Greenhouse Gases and Their Effect on Earth’s Climate

**This activity requires installation of the Javs runtime environment.**

Access the pHet greenhouse simulation either in the provided app (requires Java) or at:

[**https://web.archive.org/web/20210908214133mp\_/https://phet.colorado.edu/en/simulations/greenhouse**](https://web.archive.org/web/20210908214133mp_/https://phet.colorado.edu/en/simulations/greenhouse)

Once you have navigated to PhET’s *The Greenhouse Effect* simulation page, select the large PLAY button in the middle of the simulation window.

Select ‘Open With JAVA’ and then select the button that says ‘Run’. **If you’re unable to open the simulation on your computer, make sure that you have an updated version of JAVA. Otherwise, you will have to complete this activity from another computer.**

## Part I Photon Absorption

To start, let’s examine the influence that photons have on earth’s atmosphere at the microscopic scale, and the impact that different photons have on different components of the atmosphere.

To do this, select the tab labeled ‘**Photon Absorption**’ and take a minute to familiarize yourself with the various settings.

Once you’re ready to begin answering questions, hit the ‘**Reset All**’ button at the bottom of the right-hand side of the screen.

1. What are photons? How are *Infrared* and *Visible* photons different from one another? You may need to do a bit of research in your textbook, or online to answer this question.
2. Identify the atmospheric gases listed at the right of the screen and whether their presence in the atmosphere depends on human activity. You may need to do a bit of research in your textbook or online to answer this question.

CH4:

CO2:

H2O:

N2:

O2:

1. Test each gas to see how it interacts with light. Do the various atmospheric gasses behave the same when interacting with the different types of photons (infrared vs. visible)? What observations lead you to this conclusion? Be as descriptive as possible with your answer.
2. Which gasses appear to be influenced the most by the presence of infrared photons? Which the least? How do you know?
3. If 99% of earth’s atmosphere is nitrogen and oxygen, why are we concerned about carbon dioxide? (Carbon dioxide makes up approximately 0.04% of earth’s atmosphere)
4. Create your own atmosphere using the simulator and see what happens. Write your thinking in creating your atmosphere.

***Discuss your results with your instructor at this point***

## Part II: The Greenhouse

We’re now ready to explore the impact that adding varying thicknesses of glass has on photons near earth’s surface. To do this, select the tab on the top of the screen labeled ‘**Glass Layers**.’

Take a minute to familiarize yourself with the various settings before you proceed.

Once you’re ready to begin answering questions, hit the ‘**Reset All**’ button at the bottom of the right side of the screen.

1. Comment on the relative directions that the different types of photons travel. Do they seem to behave identically or does one behave differently than the other? Be as descriptive as possible with your answer.
2. What effect does adding panes of glass have on the system? What leads you to believe that this is true? Try to incorporate the behavior of the infrared photons into your answer.
3. How is what you observed similar to the behavior of a greenhouse? How do you know?

***Discuss your results with your instructor at this point***

## Part III: The Atmospheric Greenhouse

We will conclude by exploring the tab labeled ‘**Greenhouse Effect**.’ Take a minute to familiarize yourself with the various controls.

When you are ready to start answering questions, hit the ‘**Reset All**’ button at the bottom of the right side of the screen.

1. What effect does changing the **Greenhouse Gas Concentration** appear to have on the system? Based on your previous observations, why do you think this happens?
2. Between what time periods (Ice Age, 1750, and Today) does there appear to be the largest increase in CO2 concentration? Which time period experiences the largest increase in temperatures? Can you think of any reasons why this might be the case?
3. Calculate the average rate of increase in CO2 concentration between 1750 and today (in ppm/year). Use this value, coupled with your findings from the previous question, to estimate when the Ice Age happened. Compare your answer to the geologic value of the date of the most recent Ice Age. What might any differences in these values tell you about the how the rate of increase in CO2 concentration has changed over time? **Please be sure to show all of your work here**.
4. Sketch a graph of CO2 concentration (on the vertical axis) vs. time (on the horizontal axes) using the data provided in the simulation. Be sure to label your axes and include appropriate units and scaling.
5. Based on your observations, what connection can you make between the ‘activity’ of the atmospheric greenhouse gas molecules you observed in the first part (**Photon Absorption**) and the temperature of the atmosphere?
6. In your own words, summarize the phenomenon you’ve just explored, known as the *Greenhouse Effect*.
7. In your opinion are greenhouse gasses (and thus the ‘*Greenhouse Effect’*) a good thing, or a bad thing for Earth and her inhabitants? Be sure to support your opinion with evidence.

***Discuss your results with your instructor at this point***

## Questions

1. As you’ve probably noticed, climate change is VERY contentious. As an example of how this sort of thing usually goes, here is a graph from a 2017 article by Steiger, et. al. (Climate reconstruction using data assimilation of water isotope ratios from ice cores, JGR Atmospheres, Volume122, Issue3, 16 February 2017, Pages 1545-1568).

BEarth refers to a database of actual global temperatures kept by the University of California at Berkeley. Recon. is an attempt to reproduce that data from ice core samples taken in Antarctica. They were trying to see if global temperature could be estimated from local data using a computer model based solely on Antarctic data. They conclude:

“…the pseudoproxy experiments suggest that ice cores can in principle be used to reconstruct nonlocal variables, particularly in the tropics. Though this nonlocal skill is spatially variable and even if ice core locations have a known seasonal link to other regions, this does not guarantee skillful ice core isotope-based reconstructions of these other linked regions.”

The graph they present shows how well the reconstruction matches the actual data.

So to summarize, the black line is actual data. The blue line is a computer simulation that didn’t work.

A graph showing the temperature of the earth


There is a climate skeptic site that purports to display “80 graphs that disprove climate change.” This graph is one of the ones they used. Here is how they present it:

A graph showing the temperature of the earth



What did they do here and why is it deceptive?

2. Here is another graph from a climate skeptic and a proposed better version of the graph from a climate scientist. Is it better? If so, why?

![A screenshot of a weather forecast
]()

![A graph showing the global warming
]()

3. One of the nice things about having more than one planet to look at is that it allows us to make predictions about what *should* be true under different local circumstances if a given theory is true. Venus and Mars are most like Earth and most nearly in the same part of the solar system. The Moon is right next door. Find out what you can about the composition of the atmospheres of Venus, Mars, and the Moon. If the greenhouse theory is true, what would it predict about the surface temperatures on each of these worlds? Is the prediction accurate? Is it feasible that distance from the Sun alone could account for these temperatures?

***Discuss your results with your instructor***