Teacher Guide

New Host, New Species?

An Apple and Hawthorn Fly Case Study

Abstract

Students examine several lines of evidence to determine whether or not a population of flies is differentiating into a new species. In this multi-step activity, students will learn about hawthorn and apple flies; break into "expert groups" to evaluate one of three evidence documents; report a summary of their evidence to the class; record evidence from all groups onto a Speciation Organizer; and finally, use the organizer to write an evidence-based argument about whether or not the flies are becoming two different species.

Learning Objectives

- A population is a group of individuals that live in the same area and whose alleles are mixed through reproduction.
- Speciation begins when barriers to reproduction within a population lead to two reproductively isolated populations whose alleles are no longer mixing.
- Speciation is the process through which new species form. A speciation event represents a branch point, where one genetic lineage splits into two.
- Barriers to reproduction, selection for different heritable traits, reduced ability to make hybrid offspring, and reduced allele mixing contribute to speciation.
- (Argumentation Practice) Gather evidence and write an argument that includes claim, evidence, and reasoning.

Estimated time

90-120 minutes

Materials

- Internet access, speakers, and projector
- Expert Group documents (there are 3 Expert Groups: Fruit Preference, Life Cycle Timing, and Alleles): Each student should get one copy of one of the documents.
- Speciation Organizer: One copy per student
- Document camera (optional; use during whole-group student report-out)

Instructions

1. To introduce the case study, project the *Hawthorns to Apples* video to the class.
2. Divide the class in to 3 "Expert Groups": Host Fruit Preference, Life Cycle Timing, and Alleles.

© 2016 University of Utah

Hand out the appropriate Expert Group document and a Speciation Organizer to each student.

Each Expert Group is designed to take about the same amount of time to complete, though of course timing will vary with different student groups.

Several teachers reported that they thought the analysis for Host Fruit Preference was easiest, Life Cycles was in the middle, and Alleles was the most challenging.

If group size is too large, you may wish to create smaller, duplicate expert groups. Before reporting out to the class, duplicate groups should meet to compare answers and assign reporting responsibilities (see step 4 below).

3. Have groups of students work together to complete their worksheets, and then answer the questions that they can on the Speciation Organizer. This should take about 30 minutes.

Notes: Each expert group has evidence that will allow them to answer only some of the questions (see the answer key for details). Tell students NOT to circle any numbers on the scales or fill in an answer for the final question. They will do this later.

4. Have each expert group take turns reporting out to the class, following the steps below. This should take about 15 minutes total.

a. Explain the experiment(s) in 2 sentences.

b. Summarize the data by displaying the graph (or whatever) from their worksheet and walking the class through what it means.

c. Share their responses to questions on the Speciation Organizer, providing enough time for the audience to write it on their own Organizers.

Note: By the end, some questions will have multiple pieces of evidence from different groups.

5. As each expert group reports, each student in the "audience" should add each expert group's evidence to their own Speciation Organizer. The end result should be the same for each student: a Speciation Organizer with responses and information from all three expert groups (see key).

6. Using the information on their completed Speciation Organizer, each student should decide where they think this example best fits on the speciation continuum (the box on the bottom page 3) and write an argument that includes a claim, evidence and reasoning. This should take about 30 minutes.

Adaptations

Below are some variations on the basic instructions for the activity. Use the approach that works best for you and your class.

- Instead of doing a whole-group report-out, have students report to small groups in a jigsaw format. Note that doing a whole-group report will allow you to ensure that students accurately report and summarize their evidence.

© 2016 University of Utah

- Instead of having all students compile the Organizer responses from each group by hand, compile the responses onto one Organizer and make copies for the class.

Extensions

1. Explore the following question with your class:

Someone hands you a bag of live flies. They tell you that the flies are all from one population (either hawthorn or apple), but they don't know which one because the label fell off the bag. Using what you have learned, design an experiment or a set of experiments that will tell you which type of flies are in the bag.

2. Have students use the Speciation Organizer to evaluate another example. They can use articles or other resources that you give them or that they find themselves.

Notes About the Expert Groups

You may use the information below for your own purposes, or offer it to the expert groups that finish early or students who may want more information.

Host Fruit Preference group

As part of the same set of experiments, researchers also tested parental and hybrid flies in the flight tunnel assay with ten times the amount of fruit odor. The results were surprising:

Flies' responses to 10x the amount of fruit odor

	Type of flies	Number of flies tested	Percent of flies that landed on the fruit bait *		
			Hawthorn odor	Apple odor	Dogwood odor
Populations (parents)	Apple flies	44	–	0	–
	Hawthorn flies	34	0	–	–
	Dogwood flies	46	–	–	4%
Hybrid offspring	Apple x Hawthorn	315	15%	16%	–
	Apple x Dogwood	61	–	25%	30%
	Hawthorn x Dogwood	48	10%	–	19%

* the symbol "–" means not tested

Researchers don't know why the parents were not attracted by the higher concentration of fruit odor. This may be an interesting experiment to discuss with your students.

Life Cycle Timing group

The evidence for partial reproductive isolation in this group's data is compelling, but not as strong as it is for some of the other experiments. You may want to focus students' attention on the fact that it seems to take longer for hawthorn flies to reach maturity (when the adults begin mating and laying eggs). This further increases the lag in the peak mating periods between the apple and hawthorn fly populations.

© 2016 University of Utah

Alleles group

It might be worth reminding students that each fly has two alleles for each gene.

The genes used for calculating allele frequencies in experiment 2 are basically just well-characterized genetic markers, which the authors refer to as "allozymes." These genes don't necessarily directly influence a phenotype that is under differential selection between the apple and hawthorn fly populations. Rather, they are in areas of the genome where something—possibly an allele of another gene—is being acted upon by natural selection.

In Feder et al (2003), researchers show that the six allozymes that have different allele frequencies between apple and hawthorn fly populations are located in three regions of the genome that are inverted. That is, large regions of the chromosome containing several genes have been flipped 180 degrees. Consequently, no recombination can happen between inverted and non-inverted versions of the chromosome, and these regions tend to be inherited as one large chunk.

The allele frequencies for same allozymes, and several other genetic markers, have been calculated for several other *Rhagoletis* species. For some alleles, the various species show even greater differences in allele frequencies, demonstrating that the same basic mechanisms (mutation and natural selection) acting over longer periods of time cause species to become increasingly different from one another.

References

Fruit Odor group

Lin, C.E., Dambroski, H.R., Feder, J.L., Berlocher, S.H., Nojima, S. & Roelofs, W.L. (2004). Postzygotic isolating factor in sympatric speciation in *Rhagoletis* flies: reduced response of hybrids to parental host-fruit odors. *Proceedings of the National Academy of Sciences of the United States of America, 101*(51), 17753-17758. doi: 10.1073/pnas.0408255101

Life Cycle group

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

Allele Frequency group

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

Feder, J.L., Hunt, T.A., & Bush, G. L. (1993)

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.

More information on allozymes and chromosomal arrangement

Feder, J.L., Roethele, J.B., Filchak, K., Jiedbalski, J. & Romero-Severson, J. (2003). Evidence for inversion polymorphism related to sympatric host race formation in the apple maggot fly, *Rhagoletis pomonella*. *Genetics* 163, 939-953.

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1418136. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

© 2016 University of Utah