Why So Blue?

Recessive Gene Inheritance

K20 Center, Heather Shaffery, Erica Stewart
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Grade Level	9th – 12th Grade	**Time Frame**	120 minutes
Subject	Science	**Duration**	2-3 class period(s)
Course	Biology		

Essential Question

How do rare, recessive traits become common in a population?

Summary

Centered on the phenomenon of the Blue Fugates, students will explore how recessive traits increase in a population using a Punnett square activity, genotype/phenotype ratios and allele frequency calculations, and pedigree analysis. By the end of the lesson they will be able to explain how social, genetic, and physiological factors interacted to cause the high number of blue people in the Troublesome Creek region of Kentucky. Basic understanding of genetics, heritability, and constructing a Punnett square is required for this lesson, and it works best in the middle of a unit over genetics. This is a great second lesson after A Trait Accompli, which introduces phenotypes and genotypes.

Snapshot

Engage

Students complete a collective brain dump after watching a video about the Blue Fugates.

Explore

Students complete a Punnett square activity using model chromosomes to understand the relationships among genotype, phenotype, and protein synthesis.

Explain

Students learn how to calculate genotypic and phenotypic ratios and allele frequency, and Why-Light a reading about the Blue People of Troublesome Creek.

Extend

Students analyze a Fugate family pedigree as evidence of the genetic factors contributing to the blue trait in the family.

Evaluate

Students complete a Five Whys activity to explain the interconnected factors that can lead to an increase of a recessive allele/trait in a population.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Oklahoma Academic Standards (Biology)

B.LS3.3 : Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Attachments

- Fugate Pedigree Teacher Key—Why So Blue.docx
- Fugate Pedigree Teacher Key—Why So Blue.pdf
- Fugate Pedigree—Why So Blue - Spanish.docx
- Fugate Pedigree—Why So Blue - Spanish.pdf
- Fugate Pedigree—Why So Blue.docx
- Fugate Pedigree—Why So Blue.pdf
- Punnett Square Exercise Teacher Key—Why So Blue.docx
- Punnett Square Exercise—Why So Blue - Spanish.docx
- Punnett Square Exercise—Why So Blue - Spanish.pdf
- Punnett Square Exercise—Why So Blue.docx
- Punnett Square Exercise—Why So Blue.pdf
- Ratios and Frequencies Teacher Key—Why So Blue.docx
- Ratios and Frequencies—Why So Blue - Spanish.docx
- Ratios and Frequencies—Why So Blue - Spanish.pdf
- Ratios and Frequencies—Why So Blue.docx
- Ratios and Frequencies—Why So Blue.pdf
- The Blue People of Troublesome Creek—Why So Blue - Spanish.docx
- The Blue People of Troublesome Creek—Why So Blue - Spanish.pdf
- The Blue People of Troublesome Creek—Why So Blue.docx
- The Blue People of Troublesome Creek—Why So Blue.pdf

Materials

- Punnett Square Exercise (attached; one per student)
- Punnett Square Exercise Teacher Key (attached)
- Ratios and Frequencies (attached; one per student)
- Ratios and Frequencies Teacher Key (attached)
- Fugate Pedigree (attached; one per student)
- Fugate Pedigree Teacher Key (attached)
- The Blue People of Troublesome Creek (attached; one per student)
- Full page Fugate pedigree
- Pipe cleaners
- Plastic beads
- Meiosis manipulative kit (see Explore)

Engage

Show students the video The Incredible Story of the Blue Fugate Family. **Stop the video at 2:28** so you don't give away the information students discover throughout the lesson.

Embedded video

https://youtube.com/watch?v=u68azJCy1hs

After, have the class complete a Collective Brain Dump to record all of the information they know about the phenomena based on the video. Before moving on, ask students to speculate why the people in the video were blue.

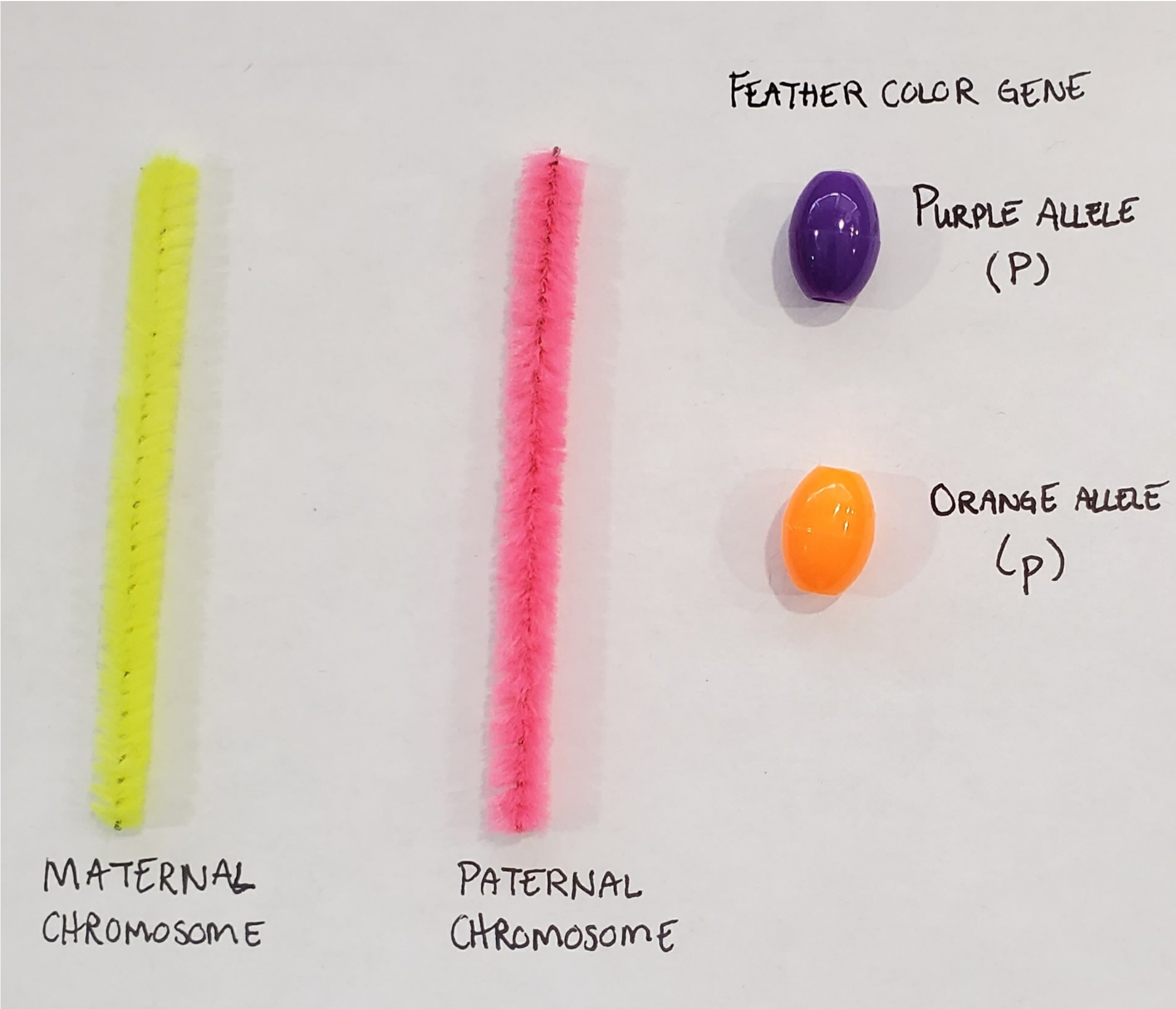
Teacher's Note

Play the video more than once if students seem to need more time to process the information. The Collective Brain Dump can occur between viewings or after the video has been played more than once.

The video narrator has an accent so consider using closed captions while watching.

Explore

In the following activity, students will use Punnett squares and a simple model of chromosomes to synthesize their understanding of meiosis, and how genotypes represent genes which code for the proteins that produce phenotypes. The purpose is to get students thinking explicitly about the biological mechanisms that Punnett squares are used to model, rather than simply practicing how to use a Punnett square. Provide each student with a copy of the **Punnett Square Exercise Student** handout.



Example of model components for activity scenario.

Activity 1: Individual

Each student should have four "chromosomes" with two of each "allele," where the chromosome is a piece of pipe cleaner and and alleles are represented by two different colors of beads threaded onto the pipe cleaners. Ask students to explain the relationship between these parental chromosomes and meiosis before they begin.

Teacher's Note: Meiosis Review

This is a good opportunity to review meiosis, specifically the final products of the process. If students need a more in-depth review, consider using manipulatives to model meiosis. The [Meiosis Manipulatives Kit] from Carolina would be a useful tool for this purpose, especially to model crossing-over.

Students should complete Part 1 independently. After they have a few minutes to complete the exercise, have the students share out their answers. Prompt them to explain the relationship between alleles and functional proteins in the example (i.e., one allele of the gene produces proteins that don't work and therefore can't produce the dominant phenotype).

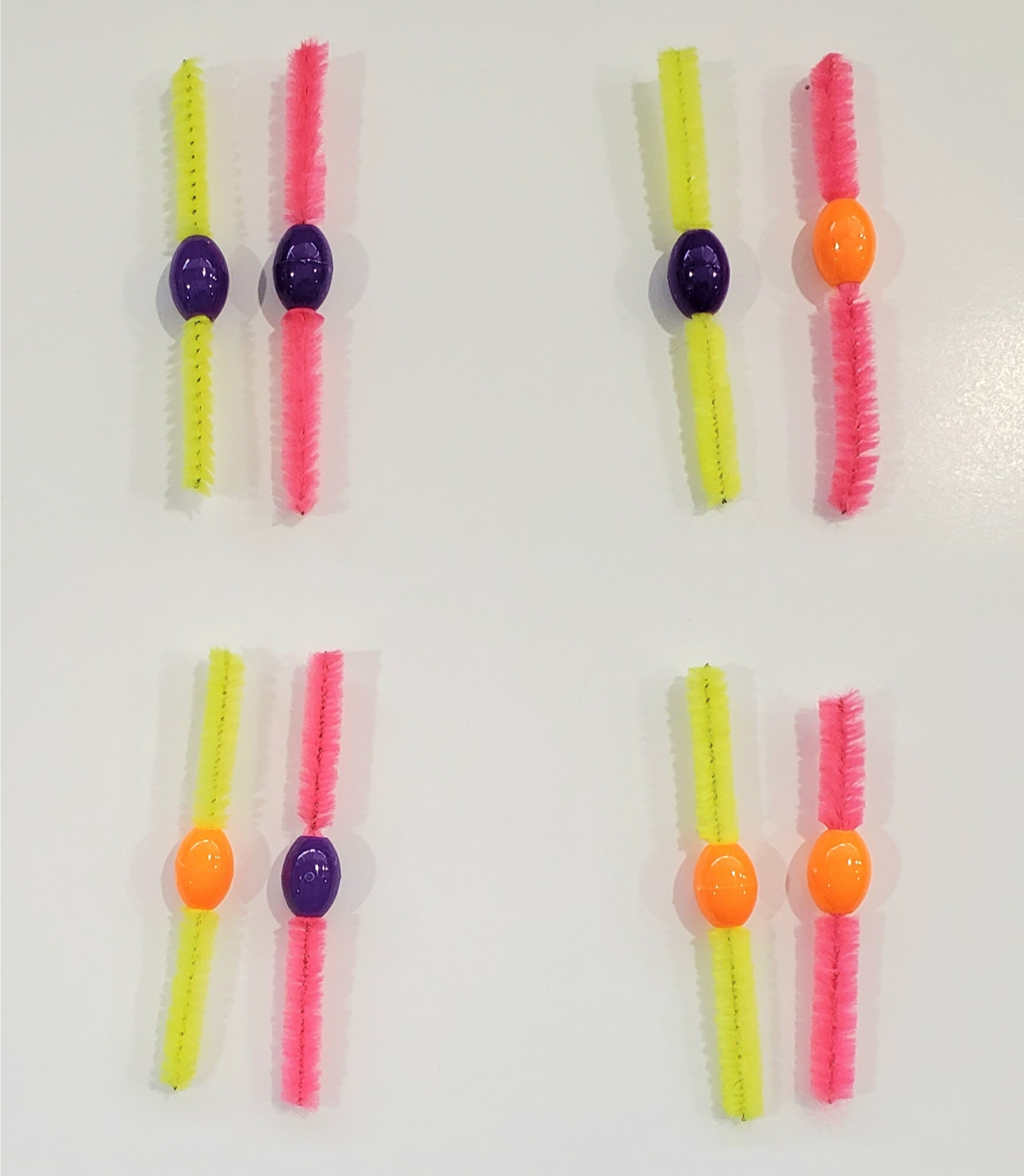
Activity 2: Pairs

Divide the students into six groups and provide each of them with four chromosomes as follows:

- Maternal chromosomes, four copies of dominant allele
- Maternal chromosomes, two copies of each allele
- Maternal chromosomes, four copies of recessive allele
- Paternal chromosomes, four copies of dominant allele
- Paternal chromosomes, two copies of each allele
- Paternal chromosomes, four copies of recessive allele

It is not necessary to literally separate students; the grouping is strictly to ensure that you have students who represent all genotype combinations for both parents.

Have students with maternal chromosomes pair up randomly with students with paternal chromosomes and complete the part 2 activity. Repeat this one more time with new pairs. As in part 1, have students describe the relationship among genotypes, proteins, and phenotype through discussion following the activity.



All possible combinations of alleles and parental chromosomes.

Explain

Remind students that Punnett squares help us determine all possible genotypes for the offspring of hypothetical parents, not what offspring are actually produced. In general, the individual offspring of specific parents are not important to our understanding of genetics; instead, we must look at genotypes and phenotypes at a population level. One easy way to approach this is to use ratios and frequencies.

Hand out the **Ratios and Frequencies Student** handout. The dominant allele (P) has been bolded in several places on the handout to help visually distinguish it from the recessive allele (p). Using the Punnett squares as simple examples, walk students through the difference between genotypic and phenotypic ratios, and show them how to calculate allele frequency. They will be applying this to a later activity related to the Fugate family. Reinforce for students that this is the same process used with data from entire populations and is not restricted to simple Punnett square examples.

After the students finish the calculations, pass out **The Blue People of Troublesome Creek** handout. Have students use the Why-Lighting strategy to address the question: "Why did the Fugates have so many blue-skinned family members?" Students should read, and when they find something that they feel contributes to the answer, highlight that portion and write their reasoning for the highlight in the margins.

Easy On the Highlight

The article is written more as a narrative than straight expository. Why-Lighting is an effective strategy here to help students move away from highlighting everything. The story-telling "fluff" isn't necessary to answer the question and shouldn't be highlighted. If this is the first time your students have done something like Why-Lighting, you'll probably have to talk them through what relevant information might include.

Teacher's Note: Fugate Mythology

Nearly all sources describing the Fugate family history base their information off of a single publication from 1982. However, subsequent genealogical records do not support this widely-told story of an orphaned French immigrant named Martin who came to America in 1820. Instead, the records suggest that earlier generations of the Fugates immigrated to America and settled in Virginia in the late 1600s, with some moving to the Troublesome Creek area of Kentucky a few generations later. The Martin Fugate who married Elizabeth Smith, as described in the story, was *born* in 1820. Rather than Martin's own, the seven children described in the story seem to be those of a more distant cousin, also named Martin Fugate.

These details do not change the circumstances or genetic factors that led to the abundance of blue Fugates, but it is of interesting note.

When the students are done with the article, have the class complete an I Think/We Think exercise. Students should compare what they highlighted with a partner, and then the pairs share their most important idea or ideas with the whole class.

Extend

Next, pass the **Fugate Pedigree** out to each student. The activity can be completed most effectively either independently or in pairs. Give them time to complete problems 1-5 before reviewing the answers with the class. Ask students to share their answers and provide justifications for the genotype questions (1-4) and have a student or two work out the allele frequency question (5) for the class. Allow students to complete question 6 independently as a formative assessment for the complexity of student understanding.

Teacher's Note

Question 6 is marked as a "bonus" question because it is more complicated than others that students have been asked to complete. It requires students to work backward a few generations to figure out the genotypes of the siblings for which they are calculating the allele frequencies.

Evaluate

Wrap up the lesson by asking students to complete the Five Whys strategy to answer the question: "Why are so many Fugates blue?" They should use evidence from their reading and the Extend activity to support and explain each reason they identify.

Teacher's Note

Student responses will vary depending on how they approach the question, but a chain of whys might progress something like this:

1. (Why blue?) Enzyme deficiency from faulty proteins
2. (Why faulty proteins?) Homozygous recessive genotype
3. (Why homozygous recessive?) Increase in recessive allele frequency among Fugates
4. (Why high frequency?) Inbreeding increases chance of getting two recessive alleles
5. (Why inbreeding?) Geographic isolation

Resources

- DisInfluence. (June 8, 2021). The Incredible True Story of the Blue Fugates Family. YouTube. https://youtu.be/u68azJCy1hs
- K20 Center. (n.d.). Collective brain dump. Strategies. https://learn.k20center.ou.edu/strategy/111
- K20 Center. (n.d.). Five whys. Strategies. https://learn.k20center.ou.edu/strategy/90?rev=658
- K20 Center. (n.d.). Why-lighting. Strategies. https://learn.k20center.ou.edu/strategy/128
- K20 Center. (n.d.). I think / we think. Strategies. https://learn.k20center.ou.edu/strategy/141