15.3 Applications of Genetic Engineering

Agriculture and Industry

- Almost everything we eat and much of what we wear come from living organisms.

- Researchers have used genetic engineering to try to improve the products we get from plants and animals.

- Genetic modification could lead to better, less expensive, and more nutritious food as well as less harmful manufacturing processes.

GM Crops

- Since their introduction in 1996, genetically modified (GM) plants have become an important component of our food supply.
- One genetic modification uses bacterial genes that produce a protein known as Bt toxin.
- This toxin is harmless to humans and most other animals, but enzymes in the digestive systems of insects convert Bt to a form that kills the insects.
- Plants with the Bt gene do not have to be sprayed with pesticides.
- In addition, they produce higher yields of crops.

GM Animals

- Transgenic animals are becoming more important to our food supply.
- About 30 percent of the milk in U.S. markets comes from cows that have been injected with hormones made by recombinant-DNA techniques to increase milk production.
- Pigs can be genetically modified to produce more lean meat or high levels of healthy omega-3 acids.
- Using growth-hormone genes, scientists have developed transgenic salmon that grow much more quickly than wild salmon.
- Scientists are working to combine a gene for lysozyme—an antibacterial protein found in human tears and breast milk—into the DNA of goats.
- Milk from these goats may help prevent infections in young children who drink it.

Preventing Disease

- Golden rice is a GM plant that contains increased amounts of provitamin A, also known as beta-carotene—a nutrient that is essential for human health. Two genes engineered into the rice genome help the grains produce and accumulate beta-carotene.

  Provitamin A deficiencies produce serious medical problems, including infant blindness. There is hope that provitamin A–rich golden rice will help prevent these problems.

- Other scientists are developing transgenic plants and animals that produce human antibodies to fight disease.

Treating Disease

- Recombinant-DNA technology can be used to make important proteins that could prolong and even save human lives.

- For example, human growth hormone, which is used to treat patients suffering from pituitary dwarfism, is now widely available because it is mass-produced by recombinant bacteria.

- Other products now made in genetically engineered bacteria include insulin to treat diabetes, blood-clotting factors for hemophiliacs, and potential cancer-fighting molecules.

Treating Disease

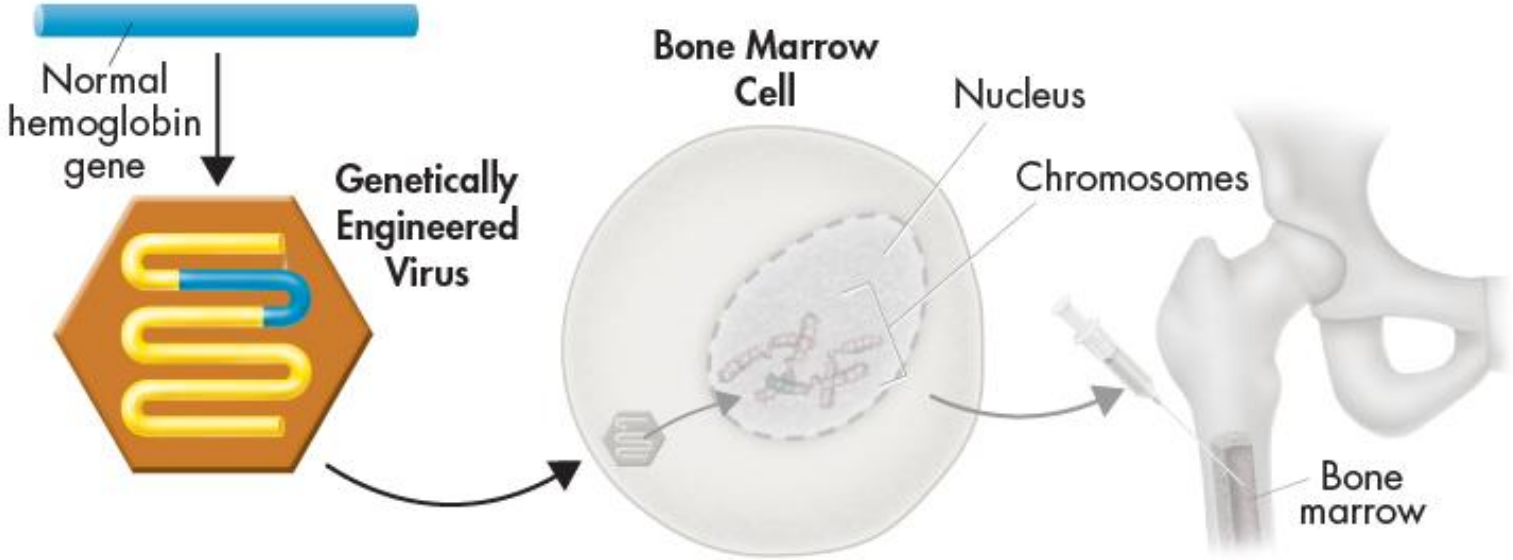
- **Gene therapy** is the process of changing a gene to treat a medical disease or disorder.

- In gene therapy, an absent or faulty gene is replaced by a normal, working gene.

- This process allows the body to make the protein or enzyme it needs, which eliminates the cause of the disorder.

Treating Disease —
One Example of Gene Therapy

- To deliver therapeutic genes to target cells researchers engineer a virus that cannot reproduce or cause harm.
- The DNA containing the therapeutic gene is inserted into the modified virus.
- The patient's cells are then infected with the genetically engineered virus.
- In theory the virus will insert the healthy gene into the target cell and correct the defect.



Treating Disease

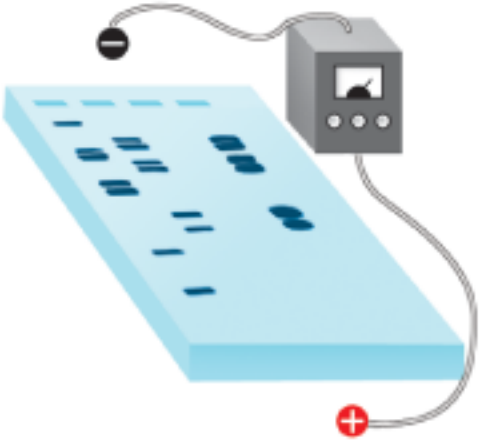
- Gene therapy can be risky.

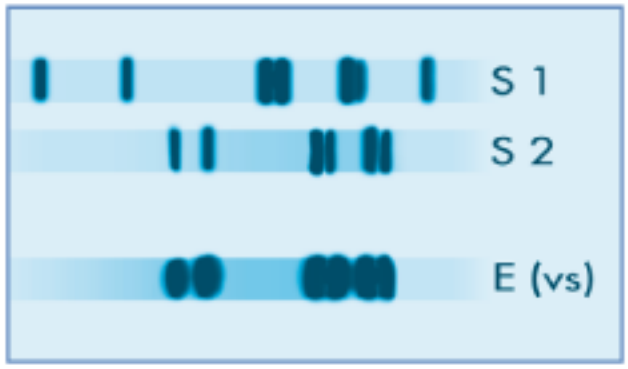
- In 1999, 18-year-old Jesse Gelsinger volunteered for a gene therapy experiment designed to treat a genetic disorder of his liver. He suffered a massive reaction from the viruses used to carry genes into his liver cells, and he died a few days later.

- For gene therapy to become an accepted treatment, we need more reliable ways to insert working genes and to ensure that the DNA used in the therapy does no harm.

Personal Identification

- In DNA fingerprinting, restriction enzymes first cut a small sample of human DNA into fragments containing genes and repeats. Note that the repeat fragments from these two samples are of different lengths.
- Next, gel electrophoresis separates the restriction fragments by size.
- DNA samples can be obtained from blood, sperm, or tissue—even from a hair strand if it has tissue at the root.





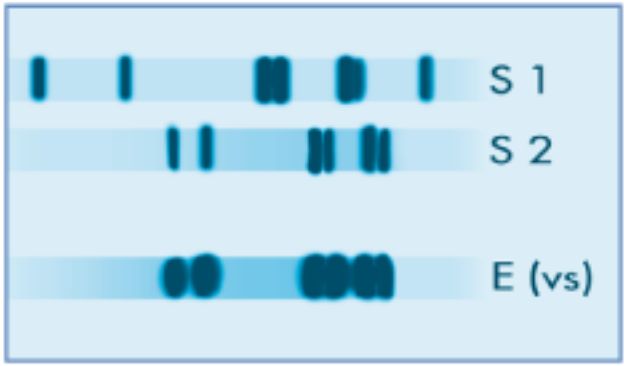
DNA fingerprint

Forensic Science

- The precision and reliability of DNA fingerprinting has revolutionized **forensics**—the scientific study of crime scene evidence.

- DNA fingerprinting has helped solve crimes, convict criminals, and even overturn wrongful convictions.

- To date, DNA evidence has saved more than 110 wrongfully convicted prisoners from death sentences.



DNA fingerprint