version of the problem is acute. Many levels are concurrently active. For example, the internal parts of syntactic structures must cohere in specific ways, but they must also link externally to phonological and prosodic structures, to conceptual structure, and to transient background structures. Although the time course for elaboration of these intricately cross-linked structures during processing is not well understood, it is very likely that the same element must be simultaneously linked to multiple sites. Whether such linkages could be effected by degrees of synchrony is unknown. Jackendoff argues that these problems and their nonlinguistic analogs have not been addressed in current neural accounts, and plausible solutions must address the special structural constraints he outlines.

As the book's subtitle suggests, Jackendoff addresses many other topics—both unconventional and conventional. He uses the framework of the three generative systems to consider some provocative evolutionary ideas and language processing issues. He tackles questions of meaning and its treatment within linguistic theory head on: his tripartite architecture incorporates a conceptual system directly modeled on the combinatorial principles that animate syntax and phonology. His discussion of nativism ranges widely from traditional concerns about the nature of universal grammar (namely, the set of innate constraints on possible human languages) to questions about how specific behavioral constraints could be represented in the genetic code. It's a rich mix, but one laid out in refreshingly plain language.

Jackendoff also includes plenty of basic linguistics, but his emphasis is on linguistics in a broader cognitive mode. Reading the book, some linguists, psycholinguists, and artificial intelligence researchers may find themselves muttering, "Well, this is what I've been saying for years. What's the big deal?" The author does not claim that there are not multiple precedents for his perspective. What he does argue—and I think he is entirely correct—is that these views have not been articulated in a systematic way that ties the components of formal linguistic theory to the broader issues in human cognition. *Foundations of Language* advances a unified framework for building those links and offers a formidable array of examples and arguments in support of that framework. Whether or not you agree with Jackendoff's proposed revisions, he provides challenging ideas and a fruitful combination of observation and analysis. My advice is to read the book for the exceptional effort at synthesis that it is.

BOOKS: HUMAN EVOLUTION

Out of the Chattering Ice

Robert N. Proctor

Neocatastrophism has become fashionable in climatology and the geosciences. In the 1970s, there was the discovery that the Mediterranean every now and again pinches off from the Atlantic, dries up, and then catastrophically refloods when the Straits of Gibraltar are once again breached. The 1980s brought us the idea that meteorites could cause mass extinctions, notably the Cretaceous-Tertiary event later traced to the Chicxulub crater beneath the Yucatan Peninsula. The 1990s introduced the suggestion that all the world's oceans froze, perhaps as far down as a kilometer, for a few million years in the Neoproterozoic, and that the melting of this snowball Earth opened up some of the niches that made possible the Cambrian explosion. Today, geomorphologists are realizing that the Grand Canyon is surprisingly young: Five or six million years was the commonly cited age only a decade ago, but the uplift of the Colorado Plateau that led to the cutting of the canyon may actually be only a million or so years old—a revision creationists will no doubt try to exploit.

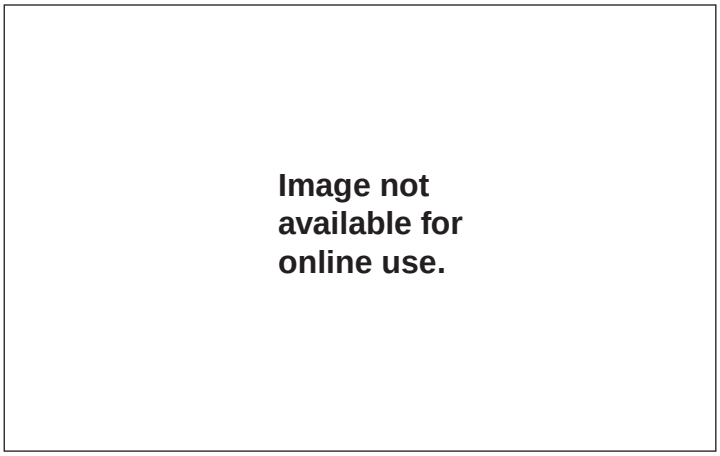
The author is in the Department of History, Weaver Building, Pennsylvania State University, University Park, PA 16802, USA. E-mail: rnp5@psu.edu

Historians have not yet sorted out the causes of all this attention to calamity. It could have something to do with those apocalyptic scenarios fretted over in the Reagan era (e.g., nuclear winter), or with social critics of the 1960s and 1970s gaining professorships (Stephen Jay Gould used to call himself a "dialectical materialist"), or even with the fact that catastrophes make good television. One also has to reckon, though, with the blunt fact that nature has been reasserting itself against the blinders of gradualistic prejudices, as Gould and others began to stress more than 20 years ago. Some catastrophes are just plain real.

A Brain for All Seasons
Human Evolution and Abrupt Climate Change
by William H. Calvin

University of Chicago Press, Chicago, 2002. 349 pp. $25, £16. ISBN 0-226-09201-1.

The first two-thirds of William Calvin's *A Brain for All Seasons* is a creative attempt to incorporate abrupt climate change into theories of human origins. A neurobiologist at the University of Washington School of Medicine, Calvin builds on the discovery, a decade or so ago, that the temperature swings we have experienced over the past 8000 years are small compared with fluctuations in the deeper past. Contrary to previous assumptions of slow and stately coolings extending over millennia, ice cores from northern Greenland and elsewhere have shown that ice ages can begin quite suddenly, perhaps even within a space of only a few years. Climatologists believe that interruptions in the flow of the Gulf Stream may be one of the causes of such abrupt coolings: If, for some reason, the warming waters flowing from the south cannot reach higher latitudes in the North Atlantic, glaciers will start growing, reflecting more and more sunlight into space, causing runaway cooling.



Cold from the warming. Calvin argues that increased global warming may flip the climate into a cold mode in which ice sheets again appear far south of these Greenland glaciers.

Calvin argues that these repeated coolings had profound consequences for human evolution. Abrupt coolings were accompanied by prolonged droughts at lower latitudes, reducing herbivore populations and shrinking the numbers of predators eating those herbivores. In Africa circa 2 to 3 million years ago, when bipedal primates first began making and using stone tools, abrupt climate change rewarded those creatures able to improve their hunting powers. "Whiplash" climate fluctuations forced hominid populations through hundreds of severe-drought bottlenecks, during which those with the bet-

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ter survival skills (including bigger brains and greater intelligence) survived to flourish when the good times began again. Calvin claims that selection did not work on braininess per se, but rather on the faculties responsible for things like the neuromotor skills involved in accurate throwing, which had a long "learning curve." Tool-using hominids had invented a novel techno-niche not available to other predators (like the big cats), and when proto-human brains began to expand to capitalize on the selective advantages of accurate throwing, other faculties were dragged along. The net result was cerebral modernity, a flexible and capacious hominid brain "for all seasons."

This is a variant on the "man the hunter" thesis, but with a couple of new and intriguing twists: Calvin holds that the improvement was not slow and steady but episodic, according to what he calls "catastrophic gradualism." He proposes that these warm-to-cold, boom-to-bust cycles (limiting access to hoofed prey) augmented brain function in tiny spurts, as ice-age oscillations ("chatterings") and the resulting bottlenecks sharpened hunting skills. Calvin also elaborates his theory of how chimp-like australopithecines first began to hunt with tools: Stones or sticks, he says, may originally have been thrown into herds gathered at water holes, in the hope that the commotion might cause an animal or two to be trampled. The predators eventually learned that sharper stones worked better than dull stones and that, by battering the edges, they could be made sharper still. Certain shapes were then found to fly farther and hurt more than others, whence the origin of all those enigmatic Acheulian "handaxes."

The last third of the book strays a bit, offering nonspecialist readers an excellent overview of the geophysics behind abrupt climate change. Calvin focuses on the forces involved in stabilizing the Gulf Stream and North Atlantic Current—the "Achilles heel" in much recent climate modeling (though itself perhaps only an index of some larger process). The flow of the book is interrupted here to a certain extent, as human evolution is put on a back burner and our attention is drawn to the dangers posed to modern civilization should global warming launch us into cooling mode. Calvin gets graphic: We might first feel the effects of drought, including crop failure, massive fires from lightning, and dust storms kicked up by loss of vegetation. Populations would crash, and wars would break out over control of resources. Calvin is clearly aware of the uncertainties in such prognostications, but he also reminds us that if history (as preserved in the ice cores) is any guide, we are due for a cooling. Prior to the relatively mild climate of the past eight millennia, there were catastrophic cooling events like the Younger Dryas (12,900 to 11,600 years ago), when North Atlantic temperatures dropped by about 8°C. If such a cooling were to repeat today, it would devastate most of the world's agriculture and then some.

Readers may be disappointed to find certain topics missing from the text: Calvin talks about bombing ice jams in Scandinavian fjords to prevent catastrophic releases of fresh water into the North Atlantic, and speculates on the value of reopening the trans-Panama oceanic throughway closed off 3 to 4 million years ago, but we hear little or nothing about some of the more obvious ways to reduce warming—and therefore the threat of abrupt cooling—such as conservation, curbing greenhouse gases, and a serious shift to globally responsible fuels.

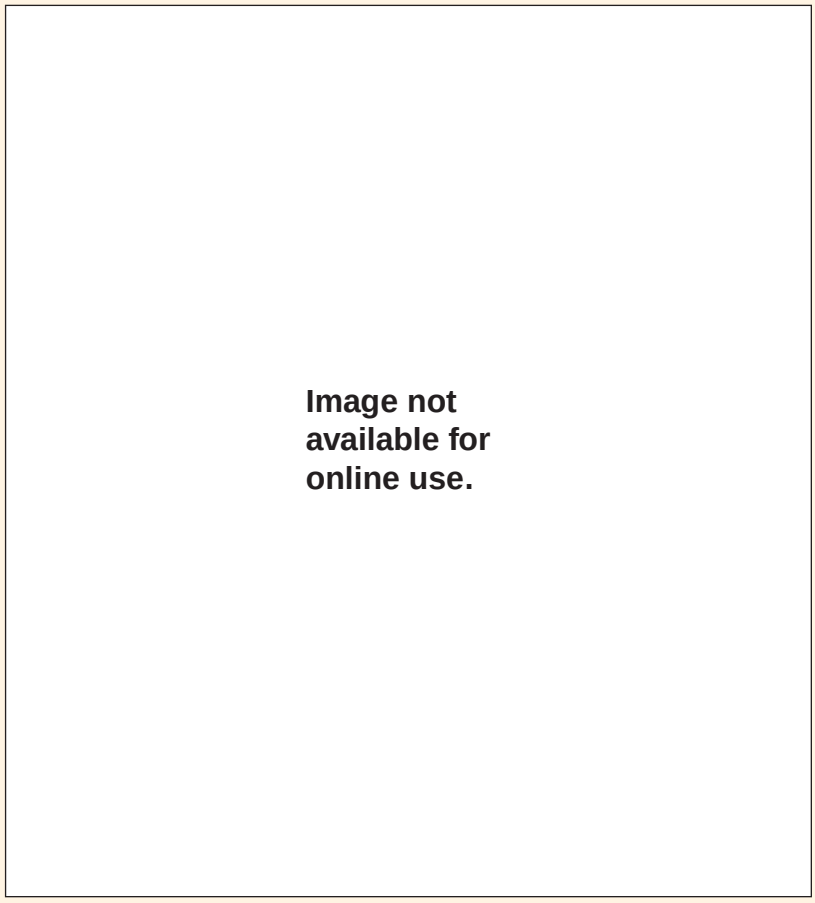
Calvin does make it clear, though, that too much focus on global warming in itself—i.e., the heat—could obscure this larger danger of catastrophic cooling. He aptly cites Ray Pierrehumbert's caution that if one pulls on a sleeping dragon's tail without knowing how much it takes to waken it, one had better be prepared for the unexpected.

BROWSINGS

Emmet Gowin: Changing the Earth. Aerial Photographs. *Jock Reynolds*. Yale University Press, New Haven, CT, 2002. 164 pp. $45. ISBN 0-300-09361-6.

Emmet Gowin: Changing the Earth, Aerial Photographs. An exhibit at the Yale University Art Gallery, New Haven, CT, through 28 July 2002; Corcoran Gallery of Art, Washington, DC, 26 October 2002 to 6 January 2003; Utah Museum of Fine Arts, Salt Lake City, UT, 19 April to 13 July 2003; Yellowstone Art Museum, Billings, MT, 23 August to 30 November 2003; James A. Michener Art Museum, Doylestown, PA, 10 January to 4 April 2004; El Paso Museum of Art, El Paso, TX, 2 May to 18 July 2004; Henry Art Gallery, University of Washington, Seattle, WA, 7 August to 7 November 2004; Fogg Art Museum, Harvard University, Cambridge, MA, dates to be determined.

Most of the 92 aerial photographs in this collection capture patterns of light and form caused by human disruptions of the land's surface. Gowin's finely toned black-and-white images include scenes of pivot-irrigation agriculture in Kansas, mining scars in Arizona and the Czech Republic, the battlefields of Kuwait, and weapons disposal sites in Utah. *Sedan Crater, Northen End of Yucca Flat...1996* (right) is one of the many taken at the Nevada Test Site. The catalog also contains an essay by Terry Tempest Williams and an interview of Gowin by Philip Brookman.



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