Build-an-Animal

A Genetics Activity for Grades 5 – 8

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Provided by:
The GENETICS Project
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Introduction

Build-an-Animal is an activity that introduces or reinforces a number of basic genetics principles:

- there are two copies of each gene
- offspring receive one copy of each gene from each parent
- which gene the offspring receives from each parent is random
- offspring resemble their parents
- the offspring produced by two parents are usually different from each other
- some genes are dominant and some are recessive
- some traits are affected by both genes and the environment

Build-an-Animal also indirectly models meiosis and helps students understand an important means of generating genetic diversity within a species. Perhaps the central message of the activity is that each species is tremendously diverse and that genes play a major role in determining this diversity. The use of egg cartons to keep gene pairs separate from each other helps reinforce the basic organization of genes and their behavior during meiosis and formation of a new offspring.

Prerequisite knowledge

Elementary students may successfully do the activity even without previous exposure to meiosis. You needn't even mention the word "meiosis" when doing the activity.

Middle school students who have already studied meiosis will find this activity reinforces their knowledge of that important process and provides an engaging and hands-on demonstration of meiosis and the principles of Mendel in action.

Before beginning this activity, students should have had prior exposure to the concept of dominant and recessive genes. For a graphic demonstration of this abstract concept, we recommend *A Matter of Control*, an activity in *Genes and Surroundings* (Kendall/Hunt, 1999), a middle school genetics text. We have successfully used *A Matter of Control* in 5th-6th grade upper elementary classrooms as well as with middle school students.

Crosses

In this activity, students will perform a cross in which two fully heterozygous creatures serve as the parents. The parent animals appear identical but yet their offspring will show tremendous diversity. A heterozygous animal is pictured in Figure 1.

Although not described here, the materials could also be used to set up additional crosses, for example, the initial cross could be between two fully homozygous parents, one with all dominant genes and one with all recessive genes. A second cross could then be done with two heterozygotes. A fully recessive animal is pictured in Figure 1.

Materials

Item	Vendor	Cost (U.S. $)
Egg cartons, 3 x 6 egg size	Eggcartons.com	$25/100 cartons
Pipe cleaners, black, 12” x 6 mm (ears)	Crafts store	$0.79/25
Pipe cleaners, brown and green, 12 “ x 9 mm (tails); blue required for environment activity	Crafts store	$0.99/15
Thumb tacks, brown, green, and blue (spots and eyes)	Office supply store	$0.99/40
Push pins (horns)	Office supply store	$6.49/100
Pompoms, large, black and red, 0.5” (noses)	Crafts store	$0.49/16
Pompoms, small, black and red, 5mm (noses)	Crafts store	$0.49/40
Styrofoam cylinders, 2” diameter (bodies)	Crafts store	$2.25/24” x 2”
Styrofoam egg shapes (head)	Crafts store	$2.15/6
Toothpicks (for attaching head to body)	Grocery store	
Nails with heads, 1.5 & 2.0” long (legs)	Hardware store	$0.25/60–100
Rubber tubing, black (legs)	Hardware store	$0.20/12”
Straight pins (for attaching noses)	Fabric store	$3.79/350
Pony beads, black and clear	Crafts store	$1.99/245
Colored markers, crayons, or pencils (if using the *Animal Data Sheet* option)	Crafts or Drug store	

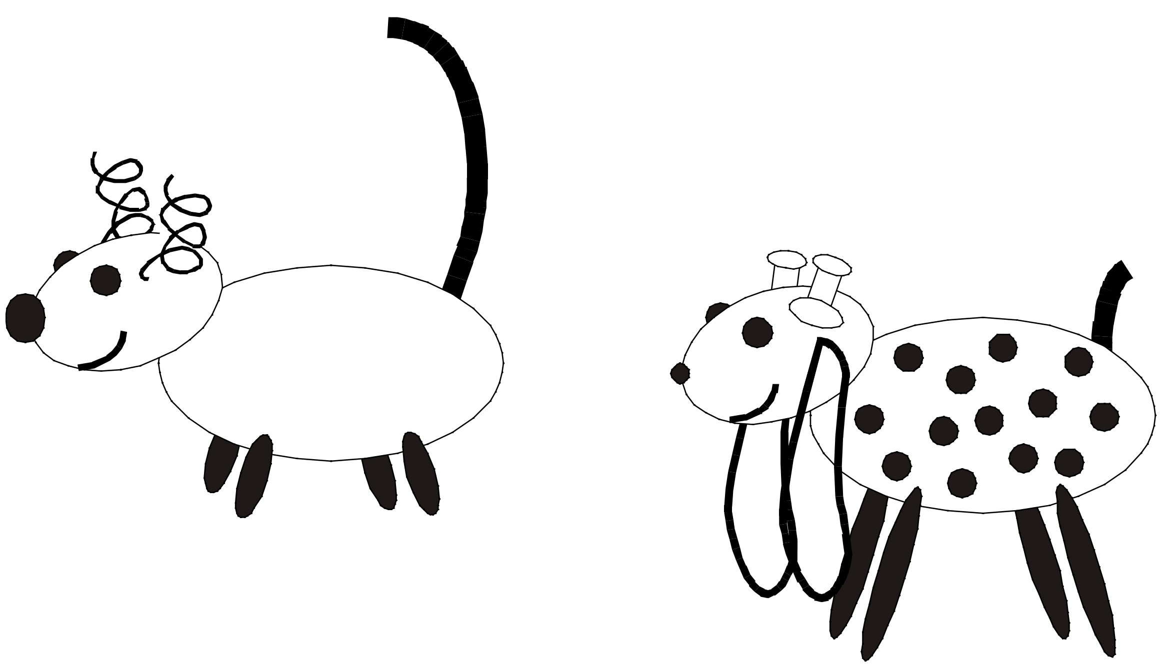


Figure 1. Heterozygous (left) and completely recessive (right) animals.

Directions for Animal Pre-Assembly

Complete these steps before giving materials to students.

- Cut rubber tubing pieces into 1.0" and 1.5" long pieces.
- Assemble legs by threading 1.0" tubing onto 1.5" nails and 1.5" tubing onto 2.0" nails.
- Draw or paint red mouths on egg shape styrofoam pieces with red marker or acrylic paint.
- Cut styrofoam cylinders into 3" segments.
- Attach one egg shape styrofoam piece to the 3" styrofoam cylinder piece using a toothpick. This is the head and body.

Classroom Set-up

Give each group of 2 students a set of materials to build their animals, 2 egg cartons (one 6 x 3 and one 3 x 3), a bowl of black and clear beads, and a copy of the *Traits and Genes* table.

Alternative Materials

If any of the materials above is difficult to obtain, other materials can be substituted. Some teachers also prefer not to use so many sharp items such as tacks, push pins, and nails. Here are some alternatives that have been suggested by teachers:

<u>Legs</u>

Substitute different lengths of straws for nails and rubber tubing.

<u>Tails</u>

Substitute different lengths and colors of straws for pipe cleaners.

<u>Horns</u>

Use short lengths of pipe cleaners instead of push pins.

<u>Spots</u>

Use round colored stickers instead of tacks. Or have animals be striped instead of spotted. Use several rubber bands around body as stripes.

<u>Pony Beads</u>

Use red and white beans instead of black and clear beads.

<u>Eyes</u>

Use round colored stickers instead of tacks.

<u>Egg cartons</u>

Use individual paper muffin cups instead of egg cartons.

<u>Edible Materials</u>

Some teachers like to incorporate edible materials into their animals, for example, using marshmallows as body and head parts. Although this may seem cost effective in the short term, costs can mount if multiple classes will be doing the activity or if teachers want to do it year after year. Marshmallows and other candies can also be very sticky and the materials become quite grubby after only minimal handling. This raises health concerns when students sneak tastes of the materials, a not infrequent occurrence. Our advice is to use edible materials only if you plan to do the activity once or with one class.

A “Paper and Pencil” Build-an-Animal
Some teachers find Build-an-Animal too materials intensive. They have requested a shorter activity with minimal set-up and preparation that teaches the same concepts. If this describes your situation, then you may be interested in doing the “no materials” version of Build-an-Animal.

You will still need egg cartons and beads, but no animal components. Instead students draw the traits of each animal they create on the pre-drawn animal templates contained on the *Animal Data Sheet* using colored markers. Each group will need a set of markers or crayons containing these colors: red, black, brown, green, blue. Since students will not be familiar with how certain traits are supposed to appear (e.g. the two types of ears), they can follow the diagrams in Figure 1. Therefore, each student pair will need a copy of Figure 1, or this figure can be displayed for all on the overhead projector.

Animal Data Sheet
The *Animal Data Sheet* provides an easy way for students to record their “data,” i.e. the appearance of each animal. The *Animal Data Sheet* can be used, as described above, in a “no materials” version of Build-an-Animal. Some teachers also like to have their students use the *Animal Data Sheet* even if they are building animals with hands-on materials. The sheets provide a convenient way for students to store their data long after their animals are disassembled.

Teacher's Guide to Discussion Questions

There are a number of questions sprinkled throughout Parts I, II, and III of Build-an-Animal on the student pages. Students should either discuss the questions out loud with other students or write the answers in their lab notebooks or on a worksheet to hand in. Here are possible answers to the questions.

<u>Questions from Part I. Building a Parent Animal.</u>

Does your animal look like the fathers that other students have built?

If students have built their fathers correctly, they should all be identical because their genes are identical.

What will the mother look like?

The mother should look like the father because she has the same genes as he does.

If the genes are the same as the father's, will the mother look the same?

Yes.

<u>Questions from Part II. Building a Baby Animal.</u>

Does your new animal look like its parents? Or is it different?

The new baby will probably not look like its parents but there is a small chance that it will.

Compare your animal to others at your table. Is your animal like any of the other new babies?

In a small group of only 3-4 animals, it is not likely that any two will be exactly alike.

Can you find another animal just like yours? If yes, how many?

There may be a couple of new babies that are identical. If students cannot find a "twin" to their animal, they may enjoy finding an animal that is as close a match as possible.

How many baby animals look just like their parents?

There may be a couple of new animals that are exact matches to their parents.

What if we had looked at more traits than just nine? How would the variety of baby animals change?

With only 9 genes, we have seen quite a bit of variation in our population of baby animals. If we looked at even more genes, it would be even more difficult to find a match to our baby. The more genes, the more variety.

Challenge Questions (for middle school grades):

What is the chance that your baby animal will look just like its parents?

This question and the next one are appropriate for middle students who have previously studied probability. Since there is a 3/4 chance that each of the nine traits will be like that of the parent, and each of the nine traits is independent of the others, the answer would be 3/4 to the ninth power or 0.075 (7.5%).

Was the fraction of classroom animal offspring looking just like their parents close to this number? If not, why?

Students should count the number of animals looking just like parents and see how closely it matches the predicted number (7.5% of the total animals). Due to small sample size, the number may not be 7.5%.

Considering that humans have about 40,000 genes, what sort of variation might you expect in the human population?

Tremendous! Consider how much variation we saw among our baby animals when we looked at only 9 traits. The amount of variation would increase as the number of genes increased.

If the starting genotype of your parent animals was Aa Bb Cc Dd Ee Ff Gg Hh Jj, what is the genotype of your baby animal?

Answers will vary depending on which beads were picked for the offspring.

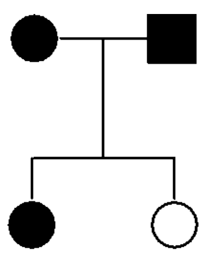
Why are you supposed to close your eyes when you pick which gene from the mother and which gene from the father the baby animal will inherit?

Closing your eyes means that you are picking randomly which gene of the two available the baby inherits. This models the real life genetic process of meiosis. In meiosis, one gene of each gene pair is **randomly** segregated into each gamete.

Diagram the inheritance of one trait in your animal family by drawing a pedigree.

Students can choose any of the nine traits and draw a two generation pedigree that includes the mother and father animals and their baby animal. Since the baby animals of students around them have the same parents, they can add also these babies to their pedigrees, if desired. A sample pedigree is shown in Figure 2.

Figure 2. Simple pedigree showing parents with trait, one baby with trait and one without.



Questions from Part III. The Animals of Copper Valley

Compare the animals that were born in the two valleys. How are they different?

The animals from Copper Valley all have blue tails. The animals from Grass Valley have brown or green tails.

Why do you think the animals born in the two valleys are different?

There are many possible answers and the goal is that students should speculate. Some answers might include, the food the animals eat is different in the two valleys, the water they drink is different, the air is different, etc. The name of Copper Valley might provide a clue. Perhaps the soil in Copper Valley is rich in copper and affects the plants that live there and that are eaten by the animals. An animal eating foods rich in copper might very well be a different color. The tail might be especially sensitive to the copper balance when it is being formed in the womb.

Do you think an inherited trait could really be changed by the place an animal was born? Can you think of any examples from real life where a part of the environment affects how an animal looks?

Discuss with students the many examples in which environment can affect phenotype. For example, a good nutrition environment can lead to taller or heavier organisms, a poor nutrition environment to shorter or thinner organisms. Other examples include flower color in hydrangea (flowers are blue or purple depending on soil pH), sex determination in turtles (higher temperatures favor formation of females), and the distinctive coloring of "the points" in Siamese cats (color is only developed on the cooler parts of the body—paws, ears, and tail).

Challenge Question (for middle school students):

What do you think would happen if a male and female animal from Copper Valley went to live in Grass Valley and had babies? Would the tails of the new animals look like the tails of their parents? Why?

The tails would probably resemble Grass Valley animals, that is, brown or green, but not blue like their Copper Valley born parents. Students should recognize that a feature determined by the environment, such as the blue tail color of Copper Valley animals, is not heritable. If students have trouble with this concept, ask them whether they think a man who had lost a finger in an accident would pass on this trait to his children.

Extensions for Middle School

If your students are in grades 7-8, they will have covered more genetics in class or be capable of learning more. We have included some "challenge" questions for these older students on the student pages. And below are ideas for further activities that could be done with these more advanced students.

- Assign genes to each trait and then have students record the genotype of the parents and offspring. For example, Leg Length could be "A", Body Color "B", etc. The genotypes of the heterozygous parents could be defined as Aa Bb Cc Dd Ee Ff Gg Hh Jj (or similar). Students could also be given the genotypes of animals and asked to build them. Such an exercise would assess how well the students understood the use of the *Traits and Genes* table and the concept of dominant and recessive.
- Have students draw pedigrees of specific traits in their animal families through several crosses or several generations. Be sure to remind them that they can only show one trait at a time in a pedigree.
- Have a trait such as leg length represent a trait that is determined by both genes and environment, e.g. nutrition. For example, even with the gene combination "aa", for long legs, the legs would remain short in a poor nutrition environment. This is similar to the Animals of Copper Valley activity.
- Model polygenic inheritance by having multiple genes contribute to one aspect of a trait, e.g. tail length or eye color.

References

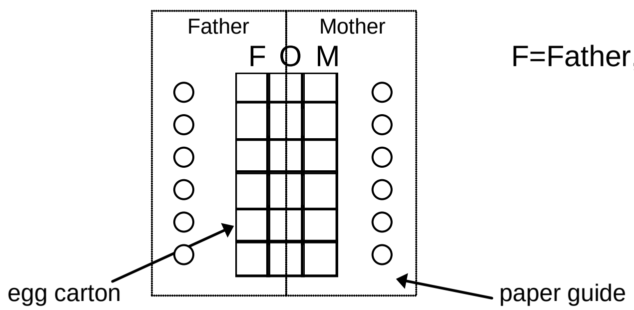
Marshmallow Meiosis (1992) P. Soderberg. *The Science Teacher.* November, pp 28-31.
Build creatures made of candy to demonstrate genetic diversity. Sticky, but fun.

Overview

In this activity you will “make a baby” for an imaginary pair of animals by randomly picking the genes each parent will give to the baby for each of nine different physical traits. You will then look at how your baby animal is the same or different from the babies other students in the class make.

Part I. Building a Parent Animal

1. Working with a partner, place the paper guides labeled “Father” and “Mother” side by side on your desk with Father guide on the left. Place the egg cartons on top of guides as shown below.



F=Father, O=Offspring, M=Mother

3. Put the beads into the egg carton cups as shown on the paper guides. Each cup should contain only two beads. These beads stand for the genes of the mother and father. Black beads stand for dominant genes; clear beads stand for recessive genes.

   The left column of cups will hold beads representing the father’s genes. The right column will hold beads representing the mother’s genes. The middle column will hold the new baby or offspring’s genes.

4. What do the parent animals look like? Build the father animal to find out. Look at the *Traits and Genes* table. Use the table to help you figure out how to build the father. For each trait, find the father’s genes in the table (either black + black, black + clear, or clear + clear). Then add the materials to your animal that are listed in the table. Your teacher may wish the entire class to build this animal together, so wait for your teacher’s instructions.

Does your animal look like the fathers that other students have built? Compare your animal to theirs.

Since all students have paper guides with the same genes for father, all the animals should look alike. Adjust your animal until it looks like the others in the class. You may need to discuss this with other students or refer back to the *Traits and Genes* table.

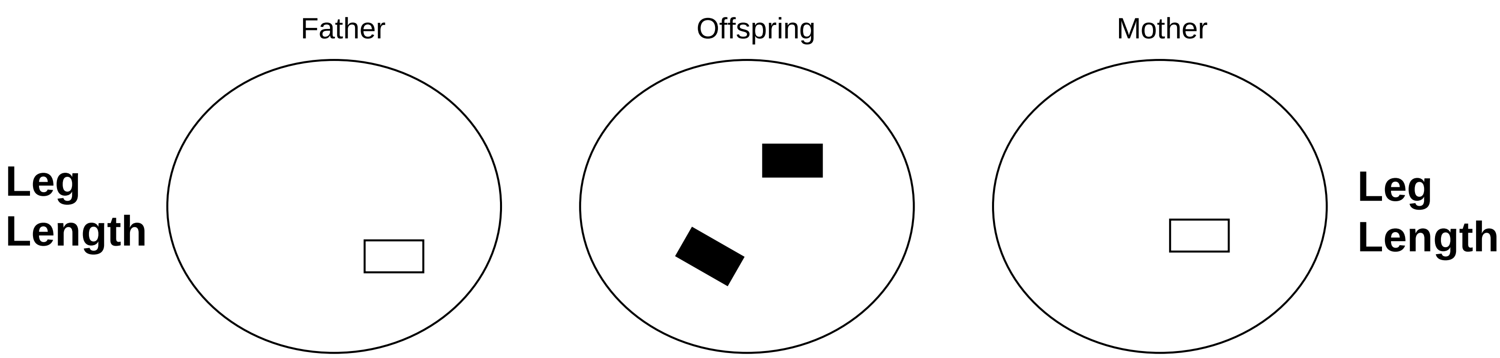
What will the mother look like? You don’t need to build another animal to find out. Just look at the beads in the mother’s column of cups*. If the genes are the same as the father’s, will the mother look the same?*

5. Record what the father animal looks like on the *Animal Data Sheet* (optional—check with your teacher). Now take apart the father animal and return his materials to the containers. Your teacher will keep one animal that looks like father at the front of your classroom.

Part II. Building a Baby Animal

1. The mother and father are going to have a baby. For each trait, choose one of the baby's genes (beads) from the father's egg carton cups and one from the mother's.

   For example, **close your eyes** and pick one bead from the father "Leg Length" cup. Place in the top cup of the offspring column. Now pick one bead from the mother "Leg Length" cup and place in the top cup of the offspring column. Make sure to keep your eyes closed! The top row of your cups should now look something like the picture below.



2. Repeat for the other 8 traits. You may find it easy to pick the mother and father beads for each trait at the same time, one with each hand. When you are done, your egg carton should have 2 beads in each cup of the central (offspring) column. These beads are the new baby's genes for the 9 traits.

3. Now build your baby animal using the *Traits and Genes* table. Record the appearance of your animal on the *Animal Data Sheet.*

Before discussing the questions below with the class, think about and discuss them with other students at your table.

- *Does your new animal look like its parents? Or is it different?*
- *Compare your animal to others at your table. Is your animal like any of the other new babies?*

Bring your animal to the front of the classroom and put it with the other new animals.

- *Can you find another animal just like yours? If yes, how many? If no, how close a match can you find?*
- *How many baby animals look just like their parents?*

- *What if we had looked at more traits than just nine? How would the variety of baby animals change?*

You may build additional animal babies with your extra materials if time permits. Check with your teacher first. Record the new babies on the *Animal Data Sheet.*

Challenge Questions (for middle school grades):
(Write the answers to these questions in your lab notebook or on your worksheet.)

What is the chance that your baby animal will look just like its parents?

Was the fraction of classroom animal offspring looking just like their parents close to this number? If not, why?

Considering that humans have about 40,000 genes, what sort of variation might you expect in the human population?

If the starting genotype of your parent animals was Aa Bb Cc Dd Ee Ff Gg Hh Jj, what is the genotype of your baby animal?

Why are you supposed to close your eyes when you pick which gene from the mother and which gene from the father the baby animal will inherit?

Diagram the inheritance of one trait in your animal family by drawing a pedigree.

Part III. The Animals of Copper Valley.
(for middle school students only)

The new babies you built in Part II were all born in Grass Valley. Part of the animal herd has migrated to another valley called Copper Valley and is beginning to have babies there. There's something very unusual about the new babies. Build a new baby and compare the offspring from the two valleys.

1. Replace the black and clear beads in the egg cartons just as they were before you built your baby animal.

2. Pick beads from the mother and father egg carton cups for each of the 9 traits and place them in the central column of the egg cartons. These are the genes of the new baby. Remember not to open your eyes!

3. Where was your baby animal born? Flip a coin to see if your animal was born in Grass Valley or Copper Valley. Build your animal as before, but follow the chart below when choosing your animal's tail:

Coin	**Birthplace**	**Tail Color**
Heads	Grass Valley	Brown if ■ ■ or ■ □ Green if □ □
Tails	Copper Valley	Blue

4. Bring your animals to the front of the room. Place all the Grass Valley animals together and all the Copper Valley animals together.

Compare the animals that were born in the two valleys. *How are they different?* Discuss what you see with other students at your table or with the whole class.

Why do you think the animals born in the two valleys are different?

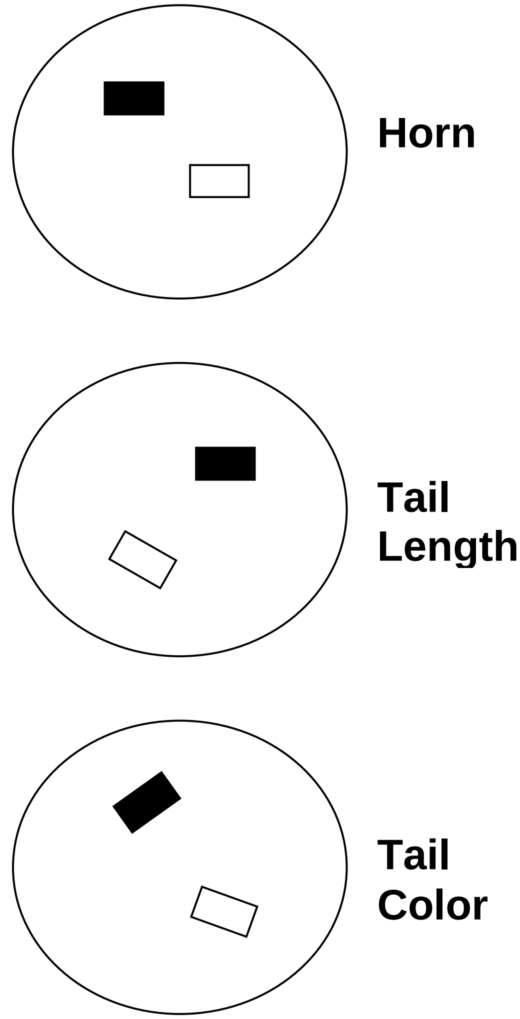
Do you think an inherited trait could really be changed by the place an animal was born? Can you think of any examples from real life where a part of the environment affects how an animal looks?

Challenge Question (for middle school students):
(Write the answer in your lab notebook or on your worksheet.)

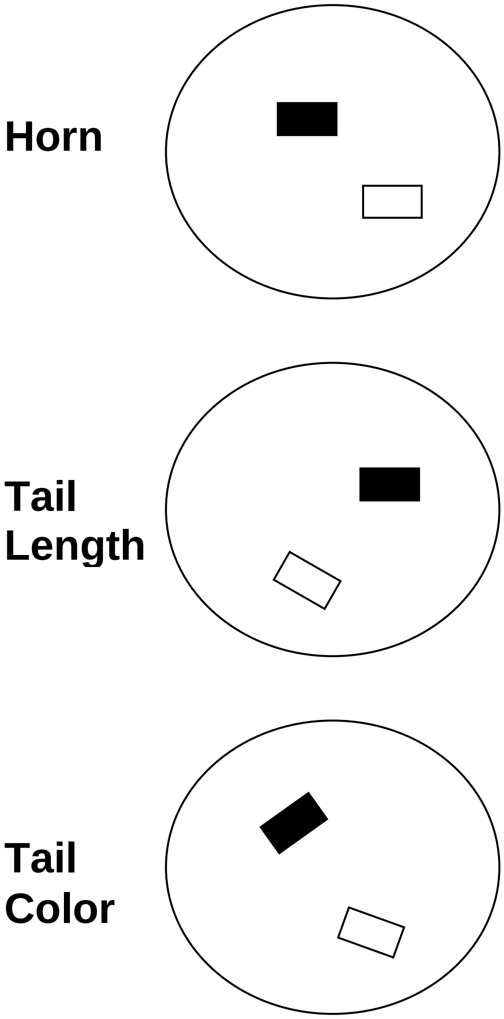
What do you think would happen if a male and female animal from Copper Valley went to live in Grass Valley and had babies? Would the tails of the new animals look like the tails of their parents? Why?

Traits and Genes Table

Trait	Genes	Add to your organism
Leg Length	■ ■	4 Short legs
	■ □	
	□ □	4 Long legs
Body Color	■ ■	No spots
	■ □	
	□ □	Spots (15 brown tacks on body)
Ear Shape	■ ■	Spiral ears
	■ □	
	□ □	Floppy ears
Eye Color	■ ■	Blue eyes
	■ □	
	□ □	Green eyes
Nose Size	■ ■	Big nose
	■ □	
	□ □	Small nose
Nose Color	■ ■	Black nose
	■ □	
	□ □	Red nose
Horns	■ ■	No Horns
	■ □	
	□ □	Horns (add 2 push-pins to head)
Tail Length	■ ■	Long tail
	■ □	
	□ □	Short tail
Tail Color	■ ■	Brown tail
	■ □	
	□ □	Green tail

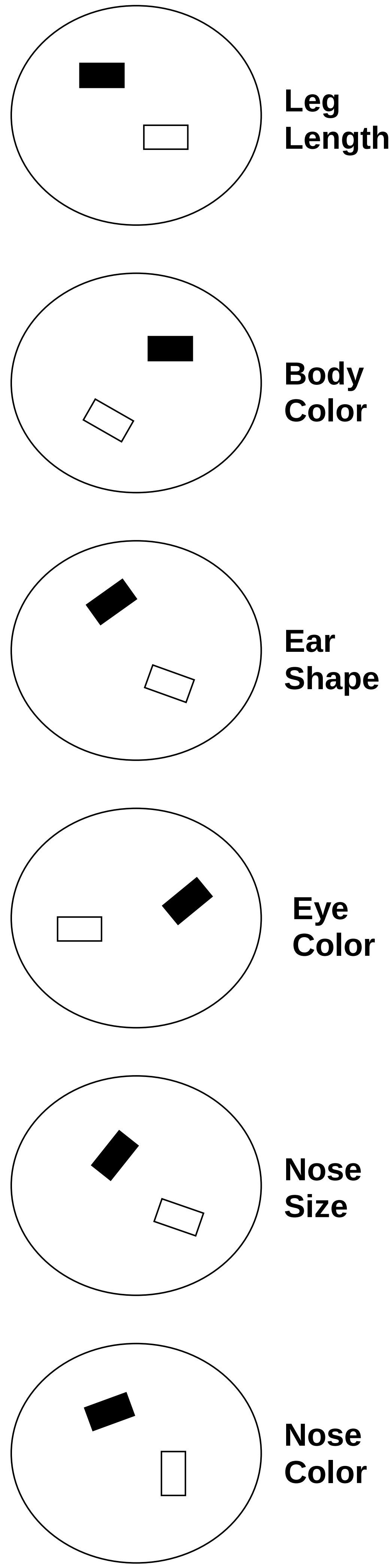


Mother



Father

Mother



The GENETICS Project, http://gsoutreach.gs.washington.edu
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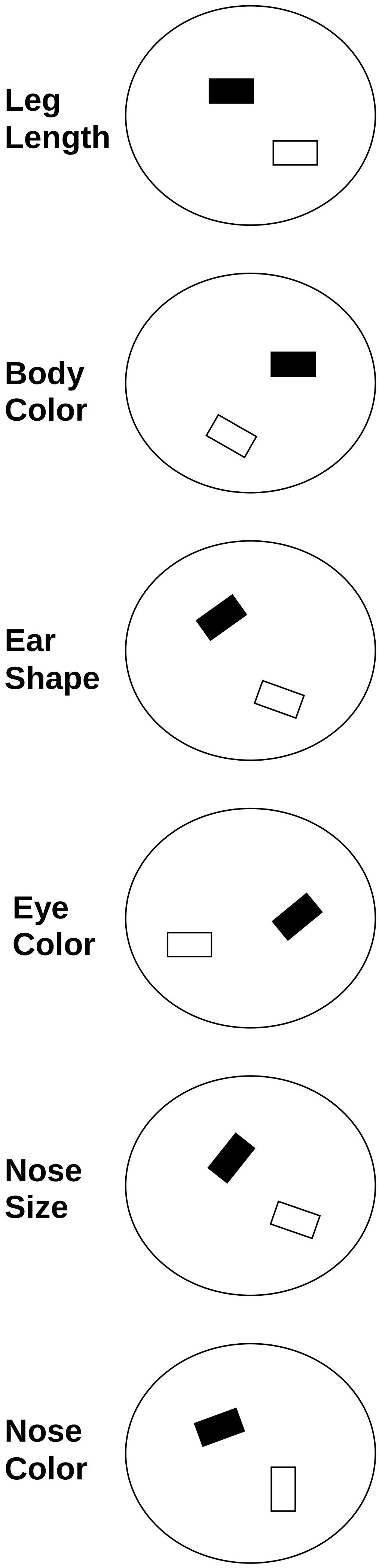
Father


Leg Length
Body Color
Ear Shape
Eye Color
Nose Size
Nose Color