providing deep insight. McClintock's powers derived from reasoning so well developed that the therefores and QEDs of her papers and conversations left others straining to catch up. Could it be that the information available from manipulating maize chromosomes and studying effects on kernel and plant development was simply underestimated by those who decided the system had outlived its usefulness? Even today, maize chromosomes remain arguably the best material for the analysis of heterochromatic chromosome regions, a prime residence of transposable elements. Could it be that to such a gifted mind knowledge of the emergent properties of the biological world's higher organizational levels—the plant galls and the patterns on beetles' wings—provided valuable insights into its lower levels, rather than just vice versa? Perhaps, to those recently entering biology, to those working primarily at a single level, or to those still recovering from self-inflicted wounds with Occam's razor, this could seem like vitalism resurgent.

Barbara McClintock's life and the issues she addressed are too large to be fully encompassed by this volume. But it is a pure pleasure for anyone interested in the history of genetics and the life of one of its greatest exponents. James Shapiro suggests that McClintock may eventually be seen as the "central figure in 20th century biology." Perhaps Allan Campbell best summarizes the lessons we can learn from her life: "Throughout her career she has shown that true originality has no need to fear competition, that a first-rate intellect can set its own criteria for self-esteem, and that the joy of discovery can be given precedence over all else."

Allan C. Spradling
Howard Hughes Medical Institute
Research Laboratories,
Carnegie Institution of Washington,
Baltimore, MD 21210

■

Insects Recaptured

The Treatise on Invertebrate Paleontology. Part R, Arthropoda 4. Vols. 3 and 4, Superclass Hexapoda. F. M. CARPENTER. Geological Society of America, Boulder, CO (distributor), and University of Kansas, Lawrence, 1992. xxiv, 655 pp., illus. $87.50.

Insects are the most abundant animals on earth, in terms both of species and of individuals. About a million extant species have been described, but students of tropical forest canopies are finding so many previously unknown species that they suggest that there may be as many as 30 million species when all have been described. One estimate of the number of individuals present at one point in time puts it at 10^{18}. Study of the evolution of this exceedingly successful group of organisms has challenged biologists for many years. Unfortunately, the fossil record is not as helpful as we would like it to be. For most animal phyla (such as the Chordata and Mollusca) at least a third of the total known species are represented as fossils, but for insects the figure is more like 1 percent. Insects do not occur in marine sediments, and their delicate forms are preserved only in certain fine-grained terrestrial sediments and in amber—and even then often only as tantalizing fragments.

Nevertheless there is much to be learned from Frank M. Carpenter's long-awaited two volumes on Hexapoda in the *Treatise on Invertebrate Paleontology*. Carpenter's first paper on fossil insects was published in 1928, his latest in 1992—a span of 64 years. He explains that teaching and administrative duties prevented him from devoting full time to this project until he retired in 1974. We may feel fortunate that he has enjoyed such a long retirement, for the labor of synthesizing the scattered literature was enormous, and there is no one else who could have done it and done it so well. A great deal of research on fossil insects has been conducted in Russia, and having the results of this research made available to those of us who do not read Russian is a special reward from these volumes. All groups of insects (and the few non-insectan hexapods) that are represented in the fossil record are reviewed, although the Blattaria (cockroaches) are not covered as to families and genera, in deference to the ongoing studies of Jörg Schneider on the rich fossil record of that group.

Fifty-five orders of insects known only from fossils have been described, many of these on the basis of small fragments. Carpenter reduces these to ten, either by placing taxa in other, more inclusive orders or by simply listing them as "order unknown." Eleven orders were already present in the Upper Carboniferous; most were already fully winged, and two are still with us (mayflies and cockroaches). Yet the Lower Carboniferous is a void, and the Devonian contains only a few fragments of springtails (wingless hexapods, not here considered insects). Much obviously occurred in the Lower Carboniferous, including the origin of wings. Insects were on the wing long before birds and bats, and they are the only organisms that did not sacrifice their forelimbs when they acquired flight (aside, some wag has said, from angels). Carpenter briefly reviews some of the hypotheses that have been proposed concerning the origin of wings, but the secrets remain locked in the Lower Carboniferous.

For persons not well acquainted with the insect fossil record, there are many surprises in these volumes. Who would have supposed that the Mecoptera (scorpion flies), now a minor group, were represented by 24 families in the Mesozoic? Or that the Psocoptera (book and bark lice), hardly a significant component of contemporary ecosystems, had a diverse assemblage in the Permian (20 genera in seven families)? The Palaeodictyoptera, an order of over 100 genera occurring in the late Paleozoic, all possessed stout beaks that they may have used to extract juices from Cordaitales (forerunners of modern conifers). The Titanoptera had large stridulatory areas on their wings; they were large insects, and one can imagine *Mesotitan giganteus* resounding through Triassic forests, long before there were birds to join in the chorus. Many, but not all, early groups of insects were large, one of the largest being a dragonfly-like insect with a wingspan of 70 centimeters. Persons addicted to attributing the demise of the dinosaurs to a comet from space at the end of the Cretaceous will find little evidence to support their beliefs here; many groups of insects flourished and expanded through the Cretaceous-Tertiary interface.

Special bonuses in these volumes include a preliminary section on nomenclature by the editor of the *Treatise*, Roger Kaesler, and several useful stratigraphic range charts. Many genera are illustrated by line drawings, and there are several excellent photographs, taken by the author. Altogether these are extremely useful volumes that will not be rivaled for many years to come.

Howard E. Evans
Department of Entomology,
Colorado State University,
Fort Collins, CO 80523

■

Progress in Physiology

A History of Gastric Secretion and Digestion. Experimental Studies to 1975. HORACE W. DAVENPORT. Oxford University Press, New York, 1992. xviii, 414 pp., illus. $75.

Gastric secretion and digestion haven't been the same since the farmer's son from Lebanon, Connecticut, set out from home with a new mare and a hundred dollars. Who cares why? Horace W. Davenport, one of the deans of gastrointestinal physiology. Davenport, who occupied the

William Beaumont chair, named after the farmer's son, at the University of Michigan, has written an account of the subject that anyone who is interested in its past—or its future—should read. The story is rooted in the first piece of good Yankee science and is told in a way that conveys the rhythm and the motivation of the work of the next century and a half.

This is not a chatty book. The history here is all science, loaded with information, well referenced, and written with a critical eye on the evolution of methods. The book is nonetheless warm and deeply human in its appreciation of the contributions of individual scientists.

To those acquainted with Davenport's own work it should come as no surprise that the account of the secretion of hydrochloric acid is his first, longest, and perhaps most interesting chapter. He moves quickly through the discovery that hydrochloric acid is the secretory product of the gastric mucosa, reminding us that no less a physiologist than Claude Bernard had concluded that lactic acid was responsible for gastric acidity, and lingers just long enough on studies in which indicator dyes were used to establish that the acid is formed in the canaliculi of parietal cells. He then leads us through the development of concepts and methods that determined the concentration of acid in gastric juice.

In this regard Davenport notes that "by 1975, few gastroenterologists were paying much attention to the concentration of acid in gastric juice." This is certainly the case today; in recent years the majority of patients referred to me by gastroenterologists for management of Zollinger-Ellison syndrome, a condition in which gastrin-secreting tumors cause colossal hypersecretion of hydrochloric acid, have been found to be unable to secrete any acid at all. At the same time the use of medications meant to neutralize or suppress gastric acid secretion has created a business yielding more than $4 billion in drug profits each year. A bit more of a physiological approach, the measurement of acid secretory rates or just the determination of the *p*H of gastric juice, would save some patients costly treatments, tests, and even exploratory surgery.

Davenport describes other people's work with care and precision throughout the book, but when he turns to the mechanism of acid secretion the account warms up. In these passages the strong voice of a master sets out issues, methods, and conclusions without either self-importance or false modesty. In his first chapter he writes, for instance, "My demonstration in 1938–1939 that carbonic anhydrase is present in high concentration in parietal cells is important not because it permitted speculation that hydration of carbon dioxide is the source of secreted hydrogen ions, but because it was the first fragment of evidence concerning the biochemical constitution of the cells." In tracing the course of his work with inhibitors of carbonic anhydrase activity he points out that some of his assumptions and arguments were "ludicrously wrong," always allowing us to see the line of the field developing. Wisely, he ushers the reader just beyond 1975 in mentioning crucial studies of the H^+ pump published by George Sachs in 1976 and 1978, introducing concepts that have dominated the field to the present.

Subsequent chapters cover in a similar style studies of pepsins and pepsinogens, mucus and cell renewal, reflex control of gastric secretion, histamine, chemical control of gastric secretion, the gastric mucosal barrier, blood flow and secretion, and digestion and absorption, beginning the account of each subject with the 19th century or earlier and ending with a summary of its status as of 1975.

Special attention is given in the book to the work of Charles Code of the Mayo Clinic and Foundation, to whom the book is dedicated and whose retirement provides the cutoff date for the coverage. In a typical aside Davenport cites one of the many maxims Code was given to quoting from his teacher Frank Mann: "Dr. Mann used to say that no experiment is any good unless the dog is smiling and wagging its tail while you are doing it." The essence that distills is Davenport's own love of science.

Eugene Straus
Health Science Center,
State University of New York,
Brooklyn, NY 11203

TABLE, 269

Showing the mean time of digestion of the different Articles of Diet, naturally, in the Stomach, and artificially, in Vials, on a bath.

The proportion of gastric juice to aliment, in artificial digestion, was *generally* calculated at one ounce of the former to one drachm of the latter, the bath being kept as near as practicable at the natural temperature, 100° Fahrenheit, with frequent agitation.

Articles of Diet.	*Mean time of chymification*			
	In Stomach.		In Vials.	
	prep.	h. m.	prep.	h. m.
Rice, -	boiled	1 00		
Sago, -	do.	1 45	boiled	3 15
Tapioca, -	do.	2 00	do.	3 20
Barley, -	do.	2 00		
Milk, -	do.	2 00	do.	4 15
Do. -	raw	2 15	raw	4 45
Gelatine. -	boiled	2 30	boiled	4 45
Pig's feet, soused,	do.	1 00		
Tripe, do.	do.	1 00		
Brains, animal,	do.	1 45	do.	4 30
Venison, steak,	broiled	1 35		
Spinal marrow, animal,	boiled	2 40	do.	5 25
Turkey, domesticated,	roasted	2 30		
Do. do.	boiled	2 25		
Do. wild,	roasted	2 18		
Goose, do.	do.	2 30		
Pig, sucking -	do.	2 30		
Liver, beef's, fresh,	broiled	2 00	cut fine	6 30
Lamb, fresh,	do.	2 30		
Chicken, full grown,	fricas'd	2 45		
Eggs, fresh,	h'rd bld	3 30	h'rd bld	8 00
Do. do.	soft bld	3 00	soft bld	6 30
Do. do.	fried	3 30		
Do. do.	roasted	2 15		
Do. do.	raw	2 00	raw	4 15
Do. whipped.	do.	1 30	whipped	4 00
Custard, -	baked	2 45	baked	6 30
Codfish, cured dry,	boiled	2 00	boiled	5 00

"Table from William Beaumont's *Experiments and Observations on the Gastric Juice and the Physiology of Digestion* (Plattsburg, NY, 1833). The table continues for two and a half more pages." [From *A History of Gastric Secretion and Digestion*]

■

Spectra at a Distance

Spectroscopy of the Earth's Atmosphere and Interstellar Medium. K. NARAHARI RAO and ALFONS WEBER, Eds. Academic Press, San Diego, CA, 1992. xii, 526 pp., illus. $129.50.

The use of spectroscopy in remote sensing has a long history that reaches back to the discovery of the Fraunhofer lines in the solar spectrum. In the last few decades, however, there has been a great increase in interest in such uses, deriving in part from the onset of planetary exploration and the perceived need to understand our changing environment on a global basis. Instrumentation for this purpose has matured rapidly and has sometimes led laboratory spectroscopy, which provides baseline data against which to interpret those from the atmosphere. This book is a collection of six disparate chapters that deal with various elements of the remote sensing applications. The wavelengths used range from microwave to near-infrared, and the instrumental techniques differ greatly. This provides a natural division of the subject and hence of the book.

In the opening chapter Carli and Carlotti explain how microwave and millimeter-wave observations are made. In this frequency regime the measurements are made by observation of the thermal emission from the atmosphere. The authors go into some detail about the peculiarities of the spectroscopy of the atmosphere in this regime, the species observed, the technologies of observation, and the method of retrieval of the atmospheric physical and chemical parameters from the radiometrically calibrated observations. Since many of the analytical tools derived for the retrieval of atmospheric parameters from observations made in this spectral regime pertain to the mid-infrared as well, this is an excellent introduction to the technology of remote sensing more generally.

Brown *et al.* provide a brief historical overview and describe the methods and re-