Summary

Section 16.1 Recombinant DNA technology uses restriction enzymes that can cut DNA into fragments. DNA ligases can splice the fragments into plasmids or some other cloning vector. Recombinant plasmids may be taken up by rapidly dividing cells, such as bacteria. When the host cells replicate, they make multiple, identical copies of the foreign DNA as well.

Bacteria cannot correctly express eukaryotic genes, which contain introns. Reverse transcriptase, a viral enzyme, can make a complementary DNA strand on mRNA. The hybrid molecule can then be converted to cDNA for cloning.

Biology Now

Explore the tools used to make recombinant DNA with the animation on BiologyNow.

Section 16.2 A gene library is a mixed collection of cells that have taken up cloned DNA. Researchers can isolate a gene of interest from a library by using a probe, a short stretch of DNA that can base-pair with the gene and that is traceable (it is labeled with a detectable tag, such as a radioisotope). Probes can help researchers locate and base-pair with one clone among millions. Such base pairing between nucleotide sequences from different sources is known as nucleic acid hybridization.

The polymerase chain reaction (PCR) is a technique for rapidly copying DNA fragments. A sample of a DNA template is mixed with nucleotides, primers, and a heat-resistant DNA polymerase. Each round of PCR proceeds through a series of temperature changes that amplifies the number of DNA molecules exponentially.

Biology Now

Learn how researchers isolate and copy genes with the interaction on BiologyNow.

Section 16.3 Automated DNA sequencing rapidly reveals the order of nucleotides in DNA fragments. As DNA polymerase copies a template DNA, progressively longer fragments stop growing as soon as one of four different fluorescent nucleotides becomes attached to them. Electrophoresis separates the labeled fragments into bands according to length. The order of the colored bands as they migrate through the gel reflects which fluorescent base was added to the end of each fragment, and so indicates the template DNA base sequence.

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Investigate DNA sequencing with the animation on BiologyNow.

Section 16.4 Tandem repeats are multiple copies of a short DNA sequence that follow one another along a chromosome. The number and distribution of tandem repeats, unique in each person, can be revealed by gel electrophoresis; they form a DNA fingerprint.

Biology Now

Observe the process of DNA fingerprinting with the animation on BiologyNow.

Section 16.5 The entire human genome has been sequenced and is now being analyzed. Genomes of other organisms also have been fully sequenced.

The new field of genomics is concerned with the mapping and analysis of genomes. One branch, called comparative genomics, uses similarities and differences between DNA sequences of major groups of organisms to identify their evolutionary relationships.

DNA chips are microarrays used to compare patterns of gene expression within a genome.

Sections 16.6–16.8 Recombinant DNA technology and the mapping and analysis of genomes is the basis for genetic engineering. Genetic engineering is the directed modification of the genetic makeup of an organism, often to modify its phenotype. Researchers insert normal or modified genes from one organism into another of the same or different species. Gene therapies insert copies of modified genes into individuals to cover the functions of a mutant or altered gene.

Genetically engineered bacteria that contain plasmid vectors have diverse uses in basic research, medicine, agriculture, industry, and ecology. Transgenic crop plants help farmers use less toxic pesticides and produce food more efficiently. Genetic engineering of animals allows commercial production of human proteins, as well as research into genetic disorders.

Biology Now

See how the Ti plasmid is used to genetically engineer plants with the animation on BiologyNow.

Section 16.9 There is always a risk that genetically modified experimental organisms can escape from the laboratory. Typically, potentially dangerous types have fail-safe genes built into their genome that will destroy them when exposed to conditions that exist anywhere except in the laboratory. Rigorous tests for safety must precede the release of any modified organism into the environment.

Section 16.10 The goal of human gene therapy is to transfer normal or modified genes into body cells to correct genetic defects. As with any new technology, the benefits must be weighed against potential risks.

Self-Quiz

Answers in Appendix II

1. Researchers can cut DNA molecules at specific sites by using _____ .
   a. DNA polymerase
   b. DNA probes
   c. restriction enzymes
   d. reverse transcriptase

2. Fill in the blank: A _____ is a small circle of bacterial DNA that contains only a few genes and is separate from the bacterial chromosome.

3. By reverse transcription, _____ is assembled on a(n) _____ template.
   a. mRNA; DNA
   b. cDNA; mRNA
   c. DNA; ribosome
   d. protein; mRNA

4. PCR stands for _____ .
   a. polymerase chain reaction
   b. polyploid chromosome restrictions
   c. polygraphed criminal rating
   d. politically correct research

5. Automated DNA sequencing relies on _____ .
   a. supplies of standard and labeled nucleotides
   b. primers and DNA polymerases
   c. gel electrophoresis and a laser beam
   d. all of the above

6. By gel electrophoresis, fragments of DNA can be separated according to _____ .
   a. sequence b. length c. species

7. _____ can be used to insert genes into human cells.
   a. PCR c. Xenotransplantation
   b. Modified viruses d. DNA microarrays

8. For each species, all _____ in a haploid number of chromosomes is the _____ .
   a. genomes; phenotype c. mRNA; start of cDNA
   b. DNA; genome d. cDNA; start of mRNA

9. Match the terms with the most suitable description.
   ____ DNA fingerprint a. selecting "desirable" traits
   ____ Ti plasmid b. mutations, crossovers
   ____ nature's genetic experiments c. used in some gene transfers
   ____ nucleic acid hybridization d. a person's unique collection of tandem repeats
   ____ eugenic engineering e. base pairing of nucleotide sequences from different DNA or RNA source

Additional questions are available on Biology Now™

Critical Thinking

1. Lunardi's Market put out a bin of tomatoes having vine-ripened redness, flavor, and texture. A sign identified them as genetically engineered produce. Most shoppers selected unmodified tomatoes in the adjacent bin even though those tomatoes were pale pink, mealy textured, and tasteless. Which tomatoes would you pick? Why?

2. Biotechnologists envision a new Green Revolution. As they see it, designer plants hold down food production costs, reduce dependence on pesticides and herbicides, enhance crop yields, offer improved flavor and nutritional value, and often produce plants with salt tolerance and drought tolerance. Fruits and vegetables can be designed for flavor, nutritional value, and extended shelf life.

Genetically engineered food crops are widespread in the United States. At least 45 percent of cotton crops, 38 percent of soybean crops, and 25 percent of corn crops have been modified to withstand weedkillers or make their own pesticides. For years, modified corn and soybeans have been used in tofu, cereals, soy sauce, vegetable oils, beer, and soft drinks. They are fed to farm animals.

In Europe especially, public resistance to modified food runs high. Besides arguing that modified foods might be toxic and have lower nutritional value, many people worry that designer plants might cross-pollinate wild plants and produce "superweeds." The chorus of critics in Europe has forced American farmers to keep genetically engineered crops separated from traditional crops. Traditional crops only are exported to Europe. Such separation is both costly and difficult.

Read up on scientific research related to this issue and form your own opinions. The alternatives are to be swayed either by media hype (the term Frankenfood, for instance) or by sometimes biased reports from groups (such as chemical manufacturers), which have their own agendas.

3. The sequencing of the human genome is completed, and knowledge about many genes is being used to detect genetic disorders. Many insurance companies will pay for their female subscribers to take advantage of genetic testing for breast cancer and are willing to allow them to keep the results confidential.

Explain how a health insurance company might benefit financially if it were to encourage its subscribers to take confidential tests for breast cancer susceptibility.

4. Scientists at Oregon Health Sciences University produced Tetra, the first primate clone. They also made the first transgenic primate by inserting a jellyfish gene into a fertilized egg of a rhesus monkey. (The gene codes for a bioluminescent protein that fluoresces green; refer to Section 6.6). The egg was implanted in a surrogate monkey's uterus, where it developed into a male.

The long-term goal of this gene transfer project is not to make glowing-green monkeys. It is the transfer of human genes into primates whose genomes are most like ours. Transgenic primates could yield insight into genetic disorders. That insight might lead to the development of cures for those who are affected and of vaccines for those who are at risk.

Something more controversial is at stake. Will the time come when foreign genes can be inserted into human embryos? Would it be ethical to transfer a chimpanzee or monkey gene into a human embryo to cure a genetic defect? To bestow immunity against a potentially fatal disease such as AIDS? Think about it.