CaSTL Center

Invisible Attraction between Water Molecules

NSF Center for Chemical Innovation
Chemistry at the Space Time Limit (CaSTL)
https://www.castl.uci.edu/

Essential Question: How do atomic and molecular interactions explain the properties of matter that we see and feel?

Content Standard(s) Addressed:
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. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipoledipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's Law calculations of vapor pressure.

NGSS Practice Standard(s):
Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
(HS-PS1-3)

Disciplinary Core Idea:
PS1.A: Structure and Properties of Matter
The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3)

Cross-Cutting Concept
Patterns
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Content Learning Objective:
After observing images of water striders in a pond. students will be able to plan and conduct an investigation about the number of drops of water that can be placed on a penny. They will also investigate the number of drops of rubbing alcohol that can be placed on a different penny. They will use the information they learned from their investigation to revise their initial model to explain the attraction between water molecules that allow the water striders to remain on the surface of a pond (surface tension).

Cooperative Groups:
Teacher will have already set norms for working in groups:

- Take turns
- Everyone shares

- Look at the speaker
- Actively listen
    - Nodding
    - Asking questions for clarification
- Respect others' thinking
- Think before speaking
  (from Ferris, S. (2015, July). Making talk productive. *Science and Children, 52*(9), 67 – 73.)

This is a multiple day lesson.

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ENGAGE: ***Anchoring phenomena and central question, relating lesson to phenomena found in students' everyday lives or phenomena that are potentially intriguing, students come up with ideas or hypotheses that may help answer the central question, students construct an initial model***

Estimated time: 45 minutes

Description of Engage: Teacher shows students a short video of water striders walking on water and asks students how this is possible. You Tube video: https://www.youtube.com/watch?v=RphuMEUY3Og **(from beginning to 1:00). Students will come up with ideas in their small groups to explain their observations and will create a drawing on the molecular level that will attempt to explain what they observed. Model must have: a drawing at the molecular level of water molecules, the water strider, forces and their interactions using arrows of various lengths, labels, a written explanation of the phenomenon.**

Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Asking questions Developing a model	I am going to show you a video and I want you to watch it without talking to your group. After I show the video two times, I want you to then talk to your group to share your ideas about what happened and why it happened.	 Students talk in their groups and share their ideas.

	The question we are trying to answer is: **How do atomic and molecular interactions explain the properties of matter that we see and feel?** You are going to create a model to conceptually and visually explain what you observed in the video. Be sure to label the components in your drawing, especially the forces and their interactions. The teacher will walk around the room and probe for understanding. **"***What are the forces in your drawing? How are you displaying those? What is your evidence for the forces you drew?"*	They get chart paper and markers and draw what happened and attempt to explain what happened in their groups, using everyone's ideas. Groups put their models aside for later. They will add to these models after the investigation. **"***The water is holding up the insect. See these arrows. They are pointing up toward the water strider. The water strider doesn't sink so that means that the water is holding it up."*
EXPLORE: ***Students conduct a set of empirical investigations about the phenomena, investigations provide evidence that might be useful for addressing the central question and for revising the students' model, students make observations*** **Estimated time: 30 minutes** **Description of Explore: Teacher assembles the materials ahead of time (1 set for each group): cup of tap water, cup of rubbing alcohol, both labeled; 2 dropper pipettes, one for each cup; 2 or 3 pennies.**		
Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Asking questions Planning an investigation	The teacher will tell the students that they will conduct an investigation to collect evidence to help explain the phenomenon.	

	The teacher tells students that they will try to determine how many drops of water they can put onto a penny. The teacher may model the procedures as well so that the students can see how they will conduct their tests. Then the teacher tells the students that they will repeat the investigation using rubbing alcohol. The teacher will walk around the room and probe for understanding. "*What do you notice?"* "*What might be going on here that we can't see?*" "*What do you think causes the shape of the water on the penny?*" *Are there any patterns or trends?"* "*Why do you think this happens this way?*" Teacher monitors students' conversations and answers to questions to plan which groups will report out in the Explain. The teacher selects groups purposefully and decides how to sequence ideas shared to build conceptual	Students need to determine which variables they will measure. Depending on when in the school year the students do this investigation, the teacher may give them more or less support. Students need to decide how to hold the pipette, how high the pipette should be above the penny, how to decide when the investigation is finished—when to finish collecting data. Students watch the teacher to review the steps of the investigations. Students conduct another sequence of steps to follow the same procedure with the rubbing alcohol. **"***We can put quite a few drops of water on the penny. The water forms a half dome shape on the penny."* *"The water seems to be pulling down on itself."* *"The alcohol does not stay on the penny."* *"The alcohol does not seem to hold onto itself like water."*

	understanding.	Students complete their data table with data from their investigations.
EXPLAIN: ***Students identify and analyze the patterns they find, explain the result, and reflect the results in relation to their model*** **Estimated time: 30 minutes** **Description of Explain: Students talk in their groups about the data and the patterns that they observe. They try to explain what happened in the investigation and try to apply their explanations to the phenomenon and their model. Teacher also asks questions related to the central question that arose from the phenomenon.**		
Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Creating an explanation Drawing a conclusion from evidence	Teacher tells students to talk in their groups to be sure everyone has an explanation for the patterns they observed in the investigation. Teacher asks questions and chooses groups to reply based on the monitoring done in the Explore, choosing groups based on misconceptions, then simple answers then more complex, abstract answers. "*What did you find in your activity?"* "*What patterns did you see in the data?"* "*How might what we did in this activity explain the phenomenon of the water striders walking on water?"* "*How could molecular interactions help us understand what we saw?"* Use evidence from the	Students talk in their groups to be sure they all agree on their explanation. "*We found _____.*" *"The water behaved differently from the alcohol. The alcohol fell off the penny but the water stayed on it, even though we added many drops."* *"There seem to be forces pulling on the water and forces pushing up on the water striders."* *"The water made a half dome*

	investigation to support your statement.	*on the penny so there seems to be forces pulling inward on the outside water molecules."*
EVALUATE: ***Students evaluate their initial model with empirical findings and revise their model*** **Estimated time: 20 minutes** **Description of Evaluate: Students return to their models and revise their models based on their new information from their investigation. They refine their explanations based on their evidence.**		
Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Developing a model Arguing from evidence Communicating information	Teacher directs students to take out their models and add to their drawing, labels, and explanations based on any new evidence they collected in the investigation. Teacher walks around and monitors student work to assess whether students are changing their ideas and adding to their explanations.	Students work productively to change or add to their models and explanations.
EXPLORE: ***Students investigate fundamental scientific concepts, ideas, and theories related to the phenomena or model that they cannot access through empirical investigations—through text, the teacher or computer simulations*** **Estimated time: 30 minutes** **Description of Explore: Teacher gives the students the link to Test Tube Games: Classroom Edition https://testtubegames.com/bondbreaker3.html** **Students can work independently or with one partner to play the first 4 levels of the game. These levels will give the students more information about attraction and repulsion of particles. Students could access the game in class or on their own since the game can be accessed by their phones or by their tablets if they are in a one-to-one district. The levels that pertain to this lesson are Levels 19, 20 and 36. The students should write down important information that they think could help them revise their models.**		
Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Planning an investigation Drawing a conclusion from evidence	When students have completed the levels of the game, students share with each other what they learned	Students tell each other what they learned in the lesson.

Obtaining information Communicating information	in the game that they think can help them with their model. Teacher brings them together to ask questions about particles interacting with each other. "*When did the particles in the game repel each other?"* "*When did they attract each other?"* "*What did you learn about the structure of water that you might use in revising your model?"*	"*Protons repelled each other because they were like charges."* *"When the charges were positive and negative (unlike charges)."* "*Water molecules are attracted to other water molecules."*

EVALUATE: ***Students evaluate and revise their model using scientific ideas to which they have been introduced***

Estimated time: 15 minutes

Description of Evaluate: Students return to their models one more time to add more information from the game. Students then visit each other's posters to see what others have done with the intent of adding to their own poster. While they look at the posters of other groups, they carry post it notes with them to ask clarifying questions, agree with the information they see on the posters, disagree with the information they see, or add on to the information. Each group then returns to its poster and reads the post its that were left by other students. The students make one last revision to the model.

Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Developing a model Creating an explanation Arguing from evidence Communicating information	Teacher tells students to add information to their poster based on the class discussion. Teacher then gives directions on how students will ask clarifying questions, agree with the information they see on the posters, disagree with the information they see, or add on to the information.	Students work productively to make more revisions. Students then walk around and leave productive comments on post its as feedback to classmates.

	Students then visit each other's posters to observe what others have done. They leave feedback on the posters with post it notes.	

EXTEND/ELABORATE: ***Students construct a consensus model either within a small group or as a whole class, using the strengths of each individual's model, students use the consensus model to predict or explain other related phenomena, students determine strengths and limitations of their model for further revision***

Estimated Time: 10 minutes

Description of Extend/Elaborate: Teacher shows the phenomenon video again from the beginning, this time with the sound unmuted. Teacher pauses the video every 10 seconds or so in order to give students a chance to take notes. Students listen to the narrator's explanations and watch his demonstration with milk (beyond the 1:00 minute mark on the video). The teacher asks them if they agree or disagree based on evidence from their investigation or information from the game. Students decide if their model is sufficient to explain the phenomenon.

Science Practice	**Teacher's Role and Teacher Questions**	**Students' Role and Expected Student Answers to Teacher Questions**
Arguing from evidence Communicating information	Teacher tells the students that they will now look at the video again, this time with the sound on so that they can hear the narrator's words. Teacher tells students that they will be able to take notes when the video is paused. After they have had a chance to think about what the narrator said, teacher gives them time to talk in their groups about whether they agree or disagree with the narrator based on their evidence or information from the game. Teacher facilitates a whole class discussion.	Students take notes about the interactions they see in the video. Students might have an alternative explanation for the phenomenon that is different from the narrator's, based on their water drop and alcohol investigations or the game.

	Teacher asks students if their models have enough information to explain the phenomenon. What is their evidence? Teacher then asks students to write three sentences that explain the patterns of interactions they observed in the phenomenon.	Students will look at their model and decide if they can explain the phenomenon based on what they put on their posters. They need to support their statements with evidence from their model. Students should write about: How charged particles repel How charged particles attract How water molecules attract each other

Tools, Materials, & Resources

Equipment needs:	Item: 1 cup of tap water (25 ml)--labeled, 1 cup of alcohol (10 ml)--labeled, 2 or 3 pennies, 2 dropper pipettes—one for each cup
Safety requirements	Keep alcohol away from open flames. Do not breathe alcohol fumes.
Visual aids, Powerpoint slides, handouts.	**TestTube Games: Bond Breaker Classroom Edition** **https://testtubegames.com/bondbreaker3.html** **TestTube Games: Bond Breaker 2.0 (full game)** **http://www.testtubegames.com/bondbreaker.html**

Drop and Penny Investigation

Data Table

Test each of the liquids separately, one at a time, to find out how many drops of each will stay on a penny.

Decide with your group how you will drop each liquid.

Be consistent and record the largest number of drops that stay on the penny before falling off the penny.

	Test	Test	Test
Drops of water			
Drops of alcohol			

What patterns do you notice?