Adv. Biology: Gene Technology Unit
Study Guide

- Chapter 13
- All vocabulary – Textbook Printouts
- **Selective breeding** – the process by which desired traits of certain plants and animals are selected and passed on to their future generations.
    - Produces organisms with desired traits
    - Increasing the frequency of certain alleles in a population is the essence of genetic technology.
    - Through the processes of hybridization and inbreeding, desired traits can be passed on to future generations.
- Why is selective breeding used? – to have organisms with desired traits
    - Dog breeding – to do certain tasks, be a show dog – nicest coat and teeth
    - Horses – for racing and showing
    - Example: In 1947, cows were producing 4997 pounds of milk on average, but because of selective breeding in 1997 the average went up to 16, 915 pounds of milk in a year
- **Inbreeding** - the process, in which two closely related organism are bred to have the desired traits and to eliminate the undesired ones in future generations.
    - Mating between closely related individuals,
        - Ensures that the organisms are homozygous for most traits.
    - Why would breeders do this?
        - To make sure breeding is pure and the organism has desired traits.
    - Can bring out harmful recessive traits because 2 individuals are closely related and can both carry a harmful allele.
        - Example: Horses and dogs are organisms that breeders have developed as pure breeds through inbreeding.
- Compare inbreeding with hybridization.
    - **Inbreeding** is the process in which two closely related organisms are bred to have the desired traits and to eliminate the undesired ones in future generations. It creates pure breeds. A disadvantage of inbreeding is that harmful recessive traits also can be passed onto future generations. Inbreeding increases the chance of homozygous recessive offspring. If both parents carry the recessive allele, the harmful trait likely will not be eliminated.
    - **Hybridization** produces organism with desired/specific traits from parent organisms with different traits. Traits are selected that will give hybrid organisms a competitive edge such as more disease-resistant, able to produce more offspring, or grow faster. A disadvantage is that it is time consuming and expensive. The advantages sometimes outweigh the disadvantages.
- Genetic Engineering and recombinant DNA
    - **Genetic Engineering** – technology that involves manipulating the DNA of one organism in order to insert exogenous DNA (the DNA of another organism.)

        - Example: Researchers have inserted a gene for a bioluminescent protein called green fluorescent protein (GFP) into various organisms. GFP, which is a substance naturally found in jellyfishes that live in the north Pacific Ocean, emits a green light when it its exposed to ultraviolet light.
    - **Recombinant DNA** - newly generated DNA molecule, with DNA from different sources / DNA from different sources combined together
        - When DNA fragments have been separated by gel electrophoresis, fragments of a specific size can be removed from the gel and combined with DNA fragments from another source.
        - Recombinant DNA technology has revolutionized the way scientists study DNA because it enables individual genes to be studied.
        - Large quantities of recombinant DNA molecules are needed in order to study them. A carrier, called a vector, transfers the recombinant DNA into a bacterial cell called the host cell. Plasmids and viruses are commonly used vectors.
        - **Enables individual genes in DNA to be studied**
        - **Circular DNA, called plasmids are in bacteria and yeast, they can be used to transfer recombinant DNA.**
        - **If you want to make a large amount of recombinant plasmids, mix bacterial cells with recombinant DNA and some bacterial cells might take up the recombinant plasmid DNA through a process called <u>transformation</u>**.
- How can genetic engineering improve human health?/ How does genetic engineering manipulate DNA?
    - These genetically engineering organisms are used in various processes, such as studying the expression of a particular gene, investing cellular processes, studying the development of a certain disease, and selecting traits that might be beneficial to humans.
    - These genetically engineering organisms are used in various processes, such as studying the expression of a particular gene, investing cellular processes, studying the development of a certain disease, and selecting traits that might be beneficial to humans.
- Compare and contrast selective breeding and genetic engineering
    - You have learned that selective breeding is used to produce plants and animals with desired traits. Genetic engineering can be used to increase or decrease the expression of specific genes in selected organisms. It has many applications from human health to agriculture.
- Genome
    - **An organism's genome is the total DNA present in the nucleus of each cell.** Genomes, such as the human genome, can contain millions and millions of nucleotides. In order to study a specific gene, DNA tools can be used to manipulate DNA and to isolate genes from the rest of the genome.
- Restriction enzymes
    - Some types of bacteria contain powerful defenses against viruses.

- **These cells contain proteins called restriction enzymes that recognize and bind to specific DNA sequences and cleave the DNA within that sequence.** A restriction enzyme, also called an endonuclease, cuts the viral DNA into fragments after it enters the bacteria. Since their discovery in the late 1960s, scientists have identified and isolated hundreds of restriction enzymes. Restriction enzymes are used as powerful tools for isolating specific genes or regions of the genome. When the restriction enzyme cleaves genomic DNA, it crates fragments of different sizes that are unique to every individual.
- EcoRI - A restriction enzyme used widely by scientists is EcoRI. As shown in **figure 13.4 below**, EcoRI specifically cuts DNA containing the sequence GAATTC. The ends of the DNA fragments created by EcoRI are called sticky ends because they contain single-stranded DNA that is complementary. The ability of some restriction enzymes to create fragments with sticky ends is important because these sticky ends can be joined together with other DNA fragments that have complementary sticky ends.

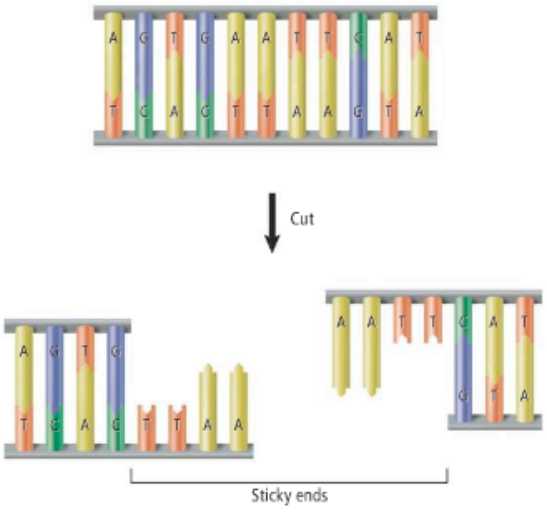
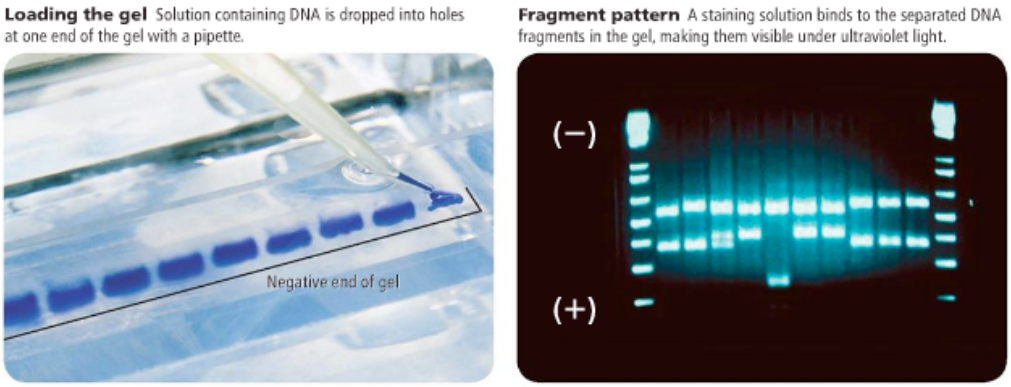


Figure 13.4 DNA containing the sequence GAATTC can be cut by the restriction enzyme *EcoRI* to produce sticky ends.

Concepts in Motion

Interactive Figure To see an animation of restriction enzymes cleaving strands of DNA between specific nucleotides, visit biologygmh.com.

- Gel electrophoresis and DNA Fingerprinting **(See Gel ?s and Fingerprinting Notes)** –
  - Gel electrophoresis – An electric current is used to separate the DNA fragments according to the site of the fragments in a process called gel electrophoresis.
    - The **figure 13.5 below** shows how the DNA fragments are loaded on the negatively charged end of a gel. When an electric current is applied, the DNA fragments move toward the positive end of the gel. The smaller fragments move further faster than the larger ones. The unique pattern created based on the size of the DNA fragment can be compared to known DNA fragments for identification. Also, portions of the gel containing each band can be removed for further study.



However, not all restriction enzymes create sticky ends. Some enzymes produce fragments containing blunt ends—created when the restriction enzyme cuts straight across both strands. Blunt ends do not

Figure 13.5 When the loaded gel is placed in an electrophoresis tank and the electric current is turned on, the DNA fragments separate.

- DNA Fingerprinting – involves separating these DNA fragments using gel electrophoresis in order to observe the distinct banding patterns that are unique to every individual.

- How do forensic scientists use DNA Fingerprinting? - Forensic scientists use DNA fingerprinting to identify suspects and victims in criminal cases, to determine paternity, and to identify soldiers killed in war.

Figure 13.13 People can be identified using the genetic information contained in blood, hair, semen, or skin.

Figure 13.13 shows a sample obtained from hair that forensic scientists can use for DNA fingerprinting. PCR is used to copy this small amount of DNA to create a larger sample for analysis. The amplified DNA then is cut using different combinations of restriction enzymes. The fragments are separated by gel electrophoresis and compared to DNA fragments from known sources, such as victims and suspects in a criminal case, to locate similar fragmentation patterns. There is a high probability that the two DNA samples came from the same person if two fragmentation patterns match. Since its development in England in 1985, DNA fingerprinting has been used not only to convict criminals but also to free innocent people who had been wrongfully imprisoned. **Figure 13.14** provides a closer look at the history of genetic technology.

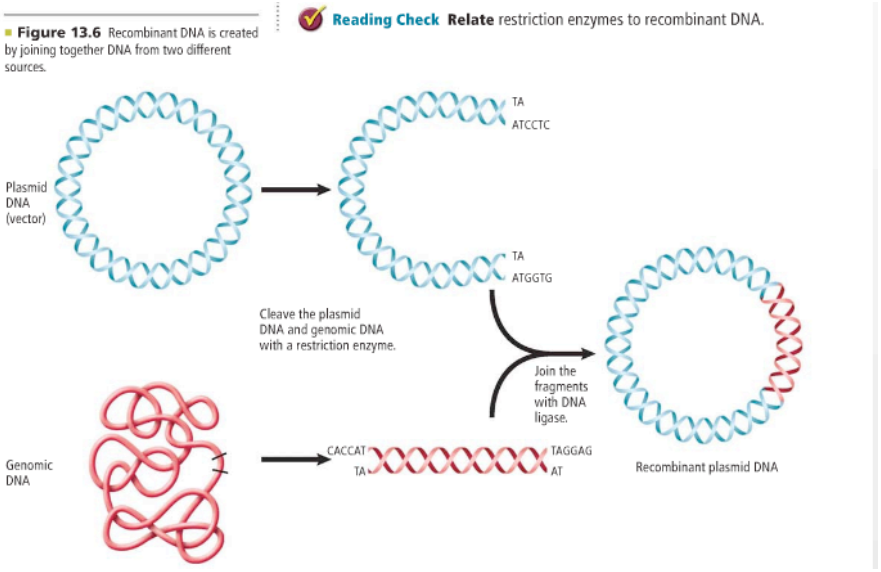
Reading Check **Summarize** how forensic scientists use DNA fingerprinting.

Identifying Genes

Once the genome has been sequenced, the next step in the process is to identify the genes and determine their functions. The functions of many of the genes in the human genome are still unknown. Researchers use techniques that integrate computer analysis and recombinant DNA technology to determine the function of these genes.

For organisms such as bacteria and yeast, whose genomes do not have large regions of noncoding DNA, researchers have identified genes

- Know how to read a DNA Fingerprint. – See Notes/?s
- Plasmids - small, circular, double-stranded DNA molecules that occur naturally in bacteria and yeast cells – can be used as vectors because they can be cut with restriction enzymes, If a plasmid and a DNA fragment obtained from another genome have been cleaved by the same restriction enzyme, the ends of each DNA fragment will be complementary and can be combined, as shown in Figure 13.6 below.
    - (An enzyme normally used by cells in DNA repair and replication, called **DNA ligase**, joins the two DNA fragments chemically. Ligase joins DNA fragments that have sticky ends as well as those that have blunt ends.)



- Transformations
  - To make a large quantity of recombinant plasmid DNA, bacterial cells are mixed with recombinant plasmid DNA.
  - **Some of the bacterial cells take up the recombinant plasma DNA through a process called transformation, as shown in Figure 13.7 below**. Bacterial cells can be transformed using electric pulsation or heat Recall that all cells, including bacterial cells, have plasma membranes. A short electric pulse or a brief rise in temperature temporarily creates openings in the plasma membrane of the bacteria. These temporary openings allow small molecules, such as the recombinant plasmid DNA, to enter the bacterial cells. The bacterial cells make copes of the recombinant plasmid DNA during cell replication.

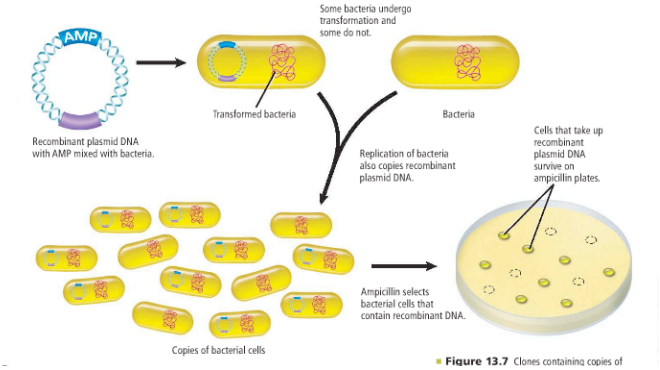
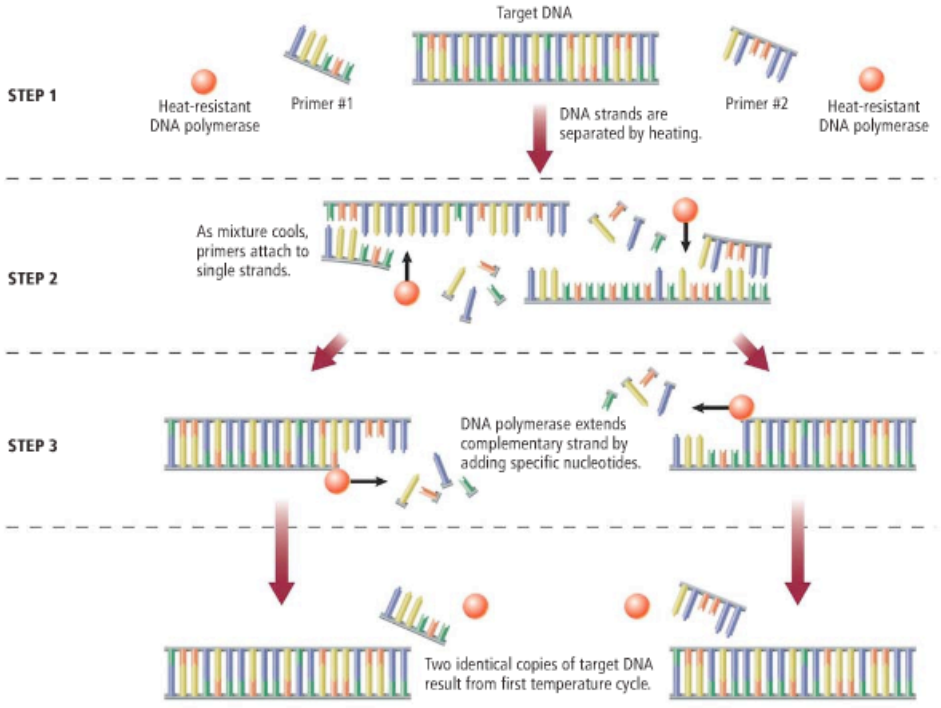


Figure 13.7 Clones containing copies of the recombinant DNA can be identified and used for further study when the bacterial cells that do not contain recombinant DNA die.

- Cloning – large numbers of identical bacteria, each containing the inserted DNA molecules, can produce through this process called cloning.
  - Two types of cloning
    - Reproductive – animal or person in cloned
    - Therapeutic – spare parts that help the sick are cloned
  - Dolly cloned sheep, was 1st clone – some
  - Are ethical issues w/ cloning – try to create perfect human, against nature
  - Pigs can be genetically modified to produce organs for humans

    - Environment can affect how clone acts or appears – UV Rays effect this
    - Identical twins = clones
- How does cloning occur? – see above
- PCR **(sheet)**– Once the sequence of the DNA fragment is known, a technique called the polymerase chain reaction that can be used to make millions of copies of a specific region of a DNA fragment. PCR is extremely sensitive and can detect a single DNA molecule in a sample. PCR is useful because this single DNA molecule then can be copied, or amplified, numerous times to be used for DNA analysis. **Below in Figure 13.9** are the steps of PCR.
    - Millions of copies of DNA would be needed at a crime scene – need to do DNA analysis

Figure 13.9 PCR is a biological version of a copy machine. During each PCR cycle, the reaction mixture is heated to separate the DNA strands and then cooled to allow primers to bind to complementary sequences. The DNA polymerase then adds nucleotides to form new DNA molecules.



- Transgenic organisms – organisms, such as the mosquito larvae, genetically engineering by inserting a gene from another organism. Transgenic animals, plants, and bacteria are used not only for research, but also for medical and agricultural purposes.
- The human genome – see Notes Sheet
- What are the parts of the human genome? – **The goal of the HGP was to determine the sequence of the approximately three billion nucleotides that make up human DNA and to identify all the 23,299 human genes.**

- After sequencing the human genome, scientists observed that less than 2% of all the nucleotides in the human genome code for all the proteins in the body. That is, the genome is filled w/ long stretches of repeated sequences that have no direct function. These regions are called noncoding sequences.

- How can information from the human genome project be used to treat human diseases? – see pgs. 377+378 for important

The Genome and Genetic Disorders

Although more than 99 percent of all nucleotide base sequences are exactly the same in all people, sometimes there are variations that are linked to human diseases. These variations in the DNA sequence that occur when a single nucleotide in the genome is altered are called **single nucleotide polymorphisms** or SNPs (SNIHPS). For a variation to be considered an SNP, it must occur in at least one percent of the population. Many SNPs have no effect on cell function, but scientists hypothesize that SNP maps will help identify many genes associated with many different types of genetic disorders.

The HapMap project An internationl group of scientists is creating a catalog of common genetic variations that occur in humans. Recall from Chapter 10 that linked genes are inherited together. Similarly, genetic variations located close together also tend to be inherited together. Therefore, regions of linked variations in the human genome, known as **haplotypes,** can be located. The project to create this catalog is called the haplotype map, or HapMap project. Assembling the HapMap involves identifying groups of SNPs in a specific region of DNA.

Figure 13.16 shows how the genome is divided into haplotypes. Once completed, the HapMap will describe what these variations are, where they occur in our DNA, and how they are distributed among people within populations and among populations in different parts of the world. This information will help researchers find genes that cause disease and affect an individual's response to drugs.

Pharmacogenomics Sequencing the human genome combines the knowledge of genes, proteins, and SNPs with other areas of science. The study of how genetic inheritance affects the body's response to drugs is called **pharmacogenomics** (far muh koh jeh NAW mihks). The benefits of pharmacogenomics include more accurate dosing of drugs that are safer and more specific. Researchers hope that pharmacogenomics will allow for drugs to be custom-made for individuals based on their genetic makeups. Prescribing drugs based on an individual's genetic makeup will increase safety, speed recovery, and reduce side effects. Perhaps one day when you are sick, your doctor will read your genetic code and prescribe medicine tailor-made for you.

- Gene therapy – a technique aimed at correcting mutated genes that cause human diseases.
  - Scientists insert a normal gene into a chromosome to replace a dysfunctional gene. In most gene therapy studies, inserting a normal gene into a viral vector, like the one in **figure 13.17 below,** produces recombinant DNA. Target cells in the patient are infected with the virus and the recombinant DNA material is released into the affected cells. Once deposited into cells, the normal gene inserts itself into the genome and begins functioning.

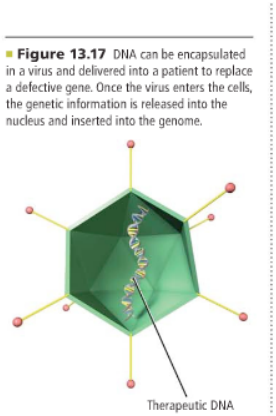


Figure 13.17 DNA can be encapsulated in a virus and delivered into a patient to replace a defective gene. Once the virus enters the cells, the genetic information is released into the nucleus and inserted into the genome.

- Genomics – the study of an organism's genome
  - Sequencing the human genome began what researchers call "the genomic era". Genomics has become one of the most powerful strategies for identifying human genes and interpreting their functions. In addition to the mass of data obtained from sequencing the genomes of humans, rice, mice, fruit flies, and corn, scientists also are investing the proteins produced by these genes.
- Stem cells – **(See notes sheet)** cells that remain undifferentiated during development. They have the ability to become many different types of cells.
  - There are two kinds of stem cells
    - Embryonic Stem Cells
    - Adult Stem Cells
- What are stems cells? What can they be used for? – see above