TEACHER GUIDE: Spudoodle Activity

ACTIVITY OVERVIEW: written by Jennifer Tolleson

Abstract:
Students will assemble a "spudoodle baby" using what they have learned about genetics and inherited traits.

Prior knowledge needed:
Every organism requires a set of instructions that specifies its traits. These instructions are stored in the organism's chromosomes. Heredity is the passage of these instructions from one generation to another in genes located in the chromosomes.

Key concepts:
Genotype & phenotype, recessive allele, dominant allele, homozygous, heterozygous, heredity, complete dominance, incomplete dominance, codominance, and Punnett squares. These concepts should be covered in readings, notes and classroom discussions in the week or two prior to doing the activity.

Materials: (Students provide their own potato and are asked to donate items for the class to use)
Student handouts, russet/Idaho potato (1 per group), toothpicks (the type with two pointed ends), glue dots, small cork stoppers (from craft store), two sizes of google eyes (small and medium), colored mini marshmallows (green, pink, and yellow), 4" lengths of pipe cleaner, paper clips (standard and jumbo size), colorless pushpins, quarters, nickels and pennies.

Appropriate for:
Ages: 12 - 14
USA grades: 7 – 9

Prep Time:
Two or more hours: copying handouts, preparing "mom and dad" bags of genes (one of each per group, gathering and setting up materials, reviewing activity. It will take less time to prep for this lesson in the future because you will have the "mom and dad" bags of genes already prepared.

Class Time:
120 minutes (approx.) – 2 or 3 class periods depending on the length of classes.

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PEDAGOGY

A. Learning Objectives

- Students will be able to describe the genotype and phenotype of the mother, father and baby spudoodle.
- Students will be able to complete Punnett squares to determine the probability of their baby spudoodle inheriting each of the eight traits being studied.
- Students will understand that traits are passed from parents to their offspring through genes that are located on the chromosomes.
- Students will understand the difference between homozygous and heterozygous traits.
- Students will be able to describe the difference between complete dominance, incomplete dominance, and codominance by giving at least one example of each type of trait as it pertains to the spudoodle.

B. Background Information

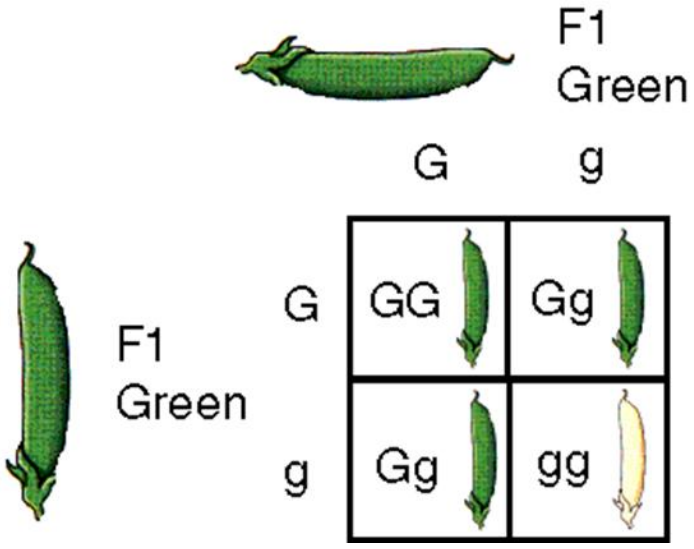
DNA contains the instructions for assembling and operating all living things. The DNA is composed of many different genes which are responsible for controlling the many traits that an organism exhibits. **Traits** are the physical characteristics of an organism. When Gregor Mendel studied pea plants, he noticed that the traits of the offspring plants were similar to the traits of the parent plants that produced them. **Heredity** is the passing of traits from parents to their offspring. Mendel's work formed the basis of **genetics**, which is the scientific study of heredity.

The different forms of genes are called **alleles**, with one allele being contributed from each parent. Alleles control how traits are inherited. Some alleles are considered **dominant**, their trait will always show up in the organism if the allele is present. Some alleles are considered **recessive**, their trait can only show up if two recessive alleles are present because the recessive trait will always be masked if the dominant allele is present. The **genotype** of an organism shows the combination of alleles that are present, for example Tt for pea plant height. The capital letter represents the dominant allele (tall), while the lower case letter represents the recessive allele (short). The **phenotype** of an organism is its physical appearance, or what traits are visible. If a pea plant has a genotype of Tt, its phenotype will be tall. If an organism has two identical alleles for a trait, TT or tt, it is said to be **homozygous** for that trait. If an organism has two different alleles for a trait, Tt, it is said to be **heterozygous** for that trait.

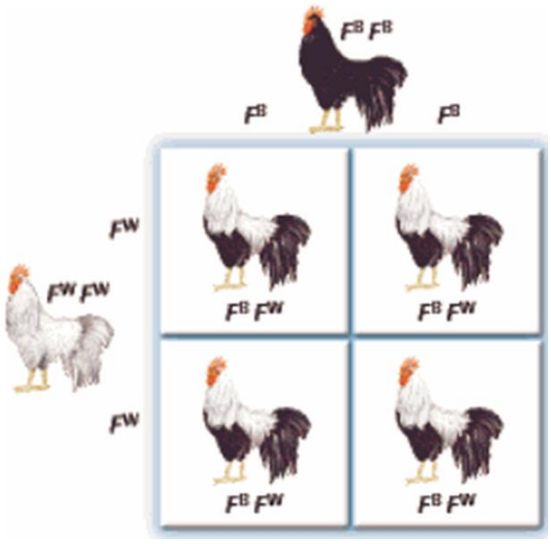
In the process of doing thousands of crosses of pea plants, Gregor Mendel came to realize that the mathematical principles of probability could be used to determine the potential results of his genetic crosses. **Probability** is simply the likelihood that a particular event will occur. A **Punnett square** is a chart that shows the potential outcomes of a genetic cross and can be used to determine the probability that an offspring with a particular genotype or phenotype will be produced.

For all of the traits that Gregor Mendel studied, one allele was always dominant and one was always recessive, this is called **complete dominance**. This type of inheritance pattern is not always the case. Another inheritance pattern is called **codominance**. In this case neither allele is dominant or recessive. As a result, the offspring exhibit both traits. A third type of inheritance pattern is **incomplete dominance**. In this type of inheritance, the heterozygous offspring exhibit an intermediate phenotype different from both the dominant and recessive trait. The expressed trait is somewhere "in-between" the two homozygous phenotypes.

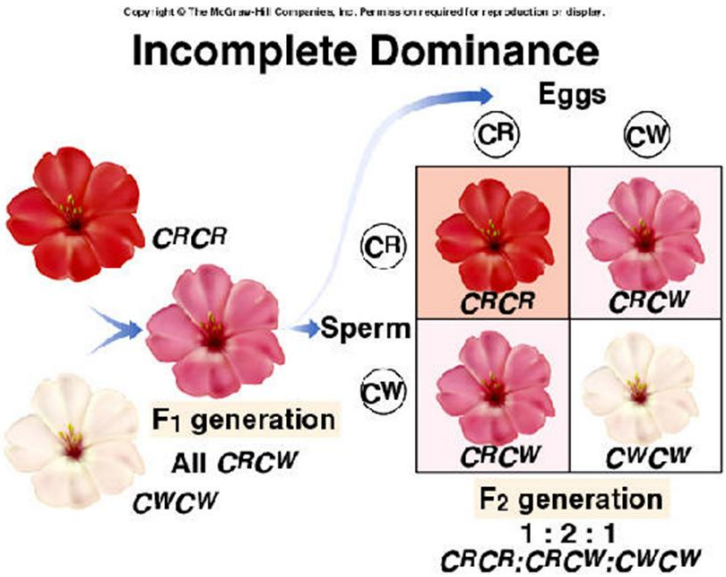
Examples of different types of inheritance patterns, using Punnett squares:



This is an example of **complete dominance** as shown in pea plants. The green pea pod color (G) is dominant over the yellow pea pod color (g). If there is a dominant allele present, either GG or Gg, the pea pod will be green. The only way for an offspring to have a yellow pea pod is if it is homozygous recessive (gg).



This is an example of **codominance**. In Erminette chickens neither black feathers nor white feathers is dominant. All heterozygous individuals will have both black and white feathers. The only way to have either all black or all white feathers is to be homozygous for that trait.



This is an example of **incomplete dominance**. All of the offspring of the first cross, the F_1 generation are heterozygous and their flowers are pink in color. This color is different from either of the parent plants, it is somewhere "in-between" the red and white colors of the parents. The second cross produces the F_2 generation, which has 3 different genotypes and therefore 3 different phenotypes.

C. Teaching Strategies

1. Timeline and classroom implementation
    - One week before the activity
        - Provide students with a list of materials needed for the activity and ask students to donate some items (you can offer extra credit if you want to). I picked up the small corks, two different sized google eyes and glue dots to ensure that we had the proper items. Doing this a week in advance gives you a couple of days before the activity to pick up any necessary items that were not brought in by students.

  - Start cutting out the circles that will represent the alleles that will go in the Mom and Dad bags that each group will have. You will need 8 different colors of card stock. I used a 1 inch diameter circular hole-punch from the scrapbooking section of a craft supply store to punch out the circles that represented the alleles. You will need to determine how many lab groups you will have. I had my students work in groups of two. The number of lab groups will determine the total number of circles that you will need to punch out.
- Two to three days before the activity
  - Assemble the Mom and Dad bags of alleles. I just used brown paper lunch bags labeled "Mom" and "Dad." Make sure that each bag contains two circles of each color and that you have labeled each circle with the proper letter for that trait and that some are dominant and some are recessive.
  - Make photocopies of the student handouts and staple them into packets, one packet per student.
- Day before the activity
  - Pick the partners for the activity – in some cases you will have two boys or two girls, just explain that for the purposes of the experiment one is responsible for handling the alleles in the mom bag and one is responsible for the dad bag.
  - Review the steps of the activity, have students follow along with the instructions in the lab packet – don't let them take the packets home today.
  - Stress the importance of reading and following all instructions in a step-by-step manner.
  - Remind students to bring in their potatoes for the activity on day one– one per group. It should be a reasonably sized Russet or Idaho potato. Don't use red bliss (too small) or sweet potatoes (too hard).
  - Before leaving school for the day push desks together in groups of two for each group.
- Day one of the activity
  - Have one member of each group pick up one Mom and one Dad bag for their group as well as two lab packets, one for each member of the group.
  - Remind students that they are to carefully read and follow all instructions.
  - Students should complete steps 1 – 9 of the Spudoodle instructions as well as fill in the entire first page of the Spudoodle report sheet along with the very first section of the second page of the report sheet (the genotype and phenotype for their baby spudoodle) – complete for homework if not finished during class time.
  - Students should stop work where it says: **STOP HERE!!**

- Day two of the activity
    - Have stations set up along one side of the room if possible with all of the necessary materials that students will need to assemble their spudoodle babies.
    - Students will continue to work with their lab partner from yesterday.
    - Students need to have their lab sheet from the day before. Do a quick check to confirm that everyone completed the necessary sections before proceeding.
    - Students will leave their potato at their desk and bring one copy of the report sheet with them to the side of the room to get the materials that they need to assemble their baby spudoodle. Let about two groups go at a time.
    - Students assemble their baby spudoodles – this is a good time to take pictures if your school/students allow you to do so.
    - Once the baby spudoodle is assembled students should complete the remaining questions on the report sheet individually. This can be completed as homework if time does not allow in class.
    - **Optional Math Extension** – this may be better to do together as a class on day 3 as it can be challenging for some students to do on their own.
    - Have each group fill in the "Spudoodle Wrap-up" sheet. I added this to the original activity found online as a way to do a quick view of all of the spudoodles to see if any of them had an identical set of traits – this will be reported back on Day 3 of the activity.
- Day three of activity (if needed)
    - Complete optional math extension if you decide to include this portion of the activity.
    - Collect completed report sheets.
    - Go over the results of the spudoodle wrap-up. Have students discuss why they think there were so few identical spudoodles.
    - Show spudoodle flowchart (attached). I added this to show how with the addition of each trait, the number of possible baby combinations increases exponentially. The fact that a few of the traits had incomplete dominance and codominance inheritance patterns also led to an increase in the total number of combinations.

2. Assessment
    - Completion of all sections of the report sheet, showing accurate work, and well formulated responses to questions.
    - Follow-up quiz or several questions on a unit test related to the activity.

3. Extensions
    - Have students research how and why traits that are controlled by more than one gene, with two alleles can show so much more variety in their phenotypes.
    - High school age students should be able to complete the optional Mathematical Extension portion of the report sheet on their own.

RESOURCES

- Book: *Cells and Heredity*, by Donald Cronkite, Ph.D. 2002. Prentice-Hall, Inc., Upper Saddle River, NJ. ISBN# 0-13-054064-1
- Massachusetts Science and Technology/Engineering Curriculum Framework. 2006. Massachusetts Department of Education.

MATERIALS

A. Detailed Materials list – for preparing Mom and Dad bags of alleles
    - Small brown lunch bags, enough for two per group
    - 8 different colors of card stock – you can match the colors I used or use different colors. If you used different colors make sure that you make the appropriate changes on all handouts.
    - Paper punch from scrapbooking section of the craft store – I used one with a one-inch diameter circle, but you can use any shape that you like.

B. Detailed Materials list – for assembling the spudoodle babies
    - Student handout packet (S-1 to S-5), one packet per student
    - Potato, Russet or Idaho, one per group (provided by students)
    - Toothpicks – get the kind with the pointed ends (hair and dorsal spines)
    - Quarters, nickels, and pennies (mouths)
    - Small cork stopper (ears) – I bought these myself at the craft store – can be cut in half so you don't have to buy as many
    - Google eyes (two different sizes) – I picked up these as well to ensure 2 different sizes and to make sure that they weren't too big or too small
    - Glue dots (to attach ears and eyes) – I purchased this as well to ensure the proper size.
    - Pastel colored mini-marshmallows (1 bag should be enough for 50 lab groups)
    - Pipe cleaners (assorted colors) – cut into 4" or 6" lengths for tail
    - Large and small paper clips (feet)
    - Clear pushpins (nostrils)
    - Small paper plates and index cards to set up and label the supply stations for all of the materials used to assemble the spudoodle babies

SAFETY ISSUES

- There are a few sharp items in this lab (pushpins, toothpicks, paper clips).
- Advise students prior to the lab to take care with sharp items and to use them only for the purposes of creating their spudoodle babies.
- I did not have students wear safety goggles for this activity.

STANDARDS

A. Massachusetts Science and Technology/Engineering Curriculum Framework (Grades 6 – 8)
   - Life Science (Biology)
     - L7: Every organism requires a set of instructions that specifies its traits. Heredity is the passage of these instructions from one generation to another.
     - L8: Hereditary information is contained in genes located in the chromosomes of each cell.
     - L9: Sexual reproduction and asexual reproduction.

B. Massachusetts Science and Technology/Engineering Curriculum Framework (Grades 9 – 12)
   - Life Science (Biology)
     - 3.4: Genetic traits result in observed inheritance patterns.
     - 3.5: Patterns of inheritance can be explained through Mendel's laws of segregation and independent assortment.
     - 3.6: Probabilities for genotype and phenotype combinations in monohybrid crossed can be modeled using a Punnett Square.

CREDITS

- This activity was adapted from information originally found on the blog of Mr. McClung: http://mcclungsworld.com/2009/10/05/spudoodle/

ADDITONAL INFORMATION

- Some things I learned doing this activity for the first time:
  - Have several extra "Mom" and "Dad" bags of alleles ready to go in case items get lost or mixed up between classes.
  - Have extra colored circles (alleles) cut out and ready to go in case just one circle is lost you can quickly replace it.
  - Make sure you have plenty of recessive alleles in the mix so that you don't end up with all dominant traits in the babies.

GLOSSARY OF TERMS

Alleles: the different forms of a gene**.**

Dominant Allele: an allele whose trait always shows up in the organism when the allele is present.

Recessive Allele: an allele that is masked when a dominant allele is present.

Chromosome: a doubled rod of condensed chromatin; contains DNA that carries genetic information.

Deoxyribonucleic Acid (DNA): the genetic material that carries information about an organism and is passed from parent to offspring.

Gene: a segment of DNA on a chromosome that codes for a specific trait.

Punnett square: a chart that shows all the possible combinations of alleles that can result from a genetic cross.

Complete dominance[2]: A kind of dominance wherein the dominant allele completely masks the effect of the recessive allele in heterozygous condition.

Codominance[2]: A condition in which the alleles of a gene pair in a heterozygote are fully expressed thereby resulting in offspring with a phenotype that is neither dominant nor recessive.

Incomplete dominance[2]: A kind of dominance occurring in heterozygotes in which the dominant allele is only partially expressed, and usually resulting in an offspring with an intermediate phenotype.

Genotype: an organism's genetic makeup, or allele combinations.

Phenotype: an organism's physical appearance, or visible traits.

Trait: a characteristic that an organism can pass on to its offspring through its genes.

Probability: the likelihood that a particular event will occur.

Heredity: the passing of traits from parents to offspring.

Genetics: the scientific study of heredity.

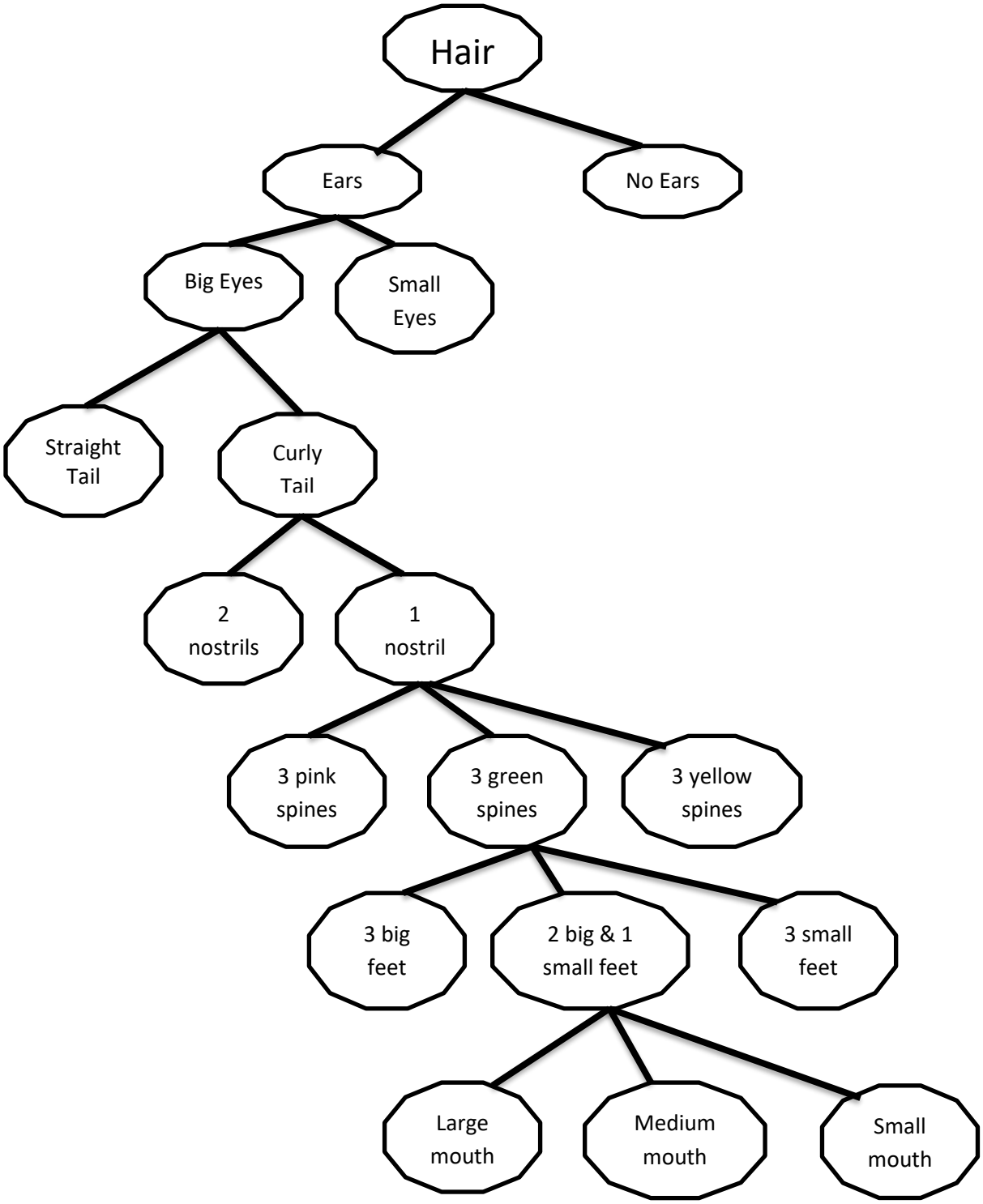
Homozygous: having two identical alleles for a trait.

Heterozygous: having two different alleles for a trait.

Sources:

- All definitions, except those denoted by the number 2, were obtained from the book: *Cells and Heredity*, by Donald Cronkite, Ph.D. 2002. Prentice-Hall, Inc., Upper Saddle River, NJ. ISBN# 0-13-054064-1
- Source 2: http://www.biology-online.org/dictionary/

SPUDOODLE FLOWCHART & CLOSING DISCUSSION NOTES



This flowchart shows only the spudoodles who have hair. There is another flowchart that looks just like this for all of the spudoodles without hair.

It is not possible to show every branch of the flowchart as there isn't enough room. Realize that each of the ovals has all of the branching coming off of it, until you have identified all eight traits for that individual.

With these 8 traits:

Five of the traits having only two possible outcomes.

Three of the traits having three possible outcomes.

There are 864 total possible combinations of spudoodle babies.

SAMPLE SPUDOODLE GENOTYPE:

I made this sample spudoodle genotype to show students on the day before the activity to give them an example of what they should have when they completed picking all of the alleles for their baby spudoodle.

I attached the circles to an 8.5” x 11” piece of paper and then laminated it so that I could have it for future use.

This also gives you an idea of the colors of cardstock that I used and how I labeled them.

Names: _____

Period: _____

SPUDOODLE WRAP-UP

CIRCLE YOUR SPUDOODLE'S TRAITS

HAIR: YES NO

EARS: YES NO

SPINES: 3 PINK 3 GREEN 3 YELLOW

FEET: 3 BIG 2 BIG & 1 SMALL 3 SMALL

MOUTH: LARGE MEDIUM SMALL

EYES: BIG SMALL

TAIL: CURLY STRAIGHT

NOSE: 1 NOSTRIL 2 NOSTRILS

Names: _____

Period: _____

SPUDOODLE WRAP-UP

CIRCLE YOUR SPUDOODLE'S TRAITS

HAIR: YES NO

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Names: _____

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TAIL: CURLY STRAIGHT

NOSE: 1 NOSTRIL 2 NOSTRILS

SPUDOODLE ACTIVITY INSTRUCTIONS – READ CAREFULLY

Goals: In this investigation you will build an imaginary creature called a spudoodle. The traits of your organism will be determined by the genes your spudoodle inherits from its parents.

1. You will get two bags, each containing genes from a potential spudoodle parent (Mom and Dad bag). Each partner in the team will be responsible for one of the bags (you will be one of the parents). There will be two alleles for each gene in the bag. This represents the genotype for the parent for each trait.

2. Each partner removes the genes (colored paper circles) of their potential parent from their bag and places them on their desk. For each trait (color type) write the genotype for that parent on your **Spudoodle Report Sheet**. Now turn the "alleles" upside down so you cannot see the letters on them. Do the same for the other parent. **Make sure that both partners have the same information for the parents recorded on the report sheet.** You should have two sets of genes now – one on each of your desks. One set should be the "father's" and the other set should be the "mother's." You should also have the genotypes for all of the traits of both parents recorded on your sheet.

   Do not mix the sets of genes!

3. Organize the "genes" by color (letter side down) on each of your desks – have them in the same order.

   DO NOT MIX THE GENES OF THE TWO PARENTS TOGETHER.

4. Pick one allele from the "mother" and one from the "father" for a particular color (gene). Put the two alleles you selected in a separate "baby spudoodle" pile. Do the same for each colored gene pair, and so on for all the gene pairs.

5. Return the remaining parent genes to their respective bags **(make sure you put one set in each bag),** and place them aside.

6. Arrange the baby spudoodle's alleles in pairs by color.

7. Turn the alleles over to reveal the genotype for each trait.

8. Record your baby spudoodle's genotype on your sheet and answer the questions. Put the baby alleles back into the parent bags, **one of each color in each parent bag**. It doesn't matter which bag they originally came from, as long as they get divided evenly - one of each color into each of the parent bags. Close up the bags. Continue to work through your report sheet.

9. Once you have completed all of the punnett squares and figured out the genotype and phenotype for your baby spudoodle you are done with today's portion of the activity. **STOP HERE FOR THE DAY!!**

1. **ACTIVITY DAY #2**: you will put spudoodle together using the spudoodle genotype key on shown below. Use only the materials needed to give your spudoodle baby your baby the proper traits, as determined yesterday.

2. I will take a photo of your completed baby spudoodle that you can include with your final report.

Spudoodle Genotype Key

Two- letter code	Trait
HH or Hh hh	Has hair (toothpicks – No more than 6) No hair
AA Aa aa	Large mouth (quarter) Medium mouth (nickel) Small mouth (penny)
EE or Ee ee	Has ears (use pieces of cork attached with glue dots) No ears (deaf)
BB or Bb bb	Big Eyes (glue on google eyes with glue dots) Small eyes (glue on google eyes with glue dots)
DD Dd dd	3 Green dorsal spines (green marshmallows) 3 Pink dorsal spines (pink marshmallows) 3 Yellow dorsal spines (yellow marshmallows)
RR or Rr rr	Curly tail (pipe cleaner) Straight tail (pipe cleaner)
GG Gg gg	3 Large feet (large paperclips) Two Large feet one small foot (2 large paperclips & 1 small paperclip). All Small feet (3 small paper clips) (fold up one pointed end of the paper clip to push into the potato, the remainder of the paper clip forms the foot)
NN or Nn nn	Two nostril nose (clear push pins) One- nostril nose (clear push pins)

Name: _____ Period: _____

Spudoodle Report Sheet

Father's Genotypes for each trait:

Hair (green) _____ Mouth (light blue) _____

Ears (yellow) _____ Eyes (orange) _____

Spine (dark blue)_____ Tail (purple) _____

Feet (bright pink)_____ Nose (red) _____

Mother's Genotypes for each trait:

Hair (green) _____ Mouth (light blue) _____

Ears (yellow) _____ Eyes (orange) _____

Spine (dark blue)_____ Tail (purple) _____

Feet (bright pink)_____ Nose (red) _____

Cross each trait to find the possible genotypes of their baby spudoodle:

Hair:

Mouth:

Ears:

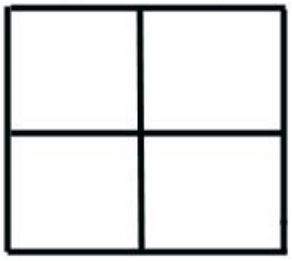
Eyes:

Spine:

Tail:

Feet:

Nose:



Baby: Write the genotype and phenotype for each trait that your baby spudoodle has on the lines below:

Hair (green) _____ Mouth (light blue) _____

Ears (yellow) _____ Eyes (orange) _____

Spine (dark blue)_____ Tail (purple) _____

Feet (bright pink)_____ Nose (red) _____

END OF DAY 1 OF ACTIVITY – STOP HERE FOR THE DAY!!

DAY 2: Assemble your baby spudoodle and then answer the questions below – use complete sentence.

Describe what the father looks like. Be sure to mention all 8 traits: _____

_____

_____

_____

_____

Describe what the mother looks like. Be sure to mention all 8 traits: _____

_____

_____

_____

_____

How does the baby spudoodle you created compare to the parents? Explain similarities and differences: ____

_____

_____

_____

_____

_____

Which of your baby spudoodle's traits are heterozygous and which ones are homozygous? Explain

_____

_____

_____

_____

_____

_____

Three different types of inheritance patterns were shown in the spudoodle traits – complete dominance, incomplete dominance, and codominance. Give at least one example of a trait for each type of inheritance pattern and explain how you know what type of inheritance pattern is being shown.

_____
_____
_____
_____
_____
_____
_____
_____

Math Extension (optional):
For each **phenotype** above write down the odds of that particular **trait** showing up. This answer you should get from the punnett squares that you completed on the first page of the report sheet.

Probability of occurrence:

Hair (green) _____ Mouth (light blue) _____

Ears (yellow) _____ Eyes (orange) _____

Spine (dark blue)_____ Tail (purple) _____

Feet (bright pink)_____ Nose (red) _____

How unique is your spudoodle? Multiply all the odds together to get the combined odds of that particular baby. Convert to a percentage:

Uniqueness: _____