Flatheads Pursue Diversity: Beyond the Phases of Meiosis

Janet L.Vigna
Department of Biology
Grand Valley State University
Allendale, MI 49401

Grand Valley State University
www.gvsu.edu

Introduction

Labs teaching meiosis often depend on students viewing cells suspended in their various static phases. As a result, students tend to remember the names of the phases, but not always the importance of what the phases accomplish. In addition, it is difficult for students to connect the molecular process of meiosis to the diversity of physical traits we see in populations. To engage students in the dynamic process of meiosis we developed a lab activity where students become members of a fictional Flathead population. As members of the population students go through the process of meiosis to produce gametes and reproduce offspring bearing various inherited traits. The model "Flathead" organism is a great visual tool to demonstrate the relationship of genotype to phenotype, and also to demonstrate how independent assortment and fertilization result in diversity within populations. The content complexity of this lab activity can be adjusted for use in both non-majors and majors biology and genetics labs. Genes, alleles and physical traits can be easily altered to incorporate different modes of inheritance and gene expression.

The Flathead Species

Genotype to Phenotype:

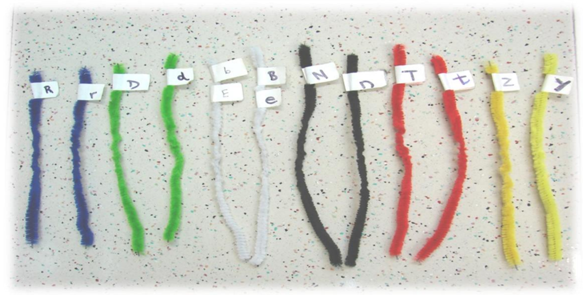
To begin the exercise, each group of two should gather two pipe cleaners of each color into a pile. For each color, choose one pipe cleaner that has an uppercase letter and one pipe cleaner that has a lower case letter (So, each group will produce one Flathead individual that is heterozygous at every gene we're studying). In the case of the yellow pipe cleaners, designate groups on one side of the class to choose the ZY combination, and groups on the other side to choose the ZZ combination.

Determine the genotype of your Flathead person. Use the following chart to determine the phenotype of your Flathead person.

Trait	Phenotype	Genotype
Gender	Male	Zy
	Female	ZZ
Nose Shape	Narrow	NN or Nn
	Wide	nn
Eye Color	Blue	BB or Bb
	Brown	bb
Eyebrows	Bushy	EE or Ee
	Thin	ee
Chin Dimple	No Dimple	DD or Dd
	Dimple	dd
Ear Shape	Long oval	RR or Rr
	Rounded	rr
Mouth	Smiling	TT
	Toothy	Tt
	Pucker	tt

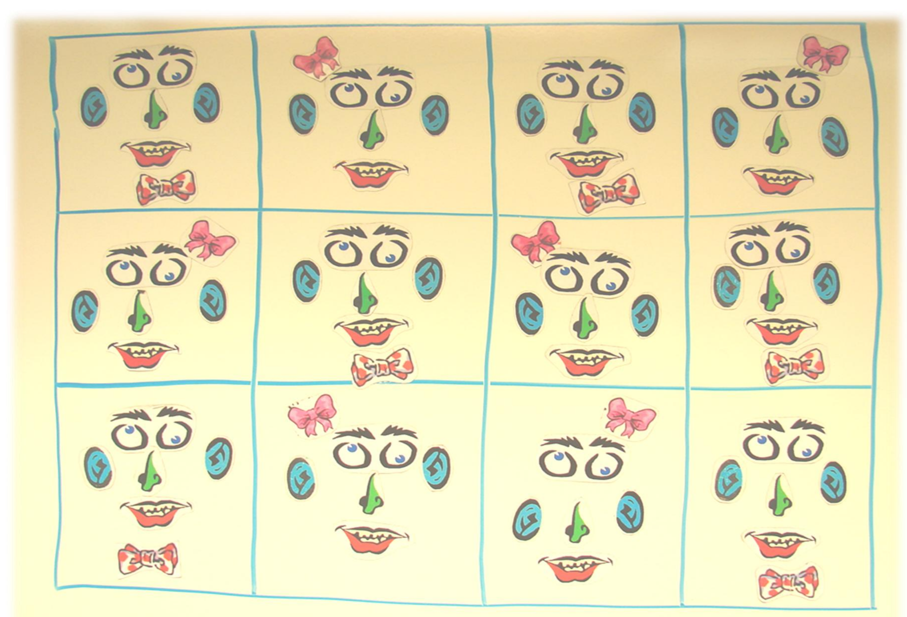
Create Your Flathead Population

These allele combinations (genotype): NnBbDdEeRrTtZy



Produced this Flathead individual (phenotype): Male

And this is the class Flathead population (all have identical genotype, except for gender):



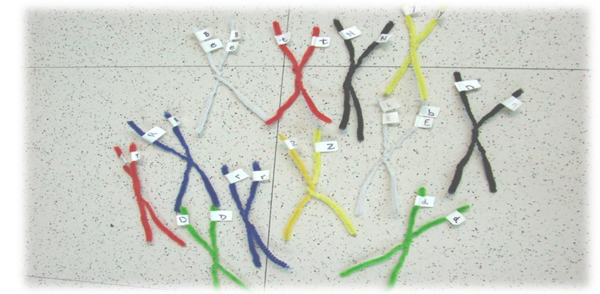
Flathead phenotypes are printed on inkjet magnet sheets and cut out. Faces are assembled on magnetic whiteboards we use regularly in class.

Making Offspring

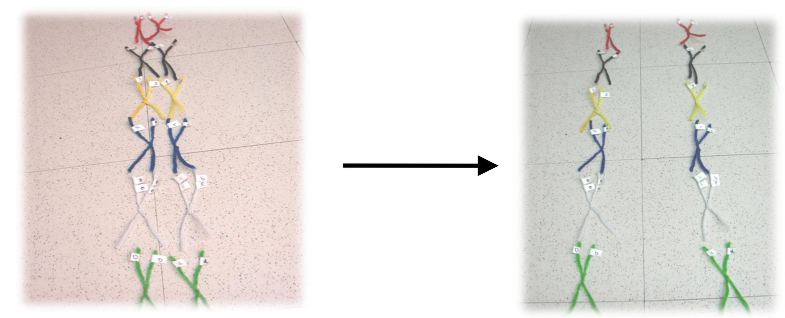
The population has matured and reached adulthood. It's time to reproduce!

Start with Meiosis – just 3 steps

1. Every chromosome replicates. Students pull out another pipe cleaner with the same allele on it and join them together. Identical "Sisters" are held together at the centromere (don't let students twist homologous chromosomes together).

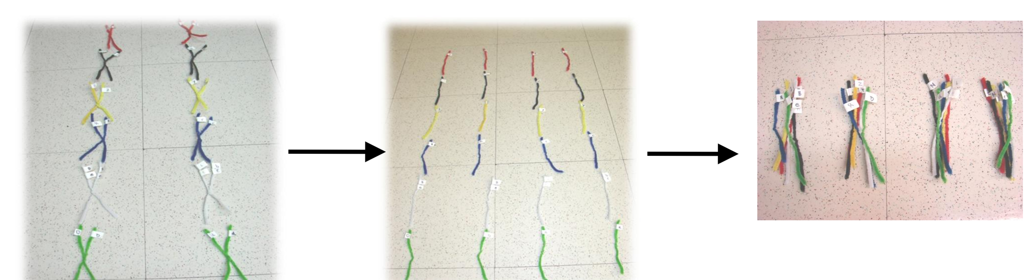


2. Homologous Chromosomes line up next to one another (have groups compare how they line d their chromosomes up – Independent Assortment) and split apart.



Homologous Chromosomes Line Up — Homologous Chromosomes Separate (2 cells)

3. Sister Chromatids line up on top of one another and split.



Sisters Line Up in each cell — Sisters Separate (4 cells) — Each Column Becomes a Gamete (4 haploid eggs or sperm)

Fertilization

Now two flathead organisms are going to make offspring.

Each female will hold up an egg. Each male will take a gamete and add it to the chromosomes of an egg **(check to see if you are ZZ or ZY, not if you have a Z or Y in the gamete you're holding)**. The female keeps the fertilized embryo – Offspring A.

This time each male will hold up a gamete. Each female will take an egg and add it to a different male's gamete than the first time. The male keeps this fertilized embryo – his Offspring A

Repeat steps 1 and 2 for Offspring B.

Each person should now have two offspring.

Offspring A

Making Grandchildren

Record the Offspring A and Offspring B genotypes and phenotypes. Then, have students arbitrarily decide if Offspring A or Offspring B will not get to produce children this year. So sad!

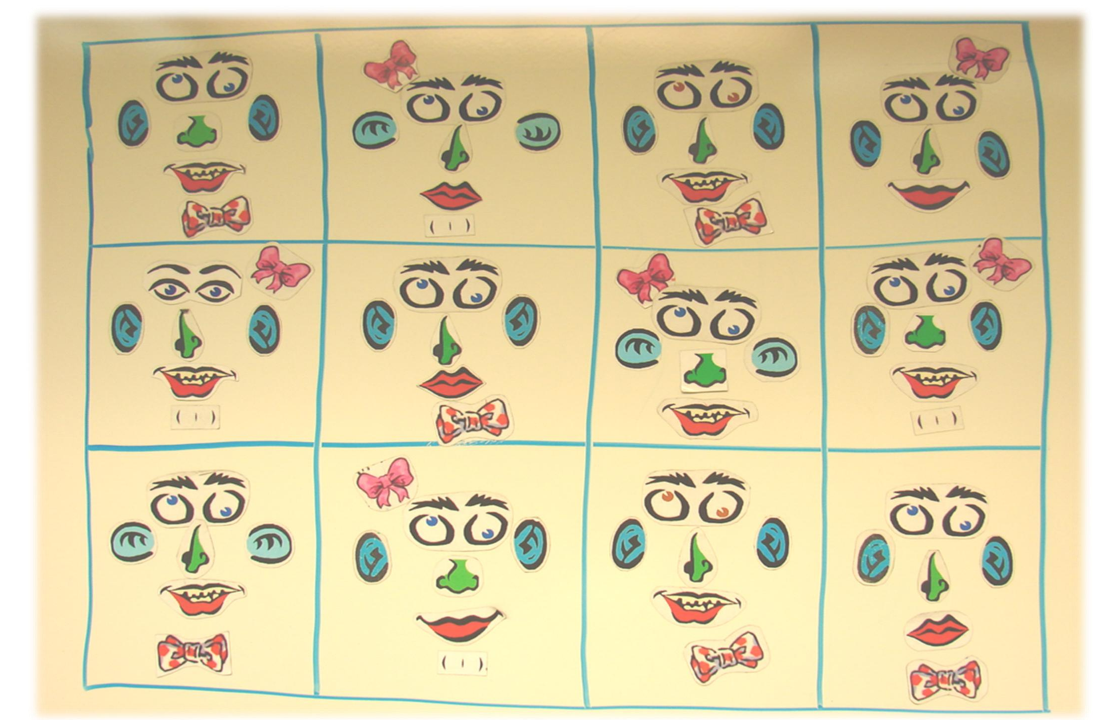
Place this offspring aside and focus on the other one. **Instructors, make sure you have equal numbers of males and females that will reproduce in this generation.** If you don't have even numbers, then have a group switch offspring to make up the gender imbalance.

Now, repeat Meiosis (3 steps) in this offspring, followed by random fertilization to produce Grandchildren.

A Cautionary Note!
For this round of fertilization the males and females are scattered around the room. Make sure students know if they did meiosis for a female or male offspring before they attempt fertilization. Students have a tendancy to check their gamete to determine gender, instead of their original offspring genotype.

Once fertilization has been accomplished, write down both Grandchildren's genotype and phenotype.

Then, build the faces of these Grandchildren and place them on the whiteboard.



Where Did the Diversity Come From??

Compare the original population with the grandchildren population. Even with extensive inbreeding, using genetic clones and no crossing over, there is an amazing amount of diversity.

There are "new" traits: round noses, round ears, pucker lips, smiles, brown eyes, thin eyebrows. . .

a. Independent Assortment during Meiosis I
   - 23 chromosome pairs can make 2 choices each time = over 8 million different chromosome combinations in each egg or sperm.

b. Fertilization
   - One of 8 million eggs can join with one of 8 million sperm = 6.4 X 10^{13} possible genetic combinations in offspring
   - "Hidden" recessive alleles pair to display new traits.

This activity can be used to demonstrate linked genes, incomplete dominance, and other forms of inheritance. It can be expanded to include punnet squares and pedigree analysis. It's great for visual and hands-on learners. It teaches the process of meiosis, and the powerful diversity it generates in populations.