Lesson Title: Punnett Squares with Piebald Deer

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Grade Level: Middle School Life Science

Type of Lesson: STEM

Objectives: 1) Understand how to set-up and complete a Punnett Square 2) Understand how each square of a Punnett Square has equal probability of occurring and 3) Understand how to generate predictions about the genotypes and phenotypes of potential offsprings from a Punnett Square

Background Information: It will help if the students have an understanding about how genes are handed down from parents to the offspring and that the genes carry traits.

References:

Campbell, N. A., & Reece, J. B. (Eds.). (2002). Biology (Sixth Edition). California: Benjamin Cummings.

Lesson Vocabulary: Gene, allele, dominant allele, recessive allele, genotype, phenotype, heterozygous, homozygous, incomplete dominance, codominance

Materials Required: Pennies for everyone in the class, pencils, paper, pictures: pictures of piebald deer, red carnations, pink carnations, white carnations, roan cattle (provided at end of lesson)

Preparation: Make a handout with empty Punnett Squares and a vocabulary sheet where the students can define and give examples of terms.

Safety Information: Don't swallow the pennies.

Engagement: Ask the students why they **do** and **do not** look like their parents. Have them discuss in small groups and have share a few of their answers. Jump into the lesson with a picture of a piebald deer.
Point 1: This is a piebald deer, which is a deer with brown and white spots. The white hair is caused not by parasites or diseases but by an interesting genetic quirk. They can be almost entirely white. We are going to figure out how a deer can turn out white by looking at the genetics of the deer's parents.

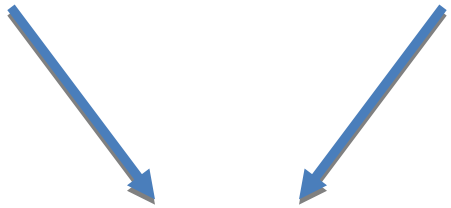
Exploration: Point 2: Each parent has two *genes*, but each parent is only going to give one gene to the offspring. A gene is a unit of hereditary information of a specific sequence of DNA, which codes for a certain trait. It is basically a flip of the coin as to which gene will be given to the offspring.

Point 3: A gene can have multiple variations, which we call *alleles*. When writing them out we usually use capital and lowercase letters. We are going to be studying the "Hair Gene" for our piebald deer. Since the deer are more apt to be brown, we say the capital H equals brown, and white is more uncommon than brown so we say the lowercase h equals white. H is the *dominant allele* over the h, which is the *recessive allele*. If the offspring receives an H from one parent and an h from the other, the H will DOMINATE (I like to say it in a Terminator voice) over the h and the deer will be brown.

Point 4: So we have…..

Female **Male**

Mom Gene 1 _____ Mom Gene 2 _____ Dad Gene 1 _____ Dad Gene 2 _____



Offspring Gene from Female _____ _____ Offspring Gene from Male

Point 5: Depending on the combination of alleles that the offspring gets from its parents, the offspring will look a certain way. With the "Hair Gene", the deer will be brown if it receives HH, brown if it receives Hh (because the H is dominant over the recessive h), and white if it receives hh.

Point 6: Let's say our baby deer is white like the picture. What combination of h's will the baby deer have? (Answer: hh)

Point 7: If dad is "hh", will the baby absolutely be white? (Answer: No, the dad can only give one gene so the baby is only getting one of its h's from dad. We also have to look at the mom.)

Point 8: So what are the possibilities of alleles can the mom have if our baby is white? (Answer: The mom needs to have at least one h that can be inherited by the offspring. The other allele can be either H or h.) If this female and male have another offspring, what are the potential offspring's genes going to look like? (Answer: Hh or hh) What are the potential hair colors for the offspring ? (Hh=Brown, hh=white).

Explanation: Point 9: There is an easy way to figure out what the possible offspring will be for a male and a female if you know the alleles that each poses. Make a Punnett Square with the female's alleles across the top and the male's along the side. Show how to fill in the chart. Follow the arrows down for the female's alleles and across for the male's alleles.

	Female H↓	Female h↓
Male h→	Hh	hh
Male h→	Hh	hh

Point 10: Let's try another one. Cross a female HH with a male Hh. Fill in the table.

	Female H	Female H
Male H	HH	HH
Male h	Hh	Hh

A bonus about Punnett Squares is that each square has a 25% chance of occurring since which gene you get from each parent is a flip-of-the-coin. So what is the percent chance of having a deer with Hh? (Answer: 50%) hh (Answer: 0%) HH (Answer: 50%). What are the chances of having a Brown deer? (Answer: 100%) White deer? (Answer: 0%).

Point 11: Here are two new terms that are used by geneticists. A *phenotype* is the physical and physiological traits of an organism (aka what the organism looks like). I could reword the questions about an offspring's potential hair color as "What percent chance is there that the phenotype of the deer will be brown?" A *genotype* is the genetic makeup of an organism. I could reword the questions about an offspring's potential for having Hh as "What percent chance is there that the genotype of the deer will be Hh?"

Point 12:Let's try another. On your paper cross an Hh female and an Hh male. Fill in the Punnett Square.

	Female H	Female h
Male H	HH	hH
Male h	Hh	hh

A note: Whether you write Hh as "Hh" or "hH", the answer is correct. It is more common to see the dominant allele listed first aka Hh. What are the potential genotypes of the offspring? (Answer: HH, Hh, hh) What are the potential phenotypes of the offspring? (Answer: Brown and White) What percent of the offspring will have each genotype? (Answer: HH 25%, Hh 50%, hh 25%) What percent of the offspring will have each phenotype? (Answer: Brown 75% and White 25%)). Let's see if this occurs in nature. Have each student flip a coin for whether mom gives an H or an h. Have each student flip a coin for whether dad gives an H or an h. Write down the number of student who got HH, Hh (with mom H), hH (with dad H), and hh. Were the numbers what were expected? If not, discuss why this may not be the case.

Point 13: Here are a few more terms to use. If an organism's genotype has identical alleles for a given trait aka HH or hh for hair color, it is said to be *homozygous*. If an organism's genotype has two different alleles for a given trait aka Hh for hair color, it is said to be *heterozygous*. Circle the homozygous offspring on your last Punnett Square. Put a square around the heterozygous offspring on your last Punnett Square.

Elaboration, Extension: Point 14: Rules are meant to be broken. Remember, H dominates over h when an organism's geneotype is Hh. Sometimes this rule is not followed but always assume that the rule persists unless told otherwise. *Incomplete dominance* is when the combination of two different alleles blend to create a new phenotype different than the two original phenotypes. For example, if a red carnation (WW) reproduces with a white carnation (ww), a pink carnation (Ww) is the offspring. Basically you get a blending of alleles. There can also be *codominance*, which is when two alleles affect the phenotype of the offspring in separate, distinguishable ways. Basically both alleles are seen on the organism. For example, the combination of red haired cattle (HH) and white haired cattle (hh) create a roan cattle (Hh), which has both white and red hair (not pink).

Evaluation: Throughout the lesson the students are being asked to create Punnett Squares and to predict phenotypes and genotypes of offspring, which the teacher can check. The teacher will be able to see whether the students understand the concepts. Any of these questions can be tweaked for use as homework, a quiz or a test. Have students turn in their completed Punnett Squares and terms worksheet.

Wrap-up: Why is it important to understand Punnett Squares and how we inherit our traits from our parents? Can you think of an example in real life where this would be important?

Piebald Deer

Incomplete Dominance with Carnations

Roan Cattle

Punnett Squares

Vocabulary	Definition	Example / Drawing
Gene		
Allele		
Dominant allele		
Recessive allele		
Genotype		
Phenotype		
Heterozygous		
Homozygous		
Incomplete dominance		
Codominance		