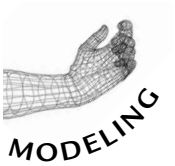
Creature Features 58

1-2
40- to 50-minute sessions



ACTIVITY OVERVIEW

Students develop hypotheses to explain the behavior of genes in a story about zoo scientists breeding imaginary creatures. They use models to evaluate how well the hypotheses fit additional evidence about the critter offspring.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Students create models to understand and communicate scientific information. (INQUIRY: 1)
2. Reproduction is a characteristic of all living systems, and breeding experiments can provide information about the behavior of genes. (LIFE SCIENCE: 2)
3. Genes contain hereditary information. (LIFE SCIENCE: 2)
4. Scientists test some hypotheses by creating models and evaluating how well these models fit experimental evidence. (HISTORY AND NATURE OF SCIENCE: 2)

KEY VOCABULARY

gene
hypothesis
inherited
model
offspring
trait
sexual reproduction
trade-off

MATERIALS AND ADVANCE PREPARATION

For the teacher

- 1 Transparency 58.1, "Critters Breed 1"
- 1 Transparency 58.2, "Critters Breed 2"
- 1 Transparency 58.3, "Critters Breed 3"
- 1 Transparency 58.4, "Critter Template"
- * orange and blue overhead transparency pens
- * 1 overhead projector
- 1 Scoring Guide: GROUP INTERACTION (GI)

For the class

- * 8 pieces of chart paper (unlined or lined)

For each group of four students

- 20 orange plastic disks
- 30 blue plastic disks
- 1 copy of Transparency 58.4, "Critter Template"
- orange and blue colored pencils

For each student

- 1 Student Sheet 58.1, "Modeling Genes"
- 1 Student Sheet 58.2, "Alternative Hypotheses" (optional)
- 1 Group Interaction Student Sheet 1, "Evaluating Group Interaction" (optional)
- 1 Group Interaction Student Sheet 2, "Developing Communication Skills" (optional)
- 1 Scoring Guide: GROUP INTERACTION (GI) (optional)

**Not supplied in kit*

Masters for Scoring Guides are in Teacher Resources III: Assessment. Group Interaction Student Sheets are in Teacher Resources II: Diverse Learners.

Review the Teachers' Note in Doing the Activity Step 3 in this activity and decide if you will use Student Sheet 58.2. The first time you teach the activity, you may want to hold them in reserve and supply them only to those classes or students who need them. Use transparency pens to color Skye's tail blue and Poppy's tail orange on Transparency 58.1, "Critters Breed 1."

Draw the critter template on Transparency 58.4 on the chart paper. You or a student helper should use a thick black marker to make a copy of Transparency 58.4 "Critter Template," on each piece of chart paper. (This can be done in about 5 minutes.) Alternatively, you can have each group of students in your first IALS class copy their own template from the transparency. Another option would be to use photocopies of the transparency instead of the chart paper, but they are smaller and more difficult for student groups to use.

TEACHING SUMMARY

Getting Started

1. Explore students' ideas about gene transmission.
2. Explain the use of breeding to study gene transmission.

Doing the Activity

3. Read and discuss the story presented in the reading and develop hypotheses for the behavior of genes.
4. (GI ASSESSMENT) Students model the transfer of genes from parents to offspring.

Follow-Up

5. Discuss the students' models and how they help them to think about the hypotheses.

BACKGROUND INFORMATION

The Critters as a Model for Breeding Experiments

This activity is based on results similar to those obtained by Mendel in his investigations of peas. These studies provided the basis for our understanding of genetics. Do not bring up the subject of Mendel and his experiments with peas at this time—they will be addressed in Activity 60, "Mendel, First Geneticist."

We have chosen to use an imaginary creature to simulate the behavior of genes because this is more amusing and motivating to students and because the imaginary creatures can be constructed in Activity 65, "Breeding Critters—More Traits," to investigate multiple traits and the diversity of individuals within a species. If students ask if the story is "real," indicate that the critters are imaginary, but the results presented are similar to the actual behavior of many genes in humans and other organisms.

Students are given a chance to formulate their own hypotheses, and then determine how well they fit the evidence provided. This approach gives students a chance to think about the evidence, while giving you a chance to hear students' ideas about heredity. In this activity the students focus only on the tail colors of the critters, but in Activity 65, students will explore several more differences between the two strains of critters.

A reasonable expectation for this activity will be the rejection of Hypothesis B, which is inconsistent with the reappearance of the orange tail in the third generation. Distinguishing between Hypothesis A and Hypothesis C will not be possible for most students until they complete Activity 59, "Gene Combo."

REFERENCES

Soderberg, P. "Marshmallow Meiosis," *The Science Teacher* (Nov. 1992): 28–31. The critters in this activity are based on an activity presented in this article.

TEACHING SUGGESTIONS

GETTING STARTED

1. Explore students' ideas about gene transmission.

To find out students' current ideas about the transmission of genes to offspring, ask them to explain why children of the same parents are not identical. Listen carefully to their responses, which may relate to the idea of children getting different numbers or kinds of genes from their two parents. These responses will help you to address students' ideas during the activity.

2. Explain the use of breeding to study gene transmission.

Explain that in this unit, students will investigate how inherited traits are passed from parents to their offspring and then to subsequent generations. Explain that one way to study traits is to breed and analyze the offspring produced by various parents. (This method can be used with plants or animals, but not with humans.) Breeding is the deliberate mating of two individuals to produce offspring with desired characteristics, to maintain a species, or to study the genetics of a species. The seeds germinated in Activity 55, "Plants Have Genes, Too!" were obtained by breeding specific parent plants. Breeding has played a key role in modern agriculture and husbandry and in zoo programs aiming to increase the population of endangered species. You may wish to discuss the importance of breeding new varieties of animals and plants to modern careers in agriculture.

Remind students that genes can be defined as bits of information that determine the traits of all living organisms. Discuss with students the idea that something in the body (cells) of the parents must be passed from the parents to the offspring via the egg and sperm.

DOING THE ACTIVITY

3. Read and discuss the story presented in the reading and develop hypotheses for the behavior of genes.

A good way to begin this activity is to read each section of the creature-breeding story orally, to the class. It helps to engage the students and also discourages students from looking ahead to Part B. An alternative is to have a volunteer read aloud the Introduction and Part A in the Student Book. Use Transparency 58.1, "Critters Breed 1," to illustrate the beginning of the story. Allow time for students to discuss the Stopping to Think 1 question and then discuss students' ideas. They may suggest all blue or orange tails, some of each, or some kind of striping, spotting, or other mixture of tail colors. It is possible that one or several students will introduce the idea of one color being dominant over another. If so, write the word *dominant* on the board and have students suggest an operational definition, such as the idea that one color might overwhelm another. Students are often familiar with the idea of dominance in the context of brown and blue eye color. If no students suggest the term, wait until later to introduce it.

Continue with the reading of Part B: The Second Generation. Show Transparency 58.2, "Critters Breed 2." Note the use of a circle in a square to represent an individual without specifying whether it is a male or female. Have students work on a response to Stopping to Think 2 in their small groups. Give them about 5 minutes to formulate and record their hypotheses. Then ask each group to share one hypothesis with the class. Develop a list of hypotheses on the board or a transparency. At this point, the term dominant may appear, if it has not already. Address it as suggested in the previous paragraph.

■ **Teacher's Note:** The alternative hypotheses provided on optional Student Sheet 58.2, "Alternative Hypotheses," are likely to represent all of the students' ideas and can be used to clearly state the three major hypotheses possible. Alternatively, you can use the hypotheses exactly as they are developed by the class. This provides a more open-ended

experience and encourages greater student independence. If you use Student Sheet 58.2, allow some time for students to determine which of the three hypotheses on the student sheet is closest to their own hypothesis. Emphasize the idea that a number of hypotheses can be generated, but that each must be closely compared to the evidence to see if it is supported.

Continue with Part C of the reading. Use Transparency 58.3, "Critters Breed 3," to discuss the third-generation results. Allow students some time to discuss Stopping to Think 3. Some students may quickly argue that any models that resemble Hypothesis B on Student Sheet 58.2 are not possible.

4. (GI Assessment) Students model the transfer of genes from parents to offspring.

■ **Teacher's Note:** Student Sheet 58.1, "Modeling Genes," is designed to allow students to manipulate the genes and better understand how each of the three hypotheses would play out over three generations. If you are concerned about students having difficulty and becoming frustrated, you can do the modeling as a class demonstration. However, allow students to explore and express their ideas. For a more open-ended variant of the activity, omit Student Sheet 58.1 as well as 58.2, and have students develop their own models and rules.

The Procedure in this activity is an opportunity for evaluating students' group interaction skills. Before beginning the activity, explain to the students that you will use the Group Interaction (GI) Scoring Guide to provide feedback on their ability to work together in groups. Let them know that this scoring guide requires a different approach from other scoring guides. Since this one helps evaluate how students interact with each other, you will be scoring them while they conduct the experiment rather than scoring a response to a written question. Review your expectations for group work and, if appropriate, provide each student with a copy of the GI Scoring Guide. Information about how to use scoring guides is in Teacher Resources III: Assessment. Alternatively, you may wish to use Group Interaction Student Sheet 1, "Evaluating Group Interaction," and/or Group Interaction Student Sheet 2, "Developing Communication Skills." See the Facilitating Group Interaction section of Teacher Resources II: Diverse Learners, for suggestions for fostering effective group work and collaboration.

Students will probably not be able to get all the way to the "right answer" at this point. However, they should be able to manipulate the disks to show what each hypothesis would look like. Some students may begin to comment that some hypotheses work better than others do. For example, a significant number are likely to realize that Hypothesis B does not make much sense. They may ask: "If Generation Two doesn't have any orange genes, then how could Generation Three have orange-tailed critters?" This is exactly the question we hope they will ask. However, most students will not be able to use the evidence so far to decide between Hypothesis A and Hypothesis C. Some students may come up with what appear to be very logical explanations to support either Hypothesis A or Hypothesis C. Activity 59, "Gene Combo," will help students model the fact that Hypothesis C best fits the breeding results. Tell them to work in their groups to prepare to explain any inconsistencies they discover.

Distribute the blue and orange disks and Student Sheet 58.2. The following discussion assumes you are using Student Sheet 58.2 as your list of hypotheses. If not, then adapt the discussion to fit the students' hypotheses. Do a quick count of which hypothesis students favor. Ask a few students to explain their reasoning to the class, and discuss and summarize students' comments.

Introduce the use of blue and orange disks to model the genes within Skye and Poppy and their offspring. Tell students that many lines of evidence suggest that genes are present within cells, and that copies are made and passed to the offspring. This idea of copies being transmitted is important; otherwise, students may get the idea that the parents could run out of genes to give to their offspring. If students mention chromosomes or DNA, ask them if they can define these terms. If they are familiar

with them from previous experiences, briefly review them. If not, these ideas can wait until Activity 63, "Show Me the Genes!" The students (like Mendel) can think about genes without knowing exactly where they are or what they are made of.

The students' assignment is to explore models of each of the three hypotheses and see which fits best with the results of the creature-breeding program. Review the Procedure steps on Student Sheet 58.1. You may have to demonstrate how to do the model. Use Transparency 58.4, "Critter Template," and the transparent blue and orange plastic disks to demonstrate on the overhead how to model one of the hypotheses, following the steps on Student Sheet 58.1. Encourage students to look for logical rules for how genes are passed from parents to offspring.

Circulate around the classroom to help groups get started. When necessary, prompt them to begin by placing an equal number of blue disks in Skye's outline and orange disks in Poppy's outline. For each hypothesis, they should place an appropriate number of orange and blue disks in the second-generation offspring. Then they should decide on the number of orange and blue disks to place in each of the third-generation offspring.

FOLLOW–UP

5. Discuss the students' models and how they help them to think about the hypotheses.

Choose three different pairs of students to demonstrate a model for the three different hypotheses. They can do this by taping disks to a large template on a piece of chart paper or by using the transparency and the plastic disks you used for the demonstration. Allow students to comment on whether their favored model was the same as or different from the one presented, and why.

SUGGESTED ANSWERS TO QUESTIONS

1.  *Based on the breeding results and your simulations, which hypothesis do you think best fits the evidence? Explain your answer.*

   At this point, many students will be ready to rule out Hypothesis B. They will see that the absence of any orange genes in the second generation in this model conflicts with the reappearance of the orange-tail trait in the third generation. Allow plenty of time to discuss this idea. Be sure everyone in the class can demonstrate the shortcomings of this hypothesis. However, very few students, if any, will have come to the "correct" reasoning about Hypotheses A and C.

   Listen to students' ideas and clarify any discrepancies in their thinking, but leave the question of whether A or C is correct open until after the next activity (which allows students to explore Hypothesis C in more depth).

2. *Based on the reading, create at least three rules for how genes are passed through generations. Be prepared to share your rules with the class.*

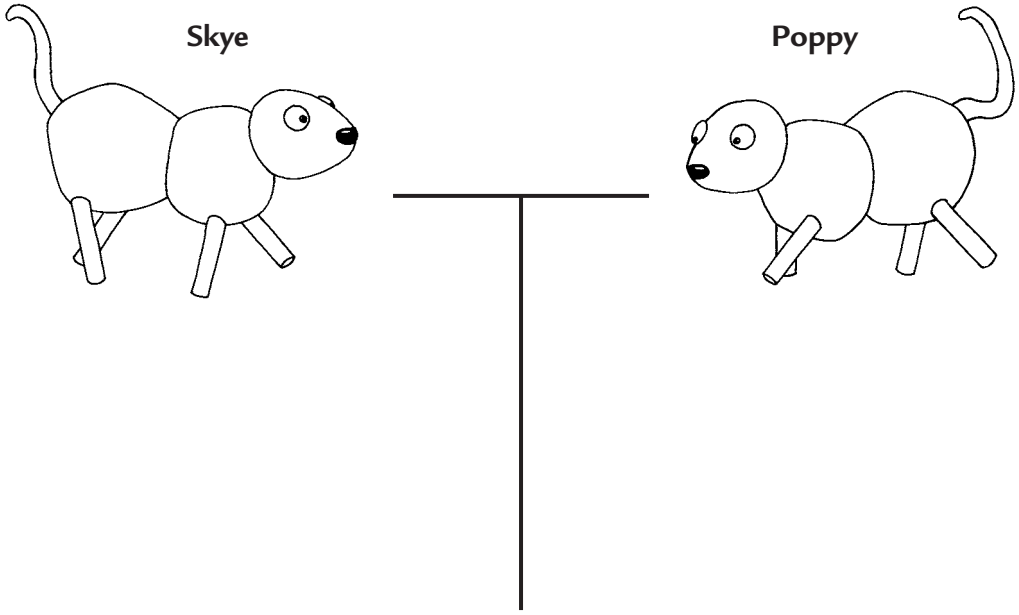
   Although students' answers will vary, possible responses include:

   - All members of a species have the same number of genes.
   - An organism's genes come from its parents
   - Some traits are dominant over others.

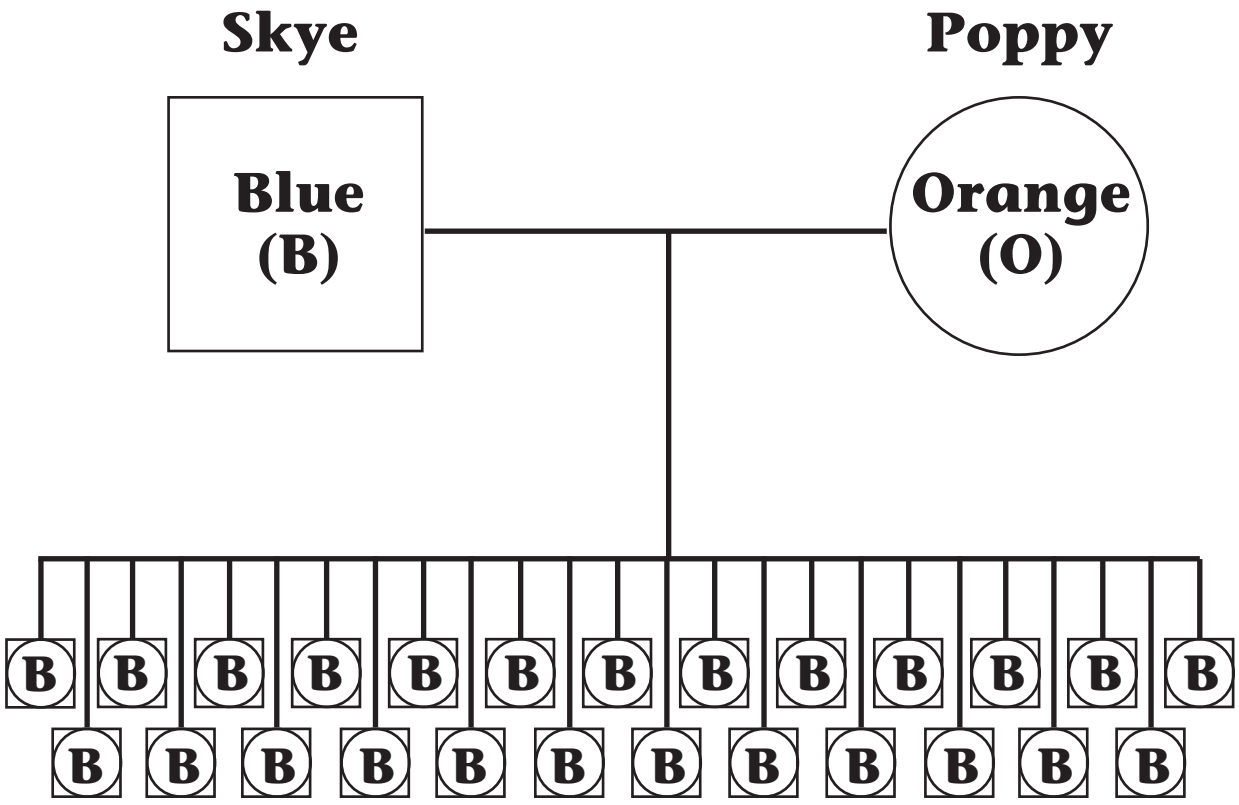
3. ***Reflection:*** *You have used models to investigate several scientific questions in Issues and Life Science. What are the trade-offs of using models to investigate the real world?*

   Models help us represent abstract ideas, invisible things like genes, or things that are impractical to investigate directly. The advantage is that they help us think about things that are impossible to see. The trade-offs are that no model can perfectly represent the real world, and models can result in oversimplification or inaccurate ideas.

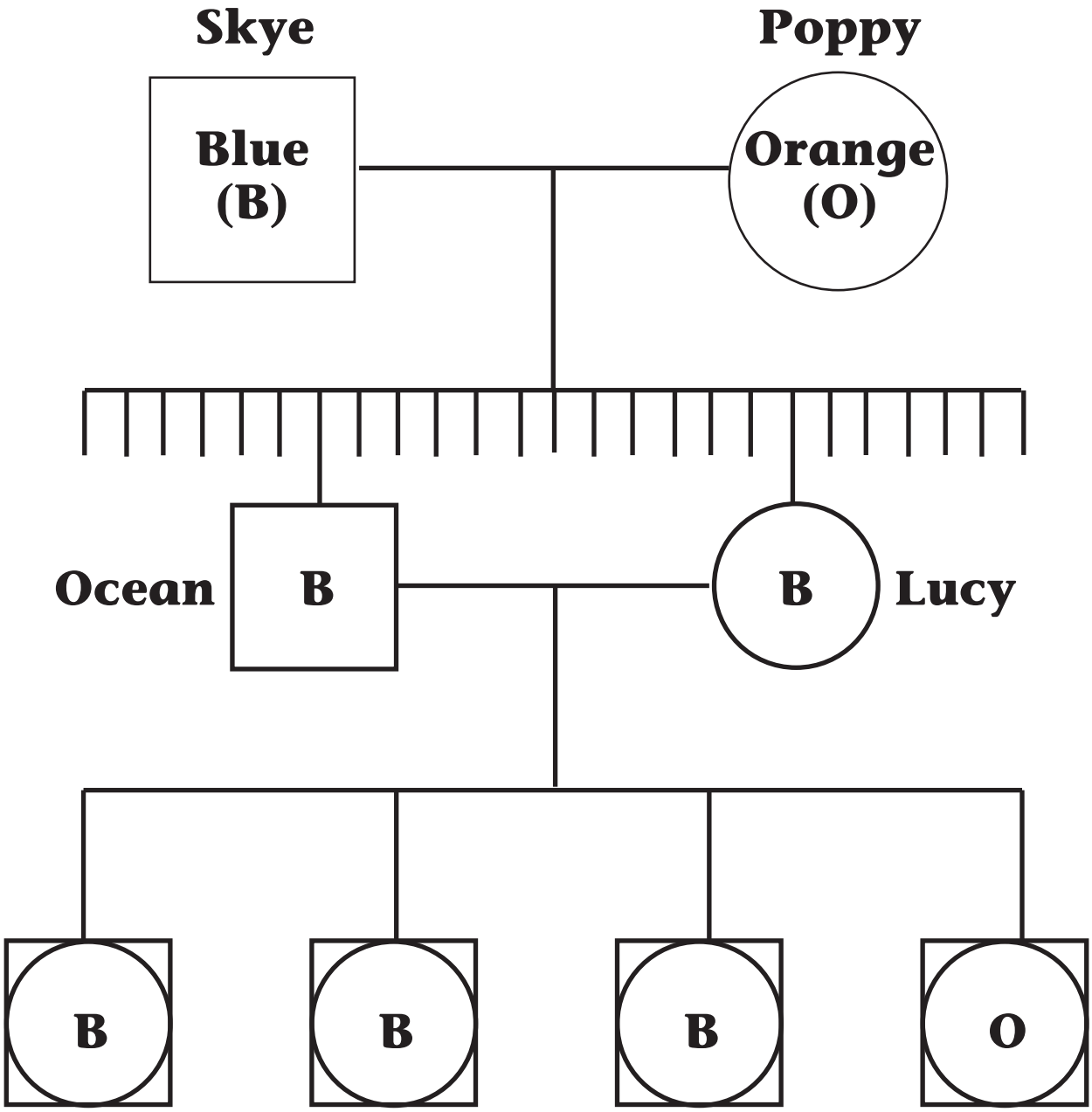
Critters Breed 1



Critters Breed 2

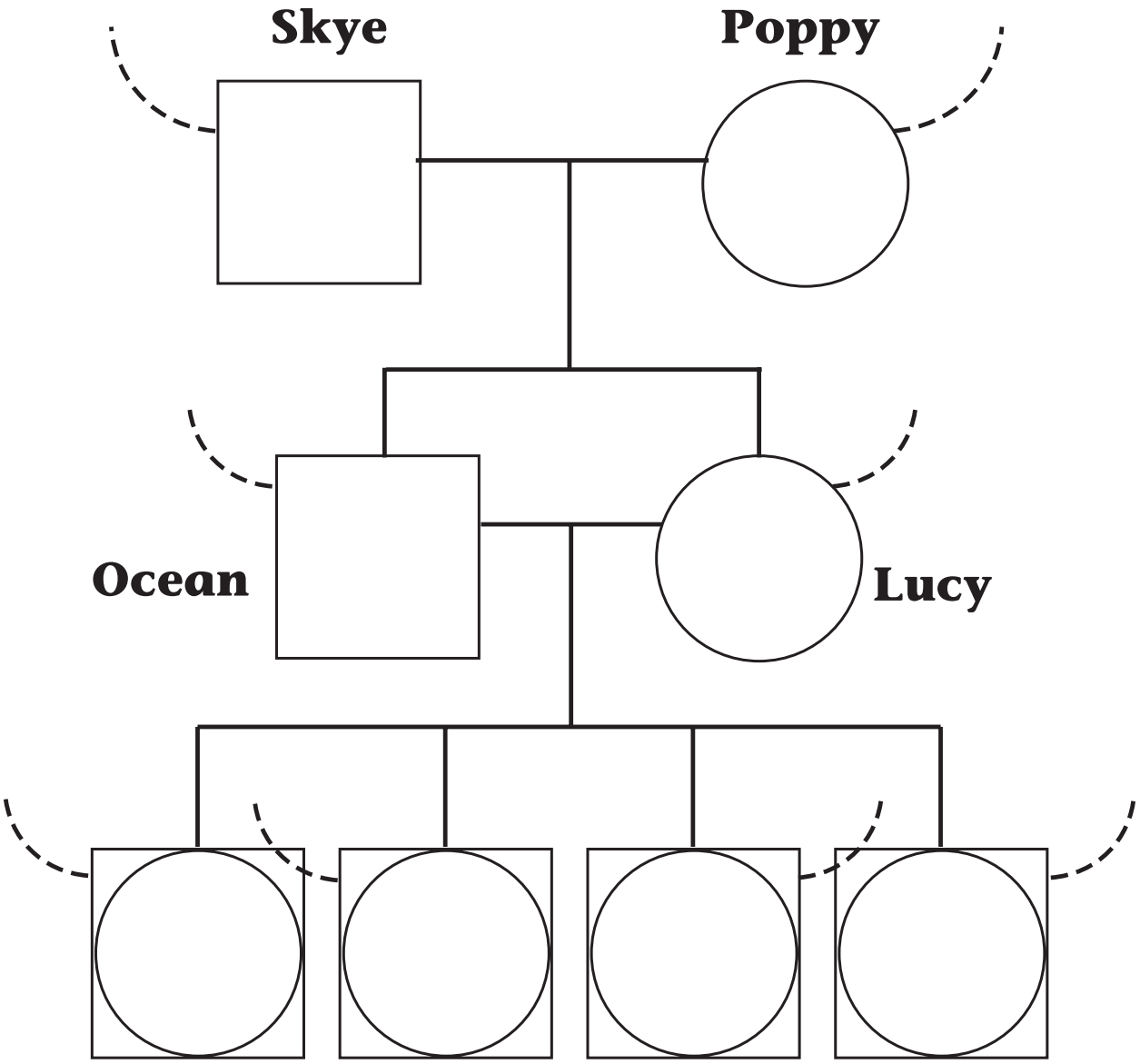


Critters Breed 3



The ratio of blue-tailed to orange-tailed offspring is approximately 3:1

Critters Template



Name _____ Date _____

Modeling Genes

Scientists often construct simple models that help them test hypotheses. In this activity, you will use colored disks to represent genes for tail color. You can think of the genes as bits of information that carry directions for the traits of the organism.

CHALLENGE

How are simple inherited traits passed from parents to their offspring and then to the next generation?

MATERIALS

For each group of four students

- 1 copy of Transparency 58.4, "Critter Template"
- 20 orange plastic disks
- 30 blue plastic disks

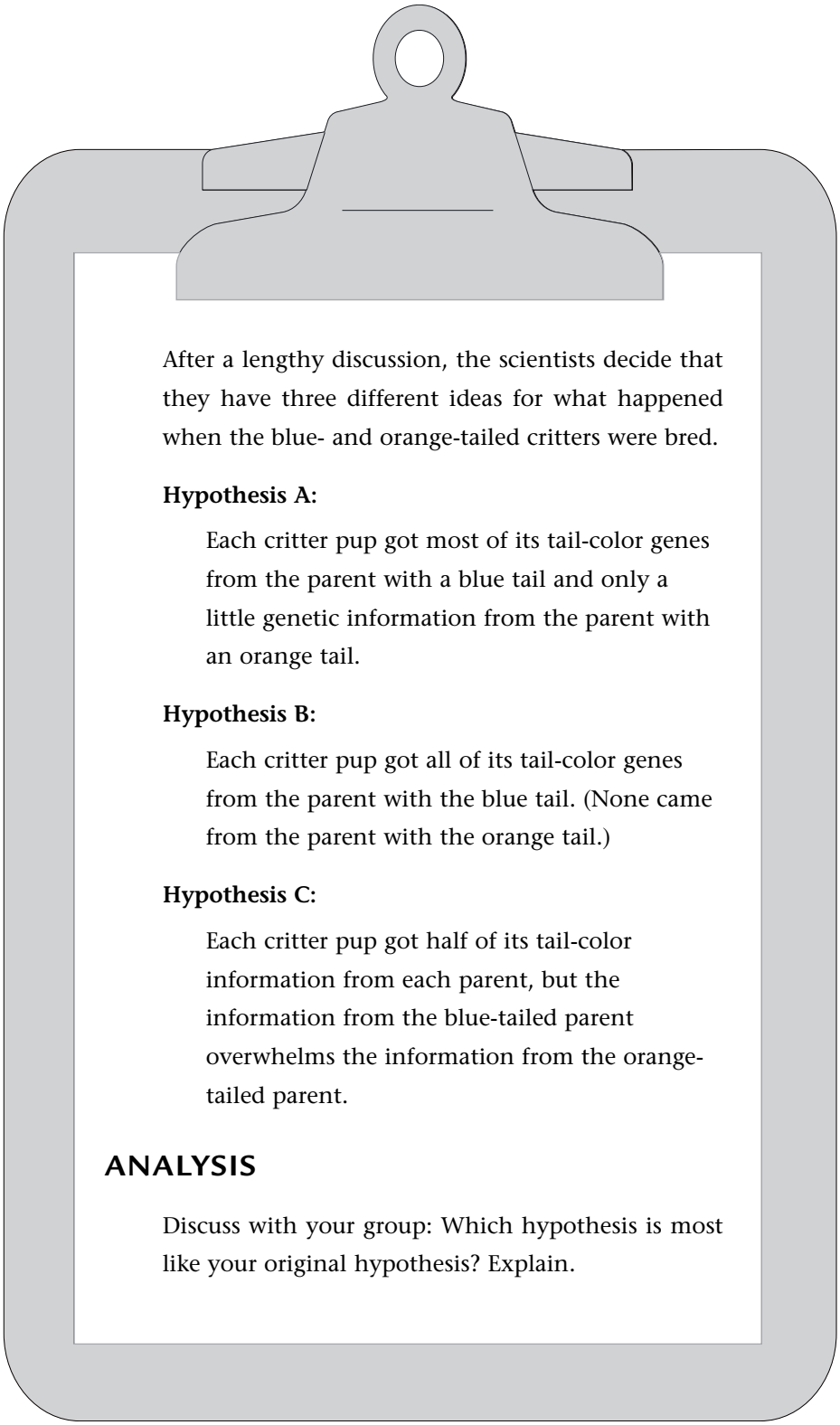
PROCEDURE

1. Decide which hypothesis you will model first.
2. Assume that each critter has the same total number of tail-color genes. To keep your simulation simple, decide with your partner whether to try the simulation with 2, 3, or 4 tail-color genes in each critter.
3. Place the number of orange tail-color genes (orange disks) you have chosen into Poppy's outline on your critter-breeding template.
4. Place the number of blue tail-color genes (blue disks) you have chosen into Skye's outline on your critter-breeding template.
5. Decide how many genes you think each parent (Skye and Poppy) gives to each offspring. Don't take the genes away from Skye and Poppy. Skye and Poppy give copies to their offspring. Take the copies you need from your pile of disks. Place the appropriate number of orange and blue disks in the outline for each offspring. *Remember, each offspring has to have the same total number of tail-color genes as Skye and Poppy.*

6. Review what you did in Steps 4 and 5. Be sure it fits the hypothesis you are modeling.
7. Decide how many blue and orange genes you think each parent in the second generation gives to each of the offspring in the third generation. Try to develop a logical model that will result in approximately 3 blue-tailed creatures for every 1 orange-tailed creature. Place the number of blue and orange disks that each offspring must receive into the outlines for the third-generation offspring.
8. Keep a record of your group's model. Be prepared to explain your ideas to the class.
9. Next try simulating the transfer of genes from Poppy and Skye to their offspring according to each of the other hypotheses developed in class. Follow Steps 1–7.
10. Answer the Analysis Questions on page D-29 in your Student Book.

Name _____ Date _____

Alternative Hypotheses



After a lengthy discussion, the scientists decide that they have three different ideas for what happened when the blue- and orange-tailed critters were bred.

Hypothesis A:

Each critter pup got most of its tail-color genes from the parent with a blue tail and only a little genetic information from the parent with an orange tail.

Hypothesis B:

Each critter pup got all of its tail-color genes from the parent with the blue tail. (None came from the parent with the orange tail.)

Hypothesis C:

Each critter pup got half of its tail-color information from each parent, but the information from the blue-tailed parent overwhelms the information from the orange-tailed parent.

ANALYSIS

Discuss with your group: Which hypothesis is most like your original hypothesis? Explain.