For this assignment you will investigate the properties of a variety of models for growth by using Excel to generate plots. Complete the introduction to graphing with Excel lab before doing this assignment

Answer all the questions in the assignment using complete sentences in a text box in Excel. Copy and paste your complete spreadsheet in the DropBox into the Emerging Order program space on MASU using the naming convention:

`Graphing_Lab_LastName_FirstName.xls`

1. For each of the following arithmetic sequence (defined recursively) create a plot of u_n vs n and another plot of s_n vs n, where s_n is the sum of the first n terms of the sequence u_n (ie the partial sum of u_n). You can do this using the formulas we derived in workshop, or you can just get Excel to generate the terms recursively as you did in the first Excel lab. In a text box describe the shapes of the graphs and how the values of the first term a and the common difference d affect the graph. Compare the graphs of u_n and s_n.
   (a) $u_n = u_{n-1} + 5,\ u_1 = 8$
   (b) $u_n = u_{n-1} + 2,\ u_1 = 8$
   (c) $u_n = u_{n-1} - 3,\ u_1 = 10$
2. For each of the following geometric sequences (defined recursively) create a plot of u_n vs n and another plot of s_n vs n, where s_n is the sum of the first n terms of the sequence u_n (ie the partial sum of u_n). You can do this using the formulas we derived in workshop, or you can just get Excel to generate the terms recursively as you did in the first Excel lab. In a text box describe the shapes of the graphs and how the values of the first term a and the growth factor r affect the graph. Compare the graphs of u_n and s_n. Do any of the graphs converge to a limiting value? If so, what is the value?
   (a) $u_n = 2u_{n-1},\ u_1 = 3$
   (b) $u_n = 1.2u_{n-1},\ u_1 = 3$
   (c) $u_n = 0.5u_{n-1},\ u_1 = 3$
3. We have seen that an recursive formula of the form $u_n = ru_{n-1}$, where r is a constant number, results in exponential growth or decay depending on the value of r. Many Biological populations exhibit this kind of growth rule when the population is relatively small. However, this kind of growth cannot be sustained indefinitely due to limited resources. A more realistic model is given by a modified version of this formula $u_n = ru_{n-1}(1 - u_{n-1})$. This formula is called the Logistic Equation and the extra factor serves to limit the growth.

   In the following investigation choose the first term to be $u_1 = 0.1$ and investigate what happens to the sequence for $r = 2$, $r = 2.5$, $r = 3$, $r = 3.5$, $r = 4$. In each case plot a graph of u_n versus n and describe what you observe mathematically. Is the sequence convergent, divergent, periodic or chaotic? For some cases you may need to evaluate and plot a large number of terms to be confident about what is happening. That the logistic equation can have such different behavior for seemingly small changes turns how to have deep implications for determinism in the natural world. We will discuss further examples of determinism and chaos in Winter quarter.