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Book Review: GENETICALLY ENGINEERED ORGANISMS: BENEFITS AND RISKS

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GENETICS & EVOLUTION

LONGEVITY, SENESCENCE, AND THE GENOME. *The John D. and Catherine T. MacArthur Foundation Series on Mental Health and Development.*

By Caleb E. Finch. *The University of Chicago Press, Chicago (Illinois).* \$49.95. xv + 922 p.; ill.; author, species, and subject indexes. ISBN: 0-226-24888-7. 1990.

The phenomenon of senescence has long puzzled biologists. In a famous essay that founded the evolutionary theory of senescence, Sir Peter Medawar referred to senescence as "an unsolved problem of biology." This remains true in a certain sense: despite a vast body of work on the degenerative changes in biological mechanisms associated with senescence, there is no one process that can unequivocally be singled out as a proximate cause. On the other hand, there is now a body of theory and data that provide a convincing general explanation of how natural selection can bring about the apparently nonadaptive phenomenon of a decline in survival or fertility with advancing age.

Finch's monumental book is an attempt to sum up the current status of our knowledge of both the mechanistic and evolutionary biology of senescence. As a biomedical scientist confronting evolutionary biology, he approaches the subject from a direction opposite to that of Michael Rose in his recent book, *The Evolutionary Biology of Aging* (Oxford Univ. Press, New York, 1991), and so the two works complement each other very much. The coverage is exhaustive, ranging from discussions of the comparative biology of life span to the latest biochemical work on cellular aging. If nothing else, Finch has done the gerontological community an immense service by bringing together information from many disparate fields.

By and large Finch's analyses and conclusions are sensible and helpful, although I feel that a more extensive algebraic treatment of the way in which the effectiveness of selection on age-specific changes in survival or fertility would have enhanced the clarity of his discussions of evolution. His rather cursory treatment leads to some confusing remarks, such as "continuously increasing reproductive capacity as a function of age would select against senescence" (p. 39), which he later tentatively applies to the interpretation of cases where senescence is apparently absent (p. 243). In fact, the correct genetic formulas, based on W. D. Hamilton's calculations, show that the intensity of selection on age-specific traits *always* declines throughout reproductive life, although the rate of

decline is lower in species where fecundity increases with age. This has the consequence that senescence is always expected to evolve whenever a clear distinction between reproductive and vegetative structures can be made. Finch's examples of apparently nonsenescenting sexual species are indeed a challenge to evolutionary theory (Chapter 4), although one may question the reliability of data on the pattern of increases in mortality late in life in very long-lived organisms that cannot be studied under controlled conditions.

His review of the information on age-related changes in taxa with gradual senescence, such as mammals (Chapter 3), leads to the conclusions that many different age-associated changes contribute to the decline in survival rates and fertility with age, that there are great individual and genotypic differences with respect to the age-specific patterns of particular pathologies, but that there is a general tendency for life history events in related forms to occur at similar times relative to the overall duration of the adult life span. Finch regards the latter result as presenting a considerable difficulty for evolutionary theory, a point emphasized several times throughout the book. I found this rather puzzling: It is a straightforward prediction of the evolutionary models that the rate of decline with age in the effectiveness of selection, measured in clock time, will be influenced by the overall rate at which individuals die off in the population as a whole. Thus the form of the life history produced by selection will be roughly invariant if time is measured in generations.

Errors of this kind are inevitable when an individual trained in one field attempts to synthesize ideas and data from other branches of biology. They are far preferable to the narrow specialization that threatens to overwhelm contemporary biology. Finch's book is an invaluable resource, and he is to be congratulated on his open-minded and wide-ranging survey of the manifestations of senescence from the level of the cell to that of the population.

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GENETICALLY ENGINEERED ORGANISMS: BENEFITS AND RISKS.

By J. R. S. Fincham and J. R. Ravetz. *Published in cooperation with the Council for Science and Society by University of Toronto Press, Toronto and Buffalo (New York).* \$50.00 (hardcover); \$15.95 (paper). xiii + 158 p.; ill.; index. ISBN: 0-8020-5918-X (hc); 0-8020-6863-4 (pb). 1990.

In the continuing debate on the introduction into the environment of genetically modified organisms, particularly those modified by recombinant DNA, there are few books suitably written for poli-

cymakers, the lay public and scientists in other fields. This book describes the current state of the science and art of genetic engineering, potential uses (particularly outside the laboratory), and the benefits that can be expected. It is particularly pertinent for examining potential risk and management of risk from the perspective of the United Kingdom.

The strength of the book is in its discussion of scientific aspects of genetic manipulation. The science is presented with excellent and appropriate background material. Generally appropriate analogies are used to show that much of what is being done and is expected to be done is an extension of scientific and commercial practices with which we are familiar. In the scientific chapters (Chapters 2-8), the authors are circumspect in pointing out that potential hazards remain hypothetical and speculative. In otherwise accurate representations, there are two notable errors. One is in Figure 2.3, which shows RNA polymerase tracking along double-stranded RNA, instead of DNA. A more serious error is the incorrect description (in Chapter 5) of the most promising plant virus for use as a vector as having RNA as its infective particles and as a retrovirus. Cauliflower mosaic virus has DNA in its infective particles and its genome is replicated by way of an RNA intermediate. It is an example of a pararetrovirus, in which RNA copies of the viral genomic DNA are copied back into infectious DNA by a virally encoded reverse transcriptase. There are minor typographical errors elsewhere.

In discussing science policy, risk assessment, and managing the uncertainties of risk assessment (Chapters 1, 9 and 10), there is, surprisingly, some unwarranted absolutist statements and inappropriate analogies, some of which are contradicted in different chapters. Discussion of categories of risk, by and large, is missing from the policy chapters. That is, all genetically engineered manipulations are considered to be of equal concern. Of the "five problems of deliberate release" (Chapter 1), it is not pointed out that none of these are unique to biotechnology. Yet the authors (Chapter 2) point out that not only have there been no documented examples of harm through gene cloning, but that what matters are the demonstrable consequences or performance of the cloned material, not the method by which it was derived.

There is a general concern, almost to the point of microphobia, about the use of microorganisms in the environment. For example, the authors recommend designing organisms to not only do their job, but also to limit their survival. They do not acknowledge the desirability or need, on occasion, to have relatively persistent useful microorganisms, e.g., for biological control of pathogens or

pests. Microphobia is further indicated by a statement that "a microorganism is effectively out of sight and out of control from the moment it is inoculated into an agricultural field" (p. 43). Such a statement would surprise applied scientists such as plant breeders and pathologists. The book is particularly weak in acknowledging the success, not simply the failures, of applied sciences in the environment. Further, while excellent discussion is given of the means of genetic transfer in multiple organisms, there is not a single statement that alludes to the inherent stability of genetic material, including that of microorganisms.

In the chapter on risk assessment (p. 121), the authors assert that our experience in coping with genetically manipulated robust organisms on a large scale is limited. Is over a century of worldwide experimental and scientific breeding and commercial production of genetically modified microorganisms, plants and animals "limited"? Further, it is categorically stated that only laboratory experiments can be precise, controlled or subject to hypothesis testing (p. 130). This would be challenged by those scientists who work in the environment. These statements illustrate the continuing difficulty of scientists from different disciplines communicating and understanding one another's approaches and results. Precautions with genetically modified and nonmodified organisms are appropriate in assessing unknown and/or unpredictable consequences. The authors acknowledge that the "discussion of the risks of genetic engineering has been too much dominated by an over-dramatic view, verging at times on the apocalyptic" (pp. 125-126).

It is disappointing that there are no illustrative standards of practice given for the normal introductions of plants and animals. For example, the experimental origin of the bread on the breakfast table would be surprising to many, including quite a few in the scientific community.

Regulation is presented in both a generic and a legal sense. The authors point to the successful use in research and industry of a body of rules and procedures, some of which have been codified. Potential levels of oversight, appropriate to categorization of risk, are not mentioned. In the United States, for example, categorization of risk is acknowledged in laboratory experiments by decentralization of oversight for low-risk experiments that were decided upon by both scientists and the public; comparable decentralization for experiments in the environment have not been forthcoming to date.

In the last chapter, on managing the uncertainties of risk assessment, a need for balance is recognized, "in which scientific uncertainties are managed by prudence and tact, and in which the

differing perceptions of the different parties," including the public, "are recognized and respected" (p. 131). The statement, however, that "there can be none of the certainties" with introduction into the environment "that have traditionally been associated with scientific knowledge as it has been taught and popularized" (p. 132) is contradicted by examples and discussion of recognition of the differing levels of potential risks in other chapters.

The book has a very useful glossary of terms that is clear and precise. There is also a helpful index, and references are given at the end of all chapters, save one. Since the book is useful for showing the spectrum of thinking within the scientific establishment of the United Kingdom, it deserves the attention of scientists, the public and policymakers.

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RESHAPING LIFE: KEY ISSUES IN GENETIC ENGINEERING. *Second Edition.*

By G. J. V. Nossal and Ross L. Coppel. Cambridge University Press, Cambridge and New York. \$14.95 (paper). xii + 179 p.; ill.; index. ISBN: 0-521-38969-0. 1990.

This book takes the reader through logical steps from the fundamental principles of biology to the sophisticated and complex realm of genetic engineering technology. The developmental basis of DNA technology and its applications toward reshaping life are described in a lucid and easy to understand fashion. This has been greatly facilitated by the carefully designed illustrations supplemented by the glossary of scientific words used in the text. The authors give relevant examples of current achievements derived from DNA technology in the areas of medicine and health, agriculture and food, industrial production, and biotechnology innovations. The authors do a commendable job of prophesizing the exciting developments awaiting us in the not too distant future. Here they might have underestimated the potential of recombinant DNA technology, given the tremendous research activities in many new areas. The newly developed polymerase chain reaction technology, for example, has already been established as a powerful tool for unraveling the basic developmental processes that defied detailed examination earlier for lack of methodology to track minute changes. The authors have elegantly described the application of DNA probes and gene amplification techniques in various fields. The book covers major current advances derived from DNA technology, and projects new avenues where future advances may significantly influence our lives in the coming years. Although slightly controversial, I tend to agree with the authors that the benefits of this tech-

nology outweigh the concerns expressed by some people.

Overall, the book provides an excellent overview of modern genetic engineering technology. It is informative, instructive and visionary, and is especially suited for persons who need a quick lesson on the subject. They will find the presentation very refreshing and intellectually satisfying to gauge the current trends in this field. The authors have succeeded in their mission and deserve kudos for this updated edition.

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ECOLOGICAL AND EVOLUTIONARY GENETICS OF *DROSOPHILA*. *Proceedings of a workshop held in Armidale, Australia, 5-10 January 1989. Monographs in Evolutionary Biology.*

Edited by J. S. F. Barker, William T. Starmer, and Ross J. MacIntyre; Series Editors: Max K. Hecht et al. Plenum Press, New York. \$95.00. xvii + 524 p.; ill.; author, organism, and subject indexes. ISBN: 0-306-43671-X. 1990.

This collection of twenty-three contributions by sixty authors resulted from a joint Australia-USA workshop; it is dedicated to Professor W. B. Heed, a biography of whom also appears in the book. Heed must be proud of the number of friends he has around the world and of the quality of papers appearing in this volume.

The contributions are organized in four sections: Ecological Genetics, Habitat Selection, Biochemical Genetics, and Molecular Evolution. The editors provide an introduction to each section with the purpose of blending the contributions together and highlighting their main points.

The Ecological Genetics section contains two chapters on life history traits. In the first, Templeton et al. examine the effects of the abnormal-abdomen syndrome of *Drosophila mercatorum*, and in the second, Etges experiments with different host plants of *D. mojavensis*. Asymmetry is the common theme of the chapters by McKenzie and collaborators and by Parsons. In the first, asymmetry results from selection for resistance to insecticides; in the second, it results from environmental stress. The last two chapters in this section deal with transposition. Murphy and Sved ask what environmental factors may affect transposon distribution in a population, and Moran and Torkamanzahi give an update on P-element transposition effects on quantitative characters.

The Habitat Selection section is more uniform than the others. Fogleman and Abril examine the host-plant association in cactus-feeding *Drosophila* species, and Starmer and Aberdeen discuss the effects of different yeast cultures on *Drosophila mul-*