

LETTERS

Create Life From Scratch? It's a Matter of Time

Howard Berg (PHYSICS TODAY, January, page 24) summarizes an impressive body of knowledge about one of the simplest living organisms, and refers to *Escherichia coli* as a "nanotechnologist's dream." Has a living organism, say *E. coli*, ever been made by humans from scratch? To sharpen the question, have humans ever taken a collection of clearly "dead" ingredients and made a clearly "alive" organism? Aside from demonstrating technical prowess, would creation of life in the laboratory be philosophically profound or trivial?

ROBERT T. NACHTRIEB

Massachusetts Institute of Technology
Cambridge, Massachusetts

BERG REPLIES: No free-living (independently replicating) organism has been synthesized from scratch. The possibility of doing so is still remote. The simplest case, a wall-less bacterium called *Mycoplasma*, requires DNA encoding of about 300 genes for growth under laboratory conditions.¹ The functions of about 100 of these are unknown. When isolated from nature, the species in question, *M. genitalium*, had 517 genes; compare *E. coli* at 4288. But synthesizing the DNA would not be enough: one would need to know what other components (proteins, lipids, sugars, etc.) are required and how they might be assembled.

The DNA needed to specify the bacterial virus ϕ X174 was synthesized in 1967 (enzymatically, from a viral template).² Cells of *E. coli* exposed to this synthetic DNA made new virus, giving up their lives in the process. The DNA of ϕ X174 is a single-stranded circle comprising 5386 nucleotides that encode 11 genes (several overlapping). It was sequenced in 1977.³ The intact virus is icosahedral, with a protein coat comprising 60, 60, and 12 copies of proteins specified by genes F, G, and H, respectively. But it was *E. coli*,

Letters submitted for publication should be sent to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3843 or by e-mail to ptletter@aip.org (using your surname as "Subject"). Please include your affiliation, mailing address, and daytime phone number. We reserve the right to edit letters.

with its machinery for DNA replication and protein synthesis, that made the virus.

Whether creation of life in the laboratory would be philosophically profound or not depends, I suppose, on one's philosophy. I happen to believe that life, albeit highly complex, is a matter of physics and chemistry. And I include consciousness: see Crick.⁴ So for me, it's simply a matter of time. However, such a feat would signal an enormous extension of current understanding. For a timely discussion of broader issues, see ref. 5.

References

1. C. A. Hutchison III, S. N. Peterson, S. R. Gill, R. T. Cline, O. White, C. M. Fraser, H. O. Smith, J. C. Venter, *Science* **286**, 2165 (1999).
2. M. Goulian, A. Kornberg, R. L. Sinsheimer, *Proc. Natl. Acad. Sci. USA* **58**, 2321 (1967).
3. F. Sanger, G. M. Air, B. G. Barrell, N. L. Brown, A. R. Coulson, J. C. Fiddes, C. A. Hutchison III, P. M. Slocumbe, M. Smith, *Nature* **265**, 687 (1977).
4. F. Crick, *The Astonishing Hypothesis*, Scribners, New York (1994).
5. M. K. Cho, D. Magnus, A. L. Caplan, D. McGee, *The Ethics of Genomics* Group, *Science* **286**, 2087 (1999).

HOWARD C. BERG

(hberg@biosun.harvard.edu)

Harvard University

Cambridge, Massachusetts

Feynman Brainwashed?

Philip Anderson's Reference Frame article "Brainwashed by Feynman" (PHYSICS TODAY, February, page 11) reminded me of a Feynman story on this very subject. Even today I find myself explaining, as Anderson does so well, why meson-exchange Feynman diagrams are not sufficient to understand the origin of the nucleon-nucleon force. But in the 1980s, when I gave the Caltech colloquium on this subject, the idea that the nuclear forces could have important nonmesonic components due to the composite character of the nucleons was considered somewhat far-fetched.

Given my youth, the controversial character of the talk, the presence in the audience of many of the professors from whom I had learned the meson exchange orthodoxy, and

Feynman's sitting in the first row of the lecture theater, I was a little anxious as I began the talk. However, after I warmed up, it went reasonably well. I closed with the punch line that not only were such new forces allowed in principle, but the calculations by Maltman and myself,¹ among others, indicated that they were dominant at short distances.

Feynman stood up to ask the first question, and the room went silent. My diagram (showing two clusters of three quarks with a pair of quarks being swapped between the two clusters) looked like meson exchange to him, so why was I claiming a new kind of force? (The similar-looking Feynman diagrams have in them time-orderings that do correspond to meson exchange.) I believe Anderson will appreciate my reply: "The problem is that you are used to thinking in terms of Feynman diagrams." In the time it took the laughter to subside, Feynman had understood everything, and proceeded to explain to the audience why it was dangerous to be "brainwashed by Feynman."

Reference

1. K. Maltman, N. Isgur, *Phys. Rev. D* **29**, 952 (1984).

NATHAN ISGUR

(isgur@jlab.org)

Jefferson Lab

Newport News, Virginia

The Matter of WIMPs

The article on weakly interacting dark matter by Barbara Goss Levi (PHYSICS TODAY, April, page 17) calls on readers to imagine a halo of dark matter "which does not participate in the galactic rotation." This is difficult to imagine, because the whole purpose of introducing the weakly interacting massive particles (WIMPs) is to explain gravitational behavior of the Galaxy. Now the reader is asked to imagine that the WIMPs themselves are not influenced by the galactic gravitational field. Maybe the intent is to assume that each particle rotates in a separate plane about the galactic center, and the average speed of the cloud is zero.

It is an interesting speculation that the angular momentum of the WIMP cloud may cancel out the total