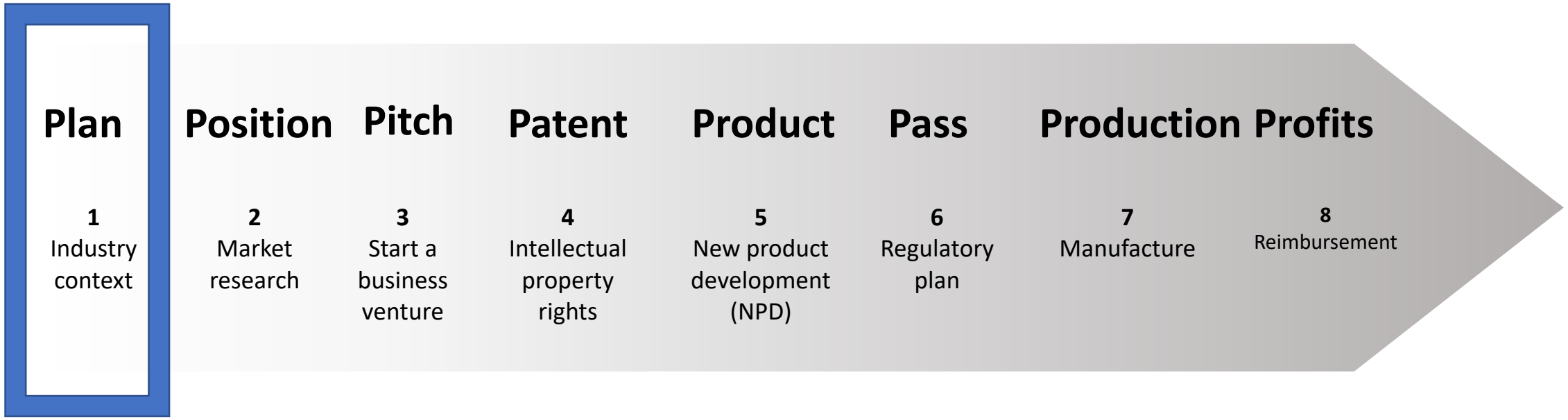
Commercializing Successful Biomedical Technologies 2nd Ed.

Shreefal Mehta



The biomedical device and drug industry and their markets

SHREEFAL MEHTA

Chapter 1

The healthcare industry

Unique features of the healthcare marketplace

- ❑ End users (patients) rarely make the purchasing decision. Care providers and intermediaries like pharmacy benefit managers or payers pre-select and guide health care selection and decisions.
- ❑ The end customer (patient) is usually not the direct payer. Insurance company or govt is the payer.
- ❑ Marketplace is highly regulated
- ❑ The patient usually does not get all the information about the products used
- ❑ In general, patients do not have the knowledge or training necessary to make an informed decision even if information or choice is provided

Large cycle trends

Wealth of information is now available to the caregiver and the patient at the point of service

- ✓ advice from machine learning or artificial intelligence software extracting patterns from large pools of “big data.”
- ✓ patient is now a “google” doctor
- ✓ Decision-power slowly shifting from the caregiver to companies that control the data and analysis.
- ✓ Advances in mobile computing power and AI tools are impacting many parts of the healthcare value chain

Regulated Products

(generally regarded as unsafe until proven safe; manufacturer can market with claim to treat disease)

Drugs, Biologics

Medical devices used to treat or cure a disease

Diagnostic devices

Veterinary Drugs

Minimally Regulated or Un-regulated Products

(generally regarded as safe until proven otherwise; manufacturer cannot claim to treat a particular disease)

Alternative and Complementary medicine: Dietary supplements, traditional or herbal medicines, homeopathy

Mobile apps, fitness trackers, exercise equipment, cosmetics skincare products

Devices specifically exempted by FDA in Code of Federal Register Title 21: Parts 862-892 Veterinary devices

Drugs and biotechnology – definition and scope

"Biotechnology"

- "The use of cellular and molecular processes to solve problems or make products."

"Drugs"

- Incorporates biologics and small molecule pharmaceuticals as two distinct technology platforms
- Intended to affect the structure or any function of the body

Biologic drug products

- ✓ **Erythropoietin** : one of the first blockbuster biologic drugs, with over $7 billion of sales in 2015 for blood disorders.
- ✓ **A monoclonal antibody (mAb):** A highly specific, purified antibody (protein)
- ✓ **Next-generation antibodies:** antibodies conjugated with other molecules for targeted delivery and dual action
- ✓ **Cell-based therapies and tissue engineering**: Used for tissue and organ replacement, regenerative medicine or functional augmentation
- ✓ **Nucleic acid therapies;** include gene therapy

Devices and diagnostics – definition and scope

Medical devices industry

- Devices are defined as: “an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, … *which does not achieve any of its primary intended purposes through chemical action within or on the body of man or other animals and which is not dependent upon being metabolized for the achievement of any of its primary intended purposes”*
- ***Classifications***
  - ✓ ***Commodity products and innovative medical device products***
  - ✓ ***Implantable and non implantable***
  - ✓ ***Diagnostic vs therapeutic***
  - ✓ ***New class of digital software medical devices both diagnostics and digital therapeutics***
- The medical device industry’s gross revenues have grown to $371 billion in 2017
- Orthopedics and cardiovascular are the two largest device application areas

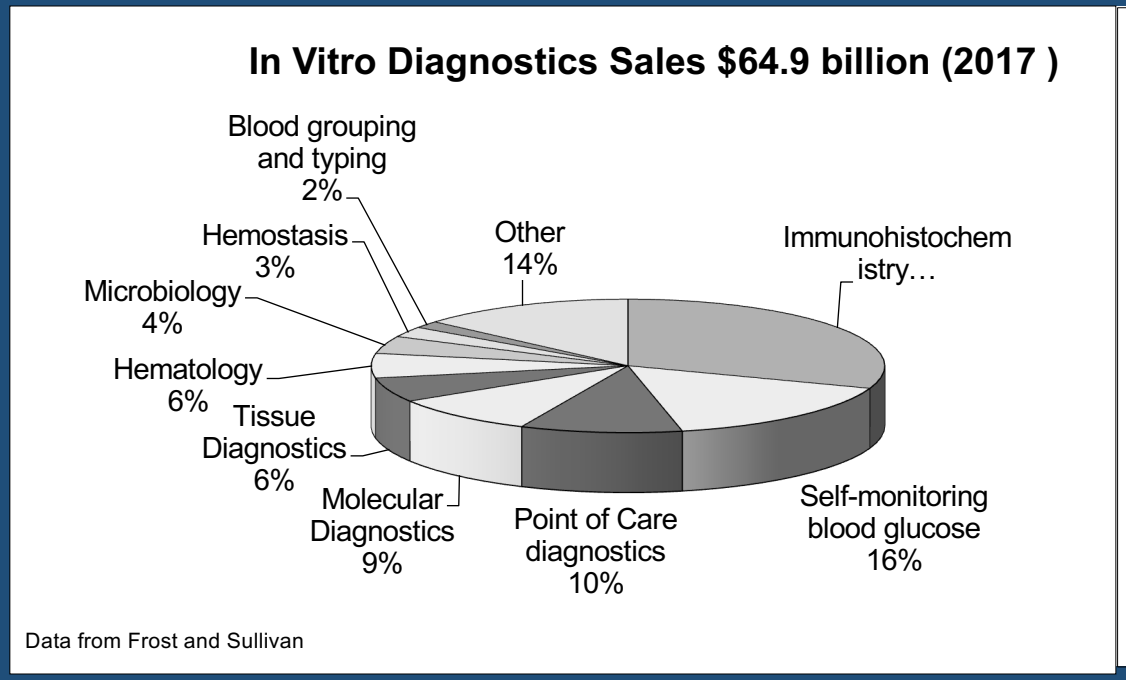


Figure 1.2

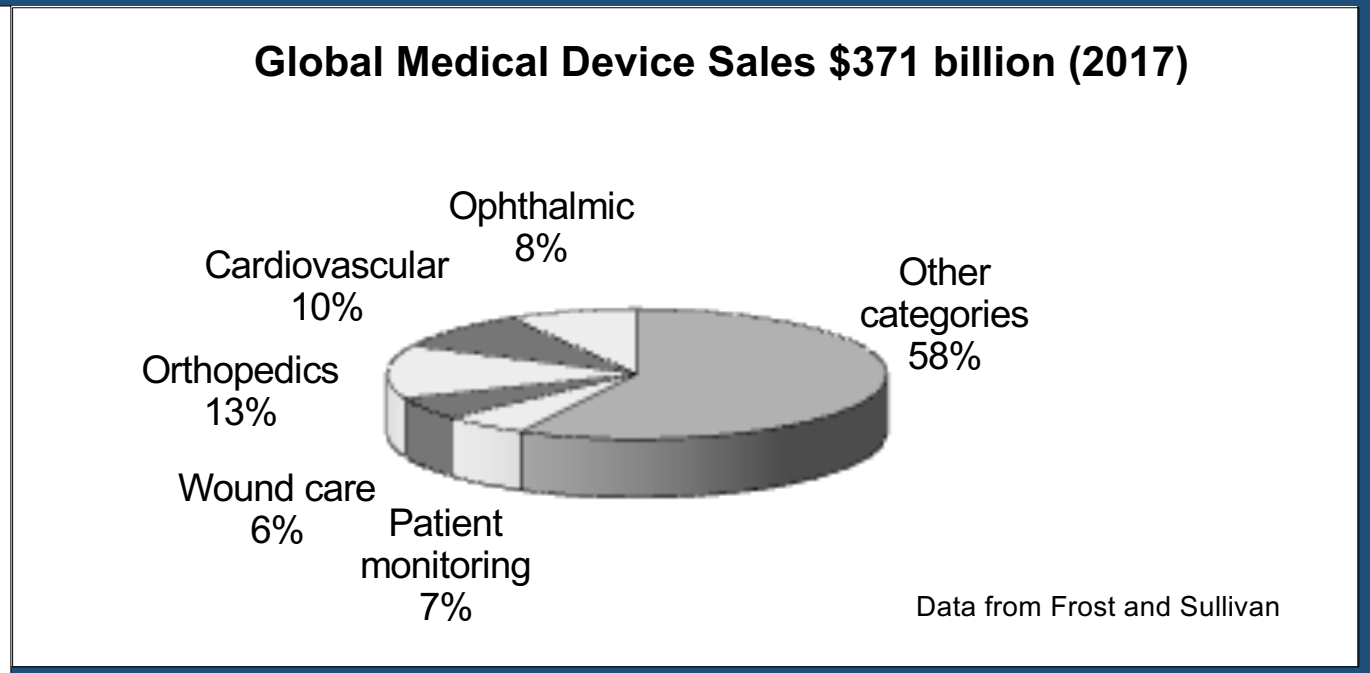


Figure 1.3

Devices and diagnostics – definition and scope

Diagnostics – IVD industry

I. *In vitro : means in the test tube, laboratory, or outside the organism*

II. *In vivo : means within a living organism).*

In vitro diagnostics products - This book will focus mainly on IVD

- In vitro diagnostics products are largely regulated as devices by the US FDA.
- There are two types of IVD products: devices (analyzers for samples such as blood, serum, urine, tissue) and reagents
- In vitro diagnostics is a mature market with a high volume of clinical tests using immunoassays and simple blood tests that have not changed in decades.
- More than 20 billion blood tests are performed annually worldwide.
- The overall estimated IVD market was $65 billion in 2017

In vitro molecular diagnostics

- A rapidly growing segment of IVD markets
- which analyzes DNA or RNA from a patient to identify a pathogen, a disease, or the predisposition of a disease

Lab testing industry

- In terms of lab service revenues, 60% is captured by hospital labs
- Independent labs hold about 30% market share

Healthcare IT, digital therapeutics and diagnostics trends

The role of IT in biomedical product development and integration into the delivery of healthcare

- ✓ *Faster and high-power computing cycles*
- ✓ *Wireless internet with higher bandwidths*
- ✓ *Always-connected mobile devices*
- ✓ *Medical software applications (Software as Medical Device, digital therapeutics)*

Intelligent or Smart Medical Devices, with increasing integration of software and hardware as higher-density, faster computing chips in connected devices become more common:

- ✓ Augmented reality eyeglasses, Retinal implants
- ✓ Implantable defibrillators
- ✓ Cameras in a pill

In diagnostics product development, **low-cost genomic sequencing** is transforming the industry with data and insight into diseases and supporting move towards **personalized/precision medicine.**

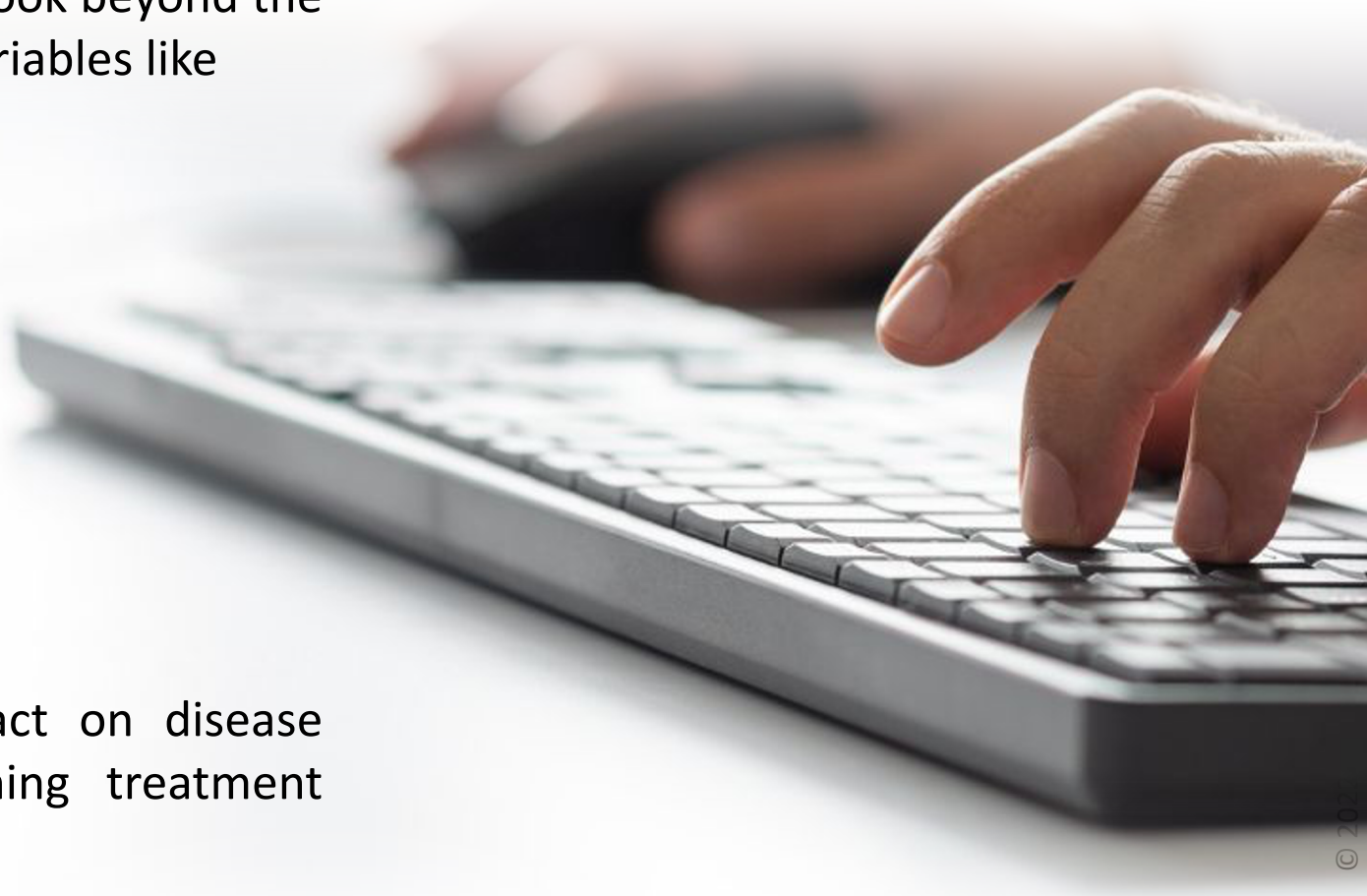
Software diagnostic solutions are providing Decision Support for caregivers, with machine learning and AI reducing errors and improving diagnostic outcome

Diagnostic wearable sensors are becoming ubiquitous

Healthcare IT and digital therapeutics cont..

The use of the internet and access to large databases can obtain differential diagnosis by programs that look beyond the standard diagnostic assays and into multiple variables like

- Social status
- Geography
- Life incidents
- Social media connections
- Emotional responses
- other indicators that may have an impact on disease health and may be relevant for assigning treatment options.



Industrial value chain

- Useful to analyze specific primary and secondary activities
- Use technology better in specific areas, or reduce costs, or reconfigure operations to add value
- Compare a firm's position with its competitive strategy
- Assess any strategic gaps
- Carry out cost advantage analysis
- Product differentiation positioning
- Helpful in reviewing the business model

Primary functions in value chain

1. Inbound logistics
2. Operations
3. Goods, and delivery
4. Marketing and sales
5. After-sales service

Secondary functions in value chain

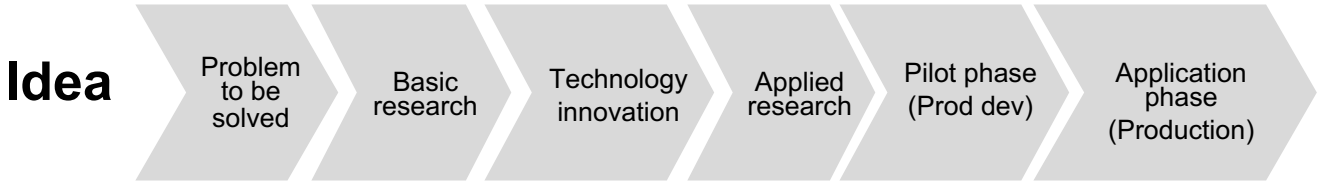
1. General management
2. Human resource management
3. Technology development
4. Procurement

Value Chain Analysis - Quantifying various measures (e.g. profit margins, return on investment) and their incremental value allows identification of highest value-added component of the value chain

Primary and secondary activities and their interactions with one another are systematically reviewed in a value chain analysis

Biomedical Products Industry Value Chain

INPUT VALUE CHAIN



Exploratory/discovery research and development

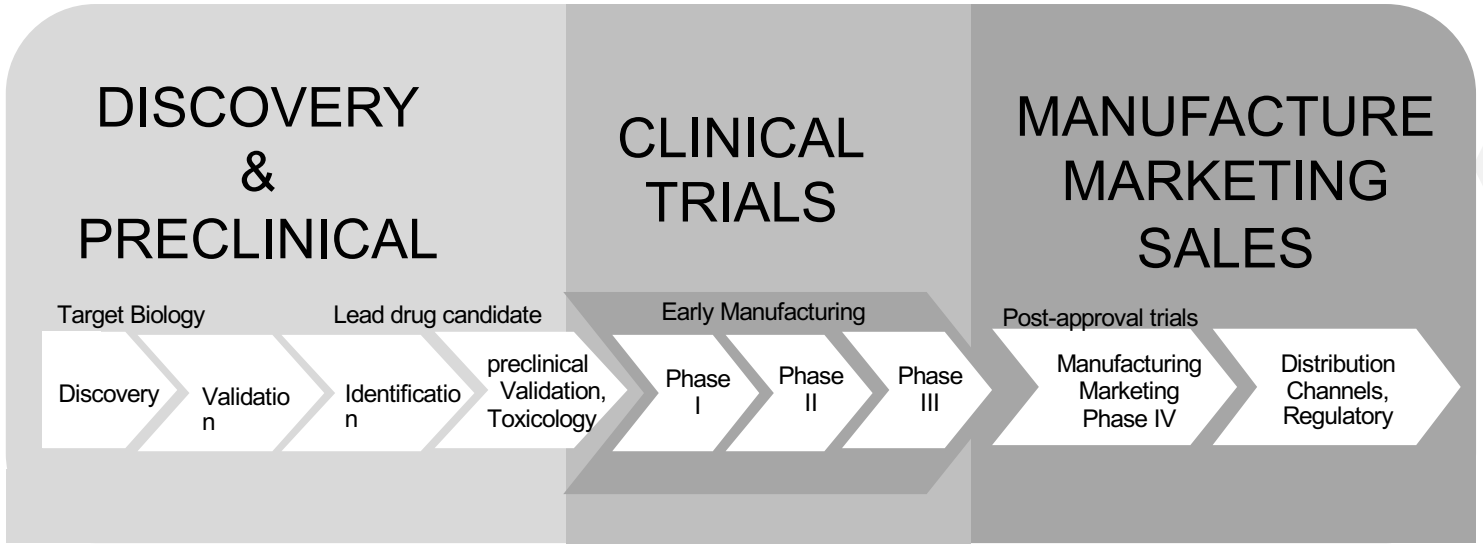
Product Development

OUTPUT VALUE CHAIN

Manufacturing, Marketing and Sales/Distribution

Figure 1.4

Drug Products Value Chain



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Physician
Hospital
Consumer

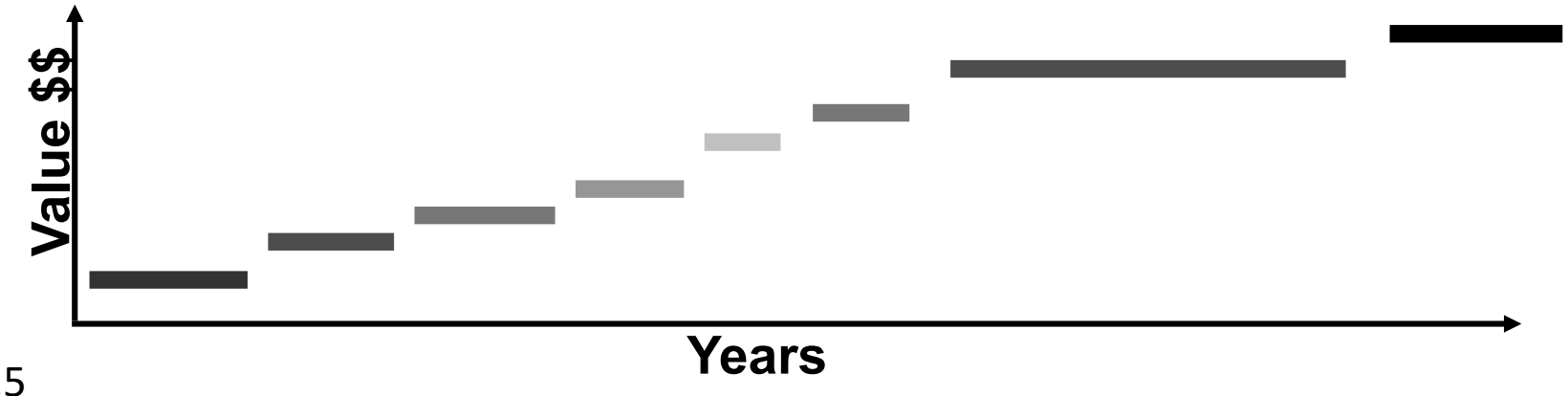
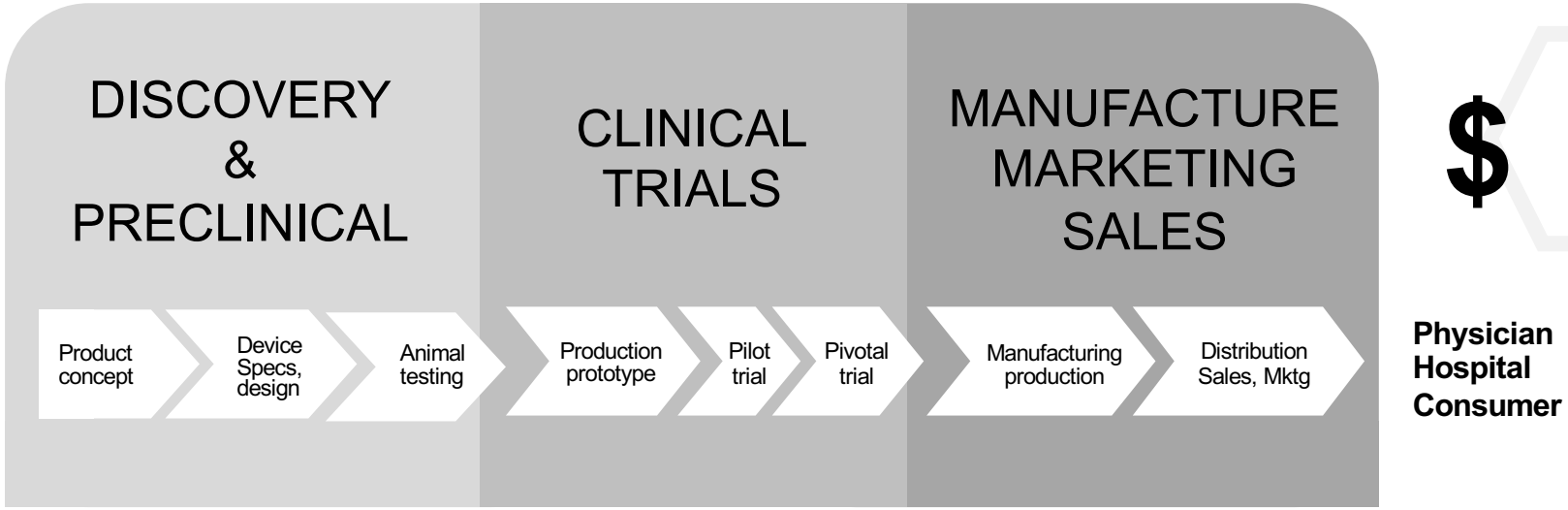


Figure 1.5

Med Device and Diagnostics Value Chain



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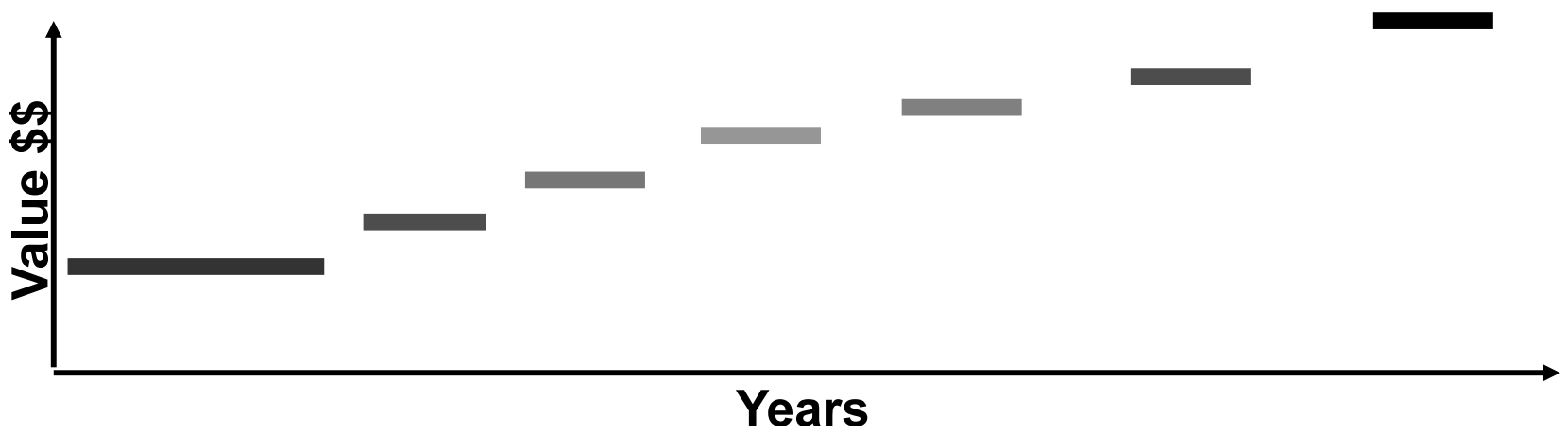


Figure 1.6

Diagnostics – Value Chain Commercial Opportunities

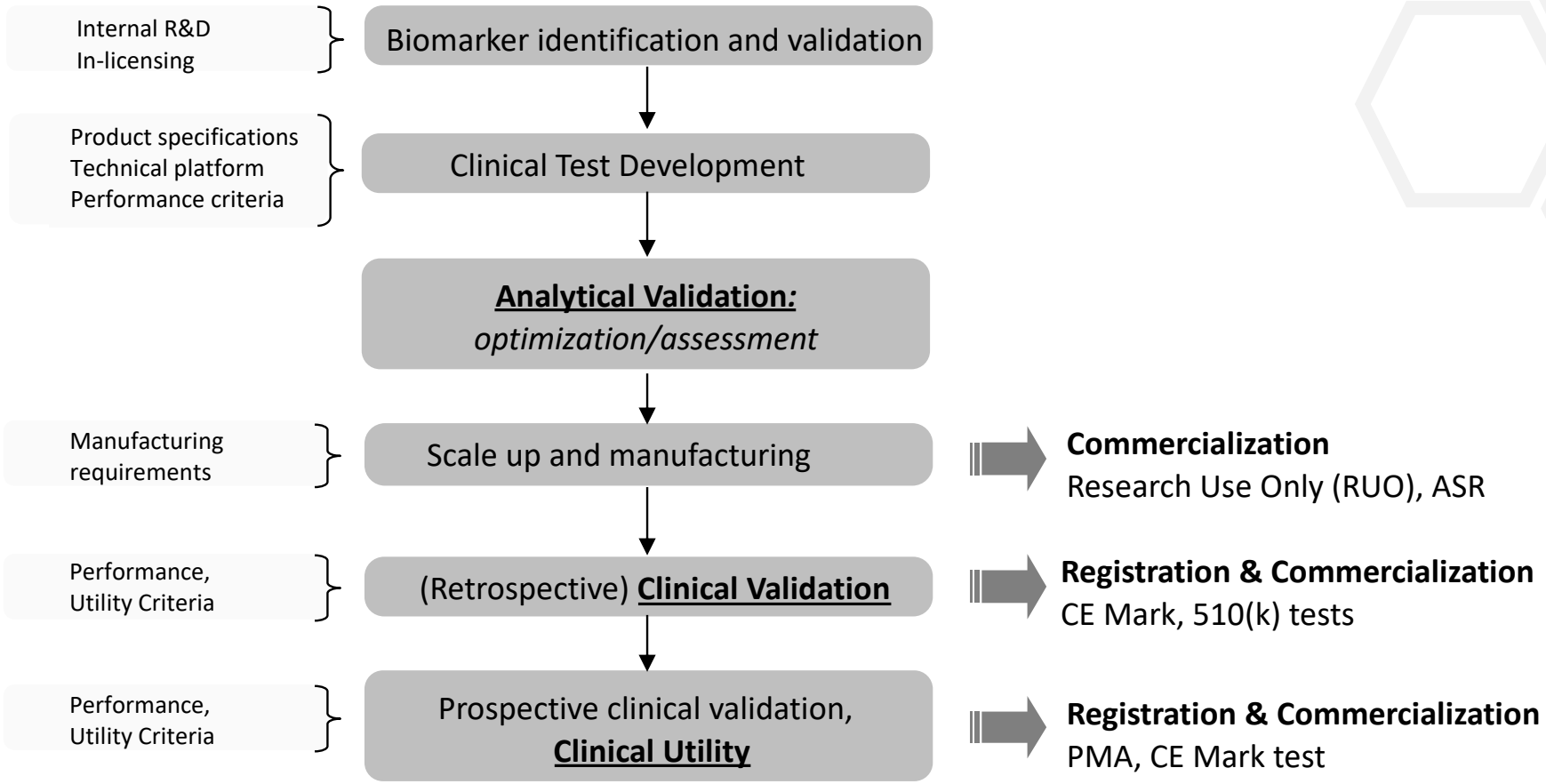


Figure 1.7

Porter's Five Forces Analysis Diagram

Figure 1.8

New Information = New Inventions Virtuous Cycle

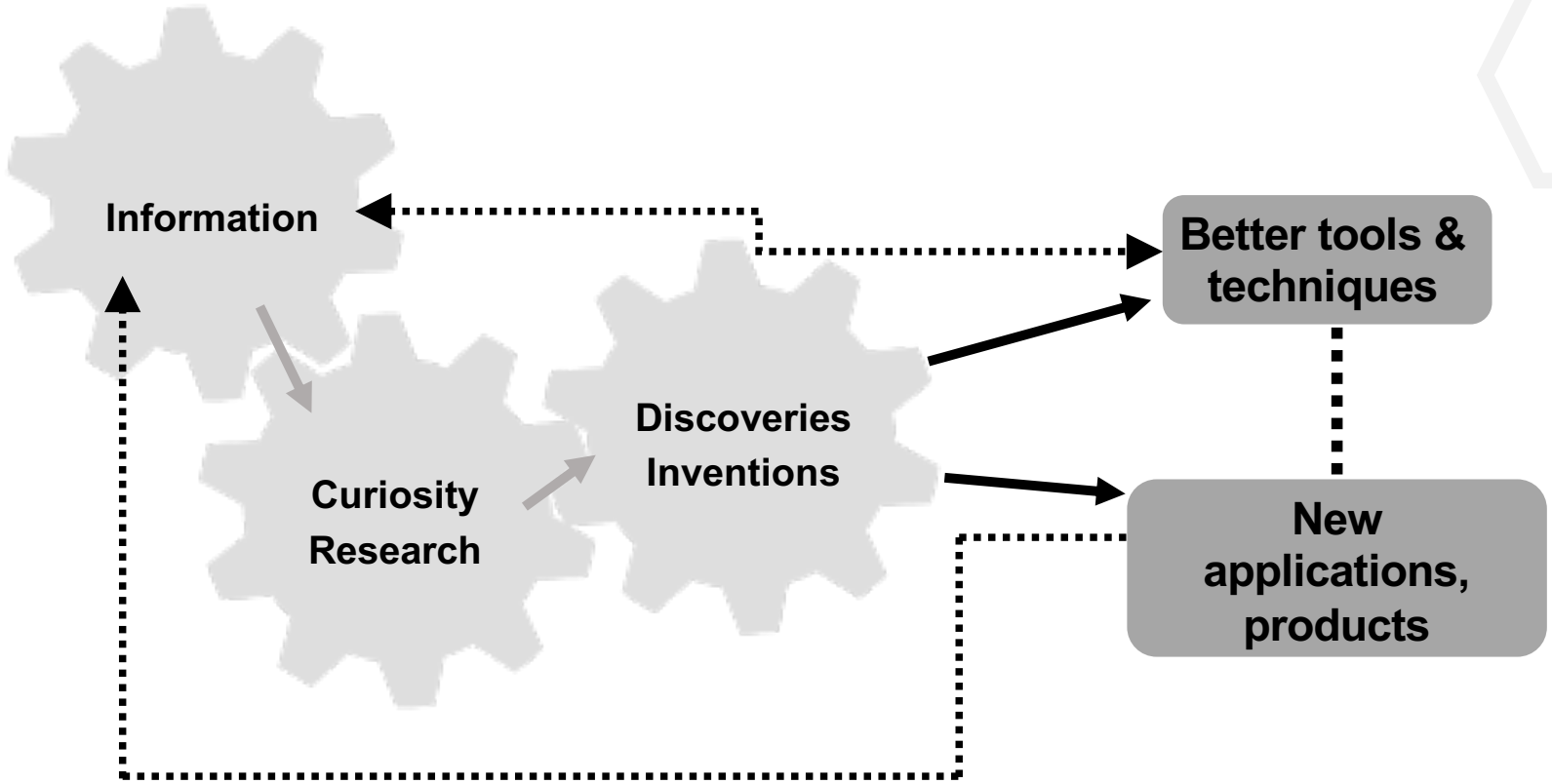
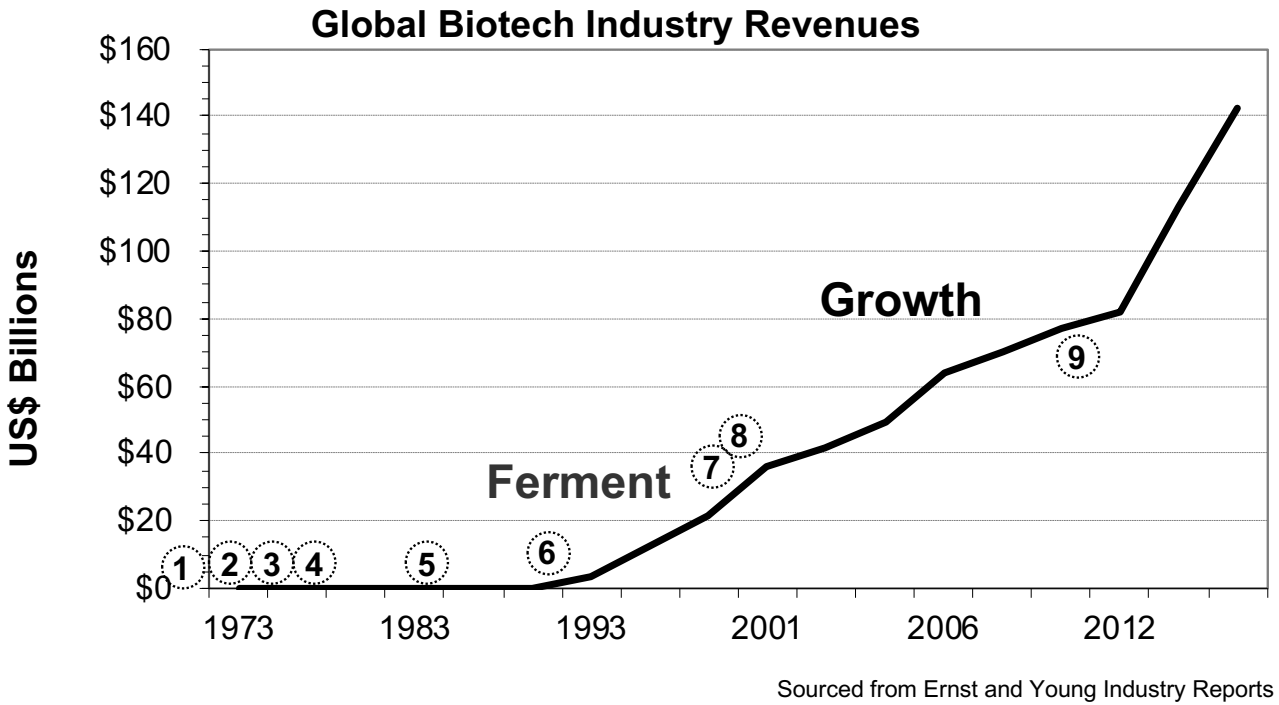


Figure 1.9

Biotech Industry Growth Milestones

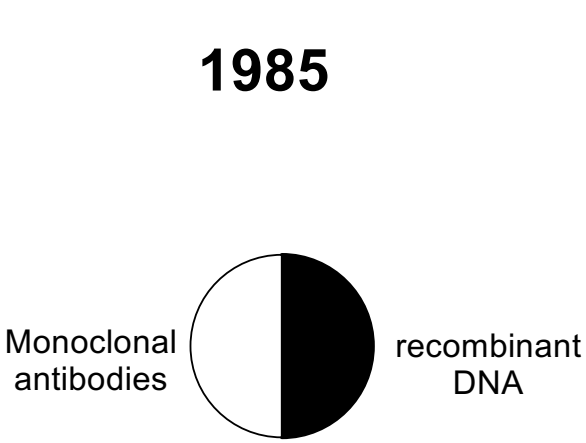


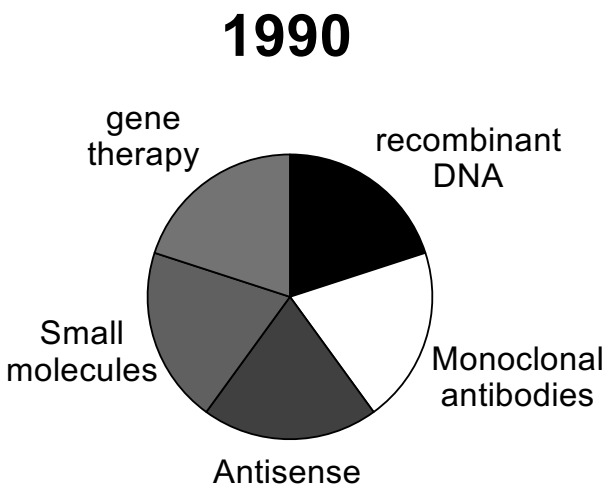
Sourced from Ernst and Young Industry Reports

Figure 1.10

#	KEY GROWTH STEPS FOR INDUSTRY
1	1953 - DNA structure solved Crick and Watson
2	1973 – Cohen and Boyer perfect recombinant DNA techniques 1975 – Kohler and Milstein produce mABs from hybridomas
3	1976 – Genentech founded – first commercial life sciences company
4	1980 – Diamond vs Chakrabarty – Supreme court case approves principle of patenting genetically modified organisms
5	1983 – PCR technique is developed
6	1990 – The International Human Genome Project is launched
7	1998 – RNA interference phenomenon published
8	2000 – Human Genome Project 1st draft completed – genomics and technology stock markets spike and fall.
9	2012 – Next generation sequencing, New therapeutic insights

Drug Development Technologies Complexity





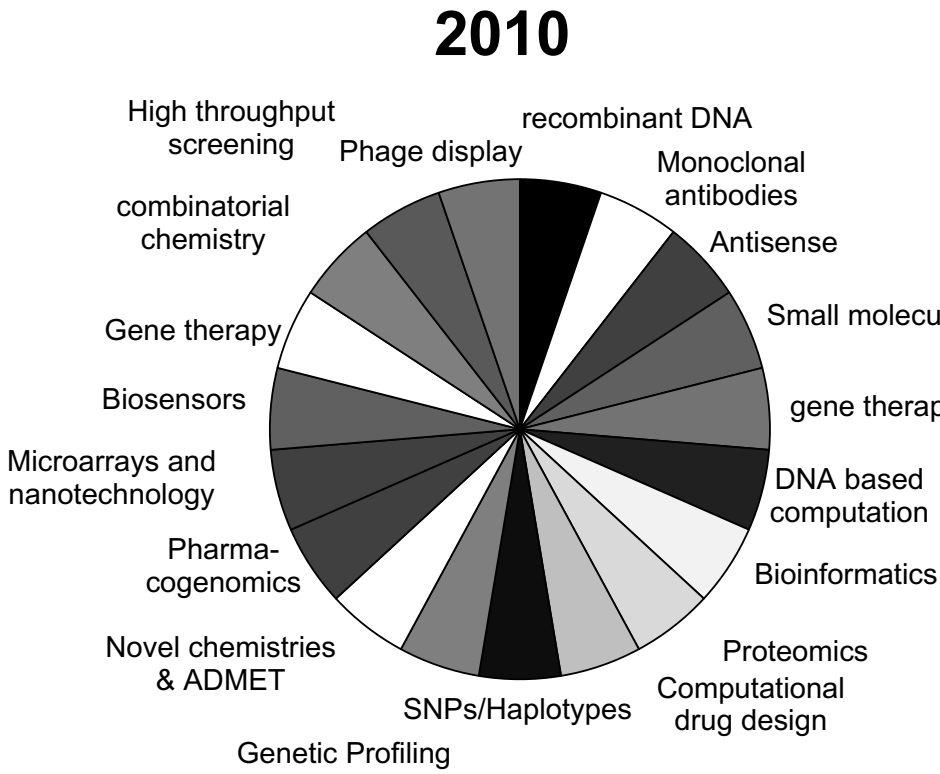
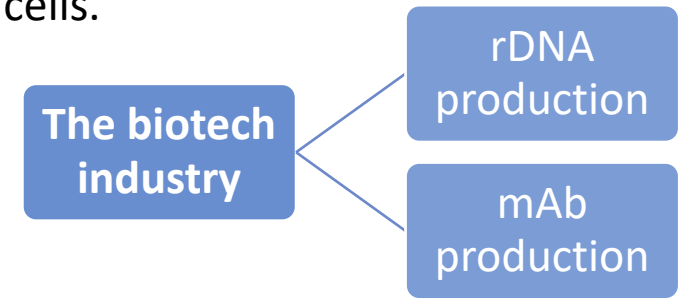


Figure 1.11

Drug development technology trends

- Technology has played an important part in drug development and discovery
- **Early drugs** : were derived as extracts from natural sources.
  - ✓ To synthesize these compounds using chemical synthesis methods : Medicinal chemists take some guidance from molecular modeling of drug–protein interactions

- **Biotechnology drugs (biologics)** : totally different methods of discovery, development, and production used for these new drugs
  - ✓ Biotechnology drugs: typically proteins that are enzymes or antibodies are produced using genetically engineered living cells.



Emerging technologies

- ✓ Stem cells
- ✓ Tissue engineering
- ✓ Gene therapy
- ✓ siRNA
- ✓ In silico biology

Advanced material technologies

- ✓ Nano-structured polymers
- ✓ Analytical life sciences instrumentation
- ✓ Biochips
- ✓ Membranes
- ✓ Bioreactor design
- ✓ Coatings
- ✓ Fine chemicals

Medical device and diagnostics technology trends

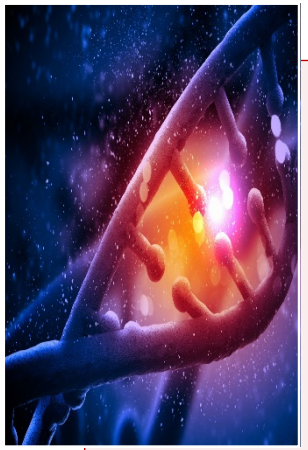
- **Medical products technologies:** Metallurgy, materials science, electronics and microelectronics, precision machining etc
- ***The general technology trend***
  - Increased miniaturization of devices over time
  - Rapidly advancing computing density
  - Sensing and processing now imbedded in a single device
  - Ubiquity of mobile computing platforms : *integration of the outside world with medical devices with concerns of privacy and security*
  - New materials that are biologically active
- Mixed types of materials and technologies :
  - ✓ Electronics and microfluidics
  - ✓ Cell-encapsulation
  - ✓ Metals with protein coatings,
  - ✓ Nanomaterials,
  - ✓ Bio-compatible electronic circuits that can flex,
  - ✓ Tissue-engineering scaffolding biodegradable materials that can also be printed.
- Three-dimensional printing
- Additional advances in materials and computing analytics: dramatic improvements in the neural computing interface
- Improved devices with computation to be increasingly integrated into our body function with minimal disruption and maximal benefit.

Emerging technologies and materials in the nucleic acid diagnostics field

Next-generation sequencing (NGS)

- New techniques for copying genetic material for increased sensitivity or speed of testing

- The first point of care rapid test for influenza A and B virus



Bio-chips and lab-on-a chip

-DNA, protein, glycosaccharides, and lipid array chips with multiple probes arrayed on a chip

- can provide large amounts of information from a single sample

- Microfluidic technology and micro-electromechanical system (MEMs) technologies have matured

Knowledge-Based Development

Technology and data convergence is leading to personalized medicine, with a more thorough predictive model of the entire physiology as the ultimate goal

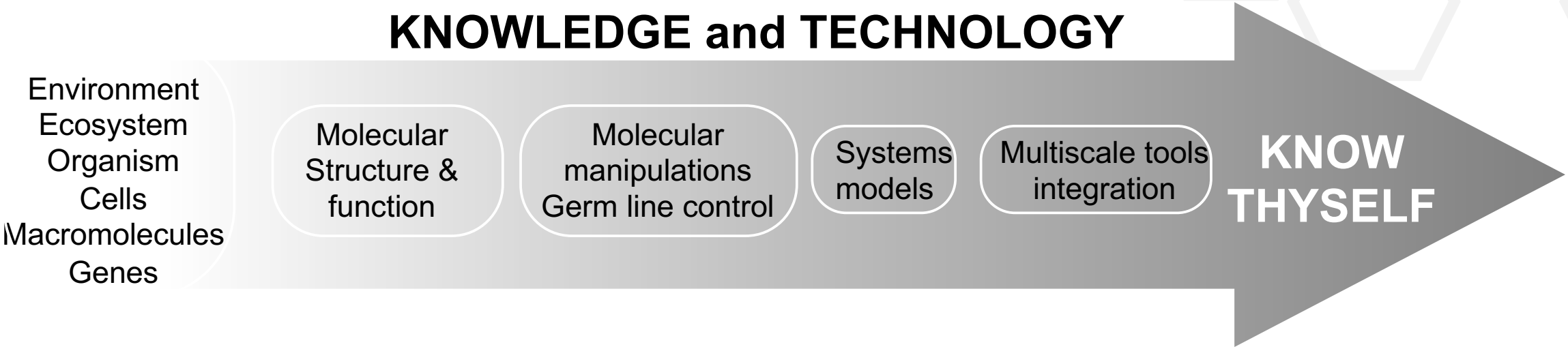


Figure 1.12 *Refer to text (section 1.8) for more details*

Many disciplines interact in biotechnology science and product development

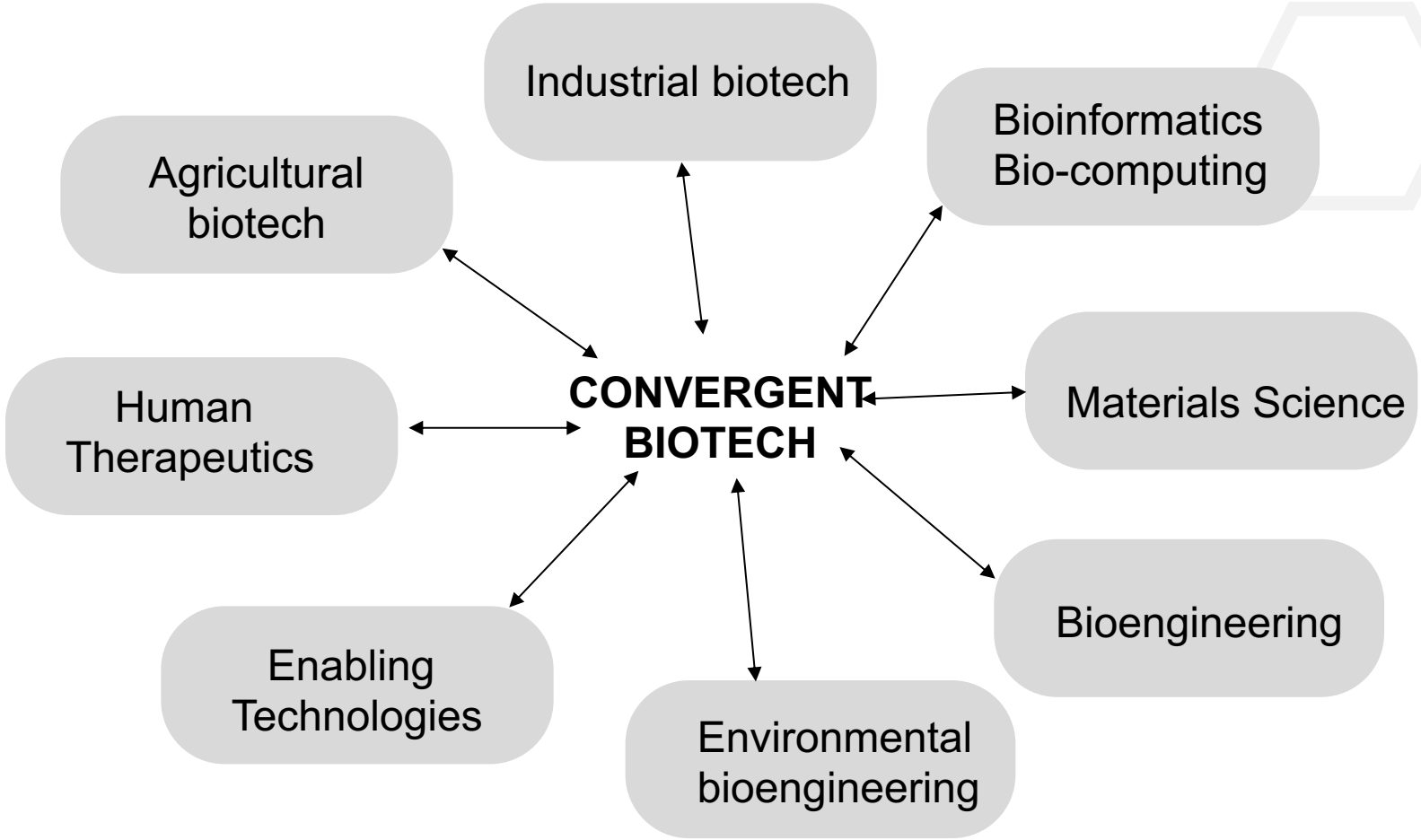


Figure 1.13

Breakthroughs Happen Where Diverse Technical Fields Intersect

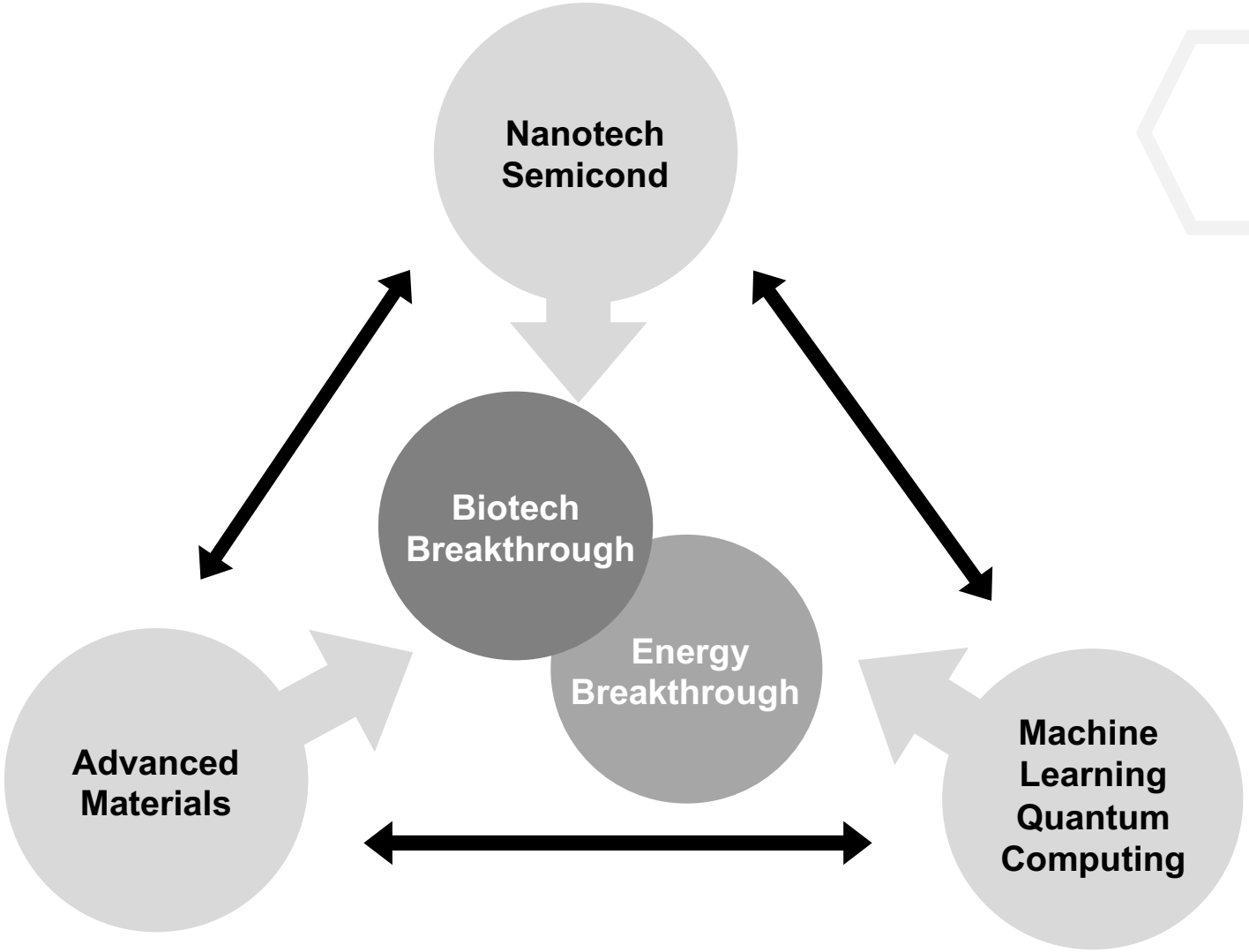
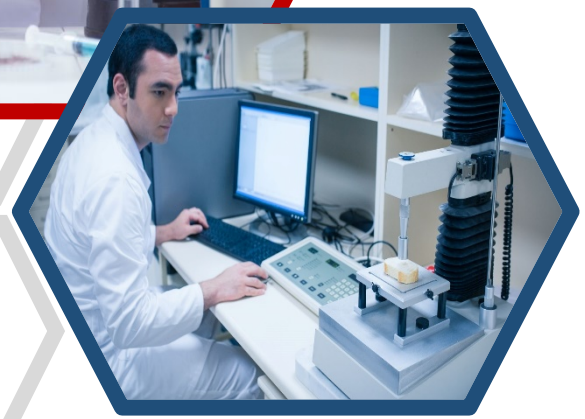


Figure 1.14



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Thank you…