Chromobug Genetics

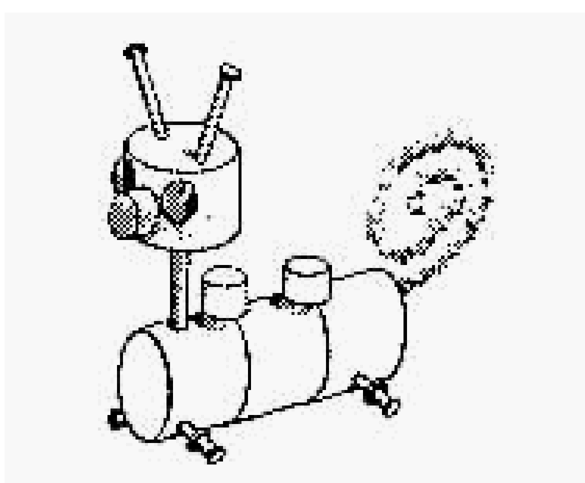
Chromobug Genetics is a series of activities to help you understand the ideas of genetics and heredity.

You will work in groups of four. Each group will get one manila envelope containing:

- 2 Chromobug Instruction Packets
- Mother "Cell"
- Father "Cell"
- Chromobug Genetic Code
- Colored Chromobug "Gene Pool"

Each student will receive a copy of the Chromobug Chronicle to record data, answers, and other information during the course of this unit.

Other materials & supplies will be available as needed in the classroom.



General Background Information:

Mitosis is the reproduction of skin, heart, stomach, cheek, and hair, etc. cells. This is also a form of "**Asexual**" reproduction, where one organism or cell reproduces itself. Some organisms that reproduce asexually are hydra, bacteria, and single celled organisms.
Offspring that result from asexual reproduction are identical to the parent cells and to the other offspring.

Most types of plants and animals, including humans, need two parents, one male and one female, to reproduce. Each parent makes reproductive cells that are called **gametes**. The gametes in females are eggs; the gametes in males are sperm. Each of the gametes holds half of the parent's genetic material or chromosomes. A human body cell, like a muscle cell, has 23 pairs of chromosomes or a total of 46 chromosomes. A human gamete (egg or sperm) has only 23 total chromosomes because it has only one chromosome from each pair.

Meiosis is the production of sperm and egg cells. Each cell has to go through the cell division process twice in order for the cell to end up with half the number of chromosomes. The cells pass on genetic information to the offspring. This is a form of "**Sexual**" reproduction, where one organism or cells reproduces by crossing with another organism or cell. Types of organisms that reproduce sexually are; plants, animals, and insects.
Offspring that result from sexual reproduction can be very different from the parents and from the other offspring.

If a regular body cell were used for reproduction, we would have a lot of problems! A normal human has 46 chromosomes. If a father and mother each contribute a cell containing 46 chromosomes to their offspring, this child would have 92 chromosomes, and the next generation would have 184 chromosomes!
Meiosis solves this problem. Gametes are made from special cells during meiosis; it creates cells that have one-half the regular number of chromosomes.

Body Cells
asexual

Sex Cells (Gametes)
sexual

Chromosomes copy themselves so that there are two identical sets of chromosomes.
They line up in the middle of the cell, the cell splits apart, with one complete set of chromosomes going one way, and the other set going another way.

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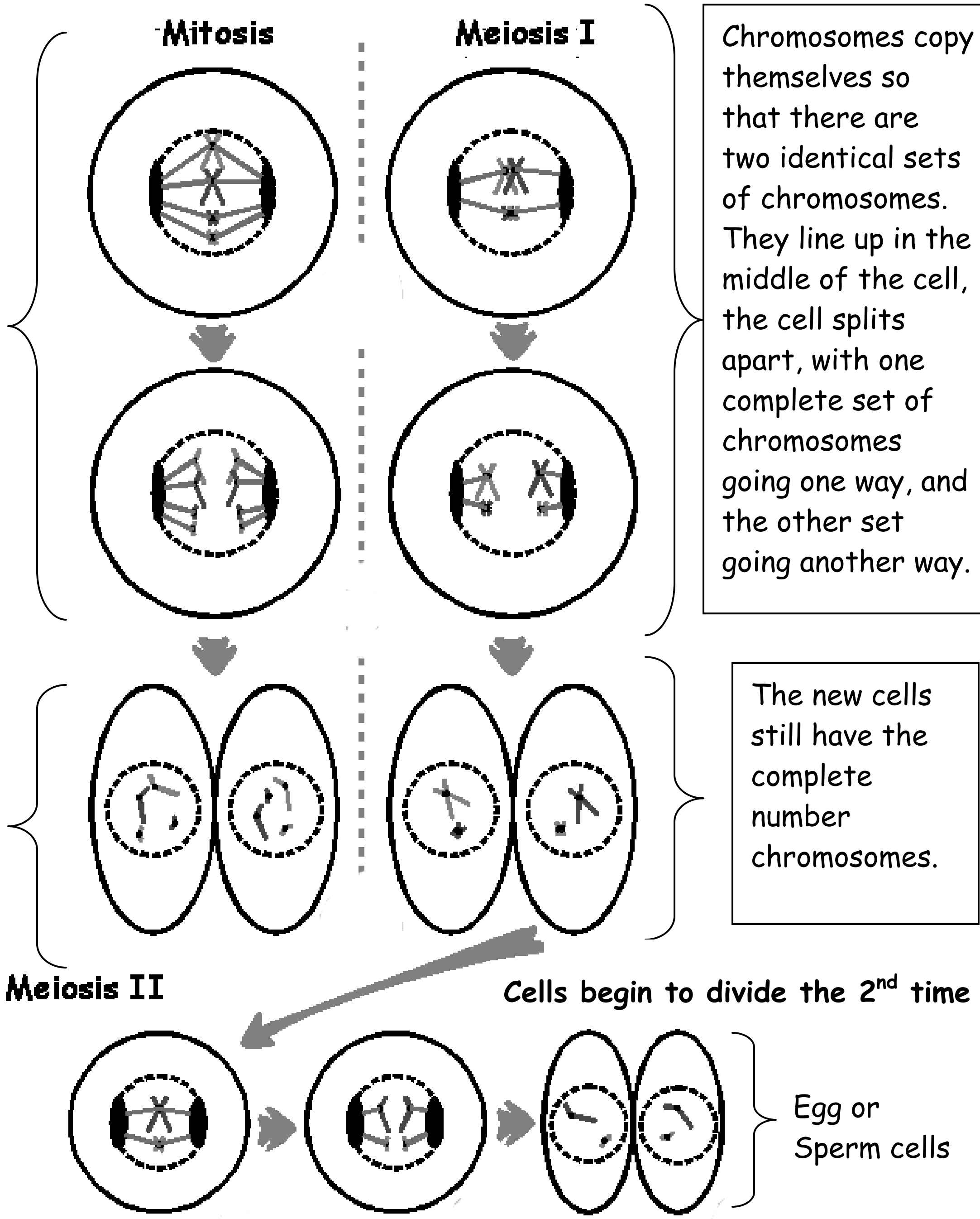


Two new cells, called "daughter cells" are made from the split of the parent cell.
Each cell has exactly the same genes as each other and the parent cell.
Cell division is complete.

The new cells still have the complete number chromosomes.

New cells are genetically different from parent cells; they have half the number of chromosomes. Only when these cells join during fertilization will they again have the complete number of chromosomes.

When a sperm joins with an egg, it is called **fertilization**. The fertilized egg has genetic information from the mother and the father. The fertilized egg is called a zygote, and it divides by mitosis to form two new cells, which divide into four cells. The cell division continues and the organisms develop.

Genes are the material that control which traits are expressed in an organism. There are two copies of each gene, one from the mother and one from the father. These genes can take different forms called **alleles**. For example, there is a gene for the height of a pea plant. The gene has two alleles, one for tall and one for short. Genes are located on **chromosomes** in the nucleus of a cell. Genes come in pairs and offspring inherit one copy of each gene from each parent. Which copy of the gene inherited by the offspring occurs by random chance?

A **dominant allele** is one whose trait always shows up, even when only one of the two alleles is in the dominant form. A dominant allele is shown by a capital letter. A **recessive allele** is one that is hidden when the other copy of the gene contains the dominant allele. A recessive allele shows up only when there is no dominant allele present.

When offspring inherit two dominant genes, (one dominant gene from each parent) they are said to be **homozygous dominant**.
When offspring inherit two recessive genes, (one recessive gene from each parent) they are said to be **homozygous recessive**.
When offspring inherit one dominant gene and one recessive gene, they are said to be **heterozygous dominant**.

Some traits do not follow the dominant-recessive pattern. When an organism has two different alleles for a gene that does not follow the pattern, it shows a trait that is a blend of the traits represented by the two alleles. For example, the gene for the color of some flowers has one allele for red and one for white. When both alleles are present, neither is dominant, and the flower color is pink. This is called **co - dominance**.

Changes in genes can result in changes in the traits of organisms. When changes help the organism survive and reproduce, it is called an **adaptation**. All of the genes of a species in a given population are called the **gene pool**. A **population** is all

of the individuals of one species in a particular environment or ecosystem. The kind of genes in a gene pool can change over several generations.
The probability of certain traits being shown can be figured by using **Punnett Squares**. A Punnett Square is a chart that shows all the possible combinations of alleles that can result when genes are crossed.

Probability is the chance that something will happen. The probability of an outcome for a particular event is a number telling us how likely a particular outcome is to occur. This number is the ratio of the number of ways the outcome may occur to the number of total possible outcomes for the event. Probability is usually expressed as a fraction or decimal.

Ratio is a way to compare two numbers. The numbers are usually separated by a colon (:). The ratio of three blue-legged Chromobugs to one red-legged Chromobug would be written 3:1. It can also be written as a fraction – 3/1. We say the ratio is 3 *to* 1.

A **proportion** is an equation with a ratio on each side. It is a statement that two ratios are equal.
3/4 = 6/8 is an example of a proportion.
When one of the four numbers in a proportion is unknown, cross products may be used to find the unknown number. This is called solving the proportion. Question marks or letters are frequently used in place of the unknown number.

A **percent** is a ratio of a number to 100. A percent can be expressed using the percent symbol %.
Example: 10 percent or 10% are both the same, and stand for the ratio 10:100.
A percent is equivalent to a fraction with denominator 100.
Example: 5% of something = 5/100 of that thing.

Chromobugs are make-believe organisms. You will use these to model how inherited traits are passed from parents to offspring.
Chromobugs are not exactly like living organisms because they only have one gene on each chromosome. Real living things can have thousands of genes on one single chromosome. However, both Chromobugs and real-life organisms both have dominant and recessive genes.

Part 1 –

Background Information:
Chromobugs have 14 chromosomes (7 pairs).
The genetic code for Chromobugs is:

Chromobugs can have one, two, or no antennae; red or blue legs, one or two eyes, and one, two, or three humps. Their tails may be straight or curly; their noses may be red, orange or yellow and they may have two or three body segments.			
Body Part	**Variations in Trait**	**Phenotype**	**Genotype**
Antennae	Number	Two One None	AA Aa aa
Legs	Color	Blue Red	LL or Ll ll
Eyes	Number	Two One	EE or Ee ee
Humps	Number	One Two Three	HH Hh hh
Tail	Shape	Curly Straight	TT or Tt tt
Nose	Color	Red Orange Yellow	NN Nn nn
Body Segments	Number	Three Two	SS or Ss ss

In chromobugs, the blue leg color is dominant. This means that a chromobug with a genotype of LL will have blue legs. It also means that a chromobug with a genotype of Ll will have blue legs too. Blue legs are the phenotype for chromobugs with these two genotypes. However, a chromobug with a genotype of ll will have a phenotype of red legs because it inherited the red leg gene from both parents.

Examine the nose color of chromobugs. Co - dominance is shown in this trait. Two N forms of each gene (NN) will result in a red nose phenotype. Two n forms of the gene will shoe a yellow nose phenotype. A genotype of Nn will show an orange nose phenotype.

Procedure:

1. Discuss the chromobug genetic code with your group. Why do the body traits vary? (Hint: Think about *meiosis*) ***Write your explanation in your Chromobug Chronicle:***

Part 2 –

Background Information: You cannot always tell what an organisms genotype is by looking at the phenotype.

Procedure:

1. Make a prediction about the genotypes of the mother and father chromobug. You cannot actually see the genotype, so you will have to base your predictions on the phenotype. Look carefully at both the mother & father. Is it possible for two parents who have the same phenotype (look the same) to have different genotypes**?** ***Explain your answer in your Chromobug Chronicle***.
2. Use the chromobug genetic code to fill in the phenotype and possible genotypes in the ***chart in the Chromobug Chronicle***.. You will complete the actual genotype columns later.

Body Part	Variation / Trait	Phenotype	Possible Genotypes for Parent Phenotypes	Actual Genotype	
				Mother	Father
Legs	Color	*Blue*	*LL, Ll*		
Antennae	Number				
Eyes	Number				
Humps	Number				
Tail	Shape				
Nose	Color				
Body Segments	Number				

Record in Chromobug Chronicle

3. Check your predictions. Get out your chromobug mother and father "cells". Examine the cells and find the set of genes. Do these parents each have a genotype that matches on of the possible genotypes that you listed in the chart? ***Answer in your Chromobug Chronicle***

4. ***Record the actual genotype for each chromobug parent in the chart in your Chromobug Chronicle*.**

Analysis:

1. What is the total number of genes for each chromobug? ***Answer in your Chromobug Chronicle***
2. How many traits does each chromobug have? ***Answer in your Chromobug Chronicle***
3. ***Explain why there are a different number of genes and traits in your Chromobug Chronicle*.**
4. ***Explain where these genes come from in your Chromobug Chronicle.***

Part 3 –

Background Information: Chromobugs reproduce sexually to create new offspring. This means that they need both a male and a female parent. Sexual reproduction requires a sperm cell from the father and an egg cell from the mother.

Materials:

Father "cell" Mother "cell" Blank Envelope

Procedure:

1. Divide your group into two new groups. One group will be the Mother. The other group will be the Father.

How many traits does a Chromobug have? ***Answer in your Chromobug Chronicle***

How many genes are in the mother cell? ***Answer in your Chromobug Chronicle***

How many genes are in the father cell? ***Answer in your Chromobug Chronicle***

Why do you think there a different number of genes and traits? ***Answer in your Chromobug Chronicle***

How many of the genes will be passed on by each parent to the baby Chromobug? ***Answer in your Chromobug Chronicle***

How many chromosomes will a baby Chromobug cell have? ***Answer in your Chromobug Chronicle***

2. As a group, discuss what must happen so that the baby Chromobug will have all of the genes it needs. ***Write the steps in your Chromobug Chronicle***.

Part 4 –

Materials: Chromobug Genes

Procedure:

Work with your group to answer these questions. You may use any other resources available.

1. Arrange your Mother ***or*** Father (not both) chromosome (genes) in pairs by trait, with the code letters facing down. For example, both leg genes will be placed side by side. The chromosome pairs for a trait will be the same length. Randomly choose one chromosome (gene) for each trait. You should have half the number of your Mother or Father chromosomes (genes). If you did this again, would you end up with the same number of genes? ***Explain your answer in your Chromobug Chronicle***. (If you are not sure, try it and find out!)
2. Pretend you repeated this 50 times. What would be the chance or probability of selecting the same two genes for each trait? Answer in your Chromobug Chronicle

   Meiosis is the name of the process that produces cells that have half the number of chromosomes of the parent.

   - What kind of cell contains only half the number of a father's genes? ***Answer in your Chromobug Chronicle .***
   - What kind of cell contains only half the number of a mother's genes? ***Answer in your Chromobug Chronicle.***

3. Combine the chromosomes (genes) of the mother with the chromosomes (genes) of the father. What is the name of the process when the parent's genes are combined? ***Answer in your Chromobug Chronicle***
   - What does this process produce? ***Answer in your Chromobug Chronicle***

4. Place the chromosomes that you did not use back in the "Mother" and "Father" cell envelopes.
   Place the chromosomes that you combined with your partner in the blank envelope. Label it with the word you used in question 2.

5. ***Describe what you know about how chromobug babies receive genes from their parents in your Chromobug Chronicle***.

Part 5 –

Background Information: In part 4 of this activity, you created to gametes – the egg cell and the sperm cell. Then you "fertilized" the egg cell by joining the genetic material from the father with the genetic material from the mother. This created a fertilized egg.
What do you need to know to find out what your baby will look like?

Answer in your Chromobug Chronicle

Materials:

Map Pencils	Large Marshmallows
Pipe Cleaners	Small Colored Marshmallows
Toothpicks	Gum Drops

Procedure:

1. Examine your baby's chromosomes and ***fill in its genotype in the table below in your Chromobug Chronicle***. Using the chromobug genetic code, fill in the baby's phenotype.

Your Chromobug Baby			
Body Part	**Variation / Trait**	**Genotype**	**Phenotype**
Legs	Color		
Antennae	Number		
Eyes	Number		
Humps	Number		
Tail	Shape		
Nose	Color		
Body Segments	Number		

Record in Chromobug Chronicle

2. Working with your partner, follow the phenotype to create a baby chromobug.

3. Compare your baby with the other babies. ***Explain why you think there is such diversity in your Chromobug Chronicle***.

4. ***Draw and color a picture of your baby Chromobug in your Chromobug Chronicle***.

Part 6 –

Materials: "Mother Cell" Father "Cell"

Procedure:

1. Look at your mother and father chromobugs' leg color genes. Can you predict the leg color of their babies? ***Explain your answer in your Chromobug Chronicle***.

2. Divide your group into two. One half of the group will be the "mother"; the other half of the group will be the "father". Look at the Mother and Father chromosomes in the cell envelopes.

3. What genes for leg color does the father have? ***Answer in your Chromobug Chronicle***.

4. What genes for leg color does the mother have? ***Answer in your Chromobug Chronicle***.

5. When an egg cell is made, what gene for leg color could the egg cell have? ***Answer in your Chromobug Chronicle***.

6. In the chart below, list all the possible combinations of genes, genotypes, and phenotypes for leg color that a baby could have.

Gene From Mother	Gene From Father	Genotype of Baby	Phenotype of Baby

Record in Chromobug Chronicle

7. Are there any babies that have exactly the same genes? If so, why are they on different lines in the chart? ***Answer in your Chromobug Chronicle***.

8. This chart can be used to figure out the probability of having red-legged or blue-legged babies. ***Describe how you would figure the probability as a ratio in your Chromobug Chronicle***.

9. ***Describe how you would figure the probability as a percent. Answer in your Chromobug Chronicle***.

Part 7 –

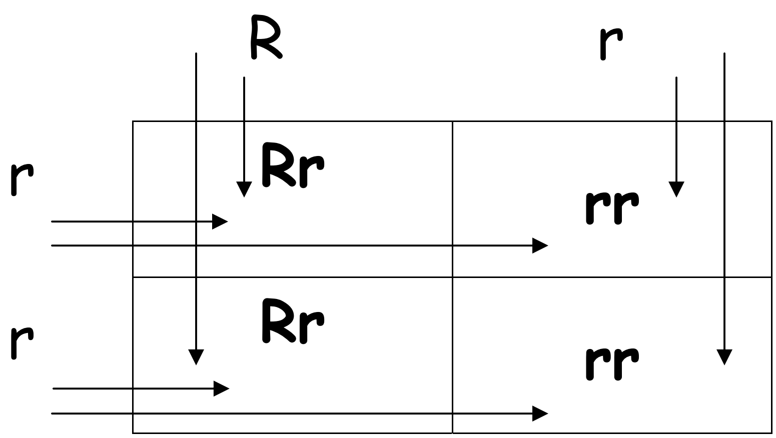
Background Information: One easy way to show all of the genotypes is to use a Punnett Square. A Punnett Square is a mathematical tool used to predict the probability of certain traits in offspring by showing the possible combinations of alleles. In a Punnett Square, letters stand for dominant and recessive alleles. An uppercase letter stands for a dominant allele and lowercase letters stand for recessive alleles.

To set up a Punnett square, draw a large square, and then divide it into 4 equal sections (also squares). It should look something like this:

Now you need two parents to mate, ones with a known genotype. For example, a red flower (genotype Rr) and a white flower (genotype rr). **Rr x rr**
Place one of the parents on top, and one on the left. You should get a something similar to this:

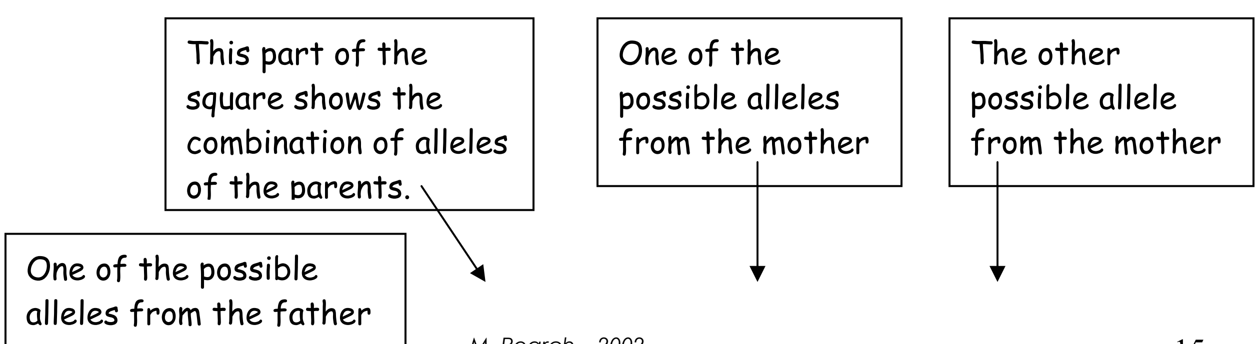
	R	r
r		
r		

Finally, take each letter in each column and combine it with each letter from each row in the corresponding square. You should now have a picture close to this:



The two-letter combinations are the possible genotypes of offspring. They are: Rr, Rr, rr, and rr genotypes. From this it is possible to determine the probability (chance) that a flower will have a red phenotype (2/4 or 50%) or a white phenotype (2/4 or 50%).

A chromobug example for leg color would look like this:
Ll x Ll → A parent with the genotype Ll crossing with a parent with the genotype Ll



Ll x Ll	L	l
L	LL (blue)	Ll (blue)
l	Ll (blue)	Ll (red)

The other possible allele from the father

Possible genotypes & phenotypes of offspring

From this Punnett Square, you can see that the chromobugs could have red-legged or blue-legged babies. There is a 1 out 4 or 25% chance that a baby will have red legs. There is a 3 out of 4 or 75% chance that the offspring will have blue legs.

Use the Punnett Square to figure out the probability of these parents having off spring with curly tails. ***Show the genotype and phenotype as a <u>ratio</u> in your Chromobug Chronicle*. *Include a list of Homozygous Dominant, Heterozygous Dominant, and Homozygous Recessive genotypes.***

TT X Tt		

Record in Chromobug Chronicle

What is the probability of these parents having offspring with two or three body segments? . ***Show the genotype and phenotype as a <u>proportion</u> in your Chromobug Chronicle*. *Include a list of Homozygous Dominant, Heterozygous Dominant, and Homozygous Recessive genotypes.***

Ss x ss		

Record in Chromobug Chronicle

One or two eyes? . ***Show the genotype and phenotype as <u>percents</u> in your Chromobug Chronicle. Include a list of Homozygous Dominant, Heterozygous Dominant, and Homozygous Recessive genotypes.***

Ee x Ee		

Record in Chromobug Chronicle

One, two, or three humps? . ***Show the genotype and phenotype as a <u>ratio</u> in your Chromobug Chronicle. Include a list of Homozygous Dominant, Heterozygous Dominant, and Homozygous Recessive genotypes.***

HH x hh		

Record in Chromobug Chronicle

Red, orange, or yellow nose? . ***Show the genotype and phenotype as a <u>proportion</u> in your Chromobug Chronicle. Include a list of Homozygous Dominant, Heterozygous Dominant, and Homozygous Recessive genotypes.***

NN x Nn		

Record in Chromobug Chronicle

What are all the possible genotypes and phenotypes for the offspring of a father who is Aa and Ll and a mother who is AA and ll? ***Show how you found the answer in your Chromobug Chronicle.***

Think!

Part 8 –

Background Information: An **adaptation** is a change that makes an organism better suited to its environment and more likely to survive and reproduce. Adaptations usually occur due to a change in a gene or genes.

Examples of adaptations:

ENVIRONMENT	ADAPTATION (and advantage)
Dry	plant - needles/spines instead of leaves (reduces water loss)
Dry	plant - shallow, widespread roots (takes advantage of limited rainfall)
Dry	plant - waxy layer on outer surface of leaf (reduces water loss)
Hot	animal - large ears, e.g. jackrabbit (more surface area to give off more heat from body)
Cold	plant - lie close to the ground (reduces water loss due to wind; snow cover may provide some insulation)
Cold	animal - thick fur (reduces heat loss)
Water	animal - gills (to remove and use oxygen from the water)
Water	animal - fins (to move through the water)

Materials: Map Pencils Drawing Paper

Procedure:

1. Use white drawing paper and map pencils to illustrate the environment that your baby chromobug would be best suited for. Include plants, animals, food sources, habitats, predators, and climate.

2. ***Use the space provided in your Chromobug Chronicle to write an explanation of why the chromobug's adaptations give it an advantage in the environment you have designed for it.***

Part 9 –

Background Information: Species of organisms can sometimes adapt to changing environments. When there is a dramatic change in the environment, the organisms that are best suited for the changes are the ones that will be able to survive and reproduce.

Materials: Map Pencils Drawing Paper

Procedure:

1. As a group, pick ***ONE*** of the following natural environmental disasters:
    a. Wildfire
    b. Massive flooding

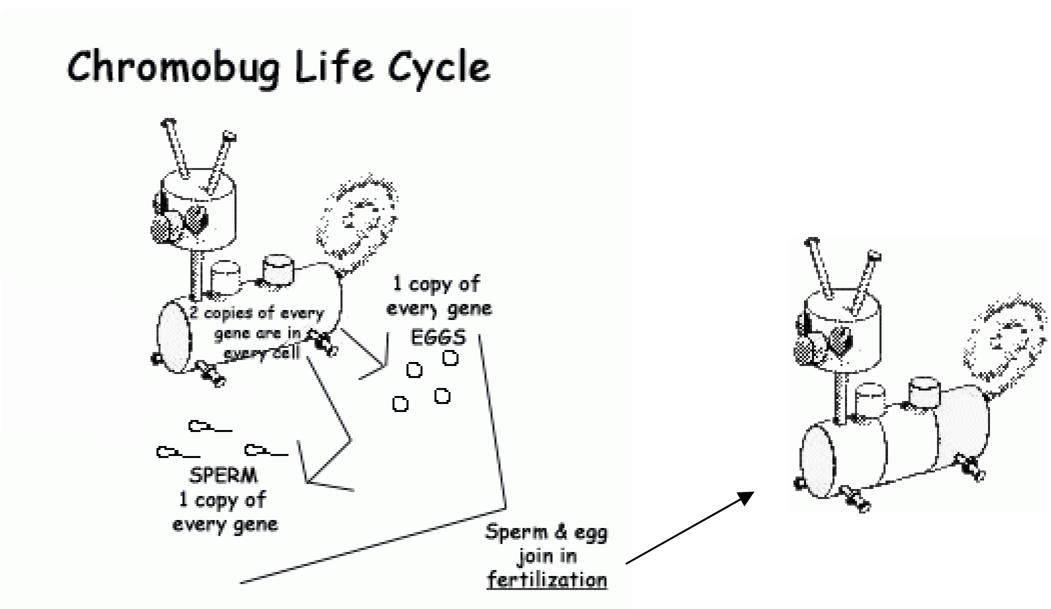
2. Discuss what would happen to the Chromobug's environment if the natural environmental disaster were to happen. ***Record your discussion in your Chromobug Chronicle.***

3. Discuss the kinds of traits that would be needed to survive in the new environment. ***List these traits and explain why they would be useful in your Chromobug Chronicle***.

4. Draw a picture of the new environment and show the type of organisms that would be able to live in it. Use white drawing paper.

Part 10 –

Background Information: The frequency of genes in a population of any species can change. When the environment changes, the types of genes that are most common can change as well.
A Chromobug life cycle looks something like this:



Some chromobugs have developed skin color over many years, the genes for skin color are:

- Green (G) skin is dominant to all other colors
- Red (R) skin is recessive to green
- Red (R) skin is co-dominant to yellow
- Yellow (Y) skin is recessive to green
- Yellow (Y) skin is co-dominant to red
- A combination of red and yellow genes causes orange skin

Materials: Colored Chromobug Chromosomes "gene pool"

Procedure:

1. Fill in the chart to show which combinations of alleles cause which colors of skin in chromobugs.

Chromobug Color	Gene Combinations
Green	Record in Chromobug Chronicle
Red	
Yellow	
Orange	

2. Can two red chromobugs mate and have green offspring? ***Explain your answer in your Chromobug Chronicle***.

3. Can two orange chromobugs mate and have red offspring? ***Explain your answer in your Chromobug Chronicle***.

4. Can two green chromobugs mate and have orange offspring? ***Explain your answer in your Chromobug Chronicle***.

5. As a group, create the first generation of chromobugs. To do this, randomly pull out two "genes" from the colored chromosomes cell. Set them aside so that they stay in a pair. This simulates the random way an egg and a sperm combine. ***Record the gene combination and color in the 1st generation column in Table 1 in your Chromobug Chronicle***. Repeat for a total of 12 times.

Table 1	1st Generation		2nd Generation		3rd Generation		4th Generation	
Offspring	Gene Pair	Color	Gene Pair	Color	Gene Pair	Color	Gene Pair	Color
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Record in Chromobug Chronicle

6. The environment where the colored chromobugs live is very green and lush. Many different types of plants live there. Many of the plants have flowers. Green chromobugs can escape predators very easily because they are camouflaged by the plants. Red and orange chromobugs are also camouflaged pretty well by the flowers. However, the yellow chromobugs stand out like a sore thumb. Predators can pick them out of the green environment very easily. If you have any yellow chromobugs (both genes were yellow), set them aside. These genes have been taken out of the gene pool because the parent chromobugs were eaten and could not survive to reproduce.

7. Count how many chromobugs you have of each color and ***record this number in Table 2 in your Chromobug Chronicle in the 1st generation row***.

Table 2 - Colored Chromobug Offspring by Generation

Environment	Generation	Green	Red	Orange	Yellow
Many green plants and ground cover. Many different types of green plants everywhere.	1st				
	2nd				
	3rd				
T o x i c S p i l l F r o m F a c t o r y					
Toxic spill from nearby factory destroys most green plant life. Rock & sand left behind.	4th				
	4th Survivors				

Record in Chromobug Chronicle

8. Put all of the genes (except any yellows that were taken out of the gene pool) back into the gene pool envelope. Randomly draw a second generation

of chromobugs. ***Record the gene combination and color in the 2nd generation column in Table 1 in your Chromobug Chronicle***.

9. Set aside any yellow chromobugs, add up the number of each color and ***record this number in Table 2 in your Chromobug Chronicle in the 2nd generation row***.

10. The chromobugs that are well camouflaged are surviving longer and reproducing more, so their numbers are growing. Select gene pairs from the gene pool for a third generation of chromobugs. ***Record the gene combination and color in the 3rd generation column in Table 1 in your Chromobug Chronicle***.

11. Set aside any yellow chromobugs, add up the number of each color and ***record this number in Table 2 in your Chromobug Chronicle in 3rd generation row***.

12. Discuss these questions with your group, then ***answer in your Chromobug Chronicle***.
    - Have all the yellow genes disappeared?
    - Has the population size changed? How? Would you expect this to occur in nature? Explain your answer.
    - How does the population of the third generation compare to the earlier generations?

13. Select gene pairs from the gene pool for a fourth generation of chromobugs. ***Record the gene combination and color in the 4th generation column in Table 1 in your Chromobug Chronicle***.

14. <u>Do not remove any yellow chromobugs</u>! A man-made environmental disaster happens!!! Toxic waste from a nearby factory is spilled into the environment. Much of the green plant life is killed. The rocks and sand that are left are good camouflage for the red, orange and yellow chromobugs. Now the <u>green</u> chromobugs are easy targets for predators. Because the green chromobugs cannot survive, set them aside. ***Record the surviving***

offspring (all but the green) in the last row of Table 2 in your Chromobug Chronicle. These are the 4th generation survivors.

15. Collect the data from your classmates to get the total class count of the Chromobug genes and colors.

4th Generation Survivors	Green	Red	Orange	Yellow
	Record in Chromobug Chronicle			

16. Discuss these questions with your group, and then ***answer in your Chromobug Chronicle***.
    - Has the population changed compared to earlier generations? Explain your answer.
    - Have any genes disappeared entirely?
    - Yellow genes are recessive to green; green genes are dominant to both red and yellow. Which color of genes disappeared faster when the environment was hostile to them? Explain your answer.

Think!

17. If the chromobugs from a particular environment become genetically adapted to this environment over many generations, what could happen if their fertilized eggs are used to "restock" a different environment? ***Answer in your Chromobug Chronicle***.

18. Real populations change much more slowly than our Chromobug population. Why? ***Answer in your Chromobug Chronicle***.