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# New Host, New Species? Alleles

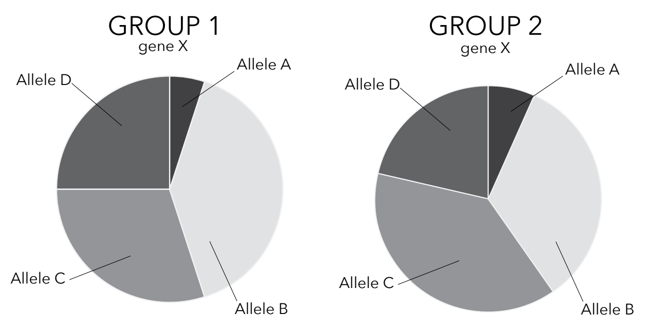
## Guiding Question

Apples were brought to North America, about 400 years ago. Sometime around 1850, some *Rhagoletis* flies moved from living on their native hawthorn fruit to living on apples. Is the population of hawthorn flies living on the apples becoming a new species?

## Background

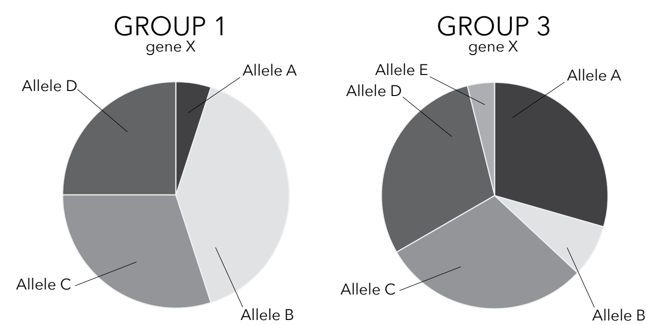
If flies from the apple and hawthorn populations are freely interbreeding with one another, then they would be considered the same species. One way we can tell if interbreeding is happening or not is to see if alleles (different versions of the same genes) in the populations are present in similar or different frequencies.

**Group 1 and 2 are Interbreeding**




If two groups are interbreeding freely, then alleles from the parents are mixed together in the offspring. We would expect to see the same alleles in both populations at about the same frequency.

**Group 1 and 3 are NOT Interbreeding**




If two groups are not interbreeding freely, then their alleles are ***not*** mixing in offspring. As natural selection causes reproductively isolated groups to become more genetically different over time, the allele frequencies shift differently in the two groups. Often, one group has alleles that another lacks completely.

## Experiment 1

> **Research question:** Do fly populations from apple vs. hawthorn fruit have different allele frequencies for some genes?

### Procedure

1. Collect several hundred flies from hawthorn and apple fruit.
2. Isolated the flies' DNA. For several genes, determine what alleles each individual fly has.
3. For each population, calculated the allele frequencies: For a certain gene, what percentage of the alleles are allele A vs. allele B, etc.

**Results** are summarized in the tables on the next page.

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# Allele Frequency Pie Charts

*Worksheet*

## Instructions

Use the data from Experiment 1 (provided below) to fill in the pie charts. Color in the allele frequencies in both fly populations for each gene.

Each pie wedge represents 10%.

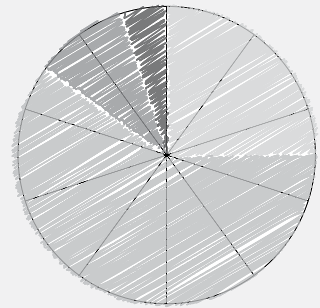
Use a different color for each allele. Mark the corresponding allele color in the circle on the bottom of the table.

### EXAMPLE GENE

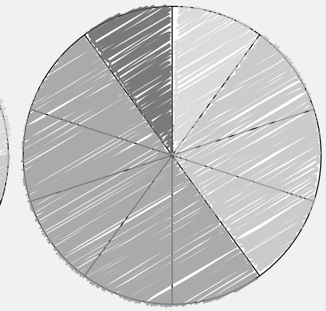
Allele Frequencies (%):

| | Allele | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Apple | 25 | 60 | 10 | 5 |
| Hawthorn | 10 | 30 | 50 | 10 |
| | ◯ | ◯ | ◯ | ◯ |

**Apple Population Flies**



**Hawthorn Population Flies**

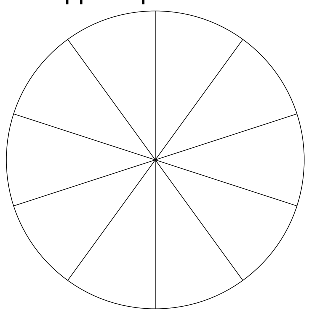


### GENE 1

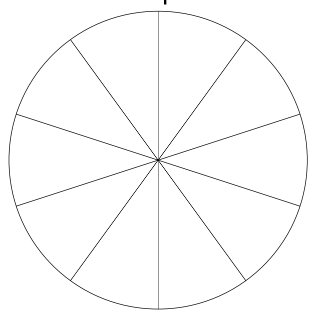
Allele Frequencies (%):

| | Allele | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Apple | 9 | 19 | 57 | 15 |
| Hawthorn | 9 | 48 | 35 | 8 |
| | ◯ | ◯ | ◯ | ◯ |

**Apple Population Flies**



**Hawthorn Population Flies**

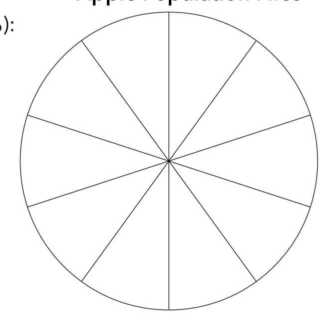


### GENE 2

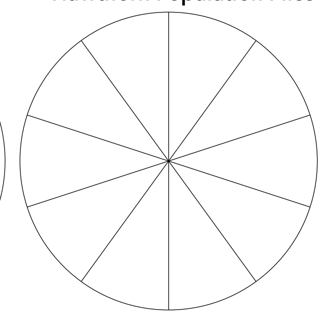
Allele Frequencies (%):

| | Allele | |
|---|---|---|
| | A | B |
| Apple | 62 | 38 |
| Hawthorn | 34 | 66 |
| | ◯ | ◯ |

**Apple Population Flies**



**Hawthorn Population Flies**

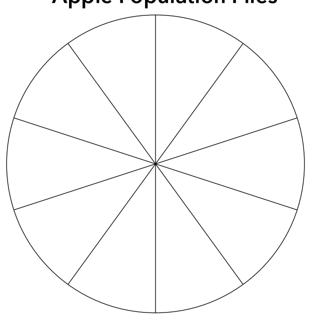


### GENE 3

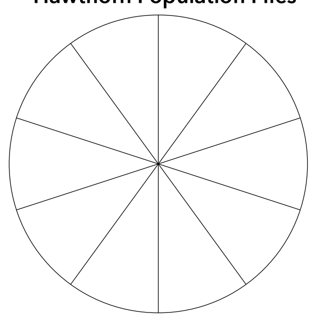
Allele Frequencies (%):

| | Allele | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Apple | 1 | 5 | 5 | 89 |
| Hawthorn | 4 | 10 | 5 | 81 |
| | ◯ | ◯ | ◯ | ◯ |

**Apple Population Flies**



**Hawthorn Population Flies**

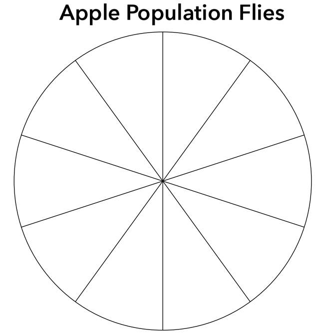


### GENE 4

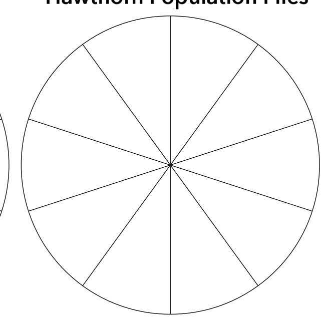
Allele Frequencies (%):

| | Allele | | |
|---|---|---|---|
| | A | B | C |
| Apple | 30 | 69 | 1 |
| Hawthorn | 20 | 79 | 1 |
| | ◯ | ◯ | ◯ |

**Apple Population Flies**



**Hawthorn Population Flies**



*(data based on Feder et al, 1990)*

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## Questions

**1.** Using the data in the tables on the Allele Frequency Pie Charts (page 2), color in the allele frequencies on the pie charts.

**2.** In one sentence, summarize the results.

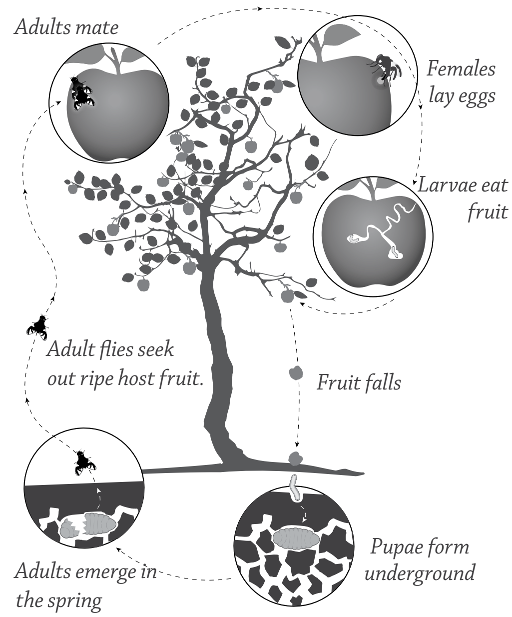
## Experiment 2

In order for flies to mate and lay eggs, their life cycle must be timed so that they become adults when their host fruit is ripe. If they are too early or too late, they will miss their window of opportunity.

Apples get ripe about 30 days earlier than hawthorn fruit, and hawthorn flies vary in their emergence time. Researchers hypothesized that, after apples were introduced, hawthorn flies that became adults earlier were more likely to mate and lay eggs on apples.

Their logic looked like this:

- The timing of events in a fly's life cycle (like when adults emerge from the ground) is influenced by genes.
- Variations in these genes—in other words, alleles—may cause differences in life cycle timing.



*Rhagoletis* life cycle

- Alleles associated with an earlier emergence and mating time might have been acted upon by natural selection in the population of flies that moved from hawthorns to apples.

| |
|---|
| **Research question:** Are any alleles in hawthorn flies associated with differences in life cycle timing? |

### Procedure

1. Collect fly larvae from hawthorn fruit. Bring them to the lab and wait for them to become pupae.
2. To mimic winter, keep the pupae cold for several months. To mimic spring, warm them.
3. Wait for adults to begin to emerge.
4. Every day, collect the newly emerged adults.
5. Test the flies' DNA to see what alleles they have for genes 1–4, and calculate allele frequencies (for a certain gene, the percent of alleles that are A vs. B, etc.)

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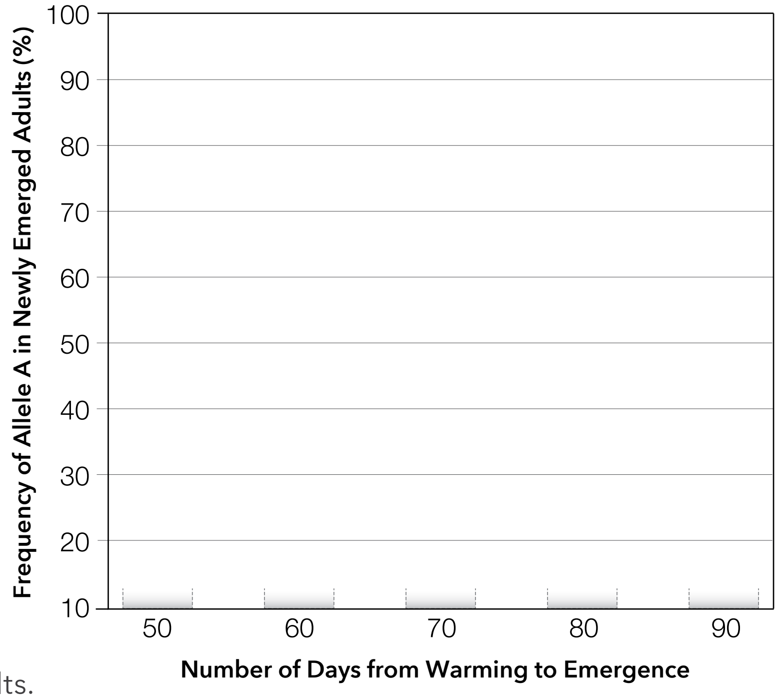
### Results for Gene 2, Allele A

*(Data based on Feder et al, 1993)*:

| Days from warming to adults emerging* | Frequency of allele A (percent) |
|---|---|
| 50 | 91 |
| 60 | 64 |
| 70 | 42 |
| 80 | 23 |
| 90 | 15 |

** Adult flies normally emerge from the ground at different times.*

### Emergence Time vs. Allele Frequency for Gene 2




## Questions

**3.** Use the data from the table to fill in the bar graph on the right.

**4.** In one sentence, summarize the results.

**5.** Compare the results above with those for Gene 2 in Experiment 1. Do the data support the researchers' hypothesis that hawthorn flies that became adults earlier were more likely to mate and lay eggs on apples? Explain.

**6.** Do you think that alleles are freely mixing between apple and hawthorn fly populations? Make a claim, and support it with evidence and reasoning from experiment 1.

**7.** Do you think that different heritable traits are being selected for in the apple and hawthorn fly populations? Make a claim, and support it with evidence and reasoning from experiments 1 & 2.


**References**

Feder, J.L., Hunt, T.A., & Bush, G. L. (1993). The effects of climate, host phenology and host fidelity on the genetics of apple and hawthorn infesting races of Rhagoletis pomonella. *Entomologia Experimentalis et Applicata, 69*(2), 117-135. doi: 10.1111/j.1570-7458.1993.tb01735.x

Feder, J.L., Opp, S.B., Wlazlo, B., Reynolds, K., Go, W. & Spisak, S. (1994). Host fidelity is an effective premating barrier between sympatric races of the apple maggot fly. *Proceedings of the National Academy of Sciences of the United States of America, 91*(17), 7990-7994.

Feder, J.L., Chilcote, C.A. & Bush, G.L. (1990). The geographic pattern of genetic differentiation be- tween host associated populations of *Rhagoletis pomonella* (*Diptera: tephritidae*) in the eastern United States and Canada. *Evolution, 44*(3), 570-594.