Guided Inquiry Activity
Predator Prey Interactions

Background: Predator prey relationships are dynamic meaning that the number of predators can affect the population of prey (because they eat some of them) and the number of prey can affect the population of predators (because if they have more to eat, the predators can reproduce more). This interaction can result in stable coexistence, extinction of both species, or population cycles. We will see how this can happen.

Key terms: Predator - an animal who eats other animals (or plants)
Prey – they one who gets eaten

There are three ways to model this system:

**The verbal model:**

Critical thinking questions:
- What happens to the prey population when there are a lot of predators?
- What happens to the prey population when there are a very few predators?
- What happens to the predator population when there are a lot of prey?
- What happens to the predator population when there are a very few prey?
- Describe what might happen over time with these four interactions going on.

**The Graphical model.** Now let’s look at the graphical model. We will use a phase plane graph, where the X axis is one of the species rather than time, and the Y axis is the other species. But first let’s focus on the X axis which graphs the number of prey. I have divided they graph into two section with a vertical line.
- Referring to the last two questions above, when there are few prey, what happens to the predator population? How can you represent this on the graph? Hint: put a point to the left of the dotted line and draw an arrow in the direction which shows an increase or decrease in predators. Do this for several more points on the left.
- Now do the same thing for when there are lots of prey.
Now let’s do the same thing for how the predators effect the prey population.

- In the graph below, when there are few predators, what happens to the prey population? How can you represent this on the graph? Hint: put a point below the dotted line and draw an arrow in the direction which shows an increase or decrease in prey. Do this for several more points on the bottom.
- Now do the same thing for when there are lots of predators.

Now put the two graphs together. In the combined graph below, there are four quadrants. Put one point in each of these and combine the results above to see what direction the combined predators and prey populations will go. Remember that an
arrow to the right and one going up result in a diagonal going up and to the right. It will be useful to put predator changes in one color, prey in another and combined in a third.

Start at a point in the lower left quadrant and draw arrows, so that the base of one starts at the point of the previous one. Make the arrows short. Each one might represent a generation. When your arrows cross into another quadrant, keep making arrows in that one until you resolve what is going on.

Thinking question: What are all the possibilities for the final outcome of this predator prey interaction?

Now let’s put this into a format that we are more used to: a graph with times as the x axis. Number your points in the above graph in sequence and graph the prey population below. What form does it take? You do not need real numbers, just put a point above the line when prey is high and one below when it is low (put higher points when the population is very high, and medium points when it is intermediate).

Now do the same thing for the predator population (on the same graph). Keep the points in line (point 1 for both predators and prey should be at the same point on the x axis).
The Mathematical Model  Finally, let look at this model of predator prey interactions with the equations, the symbolic technique. Start with the simple equation for population increase below, ignoring carrying capacity (predators probably keep prey populations well below carrying capacity). Let’s do the prey first.

\[ \frac{dN_{\text{prey}}}{dt} = r_{\text{prey}} \times N_{\text{prey}} \]

See if you can add a factor to this equation that accounts for the number of prey eaten by predators each generation. Hint, you should subtract something, but what does that something depend on? (What determines how many prey are eaten?)

See if you can do the same thing for the predator population. In the book, this is formulated from the starting point of an expanded equation:

\[ \frac{dN_{\text{predator}}}{dt} = b_{\text{predator}} \times N_{\text{predator}} - d_{\text{predator}} \times N_{\text{predator}} \]

where \( b = \) birth rate of the predator and \( d = \) death rate of the predator. This is really the same equation, because \( r = b - d \). What other factor might affect the birth rate of the predator? (At this point we can assume that the death rate is not affected by how much food they get). Re-write the birth rate part of the equation to add this factor.

These equations produce the cycles that you graphed and that can be viewed at this site [http://www.sumanasinc.com/webcontent/animations/content/predatorprey.html](http://www.sumanasinc.com/webcontent/animations/content/predatorprey.html) and many others.