Analyze

1. Why does the author suggest that the elevated levels of modern carbon dioxide emissions are produced by humans? How exactly do human activities produce carbon dioxide?
2. What kind of information does this writer use to make his point? To what kind of audience do you think such appeals would be the most convincing? Do you find his argument compelling? Why or why not?
3. Dr. Cicerone was speaking to a room of scientists and he used many graphs and diagrams. Which of the figures was the most convincing to you? Which one do you want help interpreting?

Explore

1. The author states that "communicating with the general public is ever more important. All of us have much to learn and to discuss about what climate is, and what it means to us." Often, celebrities and songwriters use their status and popularity to share their own opinions on issues like climate change with a wide audience. Locate a song in which the artist expresses his or her opinion on climate change and write a rhetorical analysis of the piece. What message does the artist hope to get across? Who is the target audience? How does the artist try to speak and relate to the audience through word choice and tone?
2. Do some research to determine if there are any local organizations in your community that are working on behalf of climate change initiatives. Where are they? What do they do? Write a profile of this organization for your community or school newspaper detailing the mission and activities of one such organization—be sure to reference any accomplishments they have achieved for the community so far. Alternatively, contact this organization to see if you can collaborate with them on the things they write.
3. Cicerone delivered this talk in 2006 and there has been a great deal of climate research since then. And, unfortunately, the change is even more obvious now. NASA, the National Oceanographic and Atmospheric Administration, and many environmental organizations such as Greenpeace have websites with the most recent information on climate change. Do some research on the most recent discoveries and data on climate change. Then briefly summarize Cicerone's argument about climate change and use the new data to support and extend his argument.

National Research Council
"Advancing the Science of Climate Change"

The National Research Council (NRC) was organized in 1916 by the National Academy of Sciences, the leading interdisciplinary scientific organization in the United States if not the world. The purpose of the NRC is to provide information to the science and engineering community, the government, and the public. The organization is directed by senior scientists and engineers from across America. *Advancing the Science of Climate Change*, from which our selection is taken, is one of four reports on climate change produced by the NRC in 2010. In this report, a panel of scientists summarizes the peer-reviewed research from the national and international community. This report represents a synthesis of the best, most authoritative, and most current research on global climate change. The selections included below offer a brief history of climate science and a clear explanation of "uncertainty" in science; a factual description of the extent of sea-level rise due to climate change and the potential consequences; the effect of climate change on ocean ecosystems such as coral reefs and polar bears; and the consequences for human health. As you read this report, consider how you might explain these complex connections to your friends.

Class work #2 Explore answer

Introduction: Science for Understanding and Responding to Climate Change

#1 Group work pgs. 90

Humans have always been influenced by climate. Despite the wealth and technology of modern industrial societies, climate still affects human well-being in fundamental ways. Climate influences, for example, where people live, what they eat, how they earn their livings, how they move around, and what they do for recreation. Climate regulates food production and water resources and influences energy use, disease transmission, and other aspects of human health and well-being. It also influences the health of ecosystems that provide goods and services for humans and for the other species with which we share the planet.

In turn, human activities are influencing climate. As discussed in the following chapters, scientific evidence that the Earth is warming is now

GHG Fossil fuels in air

overwhelming. There is also a multitude of evidence that this warming results primarily from human activities, especially burning fossil fuels and other activities that release heat-trapping greenhouse gases (GHGs) into the atmosphere. Projections of future climate change indicate that Earth will continue to warm unless significant and sustained actions are taken to limit emissions of GHGs. Increasing temperatures and GHG concentrations are driving a multitude of related and interacting changes in the Earth system, including decreases in the amounts of ice stored in mountain glaciers and polar regions, increases in sea level, changes in ocean chemistry, and changes in the frequency and intensity of heat waves, precipitation events, and droughts. These changes in turn pose significant risks to both human and ecological systems. Although the details of how the future impacts of climate change will unfold are not as well understood as the basic causes and mechanisms of climate change, we can reasonably expect that the consequences of climate change will be more severe if actions are not taken to limit its magnitude and adapt to its impacts.

Scientific research will never completely eliminate uncertainties about climate change and its risks to human health and well-being, but it can provide information that can be helpful to decision makers who must make choices in the face of risks. In 2008, the U.S. Congress asked the National Academy of Sciences to "investigate and study the serious and sweeping issues relating to global climate change and make recommendations regarding what steps must be taken and what strategies must be adopted in response . . . including the science and technology challenges thereof." This report is part of the resulting study, called *America's Climate Choices.* In the chapters that follow, this report reviews what science has learned about climate change and its causes and consequences across a variety of sectors. The report also identifies scientific advances that could improve understanding of climate change and the effectiveness of actions taken to limit the magnitude of future climate change or adapt to its impacts. Finally, the report identifies the activities and tools needed to make these scientific advances and the physical and human assets needed to support these activities (for the detailed statement of task). Companion reports provide information and advice on *Limiting the Magnitude of Future Climate Change* (NRC, 2010c), *Adapting to the Impacts of Climate Change* (NRC, 2010a), and *Informing an Effective Response to Climate Change* (NRC, 2010b).

Scientific Learning About Climate Change

Climate science, like all science, is a process of collective learning that proceeds through the accumulation of data; the formulation, testing, and refinement of hypotheses; the construction of theories and models to synthesize understanding and generate new predictions; and the testing of hypotheses, theories, and models through experiments or other observations. Scientific knowledge builds over time as theories are refined and expanded and as new observations and data confirm or refute the predictions of current theories and models. Confidence in a theory grows if it survives this rigorous testing process, if multiple lines of evidence lead to the same conclusion, or if competing explanations can be ruled out.

In the case of climate science, this process of learning extends back more than 150 years, to mid-19th-century attempts to explain what caused the ice ages, which had only recently been discovered. Several hypotheses were proposed to explain how thick blankets of ice could have once covered much of the Northern Hemisphere, including changes in solar radiation, atmospheric composition, the placement of mountain ranges, and volcanic activity. These and other ideas were tested and debated by the scientific community, eventually leading to an understanding (discussed in detail in Chapter 6) that ice ages are initiated by small recurring variations in Earth's orbit around the Sun. This early scientific interest in climate eventually led scientists working in the late 19th century to recognize that carbon dioxide (CO_2) and other GHGs have a profound effect on the Earth's temperature. A Swedish scientist named Svante Arrhenius was the first to hypothesize that the burning of fossil fuels, which releases CO_2, would eventually lead to global warming. This was the beginning of a more than 100-year history of ever more careful measurements and calculations to pin down exactly how GHG emissions and other factors influence Earth's climate (Weart, 2008).

Progress in scientific understanding, of course, does not proceed in a simple straight line. For example, calculations performed during the first decades of the 20th century, before the behavior of GHGs in the atmosphere was understood in detail, suggested that the amount of warming from elevated CO_2 levels would be small. More precise experiments and observations in the mid-20th century showed that this was not the case, and that increases in CO_2 or other GHGs could indeed cause significant warming. Similarly, a scientific debate in the 1970s briefly considered the possibility that human emissions of aerosols—small particles that reflect sunlight back to space—might lead to a long-term cooling of the Earth's surface. Although prominently reported in a few news magazines at the time, this speculation did not gain widespread scientific acceptance and was soon overtaken by new evidence and refined calculations showing that warming from emissions of CO_2 and other GHGs represented a larger long-term effect on climate.

Thus, scientists have understood for a long time that the basic principles of chemistry and physics predict that burning fossil fuels will lead to increases in the Earth's average surface temperature. Decades of observations and research have tested, refined, and extended that understanding, for example, by identifying other factors that influence climate, such as changes in land use, and by identifying modes of natural variability that modulate the long-term warming trend. Detailed process studies and models of the climate system have also allowed scientists to project future climate changes. These projections are based on scenarios of future GHG emissions from energy use and other human activities, each of which represents a different set of choices that societies around the world might make. Finally, research across a broad range of scientific disciplines has improved our understanding of how the climate system interacts with other environmental systems and with human systems, including water resources, agricultural systems, ecosystems, and built environments.

Uncertainty in Scientific Knowledge

From a philosophical perspective, science never *proves* anything—in the manner that mathematics or other formal logical systems prove things—because science is fundamentally based on observations. Any scientific theory is thus, in principle, subject to being refined or overturned by new observations. In practical terms, however, scientific uncertainties are not all the same. Some scientific conclusions or theories have been so thoroughly examined and tested, and supported by so many independent observations and results, that their likelihood of subsequently being found to be wrong is vanishingly small. Such conclusions and theories are then regarded as settled facts. This is the case for the conclusions that the Earth system is warming and that much of this warming is very likely due to human activities. In other cases, particularly for matters that are at the

leading edge of active research, uncertainties may be substantial and important. In these cases, care must be taken not to draw stronger conclusions than warranted by the available evidence.

The characterization of uncertainty is thus an important part of the scientific enterprise. In some areas of inquiry, uncertainties can be quantified through a long sequence of repeated observations, trials, or model runs. For other areas, including many aspects of climate change research, precise quantification of uncertainty is not always possible due to the complexity or uniqueness of the system being studied. In these cases, researchers adopt various approaches to subjectively but rigorously assess their degree of confidence in particular results or theories, given available observations, analyses, and model results. These approaches include estimated uncertainty ranges (or error bars) for measured quantities and the estimated likelihood of a particular result having arisen by chance rather than as a result of the theory or phenomenon being tested. These scientific characterizations of uncertainty can be misunderstood, however, because for many people "uncertainty" means that little or nothing is known, whereas in scientific parlance uncertainty is a way of describing how precisely or how confidently something is known. To reduce such misunderstandings, scientists have developed explicit techniques for conveying the precision in a particular result or the confidence in a particular theory or conclusion to policy makers (see Box 4.1).

A New Era of Climate Change Science: Research for Understanding and Responding to Climate Change

In the process of scientific learning about climate change, it has become 10
evident that climate change holds significant risks for people and the natural resources and ecosystems on which they depend. In some ways, climate change risks are different from many other risks with which people normally deal. For example, as discussed in Chapters 2 and 3, climate change processes have considerable inertia and long time lags. The actions of today, therefore, will be reflected in climate system changes several decades to centuries from now. Future generations will be exposed to risks, some potentially severe, because of today's actions, and in some cases these changes will be irreversible. Likewise, climate changes can be abrupt—they

BOX 4.1 UNCERTAINTY TERMINOLOGY

In assessing and reporting the state of knowledge about climate change, scientists have devoted serious debate and discussion to appropriate ways of expressing uncertainty to policy makers (Moss and Schneider, 2000). Recent climate change assessment reports have adopted specific procedures and terminology to describe the degree of confidence in specific conclusions or the estimated likelihood of a certain outcome (see, e.g., Manning et al., 2004). For example, a statement that something is "very likely" in the assessments by the Intergovernmental Panel on Climate Change indicates an estimated 9 out of 10 or better chance that a certain outcome will occur.

In estimating confidence, scientific assessment teams draw on information about "the strength and consistency of the observed evidence, the range and consistency of model projections, the reliability of particular models as tested by various methods, and, most importantly, the body of work addressed in earlier synthesis and assessment reports" (USGCRP, 2009a). Teams are also encouraged to provide "traceable accounts" of how these estimates were constructed, including important lines of evidence used, standards of evidence applied, approaches taken to combining and reconciling multiple lines of evidence, explicit explanations of any statistical or other methods used, and identification of critical uncertainties. In general, statements about the future are more uncertain than statements about observed changes or current trends, and it is easier to employ precise uncertainty language in situations where conclusions are based on extensive quantitative data or models than in areas where data are less extensive, important research is qualitative, or models are in an earlier stage of development.

In this report, *Advancing the Science of Climate Change*, when we draw directly on the statements of the formal national and international assessments, we adopt their terminology to describe uncertainty. However, because of the more concise nature and intent of this report, we do not attempt to quantify confidence and certainty about every statement of the science.

GHG

have the potential to cross tipping points or thresholds that result in large changes or impacts. The likelihood of such abrupt changes is not well known, however, which makes it difficult to quantify the risks posed by such changes. Climate change also interacts in complex ways with other ongoing changes in human and environmental systems. Society's decisions about land use and food production, for example, both affect and are affected by climate change.

On the basis of decades of scientific progress in understanding changes in the physical climate system and the growing evidence of the risks posed by climate change, many decision makers—including individuals, businesses, and governments at all levels—are either taking actions to respond to climate change or asking what actions they might take to respond effectively. Many of these questions center on what specific actions might need to be taken to limit climate change by reducing emissions of GHGs: what gases, from what sources, when and where, through what specific technology investments or changes in management practices, motivated and coordinated by what policies, with what co-benefits or unintended consequences, and monitored and verified through what means? Other questions focus on the specific impacts that are expected and the actions that can be taken to prepare for and adapt to them, such as reducing vulnerabilities or improving society's coping and adaptive capacity.

This report explores what these emerging questions and decision needs imply for future scientific learning about climate change and for the scientific research enterprise. As the need for science expands to include both *improving understanding* and *informing and supporting decision making*, the production, synthesis, and translation of scientific knowledge into forms that are useful to decision makers becomes increasingly important. It may also imply a need to change scientific practices, with scientists working more closely with decision makers to improve the scientific decision support that researchers can offer. However, even with this decision focus, scientific knowledge cannot by itself specify or determine any choice. It cannot tell decision makers what they *should* do; their responsibilities, preferences, and values also influence their decisions. Science can inform decisions by describing the potential consequences of different choices, and it can contribute by improving or expanding available options, but it cannot say what actions are required or preferred.

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Water #1 p. 190-193 - large group - 4 (6) summarize

Sea Level Rise and the Coastal Environment

The coastlines of the United States and the world are major centers of economic and cultural development, where populations and associated structural development continue to grow. The coasts are also home to critical ecological and environmental resources. Coastal areas have always experienced various risks and hazards, such as flooding from coastal storms. However, coastal managers and property owners are concerned about how these risks are being and will be intensified by sea level rise and other climate changes.

risk or hydro

Observations of Sea Level Rise

Sea level has been systematically measured by tide gauges for more than 100 years. Other direct and indirect observations have allowed oceanographers to estimate (with lower precision) past sea levels going back many thousands of years. We know that sea level has risen more than 400 feet (120 meters) since the peak of the last ice age 26,000 years ago, with periods of rapid rise predating a relatively steady level over the past 6,000 years. During the past few decades, tide gauge records augmented by satellite

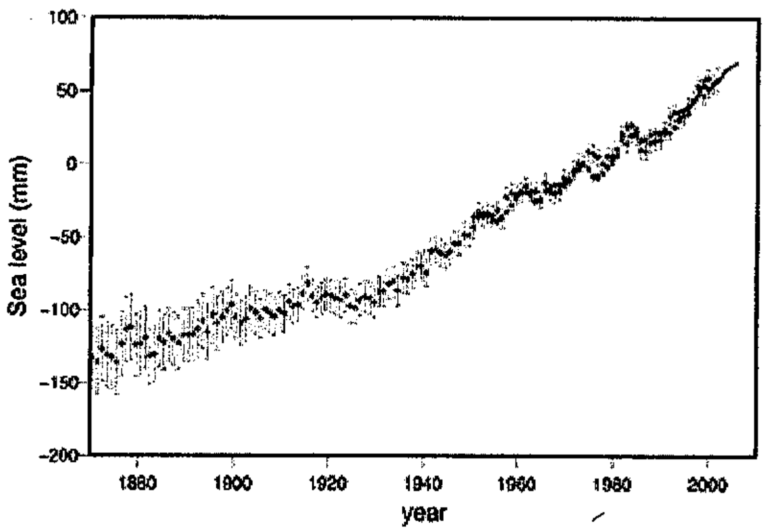

Figure 4.20 Annual, global mean sea level as determined by records of tide gauges and satellite altimetry. Source: Bindoff et al. (2007).

measurements have been used to produce precise sea level maps across the entire globe. These modern records indicate that the rate of sea level rise has accelerated since the mid-19th century, with possibly greater acceleration over the past two decades. The exact amount of sea level change experienced in different locations varies because of different rates of settling or uplift of land and because of differences in ocean circulation.

Causes of Sea Level Rise

Past, present, and future changes in global sea level are mainly caused by two fundamental processes: (1) the thermal expansion of the existing water in the world's ocean basins as it absorbs heat and (2) the addition of water from land-based sources—mainly the shrinking of ice sheets and glaciers.

Because of the huge capacity of the oceans to absorb heat, 80 to 90 percent of the heating associated with human GHG emissions over the past 50 years has gone into raising the temperature of the oceans. The subsequent thermal expansion of the oceans is responsible for an estimated 50 percent of the observed sea level rise since the late 19th century. Even if GHG concentrations are stabilized, ocean warming and the accompanying sea level rise will continue until the oceans reach a new thermal equilibrium with the atmosphere. Ice in the world's glaciers and ice sheets contributes directly to sea level rise through melt or the flow of ice into the sea. The major ice sheets of Greenland and Antarctica contain the equivalent of 23 and 197 feet (7 and 60 meters) of sea level, respectively.

Projections of Sea Level Rise

Projections of future sea level have been the subject of active discussion in the recent literature on climate change impacts. The 2007 Assessment Report by the IPCC estimated that sea level would likely rise by an additional 0.6 to 1.9 feet (0.18 to 0.59 meters) by 2100. This projection was based largely on the observed rates of change in ice sheets and projected future thermal expansion over the past several decades and did not include the possibility of changes in ice sheet dynamics. Scientists are working to improve how ice dynamics can be resolved in models. Recent research, including investigations of how sea level responded to temperature variations during the ice age cycles, suggests that sea levels could potentially rise another 2.5 to 6.5 feet (0.8 to 2 meters) by 2100, which is several times larger than the IPCC estimates. However, sea level rise estimates are rather uncertain, due mainly to limits in scientific understanding of glacier and ice sheet dynamics. For instance, recent findings of a warming ocean around Greenland suggest an explanation for the accelerated calving of outlet glaciers into the sea, but the limited data and lack of insight into the mechanisms involved prevent a quantitative estimate of the rate of ice loss at this time. Nevertheless, it is clear that global sea level rise will continue throughout the 21st century due to the GHGs that have already been emitted, that the rate and ultimate amount of sea level rise will be higher if GHG concentrations continue to increase, and that there is a risk of much larger and more rapid increases in sea level. While this risk cannot be quantified at present, the consequences of extreme and rapid sea level rise could be economically and socially devastating for highly built-up and densely populated coastal areas around the world, especially low-lying deltas and estuaries.

Ice Sheet Processes Could Potentially Lead to Abrupt Changes

In addition to rapid accelerations in the rate of sea level rise, a collapse or rapid wastage of major ice sheets could lead to other abrupt changes. For example, if the Greenland ice sheet were to shrink substantially over several decades, a large amount of freshwater would be delivered to key regions of the North Atlantic. This influx of freshwater could alter the ocean structure and influence ocean circulation, with implications for regional and global weather patterns. Compelling evidence has been assembled indicating that rapid freshwater discharges at the end of the last ice age caused abrupt ocean circulation changes, which in turn led to significant impacts on regional climate. The recent ice melting on Greenland and other areas in the Arctic, combined with increased river discharges in the Arctic region (see discussion of precipitation and runoff changes below), may have already led to changes in ocean circulation patterns. However, much work remains to develop confident projections of future ocean circulation changes—and the influence of these changes on regional climate patterns—resulting from ongoing freshwater discharges in the North Atlantic.

Sea Level Rise Is Associated with a Range of Impacts on Coastal Environments

Coastal areas are among the most densely populated and fastest-growing regions of the United States, as well as the rest of the world. Such population concentration and growth are accompanied by a high degree of development and use of coastal resources for economic purposes, including industrial activities, transportation, trade, resource extraction, fisheries,

tourism, and recreation. Sea level rise can potentially affect all of these activities and their accompanying infrastructure, and it could also magnify other climate changes, such as an increase in the frequency or intensity of storms (see below). Even if the frequency or intensity of coastal storms does not change, increases in average sea level will magnify the impacts of extreme events on coastal landscapes.

The economic impacts of climate change and sea level rise on coastal 20
areas in the United States have been an important focus for research. While economic impact assessments have become increasingly sophisticated, they remain incomplete and are subject to the well-recognized challenges of cost-benefit analyses (see Chapter 17). In addition, while studies of economic impacts may be useful at a regional level, general conclusions regarding the total magnitude of economic impacts in the United States cannot be drawn from existing studies; this is because the metrics, modeling approaches, sea level rise projections, inclusions of coastal storms, and assumptions about human responses (e.g., the type and level of protection) vary considerably across the studies.

Coastal ecosystems such as dunes, wetlands, estuaries, seagrass beds, and mangroves provide numerous ecosystem goods and services, ranging from nursery habitat for certain fish and shellfish to habitat for bird, mammal, and reptilian species, including some endangered ones; protective or buffering services for coastal infrastructure against the onslaught of storms; water filtering and flood retention; carbon storage; and the aesthetic, cultural, and economic value of beaches and coastal environments for recreation, tourism, and simple enjoyment. The impact of sea level rise on these and other non-market values is often omitted from economic impact assessments of coastal areas because of difficulties in assigning values.

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Weather

Public Health

#2 p. 193 - 195

Weather and climate influence the distribution and incidence of a variety of public health outcomes. Indeed, any health outcome that is influenced by environmental conditions may be impacted by a changing climate. However, the causal chain linking climate change to shifting patterns of health threats and outcomes is complicated by factors such as wealth, distribution of income, status of public health infrastructure, provision of preventive and acute medical care, and access to and appropriate use of health care information. Additionally, the severity of future health impacts will be strongly influenced by concurrent changes in nonclimatic factors as well as strategies to limit and adapt to climate change.

Extreme Temperatures and Thermal Stress

Heat waves are the leading causes of weather-related morbidity and mortality in the United States, and hot days and hot nights have become more frequent and more intense in recent decades. Their frequency, intensity, and duration are projected to increase, especially under the higher warming scenarios. Warming temperatures may also reduce exposure and health impacts associated with cold temperatures, although the extent of any reduction is highly uncertain, and analyses and projections of the impacts of temperature changes on human health are complicated by other factors. In particular, death rates depend on a range of circumstances other than temperature, including housing characteristics and personal behaviors, and these have not been extensively studied in the context of future climate projections.

Severe Weather

Deaths and physical injuries from hurricanes, tornadoes, floods, and wildfire occur annually across the United States. Direct morbidity and mortality increase with the intensity and duration of such events. As a general trend, climate change will lead to an increase in the intensity of rainfall and the frequency of heat waves, flooding, and wildfire. Uncertainties remain in projections of future storm patterns, including hurricanes. The number of deaths and injuries that result from all of these extreme events can be decreased through advanced warning and preparation. Changes in severe weather events may also lead to increases in diarrheal disease and increased incidence of respiratory symptoms, particularly in developing countries. Mental health impacts are often overlooked in the discussion of climate change and public health. Severe weather often results in increased anxiety, depression, and even posttraumatic stress disorder.

Infectious Diseases

25 The ranges and impacts of a number of important pathogens may change as a result of changing temperatures, precipitation, and extreme events. Increasing temperatures may increase or shift the ranges of disease vectors (and their associated pathogens), including mosquitoes (malaria, dengue

Variance by degrees and measurements.

fever, West Nile virus, Saint Louis encephalitis virus), ticks (Rocky Mountain spotted fever, Lyme disease, and encephalitis), and rodents (hantavirus and leptospirosis). Consequently, additional people will be exposed to infectious diseases in many parts of the world. Several pathogens that cause food- and waterborne diseases are sensitive to ambient temperature, with faster replication rates at higher temperatures. Waterborne disease outbreaks are also associated with heavy rainfall and flooding and, therefore, may also increase.

Air Quality #3 Smaller (2)

Poor air quality—specifically increased ground-level ozone and/or aerosol concentrations—results in increased incidence of respiratory illness. For example, acute ozone exposure is associated with increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma, and allergic rhinitis, and also with premature mortality. Temperature and ozone concentrations are closely connected; projected increases in temperatures in coming decades may increase the occurrence of high-ozone events and related health effects. Climate change could also affect local to regional air quality through changes in chemical reaction rates, boundary layer heights that affect vertical mixing of pollutants, and changes in airflow patterns that govern pollutant transport. In addition to air quality problems driven by pollution, preliminary evidence suggests that allergen production by species such as ragweed increases with high temperature and/or high CO_2 concentration.

The relationship between climate change, air quality, and public health is further complicated by the fact that policies designed to limit the magnitude of climate change may be at odds with improving public health outcomes. For example, reducing aerosol concentrations would reduce air pollution–related health impacts, but the resulting changes in atmospheric reflectivity could further increase temperatures.

Vulnerable Populations #4 Smaller (3)

Vulnerability to the public health challenges discussed above will vary within and between populations. Overall, older adults, infants, children, and those with chronic medical conditions tend to be more sensitive to the health impacts of climate change. Susceptibility varies geographically, with the status of public health infrastructure playing a large role in determining vulnerability differences between populations.

There is variance & uncertainty

Analyze

1. The author states that progress in scientific understanding "does not proceed in a straight line." What does he mean by this? How so?
2. Can science tell us exactly how much or where seal levels will rise as a result of global climate change? Why or why not?
3. What does the author mean when he says that science never proves anything? If these facts cannot be proven, how do we know they are facts? How do scientists move forward in the face of this uncertainty?

Explore

1. Do some research to determine what, if any, policies are in place or under debate at your local government regarding climate change. Draw up a blog post that captures a snapshot of the political stance on climate policy in your area, as well as the stances on climate initiatives held by your area's representatives.
2. Throughout these readings, you have learned a lot about the tension between scientific findings regarding climate change and public understanding and acceptance of climate science. Can you think of other social situations that arose in the past that have been characterized by similar public tension? What were the circumstances of that situation? What was the public's initial reaction? How did that reaction change? What caused the change? Write a blog post that uses the comparison between public acceptance of climate change and the struggle for the public to accept another issue such as cigarette smoking to convince your peers about the reality of climate change.

#2 Explore

3. The NRC is an organization that provides scientific information to the public and to the legislatures that make public policy. Go to their website and to the websites of other similar organizations (NOAA, NASA, NIH, NSF) and read what they say about the connection between science and public policy. When you have read a number of these statements, write your own position paper on whether and how science should be part of our public policy and decision-making processes.

Terry Cannon
"Gender and Climate Hazards in Bangladesh"

The following article appeared in the July 2002 issue of *Gender and Development*, a journal dedicated to supporting development policy and practices that promote gender equality. The author, Terry Cannon, is the director for the Strengthening Climate Resilience program at the Institute of Development Studies. There, he researches rural livelihoods, disaster vulnerability, and climate change adaptation. In 2004, he co-authored *At Risk: Natural Hazards, People's Vulnerability and Disasters*, one of the most widely cited books in the field. In the article below, Cannon says that extreme climate events attributed to climate change are likely to have worse consequences for women than for men because of their different economic situations. Using Bangladesh as a case study, he outlines the unique challenges facing women in climate-related disasters. As you read, consider the connections between this essay and Roman Krznaric's essay on empathy in this chapter and the story of Kettleman City residents in Chapter 2. Is sustainability just about water, soil, food, and energy?

Bangladesh has recently experienced a number of high-profile disasters, including devastating cyclones and annual floods. Poverty is both a cause of vulnerability, and a consequence of hazard impacts. Evidence that the impacts of disasters are worse for women is inconclusive or variable. However, since being female is strongly linked to being poor, unless poverty is reduced, the increase in disasters and extreme climate events linked with climate change is likely to affect women more than men. In addition, there are some specific gender attributes which increase women's vulnerability in some respects. These gendered vulnerabilities may, however, be reduced by social changes.

To many from outside, Bangladesh is almost synonymous with disasters. In a country smaller than Britain, and with more than twice as many people, around one-third of the land is flooded every summer. The monsoon rains cover the low-lying land, and swell the three major river systems that struggle to find outlets to the sea. In some years, such as in 1998, nearly half of the land area of Bangladesh is under water. Tropical cyclones strike the coast at least once a year, bringing rainwater floods, salt-water incursions,