10 Animal Behavior

INVESTIGATION

Most of the traits you have looked at have been physical traits, such as the color, number, or shape of various body parts. The last activity introduced calling behavior in critters. The calls and other sounds animals make are examples of behavioral traits. Genes influence many animal behaviors, from behaviors that help animals find food to behaviors involved in mating and caring for offspring.

Some of the physical and behavioral traits influenced by genes increase the chances an animal will successfully reproduce. For example, why do male deer have antlers? Aren't antlers heavy? Why do birds sing and dance? Wouldn't all that singing and dancing make birds more obvious to predators?

In this activity, you will examine results from scientific investigations that looked at these questions and others that help explain how various traits affect the probability of an animal's successful reproduction. **Reproductive success** is a measure of how many successful offspring an individual organism has. Behaviors and other traits that affect reproductive success may be determined by both genetic and environmental factors.

A pair of blue-footed boobies perform a mating dance.

GUIDING QUESTION

How do animal behaviors and other traits affect the probability of successful reproduction?

PROCEDURE

1. Your teacher will assign your group to one of the four investigations below.

Investigation 1: Long-tailed Widowbird

The long-tailed widowbird (*Euplectes progne*) is a small bird found in sub-Saharan Africa. Males of this species are solid black with red shoulder patches. They have very long tails, up to half a meter in length (two to three times the length of the body). Males establish breeding territories in grasslands and will fly slowly over their territories approximately 1–2 meters (m) above the top of the grass. When they do this, their tails are visible from 1 kilometer (km) away. Female long-tailed widowbirds are brown with streaks, have short tails, and do not perform this kind of flight.

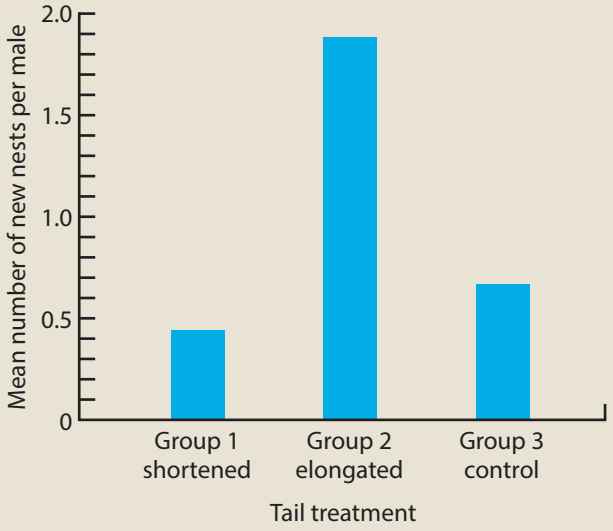
Scientists wondered why the male has such a long, conspicuous tail. One scientist, Malte Andersson, conducted an experiment to see what would happen if he made their tails either longer or shorter. He divided the birds into three groups. He modified the tails of Groups 1 and 2 as described in the table below. Group 3 served as a control group.

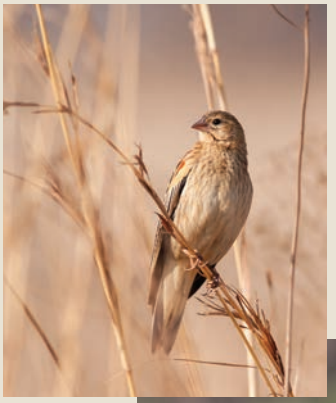
Widowbird Experiment

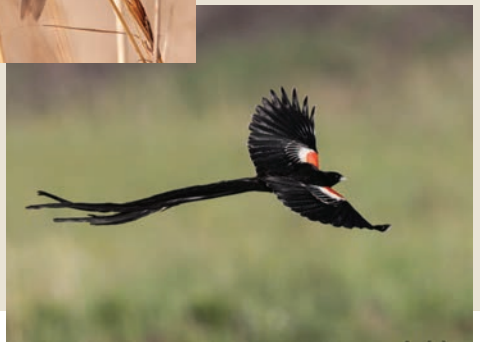
BIRD GROUP	TAIL MODIFICATION
1	Tail feathers cut shorter
2	Tail feathers lengthened by gluing on feathers cut from Group 1
3	Tails left at natural length, or cut and glued back on

He then looked at the number of new nests in each male's territory. The results are shown in the graph below and to the left.

Widowbird Results







A female long-tailed widowbird (left)

A male long-tailed widowbird (below)

Nest A Nest B Nest C

These nests show a parasitic egg that looks very similar (A), looks somewhat similar (B), and looks different (C) from the host eggs.

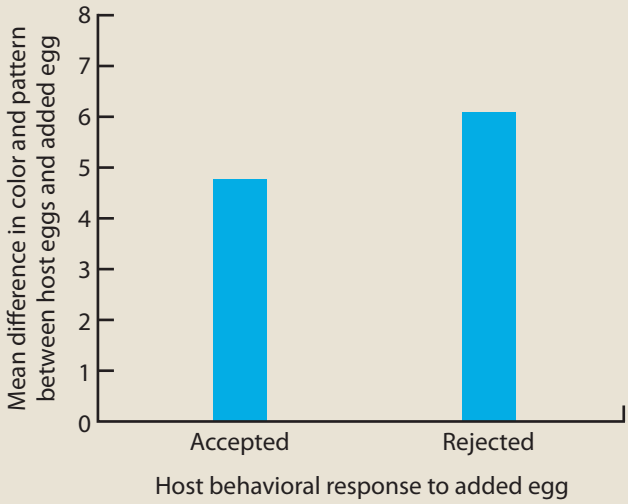
Investigation 2: Egg Color

Scientists have discovered that there are certain species of birds that don't build their own nests. Instead, they lay their eggs in the nests of other species. These species are known as *brood parasites*. One example of a brood parasite is the cowbird. The bird whose nest receives a cowbird egg (the host) suffers a loss because the female cowbird will remove one of the host's eggs. And when the parasitic cowbird chick hatches, it may remove all of the host's eggs and chicks.

Researchers studying another kind of brood parasite, the cuckoo finch (*Anomalospiza imberbis*), wondered if one of its hosts, the tawny-flanked prinia (*Prinia subflava*), has any mechanisms, or adaptations, for reducing the potential losses from having an alien egg in the nest. They wondered if prinias had the ability to detect differences in egg color and pattern between their own eggs and the cuckoo finch's eggs. Scientists tested their ideas by conducting experiments that involved placing artificial cuckoo finch eggs (made with a 3-D printer) into prinia nests. The scientists recorded the prinias' behavioral responses to these "parasitic" eggs—either accepting the egg or physically rejecting the egg from the nest.

They also kept track of how much the added eggs differed in color and pattern from the hosts' eggs, using a rating scale that they developed. In their study, a difference of 0 meant that the eggs were the same color and pattern. A difference of 8 meant that the eggs were very different in color and pattern. They kept track of the behavioral responses of the host prinias and compared the colors of their own eggs with the "parasitic" eggs. Here is what they found:

Egg Color Results



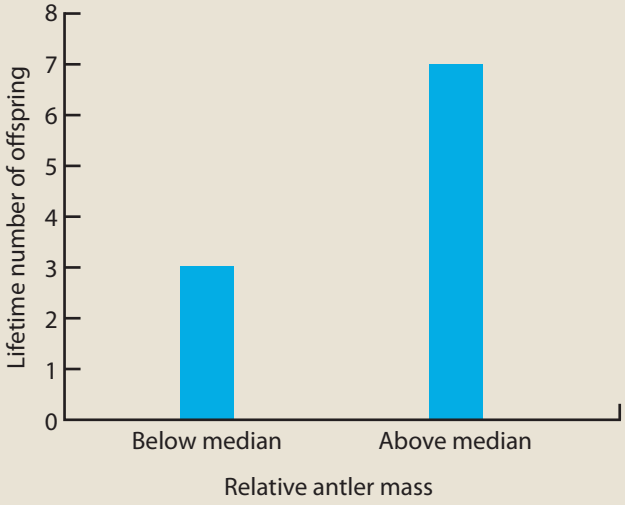
Investigation 3: Deer Antlers

Off the coast of Scotland in the United Kingdom is an island called the Isle of Rum. On this island lives a population of red deer (*Cervus elaphus*) that scientists have been studying since 1952. Researchers know the relationships and history of all deer currently living on the island—to whom they are related, who their parents and grandparents are, and how many offspring each male and female has ever had.

Male red deer are larger than females, with males weighing 90–190 kilograms (kg) and females weighing 63–120 kg. At the start of the breeding season, male deer grow antlers that can weigh as much as 1 kg and can be over 86 cm in length. These antlers are made of bone and are shed at the end of winter only to be regrown at the start of the next breeding season. Males compete among themselves for home ranges and engage in elaborate behavioral displays of dominance, including roaring and fighting. Males can be seriously injured or killed during these fights. Females do not grow antlers, and they do not engage in these behaviors.

The researchers wondered why males would risk injury or even death to engage in these fights. They analyzed the data they had on lifetime reproductive success (the total number of offspring over an individual's life) for all of the males on the Isle of Rum, and this is what they discovered:

Deer Antler Results



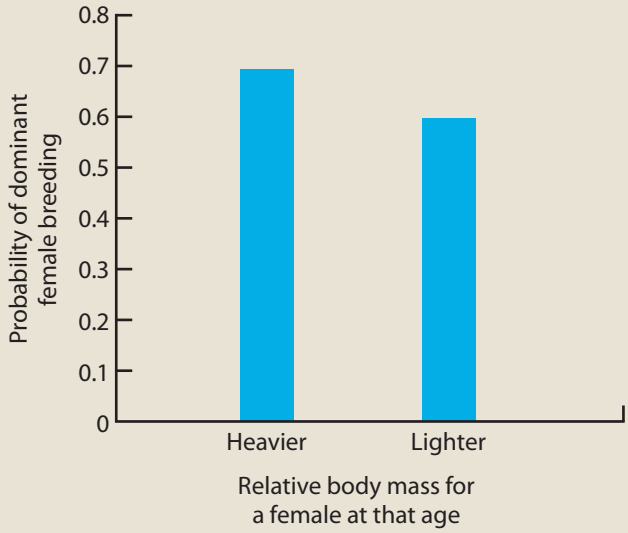
Red deer

Investigation 4: Meerkats

Meerkats (*Suricata suricatta*) are small predatory mammals that live in cooperative groups of between three and 50 individuals in the desert in southern Africa. They live in underground tunnels, which they use for breeding and to escape predators. Groups compete with each other for resources, especially ground nests and territory, as well as food.

Each group has a dominant female that produces most of the offspring in the group in a breeding season. In some cases, no other females produce offspring. Females compete vigorously for the dominant position. A dominant female's reproductive success over her lifetime depends on how long she holds her position within the group. Researchers wanted to determine what traits or factors affect a dominant female's reproductive success within one breeding season. Here is what they found:

Meerkat Results



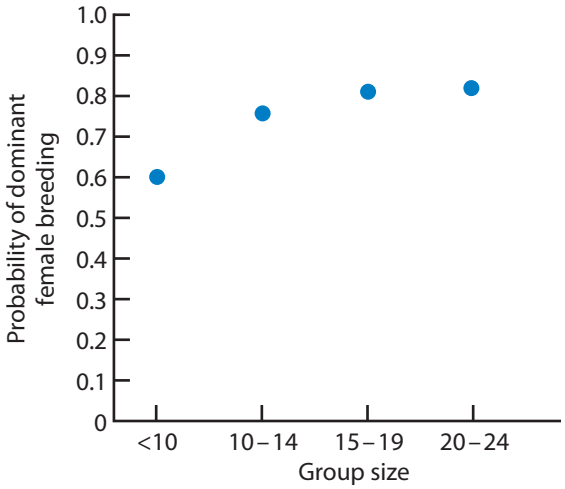
Meerkats

2. In your group, read the investigation you have been assigned.
3. Prepare to present the investigation to the rest of the class, being sure to
   - summarize how the scientists conducted the investigation.
   - describe patterns in the data.
   - explain what the patterns tell you.
4. Follow your teacher's instructions for your presentations.

ANALYSIS

1. For the investigation your group presented, write an argument that explains how that trait increases an organism's reproductive success.
2. Which of the traits in the examples above are likely to be affected primarily by genetics? by the environment? by a combination of both? Explain your reasoning.
3. The researchers studying the meerkats also looked at other relationships that influence the reproductive success of dominant females.
   a. What pattern(s) do you see in the data below?
   b. Explain what these patterns tell you?

Meerkat Group Size Results



11 Plant–Animal Interactions

INVESTIGATION

One Sunday morning, Joe's father suggested that they go fishing to give them both a break from thinking about Marfan syndrome.

After they found a good spot along the shore of the pond, they baited their hooks, dropped their lines, and sat quietly waiting for a fish to take the bait. Joe noticed some butterflies visiting some of the flowers along the shore. Then, out of the corner of his eye, he caught a quick movement. When he was able to spot what was moving, he saw that it was a bird moving from flower to flower. Then he saw another nearby.

After watching silently for a while, Joe said, "It looks like the hummingbirds are visiting different flowers than the ones the butterflies are visiting."

Joe's father paused for a moment to observe both the hummingbirds and the butterflies. "I've never noticed that before. I wonder why that is?"

Joe wondered how the birds and butterflies know what flowers to visit. Do they learn, or is it genetic? He decided that this would be a good question to ask his science teacher, Ms. Bohanic, when he returned to school on Monday. Now if only a fish would take the bait.

In this activity, you will explore some traits of plants that are associated with some traits of certain kinds of animals.

GUIDING QUESTION

How do specialized plant structures and traits affect the probability of successful reproduction in plants?

MATERIALS

For each group of four students

1 Scratch-and-Sniff card

SAFETY

If you are sensitive to strong odors, inform your teacher.

PROCEDURE

Part A: Pollination Patterns

1. Read the descriptions below of four plants, and take notes in your science notebook.

Gardenia

Gardenias are native to tropical regions in Asia, Africa, and the Pacific Islands. It is an evergreen shrub that grows from 0.6 m to 2.4 m tall and wide. Gardenia flowers are white or yellow, flat, and distributed over the entire shrub. The flowers give off a strong, sweet fragrance.

Agave

Agaves grow in the hot, dry regions of the Southwestern United States and Mexico. Their leaves are fleshy to store water. Agave flowers bloom in clusters on a stalk that can grow up to 3 m high. The flowers open at night and smell like rotting fruit.

Cardinal Flower

The cardinal flower is native to the Americas, and is found in the eastern and southwestern United States. The plant grows to about 1.4 m in height in wet places, including along streams and in swamps. The flowers grow in clusters and are typically bright red. The flowers do not produce a strong fragrance.

Corpse Flower

The corpse flower, *Rafflesia arnoldii*, native to southeast Asia, is the largest flower in the world. It can grow to over 1 meter in diameter and weigh up to 10 kg. The flower is reddish brown with spots all over it. The aroma given off by the flower smells like rotting flesh, giving the flower its name.

2. Read the box below about the function of flowers in plant reproduction.

Function of Flowers

Flowers contain the reproductive structures of plants. Flowers produce pollen, which contains the male sex cells (sperm), while female sex cells (eggs) are produced in the ovary, which is typically at the base of a flower. For fertilization to take place, pollen must come into contact with the structure containing the ovary, a process called **pollination**. Pollination leads to the production of seeds, and sometimes fruits around the seeds. These seeds may eventually grow into new individual plants. Some plants are pollinated by animals. These animals are called **pollinators**. When the animal visits a flower, pollen may get caught on its fur, feathers, antennae, or legs. Then when the animal visits another flower, the pollen may come loose and be deposited onto this other flower. Flowers produce nectar, a sugar substance that provides nutrients for the animal.

3. Below are descriptions of four kinds of animals that are important plant pollinators. As you read about these animals, think about which of them pollinates each of the four kinds of flowers in Step 1. Take notes as you read.

Hummingbird

Hummingbirds are very small birds (some weigh as little as 3 g). They flap their wings so rapidly that they can hover above a flower. They feed on nectar by inserting their long, narrow bills and tongues down into a flower. Hummingbirds have good color vision (better than humans) but a weak sense of smell.

Bat

Bats are the only mammal capable of true flight. They are nocturnal, feeding at night. Some bats are nectivorous (feed on nectar). Nectivorous bats hover at the flowers from which they are feeding. Bats can see relatively well, but they cannot see in color. They have a good sense of smell.

Fly

Flies are a very diverse group of insects with over 150,000 species. They mostly feed on nectar or other plant or animal liquids, although some species feed on only animal tissue. Flies have a very good sense of smell, detecting odors from as far as 7 km away. Flies see only ultraviolet, blue, and yellow colors.

Moth

Moths are insects that feed on nectar using their long tongues to reach down into the flower. Some moths hover at the flowers from which they are feeding while others land on the flowers to feed. Moths have a good sense of smell. They see only ultraviolet, blue, and yellow colors.

4. Take turns passing around the Scratch-and-Sniff card, with one person in your group scratching off the first patch and everyone taking note of the odor. Make a data table to record how you matched each flower to a scent and pollinator. The second person should scratch off the second patch, and so on. You should only need to scratch the box lightly a couple of times. Do not scratch too hard.
5. Think about the pollinator that you matched with each flower. Now match the odor with the flower you think produces it.
6. Answer Analysis item 1 as instructed by your teacher.

Part B: Making Predictions

7. Read about the plants below, and be prepared to share your answers to the following questions as instructed by your teacher:
   - How do you think the following flowers are pollinated?
   - What is your evidence and reasoning?

California Poppy

The California poppy (*Eschscholzia californica*) is a plant that grows 25–45 cm tall. It is native to the western part of the United States. It grows in meadows and other open areas. The flowers are usually orange but can be yellow or red. They do not have a strong fragrance.

Big Bluestem

Big bluestem (*Andropogon gerardii*) is a grass native to prairies in North America. It can grow over 2 m tall. The flowers grow on spikes in clusters. The flowers are very small (less than 1 cm) and are pale greenish yellow. They do not produce a strong fragrance.

ANALYSIS

1. Create an argument that explains your matching of plants, scents, and pollinators.
2. If you wanted to plant a garden that would attract butterflies and hummingbirds, what types of flowers would you want to plant and why?
3. Bees are important pollinators for many wildflowers, but they are also important for pollination of fruit crops, like apples, melons, and cherries. Populations of bees are declining because of pesticides and diseases. Predict what will happen if bee populations continue to decline.

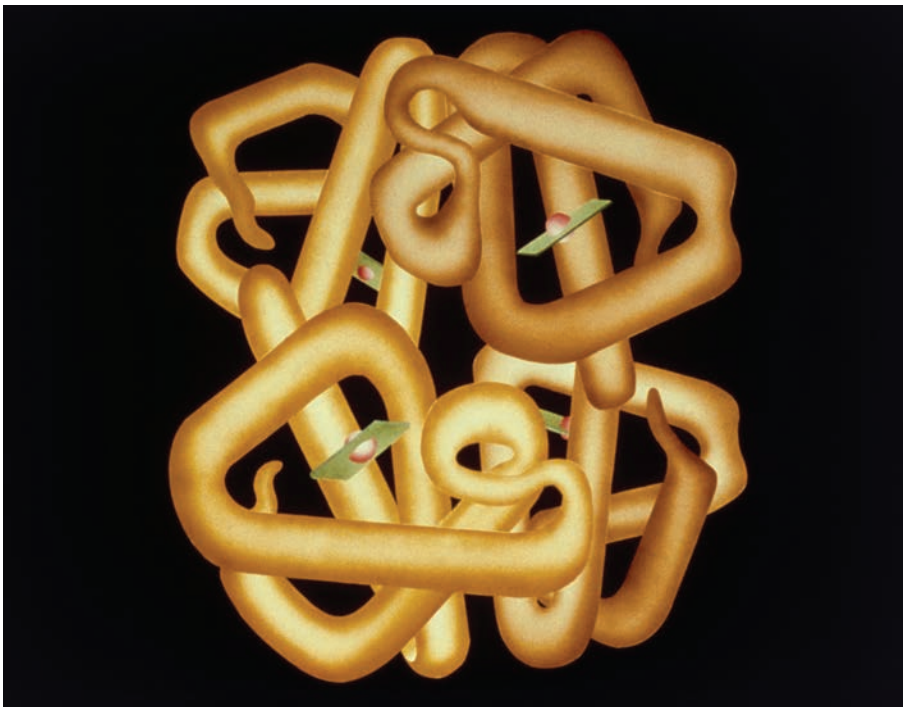
12 How Do Genes Produce Traits?

MODELING

JOE HAS BEEN learning more and more about genes and how they influence physical and behavioral traits. He knows there is a gene that causes Marfan syndrome and has learned about the likelihood of passing it along to his future children. But Joe doesn't understand how a gene can affect how his body works.

As you learned in previous activities, the chromosomes in your cells are made of DNA. Each chromosome contains hundreds to thousands of genes. These genes hold information that influences how you look and behave. The DNA in each gene determines the structure of a protein in your body.

In this activity, you will explore the cause-and-effect relationship between the information in DNA and an organism's observable traits. The example you will investigate is the gene associated with Marfan syndrome, which codes for a protein called fibrillin.



A model of the three-dimensional structure of hemoglobin, a protein that carries oxygen in your red blood cells. This model is enlarged approximately 10 million times!

GUIDING QUESTION

How does a gene produce a trait?

MATERIALS

For each pair of students

- 1 wire (1-m)
- 10 red chenille stems
- 10 blue chenille stems
- 5 white chenille stems
- 5 green chenille stems

For each student

- 1 Student Sheet 12.1, "Converting DNA to Proteins"

PROCEDURE

Part A: Determine the Protein Sequence

1. Read the information in the figure below about how a DNA sequence codes for a protein sequence.

DNA and Protein Sequences

A gene is a long sequence of DNA subunits. The letters below (A,T, C, and G) represent the four DNA subunits.

A DNA sequence is read in three-subunit codes. The brackets below show the codes in this piece of DNA.

Each code specifies a protein subunit in a protein sequence. The blue, red, green, and white circles below represent the four types of protein subunits.

2. The following DNA sequence from the fibrillin gene is spaced into three-subunit codes. Each code has been entered into the "DNA sequence" column of the table on Student Sheet 12.1, "Converting DNA to Proteins."

   (start) AGT TGT CGA GAA CTT CAA TGT CCC GTT GGT ATT CCC TGC CAG CAA (end)

3. Use the "Subunit Code" table on your Student Sheet to determine the sequence of the four types of protein subunits in the protein. Complete the table on your Student Sheet for your entire sequence.

Part B: Determine Your Protein Structure

4. Read the information below to learn about fibrillin's structure and function in your body.

The Fibrillin Protein's Structure and Function[2]

Proteins perform specific functions that help the body to work normally. Fibrillin is an example of a protein that functions by providing structural support. It provides strength and flexibility in connective tissue—the stuff that connects, supports, and maintains the structure of parts of your body. Connective tissue surrounds your bones, ligaments, muscles, blood vessels, and heart valves.

In Part A, you figured out the order of the protein subunits in a portion of fibrillin. The order of these protein subunits distinguishes fibrillin from other proteins. For a protein to do its job, it must fold into a specific shape. This folding depends on the way the four kinds of protein subunits interact with each other and with water in the cell. Some subunits repel each other and water while other subunits attract each other and water. These interactions cause the protein to fold into a unique shape.

5. Use the fibrillin sequence you just determined to model and examine the structure of the fibrillin protein.

   Working in pairs, model your protein as follows:

   - Use the coated wire to represent the backbone of your protein chain.
   - Use colored chenille stems to represent the four kinds of subunits of the protein.
   - Evenly space your colored chenille stems along the coated wire (approximately every 6 to 7 centimeters). Lay out all of your chenille stems along the length of the coated wire to evenly space them before attaching any to make sure you use the entire length of the coated wire. Loop one end around the coated wire so the remaining part of the chenille stem extends away from the coated wire, and give just one twist to hold the chenille stem in place. Your subunits do not need to point in the same direction away from the coated wire.

6. Using the information in the table below, complete the final column on your Student Sheet about the orientation of the subunit. This information indicates where each type of subunit prefers to be when folded into a three-dimensional structure.

Orientation of Protein Subunits

COLOR	TYPE OF SUBUNIT	SUBUNIT ORIENTATION IN PROTEIN
Blue	Hydrophilic	Attracted to water; tends to be on the surface
Red	Hydrophobic	Repelled by water; tends to be buried inside away from any water
White	Positive	Attracted to negative (green); on or near the surface
Green	Negative	Attracted to positive (white); on or near the surface

7. Fold your protein so the chenille stems face the correct direction.

   Hint: Since the red, hydrophobic subunits prefer to be on the inside, start by folding your coated wire so the red subunits are all together to form a center that the rest of your protein might fold around.

8. Following your teacher's instructions, compare your folded fibrillin protein molecule with your classmates' molecules.

ANALYSIS

1. The cell has a way of knowing where to start reading a DNA sequence in order to determine the correct three-subunit codes.
   a. Why do you think that is important?
   b. If the cell started reading one or two letters later, what effect might that have?
2. The same protein sequence always folds into the same three-dimensional structure (shape) within a cell. Why do you think this is important?
3. Joe doesn't understand how one gene affecting one protein can cause all the symptoms related to Marfan syndrome. Based on what you know now, how can you start to explain the relationship between the fibrillin gene and the symptoms of Marfan syndrome?
4. In this activity you investigated how a gene leads to a protein with a structural function. How do you think a gene could code for a protein that influences an organism's behavior?

13 Fault in the Genes

MODELING

Joe has been *learning a lot about genes and how they are like the instructions for his cells to make proteins. All proteins have an important function in his body, but Joe is still wondering what could be wrong with his fibrillin gene or protein that is causing Marfan syndrome symptoms.*

When an organism reproduces, it must copy its DNA in order to pass genetic information to the next generation. You can imagine that during all of this copying that a cell might make a mistake every now and then, similar to how you might make a mistake when taking notes and copying what your teacher wrote on the board. As you read about in "Show Me the Genes!" if a mistake occurs in the DNA, we call it a mutation. If a mutation occurs, it will be passed on to the next generation of cells. If the cell is an egg or a sperm, the mutation will be passed to the offspring. In this activity, you will learn how a mutation in a gene can lead to changes in its corresponding protein's structure and function.

The Drosophila *fruit fly on the left has red eyes. The fly on the right has a mutation that results in white eyes.*

GUIDING QUESTION

How can a change in a gene, like the gene linked to Marfan syndrome, lead to a change in the function of a person's body?

MATERIALS

For each pair of students

- 1 wire (1-m)
- 10 red chenille stems
- 10 blue chenille stems
- 5 white chenille stems
- 5 green chenille stems
- 1 6-sided number cube

For each student

- 1 Science Skill Sheet 7, "Analyzing Models"
- Completed Student Sheet 12.1, "Converting DNA to Proteins," from the "How Do Genes Produce Traits?" activity

PROCEDURE

1. Working with a partner in your group, refer to the table on Student Sheet 12.1, "Converting DNA to Proteins," which you completed during the "How Do Genes Produce Traits?" activity. Use this information to remake the fibrillin sequence from a coated wire and chenille stems.

2. Use the information in the table below to refold the fibrillin protein sequence of colored chenille stem subunits into a three-dimensional protein.

Orientation of Protein Subunits

COLOR	TYPE OF SUBUNIT	SUBUNIT ORIENTATION IN PROTEIN
Blue	Hydrophilic	Attracted to water; tends to be on the surface
Red	Hydrophobic	Repelled by water; tends to be buried inside away from any water
White	Positive	Attracted to negative (green); on or near the surface
Green	Negative	Attracted to positive (white); on or near the surface

3. Discuss the following idea with your group: How might a mutation that causes a single letter change in the DNA sequence affect your protein structure and function?

   Hint: You might want to refer back to the "Subunit Code" table on Student Sheet 12.1.

4. With your partner, roll the number cube to find out how a mutation affects your protein. Refer to the table below to determine the change you need to make to your protein.

   a. Before making the change to your model, predict what you think will happen to the overall structure and function of the protein. Be sure to record your predictions in your science notebook.

   b. Make the change to your model, rearranging the structure if needed. Remember to check the "Orientation of Protein Subunits" table to see if you need to refold your protein.

Fibrillin Mutations

NUMBER ROLL	CHANGE TO PROTEIN
1	Change subunit 9 from a red chenille stem to a blue chenille stem.
2	Change subunit 1 from a blue chenille stem to a red chenille stem.
3	Add a white chenille stem between subunits 10 and 11.
4	Remove the green chenille stem.
5	Change subunit 12 from a red chenille stem to a blue chenille stem.
6	Change subunit 2 from a blue chenille stem to a green chenille stem.

   c. Describe how the change affected the shape of your protein.

5. Return your fibrillin protein back to its original sequence and structure.

6. Repeat Step 4. If you roll the same number, reroll the number cube until you analyze a different mutation.

7. Compare your two mutations, predictions, and the resulting changes to your protein with the other pair in your small group.

ANALYSIS

1. In this activity and the "How Do Genes Produce Traits?" activity, you used a coated wire and chenille stems to model protein structure.
   a. Using Science Skills Sheet 7, "Analyzing Models," identify the parts of the model, what each part represents in the real world, and how each part is similar to and different from the real world.

      Hint: You may want to refer back to the "How Do Genes Produce Traits?" activity for more information.

   b. Do you think the coated wire model is an effective model for understanding protein structure and function? Explain.
2. Do all mutations have the same effect on DNA? Why or why not?
3. Consider the effects of mutations on proteins.
   a. Do all mutations lead to a change in protein structure? What evidence do you have to support this?
   b. Do all mutations lead to a change in protein function? What evidence do you have to support this?
4. Think back to what you know about Marfan syndrome and fibrillin. Draw a labeled diagram that models the cause-and-effect relationship between the fibrillin gene, fibrillin protein, and traits/symptoms for
   a. a person without Marfan syndrome.
   b. a person with Marfan syndrome.

      Hint: Joe (like all humans) has two alleles for the fibrillin gene, one from mom and one from dad.

14 Advising Joe

TALKING IT OVER

SINCE JOE SHARED his situation with his family, his mother's sister has begun to suspect that she and her daughter and baby grandson might also have Marfan syndrome. The family is considering having some testing done. They are meeting next weekend to talk over their concerns.

You have learned about the scientific causes and effects of Marfan syndrome. You have also learned about possible medical treatments Joe will face if he has Marfan syndrome. In this activity, you will use what you have learned to help Joe and his family understand their situation.

GUIDING QUESTION

What have you learned that could help Joe understand and make choices about his situation if he does have Marfan syndrome?

MATERIALS

For each student

1 Student Sheet 14.1, "What We Know About Marfan Syndrome"

PROCEDURE

1. Re-read the email Joe sent his friend Megan in "Joe's Situation."
2. Review the list of questions you recorded in your science notebook that you thought Joe should ask his doctor and genetic counselor in the "Joe's Situation" activity.
3. Based on what you have learned in this unit, answer any questions that you may have left unanswered before.
4. Use Student Sheet 14.1, "What We Know About Marfan Syndrome," to summarize what you have learned about Marfan syndrome.
5. Imagine you are Joe's friend. By chance, you started learning about genetics and Marfan syndrome in your science class after you received Joe's email. Write an email to Joe. In this email, be sure to include the following:
   - Explain your new understandings about the science that explains Marfan syndrome, including how it is inherited, Joe's chance of transmitting it to any future offspring if he has Marfan syndrome, and the role of genes and environment in its symptoms and effects. Be sure to use the information from Student Sheet 14.1. You may also want to include answers to the questions you generated in "Joe's Situation."
   - Tell Joe and his father what you think he should do about his situation.

ANALYSIS

1. Marfan syndrome is a dominant trait. Write your own definition of *dominant trait* as it is used in genetics. Use evidence from this unit to explain whether the dominant trait is always the most common trait in a human population.
2. Joe and his family have realized that four other family members show some signs of Marfan syndrome: his sister, aunt, cousin, and cousin's baby. Joe's aunt wants everyone in the family who might have Marfan syndrome to be tested to see if their family has a mutation. Their insurance will not cover the $3,500 it would cost for all of them to be tested. Joe's aunt suggested they pay for the test instead of going away for a summer vacation. Do you recommend they have the test? Be sure to include any trade-offs of your recommendation.
3. **Reflection:** New tests are being developed for genetic conditions as scientists learn more about the genes that cause them. These tests could help people plan their lives, help doctors treat their patients, and lead to actions that help prevent some conditions from having serious effects. But these new tests also raise issues for individuals and for society.
   a. What are some of these issues?
   b. Would you be tested to find out about your genetic makeup? Explain.
   c. How would you feel if you were in Joe's situation?