How scientists can try to change the minds of climate denialists

Gordon J. Aubrecht, II
Department of Physics, Ohio State University, Marion, Ohio 43302 and Columbus, Ohio 43210.

E-mail: aubrecht.1@osu.edu

(Received 29 July 2011; accepted 25 October 2011)

Abstract

Stewardship of Earth is not only moral: It is necessary to preserve the richness of our lives. Unless something is done, millennium-length consequences of the greenhouse gases we have already released will cause harm to the planet. Groups of people supported by political forces and money have decided that denial of scientific data is not only reasonable, but a moral force that opposes that of stewardship. I characterize these people as “denialists”, to distinguish them from true skeptics, scientists who must be skeptical to do their work. Denialists have succored the people who just want the problem to go away by sowing doubt about scientific integrity and distorting the meaning of scientific uncertainty. How scientists can change the framing of the issue and how individual scientists can influence the public through reasoning with fellow citizens and writing letters to their local papers countering misinformation is the focus of this work.

Keywords: Unscientific worldview, Climate change, Philosophy of science.

Resumen

La mayordomía de la Tierra no sólo es moral: Es necesario para preservar la riqueza de nuestras vidas. A menos que se haga algo, un milenio de duración de las consecuencias de los gases de efecto invernadero que ya hemos lanzado causará daño al planeta. Grupos de personas con el apoyo de las fuerzas políticas y el dinero han decidido que la negación de los datos científicos no es sólo razonable, sino una fuerza moral que se opone a la de la mayordomía. Yo caracterizan a estas personas como "negacionistas", para distinguirlos de los verdaderos escépticos; los científicos que debe ser escéptico para hacer su trabajo. Negacionistas han apoyado a las personas que sólo quieren que el problema desaparezca por sembrar la duda sobre la integridad científica y distorsionar el significado de la incertidumbre científica. Cómo los científicos pueden cambiar el encuadre de la cuestión y cómo los científicos pueden influir en la opinión pública a través del razonamiento con sus conciudadanos y escribir cartas a sus periódicos locales en la lucha contra la desinformación es el tema central de este trabajo.

Palabras clave: Falta de visión científica del mundo, Cambio climático, Filosofía de la ciencia.

PACS: 01.50.Zv; 92.05.Df; 01.70.+w **ISSN 1870-9095**

I. INTRODUCTION

Oh what a tangled web we weave,
When first we practice to deceive!
—Sir Walter Scott, *Marmion*, Canto vi. Stanza 17.

In general, research on many topics (especially, recently, climate change [1, 2] has shown that people are disinclined to change beliefs, even when presented with factual information contradictory to those beliefs. Scientists think of themselves as skeptics, and the tendency of the media to characterize anyone who is saying that anthropogenic climate change has problems as “skeptics”. There are indeed *skeptic*s, scientists mainly, who on the basis of their skepticism are willing to consider alternate ideas, but there are also those who simply, on the basis of deeply held belief deny some idea of science. For example, purveyors of perpetual motion machines deny the Second Law of Thermodynamics, which has a strong basis in both theory and experiment. People deny the holocaust (this is the origin of the term “denialist” characterizing “refusal to accept an empirically verifiable reality. It is an essentially irrational action that withholds validation of a historical experience or event”) [3]. Therefore, in this paper we shall designate those who have serious or plausible arguments against aspects of anthropogenic climate change as skeptics who are consonant with science, and those who take a position as a matter of ideology or faith as denialists, who disregard science. The former operate within the confines of scientific discourse, the latter do not.

In the United States, science is under attack by people who believe that evolution is not credible, that vaccination is not a useful public health measure, that the universe did not experience an expansion from infinitesimal size to the present 14x10^9 light-years size over a period of 14x10^9 years. How do science teachers cope? In this paper, we will examine the broader literature to attempt to discover how we, as physics teachers, can address the contentious scientific issues of our time with denialists, our fellow citizens, and our students.

II. WHAT SUPPORTS DENIAL OF ANTHROPOGENIC CLIMATE CHANGE?

Some have blamed the media for distortion of the climate science [1, 2, 4]. The media also have an influence on perceptions of nuclear matters (see, for example, Ref. 5). According to Rowe *et al.* [5], "The limited focus of [newspaper] reports meant that there were a number of mechanisms and perspectives that were rarely used or discussed. For example, there was very little use of statistics to express risk (as previously noted by, for example, Schanne and Meier) or the use of comparisons with other, perhaps better-known risks (except for nuclear issues in Sweden)".

People with axes to grind have distorted the situation, for climate [4, 5] as well as for nuclear phenomena. As Moser [4] writes, "those with significant interest in maintaining the fossil-fuel intensive status quo have deliberately created a public perception of a lack of scientific consensus and greater uncertainty about the extent and causes of modern climate change, suggesting that a wait-and-see stance is the most responsible and scientifically justified course of action". This is reinforced by many websites that mischaracterize climate change, in which like-minded people reinforce their shared biases. Indeed, the internet, seemingly so accessible and so full of information, is rife with misinformation on nuclear physics [6] as well as on climate science, a great danger to students (and citizens) in an age when people search the internet uncritically [7].

In a guest editorial for the American Journal of Physics [8], I suggested several reasons to be concerned about media approaches: "Headlines containing phrases such as 'damage to public trust', climate scientists 'losing credibility' and having an 'imperious attitude', skepticism 'on the rise', and references to 'errors' in the IPCC report were common. A February [2010] BBC poll in Britain showed that 25% of Britons did not believe in global warming. An additional 10% subscribed to the notion that climate change is occurring, but that it is 'environmentalist propaganda that it is man-made'. In the same poll, only 26% subscribed to the idea that 'climate change is happening and is now established as largely man-made', and 38% chose that climate change is happening and is not yet proven to be largely man-made'". This poll showed a great difference in opinion between November 2009 and February 2010, and the only intervening event was the release of the "climategate" emails. As one example of the influence of "those with significant interest" in casting doubt on climate science, the "climategate" emails were reported in many media outlets exactly as denialists would have wished [7]—as examples of scientists "cooking the books", acting petty, and working to "hide the decline" in global temperatures—no matter that these were mostly misunderstandings of scientific terms (the scientists were, as revealed, human and petty on occasion).

Clearly, the media were not helping to explain the context—the charged wording in the articles and TV stories created a false impression [7]. The sensationalism garnered the attention.

Every official report on the so-called "climategate" hacked emails has judged that the allegations that were so demonized in media descriptions were baseless [9]. As one article reported [10], "The exonerations haven't generated anything like the intense media coverage that the initial scandal did. Newspapers have typically covered them with small stories far removed from the front page — or ignored them altogether. 'The accusations were on A1, the exonerations are usually on A15,' said Aaron Huertas, press secretary for the Union of Concerned Scientists".

III. WHAT IS THE EVIDENCE FOR ANTHROPOGENIC CLIMATE CHANGE?

The evidence for anthropogenic (human-caused) climate change is overwhelming. The IPCC 2007 Reports [11] present abundant evidence based on data that carbon dioxide and other greenhouse gases are altering the present climate, that impacts will be felt locally and globally, that the impacts may be severe—weather will be less predictable, droughts and floods' frequencies will increase, icecap melting will raise sea levels, and so on. Carbon dioxide levels would drop naturally if humans stopped burning fossil fuels, but it would take over a millennium for concentrations in the atmosphere to drop to preindustrial levels.

Current effects lag the causes because of considerable inertia in the climate system (oceanic heat capacity, etc.). Climate scientists speak of "committed warming" to capture this inertial effect. It is believed that humans can take effective action to prevent warming of above 2°C above preindustrial levels. Unless actions are undertaken relatively soon, the consequences may seem unacceptable.

IV. WHAT CAN A PHYSICS TEACHER DO TO COMMUNICATE BETTER?

Because we are scientists, we have a view of nature that differs from "ordinary citizens". To us, there are problems with the way the media approach science in many cases. In journalism school, students are told to give both sides ("controversy sells papers"). But in many cases there are not two sides, and it is silly to make it seem so. Earth is an oblate spheroid, it is not flat. People have walked on our Moon. Keys tossed up in the air fall downward. And human actions are causing the observed warming; it is not volcanoes, solar cycles, or anything else natural. Also, there are levels of uncertainty in all data. These do not translate clearly to nonscientists.

This uncertainty in data and mandated tentativeness of science does not mean we do not proceed. We build bridges using principles that are tentative, because the knowledge is acceptable for all practical purposes. It's not only for this single case of climate science, or of nuclear physics, but is the case in all science. Lack of ultimate certainty is no excuse for ignoring science in building a bridge, for example).

Clear communication is prized by scientists, but that is mainly accomplished by our use of the universal language of mathematics to reduce semantic confusion. We needed to attend graduate school to learn from equations. Laypeople cannot easily follow our understanding of information. Scientists also generally use their own scientific terms, but these are not well understood by the public, they're seen as buzzwords at best, muddying things even more. We can be our worst enemies in communicating clearly.

Seeding doubt by denialists is enough to distract public attention and allow plausibility and inertia to have their way. As a result of the urgency of public understanding of climate change, desperate climate scientists have sought advice from psychologists and sociologists about more fruitful ways to address this disinclination to judge the evidence [9, 12, 13, 14, 15, 16].

For similar reasons, nuclear physicists have had public crises, too [17]. The threat of nuclear destruction during the Cold War affected attitudes to nuclear energy even before the accidents at Three Mile Island and Chernobyl, and many citizens believed untrue things about nuclear energy. We physics teachers need to be aware of the affective issues raised in the psychology and sociology literature as well as in our own [17] and heed them. This is demonstrated to be true about radiation and radioactivity in some of the studies in the literature [18, 19]. Given this characteristic, many attempts to change student thinking about nuclear energy have been less effective than the instructors believed.

A. Where physics teachers can start

There are some things physics teachers can do that would be useful for students: We can give our students actual physical experiences to discuss and build their own understanding. We can be clear about the meaning of the word "theory" in science, that it is far more than a proffered idea that is expressed, as many laypeople think. We can explain the tentativeness of our understanding, explain that models are not actual reality but a close approach, and that, the better the model, the better the correspondence with observation. We can give them access to the science of (in this case) climate change.

Scientists are aware that science cannot ever *prove* anything, only *dis*prove things. The evidence of the data emphatically do not disprove the human effect on climate. Not many of our fellow citizens (or students) will appreciate that, as a result, *all understanding* in all science is subject to change should disproof occur.

Teaching solely by filling in lacks of facts is not enough. We have to find a better way to communicate science to students and the public.

What the studies say is composed of many parts, some obvious, some not so obvious. In any case, physicists and physics teachers are mostly unaware of these ideas for enhancing clear communication.

Moser [4] characterizes communication problems of climate scientists as due to several causes: "invisible" causes (one can't see the carbon dioxide problem out the window); temporally and spatially distant impacts (it will happen to other people, and in the distant future); insulation of modern-day humans from our environment (there is not as much vulnerability to weather); delay or absence of gratification for taking action ("It is virtually certain that no individual alive today will see the Earth's climate return to its state under current, much less pre-industrial concentrations of greenhouse gases and temperatures" [4]); inability to encompass the scale of the change in ability due to adoption of technology ("it was both rational and an evolutionary advantage to focus only on the here and now" [4]); complexity of the issue; uncertainty (misused as an excuse to do nothing by denialists); and weak signaling of the need for change (for example, relatively cheap fossil fuel prices). These are clearly relevant (with a few caveats) to nuclear science issues as well. Moser's list must be something we are aware of in formulating how to communicate with the public.

B. Framing the science matters

George Lakoff has become well known for discussing the idea of frames. As Lakoff notes [17], "Frames include semantic roles, relations between roles, and relations to other frames. A hospital frame, for example, includes the roles: Doctor, Nurse, Patient, Visitor, Receptionist, ... Among the relations are specifications of what happens in a hospital, *e.g.*, Doctors operate on Patients in Operating Rooms with Scalpels. These structures are physically realized in neural circuits in the brain. All of our knowledge makes use of frames, and every word is defined through the frames it neurally activates… many frame-circuits have direct connections to the emotional region of the brain. Emotions are an inescapable part of normal thought. Indeed, you cannot be rational without emotions". Lakoff emphasizes the role of frames in ideology, which predisposes people to think about issues in certain ways depending on the frame adopted. Lakoff's idea is that people are less rational than was assumed during the Enlightenment, and communication needs to be reframed in some cases to be effective. He concludes by writing "Truth must be framed effectively to be seen at all. That is why an understanding of framing matters".

Moser [4], Pidgeon and Fischhoff [12], Shome and Marx [14], O'Neill *et al*. [15], Spence and Pidgeon [20] and Spence *et al*. [21], all agree that communication must be framed. Common frames around climate change might be analogies to national security or terrorism (catastrophic harm might result), stewardship (Earth needs careful, loving attention), or health (climate shifts can cause diseases to invade our territory; these are all so-called attribute framing) or might deal with gains and losses (so-called outcome framing). In terms of the latter frame, people have consistently been shown to *dislike* losses more than they *like* gains. Spence and Pidgeon [20] find that outcomes framed as low risk do best when the frame is in terms of gains (they call this the "gain frame advantage"), while loss frames promoted fearfulness and perception of climate change as more severe as well as greater memory of pertinent information.

C. Mental models matter

In physics education research, we attempt to identify students' mental models [22] so that we can craft materials that will help them appreciate and accept the scientific consensus. Psychologists have found that, in the words of Moser [4], "mental shortcuts and heuristics people employ to 'manage' cognitive and emotional complexity tend to be ill-suited to adequately respond to climate change".

Mental models based on frames can focus on promotion or prevention [14]. People with the former view see goals as ideals and "are concerned with advancement". People with the latter view see the goal as something they must attain and "are concerned with maintaining the status quo".

Physics teachers can use questionnaires such as the Yale's Knowledge of Climate Change quiz [23] or their own to judge the initial knowledge state of the students. This is, of course, harder to accomplish when communicating with fellow citizens.

However, even sophisticated people can believe impossible things, as a study of climate knowledge among MIT students showed [24]: "We conducted experiments to determine the extent to which highly educated adults understand the fundamental relationship between flows of GHGs and the stock of GHGs in the atmosphere. We find significant misperceptions of basic climate dynamics in a population of graduate students at an elite university. ... [A] large majority violate fundamental physical constraints including conservation of mass. Most believe atmospheric greenhouse gas concentrations can be stabilized even as emissions into the atmosphere continuously exceed removal of GHGs from it, analogous to arguing a bathtub filled faster than it drains will never overflow. These beliefs favor wait-and-see policies, but violate basic laws of physics".

If flawed mental models can emerge in this highly-educated group, they are likely also to be widespread among the less-educated populace. Such "popular" models should not be allowed to be the basis of policy.

D. Confirmation bias must be expected

Psychologists refer to the tendency of people to look for and accept readily any evidence that supports a view they currently hold and to discredit data that does not support that view, perhaps even refusing to hear it. We must be prepared to see this effect in people with whom we interact. This is connected to a person's frames (and ideology) as well as to the underlying assumptions of the person expressing the views.

E. Who delivers the information matters

Moser [4] says, "People tend to find some individuals or professionals (*e.g.*, scientists, environmental groups) more trustworthy on certain issues than others (*e.g.*, 'the media', industry representatives). This fact has been exploited by 'climate contrarians', who have used PhD-carrying messengers (even if they were not active climate scientists) to convey a contradictory message to lay audiences otherwise ill-equipped to judge the accuracy or reasonableness of their arguments".

The author has examined several lists of "1000 climate scientists" who supposedly disbelieve human-caused climate change and found them mainly specious. The notorious Oregon Petition Project now has a list of "31,000 scientists and engineers" who do not support human-caused climate change. A small cabal of people started the Oregon Institute of Science and Medicine, then wrote up a paper that looks as if it was published in a scientific journal (rubbish, but plausible [25]), sent it to "all persons who have received a bachelor's degree or higher in a science, engineering (S&E), or S&E-related field" and asked them to sign a petition. They got 19,000 names, some phony, out of over 20 million people eligible. Then ten years later they published an updated version of their unpublished "scientific paper" in an obscure medical journal edited by one of the Institute's associates, send it around again and get an additional 12,000 signatures, some duplicates [26]. They now tout over 31,000 "scientists and engineers" who signed one or the other version of the petition as if that gave it credibility.

For us a scientists and science teachers, the respect still accorded scientists may lead to less antagonism and greater open-mindedness among our listeners as we teach and interact with fellow citizens.

F. Proximity matters

It seems likely that everyone reading this paper would believe that events closer to us in space and time would have more effect. This is true of climate science. Spence *et al.* [21] find that "the experience of an event that may be interpreted as being due to climate change confers to the individual a greater feeling of being able to have a personal impact, and perceptions also translate into a greater preparedness to act in ways that help tackle the issue".

G. Response times matter

In addition, people need to understand their own bias that only things happen quickly are worthy of notice. This leads them to discount things that occur slowly and to disbelieve that there can be long intervals between replenishing (of a clean atmosphere, for example).

Sterman and Sweeney [24] explain that the wait and see attitude of many people assumes a first-order linear system and discounts climate inertia. Neither is relevant to the climate system. It is nonlinear and effects linger long after causes cease to have an effect.

H. Scales matter

People see 2°C and think that that is so small that it does not really matter. They see the oceans and do not think puny humans can affect such a huge and awesome thing. Common sense does not always work. Mental ideas of the appropriate scale interfere with understanding.

V. CONCLUSIONS

We have suggested several ideas that teachers should bear in mind when discussing any apparently controversial issue such as climate change. Our heuristics, which were designed for rapid response to environmental threats such as predators, can fail us. For example, Chen [27] even suggests people see climate change as an object! With proper help, all the communication problems can be overcome.

REFERENCES

[1] Huntingford, C. and Fowler, D., *Climate change: seeking balance in media reports*, Environ. Res. Lett. **3**, 021001 (2008).
[2] Boykoff, M. T. and Mansfield, M., *'Ye olde hot aire': reporting on human contributions to climate change in the UK tabloid press*, Environ. Res. Lett. **3**, 024002 (2008).
[3] O'Shea, P., *A Cross Too Heavy: Eugenio Pacelli, Politics and the Jews of Europe 1917-1943,* (Rosenberg Publishing, Dural Delivery Centre, N.S.W., 2008).
[4] Moser, S. C., *Communicating climate change: history, challenges, process and future directions*, Clim. Change **1**, 31-53 (2010).
[5] Rowe, G., Frewer, L. and Sjöberg, L., *Newspaper reporting of hazards in the UK and Sweden,* Public Understand Sci. **9**, 59–78 (2000).
[6] Acar S. B. and Ince, E., *Internet as a source of misconception: 'radiation and radioactivity'*, Turkish Online J. Educ. Tech. **9**, 94-100 (2010).
[7] Gavin, N. T. and Marshall, T., *Mediated climate change in Britain: Scepticism on the web and on television around Copenhagen*, Glob. Environ Change **21**, 1035–1044 (2011).
[8] Aubrecht, G., *Helping scientists communicate to people,* Am. J. Phys. 7**9**, 437-439 (2011).
[9] See, in the United Kingdom for example, House of Commons Science and Technology Committee, *The Reviews into the University of East Anglia's Climatic Research Unit's E-mails, First Report of Session 2010–11B* or Russell, M., Boulton, G., Clarke, P., Eyton, D., and Norton, J., *The Independent Climate Change E-mails Review*, July 2010. For America, see Assman, S. M., Castleman, W., Irwin, M. J., Jablonsk, N. G., and Vondracek, F. W., *RA-10 Final Investigation Report Involving Dr. Michael E, Mann*, The Pennsylvania State University, June 4 (2010).
[10] Baker, D. R., *'Climategate' fallout may impact legislation*, (San Francisco Chronicle, 19 July 2010).
[11] Contribution of Working Group I to the Fourth Assessment Report of the IPCC, *Climate Change 2007 - The Physical Science Basis,* (Cambridge University Press, New York, 2007); Contribution of Working Group II to the Fourth Assessment Report of the IPCC, *Climate Change 2007 - Impacts, Adaptation and Vulnerability* (Cambridge University Press, New York, 2007); Contribution of Working Group III to the Fourth Assessment Report of the IPCC, *Climate Change 2007 - Mitigation of Climate Change* (Cambridge University Press, New York, 2007).
[12] Pidgeon, N. and Fischhoff, B., *The role of social and decision sciences in communicating uncertain climate risks*, Nature Clim. Change **1**, 35-41 (2011).
[13] Newell, B. R. and Pitman, A. J., *The psychology of global warming: improving the fit between the science and the message*, Bull. Amer. Meteor Soc. **91**, 1003-1014 (2010).
[14] Shome, S. and Marx, S., *The Psychology of Climate Change Communication,* (Center for Research on Environmental Decisions, Columbia University, New York, 2009).
[15] O'Neill, S. J., Hulme, M., Turnpenny, J. and Screen, J. A., *Disciplines, geography, and gender in the framing of climate change*, Bull. Amer. Meteor Soc. **91**, 997–1002 (2010).
[16] Lakoff, G., *Why it matters how we frame the environment,* Env. Comm. **4**, 70-81 (2010).
[17] See, for example, Alsop, S., *Understanding understanding: A model for the public learning of radioactivity*, Public Understand Sci. **8**, 267-284 (1999).
[18] Henriksen, E. K. and Jorde, D., *High school students' understanding of radiation and the environment: can museums play a role?*, Sci. Educ. **85**, 189-206 (2001).
[19] Cooper, S., Yeo1, S. and Zadnik M., *Australian students' views on nuclear issues: Does teaching alter prior beliefs?*, Phys. Educ. **38**, 123-129 (2003).
[20] Spence, A. and Pidgeon, N., *Framing and communicating climate change: The effects of distance and outcome frame manipulations*, Glob. Environ Change **20**, 656–667 (2010).
[21] Spence, A., Poortinga, W., Butler, C. and Pidgeon, N. F., *Perceptions of climate change and willingness to save energy related to flood experience*, Nature Clim. Change **1**, 46-49 (2011).
[22] See McDermott, L. C. and Redish, E. F., *Resource Letter: PER-1: Physics Education Research*, Am. J. Phys. **67**, 755-767 (1999).
[23] Yale Project on Climate Change Communication, http://environment.yale.edu/climate/publications/knowledge-of-climate-change accessed 12 July 2011.
[24] Sterman, J. D. and Sweeney, L. B., *Understanding public complacency about climate change: adults' mental models of climate change violate conservation of matter*, Climatic Change **80**, 213–238 (2007).
[25] See a fairly long list of the paper's falsehoods at http://rabett.blogspot.com/2008/06/oism-meets-mike-powell.html from 27 June 2008, accessed 12 July 2011.

[26] Chris Colose lists the "credentials" of randomly selected petition signers as of 22 May 2008 at http://chriscolose.wordpress.com/2008/05/22/one-more-petition-still-a-consensus/ accessed 12 July 2011.

[27] Chen, X., *Why do people misunderstand climate change? Heuristics, mental models and ontological assumptions*, Clim. Change **108**, 31-46 (2011).