

Supplemental Lesson Material

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Thanks for checking out the Earth & Space QUEST for Elizabeth Kolbert's Field Notes from a Catastrophe! This document contains material that can be used in conjunction with the .KMZ file that can be opened in Google Earth:

- There are two questions listed for each chapter; these questions vary in difficulty, and require different levels of thinking (based on Bloom's Taxonomy)
- Key terms include significant people, places, organizations, movements, and pieces of legislature
- Vocabulary words are related to the scientific content of Kolbert's book
- For each chapter, there are 2-3 quotes from the pages of the book that can be used for discussion or reflective writing assignments

Please do not hesitate to contact me with any questions, suggestions, or recommendations! Email me at earthandspacequest@gmail.com or leave a comment on my blog: <http://earthandspacequest.tumblr.com>.

Thank you for your interest,
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Getting Started

- Open the .KMZ file in Google Earth.
- Guide yourself through the content by clicking through the folders and yellow push pins in the "Places" menu on the left-hand side of the Google Earth window.
- To zoom into a specific push pin's location, double click on links in the "Places" menu.
- Scroll (either using your mouse or the navigation buttons on the right-hand side of the Google Earth window) to zoom in to and out from locations on the globe.
- *If you cannot see the navigation buttons on the right-hand side (there is a compass with cardinal directions and a sliding bar with + and - signs to zoom in and out), go to the top menu of Google Earth, click on View > Show Navigation, and click "Always").*
- Explore and enjoy!

Questions

CHAPTER 1

1. Can you think of other ways melted permafrost can negatively affect humans and the environment?
2. The earth's average albedo is 0.3. What does this mean? How much light is reflected and how much is absorbed?

CHAPTER 2

1. Describe what greenhouse gases do to the environment.
2. Who coined the term "the greenhouse effect"?

CHAPTER 3

1. In the second pin for Chapter 3 (Ice Cores & Iceland's Glaciers), click the link to NOVA Online. In your own words, describe how scientists collect ice cores.
2. List the eight Arctic nations

CHAPTER 4

1. What do you think a lepidopterist is?
2. Using the ruler tool, how far is it from Liverpool to Norfolk?

CHAPTER 5

1. What is a forcing? Describe in your own words.
2. Re-read Kolbert's quote: "You can argue that man through culture creates stability, or you can argue, just as plausibly, that stability is for culture an essential precondition" (p. 119). What do you think this means? What kind of stability is the author referring to?

CHAPTER 6

1. The pin that marks the Zaan River in the Netherlands contains information about how climate change will affect flooding in the Netherlands. Can you think of any other ways a rising global temperature can affect bodies of water? Describe at least two.
2. What does DAI stand for? What is it?

CHAPTER 7

1. Name three types of fossil fuels.
2. What is a stabilization wedge?
 - a. What types of energy are addressed in stabilization wedges No. 10 and No. 11?
 - b. What other types of energy may be represented in the other thirteen stabilization wedges? Give one example.

CHAPTER 8

1. Name five of the countries that did not accept the Kyoto Protocol in 2005.
2. Create mandatory guidelines for reducing greenhouse gas emissions, as if you were a member of the U.N. who worked on the Framework Convention and the Kyoto

Protocol. Keep in mind the treaty's goals were different for each country based on economic and political history. List three rules that can be used to reduce emissions, and differentiate at least two of them for other countries.

CHAPTER 9

1. According to Kolbert, the thirty-six million people who live in communities governed by the U.S. Mayors Climate Protection Agreement are approximately 12% of the U.S. population. Using ratios/proportions, find the approximate value of the current U.S. population.
2. What are some small changes you can make to decrease your emissions growth? Name at least 5.

CHAPTER 10

1. Take a look at the photo of the geologic time scale in From the Holocene to the Anthropocene. What do you think "Ma" represents?
2. Describe, in your own words, why CFCs are contributing to ozone depletion.

Key Terms & Vocabulary

People

- Donald Perovich
- John Tyndall
- Svante Arrhenius
- Charles David Keeling
- Konrad Steffen
- Oddur Sigurdsson
- Robert Correll
- Harvey Weiss
- James Hansen
- Peter deMenocal
- Robert Socolow
- Marty Hoffert
- Paula Dobriansky
- Tony Blair
- Jacques Chirac
- Sir Emyr Jones Parry
- Peter Clavelle
- Greg Nickels
- David Hawkins

Places

- Mauna Loa
- Swiss Camp
- Monteverde Cloud Forest
- Shekhna
- Tell Leilan
- Zaan River
- Rio de Janeiro

Organizations

- National Academy of Sciences
- National Aeronautics & Space Administration (NASA)
- U.S. Weather Bureau
- National Oceanic & Atmospheric Administration (NOAA)
- National Science Foundation (NSF)
- NASA's Goddard Institute for Space Study (GISS)
- United Nations (UN)
- National Resources Defense Council (NRDC)

Legislation & Other Movements

- The Framework Convention
- Kyoto Protocol

- Byrd-Hagel Resolution
- “The 10% Challenge”
- U.S. Mayors Climate Protection Agreement

General Vocabulary

- global warming
- climate change
- greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, chlorofluorocarbons
- emissions, emissions growth
- fossil fuels
- carbon footprint
- sustainability
- geologic time scale
- qualitative observations
- quantitative observations
- equilibrium
- radiation
- forcings (natural, anthropogenic)
- ppm (parts per million)
- The Keeling Curve

Specific Vocabulary

- permafrost
- spectroradiometer
- albedo
- sea ice (perennial sea ice)
- sea dikes
- lepidopterist
- paleoclimatologist
- Mesopotamian history/Mesopotamia
- DAI (dangerous anthropogenic interference)
- amphibious houses
- stabilization wedges
- decarbonization

Supplemental Quotes for Discussion

The following quotes have been pulled from the pages of Elizabeth Kolbert's book. The quotes are grouped based on the topics covered in the Earth & Space QUEST. Bolded headings are Kolbert's chapter titles (and there are 2-3 quotes per chapter); underlined headings represent titles of pins in the Field Notes From a Catastrophe Earth & Space QUEST (from the .KMZ file).

Chapter 1: Shishmaref, Alaska

The Climate Study

Our planet's "energy balance," explained to Kolbert by the Ad Hoc Study Group on Carbon Dioxide and Climate (also known as the Charney Panel):

- "The effect of adding CO₂ to the atmosphere is to throw the earth out of 'energy balance.' In order for balance to be restored--as, according to the laws of physics, it eventually must be--the entire planet has to heat up, including the oceans, a process [...] that could take 'several decades'" (Kolbert, p. 11).

Sea Ice & Glacial Cycles

Donald Perovich, employee of the Cold Regions Research and Engineering Laboratory talks climate with Kolbert:

- "On the one hand, you think, It's the earth's climate system; it's big, it's robust. And, indeed, it has to be somewhat robust or else it would be changing all the time.' On the other hand, the climate record shows that it would be a mistake to assume that change, when it comes, will come gradually" (Kolbert, p. 34).
- "Perovich offered a comparison that he had heard from a glaciologist friend. The friend likened the climate system to a rowboat: 'You can tip and then you'll just go back. You can tip it and just go back. And then you tip it and you get to the other stable state, which is upside down'" (Kolbert, p. 34).

Chapter 2: A Warmer Sky

Global Warming: An Outdated Idea?

On Earth's equilibrium:

- "In order for the earth to be in equilibrium, the quantity of energy it radiates out into space must equal the quantity of radiation it is receiving. When, for whatever reason, equilibrium is disturbed, the planet will either warm up or cool down until its temperature is once again sufficient to make the two energy streams balance out" (Kolbert, p. 38).

On the effect of greenhouse gases on global temperature:

- “If there were no greenhouse gases in the atmosphere, energy radiating from the surface of the earth would flow away unimpeded [...] greenhouse gases alter the situation because of their selectively absorptive properties [...] the earth’s radiation, which is emitted in the infrared part of the [light] spectrum is partially blocked. Greenhouse gases absorb infrared radiation and then re-emit it [...] This process of absorption and re-emission has the effect of limiting the outward flow of energy; as a result, the earth’s surface and its lower atmosphere need to be that much warmer before the planet can radiate out the necessary 235 watts per square meter. The presence of greenhouse gases largely accounts for the fact that the average global temperature, instead of zero, is actually a far more comfortable fifty-seven degrees” (Kolbert, p. 39).

Chapter 3: Under the Glacier

Ice Cores & Iceland’s Glaciers

On melting sheets of ice:

- “Once an ice sheet begins to melt, it starts to flow faster, which means it also thins out faster, encouraging further melt” (Kolbert, p. 54).

A Meeting of the Minds

Robert Corell, an American oceanographer and former assistant director at the National Science Foundation:

- “‘Let’s say there’s three hundred people in this room,’ he told me. ‘I don’t think you’ll find five who would say that global warming is just a natural process.’ (While I was at the conference, I spoke to more than twenty scientists, and I couldn’t find one who described it that way)” (Kolbert, p. 63).

Chapter 4: The Butterfly & The Toad

The Golden Toad from Monteverde

On tracking species’ expansion:

- “Documenting a species’ contraction is more difficult than documenting its expansion -- is it really gone, or did someone just miss it?” (Kolbert, p. 89).

Kolbert speaks with Chris Thomas, a biologist at the University of York:

- “If there is this overwhelming evidence that species are changing their distributions, we’re going to have to expect the same for crops and pests and diseases. Part of it simply is we’ve got one planet, and we are heading it in a direction that, quite

fundamentally, we don't know what the consequences are going to be" (Kolbert, p. 90).

Chapter 5: The Curse of Akkad

The Goddard Institute for Space Science

On the effectiveness of the GISS climate model, ModelE (which deals with the formation of clouds):

- "Hansen told the group that he was pleased with how ModelE had reproduced the aftermath of the eruption of Mount Pinatubo, in the Philippines, which took place in June 1991. Volcanic eruptions release huge quantities of sulfur dioxide -- Pinatubo produced some twenty million tons of the gas -- which, once in the stratosphere, condenses into tiny sulfate droplets. These droplets, or aerosols, tend to cool the earth by reflecting sunlight back into space [...] the cooling effect of aerosols lasts only as long as the droplets remain suspended in the atmosphere. In 1992, following the Pinatubo eruption, global temperatures, which had been rising sharply, fell by half a degree. Then they began to climb again. ModelE had succeeded in simulating this effect to within nine hundredths of a degree. 'That's a pretty nice test,' Hansen observed laconically" (Kolbert, p. 105).

Forcings

Kolbert speaks with David Rind, climate scientist at GISS:

- "We may say that we're more technologically able than earlier societies. But one thing about climate change is it's potentially geopolitically destabilizing. And we're not only more technologically able; we're more technologically able destructively as well. I think it's impossible to predict what will happen. I guess -- thought I won't be around to see it -- I wouldn't be shocked to find out that by 2100 most things were destroyed.' He paused. 'That's sort of an extreme view'" (Kolbert, p. 112).

What Really Happened in History

On Harvey Weiss' talk, "What Happened in the Holocene" at Yale University (cultural events outlined for attendees in black ink, climatological events outlines in red):

- "Around 6200 B.C., a severe global cold snap produced aridity in the Near East. (The cause of the cold snap -- red ink -- is believed to have been a catastrophic flood that emptied an enormous glacial lake -- Lake Agassiz -- into the North Atlantic.) Right around the same time -- black ink -- farming villages in northern Mesopotamia were abandoned, while in central and southern Mesopotamia the art of irrigation was invented. Three thousand years later, there was another cold snap, after which settlements in northern Mesopotamia once again were deserted. The most recent red event, in 2200 B.C., was followed by the dissolution of the Old Kingdom in Egypt, the abandonment of villages in ancient Palestine, and the fall of Akkad" (Kolbert, p. 118).

Chapter 6: Floating Houses

Antarctic Ice & Climate Change

On global warming and flooding:

- “There are several reasons why global warming produces flooding. The first has to do simply with the physics of liquids. As water warms, it expands [...] Meanwhile, a warming Earth means changing precipitation” (Kolbert, p.125).

Working with the Water

A scientist with the National Oceanic and Atmospheric Administration:

- “It’s true that we’ve had higher CO₂ levels before. But, then, of course, we also had dinosaurs” (Kolbert, p. 131).

Chapter 7: Business as Usual

Greenhouse Gas Emissions

On the carbon emissions in the U.S.:

- “The largest single source of carbon emissions in the United States is electricity production, at 39 percent, followed by transportation, at 32 percent. In a country like France, where three quarters of the power is produced by nuclear plants, this ratio is very different, and it’s different again in countries like Bhutan, where many people don’t even have access to electricity and where they burn wood and animal waste to cook and heat their homes” (Kolbert, p. 136).

Carbon-free Energy

NYU physics professor Marty Hoffert addresses the search for new carbon emissions-free technology:

- “There’s an argument that our civilization can continue to exist with the present number of people and the present kind of high technology through conservation. I see that argument as similar to a man being locked in a sealed room with a limited amount of oxygen. And if he breathes more slowly, he’ll be able to live longer, but what he really needs is to get out of the room. And I want to get out of the room” (Kolbert, p. 146)

Chapter 8: The Day After Kyoto

U.S. Resistance

On greenhouse gas intensity:

- “Greenhouse gas intensity is not a quantity that can be measured directly. Rather, it is a ratio that relates emissions to economic output. Say, for example, that one year a business produces a hundred pounds of carbon and a hundred dollars’ worth of goods. Its greenhouse gas intensity in that case would be one pound per dollar. If the next year that company produces the same amount of carbon but an extra dollar’s worth of goods, its intensity will have fallen by one percent. Even if it doubles its total emissions of carbon, a company -- or a country -- can still claim a reduced intensity provided that it more than doubles its output of goods” (Kolbert, p. 161).

Pollster Frank Luntz, on voters and global warming:

- “Voters believe that there is *no consensus* about global warming in the scientific community. Should the public come to believe that the scientific issues are settled, their views about global warming will change accordingly. The most important principle in any discussion of global warming is your commitment to sound science” (Kolbert, p. 165).

Chapter 9: Burlington, Vermont

Burlington’s Revolution

Peter Clavelle, Burlington’s mayor since ’89, on his two-year sabbatical:

- “Living on an island, you really get in touch with practices that are sustainable and practices that are unsustainable” (Kolbert, p. 173).

Peter Clavelle, on persistence:

- “It would be so much easier if we could say, ‘Well, if we approved this one project or this action, the problem would be solved’ [...] But there’s no silver bullet. There’s no one thing we can do. There’s no *ten* things we can do. There’s hundreds and hundreds of things that we need to do. I’m frustrated [...] but you need to remain hopeful” (Kolbert, p. 178).

International Efforts

David Hawkins, of the NRDC, on why China takes cues from America:

- “There’s a very practical reason why this works, and that is if a country like the United States embraces a cleanup technology, then the market starts to drive the price down, and other countries start to see that it is ‘doable’” (Kolbert, p. 182).

Chapter 10: Man in the Anthropocene

From the Holocene to the Anthropocene

On Dutch chemist, Paul Crutzen's article in *Nature* magazine:

- "No longer, [Crutzen] wrote, should we think of ourselves as living in the Holocene. Instead, an epoch unlike any of those which preceded it had begun. This new age was defined by one creature--man--who had become so dominant that he was capable of altering the planet on a geological scale. Crutzen dubbed this age the 'Anthropocene'" (Kolbert, p. 183).

What Now?

On the consequences of our consumption patterns:

- "Whether the threshold for 'dangerous anthropogenic forces' is 450 parts per million of CO₂ or 500, or even 550 or 600, the world is rapidly approaching the point at which, for all practical purposes, the crossing of that threshold will become impossible to prevent. To refuse to act, on the grounds that still more study is needed or that meaningful efforts are too costly or that they impose an unfair burden on industrialized nations, is not to put off the consequences, but to rush toward them" (Kolbert, p. 187).

National Geography Standards

The World in Spatial Terms (Grades 5-12)

1. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.
3. How to analyze the spatial organization of people, places, and environments on Earth's surface.

Places and Regions (Grades 9-12)

4. The physical and human characteristics of places.

Physical Systems (Grades 9-12)

8. The characteristics and spatial distribution of ecosystems on Earth's surface.

Human Systems (Grades 9-12)

13. How the forces of cooperation and conflict among people influence the division and control of Earth's surface.

The Environment and Society (Grades 5-12)

14. How human actions modify the physical environment.
15. How physical systems affect human systems.

The Uses of Geography (Grades 5-12)

17. How to apply geography to interpret the past.
18. How to apply geography to interpret the present and plan for the future

Source: National Geography Standards, Geography Education Standards Project. 1994. *Geography for Life: The National Geography Standards*. Washington, DC: National Geographic Society Committee on Research and Exploration.

National Science Standards

A. Science as Inquiry

Understandings about scientific inquiry (p. 148, 176; grades 5-12)

C. Life Science

Diversity and adaptation of organisms (p. 158; grades 5-8)

Biological evolution (p. 185; grades 9-12)

E. Science and Technology

Understandings about science and technology (p. 166, 192; grades 5-12)

F. Science in Personal and Social Perspectives

Populations, resources, and environments (p. 168; grades 5-8)

Science and technology in society (p. 169; grades 5-8)

Environmental quality (p. 198; grades 9-12)

Natural and human-induced hazards (p. 198; grades 9-12)

Science and technology in local, national, and global challenges (p. 199; grades 9-12)

G. History and Nature of Science

History of science (p. 171; grades 5-8)

Source. National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

National Technology Standards

3. Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information.

- d. Students process data and report results.

4. Critical Thinking, Problem Solving, and Decision Making

Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

- c. Students collect and analyze data to identify solutions and/or make informed decisions.

5. Digital Citizenship

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.

- b. Students exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.

6. Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations.

- a. Students understand and use technology systems.
- d. Students transfer current knowledge to learning of new technologies.

Source: International Society for Technology in Education. 2007. National educational technology standards (NETS-S) and performance indicators for students.

References

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National Geography Standards, Geography Education Standards Project. 1994. *Geography for Life: The National Geography Standards*. Washington, DC: National Geographic Society Committee on Research and Exploration.

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.