



What is Biotechnology?

Micro 566 Microbial biotechnology

Presented by

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1.1 Defining Biotechnology

Biotechnology- the study and manipulation of living things or their component molecules, cells, tissues, or organs to improve living systems.



The beginning of biotechnology

- Humans have been manipulating living things for thousands of years
- **Selective breeding**- manipulating living things with desired characteristics
- Produces variety/diversity in living things

Beginning of Biotechnology



- Over 100 breeds of dogs created through selective breeding

Beginning of Biotechnology



- Different varieties of apples commonly found in grocery stores

Beginning of Biotechnology



- Range of size, color, and fragrance for a variety of roses

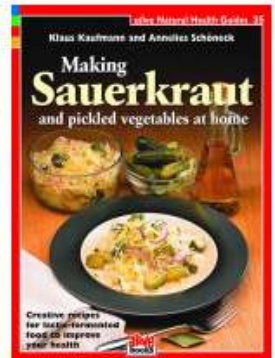
Beginning of Biotechnology



- Cows, goats, sheep, and chickens for milk, meat, and egg production

Beginning of Biotechnology

- Fermentation of foods and beverages





The 1970's

- Scientists have learned not just to manipulate whole organisms but also molecules, cells, tissues, and organs
- New technologies are applied to the research and development of products from plant and animal tissues
- The term “**Biotechnology**” was coined

Recent uses of biotechnology

- **Insulin-** made in bacteria cells to treat diabetes
- Originally insulin was harvested from the pancreas of a slaughtered animal for treatment



Recent uses of biotechnology

- **Proteases**- proteins that break down other proteins
- Commonly used in stain removal products



Recent uses of biotechnology

- **Antibiotics**- proteins developed by the immune system that recognize a specific molecule (antigen)
- Used to fight diseases

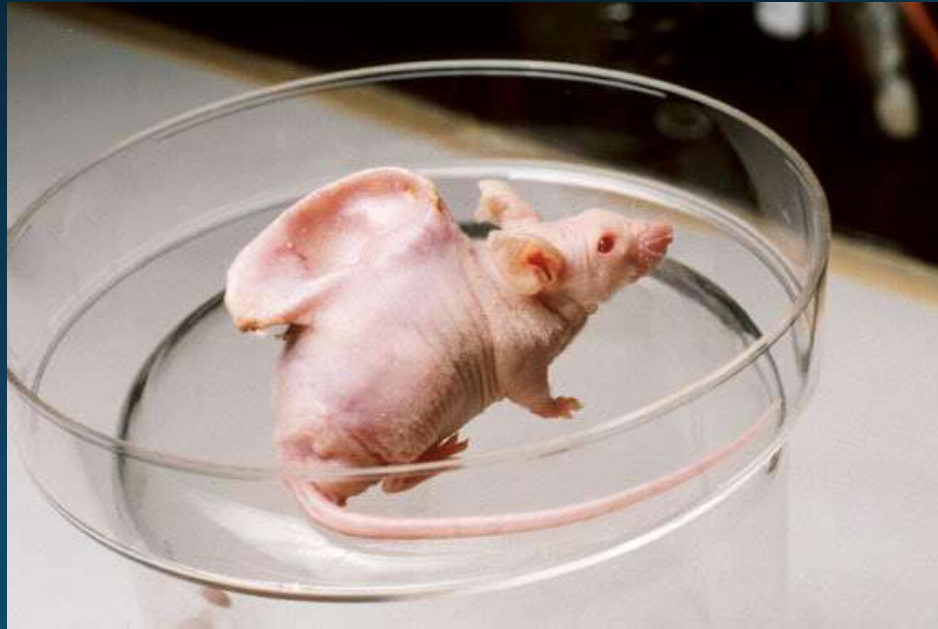


Recent uses of biotechnology

- **Indiage-** protein (enzyme) that causes denim to fade to produce “stonewashed” appearance

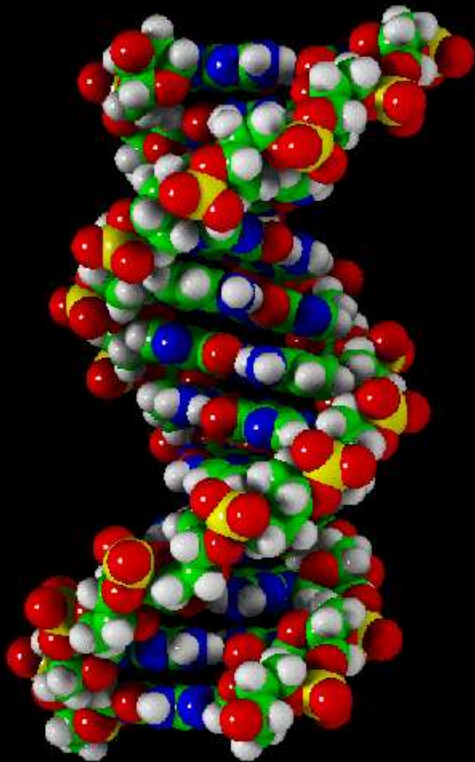


Recent uses of Biotechnology



- Mouse cells “tricked” into growing outer portion of a human ear which can be surgically transferred to a human patient

Biotechnology today



- Focuses on **DNA Deoxyribonucleic Acid**- a double-stranded helical molecule that stores genetic information for the production of all the organism's proteins

Techniques used to manipulate DNA

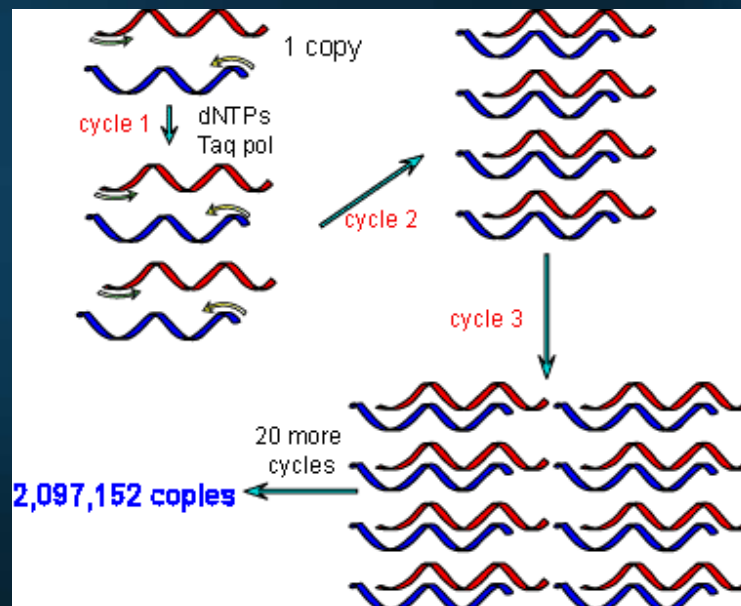
- Recombinant DNA (rDNA) technology-
cutting and recombining DNA
molecules



E. Coli transformation

Techniques used to manipulate DNA


- **Polymerase Chain Reaction (PCR)-** copying short pieces of DNA
- Amplifies DNA sample



Techniques used to manipulate DNA

- **Cloning**- producing identical organisms

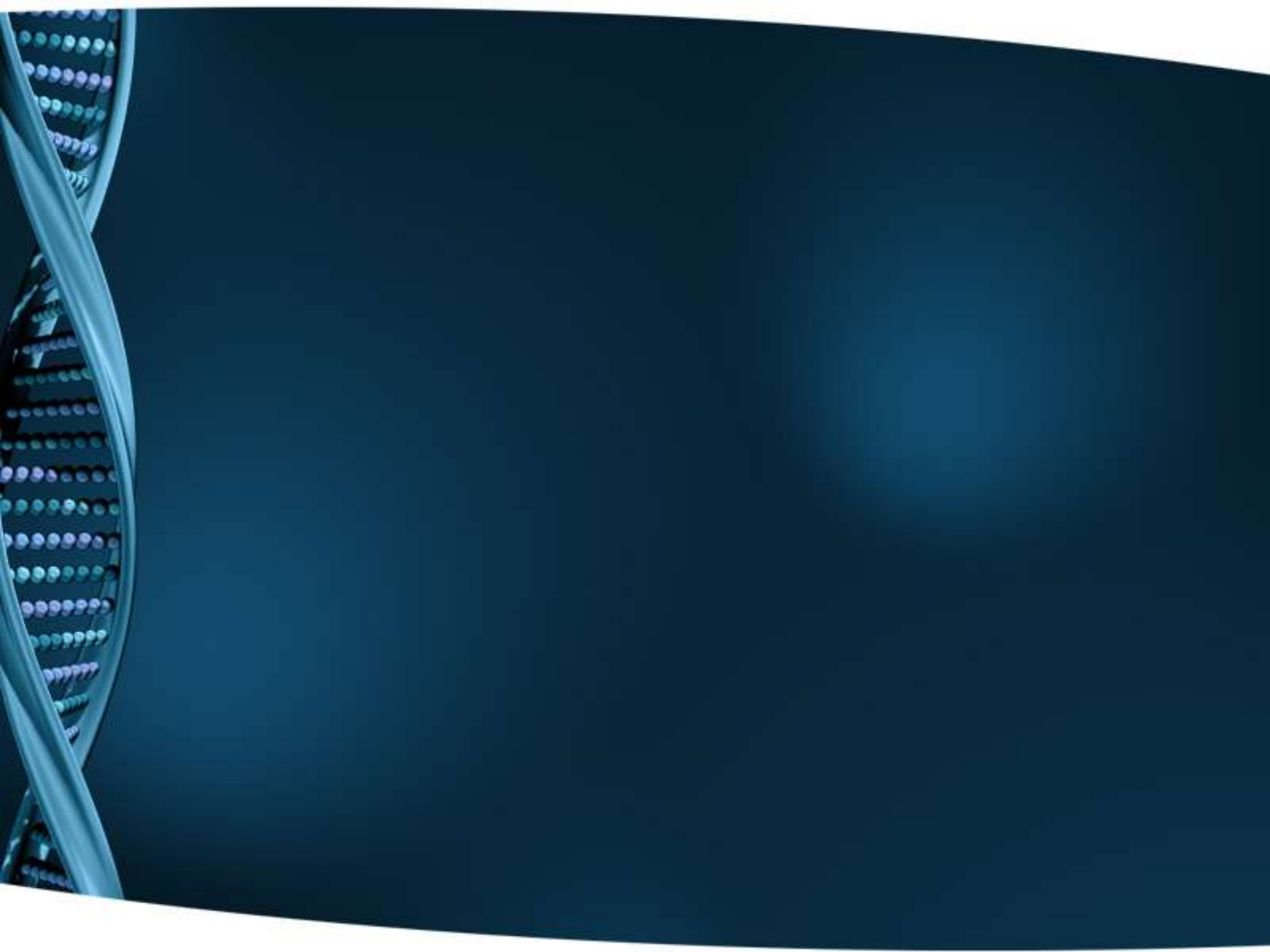





To manufacture biotechnology products, we must work with organisms and their components.

These are the “raw materials” of biotechnology.

**DNA → RNA → protein →
cell structure and function**





Biotechnology Workers and the Biotechnology Workplace

- **Biotechnology Companies** - goal is to produce and sell commercial “for-profit” products
 - Staff- **scientists, researchers, lab technicians, manufacturing, marketing, sales**
- **Universities and Government Labs** - conduct “pure science”, research
 - Report results in scientific journals or meetings for the “public good”



Industrial and Environmental Biotechnology

- fermented foods and beverages
- genetically engineered proteins for industry
- DNA identification/fingerprinting of endangered species
- biocatalysts
- biopolymers
- biosensors, bioterrorism, and biodefense
- bioremediation

Medical/Pharmaceutical Biotechnology

- medicines from plants, animals, fungi
- medicines from genetically engineered cells
- monoclonal and polyclonal antibodies
- vaccine and gene therapy
- prosthetics, artificial or engineered organs and tissues
- designer drugs and antibodies

Biotechnology
the manipulation of organisms or their parts

Agricultural Biotechnology

- breeding of livestock and plant crops
- aquaculture and marine biotechnology
- horticultural products
- asexual plant propagation and plant tissue culture
- transgenic plants and animals
- production of plant fibers
- pharmaceuticals in genetically engineered plant crops

Diagnostic Research Biotechnology

- DNA and protein synthesis
- DNA and protein sequencing, genomics, proteomics
- genetic testing and screening
- DNA identification and DNA fingerprinting, forensics
- bioinformatics, microarrays
- polymerase chain reaction (PCR)
- ELISA, Western Blots, protein identification, purification
- nanotechnology

Domains of Biotechnology.

- 1) industrial and environmental
- 2) medical/pharmaceutical
- 3) Agricultural



Government Agencies

- **CDC Centers for Disease Control and Prevention** -national research center for developing and applying disease prevention and control, environmental health, and health promotion and education activities to improve public health
- **NIH National Institutes of Health**- the federal agency that funds and conducts biomedical research



Review Questions

1. What is biotechnology?
2. Name a biotechnology product that has a medical use.
3. Besides biotechnology companies, where can biotechnologists work?
4. Biotechnology companies are grouped into four categories based on the products they make and sell. Name the four categories of products.



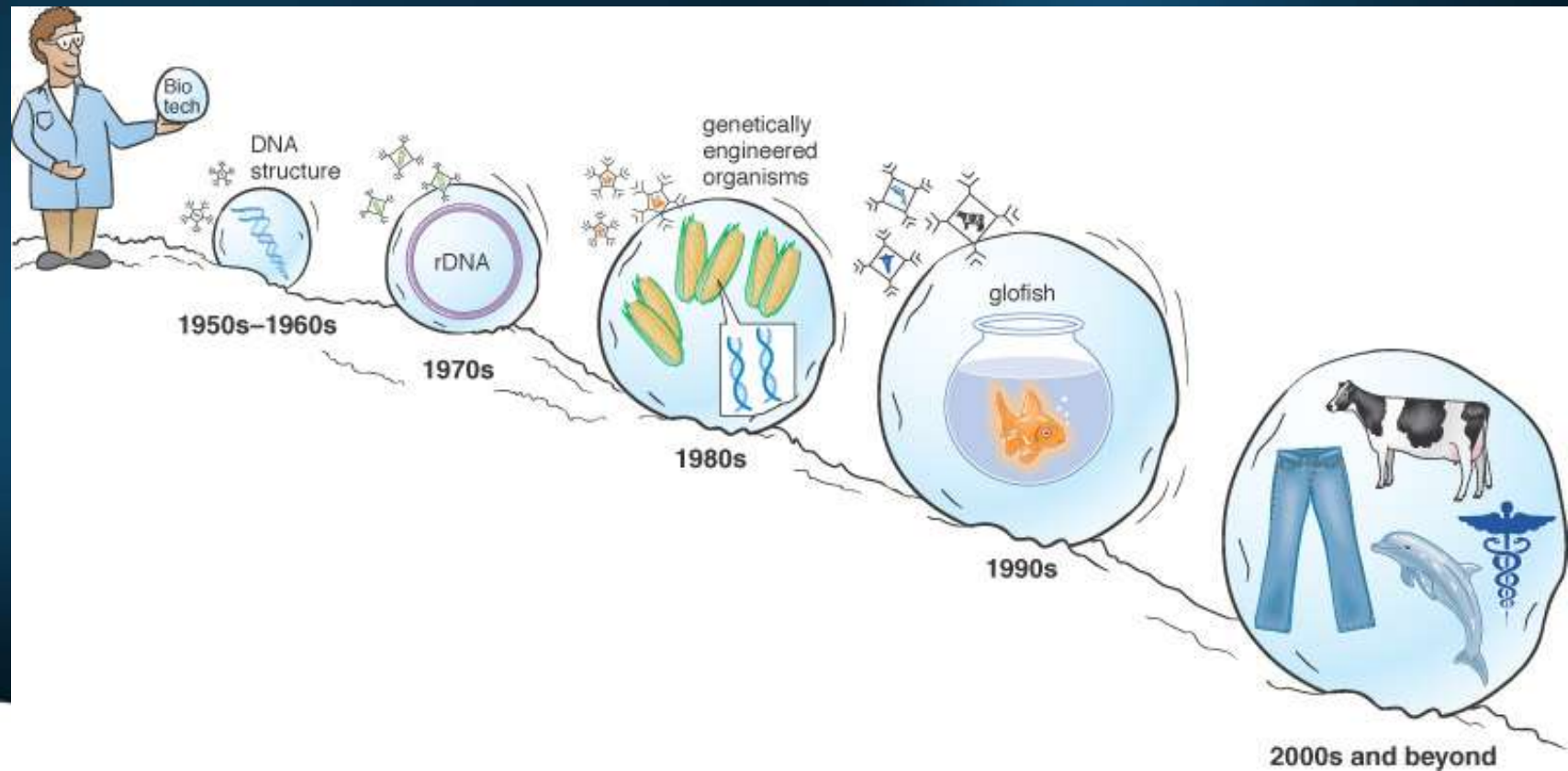
1.2 Biotechnology Products

“In the past 100 years, scientists have increased the pace of searching for products that improve the quality of life.”

- Antibiotics
- Industrial products such as rubber, turpentine, and maple syrup

Bioengineered Products

- As the methods of manipulating living things have become more sophisticated, the number and variety of biological products have increased at an incredible rate



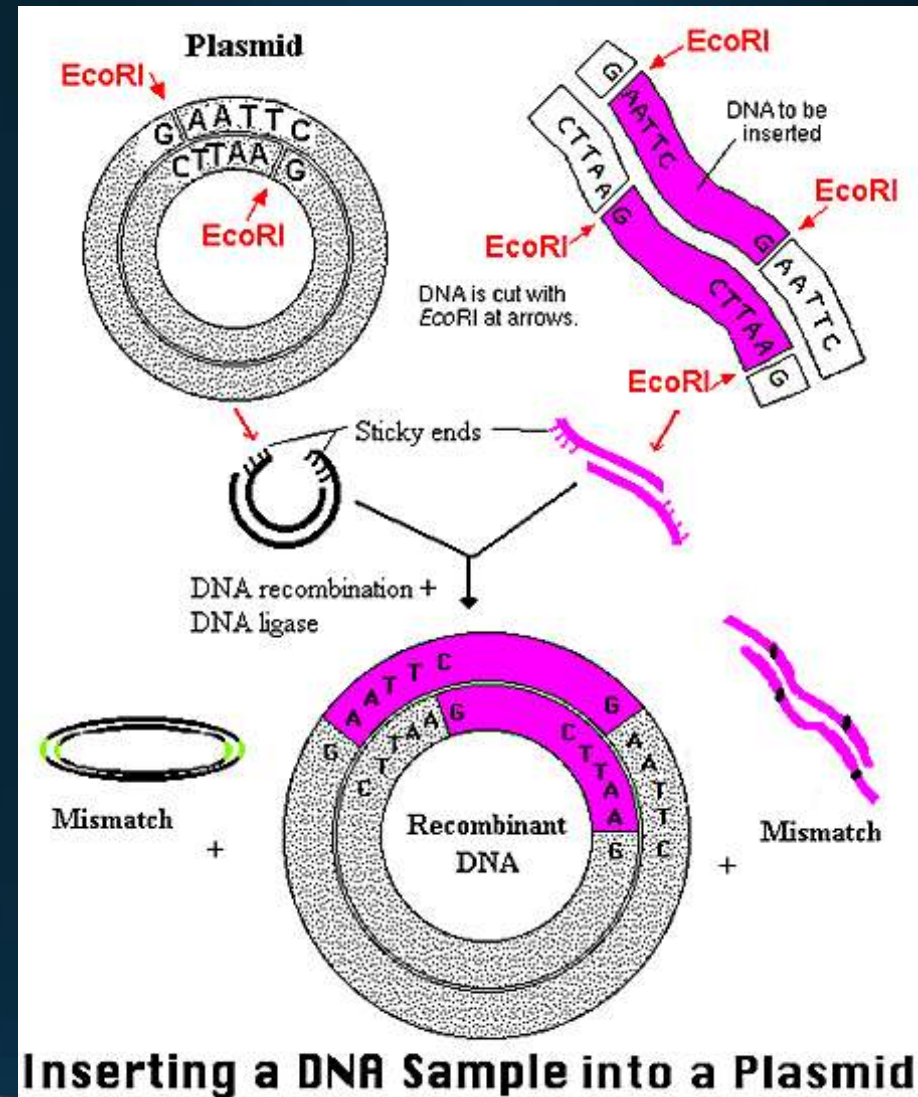


Techniques created in the 70's

- **Restriction enzymes** – cuts nucleotide sequence at specific sites on DNA molecule
- **DNA ligase** – enzyme that pastes DNA molecules together allowing for new combinations

Techniques created in the 70's

- **Plasmid** – tiny circular piece of DNA usually from bacteria that is used to insert recombinant DNA into an organism





Techniques created in the 70's

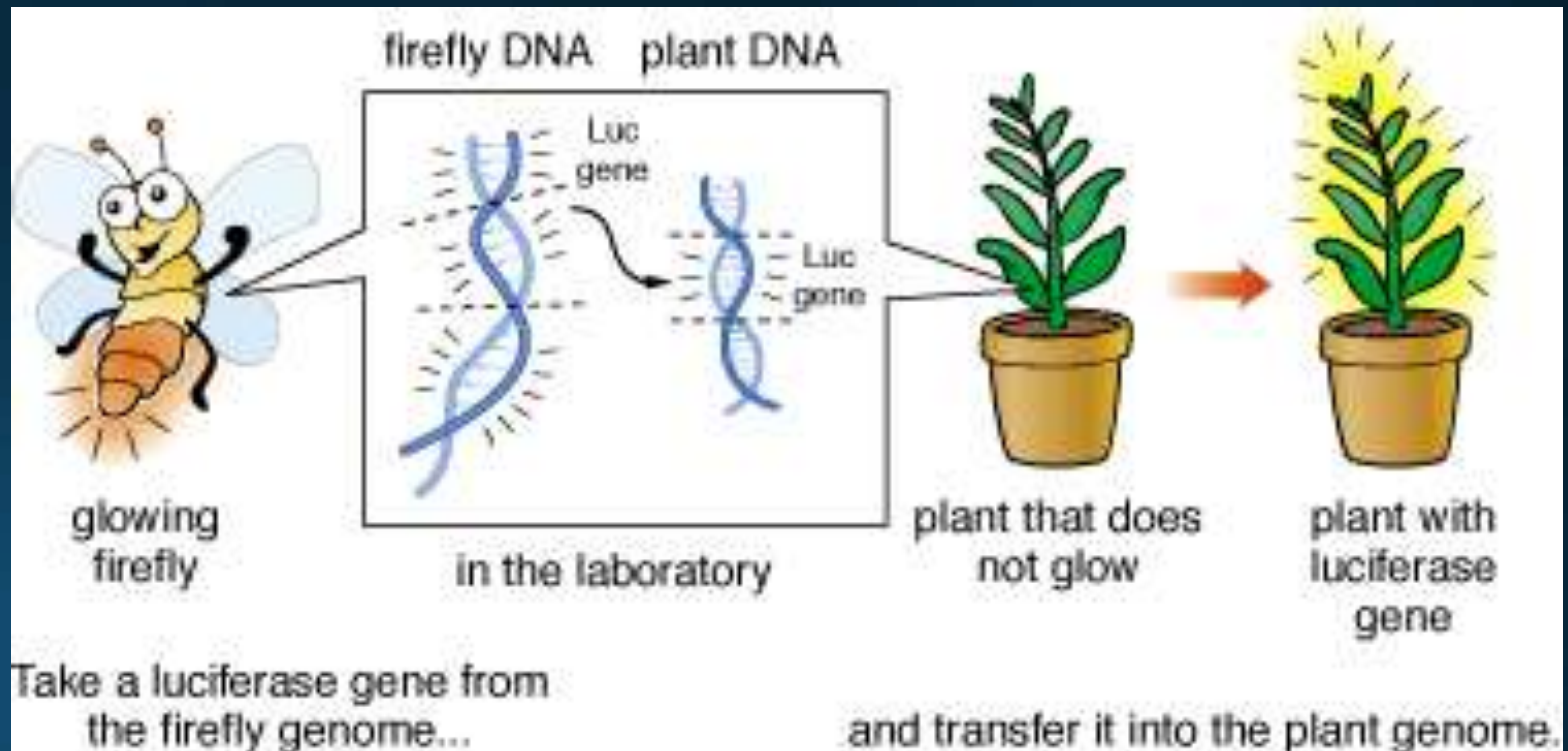
Restriction enzymes, DNA ligase, and plasmids
allows for

- ↓
- Recombinant DNA – DNA created from two or more sources

↓ leads to

- Genetically modified organism (GMO) – organism that contains DNA from another organism and produces new proteins encoded on the acquired DNA

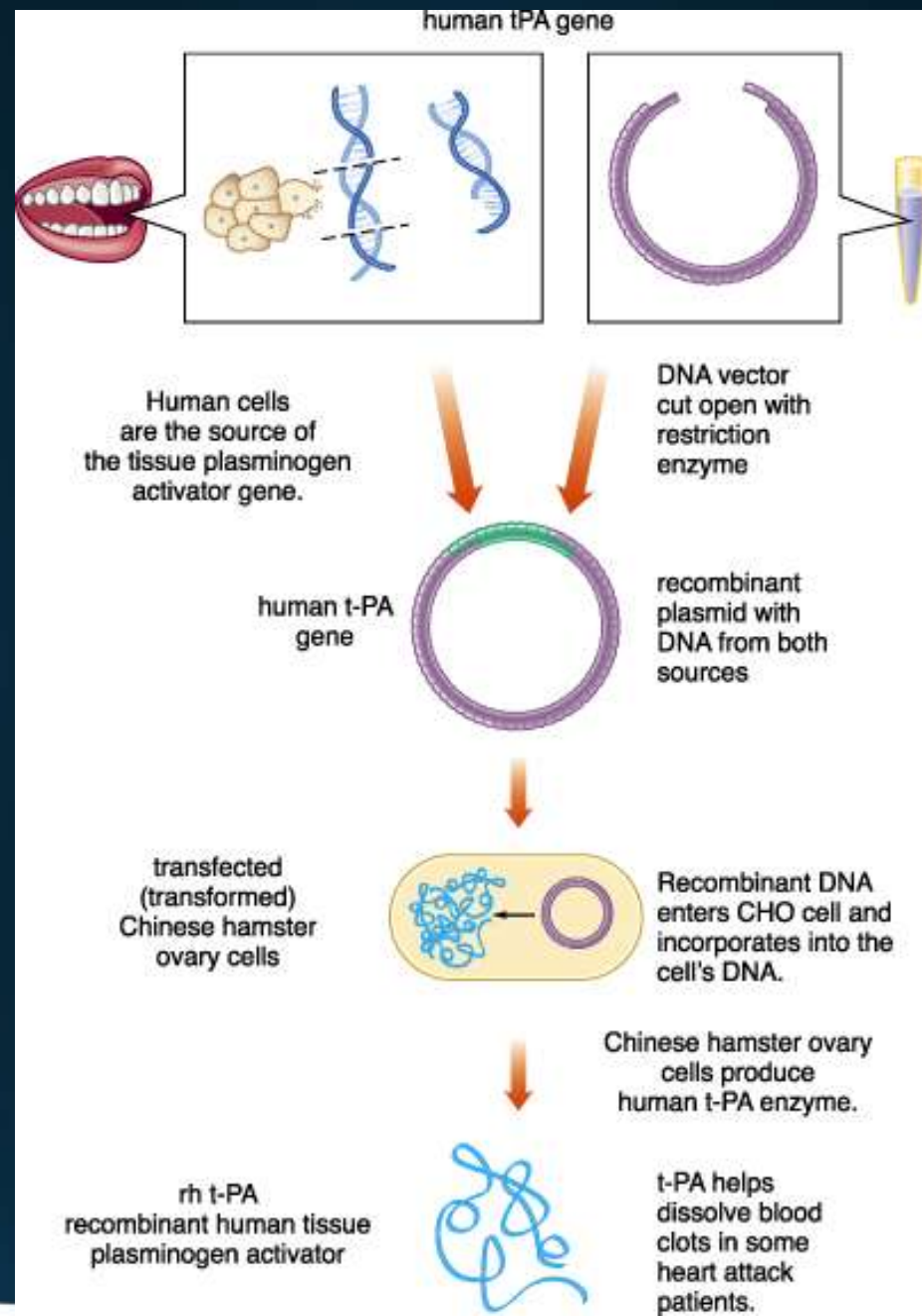
Examples of GMOs



Gene Engineered Plant. Scientists have learned how to insert genes that code for certain traits and transfer them from one species to another. The organism that gets the new genes will then have the potential to express the new traits coded in the newly acquired genes.

Examples of GMOs

Producing Genetically Engineered t-PA. Humans make only a small amount of human tissue plasminogen activator (t-PA) naturally. By genetically modifying Chinese hamster ovary (CHO) cells, scientists can make large amounts of t-PA for therapeutic purposes, such as to clear blood vessels in the event of a heart attack or stroke.



Examples of GMOs

- Recombinant DNA and genetic engineering produces 100's of products


Table 1.1. Biotechnology Products


Product	Application
Roundup Ready® Soybeans (Monsanto Canada, Inc)	herbicide-resistant soybeans
Alferon N® (Hemispherx® Biopharma, Inc)	drug used to treat genital warts
M-Pede™ (Mycogen Corporation)	herbicide that prevents powdery mildew on fruits and vegetables
nerve growth factor (NGF)	growth factor that stimulates nerve cell growth and reproduction
ABI High-Throughput DNA Synthesizer (Applied Biosystems, Inc)	instrument used to produce short DNA sequences
Purafect® protease (Genencor International, Inc)	protein-digesting enzyme
Posilac® bovine somatotropin (Monsanto, Inc)	growth hormone used in livestock
Thrombopoietin	blood-clotting agent
Bollgard® II cotton (Monsanto, Inc)	insect-resistant cotton
Anti-IgE monoclonal antibody	antibody that boosts the immune system
ABI Procise® sequencing system (Applied Biosystems, Inc)	instrument used to determine protein sequences
tissue plasminogen activator (t-PA); marketed as Activase® (Genentech, Inc)	enzyme that dissolves blood clots
Humulin® (Eli Lilly and Company)	drug used to treat diabetes
Sunup® papaya (Hawaii's Papaya Administrative Committee)	virus-resistant papaya
Recombivax® (Merck & Co. Inc)	vaccine for hepatitis B
Premise™ 75 (Bayer Corp)	termiticide (kills termites)
EPOGEN® (Amgen, Inc)	drug that produces red blood cells in anemic patients



The Human Genome Project

- Determined the human DNA sequence
- Scientists now work on:
 - Identifying all of the genes
 - Determining their functions
 - Understanding how and when genes are turned on and off

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1. The use of what kind of enzymes allows scientists to cut and paste pieces of DNA together to form recombinant DNA?
 2. Explain how making human tissue plasminogen activator (t-PA) in Chinese hamster ovary (CHO) cells is an example of genetic engineering.

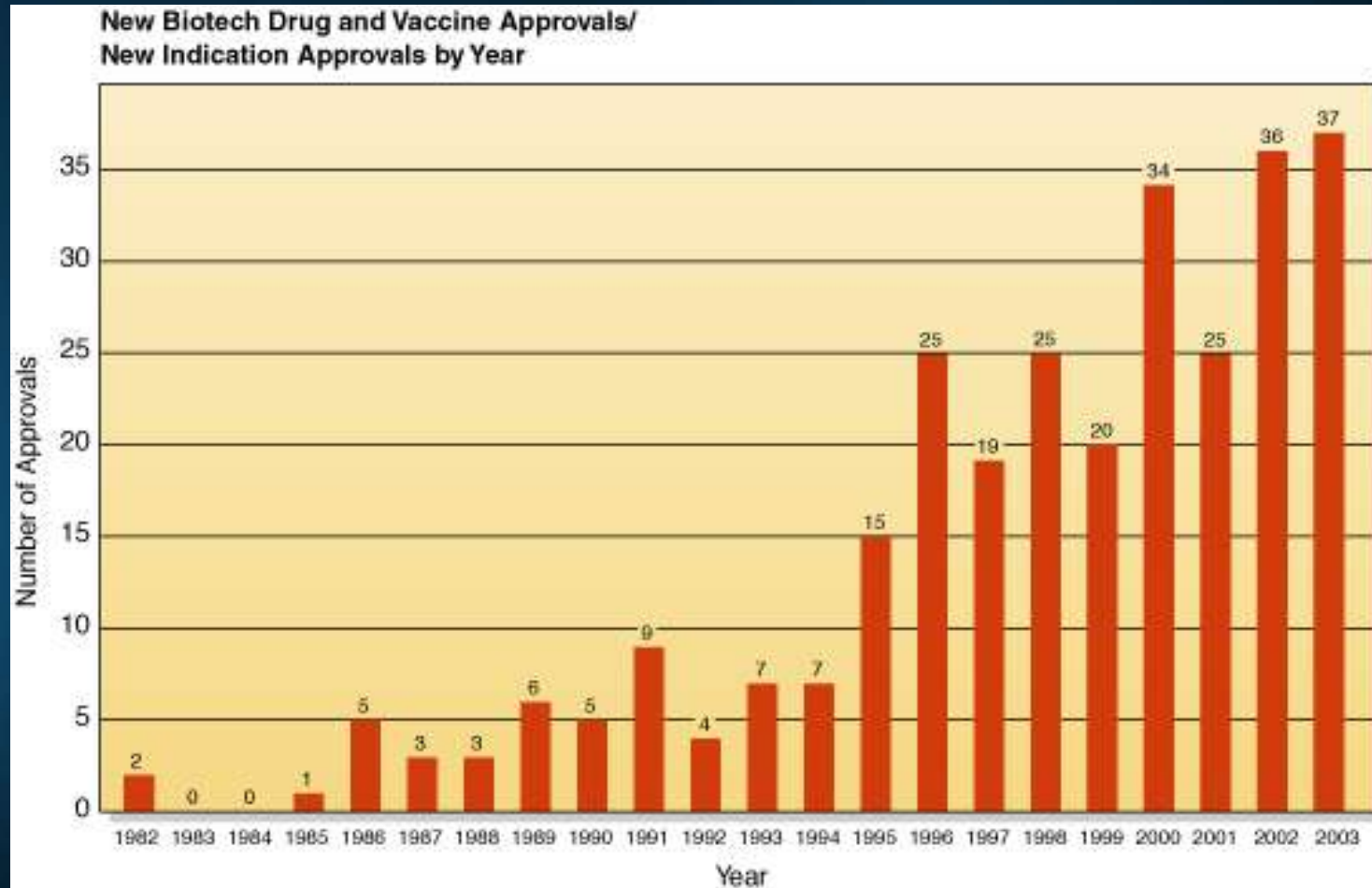


Federal agencies governing product development

1. **Food and Drug Administration (FDA)**- regulates the use and production of food, feed, food additives, veterinary drugs, human drugs, and medical devices
2. **Environmental Protection Agency (EPA)**- enforces environmental laws including the use and production of microorganisms, herbicides, pesticides, and genetically modified microorganisms
3. **United States Department of Agriculture (USDA)**- regulates the use and production of plants, plant products, plant tests, veterinary supplies and medications, and genetically modified plants and animals

Regulations Governing Product Development

New Biotech Drug Approvals. Even with all the government regulations, the number of new drugs approved for market increased nearly seven times in the 10 years between 1990 and 2000.



Source: BIO



H. Careers in the Biotechnology Industry

- One of the fastest growing commercial industries
- 7 out of 10 jobs posted with large companies are for laboratory technicians
- Industry will be studying DNA sequence for most of the 21st century



Academic Degrees and Job Titles



Postdoctorate 1 or more years of experience		Scientist
Doctorate 4–6 years after Bachelor's degree		Scientist
Master's Degree 1–3 years after Bachelor's degree		Research Associate
Bachelor's Degree 4 years of college		Research Associate
Certificate 1-2 years of community or career college		Biotechnician
High School Diploma pre-college training/experience		Lab Assistant



Categories of Biotechnology Jobs

- Scientific Positions
 - Research and Development
 - Manufacturing and Production
 - Clinical Research
 - Quality Control
- Nonscientific Positions
 - Information Systems
 - Marketing and Sales
 - Regulatory Affairs
 - Administration/Legal Affairs

The Innovation Crescent

- Georgia is ranked 7th in total number of life science companies in the country, and has seen a 140 percent growth in the life science industry since 1993. More than 250 life science companies call the Innovation Crescent home.





Schools

- Georgia has the 4th largest public university system in the nation, and the region ranks 7th in the nation in producing college and university graduates with a bachelor's degree or higher.




Schools


- Universities that offer Life Science Programs
 - **Clark Atlanta University**
 - **Mercer University**
 - **University of Georgia**
 - **Georgia Institute of Technology**
 - **Emory University**
 - **Georgia State University**
 - **Medical College of Georgia**
 - **Morehouse School of Medicine**
 - **Agnes Scott University**
 - **Clayton State University**
 - **Georgia Gwinnett College**
 - **Kennesaw State University**
 - **Oglethorpe University**



Schools

- Technical schools that offer certification in biosciences (33 in Georgia)
 - Georgia Bioscience Technical Institute (GTBI)
 - A partnership between:
 - Gwinnett Technical Institute
 - Athens Technical Institute
 - Video on [Biotechnology at GTBI](#)
 - Central Georgia Technical College
 - Lanier Technical College
 - Atlanta Technical College
 - Chattahoochee Technical College
 - DeKalb Technical College
 - North Metro Technical College

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1. For which types of biotechnology employees is there currently a large demand? What are the educational requirements for these types of employees?
 2. Scientific positions in most biotechnology companies fall into one of four categories. List them.
 3. Why might having laboratory experience be a benefit for a nonscientific employee at a biotechnology company?




Biotechnology with a Conscience - Bioethics

- How do we learn what is right and wrong behavior?
- As new situations arise in your life, how do you decide what is acceptable behavior and what is unacceptable?
- How do you decide what is fair and just?
- Read p. 27-28



Bioethics

- **Morals**- a person's beliefs of right and wrong
- **Ethics**- the study of moral standards and how they affect conduct
- New technologies generate ethical questions that cannot be answered using scientific methods.
- **Bioethics**- the study of decision-making as it applies to moral decisions that have to be made because of advances in biology, medicine, and technology



Strategy for Values Clarification

1. Identify and understand the problem or issue. Learn as much as possible about the issue.
2. List all possible solutions to the issue.
3. Identify the pros and cons of adopting each solution. Examine the consequences of adopting one solution (or position) as opposed to another. Consider legal, financial, medical, personal, social, and environmental aspects.
4. Based on the pros and cons for each solution, rank all solutions from best to worst.
5. Decide if the problem is important enough to take a position. If it is, decide what your position is and be prepared to describe and defend it.



Review Questions

1. Define the term “bioethics.”
2. Give an example of an event that might lead a lab employee to be faced with an ethical issue.
3. Describe how the Strategy for Values Clarification can be used to solve a problem such as the use of embryonic stem cells for basic research.



Biotechnology:
Something for everyone!