

## **The Power Of a Good Story. Scare Them Into Action**

### **Using Science Fiction to Provoke Action Towards Environmental Concerns**

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#### **Introduction & Rationale**

Science and subsequent technology have always impacted society. Now these changes are occurring at more rapid rates and are being commercialized such that it appears that we have no choices over their use and certainly no anticipation of their impact on us, either for the improvement of life or the problems which may result. For this reason I encourage the students in my 10th grade gifted chemistry class to examine these issues and to accept the responsibility of critical appraisal as citizens of the world and as future scientists. Each quarter I include an independent project which provokes discussion around issues facing the world, such as environmental damage, population growth and diminishing food supply, energy crisis, human genome project, global warming, space exploration etc. During the first quarter the students are asked to develop a rubric to decide which research projects to fund and to justify the proportion of the distribution of funds to each project. In the second quarter students are asked to take a side on one of several topics and debate this topic with another student. The remainder of the class is asked to give written comments and vote on a winner. The debate process is a way that many topics are researched so that the whole class benefits. A description of both assignments is given in the Appendix.

From these assignments the students realize that we have recognized these problems for many years and that strategies and solutions have been developed. But implementing these is a different matter. Many solutions require a change in how we live and this will only happen if people are convinced of the severity of the problem and the need for action. I see a science fiction story as a wonderful way to anticipate where our technology may take us, the responsible and irresponsible uses of the technology and present it in such a way as to capture the imagination of a public and move them to action.

A strong emphasis of the Pittsburgh Public School Standards as they relate to Science and Technology, is for students to understand the impact of technology on society. Most of the text books are aware of this emphasis, since it reflects a national focus as well, and so they have developed small sections in most chapters of the books about these kinds of issues. These sections are generally no more than a few paragraphs and are basically superficial. It is very difficult to use these sections as students will only read the text if they are required to answer questions or will be tested on the material. They tend to seek only the parts of the text needed to answer the questions and most of the time lose the big picture, unless you the teacher really emphasize it. Also as you are focusing on important course material at the same time, these vignettes seem to get overlooked. I feel a more focused look at the issues once a quarter is more meaningful for the students. These projects are stand alone from the core curriculum of chemistry and weighted as half a test grade. This means that students must take the assignments seriously and that I consider this emphasis as an important part of my course.

I also try to fight the stereotype of the nerd scientist and emphasize the need to be able to communicate and express ideas to others, in particular to a lay audience. As a scientist you will not be funded unless you can convince others of the value of your work. Your value as an "expert" is only as good as your ability to explain your knowledge in terms that anyone can understand. This is only accomplished if you truly understand the topic and can then begin to make analogies and drop the crutch of the 'jargon' of your field. Writing stories means that students are forced to use their own words and express their creativity. Through this unit students

will have an opportunity to address the communications standards of the Pittsburgh Public Schools in a class other than English and develop a document for their portfolios. It also seems that in English classes students are given very few opportunities for creative writing.

### **What is Science Fiction.?**

Before asking students to write a science fiction story it will be necessary to determine what do we mean by science fiction. Generally there are several students who are very keen science fiction readers and they will start any discussion about this subject. Science Fiction is about the future. Sometimes SF is defined as standing for "speculative fiction" rather than science fiction. Well known science fiction writer and champion of the genre, Damon Knight developed the following list as features of science fiction. Any story including two or more of the features should be considered science fiction.

1. Science
2. Technology and invention.
3. The future and the remote past, including all time travel stories.
4. Extrapolation.
5. Scientific method.
6. Other places - planets, dimensions, etc.
7. Catastrophes, natural or manmade.

James Blish, well known science fiction writer and critic from the sixties, gives three reasons for the influence of science fiction on the lay reader's understanding of science.

1. It confronts the theories and data of modern science with questions of modern philosophy, to create "thought experiments" ... which may in themselves advance science.

2. ... science fiction evokes for the non-scientist the basic scientific emotions : The thrill of discovery , the delight in intellectual rigor, and the sense of wonder, even of awe, before the order and complexity of the physical universe.

3. Science fiction creates myths in which, because the authority of modern science is invoked to back them, modern man can believe.

Science fiction then is an intellectual challenge to ask "what if" of the science, technology and society of our day to day existence. It can be a way for scientists to fantasize and this allows them to question in such away that their own work takes a creative leap and they are able to move forward. Also scientists now use "thought experiments" to try to understand the social implications of the technological innovations. Science fiction allows us to become familiar and comfortable about changes in our lives.

Science Fiction anticipates a future and challenges you to think about that future and the role that you might want to take in shaping or changing the future. This is an important message for adolescents as they begin to mature and think beyond their very immediate group of friends. If they can imagine a future for society then surely they can begin to see themselves in a future as well. As they complete this project I am hoping they will gain this insight so that they can begin to make choices and plan for a future for themselves and society. Again

as Damon Knight states Science Fiction is distinguished by its implicit assumption that man can change himself and his environment.

I also want to emphasize the science part of science fiction. The science implies that although you are talking about the unknown, your projection should have some logical foundation and not be pure fantasy. It is an opportunity for the writer to be outrageous and very inventive, but remain within some logical framework. As you create a world of the future you want to make sure that the world is consistent. If you have projected that the sun will be too hot for anyone to go outside, then if someone was to go outside then they had better burn very badly or have worn protective clothing.

Science fiction also reflects the age in which it is written. Many times the stories are put in weird settings but the people seem to behave just as they would in the present. Their values, behaviors and relationships don't seem to change very much. For this reason it is difficult to judge a science fiction story written 30 years ago for its accuracy of prediction. With this caveat in mind it would be useful to read and discuss an older story and look at how its predictions reflected and influenced the thinking at the time.

### **Science Fiction Playing a Role in History**

Consistent with the theme of using exaggerated hyperbole as a way to inspire change or to challenge the status quo, I have chosen to look at science fiction shortly after the bombs were dropped on Hiroshima and Nagasaki. Since the bomb was a military weapon and the US was the first to develop the technology, the science and the risks were kept secret. The public had seen the devastation in Japan and having just witnessed 5 years of war and unbelievable atrocities were skeptical of such an instrument of destruction being in the hands of mere mortals. What more apocalyptic dread than the bomb in the hands of totally irrational men. It was a science fiction writers dream and dominated the genre in the 1950's. An eloquent short story is Ray Bradbury's nuclear parable "*There Will Come Soft Rains*". Bradbury describes an automated house in the year 2057, where the routines of the house keep running despite the absence of humans. The family has been burned into the side of the house after a radioactive explosion. Finally this last intact piece of the town also crumbles. I chose this story as it is short enough to be quickly read and then have a discussion. It makes its point without a lot of "blood and guts" or horrible mutant beasts. It also shows that automation was still young and so the story describes what the house of the 50's would look like if automated. The students should find the comparison with life as they know it, very interesting. There are no cell phones, no microwave ovens, no remote controls, no CD players, and there are robots doing all the household tasks. The technology helped maintain the comfortable family life of the 50's. It was about comfort and family interaction and traditions. The impact of the atomic bomb was to bring to an end this ordinary and comfortable life. This was more chilling than any monsters or detailed descriptions of bleeding.

The students will be asked to read the story and respond to the questions below.

1. Describe how effective you think the story was in persuading you that the nuclear bomb can be destructive. Give examples in the story which you felt helped the author emphasize his point.
2. Based on the story what do you think may have been some recent technology in the early 1950's ?

The students will then share their responses in a class discussion.

The scare tactics of the science fiction stories about the atomic bomb and uncontrolled nuclear power, finally numbed an American Public as they realized that wars had been fought, nations angered and yet no bombs used. And the threat of a nuclear war no longer became a concern. So a lighter side was presented and fun made of anxieties. The best example of this being "*Dr. Strangelove or How I Learned to Stop Worrying and Love the Bomb*." The students will view the first 20 minutes which sets the scenario that an American general has lost his mind and initiated an atomic attack on Russia. Many protocols have been set up to protect a spy from calling off an attack. The Russians have a Doomsday machine which is just as potent and has automatic detonation as a defensive reaction. The teacher will fill in the roadblocks to stopping the attack and show the final

10 minutes. The discussion will center around the popularity of the film and the exaggerated situations which were only small extensions of people's fears at the time. The finale re-emphasizes that even after the scare, the politicians cannot be trusted to put aside traditional distrust and posturing in order to make rational decisions. Again the class will look at the role the movie would play in helping citizens to make their views heard and encouraging them to become responsible voters who demand accountability to real issues.

I have found that students are unaware of the development of the atomic bomb, the destruction that it caused, and the advances since the 1950's . They know little of the long and continuing battle to limit arms and the recent success. They are also unaware of the threat posed by the ability of India to produce a bomb, combined with a centuries' long animosity between India and Pakistan . This irrational battle over borders presents a highly inflammatory situation. This historical look at the scare the bomb produced, the secrecy and public ignorance at the time and even the final complacency is necessary for students, as they too will have to decide under what terms they will live in the shadow of the bomb.

### **Evaluating a Science Fiction Story and Examining the Science Content and How it is Used.**

This unit will be implemented in conjunction with the unit on the quantum mechanical model of the atom. A Science Fiction emphasis fits perfectly with this unit both for the timing and the nature of the topic being taught. Quantum mechanics is a difficult topic for students as it is highly conceptual, abstract and intangible, does not easily lend itself to analogy, appears to contradict both experience and prior knowledge, and describes a world very foreign to students - very much like science fiction !! Hopefully reading a couple of science fiction stories will help students make analogies or understand the implications of some of this theory. Science Fiction stories take a "What If " approach to certain science facts. Too often we do not challenge our students to see the full implications of what they are learning but instead settle for reproducing a bunch of facts. By looking at legitimate and incorrect applications of a theory or fact, the students will understand the implications better and the science will be more meaningful. I chose the two stories : Stephen Baxter's "*Plank Zero*" and "*Neutron Star*" by Larry Niven.

"*Plank Zero*" describes the Universe in the year 5653 when a group is attempting to reduce Plank's constant to zero in the hopes of creating unlimited energy. Throughout this 12 page story the Uncertainty Principle, Plank's constant, Pauli Exclusion Principle are discussed and applied in novel ways. I chose this story as I feel that it uses these topics from Quantum physics, explains them well and also challenges the students to decide if the extensions are reasonable and scientifically sound.

In the few pages of the opening of this story an imaginative yet bizarre universe is described. Technology is such that you may store the thoughts and images of someone who has died and converse with this virtual image as if it were alive. A man is reconstructed to have the capabilities of another species, called Ghosts, so that he can function in their world. He needs no food, he can see in light intensities where human eyes normally cannot see, small motors give him motion and he can counter the effects of a changing gravity. Although he does seem to retain his human emotions which set him apart from the Ghosts.

The primary science behind the story is that if you could make Planck's constant smaller you would have smaller energy units and could build unlimited computing power which would make the owners controllers of the world. Also as Planck's constant shrank there would be a creation of energy. Students often do not fully grasp what is meant by a physical constant and will often ask if  $h$  (Planck's constant) is still  $6.67 \times 10^{-34} \text{Js}$  for this problem. Of course a constant is just that, a constant and unchangeable. Many constants have a physical significance but Planck's constant in fact does not and just makes the math right, so that it is not so unreasonable to suggest that it does change. So this story takes a "what if" look at a constant that changes and shows that all the rules of physics collapses. This makes the story valuable to student's understanding of this principle.

The students will be asked to read the story overnight, take notes and complete certain questions on the worksheet. The next day they will be split into groups and asked to complete the remainder of the worksheet. I anticipate that they will have questions and need help with some of the calculations. Hopefully by grouping the students they can combine their understandings and gain a richer interpretation. Completing the worksheet will probably take a whole period. so I anticipate having time to review and summarize the different responses and clarify any misinterpretations of the science. Sharing the responses of the effectiveness of the story will also be of value.

"*Neutron Star*" describes the trip undertaken by a human daredevil to replicate another journey which ended in death for its pilots. He must fly within 1 mile of the surface of a neutron star and try to determine the kind of force which destroyed the first vessel. A neutron star is what results when an atom collapses and so the story further shows the impact of atomic structure on matter as we know it. Although technical explanations are given to describe what is happening there is still quite a lot of humor. Both stories give wonderful descriptions, and create a world with differences and similarities to ours, in just a few pages. The inhabitants and the universes of the two stories are very rich but also very different, so the students will have two effective yet contrasting examples to discuss.

The students will then be asked to read the second story and respond according to the worksheet at the end. This will be an overnight assignment with some discussion the next day. Having more fully analyzed "*Plank Zero*" as a group they should be able to read and respond to the second story independently. From the two stories we will develop a list of some of the techniques which enhance a story.

Both worksheets were designed in three sections : The Science; the Implications; the Story. In the first section I have asked them to recall or look up the relevant facts or theories that they will need to analyze the story. Then I ask them to take these facts and apply them to the situations in the story so that they can better understand the story or evaluate the accuracy of the implications made. In some cases I have asked them to back up these with calculations. This is a more demanding worksheet as it is not just a summary of the day's lesson or more examples of the problems done in class. Rather it requires them to integrate their knowledge and decide what is relevant and apply it in a "real" situation. So they should be stretching much more than usual. The third analysis I want them to make is to understand some of the choices that the author made and decide which were effective in the telling of their tale.

Some of the attributes that I feel are part of a good science fiction story are:

1. Every story needs a main character. The main character must be described in some way - through conversation, interaction with others and by their actions.
2. Since the purpose of their stories is to show the consequences of our technology or careless care of the environment, the students must decide which problems they will use as their focus.
3. The story also needs a setting. Is it on earth or is it somewhere else ? Since environmental problems are the purpose for their stories, a good description of the setting and how that setting impacts the lives of the characters is critical.

4. What changes will the story describe so that the reader knows it is set in the future ? Some of these could be logical extensions of our current life. Others could be fanciful and quite outrageous.
5. How to make it believable and "scientific" sounding ? Use some science words. Even use modified science words such as "quantumisa "etc.
6. Finally there needs to be some conflict or action to create a plot.

Students may develop a similar list themselves, but you can use the list to help them analyze the two stories and see where the authors were effective.

### **Writing Their Own Stories.**

Finally it is time for the students to write their own stories. The students will be given one week to complete the assignment described below.

#### Science, Society and Technology -- Assignment 3

The previous quarters we have focused on some of the problems facing the future of the world. Some of these are due to increasing demand and shrinking resources or capacity; others are unforeseen consequences of modern technology and life on the environment. What we did identify in these discussions is that much of the information has been around for quite some time but people have still been reluctant to change.

Now it is time for you to fast forward into the future and try to predict where we will be in terms of these problems and what our lives might be like. You are to write a science fiction story which describes what might have happened if we had not solved some of the problems that we have discussed earlier or you may describe a life where some of our problems have been "solved". If you choose the "gloom and doom" option make sure that your story steps through the sequence which lead to the future that you are describing. The purpose of your story will be to persuade people to make changes NOW. If you choose a more optimistic scenario, make sure that you identify how you solved the problems and the worlds of your story.

The story should be at least three pages long. It will be evaluated according to the following rubric.

#### *Grading Rubric*

1. Does the story show a consequence for a problem as discussed earlier ?
2. Is the conclusion, either bad or good, a reasonable consequence for the problem(s) ?
3. Are the setting, characters and circumstances consistent ?
4. Are the mechanics of good grammar, punctuation, use of words and organization apparent ?
5. Was the story convincing ?

The rubric above emphasizes the goals I have for the project and is to help the students focus their efforts. The paper was to take a "What if" look at some of the very pressing environmental, technological issues that we are facing. So I expect to be able to identify the problems that are being addressed and also their consequences. I also want the students to think through all the details about this "new" world so that it becomes alive and its consistency makes it believable. Finally the purpose of the story was to convince people to action and so this must be final benchmark .

### **Sharing and Evaluating the Stories.**

Since the students have been so creative they will be very excited about what they have written. They will be anxious to share their stories and read those of others. Reading a story out loud is a luxury that we can't always indulge, especially to read everyone's story, but it is certainly worthwhile to read at least one to each class. The sharing of stories is better done after the student's have read and evaluated some on their own. I would suggest copying each story several times and asking each student to read and evaluate two stories. Students will provide feedback using the form below. The teacher will collect the forms and after reading them, give the author's their peers' feedback.

*FEEDBACK: TITLE of STORY:*

1. What problems of today were addressed in this story ?
2. What were the consequences of these problems if they were not solved ? How did society change or accommodate the problems ? Were any problems solved ?
3. How far into the future is this story ? How has society changed ? Where do people live and how ?
4. Is the setting consistent ? Do you have a clear picture of what this "new" world is like?
5. How effective was the story in convincing you that changes are needed ? Explain.

Hopefully then each story will be read at least twice by two different people. Collect all the stories and put into a folder so that students may borrow and read stories that they missed and had heard about. If you repeat this over several years, you could keep the best from each year and share these. This would then be the appropriate time to read some of the exceptional stories. As a conclusion to the assignment, create a bulletin board which shows all the problems of today which were focused in the stories; the ultimate conclusion to these problems; the kinds of protagonists; settings; optimistic or pessimistic; format etc.

### **Stories.**

I gave my students this assignment this year although I did not present any of the other material. I just wanted to see their reaction to the assignment and the work that they would generate. I gave them the choice to write a science fiction story or an expository essay. Only 3 students from 63 chose to write a plain essay. Everyone else was extremely excited by the project and wanted to read both their own and others' stories. As part of the curriculum for gifted students, they must also carry out an independent project in one of their classes. Three students chose to continue to write their stories. Two of the students originally submitted stories between 10 and 15 pages long . They are now up to 40 page stories each. This is testimony to the creativity which can be generated.

The students created stories which covered a wide range of topics and settings. There were very few that were similar. Two were exactly the same - they dealt with the consequences of knowing your DNA and your future health. Some stories used a fictional setting to explain a large number of facts that they had gathered from their research. These were not really fiction as such, but I accepted these as I felt that not every student is creative and just by rewording information they demonstrated understanding of the material. Cloning and the creating of monsters is one of the less imaginative themes. You may need to decide on some other criteria that will help to differentiate the superficial from the more in-depth stories. I did not use the rubric suggested in this paper. It was developed after I had graded my students' work and reflects the communication that I want to make to the students and what I felt was important as I read their stories. Hopefully the rubric will help students to differentiate between the stories which have logical consequences from those creating monsters with super powers. Several people dealt with the loss of all sources of energy. Most of these stories had a protagonist in the first person describing an era and life-style long gone. Several students projected that the earth was no longer habitable and that the only solution was moving to another planet. Very few of the stories promised a world where the problems had been solved. Most predicted the end of the earth while some predicted a world with a life grimmer and more limited than life as we know it. There was not much faith in the human race making good decisions or changing their life-style. Admittedly their task had been to create a story which would encourage change, so scaring people into action is a legitimate response. One story in particular was very optimistic. The student created a world where everyone cooperated to share limited resources and to create needed commodities. Like many science fiction stories these stories were our lives projected into the future. Most students did not create some way out world but kept the settings very familiar. Again this is logical for the purpose of the stories. There was a rich variety in the students' work which made it very enjoyable for both the students and I.

This project was done by gifted students who pretty much took the concept and ran with it. I feel that the stories that the students are required to read as part of this unit and write, will hopefully motivate less gifted students to understand the science better and to enjoy reading. In high school the students are not given many opportunities to write creatively. The focus is more on expository writing. So I feel that if the teacher spends time discussing the project and giving examples that the students will find confidence to write and produce their own works. The weaker students are often less confident to try something new and need a lot of encouragement to take the risk. They also need to be very clear on the expectations. For this group of students I would suggest more time spent on pre-writing brain storming and a template to help the students think through and flesh out a story.

### **Continuing What You Started**

Hopefully a lot of interest in science fiction will be generated. I would suggest that you encourage the students to bring in stories related to the science content of your class as the year progresses. I normally shun any kind of extra credit but I might support this as it encourages reading and an awareness of the topics being studied. Students who have an interest and do read science fiction could also contribute to a recommended science fiction reading list to be posted on the bulletin board. Another idea would be to have book swaps or start a little library of science fiction. I personally had read very little of this genre before this course but will read more books and stories myself. So I would like to contribute my "finds" to a class library. I will try a subscription to *ANALOG* and *ASIMOV* magazine and photocopy good stories for interested students.

First Quarter Project : Science, Technology and Society

### **FINANCING RESEARCH**

You have been given the responsibility of determining the budget allocation for scientific research for the US for the next five years. For simplicity you have been given an annual budget of 100 million dollars. There are

many areas where science could make a difference. You must first determine the kinds of problems facing both the US and the world. You must consider the US as being a part of an international community where the actions of each member is felt by the other. Looking at the list of possibilities you must now decide where to concentrate spending. For this you will need to develop a rubric or set of criteria against which every project will be evaluated. This rubric should then be used to prioritize your projects and justify the amount that you have allocated. You need to consider at least 7 options and then show how you eliminated or selected from your list. The projects should not be similar categories. For instance I do not want the cure to three diseases. You will need to be able to justify your rubric and be able to show how each project meets the criteria. Your decisions must be clearly and strongly supported as you are going before the budget committee to argue for your allocations. Your arguments should flow and the paper well organized. Make sure that you say something -- don't be wishy-washy - have an opinion.

You will be graded according to the following criteria:

rubric is clearly explained and justified 30 pts.

list of possible projects given 20 pts.

final selection justified by applying rubric 20 pts.

good mechanics - spelling, punctuation etc. 10 pts.

indications of research 10 pts.

paper is convincing 10 pts.

## DEBATE PROJECT 2nd quarter

You will be given a topic and the side of the topic which you are to argue. You will be given 8 minutes to present your argument. You will be cut off after 8 minutes. Your opponent will be given the same time. When you have both finished presenting your arguments. You will then each have the opportunity to ask your opponent one question. This should be a question that should highlight a major flaw in the argument of the other side. Remember your task is to convince me of your side of the argument. You should try to anticipate your opponent's arguments so that you can discredit them either in your own argument or through your question. You need to be as convincing as possible, both through good reasoning and your passion. This is not like a report. You must select the information which you believe is the most powerful and take your time to present it so that it makes a strong impact. It is a balance between using information and creating rhetoric. The class will decide the winner but I will decide the grade. You may not get a side with which you agree. If you are ever going to convince someone of your point of view then you need to understand the arguments of the other side.

## TOPICS

1. Natural drugs are better than their chemically produced replicas.

For natural version \_\_\_\_\_

For the chemical replica \_\_\_\_\_

2. Research should continue for space travel and exploration Vs discontinue the research.

For research in space \_\_\_\_\_

Against continuing research in space \_\_\_\_\_

3. Nuclear power is an answer to the looming energy crisis Vs nuclear power should not be considered as an option.

Foe nuclear power \_\_\_\_\_

Against nuclear power \_\_\_\_\_

4. Should scientific research be government supported or supported by private industry.

For government supported research \_\_\_\_\_

For private industry supporting research \_\_\_\_\_

5. If energy was dwindling and there wasn't enough to meet demand, should it be rationed or should it be left to a free market where price will control distribution.

For rationing \_\_\_\_\_

For free market \_\_\_\_\_

6. Can we make a difference to the environment or are there just too many problems ?

We CAN make a difference \_\_\_\_\_

We CAN'T make a difference \_\_\_\_\_

7. Will man with his/her technological skills continue to solve any problem which comes along or is the world basically doomed ?

Optimist \_\_\_\_\_

Gloom & Doom \_\_\_\_\_

8. We should continue to use chemicals ( fertilizers, pesticides, hormones etc.) to promote agricultural output.

For \_\_\_\_\_

Against \_\_\_\_\_

9. The scientists who developed the atomic bomb should assume responsibility for the destruction which it caused.

For \_\_\_\_\_

Against \_\_\_\_\_

10. Should we allow Genetic engineering

For \_\_\_\_\_

Against \_\_\_\_\_

## **STANDARDS**

This unit will focus on the following Standards of the Pittsburgh Public Schools:

1. Science and Technology Standard #4. All students explain the relationships among science, technology and society. The budget rubric , the debates and their final story all require the students to understand this standard.

2. Science and Technology Standard #7 All students evaluate advantages and disadvantages and ethical implications associated the impact of science and technology on current and future life. The budget rubric , the debates and their final story all require the students to understand this standard.

3. Communications Standard #2 All students read and use a variety of methods to make sense of various kinds of complex texts. Students read science fiction stories and independent research.

4. Communications Standard #3 All students respond orally and in writing to information and ideas gained by reading narrative and informational texts and use the information and ideas to make decisions and solve problems. Students read information gathered by their research and make decisions about importance of environmental issues and evaluate suggested solutions.

5. Communications Standard #4 All students write for a variety of purposes including to narrate, inform and persuade, in all subject areas. The final project, a science fiction story is a narration with a persuasive objective.

## **PLANK ZERO WORKSHEET - The Science, The Implications and The Story**

### **The Science:**

1. To help you keep track of everything, write down the two equations which involve Plank's constant and while you're at it give the value of Plank's constant.

2. Heisenberg's Uncertainty Principle:

a) State this in your own words and describe what its implication is in chemistry.

b) Test the assertion on p174.

i) Find the uncertainty in momentum if the uncertainty of the electron's position is one billionth of an inch. You will need to know that

1 Joule =  $g \times m^2 \times s^{-2}$  and that 1 inch = 2.54 cm. The units for momentum should be  $g \text{ m s}^{-1}$

ii) Now using the mass of an electron and the fact that momentum equals mass x velocity, calculate the uncertainty in velocity for the electron. Unit for velocity is  $\text{m s}^{-1}$

iii) velocity gives the distance traveled in 1 sec. So in 1 sec how far could the electron have traveled. To compare it to the units given in the book you may need to recall that 1 mile = 5280 ft.

### 3. Pauli Exclusion Principle:

Explain in your own words.

### 4. The Superforce.

Explain how the superforce relates to the four basic forces and the Big Bang theory.

**The Implications:** As described in this story

#### 1. Heisenberg's Uncertainty Principle:

i) How is this principle used in the story ?

ii) What are the implications of the Heisenberg Uncertainty Principle to the concept of Teleportation

#### 2. Pauli Exclusion Principle

i) How does this principle explain why the core of the star does not collapse ?

3. What is quagma ?

4. Why is the shell of the experiment silvered ? Remember that within the shell Planck's constant is smaller than it's value is outside.

5. What is the implication of a changed value of Planck's constant for us ?

6. What did the Ghosts hope to achieve by reducing Planck's constant ?

7. What do you think is meant by Quantum Loneliness ?

8. The premise of this story is that by changing a constant we can change how matter and energy interact because of their mathematical relationship. This would suggest that math governs nature, rather than math describes nature. Do you think there is a fallacy in the argument and if so where is it ?

### **The Story.**

1. What is different in the world as described in this story ?
2. How did Jack "talk" to his dead wife ?
3. New words are used, actually totally made-up words. Can you list some ? Were you able to figure out what they meant ? Was literally knowing their meaning important to the story ?
4. A bizarre world was described. How effective was the author in creating this world ? Was it strange enough to be different or too strange to be believable ?
5. What hasn't changed in this world ?
6. Explain how the author made this an effective story. What kept your interest ? What made it exciting ?

### **NEUTRON STAR WORKSHEET-- The Science, The Implication & The Story.**

#### **The Science**

1. What is the radius of the nucleus of an atom compared to that of the atom ?
2. What forms the "outside " of an atom ?
3. What stops an electron from "falling" into a nucleus ?
4. Why don't atoms "crawl" inside each other ?
5. Find out what a ghee measures and its value.
6. The story states that the neutron star is 1.3 times the mass of the sun. Find an approximation of the sun's mass and determine the mass of the neutron star.
7. What causes tides ?

#### **The Implications**

8. What results when a proton and a neutron are finally attracted ?

9. Why would "compressed" atoms be a very dense form of matter ? By what factor is the degenerate matter more dense than normal matter ?

10. Use mass information of a proton, neutron and electron and Einstein's equation to predict the energy produced per collision of proton and electron. Convert to energy per gram of protons and energy per 1,000 kg of protons.

11. Shaefer needs to drop 1,000,000 miles in 24 hours. What speed would he have to be traveling ? Is this faster or slower than the speed of light ?

12. What forces are acting on the spaceship ?

13. Why are the forces so strong if the neutron star is not significantly heavier than the sun ?

### **The Story**

14. This story is rich with descriptions. Choose three descriptions which you particularly liked.

15. Are there more than two species in this universe ?

16. What do you learn about the "We Made It" planet ?

17. List all the features of a puppeteer and describe its skills. Sketch what you think it looks like from the description in the story.

18. This story blended our world with many new features. How effective was the mix ? Did it capture your imagination ?

19. Explain how the author made this an effective story. What kept your interest ? What made it exciting ?

### **BIBLIOGRAPHY**

It should be noted that many of the references which I found are from old and out of print books. I found many of these in the library only. Many books which were referenced in some of the literature could not be found. Hopefully if more teachers become interested they can begin to create a bibliography of newer and more available works cross-referenced by scientific topics addressed.

1. *ANALOG Science Fiction and Fact*. USPS 488-910 A monthly magazine published by Dell Magazines, a division of Crosstown Publications. Subscription is \$39.97 a year.

This magazine features novellas, novelettes, short stories and poems from well known writers of the genre. There is also a section which presents current science facts in easy to understand language.

2. Asimov, Issac, Editor, *Where do We Go From Here*. Doubleday & Co, 1971. Library of Congress Catalog Card Number 75-142033

Asimov, both a prolific science fiction writer and scientist in his own right, has selected well written science fiction stories which have strong science content. He also explains the science at the end and suggests follow-up questions to use with students.

3. Bishop Michael, Editor , *Nebula Awards 1989*. San Diego, California :Harcourt Brace Jovanovich ISBN 0-15-164933-2

Contains an excellent introduction by Damon Knight, novelist, founder and first president of Science Fiction Writers Association, discussing "What is Science Fiction". The remaining stories are the best stories selected by the SFWA for 1989. Each story is prefaced by a short comment from the author about their motivation and intent for the story. Any Nebula Awards books will give the reader a selection of the best of the genre for that particular year.

4. Blish, James, *The Tale That Wags The God*. Chicago: Advent Publishers 1987. ISBN0-911682-29-5

A collection of essays on science fiction written by a noted writer.

5. Disch, Thomas M., *The Dreams Our Stuff Is Made Of: How Science Fiction Conquered The World*. New York: Free Press, a division of Simon and Schuster. ISBN 0-684-82405-1

Thomas Dish, a well know science fiction writer describes the impact that science fiction has had on American culture.

6. Disch, Thomas, *Ruins of Earth*. New York: G.P. Putnman's Sons 1971Library of Congress Catalog Card Number 72-163409

Another collection from science fiction writers projecting the future. The collection is divided into four sections: The Way It Is, Why It Is The Way It Is, How It Could Get Worse, Unfortunate Solutions.

7. Harrison, Harry, Editor, *The Year 2000*. New York: Doubleday Company. 1970

Thirteen stories, contributed by some of science fiction's most noted writers are their projections for the year 2000.

8. Heinlein, Robert, *The Past Through Tomorrow*. New York: G.P. Putnman's Sons 1967. Library of Congress Catalog Card Number 67-15112

These stories are projections of the future as seen in 1967. Robert Heinlein is one of the masters of this genre. These stories are not only well written but can be read to analyze the concerns of the time as they relate to predictions of the future. *The Man Who Sold The Moon* is a classic found in this book.

9. Preiss, Byron, Editor, *The Microverse*. New York: Bantum Books, 1989. ISBN -0-553-05705-7

Articles by noted scientists on cells, DNA, subatomic particles, quarks and quantum theory followed by SF stories incorporating the concepts.

10. Niven, Larry, *Rainbow Mars*. New York: Tom Doherty Associates 1999. ISBN 0-312-86777-8

An unlikely hero Hanville Svetz was born into a future to match the sorriest predictions of Greenpeace. He goes back in time to retrieve Earth's original life forms. He also struggles to find out how Mars was wiped out so that he can prevent a similar disaster.

11. Stocker, Jack H., Editor *Chemistry and Science Fiction*. Washington, D.C.: American Chemical Society 1998. ISBN 0-8412-3248-2

Articles which discuss the role of science fiction in the teaching of science. Other articles discuss specific stories and their chemistry content. Written by chemists with a strong interest in science fiction, there is a large and useful bibliography at the end, which organizes science fiction stories by science topics.

12. Sheffield, Charles, *Borderlands of Science*. Riverdale, NY: Baen Publishing Enterprises, 1999. ISBN 0-671-57836-7

Gives an overview of many science topics which are likely to be used in a science fiction story. It sorts the myth from the truth. A good resource for teacher and student.

## **STORIES USED IN UNIT**

Baxter, Stephen, *Plank Zero* from *Vacuum Diagrams*,

Bradbury, Ray, *There Will Come Soft Rains*, in *The Martian Chronicles*. New York: Avon 1997. ISBN 0-380-97383-9

A series of stories describing the demise of Earth and the discovery of a wonderful place called Mars which again Man manages to destroy.

Niven, Larry, *Neutron Star*, from Isaac Asimov's, *Where do We Go From Here*.