Chapter 13 Organizer

Refer to pages 4T-5T of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section	Objectives	Activities/Features
Section 13.1 **Applied Genetics** National Science Education Standards UCP.2, UCP.3; A.1, A.2; C.2; E.1, E.2; F.1; G.1-3 (1 session)	1. **Predict** the outcome of a test cross. 2. **Evaluate** the importance of plant and animal breeding to humans.	**Focus On** Selective Breeding of Cats, p. 344 **Problem-Solving Lab 13-1,** p. 347
Section 13.2 **Recombinant DNA Technology** National Science Education Standards UCP.2, UCP.3, UCP.5; A.1, A.2; C.2; E.1, E.2; F.1, F.4, F.5, F.6; G.1, G.2 (2 sessions)	3. **Summarize** the steps used to engineer transgenic organisms. 4. **Give examples** of applications and benefits of genetic engineering.	**MiniLab 13-1:** Matching Restriction Enzymes to Cleavage Sites, p. 351 **Inside Story:** Gel Electrophoresis, p. 354 **Problem-Solving Lab 13-2,** p. 355 **Investigate BioLab:** Modeling Recombinant DNA, p. 362 **BioTechnology:** How to Clone a Mammal, p.364
Section 13.3 **The Human Genome** National Science Education Standards UCP.2, UCP.3; A.1, A.2; C.2; E.1, E.2; F.1, F.6; G.1-3 (2 sessions)	5. **Analyze** how the effort to completely map and sequence the human genome will advance human knowledge. 6. **Predict** future applications of the Human Genome Project.	**MiniLab 13-2:** Storing the Human Genome, p. 358 **Careers in Biology:** Forensic Analyst, p. 359 **Problem-Solving Lab 13-3,** p. 361

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at **http://www.carolina.com**

MATERIALS LIST

BioLab

p. 362 paper, transparent tape, scissors, red and green pencils

MiniLabs

p. 351 paper, pencil
p. 358 paper, pencil, book, calculator (optional)

Alternative Lab

p. 358 microscope, microscope slide, prepared slide of female cheek cells, T-shirt, red ink, red grape juice, human hair (blond and dark), envelopes (4), bar codes (5)

Quick Demos

p. 346 photographs of pets
p. 350 Chromosome Simulation Biokit
p. 359 human chromosome map

Key to Teaching Strategies

- L1 Level 1 activities should be appropriate for students with learning difficulties.
- L2 Level 2 activities should be within the ability range of all students.
- L3 Level 3 activities are designed for above-average students.
- ELL ELL activities should be within the ability range of English Language Learners.
- COOP LEARN Cooperative Learning activities are designed for small group work.
- P These strategies represent student products that can be placed into a best-work portfolio.
- These strategies are useful in a block scheduling format.

Genetic Technology

Teacher Classroom Resources

Section	Reproducible Masters	Transparencies
Section 13.1 **Applied Genetics**	**Reinforcement and Study Guide,** p. 55 L2 **Laboratory Manual,** pp. 91-94 L2 **Content Mastery,** pp. 61, 64 L1	**Section Focus Transparency 32** L1 ELL **Basic Concepts Transparency 19** L2 ELL
Section 13.2 **Recombinant DNA Technology**	**Reinforcement and Study Guide,** pp. 56-57 L2 **BioLab and MiniLab Worksheets,** pp. 61-62 L2 **Laboratory Manual,** pp. 95-98 L2 **Tech Prep Applications,** pp. 21-22 L2 **Content Mastery,** pp. 61-62, 64 L1	**Section Focus Transparency 33** L1 ELL **Reteaching Skills Transparency 22** L1 ELL
Section 13.3 **The Human Genome**	**Reinforcement and Study Guide,** p. 58 L2 **Concept Mapping,** p. 13 L3 ELL **Critical Thinking/Problem Solving,** p. 13 L3 **BioLab and MiniLab Worksheets,** pp. 63-66 L2 **Content Mastery,** pp. 61, 63-64 L1 **Tech Prep Applications,** pp. 21-22 L2	**Section Focus Transparency 34** L1 ELL

Assessment Resources

Chapter Assessment, pp. 73-78
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 13 quiz

Additional Resources

Spanish Resources ELL
English/Spanish Audiocassettes ELL
Cooperative Learning in the Science Classroom COOP LEARN
Lesson Plans/Block Scheduling

NATIONAL GEOGRAPHIC Teacher's Corner

Products Available From National Geographic Society
To order the following products, call National Geographic Society at 1-800-368-2728:
Video
DNA: Laboratory of Life

GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life
CD-ROM ELL
Animation: *Gene Cloning*
Video: *Bioengineering*
Animation: *Recombinant DNA*
Videodisc Program
Gene Cloning
Bioengineering
Recombinant DNA

The Infinite Voyage
The Geometry of Life
Testcross–Homozygous
Testcross–Heterozygous
Miracles by Design

Chapter 13

Getting Started Demo

Bring in several vegetables and fruits such as corn or strawberries and ask how genetic technology could improve them. Answers may include making produce larger, making them bruise less easily, or helping them survive adverse weather conditions such as frost.

Theme Development

The theme of **evolution** is alluded to as students are introduced to selective breeding techniques that achieve new and different traits in offspring. The theme **nature of science** is developed in this chapter as the techniques for changing the genetic makeup of organisms are discussed. Some of the techniques may be used to restore **homeostasis** to organisms afflicted with genetic disorders.

0:00 Out of Time?

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

Chapter

13 Genetic Technology

What You'll Learn

- You will evaluate the importance of plant and animal breeding to humans.
- You will summarize the steps used to engineer transgenic organisms.
- You will analyze how mapping the human genome will benefit human life.

Why It's Important

Genetic technology will continue to impact every aspect of your life, from growing the food you eat to treating a disease you might inherit.

Getting Started

Genetic Technology in Our Lives

Bring in articles from magazines or newspapers dealing with such genetic technology as cloning animals or new medicines. Create a poster with your articles. *What potential do you see for genetic technology to affect your future?*

interNET CONNECTION To find out more about genetic technology, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science**

Genetic technology provides opportunities for changing plants and animals. Dolly the sheep was the first cloned mammal. Strawberry plants have been made frost-resistant by genetic engineering.

Section

13.1 Applied Genetics

SECTION PREVIEW

Objectives

Predict the outcome of a test cross.

Evaluate the importance of plant and animal breeding to humans.

Vocabulary

inbreeding
test cross

For thousands of years, humans have admired the strength, power, and grace of animals like this mountain lion. Through years of selective breeding, people have been able to select certain qualities in plants and animals and breed them so that these qualities are common and more useful to humans. The traits of the mountain lion would not be desirable in a domesticated cat. Instead, gentleness and the ability to provide companionship are traits that have been selectively bred into these pets.

Mountain lion (above) and domesticated cat (inset)

Selective Breeding

The same principle of selective breeding that applies to cats also applies to much of the food we eat and to the animals such as horses that help us with hard labor. You can read about the selective breeding of domesticated cats in the *Focus On* feature on the next page. The process of selective breeding requires time, patience, and several generations of offspring before the desired trait becomes common in a population. Although our ancestors did not realize it, their efforts at selective breeding increased the frequency of a desired allele within a population. Increasing the frequency of desired alleles in a population is the essence of genetic technology.

Selective breeding produces organisms with desired traits

From ancient times, breeders have chosen the plants and animals with the most desired traits to serve as parents of the next generation. Farmers use for seed the largest heads of grain, the juiciest berries, and the most disease-resistant clover. They raise the calves of the best milk producer and save the eggs of the best egg-laying hen for hatching. Breeders of plants and animals want to be sure that their populations breed consistently so that each member shows the desired trait.

Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

Kinesthetic Tech Prep, p. 345; Meeting Individual Needs, p. 350; Project, p. 352; Reteach, 356; Extension, p. 361; Going Further, p. 363

Visual-Spatial Portfolio, p. 345; Meeting Individual Needs, p. 345; Quick Demo, p. 359

Intrapersonal Enrichment, p. 352

Linguistic Biology Journal, pp. 346, 355, 360; Portfolio, p. 353; Meeting Individual Needs, p. 357

Assessment Planner

Portfolio Assessment
- **Portfolio, TWE,** pp. 345, 353, 360
- **MiniLab, TWE,** pp. 351, 358

Performance Assessment
- **Assessment, TWE,** p. 353
- **Problem-Solving Lab, TWE,** p. 355
- **Alternative Lab, TWE,** pp. 358-359
- **BioLab, TWE,** pp. 362-363
- **BioLab, SE,** pp. 362-363
- **MiniLab, SE,** pp. 351, 358

Knowledge Assessment
- **Assessment, TWE,** pp. 346, 348, 356
- **Problem-Solving Lab, TWE,** p. 360
- **Section Assessment, SE,** pp. 348, 356, 361
- **Chapter Assessment, SE,** pp. 365-367

Skill Assessment
- **Problem-Solving Lab, TWE,** p. 347
- **Assessment, TWE,** p. 361

Prepare

Key Concepts

Students will study the role of the test cross as a tool in determining genotypes. They investigate means of achieving desirable traits in plants and animals through the practices of selective breeding and hybridization.

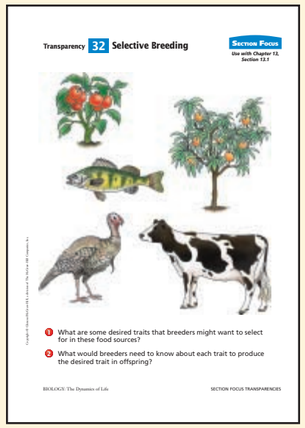
Planning

- Purchase fruits and vegetables for the Getting Started Demo.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 32** on the overhead projector and have students answer the accompanying questions. L1 ELL



Resource Manager

Section Focus Transparency 32 and Master L1 ELL
Tech Prep Applications, pp. 19-20 L2

2 Teach

Focus On

Selective Breeding of Cats

Purpose

Students will gain some insight into the breeding of cats and the influence of cats on human life throughout history.

Background

Cats can be bred for a number of characteristics, including physical traits such as hair length or color. Temperament can also be selected by breeding. Certain breeds have a reputation for being quiet and loving, others for being noisy.

Teaching Strategies

- Make sure that students are familiar with the meaning of the terms *breed* and *selective breeding*.
- Ask students to bring in photographs of their pet cats. If any student's cat is a pure breed, have the student describe distinctive traits or qualities of the breed.

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage
The Geometry of Life
Selective Breeding (Ch. 7)
2 min. 30 sec.

VIDEOTAPE
The Secret of Life
Gone Before You Know It: The Biodiversity Crisis

FOCUS ON

Selective Breeding of Cats

KITTENS (ABOVE AND BELOW) WITH DOMINANT WHITE MARKINGS ON FACE, PAWS, AND THROAT

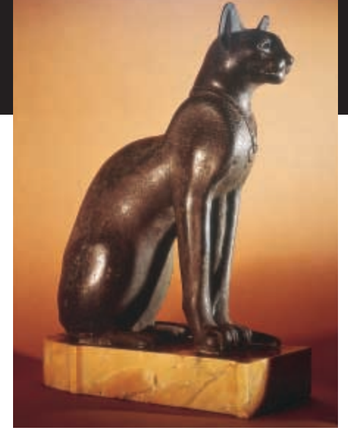
Graceful, agile, and independent, cats are popular pets. In the United States alone, more than 55 million cats are kept as pets. Although the origin of the domestic cat is lost in antiquity, archeological evidence indicates that an association between cats and people existed as much as 3500 years ago in ancient Egypt. Unlike dogs, cattle, and many other domesticated animals, however, cats have only recently been bred selectively to exhibit specific traits. Currently about 40 recognized breeds exist—developed by selectively mating cats having especially desirable or distinctive characteristics. Different breeds vary primarily in color, in length and texture of fur, and in temperament.

SIAMESE

SOMALI—A LONGHAIRED ABYSSINIAN BREED—AT CAT SHOW

COLORFUL COATS

Cats come in many colors, but the most common coats are tabby (a striped or blotchy pattern), black, and orange. Cats with "orange" coats range in color from creamy yellow to dark ginger red. The genetic control of cat fur color is complex and only partially understood. Solid white fur is dominant to all other fur colors. Spots of white—especially on the face, throat, and paws—are also dominant to solid color coats. Some breeds such as the Siamese (below) have been bred for a light-colored body with dark legs, tail, ears, and face—the perfect frame for bright blue eyes.



SCULPTURE OF EGYPTIAN GODDESS BASTET AS A CAT

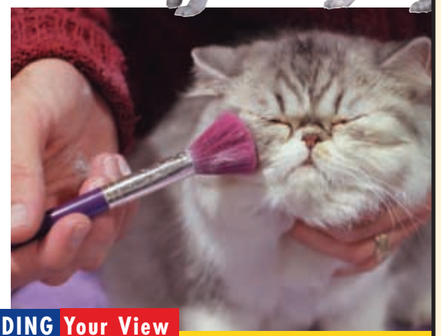
SHORT VERSUS LONG

Cat breeds can be divided into two major groups: those with short hair and those with long. The Abyssinian—slender and regal-looking with large ears and almond-shaped eyes—is a popular short-haired breed. The ancestry of Abyssinians is unclear, but they may be descended from the sacred cats of ancient Egypt. Certainly, their similarity to Egyptian cat sculptures, such as the one at left, is striking. The American shorthair, on the other hand, is a sturdy muscular breed developed from cats that accompanied European settlers to the American colonies.

There are about a dozen breeds of longhaired cats, ranging from the large (up to 13.5 kg, or 30 pounds), shaggy Maine coon cat to the ever-popular Persian. Persian cats (below) are prized for their extremely long fur that stands out from their bodies, especially on the neck, face, and tail. Hundreds of years of careful breeding have refined the distinct "powder puff" appearance of the modern Persian.

TRAITS AND TEMPERAMENTS

Some cats have been bred for special traits. The Manx (right), for example, is tailless. Manx cats trace their roots to the Isle of Man off the coast of England. With hind legs longer than front legs, Manx cats run with a rabbitlike, hopping gait. The breed known as Ragdoll gets its name from the fact that it relaxes its muscles and goes completely limp when picked up. Fearless and calm, the Ragdoll is a fairly new breed of cat, which originated in the United States in the 1960s. Different breeds of cats have different temperaments, or personalities. Siamese tend to be vocal and demanding. The Japanese bobtail—thought to bring good luck—is playful and adaptable. The elegant Abyssinian is known for being quiet and very affectionate.



SILVER MANX TABBY (ABOVE), AND WHITE PERSIAN GETTING GROOMED

EXPANDING Your View

1. **THINKING CRITICALLY** The ancient Egyptians stored large amounts of grain near their cities to ensure there would be enough to eat when crops failed. Speculate on why the ancient Egyptians may have been motivated to domesticate cats.
2. **JOURNAL WRITING** Research a breed of domestic cat. In your journal, write about the breed's history and specific traits for which it was bred.

Visual Learning

- Make a bulletin-board display showing a variety of cat breeds. Have interested students research the history of some of these breeds. L1
- Locate a local cat breeder and have the breeder bring in a cat to demonstrate how you would show a cat at a cat show.

Answers to Expanding Your View

1. Grain would attract rodents that would also carry diseases. Cats would keep the rodent population at a minimum.
2. Answers will vary depending on the breed selected. Check to see whether physical traits such as hair length or color or temperament are mentioned.

TECHPREP

Plant Breeding

Kinesthetic Have students visit a grocery store and take notes and make diagrams of squash varieties. Include any information the store might provide. Then, after the diagrams and information are recorded, advise students that summer squash (crookneck, custard marrow, pattypan, and cymling) are all the same species, *Cucurbita pepo,* and that winter squash (butternut, acorn, hubbard, butterball, spaghetti, pumpkin) are also all the same species, *Cucurbita maxima.* Ask students to write an explanation of how people have achieved such a variety of squash. L2

Cultural Diversity

Cultural Taboos Against Inbreeding

Although inbreeding can result in high rates of stillbirths and children with congenital disorders, scientists are not sure whether taboos against incest are culturally or naturally selected. Explain to students that taboos against inbreeding are not universal, indicating that their origins are cultural rather than genetic. However, individuals brought up in close proximity to each other as family members usually are less likely to develop a sexual interest in each other. This suggests that incest taboos may have a biological component.

Portfolio

Test Cross

Visual-Spatial Have students draw Punnett squares to show: a guinea pig of unknown genotype and normal phenotype mated with one known to be homozygous for a recessive allele, *dd,* which causes a bone deformity. Half the offspring have normal bones; half have the deformity. L2 P

Meeting Individual Needs

Gifted

Visual-Spatial Have students do library research to determine the lineage of domestic cats. They can design a chart or poster that traces the taxonomy of cats and shows relatives of cats that are not domesticated. Students will require a basic understanding of levels of classification in order to do the project. L3

Assessment

Knowledge Have students write a paragraph differentiating among selective breeding, inbreeding, and hybridization. What are the goals of each? *Selective breeding attempts to gradually increase the frequency of desirable alleles in a population by selecting certain individuals as parents. Inbreeding ensures that a breed is homozygous for desired traits. Hybridization combines two desirable traits of different breeds into a single organism by mating the breeds.* L2

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Test Cross-Homozygous

Test Cross-Heterozygous

Quick Demo

Have volunteers bring in pictures of their pets and pets' parents, offspring, and/or siblings. At least some of the animals should be mixed breeds. Arrange the pictures on poster board and have students attempt to match the animals with their relatives. Discuss the characteristics used to identify the pet families. L1 ELL

Figure 13.1
A pure breed, such as this German shepherd dog, is homozygous for the particular characteristics for which it has been bred.

Figure 13.2
These roses, all different cultivars, have been hybridized to combine traits such as color, aroma, and flower shape.

One example of the effectiveness of selective breeding is seen in a comparison of milk production in cattle in 1947 and 1997. In 1947, an average milk cow produced 4997 pounds of milk per year. In 1997, 50 years later, an average milk cow produced 16 915 pounds of milk in a year, more than three times more milk per cow. Fewer than half the number of cows are now needed to produce the same amount of milk, resulting in savings for dairy farmers.

Inbreeding develops pure lines

To make sure that breeds consistently exhibit a trait and to eliminate any undesired traits from their breeding lines, breeders often use the method of inbreeding. **Inbreeding** is mating between closely related individuals. It ensures that the offspring are homozygous for most traits. However, inbreeding also brings out harmful, recessive traits because there is a greater chance that two closely related individuals may both carry a harmful recessive allele for the trait.

Horses and dogs are two examples of animals that breeders have developed as pure breeds. A breed (called a cultivar in plants) is a selected group of organisms within a species that has been bred for particular characteristics. For example, the pure breed German shepherd dog has long hair, is black with a buff-colored base, has a black muzzle, and resembles a wolf, ***Figure 13.1***.

Hybrids are usually bigger and better

Selective breeding of plants can increase productivity of food for humans. For example, plants that are disease resistant can be crossed with others that produce larger and more numerous fruit. The result is a plant that will produce a lot of fruit and be more disease resistant. Recall that a hybrid is the offspring of parents that have different forms of a trait. When two cultivars or closely related species are crossed, their offspring will be hybrids. Hybrids produced by crossing two purebred plants are often larger and stronger than their parents. Many crop plants such as wheat, corn, and rice, and garden flowers such as roses and dahlias have been developed by hybridization. ***Figure 13.2*** shows some examples.

Biology Journal

Test Crosses

Linguistic Ask students to write a paragraph that tells why it would not be helpful when conducting a test cross to mate the animal being tested with either homozygous dominant or heterozygous individuals. Have students use Punnett squares to help with technical explanations. *Mating with a homozygous dominant individual would not determine the genotype of the animal being tested because all offspring would show the dominant trait. If the animal being tested were heterozygous, mating with a heterozygous test animal reduces the chances of an offspring showing the recessive trait from 50% to 25%.* L3

Determining Genotypes

A good breeder must be careful to determine which plants or animals will have the greatest chances of transmitting a desired trait to the next generation. Choosing the best parents may be difficult. The genotype of an organism that is homozygous recessive for a trait is obvious to an observer because the recessive trait is expressed. However, organisms that are either homozygous dominant or heterozygous for a trait controlled by Mendelian inheritance have the same phenotype. How can a breeder learn which genotype should be used for breeding?

Test crosses can determine genotypes

One way to determine the genotype of an organism is to perform a test cross. A **test cross** is a cross of an individual of unknown genotype with an individual of known genotype. The pattern of observed phenotypes in the offspring can help determine the unknown genotype of the parent. Usually, the parent with the known genotype is homozygous recessive for the trait in question.

Many traits, such as disease vulnerability in rose plants and progressive blindness in German shepherd dogs, are inherited as recessive alleles. These undesired traits are maintained in the population by carriers of the trait. A carrier, or heterozygous individual, appears to have the same phenotype as an individual that is homozygous dominant.

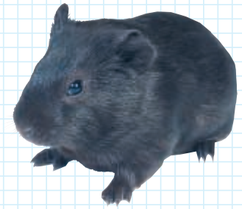
What are the possible results of a test cross? If the known parent is homozygous recessive and the unknown parent is homozygous dominant, all of the offspring will be heterozygous for the trait and will show the dominant trait (be phenotypically dominant), as shown in ***Figure 13.3*** on the next page. However, if the organism being tested is heterozygous, the predicted 1: 1 phenotypic ratio will be observed. If any of the offspring have the undesired trait, the parent in question must be heterozygous. Doing the *Problem-Solving Lab* will show you how to set up and analyze a test cross.

Problem-Solving Lab 13-1

Designing an Experiment

When is a test cross practical? How can you tell the genotype of an organism that has a dominant phenotype? There are two ways. The first is through the use of pedigree studies. This technique works well as long as a family is fairly large and records are accurate. The second technique is a test cross. Test crosses help determine whether an organism is homozygous or heterozygous for a dominant trait.

Analysis



Your pet guinea pig has black hair. This trait is dominant and can be represented by a *B* allele. Your neighbor has a white guinea pig. This trait is recessive and can be represented by a *b* allele. You want to breed the two guinea pigs but want all offspring from the mating to be black. You are not sure, however, of the genotype of your black guinea pig and want to find out before starting the breeding program.

Thinking Critically

1. What may be the possible genotypes of your black guinea pig? Explain why you are unable to tell even though the animal has a black phenotype.
2. What is the genotype of the white guinea pig? Explain how you are able to tell.
3. Outline a procedure that will determine the coat color genotype for your black guinea pig. Include Punnett squares to illustrate the conclusions that you will reach. (Hint: You will be doing a test cross.)
4. What options do you have for breeding all black offspring if you determine that your guinea pig is heterozygous for black color?
5. Explain why a test cross is not practical when trying to determine human genotypes.

Resource Manager

Reinforcement and Study Guide, p. 55 L2
Laboratory Manual, pp. 91-94 L2

Assessment

Skill Ask students to prepare Punnett squares that would illustrate the results of a cross between two heterozygous black guinea pigs and between one heterozygous and one homozygous black. Which mating would be preferred if only black offspring were desired? Use the Performance Task Assessment List for Scientific Drawing in **PASC,** p. 55. L1

Problem-Solving Lab 13-1

Purpose

Students will describe a procedure for determining a genotype.

Process Skills

think critically, apply concepts, draw a conclusion

Teaching Strategies

■ Pedigree studies will work in determining genotypes only when there are many offspring and when certain individuals are homozygous recessive. Illustrate this point with a pedigree that shows a small family of two parents (both with a dominant phenotype) and one offspring (with a dominant phenotype). There is no way to predict whether any individuals are heterozygous.

Thinking Critically

1. *BB* or *Bb;* both genotypes show a black phenotype.
2. *bb;* the trait is recessive and the white phenotype can show only when both alleles are recessive.
3. Mate an unknown black guinea pig with a white guinea pig. If all offspring are black, you may conclude that the black guinea pig is *BB.* If any white offspring are born, however, the black guinea pig must be heterozygous.
4. Continue to breed your guinea pig with a white guinea pig but understand that half of all offspring will be white, or do not breed your guinea pig, or breed your black guinea pig with a homozygous black guinea pig. In the last case, all offspring will be black but half will be heterozygous.
5. Because humans usually have only one offspring per birth, it would require too much time for determining genotype. The person would have to mate with a homozygous recessive individual for the trait in question.

3 Assess

Check for Understanding

Have students explain the role of a test cross and what breeding programs attempt to accomplish. L1

Reteach

Albinism, or white fur, in rabbits is due to a recessive allele. Let *A* = normal fur pigment and *a* = albinism (no fur pigment). A breeder wishes to know if a male rabbit is homozygous or heterozygous for pigmented fur. Have students diagram the possible crosses in Punnett squares and interpret the results. L1

Extension

Have students explore the problems that occur when horses are bred to donkeys to produce mules and hinnies. Have them speculate as to how Mendel's laws might have differed if he had worked with these animals. L3

Assessment

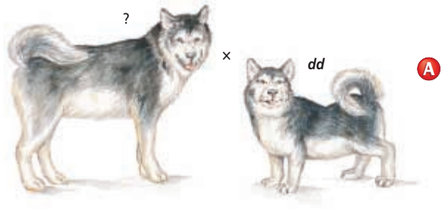
Knowledge Provide students with a test cross for a trait. Ask students to complete the genotypes for the test cross. L1

4 Close

Discussion

Discuss with students that there is currently an interest in eggs with low cholesterol content. Then ask students how they might proceed to breed chickens that produce such low-cholesterol eggs.

Figure 13.3
In this test cross of Alaskan malamutes, the known test dog is homozygous recessive for a dwarf allele *(dd),* and the other dog's genotype is unknown.



A **The unknown dog can be either homozygous dominant *(DD)* or heterozygous *(Dd)* for the trait.**

B **If the unknown dog's genotype is homozygous dominant, all of the offspring will be phenotypically dominant.**

Homozygous × Homozygous

	DD	*dd*
	d	*d*
D	*Dd*	*Dd*
D	*Dd*	*Dd*

Offspring: all dominant

C **If the unknown dog's genotype is heterozygous, half the offspring will express the recessive trait and appear dwarf. The other half will express the dominant trait and be of normal size.**

Heterozygous × Homozygous

	Dd	*dd*
	d	*d*
D	*Dd*	*Dd*
d	*dd*	*dd*

Offspring: 1/2 dominant
1/2 recessive

Section Assessment

Understanding Main Ideas

1. A test cross made on a cat that may be heterozygous for a recessive trait produces ten kittens, none of which has the trait. What is the presumed genotype of the cat? Explain.
2. Suppose you want to produce a plant cultivar that has red flowers and speckled leaves. You have two cultivars, each having one of the desired traits. How would you proceed?
3. Why is inbreeding rarely a problem among animals in the wild?
4. Hybrid corn is produced that is resistant to bacterial infection and is highly productive. What might have been the phenotypes of the two parents ?

Thinking Critically

5. What effect might selective breeding of plants and animals have on the size of Earth's human population? Why?

Skill Review

6. **Making and Using Tables** A bull is suspected of carrying a rare, recessive allele. Following a test cross with a homozygous recessive cow, four calves are born, two that express the recessive trait and two that do not. Draw a Punnett square that shows the test cross, and determine the genotype of the bull. For more help, refer to *Organizing Information* in the **Skill Handbook.**

Section Assessment

1. The cat is probably homozygous dominant. If it were heterozygous, there would probably have been some offspring with the recessive trait.
2. First breed the red flower plants among themselves to ensure that they are breeding true. Do the same for the plants with speckled leaves. Then, hybridize the two cultivars by breeding them together.
3. In nature, mate selection is random and the chance that a mate will be closely related is greatly reduced.
4. One parent was highly productive. The other was resistant to bacterial infection.
5. Selective breeding can increase crop size and provide for more nutritious and more disease-resistant crops, and this might increase the human population.
6. Students' Punnett squares should show a cross between a homozygous recessive individual and a heterozygous individual. Half the offspring will be normal and half will express the recessive trait. This is what was observed, so the bull was heterozygous.

Section

13.2 Recombinant DNA Technology

SECTION PREVIEW

Objectives

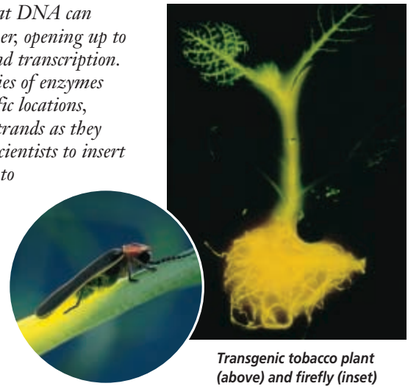
Summarize the steps used to engineer transgenic organisms.

Give examples of applications and benefits of genetic engineering.

Vocabulary

genetic engineering
recombinant DNA
transgenic organism
restriction enzyme
vector
plasmid
gene splicing
clone

You have learned that DNA can function like a zipper, opening up to allow replication and transcription. Scientists have found a series of enzymes that can cut DNA at specific locations, sometimes unzipping the strands as they cut. These enzymes allow scientists to insert genes from other sources into DNA. The glowing plant shown here was created by inserting a firefly gene into the DNA of a tobacco plant.



Transgenic tobacco plant (above) and firefly (inset)

Genetic Engineering

You learned that selective breeding is a form of genetic technology because it increases the frequency of an allele in a population. You also learned that it may take many generations of breeding for a trait to become homozygous and consistently expressed in the population. **Genetic engineering** is a much faster and more reliable method for increasing the frequency of a specific allele in a population. This method involves cutting—or cleaving—DNA from one organism into small fragments and inserting the fragments into a host organism of the same or a different species. You may also hear genetic engineering referred to as recombinant (ree KAHM buh nunt) DNA technology. **Recombinant DNA** is made by connecting, or recombining, fragments of DNA from different sources.

Transgenic organisms contain recombinant DNA

Recombinant DNA can be inserted into a host organism's chromosomes and that organism will use the foreign DNA as if it were its own. Plants and animals that contain functional recombinant DNA, such as the glowing tobacco plant, are known as **transgenic organisms** because they contain foreign DNA.

The glowing tobacco plant is the result of a three-step process that is used to produce a transgenic organism.

WORD Origin

transgenic
From the Latin word *trans*, meaning "across," and the Greek word *genos*, meaning "race." A transgenic organism contains genes from another species.

Internet Address Book

internet CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

Resource Manager

Section Focus Transparency 33 and Master L1 ELL
Basic Concepts Transparency 19 and Master L2 ELL

Prepare

Key Concepts

Students will learn that genetic engineering involves a three-step process that produces a transgenic organism. Students will explore techniques used to sequence DNA and applications of DNA technology in agriculture, industry, and medicine.

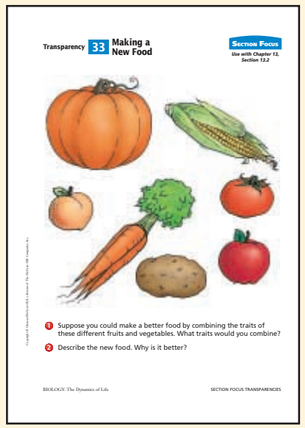
Planning

- Make cutouts of bases for the Meeting Individual Needs.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 33** on the overhead projector and have students answer the accompanying questions. L1 ELL



2 Teach

Discussion

Ask students what genetic changes people might want to engineer into their pets. *Students might suggest stamina, intelligence, hair retention, and disease resistance.*

Concept Development

To help students remember EcoR1, explain that this enzyme was discovered in the bacterium *Escherichia coli*. E comes from *Escherichia*, co from *coli*, R from Restriction enzyme, and 1 indicates that this enzyme was the first restriction enzyme found in this bacterium.

Quick Demo

The use of restriction enzymes and sticky ends can be demonstrated by using the materials in the Chromosome Simulation Biokit available from Carolina Biological Supply Company.

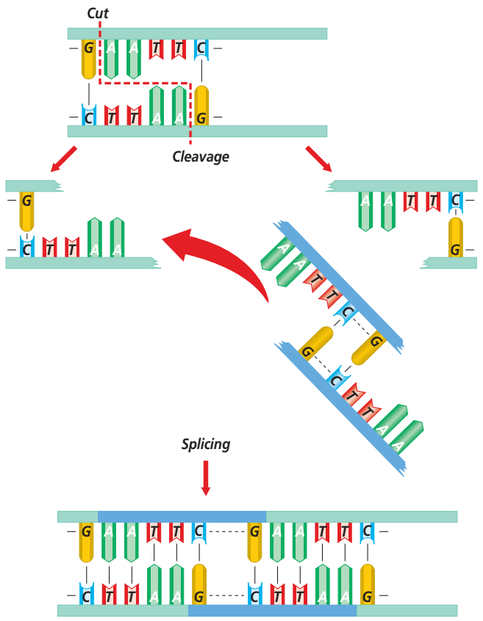


Figure 13.4
In the presence of the restriction enzyme *Eco*R1, a double strand of DNA containing the sequence—GAATTC—is cleaved between the G and the A.

The first step is to isolate the foreign DNA fragment that will be inserted. The second step is to attach the DNA fragment to a "vehicle." The third step is the transfer of the vehicle into the host organism. Each of these three steps now will be discussed in greater detail.

Restriction enzymes cleave DNA

To isolate a DNA fragment, small pieces of DNA must be cut from a larger chromosome. In the example of the glowing tobacco plant, this fragment is a section of firefly DNA that codes for the light-producing enzyme. The discovery in the early 1970s of DNA-cleaving enzymes made it possible to cut DNA. These **restriction enzymes** are bacterial proteins that have the ability to cut both strands of the DNA molecule at a specific nucleotide sequence. There are hundreds of restriction enzymes, each capable of cutting DNA at a specific point in a specific nucleotide sequence. The resulting DNA fragments are of different lengths. When restriction enzymes cut DNA, it is similar to cutting a zipper into pieces by cutting only between certain teeth of the zipper. Note in ***Figure 13.4*** that the same sequence of bases is found on both DNA strands, but running in opposite directions. This arrangement is called a palindrome (pal uhn drohm). Palindromes are words or sentences that read the same forwards or backwards. The words *mom* and *dad* are two very simple examples of palindromes.

Some enzymes produce fragments in which the DNA is cut straight across both strands. These are called blunt ends. Other enzymes, such as the enzyme called *Eco*R1, cut palendromic sequences of DNA by unzipping them for a few nucleotides, as shown in ***Figure 13.4.*** When this DNA is cut, double-stranded fragments with single-stranded ends are formed. The single-stranded ends have a tendency to join with other single-stranded ends to become double stranded, so they attract DNA they can join with. For this reason, these ends are called sticky ends. This is the key to recombinant DNA because if the same enzyme is used to cleave DNA from two organisms, such as firefly DNA and bacterial DNA, the two pieces of DNA will have matching sticky ends and will join together at these ends. When the firefly DNA joins with bacterial DNA, recombinant DNA is formed. The *MiniLab* on the opposite page models the way restriction enzymes work.

Vectors transfer DNA

Loose fragments of DNA do not readily become part of a host organism's chromosomes. To make this process easier, the fragments are first attached to a vehicle that will carry them into the host organism's cells. In the case of the transgenic tobacco plant, the light-producing firefly DNA has to be inserted into bacterial DNA before it can be placed inside the plant. The bacterial DNA is a **vector.** A vector is a means by which DNA from another species can be carried into the host cell. Vectors may be biological or mechanical.

Biological vectors include viruses and plasmids. A **plasmid,** shown in ***Figure 13.5,*** is a small ring of DNA found in a bacterial cell. The genes it carries are different from those on the larger bacterial chromosome.

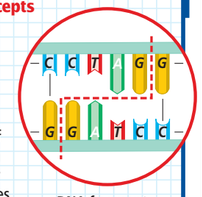
Two mechanical vectors carry foreign DNA into the nucleus of a cell. One, a micropipette, is inserted into a cell; the other is a tiny metal bullet coated with DNA that is shot into the cell using a device called a gene gun.

Figure 13.5
Plasmids are small rings of DNA. The large ring is the bacterium's chromosome.


Magnification: 157 500×

MiniLab 13-1 Applying Concepts

Matching Restriction Enzymes to Cleavage Sites Many restriction enzymes cut sequences of DNA that are palindromes. As a result of cuts to the DNA, single-stranded sequences of DNA are left dangling at the ends of a fragment. These ends are available for pairing with their complementary bases in a plasmid or piece of viral DNA.


DNA fragment

Procedure

1. Copy the data table below.

Data Table

DNA fragment	Enzyme letter (D-F)	Action of restriction enzyme	Cleaved fragment of DNA
—GGTACC— / —CCATGG—	E	—G GTACC— / —CCATGG—	—G GTACC— / —CCATG G—
—CCATGG— / —GGTACC—			
—CAATTG— / —GTTAAC—			
—GATATC— / —CTATAG—			

2. Figure out which restriction enzyme will cleave each DNA fragment. Use the following guides.
   Enzyme D cleaves at an A-A site and leaves 3 single-stranded bases on each end.
   Enzyme E cleaves at a G-G site and leaves 4 single-stranded bases on each end.
   Enzyme F cleaves at a G-A site and leaves 4 single-stranded bases on each end.
3. Draw in the action of each enzyme. Record its letter.
4. Diagram each fragment of DNA as it would appear if cleaved by the proper restriction enzyme.
5. Use the top row in the table as an example and guide.

Analysis

1. Use the example provided in the data table to illustrate a single-stranded dangling end of DNA.
2. Record the DNA base sequence that must be present on a piece of viral DNA if these ends could "stick to" the dangling bases in the example shown in the data table.
3. Are restriction enzymes very specific as to where they cleave DNA? Explain your answer and give an example.

MiniLab 13-1

Purpose
Students will match restriction enzymes with their proper base sequences in a DNA strand.

Process Skills
think critically, analyze information, apply concepts, define operationally, draw a conclusion

Teaching Strategies
- Be sure that students have read over the applicable material in the text before starting this MiniLab.
- Allow students to work in small groups to complete this activity.
- Remind students that the DNA segments shown are only a small portion of the DNA molecule.
- Point out to students that in the example provided, the complementary bases are joined together to form a double strand but are not joined together after being cleaved by the enzyme. Thus, single-stranded sticky ends are created.

Expected Results
See data table below.

Analysis
1. GTAC– is a dangling end.
2. –CATG
3. Yes; each enzyme can cleave only a specific site and can leave only a specific number of single-stranded DNA bases. Enzyme F cleaves between G and A but must leave 4 bases in the dangling end.

Data Table

DNA fragment	Enzyme letter (D-F)	Action of restriction enzyme	Cleaved fragment of DNA
—GGTACC— / —CCATGG—	E	—G GTACC— / —CCATGG—	—G GTACC— / —CCATG G—
—CCATGG— / —GGTACC—	E	—CCATGG— / —GGTACC—	—CCATG G— / —G GTACC—
—CAATTG— / —GTTAAC—	D	—CA ATTG— / —GTTA AC—	—CA ATTG— / —GTTA AC—
—GATATC— / —CTATAG—	F	—G ATATC— / —CTATA G—	—G ATATC— / —CTATA G—

Assessment
Portfolio Ask students to invent a plasmid strand of DNA that would fit the cleaved ends of the second example in the data table. Use the Performance Task Assessment List for Invention in **PASC,** p. 45. L2

Meeting Individual Needs

Visually Impaired
Kinesthetic Have students who are visually impaired use large pieces of cardboard cut into four shapes (several pieces of each shape) to represent each of the four bases: A, T, C, and G. Use them to demonstrate a palindrome and to model the action of restriction enzymes. L1 ELL

Resource Manager

BioLab and MiniLab Worksheets, pp. 61-62 L2
Reteaching Skills Transparency 22 and Master L1 ELL

Enrichment

Intrapersonal Mice with mutant genes are particularly valuable to scientists studying human diseases. Using a grant from the National Institute of General Medical Services, scientists have developed what they call knockout mice. Have capable students find out how these mice are produced and how scientists study the effect of missing genes in the mice on conditions such as aging or cancer. L3

INVESTIGATE BioLab

The BioLab at the end of the chapter can be used at this point in the lesson.

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Animation: *Gene Cloning*
Disc 2

VIDEODISC
Biology: The Dynamics of Life
Gene Cloning (Ch. 38)
Disc 1, Side 1, 23 sec.

The Infinite Voyage *Miracles by Design, Biodegradable Plastic: The Miracle Material?* (Ch. 4)
7 min.

The Infinite Voyage *The Geometry of Life, Manipulating Genetic Engineering* (Ch. 10)
3 min.

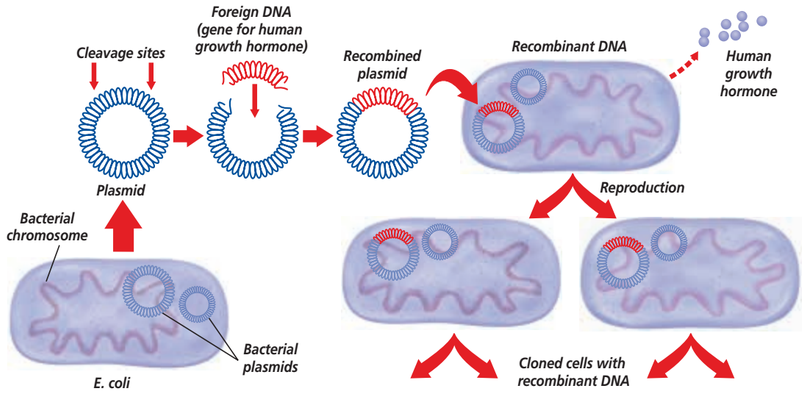


Figure 13.6
Foreign DNA is spliced into a plasmid vector. The recombined plasmid then carries the foreign DNA into the bacterial cell, where it is cloned when the cell reproduces. If the foreign DNA contained a gene for human growth hormone, each cell will make the hormone.

Gene splicing

As you have learned, if a plasmid and foreign DNA have been cleaved with the same restriction enzyme, the ends of each will match and they will join together, reconnecting the plasmid ring. Rejoining of DNA fragments is called **gene splicing.** The foreign DNA is recombined into a plasmid or viral DNA with the help of a second enzyme. You can practice modeling gene splicing in the *BioLab* at the end of this chapter.

Gene cloning

After the foreign DNA has been spliced into the plasmid or the virus vector, the recombined DNA is transferred into a cell of the host organism. The host cell can be a plant or animal cell or a bacterial cell. When the host cell prepares to divide, it copies the recombinant DNA along with its own DNA. The process of making extra copies of recombinant DNA is a form of cloning. **Clones** are genetically identical copies. Each identical recombinant DNA molecule is called a gene clone. Gene cloning is an important step in the process of genetic engineering because multiple copies of the desired DNA are produced.

Why clones are possible

Cloning is possible because a foreign piece of DNA introduced into a host cell has been integrated into that cell so completely that the foreign DNA is replicated as if it were the host's DNA. Each cell makes the desired product. For example, if the foreign DNA contains a gene for insulin production, each cell containing that DNA will make insulin.

An advantage to using bacterial cells to clone DNA is that they reproduce quickly. If a bacterial cell were engineered to produce human growth hormone, billions of cloned cells could generate the large quantities of hormone that are needed for patients who require it. It would be impossible to obtain such large amounts of the product from humans because hormones are produced in the body in very small amounts. ***Figure 13.6*** summarizes the formation and cloning of recombinant DNA in a bacterial host cell.

Cloning of animals

So far, you have read about cloning a single gene. For decades, scientists attempted to expand the technique from a single gene to an entire organism. The most famous cloned animal is Dolly, the sheep. You can read more about Dolly in the *BioTechnology* feature at the end of this chapter. Although their techniques differ, scientists are coming closer to perfecting the technique of cloning animals. One of the benefits for humans in cloning animals is that ranchers and dairy farmers can clone particularly productive, healthy animals to increase yields.

Sequencing DNA

Genetic engineering techniques can also provide pure DNA for use in genetic studies. After large amounts of DNA have been produced by cloning, scientists can determine the sequence of DNA bases. This information is critical for scientists because they can identify and study specific genes and pieces of DNA that regulate the transcription of these genes.

In DNA sequencing, millions of copies of a double-stranded DNA fragment are cloned by bacterial culture of plasmids. Then, the strands are separated from each other. The single-stranded fragments are mixed in test tubes with enzymes, radioactively labeled nucleotides, and dyes to produce many new complementary strands of varying lengths. These new strands can be separated according to size by gel electrophoresis (ih lek troh fuh REE sus), producing a pattern of dyed bands in the gel. The radioactive label allows a direct reading of the sequence of bases on x-ray film. How do the DNA strands separate from each other in the gel? Read the *Inside Story* on the next page to find out.

Applications of DNA Technology

Once it became possible to transfer genes from one organism to another, large quantities of hormones and other products could be produced. How is this technology of use to humans? Many species of bacteria have been engineered to produce chemical compounds that are of use to humans. The three main areas proposed for recombinant bacteria are in industry, medicine, and agriculture.

Recombinant bacteria in industry

In industry, recombinant bacteria have been engineered to break down pollutants into harmless products. Laboratory experiments with recombinant bacteria first showed that these engineered bacteria could degrade oil more rapidly than the same species of naturally occurring bacteria, as seen in ***Figure 13.7.*** These recombinant bacteria were used with some success in the Gulf of Mexico to clean up an oil spill off the coast of Texas. Mining companies also are interested in bioengineering bacteria that will extract valuable minerals from ores.

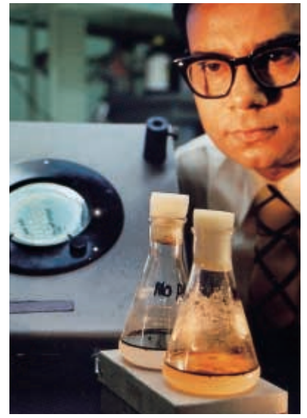


Figure 13.7
The first patented organism, a bacterium that breaks down oil, was engineered by Dr. Ananda Chakrabarty. The flask in the rear contains oil and natural bacteria. The flask at the front contains the engineered bacteria and is almost free of oil.

Enrichment

Introducing human genes into plants that are grown in the field has obvious benefits in producing large amounts of proteins. Critics point out that the environmental and ethical implications of these experiments have not been explored. To invite a class discussion on this topic, ask students the following question: What might be the consequences on the environment if the new genes get into the wild gene pool?

Assessment
Performance Assessment in the Biology Classroom, p. 19, *Making a Model of Recombinant DNA.* Have students carry out this activity after they have completed the study of recombinant DNA. L1

GLENCOE TECHNOLOGY

VIDEODISC
Biology: The Dynamics of Life
Bioengineering (Ch. 37)
Disc 1, Side 1, 57 sec.

Recombinant DNA (Ch. 36)
Disc 1, Side 1, 38 sec.

CD-ROM
Biology: The Dynamics of Life
Video: *Bioengineering*
Disc 2

PROJECT

Enzyme Model

Kinesthetic Have students build a model demonstrating the use of restriction enzymes on DNA. They could use various materials to represent the DNA nucleotides, such as colored push pins, colored paper clips, or M & Ms. L1 ELL COOP LEARN

Resource Manager

Laboratory Manual, pp. 95-98 L2

Internet Address Book

internet CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

Portfolio

Engineered Bacteria

Linguistic Have students research and write an essay on whether scientists should be allowed to alter bacteria genetically and release them into the environment. Have students include a copy of their essays in their portfolios. L2 P

INSIDE STORY

Purpose

Students will learn how gel electrophoresis separates DNA fragments of different sizes.

Background

Gel electrophoresis is a basic technique used in the preparation of DNA samples for other techniques such as DNA sequencing.

Teaching Strategies

- Give students several paper "DNA fragments" of different sizes. Have them draw what a gel electrophoresis of these fragments would look like. Make sure they indicate at which end of the gel the fragments were added. L1
- Have students describe orally the steps necessary to run a gel.

Visual Learning

- Use colored chalk to demonstrate different sized DNA fragments that have been run in a gel.

Critical Thinking

DNA sequencing can be done only on small pieces of DNA. Gel electrophoresis separates the small pieces of DNA from large pieces before sequencing takes place.

Resource Manager

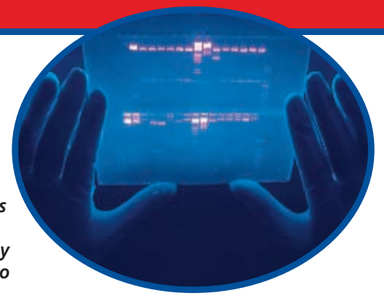
Reinforcement and Study Guide, pp. 56-57 L2
Content Mastery, p. 62 L1

INSIDE STORY

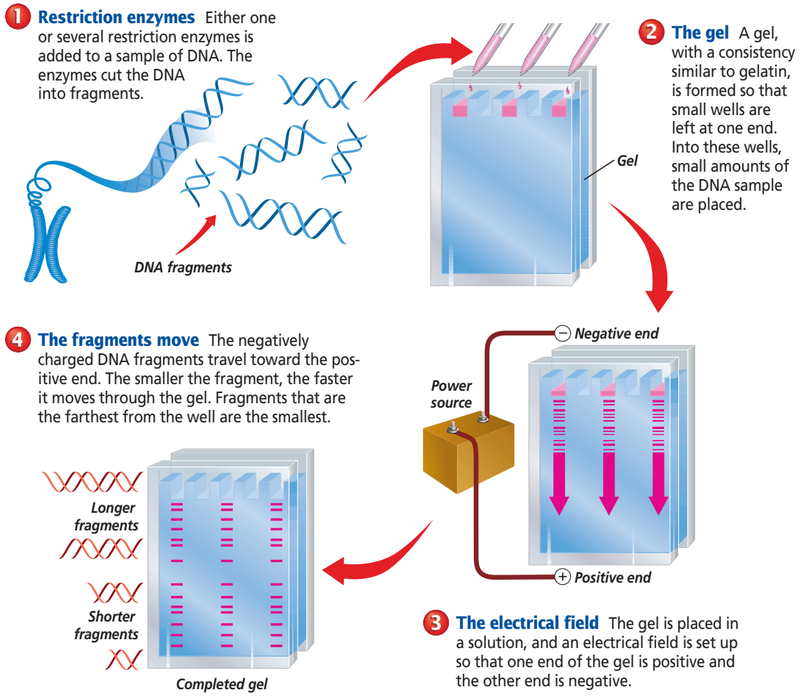
Gel Electrophoresis

Restriction enzymes are the perfect tools for cutting DNA. However, once the DNA is cut, a scientist needs to determine exactly what fragments have been formed. Once DNA fragments have been separated on a gel, many other techniques, such as DNA sequencing, can be used to specifically identify a DNA fragment.

Critical Thinking ***Why might gel electrophoresis be an important step before DNA sequencing can be done?***



Before the DNA fragments are added to the wells, they are treated with a dye that glows under ultraviolet light, allowing the bands to be studied.



GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Electrophoresis and PCR Segment

Recombinant bacteria in medicine

In medicine, pharmaceutical companies already are producing molecules made by recombinant bacteria to treat human diseases. Recombinant bacteria are employed in the production of human growth hormone to treat dwarfism, and of insulin to treat diabetes. The human gene for insulin is inserted into a bacterial plasmid by genetic engineering techniques. Recombinant bacteria produce such large quantities of insulin that they bulge. Another strain of recombinant bacteria is being used to produce phenylalanine, an amino acid that is needed to make aspartame, an artificial sweetener found in many diet products.

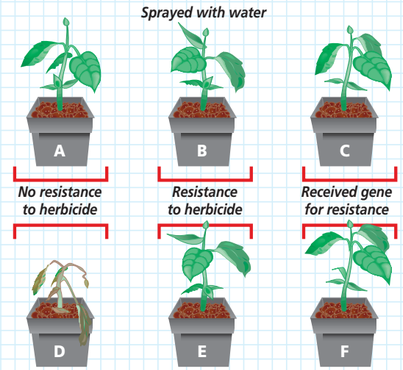
Transgenic animals

Transgenic animals are opening up new avenues through which scientists can study diseases and the role specific genes play in an organism. A favorite animal for transgenic studies is the mouse because mice reproduce quickly, within three weeks, and mouse chromosomes are similar to human chromosomes. In addition, scientists know a lot about where genes are located on mouse chromosomes. The roundworm *Caenorhabditis elegans* is another organism with simple genetics that is well understood and is used for transgenic studies. A third animal commonly used for transgenic studies is the fruit fly, *Drosophila melanogaster*.

Although animals such as a worm and a fruit fly may seem very different from humans, it is surprising how many genes are common to all. One way in which scientists use genetic engineering is to create animals with human diseases. By studying these animals, scientists hope to treat and cure these diseases in humans.

Problem-Solving Lab 13-2 Thinking Critically

How might gene transfer be verified? When you spray weeds with a chemical herbicide, they die. Glyphosate is the active ingredient in some herbicides. The problem with herbicides, however, is that glyphosate often gets sprayed accidentally onto crops and they also die. A certain gene will confer resistance to glyphosate. If this gene can be genetically engineered into crop plants, they will survive when sprayed with this herbicide. The following experiment is a test to determine to which plants the gene has been successfully transferred.



Analysis

Two groups of pots are each planted with three plants, according to the diagram above. Plants A, B, and C are sprayed with water. Plants D, E, and F are sprayed with a herbicide containing glyphosate.

Thinking Critically

1. Assume that the transfer of glyphosate resistance was successful in plant F. Predict whether each of plants D, E, and F will remain healthy after being sprayed with glyphosate. Explain your prediction.
2. Predict whether plant F will remain healthy if the transfer of glyphosate resistance was not successful.
3. Which plants are transgenic organisms? Explain your answer.
4. Explain why a glyphosate-resistant plant will produce seeds that show resistance to the herbicide.
5. Why were plants A, B, and C sprayed with water? What was the purpose of these plants in the experiment?

BIOLOGY JOURNAL

Ethics

Linguistic Have students write an essay about the ethics of using transgenic animals to study human diseases. L2

Assessment

Performance Have students design and carry out an experiment to test whether glyphosate (Roundup) affects seeds of plants. Use the Performance Task Assessment List for Designing an Experiment in **PASC,** p. 23. L3

Problem-Solving Lab 13-2

Purpose

Students will analyze the results of an experiment designed to illustrate genetic transfer.

Process Skills

think critically, analyze information, apply concepts, draw a conclusion, interpret data, predict

Background

Glyphosate blocks the synthesis of amino acids phenylalanine, tyrosine, and tryptophan. Cells unable to form these amino acids die. Glyphosate inhibits the enzyme EPSP synthase from synthesizing these amino acids.

Teaching Strategies

- You may wish to discuss the technique that is used to transfer the resistant gene to its host plant. The organism or vector is *Agrobacterium tumefaciens*, a bacterium that infects plants.
- Make sure that students understand that plants sprayed with glyphosate will die if they do not contain genes making them resistant to the chemical.
- Students may work in small cooperative groups to complete this activity.

Thinking Critically

1. Plants E and F will remain healthy because they have the gene that imparts resistance. Plant D will die because it is not resistant to glyphosate.
2. If resistance is not transferred, plant F will die because it is not resistant to glyphosate.
3. Plants C and F are transgenic organisms. They contain foreign DNA.
4. All the cells of a resistant plant, including cells that produce gametes, contain the gene for resistance.
5. Plants A, B, and C were controls. They were sprayed with water to show that spraying does not transfer resistance to the chemical.

3 Assess

Check for Understanding

Write a sequence of DNA that includes two of the sequences GAATTC and ask students to demonstrate where EcoR1 will cut the strand of DNA. L1

Reteach

Kinesthetic Have students model how restriction enzymes create sticky ends, using other restriction enzymes so they can see that choice of the particular enzyme is important. For example, BamH1 recognizes GGATCC and cuts between the two Gs. Hind III recognizes AAGCTT and cuts between the two As. L1

Extension

Interested students can look into the applications of protein engineering and computer modeling to produce modified natural proteins or to create entirely new proteins. L3

Assessment

Knowledge Have students summarize the formation of recombinant DNA. L2

4 Close

Discussion

Lead into the next section by discussing how DNA technology may provide therapy for many genetic disorders.

Figure 13.8
The bacterium that causes these tumorlike plant galls is the only known biological plant vector. Unfortunately, it does not work on many kinds of plants.

Recombinant bacteria in agriculture

One species of bacteria has already been engineered successfully for use on agricultural crops. These particular bacteria normally occur on strawberry plants and cause frost damage to the leaves and fruits because ice crystals form around a protein on the surface of each bacterium. After engineering the bacteria to remove the gene for this protein, the recombinant bacteria are applied to the leaves of the plants. They replace the natural bacteria, and frost damage is prevented.

Farmers hope that another species of bacteria that lives in soil and in the roots of some plants can be engineered to increase the rate of conversion of atmospheric nitrogen to nitrates, a natural fertilizer used by plants. If this can be accomplished, farmers will be able to save money by cutting back on fertilizer.

Transgenic plants

The *Problem-Solving Lab* on the previous page shows one way plants could be improved by genetic bioengineering. Plants are more difficult to genetically engineer than bacteria because plant cells do not have the plasmids or kinds of viruses needed for taking up foreign pieces of DNA that bacterial cells have. Also, because plant cells are surrounded by thick cell walls, it is difficult to insert the foreign DNA.

A bacterium that normally causes tumorlike growths in the tissues of certain plants, ***Figure 13.8***, has been used to carry foreign genes into plant cells. Most engineering of plants uses mechanical vectors such as DNA-coated "bullets." Brief jolts of high-voltage electricity also can be used. The jolts cause temporary pores to form in the plasma membrane, through which the DNA can enter.

Plants have been genetically engineered to resist herbicides, produce internal pesticides, or increase their protein production. These plants have been used in field trials, and are now used extensively.

Section Assessment

Understanding Main Ideas

1. How are transgenic organisms different from natural organisms of the same species?
2. How are sticky ends important in making recombinant DNA?
3. Why is it presently more difficult to engineer transgenic plants and animals than it is to engineer bacteria?
4. Explain two ways in which recombinant bacteria are used for human applications.

Thinking Critically

5. Many scientists consider genetic engineering to be simply an efficient method of selective breeding. Explain.

Skill Review

6. **Sequencing** Order the steps in producing recombinant DNA in a bacterial plasmid. For more help, refer to *Organizing Information* in the **Skill Handbook.**

Section

13.3 The Human Genome

SECTION PREVIEW

Objectives

Analyze how the effort to completely map and sequence the human genome will advance human knowledge.

Predict future applications of the Human Genome Project.

Vocabulary

human genome
linkage map
gene therapy

You have already learned about several genetic disorders that affect humans—Huntington's disease, cystic fibrosis, Tay Sach's disease, and sickle-cell anemia. In the last section, you learned that transgenic bacteria are being designed to treat disorders such as diabetes and dwarfism. Scientists hope someday to be able to treat more disorders. To accomplish this, they are sequencing the entire human genome. How are they doing this and what do they hope to accomplish?

Sickled red blood cells (above) and human chromosomes (inset)

Mapping and Sequencing the Human Genome

In 1990, scientists in the United States organized the Human Genome Project. It is an international effort to completely map and sequence the **human genome,** the approximately 80 000 genes on the 46 human chromosomes. The project is still underway. Maps currently are being prepared that show the locations of known genes on each chromosome. At the same time, the sequence of the 3 billion base pairs of DNA in the human genome is being analyzed and mapped. Eventually, the two maps will be synchronized. The *MiniLab* on the next page gives you an idea of the size of the human genome.

Linkage maps

The locations of only a few thousand of the total number of known human genes have been mapped on particular chromosomes. This means that for most human genes, scientists don't know the exact or even the approximate locations on chromosomes. The genetic map that shows the location of genes on a chromosome is called a **linkage map.**

WORD Origin

genome
From the Greek word *genos*, meaning "race." A genome is the total number of genes in an individual.

Section 13.3

Prepare

Key Concepts

The organized effort to map and sequence the human genome using DNA technology is presented. Students will also explore applications of this project.

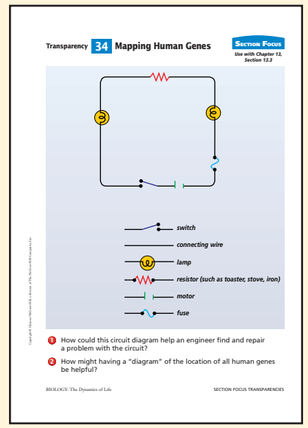
Planning

- Obtain a chromosome linkage map for the Quick Demo.
- Gather the materials for the Alternative Lab.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 34** on the overhead projector and have students answer the accompanying questions. L1 ELL



Section Assessment

1. Transgenic organisms contain DNA from other sources.
2. Sticky ends allow the cleaved DNA to join to complementary single strands on DNA molecules from another organism.
3. Plants and animals do not readily accept plasmids into their DNA, and plants have tough cell walls that make it difficult to insert DNA.
4. Recombinant bacteria produce human growth hormone, insulin, and phenylalanine. They are also used for better crop production such as frost-resistant strawberries.
5. Answers may include that both genetic engineering and selective breeding involve increasing the frequency of a desired gene in a population by human intervention
6. Cleave the plasmid and foreign DNA with the same restriction enzyme, and the sticky ends will join, reconnecting the plasmid ring.

MEETING INDIVIDUAL NEEDS

Gifted

Linguistic Have gifted students look in recent issues of *Science* or *Science News* and report on the progress of the Human Genome Project and other DNA technology. L3

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage
The Geometry of Life
The Human Genome Project
(Ch. 11), 4 min.

Resource Manager

Section Focus Transparency 34 and Master L1 ELL

2 Teach

MiniLab 13-2

Purpose
Students will use an analogy to calculate the size of the human genome.

Process Skills
acquire information, interpret data, think critically, use numbers

Teaching Strategies
- Go through calculations with students. Place the data table on an overhead projector as you work through each step.
- To provide consistency of data, photocopy a page from a novel and allow all students to use it to gather their initial data. Advise them of the total number of pages in the book.

Expected Results
Sample data: A = 80; B = 45; C = 3600; D = 1800; E = 400; F = 720 000; G = 4167

Analysis
1. Take an average of several pages to arrive at total number of characters per page.
2. The human genome is made up of 3 billion bases.
3. DNA bases are paired (A-T, C-G). Thus, the total genome is expressed in pairs so the number of characters must be expressed in pairs.
4. **a.** 4167 books **b.** 4.17 books

Assessment
Portfolio Have students calculate the number of base pairs on each chromosome, assuming that all chromosomes are the same length. Use the Performance Task Assessment List for Using Math in Science in **PASC,** p. 29. L2

MiniLab 13-2 Using Numbers

Storing the Human Genome It has been estimated that the human genome consists of three billion nitrogen base pairs. How much room would all of the genetic information in a single cell take up if it were printed in a book the size of a typical novel?

Procedure
1. Copy the right column of the data table marked "Letters and numbers."
2. Select a random page from a novel.
3. Follow the directions in the table. Record your calculations in your data table.

Data Table

Directions	Letters and numbers
A. Count the number of characters (letters, punctuation marks, and spaces) across one entire line of your selected page.	
B. Count the number of lines on the page.	
C. Calculate the number of characters on the page. (Multiply A × B.)	
D. Let one nitrogen base equal one character. Knowing that DNA is made of nitrogen base pairs, divide C by 2.	
E. Record the number of pages in your novel.	
F. Calculate the number of base pairs in your novel. (Multiply E × D.)	
G. Calculate the number of books the size of your novel needed to hold the human genome. (Divide 3 billion by F.)	

Analysis
1. What changes could be taken to improve the accuracy of this activity at steps A-C?
2. What assumption is being made at step G?
3. Explain the logic for step D.
4. **a.** How many books the size of your novel would be needed to store the human genome?
   b. How many books the size of your novel would be needed to store a typical bacterial genome? Assume there are three million base pairs in the genome of a bacterium.

The historical method used to assign genes to a particular human chromosome was to study linkage data from human pedigrees. Recall from your study of meiosis that crossing over occurs during prophase I. As a result of crossing over, the offspring have a combination of alleles not found in either parent. The frequency with which these alleles occur together is a measure of the distance between the genes. Genes that cross over frequently must be farther apart than genes that rarely cross over. The percentage of these crossed-over traits appearing in offspring is then used to determine the relative position of genes on the chromosome, and thus to create a linkage map.

Because humans have only a few offspring compared with the larger numbers of offspring in other species and because the generation time is so long, mapping by linkage data is extremely inefficient. Biotechnology has now provided scientists with new methods of mapping genes. By a technique called polymerase chain reaction (PCR), millions of copies of tiny DNA fragments are cloned in a matter of a few hours. Scientists can copy the DNA from thousands of separate sperm cells produced by one individual and analyze the results of crossing over that occurred during the meioses that produced the sperm. Instead of examining actual offspring, they examine sperm cells—hundreds and even thousands of potential offspring—to create linkage maps. Another method of mapping chromosomes is shown in ***Figure 13.9.***

Sequencing the human genome

The difficult job of sequencing the human genome is accomplished by cleaving samples of DNA into fragments using restriction enzymes, as described earlier in this chapter. Each fragment is then individually cloned and sequenced. The cloned fragments are aligned in the proper order by overlapping matching sequences, thus determining the sequence of a longer fragment. Automated machines can perform this work, greatly increasing the speed of map development. It is expected that the entire human genome may be mapped and sequenced by the year 2003.

Applications of the Human Genome Project

As chromosome maps are made, how can they be used? Improved techniques for prenatal diagnosis of human disorders, use of gene therapy, and development of new methods of crime detection are current areas of research.

Diagnosis of genetic disorders

Once it is clearly understood where a gene is located and the gene's DNA sequence is known, a diagnosis of a genetic disorder may be made before birth. What technique leads to making this diagnosis? The DNA of people with the disorder is analyzed for common patterns that appear to be associated with the disorder. A few cells are obtained from a fetus or from the fluid surrounding the fetus. To obtain a large enough sample of DNA, the cells are grown in a nutrient medium until many cells have formed, a technique known as cell culture. Cells in a cell culture all have the same genetic material; that is, they are clones. Thus, when the cultured fetal cells are examined and found to have DNA with the pattern associated with the disorder, there is a strong probability that the fetus will develop the disorder.

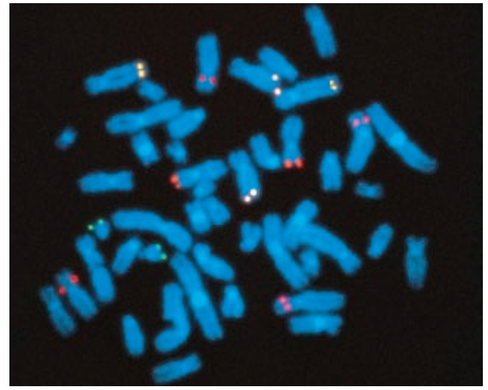


Figure 13.9
Radioactively labeled complementary DNA for the gene to be mapped is made and added to metaphase chromosomes. The labeled DNA binds to the gene and indicates its location as a spot. In this photo, six genes are mapped simultaneously.

Careers in Biology

Forensic Analyst

Would you like to work in a crime laboratory, helping police and investigators figure out "who done it?" Then consider a career as a forensic analyst.

Skills for the Job

Forensic analysts include identification technicians (who work with fingerprints), crime lab technologists (who use microscopes, lasers, and other tools to analyze tissue samples and other evidence), and medical examiners (who perform autopsies to determine the cause of death). Most forensic analysts work in labs operated by the federal, state, or local government. Requirements include on-the-job training for technicians, one or more college degrees that include crime lab work for technologists, and a medical degree for medical examiners. Analysts hired by the FBI complete an additional 14-week training program.

internNET CONNECTION For more careers in related fields, be sure to check the Glencoe Science Web Site.
www.glencoe.com/sec/science

Quick Demo

Visual-Spatial Show students a human chromosome map so they can see how many genes have been mapped. Such maps have been published by *Science* magazine.

Careers in Biology

Career Path
Courses in high school: computer science, mathematics, physics, photography, and English
College: bachelor's degree or higher in criminal justice with crime laboratory work
Other education source: on-the-job training for forensic technicians

Career Issue
Every year, new forensic technology is developed, yet society gradually undergoes many other kinds of changes, too. Ask students whether a forensic analyst's job is easier or more difficult than it was 20 years ago. Explain your answer.

For More Information
For more information about forensic sciences, write to:
American Academy of Forensic Sciences
218 East Cache La Poudre
Colorado Springs, CO 80903

Alternative Lab

Crime Analysis

Purpose
Students will solve a crime using human genetics and DNA technology.

Materials
glass slide, red juice, 5 bar codes (2 that match), 2 strands of human hair (blond and dark), T-shirt with spot of red ink, stained slide of female cheek cells, microscope

Preparation
Table 1: hair from the scene. Table 2: shirt with a blood stain (red ink) and a slide with two drops of juice to represent blood typing (no clotting with the addition of anti-A and anti-B sera). Table 3: slide of stained cheek cells with microscope pointer on a Barr body. Table 4: bar code representing the DNA fingerprint of blood from the crime scene (one of two that match). Place a bar code in each of four envelopes marked: blond female, type O blood (matching bar code); blond male, type B blood; dark-haired male, type O blood; and dark-haired male, type B blood.

Procedure
1. Roger Trueblood, dark hair, type B blood, was shot and killed. You must find which suspect is guilty.
2. Rotate to the tables and collect information. At the last table, decide who is guilty and open the envelope to see if the DNA fingerprint matches that at the crime scene.

Analysis
1. What information did you learn from the table displays? *The clues included blond hair, type O blood, and female cheek cells (presence of Barr bodies).*
2. How are the bar codes like DNA fingerprinting? *They are a series of lines of varying thickness.*

Assessment
Performance Have students write a report stating their conclusions about the crime. *The blond female is guilty because her hair, type of blood, and cheek cells were found at the scene.* Use the Performance Task Assessment List for Lab Report in **PASC,** p. 47. L2

Problem-Solving Lab 13-3

Purpose

Students will analyze DNA fingerprints to determine identity of an unidentified soldier.

Process Skills

think critically, analyze information, apply concepts, compare and contrast, interpret data, interpret scientific illustrations

Teaching Strategies

- Advise students that photos of DNA fingerprints are X rays of electrophoresis results. The DNA is treated with radioactive dyes that expose X-ray film.
- Remind students that each person has unique DNA (except for identical twins). Each contains DNA from both parental DNA. Ask them to recall the number of chromosomes contributed at fertilization by each parent to future offspring.
- Photocopy the diagram for student use so that they do not write in the book.
- Suggest that a ruler be placed along the bottom edge of each band for ease in matching.

Thinking Critically

1. Parents C and D; half of the soldier's DNA matched parent C and the other half matched parent D.
2. 50% from each parent; each parent contributes half of their DNA to an offspring.
3. Yes, the soldier's DNA would still match the living parent's half.

Assessment

Knowledge Ask students: Could the unidentified soldier be identified if he were adopted? *not unless his birth parents are known* Can the unknown soldier from WW I be identified through DNA technology? *Not likely; his parents must be deceased.* Use the Performance Task Assessment List for Writing in Science in **PASC,** p. 87. L1

Gene therapy

Individuals who inherit a serious genetic disorder now have a reason to hope for a bright future—gene therapy. **Gene therapy** is the insertion of normal genes into human cells to correct genetic disorders. This technology has already entered trial stages in a number of attempts to treat or cure genetic disorders; some of the first trials were on patients suffering from cystic fibrosis. The method used in these trials is shown in ***Figure 13.10.*** Doctors hope that copies of the normal gene introduced into the lungs by way of a nasal spray will cause lung cells to produce normal mucus.

Another example of successful gene therapy is with people affected by SCID (severe combined immunodeficiency disease). One particular type of SCID is caused by a defect in an enzyme within a specific cell in the immune system. Without the normal enzyme, a substrate of the enzyme builds up in the cells of the immune system and eventually kills the cells. The immune system is shut down with the result that in these patients, even slight colds can be deadly. In gene therapy for this disorder, the cells of the immune system are separated from blood samples and the functional gene is added to them. The cells are then injected back into the patient. The drawback with most current forms of gene therapy is that the gene does not always stay active for very long periods of time, or the cells themselves do not have long life spans, so the treatments must be repeated often, sometimes every two weeks. Still, it seems likely that the next decade will see the use of DNA technology to cure many genetic disorders.

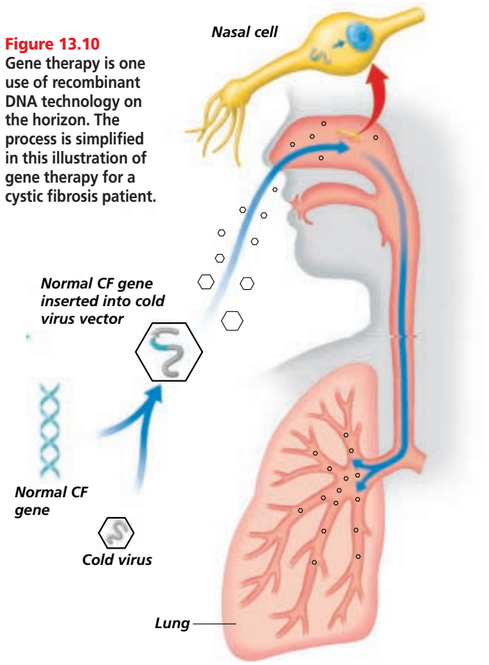


Figure 13.10
Gene therapy is one use of recombinant DNA technology on the horizon. The process is simplified in this illustration of gene therapy for a cystic fibrosis patient.

DNA fingerprinting

Law-enforcement workers use unique fingerprint patterns to determine whether suspects have been at a crime scene. In the past ten years, biotechnologists have developed a method that determines DNA fingerprints. DNA fingerprinting can be used to convict or acquit individuals of criminal offenses because every person is genetically unique.

Small DNA samples can be obtained from blood, hair, skin, or semen and copied millions of times using polymerase chain reaction techniques. When an individual's DNA is cleaved with a restriction enzyme, the DNA is cut into fragments of different lengths. DNA fragments can then be separated by electrophoresis and compared with those obtained from a crime scene.

Chromosomes consist of genes that are separated by segments of noncoding DNA, DNA that doesn't code for proteins. Both the genes and the noncoding segments follow fairly standard patterns from person to person, but there is also a distinct pattern in each individual—so distinct, in fact, that DNA patterns can be used like fingerprints to identify the person (or other organism) from whom they came. DNA fingerprinting works because no two individuals (except identical twins) have the same DNA sequences, and because all cells (except gametes) of an individual have the same DNA. You can read about a real example of DNA fingerprinting in the *Problem-Solving Lab.*

PCR techniques have been used to clone DNA from many sources. Geneticists are cloning DNA from mummies and analyzing it in order to better understand ancient life. Abraham Lincoln's DNA has been taken from the tips of a lock of his hair and studied for evidence of a possible genetic disorder. The DNA from fossils has been analyzed and used to compare extinct species with living species, or even two extinct species with each other. The uses of DNA technology are unlimited.

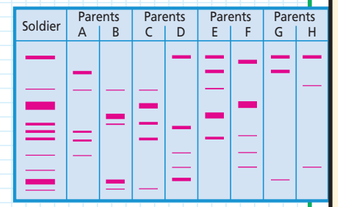
Problem-Solving Lab 13-3 Applying Concepts

How is identification made from a DNA fingerprint?

DNA fingerprint analysis requires a sample of DNA from a person, either living or dead. The DNA is first cut up into smaller segments with enzymes. The segments are then separated according to size using electrophoresis. When stained, the DNA segments appear as colored bands in a specific order. These bands form a person's DNA fingerprint.

Analysis

An unidentified soldier from the Vietnam War who had been placed in the Tomb of the Unknowns at Arlington National Cemetery was identified through DNA fingerprinting. The soldier could have been one of four possible individuals. A DNA sample from his body was analyzed. The DNA from the parents of the four suspected soldiers was analyzed. The diagram shows a DNA fingerprint pattern analysis similar to the one that was actually done. Find the correct match between the soldier's DNA fingerprint pattern and those of his parents. Remember, a child's DNA is a combination of parental DNA.



Thinking Critically

1. Which parental DNA matched the unknown soldier? How did the DNA pattern allow you to decide?
2. What percent of the soldier's DNA matched his father's DNA? His mother's? Explain why.
3. Could an exact identification have been made if only one parent were alive? Explain why.

Section Assessment

Understanding Main Ideas

1. What is the Human Genome Project?
2. Compare a linkage map and a sequencing map.
3. What is gene therapy?
4. Explain why DNA fingerprinting can be used as evidence in law enforcement.

Thinking Critically

5. Describe some possible benefits of the Human Genome Project.

Skill Review

6. **Observing and Inferring** Suppose a cystic fibrosis patient has been treated with gene therapy, in which a normal allele is inserted into lung cells of the patient using a virus vector. Does this person still run the risk of passing the disorder to his or her offspring? Explain. For more help, refer to *Thinking Critically* in the **Skill Handbook.**

Biology Journal

Gene Therapy

Linguistic Have students research the current progress being made on gene therapy in the treatment of cystic fibrosis or other genetic disorders. They can then write reports to include in their journals. L2

Portfolio

Bioethics

Ask students to write an essay giving their opinions on whether parents should change a child's genes before birth for each of the following: to correct a child's genetic disorder, to make a child more attractive, to change the child's gender. L1 P

Section Assessment

1. an international effort to completely map and sequence the human genome
2. A sequencing map shows the sequence of DNA bases; a linkage map shows the position of genes on a chromosome.
3. the insertion of normal alleles into human cells to correct genetic disorders
4. The DNA of every individual, except identical twins, is unique. It can be used to identify individuals with great accuracy.
5. If the location of genes is known, then gene therapy can be used to replace defective genes and cure a disorder.
6. Because only the lung cells had the allele replaced, the sex cells would still contain a cystic fibrosis allele and the disorder would be passed on to the offspring.

3 Assess

Check for Understanding

Ask students to explain what the Human Genome Project proposes to do. *map and sequence all the genes on human chromosomes*

Reteach

Ask students to list applications of the Human Genome Project. *diagnosis of genetic disorders, gene therapy, and DNA fingerprinting*

Extension

Kinesthetic Cloning kits can be purchased from biological supply companies. L3

Assessment

Skill Ask students to predict future applications of the Human Genome Project. L1

4 Close

Discussion

Ask students whether couples should be able to change features of their unborn children if the features are not disorders, such as eye color, hair color, or gender.

Resource Manager

- **Concept Mapping,** p. 13 L3 ELL
- **Critical Thinking/Problem Solving,** p. 13 L3
- **BioLab and MiniLab Worksheets,** pp. 63-64 L2
- **Reinforcement and Study Guide,** p. 58 L2
- **Content Mastery,** pp. 63-64 L1
- **Tech Prep Applications,** pp. 21-22 L2

INVESTIGATE BioLab

Time Allotment
One class period

Process Skills
compare and contrast, observe and infer, recognize cause and effect

Safety Precautions
Be careful with sharp edges of scissors. Always cut away from the body.

Preparation

- Review the chemical structure of DNA from Chapter 11 before students begin the BioLab.
- Additional background material on modeling recombinant DNA can be found in the article, "Recombinant Paper Plasmids" by Christie L. Jenkins, *The Science Teacher*, April 1987. You may wish to read this article before you teach the BioLab.

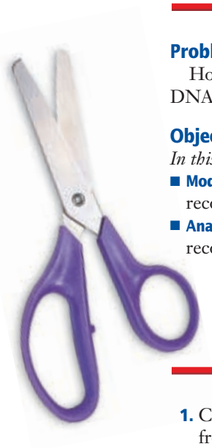
Resource Manager

BioLab and MiniLab Worksheets, pp. 65-66 L2

INVESTIGATE BioLab

Modeling Recombinant DNA

Experimental procedures have been developed that allow recombinant DNA molecules to be engineered in a test tube. From a wide variety of restriction enzymes available, scientists choose one or two that recognize particular sequences of DNA within a longer DNA sequence of a chromosome. The enzymes are added to the DNA, which is cleaved at the recognition sites. Because the cleaved fragments have ends that are available for attachment to complementary strands, the fragments can be added to plasmids or to viral DNA that has been similarly cut. When the fragment has been incorporated into the DNA of the plasmid or virus, it is called recombinant DNA.



Preparation

Problem
How can you model recombinant DNA technology?

Objectives
In this BioLab, you will:
- **Model** the process of preparing recombinant DNA.
- **Analyze** a model for preparation of recombinant DNA.

Materials
white paper
colored pencils, red and green
tape
scissors

Safety Precautions
Always wear goggles in the lab. Be careful with sharp objects.

Skill Handbook
Use the **Skill Handbook** if you need additional help with this lab.

Procedure

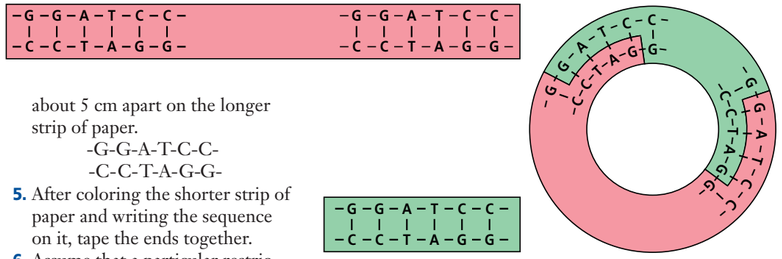
1. Cut a lengthwise strip of paper from a sheet of white paper into a rectangle about 3 cm by 28 cm. This strip of paper represents a long sequence of DNA containing a particular gene that you wish to combine with a plasmid.
2. Cut another lengthwise strip of paper into a rectangle about 3 cm by 10 cm. When taped into a ring, this piece of paper will represent a bacterial plasmid.
3. Use your colored pencils to color the longer strip red and the shorter strip green.
4. Write the following DNA sequence once on the shorter strip of paper and two times about 5 cm apart on the longer strip of paper.

-G-G-A-T-C-C-
-C-C-T-A-G-G-

5. After coloring the shorter strip of paper and writing the sequence on it, tape the ends together.
6. Assume that a particular restriction enzyme is able to cleave DNA in a staggered way as illustrated here.

-G G-A-T-C-C-
-C-C-T-A-G G-

Cut the longer strand of DNA in both places as shown. You now have a cleaved foreign DNA fragment containing a gene that can be inserted into the plasmid.
7. Once the sequence containing the foreign gene has been cleaved, cut the plasmid in the same way.
8. Splice the foreign gene into the plasmid by taping the paper together where the sticky ends pair properly. The new plasmid represents recombinant DNA.



Data Table

Term	BioLab model
Gene splicing	
Plasmid	
Restriction enzyme	
Sticky ends	
Recombinant DNA	

9. Copy the data table. Relate the steps of producing recombinant DNA to the activities of the modeling procedure by explaining how the terms relate to the model.

Analyze and Conclude

1. **Comparing and Contrasting** How does the paper model of a plasmid resemble a bacterial plasmid?
2. **Comparing and Contrasting** How is cutting with the scissors different from cleaving with a restriction enzyme?
3. **Thinking Critically** Enzymes that modify DNA, such as restriction enzymes, have been discovered and isolated from living cells. What functions do you think they have in living cells?

Going Further
Project Design and construct a three-dimensional model that illustrates the process of preparing recombinant DNA. Consider using clay, plaster of Paris, or other materials in your model. Label the model and explain it to your classmates.

internet CONNECTION To find out more about recombinant DNA, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Procedure

Teaching Strategies
- Students can do this lab alone or with partners.
- If red and green colored paper is available, then colored pencils will not be necessary.
- If you make cardboard models of DNA bases for the Meeting Individual Needs on page 350, use them in this BioLab.

Data and Observations
Data for completing the table should be as follows: Gene splicing—process of taping green and red paper together; Plasmid—green strip; Restriction enzyme—scissors; Sticky ends—cut ends on paper; Recombinant DNA—red and green strips taped together.

INVESTIGATE BioLab

Analyze and Conclude

1. It is a small circular piece of DNA.
2. The scissors can cut the DNA anywhere, but the restriction enzyme recognizes a particular sequence.
3. These enzymes may function in a cell by cutting up and destroying invading viral DNA.

Assessment
Performance Have students write a paragraph summarizing what they have learned about the use of restriction enzymes. Have students explain how the BioLab model is like the terms listed in the data table. Use the Performance Task Assessment List for Writing in Science in **PASC,** p. 87.

Going Further
Kinesthetic Students could use different colors of clay, or use food coloring to dye plaster of Paris, to show recombinant DNA in their models. L1 ELL

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Animation: *Recombinant DNA*
Disc 2

BIO Technology

Purpose

Students learn about the technique used to produce the first successful clone of an adult mammal and are introduced to some of the potential benefits of cloning technology.

Background

Frogs were the first vertebrate animals to be cloned. During the 1950s and 1960s, scientists even managed to clone adult frogs, but none of the clones survived past the tadpole stage. Clones of mammals may have the same genes, but they are not necessarily identical. The uterine environment in which an individual develops, and the conditions under which it is raised, have a profound effect on its appearance and behavior. Identical twins may actually be more alike than clones because they share the same uterine environment and are usually raised under the same conditions.

Teaching Strategies

- Review with students the steps in the reproductive process. An egg cell and sperm cell each contain half the normal complement of chromosomes. When fertilization occurs, the two cells fuse to form a zygote with a full complement of chromosomes. The zygote divides by mitosis to form a multicellular embryo. As the embryo grows, cell division continues and the cells begin to differentiate as the body systems are formed. When all body systems are present, the embryo becomes a fetus. The fetus continues to grow and develop until it is mature enough to survive outside the mother's uterus.

Investigating the Technology

The genes had to be turned on in order for all organs and systems to develop.

BIO Technology

How to Clone a Mammal

A cloned organism has exactly the same genes as its parent. A single cell from the parent is used to produce the clone. During the 1980s and early 1990s, the first successful clones of mammals were produced from embryo cells of mice, sheep, cattle, goats, rabbits, and monkeys. Creating a clone from an adult mammal cell proved to be more difficult, but was achieved in 1997.

When an egg is fertilized by a sperm, a zygote is formed that rapidly divides into a multicellular embryo. During the very early stages of development, all the genes present in each embryo cell are functional, or turned on. At this point, each embryo cell has the capacity to develop into a separate and complete individual. But during later stages of development, as the embryo grows into a fetus, its cells begin to differentiate. They become specialized for different tasks. Liver cells become distinct from muscle cells. Skin cells become different from blood cells. Once a cell has become specialized, most of its genes turn off and stop functioning. Only the genes needed to operate that particular kind of cell remain turned on, and the cell can no longer perform any other tasks. Because all the cells of an adult animal are specialized, cloning an animal from an adult cell requires finding a way to turn on all the genes in the cell.

A sheep called Dolly Dolly, a lamb born in Scotland in February 1997, was the first mammal to be cloned from an adult cell. To produce Dolly, researchers took an udder cell from a full-grown ewe, a female sheep. They used an electric charge to force the udder cell to fuse with an unfertilized sheep egg cell from which the nucleus had been removed. The electric charge created openings in the membrane of the egg cell large enough to admit the udder cell. The fused cell began to divide and develop into an embryo. The embryo was implanted into the uterus of another sheep, which gave birth to Dolly several months later. The method worked, but it took 277 cloning attempts to produce a single lamb. Since Dolly was cloned, mice and other animals have been cloned by slightly different techniques. These new techniques are much more efficient.

Cloned mice

Applications for the Future

Cloning experiments help to increase our knowledge of how genes and cells operate. Learning how specific genes are turned on and off can provide clues about how a fetus grows and develops. It may also contribute to our understanding of genetic diseases. For example, if the activity of a particular gene is found to be responsible for a disease, scientists could treat the disease by turning off the gene. Cloning techniques could also be used to change the function of a cell, such as altering skin cells to create blood cells for a transfusion or to grow bone or cartilage to replace damaged tissue.

Investigating the Technology

Analyzing Concepts Do you think the genes in the fused cell that produced Dolly were turned on or turned off? Explain.

*inter*NET CONNECTION To find out more about genetic technology, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Going Further

Encourage students to research the latest developments in cloning technology and its uses in medicine and other industries. Invite them to discuss or write about ethical issues arising from the development of cloning.

Chapter 13 Assessment

Summary

Section 13.1

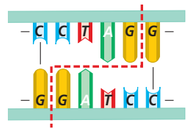
Applied Genetics

Main Ideas
- Geneticists use test crosses to determine the genotypes of individuals and the probability that offspring will have a particular allele.
- Plant and animal breeders use genetics to selectively breed organisms with desirable traits.

Vocabulary
inbreeding (p. 346)
test cross (p. 347)

Section 13.2

Recombinant DNA



Main Ideas
- Scientists have developed methods to move genes from one species into another. This process uses restriction enzymes to cleave one organism's DNA into fragments and other enzymes to splice the DNA fragment into a plasmid or viral DNA. Transgenic organisms are able to manufacture genetic products foreign to themselves using recombinant DNA.
- Genetic engineering has already been applied to bacteria, plants, and animals. These organisms are engineered to be of use to humans.

Vocabulary
clone (p. 352)
gene splicing (p. 352)
genetic engineering (p. 349)
plasmid (p. 351)
recombinant DNA (p. 349)
restriction enzyme (p. 350)
transgenic organism (p. 349)
vector (p. 351)

Section 13.3

The Human Genome

Main Ideas
- International efforts are presently underway to sequence the DNA of the entire human genome and to determine the chromosome location for every gene.
- Applications of the Human Genome Project include the goals of detecting, treating, and curing genetic disorders. DNA fingerprinting can be used to identify persons responsible for crimes and to provide evidence that certain persons are not responsible for crimes.

Vocabulary
gene therapy (p. 360)
human genome (p. 357)
linkage map (p. 357)

Understanding Main Ideas

1. What is the purpose of a test cross?
   a. produce offspring that consistently exhibit a specific trait
   b. check for carriers of a trait
   c. explain recessiveness
   d. show polygenic inheritance

2. Two closely related cattle are mated. Their offspring are _____.
   a. vectors **c.** mutants
   b. carriers **d.** inbred

3. A section of mouse DNA is joined to a bacterial plasmid. The DNA formed is _____.
   a. translated DNA **c.** recombinant DNA
   b. restricted DNA **d.** transcripted DNA

GLENCOE TECHNOLOGY

VIDEOTAPE
MindJogger Videoquizzes
Chapter 13: *Genetic Technology*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

Resource Manager

Chapter Assessment, pp. 73-78
MindJogger Videoquizzes
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 13 quiz

Chapter 13 Assessment

Main Ideas

Summary statements can be used by students to review the major concepts of the chapter.

Using the Vocabulary

To reinforce chapter vocabulary, use the Content Mastery Booklet and the activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web Site.
www.glencoe.com/sec/science

THE PRINCETON REVIEW

All Chapter Assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.

Understanding Main Ideas

1. b
2. d
3. c

4. c
5. d
6. c
7. b
8. a
9. c
10. a
11. Inbreeding
12. DNA sequencing
13. palindrome
14. Bacterial
15. Three
16. cloning or PCR
17. vector
18. linkage
19. clones
20. test cross

Applying Main Ideas

21. treating and curing human genetic disorders
22. Bacteria are capable of making large quantities of human proteins when they carry human genes. These proteins have potential medicinal and industrial usages.
23. This may upset the balance between the natural nitrogen-converting bacteria and the plants, possibly disrupting the soil ecosystem. Plant growth would increase because nitrogen is usually a limiting factor.

Chapter 13 Assessment

4. When a bacterial plasmid transfers a piece of foreign DNA to a host cell, the plasmid serves as a(n) _____.
   a. transgenic cell **c.** vector
   b. hybrid **d.** enzyme
5. The goal of gene therapy is to insert a _____ into cells to correct a genetic disorder.
   a. recessive allele **c.** dominant allele
   b. growth hormone **d.** normal allele
6. _____ are genetically identical copies of DNA.
   a. Vectors **c.** Clones
   b. Plasmids **d.** Spliced genes
7. Plant cells are difficult to genetically engineer because they do not have the _____ needed for taking up foreign DNA.
   a. amino acids **c.** clones
   b. plasmids **d.** enzymes
8. The process of gel electrophoresis separates _____ fragments by using an electric field.
   a. DNA **c.** gel
   b. cell **d.** enzyme
9. An organism that contains functional recombinant DNA is called a _____ organism.
   a. cleaved **c.** transgenic
   b. cloned **d.** spliced
10. Restriction enzyme *Eco*R1 cuts DNA strands, leaving _____ ends.
    a. sticky **c.** blunt
    b. smooth **d.** spliced
11. _____ usually increases the appearance of genetic disorders.
12. _____ is a method used to determine the order of the DNA nucleotides.

Test-Taking Tip

Let Bygones Be Bygones

Once you have read a question, considered the answers, and chosen one, put that question behind you. Don't try to keep the question in the back of your mind, thinking that maybe a better answer will come to you as the test continues.

13. A _____ occurs when the same sequence of bases, running in opposite directions, is found on both DNA strands.
14. _____ cells are the primary source of the plasmids used in DNA technology today.
15. *Eco*R1 restriction enzyme recognizes the sequence GAATTC in double-stranded DNA. _____ pieces of DNA would result if *Eco*R1 were added to the following DNA.

16. The technique _____ is used to make millions of copies of DNA fragments.
17. A gene gun is used to deliver a mechanical type of _____.
18. The genetic map that shows the location of genes on a chromosome is a _____ map.
19. Cells in a cell culture all have the same genetic material because they are _____.
20. The Punnett square to the right illustrates a _____.

	a	a
A	Aa	Aa
a	aa	aa

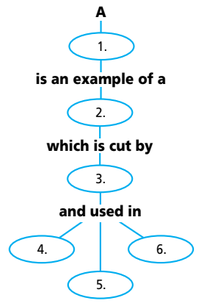
Applying Main Ideas

21. What is the potential use of a map showing the sequence of DNA bases in a human chromosome?
22. Why might it be important to be able to have a human gene expressed in a bacterium?
23. Assume that transgenic organisms can be developed to speed the conversion of nitrogen from the air into nitrates that plants can use as fertilizer. How might use of this organism affect an ecosystem?

Chapter 13 Assessment

Thinking Critically

24. **Observing and Inferring** Explain why the use of bacterial plasmids for gene splicing does not interfere with normal cell functions such as growth and reproduction.
25. **Recognizing Cause and Effect** How may using biotechnology to engineer many different transgenic organisms of a given species alter the course of evolution for that species?
26. **Sequencing** Once a foreign gene has been inserted into a plasmid to form a recombinant plasmid, what would be the next step if you were to continue the model of recombinant DNA technology?
27. **Interpreting Data** If all human genes have similar patterns, how can DNA fragments from hair or skin be used to identify distinct individuals by DNA fingerprinting?
28. **Concept Mapping** Complete the concept map by using the following vocabulary words: genetic engineering, transgenic organisms, restriction enzymes, vector, plasmid, gene splicing.

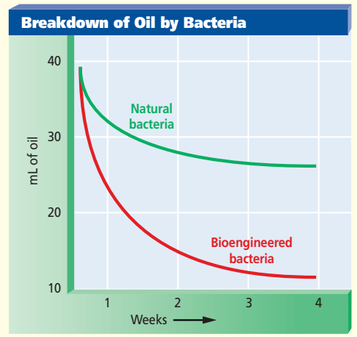


CD-ROM

For additional review, use the assessment options for this chapter found on the ***Biology: The Dynamics of Life Interactive CD-ROM*** and on the Glencoe Science Web Site.
www.glencoe.com/sec/science

Assessing Knowledge & Skills

The following graph shows the results of an experiment using natural and bioengineered bacteria of the same species that can break down oil. Each culture had 40 mL of oil added on Day 1.



Interpreting Data Use the graph to answer the following questions.

1. Approximately how much oil had been converted into harmless products by the natural bacteria after four weeks?
   a. 4 mL **c.** 24 mL
   b. 14 mL **d.** 40 mL
2. How much oil had been converted by bioengineered bacteria after four weeks?
   a. 4 mL **c.** 28 mL
   b. 14 mL **d.** 40 mL
3. How much more efficient are the bioengineered bacteria than the naturally occurring species?
   a. 1× **c.** 2×
   b. 1.5× **d.** 3×
4. **Interpreting Data** How can this technology be applied to an oil spill?

Chapter 13 Assessment

Thinking Critically

24. Plasmids used for gene splicing are not part of the cells' chromosome. Thus, they can be spliced and manipulated without affecting normal cell functions.
25. If many alleles were to be transferred into the normal population, their frequency would change. This would affect the genetic makeup of the population.
26. The recombinant DNA is then transferred into a host cell.
27. DNA fingerprinting uses the segments of noncoding DNA, which are in distinct, individual patterns.
28. 1. Plasmid; 2. Vector; 3. Restriction enzymes; 4. Genetic engineering; 5. Transgenic organisms; 6. Gene splicing

Assessing Knowledge & Skills

1. b
2. c
3. c
4. Because these bacteria have the ability to digest oil into a harmless product, the bacteria could be added to oil spills to clean them up quickly.

National Science Education Standards
UCP.1, UCP.2, UCP.3, UCP.5, C.1, C.5, E.2, F.1, F.5, F.6, G.1, G.3

Prepare

Purpose

This BioDigest can be used as an introduction to or as an overview of genetics. If time is limited, you may wish to use this unit summary to teach genetics in place of the chapters in the Genetics unit.

Key Concepts

Students will learn about Mendel and his insights into heredity. The process by which genetic information is copied and proteins are formed by the genetic code is described. Finally, the patterns of human heredity and DNA technology are discussed.

1 Focus

Bellringer

Visual-Spatial Have students closely examine the flower of a pea plant so they can become familiar with the materials with which Mendel worked. L1 ELL

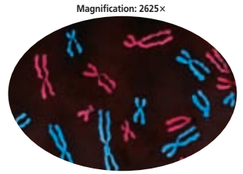
GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Exploration: *Trait Inheritance*
Exploration: *Punnett Square*
Animation: *Meiosis*
Disc 2

For a **preview** of the genetics unit, study this BioDigest before you read the chapters. After you have studied the genetics chapters, you can use the BioDigest to **review** the unit.

Genetics

Genetics is the study of inheritance. The physical traits, or phenotype, of an individual are encoded in small segments of chromosomes called genes. Not all genes are expressed as a phenotype. Therefore, the genotype, the traits encoded in the genes, may be different from the expressed phenotype.

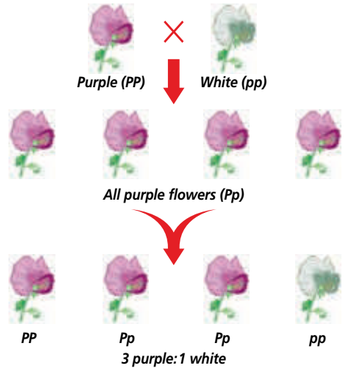


Chromosomes

Simple Mendelian Inheritance

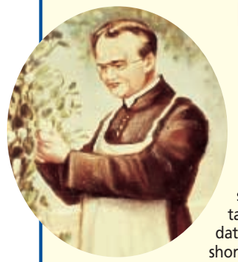
A trait is dominant if only one allele of a gene is needed for that trait to be expressed. If two alleles are needed for expression, the trait is said to be recessive. In pea plants, the allele for purple flowers is dominant and the allele for white flowers is recessive. Any plant with *PP* or *Pp* alleles will have purple flowers. Any plant with *pp* alleles will have white flowers.

When a *PP* purple pea plant is crossed with a *pp* white plant, all the offspring are purple, *Pp*. When two *Pp* plants are crossed, three-fourths of the plants in the next generation will be purple and one-fourth will be white.



Focus on History

Mendel


Gregor Mendel

To investigate the genetic inheritance of pea plant traits, the Austrian monk Gregor Mendel used critical thinking skills to design his experiments. When he collected data, he considered not only the qualitative characteristics, such as whether the plants were tall or short, but also the quantitative data by analyzing the ratios of tall to short plants in each generation. Mendel observed that there were two variations for each trait, such as tall and short plants. He formed the hypothesis that alleles transmitted these traits from one generation to the next. After studying several traits for many generations, Mendel formed two laws. The law of segregation states that the two alleles for each trait separate when gametes are formed. The law of independent assortment states that genes for different traits are inherited independently of each other.

Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

Kinesthetic Quick Demo, p. 372; Meeting Individual Needs, p. 372
Visual-Spatial Bellringer, p. 368; Quick Demo, p. 369; Activity, p. 369; Demonstration, p. 371; Portfolio, p. 371
Intrapersonal Extension, p. 373
Linguistic Biology Journal, p. 370

Vital Statistics

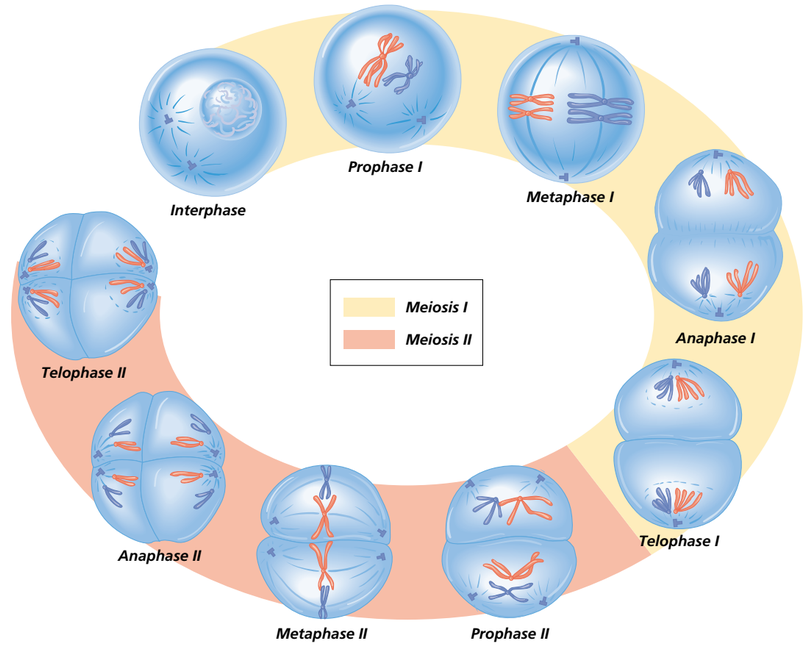
Mendel's Ratios of Inherited Traits

Seed Color 3:1	Yellow 6022, Green 2001
Flower Position 3:1	Lateral 651, Terminal 207
Pod Color 3:1	Green 428, Yellow 152
Pod Shape 3:1	Inflated 882, Constricted 299

Meiosis

Meiosis produces gametes that contain only one copy of each chromosome instead of two. Some stages of meiosis are similar to those of mitosis, but in meiosis, homologous chromosomes come together as tetrads to exchange genes during a process called crossing over. Meiosis also provides a mechanism for rearranging the genetic information carried by cells. Both crossing over and the rearrangement of genes during meiosis produce genetic variability, which may give offspring a survival advantage if the environment changes.

Meiosis consists of two divisions, meiosis I and meiosis II. During meiosis I, the homologous chromosomes separate from each other. In meiosis II, the sister chromatids of each chromosome separate from each other.



Assessment Planner

Portfolio Assessment
Portfolio, TWE, p. 371
Knowledge Assessment
Assessment, TWE, p. 373
BioDigest Assessment, SE, p. 373
Skill Assessment
Assessment, TWE, p. 369

2 Teach

Assessment

Skill Have students calculate the ratios from Mendel's data as listed in the Vital Statistics box. Ask students why the ratios are not exactly 3:1. L2

Discussion

Have students discuss Mendelian inheritance. Begin by comparing and contrasting genotype and phenotype. What are the possible genotype(s) of a dominant trait? A recessive trait? *A genotype is the alleles for a trait that an individual possesses. A phenotype is the physical appearance of that trait. The possible genotypes of a dominant trait are homozygous,* PP, *or heterozygous,* Pp *for the purple flower color. A recessive trait must be homozygous,* pp, *for the recessive phenotype.*

Quick Demo

Visual-Spatial Draw a Punnett square for another cross of Mendel's experiments mentioned in the Vital Statistics box. Correlate this to the pea crosses for petal color. Ask students whether the ratios of offspring are the same.

Activity

Visual-Spatial Have students draw a cell undergoing meiosis. Make sure they label homologous chromosomes and sister chromatids. L1 ELL

Visual Learning

Put up an overhead of transcription and ask students questions about the process. Ask them to define a gene, transcription, and mRNA. Have them identify the bases of DNA. *A gene is a segment of DNA containing the information for making a protein. Transcription is the process whereby a DNA sequence of bases is copied into a sequence of bases in mRNA. mRNA will carry the information for proteins into the cytoplasm. The bases of DNA are adenine, thymine, cytosine, and guanine.*

Discussion

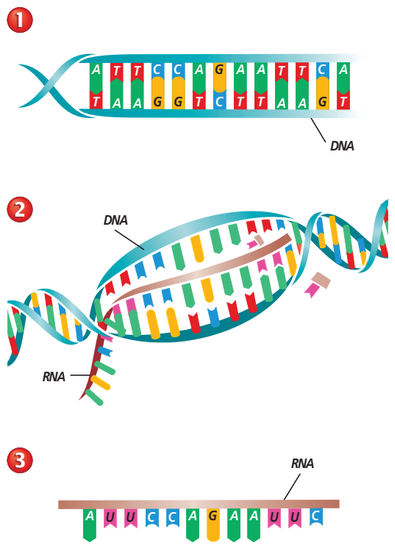
Discuss the idea that some traits such as sickle-cell anemia may confer an advantage for survival to a heterozygote. How might this idea have been used throughout evolution to define characteristics of living species? *Traits that confer an advantage to individuals in a species increase the chances of that individual surviving to reproduce and pass on the traits.*

Producing Physical Traits

Deoxyribonucleic acid (DNA) is a double-stranded molecule made up of a sequence of nucleotide base pairs that encode each gene on a chromosome. There are four bases in DNA: A, T, C, and G. Because of their molecular shape, A can pair only with T, and C can pair only with G. This precise pairing allows the DNA molecule to copy itself in a process called DNA replication.

Transcription

To make a protein, the segment of DNA containing the gene for that protein must be transcribed. First, the sequence of bases in the DNA segment is copied into a molecule of messenger ribonucleic acid (mRNA), which then moves from the nucleus to the cytoplasm. RNA is similar to DNA except that RNA is single-stranded and contains the base U in place of T.

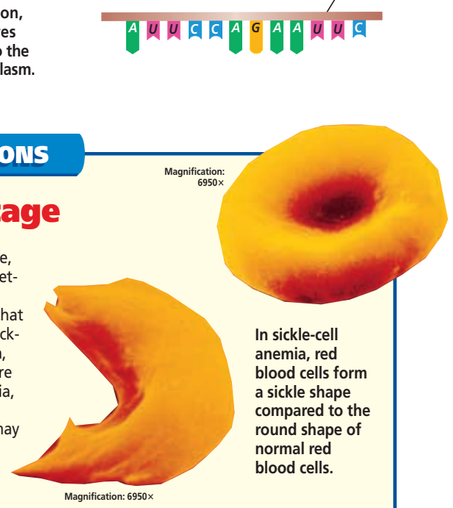


In transcription, the two strands of DNA separate and a molecule of mRNA is made according to the sequence of bases in the DNA. After transcription, the mRNA strand leaves the nucleus to travel to the ribosomes in the cytoplasm.

Focus on Adaptations

Heterozygote Advantage

Some recessive alleles, such as the sickle-cell allele, remain in a population because they give the heterozygote a genetic advantage in certain environments. Sickle-cell anemia affects red blood cells so that they change shape when oxygen levels are low, blocking blood vessels. The disorder is prevalent in Africa, where malaria is common. When individuals who are heterozygous for the sickle-cell trait contract malaria, they suffer fewer and milder symptoms of malaria, whereas normal individuals who contract malaria may die. Therefore, sickle-cell alleles in heterozygotes remain in the population.

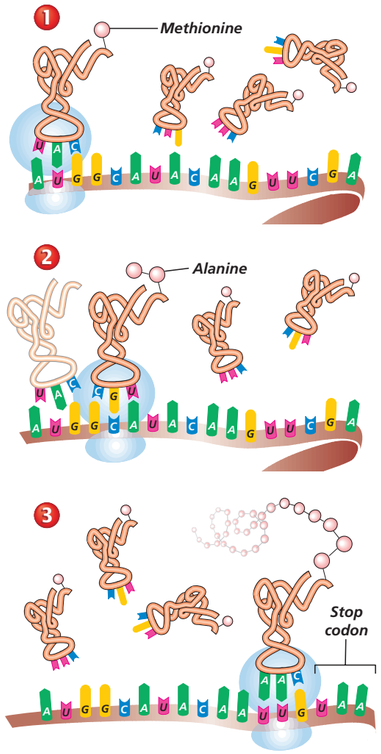


In sickle-cell anemia, red blood cells form a sickle shape compared to the round shape of normal red blood cells.

Translation

A codon, a sequence of three bases in the mRNA, serves as a code for an amino acid. In a process called translation, a ribosome "reads" the codons on the molecule of mRNA. Transfer RNA (tRNA) molecules bring the appropriate amino acids to the mRNA at the ribosome. The amino acids are bonded together to form a protein.

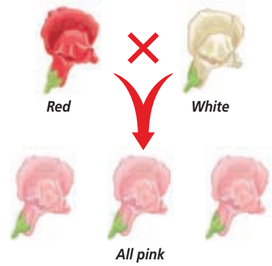
In translation, the sequence of bases in the mRNA is translated into a sequence of amino acids in a protein chain. Every three nucleotides code for a specific amino acid.

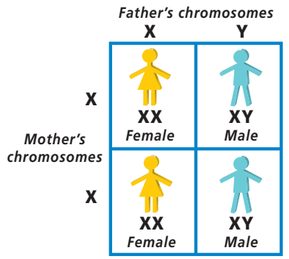


Complex Inheritance Patterns

An incomplete dominance pattern of inheritance produces an intermediate phenotype in the heterozygote. In codominant inheritance, the heterozygote expresses both alleles. Some traits, such as human blood types, are governed by multiple alleles, although any individual can carry only two of those alleles.

Flower color in snapdragons is an example of incomplete dominance. The flower color of the heterozygote is intermediate to that of the two homozygotes.





In any mating between humans, half the offspring will have the XX genotype, which are females, and half the offspring will have the genotype XY, which are males.

Visual Learning

Put up an overhead of translation and ask students questions. Have them differentiate between mRNA and tRNA. Give students a sequence of several mRNA codons and ask them to "translate" the RNA bases into an amino acid sequence. *mRNA contains a copy of a gene from DNA. tRNA carries amino acids to ribosomes.*

Demonstration

Visual-Spatial Grow red, white, and pink snapdragons. Ask students to draw Punnett squares for various matings of the snapdragons. Have them identify this trait as incomplete dominance. L1 ELL

GLENCOE TECHNOLOGY

VIDEODISC
Biology: The Dynamics of Life
Sex-Linked Traits (Ch. 35)
Disc 1, Side 1, 1 min. 49 sec.

Fruit Fly Genetics (Ch. 34)
Disc 1, Side 1, 50 sec.

Biology Journal

Mendel's Experiments

Linguistic Have students write about Mendel's experiments and his conclusions. How did he follow the scientific method in testing his hypotheses? What two laws did he derive from his studies? L2

Portfolio

Punnett Squares

Visual-Spatial Make Punnett squares demonstrating various crosses between individuals with a dominant trait, a recessive trait, incomplete dominance, codominance, and a sex-linked trait. L1 ELL P

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Animation: *DNA Replication*
Animation: *DNA Transcription*
Animation: *Translation*
BioQuest: *Building a Protein*
Disc 2

Reinforcement

Have students make a table with the following headings: Dominant, Recessive, Incomplete dominance, Codominance, Multiple alleles, Polygenic inheritance, and X-linked traits. Under each heading, they should list the following: genotype(s), whether the trait is more common in males or females, one specific example from the text, and how many phenotypes are possible.

Quick Demo

Kinesthetic Take two pieces of electrical wire of different colors. Use clippers as restriction enzymes to cut the wires. Peel some of the colored coating from the cut edges of the wires to demonstrate sticky ends. Then splice the two wires together to simulate recombinant DNA.

GLENCOE TECHNOLOGY

VIDEODISC
VIDEOTAPE
The Secret of Life
In the Land of Milk and Money: Biotechnology

Tinkering With Our Genes: Genetic Medicine

Resource Manager

Reinforcement and Study Guide, pp. 59-60 L2
Content Mastery, pp. 65-68 L1

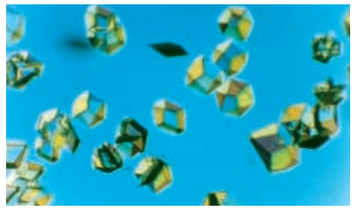
The X chromosome, one of two sex chromosomes, carries many genes, including the genes for hemophilia and for color blindness. Most X-linked disorders appear in males because they inherit only one X chromosome. In females, a normal allele on one X chromosome can mask the expression of a recessive allele on the other X chromosome. Finally, some traits, such as skin color, are polygenic—governed by several genes.

Vital Statistics

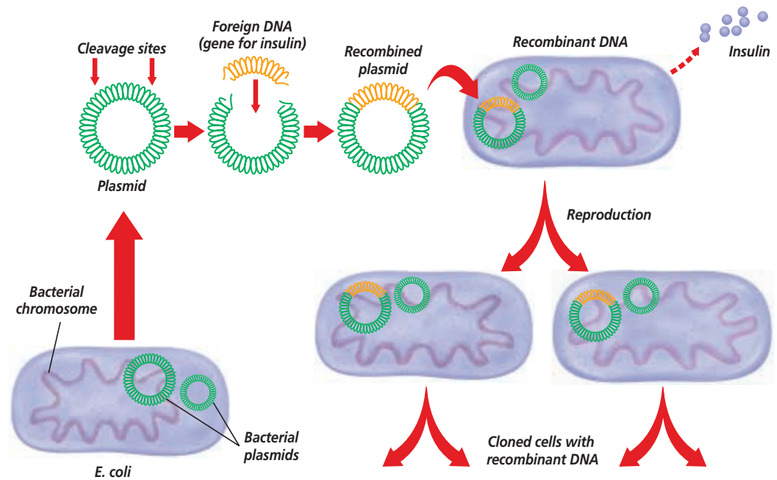
Frequency of Genetic Disorders in the Population
Cystic Fibrosis: 1 in 2000 white Americans is homozygous recessive.
Sickle-Cell Anemia: 1 in 500 African Americans is homozygous recessive.
Tay-Sachs Disease: 1 in 3600 Jews of eastern European ancestry is homozygous reces-

Recombinant DNA Technology

To make recombinant DNA, a small segment of DNA containing a desired gene is inserted into a bacterial plasmid, a small ring of DNA. The plasmid acts as a vector to carry the DNA segment into a host bacterial cell. Every time the bacterium reproduces, the plasmid containing the inserted DNA is duplicated, producing copies of the recombinant DNA along with the host chromosome. Because these new DNA segments are identical to the original, they are called clones. The host cell produces large quantities of the protein encoded by the recombinant DNA it con-



Recombinant DNA can be cloned to produce many copies of a specific segment of DNA. The inset photo shows crystals of insulin that were purified from a culture of recombinant bacteria.



Meeting Individual Needs

Learning Disabled

Kinesthetic Have students use a model of a human respiratory system to simulate gene therapy for cystic fibrosis. Students should show the pathway taken by viral DNA containing a normal allele. L1 ELL

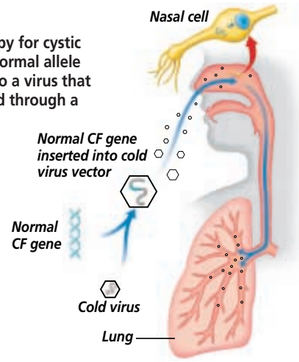
GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Recombinant DNA Segment

Gene Therapy

Gene therapy involves the insertion of normal alleles into human cells to correct genetic disorders. Gene therapy is used to treat cystic fibrosis, a serious genetic disorder caused by a missing protein in the cell membrane. In gene therapy for this disorder, the normal allele is inserted into a virus that causes the common cold. The virus carries the gene into the patient's cells, which begin to produce the missing protein.

In gene therapy for cystic fibrosis, the normal allele is inserted into a virus that can be inhaled through a nasal spray.



BioDigest Assessment

Understanding Main Ideas

1. An example of a dominant trait is _____.
   a. cystic fibrosis
   b. white pea flowers
   c. purple pea flowers
   d. sickle-cell anemia
2. The three-nucleotide base sequence that codes for an amino acid is called _____.
   a. a codon **c.** tRNA
   b. a base pair **d.** mRNA
3. Something that carries a piece of DNA into a host cell is called a _____.
   a. clone **c.** vector
   b. bacterial cell **d.** recombinant DNA
4. A base sequence that would be found in RNA but not in DNA is _____.
   a. ATTCGA **c.** AUUCCG
   b. TTTGGC **d.** TUCCGT
5. A broad range of phenotypes for a given trait is usually the result of _____.
   a. multiple alleleic inheritance
   b. incomplete dominance
   c. codominance
   d. polygenic inheritance
6. A base pair that can be found in a DNA molecule is _____.
   a. A—T **c.** A—G
   b. A—C **d.** C—C
7. The process of copying DNA into mRNA is called _____.
   a. translation **c.** replication
   b. transcription **d.** cloning
8. A trait that can be expressed only as a homozygous genotype is _____.
   a. dominant **c.** codominant
   b. recessive **d.** X-linked
9. Meiosis differs from mitosis in that the cells produced by meiosis have _____ the number of chromosomes as the parent cell.
   a. half **c.** twice
   b. three times **d.** the same as
10. In crossing over, genetic material is exchanged between _____, resulting in genetic variability of offspring.
    a. cells **c.** genes
    b. chromatids **d.** alleles

Thinking Critically

1. State Mendel's law of independent assortment and explain what it means.
2. Compare the phenotypes of the heterozygotes in simple Mendelian inheritance, incomplete dominance, and codominance.
3. Describe the process for producing a bacterium that contains recombinant DNA.

BioDigest Assessment

Understanding Main Ideas

1. c
2. a
3. c
4. c
5. d
6. a
7. b
8. b
9. a
10. b

Thinking Critically

1. Each gene on a chromosome will separate independently of any other gene during meiosis.
2. In simple Mendelian inheritance, a heterozygote will carry the phenotype of the dominant allele. In incomplete dominance, the phenotype will be a blend of that of the two homozygotes. In codominance, the phenotype shows the products of both alleles.
3. Restriction enzymes must be used to cut the DNA fragment and the bacterial plasmid. Then the two may be spliced together and inserted into a bacterium.

3 Assess

Check for Understanding

Ask students to define transcription and translation and to explain each process.

Reteach

Put up an overhead of the stages of meiosis and ask students to identify the stages.

Extension

Intrapersonal Have students research some of the uses of genetic technology, such as the production of human insulin and human growth hormone. L3

Assessment

Knowledge Put an example of incomplete dominance or codominance on the board and ask students to identify the pattern of inheritance. L1

4 Close

Discussion

Discuss the implications of gene therapy using cystic fibrosis as an example. Will effective treatment alter the possibility of passing this trait to future generations?