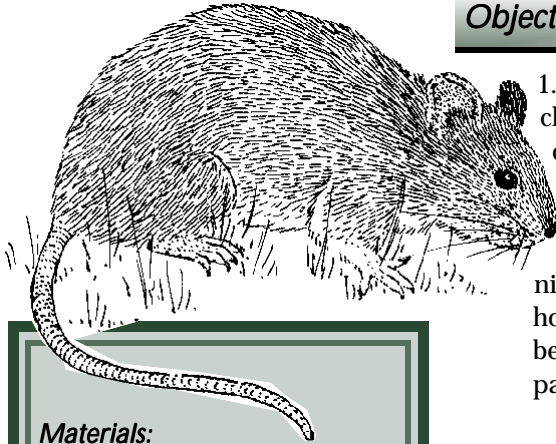




# Oh Rats!!!



## Objectives

1. Students will use changes in the allelic frequency of a population to observe phenotypic changes, thus illustrating the diversifying mechanism of microevolution and how genetic differences can be environmentally impacted.

### Materials:

- ☆ a bag containing twenty beige and twenty grey pipe cleaners for each group
- ☆ a class box containing extra pipe cleaners of both colors for a gene pool
- ☆ a class morgue box for the alleles of dead rats
- ☆ group copies of all hand-outs

*allele* – one of a group of genes that occur alternatively at a given location; either of a pair of Mendelian characters.

## Procedure

1. Students should work in groups of three to four. Approximately two hours are needed to complete this activity. If necessary the graphing, analysis and questions can be done outside of class and shared at the next meeting.
2. Discuss the background information and the simulation directions with students. Impress on the students that they must read and follow the directions carefully.



## Rationale

A simulation of natural selection demonstrates how the frequency of alleles in a population can change due to environmental pressures. Biodiversity at the gene level directly contributes to biodiversity at all higher levels.

### **Correlation to**

### **National Science Standards**

Unifying Concepts and Processes  
Life Science

### **Correlation to**

### **Arkansas Frameworks**

Science: 9-12: LS2.4, LS2.7, LS3.4

## Oh Rats!!!

*Rattus ridgebackus*, the razorback rat, is a rodent common to many Arkansas prairies. The rats are opportunistic omnivores, feeding on a wide variety of seeds and small insects. As do most rodents, *R. ridgebackus* leans to the r-selected end of the population spectrum. Life span is short, body size small, and often there is much intra-specific competition. Breeding occurs in the spring, producing medium to large litters of offspring that mature quickly. The rats exhibit species diversity by the occurrence of two different common morphs, beige rats that are either homozygous dominant (BB) or heterozygous (Bb) and gray rats that are homozygous recessive (bb). There are anecdotal accounts of an occasional bright red morph with pronounced dorsal ridges, but these sightings have not been scientifically substantiated.

Predators of these rats include coyotes, marsh hawks and burrowing owls. Since prairie grasses are beige to brown during the summer months, predators tend to spot and capture more of the rats that display the grey phenotype. Rats spend much of the winter in burrows living off stored food, with an occasional foray to the surface on mild days.

The particular rat habitat we will consider in this exercise has a carrying capacity of twenty, meaning that the environment has only enough resources (food, shelter, water, etc.) to support a maximum of twenty individual rats. The population can fall below twenty, but it may not exceed that number. This number cap suggests that even if one coat color is favored by environmental conditions (selected more often), not all of the individuals with the favored trait will get to reproduce, and not all offspring will survive. Keep in mind that one trait does not determine the fate of an individual or a population. There are many other contributing factors.



*NOTE: The razorback rat, Rattus ridgebackus, used in this exercise is only an imaginary rat. Students may want to design their own animals and characteristics to fit the criteria.*

## *Procedure for Oh Rats !!*

Each group should receive a bag containing 40 pipe cleaners:  
20 representing alleles for beige fur (BB,Bb)  
20 representing alleles for gray fur (bb)

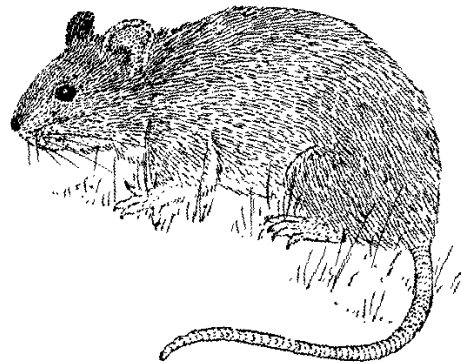
Have one group member reach into the bag without looking and draw out 2 pipe cleaners (genes) at a time. Place them together on the desk or table. Continue this until there are 20 pairs of alleles, each pair representing the genotype of one rat.  
This is your groups beginning population—generation 1.

1. Count the number of individuals of each phenotype (BB, Bb-beige; bb-gray) and enter the data in Table One. Also enter the total number of rats and the frequency of each phenotype. A phenotypic frequency is the number of rats with a particular phenotype divided by the total number of rats.
2. Count the number of B and b alleles in the population, and record the data in Table Two. Also record the frequency of each allele. Allelic frequencies are calculated as the number of each type of allele divided by the total number of alleles in the population.
3. In the summer, predators are able to kill gray rats more easily than they can kill beige rats, because beige rats are less visible in dry, brown grass. For each individual with a gray phenotype (bb) flip a coin to determine if predators kill it. Heads the animal dies, tails the animal lives. Remove all dead rats from the population by placing their alleles in the morgue box.
4. During winter, some adults will die from causes unrelated to fur coloration, such as starvation, freezing and old age. For each individual (regardless of genotype or phenotype) flip a coin to determine if it dies during the winter. Heads the animal dies, tails the animal lives. Again move all dead rats to the morgue. Those left are the ones that survive until spring.
5. In spring, the surviving females come into estrous and breeding begins. The average number of offspring for the entire surviving population works out to three young for each individual rat (remember not all rats are able to breed and not all offspring survive). Below the alleles of each surviving parent, place three additional pairs of alleles that are identical to those of the parent. These three new pairs of alleles represent the alleles of the offspring. Get offspring alleles from the gene pool box. Place all the offspring alleles into your original bag, leaving the surviving parents on the desk.

*Procedure continued on next page*



6. Determine which of the young (those in the bag) survive to adulthood. Shake the bag, reach in and draw out alleles two at a time. Each pair of alleles represents a young rat that survives to adulthood. As you draw allele pairs, place them on the desk next to the surviving adults. Continue to randomly select pairs of alleles until there is a total of twenty individuals in the population, or until you run out of alleles in the bag. It is possible for the population to dip below the carrying capacity of twenty individuals. It is also possible that you will have some alleles left in the bag after the population has reached the carrying capacity. Take any alleles left in the bag to the morgue. The individuals on the desk make up the population that has survived and must now face the summer's predation. This is your group's second generation of rats.
7. Repeat steps three through seven until you have data for at least five generations of the rat population.
8. Construct a line graph to illustrate how the frequency of the two alleles changed. On the horizontal axis (the independent variable), plot time in generations. On the vertical axis (the dependent variable), plot frequency for both alleles. Explain your findings in light of this graph.
9. Answer the following questions:
  - How does the rat population exhibit biodiversity?
  - How does the ecosystem exhibit diversity?
  - Explain ways in which the ecosystem impacts the diversity of the rats and vice versa.
  - Speculate on why the red morph seems to be so rare. What might happen to the diversity balance if the red rat became common?
  - Which species type would you expect to be more diverse, an r-selected such as rats or a k-selected such as cougars? Discuss your reasoning.



## *Extensions to Oh Rats!!!*

1. Use the Hardy-Weinberg equation,  $p^2 + 2pq + q^2 = 1$ , to determine the frequency of heterozygotes (Bb).
2. Discuss your rat population in light of the Hardy-Weinberg Theory.
3. Discuss how your data illustrates the carrying capacity for your rat's habitat.
4. Discuss density-dependent and density-independent population control factors that acted on your population.
5. Design a food web based on this ecosystem.
6. Describe the biotic and abiotic factors of this ecosystem.
7. Describe your rat's niche and how its adaptations fit that niche.
8. Discuss biological potential versus environmental resistance for population size.
9. Introduce a mutation into your population. Describe the mutation and its effect on your population. Devise a scenario that could support this development.

## *Tables I and II for Oh Rats!!!*

**TABLE I: PHENOTYPIC FREQUENCIES**

#BB Beige	#Bb Beige	#bb Gray	Total # Rats	Frequency BB Beige	Frequency Bb Beige	Frequency bbGray

**TABLE II: ALLELIC FREQUENCIES**

# B Alleles	# b Alleles	Total # Alleles	Frequency of B alleles	Frequency of b alleles

