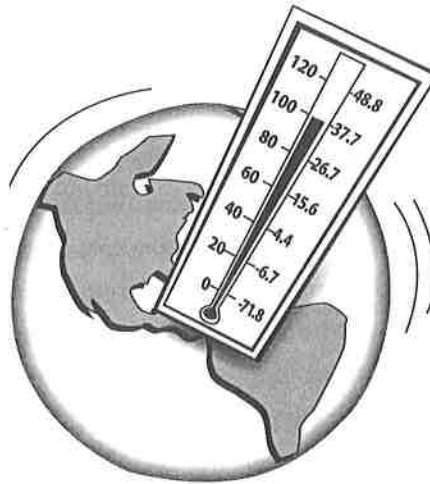


Global Warming

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about global warming. The probe is designed to find out what students think contributes to global warming.

Related Concepts

climate change, global warming, greenhouse gas

Explanation

The best answers are from Natalie and Tessa. The major cause of human-induced global warming comes from our use of fossil fuels that produce greenhouse gases. As solar radiation reaches Earth, clouds and dust reflect some of this back toward space, while some solar radiation warms the surface of the Earth. As a result, the Earth emits infrared radiation into the atmosphere, where some of the

atmospheric gases, including water vapor, carbon dioxide, methane, and nitrous oxide, are capable of absorbing the longer wavelength radiant energy. These gases are collectively called greenhouse gases, which warm the atmosphere, resulting in a climate that keeps our planet warm and livable.

This greenhouse effect is natural and necessary for life as we know it. In recent years, however, there has been an increase in the anthropogenic (produced by humans) production of greenhouse gases. Global atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed preindustrial values (IPCC 2007). Carbon dioxide is the most significant anthropogenic greenhouse gas. The primary source of the increased atmospheric concentration of carbon

dioxide is a result of the use of fossil fuels, such as coal and gasoline, because burning of fossil fuels (hydrocarbons found in the top layer of the Earth's crust) produces carbon dioxide gas.

The increased concentration of greenhouse gases has resulted in an increased absorption of radiant energy in the atmosphere, resulting in a warming of the global climate system as evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level (IPCC 2007).

There are a number of human-caused phenomena that are of significant environmental concern but are not major causes of global warming. Acid rain, caused by emissions of sulfur and nitrogen compounds that react in the atmosphere to produce acids, can affect a region's atmosphere, hydrosphere, geosphere, and biosphere. Air pollution and toxic chemicals can have similar impacts. Ozone depletion in the stratosphere may have some bearing on the chemistry of the atmosphere, but more important, it is linked to biological concerns—for example, skin cancer and cataracts, damage to plants, and reduction of plankton populations in the ocean—due to allowing more ultraviolet radiation to penetrate our atmosphere.

Curricular and Instructional Considerations

Elementary Students

In the elementary grades, students become familiar with energy sources and have oppor-

tunities to learn about the Sun's energy and how it heats the Earth. Students keep daily records of temperature, looking for patterns, before they develop an understanding of climate. Because the issue of global warming is common in the media, students at this age begin developing early conceptions of what it is and what causes it.

Middle School Students

In the middle grades, students may confuse the concepts of energy and energy sources and benefit from experiences that focus on energy transformation with design challenges and energy conversion systems. They trace where energy comes from and goes, using examples that involve different forms of energy such as heat and light. They begin to understand the laws of nature and to become aware that although energy can be transformed, it is not destroyed. Students connect their prior knowledge of the Earth and its weather to an understanding of climate. Their geometric reasoning and experiences with scale help them to shift their frame of reference away from the Earth's surface and to examine the effects of radiation at different angles to explain the seasons. They examine issues related to the impact of technology, such as burning fossil fuels. They analyze the causes and formulate ideas for solutions.

High School Students

Students at the high school level compare industrial and nonindustrial societies by their standards of living and energy consumption. They examine the consequences of the

world's dependence on fossil fuels, explore a wide range of alternative energy resources and technologies, consider trade-offs in each, and propose policies for conserving and managing limited energy resources. Principles of radiation, energy, and conservation are integrated into their views of Earth systems science. Their growing knowledge of chemistry helps them understand what greenhouse gases are and their impact on the atmosphere. A consciousness is developed that important decisions we make about our daily lives sometimes require us to make compromises; societal impacts are studied as well as those that affect human health and the environment.

Administering the Probe

This probe is best used at the middle and high school levels, particularly if students have been previously exposed to the terms *climate change* and *global warming*. You may want to encourage students to explain not only why they agree with the choice(s) they selected but also why they did not select the other choices.

Related Ideas in National Science Education Standards (NRC 1996)

K-4 Changes in Environments

- Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad.

5-8 Structure of the Earth System

- The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.

5-8 Earth in the Solar System

- The Sun is the major source of energy for phenomena on the Earth's surface.

5-8 Understandings About Science and Technology

- Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.

9-12 Energy in the Earth System

- Earth systems have internal and external sources of energy, both of which create heat. The Sun is the major external source of energy.
- Global climate is determined by energy transfer from the Sun at and near the Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and the Earth's rotation, and static conditions, such as the position of mountain ranges and oceans.

9-12 Science in Personal and Social Perspectives

- Materials from human societies affect both physical and chemical cycles of the Earth.

Related Ideas in Benchmarks for Science Literacy (AAAS 1993 and 2008)

Note: Benchmarks revised in 2008 are indicated by (R). New benchmarks added in 2008 are indicated by (N).

K–2 Energy Sources and Use

- People burn fuels such as wood, oil, coal, or natural gas, or use electricity to cook their food and warm their houses.

K–2 Energy Transformations

- The Sun warms the land, air, and water.

3–5 The Earth

- Air is a substance that surrounds us and takes up space. It is also a substance whose movement we feel as wind.

6–8 Energy Sources and Use

- Different ways of obtaining, transforming, and distributing energy have different environmental consequences.
- ★ By burning fuels, people are releasing large amounts of carbon dioxide into the atmosphere and transforming chemical energy into thermal energy, which spreads throughout the environment.

6–8 Processes That Shape the Earth

- Human activities such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farm-

ing have changed the Earth's land, oceans, and atmosphere.

9–12 Energy Sources and Use

- At present, all fuels have advantages and disadvantages so society must consider the trade-offs among them.
- Industrialization brings an increased demand for and use of energy. Such usage contributes to the high standard of living in the industrially developing nations but also leads to more rapid depletion of the Earth's energy resources and to environmental risks associated with the use of fossil and nuclear fuels.

9–12 The Earth

- Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans, and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the oceans results in layers of different temperatures and densities in both the ocean and atmosphere.
- ★ Greenhouse gases in the atmosphere, such as carbon dioxide and water vapor, are transparent to much of the incoming sunlight but not to the infrared light from the warmed surface of the Earth. When greenhouse gases increase, more thermal energy is trapped in the atmosphere, and the temperature of the Earth increases the light energy radiated into space until it again equals the light energy absorbed from the Sun. (N)

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

- ★ The Earth's climates have changed in the past, are currently changing, and are expected to change in the future, primarily due to changes in the amount of light reaching places on the Earth and the composition of the atmosphere. The burning of fossil fuels in the last century has increased the amount of greenhouse gases in the atmosphere, which has contributed to Earth's warming.

Related Research

- Students of all ages may confuse the ozone layer with the greenhouse effect and may have a tendency to imagine that all environmentally friendly actions help to solve all environmental problems (e.g., that the use of unleaded gas reduces the risk of global warming [AAAS 2007]).
- Students have difficulty linking relevant elements of knowledge when explaining the greenhouse effect and may confuse the natural greenhouse effect with the enhancements of that effect (AAAS 2007).
- Students may identify the transfer of energy to the environment with pollution or waste materials being thrown into the environment (AAAS 1993).
- Some students confuse lead and other types of pollution with the greenhouse effect (Driver et al. 1994).

Suggestions for Instruction and Assessment

- Discuss the distinction between the natural greenhouse effect and global warming,

highlighting the ability of greenhouse gases to trap infrared radiation as natural and necessary for life as we know it. It is the increase in concentration of greenhouse gases that is producing the global warming effect, resulting in an increase in global average air and ocean temperatures.

- Hold a climate-change town hall meeting. Have students assume a variety of citizen and government agency roles and discuss the factors contributing to global warming. Encourage the group to make decisions that would reduce the anthropogenic production of greenhouse gases, considering the personal, national, and global impacts and the economic, societal, and scientific costs and benefits. Their goal should be to reach a consensus on how to reduce the consumption in a realistic way, not to debate and have a "loser" and a "winner."
- Encourage students to consider ways they can "think globally, act locally." Identify steps they can take to reduce their carbon footprint. Use a carbon dioxide emissions calculator. These and other global climate change education resources can be found at the American Association for the Advancement of Science website: www.aaas.org/climate.
- Include understandings of the nature of science as you explore complex issues of global warming and climate change. The Intergovernmental Panel on Climate Change (IPCC) was established to bring an international group of scientists together

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

in order to evaluate the risk of climate change caused by human activity. For more information, go to www.ipcc.ch. Examine, analyze, and interpret the data that have been summarized in the *Climate Change 2007: Synthesis Report* (IPCC 2007).

Related NSTA Science Store Publications, NSTA Journal Articles, NSTA SciGuides, NSTA SciPacks, and NSTA Science Objects

- Constible, J., L. Sandro, and R. E. Lee, Jr. 2007. A cooperative classroom investigation of climate change. *The Science Teacher* (Sept.): 56–63.
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Related Curriculum Topic Study Guide

(Keeley 2005)

“Weather and Climate”

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