



## Repel or Attract?

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

**Essential Question:** How can one explain the structure, properties, and interactions of matter?

### Content Standard(s) Addressed:

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

### NGSS Science Practice:

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Use a model to predict the relationships between systems or between components of a system.

### Disciplinary Core Idea:

PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.

### 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/Language Learning Objective:

Students will be able to use a model to predict the relationships between charged particles by working in small groups to conduct investigations with everyday materials to observe their interactions and will show their understanding by writing three sentences that explain the patterns of interactions they observed.

### 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: 30 minutes**

**Description of Engage:** Teacher will introduce the phenomenon of materials attracting each other by showing a YouTube video [https://www.youtube.com/watch?v=riMrg\\_kO\\_w](https://www.youtube.com/watch?v=riMrg_kO_w) from 1:00 to 1:41. In the video a stream of water is attracted to a plastic tube that has been charged with electrons by being rubbed with a piece of wool. The water is also attracted to a stick with a positive charge. The narrator in the video gives away too much information so the teacher will show the video with the sound muted, for students to observe. 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.

Science Practice	Teacher's Role and Teacher Questions	Students' Role and Expected Student Answers to Teacher Questions
Asking questions  Developing a model	<p>I am going to show you a video and I want you to watch it without talking to your group.</p> <p>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.</p> <p>The question we are trying to answer is: <b>How can we</b></p>	<p>Students talk in their groups and share their ideas.</p> <p>They get chart paper and markers and draw what happened and attempt to explain what happened.</p> <p>Groups put their models aside for later. They will add to these models</p>

	<p><b>explain the structure, properties, and interactions of matter?</b></p> <p>Be sure to label the components in your drawing.</p> <p>The teacher will walk around the room and probe for understanding.</p> <p>“Do you think both tubes had the same charge? What is your evidence?”</p>	<p>after the investigation.</p> <p><i>“The water was attracted to both the plastic tube and the blue tube. They must have been charged for the water to be attracted to them. The water was attracted to both so the charges on the tubes must have been the same.”</i></p>
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**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: 40 minutes**

**Description of Explore:** Teacher assembles the materials ahead of time (1 set for each group): transparent tape, black sharpie marker, 2 pieces of aluminum foil (1 inch by 6 in) and 2 pieces of white paper (1 in by 6 in). Teacher shows the YouTube video to demonstrate the procedures to the students:

<https://www.youtube.com/watch?v=CW9mfd1EszM>

Teacher starts the video at time 0:28 and ends at 4:46. The teacher will model the directions as well and may ask students to tell what should be done in the investigations to be sure students understand the tests they are conducting.

<b>Science Practice</b>	<b>Teacher’s Role and Teacher Questions</b>	<b>Students’ Role and Expected Student Answers to Teacher Questions</b>
<p>Asking questions</p> <p>Developing a model</p>	<p>The teacher will tell the students that they will conduct an investigation to collect evidence to help explain the phenomenon.</p> <p>Teacher shows the video of the Sticky Tape Investigation with the sound so students can see what they will be doing.</p> <p>Teacher stops the video so students can copy the Data</p>	<p>Students watch video to understand the tests they will conduct.</p>

	<p>Table. Teacher may choose to not do the Plastic and the Glass tests on the Data Table.</p> <p>The teacher may model the procedures as well so that the students can see again how they will conduct their tests. Teacher points out that each material hanging from the table will be tested 4 times: by another tape T, another tape B, another white paper, and another aluminum foil.</p> <p>Teacher asks these questions to be sure everyone is ready: “What will we be seeing happen?”</p> <p>Teacher assigns a student to collect the materials for the investigation for each group. This could be done with assigned roles or Numbered Heads.</p> <p>The teacher will walk around the room and probe for understanding.</p> <p>“What do you see going on here?”</p> <p>“What did you notice when ____ happened?”</p> <p>“What might be going on here that we can’t see?”</p> <p>“Why do you think this happens this way?”</p>	<p>Students watch the teacher to review the steps of the investigations.</p> <p><i>“The materials may move toward each other or away from each other or may not move at all.”</i></p> <p>Assigned student from each group collects the materials for the group.</p> <p><i>“Sometimes the materials attract, sometimes they repel, sometimes nothing happens.”</i></p> <p><i>“The materials must be charged to attract and repel.”</i></p> <p><i>“Like charges repel; unlike charges attract”</i></p> <p>Students complete their data table with data from their investigations.</p>
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	<p>“What do you think causes _____?”</p> <p>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 understanding.</p>	
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**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.**

<b>Science Practice</b>	<b>Teacher’s Role and Teacher Questions</b>	<b>Students’ Role and Expected Student Answers to Teacher Questions</b>
<p>Creating an explanation</p> <p>Drawing a conclusion from evidence</p>	<p>Teacher tells students to talk in their groups to be sure everyone has an explanation for the patterns they observed in the investigation.</p> <p>Teacher asks questions and chooses groups to reply based on the monitoring done in the Explore.</p> <p>“What did you find in your activity?”</p> <p>“What patterns did you see in the data?”</p> <p>“How is what we did in this activity like or unlike the phenomenon we</p>	<p>Students talk in their groups to be sure they all agree on their explanation.</p> <p>“We found that _____”</p> <p>“The tape T repelled tape T but attracted tape B”</p> <p>“The tubes always attracted the water so that is not like what we observed. Sometimes the tester attracted and sometimes repelled.”</p>

	<p>observed?”</p> <p>“What does this help us understand about how materials interact?”</p> <p>“Do we know if our testers were positively charged or if they were negatively charged? What do you think? Use your evidence to support your statement.”</p>	<p>“Materials can attract or repel even though one of the materials is not charged.”</p> <p>“We do not know.”</p> <p>“We tested the tapes on other materials and we think tape T was positive/negative because _____”</p>
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**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.

<b>Science Practice</b>	<b>Teacher’s Role and Teacher Questions</b>	<b>Students’ Role and Expected Student Answers to Teacher Questions</b>
<p>Developing a model</p> <p>Arguing from evidence</p> <p>Communicating information</p>	<p>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.</p> <p>Teacher walks around and monitors student work to assess whether students are changing their ideas and adding to their explanations.</p>	<p>Students work productively to change or add to their models and explanations.</p>

**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: Bond Breaker 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. Teacher will tell students to read the “Tap to Learn More” links as they successfully open the gates to grab the stars. They 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  Obtaining information  Communicating information	<p>When students have completed the four levels, students share with each other what they learned in the game that they think can help them with their model.</p> <p>Teacher brings them together to ask questions about particles interacting with each other.</p> <p>“When did the particles in the game repel each other?”</p> <p>“When did they attract each other?”</p> <p>“What information in the game will help you in revising your model?”</p>	<p>Students tell each other what they learned in the lesson.</p> <p>“Protons repelled each other because they were like charges.”</p> <p>“The hydrogen atom attracted protons because it had an electron between the two protons—the one in the nucleus and the other proton floating free.”</p> <p>“Maybe one of the tubes was positive, like a proton, and it attracted the hydrogen in the water.”</p>

**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, 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. 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	<p>Teacher tells students to add information to their poster based on the class discussion.</p> <p>Teacher then gives directions on how students will <u>ask clarifying questions</u>, <u>agree</u> with the information they see on the posters, <u>disagree</u> with the information they see, or <u>add on</u> to the information.</p> <p>Students then visit each other's posters to observe what others have done. They leave feedback on the posters with post it notes.</p>	<p>Students work productively to make more revisions.</p> <p>Students then walk around and leave productive comments on post its as feedback to classmates.</p>
<p><b>EXTEND/ELABORATE:</b> <i>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</i></p> <p><b>Estimated Time: 20 minutes</b></p> <p><b>Description of Extend/Elaborate:</b> 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 learn that the PVC pipe is negatively charged and the "magic tube" is positively charged. They both attract the water. Students listen to the narrator's explanations. 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.</p>		
Science Practice	Teacher's Role and Teacher Questions	Students' Role and Expected Student Answers to Teacher Questions
Arguing from evidence Communicating information	<p>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.</p>	



	<p>Teacher tells students that they will be able to take notes when the video is paused.</p> <p>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.</p> <p>Teacher facilitates a whole class discussion.</p> <p>Teacher asks students if their models have enough information to explain the phenomenon. What is their evidence?</p> <p>Teacher then asks students to write three sentences that explain the patterns of interactions they observed in the phenomenon</p>	<p>Students take notes about the interactions they see in the video.</p> <p>Students might have an alternative explanation for the phenomenon that is different from the narrator's, based on their Sticky Tape investigation or the game.</p> <p>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.</p> <p>Students should write about:  How charged particles repel  How charged particles attract  How charged materials can repel or attract neutral materials</p>
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### Tools, Materials, & Resources

Equipment needs: per group	<p>Item and Quantity:</p> <p>Role of transparent tape to cut 5 pieces of tape: 4 pieces will have little "handles"</p> <p>2 pieces of aluminum foil (1 inch by 6 inch)</p> <p>2 pieces of white paper (1 inch by 6 inch)</p> <p>black sharpie marker</p>
Safety requirements	Students should use the black sharpies appropriately to label the pieces of tape only.
Visual aids, Powerpoint slides, handouts.	<b>YouTube video</b> <a href="https://www.youtube.com/watch?v=riMrg_kO_w">https://www.youtube.com/watch?v=riMrg_kO_w</a>

	<p><b>YouTube video</b> <a href="https://www.youtube.com/watch?v=CW9mfd1EszM">https://www.youtube.com/watch?v=CW9mfd1EszM</a></p> <p><b>Stated Clearly: What is an Atom and How Do We Know?</b> <a href="https://youtu.be/LhveTGblGHY">https://youtu.be/LhveTGblGHY</a></p> <p><b>Stated Clearly: What Are Atoms Made Of?</b> <a href="https://youtu.be/ooWfzpUIoNM">https://youtu.be/ooWfzpUIoNM</a></p> <p><b>TestTube Games: Bond Breaker Classroom Edition</b> <a href="https://testtubegames.com/bondbreaker3.html">https://testtubegames.com/bondbreaker3.html</a></p> <p><b>TestTube Games: Bond Breaker 2.0 (full game)</b> <a href="http://www.testtubegames.com/bondbreaker.html">http://www.testtubegames.com/bondbreaker.html</a></p>
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## Sticky Tape Investigation

### Data Table

Test each of the four materials hanging from the table with each of the testing materials.

Put **A** if the materials **Attract**, **R** if the materials **repel**, or **N** if there is **no movement**.

	<b>Tape T</b>	<b>Tape B</b>	<b>Foil</b>	<b>Paper</b>
<b>Tape T</b>				
<b>Tape B</b>				
<b>Foil</b>				
<b>Paper</b>				

What patterns do you notice?