



Reforming Undergrad Biology Curriculum

IN HIS ARTICLE ON THE NEW NATIONAL Research Council (NRC) report on needed reforms in undergraduate biology education, Erik Stokstad ("Biology departments urged to bone up," *News of the Week*, 13 Sept., p. 1789) mentions some of the obstacles to effective curriculum reform—the immense inertia of the faculty and their reluctance to give up "their" subject. One of the primary drivers of these impediments was identified in the Editorial by Timothy Goldsmith in the same issue ("Why is a liberal education so elusive?", 13 Sept., p. 1769): Faculty are usually reluctant to teach outside their areas of expertise. From the perspective of curriculum reform, this combination can be deadly. It also leads to a curriculum whose composition is stochastic rather than planned, as courses are added or dropped as faculty arrive and leave. But at least for the first 2 or 3 years of undergraduate education, most biology faculty ought to be able to teach effectively in several broad areas—why do we insist that an upper-year high school teacher cover all areas but that only 1 or 2 years later, students must be taught in a specialist fashion?

The solution is obvious but very challenging: design a curriculum around goals rather than content and involve the faculty in teaching fundamental, cross-disciplinary courses and courses outside their area of expertise. This could be enormously stimulating! For many years in a biology department, I taught biostatistics, a course whose content cut aggressively across all discipline areas. The freedom from parochial, specialty-driven course content and the sheer joy of teaching something that was fundamentally and enduringly important enlivened and invigorated my teaching.

A curriculum designed on goals and cross-disciplinary content could be a lot

slimmer than the obese, fact-filled, overlapping and often repetitive courses that constitute the typical biology curriculum. Such a lean curriculum would free up the time needed to involve undergraduates in real, meaningful research activity—a real benefit to both students and faculty.

STEPHEN M. SMITH

Department of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada. E-mail: smithsm@uwaterloo.ca

IT IS ENCOURAGING TO LEARN THAT BIOLOGY faculty recognize that "undergraduates [need] a better appreciation of the connections between biology and the physical sciences" ("Biology departments urged to



bone up," E. Stokstad, *News of the Week*, 13 Sept., p. 1789) and that steps are being taken to improve the situation.

Let me suggest a method established 30 years ago at the University of California, Irvine, that required two luncheon meetings to implement: one with David Brandt (chemistry) and myself (biology) and the other between William Parker (physics) and myself.

I asked these researchers and teachers to tell me what they teach in their beginning chemistry and physics courses: the gas laws, pH, oxidation and reduction, and kinetics and thermodynamics.

I then made it a point in my beginning cell biology course to correlate those subjects with my lectures on osmotic pressure; colligative properties and determining the molecular weight of proteins; the Henderson-Hasselbach principles of buffers; electron transfer reactions in the

mitochondria; Michaelis-Menton enzyme kinetics; and the production and utilization of energy in metabolism.

As a result, the students grasped these concepts of cell biology more easily because they had already learned the basic chemistry and physics involved. They also recognized that chemistry and physics were necessary for a deeper understanding of biology and that those courses were not just requirements to take and then forget.

And the lunches were good, too.

HOWARD M. LENHOFF

Professor Emeritus, Biological Sciences, University of California, Irvine, CA 92697-2310, USA.

Discussing the Origin of Life

J. L. BADA AND A. LAZCANO ("SOME LIKE IT hot, but not the first biomolecules," *Perspectives*, 14 June, p. 1982) discuss, among other things, the pros and cons of low-temperature versus high-temperature (deep-sea hydrothermal) sites for the origin of life. They seem to have overlooked that the hydrothermal sites all have both high- and low-temperature areas within a few meters of one another and that the turbulence associated with the vents will ensure at least sporadic mixing of these environments.

WARREN BORGESON

2784 Oakmont Drive, Flagstaff, AZ 86004-7436, USA.

IN THEIR PERSPECTIVE "SOME LIKE IT HOT, but not the first biomolecules," J. L. Bada and A. Lazcano (14 June, p. 1982) state that for monomers to undergo polymerization in the early "prebiotic soup," concentration would have been necessary. Yet, although they cite the work of Oparin (1), they do not refer to his statements on coacervation. Coacervates could form in dilute solution and reaction with cations, or other insolubilizing moieties could then have formed enclosing membranes.

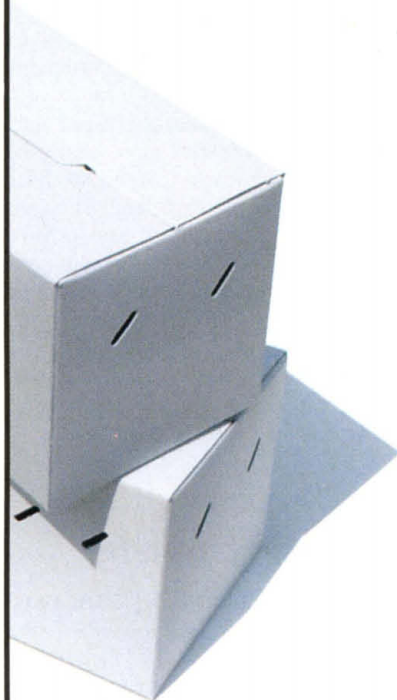
NATHANIEL A. MATLIN

The Matlin Company, 1078 Taylorsville Road, PO Box 600, Washington Crossing, PA 18977, USA.

Reference

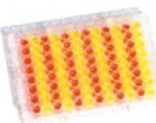
1. A. Oparin, *The Origin of Life* (Macmillan, London, 1938).

Now Shipping

LIVE
GENES

Open Biosystems is the Mammalian Gene Collection (MGC) and IMAGE clone distributor that is a step above the rest. We are the only clone distributor that has a clear test for growth, which is performed on each and every clone before it ships.

As demonstrated in this test plate, our growth indicator is either red or yellow, so there's no mistaking whether or not your clones have grown and are ready to ship.



The high quality tools available from Open Biosystems will go far beyond cDNA clones. Visit us at www.openbiosystems.com for details on many exciting new resources as they are released in the coming months. Move to the company that understands the importance of your research and is ready to provide the tools you need.



Open Biosystems, Inc.
Toll Free: 1-888-412-2225
FAX: 1-256-704-4849
www.openbiosystems.com

IN THE FIELD OF THE ORIGIN OF LIFE, SCIENTISTS are divided into segregated schools that do not even agree on the standards of scientific inquiry. Ordinarily, science is perceived as the difficult search for an ever-more-comprehensive, true explanation of the world. But in the words of J. L. Bada and A. Lazcano ("Some like it hot, but not the first biomolecules," *Perspectives*, 14 June, p. 1982), the research into the prebiotic soup theory of the origin of life aims "to construct a coherent narrative." This is a remarkable statement. The objective scientific principle of a search for the truth is replaced by the subjective aesthetic principle of a well-constructed story.

The search for truth is only possible as a community effort for which a critical rational discourse is a *conditio sine qua non*. This discourse is of value to the extent that the theory to be criticized and the references used for the criticism are not misrepresented. Bada and Lazcano address two theories on the origin of life: (i) a global heterotrophic origin of life in a cold prebiotic soup, in which organic compounds slowly accumulated over thousands or millions of years, eventually leading to the origin of evolution by the onset of nucleic acid replication, and (ii) my theory of a local chemo-autotrophic origin of life in hot volcanic exhalations by synthetic autocat-

alytic domino reactions of low molecular organic constituents on mineral surfaces of transition metal sulfides (1, 2).

According to the first theory, the compounds accumulating in the prebiotic soup must be hydrolytically inactive. Otherwise, they could not accumulate so slowly. In the second theory, the organic compounds (e.g., organo-metal compounds, thioesters, keto acids, and active amino acid derivatives), which are constituents of the domino reactions, must be synthesized in an activated form and must undergo rapid subsequent conversion. A slow accumulation of such activated organic compounds under the hydrolyzing conditions of an aqueous solution is not possible. Therefore, these two theories are incompatible. Bada and Lazcano overlook that fact when they claim that the theory of a chemo-autotrophic origin of life "is not a new idea" but rather was anticipated in 1955 by M. Ycas (3). Ycas wrote, "Under the influence of the energy of light or electrical discharges, simple compounds (methane, ammonia, etc.) of the original atmosphere form a great variety of organic compounds in solution in the ocean... While in solution in the ocean, the organic compounds will interact, forming... a system of interlocking cycles... as one living thing, the metabolizing ocean. The further evolution of this system presumably led to the production of catalysts of a high molecular weight" (p. 715). It is clear from this quotation that Ycas's proposal is fully within the prebiotic soup theory. Therefore, it cannot anticipate the theory of a chemo-autotrophic origin of life, with which it is incompatible.

Bada and Lazcano go even further in stating that my theory of a chemo-autotrophic origin of life is "a component of the prebiotic soup theory" in the sense that its reactions "could have played an important role in enriching the prebiotic soup in molecules not readily synthesized by other abiotic reactions or derived from space." This shows what it means to strip the field down to mere story construction, controlled only by the need for narrative coherence. It seems that any reaction that comes along as a result of my theory or any other future theory will be added to the soup theory. In this vein, telling the story of a prebiotic soup becomes all-inclusive. True science, however, is exclusive, thriving on conflict and refutation and having content by what it forbids.

GÜNTER WÄCHTERSCHÄUSER

Tal 29, D-80331 Munich, Germany. E-mail: info@patent.de

References

1. G. Wächtershäuser, *Microbiol. Rev.* **52**, 452 (1988).
2. ———, *Prog. Biophys. Mol. Biol.* **58**, 85 (1992).
3. M. Ycas, *Proc. Natl. Acad. Sci. U.S.A.* **41**, 714 (1955).

Why do smart engineers become patent attorneys?

An article that appeared in
The Wall Street Journal
July 5, 2002
explains why.

Did you know that
smart engineers and
scientists often become
patent *agents*
for the same reasons?

To view the *WSJ* article and to
find out much more:

ProfessorKayton.com

Response

BORGESON SUGGESTS THAT NEIGHBORING high- and low-temperature areas around hydrothermal vents may have had some prebiotic significance. There are indeed temperature gradients associated with hydrothermal systems, and these arise from the mixing of hot vent waters with cold ambient seawater. As has been demonstrated elsewhere (1), organic compounds are rapidly decomposed at the elevated temperatures characteristic of hot vent waters. Minerals (such as pyrite) that form around vent discharges could have played a role in assisting in the synthesis of complex organic molecules from simple reagents (HCN, aldehydes/ketones, and so forth) present in seawater, but there were likely many environments on the primitive Earth besides hydrothermal vents where this could have occurred.

Matlin mentions that coacervates as imagined by Oparin might serve as laboratory models of precellular systems. Indeed, liposomes and micelles formed from abiotically synthesized amphiphilic molecules may have played an important role in the emergence of the first membrane-bound precellular systems (2).

As he has shown elsewhere (3), Wächtershäuser is fixated on what he considers proper scientific methodologies, especially in the context of the philosophy of Karl Popper. He considers our relatively modest attempt to describe the emergence of life, using an evolutionary narrative consistent with the possible prebiotic environments and the essential properties of living entities, as unpalatable. He does not mention that a core theme of his autotrophic theory is the appearance of pyrite-based "life" that consisted of only autocatalytic metabolic reaction networks in which no genetic information material was present. There is indeed some evidence that iron/nickel sulfide could have played an important catalytic role in the synthesis of organic molecules on early Earth, as Wächtershäuser has advocated. But the fact is, whether in solution in the entire ocean or associated with mineral surfaces, metabolism in whatever form is not life as we know it. As we emphasized in our Perspective, regardless of what Wächtershäuser may speculate, it is unlikely that life could have evolved into modern biochemistry in the absence of a genetic replication mechanism to ensure the stability, survival, and diversification of its basic components. The central tenet of Wächtershäuser's criticism is his belief that the prebiotic soup theory and his autotrophic reaction schemes are incompatible. However, it is hard to see why the re-

sults that have been achieved so far from experimental work that has been performed within the framework of his autotrophic theory cannot be quite easily accommodated into the prebiotic soup heterotrophic theory of the origin of life, given its open epistemological character.

ANTONIO LAZCANO¹ AND JEFFREY L. BADA²

¹Facultad de Ciencias, UNAM, Apdo. Postal 70-407, Cd. Universitaria, 04510 Mexico D.F., Mexico. E-mail: alar@correo.unam.mx. ²Scripps Institution of Oceanography, University of California at San Diego, La Jolla, CA 92093-0212, USA. E-mail: jbada@ucsd.edu

References

1. J. L. Bada, S. L. Miller, M. Zhao, *Origins Life Evol. Biosphere* **25**, 111 (1995).
2. J. W. Szostak, D. P. Bartel, P. L. Luisi, *Nature* **409**, 387 (2001).
3. G. Wächtershäuser, *J. Theor. Biol.* **187**, 483 (1997).

Another Form of Bias in Conservation Research

IN THEIR RECENT ANALYSIS OF CONSERVATION research literature, J. A. Clark and R. M. May ("Taxonomic bias in conservation research, Letters, 12 July, p. 191) show that vertebrates are grossly overrepresented in conservation research, whereas invertebrates are underrepresented and plants are adequately represented when compared with their prevalence in nature. The authors show disappointment in this trend because successful conservation requires the study of all groups of organisms. I completely agree, and for this reason, I in turn was disappointed in their analysis of the literature because they considered only plant and animal taxa, ignoring other groups, particularly microorganisms. Yet, there is increasing evidence within the published ecological literature that microbes can play important roles in the functioning of ecosystems and in the regulation of plant and animal populations and communities. To evaluate any existing bias against microbial taxa, I reviewed 5 years of issues (1997–2001) in three journals (*Conservation Biology*, *Biodiversity and Conservation*, and *Biodiversity and Distribution*). I found that microbes were rarely studied at all: fungi/lichens, 0.024 as a proportion of all articles; protists, 0.007; and bacteria/viruses, 0.006. These values are far lower than the proportion of articles considering plants or animal taxa, as reported by Clark and May, even though microbes may arguably represent the majority of the taxonomic diversity in natural ecosystems. It is clear from these data that conservation research is even more unbalanced than reported by Clark and May.

JOHN N. KLIRONOMOS

Department of Botany, University of Guelph, Guelph, Ontario N1G 2W1, Canada. E-mail: jkliriono@uoguelph.ca

deliver more

You need to quickly turn your discoveries into full-scale drug production. You need to produce pure molecules in large quantities, in safe, reliable, cost effective ways.

Amersham Biosciences creates scalable purification solutions for biopharmaceutical manufacturers. We design them to be fast and efficient. We design them to make it easier to meet regulatory requirements.

It's no coincidence that nearly all the biopharmaceuticals so far licensed are produced using our technology.

MabSelect™: provides efficient downstream purification of Mabs

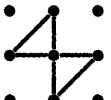
AKTApilot™: allows the scaling and validation of methods of the production of biomolecules

Sepharose™ Fast Flow: provides an established industry standard for downstream purification of biopharmaceuticals

BioProcess Systems: standard or customized, fulfil the exacting demands for industrial manufacture of biomolecules

Hollow fiber filters: strong and robust giving high recovery rates in cross flow filtration

www.amershambiosciences.com

 **Amersham Biosciences**

Amersham Biosciences UK Limited, Amersham Place, Little Chalfont, Buckinghamshire, HP7 9NA
AD 21-02