Punnett Squares

Lesson Overview

In this lesson, students will use their understanding of Punnett squares to connect to the mathematics of probability.

Alignment

Standard/Indicator Addressed

SCCCR Math 7.RP.2	Identify and model proportional relationships given multiple representations, including tables, graphs, equations, diagrams, verbal descriptions, and real-world situations. a. Determine when two quantities are in a proportional relationship. d. Use equations to model proportional relationships.
SCCCR Math 7.RP.3	Solve real-world and mathematical problems involving ratios and percentages using proportional reasoning (e.g., multi-step dimensional analysis, percent increase/decrease/ tax).
SCCCR Math 7.DSP.6	Investigate the relationship between theoretical and experimental probabilities for simple events. a. Determine approximate outcomes using theoretical probability.
SCCCR Math 7.DSP.8	Extend the concepts of simple events to investigate compound events. a. Understand that the probability of a compound event is between 0 and 1. b. Identify the outcomes in a sample space using organized lists, tables, and tree diagrams. c. Determine the probabilities of compound events using organized lists, tables, and tree diagrams. d. Design and use simulations to collect data and determine probabilities. e. Compare theoretical and experimental probabilities for compound events.

Standards for Mathematical Practice (as appropriate)

Standard 1: Make sense of problems and persevere in solving them.

a. Relate a problem to prior knowledge.

Standard 2: Reason both contextually and abstractly.

a. Make sense of quantities and their relationships in mathematical and real-world situations.

Standard 3: Use critical thinking skills to justify mathematical reasoning and critique the reasoning of others.

a. Construct and justify a solution to a problem.
b. Compare and discuss the validity of various reasoning strategies.
c. Make conjectures and explore their validity.
d. Reflect on and provide thoughtful responses to the reasoning of others.

Standard 6: Communicate mathematically and approach mathematical situations with precision.

a. Express numerical answers with the degree of precision appropriate for the context of a situation.
b. Represent numbers in an appropriate form according to the context of the situation.
c. Use appropriate and precise mathematical language

Standard 7: Identify and utilize structure and patterns.

c. Look for structures to interpret meaning and develop solution strategies.

Science and Engineering Practices (as appropriate)

S.1A.4: Analyze and interpret data.

S.1A.5: Use mathematics and computational thinking.

S.1A.6: Construct explanations.

S.1A.8: Obtain, evaluate, and communicate information.

ELA Inquiry Standards (as appropriate)

Connections

Active Learning Strategies (for Purposeful Reading, Meaningful Writing, and Productive Dialogue)

Show Me

Say Something

Content Connections

This lesson supports student understanding of Punnett Squares and how they may be used as a mathematical tool to predict inherited genetic traits.

Lesson Plan

Time Required – One 60-minute class period

Disciplinary Vocabulary – ratio, percentage, genotype, phenotype, dominant, recessive

Materials Needed:

- Engage slides (included)
- personal white boards (1 per student)
- dry erase markers (1 per student)
- erasers (1 per student)
- Exploring the Genetics of Albinism article (1 for each student)
- Exploring the Genetics of Albinism student handout (1 for each student)

Formative Assessment Strategies: Student dialogue, Show Me, Exploring the Genetics of Albinism student handout

Computational Thinking:

- **Logically organizing and analyzing data**
  Students research a specific genetic trait and organize data about that trait using a Punnett square.
- **Tolerance for ambiguity & the ability to deal with open ended problems**
  Punnett squares provide students a tool they can use to predict the phenotypes of inherited traits and students must understand that the actual outcomes don't always match the predicted outcomes.

Misconceptions:

- Students may make the assumption that outcomes are equally likely (in order to calculate theoretical probabilities) when they are not.
- Students may think the probability of an event is greater than 1, rather than $0 \leq p \leq 1$.
- Students may think that when representing the probability in fraction form, they write the number of probable outcomes over the number of not possible outcomes rather than the number of favorable outcomes over the total number of outcomes in fraction form.
- Students may not realize the probability of an outcome can be renamed into a simplified ratio. Students may not accurately reflect the total possible outcomes of an event, which may be affected by the outcome of another event, specifically when the items are not replaced to the original set.
- Students may not be able to distinguish between experimental and theoretical probability.
- Students may think that because they look similar to an aunt or uncle that they received those traits from them.
- Students may think that a dominant trait is the trait most likely found in the population However, a dominant trait does not mean "more potent," and recessive does not mean "weaker." The terms simply refer to the visible trait, the phenotype.
- Students may believe that one set of alleles is responsible for determining each trait, and there are only 2 different alleles (dominant and recessive) for each gene.

Engage

Connection to Science

- Display this slide for students.

Draw a Punnett square that displays the possible genotypes than might result in someone having eyes like those in this picture.

B denotes the dominant gene
b denotes the recessive gene

- Students independently complete the Punnett square then check in with their elbow partners to discuss the work.
- Use SHOW ME to check for student understanding.
- After each question, give students time to write the answer on their personal white boards. Then, without letting them look at their peers' answers, say, "Show me!" and have students hold up their boards.
- SHOW ME Questions:
    - Show your completed Punnett square

	B	b
B	BB	Bb
b	Bb	bb

Possibility #1

	B	b
b	Bb	bb
b	Bb	bb

Possibility #2

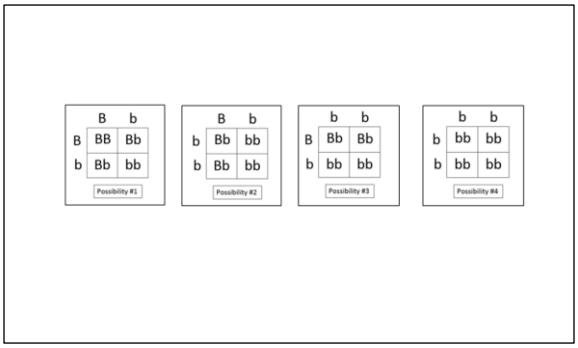
	b	b
B	Bb	Bb
b	bb	bb

Possibility #3

	b	b
b	bb	bb
b	bb	bb

Possibility #4

    - What is the phenotype for the genotype BB?
    - What is the phenotype for the genotype bb?
    - What other possible genotypes might result in blue eyes?
- Display the following slide:



    - Which possibilities show a 25% chance of blue eyes? A 50% chance? A 100% chance?

Explore

- Students continue to work in pairs. They will read an article on albinism using the strategy SAY SOMETHING. This strategy involves breaking a longer article into shorter chunks, with students taking turns reading and stopping to SAY SOMETHING at predetermined intervals. You may choose to have questions for students to answer or some simple guidelines for what they should talk about.
- Distribute one copy of the article "Albinism" (Handout 1) to each pair of students. If possible, having electronic copies would be good.
- Students should decide who will be Partner A and who will be Partner B. Partner A reads first, while Partner B follows along silently. When the students get to the STOP icon, they should take time to discuss the questions in the box.
- Partner B picks up reading where Partner A left off, following the same procedure.
- Reading / answering questions continues through the end of the article.

Explain

- As students finish reading, they should pick up a copy of the Exploring the Genetics of Albinism handout (Handout 2) and work through it with their partner.
- As partners finish, pairs should join to make groups of four and compare their work.
- Circulate as students work to ask guiding questions and check progress.

Albinism

Have you ever heard the word **albino**? It's a word that's sometimes used to describe a condition called albinism (say: AL-buh-nih-zum). Humans, animals, and even plants can have this condition, which means that the person, animal, or plant doesn't have the usual amount of pigment, or color.

You might know that albinism causes a kind of pale appearance. But what exactly causes albinism?

Understanding Albinism

Words Can Hurt

It's unkind to call someone "an albino." It makes people with albinism seem different, when they are just regular people who have trouble with pigment.

To understand albinism, you need to first know about melanin (say: MEL-uh-nin). Melanin is a chemical in our bodies that colors our skin, eyes, and hair. It's made by melanocytes (say: muh-LAH-nuh-sytes), which are cells found in the bottom layer of your skin.

Sometimes, a kid or an animal might be born whose body can't make a normal amount of melanin. This is what happens with albinism, which can show up as a lack of pigment (color) in the skin, eyes, hair, fur, or feathers of that kid or animal. There are different kinds of albinism. Some kids with albinism might have pale skin or hair. Other types of albinism might affect only the eyes.

Most kids with albinism have blue eyes, and others have brownish eyes. In some cases of albinism, a kid's eyes might appear pink or reddish. This isn't because the iris (the colored part of the eye) is pink or red. It's because the iris actually has very little color. The eyes appear pink or red because the blood vessels inside of the eye (on the retina) show through the iris.

SAY SOMETHING:

- How would you describe albinism to someone who didn't know about it?
- Recall a time when someone was unkind to you. How did that make you feel?

Stay in the Shade

Besides giving your skin, eyes, and hair its color, melanin helps protect your skin from the sun. You know how a person's skin gets darker after hanging out at the beach? That's your melanin at work, darkening your skin to give it more protection from the sun's rays. So, without enough melanin, your skin won't be able to protect itself. Kids with albinism can get sunburned very easily.

That's why it's a good idea for anyone with albinism to stay covered while in the sun (or even to stay out of the sun completely). Kids with albinism can go to the beach and spend time outdoors, but they have to use lots of sunscreen and watch the amount of time they're soaking up rays. Kids with albinism should talk to their doctors to find out whether it's OK to spend any time in the sun.

Vision Problems

Some kids with albinism wear glasses or contact lenses to help them see better. Others might need eye surgery. An eye doctor can help figure out ways to help a person with albinism see better.

Another problem for kids with albinism is that their eyes can be very sensitive to light. The iris usually helps control the amount of light coming into your eye and hitting your retina, which is located at the back of your eyeball. When a person has albinism, the iris doesn't have enough color and can't properly shield the retina from light. So, kids with albinism often squint in bright light. Wearing sunglasses or tinted contact lenses can help make a kid with albinism more comfortable out in the sun.

SAY SOMETHING:

- Why is it important for people with albinism to be careful when out in the sun?
- How would your life be different if you had to be as careful when out in the sun as someone with albinism?

What Causes It?

You can't "catch" albinism, like you catch a cold or the flu. It's caused by a person's genes. You might have learned about genes in science class, but what exactly are they?

Everyone's body is made up of billions of cells, which are too small to see without a strong microscope. Inside these cells are things called chromosomes, which contain hundreds, or even thousands, of genes. These genes give us our physical traits — how we look — and lots of other stuff about us, like the instructions our body parts need to work properly.

Genes carry the information that makes you an individual. Genes tell your body whether to give you curly or straight hair, long or short legs, or even brown or blue eyes. You might have heard people say you have eyes like your mom, hair like your dad, a smile like your grandma, or a laugh like your grandpa. Why? Because they passed some of their genes on to you!

SAY SOMETHING:

- What do you remember from Science about genes?
- Who does your family say you look like or sound like?

Everyone has two sets of genes. Half of your genes are from your dad, and half are from your mom. Sometimes, a mom and a dad might carry an "albinism gene" but not show any signs of albinism themselves. But they might have a kid who has albinism. How can that be?

Well, this happens because each parent has a normal pigment gene and an albinism gene. For a kid to have albinism, the dad's albinism gene and the mom's albinism gene both have to get passed on to the kid.

But if a kid gets an albinism gene from one parent and a normal pigment gene from the other, the kid won't have albinism. Instead, the kid will be a "carrier" of an albinism gene — which means he or she would have one normal pigment gene and one albinism gene. So, if that kid grows up and has a child with someone who is also a carrier of an albinism gene, there would be a chance that their child might have albinism.

So what about kids with light skin and light hair . . . or animals with white fur or feathers? Do they have albinism? Not necessarily. Their genes may tell them to be light-skinned or fair-haired, like their mom or dad. Likewise, not all animals with white fur or feathers have albinism. Polar bears, for instance, have genes that tell them to be white.

SAY SOMETHING:

- What has to happen in order for the albinism gene to be passed onto a child?
- Why is it true that all kids with light skin and hair DO NOT have albinism?

What's Life Like for Someone With Albinism?

Kids with albinism are just like other kids — they just need to talk with their doctor about taking care of their eyes and skin, especially if they're going to be in the sun. And albinism doesn't stop kids from reaching their goals. Lots of kids with albinism have grown up to be doctors, lawyers, musicians, and athletes. Most kids with albinism can be anything they want to be, just like any other kid!

SAY SOMETHING:

- What three facts from the article do you find most interesting?

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Retrieved from: https://www.etch.com/kids-health/kids/albinism.html

Exploring the Genetics of Albinism

You just finished reading an article about albinism, a condition which humans, animals, or even plants can have. Albinism means that the organism doesn't have the usual amount of pigment, or color, resulting in a pale appearance.

The Punnett square below describes the possible offspring of two human parents. Use it to analyze genotypes of offspring.

	A	a
A	AA	Aa
a	Aa	aa

A denotes the dominant gene

a denotes the recessive gene

1. What can you say about the parents from studying the Punnett square?

2. What is the ratio for having albinism to not having it?

3. What possible genotype(s) indicate typical pigmentation? What genotype(s) indicate albinism?

4. What ratio of children will have pigmented skin? Write this as a fraction, a decimal, and a percentage.

5. Determine how many children would most likely have albinism if the parents had 4 children.

   Each time these parents have a child, what is the likelihood that the child will have albinism? What is the likelihood 4 children born to these parents will all have albinism?

6. What would happen if one of the parents was **Aa** and one of the parents was **aa**? Complete a Punnett square for that combination.

a. What ratio of these parents' children will most likely have albinism? Write this as a fraction, a decimal, and a percentage. Show this as a ratio of pigmented skin to albinism.

b. Each time these parents have a child, what is the likelihood that the child will have albinism? What is the likelihood 4 children born to these parents will all have albinism?