Getting Into Hot Water

Grade: «grade»

Subject: «subject»

Date: «date»

In *Moving Heat*, you saw how convection moved heat in air and water.

But earth has several states of matter that become warm from the Sun's energy.

They consist of **solid**'s of earth, **liquids** of the hydrosphere, and **gases** of the atmosphere. Transferring heat on earth needs to involve each of these.

How does heat move away from the equator?

Torrid Tropics, Cold Poles

You've talked about the heating of earth's surface and air at several scales- from the globe to the convection box.
Near the equator, **solar radiation** is most intense. Climates there are **tropical**, or "torrid".
At higher latitudes, solar energy arrives to earth at an **angle**.
Because of this, heat gathers fastest at the equator.

Even for the water in the oceans, the equator is a region of heating.

In fact, most of the equatorial regions are **ocean**.
Only a small amount of land lies along the equator.

1 What type of matter is mostly found at the equator?

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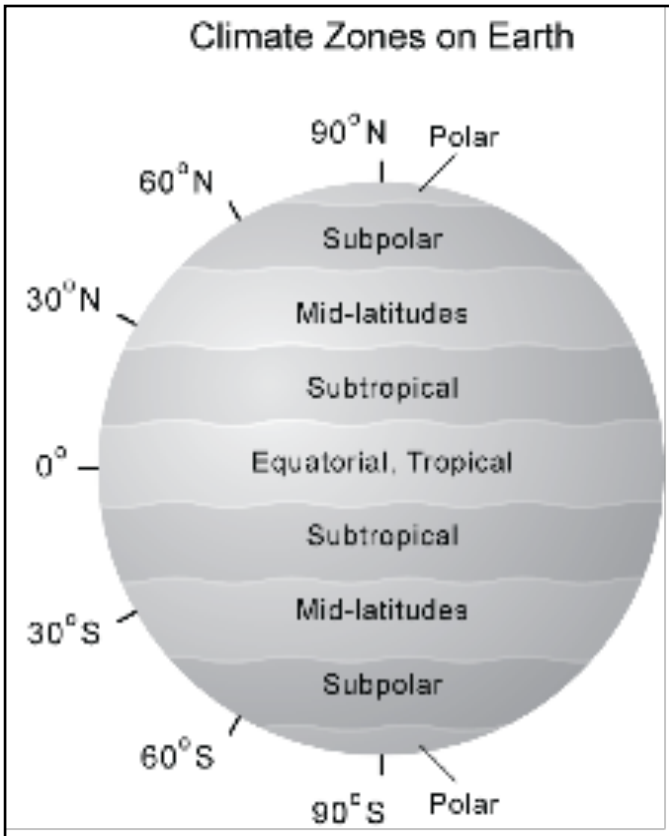

Figure 6: Climate Zones. Earth has several climate zones. They depend on latitude. Most parts of the U.S. are in the mid-latitudes. Some parts of Florida are subtropical.

1 How many different types of climate zones are there on earth?

A 2

B 3

C 4

D 5

E 6

F 7

G 9

In other science classes, you may have also studied factors that cause the weather patterns you see on earth. The energy for these patterns comes from **the Sun**, of course.
But there's another key player that is a big part of climate and weather. That's water- the **molecule H2O**.

The map on the next screen shows how solar heating leads to high water temperatures near the equator.

You also know what happens when the Sun warms bodies of water like the ocean. The water evaporates.

Evaporation is the process where **H2O absorbs heat** and changes from the **liquid** state to the **vapor state**.

2 What state of matter for water results from evaporation?

Hot water

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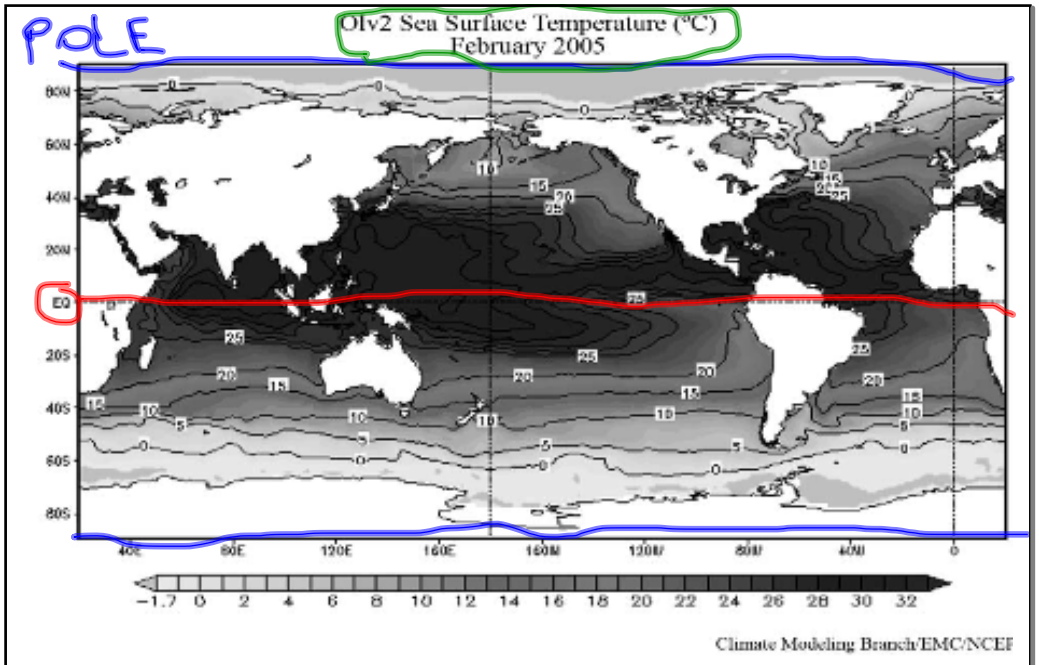


Figure 7: Hot Water. Energy from the Sun heats the Pacific, Indian, and Atlantic Oceans at the equator. This heating drives convection over the hot water. Winds then move that heat.

When water **evaporates** from warm oceans, it transfers **energy** from the heated water back to the **atmosphere**.

As the moist, warm air rises, it also cools. When the air cools enough, water vapor condenses to form clouds.

Why did the air rise? Because it is warmer than its surroundings.

In previous activities you saw examples where hot air or water carried heat upward. You also saw cooler water or air move downward.

The process was called convection.

The cycle of air flow that you saw in the convection box is called a **convection cell**.

1 A cycle of warm air rising and cool air sinking is called a convection _____.

2 What happens to moist, warm air as it rises?

You can **compare** evaporation of a pan of warm water with that of warm, tropical oceans.

You can also **compare** *convection cells* from the box with *convection cells* around the globe.

In the early 1700s, **George Hadley**, a British scientist, thought about the uneven heating of earth with latitude. He reasoned that these conditions should result in a **large convection cell**.

Such a convection cell would lead to warm air rising at the equator. The rising air would then flow away from the equator. **This would carry heat to higher latitudes**. It would also draw surface air back to the equator.

And it should result in a large convection cell.

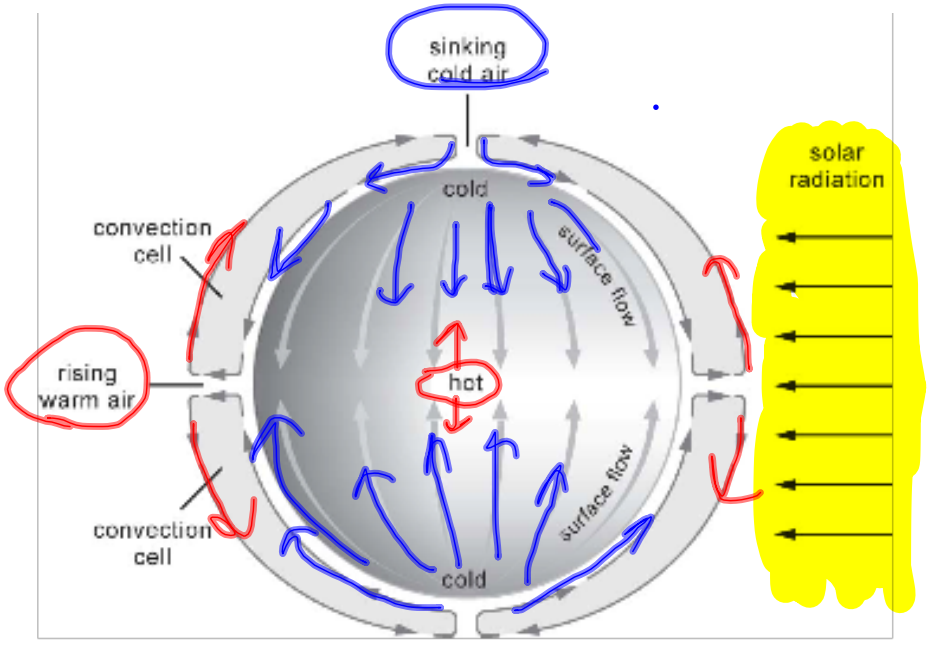


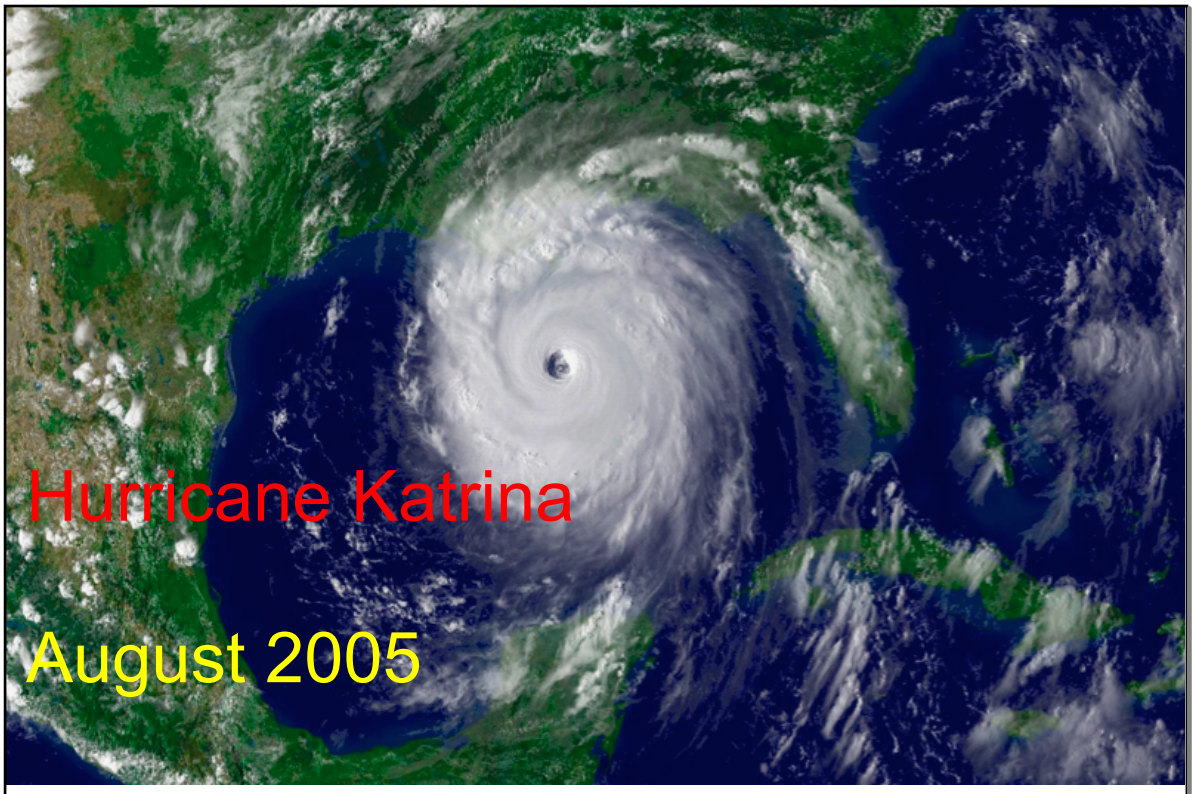
Figure 8: A Simple Convection Model. Hadly suggested a model like this for convection cells. Warm air rises at the equator, and sinks at the poles. Surface winds return cool air to the equator, where they warm-up.

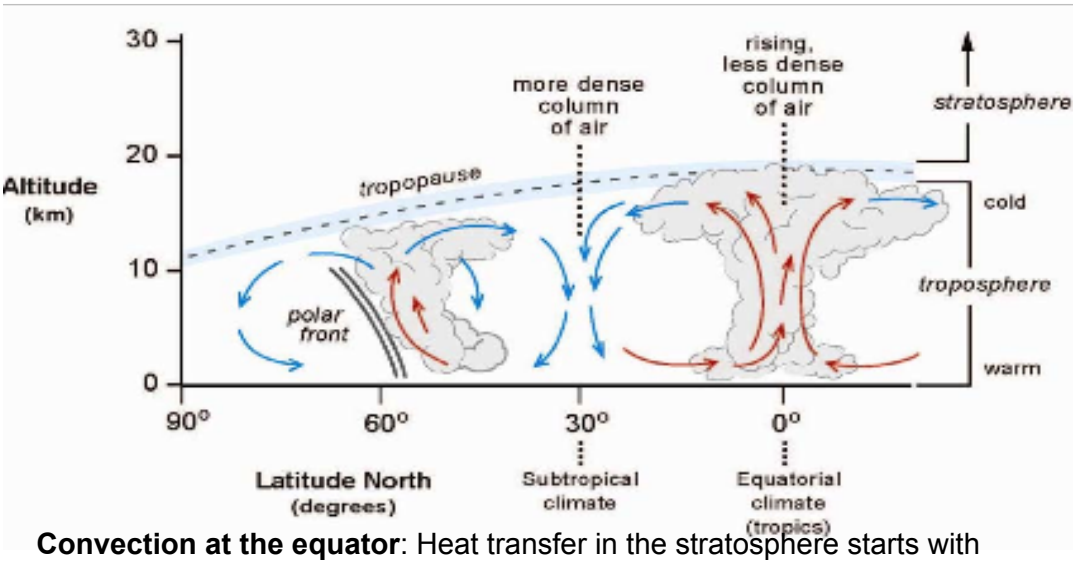
However, the Hadley model did not answer key questions. For example, his model did not account for *east-west* directions. It also didn't address uneven heating between **land and water**.

Later, scientists noted two reasons why Hadley's model was too simple. One was **the earth rotates**. This causes surface winds to curve from a straight line. Another reason is that earth's surface is made up of **water (70%)** and land (30%). They **heat up at different rates**.

The total effect is a **pattern** where warm, moist air rises at the equator. This air then sinks at latitudes of about 30 degrees North and 30 degrees South. The flow of air returning to the equator has a ***curved path*** due to **the rotation of earth**.

The pattern of rotation is visible in images of tropical cyclones and hurricanes. **These storm systems are key vehicles that move heat to higher latitudes**.





Convection at the equator: Heat transfer in the stratosphere starts with convection at the equator. This air is warm and moist. The air moves toward the poles and cools. It sinks to earth at about latitudes of 30 degrees. This flow sets up several convection cells.

The kettle is plugged in and turned on. The glass plate is cold. Describe what will happen as the water in the kettle heats.

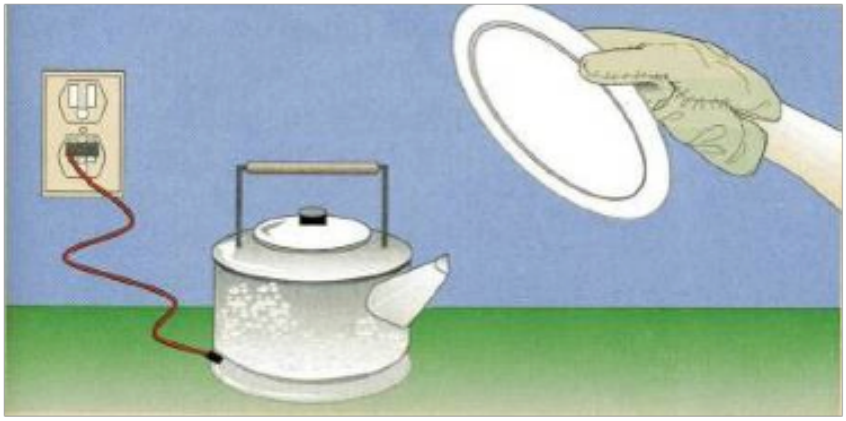


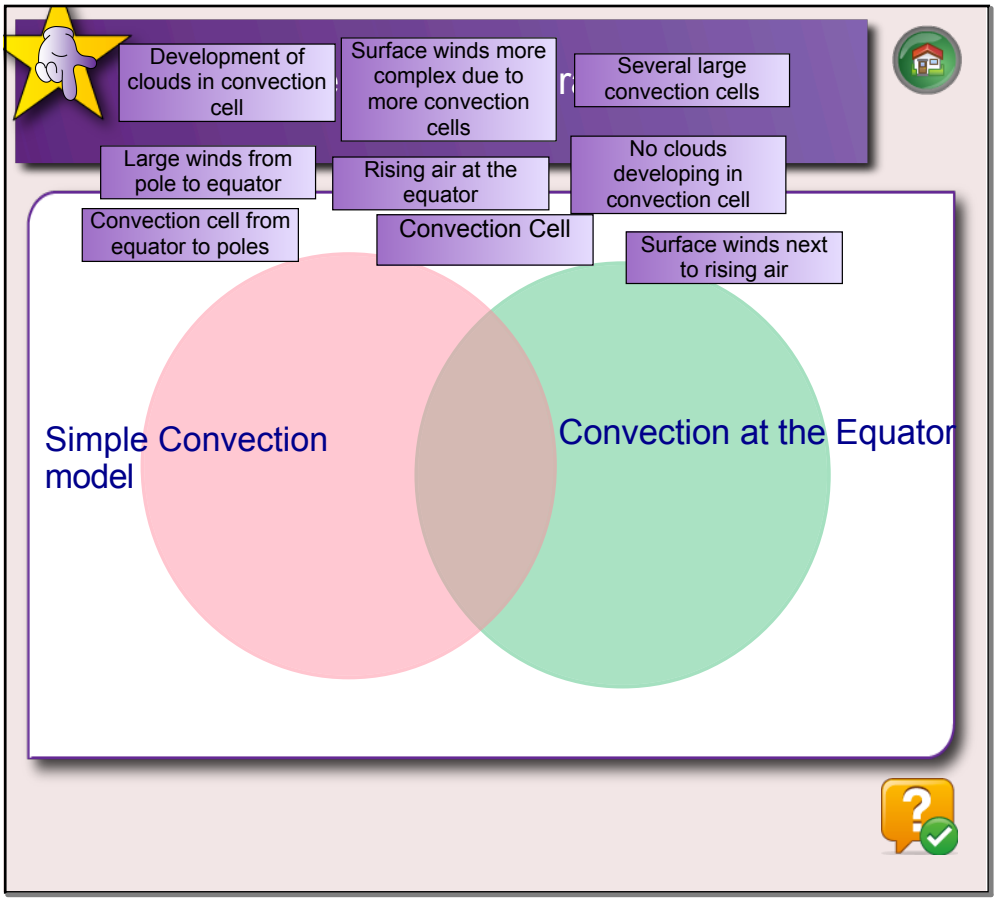
Figure 10: Kettle with Water. The water in this kettle is being heated. What happens to the water and plate? What direction does heat flow?

a. Draw a diagram to show what you think will happen.

b. Add a red arrow to your diagram to show transfer of heat.

Hadley's model for convection on earth was too simple. Answer these questions about Hadley's model.

a. What **two factors** did Hadley not account for?
b. **Look** at the two models again
c. Make a *Venn Diagram* in your notebook to show how these figures are **similar and different**



The following 4 diagrams show situations where **volumes of warm and cold fluids** are in contact.

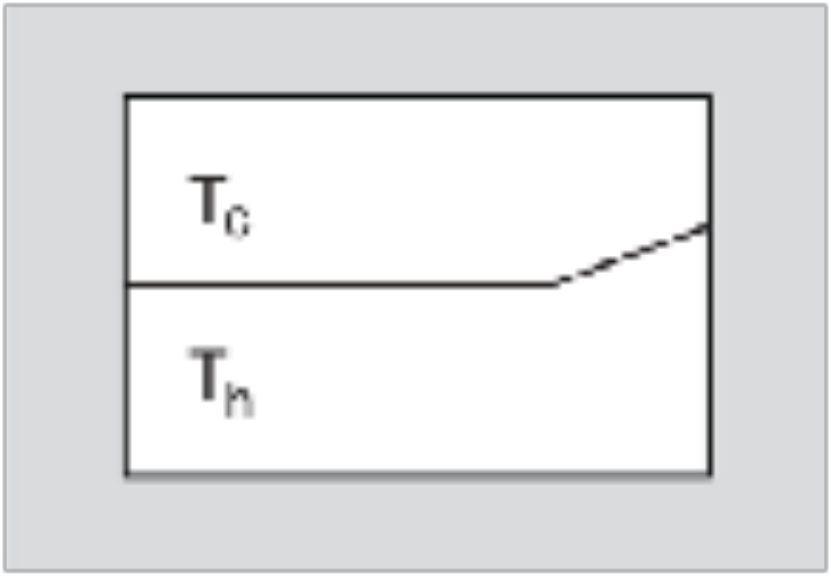
a. For each situation, decide whether you wish to color hot as **red** and cold as **blue**.

b. To the right of each diagram, **redraw it** to show what it will look like some time later **after convection** has occurred.

c. Use **arrows** to show movement or change in position.

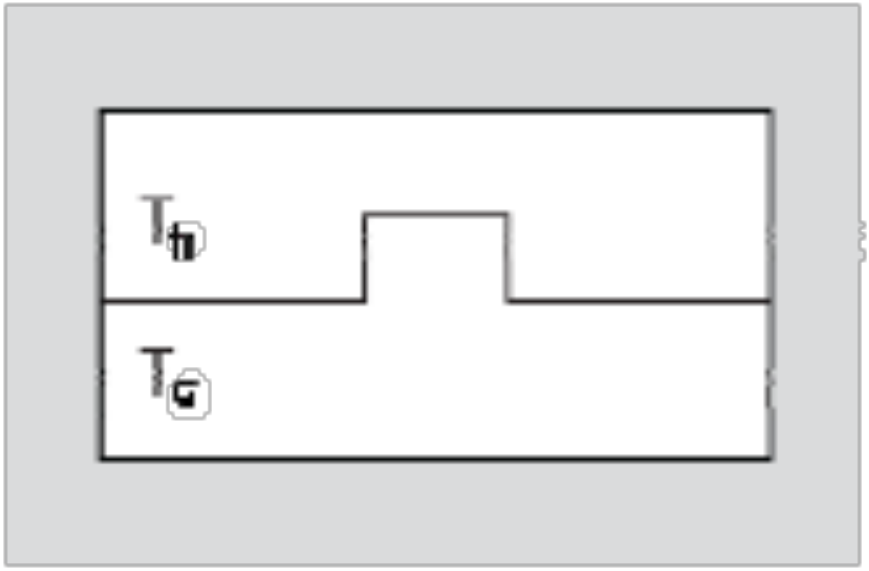
d. What types of substances could the fluids be?

In this example, cold water is on the top and hot water on the bottom, but there is more hot water on one side.



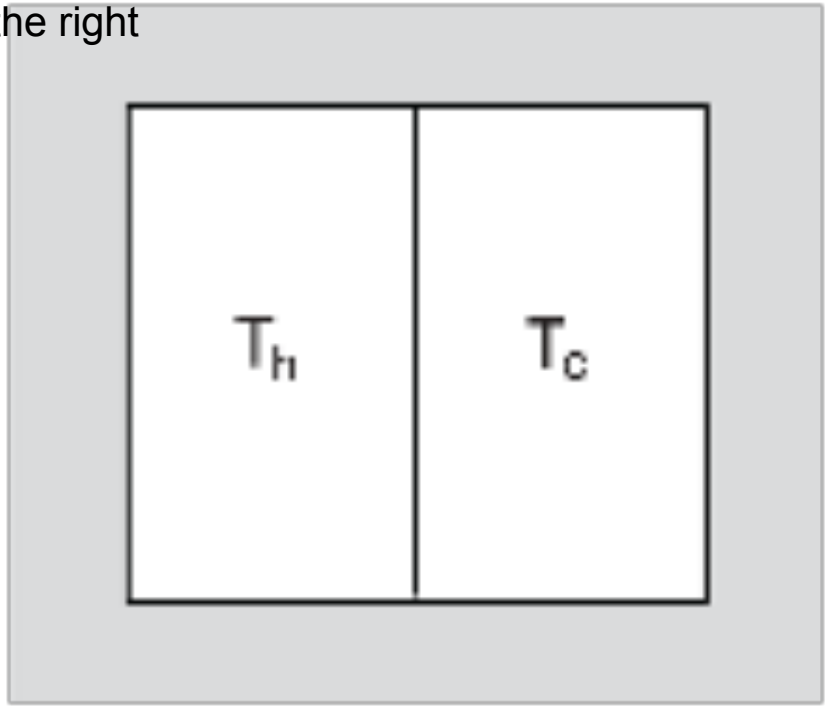
In this example, cold water is on the bottom and hot water on the top. Notice the shape of the cold water in the center.

2.

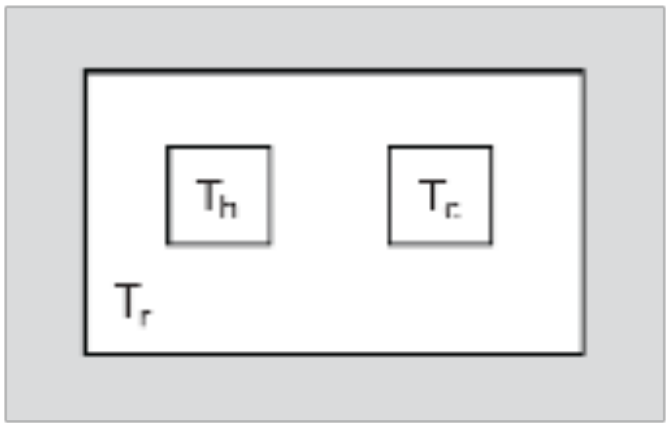


In this example, hot water is on the left and cold water on the right

3.



In this example, the water is room temperature except for the small volume of hot and cold water.



Key
T_h = temperature hot
T_c = temperature cold
T_r = room temperature

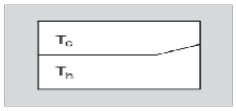
Turn in your **"Hot and Cold Volumes"** sketches for assessment.

You need to include a written description for each of the four examples. Include a legend at the bottom.

Hot, Cold Volumes

Draw a picture of what you think will happen.

1.



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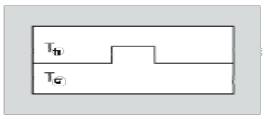

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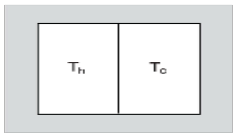

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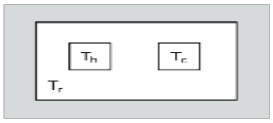

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