Witness The ARCTIC

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Arctic Research at Dartmouth College

Dartmouth College has a long tradition of research and teaching in northern and polar studies. Originally founded in 1769 for the education of Native Americans, Dartmouth is the ninth oldest college in the U.S. Enrollment is approximately 1,800 graduate and 4,100 undergraduate students and includes the highest percentage of Native American students of any Ivy League institution. The college has 19 graduate programs in the arts and sciences, Dartmouth Medical School, Thayer School of Engineering, and Tuck School of Business, and has had a long collaborative relationship with the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) located nearby.

Dartmouth's Institute of Arctic Studies at the Dickey Center for International Understanding facilitates faculty and student research, teaching, and an understanding of scientific and social issues facing high-latitude regions through seminars, visiting scholars, student exchanges, institutional collaborations, and research and policy discussions. The institute administers an interdisciplinary Ph.D. program in polar environmental change offered through the Department of Earth Sciences, the Ecology and Evolutionary Biology Graduate Program, and the Thayer School of Engineering.

Dartmouth's involvement with polar regions began in the 1700s when student and explorer John Ledyard set out for northern Canada; he later walked across a vast region of Siberia. During the 1950s and 1960s, polar explorer Vilhjalmur Stefansson founded Dartmouth's Northern and Polar Studies Program and inaugurated the Stefansson Special Collection on Polar Exploration, which is now a premier library collection on history of the Arctic and Antarctic. Dartmouth's commitment to the bond between people and the natural environment continues today with its focus on research and education related to the science and human consequences of climate change, led by the Dickey Center's Institute of Arctic Studies. Dartmouth is also home to the Ice Drilling Program Office, which provides scientific leadership and oversight of ice coring and drilling activities funded by NSF.

This insert highlights current arctic research activities at Dartmouth College.

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Dartmouth College is situated in the rural town of Hanover, New Hampshire, located in the Upper Connecticut River Valley. The 269-acre campus is centered around a five-acre "green" (right side of image) that in 1770 was covered by pine trees up to 270 feet tall. Photo courtesy of Dartmouth College.

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Department of Earth Sciences

In the Department of Earth Sciences (www.dartmouth.edu/~earthsci/), research and teaching emphasize watershed processes, environmental geochemistry, glaciology, geomicrobiology, structural geology and geophysics, sedimentology, paleontology, and remote sensing. A number of faculty specialize in low temperature geochemistry, stable and radiogenic isotopes, hydrology, glacial dynamics, geomorphology, soils, and climate.

With funding from the NSF Arctic Natural Sciences Program, Meredith Kelly examines past extents of ice sheets and mountain glaciers to better understand both recent and ancient (10,000 to 100,000 years ago) climate events. Shrinking glaciers in Greenland's Scoresby Sund region have revealed partially fossilized vegetation that grew at times when glaciers were smaller than at present. By examining this vegetation, as well as sediment cores and moraines, Kelly and Integrative Graduate Education and Research Traineeship (IGERT) student Laura Levy are learning about glacial response to temperatures as high as, or higher than, at present.

Bob Hawley's research primarily focuses on the firn layer of polar ice sheets. "Firn" is old snow that has become granular and compacted. Hawley's investigations into techniques for measuring in-situ density profiles of polar firn in 2002 led to the development of a technique called Borehole Optical Stratigraphy, in which a video camera is lowered down a borehole in the ice, and a recording is made of the patterns of light and dark in the borehole walls. These patterns of light and dark are associated with variations in ice grain size and density and can be related to the annual layers commonly used to date ice cores in high-accumulation locations.

Hawley is currently working with researchers from the University of Texas, National Aeronautics and Space Administration (NASA), and Swiss Federal Institute of Technology on an NSF-funded project investigating the nature and cause of short-term velocity changes of the Greenland Ice Sheet. The research team is using an integrated observational approach, which includes borehole geophysics, Global Positioning Systems (GPS), and modeling, to examine interactions between the ice sheet, atmosphere, and base of the ice.

From March through June 2010, Hawley will complete a coast-to-summit trek

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Integrative Graduate Education and Research Traineeship (IGERT) students Laura Levy (right) and Simone Whitecloud (left) sampling a boulder for surface exposure dating on a glacial moraine near Kangerlussuaq, West Greenland, during summer 2009. Levy is working with Meredith Kelly in the Department of Earth Sciences examining recent and ancient climate events based on past glacial extents. The surface exposure dating method enables determination of the time that the boulder has been exposed to the atmosphere based on the concentration of cosmogenic-produced nuclides on its surface, such as Beryllium-10 and Aluminum-26. In this photo, Levy and Whitecloud are measuring the angle to the topographic horizon to calculate the amount of cosmogenic radiation the sample is exposed to. Horizon measurements are used to determine the amount of shielding by local landforms that incoming cosmic rays experience. Photo by Meredith Kelly.

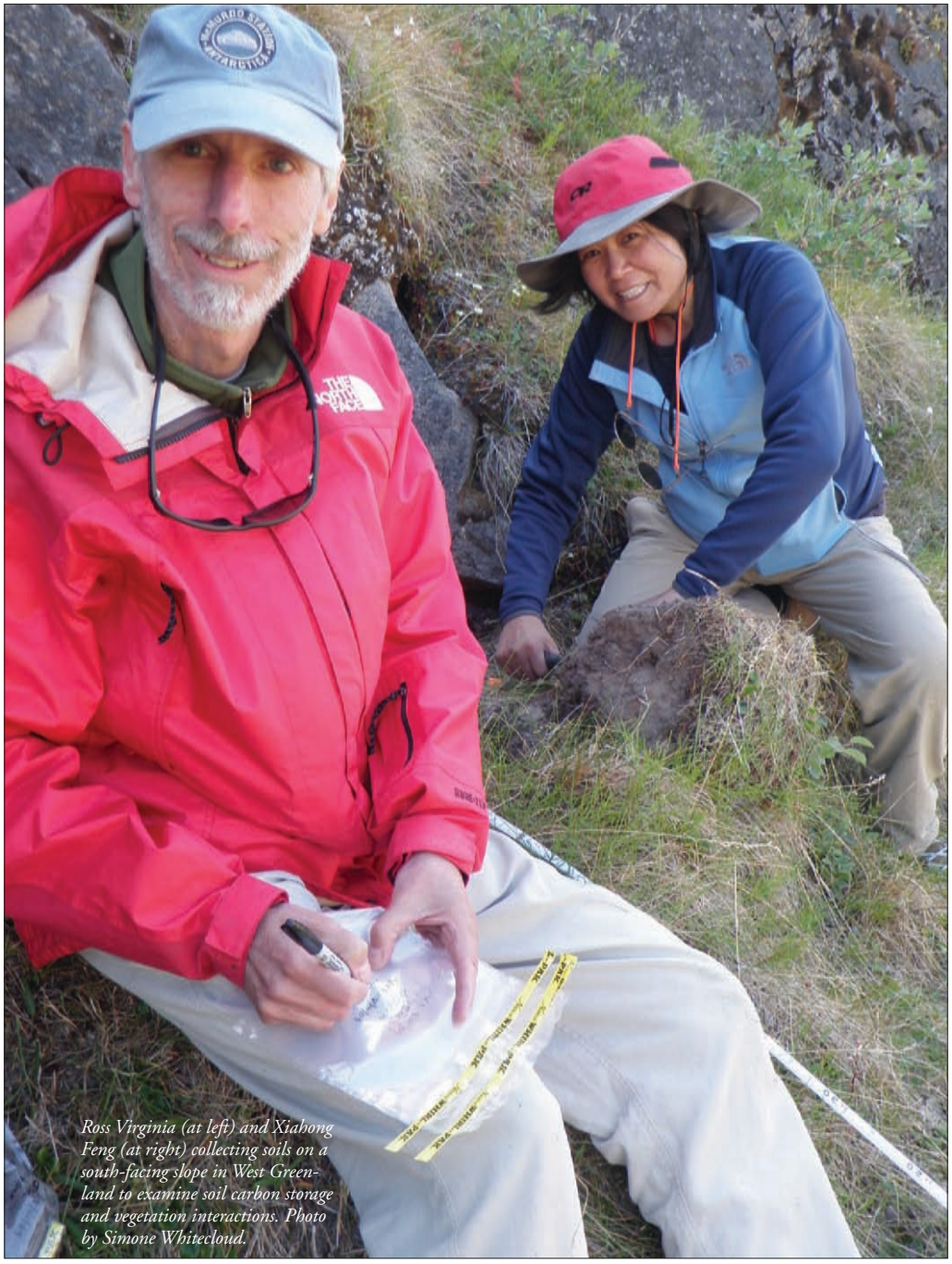
Ecology and Evolutionary Biology Program

The Ecology and Evolutionary Biology Program (http://www.dartmouth.edu/~biology/eeb/index.html) encompasses all areas of ecology, evolutionary biology, and related disciplines.

With funding from the U.S. Department of Agriculture, NSF, and others, Matthew Ayres studies the causes of spatiotemporal patterns in the abundance of forest insects and pathogens. One of his interests is the impact of climate change on biotic disturbance regimes. In August 2009, Ayres and graduate student Lauren Culler investigated entomofauna and aquatic habitats near Kangerlussuaq, Greenland. They installed iButton data loggers to record temperature at set intervals in order to study climatic gradients in aquatic habitats from the ice sheet down to a fjord. Culler is using these data to design experiments that test the mechanisms by which climate change affects freshwater insects. She received a Harp Fellowship from the Institute of Arctic Studies to facilitate her research.

Graduate student Simone Whitecloud works with ecology professor Mark McPeek studying plant interactions in arctic and New England alpine systems and how climate change affects these dynamics. Thirty percent of alpine species are also found in the Arctic. One of Whitecloud's current projects compares abiotic factors—temperature, wind, and growing season—in alpine and arctic plant communities as controllers of plant community composition. As part of this research, Whitecloud briefly worked in Greenland last summer preparing for an extensive sampling of plants there in summer 2010. She is also researching the effects of climate change on indigenous populations who are subsistence hunters and depend on arctic plants as food for large grazers.

Ross Virginia, director of the Institute of Arctic Studies, is an ecosystem ecologist interested in human influences on biogeochemical cycles. His research involves understanding how climate change alters soil biodiversity and plant-soil interactions in high latitude ecosystems and examination of carbon and nitrogen cycling in the polar deserts of Antarctica. He is a lead investigator on the McMurdo Dry Valleys Long Term Ecological Research (LTER) Program and is principal investigator on Dartmouth's NSF-funded Integrative Graduate Education and Research Traineeship (IGERT) Polar Environmental Change Program, which facilitates interdisciplinary graduate education and research related to the science and human dimensions of rapid environmental change in high latitudes. He is also involved with studies of the relationships between ecosystem science, environmental law, and policy.



Ross Virginia (at left) and Xiahong Feng (at right) collecting soils on a south-facing slope in West Greenland to examine soil carbon storage and vegetation interactions. Photo by Simone Whitecloud.

Thayer School of Engineering

The three main research areas at the Thayer School of Engineering (http://engineering.dartmouth.edu/) are engineering in medicine, energy technologies, and complex systems. Thayer faculty work on many aspects of ice physics and engineering. Thayer supports advanced instrumentation to characterize the microstructure and mechanical and electrical properties of ice and icy materials, including scanning electron microscopy with energy dispersive spectroscopy and electron backscatter diffraction capabilities, confocal Raman spectroscopy, and micro-computed X-ray tomography.

With funding from NSF's Office of Polar Programs, the Army Research Office, and others, Ian Baker studies the microstructural properties and processes of snow, firn, and ice. Understanding the pore structure in these materials is important to the correct interpretation of radar data used for mass balance calculations and for the development of accurate climate models. Baker and his colleagues are currently investigating whether and how impurities in ice cores, which are important for the analysis of past climates, have changed or moved and how their presence may affect interpretation of the ice core record.

Rachel Obbard, a research scientist, is adapting advanced materials characterization techniques for the study of brine channels in sea ice—she is currently working with ice cores from the Healy-Oden TransArctic Expedition (HOTRAX) and the Amundsen Sea.

Erland Schulson and Victor Petrenko study the behavior and modeling of ice as a brittle material and problems related to ice adhesion to surfaces such as airplanes, buildings, and roads.

Since the mid-1980s, Dartmouth has collaborated with the U.S. Army Cold Regions Research and Engineering Lab (CRREL). Don Perovich, a research geophysicist at CRREL, works on sea ice geophysics and the interaction of sunlight with ice and snow. He and IGERT graduate student Chris Polashenski are researching seasonal ice melt processes in the Arctic due to climate change.

Thayer is also home to NSF's Ice Drilling Program Office (IDPO), which is led by Mary Albert and collaborators at the University of Wisconsin-Madison and the University of New Hampshire. IDPO is responsible for scientific leadership and oversight of ice coring and drilling activities funded by NSF. Albert's research centers on transfer processes in porous media, including air-snow exchange in polar regions, and understanding the physical properties of firn for ice core interpretation. Albert is chief scientist of the Norwegian-U.S. Traverse of East Antarctica Project and has conducted many studies on snow and atmosphere interaction at Summit Camp in Greenland. She is also a co-investigator on studies of the North Greenland Eemian Ice Drilling (NEEM) ice core in Greenland, aimed at extending our climate record to the Eemian interglacial period, which began about 130,000 years ago.

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across the Greenland Ice Sheet as part of a collaborative project with the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). He and his team, which includes IGERT graduate student Gifford Wong, will dig snow pits and drill shallow boreholes to measure physical properties of the snowpack. The data will help interpret measurements of the ice sheet made from space. His traverse will pass near several routes taken by Carl Benson of CRREL during the 1950s and will allow him to observe long-term changes in the nature of the snowpack at many elevations.

Xiahong Feng investigates climate and environmental change using stable isotopes and meteorological and ecological observations. With funding from the U.S. Department of Energy and the Jet Propulsion Laboratory, one of her current projects will provide a quantitative understanding of the link between sea ice and moisture sources of arctic precipitation. Specifically, Feng and her team are studying the composition of oxygen and hydrogen isotopes in precipitation collected during storm events at stations in Barrow and Atqasuk, Alaska. By looking at isotopic ratios in precipitation in association with weather patterns and ocean surface conditions, the researchers can determine how much moisture in a given storm is contributed by the arctic sea surface and how much of this contribution is controlled by sea ice extent. Stations in Canada, Norway, Greenland, and Russia are under development for similar sampling programs.

In collaboration with Ross Virginia, professor of environmental studies, and researchers at the National Oceanic and Atmospheric Administration (NOAA), Norwegian Institute for Air Research, CRREL, and others, Feng also investigates ecological and hydrological responses of the Arctic to climate change using stable isotopic measurements of soil organic matter, plant tissue, and surface water.

Department of Physics and Astronomy

The Department of Physics and Astronomy has a strong program in theoretical and experimental space physics (http://www.dartmouth.edu/~physics/research/space.physics.html). Faculty members Jim LaBelle, Kristina Lynch, and Robyn Millan have a long history of rocket and balloon studies of the solar wind and its interactions with the Earth's magnetosphere. In the Arctic, these interactions appear as the aurora borealis or "northern lights." Instrument packages have been sent into the upper atmosphere from many northern locations including Alaska, Sweden, and Canada. Similar work has also been conducted in Antarctica.

Graduate Education in Polar Environmental Change

In 2008, Dartmouth's Dickey Center for International Understanding was awarded a five-year NSF Interdisciplinary Graduate Education and Research Traineeship (IGERT) grant to develop a Ph.D. program in polar environmental change (www.dartmouth.edu/~igert/). The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) is a collaborator on the project. The program integrates departmental graduate requirements in earth sciences, ecology and evolutionary biology, and engineering with an interdisciplinary framework for studying polar environmental change. While science-based, the program also considers the human dimensions of climate change and ways scientists can more effectively communicate with policymakers and the public about the consequences of rapid climate change.

An important part of the Dartmouth program is a field seminar in Greenland, a country currently experiencing the consequences of melting sea ice and receding glaciers. Students study and research terrestrial and aquatic ecosystems near Kangerlussuaq, snow and ice cryosphere processes on the Greenland Ice Sheet at Summit Camp, and environmental policy and science communication in Nuuk, the capital of Greenland.

Undergraduate Fellowships for Arctic Research

Part of Dartmouth's commitment to undergraduate education includes getting students involved in the research process early on—the Institute of Arctic Studies awards Stefansson Fellowships to undergraduate students whose research requires travel to arctic locations. Supported projects span the academic spectrum.

Elizabeth Parker spent the summer of 2009 at the National Oceanic and Atmospheric Administration's (NOAA) Auke Creek Research Station in Juneau, Alaska, studying how selection pressures related to latitude affect the lipid allocation strategy used by capelin fish. Hanul Kim spent the same summer working with William Fitzhugh, director of the Arctic Studies Center at the Smithsonian Institution, excavating ancient artifacts related to the cooperative relationship between Basque whalers and Inuit inhabitants in Newfoundland. In 2006, Mary Hiratsuka, a Native American studies major, traveled to Greenland to study preservation of the Inuit language—she worked closely with Aqqaluk Lynge and Lene Holm of the Inuit Circumpolar Council and with faculty at the University of Greenland.

As an undergraduate engineering major and 2007 Stefansson Fellow, Chris Polashenski tracked mercury in snowmelt as it entered the arctic ecosystem in Barrow, Alaska. He is now a third year Ph.D. student in Dartmouth's Polar Environmental Change Program working with Donald Perovich at the U.S. Cold Regions Research and Engineering Laboratory (CRREL) studying seasonal sea ice melt processes in the Arctic.

More information about the fellowship program is available at: http://dickey.dartmouth.edu/content/view/106/140/.

Undergraduate Elizabeth Parker (at right) received a Stefansson Fellowship award in 2009 to support her research on capelin, a type of smelt that is an important food source for birds and whales. She spent the summer working at NOAA's Auke Creek Research Station in Juneau, Alaska. Photo courtesy of Elizabeth Parker.

Art and Artifacts of the North

The Dartmouth College Library (http://library.dartmouth.edu/) houses rare research collections in polar studies that range from the latest scientific journal articles to historical photographs and manuscripts in the Stefansson Collection on Polar Exploration in the Rauner Special Collections Library. Much of Dartmouth's northern material was the result of the remarkable period of northern activity at the college in the l950s and 1960s, as well as support for Canadian and arctic endeavors on the part of then-president John Sloan Dickey.

Founded as the private research collection of the arctic explorer Vilhjalmur Stefansson, the Stefansson Collection is a rich body of material for research on the history of both the Arctic and Antarctic. It includes published expedition records and diaries, biographies, bibliographies, and general histories of the polar regions, as well as original logbooks, journals, correspondence, and personal papers of many polar explorers.

Many of the photographic holdings relate to the Canadian Arctic Expedition of 1913–1918, but there are also photographs of other expeditions, ships, events, peoples, flora and fauna, and equipment in the collection. The Stefansson Collection also contains paintings, drawings, prints, and sketchbooks, all of which are part of Dartmouth's overall collection of objects related to the art and material culture of Canada and the circumpolar North numbering more than 3,000 items.

Vilhjalmur Stefansson (1879–1962), a Canadian Arctic explorer and ethnologist, came to Dartmouth in 1947 and was instrumental in founding the Institute of Arctic Studies and the Northern and Polar Studies Program. He and his wife, Evelyn, remained involved in arctic studies at Dartmouth until his death. This image of him is from a lantern slide probably taken around 1916 during the Canadian Arctic Expedition and was hand-colored by him. Between 1906 and 1918, he spent ten winters in the Arctic, a record for any non-Eskimo at the time. Stefansson considered the Arctic "friendly"—suitable for human and animal habitation with untapped natural resources. He devoted his life to educating the world about the region and its strategic position in world affairs. Stefansson is buried at the Pine Knoll Cemetery in Hanover, NH. Photo coutesy of Dartmouth College.

During the International Polar Year 2007–2008, the Hood Museum of Art partnered with the Institute of Arctic Studies to develop the exhibit Thin Ice: Inuit Traditions within a Changing Environment (http://hoodmuseum.dartmouth.edu/exhibitions/thinice/index.html), which explored traditional Inuit life through 19th and early 20th century art and artifacts that indigenous arctic peoples used to survive challenging environments. The exhibit highlighted the impact of rapid climate change and the melting of sea ice on Inuit ways of life.

Institute for Applied Circumpolar Policy

The University of the Arctic's Institute for Applied Circumpolar Policy (IACP; http://iacp.dartmouth.edu/), a collaboration with the University of Alaska Fairbanks, was established in 2008 and is located at the Dickey Center for International Understanding at Dartmouth. The mission of IACP is to explore critical policy issues facing citizens of the circumpolar North.

In December 2008, IACP held a three-day conference on the subject of arctic climate change and security policy. The meeting, attended by scientists, policymakers, and representatives from indigenous communities, resulted in a report on the accelerating pace of climate change and increasing competition for resources and territorial claims that are creating pressures on the region. *Arctic Climate Change and Security Policy Conference: Final Report and Findings* was released by the Carnegie Endowment for International Peace, a conference partner, and is available at http://iacp.dartmouth.edu/meetings.

In October 2009, IACP sponsored similar discussions, attended by military and government officials, on the Arctic Council's Arctic Marine Shipping Assessment (AMSA). A draft report will be available in February 2010.

IACP has plans to offer executive training and education to increase northern capacity to respond to the human dimensions of climate change. IACP is also collaborating with the Tuck School of Business at Dartmouth to offer entrepreneurial educational programs for those whose livelihoods and way-of-life are altered by environmental change and, more generally, for the economic development of indigenous enterprises.