<u>Genetics</u>

Extra Credit Math Project

Goal: To apply your probability skills to the field of genetics.

PART 1: Background

Pythagoras, who died in 509 B.C., theorized that the traits of an offspring depended entirely on the father's characteristics. Aristotle, however, believed both the father and the mother contributed to the characteristics of the offspring. Johann Mendel was born in 1822 and is credited with discovering three basic laws of heredity. Mendel conducted a famous set of experiments by cross breeding plants. When he crossed a pure tall plant with a pure short one, the offspring of the first generation was always tall. However, when we breaded two first-generation tall plants, he found that approximately three out of four of the offspring were still tall (called the ***dominant*** gene shown by an uppercase T) whereas one of four was short (called the ***recessive*** gene shown by a lowercase t).

Two genes account for every trait. If the genes for a certain characteristic are TT or tt, such that the genes in the pair are the same, it is called ***homozygous***. If they are different (Tt), then the gene pair is referred to as ***heterozygous***.

PART 2: Punnett Square

A Punnett square is useful when discussing Mendel's experiments. A Punnett square is simply a matrix in which the row headings represent the genes (or ***alleles***) from one parent and the column headings represent the genes from the other parent.

Figure A

	T	**T**
T	TT	TT
T	TT	TT

Figure B

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

Figure A represents a cross between two dominant homozygous genes. Their offspring are also dominant homozygous genes. Figure B shows a cross between a dominant homozygous gene and a recessive homozygous gene. The first-generation offspring always have the dominant gene, T, and they are all heterozygous in that they now contain one dominant gene and one recessive gene, t.

Another Punnett square can now show the second-generation breeding of two heterozygous genes (Tt x Tt).

Figure C

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

The four outcomes are (1) a dominant homozygous offspring (TT), (2) a recessive homozygous offspring (tt), or (3) and (4) two possibilities of a heterozygous offspring.

Since T dominates t, the probability that the offspring will have the dominant characteristic is three out of four times – exactly what Mendel found in his research.

PART 3: **Genetics and Probability**

On a separate sheet of paper, answer each question.

1.	In rabbits, the gene (*allele*) for a black coat color (B) is dominant over the allele for brown coat color (b). What would be the results of a cross between an animal homozygous for black coat color (BB) and one homozygous for brown coat color (bb)? Complete the following: A) Draw the Punnett square for a BB rabbit crossed with a bb rabbit. B) Find the probability of producing a "pure" black-coated rabbit (BB). C) Find the probability of producing a brown rabbit.
2.	In guinea pigs, the allele for a rough coat (R) is dominant over the allele for a smooth coat (r). For the offspring to be smooth-coated, what should the alleles of the parent be? A) Show the Punnett square that will produce the smooth coat. B) Is more than one answer possible? Explain your answer. C) Can two rough-coated parents produce a smooth-coated offspring? Use a diagram to explain your answer.
3.	In Japanese four o'clock plants, the alleles for a red flower (R) and for a white flower (R') are codominant – that is one does not dominate over the other. Therefore, a plant with the gene RR' will have pink flowers, whereas a plant with RR is red and with R'R' is white. A) Draw a Punnett square for the cross of two pink flowers. What is the probability that the new flower will be white? B) Draw a Punnett square for the cross of a red flower with a pink flower. What is the probability that the new flower will be white? Red? Pink?
4.	Suppose that you crossbred plants and planted the seeds. When they sprouted, 50% of the plants were green, whereas 50% were albino (white). Green plants (G) are dominant; white plants (g) are recessive. A) Draw a Punnett square that shows how this outcome could happen. B) What genes would the parent plants have had?

5\. Cystic fibrosis is a genetically transmitted condition in which the body produces excessive mucus that clogs the lungs and the intestines. Persons who are homozygous recessive (ff) have the disease, whereas persons who as heterozygous (Ff) for cystic fibrosis are carriers but do not show signs of having the disease. The Punnett square below shows the cross between a noncarrier adult (FF) and a carrier. Note that none of the offspring will display the condition.

	F	F
F	FF	FF
f	Ff	Ff

A) Show the Punnett squares for the crosses between each of these four individuals and another who is a carrier.
B) How many individuals out of 16 in this 2nd generation will be carriers but not actually show signs of having the disease?
C) What percent of this second generation will be affected by the disease?

6\. The general idea of a Punnett square can be applied to another situation: Suppose that a husband and wife have two children. The first child can be either a boy (B) or a girl (G). The second child can also be either a boy or a girl. A diagram of the situation would look like this:

	B	G
B	BB	GB
G	BG	GG

A) What is the probability that both children are girls?
B) What is the probability of having one boy and one girl, in either order?
C) Suppose that a family has a third child. A matrix or lattice could be drawn like this:

	BB	BG	GB	GG
B				
G				

This is another way to show the outcomes, similar to a tree diagram. The column headings represent the possibilities for the first two children, and the row headings represent the third child. Complete the table, and find the probability of having one boy and two girls.

D) Create another matrix, showing what happens if the family has a fourth child.
E) What is the probability that all four children will be boys? Three boys and one girl?
F) If a family has one child, that child can be two possible genders – boy or girl. If the family has two children, four possibilities arise – BB, BG, GB, or GG. How many possibilities occur when the family has three children? Four? What pattern do you see? Can you use this pattern to predict that number of possibilities if the family has eight children?

7\. Take a survey of at least 15 sixth graders to determine the eye color of all the students, their parents, and their siblings. Place the data into a table.

A) What patterns do you notice about heredity and eye color?
B) What conclusions can you draw about eye color on the basis of the sample?

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