Lesson Plan: Evolutionary Factors

**General Description**
This activity will challenge students to consider how evolutionary factors other than natural selection influence population genetics. These factors include genetic drift, migration, mutation and dominance. This activity is a good follow up to the natural selection activity; however, it can stand alone.

**Objectives**
Students will be able to:
- recognize the significance of varying evolutionary forces by making and evaluating predictions
- construct a ‘big-picture’ viewpoint on the role of different evolutionary forces and their potential interactions
- interpret the outcomes of the in-class simulation

**Concepts**
population genetics, genetic drift, migration, mutation, dominance

**Time** 30-50 minutes

**Prerequisite Skills**
At least one lecture covering basic population genetics

**Materials**
Student handouts: Evolutionary Factors Worksheet
Transparencies: evolutionary factors questions, simulation results
Set of four simulation cards for each group
**UTI Instructions: Evolutionary Factors**

**Introduction:**
This week students will explore what happens to allele frequencies when a population is NOT in Hardy-Weinberg equilibrium. The major tasks are creating predictions and evaluating those predictions using simulation printouts.

**Procedure:**
Hardy Weinberg equilibrium captures the allele frequencies in a population when ‘nothing else is happening’. Students should be familiar with the concept of Hardy Weinberg equilibrium and should have a basic understanding of how natural selection influences population genetics based on experience in lecture or previous discussion activities. But how do other evolutionary factors influence population genetics?

If you used the Natural Selection activity in discussion group last week, briefly remind students about what you covered. If not, describe the following scenario: A population is comprised of organisms that express one of two appendage phenotypes depending on the alleles present at the A locus. Individuals express the "spoon phenotype" if they have AA/Aa genotype or the "knife phenotype" if they have aa genotype. In this population the only food resource that individuals eat is hard candy. Individuals that express the “spoon phenotype” are better able to scoop up the candy and consequently leave more offspring. The “spoon phenotype” has higher fitness than the “knife phenotype”, therefore over evolutionary time the A allele and the “spoon phenotype” increase in the population due to natural selection.

Have students create small groups and put up the Evolutionary Factors overhead (Read through these questions once for clarification.). Allow students time to make predictions in their small groups about how each of the evolutionary factors will influence changes in allele, genotype, and phenotype frequencies on the predictions worksheet. Each group should work through all evolutionary factors.

Solicit volunteers from each group to state their predictions to the rest of the class regarding a single evolutionary factor. Discuss any questions that arise. Cover predictions for each evolutionary factor.

Distribute the Simulation Results cards to the groups. Each group should evaluate their predictions for each evolutionary factor. When most groups are nearing completion, have one person report on their group’s evaluation. Cover the analysis of all evaluations in this manner. Alternatively, you can create a puzzle scheme in which students reform their groups and compare their results. Engage students in an open discussion about how these simulation results did or did not match their predictions.

If directed, collect Evolutionary Factors worksheet from students and administer the Individual Accountability question.
Initial Conditions: Population Size: 1000

- Migration: from $p(A)=0.5$
- Fitness: $w_{AA}=1.0$
- Mutation: none
- $w_{Aa}=1.0$
- Random Mating: yes
- $w_{aa}=1.0$

Initial Conditions: Population Size: 1000

- Migration: from $p(A)=0.1$
- Fitness: $w_{AA}=1.0$
- Mutation: none
- $w_{Aa}=1.0$
- Random Mating: yes
- $w_{aa}=1.0$
Mutation

Initial Conditions: Population Size: 1000
Fitness: $A_A = 1.0$
        $A_a = 1.0$
        $a_a = 1.0$
Migration: none
Mutation: A to a at 0.10/gen
Random Mating: yes

Initial Conditions: Population Size: 1000
Fitness: $A_A = 1.0$
        $A_a = 1.0$
        $a_a = 1.0$
Migration: none
Mutation: A to a at 0.01/gen
Random Mating: yes
Small Population/Genetic Drift

Initial Conditions:
- Population Size: 25
- Migration: none
- Fitness:
  - $w_{AA} = 1.0$
  - $w_{Aa} = 1.0$
  - $w_{aa} = 1.0$
- Mutation: none
- Random Mating: yes

![Graph 1](image1)

Initial Conditions:
- Population Size: 25
- Migration: none
- Fitness:
  - $w_{AA} = 1.0$
  - $w_{Aa} = 1.0$
  - $w_{aa} = 1.0$
- Mutation: none
- Random Mating: yes

![Graph 2](image2)
Initial Conditions: Population Size: 1000  Migration: none
Fitness:  $w_{AA}=1.0$  Mutation: none
          $w_{Aa}=1.0$  Random Mating: yes
          $w_{aa}=0.9$

a allele dominant to A allele
**Evolutionary Factors**

(1) Different Dominant/Recessive relationships

What if $a$ was dominant over $A$, such that an $Aa$ genotype conferred the knife phenotype rather than the spoon phenotype?

(2) Migration

What if individuals from a population with only a few $A$ alleles were migrating into our population?

(3) Mutation

What if every once in a while an $A$ allele changed to an $a$ allele, or *vice versa*?

(4) Random Genetic Drift

What if one of the alleles or genotypes increased or decreased by chance alone, not because the individuals were better or worse at foraging?
Pre-Activity Worksheet: Evolutionary Factors

**General Description**
In the activity you will do this week during your learning/discussion group, you will be examining ways that allele and genotype frequencies change in populations. In order to be prepared for this activity, complete this worksheet.

**Reading**
Browse the “Genes Within Populations” chapter in your text (Ch. 21). Pay particular attention to figure 21.4 and 21.6. Carefully read sections 21.1 and 21.2 on pages 434-441.

**Definitions**
Write a definition of the following words. Use your text, textbook glossary, and your previous knowledge to create the best definition possible. Remember to connect your definitions to population genetics and violations of hardy-Weinberg equilibrium.

1) genetic drift

2) migration

3) mutation

4) dominance

**Questions**
Answer the following questions. You will explore your answers to these questions in-depth during learning/discussion group.
1) Why is Hardy-Weinberg equilibrium the starting point for understanding evolutionary change?

2) Which evolutionary factors introduce more genetic variation to populations?

3) Describe why assortative mating does not alter allele frequencies.
Evolutionary Factors

In this activity you will explore genetic changes in populations, resulting in evolution. This baseline for your exploration is the Hardy-Weinberg equilibrium.

What will happen, if anything, to phenotype frequencies, allele frequencies, and genotype frequencies in response to the following evolutionary factors?

1. **Genetic Drift**

   *Increase, Decrease, or Stay the Same:*

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<th>Prediction</th>
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2. **Migration**

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3. **Mutation**

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4. **Dominance**

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Demonstrate your new understanding of evolutionary factors by answering the following questions.

1) If the population size is really small, will natural selection or genetic drift have a greater influence on allele and genotype frequencies? Defend your answer in four or five sentences.

2) Of the evolutionary factors you explored today, which one introduces the most genetic variation into the population? Why?