"Coming Together and Moving Forward"

Systems Thinking & Dynamic Modeling

A Conference for K-12 Education

June 25 - June 27, 2000

The Dynamics of Health Education

Harriet Tubman Middle School

Waters Foundation

Systems Thinking & Dynamic Modeling K-12 Education Project

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Outline

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Portland Public Schools

8th Grade Health Sciences

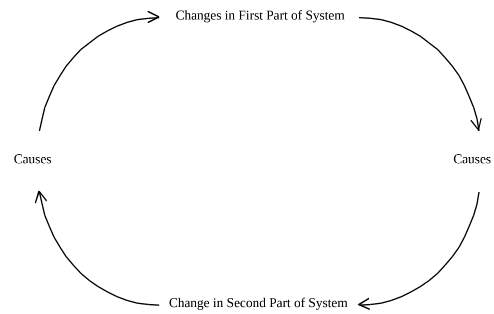
What is a System?

"A System is a collection of things which interact with each other to function as a whole"

"If one part has an effect on the rest of the system and the system as a whole has an effect on that one part, then a "circular" relationship - or "loop" - has been created.

The Art of Systems Thinking, O'Connor & McDermott (Hammersmith, London, Thorsons Publishers 1997)

Feedback



"All systems have a goal-even if that goal is only to survive. The goal is it's desired state, when the system is at rest or balanced. Balancing feedback acts to reduce the difference between where a system is and where it should be. It drives the system towards the goal".

The Art of Systems Thinking, O'Connor & McDermott (Hammersmith, London, Thorsons Publishers, 1997)

Is this tree a System?

Is this a system?

Why or why not?

A System vs. Heap

A System	**A Heap**
Interconnecting parts functioning as a whole.	A collection of parts.
Changed if you take away pieces or add more pieces. If you cut a system in half you do not get two smaller systems, but a damaged system that will probably not function.	Essential properties a unchanged whether you add or take away pieces. When you halve a heap, you get two smaller heaps.
The arrangement of the pieces is crucial.	The arrangement of the pieces is irrelevant.
The parts are connected and work together.	The parts are not connected and can function separately.
Its behavior depends on the total structure. Change the structure and the behavior changes.	Its behavior depends on its size or on the number of pieces in the heap.

A Heap vs. A System

Exponential Growth

“When something grows exponentially, it grows steadily. It increases at a fixed rate - in a fixed interval of time.”

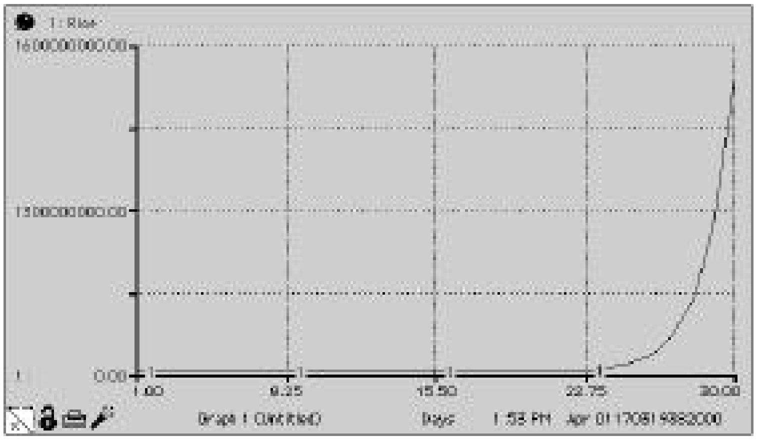
Doubling Time: The time it takes something that is growing steadily to double.

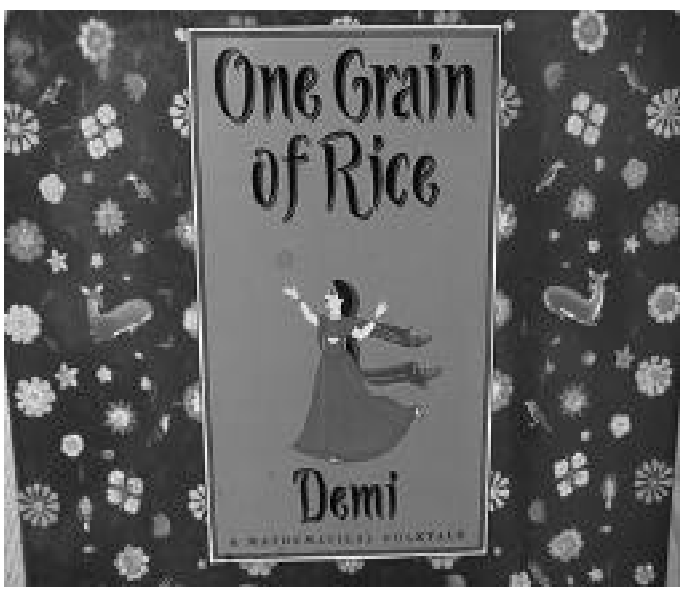
“Anything that is increasing will double eventually if it keeps growing.”

Source: Science & Technology: Systems and Change, BSCS, Kendall/Hunt Publishing Co., 1999

“If you graph the quantity of anything that grows exponentially for a long enough period of time the graph always will be shaped like the letter J.”

Source: Science & Technology: Systems and Change, BSCS, Kendall/Hunt Publishing Co., 1999





How Quickly Can Bacteria Multiply

Your teacher will give you some beans and paper cups. Number the cups 1 through 8.
Each bean will represent a bacterial cell.

Put one bean into cup 1 to represent the first generation of bacteria. Approximately every 20 minutes, a bacterial cell reproduces by dividing into two cells. Put two beans into cup 2 to represent the second generation of bacteria.

Calculate how many bacterial cells there would be in the third generation if each cell in cup 2 divided into two cells. Place the correct number of beans in cup 3.

Repeat step 3 five more times. All the cups should now contain beans.

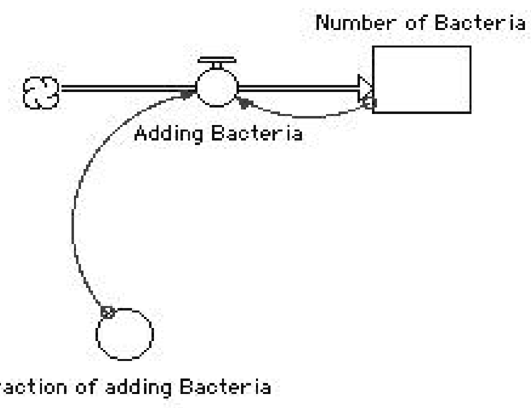
How many cells are in the eighth generation?

How much time has elapsed since the first generation?

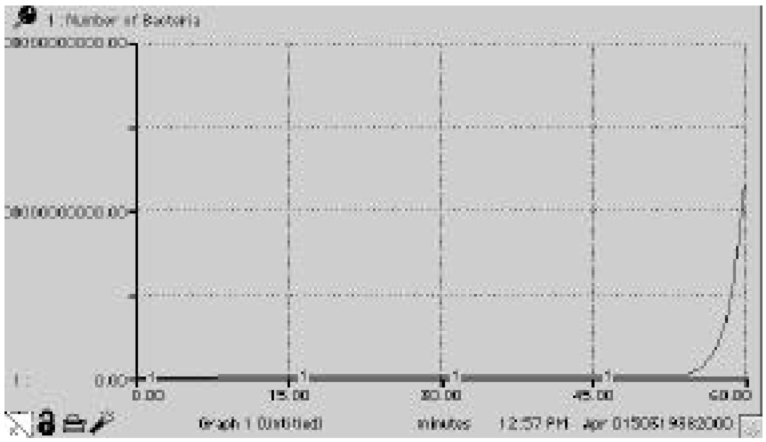
Think it Over: Inferring - Based on this activity, explain why the number of bacteria can increase rapidly in a short period of time:

Source: BSCS Middle School Science & Technology / Systems and Change, Kendall / Hunt Publishing Co. 1994

Bacteria Model
Generic Population Model



Bacteria Model
Behavior Over Time Graph



Bacteria Model
Equations

Number_of_Bacteria(t) = Number_of_Bacteria(t - dt) + (Adding_Bacteria) * dt
INIT Number_of_Bacteria = 1
INFLOWS:
Adding_Bacteria = Number_of_Bacteria*Fraction_of_adding_Bacteria
Fraction_of_adding_Bacteria = 1

Simple Infection Game

Here are the steps for the Infection Game:

1) Greet 5 people per cycle with a hand shake

2) If you get your hand squeezed twice, you've become infected

3) Infected people pass on their infection (through a double hand squeeze) to only one person each cycle.

Don't start infecting people until the next complete cycle after the cycle in which you became infected

4) We will simulate this game through 6 cycles

Cycle	Number of people infected
1	
2	
3	
4	
5	
6	

How do Infectious Diseases Spread

1. Put on goggles and plastic gloves. Your teacher will give you a plastic dropper and a plastic cup half-filled with a liquid. Do not taste, smell, or touch the liquid.

2. In this activity, you will model how some diseases spread. Your teacher will signal the start of a "talking" period. Choose a classmate to talk with briefly. As you talk, exchange a dropper full of the liquid in your cup with your classmates.

3. At your teacher's signal, talk to another classmate. Exchange a dropper full of liquid.

4. Repeat step 3 two more times.

5. Your teacher will add a few drops of liquid to each student's cup. If your fluid turns pink, it indicates that you have "contracted a disease" from one of your classmates. Wash hands when you have finished the activity.

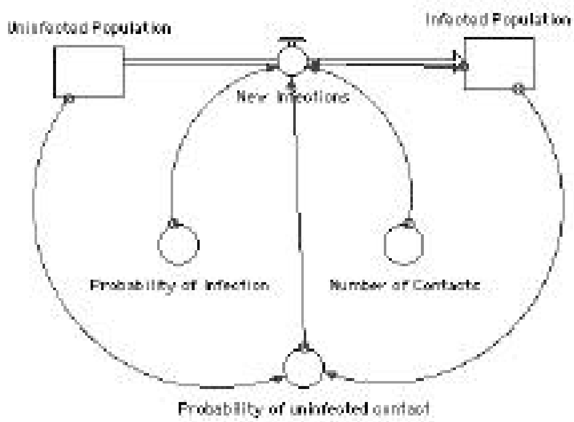
Think it Over

How many more rounds would it take for everyone in your class to "become infected"?

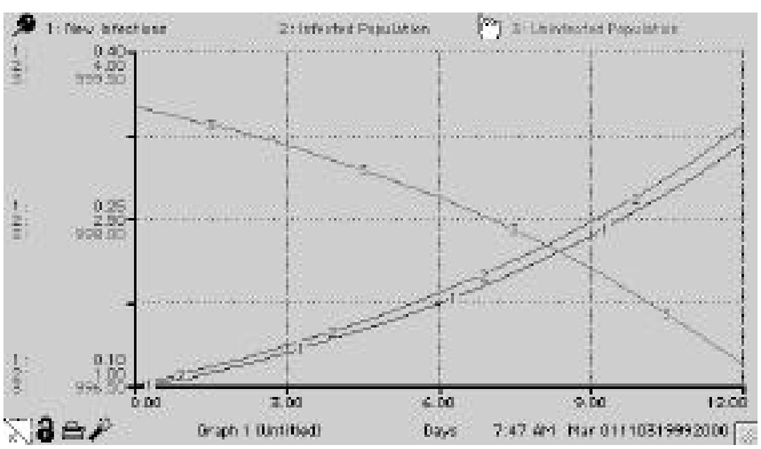
Use your prediction to explain why some diseases can spread quickly through a population:

Source: Science & Technology: Systems and Change, BSCS, Kendall/Hunt Publishing Co., 1999

Infection Model



Infection Model
Behavior Over Time Graph



Infection Model
Equations

```
Infected_Population(t) = Infected_Population(t - dt) + (New_Infections) * dt
INIT Infected_Population = 1
INFLOWS:
    New_Infections =
    Probability_of_uninfected_contact*Probability_of_Infection*Number_of_Contacts*Infected_Population
Uninfected_Population(t) = Uninfected_Population(t - dt) + (- New_Infections) * dt
INIT Uninfected_Population = 999
OUTFLOWS:
    New_Infections =
    Probability_of_uninfected_contact*Probability_of_Infection*Number_of_Contacts*Infected_Population
Number_of_Contacts = 5
Probability_of_Infection = .02
Probability_of_uninfected_contact = Uninfected_Population/(Uninfected_Population+Infected_Population-1)
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