tradition, of historians expressing their judgment after the fact, and finally of the living tradition in the science concerned. Among these criteria, he attaches the greatest importance to the evidence given by contemporary witnesses.

So much for the analytical scheme. Cohen employs it in discussion of the two main types of revolutionary change, the one associated with great leaders and the other with great movements. These are not, obviously, mutually exclusive categories, and Cohen groups episodes of both sorts by century, beginning with the 17th and continuing through the 20th. He is a scholar of extraordinary erudition, widely and deeply read in the secondary literature no less than in the scientific texts. The thought has crossed my mind, indeed, that he may well know more history of science than any scholar now alive.

His organization gives him principles of selection for the wealth of material that he adduces in elucidating the relevance of the evolving concept of revolution to our understanding of the development of science itself. It is one of the signal merits of his book, however, that the reader need not keep the scheme constantly in mind in order to profit from the many discussions. One test of the value of a work of historical scholarship may be to consider what can be learned by readers who, for whatever reason, remain unconvinced by the author's argument. In making that remark, I do not mean to imply anything dismissive or negative about Cohen's. But the chapters are essays that can be, and I think will be, read for what they convey about their subjects in general, and not only in relation to the topic of revolution.

It is notable, for example, that a scholar who has devoted much of his career to Newton should be able to distill from his knowledge 15 pages that constitute as lucid a summary of Newton's importance in science as can be found in the enormous literature. The succeeding chapter on Vesalius, Paracelsus, and Harvey can serve equally as an introduction to the study of those figures and as a summary of the present state of knowledge of their work. It can do so, moreover, quite apart from any need to share the author's conclusion about the extent to which their innovations were instances of revolution in the life sciences prior to Darwin.

Cohen himself may feel that the important thing is to write history of science rather than to argue a thesis about it. He appends a supplement consisting of some 29 notes on attributions of revolutionary significance to a great miscellany of people and episodes, many of them little known, that are sometimes extraneous to and sometimes enlargements upon his central chapters.

One possible effect of assembling so vast an array of allusions to revolutions in science I do find troublesome, or slightly so. Since no provision is made for the role of nonrevolutionary science, the possibility of a cheapening or even a trivialization of the notion of revolution exists. The force of the word, at least in its modern meaning, derives from the implication that it connotes an extraordinary event. If quite as many changes as are discussed in this book were revolutionary, they cease to be unusual and become almost mundane. But perhaps a conscientious application of Cohen's criteria will obviate this danger, if it is one, and will serve to distinguish effective revolutions from the claims advanced by many an innovator, would-be or real.

However that may be, the scheme as a whole appears to particularly good advantage in the last substantive chapter, which I find especially informative. It deals with the recent revolution in earth sciences that has established the theory of continental drift and the study of plate tectonics. For one thing, the material treated as history of science is quite new, at least to me. In another, and more important, respect, Cohen's account of the resistance to the former of the two sets of ideas, the notion of mobile continents advanced by Alfred Wegener between 1915 and 1930, is admirably clear and dispassionate. So long as Wegener and his few adherents were the only proponents, the revolution remained on paper. It is quite conceivable that its fate might have been to languish forever in the limbo of abortive or failed innovations. The interval prior to its passage into the stage of revolution in science seems surprisingly long, given the pace of modern research. For only in the 1950's and 1960's did the theory of continental mobility begin to prevail, and then in consequence of two lines of evidence quite different from anything imagined by Wegener, and also from each other. The study of paleomagnetism by Blackett, Runcorn, and others strongly suggested that the southern continents had once been joined, and Harry Hess's theory of seafloor spreading on either side of mid-ocean ridges explained how they had moved apart.

Cohen points out very nicely that modern plate tectonics represents as great a transformation of Wegener's theory of mobile continents as did the Newtonian world picture of the Copernican theory of a moving earth. The treatment has the further interest that it exhibits one of the junctures at which Cohen's historical approach intersects with Kuhn's philosophical analysis, although in a somewhat unexpected way. The discussion of Kuhn's theory of scientific revolutions in the 1960's largely coincided with the adoption of plate tectonics. Participants in the latter, notably J. Tuzo Wilson, have testified that their thinking was stimulated and encouraged by their sense of living through just the kind of changes that Kuhn was simultaneously elucidating.

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Oogenesis

Developmental Biology. A Comprehensive Synthesis. Vol. 1, Oogenesis. LEON W. BROWDER, Ed. Plenum, New York, 1985, xiv, 632 pp., illus. $75.

This is the first volume of a new series in developmental biology. Three more volumes, on the cellular basis of morphogenesis, the cell surface in development and cancer, and manipulation of mammalian development, will be forthcoming. If the forthcoming volumes are as well done as this one, the series will be a great contribution. The book demonstrates, as it sets out to, that oogenesis is an exciting and rapidly advancing subject of research. Each chapter is an in-depth treatment of oogenesis from the point of view of morphology, physiology, cell biology, or molecular biology. Each concludes with a statement of the major experimental questions and the avenues of research that may lead to their resolutions. The volume is light on the endocrine control of oogenesis and heavy on the cell biology, biochemistry, and molecular biology. It is written by cell, developmental, and molecular biologists for an audience of similar persuasion. It is not a book for clinicians or reproductive endocrine physiologists. There are only five entries in the subject index on human oocytes.

The volume is divided into two sections, the first being Physiological and Morphological Aspects. "Local control mechanisms during oogenesis and folliculogenesis" by A. W. Schuetz is an excellent, up-to-date, and comprehensive treatment written from the viewpoint of comparative zoology and covering echinoderms, mollusks, and the ma-

jor classes of vertebrates. "Vitellogenesis in insects" by J. H. Postlethwait and F. Giorgi reviews the developmental and molecular biology of yolk genes in *Drosophila*. "Vitellogenesis and oocyte growth in nonmammalian vertebrates" by R. A. Wallace summarizes work on amphibians, fish, and birds, integrating data on the ultrastructure, biochemistry, and molecular biology of these processes. "Annulate lamellae" by R. G. Kessel deals with the occurrence and morphology (54 excellent electron micrographs) of these mysterious and beautiful structures. Because we lack the ability to isolate these structures, nothing is known of their biochemistry. "Egg envelopes in vertebrates" by J. N. Dumont and A. R. Brummett is a morphological description of the extracellular matrix of eggs in the major vertebrate classes. A summary of work on the mammalian zona pellucida will help those interested in mammalian fertilization. "Oocyte maturation in amphibians" by J. L. Maller summarizes the elegant work on the involvement of cAMP-dependent protein kinase and cyclic nucleotide metabolism on the maintenance of meiotic arrest and the reinitiation of meiosis as evidenced by the breakdown of germinal vesicles. The chapter is straight biochemistry and includes discussion of the roles of protein phosphatase, calcium-calmodulin, phosphodiesterase, protein phosphorylation, maturation-promoting factor, and intracellular *p*H. "Oocyte-somatic cell interactions during oocyte growth and maturation in the mammal" by J. J. Eppig concentrates on the roles of gap junctions, cyclic AMP, and the hormonal control of cumulus cell–oocyte interaction.

The second section of the book is entitled Gene Expression: Regulation and Consequences for Oogenesis and Early Development. "RNA synthesis and storage during insect oogenesis" by S. J. Berry covers work on the cytology and biochemistry of the various classes of RNA in a variety of insect species. "Functional organization of the amphibian oocyte nucleus" by A. Scheer and M.-C. Dabauvalle is the most exciting of the chapters in the book. It summarizes what we know about lampbrush chromosomes and contains beautiful micrographs of gene transcription in action. It also describes the structure of ribonucleoprotein transcripts, amplified nucleoli, the nuclear envelope, the nucleoplasm, the storage of maternal RNA in the oocyte nucleus, and the microinjection of DNA into the nucleus. "5*S* ribosomal gene transcription during *Xenopus* oogenesis" by A. Krämer presents what is understood of the molecular biology of the control mechanisms governing the initiation and termination of transcription of these genes. "Gene expression during oogenesis and oocyte development in mammals" by R. Bachvarova reviews the cytology of oocyte development, RNA synthesis and storage in mature oocytes, chromosome structure, protein synthesis, and the role of stored macromolecules in mouse oocytes. "Informational content of the echinoderm egg" by B. P. Brandhorst covers everything known about maternal RNA in these eggs from the standpoint of molecular biology. It is an excellent concise synthesis of a large and sometimes controversial literature. "Genetic analysis of oogenesis and the role of maternal gene expression in early development" by K. D. Konrad, L. Engstrom, N. Perrimon, and A. P. Mahowald deals almost exclusively with *Drosophila* and includes a helpful section on maternal effect mutations.

This is an excellent book that will be a valuable reference source for teachers of upper-division and graduate courses in developmental biology. The illustrations are of high quality, and the subject index is extensive.

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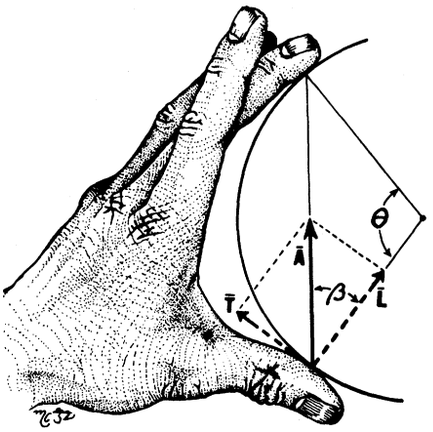
Anatomical Adaptation

Functional Vertebrate Morphology. MILTON HILDEBRAND, DENNIS M. BRAMBLE, KAREL F. LIEM, and DAVID B. WAKE, Eds. Belknap (Harvard University Press), Cambridge, Mass., 1985. x, 430 pp., illus. $35.

Intended as a second-level undergraduate textbook and general reference, this excellent book will help biologists at all levels to understand the achievements and problems of functional vertebrate morphology. The 18 chapters by 21 authors may be grouped according to a few major themes: skeletal adaptation and mechanics, locomotion, ventilation and feeding, and special senses. There is also an overview chapter by Liem and Wake.

Functional morphologists use modern analytical techniques to determine how animals work. Among the methods utilized in work described in the book are electromyography, high-speed cinematography, cinefluorography, force plates, and various transducers placed directly into skeletal or muscle tissues.



"A clawless animal grasping an object with a circular cross section exerts adduction force (*A*) along the chord of the arc (θ) that the animal subtends. Adduction force can be analyzed into a component normal to the surface (*L*) and a tangential component (*T*). Normal force equals $A \cos \beta$, and tangential force equals $A \sin \beta$, where $\beta = (180° - \theta)/2$." [From M. Cartmill's chapter in *Functional Vertebrate Morphology*]

Additional techniques include respiratory gas analysis, and, for many approaches, computerized analysis of the often voluminous data generated.

Chapters by Lanyon and Rubin and by Alexander review the physical properties of skeletal tissues and provide a foundation for those that follow. Various authors consider different modes of locomotion by examining the biomechanical principles of bone-muscle systems. Although there is some consideration of comparative morphology, as in Norberg's discussion of the mechanics of bird, bat, and pterosaur wings, most of the analyses aim more for the construction of general models than for the study of adaptive diversity. Some attempts at synthesis are made in Bennett's chapter on energetics and locomotion and in Goslow's especially fine review of the neural control of locomotion.

A central idea in the work of several authors is that the evolution of functional mechanisms may be underlain by the conservation through time of intrinsic neuronal mechanisms. Pattern generators are hypothesized to produce motor output driving the muscular systems involved in repetitive actions such as breathing, chewing, swimming, and walking. Though constantly modulated by sensory feedback and input from supraspinal centers, they produce a highly stereotyped output that appears to evolve much more slowly than do the musculoskeletal mechanisms they control. Liem shows that the pattern of air ventilation in advanced teleosts is derived from that of prey capture with very