NetLogo is a programming language for simulating interactions between “agents” in a suitable environment (such as the interactions between ants in a colony, or sheep and wolves in a field). This approach to modeling makes it possible to examine how the simple behavior of individuals results in the complex collective behavior of a group. The scope of the language as a modeling tool encompasses biology, economics, social sciences, physics and chemistry.

NetLogo can be used in a number of ways. First, we can explore the large number of existing models of emergent phenomena that come with NetLogo to see the types of phenomena that NetLogo is well suited to modeling. We can conduct virtual experiments to adjust the various model parameters and observe the response of the system. By so doing we can test whether the model fits with observations in the real world, and whether it predicts unexpected behavior. We can also modify existing models, for example, by adding a new species to a predator/prey model. The ultimate goal, however, is to learn the programming language in sufficient detail to create our own models. In this first lab we will start by familiarizing ourselves with the NetLogo interface and some of the basic commands for controlling the “agents” and their environment. If you need help understanding any of the commands there is a helpful User Manual available under the help menu. The programming guide and primitives dictionary will be useful references for you in these workshops. Let’s start with the first two tutorials provided in the NetLogo User Manual.

Tutorial #1: Models
Complete Tutorial #1: Models, from the NetLogo User Manual. This tutorial explores one particular model form the models library and serves as an introduction to NetLogo's graphical user interface and the elements that allow you to control the model. The tutorial poses questions and asks you to make predictions.

Tutorial #2: Commands
Complete Tutorial #2: Commands, from the NetLogo User Manual. This tutorial is an introduction to the different ways to interactively control your modeling environment using commands. This is an important precursor to writing procedures.

Writing Procedures
You have seen how to control NetLogo Models using sliders and buttons and have learned how to use the Command Center and agent monitors to interact with patches and turtles. Now you will learn how to control the interactions of patches and turtles by writing procedures. Procedures are groups of NetLogo *commands* or *reporters. Commands* are actions that patches or agents carry out. *Reporters* are commands that return a value that might be acted on by another command. Together these are referred to as NetLogo *primitives.* An example of a simple procedure is given below:

```
to wiggle
     ask turtles [
          left random 40
          right random 40
          forward 1 ]
end
```

In this procedure ask, left, right and forward are commands, and random 40 is a reporter that returns an integer between 0 and 39. Note that a procedure starts with

a `to` and end with an `end`. The next tutorial shows how to write procedures. If you are using NetLogo 3.1 you should get Tutorial #3 from the handouts folder on Masu. If you are using NetLogo 4.0 you can use the Tutorial #3 in the user manual.

Tutorial #3: Procedures
Complete the tutorial #3. Work through this tutorial carefully. As you learn a new command or reporter take the time to play around with it so that you fully understand how to use it and what it can do. Resist the urge to copy and paste code from the tutorial to your program. As you type it yourself you will reinforce the logic of each command. At the end of the tutorial you should be well on your way to writing your own programs. Save your work using the naming convention: Lastname_Firsname_Lab_04.nlogo.

Lab Assignment
The model you created shows the growth of turtle in the presence of limited resources. With the initial number of turtles at 50 and birth energy at 50 and the energy from grass at 50 run the model a few times. You should see that the growth is exponential initially and then becomes linear. At some point the population reaches a peak and then drops until it reaches a steady level. Let the model run for about 50 time steps then stop it and answer the following questions.

1. In the exponential growth region of the graph (called the *log phase* by biologists), pick two points using your mouse on the graph (the first point can be the initial value). And use that information to find the growth factor, *r*, for this population.
2. In the linear growth phase of graph pick to points to find the constant rate of increase, *d*, in population in this linear phase of growth.

Changing the Model
Use the user manual to help modify your model to do the following

3. Make all the turtles red at the start. Change their shape to a circle and give them 10 units of energy.
4. Make a turtle turn a patch brown when it has eaten the grass there.
5. In the go procedure make the turtle's size proportional to its energy, so that if it has energy 50 it has size 2, but if it has energy 100 it has size 4
6. Make a turtle reproduce only if it has enough energy and if there is another turtle on the same patch as it.
7. Make the program stop if the population ever reaches 1000.

Upload your to the our Moodle site by February 2nd, using the naming convention Lastname_Firstname_Lab04.nlogo