Go Beyond: Thinking in Systems Part 1

How did phosphorus shape early agriculture?

Systems and Cycles

Systems and cycles form an important part of science. A system is the setting in which cycles occur. A cycle can be changes in state, such as the water cycle: for example, liquid to solid to gas and back again. A cycle can also be a change in life phase such as the life cycle: birth to adulthood to reproduction, then death. Cycles can also involve changes in composition, such as the carbon cycle could involve the change of CO_2 to $CH_2O + O_2$ (organic matter) to decomposition, where carbon is broken down and released as CO_2 or CH_4. Systems include both a cycle and all the factors that may influence the cycle. In order to study and better understand them, systems can be represented by simple models.

The basic idea of this activity is to develop a systems model with inputs, outputs, stocks (or "pools"), and flows (or "fluxes").

In the series of videos on phosphorus, Dr. Crews uses a technique common to many scientists to simplify a complex system for further understanding it or better communicating it to others. In this activity you will think about how to use a simple model to illustrate a complex system found in your everyday life.

In part 1, you will diagram this system in its simplest form, assuming the system is fully functioning. In part 2, you will think about what can cause this system to not work well, adding complexity to your simple model to use it as a tool to explain the cause of proper/improper functioning.

Part 1: Diagramming a System

TERMS *adapted from Thinking in Systems by Donella Meadows, pg 177-178*

- *System*: "A set of elements or parts that is coherently organized and inter-connected in a pattern or structure that produces a characteristic set of behaviors."
  Everyday examples: The U.S. interstate highway system, a desktop printer, your Facebook news feed, a human digestive system
- *Stock*: "an accumulation of material or information that has built up in a system over time"
  Everyday examples: the number of cars in a parking garage, a ream of paper, a plate of food
- *Flow*: "material or information that enters or leaves a stock over a period of time" *(a.k.a. pool)*
  Everyday examples: the rate of cars entering a highway from an on-ramp, the rate in pages per minute a printer can accomplish; the number of new posts made by friends on your Facebook newsfeed every hour *(a.k.a. flux)*

Go Beyond: Thinking in Systems Part 1--continued

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Instructions

1. Think of a system in your everyday life that sometimes works well and sometimes doesn't work well or at all.

2. Take a picture of or draw something that represents that system. Put that image in a power point slide, like Dr. Crews did. *Alternatively, images and can be added to a science journal.*

3. Identify the basic function of the system and basic flows in and out of the system. Flows might be money, energy, parts of a product or something else. Add these flows to your image as arrows. If you have numbers for each aspect, be sure to include these numbers clearly.

Example:
Some cities offer a bike-share system to help residents and visitors get around without using cars or buses.

In such systems, bikes are the item that moves throughout the system (like phosphorus through the air, water, and soil).

Unlike phosphorus, the bikes (hopefully) do not change form: they move from one area to another within the bike system and under special circumstances (purchase or theft) bikes may join or leave the system altogether.

4. Identify places in the process where your moving component (energy, money, etc.) might be lost or changed into something new.

5. What processes that happen within the system might affect its functioning? What would slow down or speed up the process? Is there anything that would shut the system down altogether?

6. Think about ways that people, even you, could alter or improve this system to get a desirable outcome. Share your ideas with a friend or in a journal.