



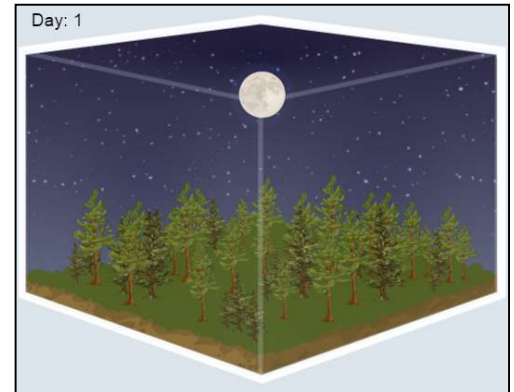
## Student Exploration: Greenhouse Effect

**Vocabulary:** global warming, greenhouse effect, greenhouse gas, heat flow

### Gizmo Warm-up

Like the windows of a car, **greenhouse gases** play a major role in regulating Earth's climate. Without the gases that trap heat in Earth's atmosphere, Earth would be a frigid desert like Mars (average temperature  $-55^{\circ}\text{C}$ , or  $-67^{\circ}\text{F}$ ). Too much greenhouse gas and Earth could be a fiery inferno like Venus (average temperature  $450^{\circ}\text{C}$ , or  $850^{\circ}\text{F}$ ).

On the *Greenhouse Effect* Gizmo, set the **Greenhouse gases** to 0% and the **Simulation speed** to **fast**.



1. Click **Play** (▶) and view the BAR CHART tab. The temperature will go up and down every day, but try to look at the overall trend. What happens to the temperature over time?
2. Now set the **Greenhouse gases** to 100% and let the simulation run for a while. How does a maximum amount of greenhouse gas affect the temperature?

<b>Activity:</b> <b>Heat in, heat out</b>	<u>Get the Gizmo ready:</u>	
	<ul style="list-style-type: none"> <li>• Click <b>Reset</b> (↺).</li> <li>• Set <b>Simulation speed</b> to <b>slow</b>.</li> <li>• Be sure the <b>Greenhouse gases</b> level is 10%.</li> </ul>	

### Question: How do greenhouse gases affect Earth's climate?

1. Observe: Select the BAR CHART tab and click **Play**. After about 24 simulated hours, click **Pause** (||). What do you notice about the **heat flow** into and out of Earth's atmosphere?
2. Analyze: Select the TABLE tab.
  - A. At what time of day is heat flow into the atmosphere ( $H_{in}$ ) greatest? \_\_\_\_\_
  - B. At what time of day is heat flow into the atmosphere ( $H_{in}$ ) least? \_\_\_\_\_
  - C. Does heat flow out of the atmosphere ( $H_{out}$ ) change during a day? \_\_\_\_\_
  - D. At what time of day is surface temperature highest? \_\_\_\_\_ Lowest? \_\_\_\_\_
3. Predict: Click **Reset**. When you change the amounts of greenhouse gases in the atmosphere, which factor(s) do you expect to change? (Circle your answer/answers.)

Heat flow in

Heat flow out

Temperature



4. Experiment: Select the BAR CHART tab, and click **Play**. While the simulation is playing, move the **Greenhouse gases** slider back and forth. What do you notice?
  
  5. Experiment: Click **Play**, and this time observe the GRAPH tab as you change the **Greenhouse gases**. What do you notice?
  
  6. Draw conclusions: The influence of greenhouse gases on temperature is called the **greenhouse effect**. Based on what you have seen, how do greenhouse gases affect the heat flow into and out of Earth's atmosphere?
  
  7. Extend your thinking: Atmospheric concentrations of greenhouse gases such as carbon dioxide have risen dramatically in the past century. Most scientists agree that this has begun to result in **global warming**, a slow increase in average temperature worldwide. Describe possible consequences of global warming?
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*Note: The reason greenhouse gases raise the temperature of Earth's atmosphere is similar to, but not identical to, the way that the glass in a greenhouse raises the temperature inside.*

*In a greenhouse, sunlight passes through the transparent glass and is absorbed by the plants and soil below. Heat is then radiated from plants and soil, which heats the air inside the greenhouse. The hot air is trapped by the glass. If the glass were not there, the hot air would mix with the colder air outside, and the result would be similar temperatures inside and outside the greenhouse.*

*In Earth's atmosphere, greenhouse gases are transparent to visible light but absorb heat that is emitted from Earth's surface. Some of this heat is then reflected back to Earth. If the greenhouse gases were not present, all of the heat would radiate into space instead.*

