BOOKS: MICROBIOLGY

Life from Smut

Lynn Margulis

Must all life come from preexisting life? Do all cells, including those of the tiniest wall-less bacteria, arise only from division of parental cells that they resemble? Isn't the central idea of evolution that all life "is descended with modification" from previous, ancestral life? If so, then how could the earliest life originate without living predecessors? If life today comes from previous life and that life from even earlier, presumably more primitive and minute life, how does an evolutionist account for the beginning of the first living organism? These questions abounded in intellectual, medical, and naturalist circles in the decades just after Lyell's geological and Darwin's biological books became widely known. They are the focus of James Strick's *Sparks of Life*. Thankfully for the reader, Strick approaches them as an historian but one having scientific acumen and, especially, knowledge of modern microbiology and its antecedents.

Sparks of Life
Darwinism and the Victorian Debates over Spontaneous Generation
by James E. Strick

Harvard University Press, Cambridge, MA, 2000. 298 pp. $45, £30.95. ISBN 0-674-00292-X.

The savvy reader must first recognize the Fleckian notion of "thought-style" (*1*). Concepts and terms familiar today had quite different meanings in the 19th century. An "active molecule" was a bacteria-sized particle produced by the breakdown of live and inanimate matter in water. A "gemmule" conveyed hereditary material from the body to the sperm or the egg. A "germ" (like a seed) was anything small that could grow. A "molecule" was something microscopic and organic (it could burn in air) that could cluster together to form a cell. A "virus" was poison. "Zymosis" was the term given to the production of a communicable disease within the body of an organism infected by some droplet or particle (some "contagion"). And "zymads" were chemical (not living, not organic) particles of contagion.

Henry Charlton Bastian (1837–1915), an experimental biologist, neurologist, and professor of "pathological anatomy" at University College London, is a central figure in Strick's account. The "last great supporter of spontaneous generation," Bastian authored *Modes of Origin of Lowest Organisms* (1871) and the two volumes of *The Beginnings of Life* (1872). He championed the theories of "archebiosis" (that living things begin from nonliving starting materials) and "heterogenesis" (that living things form from degenerating material itself derived from previously living things such as meat infusions). Archebiosis dispensed with the need for a creator God to originate life either now or in the beginning. Bastian explained present-day transitions from nonliving to living matter primarily in colloidal chemistry terms. Subsequently, he and others, including Jacques Loeb and The Svedberg, generated much experimental work that would ultimately serve as the background for Alexander Ivanovich Oparin's coacervates, Alfonso Herrera's plasmogenesis, Félix d'Hérelle's bacteriophage, and Sidney Fox's proteinoid microspheres.

Aqueous beginnings. Diego Rivera's fresco *Water, Origin of Life* decorates a fountain in Mexico City.

The young, polymathic Bastian was the evolutionist champion of spontaneous generation. Strick chronicles his rise and fall. It was the most famous of the evolutionists, Darwin's champion Thomas Henry Huxley, who eventually (and after polite wrangling) relegated Bastian's observations to the dustbin of oblivion.

Bastian, for example, touted the appearance of new organisms in fluid exposed to 150°C for four hours and in ammonium and other strong salt solutions. Huxley's own 1870 claim of observing the transformation of *Cladospora* (a mycelial fungus) through *Torula* (a yeast) to a *Penicillium* conidium that gave rise to bacteria that strung themselves into chains to become *Leptothrix* was the epitome of heterogenesis. Yet Bastian's interpretations of archebiosis and heterogenesis were squelched by Huxley in ignominy. The irony is that the spontaneous generation debates, in which Bastian figured prominently, did give rise to an entire scientific enterprise: subsequent studies on pleiomorphy, propagules and their resistance, as well as chemical-microbiological continuities in the context of the origin and early evolution of life. But Bastian was silenced ultimately not only by Huxley's organizational astuteness, but also by the two major nonmedical advocates of the "germ theory of disease." John Tyndall, the materialist pro-evolution physicist and professor of natural philosophy at London's Royal Institution, and Louis Pasteur, the monotheist chemist who believed that only the Deity created life, were curiously aligned in their agreement that only life begets life. However, as Strick masterfully shows, "the very multiplicity of germ theories of disease made accommodation with spontaneous generation possible for longer than has been supposed." British physicians and others not only argued that contagions, active molecules, poisons, zymads, and fungi "heterogenetically" transformed from one to another, but that white blood cells (called the "germs of the poison") that accumulate in the pus of smallpox pustules conveyed the disease. Indeed, for many, germs were produced by spontaneous generation as direct by-products of the disease itself!

In accessible language and an engaging narrative style, Strick navigates through the Victorian power politics of both observational and experimental science (Darwin's immediate 19th-century legacy) and the old (and inevitable) rifts between men of science and arrogant medical practitioners. He illuminates especially the European backdrop and the relations of the debates over spontaneous generation to the "big questions." The practical and the experimental studies were already linked—as they remain today—to the philosophical mindsets evident in Britain, France, and Germany. Participants in this confused and theatrical debut of microbiology, a science with so much application to the world at large, were preoccupied with the origin of earthly life, the creation of the world by God or not, the relative morality of the vital and other forces, the relations between vital and inanimate matter,

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the transformation of propagules from inert to trophic forms and back, and the limits of life at high temperatures and extreme acidities. Such topics remain of interest to modern microbiology, as does, most importantly, the extent to which any of these "thought-style" issues are even approachable by experiment.

References

1. L. Fleck, *Genesis and Development of a Scientific Fact* (Univ. of Chicago Press, Chicago, 1979).

BOOKS: THEORETICAL BIOLOGY

Viral Immunology from Math

Charles R. M. Bangham and Becca Asquith

It is a widespread fallacy that what mathematics contributes to biology is quantification of an otherwise innumerate science. But experimental biologists have long been expert at measuring and quantifying. The real contribution of mathematics lies in a precise qualitative framework of reasoning. The rate-limiting step in the advance of biology is usually experiment, not theory. (One of the very few notable exceptions was the theory of evolution by natural selection.) Experiment, however, is in no sense superior to theory, nor vice versa: both are necessary ingredients of a proper understanding of nature. An experiment done with no theoretical framework to analyze or interpret the results (let alone a hypothesis) is meaningless; theory in the absence of experiment remains mere theory.

Mathematics now occupies a central position in ecology, evolution, and genetics, and it has provided vital contributions to countless other areas of biology such as nerve conduction. But until recently it made little impact on immunology, largely because of our ignorance of much of the basic biology. In the last decade, immunologists have realized that the dynamics of the response to an infection within one host might be amenable to mathematical analysis. Such analysis is particularly applicable to viral infections, because of the relatively simple genetic structure of viruses and the rapidity with which they reproduce and generate genetic variation. In addition, experiments using viral infections to test evolutionary hypotheses can often be completed in days; viruses provide the kinds of sample numbers and reproductive rates that epidemiologists and animal geneticists can only dream about.

Martin Nowak and Robert May have played an important part in the development of this field. In *Viral Dynamics*, they offer "a personal view of one emerging and potentially highly useful area" of the subject rather than an exhaustive textbook on theoretical immunology. Both authors come to the subject from theory and mathematics, not from experiment. As a result, the biology is pared down to the minimum and sometimes reads like a student's lecture notes. This approach may annoy some experimental biologists, because it can give the impression that the authors long to escape from the overgrown jungle of experiment into the clear air of theory. But it carries the advantages of precise and economical reasoning, and it demonstrates the wealth of conclusions that can follow from a small number of assumptions.

Virus Dynamics
Mathematical Principles of Immunology and Virology
by Martin A. Nowak and Robert M. May

Oxford University Press, Oxford, 2000. 249 pp. \$70, £40. ISBN 0-19-850418-7. Paper, \$34.95, £19.50. ISBN 0-19-850417-9.

The HIV epidemic has given the field a strong impetus and a natural focus, so it is no surprise to find that most of the book is concerned with the dynamics of HIV-1. The chief questions the authors tackle are the most important in HIV-1 biology: Why does the CD4+ T cell count slowly and inexorably decline in most HIV-1–infected people? What part does the immune response play in limiting the progression of the infection? What is the role, if any, played in disease progression by the virus's immune escape? What determines the rate of emergence of drug resistance in HIV–1? What is the best strategy for drug treatment of the infection?

Although other virus infections are mentioned, particularly hepatitis B virus infection, there remains a danger that conclusions from HIV-1 infection are assumed to be generally true for all viruses, whereas there are often good reasons to suppose the opposite.

The authors rely on simple ordinary differential equations and basic linear algebra, and much of their discussion can be followed by anyone with a first-year-undergraduate training in mathematics. Readers with less mathematical background might wish that some steps in the reasoning were explained more fully. However, Nowak and May have tried hard (and, by and large, successfully) to give simple verbal renditions of the assumptions and conclusions in each chapter.

The ideal reader of *Viral Dynamics* will be someone prepared to bridge the gulf between theory and experiment. The book is more suited to one from the mathematical side of the gulf, but experimentalists will gain greatly from being asked for more precision about their assumptions and their reasoning. As biological knowledge becomes ever more complex and detailed, so natural language becomes more inadequate for certain types of biological questions. Mathematics provides an efficient, precise, and rigorous alternative; as the authors note, "mathematics is no more, but no less, than a way of thinking clearly." It is unfortunate that the authors omitted a chapter explaining the mathematical techniques they use to those biologists who wish to cross the gulf but lack the necessary mathematical training.

In the book's preface, Nowak and May emphasize the extraordinary disparity between the richness and sophistication of biological knowledge and the fundamental nature of certain questions that biology remains ill-equipped to answer. Mathematics provides an extremely useful tool to help answer some of these questions, by making possible thought experiments in which the variables can be precisely controlled. We hope that both mathematical and experimental biologists will read this book and bring their two fields closer together; both will gain.

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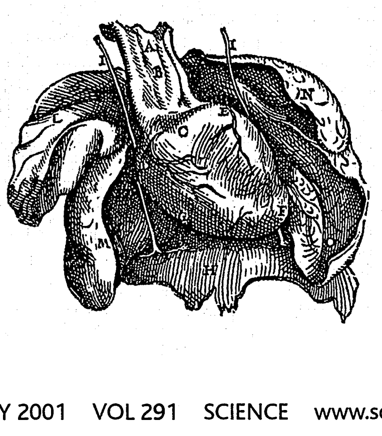
BROWSINGS

The Shape of the Heart. *Pierre Vinken.* Elsevier, Amsterdam, 1999. 208 pp. \$20, NLG 44. ISBN 0-444-82987-3.

With its scalloped top, convex sides, and pointed bottom, the red Valentine heart is instantaneously recognizable. The actual human heart, however, is a "light brown, cone-shaped clod."



In his consideration of how the icon got its shape, Vinken discusses the findings of classical and medieval anatomists and presents examples of depictions of hearts ranging from 3000-year-old Mexican ceramics to contemporary advertising. He traces the crucial indented crown, which first appeared in the visual arts in early 14th-century Italy, to an error in an anatomical text by Aristotle. As this illustration from Vesalius's *Fabrica* (1543) indicates, by the 16th century anatomists had corrected the mistake. But the Valentine shape was already ubiquitous and so it remains.

CREDIT: FROM *THE SHAPE OF THE HEART*