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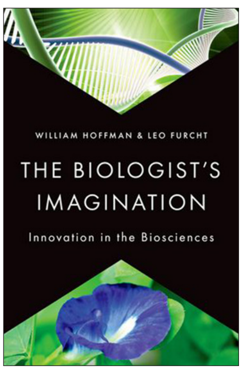
A History of New Ideas in the Biosciences

The Biologist's Imagination: Innovation in the Biosciences. William Hoffman and Leo Furcht. Oxford University Press, 2014. 284 pp., illus. $34.95 (ISBN 9780199974597 cloth).

William Hoffman and Leo Furcht's *The Biologist's Imagination* is a history of the ancient developmental work in biology and its way forward over the years, which has culminated in recent contentious issues involving the US Supreme Court verdict on the patenting of human genes. The book is not just a history of the biological innovations in the United States; it encompasses a worldwide view, with particular emphasis in China and India as the presumed sources of next-generation innovations in biology. The authors provide a historical definition of *innovation* and then succinctly explain the content of the book—as phrased in their own words, "We cover subjects as seemingly disparate as the history of technology, economics, molecular biology and genetics, neuroscience, geography, evolution, education, globalization, clinical trials, technology transfer, the digital revolution, patent law, and public policy."



Can all these items be covered in a single book that defines its goals as recounting innovation in biosciences for the last couple of centuries? Indeed, the authors follow the trail from premolecular biology and immunology to the current advances in *-omics* technology, such as genomics, proteomics, and metabolomics. The authors emphatically point out how the costs of research and development in biology have gone down during the last 25 years, citing the example of human genome sequencing and the declining cost of computing power over the last few decades. In one chapter, the authors emphasize how the pharmaceutical industry has taken advantage of innovations in high-throughput screening of thousands of compounds as potential drug candidates, defining *hits* and then taking them through clinical trials only for those patients who will likely benefit the most because of their genetic profile and susceptibility to particular diseases, such as cancer. The issues of race and ethnicity in regard to drug efficacy and genomic profile in countries such as Japan, China, and Singapore have been cited as examples of the reach of modern bioscience.

Elsewhere, the authors emphasize how entrepreneurship, scientific research, and scholarship and funding opportunities, all from government, industry, and private sources have contributed to region-specific centers of excellence in bioscience. They cite the example of Silicon Valley as the earliest catalyst in modern molecular biology research advances, including recombinant DNA technology and the emergence of Genentech (and Cetus) as startup companies relying on such technologies. This trend in the United States subsequently led to regional bio-innovation in the rest of the world, including industrial biotechnology clusters and science parks such as Edinburgh's BioQuarter, Singapore's Biopolis, Skolkovo Innovation Center near Moscow, Hsinchu Science Park in Taiwan, and Tsukuba Science City in Japan. The emergence of mega-centers and megacities around the world has broken down the barriers of trade secrecy and localized research and innovation activities, promoting, instead, a culture of international scientific exchange, joint ventures, cross-border talent search, recruitment, intercountry investments, and the formation of startup companies.

The book also deals with how Gregor Mendel's studies on the genetics of peas eventually led to a worldwide surge in genetics studies and, most notably, led to a $200-million life-science campus developed at Masaryk University in Brno, Czech Republic, where Mendel initiated the work. The open-access movement, which advocates free access to and use of digital scientific and scholarly activities emanated from Mendel's discovery of how genetic information is transmitted through succeeding generations. Such concepts, coupled with Darwin's theory of evolution by means of natural selection, ultimately led to the modern concepts of evolutionary biology, although Mendel's conceptual framework of using mathematical deductions was not much appreciated at that time. As is pointed out in the book, however, Mendel's mathematical deductions were the first steps in the evolution of the field of bioinformatics and computational biology that dominate today's genomic sequencing and other cutting-edge areas of biology. Mendel's early innovations also triggered the emergence of companies bearing his name, such as Mendel Biotechnology in the Silicon Valley area, which is trying to develop novel, fast-growing plants with high cellulose content. Ostensibly, such plants could act as a source for biofuels, such as ethanol through cellulosic fermentation. A downside of such potential advancements is, of course, their impact on climate change through the formation and release to the atmosphere of large amounts of carbon dioxide during their production and use. This chapter of the book presents an exhaustive account of how innovations in plant breeding and genetics, as well as rapid sequencing technologies, are not only addressing the problems of defining genetic alterations affecting human health, novel methods of enhancing agricultural productivity, and future energy generation but also the associated problems yet unseen that could result from their long-term development and use.

The next chapter discusses the role of universities as the source of successful entrepreneurship in regional and economic development. Starting from the University of Bologna in the Emilia Romagna region of Italy to the so-called "triple helix" of university–industry–government cooperation, such efforts have contributed to fostering entrepreneurship, promoting university–industry collaboration and joint ventures, and patenting and licensing of new technologies to set up startup companies. The modern era of biological and other innovations owes much to the 1980 Bayh–Dole Act that facilitates the government-funded research in academia or small businesses owned by the fund recipients by supporting technology development, patent filing, licensing, and commercialization. The book describes in detail the circumstances that led to the successful congressional passage of the Senate bill. Sponsored by Birch Bayh (D–IN) and Robert Dole (R–KS), the University and Small Business Patent Procedures Act, more commonly known as the Bayh–Dole Act, was passed in 1980. The passage of this act was not easy, but it succeeded in a lame duck session of the 96th Congress and became law on 12 December 1980, with President Jimmy Carter's signature. The passage of this act has encouraged not only the growth of a large number of technology transfer offices in various universities, leading to the establishment of the Association of University Technology Managers, with more than 350 institutional members in the United States, but it has engendered a significant rise in the number of university-owned patents and the ensuing royalty payments to the universities. There has been fallout from the act: One negative effect of universities' preoccupation with patent ownership and licensing under the Bayh–Dole Act is that they are no longer considered the home of pure academic research. This might deprive universities of their experimental limited use advantage of using patented products or processes without royalty payments, as was established in the 2002 court case *Madey v. Duke University.*

The final chapters in the book deal with patent laws, the role of the individual inventor rather than the employer, and the limits of the patent laws in defining and protecting the products of nature. US patent law finds its basis in the Constitution, framed in 1790. The first US patent was issued on 31 July 1790 to Samuel Hopkins for an improved method of making potash. Since that time, the US patent laws have gone through several modifications, including the Plant Breeding Act, which allowed the patenting of asexually reproduced plants, as well as the 2011 America Invents Act, which eliminated the first-to-invent system in favor of a more widely accepted first-to-file system. The 1980 US Supreme Court decision in *Diamond v. Chakrabarty* that boldly declared "anything under the sun that is made by man" is patent eligible in the United States has led to the patenting of many genetically engineered life forms, including microorganisms, plants, and animals. The book deals fairly extensively with the emergence and patenting of synthetic genomes and also devotes space to the court case known as *Association for Molecular Pathology v. US Patent & Trademark Office*, in which the patent eligibility of two human genes, *BRCA1* and *BRCA2*, was questioned. Certain mutations in those genes lead to a predisposition to developing breast and ovarian cancers in women. In a unanimous decision in 2013, the US Supreme Court ruled that such human genes are products of nature and, unless they are substantially modified, cannot be patented.

Overall, Hoffman and Furcht's book constitutes a historical account that traces the worldwide development of bioscience over a century or more. The major emphasis is, of course, on the development of bioscience in the United States over the past 50 years and the future advancements in genomics, proteomics, open-source communication, and synthetic biology, with a discussion of the associated intellectual property protection and technology transfer issues. An added strength of the book is the extensive list of references at the end of each chapter. Readers interested in the history of biotechnology development, contentious court cases involving patent eligibility issues, and what lies ahead will find the book worth spending time with.

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