algae by Laurens Mets (of the University of Chicago's department of molecular genetics) and spread them on a mica surface. The researchers then did a simultaneous shear-force scan and near-field optical scan. The former provided a topographic image of the 7-nm-thick membrane fragments, while the latter revealed which regions were fluorescing. (See the figure on page 17.) Xie and his group have also performed separate scans of allophycocyanin and sulforhodamine 101 molecules dispersed on glass, with sensitivity and resolution sufficient to detect individual molecules. (Allophycocyanin is a six-chromophore light-harvesting protein that occurs in red algae, and sulforhodamine 101 is a single-chromophore laser dye.) After doing a scan they positioned their microscope tip over a bright region of the membrane or over a single sulforhodamine 101 molecule and took time-correlated photon counts, which revealed the fluorescence lifetime of that region or molecule. The field of fluorescence-lifetime imaging is very active, but most work uses confocal microscopy, which is diffraction limited.

Ultimately Xie's goal is to map the photosynthetic membrane spectroscopically and to study the many reactions involved in photosynthesis at the single-molecule level, including electron transfer, proton transfer, energy transfer and protein conformational changes.

His group has also made a movie of a 2-micron-square field of sulforhodamine 101 molecules fluorescing after being hit by a pulse of laser light. (Strictly speaking, the movie shows the temporal probability distribution of the fluorescence, since it is mapped out with a series of laser pulses.) Hollywood epics are not under challenge, however: The movie's 64 frames represent 6 nanoseconds of action.

In addition, Xie's group has studied the effect of the microscope tip itself on fluorescence. When the edge of the tip was close to a fluorescing molecule the aluminum in the tip quenched the fluorescence, reducing the lifetime in one experiment from about 3 nsec to about 1 nsec. When the center of the tip was over the molecule, however, the lifetime was close to the bulk lifetime (measured for a collection of molecules using far-field light), suggesting that the tip is not greatly influencing the results in that case.

Patrick Ambrose and collaborators at Los Alamos have also done time-resolved studies of single-chromophore molecules.[6] They saw individual molecules' fluorescence blinking out due to photobleaching and they also observed the effect of the tip on fluorescence lifetimes. In their experiments, using the dye rhodamine 6G on silica, they saw both lengthening and shortening of the fluorescence lifetime according to whether the molecule was centered under the tip or was near the edge of the tip, respectively. Ambrose attributes this effect to phenomena observed in the 1960s with molecular layers close to metal surfaces: As a molecule approaches the surface, radiation reflected from the metal suppresses or enhances the spontaneous emission rate, depending on the distance from the metal. Within 50 nm of the metal, direct energy transfer from the molecule to the metal can occur, quenching the fluorescence.

In the immediate future a rapidly growing body of researchers will likely be using fiber-probe scanners based on Betzig's design for increasingly detailed studies of small, delicate systems such as photosynthetic membranes and silicon clusters. When asked about his own future plans, Betzig only hints suggestively about the prospects for a near-field optical microscope with a molecule-sized tip. He and Trautman took out a general patent on such a concept a couple of years ago.

—GRAHAM P. COLLINS

References

1. E. Betzig, R. J. Chichester, Science **262**, 1422 (1993).
2. R. C. Dunn, G. R. Holtom, L. Mets, X. S. Xie, J. Phys. Chem. **98**, 3094 (1994).
3. R. C. Dunn, E. V. Allen, S. A. Joyce, G. A. Anderson, X. S. Xie, "Near-Field Fluorescent Imaging of Single Proteins," Ultramicroscopy, in press (1994). X. S. Xie, R. C. Dunn, "Probing Single Molecule Dynamics," Pacific Northwest Lab. preprint, April 1994.
4. E. Betzig, J. K. Trautman, T. D. Harris, J. S. Weiner, R. L. Kostelak, Science **251**, 1468 (1991).
5. J. K. Trautman, J. J. Macklin, L. E. Brus, E. Betzig, Nature, in press (1994).
6. W. P. Ambrose, P. M. Goodwin, J. C. Martin, R. A. Keller, Phys. Rev. Lett. **72**, 160 (1994). W. P. Ambrose, P. M. Goodwin, J. C. Martin, R. A. Keller, Proc. SPIE **2125**, in press (1994).
7. E. H. Synge, Philos. Mag. **6**, 356 (1928). D. McMullan, Proc. R. Microsc. Soc. **25**, 127 (1990).
8. E. Betzig, J. K. Trautman, Science **257**, 189 (1992).
9. E. A. Ash, G. Nicholls, Nature **237**, 510 (1972).
10. F. Zenhausern, H. K. Wickramasinghe, "An Apertureless Near-Field Optical Microscope," IBM preprint, April 1994. ■

Reaching for the Top

The uninitiated would have had difficulty explaining the excited crowd of physicists filling Fermilab's auditorium on 26 April—especially since the presenters were careful to disclaim an actual discovery. Yet even though skepticism remained the watchword, the excitement of even the most ardent critics was palpable. The multinational 440-member Collider Detector Facility group at Fermilab's Tevatron may have glimpsed the top quark—the long-sought partner of the bottom quark—at 174 ± 17 GeV. This would make the t quark the heaviest fundamental particle yet seen. Indeed, because the observed mass is so close to the mass at which electroweak unification becomes manifest, many speculate that the top quark may hold the secrets to the primordial breaking of vacuum symmetry that is thought to have given masses to elementary particles.

CDF spokesmen William Carithers and Melvyn Shochet discussed the t-quark candidates distilled from 10^{12} 1.8-GeV $p\bar{p}$ interactions that took place during the ten-month run beginning August 1992. Three analyses looking for different final states of t quarks decaying into a W boson and a b quark found a total of 12 candidates. Three of those events were seen independently by two of the analyses, adding to their credibility. Depending on the background estimates used the statistical significance of the observation lay between 2.8 and 3.5 standard deviations. The t-quark hypothesis is also supported by most subsequent analyses of the top sample. On the other hand, spokesmen for CDF and the other Fermilab collider experiment, D0 (which reports no significant signal, despite similar sensitivity), pointed out that limited statistics, inconsistencies in some backgrounds and event complexity (many events produce more than 100 charged particles) suggest caution. The CDF analyses are so complex that the paper submitted to *Physical Review D* on 22 April was 153 pages long. As CDF physicist, Paul Tipton said, "If we'd had twice the signal or half the signal, it would have been a much shorter paper." The CDF and D0 teams hope that the 1994–95 data run will help them make an intriguing observation believable. —RAY LADBURY