Beebops
Genetics and Evolution
Teacher Information

science take-out
just add students™

Summary

In Part 1 students model meiosis and fertilization using chromosomes/genes from fictitious *Beebop* parents. They "decode" the genes in the zygote to produce a baby *Beebop.* They compare the baby they made with others in the *Beebop Family Album* to observe the variation that results from sexual reproduction. In Part 2 students model the effect of natural selection on the frequency of traits and genes in the *Beebop* population.

Core Concepts

Part 1: Genetics of *Beebops*

- The process of meiosis results in the production of eggs and sperm which each contain half of the genetic information.
- During fertilization, gametes unite to form a zygote, which contains the complete genetic information for the offspring.
- An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait.
- Sorting and recombining of genes during meiosis and fertilization results in a great variety of gene combinations and in new heritable characteristics.
- Alleles are alternate forms of a gene.

Part 2: Evolution of *Beebops*

- The proportion of individuals in a population that have advantageous characteristics will increase over time.
- Species evolve over time. Evolution is the consequence of the interactions of:
  - The potential for species to increase its numbers
  - The genetic variability of offspring due to mutation and recombination of genes.
  - A finite supply of resources required for life.
  - The selection by the environment of those offspring better able to survive and leave offspring.
- Natural selection causes the frequency of advantageous alleles in a population to increase and the frequency of disadvantageous genes in the population to decrease.
- Behaviors have evolved through natural selection. The broad patterns of behavior exhibited by organisms are those that have resulted in greater reproductive success.

Time Required

The amount of time required will depend on the student's amount of prior knowledge of meiosis and genetics.

- Part 1: Two or three class periods + homework
- Part 2: One or two class periods + homework

Kit contains

- 1 white foam *Beebop* body
- 1 sticky glue dot
- 1 pom pom
- 2 green pipe cleaners (4 inches long)
- 2 blue pipe cleaners (4 inches long)
- 2 yellow pipe cleaners (4 inches long)
- 1 frilled toothpick
- 2 black eye stickers
- 2 colored eye stickers
- 1 black round push pin (*Beebop* nose)
- 1 white round push pin (*Beebop* nose)
- 1 clear push pin
- 4 beads
- 6 arrow picks (*Beebop* legs)
- 1 paper umbrella
- 2 squares of colored tissue paper
- 2 squares of white tissue paper
- Parent *Beebop* diagram (color print)
- *Beebop* family album (color print)
- *Beebop* decoding chart
- Male (blue) and female (pink) *Beebop* chromosome sheets

Teacher Provides

- Tape
- Scissors
- Colored pencils, markers, or crayons

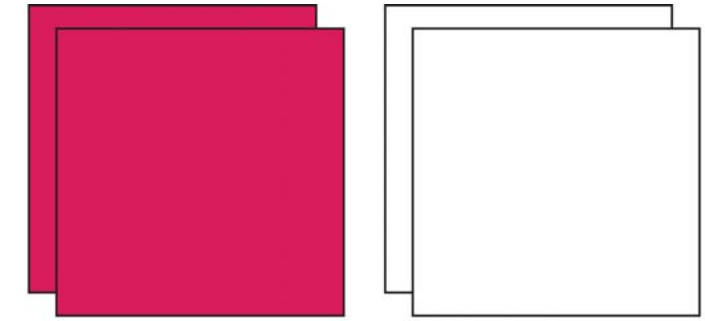
Note

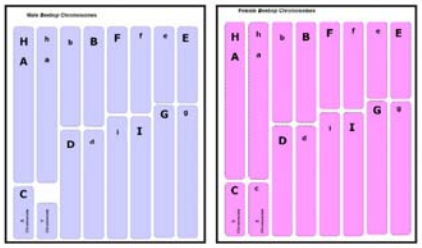
If students are working as part of a class encourage them to use both the class population of *Beebops* and the *Beebop* Family Album when they select the surviving *Beebops* in Part 2.

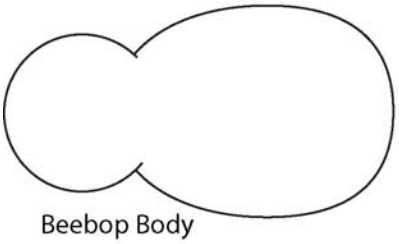
This activity is modified from: Soderberg, P. (1992) Marshmallow Meiosis. The Science Teacher, *59(8):28-31.*

Warning: Choking Hazard This Science Take-Out kit contains small parts and sharp objects. Do not allow children under the age of seven to have access to any kit components.

Kit Contents Quick Guide


Tissue Paper Squares


Beebop Chromosomes

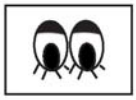

Beebop Body


Pom Pom

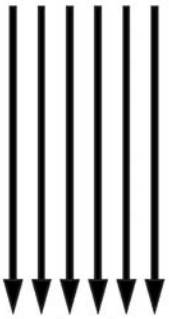

Glue Dot


Toothpick

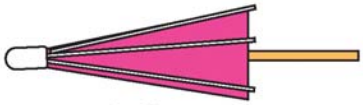

Push Pins


Eye Stickers


Beads

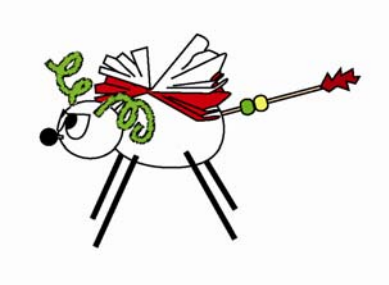

Beebop legs


Chenille stems


Umbrella

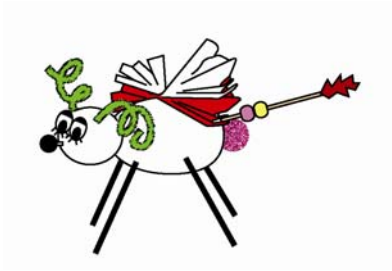
Beebops Genetics and Evolution:

Part 1: Breeding *Beebops*



Introduction:

A male and a female *Beebop* have just arrived on an island where no other *Beebops* are found. *Beebops* are carnivores that consume tiny insects present on the island. They use their eyes and antennae to locate insect prey. The parent *Beebop* diagrams in your lab kit show what the two *Beebops* on the island look like.



Your Tasks:

Because the *Beebops* could be useful in reducing the insect problem on the island, you would like to be sure that that the *Beebop* population on the island continues. To do this you will need to:

- Breed the *Beebop* adults using the pink and blue chromosomes in your kit.
- Observe the effect of meiosis and fertilization on variation in the *Beebop* population.
- Decode the information (genes) on the chromosomes to determine the traits of a baby *Beebop*.

Procedure:

A. The *Beebop* Parents

1. Observe the colored diagrams of the two parent *Beebops* in your lab kit. In Table 1 below, write a description of the **phenotypes** (appearance) for each trait by filling in the **Phenotype** column for the male parent and the **Phenotype** column for the female parent. Note that the first row boxes have been completed as an example. (DO NOT fill in the Genotype columns yet – you will do that later).

Table 1: *Beebop* Parents

		Male Parent		Female Parent	
Trait	**Possible Alleles**	**Phenotype**	**Genotype**	**Phenotype**	**Genotype**
Number of antennae	A or a	2 antennae	Aa	2 antennae	Aa
Color of antennae	B or b				
Shape of antennae	C or c				
Color of eyes Color of mouth	D or d				
Number of tail beads	E or e F or f				
Color of wings	G or g				
Number of legs	H or h				
Umbrella carrying	I or i				

B. *Beebop* Parents' Chromosomes and Genes

2. Obtain the pink and blue sheets of *Beebop* chromosomes from your kit. Cut out the sixteen chromosomes from the female *Beebop* (pink) and the sixteen chromosomes from the male *Beebop* (blue). Keep the pink and blue chromosomes separate.

3. Sort the blue male *Beebop* chromosomes to form pairs and then arrange the chromosome pairs by size from largest to smallest. Then, do the same thing with the pink female *Beebop* chromosomes.

   Note: For the male *Beebop* you will find two chromosomes that don't match in size. These two chromosomes form a "mismatched" pair of sex chromosomes – a larger X chromosome and smaller Y chromosome. In the female *Beebop*, there should be a "matched" pair of sex chromosomes – these are the two X chromosomes.

A gene carries genetic information that codes for a specific trait. Each gene is located at a specific position on a specific chromosome. Notice that at each gene location, the parent *Beebops* have two different forms of the gene, represented by an upper case (A) and a lower case (a) letter. These different forms of a gene are called **alleles**.

For example, each *Beebop* parent has: one "A" allele and one "a" allele for the gene that determines the number of antennae. The "A" allele carries information for two antennae. The "a" allele carries information for one antenna.

4. The letters on the chromosomes represent the gene alleles that determine the parent *Beebops'* traits. Go back to Table 1 and record the **genotypes** of the *Beebop* parents for each of the traits – these are the gene alleles found on the male and female parent chromosomes. Fill in the boxes of the male parent **Genotype** column and the female parent **Genotype** column. Note that the first row boxes have been completed as an example.

   Notice that the parents are **heterozygous** for each of the gene pairs – they have two different alleles for each gene.

C. *Beebop* Chromosomes in Gametes

5. Turn the pairs of *Beebop* parent chromosomes over so that you cannot see the letters representing the gene alleles on the chromosomes.

6. During **meiosis** to produce **gametes** (egg or sperm), the chromosome pairs are sorted so that each gamete receives one chromosome from each pair.

   - Model the sorting of chromosomes that occurs during meiosis in the male *Beebop.* Without looking at the letters on the chromosomes, select one chromosome from each blue pair. These are the chromosomes that end up in a sperm cell. Put the blue chromosomes that you did not select back into the lab kit.
   - Model the sorting of chromosomes that occurs during meiosis in the female *Beebop.* Without looking at the letters on the chromosomes, select one chromosome from each pink pair. These are the chromosomes that end up in a sperm cell. Put the pink chromosomes that you did not select back into the lab kit

7. Now turn the pink chromosomes of the *Beebop* egg cell and blue chromosomes of the *Beebop* sperm cell over so that you can see the letters representing alleles. Record the genotypes (the alleles present) for the sperm cell and the egg cell on Table 2, below.

Table 2: Gametes Produced by Parent *Beebops*

Trait	Possible alleles	Genotype of Sperm Cell	Genotype of Egg Cell
Number of antennae	A or a		
Color of antennae	B or b		
Shape of antennae	C or c		
Color of eyes and Color of mouth	D or d		
Number of tail beads	E or e F or f		
Color of wings	G or g		
Number of legs	H or h		
Umbrella carrying	I or i		

8. Compare the number of <u>chromosomes</u> present in a *Beebop* parent cell with the number of chromosomes present in a *Beebop* gamete (a sperm cell or egg cell).

9. Compare the number of <u>genes</u> present in a *Beebop* parent cell with the number of genes present in a *Beebop* gamete (sperm or egg).

10. If you repeated the sorting (separation) of chromosomes during meiosis to make additional egg cells and sperm cells, do you think the genotypes of these gametes would be identical to the ones that you produced? Explain your answer.

D. Chromosomes in the *Beebop* Zygote and Baby

11. During fertilization the pairs of chromosomes and gene alleles are recombined when the sperm combines with the egg. Model the process of fertilization by combining the chromosomes in the *Beebop* egg cell with the chromosomes in the *Beebop* sperm cell to form a **zygote** (the cell that will grow into a baby *Beebop*).

12. Tape or glue the chromosomes from the zygote that you made to ***Diagram 1: Chromosomes and Gene Alleles in the Beebop Zygote*** (found on page 8).

13. Look at the chromosomes that you have taped to *Diagram 1: Chromosomes and Gene Alleles in the Beebop Zygote*. Record the **genotype** (genes present for each trait) for the *Beebop* zygote by filling in the boxes in the **Genotype** column on Table 3, below. (DO NOT fill out the boxes in the phenotype column yet – you will do that later).

Table 3: *Beebop* Zygote and Baby

Trait	Possible alleles	Genotype	Phenotype
Number of antennae	A or a		
Color of antennae	B or b		
Shape of antennae	C or c		
Color of eyes and Color of mouth	D or d		
Number of tail beads	E or e F or f		
Color of wings	G or g		
Number of legs	H or h		
Umbrella carrying	I or i		

14. Compare the numbers of chromosomes present in a *Beebop* egg or sperm cell with the number of chromosomes present in a *Beebop* zygote.

15. Compare the number of genes present in a *Beebop* zygote with the number of genes present in a parent *Beebop's* cells.

16. If there are two different alleles for a gene pair, it is called **heterozygous**. For example, "*Aa*" is a heterozygous gene pair. For how many gene pairs is your *Beebop* zygote heterozygous?

    If there are two of the same alleles in a gene pair, it is called **homozygous.** For example, "*aa*" is a homozygous gene pair. For how many genes pairs is your *Beebop* zygote homozygous?

E. The *Beebop* Baby's Traits

17. The one-celled zygote divides by mitosis and grows into a multi-cellular baby *Beebop*. As it does, the inherited information on the baby's genes is used to determine the baby's traits. Use the ***Beebop Gene Allele Decoding Chart*** in your kit to decode the gene alleles in the zygote and determine the traits (phenotype) of your baby *Beebop*.

    Determine the trait associated with each pair of alleles. Record the **phenotypes** of each of these traits by filling in the boxes in the last column of Table 3 (on the previous page).

18. Construct a baby *Beebop* with the appropriate traits using the materials in your lab kit. Place any unused pieces back in your lab kit.

19. Make a colored diagram of your baby *Beebop* in **Diagram 2: *Beebop* Baby** (found on page 10). You may draw a side view or a top view of your baby *Beebop*.

Congratulations on your new baby *Beebop*! Save your *Beebop* baby to use in the next activity.

F. Analyzing the Results of the *Beebop* Breeding

20. Observe the ***Beebop* Family Album** that shows 9 other offspring produced by the parent *Beebops*. Each of these offspring was produced by the same parents that you used to create your baby *Beebop.* Explain how it is possible for these parents to produce babies that are different from their parents and each other.

One textbook author explains the heritable variation present in a population by stating, "The sorting of chromosomes during meiosis (gamete formation) and the recombining of chromosomes during fertilization results in a great variety of gene allele combinations and in new heritable characteristics."

21. List 5 examples of the ways in which *Beebop* babies could illustrate variation in heritable characteristics.

22. What part of the activity that you did represented the sorting of chromosomes that occurs during meiosis?

23. What part of the activity that you did represented recombining of chromosomes that occurs during fertilization?

24. Which do you think would be better for the members of the *Beebop* population on the island – being like one another or being different from one another? Explain your answer.

Diagram 1: Chromosomes and Gene Alleles in the *Beebop* Zygote

Beebop **baby's Name** _____

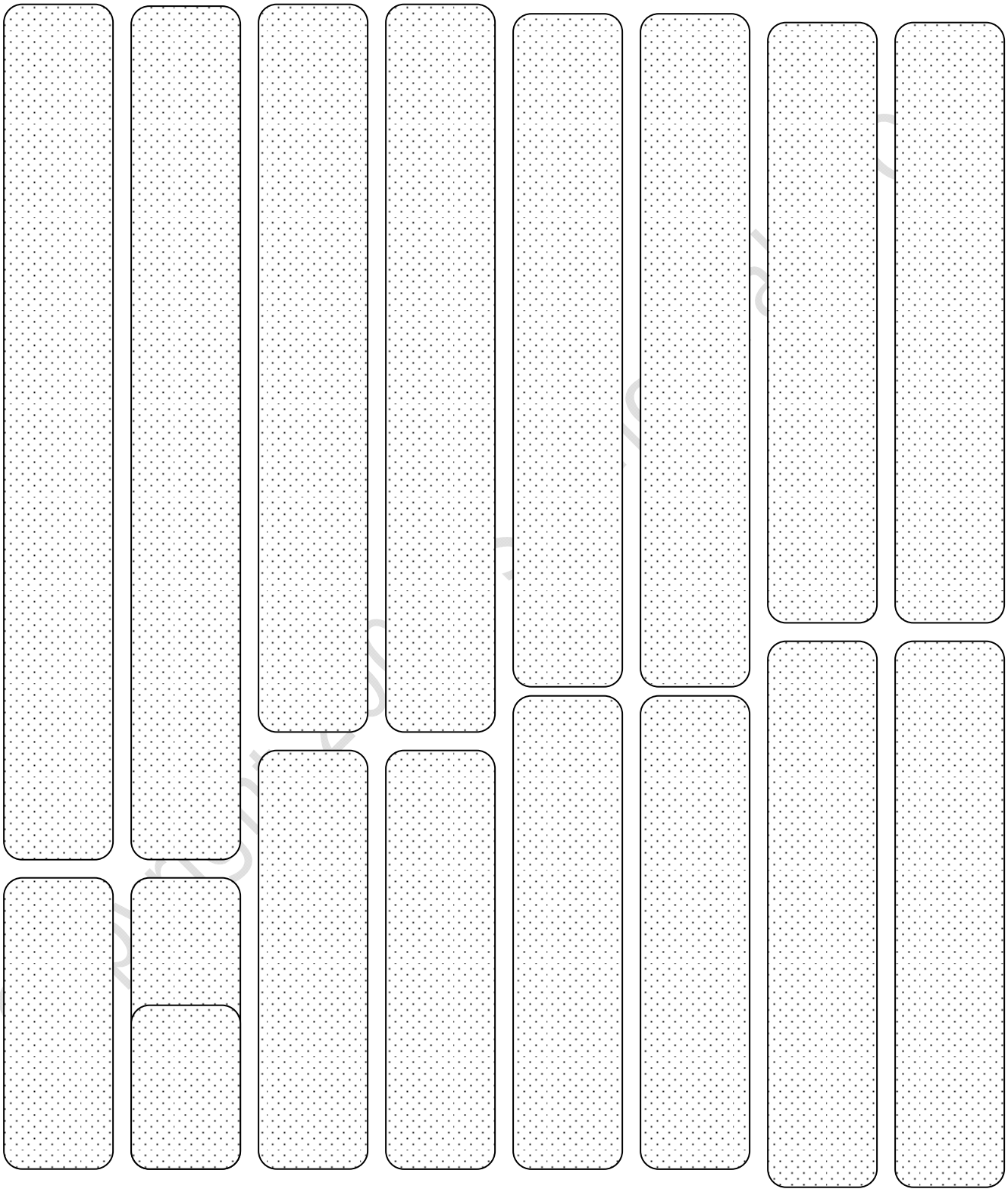
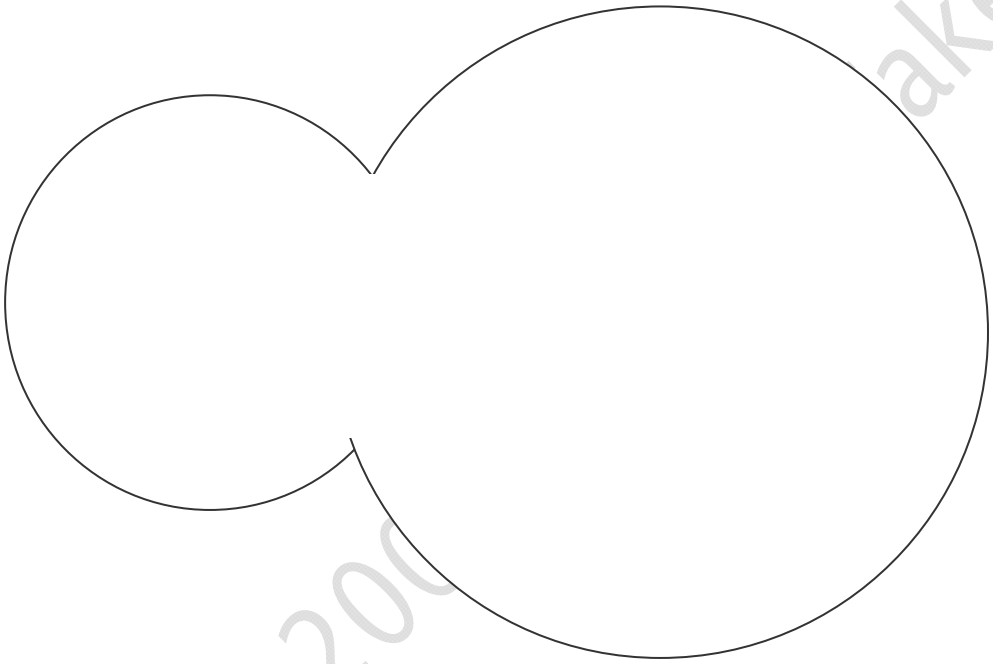


Diagram 2: *Beebop* Baby

Beebop **baby's Name** _____



Part 2: Evolution and *Beebop Populations*

Introduction:

After one breeding season, the reproduction by the original pair of adults has increased the *Beebop* population on the island to 10 baby *Beebops* – the one you made and the 9 *Beebops* shown in the ***Beebop*** **Family Album**. Adult *Beebops* have a short lifespan and die soon after they reproduce.

The food supply on the island can only support a population of four *Beebops*. The baby *Beebops* are carnivores that consume tiny insects present on the island. They use their eyes to locate insect prey. The larger *Beebop* population has caused an increase in the competition for the limited supply of tiny insects on the island.

Some characteristics give individual *Beebops* an advantage over others in surviving and reproducing. Research on *Beebop* behavior has provided the following information:

- *Beebops* with 2 antenna have better hearing than *Beebops* with 1 antenna
- Female *Beebops* with larger numbers of beads on their tails attract more mates than those with fewer beads.
- Umbrella carrying behavior enables *Beebops* to hide from predators.

Your Tasks:

- Observe the effects of selective forces on the characteristics and genes in the *Beebop* population.
- Predict the effect of natural selection on the genes in the *Beebop* population.

1. Do you think that the *Beebop* population might undergo evolution in its new island environment? If so, how would you tell if the *Beebop* population had evolved?

2. Observe the *Beebop* that you made and the 9 baby *Beebops* shown in the *Beebop* Family Album. Decide which four *Beebops* are most likely to survive and reproduce. Write the names of these four babies and explain why their traits make them better adapted for survival and reproduction on the island. You can only select four baby *Beebops!*

   - _____
     _____
   - _____
     _____
   - _____
     _____
   - _____
     _____

According to Darwin's Theory of Natural Selection, the proportion of individuals in a population that have advantageous characteristics (for survival and reproduction) will increase.

3. Observe the characteristics of the four baby *Beebops* that you selected to survive and reproduce. List three examples of advantageous characteristics.

4. Do your observations support or refute the statement in the box above? Provide evidence from your observations.

The term **allele frequency** refers to how often a specific gene allele occurs in a population. Evolution occurs when allele frequencies change in a population. According to the modern theory of natural selection, the frequency of gene alleles associated with advantageous (helpful) traits will increase in a population. Environmental conditions such as predation, food availability, climate, and disease are all examples of selective forces that can change allele frequencies.

5. The allele frequencies for each of the gene alleles from the *Beebop* parents are 50%. For example:
    - There are two gene alleles that code for the number of antennae – the **A** allele (2 antennae) and the **a** allele (1 antenna).
    - Each *Beebop* parent has one **A** allele and one **a** allele. This means that one-half of the alleles in the *Beebop* parent population are **A** and one-half of the alleles in the parent population are **a.**
    - Therefore, the gene allele frequency for the **A** allele is 50% and the allele frequency for the **a** allele is 50%.

6. Read the information in the introduction to Part 2. What is the main selective force that might be affecting allele frequencies for the baby *Beebop* population?

7. Observe the surviving four baby *Beebops* and re-read the Introduction to Part 2 (on page 12). Do you think that the surviving baby *Beebop* population has the same allele frequencies for the **A** (2 antennae) and **a** (1 antenna) genes as the parent *Beebop* population? Why, or why not?

8. Based on the information in the Introduction to Part 2 and on your observations of the surviving baby *Beebops*, predict whether the frequency for each of the alleles listed in the table below will increase or decrease in future *Beebop* population generations. Record your predictions in Table 4 below.

Table 4: *Beebop* Allele Frequencies for Selected Gene Alleles

Gene Allele	Trait	Your Prediction: Will the frequency of this allele increase, decrease, or remain the same?	Explain your prediction
A	2 antennae		
a	1 antenna		
E	Add 1 tail bead		
e	Add 0 tail beads		
H	4 legs		
h	6 legs		
I	Does not carry umbrella		
i	Carries umbrella		

9. In the space below, make a drawing to illustrate 5 *Beebops* that are likely to be present on the island after 20 generations if the environmental conditions remain the same.