LOOKING AT LIFE THROUGH (AND IN) A CELL

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An Ode to Odum

Eugene Odum: Ecosystem Ecologist and Environmentalist. Reprint ed. Betty Jean Craige. University of Georgia Press, Athens, 2002. 226 pp., illus. $17.95 (ISBN 0820324736 paper).

Last year saw the death of Eugene Odum, often hailed as "the father of modern ecology." Gene Odum's ideas about ecosystem ecology inspired a whole generation of ecologists (I was one of them). With his pioneering *Fundamentals of Ecology,* published in 1953, he propelled ecology from a subdiscipline of biology to a separate and reputable discipline. Later, with the advent of Earth Day, ecology became a household word and, to many people, indistinguishable from environmentalism.

Eugene Odum: Ecosystem Ecologist and Environmentalist is the first biography of Odum. The author, Betty Jean Craige—University Professor of Comparative Literature and director of the Center for Humanities and Arts at the University of Georgia—was a personal friend of Eugene and Martha Odum for many years. She has written several books on cultural holism.

Craige's book chronicles Gene Odum's personal and academic career paths. Although this book, like most biographies, documents the major events of the subject's life, Craige focuses on the influences that shaped Odum's ideas about ecosystem ecology and his intellectual journey through that discipline into environmental activism. As with many histories, this volume presents Odum's academic career as more deliberate than it probably was—a common distortion in biographies, induced by hindsight.

From the time of his early graduate work at the University of Illinois studying bird physiology, Odum was drawn to researchers who studied "the whole," and especially to animal ecologist Victor Shelford and plant ecologist Frederic Clements. Odum became a prophet of the top-down approach to the study of natural systems, emphasizing the ecosystem as the basic unit with which ecologists must ultimately deal. He would eventually be identified by his maxim "the whole is greater than the sum of the parts."

Odum inherited from his father, a sociologist, a predisposition to look at the whole of a system and to be keenly aware of social responsibilities. His book *Fundamentals of Ecology* included human beings in ecosystems and argued that cooperation was as important in ecosystems as competition. Another important family influence was Gene Odum's brother, Howard Thomas (H. T.) Odum, a physical scientist 10 years younger than Gene. Craige's book outlines the unusual and prolific scientific relationship between the brothers.

Odum was always connecting specific research to the larger picture—an uncommon practice in academia, which specializes in reducing complex phenomena to narrow, researchable questions. He had an ability, rare among academics, to synthesize information from different disciplines, especially from the natural and social sciences. One of my fondest memories of Odum is from my time as a PhD student at the University of Georgia, on my first day at the Institute of Ecology. My major professor, Bob Todd, was introducing me to people.

Invariably, once they learned that I had just completed my master's degree at Plattsburgh State University in New York, they would inquire, "What did you do your thesis on?" and I would respond quite automatically with the title of my research project, "The effects of 2,4-D [a herbicide] on nitrogen fixation and soil respiration." They would usually nod and move the conversation to what I would be doing at the institute. Gene Odum was the only one who pensively responded, "What are the effects of 2,4-D on soil processes? We need to know the impacts of the agricultural chemicals added to our lands." The question illustrated his abiding desire to apply academic research in a practical way.

Odum's legacy is the result of his tireless efforts to encourage students and the public to consider the social implications of ecosystem science. This, he hoped, would inspire alternative patterns of behavior. He never failed to emphasize the implications of ecosystem science for environmentalism. At the end of the 1960s and during the 1970s, when youth rebelled against capitalism and government in general, the concept of the ecosystem became a basis for measuring harm to the environment inflicted by corporate greed.

The book is well researched. Sources include friends, colleagues, students, and the Odums themselves, who provided letters and allowed Craige to use taped interviews. Craige's close association with Gene Odum enabled her to present a personal and in-depth account that treats those parts of a life that are often hard to document—for example, character, habits, and attitude. She explains the main concepts of Odum's famous articles quite well, in terms understandable by nonecologists (much as Odum himself did). Indeed, large sections of the book are devoted to explaining Odum's ideas of ecosystem development, and the intellectual reactions and challenges to them, sometimes with more repetition than necessary. Two appendixes list Odum's publications, professional milestones, and honors.

All scientists could benefit from reading the description of how Odum identified and pursued emerging concerns, sought and obtained federal funding, and built long-lasting research institutions such as the Savannah River Ecology Laboratory, the Marine Institute at Sapelo Island, and the Institute of Ecology at the University of Georgia. Countless students, faculty, and visiting researchers have benefited from these institutions and especially from personal encounters with Gene. Some of my fondest graduate school memories are of having lunch with him on humid, sunny Georgia days. He was approachable and unassuming, graciously encouraging students to eat with him. He had a reputation for giving students high priority; he always enjoyed talking to them—and listening as well.

Craige's book portrays the life and vision of a remarkable individual. It will be an inspiration to scientists from many disciplines.

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LOOKING AT LIFE THROUGH (AND IN) A CELL

The Way of the Cell: Molecules, Organisms, and the Order of Life. Franklin M. Harold. Oxford University Press, Oxford, United Kingdom, 2003. 320 pp., illus. $17.95 (ISBN 0195163389 paper).

The author of this book, Franklin M. Harold, is a professor emeritus of biochemistry at Colorado State University in Fort Collins. His scientific interests have centered on the physiology, energetics, and morphogenesis of microorganisms. These interests are amply demonstrated in *The Way of the Cell,* but the reader soon realizes that Professor Harold is engaging with the wider issues of biology, such as morphogenesis and evolution, to grapple with the nature of life itself.

Harold starts by reminding his readers of Erwin Schrödinger's book *What Is Life?* (1944) and the extraordinary influence it had in spreading the idea that genetic information in the cell must exist in the form of "aperiodic crystals." Nearly 60 years later, how much better do we understand the nature of life? There can be no doubt that the composition and structure of these "aperiodic crystals" have been elucidated to a fine degree of detail. Nevertheless, Harold states that although "every biological phenomenon, however complex, is ultimately based on chemical and physical interactions among molecules,...yet, the levels of complexity of cells and organisms must be taken into account in order to understand life, the essential nature of which continues to elude us" (p. 7). Such humility is rare in today's science. The more usual attitude is exemplified by the molecular biologist Walter Gilbert, who has said that when we have the complete sequence of the human genome, "we will know what it is to be human" (Lewontin 2000).

One of the first things students learn in elementary biology is a list of the characteristics of life: fluxes of matter and energy, self-reproduction, organization, and adaptation. This list of mechanical properties, however, has to be supplemented by a more holistic outlook: Whenever a system is assembled from its constituent parts, novel properties emerge that could not have been predicted from the knowledge of those parts alone. In the contemplation of any living organism, both reductionist and holistic approaches are needed. As Harold points out, in recent years "the single-minded concentration on the relatively tractable problems of chemical structures and interactions has been accompanied by neglect of the higher levels of biological order, often to the point of absurdity" (p. 31).

After explaining his general outlook on biology in chapters 1 and 2, Harold then gets down in chapter 3 to a detailed consideration of cell types and their organization into eubacteria, archaebacteria, and eukaryotes. He also takes his readers on a concise tour of the cell. Chapter 4 presents a bird's-eye view of energetics, the gene, and protein synthesis. Presumably it was written with the general reader in mind. However, this chapter is too short to be comprehensive and too long to keep the reader's attention.

Chapter 5, "A (almost) Comprehensible Cell," gives the author the opportunity to state the rationale for his book. After mentioning the massive compendium by Neidhardt and colleagues (1996) on *Escherichia coli* and *Salmonella,* with its 2800 double-column pages and more than 20,000 references, he adds that "the single-minded dissection to the molecular level" gives no idea of the living organism that has been "shattered into bits and bytes.... The time has come to put the cell together again, form, function and history and all." Harold has heard the siren song of DNA and has sailed on.

Harold continues this theme in chapter 6, which deals with cell division. Taking Virchow ("every cell comes from a pre-existent cell") as the starting point, he describes the division of the *E. coli* cell in some detail. Every cell provides the templet on which the daughter cell organizes itself. The continuity of cellular structure, Harold suggests, is a necessary complement to the continuity of genetic information. This is regarded as heresy nowadays in the present climate of research and in the popular press. According to the genetic paradigm, a cell's molecular composition, structural anatomy, form, and behavior are determined by its complement of genes (p. 111). But "knowledge of the genes and what they encode is nowhere near sufficient to explain how the *E. coli* cell elongates, divides and shortly produces a pair of rods with rounded caps. Upper levels of order can be seen everywhere" (p. 112).

I found chapter 7, "Morphogenesis: Where Form and Function Meet," to be the most exciting of the book. This chapter describes a score of problems that science has as yet barely begun to solve: For example, how do fungal hyphae grow at the tip? How is the polarity of the brown algal oocyte established? How do amoebae control their shape? How do cells such as *Paramecium* become asymmetric? Also, there is a brief account of the extraordinary work of Lionel Harrison and Brian Goodwin on *Acetabularia* (pp. 153–154). These researchers have devised a set of more than 20 differential equations that define a morphogenetic field within the apical region of the cell that controls the growth of the umbrella-shaped cap. Elsewhere, Harold mentions morphogens: diffusible proteins in the developing embryo of *Drosophila* that bring about a grid of gradients.

Chapter 9 finds the author again in a combative mood as he takes a critical look at evolution. He surveys work suggesting that allowance must be made for evolutionary forces additional to the primary ones of variation and selection. He mentions Stephen Jay Gould, who was among the first to challenge the belief that evolutionary change must always be gradual. Scott F. Gilbert, John M. Opitz, and Rudolf A. Raff did research on embryology that led them to reevaluate homology and morphogenetic fields. Novelty can also be generated from gene duplication and divergence, symbiosis, and embryogenesis. The idea of epigenesis will please those researchers who, like the present reviewer, have seen moderately salt-tolerant algae become strongly halophilic when the salt concentration of the growth medium is increased. (I was sorry to see that Harold is not much impressed by work on the origins of life, and in particular that he did not mention Freeman Dyson's work on the possible origins of metabolism; but we are all entitled to our preferences.) The book ends with another look at the question, "What is life?" And now the definition Harold offers is a far broader one: Life is the property of autonomously reproducing systems that are capable of evolving by variation and natural selection.

This book seems to have been designed with the general reader in mind, but I would hesitate before recommending it to such a person. For one thing, it would take extraordinary dedication for the reader to struggle through a book whose value lies in its detail. More seriously, although the author mentions (briefly) the philosopher Mary Midgley, he has not engaged in any depth her criticisms of modern science. He ends his book by concluding that he has come to think of science "as a kind of game.... It provides no basis for ethical choice, nor the will to act." General readers cannot, therefore, expect to find anything in this book to help them solve their own human concerns.

However, there are other potential readers who could gain immensely from reading Harold's book. Young scientists trying to decide on a field of specialization will be helped by the breadth of the knowledge evident in the book and by the balanced tone in which it is written. The author notes, "If I were a young investigator, I would not be content to bash promoter sequences; I'd want to go and look behind the ranges, where something new may be hidden" (p. 115). *The Way of the Cell* can act as a map to those unexplored ranges, just as *What Is Life?* inspired other young scientists 60 years ago.

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NEW CLASSIC ABOUT PLANT RESINS

Plant Resins: Chemistry, Evolution, Ecology, and Ethnobotany. Jean H. Langenheim. Timber Press, Portland, Oregon, 2003. 586 pp., illus. $49.95 (ISBN 0881925748 cloth).

This new work by Jean H. Langenheim is destined to become this generation's most widely read and cited book about plant resins. Dr. Langenheim is a professor emeritus of biology and a research professor at the University of California, Santa Cruz. She is eminently qualified to present this comprehensive examination of plant resins, since she has been one of the premier researchers in the field for over 40 years. Her work provides an overdue successor to *Vegetable Gums and Resins,* by F. N. Howes (Chronica Botanica, 1949), as the classic treatment of this subject.

The ambitious goal of the book is to present an interdisciplinary look at plant resins, encompassing their formation, their composition, their defensive functions for the plants that make them, and their utility to the many insects and mammals (including people) that also use them. The book is divided into three major parts. The first section covers the production of resin by plants, with chapters focusing on the definition and basic chemistry of different types of resin, an evolutionary overview of resin-producing plants, and a description of plant structures involved in resin secretion and storage. The second section covers the geological history and ecology of resins, with chapters that describe what is known and what remains a mystery about amber (fossil resin) and the interactions between plants, resins, and herbivores. The final section covers the ethnobotany of resins, with chapters focusing on the historical importance and future use of resins and on specific types of resins, including oleoresins, balsams, and varnish resins.

Because a variety of plant exudates have been loosely called resins, one of the book's simplest and most important contributions is presenting clear definitions of what plant resins and their finer categories are and, equally important, what they are not. These definitions give a solid foundation for understanding each chapter of the book and provide an invaluable reference to better comprehend and evaluate other works about plant exudates, written by less precise authors. For example, Langenheim helps clarify the misleading trade term "essential oil," which refers to volatile monoterpenes and sesquiterpenes in some plants, by pointing out that these compounds are "neither essential to plant metabolism nor are they true oils; essential refers to their essence or fragrance, and oil to their feel." As a nonchemist, I liked the early, clear descriptions of the basic classes of terpenoid and phenolic resins. The understanding I gained from these descriptions helped me appreciate discussions in later sections of the book on how differences in resin composition influence the extent to which a resin remains fluid or hardens after exposure to air, a key property that affects its ecological function. These differences also determine the probability that a resin may turn to amber over time.

Plant Resins is arranged in a logical progression of chapters, but each chapter is sufficiently self-contained that someone interested in a particular topic could readily digest that subject's main points. It would be incorrect to assume, however, that any one chapter provides total coverage of its main topic. The excellent chapter about the ecological roles of resins, for example, includes a summary of plants with floral structures that offer liquid resin to reward certain bee pollinators. I also found numerous other references to bee and resin interactions dispersed in other chapters, which expanded my comprehension of this topic even further. Although the index will aid such specific pursuits to some extent, I would encourage people to read the entire work, because it tells a fascinating multifaceted story.

I consider plant resins one of the most compelling topics in tropical forest ecology, because they connect so many plants, insect herbivores, stingless bee pollinators, and human collectors. My thorough reading of this book gave me an integrated understanding of what is known about the evolutionary processes that led to the formation of resins in independent lineages of plants; about the ways that the different chemical and physical properties and delivery systems of resins defend plants; about the ingenious strategies various insects have evolved to circumvent resin defenses; and about the profound effects (both mystical and practical) of plant resins on human cultures and economies over thousands of years. It helped me formulate some of the fundamental questions that I need to address in my own research with *Copaifera* oleoresin and Burseraceae balsam, investigating the roles that tree growth and senescence, microbes, and insects play in stimulating and terminating resin production and flow.

Any chemist, biologist, anthropologist, or entrepreneur who has studied or been interested in a plant resin and who reads this book will gain a deeper appreciation for resins by learning about them through the eyes and efforts of diverse investigators. The author writes about all of the book's major disciplines with consistent clarity, confidence, and precision; the text is accessible and valuable to scientists from any discipline. With the help of the well-thought-out glossary, a reader with no scientific background could also readily digest most of the information in the book with little or no effort. While the author draws heavily on her own extensive work, her scholarship, devoted to weaving together the salient points of the efforts of hundreds of other researchers, is rigorous and meticulous. Dr. Langenheim is fair-minded in her treatment of all investigators, but she does not shy away from expressing her skepticism about other researchers' conclusions if they are not supported by solid evidence.

Each paragraph contains numerous references, but not every claim is backed up by a citation. This saves some pages from the lengthy volume and makes it more readable; however, on occasion I was left hungry for a reference about a specific point. Extensive effort has gone into preparing illustrations and collecting photographs that do an excellent job of complementing the text. The clear photographs make it easier to understand the processes relating to resin formation and harvest. The figures are drawn with the right balance of detail and simplicity to portray chemical and botanical structures and processes.

Dr. Langenheim's prowess as a scholar has allowed her to synthesize in one book what has been learned so far about plant resins. Her depth of experience and insight into this topic have also allowed her to astutely assess this information and describe what questions can and should be explored in the future. Elaborating resin processes in plants, discerning the physiological and ecological aspects of resin's interactions with insects, and developing new plant resin contributions to human society could provide a host of researchers with countless compelling puzzles to probe for decades. *Plant Resins* will become a benchmark work, because it comprehensively summarizes the history of plant resin research and will inspire the current and next generation of detective researchers to tackle new plant resin mysteries.

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NEW TITLES

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The Bioarchaeology of Tuberculosis: A Global View on a Reemerging Disease. Charlotte A. Roberts and Jane E. Buikstra. University Press of Florida, Gainesville, 2003. 368 pp., illus. $59.95 (ISBN 0813026431 cloth).

Bioinformatics and Functional Genomics. Jonathan Pevsner. John Wiley and Sons, Hoboken, NJ, 2003. 753 pp., illus. $89.95 (ISBN 0471210048 paper).

Dangerous Liaisons? When Cultivated Plants Mate with Their Wild Relatives. Norman C. Ellstrand. Johns Hopkins University Press, Baltimore, 2003. 244 pp., illus. $65.00 (ISBN 080187405X cloth).

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