

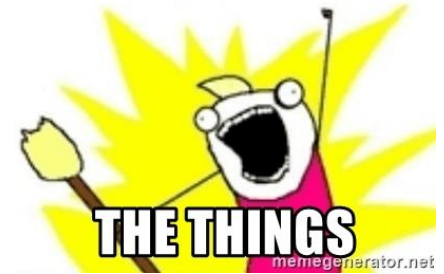
14622: The (Not So) Many Faces of Biotech

Arbri Kopliku, MIT Department of Biology

DAY 1

Day 1 Outline

- Introductions and structure of the series
- Very quick ice-breaker
- Definitions, definitions... with a crash course on medications!
- Pharma against biotech or just biopharma?
- How to tackle a Herculean problem *like a pro* -> Innovation
- *This sounds elementary, dear Watson, but it isn't.*
- Niche creation as the first theme of the biotech-innovation romance.
- Magic bullets and their legacy
- Some extra ideas to inspire our next sessions, including Character Spotlight!



So what does Biotech mean to you?

- You will have 5 seconds to type a single word which, according to your very professional opinion, best summarizes biotechnology.
- We will then count to three and have everyone send their word to the Zoom chat for everyone else to see.



What counts as Biotechnology?

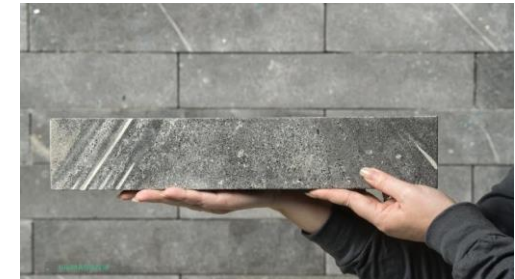
- “Biotechnology is a broad area of biology, involving the use of living systems and organisms to develop or make products. Depending on the tools and applications, it often overlaps with related scientific fields.”
- Not the most specific of definitions, as it doesn’t give us a consistent window of time or applications!



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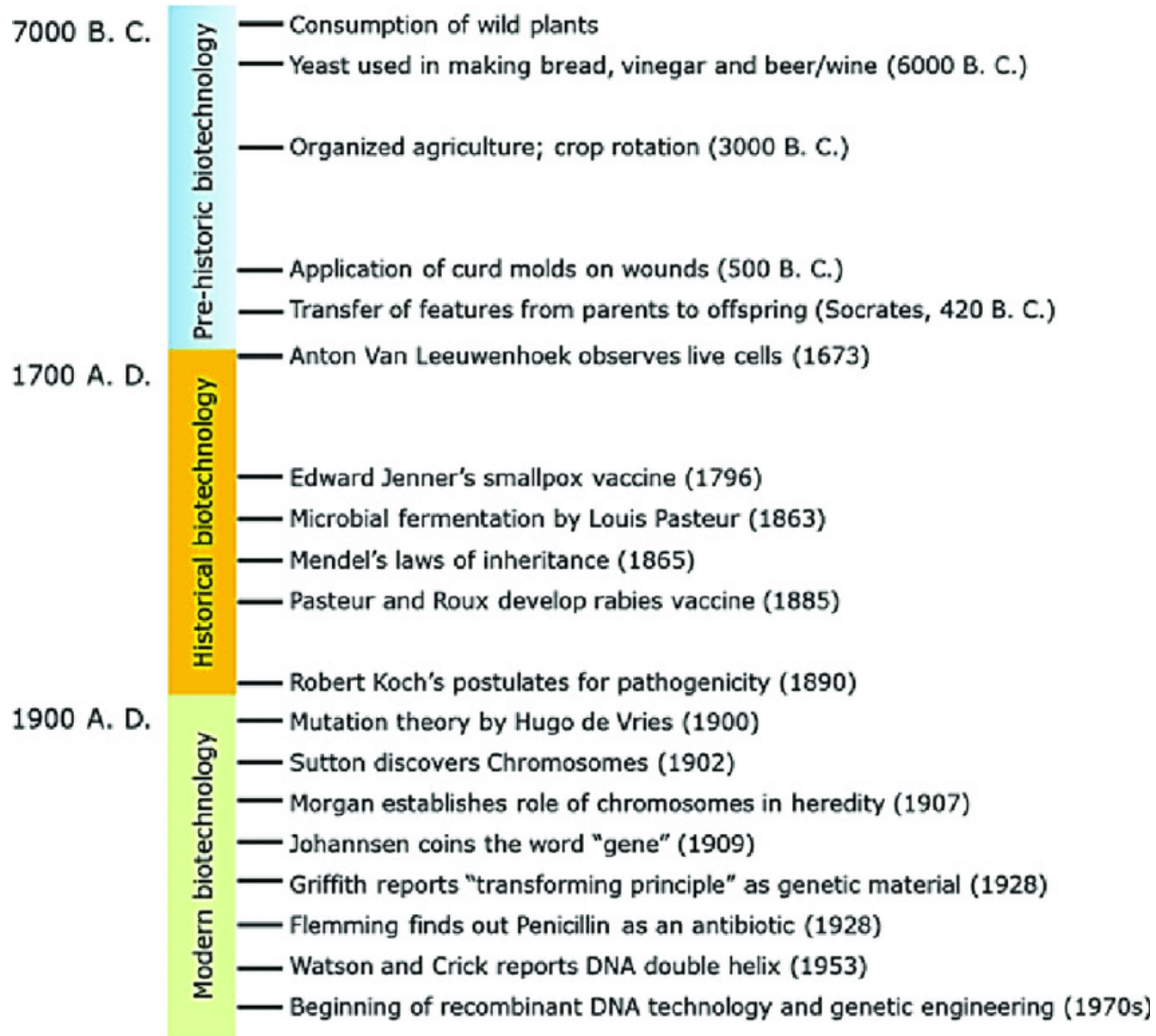


Fig. 1: Concise timeline of biotechnology in its entirety, broken down into 3 categories. Verma, Gaurav & Ravichandran, Srividhya. (2020). Evolution of Biotechnology as a Million Dollar Market: The Management and Commerce of a Biotech Start-up. 10.1007/978-3-030-36130-3_9.

The Discovery of Recombinant DNA

- In essence, the realization that one can manufacture DNA from different source organisms, usually different species.
- Greatly simplifies finding trends and predicting the outcomes of projects, since we have a (relatively) short window of time for which to collect data, from 1973 to the present.
- Our first contact with the Genentech story.

Genentech

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But can't Pharma do this too?

- A rather complicated relationship between the Pharmaceutical and Biotechnology industries which can be seen more as a blessing than competition.
- Understanding what lies in between these (for our purposes) distinct entities requires a little bit of knowledge on pharmaceuticals, so let's get to it!



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Maintaining an Edge

- In the late 1960s, the pharmaceutical industry giants continued to rely on “traditional” pharmacology mechanisms, mainly biochemistry and enzyme-inhibition related medications. After all, they had the funds and staff to continue making a profit out of them!



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Creating an Edge

- Meanwhile, many faculty members from different universities across the US, MIT included, took this time to consider creating biotechnology companies out of their research on recombinant DNA.
- The very first such product was **Human Insulin**, by Genentech, in 1978.
- Thus came into being the concept of “biologics”, or biopharmaceutical medications.



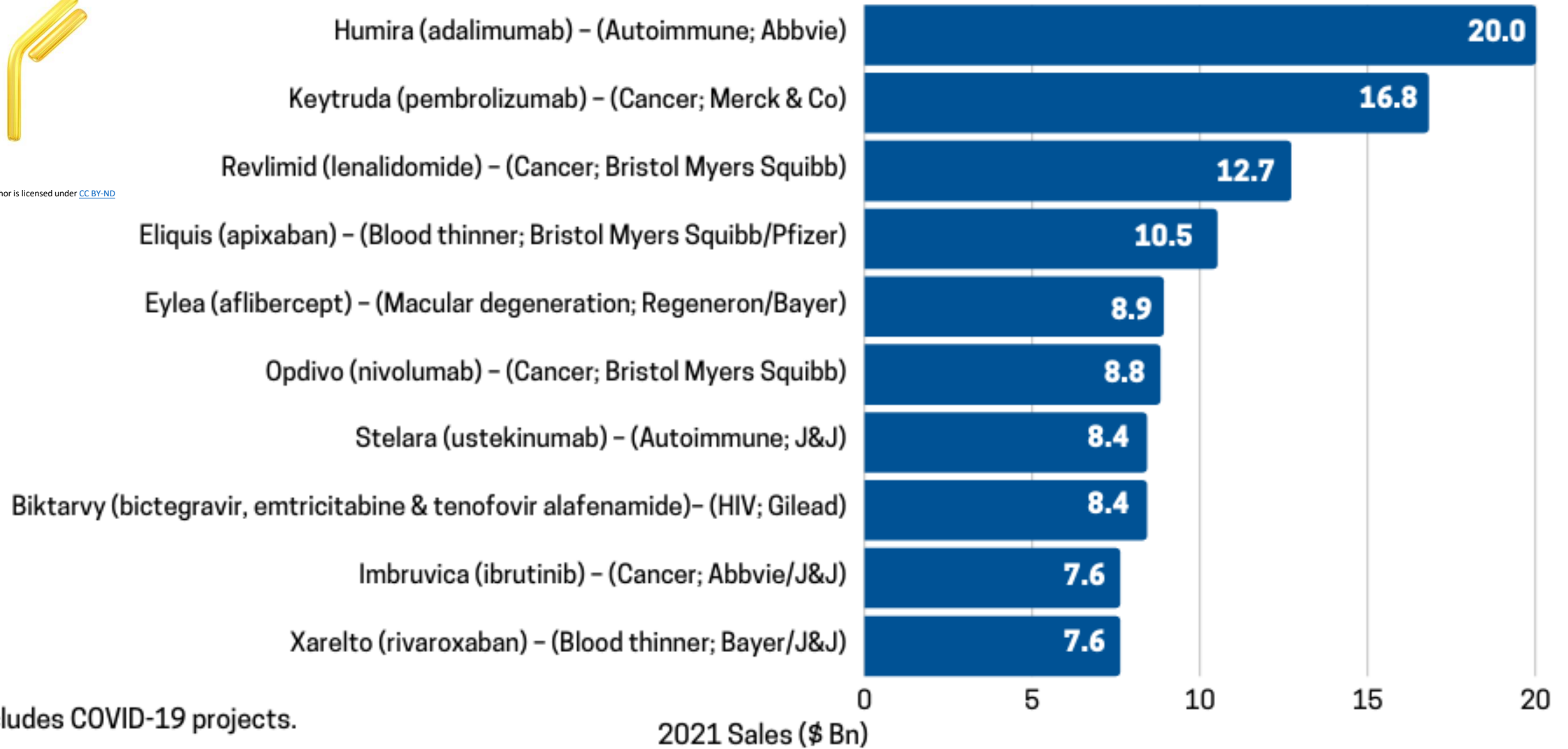
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Figure 3: Projected Biggest Selling Drugs in 2021



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Note: excludes COVID-19 projects.

Source: EvaluatePharma, Evaluate Ltd.

An Industry Built to Last

- From an economics perspective, it was much more favorable for big pharmaceutical companies to rely on marketing and distribution of medications, as was noted by the Kefauver investigations, instead of in-house Research and Development (R&D).
- This innovation gap made possible a trend that continued to this day: certain actors are specialized for certain stages in taking a drug from the lab bench to the bedside.

Lilly

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Two Solutions for the Same Problem



- In drug development, just like anywhere else in the business world, time is worth a great deal of money: the cost of generating a successful cancer drug is quite north of \$300M, so you would surely want to be the first in market for collecting the sales revenue!
- Major pharmaceutical companies then had to choose between lagging behind the market, or two possible solutions:
 - Develop the manufacturing capabilities quickly enough, license the drug and its protocols from the inventing smaller company, and produce everything in-house. *Lilly*
 - Purchase the entire inventing company and let them follow their own procedures, but still sell under your brand. 

Backtracking: The Herculean Problem

- The exact line of differences between biotech and pharma companies remains highly debated, and the fact that well-established biotech companies move into the pharma sector (Genentech, Amgen and Biogen) doesn't really help!
- An often-employed and quite effective approach is the concept of innovation, and it is precisely innovation in biotechnology that we will focus on in our series.



Back to the Defining Board



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- It as an acceptable, though surely not exhaustive, approach to defining modern biotechnology as the intersection between university-exclusive practices (where all the basic science originated from) and mechanical/chemical engineering formats of generating commodities.
- As such, biotechnology formed its own labor market distinct from the above two fields, and also to a great extent separate from pharmaceuticals.



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Have We Seen This Before?



- Having a unique new industry arise from the involvement and cooperation between unconventional actors has arguably happened before, with what many people would refer to as the prequel of the biotech revolution: the tech revolution.
- The tech revolution, held to begin with the invention of the transistor in 1947, defined the progress of commercial tech product development in Silicon Valley and beyond for a span of over 30 years, and the involvement of venture funding is of interest to us too.



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Common Features of the Two Revolutions

- The greater presence of “mobilizable capital” during the biotech revolution is undoubtedly a consequence of the tech one, and it came from the growing confidence of investors to take such bizarre risks, as well as the larger number of venture capitalism funds.
- The choice of geographical position for the new companies’ locations remained close to major research institutions, as a way of directly luring in the highly qualified graduates (and it goes in a closed cycle!).
- The presence of an innovative technology as a justification for any new startup’s existence also remained.





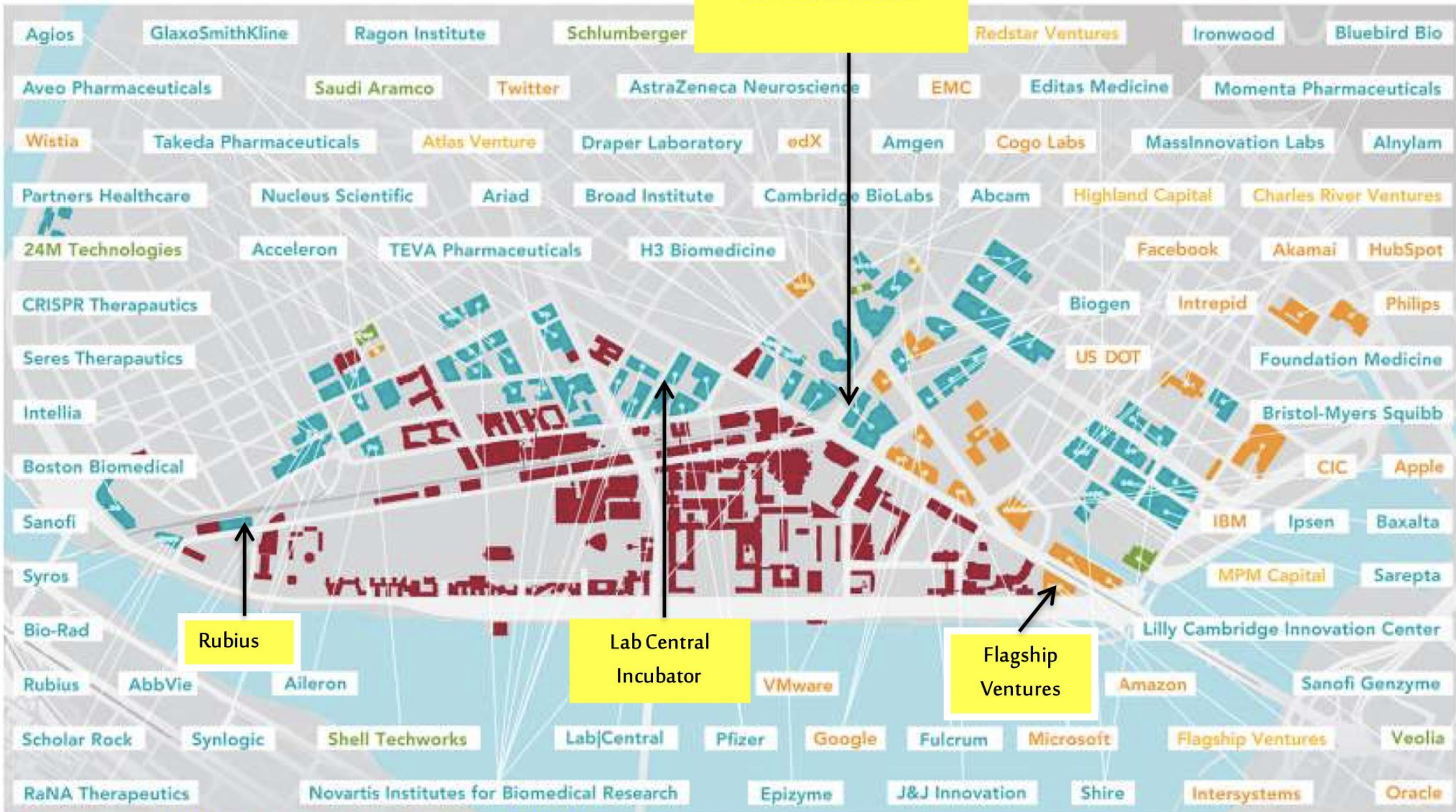
Badger

DOT

Draper

Tech

Whitehead Institute for
Biomedical Research



But Parallels Only Take You Far Enough!

- There are two key distinctions between the aforementioned 20th century revolutions, which help us characterize our interest in biotech.
- The risks involved in biotech investments are tremendously higher than those in mainstream tech, which set a huge border in time between the two straight away.
- Biotech companies couldn't just create a whole new set of skills and missions for themselves, like early tech companies did: instead, the jostling for pole position with pharma grew to define the your biotech companies.



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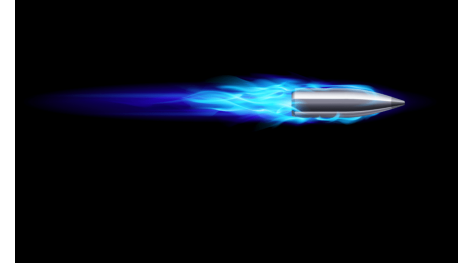
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Theme of the Day: Niche Creation

- This is what we were building up to, and denotes one of the three key themes in the relationship of biotech to innovation.
- We are using this very relationship to define modern biotechnology as a whole, and niche creation gives us the right context to begin with.
- Comparing the biotech and tech revolutions gives us more insight on what makes biotech so unique and at the same time so rewarding to characterize, as we will soon see.



The Legacy of Magic Bullets



- The association with scientific wonders accompanied biotechnology from its industrial conception, and the reason behind that is, well, that “Good news sells”.
- As opposed to powerful but indiscriminate medications (think cancer radiotherapy), biologics offered the hope of hyper-specific treatments that would drastically minimize side effects (now think antibodies!).
- This colorful magazine tone entered into the daily biotech entrepreneurship and investment conversations, as can be seen by looking at early annual reports of biotech companies.

Genentech, Inc.
 Genentech, Inc.
 Genentech, Inc.
Genentech, Inc.
 Genentech, Inc.



1984 ANNUAL REPORT

Bringing to market
 new therapeutics based on
 advancing knowledge
 in biological sciences.



2000 Annual Report



Theresa Beer
 Executive Director



Drew Wilton
 Rituxan trial patient

ONCE UPON A

GENENTECH



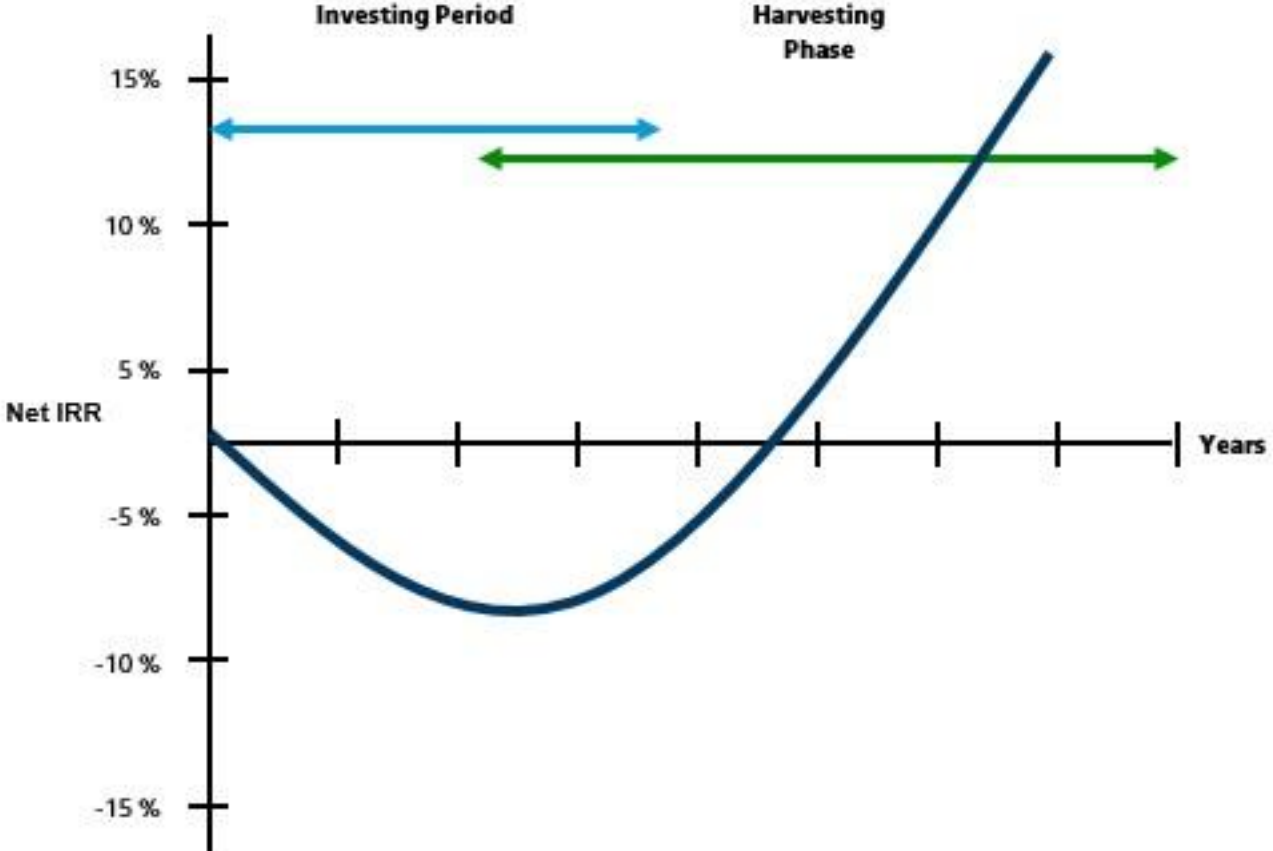
Phyllis Harris
 Rituxan trial patient



Ronald Pearson, M.D.
 Rituxan patient

Genentech, Inc. **25**
 IN BUSINESS FOR LIFE YEARS

EXTRAS: The J-Curve and Biotech Investment



Credits to Mercer, graph from [here](#).



EXTRAS: Character Spotlight – Robert Langer

- Chemical engineer, scientist, entrepreneur, inventor and one of the twelve Institute Professors at MIT.
- Has 1,400 granted or pending patents.
- Most cited engineer and 4th most cited individual in any field of all time, according to Google Scholar.
- Co-founder of more than 40 companies, including Moderna.
- His laboratory at MIT is the largest biomedical engineering lab in the world, with over \$10M in annual grants and 100 full-time researchers.
- The youngest person in history to be elected at all three American science academies.
- He isolated the first angiogenesis inhibitor, which constricts blood flow to tumor clumps.



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