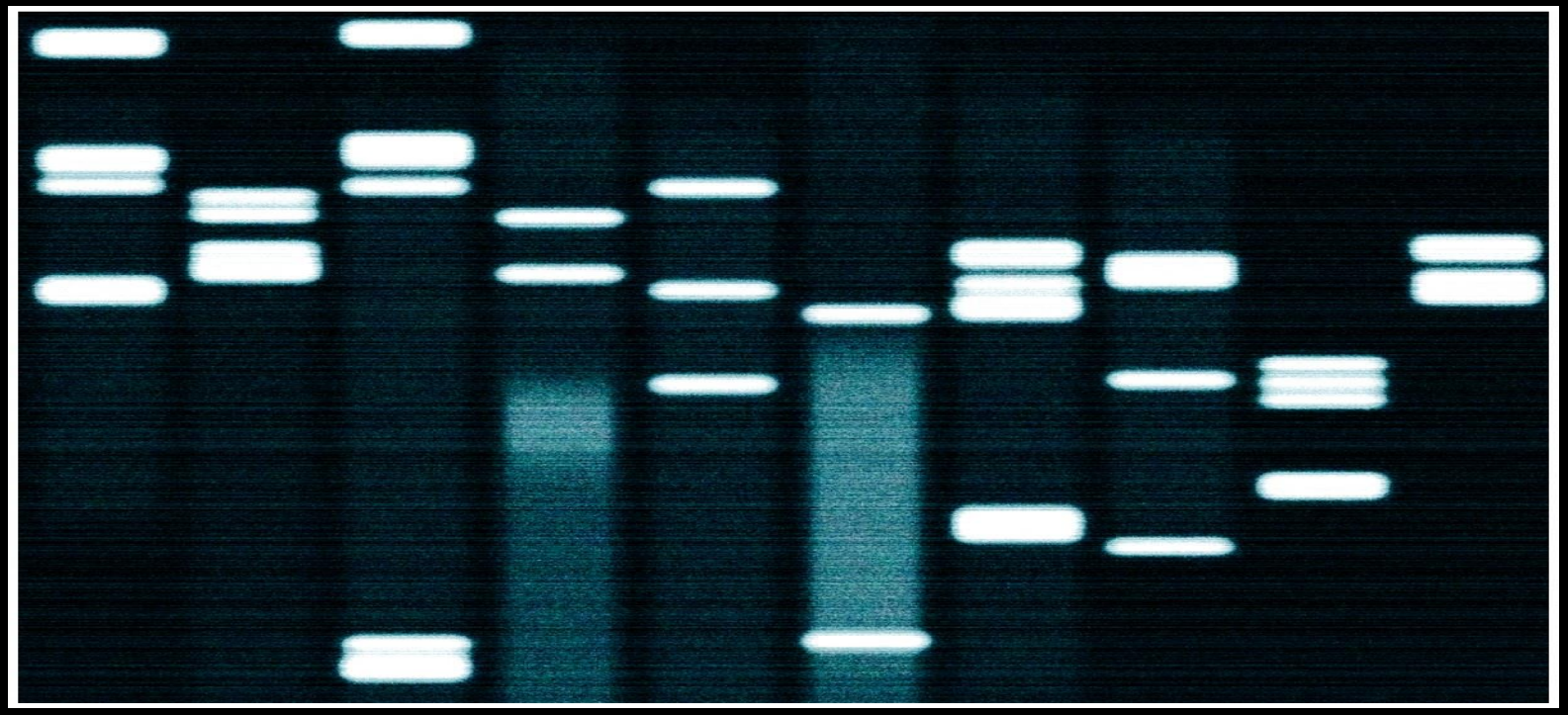
Chapter 5: Biotechnology



How can the genetic code be altered?

Lectures by Mark Manteuffel, St. Louis Community College

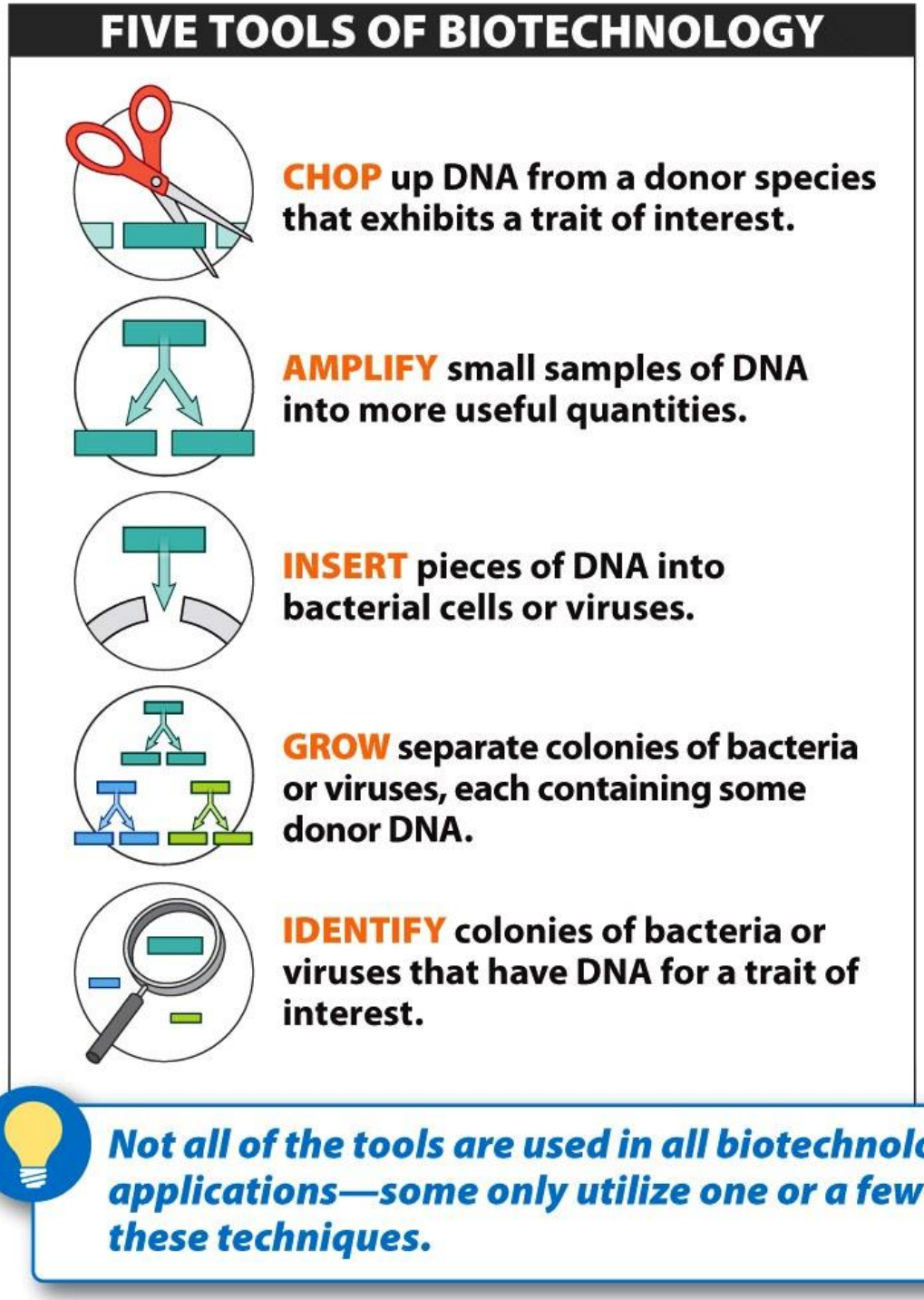
5.11–5.13
Biotechnology is producing improvements in agriculture.

5.11 What is biotechnology?

Genetic engineering

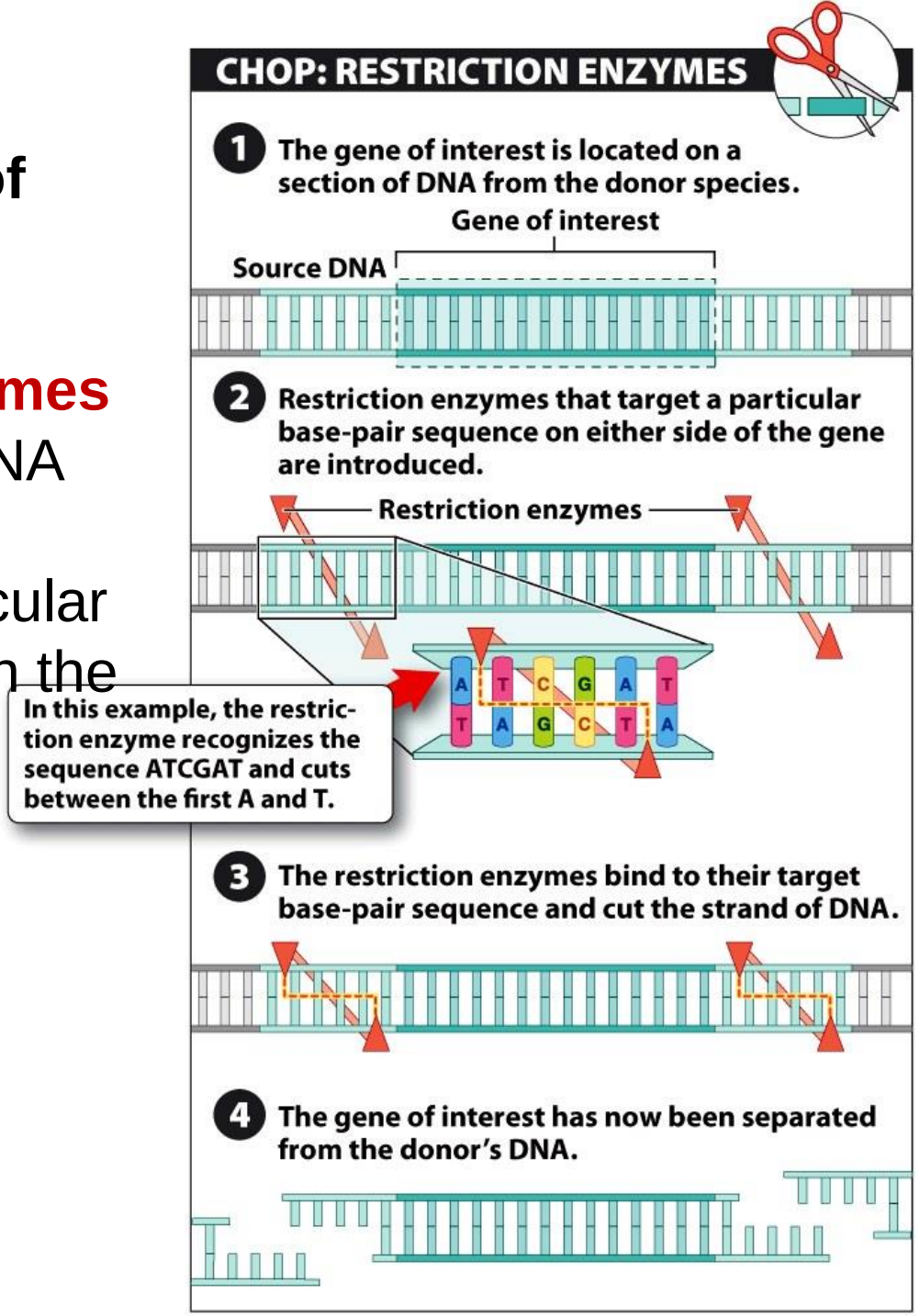
- Adding, deleting, or transplanting genes from one organism to another, to alter the organisms in useful ways

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



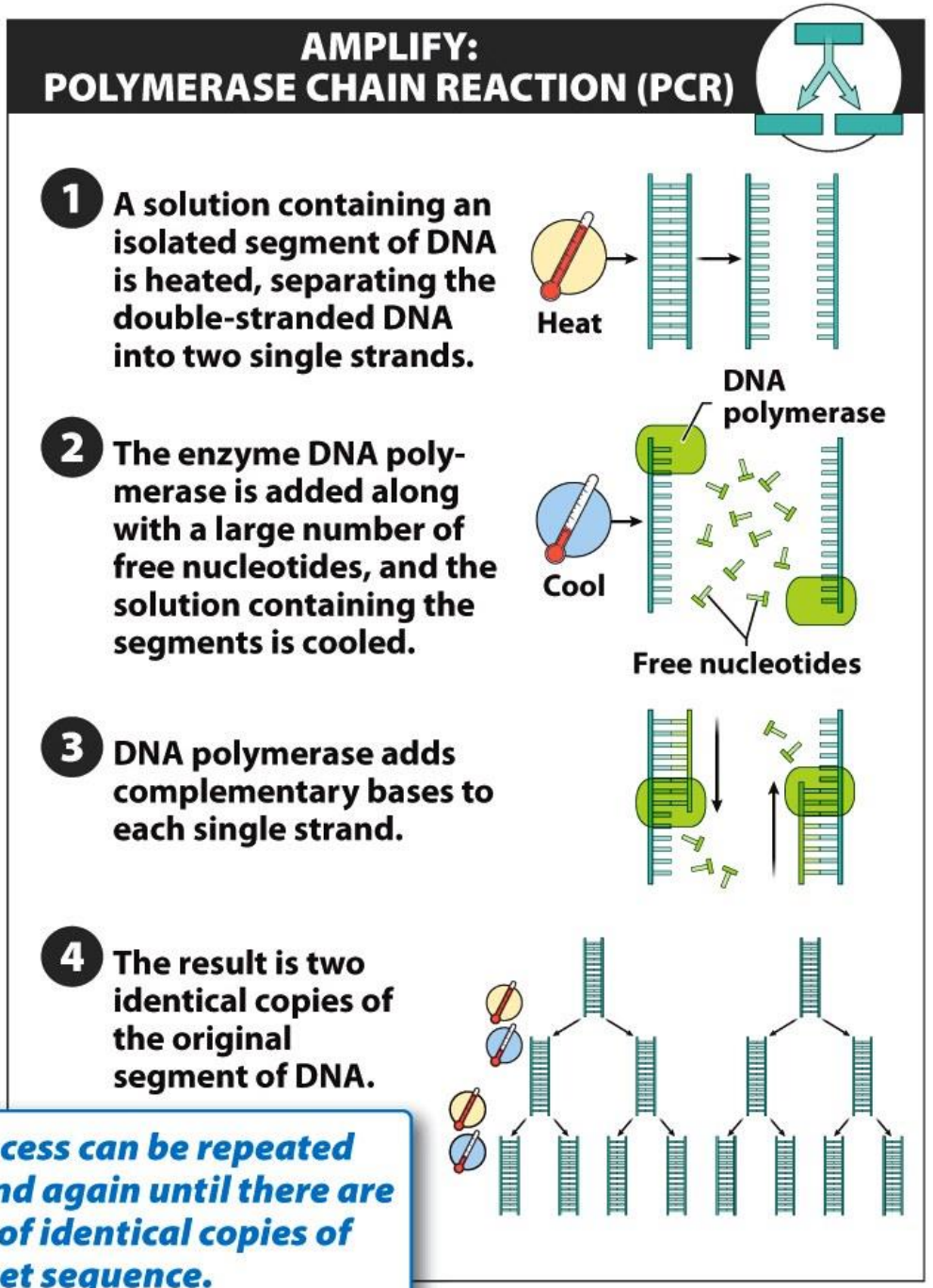
Step 1: Cut a section of DNA

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).



Step 2: Amplify DNA

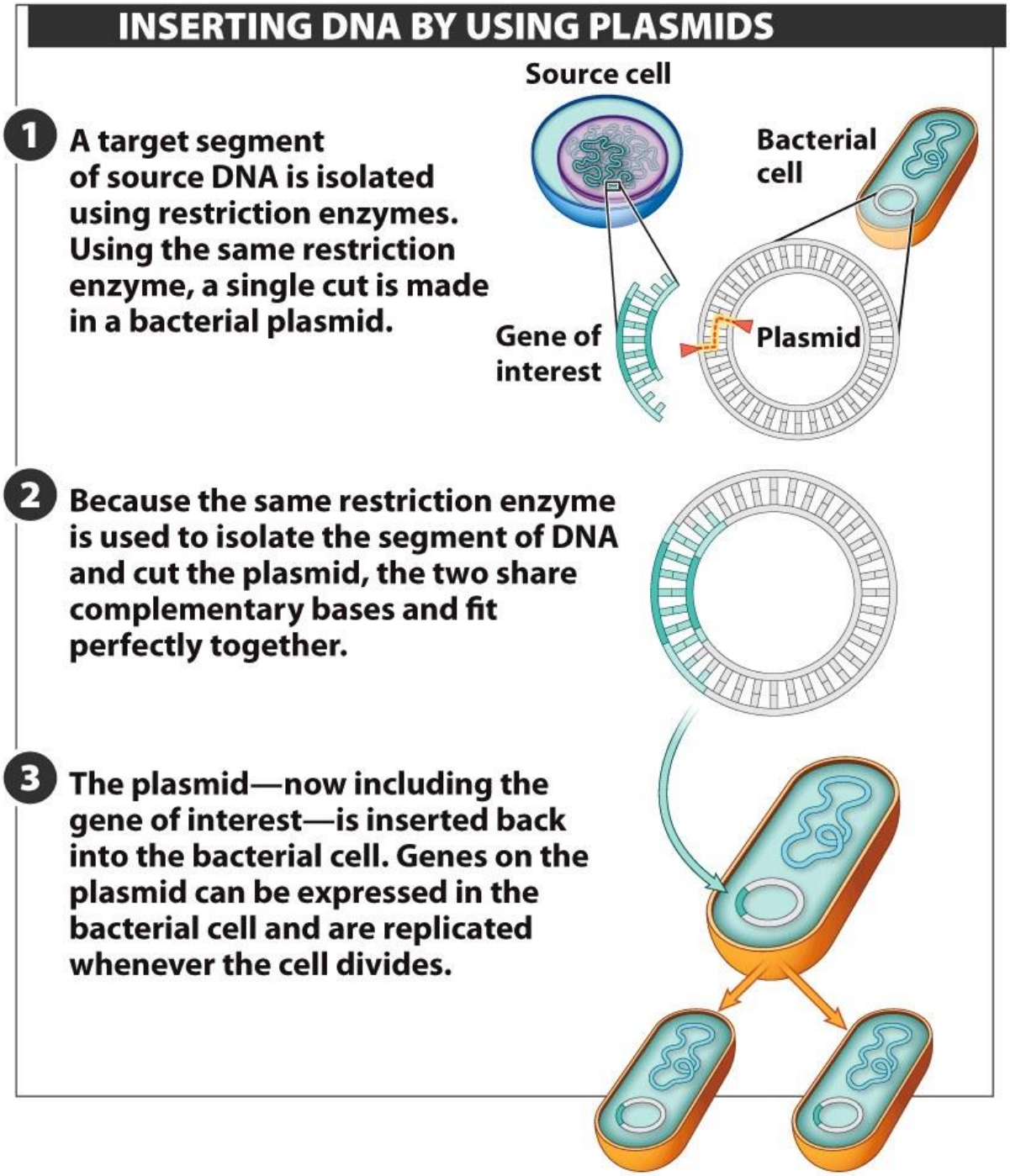
Make numerous copies using PCR



Step 3: Insert DNA

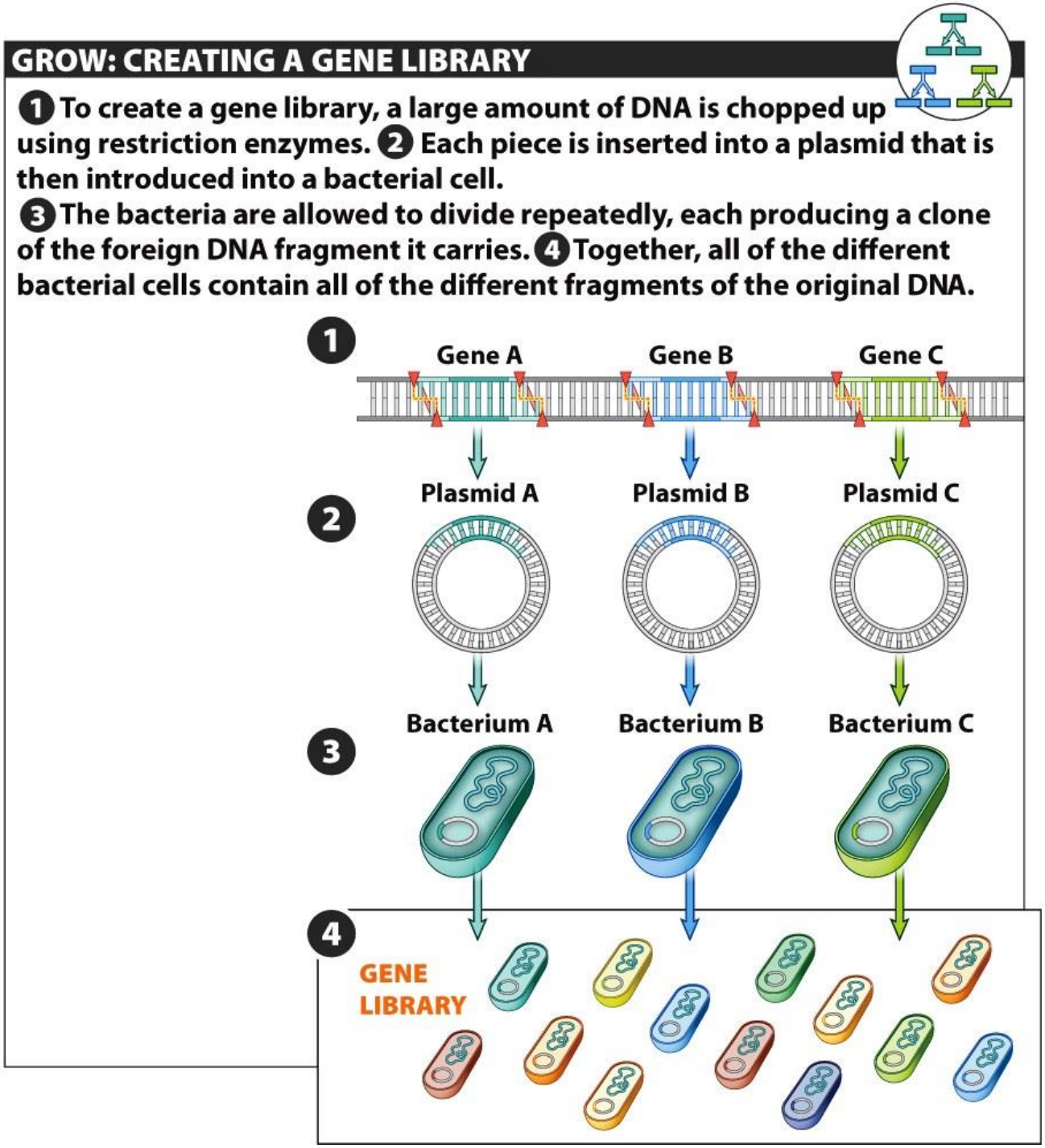
DNA my be inserted into a plasmid or other carrier

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



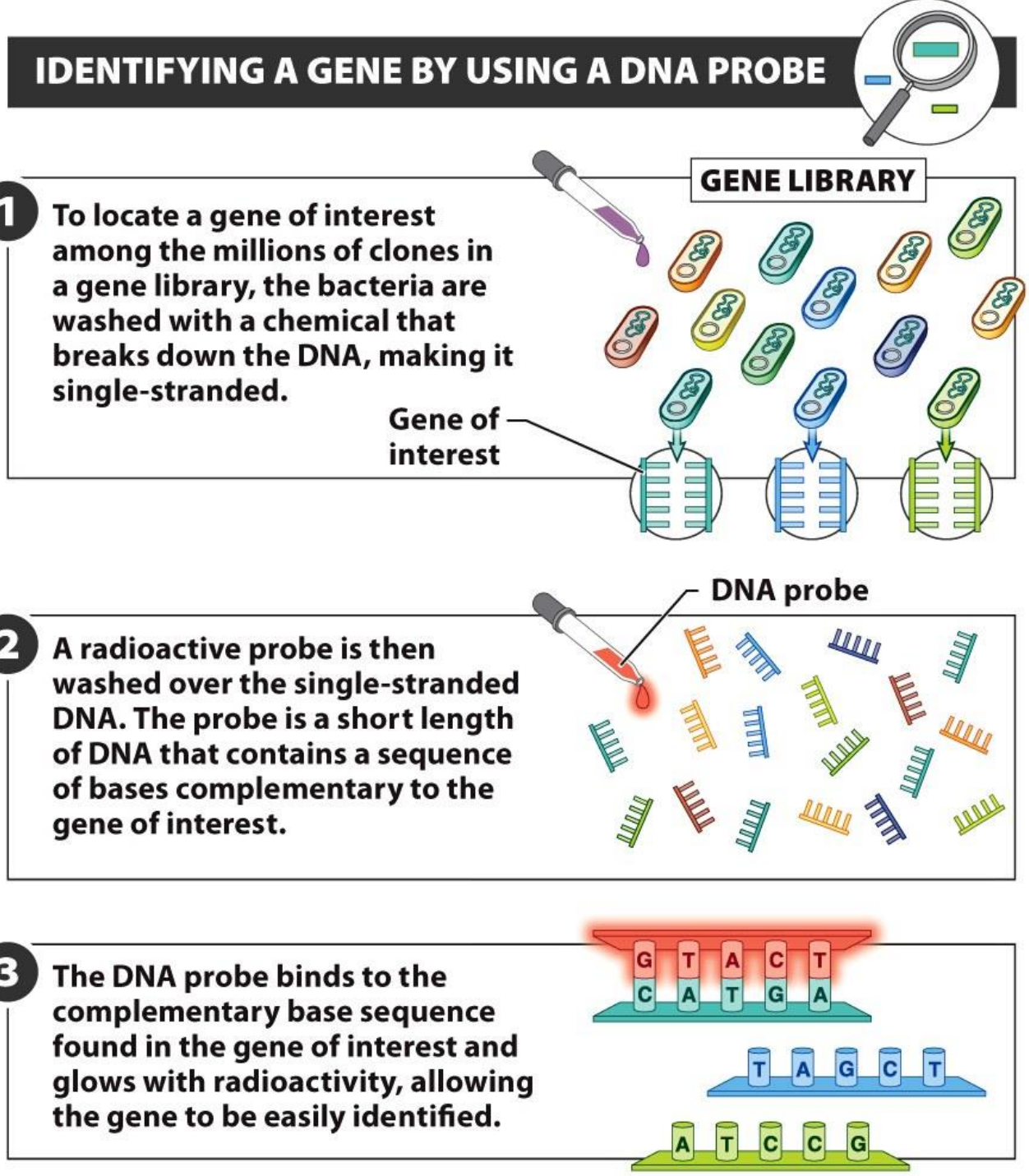
Step 4: Grow

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.



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.

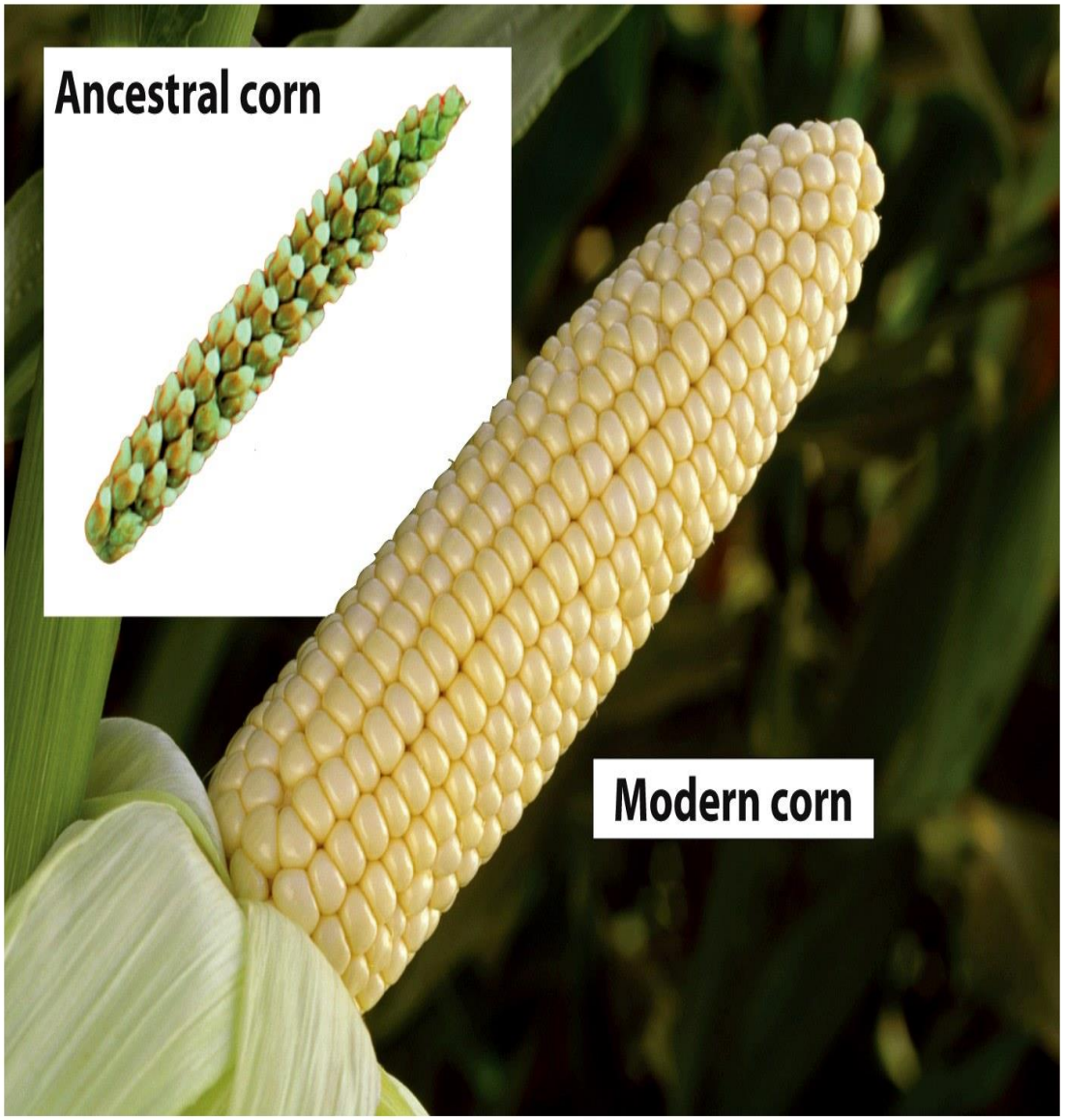


Figure 5-30
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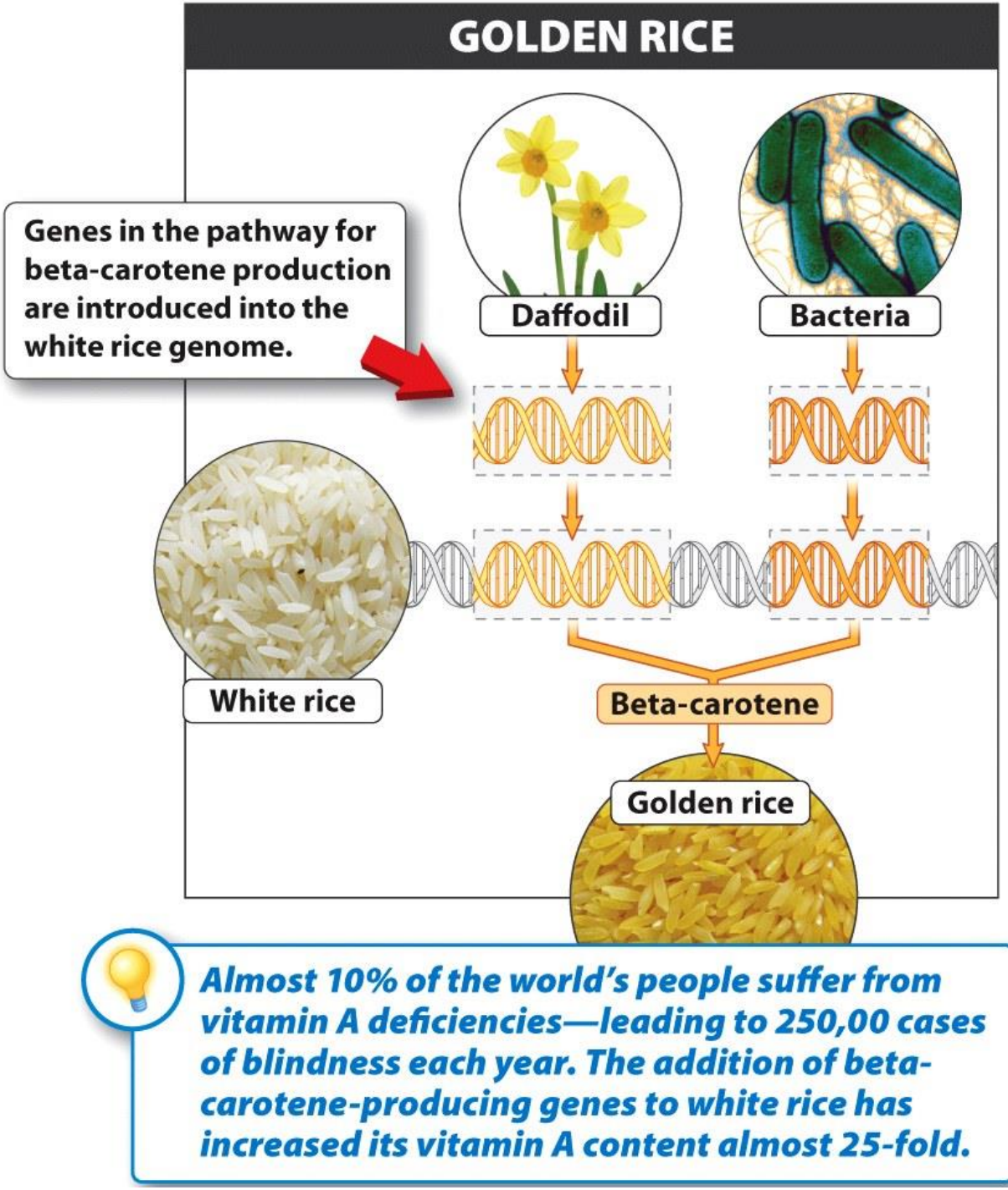
How might a genetically modified plant help 500 million malnourished people?

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

What foods are responsible for this?

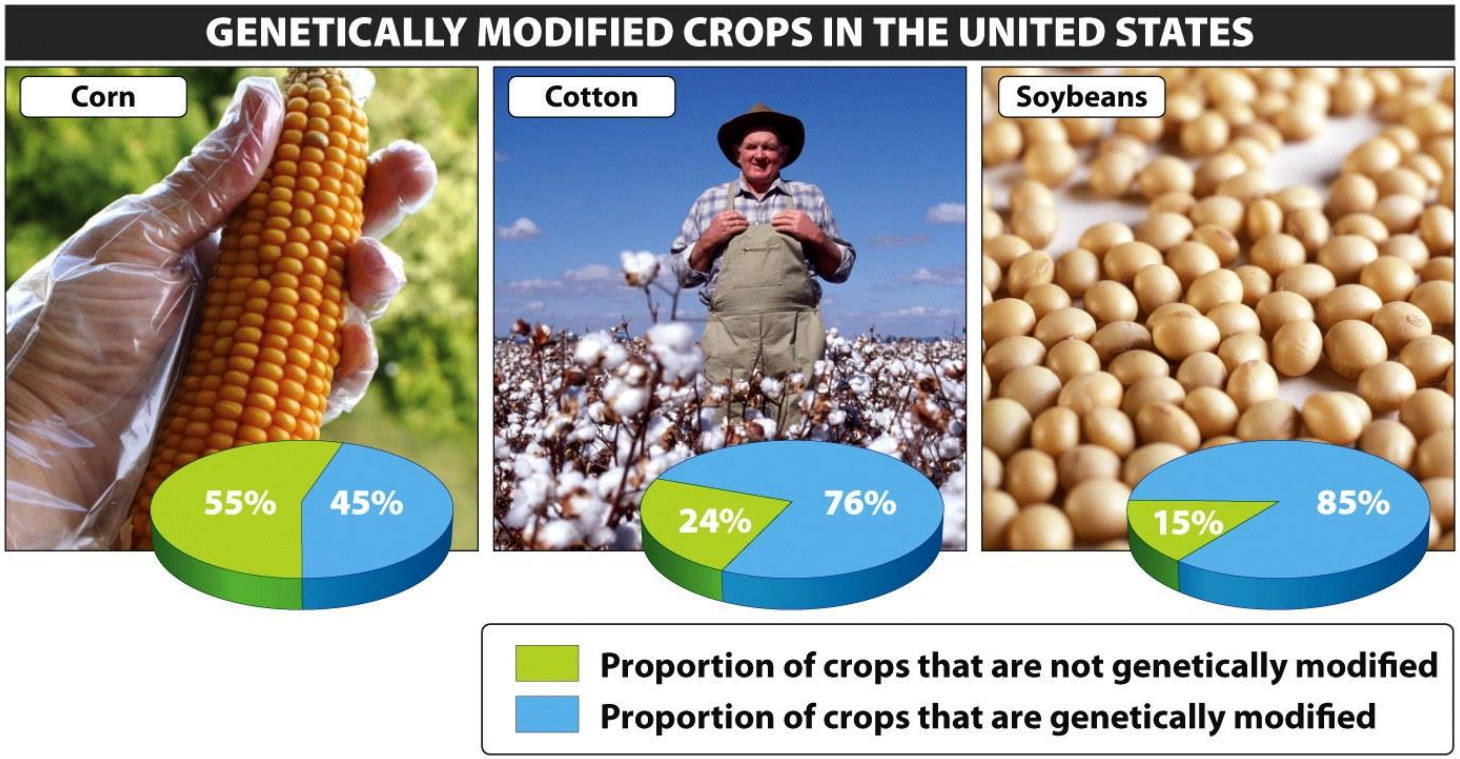


Figure 5-32

Insect Resistance – Toxic Bt crystals spryaed on plants

Figure 5-33
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How can genetically modified plants lead to reduced pesticide use by farmers?

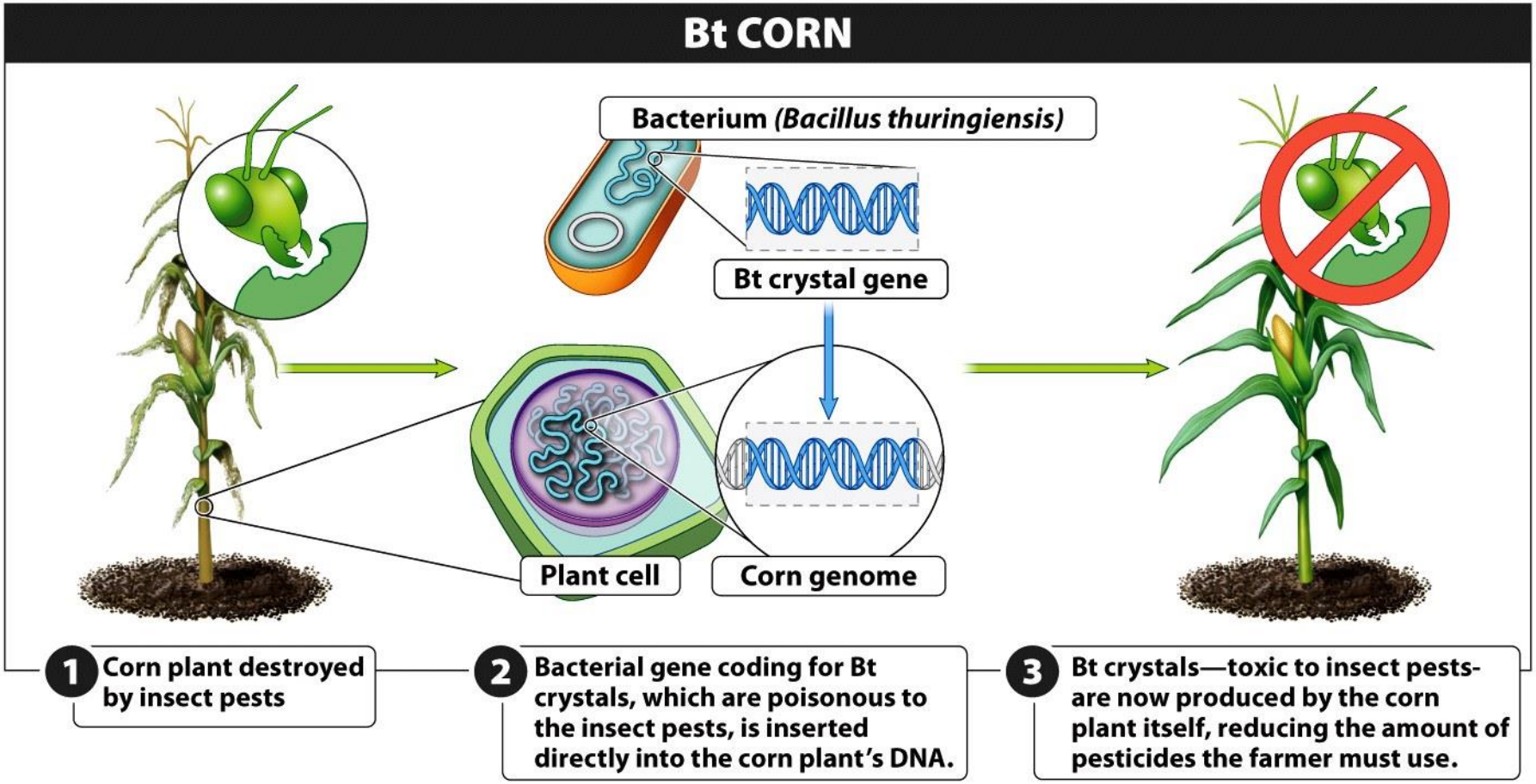

Figure 5-34
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Herbicide Resistance

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

Figure 5-35
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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.

Figure 5-38
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- Fear #4. Eating genetically modified foods is dangerous
- Fear #5. Loss of genetic diversity among crop plants is risky.
- Fear #6. Hidden costs may reduce the financial advantages of genetically modified crops.

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

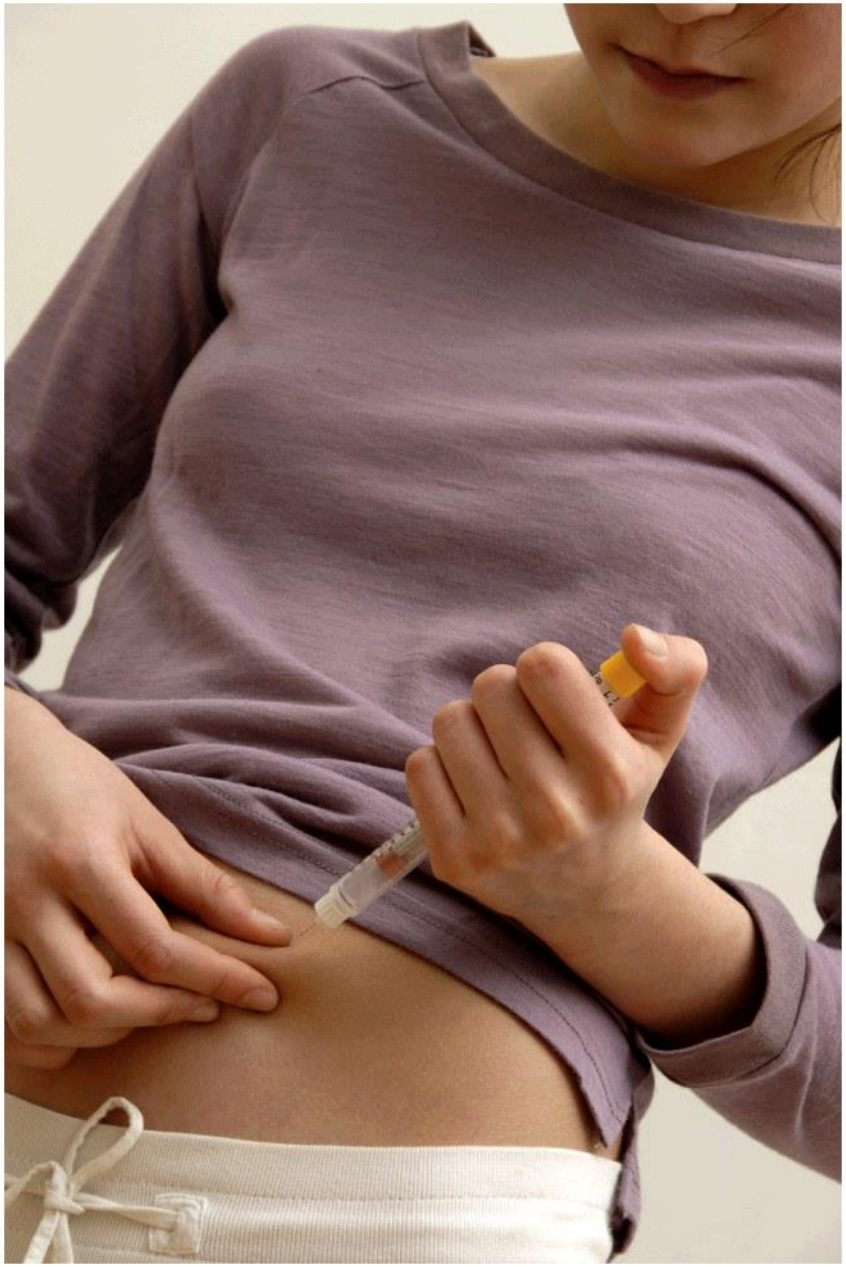

Figure 5-39
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Several important achievements followed the development of insulin-producing bacteria, including:

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?

Figure 5-41
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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?

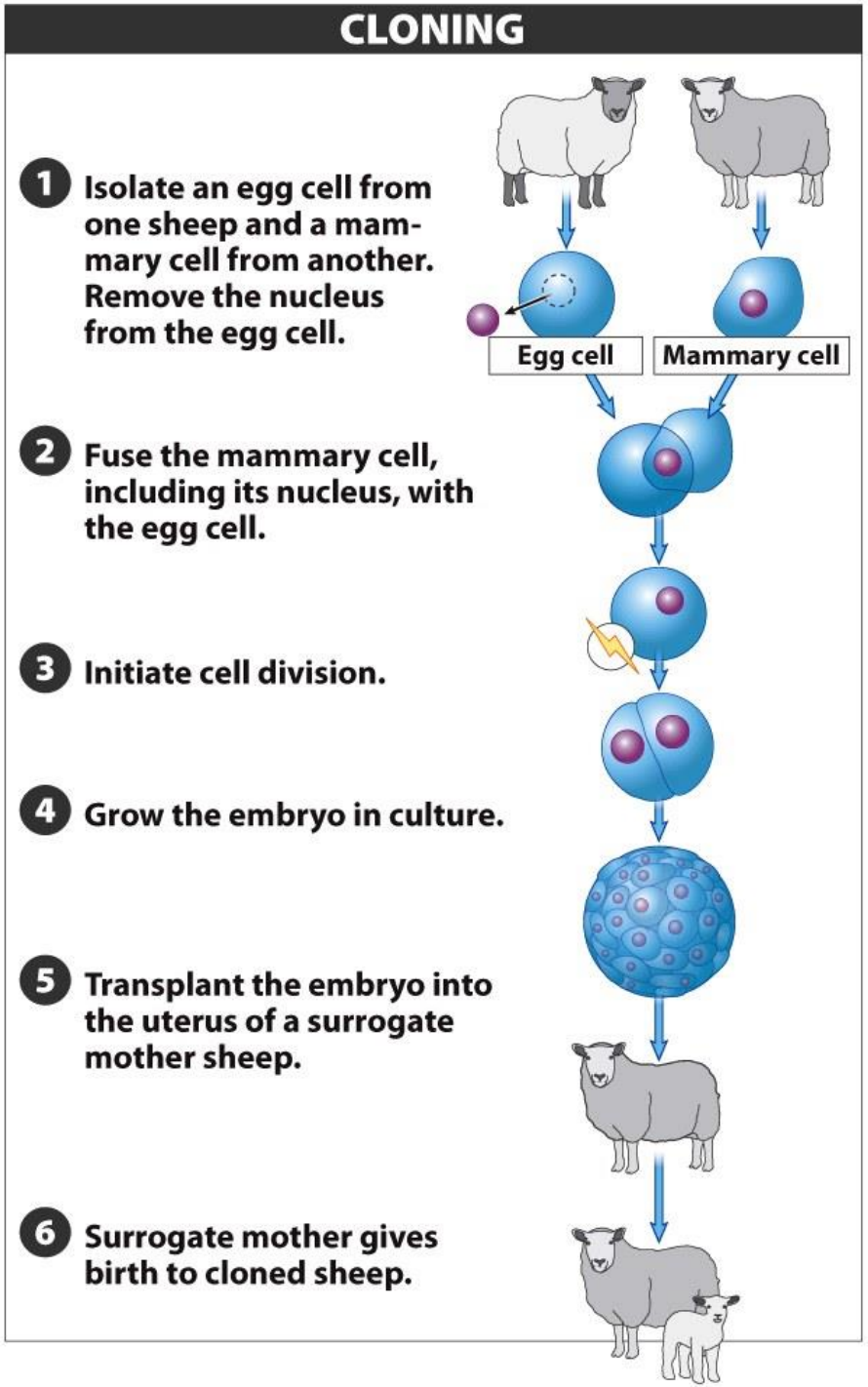
- Breast cancer
- Prostate cancer
- Skin cancer

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

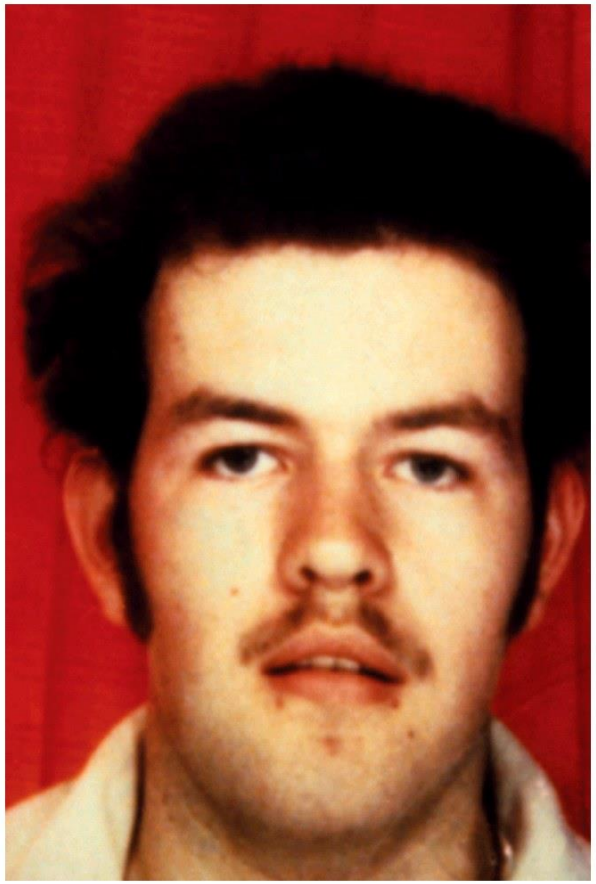


Figure 5-45a
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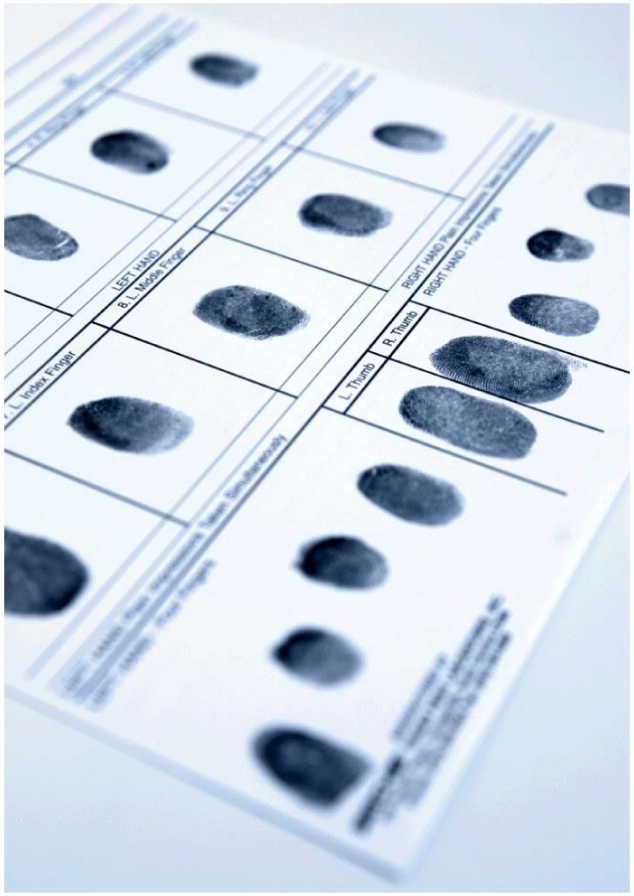

Figure 5-45b
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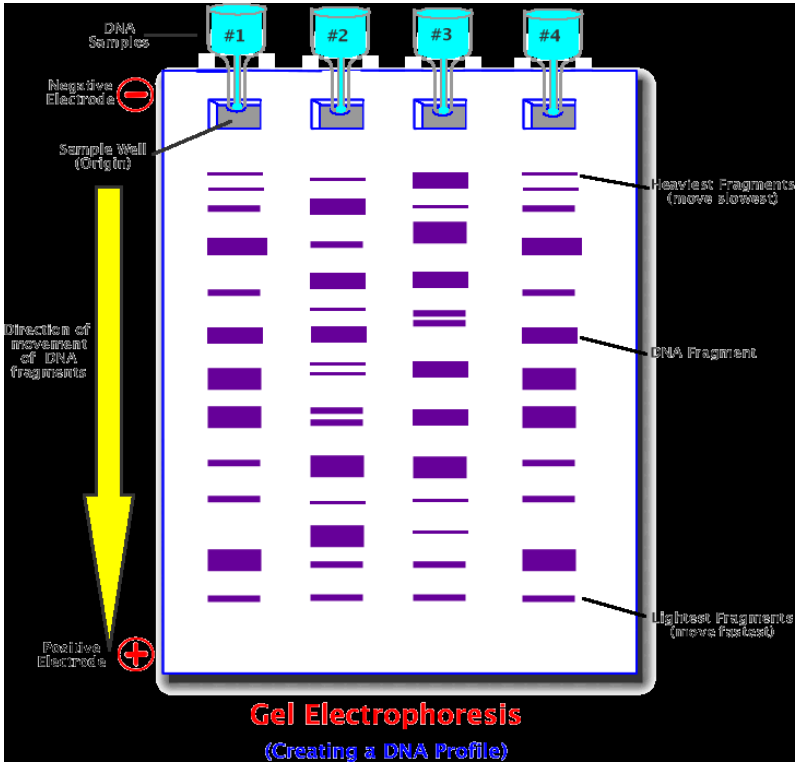
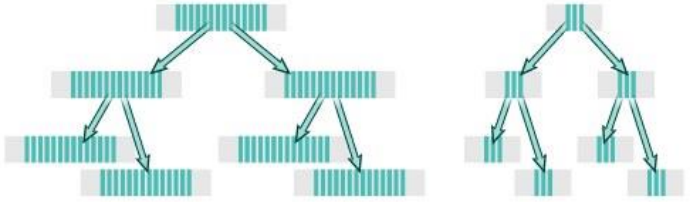
What is a DNA fingerprint?



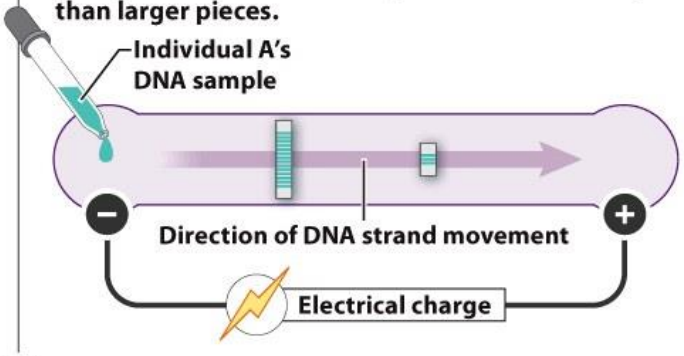
CREATING A DNA FINGERPRINT

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

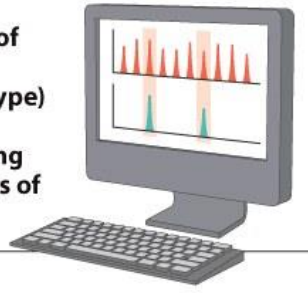
1 For each of the 13 STR loci used to construct an individual's DNA fingerprint, the DNA fragment containing each STR region is amplified using PCR, resulting in huge numbers of those fragments. The amplified DNA fragments differ in size, depending on how many times the repeating unit of that STR is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