Pasta Genetics

An Elementary School Activity for Teaching Basic Concepts of Inheritance

Developed by:
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Based on:
Genes and Generations from *You, Me, and Others*
(1995; BSCS and March of Dimes)

Provided by:
The GENETICS Project
http://chroma.mbt.washington.edu/outreach/genetics

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Contents:

About this Activity *Pasta Genetics*

Pasta Genetics is an adaptation of an activity developed by the Biological Sciences Curriculum Study (BSCS) and published in two places:

1. as the activity *Genes and Generations* from *You, Me, and Others* (1995; BSCS and March of Dimes), a genetics curriculum for the elementary school level.

2. as the activity *Generations* from *Genes and Surroundings* (2000; BSCS), a middle school genetics curriculum.

In both the *Genes and Generations* and *Generations* activities, students use 8 identically shaped jelly beans or beads to represent genes. Instead of beans/beads, we have used different shaped pasta for each gene pair because we felt it more accurate to represent the genes in pairs, as occurs in real life. Since our later activities build on this one, we wanted to make sure we didn't introduce any misconceptions early on.

We wish to stress that the main idea for this activity came from BSCS and not ourselves. We strongly recommend many of the materials developed by BSCS and suggest that interested teachers consult the two references above for additional genetics activities.

We wish to acknowledge the contribution of elementary school teacher Laura Tyler, University of Washington MESA program, in the early stages of development of this activity.

Teacher Information *Pasta Genetics*

Time
60 minutes

Target Audience
Upper Elementary (grades 5 and 6). This activity can also serve as a first Mendelian Genetics activity for middle school or junior high school students.

Learning Objectives
Through carrying out the Pasta Genetics activity, students will learn:

- how genes are passed from generation to generation
- that there are two copies of each gene (i.e. genes occur in pairs)
- that a child receives one copy of each gene from each parent
- that which copy of a parent's gene a child receives is random
- that a child doesn't look exactly like his brothers and sisters because they have different genes (i.e. why each of us is unique)
- that identical twins look alike because they have the same genes

Reference
This activity was based on the "Genes and Generations" activity in *You, Me, and Others (1995),* an elementary school genetics curriculum developed by BSCS and March of Dimes. In that activity, students used 8 identically shaped jelly beans to represent genes. We felt it more accurate to represent the genes in pairs, as occurs in real life, so we have substituted pasta pieces of different shapes for the beans. Each pasta shape represents a different gene. Each person in the pedigree has 8 genes — 2 each of 4 different shapes of pasta. Since our later activities build on this one, we wanted to make sure we didn't introduce any misconceptions early on.

Engage and Encounter
Ask students, "Where do you think the **directions** for making **you** came from?"

Some students will suggest they got the directions from their parents. Establish that the directions for making a person are called **genes.**

Ask students, "Do you think you got any directions (genes) from your grandparents?"

Explore and Investigate
In this activity, four different shaped pasta pieces are used to represent four different genes. Because we have two copies of all our genes, there are two of each pasta shape. Thus, in our model, each person has four pairs of genes, or eight genes total. (In real life it's more like 40,000 pairs of genes!) The four different colors are used to denote which of the four grandparents the genes came from.

Students will receive a two page handout with instructions on how to do the activity. The second page of the handout contains a table for students to fill in. Students will also receive a one page pasta diagram on which to color in their results.

Students will randomly select genes from two pairs of grandparents to make a Mother and a Father. Then they select genes from Mother and Father, again randomly, to make four children. By observing and recording the colors of the genes in the four children, students learn how

genes become mixed from one generation to the next. Students record the color of genes of each individual by coloring the different pasta shapes on the diagram.

Reflect and Explain
After completing the activity, students can show which grandparents contributed genes to each child by counting how many genes of each color each child has and recording the data in the table. Put the student questions on the overhead projector and have the children write the Reflect & Explain questions and answers in their notebooks. These questions will help guide students' understanding of the activity.

Apply and Extend
Lead the students through answering the Apply & Extend questions on the overhead. These questions are designed to help students relate this activity to real life.

Basic Probability Questions
These questions are intended for middle school students who have covered basic principles of probability in their math classes. Do not use with students who have not yet covered probability. Do not use in the elementary school classroom.

Materials

4 bags pasta of different shapes
4 small vials food coloring: red, blue, green, and yellow
2 gallons white vinegar (inexpensive brand)
Paper muffin cups or small petri dishes, enough for 7 per student group

Overhead Master (1)
Reflect & Explain Questions + Apply & Extend Questions

Colored Pasta Preparation
Prior to class, purchase four distinctly shaped dried pastas. We have used wagon wheels, shells, fusilli (snakes), and macaroni. Dye one quarter of each shape red, green, yellow, or blue using the following easy procedure.

Place one half gallon vinegar and one small vial food coloring in a large bowl. Stir to mix. Place one quarter of each of the 4 bags of pasta in each bowl. Stir well. Let pasta sit in dye-vinegar mixture for one hour, stirring occasionally. Drain pasta and rinse briefly in cold water. Note: if you do not rinse the pasta, it will remain very aromatic. If you rinse too vigorously or for too long, some of the color may leach out. Cover cookie sheet with foil and place dyed pasta on top in single layer. Bake in 250° oven for 10 minutes to dry the pasta.

To carry out the activity, give each student group (pairs work well) the following:

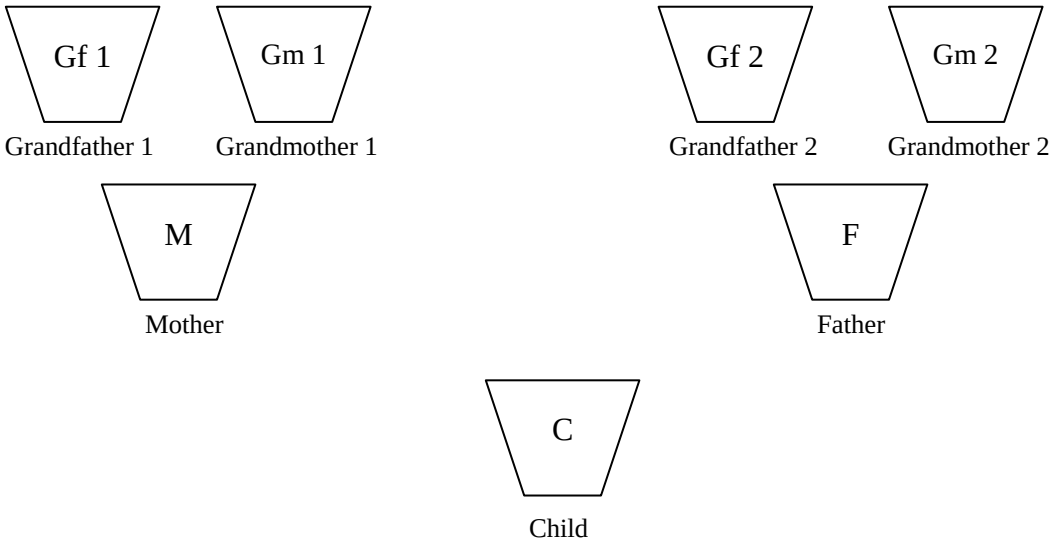
1 set of directions for Pasta Genetics
1 **template** on which to place cups (optional; see explanation below)
7 paper muffin cups
8 red pasta shapes (2 of each shape)
8 green pasta shapes (2 of each shape)
8 yellow pasta shapes (2 of each shape)
8 blue pasta shapes (2 of each shape)

In addition, each student will need:
1 Pasta Genetics diagram (to score results by coloring in pasta shapes)

What is the "template"?
The template is like a large place mat on which students can place their muffin cups. It contains a diagram of the grandparent-parent-child pedigree and helps students arrange their cups properly. We have found it extremely useful, but its use is optional. It is provided to teachers as a two page black and white master. Teachers will need to tape the two sheets together and use a black pen to connect the top pedigree line down to the bottom sheet. We like to color in the grandparent pasta shapes on the template with colored pens or pencils to help students get started. Do not color in the parental pasta shapes (2^{nd} generation). We then laminate the sheets to form a durable template for classroom use. Each group of students gets a template to go along with their pasta and cups. We also use small, transparent petri plates to tape to our template (so students can see the colored grandparent pasta on the template through the plate), but we realize most teachers will not have petri plates and will just use the muffin cups.

This activity will show you how **genes**, the directions for building a person, are passed from grandparents to parents to children and why each of us is unique.

1. Label the muffin cups and arrange them on the template as shown:



2. Place eight pieces of pasta, two of each shape, into each cup, using the following color code:

   Grandfather 1: red Grandfather 2: yellow
   Grandmother 1: green Grandmother 2: blue

Using this code, color the pasta for each grandparent on your diagram.

3. The pasta pieces stand for genes, and each pasta shape is a different gene. There are two of each pasta shape because **we have two copies of each of our genes.** In this example, Grandfather 1 has four pairs of genes, all colored red, and Grandmother 1 has four pairs of genes colored green.

   Now you are going to choose the genes for the daughter of Grandfather 1 and Grandmother 1. To do this, select four genes from the Grandfather 1 cup, making sure that you take one of each shape, and take four genes from the Grandmother 1 cup, one of each shape. Close your eyes as you select the genes. Place these pasta pieces in the cup labeled "Mother." The eight pasta pieces in the "Mother" cup are Mother's genes, half from her father and half from her mother. Color your diagram.

4. Without looking, take four different genes from Grandfather 2 and four different genes from Grandmother 2 and place in the cup called "Father." Color the diagram.

5. Mother and Father are going to have four children. Each child gets half of his or her genes from Mother and half from Father. For the first child, select four genes, one of each shape, from Mother's cup and four genes, one of each shape, from Father's cup, and place in the cup labeled "Child." Be sure to close your eyes when you select the genes! Color the diagram to show which genes Child 1 has. What is your child's name?

6. Return the child's genes to the Mother and Father cups. (Mother's genes are red and green, and Father's genes are yellow and blue.) Select genes for Child 2 as you did for the first child, and record your results on the diagram. Repeat this step for Child 3 and Child 4. Remember to color the diagram after each child and return all of Mother's and Father's genes to the correct cups before choosing genes for the next child. Don't forget to name your children!

7. Fill in the data table and answer the questions on the overhead projector in your student notebook.

Data Table: Pasta Genes

Number of genes from:	**Child 1** _____	**Child 2** _____	**Child 3** _____	**Child 4** _____
Grandfather 1 (red)				
Grandmother 1 (green)				
Grandfather 2 (yellow)				
Grandmother 2 (blue)				
Total # of genes	8			
Total # of gene pairs	4			

Student Questions

■ Reflect and Explain

1. How many genes did each child inherit from Mother? From Father?

2. How many of each gene (pasta type) does each child receive?

3. Did any of the four children have exactly the same combination of genes?

4. Did every child get at least one of his/her genes from each grandparent?

5. Would it be possible for a child in this activity to have the following combinations of genes:
   - eight yellow genes?
   - four yellow genes and four red genes?
   - three blue genes, two green genes, and three red genes?

■ Apply and Extend

Work with a partner or group to answer the following questions:

1. Where did the four grandparents get their genes?

2. Scientists estimate that we each have about 80,000 genes (40,000 gene pairs). How many genes did you get from your mother? From your father?

3. Do you think it would be possible for a mother and father to have four children with the same combination of genes?

Overhead Master

Basic Probability Questions *Pasta Genetics*

For middle school students with prior exposure to probability

1. What is the probability that a child will receive the blue shell gene?

2. What is the probability that a child will receive the blue shell gene or the yellow shell gene?

3. What is the probability that a child will receive the blue shell gene and the yellow shell gene?

4. What is the probability that a child will receive the blue shell gene and the blue wagon wheel gene?

5. What is the probability that a child will receive the blue shell gene or the blue wagon wheel gene?

6. What is the probability that a child will receive all 4 of his maternal genes from Grandmother 1 (blue pasta)?

7. If the human genome consists of approximately 80,000 genes (40,000 gene pairs), what is the probability that a child will receive all 40,000 of his maternal genes from Grandmother 1? (hint: refer to your question 6 calculation)

Answers to Basic Probability Questions Pasta Genetics

1. 1/2

2. 1/2 + 1/2 = 1

3. 0

4. 1/2 X 1/2 = 1/4

5. 3/4

There are 4 possible combinations of shells and wagon wheels the child could receive from his father: BS BW, BS YW, YS BW, and YS YW. (B = blue, Y = yellow, S = shell, W = wheel) 3 out of 4 of these combinations has a blue shell or blue wagon wheel.

6. 1/2 X 1/2 X 1/2 X 1/2 = 1/16 [or (1/2) to the 4^{th} power]

7. (1/2) to the $40{,}000^{th}$ power.

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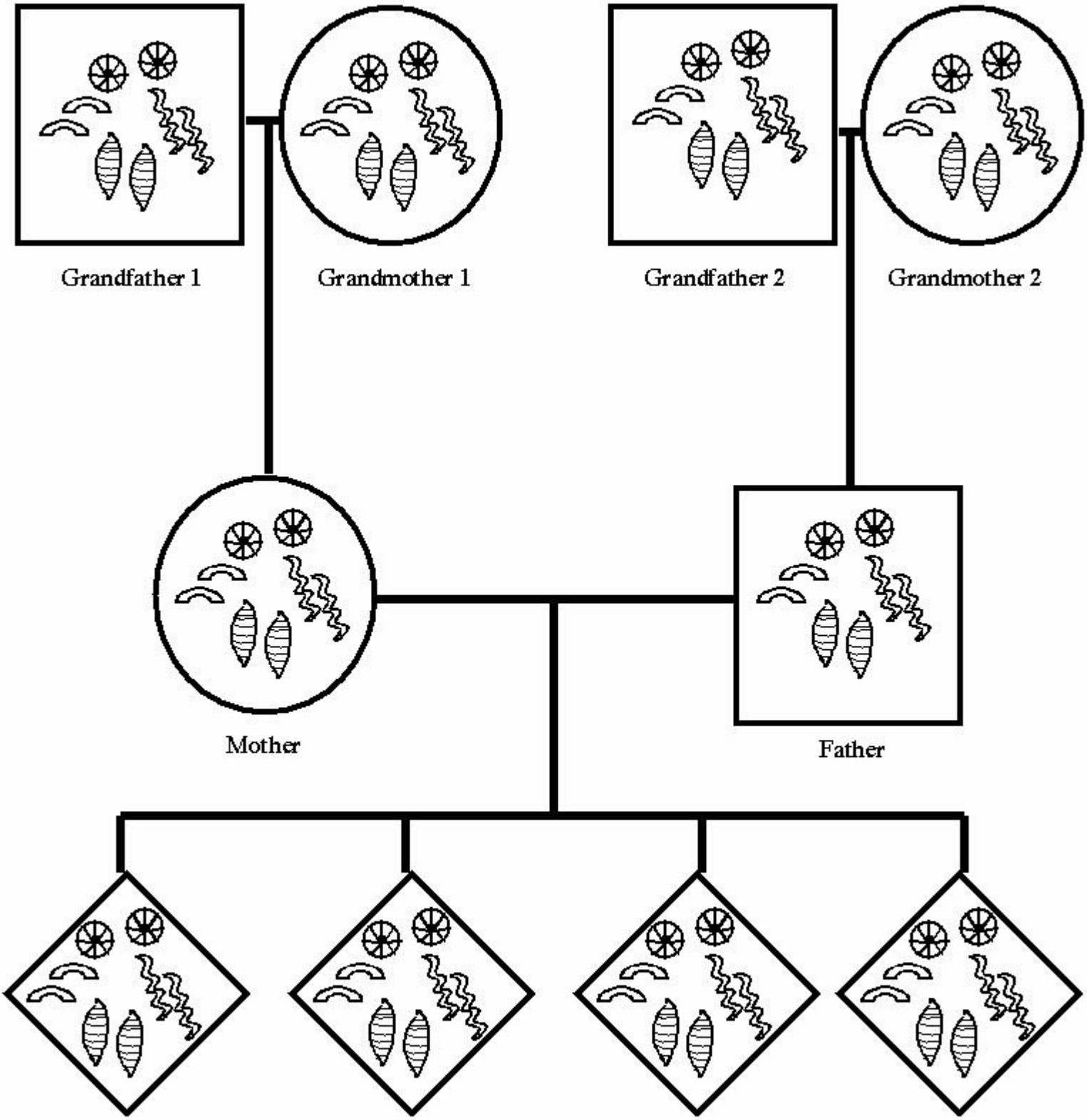
Pasta Genetics



Pasta Genetics

Grandfather 1 (red)

Grandmother 1 (green)

Grandfather 2 (yellow)

Grandmother 2 (blue)

Step 1: Place 8 pasta pieces of the color shown into each of the grandparents' dishes.

Step 2: Without looking, choose 4 different genes (1 of each pasta shape) from Grandfather 1 and 4 genes (one of each shape) from Grandmother 1 and place into Mother's dish. Color Mother's genes on your diagram.

Step 3: Without looking, choose 4 different genes (1 of each pasta shape) from Grandfather 2 and 4 genes (1 of each shape) from Grandmother 2 and place into Father's dish. Color Father's genes on your diagram.

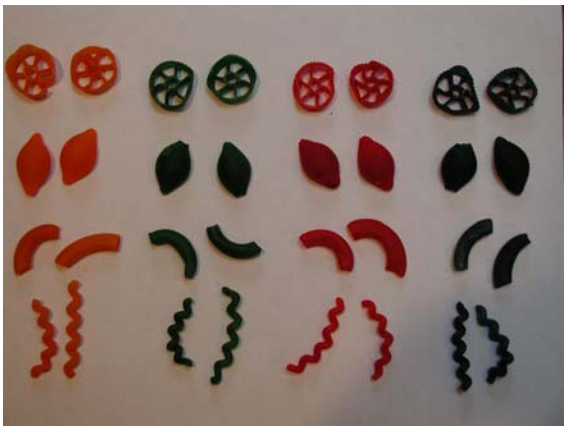
Mother

Father

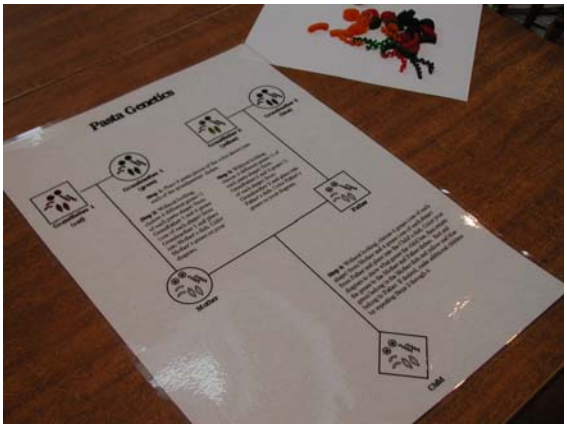
Step 4: Without looking, choose 4 genes (one of each shape) from Mother and 4 genes (one of each shape) from Father and place into the Child's dish. Color your diagram to show what genes the child has, then return the genes to the Mother and Father dishes. Red and green belong in the Mother dish and yellow and blue belong to Father. If desired, make additional children by repeating Steps 2 through 4.

Child

Images from Pasta Genetics



The Pasta
It is important to use pasta of 4 distinct types that can be readily distinguished from each other by touch alone.



The Template
The laminated mat helps students organize the pasta through three generations.

Pasta Genetics in Action
Students find the activity very engaging and especially enjoy choosing the pasta pieces with their eyes closed (to simulate random inheritance of one or the other copy of a particular gene).