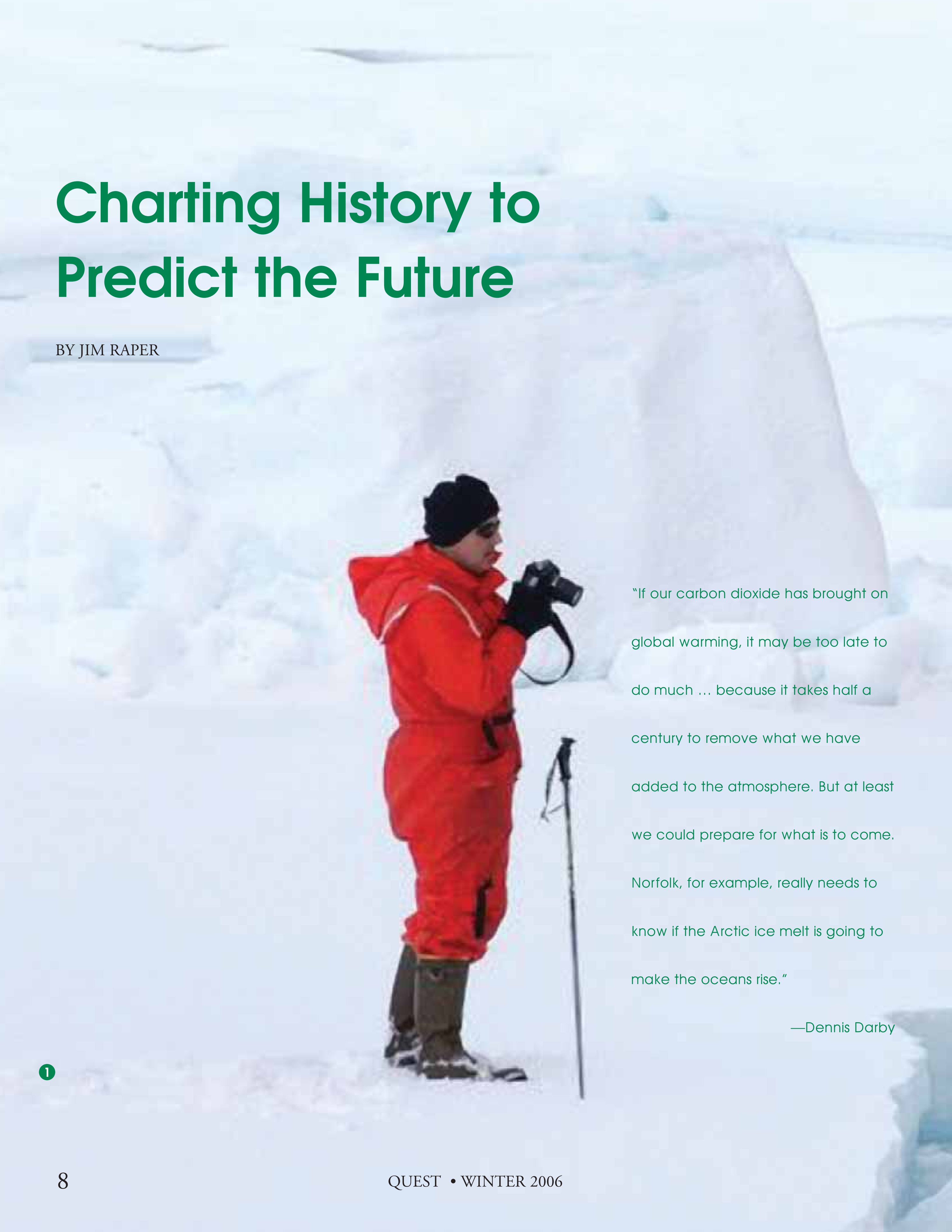
Charting History to Predict the Future

BY JIM RAPER



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—Dennis Darby

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(1) At left, Dr. Don Perovich, of Cold Regions Research and Engineering Lab in New Hampshire, photographs 8-foot-thick ice broken by U.S. Coast Guard Cutter Healy near the North Pole. **(2)** Top, above, D. Darby, M. Jakobsson (University of Stockholm), B. Elder and Perovich (both at CRREL) check dirty ice and ice properties at a sample station. **(3)** Bottom left, HOTRAX scientists core ice with auger to sample dirty sea ice. **(4)** At right, B. Elder and D. Perovich secure ice core samples for lab measurements. Photos by B. Erikson.

Satellite photos recorded an unusual melt-back of the Arctic Ocean ice cap during the summer of 2005, giving credence to dire warnings issued by some scientists about human-generated global warming. But comprehensive information about the ice cap exists only for the last three decades or so, making it difficult for anyone to say with certainty how much of the melting can be blamed on greenhouse gas buildup and how much is caused by climate patterns that have existed for tens of thousands of years.

"Understanding the climate system at the Arctic is so important to us, and we, as scientists, have two choices," explains Dennis Darby, professor of ocean, earth and atmospheric sciences at Old Dominion University. "We can watch for a few more decades, or more, to see what happens, and we probably will not like what happens. Or we can go back in time to try to create a climate history to better predict the future for the Arctic."

For Darby, going back in time means collecting physical evidence such as sediment cores from the bottom of the Arctic Ocean or sediment embedded in modern sea ice. Like police detectives searching for fingerprints and footprints, he and colleagues hope to bring convincing evidence to bear on the global warming debate.

"If our carbon dioxide has brought on global warming, it may be too late to do much about the situation we are in, because it takes half a century to remove what we have added to the atmosphere," Darby says. "But at least we could prepare for what is to come. Norfolk, for example, really needs to know if the Arctic ice melt is going to make the oceans rise."

Darby was interviewed in October 2005, a few days after he returned from the historic, 10-week Healy-Oden Trans-Arctic (HOTRAX) Expedition, which he helped to organize and supervise.

Expedition Gathers International Experts

More than 80 scientists and researchers from nine countries collected the richest trove ever of geologic samples and oceanographic data from the Arctic during the expedition. They also endured icing conditions and bitterly cold winds that explain why so little research has been done in the region. More is known today about the nature and origins of the surface of the moon than about the floor of the Arctic Ocean.

A marine geologist and Arctic specialist, Darby is an expert at "reading" ocean sediment samples and other geophysical data in order to gather clues about the climate patterns or cycles that a particular zone has experienced through the ages. He has perfected an iron oxide "fingerprinting" system that can establish where a grain of sand originated. Because wind currents, ocean currents and ice drift are indicators of climate change, the travels of a grain of sand can provide valuable information to scientists who are trying to develop climate histories.

Darby's expertise was recognized by his roles as chief scientist of the HOTRAX Leg 1 in the western Arctic off Alaska in June and co-chief scientist of the Leg 2 traverse of the central and eastern Arctic in August and September. HOTRAX was sponsored by the National Science Foundation, the U.S. Coast Guard and the governments of Norway and Sweden.

The expedition included a 47-member science team and 95 men and women of the U.S. Coast Guard who were aboard the USCGC Healy. As the nation's largest icebreaker and the one with the best accommodations for researchers, the Healy served as mobile headquarters for Leg 1 and Leg 2. Its skipper was Capt. Dan Oliver, who has more than 15 years of Arctic experience. Also during Leg 2, the Swedish icebreaker Oden, with 22 crew members and 47 scientists, journalists and technicians, rendezvoused with the Healy, two weeks before the vessels reached the North Pole.

Thick ice across the central Arctic required that the two icebreakers work together to clear the way. After more than three weeks together, they parted when the Oden went south to the Norwegian island territory of Svalbard and the Healy veered into the Fram Strait, east of Greenland, for its last week of coring. The expedition ended when the Healy arrived in Tromso, Norway, on Sept. 30.

The Healy's crossing of the Arctic Ocean was only the second ever by a surface vessel, and when the two ships made their way to the North Pole on Sept. 12 they set a record for latest-in-the-year visit by surface vessels. (Most previous visits to the North Pole had been in the warmest weeks of the summer, when ice is thinnest.)

Darby was responsible for coring operations on the Healy, and was joined during Leg 1 by two other members of the ODU oceanography faculty, Greg Cutter, professor, and Jens Bischof, research professor and lecturer, as well as by graduate student Steven Marshall. For Leg 2, Darby's sedimentology crew included ODU oceanography graduate students John Rand and Paula Zimmerman.

At a typical coring site, a 6,000-pound piston corer and smaller multi-corer were lowered 1-2 miles below the surface to obtain core samples from the ocean floor. The multi-corer gathered several cores at a time that reveal sediment layers of the first 12 inches or so of the ocean bottom. A piston corer obtained a single cylindrical sample at a time, each 4 inches in diameter and revealing sediment layering as far down as about 60 feet. Altogether, the Healy collected about 1,500 feet of sediment core during HOTRAX, more than any coring expedition ever in the central Arctic Ocean. Some of the cores come from areas of the Arctic that have rarely been visited by researchers and where existing cores are no longer than 10 feet.

Because the core samples are temperature sensitive—freezing or heating could compromise the data that scientists glean from the sediment layers—the samples were stored in a climate-controlled container lashed to the deck of the Healy. At the conclusion of the expedition, the 25,000-pound container was off-loaded and taken to the University of Stockholm, which served as the post-expedition research coordination center.

Just a few days into October, as the Healy was returning to the United States, it encountered a fierce storm in the North Atlantic that ripped a portion of a crane from the cutter's bow. "I had a recurring nightmare about losing our container to such a wave in the Norwegian Sea. We were supposed to run into 25- to 30-foot seas during the crossing into Tromso, but the storm moved south, away from us," Darby says. "Then I later learned about the storm from the Healy's skipper. If our container had still been on the bow

Clockwise, from top left: (1) D. Perovich (CRREL) with ice thickness electromagnetic measuring device.
(2) D. Gaona (USCG) and D. Darby (ODU) struggle with large pipe wrenches to remove collar from core barrel that bent when it hit rocks on the sea floor. Paula Zimmerman, ODU graduate student, watches.
(3) D. Darby and crew member remove core liner from core barrel. **(4)** L. Polyak (Ohio State University) and D. Darby examine split core segment onboard Healy.
(5) Large dropstone from iceberg found about 4 meters below the sea floor in a HOTRAX core. **(6)** D. Darby gets a closer look with hand-lens. **(7)** J. Bischof and D. Darby (both ODU) unwrap plastic core liner before cutting multi-core tube cores in Healy science lab. **(8)** D. Darby and J. Bischof cut plastic liner for multicorer. P. Kalk, core tech, in background. **(Center)** D. Darby examines sand from a core under a microscope in Healy's science lab.
Photos by B. Erikson, S. Marshall and M. Jakobsson.


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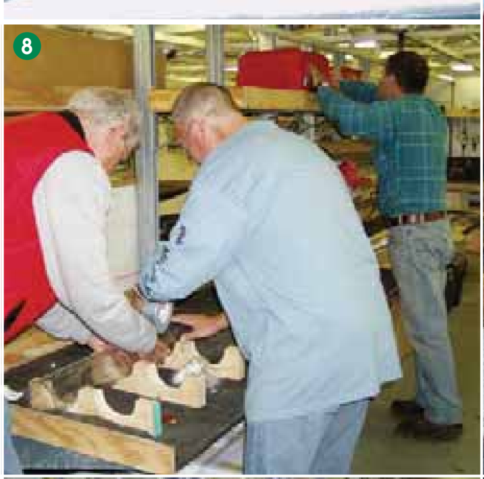
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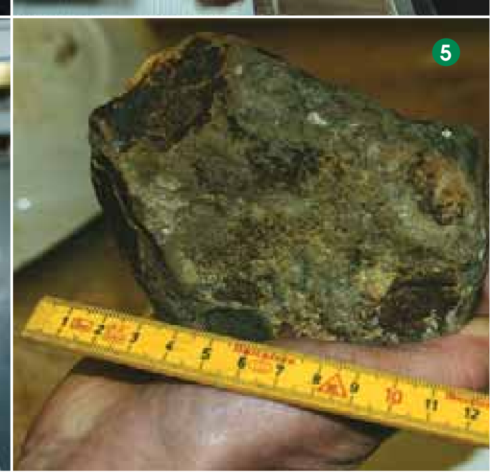
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next to the crane, it could have been lost. And with it, most of our work."

Analyzing the Data

With the end of the shipboard expedition came the beginning of two or three years of research that Darby and other scientists must accomplish to wrap up HOTRAX. In addition to sediment records, their reports will focus on Arctic Ocean bottom mapping, water currents, deep-water exchanges between the two distinct basins of the ocean, glacial ice erosion on ridges as deep as 3,000 feet, and underway profiling of sea-ice thickness. Information gathered from the icebreakers will elaborate and expand upon data received regularly from satellites and sensor buoys. Satellite monitoring can show changes in the surface area of the ice cap, but only from on-site tests and observations can the thickness and physical properties of the ice be fully assessed.

Darby says he and colleagues will try to create a paleoclimate record for the Arctic. Sedimentation rates vary, but a bottom sample only a few inches deep can take researchers back more than a thousand years. "We hope to end up with a pan-Arctic record of climate change over the last 60,000 to 100,000 years and perhaps older," he says. "This record will provide sufficient detail to be used to better understand the interaction of the two halves of the Arctic Ocean in climate change and their relationship with the rest of the world's oceans. This is critical to our understanding of how sudden changes in climate occur."

The Arctic climate is particularly interesting and important because of its effect on more temperate zones. Perhaps the most often heard example is glacial melting and water expansion due to warming, causing all oceans to rise. But the relationship is much more complex than that, Darby says. The fluctuating atmospheric pressure changes of the Arctic Oscillation seems to cause warming in parts of the Northern Hemisphere during one of its phases, then flip-flops to an opposing phase. In one phase, it causes more ice and low salinity water to be exported from the Arctic through Fram Strait. This causes cooling in Scandinavia, which could spread throughout the Northern Hemisphere. Also, research has shown that the Arctic is a critical "heat sink" for the entire Earth, and a diminishing ice cover means more heat will be absorbed by the ice-free ocean in the summer, lessening the Arctic's ability to absorb heat and prevent runaway global warming. "If the Arctic diminishes in its role as a heat sink," Darby says, "global warming will accelerate far beyond predictions based on models."

Early Signs Support Melting Scenario

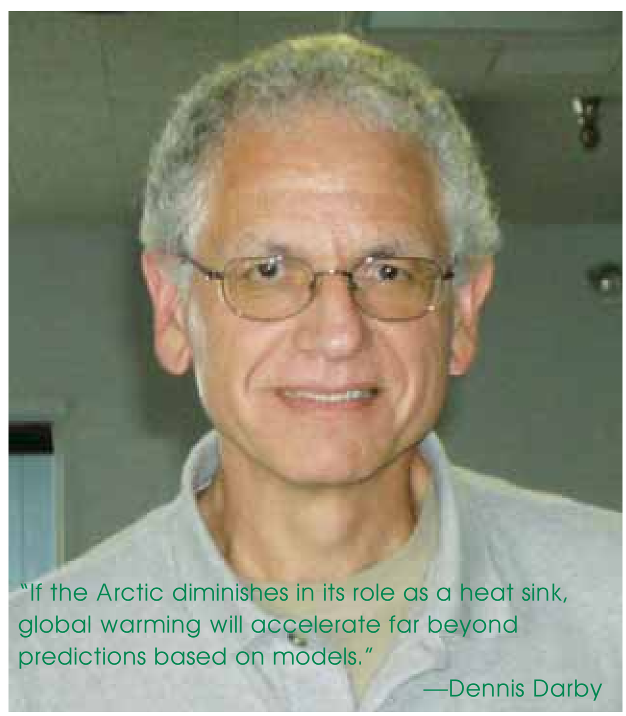
Much of the anecdotal evidence that Darby collected during Leg 2 supports a significant melting scenario. "The first thing we found that was a surprise was the degree of melting. We had deep meltponds as far north as 74 degrees, and the ice was very weak as far north as 82 degrees. Even north of there we found patches of rotten ice due to more than normal melting."

Nevertheless, there also were days when global warming seemed far-fetched. During Leg 1, the Healy became stuck in ice and was trapped for four frigid days before heroics of its crew managed to free it. After leaving the North Pole, the two icebreakers ran into ice so thick (about 12 feet and with pressure ridges more than double that depth) that progress almost stopped and there was talk of "wintering over," Darby says.

More routine icebreaking, of ice only 3 feet or 4 feet thick, hardly slows down the 420-foot Healy. In thicker ice, however, the vessel must back up occasionally and return for a bow ram. "You get used to the ramming after awhile," Darby says. "It really is amazing how the Healy can back up two ship's lengths, and then its 30,000-horsepower engines accelerate its 19,000 tons to 7 knots in less than 10 seconds."

How did he know so much about the cutter's ramming capability? "I was allowed to drive it once in 3- to 6-foot ice for three hours straight. I averaged 6.5 knots for the three hours. Not bad for a novice."

Michele Darby, an ODU eminent scholar and graduate program director for the Gene W. Hirshfeld School of Dental Hygiene, says her husband always picks remote, adventurous places to conduct research. "If it's not the jungles of Colombia in South America, it's the Arctic. After over 35 years together, I'm used to it. But, one of these future Arctic trips, I would love to tag along. I could help with the dental health needs of the crew, because that is the most common medical emergency on these expeditions."



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