Sweden) indicated that the tranquilizer chlorpromazine can induce genetic effects in *E. coli* and in yeast. This drug causes mutations in these organisms only if they are exposed to light. Possibly chlorpromazine could be carcinogenic in skin that has been exposed to the sun.

Phencyclidine is a veterinary anesthetic currently sold on the illicit market as a hallucinogen. F. Walker (Childrens Psychiatric Reseach Institute, London, Ontario) found this drug to be teratogenic. Users of phencyclidine had increased rates of fetal loss, decreased fertility, extensive chromosome breakage, and increased presence of a small chromosome that resembled the Philadelphia chromosome. Their offspring had an abnormally large incidence of spinal defects, limb reduction anomalies, triploidy, and trisomy.

Industrial chemicals are another source of potential mutagens. B. Kilbey (University of Edinburgh) studied effects of various amounts of the carcinogen diepoxybutane (DEB) on the rates of reversion of adenine-requiring mutants of *Neurospora.* This chemical is used to cure polymers and cross-link textile fibers. Effects on *Neurospora* that were related to the dose of DEB appeared only at low DEB concentrations. It is believed that DEB may interfere with both DNA and its repair systems. This theory is supported by increased sensitivity to mutagenic effects of ultraviolet light and of DEB after pretreatment with DEB. The effect is transient, indicating that the damage to the DNA repair system is itself repairable. Actidione prevents this repair, suggesting that the restoration of repair function requires protein synthesis.

Mutants of *Salmonella* and *E. coli* were used by F. Mukai and I. Hawryluk (New York University Medical Center) to demonstrate the mutagenicity of a series of haloethers and haloketones, including dimethyl carbamyl chloride, epichlorohydrin, chloropentafluoroacetone, and chlorotetrafluoroacetone.

The harmful effects of radiation exposure emphasize the need for tests that can measure radiation exposure and chromosome damage in man. In an effort to validate the extrapolation of animal data to man, J. Brewen and J. Preston (Oak Ridge National Laboratory) studied x-ray–induced aberrations in the chromosomes of peripheral leukocytes of six mammalian species. They concluded that in vitro radiation experiments correlated well with in vivo ones. They found human leukocytes twice as sensitive to radiation-induced translocations as those of the mouse. Marmoset leukocytes, cultured for the first time, may be particularly useful because the marmoset has the same number of chromosomes as man.

W. Brandon (University of Denver) found a marked increase in the occurrence of chromosomal aberrations in cultured peripheral lymphocytes from workers exposed to plutonium. He also found that uranium miners exposed to radon-222 showed an increase in chromosomal aberrations. This may prove of value as a biological indicator of mining radiation exposure.

It was the consensus among conference participants that environmental mutagens constitute a significant social problem, the magnitude of which must be carefully evaluated, and that adequate methods of societal control of genetically active substances should be established.

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Enzyme Engineering

Considerable worldwide interest has arisen in recent years in the controlled use of enzymes as catalysts in industrial processing, analytical chemistry, and medical therapy. Significant new approaches with high economical and technological potential for solution of a number of problems in each of these areas currently are under investigation. Much of this potential has evolved from the development of techniques for enzyme immobilization on a wide variety of support materials, improved enzyme purification, and induction of microorganisms to produce large amounts of selected enzymes. This interest has generated the new interdisciplinary field of enzyme engineering, which includes both the scientific and technological aspects of the production, isolation and purification, immobilization, and application of enzymes in a variety of situations and reactor configurations.

Although several applications of immobilized enzymes are in commercial use or appear very promising, a number of technical problems limit other practical applications in industry, chemical analysis, and medicine. In order to generate ideas and direction for overcoming these problems, the Engineering Foundation with financial support from the Corning Glass Works sponsored the Second International Conference on Enzyme Engineering held on 5 to 10 August 1973 at Henniker, New Hampshire. More than 190 selected speakers and scientists from 18 countries participated, including biochemists, chemical engineers, microbiologists, and a variety of other specialists from industry, government, and universities. L. B. Wingard, Jr. (University of Pittsburgh) served as executive chairman and E. K. Pye (University of Pennsylvania) was program chairman with the assistance of an international advisory board.

Two major emphases of the conference were the application of immobilized enzymes and the problems of utilizing cofactor-requiring enzyme systems. L. B. Wingard, Jr. (University of Pittsburgh) opened the conference by citing the developments since the 1971 conference and by challenging the participants with the need for definitive economic and technical evaluations of specific applications of immobilized enzymes, for greatly improved feedback on economic and operational problems from industry to universities and granting agencies, and for more academic input toward resolving the more difficult problems of enzyme stability, cofactor systems, multienzyme systems, and enzyme moderated energy transfer.

Many of the potential applications of immobilized enzymes necessitate systems that require cofactors, which like the enzymes may be too expensive to use once and discard. By the immobilization of cofactors to either soluble or insoluble supports together with the provision for regeneration of these cofactors, several reaction schemes and reactor configurations can be visualized that may lead to the development of practical immobilized enzyme-cofactor catalytic systems. M. K. Weibel (University of Pennsylvania) and K. Mosbach (University of Lund) described the immobilization of nicotinamide adenine dinucleotide (NAD) and I. Chibata (Tanabe Seiyaku Co., Japan) reported the immobilization of coenzyme A. Several cofactor regeneration schemes were described: nicotinamide adenine dinucleotide phosphate by N. L. Smith (University of California at Irvine), NAD by R. P. Chambers (Tulane University), and adenosine triphosphate by D. Marshall (Battelle at Columbus) and C. K. Colton (Massachusetts Institute of Technology).

Reports on industrial applications of immobilized enzymes included the treatment of milk with proteases (N. Olson,

University of Wisconsin), continuous conversion of glucose to fructose using glucose isomerase (W. H. Pitcher, Corning Glass), and a variety of potential uses of enzymes trapped in textile fibers (D. Dinelli, SNAM Progetti). A new heat-stable amylase for use in the starch industry was described by S. Slott (Novo Industry), while A. R. Doig (Massachusetts Institute of Technology) reported on the advantages of thermophilic microorganisms as sources of more heat-stable enzymes. D. Scheel (National Institute for Occupational Safety and Health) gave an extensive review of human immunological reactions to detergent additive proteolytic enzymes; and the results of an extensive 1972 survey of the U.S. enzyme industry were presented by B. Wolnack (Wolnack Associates).

Two analytical methods that use immobilized enzymes and are in the final stages of precommercial trials were discussed. Enzymes immobilized on the surface of nylon tubes have been designed for automated clinical analysis by W. E. Hornby (University of St. Andrews). Thousands of analyses have been performed with the same enzyme tube. G. G. Guilbault (Louisiana State University) added to his previous encyclopedic list of enzyme electrodes and enzyme pad devices for use in clinical and trace chemical analyses. A more futuristic analytical application of enzymes, as thermal probes, was described by C. Cooney (Massachusetts Institute of Technology).

In the medical area several potential uses of immobilized enzymes and immunological proteins have stimulated considerable research. Progress on the use of microencapsulation with the artificial kidney was reported by T. M. S. Chang (McGill University). The use of collagen-immobilized enzymes in blood treatment was mentioned by F. Bernath (Rutgers University); and some ideas for medical uses of immobilized enzymes were offered by G. Broun (Centre Hospitalier Regional de Rouen, France).

Other selected topics included the culture of animal cells as sources of enzymes (M. Posner, Beth Israel Hospital), continuous isolation of enzymes (P. Dunnill, University College London), and affinity chromatographic purification of urokinase (E. K. Pye), L. Goldstein (Tel Aviv University) described a new method for bonding enzymes to derivatized nylons; and J. Porath (Uppsala University), D. Jaworek (Boehringer Mannheim), and O. Zaborsky (Esso Research) described several approaches and problems in enzyme immobilization. Progress in the immobilization of multienzyme systems was presented by K. Mosbach and N. O. Kaplan (University of California at San Diego).

More than 60 invited papers and 20 research briefs were presented. The enthusiasm for the future potential of this field was strongly in evidence. Significant funding for enzyme engineering is being provided in at least seven countries; however, very strong concern was voiced for the U.S. effort because of the cutback of federal funding for this interdisciplinary area.

A conference proceedings is being published by Plenum Press.

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Forthcoming Events

May

12–17. **Electrochemical** Soc. (Electronics Div.), San Francisco, Calif. (E. G. Enck, ES, P.O. Box 2071, Princeton, N.J. 08540)

12–17. American **Industrial Hygiene** Assoc., Miami Beach, Fla. (W. E. McCormick, 66 S. Miller Rd., Akron, Ohio 44313)

12–17. International **Magnetics** Conf., Inst. of Electrical and Electronics Engineers, Toronto, Ont., Canada. (R. C. Byloff, Wolf Research and Development Corp., 6801 Kenilworth Ave., Riverdale, Md. 20840)

12–17. American Soc. for **Microbiology**, Chicago, Ill. (R. W. Sarber, ASM, 1913 I St., NW, Washington, D.C. 20006)

13–14. Council of **Biology Editors**, Albuquerque, N.M. (H. E. Kennedy, Bio-Sciences Information Service, 2100 Arch St., Philadelphia, Pa. 19103)

13–14. **Mapping Environmental Geology**, Austin, Tex. (E. G. Wermund, Bureau of Economic Geology, Univ. of Texas, University Station, Austin 78712)

13–14. **Microelectronics Applications of the Scanning Electron Microscope** Conf., Rockville, Md. (J. M. Wehrung, EMventions Microanalysis Lab., 2351 Shady Grove Rd., Rockville 20850)

13–15. **Electronic Components** Conf., Inst. of Electrical and Electronics Engineers, Washington, D.C. (IEEE, 345 E. 47 St., New York 10017)

13–16. Society of **Plastics Engineers**, San Francisco, Calif. (R. D. Forger, SPE, 656 W. Putnam Ave., Greenwich, Conn. 06830)

13–17. International **Childbirth Education** Assoc., St. Petersburg, Fla. (K. Myrtle, 819 20th Ave. N, St. Petersburg 33704)

14. **Ferroalloys and Alloying Additives** Conf., Committee A-9, American Soc. for Testing and Materials, Philadelphia, Pa. (J. McFadden, Meetings Dept., ASTM, 1916 Race St., Philadelphia 19103)

14–16. International Conf. on **Neurobiology of CNS–Hormone Interactions**, Chapel Hill, N.C. (W. E. Stumpf, Labs. for Reproductive Biology, 111 Swing Bldg., Univ. of North Carolina, Chapel Hill 27514)

14–17. Society for **Experimental Stress Analysis**, Detroit, Mich. (B. E. Rossi, SESA, 21 Bridge Sq., Westport, Conn. 06880)

14–17. International **Magnetics** Conf., 12th, Magnetics Soc., Inst. of Electrical and Electronics Engineers, Toronto, Ont., Canada. (H. Chang, IBM T. J. Watson Research Center, P.O. Box 218, Yorktown Heights, N.Y. 10598)

14–17. South African Conf. on **Rheumatism, Arthritis and Allied Disorders**, 4th, Durban. (W. G. McNeill, Medical School, P.O. Box 39, Congella, Durban, Natal, Union of South Africa)

15–17. Minnesota State **Medical** Assoc., Duluth. (H. W. Brunn, 375 Jackson St., St. Paul, Minn. 55101)

15–17. International Conf. on **Plasma Science**, Inst. of Electrical and Electronics Engineers, Knoxville, Tenn. (IEEE, 345 E. 47 St., New York 10017)

15–18. Society for **Technical Communication**, 21st, St. Louis, Mo. (C. T. Youngblood, STC, Suite 421, 1010 Vermont Ave., NW, Washington, D.C. 20005)

15–19. **Neurological** Soc. of America, Key Biscayne, Fla. (S. N. Chou, Univ. of Minnesota Medical School, Minneapolis 55455)

16–17. **Sensory Evaluation of Materials and Products** Conf., Committee E-18, American Soc. for Testing and Materials, New Orleans, La. (J. McFadden, Meetings Dept., ASTM, 1916 Race St. Philadelphia, Pa. 19103)

16–17. Southern **Textile Research** Conf., 14th, American Assoc. of Textile Chemists and Colorists, Hilton Head Island, S.C. (H. B. Goldstein, Sun Chemical Corp., Chester, S.C. 29706)

16–18. National Conf. on **Childhood Cancer**, American Cancer Soc., Dallas, Tex. (S. L. Arje, ACS, 219 E. 42 St., New York 10017)

16–18. Oklahoma State **Medical** Assoc., Oklahoma City. (D. Blair, OSMA, 601 N.W. Expressway, Oklahoma City 73118)

16–1. International Congr. on **Ophthalmic and Otolaryngic Plastic Surgery**, 6th, Johannesburg, S.A. (R. L. Dicker, 395 W. Blackwell St., Dover, N.J. 07801)

17–18. American Assoc. of **Clinical Urologists**, St. Louis, Mo. (R. H. Bradley, Jr., 33 E. Chestnut Hill Ave., Philadelphia, Pa. 19118)

17–20. National Assoc. of **Blue Shield Plans**, San Francisco, Calif. (N. F. Parrish, 211 E. Chicago Ave., Chicago, Ill. 60611)

18–22. North Carolina **Medical** Soc., Pinehurst. (W. N. Hilliard, 222 N. Person St., P.O. Box 27167, Raleigh, N.C. 27611)

19–22. American **Ophthalmological** Soc., Hot Springs, Va. (R. W. Hollenhorst, 20