Mathbiology: How to Model a Disease

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INTRODUCTION

In the common view of the sciences, physics and chemistry are thought to be heavily dependent on mathematics, while biology is often seen as a science, which only in a minor way leans on quantitative methods. Therefore, high school students intending to study biology generally do not feel a need to prepare themselves with courses in mathematics. Once that may have been true, but based on current research today the situation has substantially changed. In contemporary biology, there are many areas, which depend heavily on rather advanced mathematics. This unit will explore the use of *mathematical modeling* to study diseases. Students will have the opportunity to explore basic techniques used to build simple math models from biology story problems. Those who do not have a fundamental grasp of algebraic equations will require a review, but a basic understanding of elementary math operations is a good start: addition, subtraction, multiplication and division. The examples in this curriculum unit are only a small selection of the areas of biology in which mathematics plays a crucial role. Because of the importance of mathematics in contemporary biology, it is vital that high school students who may seek to become prospective students in the biological sciences get as much mathbiology as possible. The math courses that are taken in high school form the basis of a student's mathematical future. Not all students who are thinking that they may study any of the biological sciences take advantage of all math courses, which are open to them while they are in high school. Four full years of high school math are a requirement for any student who might want to pursue a career involving biology. Only with this preparation will they be able to take the advanced mathematics courses offered at universities that they will need to be successful in any biological field.

AUDIENCE

The initial delivery of this curriculum unit will go to ninth grade students enrolled in Algebra I classes. These students will be recruited from middle schools as students who are undergoing the difficult transition from middle school to high school. These students will complete their ninth grade math credits in our *Ninth Grade Academy of Leadership*. The academy is developed to ease the transition from middle school to high school and help more students stay in school and earn promotion by serving students in the Ninth Grade Academy of Leadership. The academy's primary focus is to serve as a bridge that spans the rough waters of adolescence and prepare students academically and socially for the rigors of high school and their future college interests.

Enrichment Students

This curriculum unit will be delivered in a "mixed-ability" classroom. Therefore, there will students who are taking Algebra I class in the Leadership Academy who are classified as Magnet students. This will make the learning of mathbiology even more extensive as we explore other diseases and advanced mathematical models. A combination of Geometry and Algebra skills will be comprised for extra project work for students who require enrichment activities. There are also scores of software packages that are cited in the bibliography of this unit, which will help enhance the Magnet students' understanding of biomathematics, modeling, graphs, and analyzing a disease model. Magnet students are likely involved more with computers and technology than the other students. There are spreadsheets and small Visual Basic applets that can be developed to calculate and give a visual representation of the propagation of disease. As individuals or as a group, these students will be directed to use their application development skills to create small applications that show their understanding of using differential equations and algebraic formulas to write-up their research. Students will be given specific scenarios of the spread of diseases in our current environment. AIDS, cancer, mononucleosis and sickle cell anemia are a few examples on which students can select to do more expanded research. Oral presentations with the use of an LCD (liquid crystal display) projector for PowerPoint presentations will be a means used for enrichment when students present their research findings to the class.

Content Mastery Students

These students present a different set of challenges than the *Enrichment Students.* A stronger emphasis on motivational activities will be crucial for arousing the participation for the *Content Mastery Student* (Special Education). The Content Mastery Student can receive additional assistance from a content mastery teacher who specializes in working with students who have special needs. A great advantage for the Content Mastery Student who will participate in this unit is that the unit offers an enormous amount of visuals, films, Internet research, geographical drawings, basic math skill practice, and group work. These students tend to work better as a group, and when they are assigned smaller tasks to complete. The teacher needs to become well abreast to these students' strengths and weaknesses. For example the graphical representations of the disease using graph paper and plotting points may be a simple task that these students can graph to visually represent the propagation of the disease. Their participation in a group setting could be to list keywords related to the disease they are researching before we go to the computer and start to find sites relating to the disease. Also, the software programs introduced with this unit have some game formats, and these could be used to pique or maintain the content mastery student's interest. The use of several hands-on manipulatives will help guide the students through the understanding of the mathematical concepts taught in this unit.

Central Features of the Ninth Grade Leadership Academy

A school within a school. The academy is self-contained, with its own administrative and teaching staff, its own entrance, and walls and doors that physically separate it from the rest of the school building. This structure enables teachers and students to know each other well and fosters collaboration among faculty. The Ninth Grade Academy of Leadership is organized around an interdisciplinary team made up of at least four teachers – a math, English, a science, and a social studies teacher – who share the same group of 150-200 students. These teachers will share a common planning period, which they use to address individual student problems, coordinate instruction, and plan other team activities. Teachers on the same team, teach the same groups of students during the same block of time each school day. This allows students to be regrouped according to instruction needs and provides flexibility in the day for longer lessons or special activities.

EXPLANATION OF MATHBIOLOGY PREREQUISITES

The mathematical prerequisites for this curriculum unit are a basic understanding of probabilities, sequences, story problems, and formulas (equations). Students will be required to use the following Microsoft Office ® products: Word, Excel, and PowerPoint.

This curriculum unit is about using the mathematics that the students have previously learned in eighth grade and are currently learning in their ninth grade courses involving population studies:

- Fundamentals of mathematics
- Pre-Algebra
- Algebra

This curriculum will cover an idealized population of rabbits to introduce mathbiology concepts. The teacher will need to guide the students to make assumptions by providing them with a story problem of about the groups of rabbits. The primary model this unit focuses on using is an **SIR model**, which is a model that is used in mathbiology to analyze information about diseases in a population. Much emphasis in this curriculum unit will be placed on how well the students critically examine solutions to the problem the teacher will provide them about the rabbit population and how they visually represent their findings.

Main Aims of Mathbiology

The main aims of this curriculum unit are for the students to:

- enjoy mathematics
- develop critical thinking skills

- develop mathematical communication skills, both written and verbal
- develop creativity
- develop group work skills

Assessment

The assessment will be based on six components:

- participation (5%)
- creating models (20%)
- group modeling report (40%)
- research write-ups (10%)
- use of technology (5%)
- visual representations of models (20%)

Objectives

By the end of the curriculum unit "diligent students" will:

- know the steps for developing a basic SIR model of diseases
- know how to make and simplify a story problem so that a mathematical model can be constructed
- know how to change the parameters in a model based on changes in the spread of a disease
- know how to practice their written mathematical skills
- know how to practice their verbal mathematical skills

Transferable Skills

This unit is designed to build the student's confidence and competence in basic mathbiology and enhance their knowledge of how math is used in other disciplines. Students will have the abilities to:

- write mathematical equations and formulas for solving biology related story problems
- communicate mathematical information verbally and written to peers
- work in a group setting
- think critically
- design and present information to a class

OVERVIEW OF A BASIC S.I.R. MATHEMATICAL MODEL

Almost all mathematical models of diseases start from the same basic premise: that the population can be subdivided into categories, dependent upon their experience with

respect to a disease. The most simple of these models classifies individuals as one of **susceptible**, **infectious**, or **recovered**. This is why it is called the SIR model. Groups are born into the susceptible class. Susceptible groups have never come into contact with the disease and are able to catch the disease, after which they move into the infectious category. Infectious groups spread the disease to susceptible, and remain in the infectious category for a given period of time before moving into the recovered category. Finally, we will look at the offspring from each category that can vary based on how the disease spreads. Math concepts are better understood if the students can relate them to something in real life. For this unit, the categories are visually represented using Happy, Sad, and Blank symbols along with SIR labels. This visually representation will be used throughout this unit, so if there is a reference to the "happy" category we are also referring to the "recovered" category as well.

Categories of the SIR Model

Susceptible **Infected** **Recovered**

This curriculum unit will teach students how to make this description more mathematical by formulating *equations* about a biological story problem dealing with generations of rabbits who have been categorized as Susceptible, Infectious, or Recovered. Tables that represent the model will be completed using Microsoft Excel spreadsheets, and visuals will be created using PowerPoint presentations.

Steps for Modeling a Biological Story Problem

To make the model, we begin with a scenario that will provide some biological information about our population. The second step is where we define the categories for our population. We should be able to divide the population into three groups, at any given time. Third, we will develop an initial table in an Excel spreadsheet to represent our story problem using algebraic equations. Fourth, we will analyze the information and identify the patterns we see in the spreadsheet and list equations we used to complete the sequence. Fifth, we will complete a PowerPoint presentation to visually explain our process for completing the model.

Step One: Review the Biology Story Problem

"In this biological story problem we are asked to create an SIR model for a group of rabbits that have been plagued by an unknown disease. Most of the rabbits are born with the disease; however in this group of rabbits, we have found even though there are some who are susceptible to the disease, their babies are born infected. Some of the infected

rabbits have babies that have recovered from the disease, and likewise the recovered rabbits may have infected babies. Susceptible, infected, and recovered rabbits are chosen to study from the whole population. The disease causes the rabbits to have only two babies for each generation. *Each rabbit dies after giving birth to the two babies*.
We are asking a class of mathematicians to use their mathbiology skills to help us understand patterns of the disease and possibly predict how the disease will spread. We need an SIR model spreadsheet that shows at least 12 generations and the formula for finding the n^{th} generation. We also need to know your predictions about the population if the first generation starts with a recovered rabbit, an infected rabbit or a susceptible rabbit."

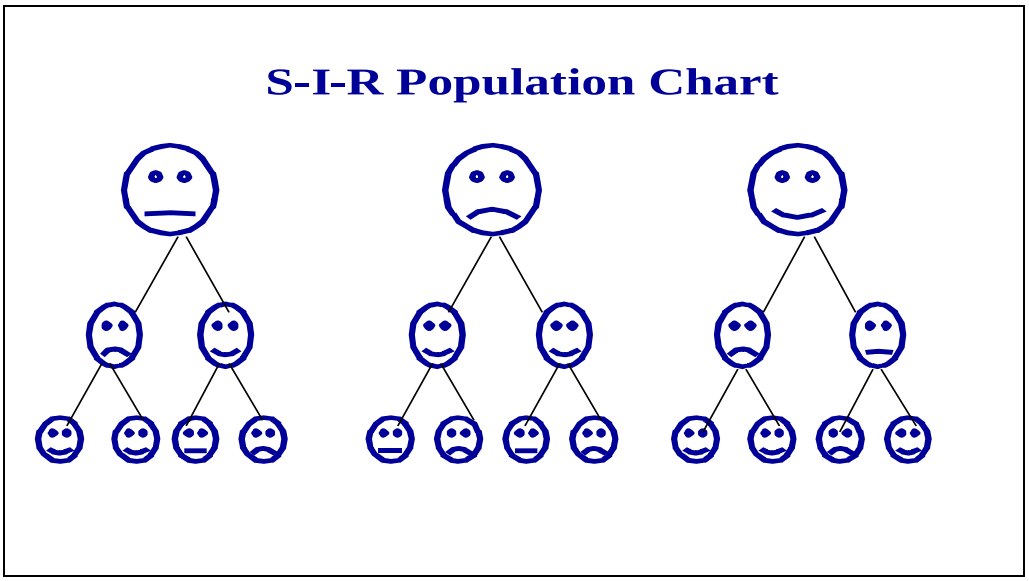
The information for the model is:

- A susceptible rabbit has two babies: an infected rabbit and a recovered rabbit.
- An infected rabbit has two babies: both are susceptible rabbits.
- A recovered rabbit has two babies: an infected rabbit and a susceptible rabbit.
- The first generation starts off with *one recovered rabbit*, which has two babies and forms the second generation.
- The rabbits die when they have two babies.
- All of the rabbits live the same amount of time.

Step Two: Categorize the Population

The most obvious division of the three rabbits is susceptible, infected, and recovered. The students will first create a visual using PowerPoint that shows the division of the population. The visual will be used as a reference for developing the mathematical equations and entering the information in an Excel spreadsheet.

Below is a visual representation of the first three generations based on the biology story problem. Here we are using happy for recovered rabbits, sad for infected rabbits, and blank for susceptible rabbits. This visual will be used as a reference for students when they begin adding numerical data in a spreadsheet.



Step Three: Develop the SIR Spreadsheets

Students will create a set of spreadsheets using Excel. The teacher will assist students in developing the first three worksheets using algebra and the following variables. After opening Excel, students will create three worksheets: SIR Table, SIR chart, and Information spreadsheet. (If necessary, see Excel help files for more information on creating a worksheet.)

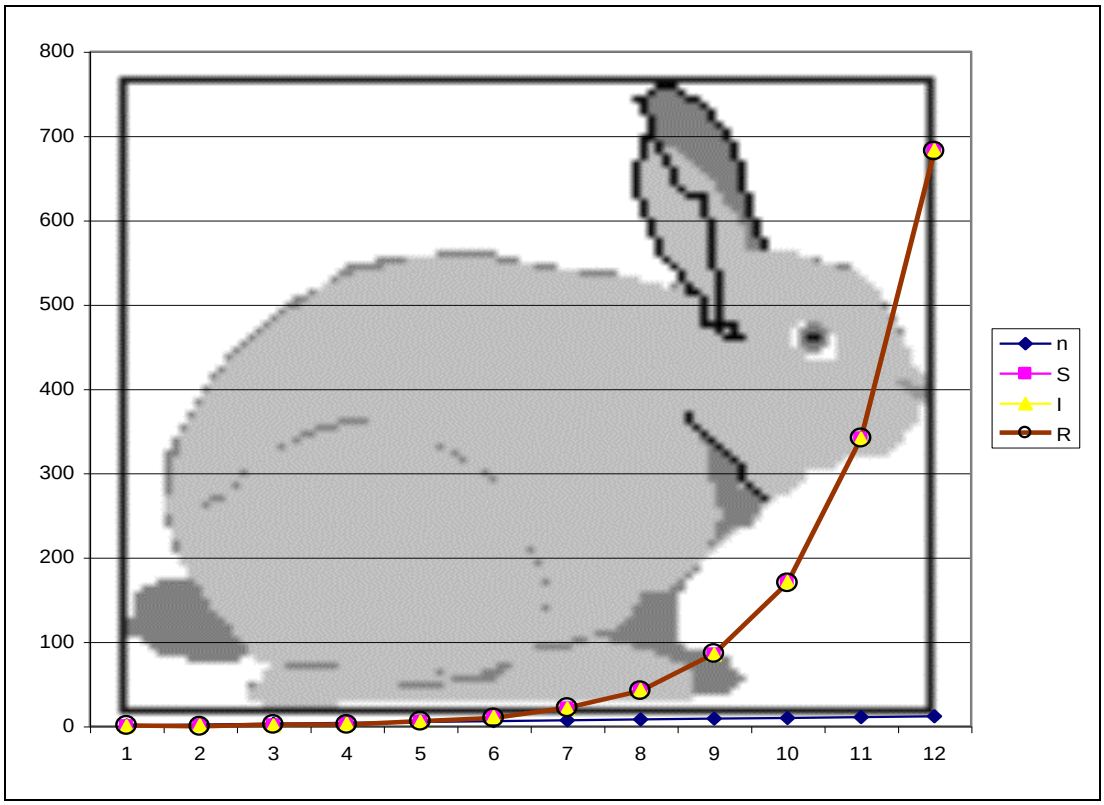
This is an SIR Table spreadsheet.

Mathematical Model for Biology Story Problem

n	1	2	3	4	5	6	7	8	9	10	11	12
S	0	1	1	3	5	11	21	43	85	171	341	683
I	0	1	1	3	5	11	21	43	85	171	341	683
R	1	0	2	2	6	10	22	42	86	170	342	682
Totals	1	2	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^10	2^11

Note: See the SIR Information sheet for step-by-step instructions for entering data.

SIR Chart spreadsheet



SIR Information spreadsheet

This is information is for the S-I-R model pertaining to the rabbit population. There are two additional sheets: SIR Table, and SIR chart. Both sheets show the solutions to the Biology story problem.

Here are the steps we took to complete the model:
1) we placed the variable as row headers- n = generation, s = susceptible, i = infected, r = recovered, and "Total "as the last row.
2) the 1st generation is 0-suspectible, 0-infected, and 1-recovered, this information was given.
3) Using a picture we visually represented the first five generations and added to the table.
4) We found that the recovered row of information for each generation is one more and one less (alternating) for the susceptible and infected as we moved up the generations.
5) We started looking for a sequence by totaling the columns, which gave us (1, 2, 4, 8, 16...)
6) We got the numbers in the sequence by using 2 as a base number and (n-1) as an exponent.
7) We came up with an equation: 2^n-1 to complete the table to the 12th generation.
8) We selected all of the information in the spreadsheet except the Totals, and added another worksheet for the S-I-R chart using a line graph.
9) We copied the spreadsheets into PowerPoint for our presentation.

Step Four: Generate Math Equations

The biology story problems asked the students to complete a model based on information about the rabbits' babies up to the twelfth generation. Also, we ask the students to create models if the first generation was susceptible or infected versus recovered. Depending on the generation (whether it is an Odd or Even number), the students will use the following equations:

(n) even	**(n) odd**
$S = (2^{n-1}+1)/3$	$S = (2^{n-1}-1)/3$
$I = (2^{n-1}+1)/3$	**$I = (2^{n-1}-1)/3$**
$R = (2^{n-1}-2)/3$	**$R = (2^{n-1}+2)/3$**

If we were going to start the first generation with susceptible or infected, we would use the same equations except we would change (n-1) to just n. And swap Odd and Even labels.

(n) odd	**(n) even**
$S = (2^{n}+1)/3$	$S = (2^{n}-1)/3$
$I = (2^{n}+1)/3$	**$I = (2^{n}-1)/3$**
$R = (2^{n}-2)/3$	**$R = (2^{n}+2)/3$**

Step Five: Present Mathematical Findings

The final step required by students is to create a slideshow using PowerPoint that explains and visually represents their math models. Each student will contribute to the group presentation, and this is measured by how everyone presents a part of the presentation. Students may comprise different slideshows separately, and then later add them to one presentation.

LESSON PLANS

These lessons provide the students with a foundation in mathbiology. Students will be introduced to mathematical modeling using patterns, sequences, algebra, equations, and story problems. The lesson plans are written to follow the order as they are listed. This will enhance the student's knowledge and build on previous skills. Each lesson plan will include additional information for Enrichment students and Content Mastery students.

Primary Audience

The primary audience for the lessons are ninth grade Algebra and Geometry students.

Lesson Plan Topics

I. What is Mathbiology?
II. Disease Introductions
III. Making a Model
IV. Look for a Formula
V. Mathbiology "Write-Ups"

Lesson Length

It is estimated that it will take from 2-4 weeks to complete the lessons, and a formal assessment will follow.

Lesson One: What is Mathbiology?

This plan is intended to introduce students to what brings biology and mathematics together as a field of study. Students will be given some simple biology problems involving plagues, diseases, DNA, populations, and graphs involving slopes. Students will review the examples and discuss how mathbiology is used to solve the problems.

Required Materials

Students are assigned a computer in the computer lab. Students will look at website: http://math.rice.edu/Algebra, and review the lessons on biology to see if they can find mathematics as a part of the lessons. A LCD projector will be used so students can follow the teacher and see the steps for starting the research. Visuals depicting matrices, sequences, and patterns involving populations will be used to discuss the topic. Additional materials are a student textbook, computers, and TI scientific calculators.

Objectives

The students will:

- Become familiar with mathbiology and the terminology of the field.
- Research different mathematics used to solve biology problems.
- Make conclusions about mathematical modeling visuals that indicate a study in biology.
- Define mathematical examples of patterns, sequences, graphing and algebraic equations used to solve story problems.

Prerequisites

Students may need a review of how to interpret story problems and graphs. Several examples for examining and picturing information should be used for student discussions.

Teaching the Lesson

Write the word mathbiology on the chalkboard, and ask students what they think the word means. Discuss why they need to know about mathbiology; they can possibly realize the career opportunities involving biomathematicians. State that one of the things biologists and mathematicians do together is create mathematical models that analyze biological problems. Tell the students that today they will get an introduction to Biomathematics, and later we will focus on one model, the SIR model. Direct students to the website www.biomathematics.com using the LCD panel. Briefly discuss the types of models and the course syllabus on the site. Ask the students what types of math concepts do they need to complete the models. Ask the students if they are familiar with any of the math concepts they see on the site. Use the visual representations that show sequences and patterns and ask students how they would solve the questions involving the patterns. (Will they use equations or pictures?)

Lesson Two: Disease Introductions

Students will be introduced to various diseases using a preliminary disease list given by the teacher and gather information about the diseases. This is a group activity. Students can choose a disease and be grouped, or the teacher can assign students to groups.

Preliminary Disease List

The following list contains choices from which students can choose to research. Using the Internet and information gathered through class surveys and discussions, the class will compile a sufficient list of choices.

- Mononucleosis
- Herpes
- AIDS
- Gonorrhea
- Hepatitis
- Measles
- Flu
- Mumps
- Pneumonia
- Salmonella

Students will pick an infectious disease of some interest to them and create a story problem using the data.

Show the video, AIDS: *And the Band Played On*.

Required Materials

Students are assigned a computer in the computer lab. Students will search websites about their chosen disease using search engines such as Yahoo, Webcrawler, Netscape, MSN, AltaVista, Dogpile, and About.com. Issue a preliminary disease list for students to choose from for research. LCD projector.

Objectives

The students will:

- Recognize the spread of disease over various time frames.
- Establish research information using common web search engines.
- Write-up information pertaining to diseases as word problems.

Prerequisites

Review steps for interpreting word problems. Practice steps for writing a story problem.

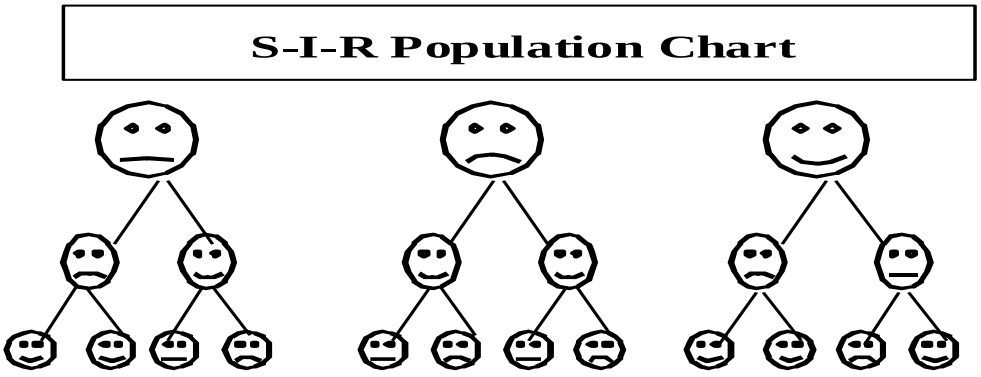
Teaching the Lesson

Introduce the following information for the students to use for writing their own story problems. "In this biological story problem, we are asked to create an SIR model for a group of rabbits that have been plagued by an unknown disease. Most of the rabbits are born with the disease, however in this group of rabbits we have found even though there are some who are susceptible to the disease, their babies are born infected. Some of the Infected rabbits have babies that are recovered from the disease, and likewise the Recovered rabbits may have infected babies. Susceptible, infected, and recovered rabbits are chosen to study from the whole population. The disease causes the rabbits to have only two babies for each generation. *Each rabbit dies after giving birth to the two babies*. We are asking a class of mathematicians to use their mathbiology skills to help us understand patterns of the disease, and possibly predict how the disease will spread. We need an SIR model spreadsheet that shows at least 12 generations and the formula for finding the n^{th} generation. We also need to know your predictions about the population if the first generation starts with a recovered rabbit, an infected rabbit or a susceptible rabbit." The information for the model is:

- A susceptible rabbit has two babies: an infected rabbit, and a recovered rabbit.
- An infected rabbit has two babies: both are susceptible rabbits.
- A recovered rabbit has two babies: an infected rabbit, and a susceptible rabbit.
- The first generation starts off with *one recovered rabbit*, which has two babies and forms the second generation.
- The rabbits die when they have two babies.
- All of the rabbits live the same amount of time.

Students are asked to use the data they found on their disease and create a similar story problem like the example above. Show the pictorial representation of the story problem, and ask students to create a picture that represents their story problems.

Use the following picture below for an example of the story problem



Lesson Three: Making a Model of a Disease

This lesson is intended for students to begin their initial spreadsheet tables representing their biology story problems. A definition of SIR models will be introduced in this lesson.

Required Materials

Students are assigned a computer in the computer lab. Students will look at the website, http://math.rice.edu/Algebra, and review the lessons on biology to see if they can find mathematics as a part of the lessons. A LCD projector will be used so students can follow the teacher and see the steps for starting the research. Visuals depicting matrices, sequences, and patterns involving populations will be used to discuss the topic. Additional materials are a student textbook, computers, and TI scientific calculators.

Objectives

The students will:

- Become familiar with an SIR model using a population of rabbits.
- Distinguish patterns and sequences based on the information in the table.
- Students will list equations for solving the sequences.
- Students will place the data in an Excel spreadsheet.
- Students will begin charting data using Excel.

Prerequisites

Students will need guidance from the teacher for how to sort information into rows and columns using Excel. Students will need to review how to create line graphs in Excel. Review of algebra equations, patterns, and sequences. Use examples of patterns and sequences, and finding the n^{th} terms. Students will use the computers, TI calculators, and chalkboard.

Teaching the Lesson

State the following information:

> Many human diseases are contagious; you "catch" them from someone who is already infected. Contagious diseases are of many kinds. Smallpox, polio, and plague are severe and even fatal, while the common cold and the childhood illnesses of measles, mumps, and rubella are usually relatively mild. Moreover, you can catch a cold over and over again, but you get measles only once. A disease like measles is said to "confer immunity" on someone who recovers from it. Some diseases have the potential to affect large segments of a population; they are called *epidemics* (from the Greek words *epi*, meaning "upon" and *demos*, meaning "the people"). *Epidemiology* is the scientific study of these diseases. An epidemic is a complicated matter, but the dangers posed by contagion – and especially by the appearance of new and uncontrollable diseases – compel us to learn as much as we can about the nature of epidemics. Mathematics offers a very special kind of help. First, we can try to draw out of the situation its essential features and describe them mathematically. This is calculus as a *language*. We substitute an "ideal" mathematical world for the real one. This mathematical world is called a **model**. Second, we can use mathematical insights and methods to analyze the model. This is calculus as a *tool*. Any conclusion we reach about the model can then be interpreted to tell us something about the reality. To give you an idea how this process works, we'll build a model of an epidemic. Its basic purpose is to help us understand the way a contagious disease spreads through a population, to the point where we can even predict what fraction falls ill and when. Let's suppose the disease we want to model is like measles. In particular, it is mild, so anyone who falls ill eventually recovers; it confers permanent immunity on every recovered victim. In addition, we will assume that the affected population is large but fixed in size and confined to a geographically well-defined region. To have a concrete image, you can imagine the elementary school population of a big city.

Write the following definitions on the chalkboard and discuss them with the students.

- Susceptible: Those who have never had the illness and can catch it.
- Infected: Those who currently have the illness and are contagious.
- Recovered: Those who have already had the illness and are immune.

Lesson Four: Look for a Formula

This plan is intended to introduce students to a variable strategy for finding a formula in number patterns.

Required Materials

Students are assigned a computer in the computer lab. Students will use Excel to create tables and charts. A LCD projector will be used so students can follow the teacher and see the steps for creating tables using Excel. Computer game demos.

Show the video, *A Beautiful Mind*.

Objectives

The students will:

- Develop and apply various ways to solve problems.
- Verify and interpret results with respect to the original biology story problem.
- Translate words into equivalent mathematical terminology.
- Model successful problem solving using variables in equations.

Prerequisites

Several work examples using story problems and the quick reference material for solving word problems.

Teaching the Lesson

Issue students the following problem to the students:

> Problem: Show that the sum of any five consecutive odd whole numbers has a factor of 5.

Give the students the information needed to solve the problem. Step 1: Understand the problem. Ask the students, "What factor does any even number have?" Step 2: Ask the students, "What is a good variable to represent whole number?" [W or any letter.] Ask, "Is it true that any even number can be expressed by $2w$?" [Yes.] Demonstrate to students that any odd number can be expressed as $2w + 1$. Write the following sequence on the chalkboard: 9, 11, 13, 15, 17… Ask students to state what the next three terms will be. Challenge students to write an equation to represent how they found the terms. Ask students to use their equation to find the 50^{th} term. Enter the data into a spreadsheet, and calculate each row of information to 50.

Lesson Five: Write-Ups about SIR Model

This is the final part of the mathbiology unit. It is intended for students to report on what they have learned about an SIR model, and is called a "Write-up." The write-ups will be conducted using PowerPoint presentation software.

Required Materials

Students are assigned a computer in the computer lab. Storyboard pages for students to use to design their presentation. Issue examples of mathbiology presentation. Provide websites for downloading clipart to be used in presentation.

Show the video, *Invasion of the Body Snatchers*.

Objectives

The students will:

- Create slide presentations with complete data.
- Present information to classroom of peers.

Prerequisites

Students will need quick review on how to use PowerPoint and how to design information for a presentation.

Teaching the Lesson

Students will follow how to use PowerPoint to explain steps for developing their math model while the teacher uses the LCD projector. Answer any questions students may have about using PowerPoint. Allow each group to choose a day when they will present their information to the class.

Computer Games about Diseases

Computer games that students find entertaining enhancing their interest in learning mathbiology. Most of the computer games come with a demo that can be downloaded from CNET® (see Electronic Sources for URL) for the teacher to review up to 30 days. Some are "freeware" and do not require licenses for students to use in the classroom and can be retained at no charge. Below are a few listings of games with a description of what each game challenges the user to do.

Dr. Goo: The Plague

In Dr. Goo, a new germ has been developed through genetic engineering. Its purpose was for biological warfare; however, the scientists underestimated the effects of the germ, and tested it on unknowing victims. These people became sick within hours and were dead after 24 hours. No vaccine was made. The heroic Dr. Goo has volunteered to collect the required substances to make a vaccine. But the germ is spreading fast and there is not much time! Help Dr. Goo find the ingredients for the vaccine and save the world before time runs out. This platform action video game lets you jump around and manipulate objects in the search for the vaccine.

Mad Cow Disease

This game involves shooting cows and getting blown up. A person has been caught behind enemy lines in Moosylvania, a country notorious for Mad Cow disease. Help the person get back home by avoiding enemy rocket launchers, treacherous oil slicks, and swamps. This game is enjoyable by everyone except those sympathetic towards cows.

Aspirin Protector

Protect the human body from disease with this three-level game. "The game has three levels with different views. First you are inside a vein, then inside the heart and inside the brain. Beside red and white corpuscles you see the white platelets with their arms. Now you have to shoot these white platelets with the Aspirin tablets."

Drug Design Optimization Lab

This games deals with targeting bioterrorist weapons and diseases with no known cures, such as smallpox and anthrax. Does not require a dedicated Internet connection, is unobtrusive and provides a GUI (graphical user interface) to display the drug.

ANNOTATED BIBLIOGRAPHY

Aichele. *Geometry: Explorations and Applications*. Evanston, Ill.: McDougal Littell, 1998.

This is the classroom text used in Geometry courses at my high school. There are several chapters within the book, where students will transfer skills into understanding charting, statistics, and modeling mathematics. The book is accompanied with pre-testing material, practice workbooks, enrichment exercises, technology components, and references to other disciplines where the math concepts can be used.

Brown, Richard G. and Miriam A. Leiva. *Algebra I: Explorations and Applications.* McDougal Littell, 1998.

This is a high school text that emphasizes using functions, equations and graphs. This book is used daily in Algebra courses and offers mathematical content that students can reference for solving different types of problems.

Edelstein-Keshet, Leah. *Mathematical Models in Biology*. New York: Random House, 1987.

This book can give good ideas for classroom discussions and presentations if you want to spend all or the majority of the time on models in biology. This book explains how the two subjects, math and biology, interact. I found the examples of applications of mathematics to real-life problems very helpful. Prerequisite: Some pre-calculus.

Hiekleman, T. *The High School Pre-Calculus Tutor*. Research and Education Association, 1996.

Includes every type of mathematical problem and makes pre-calculus concepts easy. The book comes with fully explained answers to problems.

McDougal Littell. *Mathematical Connections: A Bridge to Algebra and Geometry.* McDougal Littell/Houghton Mifflin, 1994.

This is an additional math book used in High School Geometry and Algebra classes. This book comes with a resource guide that enables the teacher when developing lesson plans. There are two units devoted entirely to statistics in Unit 54 and 55.

Mooney, D. and R. Swift, eds. *A Course in Mathematical Modeling (Classroom Resources Materials*). The Mathematical Association of America, 1999.

The first chapter on pp. 1-7 of this book provides a very basic understanding for models used in mathematics. The book is intended for college-level students but will be very helpful for the teacher when seeking introductory material for a high school audience.

Slavin, Steve. *PreCalculus*. New York: John Wiley & Sons, 2001.
This book is excellent for pre-testing math skills before going into basic calculus. It offers an excellent bridge from elementary algebra to intermediate algebra. There is wonderful pre-test with answers in Chapter 1, page 2.

Internet Resources

http://www.frii.com/~uliasz/modeling/mod.htm
Front Range Internet Inc.
This site offers an overview of mathematical models and how they pertain to diseases. An example of an SIR model link is located on the site.

http://www.aspire.cs.uah.edu/textbook/projdev2006.html
Alabama Supercomputing Program to Inspire computational Research in Education
This site lists the steps involved when beginning a mathematical model. The information is helpful with basics (diagrams, write-ups, etc.). This site offers a wonderful overview of what mathematical modeling is and how high school students can learn how to use them. There is a great example of a "population growth" model.

http://www.cnet.com
CNET
This site is great for downloads of freeware that can be used for math, biology, and other subjects. Most of the software offers a demo version for 30 days, and options to purchase the product after the trial review.

http://www.smb.org
Society for Mathematical Biology
This website is dedicated to mathematics applied to or motivated by biology. There is a lot of helpful information for developing lesson plans.

http://www.eric.com
Eric.com
Includes a huge database of curriculum and unit topics to search. Offers other resources for review, and a complete database of reports, white papers, and expert information on any subject.

http://www.elibrary.com/education
Electronic Library
Lists databases of articles suitable for schools from hundreds of newspapers, magazines, book pictures, maps, and radio and TV transcripts. Source type, as well as subject, keyword, or date can limit searches.

http://www.learn.motion.com
Learning in Motion

Excellent website that offers programs and pre-designed activities that explore mathematics and science concepts.

Student Resources

http://www.askjeeves.com
Ask Jeeves

Great site for students to get expert answers to questions they may have about diseases or mathematical concepts.

http://www.sciencefriday.com
Science Friday

This is the National Public Radio site. A wonderful site that contains archives and discussions about various topics that deals with science and mathematics.

http://www.elibrary.com
Electronic Library

This site contains library links to many subjects that students are researching.

Disease Research

http://www.cdc.gov
Centers for Disease Control and Prevention

Offers a fact sheet about mononucleosis. Gives in depth information about National Center for Infectious Diseases, Epstein-Barr Virus, and Infectious Mononucleosis.

Filmography

The following titles are movies that deal with mathematics or diseases. These are used as an activity for discussion about diseases and epidemics. They offer a better understanding for students to see the spread of disease and how society has reacted to each other during those times. Some of the films are based on true facts; others have a science fiction theme.

- AIDS: *And the Band Played On*
- Population Epidemic: *Invasion of the Body Snatchers*
- *The Matrix*
- *PI*
- *Proof*
- *Good Will Hunting*
- *A Beautiful Mind*