Biotechnology and the Environment

Introduction of Genetically Modified Organisms into the Environment. HAROLD A. MOONEY and GIORGIO BERNARDI, Eds. Published on behalf of the Scientific Committee on Problems of the Environment and the Scientific Committee on Genetic Experimentation of the International Council of Scientific Unions by Wiley, New York, 1990. xx, 201 pp., illus. $110. SCOPE 44. From a meeting, Bellagio, Italy.

Risk Assessment in Genetic Engineering. MORRIS A. LEVIN and HARLEE S. STRAUSS, Eds. McGraw-Hill, New York, 1991. xii, 404 pp., illus. $39.95. McGraw-Hill Environmental Biotechnology Series.

Assessing Ecological Risks of Biotechnology. LEV R. GINZBURG, Ed. Butterworth-Heinemann, Boston, MA, 1991. xx, 379 pp., illus. $79.95. Biotechnology Series, 15.

For some, genetic engineering technologies offer the promise of solving serious environmental and food production problems facing the earth's burgeoning human population. Microorganisms that can control pests and weeds in agriculture, clean up toxic chemicals at waste sites, leach mineral ores, or enhance oil recovery are being developed or proposed. Crop plants are being genetically engineered to resist insect and microbial pests and herbicides, tolerate drought, have enhanced shelf life and transport qualities, and have improved nutritional value.

For others, genetic engineering is the route to large-scale ecological and social catastrophes. Introduced exotic pests, mutated pathogenic microorganisms, crop plants gone weedy, and horizontal gene transfer between domesticated plants and weedy relatives are offered as paradigms for what can go wrong if transgenic organisms are introduced into the environment. Even the benefits of increased yields and productivity from agricultural biotechnology can be considered an economic boon for only a few; increased competition may lead to social and economic disruption for many if small family farms are unable to compete.

The debate over the release of genetically engineered microorganisms and plants has not abated and apparently will not end soon. The debate has evolved, however, and these three volumes are interesting progress reports, offering a wealth of information, history, and access to a diverse literature in the ecology, genetics, and molecular biology of microorganisms and plants. Each deals with the risks of releasing genetically modified organisms into the environment, but there are surprisingly few overlaps.

Introduction of Genetically Modified Organisms into the Environment is the result of an international meeting cosponsored by the Scientific Committee on Problems of the Environment (SCOPE) and the Scientific Committee on Genetic Experimentation (COGENE). The participants, molecular biologists, population geneticists, and ecologists, were charged with providing the scientific background to make a statement about the potential benefits and hazards of introducing genetically engineered organisms into the environment.

Excessive applications of chemical pesticides, accumulation of nonbiodegradable products, production of toxic wastes that pollute the air, soil, and water, and loss of biological diversity have created widespread public dissatisfaction with current environmental practices and concerns about future practices. Nonetheless, the exploding world population places extreme pressures on the earth's limited resources, making it imperative to consider the costs of excessive regulation of biotechnology. This SCOPE-COGENE statement concludes that: "In view of the great potential of new technologies for addressing environmental and other problems, and because most introductions of modified organisms are likely to represent low or negligible ecological risk, generic arguments against the use of new genetic methodologies must be rejected." Furthermore, the greatest impact on the biosphere is through human activity, although there is a need to "exercise our power wisely." Thus, genetic engineering methodologies add additional tools to the spectrum of techniques available to improve the human condition and could "lead to rapid improvements in the development of ecologically sound approaches to agriculture and to environmental management, *and in the acquisition of a better understanding of biological systems*" (emphasis my own). The SCOPE 44 volume includes 15 chapters and the joint policy statement.

The volume edited by Levin and Strauss, *Risk Assessment in Genetic Engineering*, contains 17 chapters and an introduction and covers four major topics: identification and assessment of hazards and their effects, assessment of exposure, integration of hazard and exposure assessment, and societal impacts. The editors begin with an overview of risk assessment and regulation of genetically engineered microorganisms and plants, primarily from an American viewpoint. They review the major points in key publications by the National Academy of Sciences, the Ecological Society of America, and the American Society for Microbiology. There are "traditional" chapters on ecological aspects of hazard identification; release and transport of entomopathogenic microorganisms; persistence, establishment, and mitigation of phytopathogenic viruses; genetic transfer in plants by viruses; the implications of horizontal gene transfer; and management of transgenic plants in the environment. But several chapters are unusual: one discusses statistical techniques for field-testing genetically engineered microorganisms, one the potential for using knowledge-based systems (expert systems) for risk assessment and management, one the lessons learned from chemical risk assessment, and one the benefits and problems of using expert panels to assess risks, taking as a case study the 1986 assessments of Frostban®. The author of this last chapter concludes that although expert panels are used by federal, state, and local agencies, their usefulness depends on their having a clear charge, on the qualifications of the panelists, and on the policy framework provided. Specific recommendations are provided for improving the usefulness of expert panels, with the suggestion that expert panels can and should educate regulators on the evolving scientific basis for risk analysis, develop improved conceptual frameworks for evaluating environmental risks, develop criteria and protocols to help agency staff evaluate data, and identify adverse-effect scenarios for evaluation.

A chapter on the social psychology of risk assessment is particularly interesting. The difficulties of describing risks in neutral terms and of understanding probability appear to be serious obstacles both for the public and for many scientists. According to the author's thesis, risk descriptions may never be neutral, the range of harms identified will nearly always be controversial, and the estimated probabilities may always be subjective. Attempts to achieve neutrality by telling all sides of the story so that biases will cancel each other out may confuse rather than inform; two differing views may not balance each other if one is more extreme than the other. Risk analyses are thus polit-

ical and social decisions because "it turns on the goals of the society and what trade-offs are deemed acceptable."

The third compilation, *Assessing Ecological Risks of Biotechnology*, focuses on ecological issues in its 17 chapters. Introductory chapters deal with the effects of biological introductions on communities and planned introductions in the biological control of arthropod and weed pests. I would have preferred the use of microorganisms as examples in these chapters, because the remaining chapters focus on microorganisms. There are five chapters on the ecology and genetics of microbial populations, providing overviews of surface transport of microorganisms by water, soil and groundwater transport of microorganisms, aerial dispersal of bacteria, transfer of genetic information among soil microorganisms, and genetic stability in bacterial populations. There are also chapters on modeling the dynamics of transposable elements, quantifying fitness and gene stability, quantifying risks of invasion of genetically engineered microorganisms, and quantifying the spread of recombinant genes and organisms. Finally, there are four chapters dealing with regulation (by the Environmental Protection Agency, the Department of Agriculture, and in the European Community) and a chapter on risk analysis associated with biotechnology of waste treatment.

The final chapter is a provocative essay "On making nature safe for biotechnology" by Mark Sagoff. In a wide-ranging discussion of ecological restoration, agricultural economics, and history of agriculture, Sagoff presents scenarios for agriculture, forestry, and aquaculture that are revolutionized by biotechnology. He points out that some fear biotechnology not because some genetic monster will be set loose but because "the nation will drown in a sea of surplus agriculture commodities." He is concerned that "the unparalleled speed and magnitude of the expected productivity gains" will overwhelm saturated world markets and suggests that the issues have nothing to do with the *unpredictable* risks of biotechnology but concern the profitable, predictable, intentional, and successful effects of biotechnology. Sagoff argues that the major effects of biotechnology will be twofold. First, many ecosystems may be converted to species and processes suitable to large-scale, highly controlled production. Second, as agricultural surpluses begin to be seen as infinite, and as the factory replaces the field as the location where food and fiber are fabricated, many farms will go out of production, which will allow large tracts of land to be restored to their "natural" state. Sagoff argues that esthetic, moral, cultural, and historical arguments for preserving nature are being lost in the intricacies of arcane arguments over speculative risks and that the policy issue is whether increased efficiency of production can be compatible with maintaining the integrity of the global environment.

The introduction into the environment of genetically modified microorganisms and plants is considered by some to be a risky business. In one sense, it is ironic that risk issues have played such a dominant role in agricultural biotechnology despite its history of self-regulation since the Asilomar conference in 1975. By the end of 1989, more than 52 engineered plants and 56 engineered microbes had been released into the environment with no detectable harm.

The debate on the role of biotechnology in agriculture has expanded. Whether the revolution in agriculture that could result from the use of genetically engineered microorganisms and plants can be managed so that cultural, historical, moral, and esthetic values are upheld is the core of the problem.

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Reprints of Books Previously Reviewed

Dinosaur Tracks and Traces. David D. Gillette and Martin G. Lockley, Eds. Cambridge University Press, New York, 1991. Paper, $29.95. *Reviewed* **247**, 732 (1990).

Embryos, Genes, and Evolution. The Developmental-Genetic Basis of Evolutionary Change. Rudolf A. Raff and Thomas G. Kaufman. New introduction added. Indiana University Press, Bloomington, 1991. $49.95; paper, $24.95. *Reviewed* **221**, 257 (1983).

Books Received

Advances in Neuroblastoma Research 3. Liss (Wiley), New York, 1991. xxxii, 633 pp., illus. $150. Progress in Clinical and Biological Research, vol. 366. From a symposium, Philadelphia, PA, May 1990.

AIDS. Anti-HIV Agents, Therapies, and Vaccines. Vassil St. Georgiev and John J. McGowan, Eds. New York Academy of Sciences, New York, 1990. xvi, 634 pp., illus. $163. Annals of the New York Academy of Sciences, vol. 616. From a conference, Arlington, VA, Nov. 1989.

Alternative Energy Sourcebook 1991. John Schaeffer, Ed. Real Goods Trading, Ukiah, CA, 1991. 398 pp., illus. Paper, $14.

Atom. Journey Across the Subatomic Cosmos. Isaac Asimov. Dutton (Penguin), New York, 1991. xii, 319 pp., illus. $21.95. Truman Talley Books.

Biocatalysts for Industry. Jonathan S. Dordick, Ed. Plenum, New York, 1991. xvi, 330 pp., illus. $75. Topics in Applied Chemistry.

Biochemical Markers in the Population Genetics of Forest Trees. S. Fineschi *et al.*, Eds. SPB Academic Publishing, the Hague, The Netherlands, 1991. vi, 251 pp., illus. Paper, $47. From a meeting, Porano, Italy, Oct. 1988.

Calculus. James Stewart. 2nd ed. Brooks/Cole, Pacific Grove, CA, 1991. xviii, 1086 pp., illus. $65.

Cell Communication in Health and Disease. Readings from *Scientific American* Magazine. Howard Rasmussen, Ed. Freeman, New York, 1991. xiv, 185 pp., illus. Paper, $13.95.

Cellular and Molecular Immunology. Abul K. Abbas, Andrew H. Lichtman, and Jordan S. Pober. Saunders, Philadelphia, PA, 1991. xii, 417 pp., illus. Paper, $26.95.

The Development and Neural Bases of Higher Cognitive Functions. Adele Diamond, Ed. New York Academy of Sciences, New York, 1990. lvi, 749 pp., illus. Cloth or paper, $180. Annals of the new York Academy of Sciences, vol. 608. From a conference, Philadelphia, PA, May 1989.

A Dictionary of Genetics. Robert C. King and William D. Stansfield. 4th ed. Oxford University Press, New York, 1990. viii, 406 pp., illus. $39.95; paper, $19.95.

The Effectiveness of Methadone Maintenance Treatment. Patients, Programs, Services, and Outcome. John C. Ball and Alan Ross. Springer-Verlag, New York, 1991. xiv, 283 pp., illus. $59.

Electronic Conduction in Oxides. N. Tsuda *et al.* Springer-Verlag, New York, 1991. x, 323 pp., illus. $79. Springer Series in Solid-State Sciences, 94. Translated form the Japanese edition (Tokyo, 1983) with revisions.

Exploring the Sun. Solar Science since Galileo. Karl Hufbauer. Johns Hopkins University Press, Baltimore, MD, 1991. xviii, 370 pp., illus. $39.95. New Series in NASA History.

Fibrinogen, Thrombosis, Coagulation, and Fibrinolysis. Chung Yuan Liu and Shu Chien, Eds. Plenum, New York, 1991. x, 450 pp., illus. $95. Advances in Experimental Medicine and Biology, vol. 281. From a symposium, Taipei, R.O.C., Aug. 1989.

Fractals, Chaos, Power Laws. Minutes from an Infinite Paradise. Manfred Schroeder. Freeman, New York, 1991. xviii, 429 pp., illus., + plates. $32.95.

Fundamental Astronomy. H. Karttunen *et al.*, Eds. Springer-Verlag, New York, 1991. xiv, 478 pp., illus. Paper, $34.95. Springer Study Edition. Reprint, 1987 ed.

Hybrid Control Systems in Manufacturing. Agostino Villa. Gordon and Breach, New York, 1991. xvi, 231 pp., illus., + index. $80.

Immunology. A Short Course. Eli Benjamini and Sidney Leskowitz. 2nd ed. Liss (Wiley), New York, 1991. xxvi, 459 pp., illus. Paper, $29.95.

Knowing Children. Experiments in Conversation and Cognition. Michael Siegal. Erlbaum, Hillsdale, NJ, 1991. x, 154 pp., illus. $32.50.

Lipid Biochemistry. An Introduction. M. I. Gurr and J. L. Harwood. 4th ed. Chapman and Hall, New York, 1991. viii, 406 pp., illus. $89.95; paper, $42.

Luminescence and the Solid State. R. C. Ropp. Elsevier, New York, 1991. xvi, 453 pp., illus. $185.50. Studies in Inorganic Chemistry, 12.

The Magic of Numbers and Motion. The Scientific Career of René Descartes. William R. Shea. Science History Publications (Watson), Canton, MA, 1991. xii, 371 pp., illus. $54.95.

Nomads in Archaeology. Roger Cribb. Cambridge University Press, New York, 1991. xiv, 253 pp., illus. $54.50. New Studies in Archaeology.

Organic Spectroscopy. William Kemp. 3rd ed. Freeman, New York, 1991. xxii, 393 pp., illus. $34.95; paper, $24.95.

Particles and Waves. Historical Essays in the Philosophy of Science. Peter Achinstein. Oxford University Press, New York, 1991. viii, 337 pp., illus. $49.95; paper, $24.95.

Physics and the Rise of Scientific Research in Canada. Yves Gingras. McGill-Queen's University Press, Buffalo, NY, 1991. xii, 203 pp., illus. $37.50. Translated from the French by Peter Keating.

The Structure of the Proton. Deep Inelastic Scattering. R. G. Roberts. Cambridge University Press, New York, 1991. x, 182 pp., illus. $49.50. Cambridge Monographs on Mathematical Physics.

The Surgical Solution. A History of Involuntary Sterilization in the United States. Philip R. Reilly. Johns Hopkins University Press, Baltimore, MD, 1991. xviii, 190 pp. $19.95.

Taking Society's Measure. A Personal History of Survey Research. Herbert H. Hyman. Hubert J. O'Gorman, Ed. Russell Sage Foundation, New York, 1991. xxiv, 257 pp. $34.95.

The Unified Field Theory's Principles of Dimensional Relativity. Shawn Jade. Carlton, New York, 1991. 261 pp., illus. $18.95. A Hearthstone Book.

Visualization. The Second Computer Revolution. Richard Mark Friedhoff and William Benzon. Freeman, New York, 1991. 215 pp., illus. Paper, $25.95. Reprint, 1989 ed.