BOOKS: PALEONTOLOGY

Learning from the Dead

Karl W. Flessa

Taphonomy
A Process Approach
by Ronald E. Martin
Cambridge University Press, New York, 1999. 524 pp. $100. ISBN 0-521-59171-6. Paper, $44.95. ISBN 0-521-59833-8.

The quality of the fossil record used to be like the weather: everybody complained, but nobody did anything about it. In the 19th century, the imperfections proved useful. Darwin argued that his theory fit poorly with what was known about past life because the record was poor, not because his theory was shoddy. Today, fossils are better used because our knowledge of the fossil record, like our knowledge of every other facet of evolutionary biology, has increased enormously since the 1860s. More fossils are known from more time intervals and from more places. As far as our knowledge of the history of life is concerned, more is indeed better. But that's not all we have gained. We now have a sophisticated understanding of how living organisms become fossils, why some are more likely to become fossils than others, why fossils are found where they are found, and why fossils are better represented in some intervals of time than in others.

Dealing with incomplete and biased information is not a problem just for paleontologists. After all, estimates of global diversity are based on the small proportion of life that has been cataloged. And cladograms are based on a subset of all potentially relevant characters. Paleontologists, however, have a name for their study of incompleteness and bias: taphonomy.

Taphonomy: A Process Approach is a good measure of how far taphonomy and paleontology have come in the past decades: from case studies to grand syntheses, from documenting patterns to understanding processes, and from bemoaning the quality of the fossil record to putting meaningful confidence limits on fossil data.

Traditional taphonomic research often focused on individual specimens—their death throes or the postmortem fate of their hard parts. Another traditional approach compares living faunas or floras to their accumulating remains. Case study after case study, some patterns have emerged. Ronald Martin's book is the first review of this discipline that pulls together studies from marine microfossils, marine invertebrates, vertebrates, plants, and pollen.

This synthesis is enormously valuable in the search for the general principles and rules that govern the fate of fossils. Indeed, Martin is captivated by the search for rules. The first chapter enumerates ten generally accepted principles. Some, such as the importance of hard parts and rapid burial to fossilization, seem like common sense. Others are less obvious: for example, taphonomic processes can serve to enhance the amount and quality of information preserved in the fossil record by dampening the effects of short-term variation. In the following chapters, Martin reviews a wide range of studies. From these he derives ten additional rules, which he presents in the final chapter. These include significant insights into the importance of sediment accumulation rates on the nature of fossil assemblages and admonitions about the dangers of a literal reading of the fossil and stratigraphic record. It is certainly hard to take issue with any of them, although it is sometimes difficult to discern just how they emerge from the case studies.

The case studies themselves are organized by process: decay, transport and abrasion, diagenesis, bioturbation, and time averaging. Martin makes excellent use of the research literature in these chapters, but more critical evaluations would have been welcome, even if presented only as chapter summaries that highlight under-explored topics or conflicts in need of resolution.

Some of the most spectacular samples of past life come from instances of exceptional preservation: the weird wonders of the Burgess Shale or insects in amber, to name two. These and other fossil *Lagerstätten* are covered in a brief chapter that treats the processes important in the formation of such deposits. But one will need to look elsewhere for actual illustrations of the most spectacular products of fossilization, for this book is illustrated only by tables and graphs: there are no photos or drawings to depict the rich detail and beauty of much of the fossil record.

Other chapters treat the big-picture aspects of taphonomy: the Signor-Lipps effect (in which observed range endpoints precede actual endpoints), measures of stratigraphic completeness, the construction of confidence limits on stratigraphic ranges, and the biases of sampling and preservation that affect the record of Phanerozoic diversity. Most of these are done well, though the pull of the Recent—the extension of stratigraphic ranges to include living representatives—is conflated with the effects of increased availability of fossiliferous rocks toward the present day. (Both phenomena will tend to increase diversity in younger rocks, but for different reasons.) I was also struck by an error of omission: there is no discussion of the attempts to measure the quality of the fossil record by the degree to which the stratigraphic order of appearance of clades corresponds to their order of appearance in cladograms. Although I think such comparisons are dubious for this purpose, Martin misses an opportunity to discuss the importance of the fossil record in evolutionary reconstruction.

Martin does develop a good argument that the most cherished aphorism of geolo-

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BROWSINGS

Wildlife of Gondwana. Dinosaurs and Other Vertebrates from the Ancient Supercontinent. *Patricia Vickers-Rich and Thomas Hewitt Rich.* Indiana University Press, Bloomington, IN, 1999. 304 pp. $59.95, £45. ISBN 0-253-33643-0.

This history of Gondwana's vertebrate faunas is profusely illustrated with photographs, drawings, and reconstructions of fossils from the now-scattered southern land masses. The book's many spectacular specimens include the above Pleistocene marsupial lion (*Thylacoleo carnifex*), with a wombat femur in its mouth, from cave deposits in South Australia.

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gy—that the present is the key to the past—can limit rather than enhance our understanding of the fossil record. Without an understanding of process and geologic context, simple extrapolation from the present to the past can be misleading. After all, we live today in an unusual world: sea level is low, the continents are dispersed, ice occupies the poles, and the shelly fauna of the oceans is composed largely of aragonite rather than calcite. The full range of possible environmental conditions on Earth has not been experienced in the short span of human history, or even the past few hundred thousand years. This lack of Recent analogs for many phenomena seen in the geologic record makes the present-day world an incomplete and biased sample of life on earth.

BOOKS: PHARMACOLOGY

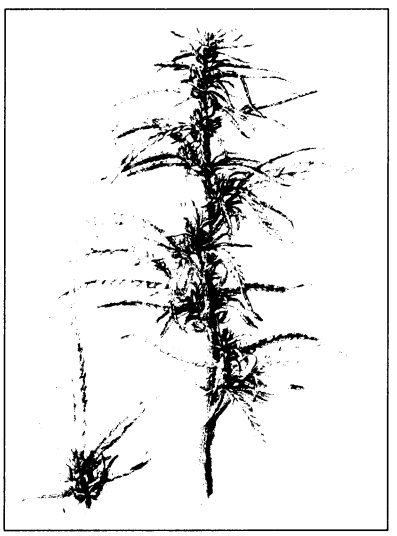
How Cannabis Acts

Steven R. Childers

There are few topics more controversial than marijuana. It is an ancient drug, and the history of cultivation of the marijuana plant, *Cannabis sativa*, goes back at least 12,000 years. The modern debate on marijuana's medicinal potential, which dominates current public interest in the United States and Europe, is also not new. Numerous detailed inquiries have explored both the safety and the possible therapeutic value of marijuana; these include reports from the Hemp Drugs Commission of the government of British India (1894) and from Mayor La Guardia's committee on marijuana in New York City (1944). Remarkably, even such older reports provided balanced evaluations of the advantages and potential hazards of marijuana, but their conclusions have been overshadowed by the arguments that dominate both sides of the marijuana debate.

The Science of Marijuana
by Leslie L. Iversen
Oxford University Press, Oxford, 2000. 301 pp. 29.95, £18.99. ISBN 0-19-513123-1.

Until recently, scientific research on the cannabinoids contributed little to this debate. Delta-9 tetrahydrocannabinol (Δ^9-THC), the principal psychoactive ingredient of marijuana, is virtually insoluble in water and is difficult to study in vitro or in vivo. For years, researchers believed that THC acted in the brain via relatively nonspecific mechanisms such as altering the fluidity of nerve cell membranes. Cannabinoid research lagged behind other fields of psychopharmacology, and progress in understanding the mechanisms of THC was slow. But the field changed dramatically in the mid to late 1980s, when a specific receptor for THC, the CB_1 cannabinoid receptor, was found in high densities in various regions of the brain. We now recognize that the body contains its own endogenous cannabinoid systems, comprising cannabinoid receptors in neurons and immune cells, together with endogenous cannabinoid-like substances (which include anandamide and related arachidonic acid compounds). Cannabinoid research has provided important information on mechanisms of THC action. For example, high levels of CB_1 receptors in such areas as the cerebellum, substantia nigra, and globus pallidus contribute to the effects of marijuana on motor control and coordination, whereas CB_1 receptors in hippocampus mediate effects on short-term memory. This research has developed a scientific basis for understanding many of the actions of THC, along with some proposed therapeutic targets of the drug. Such information was crucial for the much-anticipated 1999 report from the Institute of Medicine of the U.S. National Academy of Sciences that reviewed the scientific basis for marijuana therapeutics and made specific recommendations for further study.



Pot heads. Engraving from R. Wisset's 1808 *Treatise on Hemp* showing flowering heads of female cannabis plants.

CREDIT: FROM R. WISSET, *A TREATISE ON HEMP* [J. HARDING, LONDON, 1808]/COURTESY L. IVERSEN

These results also provide the basis for Leslie Iversen's *The Science of Marijuana*. A well-known neuropharmacologist, Iversen was an important contributor to the House of Lords select committee report on cannabis. He is, therefore, in an excellent position to summarize historical and recent research on cannabinoid actions. He has written a remarkably well-balanced volume that provides the scientific background for the current debate on marijuana use. Readers who wish to know only one side of this question, or want only final answers to the complex issues of marijuana therapeutics, should look elsewhere. Iversen's book explores these issues from all sides, with reports from diverse scientific fields. It is a treasure trove of information about the history of marijuana use and legislation, and it effectively summarizes in lay terms the cannabinoid research that now offers a potential scientific foundation for medical, political, and legal decisions about marijuana.

The most important, and most extensive, part of the book deals with the potential therapeutic uses of marijuana, the cornerstone of the current public debate. Here, Iversen not only summarizes the potential advantages and side effects of marijuana for each of the proposed therapeutic uses of the drug, but also discusses therapeutic alternatives and whether marijuana offers any actual advantages over currently legal prescription drugs. He concludes that for some, but not all, of the proposed therapeutic targets, cannabinoids could offer potential advantages in terms of efficacy and safety, as long as negative side effects and issues of drug delivery are adequately addressed. Only well-controlled clinical trials will be able to provide clear answers to these questions, and Iversen has presented an effective blueprint for future studies.

One interesting puzzle of cannabinoid science remains unanswered: the mammalian brain contains extremely high levels of CB_1 cannabinoid receptors, among the highest amount of any class of neurotransmitter receptor in the brain. Why do we need so many receptors for THC-like substances? Perhaps the endogenous cannabinoid system mediates a number of important brain functions—but these are clearly not vital functions, because CB_1 knockout mice remain viable despite the loss of the CB_1 receptor gene. It is also likely that such high numbers of receptors are crucial for the observed actions of marijuana. THC itself is a weak partial agonist at these receptors; if these receptors were present at the levels typical for those of other neurotransmitters, marijuana might produce only slight effects. But with a high number of receptors, even partial agonists can have substantial effects. We can speculate that it is our brains' supply of cannabinoid receptors that determines the effects of marijuana, whether as a drug of abuse or as a therapeutic agent.

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