dependent on U.S. charity and on employment at the military base. "The tragedy of Kwajalein and the Marshall Islands," the authors say, "was that the only thing worse than the American presence would be the absence of the American presence."

The chapter on the authors' visit to Iran (approved by the Iranian government at the last minute, just as their flight to Tehran was about to depart) is fascinating, because we at least get to hear Iranians defend their right to enrich uranium—a side of the story we seldom encounter in the American press. The chapter on Russia, on the other hand, is weak. After the Cold War, the United States began giving millions of dollars a year to the Russian nuclear weapons complex to help with security upgrades and to give Russian weapons scientists a reason to stay in place rather than moonlight for Iran or North Korea. Hodge and Weinberger say they wanted to visit Russia "to see if the billions being spent on preventing nuclear terrorism . . . were really making the world any safer"—as if in just a few days they could find out anything that countless government studies have not already found. In fact, they were denied access to almost everything they wanted to see in Russia. The chapter jumbles secondhand accounts of the Russian nuclear complex with stories of brief encounters with uncooperative Russian officials. The chapter is also marred by the patronizing attitude that the authors adopt toward their hosts: For example, the Minister of Atomic Energy does not just have bad teeth, he suffers from "Soviet dentistry"; and, although Bill Clinton's peccadilloes go unmentioned, Boris Yeltsin is "erratic, binge-drinking president Boris Yeltsin."

What are we left with at the end of our nuclear tour? Although Hodge and Weinberger are forced by the scope of their travels to miniaturize their account of each facility, by juxtaposing so many sites they are able to convey the surprising disconnectedness of people at each facility from the people at all the other facilities. In addition, readers get a sense of the breathtaking scale of the nuclear weapons enterprise that has been built in the shadows since the early 1940s. It is a project on the scale of the pyramids, and if Hodge and Weinberger are to be believed, no one quite knows what to do with it anymore.

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NEUROHISTORY

Recovering the Past

Robert J. Richards

ON DEEP HISTORY AND THE BRAIN. Daniel Lord Smail. xiv + 271 pp. University of California Press, 2008. $21.95.

The doyen of modern historical research, the great 19th-century scholar Leopold von Ranke (1795–1886), maintained that history should be conducted as a science (*Wissenschaft*), a systematic inquiry based on the kind of evidence that would allow the explanation of particular events. He also thought of it as an art, one that recreated in imagination the individual actions and accomplishments of human beings. But as science or as art, history had the aim, as Ranke famously put it, to demonstrate "wie es eigentlich gewesen [ist]" (how it actually was).

In Ranke's view, written documents—letters, diaries, government dispatches and civic records—formed the indispensable kind of evidence required for this purpose. Documents allowed one to determine those plans and schemes that revealed human motivation, intention and judgment, either directly or as inferred between the lines. Without documents, he believed, we could have no reliable evidence of human thought and action; and so he explicitly rejected speculation about what is usually and anomalously called "prehistory," that period prior to the advent of writing.

Ranke's conviction reflected a general assumption of 19th-century scholars, especially those in the German tradition: namely, that language was a distinctive trait of human beings and was a causal factor in becoming human. Georg Wilhelm Friedrich Hegel (1770–1831), in his *Lectures on the Philosophy of World History*, argued further that the rational spirit arose only when the writing of history itself did. In his view, the period prior to the advent of writing existed outside the sphere of history proper, because human beings did not yet have the tools to recognize a past and its bearing on the present so as to formulate laws and establish a state. For Hegel it was a period of "prehistory" (*Vorgeschichte*).

In the same year as Hegel's death, the young Charles Darwin (1809–1882) embarked on his *Beagle* voyage. The theory that he wrought in the wake of his travels infused history into the very bones of the animals he studied; history thus had consequence for all organisms, not just human beings. In *On the Origin of Species*, he reflected precisely on the implications of this new understanding:

> When we no longer look at an organic being as a savage looks at a ship, as at something wholly beyond his comprehension; when we regard every production of nature as one which has had a history; . . . when we thus view each organic being, how far more interesting, I speak from experience, will the study of natural history become!

Daniel Lord Smail, in his intriguing little book *On Deep History and the Brain*, recognizes Darwin's accomplishment and performs the reciprocal task of showing the relevance of biology for history. He thereby attempts to render moot the 19th-century concept of prehistory.

As introduction to his study, Smail describes the billowing spread of Ranke's restrictive methods during the late 19th and early 20th centuries. Rankean history furnishes the foil to Smail's argument. Smail contends that evolutionary considerations and related advances in the neurosciences offer ways of traversing the divide between the earliest eras of human appearance and the documented periods of human history. The central part of his book

sketches the explanatory possibilities of the new sciences—especially as instantiated in sociobiology and theories of brain development. Those disciplines provide instruments not only for capturing the early stages of human becoming but also for enriching our understanding of even those periods that have been amply documented.

Since Ranke's time, historians have generally constructed their explanatory narratives on a foundation of documents, but not exclusively so. Even the father of scientific history, Thucydides, showed how the historian might reach back to undocumented periods (for him, the times prior to the Peloponnesian War) to recover a reasonable portrait of that past. In arguing that no great enterprises could have occurred prior to the war that he described, Thucydides employed archaeological remains (including evidence from skeletons), sociological inferences (from habits of rustics to those of city-dwelling ancestors, for example), economic analyses (such as lack of accumulated capital for great undertakings), linguistic implications (for instance, the early Greeks having no common name for themselves), statistical analyses (as applied to Homeric exaggerations, say) and a variety of other means to extend the scope of a recoverable past. Few historians today would hesitate to use the techniques pioneered by Thucydides, along with the several others that have subsequently become available. Moreover, the metaphysical justifications stemming from German idealism for restricting historical analysis to the written word have completely evanesced. Smail, of course, knows this. His aim in specifying the Rankean restriction seems more to make obvious the utility of evolutionary theory and neurobiology for augmenting the historian's repertoire of investigative resources.

The chapters that describe these modern sciences are intelligently done, providing an account that is detailed enough to satisfy curious readers interested in exploring these matters further. The heart of Smail's proposal for rethinking historical techniques concerns overcoming two barriers: that between biological evolution and cultural evolution, and that between emotional development and rational thinking. Usually cultural evolution and rational thinking have been the province of historians, whereas natural scientists have concerned themselves with biological evolution and emotional development.

Some scholars, including Stephen Jay Gould, have suggested that at a certain point in human evolution, Lamarckian cultural acquisition and inheritance took over from Darwinian natural selection of genetically based traits. Smail believes this to be a too-hasty abandonment of Darwinism. Drawing on ideas from Donald Campbell, David Sloan Wilson, Richard Dawkins, Clifford Geertz, and Robert Boyd and Peter Richerson, he proposes a role for the natural selection of cultural traits.

The process Smail suggests would not be biological but would instead occur through conceptual variation and selective retention of ideas. Important cultural acquisitions—for instance, an early Indian tribe's adopting a new design for arrowheads—can be regarded as the result of many chance trials, with the most successful innovations spreading through the group. Smail acknowledges that at some point, one generation would directly teach the next how to construct

the new implements, but he thinks that the early introduction could best be understood as a Darwinian process. This means that in preliterate cultures—or even in fully literate ones—new discoveries can profitably be construed as resulting from a process of cognitive variation and selective retention, a process isomorphic with the biological one. For historians, the payoff is this: New cultural shifts need not be attributed to any one individual or the work of a great person; rather, they can be understood as the work of a great process.

This kind of Darwinian analysis, in Smail's estimation, can be pushed even further back, so that the very receptivity to cultural learning itself might be regarded as a biological adaptation. Thus the human brain seems designed by natural selection to be responsive to oral communication and to organize that communication, if Noam Chomsky is right, into general grammatical patterns. However, the specific language and grammar learned depend on quite contingent social and geographical circumstances. Smail comparably argues that evolution has instilled general synaptic connections for cultural learning, but a given cultural milieu inscribes in the developing brain of the child specific kinds of circuits. These circuits enable what he calls "psychotropic" sensitivity—that is, emotional reactions to such general cultural institutions as dance, ritual, games and so forth. An example (if I understand him rightly) might be something like this: Those children brought up on computer games that require a quick response to rapidly changing target opportunities may have their hormonal juices primed so that as young adults they are emotionally adapted to the requirements of modern warfare. Military historians might thus have another conceptual resource for understanding the character of contemporary combat.

Smail is quite right that most historians deploy, in the construction of their narratives, some general psychological assumptions. So it would seem the mark of historiographic wisdom to reform those assumptions in light of contemporary science. Yet the conclusions he draws from modern evolutionary theory and neurobiology remain quite general and tentative. The abstemious Rankean mode of historical investigation has long since been abandoned, although most historians will hesitate to embrace a construction of the past driven by theories dancing on the border of what used to be called psychohistory, especially when the sources themselves (such as sociobiology and cerebral determination) remain highly contested within the sciences. Darwin clearly demonstrated how history mattered to biology; we await a new Ranke to show more precisely how biology matters to history. Smail, though, has made a start.

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MATHEMATICS

Applied Geometry

Stan Wagon

HOW ROUND IS YOUR CIRCLE?: Where Engineering and Mathematics Meet. John Bryant and Chris Sangwin. xxii + 306 pp. Princeton University Press, 2008. $29.95.

The great power of computers to model various aspects of geometry and mechanics has made it possible to visualize things quickly and in useful and innovative ways. But nothing beats the construction of a physical model. And when the model conforms exactly to the mathematical prediction, it is very satisfying. *How Round Is Your Circle?*, by John Bryant and Chris Sangwin, is a guide to making physical models of various phenomena of geometry that are related to serious applications, both historical and contemporary. The mathematics required is elementary: standard geometry and trigonometry, with occasional bits of calculus.

Let's start with the book's title, which is connected to the problem of how to determine whether a roundish object is exactly round, to a certain tolerance. This turns out to be much trickier than one would expect. For a start, there are the curves of constant width (such as the Reuleaux triangle, which is made by drawing three 60-degree arcs of a circle centered at the vertices of an equilateral triangle). Because one can make such curves with many bumps, a device that just checks several diameters for equality can be fooled. The authors describe various ways in which one might try to confirm roundness, but they all have drawbacks, and when it comes to the definitive answer, Bryant and Sangwin admit that it takes very complicated machinery to perform a proper check (basically by rotating the given object around an axis).

The discussion of roundness leads naturally to a discussion of curves of constant width, and that is very well done here, with lots of detail. The authors describe two applications—the design of the British 50-pence coin (a 7-sided curve of constant width) and the design of the rotary (Wankel) engine used to power some cars. Bryant and Sangwin, who are British, are probably not aware of a beautiful American application: In San Francisco there are manhole covers in the shape of Reuleaux triangles (see image at www.drainspotting.com/view_photo.php?photoid=2662), which are easily distinguished from round covers, yet will not fall through the hole.

The authors do discuss in detail a little-known application: a device that can drill square holes. I was aware that Reuleaux triangles could be used

This device, based on a variation of the Reuleaux triangle, drills holes that are perfectly square. From *How Round Is Your Circle?*