ATHENA Submission

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Lesson Title (max 100 characters): Modeling the Greenhouse Effect

Context / Background:
This lesson is part of a larger NGSS Climate Change Unit designed through grant funds in Rhode Island. The Unit explores Climate Change, sea level rise, and the disappearance of marshes in New England. As part of the unit, students are challenged to establish a cause-and-effect relationship between rising CO_2 levels and average global temperatures. In order to do this, students investigate where CO_2 comes from, and other sources of greenhouse gases.

Lesson Description:
During this lesson, students collect information about what greenhouse gases are and their sources. They analyze a model of the "natural greenhouse effect" and consider what might happen if the greenhouse layer were thicker and thinner. Students predict and create new models to reflect both new scenarios. They use the models to explore the relationships between solar radiation coming in, and solar radiation going out of earth's atmosphere. Understanding that the greenhouse effect is vital to life on earth, but that a human-amplified greenhouse effect is a disruption in the stability of this system is important. That humans contribute to greenhouse gases is key to this lesson because students are challenged to explore and consider ways to reduce their carbon footprints in future lessons.

Type of Lesson (check ONE only):
- Laboratory / Hands-On Activity
- Engineering Challenge
- Digital Learning Activity
- Research Project
- Interdisciplinary Lesson

JASON Connection(s):
- **Curriculum/a (REQUIRED)**: Climate: Seas of Change, Expedition 2, Stage 1
- **Specific JASON Lesson or Activity (optional)**: This is a new lesson intended to provide students with opportunities to develop and use models.

Recommended Grade (can be a range): 6-8

Estimated Time Required: App. two 45 minute lessons

Key Words:
Greenhouse Effect
Cause and Effect
Developing and Using Models
Earth Systems and Human Impact
Carbon dioxide levels
Greenhouse gas
Sea level rise
Solar radiation

Investigation	Mapping / Modeling the Greenhouse Effect
Materials	Modified Greenhouse Effect Article (slightly modified from website version) - one per student Projector/computer Devices students can use to look up greenhouse gases Chart paper or 8 1/2" x 11" Greenhouse effect Modeling Activity sheet - one per student Optional - greenhouse effect model template (may use for students with modifications) Markers or crayons Exit tickets (one copy per student)
Lesson-level Phenomenon	Global average temperatures are on the rise as are carbon dioxide levels.
Focus Question	Is there a relationship between these two things?
What should students be figuring out? / Hinge Idea	CO_2 is a "greenhouse gas". The Greenhouse effect is vital to life on earth. By keeping some of the sun's energy trapped, the earth is kept warm and makes earth habitable. However, too much greenhouse effect causes overall warming, and too little would result in a cold earth. Earth's greenhouse effect must remain stable / balanced.
How do these ideas eventually help explain /connect back to the anchoring phenomenon?	Students should be closer to establishing a cause and effect relationship between CO_2 and average temperatures. This is important because, ultimately, the rise in temps are causing sea levels to rise - and this is causing Rhode Island's wetlands to flood for longer periods of time. Recognizing that CO_2 is a major contributing factor (and therefore, human activity) is key to this learning sequence - b/c it is something humans have the power to reduce. In LSQ4, students are asked to develop possible solutions to the disappearing wetlands. Reducing their carbon footprint is one of these options.

Alignments	**PE/Practice/Concept/Core Idea** (highlight words or phrases learning sequence addresses)	**Evidence that students are using practice /applying concept/ developing idea**
Targeted PE(s)	**MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the**	

	past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]	Students research - gather information on what greenhouse gases are and where sources of CO_2 come from. They continue to be presented with the challenge of establishing a cause-and-effect relationship between CO_2 and global temps.
Science & Engineering Practices students use in this lesson	**Developing and Using Models** • Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed. • Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. • Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms. **Asking Questions** • Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. • Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument. • Ask questions to determine relationships between independent and dependent variables and relationships in models. • Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.	Students are asked to examine the diagram of the Earth's natural greenhouse effect which shows Earth's solar radiation coming in and (with varied thickness of arrows), heat that is re-radiated out, re-emitted in, and some radiation escaping into space. Students are then asked to predict what would happen if the greenhouse gas layer in the atmosphere was thicker. They are asked to draw models showing their prediction. Students will ask questions such as: How can I represent a thicker layer of greenhouse gases? How can I represent less heat escaping into space? How do we know that greenhouse gases hold onto heat in our atmosphere?
Disciplinary Core Ideas	• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6) • Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5)	By examining the diagrams of the Earth's Greenhouse Effect, students discover that the sun's solar radiation influences climate on Earth.

	• **Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)** • **Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	After predicting, revising diagrams, sharing, and discussing, students are coming to an understanding that the increase in greenhouse gases in the Earth's atmosphere is due to human activities as discussed in the article used in lesson 2.3. Here students should also recall the graph in lesson 2.2 showing increases in human population. Through the use of these articles, diagrams, and discussions, students should be developing a level of understanding that human activities are major factors in the rise of Earth's surface temperatures. Students should be reminded of the salt marshes and salt marsh sparrow that are feeling the effects of this rise in temperature.
Crosscutting Concepts	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. • Small changes in one part of a system might cause large changes in another part. • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and	By revising the diagram of the earth's greenhouse effect, student realize that the earth's stability may be disturbed by gradual changes in temperature caused by the burning of fossil fuels since the 1880's, the rise in human population, and the production of methane by livestock. Students use the "Earth's Greenhouse Effect" diagram as a model representing solar radiation as an energy input and radiation being re-emitted into the atmosphere and space as energy outputs.

	energy, matter, and information flows within systems. • Models are limited in that they only represent certain aspects of the system under study. **Energy and Matter** The transfer of energy can be tracked as energy flows through a designed or natural system.	This diagram is also used by students to demonstrate the transfer of solar radiation through the earth system.
CCSS ELA Connections	**Integration of Knowledge and Ideas:** CCSS.ELA-LITERACY.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	Students both read the article and analyze the model of the Earth's greenhouse effect to understand the relationship between greenhouse gases and the temperature of Earth's atmosphere.
Differentiation	Students may use the template when modelling human-amplified greenhouse gases and no greenhouse gases.	
Formative assessment Ideas	Teacher circulates constantly while students create diagrams and checks for understanding.	
Summative assessment ideas	Exit ticket - Students look at 2 models of the greenhouse effect (natural, human-induced, and need to identify which is which based on reasoning)	

Teaching Guide	
What the Teacher Does	**What the Students Do**
1. Push on questions that relate to what CO_2 is and where it comes from. Students may likely bring up term greenhouse gas - when they do - ask them exactly what they are. 2. Have students take 5 minutes to do some short research on their own - what are greenhouse gases and what are sources of greenhouse gases? Discuss. 3. Present students with the modified article "Greenhouse Gases" 4. Explain that models are not always or only 3D	Students do some short research on their own to find examples of greenhouse gases and the sources of those gases.

representations of something - models are used to help explain the way something works - models can be diagrams that show how a system functions and how the different parts of the system are related. The diagram of the natural greenhouse effect in the article is a model. 5. Challenge students to complete / draw two additional models predicting what would happen to earth's overall energy budget and temperatures if greenhouse layer was thicker (human amplified) or thinner than it is now. Provide the handout "Greenhouse effect Modeling Activity". Have students develop their models on chart paper or 81/2 x 11" (either works). For students who need extra assistance, you might opt to give them the template that has the basics of the diagram drawn in already (sun/earth). 6. Have students trade diagrams with a partner once finished to compare and discuss in small groups / at table - give students time to revise their models. 7. Show diagram from Expedition 2, Article on Greenhouse Effect Human-amplified greenhouse effect diagram. Have students reflect on how their models/drawings compare. 8. Ask students to share models of what would happen if there were no greenhouse effect. * This is really important b/c one of the big ideas in NGSS for middle school about climate is that the greenhouse effect makes earth habitable - and that without it, earth would be too cold to support life. It's the balance of having a thick enough layer that is crucial to our survival - bring in ideas of stability and change. Earth was stable for many years - now the greenhouse layer is expanding, and earth is changing as a result. What will happen if greenhouse gases go unchecked? 9. How does an understanding of climate science help us? (answers may vary but getting to the idea here that when you deeply understand something, you are in a much better position to consider or develop realistic solutions that might actually work! This emphasized in LSQ 4) 10. Exit ticket - handout greenhouse gas	Students draw/complete 2 additional models to predict what would happen to earth's overall energy budget and temperatures if the layer of greenhouse gases in the atmosphere was thicker (human amplified) or thinner than it is now. Students will trade diagrams with a partner and compare/discuss.

scenarios (unlabeled) and have students draw lines to match each one to its proper label. Students must provide a sentence or two for each one to explain their reasoning. (Chloe - ask me about this if not in folder when you come to this point - Amy)	Students will complete an exit ticket - greenhouse gas scenarios and match each one to its proper label with a sentence explaining their reasoning.

JASON Learning

MODIFIED VERSION of ARTICLE

The Greenhouse Effect

The Greenhouse Effect

Earth is habitable because of its atmosphere. Not only does the atmosphere provide air for us to breathe, but it also protects us from the sun's harmful ultraviolet radiation while allowing other wavelengths of the sun's energy to reach Earth's surface. The atmosphere also absorbs and emits enough heat energy from Earth to maintain a temperature where water is usually liquid and life as we know it can function.

When Earth's surface re-radiates and conducts heat back into the atmosphere, not all of it escapes into space. Some of that energy is absorbed by gases in the air, and the air heats up. The energy that might have escaped into space is trapped by the atmosphere. The trapping of heat near the planet's surface by gases in the atmosphere is called the greenhouse effect. Water vapor, carbon dioxide, methane, and other gases are all greenhouse gases.

The greenhouse effect is a natural process. Without it, life on Earth would not be possible. A planet the same distance from the sun as Earth, but without an atmosphere like Earth's to act as a natural greenhouse, would be too cold to support life. Look carefully at the model of the natural greenhouse effect that occurs on our Earth.

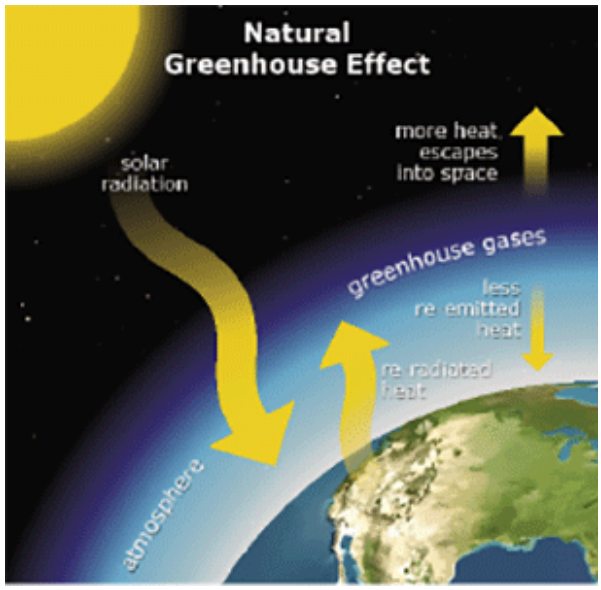
Check for Understanding

- In what way is the greenhouse effect essential for life on Earth?
- What change in the atmosphere is making Earth's greenhouse effect into a challenge for humans and life on Earth?

So why do we sometimes refer to the greenhouse effect as a problem? Humans are changing the atmosphere, which changes the way Earth's greenhouse effect works. Human activity is releasing large quantities of greenhouse gases — such as carbon dioxide, methane, and nitrous oxides — into the atmosphere. Carbon dioxide occurs naturally, but is also added to the atmosphere as humans burn fossil fuels and manufacture cement. Methane also occurs naturally, but is emitted in large amounts by industry, livestock, and decaying waste in landfills. How do you think the excess of greenhouses gases affects earth's energy budget?

Fast Fact

Greenhouses have been around, in one form or another, for about 2,000 years. The Romans grew fruits and vegetables in a structure called a specularium. The specularium used windows made from thin sheets of the mineral mica. Glass came later. The knowledge of how to make glass was lost in the Dark Ages and then rediscovered by the French in the Middle Ages. Greenhouses became more popular in the 1800s, when the cost of glass sheets fell and stronger steel was available on a large scale. Today's greenhouses often use fiberglass or plastic sheets instead of glass. However, plastic can become cloudy over time, making it less transparent. How would cloudy windows affect a greenhouse?



Modeling the Greenhouse Effect

Name: _____ **Date:** _____

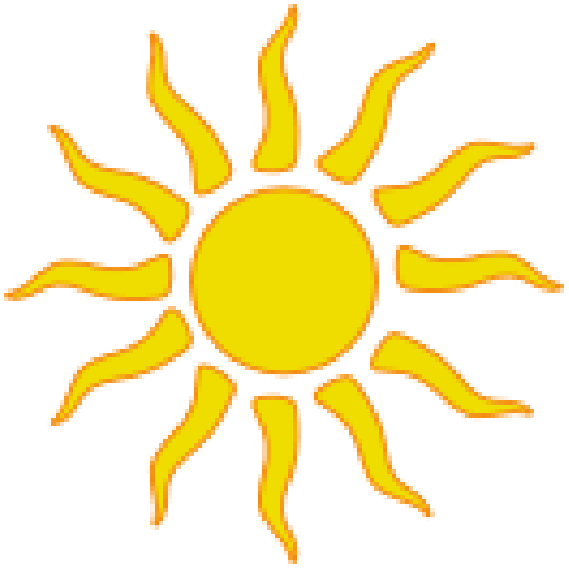
Read the article called *The Greenhouse Effect.* Compared to the model of the natural greenhouse effect, what would a model of human-amplified greenhouse effect look like? What would a model of no greenhouse effect look like? Create the following models on a piece of chart paper or use the template provided by your teacher.

A) Model the human-amplified greenhouse effect. Explain what happens to earth's energy budget (amount of energy entering the earth's atmosphere vs. the amount of energy leaving the earth's atmosphere) and overall temperatures?

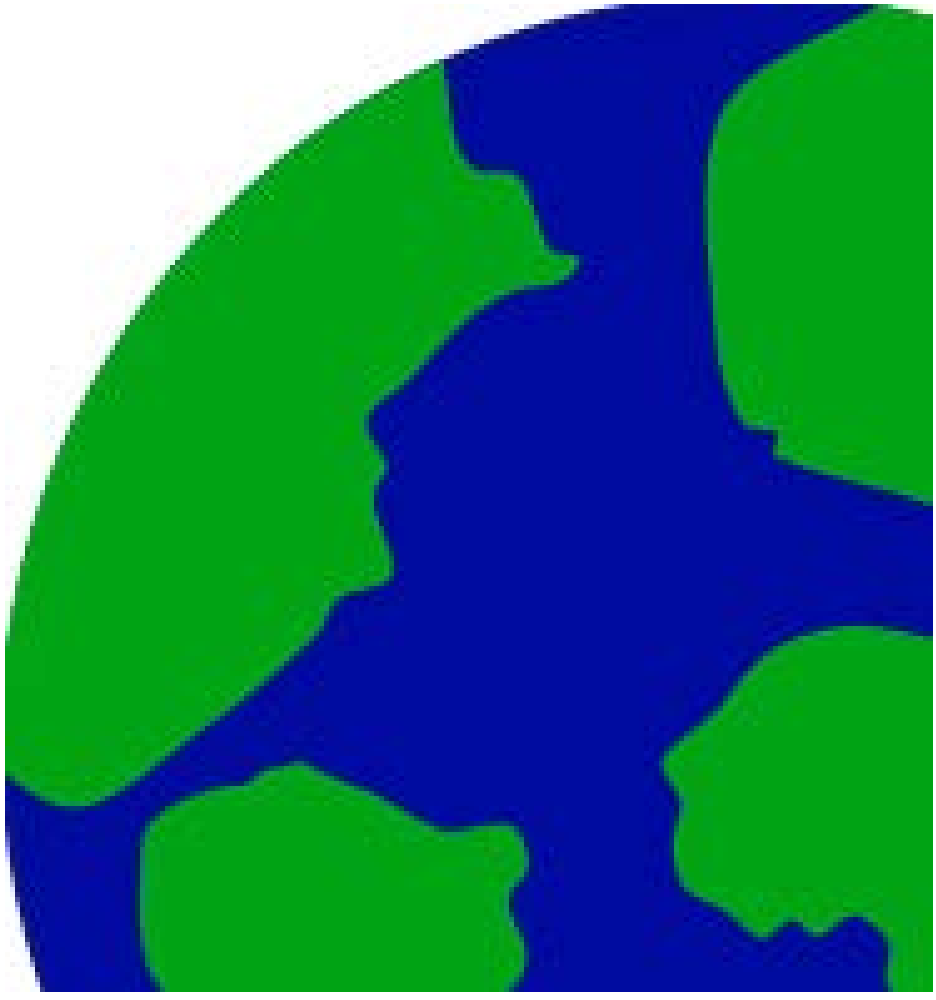
B) Model "no greenhouse effect". What would happen to the earth if there were no greenhouse effect? Why does the earth need it?

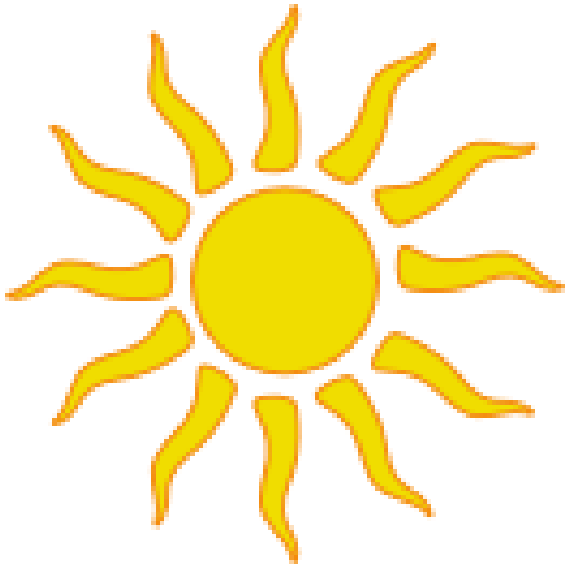
To help you think about this, consider how the following components of the system would compare to the natural greenhouse effect: For example, you might write "more", "less" or "same" in each cell and then draw and label it on your model. On your models, you can use large arrows to indicate relatively large amounts and small arrows to indicate relatively small amounts.

Comparisons to the Natural Greenhouse Effect		
	Model A Human Amplified Greenhouse Effect	**Model B** No Greenhouse Effect
Earth's atmosphere		
Amount of greenhouse gases		
Solar radiation coming in from the sun		
Re-radiated heat from earth back out		
Heat escaping into space		
Heat re-emitted back to earth		

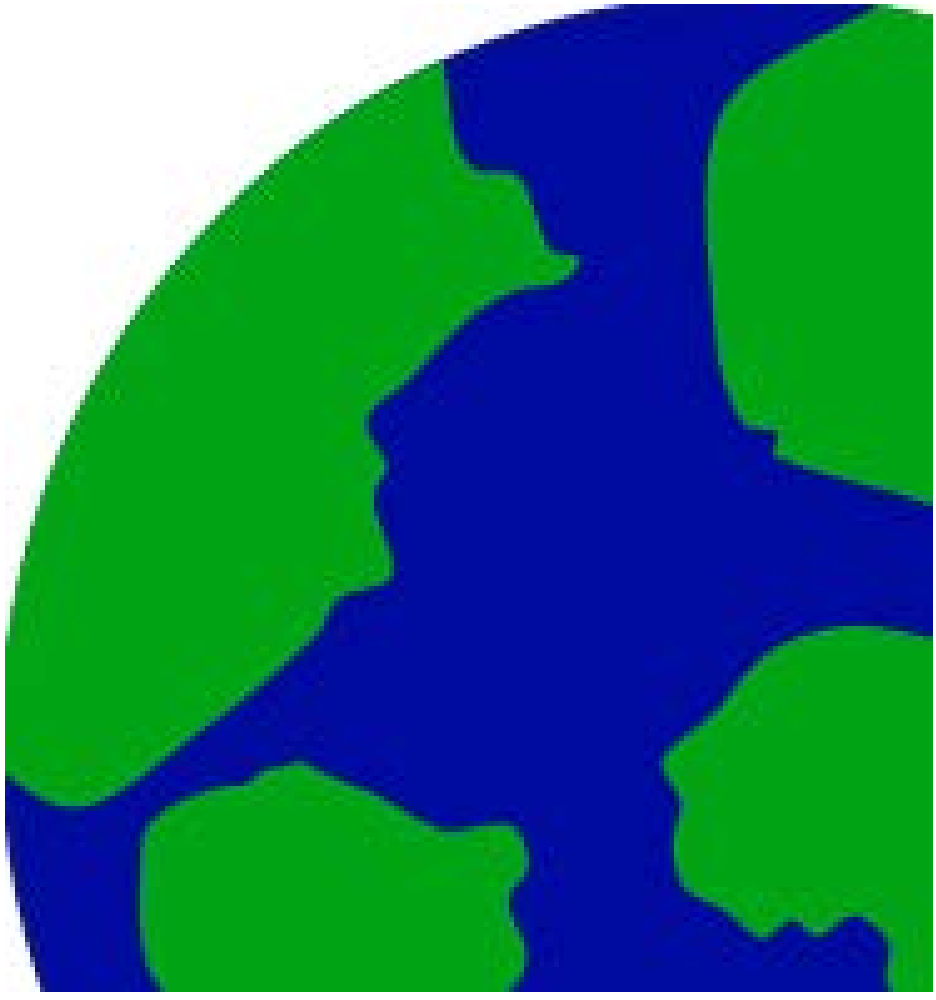


Model of Human-Amplified Greenhouse Effect



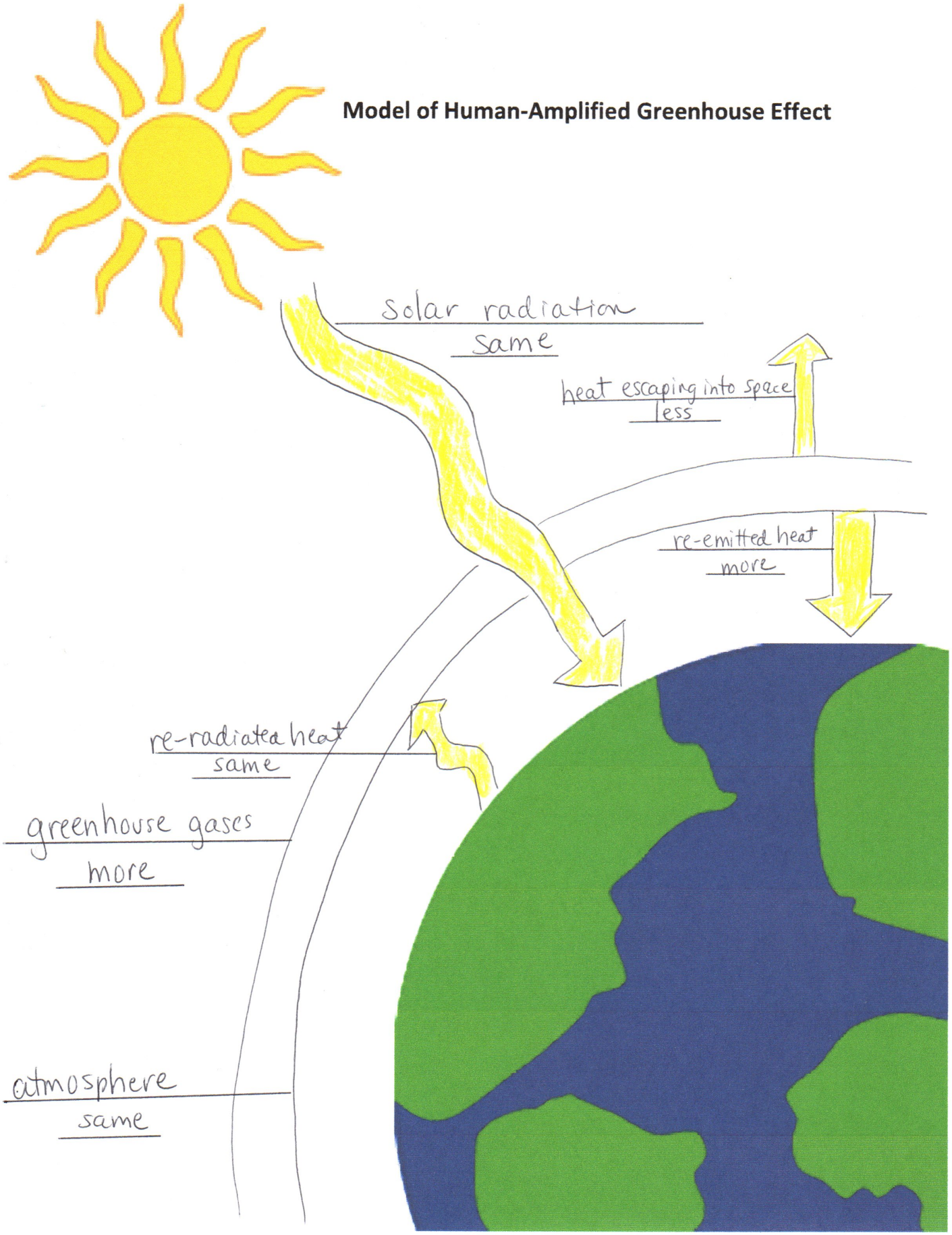


Model of No Greenhouse Effect



SAMPLE ANSWER KEY / MODEL - TEACHER USE ONLY

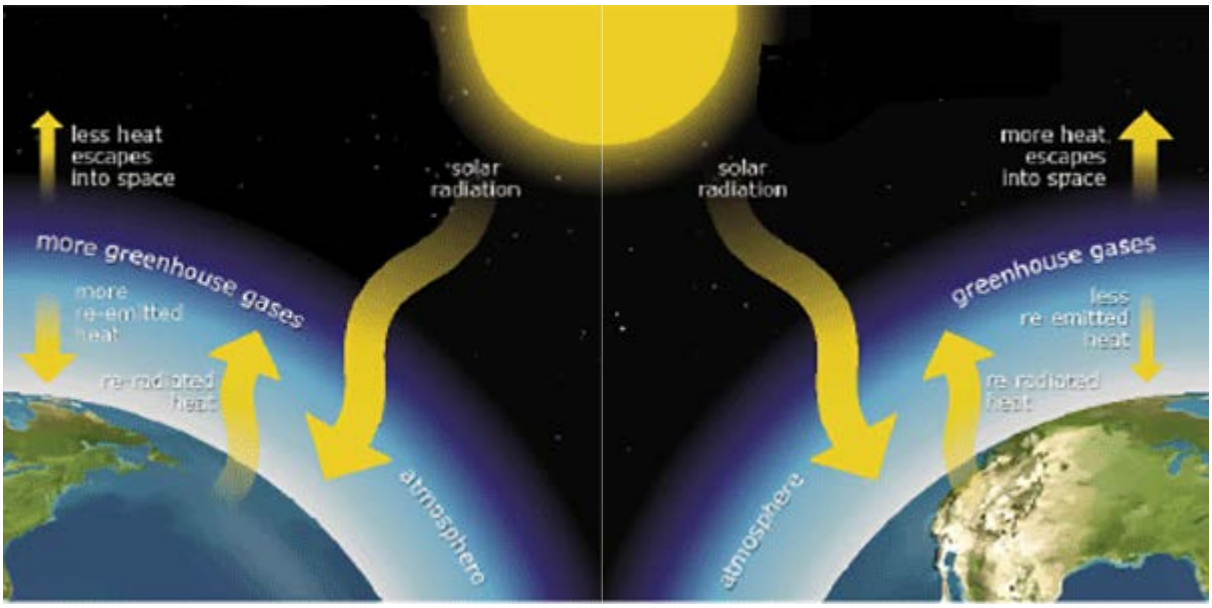
Model of Human-Amplified Greenhouse Effect



Climate: Seas of Change: Expedition 3
Greenhouse Effect Exit "Ticket"

Name: _____ Date: _____ Per: _____

1. Take a look at the two diagrams below. One diagram shows the natural greenhouse effect. The other diagram shows a human-amplified greenhouse effect. Explain which diagram is which. How do you know?



2. What would happen if there were no greenhouse effect on earth?