PROBABILITY OF TRAITS

INSTRUCTIONS

Overview:

Students will use coin flipping to understand the probability of dominant and recessive traits. Students will use Punnett Squares to calculate the likelihood of genotype and phenotype of offspring from known parents.

Objectives:

The student will:

- calculate probabilities of traits for mono hybrid crosses; and
- use Punnett squares to identify the likelihood of offspring traits based on known parents.

Targeted Alaska Grade Level Expectations:

Science

[9] SC1.2 The student demonstrates an understanding of how science explains changes in life forms over time, including genetics, heredity, the process of natural selection, and biological evolution by using probabilities to recognize patterns of inheritance (e.g., Punnett Squares).

Materials:

- Coins (two per student)
- STUDENT WORKSHEET: "Probability"
- STUDENT WORKSHEET: "Genotype and Phenotype"
- STUDENT WORKSHEET: "Punnett squares"

Vocabulary:

allele – one of two or more alternative forms of a gene

gene – a segment of DNA, occupying a specific place on a chromosome, that is the basic unit of heredity; genes act by directing the synthesis of proteins, which are the main component of cells and are the catalysts of all cellular processes; physical traits, such as the shape of a plant leaf, the coloration of an animal's coat, and the texture of a person's hair, are all determined by genes

dominant allele – an allele that is fully expressed in the phenotype, overriding a recessive allele

Punnett square – the diagram used to predict an outcome of a particular cross or breeding experiment (Named after Reginald C. Punnett)

genotype – the allelic composition of a gene (example: Bb)

phenotype – the observable manifestation of a specific genotype (example: brown hair)

heterozygous – having different alleles for a single trait

homozygous –having the same alleles for a single trait

probability – the likelihood of an event happing in the future. It is expressed as a number between 0 (can not happen) and 1 (it will always happen). It can be expressed as fraction, decimal, or a percent. The formula for probability is; $P = \frac{\text{number of ways an event can occur}}{\text{number of possible outcomes}}$

codominant trait – in a heterozygote the phenotypes of both alleles are expressed

recessive allele – an allele that is only expressed when the dominant allele is absent

trait – the precise description of an individual's characteristics

Whole Picture:

In the early 1800s, European and American scientists were trying to answer the question of how offspring had many of the traits of their parents. A popular hypotheses at the time was that every trait from both parents became blended in the offspring. Based on this blending hypothesis one would predict that traits from both parents would be equally combined in their offspring. The flaws in this idea were clear to many at the time because blending hypothesis does not explain many inheritance patterns; such as dominant and recessive traits.

PROBABILITY OF TRAITS

INSTRUCTIONS

In the mid-1800's Gregor Mendel experimented with pea plants and discovered that some traits followed the rules of probability and that by knowing the genotype of the parents he was able to predict the likelihood of the offspring's traits. It is important to note that not all traits follow Mendels' pattern. For example co-dominant traits such as blood type express both traits when the alleles are present. Additionally polygenetic inheritance is an additive effect of two or more genes such as three or more genes that govern skin color or height, for example. It is also important to remember that the environment interacts with gene expression, and can influence the eventual phenotype.

A key concept in understanding Mendelian genetics is probability. Probability is calculated by dividing the number of ways an event can occur by the number of possible outcomes, $P = \frac{\text{number of ways an event can occur}}{\text{number of possible outcomes}}$. For example the probability of flipping a coin and it landing on heads is P= 1(only 1 head on a coin)/ 2 (heads or tails) = ½ = 50%. The probability of using one coin and flipping it two times in a row for heads is 50% for each flip. But if you were to flip two coins at the same time the probability of both landing on heads is ½ * ½ = ¼ or 25%. Another example of probability is rolling a six-sided die. What is the probability of rolling a 2? $P = \frac{\text{\# of ways to roll a 2}}{\text{total \# of sides}}$, P= ⅙ or 17%. Probabilities range from 0 (will never occur) to 1 (will always occur). Alleles for certain traits are similar to flipping a coin or rolling dice; that is by understanding the genotype of parents we can predict probability of certain alleles and traits in the offspring.

Activity Preparation:

1. Review Punnett squares and mono-hybrid crosses, and probabilities.
2. Make copies of student worksheets and ensure there are enough coins available for students.

Pre-Assessment:

Quick-write

1. Write on the board: "Why would it be useful to predict genetic traits?" Students take 3 minutes to brainstorm. They should write down every idea they can think of.
2. In the last two minutes of the activity, students take their brainstorm ideas and answer the questions in two complete sentences. Students share their ideas with their partner. Have one partner from each pair come to the board and write down one answer to the question. Review student ideas as a whole class.

Activity Procedure:

1. Review Mendel's Laws of Genetic Inheritance and probabilities with the students. As you go through the lesson, be sure to touch on key vocabulary words.
2. Explain that it is relatively easy to predict the likelihood of certain traits that parents will pass on to their offspring such as blood type in humans or coat color in dogs with nothing more than a pencil, paper and a little knowledge.
3. Demonstrate the cross of a male with type AB blood and a woman with type AB blood by using a Punnett Square.

NOTE: Blood type in humans is a codominant trait where the allele for type A and B both code for proteins. A lack of protein coding alleles results in type O blood.

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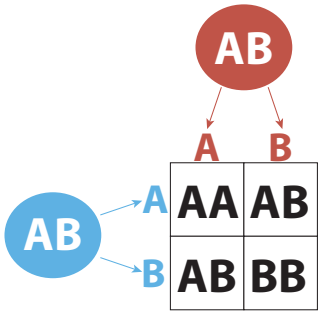
4. Draw the following genetic cross of two blood type AB individuals on the board.
5. Using the illustration, explain that somatic (body) cells have two copies of the allele for blood type (AB). The chromosomes are divided to produce the reproductive germ (sperm and egg) cells. Each germ cell contains a single copy of the allele for blood type. Fifty percent of the sperm cells have an allele that codes for blood type A, and 50% have an allele that codes for blood type B. The same ratio applies to the egg cells.
6. Combining the germ cells on the outside of the Punnett square results in the possible genotypes of the offspring inside the Punnett square.
7. By knowing their blood types, the couple is able to predict the likelihood of their children being born with, A, B or AB blood.



8. Observing the results of the Punnett square shows the following number of genotypes: 1 AA, 2 AB, and 1 BB. In this exercise the offspring of blood type AB parents have a ¼ (25%) chance of having type A blood, ½ (50%) chance of having type AB blood and ¼ (25%) type B blood.
9. Instruct students they will practice determining probability of dominant and recessive alleles by flipping a coin.
10. Hand out STUDENT WORKSHEET: "Probability" and one coin per pair of students.

NOTE: Dominant alleles are written in upper case (H) while recessive alleles are written in lower case (h). When writing, the dominant allele should come before the recessive allele (Hh). When choosing letters to represent alleles avoid letters that look similar as upper and lower case such as Oo, Ii, Xx, and Zz.

11. After students have collected their data have them share their results with the class and record the class results. Explain to the class about sample size and why a larger number of samples will give a number closer to the expected result, and that while they might expect heads and tails to be 50/50 the actual data will likely be different. Hand out STUDENT WORKSHEET: "Genotype and Phenotype" and the second coin.

NOTE: Review genotype and phenotype with students.

12. Ask students what physical variations they have observed in dogs. List them on the board. Some of these traits are controlled by dominant and recessive alleles. In the next activity the head and tails of the coin will represent alleles for ear length of dogs, with dominate alleles resulting in long ears and recessive alleles resulting in short ears.

NOTE: It should be noted that current research suggests that there may be several more alleles that determine ear length in dogs.

13. After students have completed the second activity discuss that dog breeders are able to predict some of the traits of puppies. Tell students they are in charge of predicting the probabilities of several litters of puppies that will be born from parents with known genotypes. Hand out STUDENT WORKSHEET: "Punnett squares."
14. When students are finished have them turn in their worksheets.

Extension Activities:

- A simple mono hybrid virtual Punnett square activity: http://vital.cs.ohiou.edu/?page_id=287
- An In-depth genetic cross simulator which allows for customization and experimentation: http://web.mit.edu/star/genetics/index.html
- Background information and interactive activities relating to genes and human traits: http://learn.genetics.utah.edu/content/begin/traits/

Answers:

STUDENT WORKSHEET: "Probability"

Data Section: Answers will vary

1. Answers will vary
2. Answers will vary
3. Answers will vary
4. Answers will vary
5. Answers will vary
6. 50% and 50%
7. Answer will vary, if they did not flip 25 heads and 25 tails the sample size is too small as 50/50 result is the idealized probability. More times the coin is tossed the closer the results get to the idealized number.

STUDENT WORKSHEET: "Genotype and Phenotype"

Data Section: Answers will vary

1. Answers will vary
2. Answers will vary
3. Answers will vary
4. Answers will vary
5. Answers will vary
6. Answers will vary
7. Answers will vary
8. Answers will vary
9. Answers will vary

STUDENT WORKSHEET: "Punnett Squares"

1. The male dog genotype is HH and the female genotype is HH.

	H	**H**
H	HH	HH
H	HH	HH

What is the probability of puppies being born with long ears **100%** and short ears **0%**?

2. The male dog genotype is Hh and the female genotype is Hh.

	H	**h**
H	HH	Hh
h	Hh	hh

What is the probability of puppies being born with long ears **75%** and short ears **25%**?

3. The male dog genotype is hh and the female genotype is hh.

	h	**h**
h	hh	hh
h	hh	hh

What is the probability of puppies being born with long ears **0%** and short ears **100%**?

NAME: _____

PROBABILITY

Directions: Working in groups of two, one coin flipper and one recorder, toss a coin 50 times. Record the results of each toss by putting a 1 in the heads or tails box. Answer the questions at the bottom of the page. Once everyone has answered questions about their data, we will compile results from the whole class to see how larger numbers affect probability.

Toss #	Heads	Tails	Toss #	Heads	Tails
1			26		
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		
8			33		
9			34		
10			35		
11			36		
12			37		
13			38		
14			39		
15			40		
16			41		
17			42		
18			43		
19			44		
20			45		
21			46		
22			47		
23			48		
24			49		
25			50		
Total			Total		

NAME: _____

PROBABILITY

Your Data:

1. Total number of tosses that landed on heads _____, landed on tails _____

2. Percent of heads _____ , and percent of tails _____

3. What is the probability that toss number 51 will land on heads? _____ land on tails____?

Class Data

4. Total number of tosses that landed on heads _____ landed on tails _____

5. Percent of heads _____ and percent of tails _____

6. What is the probability that the next toss will land on heads? _____land on tails_____

7. Did everyone in the class flip exactly 25 heads and 25 tails? _____

   Why or why not?

   _____

   _____

   _____

NAME: _____

GENOTYPE AND PHENOTYPE

Directions: Coins that land on heads will be dominant and recorded as "H" for long ears, and coins that land on tails will be recessive and recorded as "h" for short ears.

Toss each coin once. Record the result for coin 1 in the coin 1 box and the results for coin 2 in the coin 2 box. Once you have tossed each coin 25 times fill in the Genotype and Phenotype boxes and answer the questions.

Flip #	Coin 1 (H or h)	Coin 2 (H or h)	Genotype (The genes)	Phenotype (Long or Short Ears
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

Heads = "H," the allele for long ears and tails "h," the allele for short ears.
HH = long ears
Hh = long ears
hh = short ears

NAME: _____

GENOTYPE AND PHENOTYPE

Genotype:

1. Number of homozygous domanant (HH) combinations _____
2. Number of heterozygous (Hh) combinations _____
3. Number of homozygous recessive (hh) combinations _____

Phenotype:

Based on the genotype data you just calculated, answer the phenotype questions below:

4. How many long ear individuals were there? _____
5. How many short ear individuals were there? _____
6. Ratio of long ear/short ear _____

Probability:

7. Probability of long ear individuals? _____
8. Probability of short ear individuals? _____

Class Data:

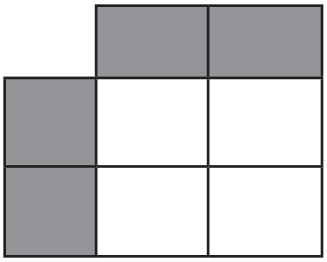
9. Long ears _____ Short ears _____ Ratio _____

NAME: _____ STUDENT WORKSHEET

PUNNETT SQUARES

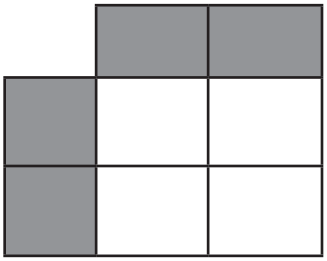
Directions: You are in charge of predicting the probability of puppy traits from pairs of known parents. Once again heads will be H for long ears and tails will be h for short ears.

1. The male dog genotype is **HH** and the female genotype is **HH.**



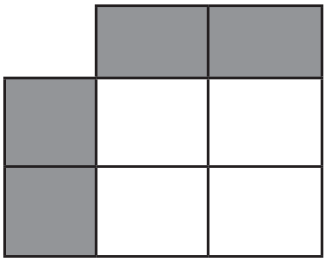
What is the probability of puppies being born with long ears_____**%** and short ears _____**%**?

2. The male dog genotype is Hh and the female genotype is Hh.



What is the probability of puppies being born with long ears _____**%** and short ears _____**%**?

3. The male dog genotype is hh and the female genotype is hh.



What is the probability of puppies being born with long ears _____**%** and short ears _____**%**?