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Simulating the Decay of Carbon 14

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Final ***integrated* project / lesson plan** (teams-Due: Thursday, August 12^{th})

Submit as hard copy AND electronically through ANGEL

Names: Douglas Brown, Brian McCue, and Socorro M. Sanchez
Grade level(s)/Subject taught: Regents Earth Science/ ninth grade, and Pre-Calculus /Grades 11-12 (Exponential Functions)
Objectives: <u>Objectives for the math teacher:</u> The students will: 1. Collect data from an Agents Sheets model simulating the decay of Carbon 14. 2. Graph data using the TI 83+ graphing calculator and apply an appropriate regression to obtain an equation. 3. Formulate predictions and answer questions based on the conclusions obtained form the model. <u>Objectives for the science teacher:</u> That the student will be able to first understand the concept that objects do not remain the same throughout time but rather objects change. For many substances, objects change at a regular (and thus predictable) rate. The students will be able to determine the amount of time which passes for one half of the parent material to decay into the product material and name this the "half life". By comparing the ratio of the original (parent) material to the decay product (what the object becomes) and calculating the number of half lives, the student will then be able to determine the age of the material.

Describe the *integrated* <u>Mathematical - Science Concep</u>ts or "key ideas" that modeling will be used to teach: (e.g. Students use mathematical modeling/ multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships and… Organisms maintain a dynamic equilibrium that sustains life).

Mathematical - Science Concepts to be integrated: For the math teacher: Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently. Students use mathematical modeling/multiple representations to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships. For the science teacher: The key idea is that objects decay into other objects and that this occurs, often, at predicable rates. By simulating the decay of an object made entirely of Carbon 14 into Nitrogen 14, the students can construct a table of quantities of parent and decay material and time. Students can then graph the amount of Carbon 14 and the amount of Nitrogen 14 versus time. The student will then analyze their graph and determine the point in time

at which the ratio of Carbon 14 to Nitrogen 14 equals 50:50. This is the half life of the substance. The half life is defined as the amount of time where 50% of the original material has decayed into the decay product. By determining how many “half lives” have passed students can determine the age of the substance. Example; if the half life is determined to be 20 seconds and it is determined that three half lives have passed then the age is about 60 seconds.

A model is created on agent sheets where the basic agent is carbon 14. This model is set up so that at a set time interval ½ the carbon 14 changes into nitrogen 14. This process continues to occur every cycle for approximately 10 cycles. At the conclusion of each cycle the program is stopped so that the student can visualize the amount of C14 and N14 as well as write the actual number of each taken from the counter. The program is then run again using the same process until no more Carbon 14 remains. The data collected in table form will then be used on the TI 84 to plot on graph form.

For your ***integrated*** **project / lesson plan)** lesson (team effort), describe how you plan on using a desired modeling software package(s) with your students AND how you might integrate or weave together the two (or more…) math and science concepts into one or more lessons. You might describe what a visitor might see walking into your classroom during this lesson. You might also describe the role of the student during the entire lesson and your role as the teacher. Please try to be specific as possible. Also, construct a tentative rubric that you might use with your students. ** see example page 5.

To begin the science lesson, we discuss how to determine how many years ago a house was painted. It should be pointed out that, typically, the paint does not all deteriorate at once but rather gradually. Conversation should focus on the concept of being able to examine the amount of deteriorated paint versus the amount of good paint and from that be able to reasonably estimate how long ago the house was painted. When students understand this principle the teacher can introduce the concept of radioactive decay.

The set for this lesson is designed to get the student into the thinking pattern that we can determine the age of something by noting how much new has turned to old.

Certain elements act much like paint on a house and decay into a variation of the original element, just as the paint turns into a variation of the original paint (chipped and dull).

The changing of an element into a variation of that element over time is known as radioactive decay. These variations of elements are named isotopes.

The following notes and accompanying chart are written on the overhead as notes.

Two facts about radioactive decay which remain essential for our class are:

1) Radioactive decay occurs at a regular and predictable rate that can never be changed
2) The time it takes for ½ of the original element to change into a decay product is known as the half life

   example: It takes 4.5 billion years for ½ of U 238 to decay into the isotope Pb 236. The half life of U 238 is thus 4.5 billion years. As each 4.5 billion years passes the the amount of U 238 decreases by ½ while the amount of Pb 236 increases by ½.

   To simplify, we can construct a chart:

Number of half lives	0	1	2	3
U 238	100	50%	25%	12.5%
Pb 236	0	50%	75%	87.5
Time passed	0	4.5 bil	9 bil	13.5 bil

During this time, the student is actively participating in the discussion and is taking notes.

A useful application of the concept of radioactive decay is the ability to age a material which contains an element with a known half life and isotope. Going back to our original example of uranium and its decay product lead we can create a hypothetical question:

If a rock is found to have ratio of 75% U238 : 25% Pb236, how old is the rock?

Allow the students time to answer this question and explain their answer to the class.

Using the previously constructed chart we find the answer to be that the rock has aged two half lives which makes it 9 billion years old.

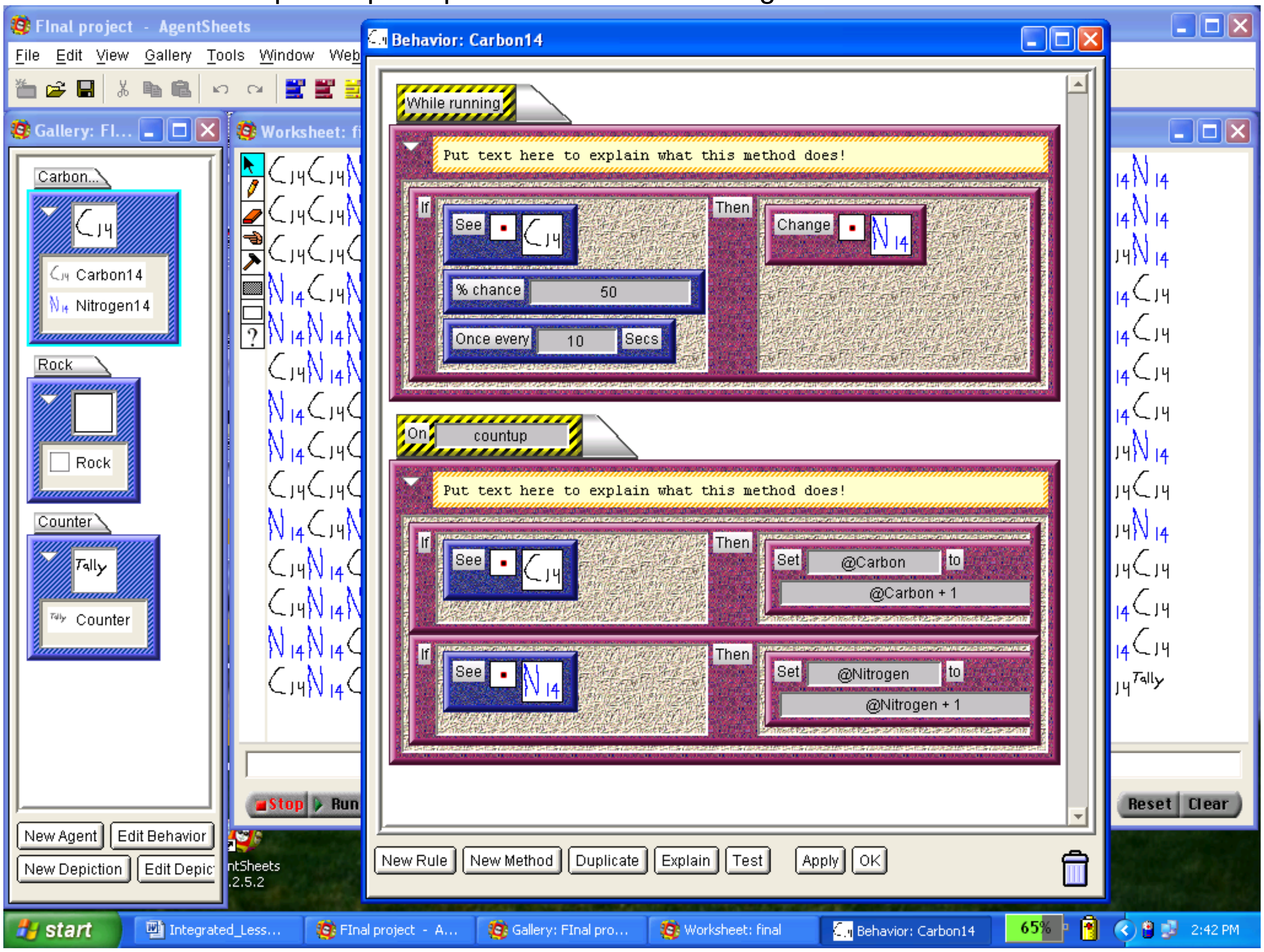
To further demonstrate the concept of using radioactive decay for aging a material we will create a model using the agent sheets program.

I will assume that for this lesson, the students do not have computers on their desktops and that we will set up one model for the entire class and that the class actively participates in created this model.

For our simulation (model) we are going to be using the familiar isotope carbon 14 (C14) and its decay product nitrogen 14 (N14).

1) Our first step will be to open a new project in Agent Sheets.
2) Second: to create one agent with two forms, they will be C14 and N14
3) Third: to create the rules which our C14 and N14 will follow (see caption)

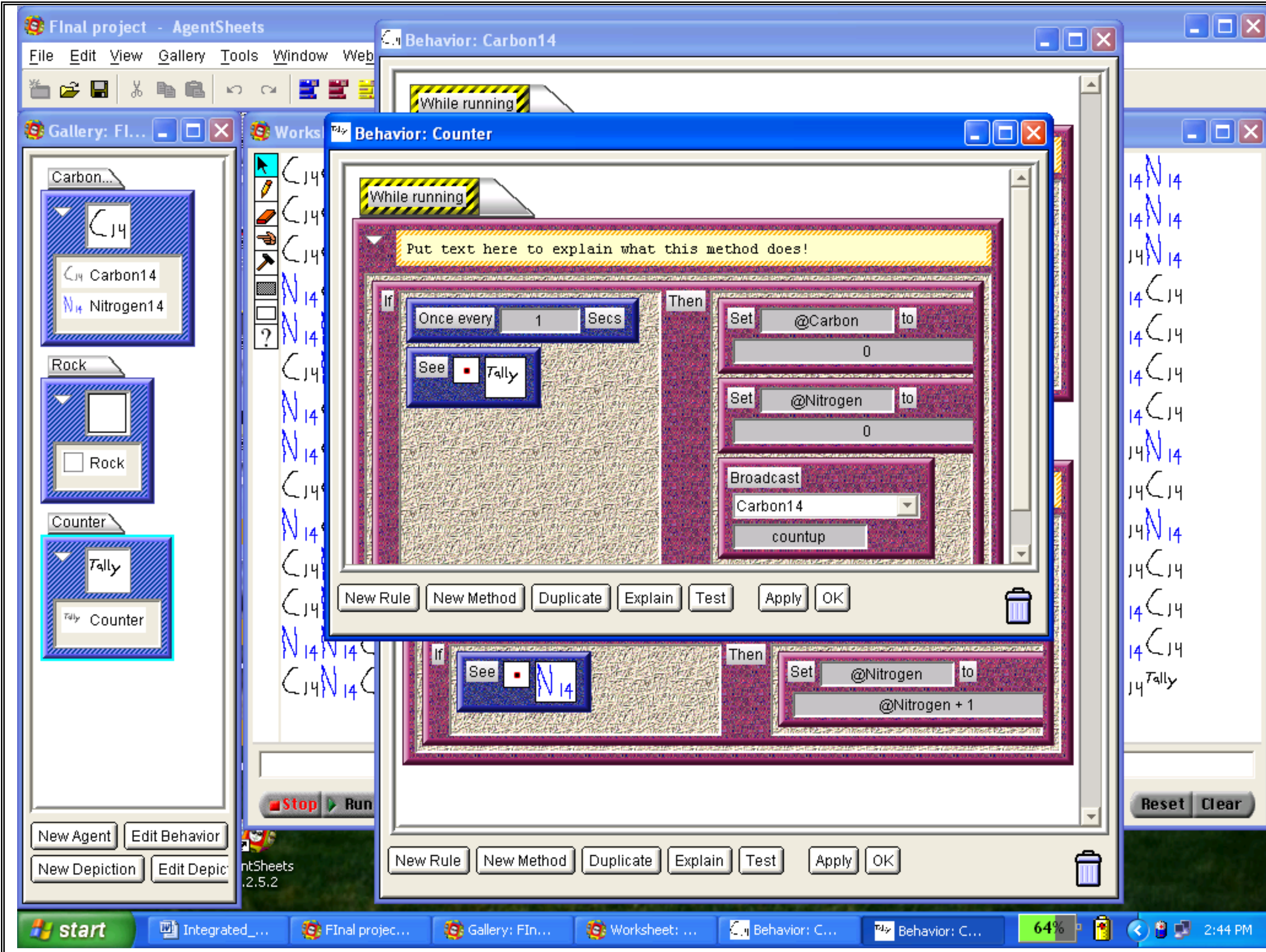
Please note that C14 has a half life of 5600 years. We do not have this time in class so we must speed up the process a bit…another great reason to use models!



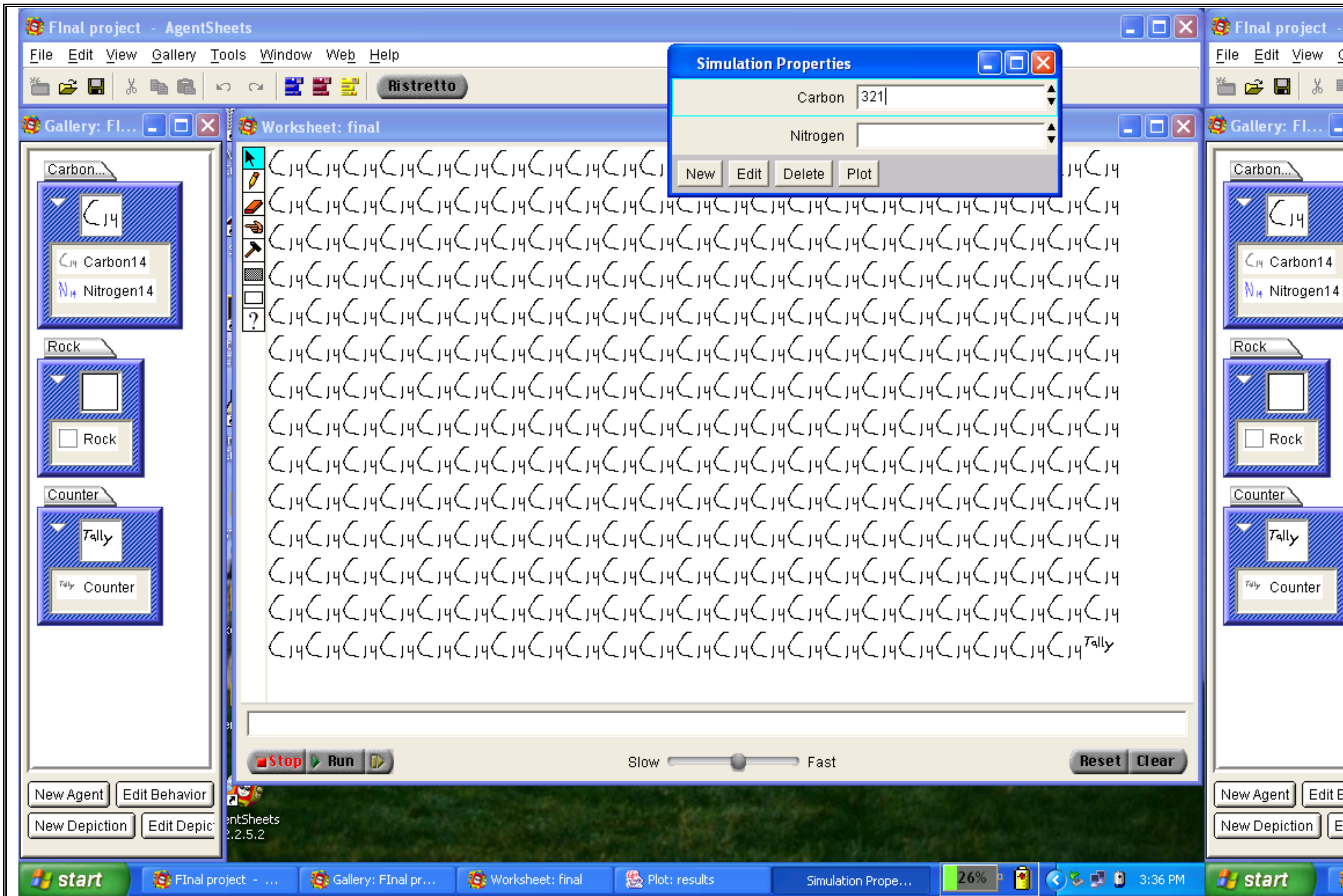
4) Fourth: to create a place where the C14 will be. For our purposes we will call this "rock" to set out rock open file and new worksheet, create a new agent called rock and shape this rock as we wish. We will then spread this agent throughout the worksheet.

5) Fifth: to spread our C14 on every part of our "rock" to represent the rock without having aged at all…zero N14 is present at this time

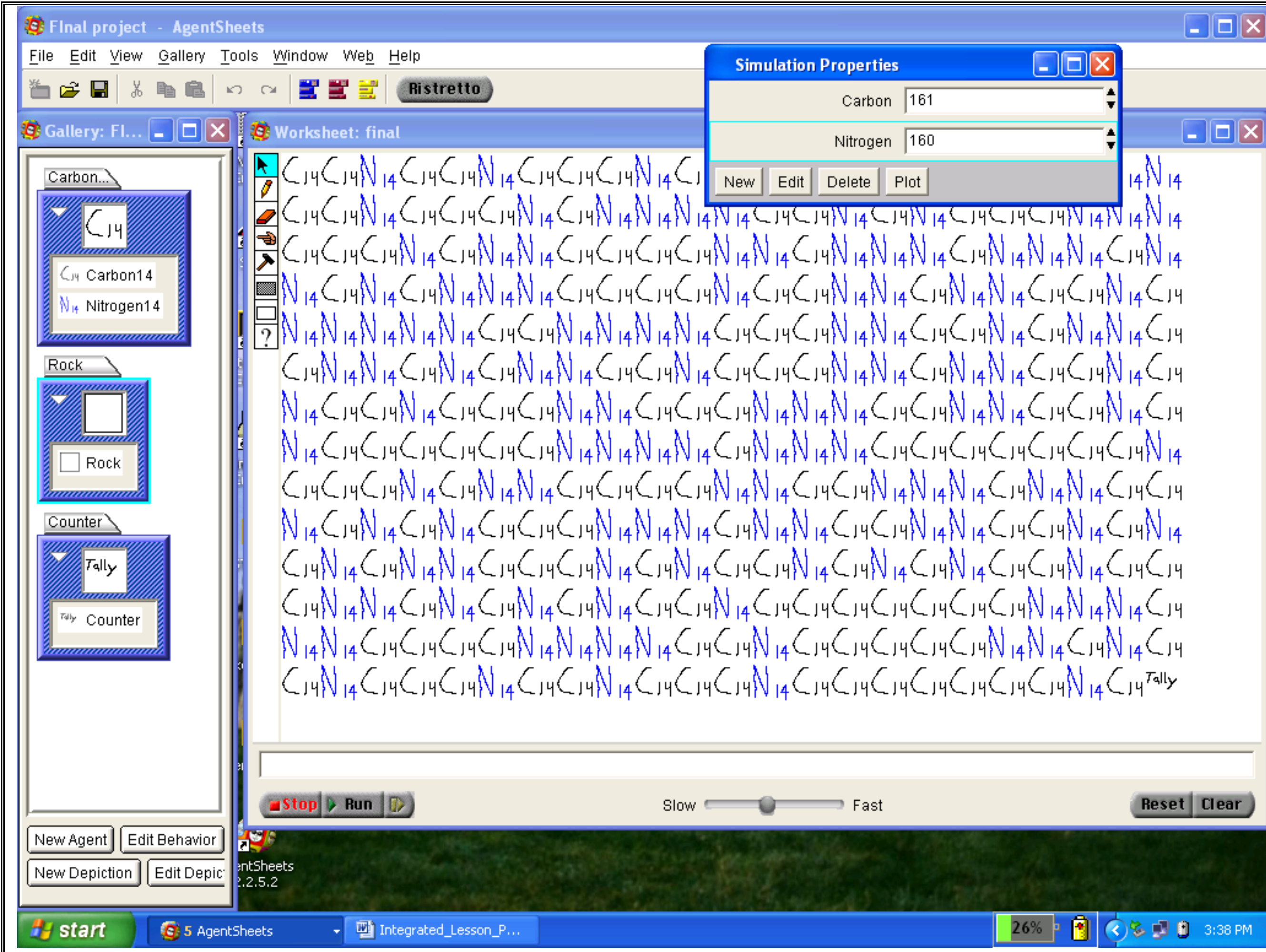
6) Sixth: to create a "counter" agent which will keep a tally of the amount of C 14 and N 14



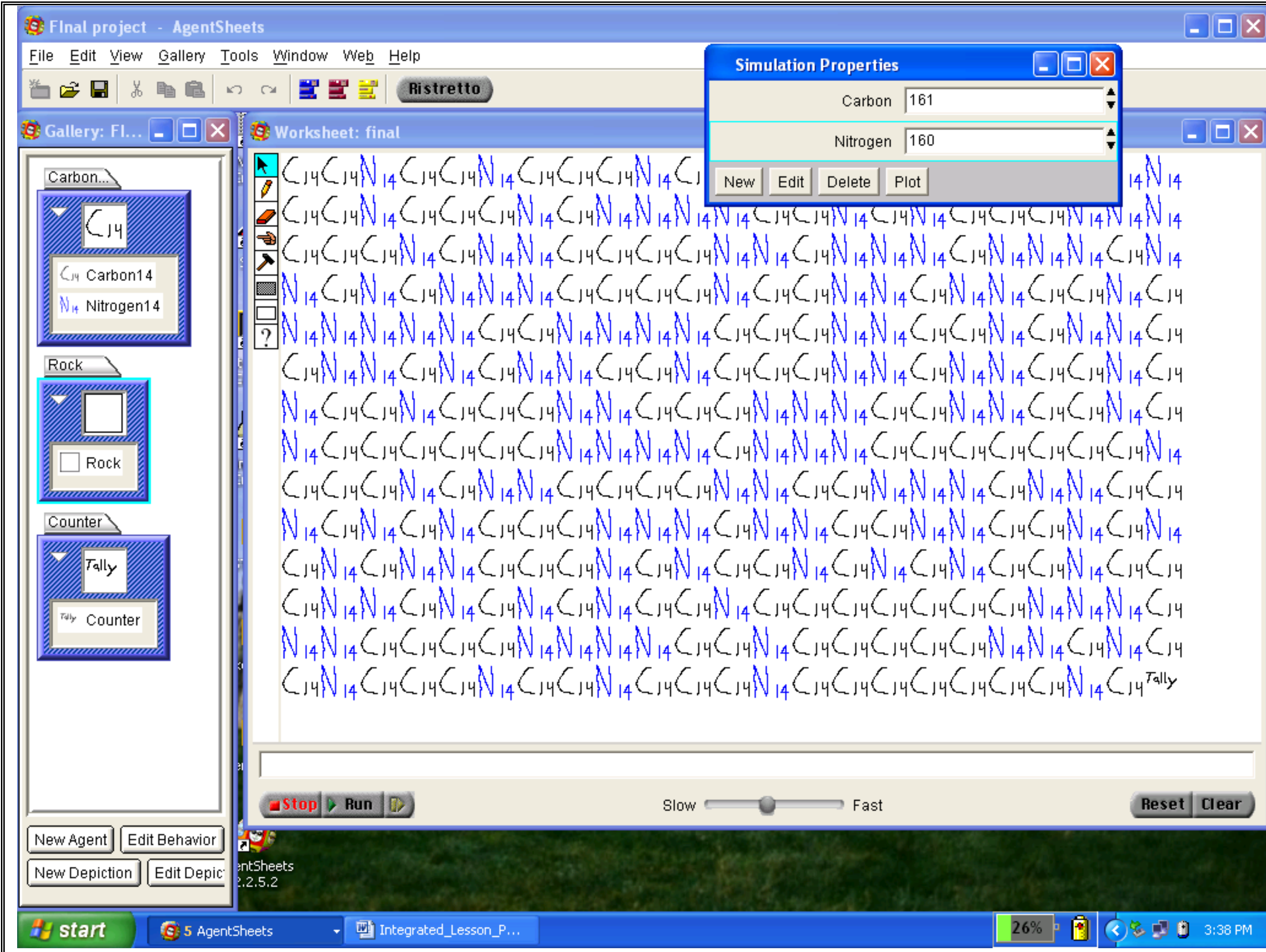
Our model is now set up to demonstrate what would occur on our “rock” to C14 as time passes.



We click run to run the program and click stop to record our quantities for C 14 and N 14 at the end of each “cycle” (half life)



As a class we continue to run the model stopping it after each cycle. At the conclusion of each Cycle we record the data on the "Get a Life!!! The Half Life of Carbon 14" chart.
It is at this point in the lesson for the science teacher when the data obtained from the model is used to construct a chart and graph to analyzed by the student. A goal of this exercise is to point out how data can be obtained by the science model and that this data can now be manipulated mathematically to derive information such as rate, slope etc.
While the remainder of this lesson is now focused on the math, the scientific principle of radioactive decay should be continually reminded to the student.


Final project - AgentSheets
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Ristretto
Simulation Properties
Carbon 161
Nitrogen 160
New Edit Delete Plot
Gallery: Fl...
Worksheet: final
Carbon...
Carbon14
Nitrogen14
Rock
Rock
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Tally
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New Agent Edit Behavior
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Stop Run
Slow Fast
Reset Clear
start
5 AgentSheets
Integrated_Lesson_P...
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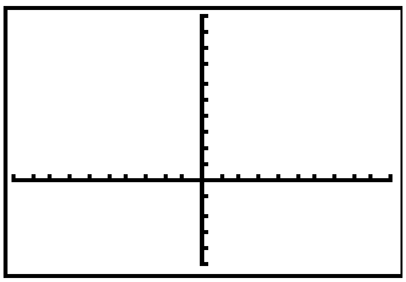
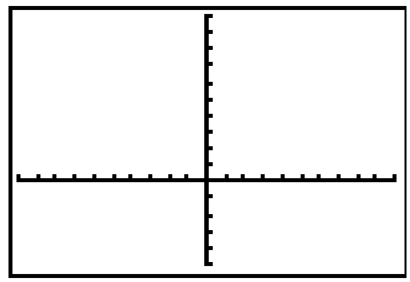
To begin the math class, we will have the students graph a pair of exponential growth functions and a pa
contrast the graphs of the functions. The handout could be the following:

Using your graphing calculator, graph the following equations. Sketch each graph on your paper, identify

a. $y = 7^x$
Window
Xmin=
Xmax=
Ymin=
Ymax=



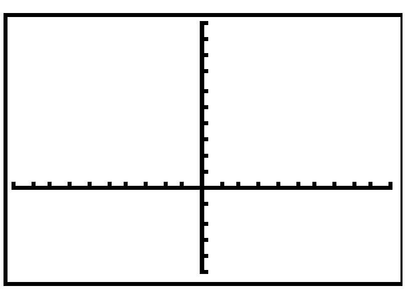
b. $y = 2.5^x$
Window
Xmin=
Xmax=
Ymin=
Ymax=



Questions:

1. How are the equations and graphs similar?
2. How are the equations and graphs different?
3. Write a conclusion comparing the equations and graphs.

c. $y = (1/5)^x$
Window
Xmin=
Xmax=
Ymin=
Ymax=



d. $y = (2/3)^x$
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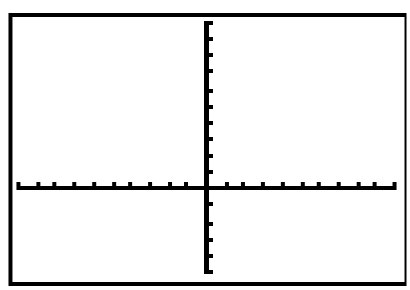
Ymax=



Questions:

4. How are the equations and graphs similar?
5. How are the equations and graphs different?
6. Write a conclusion comparing the equations and graphs.

The students will be given about 10 minutes to complete and about 5 minutes to discuss their findings.
"In our warm-up we looked at equations and their corresponding graphs. In the model that will be presen
the data."
We would then project the Agents Sheets model of the Carbon 14 Half Life simulation and ask the studer
the simulation. In the discussion, students will be asked if they are aware of what Carbon 14 and Nitroge

Note: From this point on, the lesson will be the same for the science and math courses.
To record the data generated from the Agents Sheets model, we would distribute a worksheet that conta

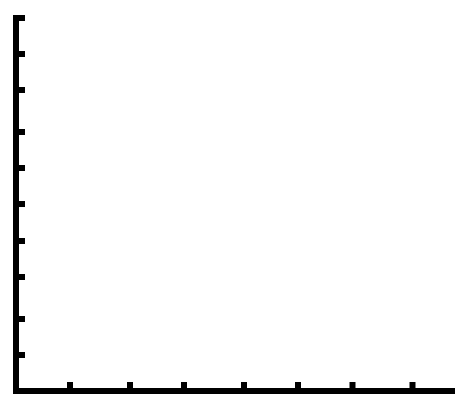
Get a Life!!! The Half Life of Ca

Question to the students before filling in data:
According to what you have observed in the simulation, what data should you record and what heading s

As a group the data will be obtained and recorded.
Once the data is obtained the students will be asked to enter it into their graphing calculator following the

Steps:

1. Enter the data obtained into Lists in your calculator. (STAT $\rightarrow$EDIT)(Use L_1 for time period, L_2 for
2. Plot the graphs. Sketch the graph on your worksheet. (2ND$\rightarrow$STAT PLOT$\rightarrow$1)(Use L_1 for Xlist ar



3. What could be a general form of the equation that would fit the data? What type of function do you
4. Use the graphing calculator to obtain an equation that would best fit the data.

(STAT$\rightarrow$CALC$\rightarrow$0:ExpReg$\rightarrow$2ND #1$\rightarrow$,$\rightarrow$2ND 2$\rightarrow$, $\rightarrow$VARS$\rightarrow$Y-VARS$\rightarrow$1:Functions$\rightarrow$1:Y_1 $-$
Copy the information on your screen in the space below. (What is the r value? What is the r^2 value
Note: These questions can be addressed if the students are familiar with the correlations coefficie

5. Graph the equation. How does the graph fit the data? Are there any points that are outliers? If so,
6. What does your regression equation predict for a time period of 3? 5? 7?
7. How does this compare to the actual data? What are differences or similarities among the data an
8. According to the data and the equation that models the data, what can you conclude about Carbo

Copy of worksheet distributed to students
Side 1

Name ___________________________
Date ___________________________
Course _________________________
Topic __________________________

Get a Life!!! The Half Life o

What is Carbon 14? Where is it found? How do scientists use it?

Enter the data from the simulation in the following chart.

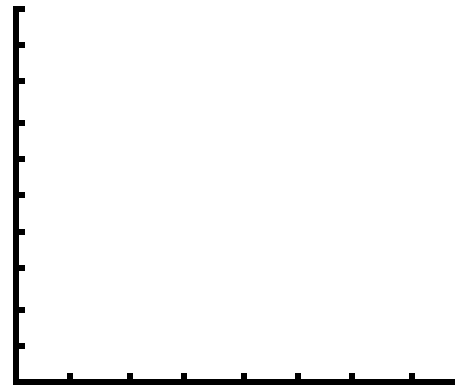
After obtaining your data, enter the values into your graphing calculator following the instr

Side 2 of worksheet.

Steps:

1. Enter the data obtained into Lists in your calculator. (STAT $\rightarrow$EDIT)(Use L_1 for time period, L_2 for

2. Plot the graphs. Sketch the graph on your worksheet. (2ND$\rightarrow$STAT PLOT$\rightarrow$1)(Use L_1 for Xlist an



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A rubric for this lesson would be to assess the attainment of the objectives. The rubric could possibly be

Target	Acceptable	Unacceptable
1. Agents Sheet model provides the data to address the problem.	Model provides appropriate set of data and includes the flexibility to modify variables (such as size of population or value for half life.)	Model provides inaccurate or insufficient data. Model is to static to respond to students request for modifications.
2. Student is capable of completing all graphing calculator activities.	Student accurately completes: a) Entering data into lists b) Graphing the scatter plot. c) Performing the exponential regression and recording the equation.	Student does not complete any or all of the requires activities.
3. Graphs are nest, accurate and based on data from the model.	Graphs accurately plots data with a suitable scale, complete with the regression curve.	Graph does not comply with these standards.
4. Math/Science concept is thoroughly addressed.	Students discuss and record concepts in rich detail.	Student discussion or writing indicates they do not understand concept or objective.
5. Students can describe model and interpret results from the data.	Students can explain in detail their conclusions to small group of peers.	Students are unable to adequately explain their thought process or conclusions.