

Global Climate Change

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Understanding global climate change is challenging, even for adults, yet having an understanding of this topic is consequential for the future. In this activity, middle school students learn about global climate change using models that allow them to make predictions, observations, and then explain mechanisms for climate change. Component ideas include change over time, deep time, and accumulation. Students are asked to act as advisers on how to lower energy use, and refine their understanding of how and why this is important, before testing their ideas and finally revising their advice.

Goals

In this project, students predict and evaluate ideas, and interpret and synthesize across models of climate change. Students develop writing skills and representational skills, and develop collaboration skills. The following concepts are focused in this project:

- Solar radiation and energy transformation
- Carbon Cycle and cumulative impact of human contributions
- Mechanisms for greenhouse effect as a natural process

Context

This activity is for middle school students. The activity is used by teachers who exclusively teach science, as well as those who teach all subjects. Should have an understanding of conduction and convection, but prior knowledge is assumed to be low. This activity stands as a third unit middle school students use to learn about energy. It is being used in 20 middle school classrooms in California, and the project undergoes a design research phase with each implementation. Thus, to see the most recent version, please follow the link below:

<http://wise4.telscenter.org/webapp/vle/preview.html?projectId=9>

Assessment

Assessments are embedded throughout the activity, and as pre/post measures ("Initial ideas" and "Reflecting" activities). These are coded using the knowledge integration framework (Linn, 2006). When teachers grade these, they sometimes adapt the knowledge integration framework, or apply their own scheme.

Linn, M. C. (2006). The knowledge integration perspective on learning and instruction. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 243-264). New York: Cambridge University Press.



Global Climate Change

Hello

[Expand All](#)

[Collapse All](#)

Initial Ideas



1.1 Introduction



1.2 Warm car cold day



1.3 Eliciting: Burning fossil fuels



1.4 My actions & global climate change



1.5 Advise Gwen



1.6 Initial MySystem



1.7 Energy Story #1

Solar Radiation



2.1 Energy transfer



2.2 What is Solar radiation?



2.3 Energy Transformation



2.4 What happens to solar radiation?



2.5 Solar radiation reflection



2.6 Types of transfer

Reflected Light



3.1 Reflected Light Prediction



3.2 Exploring Albedo



3.3 Albedo Reflection



3.4 MySystem Critique: Solar Radiation

The Atmosphere



4.1 Atmosphere Prediction



4.2 Atmosphere Model



4.3 Atmosphere Reflection

The Natural Greenhouse Effect



5.1 Greenhouse Gases



5.2 Snow-covered Earth Model



5.3 Snow-covered Earth Reflection



5.4 MySystem Critique: Greenhouse gases



5.5 Study the Greenhouse Effect

Your actions



6.1 Human Contributions to the carbon cycle



6.2 Carbon Cycle Reflection



6.3 Human activities



6.4 Research your actions!



6.5 Challenge question!



6.6 Advise Gwen again

Reflections



7.1 Final MySystem



7.2 Energy Story Putting it all together



7.3 Warm car cold day



7.4 Burning fossil fuels



7.5 Experiment

Extension Activity!



8.1 Farms versus Forest



8.2 Letter to city council



8.3 Evidence for Human Contributions



8.4 Evidence reflection

Initial Ideas

How do my actions contribute to global climate change?

In this project you will learn about energy, the atmosphere, the greenhouse effect, and how these connect to your life.



As you explore the project, think about how what you do can impact the Earth's energy balance.

Pay attention, because you'll be asked to advise others on challenges related to Earth's climate.

First, answer a couple questions to show what you already know. It's okay if you don't know the answer. Just try your best!

OPEN RESPONSE

instructions

QUESTION

On a COLD day, Akbar walks to his car, parked in the sun. When he gets into his car he is surprised that it is already warm inside.

How can it be warmer inside the car?

- A) The heat energy from the Earth rose up into the car.
- B) The light energy from the Sun is transformed into heat energy which cannot radiate through the windows.
- C) The heat energy from the Sun conducts through the metal of the car and is stored in the seats.
- D) The heat energy from the last time the car was run– two days ago– remained stored in the car.

RESPONSE

I choose answer [] because...

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

The burning of fossil fuels has increased the carbon dioxide content of the atmosphere. What possible effect could the increased amount of carbon dioxide have on our planet?

- A) A warmer climate
- B) A cooler climate
- C) Lower relative humidity
- D) More ozone in the atmosphere

RESPONSE

I choose answer [] because...

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

Think about how your actions relate to global climate change and answer the following THREE questions.

Use EVIDENCE to support your answers!

- 1) What is global climate change?
- 2) What causes global climate change?
- 3) Name TWO things you do at home that you think are related to global climate change (this can be in either a good or bad way).

RESPONSE

1) Global climate change is...
I think this because...

2) Things that cause global climate change are...
I think this because....

3) ONE thing I do at home that relates to global climate change is...
I think this because...

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

Gwen is concerned about her energy use. She'd like to make changes to lower her energy use. Which TWO of the following would make the biggest impact?

- Walk to school
- Turn off computer/lights when not in use
- Eat less meat
- Recycle aluminum cans
- Recycle paper
- Stop littering
- Take shorter, less hot showers

EXPLAIN your choices using evidence to support each choice!

RESPONSE

This is your first revision.

SAVE

MySystem Modeler



Clear Diagram



help

Objects:



Clouds

Driving

Greenhouse
Gasses

High

Properties:

GOALS

Make a MySystem to explain
Gwen how energy from the sun
and the things people do BOTH
contribute to global climate.

- Where does energy come from?
- How does energy move?
- Where does energy go?
- How does energy change?

Don't forget to label the arrow

OPEN RESPONSE

instructions

QUESTION

Write a story to explain to Gwen how BOTH: 1) energy from the sun and 2) things people do contribute to global climate change.

Be sure to include:

- Where energy comes from
- How energy moves
- Where energy goes
- How energy changes

Be sure to use scientific EVIDENCE to support your ideas.

RESPONSE

This is your first revision.

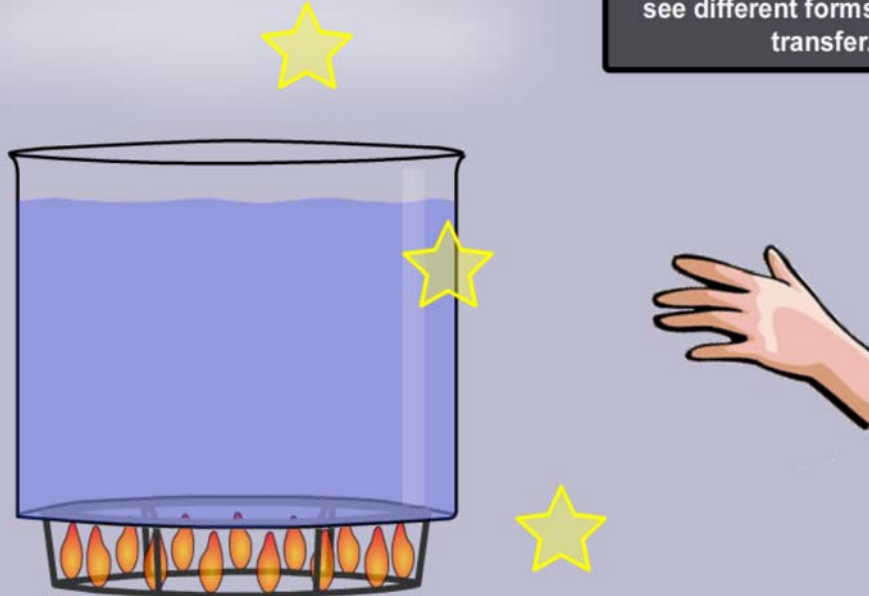
SAVE

Solar Radiation

Convection, conduction, radiation

Energy can travel in different ways: by **conduction**, **convection**, and **radiation**.
Find an example of each below.

Click on the stars to the left to
see different forms of energy
transfer.



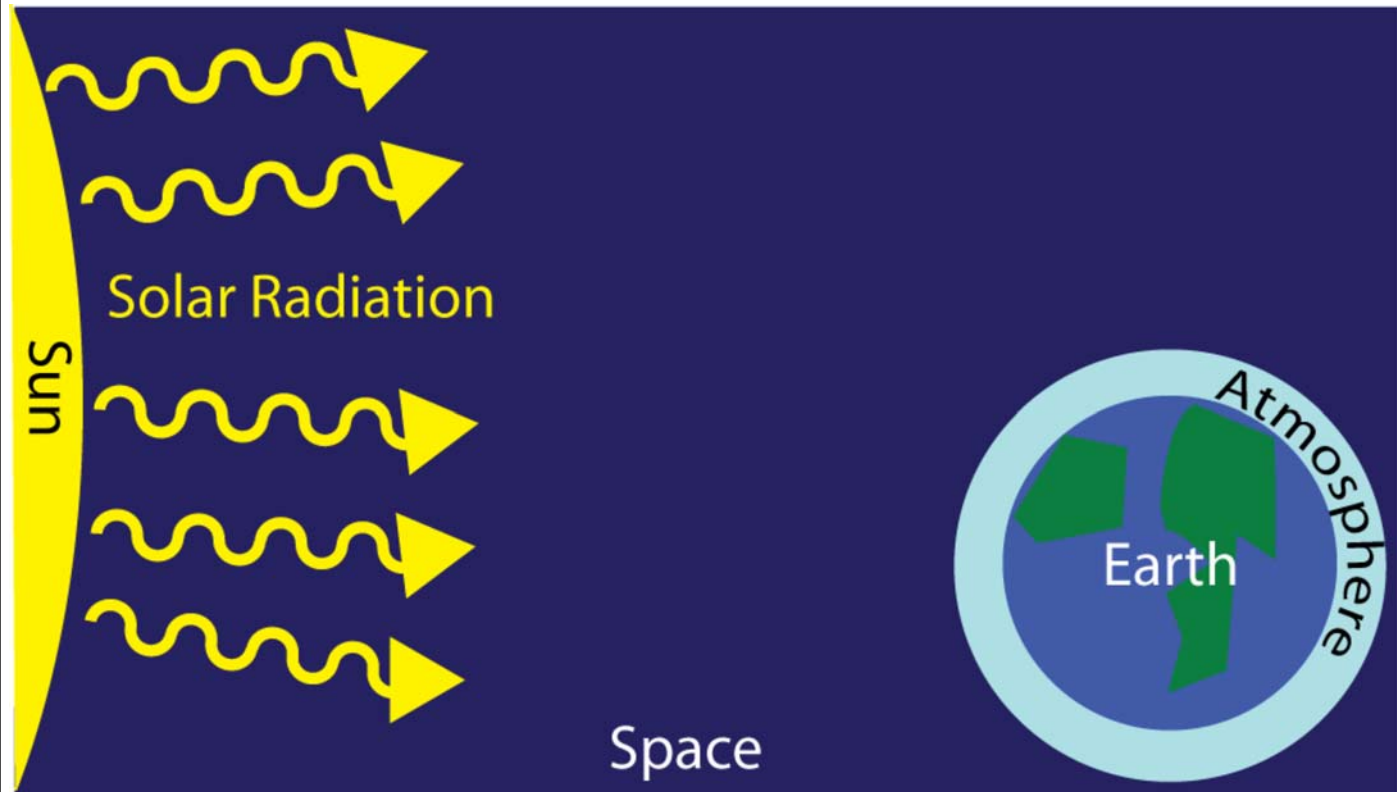
Solar Radiation

What is solar radiation?

You may have heard that solar radiation is bad, but life on Earth would not be possible without it!

Energy from the sun travels as **solar radiation**.

Radiation is the transfer of energy in the form of *electromagnetic waves*.



Solar Radiation

How is Energy Transformed?

Energy from the sun -- **solar radiation** -- can be *absorbed* or *reflected*.

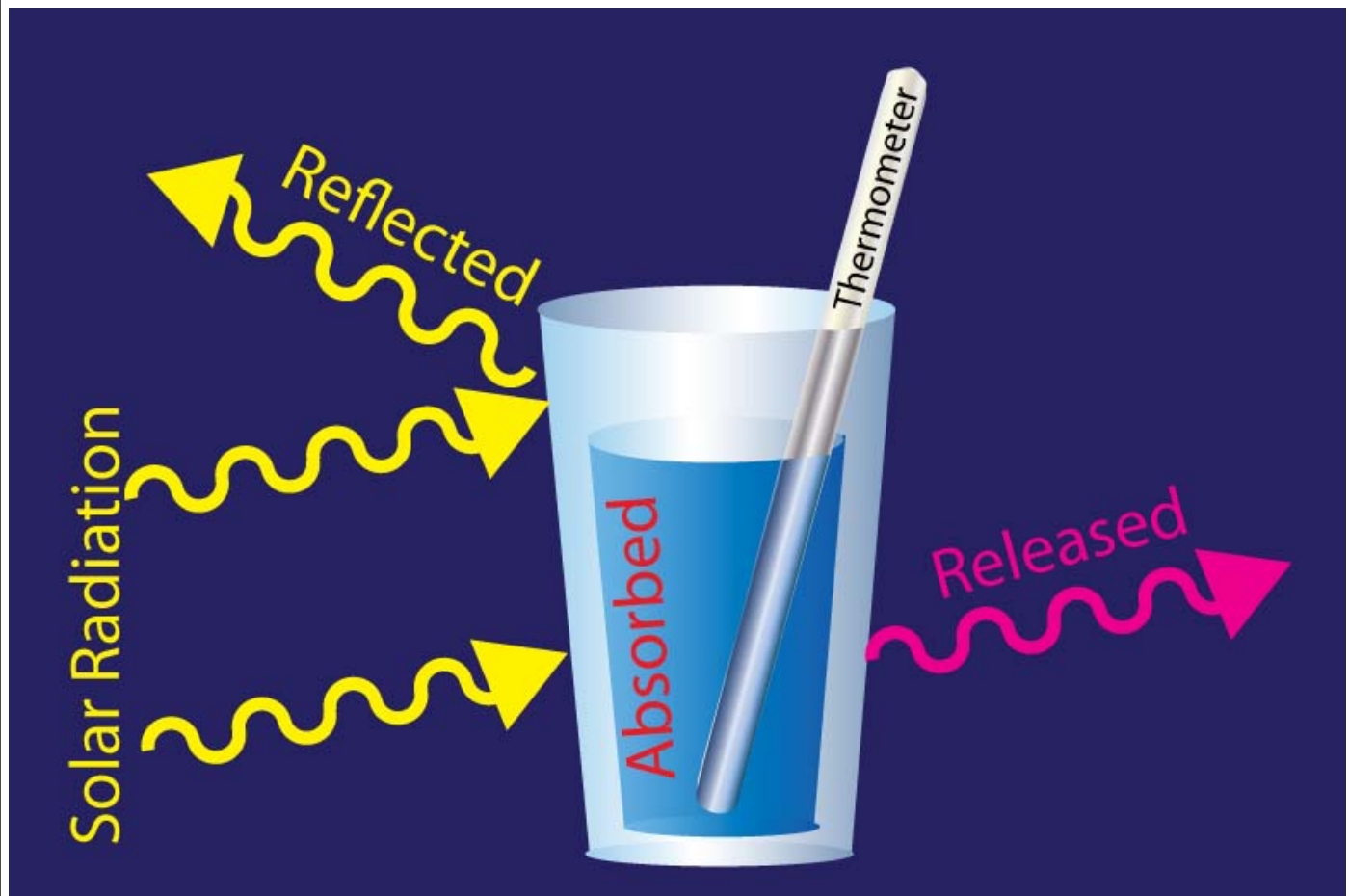
When it is absorbed, **solar radiation** is *transformed* into **heat energy**.

When the Earth is warm, the **heat energy** can be *released* to the atmosphere and space as **Infrared Radiation (IR)**.

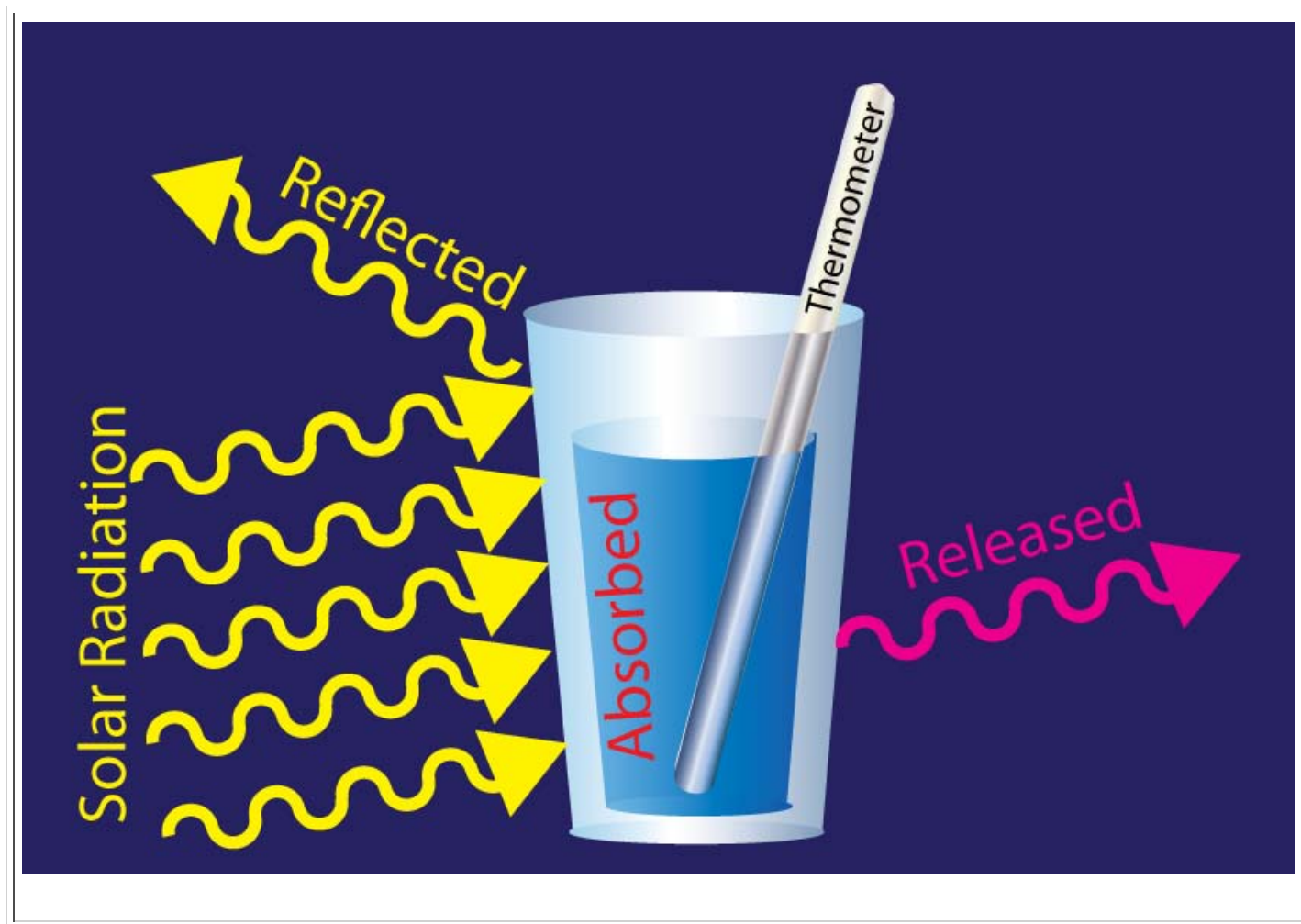
Energy Balance

In the first picture, there is an *energy balance*: One ray of energy is reflected, another is absorbed, then released.

In the second picture, more energy is absorbed than released. What would happen to the temperature of the water in this case?



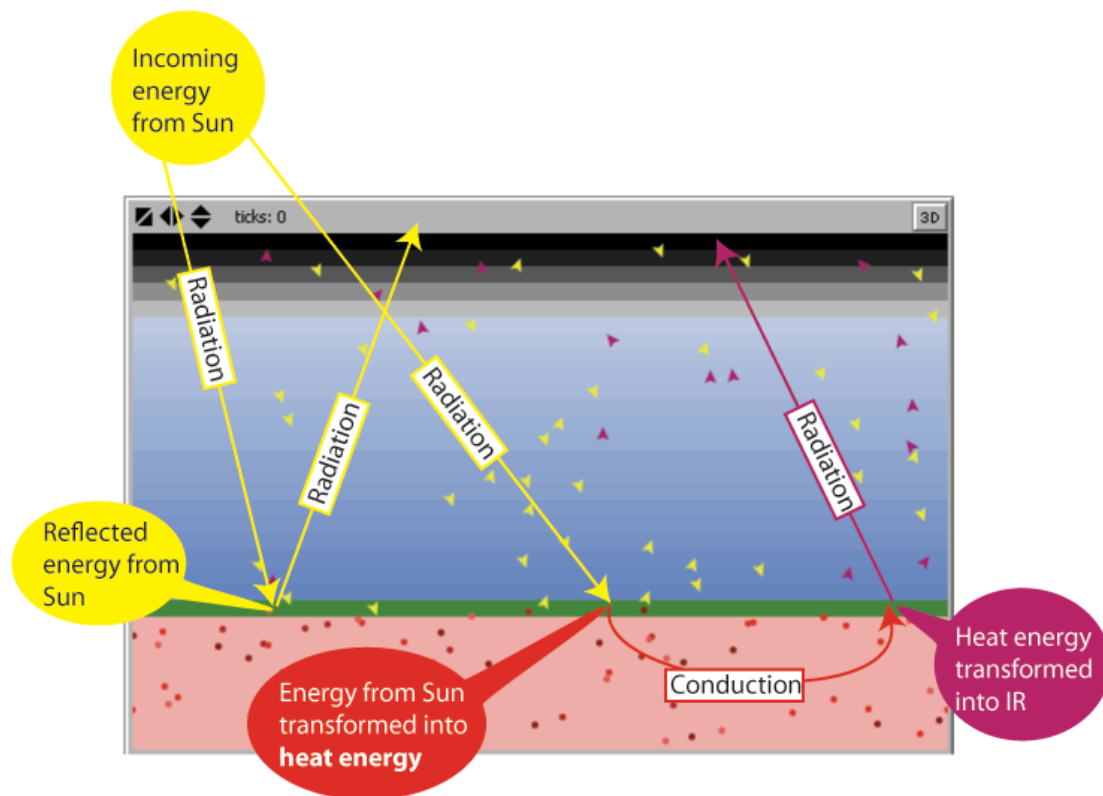
What do you think would happen to the temperature of the water if the energy was absorbed but not released?



Solar Radiation

What happens to solar radiation?

After you look at the picture, scroll down to see a model of what happens to solar radiation.

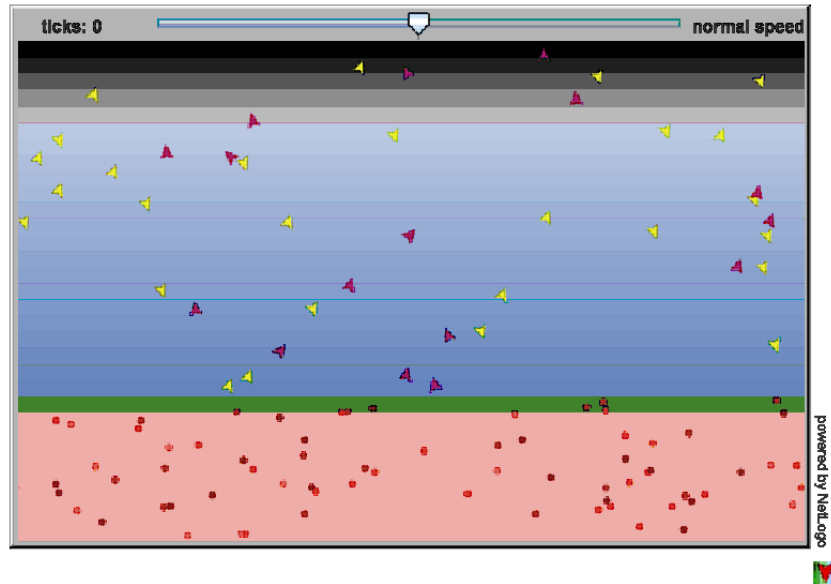
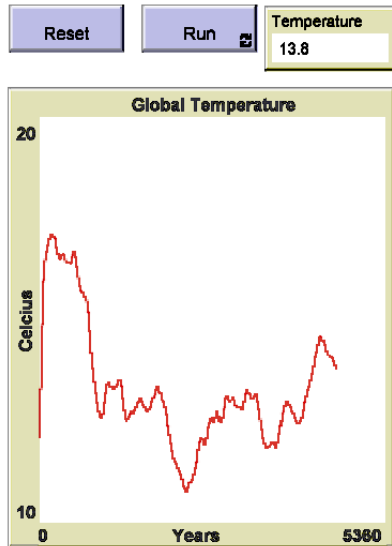


Scientists use models to test ideas.

The model below shows what happens to solar radiation.

Click the button labeled "run" to see the model.

Use the slider at the top to slow it down to see what happens to energy from the sun.



OPEN RESPONSE

instructions

QUESTION

Based on your observations with the model in Step 2.4, what happens to energy from the sun (solar radiation) when it reaches the earth?

RESPONSE

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

Energy can move by conduction, convection, and radiation. Explain IN YOUR OWN WORDS, how these are different from each other. Include examples.

RESPONSE

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

Just like a mirror can reflect light, land and water can also reflect some of the sun's light. The percent of light reflected is called *albedo*.

Which of the following environments would reflect the most solar radiation?

Which of the following environments would reflect the least solar radiation?

Environments:

- Ocean
- Desert
- Farm
- Forest
- Ice

RESPONSE

Most Reflection:

Least Reflection:

I chose these because...

This is your first revision.

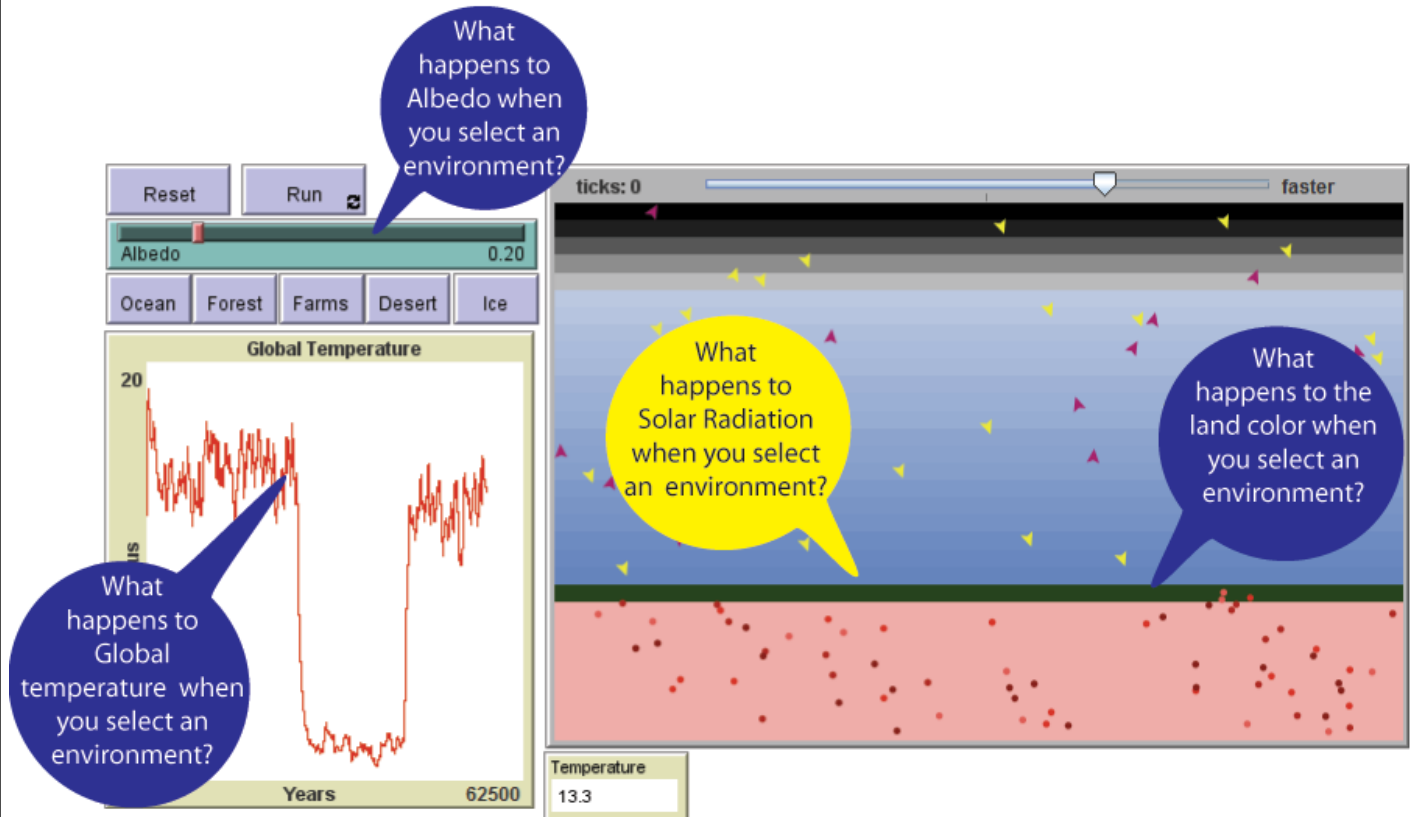
SAVE

Albedo

What is albedo?

Solar radiation can be *reflected* or *absorbed*. Scientists measure this.

The percent of light reflected is called **albedo**.

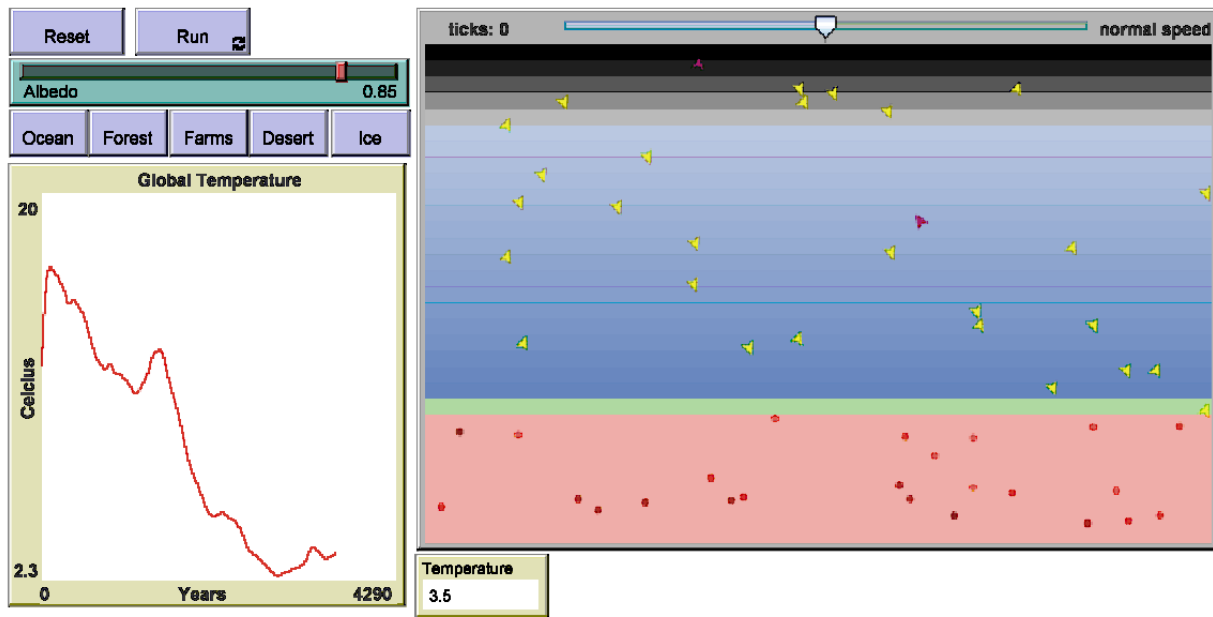


Use the model to learn about **albedo**. Try the following:

1. Select an environment (Desert, Farm, Forest, Ice, or Ocean)
2. Notice what happens to the albedo slider. It moves to match the environment, showing the albedo.
3. Watch what happens to temperature.
4. Select another environment. Now what happens?

See if you can answer the following questions:

- Which environment leads to the highest global temperature?
- Watch closely and compare Ocean to Ice. What happens to energy from the sun for each? Which one reflects more solar radiation?



OPEN RESPONSE

instructions

QUESTION

Explain what happens to solar radiation when it hits an environment with low albedo. Include evidence from the model in step 3.2 to support your claim.

RESPONSE

When solar radiation hits an environment with low albedo, it..

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SAVE

OPEN RESPONSE

instructions

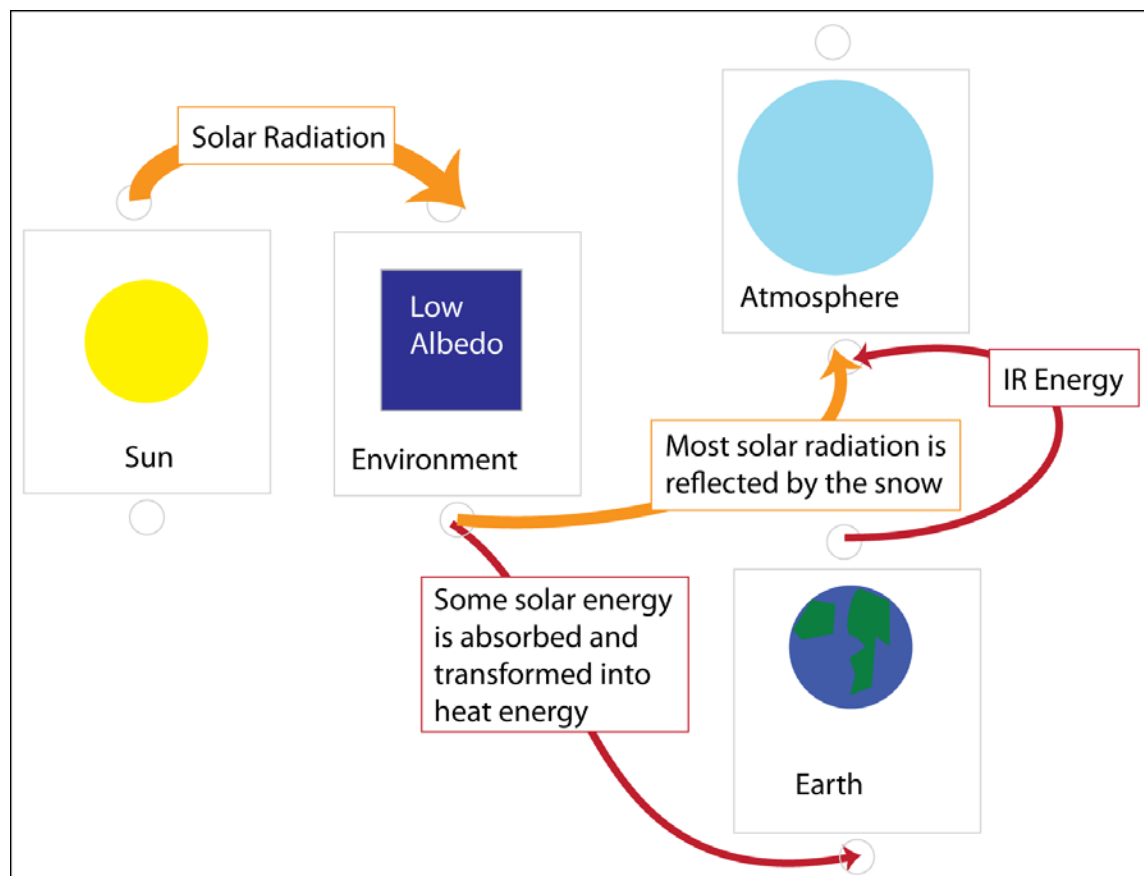
QUESTION

Gwen made a MySystem to show how energy from the sun warms the earth in a snow covered environment.

- Gwen showed how **solar radiation** transformed into **heat energy** and **IR energy**
- She showed the role of **albedo** for a **snow covered** environment.

Gwen's teacher told her she made a mistake in choosing one of her pictures, and that one of her labels is not clear enough. Gwen needs your help!

What **TWO** things should she change?



RESPONSE

Gwen should change the picture

Gwen should change the label...

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

If the Earth did not have an atmosphere, do you think the global temperature would be warmer or cooler?

RESPONSE

If the Earth did not have an atmosphere, I think the global temperature would be....

I think this because....

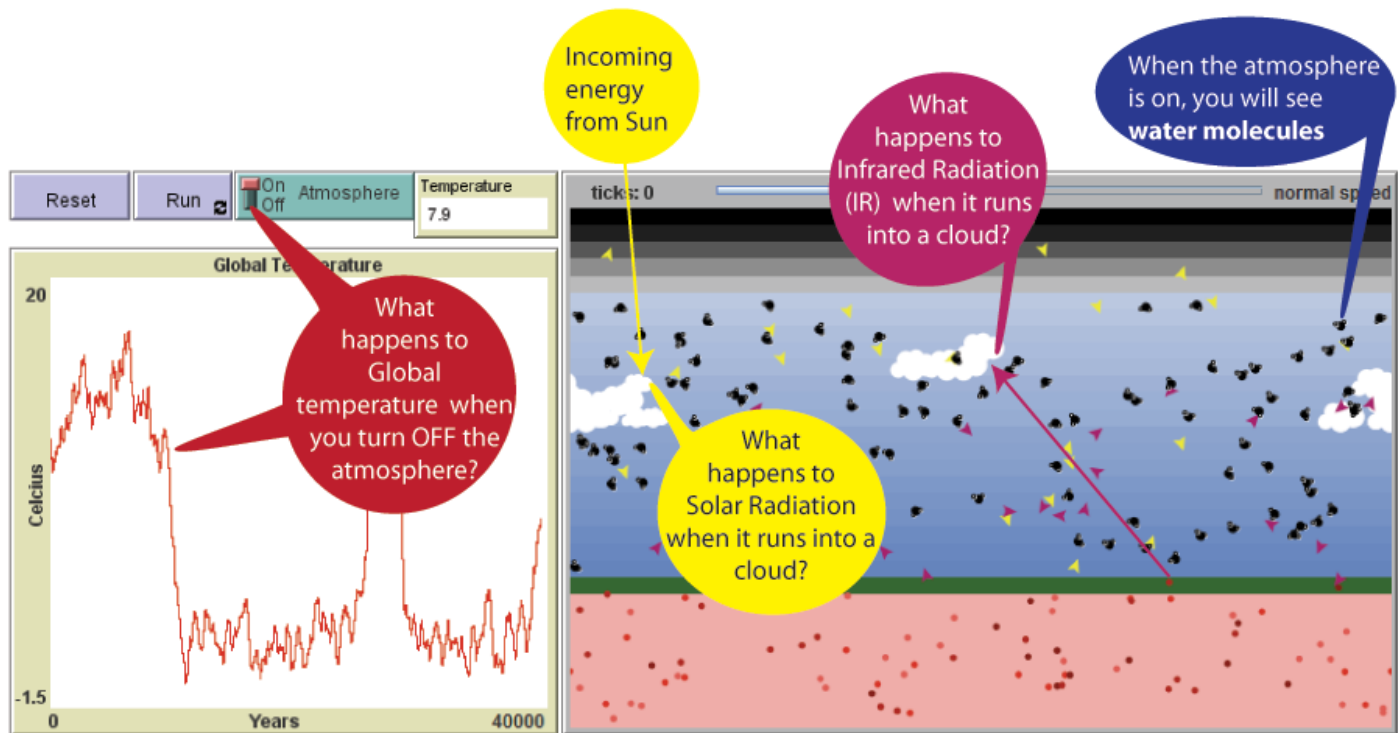
This is your first revision.

SAVE

The Atmosphere

How does having an atmosphere affect global temperature?

Use the model below to learn about the atmosphere and clouds. You can turn the atmosphere on or off.

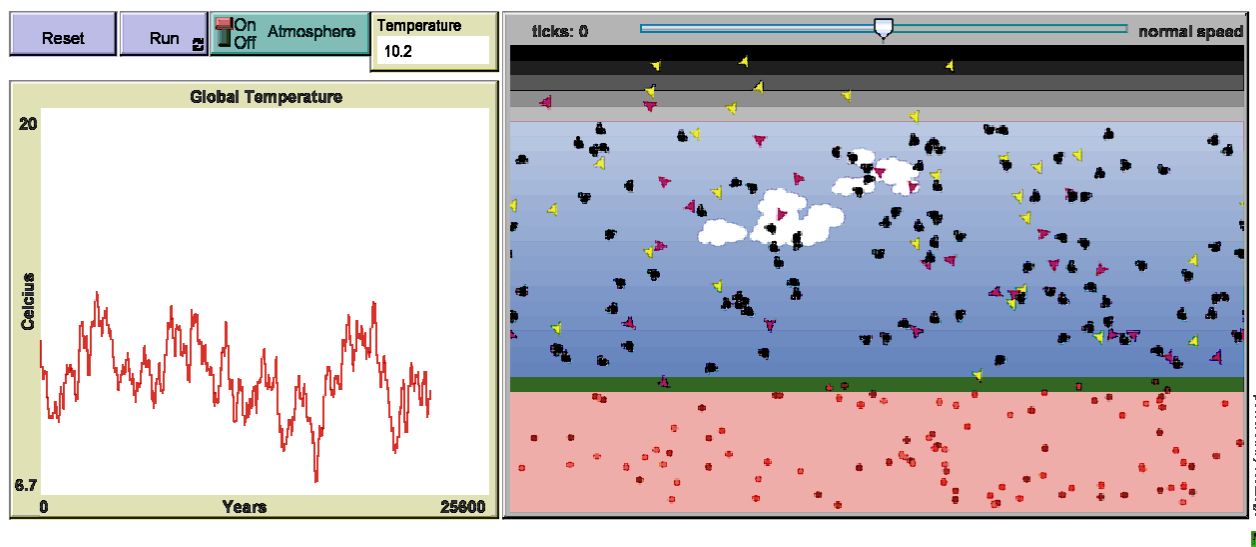


When the atmosphere is on, you will see clouds and water molecules in the air.

- What happens to the global temperature when the atmosphere is present? Absent?
- Why do you think this happens?

Slow the model down with the slider at the top to see what happens to energy.

- What happens to solar radiation when it runs into clouds?
- What happens to Infrared Radiation (IR) when it runs into clouds? (Hint: If you can't remember what IR is, take a look at Step 2.4).



OPEN RESPONSE

instructions

QUESTION

- Does having an atmosphere make global temperature warmer or cooler?
- What happens to energy from the sun when it runs into clouds?
- What happens to IR energy when it runs into clouds?

RESPONSE

Having an atmosphere makes global temperature...

When energy from the sun when it runs into clouds, it...

When IR energy runs into clouds, it...

This is your first revision.

SAVE

The Natural Greenhouse Effect

How is the atmosphere like a greenhouse?

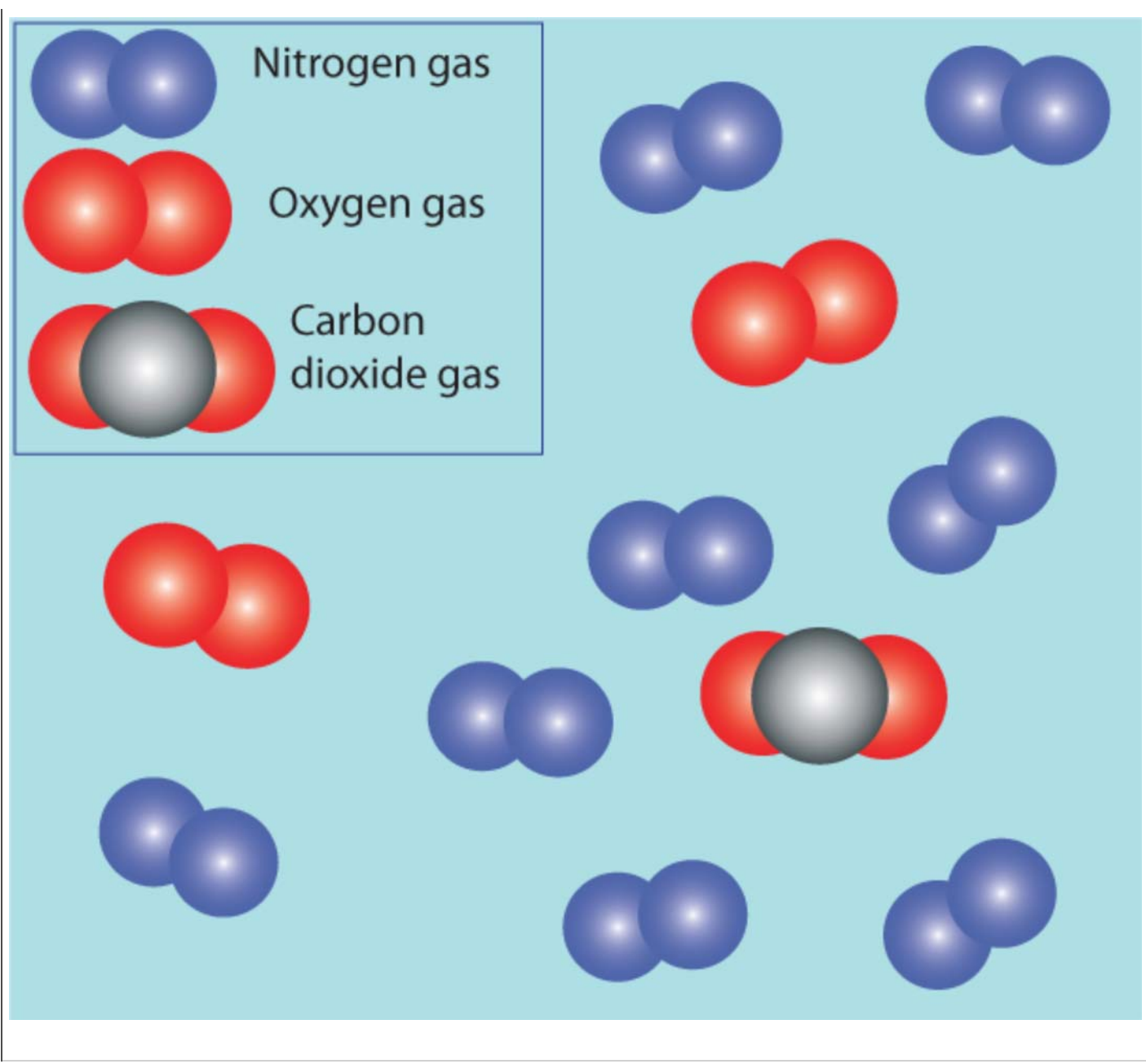
A greenhouse is a house that traps energy from the sun to help plants grow. If you have ever been in a car on a warm day with the windows closed, you have experienced this!



Although you cannot see it, the atmosphere is full of gases, such as oxygen to breathe. If you could see the gases in the air, they might look like the picture below.

Some gases are called *greenhouse gases* because they help keep the Earth warm in the same way that a greenhouse works to keep plants warm.

There are several types of greenhouse gases -- including carbon dioxide, methane, nitrous oxide, ozone, and even water vapor.



The Natural Greenhouse Effect

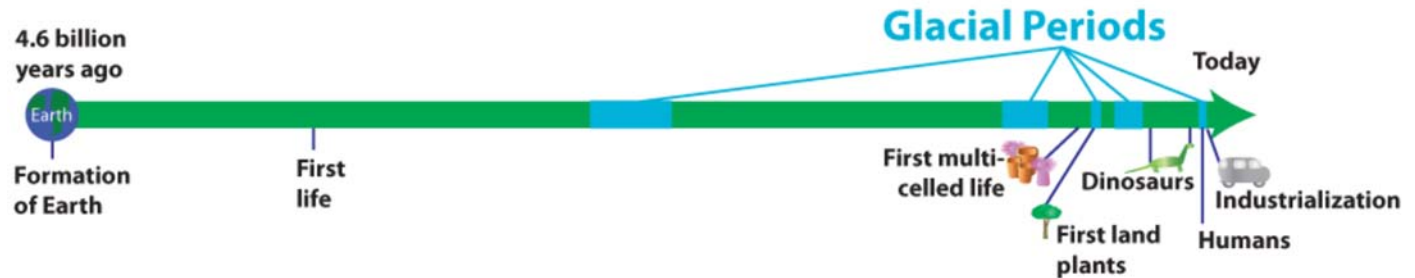
A snow-covered Earth

Scientists have evidence that the Earth's climate has changed over time.

They can tell from sea shells found in rocks all over America that the seas were much higher at one point.

They have evidence that there have been colder times with glaciers covering most of the land.

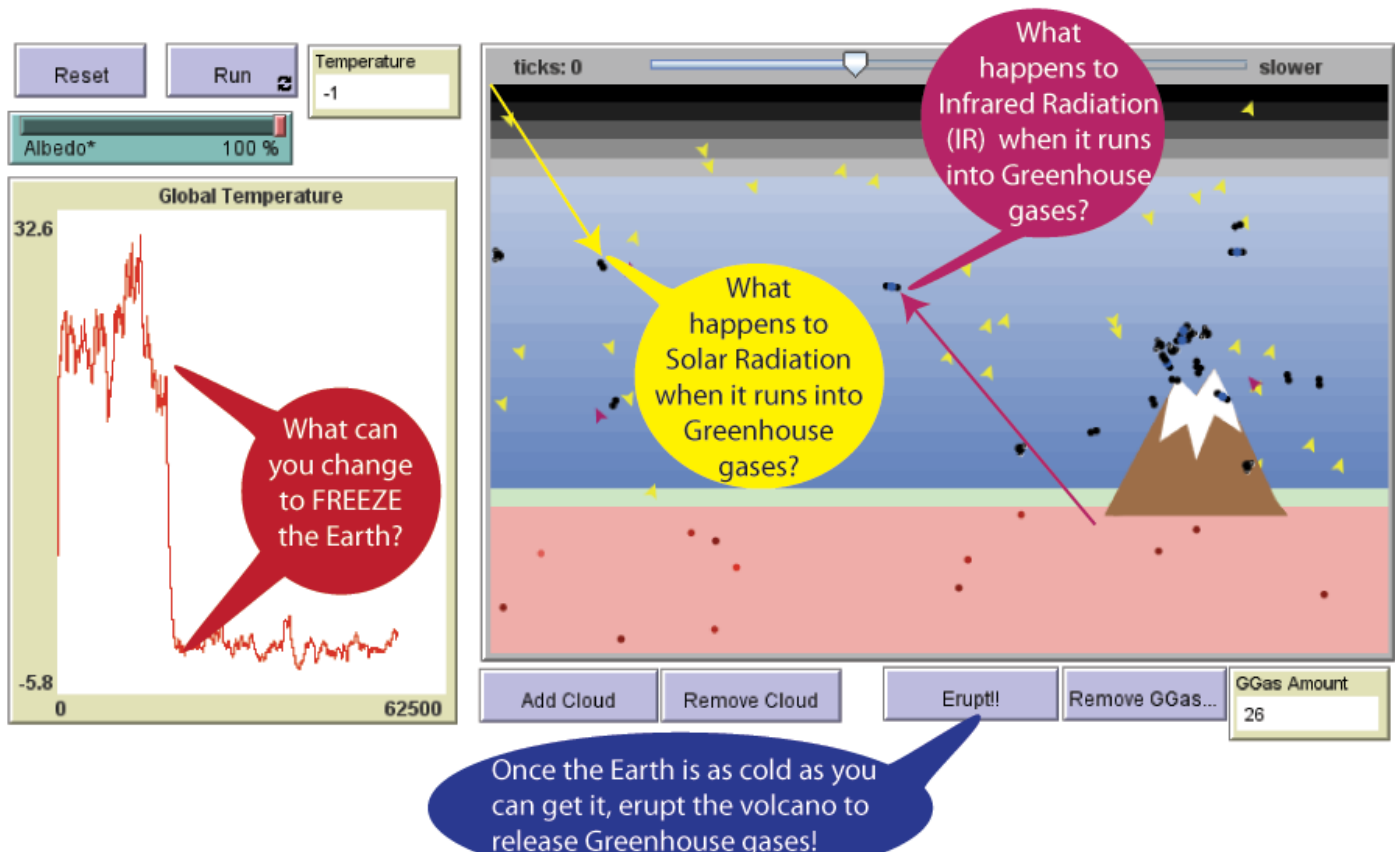
These cold *glacial periods* have occurred several times in the Earth's 4.6 billion year history!



Scientists debate how cold the Earth might have been during *glacial periods*.

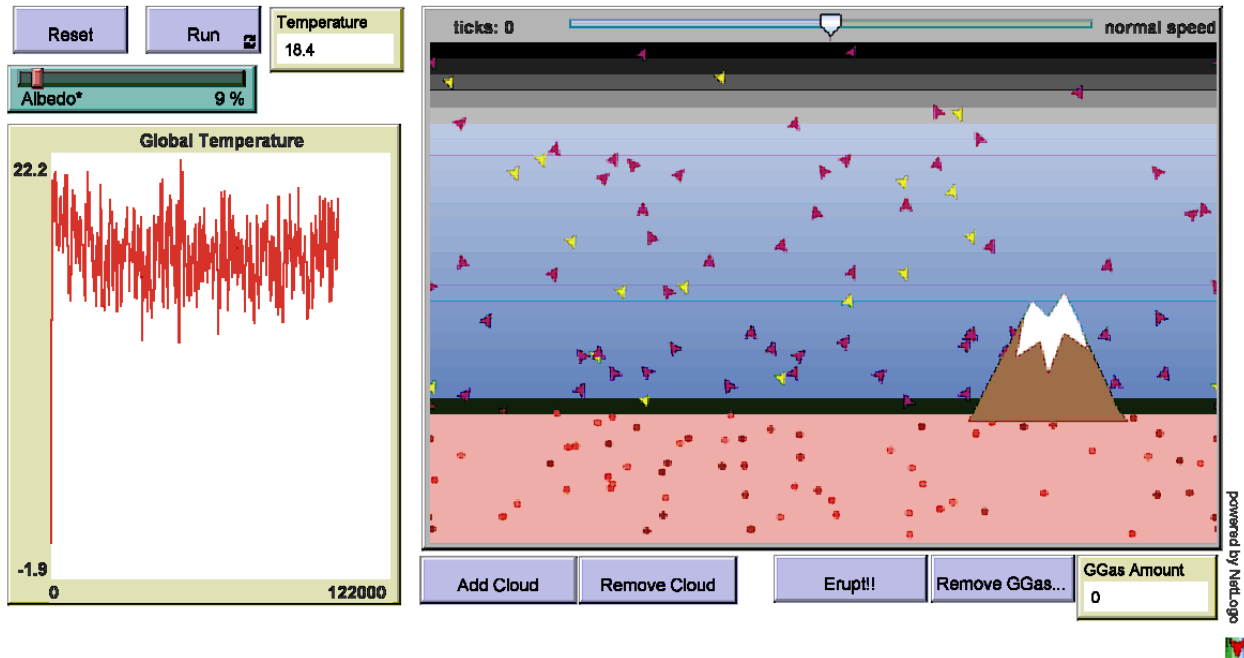
Some scientists have found evidence for many volcano eruptions, and they think volcanoes may have helped warm up the climate in the past.

When a volcano erupts, greenhouse gases, such as CO₂ are released. In the model below, these are small black circles.



Things to try:

1. What makes global temperature go down? Can you freeze the Earth?
2. Once global temperature is as low as you can make it go, find out what happens to temperature when the volcano erupts.
3. Slow down the model using the slider at the top and find out what happens to solar radiation and IR when it runs into greenhouse gases (the little black circles)



OPEN RESPONSE

instructions

QUESTION

- What happened to global temperature when you increased the number of erupting volcanoes?
- What happened to infrared radiation (IR) when it ran into greenhouse gases?

RESPONSE

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

Gwen made a MySystem to show how **light energy** from the sun is affected by:

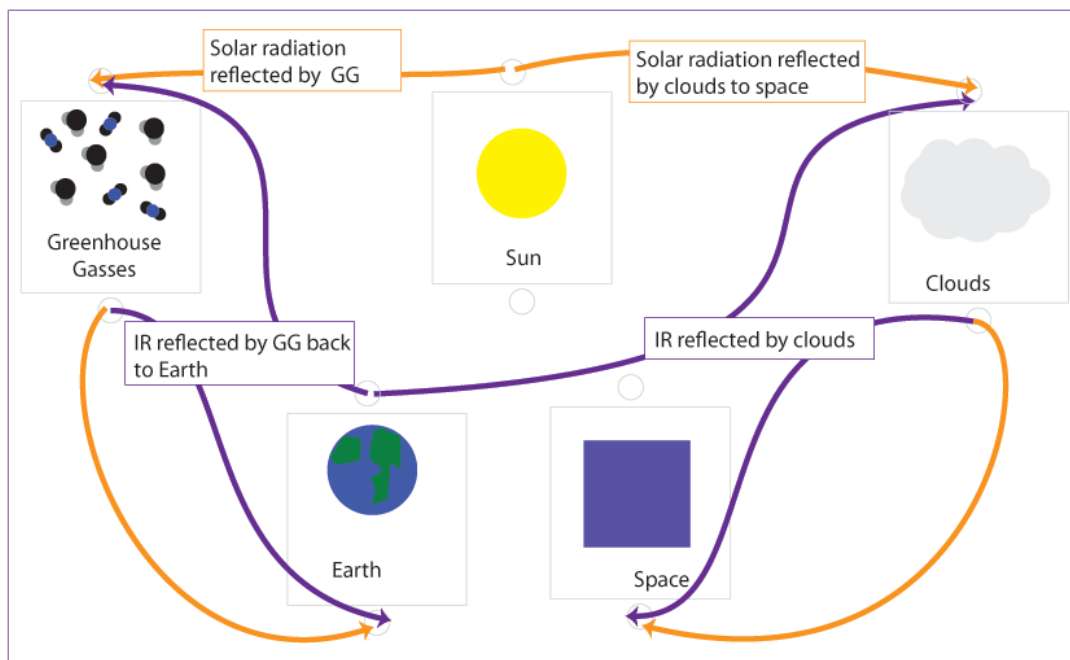
- Clouds
- Greenhouse gases

Gwen's teacher told her she had some mistakes in her labels.

What **TWO** LABELS should she change?

Hint #1: What happens to solar radiation when there are greenhouse gases?

Hint #2: What happens to IR when there are clouds?



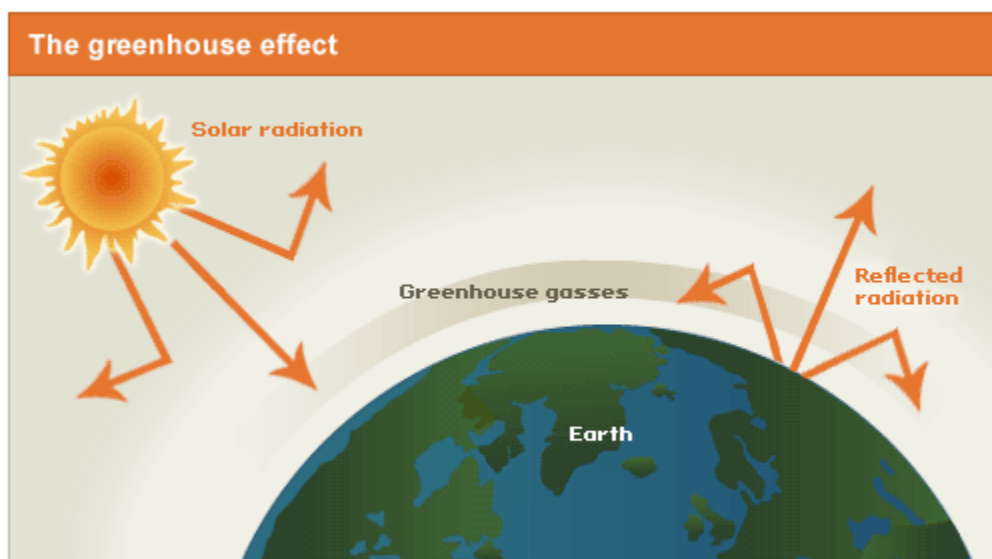
RESPONSE

This is your first revision.

The Natural Greenhouse Effect

Understanding the Greenhouse Effect

The Greenhouse Effect occurs naturally and has kept the Earth's temperature about 60 degrees Fahrenheit (15.5 degrees Celsius) warmer than it would otherwise be. Current life on Earth could not be sustained without the natural greenhouse effect. Things would get much too cold!



Click the link below to see an animation showing how the greenhouse effect happens. Watch it as many times as you need to in order to understand what is happening.

Notice what happens to solar energy and infrared energy.

[Greenhouse Animation](#)

Your Actions

How do humans impact the climate?

You have seen that the climate was different in the past.

These changes occurred over thousands of years.

Scientists worry that humans are changing the atmosphere through their energy use.

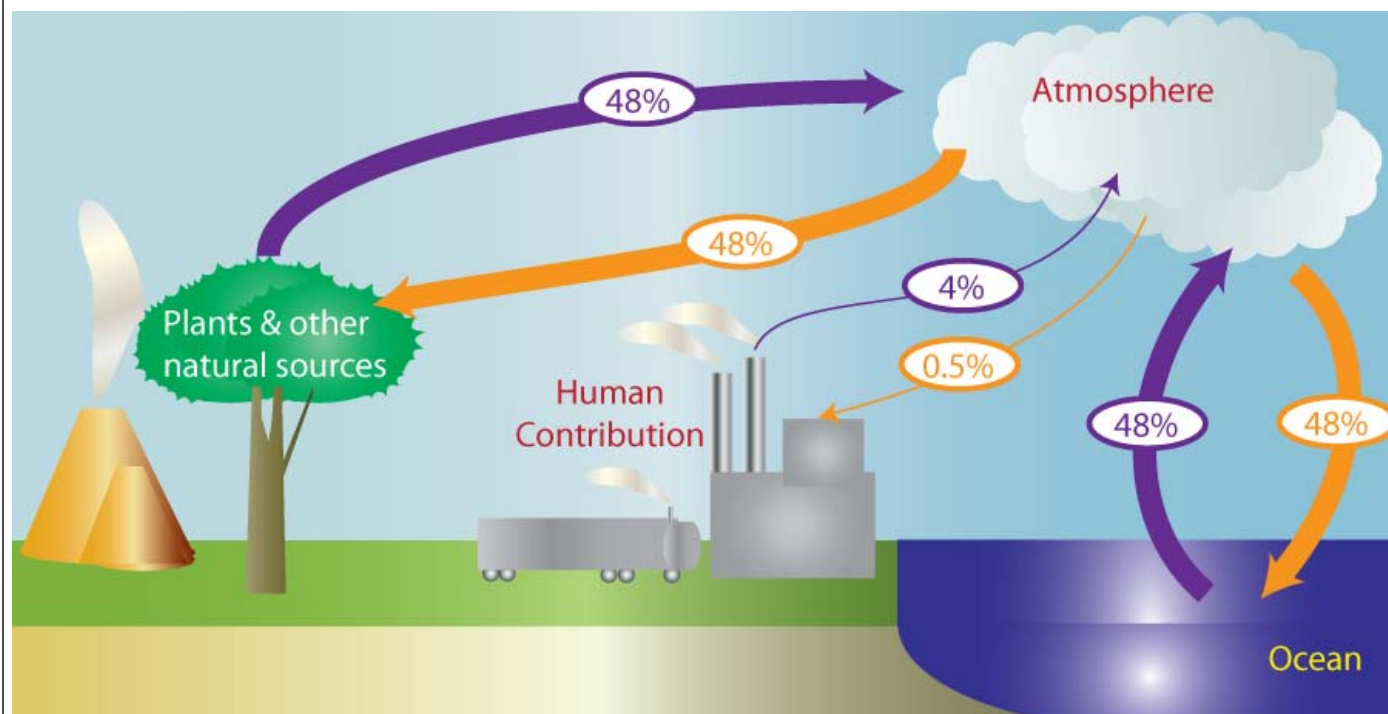
When you use energy, carbon dioxide is produced.

The picture below shows how carbon dioxide moves through the earth system EACH YEAR.

Land and ocean plants absorb carbon dioxide to live, but when they die and decay, they give off carbon dioxide. This is a natural balanced cycle.

Compared to the natural carbon cycle, humans produce very little, but scientists are still worried.

Why do you think this carbon dioxide might be a problem?



Tall

Wide

Basic

Large



instructions

QUESTION

Why do you think the carbon dioxide humans produce might be a problem?

RESPONSE

I think the carbon dioxide produced by human actions might be a problem because....

This is your first revision.

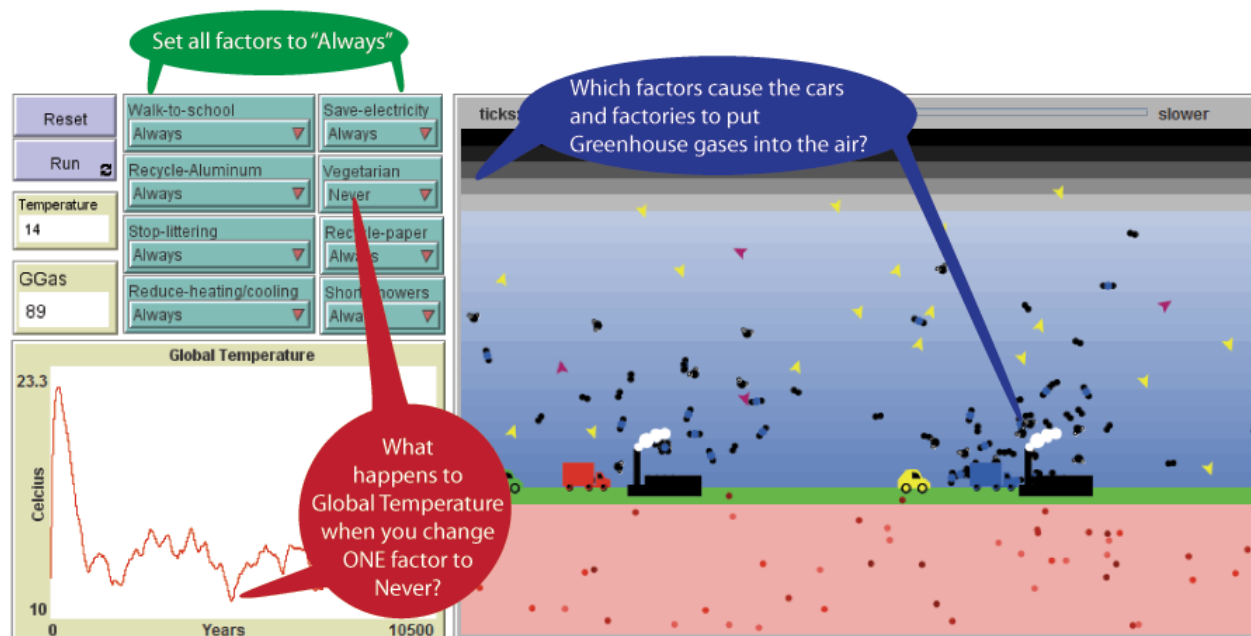
SAVE CHANGES

SAVE & CLOSE

The Greenhouse Effect and You

How do I contribute to the greenhouse effect?

At the beginning of this project, you advised Gwen on changes she could make to lower her energy usage.



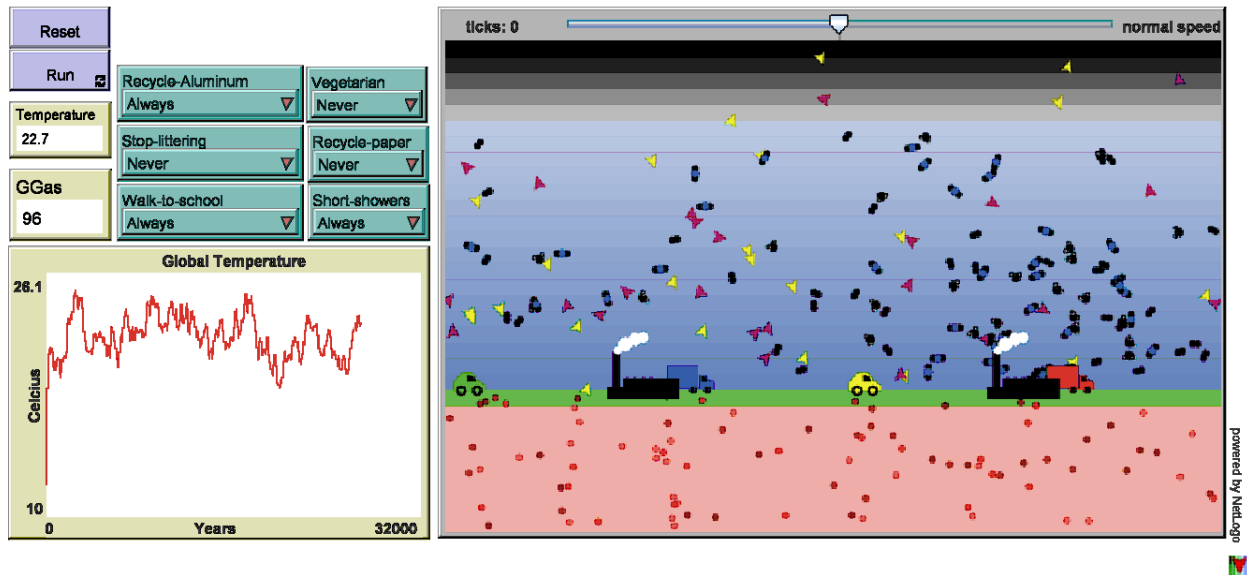
Now that you have learned how energy plays a role in the natural greenhouse effect, use the model to find out how your actions *add to the greenhouse effect*. Which factor do you think has the biggest effect on global temperature?

1. Walking to school rather than riding in a car
2. Recycling aluminum cans
3. Stop littering
4. Reducing heat/cooling (Using the heater or air conditioner less)
5. Saving electricity by turning off the computer/lights when not in use
6. Eating vegetarian meals rather than meat
7. Recycling paper
8. Taking shorter, cooler showers

Things to try:

Which actions raise global temperature the most? Test each factor ONE by ONE:

- A) Set all the factors to ALWAYS
- B) Click "reset" then click "run"
- C) After it runs for a minute, change ONE factor to NEVER and see what happens.
- D) REPEAT from step A) with a different factor.



The Greenhouse Effect and You

Do some independent research to figure out how *you* can help the Earth

How can you reduce your energy use?

Explore the links below to find out ways that you can lower your energy use.

Search for scientific evidence that supports how changing your actions will reduce your energy use.

You should explore at least TWO of the links thoroughly.

Look for evidence for why some actions might lower energy use, even though they are not electronic.

[Eartheasy blog](#)

[Climate Change for kids](#)

[Environmental Protection Agency](#)

[NASA](#)

[Global Warming for Kids](#)

[PEW Center on Global Climate for Kids](#)

Tall

Wide

Basic

Large



instructions

QUESTION

Gwen is confused. Her teacher told her that buying locally grown carrots instead of carrots from further away helps lower energy use. She thinks this is wrong because the carrots don't use electricity. What would you tell Gwen?

Hint: If you are unsure, do a little more research before answering.

RESPONSE

This is your 2nd revision.

SAVE CHANGES

SAVE & CLOSE

OPEN RESPONSE

instructions

QUESTION

Gwen is concerned about her energy use. She'd like to make **ONE** change to lower her energy use. Which **one** should she change to make the biggest impact?

- Walk to school
- Turn off lights/computer when not in use
- Eat less meat
- Recycle aluminum cans
- Recycle paper
- Stop littering
- Take shorter, less hot showers

EXPLAIN your choice using evidence!

RESPONSE

This is your first revision.

SAVE

MySystem Modeler

 Clear Diagram help

Objects:



Clouds

Driving



Greenhouse
Gasses

High

Properties:

GOALS

Make a MySystem to explain
Gwen how energy from the sun
and the things people do BOTH
contribute to global climate.

- Where does energy come from?
- How does energy move?
- Where does energy go?
- How does energy change?

Don't forget to label the arrow

OPEN RESPONSE

instructions

QUESTION

Write a story to explain to Gwen how BOTH: 1) energy from the sun and 2) things people do contribute to global climate change.

Be sure to include:

- Where energy comes from
- How energy moves
- Where energy goes
- How energy changes

Be sure to use scientific EVIDENCE to support your ideas.

RESPONSE

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

On a COLD day, Akbar walks to his car, parked in the sun. When he gets into his car he is surprised that it is already warm inside.

How can it be warmer inside the car?

- A) The heat energy from the Earth rose up into the car.
- B) The light energy from the Sun is transformed into heat energy which cannot radiate through the windows.
- C) The heat energy from the Sun conducts through the metal of the car and is stored in the seats.
- D) The heat energy from the last time the car was run– two days ago– remained stored in the car.

RESPONSE

I choose answer [] because...

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

The burning of fossil fuels has increased the carbon dioxide content of the atmosphere. What possible effect could the increased amount of carbon dioxide have on our planet?

- A) A warmer climate
- B) A cooler climate
- C) Lower relative humidity
- D) More ozone in the atmosphere

RESPONSE

I choose answer [] because...

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

Gwen conducted an experiment to show how the atmosphere works:

- She put one ice cube in a plastic bag and closed the bag.
- She put another ice cube on a plate
- She put both in the sun to melt.

Take a guess about which ice cube melted faster in the sun? Explain your answer using evidence to support your ideas.

RESPONSE

I predict the ice cube [] will melt faster because...

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

Senator George G. Warming has proposed that a state forest be used for farming. He thinks this will have no impact on temperature. Do you agree? Why or why not? Support your answer with evidence from the model in step 3.2!

RESPONSE

This is your first revision.

SAVE

OPEN RESPONSE

instructions

QUESTION

Write a letter to your city council about changes they could make to lower energy use for the whole city.

Include scientific evidence from your research to explain your suggestions.

RESPONSE

This is your 2nd revision.

SAVE

Your Actions

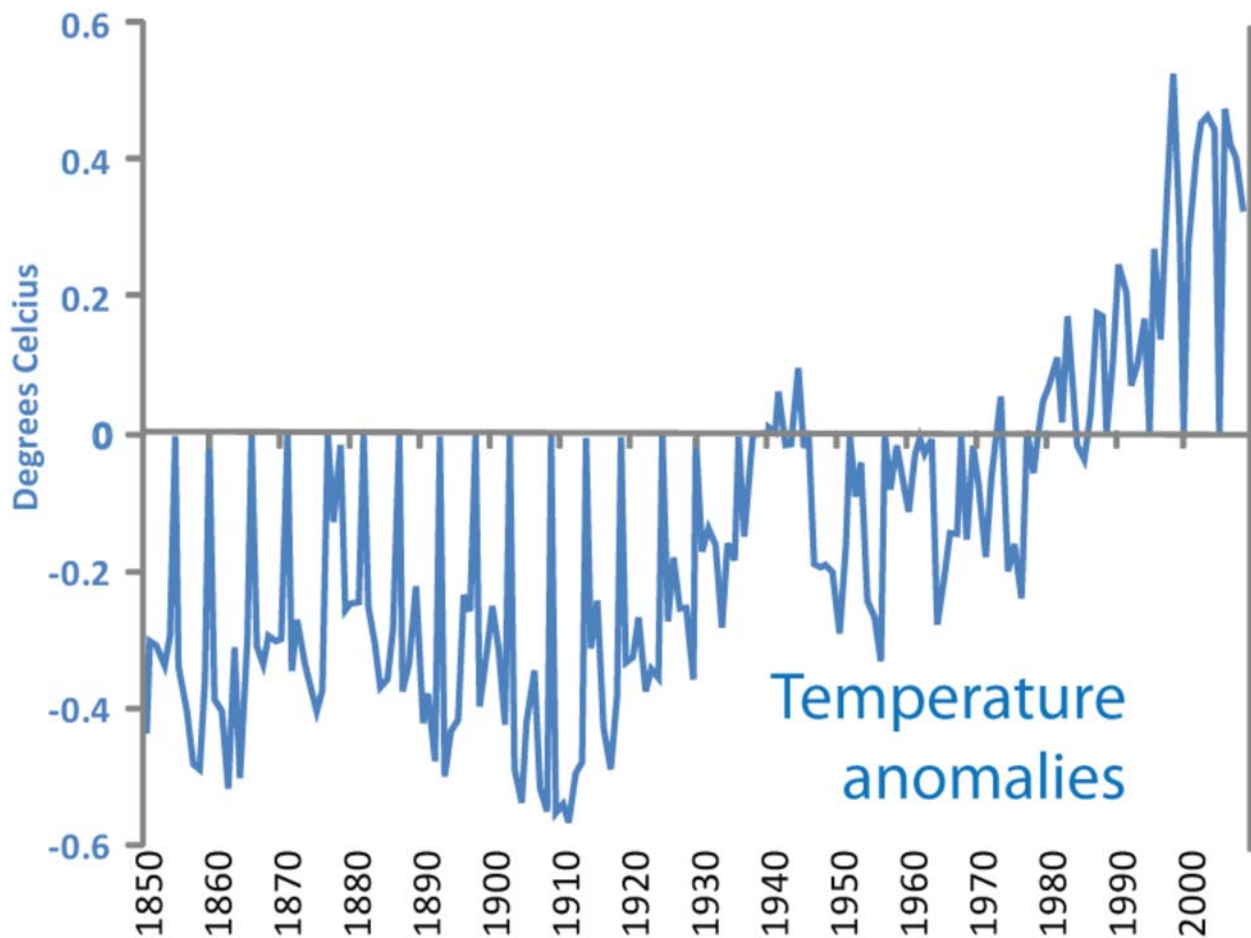
Is there evidence for climate change by humans?

The graph below shows **Temperature Anomalies** for the past 150 years.

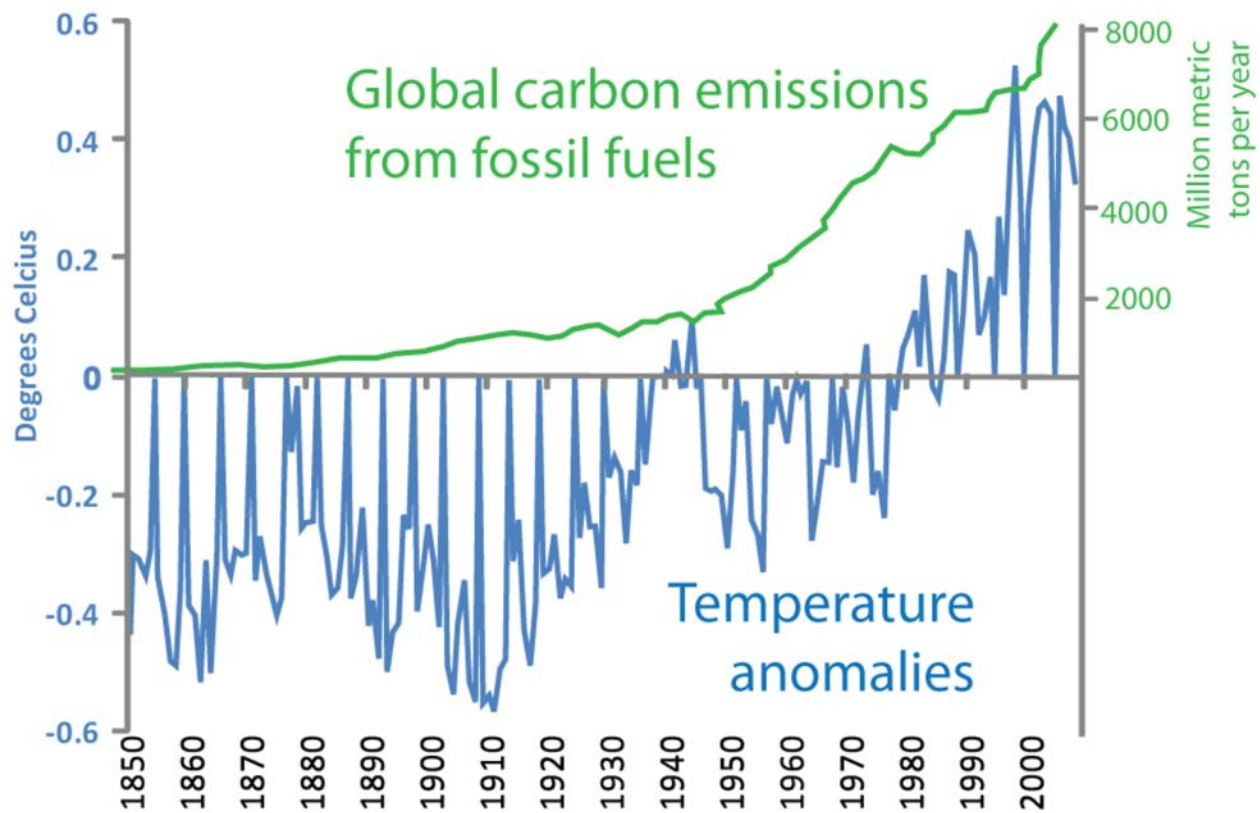
Temperature Anomalies are when the global temperature is higher or lower than normal.

What has happened to the temperature over the past 150 years? How much has it changed?

What else has changed in the past 150 years? Scroll down to investigate!



The graph below shows both the **Temperature Anomalies** and how much **Carbon** humans have added to the atmosphere for the past 150 years.



Tall

Wide

Basic

Large



instructions

QUESTION

Explain what has happened to global temperature in the last 150 years.

Make a prediction about what could happen to temperature in the future, as more people produce even more carbon dioxide.

RESPONSE

In the last 150 years, global temperature has...

I predict that in the future...

This is your 2nd revision.

SAVE CHANGES

SAVE & CLOSE