Lab 3 - Phlegm: Liquid or Solid?

Teacher Information Sheet

NGSS/Common Core State Standards

Students who demonstrate understanding can:

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to predict and/or describe phenomena.	**PS1.A: Structure and Properties of Matter** • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals) • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Connections to other topics in this grade-level:
MS.ESS2.C

Articulation across grade-levels:
HS.PS1.A; **HS.PS1.B**; **HS.PS3.A**;

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics -

6.NS.C.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.

Interpretation & Description

Students need to be able to differentiate the physical properties of the three states of matter: solids, liquids, and gases. There are endless examples of all three states of matter throughout the human body. There are also many examples that do not quite fit into one category or the other. One such example is the phlegm produced in the respiratory tract when an individual gets sick.

In this activity, students will create a batch of fake phlegm using water, white glue, and Borax They will observe its physical properties as they manipulate it and run it through a few tests. Using what they already know about the physical properties of the different states of matter, they should be able to argue which state of matter would be most appropriate to classify it.

The purpose of the activity is not for students to get to one right answer over the other. Instead, students need to be able to support their claims with the observations they make during the lab.

Learning Targets

By the end of this activity, students will be able to:

- Draw a diagram that depicts the molecular structure of a solid.
- Draw a diagram that depicts the molecular structure of a liquid.
- Determine if an object is a solid or a liquid based on its physical properties.
- Describe what happens to objects at the molecular level when thermal energy is increased.
- Describe what happens to objects at the molecular level when thermal energy is decreased.

Time

Estimated Time	*Actual Time (please make note below)*
45 - 50 minutes	

Note: Share the actual time on the forum (www.haspi.org) or at HASPI curriculum conference

Materials

Supply	Provided (P) or Needed (N)	Reusable? Yes or No	Quantity	Company/ Item #	Approximate Cost
White Glue	P	N	330 ml	http://www.amazon.com/Elmers-Washable-No-Run-School-E304/dp/B000Q3KHCM/ref=sr_1_1?ie=UTF8&qid=1394223166&sr=8-1&keywords=elmers+glue	$0.81/bottle
Borax	P	N	11 g	http://www.amazon.com/Borax-Laundry-Booster-76-Box/dp/B000R4LONQ/ref=sr_1_1?ie=UTF8&qid=1392325940&sr=8-1&keywords=Borax	$10.00/box of 76oz.
Mixing Cups	P	N	33	http://www.amazon.com/Members-Mark%C3%82%C2%AE-Clear-Plastic-Cups/dp/B004SLH7K8/ref=sr_1_2?s=home-garden&ie=UTF8&qid=1392325857&sr=1-2&keywords=plastic+cups+9oz	$23.99/pack of 200
Mixing Sticks	P	N	11	http://www.amazon.com/Cornell-1021254-Woodsies-Sticks-1000-Piece/dp/B0033F7YQW/ref=sr_1_1?ie=UTF8&qid=1389127125&sr=8-1&keywords=popsicle+sticks	$4.99/box of 100
Food	P	N	As	http://www.amazon.com/McCormick-Colors-	$4.98/box of 4

Coloring			Needed	Assorted-0-25-Ounce-Vials/dp/B004HQ9GTE/ref=sr_1_11?ie=UTF8&qid=1394223218&sr=8-11&keywords=food+coloring	
Water	N	N	660 ml		
Graduated Cylinders	N	Y	10	http://www.sks-science.com/lab-supply-p-7000.html (item #237765B)	$77.70/case of 10
Digital Balance	N	Y	As Needed	http://www.tedpella.com/scales_html/compact-scales.htm (compact scale 2000g)	$33.50 each

Additional Information

Information	Page #	Location
It is entirely up to you, but it is recommended that you do not allow your students to take their fake phlegm to their next class. If you want to allow your students to take it home with them, collect all batches of phlegm at the end of each class and have students come back after school to pick some up. You may even want to email your staff and give them a heads-up on whatever policy you decide. For pure fun, and to share the medical focus of your course, you might also invite fellow staff members to join your students during prep periods to make some fake phlegm for taking home to their families!	Setup	
This lab can and probably will get messy. Have paper towels on available.	Setup	
Students will be asked to mix the batches of phlegm on the desks. Any dirt on the tables will be incorporated into the fake phlegm and possibly affect its color. You may want to wipe down the tables before the start of the lab.	Setup	
It is ok to combine all batches of phlegm into one giant collection throughout the day and break off individual pieces as students return after school. Maybe even have students answer a few review questions about solids, liquids, and gases correctly for reinforcement before receiving their fake phlegm.	Setup	
You may want to provide sentence-starters for students that are having trouble forming a hypothesis: • "I think phlegm is a solid because…." • "I think phlegm is a liquid because…" • "I think phlegm is neither a solid nor a liquid because…."	61	Step 1

Instead of having students add their own food coloring to Cup A, it will be much faster for you to distribute it yourself. This will also give you an opportunity to assess student progress around the room.	61	Step 5
The amount of Borax will determine how thick the fake phlegm will be. If there is not enough Borax, the batch will be runny and sticky. If too much Borax is added, the batch will be thick and rigid.	62	Step 7
Be sure students DO NOT use the graduated cylinders to measure out the white glue!	62	Step 8
Re-emphasize the importance of reading through Steps 10-13 in advance and making sure everyone in the group knows what they are doing before conducting each step. Keeping the materials in motion during these steps is very important and there will be no time to stop and double-check what needs to be done.	62-63	Step 10-13
It is extremely important that the Borax is evenly distributed throughout Cup B before it is poured into Cup C. Students should be swirling Cup B constantly until it is added to Cup C. If the Borax is given a chance to settle at the bottom of Cup B before it is added to Cup C, the fake phlegm will not mix evenly.	62	Step 10
Students will notice the contents of Cup C thickening up very quickly around the mixing stick. They can scrape the fake phlegm off of the stick with their hands and continue mixing. The fake phlegm is complete when a consistent texture and color are met. There should be no excess water in the mixture. There will be a point when the fake phlegm thickens to a point that students feel they can no longer mix it in the cup with the mixing stick. At this point have them take the fake phlegm out of the cup and knead it in their hands and/or on the desk. This will be wet and messy at first, but students should be able to incorporate all excess liquid into the fake phlegm the more they knead it. If there is any water left in the cup or that has spilled onto their tables, instruct the students to work it into their fake phlegm as much as possible. If there are batches in the room that are too runny and sticky (not enough Borax) or thick and rigid (too much Borax), an easy solution would be to combine multiple student batches and knead them into one consistent mixture. ***Be ready for the excitement levels to go up in the room.*** Be sure to remind students to stay on task, as this part of the activity will test their maturity levels.	63	Step 13

Glue contains a polymer called **polyvinyl alcohol**, or **PVA**. In the glue-water mixture, these polymer chains slip and slide past each other easily. However, when you add the Borax solution to the glue, it connects one PVA molecule to another in a process known as **cross-linking**. As more chains link up, they no longer slip and slide. Instead, they form a large mat that resembles a net or spider's web. The connection between the Borax and PVA is very loose and not very strong, allowing links between polymers to be easily undone and reformed. When holding the cup at a 90-degree angle, students should notice the fake phlegm will "flow" out of the cup like a liquid. You may want to have a class discussion and highlight that particles at the molecular level are slowly sliding past each other. However, it will not be as quick as a liquid (like water) because of the links between Borax and PVA constantly being broken and reformed. When rolling the fake phlegm into a sphere and dropping it onto the desk, students should notice that the phlegm holds its shape like a solid. However, when allowed to sit on the desk undisturbed, it will flow and take the shape of the desk like a liquid.	63	Step 15
After chilling the fake phlegm in a cold water bath, students should notice it will lose its fluidity and act more like a solid. In a class discussion you may want to highlight that decreasing the temperature (amount of thermal energy) will slow the molecular motion of a substance. If the temperature is decreased enough, liquids will freeze into solids.	63	Step 16
After warming the fake phlegm in a hot water bath, students should notice it will become more fluid and act more like a liquid. In a class discussion you may want to highlight that increasing the temperature (amount of thermal energy) will increase the molecular motion of a substance. If the temperature is increased enough, solids will melt into liquids.	63	Step 17

Resources & References

- http://www.webmd.com/allergies/features/the-truth-about-mucus?page=3
- http://library.thinkquest.org/J0112390/Boogers.htm
- http://www.brainpop.com/health/personalhealth/boogers/
- http://children.webmd.com/tc/cystic-fibrosis-topic-overview
- http://en.wikipedia.org/wiki/Mucus
- http://en.wikipedia.org/wiki/Phlegm
- Branzie, Sylvia. 1995. Grossology: The Science of Really Gross Things. Addison-Wesley Publishing Company. Pg. 12-13, 32-33