

Teach Science
with
Science Fiction Films:

*A Guide For Teachers and
Library Media Specialists*

Terence W. Cavanaugh

Cathy Cavanaugh

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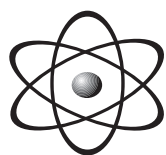


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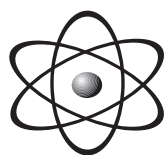
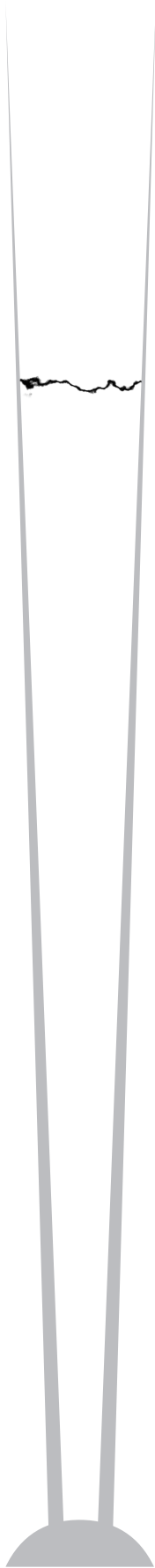
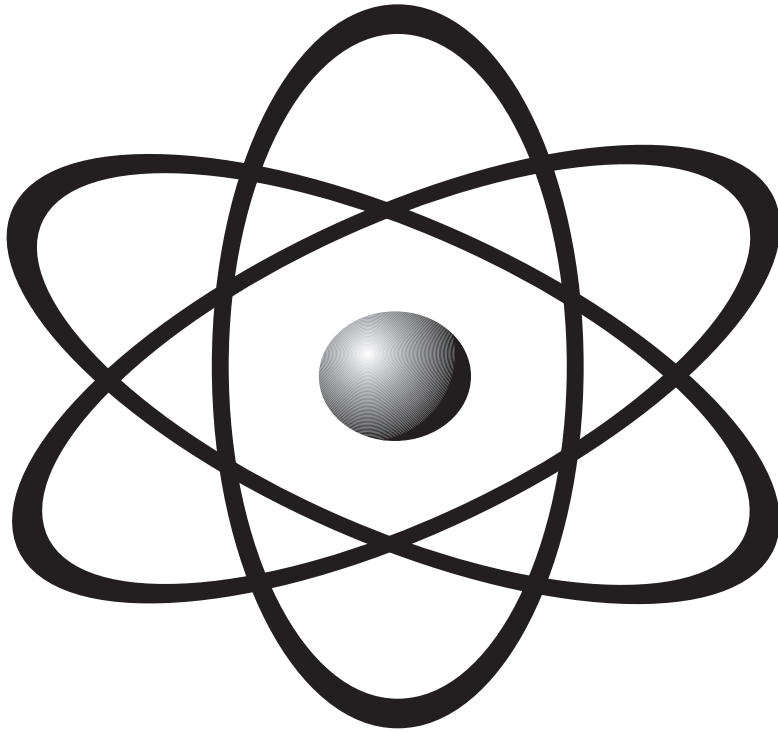


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Science Fiction Films as an Educational Tool

Science fiction has always been a staple of the motion picture industry. Film audiences have journeyed to the center of the earth and the furthest reaches of space. They have ridden in the Nautilus beneath the sea and limped around the moon and back with the crew of Apollo 13. Spielberg alone has terrorized audiences with a shark and recreated the age of the dinosaur.

In many ways, the silver screen acts as a permanent ongoing science and technology exposition; here is where most people get their regular doses of the scientific enterprise, which is good and bad. It is good because it creates tangible images of abstract ideas. It gives the audience a glimpse of the future and a nudge toward making it real. What effect did Georges Melies' groundbreaking 1903 film *A Trip to the Moon* have on the generation who helped turn that science fiction into scientific reality? At the same time good drama and good science are not always the same things. Films simplify and subvert scientific fact to fulfill the needs of dramatic storytelling. Undoubtedly it will take more than salt water to save humanity.

Science educators are in constant battle to change the misconceptions of students who are inspired—and confused—by the films and television programs they see. But, these films also open a wonderful opportunity to engage students and encourage greater understanding and interest. The film *Jurassic Park* provides educators with countless lesson opportunities. There is

the question of the theoretical science within the confines of the film as well as of the practical science that went into making the special effects. Viewing the film provides an opportunity to compare and contrast two drastically different eras of life on this planet. *Jurassic Park* also addresses the ethics of technological advancement, and it is fun to watch.

The “fun” is perhaps the best weapon in a science educator’s arsenal. Science is fun and students need to see that. Too many potential scientists have been put to sleep and lost forever by the monotonous voice-overs and bland renderings that have been the hallmarks for decades of classroom films.

Fostering students’ interest and excitement is crucial because the need for scientific knowledge has never been greater. This concept is best shown in a scene in *Apollo 13*, when astronaut Jim Lovell tells a tour group at the Space Center that one day there will be a computer that can fit into a single room. Technology is racing along at warp factor six, and in order to succeed in the new millennium, all students will need a better understanding of the sciences.

The modules in this book are designed to help students translate what they see on the small screen into the big picture. The materials and activities provided here are intended to enhance a teacher’s lesson. Pick and choose activities to meet the needs of your students and use appropriate evaluations.

Why Learn Science?

Scientific literacy is essential in a technological society. Everyone needs an increasing amount of science knowledge to understand changes in communication, transportation, energy, medicine, and the multitude of other rapidly developing science and technology fields.

Science is a vehicle for comprehension. Science allows us to understand ourselves and our surroundings and changes that occur. Beyond comprehension, science provides information used in decision making. As the world moves to an increased dependence on technology (the application of science), there will be an increase in decisions made at all levels involving scientific information and consequences. Everyone needs an understanding of science in order to participate intelligently as informed citizens in the post industrial society (National Science Foundation 98). A basic literacy in science helps in distinguishing factual media messages from pseudoscience and fallacies, thus creating more informed decision makers.

According to Rutherford and Ahlgren’s *Science for All Americans*, science can provide humanity with the knowledge needed to develop solutions to its problems. Science encourages respect for nature that influences the use of technology. Scientific patterns of thought can help people deal with problems in all aspects of their lives.

What Is Science Fiction?

Science fiction can be described as a branch of literature in which scientific discoveries and developments form elements of plot. It is based on future prediction of scientific possibilities, some of which have become reality.

Science fiction seems to have different meanings, depending on whom you ask. Some very well known science fiction authors describe their genre in a variety of ways. Robert Heinlein's definition includes realistic speculation based on understanding of the scientific method (28). Isaac Asimov's description deals with fictitious societies different from ours in technological development (167). Harlan Ellison believes that science fiction incorporates the future of man and science (5). In Theodore Sturgeon and William Atheling's view, human problems and solutions with scientific content are the basis around which science fiction stories are built (14). Damon Knight has identified common elements in science fiction including science, technology, a distant time or place, and the scientific method (64). And some people even go so far as to define science fiction as anything the publishers label as science fiction.

Science fiction film differs from science fiction literature in that film focuses on the action involved in solving a problem while literature provides more of the background reason for the problem. Science fiction films often explore modern world problems and issues and provide the opportunity to consider the future and the changes that may occur. Science fiction films can be much more than just special effects; they can be the promoters of ideas and change.

Why Use Science Fiction to Teach Science?

Science fiction media combine science and pseudoscience for entertainment. According to Purdue University research, science fiction television shows and films are the strongest influences on students for promoting science (*USA Today, The Magazine of the American Scene* 2591). Interest in science can be increased and developed by science fiction. Science fiction can also help improve attitudes toward real science.

Using science fiction allows students to experience advanced and abstract science topics such as mutations, radiation, ethics, and rocket science. While hands-on direct experience is the best way to learn, often that is not possible or practical. Using science fiction allows students to experience a wide variety of science topics. Science fiction is a way for students to encounter concepts in a new context, which provides a new avenue for learning. Students are more likely to remember information they have been involved with in an entertaining or enjoyable way.

According to Dubeck and Tatlow (319), "summative evaluation and anecdotal evidence have shown that using science films in the classroom helps reverse the negative attitudes many students have toward real science." And a 2002 National Science Foundation (NSF) report stated "interest in science fiction may be an important factor in leading men and women to become interested in science as a career" (7-35).

Viewing science fiction films improves learning science in the following various ways:

- The films allow direct visualization of abstract topics.
- High interest in science fiction facilitates learning related concepts.

- Discussion of science fiction films develops understanding of science processes and the interconnectedness of science disciplines.
- Science fiction provides a strong motivation for learning content.

The Information Literacy Standards for Student Learning developed by the American Association of School Librarians and Association for Educational Communications and Technology, and published in *Information Power*, address the development of information literacy through the application of film in teaching. When students think critically about the science content presented in films and when students learn that film is a creative medium for communication, they address two of the nine *Information Power* standards

- (1) Standard 2: The student who is information literate evaluates information critically and competently.
- (2) Standard 5: The student who is an independent learner is information literate and appreciates literature and other creative expressions of information.

Research on Teaching Science with Science Fiction Films

The results of a 1998 multi-school study by the authors support the use of science fiction films, which were science content-rich as an alternative educational resource for science educators. Science fiction film was found to be slightly more effective in increasing achievement test scores than traditional educational films or documentaries. In addition, students exhibited an improved attitude toward science, which could possibly be maintained or built upon by continued interactive use of these content-rich science fiction films. On average, an entertainment video or DVD version of a film costs less to purchase than most standard educational videos, and with proper application and use of content-rich entertainment films, science educators could stretch their budgets (Cavanaugh, Title Word here 68).

Common Fallacies and Errors in Science Fiction Films

Students come to class with many preconceptions and misconceptions about science concepts. One of the sources of these mistaken beliefs is science fiction film. It is important for educators to address these misconceptions so students will not continue to believe them as facts. Educators should be aware that their students might have misconceptions that may be supported by the film they are viewing. Educators need to point out actual errors that occur in the film and provide instruction to help correct the student's misconceptions.

Some of the more common fallacies that occur in science fiction films include traveling faster than the speed of light; instantaneous communication; self-aware, intelligent machines; gigantism; instant mutations; sound traveling in space; and the inaccurate motion of vehicles in space, just to name a few.

Each film lesson within this book contains a partial list of scientific accuracies and inaccuracies from the film.

How to Use Science Fiction in the Classroom

The lessons included in this book are not intended to stand alone as the sole methods of teaching science concepts. The lessons are meant to enhance instruction and seem to work best as introductory, review, or interdisciplinary activities.

When used to introduce a topic, a film lesson serves as a common reference point and shared experience for the class. The film can develop the students' initial interest in a subject that may be unfamiliar. *Destination Moon* can work as an excellent introduction to the study of space travel, for example, because it shows a cartoon and live action sequences, which illustrate the details involved in a moon mission.


As a concluding activity, a film lesson can provide points for discussion, reinforcement of facts learned, and a context for subject matter. Once students have the basics, they can then use the ideas from the films as areas for further research. After students have been taught about the structure of cells, for instance, they will recognize the parts encountered in the giant cell of *The Immunity Syndrome*, and will be proud to point out some cell errors.

Science fiction films can also be used as the basis of an interdisciplinary activity. Students could read a book on which a film is based, or develop their own scripts, contrast societies and customs from the movie to present day, create scale models or story board representations of scenes to learn about film production and special effects, and analyze any mathematical concepts. The film *Forbidden Planet* could easily be developed into an interdisciplinary unit. The film contains a number of math and science references, uses a variety of filming techniques, contains references to Greek mythology, and is based on Shakespeare's play *The Tempest*.

These films can provide an excellent core for the development of a lesson. A less formal use of a science fiction film is to use specific film segments or clips to illustrate a point or as an example of a concept.

The Library Media Center

A school's library media center is an essential resource for teaching students science content and critical film viewing. Library media centers provide access to science information sources including books, periodical, databases, multimedia, electronic information, science fiction media, and science-themed film for use in these lessons. Library media specialists also provide pedagogical guidance in the design of science instruction and the use of media. Library media specialists are educational partners in crafting media rich learning experiences that develop deep conceptual understanding and information skills. This book offers strategies for integrating the Learning and Teaching principles from AASL and AECT's *Information Power* (58), in particular:

- 
- Principle 1: The library media program is essential to learning and teaching and must be fully integrated into the curriculum to promote students' achievement of learning goals.
- Principle 2: The information literacy standards for student learning are integral to the content and objectives of the school's curriculum.
- Principle 3: The library media program models and promotes collaborative planning and curriculum development.
- Principle 4: The library media program models and promotes creative, effective and collaborative teaching.
- Principle 5: Access to the full range of information resources and services through the library media program is fundamental to learning.
- Principle 6: The library media program encourages and engages students in reading, viewing, and listening for understanding and enjoyment.
- Principle 8: The library media program fosters individual and collaborative inquiry.
- Principle 9: The library media program integrates the uses of technology for learning and teaching.

How to Use the Materials in This Book

The science fiction films and television shows used in this book have been grouped into major scientific fields. Each of the fields includes a number of fully developed, self-contained modules relating to science fiction films. Activities and labs are included to guide further study in the field. These labs use common household materials or items that are easily purchased locally. The modules are not intended to be self-contained lessons, but are instead designed to be incorporated into a teacher's own lesson plan. Activities, questions, and projects are adaptable to fit a wide range of grade levels.

At the beginning of each film module is an educator information page that includes the following information:

- Content Areas
- Suggested Grade Levels
- National Science Content Standards
- Synopsis of the Film
- Good Science
- Bad Science
- Library Media Center Extension
- Reading Extension
- Web Resources

Each film module contains questions that students can answer while watching the film. The purpose of these questions is to cause the student to be actively engaged with the film. These guided questions also help the student follow the story and recognize scientific events as well as to develop his/her listening skills. At first students may need assistance in answering the questions during the film; instructors may need to pause or replay segments to ensure student progress. This process of answering the questions while watching the film makes the film segments of the lesson an active event.

Next is a list of scientific vocabulary used in the film. The vocabulary list could be presented before or after the film, in order to focus on scientific or technical terms encountered in the film. To strengthen students' writing skills or to encourage students to write about science an instructor could ask each student to identify three words from the vocabulary list. Each student then writes a complete sentence using one of the identified words related to their observations of that term in the film; repeat this process for the other selected words. After writing the sentences have another student read and critique the sentences for structure, sense, and readability. Have the student select one of the critiqued sentences to use as a topic sentence for a logical paragraph.

Discussion questions encourage further development of the scientific aspects of the film. The discussion questions should act as a pool from which instructors can select the issues to discuss or expand upon. To effectively use the discussions or expansions, instructors should decide which they wish to use and then stop the film after that component was shown and have the students interact.

At the end of each topic area are lab activities that relate to the material presented in the films. While the labs are related to the film contents they are not film dependent. Labs may relate to films in several of the book's topic areas. It is not necessary or required for labs to be used with the films in the same topic area. The lab activities could be used as an introductory activity, during the film, or as follow-up activities. For additional film modules and activities visit: <http://www.drscavanaugh.org>.

Guidelines for Repurposing Films

The goal in repurposing a feature film in a science class is to provide an educational event that is still entertaining. Make sure to judge if the amount of "good" or "bad" science content is appropriate, and also provide direction for application of the film during instruction. The outcome of using a repurposed feature film should be to increase a student's experience with certain concepts of science content or to provide a common background from which students can develop.

Selecting a film

When selecting a film for repurposing, look for a film that includes high numbers of science concepts or a film that has a focus on science content. When picking an

appropriate video, look for a video that contains relevant science for the desired topic. If you are not a fan of science-content-rich or science fiction films, then you should find a film aficionado who can help (there are lots) in locating films that are relevant to the topic. When a list of films has been developed, review the films and determine which film is most appropriate and understandable for the target audience. Also the material in the film should be relevant and applicable to the lesson.

Applications for repurposed film in instruction

Instruction is more student centered when discussions and activities are generated through the use of films. According to instructional design practices, a repurposed high science content film could be useful for providing examples and non-examples of science concepts. When considering the instructional design process, the repurposed film presentation could also be applied to a number of Gagné's Nine Instructional Events (Smith and Ragan 1999):

- Event 1 **Gain attention:** Focus students' attention on the science learning objectives with stories, action, special effects, and presentation of a film.
- Event 3 **Stimulate recall of prerequisite learning:** A film that contains information from a previous class or topic assists students in recall of the previous lesson when watching and discussing that film.
- Event 4 **Present stimulus material:** Use a film to present new science concepts or to provide examples and non-examples of topics or concepts.
- Event 5 **Provide learning guidance:** While watching a film, teach students how to find science in film and learn methods to determine the validity of the science concepts presented.
- Event 6 **Elicit performance:** Make a film the focus of student work and allow students to critique the film for its science content. Or, use the film as a starting point for research.
- Event 9 **Enhance retention and transfer:** Use films to reinforce a new topic. Show a film and discuss the relevancy, validity, or appropriateness of the science presented.

Challenges of repurposing films for instruction

Using a repurposed film for instruction is a time intensive project. Make sure to consider before using a film with a class the time investment that is necessary to find films, to preview them for appropriateness, and to watch them again for lesson development. You must also allot time for materials development. Partnerships between content area teachers and library media specialists make this process more effective and efficient.

Preparing for a repurposed film

Before showing any film to a class, preview the film and review the design of the instruction to make sure that the science content is appropriate and that the method of presentation is appropriate for the viewing audience. When showing the repurposed film, ensure that the experience becomes an active experience through labs, discussion, or some other form of interaction. When you show a film in class allot some time for discussion or for pointing out relevant points during the film. Keep in mind that most films are longer than a class period; even a short film or television episode would most likely take up at least a whole standard class period to show. You might want to show films at special times to allow students to view the film in its entirety; or you may wish to show certain portions of a film during each class and have discussion or some other activity with the film for each day.

Presenting the repurposed film

When using a repurposed film in an active setting, it is important to remember that the film is only one aspect of the presentation. Before watching a film, have students work on material such as vocabulary in the film. This vocabulary activity will assist the students in focusing their attention on some of the concepts that they

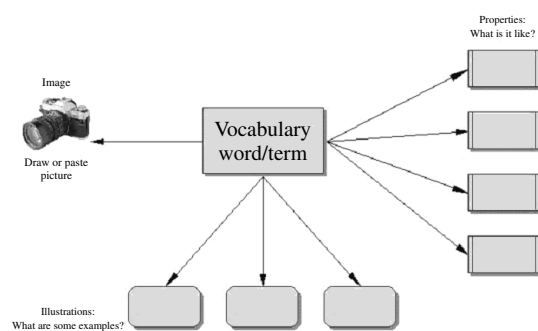


Figure 1.1: Vocabulary Concept Map

will learn. Assign students vocabulary to define and then use a vocabulary concept map (see figure 1.1) during the film to better define their words. Then while watching the film, students can answer questions or, at relevant times, you might stop the film and discuss science concepts. This action allows for a review of the concepts while eliciting student performance in a stimulating situation. While the film has been stopped or after the film

has been shown, give students a hands-on activity. The hands-on activity creates a physical link with the concepts from the repurposed film and enhances the retention and transfer of the science concepts.

How to Get Science Fiction Films

Most of the films included in this book can be purchased for less than \$20.00 as videotapes or DVDs. Look for the films and the Star Trek® TV episodes in your local video stores, music stores, department stores, and discount stores. If the stores do not have the films on hand, it is usually possible to order them from video sellers and renters. DVDs and videotapes are also available from mail order companies

such as Amazon (www.amazon.com).

Standards-Based Teaching

Standards-based teaching is a formalization of good instructional practices. In a handbook published by the Department of Education of the City of New York, the National Center on Education and the Economy (NCEE) reports that a standards-based classroom should exhibit a number of observable traits (sec. 8, p. 3). Some of the traits that are supported by the interactive use of film as a teaching tool include the following:

- Evidence of clear expectations for students in different content areas and rubrics posted in the classroom
- A “print-rich” environment
- Questions to stir thinking
- Dialogue between students and teachers
- A variety of grouping strategies for different purpose standards
- Alignment of expectations, materials, and curriculum
- Engaged students
- Different modes of learning
- Organized to facilitate conversation, activity, research

Educational Technology Standards

The International Society for Technology in Education (ISTE) (2000) developed the National Educational Technology Standards for Students, which include the following six broad technology application areas:

1. Basic operations and concepts.
2. Social, ethical, and human issues.
3. Technology productivity tools.
4. Technology communications tools.
5. Technology research tools.
6. Technology problem-solving and decision-making tools.

Through the use of film students will gain specific skills with technology and media. The application of film in teaching relates to the following specific technology standards:

- Use a variety of media and technology resources for directed and independent learning activities. (K-2)
- Use developmentally appropriate multimedia resources to support learning. (K-2)
- Use technology resources for problem solving, self-directed learning, and extended learning activities. (3-5)

- Evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources. (3-5)
- Apply productivity/multimedia tools and peripherals to support personal productivity, group collaboration, and learning throughout the curriculum. (6-8)
- Research and evaluate the accuracy, relevance, appropriateness, comprehensiveness, and bias of electronic information sources concerning real-world problems. (6-8)

National Science Standards Matrixes

The National Science Teachers Association has developed science content standards that describe what students should know, understand, and be able to do from their science classes (K-12). These standards are divided into the following eight categories:

- Unifying Concepts and Processes in Science
- Science as Inquiry
- Physical Science
- Life Science
- Earth and Space Science
- Science and Technology
- Science in Personal and Social Perspective
- History and Nature of Science

The full text of the National Science Standards is available in multiple digital formats from the National Academy Press at <http://www.nap.edu/catalog/4962.html>. In each of the content standard areas, students should become engaged in activities to help them learn the content knowledge and develop skills. These standards were developed to represent broad areas of content, and each area takes in the knowledge and skills of other standards. Because each content standard subsumes the knowledge and skills of other standards, they are designed to be used as a whole. Although material can be added to the content standards, using only a subset of the standards will leave gaps in the scientific literacy expected of students.

The following matrices were developed to provide a guide for educators to use in their lesson development. The first matrix indicates the national science education standards included by the films, and the next matrix identifies the standards for the included activities.

KEY:

✓ = Suggested Grade Level and Content Emphasis

Content Standards

A = Science as Inquiry

B = Physical Science

C = Life Science

D = Earth and Space Science

E = Science and Technology

F = Science in Personal and Social Perspectives

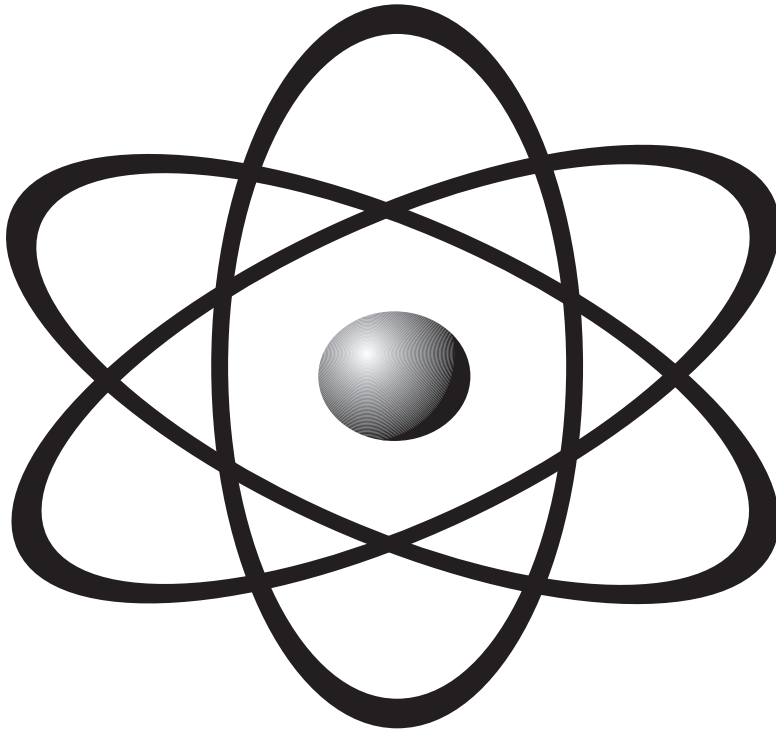
G = History and Nature of Science

Name of Video	Suggested Grade Level			Content Standards						
	K-4	5-8	9-12	A	B	C	D	E	F	G
Andromeda Strain		✓	✓	✓	✓					
Booby Trap (ST)		✓	✓	✓	✓				✓	✓
Dante's Peak		✓	✓				✓			✓
Darkness Falls (X-Files)		✓	✓			✓			✓	
Day of the Triffids		✓	✓			✓				
Day the Earth Stood Still		✓	✓		✓		✓			✓
Destination Moon	✓	✓	✓		✓	✓	✓	✓		✓
Devil in the Dark (ST)		✓	✓		✓	✓			✓	
Fantastic Voyage		✓	✓			✓				✓
Finding Nemo	✓	✓					✓	✓		
Fly Away Home	✓	✓					✓			
Forbidden Planet		✓	✓		✓					✓
Home Soil (STNG)		✓	✓	✓	✓	✓	✓	✓	✓	✓
Immunity Syndrome (ST)		✓	✓			✓			✓	
It Came from Beneath the Sea		✓	✓			✓				✓
Jaws		✓	✓						✓	✓
Journey into Amazing Caves	✓	✓	✓		✓		✓	✓	✓	✓
Journey to the Center of the Earth	✓	✓	✓			✓	✓	✓	✓	✓
Jurassic Park		✓	✓	✓		✓	✓	✓	✓	✓
Operation Anneliese (ST)		✓	✓		✓	✓				
Star Trek IV: The Voyage Home		✓	✓				✓	✓	✓	✓
The Thing		✓	✓			✓	✓			
Them		✓	✓			✓			✓	✓
Trouble with Tribbles (ST)	✓	✓	✓						✓	✓
Twister		✓	✓				✓	✓	✓	✓

Figure 1.2: National Science Standards Matrix for Film

Name of Activity	Suggested Grade Level			Content Standards						
	K-4	5-8	9-12	A	B	C	D	E	F	G
Acceleration Due to Gravity & Reaction Time	✓	✓	✓	✓	✓	✓				
Animal Population Survey: Tag and Recapture	✓	✓	✓				✓			
Growing Triops		✓	✓		✓					✓
Build a Flower		✓	✓			✓				✓
Build an Electric Motor	✓	✓	✓				✓		✓	
Catalyst Enzymes		✓	✓	✓	✓	✓				
Conductivity Tester		✓	✓	✓	✓				✓	
Crystal Growth	✓	✓	✓	✓	✓					
Crystal Systems		✓	✓	✓			✓			
Flower Dissection	✓	✓	✓	✓	✓					
Fossil Formation	✓	✓	✓		✓					
Free Fall and Forces		✓	✓				✓			
Panorama Diorama	✓	✓	✓				✓	✓		
Parallax Viewing		✓	✓			✓	✓	✓		
Personal Radiation Dose		✓	✓			✓	✓	✓		✓
pH & Indicators	✓	✓	✓			✓				
Qualitative Testing of Carbon Dioxide: a Pollutant	✓	✓	✓	✓	✓					
Shark Key		✓	✓							✓
Sizes of the Sun & Moon		✓	✓				✓	✓		
Squid Dissection		✓	✓							✓
Termites Training	✓	✓	✓	✓	✓	✓				
Tornado Bottle	✓	✓	✓	✓	✓					
Severe Weather Observation	✓	✓	✓				✓	✓	✓	✓
Using Fish Anatomy to Determine Habitat	✓	✓	✓	✓	✓					✓

Figure 1.3: National Science Standards for Activities



Human Biology

Lessons:

Fantastic Voyage

Immunity Syndrome

Activity:

Catalyst Enzymes

Fantastic Voyage Educator Information

Content Areas: Human anatomy and physiology

Grade Levels: 5-8, 9-12

National Science Content Standards:

C = Life Science

G = History and Nature of Science

Synopsis: A scientist, dying of a blood clot in the brain, holds the secret to prolonged miniaturization. A crew and submarine are miniaturized to destroy the clot. They travel through several body systems on the mission.

Good Science: An accurate depiction of blood vessels, heart, lungs, and ear. Also factual descriptions of body functions.

Bad Science: Impossibility of shrinking (breaks the law of conservation of mass/energy). Shortage of blood cells in the plasma. Brain was shown to be largely empty with flashes of light depicting the nerve impulses. Antibodies were shown to act much too quickly and with a specific target.