Title: Decoding the Mysteries of Chance: Concepts in Probability

Brief Overview:

The individual lessons of this unit are designed to address content standards for probability. Each lesson focuses on topics that are covered on state assessments required by the No Child Left Behind Act (specifically, the Maryland Student Assessment Test for math in grades 6-8). Each lesson is based on the student learning outcomes appropriate for a specific grade level. Together, the lessons comprise an overview of topics in probability covered in middle school, and could be used as a general review of probability. Lesson five also connects math content standards to science content standards (applications of probability to genetics).

NCTM Content Standard/National Science Education Standard:

NCTM Content Standards for Grades 6-8: Data Analysis and Processing

- Understand and use appropriate terminology to describe complementary and mutually exclusive events;
- Use proportionality and a basic understanding of probability to make and test conjectures about the results of experiments and simulations;
- Compute probabilities for simple compound events, using such methods as organized lists, tree diagrams and area models.

National Science Education Standards- Content Standard C

All students should develop understanding of heredity and reproduction:

- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information… A single human cell contains many thousands of different genes.

Grade/Level:

Grades 6-8

Duration/Length:

Five 50-minute Periods

Student Outcomes:

Students will:

Lesson One-

- Determine the probability of a single event
- Calculate probabilities from sample data

Lesson Two

- Construct tree diagrams to find all possible outcomes

Lesson Three

- Identify a sample space
- Describe the difference between theoretical and experimental probabilities
- Determine probabilities of independent events

Lessons Four and Five

- Identify a sample space
- Determine probabilities for compound events
- Describe the difference between theoretical and experimental probabilities
- Describe how physical traits are inherited
- Apply theoretical probability models to predict outcomes for inherited traits

Materials and Resources:

Lesson 1: Student glossary handouts, student probability lab packets, pencils, new pennies, large paper clips, marbles (yellow, green, blue, red), brown paper lunch bags, small index cards, dice, spinner templates

Lesson 2: Paper, pencils, rulers (optional), handout "Branching Possibilities", project sheet "The Haunted Mansion Party"

Lesson 3: Paper, pencils, rulers (optional), poster board, colored paper, markers or colored pencils, glue sticks, empty coffee cans, 3 x 5 index cards, handout "Independent Circumstances", project sheet "Cylindrical Words"

Lesson 4: One penny per student, Calculators, Handout "Heads Up!"

Lesson 5: Calculators, handout "Where'd You Get Those Eyes?"
Plastic poker chips- one side colored brown, one side blue
(pennies may be substituted)

Development/Procedures:

Lesson 1

Preassessment and Launch

Read the lesson objective to the students. Give each student one Probability Lab packet, a pencil, a die, a penny, a spinner template, a large paperclip, a brown lunch bag containing 15 assorted marbles (5 green, 4 blue, 3 yellow, 3 red), and a brown bag containing the numbers 1 through 10 made from small index cards. Tell the student that they have 15 minutes to complete sections I through V in their packets. Circulate to see if all students have enough prior knowledge to continue with the lesson. Reteach individual students as necessary. After 15 minutes, or sooner if all of the students have completed section V, collect everything but the Probability Lab packets, Glossary handouts, and pencils. Ask the students to turn their packets facedown until later.

Teacher Facilitation

Pass out the Probability Glossary handout. Explain that these terms will be read or heard often during the next few days. Explain that before raising their hands or asking another student to define a word for them that they should look in the Probability Glossary for the definition and an example. If they still do not understand the term, then they are permitted to raise their hands or ask another student for help. Call on students to read each term's definition. Provide additional examples if necessary. As the students to turn the Glossary face down.

Make sure that every student has a sharpened pencil. Turn on the overhead projector. Explain to the students that they will be taking notes on the back of their Probability Glossary. Tell them to copy what they see on the overhead projector screen. Ask the students to write "Probability" at the top of the paper. Ask if anyone remembers what the definition is for the term *probability* without turning over his or her Glossary handout to peek. Discuss several responses until you arrive at the correct definition. Write, "Probability is a mathematical measure of how likely an event can occur. This measure can be expressed as a fraction, a decimal, or a percent." Orally review changing a fraction to a decimal to a percent. Use an easy example, such as ¼ to 0.25 to 25%. Ask for questions about the definition for probability. Answer questions as necessary. Explain that when we do probability problems in math, we refer to a special kind of fraction called a *ratio*. Ask if anyone remembers what a ratio represents.

Write, "Ratios are used to express probability. The probability of an event occurring is the ratio, or comparison, of the number of ways the event can happen to the number of possible outcomes. Probability is calculated by using the formula P(event) = number of ways the event can happen / number of possible outcomes." Ask the students what they think the *P* represents. Make certain that all students know what the *P* represents. Ask if anyone remembers what the term *event* means. Make certain that all students know what the term *event* means. Make certain that all students know what *all-possible outcomes* represent in the formula.

Student Application

Ask the students to turn back to their Probability Lab packets and go to section VI. Go over the example with them and solicit questions. Answer questions as necessary. Instruct the students to work in their groups for this activity but to not allow any one person to do all of the work. Circulate to make sure that all students are engaged in discussions and that all students understand the concepts. Allow 30 minutes for them to complete section VI. Explain that they are to finish as many problems as possible but that it is more important to be accurate instead of rushing just to finish. The challenge problems at the end of the activity should keep your high-ability from finishing too early.

Embedded Assessment

See Probability Lab packet.

Reteaching/Extension

- Circulate while students' complete section VI in the Probability Lab. Assist those who are having difficulty with individualized teacher instruction.
- At the end of 30 minutes, collect the Probability Lab packet for use in future lessons in data and statistics. Instruct students to place their Probability Glossary into their math notebooks.
- Review the lesson by asking several questions about basic probability.
  "What have you learned about probability so far?"
  "Do you think that we all use probability in our daily lives?"
  "Has anyone ever played the game ROCK-PAPER-SCISSORS? Does that game involve any probability?"
  "Have you ever heard of a lottery? If yes, what is a lottery?"
- Conclude the lesson by saying "Probability is an exciting field of mathematics. There is much more for you to learn about probability, so tomorrow we will continue with more experiments and more new mathematical discoveries."

Lesson 2

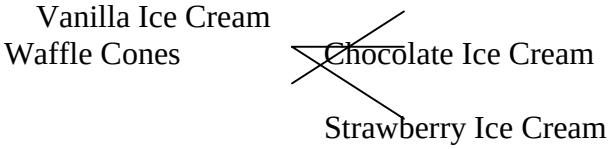
Preassessment – Students should have prior knowledge of: Completing the basic operations of adding and multiplying; working with fractions, decimals and percents; using outcomes to find the probability of events.

Launch – Remind students what they have learned in the previous lesson about probability. Use the example of rolling a die and the probability of rolling that die would be a specific number, 1/6. Another example would be to pick a card from a deck of 52 playing cards. The probability would be 1/52. Another example is to select a color off of a spinner divided into ten even parts with different colors on each part. The probability would be 1/10.

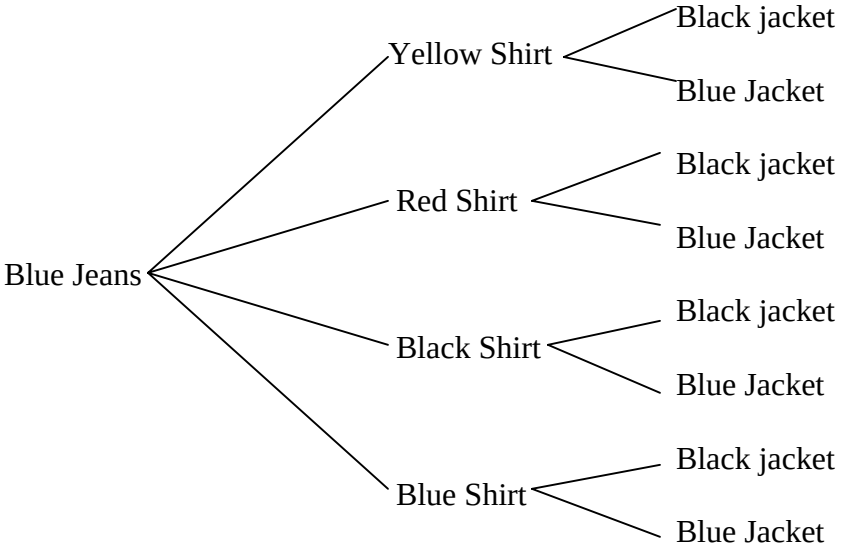
Teacher Facilitation – Direct the students in a discussion about probability. Today's lesson will focus more about probability. We will find the probability of multiple events by

find all the possible outcomes. In order to display all the possibilities of an event, we must display the information into organized lists. One such organized list is called a tree diagram. The branches on a tree diagram list all the possible outcomes of that particular event. Model and demonstrate a tree diagram for a one-step event and a two-step event.

Example of a one-step event: Cindy is going to the ice cream store. She finds that they have waffle cones and three different flavors of ice cream to pick from. The flavors are vanilla, chocolate, and strawberry.



Example of a two-step event: Kevin wants to get dressed for the school dance. He looks in his closet and finds a pair of brand new blue jeans. He has four different color shirts to wear and two different color jackets.



Student Application – A tree diagram will allow you to find all the possible outcomes. The structure of the branches shows all the possibilities of the event Now that students have an idea of how to construct a tree diagram, pass out worksheet – Branching Possibilities. Allow students time to complete the worksheet. Walk around and monitor student progress.

Embedded Assessment – After students have completed the worksheets. Divide students into groups of three and introduce the project – The Haunted Mansion. Encourage students to be creative in their drawings.

Reteaching/Extension – Evaluate student posters by having each group present the posters to the class.

Lesson 3

Preassessment – Students should have prior knowledge of:
The basic principles of probability.
Be able to interpret data.
Adding and multiplying fractions.
Understanding and using appropriate terminology.

Launch – Students are shown that when an experiment is performed, all the possible outcomes determine the experiments sample space. The set of all possible outcomes is the event. If a fair die is rolled, the possible outcomes or sample space is 1, 2, 3, 4, 5, and 6. If a coin is tossed, the sample space is heads or tails. If one card is drawn from a deck of 52 playing cards and the suit of the cards is going to be selected, the possible outcomes in the sample space are heart, spade, club and diamond.

Teacher Facilitation – The teacher should review probability rules and explain the new concepts.

The probability of an event is a measure of the number of ways the event will occur. When all the outcomes of an event are equal, the probability is expressed as a fraction.

$$P(\text{event}) = \frac{\text{number of favorable outcomes}}{\text{total number of outcomes}}$$

Probabilities range from 0 to 1. The closer the probability of an event is to 1, the more likely the event will occur.

You have conducted simple experiments in order to find all possible outcomes. When you wanted to know all of the equally likely outcomes, you used the Theoretical Probability. For example, to determine the probability of a fair coin toss to land on tails, tails represents 1 out of 2 sides. The theoretical probability of tails is ½ = 50%.

Probability based on the number of times the event occurs divided by the number of times the experiment is conducted is Experimental Probability.

The number of times the event occurs is the number of successes.

The number of times the experiment is performed is the number of trials.

For example, if you toss a fair coin 10 times, and four tosses were trials. The experimental probability for tails is 6/10 = 0.6.

In conducting an experiment, two events will not affect the outcomes of each other. When this happens, the events are independent events.
For example:

A box contains 2 purple jacks and 3 yellow jacks. A jack is drawn and replaced. Then another jack is selected. Because the first jack drawn is replaced, the second jack drawn is independent of the first event.

P(purple, then yellow) = P(purple) X P(yellow) = 2/5 x 3/5 = 6/25

Student Application – After explaining the new concept, hand students the worksheet – Independent Circumstances.

Embedded Assessment – Teacher and students review the answers together after students have completed the worksheet.

Reteaching/Extension – Students are given the project – Cylindrical Words. Teachers may use the worksheet or give students actual manipulative to use.

Lesson 4 Probabilities for Multiple Independent Events

Preassessment – Review students' abilities to determine the probability of one event by using specific examples:

What are the chances of …

a) getting heads on a coin toss? [1/2]
b) getting an even number when rolling a die (number cube)? [3/6 or 1/2]
c) getting a six when rolling a die? [1/6]
d) getting some number between one and six when rolling a die? [6/6 or 1]
e) getting a seven when rolling one die? [0/6 or 0]

Launch –Review notation for defining the probability of a single event:

$$P(\text{event}) = \frac{\text{(number of successful outcomes)}}{\text{(total number of outcomes)}}$$

Rewrite the answers from the Preassessment using the P(event) notation.

Review the probability of an event comprised of two independent events:

P(1 and 2) = P(1) x P(2)

Give an example- the probability of getting heads on a coin toss <u>and</u> rolling a six with a die:

P(heads and six) = P(heads) x P(six)
= 1/2 x 1/6
= 1/12

Next, use the worksheet "Heads Up!" to show how to construct a tree diagram to identify the sample space for a compound event:

Teacher Facilitation – Define theoretical probability, referring to the examples from the Launch.

Student Application – Have students design a probability experiment to test the theoretical probabilities for getting different numbers of heads on four coin tosses.

Embedded Assessment – Use the brief constructed response from the "Heads Up!" worksheet to assess student understanding of the relationship between theoretical and experimental probabilities.

Reteaching/Extension –

- For those who have not completely understood the lesson, discuss what theoretical probability predicts for the outcomes of ten single coin tosses [five heads, five tails] and what can happen when someone performs a probability experiment and actually does toss a coin ten times.
- For those who have understood the lesson, challenge them to construct a tree diagram and determine the theoretical probabilities for the different numbers of heads in six consecutive coin tosses

Lesson 5 The Role of Probability in Genetics

Preassessment – Review students' abilities to determine the number of outcomes in the sample space for multiple independent events:

1. How many possible outcomes can occur with…
   a) a single coin toss? [2]
   b) two consecutive coin tosses [4]
   c) three consecutive coin tosses? [8]
   d) four consecutive coin tosses? [16]

2. What is the pattern in the above examples that would allow you to predict the number of possible outcomes for six consecutive coin tosses? [a doubling pattern, powers of 2]

Launch – Review the genetic basis for inheriting physical traits using worksheet, "Where'd You Get Those Eyes?": define chromosomes and genes; describe where chromosomes

are located; compare the process of inheriting alleles during meiosis to two consecutive flips of a coin toss.

Teacher Facilitation – Explain how to use a Punnett square to represent the sample space for the possible outcomes for inheriting a single gene through sexual reproduction. Point out the similarities between the grouping of outcomes in the sample space for a double coin toss and the corresponding probabilities (two heads- 1/4, one head- 1/2, no heads- 1/4) and the combinations of alleles (two dominant, one dominant and one recessive, both recessive). Explain how these three types of outcomes in the sample space result in only two possible outcomes for the physical trait of the organism, and the associated probabilities (dominant trait- 3/4, recessive trait- 1/4).

Student Application – Using the worksheet "Where'd You Get Those Eyes?" students determine the theoretical probability for an offspring's eye color based on the assumption that eye color is determined by a single gene with dominant and recessive alleles.

Embedded Assessment – See worksheet "Where'd You Get Those Eyes?"

Reteaching/Extension – Using Internet resources (such as the web page "How are human eye colors inherited?" at http://www.athro.com/evo/gen/genefr2.html), students investigate current scientific understanding of how humans inherit eye color, and play a computer simulation to understand how a combination of several genes contributes to the outcomes of children's eye color.

Summative Assessment:

Students may take the Maryland State Assessment practice test on the Internet at the URL http://www.mdk12.org/instruction/assessment/index.html.

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Name: _____ Date: _____

PROBABILITY LAB

LIKELIHOOD OF AN OCCURRENCE

I. Fill in the circles labeled **certain, possible,** or **impossible** to describe the degree of likelihood that an event would occur.

	Certain	**Possible**	**Impossible**
You will wake up tomorrow.	◯	◯	◯
School will be cancelled forever!!	◯	◯	◯
You will eat breakfast tomorrow.	◯	◯	◯
You will have a quiz this week.	◯	◯	◯

LIKELIHOOD OF AN OCCURRENCE EXPRESSED AS A PERCENT

II. Color in the box on the **probability** scale below beside the percentage that you thing represents your choice for each event in part I.

(100% is CERTAIN, 0 is IMPOSSIBLE)

You will wake up tomorrow.

100%	
90%	
80%	
70%	
60%	
50%	
40%	
30%	
20%	
10%	
0	

School will be cancelled forever!!

100%	
90%	
80%	
70%	
60%	
50%	
40%	
30%	
20%	
10%	
0	

You will eat breakfast tomorrow.

100%	
90%	
80%	
70%	
60%	
50%	
40%	
30%	
20%	
10%	
0	

You will have a quiz this week.

100%	
90%	
80%	
70%	
60%	
50%	
40%	
30%	
20%	
10%	
0	

PREDICT THE PROBABILITY

III. Predict (guess) the **chance** (0→100%) of the event occurring in the following simple experiments.

Example:

Getting heads when flipping a fair coin one time. 50%

Landing on red when spinning a spinner with four wedges. (1 blue, 1 green, 1 yellow, 1 red) _____%

Rolling a six on the first roll of a die. _____%

Drawing a green marble from a bag of 5 green, 4 blue, 3 yellow and 2 red marbles. _____%

Choosing the number 4 from the numbers 1 thru 10. _____%

ALL POSSIBLE OUTCOMES

IV. Fill in the blanks with the possible outcomes of each of the following experiments.

Example:

Getting heads when flipping a fair coin one time.

____heads____ ____tails____

Landing on red when spinning a spinner with four wedges.
(1 blue, 1 green, 1 yellow, 1 red)

_____ _____ _____ _____

Rolling a six on the first roll of a die.

_____ _____ _____ _____ _____ _____

Drawing a green marble from a bag of 5 green, 4 blue, 3 yellow and 2 red marbles.

_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____

Choosing the number 4 from the numbers 1 thru 10.

_____ _____ _____ _____ _____
_____ _____ _____ _____ _____

EXPERIMENTAL PROBABILITY

V. Perform the experiments below. Circle your results.

Flip a coin once.	heads	tails				
Spin the spinner once.	red	green	yellow	blue		
Roll the die one time.	1	2	3	4	5	6
Draw a marble from the bag.	yellow	green	blue	red		
Choosing a number 4.	1	2	3	4	5	6	7	8	9	10

ANSWER SHEET – LESSON ONE

I. Student answers will vary.

II. Student answers should match Lab handout I.

III. Landing on red – 25%

Rolling a six – 16.6…%

Drawing a green – 33.3…%

Choosing a 4 – 10%

IV. Spinner – blue, green, yellow red

Rolling a die – 1,2,3,4,5,6

Drawing a green marble – green, green, green, green, green, blue, blue, blue, blue, yellow, yellow, yellow, red, red

Choosing a number from 1-10 – 1,2,3,4,5,6,7,8,9,10

V. Experimental results will vary.

Name _____ Date _____

CALCULATING PROBABILITY

VI. Complete the following probability problems using the format provided in the example.

Example: What is the probability of rolling an odd number on a die? Show your answer as a fraction, a decimal, and a percent.

Possible Outcomes: 1, 2, 3, 4, 5, 6
Number of ways the event can occur: 3 (rolling a 1 or a 3 or a 5)
P(odd number) = 3/6 = 0.5 = 50%

1. If the letters of the alphabet were placed in a brown lunch bag, what is the probability that you would select an "M" from the bag?

2. If you put the "M" back into the bag, what is the probability that you would select a vowel from the alphabet bag?

3. If you spin a spinner with 10 equal wedges that are half red and half blue, what is the probability that you will land on a red wedge?

4. Spin again. What is the probability that you will not land on a red or a blue?

5. If you roll a die, what is the probability that you will roll an even number?

6. If you have the numbers 1 through 15 in a brown lunch bag, what is the probability that you will draw a prime number from the bag?

7. If you have 3 red marbles, 2 blue marbles, and ten purple marbles in a brown lunch bag, what is the probability that you will draw a purple marble?

CHALLENGE PROBLEMS

8. If you hold a penny in each hand behind your back, what is the probability that the hand you partner picks will be heads?

9. A single card is drawn from a standard deck of playing cards. What is the probability that it will not be a numbered card?

ANSWERS TO CALCULATING PROBABILITY

1. Possible Outcomes: a,b,c,d,e,f,g,h,I,j,k,l,m,n,o,p,q,r,s,t,u,v,w,x,y,z
   Number of ways the event can occur: 1
   P(M) = 1/26 = 0.038 = 3.8%

2. Possible Outcomes: a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,q,r,s,t,u,v,w,x,y,z
   Number of ways the event can occur: 5 (a,e,i,o,u)
   P(vowel) = 5/26 = 0.192 = 19.2%

3. Possible Outcomes: r,r,r,r,r,b,b,b,b,b
   Number of ways the event can occur: 5
   P(red) = 5/10 = 0.5 = 50%

4. Possible Outcomes: r,r,r,r,r,r,b,b,b,b,b
   Number of ways the event can occur: 5 if red or 5 if blue
   P(red) = 5/10 P(blue) =5/10
   (Note: Student will learn more about this in lesson 2-5.)

5. Possible Outcomes: 1,2,3,4,5,6
   Number of ways the event can occur: 3 (2 or 4 or 6)
   P(even): 3/6 = 0.5 = 50%

6. Possible Outcomes: 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15
   Number of ways the event can occur: 7 (1,2,3,5,7,11,13)
   P(prime) = 7/15 = 0.467 = 46.7%

7. Possible Outcomes: r,r,r,b,b,p,p,p,p,p,p,p,p,p,p
   Number of ways the event can occur: 10
   P(purple) = 10/15 = 0.666 = 66.6%

8. Possible Outcomes: h,t,h,t
   Number of ways the event can occur: 1 (only one hand is shown)
   P(heads) = ¼ = 0.25 = 25%

9. Possible Outcomes: 52 cards (1 – 10 each suit and J,Q,K each suit)
   Number of ways the event can occur: 12 (all face cards)
   P(not a numbered cards): 12/52 = 0.23 = 23%

Name: _____ Date: _____

Branching Possibilities

Directions: Use a tree diagram to determine all the different outcomes of the event.

1. Brandy is getting ready for school. She can only wear khaki pants. But she can wear a white oxford shirt or a blue oxford shirt. How many possible combinations of shirt and pants can she wear?

2. A clothing store at the mall sells headbands. They come in five colors: yellow, orange, pink, purple, and neon green. Each color comes in plain or polka dot. How many possible headband choices are there?

3. A store sells fruit shakes. They have three different size cups to use: small, medium and large. The choices of fruit are banana, orange, pineapple, strawberry, and peach. They can also add whip cream or no whip cream. How many possible combinations of fruit drinks are there?

Name: _____ Date: _____

Project: The Haunted Mansion Party

Its October 31st, Halloween. The local amusement park has been turned into a big haunted maze. About four hundred people have paid the admission price and are ready to go through the haunted maze on their way to the party at the Haunted Mansion. The four hundred people have gone through the entrance gates. As they travel down the first path, one hundred people decide to go down Skeletal Road. Another hundred decide to go down Black Cat Drive. Another hundred travel down Pumpkin Patch Lane. An additional hundred go down Scary Road. Those that went down Skeletal Road decide to evenly split. Some travel unto Cemetery Pathway, others walk down Crow Hill. Black Cat Road divides into Boo-Ville Boulevard, Ghost Town, Candy Corn Lane and Fly Away Road. The people going down Scary Road divide up and some go down Creepy River Path, others walk down Wrong Turn Drive. But Creepy River Path splits into Dead Sea Road and Dead End Road.

Directions: Using the poster board, markers, colored paper, and glue, draw a map (tree diagram) of the paths of the haunted maze, and then answer the following questions.

1. How many people end up traveling down Crow Hill, Candy Corn Lane and Wrong Turn Drive?
2. How many people are walking along Boo-Ville Boulevard, Fly Away Road, Dead Sea Road and Dead End Road?
3. How many people only travel down one path to get to the Haunted Mansion?
4. How many people venture down Black Cat Drive and Creepy River Path?
5. How many people will safely end up at the Haunted Mansion party?

Name: _____ Date: _____

Independent Circumstances

Directions: Read each of the following situations carefully. Find the probability.

1. A coin is tossed and a single 6-sided die is rolled. Find the probability of getting a tails on the coin and a 5 on the die.

2. Two dice are rolled. Find the probability of getting a 2 on the first die and a 3 on the second one.

3. A card is chosen at random from a deck of 52 cards. It is then replaced and a second card is chosen. Find the probability of getting a six and a queen.

4. A bubble gum machine contains 4 red cherries, 6 apple green, 3 lemon yellow and 7 blue raspberry separately clear rapped bubble gum balls. You put a quarter in the machine to randomly get a bubble gum ball, but you don't like the flavor, so you put it back. You put another quarter in the machine. Find the probability of getting a green apple bubble gum and a lemon yellow bubble gum.

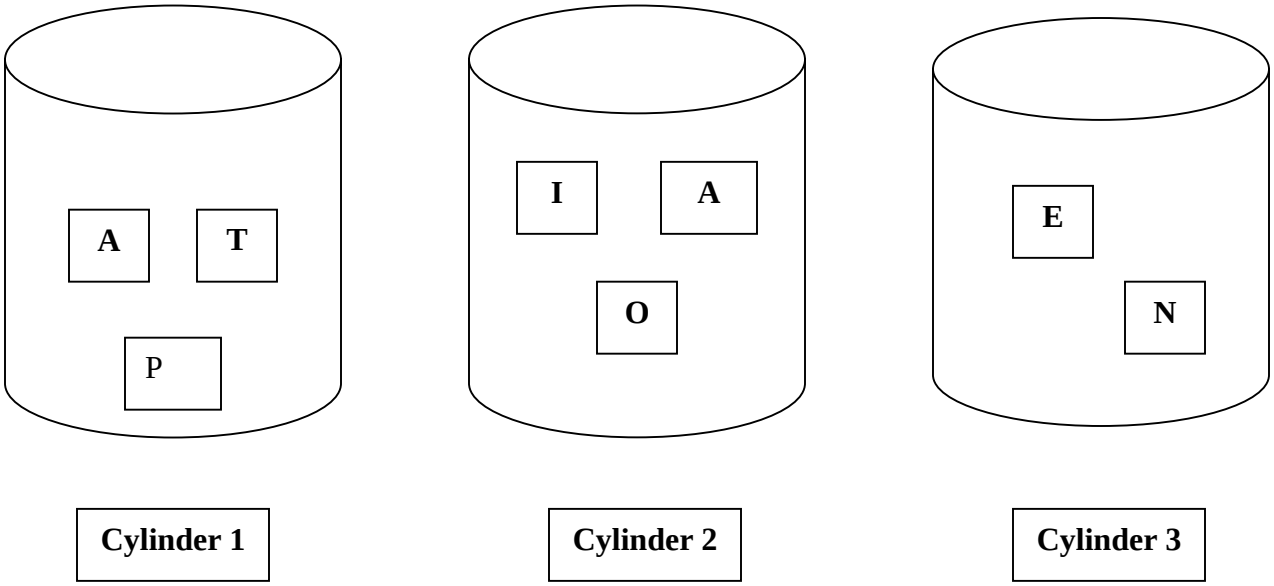
5. You roll a number cube that has the numbers 8, 11, 11, 16, 16, and 16 on it. You then spin a spinner that has 6 sections. The letters on the spinner are K, B, H, C, B and E. Find the probability of a number less than 10 and not a C.

6. You flip a coin and toss a number cube numbered from 1 to 6. You then spin a spinner with 5 different sections each with a different color. The colors on the spinner are blue, orange, silver, pink, and purple. Find the probability of not getting a 2 and not silver.

Name: _____ Date: _____

Cylindrical Words

Cylinders 1, 2, and 3 contain letter tiles as shown below.



Without looking, you draw one letter card from each cylinder. You lay the letters in a row (the Cylinder 1 letter first, the Cylinder 2 letter second, and the Cylinder 3 letter third. Then you look to see whether you have formed a word.

Determine the probability of the number of possible outcomes that the three letters you draw will form a word from the English language? The word may not be an abbreviation or a person's name.

Example: If you draw the letter P from Cylinder 1, A from Cylinder 2, and E from Cylinder 3, you get PAE. PAE is not a word in the English Language.

_____ _____

_____ _____

_____ _____

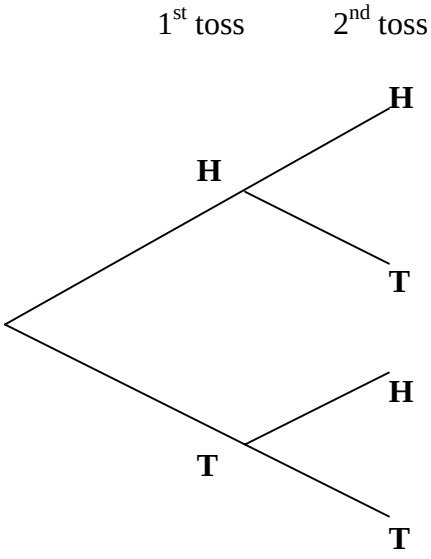
_____ _____

Name: _____ Date: _____

HEADS UP!

Two Consecutive Coin Tosses

Tree Diagram



Sample Space

_____

_____

_____

_____

In two consecutive coin tosses, what is the theoretical probability of getting…

a) two heads in a row? _____
b) one head? _____
c) no heads? _____

Probability Experiment

If you and a partner each flip a coin ten times, how many times do you think you each coin will come up heads?

To find out, conduct ten trials, and record your results:

No Heads	One Head	Two Heads

Calculate the percentage for each outcome:

No Heads	One Head	Two Heads

Now record the results for the entire class (each pair doing ten trials):

No Heads	One Head	Two Heads

Calculate the percentage for each outcome for the class data:

No Heads	One Head	Two Heads

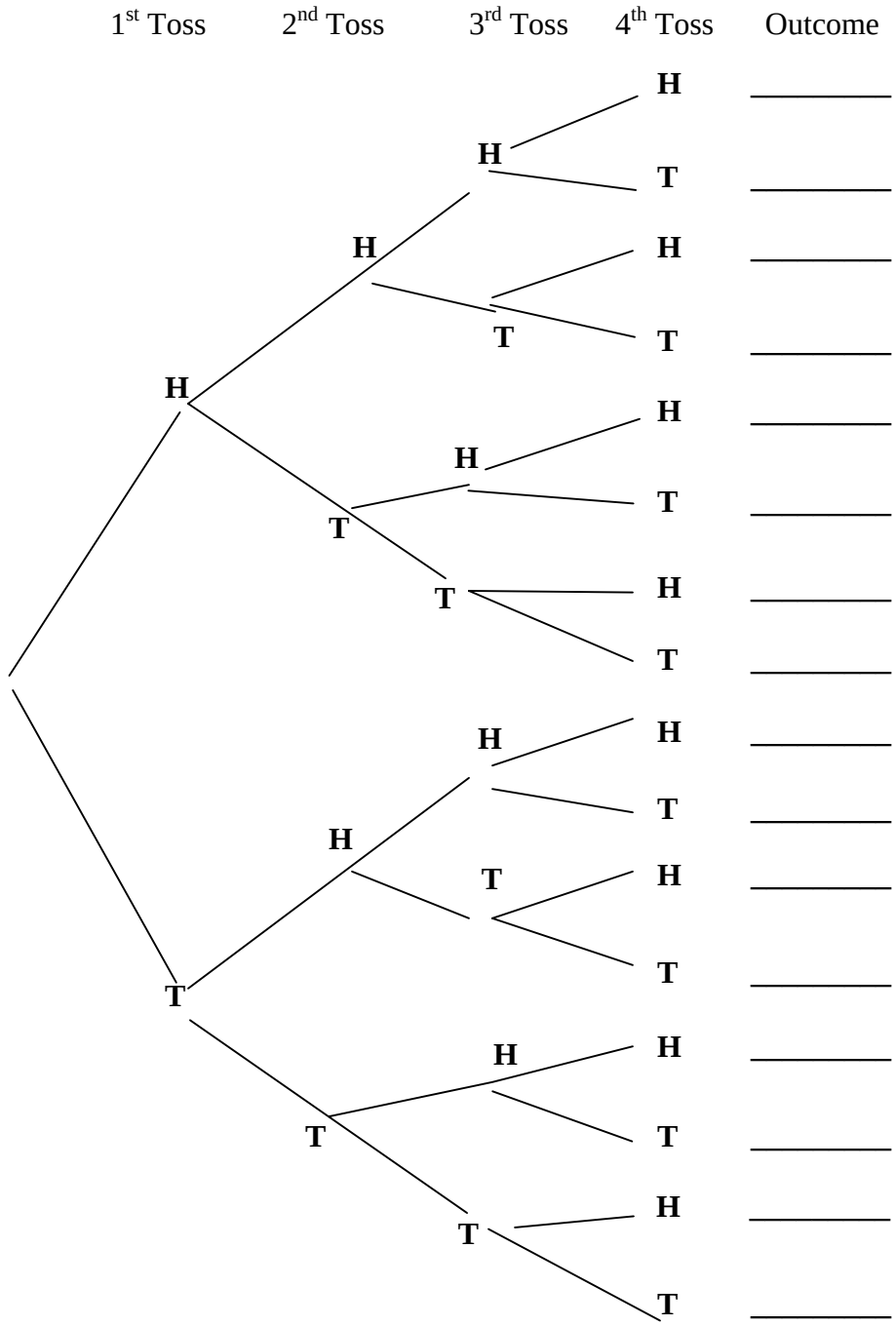
According to the results above, which set of data is closer to the theoretical probabilities for two coin tosses, the results for your pair, or the results for the entire class?

_____

Explain how you arrived at the answer above:

_____
_____
_____
_____
_____

Four Consecutive Coin Tosses


1st Toss
2nd Toss
3rd Toss
4th Toss
Outcome
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Name: _____ Date: _____

WHERE'D YOU GET THOSE EYES?

Have you ever wondered how people end up with different eye colors? The answer can be found in the branch of science called genetics. Scientists have learned how living organisms pass on physical traits to their offspring. Part of the explanation involves an application of the basic rules of probability.

Facts About Genetics

- The physical traits (eye, hair and skin color, for example) are determined by genes
- Genes are contained in groups or bundles called chromosomes, which are located in the nucleus of each cell in a human body
- Humans have over 30,000 genes in their cells

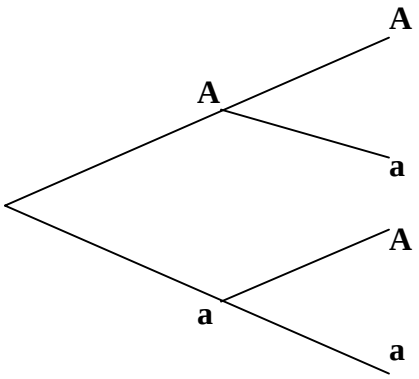
How We Inherit Physical Traits

When a person is born, he or she has inherited a unique combination of physical traits (characteristics that determine what he or she looks like) that comes from existing physical traits of both biological parents. How is this unique combination decided?

Reproduction begins with the fertilization of an egg cell with a sperm cell. For the new living organism, half the genetic information comes from the male parent, half from the female parent.

Genes normally have two versions, called alleles. One version of the gene is dominant; the other version is recessive. Each version of a gene represents a different outcome for a physical feature. For eye color, brown is the dominant version, blue is a recessive version. (Scientists usually represent a dominant allele with a capital letter, and a recessive allele with a lower case letter.) Which allele we inherit from each parent is like a coin toss. Since each person has two biological parents, the way we inherit alleles of a single gene is like the sample space for two consecutive coin tosses:

Tree Diagram



Sample Space

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Biologists use a table called a Punnett square to display the sample space of the ways a gene can be inherited:

		Father' Allele	
		A	**a**
Mother's Allele	**A**	**AA**	**Aa**
	a	**aA**	**aa**

The only way the offspring will display the recessive trait is if both alleles are recessive (aa). This means there is a 1/4 probability of inheriting the recessive trait. If either or both alleles is the dominant allele (Aa, aA or AA), the offspring will inherit the dominant trait. The probability for this is 3/4.

Eye Color

Suppose human eye color were a physical trait determined by a single gene with two alleles. The dominant allele (B) is for brown eyes; the recessive allele (b) is for blue eyes.

Complete the Punnett square below for the eye color gene:

		Father' Allele for Eyes	
		B	**b**
Mother's Allele for Eyes	**B**		
	b		

Which combination(s) will produce offspring with brown eyes? _____

Which combination(s) will produce offspring with blue eyes? _____

What is the theoretical probability that an offspring of these parents will have blue eyes? _____

To see how this theoretical model of inheriting eye color would work, perform the following probability experiment: Suppose you will be a parent of eight children. To

find out if your children will have brown eyes or blue eyes, flip two coins for each child. One coin will determine the eye color allele from the father, the other coin will determine the eye color allele from the mother. If the coin toss ends up heads, then the child receives the dominant allele from that parent (if its tails, the child receives the recessive allele from the parent:

Child	Mother's Allele for Eye Color	Father's Allele for Eye Color	Child's Alleles	Child's Eye Color
1				
2				
3				
4				
5				
6				
7				
8				

What fraction of your children have brown eye? _____ What percentage? _____

What fraction of your children have blue eye? _____ What percentage? _____

According to the theoretical probabilities, how many children out of eight should have brown eyes? _____ How many should have blue eyes? _____

Does Probability Really Explain Eye Color?

Scientists often try to explain and describe patterns they observe in the natural world using mathematics. Does the theoretical probability model we used above accurately describe the ways humans inherit eye color?

Step A

To get some example of the answer, do a survey of the eye colors for the students in your class. Create a frequency table in the space below, listing all the different categories of eye color you observe, and how often they occur.

Step B

Based on the information you gathered, explain whether or not the theoretical probability model for eye color described above does a good job of predicting the results of the eye colors of the students in your class. Use words, data and/or numbers in your explanation.

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Summing Up

As you might suspect, the full scientific explanation is more complicated than the model describe in the previous sections. To learn more about the genetic explanation of how we inherit eye color, visit the web page "Inheriting Eye Color" at the URL http://www.athro.com/evo/gen/genefr2.html

DECODING THE MYSTERIES OF CHANCE: CONCEPTS IN PROBABILITY GLOSSARY

Allele – any one of two or more alternative forms of a gene that may occur alternatively at a given location on a chromosome

Cell – the basic unit of which all-living things are composed

Chromosome – the part of a cell that contains hereditary information in the form of genes

Consecutive – one event immediately following another

Decimal – numbers that are written using place value based on ten. A whole number is a decimal number. 4.75 is a decimal number. 1.0 is a decimal number equal to the whole number 1.

Dependent Events – events for which the occurrence of one affects the probability of the other.

Dominant – one of a pair of genes that has greater influence an alternative form of a gene

Event – the particular outcome one is looking at in a probability experiment.

Experimental Probability – a probability calculated from the results of an experiment.

Fraction – a number describing part of a whole when the whole is cut into equal pieces.

Gene – a unit of hereditary information

Genetics – the branch of biology that deals with heredity

Inherit – to receive a physical characteristic from one's parents through genetic transmission

Independent Events – events for which the occurrence of one has no effect on the probability of the other.

Nucleus – a specialized structure found in most cells, separated from the rest of the cell by a membrane

Outcome (of an activity) – one of the possible events in a probability situation.

Percent – a special ratio that compares a number to 100 and used the % sign.

½ = 50%

Probability – the number of favorable outcomes compared to the number of possible outcomes of an experiment. A number from 0 to 1, which indicates how likely something, is to happen.

Punnett Square – a grid used to show all the possible outcomes of a genetic cross

Rate – a ratio comparing two different units.

Ratio – a fraction comparing two numbers or measures using division.

Recessive – one of a pair of genes that has lesser influence on an inherited trait

Sample Space – the collection of all possible outcomes of a probability experiment.

Sample space = all possible outcomes

Theoretical Probability – a probability calculated from mathematical counting technique.

Trait – a genetically determined characteristic

Tree Diagram – a branching tree-like diagram showing all possible outcomes of a situation.