

## **Science Fiction: From Black Holes to Alternate Universes for the High School Classroom**

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### **Overview:**

#### Why Read Science Fiction In The Classroom?

Learning to select books that captivate us, that inform us, that validate us, and that extend our thinking is a life skill. Keeping kids interested and motivated to read is sometimes a challenge. Some students who *can* read would rather do other things instead. Other students struggle with reading and so don't enjoy it. But in reading aloud, or reading with discussion and active involvement, we also condition the child's brain to associate reading with pleasure, create background knowledge, build vocabulary, and provide a reading role model. Reading is like riding a bicycle, driving a car, or sewing: in order to get better at it you must do it. And the more you read, the better you get at it.

Why don't students read much? Many seem to avoid books and print the same way a cat avoids a hot stove burner! One reason may be because of the large number of unpleasurable messages they received throughout their school years, coupled with the lack of pleasurable messages in the home, which nullify any attraction from the reading experience. Reading efficacy, the belief that one can be successful at reading, is vital to becoming an active reader. Reading efficacy refers to students' perceptions of themselves as competent readers and learners, which are associated with academic achievement. The last twenty-five years of reading research confirms this simple formula – regardless of sex, race, nationality, or socioeconomic background - Students who read the most, read the best, achieve the most, and stay in school the longest. Conversely, those who don't read much, cannot get better at it. And most Americans (children and adults) don't read much, and therefore aren't very good at it. These students not only have a history of reading failure, they have developed attitudes and coping strategies which lead them to avoid, rather than fix, their reading problems.

Robert A. Heinlein describes science fiction as "realistic speculation about possible future events, based solidly on adequate knowledge of the real world, past and present, and on a thorough understanding of the nature and significance of the scientific method<sup>1</sup>." Rod Serling stated: "Fantasy is the impossible made

probable. Science Fiction is the improbable made possible.<sup>2</sup> " In general, science fiction is the literature of things that might someday be possible. It is also a way to bridge the divide between thinking "inside" and "outside" the box. It is my contention that by adding science fiction into the mainstream curriculum, we can capture the imagination of some of the previous non-readers and get them excited about reading.

Many students in today's high schools are not frequent readers, although the No Child Left Behind Act entreats teachers to encourage reading outside the curriculum. Although this "outside reading" is really NOT part of a teacher's job, it is expected that they at least add some type of reading into their curriculum. This unit is designed to help teachers of typical mainstream high school students to adapt a portion of their curriculum to include reading, and to focus the students on the science concepts introduced in the reading. It is an excellent tool for use as a cross-curriculum project for science, English, and civics (or social studies) classroom. It has been adapted for use by mainstreamed, special-ed students whose reading level is at the 6<sup>th</sup> grade. For further adaptation, for students whose reading level does not match that specified, the teacher could spend more than the proposed time on the reading, and read the story OUT LOUD in the classroom, rather than have the students read on their own.

This curriculum incorporates actual science labs and concepts with reading outside the curriculum. The students are first exposed to the basic scientific principles that the reading will reinforce, and then reading, and eventually writing an original short story, culminate the curriculum. Specifically, the science introduced in this curriculum will include multiple dimensions, non-Euclidian geometry, the curving of gravity and light around objects, atomic particles and their movement, string theory, the "grandfather paradox," and tessellation. As a supplement to this curriculum, the students will read a science fiction novel, and write an original science fiction story. The students should also realize that the genre of science fiction often drives the technology which increases scientific understanding and development.

### **Introduction:**

When most people refer to Title I, they are actually talking about Title I, Part A of the No Child Left Behind Act of 2001 (NCLB)<sup>3</sup>. Part A, Improving the Academic Achievement of the Disadvantaged Program, is one of the most well known parts of federal education law. It is the largest federal education program for elementary and secondary schools. Title I funds are targeted to high-poverty schools and districts and used to provide educational services to students who are educationally disadvantaged or at risk of failing to meet state standards.<sup>4</sup> In some form, Title I has existed since the Elementary and Secondary Education Act of

1965 (ESEA), when the federal government first began to authorize formula grants to states and districts for the education of elementary and secondary students with low academic achievement who are enrolled in schools serving low-income areas.<sup>5</sup> Paris, et al,<sup>6</sup> reviewed literature indicating that students who have a sense of control over their own learning achieve more and are more active in school than other students. Bandura<sup>7</sup> and other psychologists have shown that self-efficacy, which is a belief in probable success, is associated with high performance in complex reading tasks and in mathematics<sup>8</sup>. Reading comprehension is not a simple and automatic skill, it is an active and strategic process of cognition (or thought). In order to encourage reading, a teacher or guardian needs to create varying motivations to read, which can influence a child's effort and strategy use in making meaning from text.

Helping a student to develop a love of reading is a tricky enterprise. Research generally agrees that the most critical aspect of reading is how a child feels about that reading. If kids are going to enjoy reading, the experience has to be enjoyable<sup>9</sup>. One successful approach to motivating the student to read is to use some sort of visible record of achievement. A chart or graph that marks the number of books a child has read gives him or her a sense of accomplishment. To spice it up a bit, the teacher should choose a theme that goes along with the childrens' interests. One example would be a Reading Olympics, where the child goes for the gold by reading a certain number of books. The more you read, the better you tend to read, the more you enjoy it, and... the more you read!

In order to accomplish the goal of increasing student reading, many schools throughout the United States have instituted a "read 25" program, in which all high school students, regardless of literacy level or competency, must read 25 books each year, from different genre. While teachers include their text books as several of the required readings, it is frequently only the English curriculum that encourages the reading of material outside of school hours, and encourages the reporting of the material read. It is extremely important, however, for students to realize that reading is a cross-curriculum activity; that reading belongs in all classes, and that it can relate to other classes they have as well, including history, psychology, geography, sociology, and many of the vo-tech classes, and that it is an activity which is beneficial to them outside of school, as well. In many of the nation's high schools, the English Departments help the students to identify many genre, and have required reading during the year which include samples of the different genre. The students read biographies or autobiographies, historical fiction and non-fiction, mythology, and, occasionally, romance. Rarely, however, is the genre of science fiction included. While some schools introduce *Flowers for Algernon*, or *Fahrenheit 451*, few complete the novels front to back and discuss the influence of science fiction on technology, ethics, morals, and medicine.

Science fiction has been called a "literature of ideas." It is a broad genre of fiction that often takes place in the future and usually involves speculations based on current science. In order for the genre to develop, science itself had to develop. Then, scientific ideas needed to provide the inspiration for new technologies, and finally, those technologies had to have a noticeable effect on the lives of everyday people. None of this happened until the Industrial Revolution, when technology was being created at a previously unseen rate. For this reason, this unit can be used as a cross-curriculum unit with the social studies curriculum. While the students are learning about the Industrial Revolution, its leaps and bounds through technological advances, and its impact on society, students in the science classroom are learning about some of the specific technologies introduced in science fiction *BEFORE* their invention for use in the "real world."

Science fiction often involves a setting in the future or on an alternative time line, a setting in outer space or involving aliens or unknown civilizations, the discovery or application of new scientific principles, such as time travel or psionics, or new technology, such as nanotechnology, faster-than-light travel or robots, and political or social systems different from those of the known present or past. All of these parts of science fiction can be used during active reading and its accompanying projects<sup>10</sup>, or as a bridge across curriculums. One of the keys to helping struggling readers is to provide them with books that they can and want to read. Fiction for struggling readers must have its own textual integrity: realistic characters, readable and convincing text, and a sense of the readers' interests and needs. Science fiction abounds as a literature genre. It is all too easy to find short stories and novellas with realistic characters in convincing environments to which the typical high school student can relate. To insure that education will continue to serve our students successfully, it is essential that we have a clear understanding of the purposes of education and how schools should function to prepare young people for the 21st Century. Reading is inherent in both the purpose and function of education. Relating that reading to actual experiences in that student's life, and causing the student to think about how a person's creative thoughts actually might lead to new discovery incorporates excitement for the student into his or her reading.

Science fiction is written with compelling story lines, credible characters, relevant topics, and the ability to make personal connections. All of these build the emotional bonding between reader and story, and increase the desire to read, as well as the level of comprehension. The reading that is the essence of this curriculum builds upon the basic knowledge of gravitational pull, multiple dimensions, and tessellation, the ability to "fold" space/time to step from one place to another.

## **Rationale:**

The Title I program is designed to improve the academic achievement of eligible students, reduce performance gaps between advantaged and disadvantaged students, and assist eligible students in meeting high academic standards<sup>11</sup>. In addition to providing funds for high-poverty schools, Title I, Part A is the federal government's primary instrument for holding states, districts, and schools accountable for implementing standards-based education. In a school-wide program, most federal, state, and local funds are consolidated to upgrade the entire education program of the school. In schools operating such a program, Title I is no longer a distinct program but is to be integrated into the regular educational program of the school<sup>12</sup>. School-wide programs are not required to identify eligible students for targeted Title I services, but the law requires schools to address the needs of low-achieving students<sup>13</sup> and those at risk of not meeting the state standards who are members of the target population of any program that is included in the school-wide program.

Part B, the Reading First and Even Start Family Literacy Programs, focuses on improving reading achievement. The purpose of the "Improving Literacy Through School Libraries" program is to improve literacy skills and academic achievement of students by providing students with increased access to up-to-date school library materials; a well-equipped, technologically advanced school library media center; and well-trained, professionally certified school library media specialists. *[Section 1251.Purposes]* Possibly due to the new accountability requirements and other changes in Title I, recent studies have found that Title I might be having a positive impact on student achievement<sup>14</sup>. A study of urban and suburban/rural strategies for educating disadvantaged children concluded that Title I had tended to have a positive effect on student achievement<sup>15</sup>. The National Assessment of Title I (NATI) reported similar findings<sup>16</sup>, citing gains in national reading and math performance and progress in the percentage of students in the highest-poverty schools meeting state and local standards for proficiency in math and reading<sup>17</sup>.

It is known that successful reading development is predicated on practice reading, and obviously the less a child practices, the less developed the various reading skills will become<sup>18</sup>. To counter these highly predictable declines in the motivation to learn to read, prevention and early intervention programs are critical. Over time, there will be an inverse relationship between the ease of learning to read and the effort required to learn to read – clearly, the need to exert enormous amounts of effort will take its toll on many would-be, but now discouraged, readers.

Reading aloud is often cited as one of the most beneficial ways to encourage reading, and to increase reading retention. Although active reading depends partly on comprehension abilities, it depends more on motivations for reading. A classroom environment that supports the development of active reading creates contexts that satisfy the student's needs for curiosity, aesthetic involvement, challenge, competitiveness, and social exchange. The most central of these is curiosity, the desire to know more about something<sup>19</sup>. Making connections from one's own experience to the text is an important reading strategy and a basic literacy skill. It is important that students be able to relate to the topics and issues in the books they read. Such a connection may allow a student to read material with a measured readability two grade levels or more beyond his tested ability<sup>20</sup>. Several strategies for active reading include discussion about the relevance of the material to the student's personal or emotional connection, illustration and role play of scenes throughout the reading, and frequent graphic organizing of the material read. Often, books lead to developing new hobbies or interests, or relate to hobbies or interests the student may have, but was unaware were in print form. Discussing the *ideas* found in the book also increases reading retention. As a teacher reads with their students, they can keep them involved by asking questions about the story, and let them fill in the blanks on prepared worksheets. They can also create activities related to the stories they're reading, including creating web pages and power point presentations, or a condensed version of the story for younger students.

The best materials for struggling readers are carefully written, edited, and designed to provide supports for struggling readers. These supports include: A compelling storyline and credible characters, topics and issues with which readers can make personal or emotional connections, supportive formatting that includes illustrations and appropriate text placement on the page (hyphenation is a problem for reluctant readers, line spacing is more important than type size; some type faces are more easily readable than others) and careful introduction and reinforcement of difficult vocabulary and concepts (no difficult word should be used only once, and every difficult word should be presented in such a way as to be sure its meaning is clear.)<sup>21</sup> Readers need to care what happens to the characters and how their problems will be resolved in the story<sup>22</sup>. This is particularly important for reluctant readers. Novels for struggling readers need clearly defined and differentiated characters. This does not require a lot of description; it does require that the characters are clearly distinguishable from one another. Included in this curriculum are lesson plans and accompanying worksheets to aid the students to comprehend and distinguish the decisions and personalities of the characters in the story. (see Lesson Plan section.)

Many science fiction authors are hopeful that science and technology will make our lives better, while others predict that the powerful new technologies

might in time backfire and cause problems. We are gaining scientific knowledge at an ever-increasing rate. As a result, new technologies appear every day. In addition, existing technologies, such as computers and the Internet, are becoming more advanced and more a part of our everyday lives. With this increase in technology, and our increased association with it, the amount of new material for science fiction writers to work with is growing. Reading science fiction, and learning to analyze the ideas as scientifically accurate or a prediction which may lead to new technological growth is a stimulating experience<sup>23</sup>. In the best SF, the reader is very nearly forced (by the author's skill and self-consistency) to engage the brain, to pick out the background assumptions which are behind the plot, to see the connections between a strange new world (even if that world is called Earth) and our own, and to keep thinking about what will happen next, even after the story is done. It is this incitement to deep thought about a story and the issues it concerns that makes science fiction a potentially powerful teaching tool.

Because science fiction deals with scientific technology, it can lead students to inquiry, to trying to discover how the technology in the writing was created. Often, when the student goes to research this idea, they find that the technology for the science still does not exist, and therefore, the scientific ideas offered are actually fiction. A well-written science fiction book leaves the reader feeling that there is no science in the book that is beyond their reach- it is written so believably that the student has trouble believing that it would be impossible to make the concepts real. Take, for example, the writings of Jules Verne. Now, since the technology is available, the technologies introduced in his stories, including scuba gear, steam powered trains, and space travel are easily believed. But when the books were written in which these concepts were introduced, people could not believe they would ever exist!!! Science fiction builds curiosity, the desire to know more, than what is written in the book. It drives the reader to explore further, and perhaps to invent something new!

Often, science fiction deals with events or ideas that are actively being talked about in the news. By reading something that is relevant to their personal lives, the student is able to make a connection with the material. This connection often serves as a stepping stone to further investigation. Many of the stories written in this genre deal with characters that are believable; one can almost imagine that the characters were based on someone the reader knows. The scenes, while they can be futuristic or other-worldly, are designed in a way to relate them to the reader. Although the setting may be on some planet that is make-believe, the reader can picture themselves there. This attention to detail in science fiction allows the student to graphically picture themselves in the midst of the story. This personal or emotional connection allows students to use the books to actively read, which increases retention.

In order to begin this curriculum, an introduction into the four dimensions found on Earth is necessary. Students should, by high school, have learned about the first three- height, width, and depth. To review these, the educator should have the students draw a 2-D square and a 3-D box, and explain the difference, leading the students to use the terminology. Once the students have begun to think of 3-D, other shapes can be used as well. Many students may have seen a 3-D movie over the past few years; if so, they can lead a discussion on what the glasses were like that they had to use, and what the difference between a 2-D and 3-D movie seemed to be. The included lesson plans list shapes and objects that can be used to discuss 2-D vs. 3-D images, using graph paper for ease for the student, and it is up to the instructor's discretion if they would like to bring in a 3-D video for the students to watch, so that the students can experience this for themselves. A note, however, on safety- students should NOT share 3-D glasses, as the eye has many bacteriae, which can easily be transmitted! A fun and simple lab would be to have the students follow a map. If they were told to travel forward and backward for one dimension, side to side as the second dimension, and up or down as the third dimension, it is conceivable to have the students climbing up on chairs and tables, or climbing ropes and bleachers in a gym! These three dimensions are common to Euclidian geometry, which is typically taught in either junior or senior high school. However, there is a non-Euclidian geometry which applies to other dimensions. By Newton's era people had already used algebra and geometry to build marvelous works of architecture, including the great cathedrals of Europe, but algebra and geometry only describe things that are sitting still. In order to describe things that are moving or changing in some way, Newton invented calculus. The students should be aware that calculus is one of the math courses offered in most high schools, and that, when they take the course, they are actually working with math that was invented by Newton in order to be able to describe actual phenomenae on Earth. Today's theoretical physicists are often working on the boundaries of known mathematics, sometimes inventing new mathematics as they need it, like Newton did with calculus.

Using this information, the concept of space can be discussed more correctly. Students can begin to realize that space is curved, so light traveling around a massive object like the sun will be "curved" around it. This has been proven empirically on quite a few occasions. Once the students are familiar with 3-D, the fourth dimension must be discussed. Because of Einstein, we often call time the fourth dimension, although there are many physicists who claim that time is not the fourth dimension<sup>24</sup>. Special relativity shows that time behaves surprisingly like the three spatial dimensions. The Lorenz equations show this. Length contracts as speed increases. Time expands as speed increases. While Einstein himself felt that time was the fourth dimension, many people feel that the fourth dimension is a spatial dimension as well. The only way we have to describe the fourth dimension is by analogy with the second and third dimensions. Namely,

"How would you describe the third dimension to a two-dimensional creature?" The best way to describe it is to say the third dimension is infinitely many two-dimensional worlds put together "on top of each other", if you will. So a 3-D cube can be created by stacking infinitely many 2-D squares on top of one another. The fourth dimension is just infinitely many three-dimensional worlds put together "on top of each other". So a three-dimensional creature traveling through the fourth dimension would see only one three-dimensional "slice" at a time. And these slices may be radically different from his or her "home space", or they may be quite similar. If, indeed, all the 3-D creature would see would be one 3-D slice at a time, as we do, then it is quite possible to theorize that a 4<sup>th</sup> dimensional space *actually exists*, but that we are ill-equipped to visualize it.

A simple lab to demonstrate non-Euclidian geometry would be to take a white bed sheet. Draw on it, in dark marker, two parallel lines approximately 2 feet from each other. Have all students hold the sheet around the edges, and roll a bowling ball into the middle of the sheet and observe the parallel lines. They no longer seem straight, nor parallel! We *know* that they are, as we drew them that way, and the drawing could not have changed, but we *SEE* that they are no longer parallel! Interestingly enough, this non-Euclidian geometry applies to gravity as well. When space comes close to a gravitational planet, it "bends", or warps, and no longer seems straight. The same applies to drawing gravitational lines from above the earth to within the center of the earth. We know that two objects falling due to the force of gravity are falling on parallel lines. However, as they approach the center of the earth, where gravity is centered, the two parallel lines actually converge!!!! This goes against all Euclidian geometry, which defines parallel lines as two lines which never intersect!!! Students are often fascinated by the fact that parallel lines might converge!

In the book that is to be read as part of this curriculum, Madeline L'Engle uses a term "tessellation" to refer to traveling instantaneously from one space or planet to another. In order to have an understanding before reading the book, analogies must be used to help the students understand the use of dimensions in travel through space. As an analogy of one-dimensional travel, we will use a train that has no windows and a glass bottom. It travels along a track in one dimension -- either forward or backward. It cannot move left or right. In fact, these terms mean nothing to a train on a track. However, the train track could curve left or right, but the people on the train could only see the train track below, and for all they know the train is either traveling forward or backward throughout the entire trip. So while they believe they are traveling in one dimension, they are actually curving through the second. As an analogy of two-dimensional travel, we will use a car with no windows and a glass bottom. This way, all we can see is the two-dimensional road. We can still travel forward and backward, but now we can also travel left and right, or "forward in the second dimension and backward in the

second dimension". However, the road could curve up and down a mountain or even hills (through the third dimension), but to our "two-dimensional" observer, the car constantly travels in only two dimensions. As an analogy for three-dimensional travel, we will use the spaceship. This can move forward, backward, left, right, and now up and down (or forward and backward in the third dimension). We have seen that our three-dimensional space curves through the fourth dimension, even though we cannot detect it. So the shortest distance between two points may not be through our three dimensions after all. Instead it would be through the fourth dimension, bypassing all of the "curves" in our way. This is the essence of tessellation -- to cut through all of the curves of our limited three-dimensional world by passing out of it and into others. Tessellation is the underlying form of travel in the book that will be read in this curriculum, *A Wrinkle In Time*.

A newer study being conducted in physics, which may someday actually lead to the ability to tessellate, is that of string theory. Before discussion of string theory, however, students should be introduced to particles and the theories about their movement and relativity. Protons, electrons, their charges, and the forces of attraction and repulsion must all be explored so that the students feel they have a basic understanding of the current theories of atoms. After a basic introduction to the Periodic Table of Elements, students should be introduced to the particles themselves. Electron configuration is intimately related to the structure of the periodic table. The chemical properties of an atom are largely determined by the arrangement of the electrons in its outermost ("valence") shell (although other factors, such as atomic radius, atomic mass, and increased accessibility of additional electronic states also contribute to the chemistry of the elements as atomic size increases).

Although the name "atom" was applied at a time when atoms were thought to be indivisible, it is now known that the atom can be broken down into a number of smaller components. This requires understanding that whereas the word *atom* originally denoted a particle that cannot be cut into smaller particles, the atoms of modern science are composed of subatomic particles including electrons, which was the first of these to be discovered, which have a negative charge, are of a miniscule but measurable size, and which are the least heavy (i.e., massive) of the three. These can easily be ejected from atoms during ionization. The electrons form the much larger electron cloud surrounding the nucleus. The electrons (or more specifically, electron clouds) orbit a small, dense body containing all of the positive charge in the atom, called the atomic nucleus. This nucleus is itself made up of other particles, positively charged protons and chargeless neutrons. Protons are about 1836 times more massive than electrons; and neutrons, which are the about the same size as protons. Protons and neutrons make up a dense, massive atomic nucleus, and are collectively called nucleons. Electrons are bound to the

nucleus by photons carrying the electromagnetic force. Protons and neutrons are bound together in the nucleus by the strong nuclear force.

Before 1961, the subatomic particles that make up atoms were thought to consist of only protons, neutrons and electrons. However, protons and neutrons themselves are now known to consist of still smaller particles called quarks. In addition, the electron is known to have a nearly massless neutral partner called a neutrino, which appears whenever an electron is created from a quark reaction. Together, the electron and neutrino are both termed leptons-- particles with mass which are not subject to the strong nuclear force. All of these smaller particles are studied in quantum mechanics and quantum chromodynamics, and are worth mentioning in a biology I class only to stimulate the students' quest for further scientific research, and to demonstrate that as technology improves, so does our understanding of the universe, (or at least our ability to question it.) The students should then learn to draw models of the movements of the electrons and nucleons using Bohr's method and electron clouds. Explaining the behavior of the electrons that "orbit" an atom was one of the driving forces behind the development of quantum mechanics. In quantum mechanics, the atomic orbitals are the quantum states that electrons surrounding an atom may exist in. These can be described as a wave function over space, by the  $n$ ,  $l$ , and  $m$  quantum numbers of the orbital, or by the names of the orbitals, as used in electron configurations. This is the specific point where string theory comes in. According to string theory, perhaps matter is not found at POINTS, but in STRINGS.

In order to help students understand the basic idea of string theory, the game "cat's cradle" can be used. This can show how the movement of strings around a central location (the hand) retains the same inherent parts, but simply changes the shape. (All points on the strings are still there, they are just shifted from place to place as the strings move.) This game can further demonstrate how alternate universes can lay beside each other, and how the movement of the strings (in the game) can change the actual positions of matter. If the students are told that each string length is a different universe, and these lengths are colored with marker before the game is begun, the students can see how alternate universes can easily be manipulated to come into contact with various other universes at different times. While oversimplifying the idea of string theory, this practical understanding will allow the students, again, to be able to envision the "tessellation" in the book to be read. This "string theory" is the latest in physics development, and as the students complete high school and enter college, they may hear that science has yet again found an entirely new field to study. The students should be able to see that science is ever changing and often requires "thinking outside the box."

At this point, the students have a basic knowledge of some of the science that will be introduced in the book. The students are to read *A Wrinkle in Time*- by Madeleine L'Engle- together. The students will be given daily synopsis sheets to fill out to go along with their reading, and discussion will include what they feel is, and is not, realistic in each section of the book. In addition, students will try to imagine what was, and was not, working scientific knowledge at the time this book was written, in 1962. Time travel stories are complicated by logical problems such as the grandfather paradox, in which the question arises as to what would happen if you went back in time and killed your grandfather before he met your grandmother. If this occurred, your grandfather would not have met your grandmother, so you would not have been born. But, if you had not been born, how could you have gone back to kill your grandfather? This should invoke a lively discussion amongst the students. After reading *A Wrinkle in Time*, students should be able to discuss their theories on the feasibility of time/space travel and alternate universes, both of which are mentioned in the book. They should also be able to discuss why the book is included in the science fiction genre, namely that each of the conditions mentioned at the outset are actually present in this book.

The last exercise for this unit would be one in which the students wrote their own science fiction short story. A list of topics could be given, as well as a list of different technologies, characters and possible challenges to be overcome, and the students could choose from those lists to create their own story. While spelling and grammar may be an inherent problem, the creative process would be invaluable for these students to make a final connection to the genre of science fiction.

By the time we would complete this unit, the students should have a strong grasp of the concept that science improves as technology improves, and technology improves as people imagine the improvement, which is often driven by science fiction authors. The students should have come to understand that the orbits are controlled by gravitational pull, which does not follow the typical Euclidian geometry that they have already learned. They should be able to imagine that there are actually other solar systems and planets outside our own solar system, which has been inscrutably proven. It will also be interesting to see their new thoughts about alternate universes. These are distinct events that are in existence, and explored and expounded upon through the use of physics. They should have gained an understanding of basic atomic makeup, and how science and technology are related. The ultimate goal, however is to create a love of reading the genre of science fiction, which may likely lead some of the students to question the ideas in the stories they read, and become more interested in science itself.

If Isaac Asimov is to be believed (and if you can't believe Ike, who can you believe?), there's a strong correlation between reading science fiction as a child and entering a technical profession. If as a nation we want more homegrown scientists, engineers, and programmers, the long-term solution is obvious- READ SCIENCE FICTION!!!

**LESSON PLANS:**

Day 1: 3-Dimensional Space and Movement in the Dimensions

Standards:	S&T 3.1, 3.2, 3.3
Objectives:	TSWBAT: Identify the three dimensions in which they live.
Intended Length of Lesson:	One class lesson.
Warm-up:	Have students write a pre-knowledge quiz: what does 3-D mean?
Materials:	Pre-conceptualized idea of space to be used so that instructor does not give incorrect dimensional direction which would be a direction the students could not obtain.
Instructional Procedures:	<p>Explain the three dimensions as X (side to side) Y (forward and backward) and Z (upwards and downwards)</p> <p>Explain to students that they might follow the directions correctly and end up in a different space than other students.</p> <p>Explain that the students may only follow the teacher's directions, as in "Mother May I" game.</p> <p>Have all students start in center of gymnasium. Give them directions as to how many steps in each of the dimensions allowed at one time. Assess as you go that each student is following those directions!!!! Try to include all three dimensions so that students either climb bleachers or climb ropes!!!</p>
Worksheets:	<p>None, but permission to use gym must be obtained in advance!</p> <p>*For students, a small slip of paper with X,Y, and Z explained for them to hold in their hands might help them to stay on track.</p>
Assessment:	Did all students use the dimensions correctly?

Day 2: Space is Curved: Introduction to Gravity, Gravity Lab with Sheet and discussion of Non-Euclidian geometry

Standards:	S&T 3.1, 3.2, 3.3
Objectives:	TSWBAT: Explain gravity as a force on Earth. Determine their weight using the force of gravity on other planets. Explain the definition of parallel lines in Euclidian geometry. Determine that gravity does not fit in Euclidian geometry. Analyze the effect of gravity on light waves.
Intended Length of Lesson:	One to Two Class Lessons.
Warm-up:	Have students quickly write their pre-knowledge of the definition of gravity. Have students demonstrate pre-knowledge of Euclidian geometry by having them draw what they determine to be parallel lines.
Materials:	Worksheet #1, standard white bed sheet with parallel lines drawn on it, bowling ball or basketball.
Instructional Procedures:	Begin by helping students to determine their mass using Earth's gravitational constant and their known weight. Have them apply this information to other planets to determine on which planet in our solar system they would weigh the most, and the least. Discuss gravity and how it was determined to exist. Discuss Euclidian parallel lines. Explain to students that gravity is parallel lines, but those lines eventually converge at the center of the Earth, so the definition of parallel lines they have known to date does not fit. Explain that scientists must create new math to fit new scientific facts, and that is how calculus was invented. Have students hold sheet tightly to see that the parallel lines are drawn in Euclidian definition. Place ball carefully on sheet and have students pick it up again and observe the parallel lines to see that they no longer seem parallel. Explain that this is what happens to "atmosphere" and light waves as they approach any planet with gravity.
Worksheets:	Worksheet #1 (Front to back)
Assessment:	Have students assess their knowledge by drawing each example of parallel lines. Have them explain what would happen to a space ship as it traveled past a planet with gravitational pull.

#### Day 4: Atoms, Their Particles, and The Particle Movement

Standards:	S&T 3.1, 3.2, 3.3
Objectives:	<p>TSWBAT:</p> <p>Identify proton, electron, and neutron in an atom.</p> <p>Use the periodic table of elements to determine how many protons and electrons are found in different elements.</p> <p>Illustrate the cloud model and explain the 2-8-8 model of electron movement.</p> <p>Analyze the spatial placement of electrons to bonding between elements.</p>
Intended Length of Lesson:	2 Class Lessons
Warm-up:	Ask students to give the elemental symbol for Hydrogen, Oxygen, Carbon, and Sulfur. Ask students to tell you what elements are in H <sub>2</sub> O.
Materials:	<p>Worksheet #2</p> <p>Worksheet #3</p> <p>Periodic Table of Elements for each student</p>
Instructional Procedures:	<p>Remind students that they have seen these notations before, as in H<sub>2</sub>O. Explain that most elemental names start with the common letter of the known name, but some use the first two letters, as in Helium, and Neon.</p> <p>Explain that several of the elements' names are Latin or Greek, and do not seem to correspond to what we commonly call them, as in Iron (Fe) Potassium (K) Gold (Au) Silver (Ag) or Copper (Cu), yet they all use the first letters of the Latin (or Greek) name. Note that all elements start with Capital letter, but if there is a second letter, it is NOT capitalized.</p> <p>Have students identify the elemental number for each of the elements. Explain that this number tells the student how many protons AND how many electrons are found in one atom of that element.</p> <p>Explain that protons carry a positive charge, electrons carry a negative charge, and neutrons are neutral (no charge.)</p> <p>Have students complete Worksheet #2.</p> <p>Explain the 2-8-8 rule as shown on Worksheet #3. Have students complete the illustrations using the number of electrons present.</p> <p>Explain that the VALENCE shell, or outermost shell, wants to be full. Have students understand that in all shells but the first, a total of 8 are required. Explain that this determines how many things can bond to an element. Explain that Lewis dot diagrams show only the outer shell electrons. Have students complete Worksheet #3.</p>
Worksheets:	Worksheet #2 (Front to Back), Worksheet #3
Assessment:	Correct illustrations for bonding of elements.

Day 6: Cat's Cradle and Introduction to String Theory

Cat's Cradle and Introduction to String Theory

Standards:	S&T 3.1, 3.2, 3.3
Objectives:	TSWBAT: Recognize that if the electrons in atoms of elements move in WAVES, as strings, instead of in points, they still remain electrons- they are just moving differently.
Intended Length of Lesson:	One class lesson.
Warm-up:	Ask which students have played the cat's cradle game; try to partner them with students who have not for ease in directions.
Materials:	18" string, tied in a loop, for each partnered pair.
Instructional Procedures:	Demonstrate how to first set up the string on the first partner's hand. Step by step, demonstrate the next move. After the students have had a bit of fun, have them stop for discussion. Ask students the following: If each string section were one electron, what element is being represented by each step? (allow students to play again to count the number of elements/string sections) Stop the students again, and review that physics is the science of matter and energy and of interactions between the two, grouped in traditional fields such as acoustics, optics, mechanics, thermodynamics, and electromagnetism, as well as in modern extensions including atomic and nuclear physics, cryogenics, solid-state physics, particle physics, and plasma physics. Explain to students that physics is now at a place where we can separate electrons and protons from atoms and measure their size and movement patterns. There is a new theory in physics, called STRING theory, in which physicists now believe that particles do not travel as points, but as strings. Explain that this is a developing theory, and that as students go to college, an entire new world of science is opening up for them to study. Explain that if particles do move as strings, it would be easy for us to fold those strings so that space is contracted, theoretically allowing us to "step" from one space to another, enabling us to travel to other planets or galaxies. Allow students to discuss this idea.
Worksheets:	None.
Assessment:	Participation in cat's cradle game, discussion.

Day 7-15: Reading *A Wrinkle In Time*

Standards:	C&G 5.1, 5.2 RWSL 1.1, 1.2, 1.3 F&CS 11.2 S&T 3.1, 3.2, 3.3
Objectives:	TSWBAT: Complete reading the novel <i>A Wrinkle in Time</i> . Outline each chapter of the novel. Discuss the scientific concepts in each chapter of the novel. Explain whether each concept was, at the time of writing, already part of scientific understanding, or leading to future scientific knowledge.
Intended Length of Lesson:	7 to 8 days of reading in class. (12 chapter book, some is assigned as homework reading.)
Warm-up:	Ask students to quickly identify what they think science fiction is. Discuss each day the previous day's reading, and which scientific concepts were yet to be discovered at the time of writing for each day's reading.
Materials:	One book per student, worksheet #4 for each day, Worksheet # 5 at end of reading.
Instructional Procedures:	This can be read out loud during class by teacher or by student (this touches then on another RWSL standard) or silently.
Worksheets:	Worksheet #4, (multiple uses while reading each chapter) Worksheet #5, review of entire book
Assessment:	Completed worksheets and discussions.

Day 16-20: Writing an Original Short Story and Peer Reviews

Standards:	RWSL 1.1, 1.2, 1.3 F&CS 11.2 S&T 3.1, 3.2, 3.3
Objectives:	TSWBAT: Write a rough draft of an original science fiction story. Use peer review skills to help a fellow student with their story. Complete a final draft of an original science fiction story.
Intended Length of Lesson:	4+ days
Warm-up:	Have students choose topics and characters from those listed on board.
Materials:	Paper, pencil, characters and topics on board, peer review sheet.
Instructional Procedures:	Have students concentrate on originality while writing. Review the idea of plagiarism.
Worksheets:	Peer Review Worksheet.
Assessment:	Finalized copy attached to rough draft and peer review.

**Extension:**

Most new scientific discoveries spawn science fiction stories warning of the problems that the breakthrough or new understanding will bring. As an example, the further understanding of human impact on the ozone layer led to an overwhelmingly popular science fiction movie, *The Day After Tomorrow*<sup>25</sup>. This movie encouraged people to discuss global warming and its consequences much more than the sterile scientific reports that had been written for years. A study of the history of the Industrial Revolution may help students to understand why scientific progress has boomed within the past 175 years. This can easily be made into a cross-curriculum unit with the social studies department.

Many opportunities arise for further integration of science fiction into the science classroom. The short story *Waldo* will demonstrate conclusively how science fiction drives technology. This would be an excellent opportunity to have a guest speaker for the classroom bring an example of a waldo, as well as an artificial heart and lung. UPMC provides this service, and the guest speaker includes a video about a teenage boy with an artificial heart. This will further relate the improvement of technology to the students' lives themselves.

Often it is helpful to review Newton's "Laws of Motion", a mathematical model for the force of gravity that not only described the observed motions of planets and stars in the night sky, but also of swinging weights and flying cannonballs in England. A lab could be created to demonstrate the pendulum swing of weights, another on angles and distance when shooting a marble, and another on the "falling matter" syndrome which so stumps many children. (Few intuitively understand that ALL objects, regardless of their weight, fall at the same speed, when in a vacuum.) A further example, with a drawing of a person, bowling balls, and pizza in an elevator, which has its cable disconnected, can test the students' intuitive ideas of falling objects. Even after having taken physics (twice) I still intuitively get this one wrong!!!!

There are a number of science fiction texts available to be used in the classroom, or outside of school, to drive the students to explore how science fiction drives technology. This genre is a powerful medium which drives scientific discovery and technological advances. Note the invention of scuba gear, television, and space travel, all written about, well before their invention, by Jules Verne. Through the use of such works as *A Wrinkle in Time*<sup>26</sup> - by Madeleine L'Engle, *Waldo*<sup>27</sup>, a novella by Robert A. Heinlein, *The Time Machine*<sup>28</sup> by H. G. Wells, and *Childhood's End*<sup>29</sup>, by Arthur C. Clarke, or such television shows as *Star Trek*<sup>30</sup>, *Babylon 5*<sup>31</sup>, or *Andromeda*<sup>32</sup>, a student can be encouraged to think deeply about subjects he may otherwise never consider. A student who becomes familiar with the genre is one who also becomes aware that science is not static, and that "thinking outside the box" can actually lead to further useful developments for society.

A quick sample of the *Star Trek* series for the students to see a different media's representation of science fiction can lead to discuss the sun and its makeup, and how we use mathematics and the movement of photons to know where stars and planets are located. Included should be a discussion about the forces that work on the world (very briefly,) then a discussion about supernovas and the way that the forces interact to create the phenomenon. At this point, the theory of General Relativity, which encompasses the expanding universe, and black holes, can also be discussed. Both have been observed, both brush up against the very nature of reality and existence, and should lead to further stimulating discussion in the classroom as to whether the students believe the universe is expanding or shrinking, and whether they believe what they see on *Star Trek* about black holes. A short story, called *The High Test*<sup>33</sup>, which again mentions black holes and the pursuant gravitational forces involved, can supplement this discussion. This would then be a good time to introduce the students to the differences of the number of daylight hours found on our planet, and reading the short story *All Summer in a Day*<sup>34</sup>. In this short story, the children live on a planet on which it rains for 7 years, then has one day of sunlight, before

the cycle repeats. The students should be able to see that Bradbury took actual scientific fact and creatively manipulated it to write this story.

A basic understanding of gravity will include introduction into mass and rotation. A simple lab can demonstrate each of these. Once the students have learned to measure mass, they can then compare their weight on each of the planets in our solar system, which can, in turn, accompany a unit on mathematical conversion. Rotation can be best expressed using a vinyl record and record player. Clocking the speed at which an object placed at different depths from the center of the record makes a rotation should help the students to understand that the closer something is to the core, the faster it will rotate. Note: objects placed on the vinyl will scratch the record, so a damaged record should be used. In addition, some objects at certain speeds may become projectiles. This experiment should be sampled by the teacher before use in the classroom.

A simple look at the Periodic Table of Elements at this stage will introduce different elemental temperatures. At this point, a simple classic novella, named *Mission of Gravity*<sup>35</sup>, will complement the learning achieved. In this novella, humans are investigating Mesklin, a giant planet with a mass so great and rotation so rapid that the gravity varies from 3 gs at the equator to 700 gs at the poles. It's also cold enough to have a methane ocean. Unfortunately, the human investigators have lost a rocket with expensive instrumentation in the polar region, and they'd like it back. While humans can survive at the equator in spacesuits, there's no way they could survive an expedition to the polar regions. Fortunately, they have discovered intelligent life on the planet, a species resembling a 15-inch caterpillar with pincers that they can communicate with. After reading this novella together, and completing worksheets created to go with it, the students should be able to describe how the basic scientific concepts of gravity, mass, rotation, and elemental behavior were used in the novella.

### **Annotated Bibliography And Suggested Further Reading**

*Adoni, H., & Shadmi, E., 1980.* Uses layman text to demonstrate concrete examples of active reading contexts to build reading comfort in the student. For use in a college education course.

Bradbury, Ray. Holt Anthology of Science Fiction. 1999. *All Summer In A Day*. This book is actually a comment on social bullying behavior, but focuses around a planet on which the sun shines only once every 7 years. A young student, newly arrived to the planet from Earth, on which the sun is seen regularly, longs for the advent of the sun, but, because she is an “outsider,” gets bullied and misses the

event. This book is an excellent example of the way that students often get away with things even with an adult present, and introduces the possibility for discussion of cliques and bullying behavior. For use in English, sociology, lifeskills, or science classroom.

Clarke, Sir Arthur C. Ballantine Books, UK. 1953. *Childhood's End*. The Overlords, after a hundred years on Earth, reveal their true purpose. They are in service to a non-corporeal being of pure energy known as the Overmind. It has charged them with the duty to foster humanity's transition to a higher plane of existence and merger with the Overmind. One day, humanity's children (starting in New Athens) start displaying telepathic and telekinetic abilities. These children soon become distant from their parents, and the Overlords quarantine all of them to their own continent. Deals with social issues and the "ultimate race." For use in sociology or science classrooms.

Clement, Hal. Del Rey 1984. *Mission of Gravity*. As space travelers must rely on indigenous creatures to a planet on which they are stranded, this book demonstrates basic concepts of human requirements in a futuristic world. Allows students to debate what types of environments would be necessary for the survival of humans on other planets, and allows for discussion of social behavior in unknown situations. For use in science or bioethics classrooms.

"The Day After Tomorrow," 2004. Directed by Roland Emmerich, Produced by Roland Emmerich and Mark Gordon, Written by Roland Emmerich and Jeffery Nachmanoff. Worldwide, it is the 39th top grossing film of all time, with total revenue of US\$542,771,772. It is the second highest grossing movie not to be #1 in the US box office. Based on *The Sixth Column*, by Heinlein, Robert A. This movie demonstrates the possible outcome of unchecked global warming. Its graphics are modern, and the story characters believable. Because the main characters are teenagers and their parents, the movie appeals to high school students. For use in media, science, or sociology classrooms.

Freeman, Ira M. with Durden, William J. *Physics Made Simple*. Bantam Dell Pub Group; Jan 31 2005. First published in 1954, this approach to physics is a welcome relief from the standard intimidating textbooks. It features timely and engaging examples and common applications of theories, historical anecdotes of significant discoveries, and clear and contemporary graphics. For use in an alternative physics course, such as physics for poets, or in post-secondary classroom as introduction to physics.

Gaskins, I., Guthrie, J. T., Satlow, E., Ostertag, F., Six, L., Byrne, J., & Conner, B. (in press). *Integrating instruction of science and reading/writing processes: Goals, assessments, and teacher development*. Journal of Research in Science

Teaching. Provides ideas for active reading and accompanying projects to increase retention. For use by the future teacher in an Education or teacher in an early elementary classroom.

Heinlein, Robert A. Astounding Magazine, August 1942, using the pseudonym Anson Macdonald. *Waldo*. A story about a man whose disease causes such severe weight gain that he is forced to build a home outside the earth's atmosphere in order to be able to move. In addition, he must create a means to accomplish things that his fingers, in his obesity, are unable to perform. For use in a health course, sociology course, English course, or science course. An excellent lead-in to an in-class visit by local prosthesis center, with artificial heart, lung, limb, and waldos as concrete examples for the students to identify as life-saving technology.

Kropp, P. (2000) *How to make your child a reader for life*. New York, NY: *Doubleday*. Actually gives concrete examples of how to build a love of reading in your child. For use in an Education course.

L'Engle, Madeleine (Author), Jody A. Lee (Illustrator). Bantam Doubleday Books for Young Readers. New York. 1962. This story is about a group of siblings who must travel through space dimension in order to save their father, and the universe, from an unspeakable disaster. The supporting characters are quirky and fun, and the book as a whole appeals to students from 6<sup>th</sup> grade up. It introduces the idea of tessellation between planets. For use in a science classroom.

Paris, S., B. Wasik, and J. Turner. 1991. "The development of strategic readers." In M. Kamil, P. Mosenthal, P. D. Pearson, R. Barr (Eds.), *Handbook of Reading Research*, Vol II:609-640. NY: Longman. This book gives specific reasons for the non-reader, and specific steps to help to overcome the obstacles they create for themselves. An excellent source to be used in an education classroom.

Pohl, Frederik. Asimov's Science Fiction, Bantam Doubleday Dell June 1983. *The High Test*. A naive twenty-six-year-old driving instructor from Earth named James Paul Madigan teaches lessons to various students, including a spoiled brat named Tonda and a two-headed reptilian alien named Torklemiggen, who eventually gets sucked into a black hole. For use in a science classroom, or for easy reading in an English course. Can also be used, as a satirical piece, in a driver's ed course.

Schunk & Rice, 1987. These two psychologists help to explain how a child who feels good about themselves creates a self-fulfilling prophecy in which they learn to read and actually enjoy it! For use in an education course, this book gives POSITIVE reinforcement ideas.

Serling, Rod. (1962-03-09). *The Twilight Zone*. Serling was an outspoken concern for morality in society. Fed up with the difficulties of writing about serious issues on the conservative networks, which continually censored his work, Serling turned to science fiction and fantasy. He was able to circumvent the timidity and conservatism of the television networks and sponsors by self-producing a series of vignettes that placed average people in extraordinary situations. He found that he could address controversial subjects if they were cloaked in a veil of fantasy, saying "I found that it was all right to have Martians saying things Democrats and Republicans could never say." The series was called THE TWILIGHT ZONE and was incredibly popular, winning Serling three Emmy Awards. A MUST SEE for science fiction advocates, any of the five seasons' worth!

Serling, Rod. (1962-03-09). "*The Fugitive*" Episode 90. In this episode, Serling introduces his ideas of science fiction ("the improbable made possible") with fantasy ("the impossible made probable").

Stanovich, K. E., & West, R. F. (1989). *Exposure to print and orthographic processing*. Reading Research Quarterly, 24(4), 402-433. Provides specific concrete examples to provide support for struggling readers. For use in an education classroom to help future teachers create adjusted lesson plans.

Verne, Jules. *20,000 Leagues Under the Sea*. An excellent source for examples of how science fiction drives technology, this author proposed underwater clothing and breathing gear (which became scuba gear and wetsuits in the "real world" years later.) A great source for teaching autocracy or anti-social behavior, this book can be used in an English, sociology, or science classroom.

Wells, H. G.. 1895 William Heinemann, Harcourt Education. Covent Garden, London. *The Time Machine*. A chilling look into the future of Earth, with those who control the world living below, and those who THINK they are in control living on the surface. An EXCELLENT source of discussion in a sociology classroom, this also can be used to discuss the Industrial Revolution. This book can easily be incorporated into a science, English, or civics classroom.

<http://www.pgtc.com/~slmiller/index.htm> An absolutely WONDERFUL source to use in ANY classroom from Junior High through Senior High, and beyond. Offers many suggestions for writing, as well as offering ways to get beyond writer's block! This is the website specifically quoted from for worksheet #5. All information belongs to the author of this website, and I cannot take credit for anything on this worksheet, beyond spacing.

**APPENDICES** (Appendices are to be found after end notes.)

Worksheet #1- Weight as a function of gravity and mass. (Front to back)

Worksheet #2- Elements and Their Symbols, Proton #, and Electron # (Front to Back)

Worksheet #3- Lewis Dot Structures (Front to back)

Worksheet # 4- Character Sketch, Development of Science in Book. (Front to Back)

Worksheet #5- Ideas for Original Short Story<sup>36</sup> (two pages, Front to Back)

Worksheet #6- Peer Review Sheet for Original Short Story (can be printed front to back for multiple peer reviews) (Front to Back)

Pennsylvania Standards for Academics

Worksheet #1: Weight as a function of gravity and mass.

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Period: \_\_\_\_\_

**Weight** is a measurement of the force on a object caused by **gravity** trying to pull the object down. Mars has less gravity than Earth. Therefore if you were on Mars you'd weigh less because the force of gravity wouldn't be as strong as it is here on Earth. Does this mean you would suddenly be thinner on Mars? No. You would have the same amount of mass as you do on Earth. (Mass is the amount of stuff inside an object.) So, on Mars, your mass would be the same as it is here on Earth. But you'd weigh less because Mars has less gravity than Earth.

**Gravity** is an attractive force. This doesn't mean it's pretty. What "attractive" means is that an object's gravity pulls other objects toward it. Look at the chart (see below). The Earth's gravity naturally pulls us, and everything else, toward the center of the planet, which keeps us from drifting off into space. The Earth isn't the only thing that has gravity. In fact, every single object in the universe has gravity. The tables you're sitting at have gravity. They are pulling you towards them. You have gravity, and you are pulling the tables towards you. We can't see or feel these things happening because people and tables have a such a small mass that the effects of gravity cannot be seen.

**Mass** is the amount of stuff contained inside an object. It takes a lot of mass to make a lot of gravity. The Earth has a lot of mass, so it has a lot of gravity. The moon's gravity is about 1/6 the amount of the Earth's because the moon has less mass than the Earth. So what does all this have to do with **weight**? Well, **weight** is the force on a object caused by gravity trying to pull the object down. A scale measures how much gravity your mass has. **A person with more mass has more gravity, and therefore weighs more.**

You've probably seen video footage of astronauts walking on the moon. They seem to float between each step. Remember that the moon has about 1/6 the amount of gravity that the Earth has? Well, if you went to the moon, you'd weigh less than you do here on Earth. Does this mean you would suddenly be thinner on the moon? Absolutely not. Your mass would be the same -- there is no less of you on the moon. But your weight is different because the moon's gravity is different.

Write your weight here: \_\_\_\_\_ pounds.

Your weight is your mass times the gravity of Earth, which is  $9.86 \text{ m/s}^2$ . Using algebra, determine your mass using this equation!

- Using your weight, multiply it by the gravity constant given to determine your new weight on the other planets.
- Record your mass. Note that your mass DOES NOT CHANGE!!!!
- Divide your new weight by your mass to determine the gravitational constant on each planet.
- answer the questions below.

Location	Gravity	a. New Weight	b. Mass (determined on other page)	c. Gravity on planet
Earth	1			
Earth's moon	0.17			
Venus	0.90			
Mars	0.38			
Mercury	0.38			
Jupiter	2.36			
Saturn	0.92			
Uranus	0.89			
Neptune	1.13			

d.  
On which planet do you weigh the most? \_\_\_\_\_

On which planet do you weigh the least? \_\_\_\_\_

Explain how you determine weight on any planet: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Which planet has the highest gravitational pull? \_\_\_\_\_

Which planet has the least gravitational pull? \_\_\_\_\_

Worksheet #2: Elements and Their Symbols, Proton #, and Electron #

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Period: \_\_\_\_\_

Using your periodic table of elements, fill in the table below.

# E	Symbol	# P	#E	Symbol	#P
	Aluminum			Magnesium	
	Argon			Mercury	
	Barium			Neon	
	Boron			Nickel	
	Calcium			Nitrogen	
	Carbon			Oxygen	
	Chlorine			Phosphorus	
	Copper			Plutonium	
	Fluorine			Potassium	
	Gold			Silicon	
	Helium			Silver	
	Hydrogen			Sodium	
	Iodine			Sulfur	
	Iron			Tin	
	Krypton			Titanium	
	Lead			Zinc	

Which element is added to toothpaste to promote healthy teeth?

Which element is found in bleach and can stain your clothing?

What is a typical material used to build bicycles today?

What element is used in making soup cans?

What element is used in making pennies?

When there is only one atom of an element present in a molecule, the letter is shown. When there is more than one atom of an element present in a molecule, a number is written directly after that element's symbol to show how many molecules are present.

Example:

H<sub>2</sub>O: There is a small number 2 after the H, which shows us there are TWO atoms of Hydrogen in this molecule. There is only the symbol O, with no number afterward, so there is only one atom of Oxygen in this molecule. Therefore, there are three atoms involved; 2 Hydrogen + 1 Oxygen.

If I had **TWO** molecules of H<sub>2</sub>O, how many Hydrogen would there be?

How many Oxygen? \_\_\_\_\_ How many atoms *total*?

\_\_\_\_\_

Name the elements involved in each of the following molecules, and list how many atoms of each of the elements are present in ONE molecule, and TWO molecules.

a. C<sub>4</sub>

b. MgO

c. CO<sub>2</sub>

d. C<sub>2</sub>H<sub>6</sub>

e. CuCl<sub>2</sub>

### Worksheet #3: Valence Shells and Bonding

Name: \_\_\_\_\_ Date: \_\_\_\_\_

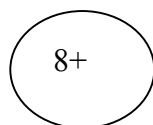
Period: \_\_\_\_\_

Electrons are sometimes shown in illustrations as ORBITING the nucleus, which contains all the protons and neutrons. Each orbit is sometimes called a SHELL. Each shell, from the proton outward, can hold only so many electrons.

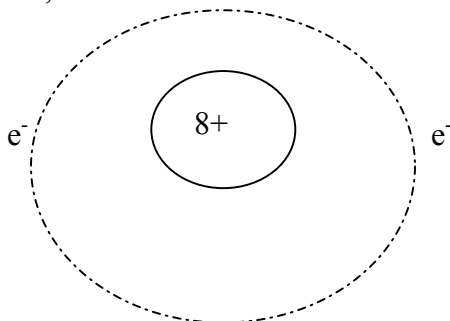
Because the first shell is so close to the protons and neutrons, only 2 electrons can inhabit this space. In order to draw this, we would create the nucleus, and mark how many protons ( $p^+$ ) are in the nucleus, using the information given on the periodic table of elements.

Example:

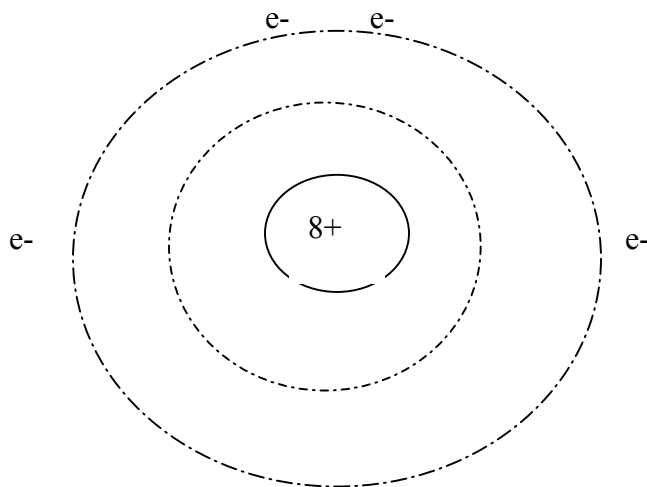
Oxygen:



We then would place the 2 electrons on the innermost shell evenly spaced apart as two dots, or we can use  $e^-$  instead of dots.



Because we know that Oxygen has a total of 8 electrons, and we have so far only used two of them for the innermost shell, we must place the remaining 6 on the next innermost shell. We put the first four at North, South, East, and West, and the PAIR the other two.



Now, you try:

Draw the nucleus, th <sup>e-</sup> <sup>e-</sup> two electrons, then the outermost electrons  
for the following elements:

Nitrogen, Carbon, Boron, Beryllium, Fluorine, Neon.

Some elements have enough electrons to fill more than the innermost, and the  
next innermost shells. **NO SHELL CAN EVER HAVE MORE THAN 8  
ELECTRONS!!**

Now, you try to draw the following elements. You will have three shells instead  
of two!

Sulfur, Aluminum, Magnesium, Sodium, Phosphorous

Worksheet #4: Outlining each chapter and its concepts for A Wrinkle In Time

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Period: \_\_\_\_\_

Chapter #: \_\_\_\_\_

Chapter Title:

---

List each character as they are introduced in this chapter. As you read the chapter, go back and give as much information as you can for each character. Focus on the following for character development: Name, Age, Height, Eye color, Hair color, What is this character's major goal?, Why is this goal so important to this character?, Are there any events in the character's past that affect the significance of this goal?, Describe the character's life until now, motivations, family situation, pet peeves, etc.

You may have encountered this character in a previous chapter. If so, add them again on this paper, and do a further character sketch.

Which of the characters listed for this chapter do you think was the main character? Why do you think this?

Without reading ahead, what do you THINK is going to happen next?  
What scientific concepts were introduced in this chapter?

Which of these concepts do you NOT understand?

Which of these concepts do you think were FICTION at the time this book was written? Why do you think so?

Worksheet #5:

Tips for Original Fiction Story Writing

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Period: \_\_\_\_\_

Possible Fantasy Names to Use:

**Female**

Agate Alyvia Arabeth Ardra Brenna Caryne  
Dasi Derris Dynie Eryke Errine Farale  
Gavina Glynnia Karran Kierst Kira Kyale  
Ladia Mora Moriana Quiss Sadi Salina  
Samia Sephya Shaundra Siveth Thana  
Valiah Zelda

**Male**

Alaric Alaron Alynd Asgoth Berryn  
Derrib Eryk Evo Fausto Gavin Gorth  
Jarak Jasek Kurn Lan Ledo Lor Mavel  
Milandro Sandar Sharn Tarran Thane  
Topaz Tor Torc Travys Trebor Tylien  
Vicart Zircon

Of course, you can use normal names as well, or even try normal names BACKWARDS!!!!

Story Line Ideas:

We are all greatly influenced by our relationship with our parents. How was this character's relationship with his/her parents? What kind of people were the parents? Did they have any odd beliefs/habits that your character has adopted or is rebelling from? What are your character's vices? Unfortunately, we all have them. A vice for your character doesn't necessarily have to be drinking or swearing--perhaps your character is a compulsive spender. Perhaps your character's vice is something as innocuous as a habitual over-consumption of sweets; maybe your character is a chocoholic. And perhaps your character has just been diagnosed with diabetes. What are your character's pet peeves? Sometimes a person's pet peeve can give you insight into their personality, and what things are important to them. What is your character's typical daily schedule like? Unless your story is the sort that will completely disrupt the character's life and put everything in limbo, you're going to have to weave your tale around this schedule. What is your character's strong point? Every story involves hardship, and your character will need a way to survive this hardship. Usually, this involves the character's strong personality strength, or plays off of that strength somehow. Is your character right or left-handed?

Does your character wear glasses, or contact lenses? What about weight? Shoe size? Clothing size? What is your character's favorite color? Favorite song? What does your character think is his/her best feature? Worst feature? Is your character's handwriting neat and precise, or sloppy and unintelligible? Does your

character care? What kind of car does your character drive? Is it neat and usually washed, or cluttered and "lived-in"?

Does your character have a collection of anything? What is your character's attitude toward money? Is your character a bit of a spendthrift, or prone to spend freely? What are your character's hobbies? What are your character's talents? Do his/her friends routinely call him/her when they need help in a certain area? What is your character most proud of? Most embarrassed about? Does your character donate to any charities? Play the stock market? Gamble? Pay child support or alimony? Who are your character's heroes?

Theme, Setting, Perspective, POV:

Choosing a **perspective** means choosing a character to tell the story. Stories are generally told through the eyes of a single character, and although that's usually the main character, that isn't always the case.

**Point of View** is a little more difficult to describe. Selecting a point of view means deciding how to tell the story. Point of view is traditionally divided into four methods: **First person**--This is used very frequently in young-adult fiction, somewhat less frequently in mainstream fiction. The story is told as if the perspective character is telling it directly. The major pronoun here is I. **Second person**--This is probably the least used point of view in mainstream fiction. It is occasionally used in young adult fiction (the Choose Your Own Adventure series, for instance). The story is told as if it is happening to the reader. The major pronoun here is you. **Third person, limited**--The story is told as though by a narrator, but the narrator only knows the thoughts of the main character. The major pronoun here is He/She. This is probably the most-used point of view in modern mainstream fiction. **Third person, omniscient**--The story is told as though by an all-knowing narrator who can describe the thoughts and actions of all characters.

What requirements does your story place on its environment? Does your story require a setting near water? In the city? Way out in the country? Is this a cold climate? Tropical? What time of year is it? What sort of people and animals might your characters encounter? What kind of social change is going on? What sort of issues are important to your characters? You'll need a whole extra set of questions to develop a fantasy setting. What sort of magic is standard here? What sort of governing body is there? What kind of currency do they use? How do they dress? What patterns of speech might they use? How technologically advanced are they?

Don't neglect the passage of time in your storytelling. Everything your characters do will take time, and it is up to you to provide a realistic sense of the time

passing while they do it. Don't forget that even the hardest heroes need to sleep! A common beginners' mistake is a story that reads like one *long* day, or heroes who never stop to sleep. This kind of pace will exhaust your readers too! Let your characters progress through time naturally, and keep a timeline so you can see what happened when, and make sure your days are broken up realistically. What about weather? The weather in your character's world will change. Depending on the season, you may have rain, or snow, or blistering heat. If you don't provide a sense of the weather--and the greater context of season--the reader is left with a sense of unreality about this place. It wouldn't hurt to note the weather on your timeline, so that you can make sure your seasons progress as they should.

Draw a map. Especially in fantasy story-telling, a map will often show you things about your world or give you plot ideas that you would not have found otherwise. It also makes sure you have a clear idea of the layout of your setting, and keeps your directions and sense of space constant.

Possible Science Theories to Go Beyond:

Gravity

Time Travel

Medical Technology

Space Exploration

New Community on Other Planet

Animals on Other Planets

Weather Control

Driver's License/Piloting License

Now, **OUTLINE** the **BASIC IDEA** of what you want to write about. Don't be afraid to get creative!

Remember, you do **NOT** have to use the ideas given above; they are just there to help you get started!!!

Worksheet #6: Peer Review of Original Short Story

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Period: \_\_\_\_\_

Name of Original Writer:

Name of Peer Review Editor:

GENERAL GUIDELINES

1. Find two people to exchange papers with.
2. Fill out a form for each paper you read.
3. Read the entire peer review sheet before doing anything else.
4. Read the entire student essay before you make any comments at all.
5. When responding, try to be sensitive to other people's feelings without being wishy-washy. You can help them improve their grade if you give them substantial feedback. Conversely, being cruel helps no one.
6. Write your comments on the draft itself and on the peer review sheet. **DO NOT** change the other student's writing in any way. Instead, make comments to help the student change the paper on his/her own.
7. Do not grade the paper you are reading.

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a. Does the opening paragraph 'grab' you? Does it begin energetically, with plenty of active verbs? How else could it be improved? List some of the active verbs.

b. Does the introduction explain the story and its importance? Any suggestions?

c. What is the story about? Does the writer focus upon a pivotal incident (or incidents)?

d. Does the story seem able to be related to? Is it possible to imagine yourself in this situation?

e. Does the writer vividly and clearly describe the situation in the life of the character, making it come alive for the reader? Make some suggestions aimed toward a more lively personal account.

f. Does the paper have specific details about setting? Give examples.

g. Does the story have specific details about characters? List and describe them. Is there anything else you might want to know about any of them?

h. What is the main conflict in this story? Is there information included that does not seem relevant to the stated thesis/purpose?

g. *After reading the whole paper*, explain whether you think the introduction effectively prepares the reader for the story or not.

h. Conclusion: Does the concluding section sum up—without being repetitive—the major points/conclusions of the story? Does it offer suggestions for further research or action regarding the topic? Does it leave you hanging on the edge of your seat, wanting more?

i. How could this essay be improved on the sentence level? Mark your copies of the draft, making specific suggestions to improve sentence structure and overall clarity.

j. Finally, shut your eyes and think about the paper. What did you get out of it?

Overall: How near to completion is this draft? What steps should the author take to complete this assignment? Be specific and helpful by listing the three most important steps the author should take:

a.

- b.
- c.

**STANDARDS<sup>37</sup>:**

**Academic Standards for Civics and Government**

*Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to . . .*

5.1 Principles and Documents of Government

5.1.9. **GRADE 9**

- A. Identify and explain the major arguments advanced for the necessity of government.
- J. Explain how law protects individual rights and the common good.

5.1.12 **GRADE 12**

- A. Evaluate the major arguments advanced for the necessity of government.
- B. Analyze the sources, purposes and functions of law.
- J. Analyze how the law promotes the common good and protects individual rights.

5.2 Rights and Responsibilities of Citizenship

5.2.9. **GRADE 9**

- G. Analyze political and civic participation in government and society.

5.2.12 **GRADE 12**

- C. Interpret the causes of conflict in society and analyze techniques to resolve those conflicts.
- F. Evaluate how individual rights may conflict with or support the common good.

**Academic Standards for Reading Writing Speaking and Listening**

*Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:*

1.1. Learning to Read Independently

1.1.8. **GRADE 8**

- B. Identify and use common organizational structures and graphic features to comprehend information.
- C. Identify basic facts and ideas in text using specific strategies (e.g., recall

genre characteristics, set a purpose for reading, generate essential questions as aids to comprehension and clarify understanding through rereading and discussion).

- G. Demonstrate after reading understanding and interpretation of both fiction and nonfiction text, including public documents.
  - Make, and support with evidence, assertions about texts.
  - Make extensions to related ideas, topics or information.

#### 1.1.11 **GRADE 11**

- A. Locate various texts, media and traditional resources for assigned and independent projects before reading.
- F. Understand the meaning of and apply key vocabulary across the various subject areas.
- G. Demonstrate after reading understanding and interpretation of both fiction and nonfiction text, including public documents.
  - Make, and support with evidence, assertions about texts.
  - Make extensions to related ideas, topics or information.
  - Evaluate the author's strategies.

### 1.2. Reading Critically in All Content Areas

#### 1.2.8 **GRADE 8**

- B. Produce work in at least one literary genre that follows the conventions of the genre.

#### 1.2.11 **GRADE 11**

- A. Produce work in at least one literary genre that follows the conventions of the genre.

### 1.3. Reading, Analyzing and Interpreting Literature

#### 1.3.8 **GRADE 8**

- B. Read and understand works of literature.
- C. Analyze the use of literary elements by an author including characterization, setting, plot, theme, point of view, tone and style.
- F. Read and respond to nonfiction and fiction including poetry and drama.

### **Academic Standards for Family and Consumer Science**

*Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .*

## 11.2. Balancing Family, Work and Community Responsibility

### 11.2.9. GRADE 9

- A. Solve dilemmas using a practical reasoning approach
  - Identify situation
  - List choices and examine the consequences of each
  - Develop a plan of action
  - Draw conclusions
  - Reflect on decisions
- B. Assess the effectiveness of the use of teamwork and leadership skills in accomplishing the work of the family.
- H. Justify the significance of interpersonal communication skills in the practical reasoning method of decision making.

### 11.2.12. GRADE 12

- A. Justify solutions developed by using practical reasoning skills.
- C. Analyze teamwork and leadership skills and their application in various family and work situations.
- H. Evaluate the effectiveness of using interpersonal communication skills to resolve conflict.

## Academic Standards for Science and Technology

### 3.1. Unifying Themes

*Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to . . .*

#### 3.1.10. GRADE 10

- E. Describe patterns of change in nature, physical and man made systems.
  - Describe how fundamental science and technology concepts are used to solve practical problems (e.g., momentum, Newton's laws of universal gravitation, tectonics, conservation of mass and energy, cell theory, theory of evolution, atomic theory, theory of relativity, Pasteur's germ theory, relativity, heliocentric theory, gas laws, feedback systems).
  - Recognize that stable systems often involve underlying dynamic changes (e.g., a chemical reaction at equilibrium has molecules reforming continuously).

#### 3.1.12 GRADE 12

- E. Evaluate change in nature, physical systems and man made systems.
  - Analyze how models, systems and technologies have changed over time (e.g., germ theory, theory of evolution, solar system, cause of fire).

- Evaluate the patterns of change within a technology (e.g., changes in engineering in the automotive industry).

### **3.2. Inquiry and Design**

*Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to . . .*

#### **3.2.10 GRADE 10**

- A. Apply knowledge and understanding about the nature of scientific and technological knowledge.
- Compare and contrast scientific theories and beliefs.
  - Know that science uses both direct and indirect observation means to study the world and the universe.
  - Integrate new information into existing theories and explain implied results.

#### **3.2.12. GRADE 12**

- A. Evaluate the nature of scientific and technological knowledge.
- Know and use the ongoing scientific processes to continually improve and better understand how things work.
  - Critically evaluate the status of existing theories (e.g., germ theory of disease, wave theory of light, classification of subatomic particles, theory of evolution, epidemiology of aids).

### **3.3. Biological Sciences**

*Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to . . .*

#### **3.3.10 GRADE 10**

- A. Explain the structural and functional similarities and differences found among living things.
- Identify and characterize major life forms according to their placement in existing classification groups.

#### **3.3.12 GRADE 12**

- A. Explain the relationship between structure and function at all levels of organization.
- Identify and explain interactions among organisms (e.g., mutually beneficial, harmful relationships).

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- <sup>4</sup> [http://www.cde.ca.gov/sp/sw/t1/-](http://www.cde.ca.gov/sp/sw/t1/) Title I information
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<sup>24</sup> <http://tetraspace.alkaline.org/> An introduction and explanation to Tetraspace, often considered by scientists to be the actual fourth dimension.

<sup>25</sup> *The Day After Tomorrow*, 2004. Directed by Roland Emmerich, Produced by Roland Emmerich and Mark Gordon, Written by Roland Emmerich and Jeffery Nachmanoff. Worldwide, it is the 39th top grossing film of all time, with total revenue of US\$542,771,772. It is the second highest grossing movie not to be #1 in the US box office. Based on *The Sixth Column*, by Heinlein, Robert A

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