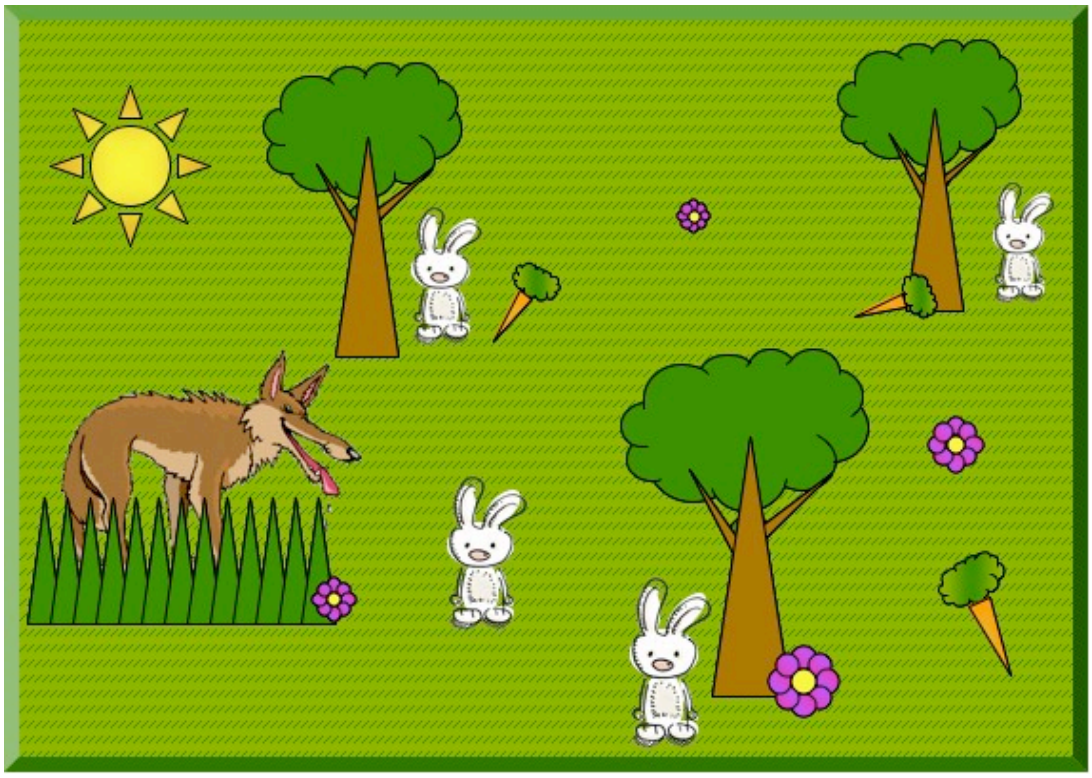
Teacher Instructions

Population Dynamics

Introduction

To encourage student interaction during the lab introduction, we suggest asking the students questions throughout the introduction and explaining concepts using simple drawings. Suggestions for questions to ask the students are highlighted in ***bold text****, and sample illustrations will also be provided.*

Let us pretend that we are looking down at a meadow where a *population* of bunnies lives. We define a *population* as a collection of all the individual animals (organisms) living in a given area – in this case all of the bunnies who live in the meadow. **What is the population of bunnies in the meadow?**



Over time the population of bunnies will change. **What might cause changes in the population? How might the population increase?** The population will increase with the birth and migration of bunnies into the meadow. **How might the population decrease?** The population will decrease with the death and migration of bunnies out of the meadow. **What might cause these changes to occur?** Lack of resources, such as food, may also cause bunnies to migrate out of the meadow. **What might cause the bunnies to die?** Bunnies in the meadow may die due to a lack of food (starvation) or *predators* (such as the wolf in the illustration below looking for a snack!). **What animals might be predators of the bunnies? What are some other examples of predator/prey relationships?** We refer to the changes in a population over time as the *population dynamics*.

What would happen if there were no predators of these animals, i.e. if the population was "unchecked"? Let's return to the four bunnies in the meadow. If there are no predators and the food source is unlimited, then the population of bunnies will grow in a non-linear fashion. During this time the population of bunnies will double at each time point. This occurs because we assume that each bunny will give birth to one offspring at each time point. **If we start with one bunny at time 0 and it reproduces,**

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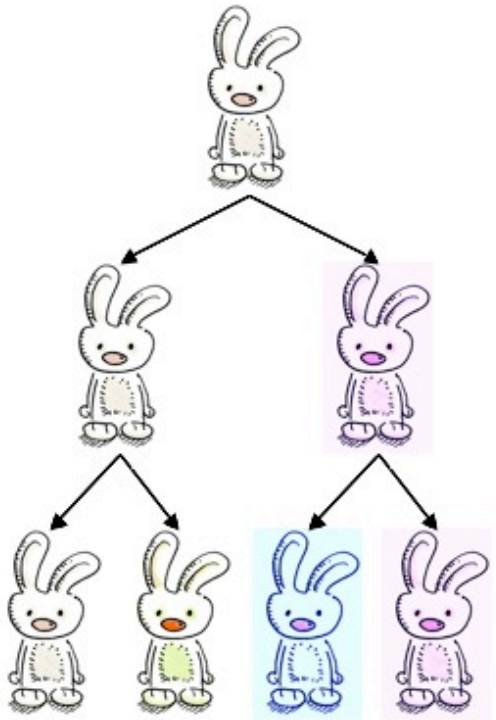
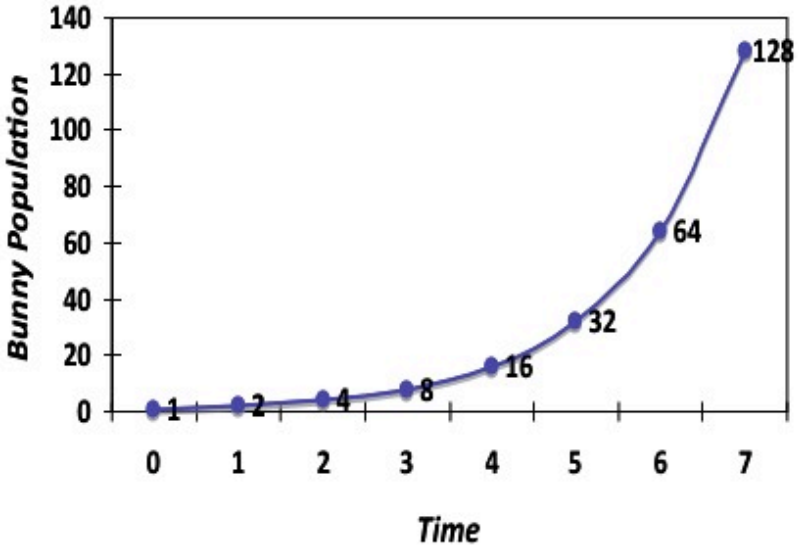
how many bunnies will there be at time point #1? #2? #3?





However, if there is competition for food and other resources the population will fluctuate around some *carrying capacity*. **What are some examples of things that bunnies might like to eat?** In the top figure there are four bunnies and only three carrots available. If each bunny needs to eat one carrot to survive, then the meadow can only support three bunnies and the *carrying capacity* is three rabbits. If the current population of bunnies in the meadow is four, as in the illustration, then one bunny will either starve or migrate out of the meadow.

In the lab today, you will see how introducing a population of predators (in this case a population of wolves) into the meadow will affect the dynamics of the bunny population and how the two populations interact with one another.

Population Dynamics Simulation

Materials

One 11” x 17” sheet of paper: “the meadow”
30 2.5” x 2.5” gray paper squares: “the wolves”
75 1” x 1” pink paper squares: “the bunnies”

Overview:
This simulation requires three or more participants. The three necessary roles are ***wolf manager***, ***bunny manager*** and ***data manager***. The wolves (pink squares) will be randomly dropped onto the meadow (large sheet) covered in bunnies (gray squares) to represent wolves catching and eating bunnies, which is necessary for the wolves to survive and reproduce. This process will be repeated for 20 rounds, and in each round, a varying number of wolves will be dropped onto a varying population of bunnies. The populations of wolves and bunnies in each round will depend on the previous round’s results.

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It is necessary to assume certain requirements for both species' survival and reproduction. In this simulation, we will use the following assumptions:

A bunny does not survive if it is "eaten" by wolves, which is represented by a wolf partially covering that bunny after being thrown onto the meadow.
A bunny reproduces (generates a single additional bunny in the next round) if, after the entire population of wolves is thrown onto the meadow, it is not eaten. However, once the bunny population reaches a total of 75, no more bunnies can reproduce.
If no bunnies are left surviving after a round, three new bunnies repopulate the meadow by migration for the next round.

A wolf does not survive if, after being thrown onto the meadow, it has eaten (is partially covering) two or less bunnies
A wolf reproduces if it eats 3 or more bunnies after a single throw into the meadow. It generates an additional wolf in the next round for every multiple of 3 bunnies that it is partially covering. (*Example:* 3 bunnies = 1 wolf, 5 bunnies = 1 wolf, 6 bunnies = 2 wolves).
If no wolves survive a round, a single new wolf migrates to the meadow, and attempts to catch bunnies in the next round.

All of these assumptions are included in the calculations within the Excel workbook, "LPCH Predator Prey 2009.xls", so you don't need to keep track of all the rules as you play. Simply follow the "Specific Tasks" outlined below.

Setup:

Data Manager: Open the Microsoft Excel workbook "LPCH Predator Prey 2009.xls". The "Data Entry" sheet should be displayed, with headings for each of the 20 round numbers displayed along the top row, above periodic yellow columns under the heading "Bunnies Caught". These yellow columns will be the only cells you will be altering. ***Do not change any other cells***, as they may affect the accuracy of the calculations this data sheet will be conducting.

Concept Questions:

1. Open the sheet "Results Plot" in the Excel Workbook. This shows the populations of wolves and bunnies throughout the rounds. Either print out the plot that is shown, or describe and sketch it.
   Both the wolf and bunny populations will move up to a maximum, then decrease down to their original level, and most likely start this cycle over again by Round 20. It's unlikely that a second period of this behavior will occur before the end of the simulation. Generally speaking, both populations exhibit oscillatory behavior. Also, the wolf population oscillations should have roughly the same frequency as the bunny population, but lag behind the bunny oscillations.
2. What happens to the bunny population when the wolf population increases?
   The bunny population slows its rate of increase and then decreases as the wolf population increases.
3. What happens to the wolf population when the bunny population decreases?
   The wolf population slows its rate of increase and then decreases as the bunny population decreases.
4. Does the wolf population ever outnumber the bunny population? For how long? If this period of time is very short compared to the entire simulation, why do you think that is the case?
   It is most likely that the wolf population will outnumber the bunny population for a short

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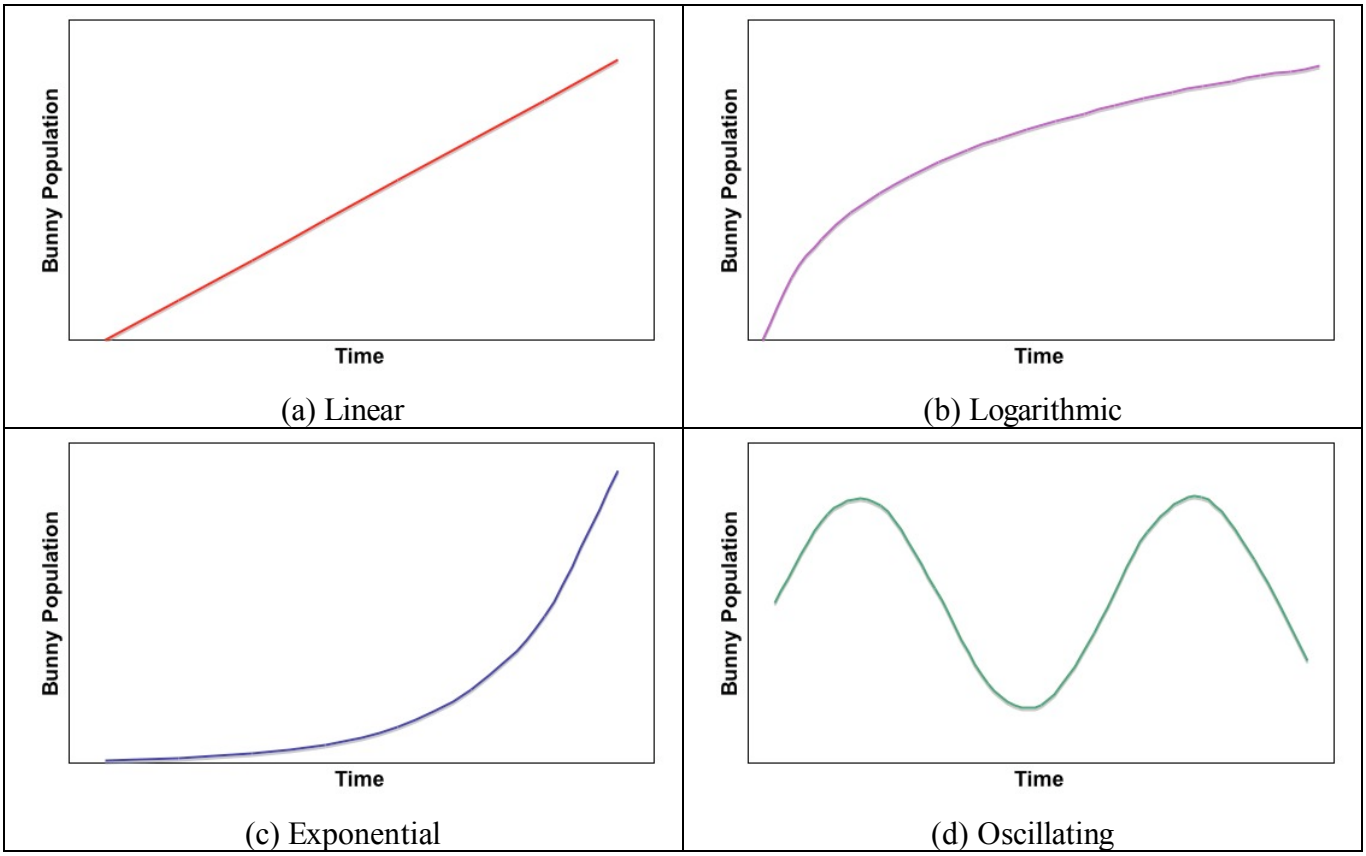
period of time, though there is probably a small chance that this will never happen during the simulation. The reason this period of wolves outnumbering bunnies is because each wolf requires three bunnies to survive into the next round. Unless there are three times as many bunnies as wolves, some wolves will definitely not survive into the next round. When the number of bunnies doesn't even match that of the wolves, then there is an extreme shortage of food for the wolves, and an absolute maximum of 1/3 of the current wolves have a chance of surviving, thereby reducing their numbers drastically in the next round.

5. Which graph from below (a, b, c, or d) best illustrates the bunny population given no predators and unlimited resources? Which one most closely illustrates the results of the simulation you just performed?

   Without predators, and unlimited resources, the bunny population will follow an exponential curve (c). The simulation, however, included predators and a limit on resources, so the resulting curve is oscillatory (d).



References:

Gatton, M. *Predator-Prey Population Dynamics*, Professional Performing Arts School, New York, NY. Adapted from: http://educ.queensu.ca/%7Escience/main/concept/biol/b11/B11LACG2.htm,