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Chapter 4

BEYOND REASON: SCIENCE IN THE MASS MEDIA

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> ***"We've arranged a global civilization in which most critical elements profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster."***

Carl Sagan, 1996

INTRODUCTION

I am outraged by the pseudoscience, antiscience, and plain lack of common sense that I see on television, read in books, magazines and tabloids, and hear on the radio. All of these distort, confuse, and plain misinform about science, how science is done, and who practices science. Much of the media, especially television, preys on the superstitions and fears of unknowledgeable citizens who live in a civilization acutely dependent on science and on scientific reasoning, simply to sell their products. Americans deserve much, much better! That is what I want to show in this chapter.

As a scientist, I understand the processes of science and its importance to us, as an instructor of some of the best young people at one of the premier universities in the United States, I see the enormity of the job before us, and as a parent, I worry a lot about what it means for America's future, just as Carl Sagan did. One thing is clear to me--we have pathetically little help from the mass media, television in particular. In fact, they work strongly against achieving a scientifically literate people. Why? To make a buck. And they are afraid to lose even a tiny fraction of their audience by moving from the shock 'em, amaze 'em, fool 'em, and scare 'em approaches to one that could be just as interesting based on real science. Tony Tavares, President of Disney's Anaheim Sports, was quoted in Time Magazine (August 4, 1997): "Our main goal is to get people to spend their disposable income with properties associated with the company, whether they're our theme parks, videos, movies or our sports teams. If you've got a dollar, we want it." How very, very sad. Instead, why not: "we'd like to earn your dollar with something worthwhile? Why not truth, honesty and quality, as well as real entertainment, rather than simply more crud to get your last dollar? For the most part, these are Americans doing significant damage to Americans and to our country. It is truly a prescription for disaster! It is not a matter of freedom of speech--it is a matter of responsibility and honor. Television and tabloids, as well as some of the others, have hardly even tried those.

In this chapter, I briefly lay out the immensity of the problem, cite a few examples, and provide some suggestions on what we can do about the mass media and scientific illiteracy. Much more could be, indeed, has been, written about this topic. Where I differ from some others, is that I place significant blame on the mass media. I recognize that the mass media are controlled by people as ignorant of science as Americans in general. Hence, I accept the responsibility, as a scientist, to try to inform people about this problem and to suggest alternatives. I'd even like to work with the mass media. But the mass media are the problem because they don't know enough about science, and so they enthusiastically embrace junk-science because they are unwilling to risk losing their audiences with real science they don't comprehend. Yet they are also the solution, if only they would try! I therefore end with a proposal to the mass media to collaborate on entertaining or newsworthy programming and readings that properly convey science so people gain rather than lose something of value in their daily lives.

What is the problem?

Ninety-five percent of Americans are scientifically illiterate, according to a worried Carl Sagan (1996). That means that about 197 million people (Table 1) in the United States cannot understand how science works, what the process is of evidential reasoning, or whose opinions to trust. Only about 10 million people can; most of these are professional scientists, engineers or technicians. While it is not easy to determine the degree of scientific literacy, the National Science Board's (NSB) survey (1996) of Americans indicated that only 2% understood how scientific theories are developed and tested, and only 23% were minimally able to explain the nature of scientific study. When it comes to scientific facts, Americans are not much better. Some 75% of them fail a rather simple test of eight multiple-choice and two long answer questions (Table 2; National Science Board, 1996a). This is just not good enough (Ehrlich and Ehrlich, 1996; Lederman, 1996; Sagan, 1996).

TABLE 1. Number of Americans (in millions) over the age of 16 who will be scientifically illiterate and literate based on an population projections for July 1 of the year indicated (US. Census Bureau, 1997) and an estimated present rate of illiteracy of 95% extended to the year 2020. Illiteracy rates have been estimated to lie between 93 and 97% depending on how illiteracy is measured, hence these numbers are very approximate

Year and Total US Population	*Scientifically Illiterate (95%) over age 16*	*Scientifically Literate (5%) over age 16*
1998: 270+ million	197+ million	10+ million
2000: 274.6 million	201+ million	10.5+ million
2010: 297.7 million	222+ million	11.6+ million
2020: 322.7 million	240+ million	12.6+ million

TABLE 2. What do we know? Results of the National Science Board's (1996) survey of American's grasp of science. The survey (2006 adults selected randomly) included 10 questions about science facts. Three-quarters of Americans could not pass the quiz. The first 8 questions were multiple choice and the last two were simple word answers. The statements here have been reworded for this table.

Statement or question	*Percentage of Americans agreeing with the statement or who could provide the correct answer*
The center of the earth is very hot	78%
Radioactivity is both man made and natural	28%
The oxygen we breath comes from plants	85%
The earth goes around the sun once a year	47%
The universe began with a huge explosion	35%
Humans developed from an earlier species of animal	44%
Cigarette smoking causes cancer	91%
Humans did not live with dinosaurs	52%
Antibiotics kill bacteria but not viruses	60%
What is DNA?	21% gave a reasonable explanation
What is a molecule?	9% gave a reasonable explanation

Scientific illiteracy contributes to an antiscience mentality that threatens our very existence (Ehrlich and Ehrlich, 1996). This "prescription for disaster" may well have everlasting consequences for our country. Science is ubiquitous in America, and many of our decisions, nationally and personally, depend on an understanding of it. We, as a nation, cannot tolerate widespread scientific illiteracy.

So, what are we doing about it? The NSB (1996b) recommended "The Nation must put absolute priority on educating and training all members of society in mathematics, science, and engineering so they may be productively employed in an increasingly sophisticated global economy. This educational process is a lifelong endeavor . . . . ". Indeed, the President and Vice President of the United States, the National Science Foundation, the National Academy of Sciences, the National Science Teachers Association, and a multitude of other people, organizations, scientific societies, and institutions work hard to improve science education. And we are making some progress in our schools because of these programs. This work pays off too, for the NSB report shows that the more education a person has, the better that person understands science. However, that very progress in the general non-scientific public is soon diluted or erased by that other most ubiquitous element of America, the mass media, television in particular.

Scientific illiteracy is not confined to America, of course--it is a world-wide problem. While some countries may do a little better than the US, most others accomplish much less in the way of science education. The data are not available for world-wide scientific illiteracy, but if the American rate of about 95% is taken as a minimum for the rest of the world, then we have billions of people (Table 3) unable to understand a large portion of what effects them. If science is important to America, it is just as important, if not more so, to much of the rest of the world. Population growth, environmental deterioration, biodiversity decline, greenhouse effects, health problems, food and air quality, natural hazards, and a multitude of other scientific problems face these countries in larger measure than in the United States. The consequences for them are significantly greater than for America. The use of pesticides, toxic chemicals, tobacco, and false health remedies are foisted on the rest of the world in larger amounts than in the U. S. because of less stringent rules and regulations and understanding by their populaces. With a knowledgeable population, countries around the world could more effectively deal with these problems. Many of the problems naturally cross political boundaries, and so, threaten even countries with some scientific literacy, if not the entire world.

TABLE 3. Number of people (in millions) over the age of 15 in the world who will be scientifically illiterate or literate based on population projections for mid-years as shown (McDevitt, 1996) and assuming an illiteracy rate identical to that estimated for the United States. This percentage is undoubtedly too low and may increase through time because the increasing populations of most countries will tax their educational systems even more than they are now.

Year and Total World Population	*Scientifically Illiterate (95%) over age 15*	*Scientifically Literate (5%) over age 15*
1998: 5771 million	3700+ million	199+ million
2000: 6090 million	4000+ million	213+ million
2010: 6861 million	4700+ million	250+ million
2020: 7599 million	5400+ million	285+ million

Are 10+ million people enough to safeguard the other 270 million inhabitants of the United States and less than 199 million enough to assist the other 5771 million world-wide to deal with their scientific problems? This seems improbable, however, for people are faced with individual scientific decisions almost daily, many must vote or otherwise decide about scientific matters affecting their country or region, they must choose people to represent them who should also be able to understand the scientific problems, and they seek satisfying employment that is increasingly dependent on a basic scientific knowledge. The answer then is surely that most people, most everywhere, should be able to understand the basics of the scientific process.

WHAT DO WE KNOW ABOUT SCIENCE?

What is Science?

A fundamental misunderstanding everywhere in the world is that material in the mass media presented in a scientific manner is real science. Unfortunately, it seldom is. It is largely pseudoscience, antiscience, superstition, and dogma (Table 4). This deluge contributes hugely to scientific illiteracy by confusing fact with fiction, scientific theory with belief, and scientists with non-scientists. Why people are fascinated with and will pay good money for pseudoscientific or antiscientific claims is a deep problem, but it involves poor education, personal and mass delusion, indoctrination, hopelessness, fear of other people, apprehension about the world around them, dread of the unfamiliar, and a multitude of others (Eve and Harrold, 1991; Miller, 1987; Shermer, 1997). The answer here is education by all means possible--schools, individuals, political bodies, corporations, and the mass media, especially television.

TABLE 4. Pseudoscience in America overwhelms and is increasing as the new millennium approaches.

Pseudoscience	*Reason for Rejection*
Astrology	Ancient pagan beliefs
Crystal worship	No evidence; beliefs
Creationism	Beliefs
Numerology	Failed tests
Phrenology	Insufficient evidence; failed tests
Psychic Healing	Insufficient evidence
Psychic Prediction	Disproved by failure to perform
UFO-ology	Insufficient evidence

Pseudoscience, antiscience and weird beliefs are all around us--in movies, books, TV, radio, newspapers, street corners, pulpits, meetings, school boards, political bodies, and even universities and colleges--and real science is obscure by comparison (the Martian Pathfinder landing on Mars in 1997 is a nice exception). Antiscience simply ignores scientific reasoning altogether in making its claims. Pseudoscience makes claims that claim to be and sound scientific but that are based on selected or inadequate evidence, false authority, unsupported beliefs, and it disallows proper tests of the claims. The results can be often humorous and entertaining, but sometimes tragic and costly. For example, billions of dollars are spent each year by Americans on pseudoscientific solutions to health problems alone.

Science, on the other hand, uses logic, critical thinking, appropriate evidence, subjects all authority to scrutiny, and allows testing of its claims. Most anybody can learn these basic ways of science. While scientists tout the "scientific method" as the way we do science, it is mostly a reordering of the actual activities that scientists go through so it makes sense. Unfortunately, the scientific method is taught as the way science is done and it appears dull and agonizing. This formalization of the scientific thinking process makes people fear science. Few scientists actually work that way. Instead, they get excited, hopeful, interested, intrigued, and puzzled. Their ideas come to them in the shower, on the freeway, while playing baseball with their kids, as well as in the laboratory or library. Science is creative and exciting. It certainly can be just as fun and entertaining as pseudoscience. In most cases, it is more so. And it provides a challenge and reward to get it right. You do not need to formalize your thinking in this way to understand how science is done or to practice it on a personal basis.

The extraterrestrial Unidentified Flying Object (UFO) phenomenon is a good example of a clash between pseudoscience and science. A large segment of the scientific community readily accepts a high probability of extraterrestrial life (including intelligent life) somewhere in the Universe, but few scientists accept UFOs. The photographs, unsupported personal accounts, and evidence more logically explained by known earthly phenomena are woefully inadequate to support such a significant claim as spaceships with aliens from another place in the Universe visiting Earth. This is a serious claim that would have enormous impact on our lives and our civilization, if true. No one has ever produced any evidence to unequivocally support the claims. Claimants, of course, have explanations to account for such inadequacies: the government is covering up evidence, alien bodies in particular; the scientific community is conspiring to suppress the facts; scientists are biased; or the extraterrestrials have modified the minds of people who have encountered or been abducted by the aliens so they cannot remember everything (Corso, 1997; Fawcett and Greenwood, 1992; Marrs, 1997). There is always some reason that the scientific community and disbelievers cannot be trusted, no matter what the pseudoscientific or antiscientific claim is. It is such a common explanation that it is a sure index that the claim is pseudoscientific.

The UFO beliefs, as with other ones, run deep, too (Shermer, 1997). The World Wide Web is full of sites promoting them, innumerable books are published, meetings are held, 10's of thousands of people attend celebrations about them, and a good deal of money is spent by adherents on UFO books, trinkets, shirts, etc. Take a look at the UFO books in your local bookstore--there are hundreds of them promoting claims that cannot be supported by any substantial evidence, but instead assert that there is a cover-up of some sort.

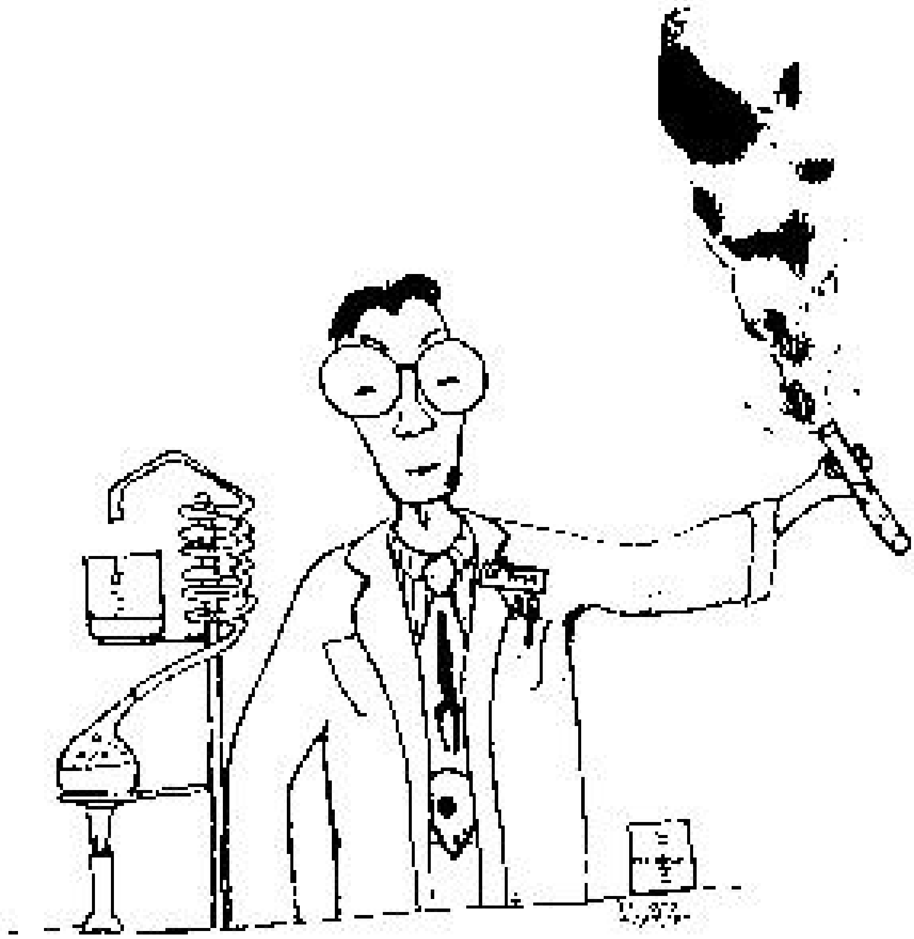
Once in a while such claims lead to tragedy. For example, thirty-nine people of the Heaven's Gate cult believed that they would join a spaceship following Comet Hale-Bopp (no evidence whatsoever of anything following the comet, other than its tail), if they all committed suicide. They did just that in 1997. It is sad that so many people could be so deceived, but these beliefs were reinforced by far too many television programs, articles in tabloids, and books all touting the same pseudoscientific views of UFO visits and crashes, alien autopsies, abductions by aliens, and sexual experimentation on humans by aliens. Credence was lent to these UFO stories by a wholly unexpected source--the insurance industry. The London firm of Goodfellow Rebecca Ingrams Pearson Insurance Co. offered policies covering abduction, impregnation, and death caused by aliens (Underwriter's Report, April 10, 1997). Several hundred people actually bought this coverage, among them the Heaven's Gate cult which paid $1,000 to cover 50 members. Now, at least one California lawyer thinks the cult has a claim--after all, he notes, who can prove the members were not abducted. The cult would be entitled to $39 million. The insurance company no longer issues coverage against aliens because "We don't want to contribute to a repetition of the Heaven's Gate deaths" (Underwriter's Report, April 10, 1997).

Even the State of Nevada has jumped onto the claims of UFO aficionados. Nevada named the Extraterrestrial Highway (and erected signs showing aliens and UFOs) for a desolate 98-mile stretch of Highway 375, largely in response to the many so-called sightings of UFOs there (Wheeler, 1996). The highway passes near a classified US Airbase, which, the UFO'ers claim, conveniently covers up the UFO activity. They say alien bodies are actually kept there. Highway 375 is now heavily promoted by the Nevada Commission on Tourism with advertisements like the one that appeared in Sunset Magazine in September 1996. Funnily, the ET Highway actually passes through rocks of Devonian age that are now thought, based on good scientific evidence, to have been formed by an extraterrestrial impact around 360 million years ago (Warme and Sandberg, 1996; Leroux, Warme and Doukhan, 1995). Thus, there may be some truth to the highway's name, after all!

Science sometimes can be frightening and remote. It commonly deals with esoteric and difficult subjects, and many of it's more obvious technical manifestations have caused the world significant problems. It's best known practitioner, Einstein, is regarded as a genius who had knowledge unattainable by the average person. Many scientists, when speaking or writing publicly, use technical jargon that alienates, graphs and charts that are confusing at best, and illustrations unrecognizable to the public. We scientists tend to criticize, even penalize, those among us who do try to make science understandable to the public at large. No wonder that the mass media portrays scientists as weirdoes, nerds, crazies, or evil-doers (Figure 1).

Yet, in spite of the public image of scientists and widespread scientific illiteracy, 40% of Americans have a high interest in science discoveries and 70% in new medical findings (National Science Board, 1996). Interest in things scientific is fairly large and provides potential for increasing literacy, if the proper means are provided.

Figure 1. Scientists are commonly regarded as nerds, weirdoes, or evil-doers by the general public. Actually, they are ordinary people with ordinary concerns, emotions, and fears, who have learned to use their critical skills and evidential reasoning to understand their surroundings. They usually love doing their jobs, and in this way, they may differ from many other people. (Cartoon by Jeremy C. Lipps)



Scientific Literacy

Scientific literacy can be defined in several ways. One way includes the following elements: 1. the ability to think critically; 2. the ability to use evidential reasoning to draw conclusions; and 3. the ability to evaluate scientific authority. It does not necessarily mean the accumulation of scientific facts, although a certain basic factual knowledge seems imperative.

Critical thinking can be learned by most anyone. Although it is important in scientific reasoning, it is even more important in our daily lives, for a clear understanding of our surroundings and problems makes life enjoyable and safer. All people make assumptions, all hold biases based on previous experience, and all have emotions. These interfere with our interpretations of the world around us and how we solve our problems. They must be set aside in order to evaluate information and problems. As a matter of self-defense against those who would victimize us with hoaxes, frauds, flaky schemes, or do us physical harm, critical thinking is essential.

Critical thinking involves 8 skills (Table 5) that help people get closer to a rational evaluation. These promote clear and creative thinking that commonly simplifies the solution to our daily and larger problems. Perhaps the most important one is to start by asking questions. Make them good, relevant questions that are testable by evidence, not explained away by assumptions, biases, and emotions. Think of other possibilities, and accept the fact that not everything you would like to know can be attained or will remain constant through time. Uncertainty and change are certain!

TABLE 5. Skills for critical thinking (from Wade and Travis, 1990). These can be acquired readily by most people.

Skills	*Simple Techniques*
1. Ask questions: be willing to wonder	Start by asking "Why?"
2. Define the problem	Restate the issue several different ways so it is clear.
3. Examine the evidence	Ask what evidence supports or refutes the claim. Is it reliable?
4. Analyze assumptions and biases	List the evidence on which each part of the argument based. The assumptions and biases will be unsupported.
5. Avoid emotional reasoning	Identify emotional influence and "gut feelings" in the arguments, and exclude them.
6. Don't oversimplify	Do not allow generalization from too little evidence.
7. Consider other interpretations	Make sure alternate views are included in the discussion.
8. Tolerate uncertainty	Be ready to accept tentative answers when evidence is incomplete, and new answers when further evidence warrants them.

Evidential reasoning can also be learned. It involves six rules (Table 6) with which to examine any claim. I consider these rules to be the basis not only of the way scientists work, but also as a guide to intelligent living. Is the evidence presented to you sufficient to support the claim? Can you think of other evidence that would disprove the claim? These require critical skills to evaluate whether or not enough evidence has been presented and whether or not other evidence might be discovered, if other avenues of investigation were employed. Are you being honest about the evidence yourself or are you deceiving yourself? Has the claimant repeated the observations and gotten the same result each time? Has the claimant put the evidence together in a logical way? Logic is often presented in formal and formidable ways, but it is not really so difficult (Perkins, 1995). It requires critical and clear thinking, to be sure. Extraordinary claims require that the claimant present very strong or abundant evidence to support them. Simple photographs or marks on the soil are insufficient to support claims of extraterrestrial visitors. Such a claim probably requires evidence of the aliens themselves--a live specimen, a body, an appendage, or DNA test of tissue samples--and the evidence must be available to scientists for further testing. Anything less can be explained by too many other alternatives (mistaken identity, delusions of the observer, hoaxes, etc.). Lastly, do not accept authority or testimonials alone as support for claims. Anyone can say anything. You need evidence.

TABLE 6. Rules for evidential reasoning (from Lett, 1990): A guide to intelligent living and the scientific method. All claims should be subjected to these rules.

Falsifiability	Conceive of all evidence that would prove the claim false
Logic	Argument must be sound
Comprehensiveness	Must use all the available evidence
Honesty	Evaluate evidence without self-deception
Replicability	Evidence must be repeatable
Sufficiency	1. Burden of proof rests on the claimant. 2. Extraordinary claims require extraordinary evidence. 3. Authority and/or testimony is always inadequate

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The evaluation of scientific authority is dependent initially on critical thinking and evidential reasoning too. Apply these first to see if the authority's claims stand the test. Does the authority use critical thinking and evidential reasoning her- or himself? Does the so-called authority present the arguments without undue call on unsupported claims? Be skeptical. All claims should be evaluated by considering whether or not the evidence presented is sufficiently robust to support the claim. A fuzzy photograph of a shiny disc in the sky is not sufficient to support the claim of extraterrestrial alien spaceships, for example. Does the authority have standard credentials or not? Most true authorities in science have positions that allow them to practice science actively, usually in an institute, corporation, university, or government agency engaged in science. False authorities often lack such an affiliation, and claim to be authorities by virtue of false degrees, degrees from obscure colleges or universities, authorship of so-called "authoritative books", or affiliation with a scientific-sounding organization. Some simply proclaim themselves authorities based on their experience and self-attained knowledge. While this is certainly possible, it is rare. Importantly, has the authority allowed his or her claims to be subjected to scrutiny by the rest of the scientific community by publishing results and hypotheses in recognized scientific journals? Most false authorities will claim that the "scientific community" has suppressed their work and they cannot get it published. In fact, they never even submit their work to recognized peer-reviewed scientific journals (Scott and Cole, 1985).

SCIENCE IN THE MASS MEDIA?

The mass media has a good deal of trouble with science, yet its influence is enormous. The mass media assail us daily with both good and bad information. How do they do with science? In general, those responsible in the media are as uninformed about science and its processes as the general public. Indeed, newspaper editors in general, have the same understanding of science processes and topics (like humans lived with dinosaurs) as that of the public at large. Screen writers, although they would like to do intelligent stories about science, simply do not have the basic knowledge to do so (Steve Allen, personal communication, 1997). As a result, the mass media serve science very poorly.

The influence of the mass media varies from medium to medium and the public's view of each. I know of no evaluation and comparison of all the media. So I give my own impression of each in Table 7. Here I separate the mass media into two categories: Active and Passive Mass Media.

TABLE 7. Inferred relative influence on the general public and the scientific content of the various media.

Medium	*Influence*	*Science*
Television	++++++	-----+
Newspapers	++++	--++
Tabloids	+++	-----
Movies	++	----+
Magazines		
Internet	++	-+
Radio	++	---+
Books	+	--++

The Active Mass Media require considerable effort on the public's part in order to absorb their message, whatever it is. A person must make a positive decision to engage the medium and must actively participate throughout the encounter. The Passive Mass Media require only a minimum of decision-making, and the reception of the ideas is entirely passive. Little is required of the recipient. Books, newspapers, magazines, tabloids, and the Internet are active mass media; whereas television, radio and the movies are passive. Of course, gradations exist in these categories because some people select books or magazines without much thought and flip pages, and some people are very choosy about television programming they view.

Active Mass Media

Americans read a great deal each year. However, they select these books, magazines, newspapers, tabloids, and Internet sites, or articles in them, based on their own interests. Thus, people who like romance stories or paranormal books are unlikely to read books and articles about science, if they also don't like that. Pseudoscientific books and magazines far outnumber science books in all bookstores I have visited (well over

100 in several cities), suggesting a much larger audience. Indeed, some bookstores are dedicated solely to the paranormal.

The most popular magazines seldom present science at all, although pseudoscience appears regularly in many of them. *Time* , *U. S. News and World Report,* and *Newsweek* regularly include science stories, although they also regularly report on pseudoscientific topics without enough critical comment. All in all, millions of people take these kinds of magazines, but even so, other media are far more influential because they reach even more people more easily.

Newspapers, in general, seem to do a reasonable job of science reporting, especially when the writers are trained in science or are dedicated only to science writing. General reporters do not seem to be any better with science than the general public. They ask inappropriate questions, probe for "newsworthy" stories that may not exist, and may well badly distort scientific stories.

The grocery store check-out stand tabloids clearly aim to do one thing--make a lot of money for their publishers. They sensationalize everything, including what little science appears in their pages. Science may be degraded or uplifted, depending on the slant the publishers think will sell. While many people believe these papers are simply entertaining, some of the tabloids have begun rather successful investigative reporting about particularly sensational events, even beating regular newspapers with exclusive stories. These successes increase the apparent veracity of the other stories enormously.

Use of the Internet via the World Wide Web to access information is highly selective. Millions of sites now exist on the WWW, but few of these are accessed by many people. Our own Museum of Paleontology site (http://www.ucmp.berkeley.edu), one of the first on the Web and containing 3000 pages of paleontology, is now accessed about 2 million times a month. This represents far fewer users, as many of them make multiple hits. Even so, it is a paltry number compared to some non-science sites on the Web. Most other scientific sites have even fewer hits.

More importantly, anyone can establish a site on the WWW, and so paranormal sites abound. Although 50 or more million people use the Web, these people are influenced only by sites they choose to access, which are again largely those that match their existing interests. In fact, since much use of the Internet depends on searches made by key words, the selectivity may be even more specific than in newspapers or magazines. I think it unlikely that the Web will increase scientific literacy simply because the Web is cluttered with so many sites, individuals will continue to choose sites that interest them, and the paranormal is better represented than science.

Certainly exceptions exist. Martian Pathfinder World Wide Web Internet sites have exceeded 550 million hits in the first few weeks after the landing on Mars on July 4, 1997. This represents an unusually large number of people. Likewise, National Geographic Magazine , with a circulation of over 15 million, includes many scientific articles, Discover Magazine deals with science and debunks pseudoscience, and even the major news magazines occasionally have excellent science articles. Carl Sagan's book Cosmos was bought widely, chiefly because it supported his very popular television program. His other books have sold well too, based on the public's awareness of him as a television personality and award-winning author. Other authors who promote antiscientific or pseudoscientific views have equally large or larger readership and there are many more books, magazines, and articles devoted to these views. Rush Limbaugh, for example, has sold over 7 million copies of his books (1992, 1993), which have remained on the New York Times Best Seller List for many weeks, in spite of an abundance of antiscientific and pseudoscientific errors and incorrect logic (Perkins, 1995).

In general, these active media reinforce already established interests and knowledge, and do not attract new readers. Compared to the passive media, these numbers are very low. Hence they have little influence in changing the general awareness of science in the public.

Passive Mass Media

Television, movies and radio provide very little good understanding of science. Modern radio is mostly music and talk shows, few of which practice critical thinking and evidential reasoning. In fact, a number of talk shows, like the Rush Limbaugh Show, actually put science down all the time. Limbaugh's listeners number over 20 million. This is significant. Other talk show hosts, like Dr. Dean Edell, have large numbers too, and he debunks pseudoscience and antiscience all the time and most effectively.

Movies deal with many scientific topics, from dinosaurs to aliens. These kinds of movies, in general, seem not to be detrimental to scientific understanding because few people go to movies to learn anything; they go to be entertained. Yet, even here, movies have influence. They give an impression of what scientists do (crazy stuff usually), who scientists are (flakes and bad guys), and little indication of the scientific process. They may reinforce pseudoscientific themes. I took my son to see Independence Day, the fantasy film about a massive alien invasion. When the alleged Roswell UFO crash and supposed capture of aliens was mentioned, a woman behind me excitedly told her three children, "That's true! I saw it on television!!"

Television has little to be proud of when it comes to science. TV reaches so many homes and is so easily absorbed passively, that it is very, very influential. Most children and adults uncritically watch many hours of television weekly. The average kid in America now spends more time watching TV than he or she does in school! For these reasons it is particularly unfortunate that science is so poorly presented. People learn a good deal from television; their views and behavior are commonly shaped by what they see. Television executives have told us that their programs do not influence people, yet they turn around and sell billions of dollars worth of advertising based on just the opposite claim. It can't be both ways

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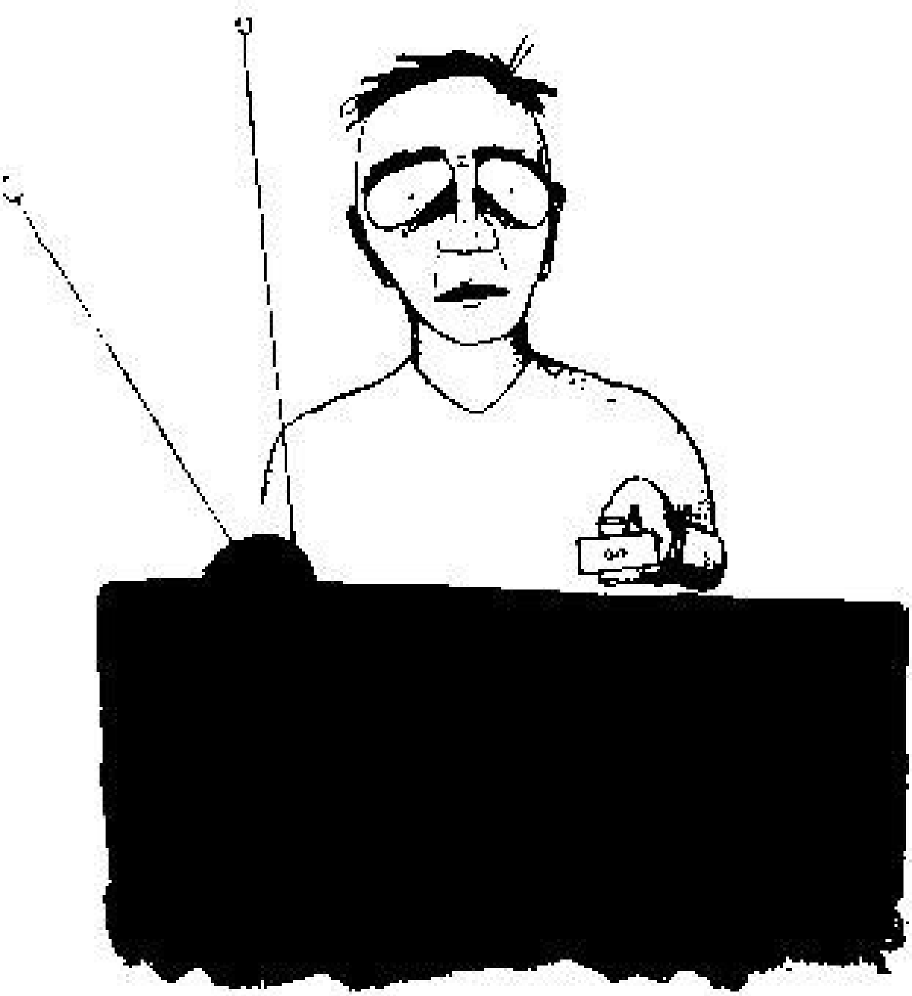
Figure 2. Television is mesmerizing, passive and highly influential. (Cartoon by Jeremy C. Lipps).



Television distorts and misinforms by mixing programming. Entertainment programs look like news programs and news programs look like entertainment. Documentaries are designed to be entertaining, not necessarily factual. People cannot easily distinguish between reality and fantasy any more on TV.

Sometimes television promotes a whole series of such pseudoscientific programs. For example, the week of March 24, 1997, was declared "Alien Invasion Week" on the Learning Channel (an odd juxtaposition of terms!). During this week, pseudoscientific programs were shown each night concerning UFOs, alien abductions, alien autopsies, and similar topics. While most programs included a sprinkling of terms like "might have been", "could have been", "alleged", these terms were surrounded with images of flying saucers, big-eyed aliens, and impressive sounding people all accompanied by dramatic music. In a few cases, a skeptic or scientist waxed forth on why these things were unacceptable, but the music, images, and general tenor of the segment changed from the dramatic ones used when UFO phenomena were shown. While UFOs may well exist somewhere, lights in the sky, Biblical tales, fuzzy recollections of years ago, blurry photos, and outright fakes are hardly the kind of evidence that such claims require. This is not learning in any sense of the word, but rather indoctrination. Such programs have enormous influence because they reach millions of people and many people believe, in the absence of other sources of information, that television tells the truth.

Most American viewers cannot remember the efforts of those good people and organizations who tried to teach them how to reason and think scientifically while in school. They are faced with the trash-science of TV continuously. They often accept it uncritically, unthinkingly, and without recourse to their memories of what science is. These programs degrade what was learned in the past and contribute to scientific illiteracy. This is more than a prescription for disaster, it is a great waste of time, effort and money, and an opportunity for international and local charlatans to foist who-knows-what on the American politic and public. It is truly "the dumbing of America".

Of course, it does not end there. Each program is shown on television channels in other countries. In Australia, for example, many programs are seen soon after they appear on American screens. And so it goes around the world. It is, indeed, "the dumbing of the World". While that may be of some consolation in terms of competition in the world, dominated by science today, other societies try very hard to ensure a scientifically useful, if not completely literate, citizenry. In fact, American megalithic companies now move offshore not to pay lower wages alone, but also to find a workforce sufficiently smart in science and technology to be useful. California already faces the loss of high-technology companies because the workforce cannot understand simple scientific and technological concepts necessary to understand their work (Oakland Tribune, 1996).

There are good science programs presented in the passive media once in a while. National Geographic Specials, Nova, and similar TV programming are good examples. The Jacques Cousteau programs were good examples of how science was done. Usually, a problem was identified, an hypothesis proposed, and then his divers went out to solve the problem. The programs were a bit dramatic and took poetic license at times, but they were widely viewed around the world. Other programs, shown especially on PBS or other "educational channels", often thought to represent science fairly fail to provide an antidote to the TV trash science. They are merely films of scientific subjects, most commonly animals and plants, with a monotonous voice-over describing the scenes. Rarely, is the scientific process part of the program. The thrill of discovery, the sorting of hypotheses, evidential reasoning and critical thinking--none of these are seen on television.

This cannot be acceptable in America today. Science must become as familiar on television to Americans of all kinds, as the sex and violence that is learned in great detail from TV. If Americans can learn about these things from television, they also can learn about the workings of science, if only television will take some responsibility and show real science in their programming. What does this mean? Understanding science is not so difficult, the process and activities of science and scientists are often dramatic and hilarious, and, since scientists are people, they get themselves into the same situations that most people do; in other words, this is the fodder of TV programs, as we know them anyway. Leon Lederman has taken the first step to produce a dramatic, prime time TV program (Hirshon and Lederman, 1996). Science as we do it must be incorporated into regular prime time programs, including situation comedies.

WHAT CAN WE DO ABOUT SCIENTIFIC ILLITERACY?

As scientists, educators and parents, we can do lots of things. Our chief targets should be fair representation of the process of science in the mass media, especially television. We need some creative thinking in ways to do it, and some energy. We need to present our criticisms constructively and in a way that will not threaten the monetary bottom line of the mass media corporations. Tell them that real science sells well, that it is dramatic, funny and tragic, and therefore it is the material that makes for well-received programming in prime time, and that it makes excellent reading. We have much hope, indeed, quite a future in correcting illiteracy in science, if we so chose. We have much good material in science. If the media can so effectively peddle trash science, it can promote good science just as easily (Figure 3).

Figure 3. The solution is not to destroy or ignore the mass media, but to use it to enhance scientific literacy.

Here I give you a few of my ideas for scientists, but anyone concerned with scientific literacy and the future of our country and world can contribute to the solution. You only need to think critically, evidentially, and creatively, and you will think of more based on your own experiences and situation. Then put your ideas into action!

1. Join the battle, in spirit if not in action. Scientists commonly put down other scientists who deal with the public. Those who go public may fail to get promotions, fail to get awards, fail to gain entrance to prestigious organizations, and fail to get grants. Since most science in America and elsewhere is supported by taxpayers, this behavior seems eventually to be self-defeating. Instead of derogatory statements and actions, scientists should heap praise and support on scientists who are willing to do something. Not every scientist needs to do anything, but some must.

2. Scientists should give stimulating and exciting public lectures, especially to children's groups. Many scientists are glad to do this, and it helps.

3. Scientists should connect with journalists. An easy way to do this is to rely on public relations officers that so many universities and scientific institutions employ. News organizations will almost always work on and publish stories coming from such sources.

4. Scientists must work with television writers and producers to get good, exciting science on television and in the movies. Many of these people have no one to talk to, and they embrace pseudoscience for lack of knowledge. Scientists need to work with the television industry and not simply criticize from the outside (as I have done in this chapter!).

5. Write good science for TV, movies, magazines, and newspapers. Television may be a difficult market to break into, but many newspapers will gladly publish a column or story from a scientist because it looks good, fills the newspaper, and costs them little.

6. . Tell your local TV, movie, book, or radio reviewer what is bad. Let them know what is real science and what is pseudoscience in programs, films, books, etc. These reviewers need story ideas too. And it will help.

7. Ask the TV Academy of Arts and Sciences to institute a "best science" category in the Emmy Awards. After all, lighting and a number of different kinds of music each have an award category. Why not just one for science?

8. Issue statements about bad science and pseudoscience to the media. The Committee for the Scientific Investigation of Claims of the Paranormal has formed a Council for Media Integrity. The Council has held press conferences, and issued awards. It has given its "Candle in the Dark" Award (after Carl Sagan's 1996 book subtitle) for excellence in television science this year to Bill Nye the Science Guy, a program aimed at youngsters. It also gave its "Snuffed Candle in the Dark" Award for the worst science portrayal to Dan Aykroyd for his production of the seemingly truthful, but really super-pseudoscientific, program "Psi Factor" (http://www.psifactor.com/).

9. Use money. The Council for Media Integrity is now asking for donations to buy stock in television companies. Even one share provides the holder with influence with the company.

10. Write letters and commentary on pseudoscientific programs, events, books and articles.

11. Lastly, we must keep supporting science education. We must insist the local, state and federal governments continue to fund science education fully. Some school boards take a definite antiscience approach and even forbid teaching of valid science. These must be watched and countered carefully. Teacher training programs in colleges and universities must include real science, and scientific societies and organizations must provide programs for them as well, as many of them already do.

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