The BEHAVIOR ANALYST

SPECIAL EDITION

THE HUMAN RESPONSE TO CLIMATE CHANGE: IDEAS FROM BEHAVIOR ANALYSIS

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Introduction: Dealing With What Is

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For a long time, we ignored the warnings. At first, even most climate scientists couldn't believe the evidence, but it kept rolling in. Gradually, more and more of them were won over and started trying to persuade the rest of us, but most of us ignored the warnings. Now, virtually all the legitimate climate scientists are convinced that the Earth is sick, and we gave it the disease.

Here are the basic facts: Climate scientists have published many peer-reviewed papers reporting evidence that the mean temperature of the planet is higher than at any time in recorded history; that it is rising at an unprecedented rate; and that the rising temperature is largely the result of human activity, primarily the burning of coal and oil to power electric generating plants and fuel our cars and trucks. These scientific findings have occasioned numerous reports that predict a variety of dire outcomes that society will face if the global emissions of heat-trapping greenhouse gases are not curbed. Beyond predictions of future calamities, there is evidence that climate change is already wreaking havoc in parts of the world. For example, one report claimed that human-influenced climate change, mainly by increasing flooding and draught, is causing more than 300,000 deaths and $125 billion in economic losses each year (Whiteman, 2009). This report also claimed that climate change is seriously affecting the lives of 325 million people, a number projected to double by 2030, and that more than 90% of the human and economic losses from climate change are occurring in poor countries. Although the report has been criticized for its methods and its author acknowledges that the numbers are rough estimates, he contends that "the suffering documented in this report is only the beginning" (p. 1).

Despite the steady stream of scientific facts and scary warnings, many people remain unmoved. Disbelief in global warming is a common reason for inaction and is usually the product of one of the following perspectives: "How could anything we tiny humans do affect a system so vast as the Earth's climate?" or "I understand there's a great deal of disagreement among scientists on whether global warming is real." A commonly voiced reason for inaction among people who accept the fact of global warming yet are making no changes in their behavior to reduce their contribution to it is: "I realize that if rate of greenhouse gas emissions is left unchecked, it will lead to terrible consequences. But I'm confident that scientists will come up with a solution in time to save us."

Technological breakthroughs have saved us in the past (e.g., pasteuriza-

We thank Michael Dougher, the previous editor of *The Behavior Analyst*, for approving the proposal for this special section and encouraging us to pursue it. Henry D. Schlinger, Jr., the current editor, provided much appreciated support and assistance. We are especially indebted to Lonnie Thompson, the authors of the essays, and the more than 40 behavior analysts whose reviews helped strengthen the content.

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tion, polio vaccine), and they might save us from climate change. Many ideas are on the table (catching carbon before it is released, recapturing it afterwards and storing it, and discovering and harnessing totally new forms of nonpolluting energy), but no technological solutions to global warming are available now and none are on the horizon. A good example is nuclear fusion: It has been ''nearly there'' since the 1970s, and we are no closer to adding fusion to the energy grid today than we were 40 years ago. Everyone hopes that technological research and development will bear fruit in time, but we cannot count on it, and dare not wait.

Changing the behavior of people around the world in ways that significantly reduce carbon dioxide (CO_2) emissions is the only thing that might buy enough time for the scientists and engineers to come up with an effective solution.

The good news is that many members of the general public, government leaders, and business owners are concerned about climate change and want to know what they can do to combat it. We agree with Kazdin (2009) that the psychological sciences can and should help in creating and maintaining a sustainable environment. One discipline within the psychological sciences that is especially well suited to help is behavior analysis.

THE ROLE AND RESPONSIBILITY OF BEHAVIOR ANALYSIS

Behavior analysis, the science of behavior change, can and must help society combat climate change. The very purpose of applied behavior analysis is to develop a reliable technology for improving socially significant behavior (Cooper, Heron, & Heward, 2007; Morris & Smith, 2003). Is there any behavior more socially significant than behavior that could save civilization?

Applied behavior analysis has developed at least partial solutions to many problems faced by society, including the prevention of AIDS (DeVries, Burnette, & Redmon, 1991), helping people to achieve healthier lifestyles (McKenzie et al., 1991), enhancing the quality of life for people with autism and other developmental disabilities (Eikeseth, 2009; Maurice, Green, & Foxx, 2001), improving education (Heward et al., 2005; Johnson & Layng, 1994), making the workplace and highways safer (Fox, Hopkins, & Anger, 1987; Sulzer-Azaroff, 1998), treating drug addiction (Silverman, Roll, & Higgins, 2008), increasing employee productivity (Daniels & Daniels, 1999), but the field has paid relatively little attention to the effects of behavior on the environment. This is curious because behavior analysis is, in many ways, an environmental science. The independent variables of primary importance to behavior analysts are changes in the environment, that is, antecedent events that elicit, evoke, and cue behavior, and consequent events that select and maintain it. The environment also provides the context by which the function or ''meaning'' of behavior is determined.

A promising spate of applied research on environmental problems did appear in the *Journal of Applied Behavior Analysis* from the 1970s to the mid-1980s. The authors of these pioneering studies demonstrated practical interventions in several ecological domains: litter and pollution control (e.g., Bacon-Prue, Blount, Pickering, & Drabman, 1980; Clark, Burgess, & Hendee, 1972; Geller, Farris, & Post, 1973; Hayes, Johnson, & Cone, 1975; Powers, Osborne, & Anderson, 1973), recycling (e.g., Jacobs, Bailey, & Crews, 1984; Keller, 1991/2010; Witmer & Geller, 1976), and energy conservation (e.g., Winett et al., 1982). However, with some notable exceptions (e.g., Brothers, Krantz, & McClannahan, 1994; Geller, 1990; Schroeder, Hovell, Kol-

ody, & Elder, 2004), interest in research on protecting the environment waned after the 1980s.

Like the rest of society, behavior analysis has been slow to respond to climate change. There are signs, however, that this is changing: symposia and papers at recent annual conventions of the Association for Behavior Analysis International (ABAI) by ecologists and climate change scientists (e.g., Thompson, 2009; Wagner, 2009) and sessions on the responsibilities and opportunities for behavior analysts to help society respond to global warming (e.g., Aquirre, 2010; Biglan, 2009); a movement to establish a special interest group within ABAI on sustainability (Julia Fiebig, personal communication, June 19, 2010); the development of academic programs integrating behavior analysis and environmental science (Mark Alavosius, personal communication, August 5, 2010); and the use of behavior analysis to reduce energy consumption on college campuses (Jeanine Stratton, personal communication, June 30, 2010). This special section is an effort to fuel that burgeoning interest by showing those inside and outside the field how behavior analysis can help combat climate change.

CONTENTS OF THE SPECIAL SECTION

The Science of Climate Change

In "Climate Change: The Evidence and Our Options," Lonnie Thompson explains how the findings from ice core paleoclimatology (the use of physical evidence trapped in ice to understand Earth's climate system and the variables that influence it) and data from related climate sciences yield a preponderance of evidence that our planet's temperature is rising, that global warming is occurring at an accelerating rate, and that the only plausible explanation for it is human activity, chiefly the burning of fossil fuels.

Thompson has led 56 expeditions to remote ice caps atop the world's highest mountains, and has spent nearly four years of his life above 18,000 feet, more time than any person in history. His findings have resulted in major advances in our understanding of climate change by demonstrating how tropical regions have undergone significant climate variability, countering the earlier view that higher latitudes dominate climate change. Thompson's research has been featured in hundreds of publications, including *National Geographic* and *National Geographic Adventure* magazines, in the book *Thin Ice* (Bowen, 2006), and is highlighted in Al Gore's documentary film on global warming, *An Inconvenient Truth*. One of *Time* magazine's 2008 Heroes of the Environment, Thompson was identified as one of six scientists and innovators whose work is key to addressing global climate change. An elected member of the National Academy of Sciences, Thompson's numerous honors and awards include the Tyler World Prize for Environmental Achievement (2005), the environmental sciences equivalent of a Nobel Prize; the Einstein Lecturer Award from the Chinese Academy of Sciences; and the National Medal of Science (2007), the highest honor the United States bestows on American scientists.

Like many climate scientists, Thompson was initially skeptical of global warming, but the overwhelming consistency of the physical evidence he has discovered (bubbles of CO_2, methane, and nitrous oxide trapped in ice) combined with the findings of other climate scientists has convinced him. "When you can see the heartbeat of the Earth's climate system in the rise and fall of CO_2 over 800,000 years—long before humans played any role—that's why you become concerned about where we are in today's world. There's no analogue in that entire history to the levels of CO_2 in the atmosphere today" (West Virginia Public Broadcasting, 2010).

What does Thompson say to skeptics who contend that the recent rise in Earth's temperature is due to natural variations in cycles and that man-made global warming is an unproven theory that hurts jobs and businesses? He predicts that by 2020, there will be no global warming skeptics.

> At the end of the day, *you have to deal with what is*. Not what you believe or wish was the case. In the end, we will deal with this issue because we will have no choice but to do so. … I understand the importance of jobs, being able to go to work and feed your family. But on the other hand, we live on a planet with limited resources, and if we continue on this path, there are a lot of families that aren't going to make it going forward in time. That is the hardest part: short-term gain versus long-term well-being. (West Virginia Public Broadcasting, 2010)[1]

Thompson sees no "technological quick fixes for global warming" on the horizon and concludes that "our only hope is to change our behavior" (2010, p. 168). His article is the best introduction to the science behind climate change that we have seen, and we think it will be difficult for anyone to read it and not be convinced that global warming is real and is the result of human activity.

Ideas from Behavior Analysts

We e-mailed more than 50 behavior analysts in the U.S. and 10 other countries describing our plans for the special section and inviting them to submit ideas for essays on ways of using behavioral principles to combat global warming. We were encouraged by the positive reactions. Many of those we contacted submitted an essay proposal or offered to serve as reviewers for the essays.

Several people wanted to write conceptual papers on the behavioral principles that underlie our excessive use of energy. We said no; we did not want analyses of the problem, we wanted proposals for solving it. We asked for new ideas about how to change behavior and reduce global warming. And we wanted them to do it in about 1,000 words, in plain language that educated laypeople could understand. We had two goals: stir interest among behavior analysts, especially those beginning their careers, and get people outside of behavior analysis (politicians, environmentalists, business owners) to implement or build on the proposals. We wanted the essays themselves to change behavior.

To say that this was not an easy assignment would be gross understatement. We received many proposals that would have made the basis for fine scholarly treatises analyzing the problem but failed the test for this special section. We commissioned authors of the proposals with the most promise to prepare essays for peer review. The process yielded six essays—six brilliant essays in our opinion—that propose new ideas for changing behavior in ways that will reduce greenhouse gas emissions.

Given the central role children will play in creating a greener world, we go back to the future to preface the special section's six original essays with a reprint of "The Recycling Solution: How I Increased Recycling on Dilworth Road" by Jacob Keller (1991/2010). The grandson of Fred Keller, one of the founders of behavior analysis, Jacob was 10 years old when he conducted the project for his elementary school science fair. We recently contacted Jacob to learn more about his project. He told us the inspiration came from a class field trip to the county recycling center, which included seeing video footage of landfills. "Those depressing images of the seemingly infinite oceans of trash inspired me more than anything to want to be proactive

[1] To hear Thompson and his wife, Ellen Mosley-Thompson, who has led 15 ice drilling expeditions to Greenland and Antarctica, talk about their research and perspectives on climate change, and to see how ice cores are harvested, transported, and data extracted from them, go to http://www.youtube.com/watch?v=eNmYLvvE7iQ

about recycling and get more people involved'' (Jacob Keller, personal communication, August 12, 2010). When asked if his experience with the recycling project has affected his behavior as an adult, he said, ''I recycle every week and am probably more eco-conscious as an adult having done the project. I drive a car that gets 41 mpg on the highway!''

In ''Buying Green,'' Joe Layng recognizes that, like all choices we make, our decisions as consumers are more likely to be influenced by their short-term consequences for us as individuals (price, quality) than they are by their long-term consequences for society (environmental impact). He believes that the equation can be tilted in favor of greener choices by giving consumers immediate access to reliable information about a product's environmental impact at the point of purchase and proposes a way to do just that.

In the provocatively titled ''I'll Save the World from Global Warming—Tomorrow,'' Dick Malott says that although we all want to do the right thing to help the environment, whether it's buying and installing compact fluorescent lightbulbs (CFLs) or replacing an energy-guzzling appliance with a more efficient one, we put it off because there's no penalty for delay. He proposes a practical way in which the Web can put our feet to the fire.

In ''Helping for Change,'' Allen Neuringer and Kathryn Oleson describe another strategy that individuals can use to achieve their green goals. You might ask, ''How can helping someone else help me change when I'm in the habit of not fulfilling my own promises?'' The authors answer that question by explaining how the social reinforcement in a helping relationship keeps us on task and builds correspondence between what we say and what we do.

Carbon dioxide from automobiles is a major contributor to global climate change. In ''Virtual Rewards for Driving Green,'' Josh Pritchard proposes a computer application that will enable fuel-efficient drivers to earn ''green'' dollars with which to buy digital merchandise on the Web. Can getting items that exist only in cyberspace actually change a person's driving behavior? Pritchard, who notes that people are spending billions of real dollars on virtual items each year, is currently developing an app called Green Wheels to find out.

In ''The Power of Cooperation,'' Tony Nevin tells how the townspeople of Martha's Vineyard, Massachusetts, are attempting to replicate a successful alternative-energy project in Samsø, Denmark, where thinking about ways to reduce fossil-fuel use ''became a kind of sport.'' Nevin says that thinking and acting locally helps people to identify and pursue small-scale cooperative energy projects, celebrate their successes, and ''take pride in the fact that they are ameliorating rather than exacerbating global warming'' (p. 191).

Whatever adults might accomplish on the green behavior change front, any sustained success in combating climate change will require the help of the world's more than 2.2 billion children. In ''TerraKids,'' Janet Twyman describes a possible Web site where kids learn about their family's carbon footprint and what they can do to help reduce it. TerraKids establishes the child as an agent for changing the green behaviors of other family members. A virtual community within TerraKids encourages kids to team up with other ''CarbonBusters'' to help create and sustain a greener world.

The Challenge

In ''Climate Change: Meeting the Challenge,'' we conclude the special section by assuming that you have been persuaded by Thompson's paper or other evidence that global warming is real and poses a threat that must be dealt with, and that for now the only way to deal with it is by

changing behavior. Then we ask what you, as behavior analysts, can do (aside from replacing your incandescent bulbs with CFLs like everybody else), and we remind you that you have special skills in behavior change and therefore a special responsibility to help meet this challenge.

We go on to suggest a different perspective for dealing with this problem: Instead of dwelling on how discounting and weak reinforcement schedules and the side effects of punishment incline people to consume and waste too much, think about how these tendencies can be used to change behavior in desirable ways. We then give examples of interventions this kind of thinking can produce. One such intervention, called Carrotmobbing, is already being done. It starts with the fact that people are typically motivated by self-interest, and uses that fact to get them to go green. Then we go on to suggest a number of proposals of our own for doing the same sort of thing, using behavior principles to work for us rather than against us.

Our final proposal for restoring the health of our planet is to move toward a sustainable society. To do that we must reach a stable world population and do a better job of husbanding the earth's limited resources. This is a very long-term project and is not likely to be pain free, but many experts believe it can be done without accepting a markedly lower standard of living. Behavior analysts need to get involved in this project and help to work toward sustainability.

A good way to begin your effort to save our environment is by reading Lonnie Thompson's article. If you do, we think you will understand why he is convinced that there will be no global warming deniers by 2020. After all, you have to deal with what is.

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The Human Response to Climate Change: Ideas from Behavior Analysis Reviewers

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Climate Change: The Evidence and Our Options

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Glaciers serve as early indicators of climate change. Over the last 35 years, our research team has recovered ice-core records of climatic and environmental variations from the polar regions and from low-latitude high-elevation ice fields from 16 countries. The ongoing widespread melting of high-elevation glaciers and ice caps, particularly in low to middle latitudes, provides some of the strongest evidence to date that a large-scale, pervasive, and, in some cases, rapid change in Earth's climate system is underway. This paper highlights observations of 20th and 21st century glacier shrinkage in the Andes, the Himalayas, and on Mount Kilimanjaro. Ice cores retrieved from shrinking glaciers around the world confirm their continuous existence for periods ranging from hundreds of years to multiple millennia, suggesting that climatological conditions that dominate those regions today are different from those under which these ice fields originally accumulated and have been sustained. The current warming is therefore unusual when viewed from the millennial perspective provided by multiple lines of proxy evidence and the 160-year record of direct temperature measurements. Despite all this evidence, plus the well-documented continual increase in atmospheric greenhouse gas concentrations, societies have taken little action to address this global-scale problem. Hence, the rate of global carbon dioxide emissions continues to accelerate. As a result of our inaction, we have three options: mitigation, adaptation, and suffering.

Key words: climate, global warming

Climatologists, like other scientists, tend to be a stolid group. We are not given to theatrical rantings about falling skies. Most of us are far more comfortable in our laboratories or gathering data in the field than we are giving interviews to journalists or speaking before Congressional committees. Why then are climatologists speaking out about the dangers of global warming? The answer is that virtually all of us are now convinced that global warming poses a clear and present danger to civilization (''Climate Change,'' 2010).

That bold statement may seem like hyperbole, but there is now a very clear pattern in the scientific evidence documenting that the earth is warming, that warming is due largely to human activity, that warming is causing important changes in climate, and that rapid and potentially catastrophic changes in the near future are very possible. This pattern emerges not, as is so often suggested, simply from computer simulations, but from the weight and balance of the empirical evidence as well.

THE EVIDENCE

Figure 1 shows northern hemisphere temperature profiles for the last 1,000 years from a variety of high-resolution climate recorders such as glacier lengths (Oerlemans, 2005), tree rings (Briffa, Jones, Schwerngruber,

This paper is based on the Presidential Scholar's Address given at the 35th annual meeting of the Association for Behavior Analysis International, Phoenix, Arizona. I am grateful to Bill Heward for inviting me to give the address. I thank Mary Davis for her help editing the text and figures. I wish to thank all the field and laboratory team members from the Byrd Polar Research Center who have worked so diligently over the years. I am especially indebted to the hard work of our current research team: Ellen Mosley-Thompson, Henry Brecher, Mary Davis, Paolo Gabrielli, Ping-Nan Lin, Matt Makou, Victor Zagorodnov, and all of our graduate students. Funding for our research over the years has been provided by the National Science Foundation's Paleoclimate Program, the National Oceanic and Atmospheric Administration's Paleoclimatology and Polar Programs, the National Aeronautic and Space Administration, Gary Comer Foundation, and The Ohio State University's Climate, Water and Carbon Program. This is Byrd Polar Research Center Publication 1402.

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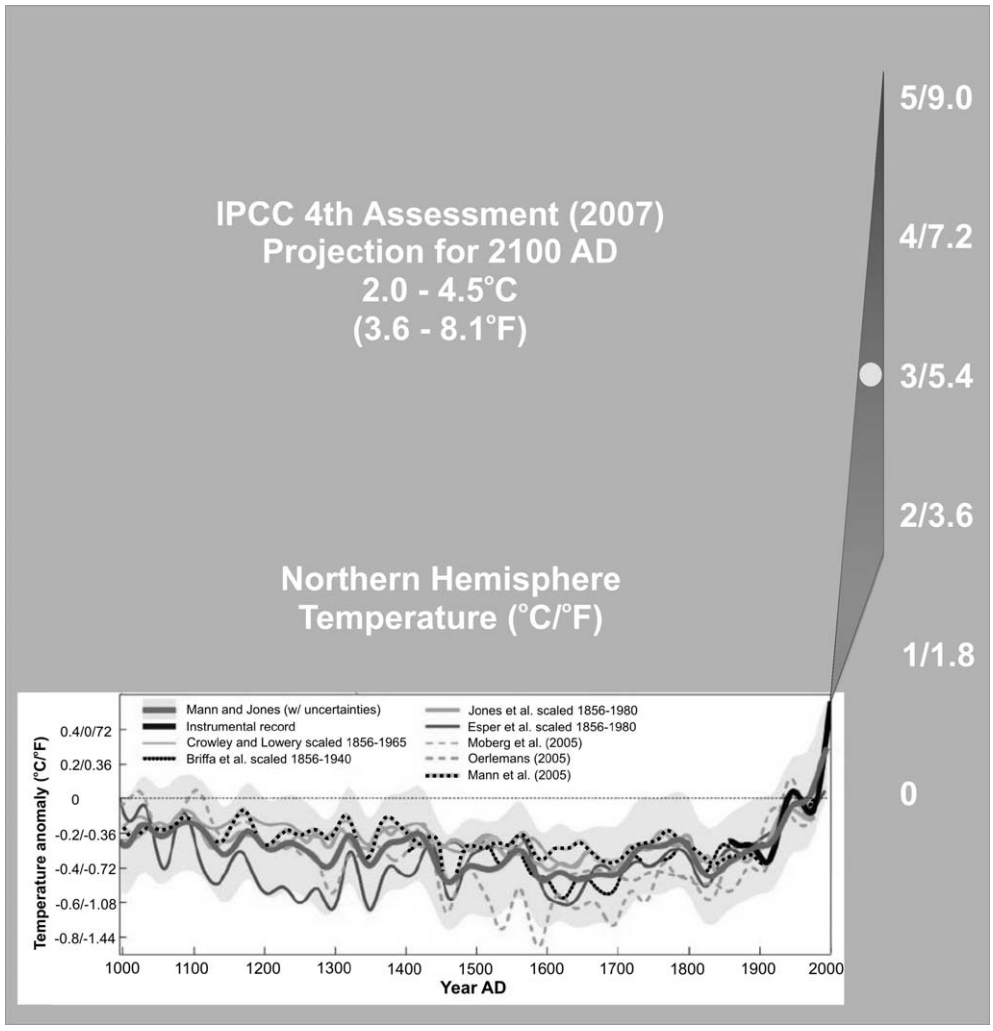

Figure 1. A variety of temperature records over the last 1,000 years, based on a variety of proxy recorders such as tree rings, ice cores, historical records, instrumental data, etc., shows the extent of the recent warming. The range of temperature projected by Meehl et al. (2007) to 2100 AD is shown by the shaded region, and the average of the range is depicted by the filled circle.

Shiyatov, & Cook, 2002; Esper, Cook, & Schweingruber, 2002), and combined sources that include some or all of the following: tree rings, sediment cores, ice cores, corals, and historical records (Crowley & Lowery, 2000; Jones, Briffa, Barnett, & Tett, 1998; Mann, Bradley, & Hughes, 1999; Moberg, Sonechkin, Holmgrem, Datsenko, & Karlen, 2005). The heavy gray line is a composite of all these temperatures (Mann & Jones, 2003), and the heavy black line depicts actual thermometer readings back to 1850 (see National Research Council, 2006, for a review of surface temperature reconstructions). Although the various curves differ from one another, their general shapes are similar. Each data source shows that average northern hemisphere temperatures remained relatively stable until the late 20th century. It is the agreement of these diverse data sets and the pattern that make climatologists confident that the warming trend is real.

Because these temperature numbers are based on northern hemi-

sphere averages, they do not reflect regional, seasonal, and altitudinal variations. For example, the average temperature in the western United States is rising more rapidly than in the eastern part of the country, and on average winters are warming faster than summers (Meehl, Arblaster, & Tebaldi, 2007). The most severe temperature increases appear to be concentrated in the Arctic and over the Antarctic Peninsula as well as within the interior of the large continents. This variability complicates matters, and adds to the difficulty of convincing the public, and even scientists in other fields, that global warming is occurring. Because of this, it may be useful to examine another kind of evidence: melting ice.

Retreat of Mountain Glaciers

The world's mountain glaciers and ice caps contain less than 4% of the world's ice cover, but they provide invaluable information about changes in climate. Because glaciers are smaller and thinner than the polar ice sheets, their ratio of surface area to volume is much greater; thus, they respond more quickly to temperature changes. In addition, warming trends are amplified at higher altitudes where most glaciers are located (Bradley, Keimig, Diaz, & Hardy, 2009; Bradley, Vuille, Diaz, & Vergara, 2006). Thus, glaciers provide an early warning system of climate change; they are our ''canaries in the coal mine.''

Consider the glaciers of Africa's Mount Kilimanjaro (Figure 2). Using a combination of terrestrial photogrammetric maps, satellite images, and aerial photographs, we have determined that the ice fields on Kibo, the highest crater on Kilimanjaro, have lost 85% of their coverage since 1912 (Thompson, Brecher, Mosley-Thompson, Hardy, & Mark, 2009).

Figure 3 shows a series of aerial photographs of Furtwängler glacier, in the center of Kibo crater, taken between 2000 and 2007, when the glacier split into two sections. As Furtwängler recedes, it is also thinning rapidly, from 9.5 m in 2000 to 4.7 m in 2009 (for more images of Furtwängler's retreat, see http://www.examiner.com/examiner/x-10722-Orlando-Science-Policy-Examiner~y2009m11d2-Mt-Kilimanjaros-Furtwängler-Glacier-in-retreat). If you connect the dots on the changes seen to date and assume the same rate of loss in the future, within the next decade many of the glaciers of Kilimanjaro, a Swahili word meaning ''shining mountain,'' will have disappeared.

The Quelccaya ice cap, which is located in southern Peru adjacent to the Amazon Basin, is the largest tropical ice field on Earth. Quelccaya has several outlet glaciers, glaciers that extend from the edges of an ice cap like fingers from a hand. The retreat of one of these, Qori Kalis, has been studied and photographed since 1963. At the beginning of this study, Qori Kalis extended 1,200 m out from the ice cap, and there was no melt water at the end (Figure 4, map top left). By the summer of 2008, Qori Kalis had retreated to the very edge of Quelccaya, leaving behind an 84-acre lake, 60 m deep. Over the years, a boulder near the base camp has served as a benchmark against which to record the changes in the position of the edge of the ice. In 1977 the ice was actually pushing against the boulder (Figure 5, top), but by 2006 a substantial gap had appeared and been filled by a lake (Figure 5, bottom). Thus, the loss of Quelccaya's ice is not only on the Qori Kalis glacier but also on the margin of the ice cap itself. Since 1978, about 25% of this tropical ice cap has disappeared.

The Himalayan Mountains are home to more than 15,000 glaciers. Unfortunately, only a few of these glaciers have been monitored over an extended period, so reliable ground observations that are crucial for

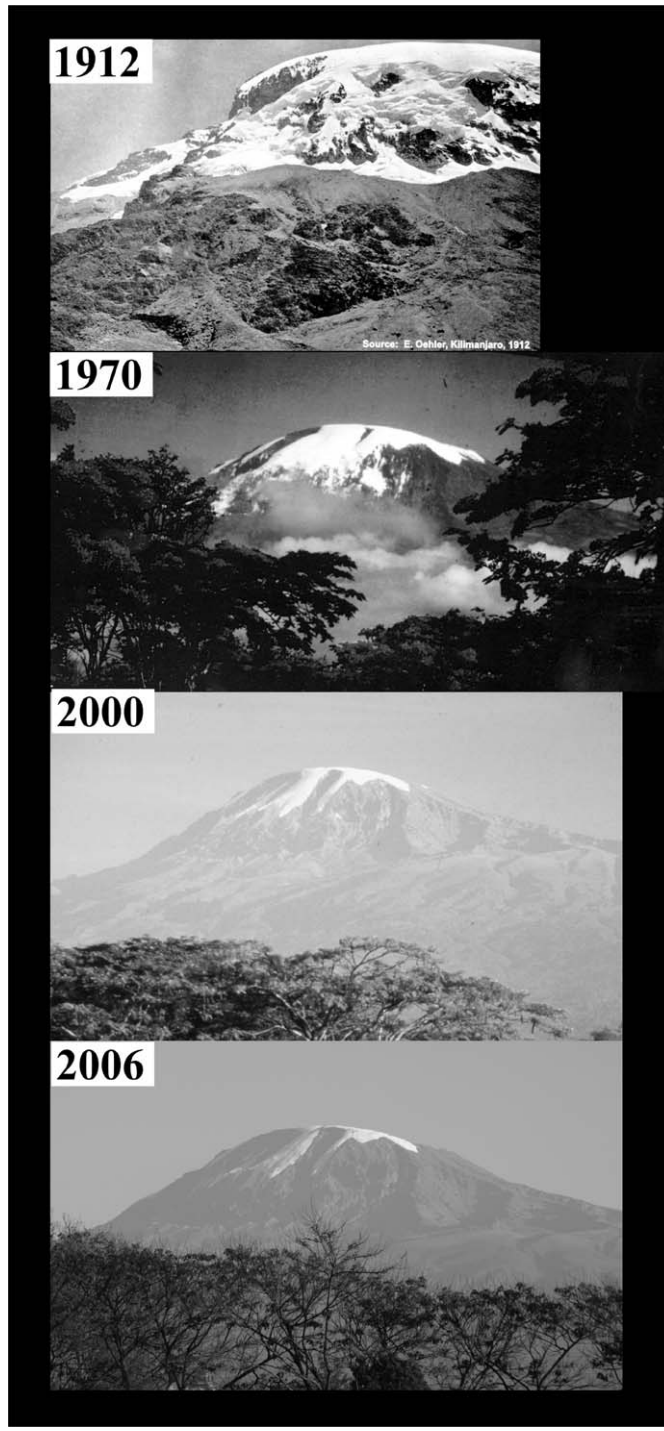

Figure 2. The retreat of glaciers on Mount Kilimanjaro can be seen in the photographs from 1912, 1970, 2000, and 2006; from 1912 to 2006, 85% of the ice has disappeared.

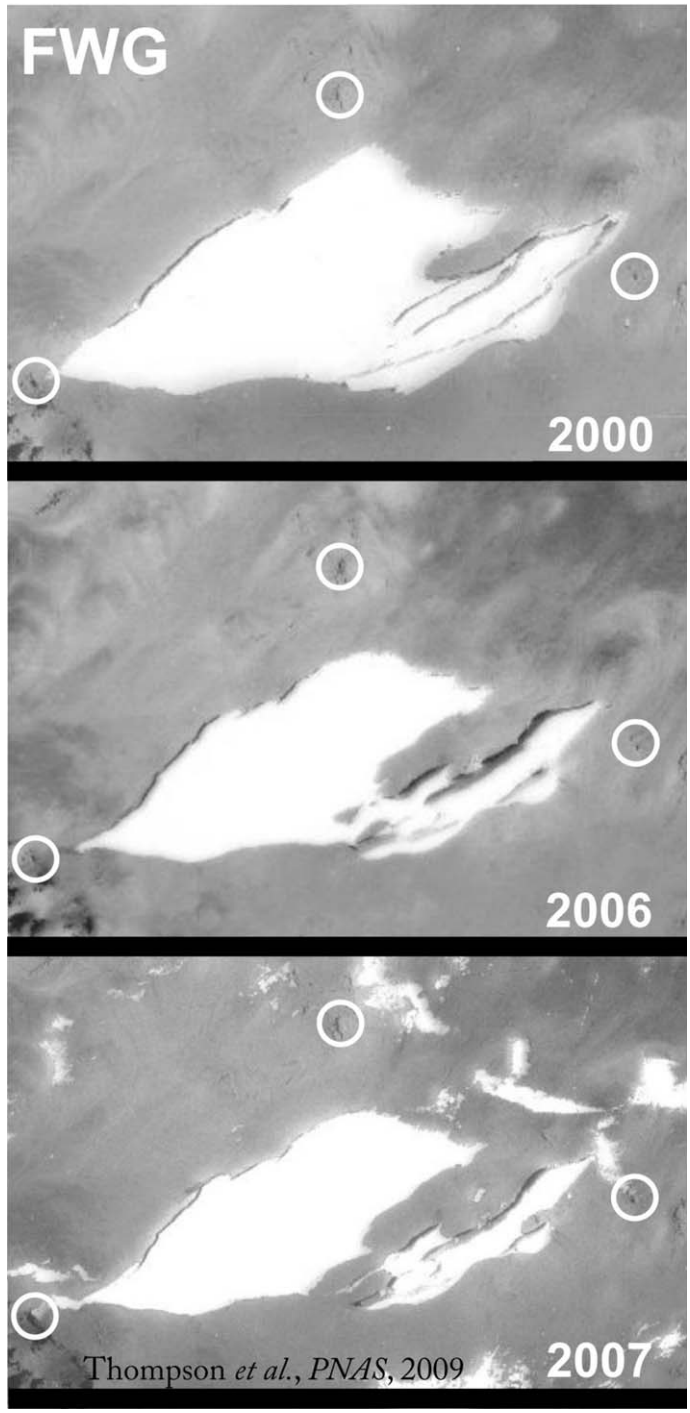

Figure 3. Deterioration of the Furtwängler glacier in the center of Kibo crater on Mount Kilimanjaro. Since 2000 the ice field has decreased in size and thickness and has divided in two.

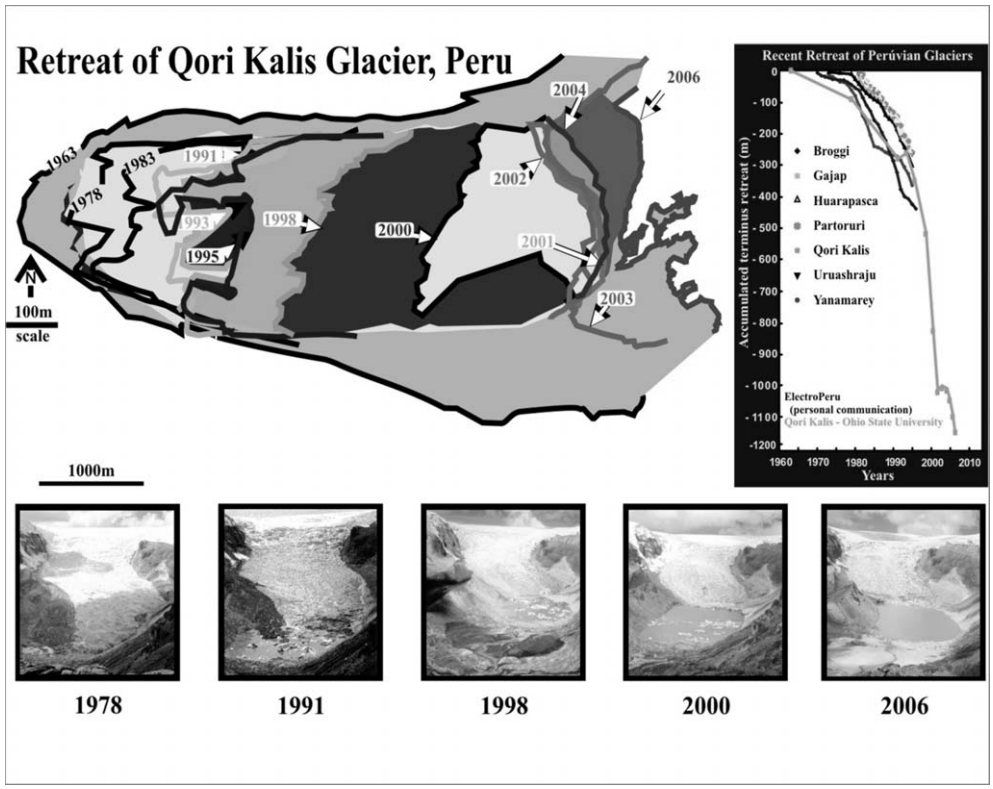

Figure 4. Retreat of the Qori Kalis outlet glacier on the Quelccaya ice cap. Each line shows the extent of the ice. The photos along the bottom provide a pictorial history of the melting of the Qori Kalis outlet glacier and the formation of a lake. The retreat of Qori Kalis is similar to the loss of several Peruvian glaciers, as shown in the graph insert.

determining regional retreat rates do not yet exist. However, a recent study of an ice core from the Naimona'nyi glacier in the southwestern Himalayas (Kehrwald et al., 2008) shows that ice is disappearing from the top of the glacier, as shown by the lack of the radioactive bomb layers from the 1950s and early 1960s that appear in all Tibetan and Himalayan ice core records (Thompson, 2000; Thompson et al., 1990, 1997, 2006).

Glaciologists at the Institute of Tibetan Plateau Research in Beijing have been monitoring 612 glaciers across the High Asian region since 1980. These scientists found that from 1980 to 1990, 90% of these glaciers were retreating; from 1990 to 2005, the proportion of retreating glaciers increased to 95% (Yao, Pu, Lu, Wang, & Yu, 2007).

A study of 67 glaciers in Alaska from the mid-1950s to the mid-1990s shows that all are thinning (Arendt, Echelmeyer, Harrison, Lingle, & Valentine, 2002). In northern Alaska's Brooks Range, 100% of the glaciers are in retreat, and in southeastern Alaska 98% are shrinking (Molnia, 2007). Glacier National Park in Montana contained more than 100 glaciers when it was established in 1910. Today, just 26 remain, and at the current rate of decrease it is estimated that by 2030 there will be no glaciers in Glacier National Park (Hall & Fagre, 2003). The oldest glacier photos come from the Alps. Ninety-nine percent of the glaciers in the Alps are retreating, and 92% of Chile's Andean glaciers are retreating (Vince, 2010).

The pattern described here is repeated around the world. Mountain

Figure 5. Top: photo taken in 1978 shows a margin of the Quelccaya ice cap pushing against a boulder. Bottom: the same margin is shown in a 2005 photo. The ice has receded and has been replaced by a small lake. The boulder shown in the top photo is located in the center of the white circle to the right.

glaciers nearly everywhere are retreating.

Loss of Polar Ice

Satellite documentation of the area covered by sea ice in the Arctic Ocean extends back three decades. This area, measured each September, decreased at a rate of about 8.6% per decade from 1979 to 2007. In 2007 alone, 24% of the ice disappeared. In 2006 the Northwest Passage was ice free for the first time in recorded history.

As noted earlier, polar ice sheets are slower to respond to temperature rise than the smaller mountain glaciers, but they, too, are melting. The Greenland ice sheet has also experienced dramatic ice melt in recent years. There has been an increase in both the number and the size of lakes in the southern part of the ice sheet, and crevices can serve as conduits (called moulins) that transport meltwater rapidly into the glacier. Water has been observed flowing through these moulins down to the bottom of the ice sheet where it acts as a lubricant that speeds the flow of ice to the sea (Das et al., 2008; Zwally et al., 2002).

The ice in Antarctica is also melting. The late John Mercer, a glacial geologist at The Ohio State University, long ago concluded that the first evidence of global warming due to increasing carbon dioxide (CO_2) would be the breakup of the Antarctic ice shelves (Mercer, 1978). Mean temperatures on the Antarctic Peninsula have risen 2.5° C (4.5° F) in the last 50 years, resulting in the breakup of the ice shelves in just the way Mercer predicted. One of the most rapid of these shelf deteriorations occurred in 2002, when the Larsen B, a body of ice over 200 m deep that covered an area the size of Rhode Island, collapsed in just 31 days (see images http://earthobservatory.nasa.gov/IOTD/view.php?id=2351). An ice shelf is essentially an iceberg attached to land ice. Just as an ice cube does not raise the water level in a glass when it melts, so a melting ice shelf leaves sea levels unchanged. But ice shelves serve as buttresses to glaciers on land, and when those ice shelves collapse it speeds the flow of the glaciers they were holding back into the ocean, which causes sea level to rise rapidly.

Just days before this paper went to press, a giant ice island four times the size of Manhattan broke off the Petermann glacier in Greenland. This event alone does not prove global climate change, because half of the ice loss from Greenland each year comes from icebergs calving from the margins. It is the fact that this event is part of a long-term trend of increasing rates of ice loss, coupled with the fact that temperature is increasing in this region at the rate of 2° C (3.6° F) per decade, that indicates that larger scale global climate change is underway.

The loss of ice in the Arctic and Antarctic regions is especially troubling because these are the locations of the largest ice sheets in the world. Of the land ice on the planet, 96% is found on Greenland and Antarctica. Should all this ice melt, sea level would rise over 64 m (Church et al., 2001; Lemke et al., 2007), and of course the actual sea level would be much higher due to thermal expansion of the world's oceans as they warm.

Although research shows some variability in the rate of ice loss, it is clear that mountain glaciers and polar ice sheets are melting, and there is no plausible explanation for this but global warming. Add to this the laboratory evidence and the meteorological measurements, and the case for global warming cannot be denied. So what causes global temperatures to rise?

CAUSES OF GLOBAL WARMING

Climatologists strive to reconstruct past climate variations on regional

and global scales, but they also try to determine the mechanisms, called *forcers*, that drive climate change. Climatologists recognize two basic categories of forcers. Natural forcers are recurring processes that have been around for millions of years; anthropogenic forcers are more recent processes caused by human activity.

One familiar natural forcer is the earth's orbit around the sun, which gives us our seasons. In the northern hemisphere, June is warm because the sun's rays fall more directly on it, and the sun appears high in the sky; in the southern hemisphere, June is cool because the sun's rays hit the earth at a deep angle, and the sun appears low in the sky.

Less obvious natural forcers include short- and long-term changes in the atmosphere and ocean. For example, when Mount Pinatubo erupted in the Philippines in 1991, it spewed millions of tons of sulfuric gases and ash particles high into the atmosphere, blocking the sun's rays. This lowered global temperatures for the next few years. Another natural forcer is the linked oceanic and atmospheric system in the equatorial Pacific Ocean known as the El Niño-Southern Oscillation (ENSO). ENSO occurs every 3 to 7 years in the tropical Pacific and brings warm, wet weather to some regions and cool, dry weather to other areas.

Other natural forcers include periodic changes in energy from the sun. These include the 11- to 12-year sunspot cycle and the 70- to 90-year Wolf-Gleissberg cycle, a modulation of the amplitude of the 11-year solar cycle. These changes in solar energy can affect atmospheric temperature across large regions for hundreds of years and may have caused the ''medieval climate anomaly'' in the northern hemisphere that lasted from about 1100 AD to 1300 AD. Solar cycles may also have played a role in the cause of the ''little ice age'' in North America and Europe during the 16th to 19th centuries. These changes in climate, which are often cited by those who dismiss global warming as a normal, cyclical event, affected large areas, but not the Earth as a whole. The medieval climate anomaly showed warmth that matches or exceeds that of the past decade in some regions, but it fell well below recent levels globally (Mann et al., 2009).

The most powerful natural forcers are variations in the orbit of the Earth around the Sun, which last from 22,000 to 100,000 years. These ''orbital forcings'' are partly responsible for both the ice ages (the glacial periods during which large regions at high and midddle latitudes are covered by thick ice sheets), and for the warm interglacial periods such as the present Holocene epoch which began about 10,000 years ago.

There is consensus among climatologists that the warming trend we have been experiencing for the past 100 years or so cannot be accounted for by any of the known natural forcers. Sunspot cycles, for example, can increase the sun's output, raising temperatures in our atmosphere. We are seeing a temperature increase in the troposphere, the lower level of our atmosphere, and a temperature decrease in the stratosphere, the upper level. But this is the exact opposite of what we would get if increased solar energy were responsible. Similarly, global temperatures have increased more at night than during the day, again the opposite of what would occur if the sun were driving global warming. In addition, temperatures have risen more in winter than in summer. This, too, is the opposite of what would be expected if the sun were responsible for the planet's warming. High latitudes have warmed more than low latitudes, and because we get more radiation from the sun at low latitudes, we again would expect the opposite if the sun were driving these changes. Thus, changes in solar output cannot ac-

count for the current period of global warming (Meehl et al., 2007). ENSO and other natural forcers also fail to explain the steady, rapid rise in the earth's temperature. The inescapable conclusion is that the rise in temperature is due to anthropogenic forces, that is, human behavior.

The relatively mild temperatures of the past 10,000 years have been maintained by the greenhouse effect, a natural phenomenon. As orbital forcing brought the last ice age to an end, the oceans warmed, releasing CO_2 into the atmosphere, where it trapped infrared energy reflected from the earth's surface. This warmed the planet. The greenhouse effect is a natural, self-regulating process that is absolutely essential to sustain life on the planet. However, it is not immutable. Change the level of greenhouse gases in the atmosphere, and the planet heats up or cools down.

Greenhouse gases are captured in ice, so ice cores allow us to see the levels of greenhouse gases in ages past. The longest ice core ever recovered (from the European Project for Ice Coring in Antarctica) takes us 800,000 years back in time, and includes a history of CO_2 and methane levels preserved in bubbles in the ice (Loulergue et al., 2008; Lüthi et al., 2008). The CO_2 and methane curves illustrated in Figure 6 show that the modern levels of these gases are unprecedented in the last 800 millennia.

Globally, CO_2 concentrations have varied between 180 and 190 parts per million per volume (ppmv) during glacial (cold) periods and between 270 and 290 ppmv during interglacial (warm) periods. However, since the onset of the Industrial Revolution, when fossil fuel use (chiefly coal and oil) began to burgeon, CO_2 concentration has increased about 38% over the natural interglacial levels (Forster et al., 2007). Between 1975 and 2005, CO_2 emissions increased 70%, and between 1999 and 2005 global emissions increased 3% per year (Marland, Boden, & Andres, 2006). As of this writing, the CO_2 concentration in the atmosphere is 391 ppmv (Mauna Loa CO_2 annual mean data from the National Oceanic and Atmospheric Administration, 2010), a level not seen at any time in 800,000 years. Climatologists have identified no natural forcers that could account for this rapid and previously unseen rise in CO_2.

Methane raises temperature even more than CO_2, and the amount of methane in the atmosphere, like that of CO_2, is also at a level not seen in 800 millennia. Two thirds of current emissions of methane are by-products of human activity, things like the production of oil and natural gas, deforestation, decomposition of garbage and sewage, and raising farm animals.

Many people find it difficult to believe that human activity can affect a system as large as Earth's climate. After all, we are so tiny compared to the planet. But every day we tiny human beings drive cars; watch television; turn on lamps; heat or cool our houses and offices; eat food transported to us by planes, ships, and trucks; clear or burn forests; and behave in countless other ways that directly or indirectly release greenhouse gases into the air. Together, we humans emitted eight *billion* metric tons of carbon to our planet's atmosphere in 2007 alone (Boden, Marland, & Andres, 2009). (CO_2 weighs 3.66 times more than carbon; that means we released 29.3 billion metric tons of CO_2.) The evidence is overwhelming that human activity is responsible for the rise in CO_2, methane, and other greenhouse gas levels, and that the increase in these gases is fueling the rise in mean global temperature.

A global temperature rise of a few degrees may not seem such a bad thing, especially to people living in harsh, cold climates. But global warming does not mean merely that we will trade parkas for T-shirts or

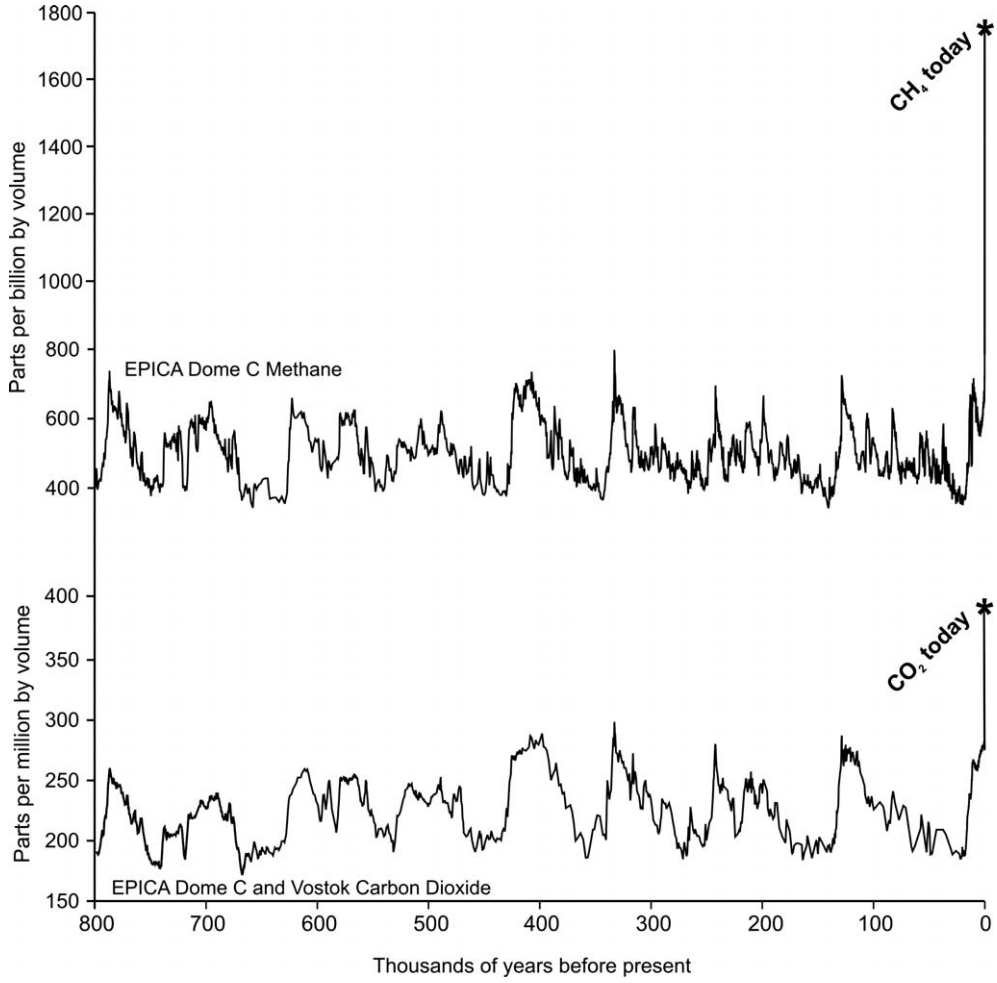

Figure 6. Concentrations of carbon dioxide (CO_2) and methane (CH_4) over the last 800,000 years (eight glacial cycles) from East Antarctic ice cores. Data from Loulergue et al. (2008) and Lüthi et al. (2008). The current concentrations of CO_2 and CH_4 are also shown (Forster et al., 2007).

turn up the air conditioning. A warming planet is a changing planet, and the changes will have profound consequences for all species that live on it, including humans. Those changes are not just something our children and grandchildren will have to deal with in the future; they are taking place now, and are affecting millions of people.

EFFECTS OF GLOBAL WARMING

One effect of global warming that everyone has heard about is a rise in sea levels. About half of this rise is due to thermal expansion: Ocean temperatures are rising, and as water warms it expands. Put a nearly full cup of water in a microwave and heat it, and the water will spill over the cup.

In addition to thermal expansion, the oceans are rising because ice is melting, and most of that water inevitably finds its way to the sea. So far, most of that water has come from mountain glaciers and ice caps (Meier et al., 2007). As global temperatures increase, sea level rise will mainly reflect polar ice melt. So far, ocean rise has been measured in

millimeters, but there is enough water in the Greenland ice sheet alone to raise sea levels by about 7 m, West Antarctica over 5 m, and East Antarctica about 50 m (Lemke et al., 2007). If the Earth were to lose just 8% of its ice, the consequences for some coastal regions would be dramatic. The lower part of the Florida peninsula and much of Louisiana, including New Orleans, would be submerged, and low-lying cities, including London, New York, and Shanghai, would be endangered (to see the effects of various magnitudes of sea level rise in the San Francisco Bay area, go to http://cascade.wr.usgs.gov/data/Task2b-SFBay/data.shtm).

Low-lying continental countries such as the Netherlands and much of Bangladesh already find themselves battling flooding more than ever before. Many small island nations in the western Pacific (e.g., Vanuatu) are facing imminent destruction as they are gradually overrun by the rising ocean. Indonesia is an island nation, and many of its 17,000 islands are just above sea level. At the 2007 United Nations Climate Change Conference in Bali, Indonesian environmental minister Rachmat Witoelar stated that 2,000 of his country's islands could be lost to sea level rise by 2030. At current rates of sea level rise, another island nation, the Republic of Maldives, will become uninhabitable by the end of the century (http://unfcc.int/resource/docs/napa/mdv01.pdf). In 2008, the president of that country, Mohamed Nasheed, announced that he was contemplating moving his people to India, Sri Lanka, and Australia (Schmidle, 2009). One of the major effects of continued sea level rise will be the displacement of millions of people. Where millions of climate refugees will find welcome is unclear. The migration of large numbers of people to new territories with different languages and cultures will be disruptive, to say the least.

In addition to the danger of inundation, rising sea levels bring salt water into rivers, spoil drinking wells, and turn fertile farmland into useless fields of salty soil. These effects of global warming are occurring now in places like the lowlands of Bangladesh (Church et al., 2001).

People on dry land need the fresh water that is running into the sea. In the spring, melting ice from mountain glaciers, ice caps, and snowfields furnish wells and rivers that provide fresh water for drinking, agriculture, and hydroelectric power. For example, in the dry season, people in large areas of India, Nepal, and southern China depend on rivers fed by Himalayan glaciers. The retreat of these glaciers threatens the water supply of millions of people in this part of the world. Peru relies on hydroelectric power for 80% of its energy (Vergara et al., 2007), a significant portion of which comes from mountain streams that are fed by mountain glaciers and ice fields. In Tanzania, the loss of Mount Kilimanjaro's fabled ice cover would likely have a negative impact on tourism, which is the country's primary source of foreign currency. The glaciers and snow packs in the Rocky Mountains are essential for farming in California, one of the world's most productive agricultural areas.

Global warming is expanding arid areas of the Earth. Warming at the equator drives a climate system called the Hadley Cell. Warm, moist air rises from the equator, loses its moisture through rainfall, moves north and south, and then falls to the Earth at 30° north and south latitude, creating deserts and arid regions. There is evidence that over the last 20 years the Hadley Cell has expanded north and south by about 2° latitude, which may broaden the desert zones (Seidel, Fu, Randel, & Reichler, 2008; Seidel & Randel, 2007). If so, droughts may become more persistent in the American

Southwest, the Mediterranean, Australia, South America, and Africa.

Global warming can also have effects that seem paradoxical. Continued warming may change ocean currents that now bring warm water to the North Atlantic region, giving it a temperate climate. If this happens, Europe could experience a cooling even as other areas of the world become warmer.

Accelerating Change

It is difficult to assess the full effects of global warming, and harder still to predict future effects. Climate predictions are made with computer models, but these models have assumed a slow, steady rate of change. Our best models predict a temperature rise in this century of between 2.4° and 4.5° C (4.3° and 8.1° F), with an average of about 3° C (5.4° F; Meehl et al., 2007; Figure 1). But these models assume a linear rise in temperature. Increasingly, computer models have underestimated the trends because, in fact, the rate of global temperature rise is accelerating. The average rise in global temperature was 0.11° F per decade over the last century (National Oceanic and Atmospheric Administration, 2009). Since the late 1970s, however, this rate has increased to 0.29° F per decade, and 11 of the warmest years on record have occurred in the last 12 years. May, 2010, was the 303rd consecutive month with a global temperature warmer than its 20th-century average (National Oceanic and Atmospheric Administration, 2010).

The acceleration of global temperature is reflected in increases in the rate of ice melt. From 1963 to 1978, the rate of ice loss on Quelccaya was about 6 m per year. From 1991 to 2006, it averaged 60 m per year, 10 times faster than the initial rate (Thompson et al., 2006). A recent paper by Matsuo and Heki (2010) reports uneven ice loss from the high Asian ice fields, as measured by the Gravity Recovery and Climate Experiment satellite observations between 2003 and 2009. Ice retreat in the Himalayas slowed slightly during this period, and loss in the mountains to the northwest increased markedly over the last few years. Nevertheless, the average rate of ice melt in the region was twice the rate of four decades before. In the last decade, many of the glaciers that drain Greenland and Antarctica have accelerated their discharge into the world's oceans from 20% to 100% (Lemke et al., 2007).

Increasing rates of ice melt should mean an increasing rate of sea level rise, and this is in fact the case. Over most of the 20th century, sea level rose about 2 mm per year. Since 1990, the rate has been about 3 mm per year.

So, not only is Earth's temperature rising, but the rate of this change is accelerating. This means that our future may not be a steady, gradual change in the world's climate, but an abrupt and devastating deterioration from which we cannot recover.

Abrupt Climate Change Possible

We know that very rapid change in climate is possible because it has occurred in the past. One of the most remarkable examples was a sudden cold, wet event that occurred about 5,200 years ago, and left its mark in many paleoclimate records around the world.

The most famous evidence of this abrupt weather change comes from Otzi, the "Tyrolean ice man" whose remarkably preserved body was discovered in the Eastern Alps in 1991 after it was exposed by a melting glacier. Forensic evidence suggests that Otzi was shot in the back with an arrow, escaped his enemies, then sat down behind a boulder and bled to death. We know that within days of Otzi's dying there must have been a climate event large enough to

entomb him in snow; otherwise, his body would have decayed or been eaten by scavengers. Radiocarbon dating of Otzi's remains revealed that he died around 5,200 years ago (Baroni & Orombelli, 1996).

The event that preserved Otzi could have been local, but other evidence points to a global event of abrupt cooling. Around the world organic material is being exposed for the first time in 5,200 years as glaciers recede. In 2002, when we studied the Quelccaya ice cap in southern Peru, we found a perfectly preserved wetland plant. It was identified as *Distichia muscoides*, which today grows in the valleys below the ice cap. Our specimen was radiocarbon dated at 5,200 years before present (Thompson et al., 2006). As the glacier continues to retreat, more plants have been collected and radiocarbon dated, almost all of which confirm the original findings (Buffen, Thompson, Mosley-Thompson, & Huh, 2009).

Another record of this event comes from the ice fields on Mount Kilimanjaro. The ice dating back 5,200 years shows a very intense, very sudden decrease in the concentration of heavy oxygen atoms, or isotopes, in the water molecules that compose the ice (Thompson et al., 2002). Such a decrease is indicative of colder temperatures, more intense snowfall, or both.

The Soreq Cave in Israel contains speleothems that have produced continuous climate records spanning tens of thousands of years. The record shows that an abrupt cooling also occurred in the Middle East about 5,200 years ago, and that it was the most extreme climatic event in the last 13,000 years (Bar-Matthews, Ayalon, Kaufman, & Wasserburg, 1999).

One way that rapid climate change can occur is through positive feedback. In the physical sciences, positive feedback means that an event has an effect which, in turn, produces more of the initial event. The best way to understand this phenomenon as it relates to climate change is through some very plausible examples:

Higher global temperatures mean dryer forests in some areas, which means more forest fires, which means more CO_2 and ash in the air, which raises global temperature, which means more forest fires, which means …

Higher global temperatures mean melting ice, which exposes darker areas (dirt, rock, water) that reflect less solar energy than ice, which means higher global temperatures, which means more melting ice, which means …

Higher global temperatures mean tundra permafrost melts, releasing CO_2 and methane from rotted organic material, which means higher global temperature, which means more permafrost melting, which means …

Positive feedback increases the *rate* of change. Eventually a tipping point may be reached, after which it could be impossible to restore normal conditions. Think of a very large boulder rolling down a hill: When it first starts to move, we might stop it by pushing against it or wedging chocks under it or building a barrier, but once it has reached a certain velocity, there is no stopping it. We do not know if there is a tipping point for global warming, but the possibility cannot be dismissed, and it has ominous implications. Global warming is a very, very large boulder.

Even if there is no tipping point (or we manage to avoid it), the acceleration of warming means serious trouble. In fact, if we stopped emitting greenhouse gases into the atmosphere tomorrow, temperatures would continue to rise for 20 to 30 years because of what is already in the atmosphere. Once methane is injected into the troposphere, it remains for about 8 to 12 years (Prinn et al., 1987). Carbon dioxide

has a much longer residence: 70 to 120 years. Twenty percent of the CO_2 being emitted today will still affect the earth's climate 1,000 years from now (Archer & Brovkin, 2008).

If, as predicted, global temperature rises another 3° C (5.4° F) by the end of the century, the earth will be warmer than it has been in about 3 million years (Dowsett et al., 1994; Rahmstorf, 2007). Oceans were then about 25 m higher than they are today. We are already seeing important effects from global warming; the effects of another 3° C (5.4° F) increase are hard to predict. However, such a drastic change would, at the very least, put severe pressure on civilization as we know it.

OUR OPTIONS

Global warming is here and is already affecting our climate, so prevention is no longer an option. Three options remain for dealing with the crisis: mitigate, adapt, and suffer.

Mitigation is proactive, and in the case of anthropogenic climate change it involves doing things to reduce the pace and magnitude of the changes by altering the underlying causes. The obvious, and most hotly debated, remedies include those that reduce the volume of greenhouse gas emissions, especially CO_2 and methane. Examples include not only using compact fluorescent lightbulbs, adding insulation to our homes, and driving less, but societal changes such as shutting down coal-fired power plants, establishing a federal carbon tax (as was recently recommended by the National Academy of Sciences), and substantially raising minimum mileage standards on cars (National Research Council, 2010). Another approach to mitigation that has received widespread attention recently is to enhance the natural carbon sinks (storage systems) through expansion of forests. Some have suggested various geo-engineering procedures (e.g., Govindasamy & Caldeira, 2000; Wigley, 2006). One example is burying carbon in the ocean or under land surfaces (Brewer, Friederich, Peltzer, & Orr, 1999). Geoengineering ideas are intriguing, but some are considered radical and may lead to unintended negative consequences (Parkinson, 2010).

Adaptation is reactive. It involves reducing the potential adverse impacts resulting from the by-products of climate change. This might include constructing sea barriers such as dikes and tidal barriers (similar to those on the Thames River in London and in New Orleans), relocating coastal towns and cities inland, changing agricultural practices to counteract shifting weather patterns, and strengthening human and animal immunity to climate-related diseases.

Our third option, suffering, means enduring the adverse impacts that cannot be staved off by mitigation or adaptation. Everyone will be affected by global warming, but those with the fewest resources for adapting will suffer most. It is a cruel irony that so many of these people live in or near ecologically sensitive areas, such as grasslands (Outer Mongolia), dry lands (Sudan and Ethiopia), mountain glaciers (the Quechua of the Peruvian Andes), and coastal lowlands (Bangledesh and the South Sea island region). Humans will not be the only species to suffer.

Clearly mitigation is our best option, but so far most societies around the world, including the United States and the other largest emitters of greenhouse gases, have done little more than talk about the importance of mitigation. Many Americans do not even accept the reality of global warming. The fossil fuel industry has spent millions of dollars on a disinformation campaign to delude the public about the threat, and the campaign has been amazingly successful. (This effort is reminiscent of the tobacco industry's effort to convince Americans that smoking

poses no serious health hazards.) As the evidence for human-caused climate change has increased, the number of Americans who believe it has decreased. The latest Pew Research Center (2010) poll in October, 2009, shows that only 57% of Americans believe global warming is real, down from 71% in April, 2008.

There are currently no technological quick fixes for global warming. Our only hope is to change our behavior in ways that significantly slow the rate of global warming, thereby giving the engineers time to devise, develop, and deploy technological solutions where possible. Unless large numbers of people take appropriate steps, including supporting governmental regulations aimed at reducing greenhouse gas emissions, our only options will be adaptation and suffering. And the longer we delay, the more unpleasant the adaptations and the greater the suffering will be.

Sooner or later, we will all deal with global warming. The only question is how much we will mitigate, adapt, and suffer.

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The Recycling Solution: How I Increased Recycling on Dilworth Road[1]

J. Jacob Keller
Dilworth Elementary School

When we throw out our trash it is burned in an incinerator or buried in a landfill. If we burn our trash, it pollutes the air. If we bury it, it fills up our landfills and gets out of hand. But if we recycle things, it will not pollute anything and we can use it over again. By recycling we also save money.

Our county has a recycling program. Every Friday, you have a chance to put out your trash for recycling and the garbage men will pick it up. We can recycle milk jugs, aluminum cans, plastic soda bottles, and newspaper.

Unfortunately, not everybody takes part in this program. Some people don't recycle at all, and others don't put out as much as they could.

Purpose

My purpose was to try and get more people to recycle. I gave them notes that told them how well their street was doing each week. I also promised that two gift certificates from the Bi-Lo grocery store would go to a homeless shelter if they increased their recycling.

Hypothesis

What I thought would happen was that on the street where I gave the notes more people would recycle. I didn't think there would be any change on the other street where I didn't give notes.

Method

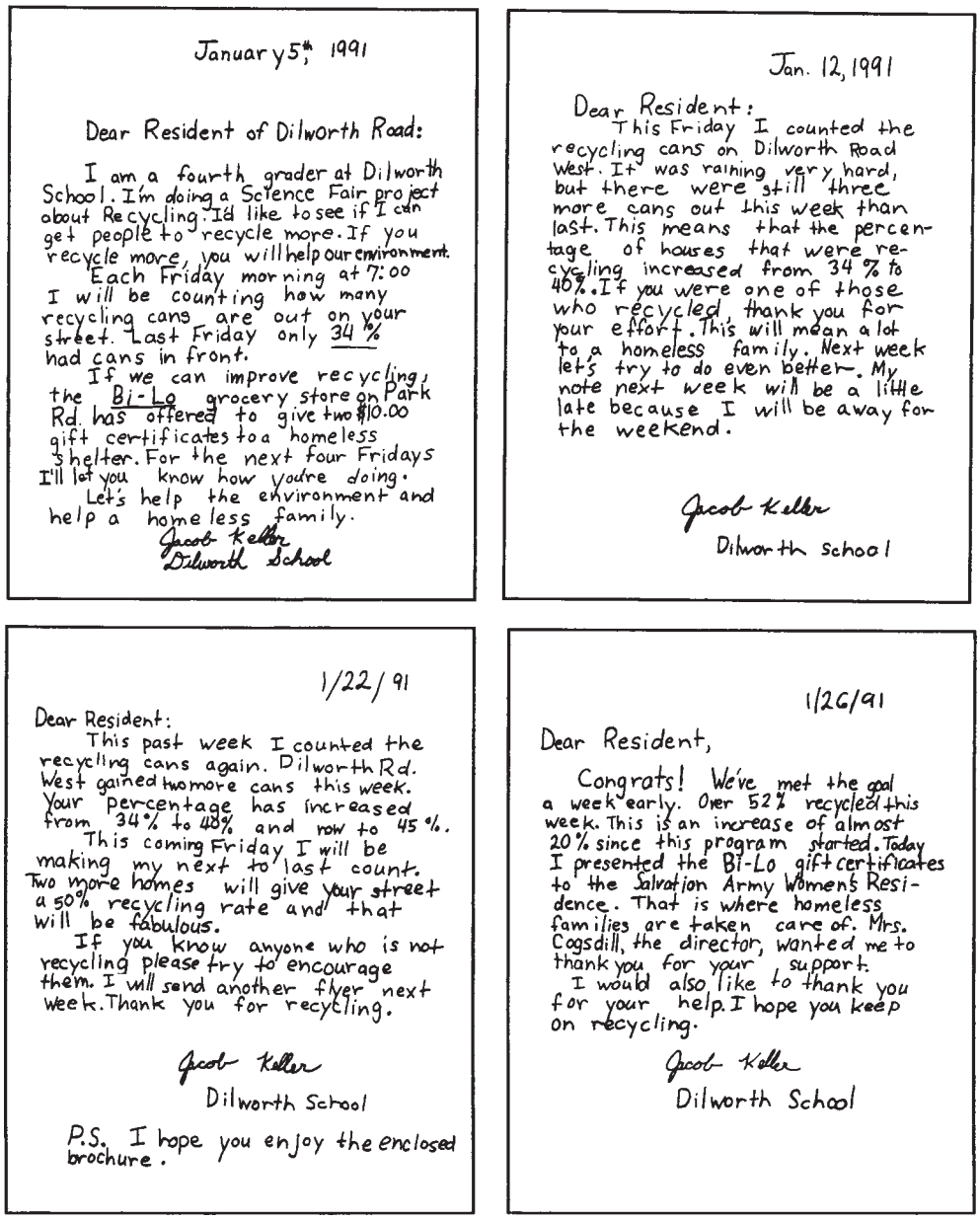
Variables. The variable I measured was how many houses had a recycling bin out on Friday morning. At first I was going to measure how much trash was in the bin, but I thought people wouldn't like me looking through their trash.

The variable I changed was the notes I delivered on one street. I put these notes on the door step. The notes said how many people had recycled that week. Examples of the different notes I delivered each week are shown in Figure 1.

Another variable was the Bi-Lo gift certificate. The manager of the Bi-Lo grocery store on Park Road gave me two $10.00 gift certificates for the project. I told the people that

I would like to thank all the people on Dilworth Road West for participating. I'd also like to thank Mr. Franklin, the manager of the Bi-Lo grocery store, who donated the two gift certificates; Connie Cogsdill, the Director of the Salvation Army Women's Residence, for her help; Scott Lipscomb and Nakia Lewis who helped me deliver the notes to the houses; Paula Hoffman, the Director of Education at the Mecklenburg County Recycling Center, who gave me a tour of the Center; Cindy Clemens, Resource Specialist, who sent me a lot of information and stickers; Ellen Silverman, PhD candidate at Virginia Tech, who put my paper on computer disc for the journal printers; Thomas Berry, PhD candidate at Virginia Tech, who helped me prepare Figure 2.

[1] *Editor's Note:* On August 16, 1991, I received this research report from Fred S. Keller, grandfather of the author, when Thomas Berry and I were in the midst of finalizing the articles for this special issue on behavioral community intervention. The paper, handwritten by 10-year-old Jacob Keller, illustrated an inspirational example of "active caring" —the theme of my editorial for this issue. The paper was accepted without revision and printed here with minimal editing to reflect the sincerity and insight of this young behavioral community researcher. When actively caring, one can make a difference at any age.—*E.S. Geller*



January 5th, 1991

Dear Resident of Dilworth Road:

I am a fourth grader at Dilworth School. I'm doing a Science Fair project about Recycling. I'd like to see if I can get people to recycle more. If you recycle more, you will help our environment.

Each Friday morning at 7:00 I will be counting how many recycling cans are out on your street. Last Friday only 34% had cans in front.

If we can improve recycling, the Bi-Lo grocery store on Park Rd. has offered to give two $10.00 gift certificates to a homeless shelter. For the next four Fridays I'll let you know how you're doing.

Let's help the environment and help a homeless family.

Jacob Keller
Dilworth School

Jan. 12, 1991

Dear Resident:

This Friday I counted the recycling cans on Dilworth Road West. It was raining very hard, but there were still three more cans out this week than last. This means that the percentage of houses that were recycling increased from 34% to 40%. If you were one of those who recycled, thank you for your effort. This will mean a lot to a homeless family. Next week let's try to do even better. My note next week will be a little late because I will be away for the weekend.

Jacob Keller
Dilworth School

1/22/91

Dear Resident:

This past week I counted the recycling cans again. Dilworth Rd. West gained two more cans this week. Your percentage has increased from 34% to 48% and now to 45%.

This coming Friday I will be making my next to last count. Two more homes will give your street a 50% recycling rate and that will be fabulous.

If you know anyone who is not recycling please try to encourage them. I will send another flyer next week. Thank you for recycling.

Jacob Keller
Dilworth School

P.S. I hope you enjoy the enclosed brochure.

1/26/91

Dear Resident,

Congrats! We've met the goal a week early. Over 52% recycled this week. This is an increase of almost 20% since this program started. Today I presented the Bi-Lo gift certificates to the Salvation Army Women's Residence. That is where homeless families are taken care of. Mrs. Cogsdill, the director, wanted me to thank you for your support.

I would also like to thank you for your help. I hope you keep on recycling.

Jacob Keller
Dilworth School

Figure 1. The notes I delivered to the homes on Dilworth Road West to get more people to recycle. I gave out the first note on Saturday, January 5, after taking my first measurements on Friday, January 4. The second, third, and fourth notes were delivered during the next 3 weeks.

TABLE 1

Percentage of Homes Recycling on Dilworth Road West (Notes) and Dilworth Road East (No Notes)

	Dilworth Road West	Dilworth Road East
1st week (before notes)	34	38
2nd week (with notes)	40	35
3rd week (with notes)	45	38
4th week (with notes)	53	35
5th week (after notes)	53	35

these would go to a homeless shelter if they increased their recycling.

Results

There were 44 total homes on Dilworth Road West (where I gave notes) and 40 total homes on Dilworth Road East (where I didn't give notes). I figured out what percentage of the homes recycled on the two streets. Dilworth Road West, which got the notes, changed more than Dilworth Road East, which didn't get notes. When the experiment first started, the percentages were about the same. After I started giving notes, the percentages increased for Dilworth Road West. Even after I told the people on Dilworth Road West that the experiment was over, they still kept going strong. The percentages are shown in Table 1.

I have shown the same information in a graph (see Figure 2). This graph shows how much Dilworth Road West improved. The people on Dilworth Road East kept at about the same level. Dilworth Road East didn't know anything about this project.

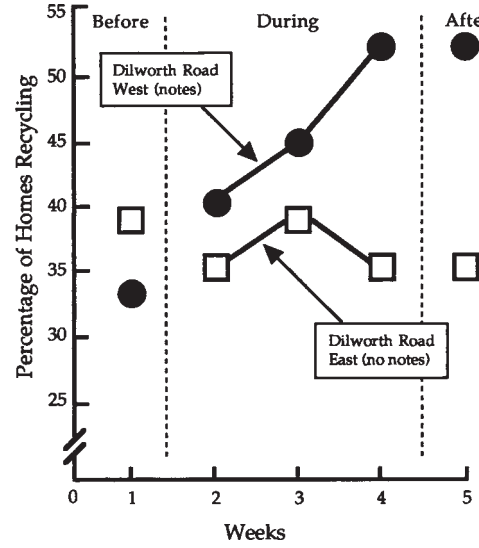


Figure 2. Percentage of homes on Dilworth Road West (notes) and Dilworth Road East (no notes) with materials for recycling on five consecutive Fridays.

Conclusions

This experiment has shown that it is possible to increase the number of people who recycle. With a little encouragement and showing them how well they are doing, people will be more likely to remember to recycle. Also, I think that people like to help other people. In this experiment they could provide a donation to a homeless shelter by recycling. They showed that they were willing to make an effort. My study also showed that even after the experiment was over, they still kept recycling at the same rate. Hopefully, they'll continue to recycle.

Note. Reprinted from *Journal of Applied Behavior Analysis*, *24*, 617–619, 1991, with permission from the Society for the Experimental Analysis of Behavior.

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Buying Green

T. V. Joe Layng
Headsprout

Thanks to innovations in technology and the Internet, informed purchases are rapidly becoming a part of everyday life. One reason for this is the growing number of amazing applications now available for mobile devices, such as Apple's iPhone and Motorola's Droid, that put important consumer information at our fingertips.

I walk into my local Costco and find it is featuring a toaster oven. The price looks good, but is it? I tap the RedLaser application (www.redlaser.com) button on my iPhone and instantly get a screen labeled "Scanned Items." I touch a scan button at the bottom of the page. A camera aperture opens and a rectangular outline appears. I turn the toaster oven's box on its side and position the bar code inside the rectangle. In a few seconds a page appears listing local stores and online vendors who sell the same item along with the price. Instantly I know if Costco's price is a good deal, how far I would have to travel to get the lowest price, and how long I have to wait for an Internet purchase. Tapping another button takes me to product and vendor reviews. Thanks to the RedLaser application, everything I need to make an informed decision about a product is right there in my hand.

Everything, that is, except information about the product's environmental impact. How much electricity does the oven use compared to others on the market? How environmentally friendly is its manufacturing process? What about the level of toxic chemicals that will end up in a landfill? What is the overall carbon footprint over the life of the product? Wouldn't it be great if, in addition to information about price, reliability, and customer satisfaction, I could get a rating for a product's greenness?

There have been some recent efforts to use bar codes to provide green information to consumers. One notable example is GoodGuide (www.goodguide.com), an iPhone, iPod touch, and iPad application that provides "health, environmental, and social performance ratings for over 65,000 food, toys, personal care, and household products" (GoodGuide/iTunes, 2010). Simply scan a product's bar code and GoodGuide provides a rating. GoodGuide is a very good start in providing the information needed to change consumer behavior. I say "good start" because the number of products covered is limited, and its database does not automatically intersect with the pricing and other features available with apps such as RedLaser.

What's needed, and what I propose, is the establishment of an international database, tied to the bar code of every consumer item, that can be accessed by mobile-device applications. Such a database has the potential of encouraging consumers worldwide to make greener choices.

The database could be established by an agency of the United Nations, by various private agencies or foundations interested in combating global warming, or even by for-profit corporations, such as eBay (which recently acquired RedLaser), to provide a better consumer experience. Perhaps a partnership or consortium of international agencies, such as Consumer's Union and the Union of Concerned Scientists, could create

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and oversee the database. Manufacturers would not be required by law to submit environmental data, but those that did not do so might be at a disadvantage in the marketplace: If one toaster oven has a green rating of A and another N/A for "data not available," the consumer may suspect the worst and buy the greener product. The free market alone should be enough to drive corporate participation.

I'm not suggesting that a green rating alone will dictate consumer choices. When people make purchasing decisions, a range of variables come into play (availability, features, customer reviews, reliability ratings, etc.). However, price is usually the single most important variable. When similar items have very different prices, the cheaper item typically wins. But when prices are similar, other factors come into play. Consider availability. I may be willing to pay a little more to get the toaster oven now, rather than wait a week to get it from an online store. And I may opt for a product that has received uniformly positive reviews rather than a product many users found unsatisfactory, even though the higher rated product is more expensive. Green ratings, if readily available, might affect consumer behavior in the same way.

Let's revisit my toaster oven. The two toasters before me have similar features and are about the same price, but one has a green rating of A− and the other C+. There's another brand in a store down the street with an A+ rating, but it costs several dollars more. My decision will depend on a host of variables, including my budget, schedule, and level of knowledge and concern about how my choice affects the environment. But even if I don't buy the greenest oven, buying the greener of the two before me leaves the planet better off than it would have been had I not had information about their environmental impact.

It would be naive to suggest that most consumers will make green ratings their number one criterion in choosing products. Some new Energy Star refrigerators use much less electricity than other models. That's great, and I'd love to buy one. But if the Energy Star refrigerator costs twice as much as other refrigerators with similar features, I may have a hard time opening my wallet that far. Consumer decisions, like all choices we make, are determined largely by their short-term consequences for the individual, not by their long-term consequences for society. But as more and more people realize that protecting the environment is in their own interest, the greenness of products will play a greater role in their behavior, including the purchases they make. One of the most important things we can do to encourage green purchases is to make information about the environmental impact of products readily available. An international database of every product's greenness and a way to readily access it would do just that.

But would providing easily accessible applications for smart phones really have much of an impact? Smart phones have become the default communication devices worldwide and are quickly being adopted by everyday consumers. In its most recent quarterly report, Apple claimed sales of over 60 million iPhones worldwide. AT&T reported 3.3 million new iPhone activations during the second quarter of 2010 in the U.S. Apple recently reported the sale, in the U.S. alone, of over 1.7 million new fourth generation iPhones in just 3 days. Other vendors of smart phones are seeing similar growth. Cellular-news (www.cellular-news.com; June, 2010) reports that smart phone sales in Asia will exceed 76 million in 2010 and increase to more than 100 million by 2011. Electronista (www.electronista.com; June, 2010) reports there are currently about 74 million smart phone users in Europe and the

numbers are growing rapidly. At this rate, the smart phone will have replaced the simple cellular phone within the next few years. Coda Research Consultancy (www.sribd.com; May, 2010) forecasts "that worldwide sales of smart phones will total 2.5 billion units throughout 2010 to 2015." With the application and database proposed here, every one of those 2.5 billion individuals could make purchases informed not only by price and quality but also by the impact of the products on the environment.

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I'll Save the World from Global Warming—Tomorrow: Using Procrastination Management to Combat Global Warming

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I need to replace both my 30 year-old energy-guzzling fridge and freezer with an energy-efficient combo. When? Ah … tomorrow. Or maybe the day after that or the day after the day after that. People like me (which means practically everybody, including you, I'll bet) tend to procrastinate. You know how it is: I'm going to start my diet tomorrow, work out tomorrow, write that novel, and so on, tomorrow. And I'm going to stop smoking, speeding, staying up late, and watching the tube tomorrow. Am I going to help save the planet from global warming? Of course—first thing tomorrow.

We're people of good will, you and I. We sincerely *want* to do what's best for others as well as ourselves, and we're beyond rationalizing our failure to do what our hearts, our heads, and the data say we should. We know, for example, that we have an obligation to use less energy to help the environment and, for that matter, our own pocketbook. Yet we don't get around to it.

Of course, sometimes our hand is forced. If I procrastinate until my fridge dies, then I'll hustle to get a new one right away; and why not make it energy efficient while I'm at it? But that old energy-wasting appliance might be around for a long time before it gives out.

Okay, sometimes we start to feel so guilty for not doing the right thing that we actually invest the time and effort necessary to escape those feelings of guilt. We're often more effectively motivated by feelings of guilt or fear than by the usual feel-good incentives, because we can always wait until tomorrow to feel good, whereas we're feeling guilty or fearful right now. But our feelings of guilt and fear aren't always strong enough to get us moving. So we put off what we know we should do, not because we don't care, not because we don't believe the data, but because we can always do it tomorrow; after all, one more day doesn't really matter—and, in fact, it really doesn't. The problem is that the days turn into weeks, then months, then years.

Why do we procrastinate? Because there's no significant penalty for failing to act by a particular time—no DEADLINE. Each day we fail to act isn't such a big deal; it's the accumulation of days of inaction that becomes a problem. The problem is not, as is commonly believed, as simple as saying that minor immediate consequences influence behavior more effectively than important, delayed consequences. For example, suppose I knew that if I didn't replace my fridge and freezer by next Monday (DEADLINE), five polar bears would die a year from now because they'd lost their ice flow; I'd be on it in a flash.

Even trivial consequences can be effective as long as they are attached to a deadline. For example, if I know that failing to replace my fridge with an energy-efficient model by February 20, 2011, will result in having to confess to my students what an eco-trashing loser I am, that would get

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me to the appliance store no later than February 19, guaranteed.

But sometimes those trivial consequences won't do the trick. That's when we can use penalties to make the deadline meaningful. For example, we can give a trusted friend $100 with instructions to return it to us if and only if we replace all our incandescent bulbs with compact fluorescents by noon next Tuesday. If we don't deliver, the friend is free to do what he likes with the money.

Making yourself accountable to someone in this way is an important feature of procrastination management. I can tell myself that if I don't replace my incandescent bulbs by next Tuesday I'll donate $100 to RePower America (an organization devoted to getting us off fossil fuels), but when the deadline passes, I may not get around to writing the check. So, in my weekly meetings with one of my grad students, the agenda includes a review of my previous week's performance. (It's called ''Malott's Resource-Conservation Efforts.'') If I fail to make the progress I've committed to, including purchasing an energy-saving fridge, I have to write a check for $100 to RePower America right then and there, and give it to the student to post. And if that doesn't do the trick, then I make it $200, or have the $100 go to someone who's trying to take my job. Remember, gentle reader, even the best of us sometimes needs someone to hold our toes to the fire.

However, not everyone has a trusted friend willing to hold the $100, so it would be great if someone were to set up and manage something like ProcrastinateNoMore.org. The site could help people set up their periodic goals and make a temporary procrastination-management donation of from $1 to $100. Of course, the client would need to send proof of meeting the obligations—a fax of the purchase receipt or a photo of the client standing next to the environmentally cool fridge in his or her home. Each time a client failed to meet one of their environmentally friendly targets, ProcrastinateNoMore.org could deduct that amount from the client's account and send it to RePower America or another proenvironment group. If the client blew no deadlines and got the fridge or whatever, the $100 would be returned.

Fortunately a site much like this already exists; it's called Stickk (http://www.Stickk.com). At Stickk, those who fail to do their self-determined green tasks are billed on their credit card for whatever amount they committed to as a penalty. And those more responsive to social penalties can provide Stickk.com with the e-mail addresses of supporters (friends and family) who will feel their shame and perhaps get on their case when they drop the green ball. For those who need even more social whipping, Stickk.com will link their performance to twitter.com and facebook.com. Stickk.com provides self-management options not only for one-shots like buying a green fridge but also for repeated activities like clients keeping their electric consumption below some maximum level. Will people really use a site like Stickk to help them meet their behavior change goals? Stickk's page reported that as of August, 2010, 52,010 people had put $4.6 million on the line to meet 47,540 self-contracts for behavior change.

Like I said, you and I have good intentions. We want to do our part to fight global warming and restore Mother Nature's health. By understanding why we procrastinate and what we can do about it, we're halfway there. Open an account at Stickk.org or join a friend and build a site modeled on ProcrastinateNoMore. (I'll hold your coat while you do the heavy lifting.)

Don't put it off 'til tomorrow.

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Helping For Change

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You have been worrying about global warming and wanting to change some ways in which you contribute to it. But you continue to add too much carbon to the atmosphere—when you heat or cool your house, drive your car, or purchase goods. A long chain of responses is required to get from a state of concern to new habits, and you've found yourself stuck, doing things as you always have. Consider this: Helping another person can be a powerful method for changing your own behavior. To begin the process, seek occasions to help another change in a way consistent with your goals.

"How does helping someone else change *me*?" you ask. The answer is paradoxical on the surface, but is based on the potency of social contingencies, those that involve relationships between you and others. We'll describe one scenario as a model and then explain why helping for change can be a useful tool for modifying behavior, including your own.

At a dinner party, your friend Jim mentions that he has been thinking about installing a solar heating, cooling, and hot water system in his house but doesn't know much about what he'd need to buy, how to find a contractor, reasonable costs, and so on. Jim's interest is an opportunity for you to apply helping-for-change principles. You indicate similar interests and offer to join him in learning about solar energy and the process of installing solar panels. If Jim responds positively, that provides the impetus for you to gather information (e.g., do a Web search on private-house solar systems, obtain library books, check out local solar-panel distributors). Weeks of occasional contacts follow, and at some point the two of you visit a local contractor who tells you about the various state and federal tax incentives, something you had known little about. We can continue the scenario, possibly to a desirable conclusion, but the important point is that, beginning with Jim's expression of interest and your offering of assistance, *you* have become engaged with solar energy and have thereby increased the probability that you'll *both* eventually install solar panels.

Let's briefly analyze why.

You may be more likely to accept at face value Jim's stated interest than your own, because you are well aware of your previous failures to change and have worries about the cost and time it would take to carry out such a project. You know more about your own inabilities and insecurities than about Jim's, and it is therefore easier (and more likely) for you to start the process when focused on Jim than on yourself.

Discussions with Jim highlight the inconsistency between your offer of assistance and your past behavior, and this can be helpful. There is experimental evidence that prosocial or proenvironmental activities become more likely when one discusses the benefits of such behavior, especially while honestly acknowledging past inaction (Stone & Fernandez, 2008).

Initial steps in a lengthy task are especially vulnerable to interruption.

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We often say "I'd like to —" or "I'm thinking about doing —" but then fail to follow up. Two problems are involved. The first is a lack of correspondence between what we say and what we actually do. Many of us are in the habit of not following our own verbal commitments to change, but the good news is that we can learn to "do what I say I'll do" when following through is reinforced (Da Silva & Lattal, 2010; Rogers-Warren & Baer, 1976). The second problem is that other behaviors often intrude at the point of initiating a task, whether it is to write a paper, to exercise, or to limit carbon emissions (Schlinger, Derenne, & Baron, 2008; Staddon & Simmelhag, 1971). Rather than letting the dinner conversation devolve into other topics or activities, your continued assistance can help Jim through these first steps, and his responses can do the same for you. Once over the difficulty of getting started, as you engage in more and more of the activities related to your goal, the chances of continuing will increase, a phenomenon referred to as *soft commitment* (Siegel & Rachlin, 1995). A series of actions towards a goal helps to maintain continuing efforts.

Throughout the process, social interactions contribute to sustained interest. For example, telling Jim that you've acquired new information about solar panels serves as a discriminative cue that reminds him of what he intended to do. Or the information you mailed to him provides the occasion for his next responses, which in turn serve to reinforce *your* continuing efforts. As we work toward a distant goal, our focus often wanes, and the stimuli and reinforcers provided by our collaborators help to prompt and maintain the desired course of action. Many experimental examples of observational and social learning show how activities by one individual engender similar actions by others, especially when the modeled behavior is reinforced (e.g., Bandura, 1986; Laland, 2004). Cooperative performances towards a shared goal provide additional reinforcers (Schuster, 2002; Slavin, 1995).

Coaction has other desirable consequences. For example, given that you intend to share information with Jim, you are more likely to digest that information in a way that can be explained to another because, as Seneca wrote 2,000 years ago, "We learn by teaching" (see Maheady, Mallette, & Harper, 2006).

The act of assisting another can reinforce the helper as well as the recipient (Weinstein & Ryan, 2010). For example, Dunn, Aknin, and Norton (2008) gave one group of participants money to spend on themselves (pay a bill, buy something for themselves) and another group an equal amount to spend on someone else (give the money to charity, purchase a gift for a friend). Those in the "help another" group reported a greater increase in feelings of happiness at the end of the day than those in the "help themselves" group. Helping others may provide reinforcement for maintaining your own efforts to change.

Another beneficial consequence of social collaboration derives from the mutual and interactive contingencies involved. Some of these may be explicitly stated, such as "If you succeed in installing a solar panel, I'll take you to dinner" or "If both of us find information within 2 weeks, we'll meet for a beer" (Neuringer, 1988). Other interactive contingencies flow naturally from the joint effort. For instance, Allen (the senior author) and Martha Neuringer have been working with a small group of Oregonians for 2 years to stop the importation of liquefied natural gas (LNG) from the Middle East and Russia. LNG has a 30% higher carbon footprint than domestic gas, and its importation helps to maintain dependence for energy supplies on

foreign countries. It also competes with the development of alternative environmentally friendly sources of energy, such as solar, wind, and geothermal. Organizing against powerful energy companies takes much time, money, and energy, and the outcome is far from certain, but the actions of each group member serve to generate continued participation and engagement by other group members, and many hundreds of Oregonians have become involved. Coaction helps to maintain individual action.

We have described some of the principles that underlie the helping-for-change procedure, but many others may contribute: Reinforcement of even the smallest steps is important, especially early in the process; punishment, negativity, and overly critical reactions can sabotage change; permitting the other person to choose what to do next or how to go about the task will increase his or her commitment; and honesty concerning what you are trying to accomplish is necessary so as not to jeopardize the interaction. More generally, knowledge about the types of behavior–environment interactions that maintain environmentally destructive behaviors (Skinner, 1987) and about basic behavior-change techniques (Pryor, 1999) can enhance helping-for-change attempts.

The helping-for-change method can be extended to groups such as service organizations; churches, synagogues, and mosques; family and neighborhood groupings; classrooms and schools. Individuals in a socially active group can seek to identify the changes desired by other members and then offer to be helping-for-change agents. The group can provide positive consequences to both the givers and receivers of help. The goal is for numerous individuals within the group to accomplish things that are valuable to all. And, of course, many of the consequences of coaction—modeling, mutual reinforcement, progress toward a goal—would be highlighted for all members.

Various Web sites provide additional tools for implementing the helping-for-change approach. Some seek to facilitate community involvement and engagement in general (e.g., www.bettertogether.org); others focus particularly on climate change (e.g., www.350.org; www.acespace.org/dot; http://portland.1thingus.com/; www.energysavers.gov/); and some provide general resources to assist in making desired behavioral changes (www.treehugger.com; www.doityourself.com).

Changing behavior by offering to help is not a magic pill. You need to wait for opportunities, although you can increase their likelihood by initiating conversations on appropriate topics. You may be unable to assist because the issue is too technical. Jim's interest may wane more rapidly than your ability to reinforce it. Jim's spotty participation may not maintain your efforts, and you may lack the skill to get him going. His reactions may punish your attempts to help him, and you might unintentionally do the same to him, causing your interactions to suffer or cease altogether. The helping-for-change process increases the likelihood of success; it does not guarantee it.

Still, helping others to change can be a way to change both our own and others' behavior. It works because we are, at heart, social beings who, when we work together, can meet the most difficult challenges. Global warming tops the list.

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Virtual Rewards for Driving Green

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Americans drive about three *trillion* miles each year (U.S. Federal Highway Administration, 2009), so any improvement in driving efficiency is bound to produce an important reduction in carbon dioxide (CO_2) emissions. Driving green means reducing the amount of fuel needed to get from Point A to Point B. More specifically, it means starting and stopping gradually and maintaining sensible speeds (Energy and Environmental Analysis, Inc, 2001; The Road Information Program, 2010). But how can we get people to drive greener?

We know that the price of gasoline affects how people drive (Rapp, Rapp, Carroll, & Bartlett, 2010). When gas prices are high, people drive more slowly and less aggressively. Raising gas prices by levying a tax or cutting the subsidies that oil companies receive[1] would probably be the most effective way of changing driving habits, but in today's political climate that idea is about as likely to take off as a water-filled balloon.

Another approach is to provide immediate feedback to drivers about their performance. Many cars now include devices that do this. For example, the Subaru Impreza has a digital display of the miles per gallon the driver is getting, updated in real time. On the Honda Insight, the speed display changes color: Drive fast, make jackrabbit starts, or brake hard and the display is blue; drive more sensibly and the color goes from blue to green. The Ford Fusion display sprouts green leaves as your efficiency improves; the better you drive, the more leaves appear. The Toyota hybrids allow drivers to judge their progress by comparing their current driving to that of the previous trip.

Behavioral research has shown that well-designed feedback can produce significant improvements in performance (Balcazar, Hopkins, & Suarez, 1985; Balcazar, Shupert, Daniels, Mawhinney, & Hopkins, 1989). In fact, several studies found feedback to be more effective than traditional methods of reducing speed, such as police surveillance and citations (Van Houten & Nau, 1981, 1983; Van Houten et al., 1985). However, over the long term, feedback is usually most effective when it is backed up with rewards (Alvero, Bucklin, & Austin, 2001; Balcazar et al., 1985). Unfortunately, the rewards for driving green are weak. For example, feedback indicating that you are getting optimal mileage means money saved at the pump, but at today's gas prices, the pocketbook benefits are meager. Positive feedback about driving also means that the driver is helping the environment, but that consequence is negligible and delayed. After all, the sky does not get bluer when we ease off of the gas pedal.

The weak rewards for driving efficiently compete poorly with the immediate rewards for driving fast and loose: reaching our destination sooner, making it through an intersection before the light turns red, getting ahead of rush-hour traffic. What we need are stronger rewards for driving green.

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[1] Many people are unaware that the actual cost of gasoline is far higher than what they pay at the pump. In 2010, gasoline in the U.S. sells for about $2.72 a gallon, but when hidden costs such as oil company subsidies are considered, the true cost may be $4.37 and could be considerably higher (Klein, 2010; see also International Center for Technology Assessment, 1998).

Virtual merchandise (digital items that can be earned, purchased, and traded on Web sites) may do the trick. In a virtual world such as Second Life, people enjoy an alternate existence online where they acquire items ranging from clothes to real estate. Even though these items do not exist beyond cyberspace, people have become millionaires by buying and selling them (Hof, 2006). In fact, Americans spent an estimated $1 billion on virtual items in 2009, and the Chinese spent five times that amount (Boykoff, 2010). This suggests that for some people, at least, virtual merchandise could provide strong motivation for green driving.

Facebook is another site on which people spend many hours and dollars obtaining virtual aquatic life, farm animals, and assorted trophies. (Some of the most popular applications on Facebook exist solely as a means to collect and trade virtual items; e.g., Give Hearts has more than eight million active users.) With more than 400 million active users (over 25% of the global Internet population), Facebook is the top social networking Web site and ranks ninth in overall Internet traffic. More than half of Facebook members log in daily. An online presence that generates such massive return traffic clearly influences the behavior of huge numbers of people. Moreover, Facebook is not just for kids; more than 47 million members are over the age of 35 (Facebook, 2010). It provides a great platform for an application to use virtual items to reward green driving.

I am currently developing an application to do just that. Facebook is already equipped to receive driver data via wi-fi from car computers. The application under development, ''Green Wheels,'' will convert that information to ''green'' dollars with which the driver can purchase virtual items. The more fuel efficient a person's driving is, the more green dollars are deposited in his or her account.

After the driver has gone through the set-up procedure, he or she can begin to earn green dollars. The dollars earned will be based on an algorithm that combines the elements of efficient driving. This approach, as opposed to using an outcome measure such as fuel consumption, will allow the driver of any car, regardless of its fuel efficiency, to earn points. There might also be occasional bonus dollars for people who consistently get good mileage or who perform better overall than they did the previous month.

One concern about this proposal may be that drivers will be so intent on improving their driving efficiency that they will be distracted from the business of driving. This is a possibility, but the feedback devices on most cars are simple and can be interpreted at a glance. In addition, to the extent that drivers attempt to improve their efficiency, they will be driving more slowly and less aggressively, which may also lower the rate of accidents.

Drivers might also earn certificates or awards for driving green, and these items might be displayed on their Facebook walls. Much like other successful virtual competitions (e.g. fantasy sports leagues, on-line games), there might be weekly contests for most points earned and highest rankings. Finally, a counter showing the total reduction of CO_2 emissions of all the participating drivers would provide a sense of community and shared accomplishment. Public posting of a group's collective achievements can be a powerful method for motivating behavior change (Van Houten, 1984; Van Houten, Nau, & Marini, 1980).

One limitation of this proposal is that many cars are not equipped with the requisite tools to transmit a driver's data to Facebook. This application would have a limited impact on global warming if those drivers were excluded. Happily, there are aftermarket gadgets that can solve this problem for just under $100, extending the reach exponentially.

There are approximately 120 million Facebook users of driving age (Facebook, 2010). If only 1% of these drivers used Green Wheels, 1.2 million people could be driving more efficiently. Energy and Environmental Analysis, Inc. (2001) indicates that driving green can reduce fuel consumption by up to 33%. For a conservative estimate of the effect on CO_2 emissions, let's assume a 20% savings in fuel consumption. The average driver puts 5.5 metric tons of CO_2 into the atmosphere per year (U.S. Environmental Protection Agency, 2005), so a 20% improvement in driving efficiency would mean an annual reduction of about 1.3 million tons of CO_2 per year.

When gas prices go up sharply, as they are expected to do around the world (Steiner, 2009), savings from driving green will likely be sufficient to reduce consumption drastically. However, environmental damage is happening now; we can't wait for the timely arrival of high gas prices. We must seek solutions. One solution is the use of virtual rewards for green driving.

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The Power of Cooperation

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The 4,300 residents of Samsø, an island off the coast of Denmark, have set an example for communities everywhere: energy independence without adding carbon dioxide to the atmosphere. In the late 1990s, islanders began switching from oil- and coal-generated electricity imported from the mainland to alternatives such as solar and wind power. By 2005, Samsø was producing enough energy to meet all its needs and exporting surplus wind-generated electricity back to the mainland. How did they do it?

The answer might be: "Cooperative action achieves community goals." In an article in *The New Yorker*, environmental writer Elizabeth Kolbert (2008) describes how Denmark recognized windy Samsø as a prime site for renewable energy projects and hired Søren Hermansen, who taught environmental studies at a local boarding school, to guide their development. To get islanders involved, Hermansen attended local meetings on a variety of community topics and turned the discussion to wind power and the goal of island energy independence. Sometimes he brought free beer to facilitate conversations on energy. Hermansen encouraged people to devise their own ways to reduce fossil-fuel use and to cooperate in developing larger scale projects. Now, Samsø has two cooperatively owned wind farms (one on land, one offshore) that produce more power than the islanders consume, plus a variety of small-scale alternative energy projects developed by individuals. For example, some farmers have converted their cars and tractors to run on canola oil pressed from seeds grown on their own land. A farmer who now heats his house with a straw-burning furnace and solar-heated water told Kolbert that for the people of Samsø, thinking about energy "became a kind of sport."

It was a sport in which people could gain both social and financial rewards. Local meetings provided encouragement and approval by neighbors and friends for attending and getting involved. People exchanged ideas about alternative energy projects that individuals could try out, and received personal satisfaction and community recognition when the projects worked. There were also monetary rewards: Once the wind farms were in place, residents saved money by using heat pumps rather than oil to heat their homes, and shareholders received dividends based on the sale of electricity both on and off the island. In addition, the island has received a lot of attention from environmental activists in Europe and the U.S., and Kolbert reports that islanders were obviously proud of their accomplishment.

A partial replication of the Samsø model is underway on Martha's Vineyard, an island off the southeast coast of Massachusetts. Although best known for presidential vacations and celebrity summer homes, the Vineyard has a year-round population of about 15,000 ordinary people who try to conserve energy because of the unusually high cost of oil and gasoline shipped from the mainland. Many also worry about the adverse effects of global warming, such as increasing hurricane intensity, shorefront erosion, and eventual submer-

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sion of coastal villages as sea levels rise. A number of households have small wind turbines or solar water heaters, and some businesses and municipal buildings have photovoltaic panels, so a lot of islanders were ready to consider a proposal to establish a cooperatively owned offshore wind farm. The project, if successful, could generate enough power to meet the needs of all coop members and perhaps be expanded to supply the entire island. The eventual goal, inspired by Samsø, is energy independence for the Vineyard.

The project was launched at a series of small meetings, some in town halls, and some in living rooms. My wife and I attended one early meeting with 24 other people (and we stayed even though there was no beer). One of the project's originators, an engineer named Paul Pimentel, presented some background information on its scale, financing, and timetable, and went on to describe some intriguing wind-power applications. In winter, for example, when there is more wind and fewer users, homes could be warmed with heat pumps and surplus power used to charge electric car batteries. The audience was caught up in the project's possibilities and asked questions that led to lively exchanges; several people noted that self-sufficiency and cooperation were ''the Island way.'' When my wife pulled out her checkbook to buy a share in the coop, three others followed suit at once, and now, several meetings and 6 months later, there are about 750 members.

Why might people join an alternative energy venture in its early stages, with no guarantee of success, regulatory and licensing hurdles to be overcome, several million dollars to be raised, and a long delay before it can begin to replace electricity generated by fossil fuels? Once again, the answer is that people can obtain both social and financial rewards. First, it's fun to attend meetings with like-minded folks to discuss how best to increase community support for the project, and membership commitments by a few can prompt others to join. Also, future decisions, such as the siting of the turbines, will be made collectively, by members only, using the coop's Web site to express individual priorities—an intriguing experiment in participatory decision making. Second, there are monetary incentives: If the project works as planned, members can expect stabilized electricity prices when the wind turbines go on line in about 5 years, and significantly lower prices when loans are paid off; if the project expands and becomes profitable, members will receive dividends. For early joiners, a share in the cooperative cost only $50, but the fee increases every 3 months to $1,000 per share after 5 years. The rising fee schedule encourages early commitment to a risky outcome (the project could fail), but also compensates more expensive buy-ins later with lowered risk and a shorter delay to cheaper power. Also, coop membership yields an immediate cash value: big discounts on energy-saving appliances and on a home energy manager (HEM) that continuously monitors the cost of electricity and turns appliances such as water heaters and freezers off when the cost is high and on when the cost is low. (Incidentally, HEMs help homeowners exhibit self-control by revealing the cost of cranking up the furnace or the air conditioner.) Evidently, this mix of social and monetary consequences can attract members despite the long delay between joining and actually receiving clean power.

There is solid evidence that simply being in an environment in which favorable consequences are available, whether or not they depend on one's own behavior, enhances the persistence of ongoing action. Nevin (2005) showed how this process might account for environmentally harmful activities such as the persistent use of

private autos despite high costs; perhaps the same process might apply to participation in an environmentally beneficial cooperative endeavor.

But an energy coop doesn't just spring up on its own; some individual or group has to get the process started and coordinate its growth. Samsø had Søren Hermansen, Martha's Vineyard has Paul Pimentel, and nearly every community has a few activists committed to local well-being who could work together if conditions were favorable. Suppose, for example, that a town's planning board must review wind-power installations at individual homes, which are far less efficient than larger turbines with shared output. Recognizing the economies of scale, the planning board may propose zoning changes that encourage people to pool their resources in order to develop a cooperatively owned energy project on leased land. If none of the interested parties has the time or the expertise required to develop such a project, they could pool their personal funds and hire a project director. (Allen Neuringer, a contributor to this special section, notes that this sort of problem often arises in volunteer organizations; personal communication, May, 2010.) Contributions from people who wish to pursue a power cooperative would make them founding board members, with shared responsibilities, risks, and benefits. The director, given a chance to work with a supportive community group and develop the project from its inception, might prove to be another Søren Hermansen.

When Kolbert (2008) asked Hermansen for the key message from Samsø to other communities, he said "Think locally, act locally." This makes sense; the problems posed by global warming are so enormous that thinking globally, as usually prescribed, can be paralyzing. Moreover, a single local project has virtually no global impact; that is, the benefits in terms of climate change are just too small to be felt by those who produce them. For example, Paul Pimentel estimates that the Vineyard project will reduce CO_2 emissions by 81,700 tons per year, whereas the United States produces about two billion tons of CO_2 per year (Pew Center on Global Climate Change, 2010); Kolbert notes that all the CO_2 emissions avoided by Samsø over 10 years are overwhelmed by a single coal-fired plant in just 3 weeks.

If the relation between local action and global consequences is so remote, why bother? The answer is that small steps toward successful completion of a local project can maintain environmentally desirable behavior. By thinking and acting locally, people can identify and engage in small-scale cooperative energy projects, celebrate their successes, and take pride in the fact that they are ameliorating rather than exacerbating global warming. If projects like those on Samsø and Martha's Vineyard prove to be contagious, their cumulative impact could be significant.

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TerraKids: An Interactive Web Site Where Kids Learn about Saving the Environment

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"Hey, Mom …, Mom! Let's get *this* one!!!" An excited 8-year-old Seth held out a light bulb package he had pulled from the store shelf and continued his pitch, "The bulbs have an Energy Star[1] rating, last a lot longer, and the package is biodegradable—it'll be gone in 10 weeks!" Mom couldn't resist the earnest look on Seth's face as he added, "And they'll help our score on TerraKids!" She put the package in their basket.

"TerraKids" is the name of a Web site that is, for the present, purely fictional. It is a safe, secure site where 8- to 12-year-old kids become catalysts for a greener Earth by learning about the environment and the role they and their families can play in reducing global warming.

Although users of any age come to the site simply to determine their carbon footprint (CF), TerraKids engages youngsters over time by helping them monitor the things they do and the choices they make, compare their scores (and behavior) to others, participate in green virtual and real communities with awards and recognition, and see immediately and over time how their behavior affects the environment. By incorporating principles from behavior analysis in a playful, interactive social network, TerraKids captures kids' attention at the first visit and thereafter measures, supports, and reinforces green behavior change.

After creating a parent-approved username and account, kids become "CarbonBusters" and official members of the TerraKids community. Upon completing the "What's your CF?" challenge, they immediately see their very own tree icon with a number of gray, light green, or bright green leaves, depending on their family's CF score in different areas (Figure 1). This tree initially provides the family's baseline measure of "greenness." Branches of the tree represent areas related to their CF, including transportation, recycling, home utilities, groceries, and so on. As a family reduces its CF, the leaves on its tree glow greener. One of the tree's roots (with lines as "knots") simulates a line graph that shows the family's initial CF score and later changes over time, growing longer as changes in behavior alter the family's CF score. Each month (or more often if desired), users reevaluate their greenness, and a new CF data point is plotted while the trees leaves change to reflect the new score. Moving the computer cursor over the "root" brings up that score and the date it was earned. Clicking on a "knot" opens a window that shows the tree's leaves and brightness on that date.

Clicking on any of the tree branches opens a page that provides detailed information about that CF area. For example, clicking on the "transportation" branch reveals a page that lists behaviors that increase transportation CF and activities that reduce it. The page contains stories, pictures and posts from other CarbonBusters describing how they reduced their transportation CF, and includes tools to evaluate changes in a transportation CF. Want to see what effect buying a particular model of hybrid instead of a gas-only car would have?

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[1] Energy Star is the name of a federal government-supported program to designate the most energy-efficient compact fluorescent bulbs (see www.energystar.gov).

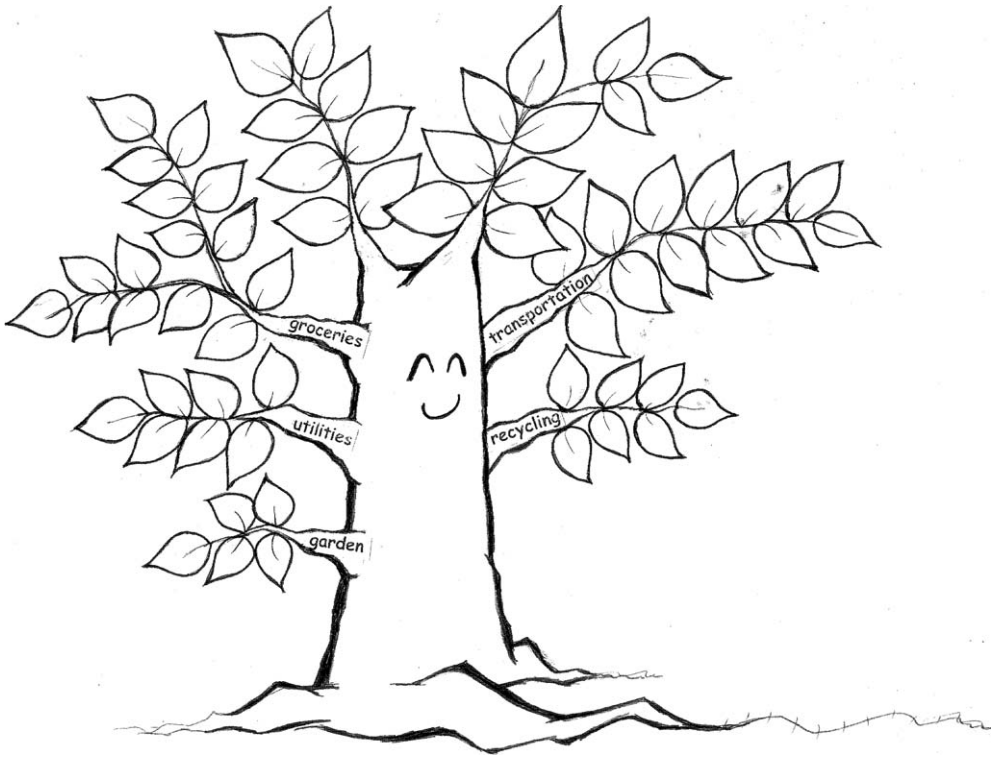

Figure 1. A conceptual example of the TerraKids' tree icon displaying the family's greenness. The branches represent different carbon footprint areas, and the leaves (which change in number and shades of green) represent the general score. An interactive line graph is represented by the longer root.

Click on the matching icon to see the family's potential new CF. Thinking of walking to school or carpooling with neighbors? Drag the slider on the page to see the effect on your CF score. Not only does the transportation (and total) CF score change, but also when a CF measure is reduced, a sample "energy saved" equivalent is immediately displayed (e.g., walking to school 3 days per week has the potential to prolong the life of five neighborhood trees).

Other branches include even more ideas that kids (and their families) can do on a daily basis to reduce their CF. For example, the "utilities" branch suggests unplugging chargers and electrical gadgets when not in use, and using rechargeable batteries in games and toys. Everyone in the family can take shorter showers or turn off the water while brushing their teeth. The "recycling" branch features art projects made from everyday recycled materials, and how to reuse items for different purposes.

All these activities are incorporated into the TerraKids' world. To support and maintain behavior change, the TerraKids site includes a token economy in which kids and their families earn points[2] for engaging in the green behaviors suggested above or other things such as composting, purchasing energy efficient products

[2] Using points to reward behavior (e.g., eating specific foods) has been used successfully by commercial enterprises. For a sustained example, see the Points System used by Weight Watchers (http://www.weightwatchers.com/plan/eat/plan.aspx). For an online example of earning points based on increasing behavior and monitoring levels, see "The President's Challenge" for physical fitness (www.presidentschallenge.org).

and appliances, and even participating in Earth Day. For example, Seth can scan the bar code on the package of the energy-efficient bulbs his mom purchased and earn points for the green purchase. CarbonBusters also earn points as they increase their knowledge of their effect on the world's environment by conducting virtual and real experiments, playing online games in the site's "Learning TreeHouse," or posting stories that could inspire others and influence their own behavior. Higher points equate to higher CarbonBuster levels, differing rewards, and more TerraKids prestige.

Because TerraKids is partially supported by manufacturers who meet a set of green criteria, accumulated points are exchanged for coupons, rebates, merchandise, event tickets, and other giveaways from these merchants based on levels and points earned. The merchants have an opportunity to promote their products tactfully and contribute to teaching about the environment. CarbonBusters may select companies they like and add them to their own page (which would also be a form of advertising for the companies, with logos displayed and links to their own Web sites), forming a favorites list somewhat similar to a fantasy sports league.[3] TerraKids presents information on the companies' green performance over time (based on indicators of how well they are helping the environment), and kids earn more points when their companies do especially well.

Another feature of the site that helps to maintain interest and participation are the TerraKids communities, both virtual and real. A click on the Earth icon from the home page takes users to the TerraKids virtual community, which represents the status of all the CarbonBusters combined. The planet itself gets brighter as more and more kids sign on and do their part to reduce their CFs. Moving the cursor over the planet causes it to rotate, and clicking on a part of the world connects to that community's page and provides information about TerraKids users there.

In the TerraKids community, the social network is designed to help support behavior for the good of the Earth. On a safe, secure, parent-approved site, kids text, chat, post messages, and meet virtually other kids in their neighborhood, community, state, country, or across the world. They can encourage peers, who might not initially be interested in helping the Earth, to join and participate in the site. They can compare their CF (now and over time) and TerraKids activities to those of other CarbonBusters across the street or across the globe. Virtual or real-time challenges help to get kids walking, recycling, or helping others in the home, school, or community. Periodic awards go to kids with scores consistently better than their baseline, and for the largest reduction in CF over a given period of time, with their accomplishments posted on the site's home or community page.

TerraKids involves local settings as well, providing templates for school or community events such as a recycling day, an afternoon of board games, or a day in the park. Friendly competition within or between schools can be arranged, with various group activities encouraging more widespread participation, such as an interdependent group contingency that awards the entire class prizes only when each student in the class meets a predetermined CF score. The learning activities built into the site can be incorporated into the school curriculum and provide research and other tools for school assignments pertaining to the environment. Be-

[3] For an example of a popular virtual community system for setting up fantasy teams and monitoring and ranking performance, see http://fantasybaseball.com.

cause it is difficult to assess reliability via a Web site, TerraKids' connection to real-life settings and events also promotes an increased correspondence between what kids report on the site and what they and their families are actually doing. Family involvement should also help to strengthen the connection between ''saying'' and ''doing.''

Other sites that focus on green behavior for kids already exist, but TerraKids could be more effective by making use of what is known about behavior change. Many of the strategies and tactics described in this essay are based on empirically evaluated techniques, such as the use of a token economy to increase behavior (Hackenberg, 2009; Phillips, Phillips, Fixsen, & Wolf, 1971). Classwide peer tutoring has been shown to increase targeted and collateral academic and social skills (Kohler & Greenwood, 1990), and research on group contingencies offers a template for improving social behavior in schools (Greenwood & Hops, 1981; Hamad, Cooper, & Semb, 1977). Research has also demonstrated the effectiveness of feedback and public posting for modifying behavior (Van Houten, Hill, & Parsons, 1975; Van Houten, Nau, & Marini, 1980). A central component of TerraKids involves establishing the child as an agent for the behavior change of other family members. Similar programs have been effective in getting students to influence teacher behavior (Alber & Heward, 2000; Craft, Alber, & Heward, 1998).

Today, TerraKids exists only in thought and in this essay, but it could be live on the Web in the very near future. By making use of what we know about a science of behavior change, we can build a Web site that can help move millions of people to a greener world.

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Climate Change: Meeting the Challenge

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The debate over global warming is over.

That was the implicit message of a public letter that appeared in the journal *Science* on May 7, 2010, signed by 255 members of the prestigious National Academy of Sciences, including Lonnie Thompson. The letter declared that "there is compelling, comprehensive, and consistent objective evidence that humans are changing the climate in ways that threaten our societies and the ecosystems on which we depend." (The NAS members' letter in *Science* is available online at http://www.sciencemag.org/cgi/reprint/328/5979/689.pdf)

The writers acknowledged that "science never absolutely proves anything," but they identified five conclusions consistently supported by climate research:

(i) The planet is warming due to increased concentrations of heat-trapping gases in our atmosphere. A snowy winter in Washington does not alter this fact.
(ii) Most of the increase in the concentration of these gases over the last century is due to human activities, especially the burning of fossil fuels and deforestation.
(iii) Natural causes always play a role in changing Earth's climate, but are now being overwhelmed by human-induced changes.
(iv) Warming the planet will cause many other climatic patterns to change at speeds unprecedented in modern times, including increasing rates of sea-level rise and alterations in the hydrologic cycle. Rising concentrations of carbon dioxide (CO_2) are making the oceans more acidic.
(v) The combination of these complex climate changes threatens coastal communities and cities, our food and water supplies, marine and freshwater ecosystems, forests, high mountain environments, and far more.

These scientists go on to say, "We urge our policymakers and the public to move forward immediately to address the causes of climate change, including the unrestrained burning of fossil fuels." Although the letter has an ominous tone, the authors conclude by adding, "The good news is that smart and effective actions are possible."

The question arises, What smart and effective actions can behavior analysts contribute to this effort?

WHAT CAN BEHAVIOR ANALYSTS DO?

As we indicated in the introduction to this special section, environmental problems have never been a major area of research for behavior analysts, although several prescient researchers did important work in the area, mainly in the 1970s and 1980s. Scott Geller was especially active in this area, and reviewed the literature in 1976 (Tuso & Geller, 1976) and again in 1990 (Geller, 1990). In the latter paper, subtitled "Where Have All the Flowers Gone?" he called for "renewed efforts to find behavioral solutions to environmental problems" (p. 27).

This work may seem to have had little impact on the environmental movement, but we disagree. Just as positive reinforcement and time-out have made their way into homes and schools, the idea of providing feedback and financial incentives to conserve energy appear to have found their way into the power

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companies (Darby, 2006). The terminology is not behavior analytic (Darby speaks of ''information, action, and feedback in synergy,'' p. 9), but the ideas are certainly familiar to readers of this journal. Some power companies provide ''Smart Meters'' that allow customers to monitor their use of electricity. Not surprisingly, the power companies are finding that these efforts produce reductions of from 5% to 15% in energy consumption (Darby). This reduces greenhouse gas emissions, and it helps the company because it can avoid blackouts and the great cost of building new plants to meet customer needs.

We applaud the pioneering work by behavior analysts in environmental protection, and we encourage applied behavior analysts to follow suit. But we also want to recommend that behavior analysts not just imitate what has been done in the past, but look for new ways of studying behavior change. Systematically replicating past experiments is essential to scientific progress, but so is bold innovation. We must not forget that some of Skinner's most important discoveries (e.g., shaping, chaining, intermittent reinforcement) were not the result of formal research designs but of looking for lawful processes and being alert ''to take advantage of accidents'' by following the data (Skinner, 1956/1982, p. 97). When you find something interesting, he said, drop everything else and study it. Some would call this ''thinking outside the box,'' but environmentalist Amory Lovins (in Kolbert, 2007) came closer to the mark when he said, ''There is no box'' (p. 35).

It was this kind of thinking that we were after when we asked behavior analysts to write essays for this special section. The essays are not likely to be loved by all readers of this journal. No doubt some will consider them poor examples of behavior analysis; some might even say that they are not *any* kind of behavior analysis. But our essayists produced just what we were after. They threw the guidebook away and asked, What can we suggest as a way to change behavior that rests on behavioral principles, but does so in a fresh way? We hope that these essays will serve as models for others to emulate.

Now we want to make a proposal of our own. Skinner pointed out that evolution has prepared us for a very different world than the one in which we live (see Chance, 2007). For example, we are designed to modify our behavior in response to consequences that are intense, immediate and certain, but many of the problems that we face today, including climate change, involve consequences that are weak, delayed, and uncertain. We also evolved to respond best to direct contact with important environmental events. The development of language made it possible for our ancestors to benefit from the experiences of others, and warnings such as ''Don't eat the green meat'' are useful even today. But we did not evolve to respond to warnings about events that might be a decade or more away, such as ''Don't eat a lot of meat because it produces greenhouse gases that can change the climate.'' We evolved in a world in which nourishment was not easy to come by, and as a result we developed a strong preference for high calorie foods. In developed countries today, calories are available in abundance, yet we still eat as if starvation were a major threat. One result is that in the U.S. and certain European countries obesity is epidemic, and raising, processing, and transporting food and disposing of its waste products are significant contributors to greenhouse gases.

Some behavior analysts look at these characteristics and despair at getting sufficient numbers of people to make the drastic changes in behavior necessary in time to save the planet. We suggest that behavior analysts think differently about these innate behavioral tendencies. We

suggest looking for ways of turning them to advantage, that is, of using them to get the desired behavior. If evolution has given us a lemon, let us see if we can make lemonade.

We offer here a few ideas to illustrate what we have in mind. Except for the first one they are speculative. We realize that we will be criticized for speculating, but there are precedents: B. F. Skinner speculated about the design of culture, verbal behavior, compulsive gambling, and the nature of the ideal society. We do not claim that our efforts are on a level with Skinner's, and we are sure that many readers of this journal can do far better. In fact, it's our hope that they—you—will do just that.

MAKING GREED GREEN

We begin with Carrotmobbing, the best example we can offer of what we have in mind. It did not come from us or from any other behavior analyst. It came from a young man in San Francisco named Brent Schulkin. He wanted to do something to help the environment, and thought that one way to do that would be to get businesses to spend money on eco-friendly things. But most businesses are not interested in helping the environment; they are interested in making money. In fact, the problem is that "companies will do anything for money." Then it occurred to him that perhaps the solution to the problem was that "companies will do anything for money." What if consumers could reward companies for going green by helping the companies make money?

Schulkin launched Carrotmob, self-described as "a network of consumers who buy products in order to reward businesses who are making the most socially responsible decisions" (http://carrotmob.org). As the Web site puts it, "We harness consumer power to make it possible for the most socially responsible business practices to also be the most profitable choices. It's the opposite of a boycott."

Carrotmobbing works like this: Someone calls stores of a particular type (e.g., convenience stores) and asks them what percentage of their profits they are willing to spend on helping the environment if the group mobs their store. The highest bidder gets mobbed: On a given date, participants go to that particular store and buy whatever they need, thereby distributing disproportionate profit to that store. The store then spends the designated share of profit as agreed. For example, they might install solar panels to generate power for their lights or they might add insulation or energy-efficient lighting. Mobbing participants are not asked to donate anything to the store, nor are they asked to buy things they would not ordinarily buy. They buy what they would have bought anyway, but the green store benefits (their improvements are paid for by their additional profits), as does the environment.

For the first test of the program, Schulkin contacted 23 liquor stores in San Francisco. Hundreds of people showed up at the highest bidder, K & D Market. The owner and his son had little if any interest in helping the environment; their only interest was in helping their bottom line. And they did. The result of the mobbing was that the business took in far more money than they normally would and the store made some improvements that will save them money on electric bills.

Carrotmobbing might be dismissed as one of those San Francisco hippie things that would not work anywhere else. Not so. The program has been, or is scheduled to be, implemented in cities around the United States and the world, including Bern, Buenos Aires, New York, Paris, Quebec, and Washington, D.C.

Carrotmobbing uses a basic principle of behavior that would seem to work against going green (people tend to be selfish) to get people to help the

environment, acts that selfishness would not ordinarily inspire. We think that behavior analysts will conceive of many other ways in which this tactic could be used to help the environment. Behavior analysts can also contribute by doing research on practices such as Carrotmobbing to provide objective data about effectiveness, evidence that could improve the design of future efforts.

POPULAR AVERSIVES

Millions of years of evolution have taught us to avoid, escape, and despise things that are injurious to us. One of the things most people consider aversive today is taxes. But it is not taxes in general that people object to, but taxes that they themselves must pay. Russell Long, former Congressman from Louisiana, captured this sentiment with the words, "Don't tax you, don't tax me, tax that fellow behind the tree." (And the truth may be that most believe it would be all right to tax *you*, too, if necessary.) We can see this anecdotally in tobacco taxes. As more and more people gave up smoking, the taxes on cigarettes increased. Smokers objected, but they were badly outnumbered by nonsmokers so their objections went unheeded. So, are there ways of levying taxes that the majority of voters will not strenuously oppose and might support?

One possibility is to levy a "green" tax on gasoline with the guarantee that all green tax dollars would be refunded to taxpayers. Each taxpayer, regardless of income, would receive an annual check or a tax credit equivalent to the amount of green tax taken in divided by the number of taxpayers. This idea, which has been around for years, would likely be opposed by the oil companies and by those who drive commercial vehicles and gas-guzzling SUVs, but welcomed by those who bike, drive fuel-efficient vehicles, or rely heavily on public transportation. The complaints of the former group might be muted somewhat by the check or tax credit, which would help defray the added expense. As people come to enjoy their annual tax refund, they would likely buy more efficient cars, drive more efficiently, and turn more and more to public transportation, thereby maximizing their green tax benefits. And as they make these changes, it is likely that they would begin to support, or at least not oppose, increases in the green tax. After all, the tax is not on *them*; it's on that fellow behind the tree.

Taxes are not the only aversive events people might learn to love. Penalties can be used to reduce consumption (Agras, Jacob, & Lebedeck, 1980), but it is difficult to get them put into effect because they provoke a public outcry. Suppose penalties were levied only against those who use a truly excessive amount of electricity, perhaps the top 10% of households, and the funds from the penalties were distributed to households that had used a more modest amount of electricity, say, the bottom 60%. Thus, 60% of users would then have an incentive to support the penalty, and only about 10% have good reason to oppose it.

It would be important to publicize the plan carefully before it is put into effect, because anything that hints of penalty will elicit objections. But once people understand that they are likely to profit from the plan, chances are they will support it. One nice thing about this proposal is that the people most likely to pay penalties are those who choose to pay them rather than conserve energy. This should help with public support.

We realize, of course, that as behavior analysts you are not in a position to levy a gas tax or impose penalties on the use of energy. But you could create a laboratory analogue or set up an analogous program in a college dorm. We will leave that to you. But if your efforts are

successful, be sure to share that information with people who *are* in a position to levy taxes and impose penalties.

EFFORTLESS GREEN

Another basic principle of behavior that often works against us is the principle of least effort (Friman & Poling, 1995; Zhou, Goff, & Iwata, 2000). Given a choice, people usually take the easier option. If you have clothes to dry, you can put them in a dryer, or hang them on a clothesline or on a drying rack outside. Air drying uses no fossil fuels and produces no greenhouse gases, but throwing clothes in the dryer is easier so chances are that is what you do. If you have dishes to wash, you can wash them by hand in the sink and that will use less water and less energy (the water won't be boiling hot), but the electric dishwasher is easier, so… If you have to get to work, there's a bus stop two blocks away that will take you practically to your office door, but it's easier to take the car, so …

Is it possible to use the principle of least work to promote green behavior? When Jacob Keller (1991/2010) did his experiment on increasing recycling 20 years ago, people had to sort their items (glass, paper, cardboard, cans, plastic), and that discouraged participation. In some recycling programs, people often had to take the items to a center miles away and put each type of item in a different bin. Today, recycling is often much simpler. You don't have to sort anything, the recyling centers are usually close by, and if you are willing to pay a small fee, you can put your items in a container at the curb and someone will pick them up. The alternative to recycling the items is to put them in a trash bin with the rest of your trash, so recycling adds almost no work. Recycling has been made easier for us, and many more of us do it.

Is there any way of making it easier for people to air dry clothes? We haven't come up with anything yet, but we hope you will.

DISCOUNTED MORTGAGES

Builders have many options in constructing a house. They can, for example, put in different kinds of lightbulbs. Incandescent bulbs (60 W) retail for about $0.50 each, CFLs are $2.00, and the new LEDs go for $43.00. They can put in a standard refrigerator (20 cubic feet) that costs about $500 or a low-end energy-efficient refrigerator of the same size with a price of about $800. And so it goes: washer, dryer, dishwasher, water heater, windows, doors, microwave, oven, range, exhaust fan. The list goes on, and if the builder consistently chooses the most energy-efficient option, the increase in the price of the house is substantial. The higher the price of the house, the harder it is to sell, so builders typically buy the less expensive, more energy wasteful items; thus, new homes are far less energy efficient than they could be.

But why are buyers reluctant to pay the extra price now, when they will save money on energy later? The answer, of course, is that *now* comes before *later*. This is another of those well-established behavioral principles that tend to undermine green decisions: Immediate consequences have a greater impact on behavior than delayed consequences. Can we turn this principle, called discounting, to our advantage? Can we, for example, make the savings come now and the higher price come later?

We're not bankers, but we think it might be possible to do that, or at least to reduce the discrepancy between short- and long-term consequences. One way would be to make the additional cost of energy-efficient appliances tax deductible. If buyers pay an additional $5,000 for appliances and can deduct that expense from their taxes that year or over a

few years, the pain of the higher price is sharply reduced.

Another approach might be to add a tax to all appliances, with the tax based on energy efficiency, so that there is little or no tax on the most efficient appliances but a substantial tax on the least efficient. This would reduce the difference in price between an energy-wasteful house and an efficient one.

THE GREEN CLASSROOM

The effort to protect the planet will, if we are lucky, last a very long time, possibly hundreds of years. One of the things we have to do is prepare young people for the challenge. That means doing a better job of teaching people about our connection to the environment, but it also means teaching them the basic principles of behavior. We are experiencing climate change because of human behavior, and if the earth recovers it will likely be because of changes in human behavior.

Unfortunately, our learning histories can make it difficult for us to accept new ideas, including ideas about behavior. Every day people see the apparent movement of the sun across the sky and deduce or are taught that the sun revolves around the earth every 24 hours, giving us our day and night. We also learn that when we approach a warm object, such as a fire, we feel warmer, so most of us conclude that summers are warm because the earth is closer to the sun. This learning history, whether taught or acquired on our own, can interfere with learning the established scientific facts about these matters (Sadler, 1992). In the same way, we learn all sorts of things about behavior that are not so, and this increases the difficulty of learning what *is* so. If we want people in the future to understand behavioral principles better than they do today, we had better find ways of teaching those principles starting in the early grades. This will not be easy, but we are confident that it can be done, because it has been done (Miller & Cheney, 1996).

Of course there also need to be educational programs aimed at children about how their behavior affects the planet. One idea is suggested by a program developed by Sarah Dunkel-Jackson and her colleagues in Michigan (http://greatlakesenergyservice.org). With a million-dollar grant from the Michigan Public Service Commission, they renovated a trailer and equipped it with solar panels, cellular batteries, and various hands-on and interactive exhibits that teach students about electricity and its conservation. The program, which we came to call the Green Bus, is strictly informational, but there is no reason why a behavior analyst could not develop a mobile program that would attempt to shape green behavior in schoolchildren. Not only are kids who learn the importance of being eco-friendly likely to behave in greener ways as adults, but as children they may influence their parents' behavior, including their purchase of items ranging from lightbulbs to cars (Foderaro, 2008).

There are, of course, college and graduate programs in environmental science, but it is unlikely that courses in behavior analysis are required or encouraged. Fortunately, Mark Alavosius (personal communication, August, 2010) and his colleagues at the University of Nevada, Reno are working with the university's environmental sciences department to put together a sequence of courses to couple behavior analysis and environmental science. The program is expected to begin in fall of 2010, and might provide a model for others around the country. The program should produce environmental scientists who know more about behavior, and behavioral scientists who know more about the environment. This is bound to lead to effective collaborations in the future, and we're sure

behavior analysts will learn from this example.

As educators, behavior analysts can find many ways to help the environment. They can talk about applications of behavioral principles to environmental issues in the courses they teach, design and teach new courses, develop continuing education and distance learning programs, give public lectures on behavior and the environment, and most important of all, they can collaborate with experts in other fields, including not only environmental scientists but also economists, sociologists, anthropologists, and social psychologists to design and test ways of increasing green behavior.

The point is that education is an important arena for influencing the impact people have on the environment in the short run and for decades to come, and we hope behavior analysts will find ways to make the most of it.

FINDING THE BIGGEST SMALL

Nevin (2005) has argued that societal contingencies have little effect on individual behavior. If, during hot weather, the local power company warns that there may be blackouts if people do not reduce consumption of electricity, everyone in the community should push their thermostat up. You may do so, but your neighbors may not. If too many people set their thermostat low, all suffer when the power goes off, but you will have suffered more. The contingencies for the group are different from the contingencies for the individual and so are often not effective in producing the desired behavior change (Slavin, Wodarski, & Blackburn, 1981).

But what would happen if you and your neighbor were the only ones at risk of experiencing a blackout? Now it seems likely that you will both turn up the thermostat. If only one of you does so and there is a power failure, the other knows whom to blame, and the guilty party has a price to pay. What if three neighbors were involved? Four? Ten? Presumably, as Nevin suggests (2010; see also Van Vugt & Samuelson, 1999) the smaller the group, the more likely the contingency will affect behavior in the desired way. But how large can the group get before the contingency becomes ineffective?

Laboratory and applied research on this question could have a tremendous impact. For instance, it may be possible for power suppliers to limit blackouts to relatively small groups of people, depending on their total use. Then the contingencies for the group are similar to the contingencies for the individual, and everyone benefits by cooperating.

THE POLITICS OF GREEN

According to a Pew Research Center survey (2009a), only 57% of Americans believe there is solid evidence for global warming. This figure is much lower than in many other countries (Pew Research Center, 2009b). However, there is a strong connection between views on global warming and politics: 49% of Republicans believe global warming is real, compared to 75% of Independents and 84% of Democrats (Pew Research Center, 2008). Moreover, it is conservative Republicans who are skeptics; 69% of liberal and moderate Republicans believe in global warming compared to 43% of conservative Republicans.

This raises an interesting question: What does global warming have to do with politics? What does political ideology have to do with the interpretation of scientific evidence? Many conservative Republicans are Christian fundamentalists, so we wonder if it is not political ideology that comes into play, but rather religion.

The issue is important because if we understood why Christian fundamentalists reject global warming, it might suggest ways to reduce their

objections. One possibility is that the objection is not based on religious dogma but is the result of emotional conditioning. There is an outspoken minority today that speaks on behalf of atheism. Harris (2008) and Dawkins (2008) are not only outspoken in their defense of atheism, but they are also openly hostile toward religion. They do not say that theism is merely wrong, but that it is bad. It is hardly surprising, then, that religious fundamentalists feel they are under attack. The atheist writers tend to be intellectuals, as do environmentalists. Is it possible that the association of environmentalism with atheism has led to a negative emotional response to anything environmentalists support, including the idea that global warming is real? If so, we wonder if a form of counterconditioning (Verplanck, 1955) might help global warming deniers to look more objectively at the scientific evidence. For example, getting political and religious conservatives who accept global warming to advocate for protecting the environment might help to reduce the negative emotional response to environmentalism. That could be a major step toward winning support for necessary environmental measures, including some that would reduce greenhouse gases.

Research along these lines is certainly far from what we usually see in behavior-analytic journals, but before we can change behavior, it is necessary to know something about the contingencies that maintain it, and that is something behavior analysts can study and, possibly, change.

Would this or any of the other proposals for reducing greenhouse gases in this special section work? We don't know. They need to be carefully examined, then tested in a laboratory or simulation, and then field tested. We hope behavior analysts will do just that. However, we do know that none of these proposals is a silver bullet; rather, they are examples of what has been called "silver buckshot." The consensus is that there is no silver bullet, and that we have to produce lots of silver buckshot. Behavior analysts are as well equipped as anyone to do that.

We have one more idea for restoring the health of the planet that we would like behavior analysts to consider working on: Nudging the societies of the world toward sustainability.[1] That means moving toward a stable population and reducing the rate of consumption (Dietz & Rosa, 1994, 1997). Like it or not, to reduce greenhouse gas emissions, we must downsize (Brown, 2009; Diamond, 2008; Latouche, 2003; Worldwatch Institute, 2010).

The transition to a less lavish, more sustainable lifestyle does not mean that we must be miserable. Rates of consumption are not closely tied to the standard of living. "Much American consumption," writes Jared Diamond (2008), geography professor and author of *Collapse: How Societies Choose to Fail or Succeed*, "is wasteful and contributes little or nothing to quality of life. For example, per capita oil consumption in Western Europe is about half of ours, yet Western Europe's standard of living is higher by any reasonable criterion, including life expectancy, health, infant mortality, access to medical care, financial security after retirement, vacation time, quality of public schools and support for the arts."

We cannot deny that material things can add to the comfort of our daily lives, but the American (and increasingly the world's) obsession with things has not made us notably happier than previous generations. As Canadian social psychologist Elizabeth Dunn and her colleagues (Dunn, Gilbert, & Wilson,

[1] We are encouraged by an effort currently underway to establish a special interest group within ABAI called Behavior Analysis for Sustainable Societies and by the establishment of an Environment/Green Solutions Group at the Cambridge Center for Behavioral Studies (www.behavior.org).

in press) write, ''Money buys happiness, but it buys less than most people think'' (see also Aknin, Norton, & Dunn, 2009; Diener & Biswas-Diener, 2002; Frey & Stutzer, 2000).

Indeed, there is reason to believe that a less opulent lifestyle will add to our enjoyment of life. When the recession hit America hard in 2008, people cut back on spending to reduce their debt and to save money in case of job loss. Instead of *buying* things, they *did* things. Instead of going out to a restaurant for a meal, they had a picnic in the park; instead of going to the arcade, they played basketball in the driveway; instead of shopping at the mall, they played cards with friends. They went back in time and discovered that not all pleasures come from the possession of the latest electronic gadget or a $400 pair of basketball shoes. Simple, small, inexpensive, or free activities add a great deal to our lives (Dunn et al., in press).

There are other ways that scaling back may improve our lives. Christopher Steiner (2009), a staff writer for *Forbes*, looked at the effects that rising oil prices are apt to have on our lives. With rapidly increasing demand, the price of oil and everything derived from oil (including not only gasoline, heating oil, and jet fuel, but lubricants, clothes, shoes, carpets, you name it) will go up. Steiner thinks gasoline may reach $20 per gallon in this century, but he notes that the increase in gas prices is likely to have a number of positive side effects. It is likely, for example, to improve our health: We will walk and bike more and drive less, which will improve fitness and lower rates of obesity, and we will breathe cleaner air and eat more locally grown food.

So there are solid grounds for hope; there *are* ''smart and effective actions'' we can take to deal with our problems. No one thinks that restoring the health of Earth will be easy or accomplished quickly, and there will undoubtedly be many failures along the way. But as we make the effort we should remember advice often attributed to Skinner: ''A failure is not always a mistake. It may simply be the best you can do under the circumstances. The real failure is to stop trying.''

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