

MODEL-BASED INQUIRY UNIT DEVELOPMENT TEMPLATE

This template is meant to scaffold the design and implementation of MBI units. We take as a starting place three-dimensional instruction as described in the NGSS, the elements of Ambitious Science Teaching, the importance of anchoring instruction in real-world phenomena, and the perspective that students' ideas are invaluable resources for instruction. These ideas provide the foundation for MBI units during which students collaboratively engage in the practices of science as they construct scientific explanations of an anchoring phenomenon. The template is divided into four stages and includes an assessment section at the end. Throughout the template, useful resources and examples are provided. Additional information and resources are available at www.modelbasedinquiry.com.

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PLANNING FOR ENGAGEMENT WITH IMPORTANT SCIENCE IDEAS

This first stage of MBI focuses on doing the intellectually rigorous work of unpacking standards, identifying an anchoring phenomenon and driving question, and pinpointing the important science ideas students will need to build a scientific explanation of the phenomenon. In addition, in this stage we plan "with the end in mind" by constructing draft models and causal explanations that we can use as learning targets throughout the unit.

Science Area Focus (e.g., Middle School Life Science, High School Chemistry):

High School Biology

What do you want to teach?

Disciplinary Core Idea(s) focus of Lesson: (Identify DCI at the bullet point(s) grade band progression)

LS3.A Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in

regulatory or structural functions, and some have no as-yet known function.

LS3.B Variation of Traits

- 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, and viable mutations are inherited.
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.

Why is the DCI above a core idea(s) in science?

Identify the DCI in *Framework for K-12 Science Education* using the following links:

Physical Science: <https://www.nap.edu/read/13165/chapter/9>

Life Science: <https://www.nap.edu/read/13165/chapter/10>

Earth and Space Science: <https://www.nap.edu/read/13165/chapter/11>

Engineering, Technology, & Applications of Science: <https://www.nap.edu/read/13165/chapter/12>

An additional resource is [*Disciplinary Core Ideas: Reshaping Teaching and Learning*](#) from NSTA Press.

What does the [*Framework*](#) say about the core idea(s)?

LS3.A: Inheritance of Traits

Chromosomes consist of DNA, and this DNA contains segments of genes that guide the formation of specific phenotypic characteristics. Some genes control the production of specific proteins that can affect phenotypic traits, i.e skin color, eye color, hair color, etc.

LS3.B: Variation of Traits

Genetic information passed from parents to offspring is coded in the DNA within the chromosomes. Each parent contributes half of the genes acquired by the offspring. During sexual reproduction, or meiosis, genetic sections of the chromosomes can move around and create new genetic combinations and more genetic variation. Errors can occur during the meiotic process and result in mutations, another source of genetic variation. Viable mutations can be inherited from parent to offspring, and affect the probability of occurrence in a population.

Summary:

After reading through the specific DCIs focusing your unit, write a summary in your own words that describes why this is a/these are core idea(s) in science, along with the facets of the core idea(s) that are most important for students to understand:

Summary: ([Guidance](#) and [Example](#) of Unpacking)

The genes present in the DNA of a chromosome help to explain the genotypic and phenotypic differences seen in organisms of the same species i.e. Fugate Family. The genes code for specific proteins, and these proteins can be varied during meiosis when parents ($\frac{1}{2}$ from each parent) are passing their genetic information to their offspring. This passing of genetic information can be predicted and traced through many generations, due to the principles of Mendelian Genetics, and can be useful when determining the starting point of a phenotype. The environment a particular species inhabits may help to explain why some genes become favorable, as small isolated populations often have connections to inbreeding (incest).

What are the Performance Expectations that you are working toward?

[Performance Expectation\(s\)](#): (Search by DCI)

HS-LS3-1:

Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

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

ANCHORING PHENOMENON

Identify a scientifically rich, complex phenomena that will require students to use multiple principles that are central to the DCI(s) and the big idea to explain (an occurrence or event that happens(ed) in the world). [This will serve as the reason for engaging in the unit.] Resources for learning about [phenomena](#) as well as [phenomena Ideas](#).

The Fugate Family a.k.a The Kentucky Blue People

In 1820, Martin Fugate settled into Troublesome Creek, Kentucky with his wife Elizabeth Smith. Martin had a blue hue to his skin, while his wife was normal-colored. Both Martin and Elizabeth possessed the recessive “blue skin” gene required to give an individual blue skin, so four out of seven of their offspring had blue skin.

Due to the Fugate Families isolated location within Kentucky, many members married and had children within the same bloodline (i.e. incest/inbreeding). This is what allowed for the continued reproduction and expression of the “blue skin” gene. When a gene passes from one family generation to another it is called a hereditary gene.

It was when two blue-skinned individuals approached Dr. Madison Cawein about their condition that a cause and cure was discovered. The Fugates carried a rare hereditary blood disorder that causes excess levels of methemoglobin in their blood. Methemoglobin is non-functional and is the blue version of the usually healthy red hemoglobin. Methemoglobin is due to the lack of an enzyme called diaphorase that aids in binding oxygen to hemoglobin, and giving it its red color. The excessive amount of Methemoglobin in the Fugates’ blood is what made their skin look blue, and was the direct result of both parents carrying the recessive ‘blue skin gene.’ The cure for the disorder is to use methylene blue dye to turn the non-functional blue hemoglobin back into the healthy red hemoglobin. The transformation is seen within minutes, and the methylene blue needs to be administered daily as it is filtered out in urine.

In 1975, Benjamin “Benjy” Stacy was born and had the same blue skin as the past Fugate Family did. It was determined that Benjy’s great grandmother, Luna Fugate, was a member of the Fugate family and had blue skin. The “blue skin” gene was passed down through Benjy’s father, and then to him.

List resources (websites, articles, books, etc.) that help you better understand the anchoring phenomenon:

- Travel Channel Video: <https://www.travelchannel.com/videos/blue-people-roaming-the-hills-0217150>
- Article: <https://allthatsinteresting.com/blue-fugate-family-kentucky>;
<https://abcnews.go.com/Health/blue-skinned-people-kentucky-reveal-todays-genetic-lesson/story?id=15759819>
- Fugate Family Tree:
 - Original: <https://kentuckybluepeople.files.wordpress.com/2011/12/family-tree.jpg>
 - Revised Version (better for the unit):
<https://docs.google.com/document/d/1L2QHm-bkoTOBZEXoOa435r61hS1sjoZ9uUsNXIm3yHw/edit?usp=sharing>

Identify the Crosscutting Concept(s) that can also be used to orient to the anchoring phenomenon in ways that can focus and support the development of the mechanistic explanation of the phenomenon (explain this connection). [The performance expectations identified above should be used as a guide]

Crosscutting Concepts:

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

- Explain how the gene for methemoglobin was able to emerge and persist

- Determine the family history of the Fugate based on genotypes

Develop a Driving Question that will help bound the work of the unit and frame the anchoring phenomenon for the students. The question should be causal and not easily answered. Causal questions usually begin with ‘why’. It is also important to make this question specific to your anchoring phenomenon by referencing the phenomenon in the question. Consider using a Crosscutting Concept to Orient Students to the Anchoring Phenomenon in your Driving Question. (e.g., [Patterns/Cause and Effect](#))

Driving question:

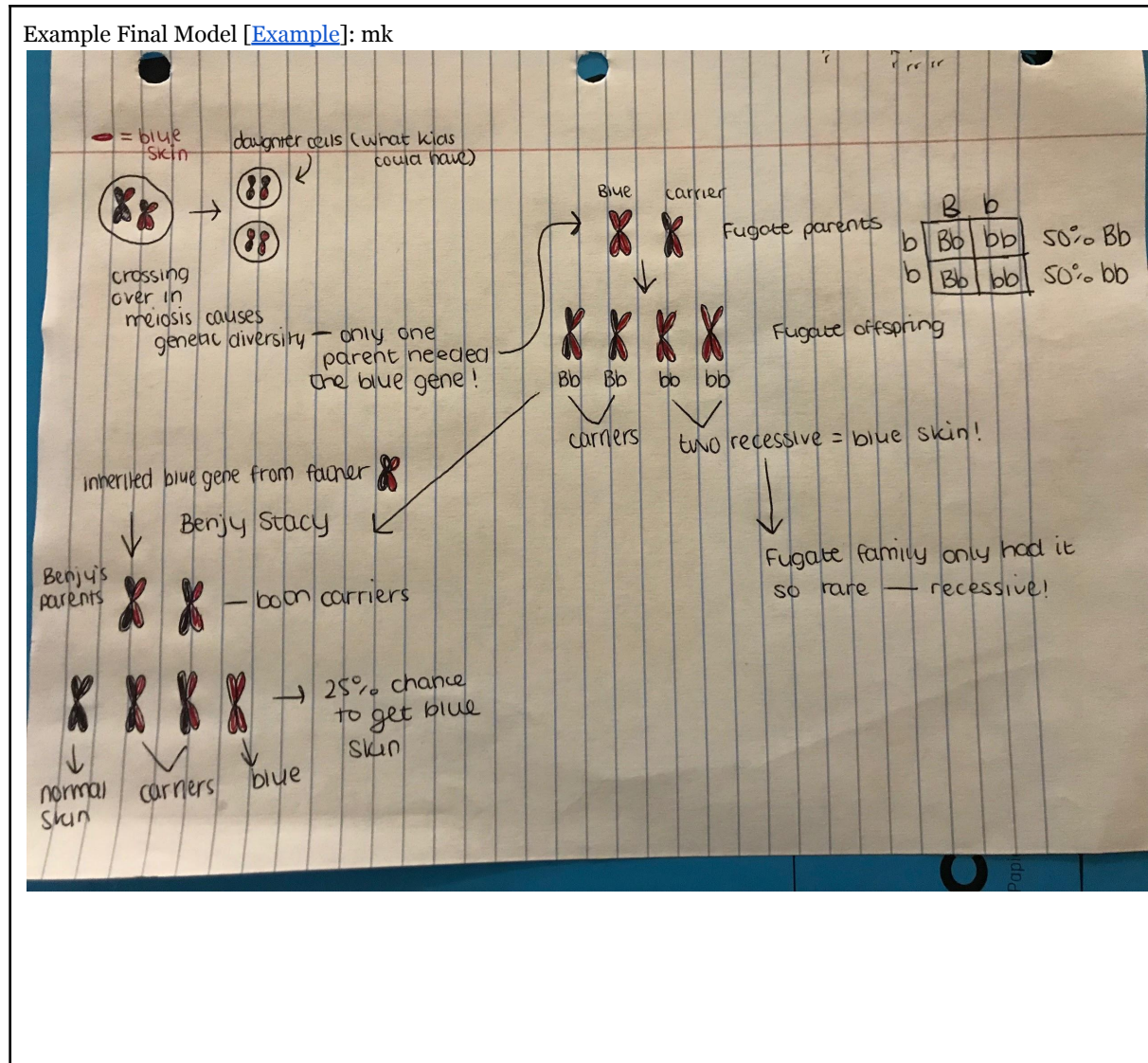
**How and why did the Kentucky Blue People turn blue?
Why were only some of the family members affected?
How did the condition persists for more than a century, as seen in Benjy Stacy?**

Provide a target written explanation of phenomenon. Be sure to consider the role of the crosscutting concept(s) you identified above as part of the explanation. This should be written slightly above that of an A student in your class and at the appropriate grade level. (Note: the explanation should identify how science ideas are coordinated to explain the occurrence or event that happened in the world) (Resources for understanding and constructing [explanations](#)):

Target explanation of phenomena:

The Fugate families blue skin was ultimately caused by a rare blood disorder that carries an excess amount of Methemoglobin in their blood. Methemoglobin is non-functional, and is the blue version of the usually healthy red hemoglobin present in blood. The excessive amount of Methemoglobin in the Fugates’ blood is what made their skin look blue, and was the direct result of two recessive methemoglobin genes from both parents coming together during meiosis. Meiosis combines the genetic traits of both parents to create four possible outcomes as to what the traits of the offspring could be. The ‘blue skin’ gene is recessive, and will only be expressed when two individuals who have the recessive gene reproduce. Since the Fugate Family was isolated in Troublesome Creek, Kentucky, they often reproduced with members of the same bloodline. This containment within the same bloodline allowed for the recessive ‘blue skin’ gene to be expressed in both parents, and give their offspring a higher chance of also having blue skin. Martin Fugate by chance had offspring with a woman who was a carrier for methemoglobin, which is what allowed for the two recessive genes to be present (not a result of incest). Only some of the Fugate Family was affected due to the genetic variation and diversity that happens as a result of meiosis. Meiosis creates four daughter cells from a single chromosome from each parent -- this single chromosome is then duplicated to create two sister chromatids and is then split into two chromatids containing the exact same genetic material. A single chromatid from the mother and a single chromatid from the father will exchange genetic information (crossing over & independent assortment) and combine in one of the four daughter cells. This exchanging of information, or crossing over, is what creates the genetic diversity of the offspring, as well as what can bring together two recessive genes into one daughter cell. The condition was able to persist for more than a century due to the fact that it was a recessive gene. A recessive gene can be carried within an individual without being phenotypically shown, as was the case with Elizabeth Smith; she is known as a gene carrier. Fugate members reproduced with others outside of their bloodline, which gave those specific offspring a decreased chance for developing blue skin due to the potential lack of two recessive genes coming together. But, just because a gene is recessive, does not mean it is completely gone from an individual’s DNA nor that it cannot be passed from generation to generation without being seen. In Benjy’s case, his great grandmother had blue skin and reproduced with someone with normal-colored skin, decreasing their offsprings chance of having blue skin, but still giving them the recessive gene to carry. The recessive blue gene was passed to Benjy’s father as a carrier, and then passed to him.

Construct an example final model that you would expect your students to develop over the course of the unit. Be sure to include the system boundaries, components of the system, connections between those components, the “unseen” mechanisms at work, and labels. This will help you develop a template and/or conventions for the students’ models. **Be sure to consider the alignment between your target explanation (above) and your final model.** Resources for understanding [scientific models](#).



From your target explanation and example final model, identify ideas in science within the explanation that are central to students explaining the phenomenon [this can serve as an early ‘Gotta Have List’]

that you go into the lesson considering, while also serving as a guide for identifying science activities students can engage in as part of the unit after initial modeling to work on developing more sophisticated explanations of the phenomenon] ([Example](#)):

Science Idea A: How Protein Synthesis Arises from DNA

- **Transcription**
- **Translation**
- **Genes code for proteins**
 - **Genes are within DNA**
 - **Nucleotide sequences within genes determine amino acids**
 - **Amino acids make up proteins**
- **Gene Expression and Mutations**

Science Idea B: Inheritance of DNA (Meiosis)

- **Phases**
 - **Meiosis 1 & 2**
 - **4 daughter sex cells (gametes) produced -- male gametes are sperm; female gametes are eggs**
 - **Sperm + egg = zygote that is diploid**
 - **Haploid vs. Diploid**
- **Crossing Over/Independent Assortment**

Science Idea C: Mendelian Genetics & How Variability Happens in Inheritance

- **Homozygous, Heterozygous, Genotype, Phenotype**
- **Gene, allele, trait, recessive gene, dominant gene**
- **Mendel Law of Dominance, Segregation, Independent Assortment**
- **Difference Between Recessive and Dominant**
- **Punnett Squares and Probability**
 - **Monohybrid & Dihybrid**
 - **Predictions**

For each science idea identified above, choose one activity, reading, video, simulation, or investigation that will help students understand this important idea and begin to see its usefulness in explaining the anchoring phenomenon. Do this for each science idea below: [possible resources: [Phet Simulations](#), [NGSS Pathfinder](#), [National Science Digital Library](#), [Argument Driven Inquiry](#)]

Science Idea A:

Protein Synthesis Animation:

<https://www.wiley.com/college/boyer/0470003790/animations/translation/translation.htm>

Protein Synthesis Video:

<https://www.youtube.com/watch?v=gG7uCsKUOrA>

Review Worksheet:

<http://www.buckeyevalley.k12.oh.us/userfiles/247/Classes/8496/Protein%20Synthesis%20wkst%20key.pdf>

Science Idea B:

McGraw Hill Meiosis Video:

http://highered.mheducation.com/sites/0072495855/student_view0/chapter28/animation_how_meiosis_works.html

Haploid vs. Diploid Picture:

<http://ib.bioninja.com.au/standard-level/topic-3-genetics/32-chromosomes/diploid-versus-haploid.html>

Independent Assortment Video:

http://highered.mheducation.com/sites/0072495855/student_view0/chapter28/animation_random_orientation_of_chromosomes_during_meiosis.html

Crossing Over Video:

https://highered.mheducation.com/sites/9834092339/student_view0/chapter11/meiosis_with_crossing_over.html

Comparing Mitosis and Meiosis Video:

https://highered.mheducation.com/sites/9834092339/student_view0/chapter11/comparison_of_meiosis_and_mitosis.html

Comparing Mitosis and Meiosis Activity:

<http://www.artgumbo.org/post.html#c183MzgxNw==>

Meiosis Drawing Activity:

http://vhenderson.weebly.com/uploads/2/1/5/9/21591494/meiosis_drawing_worksheet_with_just_blank_bubbles.png

Crossing Over Activity:

<https://www.thoughtco.com/crossing-over-lab-1224880>

Science Idea C: Modeling of Students Own Monohybrid Traits

Dominant & Recessive Gene Investigation:

http://www.awissd.org/images/Files/Outreach/traits_compairing.pdf

Mendel's Pea Plant Experiment Video:

<https://www.youtube.com/watch?v=Mehz7tCxjSE&v1=en>

Dog Breeding Online Investigation:

http://grownups.pbskids.org/dragonflytv/games/game_dogbreeding.html

Punnett Squares: Create your own Worksheet/directions

Identify the disciplinary core idea progressions for each of your DCIs. These will serve as resources for helping you draw on past learning to connect to current learning and help you understand how this learning will be useful for students in future learning. In other words, what does the progression say about your DCI in the grade bands just before and after yours?

Previous grade band (6-8)

LS3.A:

Genes chiefly regulate a specific protein, which affect an individual's traits.

LS3.B:

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.

Target grade band (9-12)

LS3.A:

DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ

LS3.B:

The variation and distribution of traits in a population depend on genetic and environmental factors. Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis.

ELICITING STUDENTS' IDEAS (TO ADAPT INSTRUCTION)

The second stage of MBI is the first enacted in the classroom with students. It involves introducing the anchoring phenomenon and driving question, eliciting students' initial ideas and experiences that may help them develop initial explanations of the phenomenon, and the construction of initial models of the phenomenon based on those current ideas. In designing units, this phase usually takes up the first day of the unit.

The [Talk Science Goals and Talk Moves](#) is a resource for responsiveness to student thinking throughout the unit. Additional resources are the [Talk Science Primer](#) and the [Ambitious Science Teaching Discourse-Primer](#).

Day 1: Outline how you plan to engage students in beginning to coordinate their initial ideas into a scientific explanation of the anchoring phenomenon. How will you introduce the phenomenon and driving question? What is your plan for eliciting student initial ideas about the phenomenon? How will student groups begin to construct models (e.g., group sizes, directions to students including some introduction to [what a model is](#), etc.). Be sure to include where and how you will use [public records](#) to help focus students reasoning during this process. Include any videos, templates, web resources, etc. you might want to use. Describe how students will share their initial models

with peers in small group and whole group discussions. Utilize the Ambitious Science Teaching [practices tool](#) and [primer \(Example Day 1\)](#). Also consider our [Openers and Closers Resource](#) for supporting the design of daily lessons.

Outline Day 1:

General Guidance

[Step 1. Introducing the anchoring phenomenon and eliciting observations (whole class)

Step 2. Eliciting hypotheses about "what might be going on" (whole class or small groups)

Step 3. Pressing for possible explanations (have them work in small groups for part of this)

Step 4. Summarizing and selecting the forms of ideas to make public (whole class) (construct public records such as initial models, initial hypotheses list, etc.)]

Outline Day 1: Introduction to phenomena/beginning of inquiry project

Instructional Context

What do I know about my students that will inform this lesson?

- Students will need support in constructing models. We will begin with a discussion about what should be included in a model, how ideas should be represented, and what to do when they don't know an answer.
- Students will have trouble regulating themselves during discussion, so some review of norms and expectations for discussion prior to beginning should happen.

How does this lesson connect with and build on previous lessons?

- Students will have done previous lessons covering cell division/mitosis, DNA structure, and protein synthesis. They will be able to make connections to how the division of cells (and the chromosomes inside) during mitosis can explain reproduction, and how DNA contains genes that form the basis for protein synthesis and genetic mutations.

How do you expect to build on this lesson in subsequent lessons?

- This lesson will be the first step in presenting the phenomena and eliciting student ideas.
- Students will need information on a different cycle of cell division that is based around creating reproductive cells that contain genetic information (meiosis) rather than the growth cell cycle they are already familiar with (mitosis)

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
5 min	Introduce phenomena	- Explain that we will be investigating the reason why the Fugate Family of Kentucky had blue skin - Play video	- Watch video - Begin to think about the things that may be the cause of the Fugate families blue skin	Introduce students to the phenomena and begin their brainstorming process
10min	Brainstorm "Gotta Have List"	Explain to students that they will be creating initial models to explain the phenomena, and ask what terms or concepts they think	Brainstorm what they know about how skin color is determined, and why the Fugate family was affected.	Give students a starting point for when they begin to construct their models

		they will need to construct their explanation		
25min	Construct models in small groups	- Divide students into groups - Circulate and prompt students with guiding / backpocket questions to elicit ideas and keep them on track	- Send one student from the group to the front of the room to get materials - Work together to construct an initial explanatory model	- Have students collaborate in small groups to begin to develop an explanation
Until End of Class	Class discussion and model sharing	- Scaffold the order in which groups will share their models - Use talk moves to regulate discussion	- Share models with class - Respond to questions and actively contribute to discussion while following class norms	- Share ideas and reach an initial group consensus

Student Supports

List what you are using to support student learning/organization:

- Phenomena video (<https://www.travelchannel.com/videos/blue-people-roaming-the-hills-0217150>)
- Pre-made list of guiding, back pocket, and discussion questions

Materials and Resources

List materials and resources needed:

- Powerpoint slides with video, discussion and modeling norms, and place for writing in initial gotta have list
- Chart paper
- Markers

SUPPORTING ON-GOING CHANGES IN THINKING (WITH THE AIM OF USING SCIENCE IDEAS BEHIND ACTIVITIES TO MAKE SENSE OF ANCHORING PHENOMENON)

The goal of the next stage is to support the students' on-going changes in thinking by providing learning experiences that help coordinate their ideas and powerful ideas in science to build a scientific explanation of the anchoring phenomenon. This involves designing or adapting a number of purposeful tasks, coordinated with the important science ideas identified earlier, and the construction and use of public records such as a Summary Table to help keep track of ideas. Important in this stage is the revision and testing of the students' models. This stage makes up the

majority of the unit as the class works to develop their explanations of the phenomenon through engagement in the practices of science.

Day 2-x:

Identify how you will ‘put on the table’ science ideas you identified above that are central to explaining the anchoring phenomenon using science activities you identified for each idea above (e.g., activity, reading, video, simulation, investigation) that prioritizes students engaging in science and engineering practices to develop an understanding of the principle that will be helpful in later stages of the unit in explaining the anchoring phenomenon. Describe how you will use Summary Tables ([examples](#)) or [activities](#) across these activities to help students keep a record of activities, ideas, and evidences that will be used to later in the unit to revise their initial models of the anchoring phenomenon. You may want to include a model revision halfway through the activities. Utilize the Ambitious Science Teaching [practices tool](#) and [primer](#). ([Example Days 2-5](#)). Also consider our [Openers and Closers Resource](#) for supporting the design of daily lessons.

Outline Day 2:

General Guidance

[Note: For each activity, be sure to include the following:

Step 1: Providing students with an idea to use as leverage during the activity.

Step 2. Getting the activity started: Helping students uncover observation and patterns (use back pocket questions).

Step 3. Helping students connect activity to the anchoring event (use back pocket questions).

Step 4. Whole class coordination of student's ideas & their questions.]

Outline Day 2: Review of Protein Synthesis & Relating to Driving Question

Instructional Context

What do I know about my students that will inform this lesson?

- Students may have never completed a summary table before. They will need support to explain its purpose and how to fill it in

How does this lesson connect with and build on previous lessons?

- Students will be reviewing the end of their previous unit (DNA structure and function), and then be applying that knowledge towards the new phenomenon of the Kentucky Blue People

How do you expect to build on this lesson in subsequent lessons?

- Gene expression is directly related to protein synthesis; meiosis is creating genetic diversity and mendelian genetics describes how genes are produced

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
5min	Recap the Driving Question/Phenomena	Review the phenomena we are investigating, and what we did yesterday in our initial models	Think about what concepts were key points in the initial models created yesterday, as well as where some confusions were	Ensure the students are still thinking about the phenomena

3min	Review of Protein Synthesis Video	- Explain to students that they will be creating a list of the most important points from the video/their prior knowledge - Play video	- Taking note of important details the video mentions - Remembering important ideas from the previous unit	Remind students of previous knowledge and get them thinking about how it could relate to the phenomena
15min	Create chart of most important points from video OR prior knowledge on the subject (first in pairs, and then as a whole class -- Think, Pair, Share)	- Give directions - Choose a student volunteer to be the scribe for the chart - Mediate the creation of the chart	- Talking with partner, and class, about most important details from video and prior knowledge - Think about connections to the phenomena	Creating a concise and agreed upon 'important facts' chart that will service students in creating the summary table and connecting to the phenomena
15min	Worksheet Completion on Protein Synthesis Basics and Mutations	- Pass out worksheet - Answer questions - Give directions	- Complete both worksheets, either individually or in pairs	Solidify the concept of protein synthesis & mutations -- no confusion
15min	Summary Table	- Explain the concept of a summary table and why we use it - Mediate classroom discussion about what to include in the table - Write finalized student ideas onto table	- Think about how the structure of DNA, protein synthesis, and mutations could relate to the Kentucky Blue People and help to answer the driving question(s) - Discuss with classmates about what to include in the table - Discuss any remaining questions	Create a visible resource for students to use throughout the unit that helps to explain the phenomena one activity at a time
3min	Exit Slip: "What do we use a Summary Table for?"	- Hand students an exit slip - Collect the exit slip before students leave the classroom	- Complete the Exit slip before leaving the classroom	Ensure that students know the purpose of a summary table, as well as its function

Student Supports

List what you are using to support student learning/organization:

- Protein Synthesis Animation:
<https://www.wiley.com/college/boyer/0470003790/animations/translation/translation.htm>
- Protein Synthesis Video:
<https://www.youtube.com/watch?v=gG7uCsKUOrA>

- Review Worksheet:
<http://www.buckeyevalley.k12.oh.us/userfiles/247/Classes/8496/Protein%20Synthesis%20wkst%20key.pdf>

Materials and Resources

List materials and resources needed:

- Video
- Worksheets printed
- Creation of the Summary Table ahead of time (including teacher version of it to ensure all relevant information is being included)
- Exit slip printed out

Outline Day 3: Introduction to Meiosis -- Stages of Meiosis

Instructional Context

What do I know about my students that will inform this lesson?

- Students will have already learned about mitosis, and will most likely draw upon that cycle as prior knowledge (could also create confusion)
- Students may need another reminder about what modeling is, having done it for the first time only two days ago

How does this lesson connect with and build on previous lessons?

- Drawing upon their prior knowledge of the similar mechanisms and stages to that of Mitosis that was learned two units ago
- Another opportunity for students to create models and begin to feel more comfortable with explaining their thinking

How do you expect to build on this lesson in subsequent lessons?

- Meiosis begins to touch upon the parental combination of genetic information that is then passed to their offspring. This is the mechanism behind Mendelian genetics, which is the next lesson

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
10min	Meiosis Challenge/Mini Model: Have students work in pairs to draw out as much of meiosis as they can, including phase names and descriptions. (Set these aside to refer back to later!)	- Observe students progress - Engage students in discussion about their mini meiosis model (backpocket questions, clarification) - Emphasize that there are no wrong answers here!	- Using prior knowledge of meiosis or related cell cycles, draw out the phases of meiosis (including descriptions)	Clear indication of what students know/do not know in relation to meiosis
5min	Introduction Video to How Meiosis Works	- Play video - Emphasize that you just want the students to be getting the general idea of what	- Watch the video - Begin to think about meiosis and its different stages, taking notes as	Introduce students to meiosis

		meiosis is, and that you will go over details after	needed in their scientists notebook	
35min	Interactive Direct Instruction of the stages of meiosis	- Give students blank meiosis sheet - Use the whiteboard to begin drawing/describing the stages of meiosis - Call upon students to participate in the instruction -- add their knowledge to it	- Take appropriate notes on the blank meiosis sheet - Add knowledge to the instruction of meiosis -- engage with the teacher, classmates, etc. - Begin to think about how these notes are different or similar to what was created at the beginning of class (Meiosis Mini Model)	Inform students of the stages of meiosis
5min	Homework: Create your Meiosis Flashcards	- Explain the homework - Handout notecards, if necessary	- Write homework down in planner - Get note cards from teacher, if needed	Artifact creation for referral, and review, during the rest of the unit

Student Supports

List what you are using to support student learning/organization:

- How Meiosis Works Video:
http://higherred.mheducation.com/sites/0072495855/student_view0/chapter28/animation_how_meiosis_works.html
- Meiosis Drawing Activity: (or create your own)
http://vhenderson.weebly.com/uploads/2/1/5/9/21591494/meiosis_drawing_worksheet_with_just_blank_bubbles.png

Materials and Resources

List materials and resources needed:

- Video
- Blank meiosis sheets (at least 2 copies per student)
- Colored pencils/markers/crayons
- Blank notecards

Outline Day 4: Introduction to Meiosis Cont. -- Haploid/Diploid & Crossing-Over/Independent Assortment

Instructional Context

What do I know about my students that will inform this lesson?

- Completely new information, so explicit discussion and clarifying of confusions will be important
- Summary table is still a new concept, so some revision of its purpose and how to fill it out may be necessary

How does this lesson connect with and build on previous lessons?

- Continuation of Meiosis, and begin to look at the details within some of the stages that emphasize its importance for inheritance and genetic diversity.

How do you expect to build on this lesson in subsequent lessons?

- Meiosis connects to the passing of genetic information from parent to offspring, and is the basis behind how Mendelian Genetics functions
- The topics (haploid/diploid; crossing over; independent assortment) are specific characteristics of meiosis, and will be crucial details for students to remember when thinking back to mitosis

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
3min	Quick recap of the Meiotic stages	- Briefly review the stages of meiosis - Hang meiosis diagram in classroom and tell students they may use it as a reference	- Listen to the teachers review, and add in any additional information - Ask any clarifying questions	Get students back into the mindset of thinking about meiosis and its stages
10min	Haploid vs. Diploid	- Show picture of what it is - Give information about it, as well as how it relates to the stages of meiosis	- Take notes about what each word means (add it to their diagram/flashcards!) - Observe where the teacher is talking about it occurring within meiosis - Ask clarifying questions, as necessary	New information to students about meiosis -- beginning of meiosis is diploid, end is haploid
20min	Crossing Over & Independent Assortment (information and activity)	- Play videos - Write more in depth notes for the students, allowing them to add their knowledge as applicable - Ask the students <i>why</i> these two aspects are so important and crucial to meiosis - Give out directions/supplies for crossing their own chromosomes	- Actively watch the video (notes not necessary) - Engage in the note-making about crossing over/independent assortment - Ask clarifying questions - Engage in discussion about the importance of both - Complete the chromosome crossing activity	Students begin to see the idea of genetic diversity develop, as well as the mechanism behind crossing genetic information
10min	Look back at Mini Model created yesterday: Use sticky notes to add in or revise information	- Give students sticky notes to use - Give directions to students, saying to look back at their 'initial' model and use	Revise mini model using sticky notes to show that initial ideas can change (information can be added, revised or	Revisit initial mini models and think how the new information does or does not support their

		the sticky notes to revise their thinking - Clear up any confusions students might have	changed) - Ask questions to clarify ideas about meiosis, haploid/diploid, crossing over/independent assortment	initial ideas put down
10min	Summary Table	- Mediate classroom discussion about what to include in the table - Write finalized student ideas onto table	- Think about how meiosis up until this point could relate to the Kentucky Blue People and help to answer the driving question(s) - Discuss with classmates about what to include in the table - Discuss any remaining questions/things we want to be answered	Visible resource for students to use throughout the unit that helps to explain the phenomena -- explains importance of meiosis as it relates directly to the phenomena

Student Supports

List what you are using to support student learning/organization:

- Haploid vs. Diploid Picture:
<http://ib.bioninja.com.au/standard-level/topic-3-genetics/32-chromosomes/diploid-versus-haploid.html>
- Independent Assortment Video:
http://highered.mheducation.com/sites/0072495855/student_view0/chapter28/animation_random_orientation_of_chromosomes_during_meiosis.html
- Crossing Over Video:
https://highered.mheducation.com/sites/9834092339/student_view0/chapter11/meiosis_with_crossing_over.html
- Crossing Over Activity:
<https://www.thoughtco.com/crossing-over-lab-1224880>

Materials and Resources

List materials and resources needed:

- Sticky notes
- Activity copies
- Video(s)
- Colored paper and markers for Crossing Over Activity
- Chart paper

Outline Day 5: Comparing Mitosis and Meiosis

Instructional Context

What do I know about my students that will inform this lesson?

- Students will feel fairly comfortable with most of the material during this lesson so I anticipate it to be fairly student led and independent of teacher assistance
- Students will know how to create Venn Diagrams/comparison tables, so little to no review will be done

How does this lesson connect with and build on previous lessons?

- This lesson is drawing upon the Mitosis units material and and creating a clear connection between the two cycles as it pertains to the replication of cellular and genetic information
- Builds upon previous lessons that were focused around student led discussions

How do you expect to build on this lesson in subsequent lessons?

- Meiosis connects to the passing of genetic information from parent to offspring, and is the basis behind how Mendelian Genetics functions

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
10min	Steps of Mitosis Review: Student-Led	- Choose one student to be the scribe for the review - Mediate the review -- ensure all students are following appropriate discussion norms	- Engage with classmates in a discussion about the steps of mitosis - Create a clear and agreed upon representation of the cycle	Review Mitosis
5min	Comparing Meiosis and Mitosis Video	- Play video	- Begin to think about the differences and similarities between the two cell cycles -- phases, end number of cells, purpose of cycle, etc.	Students begin to see the differences/similarities between the two as it pertains to the function of each cycle and its overall purpose
20min	Create Comparison Chart/Venn Diagram	- Have students first work in pairs, and then come together as a class - Incorporate students ideas into the chart	- Work with partner to create a chart of the similarities and differences between meiosis and mitosis - Engage in classwide creation of a chart - Add additional information to your own chart as it is talked about in class	Show clear distinctions between the two cycles as to not confuse them

Student Supports

List what you are using to support student learning/organization:

- Comparing Mitosis and Meiosis Video:
https://highered.mheducation.com/sites/0834092339/student_view0/chapter11/comparison_of_meiosis_and_mitosis.html

- Comparing Mitosis and Meiosis Activity:
<http://www.artgumbo.org/post.html#c183MzgxNw==>

Materials and Resources

List materials and resources needed:

- Video
- Chart paper and markers

Outline Day 6: Introduction to Genetics & Gregor Mendel

Instructional Context

What do I know about my students that will inform this lesson?

- Students will have only been exposed to a limited amount of genetics material. When in doubt, go over it again.

How does this lesson connect with and build on previous lessons?

- Uses the topic of genetic diversity and variation to connect meiosis to the phenotypic outcomes of crossing certain genes.

How do you expect to build on this lesson in subsequent lessons?

- Begin to look at the smaller details more in depth -- recessive genes, dominant genes, etc, as well introduce new vocabulary to further their understanding
- Discuss the use of Punnett Squares and probability in determining traits

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
4min	Video: Mendel's Pea Plants	- Play video	- Actively watch the video, taking notice of important details to be shared in classroom dialogue	Introduce students to Gregor Mendel, his experiment, and laws of genetics
10min	Gregor Mendel and his Experiment	- Brief History on Mendel - Work along with the students to determine some of the most important aspects of Mendel's experiment, and ask students <i>why</i> they are so important	- Participate and discuss Mendel's Pea Plant experiment - Add in prior knowledge of him or his experiment	In depth look at Mendel's experiment and its importance -- created the laws used for genetic inheritance and variation
15min	Mendel's Laws: Segregation, Independent Assortment Dominance	- Introduce the three laws Mendel determined from his experiment	- Take note of his laws - Ask clarifying questions - Think about why these laws are so crucial to understanding genetics	Basis for understanding the inheritance qualities of genetics, genotypically and phenotypically
30mi	Dog Breeding Online	- Introduce the game	- Play the game	Students begin to

n	Game	and directions - Hand out the worksheet that goes along with the game - Walk around the room and answer questions	- Fill out the worksheet and complete the questions - Begin to think about and understand the mechanisms behind genetics	understand the mechanics behind genetics and how they work (dominant, recessive, heterozygous, homozygous, etc.)
10min	Summary Table	- Mediate classroom discussion about what to include in the table - Write finalized student ideas onto table	- Think about how Mendelian genetics could relate to the Kentucky Blue People and help to answer the driving question(s) - Discuss with classmates about what to include in the table - Discuss any remaining questions/things we want to be answered	Visible resource for students to use throughout the unit that helps to explain the phenomena -- explains importance of meiosis as it relates directly to the phenomena

Student Supports

List what you are using to support student learning/organization:

- Mendel's Pea Plant Experiment:
<https://www.youtube.com/watch?v=Mehz7tCxjSE&vI=en>
- Dog Breeding Online Investigation:
http://grownups.pbskids.org/dragonflytv/games/game_dogbreeding.html
- Dog Breeding Online Investigation Worksheet:

Materials and Resources

List materials and resources needed:

- Chromebooks for each student
- Video
- Printed worksheets
- Chart paper and markers

Outline Day 7: Recessive vs. Dominant Investigation

Instructional Context

What do I know about my students that will inform this lesson?

- Students have done past investigations that have dealt with observations, collecting data, and making inferences

How does this lesson connect with and build on previous lessons?

- Students began to learn about dominant and recessive genes in the previous Dog Breeding Game, as well as the different phenotypes that can happen as a direct result of different combinations of genotypes

How do you expect to build on this lesson in subsequent lessons?

- The idea of dominant and recessive genotypes and phenotypes is an important part of understanding Punnett squares

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
5min	Brief Introduction to the investigation	- Explain the investigation -- directions, expectations, time frame, purpose, etc.	- Listen to the instructions carefully - Ask any clarifying questions	Introduce students to the activity
10min	Interactive direct instruction to determine clear definitions for what dominant and recessive means (homozygous, heterozygous, carrier, etc.)	- Alongside the students, begin to determine definitions/examples for important vocabulary terms	- Participate in the class discussion about vocabulary terms using prior knowledge or material learned earlier in this unit - Take notes in scientists notebook - Ask clarifying questions - Begin to think about how these fit into the investigation	Introduce/clarify important vocabulary terms that students will be exposed to during the investigation, as well as have seen previously in past lessons
35min	Investigation (or model)	- Walk around the class - Use back-pocket questions to gauge progress and degree of comprehension - Assist students in placing this own data on the front board - Answer any clarifying questions	- Work through the investigation at a timely pace, ensuring you are always on task and focused - Ask questions - Be respectful of classmates - Write data on board once complete - Answer questions at end of investigation (complete for homework if not finished during class)	Allow students to explore their own genes for dominant or recessive characteristics
10min (if time allows)	Summary Table	- Mediate classroom discussion about what to include in the table - Write finalized student ideas onto table	- Think about how dominant and recessive genes could relate to the Kentucky Blue People and help to answer the driving question(s) - Discuss with classmates about what to include in the table - Discuss any	Visible resource for students to use throughout the unit that helps to explain the phenomena -- explains importance of meiosis as it relates directly to the phenomena

			remaining questions/things we want to be answered	
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Student Supports

List what you are using to support student learning/organization:

- Investigation Format: (not exactly what I would do, but similar)
http://www.awissd.org/images/Files/Outreach/traits_compairing.pdf

Materials and Resources

List materials and resources needed:

- Copies of Investigation sheet
- Chart paper and markers
- Bitter Taste papers

Outline Day 8: Punnett Squares -- Modeling Their Own Monohybrid Genes (Eye or Hair Color)

Instructional Context

What do I know about my students that will inform this lesson?

- Another opportunity for modeling -- some review might be necessary
- Some students may not know the totality of their family -- have back-up plan for this! Suggest working with a gene that their partner has

How does this lesson connect with and build on previous lessons?

- Building off of the Mendelian Genetics lesson -- Dog Breeding probabilities
- Recessive and Dominant investigation -- helpful for determining hair/eye color traits that are dominant/recessive

How do you expect to build on this lesson in subsequent lessons?

- Final lesson before revision of initial models/creating a final model -- introduces critical aspect of being able to fully explain the phenomena

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
5min	Introduce modeling activity -- Modeling Your Own Genes!	- Introduce the activity - Give directions about how to complete it	- Ask clarifying questions - Begin to think about your own genetics (eye color, hair color, etc.) and how you will trace those	Allow students to explore their own genes to determine phenotypes, genotypes, recessive/dominant nature, probabilities, etc.
15-20 min	Students Create Initial Model in Pairs choosing one gene to trace (hair or eye color)	- Visit student groups to ensure they are on task - Use back-pocket questions to deepen their understanding or clarify aspects of	- Work with a partner to trace a gene's inheritance - Choose which gene you'd like to use - Think about if the gene is recessive or	Give students the opportunity to look at how their own traits were inherited -- work backwards and make predictions

		their model - Begin to think about how you would like the groups to share	dominant - Think about how it is possible the gene was inherited - Create model that explains your thinking, including pictures, words, etc.	
15min	Introduce the Concept of Punnett Squares: use, types	- Use interactive direct instruction (depending on how much students know)	- Take notes on punnett squares - Begin to think about how you may be able to use punnett squares within your model (if not already there)	Introduce the mechanism at which genetic predictions can be made or supported
15-20 min	Revision of Initial Models	- Give directions on how students should revise their models -- sticky notes, complete re-do, etc. - Ensure students are referencing concepts you went over when introducing punnett squares	- Revise model using sticky notes to show that initial ideas can change (information can be added, revised or changed) - Ask clarifying questions about punnett squares	Give students the opportunity to add more information to their models and expand their learning/explanations
10min	Summary Table	- Mediate classroom discussion about what to include in the table - Write finalized student ideas onto table	- Think about how Punnett Squares could relate to the Kentucky Blue People and help to answer the driving question(s) - Discuss with classmates about what to include in the table - Discuss any remaining questions/things we want to be answered	Visible resource for students to use throughout the unit that helps to explain the phenomena -- explains importance of meiosis as it relates directly to the phenomena

Student Supports

List what you are using to support student learning/organization:

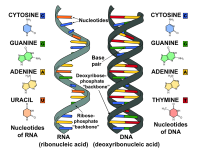
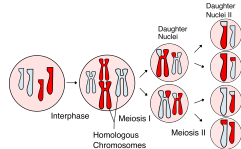
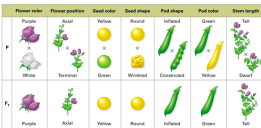
- Worksheet on Activity -- create your own!

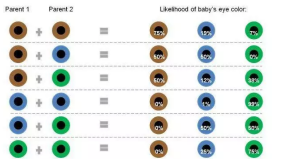
Materials and Resources

List materials and resources needed:

- Copies of activity
- Chart paper and markers
- Sticky Notes

Construct a draft summary table that includes each activity, the intended understandings from the activity, and how the activity helps develop an explanation for the anchoring phenomenon. See examples and modified templates [here](#). Adapt the table based on the number of activities in the unit. While the goal is for students to come to consensus statements to be included on the table, having already planned for what

Activity	Patterns Observed/What We Learned	How it helps us explain the phenomenon
Protein Synthesis Review 	1. Mutations can occur during the transcription or translation process of protein synthesis 2. Mutations can create different proteins that a gene originally coded for 3. Proteins are created from the genes encoded in the DNA	The Kentucky Blue People could have gotten their blue skin due to a mutation in the skins protein formation
Stages of Meiosis (including crossing-over & independent assortment) 	1. Four daughter sex cells are produced (gametes) from one parent cell that contains maternal and paternal genetic information 2. Each daughter cell contains one chromosome of shared genetic information of both parents 3. Crossing over and independent assortment of parental genes is what allows for genetic diversity	Crossing over is what allowed the blue skin gene to be passed to children -- only one parents had to have it and then share it with the other. An offspring has four different scenarios of genetic makeup.
Mendel's Laws/Pea Plants/Dog Breeding Game 	1. Children receive one allele from each parent 2. Genes for different traits are inherited independently 3. Need two copies of a recessive gene to show its trait; only one copy of a dominant gene is needed 4. Specific genes can be carried but not shown	The Kentucky Blue People had a genetic disorder due to the trait being passed down from parents to children. Some family members were carriers, but did not show blue skin.

Recessive vs. Dominant  Investigation	1. Dominant genes appear at a higher frequency than recessive genes OR Recessive genes appear at a higher frequency than dominant genes	Kentucky Blue People had a recessive genetic disorder due to it not being common
Modeling our Own Genetics 	1. Four possible outcomes children can have as a result of their parents genes 2. Predictions about genotypes and phenotypes can be made 3. Family history/inheritance can be determined 4. Monohybrid traits and dihybrid traits	Only some of the Fugate Family had blue skin -- the initial Fugate children had a 50% chance of having blue skin. Benjy Stacy had a 25% chance of having blue skin.

PRESSING FOR EVIDENCE-BASED EXPLANATIONS

At the end of an MBI unit, we press the students for evidence-based explanations. This involves, at a minimum, finalizing the student models, building consensus through discussions, the construction of the Gotta-Have Checklist, and the writing of individual evidence-based explanations of the anchoring phenomenon. We most often consider either the final model or evidence-based explanations the summative assessment of the unit.

Final 2-3 Days: (Include 2-3 days at the end of the unit)

In this part of the unit, students will engage in building or revising (with the teacher) the 'Gotta Have List' to be sure that it represents what they think should be included in the final models. Additionally, students should engage in refining their initial models by both referring to the finalized 'Gotta Have List' and 'Summary Table' that was developed across the unit. You might also consider having groups of students comment on other groups' initial models with 'Sticky Notes' prior to students making final revisions to their group models (see 'Sticky Notes [examples]'). Once students are ready to revise their models based on what they learned across the unit. Be sure to identify how you will ensure that they use the Gotta Have Lists and Summary Tables as resources for supporting their final revisions. Utilize the Ambitious Science Teaching [practices tool](#) and [primer](#). ([Example Days 6-7](#)). Also consider our [Openers and Closers Resource](#) for supporting the design of daily lessons.

General Guidance

[Step 1. Updating students' explanatory models.

Step 2. Prompting reasoning about gaps and contradictions in their explanations (in small groups).

Step 3. Preparing students to persuade others with evidence. (e.g., Gotta-Have-Checklist)

Step 4. Individual writing of evidence-based explanations.]

Outline Day 9-10: Creating a Final Model and Individual Evidence-Based Explanation

Instructional Context

What do I know about my students that will inform this lesson?

- Students will likely need support in modeling, especially since they will be incorporating many more ideas since their initial model.
- Students may also need help with staying on track, and following norms for discussion
- Students may need a quick reminder about what to include in their model

How does this lesson connect with and build on previous lessons?

- This should tie together all of the lessons done in the unit, starting with initial ideas through changes in thinking due to evidence from all of the activities

How do you expect to build on this lesson in subsequent lessons?

- This is the last lesson of this unit, but the ideas from the final model and explanations will likely be referred to in later units

Learning Tasks/Activities

<u>Time</u>	<u>Learning Task</u>	<u>Teacher Actions</u>	<u>Student Actions</u>	<u>Purpose</u>
15min	Revise "Gotta Have List"	- Present initial list - scaffold discussion about what terms need to be added or removed from the list. - encourage students to draw connections between the evidence in the summary table and the gotta have list	Use summary table to brainstorm what should be added/ removed from the list	Refresh students memories as to terms and concepts from the unit, provide a starting place for modeling
35min	Model Revision	Circulate with back-pocket questions and keep students on track	Use summary table and revised list to edit models and construct an evidence based explanation of the phenomena	Have groups reach a consensus on their explanation for the phenomena
15min	Class discussion and model sharing	Scaffold sharing of models and direct discussion	-Share models with class -Respond to questions and actively contribute to discussion while following class norms	-Share ideas and reach a final group consensus

At home	Evidence-Based Explanation	- Provide the driving question as a prompt - Provide writing scaffolds/assistance as needed (more/less) - Ensure students have access to the summary table, final model, and final gotta have list (copies or online)	Make sense of the ideas from models into a final explanation (using models, Gotta Have List, and summary table) with evidence to support claims	- Practice communicating science ideas and using evidence-based arguments and explanations - Demonstrate individual understanding
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Student Supports
List what you are using to support student learning/organization:

- Backpacket questions, talk moves
- Summary Table, Gotta Have List, Final/Initial Models

Materials and Resources
List materials and resources needed:

- Initial models and gotta have list, backpacket questions
- Chart paper and markers

ASSESSMENT OF STUDENT LEARNING

Identify formative assessment techniques you will employ throughout the unit. Note: The following is a useful framework for thinking about formative assessment: (a) anticipating and eliciting students' ideas, (b) evaluating students' ideas, and (c) crafting next steps in instruction that account for students' ideas and support students' learning. Please provide specific examples (e.g., initial "hypothesis lists"; "Gotta Have Lists"; initial models), where they occur in the unit.

What formative assessment techniques will you use?

- Developing initial Gotta Have List
- Creating initial models
- Class discussions following activities
- Revising initial models with sticky notes
- Completion of activities/investigations/online simulations

Provide a final evidence-based explanation at a level you would expect from your students at the end of the unit. The evidence-based explanation builds on the target explanation by including specific evidence from the

activities within the unit. This will look like your initial target explanation, but will include evidence from activities students will be expected to include.

Final Evidence-Based Explanation:

To begin, we initially determined that the Fugate families disease was not the result of a mutation due it being seen in multiple generations within the same family. **This was seen through our review of protein synthesis**, as mutations usually occur case by case. The excessive amount of Methemoglobin in the Fugates' blood is what made their skin look blue, and was the direct result of two recessive methemoglobin genes from both parents coming together during meiosis. **During meiosis, as seen in the crossing over activity**, the genes on the chromosomes of both parents exchange information to create four possible outcomes as to what the traits of the offspring could be. This means that the offspring will have similar genetic information to the parents, but not exact. **We saw this idea expressed while modeling our own genes**, as we often had similar traits to our parents, and our genotypes were the direct cause theirs. This helps to explain how the blue skin gene was able to be passed along to the children, as only one parent would need to have the blue skin gene and another be a carrier in order for it show. The 'blue skin' gene is recessive, and will only be expressed when two individuals who have the recessive gene reproduce. Since the Fugate Family was isolated in Troublesome Creek, Kentucky, they often reproduced with members of the same bloodline. This created a small amount of genetic diversity. This containment within the same bloodline allowed for the recessive 'blue skin' gene to be expressed in both parents, and give their offspring a higher chance of also having blue skin. **The punnett square activity and dog breeding game** helped to determine this through the use of probabilities, genotypes, and phenotypes. Martin Fugate by chance had offspring with a woman who was a carrier for methemoglobin, which is what allowed for the two recessive genes to be present (not a result of incest).

Only some of the Fugate Family was affected due to the genetic variation and diversity that happens as a result of meiosis. **During the stages of meiosis lesson**, we learned that meiosis creates four daughter cells from a single chromosome from each parent -- this single chromosome is then duplicated to create two sister chromatids and is then split into two chromatids containing the exact same genetic material. A single chromatid from the mother and a single chromatid from the father will exchange genetic information (crossing over & independent assortment) and combine in one of the four daughter cells. This exchanging of information, or crossing over, is what creates the genetic diversity of the offspring, as well as what can bring together two recessive genes into one daughter cell. This

While learning about Mendel and completing the dog breeding game, we determined that the condition was able to persist for more than a century due to the fact that it was a recessive gene. A recessive gene can be carried within an individual without being phenotypically shown, as was the case with Elizabeth Smith; she is known as a gene carrier. Fugate members reproduced with others outside of their bloodline, which gave those specific offspring a decreased chance for developing blue skin due to the potential lack of two recessive genes coming together. But, just because a gene is recessive, does not mean it is completely gone from an individual's DNA nor that it cannot be passed from generation to generation without being seen. In Benjy's case, his great grandmother had blue skin and reproduced with someone with normal-colored skin, decreasing their offsprings chance of having blue skin, but still giving them the recessive gene to carry. The recessive blue gene was passed to Benjy's father as a carrier, and then passed to him.

Provide a rubric for the evidence-based explanation. See here for an [example](#).

Rubric:



Rubric for Student's Evidence-Based Explanations

Criteria	Not Yet 1	Approaches Expectations 2	Meets Expectations 3	Advanced 4
1) Explains Phenomena: Does my explanation explain the phenomenon?	Explanation does not explain the phenomenon or only describes what happened.	Explanation includes some of the relevant parts of the explanation to explain how the phenomenon happened, but does not include the cause of the phenomenon.	Explanation connects all relevant components and relationships (observable and unobservable) to explain what caused the phenomenon.	Explanation includes the full causal story of the phenomenon including the unobservable components as well as additional components and relationships that fit the scientific explanation.
2) Fits with Evidence: Does my explanation include the evidence collected?	Evidence is not correctly related to the explanation or not included.	Explanation correctly incorporates some of the evidence collected through the investigations.	Explanation refers to a sufficient amount of relevant evidence collected through the investigations to be compelling and justifies why it is evidence.	Explanation includes all of the evidence collected and correctly justifies why it is evidence.
3) Builds on Science Ideas: Does my explanation incorporate established scientific ideas?	Explanation does not include relevant science ideas.	Explanation includes some of the essential concepts to explain the phenomena—but not all that are needed.	Explanation includes essential disciplinary science concepts AND crosscutting concepts needed to explain the phenomena.	Explanation includes essential science concepts and other relevant science ideas.
4) Clarity of Communication: Would someone else be able to understand my explanation?	Explanation is not clearly written.	Explanation is somewhat clearly written.	Explanation is clearly written in a way that allows others to understand how and why the phenomenon happens.	Explanation is clearly written and additional communication or educational pieces are included for the audience.

*adapted from the *Rubric for Student's Scientific Modeling* from the Research + Practice Collaboratory.