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Timing of Permian-Triassic Anoxia

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cluded discussion of a virus (vaccinia). Although we understand Cepica's (and presumably others') disappointment about the relative lack of "viral" subject matter in our article, we did not want to be inaccurate and lump vaccinia in with a bunch of bacteria.

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### Timing of Permian-Triassic Anoxia

Yukio Isozaki outlines thresholds in deepening oceanic anoxia and subsequent oxygenation across the Permian-Triassic boundary (Reports, 11 Apr., p. 235). He implies that mass extinction at this time was a product of oceanic stagnation many millions of years in the making. There is, however, continuing uncertainty about the position of the Permian-Triassic boundary in the Japanese section studied. That section lacks critical ammonites and conodonts, or even geochemical markers, such as the change in carbon-13 isotopic

lightening, that characterize the boundary elsewhere (1, 2). The Permian-Triassic boundary could have equally preceded or coincided with the onset of "climax superanoxia," rather than postdated it, as proposed in Isozaki's stratigraphic section. If "climax superanoxia" postdated the Permian-Triassic boundary, as in the best documented sections elsewhere (1), then there are alternative hypotheses to long-term descent into "superanoxia" and recovery. Instead, Late Permian anoxia could have been related to an extinction event during the Late Permian (end-Guadalupian extinction) (3), with "climax superanoxia" and delayed recovery forced by the greatest of all mass extinctions at the end of the Permian (end-Changxingian extinction) (1). Oceanic anoxia could then have been a consequence of death, decay, and boom-or-bust population cycles (4) forced by other agencies (5), such as voluminous volcanic eruptions (6), impact of an unusually large bolide (7), or both (8).

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**Response:** Concerning the age assignment of the Permian-Triassic boundary section in Japan, microfossil age constraints have recently been enhanced: (i) conodonts (*Neogondolella changxingensis* and *N. subcarinata*) of the Changxingian stage were found in lower gray cherts below the claystones; (ii) three radiolarian zones were newly defined for the interval of the late Wuchapingian and Changxingian in the uppermost part of the lower gray chert; (iii) Paleozoic-type radiolaria *Follicucullus* species were found (although few) from the black "boundary" claystone without any Triassic

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signature (1). Although there is still uncertainty, age assignment of the section shown in figure 3 of my report still appears reasonable. Secular change in carbon-13 values of the section looks unavailable at present because (i) the primary depth of chert sedimentation below carbonate compensation depth (usually more than 3000 meters) ousted carbonates from the section (2), and (ii) preliminary measurements of organic carbon show highly variable (thus, controversial) carbon-13 values through the section.

With regard to the comment by Retalack and Holser about the subtle timing between the onset of "superanoxia" and the real boundary, I will refrain from being too specific about whether oceanic anoxia or an apparently stratified ocean was the real culprit of the global mass extinction until more precise geochronologic data are available for the section. The apparent oceanic stratification may have been a consequence, rather than a cause, of all the unique changes across the boundary. The deposition of organic claystone around the boundary, however, was probably a result of transient blooming of anaerobic biota during the "superanoxia," not of the one-time mass dying at the end-Changxingian, because the Lower Triassic siliceous claystone also interca-

lates many organic claystone layers up to the Spathian horizons (1, 3). Likewise, the end-Guadalupian extinction alone may not have been responsible for the whole Late Permian anoxia of nearly 8 million years duration.

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#### Corrections and Clarifications

In figure 1 (p. 1249) of the article "Pathways to macroscale order in nanostructured block copolymers" by Zhong-Ren Chen *et al.* (29 Aug., p. 1248), the lower labels for the perpendicular and the transverse alignments were incorrect. They should have been " $\Delta n_{13} = >0$ " and " $\Delta n_{13} = <0$ ," respectively.

In the report "Protein transport by purified yeast Sec complex and Kar2p without membranes" by K. E. S. Matlack *et al.* (15 Aug., p. 938),

panels B and C of figure 1 (p. 939) were inadvertently interchanged during editing.

In the Research News article "Archaeologists rediscover cannibals" by Ann Gibbons (1 Aug., p. 635), the credit for the three photographs on page 635 should have read, "C. G. Turner, Arizona State University."

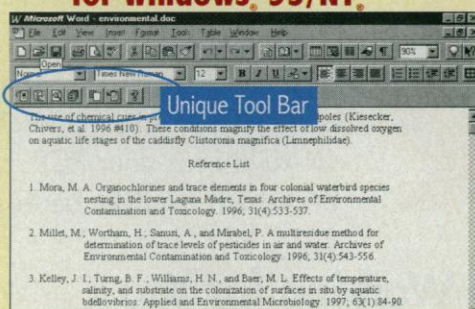
Robert F. Service's Research News article on combinatorial materials synthesis, "High-speed materials design" (25 July, p. 474), should have stated that the first materials library was created by Xiao-Dong Xiang of Lawrence Berkeley National Laboratory (LBNL) and Peter Schultz of LBNL and the University of California, Berkeley, and their colleagues.

#### Letters to the Editor

Letters may be submitted by e-mail (at [science\\_letters@aaas.org](mailto:science_letters@aaas.org)), fax (202-789-4669), or regular mail (*Science*, 1200 New York Avenue, NW, Washington, DC 20005, USA). Letters are not routinely acknowledged. Full addresses, signatures, and daytime phone numbers should be included. Letters should be brief (300 words or less) and may be edited for reasons of clarity or space. They may appear in print and/or on the World Wide Web. Letter writers are not consulted before publication.

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