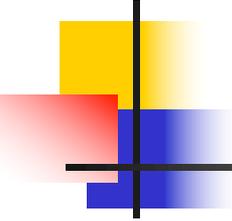


# 9.1 Manipulating DNA

## KEY CONCEPT

**Biotechnology relies on cutting DNA at specific places.**

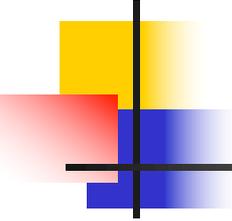




## 1.1 Defining Biotechnology

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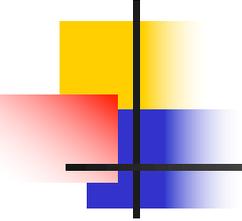
Biotechnology is defined as the study and manipulation of living things or their component molecules, cells, tissues, or organs.



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## Biotechnology Workers and the Biotechnology Workplace

- Biotechnology Companies - goal is to produce and sell commercial “for-profit” products
- Universities and Government Labs - conduct “pure science” research, nonprofit
- Growth in the Biotechnology Industry



## 1.2 The Increasing Variety of Biotechnology Products

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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.

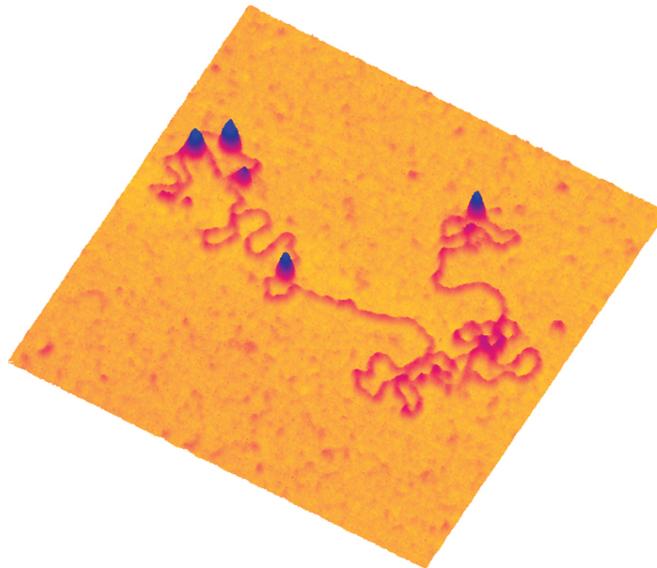
# 9.1 Manipulating DNA

- ▶ **Scientists use several techniques to manipulate DNA.**
  - Chemicals, computers, and bacteria are used to work with DNA.
  - Scientists use these tools in genetics research and biotechnology.

# 9.1 Manipulating DNA

## ▶ Restriction enzymes cut DNA.

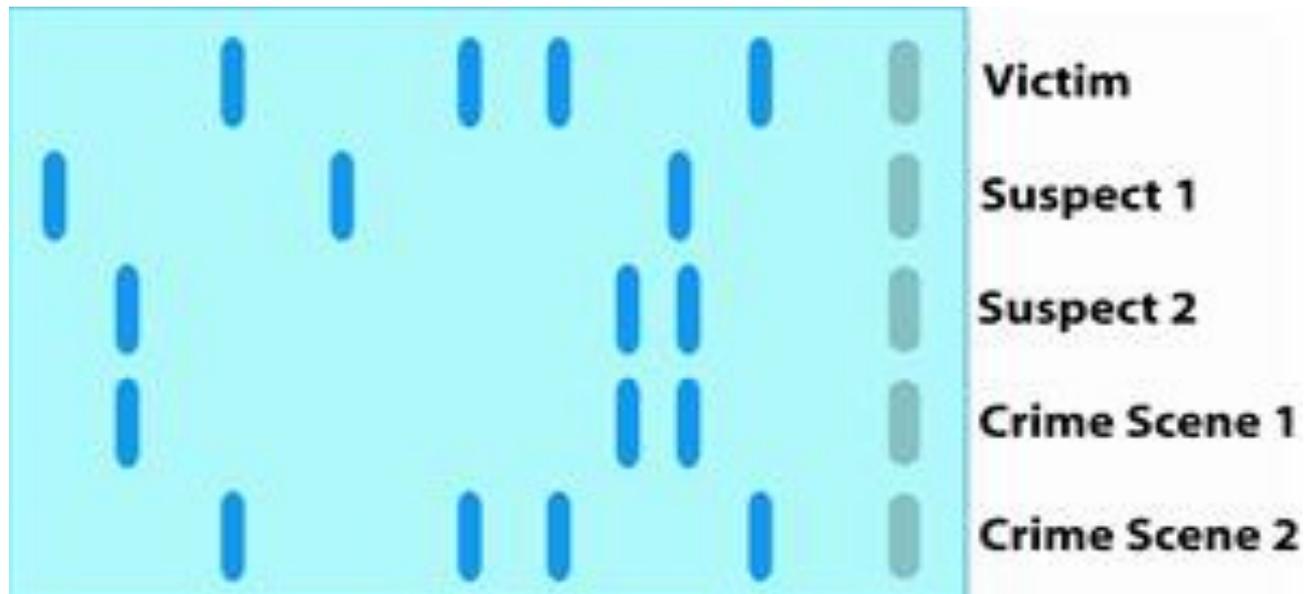
- Restriction enzymes act as “molecular scissors.”
  - come from various types of bacteria
  - allow scientists to more easily study and manipulate genes
  - cut DNA at a specific nucleotide sequence called a restriction site



# 9.1 Manipulating DNA

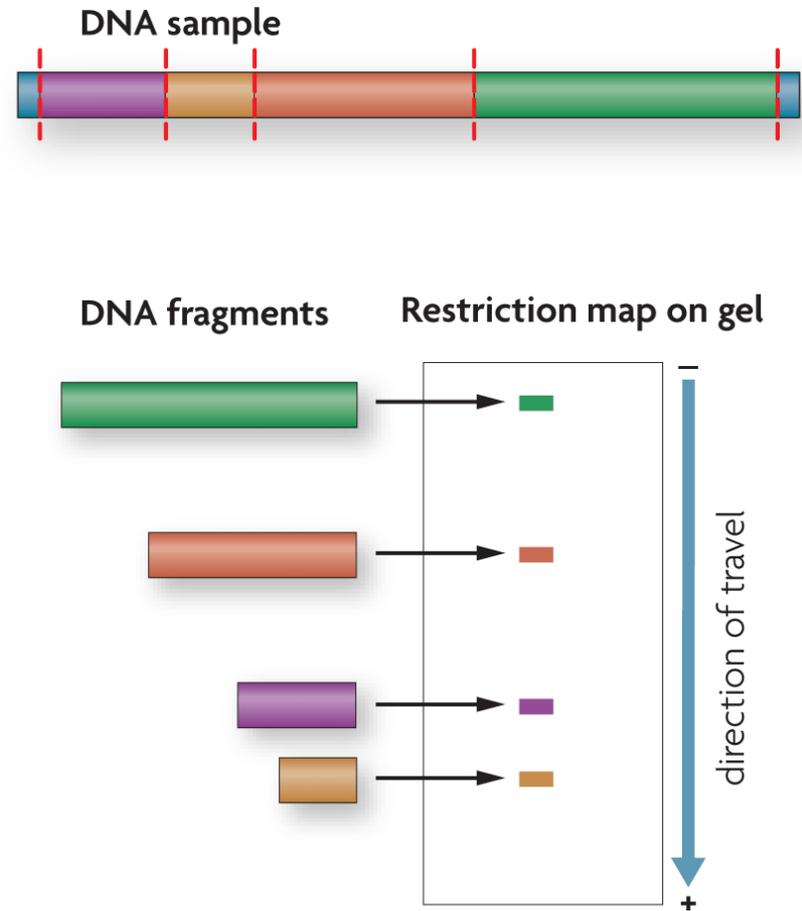
## ▶ Restriction maps show the lengths of DNA fragments.

- A **gel electrophoresis** is a process in which DNA is separated in a gel that is filled with holes as the negative DNA is attracted to the end of the electric current.
  - The **smaller** the strands, the **further** it moves down the gel



# 9.1 Manipulating DNA

- A restriction map shows the lengths of DNA fragments between restriction sites.
  - only indicate size, not DNA sequence
  - useful in genetic engineering
  - used to study mutations



## 9.2 Copying DNA

### KEY CONCEPT

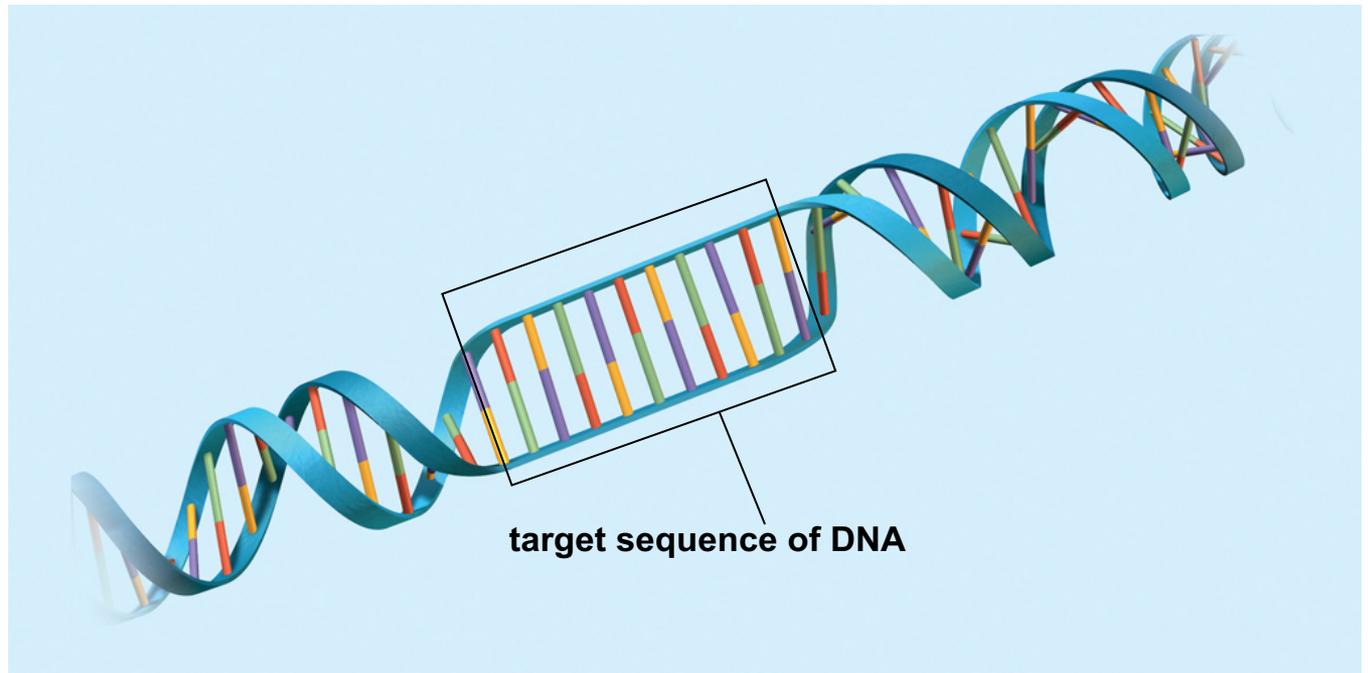
**The polymerase chain reaction rapidly copies segments of DNA.**



## 9.2 Copying DNA

### ▶ PCR uses polymerases to copy DNA segments.

- PCR makes many copies of a specific DNA sequence in a few hours.

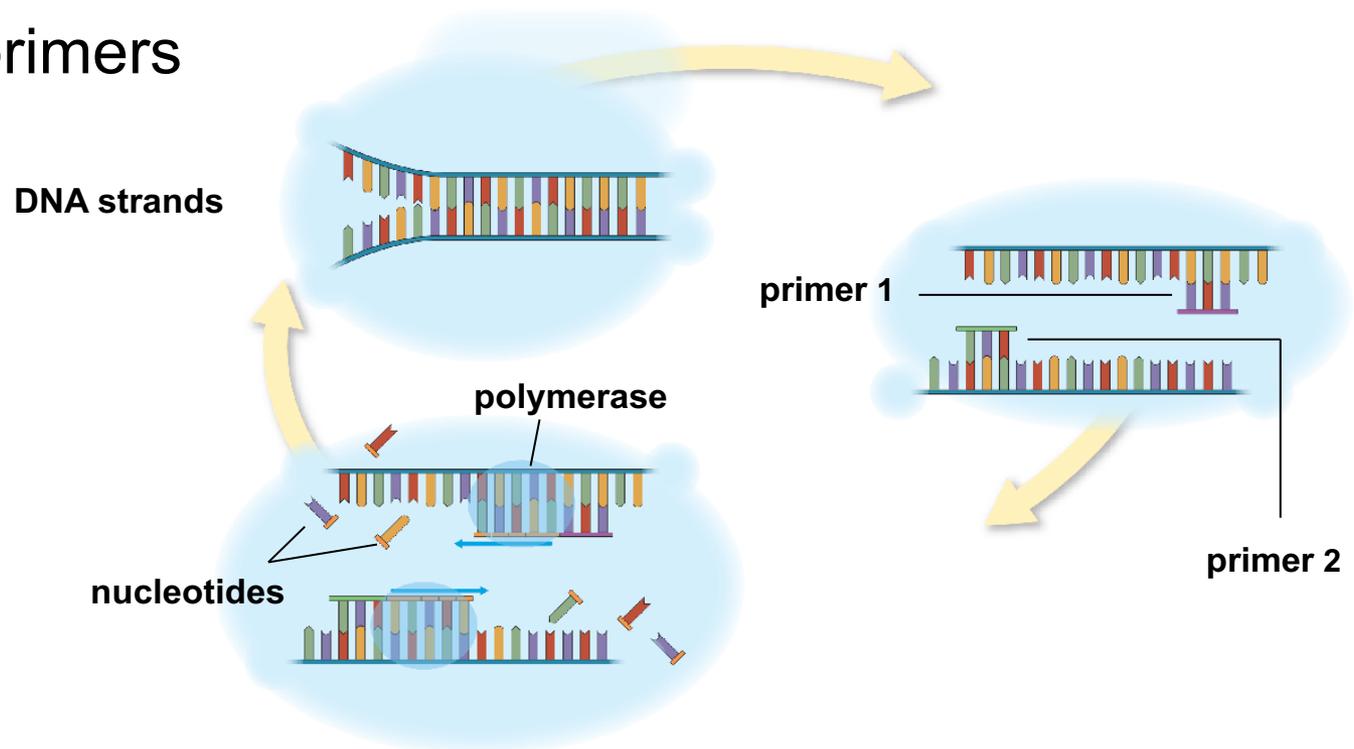


- PCR amplifies DNA samples.
- PCR is similar to DNA replication.

# 9.2 Copying DNA

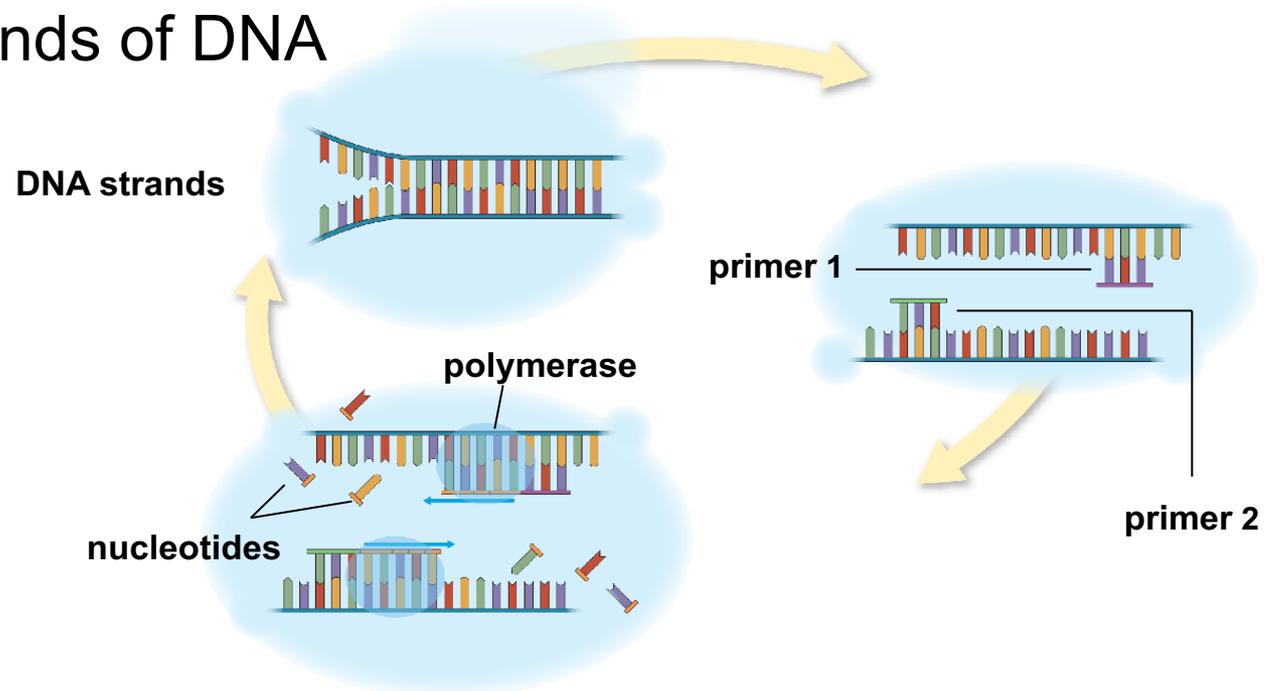
## ▶ PCR is a three-step process.

- PCR uses four materials.
  - DNA to be copied
  - DNA polymerase
  - A, T, C, and G nucleotides
  - two primers



## 9.2 Copying DNA

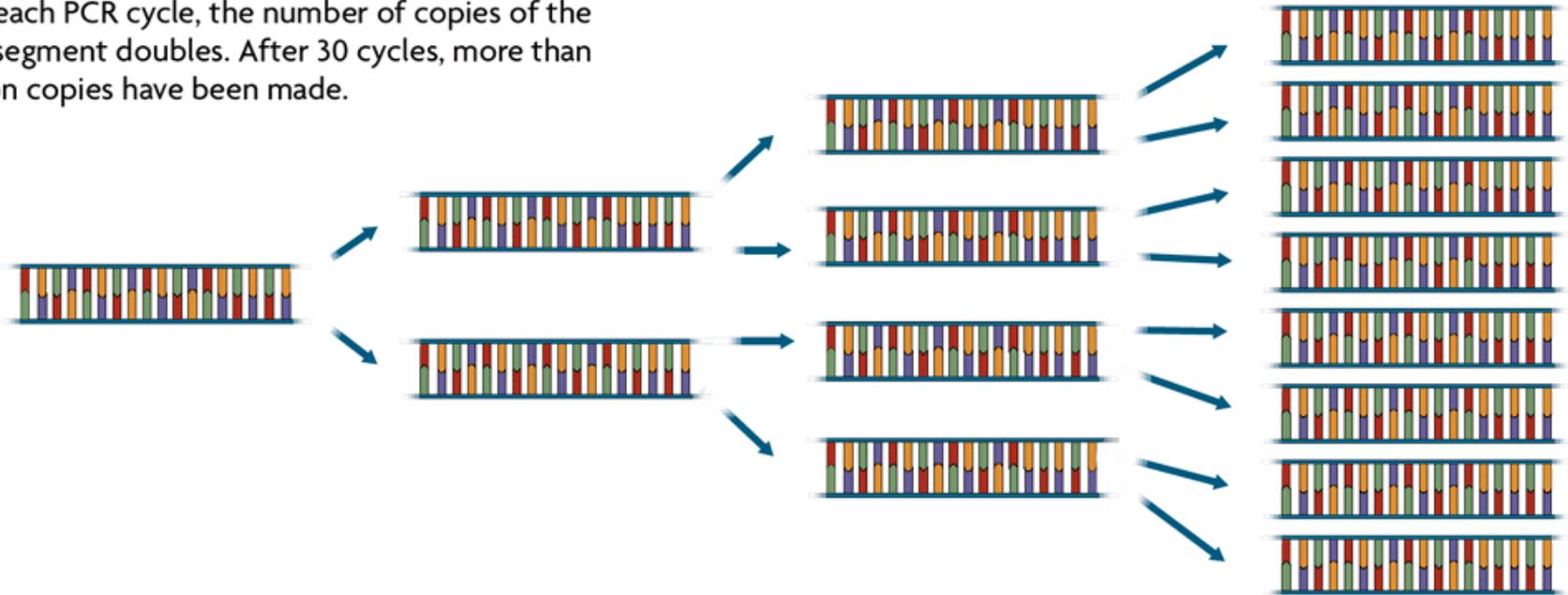
- The three steps of PCR occur in a cycle.
  - heat is used to separate double-stranded DNA molecules
  - primers bind to each DNA strand on opposite ends of the segment to be copied
  - DNA polymerase binds nucleotides together to form new strands of DNA



## 9.2 Copying DNA

- Each PCR cycle doubles the number of DNA molecules.

With each PCR cycle, the number of copies of the DNA segment doubles. After 30 cycles, more than 1 billion copies have been made.



## 9.3 DNA Fingerprinting

### KEY CONCEPT

**DNA fingerprints identify people at the molecular level.**

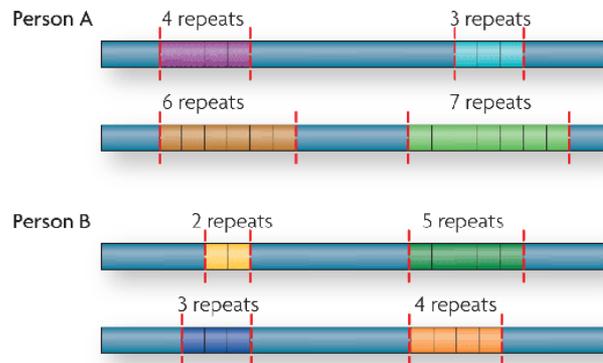


# 9.3 DNA Fingerprinting

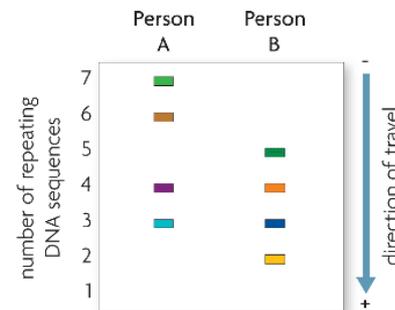
## ▶ A DNA fingerprint is a type of restriction map.

- DNA fingerprints are based on parts of an individual's DNA that can be used for identification.
  - based on noncoding regions of DNA
  - noncoding regions have repeating DNA sequences
  - number of repeats differs between people
  - banding pattern on a gel is a DNA fingerprint

This DNA sequence of 33 base pairs can be repeated many times in a sample of a person's DNA.



--- = restriction site



# 9.3 DNA Fingerprinting

## ▶ DNA fingerprinting is used for identification.

- DNA fingerprinting depends on the probability of a match.
  - Many people have the same number of repeats in a certain region of DNA.
  - The probability that two people share identical numbers of repeats in several locations is very small.



## 9.3 DNA Fingerprinting

- Individual probabilities are multiplied to find the overall probability of two DNA fingerprints randomly matching.

$$\frac{1}{500} \times \frac{1}{90} \times \frac{1}{120} = \frac{1}{5,400,000} = \text{1 chance in 5.4 million people}$$

- Several regions of DNA are used to make DNA fingerprints.



# 9.3 DNA Fingerprinting

- DNA fingerprinting is used in several ways.
  - evidence in criminal cases
  - paternity tests
  - immigration requests
  - studying biodiversity
  - tracking genetically modified crops



# 9.4 Genetic Engineering

## KEY CONCEPT

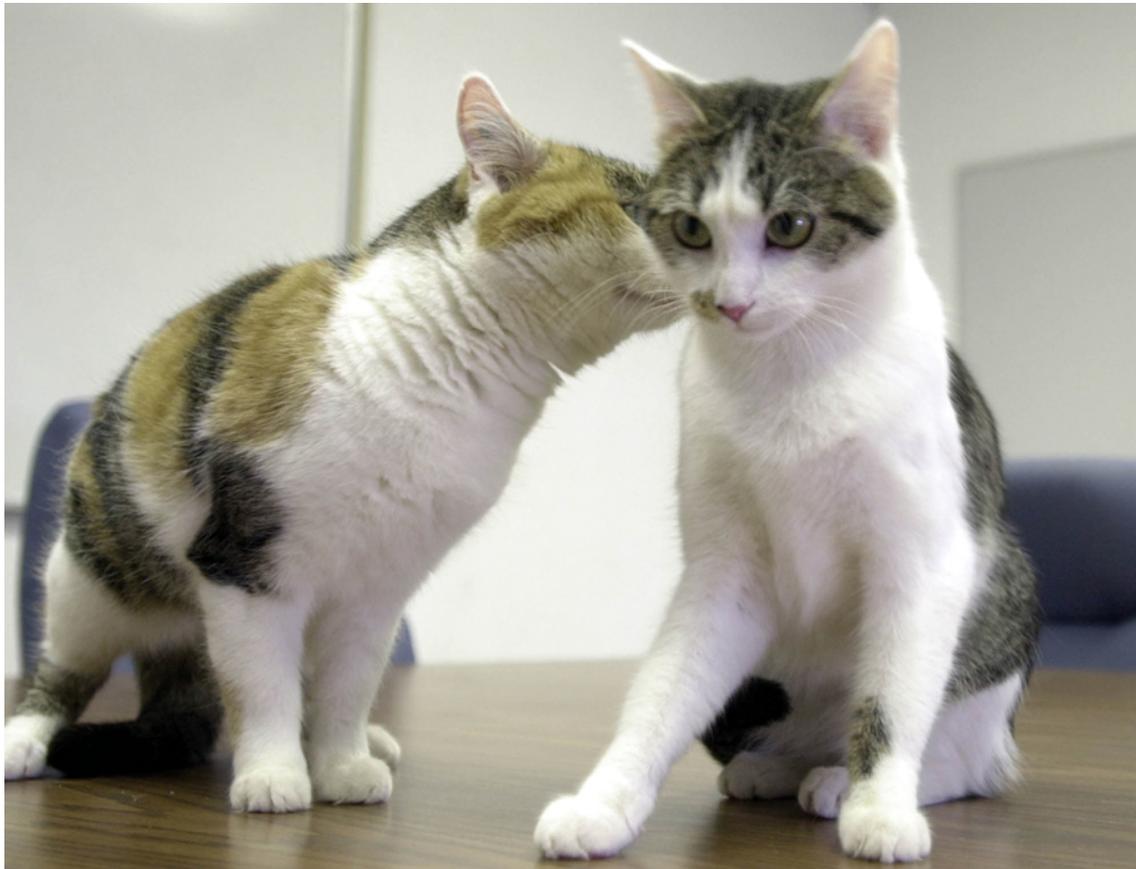
**DNA sequences of organisms can be changed.**



## 9.4 Genetic Engineering

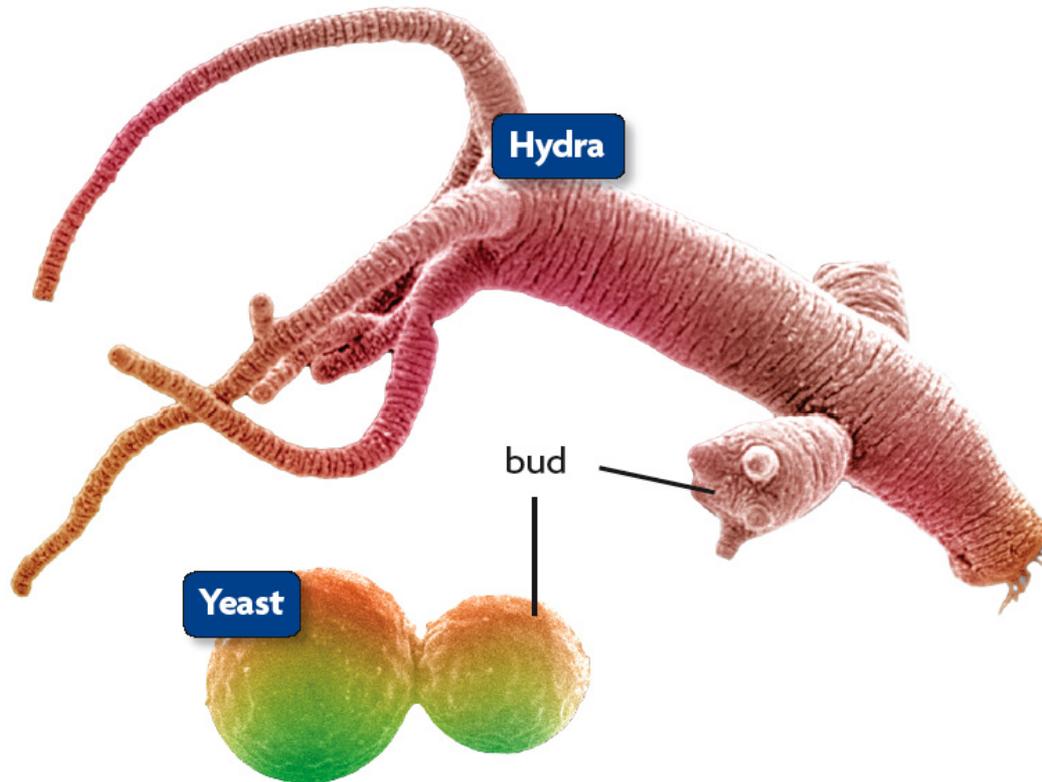
### ▶ Entire organisms can be cloned.

- A clone is a genetically identical copy of a gene or of an organism.



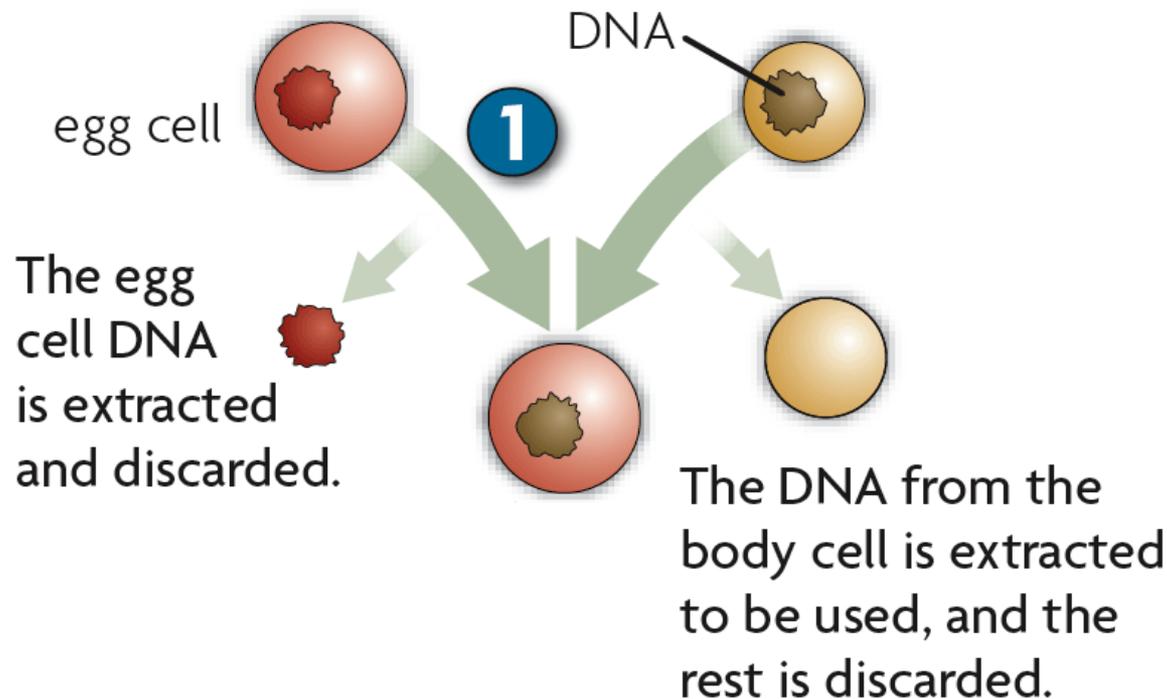
# 9.4 Genetic Engineering

- Cloning occurs in nature.
  - bacteria (binary fission)
  - some plants (from roots)
  - some simple animals (budding, regeneration)



## 9.4 Genetic Engineering

- Mammals can be cloned through a process called nuclear transfer.
  - nucleus is removed from an egg cell
  - nucleus of a cell from the animal to be cloned is implanted in the egg



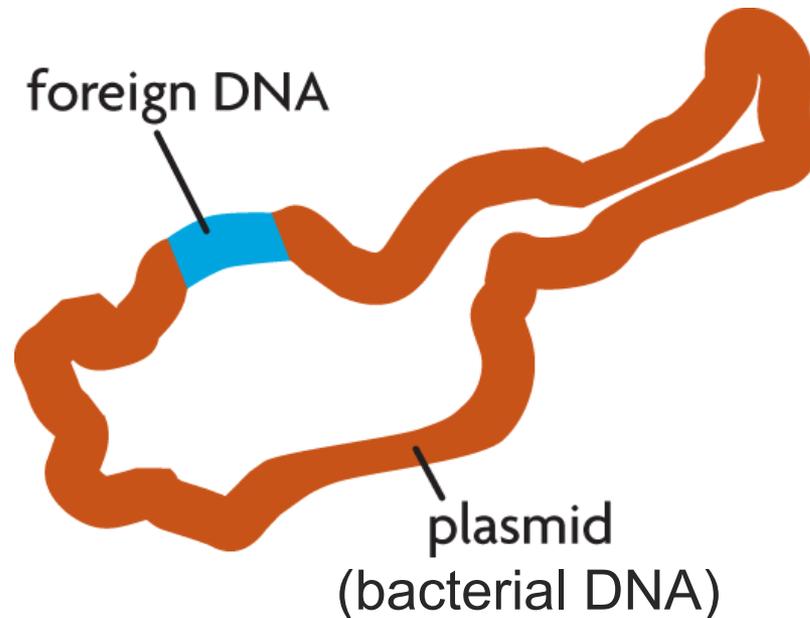
## 9.4 Genetic Engineering

- Cloning has potential benefits.
  - organs for transplant into humans
  - save endangered species
- Cloning raises concerns.
  - low success rate
  - clones “imperfect” and less healthy than original animal
  - decreased biodiversity

# 9.4 Genetic Engineering

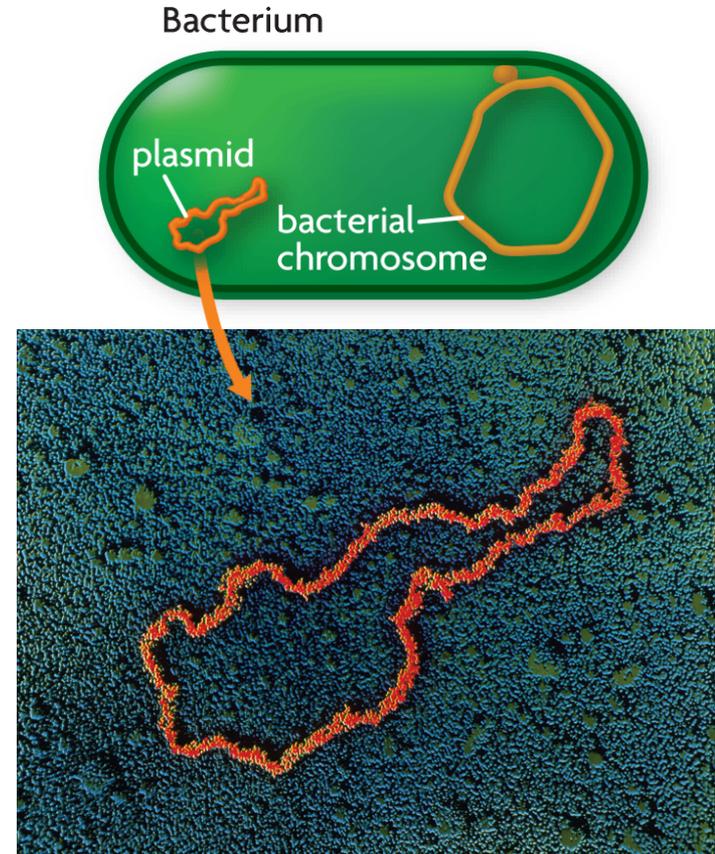
## ▶ New genes can be added to an organism's DNA.

- Genetic engineering involves changing an organism's DNA to give it new traits.
- Genetic engineering is based on the use of recombinant DNA.
- Recombinant DNA contains genes from more than one organism.



# 9.4 Genetic Engineering

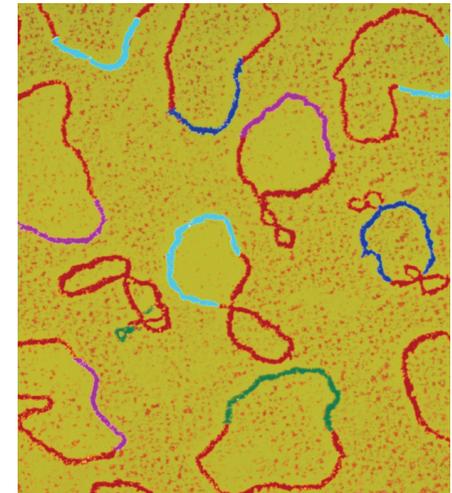
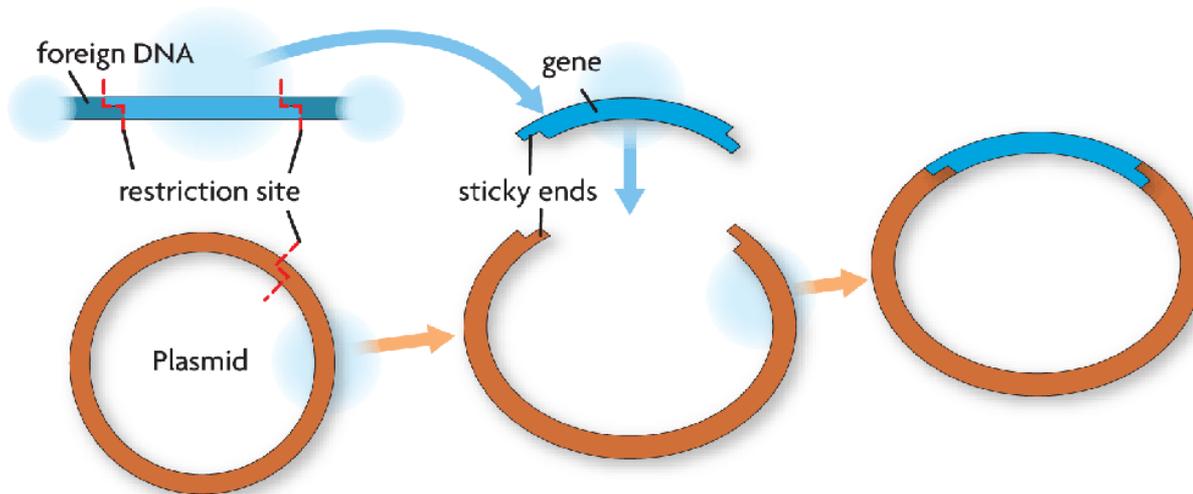
- Bacterial plasmids are often used to make recombinant DNA.
  - plasmids are loops of DNA in bacteria
  - restriction enzymes cut plasmid and foreign DNA
  - foreign gene inserted into plasmid



# 9.4 Genetic Engineering

## ▶ Genetic engineering produces organisms with new traits.

- A transgenic organism has one or more genes from another organism inserted into its genome.



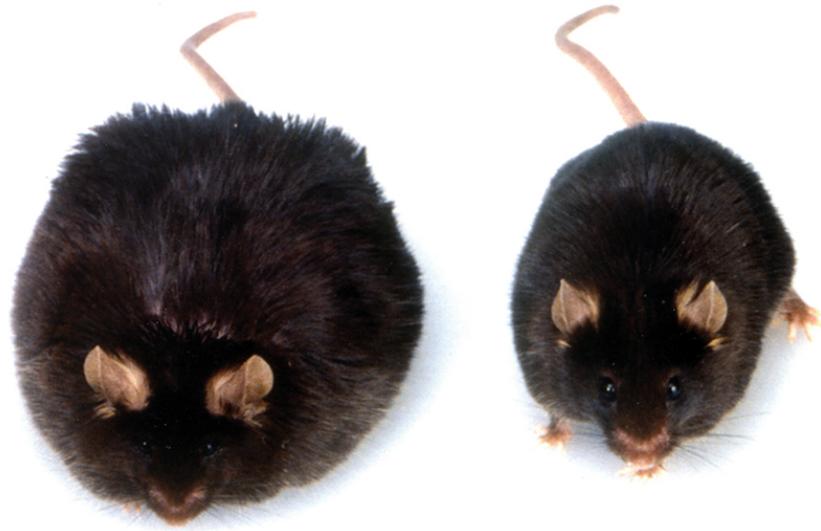
# 9.4 Genetic Engineering

- Transgenic bacteria can be used to produce human proteins.
  - gene inserted into plasmid
  - plasmid inserted into bacteria
  - bacteria express the gene
- Transgenic plants are common in agriculture.
  - transgenic bacteria infect a plant
  - plant expresses foreign gene
  - many crops are now genetically modified (GM)

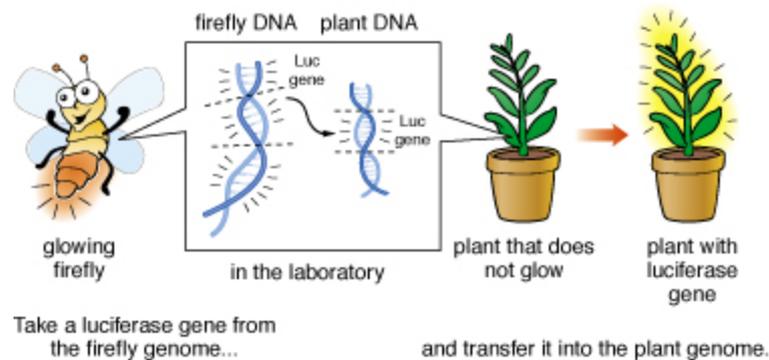


## 9.4 Genetic Engineering

- Transgenic animals are used to study diseases and gene functions.
  - transgenic mice used to study development and disease
  - gene knockout mice used to study gene function



**Genetically modified organisms** – organisms that contain DNA from another organism and produce new proteins encoded on the acquired DNA



**Gene Engineered Plant.** Scientists have learned how to 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.

## 9.4 Genetic Engineering

- Scientists have concerns about some uses of genetic engineering.
  - possible long-term health effects of eating GM foods
  - possible effects of GM plants on ecosystems and biodiversity



# 9.5 Genomics and Bioinformatics

## KEY CONCEPT

**Entire genomes are sequenced, studied, and compared.**



# 9.5 Genomics and Bioinformatics

- ▶ **Genomics involves the study of genes, gene functions, and entire genomes.**
  - Genomics is the study of genomes.
    - can include the sequencing of the genome
    - comparisons of genomes within and across species

# 9.5 Genomics and Bioinformatics

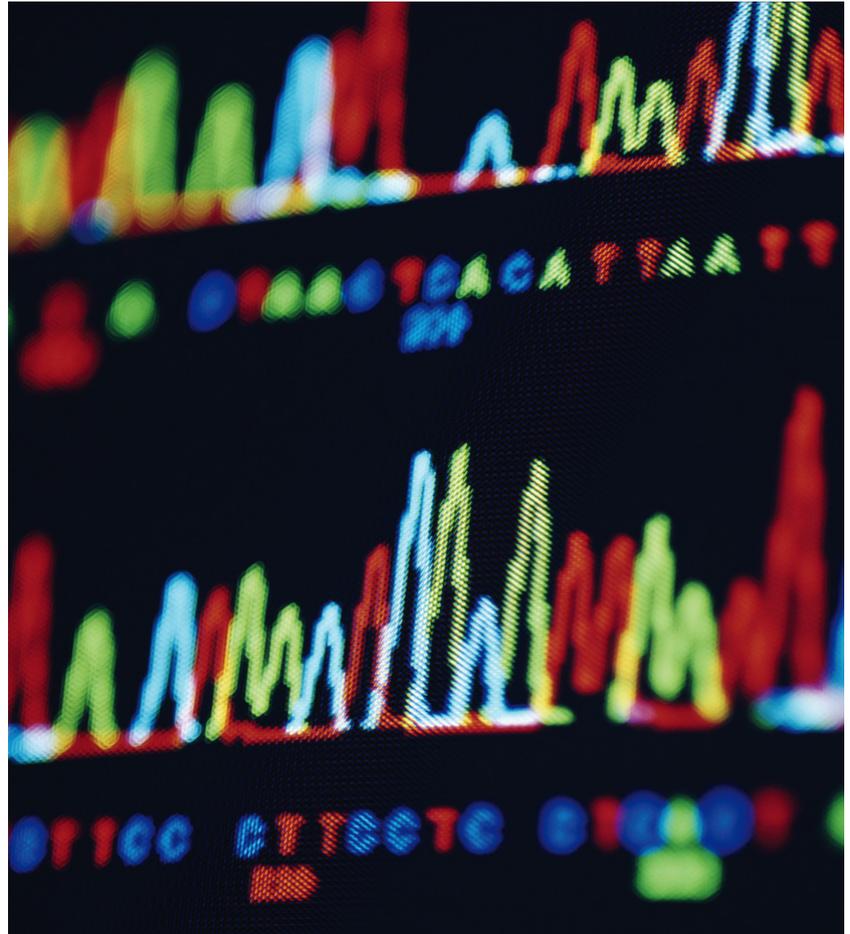
- Gene sequencing is determining the order of DNA nucleotides in genes or in genomes.
- The genomes of several different organisms have been sequenced.

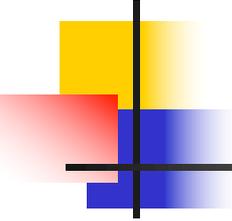
**FIGURE 9.13 COMPARING GENOME SIZES**

Organism	Approximate Total DNA (millions of bases)
<i>E. coli</i>	4.6
Fruit fly	165
Yeast	12.1
Banana	873
Chicken	1200
Humans	3000
Vanilla	7672
Crested newt	18,600
Lungfish	139,000

# 9.5 Genomics and Bioinformatics

- The Human Genome Project has sequenced all of the DNA base pairs of human chromosomes.
  - analyzed DNA from a few people
  - still working to identify and map human genes





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## The Human Genome Project

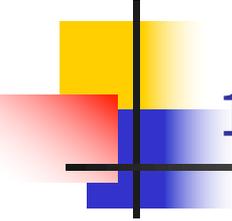
- Determining the human DNA sequence
- Understanding the function of the human genetic code
- Identifying all of the genes
- Determining their functions
- Understanding how and when genes are turned on and off throughout the lifetime of an individual

# 9.5 Genomics and Bioinformatics

- ▶ **Technology allows the study and comparison of both genes and proteins.**
  - Bioinformatics is the use of computer databases to organize and analyze biological data.
  - DNA microarrays are used to study the expression of many genes at once.



- Proteomics is the study and comparison of proteins.



## 1.3 How Companies Select Products to Manufacture

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Each biotechnology company usually specializes in a group of similar products

- Plant products
- Fermentation equipment
- Viral therapies
- DNA sequencers for research
- Enzymes for food processing

### Developing Ideas for New Products

Ideas come from many sources:

- Discussions lead to new ideas
- Reading literature reviews can lead to new ideas
- Sometimes even daydreaming can lead to new ideas

# 9.6 Genetic Screening and Gene Therapy

## KEY CONCEPT

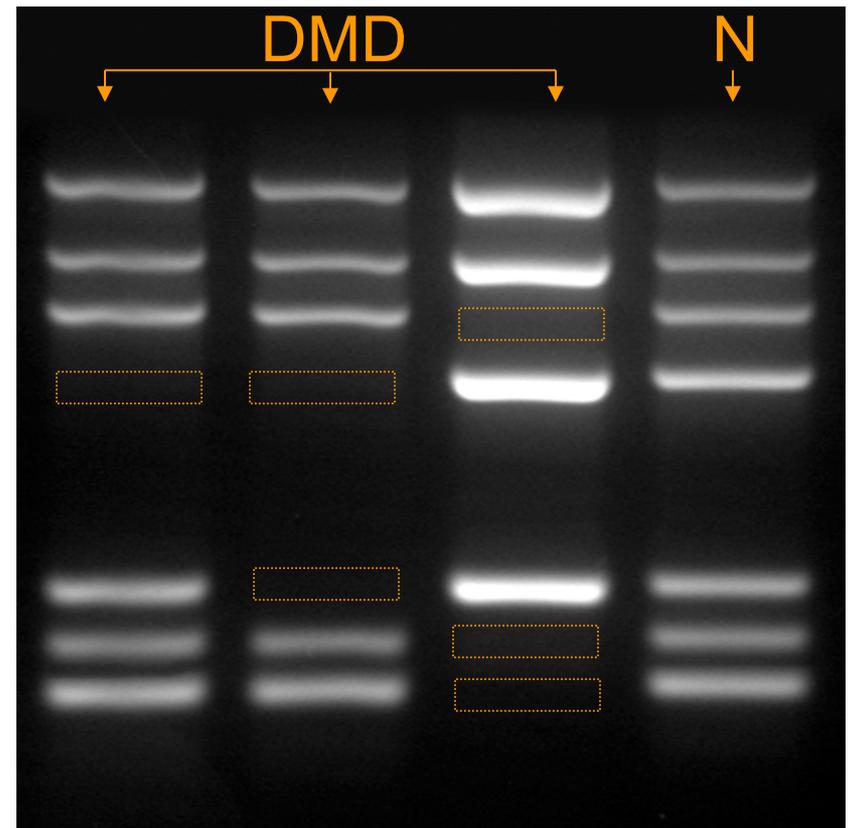
**Genetics provides a basis for new medical treatments.**



# 9.6 Genetic Screening and Gene Therapy

## ▶ Genetic screening can detect genetic disorders.

- Genetic screening involves the testing of DNA.
  - determines risk of having or passing on a genetic disorder
  - used to detect specific genes or proteins
  - can detect some genes related to an increased risk of cancer
  - can detect some genes known to cause genetic disorders



## 9.6 Genetic Screening and Gene Therapy

- ▶ **Gene therapy is the replacement of faulty genes.**
  - Gene therapy replaces defective or missing genes, or adds new genes, to treat a disease.

## 9.6 Genetic Screening and Gene Therapy

- Several experimental techniques are used for gene therapy.
  - genetically engineered viruses used to “infect” a patient’s cells
  - insert gene to stimulate immune system to attack cancer cells
  - insert “suicide” genes into cancer cells that activate a drug

## 9.6 Genetic Screening and Gene Therapy

- Gene therapy has many technical challenges.
  - inserting gene into correct cells
  - controlling gene expression
  - determining effect on other genes