States of Matter Lesson 2: *The Make*

Student Guide

Because of the great work you've done in *The Solve*, you've been contacted by the local hospital's Department of Blood Transport. They need your help.

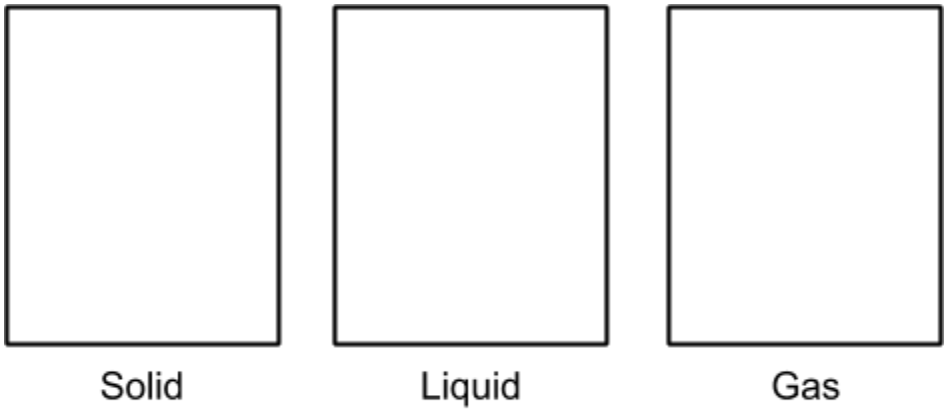
There are patients at the hospital that are in need of blood. The only problem is that the blood they need is out of state. Three doctors are consulted about the best way to safely transport the blood from the out-of-state hospital to your town's hospital, but they all disagree. Which doctor is correct? Your help is urgently needed!

For each question posed, you will:

A. Conduct or observe an experiment.
B. Draw a conclusion from that experiment.
C. Apply your conclusion to decide which doctor's recommendation is correct.

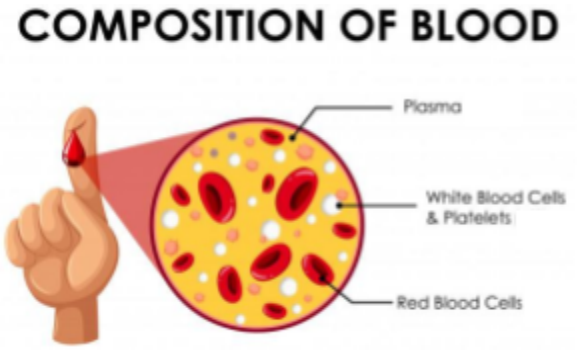
Before you begin, let's review. As you view the slide presentation, complete the States of Matter diagram below. Draw the particle motion of each state of matter and add arrows to show what happens when you:

- increase and decrease thermal energy, and
- increase and decrease pressure.



About Blood

Blood is made up of many components including red blood cells, white blood cells, platelets, and plasma, each of which serves an important purpose.



Question 1: As the blood travels to your hospital, it might be exposed to heat. Is it important to protect the blood from heat, and if so, what protocol should be used?

Investigating this question through an experiment: Metal Ball and Ring.
Your teacher will perform this demonstration, or you will view it here.

1. Draw and describe what you observe before thermal energy (heat) is applied to the ball. (This is the starting position of the ball and ring.)

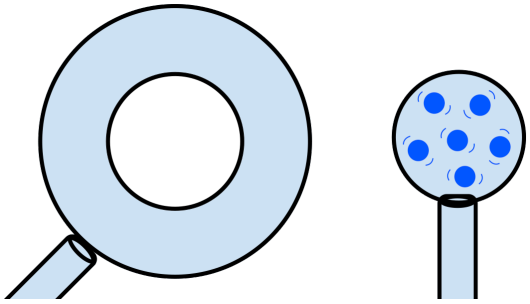
2. Make a claim about what will happen with the behavior of the particles in the metal ball when thermal energy is applied to the ball.

3. What is the source of thermal energy? Describe what happened after thermal energy was applied to the ball.

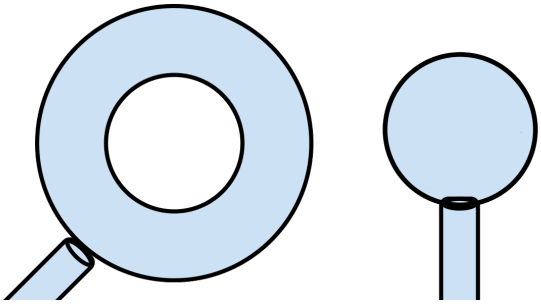
4. Make a prediction. What will happen when the ball cools down (removes thermal energy)? Include the terms “particle motion” and “thermal energy (heat)” in your prediction.

5. Below are two diagrams showing the metal ring and ball. The diagram to the left (Before Heating) shows how the particles are arranged in the metal ball before heat is applied. What happens to the particles once the ball is heated (thermal energy is added)? Draw and annotate the particles on the diagram to the right (After Heating) to show your answer.

Before Heating



After Heating



6. **Make a Claim**: What would happen if a lot more thermal energy (heat) was added to the metal ball? Would the state of matter change? If so, how? What evidence do you have to support your claim? Explain your reasoning.

7. What does this demonstration show you about how thermal energy (heat) affects the motion and average kinetic energy (temperature) of the particles in the substance?

8. **Apply your knowledge from the experiment to draw a conclusion:** As the blood travels to your hospital, it might be exposed to heat. Is it important to protect the blood from heat, and if so, what protocol should be used?

   Three doctors have three different responses to the question.

   Dr. Johnson: Protect it from the heat by keeping it in a temperature-controlled cooler. It's very important to protect the blood from heat because if it gets heated, the molecules in the blood will move faster, spread out, and burst to the point of damaging the blood cells.

   Dr. Khan: Protect it from the heat by double-bagging it. It's not too important to protect blood from the heat because the molecules in the blood won't change when exposed to heat.

   Dr. Furman: There's no need to protect the blood from heat. Heat has no impact on the state of matter of the blood molecules.

   Which doctor is correct? Explain how you used your knowledge from the investigation to come up with your answer.

Question 2: The blood will be transported from a high altitude (low pressure) to a low altitude (high pressure), which means it will be exposed to an increase in air pressure. What material should the blood bags be made of?

Investigating this question through an experiment: Air pressure on a soda can
Your teacher will perform this demonstration, or you will view it here.

1. As the air particles in the can are heated, they are expanding. These expanding particles are increasing the pressure inside the can. In the space provided below, sketch the particle motion before and after heating.

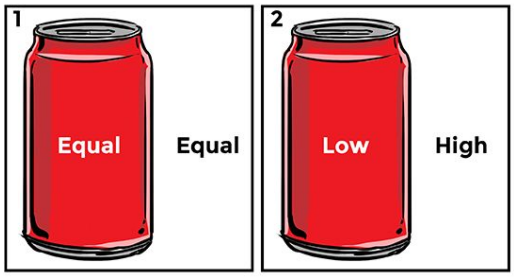
Before Heating	After Heating

2. Observe as the heated-up can is flipped **upside down** into the bowl of cold water. Draw a diagram of what you observed.

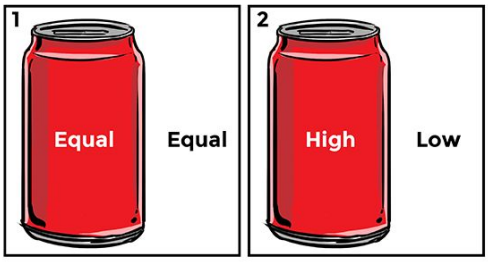
3. The cooling of these air particles causes a decrease in pressure on the inside of the can. On your diagram, label areas of high pressure and low pressure. Include an explanation of why the phenomenon occurred. Review slides 14 and 15 in the slideshow.

4. This demo shows us that when there is a low internal pressure (inside the can), and a high pressure outside of the can, the can gets crushed. Given that information, answer the following questions:

    A. The inside of a can has equal pressure to the outside of the can. If the pressure inside the can decreases and the pressure outside the can increases, will the can explode, implode, or stay the same? Write your answer then draw the final state of the can.



    B. The inside of a can has equal pressure to the outside of the can. If the pressure inside the can increases and the pressure outside the can decreases, will the can explode, implode, or stay the same? Write your answer then draw the final state of the can.



5. **Apply your knowledge from the experiment to draw a conclusion:** The blood will be transported from a high altitude (low pressure) to a low altitude (high pressure), which means it will be exposed to an increase in air pressure. What material should the blood bags be made of?

    Three doctors have three different responses to the question.

    Dr. Johnson: Blood bags should be transported in a tin can. It is the least expensive option and when the external pressure increases, the can will not be impacted.

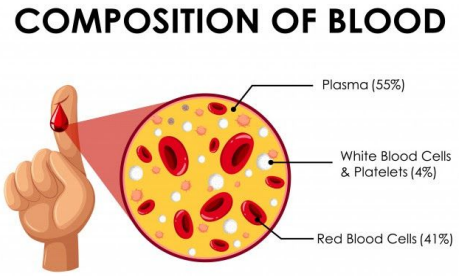
Dr. Khan: Blood bags should be transported in a flexible plastic bag. The bag would be exposed to an increase in pressure, which means the bag would ***expand****. The flexible plastic would be able to withstand that change in pressure.*

Dr. Furman: Blood bags should be transported in a flexible plastic bag. The bag would be exposed to an increase in pressure which means the bag would ***collapse****. The flexible plastic would be able to withstand that change in pressure.*

Which doctor is correct about the transportation *and* reasoning? Explain how you used your knowledge from the investigation to come up with your answer.

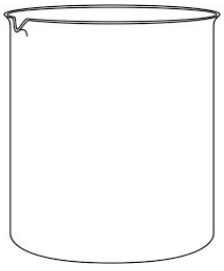
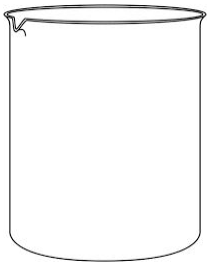
Question 3:

Blood plasma is a thick yellowish liquid in which the blood cells are suspended. Blood plasma is important because it carries nutrients, proteins, and hormones throughout the body. It also helps the body maintain a healthy blood pressure.

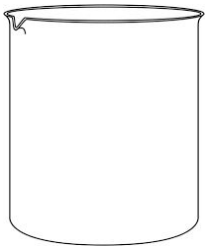
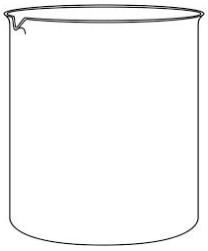


Frozen plasma has been delivered successfully to the hospital and is ready to be used. Defrosting plasma can be tricky because it can't be done too quickly or too slowly— otherwise the plasma can be ruined! The plasma is transported in bags that can withstand exposure to heat. But how should we thaw the plasma? We'll need to come up with two strategies.

Thawing the Plasma Strategy 1: Submerging the Plasma
Investigating this question through an experiment: Food Coloring and Water Molecule Mixing

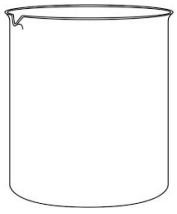
Predict: Review the diagram of particle motion you drew on the first page. How do you think the food coloring will mix in hot vs. cold water? Label and illustrate your predictions below with what you believe the water will look like at the 30-second mark.	
Hot Water 	Cold Water 

Now you will either perform this experiment in class, or you can view it here.

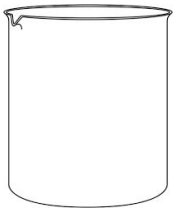
Hot Water	Cold Water
Water temperature:_____	Water temperature:_____
Draw and label a diagram of what you observed (using arrows to represent particle motion): 	Draw and label a diagram of what you observed (using arrows to represent particle motion): 
Observations:	Observations:

Reflection Questions

1. Label the beaker with the most and least thermal energy.



Cold Water



Hot Water

2. In which beaker was particle motion fastest? What is your evidence?

3. In which beaker was particle motion slowest? What is your evidence?

4. Fill in the chart below.

Thermal Energy	Particle Motion (write fast/slow)	Kinetic Energy (write high/low)	Average Kinetic Energy (Temperature) (write high/low)
High			
Low			

5. **Apply your knowledge from the experiment to draw a conclusion:** Frozen plasma has been delivered successfully to the hospital and is ready to be used. Defrosting plasma can be tricky because it can't be done too quickly or too slowly—otherwise the plasma can be ruined! How should we thaw the plasma? Three doctors have three different responses to the question.

   Dr. Johnson: Thaw the bag by submerging it in cold water. The particles in cold water will move faster than particles in warm water, which will therefore thaw the plasma quickly and consistently.

   Dr. Khan: Thaw the bag by submerging it in warm water. The particles in warm water will move faster than particles in cold water, which will therefore thaw the plasma quickly and consistently.

   Dr. Furman: Thaw the bag by submerging it in ice water that is the same temperature as the frozen plasma. The particles in frozen water will move faster than particles in warm water, which will therefore thaw the plasma quickly and consistently.

   Which doctor is correct? Explain how you used your knowledge from the investigation to come up with your answer.

Thawing the Plasma Strategy 2: Heating it on Metal

Investigating this question through an experiment: Butter Boats
You will conduct an investigation, or you will view it here.

Temperature Data Table (°C and °F): Butter Boats

	Before	After	Change in temperature (After *minus* Before)
Water			

Diagram and Reflection Questions: Butter Boats

1. Draw labeled “Before” and “After” diagrams of your setup and results. Use red arrows to show the direction of thermal energy transfer. Be sure to label areas of high temperature (average kinetic energy), thermal energy, and fast particle motion.

2. When did you witness phase change in this investigation?

3. Make a claim as to why the thermal energy transfer caused a phase change for only some of the butter. Cite your evidence and explain your reasoning.

4. **Apply your knowledge from the experiment to draw a conclusion.**
Since the frozen plasma has been delivered, the doctors feel strongly we need to think of another way to thaw the plasma, as backup. How else could they thaw the plasma? Three doctors have three different responses to the question.

   Dr. Johnson: Place the bag on an aluminum tray and float the tray in warm water, letting it sit for 45 minutes. The heat from the water will transfer to the bag to defrost it. At the end of 45 minutes, the temperature of the water will have decreased, but the temperature of the blood will have thawed, and increased.

   Dr. Khan: Place the bag on an aluminum tray and float the tray in warm water, letting it sit for 10 seconds. As soon as the plasma bag hits the water, the whole bag will thaw. At the end of the 10 minutes, the temperature of the warm water bath will remain the same as it did initially.

Dr. Furman: Place the bag on an aluminum tray and float the tray in cold water, letting it sit for 45 minutes. The heat from the blood will transfer to the water, which will thaw the bag. At the end of 45 minutes, the temperature of the water will have increased, but the temperature of the blood will have thawed, and decreased.

Which doctor is correct? Explain how you used your knowledge from the investigation to come up with your answer.

Final Conclusion

Now that you have completed all your investigations, you'll need to record your findings. To ensure that everyone can easily see your results, finish the instructions on the bags below.

Name: _____ Date: _____

Exit Ticket: Connection to the Design

1. When a substance is heated/cooled in any state (liquid, solid, or gas), what happens to its particles? Give at least two pieces of lab evidence to support your answer.

2. It is important to keep the right amount of air in your bike tires because if you have too much air inside of the tire, it will wear out more quickly. If you have too little air in your tires, too much of the tire will be rubbing against the ground, and it will force you to work harder to move the bike. You last checked the pressure in your tires in the summer. It's now winter and your tires seem deflated. Why do you think this is? Explain your answer using evidence of what you know about pressure and temperature.

3. What are the necessary conditions to cause a phase change? Use evidence from at least one of the investigations or demonstrations to explain your reasoning.

4. In a closed container (system) of water (pure substance), how do temperature changes affect kinetic energy and pressure? Fill in the following chart, using ↑ for increases, ↓ for decreases, and = for stays the same.

Temperature Change	Kinetic Energy Change	Pressure Change	Particle Motion
Water temperature is increased from 0^0C to 100^0C			
Water temperature is decreased from 80^0C to 20^0C			
Water temperature is maintained at 50^0C			

***The Make* Assessment**

Use the States of Matter *The Make* Checklist and Cognitive Skills Assessment below to make sure you have done your best possible work.

States of Matter *The Make* Checklist

Your Challenge: Collect evidence about thermal energy, kinetic energy, particle motion, and pressure to help design the best protocol for doctors who need to store, transport, and thaw blood plasma.

Project Completeness:

- ❏ **Question 1: Metal Ball and Ring Demonstration**
  - ❏ Completes all activities aligned with Metal Ball and Ring Demonstration
  - ❏ Answers Question 1: Is it important to protect the blood from heat, and if so, what protocol should be used?
- ❏ **Question 2: Soda Can Demonstration**
  - ❏ Completes all activities aligned with the Soda Can Demonstration
  - ❏ Answers Question 2: What material should the blood bags be made of?
- ❏ **Question 3: Food Coloring and Water Molecule Mixing and Butter Boat Investigation**
  - ❏ Completes all activities aligned with the Food Coloring and Water Molecule Mixing Investigation
  - ❏ Completes all activities aligned with the Butter Boat Investigation
  - ❏ Answers Question 3: But how should we thaw the plasma? We'll need to come up with two strategies.
- ❏ Describes the best protocol for storing, thawing, and transporting blood using evidence from each investigation
- ❏ Exit Ticket accurately predicts how particle motion changes as substances change state/thermal energy transfer/kinetic energy/pressure changes

DCI Standards Checklist:

- ❏ Identifies relationships among increases in temperature, increases in kinetic energy / motion of particles, change in states of matter of pure substance, and changes in pressure in a closed system.
- ❏ Describes structures and properties of states of matter (in pure substances).
- ❏ Students understand that when the kinetic energy of the object increases or decreases, the energy of other objects changes indicating that energy was transferred to or from the object.

Cognitive Skills Assessment

	Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Analyzing and Interpreting Data	Constructs diagrams or visuals that do not display all data. Analyzes data with major misconceptions or omissions.	Constructs diagrams or visuals that display all data, but does not analyze relationships. Analyzes data with minor misconceptions.	Constructs diagrams or visuals that display all data and makes simple connections between variables. Analyzes data to provide evidence for phenomena.	Constructs diagrams or visuals that display all data and makes complex connections between variables. Analyzes data to provide evidence for phenomena and acknowledges limitations.
Developing & Using Models	Drawings, diagrams, or visual models include major misconceptions or have missing parts. Explanation of the model is minimal or not present.	Drawings, diagrams, or visual models include minor misconceptions or have missing parts. Explanation of the model is minimal.	Drawings, diagrams, or visual models are complete, but contain a minor misconception. Explanation of the model is complete but lacking complexity.	Drawings, diagrams, or visual models have no misconceptions and contain all details. Explanation of the model is complete and complex.