Global Warming and the Case for the Nature of Science

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The Nature of Science …. The Science of Nature

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Global Warming & the Greenhouse Effect

- What is Global Warming/Global Climate Change?
- What is the Greenhouse Effect?

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Law vs. Theory

- Global warming is caused by emissions of carbon dioxide and other heat-trapping gases that are emitted primarily by the burning of fossil fuels and the clearing of forests. These gases remain in our atmosphere for decades or even centuries (UCS, 2005).

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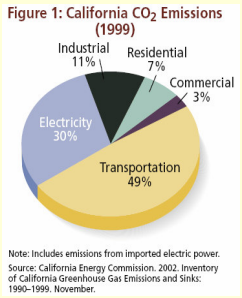
Law vs. Theory

- Global Warming is a condition caused by the accumulation of *greenhouse gases* such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) in the Earth's atmosphere.



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The Evidence…

- Global warming is already under way. The evidence is vast and the urgency of taking action becomes clearer with every new scientific study. Some of the most obvious signs are visible in the Arctic, where rising temperatures and melting ice are dramatically changing the region's unique landscapes and wildlife—as well as people's lives and livelihoods. Across the globe, other early warning signs include melting glaciers, shifting ranges of plants and animals, and the earlier onset of spring.

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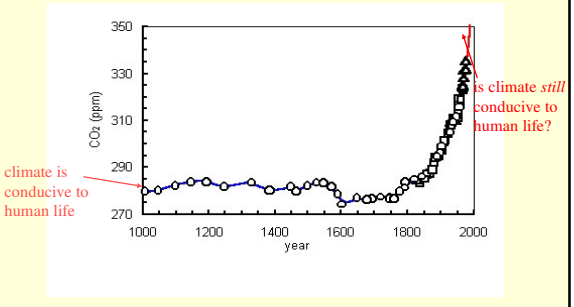
A reminder: our prodigious CO_2 production



(University of California, San Diego 2004)

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Collapse?

- The profound impact rising temperatures have had in the Arctic provides a window into a future we may all experience. With continued warming, we can expect more extreme heat and drought, rising sea levels, and higher-intensity tropical storms. At risk are our coastal property and resources, the livability of our cities in summer, and the productivity of our farms, forests, and fisheries.

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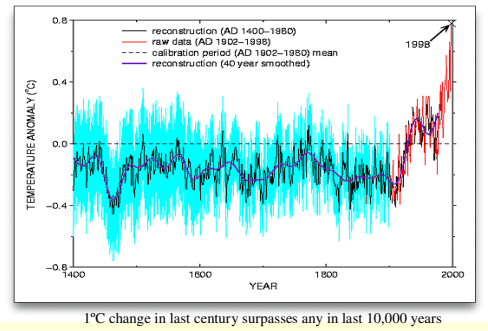
The direct effect of CO_2 on global temperature



1ºC change in last century surpasses any in last 10,000 years

(University of California, San Diego 2004)

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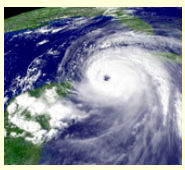
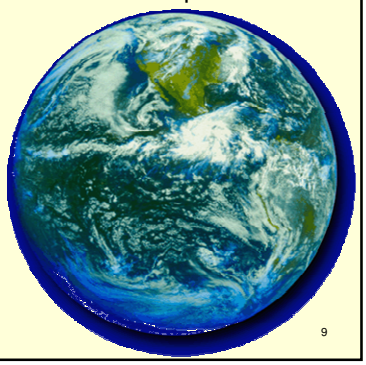
- "Education is the ability to perceive the hidden connections between phenomena" (Havel 1990).





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- Biology, chemistry, geology, physics, etc.
- The discussion of STS provides educators with something else—a significant opportunity to teach important lessons involving the Nature of Science (NOS).

Meltwater flows into a large moulin and down to the bedrock

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- Most importantly, global warming can be used to teach both children and adults the place of humans in the natural world, and how our actions affect the environment.

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- "The bottom line in STS is the involvement of learners in experiences and issues which are directly related to their lives. STS empowers students with skills which allow them to become active, responsible citizens by responding to issues which impact their lives. The experience of science education through STS strategies will create a scientifically literate citizenry for the 21st century" (NSTA 1990).

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Because most global warming emissions remain in the atmosphere for decades or centuries, the energy choices we make today greatly influence the climate our children and grandchildren inherit. We have the technology to increase energy efficiency, significantly reduce these emissions from our energy and land use, and secure a high quality of life for future generations. We must act now to avoid dangerous consequences.

(Union of Concerned Scientists 2004)

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- Students can also be aware of the advantages and disadvantages of technology and the role that society and culture can play as one of the major of factors of the decline or advancement of societies from the past, present, and future (Diamond 2005).

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Collapse of Gaia?

- Global warming will also produce big secondary effects that are difficult to predict exactly in advance and that are likely to cause huge problems, such as further climate changes resulting from changes in ocean circulation resulting in turn from melting of the Arctic ice cap (Diamond 2005).

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Global Consequences

- The earth's ocean/atmosphere/ice system is *very* complex
  - it's difficult to make predictions due to the interconnectedness
- Naïve extrapolations say that by the end of this century, the global temperature will be 1.4 to 5.8ºC warmer than today
  - this is a *huge* change!
- Same predictions have oceans rising roughly half-a-meter by 2001, and several meters by 2300
- These predictions don't account for all possible feedback scenarios

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(University of California, San Diego 2004)

Ice-age scenario

- The interconnectedness could drive us in the opposite direction
- As Greenland ice cap melts, North Atlantic becomes less salty, and the "Great Conveyor Belt" that is responsible for bringing warmth to northern latitudes (especially Europe and eastern North America could shut off
  - already faltering, possibly foreshadowing collapse
  - could shut off this year, or in next several decades
  - climate shift would be *abrupt and dramatic*

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(University of California, San Diego 2004)

The Great Conveyor Belt

- …of which the Gulf Stream is a part, it goes like this:
  - warm water from the tropics flows on the surface to the North Atlantic
  - as it goes, much evaporates, leaving saltier water
  - as water becomes colder and saltier, it becomes denser
  - dense water sinks to ocean floor (near Greenland)
  - cold, salty flow empties into Pacific
  - warm surface water from Pacific replaces lost water, flowing north and closing the cycle
  - called *thermohaline* cycle

(University of California, San Diego 2004)

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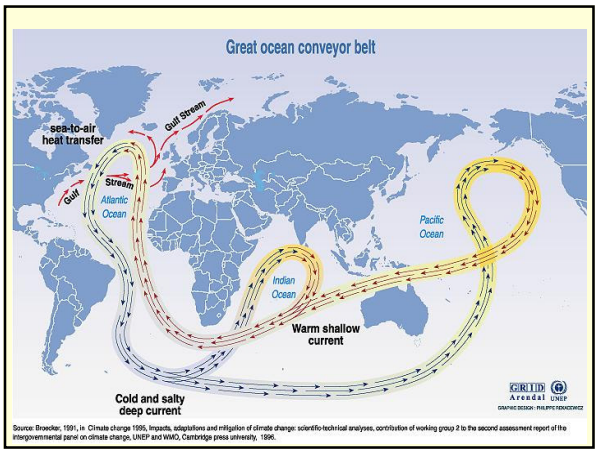

Source: Broecker, 1991, in Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

If the music stops…

- If the conveyor belt shut off, Europe, Canada, northeastern U.S. would be ***plunged into Siberian winter***
- Transition would take *only 2–3 years*, based on historical onset of ice ages
- Much greater reflectivity of snow would result in much less absorbed solar energy→global *cooling*
  - **oh—the irony**
- Condition would be sustained for 700–100,000 years, judging by durations of previous ice ages
- Lower latitudes are not spared: droughts, firestorms
  - **less evaporation off of warm surface currents in ocean**

(University of California, San Diego 2004) 20

The Venus Scenario

- Increasing temperatures could unleash a *runaway* process: positive feedback
- Example of negative feedback (tendency toward stability)
  - warmer→more clouds→more reflection→cooler
- Examples of positive feedback:
  - warmer→less CO_2 absorption by water→more greenhouse gases→gets warmer
  - colder→more ice on planet→more reflection→colder
- The open question is which type of feedback will dominate: positive feedback means runaway

(University of California, San Diego 2004) 21

Positive feedback contributors

- Warm water has diminished ability to absorb CO_2
  - already "sharp drop" observed in Pacific CO_2
- Hotter soil means CO_2 is given off
- More stable ocean (hot on top) starves plankton
  - they rely on nutrients swept up from bottom
  - net result: reduced activity means less CO_2 absorbed
- Thawing tundra→wetlands→more methane
  - a powerful greenhouse gas
- Submarine methane-hydrates frozen in place are warmed out

(University of California, San Diego 2004)

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The consensus view?

- The majority view among climate researchers globally is that positive feedback is likely to dominate over negative feedback
  - but this isn't being explicitly stated (published), as the uncertainties are still too high
  - good lesson of less-than-alarmist science community
- From 1992 IPCC report (a rather conservative body):

  "Because natural sources and sinks of greenhouse gases are sensitive to a change in climate, they may substantially modify future concentrations [of greenhouse gases]. ... It appears likely that, as climate warms, these feedbacks will lead to an overall increase rather than a decrease in natural greenhouse gas abundances. For this reason, climate change is likely to be greater than the estimates we have given." (University of California, San Diego 2004)

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How are we responding?

- Globally, the response is positive and encouraging
- The U.S., however, has been ***egregiously*** reluctant to accept the consequences
  - doing so would impact "our blessed way of life"
  - not surprising that the worst offenders/contributors are behaving the least responsibly
- A tragic human epitaph:
  - We wanted to save the world, but our leaders told us it would be too expensive
- Result: Business as Usual

(University of California, San Diego 2004)

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- Topics in relation to Global Warming can focus on how to effectively blend discussions of STS content with process.
- An examination of global warming can provide science teachers with a vast amount of resources to pull from when delivering various topics in science.
- This article also focuses on several core NOS ideas as they pertain to STS. These ideas include the concept that science is a human endeavor and that the nature of scientific knowledge demands and relies on empirical evidence (NRC 1996).

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Science and society

- Often teachers and students alike have a difficult time seeing the relationship between science and those who practice science. Science is a human endeavor which often gets lost in the designing of science curricula due to the vast amount of state science content standards that teachers feel they need to deliver to students before "the end of the school year."
- It doesn't help matters that given the current environment of *No Child Left Behind* and high stakes testing, teachers find themselves cramming more specific science content while at the same time ***leaving behind*** the bigger science issue of the connection between science and society.

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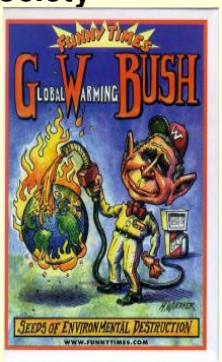
Science and society

- Past and future funding for scientific research in the United States for example (both at a federal and state level) have relied upon the whims and wishes of the President of the U.S. and Congress.
- The Bush Administration proposed to cut nearly 5% from the Environmental Protection Agency, bringing its spending to $7.3 billion.
- Pentagon spending would rise to $439.3 billion, or more than 7%.



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Science and empirical evidence

- One of the debates brewing between scientists and some members of the public and private sectors such as congressmen, governors, CEOs of oil companies, chemical, biotech, and energy plants, etc. includes the issue of ***Global Warming***.

(Union of Concerned Scientists 2004)

The 20 Hottest Years on Record*

Rank	Year
1	2005
1	1998
3	2002
4	2003
5	2004
6	2001
7	1997
8	1990
9	1995
10	1999
11	2000
12	1991
13	1987
14	1988
15	1994
16	1983
17	1996
18	1944
19	1989
20	1993

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Science and empirical evidence

- Since the beginning of the industrial revolution, about 150 years ago, the conversion of fossil fuels and coal for energy consumption has increased exponentially. As these fossil fuels are converted from one form of energy to another, CO_2 is released into the Earth's atmosphere. As these greenhouse emissions rise over time, they act as a *blanket* within the atmosphere, which causes heat to be trapped on Earth. As a result, the overall temperature on Earth has risen 1 – 2 degrees in the past 200 years (Campbell, et al. 1999).

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Science and empirical evidence

2005 Vies for Hottest Year

Global average surface temperatures pushed 2005 into a virtual tie with 1998 as the hottest year on record.* For people living in the Northern Hemisphere—most of the world's population—2005 was the hottest year on record since 1880, the earliest year for which reliable instrumental records were available worldwide.

The latest report on U.S. emissions found that 2004 marked the highest annual total of heat-trapping gases released since record keeping began in 1990.

U.S. National Oceanic and Atmospheric Administration (NOAA). 2006.

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Science and empirical evidence

- Together, these drastic changes can lead to disastrous global climate effects. In reality there is no debate among scientists whether or not global warming is occurring on Earth; it is. However, the debate among scientists and non-scientists may lie more with monetary and political concerns in dealing with this critical issue.
- More critical thinking!!!

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Science and empirical evidence

- The relevant data and supporting evidence of global warming and climate modeling include information from the geological evidence, biological evidence such as the extinction rates of organisms, and the increased rates of climate, weather patterns, and atmospheric changes (Campbell, et al. 1999). These are all vital clues that establish both the reality of global warming and the importance of data collection in science itself, but they do not all represent the same *kind* of scientific data.

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Science and empirical evidence

- Various forms of scientific evidence: *historical*, *observational*, and *experimental*.
- To explore and advance the subject of global warming, scientists have used each of the following important information-gathering tools.

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Historical and observational evidence

- Observation is another important tool in science. A major source of information regarding global warming involves the retrieval of ice core samples from the Arctic regions by scientists. These ice core samples contain gas bubbles filled with molecular data of what the atmosphere of the Earth was like over the millennia. Biologists have used similar methods in which they have collected tree ring samples.

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Historical and observational evidence

- **1827: Fourier** – theorized that greenhouse gases warm the planet
- **1896: Arrhenius** - proposed that changes in atmospheric CO_2 concentrations due to volcanic eruptions can cause climate change
- **1938: Callendar** – first noted that human emissions of CO_2 may add significantly to natural concentrations in the atmosphere
- **1957: Revelle et al.** – first warned that human emissions have started a global scale geophysical experiment and initiated an atmospheric CO_2 concentration monitoring program

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Historical and observational evidence

- Biologists have also observed the extinction rates of certain population of organisms within the past one hundred years based on drastic environmental changes and habitat destruction; all being linked to global warming either directly or indirectly (Miller 2001).

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Historical and observational evidence

- Retreating of glaciers, rising seas, and shrinking lakes along with a changing atmosphere of Earth itself; all represent significant kinds of historical and observational evidence. One can trace the historical and observational evidence used by geologists (Lutgens and Tarbuck 2003). By looking at independent lines of geological evidence, students can notice the relationships between the increase in global temperature, erosion, and other natural phenomena currently going on.

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Historical and observational evidence

- The geological, biological, and chemical record is a fundamental part of the evidence for global warming. By examining past and present scientific data in the classroom and discussing the role of such evidence, students can better understand the role of inferences and can interpret historical evidence.

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Experimental evidence

- The practice of science is unique in that scientific experimentation is used as a critical evidence-gathering tool. Experimentation is only one of the many tools used in gathering evidence unlike the misconception held by many which think experimentation is the only mode of gathering data in science (Narguizian 2004). An experiment can be defined as “a planned intervention into a natural process to observe the effects of that intervention” (Allen and Baker 2001, 35). Students can perform experiments in which they can “model” the Earth’s system or biosphere by participating in a number of in-class experiments.

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Experimental evidence

- Teachers can refer to one experiment in which students can place soil in different types of cups (i.e. plastic cups, foam cups, glass cups, etc.) and measure the temperature change (final temperature – initial temperature) after 10 minutes of exposure to direct sunlight. In doing so, students can measure temperature changes in substances which are "insulated" and they can see which objects are better able to retain heat over time.

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Science and empirical evidence

- Through evidence gathered by historical, observational, and experimental means, students can begin to understand the complexities involved in the nature of science while at the same time see the hidden connections among various topics in science and how they tie in to the concept of global warming.

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Implications and instructional strategies

- A variety of instructional strategies are available for teachers to use in the classroom that target a multitude of learning styles among students. These strategies include but are not limited to *reading assignments, laboratory experiments,* and *classroom debate*.

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Reading assignments

- Fortunately, science teachers have access to numerous books, articles, and websites devoted to the study of global warming. These resources can assist teachers in designing a science, technology, and society curriculum that addresses science content along side issues or core ideas in the NOS.

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Reading assignments

- An article I have used in the past as part of my science curriculum entitled *Global Warming: Bulletins From a Warmer World* (National Geographic 2004), outlines the science behind global warming and the role that human's have played in increasing the risk of global climate change within the past 150 – 200 years on Earth.

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Reading assignments

- Books that are useful include *The Hidden Connections: Integrating the Biological, Cognitive, and Social Dimensions of Life Into A Science of Sustainability* (Capra 2002), *The Greenhouse Effect: Life on a Warmer Planet* (Johnson 1990), and *Collapse: How Societies Choose to Fail or Succeed* (Diamond 2005). Another book entitled *Global Warming: Opposing Viewpoints* offers opposing viewpoints about many global warming issues including the causes of global warming, the seriousness of the threat, and possible effects of a changing climate (Bender and Leone 1997).

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Laboratory experiments

- To help students learn, in a more concrete way, how the greenhouse effect can take place, an activity that simulates global warming can be used (Science Activity 2005). In this simulation, students build a greenhouse model in which they make temperature comparisons between a greenhouse model and a regular container. They then compare their model to what is actually happening in our atmosphere.

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Laboratory experiments

- For more advanced students, teachers can refer to a more extensive laboratory experiment entitled *Greenhouse Gases Exposed* (EcoHealth 2001). This activity models the relationship of greenhouse gases (i.e. CO_2) and global warming through laboratory activities in which students prepare and test for the presence of CO_2 and how it can cause an increase in temperature over time.

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Classroom debate

- Teachers can also plan classroom debates. Position statements or inquiry based questions on global warming can be designed in which students provide historical, observational, or experimental evidence to defend or refute global warming as a result of increased human activity. Classroom debates offering differing points of view provide an opportunity for students to engage in higher order thinking questions, explore various components of NOS, while at the same time taking part in group discussions (Narguizian 2004).

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A detailed look at the U.S. response

- I *highly recommend* reading the document put out by the Union of Concerned Scientists in March 2004
  - titled: Scientific Integrity in Policymaking
  - www.ucsusa.org/global_environment/rsi/
    - under Reports
- Conclusion:
  - The Bush administration suppresses and distorts the truth at an unprecedented level
- See also *Sierra* magazine: May/June 2004

(University of California, San Diego 2004)

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A social responsibility

- Teachers of science have an ethical and social responsibility to teach students about global warming as well as deliver content that supports understanding the processes of science. In doing so, teachers can present students with engaging activities in both areas. As a result, teachers and students alike can take part in an integrated experience, one that will make understanding both the scientific content behind global warming and the NOS more enjoyable and genuine.

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On the Web

EcoHealth: *www.ecohealth101.org/index.html*
This website contains teacher materials and student handouts on global warming and biodiversity.

Science Activities/Global Warming and the Greenhouse Effect: *www.earth.uni.edu/EECP/mid/mod5_sc.html*
This is a good website for labs that explore global warming and the NOS.

Virtual Courseware/Global Warming: *www.sciencecourseware.com/eec/GlobalWarming/*
Students can explore various experiments and resources pertaining to global warming education through this resource.

Pew Center on Global Climate Change:
www.pewclimate.org/global-warming-basics/basic_science/
At this site, students can read articles by scientists, economists, and science educators on issues related to global warming and climate change.

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References and Additional Reading

- Global warming predictions: past and present
  - magazine.audubon.org/global.hmtl
  - well-written, highly recommended
- Global warming → Ice Age
  - www.commondreams.org/views04/0130-11.htm
- Global warming → Runaway like Venus
  - eces.org/archive/ec/globalwarming/runaway.shtml
- Scientific Integrity in Policymaking
  - www.ucsusa.org/global_environment/rsi/
- Strategic Ignorance: *Sierra* magazine: May/June 2004 (University of California, San Diego 2004)

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Well said…

"That's the end of good news about anything. Our planet's ***immune system*** is trying to get rid of people. This [global warming] is sure the way to do that."

Kurt Vonnegut, November 03, 2004

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References

Allen, G. and J. Baker. 2001. *Biology: Scientific Process and Social Issues.* Bethesda, Md.: Fitzgerald Science Press, Inc.

Allen, W.L. (Ed.). 2004. *Global Warming: Bulletins from a Warmer World* [Special Issue]. *National Geographic*, *206*(3).

Bender, D. and Leone, B. 1997. *Global Warming: Opposing Viewpoints.* San Diego, CA: Greenhaven Press.

Campbell, N.A., Reece, J.B., and Mitchell, L.G. 1999. *Biology* (5th ed.). Menlo Park, CA: Benjamin Cummings.

Capra, F. 2002. *The Hidden Connection: Intergrating the Biological, Cognitive, and Social Dimensions of Life Into A Science of Sustainability.* New York, NY: Doubleday.

Diamond, J. 2005. *Collapse: How Societies Choose to Fail or Succeed.* New York, NY: Viking.

EcoHealth. 2001. *www.ecohealth101.org/index.html.*

Johnson, R.L. 1990. *The Greenhouse Effect: Life on a Warmer Planet.* Minneapolis: Lerner Publications.

Lutgens, F.K. and Tarbuck, E.J. 2003. *Essentials of Geology* (7th dd.). Upper Saddle River, NJ: Prentice Hall.

Miller, G.T. 2001. *Environmental Science: Working With the Earth* (9th ed.). Pacific Grove, CA: Brooks/Cole Publications.

Narguizian, P. 2004. Understanding the nature of science through evolution. *The Science Teacher* 71(9): 40-45.

National Research Council. 1996. *National Science Education Standards.* Washington, DC: National Academy Press.

National Science Teachers Association. 1990. *www.nsta.org/positionstatement&psid=34.*

Science Activities/Global Warming and the Greenhouse Effect. 2005. *www.earth.uni.edu/EECP/mid/mod5_sc.html*

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