BOOKS: ECOLOGY

Cenozoic Dramas

Stuart Pimm

The Eternal Frontier
An Ecological History of North America and Its Peoples
by Tim Flannery

Atlantic Monthly Press, New York, 2001. 420 pp. $27.50. ISBN 0-87113-789-5.

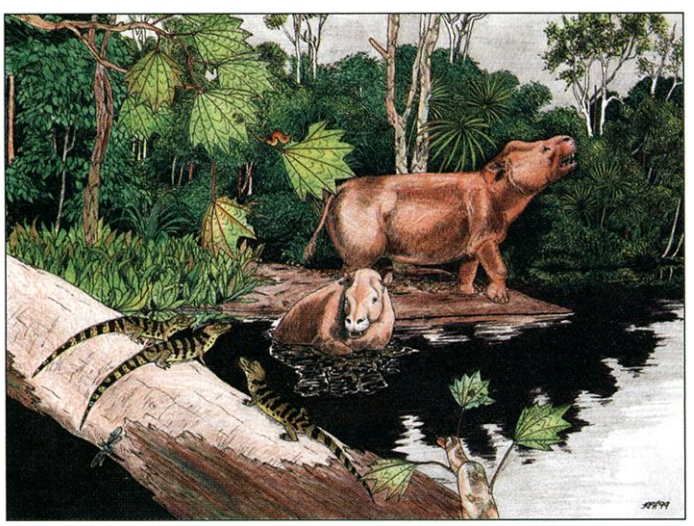
The formal introductions complete, we headed to a restaurant to help forget what had passed for food on the dozen international airlines that had brought us to New York. Tim Flannery, the director of the South Australian Museum, was more concerned about the wine list. "Are these *big* reds?" he demanded of our unfortunate server. California might not be up to the task, but Australia was, he asserted. To make his point, he produced a dozen bottles from his luggage when we adjourned to his hotel room. Flannery, I learned, presents his arguments forcefully and with flair. Would *The Eternal Frontier*, his history of North America since a very bad day 65 million years ago, be up to the task? I did not doubt it for a minute.

The subject ought to be dry stuff: bones and stones, a catalog of who was present when and where, who lost out, and who left survivors. Flannery, however, has a particular talent for assembling and presenting the strands of his engaging narrative. He effectively weaves together descriptions of moving continents, shifting climates, and changing flora and fauna.

Flannery starts the story with "the celestial chip shot" that came in low over the southern horizon on the last day of the Cretaceous. The resulting divot of molten rock and debris sterilized the continent. Flannery stands in Alberta's badlands, imagining the dust raining down onto a ghostly gray Arctic. The aftermath, a long impact-winter, extinguished the dinosaurs.

Following this winter, Earth entered a long period of warming as it became a greenhouse world. The warming, which allowed massive immigration from Eurasia, peaked in a heatwave 51 million years ago. Flannery sees this as the time when North America forgot its normal, temperate state. "[A]ncient lemurs sported in the treetops of deciduous forests growing within the Arctic Circle, while goannas and Australian turtles lurked below." Evergreen tropical jungle cloaked what are now the badlands of North Dakota.

The author follows these developments through the book's first two "Acts." The third act runs from 32 million years ago to the earliest human contacts, which he dates to 13,000 years ago. Toward the end, the continent accumulated more ice than Antarctica. Act Four continues the story until the arrival of Columbus. In these chapters, North America flirts with Europe, Asia, and finally South America as the bridges between continents open and close. Which continent gets what species from where is not a simple story. The biotic changes were complex, and they seem more so because the animals and plants are so unfamiliar. The evolutionary relationships unfold as if in some nightmare in which hedgehogs morph to look like hippos and camels shrink to look like rabbits. Flannery, however, explains the facts well and seamlessly combines the biological and geological evidence.



Tropical Wyoming. Under the greenhouse climate of the Early Eocene (56 to 52 million years ago), North America supported a diverse fauna that included many immigrant taxa from Asia. Among those that flourished was *Coryphodon*, an ancient ungulate-like mammal "the size of a cow and the shape of a hippo."

The story Flannery presents through these chapters has a modern relevance. When continents wander into each other, the resulting floral and faunal exchanges eliminate many species and some major evolutionary lineages. Humanity's exuberant movement of species around the planet is repeating that experiment.

The underlying explanations of floral and faunal changes are contentious, and no more so than in Act Four. When did humans first arrive on the continent? And were they the principal exterminators of the megafauna? Flannery does not mince words: pre-Clovis settlement is a "phantom" and his "black hole theory of extinction" refers to the human gullets down which the animals disappeared forever. He provides crisp and compelling justifications for his conclusions. Rogue asteroids may shape biological diversity. But there is also no doubt that a sparse human population equipped with state-of-the-art Clovis points and turned loose on naïve mammals could quickly drive many to extinction. Why else would Clovis points, designed to bleed their victims, appear so transiently, if not for the disappearance of the animals whose extinction they caused? If stone tools could drive so many species to extinction, today's technology can do so even more quickly.

There are additional implications in the consequences of extinctions for Earth's environments. These changed dramatically at the time the megafauna disappeared, and this book makes a good case for cause and effect. Flannery's suggestion to introduce camels, tapirs, and elephants to reverse the damage may seem wildly eccentric. But what if we need the ecological functions provided by these surrogates of now-dead relatives to maintain or restore the continent's species and communities?

The book's fifth act, which covers the last 500 years, is the least successful. Perhaps this is because it traverses such familiar terrain. Robert Askins, William Cronon, Jared Diamond, Peter Matthiessen, Marc Reisner, and David Wilcove are among those who have already written compelling and detailed accounts of North America's most recent ecological transformations. In relying on them, Flannery loses his paleontologist's voice, the tones that make the previous acts so compelling.

Through most of *The Eternal Frontier*, his voice is that of a hunter of ancient creatures: giant vampire bats, five-meter-long lizards, short-faced bears that ran down their prey in open country, and lions (twice the size of living ones) that left plate-sized paw prints in the mud. Pity Flannery's fellow Australian, currently popular on television,

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who gets only a few poisonous snakes and relatively small crocodiles to hunt. That's just the small stuff, the mere rump of 65 million years of riotous evolution. Flannery is at his very best among the vanished larger creatures, as when he's caching his mastodon kill. Describing paleobiologist Dan Fisher's next-to-the-real-thing experiments with a horse submerged in a pond near Hell, Michigan, in February, he imagines the family in August. Devoted to science, they are eating their fortnightly roast of now-aged meat, green and cheesy smelling. An Australian big red would be a perfect, perhaps even essential, accompaniment.

BROWSINGS

A Chemical History Tour. Picturing Chemistry from Alchemy to Modern Molecular Science. *Arthur Greenberg.* Wiley-Interscience, New York, 2000. 332 pp. $59.95, £38.95. ISBN 0-471-35408-2.

In 118 light-hearted essays that range from the ancient Greeks to the atomic force microscope, the author highlights selected episodes from the history of chemistry (deliberately offering only sparse coverage of 20th-century work). His highly personal accounts pay particular attention to artwork and images from historical books and papers (such as the depiction of Priestley's pneumatic trough to the right).

The Character Concept in Evolutionary Biology. *Günter P. Wagner, Ed.* Academic Press, San Diego, CA, 2000. 644 pp. $79.95. ISBN 0-12-730055-4.

The contributors to this volume offer a variety of perspectives, sometimes clashing, on how characters are defined, identified, and used in biology. Some consider the functional, genetic, and developmental architecture of characters. Others focus on the evolutionary origins of such features as flower morphology, butterfly wing patterns, and tetrapod limbs.

Enriching the Earth. Fritz Haber, Carl Bosch, and the Transformation of World Food Production. *Vaclav Smil.* MIT Press, Cambridge, MA, 2000. 358 pp. $34.95, £23.95. ISBN 0-262-19449-X.

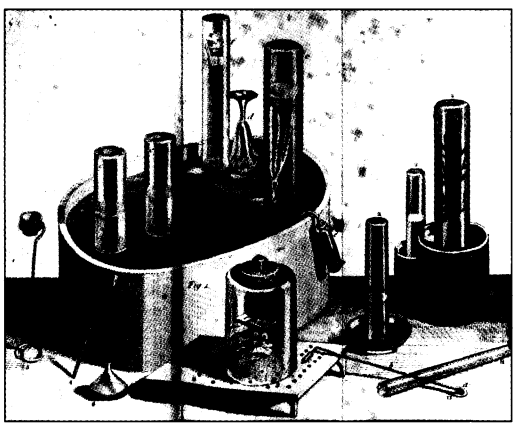
Smil provides a detailed account of the discovery and commercialization of ammonia synthesis, a process he identifies as the most important technological innovation of the 20th century. He discusses how the industrial production of fertilizer has come to directly support 40% of the global population, and he examines the ecological consequences of this intervention into Earth's nitrogen cycle. His enjoyable narrative will reward historians of science, economists, and anyone interested in how humans impact their environment.

CREDIT: COURTESY A. GREENBERG, *A CHEMICAL HISTORY TOUR* (WILEY INTERSCIENCE, NEW YORK, 2000)

NOTA BENE: CHEMISTRY

Some Things Never Change

A fictional encounter of three chemists and their wives or partners in 1777 is at the heart of Carl Djerassi and Roald Hoffmann's new play, *Oxygen*. The protagonists have come to Stockholm at the invitation of the Swedish king, who wants to see their scientific experiments on the isolation of the mysterious agent that is responsible for fire and the rusting of metal. Two of them believe that the agent is phlogiston, "the agent of fire" that leaves the metal when it rusts and is released into the air during combustion. The third believes that an element called oxygen enters the metal upon rusting and is removed from the air during combustion. History will prove him correct, but initially he meets fierce opposition.



Gas collector. The three chemists used pneumatic troughs such as this (Priestley's apparatus) to isolate gases derived from solids.

Fast forward to 2001, when a committee set up by the Nobel Foundation to decide who should be awarded the first "retro-Nobel" Prize for Chemistry. The committee quickly settles on the discovery of oxygen as the key to modern chemistry. But who should be awarded the prize? Should it be Carl Wilhelm Scheele, the Swedish apothecary who was slow to publish his discoveries but informally described his experiments to other scientists? Or Joseph Priestley, the English priest who had a passion not only for science but also for politics and who, to his death, believed that phlogiston rather than oxygen was the missing agent? Or Antoine Laurent Lavoisier, the French tax collector, lawyer, and banker who fell victim to the French revolution—but not before he had, with the assistance of his wife, performed the first accurate weight measurements of reagents and products of combustion and arrived at the conclusion that oxygen was responsible for the observations?

Written by two chemists who have in recent years expanded their activities to include writing fiction, essays, and poetry, the play shows that the familiar world of scientific competitiveness is not a new phenomenon, and that in the 18th century, scientists already followed the maxim "publish or perish." Repeated scene-switches between 1777 and 2001, with most actors playing roles in both eras, increase the feeling of continuity. After a slightly shaky start, the drama becomes entertaining, at least to an audience having some knowledge of chemistry. But I suspect that a nonscientist, or even a nonchemist, will find it hard to appreciate why the committee chooses to honor the discovery of oxygen and what distinguishes oxygen from phlogiston. The "play within a play" that is meant to illustrate this difference comes too late and does not explain the concepts very clearly. In addition, the intermission, which occurs only half an hour into the play of about an hour and a half, is quite disruptive, especially because the second act was much more engaging than the first. Reading the play might well be more satisfying.

The encounter in Stockholm and the occasional flashbacks to other events in the lives of the 18th century protagonists tell an intriguing story of scientific ambition and discovery. I found the meetings of the retro-Nobel committee less convincing. The interpersonal relationships seem a bit forced; too many strands, from women in science to scientific integrity, are pursued at once. And the absence of a science historian on the committee made no sense to me. Although *Oxygen* raises some intriguing issues and tells an interesting story, it may nonetheless fail to capture the imagination of a wider audience.

Oxygen
by Carl Djerassi and Roald Hoffmann
Wiley-VCH, New York, 2001. 128 pp. Paper, $14.95, £9.99. ISBN 3-527-30413-4.

Oxygen
by Carl Djerassi and Roald Hoffmann
Lyceum Theatre, San Diego, CA, 2 to 7 April 2001. See www.djerassi.com/oxygen/oxygen2.html for future performances.

—JULIA UPPENBRINK