

**Chapter 13 Genetic Engineering****Summary****13-1 Changing the Living World**

For thousands of years, people have chosen to breed only the animals and plants with the desired traits. This technique is called selective breeding. Selective breeding takes advantage of naturally occurring genetic variation in a group of living things.

One tool used by selective breeders is hybridization. In hybridization, individuals with different traits are crossed. Hopefully, the offspring will have the best traits of both parents. The offspring of these crosses, called hybrids, are often hardier than the parents.

Once breeders have a group of plants or animals with the desired traits, they want to keep the traits. To do so, breeders use another tool called inbreeding. In inbreeding, individuals with similar characteristics are crossed. Inbreeding helps to ensure that the characteristics that make each breed unique will be preserved. Inbreeding does have the risk of bringing together two recessive alleles for a genetic defect.

Selective breeding would be nearly impossible without large amounts of variation in traits. Breeders can increase the variation in a group of organisms by causing mutations. Mutations are inheritable changes in DNA. Mutations do occur naturally. However, breeders can increase the rate of mutation by using radiation and chemicals. Many mutations are harmful. However with luck, breeders can produce useful mutations.

The use of mutations is particularly helpful with bacteria. Their small size enables millions of organisms to be treated with radiation or chemicals at the same time. Using this technique, scientists have been able to develop hundreds of beneficial bacteria strains, including bacteria that can digest the oil from oil spills.

New varieties of plants have also been developed using mutants. If chromosomes fail to separate, extra sets of chromosomes result. This is called polyploidy. In animals, polyploidy is usually fatal. In plants, however, the new species that result are larger and stronger than their diploid relatives.

**13-2 Manipulating DNA**

To increase variation, scientists can also make changes directly to the DNA molecule. In this group of techniques, called genetic engineering, scientists can change an organism's DNA.

Scientists can easily remove DNA from a cell and separate it from the other cell parts. Scientists can also cut DNA into smaller pieces using enzymes called restriction enzymes. Each restriction enzyme cuts DNA at a specific sequence of nucleotides. These DNA fragments can be separated and analyzed in a process called gel electrophoresis.

Scientists can also read the order of nucleotide bases in a DNA fragment. They use a technique in which a single strand of DNA is copied. However, the copy is made with colored nucleotides inserted at random places. Reading the order of colored bands in a gel gives the nucleotide sequence of the DNA fragment.

Scientists can change DNA sequences in many different ways. Short sequences of DNA made in the laboratory can be joined to the DNA molecule of an organism. DNA from one organism can be attached to the DNA of another organism. These DNA molecules are called recombinant DNA because they are made by combining DNA from different sources.

Scientists often need many copies of a certain gene to study it. A technique called polymerase chain reaction (PCR) allows scientists to do that. PCR is a chain reaction in which DNA copies become templates to make more DNA copies.

### 13-3 Cell Transformation

DNA fragments cannot work by themselves. They must be part of the DNA molecule in an organism. DNA fragments become part of a cell's DNA during the process of transformation. This is the same process that Griffith observed in his experiments.

To add DNA fragments to bacteria, a fragment is joined to a small, circular piece of DNA called a plasmid. Plasmids are found naturally in some bacteria. Scientists join the fragment to the plasmid by cutting both with the same restriction enzymes. The cut pieces join together because their ends match up.

When scientists transform bacteria, not all bacteria take in the plasmid. Scientists can identify those bacteria that carry the plasmid because the plasmid also carries a genetic marker. Usually, the genetic marker is a gene that gives the bacteria resistance to a certain antibiotic.

Plant cells can also be transformed. Scientists insert the DNA fragment into a plasmid. This plasmid is transformed into a bacterium that naturally infects plants. Plant cells in a culture that have had their cell walls removed will also take up DNA on their own. Scientists can also inject DNA directly into some plant cells.

Animal cells can be transformed in ways similar to those used for plant cells. Many egg cells are large enough that DNA can be directly injected into the nucleus. Once inside, the repair enzymes may help insert the DNA fragment into the chromosomes of the injected cell.

### 13-4 Applications of Genetic Engineering

Scientists wondered whether genes from one organism would work in a different organism. Some scientists isolated the gene from fireflies that allows them to glow. Then, they inserted this gene into the DNA of a plant. These plants glowed in the dark. This showed that plants and animals use the same process to translate DNA into proteins. The glowing plant is transgenic because it has a gene from another species.

Human genes have been added to bacteria. These transgenic bacteria are used to produce human proteins such as insulin, human growth hormone, and clotting factor.

Scientists have produced transgenic animals to study the function of genes and to improve the food supply. Transgenic animals might also be used to supply us with human proteins that can be collected in the animal's milk.

Transgenic plants have been produced that can make their own insecticide. Others are resistant to weed killers. Some have even been engineered to contain vitamins needed for human health.

A clone is a member of a population of genetically identical cells that were produced from a single cell. Clones are useful because it is one way to make copies of transgenic organisms. It is easy to produce cloned bacteria and plants.

Animals are very difficult to clone. However, scientists in Scotland successfully cloned a sheep, named Dolly. Animal cloning has risks. Studies suggest that cloned animals may have genetic defects and other health problems.

**Chapter 13 Genetic Engineering**

**Section 13-1 Changing the Living World**

(pages 319-321)



**Key Concepts**

- What is the purpose of selective breeding?
- Why might breeders try to induce mutations?

**Selective Breeding (pages 319-320)**

1. What is meant by selective breeding? \_\_\_\_\_  
\_\_\_\_\_
2. Circle the letter of each organism that has been produced by selective breeding.  
a. horses      b. dogs      c. cats      d. potatoes
3. Who was Luther Burbank? \_\_\_\_\_  
\_\_\_\_\_
4. Complete the table describing the types of selective breeding.

**SELECTIVE BREEDING**

Type	Description	Examples
	Crossing dissimilar individuals to bring together the best of both organisms	
	The continued breeding of individuals with similar characteristics	

5. Is the following sentence true or false? Hybrids are often hardier than either of the parents. \_\_\_\_\_
6. What two plant traits did Luther Burbank try to combine in his crosses?  
a. \_\_\_\_\_  
b. \_\_\_\_\_
7. Is the following sentence true or false? To maintain the desired characteristics of a line of organisms, breeders often use hybridization. \_\_\_\_\_
8. Most members of a breed are genetically \_\_\_\_\_.
9. What are the risks of inbreeding? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Increasing Variation (pages 320–321)**

10. Why are biologists interested in preserving the diversity of plants and animals in the wild? \_\_\_\_\_  
\_\_\_\_\_
11. Is the following sentence true or false? The genetic variation that exists in nature is enough to satisfy the needs of breeders. \_\_\_\_\_
12. Breeders can increase the genetic variation by inducing \_\_\_\_\_, which are the ultimate source of genetic variability.
13. Circle the letter of an inheritable change in DNA.  
a. variation      b. trait      c. mutation      d. genotype
14. Is the following sentence true or false? Mutations cannot occur spontaneously.  
\_\_\_\_\_
15. Name two methods used by breeders to increase the rate of mutation.  
a. \_\_\_\_\_      b. \_\_\_\_\_
16. Is it easy for breeders to produce mutants with desirable mutations? Explain.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
17. Why are radiation and chemicals useful techniques for producing mutant bacteria?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
18. Is the following sentence true or false? Scientists have produced bacteria that can digest oil. \_\_\_\_\_
19. What technique do scientists use to produce mutant plants? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
20. Circle the letter of each sentence that is true about polyploidy.  
a. Polyploid plants have many sets of chromosomes.  
b. Polyploidy is usually fatal in animals.  
c. Polyploidy produces new species of plants that are weaker and smaller than their diploid relatives.  
d. Bananas and some citrus fruits are polyploid.

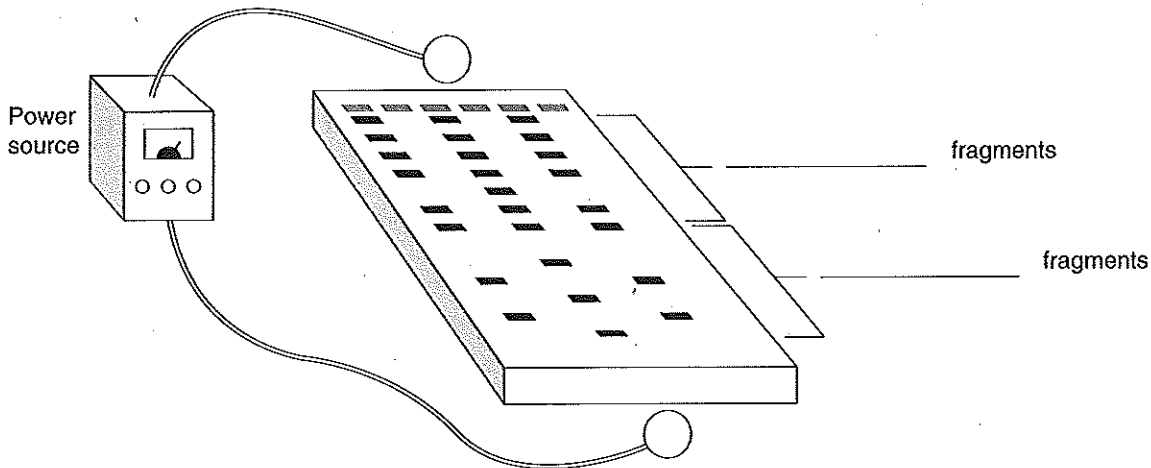
## Section 13-2 Manipulating DNA (pages 322-326)

### Key Concept

- How do scientists make changes to DNA?

### The Tools of Molecular Biology (pages 322-323)

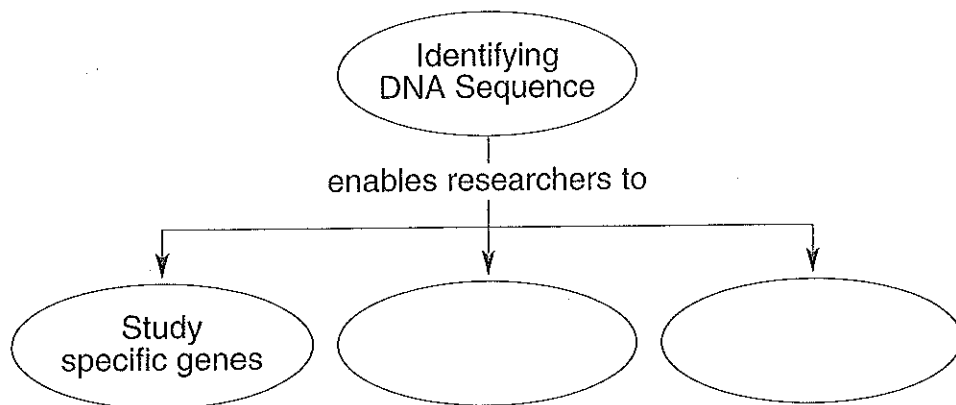
1. What is genetic engineering? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
2. Is the following sentence true or false? Making changes to the DNA code is similar to changing the code of a computer program. \_\_\_\_\_
3. Scientists use their knowledge of the \_\_\_\_\_ of DNA and its \_\_\_\_\_ properties to study and change DNA molecules.
4. List four steps that molecular biologists use to study and change DNA molecules.
  - a. \_\_\_\_\_
  - b. \_\_\_\_\_
  - c. \_\_\_\_\_
  - d. \_\_\_\_\_
5. Explain how biologists get DNA out of a cell. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
6. Biologists use \_\_\_\_\_ to cut DNA molecules at a specific sequence of nucleotides to make smaller fragments.
7. Circle the letter of the process by which DNA fragments are separated and analyzed.
  - a. gel electrophoresis
  - b. extraction
  - c. transformation
  - d. restriction
8. In the diagram below, label the positive and negative ends of the gel and identify the location of longer and shorter fragments.



9. Circle the letter of each sentence that is true about gel electrophoresis.
  - a. An electric voltage applied to the gel separates the DNA fragments.
  - b. DNA molecules are positively charged.
  - c. Gel electrophoresis is used to compare the genomes of different organisms.
  - d. Gel electrophoresis can be used to locate and identify one particular gene in an individual's genome.

**Using the DNA Sequence (pages 323–326)**

10. Complete the concept map to show how researchers use the DNA sequence of an organism.



11. List four "ingredients" added to a test tube to produce tagged DNA fragments that can be used to read a sequence of DNA.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_

12. What does the reaction in the test tube generate when complementary DNA is made for reading DNA? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

13. Is the following sentence true or false? The pattern of colored bands on a gel tells the exact sequence of bases in DNA. \_\_\_\_\_

14. Enzymes that splice DNA together can also be used to join \_\_\_\_\_ DNA sequences to natural DNA sequences.

15. How is recombinant DNA produced? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

16. What is polymerase chain reaction (PCR)? \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

17. What is the role of the primers in PCR? \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

18. Circle the letter of the first step in the polymerase chain reaction.

- a. The copies become templates to make more copies.
- b. The DNA is cooled to allow the primers to bind to the single-stranded DNA.
- c. The DNA is heated to separate its two strands.
- d. DNA polymerase makes copies of the region between the primers.

**Reading Skill Practice**

A flowchart is useful for organizing the steps in a process. Make a flowchart that shows the steps molecular biologists use to determine the order of bases in a segment of a DNA molecule.

## Section 13-3 Cell Transformation (pages 327-329)

### Key Concepts

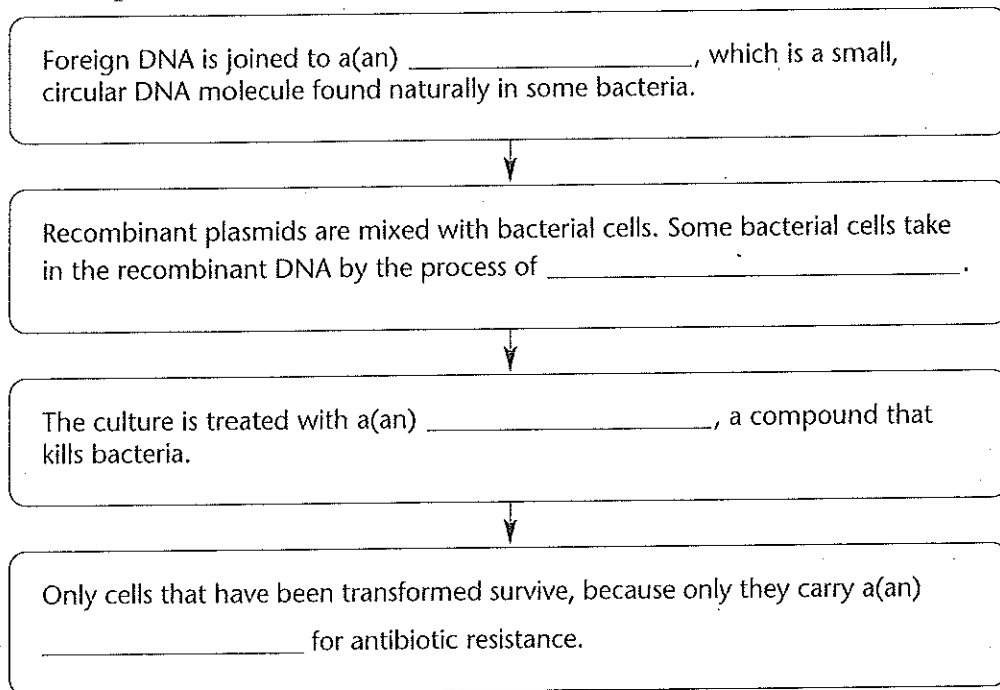
- What happens during cell transformation?
- How can you tell if a transformation experiment has been successful?

### Introduction (page 327)

1. What occurs during transformation? \_\_\_\_\_  
\_\_\_\_\_
2. Is the following sentence true or false? Griffith's extract of heat-killed bacteria contained DNA fragments. \_\_\_\_\_

### Transforming Bacteria (pages 327-328)

3. Complete the flowchart to show the steps in transforming bacteria.



4. Give two reasons why a plasmid is useful for DNA transfer.
  - a. \_\_\_\_\_  
\_\_\_\_\_
  - b. \_\_\_\_\_  
\_\_\_\_\_

### Transforming Plant Cells (pages 328-329)

5. When researchers transform plant cells using a bacterium that causes plant tumors, how do researchers prevent plant tumors from forming in the transformed cells?  
\_\_\_\_\_  
\_\_\_\_\_



6. Circle the letter of each sentence that is true about transforming plant cells.
- a. Many plant cells can be transformed by using a bacterium that will, in nature, insert a tumor-producing plasmid into plant cells.
  - b. Sometimes plant cells in culture will take up DNA on their own when their cell walls are removed.
  - c. It is impossible to inject DNA directly into plant cells.
  - d. Plant cells that are transformed cannot develop into adult plants.

7. Describe what occurs in a successful transformation of cells. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

### Transforming Animal Cells (page 329)

8. Describe how animal cells can be transformed by directly injecting DNA.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

9. Is the following sentence true or false? The DNA molecules used for transformation of animal cells do not require marker genes. \_\_\_\_\_

10. How is a DNA molecule constructed so that it will eliminate a particular gene?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

11. Is the following sentence true or false? Gene replacement has made it possible to identify the specific functions of genes in many organisms. \_\_\_\_\_

### Reading Skill Practice

When you read about related concepts, a compare-and-contrast table can help you focus on their similarities and differences. Construct a table to compare and contrast transformation in bacteria, plants, and animals. Look in Appendix A for more information about compare-and-contrast tables. Do your work on a separate sheet of paper.

## Section 13-4 Applications of Genetic Engineering (pages 331-333)

### Key Concept

- How are transgenic organisms useful to human beings?

### Introduction (page 331)

1. How do scientists know that plants and animals share the same basic mechanisms of gene expression? \_\_\_\_\_  
\_\_\_\_\_

### Transgenic Organisms (pages 331-333)

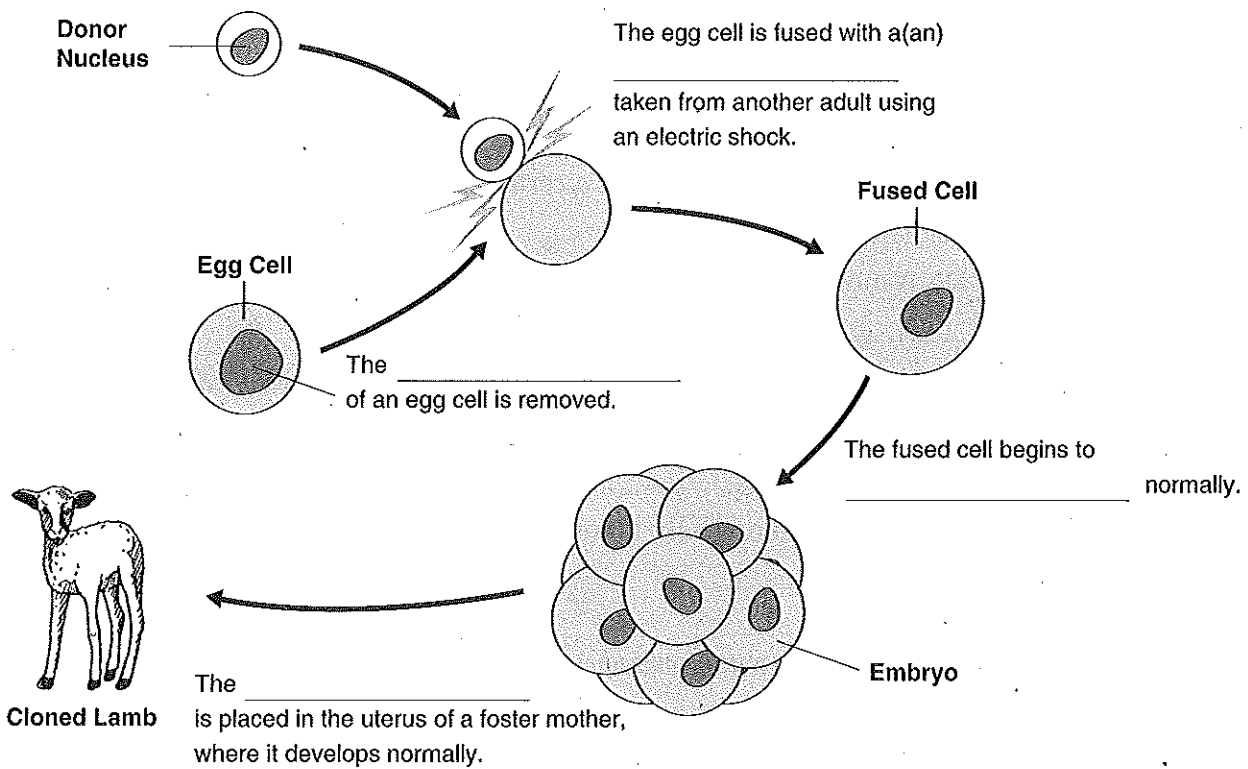
2. What is a transgenic organism? \_\_\_\_\_  
\_\_\_\_\_
3. Describe how to make a transgenic organism. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
4. Genetic engineering has spurred the growth of \_\_\_\_\_, a new industry that is changing the way we interact with the living world.
5. Circle the letter of each sentence that is true about transgenic microorganisms.
  - a. Transgenic bacteria will never produce useful substances for health and industry.
  - b. Transgenic bacteria produce human proteins cheaply and in great abundance.
  - c. People with insulin-dependent diabetes are now treated with pure human insulin.
  - d. In the future, transgenic organisms may produce the raw materials for plastics.
6. List four ways in which transgenic animals have been used.
  - a. \_\_\_\_\_
  - b. \_\_\_\_\_
  - c. \_\_\_\_\_
  - d. \_\_\_\_\_
7. Many transgenic plants contain genes that produce a natural \_\_\_\_\_, so the crops do not have to be sprayed with pesticides.

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8. Circle the letter of each item that might soon be produced by transgenic plants.
- a. human antibodies
  - b. plastics
  - c. rot-resistant foods
  - d. vitamin A-enriched rice

**Cloning (page 333)**

9. What is a clone? \_\_\_\_\_
10. Is the following sentence true or false? For years, many scientists thought that it was impossible to clone bacteria. \_\_\_\_\_
11. Complete the sentences in the diagram below to show the steps in cloning a sheep.



12. Is the following sentence true or false? All cloned animals are also transgenic.  
\_\_\_\_\_
13. What kinds of mammals have been cloned in recent years? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Chapter 13 Genetic Engineering**

## Vocabulary Review

**Completion** Fill in the blanks with terms from Chapter 13.

1. In the process of \_\_\_\_\_, only those animals with desired characteristics are allowed to produce the next generation.
2. The continued breeding of individuals with similar characteristics is \_\_\_\_\_.
3. Through the use of techniques in \_\_\_\_\_, which is the process of making changes in the DNA code of a living organism, scientists have produced bacteria that can make human proteins.
4. A procedure called \_\_\_\_\_ is used to separate a mixture of DNA fragments.
5. DNA molecules produced by combining DNA from different sources are called \_\_\_\_\_.
6. A technique used to produce many copies of a certain gene is called \_\_\_\_\_.
7. A small, circular DNA molecule found naturally in some bacteria is called a(an) \_\_\_\_\_.
8. A gene that makes it possible to identify bacteria that carry a plasmid is called a(an) \_\_\_\_\_.
9. An organism that is \_\_\_\_\_ contains genes from other species.
10. A member of a population of genetically identical cells produced from a single cell is called a(an) \_\_\_\_\_.

**True or False** In the space, write true if the statement is true. If the statement is false, write the term that makes the statement true.

- \_\_\_\_\_ 11. In hybridization, breeders cross dissimilar individuals to bring together the best of both organisms.
- \_\_\_\_\_ 12. Breeders use hybridization to maintain a dog breed.
- \_\_\_\_\_ 13. Scientists use gel electrophoresis to cut DNA at a specific nucleotide sequence.
- \_\_\_\_\_ 14. A plant that glows in the dark is an example of a transgenic organism.
- \_\_\_\_\_ 15. Dolly the sheep is an example of a plasmid.