Meiosis Unit

Part 1: Are They Really Twins?

Unit: **Standard BIO.3.3** **Genetic Patterns**	**Utah SEEd Standard / NGSS Performance Expectation:** **Engage in argument from evidence** that inheritable genetic variation is caused during the formation of gametes. Emphasize that genetic variation may be caused by epigenetics, during meiosis from new genetic combinations, or viable mutations. (LS3.B) **NGSS Correlation:** HS-LS3-2	**Time:** 80-90 minutes

Link Meiosis Unit Part 2: https://3drst.byu.edu/bio-3-3-meiosis
Link to Meiosis Unit Part 3: https://3drst.byu.edu/bio-3-3-chromosome-crossover

Anchor Phenomenon	Variation between fraternal twin siblings
Driving Question(s)	What causes variation between siblings in families? Why do we see vast amounts of variation from the same two parents?
Performance Task	HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: **(1) new genetic combinations through meiosis,** (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors

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Lesson Summary:			
	Time	**Guiding Question / Learning Objective**	**How are students answering the guiding question or meeting the learning objective?**
 **Engage**	15 minutes	What causes siblings to have different appearances? Why do we see vast amounts of variation from the same two parents?	Students formulate questions from prior knowledge, experience, curiosity, etc., to explore the cause and effect of genes and inheritance.
 **Explore**	45 minutes	Offspring get traits from their parents through a mix of genetic information	Students visualize the variation that occurs when they “mix” genes during a class activity. Students compare differences amongst their peers to see the variation amongst “species.”
 **Explain**	10 minutes	The genetic makeup of an individual is composed of half of the genetic information from each parent.	Students discuss findings and reach a consensus regarding explaining what may cause siblings (or twins) to have different looks.
 **Elaborate**	10 minutes	Siblings inherit different portions of genetic information from each parent which may result in different phenotypes (e.g., appearances)	Given more information about the family, students identify additional evidence that supports their claim (explanation) of the original information.
 **Evaluate**	5 minutes	What causes siblings to have different appearances? Why do we see vast amounts of variation from the same two parents?	Use the rubric provided with this lesson to have students conduct peer-evaluations of the claim, evidence, and reasoning and/or the instructor uses the rubric to evaluate student learning.

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Three Dimensions Focused on in This Lesson		
Disciplinary Core Idea: **NGSS Appendix E** Variation of Traits The information passed from parents to offspring is coded in the DNA molecules that form the chromosomes. In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes. Viable mutations in gametes can be inherited. Environmental factors also affect expression of traits.	**Science and Engineering Practices:** **NGSS Appendix F** **(1) Engaging in Argument From Evidence: 9-12** Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. **(2) Developing and Using Models: 9-12** Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	**Crosscutting Concept:** **NGSS Appendix G** **Cause and Effect: 9-12** Students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

Learning Objectives

- **DCI:** Students will explain that variations of traits occur from chromosomes that are passed down from parents to offspring by the formation of gametes during meiosis.
- **SEP:** Students will model and form inferences about genetic variations using pedigree charts to support their argument.
- **CCC:** Students will be able to show that genetic variation is a direct result of traits passed from parent to offspring BECAUSE of gamete formation in meiosis.

Related Knowledge and Skills from Prior Grades		
Disciplinary Core Idea: **NGSS Appendix E** **(LS3.B) 6-8** In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism	**Science and Engineering Practices:** **NGSS Appendix F** **1) Engaging in Argument from Evidence: 6-8** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **(2) Developing and Using Models:6-8** Develop a model to describe unobservable mechanisms.	**Crosscutting Concept:** **NGSS Appendix G** **Cause and Effect: 6-8** Students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

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Materials

Link to all materials on the 3DRST website (3drst.byu.edu): https://3drst.byu.edu/heredity
Link to all materials on Canvas Commons: https://tinyurl.com/3DRSTbiology

Handouts	Lab Supplies	Other Resources

Student Pedigree Worksheet
Student Pedigree Chart
	• Gummy bears (6 of each parent)
	  ○ Tip: Pre-sort colors to reduce loss of class time
	• Dissection Scissors (works best) or scalpels or razor blades (to cut gummy bears)
	  ○ Tip: Count how many are handed out and collect at the end of class
	• Cutting boards
	• Plates, bowls, or plastic bags to hold gummy bears
	• Padlet, sticky notes, or whiteboards with markers
	• Colored pencils
		Heredity PowerPoint slides
		Genetic recombination info sheet
		Grading rubric

ENGAGE

What causes variation between siblings in families?

6-10 min – Student pairs
(Engage in argument from Evidence)

1. Show students 1st picture (**brother/sister twins – slide 1**) – **DO NOT tell students the relationship between persons in the photos!**
   - Teacher: **"Please write 2 observations & 1 inference about these two people."**
   - Students: Make 1-2 observations & 1 inference (~2 min)

2. Short small group/partner discussion
   - Teacher: **"What are some of your observations? What are some of your inferences?"**
   - Follow up with, **"What do you wonder about this picture?"** (Be sure to get answers from each group)

3. Show students the 2nd picture (**dark/red-hair twins –slide 2**)
   - Teacher: **"Please write 2 observations and 1 inference about these two people."**
   - Students make 1-2 observations & 1 inference. (~2 min)

Teacher Tips:

You may want to find pictures of twins appropriate for your student's culture/community.

Ideas for collecting and sharing ideas: Padlet, sticky notes, or whiteboard(s); different colored sticky notes—one for observations and one for inferences—works well.

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4. Short small group/partner discussion • Teacher: **"What are some of your observations? What are some of your inferences?"** • Follow up with, **"What do you wonder about this picture?"** 5. Show students the third picture (**identical twins – slide 3**) • Teacher: **"Please write 2 observations and 1 inference about these two people."** • Students make 1-2 observations &1 inference. (~2 min) 6. Short small group/partner discussion • Teacher: **"What are some of your observations? What are some of your inferences?"** • Follow up with, **"What do you wonder about this picture?"** 7. Show slide with the collage of the three photos – **Slide 4** • Teacher: **"Which of these images shows a set of siblings? Please describe at least two pieces of evidence for your inference."** • Discussions with partner/small groups and class • Teacher: **"Let's make the CLAIM that all three of these pictures have a set of siblings. No adoptions, same set of parents, no stepchildren, etc."** • Teacher: **"Now that you know they are siblings, what do you wonder?"** Short Group Writing/discussion about what they wonder. Specifically, target individual students using the scientific language of inheritance of traits being passed on to offspring. Select several students to state what they wonder. Note: Student musings/questions may include or be guided to: • How can these two girls look so different (girl twins)? • Why do some families all look like their mom (or dad)? Does that mean they get more DNA from one parent? 8. Teacher: collect students' questions • Based on students' questions, develop a driving question such as: ○ "What caused these siblings to have such different appearances (effect)?" ○ "Why can we see a wide amount of variation from the same two parents?" ○ "What does variation look like in your family?" ○ "What causes variation between siblings in families?" **"We're going to explore this cause-and-effect relationship (today)."**	The following sentence frames may support students who struggle to describe their photo observations and inferences: 1. I think the two people are__ because ___. 2. The two people have different __. One appears __ and the other __. 3. The two people have similar __. They both appear __. Alternatively, or in addition to asking students what they wonder, ask students to find the evidence (observations) that supports or opposes this claim. Listen for and foster student conversations relating to prior experiences with siblings and twins.

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EXPLORE

Offspring get traits from their parents through a mix of genetic information.
Emphasis: Engaging in argument from evidence & developing & using models

- Before the activity, prep gummy bears by separating all the colors and placing 6 of each color in separate plastic bags. Make enough bags for each pair or small group of students to have two different color bags.
- Put students into small groups (such as pairs) and hand out gummy bears.
- Have students read instructions on Student Pedigree Worksheet and follow the procedures.
  - Students will only need one pedigree per group as found on this link: Student Pedigree Chart

Teacher: Ask and have students answer these questions on their student worksheet:

- How much genetic information comes from each parent?
- When offspring look more like one parent, does that mean they got more DNA from that parent? Explain.

Part 1 First generation mating – Slide 6
Procedure for F1

- **Students:** Choose one of each color given to represent the parents (P). Predict what the children will look like if they get ½ traits from the (P-generation)
- **Students** cut one of each of the parent color gummy bears in half to create "offspring" with half of each of the parent's DNA.
- **Teacher: "Now that you have made the F1 generation, create a claim using evidence as to how this represents ½ traits from both parents on your lab sheet."**

Part 2 (Second generation mating) – Slide 7
Procedure for F2

1. Students select just one of their offspring in the F1 generation and make a copy of it.
2. Take a solid color of each gummy bear from their P generation and trade the parents and offspring gummy bear with another group.
3. Take the bears from another group's F1 generation and predict what their F2 generation will look like if mated to their F1 bear.

Teacher: Look for students thinking deeper in their assembly of the bear traits to be used as examples (e.g., ears of one, arm of another, etc.) Discuss the reasoning for why bears were put together the way they were. Use examples of students who thought deeper to engage higher-level thinking and discuss how traits are given from parents but displayed very differently.

- Have students explain using evidence how the variation of traits in the F2 generation comes from the parents in the F1 but still shows traits from the original P generation.

Teacher Tips:
Keep a few of each color in a teacher bag to hand out if students need extra; students may also need to trade.

(Students could answer these questions from page one in their journal if teacher doesn't wish to copy the student worksheets for students.)

The last two slides on the PowerPoint offer a simple demonstration on how to create each generation and switch with another group.

Students can choose any parts of the gummy bear for each half. (e.g., head, legs, arm)—they are not required to cut them down the middle.

Ask students to explain their reasoning behind why they are cutting bears or putting them together the way they are. Look for interesting ways students have modeled ½ traits.
Use them to take the discussion to the next level.

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Part 3: F3 Challenge (slide 8)

- **Teacher:** Show the picture of the colored bear on slide 8. Challenge students to take one of their F2 bears and predict what their children would look like if they mated with the bear on the screen (1st analysis question). Have them use **colored pencils** to accomplish this task. Look for students who are thinking deeper about trait distribution to use those as examples for the guided discussion.
- Students answer 2nd analysis question: **"Look at the F2 and F3 generation gummy bears from several other groups. Based on what you've learned from this activity, what causes the variation in phenotype of offspring?**
    - Students share their answers with the group.

- **Teacher**: Show students **slide 9 and then slide 10**, asking students to explain how slide 9 is related to slide 10. Students answer 3rd analysis question: **"Given the amount of variation in F2 and F3 gummy bears that you observed, do you think it is possible that all three images show sets of twins? Make a claim about whether or not they are twins. Support your claim with evidence and reasoning from the gummy bear models."**
- **Teacher:** Pull examples of students' data to guide a summary discussion of how the variation of traits comes from inheritance from parents, which is different for each sibling.

Student possible wonder/ questions:

- Where does genetic variation occur?
- Why don't "I" show all the same traits as my parents if I am a "perfect mix"?
- How much information do we get from our parents and grandparents?
- How much information do we pass on?
- Is this how I got __ from my parents?
- Are there traits that are selected for more than others?

Important Points:

- We get half of our genetics from mom and half from dad.
- Mom and Dad got half their genetics from their mom and dad.
- Not every sibling gets the same genes from each parent.

Access for English Language Learners & Remedial Learners

1. Read procedures with individual students, groups, or as a class
2. Difficult words may include but are not limited to: inheritance, filial, variation, phenotype, and pedigree. Use whiteboard vocabulary explanations, short practice/example sentences, and synonyms.
3. Provide alternative simplified analysis sentences as needed
4. Provide sentence frames to help with analyses. Example**:**
Children inherit (get) approximately __ percent of__ from each of their parents.

Possible extensions: 1. If students finish this prediction activity early, challenge them to perform a second prediction of what the offspring bear will look like if they use one of their offspring bears and an offspring bear from a different group/person. Have them draw the pedigree for this prediction on the back of their paper.
2. Ask students to explain their reasoning for choosing what their second offspring bear would look like.

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EXPLAIN

Offspring get traits from their parents through a mix of genetic information**.**

1. Connect the gummy bear model to meiosis
   - Share with students that what they modeled using gummy bears to show how offspring inherit traits is called “Meiosis.”
   - Meiosis is how organisms pass traits on to their offspring. Explain that we will explore that cellular process in a future class.

2. Show students the collage (**all twins – slide 10**)
   - **Teacher**: Ask students to turn #3 on their student worksheet.
   - Restate the guiding question chosen as a class (see Engage section #9)
   (or use this question: **“What causes variation between siblings in families?”**)
   - Instruct students to write the guiding question on #3.

3. Student discussion & writing with a partner.
   1. **Teacher**: Ask partners to establish a **claim** that answers the guiding question (using their experiences and understanding of the activities today).

   2. **Teacher**: Establish a consensus claim for the class to write on their paper
      - Highlight some of the claims made by partners during the discussion.
      - A consensus claim should look something like the following: **“Combining ½ the genetic material from the male parent and ½ the genetic material from the female parent causes genetic variation.”**
      - **Students**: Write the consensus claim on their worksheet under #3.

   3. **Students**: Work as partners to record evidence under #3 on what you have learned today with the twin discussion and gummy bear activity to answer the question.

Teacher Tips

If students are not familiar with CER (Claim, Evidence, & Reasoning) format, teachers should guide them through each line of the CER document.

*Teacher Note: Possibly include process for coming to consensus claim such as this one: https://www.readwritethink.org/professional-development/strategy-guides/consensus-decision-making

Access for English Language Learners & Remedial Learners
The following sentence frames may support students who struggle to describe their reasoning.
Example
1. “There is variation between children of the same parents because ____.

2. “There is almost no variation between some children of the same parent because _____.

3. Each of the pictures shows twins.

Meiosis should be explored in another class period soon after this lesson.

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ELABORATE

Offspring get traits from their parents through a mix of genetic information**.**

1. **Teacher**: Show the picture of the family of the two women, Lucy and Maria Aylmer (Slides 11 & 12). **"How does this picture add to your evidence that they are siblings/twins from the same parents?"**
   - Instruct students to add the new evidence to #3.

2. **Students**: With a different partner, argue from the evidence that genetic variation comes from the passing of ½ the genetic material from the male parent and ½ the genetic material from the female parent.
   Add to your evidence/reasoning anything that you learned from your partner that you didn't have in your evidence.

3. **Teacher**: Have students return to their original seats. Call on 2-3 students to share one of their pieces of evidence. Use this activity to check that student evidence is accurate.
   - If needed, explain that reasoning is the explanation of how your evidence supports the claim. Explain that it is the science behind the evidence and claim.

4. **Students**: On #3 explain how your evidence supports your claim. The reasoning section is where students should have a scientific explanation for the cause and effect of the variation seen in siblings/twins.

5. **Teacher**: Check for understanding. End with a whole group discussion about the cause and effect of how siblings/twins receive such different traits and how meiosis is the process that leads to genetic variability.

EVALUATE

Offspring get traits from their parents through a mix of genetic information**.**

Use the rubric provided to evaluate students' answers to #3 on their papers or have students evaluate each other's worksheets.

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POSSIBLE EXTENSION / ALTERNATIVE ADAPTATIONS

1. Students can reproduce one of their colored pencil bears (F3) with a neighbor AND predict possible outcomes.

2. Students explore genetic recombination and how new genes are formed. See genetic recombination info sheet.

    a. Explore how students would do the gummy bear activity differently to accommodate homologous recombination?

    b. Students can explore the concept of genetic recombination and use that data to evaluate cause-and-effect relationships of parent genes to their offspring in the "**twin model**" activity.

    c. Students can explore the cause and effect of genetic recombination and how new gene combinations form by mixing up two small spheres of Play-doh (or beads). They will mix it for 5 seconds and then break it into four equal pieces. They will then roll them into spheres and compare their spheres to other students. (**Possibility to analyze their results and record their data).**

3. Gene simulation websites/resources:

    a. **CGS LAB**
    b. **EduMedia Heredity**
    c. **Legends of Learning**
    d. **Build a pigeon** (**complete folder**)

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