

# Bio- and Nanotechnology: Emerging Medical Miracles on the Horizon

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# Today's Objectives

- Understand biotechnology and nanotechnology
- Describe the biotechnology market size
- Explain what fields are parts of the emerging business of life science
- List a number of new therapies resulting from bio and nanotechnology
- Discuss the implications of these new therapies on pharmacy and its technology partners

# Why is it Important?

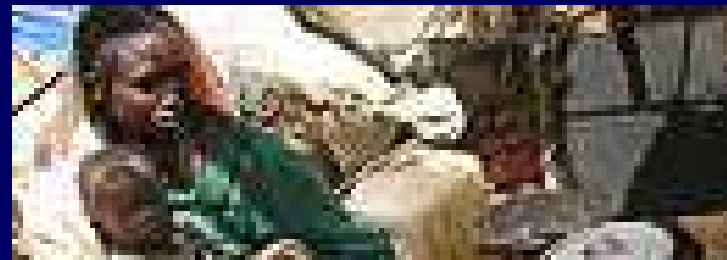


# Global Population Growth

- Earth's capacity is estimated at 12 billion people
- It took 100 million years before Earth had 1 billion people in 1830
- Yet only 170 years for the population to reach 6 billion plus
- 2005: 6,436,562,930
- 2016: 7,401,250,000
- 1/2 the people who have ever lived are on the planet today
- Less than 100 years before we reach capacity

# Biotechnology is needed to...

- Create better fuels that don't harm environment
- Create tools to clean environment, feed a burgeoning global population, cure untold human suffering



# Biotechnology Definition

- Use of cellular and biomolecular processes to solve problems or make useful products. Life sciences...biology/chemistry technology affecting discovery and development of products for:
  - Healthcare (therapeutics, diagnostics, drug delivery, cell and gene therapy, devices, drug/device combinations)
  - Agriculture (food, feed, fibers, transgenics)
  - Industrial and Environment (reduce pollution, clean energy)
- All driven by a new set of enabling technology (genomics, combinatorial chemistry, SNPs, proteomics, sequencing...)

The firsts.....

# Development is evolutionary...

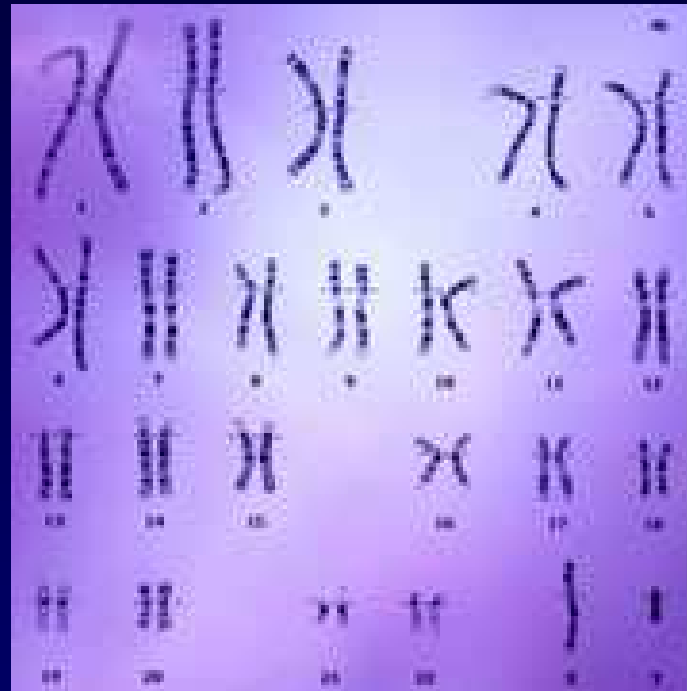
4000-2000 BC: biotech  
used to leaven bread &  
ferment beer

1830: Proteins discovered

1833: First enzyme  
discovered

1865: Genetic science  
begins-Mendel discovers  
laws of heredity

1879: Chromosomes  
discovered



# Development is evolutionary...

1906: The term genetics introduced

1919: The word biotechnology is first used in print

1938: The term molecular biology coined

1941: The term genetic engineering is first used



# Development is evolutionary...

1953: Watson and Crick DNA Structure

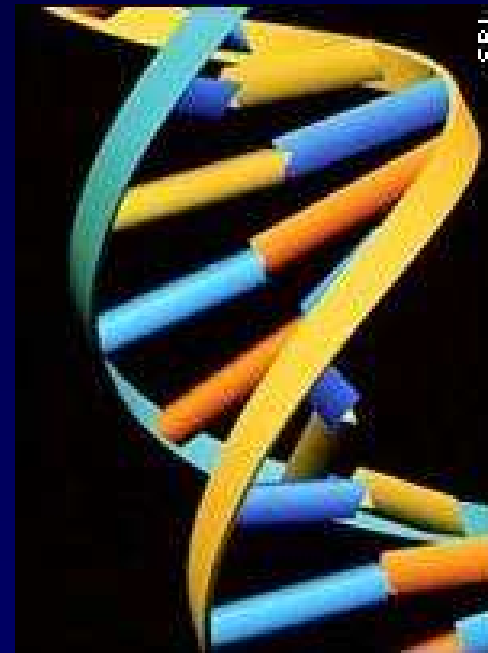
1958: DNA made in test tube  
Sickle cell caused by AA change

1960: Messenger RNA discovered

1967: First automatic protein sequencer is perfected

1969: Enzyme synthesized in vitro the first time

1970: First enzyme discovered to cut DNA molecules at a specific site



# Development is evolutionary...

1971: First complete synthesis of a gene

1973: First time DNA fragments linked

1975: First monoclonal antibodies made

1976: First NIH research guidelines

Boyer co-founds Genentech, 1<sup>st</sup> bio co.

1978: Recombinant insulin first produced

1980: Oil-eating microbes patented by Exxon

1982: First recombinant DNA vaccine for livestock

1983: First whole plant grown from biotechnology

# Development is evolutionary...

1980: First gene-synthesizers developed

1981: First transgenic animals

1982: First biotech drug: insulin

1983: First artificial chromosome synthesized

First genetic markers for inherited disease found



# Development is evolutionary...

1984: DNA fingerprinting developed

1985: Genetic fingerprinting entered  
as evidence in courtroom

1986: Interferon first anti-cancer drug  
from biotech

First genetically engineered vaccine  
for humans: Hepatitis B

Microbes used to clean oil spill



## ...but speeding up.

1988: First US patent for genetically altered animal—a transgenic mouse

1989: First DNA exoneration now 216 (4/08)

1990: First food product from biotech approved: modified yeast

1994: First FDA approval for first whole food product: FLAVRSAVR™ tomato

1997: First weed & insect resistant crops developed

First cloned animal: Hello Dolly!



## ...but speeding up.

1998: Human embryonic stem cells lines established

Herceptin approved-considered first pharmacogenomic (personalized) medicine

First complete animal genome: roundworm

2000: First complete map of a plant genome

First draft human genome

# ...but speeding up.

2004: First genetically modified pet: the GloFish

FDA clears genotyping test to aid in medication selection

First cloned pet, a kitten

2005: Skin cells converted to embryonic stem cells

1 billionth acre biotech seed planted

First complete dog genome: boxer

2006: FDA approves Gardasil-first vaccine for cancer-causing virus



## ...but speeding up.

2007: Successful reprogramming human skin cells to create cells indistinguishable from embryonic stem cells

Biotech cattle that cannot develop prions=no mad cow disease

2008: draft corn genome

10 disease bearing stem cell lines created

Mature human embryos created from adult skin cells: personalized stem cells for disease treatment

First synthetic genome: the road to creating life

First complete map of cancer patient genome

First US FDA application for gene-therapy/cancer





# 2005 and Today

- 2005: Biotechnology will transform industries, including health care
- Today: Biotechnology IS transforming industries
- Industrial convergence of farmers, doctors, drugmakers, chemical processors, computer and communication companies, energy companies and many others into the business of life science.
- Is revolutionizing healthcare and transforming economics of the Rx business. Will need to craft ways of dealing with industry's new economic landscape.



*A single herd of goats may soon replace a \$150 million drug factory...HBR 4/2000*

*2006: A Tryn approved for DVT*

# The Human Genome & Biotechnology

- “A milestone in biology unlike any other.”
- “We’ve called the human genome the book of life, but it’s really 3 books: It’s a history book. It’s a shop manual and parts list. And, it’s a textbook of medicine more profoundly detailed than ever.”

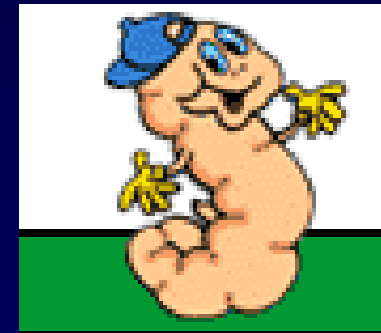
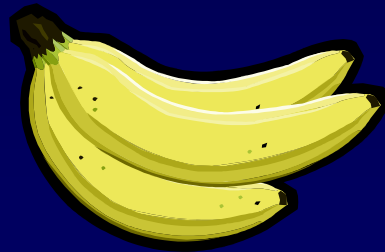
» --Francis Collins, former director NHRI director



- A short 50 years after the discovery of DNA by Watson and Crick in 1953
- A complete list of coded instructions to make a person
- Would fill a stack of paperbacks 200 feet high
- 50 years to type at 8 hours/day, 60 wpm

# The Human Genome: Fun Facts

- 30,000-40,000 genes not the 100-120,000 thought earlier
- Five times as many as in baker's yeast
- About twice as many as that needed to grow a worm or fly!
- Bananas share about 1/2 our genome while mice share 90%!



- BUT, each single human gene can make 10 proteins vs. a worm or fly's genes making just one or two.
- "We have the Cuisinart vs. the paring knife

--Francis Collins

- 5 million strands of DNA can fit through the eye of a needle



- All our DNA laid end to end would go to the sun and back 600 times!
- The genetic instructions for making a person take up less than 1" of the 6-ft long strand of DNA in each cell

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