P.O. Box 219 • Batavia, IL 60510
(800) 452-1261 • Fax (866) 452-1436
www.flinnsci.com • E-mail: flinn@flinnsci.com

Catalog No. FB2199

Publication No. 11339

Sno-ball Sillies—Genetics Simulation

Student Laboratory Kit

Introduction

As a *naturalist*, a student of natural history, you are studying organisms of the Amazon Rainforest. On an expedition, you discovered a colony of a new species—dubbed the "sno-ball sillies" due to their snow ball-shaped bodies—which has yet to be identified. Wanting to know as much as you can about this new species, you bring a male and female back to your research lab to breed them and learn about their traits.

Concepts

- Alleles
- Genotype vs. phenotype
- Dominant and recessive
- Chromosomes
- Meiosis

Background

The discovery of a new species is a time of excitement and questions. For example, *Microhyla laterite*, a new species of frog discovered in Manipal, India, in 2016 led researchers on an exhilarating adventure to determine whether this tiny frog, which can sit on the tip of your thumb, was in fact, a new species. Finally, through genetic analysis it was confirmed to be an unknown species. The frog's scientific name came from its narrow mouth (*Microhyla*) and the habitat where it was found, *laterite*—a rocky terrain of iron-rich, weathered soil.

Examining an organism at the cellular level shows that almost all cells have the same number and type of chromosomes. For example, a human body cell has 46 chromosomes. Each chromosome matches up to make a pair that is similar in shape and size. These are called *homologous chromosomes* (see Figure 1) and are inherited from the parents. One is inherited from the mother and one is inherited from the father. Each homologous chromosome in a pair carries the same sequence of genes which encode for traits. However, the version of the gene, called an *allele*, found on one homologous chromosome does not always match the other. Alleles generally are either *dominant* or *recessive*. A *genotype* represents the alleles contained in the gene of a homologous pair and can only be determined through laboratory testing, whereas a *phenotype* is the observable characteristic. A dominant phenotype only requires the presence of one allele in order for the trait to be observable, regardless of the other allele present. Recessive phenotypes require the presence of two copies of the same allele. For example, the gene for freckles is on chromosome 16 (see Figure 1a). The alleles present determine whether or not a person has freckles (dominant) or no freckles (recessive). Looking at Figure 1, one chromosome carries the dominant allele (F) for freckles and the other carries the recessive allele (f) for no freckles. In this person, freckles will be seen in the phenotype because the dominant allele hides or masks the recessive allele.

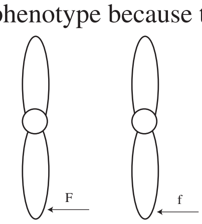

Figure 1a. Chromosomes

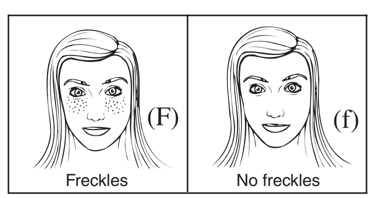

Figure 1b. Phenotype

Humans have 23 homologous pairs of chromosomes. In females, all 23 match in size and shape. In males, however, one pair does not match. The two chromosomes that do not match are the X and Y, or *sex chromosomes*. Not all species follow this pattern. For example, in birds, snakes and some insects, females carry the mismatched chromosome pair while males carry the identical pair.

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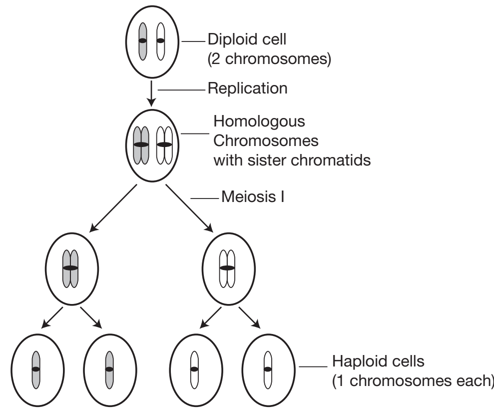
A cell that contains two homologous sets of chromosomes is knows as a *diploid cell*. The total number of chromosomes is known as the *diploid number*. In humans, a diploid cell has 46 chromosomes. Sex cells, or *gametes*, are not diploid cells. Sperm cells and egg cells each have a single set of chromosomes, one from each homologous pair. They are known as *haploid cells* and are produced through the process of *meiosis*.



Meiosis is the type of cell division that occurs in reproductive tissues. During meiosis two cellular divisions occur. In the first division, homologous chromosomes with two sister chromatids are separated, reducing the number of chromosomes. In the second division, sister chromatids are separated, just as they are in mitosis. During meiosis, the cells reduce their normal diploid chromosome number by half to create four haploid cells. By reducing the number to half, when *fertilization* (fusion of nuclei and cytoplasm from gametes resulting in a *zygote*) occurs, the number of chromosomes in the offspring return to the diploid number. Each offspring would have two homologous sets of chromosomes, one from each parent. Having haploid cells fuse rather than diploid cells prevents the doubling of chromosomes between generations, which would be detrimental.

Experiment Overview

Use your knowledge of meiosis and heredity to create an offspring from a mating pair of the new, unknown species. From the offspring created, determine the parents' genotypes.

Pre-Lab Questions

1. Each diploid cell of the new species contains 16 homologous chromosomes. How many chromosomes are present in each haploid cell?
2. Upon fertilization, how many chromosomes will the offspring possess?
3. Use a diagram to explain how the process of meiosis produces four haploid cells.

Materials

Plastic bag labeled DAD	Push pins, clear and colored
Plastic bag labeled MOM	Screws, black and silver
Chenille wire	Styrofoam balls
Corks	Toothpicks, plastic
Pop beads	Toothpicks, wooden

Safety Precautions

Pins are sharp; handle with care. Please follow all laboratory safety guidelines.

Procedure

Part A. Chromosome Sorting

1. Take the pink chromosomes out of the plastic bag labeled "MOM."
2. Put the chromosomes on the lab table with the letters face down.
3. Match the chromosomes as homologous pairs (matching size).
4. Randomly take one chromosome from each homologous pair. Place chromosomes NOT chosen back in the plastic bag.
5. Repeat steps 1-4 with the blue chromosomes in the plastic bag labeled "DAD."
6. Match the "MOM" chromosomes to the homologous "DAD" chromosomes (match size).

7. Flip the chromosomes over and fill in the table on the *Sno-ball Sillies Genetics Simulation* worksheet.
8. Return all the chromosomes to the correct plastic bags.
9. Obtain a Sno-ball Sillies Genetics Simualtion Decoder sheet from the instructor and determine the phenotype of the offspring. Fill in the correct phenotype on the worksheet.

Part B. Offspring Building

1. Using the materials provided, assemble the offspring according to the genotype selected in *Part A*.
2. Use wooden toothpicks to hold the body segments together and attach the humps. The toothpicks may be broken in half if needed.
3. After the offspring is assembled, draw the offspring on the worksheet. Used colored pencils or label the appropriate color when necessary.
4. Record the phenotype of each trait for the offspring on the class data worksheet on the board.
5. Fill in the Class Data table on the worksheet in your packet. This will be needed for the *Post-Lab Questions.*

Disposal

Consult your instructor for appropriate disposal procedures.

Name: ______________________________

Sno-ball Sillies—Genetics Simulation Worksheet

Data Table – Offspring

Allele Letter	Trait	Allele from Mom	Allele from Dad	Offspring Genotype	Offspring Phenotype
A	Antenna				
H	Humps				
N	Nose Color				
T	Tail				
E	Eyes				
B	Body Segments				
L	Leg Color				
X or Y	Gender				

Offspring Sketch

Post-Lab Questions

1. How many unique offspring phenotypes were created in the class?
2. If any two looked exactly alike, did their genotypes match also?
3. Compare the offspring to the parents.
   a. Do any of the offspring look exactly like either of the parents?
   b. What would happen if it were possible for an offspring to inherit all of its chromosomes from one parent?
4. Choose another team's offspring to be a mate for your model. Select two of the traits and complete a Punnett square for each.

Trait:__________

Genetic Cross: ________ X ________

Offspring Genotypic Ratio:

Offspring Phenotypic Ratio:

Trait:__________

Genetic Cross: ________ X ________

Offspring Genotypic Ratio:

Offspring Phenotypic Ratio:

Name: ____________________________

5. The following table includes the phenotypes of each parent. Using the class data of offspring, determine the genotypes for each parent's traits.

Trait	MOM Phenotype	MOM Genotype	DAD Phenotype	DAD Genotype
Number of Antenna	1		2	
Number of Humps	3		3	
Nose color	silver		black	
Tail shape	curly		straight	
Number of eyes	2		3	
Number of body segments	3		2	
Leg color	clear		colored	
Gender	female		male	

6. Is it possible for a mating pair of two-eyed Sno-ball Sillies to have offspring with three eyes? Explain your reasoning.

7. By random selection of one of two alleles for each of the eight traits, how many different varieties of offspring can be created? (*Hint:* If two forms for a trait exist, the possibilities are $2 \times 2 = 4$; if three traits exist, the possibilities are $2 \times 2 \times 2 = 8$).

8. If none of the offspring had three body segments, what might be inferred about the DAD's genotype for body segments? Can you be certain?

Phenotypes of Sno-ball Sillies Offspring

Trait	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	Team 9	Team 10	Team 11	Team 12	Team 13	Team 14	Team 15
Number of Antenna															
Number of Humps															
Nose color															
Tail shape															
Number of Eyes															
Number of Body Segments															
Number of Leg Segments															
Feet Color															
Gender															

Teacher's Notes
Sno-ball Sillies—Genetics Simulation

Materials Included in Kit (for 15 groups of students)

Chenille wires, 10
Corks, Size 00, 45
Dad chromosomes, blue, 16 sets
Mom chromosomes, pink, 16 sets
Plastic bags, 30
Pop beads, 100
Push pins, clear, 1 box
Push pins, colored, 1 box
Screws, black, 16
Screws, silver, 16
Styrofoam balls, 1-½″, 60
Toothpicks, plastic, 50
Toothpicks, wooden, 75

Additional Materials Needed *(for Pre-Lab Preparation)*

Scissors

Pre-Lab Preparation

1. Cut out enough sets of the pink (MOM) chromosomes for each student group and place into separate reclosable plastic bags. Label each bag "MOM."
2. Cut out enough sets of the blue (DAD) chromosomes for each student group and place into separate reclosable plastic bags. Label each bag "DAD."
3. Cut each chenille wire (tail) in half. There will be a total of 20 tails available for use.
4. Photocopy enough Sno-ball Sillies—Genetics Simulation Decoder worksheets for each student group to use after they have determined the offsprings' genotypes.

Safety Precautions

Remind students to use caution when handling sharp pins. Please follow all laboratory safety guidelines.

Disposal

Offspring can be dismantled and all items may be saved for future use or disposed of in the regular trash.

Lab Hints

- Enough materials are provided in this kit for 30 students working in pairs, or for 15 groups of students. Both parts of this laboratory activity can reasonably be completed in one 50-minute class period. The pre-laboratory assignment may be completed before coming to lab, and the data compilation may be completed the day after the lab.
- Copying and cutting out extra chromosomes is a good idea in case students lose or misplace chromosomes. This will prevent delay in future class periods. One extra set is provided.
- There are enough materials to build a "MOM" and "DAD" Sno-ball Silly to have on display in the classroom.

Teaching Tips

- This activity is ideal as a review of heredity, meiosis, dominant and recessive traits, alleles, chromosomes and Punnett squares.
- A test cross is a breeding experiment with an organism of an unknown genotype associated with the dominant phenotype. This organism is mated to an organism that possesses the homozygous recessive phenotype. Based on the offspring, the unknown genotype can be inferred.

Answers to Pre-Lab Questions *(Student answers will vary.)*

1. Each diploid cell of the new species contains 16 homologous chromosomes. How many chromosomes are present in each haploid cell?

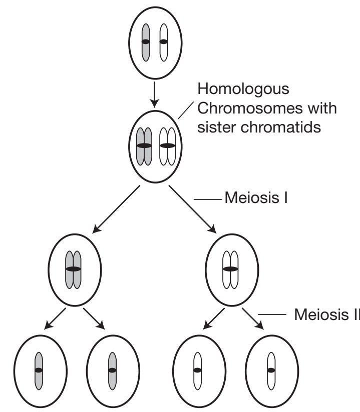
   Each haploid cell of the new species would have 8 chromosomes.

2. Upon fertilization, how many chromosomes will the offspring possess?

   After fertilization, the number of chromosomes would return to the diploid number of 16.

3. Use a diagram to explain how the process of meiosis produces four haploid cells.

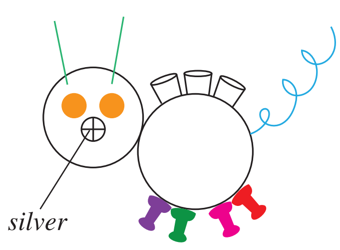
   The process of meiosis has two cellular divisions. In the first division, homologous chromosomes with two sister chromatids are separated reducing the number of chromosomes. In the second division, sister chromatids are separated just as they are in mitosis.



Sample Data Table *(Student data will vary.)*

Allele Letter	Trait	Allele from Mom	Allele from Dad	Offspring Genotype	Offspring Phenotype
A	Antenna	*a*	*a*	*aa*	*2 antenna*
H	Humps	*h*	*H*	*Hh*	*3 humps*
N	Nose Color	*n*	*n*	*nn*	*silver nose*
T	Tail	*T*	*t*	*Tt*	*curly tail*
E	Eyes	*E*	*e*	*Ee*	*2 eyes*
B	Body Segments	*b*	*B*	*Bb*	*2 body segments*
L	Leg Color	*l*	*l*	*ll*	*colored legs*
X or Y	Gender	*X*	*Y*	*XY*	*male*

Offspring Sketch



Answers to Post-Lab Questions *(Student answers will vary)*

1. How many unique offspring were created in the class?

   Data will vary. It is probable that there will be 15 unique offspring.

2. If any two were exactly alike, did their genotypes match also?

   Data will vary. It is unlikely that genotypes and gender will be identical.

3. Compare the offspring to the parents.

   a. Do any of the offspring look exactly like either of the parents?

   Student answers will vary, however, it is unlikely that an offspring will be identical to one parent.

   b. What would happen if it were possible for an offspring to inherit all of its chromosomes from one parent?

   If an offspring inherited all of the chromosomes from one parent, it would be an identical copy or a clone.

4. Choose another team's offspring to be a mate for your model. Select two of the traits and complete a Punnett square for each. *Student answers will vary. Example:*

   Trait: *Tail Shape*

   Genetic Cross: *Tt* X *Tt*

	T	t
T	TT	Tt
t	Tt	tt

   Offspring Genotypic Ratio: *1 TT: 2 Tt: 1 tt*

   Offspring Phenotypic Ratio: *3 curly: 1 straight*

   Trait: *Body Segments*

   Genetic Cross: *bb* X *Bb*

	B	b
b	Bb	bb
b	Bb	bb

   Offspring Genotypic Ratio: *0 BB: 2 Bb: 2 bb*

   Offspring Phenotypic Ratio: *2 two body segments: 2 three body segments or 1:1*

5. The following table includes the phenotypes of each parent. Using the class data of offspring, determine the genotypes for each parent's traits.

Trait	MOM Phenotype	MOM Genotype	DAD Phenotype	DAD Genotype
Number of Antenna	1	*AA or Aa**	2	*aa*
Number of Humps	3	*HH or Hh**	3	*HH or Hh**
Nose color	silver	*nn*	black	*NN or Nn**
Tail shape	curly	*TT or Tt**	straight	*tt*
Number of eyes	2	*EE or Ee**	3	*ee*
Number of body segments	3	*bb*	2	*BB or Bb**
Leg color	clear	*LL or Ll**	colored	*ll*
Gender	female	*XX*	male	*XY*

*Correct genotype based on chromosomes.

6. Is it possible for a mating pair of two-eyed Sno-ball Sillies to have offspring with three eyes? Explain your reasoning.

   It is possible. If the two-eyed Sno-ball Sillies are both heterozygous for number of eyes, then even though they both have two eyes, they possess the allele for three eyes; it is just hidden by the dominant allele. If the offspring received the recessive allele from each parent, the offspring would have three eyes.

7. By random selection of one of two alleles for each of the eight traits, how many different varieties of offspring can be created? (*Hint:* If two forms for a trait exist, the possibilites are $2 \times 2 = 4$; if three traits exist, the possibilities are $2 \times 2 \times 2 = 8$).

   $2^8 = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 256$ *different varieties could be created.*

8. If none of the offspring had three body segments, what might be inferred about the DAD's genotype for body segments? Can you be certain?

   It could be inferred that the DAD's genotype is homozygous dominant (BB); however, it cannot be certain. It is possible the DAD's genotype is Bb and the dominant allele was randomly selected for all the offspring.

The *Sno-ball Sillies—Genetics Simulation Student Laboratory Kit* is available from Flinn Scientific, Inc.

Catalog No.	Description
FB2199	Sno-ball Sillies—Genetics Simulation Student Laboratory Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Sno-ball Sillies—Genetics Simulation Decoder

Trait	Body Part Material	Genotype/Phenotype
Antenna	Plastic toothpick	AA – 1 antenna Aa – 1antenna aa – 2 antenna
Humps	Cork stopper	HH – 3 hump Hh – 3 humps hh – 1 hump
Nose color	Screws, appropriate color	NN – black nose Nn – black nose nn – silver nose
Tail	Chenille wire	TT – curly tail Tt – curly tail tt – straight tail
Eyes	Pop beads	EE – 2 eyes Ee – 2 eyes ee – 3 eyes
Body Segments	Styrofoam balls	BB – 2 body segments Bb – 2 body segments bb – 3 body segments
Leg Color	Push pins, clear or colored	LL – clear Ll – clear ll – colored
Gender/Sex		XX – female XY - male