Genetics
Lesson 6a: Real-World Questions about Inheritance

Grade 6	**Length of lesson:** 50 minutes	**Placement of lesson in unit:** 6a of 6 two-part lessons on genetics
Unit central question: Why are individuals of a species different from one another?		**Lesson focus question:** How can ideas about trait inheritance help solve real-world problems?
Main learning goal: Understanding how parents' chromosomes segregate to make sex cells and unite to produce offspring enables scientists and doctors to reconstruct a family's genetic history for particular traits across multiple generations. It can also answer questions or solve problems related to inherited traits.		
Science content storyline: In most cases, individuals have two sets of instructions, called *genes*, for any specific trait. They get one set of instructions from each parent. *Alleles* are different forms of the same gene. For certain traits, one allele is dominant and the other is recessive. Each individual has a combination of alleles that determine what a particular trait will look like. If you have a trait controlled by a recessive allele, you must have two recessive alleles, one from your mother and one from your father. If you have a trait controlled by a dominant allele, you could have either two dominant alleles—one from each parent—or a dominant allele from one parent and a recessive allele from the other. A *pedigree* is a helpful tool for tracking specific alleles through several generations of a family.		
Ideal student response to the focus question: If you know certain information, like whether a trait is dominant or recessive, you can often figure out which alleles different family members have. By knowing a person's alleles, you might be able to predict the chances of someone else in the family having a particular trait, or you might be able to figure out whether genes play a role in a certain disease.		

Preparation

Materials Needed • Science notebooks • Class chart: Our Current Ideas about Inheritance (from previous lessons) • Chart paper and markers **Student Handouts and Teacher Masters** • 6.1 Case History 1: The Wilson Family (1 per student) • 6.2 Wilson Family Pedigree *(*1 per student) • 6.2 Wilson Family Pedigree (Teacher Master)	**Ahead of Time** • Review the Genetics Content Background Document, especially sections 1, 5, and 8. • For more information and student activities related to Marfan syndrome and other rare genetic disorders, refer to *Rare Diseases and Scientific Inquiry*, an NIH supplemental curriculum series (http://science.education.nih.gov/supplements/webversions/diseases/default.html).

Lesson 6a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
10 min	**Link to previous lesson:** Students review and revise the class chart of ideas about inheritance, creating a new list represented as a simple model of inheritance. These key science ideas will guide students as they attempt to solve genetics problems during the lesson.	
3 min	**Lesson focus question:** The teacher introduces the focus question, *How can ideas about trait inheritance help solve real-world problems?*	
5 min	**Setup for activity:** Students brainstorm ways that science ideas about genetics and inheritance might be important in the real world. They also consider the questions or problems these ideas might help people resolve.	• Because trait inheritance follows certain rules that result in patterns of traits across multiple generations of a family, ideas about how traits are passed from parents to offspring can be used to answer questions related to trait variations in offspring.
15 min	**Activity:** Students solve a problem related to genetic inheritance. In this case study, a genetic disease called *Marfan syndrome* (controlled by a dominant allele) is an inherited trait in the families of a young couple, and this couple wants to know the chances of their children inheriting the disease.	• For certain traits, individuals get a set of instructions called a *gene* from each parent. Different forms of the same gene are called *alleles*. • Some alleles are dominant, which means they override any other instructions for a trait, and offspring will exhibit the dominant trait no matter what other allele is present. • Recessive alleles provide instructions for a trait variation that will appear in offspring only when two recessive alleles—one from each parent—are paired. • Individuals with a trait controlled by a recessive allele must have two recessive alleles, which means they got one from their mother and one from their father. • Individuals with a trait controlled by a dominant allele might have two dominant alleles for that trait or a dominant allele from one parent and a recessive allele from the other parent.
10 min	**Follow-up to activity:** Students share how they figured out the allele combinations of each Wilson family member. Then they use science ideas about inheritance to answer questions about the family.	• If you know certain information, such as whether a trait is dominant or recessive, you can often figure out which alleles different family members have. By knowing a person's alleles, you might be able to predict the chances of someone else in the family having a particular trait or figure out whether genes play a role in a certain disease.
6 min	**Synthesize/summarize today's lesson:** Students use science ideas about inheritance to propose an answer to the focus question.	• Understanding how parents' chromosomes and alleles recombine to produce offspring can help reconstruct a family's genetic history for particular traits and answer questions or solve real-world problems related to inherited traits.
1 min	**Link to next lesson:** The teacher announces that in the final lesson, students will apply their understandings of inheritance to another case study and answer the unit central question.	

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10 min	**Link to Previous Lesson** **Synopsis:** Students review and revise the class chart of ideas about inheritance, creating a new list represented as a simple model of inheritance. These key science ideas will guide students as they attempt to solve genetics problems during the lesson.	Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slides 1 and 2.** Today we're going to use everything we've learned so far about trait inheritance to see if we can solve some real-life problems. Throughout this unit, we've been revising and adding to our class chart of ideas about inheritance. Let's clean up this list by identifying just a few key science ideas we can use as a simple model of inheritance. We'll use these ideas to create a new class chart we can use as a model to solve real-life problems. First, look over our chart and identify a key science idea you think helps us understand how traits are passed from parents to offspring across several generations. **Whole-class share-out:** Who can identify a key science idea from our chart that you think should be included in our model of inheritance? **ELL support:** Give ELL students an opportunity to talk about the concepts by working with a same-language partner to identify key ideas before the class discussion. **NOTE TO TEACHER:** *Create a new*	*Key science ideas students may identify:* • Genes determine which traits an individual will have. • Genes are found on the chromosomes in sex cells and are passed from parents to offspring.	*Possible follow-up questions:* Can you say that idea in a complete sentence? Does anyone have a different way of expressing that idea?

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		Engage students in communicating in scientific ways. Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	*chart of key science ideas without markup or sticky dots. Title the new chart "A Simple Model of Inheritance." Before writing down any ideas students identify, ask whether the class agrees that the idea should be added to the new chart. Allow time for discussion and clarification. Encourage students to communicate scientifically, asking one another questions, agreeing or disagreeing, or adding to the proposed statement. Use the Communicating in Scientific Ways chart to support this discussion and remind students how to talk about science ideas.* *Ask probe or challenge questions to help the class reach a consensus on key science ideas to add to the new chart. Help them connect these ideas to their experiences in the lesson series by asking what they did in previous lessons that helped them understand an idea. Continue reviewing and charting ideas until all the ideas from the old chart have either been added to the new chart or eliminated.* **ELL support:** It may be useful for ELL students to experience these key science ideas in another modality. The model can be represented graphically or revisited by acting it out. Sometimes we think of a model as something physical, like a model of an	• For certain traits, individuals that reproduce sexually have two genes for each trait. They get one gene from each parent. • During reproduction, these pairs of genes separate, and one gene goes into each sex cell. • During reproduction, the sex cells of the mother and father mix randomly to create a new individual with one gene from each parent. • If an allele for a dominant trait is present, the individual will have the dominant trait. • The only time an individual shows the recessive trait is when two recessive alleles—one from each parent—are present.	

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			airplane or the solar system. But in this case, we're creating a *conceptual model* that will help us solve today's genetics challenge.		
3 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *How can ideas about trait inheritance help solve real-world problems?*	Set the purpose with a focus question or goal statement.	**Show slide 3.** Our focus question for this lesson is *How can ideas about trait inheritance help solve real-world problems?* Write this question in your science notebooks and draw a box around it.		
5 min	**Setup for Activity** **Synopsis:** Students brainstorm ways that science ideas about genetics and inheritance might be important in the real world. They also consider the questions or problems these ideas might help people resolve. **Main science idea(s):** • Because trait inheritance follows certain rules that result in patterns of traits across multiple generations of a family, ideas about how traits are passed from parents to offspring can be used to answer questions related to trait variations	Make explicit links between science ideas and activities **before** the activity. Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	Throughout this unit, we've been updating our class chart of ideas about inheritance. How do you think these ideas might be used in the world? Why would someone need or want to know this information? **NOTE TO TEACHER:** *Ask probe and challenge questions to help students clarify their understandings of the types of scenarios in which this knowledge would be helpful. Use this as an opportunity to help students connect science ideas to real-world issues.*	A farmer might want to know about how traits are passed to offspring so farm animals or crops can be bred with specific traits. It might be useful to be able to breed crops that can resist bugs or disease. A dog breeder might need to know about how	How might you use ideas about inheritance to change the characteristics of crops or farm animals?

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	in offspring.		To illustrate how ideas about inheritance can answer questions and solve problems in real life, let's consider a hypothetical situation. **NOTE TO TEACHER:** *Read the opening paragraph of handout 6.1, Case History 1: The Wilson Family.* ***Don't distribute the handout at this time.*** **Show slide 4.** So we know that Marfan syndrome runs in the Wilson and Roberts families. Susanna Wilson and some members of the Roberts family have this genetic disease. Peter Wilson doesn't have Marfan syndrome, but two members of his family do. Peter and Susanna understandably have questions and concerns about the risks of future offspring inheriting this disease. How do you think the science ideas in	traits are passed to offspring so that show dogs can be bred with certain characteristics. You might want to know the chances of getting a certain disease if it runs in your family.	How could these ideas help you know the chances of getting a disease?

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			our simple model of inheritance could help this family figure out the whether their kids might inherit Marfan syndrome? **ELL support:** To aid student comprehension, review these inheritance ideas orally. **NOTE TO TEACHER:** *In their responses to this question, students should mention that to calculate a ratio, they need to know the genotypes of the mother and father and whether the allele that causes Marfan syndrome is dominant or recessive.*		
15 min	**Activity** **Synopsis:** Students solve a problem related to genetic inheritance. In this case study, a genetic disease called *Marfan syndrome* (controlled by a dominant allele) is an inherited trait in the families of a young couple, and this couple wants to know the chances of their children inheriting the disease. **Main science idea(s):** • For certain traits, individuals get two sets of instructions called *genes* from their	Engage students in using and applying new science ideas in a variety of ways and contexts.	**Show slide 5.** **NOTE TO TEACHER:** *Distribute handouts 6.1 and 6.2 (Case History 1: The Wilson Family, and The Wilson Family Pedigree).* First, let's look at the Wilson family pedigree (handout 6.2). A capital *M* represents the dominant allele that causes Marfan syndrome. A small *m* represents the recessive allele for normal height. Is there any way to know for sure which family members have certain allele combinations? If yes, how? Whose alleles in the Wilson family can you be sure of?	Anyone with average height must have a recessive allele	

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	parents. Different forms of the same gene are called *alleles*. • Some alleles are dominant, which means they override any other instructions for a trait, and offspring will exhibit the dominant trait no matter what other allele is present. • Recessive alleles provide instructions for a trait variation that will appear in offspring only when two recessive alleles—one from each parent—are paired. • Individuals with a trait controlled by a recessive allele must have two recessive alleles, which means they got one from their mother and one from their father. • Individuals with a trait controlled by a dominant allele might have two dominant alleles for that trait or a dominant allele from one parent and a recessive allele from the other parent.		**Show slide 6.** **Small groups:** Now I'd like you to work in small groups on these handouts. First, review the case history of the Wilson family on handout 6.1 to see which family members have Marfan syndrome and which don't. Then read the pedigree instructions on the handout and decide which circles or squares on the pedigree to shade in. You can talk about the case history as a group, but each of you should shade in your own pedigree. Use this information to figure out the possible allele combinations of each family member and have groups reach a consensus before they write the allele combination under each person's name on the pedigree. First write down the alleles you're sure about and then see if you can figure out the alleles for the	combination (mm). As a recessive trait, the only way someone would end up with average height is if there's no dominant allele for Marfan syndrome. A family member with Marfan syndrome might have either two dominant alleles (MM) or a dominant allele and a recessive allele (Mm).	

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		Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	other family members. Finally, following the instructions in handout 6.1, create a Punnett square showing the possible allele combinations Peter and Susanna's offspring could inherit. Make sure to answer the questions next to the Punnett square and calculate the ratio of offspring with and without Marfan syndrome. **NOTE TO TEACHER:** *Make sure students understand the instructions on handout 6.1 before they begin the activity. Tell them **not** to answer the final two discussion questions on the handout, since those will be addressed later. Give students adequate time to trace the allele for Marfan syndrome through all three generations of the Wilson and Roberts families. Move from group to group as students work, listening to their discussions and asking probe and challenge questions as needed to clarify their thinking.*		
10 min	**Follow-Up to Activity** **Synopsis:** Students share how they figured out the allele combinations of each Wilson family member. Then they use science ideas about inheritance to answer questions about the family.		**Whole-class discussion:** So did you figure out the allele combinations for the Wilson and Roberts families? Let's hear your decisions and reasoning. I'll record on this unmarked pedigree each allele combination we agree on as a class. **NOTE TO TEACHER:** *Display on a document reader an unmarked copy of student handout 6.2 (The Wilson Family Pedigree). As you work through the*		

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	Main science idea(s): • If you know certain information, such as whether a trait is dominant or recessive, you can often figure out which alleles different family members have. By knowing a person's alleles, you might be able to predict the chances of someone else in the family having a particular trait or figure out whether genes play a role in a certain disease.	Engage students in constructing explanations and arguments.	*pedigree with students, make sure the class reaches a consensus about the allele combinations for each family member before you add it to the pedigree.* First, whose circle or square did you shade in to show that this family member has Marfan syndrome? Where did you get the information to make this decision?	We shaded the squares for Joseph and Greg Wilson. The directions said to shade the circles or squares of the family members with Marfan syndrome. On the other side, we shaded the circles for Maryanne, Susanna, and Kathy, and the square for Sam. We got the information for our decisions from the family-history charts in the handout. All the unshaded circles and squares had to have recessive (mm) alleles, because anyone who didn't have Marfan syndrome had to have a recessive allele from	Do we all agree? Does anyone have another idea?

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		Ask questions to probe student ideas and predictions.	Which allele combination did you give each member of the Wilson and Roberts families? How did you figure out that this is the right combination? **NOTE TO TEACHER:** *Discuss the allele combinations for each family member, and when consensus is reached, write the alleles below each family member's name. If students don't agree on the allele combinations, probe their thinking about the dominant (M) and recessive (m) alleles. Help them understand the process of creating a pedigree by using what they know about inheritance to figure out how genes and their alleles are passed from one generation to the next.*	each parent. The other shaded circles or squares have one dominant and one recessive allele (Mm). Both the Wilson and Roberts families had one parent with Marfan syndrome and one without, so that means their children always have one recessive allele. Except we don't know about Joseph or Maryanne. They could have either two dominant alleles (MM) or a dominant and a recessive allele (Mm). Both the Wilson and Roberts families are like the red- and orange-billed duckos. If Joseph Wilson and Maryanne Roberts were MM, like	And where did you get the information for this decision? That's interesting. How did you figure that out? Does everyone see how that happens? Does anyone have a different idea? Tell us more about your ideas.

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				our red-billed ducko parent, then all their children would have Marfan syndrome, but they don't. So Joseph and Maryanne must have a dominant and a recessive allele (Mm).	That's a good comparison. Does everyone agree with these ideas? Does anyone disagree or have anything to add?
			Based on your Punnett-square results, what are the possible allele combinations Peter and Susanna's offspring might inherit? How many times does each allele combination occur? What ratio did you calculate for offspring with and without Marfan syndrome? **Show slide 7.** Now let's talk about the discussion questions at the end of handout 6.1. Make sure to include science ideas, evidence, and reasoning in your answers. **NOTE TO TEACHER:** *Encourage students to display their completed Punnett squares from handout 6.1 and the Wilson family pedigree from handout*		

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			6.2 as they share their ideas.		
6 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students use science ideas about inheritance to propose an answer to the focus question. **Main science idea(s):** • Understanding how parents' chromosomes and alleles recombine to produce offspring can help reconstruct a family's genetic history for particular traits and answer questions or solve real-world problems related to inherited traits.	Highlight key science ideas and focus question throughout.	**Show slide 8.** Our focus question today is *How can ideas about trait inheritance help solve real-world problems?* **ELL support:** This question can be stated, *How can knowing about how traits are passed from one generation to another help solve real-world problems?* **Turn and Talk:** As you discuss this question with a partner, think specifically about the Wilson family and how science ideas about inheritance helped answer Peter and Susanna's questions about the chances of their children inheriting Marfan syndrome. Use science ideas from our new class chart—our simple model of inheritance—to help you answer this question. **Whole-class share-out:** What ideas did you and your partner come up with to answer the focus question?		
1 min	**Link to Next Lesson** **Synopsis:** The teacher announces that in the final lesson, students will apply their understandings of inheritance to another case		**Show slide 9.** In our final lesson, we'll pull together all the science ideas about inheritance that we've learned about in this unit and use them to investigate a second case history.		

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	study and answer the unit central question.		We'll also revisit our unit central question and see if we can answer it based on what we know.		