Genetics
Lesson 5a: Patterns of Traits—Punnett Squares

Grade 6	Length of lesson: 40 minutes	Placement of lesson in unit: 5a of 6 two-part lessons on genetics
Unit central question: Why are individuals of a species different from one another?		**Lesson focus questions:** Do the dominant and recessive traits of parents always result in similar patterns of trait variation in offspring? Why or why not?
Main learning goal: By understanding the movement of chromosomes (and the genes located on them) when egg and sperm are produced and unite to make a new individual, we can predict inheritance patterns for some traits. The Punnett square is a helpful tool for representing the possible combinations of alleles in offspring.		
Science content storyline: Different combinations of alleles in parents lead to trait variations in their offspring. A *Punnett square* is a helpful tool for representing all the possible allele combinations for a trait that offspring can inherit from their parents. Since recessive traits are expressed only if an individual inherits a recessive allele from each parent, a Punnett square makes it possible to predict which traits might show up in the offspring. A Punnett square can also forecast the expected frequency (ratio) of dominant to recessive traits among offspring resulting from crosses between parents who have different combinations of alleles.		
Ideal student response to the focus questions: The parents' alleles determine the possible traits their offspring might have. You can actually see the possible allele combinations if you use a Punnett square to figure out the expected pattern (ratio) of dominant and recessive traits if the parents have a lot of offspring.		

Preparation

Materials Needed	Ahead of Time
• Science notebooks • Chart paper and markers	• Review the Genetics Content Background Document, especially sections 1 and 7.

Lesson 5a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
3 min	**Link to previous lesson:** The teacher reviews key science ideas from the previous lesson.	
2 min	**Lesson focus questions:** The teacher introduces the focus questions, *Do the dominant and recessive traits of parents always result in similar patterns of trait variation in offspring? Why or why not?*	
10 min	**Setup for activity:** Students analyze the data on the Generation 2 offspring and discover a predictable 3:1 pattern (ratio) of dominant traits to recessive traits.	• In certain situations, when parents with different traits produce offspring, all of the first-generation offspring have the dominant trait. In the second generation of offspring, there is a predictable, but not exact, 3:1 pattern (ratio) of dominant traits to recessive traits.
15 min	**Activity:** The teacher reviews ideas about the segregation and recombination of parental alleles in offspring and introduces the Punnett square as a useful tool for representing possible allele combinations.	• A Punnett square is a useful way of representing all the possible allele combinations of the parents and the resulting traits their offspring could have. • Different parental allele combinations yield different expected trait ratios in offspring. • The Punnett square reveals the expected ratio of dominant to recessive traits among offspring that result from different combinations of the parents' alleles.
5 min	**Follow-up to activity:** Students make sense of the information the Punnett square provides to explain the inheritance of specific traits.	• When one parent has two different alleles for a trait (one dominant allele and one recessive allele), and the other parent has two recessive alleles for that same trait, there is a predictable, but not exact, 3:1 pattern (ratio) of dominant to recessive traits in the next generation of offspring. The Punnett square shows the possible combinations of parental alleles that lead to this ratio.
4 min	**Synthesize/summarize today's lesson:** Students revisit the focus questions and write a preliminary answer in their science notebooks.	
1 min	**Link to next lesson:** The teacher foreshadows the next lesson in which students use a Punnett square in three scenarios to help them answer the focus questions.	

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3 min	**Link to Previous Lesson** **Synopsis:** The teacher reviews key science ideas from the previous lesson.	Link science ideas to other science ideas.	**Show slide 1.** In our last lesson, you created Generation 2 ducko offspring based on allele instructions for the bill-color trait. We also identified an interesting pattern when we compared the Generation 2 duckos with other organisms. **Show slides 2 and 3.** We discovered that when two parents with different traits had offspring, the first generation of offspring all exhibited the dominant trait. But in the second generation, both the dominant and recessive traits showed up, and more of the offspring had the dominant trait than the recessive trait. **ELL support:** Review key terms, especially Tier 3 words, including *dominant* and *recessive*. ELL students benefit from a resource-rich environment, so make sure these terms are displayed where students can easily refer to them for help identifying science concepts. Today we'll think a bit more about *why* these patterns in trait variations show up from one generation to another in families.		

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2 min	**Lesson Focus Questions** **Synopsis:** The teacher introduces the focus questions, *Do the dominant and recessive traits of parents always result in similar patterns of trait variation in offspring? Why or why not?*	Set the purpose with a <u>focus question</u> or goal statement.	**Show slide 4.** Our focus questions for today's lesson are *Do the dominant and recessive traits of parents always result in similar patterns of trait variation in offspring? Why or why not?* Please write these questions in your science notebooks and draw a box around them.		
10 min	**Setup for Activity** **Synopsis:** Students analyze the data on Generation 2 offspring and discover a predictable 3:1 pattern (ratio) of dominant traits to recessive traits. **Main science idea(s):** • In certain situations, when parents with different traits produce offspring, all of the first-generation offspring have the dominant trait. In the second generation of offspring, there is a predictable, but not exact, 3:1 pattern (ratio) of dominant traits to recessive traits.	Engage students in analyzing and interpreting data and observations.	**Show slides 2 and 3 again.** Let's take another look at the Generation 2 organisms from yesterday's lesson and talk about how we might describe the pattern of traits mathematically. For each type of organism, how could we express the number of individuals with the dominant or recessive trait? Is there a way to say this mathematically?	There are more of the dominant trait and less of the recessive trait in each of the Generation 2 organisms.	Can you be more specific than "more" or "less"? Thinking mathematically, how might you describe the pattern you see?

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		Make explicit links between science ideas and activities **before** the active ity.	Each method we come up with describes the relationship between dominant and recessive traits in different ways. But if we look at these different mathematical expressions, we see a pretty consistent relationship between dominant and recessive traits that can be expressed much more simply as a ratio. So in the case of these Generation 2 organisms, we can say there is a 3:1 ratio of dominant to recessive traits, right?	We could express the numbers as a fraction. Well, for the dachshunds, the fraction for the dominant, short-hair trait would be 90 over 120, and the fraction for the recessive, long-hair trait would be 30 over 120. The 90 over 120 would be the same as 9 over 12 or 3/4. We could express the numbers as a ratio. A ratio would be 90 to 30 or 30 to 90.	What would that fraction be? Can you express that more simply? Can you be more specific?

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			Now that we've identified this pattern or ratio of dominant to recessive traits in Generation 2 offspring, why do you think it happens? What are some possible explanations for why this pattern exists? **NOTE TO TEACHER:** *Keep track on chart paper of all the ideas students have about why certain patterns occur among dominant and recessive traits so you can return to those ideas at the end of the lesson. Take special note of common misconceptions about recessive alleles being "weaker" and thus less frequent in a population.* **ELL support:** Consider documenting students' ideas on chart paper and developing one idea into a science talk in which students build their understanding collaboratively.	The dominant trait is stronger, and it overpowers the recessive trait more often. You get the dominant trait whether or not you have one or two of those alleles, so there's more of a chance of getting the dominant trait. The only way you can get the recessive trait is if you get two of the recessive alleles. That's less likely, so that's one	What do you mean by "stronger"? In what way was the red-bill trait "stronger" for our duckos? Why do you think the dominant trait shows up more often? Can you think of anything from the way we made our duckos that might explain it?

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			Today we're going to explore certain traits and combinations of alleles in parents and how these combinations result in patterns of traits in their offspring. During the lesson, pay attention to the patterns you find in the offspring and whether they always result in three dominant traits to one recessive trait. Also think about why these patterns occur.	reason why you might get less of the recessive trait.	
15 min	**Activity** **Synopsis:** The teacher reviews ideas about the segregation and recombination of parental alleles in offspring and introduces the Punnett square as a useful tool for representing possible allele combinations. **Main science idea(s):** • A Punnett square is a useful way of representing all the possible allele combinations of the parents and the resulting traits their offspring could have. • Different parental allele	Link science ideas to other science ideas.	Do you recall how many alleles everyone has for some traits, and where those alleles come from? Earlier in this unit, we learned about a scientist named Walter Sutton who figured out that when sperm and egg cells are made, each pair of chromosomes from both parents, along with the genes located on them, separate into different sex cells. **Show slide 5**. **NOTE TO TEACHER:** *This PowerPoint slide is animated, so at first, display only the parents' alleles in separate egg and sperm cells.*	Everybody has two alleles, one from their mom and one from their dad.	

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	combinations yield different expected trait ratios in offspring. • The Punnett square reveals the expected ratio of dominant to recessive traits among offspring that result from different combinations of the parents' alleles.	Make explicit links between science ideas and activities **during** the activity.	In this slide diagram, the dominant allele is represented with a capital *B*, and the recessive allele is represented with a lowercase *b*. We chose the letter *b* to represent ducko bill color, but scientists use whatever letter or symbol makes the most sense. Remember, the way the parents' sperm and egg cells come together is entirely random. So any egg could combine with any sperm when offspring are made. Let's see what could happen in the slide animation. **NOTE TO TEACHER:** *Advance the slide animation to show how each egg could combine with either sperm, but no matter which sex cells combine, all the offspring will have the same allele combination—Bb. Before moving on to the next slide, ask students the following question.* What bill color do all the Generation 1 duckos have? **Turn and Talk:** Yesterday we talked about why there were no orange-billed duckos in Generation 1. Go over the possible explanations with a partner and see if you have anything to add. Be prepared to share your ideas with the class. **Whole-class discussion:** So based on	Red!	

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		Select content representations and models matched to the learning goal and engage students in their use. Ask questions to elicit student ideas and predictions.	what we've learned so far, why do you think there weren't any orange-billed duckos in Generation 1? **Show slide 6.** **NOTE TO TEACHER:** *Display only the parents' alleles on the slide initially.* Now let's look at Generation 2 and figure out why there are more red-billed duckos than orange-billed duckos. See if you can make sense of the 3:1 pattern, or ratio, of dominant to recessive traits that appears in all these different species. What bill color do you think each of these Generation 2 offspring will have? **NOTE TO TEACHER:** *Point out on the slide that both parents have one dominant allele and one recessive allele.*	There weren't any orange-billed ducks in the first generation because no matter what allele from the mom mixed with an allele from the dad, the only combination you could come up with is one dominant allele and one recessive allele. So all the offspring would have the dominant trait.	Can you come up to the board and show us how you figured that out?

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			Ask students if they can explain why that is, referring them back to the alleles of the Generation 1 parents. *Advance through the possible combinations of parental sex cells on the slide, emphasizing again that it's random, and any sperm could combine with any egg. This time, the alleles of the offspring are animated, so after an arrow appears, you can ask students to describe which two alleles each offspring would have and then advance the animation again to confirm the answer.* **Show slide 7.** Scientists have figured out a way to represent all the possible combinations of alleles the parents could pass on to their offspring. It's called a *Punnett square*. In the Punnett square on this slide, Mom's alleles appear at the top of the square, and Dad's alleles are on the left side. To show the different allele combinations that could be passed to the offspring, an allele at the top of the square is combined with an allele on the side of the square and recorded in the appropriate box. **NOTE TO TEACHER:** *The slide animation demonstrates how to fill in the*		

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			Punnett square for Generation 2 alleles. Advance through the animation to show the possible allele combinations for the offspring. Based on this slide, can you summarize what a Punnett square shows us? How would we describe the different alleles that the second generation of ducko offspring had? How many out of the four offspring got two dominant alleles from their parents? How many got both a dominant and a recessive allele? How many got two recessive alleles? By looking at the offspring's' alleles, can you tell what bill color each of the offspring will have? **Turn and Talk:** Pair up again and see if you and your partner can agree about the	A Punnett square shows all the ways the parents' alleles might mix up in the offspring. The boxes represent different alleles that each offspring would have.	When you describe the boxes in the Punnett square, what do they represent in real life?

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			color of each offspring's bill. **NOTE TO TEACHER:** *Give pairs 1 minute to discuss this question and reach an agreement. Then advance the slide animation to show the possible traits of the offspring.*		
5 min	**Follow-Up to Activity** **Synopsis:** Students make sense of the information the Punnett square provides to explain the inheritance of specific traits. **Main science idea(s):** • When one parent has two different alleles for a trait (one dominant allele and one recessive allele), and the other parent has two recessive alleles for that same trait, there is a predictable, but not exact, 3:1 pattern (ratio) of dominant to recessive traits in the next generation of offspring. The Punnett square shows the possible combinations of parental alleles that lead to this ratio.	Make explicit links between science ideas and activities **after** the activity. Engage students in analyzing and interpreting data and observations.	**Show slide 8.** **Turn and Talk:** Now I'd like you and your partner to describe in your own words how the Punnett square provides information that can help us explain why all those different organisms had second-generation offspring in a pattern or ratio of three dominant traits to one recessive trait. **NOTE TO TEACHER:** *In addition to slide 7, it might be helpful to show slides 2 and 3 again and refer students to the class bar graph of Generation 2 duckos. Help students see that each graph has a 3:1 ratio of dominant to recessive traits (9:3, 6:2, and 3:1, respectively).* **Whole-class discussion:** So how can a Punnett square help us explain the 3:1 ratio of dominant to recessive traits in Generation 2 offspring?	The Punnett square shows all the possible combinations of alleles parents can give to their offspring. So we came	

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			In what ways is the Punnett square a useful tool for representing the possible allele combinations and trait variations from generation to generation?	up with a ratio of 3:1 in the second generation offspring because when you mix up the alleles, three boxes in the Punnett square show possible combinations that would result in the dominant trait, and only one box shows a combination that would result in the recessive trait. A Punnett square makes the possible allele combinations of the parents and traits of the offspring easier to see.	
4 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students revisit the focus questions and write a preliminary answer in their science notebooks.	Highlight key science ideas and focus question throughout.	**Show slide 9.** Let's revisit our focus questions: *Do the dominant and recessive traits of parents always result in similar patterns of trait variation in offspring? Why or why not?* **Turn and Talk (1–2 min):** Discuss today's focus questions with a partner. Then write your best answers in your science notebooks. Make sure to include in your answers what you've learned about chromosomes, genes, alleles, and		

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			dominant and recessive traits. **NOTE TO TEACHER:** *Alternatively, you could have students work on these questions in small groups.* **Whole-class share-out:** Let's hear some of your ideas for answering the focus questions. Make sure to explain your reasoning.	I think there's always a pattern because it seemed like the recessive trait always skipped a generation. The second generation of offspring showed a consistent pattern because there were always more offspring with the dominant trait than the recessive trait.	Can you give an example? What do you mean by "skipped a generation"? Do you think there will always be more of the dominant trait?
1 min	**Link to Next Lesson** **Synopsis:** The teacher foreshadows the next lesson in which students use a Punnett square in	Link science ideas to other science ideas.	**Show slide 10.** Next time, you'll have an opportunity to practice using a Punnett square to identify possible allele combinations and		

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	three scenarios to help them answer the focus questions.		traits in three different scenarios. Then we'll revisit our focus questions and see if the Punnett square helps us answer them.		