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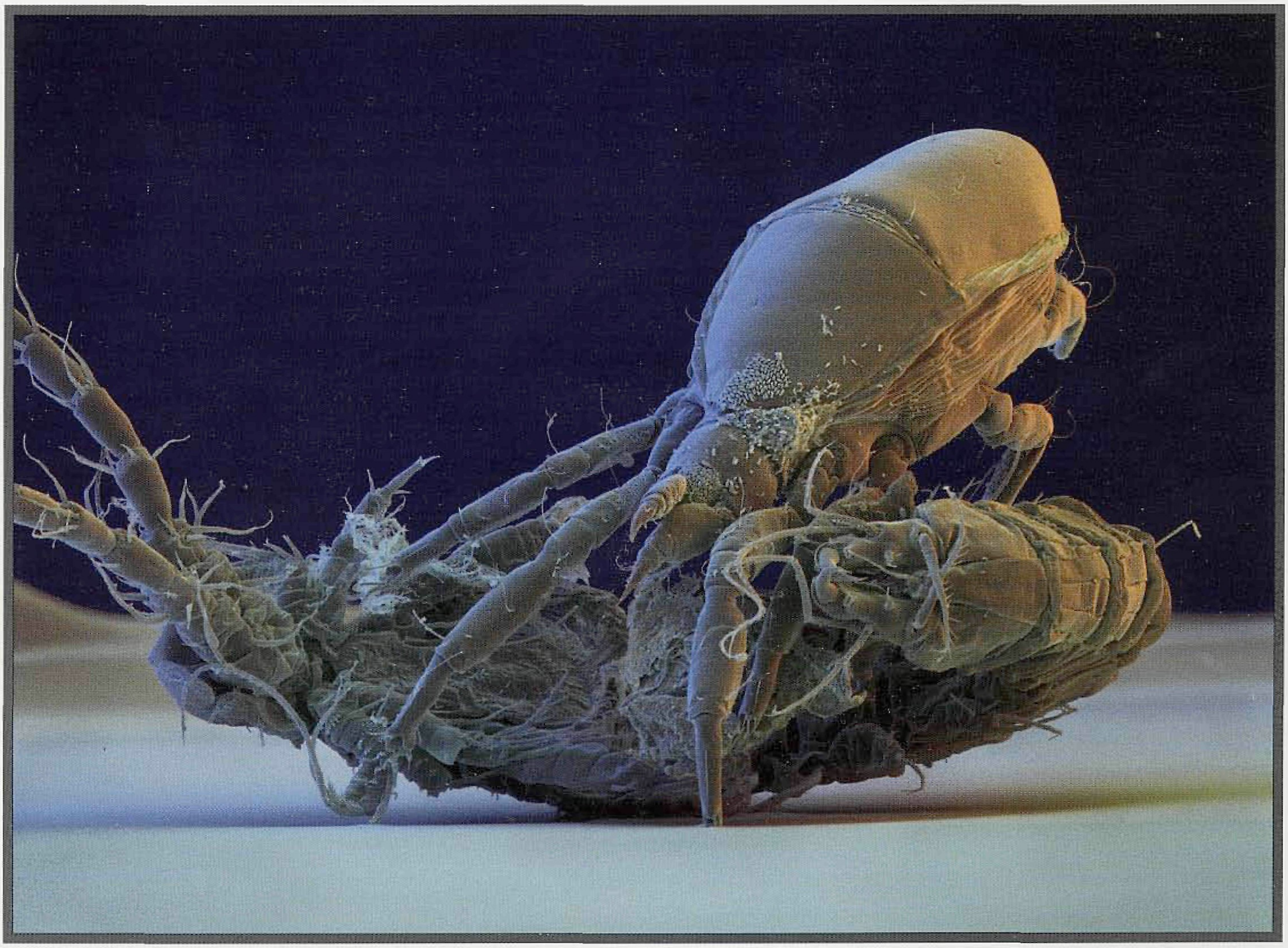

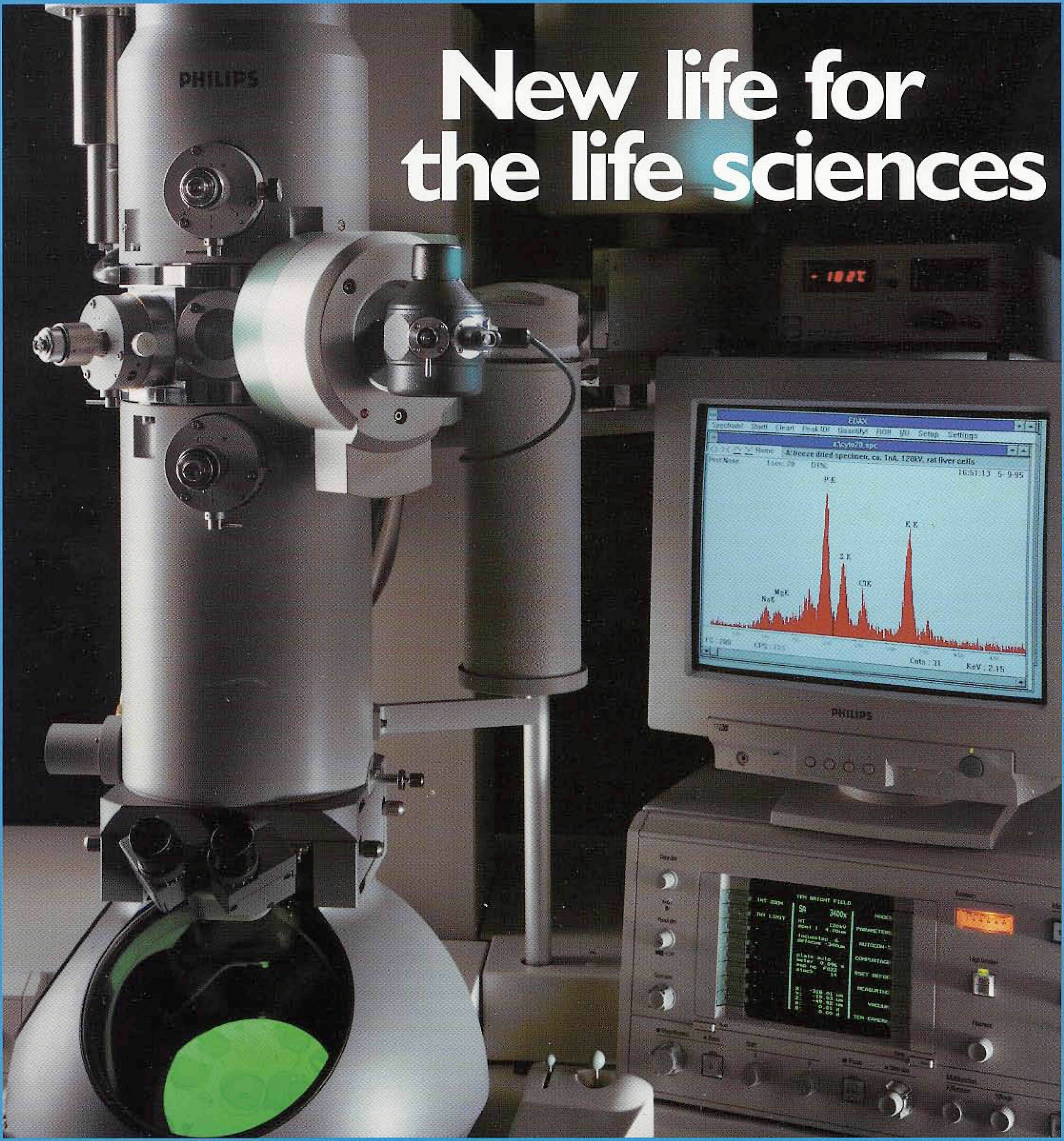

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Circle Reader Inquiry #3

SEE ATOMS IN MOTION!

Stephen W. Carmichael,[1] Mayo Clinic

It is impressive enough that individual atoms can be resolved with the atomic force microscope (AFM), but who would have thought that atomic motion would be detected so soon? Atomic resolution with the AFM was only recently achieved. As reported in this column,[2] Franz Giessibl[3] was able to demonstrate local resolution of adatoms of the Si(111) 7X7 reconstructed surface. Now, Yasuhiro Sugawara, Masahiro Ohta, Hitoshi Ueyama, and Seizo Morita of Hiroshima University have demonstrated atomic resolution of the surface of InP(110).[4] Not only that, but images taken about one minute apart show that some of the atoms had moved! Sugawara *et al.* used a very compact AFM under ultrahigh vacuum (4 X 10^{-8} Pa) to accomplish this impressive feat. A stiff (spring constant of 34 N/m) silicon cantilever was used. This stiffness, along with a mechanical resonant frequency of 151 kHz, was used to keep the cantilever from jumping onto the sample and crushing the initially sharp tip. The cantilever was scanned by a tube piezoelectric scanner, and its deflection was detected by a very sensitive optical-fiber interferometer. The frequency modulation (FM) detection method was used in the non-contact mode to measure the force gradient acting on the tip. The scanner was also used to vibrate the cantilever at the mechanical resonant frequency. A positive feedback system with automatic gain control was used to maintain a constant vibration amplitude of 20 nm. The frequency shift of the cantilever was detected by a tunable analog FM demodulator. The images were obtained at room temperature at a constant force gradient; they kept the distance between the tip and the sample constant by maintaining a constant frequency shift of -6 Hz.

In their published micrographs, Sugawara *et al.* clearly demonstrated the rectangular lattice of the InP(110) surface. Because they used the non-contact mode, they were able to avoid the distortion caused by friction between the tip and sample that is seen in the contact mode. The lattice structure represents rows of quasi-one-dimensional zigzag chains of alternating phosphorus and indium atoms. The distance between phosphorus atoms along the chain was measured at 0.43 nm and the distance between chains was 0.58 nm, in good agreement with accepted values.

Most impressive was the visualization of defects referred to as "P vacancies," thought to be caused by cleavage of the sample. Occasionally, the sites of these missing phosphorus atoms were seen in small groups, and when images were taken about 80 seconds apart, the defects had moved over a row or two, relative to each other. In one case, a single defect became two. This suggests that phosphorus atoms are moving between chains on a time frame of a minute or so.

The advantages of demonstrating this thermal motion with AFM, rather than scanning tunneling microscopy (STM), was discussed by Sugawara *et al.* The main point is that with STM the atoms may be influenced by tip-induced effects that are absent in the AFM. While the evidence suggests that these observations are of thermally-induced atomic motion, other mechanisms could not be excluded. Nevertheless, this demonstration of atoms in motion remains quite impressive! ■

[1] The author gratefully acknowledges Yasuhiro Sugawara, for reviewing this article.

[2] Atomic resolution with the atomic force microscope, *Microscopy Today*, 95-4 6, 1995.

[3] Giessibl, F., Atomic resolution of the silicon (111)-(7X7) surface by atomic force microscopy, *Science* 267:68-71, 1995.

[4] Sugawara, Y., M. Ohta, H. Ueyama, and S. Morita Defect motion on an InP(110) surface observed with noncontact atomic force microscopy, *Science* 270:1646-1648, 1995

A Note to our Readers

With this issue we start our fifth year of publication. Should you recall our first issue, all four pages of it, I trust that you will agree that there has been some improvements.

First in appreciation, I wish to acknowledge the support of a number of manufacturers and suppliers who elected to initially advertise with us - with NO idea of whether such would be of value to them. And the most satisfying element of this effort is that ALL continue to support the publication. I wish that I could list them, but do not wish to offend any of my current advertisers.

Next, but not secondary, I wish to thank an even smaller number of individuals who have assisted in providing articles and materials - who have really made this pub what it might be.

The future? It depends completely on the help with articles and materials that YOU supply!

=== Don Grimes, Editor

Front Page Image

SEM Photograph of A Marine Mite Feeding On a Mystacocarid (Typica) - Marine Meiofauna

Imaged on an ETEC SEM at 5 kV using the SEM Wideband Multi-Detector Color Synthesizer (designed, built and patented by David Scharf). Then acquired digitally at 2,048 X 1,536 pixels directly into a Macintosh Power PC as a TIFF file, using Digital Micrograph software and Digiscan hardware. Then output to a CELCO film recorder, using Ektachrome 100+ film, to produce a 4x5 transparency.

This image is available at 2,500X as a 23" x 19" high quality, lithographic print. Refer to information starting on page 19 of this issue.

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