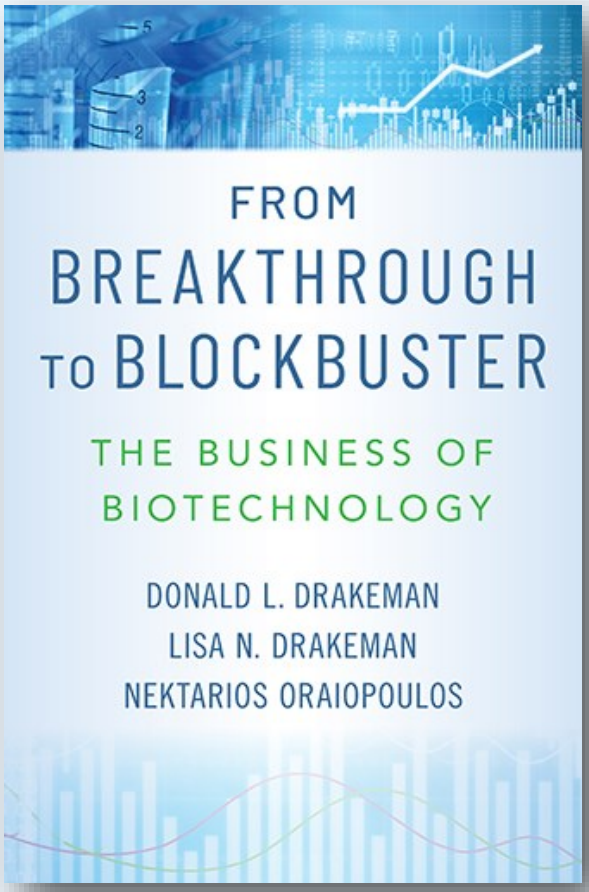
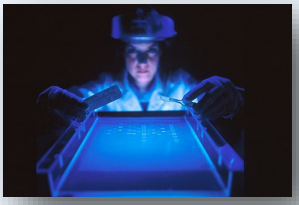
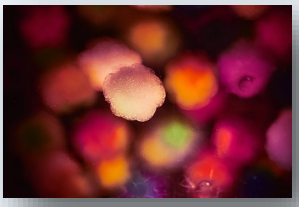
# Official Instructor Guide






***Chapter Abstracts, Discussion Questions & Classroom Activities***

Developed by the authors for use in undergraduate and graduate level courses.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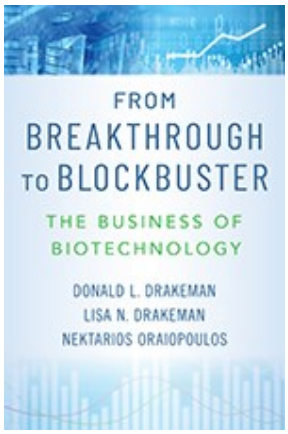


# From Breakthrough to Blockbuster: The Business of Biotechnology

Beginning in the 1970s, several scientific breakthroughs promised to transform the creation of new medicines. As investors sought to capitalize on these Nobel Prize-winning discoveries, the biotech industry grew to thousands of small companies around the world. Each sought to emulate what the major pharmaceutical companies had been doing for a century or more, but without the advantages of scale, scope, experience, and massive resources.

How could a large collection of small companies, most with fewer than 50 employees, compete in one of the world's most breathtakingly expensive and highly regulated industries?

This book shows how biotech companies have met the challenge by creating nearly 40% more of the most important treatments for unmet medical needs. Moreover, they have done so with much lower overall costs.

The book focuses on both the companies themselves and the broader biotech ecosystem that supports them. Its portrait of the crucial roles played by academic research, venture capital, contract research organizations, the capital markets, and pharmaceutical companies shows how a supportive environment enabled the entrepreneurial biotech industry to create novel medicines with unprecedented efficiency. In doing so, it also offers insights for any industry seeking to innovate in uncertain and ambiguous conditions.

Looking to the future, it concludes that biomedical research will continue to be most effective in the hands of a large group of small companies as long as national healthcare policies allow the rest of the ecosystem to continue to thrive.

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***From Breakthrough to Blockbuster: The Business of Biotechnology***

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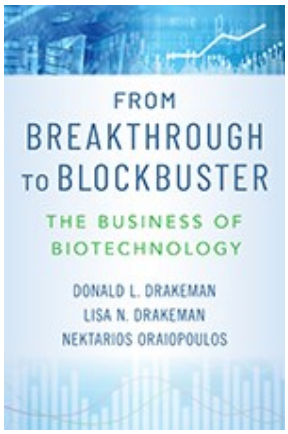



# Class Exercise:

# Oral Presentations

Ask students to prepare a 3-minute oral presentation on one of the following topics. These questions can be answered by reading the book carefully.

1. Discussing the importance of the Bayh-Dole Act for the creation of the biotechnology industry.

2. Comparing and contrasting the drug development productivity track record of the biotechnology and pharmaceutical industries.

3. Explaining why creating innovative medicines can be challenging for large pharmaceutical companies.

4. Explaining why it is so expensive to develop a new medicine.

# Chapter One: Following the Map of the Genome

This chapter introduces the biotechnology industry, tracks its growth from its origins in the 1970s to the present, and presents topline results of its track record, which has resulted in more innovative medicines at lower costs than the pharmaceutical industry. It also explains how this analysis of the remarkable efficiency of the biotech industry contrasts with prior works that have emphasized the importance of the large pharmaceutical companies' scale, scope, and experience in the development of new medicines. The chapter then outlines the main themes of the remaining chapters, which address the scientific background, the elements and costs of the drug development process, the origin and financing of biotech companies, the nature of alliances between biotech and pharmaceutical companies, the characteristics and responsibilities of biotech entrepreneurs, and the industry's R&D track record. It concludes by outlining the forces that will shape the future of the industry.

## Discussion Questions

1. What where some milestone events in the history of the biotechnology industry ?
2. What are some key challenges that biotechnology companies face from their journey to discovery to launching a drug?
3. What have been some of the earlier assessments of the track record of the industry and what might explain the difference with the current one?
4. Since the goal of biotech companies is to turn scientific discoveries into medicines, why would a book about the industry need to talk so much about raising money and other financial matters?

# Chapter Two: The Molecules

This chapter offers an overview of the major scientific advances that led to the founding of the biotech industry in the 1970s. While the first entrepreneurial life sciences companies were established primarily to take advantage of rDNA and monoclonal antibody technology, the chapter also highlights a number of other promising technologies, including antisense and gene therapy. It also shows how large pharmaceutical companies have adopted the same technologies, while biotech companies have branched out into the medicinal chemistry that has been the mainstay of the pharmaceutical industry. It explains that what distinguishes a biotech company from a large pharmaceutical company is not a focus on using any specific technology but the fact that the biotech company is smaller, newer, less experienced, and almost always unprofitable.

## Discussion Questions

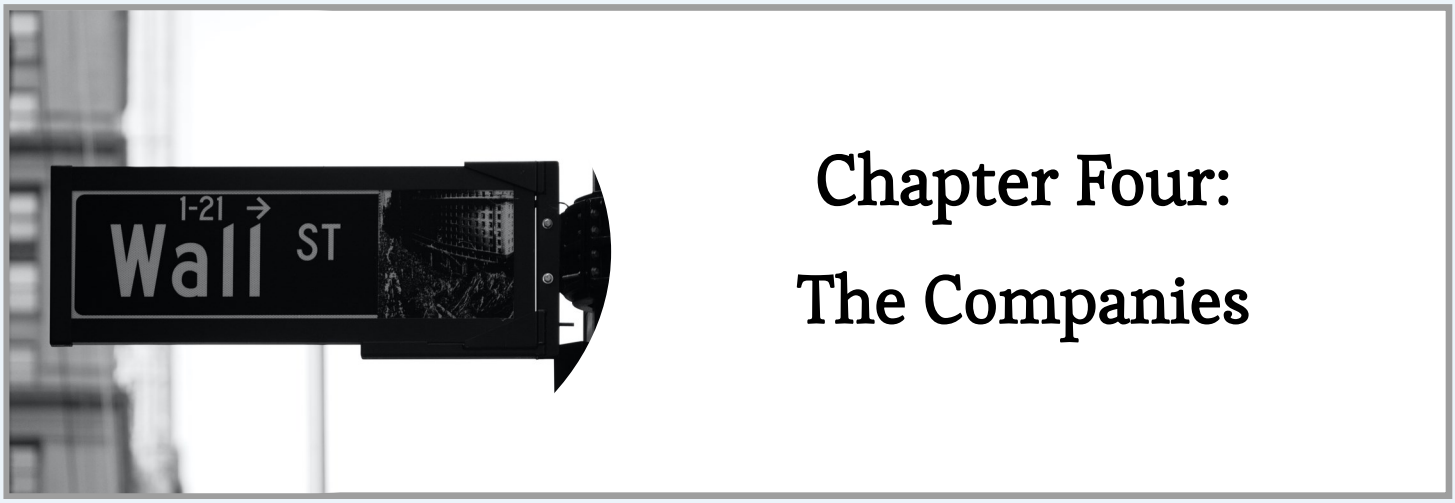
1. Discuss the significance of major scientific discoveries like recombinant DNA technology, monoclonal antibodies, and the human genome mapping in the development of new therapies?
2. What is the main difference of the above technologies compared to the discovery and development processes involved in traditional (pre-biotech) pharmaceuticals?
3. How would you define a biotechnology company?
4. By conducting an online search, identify the main technologies (modalities) used in therapeutics approved by the FDA over the past 5 years.
5. By conducting an online search, identify how many of the top ten selling drugs (of the previous year) were biologic products?

# Chapter Three: The Costly Drug Development Process

This chapter explores how new medicines are created. It describes the principal steps, the regulatory framework, and the various elements that contribute to the cost of the drug development process. To make sense of the most recent figures that put the cost per approved drug at over $2.5 billion dollars, it identifies the major components of those costs, the most important of which is the high failure rate. Still, it shows that, even in the rare case when everything in the R&D process works as expected, hundreds of millions of dollars will be needed to take the drug development process to a successful conclusion.

## Discussion Questions

1. Describe the key milestones in the drug development process: from discovery to regulatory approval. What is the role of the regulatory agencies (such as the FDA) in this process?
2. What are the key reasons that a drug might fail a particular phase in the development? Have those failure rates improved over the years?
3. What are the factors that determine the astronomically high cost of developing a new medicine?
4. How might the cost of development differ between biotech and large pharmaceutical companies?
5. Considering the exponential increase in costs over the past decades, what strategies could drug development companies employ to manage and potentially reduce these costs?




# Chapter Four: The Companies

This chapter focuses on how biotechnology companies are founded and the process by which they raise funds. Since many of the molecules have their origins in government grant-funded research, the chapter will follow the ownership of that technology as it goes through the technology transfer process and thus moves from universities and other not-for-profit research organizations into for-profit companies that have the potential to attract investors. The chapter then describes the capital-raising process through various venture capital stages and ultimately, for some companies, an initial public offering of stock.

## Discussion Questions

1. Discuss the impact of the Bayh-Dole Act on the commercialization of research from academic institutions.
2. How do collaborations between academia and biotech companies benefit both parties and what are some potential challenges?
3. In what ways has venture capital funding shaped the biotech industry?
4. Compare the biotech ecosystems in the United States with those in Europe and Asia. What factors contribute to the differences observed?
5. Evaluate the role of initial public offerings (IPOs) in the lifecycle of a biotech company. What are the benefits and potential risks? What are some factors that might determine when a company should go public?

# Chapter Five: Biotech-Pharma Alliances

This chapter covers one of the two major sources of funding for the biotech industry: strategic alliances between biotech companies and pharmaceutical companies. There are so many alliances – typically over 1,000 each year – that, even in the early days, one scholar called the volume of these transactions "without precedent in business history." Beyond funding, alliances can also provide access to drug development expertise and resources and can send a positive signal to potential investors that a very knowledgeable partner has kicked the scientific tires. The chapter describes the negotiation process, how the terms are set, and what technologies and products have most often been the subjects of the alliances. It also discusses whether information asymmetry is an issue in forming these alliances.

## Discussion Questions

1. What do you think are the drivers for the increasing number of biotech-pharma alliances?
2. What are the advantages and disadvantages to the biotech company and pharma companies in partnering negotiations?
3. What is the advantage of biotech companies taking their product to approval, then commercializing and marketing it themselves?
4. What are the drawbacks of this plan?
5. What are the advantages of having a pharmaceutical company handle the final development steps, marketing and commercialization?
6. What are some common valuation methods used for licensing and acquisitions in biotech-pharma alliances? What are their advantages and drawbacks?
7. A number of scholars highlight information asymmetry, and specifically the market for 'lemons', a key market inefficiency in the biotech industry. How important do you think such information asymmetry is for the biotech-pharma alliances? What data can be used to test such assumptions?

# Chapter Six:
# The Biotech Entrepreneur

This chapter addresses the principal challenges facing entrepreneurial biotech CEOs and offers insights into how they may choose to address them. In particular, the chapter focuses on the entrepreneur's critical role in fundraising and discusses how to make an effective venture capital pitch. It also describes biotech CEOs' impressively diverse backgrounds, which include scientists, physicians, and pharmaceutical executives, as would be expected, but also historians, lawyers, regulatory experts, investment bankers, and a range of other professions. The chapter also identifies some of the personal characteristics often shared by entrepreneurs in a way that may help prospective biotech entrepreneurs consider the attractiveness of that career path.

## Discussion Questions

1. Does being a good student qualify you to be a good entrepreneur?
2. What academic skills are a fit with entrepreneurship?
3. What skills are less applicable?
4. Why aren't all biotech entrepreneurs scientists?

## Class Activity

Construct an elevator pitch:

Have each student go to a biotech company website and construct an elevator pitch. Then have them practice the pitch on the class.


# Chapter Seven: The Biotech Industry Track Record

This chapter compares the output of the biotechnology industry, as a whole, to that of the pharmaceutical industry in terms of new FDA-approved medicines created. It shows that the biotech industry has been much more effective than the pharmaceutical industry in developing the medicines that address important unmet medical needs. It shows how this result, which was predicted by the theoretical literature on innovation management but only now shown empirically, flows from the structure of the biotech ecosystem. Having thousands of small companies competing for funding provided by thousands of independent investors fosters the high volume of risk-taking that enhances the development of genuinely novel products in an environment in which there is no way accurately to predict the product characteristics needed for success.

## Discussion Questions

1. Small biotech companies have created more novel companies at a much lower cost than large pharmaceutical companies. What factors might have contributed to their higher R&D productivity?
2. What are the differences in the funding and go/no-go decisions between biotech and pharmaceutical processes? Discuss the advantages and disadvantages of the different approaches.
3. Discuss the concept of a "shots-on-goal" strategy in drug development. How does it resonate with the overall strategy of a company? In other words, what kinds of companies might benefit from implementing such an R&D strategy.
4. What other capabilities and management processes should a company have in order to apply a "shots-on-goal" strategy effectively?
5. What is the rationale for designing "killer experiments"? What biases or organisational routines might get on the way of a company that wants to perform such experiments?

# Chapter Eight: The Future of the Biotech Industry

This chapter explores whether today's approach to innovative drug discovery will continue. The governments that invest over $100 billion a year in fundamental research do so with the dual goal of promoting the health of their citizens through the new medicines, and the wealth of their communities from the jobs created by the companies developing those medicines. But the prices of new medicines have risen to levels unimaginable at the outset of the industry. As a result, the industry's future will be determined primarily by whether policymakers, physicians, and patients decide that the costly new medicines emerging from the industry provide enough value for governments to continue to invest in basic academic research. Those decisions will similarly influence whether venture capitalists and other investors will continue to invest in the biotech industry.

## Discussion Questions

1. Discuss the reasons why the drug development industry has shown resistance to the common cyclical pattern of consolidation seen in other business sectors.
2. What factors make biotech start-ups attractive to venture capitalists, and how does this influence the direction of research and development within the sector?
3. What lessons can be drawn with respect to the economic and social impact of state-funded research programs such as the cases of New Jersey and California?
4. What are the key factors that determine the pricing and reimbursement policies in the U.S. versus the U.K. and Europe
5. How do the above policies might affect the discovery and development of new medicines?