ical compound and a semiconductor sensitive to this product. The most common enzyme transistors consist of a column containing immobilized hydrogenase, a gas-permeable membrane, and a simple palladium-based metal oxide semiconductor. These systems can detect gas concentrations as low as 0.05 mmol/l. Danielsson also suggested using enzyme transistors to measure aqueous electrolytes. Although these devices are slower than transistors operating with gas streams, using enzyme transistors in liquid media substantially widens the possibilities for commercial applications.

The potential of exploiting the electrochemical properties of proteins for creating analytical and computing devices was discussed by H. Allen Hill (University of Oxford, U.K.). Electron transfer reactions, which are key steps in generating energy in living systems, are mediated by proteins and coenzymes. Hill described how these molecules can transfer electrons to metal or semiconductor electrodes. His group has been developing electrodes that use equine heart cytochrome c, a redox protein. They found that electron transfer to this protein was much more rapid if the surface presented by the artificial electron donor (electrode) resembled the surface of the physiological electron donor. Several modified gold and graphite electrodes they tested appear to orient the protein in a productive configuration for electron transfer. Hill also described the potential use of coupled enzyme systems for information storage. However, the future use of these redox proteins in artificial systems will depend on achieving rapid and reversible electron transfer between the biological molecules and the inorganic electrodes.

Ari Aviram described work on molecular rectifiers and other electronic components, illustrating the interdisciplinary requirements of bioelectronics research. Aviram stated that the progress in the field will require more effective integration of physics, biochemistry, and optics, as well as biology and electronics, and postulated that computer components of the future will be sized at the molecular level. However, it is not at all certain that biological or organic molecules will provide the basis for these components. Aviram pointed to bioelectronic signal transport mechanisms as one area that requires substantial basic research.

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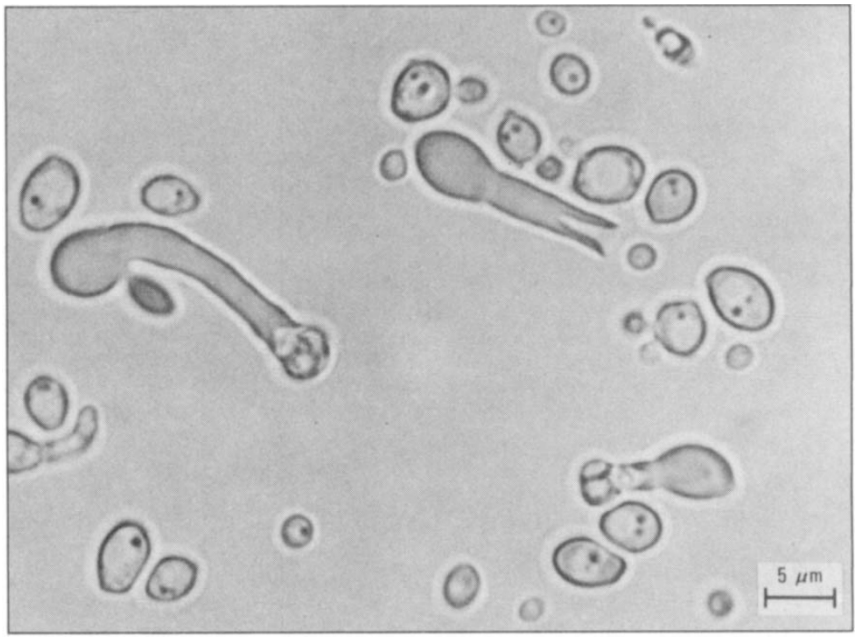
FERMENTATION OF XYLOSE FROM BIOMASS

An enormous worldwide research effort is under way to convert plant materials to ethanol and other industrially useful organic compounds. The potential of this resource is significant: in the U.S. alone, annual production of agricultural wastes and residues exceeds 500 million tons dry weight.

Plant biomass has three major constituents: cellulose, hemicellulose and lignin. The means for dealing with cellulose in relatively pure form are developing rapidly, and efficient conversions are now possible through combined saccharification and fermentation processes. Biomass cellulose, however, is not readily accessible and exists in a complex structural arrangement with lignin and hemicellulose. By contrast, hemicellulose, which is more readily obtainable in relatively pure form, may be converted to its component pentoses, hexoses, and uronic and acetic acids through mild chemical or enzymatic treatments. Xylose, the major pentose of hemicellulose, can account for up to 25 percent of the total biomass (dry basis). In view of this, the recent discovery by Schneider et al.[1] and Kurtzman et al.[2] that the yeast *Pachysolen tannophilus* can ferment D-xylose to ethanol has exciting implications for biomass utilization. However, the efficiency of fermentation and ethanol tolerance of this organism is somewhat low and must be improved for industrial application.

The report by T. W. Jeffries in this issue of BIO/TECHNOLOGY addresses one aspect of the physiology of *P. tannophilus*, the effect of different nitrogen compounds on xylose fermentation, that may lead to optimization of ethanol or acetic acid production by this yeast. Other approaches should also be explored. For example, *P. tannophilus* can also ferment glucose, galactose, and mannose, and these sugars, along with xylose, represent the major monosaccharides of sulfite waste liquor from paper manufacturing. Because the fermentation of the latter three sugars is under strong glucose catabolite repression, a mixture of mutants specific for each of these sugars would allow for more efficient fermentation.



The yeast *Pachysolen tannophilus*, unusual for its ability to ferment D-xylose, has a distinct ascosporic state morphologically unlike any other known yeast.

References

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