Gizmos

Name: _____ Date: _____

Student Exploration: Convection Cells

Vocabulary: convection, convection cell, density, global conveyor belt, mantle, mid-ocean ridge, subduction zone, vector, viscosity

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)
You place a pot of soup on the stove. As the soup warms you notice some areas where soup is rising up and other areas where soup is sinking down.

1. Why do you think some of the soup is rising up?

   _____

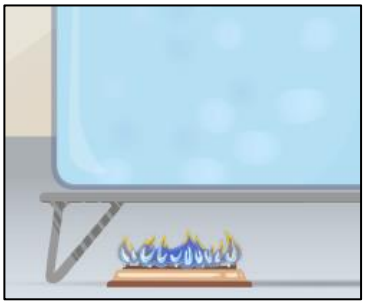
   _____

2. Why do you think some of the soup is sinking down?

   _____

   _____

Gizmo Warm-up
When fluids (gases or liquids) are heated, they tend to move. This motion is called **convection**. In the *Convection Cells* Gizmo, you will observe and experiment with convection both in a laboratory setting and in several real-world examples.



To begin, note the laboratory setup on the MODEL tab. A beaker of liquid is placed above a gas burner. Click **Play** ( ). The burner is now heating the fluid.

1. What do you notice? _____

   _____

2. Drag the eyedropper into the beaker just above the burner and let go to release a drop of orange liquid into the beaker. What do you notice about the path of the drop?

   _____

   _____

Activity A: **Convection**	Get the Gizmo ready: • Click **Reset** (↺), and set **Burner A** to **High**.	

Question: What causes convection cells to form?

1. Hypothesize: Click **Play**, add a drop, and watch the motion of the liquid. Why do you think convection tends to occur in heated fluids?

   _____

   _____

2. Observe: Click **Clear drop**. Under **Show**, select **Temperature**. The temperature scale runs from red (hot) to dark blue (colder).

   A. Where is the hottest liquid located? _____

   B. Where is the coldest liquid located? _____

   C. Add a drop. Does the hottest liquid tend to rise or sink? _____

   D. Does the coldest liquid tend to rise or sink? _____

3. Observe: Click **Clear drop**, and then add a new drop to the liquid. Turn on **Show micro view of drop**. This view shows 21 molecules in the drop. Pay attention to how fast the molecules move and how much space they occupy as the drop moves around the beaker. (Note: If the drop gets stuck, add a new drop to the beaker.)

   A. In which part of the beaker do the liquid molecules move fastest? _____

   B. In which part are the liquid molecules most spread out? _____

4. Explore: Click **Clear drop** and drag the **probe** (⊕) into the beaker. **Density** is defined as the mass per unit volume. It is a measure of how tightly the particles of a substance are packed. Move the probe to different parts of the beaker, observing the temperature and density.

   A. What relationship do you observe between the temperature and density? _____

   _____

   B. Why do you think this is so? _____

   _____

   _____

(Activity A continued on next page)

Activity A (continued from previous page)

5. Explain: In a liquid, objects denser than the liquid (such as rocks) tend to sink, while objects less dense than the liquid (such as inflatable rafts) tend to rise. How does this relate to the observed motions of the liquid in the beaker?

Convection occurs because heated fluids become less dense, causing them to rise. Cooled fluids become denser, causing them to sink.

6. Observe: Click **Reset**. Select **Motion** and turn on **Show velocity vectors**. Click **Play**. The **vectors** (arrows) show the speed and direction of the liquid at each point in the beaker.

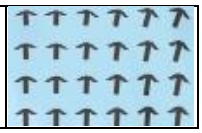
   A. What is the general pattern of motion?

   This circulation is known as a **convection cell**. In a convection cell, hotter fluid rises while cooler fluid sinks.

   B. Why do you think the liquid in the bottom of the beaker moves to the left, while liquid at the top of the beaker moves to the right?

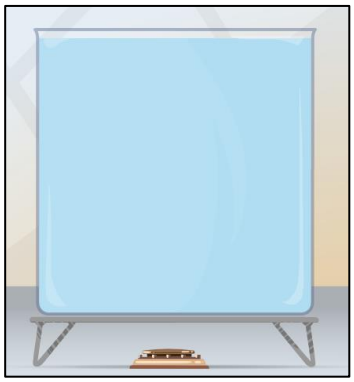
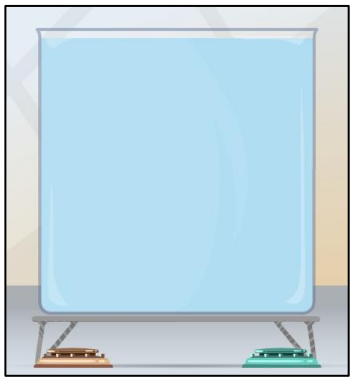
   In the convection cell, liquid moves horizontally because it is pushed by other liquid. The liquid at the top of the beaker moves to the right because it is pushed by the rising liquid on the left. The liquid at the bottom of the container is pushed to the left by the downward-moving liquid on the right. The whole beaker is a closed system, so liquid motion in one part of the beaker must be offset by liquid motion elsewhere.

7. Summarize: In your own words, describe what causes convection to happen and what causes convection cells to form.

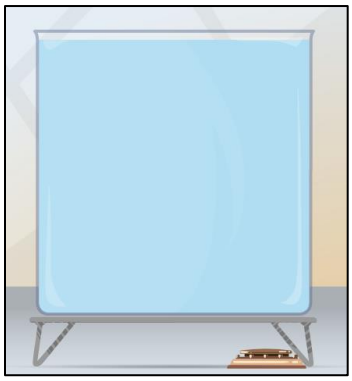
Activity B: **Factors that affect convection**	Get the Gizmo ready: • Click **Reset**. Set **Burner A** to **High**. • Turn on **Advanced features**.	

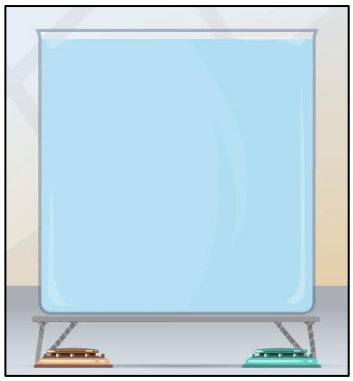
Question: What factors affect the characteristics of convection cells?

1. Predict: For each of the configurations below, predict what the convection cell (or cells) will look like. Draw a sketch with arrows showing the motion of the liquid in each diagram. (Note there are two burners in the right-hand image.)

2. Test: Use the Gizmo to model each scenario by dragging the burner left or right. In each case, set the burner to **High**. For the two-burner simulation, turn on **Advanced features** and select **Add a second burner**. For best results, set the **Viscosity** to 0.0 m^2/s. Turn on **Show velocity vectors** and sketch the results, then explain why the liquid moves as it does.





_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

(Activity B continued on next page)

Activity B (continued from previous page)

3. Experiment: Click **Reset**. Turn off the second burner and move burner A to the left side of the beaker. Experiment with the four burner settings to ***determine how the amount of heat affects the speed of the liquid.***

What did you find? _____

_____

_____

4. Explain: Why doesn't a convection cell form when the burner is turned off? _____

_____

5. Observe: Select **Atmosphere**. The atmosphere contains three large-scale convection cells. Click **Play** to observe these cells, and then select each orange dot to learn more.

   A. What causes air to rise near the equator? _____

   _____

   B. What causes air to sink near the latitude 30° N (and 30° S)? _____

   _____

   C. Why are climates generally wet near the equator, and generally dry around the latitudes 30° N and 30° S? _____

   _____

   _____