LAB 7: COMPARING RATES OF EVOLUTION & TYPES OF SELECTION

NOTE:

There is a pre–lab assignment for this lab. Before you come to lab, you must read through this handout and answer each question in the Pre–lab. Turn the pre–lab sheet in at the start of lab. The questions also appear in the lab instructions at appropriate places to help you put them in context. Before you read further, answer the questions below & copy your answers to the Pre–lab.

Pre–Lab Q1. Fill in the blanks to identify the pattern of inheritance. (5)

a. An allele which has its full phenotypic expression in heterozygotes is: _____

b. An allele which shows its phenotype only when homozygous is: _____

c. When the phenotype of the heterozygote is in–between the homozygotes' the alleles show: _____

d. When the phenotype of the heterozygote is greater then the homozygotes' the alleles show: _____

e. Heterozygote has a phenotype more extreme than either homozygote the alleles show: _____

Pre–Lab Q2. Match the letter(s) of the scenarios with the appropriate terms. The first is done for you.

	SCENARIO / EXPERIMENT							
PARAMETER	A	B	C	D	E	F	G	H
Relative fitness of AA	1	0.5	0.5	0.1	1	0.99	1	1
Relative fitness of AB	1	0.5	1	1	0.5	1	0.5	1
Relative fitness of BB	0.5	1	1	0.7	1	1	0.2	1

a. A allele is dominant A, B

b. A allele is recessive _____

c. A allele is incompletely dominant _____

d. A allele is over dominant/ heterotic _____

e. B allele is dominant _____

f. B allele is recessive _____

g. B allele is incompletely dominant _____

h. B allele is over dominant/ heterotic _____

i. A allele has evolutionary advantage _____

j. B allele has evolutionary advantage _____

Bring a USB drive to lab. You will use it to present your graphs for class discussion.

INTRODUCTION

Last week you ran experiments with beads and EVOLVE to determine what happens to a lethal recessive allele: Given the parameters in Table 1, it rapidly decreased in frequency when it was in high frequency and increasingly slowly as its frequency dropped (Fig. 1a). Such alleles are very difficult to eliminate from a population, although the more fit, adaptive, allele reaches a high frequency rather quickly (from 0.1 to over 0.8 in 4 generations, Fig. 1a).

In previous labs you have followed rather detailed instructions; this and future labs will give you more opportunity to play — to design your own experiments and research.

As we discussed early in the term, scientists formulate and test hypotheses; experiments are empirical tests of existing theories or hypotheses. They may also aim to answer a question without a specific expectation about what the experiment will reveal, or to replicate results. If an experiment is carefully conducted, the results will either support or refute (confirm or disconfirm) the hypothesis (note: never "prove" in the commons use of the term). Good experiment must control the possible *confounding* factors—any factors that would mar accuracy or repeatability of the experiment or interpretation of results. Confounding is commonly eliminated through scientific *controls* and/or, randomized samples.

A scientific control is an experiment or observation designed to measure a *dependent variable* and minimize effects of variables other than the single *independent* variable. This increases the reliability of the results, often through a comparison between controlled groups and experimental groups.

For example, we might test plant fertilizer by giving it to only half the plants in a garden: the plants that receive no fertilizer are the control group, because they establish the baseline level of growth that the fertilizer-treated plants will be compared against. Without a control group, the experiment cannot determine whether the fertilizer had a real effect.

In the experiments in this lab we will be comparing rates of evolution (rates of change of allele frequencies) as the dependent variable and will be manipulating pattern of inheritance as the independent variable. This will allow us to review patterns of inheritance and how they interact with natural selection.

Before lab, review the introduction to Lab05, and view the on–line video, *Natural Section in Humans* (http://media.hhmi.org/fittest/human_selection.html) for background on sickle–cell disease—a side–effect of selection for a trait that improves fitness in a malarial environment.

PART 1: DO DOMINANT OR RECESSIVE ALLELES EVOLVE FASTER?

In this part, we will use EVOLVE to address two related questions:

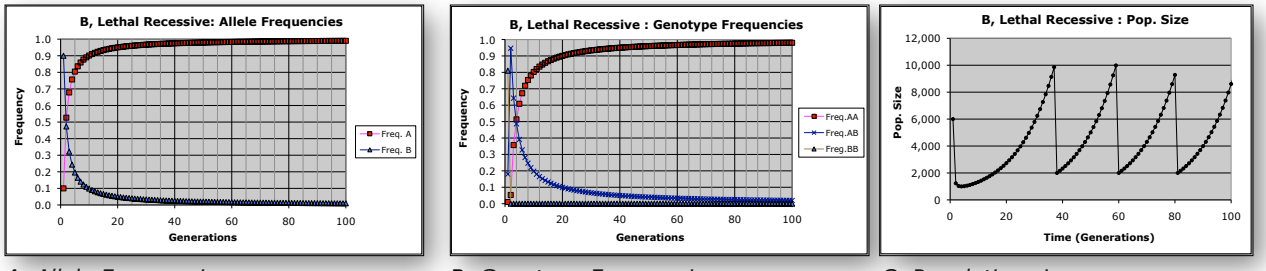
- *How will the path of allele frequencies of a population with a high–fitness phenotype determined by a dominant allele differ from the path of an otherwise identical population with the same phenotype determined by a recessive allele?*
- More concisely: W*ill an adaptive allele evolve (increase in frequency, spread through a population) faster if it is dominant or recessive*?

In these simulations, we will revisit last week's yellow and red spiders. As before, assume the new red allele has just arisen in a population. The new allele is more advantageous, i.e., is a better adaptation with higher fitness, than the alternative yellow allele, which is maladaptive, i.e., has a lower fitness.

To refresh your memory, sample EVOLVE input values and graphs from last week's spider simulation are shown in Table 1 and Fig. 1.

Table 1. Lab07, Exp't 2: Input Parameters Simulating Evolution of a Recessive Lethal Allele.

Initial Population:	P[A] = 0.10	P[B] = 0.90	Population size = 6,000
Maximum Pop. (K) =	10,000	Post–crash Population = 2,000	
	AA (red)	AB (red)	BB (yellow)
Survival Rates:	40 %	40%	0%
Reproductive Rates	2.7	2.7	2.7
Fitness (Absolute/Relative)	(108/1)	(108/1)	(0/0)



A. Allele Frequencies *B. Genotype Frequencies* *C. Population size*

Figure 1: Results from simulation of evolution of a lethal recessive allele. These are screen captures from last week's experiment 2 using EVOLVE.

In last week's lab, the red allele was dominant and the yellow, allele was recessive and lethal. To make this week's problem more realistic, assume the differences in colors, and hence survival rates, are less extreme; the yellow phenotype is not lethal, but just has a lower fitness than the red phenotype.

Based on your experience last week, you should expect the red allele to increase in frequency, whether it was dominant like last week or whether it was recessive. The questions are, would evolution happen faster or more slowly if the red allele was recessive, and would the path of frequencies be different?

As in last week's lab, make two predictions. Since you should have a little better feel for this way of looking at evolution, try to answer the questions below. Copy your answers to the last page of this handout and turn it in at the start of lab.

Pre-lab Q 3: Which will evolve faster (i.e., increase in frequency faster), an adaptive (red) allele that is

a. D*ominant* or

b. R*ecessive*?

Circle the letter of your choice and explain your choice in the space below and on the pre–lab sheet.

Pre-lab Q 4: In Experiment 1, which will have the higher allele frequency after a given number of generations? (2)
Pick a generation: ___ Which allele will have a higher frequency? ❑ Dominant red ❑ Recessive red

Pre-lab Q 5: Given your answer above, which will reach a specified allele frequency more quickly, (2)
Pick an allele frequency: ___ Which allele will reach that frequency first? ❑ Dominant red ❑ Recessive red

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To get more specific, consider the concept of speed (rate) in more detail. There are 2 easy criteria to judge speed of a car—time over a given distance (¼–mile time), and distance in a given time. The next two questions address each of these criteria separately. Fig. 2 equates these with our evolutionary experiment

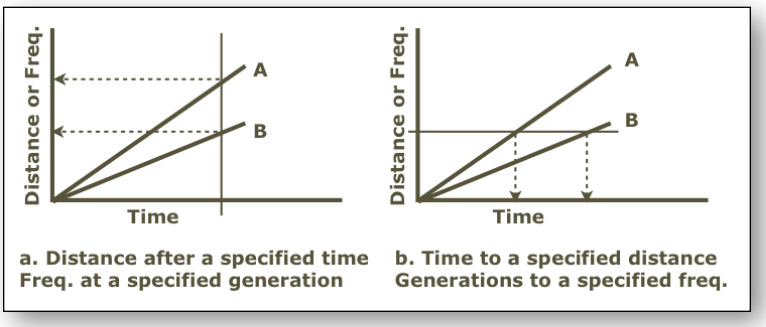

Figure 2. Criteria for judging 'faster'. *Two ways to judge acceleration of cars, & rate of evolutionary change. Two cars, A & B, can be compared by looking at a) which has gone further in a particular amount of time, or b) by looking at how long it takes to go a given distance.*

PROCEDURE

We'll run 2 simulations in which the red *A* allele's phenotype has a higher fitness. In simulation 1a, the *A* allele will be dominant, in 1b the *A* allele will be recessive. In all of these experiments keep the initial population at 6,000 and the carrying capacity and post–crash populations at 10,000 and 2,000 respectively. Other experimental parameters (initial frequency, survival & reproductive rates) are your choice; but check with your instructor for feedback before copying and comparing results.

Run Experiments

1. **Download** the Lab 06 EVOLVE workbook.
2. **Experiment 1a.** In the *Exp't 1a Rec* worksheet enter Title, Allele & Phenotype names for the experiment. Explore different experimental parameters (initial frequency, rates of survival & reproduction) that will give you a good graph of allele frequency over time. The *A* allele should be recessive, advantageous, start at a low frequency and reach a high frequency over the 100–generation experiment. The population must not go extinct.
3. **Experiment 1b.** Copy the *Exp't 1a Rec* worksheet and label it *Exp't 1b Dom*. Change the title survival & reproductive rates so that the *A* allele is dominant and the two phenotypes in the population are the same as in Exp't 1a.

Compare Results

4. **Copy the 100–generation summary results** for the A allele from each experiment into the *Exp't 1 Data* tab. Note that the first step is done for you (the first—pink—cell)
   a. Exp't 1a (set the 1st generation cell = the 1st generation P[A] in the proper column in the *Exp't 1 Data* tab It's already done for you.
   b. Enter a comparable formula to copy the equivalent datumfrom the Exp't 1b sheet into the Dom. Column.
   c. Select both columns from generation1 to generation 101; use the Fill > Down command to copy the simulation results down the two columns.
5. **Graph the histories of the *A* alleles' frequencies**. Create a scatter plot line graph of the frequencies of the two *A* allele's over the time of the two simulations. Add legend, title, axis labels, etc., and adjust axes, symbols, etc.

What we're really interested in is which of the simulations had the fastest *rate of change* (i.e., the greatest change in P[A] from one generation to the next) and how much faster it was than the other.

6. **Graph rates of change of the two *A* alleles' frequencies.** Click in the Gen 1 row below the Recessive column heading of the *Change in P[A]* part of the table. Enter a formula to subtract the frequency in generation 1 from the frequency in generation 2.
   a. Copy this formula to the adjacent cell, then down both columns.
   b. Using the data in the *Change in P[A]* part of the table, create a scatter plot of rate of change.

Be prepared to discuss your results with the class.

7. Before proceeding to Part 2, we'll discuss part 1 Be able to briefly describe your input values, your graphs & your conclusion.

LAB 6: PRE–LAB

Complete the questions below and turn this page in at the start of lab.

PART 1: DOMINANT VS RECESSIVE ALLELES

1. Fill in the blanks to identify the pattern of inheritance. (5)

a. An allele which has its full phenotypic expression in heterozygotes is: _____ **Dominant**

b. An allele which shows its phenotype only when homozygous is _____ **Recessive**

c. When the phenotype of the heterozygote is in–between the homozygotes' the alleles show: _____ **Incomplete dominance**

d. When the phenotype of the heterozygote is greater then the homozygotes' the alleles show: _____ **Heterosis/over dominance**

e. Heterozygote has a phenotype more extreme than either homozygote the alleles show: _____ **Heterosis/overdominance**

4 3 2 1 0 B

2. Match the letter(s) of the scenarios with the appropriate terms. (17)

PARAMETER	SCENARIO / EXPERIMENT A	B	C	D	E	F	G	H
Fitness of AA	1	0.5	0.5	0.1	1	0.99	1	1
Fitness of AB	1	0.5	1	1	0.5	1	0.5	1
Fitness of BB	0.5	1	1	0.7	1	1	0.2	1

a. A allele is dominant _____ **A, B**
b. A allele is recessive _____ **C, F**
c. A allele is incompletely dominant _____ **G**
d. A allele is over dominant/ heterotic _____ **D**
e. B allele is dominant _____ **C, F**
f. B allele is recessive _____ **A, B**
g. B allele is incompletely dominant _____ **G**
h. B allele is over dominant/ heterotic _____ **D**
i. A allele has evolutionary advantage _____ **A, G**
j. B allele has evolutionary advantage _____ **B, C, F (EC: D)**

16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 B

3. In Experiment 1, will the red adaptive allele evolve faster (i.e., increase in frequency faster) if it is dominant or if it is recessive? (circle the letter) (3)

a. D*ominant* or one that is

(1)

b. R*ecessive*?

Explain *why* you chose this answer. **(2)**

2 1 0 B

4. In Experiment 1, which will have the higher allele frequency after a given number of generations? (4)

Pick a generation: ___ Which allele will have a higher frequency? ❑ Dominant red ❑ Recessive red **3**

Given your answer above, which will reach a specified allele frequency more quickly, **2**

1

Pick an allele frequency: ___ Which allele will reach that frequency first? ❑ Dominant red ❑ Recessive red **0**

B