
Genetics: Our Past, Present, and Future

A Middle School Unit for Grades 6–8

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INTRODUCTION TO THE UNIT

As a student, I always enjoyed looking at topics in depth and learning about how one field of study connects to another. As I developed this unit, I designed lessons that help students explore how the field of genetics relates to other disciplinary fields. Students are asked to examine not only the core ideas of genetics but also the cross-disciplinary relationships—how one field may influence the findings in another field of study. Without helping students to make these connections, I believe that learning becomes isolated and is more than likely forgotten by the students. While conducting the research for this unit, I learned so much about the field of genetics and all of the implications that genetics has in our everyday lives, from the food we eat, to the sports we watch and participate in, to the connections it has to our family and our sense of well-being. Understanding how genetics plays a role in our past, present, and future helps us to better understand ourselves and those around us.

BACKGROUND TO THE UNIT

This unit focuses on the key concepts of form and function, expression, image, chance, order, and cycles through the window of genetics. It provides students with

opportunities to learn the basic concepts of genetics that lead to understanding about heredity, DNA, and genetic diseases. This unit contains three parallels. In the Core Curriculum parallel, students are introduced to classical genetics concepts, including the structure and function of DNA, Punnett squares and predicting heredity, and dominant and recessive genes. The Curriculum of Connections parallel uses the same concepts to connect genetics with forensics and crime fighting as well as history and the royal families of Europe. In the Curriculum of Practice parallel, students get to extract DNA from peas and also conduct in-depth research to understand the work and practices conducted by genetic scientists.

CONTENT FRAMEWORK

Organizing Concepts

Macroconcepts

- M1 Form and Function
- M2 Expression
- M3 Image
- M4 Chance
- M5 Order
- M6 Cycles
- M7 Controversy
- M8 Change

Principles

- P1 Genetics is the science of genes, heredity, and the variation of organisms.
- P2 Heredity involves probability and predicting the likelihood of a certain genotype to occur.
- P3 Science as a discipline crosses over, affects, and is affected by other disciplinary fields of study, including history, literature, and mathematics.
- P4 Outward expression of a characteristic or trait depends on the individual's genes and specific genotype.
- P5 An individual's genes play a part in an individual's identity but do not control everything.

Skills

- S1 **Answer questions through scientific investigations.** Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students

should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation.

- S2 **Design and conduct a scientific investigation.** Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.
- S3 **Use appropriate tools and techniques to gather, analyze, and interpret data.** The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.
- S4 **Develop descriptions, explanations, predictions, and models using evidence.** Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.
- S5 **Think critically and logically to make the relationships between evidence and explanations.** Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables.

Standards

Life Science Content Standard C (Grades 5–8)

- SD1 Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- SD2 Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- SD3 The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment.

SD4 Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

Life Science Content Standard C (Grades 9–12)

SD5 In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular “letters”) and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

UNIT COMPONENTS AND RATIONALE

| <i>Curriculum Component</i> | <i>Description</i> |
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| Content | The understanding of basic and complex components of genetics leads students to a better understanding of themselves and the world in which they live. They examine past discoveries in this field as well as what is currently being researched. They are also encouraged to predict the future implications of the findings in the field of genetics. |
| Assessments | Preassessments are designed to assess students’ prior knowledge. By preassessing, the teacher can know strengths and weaknesses the individual student possesses. Teachers can use this information to add or to modify curricular tasks based on student need. If the preassessment shows students know and understand the concept a teacher plans to teach, changes can be made to the curriculum to eliminate sections of content students already know. If the preassessment shows students have no knowledge in a given area, a teacher can plan to provide all the necessary scaffolding and support to help students achieve success. A variety of assessments, both informal and formal, are obtained through the use of lab experiments, research investigations, case studies, virtual lab activities, and journal entries. |
| Introductory Activities | Every lesson begins with an introductory activity or questions the students are asked. This is meant to engage the students and provide motivation by sharing what they already know about the content being presented. |
| Teaching Strategies | The following teaching strategies are used throughout the unit: lecture, direct instruction, strategy-based instruction, assisted instruction in the content areas, graphic organizers, coaching, concept attainment, demonstrations/modeling, Socratic questioning, visualization, role-playing, cooperative learning, case study, simulation, and inquiry-based instruction. |

| <i>Curriculum Component</i> | <i>Description</i> |
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| Learning Activities | Several different types of learning activities are used throughout the unit. These are designed to help the students learn deeply about critical concepts and acquire understanding of essential principles. Students complete experiments and demonstrations that require them to draw conclusions about the effects of genetics in their daily lives and the world around them. |
| Products | All products are selected to illustrate students' acquisition of the concepts, principles, and skills learned throughout the unit. |
| Modifications for All Learners | Ascending Intellectual Demand (AID) is designed specifically for students who need more intense cognitive tasks because they have greater prior knowledge than their peers. AID prompts are written throughout the unit for students who require more challenging tasks. |

UNIT SEQUENCE, DESCRIPTION, AND TEACHER REFLECTION

Lesson 1.1: Preassessment and Unit Introduction (Dominant and Recessive Genes)

Time allocation: 1 class session

Concepts

These concepts are overarching and can be associated with many different topics. By focusing on these "Big Ideas" students can gain understanding about more than just the individual topic being studied. Use these ideas to help shape the questions that you pose during class discussions.

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| M1 | Form and Function | M5 | Order |
| M2 | Expression | M6 | Cycles |
| M3 | Image | | |

Form and Function Structures in nature and science have a specific form because of their function. Phenomena have certain forms for a reason. DNA's form for example is a double helix or twisted ladder. Its form allows more information to be coded in a small amount of space.

Expression Expression plays a role in everything we see and do. Dealing with genetics, genes express certain characteristics based on an individual's genotype. Phenotype is what is actually expressed.

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Image How we see and are seen by the world around us greatly affects our image. Genetics shapes our image. Our genetic makeup determines what we are, but it is our responsibility to determine who we are.

Order Without order nothing makes sense. By learning about genetics, students can see on a micro and macro level the organization and order of the world of genetics and the world around them.

Cycles Everything goes through cycles, whether it is the Earth cycling or revolving around the sun approximately every 365 days or the human race creating new generations, or history repeating itself. By learning and studying cycles in relationship with genetics, students can see how genes are passed on from generation to generation.

Principles

P1 Genetics is the science of genes, heredity, and the variation of organisms.

P4 Outward expression of a characteristic or trait depends on the individual’s genes and specific genotype.

P5 An individual’s genes play a part in an individual’s identity but do not control everything about the individual.

Skills

S1 Questions that can be answered through scientific investigations.

S3 Use appropriate tools and techniques to gather, analyze, and interpret data.

Standards

SD1 Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.

SD3 The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited, and others result from interactions with the environment.

Guiding Questions

1. What does genetics have to do with me?
2. Do I have any dominant traits? Recessive traits?
3. What things can I inherit?
4. What do dominant and recessive traits have to do with genetics and heredity?

| <i>Unit Sequence—Core Curriculum</i> | <i>Teacher Reflections</i> |
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| Preassessment | |
| <p>Begin the unit by writing the word “Genetics” on the board. Have students brainstorm words and ideas that they know about genetics and organize them into a concept map or web. Students will connect the concepts to one another by writing what relationship exists between each of the concepts.</p> | <p>Students probably will have heard of genes and other general topics related to the study of genetics but will probably not have an understanding of how the individual topics fit together and relate to each other. These concept maps inform me as to which students have some prior knowledge of the field of genetics and will help me to determine who may benefit from AID experiences that I create.</p> <p>If students have trouble with brainstorming topics related to genetics, try to guide their thinking, but do not provide them with answers. Remember, this preassessment is about assessing what students already know. It is possible that some students have no prior knowledge of genetics, while others will be able to tell you what DNA stands for before you even teach them the concept of DNA.</p> |
| Preparation | |
| <p>After the pretest, provide each student with a copy of the Dominant and Recessive Characteristics and Genetic Traits and Me worksheets (see Appendix 1A) that list common dominant and recessive traits that are easily testable. The second worksheet is for students to record their information.</p> | <p>The student worksheets should be prepared prior to instruction. The worksheet provides all students with the same information, and students who struggle with recording information will be provided with the scaffolding that is necessary for their academic success.</p> |
| Teaching Strategies and Learning Experiences | |
| <p>Introductory Activity</p> <p>Pose the following question to students, “If you were asked to describe yourself to a stranger so she could recognize you at a school event, what would you say? What traits make you unique and different from others?”</p> <p>Next introduce students to the concepts of form and function, image, and expression. Write two words on the board, “Dominant” and “Recessive.” As a class, brainstorm how these concepts associate with the words dominant and recessive. Tell students that today they are going to discover if they express any dominant or recessive traits. Pass out the Dominant and Recessive Characteristics worksheet (see Appendix 1A), which lists traits, and have them identify which trait they express. After they complete the sheet,</p> | <p>Understanding dominant and recessive traits provides the conceptual foundation for understanding heredity and how genes are passed down from one generation to the next. Starting instruction with an understanding of dominant and recessive traits enables the teacher to use these words throughout the remainder of the unit and to be assured that the students understand their meaning. Also, an understanding of dominant and recessive traits leads to predicting heredity and using Punnett squares taught in an upcoming lesson.</p> <p>Genetics studies how living organisms inherit many of the features of their ancestors—for example, children usually look and act like other people in their family. Genetics tries to identify which features are inherited and work</p> |

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| <i>Unit Sequence—Core Curriculum</i> | <i>Teacher Reflections</i> |
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| <p>have students identify which traits they express are dominant and which traits they express are recessive (Appendix 1A).</p> <p>Tell students that all people express traits that they have inherited from their parents. Have the students write down the word “inherit” and give them the definition. Ask them what other things can they inherit? Tell the students that their traits will also be passed down to their children, and the cycle will continue.</p> | <p>out the details of how these features are passed from generation to generation.</p> <p>A trait is a characteristic or property of an organism that may be inherited, environmentally determined, or somewhere in between. Some traits are features of an organism’s physical appearance, such as eye color, height, or weight. There are other types of traits that range from aspects of behavior to resistance to disease. Traits are often inherited; for example, tall and thin people tend to have tall and thin children. Other traits come from the interaction between inherited features and the environment. For example, a child might inherit the tendency to be tall, but if there is very little food where he lives and he is poorly nourished, he will still be short. The way genetics and environment interact to produce traits can be complicated: for example, the chances of somebody dying of cancer or heart disease seem to depend on both family history and lifestyle.</p> |
| Closure | |
| <p>Conclude the lesson by projecting a family picture of yourself on a screen. Ask students which traits they see that are similar between all the people in the picture and which traits are different.</p> <p>Homework</p> <p>Ask students to bring a picture of their family to school tomorrow that can be used for further student exploration in the next lesson. Also ask students to bring information back to class regarding facial features of their parents. The data they will be gathering are the four physical features: earlobe attachment, nose shape, hair type, and the ability to roll one’s tongue. In addition, have them gather information on their parents’ hair and eye color. To record their data, they can use the worksheets that are provided at the following website: <i>The Science Behind Family Portraits</i> and produced by the DNA Diagnostics Center (http://www.dnacenter.com/science-technology/dna-education/family-portraits.html).</p> | <p>I will show a picture of my family. I have a large family and it is always fun to be able to connect with the students by showing them that their teacher is also a regular person with a family just like themselves. My family is unique because of its large size and because I have triplet sisters. Students can look at the picture and see similarities in the faces of all seven of my brothers and sisters, but also see that each one of us is uniquely different. These concepts of image and expression of traits will continue to be brought up and discussed throughout the unit.</p> |

| <i>Unit Sequence—Core Curriculum</i> | <i>Teacher Reflections</i> |
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| <p>Close the lesson by discussing the goals of this unit, provide an overview of the types of learning experiences they will encounter in this unit, and the types of questions they will ask and seek to answer. Some questions to pose to students may include the following:</p> <ul style="list-style-type: none"> • What does genetics have to do with me? • How does genetics affect the world around me? • How do scientists study genetics? | <p>Discussing with students the overview of the unit provides a scaffold for their upcoming work and creates a sense of interest prior to instruction. If they are excited about what they are doing, they will learn more in the process.</p> |

Lesson 1.2: Punnett Squares and Predicting Heredity

Time allocation: 2–3 class sessions

Concepts

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| M1 | Form and Function | M4 | Chance |
| M2 | Expression | M5 | Order |
| M3 | Image | M6 | Cycles |

Principles

- P1 Genetics is the science of genes, heredity, and the variation of organisms.
- P2 Heredity involves probability and predicting the likelihood of a certain genotype to occur.
- P4 Outward expression of a characteristic or trait depends on the individual’s genes and specific genotype.
- P5 An individual’s genes play a part in an individual’s identity but do not control everything about the individual.

Skills

- S1 Questions that can be answered through scientific investigations.
- S2 Design and conduct a scientific investigation.
- S3 Use appropriate tools and techniques to gather, analyze, and interpret data.
- S4 Develop descriptions, explanations, predictions, and models using evidence.
- S5 Think critically and logically to make the relationships between evidence and explanations.

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Standards

- SD1 Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- SD2 Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- SD3 The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited, and others result from interactions with the environment.

Guiding Questions

Students will learn the basics of predicting heredity and how traits are passed on to offspring. They learn how to use and implement the key terms genotype, phenotype, heterozygous, homozygous, parent generation, F1 generation, allele, and Punnett squares to predict probabilities of the F1 generation having a certain trait. They will create and use Punnett squares to predict the traits of offspring. They will realize that a large amount of heredity is left up to chance.

1. What does genetics have to do with me?
2. Why are some traits expressed and others not?
3. How can we predict heredity and why is it important?

| <i>Unit Sequence—Curriculum of Connections</i> | <i>Teacher Reflections</i> |
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| Preparation | |
| <p>In advance, prepare a student worksheet with information about gene expression and include key terms and important information involved in predicting inheritance. Use the Talking Points and Examples (Appendix 1B) to guide your discussion with your students.</p> <p>Key Terms</p> <ul style="list-style-type: none"> • Punnett square • Genotype • Phenotype • Heterozygous • Homozygous • Parent generation • F1 generation • Allele | <p>Introducing the vocabulary in genetics is necessary so that students can discuss the relationship between these various words, their functions, and purposes. The vocabulary can be introduced prior to this lesson or within the context of the lesson.</p> <p>The Visual Organizer for Key Terms (Appendix 1C) that I use is called the Frayer model, which is a type of graphic organizer that helps students develop relationships and categories associated with vocabulary. Students use the graphic to explain and elaborate their understandings of a concept, work, or issue. I vary the version of the chart based on the headings that are best suited for the concept or word. Students use the Internet or other</p> |

| <i>Unit Sequence—Curriculum of Connections</i> | <i>Teacher Reflections</i> |
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| | <p>sources of text to help define the words as they work in small groups or as we discuss these concepts or vocabulary in class. This format can also be recorded on chart paper and then posted on a word wall in your classroom for future use.</p> |
| <p>Teaching Strategies and Learning Experiences</p> | |
| <p>Introduction for Predicting</p> <p>Pose the following question to students: How can we predict what traits we will pass on to our offspring? Using their ideas, students examine the picture they brought from home. On a sheet of paper, have them list traits that they have that are similar to and traits that are different from their parents. Ask them why they look different and why they look similar to their parents and siblings. To enhance this discussion, use the noninteractive activity called The Science Behind Family Portraits produced by the DNA Diagnostics Center and located at this website: (http://www.dnacenter.com/science-technology/dna-education/family-portraits.html). Hand out the worksheets that are available at this site while you project the interactive on a whiteboard for students to engage with as they create their individual portraits. Students will then create their portraits using the information that they gathered and how their facial features compare with their biological parents'. Provide students with large portraiture paper to enlarge their images.</p> <p>The Role of Chance</p> <p>Lead the students in a discussion about heredity and the role of chance and its function in the process of heredity. Start off by having students, in pairs, flip a coin 10 times. Ask them to record their results and report them back to the class. The result should be about equal numbers of heads and tails. Tell the students that you could then make a prediction about how often you would toss a coin and get heads and how often you would get tails. This is the probability of that event happening. There is a 50% chance of the coin landing on heads and a 50% chance that the</p> | <p>By having students look at their own family, it brings a personal touch to the topic and gives them something they can relate to while teaching them about inheritance.</p> <p>Probabilities are powerful tools for making predictions over a large number of events. The more events you observe, the closer to predicted results the actual results will be. For example, if you flip a coin 10 times, probability predicts that the coin will land heads-up five times and tails-up five times. However, when you actually do this experiment, your results could be quite different. If you tossed the coin 100 times, you are more likely to obtain results closer to the predicted 50% of each, and tossing the coin 1,000 times will probably give you results even closer to those predicted by probability.</p> |

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| Unit Sequence—Curriculum of Connections | Teacher Reflections |
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| <p>coin would land on tails. Heredity is similar to flipping a coin in that chance plays a role. Explain to the students, “As scientists, we can predict the probability of an individual of having a certain trait based on the traits of its parents. We make Punnett squares to show us all the possible outcomes an F1 generation (first filial generation, the parents’ offspring) can have based on the traits of the parent generation.”</p> <p>Introduction to Punnett Squares</p> <p>Use the Talking Points and Examples (Appendix 1B) to guide your discussion with your students about the use of Punnett squares to determine the likelihood that some event will occur. This information can be presented by placing the document on a whiteboard, or you can group students based on their readiness levels to work more independently on their own or with your guidance as they read the information and work through the examples of Punnett squares.</p> <p>Reinforcing Punnett Squares Web Lab Activity</p> <p>Students will further their understanding and skills by engaging in the virtual Web Lab that introduces the concept of Punnett squares. At the Genetics Web Lab Directory there is a web lab called Punnett squares (http://www2.edc.org/weblabs/WebLabDirectory1.html).</p> <p>These web labs are published by Education Development Center and can be used to develop an understanding of Punnett squares as well as other topics.</p> <p>Ask students to work in groups of four based on similar readiness levels and have them complete the activities together. For some groups, you may need to provide more structured support to guide their continued understanding of Punnett squares. Throughout the web lab, students are asked to read and answer questions so they will not record anything during the web lab activity to turn in to the teacher, but some students may require the type of cognitive coaching to support their learning of Punnett squares. This web lab provides the students with good</p> | <p>Punnett squares are named for geneticist Reginald Punnett, who developed the square as a tool to help scientists predict the genotypes of offspring. The square is based on probabilities; that is, the likelihood that some event will occur. Punnett squares show all the possible outcomes that the parent generation can produce.</p> <p>This web activity helps students to understand that . . .</p> <ul style="list-style-type: none"> • Heredity is the passing of traits to offspring through genes. • Genes can be dominant or recessive. • If a dominant gene is present, that trait will be expressed. <p>Ascending Intellectual Demand (AID)</p> <p>This activity can be adjusted for advanced learners by asking students to locate additional resources or advanced reading on the web to deepen their understanding on genetics. Within this lab, students have several options to consider as they advance their level of understanding of genetics and the use of Punnett squares. Another alternative is to have students explore and then explain situations where Punnett squares do not apply.</p> |

| <i>Unit Sequence—Curriculum of Connections</i> | <i>Teacher Reflections</i> |
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| <p>foundational information about predicting heredity and the process of setting up and completing Punnett squares. Follow up the experience by asking students the following questions:</p> <ul style="list-style-type: none"> • What did you come to understand about the use of Punnett squares that you did not understand before? • What considerations did you make when trying to create offspring that had long tails and who were albino? • How do recessive and dominant traits influence the chances of predicting the traits of offspring? <p>Creating a Species</p> <p>Students are now asked to create a new species and to identify dominant and recessive traits that the species will have. Have each student create her own creature using the traits she came up with. Pair up the students and have them first create a Punnett square for each trait that will be passed down to the next generation.</p> <p>Then have the students flip a coin (heads is dominant and tails is recessive) to determine which traits their “offspring” will inherit. After they have determined which traits their offspring will inherit, have them make the new creature together. Before they create this new creature, check to make sure that their Punnett square charts are completed correctly.</p> <p>Depending on the amount of time permitted, have students produce several children, or generations. They can name each new offspring and create a family. Possibly have them produce the number of children they have in their family.</p> <p>Assessment</p> <p>The Punnett squares students create for their creatures and offspring should be evaluated to check student skill level and understanding of how squares assist in determining the likelihood of the possible outcomes.</p> | <p>Students can take this activity in many directions. Their new species can be made of food and snack items or of different shapes of paper and other craft related items. It is up to them which direction they go to making the species. It is often fun to use different snack and candy items to make creatures because the students get to eat their creatures when they have finished. Paper and other craft items are also good because they do not attract bugs and the teacher would not have to worry about students being allergic to different foods.</p> <p>By allowing students to create the list of traits and the dominant and recessive traits for the “creature,” they become excited because they have a personal interest in their creation. Making the new creature makes the abstract ideas more concrete and reinforces the ideas of inheritance and heredity.</p> <p>Pairing up the students for the F1 generation, the first generation after the parent generation, helps to ensure all students understand heredity. If a student doesn’t understand, he or she now has a built-in support system to help determine the next generation.</p> <p>By using a coin, students can see the role of chance in heredity. They have a visual example with the flipping of the coin to see that not all the alleles or form of genes present are transferred to their offspring and therefore their “children” were not the same even though they came from the same parents. Each parent contributed one allele for each trait.</p> |

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| <i>Unit Sequence—Curriculum of Connections</i> | <i>Teacher Reflections</i> |
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| | <p>Each time the dice are rolled to choose an allele for the new creature, a separate cross is performed. The students will be able to see how some traits are passed to several of the offspring but others aren't. They should begin to realize why they express some features that look like their biological father and some that look like their biological mother. What also needs to be mentioned to students is that while there were only two choices for their "creature," traits often are carried on many different genes and are not controlled by just one gene.</p> |
| Closure | |
| <p>How is your "creature" family similar in form to your actual family in the picture? How is it different? Lead a discussion about the similarities and differences between the creature and actual people.</p> <p>To close the lesson, students will be asked to complete an exit card before they leave the class to check for understanding:</p> <ul style="list-style-type: none"> • <i>What is the chance that two parents with homozygous recessive traits will pass on a dominant trait to their offspring?</i> <i>Answer: 0%</i> • <i>Explain why your creature did not look just like its parents.</i> • <i>Do you have any questions about genetics that you would like discussed or clarified? What questions do you have?</i> | |

Lesson 1.3: DNA

Time allocation: 1–2 class sessions

Concepts

This lesson will introduce students to the power of DNA and its role in our lives and in our cells.

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| M1 | Form and Function | M4 | Chance |
| M2 | Expression | M5 | Order |
| M3 | Image | M6 | Cycles |

Principles

- P1 Genetics is the science of genes, heredity, and the variation of organisms.
- P4 Outward expression of a characteristic or trait depends on the individual’s genes and specific genotype.
- P5 An individual’s genes play a part in an individual’s identity but do not control everything.

Skills

- S1 Questions that can be answered through scientific investigations.
- S2 Design and conduct a scientific investigation.
- S3 Use appropriate tools and techniques to gather, analyze, and interpret data.
- S4 Develop descriptions, explanations, predictions, and models using evidence.
- S5 Think critically and logically to make the relationships between evidence and explanations.

Standards

- SD2 Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- SD5 In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular “letters”) and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

Guiding Questions

1. What is the structure and function of DNA?
2. How does DNA code the information needed to create life?

| <i>Unit Sequence—Core Curriculum</i> | <i>Teacher Reflections</i> |
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| Preparation | |
| Prepare several “Secret Messages” that the students will have to code for using the four nitrogen pairs. Also, make sure to copy the “code” for each student so that they can code and decode their secret messages. See Appendix 1D for the DNA Alphabet . | |

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| Unit Sequence—Core Curriculum | Teacher Reflections |
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| Teaching Strategies and Learning Experiences | |
| <p>Key Terms</p> <ul style="list-style-type: none"> • DNA • Nucleotide • Amino acids • Proteins • Nitrogen bases • Adenine • Thymine • Cytosine • Guanine • Double Helix <p>As a class, define the key terms and introduce students to the structure of DNA. Show the class the structure of DNA (the double helix) and begin by having the students draw a spiral staircase in their journal. (You can get several different pictures of DNA and its structure from www.genome.gov.) After they have drawn the staircase, ask them what advantages there are to using a visual representation of a spiral staircase. Explain to the students that a spiral staircase can contain the same amount of stairs in a smaller space. Continue adding details of the structure of DNA, including the nitrogen bases, adenine, thymine, cytosine, and guanine. Have students draw these illustrations in journals and label the parts.</p> <p>Creating a DNA Molecule</p> <p>Have students create a model of the DNA molecule and to code for an “amino acid” that will perform a certain task. Students will use the DNA Alphabet (Appendix 1D) to send a secret message to a friend. Each student will select a task to code and give it to another student in the class to decode. They will code it using the DNA nitrogen bases and send it to their fellow students in the room. The other students will have to decode the message and then do what the message told them to do. An alternative to this activity would be to have the students code their name and then use their DNA names as a way to pair up students for future activities. Other students could also create the other side of their partners DNA name to make it a double helix.</p> | <p>You can use this link to take you to the glossary of genetics terms provided by National Human Genome Research institute: (http://www.genome.gov/glossary.cfm).</p> <p>This site has all the genetic terms you will need defined as well as more detailed explanations for a deeper understanding of the topic.</p> <p>Students will need an understanding of DNA and how it uses those nitrogen bases to code for amino acids and protein production. Students will use this information to make sense of the activities in this lesson.</p> <p>For more information about DNA basics, go to either of the following links.</p> <p>DNA Basics</p> <p>http://ghr.nlm.nih.gov/handbook/basics/dna</p> <p>National Human Genome Research Institute</p> <p>http://www.genome.gov/25520880#1</p> <p>To further explain how DNA coils around itself to make chromosomes, have two students take a rope and wind it in opposite directions. Soon, the rope will begin to coil in on itself and shrink in length, much like the DNA molecule does.</p> <p>This activity can be completed in several different ways. I use die-cut DNA fragments from http://www.accucut.com ; Item #: D1018.</p> <p>I use a different color of paper for each of the nitrogen base pairs, sugar, and phosphate groups and then place them in envelopes and label each. When the students go to make their name or message in DNA, they use the appropriate nitrogen base and sugar and phosphate group. Students start by making only one side of the double helix. Some of my student’s DNA names were several feet long!</p> <p>You can also use multicolored paper clips for the nitrogen base pairs. Students can make these chains of DNA using the multicolored paper clips and attaching</p> |

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| | <p>them together. This is faster, but doesn't necessarily give the students as good of a picture of what a real DNA molecule looks like.</p> <p>This activity helps students understand the complexity of the DNA molecule as well as the basics of how DNA codes for the many different traits living things have.</p> <p>Secret messages can be simple things like "Hello" or "Smile;" longer messages such as "put your finger on your nose" or "blink your eyes" would also work but would be more time consuming for students to decipher. All messages need to be rather short because coding these messages using the DNA code is a very long process.</p> |
| Closure | |
| <p>Ask the students why they think that a double helix is a good structure for the DNA molecule.</p> <p>Exit Card</p> <p>Have students complete an exit card prior to the end of class using the 3:2:1 assessment format.</p> <ol style="list-style-type: none"> 3. Name three things you learned today about DNA. 2. Name two things you found interesting about DNA. 1. List one thing you would like to learn more about DNA. | <p>After completing the activity, students should realize that it takes a lot of DNA to code for small amounts of information. The double helix allows all the information coded in DNA to be stored in a small space in the nucleus of the cell.</p> <p>The exit card will help you assess the level of understanding your students have acquired in this lesson. Use this information to clear up any misconceptions.</p> |

Lesson 1.4: DNA Extraction Lab

Time allocation: 2–3 class sessions

Concepts

Students may have the misconception that DNA is only something that is found in humans. By doing this lab, students will discover that all living things contain DNA.

- M1 Form and Function
- M2 Expression
- M3 Image

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Principles

- P1 Genetics is the science of genes, heredity, and the variation of organisms.
- P3 Science as a discipline crosses over, affects, and is affected by other disciplinary fields of study, including history, literature, and mathematics.
- P5 An individual's genes play a part in an individual's identity but do not control everything.

Skills

- S1 Questions that can be answered through scientific investigations.
- S2 Design and conduct a scientific investigation.
- S3 Use appropriate tools and techniques to gather, analyze, and interpret data.
- S4 Develop descriptions, explanations, predictions, and models using evidence.
- S5 Think critically and logically to make the relationships between evidence and explanations.

Standards

- SD2 Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- SD3 The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited, and others result from interactions with the environment.
- SD5 In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

Guiding Questions

1. Where is DNA found?
2. How do we extract DNA?

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| Teaching Strategies and Learning Experiences | |
| <p>Introductory Activity</p> <p>Have students write in their lab journal where they think they could find DNA. Have them list as many things as they can think of. After they share their lists, prepare students for the lab by explaining to them that today they will be extracting DNA from split peas.</p> <p>DNA Lab Extraction</p> <p>The lab that will be used to guide student experimentation comes from http://learn.genetics.utah.edu and is called <i>How to Extract DNA from Anything Living</i>. This online resource is produced by the Genetic Science Learning Center, University of Utah.</p> <p>In pairs have students read through the directions together to understand the procedures to follow to complete this lab. Students are also asked to use the DNA Extraction Lab worksheet (Appendix 1E) to record their observations as they work through the steps to the lab.</p> <p>To prepare students for preparation of the lab, have students look at the ingredients that they find at their lab station. Ask the following questions to begin the process of thinking about the experiment they will be conducting.</p> <p>One way to purify a molecule is to eliminate everything but that molecule. If we want to isolate DNA from peas, what parts of the cell would we need to get rid of? Some responses might include (<i>All parts of the cell besides the DNA, i.e., cell wall, cell membrane, mitochondria, Golgi apparatus, endoplasmic reticulum, vacuoles, lysosomes, and nuclear membrane</i>).</p> <p>Looking at the materials in your lab toolkit, what would you use to isolate DNA from peas? Some responses might include: <i>Something to mush the cells (blender or your hands), something to destroy membranes (soap dissolves them), something to get rid of proteins and carbohydrates (salt causes them to precipitate), something to separate insoluble cell material from soluble DNA, and something to help get the DNA (alcohol precipitates it).</i></p> | <p>There are many labs that can be conducted by students to extract DNA. Fruits and vegetables can be used to conduct the experiment. Students should be encouraged to try different detergents to see how these change the experimentation.</p> <p>Background Information: All living things store their DNA inside their cells. Cells also contain other chemicals, such as proteins, carbohydrates, and lipids, surrounded by a cell membrane. In this lab students first break the cells open. The blender breaks the peas into single cells. The detergent helps dissolve some of the chemicals in the cell membranes, letting the DNA and other chemicals out. Once the DNA is removed from the cells, students separate the DNA from the other chemicals by placing it in alcohol.</p> <p>It is important to prepare students prior to the lab experiment to ensure that as they work through the steps they are observant and record even the slightest of actions. This brainstorming prepares students for the inquiry that will take place during the experimentation.</p> |

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| <p>What can we do with the DNA once purified? Some responses might include: <i>Use it in DNA fingerprinting (solve a crime, see a genetic defect), put it into another organism to give it specific traits (this is called transformation or genetic engineering), other?</i></p> <p>After students complete the lab, have them return to these questions and write responses based on their findings to clarify their thinking.</p> <p>DNA Virtual Lab Extraction</p> <p>Students should now be prepared to complete this virtual lab to perform a cheek swab and extract DNA from human cells. This lab is located at http://learn.genetics.utah.edu/content/labs/extraction/ and produced by Learn.Genetics, Genetic Science Learning Center at The University of Utah. Ask students how this lab was similar to and different from the lab where they extracted DNA from peas.</p> | <p>AID</p> <p>Students who are ready for more advanced work can select through the other virtual labs at this site to understand how advanced technologies are being used to investigate diseases and healthy cells versus unhealthy cells. Students will be asked to describe how these technologies work.</p> |
| Closure | |
| <p>Close these lab activities by asking students the following questions:</p> <ul style="list-style-type: none"> • What did the DNA look like? (Pea Experiment) • What did you think of the DNA that you saw? (Pea Experiment) • Did you see what you expected? Why or why not? (Pea Experiment) • How was the DNA similar to and different from the way you thought it would be? (Pea Experiment) • Why might it be useful to extract DNA from cells? (Virtual Lab) • What social and ethical issues might scientists confront as they begin to work with DNA testing? (Virtual Lab) | |

Lesson 1.5: DNA Fingerprinting and Crime Lab Investigations

Time allocation: 2–3 class sessions

Concepts

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|----|-------------------|----|--------|
| M1 | Form and Function | M4 | Chance |
| M2 | Expression | M5 | Order |
| M3 | Image | M6 | Cycles |

During this lesson, students will get to meet and hear from a police officer or crime lab worker as they discuss how what they do is related to genetics. Students seeing and hearing from people in the community is important so that they know that science is used in the real world, not just in school. If it is possible to have them come in and speak to your classes that would be best. If this is not possible, there are several popular television shows and movies that show DNA being used to help solve crimes. This would also allow students to see how science is used in the real world.

Principles

- P1 Genetics is the science of genes, heredity, and the variation of organisms.
- P3 Science as a discipline crosses over, affects, and is affected by other disciplinary fields of study including history, literature, and mathematics.
- P4 Outward expression of a characteristic or trait depends on the individual's genes and specific genotype.
- P5 An individual's genes play a part in an individual's identity but do not control everything.

Skills

- S1 Questions that can be answered through scientific investigations.
- S2 Design and conduct a scientific investigation.
- S3 Use appropriate tools and techniques to gather, analyze, and interpret data.
- S4 Develop descriptions, explanations, predictions, and models using evidence.
- S5 Think critically and logically to make the relationships between evidence and explanations.

Standards

- SD2 Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- SD3 The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited, and others result from interactions with the environment.
- SD5 In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

Guiding Questions

1. What is DNA fingerprinting?
2. How does our DNA help police officers solve crimes?

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| Teaching Strategies and Learning Experiences | |
| <p>Introductory Activity</p> <p>Introduce the class to the guest speaker. He or she will introduce the topic of crime scene investigations and the role of DNA in solving crimes. Prior to this presentation, have students generate a series of questions that they wish to ask the speaker.</p> <p>After the speaker has finished presenting, have students recall key facts about DNA they have learned. Place the students in cooperative learning groups (based on readiness levels) and then take them to the computer lab where they will solve crimes and extract DNA from a virtual crime scene using the virtual lab, <i>DNA Fingerprinting</i>, found at the following website created by the Education Development Center. This virtual lab is for students who have an understanding of DNA extraction and need a challenge (http://www2.edc.org/weblabs/WebLabDirectory1.html)</p> <p>For students who require more guided support and virtual prompting, have these students use the web lab, <i>CSI: The Experience-Web Adventures</i> produced at Rice University (http://forensics.rice.edu/).</p> <p>After students complete the web labs, have them respond in groups to the following questions and then debrief their responses.</p> <ul style="list-style-type: none"> • How is DNA used to fight crime? • What techniques and tools are used to process DNA? <p>What reasoning skills do forensic scientists, detectives, or anyone involved in this type of work have to be able to use to conduct this work well?</p> | <p>During this lesson, students will get to meet and hear from a police officer or crime lab worker and they will discuss how what they do is related to genetics.</p> <p>Students seeing and hearing from people in the community is important so that they know that science is used in the real world, not just in school. If it is possible to have them come in and speak to your classes, that would be best. If that is not possible, there are several different television shows and movies that show DNA being used to help solve crimes.</p> <p>Detectives also have good information about crime scenes and genetics.</p> <p>These web labs are interesting for students to complete and provide them with the know-how and skill of extracting DNA and learning about the tools and techniques used to solve crimes. The first web lab uses advanced vocabulary words and introduces students to the technology involved in DNA extraction and fingerprinting at a more complex and abstract level. The second web lab is more user-friendly for students who may struggle with the vocabulary of genetics.</p> |
| Closure | |
| <p>Pass out individual index cards to the groups that worked together on the lab activity to respond to the following questions as homework.</p> <p>Summarize how DNA fingerprinting is used to help solve crimes.</p> <ul style="list-style-type: none"> • How have DNA extraction, technology, and coding helped to assist society in the area of crime investigation? Think of positive and negative examples. • Challenge: Explain the process of DNA fingerprinting. | <p>Use these two questions to check for student understanding. The first question should be less complex to answer, and the third question will be a challenge for most of the students. Students may need to return to the web lab to answer the question.</p> |

Lesson 1.6: Genetics and European History

Time allocation: 2–3 class sessions

Concepts

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| M1 | Form and Function | M3 | Image |
| M2 | Expression | M4 | Chance |

This lesson looks at the concepts of form and function, image, chance, and expression through the scope of the royal family. Instead of focusing on the form and function of DNA, they examine how form and function can be destroyed due to image, chance, and expression.

Students will examine the pedigree and make predictions about how hemophilia affected the royal families of Europe. The presence of hemophilia in the royal family of England spread throughout Europe as royals intermarried. This caused problems for the royal families in Europe and eventually lead to the Russian Revolution and Rasputin's rise in power.

Principles

- P1 Genetics is the science of genes, heredity, and the variation of organisms.
- P4 Outward expression of a characteristic or trait depends on the individual's genes and specific genotype.
- P5 An individual's genes play a part in an individual's identity but do not control everything.

Skills

- S1 Questions that can be answered through scientific investigations.
- S2 Design and conduct a scientific investigation.
- S3 Use appropriate tools and techniques to gather, analyze, and interpret data.
- S4 Develop descriptions, explanations, predictions, and models using evidence.
- S5 Think critically and logically to make the relationships between evidence and explanations.

Standards

- SD1 Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- SD2 Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.

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SD3 The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited, and others result from interactions with the environment.

SD4 Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

Guiding Questions

1. What are some genetic diseases?
2. How are genetic diseases passed on to offspring?
3. How can the study of genetic diseases help scientists find cures for genetic diseases?
4. What do genetic diseases and royal families have in common?
5. How have genetic diseases impacted societies today?

Key Terms

- Hemophilia
- Genetic diseases
- Pedigrees
- Sex-linked traits

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| Teaching Strategies and Learning Experiences | |
| <p>Introduction to Pedigree Charts</p> <p>A pedigree chart is a way to record all the known phenotypes for an organism and its ancestors. There are also used to track disease transmission. Pedigrees are also family trees that explain genetic history and can be used to find out the probability of a child having a disorder in a particular family. To provide an overview of the symbols that are used to read these charts, a PowerPoint presentation is recommended to guide students through how to read and interpret these charts.</p> <p>Pedigree Chart Reading Lab Experience</p> <p>Using the Pedigree Studies Lab Experience (Appendix 1F) set up file folders that contain the two lab experiences for students to complete. Students will randomly be placed in pairs based on your arrangements (readiness for the experience, style, or interest).</p> | <p>I simply went to the Internet and typed in the phrase “Pedigree Chart PowerPoints” or “how to read a Pedigree Chart” and many sources were available for me to use.</p> |

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| <p>Students will be asked to read through the background information on these two labs prior to start of these activities. As students work on these activities, rotate around the room, providing assistance and support. Ask questions that support your assurance that students understand how to read the chart, how to create a pedigree chart, and how to read and determine the genotypes of the families.</p> <p>Royal Families Activity</p> <p>Begin the lesson by reviewing what they know about pedigree charts showing the students a pedigree of the royal families of Europe. Teach them how to read the pedigree chart and discuss how sex-linked traits such as hemophilia are passed on to offspring. Use the information in Appendix 1G to discuss these traits.</p> <p>Introduce students to the case study from the National Center for Case Study Teaching. The case study is called <i>Hemophilia: “The Royal Disease”</i> written by Yelena Aronova-Tiuntseva and Clyde Freeman Herreid, from the University at Buffalo, State University of New York (http://www.sciencecases.org/hemo/hemo.asp).</p> <p>This case study uses the spread of hemophilia through successive generations of Europe’s royal families through Queen Victoria’s descendants to illustrate classical principles of genetics. Within this case study there are questions that guide student learning.</p> <p>Arrange students in groups of three so that each group has someone who can read the site, someone who can write down the responses to the questions that are posed, and someone who has the type of leadership skills to keep students managed during this process. Have the students read the case study about hemophilia (see Appendix 1G) and its impact on the royal families of Europe. After they complete the questions, work as a whole class to discuss the findings. The answers are available online, and a teacher can request access to the answers.</p> | <p>Students will need to understand what a pedigree is as well as understand basic information about sex-linked traits. The sex-link trait we will focus on is hemophilia, but make sure the students realize that there are several sex-linked traits.</p> <p>The case study that I recommend comes from National Center for Case Study Teaching in Science, whose purpose is to promote the development and dissemination of innovative materials and sound educational practices for case teaching in the sciences. The Center’s website provides access to an award-winning library of case materials. Its work has been supported over the years by the National Science Foundation, The Pew Charitable Trusts, and the U.S. Department of Education (see Appendix 1G for hemophilia readings and the case study outline).</p> <p>Guidelines for Using the Case Study Method</p> <ol style="list-style-type: none"> 1. Before you have students read through the case, prompt students to consider the impacts of genetic diseases on a society. Do they ever help to shape the way a society views people? Does the disease ever help to shape historical events? 2. Open the case by posing an interesting question to consider. Why would royal family be concerned about genetic diseases? <p>Have students establish group rules to ensure cohesion in the group. Each group can come up with a list of rules and agree to sign it like a contract.</p> |

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| Closure | |
| <p>Provide students with these two journal prompts based on their work on this case study.</p> <ol style="list-style-type: none"> 1. Why would hemophilia be such a devastating disease to the royal families of Europe? Think about form, function, image, chance, and expression as you form your response. 2. How did genetics (in particular hemophilia) affect history, politics, and geography? Provide evidence to support your response to this question. | |

Lesson 1.7: Genetics in Practice

Time allocation: 1 class session for the introduction; 2–5 class sessions for research, evidence gathering, constructing an argument, and presentations

Concepts

- M7 Controversy
- M8 Change

Principles

- P1 Genetics is the science of genes, heredity, and the variation of organisms.
- P3 Science as a discipline crosses over, affects, and is affected by other disciplinary fields of study, including history, literature, and mathematics.
- P5 An individual's genes play a part in an individual's identity but do not control everything about who they are.

Skills

- S1 Questions that can be answered through scientific investigations.
- S3 Use appropriate tools and techniques to gather, analyze, and interpret data.
- S4 Develop descriptions, explanations, predictions, and models using evidence.
- S5 Think critically and logically to make the relationships between evidence and explanations.

Standards

- SD1 Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- SD2 Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- SD3 The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited, and others result from interactions with the environment.
- SD4 Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

Guiding Questions

1. How does the process of inquiry lead to discovery and change?
2. Does discovery and exploration always lead to positive outcomes?
3. What role does the government play in protecting society against the negative outcomes of exploration, experimentation, and discovery?

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| Teaching Strategies and Learning Experiences | |
| <p>Warm-Up Activity</p> <p>Use the guiding questions to begin to ask students to reflect on how scientific inquiry relates to the words discovery, exploration, and change. Ask students what they think drives the work of practitioners in the field of genetics? Have them write down their responses into their journals. The teacher should use these responses to guide a group discussion about the process of scientific inquiry—its pros and cons.</p> <p>Calling All Researchers Scenario Task</p> <p>Give students a short list of some of the areas of research that genetic practitioners investigate. The field of genetics is broad in its approach to discover the secrets of life, so</p> | <p>Science is the process of inquiry into the unknown. Genetic practitioners and scholars work in a large field of study performing a wide variety of tasks. Some research focuses on curing diseases, others on ending world hunger, and others on discovering our history. The process begins with observation, which is followed by experimentation until findings help them to draw conclusions. Out of this inquiry approach comes controversy and change. It is not uncommon for scientists to run into ethical, social, and legal conflicts that result from their work. Some of these conflicts will include: How will they use the information they obtain? Will the research lead to new materials, inventions, or new products that will affect society? Will those products be harmful or helpful?</p> |

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| <p>this list could include others. Briefly explain each area of research and have students choose one area in which they express an interest in investigating. Some areas of research may include the following:</p> <ul style="list-style-type: none"> • Stem Cell Research • Genetically Enhanced Foods • In-vitro Fertilization • Forensics and Paternal Testing • Uncovering the Past with DNA Research • Preimplantation Genetic Diagnosis • Genetic Diseases • Intelligence • Athletics <p>Have students write down their first and second choice for research on an exit card at the close of this introductory discussion and then match these cards so there are four students assigned to a research team. Each team needs to have someone who considers the perspective of the scientist, general public (including a parent or farmer, or child of diabetes, ethicist), political leader, and governmental official. Introduce the scenario by distributing the handout from Appendix 1H.</p> <p>After students select an area of genetics to investigate, generate a list of questions to guide their research. Ask them to add to this list other questions of interest.</p> <ol style="list-style-type: none"> 1. Why/ How does your field of genetic research enhance or help society today? 2. Why would anyone want to research in this particular field? 3. What specifically do researchers in your particular field of genetics look at and work with? (What specific genes or chromosomes do they deal with? What do they do with them?) 4. Are there any ethical, moral, or legal concerns that practitioners in your field of genetic research have to deal with? How have these concerns been handled? 5. Who would directly and indirectly benefit from the research these practitioners are doing in your particular field? | <p>Will there be a need to control the use of these products?</p> <p>In this lesson students will look more closely at one area of research in which practitioners in genetic research may focus. They will find how interest in this research contributes to the betterment of society as well as any ethical issues that the practitioners in the field may encounter. After they have completed their research, each group will prepare a 30-minute presentation that shares their perspective on the future funding of the research agenda they have chosen to explore.</p> <p>AID</p> <p>Have students work on problems currently posing difficulties for experts in the discipline.</p> <p>These roles include individuals who have vested interests in the research that is conducted by scientists. The scientist plays one role, while the general public typically is interested in how the research helps them medically and socially. Ethicists have a perspective of what they believe is ethically, morally, and socially right and wrong with this type of research or what concerns a special interest group may hold. Political leaders try to understand how to address the social, moral, and ethical issues of the research, and governmental officials may be concerned with laws that would govern the regulation of certain research recommendations.</p> <p>These questions are designed to get the students to consider the ethical or moral and political concerns that face researchers as they conduct their research.</p> |

| <i>Unit Sequence—Curriculum of Practice</i> | <i>Teacher Reflections</i> |
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| <p>Allow students time to investigate and research their individual topics. Encourage students to contact medical personnel in your community that might provide them with information on the disease or issue they are investigating, stem-cell researchers who would provide them with information on the current research in the field, and so on. The research should include accessing the National Institute of Health and other major medical databases of information that will provide students with the most current research. The Calling All Researchers Scenario (Appendix 1H) lists a series of steps that can guide the research process for the students.</p> <p>Construction of the Scientific Argument and PowerPoint Presentation</p> <p>When students have completed the work, ask them to gather in their research group to construct a scientific argument that they can use for their presentation. Students can use the Construction of the Scientific Argument Worksheet to guide their group thinking (Appendix 1I).</p> <p>Presentation of Response to Scenario</p> <p>After students have completed their research and constructed their argument, they will present their information to a community of people who will judge their presentations and scientific arguments. Select individuals from your community that will encourage, applaud, and celebrate your students’ thinking, yet provide feedback to their presentations. Community participants can use the Calling All Researchers Rubric (Appendix 1J) to judge the quality of the presentation and argument.</p> | <p>Since this scenario contains multiple steps to the research process, it will be important for the groups to establish group rules, determine how they will gather the data to address their questions, and a procedure for reaching consensus. Students will also need support in addressing the perspectives that each major stakeholder holds. It is best to support some groups (those who may need this type of structure and scaffolding) by directing them to have each member of the group select a certain role, generate the questions that will be of concern to this stakeholder group, and then conduct the research to construct an argument or provide evidence to address the potential concerns that may arise from these special interest groups. For those groups who are able to manage this process, the teacher should remain the “guide on the side” to assist them in the process when necessary.</p> <p>Argumentation is what scientists do and is essential to performing science and communicating scientific claims. It is important to share with students that in conducting scientific investigations, scientific argumentation assists the scientist in constructing scientific knowledge claims, to evaluate claims constructed by other researchers, and to establish objectivity. Argumentation is also used when scientists communicate about their findings and when they justify a collection of evidence with supporting or contradictory evidence.</p> <p>To facilitate good scientific argumentation, the teacher should provide resources (links, books, or research articles) that take into account a wide variety of contradictory evidence instead of individual pieces of evidence. Encourage your students to evaluate claims against empirical evidence or data from other sources rather than solely on intuitive and surface ideas.</p> |
| Closure | |
| <p>After providing a review of key concepts, principles, and skills used within this unit of study, provide students with a copy of the Final Assessment found in Appendix 1K. This final assessment will require several days for students to complete and should serve as a performance task that can be evaluated and combined with other students learning experiences.</p> | |

Unit 1 Appendixes

APPENDIX 1A

Figure 1.1

DOMINANT AND RECESSIVE CHARACTERISTICS

| | <i>Dominant Traits</i> | <i>Recessive Traits</i> |
|-----------------|-----------------------------|-------------------------------|
| Eye coloring | brown eyes | grey, green, hazel, blue eyes |
| Vision | farsightedness | normal vision |
| | normal vision | nearsightedness |
| | normal vision | night blindness |
| | normal vision | color blindness* |
| Hair | dark hair | blonde, light, red hair |
| | nonred hair | red hair |
| | curly hair | straight hair |
| | full head of hair | baldness* |
| Facial Features | widow's peak | normal hairline |
| | dimples | no dimples |
| | unattached earlobes | attached earlobes |
| | freckles | no freckles |
| Appendages | broad lips | thin lips |
| | extra digits | normal number |
| | fused digits | normal digits |
| | short digits | normal digits |
| | fingers lack 1 joint | normal joints |
| | limb dwarfing | normal proportion |
| | clubbed thumb | normal thumb |
| | double-jointedness | normal joints |
| Other | immunity to poison ivy | susceptibility to poison ivy |
| | normal pigmented skin | albinism |
| | normal blood clotting | hemophilia* |
| | normal hearing | congenital deafness |
| | normal hearing and speaking | deaf mutism |
| | normal—no PKU | phenylketonuria (PKU) |

Source: <http://www.blinn.edu/socialscience/LDThomas/Feldman/Handouts/0203hand.htm>

*Sex-linked characteristic.

Figure 1.2

GENETIC TRAITS AND ME

Name: _____ Hour: _____ Date: _____

Use the chart, your partner, and a mirror to determine what genetic traits you have. After you make your observations, determine which of your traits are dominant and which are recessive. Record your answers below.

| <i>Trait</i> | <i>Observation</i> | <i>Dominant or Recessive?</i> |
|---------------------------------------------|--------------------|-------------------------------|
| Eye color | | |
| Hair color | | |
| Facial feature: dimples (yes or no) | | |
| Facial feature: earlobes (attached or free) | | |
| Facial feature: Freckles (yes or no) | | |
| Facial feature: lips (broad or thin) | | |
| Facial feature: tongue rolling | | |
| Appendages: double jointed (yes or no) | | |
| Vision: farsightedness or normal | | |
| Vision: normal or colorblind | | |

Thinking Critically

- Did you have more dominant or recessive traits? _____
- Which do you think occurs more often, dominant traits or recessive traits? _____
- Blonde hair and blue eyes are recessive traits. In Scandinavian countries a majority of people you see have blonde hair and blue eyes. If you answered in question 3 that dominant traits occur more often, how can you account for this? If you answered anything else in question 3, cite an additional example of a recessive trait being more common than a dominant one or explain why you answered the way you did in question 3.

APPENDIX 1B: TALKING POINTS AND EXAMPLES

Genetics is the study of heredity or the passing on of genetic material from one generation to another. The passing on of genetic material takes place in genes, which contain the actual information that gets passed on to you from birth. Only one gene from each parent is passed to each offspring for a particular trait.

There are different forms of a gene that are referred to as alleles, which are traits for which two or more possibilities exist, only one of which may be expressed in a single individual. In humans, one allele is inherited from one’s biologic father and one allele from one’s biologic mother for each genetic trait. Alleles are forms of the same gene with small differences in their DNA sequence. This pair of alleles can be dominant (BB), recessive (bb), or hybrid (Bb). The dominant and recessive conditions are called pure or homozygous since both genes present are identical. The hybrid condition possesses one of each gene type and is called heterozygous. The genetic structure is called the genotype.

Dominant alleles overpower recessive alleles and are always expressed in offspring. Recessive alleles are only expressed in offspring if both parents contribute a recessive allele. For example, in human eye color, the allele for brown eyes is dominant, and the allele for blue eyes is recessive. Therefore, if the offspring receives a brown eye allele from either parent, the offspring will have brown eyes. The offspring would have to receive a blue eye allele from each parent to have blue eyes.

Although the genotype of an individual may differ from another’s, their outward appearance for a particular trait may be identical. The outward appearance is called the phenotype.

The laws of inheritance are based on the laws of chance. In a hybrid cross (the case where the mother and father are both heterozygous for a given trait) every offspring has a 50:50 chance of inheriting the dominant or recessive gene. A common way of illustrating this is with a Punnett square, which is one tool that scientists use to predict the outcome of potential crossings of two parents. By using the Punnett square, you can figure out the likelihood that living organisms whose parents have particular gene patterns (genotypes) will develop particular characteristics (phenotypes).

Use this demonstration on the board to investigate and understand that organisms change over time. The key concept included in this lesson is that genetic variation can lead to diversity of organisms. Let’s look at how this works:

| | | | |
|--------------------|---|--------------------|----|
| | | Mother’s Phenotype | |
| | | B | b |
| Father’s Phenotype | B | BB | bB |
| | b | Bb | bb |

1. Ask students to describe how a dominant gene is written and how a recessive gene is written (i.e., B and b). They will describe this through a prompt of brown eyes being dominant over blue eyes.
2. In the example above, ask students to consider a gene with dominant B and recessive b flavors (alleles). What happens if two parents each carrying one of each allele (Bb) (heterozygous) mate? Put the possible eggs for the mother along the top of the square, and the possible sperm for the father along the side. Ask students to fill each box with the allele above it from the mother and the allele beside it from the father. This is a possible combination of alleles of that gene in a child. The four boxes in the Punnett square represent the four possible combinations of the alleles.
3. Discuss with students how this cross yields three possible genotypes in the offspring (BB, Bb, and bb). In addition to showing the possible genotypes of offspring, the Punnett square also indicates how likely a particular child of this mating is to have a given genotype. In this case, there is a one in four (25%) chance that the child would be BB, two in four (50%) that it would be Bb, and one in four (25%) that it would be bb. This outcome is similar to tossing a four-sided die, with BB written on one side, Bb written on two sides, and bb written on the other side. This die gets tossed once for each child. If the cross produces several children, each gets one toss of the die, with the exception of identical twins. On the average, about 25% of the children of this cross should have a genotype

of bb. However, remember that this is a separate combination of egg and sperm, and a separate toss of the dice for each individual. It is possible to throw the dice four times and get bb each time; likewise, it is possible to get four out of four bb children from this cross. It is simply less probable than one out of four having a genotype of bb.

4. Now let's look at this example. We have one gene with two alleles: B-dominant, b-recessive. Since an individual has a pair of each chromosome, they have two copies of the gene. An individual can have a genotype of BB (homozygous dominant), Bb (heterozygous), or bb (homozygous recessive). Any of these individuals could mate with any other; thus, several possible crosses are available as shown in the Punnett squares below:

| | | | |
|--------------------|---|--------------------|----|
| | | Mother's Phenotype | |
| | | B | B |
| Father's Phenotype | B | BB | BB |
| | B | BB | BB |

| | | | |
|--------------------|---|--------------------|----|
| | | Mother's Phenotype | |
| | | B | B |
| Father's Phenotype | B | BB | BB |
| | b | Bb | Bb |

| | | | |
|--------------------|---|--------------------|----|
| | | Mother's Phenotype | |
| | | B | b |
| Father's Phenotype | B | BB | bB |
| | b | Bb | bb |

| | | | |
|--------------------|---|--------------------|----|
| | | Mother's Phenotype | |
| | | B | b |
| Father's Phenotype | b | Bb | bb |
| | b | Bb | bb |

| | | | |
|--------------------|---|--------------------|----|
| | | Mother's Phenotype | |
| | | b | b |
| Father's Phenotype | b | bb | bb |
| | b | bb | bb |

5. Students will then be prompted as to which eye color will be seen with each combination.
6. Using the Punnett squares above, ask students to determine the number of different offspring genotype combinations. Have them calculate the percent of the genotype offspring combinations. Assist students by helping them to fill in the Punnett squares and instructing them as to how to calculate the percents for each cross. Ask the following questions each time.

(Continued)

(Continued)

How many BB are there? _____

How many Bb are there? _____

How many bb are there? _____

What percent of BB are there? _____

What percent of Bb are there? _____

What percent of bb are there? _____

Genotypes of Parents _____

Genotypes of Offspring _____

Phenotypes of Parents _____

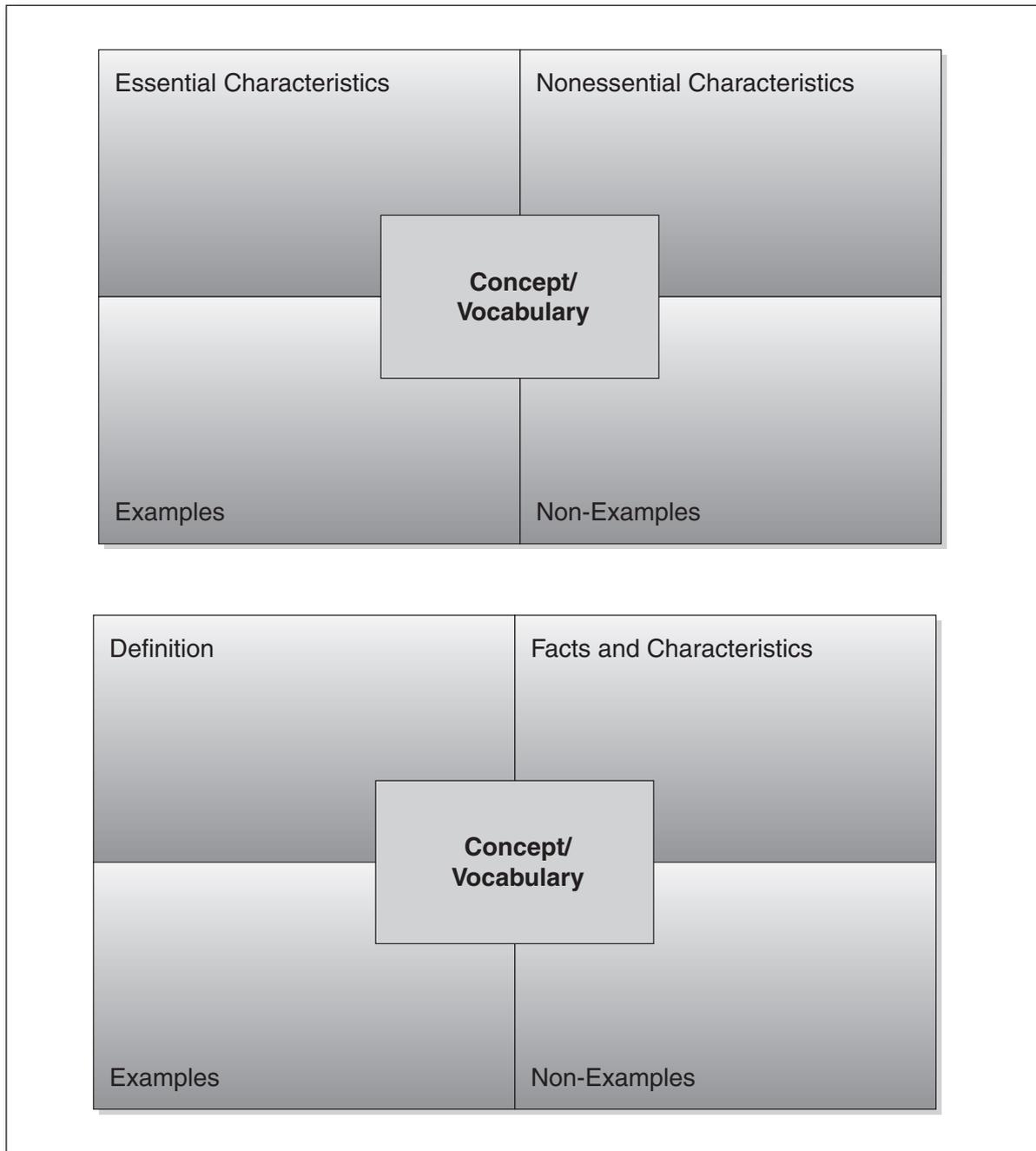
Phenotypes of Offspring _____

The cases listed above are called monohybrid (one trait) crosses, which means that there is one gene and two possible alleles for that gene. To provide Ascending Intellectual Demand, have students examine what happens when a dihybrid cross occurs. This cross occurs when two genes are independent, such as crossing attached earlobes and curly hair with unattached earlobes and straight hair.

APPENDIX 1C: VISUAL ORGANIZER FOR KEY TERMS

Figure 1.3

VISUAL ORGANIZER FOR KEY TERMS



APPENDIX 1D: DNA ALPHABET

Use the following sites to obtain information about the DNA alphabet.

- Step 1: First click onto the following site to read about the DNA alphabet. This site is produced by the Wellcome Trust Sanger Institute. Link to the DNA Code Activity: <http://www.yourgenome.org/dgg/gen>
- Step 2: Then go to this site to conduct the activity called “DNA Detectives: What is your DNA Alias?” This site is produced by the Canadian Museum of Nature (http://nature.ca/genome/05/051/0511/0511_m205_e.cfm).
- Step 3: You can also use the decoder found at the Name in DNA website: <http://www.ebi.ac.uk/training/schools/decode/>, which is produced by the European Bioinformatics Institute.

APPENDIX 1E: DNA EXTRACTION LAB

For this experiment, your group will be extracting DNA from green split peas. As you conduct each step, please record your observations and findings.

Step 1: When you separated pea cells from each other, what did you observe?

Observations:

Step 2: When you added the liquid detergent what did you observe?

Observations:

Step 3: When you added the meat tenderizer for enzymes, what observations did you make?

Observations:

Step 4: As you added the rubbing alcohol into the tube, what did you observe?

Observations:

APPENDIX 1F: PEDIGREE STUDIES LAB EXPERIENCE

Introduction

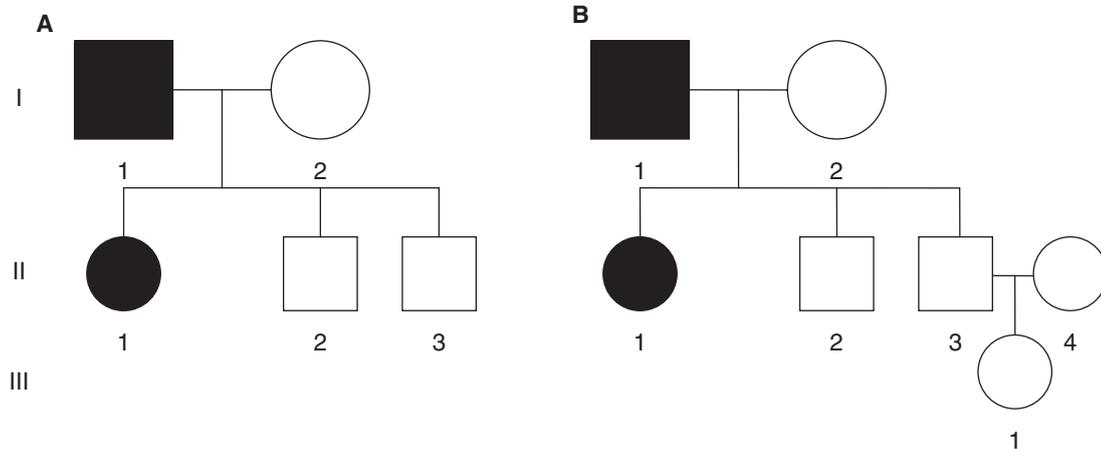
This should help you to understand how to read a pedigree chart. Pedigree charts show the phenotype of genetic traits and how they are expressed in a family from one generation to the next. The pedigree can help predict the genotype of each person for a certain trait.

Background Information

- In a pedigree chart, generations are represented by Roman numerals. Each person in each generation is numbered.
- Males are represented by a square and females by a circle.
- A horizontal line connecting a male and a female is called a marriage line.
- Vertical lines represent children.
- Children on the vertical line are always placed from left to right, with the child on the left being the oldest.

Let's Get Started

Examine Figures A and B found below. Answer the questions that follow concerning each figure.



1. What is the sex of the oldest child in Figure A? _____
2. What is the sex of the youngest child in Figure A? _____
3. Which person in Figure B is the daughter-in-law? _____
4. To whom is she married? _____
5. What is the sex of their child? _____

Determining Genotypes

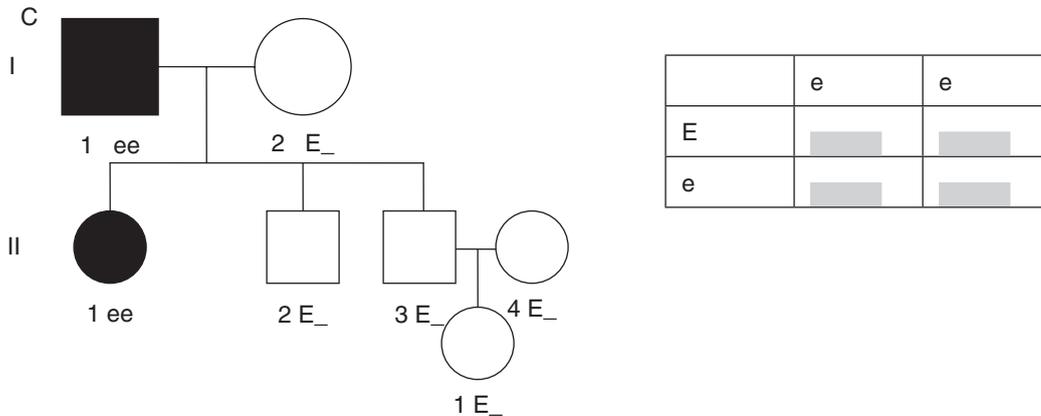
If we look at a specific trait (earlobe shape), two general shapes of earlobes exist: the dominant, *free ear lobes* (E) and the recessive, *attached ear lobes* (e). Individuals on a pedigree chart who have unshaded symbols have at least one dominant gene and show the dominant trait.

(Continued)

(Continued)

Background Information

- Any person on a pedigree chart who has a shaded symbol must be assigned two (2) recessive genes.
- Place lowercase letters under the person’s symbol.
- Any person on a pedigree chart who has an unshaded symbol must be assigned a dominant gene.
- Place a capital letter under the person’s symbol.
- To determine the second gene for persons who show a dominant trait, a Punnett square must be used.



By examining Figure C, you can determine that the grandfather (I-1) is ee. The grandmother, we know, has one dominant allele. By looking at her three children, can we determine whether her second gene is dominant or recessive? If the grandmother were to be dominant (EE), would she be able to have a child with the genotype ee? By using the Punnett square, you will be able to see that this would be impossible. Thus, the grandmother must be heterozygous (Ee).

Answer the following questions using Figure C.

1. Can an Ee parent and an ee parent have the results shown in generation II? _____
2. Predict the second gene for person II-2. _____
3. Predict the second gene for person II-3. _____
4. Could child II-2 or II-3 be EE? Explain. _____

To predict the second allele for person II-4, a different method must be used, since she could be either EE or Ee.

5. Can an EE person married to an Ee person II-3 have children with free earlobes? _____
6. Can an Ee person married to an Ee person II-3 have children with free earlobes? _____

In this case, the second gene from person II-4 cannot be predicted using the Punnett square. Either genotype EE or Ee may be correct. When this occurs, both genotypes are placed under the person’s symbol. Predicting the second gene for III-1 results in her not being able to be predicted because if you look at your Punnett square, she could be either EE or Ee, since her father is heterozygous. At some time in the future, if II-3 and II-4 have many more children, one might be able to predict II-4. When both parents show a dominant trait and their children all show a dominant trait, one cannot predict the second gene for anyone if only a small family is available.

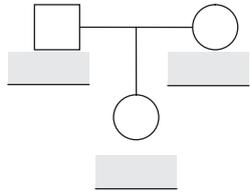
Summary

Draw a complete pedigree.

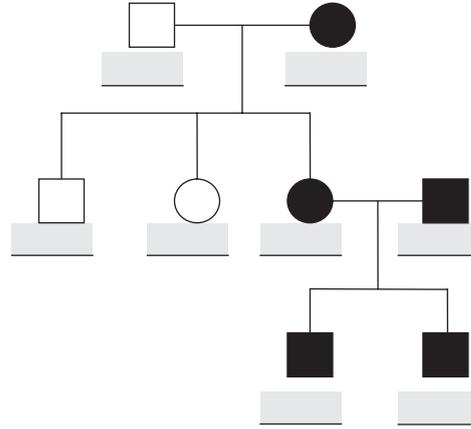
1. Label each of the main parts for a family showing two parents and four children.
2. Make the oldest two children boys and the youngest girls.
3. Indicate, on the pedigree, that child II-2 has attached earlobes.

Using pedigrees 13, 14, and 15 below, predict the genotype of these families.

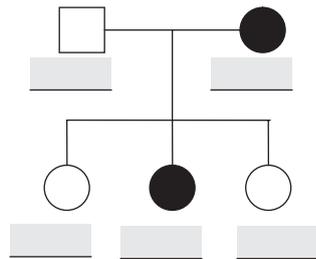
13.



14.

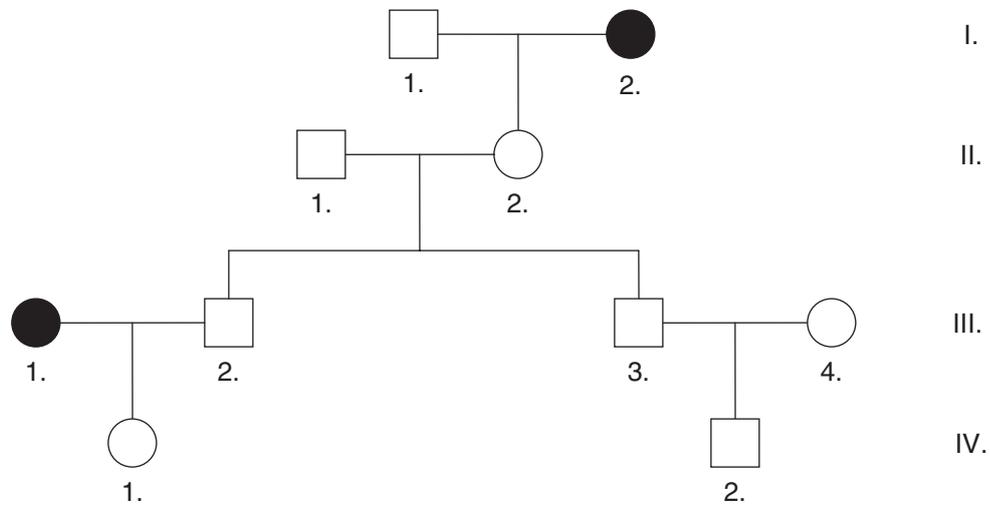


15.



Use pedigree 16 to answer the following questions.

16.



1. How many generations are shown in the above pedigree? _____
2. How many people have free earlobes? _____
3. How many people have attached earlobes? _____
4. Identify the generation number of those persons with attached earlobes. _____
5. How many children did the original generation contain? _____
6. Predict the genotypes of all persons in the pedigree above. _____

APPENDIX 1G: INFORMATION TO USE WITH THE CASE STUDY

1. Use the following Internet site to access information about hemophilia to explain the visual aspect of the disease: (<http://www.emc.maricopa.edu/faculty/farabee/biobk/BioBookhumgen.html>). Work through the visual to assist students in understanding how the allele was passed through the family. Start the discussion where you see “Sex-Linked Traits” discussed.

APPENDIX 1H: CALLING ALL RESEARCHERS SCENARIO

Directions: You will work with a team of three other students to research your area of interest to form a consensus on why this type of research should be funded by the federal government. Each member of your team will choose one of the given aspects of your topic to research. You will discuss your findings and decide the team's stance on funding allocation. Together you will determine the type of persuasive argument to construct and the type of persuasive presentation to create in order to convince a group of concerned citizens to support your topic for further research.

Calling All Researchers

The President has announced plans to fund a new program for scientific research. He wants to spend the money in the most efficient way possible that would be of benefit to society. In his proposal to the scientific community of scholars, he has asked that they prepare a presentation that would address the following issues. These issues and others the researchers wish to include must be addressed in the presentation. Priority will be given to those who address these questions:

- Why should the federal government fund research in this area?
- How does this research benefit society?
- How does this research improve the human condition?
- How can the research that you are advocating for connect to other teams of researchers from other fields of science (e.g., biology, geology, chemistry, and physics) to open new lines of communication among researchers?
- What ethical, moral, or political issues may surface as a result of this funding? How would you recommend that these issues be addressed?

Your presentation will be given to a representative group of scientists, community members, political leaders, and governmental officials who will serve as an advisory committee. The President has called these special interest groups together to make recommendations to his federal policy committee to determine which research to sponsor.

Starting the Research Process

- Step 1: Everyone must understand the background information on the type of research you have collected, so make sure that the team understands the information.
- Step 2: It's always best that you know what the concerns will be of each member of the review panel so you can consider this when preparing your argument. It is helpful to assign team members to investigate how you would address their concerns. Start this process by brainstorming a list of questions that may surface from these members. Remember your audience will include scientists, community members (ethicists, families, or careers that are affected by the area of research you conduct), political leaders, and governmental officials.
- Step 3: Decide as a team which questions should guide your research. Divide the roles and questions among your group. Conduct your research so you can respond to the types of questions these stakeholders may ask.
- Step 4: Construct your persuasive argument that uses the format listed below.
- Step 5: Create a PowerPoint presentation to present this argument. You have a 30-minute time frame to deliver your presentation.

- **Introduction.** In this section, you need to inform your audience about the issue that you have researched. You will want to state your facts and statistics that address your topic.
- **State Your Case.** You must convince your audience why funding this type of research is the most important to consider. You can share expert opinions that you have found by conducting interviews and any other evidence to support the position you are presenting.

(Continued)

(Continued)

- **Examine and Refute the Opposition.** Knowing your opposition is important, so consider how you will address the concerns that each member of your audience may have. Their concerns can be used to support your position, and their opposing viewpoints will help you to consider how to address their concerns.
- **Reconfirm Your Position.** At the end of your presentation, you will want to review and summarize the main points of your argument and then conclude that your position is the most effective option to consider based on the information you provided.

APPENDIX 11

Figure 1.4

CONSTRUCTION OF THE SCIENTIFIC ARGUMENT WORKSHEET

Directions: Use the graphic organizer below to organize your scientific argument, support or evidence, and conclusion for each argument. You must remember that in constructing an argument, it must be stated fairly, that your evidence must support the argument, and that your conclusions follow your reasoning. To make your case to the major stakeholders, you will need to include several arguments to prove your case.

| <i>The Argument/Claims</i> | <i>The Support or Evidence</i> | <i>The Conclusion</i> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Present your argument supported by data. Consider the following:</p> <ol style="list-style-type: none"> 1. Does anything seem wrong with this logic? Is this argument fair? Reasonable? Balanced? Informed? 2. What assumptions, perspectives, viewpoints, and biases may be present? 3. Do these influence the validity or strength of the argument? | <p>Gather evidence from investigations, reading information, archived data, or other sources of information. You could also conduct some interviews or gather quotes from experts. Consider the following:</p> <ol style="list-style-type: none"> 1. What data (facts, statistics, examples, comparisons, or expert viewpoints) support my argument? 2. Are my statistics presenting an honest view of what is really happening? 3. When quoting an expert, is this expert qualified to address this research topic? Are there controversial viewpoints or research that needs to be presented? | <p>In the conclusion, review the evidence that you have provided to support your claims. Make connections between the evidence your group gathered and the claims that you are making. Consider the following:</p> <ol style="list-style-type: none"> 1. Are the uses of the statements, arguments, and evidence valid? 2. Is this argument effective? 3. Is this argument persuasive? |

Figure 1.5

CONSTRUCTING AN ARGUMENT WORKSHEET

| |
|-------------------------------------------------------------------------------------------------------------------------------------------|
| The Argument: What argument do you want to prove? |
| The Support/Evidence: |
| What facts, statistics, examples, or expert viewpoints support your argument? |
| What facts, statistics, examples, or expert viewpoints do not support your argument? |
| The Conclusion: What is the conclusion of your argument? What do you want the stakeholders to think, believe, or know about the research? |

APPENDIX 1J: CALLING ALL RESEARCHERS RUBRIC

| <i>Scoring Level</i> | <i>Science and Society</i> | <i>Basic Concepts and Fundamental Principles</i> | <i>Scientific Approach</i> | <i>Nature of Science</i> |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| 4-Accomplished | Developed and defended an informed position, and discussed how science and its applications interact with three or more of the following factors (social, economic, political, environmental, cultural, and ethical). | Integrated and applied basic scientific concepts and principles. Explained all scientific ideas and concepts thoroughly. | Demonstrated comprehension of the scientific approach; illustrated with examples. Major points were supported with relevant facts, statistics, and/or examples. | Demonstrated scientific reasoning across multiple disciplines. |
| 3-Competent | Correctly described the position taken, and how science and its applications interact with two or more of the following factors (social, economic, political, environmental, cultural, and ethical). | Showed clear comprehension of basic scientific concepts and principles. Explained some of the scientific ideas and concepts. | Accurately expressed concepts related to the scientific approach. Major points were supported with facts, statistics, and/or examples, but the relevance of some of this information was questionable. | Interpreted related scientific results in a way that showed a clear recognition of the nature of science. |
| 2-Developing | Recognized the place of science in human affairs, but was unable to communicate its roles and its interactions with at least one of the following factors (social, economic, political, environmental, cultural, and ethical). | Able to state basic scientific concepts and principles in simple recall fashion only. | Uses vocabulary related to scientific methods in a rote manner or showing simple conceptualization. Some major points were supported well while others were not. | Provided simplistic or incomplete explanations of the nature of science. |
| 1-Beginning | Did not visualize a role or need for science in human affairs, could not address how science and its applications interact with any of the following factors (social, economic, political, environmental, cultural, and ethical). | Lacked an understanding of basic scientific concepts and principles. Does not recall or has faulty understanding of the scientific ideas and concepts. | Showed minimal understanding of scientific methods. Major points were not supported with evidence. | Did not distinguish between scientific, political, religious, or ethical statements. |

APPENDIX 1K: FINAL ASSESSMENT

1. Select two of the following problems to solve by constructing a Punnett square to respond to the questions posed.
2. In rabbits the allele for black coat color (B) is dominant over the allele for brown coat color (b). What is the genotypic ratio and phenotypic ratio for a cross between an animal homozygous for black coat color and one homozygous for brown coat color?
3. Albinism is recessive in humans. An albino man marries a woman who is not albino but had an albino father. What is the probability of this couple having a child that is not an albino? What are the genotypic and phenotypic ratios?
4. In “Teenage Mutant Ninja Turtles,” green shells are dominant over brown shells. Leonardo, who is heterozygous for a green shell, marries the lovely Mona Lisa, who has a brown shell. What are the genotypic and phenotypic ratios?
5. In humans, polydactyly (an extra finger on each hand or toe on each foot) is due to a dominant gene. When one parent is polydactylous, but heterozygous, and the other parent is normal, what are the genotypic and phenotypic ratios of their children?

Dihybrid Problems for Advanced Level Students

1. In humans, aniridia (a type of blindness resulting from absence of an iris) is due to a dominant gene. Migraine (a sickening headache) is due to a different dominant gene. A man with aniridia, whose mother was not blind, marries a woman who suffers from migraine. The woman’s father did not suffer from migraine. In what proportion of their children would both aniridia and migraine be expected to occur?
2. Using the DNA Coding Chart that was used in class, create the DNA code for the following words:

Science

Genetics

3. Using the *Cartoon Guide to Genetics* written by Larry Gonick and Mark Wheelis, select one of the cartoons that you think you can interpret using the principles, concepts, and skills from this lesson. You should select the cartoon from the folder that contains photocopies of each of them. Take this copy and then select from the following ideas that you wish to explain in your own words. Remember you are providing additional information so someone can get the real insider joke of the cartoon and yet a thorough scientific explanation of the ideas behind its meaning. Try to use some of the genetics vocabulary words that you learned in this unit and that are posted on wall charts throughout our classroom.
4. Choose two from the following questions to respond to and provide examples.
 - What concerns do you have about the practices of genetic research?
 - What do practitioners in this field think about?
 - To what degree is this intriguing, familiar, and/or surprising to me?
 - What difficulties do/would practitioners in this field encounter? How do they cope with them? How would I cope with them?
 - What have I learn about myself by studying the practitioners in the field of genetics?
 - What is the wisdom that this discipline has contributed to the world? How could I see myself contributing to this wisdom?

APPENDIX 1L: REFERENCE SHEET FOR ADVANCED OR INTERESTED STUDENTS AND TEACHERS IN THE FIELD OF GENETICS

Biology is defined as the branch of science dealing with the study of living organisms while genetics is the science of genes, heredity, and the variation of organisms.

1. What kinds of questions are asked in the subdivision? Students can select from these questions as more challenging questions to pursue in this unit.
 - What factors contribute to genetic disorders and diseases? How can studying genes help eliminate painful genetic disorders?
 - Where are certain genes located within the human genome?
 - What are the chances of a person having children with a certain genetic disease?
 - What are the moral implications of stem-cell research?
 - How can genetic engineering help the human race?
 - What can and should be done with unused embryos left over after *in vitro* fertilization?
 - How can and will genetic engineering impact the daily lives of ordinary citizens? Professional athletes?
 - How is DNA fingerprinting performed and how reliable is it?
 - Is there a possibility of recreating extinct animals using their DNA?
 - What type of testing should be done to an infant during pregnancy? Should babies with genetic disorders be aborted before birth?
 - How does genetic engineering and human equality fit together?
 - What happens to DNA during replication?
 - What is the structure and function of DNA and how does that create genetic material that makes organisms function?
 - How can DNA fingerprinting help to solve present-day crimes and historical mysteries such as “Did Thomas Jefferson father a child with his slave Sally Hemings?”
 - How do paternity tests determine a baby’s father?
 - Should genetic engineering be regulated by the government or other authority?
 - When and where does life begin?
 - What things have been cloned and what are the benefits and drawbacks involved with cloning?
 - What were Mendel’s discoveries about the patterns of inheritance?
 - What is DNA and why is the human genome project studying it?
2. What are key basic reference books in the discipline or subdivision?

Brooks, M. (1998). *Get a grip on genetics*. New York: NY. Ivy Press and Time Life Books.

This is an excellent small reference to help anyone get acquainted with the field of genetics. It is written in an easy to read language and contains information about the beginnings of the field of genetics, DNA, mapping genes, and the uses of genetic knowledge.

Burian, R. (2005). *The epistemology of development, evolution, and genetics*. Cambridge: United Kingdom. Cambridge University Press.

This collection of essays examines the developments in three fundamental biological disciplines: embryology, evolutionary biology, and genetics.

Endelson, E. (1990). *Genetics and heredity*. New York, NY: Chelsea House Publishers.

The history of genetics and application of genetics up until 1990 are discussed in this book. Although dated, the book does contain reader-friendly applications about beginnings and applications of genetics and heredity as well as confer a basic understanding about genetic diseases and how they are passed on to offspring.

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Keller, E. F., (1995). *Refiguring life: Metaphors of twentieth-century biology*. New York: NY. Columbia University Press.

This book discusses how genes are the primary agents of life and describes how they function.

Kristol, W., & Cohen, E. (2002). *The future is now: America confronts the new genetics*. Oxford, England: Rowman and Littlefield Publishers.

Excerpts from Huxley's *Brave New World* begin this book, which asks essential questions about genetic engineering and where it is taking the human race.

Noble, D. (2006). *The music of life*. New York, NY: Oxford University Press.

The subjects of genetics and music combine for an alternative perspective; specifically, the book delves into the similarities between genetics and the structure and function of music.

Reilly, P. (2006). *The strongest boy in the world: How genetic information is reshaping our lives*. Cold Springs Harbor, NY: Cold Springs Harbor Laboratory Press.

Genetic engineering is approached from many different angles in this book. *The Strongest Boy* examines genetic engineering's potential impact on professional sports and humanity, diseases, animals and plants, and society. It discusses ethical and moral debates associated with stem-cell research and talks about futuristic impacts of genetics on the whole of society.

Shannon, T. (2005). *Genetics: Science, ethics, and public policy*. Lanham, MD: Rowman and Littlefield Publishers.

Bioethics in four areas—reproductive technologies, genetic technologies, death and dying, and health care policy—are the focus of this book.

Starr, C., & Taggart, R. (2004). *Biology: The unity and diversity of life*. Belmont, CA: Brooks/Cole.

This is a college text on cell biology and genetics. It provides essential information about basic concepts in the field of genetics, including: Mendel's experiments, DNA structure and function, and genetic engineering.

3. What are some selected examples of insiders' knowledge, such as discipline-specific humor, trivia, abbreviations and acronyms, "meccas," scandals, hidden realities, or unspoken beliefs?
 - Re-creation of the dodo bird? Possibility of using DNA of extinct animals to recreate them.
 - DNA fingerprinting—your DNA fingerprint is as unique as your real fingerprint. This can be used to solve crimes and trace your relatives. It has been used to identify remains of soldiers from the Korean War by matching DNA and the soldiers' old shaving kits. It can also be used to identify paternity mysteries. Not only ones from today but also mysteries of the past.
 - Early genetic misconceptions—pregnant women used to be discouraged from eating strawberries because they were believed to cause birthmarks in babies.
 - During World War II, the birth of mentally retarded children was thought to be caused by trauma suffered by expectant mothers during bombings.