Preparing for the Lesson

Penny Genetics: What Are the Chances?

Big Idea 16: Heredity and Reproduction
Benchmark: SC.7.L.16.2
Objective: Predict and analyze the genetic (genotype) and physical (phenotype) characteristics of offspring using Punnett Squares and pedigrees.

Key Question: How are predicted ratios using Punnett Squares and actual ratios by coin tossing related in genetics?

Background Information:

We can use probability to predict the chances of any given genetic traits appearing in the offspring of particular parents. Punnett Squares can also be used to obtain these results. In genetics, when we are trying to figure out how traits may be passed from parents to offspring, probability is an important consideration. If we know a little bit about the trait we are studying, we can use probability to predict how the trait (gene) in question will be transferred from parents to offspring.

You can determine actual ratios by tossing a coin. If you examine a coin, you will see that it has two sides, heads and tails, and so there are two possible outcomes when the coin is tossed: it will land with the "heads" side up, or with the "tails" side up. When you toss a coin, the probability of getting a "heads" is 50% or 1 out of 2. There is also a 50% probability of getting a "tails" from this toss. The more times the coin is tossed, the more likely it is to get closer and closer to the expected probability of 50% "heads" and 50% "tails".

You can predict the likelihood of inheriting particular traits using a simple graphical method called Punnett Squares. This was invented by an early 20th century English geneticist named Reginald Punnett. This is a way of discovering all the potential combinations of genotypes that can occur in a particular offspring. It also shows the odds of each of the offspring genotypes occurring. They can be used as predictive tools when considering having children. However, some traits are not inherited with this simple mathematical probability.

Teaching Tips: (If you are concerned about time constraints, you can introduce the lab in the last 5 minutes of the previous day.)

- Emphasize that the pennies are not to play with during the activity.
- Emphasize that when flipping the coins, students need to keep them on their tables.
- Collect ALL pennies at the end of each period. If not, make sure to have additional pennies available.

Timeframe:
Approx. 2 - 50-minute class periods

Safety Precautions:

- It is essential to review all safety precautions with your students before beginning the lab.
- Do not play with the pennies.
- Do not put the pennies in your mouth.
- Wash your hands after you are finished using the pennies.

STEP 1 - ENGAGE:	**Materials**
Introduce the lab activity: Key Questions and Student Predictions/Ideas.	• Interactive Notebook (if applicable) • Student laboratory worksheet

STEP 2 - EXPLORE:

See student lab sheet for step-by-step procedure

- Interactive Notebook
- Student laboratory worksheet
- Pencil
- Pennies

STEP 3 - EXPLAIN:

1. Have the students revisit the initial predictions/ideas and compare the outcome of the activity with their initial predictions/ideas.
2. As a whole class, review the data compiled and compare the results. Then, discuss Data Analysis questions/answers.

a. Use a Punnett Square to predict the ratios in this cross: **TT x Tt**

	T	**t**
T	**TT**	**Tt**
T	**TT**	**Tt**

Based on the cross, what percentage of the offspring (out of 100) will be:
Short Toed 50% **Long Toed 50%**

b. Would you expect the coin toss method (Actual Ratios) to give a similar ratio as the Punnett Square above? Explain your answer.
Students' answers will vary.

c. What do the pennies represent in the simulation?
These pennies represent male and female parents.

d. When you toss the coin to see which side lands up, what part of the sexual reproduction process are you simulating?
When the coin is flipped, you are determining what sperm or what egg is being donated to the match.

e. After flipping the coins and putting the two coins together, what part of the sexual reproduction process are you simulating?
When you put the two flipped coins together, you are simulating fertilization.

- Interactive Notebook
- Student laboratory worksheet

STEP 4 - ELABORATE:

1. Explain how Punnett Squares are tools used to predict the possible genotypes and phenotypes of offspring.
2. Does the difference between predicted and actual probability change as the number of events increases?

- Interactive Notebook
- Student laboratory worksheet

	STEP 5 - EVALUATE:	
	The students should be able to discuss/answer this essential question: *Is sexual reproduction really the best method of passing on genetic information?* The question may be answered individually or as a whole class.	

Name_____
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Class Period_____

ENGAGE

Penny Genetics: What are the chances?

Key Questions:
How are predicted ratios using Punnett Squares and actual ratios by coin tossing related in genetics?
How well does a Punnett Square predict the actual ratios?

Student Predictions/Ideas: Record your initial ideas about the answers to the key questions.

EXPLORE

Safety Precautions:
- Do not play with the pennies.
- Do not put the pennies in your mouth.
- Wash your hands after you are done using the pennies.

Materials:
- Pencil
- Pennies

Procedure:
1. In this lab you will make predictions using Punnett Squares and you will use pennies to determine the actual ratios by simulating the crosses.
2. Then you will compare the Predicted Ratios (Punnett Squares) with the Actual Ratios (tossing coins).
3. The trait that we will use in this activity is the human toe. We will use the upper case letter **T** to represent a ***short big toe*** (dominant trait) in humans and the lower case letter **t** (recessive trait) to represent a ***long big toe*** in humans.
4. Based on the letter representations fill in the possible combinations in the **observations & data chart (1)**.
5. Use a Punnett Square to predict the ratio of offspring in a cross where the parents are both **Tt** (the Square is set up for you on **observations & data chart (2)**.
6. Now you will determine the actual ratios by using pennies to represent the crosses. You will need two pennies. One side of the penny "heads" will represent the letter **T** and the other side of the penny "tails" will represent the letter **t. These pennies represent male and female parents that have a combination (genotype) Tt.** When the coin is flipped, you are determining what sperm or what egg is being donated to the match. When you put the two flipped coins together, you are simulating fertilization.
7. To determine the Actual Ratios, **you will flip your coins 100 times**, recording how often each combination came up. This will be recorded in **observations & data (3)**.
8. To establish a comparison between the Predicted and Actual Ratios, you need to use the Percentages (results) from the data generated under observations & data 2 & 3. This comparison will be done in **observations & data chart (4)**.

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Observations & Data:

1. Fill in the possible combinations using the upper case **T** and the lower case **t** under genotype and provide a description of the appearance under phenotype:

Genotype	Phenotype (description)

2. Predict the ratio of the offspring using the Punnett Square and determine the percentage of the offspring (out of 100).

	T	**t**
T		
t		

What percentage of the offspring (out of 100) will be: (***These are your Predicted Ratios**)

TT _____ **Short Toed** _____

Tt _____

tt _____ **Long Toed** _____

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3. Flip the coin 100 times and record each combination using tally marks and then summarize as a number.

Genotype (Gene combinations)	Tally Marks	Total
TT		
Tt		
tt		

What percentage of the offspring (out of 100) will be: (***These are your Actual Ratios**)

TT _____ **Short Toed** _____

Tt _____

tt _____ **Long Toed** _____

4. Comparing Predicted to Actual Ratios:

	Predicted Ratios (from # 2)	Actual Ratios (from # 3)
TT		
Tt		
tt		
Short Toed		
Long Toed		

Would you consider the predicted and actual ratios to be (circle)
a. THE SAME b. CLOSE TO THE SAME c. NOT CLOSE TO THE SAME

Name_____
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EXPLAIN

Data Analysis:

1. Use a Punnett Square to predict the ratios in this cross: **TT x Tt**

Based on the cross, what percentage of the offspring (out of 100) will be:

Short Toed _____ Long Toed _____

2. Would you expect the coin toss method (Actual Ratios) to give a similar ratio as the Punnett Square above? Explain your answer.

3. What do the pennies represent in the simulation?

4. When you toss the coin to see which side lands up, what part of the sexual reproduction process are you simulating?

5. After flipping the coins and putting the two coins together, what part of the sexual reproduction process are you simulating?

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	Explanation of Key Question Based on Evidence: **1.** How are predicted ratios using Punnett Squares and actual ratios by coin tossing related in genetics? **2.** How well does a Punnett Square predict the actual ratios?
ELABORATE	**Reflection:** **1.** Explain how Punnett Squares are tools used to predict the possible genotypes and phenotypes of offspring. **2.** Does the difference between predicted and actual probability change as the number of events increases?