

lowed an entirely different and far less admirable tradition of using the names of politicians or famous historical figures whose relation to a facility or its purpose is far-fetched at best.

Jefferson's high regard for the sciences is hardly enough of a distinction to warrant affixing his name to a facility that, according to an account in *PHYSICS TODAY* (July 1996, page 49), is very much the achievement of a single scientist—Hermann Grunder.

I close with two questions: Is Fermilab about to become the Abraham Lincoln National Laboratory? Will Congress and the state legislatures ever set policy on the naming of publicly funded enterprises?

LAWRENCE CRANBERG
Austin, Texas

Nambu's Importance Discussed: Pion-eer or Man of 'Color'?

In his review (October 1996, page 72) of *Broken Symmetry*, a compilation of Y. Nambu's papers, Roman Jackiw shows admirable collegiality but misses a point of scientific history.

One of Nambu's most consequential works was his paper on spontaneous symmetry breaking. Published in 1960, it subsequently revolutionized particle theory.¹ Jackiw remarks that Nambu "did not appreciate the generality" of the idea in particle theory. It seems to me that, on the contrary, Nambu not only fully understood the idea of vacuum degeneracy but also gave the first successful physical application to the case of chiral symmetry breaking and the pion. In his later paper, which cited Nambu, J. Goldstone gave a mathematical model that illustrated the idea of spontaneous symmetry breaking but stated in his opening paragraph that "the present work merely considers models and has no direct physical applications."²

References

1. Y. Nambu, *Phys. Rev. Lett.* 4, 380 (1960).
2. J. Goldstone, *Nuovo Cimento* 19, 15 (1961).

PAUL FRAMPTON

University of North Carolina at Chapel Hill

JACKIW REPLIES: Paul Frampton has misread my review. I wrote that Nambu "did not appreciate the generality of a gapless mode . . . accompanying vacuum degeneracy [emphasis added]." This point I inferred from Nambu's own recollection in *Broken Symmetry* (page xii): "[Goldstone] conjectured the generality of the existence of zero modes. As for [this]

point, I had been debating . . . how to write a paper addressing it as a general phenomenon."

But I fully agree with Frampton that (as, in fact, I stated) Nambu gave us the present theory of the pion. On the other hand, I believe that Nambu's "most consequential" work was his early suggestion of the "color" degree of freedom, not only leading to a global symmetry, but also coupling to a new gauge field. With this he preceded later formulations of color quantum chromodynamics by seven years.

ROMAN JACKIW

Massachusetts Institute of Technology
Cambridge, Massachusetts

A Fizz-sics Solution: Use Limestone to Cure Lake's CO₂ Problem

In discussing possible remedies for the occasional lethal eruptions of carbon dioxide from Lake Nyos and similar lakes (*PHYSICS TODAY*, May 1996, page 20), Ray Ladbury describes "the leading proposal for degassing the lakes" as being a plan, as reported by George Kling and associates,¹ to lay pipes at the deepest layers and pump the supersaturated water to the surface layer to be degassed.

I suggest another way of getting rid of the excess carbon dioxide accumulating at the bottom of such lakes: Dump limestone (CaCO₃) into the lake; the carbonate ions will react with the CO₂ to form bicarbonate, and the bicarbonate ions will remain in solution: $\text{CO}_3^{2-} + \text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons 2\text{HCO}_3^-$.

The limestone approach may be a more environmentally benign solution to the Lake Nyos problem than controlled degassing would be. The pH at the bottom of the lake would rise from 4 or 5 to 8.3, characteristic of the dissociation constant of bicarbonate,² and that could possibly lead to the restoration of the lake's aquatic life.

Possibly, the limestone approach could also prove cheaper than the degassing approach. Because of the large volume of water to be pumped to the surface, degassing would require several pipes of very large diameter or a bundling of many smaller pipes—the "Lake Nyos organ pipes." Installing such pipes and also pumps, as well as providing the pumping energy, would be a formidable and expensive engineering task.

How much limestone would be required? To soak up all of Lake Nyos's CO₂, one would need 1.25 million metric tons. However, the yearly accretion of CO₂ in the lake is only about 9000

metric tons.¹ That would require the dumping of only 20 000 metric tons of limestone a year—a not-outrageous amount that would fill about 200 railroad cars, or about 1000 trucks.

There are potential problems associated with the limestone dumping. The dissolving of CaCO₃ in the lake water may be slow, so that the limestone would have to be pulverized and pneumatically dispersed over a large area of the lake. Perhaps of greatest concern would be the fact that inserting 20 000 metric tons of limestone in Lake Nyos could possibly trigger a premature turnover of the lake and thereby bring about a repeat of the 1986 disaster. Limnologists should look into that issue.

References

1. G. W. Kling, W. C. Evans, M. L. Tuttle, G. Tanylleke, *Nature* 368, 405 (1994).
2. V. L. Snoeyink, D. Jenkins, *Water Chemistry*, Wiley, New York (1980), p. 181.

DAN GOLOMB

University of Massachusetts at Lowell
(golombd@woods.uml.edu)

MAAD Scientists and Others Do Numerical Fracture Studies

In "How Things Break" (*PHYSICS TODAY*, September 1996, page 24), Mike Marder and Jay Fineberg present their recent studies on rapid brittle fracture (I use "their" to include the authors' collaborators). For their "crisis" phase, they describe the crack going beyond a critical speed and leaving "a thicket of small branches penetrating the surface behind [it]." This description follows from their fracture studies using a lattice model by Leonid Slepyan in which they first discovered this pattern. Later, their fracture experiments on Plexiglas showed an extensive network of microcracks radiating from the main crack, and the authors compare the results of their experiment and their simulations based on the Slepyan model. Their work and that of other researchers reflect the fact that brittle fracture is a truly rich phenomenon, and its numerical modeling is rapidly improving.

My colleagues and I have done two-dimensional molecular dynamics simulations of rapid fracture assuming Newtonian physics and a simple pair potential,¹ an *ab initio* approach in relation to the Slepyan two-dimensional lattice model. Our early simulations established the instability as an intrinsic property of the crack dynamics and not a consequence of material imperfections. Most important, our

continued on page 89