authors say, as the number of links a page has to and from other sites increases. Also, "when editors feel they need more references within a category, they lower the entry barriers."

Other search engines, such as Alta Vista, Lycos, and Hotbot, dispense with the human editors and use software "spiders" to identify candidates. Precise details about how the spiders operate are closely guarded trade secrets, which stirs the suspicion of Introna and Nissenbaum. Pages with many links from other valued sites, especially sites that themselves have many "backlinks," are likely candidates.

Getting noticed by a search engine is only the first hurdle for creators of Web pages, the authors note. "Because most search engines display the 10 most relevant hits on the first page of the search results, Web designers jealously covet those . . . top slots." Search engine owners are reluctant to detail their ranking rules, but a site's chances of doing well apparently improve if it has many keywords and they are high up in the document, and if many other sites are linked to it.

In the end, Introna and Nissenbaum argue, "popular, wealthy, and powerful sites" threaten to overwhelm the Web's other voices. They urge full disclosure of search engines' underlying rules, and the development of "more egalitarian and inclusive search mechanisms."

What Caused the Ice Ages?

"Ice, Mud Point to CO_2 Role in Glacial Cycle" by Richard A. Kerr, in *Science* (Sept. 15, 2000), 1200 New York Ave., N.W., Washington, D.C. 20005.

Every 100,000 years or so for the last million years, vast, miles-high glaciers have moved southward from the Arctic, relentlessly driving all life before them. The last ice age ended only about 10,000 years ago, when the ice retreated to its present polar extent. What caused these monstrous ice ages? In recent decades, notes Kerr, a *Science* staff writer, scientists have come to think that the glacial cycles were somehow linked to slight variations in the shape (or eccentricity) of the Earth's orbit that occur at about the same 100,000-year intervals. John Imbrie, a paleoceanographer at Brown University, has also proposed that the ice sheets themselves amplified the orbital variations' weak effects.

Kerr reports that Nicholas Shackleton, a paleoceanographer at the University of Cambridge (whose original research also appears in this issue of *Science*), has found a new actor in the drama: carbon dioxide. Shackleton "finds that orbital variations may muster carbon dioxide into and out of the atmosphere, and the resulting waxing and waning of greenhouse warming may drive the glacial cycle."

The mixture of heavy and light oxygen isotopes preserved in skeletons in deep-sea mud and in ancient air bubbles in Antarctic ice provided Shackleton with windows on conditions millennia ago.

The isotope mixture in the fossils of microscopic, bottom-dwelling marine animals depended partly on the mixture of oxygen isotopes in the seawater in which they lived—and that, in turn, depended on the amount of ice trapped on land. But the isotope mixture in the skeletons also partly depended—though to a lesser extent, it was long thought—on the temperature of the seawater. This unknown influence made the isotope mixture in the skeletons an imprecise gauge of the ice volume as it varied over time. Using that gauge, Shackleton saw an apparent correlation between the ice-volume changes and the 100,000-year orbital variations, although the link "was not impressive," Kerr says.

Shackleton then looked at air bubbles in a 400,000-year-long ice core from Antarctica. The oxygen-isotope composition of that air was not affected by ocean temperatures, but was affected by the volume of ice that existed. By comparing this geologic record with the other one, writes Kerr, Shackleton was able "to tease out [the] intimately entangled climatic influences with unprecedented accuracy."

To Shackleton's surprise, "deep-sea temperature accounted for more variation of oxygen isotopes than ice volume did." Indeed, deep-sea temperature, atmospheric carbon dioxide as recorded in the gas bubbles, and orbital eccentricity "all varied in step, on the same 100,000-year cycle," Kerr reports, while ice volume "lagged behind," apparently ruling out ice as a prime mover.

Shackleton sees the lockstep of the three factors "as a sign of cause and effect," says Kerr. When an ice age began, in his view, "changes in eccentricity—presumably by shifting the distribution of sunlight across the globe—could have decreased atmospheric carbon dioxide, weakening the greenhouse and cooling the ocean and atmosphere." The opposite changes would have occurred at the ice age's end.

Imbrie and others agree that Shackleton has made "a major step forward." But many questions remain, geochemist Daniel Schrag of Harvard University told Kerr. How, for example, do orbital variations "muster" carbon dioxide into and out of the atmosphere?

Animal (Research) Rights

"Science and Self-Doubt" by Frederick K. Goodwin and Adrian R. Morrison, in *Reason* (Oct. 2000), 3415 S. Sepulveda Blvd., Ste. 400, Los Angeles, Calif. 90034–6064.

The animal rights movement has been condemning scientists' use of animals in biomedical research for two decades now, with some extremists even resorting to terrorism. In April 1999, for instance, the Animal Liberation Front caused more than $1.5 million in dam-

EXCERPT

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The nature-nurture dichotomy, which has dominated discussions of behavior for decades, is largely a false one—all characteristics of all organisms are truly a result of the simultaneous influences of both. Genes do not dictate destiny in most cases (exceptions include those serious genetic defects that at present cannot be remedied), but they often define a range of possibilities in a given environment. The genetic endowment of a chimpanzee, even if raised as the child of a Harvard professor, would prevent it from learning to discuss philosophy or solve differential equations. Similarly, environments define a range of developmental possibilities for a given set of genes. There is no genetic endowment that a child could get from Mom and Pop that would permit the youngster to grow into an Einstein (or a Mozart or a García Marquez—or even a Hitler) as a member of an isolated rain-forest tribe without a written language.

Attempts to dichotomize nature and nurture almost always end in failure. Although I've written about how the expression of genes depends on the environment in which the genes are expressed, another way of looking at the development of a person's nature would have been to examine the contributions of three factors: genes, environment, and *gene-environment interactions. It is very difficult to tease out these contributions, however. Even under experimental conditions, where it is possible to say something mathematically about the comparative contributions of heredity and environment, it can't be done completely because there is an "interaction term." That term cannot be decomposed into nature or nurture because the effect of each depends on the contribution of the other.*

—Paul R. Ehrlich, a professor of population studies and of biological sciences at Stanford University, in *The Chronicle of Higher Education* (Sept. 22, 2000)