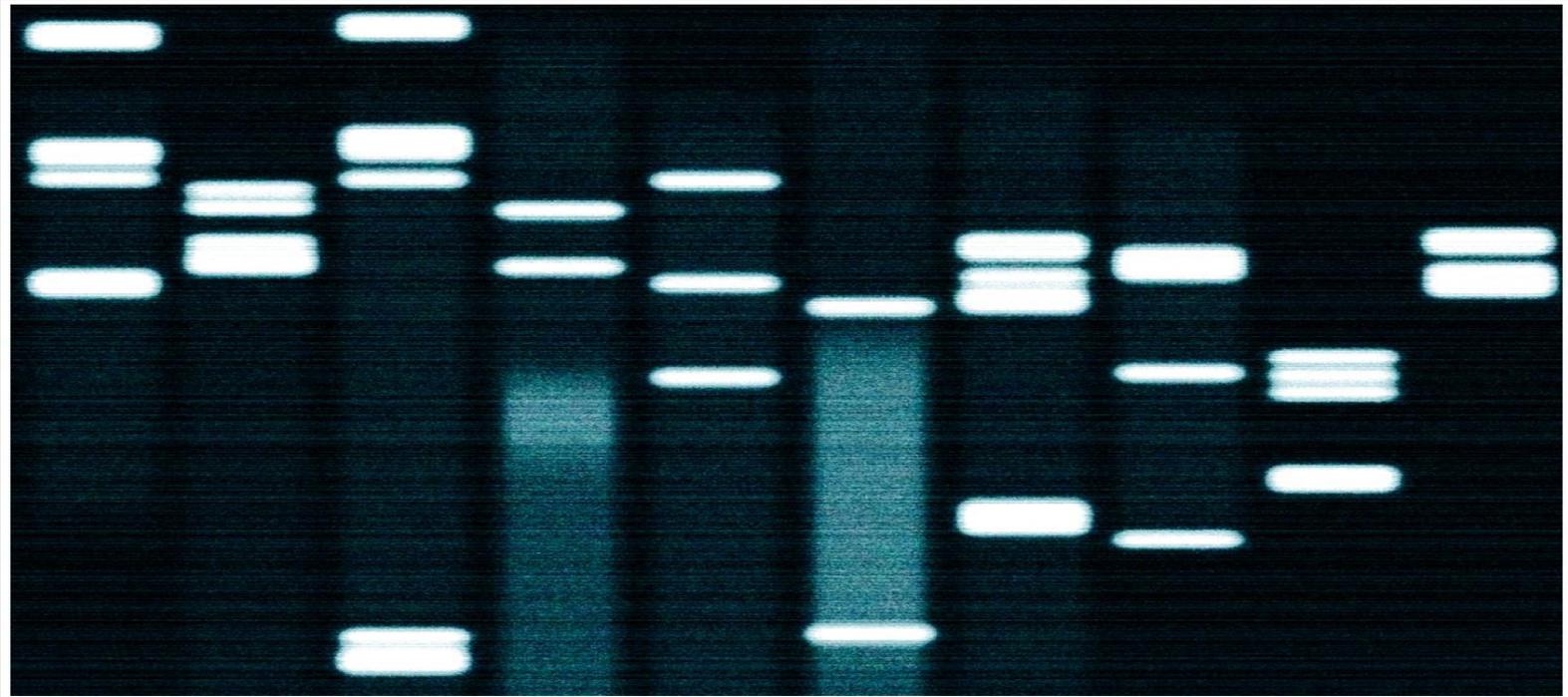


Chapter 5: Biotechnology



How can the genetic code be altered?

5.11–5.13

Biotechnology is producing improvements in agriculture.



5.11 What is biotechnology?

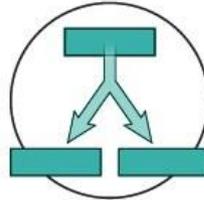
Genetic engineering

- Adding, deleting, or transplanting genes from one organism to another, to alter the organisms in useful ways

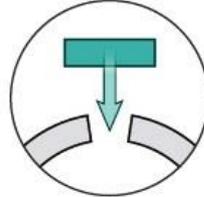
FIVE TOOLS OF BIOTECHNOLOGY



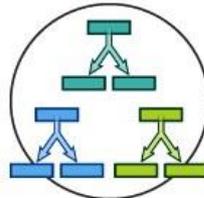
CHOP up DNA from a donor species that exhibits a trait of interest.



AMPLIFY small samples of DNA into more useful quantities.



INSERT pieces of DNA into bacterial cells or viruses.



GROW separate colonies of bacteria or viruses, each containing some donor DNA.



IDENTIFY colonies of bacteria or viruses that have DNA for a trait of interest.

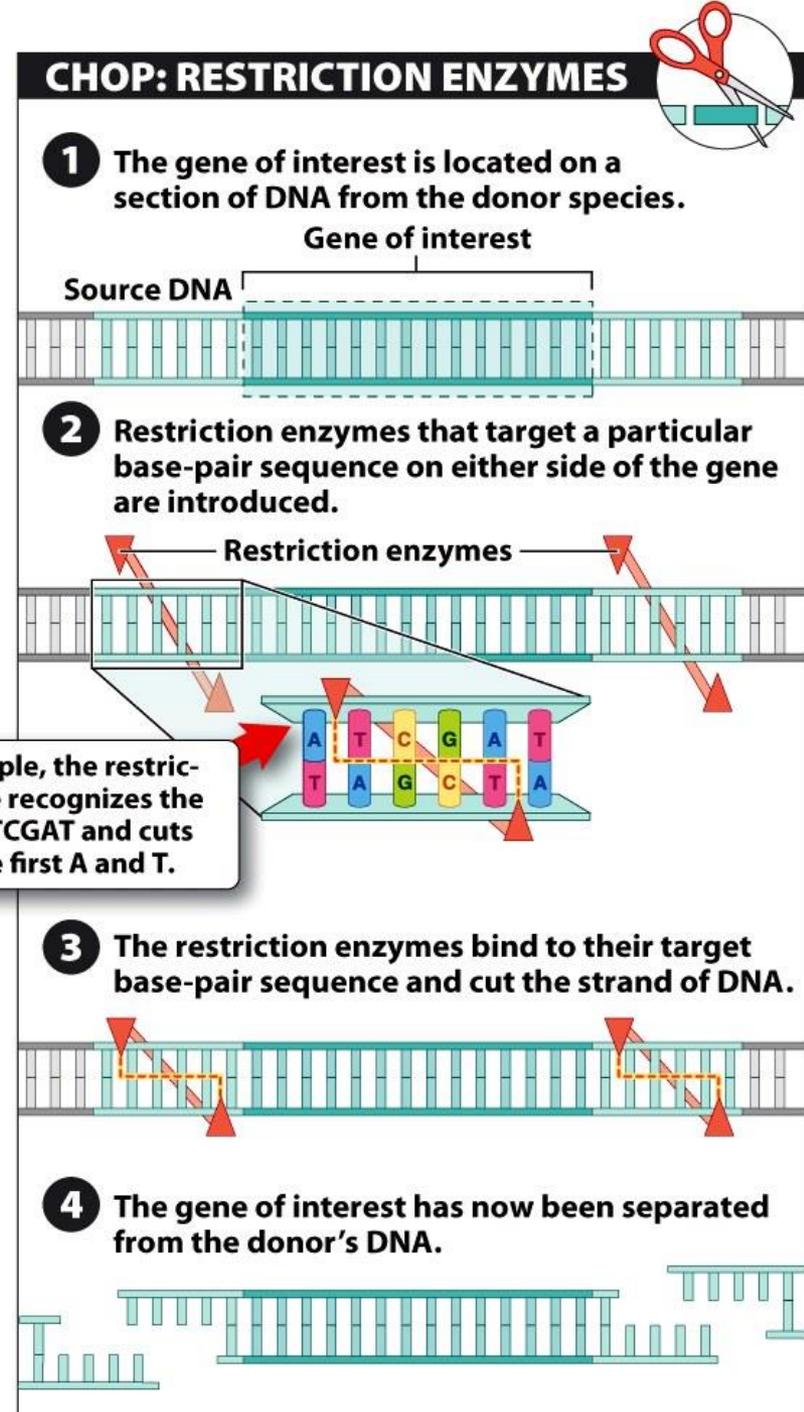
How do you create a plant resistant to being eaten by insects? Or a colony of bacteria that can produce human insulin?



Not all of the tools are used in all biotechnology applications—some only utilize one or a few of these techniques.

Step 1: Cut a section of DNA

Use of **restriction enzymes** to isolate a section of DNA (gene) and cut it. The enzymes bind to a particular section of DNA based on the sequence (4-8 bases).



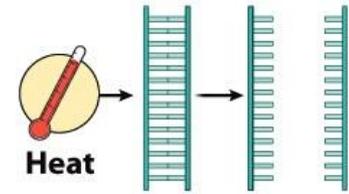
AMPLIFY: POLYMERASE CHAIN REACTION (PCR)



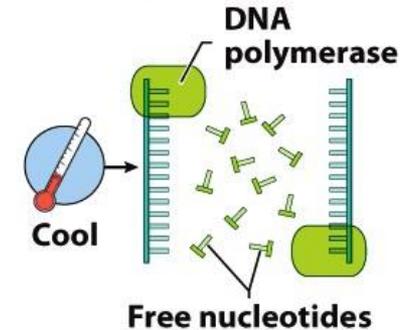
Step 2: Amplify DNA

Make numerous copies using PCR

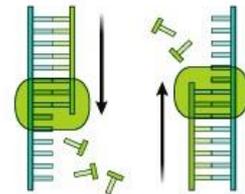
- 1** A solution containing an isolated segment of DNA is heated, separating the double-stranded DNA into two single strands.



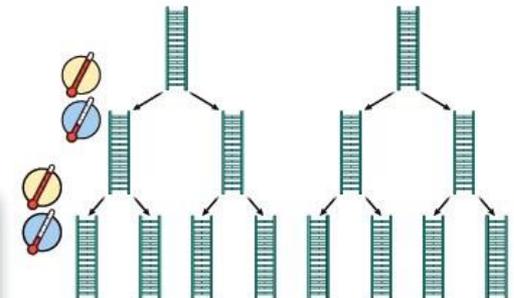
- 2** The enzyme DNA polymerase is added along with a large number of free nucleotides, and the solution containing the segments is cooled.



- 3** DNA polymerase adds complementary bases to each single strand.



- 4** The result is two identical copies of the original segment of DNA.



This process can be repeated again and again until there are billions of identical copies of the target sequence.

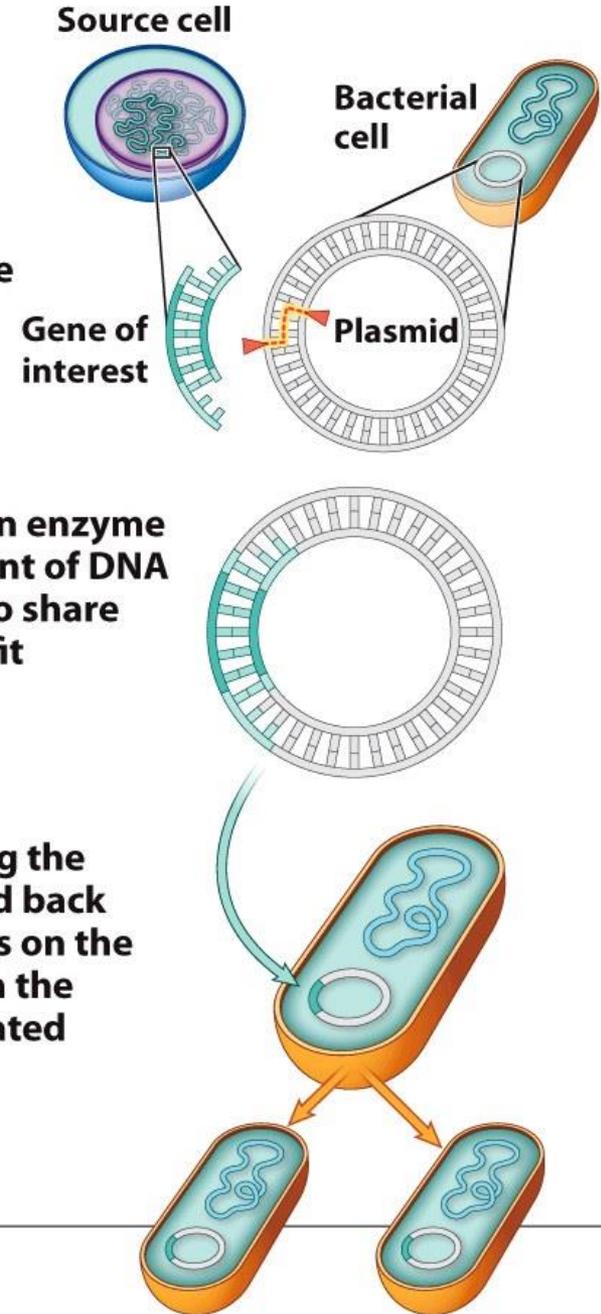
Step 3: Insert DNA

DNA may be inserted into a plasmid or other carrier

If the DNA is inserted into DNA from another organism the new organism is considered a **transgenic organism**.

INSERTING DNA BY USING PLASMIDS

- 1** A target segment of source DNA is isolated using restriction enzymes. Using the same restriction enzyme, a single cut is made in a bacterial plasmid.
- 2** Because the same restriction enzyme is used to isolate the segment of DNA and cut the plasmid, the two share complementary bases and fit perfectly together.
- 3** The plasmid—now including the gene of interest—is inserted back into the bacterial cell. Genes on the plasmid can be expressed in the bacterial cell and are replicated whenever the cell divides.



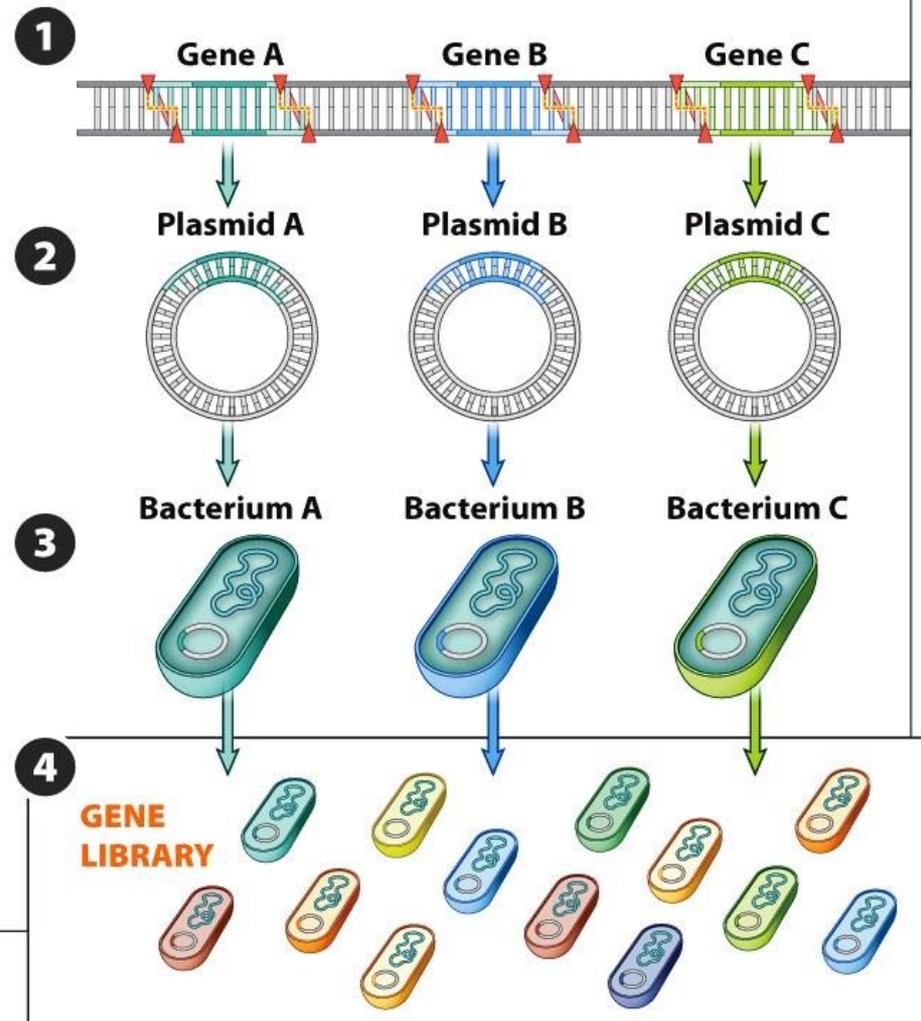


GROW: CREATING A GENE LIBRARY

Step 4: Grow

Once a piece of foreign DNA has been transferred to a bacterial cell, every time the bacterium divides, it creates a **clone**, a genetically identical cell that contains that inserted DNA.

- 1 To create a gene library, a large amount of DNA is chopped up using restriction enzymes.
- 2 Each piece is inserted into a plasmid that is then introduced into a bacterial cell.
- 3 The bacteria are allowed to divide repeatedly, each producing a clone of the foreign DNA fragment it carries.
- 4 Together, all of the different bacterial cells contain all of the different fragments of the original DNA.

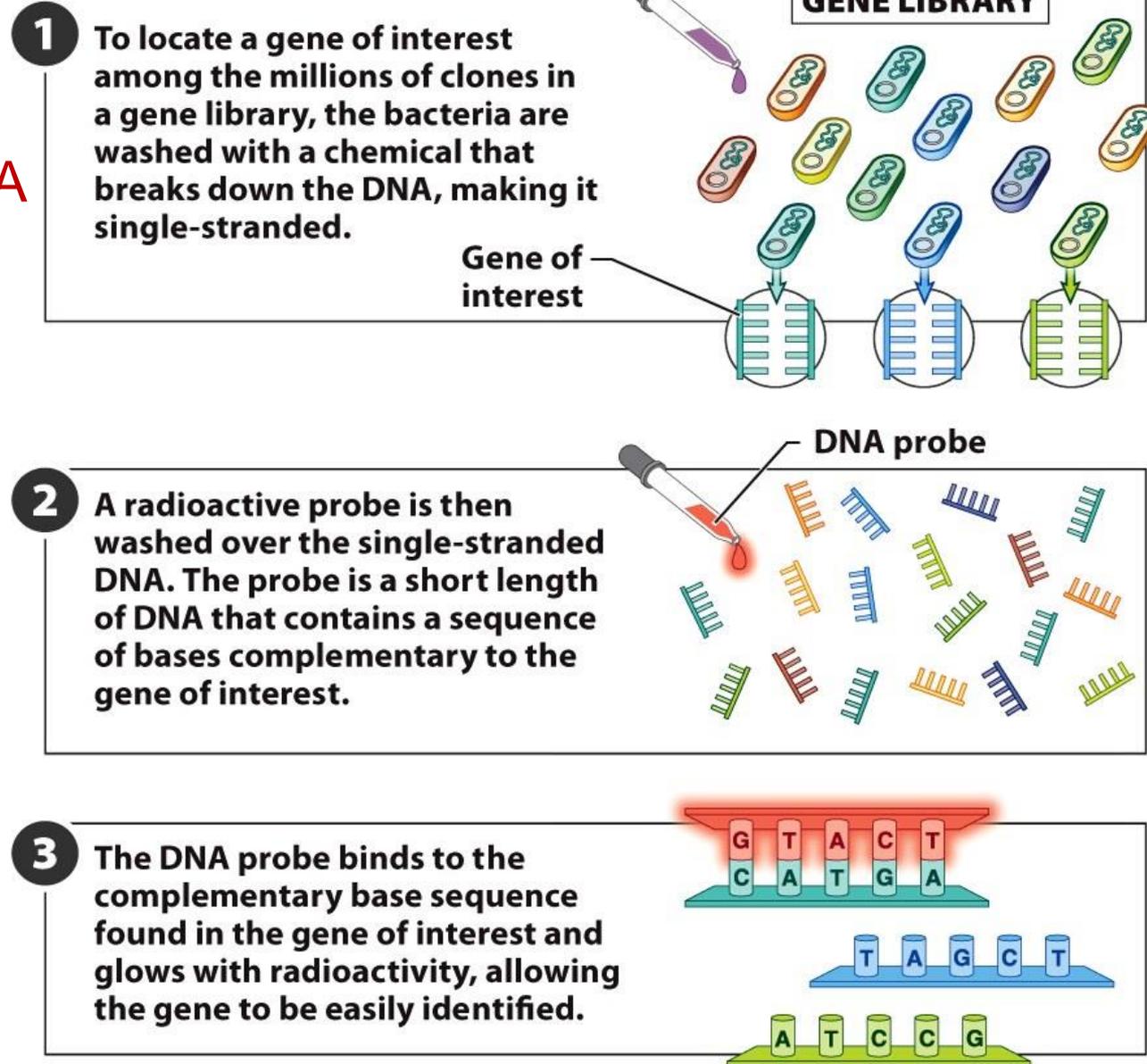


IDENTIFYING A GENE BY USING A DNA PROBE



Step 5: Identify

Once the cells are identified using a **DNA probe**, they can then be separated out and grown in large numbers—for example, vats of *E. coli* that produce human growth hormone.



Take-home message 5.11

- The methods rely on naturally occurring restriction enzymes for cutting DNA, the polymerase chain reaction for amplifying small amounts of DNA, inserting the DNA into bacterial or viral vectors, and cloning and identifying the cells with the transferred DNA of interest.

5.12 Biotechnology can improve food nutrition and make farming more efficient and eco-friendly.

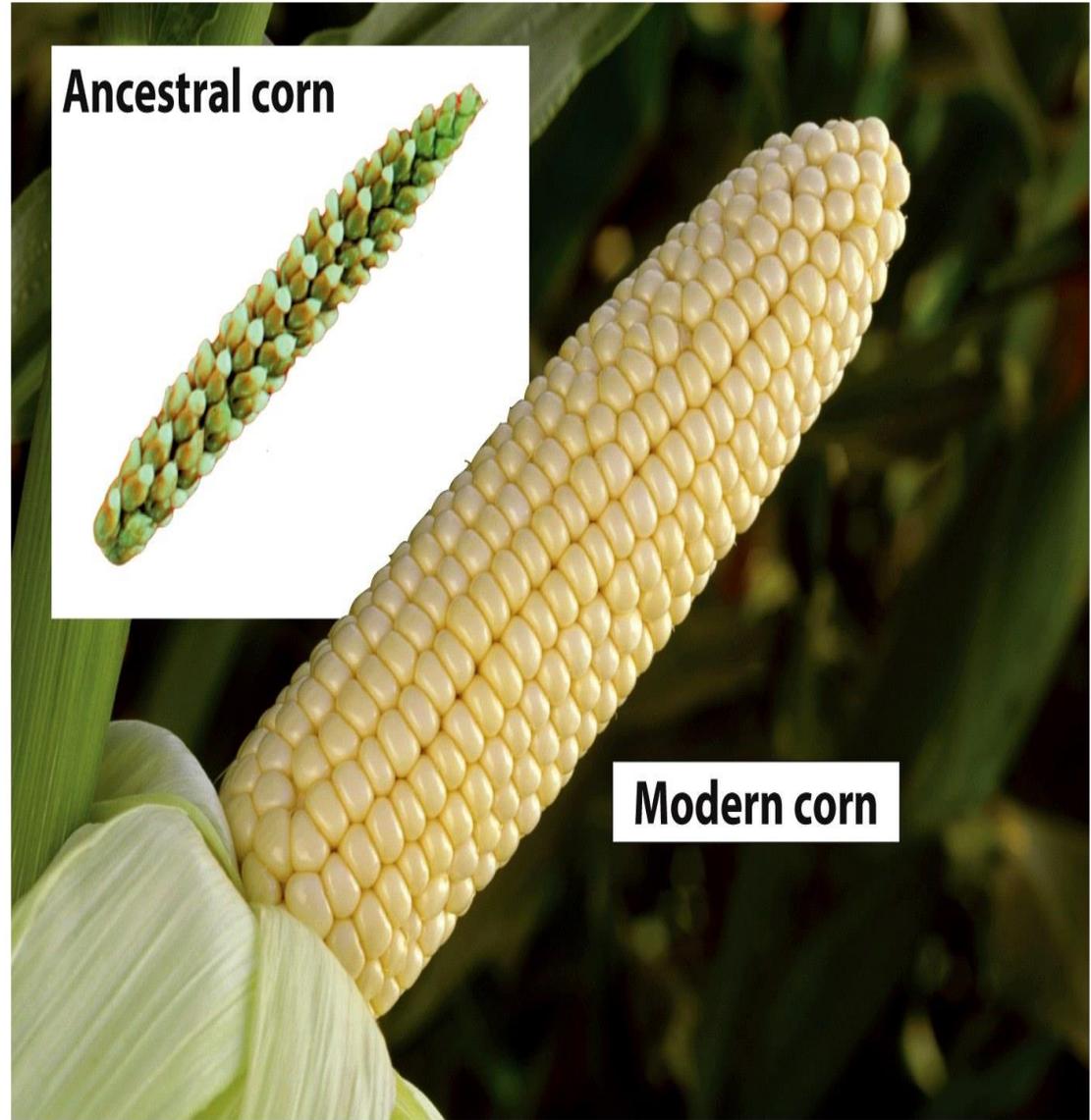
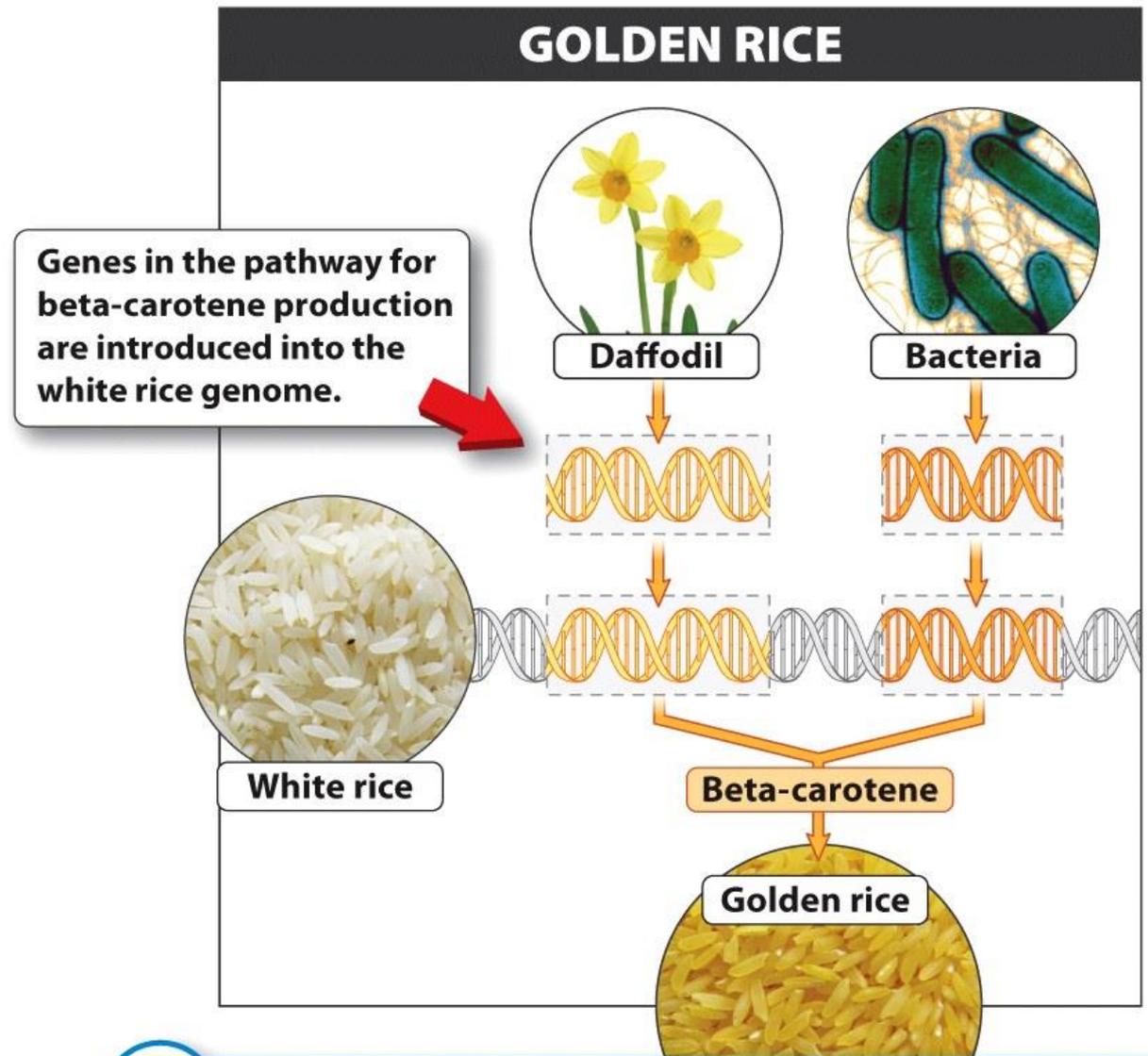


Figure 5-30
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**How might a genetically
modified plant help 500
million malnourished people?**

Nutrient-rich “golden rice”

Since golden rice was first developed in 1999, new lines have been produced with more than 25 times as much vitamin A than the original strains had.



Almost 10% of the world's people suffer from vitamin A deficiencies—leading to 250,00 cases of blindness each year. The addition of beta-carotene-producing genes to white rice has increased its vitamin A content almost 25-fold.

Almost everyone in the United States consumes genetically modified foods regularly without knowing it. What is different about Connecticut?

What foods are responsible for this?

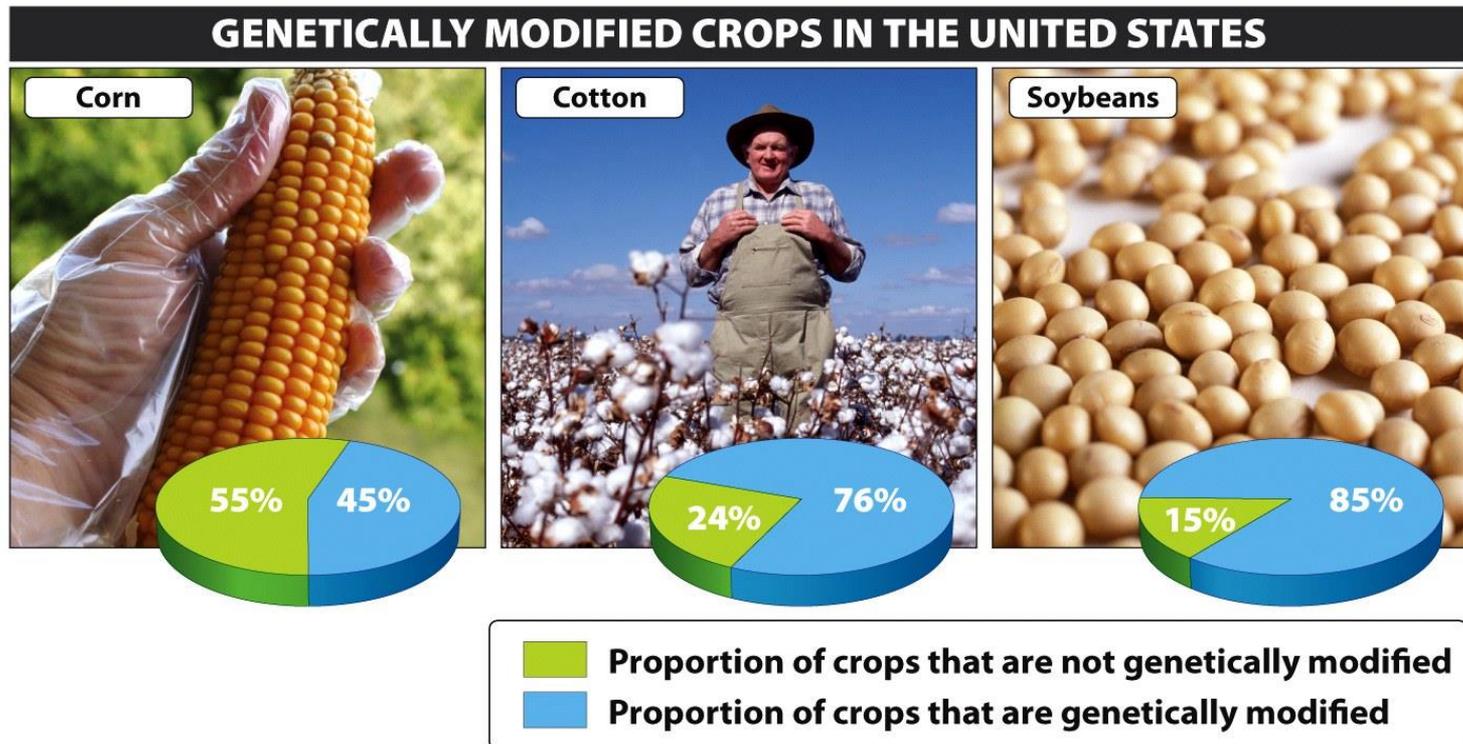


Figure 5-32

Insect Resistance – Toxic Bt crystals sprayed on plants



Figure 5-33
What Is Life? A Guide To Biology, Second Edition

How can genetically modified plants lead to reduced pesticide use by farmers?

Bt CORN

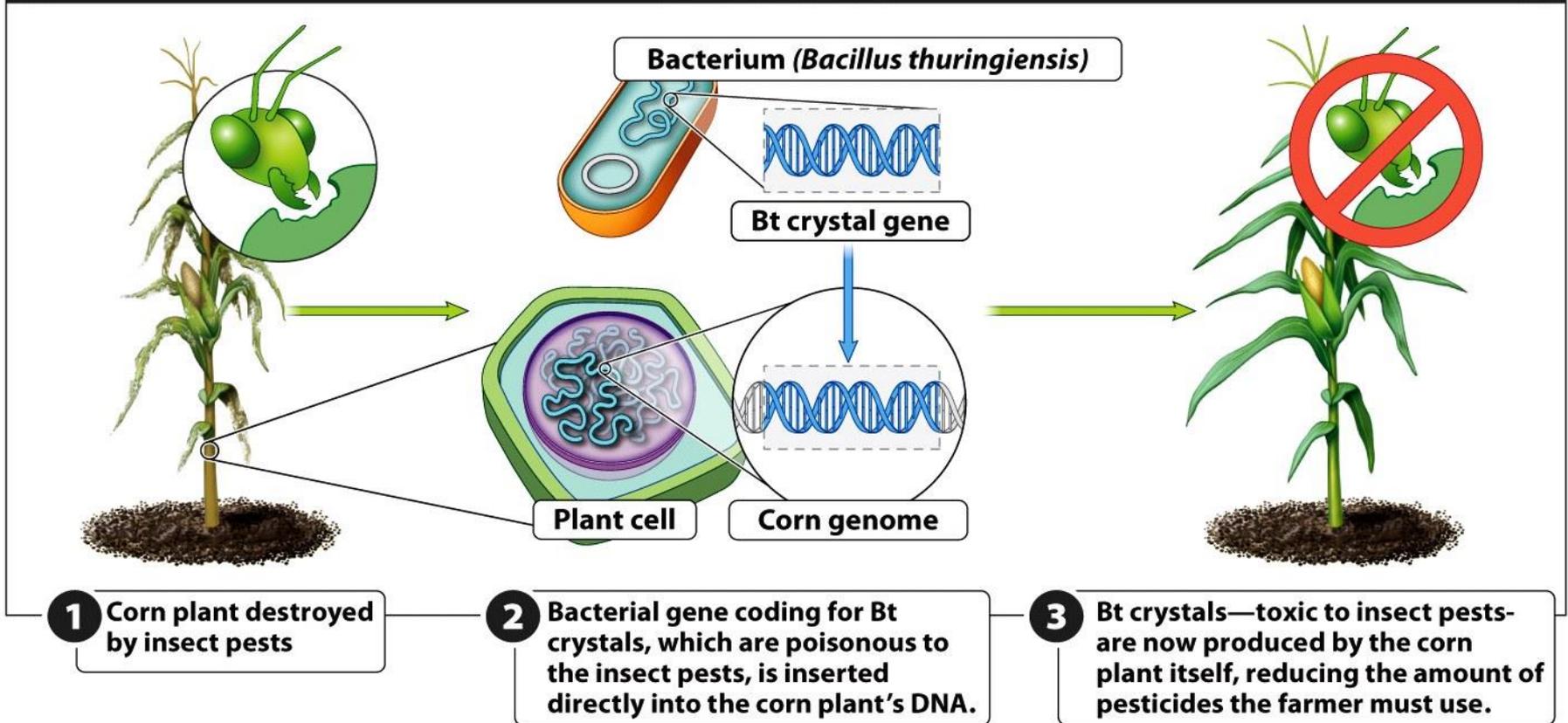


Figure 5-34

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Herbicide Resistance



Herbicide-resistance genes from bacteria protect crop plants from the herbicides used to kill the weeds competing with them.

Faster Growth and Bigger Bodies - Article and discuss



Figure 5-36

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Take-home message 5.12

- Even more significant is the extent to which biotechnology has reduced the environmental and financial costs of producing food:
 - Through the creation of herbicide-resistant and insect-resistant crops

Take-home message 5.12

- The ecological and health risks of such widespread use of transgenic species are not fully understood and are potentially great.

5.13 Fears and risks: Are genetically modified foods safe?



Featherless birds are cheaper for farmers and consumers. But there are unintended consequences, including vulnerability to mosquitoes and other parasites.



Figure 5-38
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- ❑ Fear #1. Organisms that we want to kill may become invincible.
- ❑ Fear #2. Organisms that we don't want to kill may be killed inadvertently.
- ❑ Fear #3. Genetically modified crops are not tested or regulated adequately.

5.14–5.17
Biotechnology
has the potential
for improving
human health (and
criminal justice)



5.14 The treatment of diseases and production of medicines are improved with biotechnology.

- *Preventing* diseases

- *Curing* diseases

- *Treating* diseases
 - The treatment of diabetes



Figure 5-39
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Several important achievements followed the development of insulin-producing bacteria, including:

1. Human growth hormone (HGH)
2. Erythropoietin (EPO – increase RBCs -oxygen transport)



Figure 5-27
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What is “blood doping”?

How does it improve some athletes' performance?

5.15 Gene therapy: Biotechnology can help diagnose and prevent diseases.

*But has had a limited success in
curing them*

1. Is a given set of parents likely to produce a baby with a genetic disease?



Since screening began in 1969, the incidence of Tay-Sachs disease has been reduced by more than 75%!

2. Will a baby be born with a genetic disease?

- Cystic fibrosis
- Sickle-cell anemia
- Down syndrome
- Others

3. Is an individual likely to develop a genetic disease later in life?

Breast cancer

Prostate cancer

Skin cancer

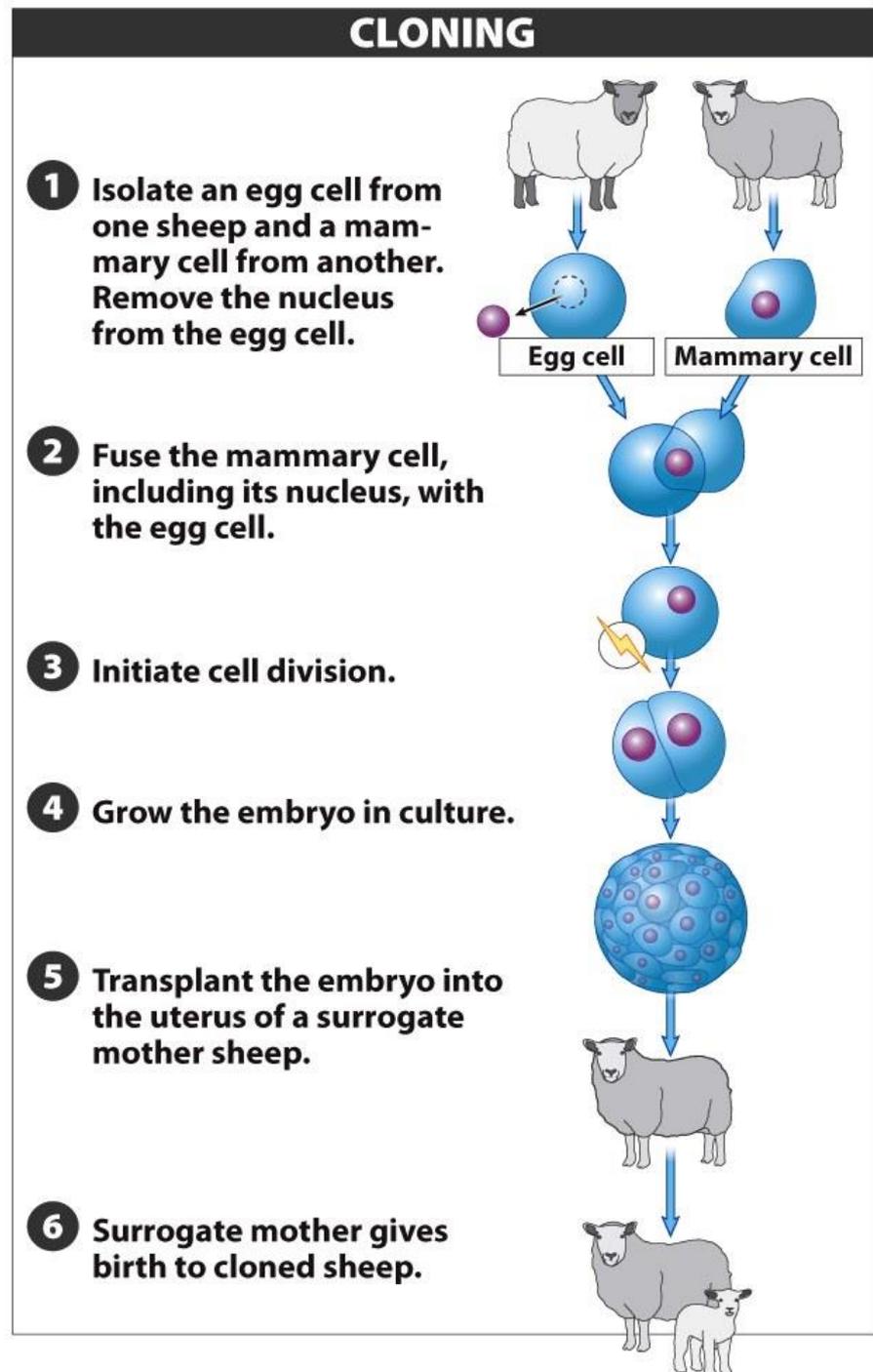
Boy in the Bubble – Severe Combined Immunodeficiency Syndrome (SCID) – GENE THERAPY



Difficulties with gene therapy have been encountered in several different areas, usually related to the organism used to transfer the normal-functioning gene into the cells of a person with a genetic disease.

5.16 Cloning—producing an identical copy

In 1997, Ian Wilmut, a British scientist, and his colleagues first reported that they had cloned a sheep—which they named Dolly.



5.17 DNA as an individual identifier: the uses and abuses of DNA fingerprinting

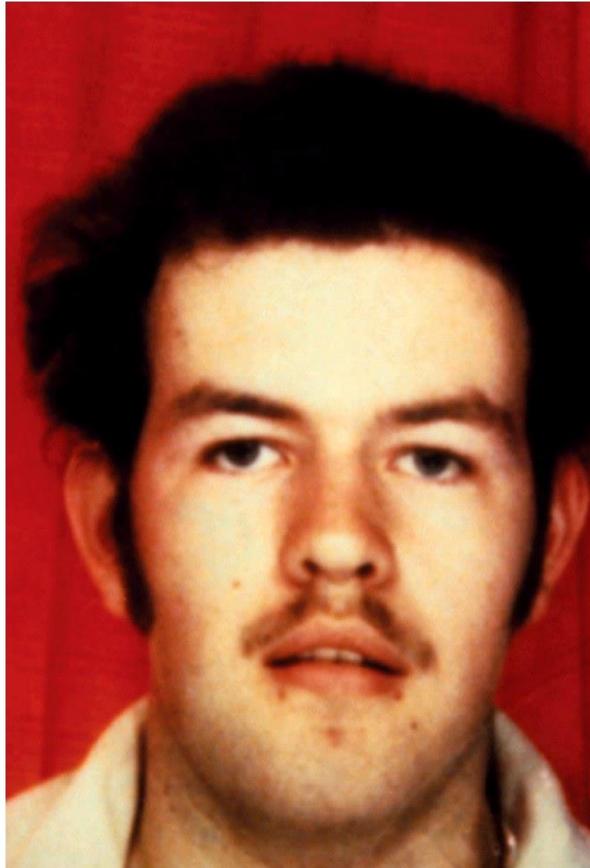
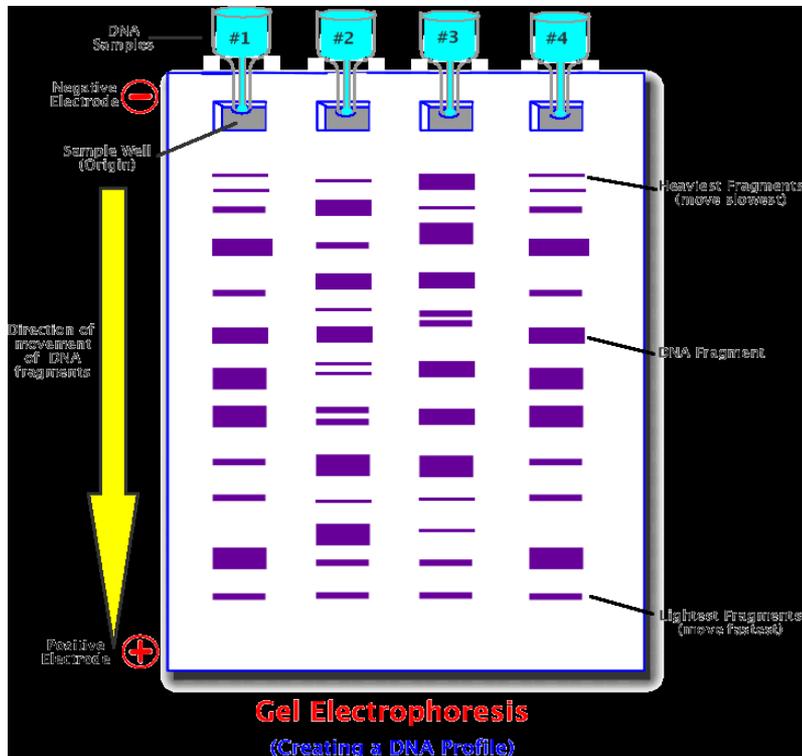


Figure 5-45a
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Figure 5-45b
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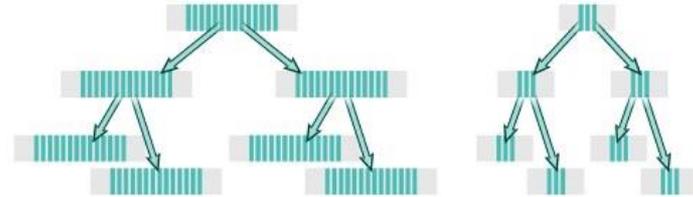
What is a DNA fingerprint?



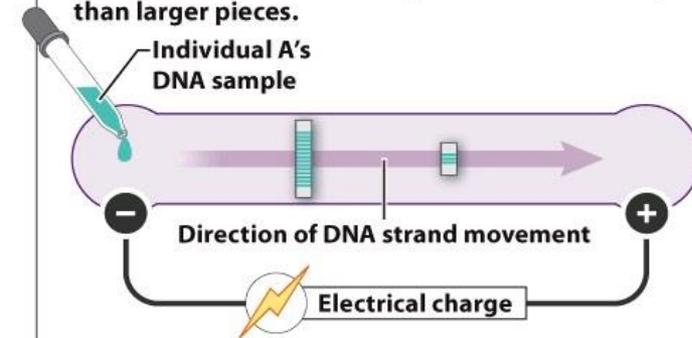
CREATING A DNA FINGERPRINT

A DNA fingerprint is created by determining which alleles an individual carries for 13 different STR loci.

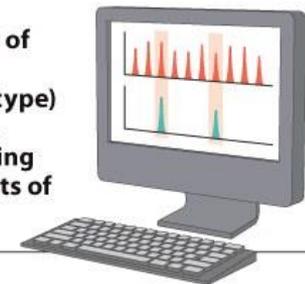
- 1 For each of the 13 STR loci used to construct an individual's DNA fingerprint, the DNA fragment containing each STR region is amplified using PCR, resulting in huge numbers of those fragments. The amplified DNA fragments differ in size, depending on how many times the repeating unit of that STR is repeated.



- 2 The amplified DNA fragments are separated by size using electrophoresis. In this process, DNA fragments are poured into a solution and an electrical charge is applied. Because DNA is a negatively charged molecule, the pieces of DNA move toward the positively charged electrode. Smaller pieces—those with fewer repeats—move more quickly than larger pieces.



- 3 Computer software is used to analyze the results. The number of repeats within an STR region (indicating an individual's genotype) is determined by comparing the length of the fragments containing that STR region to DNA fragments of known lengths.



DNA samples from:

crime scene

suspect #1

suspect #2

suspect #3

