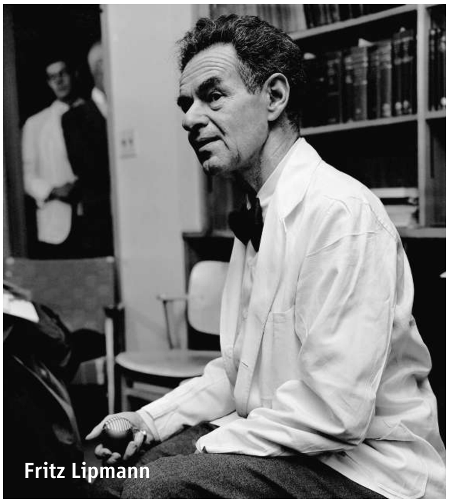
LETTERS

edited by Jennifer Sills

The Other Revolution in the Life Sciences

IN HIS PERSPECTIVE "THE REVOLUTION IN THE LIFE SCIENCES" (14 DECEMBER 2012, P. 1427), S. Brenner refers to the celebrated book *What Is Life?*, published in 1944 by the Austrian physicist Erwin Schrödinger, best known for the development of wave mechanics (*1*). Brenner focuses on only one of the two properties of life considered by Schrödinger in his definition, namely its ability to store, replicate, transfer, and express genetic information. Schrödinger, unaware of the as-yet-undiscovered DNA double helix with its base-pairing, attributed this mysterious property to an "aperiodic crystal." That Schrödinger's insight highlighted a fundamental property of life is undeniable. I can still vividly remember my immediate sense of being witness to a key event in the history of science when I read Watson and Crick's brief note titled "A structure for deoxyribonucleic acid" in a 1953 issue of *Nature* (*2*). Although that publication had been preceded 9 years earlier by the identification of the pneumococcal "transforming factor" as DNA by Avery *et al*. (*3*), the earlier landmark paper had had relatively little impact because of a prevailing bias that favored proteins as the information carrier in chromosomes. By identifying DNA base pairing as the universal mechanism of biological information transfer, the historic Watson and Crick publication indeed added a new paradigm in the Kühnian sense, as Brenner points out.



Fritz Lipmann

I have been witness to another revolution in the life sciences that Brenner did not mention. I experienced an earlier comparable feeling of excited illumination when I first read the paper by Fritz Lipmann titled "Metabolic generation and utilization of phosphate bond energy" (*4*). This historic paper introduced the notion of the "high-energy phosphate bond," symbolized by Lipmann's famous "squiggle," together with the accompanying key concepts of group potential and group transfer. This paper, even though published 3 years before Schrödinger's celebrated book, was most probably unknown to him. It clarified for the first time the second property singled out by Schrödinger in his definition of life: its ability to extract "negative entropy," better known to chemists as "free energy," from the environment and convert it into chemical and other forms of work.

This second paradigmatic element of Schrödinger's definition of life is arguably as fundamental as the first one and, in fact, preconditions it. Without group transfer and the support of high-energy phosphate bonds—to which must be added Mitchell's "chemiosmotic" mechanism (*5*), another conceptual jump that took everyone by surprise—living organisms would be unable to carry out any of the instructions conveyed by way of base pairing. They would be unable to replicate DNA and to express the information it carries into RNA and proteins and, through these, all of the other components of life.

It is even possible, probable in my opinion, that bioenergy preceded information in the origin of life. Before Gilbert's widely publicized "RNA world" (*6*), there may have been Baltcheffsky's "pyrophosphate world" (*7*), Wächtershäuser's "iron-sulfur world" (*8*), or my "thioester world" (*9*). In one or more of these worlds, ATP and the related GTP, CTP, and UTP may well have arisen as conveyers of energy before they became precursors of information-bearing RNA (*10*).

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Museums' Role: Increasing Knowledge

GREAT NATURAL HISTORY MUSEUMS ARE among the world's premier institutions of scientific research, training, and education. The research produced by these museums, based on their collections of biological, geological, and anthropological specimens, has been of incalculable importance in formulating and testing the most fundamental theories and principles of these and related disciplines. In the biological sciences, for instance, contributions from past curators of these collections form the pillars of modern evolutionary biology [e.g., (*1*–*3*)].

We therefore read with deep concern of plans to drastically reduce the role of scientific research at one of the world's greatest museums of natural history, Chicago's Field Museum ("Budget crunch to shrink science

Practicing personalized medicine
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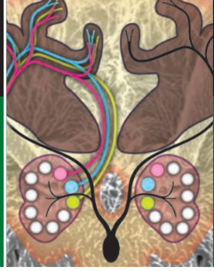

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programs at Chicago's Field Museum," V. Morell, News & Analysis, 4 January, p. 19). The collections of the Field Museum are an irreplaceable scientific resource, and the scientists who care for, augment, and make them available for study by others are also renowned contributors to science in their own right. Their loss would be a blow not just to the Museum, but to the scientific enterprise as a whole.

In making the bequest that endowed the Smithsonian, James Smithson epitomized what has become the mission of modern natural history museums: They are institutions for "the increase and diffusion of knowledge" (*4*). Many science museums can mount exhibits for the diffusion of knowledge, but only museums such as the Field, with its collections and scientists, can contribute so much to its increase. For the Field Museum to abandon this duty would be unconscionable. We urge the Museum's authorities and supporters to find a way to prevent such a calamity.

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Museums' Role: Pollen and Forensic Science

IN HER NEWS & ANALYSIS STORY, "BUDGET crunch to shrink science programs at Chicago's Field Museum" (4 January, p. 19), V. Morell reports that Chicago's Field Museum's science program will be slashed by $3 million. Now more than ever, it is essential to convey the importance of natural history research collections to forensic science. For example, museum collections are crucial to the application of pollen evidence in criminology.

Because each region on Earth has a specific plant population, and each plant produces a specific pollen or spore that is morphologically unique to the parent plant, pollen can be used as a geolocation tool (*1*). The association (diversity and relative abundance) of pollen and spore types found at a specific location, called the pollen print, links trace pollen evidence to its source location (*2*). Pollen can thus help track the provenance of illegally imported art, drugs, medicine, or food, as well as items obtained from crime scenes or terrorism investigations, including bodies, clothes, and weapons. Pollen can also provide clues to the timing of events, because pollination occurs at specific times each year.

Tying pollen prints from trace evidence to a location of origin depends on both highly trained palynologists and comprehensive collections and samples for reference. For instance, the geographic source of items such as illegal drugs brought into the United States can be identified if pollen grains from the geographic regions of interest are available for comparison. The Louisiana State University Museum of Natural Science has 4598 samples collected from 564 unique localities spread across all 31 Mexican states and its Federal District (*3*). This collection represents more than 100 years of fieldwork by several generations of curators and graduate students. The specimens not under moratorium are available upon request; scientists or community members can come to the Museum or borrow samples for research. Government agencies such as the National Oceanic and Atmospheric Administration (*4*) or the NSF-funded GeoMapApp at Columbia University (*5*) host pollen data, but for the most part do not curate the samples.

Although using pollen as a forensic tool (forensic palynology) is common in Europe and Australia, the United States lags far behind (*6*). This does not need be to be the case, because U.S. palynological collections are among the world's best. Yet, these collections can be lost in an instant with one major budget cut.

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CORRECTIONS AND CLARIFICATIONS

New Focus: "Reversal of misfortunes" by J. Cohen (22 February, p. 898). The article mistakenly reversed the first and last name of Martin Tshipuk. The HTML and PDF versions online have been corrected.

Letters: "Give shark sanctuaries a chance" by D. D. Chapman *et al*. (15 February, p. 757). The second author is Michael G. Frisk, not Michael J. Frisk. The HTML and PDF versions online have been corrected.

Editors' Choice: "Bombs below" by N. S. Wigginton (18 January, p. 253). The last sentence of the story didn't accurately describe the conclusions of the paper. The corrected sentence should read "Based on their simulations, the Xe signal from the 26 March 1992 test would have met previous criteria for a nuclear weapon only if the test had taken place at certain locations within the Nevada Test Site." The HTML and PDF versions online have been corrected.

Editors' Choice: "A washable MOF" by M. S. Lavine (4 January, p. 12). The reaction between the potassium salt of PTC and the specific metal acetate could readily be done on multigram scales, not milligram scales as stated in the summary. The HTML and PDF versions online have been corrected.

News Focus: "The year in news" (21 December 2012, p. 1534). The first June item incorrectly stated that Lonesome George was the last Galapagos giant tortoise. George was the last of the subspecies *Chelonoidis nigra ssp. abingdoni*, but other subspecies persist on the islands. The HTML version online has been corrected.

Letters to the Editor

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