acteristics and our understanding of their causes." In a sense, this single statement says it all.

The illustrations in the book, including pictures, diagrams, and several color plates, are clear and well reproduced. As is typical of the Space Science Series, a comprehensive bibliography and glossary are included. Researchers will welcome the bibliography, which contains some 1500 detailed references. The glossary provides invaluable assistance to the reader who may not be fully familiar with the terminology, abbreviations, and acronyms of contemporary planetary science. With the ever-increasing use of jargon and acronyms in today's scientific writing, the context can often be confusing, not only to the lay reader but even to those scientists who work in closely related fields. Unfortunately, inconsistencies in the content of the glossary—for example, the inclusion of acronyms for some, but not all, of the Voyager scientific instruments—would suggest that contributions to the glossary compilation were not uniform among the various authors.

The current state of funding for planetary exploration, both in this country and in Europe, is such that there can be little optimism that Uranus will be revisited by planetary spacecraft for at least a decade. And, though impressive advances in telescope design and instrumentation continue to improve the capability of gathering new knowledge from ground-based observatories, it seems unlikely that such facilities can add significantly to what Voyager has already shown us. This book is, and will continue to be, the primary source of information about the Uranus system at least to the turn of the millennium and probably longer.

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Buckyballs

Fullerenes. Synthesis, Properties, and Chemistry of Large Carbon Clusters. GEORGE S. HAMMOND and VALERIE J. KUCK, Eds. American Chemical Society, Washington, DC, 1991. xiv, 195 pp., illus. $44.95. ACS Symposium Series, 481. From a symposium, Atlanta, GA, April 1991.

It was less than two years ago that astrophysicists Krätschmer and Huffman reported the isolation of stable C_{60} and C_{70} molecules, now known as fullerenes or "buckyballs," from specially prepared graphite soot. These results substantiated previous work by Smalley, Kroto, and co-workers, who had not only suggested the structures (usually football and soccer-ball shapes, hence the term "buckyball"), but gave proof of their formation in the vapor phase. However, not until Krätschmer and Huffman's research made these compounds available on a macroscopic scale did study of their physical and chemical properties take off.

Fullerenes is the result of an American Chemical Society Fast-Breaking Events symposium organized only nine months after Krätschmer and Huffman's report, and it is remarkable that such a significant amount of pioneering research is presented in the volume. It opens with an editors' preface and an overview by Hammond. The succeeding 12 chapters include such diverse topics as synthetic approaches to C_{60} and other carbon clusters, theoretical studies, low-resolution, single-crystal x-ray structure determination, conductivity and superconductivity of alkali metal-doped C_{60} (a particularly intriguing subject with potentially great practical interest), the preparation and structural determination of the first well-defined monosubstituted C_{60} derivative (for example, osmylated C_{60}), mass spectrometry, and the chemical reactivity of C_{60}.

The expanding revelations of the properties and possible applications of fullerenes rightly fascinate chemists and physicists alike. Although the present pace of discovery will probably not continue unabated, these new caged-carbon allotropes are of great interest and their chemistry and physics hold substantial promise. How soon this promise will be fulfilled by practical application is difficult to judge. It is, however, reassuring that science continues to produce unexpected and fascinating results that open up new vistas.

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Immunological Reformulations

Metchnikoff and the Origins of Immunology. From Metaphor to Theory. ALFRED I. TAUBER and LEON CHERNYAK. Oxford University Press, New York, 1991. xx, 247 pp. + plates. $45. Monographs on the History and Philosophy of Biology.

Elie Metchnikoff clearly belongs in the pantheon of late-19th-century scientific medicine, alongside contemporaries such as Robert Koch and Paul Ehrlich. Born in 1845 as the fifth and youngest child on a minor Russian estate, Metchnikoff studied comparative zoology at the University of Kharkov and began his research career investigating the phylogenetic and ontogenetic development of a wide variety of invertebrate groups. In the 1870s he specialized in sponges and medusae in order to understand the origins of metazoans and the phylogenetic development of the digestive system.

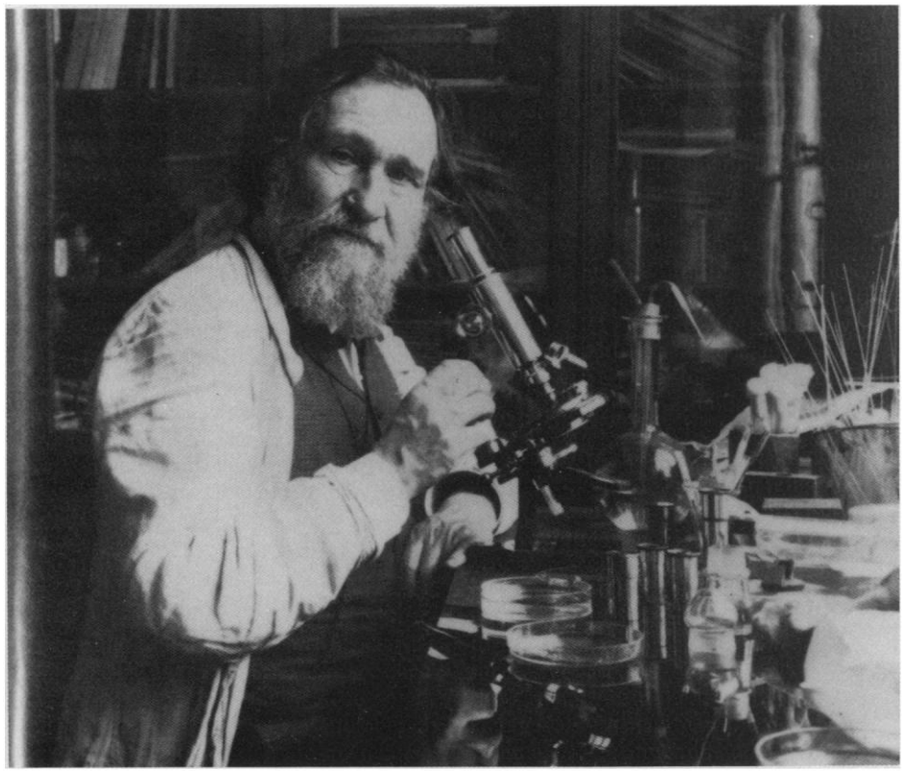
In 1883, however, his career underwent a sudden reorientation—from comparative embryology to pathology. Today he is best known for the phagocyte theory of inflammation and immunity, which states that special amoeboid cells seek out and engulf pathogenic parasites and that inflammation is essentially this active response to the invading agent. Although most pathologists immediately opposed Metchnikoff's theory for its teleology, the gravest blows came from a number of studies in the late 1880s that showed that natural and acquired immunity was more likely mediated by a humoral factor. In 1890 Emil Behring and Shibasaburo Kitasato discovered serum antitoxins (later named antibodies), and thereafter the view that cells alone were responsible for immunity became increasingly untenable. Nevertheless, Metchnikoff did share the 1908 Nobel Prize with Paul Ehrlich, the leading proponent of the idea of antibody-mediated immunity.

Notwithstanding the renaissance of cellular immunology in the 1950s and 1960s, Metchnikoff has, until recently, been of interest only to historians of science and medicine. In a series of articles in *Cellular Immunology* and other journals, however, Boston University pathologist Alfred Tauber and philosopher Leon Chernyak have set out to resuscitate Metchnikoff, or rather his metaphysics, for present-day immunologists. Although their immediate philosophical motivation is not clearly explicated in the present book, a concurrently published work edited by Tauber (*Organism and the Origins of Self*, Kluwer, 1991) indicates that they have been challenged by the recent so-called autonomous network approach to the immune system, an epistemologically radical extension of Niels Jerne's well-known theory of idiotypic networks proposed in 1973.

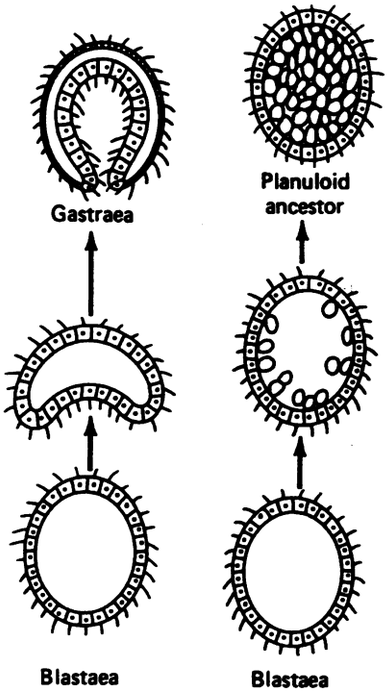
Accordingly, notions of anti-reductionism, dialectics, and self-determining systems (albeit not autopoiesis) reverberate throughout this expanded book version of Tauber and Chernyak's articles. The authors' main claim is that the real novelty in Metchnikoff's phagocyte theory of inflammation and immunity was his reformulation of the notion of organismic integrity. Tra-

ditional notions of self-healing were embedded in a metaphorical conception of integrity as an a priori given, that is, of the unproblematic harmonious nature of living beings. Metchnikoff's studies in comparative embryology led him to reject this traditional notion and to favor instead a view of organisms as disharmonious. But if organisms were not harmonious by nature, how was integrity possible? Metchnikoff's answer, according to Tauber and Chernyak, was that organismic integrity was continuously created, and recreated, through the action of phagocytes, the cells responsible for host-defense.

Tauber and Chernyak's appropriation of Metchnikoff for current immunological discourse is reminiscent of a long-rejected Whiggish tradition in the history of science. For example, they provide two appendixes summarizing the modern debate between morphologists and Darwinians and the current views of phagocyte function. But there is nothing intrinsically wrong with using historical or biographical material for present purposes. (What other legitimation has history of science in the long run?) Nor is their aim exclusively presentist. In fact, the greater part of their book is a careful and detailed study of the conceptual origins of the phagocyte theory in post-Darwinian comparative invertebrate embryology. The authors try to correct Metchnikoff's own autobiographical reconstruction, including his famous account of the discovery as a flash of insight on a visit to Messina in 1882, a classical "eureka" story, which they convincingly deconstruct in favor of an account that contextualizes the train of events.



"Metchnikoff at the Pasteur Institute, approximately 1906." [Reprinted in *Metchnikoff and the Origins of Immunology* from P. Lepine, *Elie Metchnikoff et l'immunologie*, Seghers, Vichy, 1966]



"The hypothetical development of Haeckel's *gastraea* (*left*) and the introgressive development of Metchnikoff's *parenchymella* modelled after planuloid development." [From *Metchnikoff and the Origins of Immunology*]

Past scholarship on Metchnikoff in the English language has all too often relied upon uncritical (auto)biographical accounts, such as the standard biography by his second wife, Olga, or hagiographical memoirs by his former students and disciples. To their credit, Tauber and Chernyak have mastered Metchnikoff's early, hitherto untranslated essays in Russian. Along with the recent work of Daniel Todes (*Darwin Without Malthus*, Oxford University Press, 1989), this book enriches our understanding of the non–Anglo-Saxon objections to and variations of evolutionism.

Despite their claim that this is not a biography in "the usual sense," the authors have nevertheless attempted to correlate Metchnikoff's scientific reorientation with his personality. Their view of the relation between life and work is the reverse of conventional psychobiographical approaches—instead of explaining Metchnikoff's scientific work with reference to his life, they claim that his science altered his life. The young Metchnikoff was energetic, passionate, and quick-tempered but also suicidal and infused with a pessimistic *Weltanschauung* that the authors find congruent with his view of the disharmonious organism. Around 1883, the phagocyte theory suggested a possible solution to the problem of organismic integrity, and hence Metchnikoff's dark life philosophy turned into an optimistic one. Although this existential approach seems plausible, we are not presented with much archival evidence for it. A full biography of this fascinating personality has to wait until all his personal papers are available for historical scholarship.

In spite of the bold aim to intervene in present-day immunological discourse, the highly original interpretation of the metaphysical foundations of Metchnikoff's scientific work, and the meticulously researched study of the embryological prehistory of the phagocyte theory, *Metchnikoff and the Origins of Immunology* has certain shortcomings as a book. It fails to meet the otherwise high editorial standards of the Oxford University Press monograph series to which it belongs, for it is uneven and repetitious and the grammar is convoluted, many sentences being so ill constructed as sometimes to defy the interpretative abilities of the present reviewers.

Readers who enjoy having a biography on the bedside table for relaxation from the daily torments in the lab should avoid this volume. But both scientists and non-scientists who want to do some extra hard work

to raise their level of historical awareness and philosophical sophistication will find this study of Metchnikoff extremely valuable.

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Pioneers of Embryology

A Conceptual History of Modern Embryology. SCOTT F. GILBERT, Ed. Plenum, New York, 1991. xiv, 266 pp., illus. $69.50. *Developmental Biology: A Comprehensive Synthesis*, vol. 7.

When we think of embryology around the beginning of this century, we might imagine that in those days progress was made slowly by investigators who worked in isolation and, unlike those of the present day, had time to think. Perhaps we even assume that recent advances, particularly in cell and molecular biology, have answered most, if not all, of the questions of those days. This book should dispel any such assumptions. It shows the pioneers of the discipline energetically competing for publication, disputing each other's findings, and traveling around the world to collaborate and disconcertingly reminds us of just how many of our current views about developmental control mechanisms are 100 or more years old.

Before about 1880, embryologists were addressing questions about developmental mechanisms almost exclusively by means of direct observation and drawing conclusions by extrapolation and imagination. One might describe their work as anecdotal, rather than mechanistic. Then Wilhelm Roux and contemporaries (1870–1910) such as Eduard Pflüger, Oskar Hertwig, Curt Herbst, and Hans Driesch began to use experimental manipulations to address specific questions about the rules governing cell behavior in the embryo, which we are now starting to rediscover. Some of the insights on which modern ideas are based came directly from their work. The first few chapters of the book concentrate on these early efforts (1800–1910), tracing in a concise and readable way the origins of the approach that became known as experimental embryology or developmental mechanics (*Entwicklungsmechanik*).

Johannes Holtfreter's autobiographical chapter, in which he reminisces about his life and career, is of a rather different nature from the rest of the book. It is in fact a letter, written in 1981, sent as an apology for Holtfreter's inability to accept an invitation to attend a meeting in Japan. For this reason, it is not exactly scholarly, but it is a real gem, particularly because Holtfreter recollects his feelings more than his science and records his perception of other contemporary scientists as people rather than just of their ideas.

The book is eclectic, but all the chapters are important and make interesting reading. Two themes recur throughout the book and give it a coherence uncharacteristic of collective volumes. One is the development of the concept of embryonic induction, by which one group of cells emits a signal that changes the direction of differentiation of another group of cells. Holtfreter's statement that "today there is barely anybody around who is still active in this once so exciting area of research" sounds ridiculous in 1992. But through the book one can trace the origins of this concept that is central to the way in which we now view development. It was not the famous experiment of Spemann and Mangold (1924) that led to the idea, nor even Spemann's earlier work on lens induction (1901–1906). These experiments were the culmination of a long-standing dispute over whether differentiation of the lens was a process arising entirely from within the cell

"The worries of an embryologist." [Johannes Holtfreter, in *A Conceptual History of Modern Embryology*]