
No Limits

Developing Scientific Literacy Using Science Fiction

by

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Illustrated by Larry Stewart



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ed. Julie E. Czerneda

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"We especially need imagination in science. Question everything."

Maria Mitchell (1818-1889)

First woman to be professor of Astronomy at Vassar; only woman in the National Academy of Arts & Sciences until 1943.

Dedication

I dedicate this book to the ConComs of Toronto Trek, Ad Astra, Con*Cept/Boréal, STAO, and Bucconeer. These are the people who organize conventions, arranging every detail and ensuring all runs smoothly. These are also the people who have wholeheartedly embraced the use of science fiction in the classroom and who promote scientific literacy and a love of learning at every opportunity.

Thank you.

Other titles by Julie E. Czerneda

Science Fiction

A Thousand Words for Stranger (1997) DAW Books Inc.

Beholder's Eye (1998) DAW Books Inc.

Ties of Power (1999) DAW Books Inc.

Packing Fraction and Other Tales of Science and Imagination
(1999) Trifolium Books Inc.

Science and Technology

Science texts and teacher resources published by John Wiley & Sons, D.C. Heath, and ITP Nelson

By Design (ed.) Trifolium Books Inc.

Take a Technowalk by Peter Williams and Saryl Jacobson (ed)
Trifolium Books Inc.

Career Education

Career Connections Series (1994-1997) Trifolium Books Inc. & Weigl Educational Publishers:

Great Careers for People Interested in Living Things

Great Careers for People Who Like to Work with their Hands

Great Careers for People Interested in Communications

Technology (with Victoria Vincent)

Teacher's Resource Banks I (with Dave Studd), *II* (with Caroline Toffolo), and *III* (with Susan Baker-Proud)

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Using No Limits

Science Fiction in the Classroom

Science fiction writers present their changed worlds in terms that are consistent with the language, the assumptions, and the arguments of contemporary science, or in terms that are consistent with our profound sense that human history is a continuous reality and that changes flow from what we know of that reality. Good SF says: if A is the case, it follows that B can happen.”

John Clute, author of the
*Illustrated Encyclopedia of
Science Fiction*

The use and, indeed, acceptance of science fiction as a valid tool in teaching is very similar to the situation facing information technology. While most profess to knowing its value, there is often only one teacher in a department or school who is a true convert, acting as both expert and advocate. This person may be considered as an invaluable resource by many peers. At the same time, others may avoid this person and the crazy ideas he or she brings to school, perhaps hoping it's a mildly harmless phase that will go away with experience in the real world of classroom, budgets, and time. There is almost always at least one who speaks out in scornful dismissal, no matter how passionate the presentation or eloquent the proof.

Of course, neither slavish devotion nor scorn are helpful reactions. The teacher who knows and loves science fiction may have no idea how to adopt it as a useful resource for students. I've met many such people, wonderful educators, who confess they just want to have a chance to share their love of the genre with anyone and students, willing or not, are a captive audience. As for scorn, there will always be those who view the unfamiliar with hesitation and discomfort.

But just as information technology is permeating and enriching education, from curriculum to the list of Internet sites students talk about after class, so is this body of speculative literature, known as science fiction, beginning to take on a whole new relevance in today's classrooms. I hope you find this resource helps you use science fiction in a meaningful and enjoyable way with your students.

And if they develop a love of science fiction along the way, that's fine, too.

What is Scientific Literacy?

Consider literacy on its own for a moment. As a working definition, let's call literacy the ability to read with comprehension and purpose. A literate person is comfortable using words to communicate ideas and can critically interpret the communications of others.

Science is a process of inquiry and typically includes the body of knowledge produced by that inquiry.

Where do these concepts meet? Each and every time we are faced with information that is, or purports to be, scientific. So how do we “read” science, that is, evaluate it? Is it necessary to become scientists ourselves in order to understand today's increasingly technological and information-rich world? How do we critically interpret something that has resulted from a complex interaction of many types of knowledge and processes?

And, most importantly of all, how do we prepare our young people to live in a future where science will play an increasing role? By helping them become scientifically literate.

The Role of Science Fiction in Developing Scientific Literacy

Science fiction is story-telling that springs from one simple idea: *What if?* What if this or that scientific premise were different? What if things happened in a different order, or not at all? What if? For hundreds of years, science fiction has been a testing ground for scientific and social concepts — from those that have never existed to those we live with everyday.

This makes science fiction an excellent passageway to scientific literacy. When students read a good science fiction story, they are entertained. But as you guide them deeper into the science “what if” that lies beneath the story, they learn to explore scientific concepts with a critical eye, to see the importance of context and source, and to recognize potential issues.

In *No Limits*, you will find activities to help your students express their own “what if's” about science. Students will critically evaluate what they read about science topics and how science and scientists are portrayed. In so doing, they will take

Scientific Literacy: the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.

National Education Standards
(1996) National Academy
Press Washington

Where to find it:

Use the worksheet, *Scientific Literacy Skills* (pg 115), to help students track their own progress.

Vocabulary

- Since an appreciation of the meaning of individual words is a key component of literacy, you will find vocabulary notes in the margins.
- Certain words have been defined on many of the worksheets in order to cue students to the particular usage being applied.
- It has been my experience that many students prefer to guess the meaning of words rather than ask. You may wish to start an ongoing list of words and their definitions on the bulletin board. Another approach is to challenge students to discover the meaning and correctly use a “word of the day.”



This icon indicates a relevant Internet site.

The “What if...” on this page was explored by Nancy Kress in her acclaimed novel, *Beggars in Spain*.

important steps towards becoming scientifically literate, an essential accomplishment for both today and the future.

A scientifically literate person:

- identifies the scientific issues underlying personal and societal decisions.
- expresses their views on those issues in appropriate scientific terms.
- evaluates the quality of scientific information by considering both its source and the methods used to obtain this information.
- makes and evaluates arguments based on evidence and applies conclusions from such arguments appropriately.
- asks questions about what makes them curious in everyday life, and determines or finds the answers to those questions.
- reads and understands articles about science in the popular media, and discusses with peers the validity of their conclusions.
- distinguishes between what is and what is not a scientific idea.

An Overview of *No Limits*:

- Reproducible worksheets and lesson suggestions for using any science fiction with your students to develop creativity, critical reading skills, and an improved understanding of the role of science and scientists in society.
- Annotated versions of the original science fiction stories commissioned for *No Limits*. (These stories and verse are available for students in the anthology *Packing Fraction and Other Tales of Science and Imagination*, Trifolium Books Inc.)
- Reproducible worksheets and lesson suggestions for using the commissioned stories, poems, and illustrations.
- “Where to find it” tips to help you locate materials.
- Additional information about science fiction literature, authors, and other media.
- Creative writing tips and story suggestions throughout.
- Vocabulary assistance.
- Implementation tips based on classroom experience with these materials.
- Annotated Resource List, including recommended non-fiction print materials, films, fiction titles, and Internet websites.

Selecting Your Approach

I chose the title “No Limits” for two reasons. The first is the more obvious: that as literature, science fiction imposes no limits on creativity — on believability and rigor, yes — but never on the means, topic, or approach.

The second reason was my own observation that there really is no limit to how you can use science fiction in the classroom. I’ve provided only a sampling of the ways I’ve tried. Every time I speak to teachers, I find a new approach or application. It would surprise me if that didn’t occur. Imagination begets imagination.

So, from a practical viewpoint, you need to select an approach, to decide what it is you want science fiction to help you and your students accomplish before you begin. Here are some of the criteria you may wish to consider:

Criteria

- Time allotted. Are you thinking in terms of a warmup activity to a unit of study or a project extending into 2 or more lessons?
- Type of evaluation and assessment preferred. The bulk of the activities in this book are based on a combination of participation and result.
- Is this an enhancement or part of core? While this definitely relates to time allotment, it is also an important point to consider when selecting the activities. If core, you will be dealing with a variety of reading abilities and interests as you work with the entire class. Many of the lessons in this book are geared to this variety. Watch for the group work icon.
- Is this to have a cross-curricular focus? If so, you may wish to involve the appropriate staff members in your planning.

Sources of Science Fiction: Print, Film, or Other Media

Science fiction has blossomed in every imaginable form, and, not surprisingly, makes up a majority of the new offerings in cutting-edge media such as gaming, virtual reality, and electronic publishing.

For the purposes of classroom use, however, there is still no more versatile and accessible format than the printed word. Science fiction works are found in the majority of school and

What if...

This is the underlying question of science fiction. *What* will happen to society, individuals, and/or the universe, *if* this aspect of science operates thus. It is the thrust that starts the speculation. From this point, the science within the story is as consistent with what is known as possible, within the realm of the story being told. You will encounter sample “What if’s...” to help trigger your students’ imaginations throughout this book.

“I use science fiction in my ...science courses to make abstract concepts more concrete, distant objects seem like real places, and to show the creative, imaginative side of science.”

Dr. David DeGraff,
Professor of Astronomy,
Alfred University N.Y.

Where to find it:

There is an annotated list of recommended science fiction works-in-print at the end of this book. You will also find several websites which are devoted to identifying suitable works for student use. Both of these listings were developed using the following criteria:

- The work has a solid, identifiable scientific “what if” premise.
- The work is generally available.
- The content of the work would be considered by most educators to be accessible to student readers from 12 years and up.

In most groups, one or more students seem to take fire from ideas, leading both in how they express themselves and in their ability to inspire others. These are not always the individuals you’d predict. I remember one particularly articulate and passionate young man, whose comments were often so to the point and interesting the entire group hung on his every word. Each time he spoke, I had to glance at the teacher at the back of the room who’d pointed out this student to me before the session as someone who never uttered a word in class. She was smiling so broadly it’s a wonder the students didn’t pick up on it.



This icon indicates activities that could be done at home.

public libraries. Many publishers keep even older science fiction works in print or else they can be found at second-hand bookstores. Given the vast amount of science fiction literature out there, the difficult aspect is selecting which to use. (See marginal note.)

This being said, a combination of film and print media can be extremely effective in reaching a class and quickly illustrating concepts such as world-building, plot, and pacing. I have listed some suggestions with specific Lessons. One recommendation I do have is to avoid the temptation to sit the class in front of an entire film. You will gain more by cueing up several short pieces of around 30 s each, and generating discussion between each. Then students can follow up by watching the films of interest on their own time. (See list of films, pg 122.)

Choosing an Appropriate Student Product

You will find as you read through the various lessons and activities that there is rarely only one possible product. This is because I’ve found it easier to tailor the end result to suit differing groups of students than to try and make the same project work for every situation. This flexibility means you can start any of the activities or lessons, but make your own decision where, and with which student product, you wish to end. You’ll also note that I frequently suggest enlisting the class to make this and other choices. This is my style in the classroom and is only provided as a suggestion.

Points to consider when choosing the student product:

- Should the product be well-defined or open?
- What is involved (your time) in assessing the product?
- Do you wish to have group work or individual or both?
- Are there opportunities to have a product match other program goals?
- Which products best suit individual students?
- Can this product reasonably be done outside of class?
- Do you have the resources available to ensure student success with this product? For example, is there Internet access for students at your school? Will you need to arrange a trip to the public library in order to provide a sufficient variety of science fiction resources? (Hint: If you decide to supply books of your own to the class, be sure to keep careful track. Even if all are returned, be aware that paperbacks, especially those published in the last 15 years, tend to fall apart very easily.)

Implementing in the Classroom

There are tips on how to use the lessons and activities in class throughout this book, but there are a few basic concepts to be addressed for all.

Encouraging Creative Thought

Other than in classes devoted to writing skills development, most students need to warm up to the idea of thinking creatively in science. Be prepared for some resistance from those students who like everything “by the book.” The “warm-up” icon marks activities you can use to get the class involved.

Group Dynamics

How well your class works as a unit, or in groups, will depend on two things: keeping the atmosphere non-critical and sharing expertise. A typical class contains only 1 - 5 % who admit to reading science fiction (include comics and gaming scenarios when you ask), and another 30 - 40 % who confess to following the X-files, Babylon 5, or other television series. I use “admit” and “confess” deliberately. Teenagers are very sensitive to the opinions of their peers and science fiction is often denounced as “kid’s stuff” by teens and adults alike. I always find there is a moment after announcing you will be working with science fiction in the classroom in which you can tip the scales easily one way or another, towards interested acceptance or perceived ridicule. My only advice is this: you have to show the students that you yourself take science fiction seriously and that you will expect tolerance for all ideas and opinions.

The sharing of expertise has its own interesting potential pitfall. While groups should take advantage of expertise, you will likely find your worst class critics are the science fiction readers. Once they feel safe in the class, they will be the ones to trounce on the hesitant new ideas of the non-readers. It can be very tricky keeping these individuals satisfied without letting them turn off the rest of the students.

Worksheets and Lesson Suggestions

The worksheets in this book can be used with any science fiction material you prefer, including television and film. The lesson suggestions offer similar choices, but include activities based on the short stories from the student anthology, *Packing Fraction and Other Tales of Science and Imagination*.

Adding Excitement

Science fiction is supposed to be entertaining and (often) fun. Take advantage of this reputation to “jump-start” a reluctant or timid class. Come to class dressed as a mad scientist, then act normally. Surprise the students with posters and models around the room. Use props. (I have a great time with a 1 m T-rex model that roars.) I know of one teacher who comes to class in a Star Trek uniform on the first day of using science fiction. It’s become an expected high point for students each year.



This icon marks beginning or start-up activities.

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Recommended Materials:

- a selection of science-based headlines, ideally cut out and mounted on card stock for reuse.
- a can or box to hold the headlines
- Worksheet, *Lurid Headline Collection* (pg 10)
- Worksheet, *Short Story Plot Elements* (pg 11)

Recommended Student Product:

- a statement of the story concept, starting with “what if” premise and the consequence.
- a one-page plot outline
- a short story, 500 - 750 words (only if story-writing is a key element in your program.)



Where do ideas come from?

While the answer varies with each author, it's fair to say most science fiction authors are “information junkies” who read just about everything they can find, from science publications to newspapers to history texts. Many subscribe to Internet lists in order to learn more about topics of interest. Sometimes the most interesting ideas come from conversations. When Hubble telescope scientist Ingle Heyer led a group of sf writers on a tour of the Space Telescope image archive facility and described the robotic mechanism used to locate images for on-line requests, you could see the ideas sparking in every set of eyes.

Using Science Fiction to Encourage Creativity in Science

The idea of being creative in science is unfamiliar to most students. The bulk of new information they are facing, the history underlying the scientific theories they investigate, even the precision of the instruments they use all conspire to make science in school seem immutable and solid. Yet one of the key aspects of the science is the interplay of creative and imaginative thought with observation and experiment. This flexibility is vital in order to interpret data in novel ways, to propose testable problems, and to push existing theories past what is momentarily accepted to new and more reliable explanations. Science is a human creative process as much as any art. (Throughout this book, you will find ways to help students examine this concept further.)

Science fiction is all about thinking beyond, about stretching the limits of what is known in science to what might be. The speculation of science fiction allows students to explore concepts, relationships, and potential societal impacts within their imaginations. So one of the single best uses of science fiction in any classroom, but particularly in science, is in the generation of story ideas based on scientific concepts.

How to Proceed

- If you wish, hand out the worksheet, *Lurid Headline Collection* (pg 10), a few days ahead of time to allow students to collect their own headlines to share with the class.
- Ask students “where science fiction writers obtain their ideas?” Record all responses. Point out that while most science fiction writers are not scientists, they share an interest in science concepts.
- Ask “what is the underlying question in science fiction?” Describe the questions in news accounts as “how, why, where, who” then lead to the science fiction premise of “**What if..**”

Modeling the Activity

- Choose a headline and write it where all students can see it. Explain to students that you will be using this headline as a starting point to generate a science fiction story as a class. Here is a sample of how to proceed. Note: the more enthusiasm you can bring to this stage of the activity, the better. It can take a second try at a headline to get students involved. Once

they grasp what to do, you may find the only problem is getting them to stop.

Eye in the Sky Foils Hawks

Here is a newspaper headline I've used with students. The article itself deals with technology used reduce the incidence of bird-plane collisions near an airport.

- The first step is to establish the “what if...” to be explored in the story. I give them a brief explanation of the article. Then I say, “let’s change things a bit.” As a class, we play with the content of the headline so it sounds more like science fiction. At this point, my purpose is to encourage them to speculate as freely as possible, not to take the science in this particular article and write directly from it.
- We start with “Hawk.” I ask students to substitute something else. My preference is to have them call out their ideas, getting as noisy as possible. I then pick an interesting one or have the class choose. A simple hands -up voting system works well if there are multiple good ideas. In this case, the class agreed on “Aliens.” It’s typical to have fairly stereotypical, simplistic ideas to start with, until students have warmed up their creative thinking.
- For this headline, the change to “Alien” is enough to start. I ask the class to agree on the following parameters:
 - Setting: on the Earth or off the Earth
 - Time: Now, the Future, the Past
- They picked “on Earth” and the “Future.” We refine the location (this can lead to some interesting twists), in this case: Australia; and the time period, in this case: a far distant future.
- Next, the class tosses around ideas about the “Eye in the Sky.” Ideas range from “predatory cloud organism” to “a passenger arriving on a space ship.” Any of the ideas could lead to interesting story possibilities. At this point some students are already half-writing their own stories. The class decides on a “Spy satellite.”

Spy Satellite Foils Alien

- Now it’s time to define the problem, to think creatively about the “what if...” in terms of a story’s plot. I point out the word we haven’t changed yet, “Foil” as indication of some unsuccessful effort by the alien. (In this case, the What if...revolves around an alien visiting Earth in the future.) This

Where to find it:

- Headlines - try the “Breakthrough” section of *Discover* Magazine; national newspapers, especially the science sections; news magazines which have science or technology features, such as *Time* Magazine.
- For the student’s own headline search, I’ve also recommended the tabloids as these offer a great opportunity to investigate pseudo-science at the same time.

Accept anything the class accepts.

It is essential to establish a non-judgemental atmosphere during creative activities. At first, students, particularly the younger ones, are expecting you to censor them. When they realize you are not, you should notice a reduction in their other major anxiety, the opinion of their peers. It’s worth allowing a bit of silliness to stir up their imaginations. Once they see you taking all ideas seriously, they should settle down.

Is it Science Fiction or Fantasy?

Depending on your class, you may need to distinguish between science fiction and fantasy in order to keep students writing what you wish. One quick demonstration is to show a dramatic illustration of a dragon. Ask the class to decide if a book with this image on the cover would be science fiction or fantasy. It can actually be either. A science fiction story about a dragon could be based on virtual reality, a robotic dragon, or other possibilities. A fantasy, on the other hand, would not provide a scientific rationale for the existence of a mythological creature and instead would rely on the existence of dragons as part of the world-building in the particular story.

No Limits

Record the class story elements where everyone can see them as each is determined during the open discussion.

Writing Assessment

Here is one way of breaking down your assessment of student writing:

Exceptional

- confidently integrates elements of writing
- creative and imaginative content

Solid Achievement

- control of elements of writing
- clear and complete content, not necessarily very original

Poor

- minimal to no grasp of writing elements
- unconnected, fragmented ideas

The Expert Witness

Ask students to name the expert witness - the character or device used to provide the essential scientific rationale or clues needed for the plot - in each of the different versions of Star Trek. Answers? Classic Trek: Mr. Spock; Star Trek: The Next Generation: Mr. Data; Star Trek DS9: a variety of characters, especially Dax and Dr. Bashir; Star Trek Voyager: a variety of characters, especially Torres and 7 of 9. The voice of the computer is also frequently used as an expert witness. (Star Trek names and titles are trademarks of Paramount.)

time, I gently discouraged ideas along the lines of “B-movie alien invasion” and waited for something more original to surface. Sure enough, the class decided the alien was on Earth to secretly harvest portions of the coral reef (the location was Australia). The spy satellites were there as monitors, so the people on Earth could prevent such thefts. I then asked the students why the aliens were stealing. The class decided the reef contained a substance the aliens needed to combat a fatal disease, but they couldn’t meet Earth’s price and were driven to theft.

- You can stop once students have created a scenario and proceed to repeat this exercise to this point with other headlines until you are confident they understand the process and can continue in their groups, but when time allows, I prefer to continue with the story elements of mood, protagonist, and expert witness.

Mood: Have the class concur on an overall mood to the story under construction: is it to be light and funny? dark and tragic? mysterious? etc. In my experience, most classes choose something between dark/ tragic and mysterious.

Protagonist: Given the form is a short story, there has to be a viewpoint character, through whom we experience what happens. I usually generate this character from the class by providing these choices and asking for a majority vote: *Human or Non-human* (most classes pick human at first) *Male or Female* (often leads to interesting class dynamics) *Age:* less than 20, 20-30, 30-40, 40 and up (I note the class choice, often 20-30 the first time, and remind them there has to be something about this person which makes his or her ability to solve or understand the problem believable. There are usually some sheepish looks as they realize, for example, a world-renowned expert in nuclear physics is unlikely to be less than 20.)

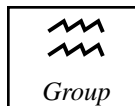
Expert Witness: The character(s) or other vehicle the author uses to provide or interpret the required science in the story, particularly within space-limited media such as a short story or TV episode. Even in novel-length, it is very difficult to keep the story flowing well around chunks of expository text and most authors do their utmost to avoid the necessity. (One of the truly helpful things that students almost unfailingly do here is become so enraptured with the story-building process that their own stereotypical views of scientists — which they honestly don’t realize they possess — come out. When I write the key words to describe the expert witness, then wait a

moment, you can hear the mental gears turning. Why did they make the expert witness a much older male? See page 20.)

- It generally takes less than five minutes to run through this the first time. Once students understand the process, it can take a little longer as more of them throw in ideas and the class debates different choices more fiercely. This is when you will need to shorten up discussion. You will also need to gently curb the enthusiasm of those students who would happily write an entire novel plot outline on the spot.

Proceeding with the Group Activity

- Once you are confident the class is ready, break them into their groups. Provide the worksheet, *Short Story Plot Elements* (pg 11) as a guide. Then let a member from each group draw a headline from the container. Tell them they can use the headline as is, or follow the pattern from the class story-building to modify the headline.
- Allow ten minutes for the group to come up with a one-sentence description of their story concept based on the headline.
- After that time, have a member from each group read the headline, then describe their story concept.
- If you have time, the class can work on each of the story concepts to refine them further, by considering mood, protagonist, and expert witness.



Extension Opportunities

1. Creative writing: I've had an average of 3 students per class submit stories on their own following this activity, some to me but also some to their regular classroom teacher. To extend this into a full-fledged creative writing exercise, students could produce a completed story based on the beginnings done in class. They should be able to produce a complete and sufficiently complex work in under 750 words (approximately 3 pages double-spaced). This can be done as a group activity. Alternatively, offer it as a voluntary enrichment to those individuals interested in taking the story ideas further.
2. Headline collection: Students can collect headlines and organize them by scientific "themes." This can be presented in the form of a scrapbook, poster, or even as part of a title page for a relevant science activity.



Recommended Story-writing Guidelines:

- Allow one "what if..." extrapolation, that is, one creative leap from what is known. From that point, all other science in the story must be believable in terms of what the student knows of real science. For example, allow the premise "what if the humming of tires on a new kind of pavement caused people to become easily enraged." From that point, cars and people should "behave" the way science currently postulates.
- Accept all ideas as equally valid during the creative building of the story.
- If you are finding it difficult to assess students in terms of participation during this activity, use smaller groups with more defined responsibilities. One approach is to divide the story elements among the group members.
- Encourage students who are submitting stories to work through more than one draft of their work. While creativity within a science fiction theme is the target, writing is a craft which benefits from practice and appropriate criticism.

Many science fiction authors attend science fiction conventions in which they participate in panel discussions on any number of topics of interest to fans and their own peers. The "Green Room" is where panelists relax before they appear, and it's traditional for the Green Room to offer beverages, snacks, and a collection of the latest supermarket tabloids. Why the tabloids? Suffice it to say that nothing starts a hilarious conversation among science fiction authors faster than the wilder claims of such publications.

Lurid Headline Collection

*Have you ever stared at a blank page or screen, wondering what on earth to write? Has a good story idea seemed as hard to find as free time? Fear not! In science fiction, ideas can jump right out of the daily headlines.
(Free time, well, not so easy.)*

1. Start your own collection of headlines. They can come from any source — “those” magazines at the grocery store, the local paper, or even from television — as long as they have something to do with science.
2. Record the headline, where you found it (source), and when.
3. Then, when you are ready to write, check over your collection for some unusual starting ideas.

<i>Headline</i>	<i>Source</i>	<i>When</i>

lurid: def'n. sensational, horrifying, or terrible (lurid details); vivid or glowing in color; showy, gaudy; revelation of facts or character in a horrific, sensational, or shocking way.

Short Story Plot Elements

Source (if any) Record the headline or other source you are using to begin your plot construction.
What if? What scientific idea will be explored by your story?
When will you set your story? Now Near Future Far Future Past
Where will you set your story? On Earth? Off Earth?
Any other details of setting? (For example, is it in your home town?)
What is the problem? Based on your “What if?” decide the peril or difficulty your characters will face.
Who? Who is/are your protagonists? Who is the expert witness? Who is/are the villain(s), if any?
Mood Based on the problem and characters, decide what mood your story will have. For example, is it going to be funny or grim? (You may change your mind as you write.).

protagonist: def'n. the chief person in a story; the principal performer; the advocate or champion of a cause.

Recommended Materials:

- One or more science fiction short stories, either from *Packing Fraction & Other Tales of Science & Imagination* or another source.
- Selection of magazines containing popular science articles; ideally some which give information about their contributors, such as *Discover*, and some which give little or none, such as newspapers or *Time*.

Option A

- Worksheet *Beyond Mere Words I* (pg 16)
- Worksheet *Beyond Mere Words II* (pg 17)

Option B

- Worksheets *Short Story Analysis* (mount on card stock for reuse) (pg 18-9)

Recommended Student Product:

- a bulletin board of selected science articles, sorted by student criteria
- a critique of a science article or book feature
- a collection of articles and information about a particular science issue in the media
- a scientific story based on a “what if” premise concerning credibility
- a biography of a non-fiction science writer
- presentation on the career of a science writer/journalist
- a list of Internet sources of scientific information considered credible by the class as a whole
- a list of Internet sources of scientific information considered less than credible by the class as a whole
- a handout by students for students on how to evaluate sources of scientific information

Using Science Fiction to Improve Critical Reading Skills

In language arts, students are routinely involved in critical analysis of what they read. They learn about the author of a particular work, the societal context of when and where the work was written, and pay attention to any underlying meanings as well as the more obvious content.

When asked to research a science topic, these same students might check the copyright date on a text or library book. And in too many cases, that will be the extent of their critical analysis of what they are reading. Even more experienced students will absorb and treat as valid scientific information from sources as varied as journals to newspaper articles, from website postings to television documentaries.

If you want to see some bemused faces, ask your class to think about who writes their science books. It’s something that simply hasn’t occurred to them before. Have them read the copyright and acknowledgement pages. Discuss what’s involved in a textbook. Emphasize that writing science is an activity performed by individuals, but usually for a publisher, (either in a business or institution), an organization or other group.

An excellent way to have students learn to critically read science, particularly popular science, is to start by having them analyze the authorship and content of a work of science fiction.

How to Proceed

Step I: Science Fiction

Choosing a science fiction story to read

I highly recommend using short stories for this type of assignment, for three reasons. First, the format forced the author to concentrate on the premise, the “what if..,” making this type of writing the most accessible to analyze. Secondly, from a practical standpoint, students can read a 5000-word story and complete a related assignment in a fraction of the time a novel would take. Thirdly, it is easier (and cheaper) to obtain a variety of good short science fiction, especially newer works, than to provide the same quality and variety in full-length novels.

If you are using stories from the companion student anthology, *Packing Fraction and Other Tales of Science &*

Imagination, you can either let students choose the story that interests them, choose a story for the class that fits into the science topic currently (or upcoming) in your program, or choose a story based on the recommended reading level supplied with the stories in this resource.

While I've provided two sets of worksheets and approaches, feel free to use both in combination. For example, you can model story and article analysis for the class, using with the cards from Option B, then assign individual work with the *Beyond Mere Words* set as guides.

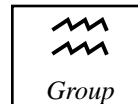
Option A - Individual Analysis

- Have students use the worksheet *Beyond Mere Words I* (pg 16) as a guide to analyzing their short story. Their predictions are important and should be as complete as possible before the research stage. This can be done in class or partially as a homework assignment.



Option B - In-Class Group Analysis

- All students who are participating should read the same short story at the same time. (See marginal note.)
- The worksheets *Short Story Analysis* (pg 18-9) contain the cards to use as guides for this activity.
- Have students work in small groups (I prefer three/group here.). There are six different cards, but more than one group can work on the same cards.
- Provide students with the short story and allow them time to read it to themselves.
- Give each group one Analysis card and allow them 10 min to discuss and answer the questions on their card.
- Have a member for each group read out the card then share their group's response with the class. Discuss.



Analyzing Science Fiction

Here is what students should gain by this activity

- **Awareness of the source:** The author is influenced by past experiences, culture, attitudes, and training, as well as by the message he or she wishes to convey through the story.
- **Awareness of the context:** A great story can be read and understood regardless of the time or setting. This being said, the social and political atmosphere when and where the story was written — the context — will have an impact. For example, I've found students better appreciate many stories written in the 1960's if they first learn about the Cold War.

Where to find it:

- Science fiction short stories are typically published in one of two formats, book anthologies (often around a theme) or in magazines. Of the magazines currently in print, *Asimov's* and *Analog* feature predominantly science fiction with a "hard" or fact-rooted premise. Collections of short stories which have won the Hugo and/or Nebula awards are published yearly as well. If students are choosing their own stories to read, just remind them it should be science fiction, not fantasy or horror.
- Information about authors, both science fiction and science, is most easily obtained through the Internet. There are also reference works such as "Works in Print" available at local libraries. Students could also contact authors or their publishers and request biographical information.

Stories from the Source

Science fiction authors are, in my experience, thrilled to know their work is being used by students. If you ask beforehand, many will grant you permission to copy one of their short stories for classroom use. Websites such as that of the Science Fiction and Fantasy Writers of America or the National Science Fiction Foundation (Canadian), list email addresses for member authors. Do not assume you have such permission until you have received a reply from the author.

Where to find it:

- A selection of back issues of popular science magazines are usually available in science departments or libraries. The broader the range of types and quality you can show students, the better.
- You can obtain interesting responses by having some students critically read articles from textbooks, especially if you have some older examples available. While the science is typically passed through extensive review and edit, the underlying themes in science texts can vary from a application and technology focus to an environmental issue focus, to name only two notable swings in the education marketplace in the last decade.



Step II: Science Non-Fiction

Once you feel students have successfully applied critical reading skills to one or more science fiction stories, move immediately to the non-fiction part of this exercise. It's important to have students read non-fiction while they are still in the mind-set produced by the analysis of the story.

Choosing a science article to read

While you can have students read the same short story, I prefer to have as wide a variety of non-fiction examined by the class as possible. This is partly a time-saver, since you can undertake a comparison of credible and less-credible sources at the same time as honing critical reading with respect to individual articles and authors.

If you wish, have students bring in articles they find on their own. If they want to examine television reports, this can be done by requesting a transcript (usually at no or nominal cost) from the broadcasting station or, less effectively, by videotaping the segment. Regardless of source, students should have the article with them when you do this activity in the classroom.

Option A: Individual Analysis

- If class time is limited, and/or you feel confident your students gain proceed without further guidance, have them repeat this activity with a non-fiction science article, using the worksheet *Beyond Mere Words II* (pg 17), then discuss the entire exercise as a class. Focus on a comparison of the two research tasks.
- If you have more time, and/or you feel your students will need more help, take up the first portion of this activity as a class, making sure students are comfortable with the task, then have them analyze the non-fiction article on their own.

Option B - In-Class Group Analysis

- If you wish to have the class analyze one article together, then proceed as for the short story activity and simply substitute the article in place of the fiction, using the worksheet *Beyond Mere Words II* (pg 17). I recommend you do at least three non-fiction articles, with one being from a less credible source.
- If you wish to have each group analyze a different article, then discuss as a whole, I suggest giving each group *Analysis Cards* # 3, 5, and 6. Focus the class discussion of each article on credibility of source and assumptions by the various authors about the scientific knowledge of readers.

Analyzing Science Non-Fiction

Here is what students should gain from this activity:

- **Awareness of the source:** It's not always possible to learn much about a non-fiction author, particularly those who report rarely in news media. The source, as a criterion for credibility, becomes the publication or venue used. Students should be able to list the clues they would use to help them rank such sources, including: any apparent bias revealed by other articles (including advertising, letters to the editor, etc.) in the same publication; reputation and/or history of the publication; process (Was the publication subject to peer review and editing? Internet sources frequently fail on this point.); and funding source.
- **Awareness of the context:** Unless you have students looking at older material, you are likely to be using non-fiction written within the students' own social and political atmosphere. This being the case, point to the publication itself as being an important indicator of context. (Hint: Have students check the Acknowledgments and/or funding sections.)

Extension Opportunities

Funny or Misleading?

Discover Magazine has, for the last few years, published “April Fool’s” jokes in its “Breakthroughs” section of short articles. One memorable instance concerned the danger to Antarctic researchers of being attacked by giant mole rats, said rats being able to melt the ice beneath ones’ feet with their hot heads. These articles are written in exactly the same style and tone as the others, although there are occasionally broad hints. (The name of the reporter for this article was “April Fool” in Italian, for example.)

Letters to the editor in subsequent issues usually contain one or more complaints about the latest joke, citing the hazard of presenting non-science alongside the credible work. Others are delighted by the chance to catch science in the act of being silly.

Have students debate this issue, assigning the roles of “reporter,” “editor,” and readers “for” and “against” the practice of these jokes. Be sure students consider the responsibility of the publication as a provider of information to non-scientists as well as the responsibility of non-scientist readers to be critical of what they read.

The Internet

As more and more people choose the Internet — with its astounding quantity of information — as their first choice when researching an issue or topic, it becomes even more vital to be critical of source and context. Carefully used, the Internet can be a superb means of finding valid, up-to-date answers. It is possible to contact many scientists directly about their work, allowing students unprecedented access to such expertise. Increasingly, one can even become a participant either through contribution or by using databases made available. This being said, there is also an access to misleading or inaccurate information as well. Be sure students are careful to question the source, use reputable websites, and look for confirmation of information from multiple sources. Establish the criteria acceptable in your classroom for Internet-based research, while encouraging students to learn how to use this resource.

Beyond Mere Words I

Story Title: _____

Author: _____

Publishing Information: _____

1. What is the scientific premise, the “what if...” underlying this story?
2. What is the attitude towards science portrayed in this story? Give an example.
3. How does the author present the scientific information needed as background to this story? (for example: an expert witness, narrative, assumption about readers’ knowledge)
4. Where and when was this story first published (hint: check the copyright page and/or acknowledgments)?
5. What do you know about the author at this point?
6. What do you predict about the author based on this story?

Research: Find out as much as you can about the author and what was happening in the world at the time this story was first published.

<p>Suggested Sources of Information About Authors</p> <ul style="list-style-type: none">☐ Public Libraries: carry or can access for you reference works with basic biographical information on published authors.☐ The Internet: Use a search engine and the author’s name (you may have to experiment with using the full name or just the last name) or visit one of the major science fiction websites such as http://www.sff.net as a starting point.☐ The Author and/or Publisher: If time permits, contact the author (through the publisher if necessary) and ask your questions directly.

7. What have you learned about the author?
8. How does this compare with your predictions?
9. How do you think the author’s views have been expressed in this story?
10. What influence, if any, do you think the original location and time of the publication of the story had on the view of science the author expressed? (Consider the social and political context as well as the state of science and/or technology.)
11. Think about your own views concerning the premise of this story. How would you change this story if it were yours? Why?

context: def'n. the circumstances relevant to something under consideration.

Beyond Mere Words II

Article Title: _____

Author: _____

Publishing Information: _____

1. What is the scientific topic or issue being presented?
2. What is the attitude toward science presented in this article? Give an example. (Hint: is science the source of information and/or the source of some problem or controversy?)
3. (a) Where and when was this article first published (hint: check the copyright page and/or acknowledgments)?
(b) In your opinion, does this make the scientific information in this article more or less credible? Explain your reasoning.
5. What do you know about the author at this point?
6. What do you predict about the author based on this article?

Research: Find out as much as you can about the author and what was happening in the world at the time this story was first published.

Suggested Sources of Information About Authors

- Public Libraries: carry or can access for you reference works with basic biographical information on published authors.
- The Internet: Use a search engine and the author's name (you may have to experiment with using the full name or just the last name). You may need to search under the name of the publication or the topic for previous articles by this author.
- The Author and/or Publisher: If time permits, contact the author (through the publisher if necessary) and ask your questions directly.

7. How have your predictions about the author compared to what you have learned? What problems, if any, did you encounter finding information about the author?
8. How do you think the author's views have been expressed in the article?
9. How has learning more about the author affected your opinion about the credibility of this article?
10. What more would you like to know about the issue in this article? How would you find out?

credible: def'n. believable or worthy of belief; convincing.

Story Analysis Cards

Analysis Card 1

Based on this story, how would you describe the author?

Think about:

- age
- sex
- physical description
- occupation (other than writing)
- education
- attitude towards science
- attitude towards people
- other

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Analysis Card 2

What area of science is the author exploring in this story? How do you know?

- Biology
- Chemistry
- Physics
- Other

What is the scientific premise of this story? Express the main idea in a “what if” statement.

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Analysis Card 3

When do you think this story was written? What clues did you use to make this decision? What effect might this have had on the author’s approach to this story’s scientific premise?

Where do you think this story was written? What helped you decide? What effect might this have had on the author’s approach to this story’s scientific premise?

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Story Analysis Cards

Analysis Card 4

What point(s) is the author trying to make about science in this story?

Do you agree or disagree? Why?

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Analysis Card 5

How did the author present the scientific information needed as background to this story?

- an expert witness (a character who knows and talks about the science)
- narrative (description)
- assumption (assumed a certain level of scientific knowledge from readers)

If there was an “expert witness,” how did the author convince you that this character could be believed?

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Analysis Card 6

What was the role of science presented in this story?

Think about:

- If any of the characters in the story were scientists, how were they portrayed?
- What role did science play in the problem that the characters faced in the story?
- What role did science play in the resolution of that problem?
- What does the author have to say about the significance of science to society (either today’s or that portrayed in the story)?

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Recommended Materials:

- Worksheet *Recipe: A Mad Scientist* (pg 24)
- Worksheet *The Real Thing* (pg 25)
- a copy of the companion anthology, *Packing Fraction and Other Tales of Science & Imagination* per student

Recommended Student Product:

- student play contrasting “media scientist” with “real scientist”
- lists that compare and contrast real scientists with popular conceptions
- lists that compare and contrast real science with popular conceptions

Caution

Several teachers have told me that they use science fiction as an example to students of the flaws in popular conceptions about science and scientists. The problem with this is that science fiction literature often portrays science and scientists quite accurately and sympathetically. Students who try to use a novel or short story as a basis for a report on stereotypes can come away frustrated. Also, the negative approach of “let’s find the flaws in the science” does less for students’ understanding than “how could this work” or “which parts of this speculation are realistic and which parts are not?”

Using Science Fiction to Investigate Popular Conceptions of Science and Scientists

Scientific literacy is about effective and reliable communication of ideas, including being able to discern the meaningful from the misleading. If there is any aspect of science in which most students come to class with potentially misleading notions, it is in their understanding of science and those who call it their profession.

These notions are not solely the fault of portrayals in the various media. They also result from a lack of exposure to real people working in science other than the teacher or doctor. Few students have the opportunity to meet firsthand those who could help them perceive the type of interactions so central to scientific endeavor.

Science fiction can be used in a number of ways to help students better understand the difference between popular conceptions of science and scientists and the reality. Once they do, it is easier for them to understand how such conceptions can affect how they perceive and evaluation scientific information.

Science fiction can help:

1. To expose students’ own stereotypical ideas;
2. In considering how science and scientists are portrayed in visual media and popular culture;
3. In considering how science and scientists are portrayed in science fiction literature.

You may wonder why I’ve distinguished between visual media and literature. By and large, science fiction literature shows science as helpful or essential to society, rather than as the source of a problem, and the role of the scientist is often either as expert witness or protagonist — not villain. This is true even if the “what if...” premise deals with some discovery or technology gone awry. In sharp contrast, much of television and film science fiction employs an irresponsible or “mad” scientist as frequent plot device and the science is something unleashed on an unsuspecting world. The scientist as hero is a relatively new phenomenon. There are exceptions, but a survey of the science fiction literature generally available in school libraries and films generally available for home rental will show this

trend quite distinctly.

This means that science fiction literature can be a painless way to introduce students to science and scientists.

How to Proceed

Exposing Stereotypes and Preconceptions

You may have to trick your class into revealing their preconceptions and stereotypes — especially the older students who may honestly (and vehemently) feel themselves free of such things. One approach I've used successfully is to wait until the class is enthusiastically engaged in a story-plotting activity such as described on page 6. I have the students develop the characteristics of a protagonist (or expert witness) who will, in their story, “know or do the science.” On a “show of hands” basis, similar to that used in the story-plotting activity, they build this character as I record the various features on the board.

Hint: In order to have this work, push the class through the character development as quickly as you can. Fire questions at them such as “Sex? Hands up for female. Hands up for male. Age? Hands up for over 20...etc.”

Even the most liberal-minded, bright group of students I've had produced basically the following result if they've been unconscious of what was happening:

The scientist is:

- male
- white (*variations*: American, British)
- older (*variations*: ancient, elderly, over 40)
- wears glasses (*variations*: bad dresser, uncool)
- has no friends (*variations*: has no life, has no family)
- works alone (*variation*: anti-social, hates people)
- takes no responsibility for his work
- motivated by curiosity
- independently wealthy

All I've had to do is stand to one side, indicate the list of characteristics, and ask: “is this a typical scientist?” The usual reaction is an abashed silence. We then take a few moments to toss around ideas of what a “real” scientist might be like. I like to finish with a discussion of the science workplace and the fact that scientists very rarely work in isolation. Any examples you can bring to the discussion will be helpful.

Where to find it:

If you do not have copies of the student anthology, look for other science fiction stories with realistic scientists and science. Consult the list of recommended works on page 122.

Being Tactful

At some point in story-plotting, investigating preconceptions, or other activities, one or more students will reveal attitudes or ideas that could provoke ridicule from their peers. It's important to encourage the free expression of all ideas by making sure you are tactful when this occurs. I've found it helps if I can expose preconceptions and stereotypes of the group rather than of individuals. Then, you can take the sting out of the revelation by immediately turning attention to where such ideas come from, for example, the visual media.

Invite a scientist into the classroom to talk about various aspects of this career. If possible, take students to visit scientists at work, such as a food science laboratory or local research facility.

Mad or Nerd?

By modern standards, the classic mad scientist, particularly if a protagonist and not a villain, is a “brilliant nerd.” This stereotype is just as offensive to real scientists as any other. But public perceptions are changing. See page 70 for activities to explore scientists as portrayed by “Other Media.”

The movie *Contact*, winner of the 1998 Hugo Award for best dramatic presentation of SF, is also regarded by many scientists as finally showing the realities of their work. You may wish to arrange a viewing of this film as part of this lesson.

The Strength of Many

Stress with students that while individual scientists are “only human,” the strength of science is in the insistence that acceptable results and conclusions are those which can be repeated by anyone else using the same procedure. This has particular significance in terms of developing of scientific literacy. Students should understand the risk of using only one source of information on a topic, or, as citizens, the risk of making decisions based on only one set of results or one set of conclusions about a scientific issue.

Where to find it:

Robert J. Sawyer’s novels reflect his understanding and respect for practicing scientists and are highly recommended. Have students read the acknowledgment section of his books.

From the Horse’s Mouth

While most science fiction writers are not scientists, there are notable exceptions, including:

- Isaac Asimov, physicist
- Gregory Benford, physicist
- David Brin, physicist
- Geoff Landis, software designer (Mars missions)
- Joan Slonczewski, molecular biologist

The Mad Scientist Mythology

- Use the worksheet, *Recipe: A Mad Scientist* (pg 24), to generate ideas of how scientists are portrayed in visual and news media (again, I make a distinction with science fiction literature here).
- Once you have the stereotypes identified, have students read a science fiction story such as “Stream of Consciousness” by Robert J. Sawyer from the companion anthology *Packing Fraction and Other Tales of Science & Imagination*. They should complete the worksheet, *The Real Thing* (pg 25), using the protagonist of the story as a model.

The Real Thing

Here is what students should gain from these activities:

An appreciation that science is:

- most often a team or group effort;
- conducted (and/or supported) by businesses and industries, organizations, institutions, and governments;
- an activity that relies heavily on the contributions of others, past and present;
- undertaken to solve problems (including design or technology problems such as commercial applications), expand understanding, and predict consequences.

An appreciation that scientists:

- are a diverse group of human beings;
- are affected by their own beliefs and convictions, as well as the context of their society and culture. This being said, scientists rely on the scientific method and peer review to maintain the essential reproducibility and reliability their work demands;
- may spend a significant portion of their time in administration and other duties related to funding their work and/ or managing others;
- may be motivated, as any set of human beings, by varying degrees of altruism and / or self-interest.

Other Approaches

Instead of using the story-plotting activity, you can simply ask students to describe a scientist and proceed to generate a list of characteristics as a class. You are more likely to get the answers the class judges to be “correct” than to reveal as much to the students themselves. However, if you then use the worksheet *Recipe: A Mad Scientist* (pg 24), you can help students identify stereotypes and preconceptions from popular media.

Extension Opportunities

Post-secondary Statistics

Have students visit the guidance department (or use the Internet) to obtain statistics on who is graduating with science degrees. They can investigate gender roles, the pattern of change over the last two decades in various fields, career prospects, etc.

Community Survey

Students design and conduct a survey to find out whose quoted opinion about a science-based issue would matter most to members of their community, that of: a scientist, a government official, a member of a non-profit group, a teacher, a doctor, an activist, a local businessperson or an elected politician. Have them draw conclusions about the decision-making process.

Science Fiction Conventions

SF conventions consist of panels in which guests discuss specific topics and answer audience questions, as well as film screenings, masquerades, art shows, and dealers. I've taken students to conventions for the past ten years and have nothing but praise for the experience. The people attending conventions are interested in science, imaginative, and willingly converse with students. Panels range within three broad categories: science (at my last convention, this included astronomy, paleontology, cybernetics, and the human genome project: all by scientists working in those fields), the creative crafts (writing, illustrating, screenwork, acting etc.), and science fiction itself in all its forms. Many conventions provide fantasy, horror, and gaming panels as well. There is a growing trend to include panels for educators, ranging from young adult literature to science fiction in the classroom. The 1998 Worldcon in Baltimore featured a day of programming linked to schools, including a non-fiction and fiction writing contest for students.

Interviewing a Scientist

- If possible, have students interview a scientist. They can use the worksheet, *The Real Thing* (pg 25) as a guide to developing their own questions. (Hint: you might also want to provide *The Business of Science*, pg 40, as well.) As a further link to scientific literacy, invite the scientist to provide sample publications you can compare with popular science materials.
- Arrange a tour of a local laboratory or other scientific establishment in your community for students (or invite a student who has completed a co-op placement in such an establishment to the class).



See page 118 for recommended websites.

Where to find it:

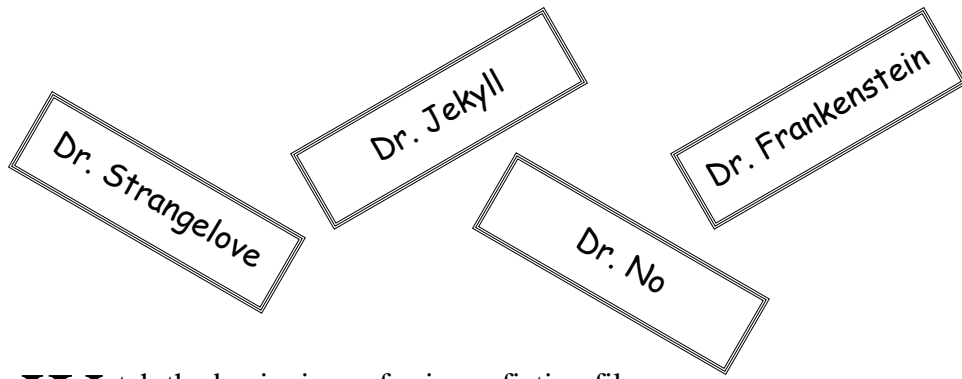
Students planning a survey could use the worksheet, *I Want to Believe! Survey* (page 59), as a model.

Convention Tips

If you've never attended a science fiction convention before, here are some tips:

- dress casually: panelists such as guest authors may wear office-type clothing, but most in attendance prefer interesting T-shirts and casual pants. (5-10 % of fans wear costumes, particularly at Star Trek conventions);
- if you can't attend the full weekend, Saturday usually offers the most in terms of panels;
- if you have special needs or requirements, let the convention staff know. All science fiction conventions pride themselves on being full-access;
- don't be deceived by appearances. The average attendee is a well-educated professional, no matter what he or she is wearing;
- take business cards so you can quickly exchange email or other contact information with individuals you wish to reach after the convention. The majority of convention guests are very approachable and willing to help.

Recipe: A Mad Scientist



Watch the beginnings of science fiction films from the 60's onward and there's no doubt about it: in most cases, science is the bad guy. And who is that turns science into a loaded gun aimed at the rest of humanity?

The Mad Scientist!

How do we recognize this classic character? Filmmakers might almost be using a recipe when it comes to showing us a scientist. What are the main ingredients?

Based on your own experience or by watching some science fiction films (yes, that would be homework), record the ingredients for a mad scientist.

Age: _____

Place of Birth: _____

Sex: _____

Physical Description: _____

Personality: _____

Fashion Sense: _____

Attitude: _____

Add any other characteristics on the back.

mad: def'n. insane; having a disordered mind; wildly foolish; wildly excited or infatuated; angry; rabid; wildly light-hearted.

The Real Things

Name of Scientist Profiled: _____

If this is a science fictional character:

Title of Story:

Author:

Context (setting and time of publication):

If this is an actual person:

How did you find this scientist?

Where does this scientist work?

In which field(s) of science does this scientist work?

You may or may not find all of the answers to the remaining questions. For any you cannot answer, think of how you could obtain this information.

1. How much education is required for this work?
2. Who or what supplies financial support for the work of this scientist?
3. What is a typical work day for this scientist? (Include other people he or she interacts with, as well as tasks and equipment.)
4. What does the scientist think about this work? (For example, is this area of science personally important, important to society, or “just a job?”) How do you know?
5. (a) Does this scientist need to communicate information about his or her work to non-scientists? If so, describe how this communication usually takes place.
(b) Does this scientist ever experience frustration or difficulty in communicating with non-scientist? If so, what is the cause?
6. Based on your opinion of this scientist, predict how he or she might react in each of the following situations:
 - (a) The scientist is incorrectly quoted in a newspaper article.
 - (b) The scientist’s name is incorrectly linked with an environmental problem.
 - (c) Some aspect of the scientist’s research is used for criminal or dangerous purposes.
7. How important is peer review to the work of this scientist? (Peer review is the process in which other scientists attempt to reproduce the results of the first in order to check their credibility.)

peer: def’n. a person who is equal in ability, standing, rank, or value: a contemporary.

Where to find it:

- Information about contests can be obtained from local libraries, writers' groups and associations, museums, and government agencies. The Internet is the best source, since up-to-date submission requirements are usually posted and can be bookmarked or printed for interested students.
- Mentors can be older students (including alumni), local writers and editors, or staff members. While a mentor can be extremely helpful for young writers, it is important to ensure the mentor is familiar with the style or genre of writing the student wishes to explore.



Website

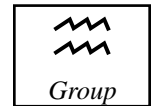
See page 118 for sites of interest to new writers.

Special Note: Encouraging Students Beyond the Classroom

Writing Fiction

You may find, as I have, that introducing science fiction into the classroom reveals the latent writers, those too shy to speak out before. I've also found keeping those students writing to be like starting a fire in damp wood with a handful of nice dry tinder. Wonderful flame and sparks to begin with, then smoke, then hardly a glow unless you work at it. Fortunately, it doesn't take a great deal in terms of resources or time to fan the flames of creativity. Here are some suggestions:

- Arranging mentors. A critical and compassionate mentor can be incredibly helpful to a young writer. A poor mentor may be worse than none at all. If you arrange mentorships, start with a trial period and allow both parties an easy escape in case the pairing isn't working.
- Offer time and space to a school writers' group. These do best when very structured and each member provides new work to be critiqued by the others at every meeting. There are websites with information on setting up and running writers' groups.
- Work with the language arts department and library staff to invite writers to conduct workshops for interested students.
- Set up a bulletin board or webpage with resources on careers in writing, marketplaces for work, contests, etc. Most writers begin their careers while in school or working elsewhere.



Group

Scientific Literacy

You can continue to promote the goals of scientific literacy outside of the classroom in several ways. Here are just a few:

- Science clubs. It isn't easy to start or maintain a school science club, yet it can be an excellent venue to encourage scientific literacy among involved students. Try linking your club to one at a university, either on-line or by monthly visits if possible. Arrange for club members to participate in national or international data-gathering exercises.
- Recognizing excellence in science writing. For example, host a local issue science background contest with winners to be published in the community newspaper.