Name: _____

INHERITANCE AND PROBABILITY

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 gene in question will be transferred from parents to offspring. As an example, let's toss a coin:

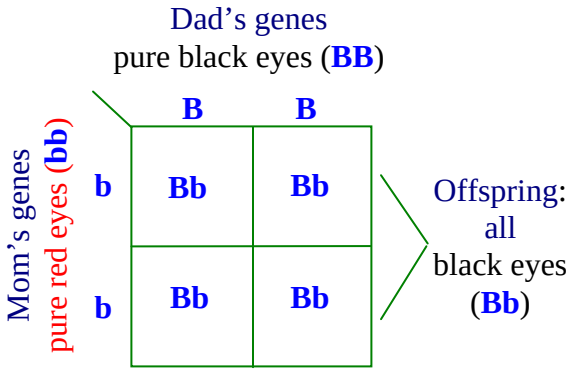
If you examine a **coin**, you'll see that it has 2 sides—heads and tails—and so there are 2 possible outcomes when the coin is tossed: it will land with the "heads" side up, or with the "tails" side up. When you toss the coin, the **probability** of getting a "heads" is ½, or 50%. This represents the number of desired outcomes (heads = 1) divided by the number of possible outcomes (heads + tails = 2). There is also a probability of ½ that we will get a "tails" if we toss the coin. If we toss our coin only two times, we might get 2 "heads", 2 "tails", or 1 "heads" and 1 "tails." But the more times we toss our coin, the more likely we are to get closer and closer to our **expected probability** of 50% "heads" and 50% "tails." Based upon what we know about coins, we form an **hypothesis** that the probability of getting a "heads" when we toss the coin is ½ or 50%. Then we **test** our hypothesis by tossing the coin and recording the results.

Eye color in mice

Now that we've explored how probability is important in genetics, let's investigate the inheritance of a genetic trait in mice that is determined by a **single gene**. Mice may have either black eyes or red eyes, and from the work of other mouse researchers we know that pure black-eyed mice bred to pure red-eyed mice always produce offspring with black eyes. Thus, we say that the gene for black eyes is **dominant** and the gene for red eyes is **recessive**, because the gene for black eyes "dominates" the gene for red eyes.

In genetics, it is often useful to represent genetic crosses like the one described above using a **Punnet square**:

We'll represent the mouse eye color gene by the letter **B**. The dominant gene for black eyes will be designated by "**B**"; the recessive gene for red eyes by "**b**". In the cross described above, because Dad is a "pure" black-eyed mouse, he's designated as **BB**. Mom is a "pure" red-eyed mouse, designated by **bb**.



BB x **bb**
Dad can produce gametes that have only "**B**" genes.
Mom can produce gametes that have only "**b**" genes.
All offspring will be **Bb** and have black eyes.

What happens if we now breed together the offspring from the cross above? Using another **Punnet square** will help us figure out what outcome we expect from this cross.

Dad's genes
black eyes (**Bb**)

Mom's genes
black eyes (**Bb**)

	B	**b**
B	**BB**	**Bb**
b	**Bb**	**bb**

Offspring:
¾ have black eyes (**BB** or **Bb**)
¼ have red eyes (**bb**)

Bb x **Bb**
Dad now produces ½ of his gametes with the dominant "**B**" gene and ½ with the recessive "**b**" gene. So does Mom. The offspring have both black and red eyes: ¾ carry the dominant **B** gene and have black eyes; ¼ carry 2 recessive **b** genes and have red eyes.

So, from this genetic cross, we **expect** to produce:

1 "pure" black-eyed mouse (**BB**)
2 black-eyed mice that each carry 1 **B** and 1 **b** gene (**Bb**)
1 "pure" red-eyed mouse (**bb**)

The Punnet square helps us form an **hypothesis** about the outcome we expect when we breed together 2 mice that each have **Bb** genes. We'll test that **prediction** by conducting a genetic cross.

School & Teacher: _____ Name: _____

LESSON 4: PROBABILITY
STUDENT DATA SHEET

A)

EXPECTED RESULTS (MY HYPOTHESIS):

IF I toss a coin **2** times, **THEN** I expect to get _____**HEADS** and _____**TAILS**.

Toss your coin **2 times**, recording **H** for "heads" and **T** for "tails" in the chart to the right:

ACTUAL RESULTS

toss #1	*toss #2*

Based on the **hypothesis** that the probability of getting a "heads" is ½ (50%) and the probability of getting a "tails" is ½ (50%), you would expect to get **1 H** and **1 T** if you toss a coin 2 times.

Did your **actual results** agree with this **hypothesis**? **YES** **NO**

B) Now toss the coin a total of **10 times**, recording and **H** for "heads" and **T** for "tails" after each toss. Trade off with your partner so everyone gets to toss the coin.

toss #1	*toss #2*	*toss #3*	*toss #4*	*toss #5*	*toss #6*	*toss #7*	*toss #8*	*toss #9*	*toss #10*

*total number of **H**s* _____ *total number of **T**s* _____

Based on the **hypothesis** that the probability of getting a "heads" is ½ (50%) and the probability of getting a "tails" is ½ (50%), you would expect to get **5 H**s and **5 T**s if you toss a coin 10 times.

Did your **actual results** agree with this **hypothesis**? **YES** **NO**

C) Now compare your results with **ALL** the other students in your class. For the entire class, what was the number of "heads" and "tails" recorded for all tosses?

EXPECTED RESULTS (MY HYPOTHESIS): IF I toss a coin _____ times,

THEN I expect to get _____**HEADS** and _____**TAILS**.

ACTUAL RESULTS

*total # **H**s*		*total # **T**s*		*total coin tosses*
	+		=	

Did the **actual results** for the entire class come closer to agreeing with the **hypothesis** that ½ (50%) of the tosses would be "heads" and ½ (50%) would be "tails" **YES** **NO**

Teacher: _____ Name: _____

ACTIVITY 4: STUDENT DATA SHEET
Inheritance of Eye Color in Mice

THE PROBLEM

You are a mouse breeder who is performing the following genetic cross: you are crossing a male black-eyed (**Bb**) mouse with a female black-eyed (**Bb**) mouse. What do you expect the offspring to look like? Complete the punnet square to find the answer.

PUNNET SQUARE

Dad's genes
black eyes (**Bb**)

Mom's genes **black** eyes (**Bb**)	**B**	**b**
B		
b		

Analyze the results of the Punnet Square:

How many offspring had…

2 genes for **black** eyes (**BB**)? _____

1 gene for **black** eyes and **1** for **red** eyes (**Bb**)? _____

2 genes for **red** eyes (**bb**)? _____

FORM AN HYPOTHESIS

Use the information above to form an **hypothesis**:

If I cross 2 mice that each carry **1** gene for **black** eyes and **1** gene for **red** eyes (**Bb** X **Bb**),

then I expect to get _____ **black** eyed mice with **BB** genes,

_____ **black** eyed mice with **Bb** genes,

_____ **red** eyed mice with **bb** genes.

_____ = total number of offspring

PROBABILITY

Using the information above, what are the chances that you will get offspring with **BB black** eyes? *(Circle your answers.)*

1 out of 4	2 out of 4	3 out of 4	4 out of 4
1/4 = 25%	2/4 or 1/2 = 50%	3/4 = 75%	4/4 = 100%

What are the chances that you will get an offspring with **Bb black** eyes?

1 out of 4	2 out of 4	3 out of 4	4 out of 4
1/4 = 25%	2/4 or 1/2 = 50%	3/4 = 75%	4/4 = 100%

What are the chances that you will get an offspring with **bb red** eyes?

1 out of 4	2 out of 4	3 out of 4	4 out of 4
1/4 = 25%	2/4 or 1/2 = 50%	3/4 = 75%	4/4 = 100%

TEST YOUR HYPOTHESES BY CONDUCTING A GENETIC CROSS

Now you will conduct a genetic cross with your partner, record the results, and determine whether your **actual results** support your **hypothesis**.

You will be given 2 sacks of checkers. One represents the male **Bb** black-eyed mouse and the other represents the female **Bb** black-eyed mouse. Each sack contains an equal number of black checkers (representing gametes with the **dominant** black-eye gene) and red checkers (representing gametes with the **recessive** red-eye gene) because both the male and female are **Bb**.

A) Draw **1** checker/gamete from the "Mom" sack while your partner draws **1** checker/gamete from the "Dad" sack.

B) **RECORD** your answer in the chart below. If you pulled a **black checker**,record a **B** for a **black gene**. If you pulled a **red checker**, record a **b** for a **red gene**. This is your 1st offspring.

TRIAL 1	1st offspring	2nd offspring	3rd offspring	4th offspring
Mom's genes				
Dad's genes				

C) Return the gametes (checkers) to the exact bags from which they were drawn and shake them up.

D) **REPEAT** steps **B** and **C** **THREE (3) more times. RECORD** the results for the **2nd, 3rd** and **4th offspring** in the correct boxes above.

E) For each of the four offspring you created in **TRIAL 1**, record the gene combinations (**BB**, **Bb**, or **bb**) and the eye colors (**black** or **red**) in the spaces below.

TRIAL 1	1st offspring	2nd offspring	3rd offspring	4th offspring
Gene combination:	_____	_____	_____	_____
Eye color:	_____	_____	_____	_____

HOW WELL DID YOUR ACTUAL RESULTS FIT YOUR HYPOTHESIS?

In Trial #1, how many of your offspring had:

2 genes for **black** eyes (**BB**)? _____

1 gene for **black** eyes and **1** for **red** eyes (**Bb**)? _____

2 genes for **red** eyes (**bb**)? _____

Based on your **hypothesis**, you **predicted** that you would get **1 BB black eyed** mouse, **2 Bb black eyed** mice, and **1 bb red eyed** mouse. Did your **actual results** support your **hypothesis**?

YES **NO**

F) CONDUCT THE CROSS A SECOND TIME

Repeat the procedure from steps **A** through **E**. **RECORD** the gene combinations and eye colors for 4 new offspring in the chart below:

TRIAL 2

	1st offspring	2nd offspring	3rd offspring	4th offspring
Mom's genes				
Dad's genes				
Gene combination:	_____	_____	_____	_____
Eye color:	_____	_____	_____	_____

HOW WELL DID YOUR ACTUAL RESULTS FIT YOUR HYPOTHESIS?

In Trial #2, how many of your offspring had:

2 genes for **black** eyes (**BB**)? _____

1 gene for **black** eyes and **1** for **red** eyes (**Bb**)? _____

2 genes for **red** eyes (**bb**)? _____

Based on your **hypothesis**, you **predicted** that you would get **1 BB black eyed** mouse, **2 Bb black eyed** mice, and **1 bb red eyed** mouse. Did your **actual results** support your **hypothesis**?

YES **NO**

G REPEAT THE CROSS A THIRD TIME

Repeat the procedure from steps **A** through **E**. **RECORD** the gene combinations and eye colors for 4 new offspring in the chart below:

TRIAL 3

	1st offspring	2nd offspring	3rd offspring	4th offspring
Mom's genes				
Dad's genes				
Gene combination:	_____	_____	_____	_____
Eye color:	_____	_____	_____	_____

HOW WELL DID YOUR ACTUAL RESULTS FIT YOUR HYPOTHESIS?

In Trial #3, how many of your offspring had:

2 genes for **black** eyes (**BB**)? _____

1 gene for **black** eyes and **1** for **red** eyes (**Bb**)? _____

2 genes for **red** eyes (**bb**)? _____

Based on your **hypothesis**, you **predicted** that you would get **1 BB black eyed** mouse, **2 Bb black eyed** mice, and **1 bb red eyed** mouse. Did your **actual results** support your **hypothesis**?

YES **NO**

ANALYZE YOUR RESULTS

A) Remember your hypothesis:

If I cross 2 mice that each carry **1** gene for **black** eyes and **1** gene for **red** eyes (**Bb** X **Bb**),
then I expect to get:

___1____ **black** eyed mice with **BB** genes
___2____ **black** eyed mice with **Bb** genes
___1____ **red** eyed mice with **bb** genes
___4____ = total number of offspring

HOWEVER,
For each of the three genetic crosses (trials) you conducted, your **actual results** may or may not have supported your **hypothesis** that the **offspring** would be **1 BB** (**black** eyes), **2 Bb** (**black** eyes), **1 bb** (**red** eyes).

B) Conducting more trials and collecting more data often results in a better fit between the **actual** experimental results and the **predicted** results (**hypothesis**). Next you will analyze all of your data and determine how well your actual results support your hypothesis by summarizing the results of the **3** genetic crosses you and your partner conducted during TRIALS 1, 2 & 3.

1. In the chart below, enter the actual number of each gene combination you obtained for each cross/trial (look back at pages 2 & 3 for the results of each cross/trial.)

2. Then, going *across* the chart, add up all the **BB**s from all three trials and enter the answer in the **"Total number from all crosses"** box. Do the same for the **Bb**s and **bb**s.

	Trial 1 1st cross		Trial 2 2nd cross		Trial 3 3rd cross		Total number from all crosses	Expected # based on hypothesis
BB		+		+		=		**3**
Bb		+		+		=		**6**
bb		+		+		=		**3**

3. Now that you've looked at a larger number of offspring (12 offspring for TRIALS 1, 2 & 3 instead of just 4 for one trial), do the total results of your **3 actual** crosses come closer to your predicted **hypothesis**? **YES** **NO**

C) COMBINE YOUR DATA WITH THAT OF YOUR ENTIRE CLASS

What results would you expect if you examined the offspring produced in the genetic crosses from your entire class? First add up the total number of **BB**, **Bb**, and **bb** offspring produced by *everyone* in your class. Determine the "Expected # based on hypothesis" using the total number of offspring produced by all the crosses/trials by everyone.

	BB		**Bb**		**bb**		**Total offspring (all crosses)**
Total number for entire class	_____	+	_____	+	_____	=	_____
Expected # based on hypothesis	_____		_____		_____		

When you have an even larger number of offspring (all the **actual results** from your entire class), do the results come closer to matching your **predicted hypothesis**? **YES** **NO**