

USING MODELS WITH RUBRICS AS A FORM OF ASSESSMENT IN
ASTRONOMY AND BIOLOGY

by

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DEDICATION

First off, I would like to thank my parents for instilling in me the importance of education. Without them and their encouragement I wouldn't be where I am today. Secondly, I would like to thank my husband and kids, for maybe not enjoying the time I spent away, working on homework and research, but understanding its importance. I love you all so much and thank you for your continued support throughout my crazy drive to want to achieve that next goal.

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ABSTRACT

This study explored the use of scientific models as a form of better understanding the processes and sequence of science ideas. The study was conducted in an Alternative Education High School in Albany, Oregon. The specific classes this unit was taught in were Biology and Astronomy. Each class was given a different set of standards to follow, models were continually drawn to aid in the understanding of a star's life cycle as well as the cell cycle. Students who participated in this study were given a Likert-scale survey as well as pre and post tests to monitor knowledge. The Likert-scale questions probed student motivation, science interest, and the use of models and rubrics. The pre and post tests for each class were centered on standards focused on for the term. The findings of this study were that the use of science models and rubrics increased student motivation and learning. Analysis of surveys and tests showed the use of visuals is important when students learned new concepts, especially those that tend to deal with cycles and the need to understand multiple steps or parts of a standard.

INTRODUCTION AND BACKGROUND

Steve Jobs and Albert Einstein are thought to be some of the most intelligent people to have ever lived, yet they have one thing in common, they didn't go to or finish college. In the typical sense of being successful, these people weren't in their younger years. However, they made huge gains and changed the world in which we live today. We need variety in the world, people who strive to be different. Steve Jobs couldn't have described our school in a more perfect quote:

Here's to the crazy ones, the misfits, the rebels, the troublemakers, the round pegs in the square holes...the ones who see things differently—they're not fond of rules... You can quote them, disagree with them, glorify or vilify them, but the only thing you can't do is ignore them because they change things...they push the human race forward, and while some may see them as the crazy ones, we see genius, because the ones who are crazy enough to think that they can change the world, are the ones who do. (Pieroni, 2014)

Albany Options School is a small alternative high school located in western Oregon. Our school accommodates over a 150 students, but only 75 are enrolled in our high school program. The other 75 are in tutoring programs, online classes, or working toward their GED. Our school is primarily based on referrals from the other two traditional high schools in town. A majority of the students referred to us are deficient in academic credits, which threaten their ability to graduate. We also have a large number of fifth-year seniors who are trying to complete credit requirements in order to graduate. We have a handful of expulsion students, as well as students who chose to come to our school because they are truly alternative learners. Our classes are required to have fewer than 15

students to help give the ideal learning environment and attention they need to be successful.

Given the unique student population in our school, teachers are encouraged to teach in a learner-centered, innovative and creative manner, but still with a high level of rigor and expectations. Having only been teaching at the school for three years, I have been consistently playing with different instructional methods to increase student success. A number of students would come in hating or thinking they are bad at science. I tried to encourage them that they are better at science than they think they are. If they skateboard I tell them they are better at physics then they realize, they usually laugh, but sometimes that's all I need to gain their respect and for them to have an open mind in my class.

One idea that was brought to my attention regarding the new Common Core standards was using models for understanding. This technique is used to help students visualize and explain new content in a manner that is easier to understand. People use diagrams or visuals their entire lives, whether it's to understand how to build a new dresser or create engineering designs for a new printer. Students should be analyzing and creating visuals to aid in their understanding of the science content being taught.

During the five years of my teaching career I have periodically used rubrics to communicate my expectations for a project or assignment. The times I have used them I have noticed an increased level of effort from the students. In real life most people are given the expectation of the task, to make sure they get there. There is no reason students should be expected to pass a class when they don't know what's expected of them.

The focus of the study was to explore how using models with rubrics helped my students to learn the material and perform better on assessments.

Sub questions

- How did using different methods of testing affect student attitude toward science?
- To what extent did providing students with rubrics help them attain a high level of understanding and was this related to their achieving a higher grade?

CONCEPTUAL FRAMEWORK

From cave drawings to detailed drawings of human anatomy to modern day computer generated images, drawings and diagrams have been used to describe the world. Integrating art in education has recently been validated as a method for increasing knowledge and success among low and high economic status students in schools (Ruppert, 2006). At the same time, model-based inquiry is the leading movement behind the Next Generation Science Standards (NGSS Lead States). One of the goals of the NGSS is to increase student knowledge and understanding in science with the implementation of models to show their understanding of concepts. Whether students are drawing for fun or creating models to explain complex science concepts, the freedom and creativity of drawing leads to higher levels of thinking, engagement and understanding in students.

The President's Committee on the Arts and Humanities stated that a student who participates in the arts is four times more likely to be recognized for academic achievement (Dwyer, 2011). Also, students who are involved in the arts are more than twice as likely to graduate from college. With cuts in school funding, art programs are

slowly being eliminated. By including art in other classes, students can remain engaged and increase their level of understanding. Art is known to reach students who might otherwise fall through the cracks of traditional education environments. Sixty-six percent of teachers say art, science, and social studies are being reduced in time due to the increased emphasis on reading, writing, and math (Engebretsen, 2013).

Art is integrated into the development of scientific drawings and diagrams. Vesalius was an amazing artist and scientist in the 15th century who had the most detailed hand-drawn pictures of human muscle systems and bone structures. Before modern science, most scientists had to have an artistic ability to convey their research; today computers augment this artistic creativity. However, according to Mishra (1999), "scientific visualization has become an important tool for scientists in all disciplines" (p. 178), scientists today still use many illustrations to convey messages and document their observations. Some misconceptions can come from illustrations and diagrams; there are textbook visuals that are not accurate. One example Mishra talked about is pictures of prehistoric times. Textbook authors make them look as though life is flourishing and crowded, when in reality it can only be speculated how crowded habitats were during those times (p. 186). Students need to become visually literate so they are able to interpret and evaluate the diagrams and illustrations that they encounter.

A study done in Korea in 2011, looked at a technique of using self-explanation with diagrams. The study was performed to learn whether this technique increased student understanding. Students were placed in three categories to see how different methods of learning impacted the learner. One group used only the diagram and another

group used only text. The third group had a diagram with text. The third group outperformed the others. Group three was asked to use a technique called self-explanation, Cho (2012) described this as, "the activity of explaining to oneself in an attempt to make sense of new information", (p. 172). Students that were placed in the self-explanation group acquired a higher ability to recall information than those who participated in the other two study groups. Another study performed by Ainsworth (2003), stated, "self-explanation helps learners to strengthen their verbal declarative knowledge and integrate it with visual knowledge" (p. 671). This increased the visual literacy of students, strengthening their general understanding of science and the world around them.

Model-based inquiry is one of the new approaches to teaching science and is included in the NGSS. An example of a standard and its incorporation is, "develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multi-cellular organisms" (Topical Arrangement). This shows that the new standards raised the expectations of students and teachers. Not only are students expected to know the information, but they need to be visually literate and have the ability to read graphics pertaining to the unit being taught, as well as infer new information from a graphics they may not know as well (NGSS Lead States).

Studies have found that roughly 40 percent of students planning engineering and science majors end up switching to other subjects or failing to get any degree (Drew, 2011). This is thought to have happened due to the misunderstanding of science concepts and a low level of rigor in science classes. With model-based inquiry, the idea is to

engage students in hands-on activities that require them to show the steps of their own learning process. Students are provided with a new topic in which they are asked to create an initial model of their understanding, typically done as a drawing. Next the students are given a variety of tasks to perform to see how their understanding of the concept has changed. They are then asked to add to or recreate their model to show the increase in learning. This should increase students' abilities to ask questions, recognize data patterns, construct explanations from data and provide criteria for judging knowledge claims (Cartier 2009).

Science educators Windschitl, Thompson, and Braaten (2007) have taken the idea of scientific inquiry and changed it to fit what real scientists do. They modified the wording of the scientific method and developed the following guidelines for students to use while conducting research: testable, explanatory, revisable, conjectural and generative. This is different from the more traditional use of observation, hypothesis, data, and conclusion. The main difference is in the level of thinking and in the need for incorporation of other theories and levels of understanding. Windschitl and his team are providing opportunities for students to interpret evidence that supports theories and to be able to connect those to existing theories that aid in their understanding of the process.

Scientists already express their ideas in the forms of text, pictures, graphic expressions, drawings, diagrams, charts, and maps. It is not unrealistic to ask students to do the same (Windschitl, 2007). Model-based inquiry is important for students in science because it increased their scientific literacy and ability to read information given in other contexts. Inquiry alone helps students to understand the importance of questioning and

understanding the world around them. In order to document inquiry, graphics and models can help to show the thought process of the student. An instructor can then look into this process to see the changes the students made or even the misconceptions they gained from the activity. Students can see their own level of understanding deepen through a series of drawings as they add to their own knowledge base (Passmore, 2009).

Student engagement in education is very important. If schools can incorporate engaging activities, this could have a direct impact on the relationships that students have with their school. Diagrams and visual representations are used everywhere. Student engagement and problem-based inquiry provide real world representations and examples that help the students to connect with their school and their education (Kidwell, 2010). Science education and understanding is becoming increasingly important in the world. As the number of jobs in technology, medicine and engineering are rapidly increasing, students' knowledge and understanding of these fields must also increase.

Accurate and consistent grading is always expected in education. By bringing models into education an accurate grading technique needs to be used to ensure, "fairness." According to Luft (1998) a rubric is defined as a "standard of performance for a defined population" (p.2). Presently rubrics are being used in many science and upper level courses to increase learning and make the learning goal clear for both the educator and the learner. The benefit of using rubrics includes improvement in student understanding, instructional methods and overall classroom environment. Rubrics are used in order to assess students' level of understanding for various science concepts.

Rubrics were first used in classrooms in the mid-1990s and have increased in popularity over time (Luft, 1998).

Students can make tremendous gains in their knowledge acquisition when rubrics are used. In classrooms where rubrics are used, “students take control of their learning process, build complex understanding of the material, and take intellectual risks” (Siegel, 2011, p.33). With the clear expectations outlined in the rubric, students can see the goal they are aiming for and get there more easily and accurately. Additionally, students are more likely to plan their work with the end result in mind when a rubric is given, as opposed to taking a shot in the dark and hoping it is right. The rubric gives students direction (Atkinson, 2013). There is more to giving a rubric than just having the students do the assignment correctly. Students need to know and understand what it is they are working toward. Being able to self-assess seems to be a struggle for some students. “Studies have also shown that self-assessment, as completed through the revision process using rubrics, improves student achievement especially with low performing students” (Siegel, 2011). Students that are in a classroom where rubrics are used are more likely to aspire to higher levels of performance due to a better understanding of the criteria. This helps them to focus and be motivated (Atkinson, 2013).

Rubrics aren't only beneficial for the students. Teachers have seen benefits as well. By providing a rubric, teachers have to understand the standard and know exactly where they want their students to be at the end of the lesson. When a teacher clarifies a standard, it helps them to better understand the material before teaching it. If teachers truly understand the standards they can make adjustments to their teaching strategies or

notice when students do not understand the material. Rubrics that are created prior to instruction allow teachers to provide immediate feedback, which increases student understanding of the content and is reflected in the students' quality of work. When immediate feedback is given it helps students to make changes and improve on the assignment. "Students have noted that the feedback they have received acts as a guide to improve their next assignments" (Atkinson, 2013). Teachers are also known to have more consistent grading when a rubric is used for assessing.

In classrooms where rubrics are given students are encouraged to take more intellectual risks (Siegel, 2011). There is more structure in the teaching and students receive feedback on assignments. There is more consistency in the teaching and the grading and students see more fairness. When a comfortable learning environment is provided for the students, the possibilities are endless. With rubrics being used, "teachers seem to communicate the criteria to focus on which motivates the students to reach higher levels of performance" (Atkinson, 2013).

METHODOLOGY

The treatment for this study was conducted midyear over a six-week period. It was administered in both a biology and astronomy class. When combined, the two classes included 17 students, 10 of whom were boys and 7 girls. Of those 17 students, 3 were on an Individual Education plan (IEP). One student was considered talented and gifted. These classes were selected because they contain standards that can easily incorporate the use of models as well as rubrics. The focus of this study was to use models and diagrams to help students better comprehend the content and to provide students with rubrics to

help them attain a higher level of understanding, which would result in a higher grade in the class. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

A general timeline of the data collection is as follows, with more details given below:

- First Week of Class
 - Initial Unit Survey
 - Pre-Test of Content Standard Test and Model Unit Question
- Performed Weekly
 - Weekly Checklist of Student Behavior and Performance
- Last Week of Class
 - Initial Unit Survey
 - Pre-Test of Content (as the post test) and Model Unit Question

To begin the treatment period, students were given the Initial Unit Survey that asked questions regarding their feelings and attitudes toward science (Appendix B). The survey was given using Google Forms and the students completed the survey in class. The Initial Unit Survey was a five-choice Likert-scale survey used to examine initial feelings and reactions of science and student motivation. The Initial Unit Survey had three categories of questions. Category 1 addressed student attitudes toward science, Category 2 addressed their attitudes toward models and drawing and Category 3 looked at student motivation and preferences for testing. Each of these sections was analyzed for

a degree of positive or negative feelings. When analyzing this data each answer was given a number ranging from - 2 *as strongly disagree*, to + 2, *strongly agree*. The instrument was scored this way to reflect individual student attitudes as positive or negative. Data from the Initial Unit Survey was analyzed to show average trends of positive or negative feelings. By turning the data into percentages the trends in the three focus areas became more apparent.

Students were administered the Pretest of Content, given in two separate sections (Appendix C& D). The Pretest of Content was given in both the astronomy and biology classes, with separate tests created to pertain to differing standards in the two classes. The first section contained multiple choice, matching and short answer questions. Section one was given using Google Forms graded one point per question, except for the short answers, which were worth 2 points.

Section two was a separate instrument called the Model Unit Question. This was a blank piece of paper the students were given and asked to address the standard being taught. Students were asked to show what they knew about the standard using a model. The Model Unit Question wasn't given until after the different types of models were taught. PowerPoint was used to teach models to the students (Appendix E). As the class went through the PowerPoint the students followed along with a worksheet, "What is a Model?" (Appendix F). The students were shown models in writing, math, and social studies, but we focused mainly on the science side of things. The Model Unit Question was graded using the Unit Rubric (Appendix G). The Unit Rubric had three categories: one that analyzed the drawing, one that analyzed the labels, and one for the explanation

of the diagram. This Model Unit Question was analyzed using the individual category scores as well as a cumulative score. With the individual and cumulative scores I was able to determine if there was growth in their knowledge using the model. Even an increase of one point in a category showed growth. This was because the students were able to show they knew enough the second time around to be graded in the next score up on the rubric.

At the end of the unit, the students were given the same Pre-test of Content, as their Post-test of Content and the Model Unit Question. The Post-test of Content was given first, and then Model Unit Question was given using a blank sheet of paper. For the final Model Unit Question, the standard was placed and students were given a word bank in astronomy (Appendix H). This was due to the large number of words the students were expected to use on their final. This may have changed the data from pre to post-test results. Students were asked to draw a model of the standard being focused on throughout the unit (Appendix I). The Post-test of Content was graded using the same grading method as the pre-test version. Scores from the Pre-test of Content were then compared to the Post-test of Content. The Pre-test of Content was analyzed using a straight percentage score. This showed if there was an increase in grade from pre to post.

A pseudo case study was used to show the data for the Model Unit Question. This helped to show the knowledge gains of the five students chosen. The Model Unit Question was graded using The Unit Rubric. A comparison was done of their pre and post test scores. This was done for each individual category being analyzed on the rubric as well as their overall score on the assessment. The Unit Rubric showed the post scores

compared to the pre-test scores, using a difference in scores as well as percentages to demonstrate growth. For example, a score of one in an area of the pre- Model Unit Question and a score of five in the same area of a post- Model Unit Question, resulted in a score of positive four. If a student received a 3 on the pre Model Unit Question and a 2 on the post Model Unit Question in the same area, it resulted in a score of -1.

Of the students that were chose, there were three boys and two girls. These students were chosen for their diverse learning styles, two of the students were on an IEP and one is considered talented and gifted, the other two were considered “average” students. To show the growth of the Model Unit Question a difference in scores was used.

As I observed the students, I filled out a Weekly Checklist (Appendix J) for each class. These observations tracked student behavior in the form of talking out, inattentiveness, and referrals written and gentle reminders to mentally return. Data from the Weekly Checklist represented levels of student engagement during the treatment and measured influences on student learning of the new treatment. By tracking student behavior, I was able to determine if there was a correlation between students’ behavior and if the material was being learned. I was able to see if no talking out, no referrals, and well attentive students led to an increase in their knowledge. I was also able to see if attendance had a direct effect on the amount of learning gained in the class.

On the last day of the week, every other week, the students were given a Student Weekly Reflection (Appendix K). This was given using a different question weekly to see how they felt they were doing in class. The student reflection then confirmed or

refuted my weekly observations regarding attitude. The Student Weekly Reflection was analyzed by placing the Likert-scale questions on a scale, similar to the initial unit survey, this showed if the students increased in agreement. This was shown by a positive increase in value and if they disagreed there was a negative decrease in overall value. This helped me to see the positive and negative feelings regarding the two-week period. From this I could see how the students felt they did that week and if they understood the material. If the students thought they were present and doing everything needed, but still didn't understand the material, this survey would tell me.

Post interviews were also conducted. These were given to four students selected, two boys and two girls. Each student was selected for a different reason. One of the girls chosen is a teen mom, who is bright but struggles to stay consistent in school. The other girl is on an Individual Education Plan (IEP) and struggles for various reasons. Out of the two boys that were selected, one was considered talented and gifted, while the other one has struggled all through school with motivation. The male student, who struggles with motivation, has terrible attendance and grapples to gain credits due to his refusal to work and lack of motivation. These interviews were conducted in our school library to give the students privacy as they answered the questions.

The interviews were analyzed by looking for trends among the students as well as the positive and negative things they said pertaining to the treatment. If all four students gave negative feedback regarding the rubrics or models, I would know that it was something that didn't work as well as expected in the classroom. If the IEP student in my

class enjoyed and gained a lot out of the lesson I would want to investigate in the future if all IEP students would benefit from hands on visual lessons such as this.

Table 1 shows the major question and three minor questions being investigated in this treatment. Each question then states the check-ins and assessments that will be used to evaluate the success of these questions.

Table 1
Classroom Models and Rubrics Triangulation Matrix

Research Questions	Data Source		
	1	2	3
<i>Primary Question:</i> How does the use of models and diagrams help students to better understand science content?	Initial Unit Survey and Model Unit Question Worksheet	Student weekly reflection. Teacher completed Weekly Checklist	Initial Unit Survey (Post-IUS) and Model Unit Question Worksheet
<i>Sub Questions:</i> Does the use of rubrics help students to achieve higher learning goals and higher grades?	Initial unit survey	Weekly Checklist and Student Weekly Reflection	Initial Unit Survey
Students Attitudes and Motivation to Learn	Initial unit survey	Weekly Checklist/ Student Weekly Reflection	Initial unit survey
Self-explanation to increase student understanding	Model unit question worksheet		Model unit question worksheet

DATA AND ANALYSIS

Student Interest in Science

In the beginning of the unit, the Initial Unit Survey asked students if science was interesting and 58% of students agreed, meaning they chose agree or strongly agree ($N=17$). On the Exit Unit Survey this number rose to 86% ($N=14$). In the beginning

17.6% of students *disagreed* that science was interesting and by the end of the unit this number dropped to 0% (Figure 1).

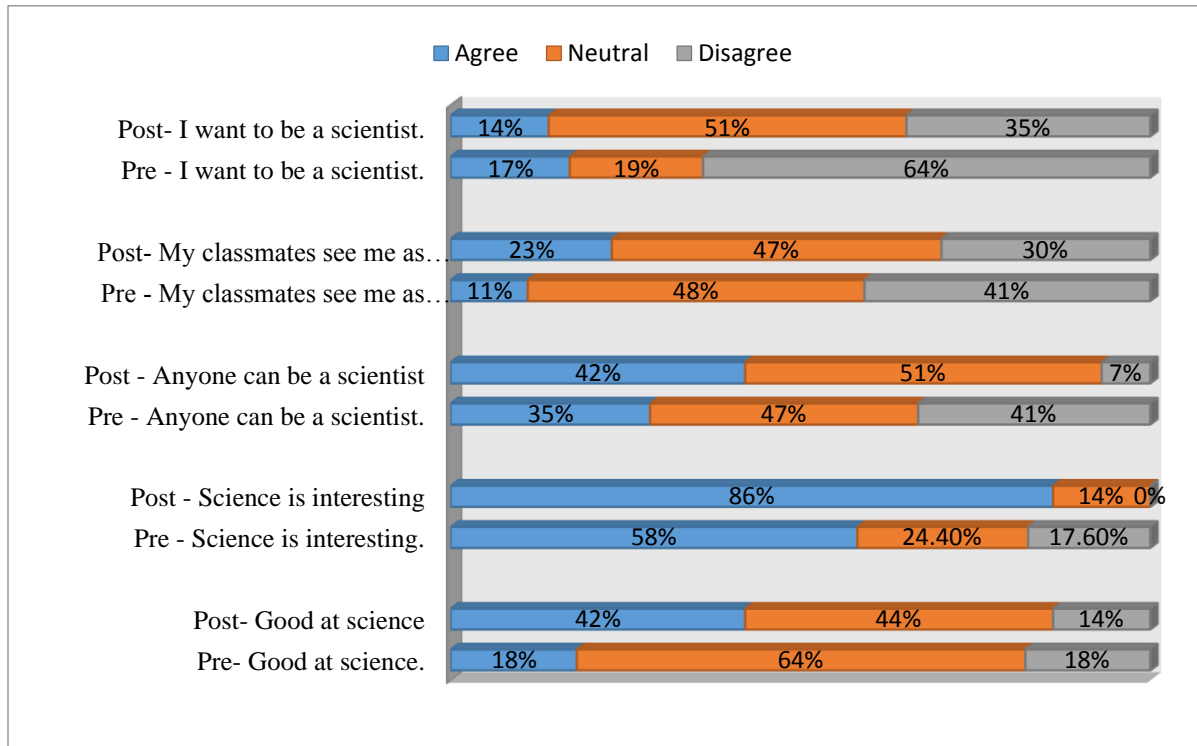


Figure 1. Student Attitudes toward science, pre and post treatment on the Initial Unit Survey and Exit Unit Survey given on the topic of interest in science, (N=17 on Initial Unit Survey) and (N=14 on Exit Unit Survey).

When students were asked about their confidence in science, their Initial Unit Survey showed that only 18% of the students *agreed* they were good at science. However, the Exit Unit Survey showed this number rose to 42% of students claiming they were good at science (Figure 1).

Thinking you are good at science is different than internalizing if your peers think you are good at science. Students were asked if their classmates saw them as being good at science. Only 11% of the students on the Initial Unit Survey *agreed* that this was true, while 41% *disagreed* (Figure 1). On the Exit Unit Survey there were some slight changes,

the students that *agreed* they were good at science went up to 23% and students who *disagreed* when down 11% to 30%.

Using the Weekly Checklist as a guide, the students made multiple comments over the week about how they have never understood science until now and that for the first time they are finding themselves enjoying science. Although no one stated they now plan on becoming a scientist, there were a couple of students that definitely seemed to make an additional effort in helping other students understand material when confused. One student in particular, John came to AOS as a disruption and was at risk of not graduating. Since his time in class he not only did well on the assignments and understood what was being discussed, but he was the one that other students would turn to when they had questions regarding the material.

Student Motivation

Prior to the unit being taught, only 17% ($N=17$) of students would categorize themselves as motivated students. A majority (43%) of the students actually *disagreed* with this statement (Figure 2). The motivation level of students did not change by the end of the unit, however, the percent of students that *disagreed* with the statement went down ($N=14$). Even though the motivation of the students did not go up, there were still no F's given in the classes in which this study was conducted (Figure 3).

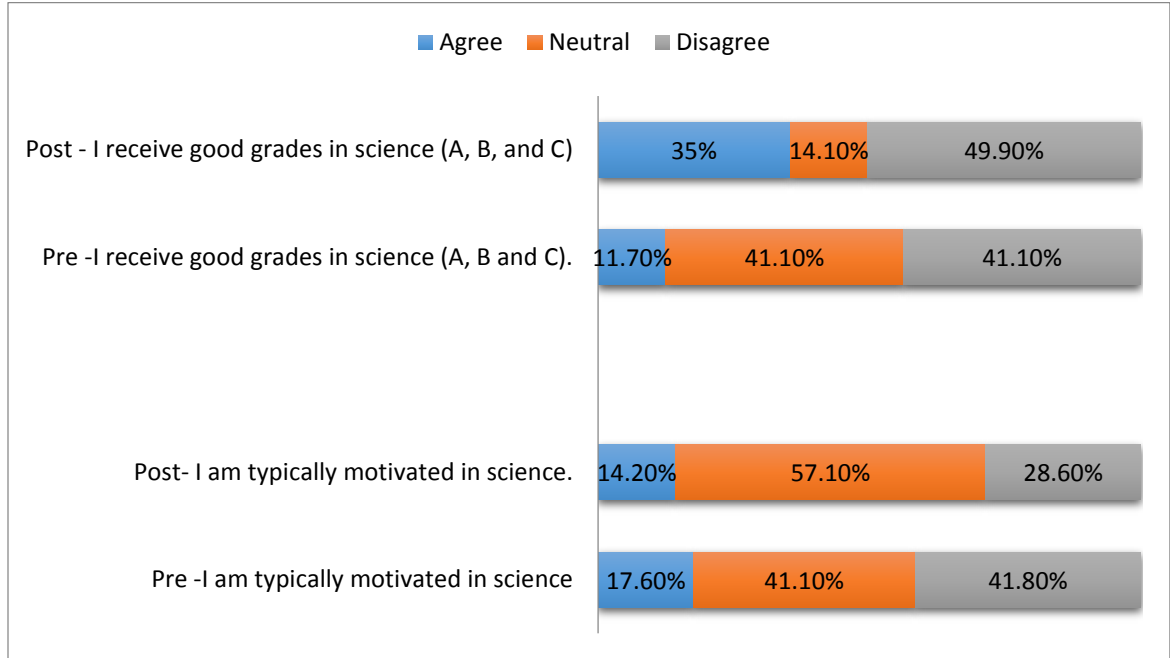


Figure 2. Student Motivation in Science, pre and post treatment on the Initial Unit Survey and Exit Unit Survey given on the topic of Student Motivation in Science, ($N=17$ on IUS) and, ($N=14$ on Exit Unit Survey).

At the end of the unit, the number of students that did admit to receiving good grades went up. The students were able to recognize their accomplishment of attaining good grades. The Initial Unit Survey showed that 11.7% of students did not believe they received good grades, while on the Exit Unit Survey 35% said they did. Although the motivation of the students may not have changed, the way they viewed themselves and their grades did.

At the end of the term in the interviews, the students were asked what their proudest moment was. One student stated, “passing this class with a high grade. I am not normally good at science.” Another student stated, “that I passed this class.” The classes being used in the study had above average attendance when compared to the rest of the school. With a school average of about 68% attendance, these classes had an 81.6%

attendance rate, with 2.5% of that being excusable absences relating to medical or school related absences. This was beneficial because it made it so attendance did not become a factor in skewing the data.

Using the Weekly Checklist, on average 88% of the students claimed they were mentally present all week and were trying to stay caught up and understand the material being taught.

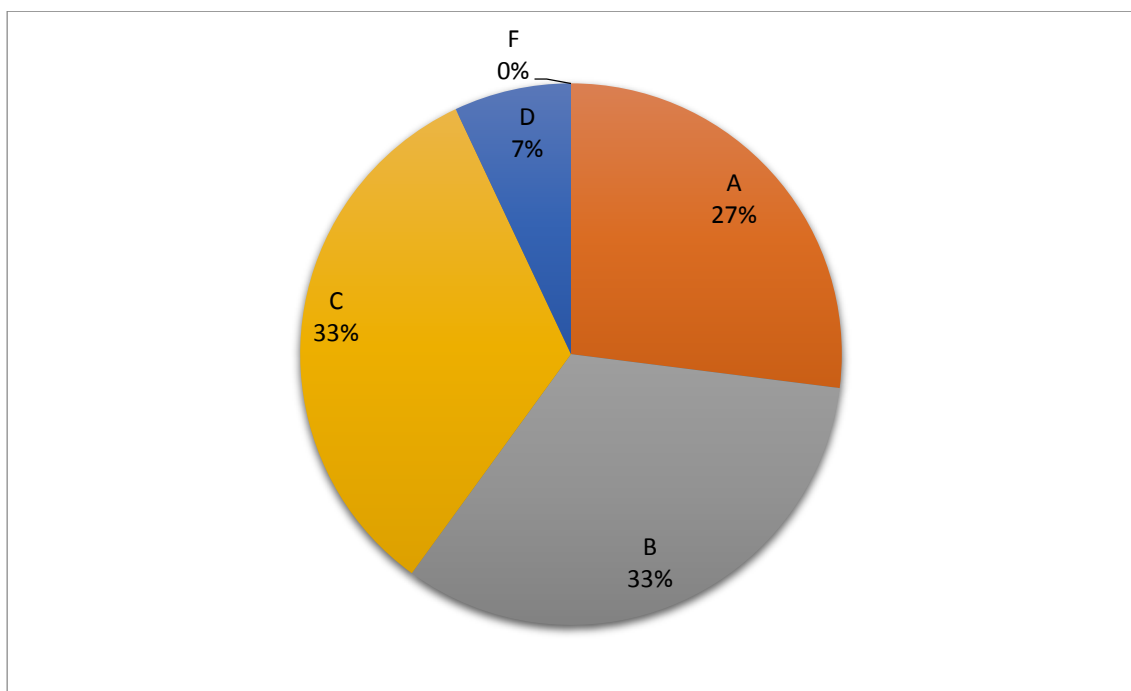


Figure 3. Percentage of final grades earned which were calculated at the end of the unit, ($N=14$).

Using Models and Rubrics

During the interviews students indicated that models were valuable to their learning, in one interview a student was asked how they felt about using models. The student responded with, “I liked it. I felt like I knew exactly what to study and what you were looking for.” Another example of student improvement, is when the students were given the Pre-Model Unit Question they were hardly able to provide any knowledge of

the cell cycle or the life cycle of a star. They were even told it did not have to be a diagram and they could just write about what they knew. The average score that was turned in was around or below a 20%, which correlates as 1's and 2's on the rubric. That means there was some effort put in, no matter how weak or wrong. The Post-Model Unit Question showed that the average score was an 88%. This combined all the categories of the rubric. One student was excluded who never showed up for the final and received a 0. A huge increase was seen from the pre to post Model Unit Question. Using the standard form of giving a test with multiple choice, true or false, etc., the students were unable to match that 88% average that came from using models. On the standard test the students averaged a 37% on the pretest and by the final had an average of 72% (Figure 4).

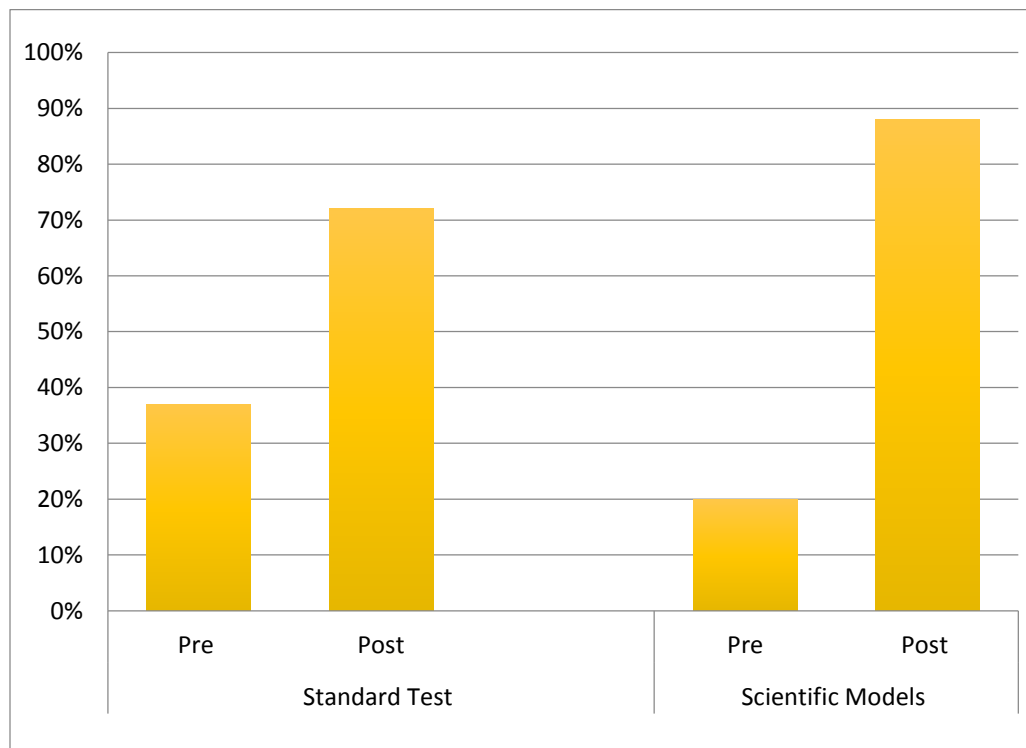


Figure 4. Standard vs Scientific Models, pre and post test results of the standard style test and the scientific models test, ($N=14$).

Improvements were made in all areas of the Model Unit Question Worksheet, the drawings, labels and explanations all made huge gains. The area that improved the most was the drawing section. In the beginning the students really could not draw anything. In the end complete drawings were given even if no explanation and labels could be given. The area that improved the least was the explanations. This seemed typical, as this is where the true test of remembering how the process actually works was tested. The average score for drawings was 4.2, whereas the average on the explanations was a 3. Student drawings can be seen in Figures 5 - 8.

1. nebula - clouds of gas and dust, mostly hydrogen and helium
2. proto star - the clouds clump together as gravity enforces
3. low mass star - when a star is born small, burns less fuel
4. high mass star - when a star is born bigger, burns through fuel quickly
5. Main sequence - when fusion starts, longest stage of a stars life
6. Red giant - when pressure starts to win in a low mass star, it inflates
7. Red super giant - when pressure starts to win in a high mass star
8. Planetary nebula - when pressure "wins" the outer layers get "puffed" away, gravity holds the core in place
9. Super nova - when gravity wins and the star explodes
10. White dwarf - the left over core from a red giant
11. neutron star/pulsar - extremely small, dense core, pulsars shoot energy into space
12. Black holes - gravity so immense, not even light can escape
13. recycled star dust - left over layers that can be made into nebulas

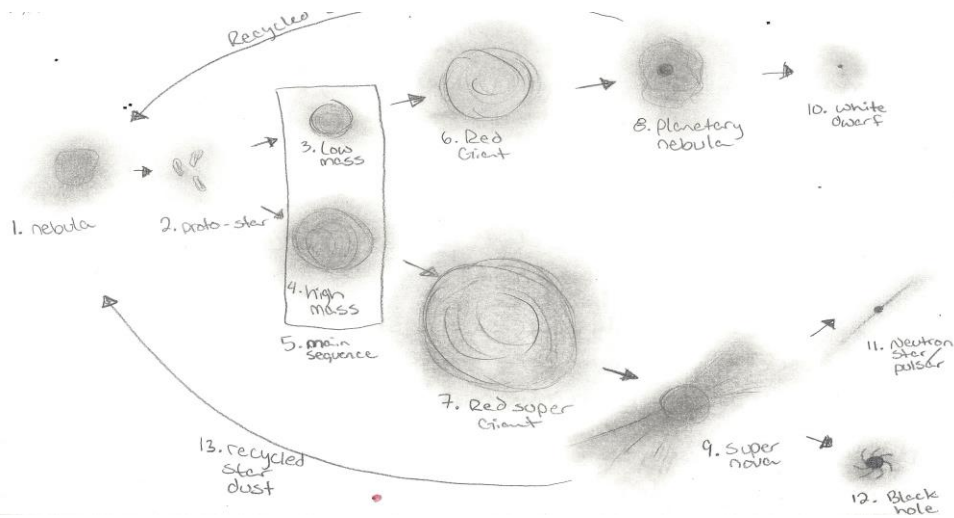


Figure 5. One student example of the Astronomy Final. This student used two sheets to complete here drawing and another for her labels and explanations.

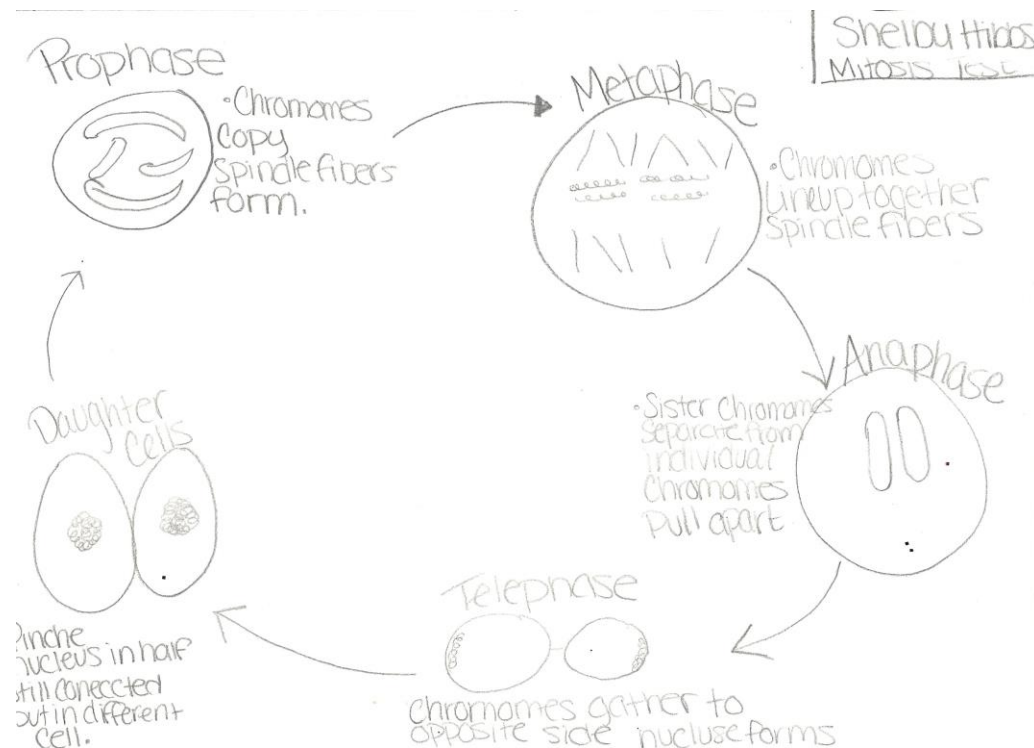


Figure 8. Biology Student Example 2. Another well drawn student example of the mitosis cycle. Short explanations but still is able to show that the student knows the basics of the mitosis cycle.

Figure 9 compared the pre and posttest scores of the model unit question for five of the students tested. You can see that most students made great gains in the process. Even the students that had a somewhat high score already such as JM, were able to fill in some of the remaining holes and receive full points according to the rubric. Another student like BB, who is one of the IEP students I looked into and I almost lost him in the beginning due to the complicated sense of a pre-test, stated since he couldn't do the pretest he didn't want to be in my class and participate any more. I was able to convince him to stay and he was still able to make a comeback and receive a good score. DJ was the TAG student in class, his scores increased by an average of 3.67 per category, which given a score out of 5, is a good increase in knowledge performance. The other two

students AD and SH also made good gains both with an average increase between 3 and 3.5.

The Unit Rubric was given when the students were asked to create the Model Unit Question, but not for the standard style test, although they were given a study guide for the test. When interviewed a student stated, “They told us exactly what we needed to know, which was nice. Not all teachers seem to do that.” One of the notes made on the Weekly Checklist did include, “students seem to at least be looking at and referencing the rubric as they are studying.” One student being interviewed was asked, “if you could change something about the rubrics what would you change?” and they responded with, “I think they were good, but maybe if you made them more specific instead of generic. I don’t know they just seemed general.” This was the student that does well on tests and he also included that he was thinking more for others than himself when he said this.

Student Initials- Class - Pre-test analysis	Pre- Test Score	Post Test Score	Difference Score (Post-Pre Score)
AD - Astronomy Pretest- Student was able to provide some labels of what occurs in the life cycle of a star but could not accurately place in the correct sequence.	1	5	+4
	2	5	+3
	2	5	+2.5
BB - Biology Pretest- He turned in the sheet blank, said he had no clue what I was asking and didn't want to participate any more.	0	3.5	+3.5
	0	4	+4
	0	4	+4
DJ- Astronomy Was able to provide some vocabulary associated with the star cycle but couldn't place them in any sort of order.	2	5	+3
	1	5	+4
	1	5	+4
SH- Biology Pretest- She was able to provide some terminology about mitosis but was unable to define what they meant and couldn't seem to relate them to the cell cycle.	1	5	+4
	0	4	+4
	0	3.5	+3.5
JM- Biology Pretest- he recently had a class that taught this material so he performed the best on the pre-test but still had holes in his knowledge.	3	5	+2
	2	5	+3
	2	5	+3

Figure 9. This chart shows five students' scores from both astronomy and biology and the scoring system that was used on the Model Unit Question assessment. The rubric was used to score the students before and after the treatment taught.

The results for this study showed gains in knowledge and increased test scores.

Student attitudes also increased from the beginning to the end of the term. Although student motivation didn't increase, the overall grades the students were given did, with an average grade of 75% given. The standard style test had a 35% increase of test scores and

the Model Unit Question had an increase from 20% to 88%. After the unit, majority of the students gave positive feedback during their interview.

INTERPRETATION AND CONCLUSION

Using models with rubrics gave students more direction in understanding what they needed to know and how to get there. The accompanying surveys showed that while students were learning they were engaged and enjoyed what they were doing. This study showed that overall the students enjoyed the units being taught and felt that they were learning. The fact that it was taught in a different and more hands-on manner was also well received. Students were continually engaged and acting as though they genuinely wanted to learn the material. Also, the fact that only one referral was written during the time of the unit, is indicative of the positive environment created, given the alternative setting I was in.

One area of success that occurred was when students were asked about their interest in science. Although student interest in science was high at the beginning of the term, it still increase by the end of the term. This is a great reflection of the behaviors and attitudes seen in class.

By incorporating visuals and having the students work with and create their own visual, there truly was more understanding and interest in the study. The data supports the idea that students' interest in science increased over the term, which also increased self-confidence. The survey questions that asked if the students received good grades and were motivated in science both improved. That motivation and self-confidence helped the students want to learn the material and do better in the class. The clear guidelines played

into this as well. With students being given the direction in which they need to go, the path was clear on how to get there. The students even said so in their interviews at the end of the term.

The students' grades reflected their knowledge in the matter. The fact that no F's were given is rather an anomaly for me. This is not a regular occurrence in my classroom or at our school. Now that I have taught the unit, I think that comparing the models to more traditional tests could be seen as comparing apples to oranges. Both forms of assessment are necessary for students to really demonstrate different levels of their knowledge. They both have benefits. By incorporating these different methods of testing it can help struggling students to synthesize and regurgitate, while encouraging higher performing students to focus on the explanations and "how" of the process being focused on. The fact that they know the expectation from the beginning and can study just that seemed to give them a little boost. Those students could at least show me something, whether it be one stage or three of the unit being taught. On standard tests at times they did not know where to start or what the question was asking.

After giving the Initial Unit Survey I realized I did not ask the questions in the right manner. Instead of giving the students a neutral option as an answer, on the surveys, it should have been cut and dry, positive and negative feelings. I think because of this the data I received is not entirely accurate, students chose the neutral option on too many questions, which didn't give me any insight into their inclination. However, in most cases, the majority of the students still took a side, very few questions had the majority in the neutral zone.

This study was a success for my students, but I greatly benefited from this study as well. I learned a lot from them, just as I hope they learned a lot from me. By providing them with the opportunity to take their learning into their own hands many students took advantage of that and excelled in it. Not only did this study help me to grow as a teacher but I learned new techniques of listening to my students and understanding some of the different ways in which they learn. With the results being as successful as they were, this unit, and others incorporating the same ideas, will be integrated into my units from here on out.

VALUE

This study showed that students benefited from engaging, hands-on learning, as well as providing them with rubrics and visuals. Working with a small group for such a short time was difficult in determining the true results of this unit. Although given such a short time it was easy to come to the conclusion that for the majority of the students these diagrams and models were beneficial. By incorporating lessons that teach scientific material in a different and more engaging way, the students had more positive attitudes throughout the unit. If the goal was to increase students' engagement, then I can confidently say I did that. Although I will not have the students drawing models daily, I do think it is something I plan to incorporate where appropriate and as much as I can.

I realized during the term that there are so many different ways to incorporate and use models in class. Purely having the students redraw and write in their own words is only one way they can be used. By giving the students an already created model and asking them to fill in parts or thoroughly explain one section, could also be a more

rigorous way to utilize the use of models. Another way, would be to give the students an incorrect model and ask them to find and make the correction to the model. Again, this takes a deeper level thinking to find the mistake and then understand how to correct it. I cannot wait to incorporate and use some of these newfound techniques as I teach with models.

By offering rubrics to the students they were able to see a clear expectation of what's expected of them, right from the beginning. This was very beneficial for many of the students and they knew the direction we were headed. I plan to create and use rubrics wherever I can. Two types of rubrics seem sufficient to start with, one that is a generic rubric I can turn to, to create others and one pertaining to each unit I teach with specific terminology and the overarching goal.

This approach differs from my previous teaching by providing the students with a very clear set of expectations on any given grade. Previously, I just assumed that students would understand what I was looking for given the verbal instructions in class. By having a written sheet of paper and target at which to aim, the results I got were much closer to my expectations. Again, this also resulted in a higher grade for the students. Before using models I used a fair amount of standard tests in which students did not seem to do well. In having conversations with the students after the exam I could tell they knew more than their test led me to see. By giving the students a different opportunity to show me what they know, given writing, drawings or something else, I was able to get a more accurate insight into their level of knowledge and understanding of the material. I really think in

an alternative setting I need to be offering more performance-based assessments and fewer standard tests, to make sure I am meeting the needs of a true alternative learner.

Throughout this process I have continually asked myself, is using models still the best method of testing for my students? I would like to eventually be able to offer multiple types of testing, to where at the same rigor level the students are able to demonstrate what they know given how they learn. Since not everyone is a "square peg in a square hole," we as teachers need to figure out how to assess students' knowledge that isn't unified in the testing, but more in the rigor of the assessment. After using this type of performance assessment, I wonder what other types of performance assessments would be beneficial.

With testing done as frequently as it is students have built up a level of anxiety given any type of test. After having done this type of testing I wonder if students' anxiety levels were higher or lower given this alternate form of assessment. Even though I didn't ask students questions pertaining to their anxiety level, I would say I observed students experiencing less anxiety given these conditions. Since students seemed to do so well given the models I wonder what other types of models I would be able to incorporate in class and get the same results.

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APPENDICES

APPENDIX A
IRB FORM



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Tassay Gillispie and John Graves
FROM: Mark Quinn, Chair *Mark Quinn CJ*
DATE: December 1, 2014
RE: "Using Models and Rubrics as a Form of Assessment in Science" [TG120114-EX]

The above research, described in your submission of December 1, 2014, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B
PRE/POST- INITIAL UNIT SURVEY

Pre/Post Unit Survey

Answer the following as best you can.

1. I think I am good at science.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
2. I think science is interesting.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
3. Anyone can be a scientist.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
4. My classmates see me as being good at science.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
5. I want to be a scientist.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
6. Drawing science models helps me understand the material better.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
7. Drawing out science models has no effect on my learning.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
8. Images and photographs help me to understand science concepts.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
9. Recreating models in my own words helps me to understand the concepts				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
10. I am typically motivated in science.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
11. I receive good grades in science (A, B or C).				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
12. I prefer to be challenged in class.				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
13. I prefer standard type tests (multiple choice, matching, short answer).				
Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

Check all that apply:

I can show what I really know about science in the following situations.

- ___ Multiple Choice Tests
- ___ Writing a summary
- ___ Creating a science model
- ___ Labeling
- ___ Verbally

APPENDIX C
PRE/POST TEST of CONTENT
ASTRONOMY

Astronomy Pre/Post Test of Content

Fusion is...

Complete the sentence.

Mark only one oval

- what's happening in our sun and most stars.
- Hydrogen atoms combining to form Helium and Lithium.
- The release of energy when nuclei combine.
- All of the above.
- None of the above

How does a star produce MOST of their energy?

Mark only one oval.

- Stars produce energy when a chain reaction fizzes hydrogen into helium and other elements.
- Stars produce energy when a chain reaction fuses hydrogen into helium and other elements.
- Stars produce energy by a fusion chain reaction of helium into hydrogen.
- Stars don't produce energy.

What type of elements are usually involved in fusion reactions?

Mark only one oval.

- Heavy Elements
- Elements with excess neutrons
- Elements with an atomic number less than 83
- Light elements
- I have no idea.

What is the heaviest element a star can make?

Mark only one oval.

- Helium
- Iron
- Carbon
- Chlorine
- I have no idea.

Which of the following best describes the big bang?

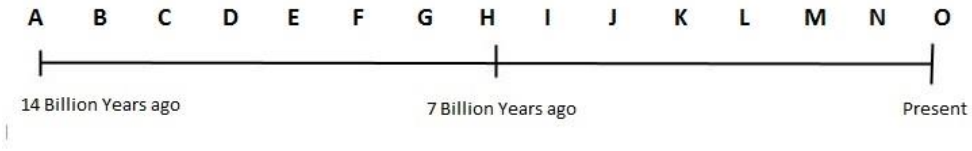
Mark only one oval.

- All matter in the universe expanded outward from a tiny area.
- All matter in the universe was created in its current location.
- Light waves condensed in a single area and matter was created.
- Several galaxies collided and exploded.
- I have no idea.

Which of the following best explains the presence of heavy elements here on Earth?
 Mark only one oval.

- heavy elements were made from fusion in the Earth’s core
- heavy elements were made from the big bang and later moved out to collect into planets
- light elements were made from the big bang and later moved out to collect into stars
- heavy elements were formed in ancient stars and some were later recycled into planets

Use this timeline of the life of the universe to answer the next question.

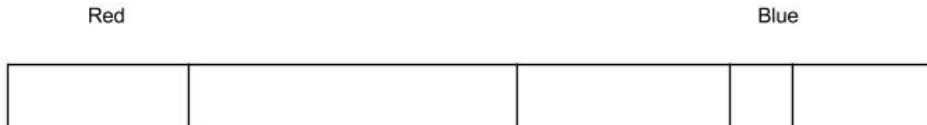


Which best describes the location on the timeline of the Big Bang?
 Mark only one oval.

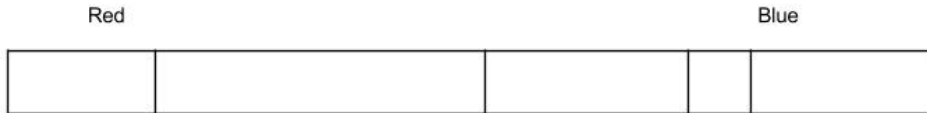
- Around A
- Between C and F
- H
- Between I and K
- Between L and N
- Around O

Use the following spectrographs of hydrogen to answer the next two questions.

Spectrum of hydrogen on Earth:



Spectrum of hydrogen from a distant galaxy:



How would an astronomer explain the difference between the two spectra?

Mark only one oval.

- hydrogen gives off light differently if the gravity of the star is large
- light traveling through space is warped by the vacuum

- the star is traveling away from us, lengthening the light waves
- the star has a slightly different kind of hydrogen it is burning.
- I don't know

How would the spectrum of hydrogen on the distant star be described?

Mark only one oval.

- Reflected
- Red-shifted
- Offset
- Refracted

Which of the following is supported by evidence from red-shifted starlight?

Mark only one oval.

- Galaxies are not moving.
- galaxies are generally moving away from each other.
- galaxies are generally moving toward each other
- movement of galaxies cannot be measured due to "shifting" of starlight.

True or False: Our Sun will produce a black hole when it dies.

Mark only one oval.

- True
- False

Match the following stages of a stars life to their definition.

A star that is continually turning hydrogen into Helium in its core and is where most the life of a star is spent.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star

- Pulsar
- Black hole

A Giant cloud made mostly of hydrogen and helium.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

When a low mass star is done converting hydrogen into helium it can fuse all the way up to carbon, then as it dies it grows bigger and glows red.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

When a high mass star is done converting hydrogen into helium it can fuse all the way up to iron, then as it dies it grows bigger and glows red.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant

- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

When a star collapses and explodes this can be created, it can contain elements up to iron and we call this recycled star dust.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

This is the size of Earth but very dense. They are the remnants of a star and can be found at the center of planetary nebula's.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

Largest stars die this way, they are the brightest object in the galaxy momentarily.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant

- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

These result from Supernovas of the most MASSIVE stars, gravity is so powerful that not even light can escape.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

A type of star that has compressed all its matter into a small sphere the size of Long Island, NY. It is said one spoonful would weigh as much as MT. Everest.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

A neutron star that spins, shooting energy into space. This resembles a light house as we get spurts of light and energy sent out way.

Mark only one oval.

- Protostar
- Main Sequence Star
- Red Giant
- Supernova
- Nebula
- Red Super Giant
- Planetary Nebula
- White Dwarf
- Neutron Star
- Pulsar
- Black hole

Please answer the following questions to the best of your ability.

The Periodic Table of the Elements

The image shows a standard periodic table of elements. The elements are arranged in rows (periods) and columns (groups). The table is color-coded by groups: Group 1 (purple), Group 2 (orange), Groups 3-10 (yellow), Group 11 (light blue), Group 12 (dark blue), Groups 13-18 (green, cyan, blue, purple, pink). The lanthanide and actinide series are shown at the bottom in green and yellow respectively. Iron (Fe) is highlighted in yellow in the center of the table, with its atomic number 26 and symbol Fe clearly visible.

Earth has elements that are way heavier than Iron, but iron is the heaviest element that a big star can fuse up to. Explain to me how Earth is able to have elements heavier than iron.

Be as specific as possible, include words like; fusion, nebula, star dust and supernova.

APPENDIX D
PRE/POST TEST of CONTENT
Biology

Biology Pre/Post Test of Content

During which stage of mitosis does DNA replication occur?

Mark only one oval.

- Prophase
- Anaphase
- Metaphase
- none of the above

Which of the following is NOT true?

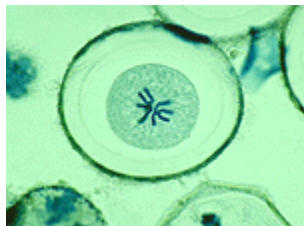
Mark only one oval.

- Mitosis produces genetically identical cells.
- Cytokinesis is part of mitosis.
- Metaphase occurs before anaphase.
- Interphase is part of mitosis

What is the function of centrioles?

Mark only one oval.

- To cause cytokinesis via the concentric shortening of microtubules.
- They are required for DNA replication.
- They are the structure which hold the 2 daughter chromatids together at the centriole.
- They produce microtubules for the chromosomes to migrate along as they move to opposite poles.



What stage of mitosis is this?

Mark only one oval.

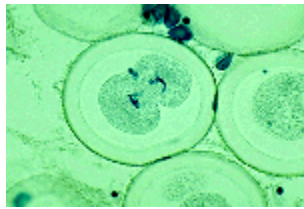
- anaphase
- telophase

- prophase
- none of the above.

Which answer gives the stages of mitosis in proper chronological order?

Mark only one oval.

- Anaphase, prophase, metaphase, telophase
- Metaphase, anaphase, telophase, prophase
- Prophase, metaphase, anaphase, telophase
- Interphase, prophase, metaphase, anaphase, telophase.



Using the above image, what stage of mitosis is this?

Mark only one oval.

- Telophase
- Anaphase
- Prophase
- Metaphase
- None of the above.

What is the order of the cell cycle?

Mark only one oval.

- M, G1, G2, S1, G0
- G0, G1, S1, G2, M
- S1, G0, G1, G2, M
- G0, G1, G2, S1, M

What does the Cell Theory state?

Mark only one oval.

- That all living things are made of cells
- Every cell has only one nucleus
- That plants cannot have cells
- Animals are the only ones that have cells

A Cell is the basic unit of life?

Mark only one oval.

- True
- False

The hierarchy of cells is...

Mark only one oval.

- cells, tissues, organs, organ systems
- tissues, organs, cells, organ systems
- organ systems, organs, cells, tissues
- None of the above

A cancer cell is one that grows _____, and a body cell is one that grows_____.

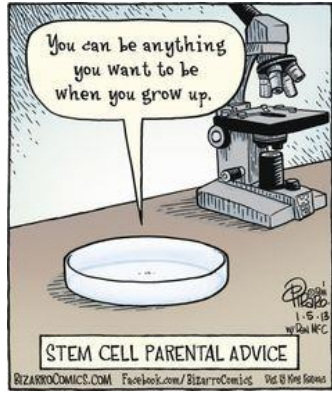
Mark only one oval.

- regulated, unregulated
- forever, never
- uncontrollably, controllably
- controllably, uncontrollably

What is a stem cell?

What is the benefit to stem cells?

Describe the size of cells in comparison to other items.



If someone didn't understand the above comic, how would you explain it to them so they could understand?

APPENDIX E
Models PowerPoint

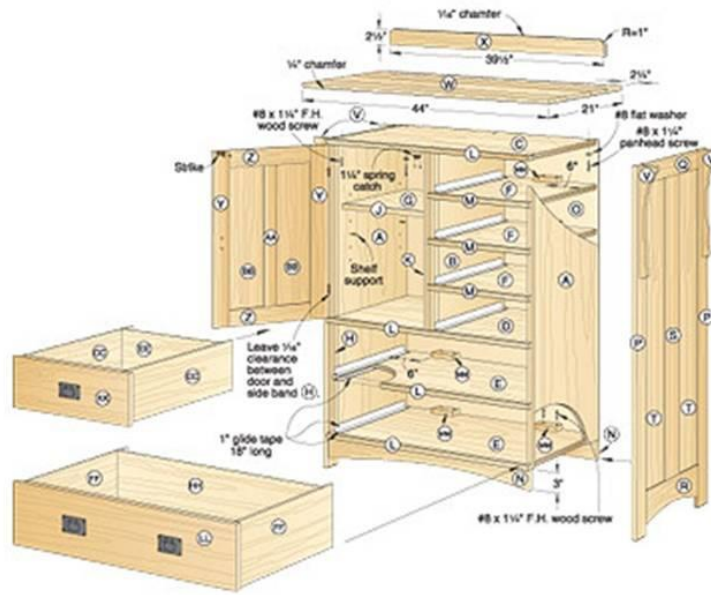
What is a model?

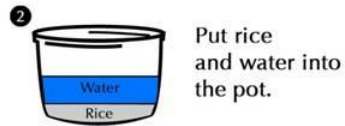
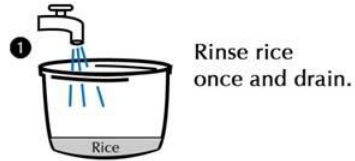
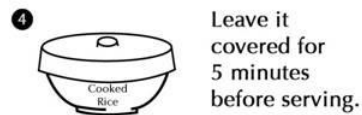
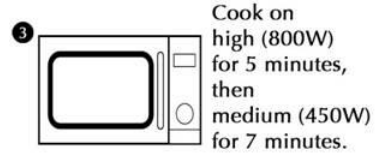
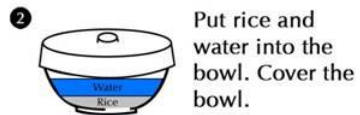
In Science when you are asked to create a model what does that mean?

So...What is a model?

A model is created to make a particular part or feature of the world easier to understand, define, quantify, visualize, or simulate.

Every Day Models

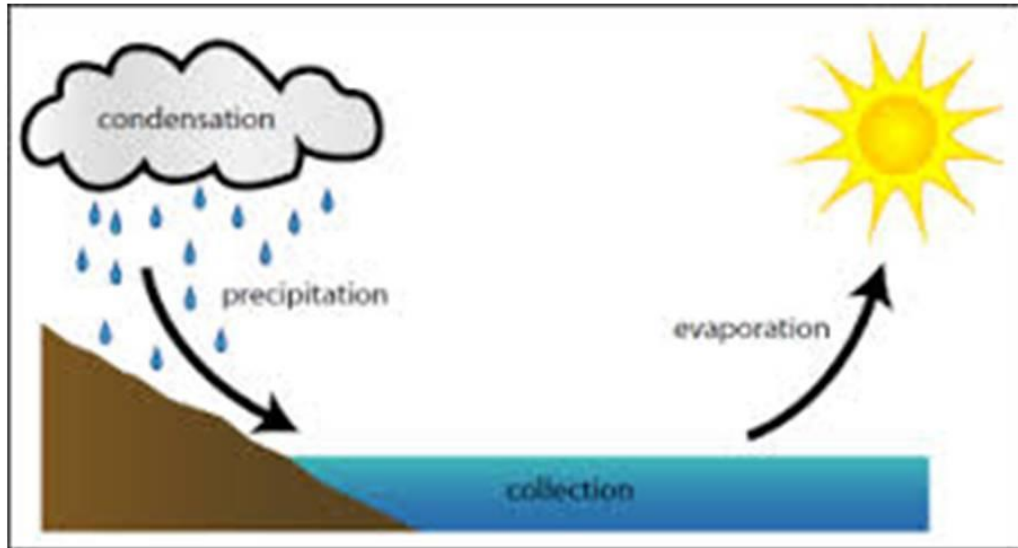


RICE COOKER METHOD**MICROWAVE METHOD**

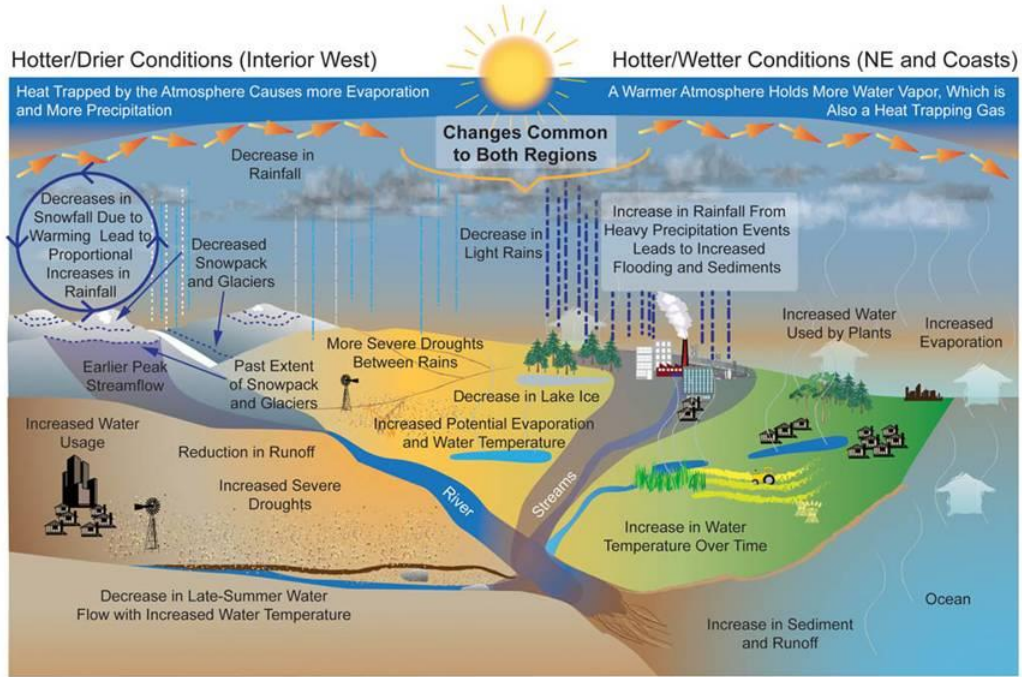
**1 cup of uncooked rice requires 1½ cups of water. This will yield 3 bowls of rice.*

Science Models...

Simple Models



Complex Models

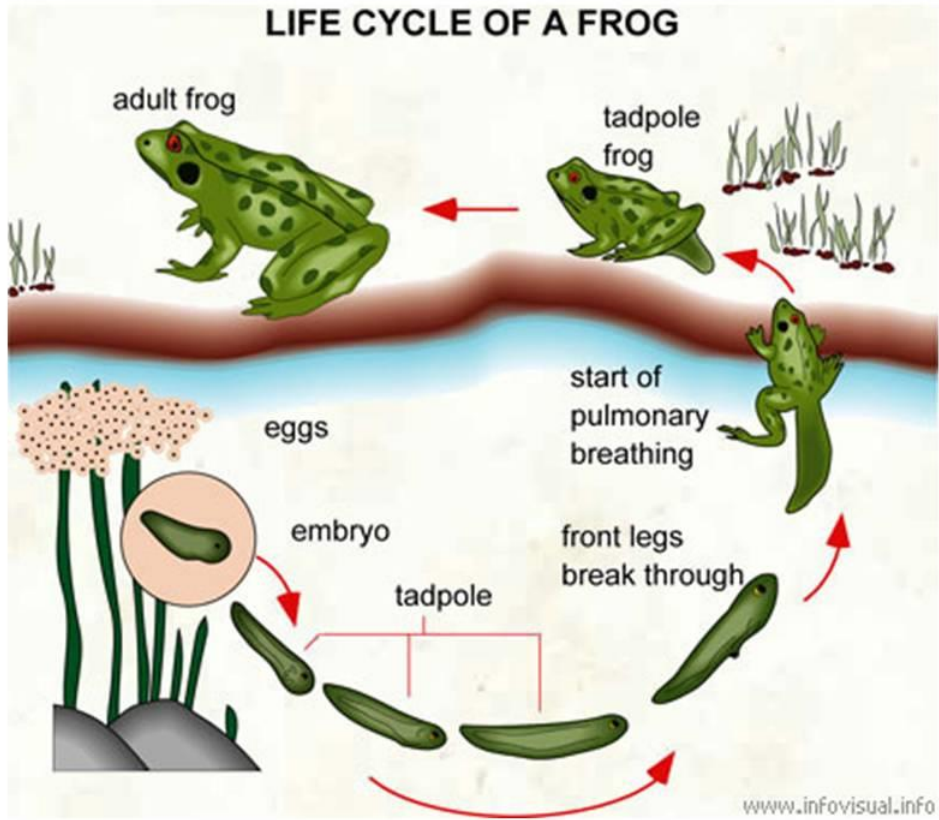


Many types...

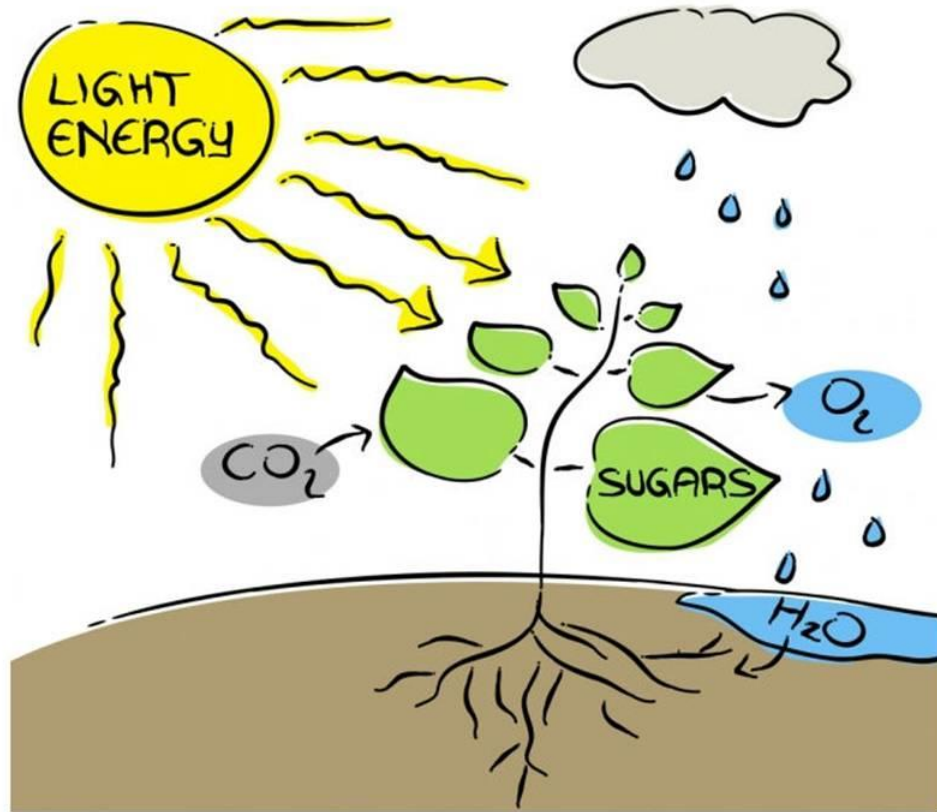
Periodic Table of the Elements

1 1IA H Hydrogen 1.00794	2 IIA He Helium 4.002602											13 IIIA Al Aluminum 26.9815385	14 IVA Si Silicon 28.0855	15 VA P Phosphorus 30.973761998	16 VIA S Sulfur 32.06	17 VIIA Cl Chlorine 35.453	18 VIIIA Ar Argon 39.948																		
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00644	8 O Oxygen 15.999	9 F Fluorine 18.9984032	10 Ne Neon 20.1797																		
11 Na Sodium 22.98976928	12 Mg Magnesium 24.304	13 Al Aluminum 26.9815385	14 Si Silicon 28.0855	15 P Phosphorus 30.973761998	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.8										
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium 98.90625	44 Ru Ruthenium 101.07	45 Rh Rhodium 101.07	46 Pd Palladium 106.3675	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.757	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.29	55 Cs Cesium 132.90545196	56 Ba Barium 137.327	57-103 Lanthanide Series	57 La Lanthanum 138.90547	58 Ce Cerium 140.12	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium 144.9127	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.5001	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93002	70 Yb Ytterbium 173.05468	71 Lu Lutetium 174.967
87 Fr Francium 223.0185	88 Ra Radium 226.0254	89-103 Actinide Series	89 Ac Actinium 227.03373	90 Th Thorium 232.0377	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	93 Np Neptunium 237.048173	94 Pu Plutonium 244.06422	95 Am Americium 243.06136	96 Cm Curium 247.07545	97 Bk Berkelium 247.0703	98 Cf Californium 251.0832	99 Es Einsteinium 252.08322	100 Fm Fermium 257.1037	101 Md Mendelevium 258.10386	102 No Nobelium 259.10386	103 Lr Lawrencium 260.10386																		

Alkali Metal
Alkaline Earth
Transition Metal
Rare Metal
Semimetal
Metalloid
Metal
Halogen
Noble Gas
Lanthanides
Actinides







We will use models...

To represent what words can't.

APPENDIX F
WHAT IS A MODEL?

What is a Model?

Name: _____

1. What do you think a model is?
2. What is Mrs. Gillespie's definition of a model?
3. Why do we use models?
4. Can you think of a model that has been beneficial to you, think outside of science if needed?
5. Can you draw a model, again it doesn't need to be science related.

APPENDIX G
MODEL GRADING RUBRIC

	5	4	3	2/1
Drawing	Thorough and concise analysis of _____ (the standard being addressed).	Clear analysis of different _____ (the standard being addressed).	Limited analysis of _____ (the standard being addressed).	Incomplete or no analysis of _____ (the standard being addressed).
Explanation	Thorough and concise analysis of the drawing with contextual evidence to support it.	Clear analysis of the drawing with some contextual evidence to support it.	Limited analysis of the drawing with little contextual evidence to support it.	Incomplete or no analysis given, with no contextual evidence.
Labels	Thorough and concise labels given, pertaining to drawing	Clear labels given, pertaining to the drawing.	Limited labels given pertaining to the drawing.	Incomplete or no labels given pertaining to the drawing.

APPENDIX H
ASTRONOMY WORD BANK

Astronomy Word Bank:

Nebula

Protostar

Main Sequence

Red Giant

Red Super Giant

Black Hold

Planetary Nebula

White Dwarf

Pulsar

Super nova

Recycled Star dust

Low Mass Star

High Mass Star

Neutron Star

APPENDIX I
STANDARD OF UNIT TAUGHT

Standards of Units Being Taught

Astronomy

1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.
2. Communicate scientific ideas about the way stars, over their life cycle, produce elements.

Biology

1. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
[Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.]

APPENDIX J
WEEKLY BEHAVIOR CHECK LIST

WEEKLY BEHAVIOR CHECK LIST

Student:			
Attentiveness	Talking out	Mental Reminders	Referrals
Student:			
Attentiveness	Talking out	Mental Reminders	Referrals
Student:			
Attentiveness	Talking out	Mental Reminders	Referrals
Student:			
Attentiveness	Talking out	Mental Reminders	Referrals
Student:			
Attentiveness	Talking out	Mental Reminders	Referrals

APPENDIX K
BI-WEEKLY STUDENT REFLECTION

WEEKLY STUDENT REFLECTION

1. I understand the concepts taught.				
Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
2. The model helped me to understand the material more clearly.				
Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
3. I am happy with my grade.				
Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
4. The rubric was helpful.				
Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
5. The rubric made the expectations clearer than if a rubric wasn't provided.				
Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree

6. I was absent _____ times in the last two weeks.

7. Anything else you think I should know about?

APPENDIX L
POST INTERVIEW QUESTIONS

POST INTERVIEW QUESTIONS

1. How did you feel about using Models? Do you feel that creating models (drawings) helped you to understand science concepts better?
2. How do you feel the use of rubrics helped you?
3. If you could change something about the rubrics what would you change?
4. What is your proudest moment this term?
5. What do you think your best diagram or model was?
6. What did you learn that you don't think you will forget?