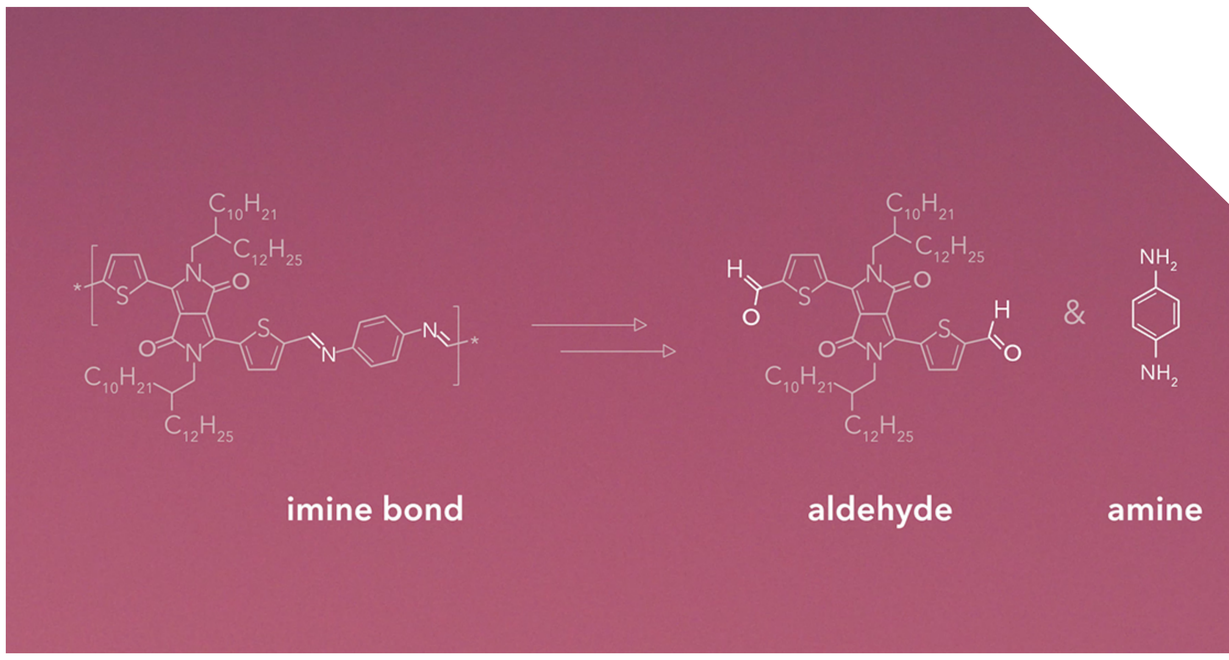
DAY 2 (cont.)

- What examples of molecules, and their unique properties, do you remember from the film? Can you recall one specific molecule mentioned in the film, and the properties of that molecule?
- What is hydrogel?
- What is a bond between molecules
- What are some of the unique problems that can be solved by an electronic skin?
- How did Dr. Bao's inventions help surgeons?
- How is chemistry supporting design and innovation in robotics?





11 Concluding assignment: Write 2-3 paragraphs in response to the following prompt.

> *At the end of the film, Dr. Bao says that she is inspired by other chemists who strive to go beyond the creation of "beautiful molecules." What do you think this phrase means? What is a beautiful molecule? After conducting your lab, and watching this film, what properties do you think a beautiful molecule might have? What makes a molecule "beautiful?"*

ROBOT CHALLENGE

Directions: *Read the scenario and think through the problem. Then, answer the questions based on your thinking.*

Scenario: Imagine that you are on a team of scientists, assigned with the task of designing the perfect robot. Take a moment to consider: what attributes would make a robot "perfect?" What characteristics would it need to have, and what would it need to be able to do, in order to be the most useful, the most lifelike, and best imitation of a living human being?

On a separate piece of paper, answer the following questions.

1. Write a detailed description of your group's robot. What does it look like? What special characteristics does it have? What capabilities? What characteristics make it "perfect?" Feel free to sketch, draw, or graph the robot or parts of it to illustrate your ideas.

2. What are the different scientific disciplines that would you need to apply in order to execute these plans? List the various sciences you'd use (chemistry, biology, physics, computer science, etc.) and describe what you'd need from each in order to build out the functionality of your perfect robot.

3. Based on your answers to questions 1 and 2, complete the following chart:

What characteristics will my robot have?	How could I make those characteristics real?	What kind of science will this entail?
It will have a brain to think	I'll need to build a big computer	Computer science

4. What do you think the most challenging functionalities would be, and why would they be the most challenging to build/ invent/ develop/ execute?

5. Draw the following chart and fill it in based on your answers from question #3. What challenges will you come up against in building your robot, and what solutions might you find to eliminate these challenges?

CHALLENGE	SOLUTION

MATERIAL STRENGTH LAB

***Directions**: Test a variety of properties for each crafting "molecule." List the type of material you're testing in the left hand column, and then, as you test for each property, document the characteristic you were testing for and your results in the chart. Follow the example below.*

Material	Test 1 Results	Test 2 Results	Test 3 Results	Test 4 Results
pompom	Tensile Strength: Comes apart when pulled on by a 250g mass standard	Flexibility: You can squeeze it flat from 0.5 inch to 0.3 inch.``		

VIEWING GUIDE – *UNDER THE SKIN*

Directions: *As you view the film UNDER THE SKIN, take note of places where the team of scientists identified a goal or objective that they wanted to accomplish, what challenge or hurdle they came up against in their investigation to meet that goal, and then what solution, idea or innovation they developed to overcome the hurdle.*

Objective / Goal	Challenge / Hurdle	Solution / Innovation

Chemistry Shorts™ is a film series that communicates the breadth and depth of chemistry's impact on humankind in an approachable manner, sponsored by the Camille and Henry Dreyfus Foundation. These films will celebrate the science and the people who share a passion for the vital role chemistry plays in the biggest issues, including human health, renewable energy, the nature of life, sustainability, new materials, and climate change. Each film incorporates a lesson plan that offers ideas for ways they may be incorporated into the classroom. We welcome your feedback at: **chemistryshorts.org.**

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