of reasonably accurate measured distances and sizes in the latter part of the seventeenth century.

The system of Copernicus not only permitted the deduction of the relative distances of the planets from the geometrical models but also revealed gaps between the spheres. Kepler explained the gaps by means of his polyhedral hypothesis and constructed a harmonic theory of the relative distances which agreed remarkably well with the empirical results based on Tycho's observations and his own planetary laws. Kepler broke with tradition in greatly enlarging the solar distance, though he kept it as small as possible; his analysis of the parallax of Mars and his calculations of eclipses had convinced him that the solar parallax could not exceed 1′. By adopting this value, he still underestimated the absolute size of the planetary system by a factor of about six. While the telescope had brought the possibility of determining the apparent diameters of the planets, the poor optical quality and the technical difficulties of observing prevented accurate measurements, so that Kepler had to combine harmonic hypotheses with observations in his derivation of their sizes. Soon after Kepler's death, the seemingly paradoxical smallness of Mercury revealed by observations of the transit in 1631 demonstrated the need for a new set of apparent diameters based entirely on telescopic measurements.

Accurate determination of the planetary distances and sizes was eventually achieved through the application of new technical inventions, namely the micrometer and telescopic sight, a better understanding of refraction and improved solar theory. Prominent among the astronomers who pursued these investigations were Flamsteed in England and Cassini in France. The popular view of historians and astronomers that the first successful measurement of the parallax of Mars (and hence of the solar parallax) resulted from the simultaneous observations made by Cassini in Paris and Richer in Cayenne in 1672 is contested by Van Helden, who explains that the error margin was too high to justify great confidence in the results obtained. Though producing values fortuitously close to those accepted today, the method employed was severely criticized by Halley, who advised that, for an accurate determination of the solar distance, astronomers would have to await the transit of Venus in the next century. Nevertheless, the publication by Flamsteed and Cassini in 1673 of a value for the solar parallax of 9.5″ or 10″ (equivalent to a solar distance of about 88 million miles) is seen by Van Helden as a watershed in the measurement of the cosmic dimensions. □

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Business of biology

Renton Righelato

Reshaping Life: Key Issues in Genetic Engineering. By G. J. V. Nossal. *Cambridge University Press: 1985. Pp.158. Pbk £6.95, $11.95.*
Setting Genes to Work: The Industrial Era of Biotechnology. By Stephanie Yanchinski. *Viking: 1985. Pp.157. £12.95.*
The Gene Factory: Inside the Biotechnology Business. By John Elkington. *Century, London: 1985. Pp.240. £12.95.*

"When historians look back on the twentieth century they will conclude that its first half was shaped by the physical sciences but its second by biology." So begins one of these three new popular books describing industrial biotechnology and the potential benefits of the applications of molecular biology. All three are short, easy to read and suitable for the educated layman and scientists outside the subject areas directly involved. The authors each succeed in being up to date, but the subject is changing so rapidly that one feels that each volume should bear a "read by" date.

The least ephemeral of the books is Dr Nossal's, *Reshaping Life*, whose introduction I quote above. He goes on to explain simply, but accurately, the key features of molecular and cell biology, and exemplifies their practical application. These early chapters on cellular organization and the genetic code can be skipped by those with a basic biological training.

There follows a discussion of a number of actual achievements and exciting potential uses, among them genetically engineered proteins for correction of metabolic disorders and new vaccines, gene therapy and gene probes in diagnosis — developments which will fundamentally effect the quality of life and longevity. Whilst health-care applications dominate, there is a section on the uses of genetic engineering in agriculture and the food industry, and another describing the growth of biotechnology companies. Two chapters give a balanced discussion of the ethical and public-policy issues surrounding this growing technological power; the author concludes that there is adequate awareness of risks in both the scientific community and the public at large, and that the existing legislative and voluntary frameworks for control are satisfactory. Nossal's particular achievement in this book is that he succeeds in being at once sound and visionary.

The other two books both deal with the commercial development of biotechnology and both are by journalists. In *Setting Genes to Work* Stephanie Yanchinski describes, in an easy style, an industrial revolution based on microbes. She touches lightly on the applications, the companies and the people involved in some of the glamorous uses of biotechnology, largely in medicine, but also in food, agriculture and even computing (a DNA-coded, self-assembling biological computer).

John Elkington, the editor of *Biotechnology Bulletin*, reviews the growth of industrial biotechnology from the late 1960s to the end of 1984. He pieces together short notes from interviews and press reports with accounts of most of the British, and many of the American, companies involved in bringing in the newer products which depend on genetic engineering and other aspects of biotechnology. Accuracy is sometimes sacrificed to style, but as a catalogue of commercial developments it is readable and reasonably comprehensive: over 200 companies are mentioned, concerned with the applications of biotechnology in medicine, agriculture, animal breeding and food production.

In both Yanchinski's and Elkington's books I would have liked a more critical analysis, perhaps through case studies, of the business and technical factors which have made ventures succeed or fail. But perhaps we should be grateful that those with the scientific and commercial acumen to write such a book are too busy with their demanding task of developing the products and building the new businesses on which the reality of our much-heralded revolution depends. □

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Milestones in the commercial development of biotechnology*

1973:	First gene cloned.
1974:	First expression of a gene cloned from a different species in bacteria.
1975:	First hybridoma created.
1976:	First firm to exploit recombinant DNA (rDNA) technology founded in the USA (Genentech).
1978:	First product made with rDNA (somatostatin).
1980:	*Diamond v. Chakrabarty*—US Supreme Court rules that microorganisms can be patented under existing law; initial public offering by Genentech sets Wall Street record for fastest price per share increase.
1981:	First monoclonal antibody diagnostic kits approved for use in the USA; initial public offering by Cetus sets Wall Street record for the largest amount of money raised in an initial public offering ($125 million).
1982:	First rDNA animal vaccine (for colibacillosis) approved for use in Europe; first rDNA pharmaceutical product (human insulin) approved for use in the USA and UK.
1983:	First plant gene expressed in a plant of a different species.
1984:	Judge John Sirica thwarts the scheduled environmental release of rDNA organisms; Stanford awarded Cohen/Boyer patent on basic rDNA process.

* Here abridged, the details are taken from Marc Lappé's *Broken Code: The Exploitation of DNA*, recently published by Sierra Club Books, San Francisco, price $17.95. The original source was *Commercial Recombinant DNA: An International Analysis*, produced by the Office of Technology Assessment, January 1984.