Watching Heredity Happen

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Core content: Structure and Function in Living Systems or The Molecular Basis of Heredity

This unit can be taught in the seventh or eighth grade. In the seventh grade the focus is on Kentucky core content SC-M-3.3.2. In the eighth grade the focus is on SC-H-3.3.2, MA-M-1.1.1, MA-M-1.2.1, MA-M-1.2.3 and MA-M-1.3.1

SC-M-3.3.2: Every organism requires a set of instructions for specifying its traits. This information is contained in genes located in the chromosomes of each cell. Heredity is the passage of these instructions from one generation to another.

SC-H-3.3.2: Multicellular organisms, including humans, form from cells that contain two copies of each chromosome. This explains many features of heredity. Transmission of genetic information through sexual reproduction to offspring occurs when male and female gametes that contain only one representative from each chromosome unite.

MA-M-1.1.1: Rational numbers (integers, fractions, decimals, percents)

MA-M-1.2.1: Add, subtract, multiply, and divide rational numbers(integers, fractions, decimals, percents) to solve problems.

MA-M-1.2.3: Apply ratios, proportional reasoning, and percents.

MA-M-1.3.1: How whole numbers, natural numbers, integers, fractions, decimals, percents, and irrational numbers relate to each other.

Academic Expectations: 2.2 Patterns of Change, 2.4 Scale and Model

Skills: gather, analyze, and interpret data, use evidence and logic to develop scientific explanations.

The Challenge: When Jeff and Ashley married they planned to eventually have several children. (4 or 5) Three years after their marriage their first child, Max, was born. Soon after his birth, Max was diagnosed with Cystic Fibrous, a genetic disease that requires a great deal of medical treatment and can sometimes be fatal.

Neither Jeff nor Ashley know of anyone in their family who had Cystic Fibrosis, yet the doctors told them it was inherited. Jeff and Ashley don't understand how Max inherited CF. Your challenge is to discover how Max inherited the disease and if Jeff and Ashley have more children what will be their chances of having CF.

Pre-test: You can use either the above challenge as an open response or the pre-test on the following page.

Tasks: 1. Baby Mars Mellows
2. Pa's Parents
3. Punnett Square Ma
4. Another Generation

Note: The nose trait in this unit is an example of incomplete dominance. It is included in case you wish to cover the concept. However, it is not discussed in the above tasks.

Additional Ideas:

1. Have a students or group of students research Gregor Mendel. Have them compare their Mars Mellows to his pea plants.
2. Have students make a pedigree chart tracing one of the first five traits in the four generations of Mars Mellows used in the tasks.

Assessments: Every task has something that can be used for a daily assessment (journal entry, Punnett squares, calculations, questions, etc.) There are two open response prompts. The one in the challenge that opens the unit assess the middle school science core content and open response found at the end of the unit, Mr. Potter's class, assess the math core content.

Watching Heredity Happen
Pre-test

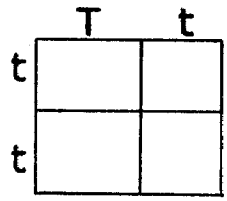
Name _____
Class _____ Date_____

Questions 1, 3, and 4, put the letter of the correct answer in the blank.

_____ 1. When round peas are crossed with wrinkled peas all the offspring have round peas. The round pea trait is a

a. recessive trait
b. dominant trait
c. random trait
d. controlling trait

2. In this Punnett square T stands for the tallness gene and t stands for the shortness gene. Complete the following Punnett Square.



_____ 3. The offspring from the above Punnett square will likely be

a. one tall, 3 short
b. one short, 3 tall
c. all tall
d. 2 tall, 2 short

_____ 4. In Gregor Mendel's experiments with pea plants, he counted 598 offspring with yellow seeds and 202 with green seeds. The gene combination of the parent plants most likely were

a. pure dominant yellow and heterozygous yellow
b. both heterozygous yellow
c. pure dominant yellow and pure recessive green
d. pure recessive green and heterozygous green

Task 1: Baby Mars Mellows

Materials: 1 zip-lock baggie per number of students in largest class,
1 set of Ma's and 1 set of Pa's chromosomes per **pair** of students in largest class,
1 small nails per total number of students,
1 clear push pins per total number of students,
2 multicolored push pins per total number of students,
2 brass thumbtacks per total number of students,
Half a pipe cleaner per total **pairs** of students,
1 paper plate per total **pairs** of students,
10 toothpicks per total **pairs** of students,
1 package of large marshmallows for every class plus one extra bag,
1 bag of small marshmallows for every two classes

Preparation: There is a good deal of preparation to be done the first time you do this task, however most of the materials can be saved and used again. I suggest a shoebox for storage.

1. Copy Ma's and Pa's chromosomes on different colored paper. You can have your first class cut of the chromosomes or you can cut them out before the activity and seal them in zip-lock baggies.
2. Several days before you plan to do this task buy your marshmallows and open the bags. This activity works best if the marshmallows are somewhat stale.
3. The morning of the task make Ma and Pa using their chromosomes to guide you.
4. Place the nails, push pins, pipe cleaners, thumbtacks, and marshmallows where students can get what the need while you can also easily supervise them.
5. Make a class tally chart on the board or on chart paper similar to the following.

Class tally chart Visible Trait	class 1		class 2		class 3		class 4		total
	tally	#	tally	#	tally	#	tally	#	frequency
2 antennas									
1 antenna									
colored legs									
clear legs									
3 body parts									
2 body parts									
curly tail									
straight tail									
2 eyes									
3 eyes									
red nose									
orange nose									
yellow nose									
female									
male									

Note: There are two student versions for this task. One includes more math concepts than the other. Most of the directions below apply to both versions. However, step 7 applies to the more math concepts version.

Note: Since the decoder key in the checklist is used in several of the tasks, you might want to write it on chart paper and post it in your room. Otherwise, make sure students keep their checklist.

Note: If you have 50 min. or less class time push your students to get through number 6 below the first day and then do the rest the next day. If you have longer class periods you will still want your class to stop after 6 and complete the rest of the task after you have the data for all your classes.

1. Introduce the class to Ma and Pa. Ask the class to describe Ma and Pa's traits. You may want to have the class define the word trait.
2. Put the students in pairs. Give each pair a paper plate, a checklist sheet, 1set of Ma's chromosomes in a zip-lock bag and 1 set of Pa's chromosomes in a zip-lock bag.
3. Depending on how well your students follow written directions you can direct the students through the checklist sheet together as a class or let them work through it themselves.
4. It is important to supervise student carefully so that they don't change any of the traits of the baby. As long as students randomly choose chromosomes your results should be similar to Mendel's 3:1 ratio.
5. Have students record their baby's traits in the class tally chart you have prepared.
6. Students need to keep their checklist. They will use the decoder chart in the next 3 tasks.
7. For best results add all classes trait totals together. Have students record these totals under frequency in Data Table 2. Under ratio have students write the unreduced ratio and then reduce the ratio and write it in the next column. Next have students write the fraction. (Frequency/total number of babies) Have students calculate the percents for each trait in Data Table 2.
8. Ask students if they see a pattern. Guide them to the ratio of 3:1 for the first five traits and a1:1 ratio for the male or female trait.
9. Discuss or have students write in their journal their hypothesis for the following question. Why do Ma and Pa look very similar and have mostly the same traits, yet their offspring have many different traits?

Chromosomes

1	1	4	4	3	3	2	2
		T male	t male	B male	b male	L male	I male
		5	5	6	6	7 F male	7 M male
A male	a male	E male	e male	N male	n male		

Chromosomes

1	1	4	4	3	3	2	2
		T female	t female	B female	b female	L female	I female
		5	5	6	6	7 F female	7 F female
A female	a female	E female	e female	N female	n female		

Baby Mars Mellows

(for those who don't know, Mars Mellows are mellow little creatures that live on Mars)

Check off each step when you finish it.

_____1. Count your chromosomes. There should be 14. Arrange them face down from the largest to smallest. You will have two for each length. (It's a chromosome pair!)

_____2. To form a sex cell (also called a gamete), randomly take one chromosome from each chromosome pair and place them in a pile. Gather the other chromosomes together in another pile. You now have two sex cells with 7 chromosomes each.

_____3. Assign one sex cell heads and the other tails. Flip a coin to see which one will join with your partner's sex cell. Put the losing sex cell in your baggie.

_____4. Pair your chromosomes with your partner's. Arrange them from largest to smallest. These are the chromosomes of the baby Mars Mellow.

_____5. Record the letter on the chromosomes in Data Table 1 exactly as they appear on the chromosomes.

_____6. Use the following decoder key to determine what visible traits the baby Mars Mellow will have. Record the visible traits in Data Table 1.

AA or Aa = 2 antenna
LL or Ll = different colored legs
BB or Bb = 3 body segments
TT or Tt = curly tail
EE or Ee = 2 eyes
NN = red nose Nn = orange nose
FF = female (one bump)

aa = 1 antenna
ll = clear legs
bb = 2 body segments
tt = straight tail
ee = 3 eyes
nn = yellow nose
FM = male (two bumps)

_____7. Record the materials and the amount of each you need in Data Table 1. The following materials are needed to make the following parts.

Antenna - small nails, legs - push pins, body segments - large marshmallows, tail - pipe cleaner, eyes - brass thumbtacks, nose - small colored marshmallows, bumps - small green marshmallows.

_____8. You will need 5 to 10 toothpicks to hold the baby Mars Mellow together. Get your materials and build your baby.

_____9. Record your visible traits on the class tally chart as instructed.

_____10. Place the baby Mars Mellow on a paper plate. Write your name, your partner's name, and the baby Mars Mellow's name on the plate.

_____11. Put your chromosomes into your baggie and seal it. Put your baby Mars mellows and your baggie of chromosomes where your teacher tells you.

_____12. Put this check sheet and your Data Sheet where your teacher tells you. You will complete Data Table 2 the next class meeting.

Data Sheet

Data Table 1

Chromosomes Pair	Baby's chromosomes	visible traits	materials
1			
2			
3			
4			
5			
6			
7			

Total number of baby Mars Mellows = _____

Data Table 2

Visible trait	frequency	ratio	reduced ratio	fraction	percent
2 antennas					
1 antenna					
colored legs					
clear legs					
3 body parts					
2 body parts					
curly tail					
straight tail					
2 eyes					
3 eyes					
red nose					
orange nose					
yellow nose					
female					
male					

Baby Mars Mellows

(for those who don't know, Mars mellows are little creatures who live on Mars)

Day One

Check off each step when you finish it.

_____ 1. Count your chromosomes. There should be 14. Arrange them face down from largest to smallest. You will have two for each length. (a chromosome pair!)

_____ 2. To form a sex cell, <u>randomly</u> take one chromosome from each chromosome pair and place them in a pile. Gather the other chromosomes together into another pile. You now have two sex cells!

_____ 3. Assign one sex cell heads and the other tails. Flip a coin to see which one will join with your partner's sex cell. Put the losing sex cell into your baggie.

_____ 4. Pair your chromosomes with your partner's. Arrange them from largest to smallest. These are the chromosomes of the baby Mars mellow. Record the letters on the chromosomes in Data table 1 <u>exactly</u> as they appear on the chromosomes.

_____ 5. Use the following decoder key to determine what visible traits the baby Mars mellow will have. Record the visible traits in Data table 1.

AA or Aa = 2 antenna	aa = 1 antenna
NN = red nose Nn= Orange nose	nn = Yellow nose
LL or Ll = different color legs	ll = clear legs
BB or Bb = 3 body segments	bb = 2 body segments
TT or Tt = Curly tail	tt = straight tail
EE or Ee = 2 eyes	ee = 3 eyes
FF = female (one bump)	FM = male (two bumps)

____ 6. The following materials are needed to make the following parts. Record the materials you need in data table 1.

antenna - small nails, Nose - small colored marshmallows, legs - push pins
body segments - large marshmallows, tail - pipe cleaner, eyes - brass thumbtacks
bumps - small green marshmallows

_____ 7. You and your partner build the baby Mars mellow. Use toothpicks to hold the parts together.

_____ **8. Place the baby Mars mellow on a paper plate. Write your name, your partner's name and the baby Mars mellow's name on the plate.**

_____ **9. Record your visible traits on the class chart as instructed.**

_____ **10. Put your chromosomes into your baggie and seal it. Put your baby Mars mellow and your baggie of chromosomes where your teacher tells you.**

Day Two

_____ **11. Use the information on the board to fill in the information on Data Table 2. Calculate the percent for each trait by using this formula.**

number with trait ÷ total number of babies x 100 = percent

_____ **12. Choose one of the following visible traits and do a pedigree chart on the back of your Data Sheet: clear legs, 1 antenna, curly tail, 3 eyes. Include the grandparents, the parents, your baby Mars mellow and four of his/her siblings.** (Ma's ma is pure dominant, Ma's pa is pure recessive, Pa's ma is pure recessive and Pa's pa is pure dominant.)

_____ **13. Answer the following questions in complete sentences on the back of the data sheet.**

1. Which traits are dominant? (don't included nose color or male and female) How can you tell?
2. From your data, what percent of babies have the dominant trait and what percent have the recessive trait? Do you think that this percent always happens? Why?
3. The nose color trait is called incomplete dominance. What do you think the term incomplete dominance means?
4. If a father has a curly tail and the mother has a curly tail, what are the chances the baby will have a straight tail? Explain.
5. If a father has a straight tail and the mother has a straight tail, what are the chances the baby will have a curly tail? Explain.
6. How is the chance of being a male or a female different from other traits. Explain why it is different.

Data Sheet

Data Table 1

Chromosome pair	Baby's chromosome	visible traits	materials
1			
2			
3			
4			
5			
6			
7			

Total number of baby Mars mellows = _____

Data Table 2

Visible trait	number	percent
2 antenna		
1 antenna		
colored legs		
clear legs		
3 body parts		
2 body parts		
curly tail		
straight tail		
2 eyes		
3 eyes		
female		
male		
red nose		
orange nose		
yellow nose		

Task 2: Pa's Parents

1. In the pervious task students were asked, "Why do Ma and Pa look similar, yet their offspring have many different traits?" Some students should have suggested that the offspring get their different traits from Ma's parents and Pa's parents. Tell students in today's activity they will be looking at the chromosomes of Pa's parents.
2. You can hand out the Pa's parents worksheet or you can write Data Table 3 on the board and have students copy it and take notes as you go through the questions on the worksheet.
3. Discuss or have students write in their journal their thoughts to the questions in the "Things to Think About" at the end of the worksheet. These questions will be investigated in the next task.

Answer Key to Pa's Parents:

1. AA
2. A
3. aa
4. a
5. Aa
6. 2 antennas
7. no
8. 2 antennas Aa
   different colored legs Ll
   3 body parts Bb
   curly tail Tt
   2 eyes Ee
9. leg color, number of body parts, tail shape, number of eyes
10. none
11. leg color, number of body parts, tail shape, number of eyes
12. none
13. leg color, number of body parts, tail shape, number of eyes
14. none
15. answers will vary
16. answers will vary
17. answers will vary

Pa's Parents

Data Table 3

Grandpa Appearance	chromosomes	Grandma Appearance	chromosomes	Pa Appearance	chromosomes
2 antenna	AA	1 antenna	aa		
different colored legs	LL	clear legs	ll		
3 body parts	BB	2 body parts	bb		
curly tail	TT	straight tail	tt		
2 eyes	EE	3 eyes	ee		

Use the above information to answer the following.

1. Grandpa's chromosomes for the antenna trait are _____.
2. When grandpa gives a chromosome to make a sex cell the only chromosome he can give is _____.
3. Grandma's chromosomes for the antenna trait are _____.
4. When Grandma gives a chromosome to make a sex cell the only chromosome she can give is _____.
5. When Grandpa's chromosomes combine with Grandma's chromosomes the only chromosome pair that can form is _____.
6. Using the decoder key from the Mars Mellow checklist, how many antennas will Grandpa and Grandma's offspring have? _____
7. Is there any chance that any of their children will have a different number of antennas? _____
8. Fill in the chart above for Pa's chromosomes and appearance.

*Because the trait of having 2 antennas seems to cover up the trait of having one antenna, the 2 antenna trait is said to be a <u>dominant</u> trait.

*Dominant traits are represented by upper case letters.

*Since Grandpa has two dominant traits (2 upper case letters) he is said to be <u>pure dominant</u> for that trait.

9. What other traits is Grandpa pure dominant?

10. What traits is Pa pure dominant?

*Because the trait of having 1 antenna seems to be covered up the trait is said to be a recessive trait.

*Recessive traits are represented by lower case letters.

*Since Grandma has two recessive traits (2 lower case letters) she is said to be pure recessive for that trait.

11. What other traits is Grandma pure recessive?

12. What traits is Pa pure recessive?

*Because Pa has one dominant trait for antenna and one recessive trait for antenna, he is said to be heterozygous for that trait.

*A heterozygote will have one upper case letter and one lower case letter. It does not matter which letter comes first.

*A heterozygote will always appear to have the dominant trait. It is impossible to tell the difference between a pure dominant and a heterozygote by looking.

13. What other traits is Pa heterozygous?

14. What traits are Grandpa and Grandma heterozygous?

15. What traits is your baby Mars Mellow pure dominant?

16. What traits is your baby Mars Mellow pure recessive?

17. What traits is your baby Mars Mellow heterozygous?

Things to think about: How did your baby Mars Mellow get the mix of traits it has? What about Ma's chromosomes? Is Ma pure dominant, pure recessive or heterozygous?

Task 3: Punnett Square Ma

1. Draw the following Data table on the board. Have students copy it in their notes.

Data table 4

Pa Appearance	Chromosomes	Ma Appearance	Chromosomes
2 antennas	Aa	2 antennas	
different colored legs	Ll	different colored legs	
3 body parts	Bb	3 body parts	
curly tail	Tt	curly tail	
2 eyes	Ee	2 eyes	

2. Ask students if there is anyway we can figure out Ma's chromosomes. Students will probably say she has the same appearance as Pa so she would have the same chromosomes. Remind students that you cannot tell the difference between a pure dominant and a heterozygote by appearance.
3. Ask students if there is another way we can figure out if she is heterozygous or pure dominant. Suggest to students trying the chromosomes one way and see if it fits the results they received.
4. First figure out her possible offspring if she is pure dominant for the antenna trait. Tell students to do this we are going to use a tool called a Punnett Square.
5. Have students write down the following in their notes.

   How to make a Punnett Square
   1. Draw a large square
   2. Divide the large square into 4 small squares
   3. Write the letters representing the father's chromosomes across the top.
   4. Write the letters representing the mother's chromosomes down the side.
   5. Fill in the small squares with the possible gene pairs.

6. Draw a Punnett Square for the antenna trait with Ma being pure dominant. Tell students that a Punnett square shows all the possible offspring and can be use to calculate the probability of offspring having a specific trait. In this Punnett Square half will be pure dominant (AA), which means their appearance will be 2 antennas. The other half will be heterozygous (Aa), which means their appearance will also be 2 antennas.

7. Ask students if all Pa's and Ma's offspring had 2 antennas. If all of them did then it is likely Ma is pure dominant, however even if there is only one with one antenna then Ma has to carry the recessive trait. Some students will have a baby with only one antenna, but if they forget refer them to Data Table 2.
8. Summarize for the students, "Since some offspring have 1 antenna then Ma cannot be pure dominant. She cannot be pure recessive because she appears to have the dominant trait." Ask students, "So, what must Ma be?" They should answer heterozygous.
9. Have students do a Punnett square with Ma as a heterozygote. Once students have drawn it on their paper, you draw it on the board. Explain to students that this Punnett Square shows one square pure dominant, (AA) which has the appearance of 2 antennas. Two squares have heterozygous chromosomes, (Aa) which also has the appearance of 2 antennas. One square has pure recessive, (aa) which has the appearance of 1 antenna. As a total there are 3 squares that will have appearance of 2 antennas for 1 square of 1 antenna. That's a 3:1 ratio. Have students look at Data Table 2. Their reduced ratio for the antenna trait should be close to 3:1. This confirms that Ma is a heterozygote.
10. Assign the following to the students.
    Draw two Punnett Squares for each of the remaining traits listed in Data Table 4. One Punnett Square should show Ma as pure dominant for the trait and the other Punnett Square should show Ma as a heterozygote for that trait. Compare your Punnett Squares to Data Table 2 to determine Ma's chromosome pairs.
11. From their assignment students have found that Ma is heterozygous for all the traits listed in Data Table 4. They should also notice the ratios for all traits in Data Table 4 are 3:1.

Task 4 : Another Generation

Note: The purpose of this task is to give students more practice with Punnett squares, ratios and percents. It also serves as a review of how dominant and recessive chromosomes interact. The only new material in this task is the inheritance of being male or female.

Note: Students will need the decoder key on the checklist from task 1.

1. Students will be working in groups of four. Each group should consist of a pair of students who made a male Mars Mellow and a pair of students who made a female Mars Mellow. You may put the groups together or let the students. You will probably not have equal numbers of male and female, so you may need to make extra males or females and have a pair of students adopt them.
2. Hand out Another Generation worksheet, chromosome sheet and scissors.
3. When students get to steps 6 and 7 monitor them carefully to make sure they randomly select chromosomes. If they are random then it is unlikely that their Punnett squares will exactly match their offspring in all traits.
4. Some students will have a hard time answering number 9. You may need to have a class discussion. Remind students that each time they made a new offspring they put all the chromosomes back in and randomly choose one from each pair. Each offspring has the same chance of getting a particular trait.

Another Generation

Data Table 5

Traits	Male appearance	chromosomes	Female appearance	chromosomes
Antennas				
Legs				
Body parts				
Tail				
Eyes				
Nose				
Sex				

1. Fill in the appearance and chromosomes of your group's Mars Mellows in Data Table 5.
2. Make a Punnett square for the antenna trait. Write the ratio of 2 antennas to 1 antenna. What is the percent probability their offspring will have 2 antennas?

3. Do the same thing with the traits for legs, body parts, tail and eyes.

4. Make a Punnett square for the sex trait. What is the percent chance the offspring will be female?

5. Explain why the offspring will always have that same chance no matter which Mars Mellows are used.

6. On your chromosome sheet write the letters of your Mars Mellows and cut them out. Line up the chromosomes face down. Randomly take one chromosomes from each pair of the male and the female. Record your results in Data Table 5 under offspring 1.
7. Separate the male and female chromosomes. Mix them up and line up the pairs again. Randomly take one from each chromosome pair. Write the results in Data Table 5 under offspring 2.
8. Repeat step 7 for offspring 3 and 4.

Data Table 5

	Trait	offspring 1	offspring 2	offspring 3	offspring 4
1	antenna				
2	legs				
3	body parts				
4	tail				
5	eyes				
6	nose				
7	sex				

9. Compare Data Table 5 to the Punnett squares you made. Do the Punnett squares exactly match your 4 offspring in all traits? Why not?

Open Response: Mr. Potter's Class

In Mr. Potter's math class there are 21 students with unattached earlobes and 7 with attached; 24 with dimples and 4 without; 5 left handed and 23 right handed; 19 with a widow's peak and 9 without; 16 are girls and 12 are boys. Make a data table showing the frequency of each trait, the trait's ratio, fractional value and percent of the class.

Scoring Guide for challenge open response

Distinguished	Includes the following: Jeff and Ashley are carriers (heterozygous), CF is a recessive trait, There is a 25% chance that any of their children will have CF, 50% chance they will be carriers and 25% chance they will not have the trait.
Proficient	Includes the following: Jeff and Ashley are carriers and there is 25% chance that any of their children will have CF.
Apprentice	Includes that Jeff and Ashley are carriers or that their children will have a 25% chance of having CF.
Novice	Answer does not show both Jeff and Ashley as carriers or does not have the correct percent chance.

Scoring Guide for open response: Mr. Potter's class

Distinguished	Set up ratios, fractions, and percents correctly and reduced to lowest terms correctly.
Proficient	Set up ratios, fractions and percents correctly, but did not reduce or made errors reducing.
Apprentice	Set up at least one correctly (ratios, fractions, or percents). May or may not reduce
Novice	Did not set up any correctly