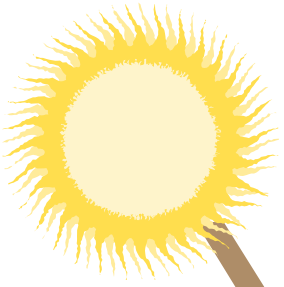
WE'VE TURNED UP THE HEAT

HUMANS' ROLE IN CHANGING EARTH'S CLIMATE



You probably have noticed the deluge of headlines and articles in the past year about human-induced (anthropogenic) climate change. A Nobel Prize and an Academy Award were awarded for efforts to raise public awareness of climate change, major magazines devoted cover stories to the topic, and international corporations included climate-change mitigation in their advertising campaigns.

Why the big fuss of late? A century of study by climate scientists the world over has produced an ever-sharpening picture of how Earth's climate system works and the role human activities have played in changing it. Recently, that picture has become much more vivid.

BY KIRA T. LAWRENCE | ILLUSTRATION BY TERRY STOUT

Nancy Parker '09 (L-R) and Laura Bochner '10 with Kira Lawrence aboard a University of Maryland research vessel on the Chesapeake Bay during an oceanography-class field trip.

KIRA T. LAWRENCE

Kira Lawrence studies the evolution of climate over the past five million years, an interval spanning the last major climate transition in Earth's history, which was marked by the rapid expansion of ice across landmasses in the Northern Hemisphere.

"My research is driven by an interest in understanding how and why Earth's climate has changed through time. My interest in this particular transition is inspired in part because the warm interval that preceded it, the Pliocene epoch, is one of the best analogs for future climate conditions," she says. "The present concentration of carbon dioxide in the atmosphere, about 380 parts per million—recently reached as a consequence of anthropogenic activities—was last reached during the Pliocene, and global average temperatures during the Pliocene were warmer than present by three degrees Celsius, consistent with the best estimates for how much warmer Earth's surface will be in the year 2100."

Lawrence joined the Department of Geology and Environmental Geosciences as an assistant professor in fall 2006, after completing her Ph.D. at Brown University. She soon received a $97,000 National Science Foundation grant to produce the first systematic look at changes in ocean-surface temperature in the high-latitude regions over the past five million years. She teaches courses on Earth's climate and oceanography.

Lawrence has published her research in peer-reviewed journals including *Science, Nature, Geology, Global Change Biology,* and *Global Ecology and Biogeography*. In addition to her doctorate, she holds master's degrees from Brown and the University of California, Santa Cruz, and an A.B. from Dartmouth College.

The Intergovernmental Panel on Climate Change, an international group of more than 100 climate scientists, was established in 1988 by the United Nations Environmental Program and the World Meteorological Organization to provide policymakers with an objective source of information about climate change. Meeting approximately every five years to synthesize and summarize the current state of scientific knowledge about climate change, the IPCC has compiled progressively more conclusive evidence that Earth's climate is changing and that humans have played a prominent role in initiating the changes. The group's most recent report, released last spring, concluded that "most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations," with the phrase "very likely" indicating greater than 90-percent confidence.

The IPCC's conclusions are persuasive, because they are derived from collaboratively written, peer-reviewed syntheses of the research of thousands of climate scientists. In essence, they represent the unfiltered, collective voice of the climate-science community. That voice is saying there is very significant cause for concern about the impact of human activities on Earth's climate system and that major, immediate action to curb human-induced climate change is warranted.

OUR DEMAND FOR ENERGY

Humans' role in changing Earth's climate stems largely from our demand for energy. We burn fossil fuels (coal, oil, and natural gas) to power our cars, trucks, trains, and planes; to heat and cool our homes; to light our buildings; and to charge our computers, cell phones, and iPods. In the process, each year billions of tons of carbon dioxide, a greenhouse gas capable of trapping extra heat in Earth's climate system, are released into Earth's atmosphere as a by-product. In addition to fossil-fuel burning, deforestation is another significant anthropogenic source of atmospheric carbon dioxide. Since the dawn of organized society, humans have cleared land for agricultural and other uses. The vegetation removed in the process either is burned or decays, producing carbon dioxide.

Human activities have also significantly augmented the abundance of atmospheric methane, a lesser-known but potent greenhouse gas. Methane-generating bacteria (methanogens) thrive in low-oxygen environments like rice paddies, cows' stomachs, and municipal landfills. More rice paddies, more livestock, and more landfills mean more methanogens and thus more methane released to the atmosphere. The unintended consequence of these "fundamental" human activities is a rapid change in the abundance of greenhouse gases in Earth's atmosphere. Even though, all told, these gases still represent only a few percent of the atmosphere, because of their energy-trapping capabilities they play a disproportionately large role in the planet's climate system.

Energy enters Earth's climate system primarily in the form of ultraviolet and visible light emitted from the Sun. Some of this energy is reflected back into space, but much of it is absorbed by the planet's atmosphere and surface. This absorbed energy drives Earth's climate system. It is reradiated as infrared energy, which interacts with greenhouse gases in the atmosphere, trapping energy that was destined for space in the climate system and warming the Earth. This process is called the "greenhouse effect" because it warms the planet much like the glass panes of a greenhouse keep the inside of the greenhouse warm. We should be thankful for this process, as without it Earth's surface temperature would be a frigid -18° Celsius (or 0° Fahrenheit) and likely uninhabitable by life. Unfortunately, it is possible to get too much of a good thing. By rapidly augmenting the concentration of greenhouse gases in the atmosphere, we are unintentionally warming Earth's climate.

Earth's climate has changed dramatically before. The most recent Ice Age brought glaciers to Lafayette's doorstep 20,000 years ago, and tens of millions of years ago dinosaurs roamed a warm, swampy Earth. In the 4.6 billion years Earth has existed, its climate has ranged from times of global glaciation to intervals in which Earth has been entirely ice-free. So why worry about human-induced climate change? Because the entirety of complex human society, born with the rise of agriculture, has only existed in a very limited range of climatic conditions. Our way of life has been established and become fundamentally dependent on the particular set of temperature and precipitation conditions that have existed fairly continuously since the first organized societies were established about ten millennia ago in the Middle East. Human beings have become entrenched in our expectations of the climate system. For instance, in the human experience, there has always been (thus we assume there will always be) the right temperature and precipitation conditions to grow corn in the central United States and wheat in central Canada. Since the rise of organized societies, we have rapidly developed real estate along every major coastline in the world, operating under the tacit assumption that sea

Individual Action

As important as national and international efforts to combat anthropogenic climate change will be, greater emission reductions are attainable if action also comes from individuals. A good place to start is determining your personal carbon footprint. The U.S. Environmental Protection Agency's carbon emissions calculator (www.epa.gov/climatechange/emissions/ind_calculator.html) allows you easily to estimate how much carbon your energy use produces and to explore how modifying your behaviors could reduce your emissions. Also, because elected officials tend to operate on the two-to-six-year timescales of election cycles, hearing that you care about the long-term issue of climate change may help these officials marshal the political will necessary to implement legislation that would greatly reduce greenhouse gas emissions.

For additional information, I recommend *The Rough Guide to Climate Change* by Robert Henson of the U.S. National Center for Atmospheric Research. It's a user-friendly summary of climate-change science and policy. Also, the IPCC's website (www.ipcc.ch) includes its reports and summaries for policymakers. Finally, the blog realclimate.org provides the responses of climate scientists to major recent climate-related news stories, scientific findings, court rulings, and public inquiries about climate change. □

—*Kira Lawrence*

level in the future will remain essentially unchanged. In a warming world, these entrenched expectations may not be fulfilled.

The IPCC's best estimate for how much warmer the average temperature of Earth will be by the year 2100 is 3°C (5.4 °F). While that doesn't sound like much, the last time the planet's average temperature was 3°C warmer than today was at least three million years ago—about the time our very distant ancestors began to walk on two legs. We are already observing the predicted impacts of a warmer world. A few manifestations: mountain glaciers all over the world are melting; sea level has risen slowly, but at a consistently accelerating rate, over the past 100 years; and last summer Arctic summer sea ice melted to an unprecedented extent.

In my view, it is the rate of change that is most alarming. A record of past atmospheric composition, measured from air bubbles trapped in Antarctic ice cores, shows that since the start of the Industrial Revolution, we have changed the abundance of carbon dioxide in the atmosphere at least 15 times faster than it had changed naturally in the previous 800,000 years. Humans are conducting an experiment with the environment that, to our knowledge, has never been run before. I wonder how living things, which are all sensitive to their environment, will respond to the rapid change in climate associated with human-caused changes in Earth's atmosphere.

ADDRESSING CLIMATE CHANGE

Addressing human-induced climate change is a daunting challenge, in part because of its very nature. Carbon dioxide is colorless, odorless, and tasteless. Because we cannot actively sense it and because its augmented presence in the atmosphere results in long-term, global changes rather than abrupt, acute, and easily observable local impacts, raising public awareness and inspiring true action is a real challenge. Also, because just about everything we do requires energy that currently comes primarily from burning fossil fuels, addressing climate change likely requires both significant modifications in our behavior and major advancements in renewable-energy technology. Furthermore, because carbon dioxide remains in the atmosphere for about 100 years, even if we stopped emitting greenhouse gases today, the Earth would still warm considerably over the next century.

While these observations are sobering, addressing climate change is feasible, and major efforts to address it are under way. Every industrialized nation in the world, with the notable exception of the United States, has signed the Kyoto Protocol, a United Nations-sponsored international agreement requiring signatory industrialized nations to reduce their greenhouse-gas emissions. The United States, which is responsible for 30 percent of the greenhouse gases currently in the atmosphere—by far the largest contribution by any single nation —has cited concerns about the impact of curbing greenhouse gas emissions on the U.S. economy as its justification for not signing the agreement. Although some U.S. states have implemented emissions-reduction legislation, and hundreds of U.S. cities have signed the Kyoto Protocol, reducing the impact of anthropogenic climate change will almost certainly require the strong support of the federal government.

In December, negotiators and diplomats from more than 180 nations met at a United Nations Framework Convention on Climate Change (UNFCCC) conference in Bali, Indonesia, to chart a roadmap for constructing a new, more ambitious resolution to curb human emissions of heat-trapping greenhouse gases. The agreement the UNFCCC eventually reaches and its reception by nation-states around the world, including the United States, will very likely determine the severity of the challenges our children, grandchildren, and great-grandchildren will face in the decades and centuries to come. □

Toward a Greener Campus

President **Daniel Weiss** has joined the signatories to the American College & University Presidents Climate Commitment. He is among more than 450 presidents who have pledged to eliminate their campuses' greenhouse-gas emissions in a period of time determined by each institution. "Lafayette is fully committed to creating a sustainable campus environment," Weiss says.

Advocating for enhanced sustainability is among the primary objectives of the College's new Department of Facilities Planning. Created principally from current College personnel and existing financial resources, the department will be responsible for the planning, development, construction, and cost-effective delivery of capital projects. **George Xiques**, formerly the College's assistant director of plant operations, will serve in the new position of manager of sustainability and environmental planning within the department.

In December, students in a Technology Clinic class wrapped up a two-semester project, commissioned by the Office of the President, to formulate recommendations for steps that would serve as "the groundwork for future actions toward a green Lafayette campus." Their report set forth many ideas for reducing the emission of greenhouse gases. "We appreciate and take very seriously the work that these students have done," Weiss says.

The College's Sustainability Committee, made up of faculty, students, and administrators, and the student organization LEAP (Lafayette Environmental Awareness and Protection) co-sponsored the College's participation in "Focus the Nation" Jan. 30-31. The campus community joined students, faculty, and others at more than 1,000 colleges, universities, high schools, and other institutions in a national conversation about global-warming solutions for America. At Lafayette, the "teach-in" included panel discussions and a national, interactive webcast called "The 2% Solution." □