All aboard the biotech express

The Biotech Century: Harnessing the Gene and Remaking the World
by Jeremy Rifkin
Tarcher: 1998. Pp. 259. $24.95

Sheldon Krimsky

This year marks the twenty-fifth anniversary of the discovery of recombinant DNA technology, or gene splicing. Various symposia and publications have paid tribute to the pioneers of genetic engineering and the new industrial developments it has spawned. The largely publicly funded field of molecular biology has provided tools, knowledge and product ideas that have attracted substantial investments from the world's pharmaceutical, diagnostics and agricultural sectors. Designer drugs, genetic screening tests and transgenic crops are moving rapidly from the Petri dish to the marketplace. But throughout this period, critics have questioned the uses to which genetic technology is being put. Of all the sceptics, Jeremy Rifkin has been the most visible in the media and the most maligned by the principal players in the new bio-academic–industrial complex.

The Biotech Century is Rifkin's third book devoted primarily to biotechnology. In 1977 he was a co-author of *Who Shall Play God?*, which describes the rise of a new eugenics movement and warns the reader that "it would be wrong to proceed with genetic engineering now". A second work, *Algeny*, published in 1983, is a selective compendium of footnotes in the history of science that positions biotechnology within a neo-Darwinist *Weltgeist* and posits two paths to the future, one with genetic engineering and one without it. ("There could be no lonelier place than a biologically engineered world.")

In *The Biotech Century*, Rifkin is no less passionate in his opposition to a genetically engineered world, but he makes a symbolic effort to dissociate himself from his image as biotechnology's "consummate contrarian", which he skilfully helped to create. He says: "In fact, there is value, great value, in some of the products of genetic engineering and that's what makes the discussion of this ultimate human technology so interesting, difficult, and challenging." This is the one moment in the book where we are led to anticipate a more complex analysis of the many sides to biotechnology. We discover soon enough that it is an empty concession. Rifkin does his best work in drawing attention to the growing inventory of real and potential dangers and the ethical conundrums raised by genetic technologies. For this role he is admired by those disenfranchised from technological choices who see him as their *vox populi*.

This book is in large measure a response to the realization of Francis Bacon's *The New Atlantis*, published in 1622, in which Bacon describes a future science that uses the existing forms of biological life as the raw materials from which to redesign nature. Rifkin's chapters "A second genesis", "Reinventing nature" and "A eugenic civilization", reflecting the Baconian prophecy, raise serious questions. Can we redesign living things to work better for us while protecting the integrity of our natural heritage? Who is the 'us' on whose behalf biotechnology is being developed? Will herbicide-tolerant crops yield a more nutritious and plentiful bounty of food that will be priced and distributed fairly? Does milk production using synthetic growth hormone meet the public need or solve the problem of rapidly declining small farms? Will those who lost out in the genetic lottery be helped by the new generation of genetic tests or will they suffer discrimination for their 'pre-existing condition?'

Some will undoubtedly read this work as another anti-science polemic, but they will not have read it correctly. It is too equivocal to draw such a conclusion. Rifkin shows signs of acknowledging that the 'biotechnology express' has long since left the station. After reports of genetic advances that could serve as copy for a promotional brochure on biotechnology, the early chapters present an inventory of worthy cautions.

The chapter on patenting takes us from the 1980 US Supreme Court decision that set the broad legal mandate for patenting living things to current trends in patenting genes, indigenous crops and human cell lines. Rifkin himself, seeking to test the public's tolerance for the bizarre implications of patenting life, recently teamed up with a scientist and applied for a patent on a human–animal chimaera (see *Nature* **392,** 423; 1998), a concept he raises in the book. Other chapters are rich in examples but deficient in the more complex analysis of how largely decentralized and diverse industrial

Ornithological opus

The imperial eagle (*Aquila heliaca*), from a plate in *The Birds of the Western Palearctic* edited by D. W. Snow and C. M. Perrins (Oxford University Press, £150). At more than 1,600 pages comprising two volumes, this is the "concise" updated edition of a nine-volume handbook published between 1977 and 1994.

sectors producing new technologies and products can be properly managed and publicly overseen to avoid ecological, ethical or human-health mishaps.

Some of this complexity is acknowledged in the final chapter, "A personal note", in which Rifkin writes of using science, and even genetics, in a manner that respects our natural world: "the question is what kind of biotechnologies will we choose in the coming Biotech Century?" Our greatest challenge lies in the social guidance and assessment of biotechnology within a democratic participatory framework and a global awareness.

Rifkin was criticized 20 years ago for exaggerating the untoward paths biotechnology would take and for opposing scientific progress. In hindsight, many of his predictions can hardly be considered hyperbole. Serious discussions are taking place on cloning humans, altering human germ cells, universal genetic screening, mandatory DNA identification and even the unmentionable prospect of 'improving' the human gene pool.

In his role as social critic of biotechnology, Rifkin has become entangled in a paradoxical situation. In an attempt to stir the reader's passions, he overdramatizes in some sections the power of biotechnology: "The biotechnology revolution will affect each of us more directly, forcefully, and intimately than any other technology revolution in history." We must be reminded that the first three main agricultural products of genetic engineering — the Flavr Savr tomato, the Ice Minus bacterium and recombinant bovine growth hormone — have either failed or are failing.

Moreover, like many of the genetic scientists he calls to task, Rifkin at times accepts uncritically a view that vastly overestimates the importance of genes in biological organisms. ("With genetic engineering, we assume control over the hereditary blueprint of life itself.") If he were to question too seriously the ability of science to carry out its "redesign of nature", the book would lose much of its moral force. But, while he plays up the power of genes ("the ultimate exercise of power") in some sections, elsewhere he tempers that view by acknowledging the poverty of genetic reductionism. He points out that, although such a view may be false, it has helped to advance the interests of those involved in molecular biology.

There is no simple reading of this book. A fair-minded reader will agree with some points and disagree with others. At a time when scientific institutions are struggling with the public understanding of science, there is much they can learn from Rifkin's success as a public communicator of scientific and technological trends. □

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Living with dinosaurs

The Rise of Birds: 225 Million Years of Evolution
by Sankar Chatterjee
Johns Hopkins University Press: 1998. Pp. 312. $39.95, £33

The Mistaken Extinction: Dinosaur Evolution and the Origin of Birds
by Lowell Dingus and Timothy Rowe
W. H. Freeman: 1997. Pp. 332. $34.95, £24.95

Taking Wing: *Archaeopteryx* and the Evolution of Bird Flight
by Pat Shipman
Simon and Schuster: 1998. Pp. 336. $25. To be published in the United Kingdom in June by Weidenfeld and Nicolson, £20

José Luis Sanz, Bernardino P. Pérez-Moreno and Francisco J. Poyato-Ariza

In recent years there has been a renaissance in Mesozoic palaeo-ornithology. This kind of reinvigoration is normal in palaeontology, as new discoveries show that old hypotheses are false and give rise to new ones. A large number of Mesozoic avian taxa have been discovered during the past 20 years, so it is perhaps not surprising that three books devoted to Mesozoic palaeo-ornithology have recently been published. They are different in structure and scope, but the main topics of each are the foremost areas of research on the early evolutionary history of birds: the origin and historical diversity of the avian clade, its phylogenetic relationships, and the development of flight.

One of the most stimulating ideas arising from vertebrate palaeontology is the dinosaurian origin of birds. Proposed by Thomas Huxley in 1868, and reformulated by John Ostrom in the 1970s, this hypothesis is now widely accepted, and is supported by a large amount of evidence that increases as new fossil forms are discovered. All three books favour this hypothesis, which is challenged nowadays by just a few researchers. In terms of current phylogenetic systematics, the dinosaurian origin hypothesis implies that birds have to be considered as short-tailed, feathered volant dinosaurs.

The interpretation of birds as present-day dinosaurs leads to the provocative idea that dinosaurs have been around ever since humans appeared on Earth, and therefore represent an important part of our natural, cultural and economic environment. So it is not surprising that palaeontologists are concerned by man's responsibility in the disappearance of extant dinosaurs, given that natural phenomena — the Cretaceous/Tertiary (K/T) biotic crisis — extinguished most of the diversity of Upper Cretaceous dinosaurs (including some avian ones, such as Enantiornithes, Hesperornithiformes and Ichthyornithiformes). Sankar Chatterjee joins Lowell Dingus and Timothy Rowe in adopting a militant point of view, describing how the pressures applied by man have led to the extinction of hundreds of modern dinosaur species. The causes of the K/T extinction are still under debate, but it is clear that man has caused many extinctions in the Holocene.

Chatterjee concludes that the impact hypothesis was the proximate cause of the K/T biotic crisis, while volcanic phenomena increased the climatic stress and enhanced the extinction process. Dingus and Rowe review earlier hypotheses about the K/T biotic crisis, and then contrast the volcanic and impact hypotheses and revise the patterns of extinction and survival. A clear consensus has yet to emerge, but many present-day researchers consider that the extinction of non-avian dinosaurs was caused by a combination of the volcanic/marine regression and impact hypotheses. So large extraterrestrial impacts and massive eruptions of flood basalts have to be considered.

The historical diversity of a group of living organisms is shaped by extinction and diversification, the pattern of which is mapped by a phylogenetic hypothesis. The discovery of new fossils shows that the phylogenetic history of Mesozoic birds is much more complex than previously thought. Chatterjee agrees with Dingus and Rowe — and most palaeo-ornithologists — that the phylogenetic map of birds is shaped by a series of successive sister taxa from *Archaeopteryx* to Neornithes (extant birds). Like that of Dingus and Rowe, the avian phylogenetic hypothesis put forward by Pat Shipman is within the consensus reached by most researchers.

Chatterjee, however, includes a problematic taxon, the Triassic *Protoavis*, which is the core of his book. He positions this enigmatic genus between *Archaeopteryx* and the Enantiornithes, implying that *Protoavis* is a basal bird but is more derived than *Archaeopteryx*. The combination of characters of *Protoavis* is very unusual because, according to Chatterjee's interpretation, it has an ornithothoracine-like pectoral region associated with a very primitive (basal archosaur-like) hand architecture. This combination challenges the transformation sequence of characters in early avian evolutionary history.

If *Protoavis* was a bird (between 60 million and 70 million years older than *Archaeopteryx*), this hypothesis predicts important modifications even in the evolutionary history of non-avian dinosaurs. A problematic consequence is that even derived theropod groups, such as dromaeosaurids, troodontids or tyrannosaurids, must appear during the Lower or Middle Triassic. Chatterjee's answer to this troubling idea is highly classical: imperfection and sampling scarcity in the fossil record. Nevertheless, that tyrannosaurids