FUTURELAB+

LIVING EARTH

Genetic Detectives: Investigating Inherited Diseases

Genetics

Developed in partnership with:

Discovery Education

In this Lesson Plan:

Print the **Teacher Section** →

Print the **Student Section** →

Cover Image
Genetic research, pipetting into a test tube in front of a DNA autoradiogram

This document is separated into two sections, For Teachers [T] *and* Student Resources [S]*, which can be printed independently.*

Select the appropriate printer icon above to print either section in its entirety.

Follow the tips below in the Range field of your Print panel to print single pages or page ranges:

Single Pages (use a comma): T3, T6

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LIVING EARTH / INVESTIGATING INHERITED DISEASES

Genetics

ACTIVITY DURATION

Six days

DRIVING QUESTION

How do you counsel patients on their risk of genetic disease while considering their health literacy?

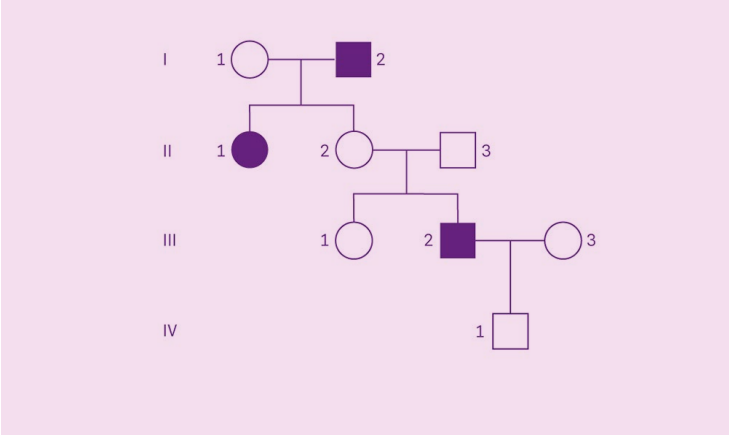
ESSENTIAL QUESTIONS

How do genes get passed from parents to offspring?

How do we conduct tests that inform us about the possibility of inherited disease?

OVERVIEW

In this lesson, students simulate the role of a Genetic Counselor. They read a variety of patient profiles and select a patient for whom they will conduct a genetic test. In order to do this work, students learn about and apply content connected to meiosis, Mendelian genetics, and pedigree charts.



OBJECTIVES

Students will be able to:

Discover how genes are passed down from parent to offspring.

Investigate how to determine the offspring genotype and phenotype ratios between two parents.

Research how to build and analyze a family pedigree chart.

Explore how genetic counselors conduct genetic tests.

STUDENT TASKS

Day 1	*Day 2*	*Day 3*	*Day 4*	*Day 5*	*Day 6*
Identify traits of the class in order to ask questions about DNA, inheritance, and inherited diseases. Review patient profiles and select a patient to work with in the role of a genetic counselor.	Examine the phases of meiosis. Get introduced to key genetic vocabulary terms.	Use a Punnett square to determine offspring genotype and phenotype of autosomal and sex-linked traits.	Learn how to do a genetic test by developing and analyzing pedigree charts.	Conduct a genetic test for the patient they selected in Day 1 by building and analyzing a family pedigree chart of the patient.	Begin developing the Genetic Test Report they will later share with their patient at the end of the unit.

MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

Identifying genetic diseases through genetic testing helps people understand whether they are at risk for certain diseases. This helps them make health decisions for themselves, and for their potential or current children. Genetic counselors must have an understanding of genetics, how testing works, how to interpret results, and which professionals to work with in order to best serve their clients and patients. Genetic counselors also need to have excellent communication skills as they interact with patients.

How does this connect to careers?

Genetic testing is facilitated by ***genetic counselors***, who help patients learn about their conditions and make decisions about how to manage them.

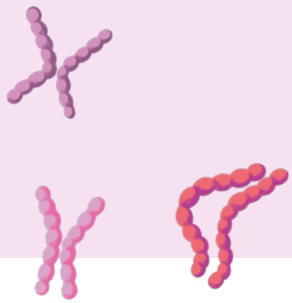
Nurse educators help nurses in their professional development. They may offer coursework and skill development workshops, or they may serve as mentors. Nurse educators help nurses focus on the overall goal of providing patients with the best care possible.

Community health workers teach people about healthy behaviors and work to expand access to medical care for patients in need.

Licensed therapists are trained mental health professionals that help individuals and families process their emotions. Therapists can help patients with a genetic disease and their family members navigate challenging moments, such as receiving a diagnosis or undergoing treatment.

How does this connect to our world?

With technological, agricultural, and medical advancements, humans are living longer than ever before. Lifestyle choices and exposure may cause detrimental genetic mutations over these lifetimes. This means humans are experiencing new genetic disorders as our bodies live longer, and are simultaneously subjected to more harmful environments. This creates a need for genetic counseling and testing, as well as gene therapy and modification. We need tools to identify needs as well as medical professionals who are capable of curing or managing these problems.



Pedagogical Framing

Instructional materials are designed to meet national education and industry standards to focus on in-demand skills needed across the full product development life cycle—from molecule to medicine—which will also expose students and educators to the breadth of education and career pathways across biotechnology.

Through this collection, educators are equipped with strategies to engage students from diverse racial, ethnic, and cultural groups, providing them with quality, equitable, and liberating educational experiences that validate and affirm student identity.

Units are designed to be problem-based and focus on workforce skill development to empower students with the knowledge and tools to be the change in reducing health disparities in communities.

SOCIAL-EMOTIONAL LEARNING

Students practice social awareness and management skills to successfully understand what others are feeling, while appreciating and interacting positively with their diverse groups during the lesson. Some students might have personal experience with genetic counseling and genetic disease. They will carry that experience with them into sensitive discussions. This requires all discussion participants to demonstrate empathy and practice self-management skills.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

This lesson applies culturally and linguistically responsive instruction to the study of content connected to meiosis, Mendelian genetics, and pedigree charts. Students will also explore the realities of being a Genetic Counselor, who must have excellent communication skills as they interact with patients. The lesson offers opportunities for the growth of critical consciousness of self and community, while encouraging students to bridge the learning to real-world professional experiences. Imagining themselves as genetic counselors will have a powerful effect on the ability of students to reflect on their own natural abilities and qualities.

ADVANCING INCLUSIVE RESEARCH

This lesson explains why it is important that health care professionals demonstrate cultural competency and effective communication skills when working with patients. In order to ensure patients are able to make informed decisions and consent, special care must be taken to ensure that the information communicated to them is culturally relevant and in the language that they speak. When patients are able to make informed decisions about their healthcare, this helps close the gaps in health disparities.

COMPUTATIONAL THINKING PRACTICES

In this lesson, students put four computational thinking strategies into practice: collecting data, analyzing data, decomposition, and finding patterns. Students gain experience with the computational thinking strategy of collecting data by contributing to a crowdsourced database on genetic traits in their class. They then take on the role of genetic counselors in order to understand how these professionals help patients analyze information about their genetic makeup. Students use Punnett squares to decompose all possible outcomes of a breeding experiment and find patterns in genetic traits passed down across generations.

CONNECTION TO THE PRODUCT LIFE CYCLE

Until recently, there were few treatment options for those with inherited conditions such as Sickle Cell Anemia. Now, many therapies are being developed to help people with these diseases live longer and more fulfilling lives. These therapies, and the careers associated with bringing them to market, are located in the Development phase of the product life cycle.

Day 1

Slides 1–12

Slides 1–12

Conduct an inventory of common traits that are seen in the class. (25–30 minutes)

1 **Prepare Ahead of Time:** In the front of the room, create a class anchor chart that replicates the table on the *Discover the Traits in Our Class* capture sheet. There should be two columns ("Yes" and "No") and 12 rows—one for each trait. You will use the anchor chart on Day 3 to discuss dominant vs. recessive alleles.

2 Have students individually do an inventory of their traits using the *Discover the Traits in Our Class* capture sheet.

3 Direct students to the blank class anchor chart in the front of the room. (We will use a *Data-Driven discussion protocol* to help students make meaning from the data they collected.)

4 Tell students that the class will now collect everyone's response to the inventory and will use a protocol to help them analyze and make meaning of the data.

a. **Phase 1, Predict:** Ask students to make predictions about what they think the class outcome for each trait will be. In pairs, have them discuss their predictions and what influenced their predictions.

b. **Phase 2, Make it Visual:** In groups no larger than three, give students time to represent the results visually (They may choose to make graphs comparing (yes or no), color code, call out patterns and trends, etc.). Have them do a brief share out of their visuals and how the visuals helped them make meaning of the numbers.

c. **Phase 3, Observation:** Briefly review what an observation is versus a prediction or an inference. What do you notice? In groups of four, pose the prompt and give time for students to make observations. Have one person record the observations. Do a class share out.

d. **Phase 4, Further Discussion:** Facilitate a conversation using the following prompts:

- Why can some people roll their tongue and some people can't?
- What other traits can you think of?
- Are all traits visible? Can you think of any traits you can't physically see?
- How is this connected to the inherited diseases you learned about in Lesson 1?

COMPUTATIONAL THINKING PRACTICES

As students add their traits to the inventory, they are contributing to a crowdsourced dataset and putting the computational thinking strategy of collecting data into practice. Then, they use the computational thinking strategy of analyzing data to make meaning of the data they collected.

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Day 1

Continued

Slides 13–16

Slides 13–16

Students simulate the role of genetic counselors by reading five *patient profiles* and selecting one patient to counsel. (20 minutes)

1 **Prepare Ahead of Time:** In five separate areas of the room, tack a large piece of chart paper on the wall. Then, on the chart paper display the patient profiles for students to examine. Be sure there is enough room left on chart paper for students to write notes, questions, and thoughts. *Do not* display the inherited disease associated with the patient.

2 **During Class:** Tell students that they are going to read about five patients in order to select which patient they would want to work with as a genetic counselor.

Direct students to the five areas of the room, and review the *Chalk Talk Protocol* directions and prompts with students

a. Directions: Students should move freely from one section of the room to another. While moving from station to station, have students use the chart paper to respond to the Chalk Talk prompt on the slide. Emphasize that the Chalk Talk Protocol is meant to be a silent protocol. Students can also build on what others write.

b. Prompts:

- What do you **think** you know about this family? How are they like you or someone you know?
- What questions or **puzzles** do you have about this family?
- What topics do you want to **explore** more based on what you have learned about this family?

3 After the Chalk Talk Protocol is complete, have students take one more walks around the room and read what peers have written.

4 Debrief as a class by asking several students to volunteer their input:

- What are your thoughts and feelings about all of the families we have learned about today? How did reading your peers' thoughts impact this?
- Which family resonates the most with you?

5 As an Exit Ticket, allow students to select the patient with which they want to work.

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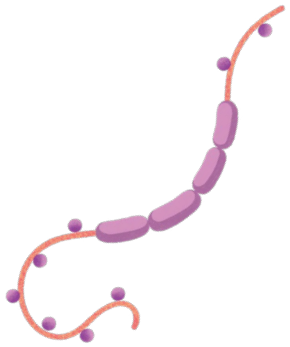
Day 2

Slides 17–20



Slides 17–20	
Let students experience the content and vocabulary they will learn in this lesson by exploring an inheritance simulation. (20 minutes)	
1	Split students up into groups or pairs in order to complete this activity.
2	Have students access the *pigeonetics simulation*, using a Safari Browser, Chromebook, or tablet.
3	Project the simulation on the board so all students can see.
4	Prompt students to complete Level One and share aloud their observations.
5	Record Level One observations on the board. Then prompt students to share any academic science words they came across in Level One. Record these words on the board.
6	If needed, show students how to complete Level One.
7	Continue the simulation and at the end of Levels 4 and 5 ask students what is the genotype and phenotype of the bird.
8	By the end of the activity, students should have identified the following vocabulary words: **chromosomes, sex chromosomes, offspring, inherited characteristics or traits, genes, eggs, sperm, alleles, genotype, phenotype, dominant, and recessive.**
9	When students have completed Level 5, stop and debrief using the following prompts: • What did you notice? • What questions do you have? • How does this connect to being able to determine if your family will have a child with your inherited disease? (Use this question to transition into the next section where students learn about meiosis)

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Day 2

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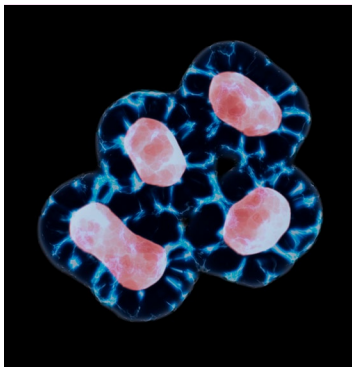
Slides 21–24

COMPUTATIONAL THINKING PRACTICES

As students each take a stage of meiosis to investigate, they are using the computational thinking strategies of collecting data and decomposition.



Slides 21–24	
Have students explore the stages of meiosis using the *Jigsaw* strategy. (25 minutes)	
1	Put students in groups of four. Assign a stage of meiosis to each person in the group.
2	Have students *watch the video of meiosis* and use the review slides under the video to investigate their stage of meiosis.
3	Each student will then meet with others who were also responsible for the same stage of meiosis. In these "same stage" groups, students should compare their notes and solidify their understanding of the events of the stage.
4	Next, have students return to their original groups in order to explain their stage of meiosis. Make sure everyone understands all the stages.
5	During this *Jigsaw* presentation, students are using the *Stages of Meiosis* capture sheet to take notes about what happens at each stage based on what their group members share.
6	Debrief by asking groups to share remaining questions and let other groups respond. Clarify understanding as needed.

Day 3

Slides 25–40

Slides 25–40

Introduce the vocabulary words associated with the different genotype allele combinations seen in monohybrid crosses in order to set up students to use Punnett squares during the next activity. (15 minutes)

1. Have the *pigeonetics activity* on the board for students and move through Level 4. Prompt students to use the vocabulary identified yesterday to identify the different alleles. Ask students to come up with a working definition of an allele.

2. Ask students why they think that when a crest allele is matched with a no-crest allele, the phenotype is no crest. Use this conversation to introduce the concept of **Dominant** and **Recessive** alleles. Add those two words to the vocabulary anchor chart.

3. Review with students the *Class Trait Anchor Chart* used during Day 1. Have students form two lines facing each other. Follow the prompt:

   a. *Think-Pair-Share*

   - What are the different alleles for the traits of the class?
   - Why do you think some people have the phenotype of one allele and some people have the other? Conduct a brief class share out.

   b. *Conga Line* Have one side of the line move down so new pairs are formed. Select one side of the line to be the teachers and repeat the prompt: "Why do some people have the phenotype of one allele and some have the other?
   Have "teachers" re-teach what they learned to their student on the other side of the line.

   c. *Think-Pair-Share* In the same pairs, pose the next prompt. Have partner 2 begin their sharing first this time.

   - Based on our data, can you guess which alleles are dominant and recessive?
   - If you have the phenotype of a recessive allele, what does that mean about the genotype of your parents? How do you know? Conduct a class share out in order to clear up any misconceptions.

   d. *Conga Line* Give the other side of the line a chance to be the teacher. Repeat the prompt, "If you have the phenotype of a recessive allele, what does that mean about the genotype of your parents? How do you know?

   e. Use this final question to transition into the next lesson on monohybrid crosses.

INDUSTRY AND CAREER CONNECTION

As students participate in the "Conga Line!" activity, they are simulating the role of community health workers. These professionals help develop a community's health literacy by teaching them about healthy behaviors and informing them about prevalent medical conditions.

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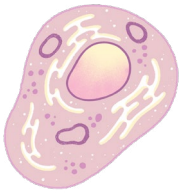
Day 3

Continued

Slides 25–41



4 Using the *Pigeonetics* simulation on Level 4, have students identify the different genotype combinations of alleles.

5 When you show students the birds tell them you are going to use a "N" for no crest and a "n" for crest. Ask students why you capitalized the "N" for no crest and "n" for crest. Inform students that when tracking traits from parents to offspring, the alleles use the same letter; the only difference is the dominant allele is capitalized and the recessive allele is in lowercase.

6 Prompt students to indicate the genotype allele combinations of the birds on the wire. As students share, write them on the board. The genotypes are: two birds with (Nn) and two birds with (NN). Tell students the names of the two genotypes shown.

- **a.** (NN) Homozygous Dominant
- **b.** (Nn) Heterozygous

7 Complete Level 4 and ask students what they think would be the name of the resulting bird at the end of Level 4—(nn).

- **a.** (nn) Homozygous Recessive

8 Use this conversation to transition into looking at Punnett squares to determine offspring frequencies.

COMPUTATIONAL THINKING IN ACTION

As they develop their Punnett squares, students are using the computational thinking strategy of decomposition to identify all possible genetic outcomes.

Slides 40–41

Introduce students to monohybrid cross problems to determine genotypic and phenotypic ratios of offspring. (10 minutes)

1 As a demonstration, put a Punnett square on the board to look at Detached vs. Attached Earlobes.

2 Point out the number of students on the *Class Traits Anchor Chart* that have attached and detached earlobes. Tell them that Detached earlobes are dominant and marked with the big letter "E". Attached earlobes are recessive and marked "e".

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Day 3

Continued

Slides 40–49

3 Create the Punnett square below for a cross between two heterozygous parents (Ee × Ee). Tell students you can use the cross to determine the likelihood that the children produced by these two individuals will have attached or detached earlobes.

	E	**e**
E	EE	Ee
e	Ee	ee

4 Show students how to complete the Punnett square.

5 Tell students that filling out the boxes shows all of the possible outcomes for their children, but it does not indicate which outcome the child of these two parents will have. It shows the odds only.

6 In this example, we see that a cross between two heterozygous parents gives the following genotype and phenotype ratios:

- **a.** Genotype: 1:2:1
- **b.** Phenotype: 3:1—this means there is a 75% chance the child will physically have detached earlobes.

7 Prompt students to make connections to what they learned about in meiosis.

COMPUTATIONAL THINKING IN ACTION

As students decode the Punnett square, they are using the computational thinking strategy of finding patterns to make predictions.

Slides 42–49

Introduce sex-linked traits and how to track them in a monohybrid cross. (15 minutes)

1 Tell students that some diseases are sex-linked traits.

2 Sex-linked traits = traits that are passed down from parents to offspring by genes found on sex chromosomes (X and Y chromosomes).

3 Sex-linked diseases are also passed down through the X and Y chromosome

- **a.** Dominant inheritance = The abnormal gene is dominant.
- **b.** Recessive inheritance = The abnormal gene is recessive.

Continues next page >

Day 3

Continued

Slides 49–50

4 Example: Duchenne Muscular Dystrophy (a recessive sex-linked disease).

	X_D	Y
X_D	X_DX_d	X_DY
X_d	X_DX_d	X_dY

- Prompt students with the following questions:
- Which is the father and the mother? How do you know?
- What is the genotype of the parents? Do they have the disease? How do you know?
- What do you notice about the difference between the *X* and *Y* chromosome?
- How many of the possible offspring are boys and how many are girls?
- How many boys have Duchenne Muscular Dystrophy and how many girls have it?
- Why is the number of boys and girls different?
- What are the chances these parents have a child with Duchenne Muscular Dystrophy?

5 Have students begin to work on the practice problems in the *Genetics Practice* capture sheet.

Slide 50

Prep students to conduct patient interviews for homework. (5 minutes)

1 Pass the interview cards *in this document* (available in English and Spanish) to students so they can interview their families for homework. Students will use the interview responses to build a "health family tree" on Day 4.

Teacher Note > *If possible, allow students access to these interview cards a week prior to this lesson. Some students will need more time to gather this information. Be aware that some students may not have relatives that are genetically related to them, making this activity difficult. Create copies of a generic form in case some students cannot, or do not, return to class with their interview cards completed.*

2 Review the information students are collecting and clarify any areas of confusion.

3 Let students know they are going to use the information they collect to build a health family tree the next day.

Day 4

Slides 51–60

COMPUTATIONAL THINKING IN ACTION

As students follow the instructions and create their family tree, they are following an algorithm.

INDUSTRY AND CAREER CONNECTION

As students create their health family tree, they begin to wrestle with complicated questions, such as whether or not they would want to know if they were a carrier of a genetic disease. Genetic counselors help patients navigate these sensitive issues by offering tests, recommendations, and treatment options.

Slides 51–56

Students make their family tree with the information from their cards. (15 minutes)

1. Students take the information from their interviews to create a health family tree following the steps *detailed here*.

2. Prompt students with the following questions:
   - Why do you think the role of a genetic counselor is important?
   - Would you want to know the likelihood that you could pass a genetic disease onto your child?
   - Knowing what you know about calculating the likelihood that parents will have offspring with specific traits or even a disease, how can you use a family tree to advise parents as genetic counselors if their children have a chance of inheriting a disease?

3. Use this last question to transition into learning how genetic counselors do Pedigree Analysis to track genes passed down through family lineage. Tell students that genetic counselors build family trees using patient information to aid in diagnosis or even to help parents determine the likelihood that their children will have a specific inherited disease. Tell students that these family trees are called “Pedigree Charts.”

Slides 57–60

Students learn about how to build and analyze a family *pedigree chart*. (30 minutes)

1. Show the pedigree chart on the next page. Prompt students to record their observations. Observations can include:
   - I see roman numerals on the left.
   - I see circles and squares.
   - I see lines connecting squares and circles.
   - I see lines drawn down and branching out to other squares and circles below.
   - I see some circles and squares are shaded in and some are not.
   - I see each circle and square has a number attached to it.

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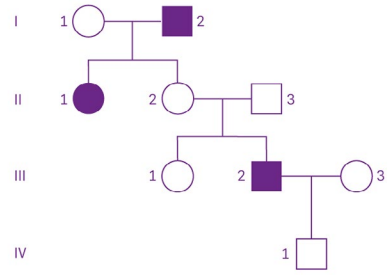
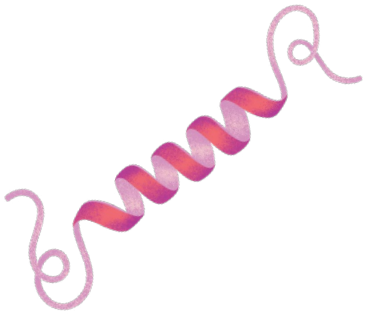
Day 4

Continued

Slides 57–60





2	Have students predict what the different parts they observed in the pedigree represent using the following prompt: "This image represents a family tree that shows how a trait or an inherited disease is passed down in a family similar to what you created at the beginning of class. Knowing this, what do you think the different parts represent?"
3	Have students share their thoughts. Throughout this conversation, label the different parts of the pedigree chart.

a. **Roman numerals** = generation in the family

b. **Numbers attached to circles and squares** = individuals within a generation

c. **Circles** = female

d. **Squares** = male

e. **Lines between squares and circles** = a marriage or union

f. **Lines drawn down and branching out to other squares and circles** = Offspring of parents in the generation above

g. **Shaded circles or squares** = an individual affected by the trait or individual's phenotype shows the trait

h. **Not shaded circle or square** = an individual unaffected by the trait or individual's phenotype does not show the trait

4	Use a *pedigree chart* to demonstrate how to trace the path of a trait for students to determine the chance two parents will have a child with that trait.
5	Have students begin the *Family Pedigree Analysis* capture sheet and finish as homework.

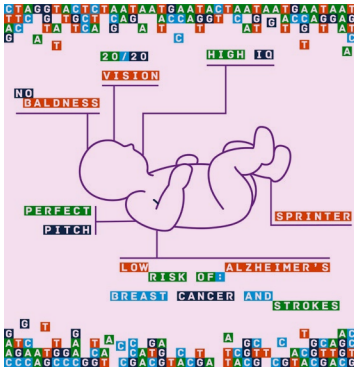
COMPUTATIONAL THINKING IN ACTION

Here, students see how genetic counselors use the computational thinking strategies of collecting and analyzing data in their day-to-day work.

Now that students have identified their patient, they need to learn about how to conduct a genetic test. Students will learn what information genetic counselors collect and how they use the information to build phylogenetic trees (pedigree chart) of the family history. In the role of a genetic counselor, students are given a case file on the patient that includes family information which will allow them to build a phylogenetic tree (pedigree chart) of the family to determine the chances of the disease occurring in their children.

Day 5

Slides 61–65



Slides 61–65

Students develop and analyze their patient's family pedigree chart (45 minutes)

1	Review the *Family Pedigree Analysis* capture sheet with students, answering and clarifying any remaining questions.
2	When students are ready to move forward, ask them, "As a genetic counselor, what questions will you need to ask the family members in order to learn more about their medical history?"
3	Create an anchor chart as students share aloud the questions they would need to ask the family.
4	Pass out the ***Patient Profiles*** for the patients students selected on Day 1 of this lesson.
5	Students will need to read the patient documents in order to build their pedigree chart using the *My Patient's Pedigree Chart* capture sheet.

Day 6

Slides 66–68

Slides 66–68

Students begin to develop their Genetic Test Report. (35 minutes)

1. Have students review the *Genetic Test Report Example*.

2. Ask students to notice how the information is organized and to decide what content they need to fill out the report.

3. Share with students their *Genetic Test Report* template that will need to be completed by the end of the unit. Tell students this is one of the final products they will need to produce for this unit.

4. Remind students that they have collected enough information about their patients to fill out the following sections:

   a. Your results

   - Who is affected?
   - How do you get the inherited disease?

   b. About the test

   - Patient Pedigree Chart

   c. What this result means for you?

   - The analysis of the pedigree chart connected to patient context.

INDUSTRY AND CAREER CONNECTION

Nurse educators are professionals who teach health care providers to explain complicated medical concepts to patients who have low health literacy.

5. Ask students if they think their patients understand how to read and interpret a pedigree chart on their own. Remind students that they need to communicate the information in the chart in such a way that any lay person can understand it. They also must consider family background, ethnicity, culture, religion, and health literacy when communicating with their patients. Remember that cultural competency by medical professionals plays a major role in the communication and education of patients. Students will need to consider their own biases as they prepare to communicate with their patients.

6. Give students the rest of class to complete all the sections detailed above.

7. Remind students that by the end of the project, they will need to include the statistics and probability of their patient having an inherited disease and/or passing the gene to their children, what test(s) or treatment(s) the patient should consider, an explanation of results, and next steps for the patient to consider.

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Day 6

Continued

Slides 69–70

Slides 69–70

Debrief Lesson 2 with students. (10 minutes)

1. For the class discussion around the prompts below, have students first discuss in their groups, and then have groups share one item from their group discussion.

2. Use the following prompts to facilitate a class debrief:

   a. Take a look at our N2K Questions. Which questions can we answer now based on the work we have done so far?

   b. What new questions do you have that we need to add to our N2K Questions?

   c. Other questions to consider or discuss:

   - How does knowing who your patient is determine how you communicate important and sensitive scientific information with them about the inherited disease?
   - Now that you know the disease diagnosis of your patient, how do you imagine it will impact their life?
   - How does your patient's cultural and socio-economic background affect the impact the disease could have on his or her life?
   - Is access to healthcare and treatment options going to be a barrier for your patient?

3. At the end of the class debrief, give students the following Exit Ticket prompt for a quick *whip around*: "In the next phase of our project you will need to communicate as a genetic counselor to discuss with parents the likelihood that their child will have an inherited disease. What do you think you will need to learn about first, in order to do that work?"

INDUSTRY & CAREER CONNECTION

Licensed therapists are trained professionals who help people process their emotions. Therapists can help patients grieve a life-altering diagnosis and navigate the ways a disease might affect their emotional lives.

National Standards

Next Generation Science Standards

Science and Engineering Practices (SEP)

Practice 4
Analyzing and Interpreting Data

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Practice 7
Engaging in Argument from Evidence

Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.

Disciplinary Core Ideas (DCI)

LS1.A
Structure and Function

All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.

LS3.A
Inheritance of Traits

Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

Crosscutting Concepts (CC)

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Scale, Proportion, and Quantity

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

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Discover the Traits in Our Class

Directions
Complete the checklist to identify the traits you possess. Then, complete the data table below by counting the number of "Yes" or "No" students for each trait. Calculate the frequency for each trait using the class data.

My Traits Checklist

Trait	Yes	No
Detached earlobes		
Tongue rolling		
Dimples		
Right-handed		
Freckles		
Naturally curly hair		
Cleft chin		
Allergies		
Cross left thumb over right		
Have a straight hairline		
Male		
Female		

Whole Class Data

Trait	Students Yes #	Students No #	Class Yes Frequency	Class No Frequency
Detached earlobes				
Tongue rolling				
Dimples				
Right-handed				
Freckles				
Naturally curly hair				
Cleft chin				
Allergies				
Cross left thumb over right				
Have a straight hairline				
Male				
Female				

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Stages of Meiosis

Directions
Use the words in the word bank to describe what is occurring at each stage of meiosis.

Word Bank

Centrioles	Microtubule
Chromatids	Nucleus
Chromosome	Spindle fiber

Stage of Meiosis	*Description*
Prophase I	
Metaphase I	
Anaphase I	
Telophase I	
Prophase II	
Metaphase II	
Anaphase II	
Telophase II	

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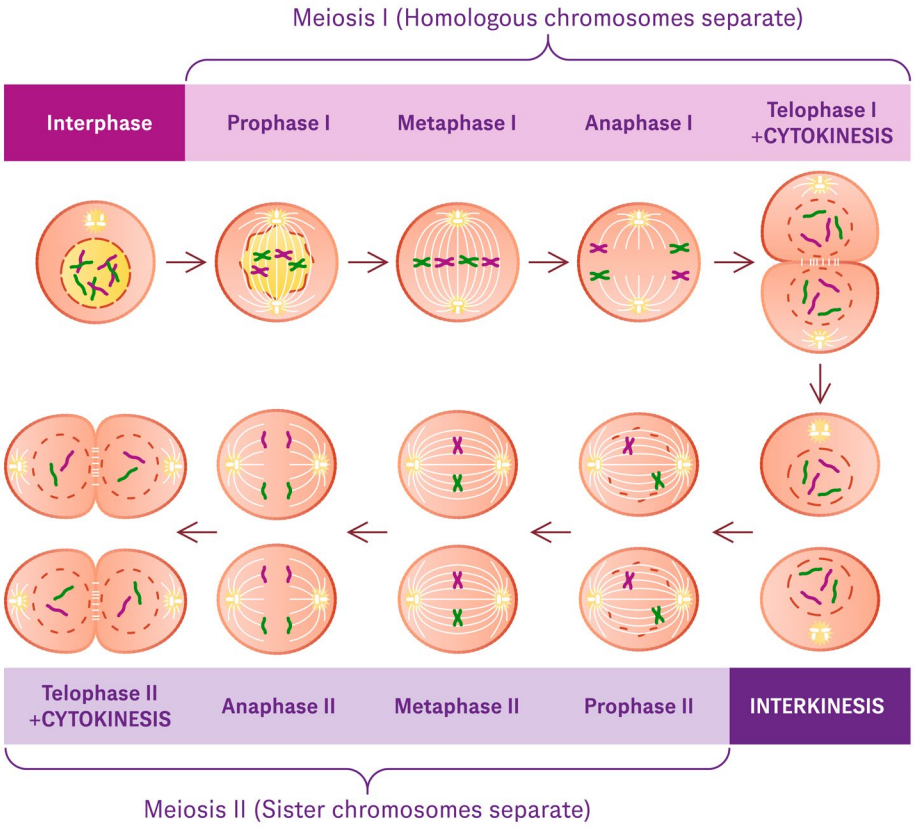
Stages of Meiosis

Continued



1. How many chromosomes does the cell start with at the beginning of meiosis?

2. How many chromosomes are present at the end of Meiosis I?

3. How many chromosomes are present at the end of Meiosis II?

4. How does meiosis result in genetically unique cells?

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Genetics Practice

Directions
Using your knowledge obtained from today's lesson, complete the genetics problems below.

1. For each genotype below, indicate whether it is heterozygous, homozygous dominant, or heterozygous recessive.

   AA _____

   Bb _____

   Cc _____

   dd _____

   EE _____

   Ff _____

   gg _____

   HH _____

2. For each genotype below, determine the phenotype.

   Purple flowers are dominant to white flowers

   PP _____

   Pp _____

   pp _____

   Brown eyes are dominant to blue eyes

   BB _____

   Bb _____

   bb _____

3. For each phenotype below, determine the possible genotype (there might be more than one).

   Straight hair is dominant to curly hair

   Straight Hair _____

   Curly Hair _____

   Pointed heads are dominant to round heads

   Pointed Head _____

   Round _____

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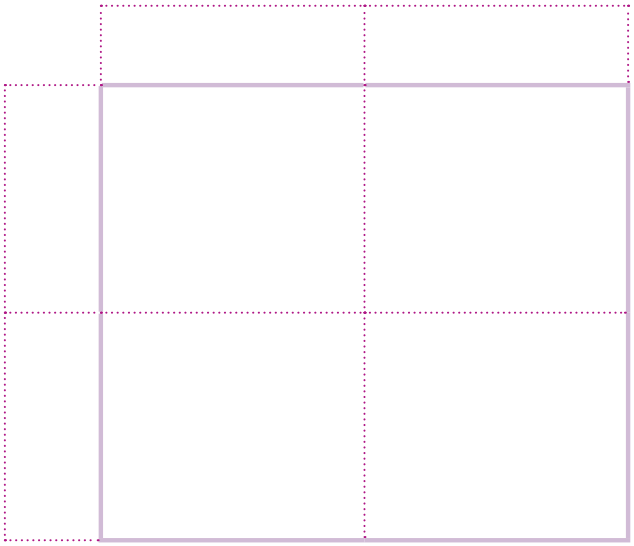
Genetics Practice

Continued

4. Complete the Punnett square diagram for the children of a couple where the father is a carrier for Huntington's disease (Hh) and the mother is a non-carrier (hh). Huntington's disease is dominant.



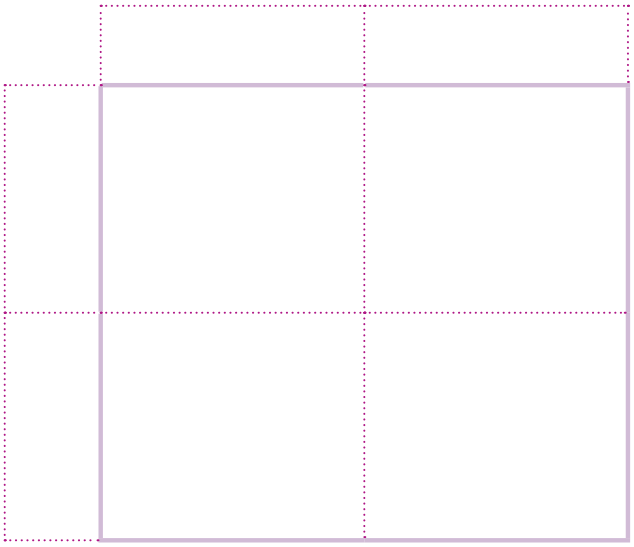
a. What is the probability that an offspring will inherit heterozygous alleles from any single pregnancy?

_____

b. What is the likelihood the parents will have a child with Huntington's disease?

_____

5. Complete the Punnett square diagram for the children of a couple where both parents carry the allele for Cystic Fibrosis (Cc), which is recessive.



a. What is the probability that an offspring will inherit heterozygous alleles from any single pregnancy?

_____

b. What is the likelihood the parents will have a child with Cystic Fibrosis?

_____

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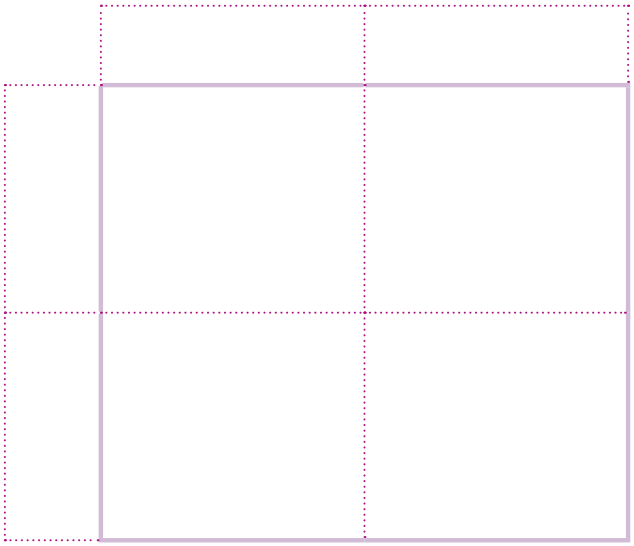
Genetics Practice

Continued

6. Complete the Punnett square diagram for the children of a couple where the father has Hemophilia (X_hY), and the mother is not a carrier (X_HX_H). Hemophilia is a recessive sex-linked disease.



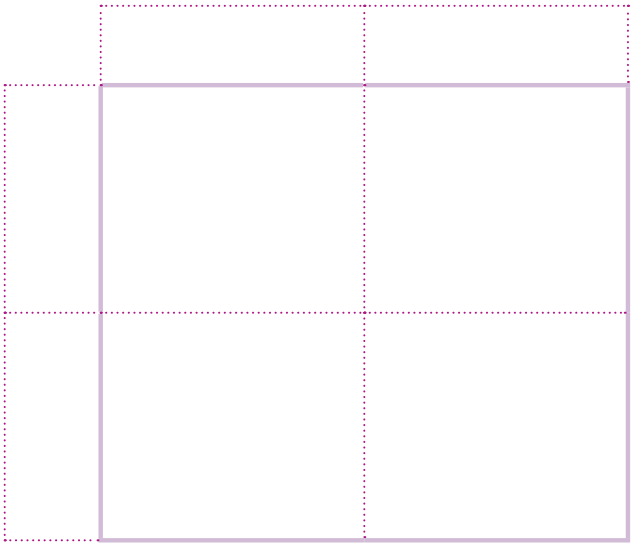
a. What is the chance with each pregnancy that the child will have Hemophilia?

_____

b. What is the likelihood the parents will have a child with hemophilia?

_____

7. Complete the Punnett square diagram for the children of a couple where the father has Sickle Cell Disease (ss), and the mother is a carrier(Ss). Sickle Cell Disease is a recessive disease.



a. What is the chance with each pregnancy that the child will have Sickle Cell Anemia?

_____

b. What is the likelihood the parents will have a child with Sickle Cell Anemia?

_____

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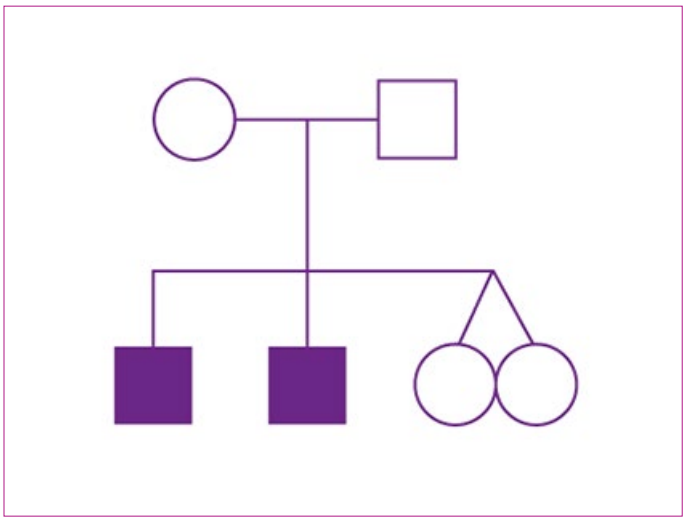
Family Pedigree Analysis, Part 1

Directions
Analyze the pedigree charts to determine the genetic characteristics of the trait.

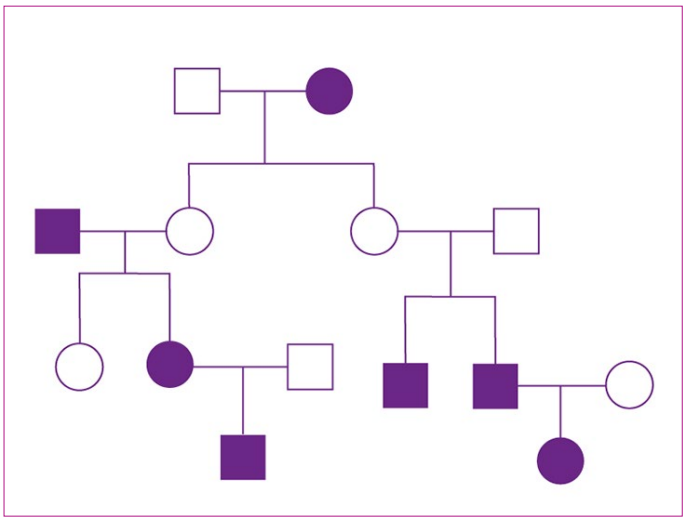
1. Pedigree Chart



a. Is the trait autosomal or sex-linked? Explain why.

b. Is it dominant or recessive? Explain why.

2. Pedigree Chart



a. Is the trait autosomal or sex-linked? Explain why.

b. Is it dominant or recessive? Explain why.

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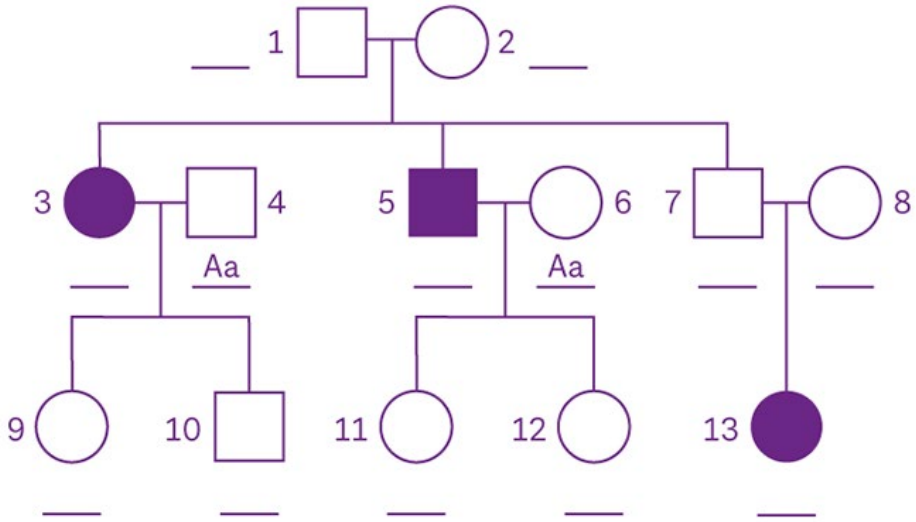
Family Pedigree Analysis, Part 2

Directions
Use the pedigree chart to answer questions about the family.

Family Information
Albinism causes deficiency of pigmentation in skin, hair, and eyes. Below is a pedigree chart showing the albinism gene passing through three generations of a family. Use the pedigree chart to answer the questions below.



1. Is albinism autosomal or sex-linked? How do you know?

2. Is albinism dominant or recessive? How do you know?

3. Write in the genotypes for each individual through all three generations.

4. What is the likelihood that parents 3 and 4 have a child with albinism? Use a Punnett square to show your work.

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Family Pedigree Analysis, Part 3

Directions

Genetic counselors gather information from parents about their family in order to build a pedigree chart to trace specific traits through family generations. Genetic counselors do this to help parents determine the likelihood their children will have an inherited disease. Use the information provided to construct a pedigree chart for the family.

Family Information

Dolly married Townes and had three children, Waylon, Loretta, and Sturgill. Townes, Waylon, and Sturgill find out they have muscular dystrophy. Sturgill married Patsy and had two children, Connie and Tammy. Connie also has muscular dystrophy and married Willie. They had two children, Tanya and Merle. Tanya has muscular dystrophy.

1. Draw a pedigree chart in the box above using the given *Family Information*. Label the tree with the names of the individuals in the description.

2. Is muscular dystrophy autosomal or sex-linked? How do you know?

3. Is it dominant or recessive? How do you know?

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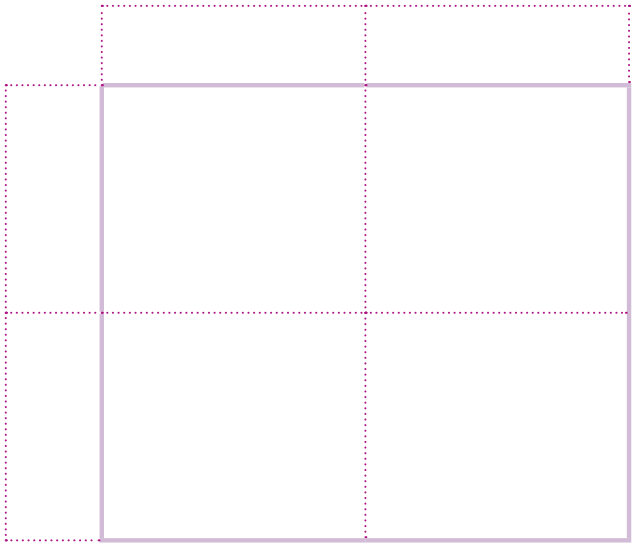
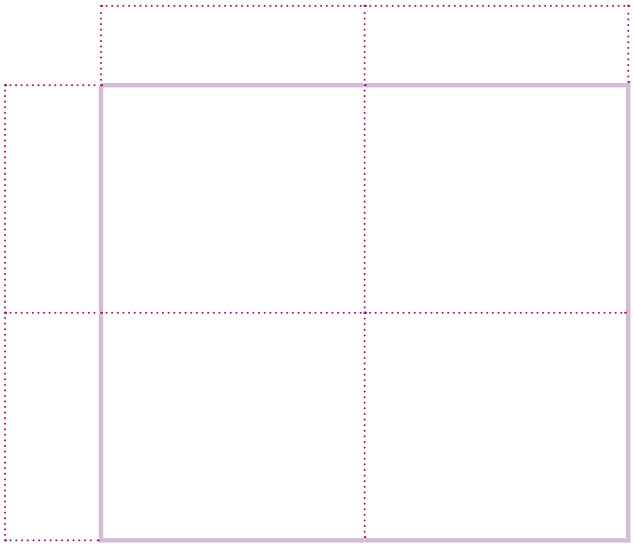
Family Pedigree Analysis, Part 3

Continued

4. What are the chances Connie and Merle have a girl with muscular dystrophy? Show your work using a Punnett square.

5. What are the chances Connie and Merle have a boy with muscular dystrophy? Show your work using a Punnett square.





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Patient Profiles

Patient Profile #1

Makayla is a nurse technician who works in a busy emergency room. She is 35 years old and lives with her sister, mother, and niece in Philadelphia, PA. Makayla's sister was recently diagnosed with breast cancer and her mother had breast cancer when she was Makayla's age. Makayla's aunt and grandmother had breast cancer and ovarian cancer. Both died when Makayla was young. Because of this family history, Makayla wants to see a genetic counselor to understand her risk of developing hereditary breast or ovarian cancer.

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Patient Profiles

Patient Profile #2

Jamila and James both grew up in Atlanta, Georgia and live there today. They were high school sweethearts that recently reconnected and married. Jamila is a pediatrician and James is a lawyer. They both have advanced degrees and live a comfortable upper-middle class lifestyle. Jamila is very active in her sorority and does a lot of community service and philanthropy through the organization. James spends lots of time with his young son Jerome, whom he had in a previous marriage.

Jamila and James have both had direct experience with Sickle Cell Anemia: Jamila's father had the disease and her brother Bobby passed away from complications of Sickle Cell in the previous year. James's son Jerome also has Sickle Cell Disease. James and Jamila want to have a child together, but first want to assess the likelihood that their child would have Sickle Cell Disease.

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Patient Profiles

Patient Profile #3

Mark and Asha live in Toronto, Canada and are the parents of five-year old Skylar. Skylar was diagnosed with Cystic Fibrosis at 6 months old and has been undergoing treatment ever since. Mark is an IT manager at an insurance company and Asha is a stay-at-home mom. They live in an apartment near Mark's company. Mark and Asha are thinking about having another child, but money is tight and they are already struggling to afford the care that Skylar needs. In order to understand the likelihood that their next child will also struggle with Cystic Fibrosis, Mark and Asha meet with a genetic counselor. They share that even though Asha does not have Cystic Fibrosis, her father did. Mark has the disease, which also presented in his father and in his maternal grandfather. Mark has two siblings, and neither has Cystic Fibrosis.

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Patient Profiles

Patient Profile #4

Cleo and Ozzy are musicians who live in Los Angeles. Cleo grew up in northern California and Ozzy moved to WLos Angeles from New Mexico. Cleo and Ozzy just found out that they are having twins: a boy and a girl! Because she has a family history of hemophilia, they want to see a genetic counselor to understand the risks that each baby might inherit the disease. They share that Cleo's maternal grandfather had the disease. No one else in her family has shown symptoms and no one in Ozzy's family has hemophilia.

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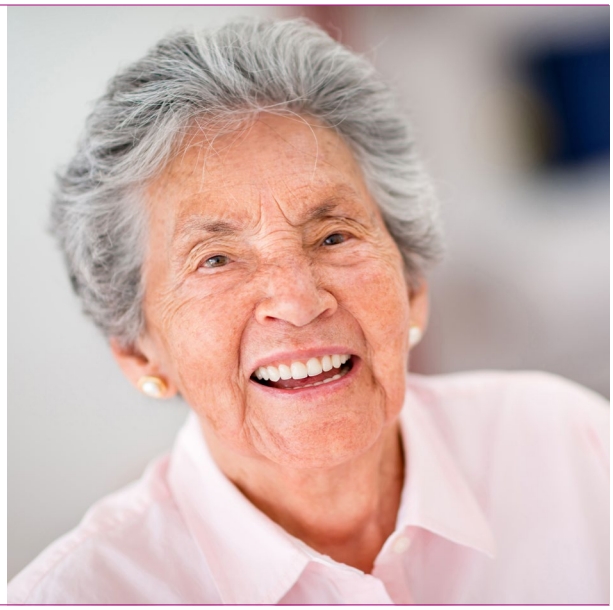
Patient Profiles

Patient Profile #5

Alma was recently in a car accident that put her in the hospital. While she is recovering, the attending physician asks her a few routine questions, such as what day it is and where she was when she got into the accident. Alma has a hard time remembering these details. The attending physician asks Alma's son, who is visiting, if he has noticed his mother becoming more forgetful recently. The son says yes, and tells the physician that his mother has been routinely misplacing things and getting into accidents. The physician recommends that Alma meet with a genetic counselor in order to understand her propensity for developing Alzheimer's Disease.



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My Patient's Pedigree Chart

Directions

Build a pedigree chart based on the information in your patient profile.

Include the following:

- *Correct figures and labels for the pedigree chart*
- *Names of individuals in the family*
- *The genotype for each individual as best that can be determined*

1. What inherited disease is your patient a carrier of or diagnosed with?

2. Is this inherited disease autosomal or sex-linked? How do you know?

3. Is this inherited disease dominant or recessive? How do you know?

4. Why did your patient seek your genetic counseling?

5. Based on your analysis of the family pedigree chart you made, what is your diagnosis to your patient? Explain why using Punnett squares as evidence.

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Genetic Test Report

Patient details

Name

Date of Birth

Sex

Genetic Counselor

Name

Organization

Date Received

Date Reported

Reason for Test	
Your Results	

About the Test

What the Results Mean for You

Next Steps

More Information and Support