

NUMERICAL SIMULATIONS OF SELECTION USING A SPREADSHEET

- Can use spreadsheet programs (like Excel) to execute repetitive calculations, like the recursion equations we have seen in this course.
 - In other words, spreadsheets can be used as a simple programming language.
- Purpose of this demonstration: show how to do this, using one-locus selection as a working example, with one of the more widely used spreadsheet programs: Microsoft Excel.
 - Note: many of the commands and procedures in this demonstration are very useful for other purposes, like analyzing data, keeping track of grades, alphabetizing, budgeting, etc.
- **Some Useful Terms and Commands**

cell location: The location of a cell is given by a number (row) and letter (column) combination). For example, cell B9 is in the 9th row of the 2nd column (column B).

function: Fills cell with the result of a calculation. Functions always start with “=”. For example, to compute $(1+2+3)*4$, type “ $=(1+2+3)*4$ ” in a cell and press return (enter).

- Excel has a wide variety of built-in functions that are useful for data analysis.

fixed and absolute cell references: References to specified cell locations.

- *Relative* references are used for a *variables*. A relative reference refers to a cell that is a fixed *relative* location from the current active cell. When a cell reference is entered by selecting a cell, Excel automatically assumes you want a relative reference.
- *Absolute* references are used for fixed *parameters*. An absolute reference refers to a fixed cell location in the spreadsheet. To create an absolute reference, either place the cursor to the right of the cell location and type “command-t” or type “\$” in front of the row and column names. For example, \$B\$9 is a absolute reference to the 9th cell of column B.

fill down: Use this to “iterate” your computations.

- Select the current cell and those below that you want to fill. Type “command-d” or select “fill down” from the “edit” menu. The cells below will be filled with the contents of the topmost cell (including adjusted relative cell references). **Fill right/fill up/fill left** are used similarly.
- NOTE: **copy** and **paste** also adjust cell references and can be used for the same purpose as fill.

freeze panes: Use to “freeze” column and/or row headings

- To freeze column headings only: select cell just below the first column heading and then choose “freeze panes” from the “window” menu
- To freeze row headings only: select cell just to the right of the first row heading.
- To freeze row and column headings: select cell in the first row and column.

• **Tutorial: Selection at a Haploid Diallelic Locus**

– Goal: compute frequency of A for 50 generations given a selection coefficient s and initial value of p using the equation: $\Delta p = pq \frac{s}{1 - sq}$

– Steps:

(1) Enter parameter value for selection coefficient, s (e.g., set $s = 0.1$).

(2) Set up column for the generation numbers.

- Enter “0” for generation 0.
- Enter the formula “= [click cell above] + 1” to generate next generation.
 - Important: use relative reference since “generation” is a variable.
 - Simply click cell to enter its location (instead of typing it into the formula).
 - Press return (enter).

- Select the previous cell and the next 49 cells below; choose “fill down” from the edit menu.
 - Note: fill down enters the correct relative reference (= 1 cell above) for each cell.

(3) In column B, enter the initial value of p . (e.g., set $p = 0.2$).

(4) In column C, enter the formula for q : Type “=1 – [click cell to the left]” .

- Hint: Type in formula, then replace letters with their respective cell locations.

(5) In column D, enter the formula for Δp .

- Important: use an absolute reference for s .
- (6) In the next row, column B, enter the formula for $p' = p + \Delta p$:
 - Type “= [click cell above]+[click cell for Δp in previous row]” .
- (7) Use “fill down” to fill in the remaining row entries.
 - Note: Fill Down gives the correct relative cell locations and keeps the absolute cell locations fixed.
- (8) Starting with the second row, use “fill down” to fill in the rows for the remaining generations.
 - Useful to freeze row headings when examining results.
- With this program in place, it is easy to explore at the effects different selection coefficients, different initial values of p , etc.
 - Change a parameter or initial value, and Excel updates the rest.
- Can even graph the results if desired.
 - Select cells containing information to be graphed, then use “Insert Chart” and the “Chart Wizard”.

• **Over- and Underdominance in Fitness at a Diallelic Diploid Locus**

- In this example, use Excel to iterate the equation $\Delta p = pq \frac{qt - ps}{1 - p^2s - q^2t}$ for various values of the selection coefficients t and s , and initial frequencies of A .
 - parameters: s, t
 - variables: $p, q, \Delta p$
- Compare results of iteration with predicted equilibrium: $\hat{p} = t/(s + t)$

• **Exploring the Adaptive Landscape and Fisher’s Fundamental Theorem**

- Use Excel to follow changes in p and \bar{w} .

– Utilize the general formula for selection at a diallelic diploid locus: $\Delta p = pq \frac{\bar{w}_A - \bar{w}_a}{\bar{w}}$

where $\bar{w}_A = pw_{AA} + qw_{Aa}$, $\bar{w}_a = pw_{Aa} + qw_{aa}$, and

$$\bar{w} = p^2w_{AA} + 2pqw_{Aa} + q^2w_{aa} = p\bar{w}_A + q\bar{w}_a.$$

• parameters: w_{AA}, w_{Aa}, w_{aa}

• variables: $p, q, \bar{w}_A, \bar{w}_a, \bar{w}$

– Compare actual value of $\Delta\bar{w} = \bar{w}' - \bar{w}$ with the predicted value based on Fisher’s

Fundamental Theorem of Natural Selection: $\Delta\bar{w} \approx \text{var}(\alpha)/\bar{w} = 2(p\alpha_A^2 + q\alpha_a^2)/\bar{w}$, where

$\alpha_A = \bar{w}_A - \bar{w}$ and $\alpha_a = \bar{w}_a - \bar{w}$.