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THE COMMUNICATION OF SCIENCE TO THE PUBLIC: A PHILOSOPHY OF TELEVISION

DISSESSATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of the Ohio State University

by

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INTRODUCTION

The code word for criticism of science and scientists these days is 'hubris'. Once you've said that word, you've said it all; it sums up, in a word, all of today's apprehensions and misgivings in the public mind - not just about what is perceived as the insufferable attitude of scientists themselves but, enclosed in the same word, what science and technology are perceived to be doing to make this century, this nearing to its ending, turn out so wrong.

- Lewis Thomas “The Hazards of Science”

You can't learn a science unless you know what it's all about.
- Aldous Huxley  Brave New World

There's always a prevailing mystique in any civilization.... It builds itself as a barrier against change, and that always leaves future generations unprepared for the universe’s treachery. All mystiques are the same in building these barriers - the religious mystique, the hero-leader mystique, the messiah mystique, the mystique of science/technology, and the mystique of nature itself.

- Frank Herbert  Children of Dune

Up until around two hundred or so years ago, science was an intellectual pursuit of common men - the art of curiosity practiced by a motley collection of gardeners, shipbuilders, inventors, and quite often, clergymen and aristocrats. Our knowledge of the world was limited and this was even more true with respect to scientific knowledge. Most individuals pursued science in their spare time, a hobby for those who wished to use their minds and investigate the world around them. Scientific research as it was known, was not the same study of the “hard sciences” we practice today, but rather of a more general character - studies like
stargazing, alchemy, and natural history. Every person saw themselves capable of understanding the basics of science. Anyone was fully capable of looking up at the stars or down at the insects scurrying underfoot. Scientists were simply those who looked a little closer, and in most cases, a little longer.

By the turn of the nineteenth century, the dam holding back scientific knowledge broke and a technological revolution swept the globe. Our knowledge of the workings of the world increased exponentially. A person could now scratch a living from the discipline of science and the system incorporated a new branch of beings - ones we called “scientists”. The society of science was born. The vast wealth of knowledge was so overpowering that it became necessary to specialize. In order to contribute something worthwhile to the existing pool of knowledge, one had to know the “business”. Gone were the days of scientific pastimes; it had become a realm far out of reach of the common man. The gap between science and the rest of society began to grow, and has increased ever since.

Nowadays, science is replete with concepts like recombinant DNA, synthetic polymers, and subatomic particles. It is little wonder that the average person views it as an intrinsically complex and ineffable enterprise. The “hubris” that Lewis Thomas speaks of is simply a result of that all-too-common viewpoint. The driving force behind this attitude is the simple fact that science is the basis for all technology. In the mind’s eye, scientists are hiding behind their curtain of complexity and technology, without society’s knowledge and control, eventually leading society to the Brave New World of Huxley. The public’s image of science in the past two hundred years has been generated from the products of science, rather than the process of science.
There are two ways to alleviate this gap between the communities of scientists and non-scientists. One is to stop the process of progress entirely (in particular, scientific and technological progress). An unfamiliar force, when kept from the outside world, can do little damage (but also, consequently, little benefit). The other way is to bring the uninformed populace into the system - admittedly, a much more difficult and monumental task. Faced with this choice, this study has followed the latter. Granted, my opinion and the pursuit of this goal are certainly biased and also, in my own self-interest -- but I think it is the only one. Even though the ultimate moral obligations may side with the continuing pursuit of knowledge, the point is already moot. Technological inertia has decided the issue for us. With the recent technological developments in biology and environmental control, the actions of today (and yesterday) have long-reaching effects far into the future. With this realization comes the conclusion that scientific literacy may soon become the single-most important issue facing our nation, and quite possibly, our world.

With this in mind, we must look to the avenues of educating an uncultivated and most likely, inattentive public in ways that reach the largest number of people and in the least restrictive manners. Many people may argue with the efficacy of this approach but in order to avoid the impending division between the scientific “haves” and “have-nots”, a distinction noted by Leah Lievrouw (1990) as scientific elitism, the disinterested public must be made aware of the issues. Principles of a democratic society often revolve around an informed and educated populace and, as some claim, until this ideal is met we will never fully achieve our political and social goals of a true democracy. Ironically, as we near the beginning of the twenty-first century, it is technology
itself that is providing the means to disseminate the vast wealth of required information so important to understanding the current status of science and technology. Television, the once idiosyncratic light show in a box, has transformed the world in ways we are only beginning to realize and comprehend. Television is the instrument from which change can emanate, pouring over the viewing public with pale gray waves of light.

Throughout history there have been several turning points in the evolution of human society - the inventions of pressure-flaking stone, melting tin with copper, steam engine power, among others. But we have entered, in only the past forty years or so, a revolution of such international dimension, such overwhelming magnitude, that we now have the ability to reach and educate every person on the face of the planet. This may seem platitudinous but one only has to walk into a forgotten cantina in the far-reaching backwaters of the Amazon basin with a mass of people huddled around the “electronic fireplace” to see the power of the medium. We have at our fingertips the most powerful educational tool known to man. Television controls political systems, molds social values, and shapes societies. Yet we fail to use it in its positive mode - as an educational feedback system for societal values. Only with knowledge of “what's out there” can we advance. Television provides that means.

Society can be taught or shown how to appreciate scientific advancement - to the benefit of each. But the wall of disinterest and the veil of misconception must be breached before the machinery of understanding can be set to motion. The general public often fails to grasp the basics of a discipline that is laden with technical jargon and complicated research apparatus, lost in a Daedalian maze of complexity. The scientists, sometimes honestly trying (and willing) to get their
point across, stammer and stutter when asked to "put it in layman's terms" - victims of their own insular system.

So far, neither side seems to be alarmed by the lack of communication. Two features of this "ignorance is bliss" attitude taken by scientists and non-scientists alike typify the approach. Both are related to the limits of science. Consistently, science has been seen by society as the "cure-all" answer to the growing human impact on our world. The attitude that technology will solve the environmental problems we are facing and will face in the future should not be a reason for careless and thoughtless misuse of resources and technologies. Even if science could solve all of our problems, it should not instill irresponsible behavior. But more likely than not - it won't be able to solve the great majority of our problems. Society needs to know this.

Finally, science has often been called on to set its own limits, to curb its own pursuit down dangerous moral and technological avenues. So far the success has held. But we have only recently stepped into the territory of immense powers. Where we proceed should be a societal judgment. In order to judge, one needs to know how things work - particularly the process (or "story") of science.

Understanding this story, therefore, is the key to solving these types of problems.

This study examines the ways in which science, or more importantly, the process of science can be presented via the television medium in a national commercial format. Science has been presented for years now, and quite successfully, on the public broadcasting venue, but little work has been done on
popularizing science through the more fickle and often volatile instrument of commercial television. Deciding to research the ways in which science can be presented to the general public via commercial television is an undertaking one should take with great trepidation. In choosing this area of study, I have committed what many scholars consider to be no less than academic suicide. As I started this study I was faced with a virtual void of information, an unending abyss that has filled in very little after several years of research and review. Either no one is doing (or has done) research on how to present science to the public via television or if they are, they complete them in a less than formal manner and their trade secrets are well guarded. Whatever the circumstance may be, I can say with some certainty that there is little published or conceivably little known on how to make a science program for commercial television.

The real question we are faced with in this study and in our society is one not easily answered. How does one “educate” the general public about science and what, exactly, do they need to know? The answer to this dilemma comes not from an organized body of research or a proven theory, but rather from a personal belief system of education I hold. I believe learning, in the ultimate sense, results from a simple, three-step process. The first is interest - capturing the attention of an individual before seeking to convey any information. The second is foundation - illuminating the principles on which the discipline is based. And finally, understanding - at first simple and basic facts, moving on to more complex and subtle points, and eventually, an ultimate understanding of the subject. Support of this theory has come from Jon Miller (1986) where he notes that “the single most important factor affecting someone's receptivity to scientific information appears to be interest.”
This study attempts to confront that first step - interest. Engaging people in scientific ventures involves the elimination of the perceptive stigma of science currently held by the non-scientific community. Ultimately, this process may be a life-long pursuit for any individual. Changing the social fabric of our nation is certainly an unwieldy task - societies are historically slow to change. Some may cry that such an attempt is simply idealistic. Others may think of it as visionary. It is important for us not to be afraid of pushing the limits of a particular discipline. Through the medium of television we are fully capable of educating the world.

However, the second half of the question still remains (Once one "educates" the general public about science what, exactly, do they need to know?). In gaining the public's attention, what is it that they need to be shown about science? By promoting "science", do we mean promoting the use of the "scientific method", the use of a "philosophy of science", or something else? Huxley has outlined the answer in his quote inscribed above. In order to learn about a science, one has to understand what it is all about.

My analysis is intended to show how science can be conveyed to an inattentive audience by employing a non-traditional approach to the communication of science. Rather than describing the facts and features of the system, the process (or "story") of science needs to be the focus and goal of television. The process supersedes any philosophy of science (the philosophy of science is a definitional and descriptive approach of the methods employed by scientists), though the process inevitably does encompass some type of philosophy as well (to a certain extent). The process shown on television programs will necessarily reflect a particular "philosophy of science", however, imposing value judgments on the methods utilized should be avoided. The
process also embodies the scientific method, but what is important to convey is the notion that there is no single "scientific method". Science often proceeds by saltations, insights, and momentous "Ahas" - not necessarily by the traditional, rigidly formalized hypo-deductivism. To restrict the pursuit of science to a narrow definition is an absurd undertaking. If a research scientist is asked whether or not their work follows the prescribed straight-line, progressive steps of the "scientific method", a gentle chuckle will usually be the reply. Some of the best of science (though not all) has been done by individuals who "fly by the seat of their pants". In addition, social scientists are regularly attacked for not performing "real" science because their methods fail to meet the strict criteria of the scientific method. The endless debate results in a negative influence on their research. "Hard" science or not, it may not invalidate their results.

More importantly, the general public needs to realize that science is a socially embedded undertaking (as often described by Gould (1981) and Kuhn (1970). As Susanna Horing (1990) notes, "Scientific truth, like other versions of reality, is socially constructed." Scientists are not individuals pursuing a purely objective course, free from the influences of the outside world. Rather, they are people subject to the triumphs and throes of everyday life and their opinions, beliefs, and biases are molded by the shifting tide of society. It is easy to criticize or reject a system if it is hidden behind a cloud of misconception and mystery. If one wished to dispel the aura of mystique and antagonism in our U.S.-centric views of our foreign relations, the best way might be to show a day in the life of a typical citizen from that particular foreign nation. Once the other side is seen as human - people who put their pants on one leg at a time - the gap between the
two cultures diminishes rapidly and better relations soon follow. The same needs
to be done for the scientific and non-scientific communities.

But not only is science a socially embedded undertaking - but society is a
scientifically embedded undertaking. Science is a standard of social reality, and
soon, may determine that reality altogether. Humans are now in ecological
control of the planet. H.G. Wells once said that human history becomes more and
more a race between education and catastrophe. Woody Allen may have put it
better when he said, "We are at a crossroads - in one direction lies disaster, in
the other lies catastrophe. God help us make the right decision." If each side
continues to pursue their idle interests without knowledge and cooperation from
the other, the result may be a global "Tragedy of the Commons". In the end - we
are all along for the ride.

This investigation seeks to diminish the gulf between the two camps (the
scientific community and the general public) on each side of the communication
issue and what follows is a three-pronged treatment of the problem in the
communication of science via television. First, I examine the role of science in
society and its portrayals in both the media and other popular arenas. I begin by
analyzing the methods employed in the dissemination of scientific information
and what role the popularizer of science plays in the public and scientific
communities. Secondly, I examine the communicative theory of television
programming and the manner in which ideas are expressed in the electronic
media. What exactly does it take to produce a successful television program and
what are the key elements in the visual transmission of these programs? Though
no one knows what makes a “hit” and what distinguishes it from a “flop” before
the true test of broadcast airing, there are several generalities that can be drawn
from past successes and failures. Finally, I devote my efforts to wedding the two analyses in an attempt to describe how science can be promulgated in commercial broadcasting. Both the current state of science on television and identifiable constraints are discussed, followed by proposed directions in programming for the ultimate capture of the disinterested, or misinformed public. This project has been undertaken to answer the insightful observation and challenge of Christopher Doman (1990) that "no definitive program to implement a sound science journalism that will also ignite popular interest has been forthcoming."
CHAPTER I
Science in Society

For most people, science is some cerebral, lofty intellectual endeavor practiced by ivory-tower eggheads in white coats. For most people, it was a required course that ruined your grade-point average and made you feel stupid.

- Arthur Caplan  “So How Are We Doing?”

What the American people don’t know can kill them.
- Dorothy Greene Friendly

The importance of scientific literacy

Science and technology have pervaded our lives to such an extent that, like the street signs and landmarks along our daily route to work, they have faded into the background and melded into the landscape, often going by unnoticed and unappreciated. A person in today’s society would be hard pressed to complete a normal day, or any normal activity for that matter, without utilizing science or the products of science in some fashion. Unlike the simpler colonial days, our worlds are replete with the variable faces of science and the marvels it has given us. Without it, our environment as we know it would simply dissolve from under our feet and the stark reality of how truly dependent upon science we are would stare at us from the empty spaces of our world. Gone would be virtually everything that
we have surrounded ourselves with: household appliances, cars, medicines, computers, most of our foods, television sets, phones, almost everything that we use in our daily activities. We cannot deny the enormous impact science has had on our lives but we also cannot deny how very little the average person understands it. As the United States continues its steady decline in relative prominence among the world's scientific and technological communities, outcry from the ranks of educators and business leaders to rectify the downward spiral has grown vociferous. The world's most powerful political and military force has taken a backseat in the strategic race for technological dominance, falling short of scientific advances by Japan, Germany, and several other countries. The battle to educate the populace, particularly the younger sector, has literally quadrupled in effort and money in the last ten years alone.

Debate centered around the new push toward scientific literacy in this country has focused on three questions principal to the issue - "Why is scientific literacy important?", "What does the public need to know?", and "How, ultimately, are they to be taught those aspects required for minimal scientific literacy?". These are layered questions, dependent upon the resolution of each issue in the order listed above, before the next question can be taken on. Surprisingly, individuals currently involved with scientific literacy campaigns have taken little notice in the reasoning behind their crusades. The assumptions under which they work are that scientific literacy and increased knowledge are inherently good for the public and any efforts to teach society will only benefit the community as a whole (and the more they learn, the better). "Why?" appears as an obviously rhetorical question and further analysis of the issue is simply a waste of time. Who could argue against improving the quantity and quality of our nation's
scientific education, particularly via the mass media? Unfortunately, the matter is not quite as simple as it may outwardly appear, for the direction and ultimate goal of the communicative process by which the information is transmitted are circumscribed by the reasoning behind the endeavor. If, for example, mass quantities of scientific information delivered to the populace are the object of a push for increased scientific literacy, high-caliber media presentations would not be the optimal means of achieving that goal. Only after a full analysis of the objective of increased scientific literacy has been completed can the means to achieve such an objective be specified.

The most common reasons ascribed to the function of scientific literacy in the masses have been summarized by Trachtman (1981) in his analysis of the effort to bring science to the public. His contention is that the current beliefs in the critical circles are based primarily upon three fundamental purposes, or assumptions, of the value of scientific literacy - 1) that the dissemination and reception of scientific knowledge, or any other form of knowledge, is always beneficial in and of itself, 2) that scientific knowledge is essential for making intelligent consumer choices, which are becoming increasingly difficult in today's rapidly changing technological arena, and 3) that the democratic process and democratic doctrine are hinged upon the presence of an informed and erudite community. Most reasons for increasing scientific literacy fall into one of these three categories and yet few individuals have formally analyzed the critical bases upon which they are presented.

Some researchers have attempted to establish the benefits of scientific literacy by pointing to the outward trends in society and the world at large. Generally accepted political philosophy rests on the assumption that the majority
of the public, particularly the nonattentive public, tends to look to their leaders or even other, unqualified individuals for guidance and influence in cases where issues of a complex or technical character are involved. Human tendency, they note, is, that in the absence of a clear and decisive choice, people will often look to others for both information and occasionally, final determination. Evidenced by the enormous effect of voting polls on electoral issues and their balance, this "looking-over-the-shoulder" decision-making process is particularly noticeable in presidential elections. Exit polls in the eastern half of the country often play key roles in the outcomes of western states, where the polls are open much later and the earlier results are often displayed via the mass media to individuals yet to cast their ballots. Without full knowledge of the issues or candidates, a pendulum effect can swing an election to the point of no return.

Scientific discourse, they argue, is similar in that knowledge of the key issues and concepts is vital in avoiding the "blind faith" behavior of societal influence. Like sheep herded along without individual control, ignorance of the events and group direction may lead to a tragic leap off a cliff by the entire community, simply because no one questioned the individuals leading the pack. Susanna Homig (1990) describes the relevance to science by pointing out that, "... science is also political, a source of power and status in a high-technology, postindustrial society... a system that can serve to legitimize the decisions made by elites." If those decisions are not beneficial to the community and are self-serving to the elite, a general move away from democratic policy and philosophy is inevitable. Science has its own political leaders, like any other faction of society, and if we are to avoid the costly mistake of letting the power-elite control
the direction and outcome of the scientific aspects of our lives, we must become educated on the issues.

Scientific influence has also slipped beyond the confines of the social community that we recognize as the “scientific enterprise” and moved into the mainstream of society, reaching most aspects of the political world and affecting policy-making decisions. As Goodell (1977) notes, over half of all political bills presented before Congress have a scientific or technological basis, and it is inevitable that scientific literacy will become increasingly important in operating in both legal and political circles. Edson (1988) also commented that, “More serious than ignorance of the content of science is lack of public appreciation of science as a cultural enterprise and its role in the decision-making processes of a modern democratic society.” Just recently the biological technology of DNA fingerprinting agitated the criminal justice system by employing a new, and more accurate technique for identifying criminal parties in rape cases, murder and assault trials. Judges, lawyers, and even juries find themselves unable to establish the principles of the identification method because of their lack of basic scientific concepts and techniques. They are having to take “crash courses” in genetic theory and technology, most of them unable to define correctly the term “DNA”.

With little scientific information to support their opinions, the scientific “have-nots” may be forced to place control in the hands of those capable of making qualified scientific decisions. The effect would not simply confine itself to the major policy-making decisions of irrelevant and detached issues of little interest to the common person, but reach the crucial components of most individual’s lives. Goodfield (1981) describes the situation in that “…the power of
science is not neutral to the affairs of states or individuals, but is central to most of the critical choices and outcomes that will be resolved either by informal decision or by default, and that it takes a heap of understanding." The reliance on others in making decisions central to our very autonomy has the proponents of scientific literacy shuddering at the mere thought of such a fascist state. But others claim that, even in democracy, there are times when delegating decisions to more educated or qualified individuals is exactly what is called for. It is precisely what we do when we turn our political decisions over to elected authorities or our medical decisions over to trained personnel - because they have had the time and opportunity to devote themselves to making these well-informed rational determinations. Ophuls (1977) compares the situation to a passenger on a large ship in distress. Democracy at times must give way to elite rule, especially if its members differ in competency. The sacrifice, in dire circumstances or when under pressure, is called for, not only by the qualified leader in charge, but also by the underlings whose survival may depend upon the sagacious decision of the authority. "In other words," he continues, "the more closely one's situation resembles a perilous sea voyage, the stronger the rationale for placing power and authority in the hands of the few who know how to run the ship." For example, few of us would stop to question the reasoning behind an emergency room doctor's decision to perform a procedure intended to save our lives.

Others have echoed this sentiment by pointing to the fact that science has little to do with the ethical, moral, and political problems of our nation and again, we would do best to leave it to the experts. Trachtman (1981) argues that even if an enlightened citizenry in scientific discourse were necessary to preserve
democratic ideology, it would only be counterproductive because of the overwhelming abundance of contradictory evidence and theory in scientific pursuits. Giving the public access to the spectrum of scientific opinion would swamp a lay audience so much so that it would paralyze, not aid, in decision-making. Doman (1990) goes so far as to say that "no examples are given of how this inadequate understanding has harmed the performance of democratic governance." But most political decisions do rely on the discourse of science, but rely is the operative word. An informed opinion is a better opinion. Blind faith in government, leaders, or even science for that matter can get you killed. "Just what the doctor ordered" should be taken with a grain of salt, simply because scientists are human too, and a knowledge of the basics goes a long way in departing from blind faith.

Several cases in our nation, currently under fierce debate, highlight this point quite clearly. Abortion rights issues have demarcated the U.S. into two distinct schisms of political positions: pro-choice and pro-life. Little mention, in the hotly debated controversy, is made of the scientific foundations that underlie their opinions. "A clump of cells" scream the pro-choice organizations; "Life begins at conception" counter the pro-lifers. Many individuals, in either camp, can triumphantly pronounce their position on the issue but in the same manner, could not tell you when the first fetal brainwaves associated with thought develop or even how an abortion is performed. Even more ironic is the fact that they have set themselves up as warring factions, at aphoristic odds with one another, but fail to realize that they are not debating the same issue. Pro-choice organizations are unconcerned with the principle of life or "personhood", but rather, are concerned with a woman's right to do with her body as she chooses. The two
ideals are not mutually exclusive and in fact, there are thousands of individuals that would describe themselves as “pro-choice” but are individually dead-set against abortion.

Nuclear power concerns have also demonstrated this lack of scientific bases. Protesters have vehemently opposed the construction or operation of nuclear power facilities but oftentimes cannot support their fears with tangible technological weaknesses. They can only point to the fact that the technology is “obviously dangerous”, yet still produce no hard evidence in defense of the perceived hazards. Nuclear power proponents on the other hand, seem determined to keep the lay public in the dark. “The less the community knows about the industry, the better off they will be” appears to be the motto of the nuclear authorities. The risks are minimal and the public is quick to blow them out of proportion, they rationalize. They are the last ones that should be making technological decisions to proceed. Unfortunately, the public is contemptuous of this method of decision-making yet is hesitant to tackle the complex and convoluted technologies of nuclear power necessary to formulate policy. Most critics, like Michael Arlen, argue we have little choice in the matter. “It wouldn't kill us to know a little bit more about the so-called boring stuff, and it might in fact kill us not to know about it,” he explains (quoted in Jerome, 1986).

Counter to the feeling that science literacy needs to be improved so that the public may become more independent, free from the intellectual constraints of the political and scientific elite, is the contention that science and the scientific community have basically received a bad rap and as a result, their image, and more importantly, their public funding have depreciated. Molony (1992) notes that, “[P]ress coverage can also influence the financial support given to
research, a fact well understood by scientists and their institutions." Science literacy is seen by some researchers as the antidote for the declining (and depressing) state of scientific research in this country (Perlman, 1974). With an increase in scientific literacy, they argue, comes an equally important increase in public confidence in science. This confidence is necessary because science is an expensive undertaking and must be supported by public funding. Without this support, the institution of science cannot properly perform its functions and society, being dependent on science, will suffer accordingly. Science yields practical results and the applications that spread to the public sector will slow, disturbing the progress of our technological community.

Unfortunately, there is little or no evidence to support the theory that increased scientific literacy will result in increased public confidence (if confidence is truly important). Gerbner (1981) demonstrated that an individual's confidence in science (and other institutions as well) was negatively correlated to their exposure to the enterprise. The more a person was exposed to the scientific community and its activities, particularly through the media, the less confident they were in the institution as a whole. This depression in confidence may not be reflective of the public's understanding of science, however, because, as Gerbner explains, the confidence of an individual appeared to be based less upon the behavior of the institution than on outside factors, including television. The lack of confidence may be based upon the public's misunderstanding of science, due to the particularly negative manner in which science is represented in most television programming. Television has, since its inception, portrayed scientists as either madmen or characters to be watched out for, and the technological
ramifications of their work, to be regarded with anxiety. Exposure to this type of image has done nothing to bolster the public's confidence.

Doman (1990) also attacks the assertion that science education would be justified in order to instill a public confidence in science and scientists. Citing Mazur's studies (1977, 1981a, 1981b) which show that public confidence in science has not suffered in comparison to other institutions and is still quite high, Doman argues that a vast shift in resources and money to the creation of science literacy programs would be uncalled for (even though there is no evidence that shows public confidence is growing). But is education really about confidence? In fact, education should do the opposite - promote the questioning of conclusions. No one became better educated to follow their leaders more ably and their decisions blindly. Education is about empowering oneself to make independent, yet informed, decisions. Most people do not trust politicians so they do not take them at face value. They delve further, then judge. Most people would not argue, with the state of the political system today, to become less informed and question the motives and the pontifications of politicians far less than before.

Doman goes on to note that the recent push for science education and awareness has been to focus on the deficiencies of the media and its negative presentations of science. The concern, he argues, is to demonstrate an "essentially positivist portrayal of science as heroic, apolitical, and inherently rational endeavor." Unfortunately, this is not the "insider's" view of science, for the process of science and the enterprise of science are bound in a social matrix of political systems, human vices, and individual errors (though they may be rational). Exposure of this side of the enterprise is what actually needs to be achieved through scientific education. A call simply to increase to bulk of
scientific information available to the public may be, as Gerbner's studies suggest, counterproductive. Public understanding of the process and politics of science would be far more useful and as Jarvie (1990) proffers, would serve "to present the various arguments on a scientific issue in popular form as an antidote to the authority science may claim."

Science, in its most simplistic doctrine, may be the best approach we have to achieve knowledge, but in being the best, it is in no way immune from the scrutiny and criticism of outside sources (Goodfield, 1981). Science, like all other components of a democratic social structure, must be made available to evaluation and accordingly, change, from entities free of vested interests. Government and military institutions are firmly entrenched in the scientific community and with the vast majority of research and funding controlled or handled directly through either of these establishments, the need for popular management becomes increasingly critical. Vast public funds may be at stake in research initiatives. Often, the demand for applied technology falls under the guise of "military interests" and without the redirecting abilities of an aware public, the government continues to incestually fund itself.

Related to the importance of a scientific background in large-scale political and social judgments, everyday aspects of modern living have fallen more and more to a reliance on technologically oriented commodities. The world used to be a much simpler place and as Jarvie (1990) once noted, "Science was a principal means to human liberation." Now, we are more likely to feel trapped by science, and particularly, its products of technology, than liberated by its actions, evidenced by the apparent inability of most adult Americans to program their VCRs. The media are burgeoning with the proclamations of science, some of
which are true - some of them not so true. "Four out of five dentists surveyed have recommended..." is a phrase off-handedly used in toothpaste commercials but rarely substantiated. "Scientists have discovered today that..." is often followed by an announcement of what many consider to be the gospel-truth. Each day, the public is pummeled with vast amounts of scientific and technological information and little consideration is given to whether they are actually comprehending the material. But as consumers, the demands of present-day society call upon each individual to be scientifically literate in their selection of goods, services, and ideas or to face the consequences. As Neal Miller (1986) puts it, "Science plays a vital role in our technologically developed society, and it is important for citizens to understand something about it in order to make wise decisions." Those decisions, be they "what new toaster to buy" or "what to do with their recyclable materials", can be enhanced with a basic understanding of the concepts of science.

Finally, there is the claim that knowledge, irrespective of the subject matter or quality, is good in and of itself. The reasoning behind increased scientific literacy may be nothing more than a desire to increase the intellectual awareness of our society. It is certainly every citizen's right to be informed of issues and information that may affect their lives - it is difficult to argue with this point of view - but what types of information, exactly, are they being given? The value of science in our culture is an idea that has few critics and, like other vital human activities, it deserves the same recognition, respect, and public awareness. "Being cultured" often entails a firm grasp of the knowledge available in disciplines such as art, literature, and music, but rarely is a fluency in scientific conversation prescribed. Science can allow us to change our perceptions of
ourselves, as much as any of the humanities, and its contributions to those efforts generally go by without much attention. Through science, we can satisfy our natural curiosity of the world around us and form the foundations of philosophical questions that we have always sought to answer - “Who am I?” ... “Why are we here?” ... “Where did we come from?” Biology, evolutionary history, quantum physics, and organic chemistry help us begin to broach those issues with a better conception of the underlying principles.

Denying scientific information and the wonders and insights of the process is as much of a crime as refusing entrance to the world’s greatest museums, cathedrals, or concert halls. Science is one of humanity’s greatest intellectual adventures (Perlman, 1974), and enticement of the young into a pursuit of this admirable endeavor should be a top priority when considering the expansion of scientific literacy (Jarvie, 1990). We are all scientists as young children, exploring and examining every aspect of our fascinating environment, and this enthusiastic force needs to be tapped into by the powers of science education. Many have claimed that scientists are simply kids that refused to grow up (Gould, S.J., personal comment) and if the opportunities and information of scientific pursuits were made available to a larger proportion of the populace, there would be many more individuals actively pursuing, or at least, actively supporting, scientific endeavors.

It would be hard to argue with the intrinsic value of education - that increased scientific literacy is an end justified without question - but before launching into an all-out war to combat scientific illiteracy, the other initial questions must be answered as well: “What does the public need to know?” and “How is this information best transmitted?” Careful consideration must be given to
what type of information is being conveyed to the public and what effect it is having on their behavior. Education may be beneficial in most circumstances, but rhetoric or misleading platitudes may actually harm the public’s capability of self-determination of their future, rather than enhance it. Efficient means must also be devised for scientific communication - throwing vast amounts of money or effort at the problem may do little in improving the overall quality of public awareness. As Jon Miller (1986) points out, the creation or enhancement of scientific literacy is a long-term and complex task, not to be taken lightly and not to be resolved with the toss of a few dollars in its direction.

**What the public needs to know about science**

When I was a young boy of three or four, I went to my father, who was a football coach, and asked him to explain his job - which to me, was merely a simple game and a confusing waste of his time. I couldn't understand why a staff of twelve grown men, a vast amount of resources and money, and an enormous output of effort was necessary in order to organize a game my neighborhood friends and I could play in the backyard. Rather than trying to explain all the complexities and intricacies of the sport, he simply took me to “work” every day, all day, for an entire week.
Not once during the week did he explain any aspect of the system to me, but rather, let me observe what transpired and assimilate it all. After those seven days, I understood what it was all about (though I did not know exactly how it worked) and more importantly, could appreciate the value of his work. He educated me about the world of football, simply by allowing me to observe the process of football. I saw how the game was run, the roles each person played, and how they fit together in the end. It is a lesson I have never forgotten. To this day, though I have no connection to my father's profession, I am one of the biggest advocates and defenders of a game seen by many as a “stupid affair” pursued by “dumb jocks” and coached by “frustrated athletes”.

In the same manner that my father taught me football, the same needs to be done for science and the general public. The public needs to see how the process of science unfolds, not simply its products (though certainly those are important - in illuminating science, the other aspects of the discipline, be they hard data or technological applications, should not be scorned). The uncertainties of the system need to be illuminated, in both the failings and deficiencies in research and innovation. The media, with their powerful influence and far-reaching capabilities should serve as the conduit through which this initiative is carried out. But, as Goodfield, in her book *Reflections on Science and the Media* (1981) explains:

*The public's right to know about science and its implications is paramount. It needs to know, first, the hard facts of scientific discovery and their relationship to past and changing ideas. Second, it needs to know what are the current scientific and trans-scientific issues, the areas of concern and debate, especially as they relate to the impact of scientific ideas on those social and political issues on which the public will be voting or on which citizens should make their opinions felt. And third, the public needs to know about the actual nature of the scientific process, for this, as*
much as the content of science, should be comprehended... Of these three tasks, the media have traditionally done the first very well indeed. The second they are only just beginning to grapple with; and the third task practically no one has done at all.

I would argue that, without addressing the third point, the understanding of the scientific process, efforts to correct the other deficiencies will be in vain. Like watching a football game without knowledge of the rules or goals of the game, simply knowing the “score” of scientific endeavors will be of little value. “How are you to know the score when you have not been told the rules of the game?” (Couper, 1992) Streams of data, results of scientific experiments, and the subsequent applications are inherently useless without a context to put them in and assuredly end in either exasperated disinterest or a strong mistrust of the system. Currently, the general public is presented with, for all intents and purposes, the “box scores” of science, out of context and unexplained. As Goodfield points out, it is the media that have failed to fulfill the third task of communicating the process of science, not because of misguided intentions or malicious deceit, but rather, as a result of the limitations the communication media impose. Neal Miller (1986) describes the current predicament of the media:

The conditions that confront most of the media, especially the pressure for time, space, and interest, favor stories that emphasize the end-products of science - the practical results, the new techniques, surprising phenomena - rather than the process by which science develops and sometimes, often quite unexpectedly, leads to important practical consequences. Yet, in order to make intelligent decisions concerning science, the public needs to know something about the process by which it advances - the fumbling trial-and-error, the logical way in which a scientist devises tests to choose between alternative hypotheses, the long chain of small advances gradually leading to new understanding, and the unexpected discoveries.
Bennet (1986) puts it more precisely when he says, "What really matters about science is the method, not the facts."

The public must be made aware of not only what happens in science today, but the long-term impacts of the research involved, the long-term effects of technology, and more often overlooked, the historical background leading up to the current conditional research status. "Most [science] programs deal with trendy, newsy subjects," says Philip Morrison, professor of physics at the Massachusetts Institute of Technology. "I think that's a huge mistake. I would like to see these shows devote more time to the background on which scientific knowledge is based. In order to understand science, you have to understand what scientists believe in." (quoted in Zoglin, 1981) In the media, as the successful results are plastered across the headlines throughout the year, the true process of science becomes hidden. Stuart Diamond, Pulitzer Prize-winning former science reporter for the New York Times and Newsday explains that science reporters:

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\text{Just be willing to communicate the process of science and not just the results, because it's the process that enables the real education of the public. The failure to reveal the process is what keeps people from understanding technology and prompts them to be suspicious of it. The way we got to the moon is more interesting than the fact that we got there. (Diamond, quoted in Technology Review 1992)}
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Granted, for the most part, the public is only interested in the effect it will have on them - "what does it mean to me?" - but out-of-context information can be misleading and is extremely difficult to process rationally. The populace seems content, within the scientific venue, to rely upon the media to evaluate the issues for them critically and forward the pertinent actions to be taken. By default, communicators are forced to tell them what they want to hear because the public,
at first glance, seems unwilling to take the time and effort to analyze the results of research. Media personnel are wont to present a balanced viewpoint, filtering out the extremist and nonsensical views, but then allowing the audience to come to its own conclusions. Politically, many of us would be appalled if the media took on the task of independently judging the candidates running for election and then announcing which of the opponents to vote for, yet this seems to be what the public has asked them to do for science and science policy.

Science writers and producers find themselves pushed into a corner in which they feel uncomfortable, so they have learned to resolve their dilemma in one of two ways. First, they either willingly accept the post and selectively present the mandates of science (and normally the scientists) or their own reasoned views of the same, or, less frequently, they present overwhelming quantities of data, all sides of an issue, and let the public draw their own conclusions. Unfortunately, the lay person, if presented with undigested scientific material, finds him/herself unequipped to deal with the technical theories, confusing jargon, and counter evidence to consider effectively the ramifications of the research or, in most cases, its validity. Research, when presented in this format, is generally pushed aside and ignored, or left to the “attentive” audience (as described by Miller, J.D., 1986 - see next section) - who are not scared off by the presentation of “nitty-gritty” scientific detail. All of this leads to unquestioned acceptance of most scientific pronouncements at face value because the public, in either circumstance, ends up passing the analytical buck to those it feels are more fully qualified.

The iconography of an overly-rationalized world of science is all that remains when left to the devices of others. Scientists, either unwilling or unable to
do otherwise, are hesitant to present their results to the outside world with an aura of uncertainty (often very large egos are involved). In the same vein, science writers and producers, dependent on scientist-sources for their life's blood, are quick to assume the role of science promoter. As a result, scientists are presented as the heroic, all-knowing symbols of educational pursuit, free from the constraints of society - unbiased and untarnished. The black box of the scientific enterprise is seen as the venue to straight-line, rational decisions - similar to Batman's computer into which he fed his queries of world-threatening dimension, waited a few seconds for the eternal whirrings and hums to subside, and upon the chime of a bell, was presented with the formulaic, elucidating response. Science has been handed that role in today's society - the answer to our every problem. Little credence is given to the tentative nature of science, the human nature involved, simply due to ignorance of how it proceeds.

For those who understand how science truly works, it is a much more convoluted and complicated affair. Goodfield (1981) once wrote, "...science progresses on a path not unlike an inebriated spider." - probably the best metaphorical description of the quasi-religious, socially embedded enterprise we call science. Once that fact is elucidated, once it is communicated to the public in a comprehensible, non-judgmental fashion, then, and only then, can the tide of waning interest in science be turned. The lay public is told what to believe, from both scientists and media, like the aphorisms of an aging grandfather. The populace, without knowledge of the internal workings of the system, must take the promulgations either as the wizened truth of a venerable elder or the crackpot ramblings of a slightly touched man. Oftentimes, the lines of distinction
separating the two become so blurry and confused that the public has nothing to do but dismiss them out of hand.

Will the public support science if it is perceived as basically a "crap shoot" - unable to predictably and reliably solve problems brought forth and lain at the foot of this almighty sorcerer? Until recently, the ruse has worked. The scientific "Wizard of Oz" has managed to hide behind its fancy veil of light-and-smoke effects as the immutable and conquering force of the rational world - a venture in unswerving success. But the public has grown weary - and wary - of the mythic figure of science and has begun to question its authoritarian stranglehold on information. Communist political systems have continued to fall victim to this type of rebellious thought process - scrapping their ideologies in one fell swoop. If science is not careful, it may soon be next. What generally works is a realistic approach. If the public is not given unattainable and idyllic promises, they cannot be disappointed. Disappointment, and the resulting disillusionment, can be the downfall of any controlling or authoritarian source.

Absolute knowledge of the system processes thus, in some sense, prevents the lay public from fully comprehending or trusting the outputs of science, leading to the dismissal of scientific interests as important to the everyday proceedings of their lives. The resulting disinterest in science as a whole is reflected in the choices they make for communication subjects, general attitudes toward science, and the condemning decrease in public confidence pointed to by Perlman (1974) and others. Rationally, one might then conclude that the other result of scientific communication - that of accepting the previously assimilated conclusions of scientific information without further critical analysis - would be the desirable outcome of scientific communication, particularly for those
not capable of ratiocination on their own. The disinterested public, it has been argued, need not involve themselves in the democratic process of scientists - not only are they not qualified to intervene in the dialogue, but most likely, would not be interested in doing so. Only those with some background in the underlying principles, some interest in the proceedings of science, need be informed. Jon Miller (1986) outlines the case:

... the attentive public needs to be informed about specific controversies for which its involvement is sought... it is imperative that the attentive public be informed of the nature of the problem, that it learn about alternative solutions to the problem, and that it become sensitive to the longer-term implications of various solutions... It also is important for the attentive public to have a general understanding of the process of scientific study and some functional understanding of the major constructs used in scientific discourse.

But, he continues:

Little agreement exists about the information needs of the nonattentive public at the bottom of the policy pyramid. The traditional view of science educators has been that all citizens ought to be scientifically literate in order to participate in the democratic processes that lead to science policy. This view is still widely held within the scientific community. More recently, some observers - including myself - have advanced the proposition that universal scientific literacy is not feasible, that a significant portion of the population is not attracted to science and technology.

His argument, circular in nature, assumes that the disinterested audiences are disinterested naturally, that they somehow cannot overcome this lack of desire. Reminiscent of the schooling-behavioral theory presented by Robert Yerkes in the early 1900s, its mix-up is in the cause and effect of behavioral norms. Granted, some people are naturally more adept at grasping particular types of concepts than others, but we do not condemn the rest to eternal failure and ignorance simply because they must work at it a little harder. Few of us have the
natural musical abilities afforded to the great composers such as Beethoven or Bach, but this does not prevent us from understanding, or more importantly, from appreciating musical compositions.

Miller's argument follows the same type of logical pattern - that nonattentive individuals are nonattentive to science and will always be that way. I would propose however, that the public is disinterested as a result of their lack of informal education about science - the "true" science of process, discovery, and excitement. The nonattentive public has simply "dropped out" of the informal scientific education process - that is, the media's presentation of the enterprise - and have become turned off by the entire venture. The "significant portion of the population that is not attracted to science and technology" is that way for a very good reason - no one has actually bothered to involve them in the discipline and no one has tried, before all else, to capture their interest. Jerome (1983) provides some additional support:

Some observers argue that the trouble with the science media is that they are just that, science media; that as long as people consider science a special category, there will be a limited audience. But just as millions read the sports pages and watch the sports segment of the evening news who don't actually subscribe to Sports Illustrated, so the vast majority of Americans may be hungry for science as part of their media menu but not as the whole meal. This may present a packaging problem for media managers--suggesting a need for more science columns and brief "spots"--but it hardly bespeaks an inattentive public.

Miller does footnote his theory with one possible exception, a case in which going outside of the normal confines of the scientific elite (and their followers) may be called for:

Although I don't think any useful purpose would be served by directing policy-relevant information to the nonattentive segment of the public under normal circumstances, when a science policy issue
By this time however, the nonattentive public may be so lost, so inextricably entwined in contempt for the endeavor, that it may be too late to pull them back into the fold. To expect a large portion of the population suddenly to take interest in a subject because it has been deemed important to their well-being by the same individuals who had been saying “none of your business” seems overly optimistic. Even if the population can be convinced that they need to be involved in the policy issue, how much ground, scientifically, must be covered to educate them on the principles? Is it reasonable to assume that a sector of the public, previously disinterested in the discipline and altogether unfamiliar with its workings or language, would be capable of making the rational and educated decisions that they had been called in to effect? They are being told the petitions and asked to vote for issues they most likely do not fully understand.

In summary, society must be educated in the ways of science in order to judge both the products and proclamations of science. The public needs to know the weaknesses of the system and its strengths. Armed with the insight into an enterprise of human endeavor, with the recognition that scientists are people and that all people, in some manner or another, are scientists, the public can fully appreciate, support, criticize, and most importantly, evaluate a valuable process by which humankind gathers information and formulates thought. Scientists appear out of touch, god-like in their domains of secular isolation, and like all gods, are to be treated with awe, reverence, and a little bit of fear. The lay public needs to see the ephemeral qualities of scientific theories and the false leads - the blind alleys. The realization that scientists err, that they critically evaluate
problems in the same manner as a mechanic fixing a car or a baker testing a new recipe, will bring them down to the same level as the rest of humanity. The more I understand about how cars work, the more I respect my mechanic for being able to fix my finicky engine… and the better prepared I am to avoid being taken advantage of.

The current status of scientific literacy and interest

Clearly very few Americans understand basic scientific principles or the methods by which scientific results are obtained, but what is not fully understood is just how much the average citizen does know about science. Some research has shown that as few as seven percent of American adults could pass a minimal test of scientific literacy, while others have suggested even lower percentages (see Miller, J.D., 1986). Most of these tests are based upon knowledge of particular scientific terms, basic scientific concepts, and more often, simplistic scientific facts - such as “In which direction does the sun rise each day?”. These tests, designed to measure base amounts of scientific information in the average citizen, probably underestimate the true lack of scientific literacy in the United States (or other industrialized nations). What most exams fail to measure is how much the lay person actually knows about the process of science. In effect, the appalling figures for scientific illiteracy are probably much worse than we may suspect. As a result, if scientific knowledge (or literacy) is to be based upon the accumulation of factual information rather than knowledge of the underlying principles and process, the current, normal procedure for addressing literacy
problems will follow. Unfortunately, those individuals designing the tests, and thereby their measures, are anchored in the determination of scientific knowledge in this manner. The fact that an individual may know in what direction the sun rises but has no idea what the scientific method is, what makes scientific results valid, or how scientists go about their everyday activities is an indication of how truly depauperate the American understanding of science may be.

In moving toward the elimination, or at least reduction, of scientific illiteracy in this country, media critics and educational consultants would do well to change tacks and approach the problem from the much simpler angle of teaching the process. One cannot learn the intricacies of a card game if they are ignorant of the playing rules. In the same sense, a person may never fully be able to grasp complex scientific concepts if they are unaware of the mechanics of the system producing them. Millions of dollars poured into literacy projects may be going to waste because of this foundational missing link. Scientific television programs such as NOVA or similarly directed magazines such as Scientific American, may have limited followings because of the inability to appreciate the foundations of the scientific enterprise by those individuals lacking the educational background, formal or otherwise, which allows them to peer into the workings of the system. The public must not only know in which direction the sun rises each day, but also the method by which that determination is made, the observations upon which the theory is founded, and the predictions that follow this hypothesis. How much good is knowledge of the fact that the sun rises in the East each day if a person doesn't know why it rises in that direction and what this means in relation to other phenomena? These are the types of questions
individuals (whom the literacy programs are aiming their efforts at) need to be informed of, but who, exactly, is going to listen?

Miller, in his theses on scientific literacy in the United States (1981, 1983, & 1986), has divided the population of individuals involved in science policy formulation into three distinct groups according to their position relative to the scientific enterprise. First, there are the policy decision makers, those directly involved in the actual public scientific policy formulation, responsible for drafting and signing into legislation the rules and regulations governing the scientific system. This group consists of individuals such as the president, congressional leaders, senators, and relevant committee members. Second, are the individuals involved within the scientific complex, such as university, corporate, and independent researchers, those involved in science communication, and those active in scientific organizations and societies. Finally, there is the lay public consisting of those individuals not actively involved in science policy formulation but having a vested interest in their outcome (basically, the rest of society) (Figure 1).

This final group, by far the larger assemblage, can be further subdivided into three additional groups - according to their level of interest and awareness in scientific issues. National survey data accumulated by Miller and his colleagues, suggest that approximately twenty percent of the last group can be described as "attentive" to science and science-related issues - where attentive is defined as having a high level of interest in science topics as well as a functional level of knowledge within those particular topics. Characteristic of this group are young, well-educated individuals that are avid NOVA and PBS viewers, consummate readers of scientific magazines and articles, and yet are not involved with the
scientific system other than by their devoted interest. A second sub-group, equal in size (approximately twenty percent) can be described as "interested" - interested being defined as a moderate level of interest in scientific issues but little or no educational background to help deal with those issues. This group consists of those individuals who occasionally turn to PBS or sporadically read science journalism reports, but are far more likely to view the less "hard-core" science programs such as *National Geographic*, the Discovery channel, and news-related science - but generally, only when the topic suits their fancy.

The third sub-group, the "disinterested" public, are those individuals who are turned off by science and who rarely watch science-related programming or read scientifically based news articles. This group, consisting of the final sixty percent of the lay public, or an astonishing fifty percent of society as a whole, is by far the largest sector of the survey. This section of the population, increasingly skeptical of science and its outgrowths, is the most rapidly expanding division of the three. Surprisingly, Miller and many other authors have focused their attentions on educating the attentive and interested sectors of the lay public, claiming that they are in the most need of educational materials and scientific information. The stress is on better educating the well-educated, attentive audience, increasing their overall capability of analyzing scientific issues, and increasing the potential baseline status of the interested portion - with the possibility of moving them up to the attentive body. This approach, basically preaching to the converted, has little effect on the overall standards of scientific literacy in the largest assemblage of individuals - the disinterested public.
Fifty percent of the nation's population is a remarkable percentage to leave out of an educational impetus toward changing attitudes and knowledge of science. Project strategy, formulated under the guise of better educating the better educated, seems to do little to strike at the heart of the matter. If science suffers in the eyes of the public, it suffers at the hands of the disinterested sector of the populace. Miller's suggestion that we start by addressing the scientific educational needs of those who know a little about science and yet not enough to deal adequately with all of the issues, begs the question of what science education, or education in general for that matter, is really about. For example, if we were to look at a school system in a small town with the aim of improving the
educational abilities of that complex, where the drop-out rate was over fifty percent, few would argue that the best way to improve the system would be to implement more instructive honors classes for those students excelling, but not quite reaching their full potential, in the upper-level divisions. Yet, this appears to be exactly what Miller and others are advocating for the national improvement of scientific literacy. What the nation needs to concentrate on is those students that have dropped out - the individuals that have stopped caring about the field of science. This results in mediocrity across the board, compared to increased superiority of the advanced and continual denial of the lesser individuals. It is a judgment call between advancement of the top portion of a group on the one hand or average abilities across the populace on the other.

But why is science frowned at (or feared) by the average person? The recent push for increased scientific literacy has not been the only one of such attempts. There were several initiatives in the 1960s, roused by national sentiments of the "space race" and technology wars, that generated enormous literacy-enhancement efforts, either producing little in terms of measurable improvement or failing altogether. These programs sought to sway younger sectors of the population toward career paths in the sciences and mathematics as well as improve the overall image of scientific enterprises. Most efforts were in vain - Americans were generally under the impression that they had won the "space race" and were so far ahead in technical fields that there was little to worry about - and the projects were shelved in order to aggrandize other, more productive programs. The most recent efforts, spurred by programs instituted by the American Association for the Advancement of Science, an organization devoted to the betterment and promotion of science, have attempted to address
the revived problems of the sixties. These problems are simply rehashed
versions of the old fears - being overtaken technologically by other countries and
the diminution of science confidence - but they are no less valid than they were
thirty years ago (and probably more so today). The problems of the sixties never
went away; they were simply forgotten about in the jubilation of our successes.

The programs instituted under the new literacy projects are aimed at
addressing the lack of concrete knowledge concerning science in the nation as
well as improving the overall image of the disciplines in order to attract the
influxes of larger and brighter young students to shift this downward slide.
Though these are noble missions, the emphasis is again on increasing the
quantity and quality of the information being presented. I would argue that this
agenda is, in principle, putting the cart before the horse. The public needs to
have their curiosity piqued, their interest captured, before they can be taught
scientific concepts or loaded down with masses of scientific information
(Goodfield, 1981). The methods by which this goal can be achieved, via the mass
media, are through the presentation of the process of science and the accurate
representations of scientists - as human beings (see further discussions in
Chapter 4).

Unfortunately, a barrier to these literacy movements is the fact that, while
the improvement of the public's awareness of science may be high on the
agenda for the AAAS and other such organizations, it is not for the scientists
themselves. Few scientists are willingly to take active roles in the dissemination
of science to the public and even fewer are very good at it. While outsiders, such
as the media and science societies, may be increasing their efforts at improving
literacy, scientists and their associated institutions are doing little to join them in
their labors. Most scientists consider it ill-advised to "go public" and the institutions backing their research often singularly promote the advancement of continued research - meagerly assisting, even impeding any efforts to communicate publicly. The axiom "Publish or perish" is extended only as far as the research circles themselves and publishing in popular forums, personally or through media resources, is given little credence and credit. As Dr. Paul Colinvaux of the Smithsonian Institute (1993) notes:

> Success in popular writing, let alone the picture media, can be fatal for a scientific career. The reward structure frowns on such success. And the frowns become heavier with efforts to prevent even financial gain to scholars who talk to the general public. Nothing readable ever comes out of the Smithsonian, for instance, because all royalties are claimed by the institution. Many in university administrations are trying to treat the world of their professors as their own commercial property in a similar manner.

Without the enhancement of communicative efforts on the part of scientists and their attendant institutions, little headway will be achieved solely through the redoubled struggle of the media and literacy projects.

But what truly is the reason most Americans are turned off at the mere mention of the word "science"? In part it may be due to the misguided perceptions of the public when the word itself is mentioned. Most people have the impression that science is both difficult and confusing and that scientific information is generally unattainable by the average person. In the same fashion, scientists, as portrayed by the media, are seen as either messengers of God or scandalous louts trying to wreak havoc on the world. Though the media may be responsible for the propagation of these attitudes, they are probably not the initial source for setting most of these stereotypes. Most likely, it is due to the dry perception of science. People often hearken back to the dreary days of high
school physics or biology, and due to the presentation of overwhelming amounts
of scientific data and the poor communication of the scientific process, the
subjects are seen as exceedingly dry and boring. Most students have
nightmarish memories of their high school science classes (and even introductory
college courses) and for them, science is nothing more than the eccentric
ruminations of nerdy instructors, bent on rote memorization of physics equations
or chemical steps in the photosynthetic process. This leads to disinterest, which
leads to further lack of knowledge. As Jon Miller (1986) notes, "Adults who did
not acquire some degree of scientific literacy during formal schooling tend to lack
both the interest and vocabulary to understand communications intended to
improve such literacy."

Primary efforts then, must also seek to improve the education of science
within classroom settings and through outside venues such as the mass media
and independent institutions (such as museums, etc.). The endeavor must be
focused on the interest factor of the audience, not the overall quantity of material
presented. Only after the interest and attention of an individual are captured, can
they adequately be taught the principles of any discipline. Before all else,
receptors of information must be "turned on", similar to a radio or television set. If
the receiver is "turned off" or has tuned to other attractions, no amount of
cajoling, no massive burst of information, is going to get through. "Rather than
recreating the unimaginative science classes taught in most schools--
dehumanized and loaded with rote rather than reasoning--TV producers need to
imbue viewers with the drama and tension and controversy inherent in the
challenge of scientific exploration." (Jerome, 1988) Most of the better scientists
that I have met seem to have been turned on to their discipline outside of formal
schooling, either by collecting fossils or bugs as a kid or by entertaining forms of intellectual pursuit. The media need to tap into this method of capturing the attention of the young, through innovative programming or technological methods (e.g., interactive computers, virtual reality, holography). As Gerbner et. al. (1981) describe the situation, it is not so much that the public has rejected science, but rather has become ambivalent to its achievements and teachings. We are living in increasingly skeptical times and all institutions, including science, have lost their mystique. This general loss of faith in institutions has led to the downward trend in confidence, and most notably, interest, in their pedagogical styles. Headline writers, television directors, and Hollywood film stars have recognized this need to capture the attention of an audience long before most of the world. Educational critics and science literacy advocates must come the same conclusion if their hopes of achieving wider science audiences are to be fulfilled and the best way to achieve their goals is through the established scientific communication venue and its participants.

**Scientific literacy and perception considerations**

The direction of scientific literacy programs is only part of the problem facing science communicators in this country (those individuals actively involved in the production, translation or dissemination of scientific concepts to the public - including, but not limited to, science writers, science television and radio producers, science communications representatives, and “visible scientists”), for not only must they determine the correct course these initiatives must take, but
they must concern themselves with dilemmas internal to the process of science communication. One of the major interests, and accordingly, grounds for debate, is the issue of accuracy. Just how accurate do portrayals of science have to be and, even more fundamental, is accuracy important? In the communication of scientific information to the public, the public serves as the receiver of information, giving almost no feedback on the substance received and thereby, little input into the accuracy of further reports. Science communicators in the media serve as the channels through which the information is conveyed but at the same time, must serve as the filters for accuracy and the controlling force for the types of erudition that is passed along. Generally, scientist-sources play no direct role in the actual portrayals communicated to the public once they have told their story and presented their findings to the media. They do, to some degree, have control of what form of information reaches the lay public in deciding what data or conclusions they choose to relay to the media, but for the most part, media personnel are the directing forces behind the communication process, and therefore, take the brunt of criticism leveled at inaccuracy shortcomings in the presentations.

Several people have suggested that accuracy, if not intellectually important to the masses, is readily acceded as long as it is at the expense of complexity. Among the most vociferous critics are the scientists themselves, who protest that “the public clearly prefers a simple lie to a complicated truth.” (Goodfield, 1981) The belief of scientists that the public does not want the truth in the portrayals of their work stems from the observation that the media, infamous in the scientists’ eyes for their inaccurate presentations of scientific issues, are communicating, they claim, what the lay public wants. Scientists, aware that the
media are simply passing the blame, continue to deride the manner in which research and technology information are transmitted. "Despite a few complaints, scientists who are concerned with the way television is treating their profession do not, as a whole, find fault with these shows over inaccuracies or distortions.... Most criticism from the scientific community is directed not at what these shows do but at what they leave out." (Zoglin, 1981) So by far the largest complaint among scientists concerning the presentation of their work is that the stories are terribly misleading and fail to include important concepts crucial to accurate communication of the issue. Several studies have exacerbated their fears - the results of studies by Tankard and Ryan (1974) show that the incidence of error in science-related newspaper stories is much higher than in other types of news. They found that only 8.8% were error-free as compared to 50% for other news items; 82.4% of the story headlines were misleading; and in 76.3% of the articles, information crucial to understanding and comprehension of the work was missing.

These results seem to suggest that science communicators are lax in the transmission of scientific research to the public and the resultant errors have compounded the problems of the negative perceptions of scientists and their work. Accuracy, in the scientific venue, is of extreme importance and the misguided conclusions of the media are laying waste to the scientists' attempts to go public. Their only response is to withdraw back into their insulated system, until the media become more accurate and careful in their portrayals of science or until the populace becomes more discerning in their demands for accuracy. So say the scientists. One of the problems with this viewpoint however is the set of assumptions behind the scientific community's version of information
dissemination, as well as the studies of critics like Tankard and Ryan. These views are views as judged by the scientists, not the professional communicators of the media nor even the public. The obvious source of critical evaluation in matters of a scientific bent may appear to be the scientists involved in similar work or the original sources. Criticism generally comes, not from scientists, but those actively involved, and therefore internally biased, on the accuracy of the reports. Even the judges of accuracy in Tankard and Ryan's studies were the original scientist-sources. The belief is this - Who would be better to judge the accuracy of a news story than the people most familiar with the enterprise involved? - i.e., the researchers.

But the failings of this system of accuracy-judgment lie in the communicative system of scientists and its underpinnings. Scientists are concerned with the accuracy of information they present to their colleagues. Their careers are dependent upon the careful communication of unbiased and veracious information relating to their work. They are hesitant to make unfounded conclusions or improperly formulated predictions. Scientists read articles as scientists and all the ingrained biases, formulaic styles, and communication guidelines come along with those readings. Scientists are accustomed to writing for specified audiences critical in the extreme and predictable in their analysis. But scientific methods of information communication and lay knowledge methods are vastly different. The accuracy studies were based upon the rendered judgments of biased observers, detailing what the scientists thought the press articles should contain, not what they actually did contain. (Dorman, 1990)

Most scientists, therefore, feel the need to proofread final news releases of the media to check for accuracy and to evaluate the subjective spin put on by
writers. They insist on having the right to examine and criticize (i.e., correct) any portions of the stories that may be in error, particularly since their scientific reputations are at stake. They fear that their colleagues, who also read the papers, will evaluate the stories in the same manner as the scientist-source and if mistakes or erroneous implications are made on the part of the reporter, they will be interpreted as his/her own. In so paraphrasing their work, accuracy and clarity lose out in the reduced version. Some journalists agree with this view, feeling that they should be answerable to the scientists (Schneider, 1986) but most agree with Russell (1986) when he states that, "While scientists would be offended if we suggested that reporters help them design their experiments or write them up for publication in a prestigious journal, they don't seem to think the reverse is a problem for us." What the scientists fail to see are the constraints of the media system, very different from their own internal constraints, and how they affect the communicative style of the reports.

In addition, scientists (and other media critics) must realize that the problems of scientific communication do not only lie in the deficiencies of the media when their paraphrasing methods tend to distort the message relayed to the public. This only takes into account the failings of the relayed signal and receivers (the media and the receptive public). Similar to a distortion or poor transmission on any communication system, the fault may lie not only in the receiver but just as likely in the transmitter - in this case, the scientist-sources. Problems are also inherent in the scientist's inability to understand how best to represent their work or how to translate it for dissemination. If they are keen to avoid the distortion and inaccuracies that crop up in translation, they should take it upon themselves to learn how the communication process works, what
methods work the best, and then present it to the media in a form that they can readily use, without having to transcribe it to the "common" language of lay terms and thinking patterns. Scientists must either accept the weaknesses of the media communication methods or learn them from the other side of the fence so that they may better facilitate the proper, and accurate transmission of their work. The lay public sets several demands on the media and these constraints, along with the constraints of the news industry, define the types and styles of materials presented. The public is generally interested in the implications of new research and though scientists are leery of propounding them, they must be the ones to suggest the possible implications of their work, or leave it to the less qualified determination of the journalists. Though scientists may consider themselves as conducting "pure" research, if their work is to be presented to the public (and if they desire public support and funding), they must be willing to talk of the "future possibilities" in their area. Journalists tend to stress issues of obvious significance and scientists must become willing to guide them in their analysis. (Flatow, 1986)

This is not to say that journalists should be free to act as they deem necessary. They too, must realize the demands put on the scientists from their political body, the constraints of the communication system within science, and the need to allow critical peer review of research before going to the press. For the most part, science journalists (those dedicated to the transmission of science information, including both science writers and science television producers) understand this obligation to report scientific coverage responsibly. No interest of theirs is served by the distortion of scientific stories and they should be allowed, as trained professionals to carry out their job as it demands. Scientists should not
be the ultimate judges of accuracy in science journalism - that should be left to those who understand the constraints of both systems - other science journalists. Details in scientific stories should not be what dictates the form and tone of the presentations - science writing is dry enough as it is.

As scientific investigation becomes more and more complex, the issues of information depth and quantity emerge as concerns, not only for accuracy requirements, but also for the types of coverage available to the public. Depending upon your view of the necessity of scientific literacy in society (and the definitional legacy of that term), the levels and types of scientific information presented in the press may appear deficient, or at least very selective, in their coverage. How much information is enough for the public and how much are they capable of handling? Is there a minimum level (or maximum) of scientific knowledge necessary in this country? Though no definitive answers to these questions may be forthcoming, several studies have testified to the disproportional coverage of current science journalism.

In a 1978 poll by Canadian science writers, 43% of lay respondents felt that the media were not providing enough science coverage, counter to the popular critical belief that the public is not interested in scientific topics. This surprising figure may well represent an underlying interest in scientific matters in a large sector of the community but if the additional 57% were to be tapped, that is enticed into the coterie of the "interested" public, the demand for scientific news and media coverage would skyrocket. Counterevidence to this articulated craving is the meager fare present in most forms of media coverage of science, best represented by the actual lack of substantive reports of scientific issues in
newspapers across the United States. Gerbner et. al. (1981) found, in their studies of scientific news coverage, that only 1% of all newspaper items contain some form of scientific subjects. This figure is three times as much for puzzles and horoscopes. A standard of this type exhibits the poor standing of science-related issues in the national media, purportedly a reflection of the populace's wishes. A 1978 study of British popular newspapers by Jones et. al. (1978) showed the correlation between science coverage and popular demands, certainly not in line with the opinions expressed by the lay respondents in the 1978 Canadian survey. They found three remarkable trends - that
1) the more popular the newspaper, the less science it presented,
2) the more popular the newspaper, the more emphasis was placed on biomedical science
3) the more popular the newspaper, therefore, the more limited the coverage of science. Though no individual can be expected to follow every science interest or topic (Miller, 1986), Jones' study found that over 75% of the science coverage was medicine and medically related topics. Even more surprising was the fact that of the entire 1% science coverage in newspapers, 38% of the total included were actually science presented in advertisements.

Clearly, these studies suggest that the public is unhappy with the current style of scientific coverage, even with the demonstrated expression of a desire to see more science in the media. They have focused only on the topics that directly affect their personal well-being and health (certainly to be expected), but beyond this, have little interest in delving into other scientific issues. The desire to see more scientific coverage can be interpreted in two ways. Either the public, when asked whether they would like to see more science coverage, is confusing the
distinction between medical news and scientific topics or they actually do wish that more coverage was present but are only interested in engaging and exciting forms of science-related stories - something they are not getting in the current media format. It may be that the media have tried to expose the lay audience to other areas of science and these attempts have failed to elicit popular responses or, more likely, the media have simply ignored these areas because they are traditionally dry and complex topics (in addition, most science journalists and their editors selectively reject topics that do not interest them personally - see Chapter 2: Constraints of science journalism). Again, the style of media coverage must change in order to accommodate and draw in those that have the underlying spark of interest in science. The stories need to refocus their attentions to the methods of science and scientists, the humanistic side of the endeavor, and, it cannot be stressed enough, the process of the scientific investigation. This change will, as I have proposed, open up new avenues of scientific interest in the populace. Most readers are hesitant to submerge themselves in jargon-laden, theoretical aspects of science, because of the prior failures of science journalism to bring the subjects down to the level of the readership, and ignite that emotive quality in even the most cut-and-dry of topics.

Increased and expanded coverage are not the only issues at stake in the coverage of science topics. The actual depth of coverage within a specified story or subject is of growing concern to those responsible for relating their information. Just how much does the general public need to know about particle physics or contaminant toxicity? The amount of detail covered in science stories varies widely according to the source of transmission and the vehicle of information dissemination. Science journalists are in a universal Catch-22. In their need to
communicate the maximum amount of information to the reader, they must also balance the necessity to present the topic in the simplest of terms in order to avoid confusing the reader and losing their interest. As Ira Flatow (1986), of *Newton's Apple* fame, the immensely popular science "explain-it-all" program of the 90s, puts it, "Unfortunately, the question of detail becomes more and more important as our technical society gets more and more complex. In a society that depends upon high technology, decision makers and the public must continually juggle their need to know with their ability to understand."

Journalists have been asked to fill the role of information providers and watchdogs. Though they are reluctant to serve as judge and jury in the administration of scientific issues, the inability of the lay public to comprehend fully the requisite details puts the journalists in a bind. Most science journalists have decent backgrounds in scientific concepts and feel themselves capable of translating serious science issues but their audiences are generally far from this vantage point. Journalists have traditionally perceived their role in the media as transmission sources, responsible for the dissemination of information important to the public and for assisting them in the interpretation of that material. They have used their positions to expose and examine particular politically and socially relevant issues, providing the prerequisites for debate and guidance in the challenges of the audience. But science journalists are not afforded this comfortable set of circumstances, for their readership is often far behind in the informational background available to them.

In most situations, the science journalist does not have the luxury of time and space to educate the reader extensively so a determinative decision must be made. The journalist can choose to present the facts of the issues, relevant
opinions, and structured syntheses of the applicable outcomes, hoping that the populace is capable of coming to terms with the complexities of the problem and making the final rationalized analysis on their own. Or the journalist can choose to examine the issue independently, using the full powers of an educated foundation and an insider's vantage, to come to some sort of judgment concerning the topic and relay this determination to the public. This "watchdog" function has always been of primary concern in journalism circles and the traditional decision-making process of science conventionally being surrounded in secrecy, has served to underline its importance (Goodfield, 1981). So journalists are presented with a dilemma - the political aspects of the scientific enterprise have obligated them to guard against the dangers of an unopposed system and multitudes of scientific interest groups, challenging the automatic acceptance of authoritarian or expert advice (Goodfield, 1981), but the overwhelming complexities and lack of prerequisite knowledge on the part of the reader have prevented them from turning the issue over to the independent determination of the lay public. If they fill the role of the reviewer and evaluator, they are becoming the substituted judges and the valued determinations based upon their decisions are no better than those following the original expert's advice. The quandary of separation from their subjects, of objective reporting in scientific issues, clouds their journalistic roles and self-governing regulations.

A final perception-based dilemma that provides a further example of the problem of role separation in the communication of scientific information is the plight scientists find themselves in when confronting the necessity of going public. A scientist's world is comprised of two separate spheres - the sphere of
the scientific enterprise, comprised of his/her connections to associates within the laboratory, close colleagues, and external peers involved in scientific endeavors - and the second sphere, comprised of everyone else. Rarely do the lines between the two worlds intersect. A scientist's movements and actions within the realm of science are perceived as completely separate from those actions taken outside of the scientific reality. Science and society are thought of as distinct entities, completely independent from one another in both perception and behavior. There is an implicit agreement within the scientific community, a policy as strong as the governmental imposition of the separation of church and state, in which the influences of the outside world are determinedly avoided to maintain the "purity" of the scientific venture. It is necessary to maintain a distinction between outside influences and the events in a lab in order to construct scientific truths (Latour & Woolgar, 1979). Scientists believe their work to be objective, incontestable by the lay public, and pristine and entered into the public domain only to be recognized as true.

Unfortunately, as Jarvie (1990) notes, scientists are caught in their own contradiction. Scientists for years have stressed the humanistic side of their nature - "we are only human" - in their pleas for a more even-handed treatment by the press, but also consider themselves and their work as divine, free from the socially embedded effects of the outside world. "Science is, and cannot but be, a social institution, engaged in by flesh and blood persons, as well as a structured intellectual activity and its products," asserts Jarvie. The perception of scientists that they are socially inert has compounded the efforts of science communicators to convey their work to lay audiences. The public arena for them is one in which
little headway is gained for their own efforts in research and to be entered only upon demand.

**Scientific communication: modus operandi**

The failure and frictions produced by most scientific communication efforts come with the failure of science journalists to acknowledge and understand the cycle of scientific communication conducted by scientists and the resulting implications it has for the informal transmission of scientific information, and the failure of scientists to recognize the trappings and weaknesses of their own system of communication and the limiting views it demands of them. As June Goodfield (1981) observes, "Science is not a game of solitaire." The communication paths of scientific information between colleagues and within the circles of science are complex and intertwined with one another. Generally, little information reaches the outside world, and only does so after a long involved process of internal communication and clarification.

Lievrouw (1990) has elucidated the process of scientific communication by scientists and their attendant institutions, noting that the conduct of science can be viewed as a communication cycle having three progressive stages: conceptualization, documentation, and popularization (Figure 2). Scientific ideas go through several staging loops before they eventually reach the public forum, most of which happens through long periods in which the ideas are continuously bounced back and forth between scientists. Scientists, Lievrouw notes, share
social and scientific information and ideals and those pathways are governed by completely different rules than the rules governing the channel by which ideas are passed along to the public domain. According to Lievrouw, most scientists surround themselves with research cliques and groups of colleagues that are receptive to (as well as coincidental with) their own ideas. The informal communication cycle starts with the conceptualization of a scientific idea or theory, which is then passed along through the system of close associates. Generally through informal chats or group meetings, the ideas are bantered about and reformed with the assistance of the proffered critiques. These groups are normally quite homogeneous and there is little chance of lasting negative repercussions in this part of the communication cycle.

The next step, once the idea has been formally tested and rigidly defined, is the communication of the idea to larger, less formal groups of colleagues in the scientific community. Through formal documentation in accepted scientific journals, the theories are presented for further analysis by individuals without a vested interest in the project (and generally in competition with them). These groups are a lot less homogeneous than the closer associates and oftentimes do not share the same conceptual framework as the idea’s sponsor. After peer review of the articles, both before and after publication, new criticisms and ideas are formulated that directly address the implications and validity of the research. Through other published comments or research, the original scientist is given a chance to restructure the theory or defend its veracity. The idea then reenters the informal group surrounding the scientist, where it goes through the same reformation process as the initial idea (including both thought and experimental
Figure 2  Three stages of the scientific communication cycle (after Lievrouw 1990)
testing) until it is once again ready to be released to the scientific community.

These cycles continue endlessly, only once in a while kicking out an important idea needing to be communicated to the public. Not all ideas are popularized (Lievrouw, 1990) - (the majority in fact are not) - and only after extended time periods are the research results advanced to the outside world. The cycle internal to the system is considered sacrosanct in the scientific community and its precepts of honest communication and outright revelation of research details are not to be broken. These rules have been followed religiously for centuries in science and anyone caught playing outside of those rules is immediately exposed and ostracized from the community.

Unfortunately, releasing the information contained in scientific research to the public at large has some very important and undesirable results (to the scientists). First, the selection process is almost always out of the scientists' hands, for it is what the media consider to be publicly important that is eventually communicated, not the choice of the scientific community. Once the ideas have broached the scientific journals, they are open to outside reception by science journalists - who rely heavily on communications in these journals for source materials. The little control scientists actually have is through the use of press conferences and the withholding of further information, but these measures rarely affect the selective procedures of the press (though they certainly can facilitate matters). Secondly, the type and accuracy of information disseminated is determined by the science journalists and their editorial staffs, rarely giving the ultimate nod of control to the scientist-sources. Journalists, and particularly their editors, tend to stress the future possibilities of the research and the implications
for society. Scientists are circumspect in their observations for further applications or hypothetical inferences of their work, as prescribed by the dictates of their system. But the two systems are under differing rules of behavior and without any say (or little say) in what is ultimately communicated, in both topic selection and accuracy, scientists have pulled up their stakes and headed back to the comfort of their own intellectual camp. There, they are familiar with the rules and are presented with few possibilities of sensationalized reports covering their work. They know what to expect and have ultimate control of every aspect of the communication process. They do not have to worry about being misquoted. They do not have to worry about a fellow researcher attacking an opinion inferred from the transmission of their words. Every word is carefully weighed. All details are comprehensively included. These are the strictures of science - but not of science in the media.

This lack of control has resulted in the withdrawal of scientists and the scientific community as a whole from the process of public communication (or more likely, they never involved themselves in the first place). Scientists began to do their own things, behind closed doors and in the privacy of their insulated society, without concerning themselves with the public. Scientists used to think that public opinion meant little, that the misconceptions and lack of confidence of the outside world did not affect them or their research. They worried little about their funds being cut off - the products of science and the aspects of pure science fascinated the community of lay persons. Up through the early seventies, science was seen as a fantastic endeavor - a barrage of space rockets, satellites, discovery of human DNA, atomic particles, etc., and “...all this activity was accompanied by cries of admiration from the onlookers.” (Simons, quoted in
Goodfield, 1981). Scientists had their own perceptions of who they were and the types of research they were conducting, and the public had theirs. If the two didn't match, it didn't matter very much and if anything, was up to those on the outside to correct.

But now, the sanctity of "pure" science has been weakened, as evidenced in the budget cuts of the planetary exploration program's of NASA and the falling rate of funding increase in National Science Foundation's pure research projects compared to "applied" research ventures, and scientists are finding themselves desperate for public approval to maintain their funding and lost in the methods of achieving that goal. Scientists are now beginning to realize that they must communicate publicly in order to drum up support for their programs and after all these years of insular behavior, they do not have the required skills to get the job done successfully. A cloud of contempt (from the public) has settled over the scientific community and along with most other large institutions, scientists are finding themselves forced to defend their territory. The public sector, now master of a great deal of research funding, is demanding applied scientific research over the simple and refined pursuit of knowledge. The public wants to see results and wants to see answers to questions relevant to their individual lives. The "usefulness" of scientific inquiry is to solve problems and cure society's ailments, not to pursue the accumulation of superfluous knowledge aimlessly. Researchers following the simple collection of knowledge are falling victim to the social demands of a community, in deference to technology-oriented researchers. Though most scientists personally continue to avow to the pursuit of intellectual gain, most have had to cave in to the pressures of funding and direct their attentions to "solution-control" science.
Jones et. al. (1978) demonstrated this bias through the examination of media presentations of science in British newspapers. They found that science issues were not widely represented unless they touched upon questions of general social interest - i.e., technological or health-related advances. They also found that a large proportion of science items included were concerned with the moral and ethical aspects of science and that there was a general tone of suspicion and criticism underlying the presentations. Although the media may be reflecting the attitudes of society, the communication process has shifted the focus of science to the more application-oriented storyline and the public's perception of science and scientists have followed this swing, gathering momentum in the process. This perception of science has vastly affected the way in which the public looks at the enterprise, giving it a distorted and unrealistic orientation.

What is wrong with the current perception of science and scientists? To begin with, the science process is seen as an all too heroic event, as the answers to technological challenges and emerging scientific discoveries continue to flood the public over the media's airwaves. This gives the deceptive view of science as the conqueror of mystical forces and the enlightening force overpowering nature's mysteries. As Bennet (1986) explains:

*It is the power of science that it transcends wrong results... Yet most science writing focuses on the putative 'facts' of science and scants the process. The result is a disturbing overemphasis on the authority of science as a source of truth, rather than on its revolutionary potential as a way of thinking. The scientist comes off as an authority, and the validity of his work is justified by his standing, not the other way around.*

What is missing is the incredible undertaking of each scientist to pursue and uncover the intricate, complicated problems leading to that published revelation.
Scientists bungle through their work, confronting technical disasters and wrong turns at each step in their research. The scientific method is not a straight-line method of solving the world’s riddles, but through perseverance and determined ability, ultimately leads, erratic as it may be, to a better understanding of the concept than before the research had begun. Science is seen as far too successful and little mention is made of the botched attempts and screw-ups along the way. This, as Doman (1990) emphasizes, inflates expectations of what science is to produce or solve. Given any problem, science will be able to discover a solution to eliminate that inconvenience, and all within a reasonably short amount of time. Not only does this type of coverage give false hopes to those looking to science to solve our technological problems as fast as we can create them, but by focusing on breakthroughs, it, in a manner of speaking, cheapens science.

The result of this attitude (of heroic science and scientists) is that scientists are given moral and ethical dominion over social issues, altogether unrelated to their research or field of study. Alston Chase (1993), in a scathing attack of the credibility afforded to scientists, remarked that:

Someday, the epitaph of our civilization may read: “It allowed science to masquerade as moral authority.” Increasingly, policy questions are treated as scientific ones. The president and Congress consult the National Academy of Sciences the way ancient Greeks appealed to the Oracle of Delphi. Thus researchers, who are moral ignoramuses just like everybody else, are encouraged to pontificate on matters they do not understand, and the nation treats their blathering like hieroglyphics written on golden tablets.

Though the situation may not be as bad as Chase makes it out to be, he certainly strikes at a weakness in the current perception of science and scientists.
Scientists may not be the ones to blame in this predicament, but they are altogether too willing to oblige the media in their “Quest for the Holy Answer”. Surprisingly, this runs counter to the general idea of science as a useful but morally blind discipline (Jones, 1978). If science is seen as independent of the human pressures associated with processes outside of their realm, then scientific research and the data generated by it serves to legitimize information. Scientists are thereby given the status of authority figures and their judgments of moral and ethical dilemmas, assuredly free from the subjective biases of other human endeavors, are infinitely more acceptable.

A second misconception of science by the public is the supposition that science and technology are interchangeable terms (Banks & Tankel, 1990). The terms are often used in equal stead of one another and the phraseology of even the most basic of scientific concepts often uses technological inferences. Science and technology in the media, (and as a result, the public as well) are seen as merged, even though they are distinct entities. As defined by Jarvie (1990) science is simply intellectual enlightenment whereas technology is inquiry under the aim of practical success. Aiding the miscommunication and mistaken reasoning conjoining the two is the fact that science coverage is laden with jargon and complicated ideas. Journalists do little to rectify this situation, partly due to ignorance of the problem and partly due to indifference. Most of the public even confuses medicine with science, again because of the inclusion of medical issues and procedures in “scientific news” reports. Though this pejorative trend may seem to be of minor importance, it only serves as a noted reminder of the miscommunication between the media and the public, the inability of science to
correct the misguided perceptions, and the lack of initiative on the part of the lay audience to participate actively in the further analysis of science in the press.

A final, and probably more critical misconception about science is the perception that science is tediously boring. Some of the blame may lie in the media's presentation style when they cover scientific topics. Bennett (1986), continuing his analysis of the science communication industry, notes that:

*The prose in the new science press, with rare exceptions, proves to be somewhat dull and predictable... There is a stylistic monotony, a shallowness in the reporting, a lack of texture and allusion. And the very blandness of science writing becomes a flaw in the journalism because it is misleading. Science is not bland.*

Because of the overwhelming complexity of modern-day scientific research and the inclusion of technical jargon, the styles of science writers tend to shift in this direction - away from the successful narratives of other features and away from the impassioned flavor of engaging journalism. It is not that science features are incapable of being translated into works of literary grandeur - there are many examples of successful pieces - but rather it is the desire to get everything correct, the fear of misleading the populace (what scientists are always deriding), that eventually levels out the flourishes present in science stories. Scientists as a group are miserably poor writers for audiences outside their immediate fields. Ask them to write something for public reading and their inclusion of the minutiae and precision of detail, leaves little room for creative insight. Scientists don't write to be exciting; they only write to get their point across. Even more critical is the fact that:

*... scientists write so dolefully because they put their careers on the line if they dare to write well, let alone well for the general public. This is part of the larger phenomenon that being articulate can be fatal to a university career in any discipline. I would argue that one*
good novelist is worth more to society than all the professors on English literature combined; and I seldom read novels. A scientist who writes well is penalized even more than is a professor of English literature... Also most of them cannot write. Most people cannot write, but the condition is exaggerated among scientists because of the tradition that you must write badly in the scientific literature, where the passive voice is encouraged and unnecessary terms and acronyms are encouraged or even required. (Colinvaux, 1993)

Science journalists, caught between the two spheres, have fallen victim to the deficiencies of both.

Scientific data, the basis of most science news, is frightfully boring stuff. This, coupled with the monastic styles of science writers, leads to the communication of some of the most inanely dry, unimaginative drivel produced on paper. It is not, I might add, the fault of the journalists. Rather, it is their focus on the wrong aspects of science stories that leads them down this pathway. As Doman (1990) succinctly puts it, "... science has in fact only one pleasure to offer: the pleasure scientists themselves derive from their work." This, as we will discuss in the next chapter, is what gets lost in the shuffle.
CHAPTER II

The Business of Reporting Science

My perception is that many scientists feel hard done by, believing that the real nature of neither their enterprise nor its practitioners has been properly communicated by the media. On the other hand, I find among journalists a strong feeling that, if there was - or is - a problem, its origin lies squarely with the scientific profession, all too many of whose members have been singularly unconcerned, unhelpful, or just plain arrogant when it comes to explaining science to the nonscientist.

- June Goodfield  

Reflections on Science and the Media

The portrayals of science in the media

Science journalism is a most demanding career choice. Caught between two tremendously different cultures, science journalists are often forced to make compromises that both limit their capabilities and weaken their most accomplished characteristics. Few members of the press are qualified to fill such a role and fewer still are willing to devote themselves to the singular pursuit of science journalism. They used to number no more than one hundred in the entire U.S., including all wire service and local reporters, and they were responsible for a large proportion of the nation’s science news and information. Within this group of a hundred, there was a smaller, elite group of seasoned science reporters, known as the “science writing inner club” - whose members played a large part in
determining what types of science news the public was exposed to. The inner elite group consisted at any time of about twenty-five to thirty members, that traveled together to scientific meetings and socialized in an informal, but cohesive group. They shared ideas for stories, conveyed scientific information to one another, and generally cooperated in the collection and transmission of scientific news stories. Since the composition of the group changed little from year to year (most of them being involved for over ten years) and their influence increased as their credibility rose, the inner club had become responsible for the majority of science coverage in this country, via wire services and the like (Dunwoody, 1986).

As a result of their cooperative behavior and shared social interests, the same basic story was published and spread throughout the U.S. The ensuing topic reduction in national science news was a consequence of their particular interests and assignments, rather than a reflection of the public's wishes for coverage. This homogenizing of science news has lasting effects on the popular opinion and perceptions of the public concerning science issues. The public becomes interested in only the items and issues they read about, and the articles available for their consumption were determined largely by the whims of the inner club. The impact of the selection of stories may be quite significant, particularly when favored topics are covered thoroughly while neglecting other areas of science (Dunwoody, 1986). Now the situation is different. There are over seven hundred science journalists in the country, many of them being committed full-time reporters. The influence of the "inner circle", though still somewhat prevalent, has been markedly reduced. The younger cadre of science writers and reporters is now much less controlled by the restrictive practices of the trade and
as a result, the coverage has widened its scope to some degree (Dunwoody, personal communication). In a survey of British newspaper coverage of science, where an equivalent inner club controls the output, the topic selection was notably slanted in favor of a select group of scientific issues and disciplines, at the expense of other, equally relevant areas. If reporters themselves are narrowing the scope of science coverage available for the public's consumption and these selective procedures can have a marked effect on the public's perception of science, who then should judge the portrayals - in terms of both topic selection and observational distortion? The media? The scientists?

Table 1  Breakdown of science-related items in British newspapers (from Jones et. al. 1978)

<table>
<thead>
<tr>
<th>Medicine (including Human Biology)</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Science</td>
<td>6%</td>
</tr>
<tr>
<td>Engineering / Technology</td>
<td>5%</td>
</tr>
<tr>
<td>Biology (Natural History)</td>
<td>4%</td>
</tr>
<tr>
<td>Space</td>
<td>3%</td>
</tr>
<tr>
<td>Earth Sciences</td>
<td>3%</td>
</tr>
<tr>
<td>Physics</td>
<td>1%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>1%</td>
</tr>
<tr>
<td>General (Science policy, etc.)</td>
<td>1%</td>
</tr>
<tr>
<td>Unclassified (Science fiction, etc.)</td>
<td>1%</td>
</tr>
</tbody>
</table>

Many of the science journalists in the inner club claim that the selective reduction may be slightly reflective of their own interests but on the whole they are a result of editorial managing decisions and the effect of wire service transmission to local markets. Most science journalists are generally free to pick and choose the topics that they feel would be best suited for their audiences and those that are newsworthy, free from editorial constraints by their managing editors. Rarely are they assigned to cover particular science items and more
often than not are simply asked to produce the science news coverage on their own terms. Though this process may seem like an open method of obtaining science news and leaves the selective decisions in the hands of the journalists, most science journalists claim that, due to the low status of science news in their media and the distinct possibility of being deleted from covered news items, they actually have little choice in the selection process. If they want to get their stories published, they need to cover issues that are going to be included by managing or wire service editors and it is actually their interests that are reflected in the news coverage. "[M]any science reporters, this writer included, feel this gives a handful of journal editors too much power over what the public hears. (Jerome, 1989) As one journalist put it, "... he could get a story on the front page of every newspaper subscribing to AP by mentioning in his lead paragraph something about the treatment of piles, ulcers, or sexual impotence. This was because every wire service editor either had these three conditions or worried about them" (Alton Blakeslee, quoted in Goodell, 1977).

Of further concern in the accuracy of science portrayals is the issue of distortion. One of the major complaints, particularly from scientists, about science news coverage is that journalists, in their attempts to translate scientific work into popular accounts for the lay audience, wind up distorting the original concept to such a degree that the new version of the scientific idea feebly resembles the primary account. The restrictions imposed by the media - the need to compress, the need to put into lay terms, simplify, and reduce references to other materials ends up conveying the wrong message about a particular idea. Scientific principles, the critics insist, are often so complicated and rely on so much outside information that the press can do nothing but distort the original idea - so much
so that the science stories relayed to the public are grossly inaccurate, misleading, and sometimes, dead wrong. However:

_Nowadays, some scientists justify that stand by saying it's impossible to communicate such knowledge accurately; you always have to simplify things because, in essence, the public is too stupid. But the dumbest thing scientists who depend on public funds can do is not tell the public what they're using the money for. It's suicidal. I think those attitudes are declining swiftly and there are lots of scientists who do an excellent job of explaining things. They convey a sense of excitement, a sense that science is worth while._ (Sagan, quoted Playboy 1991)

How much incomplete information in science stories can still be labeled as "responsible journalism"? Science journalists argue that the simplifications are necessary otherwise the lay reader would have little chance in understanding the already enormously complicated issues. Not only that, but the fact that scientists don't often have all the answers concerning an important issue can seriously affect their abilities to transfer adequately the required information to the public. Some issues are of such importance that inaccurate, incomplete, or unclarified concepts have to be disseminated to the public, for if they waited until they had all of the answers, it may be too late. As Joann Rodgers, deputy director and director of media at the Johns Hopkins Medical Institution's Office of Public Affairs, at a panel discussion during the 1982 AAAS meetings, once put it, "...if the choice is between getting some information out - even though it has a high risk of carrying some inaccurate or misleading material to the public - and getting no information out, I choose the former." (Flatow et. al., 1986) This opinion, reflective of the media's envisioned role as social and political watchdog, runs directly counter to the highly conservative nature of scientists and their institutions.
Scientists are ever cautious of releasing unqualified information, irrespective of the social and political repercussions, because of the ephemeral quality of most scientific theory. Rash judgments or injudicious actions taken in light of the inaccurate information can have long-standing effects and discharge of this type of coverage would be highly unjustified and irresponsible. Stephen Schneider, a scientist-source at the same AAAS panel discussion, gave the following words of advice to science journalists faced with this type of decision - "Don't offer as truth what you know to be rumor, speculation, or soon-to-be-revised statements." (Flatow et. al., 1986) Most scientists, feeling pressured to take responsibility for any statements falsely construed from their comments, commonly refrain from giving any such information that is uncertain or inconclusive, in order to avoid to morass before it is started. Journalists, however, need these types of angles in order the attract readers and as a result, must turn to a group of scientists described as “visible scientists” (generally liberal and politically motivated individuals - see next section) for the spin on the scientific issues involved. Even though the “visible scientists" may be unqualified in the fields covered by the article, they are willing to speak out and suggest implications and possible applications of the research - and the writers are all too willing to listen. The end result is a story that, while it may lack certain requisite detail (guarded by the cautious and idealistic researchers) needed to understand the implied concepts fully, it still offers suggested insights (from the “visible scientists") that may be neither prudential nor predicated upon the data.

Wire services also act as mechanisms of distortion in the communicative process. Even though science writers may take elaborate pains to include all of the relevant information, they lose control of the product as soon as it is
transmitted. When a story is released to the wire services (either AP or UPI), it is transferred all around the country and made available to local markets - in its original form. The problem arises when local newspapers, with generally much less space reserved for science coverage, must edit and delete particular portions of the text in order to include it into their formats. The editors assigned to do such activities are almost always unfamiliar with scientific issues and lack the educational background to understand the implications of deleting vital sections of the story. Common practice is to take the first and last paragraphs of the story, along with a couple of other interesting-looking sections, and to print them as a completed story. What ends up on the editing room floor may have been the essential information that guaranteed the accuracy and nondistortion of the text.

The manner in which science stories are packaged for dissemination also leads to minor distortion of the concept. Science journalists, after many years of general news experience, have found the most effective ways of transmitting complex scientific ideas to the public. Jones et. al. (1978) described in their research of British science journalism, the means by which complex scientific concepts were relayed to the lay audiences. They found that the three most prominent mechanisms used to convey scientific information successfully were: 1) the idea needed to be anchored and objectified (i.e., related to a singular conceptual frame), 2) the idea must be central to an "issue package" - focusing on the controversial nature of the research, and 3) ideas were generally spread through the media for either cultural resonances, promotion by sponsors, or they fit into current media practices. Lievrouw (1990) commented on the fact that most science stories are centered around conflictive storylines: one scientist against another, the "race against time" theme, or the hidden enemy of a deadly
conceptual problem (i.e., the war against cancer, the search for an AIDS cure, etc.) Susanna Homig (1990) also found these same themes prevalent in NOVA television programs, (with the addition of economic impact, miracle and innovation, and “get-there first” themes) and the resulting stereotyping of scientists and scientific progress led to a distorted view of science by the public. She noted that programs of this type inevitably package and “refract” reality, creating the sense of an all-powerful, all-knowing enterprise pursuing a righteous path of enlightenment. As she concludes, “In the code of television, then, the sacredness of science becomes transformed into the special character of scientists; they become the high priests who negotiate for us between their mysterious world and our more mundane one.” Even Paula Apsell, the program’s producer, admits to the approach. “I want an angle when I do a story, and very often that angle is controversy.” (Apsell, quoted in Technology Review 1992)

The final distortion created in the transmission of scientific information to the public occurs in what critics refer to as “the sensationalism of science”. But what is the sensationalism of science and is it necessarily bad? In their struggle to convey scientific issues to the general public and capture their attention in the process, science journalists often employ methods of “enhancement” that both increase the enticing lure of science news but also, at the same time, reduce the level of serious theory and redirect the attentions of readers to possibly unimportant factors. Lippmann (1955) explains the predicament of science journalists as they seek to balance the two provisos:

> When distant and unfamiliar and complex things are communicated to great masses of people, the truth suffers a considerable and often radical distortion. The complex is made over into the simple, the hypothetical into the dogmatic and the relative into an absolute.
These sacrifices, often made at the expense of completed detail, are what many consider to be sensationalism of science.

But exaggerated praise and alarmism are simply two sides of the same uncritical coin. When journalists don’t question, they can’t analyze, and scientific developments are reported like the girl with the curl—either all good or all bad. The ordinary reader or viewer begins to feel like a ping-pong ball batted between the equally painful paddles of exaggerated hope and sensationalized fear. (Jerome, 1983)

Scientists in particular are vehement in their demands that scientific information be conveyed in the strictest of manners. They argue that attention should be placed upon the truth of the stories, rather than the desire to promote the issues. In her book on science in the media, June Goodfield (1981) observes that “…given a contest between truth and profit, these scientists say, the truth will always go under.”

Most scientists believe that profit and the intense need to sell newspapers are what drives science journalists to write in the manner in which they do. The more intense the pressure to sell, they note, the more intense the pressure to stretch the truth. The association between periodicals such as the National Enquirer and typical journalistic behavior do little to bolster their confidence in the endeavor. Scientists clearly don’t trust the media. In their readings of journalists’ accounts, they note a lack of attention to detail and the inclusion of extraneous issues, even if it means that the entire scientific concept is lost in the confusion. Journalists, they believe, are pandering to the masses - increasing newspaper sales and profits at the scientists’ expense. Scientists have seen themselves as victims, manipulated by the press so that the public may see a simplified version of the truth, even if it means the scientists are completely misunderstood. Goodfield (1981) notes that “…many scientists believe that too many people in
the media *always will* present the public with simplistic stories rather than struggle to explain complicated truths." And they inevitably are the losers in the process.

Though a journalist's prime goal may be to create interest in the science topic by the reader, the normal methods science journalists use should not be confused with more questionable techniques. What is sensationalism? Glynn & Tims (1982) defined the conditions in which journalists step over the line of creativity and journalistic license to a form that is both distortion and sensationalism. They list them as:

1) obvious overstatement of fact
2) exceptional emphasis on unique aspects
3) introduction of apparent bias
4) association of irrelevant issues
5) frivolous treatment of the issue

If these conditions are avoided, the creative techniques employed by journalists should be acceptable in public communication. The problem is that most scientists are accustomed to the format and style of *scientific communication* but are completely unfamiliar with those involving *public communication*. As I noted before, the rules governing scientific communication are precisely delineated and defined and are not open to "creative license". But they are completely separate from those rules governing public communication. Scientists fail to recognize the difference.

But, scientists argue, why must science stories be included in the same stylistic treatment as any other type of article? They are, after all, quite different from one another and the social or political stories have much more built-in
freedom for creativity, the argument goes. Most stories do not suffer if expressive writing is used or fall apart because of the noninclusion of a minor, yet critical detail. Leave the creativity to other media subjects - science simply can't afford it. The problem with adhering to this type of approach is the fact that science is "always newsworthy but seldom news." (Norton Zinder, quoted in Goodfield, 1981) Rarely are scientific news events so notable and vital to public activity that they are essential to the news. More often, science stories are interesting to read but have little immediate impact on people's lives. Creative ploys such as focusing on future possibilities and personal applications or the use of simplistic analogies allow the science writer to draw a reader into a subject they might normally pass over. Otherwise, most science stories would be left in the cold. Dry science writing, like poor writing of any kind, doesn't get read.

Scientists also point to the obsessive nature of the press as it focuses on confrontational or irrational issues. They cite, for example, the media's glorification of the animal rights groups and their struggle against laboratory experimentation as the principle reason more attention is placed on the issue (Goldstein, 1986). The press, by bringing undue attention to a subject, blows the matter way out of proportion and scientists find themselves wasting excessive amounts of time trying to defend their actions or rectify misunderstandings. This effectively distorts the public's perception of science and scientists and leads to a further loss in public confidence in science. But science needs outside watchdogs and who, if not the media, is going to fulfill this role? Scientists, like any other political or social entity, should not be free of observation or criticism, even if it means they must allot precious time to defend themselves from the effects of public scrutiny. The media may tend to focus on more confrontational or
scandalous types of issues but it is exactly in that domain that the public needs to be informed. Normal, non-perfidious science can continue unabated. Though, in my opinion, science journalism should focus their attentions to other matters, such as the process of science, they should also maintain their watchdog function as a check on that process.

The science popularizers

Though scientists may feel that the press tends to rely on the scandalous and confrontational aspects of science, ordinarily this is not so. Most science portrayals in the media can be classified into one of two categories: those that report on the scandals and confrontational aspects of science and those that promote, or "popularize", the discipline. By far, the greatest number of science stories fall into the latter category. The scientific press, due to several relationship restrictions, generally acts as the front-man for the scientific community, giving the impression of a beneficent force at work. The image of scientists actively promoted by science journalists is an image of the all-knowing, immaculate scientist with pure and undefiled concepts and skills. Far from the defamatory image most scientists envision, science journalism spreads a "glorified portrayal of science" (Doman, 1990) and consistently promotes its activities like a prize fighter.

Dorothy Nelkin (1987) described the enterprise of science journalism as downright institutional advertisement for the scientific community, plugging the
products of research and their conceptual outputs as if they were nothing more than bars of soap or boxes of cereal. There are several reasons for this behavior, the most prominent of which is the relationship between the scientific community and the scientific press. The media are unduly subordinate to scientific community because of the fact that scientists are actually in control of the relationship. The relationships are essential and reliance upon each other is stronger than any other social or political alliance. Scientists must rely on the media to inform the public of their research and results and the press must rely upon scientists for news (Goodfield, 1981). Unfortunately, the interdependency is not balanced and the press becomes subservient to the demands of the scientific community. The press needs the cooperation of the scientific community far more than the scientists do. The media cannot survive without it, for if the scientists do not talk, the press has nothing to communicate. The scientists on the other hand, have little need of communicating their work to the outside world. They would be quite content (and most are) to communicate solely within the confines of their own community and never turn to the outside world. This results in the subordination of the press to the wishes of the scientific community.

This reliance upon the scientific community translates into science stories that are both compliant and promotional. Over the years, "...science communication...has been inextricably allied with the efforts of scientific organizations to engineer dutiful coverage and to create a public that will accede to science's claim on rational authority." as observed by Doman (1990). Not only must science journalists comply with the whims of the scientific community, they end up passing on the proclamations of science as if they were credos and decrees of the rulers. Doman mentions the fact that science communication is
marked by an enduring consensus and the consensus is that science knows all the answers and is the rational voice of the population. Their reliance on the scientists as sources of their livelihood promotes coverage dutiful to scientific interests. A successful science writer builds his/her success on the esteem of the scientists (Heseltine, quoted in Kriegbaum, 1967) and this attitude, evident in their writings, inhibits the critical analysis of science and science communication. Even though all other public affairs are open to scrutiny, doubt, and debate (Doman, 1992), science journalism does its best to discourage this type of behavior.

Doman (1990) goes on to conclude that "... the role advocated to science journalists is that of a skilled and sympathetic translator." The press becomes complicit in the advancement and protection of the interests of science, simply because of its dependence on the scientist as a source. Furthermore, science journalists often become involved in the communication of science because they themselves share in the excitement of science. Science journalism requires a devoted and processed commitment to the pursuit of scientific topics and that results in the selection of individuals that, deep down, think of it as an important endeavor. They follow science because they love it and it shows in their writings. Though this is not necessarily a bad characteristic of a writer (to be dutiful to his/her subject matter), the resultant lack of critical observation becomes the norm, rather than the exception. Despite what scientists perceive to be a body of writers stacked against them, the science journalist community is actually their number one fan.
But if there is one problem inherent in the almost total accession to the scientific community by science writers, it is not that the portrayals of scientists are overly sublime. The problem is much more subtle and comes as a by-product of this attitude. It is this - that scientists, no matter how worthy their pursuits or how questionable their techniques, are rarely portrayed as human beings (though ultimately the decision to be portrayed as people lies with the scientists). This fact, more than anything else, leads to the complete acceptance of scientific dictates as gospel truth. Scientists are portrayed as above the earthly wages of sin and incapable of subjective or agenda-laden activities. Advocacy in any form can be dealt with by the public, criticized and evaluated without favor (we are accustomed to doing this for political advocacy and advertising campaigns), but when the subject is seen as above criticism and without fault, the normal interpretive mentality never sets in. Human beings are subject to error and are influenced by the compelling prejudices of society. Recognition of this fact is key to unlocking the critical analysis of human behavior. If scientists are non-human, somehow free from the tainting pressures of society, then their actions and the results of their actions are ineluctably exempt.

**Scientists as promoters**

Some scientists, a group of scientists described by Rae Goodell (1977) as the “visible scientists”, have taken it upon themselves to by-pass the normative process of science journalism and communicate scientific ideas directly to the public. Either distrustful of the media or more often than not, consummate communicators themselves, these scientists have sought to bridge the gap between the public and the scientific community in ways that science journalists
cannot hope to match. They possess a level of credibility and a fervor for science that most public science spokespersons have trouble competing against. With a flourish of drama, they bound into the public foray like actors onto an open stage. June Goodfield (1981) describes their open challenge to the woes of scientific communication:

_Feeling their larger constituency and their image slipping, feeling, too, that for whatever reason, the public does not really understand either the nature of the scientific process or the work of the scientific enterprise, they do appreciate that their right response should be better, and honest, public communication and education about science._

They may initially enter the communicative process by either accident or intention, but once inside, they soon found out that the difficulties of the enterprise, particularly for scientists, are much more than they once assumed. It is a brave lot indeed that enters the public arena - for they are more likely to be met by hordes of hungry lions than by showers of cascading roses.

Most of them enjoin the battle, as Goodfield explains, in order to rectify the misconceptions and fading confidence that hover over their discipline like vultures waiting to descend upon a dying beast. They believe that the job simply isn't getting done by the science journalists and that if the public is left to come to the truth of their own accord, the public and scientific worlds are doomed to fall further apart. The "visible scientists" feel that matters are best left to those that know the profession well, inside and out - the ones actively involved with its processes. Almost all scientist-promoters can be defined by a narrow range of characteristics, limited by constraints and dissuasive factors involved. The current group of scientist-promoters contain the likes of Carl Sagan, Stephen J. Gould, Philip Morrison, Paul Erlich, and Steven Hawking - all of them older,
controversial, relevant, articulate, colorful, and reputable as scientists. Their characteristics, though they may be defined as what "natural" communicators are made of, are not simply those characteristics that define great communicators in other fields. Scientific promoters are unique - in the conservative disciplines that they come from and the costly repercussions they must face when "going public" (Goodell, 1977).

The "visible scientists" are more science-celebrities than anything else and as Goodell asserts, "education is merely a by-product" in their efforts to communicate to the public. As she explains:

What they popularize is science-related policy issues, not science, and they often make science unpopular in the process. Nor are they the leaders in the scientific community; on the contrary, they are typically outsiders, sometimes even outcasts among established scientists, speaking from personal conscience, not group consensus.

Their mission, apart from anything else, is to convert scientific problems into visible issues. Most of them do not spend a great deal of time actually teaching science to the public but rather, engage in debate over scientific issues. They normally do not talk about their research in particular but rather, its ramifications - not about their field of expertise but other, more distantly related subjects. They almost always come from academic backgrounds - professors and the like - and as a result, they are all teachers that want to influence people. Their desire to influence is not only promoted by their educational preparations but also by the underlying belief in the responsibilities of science and scientists. They believe that a scientist should not divorce him/herself from the issues raised by their work and should take active roles in promoting the awareness, or even better, understanding of those issues.
"Visible scientists" are generally mavericks in their fields - they have hot topics and are willing to take a stand. They are liberal, but not extreme and they advocate change most every chance they get. Most of them are older (the average age is fifty-nine) and they are almost always associated with prominent institutions (universities, NASA, the Smithsonian, etc.). Most of them were visible within their own fields before they became known to the public - winning the Nobel prize being the ultimate in preferred credentials. They may be somewhat egotistical and though the press often inflates their image to the optimal edge, these scientists do very little to discourage the activity. They are what many people, particularly members of the press, consider to be "natural" speakers. They have that certain "way with words" and every line out of their mouths seems to be a good quote. They are both sought out by the press and seek out the press themselves. They have something to say about everything, even if it has little to do with their background, and journalists often call upon them to provide input for issues far beyond their scope of expertise. But, as any of the scientist-promoters can attest, the professional price to be paid within the scientific community is often quite high (Goodell, 1977).

What scientists gain in popularity outside in the public domain, they lose in credibility in their own fields of research. The demands and constraints of the scientific system limit the amount of information leaving its confines and penalize (though maybe not blatantly) those individuals who decide to forsake the rigorous bounds. As Goodfield (1981) explains, scientist-popularizers are "regarded with profound distrust by their colleagues" and have historically, been subjected to informal excommunication by the system. "Too many people in the scientific community literally believe that the process demeans both the person who
undertakes it (popularization) and the content of what is communicated." Even today, they are the ones seen as bastardizing the discipline - the tainters of pure research and the intellectual pursuit of truth. Though they must be tolerated, they are by no means venerated. The professional scientific tenet is toward basic research, even in light of its failing image, and those that follow other paths such as the popularization of scientific concepts are simply not to be treated with equal amounts of respect. Scientists are expected to have complete devotion to narrow intellectual problems and they must be active in research of high quality. Public communication, though it may be a beneficial activity, should be engaged in by those individuals who have the added leisure for such trifling pursuits. Scientists, by definition, should be doing science.

Further complicating matters is the perception of scientists that journalists are often the ones responsible for the diminishment in public confidence of science. Journalists, in their eyes, have typically damaged the credibility of science by portraying the endeavor in far too simplistic terms or overly distorted representations, and scientists that take part in the same such activities are, by association, as guilty as the indiscriminate press. Stories in the press, such as the coverage of the cold fusion affair, have led to the derision of popularizing even further by the scientific community. Cold fusion, the "hot topic" of recent science news, resulted in the discrediting of several scientists and, according to the other researchers involved, set back the investigation into cold fusion several years. The problem arose when a small group of scientists, working together to produce a cold fusion atomic reaction, released their research results to the popular press before communicating it in the scientific community. They bypassed the normal procedures as described by Lievrouw (1990) and went directly
to the popularization stage. In the end, the scientists' results (and them as well) were discredited by scientific peer review. The public, eager to hear of such fantastic possibilities, was thoroughly discouraged to find out the techniques and results were suspect. If the scientists had only gone through the established routine of peer review, the scientific community protests, before they had announced their results to the public, the publicity disaster could have been effectively avoided.

The reason, claimed the scientists involved in the early release, was that they were behind in the race to secure funding and by going public even before they had repeatable results, they were immediately thrown into the spotlight of public attention and increased their sources of funding dramatically. This belief, noted by Lievrouw (1990) - that popularization can secure or ruin funding support - has actually not held to further scrutiny by social researchers actively pursuing the connection between popularity and funding support. Dunwoody (1985) found that media visibility may noticeably constrain a scientist's ability to secure funding. She also found that scientists, for the most part, believe that popularization may be instrumental in securing external rewards such as funding but knew of little evidence that supported such a notion. Dunwoody concluded that there was actually little to be gained within science by engaging in the public dissemination of information and the current reward system is set up to benefit those engaged in research, not the communication of science. Goodell (1977), in her study of "visible scientists", discovered that media prominence hadn't hindered most of their efforts to secure funding, but it hadn't helped either. The scientific society is then, in effect, a self-policing system.
The members of that community are also actively engaged in the exaction of non-popularizing strictures. Scientists are not rewarded by their peers for popularizing their ideas, mainly because they regard it as unethical advertising. Scientists are normally involved in stiff competition and popularizing is seen as an unfair advantage to those who engage in it readily (Goodfield, 1981). Scientists develop a sense of ownership about their ideas (Lievrouw, 1990) and to promote them actively is considered the same as fulsome self-promotion. In the end, there is little financial or narrowly academic incentive to tell the public about science. The professional reputation of a scientist is on the line if they wish to go public with their ideas and they risk not being taken seriously once they make the decision to go forward. It is mainly the social system of science that serves as a barrier for popularization (Dunwoody, 1985), not any external constraints imposed on their behavior. Expanding into the realm of popular communication is simply not worth the risk of rejection by their peers for most scientists (which is why most "visible scientists" tend to be older - a scientist must establish him/herself first, then popularize. As a result, only high-ranking scientists normally become popularizers.) A young researcher has to establish him/herself before popularizing and the only way to accomplish that, by the unwritten rules of the science social system, is through patient and extensive research.

The scientific community has structured itself to maintain the laws of controlled communication, instituting measures to manage output and release of information carefully. Some entities have even gone so far as to formalize them - the most famous of which is the "Ingelfinger rule", constructed by the New England Journal of Medicine (Russell, 1986) (Dunwoody, 1985). The rule states
that any research that receives substantial attention by the press prior to being peer reviewed, will not be accepted for publication in the journal. For most researchers that would publish in areas covered by the NEJM, one of the best journals to establish credibility and a reputation in, the message is, by all measures, an unbreakable ultimatum. The scientific system doesn’t reward public dissemination of information and in this case, punishes it. Most scientists have no choice but to comply with the rules of these unwritten covenants and follow the edict that their allegiance is to the scientific community, not to society at large. As Bennet (1986) maintains: “... I am somewhat skeptical of the notion that scientists are, as a rule, motivated to foster public understanding of their work... Generals are not hired to report on their wars.”

Not only do the prescribed aspects of the communication cycle dictate the ineffability of scientists popularizing their work, the social constructs of the institution inhibit the process as well. Methods of popularization are not included in the training of scientists. The methods of communication taught in the scientific system are unequivocally dismal when they are attempted in the public domain. Scientists as a group are ghastly failures when it comes to the written transmission of their work to the public and even worse in the visual or verbal media. Bennett (1986) described the nature of their woes:

...most scientists are not successful popularizers (because) they have been trained for a controlled - really a censored - press, the refereed journals... scientists often find it difficult to adjust to the seeming unruliness of popular journalism.

Even if a scientist is motivated enough to spread the “scientific word”, they, quite frankly, are not interesting storytellers or very good writers. They lack metaphors to get their point across (Schneider in Flatow et. al., 1986) and teaching skills do
you no good when trying to convey accurately, but attractively, the complex
issues so common to science. Even more to the point is a fact Sharon Dunwoody
(1986) notes in her analysis of scientist-sources: “Charismatic teachers don't win
Nobel prizes." Scientists are not taught, or rewarded for learning on their own,
communicative or teaching skills and professional advancement has nothing to
do with the communication to outside sources (including students). Researchers
get tenure, not teachers (or communicators). Some scientists and science critics
have suggested that a scientist should take control of the communication process
(Schneider in Flatow et. al., 1986) (Goldstein, 1986) but the social limitations
often prevent them from exploring such avenues, even if they so desired.
Scientists are rarely self-employed and they must deal with the requirements of
the larger institution, which impose these types of constraints on their behavior.
Everyone looks to discredit a popularizer and there are few places to turn to for
support in such efforts. Fellow scientists are the first to turn a cold shoulder,
followed by the public. “... The communication processes during the
popularization stage tend to isolate the scientists even further from the small
original audience of colleagues and from the public as well" (Lievrouw, 1990).
One might think that science journalists would be the best ally for scientists
looking to promote their work and popularize science in the process but most
journalists are quite suspect of a scientist seeking to advance their research.
Either the scientist has a hidden agenda (funding, self-promotion, etc.) or in most
cases, the scientist simply has little to tell (Jarvie, 1990).
Journalists as promoters

The scientific journalist may appear to be the best solution for the popularization of science. They are free from the systemic constraints imposed by the scientific monolith and are exceptionally qualified in the communication of ideas to the public. However, there are several limits to science reporting that are peculiar to the discipline and science journalists in actuality may have as many controls placed upon them as scientists. Surprisingly, most of the limitations come from the same scientific system, with the identical restrictions imposed upon the scientists. Science journalists are controlled by basically the same set of rules - for what controls a scientist, controls a science journalist. Since the science media are dependent upon scientists as sources, if a scientist is prohibited from talking (or promotion), the resulting censored effect is not readily distinguishable from those pressed upon a scientist-promoter. When a scientist adheres to the "Ingelfinger rule" (actual or implied) before announcing his/her results to the media, the slowness of journal publication ultimately retards the journalist's process of information dissemination. Scientific journals are notoriously deliberate when preparing an article for publication - oftentimes going through months of review and reediting. Science journalists, by nature of the internal scientific rules, end up waiting patiently while the information becomes "old news". They are forced to construct stories as if they happened just recently, where in fact, the information is quite old. "Scientists discovered today that..." actually happened months or even years prior to that moment but according to scientific journalism technique, it is "late-breaking" news. Scientists simply cannot announce primary data and once they are free to disseminate results, they often
find it difficult to credit colleagues tangentially involved in the story (Miller, N.E., 1986).

Science journalists must also fight for a great deal of their information when covering their beat. Private companies and researchers involved with scientific advancement are often more interested in guarding information than disseminating it. Even if they can get access to such information, journalists are wary of industrial science releases. The possibility of promotional gains by the industrial organizations sets the journalist on guard and often, they pass important research details by, just to avoid the mess altogether. In turning to the scientific community, they are forced to deal with the complications of that system. What limited cooperation they get from academic sources can be offset by the inability of the scientists to pass along what information the journalist needs. Scientists do not know how journalists or the mass media work and effectively limit the reporter's resource base to the few willing, qualified, and articulate members of the scientific community they can find. Scientists end up dreading the contact with journalists and journalists respond in the same. The stereotyped behavior on both sides leads to an uneasy tension and ultimately, a lesser quality product (see next section).

No more than 100 full-time science reporters (Friedman, 1986) are working in the United States and most of them have been in the business for several years. Nearly half majored in English or journalism while in college and most spent many years as general reporters before coming to the beat (Perlman, 1974). These facts, coupled with the limited resources of the field, result in an undereducated and generally underqualified set of reporters covering the complicated and intricate topics. In complex fields, science reporters often lack
sufficient training or knowledge in the particular discipline they are covering (Jones et. al., 1978). Unfortunately, they are often called on to be reporters, and thereby experts, on fields ranging from particle physics to human medicine. Their budgets are low compared to other sectors of the news industry and they may have few resources to allocate to the story. Their staffs are generally quite small, creating enormous pressure on individual reporters to “do it all” and “do it fast”. This is not an entirely negative aspect of the field, since they are usually afforded great autonomy and independence, allowing them to cover stories they feel are important. But it also limits their coverage due to the pressure of the sheer volume of scientific output and their inability to scan all forms of research (Goodfield, 1981). More commonly, any reporter available gets sent to do a science story (Friedman, 1986) and almost assuredly that reporter has no formal scientific education or background. Even if a newspaper is large enough to have a full-time science journalist position, that reporter may be covering a scientific meeting or other science story when the call for the “breaking story” comes in. But generally, if a newspaper’s circulation is below 500,000, there is no staff science journalist. According to several surveys of metropolitan newspapers, only one-tenth of one percent of the total newspaper was devoted to science news (Goodell, 1977). This meager percentage hardly justifies a science position on staff.

Science reporters must deal with a public that normally has little knowledge of the subject. Since scientific illiteracy is a widespread problem in our nation and each story must assume no previous knowledge of the subject, relatively in-depth discussions of scientific issues are generally restricted to specialized science magazines (Science 80, Discover, Omni, etc.) or at best, the
dedicated Sunday science sections. Reporters must build bridges between the reader's understanding and the essential information and this just cannot be accomplished in five-hundred word articles. Further complicating matters, science reporters must choose the words they use very carefully, for often, scientific endeavors utilize a great deal of jargon - basically a foreign language to the lay public. Even simplistic terms such as "enzymes" or "fulcrums" cannot go without explanatory side-bars. Oversimplification or trivialized treatment of subjects on the other hand can lead to an offhanded dismissal of the story. There is often a fine line between respectability and readability.

Science reporters also must deal with editors that have almost no scientific education or background. Since the editors are exerting final editorial control over the content of the articles, science journalists must be especially careful not to include singular essential references, that, if taken out, will cause the entire story to unravel. "Beware the sub-editor" warns John Maddox (as quoted by Goodfield, 1981), former science writer for The Guardian. Without the necessary scientific background to understand which parts of a science story are indispensable, a managing editor can ravage a wonderful science piece in one fell swoop. They also don't appear to be terribly discriminating, cutting the text at unpredictable segments. Wire service editors have become infamous for destroying the content of science news stories and of greater concern to the journalist, is the headline writer, responsible for creating the eye-catching headlines (and oftentimes blatant distortion of the text). The science journalist has absolutely no control over any of these entities and must structure his/her story so tightly that removal of any component will not unravel the conceptual foundation. As a result, science news is often exceedingly direct, and hence, narratively uninteresting.
Journalist - scientist connections

Scientists and journalists, like two quarrelsome lovers on the verge of a nasty divorce, know that they need each other but seem unable to get along long enough to make things right. Relationships between scientists and journalists have historically been thought of as very stormy - the relationship more likely to be adversarial than cooperative. Bitter debates have sprung up concerning who's right, who's wrong, and who's to blame for the whole mess. Scientists accuse reporters of twisting the facts to suit their purposes and demanding far more than the scientific community can provide; journalists accuse scientists of being dry, unimaginative prudes when it comes to disseminating information and not understanding what it takes to communicate successfully to the public. There is a great deal of distrust on each side (Goodfield, 1981) - each feeling that the other must change in order to soothe the exacerbated sore between them. "If only they would do this..." complain the reporters. "If only they would do this..." protest the scientists.

The solution to the obstacles of mistrust and miscommunication may not be so facile. "Indeed, to protest such distortions, some scientists have decided to refuse to talk to the press. But by boycotting all the media, they are ignoring a growing corps of competent, careful science journalists." (Jerome, 1983) The relationship between scientist and journalist is seldom simple and the ties that bind them are intricately woven around a framework of social constraints. Scientists are not accustomed to having to deal with reporters. Before the sixties, journalists that invaded the private realm of scientists were a rare sight. Scientists
could go about their work with little consideration of the outside world and often, never encountered a journalist in their years of research - they were, quite plainly, irrelevant (Dunwoody, 1986). Since then, science journalists have edged their way into the system slowly but once inside, find themselves still facing a closed door with a sign proclaiming “No trespassing” emblazoned across the front. The lines of communication between scientists and journalists are not normally open. Compounding this restrictive behavior is the fact that science journalists generally only use one or two sources for their stories (mostly the “visible scientists”). The resulting effect is that most of the conversation between journalists and scientists occurs between members of the press talking to the same “visible scientists”. Few others are invited into the fold and new relationships, built on the long process of establishing trust, are formed ever so slowly.

Even the relationships between these insular groups are not free from defect. There is a general feeling by the journalists of awe for the scientist-sources, due to the differences in background (educational and experiential), but journalists are often hesitant to favor scientists with obsequious treatment, mindful of becoming too close to their source (Friedman, 1986). Most journalists consider themselves to be third party intermediaries (Lievrouw, 1990) and though they must groom relationships with preferred sources, they try to remain indifferent to the scientists’ demands. This can bring about sentiments of being used from the scientists and often they harbor feelings of ill-will to some members of the press.

As noted before, science reporters are also confronted with the political workings of the system of science. Popularizing scientific research or discoveries
is often professional suicide for the practicing scientist. Carl Sagan is considered by many of his colleagues as a feeble scientist with a loud voice, simply because he has chosen to popularize his field. It makes little difference that he may be an excellent astrophysicist whose work on the Viking and Mariner missions has been of incalculable importance. Science reporters must continually battle this "scientists don't do that sort of thing" mentality.

Underlying this attitude among scientists is the belief that they have been unfairly treated by the media. Since science reporters are limited to such brief accounts of the story, they must present a selective portion of the research project, that often, scientists feel, omits important facts or details in the research. Reporters must also select aspects of the entire field, and generally give only one side of the story without competing research. Not only does this lead to a misrepresentation of the subject or field, but some researchers feel that they have not been given their fair shake. The negative feelings of scientists also arise from the habit of science reporters to concern themselves with assertion rather than evidence. Since the public is interested in "what this all means", reporters are sometimes pushed into describing implications of the research that may be ill-founded or unpredictable, reinforcing misguided beliefs of the public and increasing the wariness of scientists. Since scientists must always be concerned with further funding, or deal with competition, any possible negative consequences that result from announcing their research news are to be avoided at all costs. The best way to do this is to shun media attention. Is it news or is it information that reporters are seeking to convey? To a scientist, this may be the most important question to ask.
As a result, there are two groups of scientists - those willing to cooperate with journalists and those who can think of nothing worse (Russell, 1986). Most scientists fall into the latter category - unwilling or averse to deal with the press. Some go so far as to say that they hate the press. Normally they think of worse-case examples (of sensationalism or distorted coverage) and they generalize the behavior to the rest of the profession. As an example, I tried once, on assignment, to write an article promoting the research of an Ohio State University professor. She was very willing to communicate with me as a fellow scientist but did not want her work communicated outside of those bounds. Her research, she claimed, would be taken out of context, simplified to the point of inaccuracy, and simply could not be understood without all the details involved. Other scientists feel no personal importance in dealing with the press - it is of little consequence to their work. Many scientists simply have their own world and feel comfortable inside its familiar bounds and do not want to step out. “Why do something that might only hurt me?”, they question. Still others carry a certain elitist attitude about them, thinking that their “pure” and “objective” research would only be sullied by the improprieties of a shameless profession. Science is science; but journalism is trash.

Those scientists unwilling to deal with the press carry out their work only within the isolated world of the scientific community, enclosed in the secure walls of scientific structure and far from the prying eyes of the press. Stephen Schneider notes that there is “a substantial element of hide-and-seek between a reporter looking for juicy quotes and a scientist trying to minimize damage to his reputation from oversimple public pronouncements or outright media distortion” (Schneider, 1986). This game, carried out at the public’s expense, is one of the
best indicators of the mistrust scientists have for the media. The media are under a great deal of pressure to create interest in order to sell newspapers and occasionally they are tempted to take shortcuts. A reporter may not go deep enough into the issue or may bend the facts to suit his/her needs, but these cases are the exceptions, not the rule. Sadly, scientists, like elephants, have very good memories and they have a hard time overlooking those instances. They are also fully aware of the fact that there may be intense pressure on a reporter to find scandals to expose in order to enhance their own reputations (as the heroic watchdog) and fearful of treading on a concealed mine, they avoid the possibility altogether.

The most popular source for scientific information is the social scientist - a legacy of the fact that editors like them, even though journalists do not (Dunwoody, 1986). Editors are interested in the “human side” of stories and social scientists often research those topics near and dear to most people’s hearts - sex, power, relationships, etc. Science journalists do not particularly favor their opinions because of the belief that they are not conducting “real” scientific research, a reflection of the scientific community’s attitude. Their credibility amongst fellow scientists, and science journalists accordingly, is quite low and though they are often sought out for story material, it is only under duress (from their editors) that the science reporters do so. Their standards of credibility are quite different from that of their editors. Science journalists rely upon several indicators when assessing a source’s credibility - mainstream status (Pfund & Hofstadter, 1981), administrative credentials, and previous contact with the media (Goodell, 1981) (Dunwoody, 1986). The scientists fulfilling these requirements (and willing to talk to the press) are often asked to be experts in all
types of related fields. As Sharon Friedman (1986) notes, it is more than likely that they will be quoted on something outside their field of expertise than on what they are actively researching.

There is, on the other hand, a small group of scientists that actively seek out media attention and are quite forward when it comes to advancing their opinion. Contrary to their original intentions, these scientists are often met with a great deal of distrust and are generally avoided when story coverage requires more information. Science reporters actively turn away the overly cooperative scientists, fearful that their education or information dissemination is simply a guise under which they are operating in order to popularize their reputations, persuade financial attendants, or push a political point. Journalists, as agents of the public, are quite susceptible to public relations efforts (Friedman, 1986) and must guard against the vulnerabilities of their profession. The role of the media has traditionally been not to trust sources at their face value (including scientists) (Russell, 1986) and those too willing to talk, like politicians too willing to serve, should be heard with assiduous reservation. Journalists are in a bind because of their reliance on scientists as professional sources (Bennett, 1986). “The plain fact is that journalists need scientists but scientists don’t need journalists” (emphasis added) (Dunwoody, 1986) but those offering their services without cost are, irrespective of their credentials or concerns, generally turned away.

Science reporters have also found themselves at odds with the cooperative scientists because, for the sake of their audience, they are looking for a definitive “answer”. Most research however, involves very complicated problems, ones without simple explanations or simple answers. A scientist may hem and haw when asked to give the “bottom line”, simply because he/she does
not feel safe in knowing the answer. Also, the directions taken by both professions run counter to each other. Scientists are looking to publish first, then publicize, whereas science news is generally the opposite. The process of science is often a very gradual one, where breakthroughs are slow to develop and must be verified (if the scientist is to survive professionally) before being considered valid results. Science reporters need on-the-spot news, as it happens, and the procedural red-tape of science does little to help them with “scoops” and “news flashes”. Also, they are often not the ones who decide what is to be science news. Peer review may mandate what is real science, not the public or the eager science reporter. Unpublishable results might as well be fairy tales or dreams. Even the tabloids rely on distorting published scientific research, rather than using unpublished results.

Another obstacle to establishing better relations between scientists and journalists lies squarely within the common practices of the media. When an editor decides to publish a story, the final account may, in actuality, not resemble the true nature of the issue. The two-handed approach, typical of most journalistic styles, can lead to extremist views being included in a story. This, in essence, gives the views credence in the mind of the public and the scientists respond by crying “foul”. In their efforts to include a balanced report, science journalists often enunciate opinions counter to the generally accepted consensus of the scientific community, simply trying to provide the public with the “opposite side of the coin”. But scientific theories, particularly after considerable debate, may reflect a majority opinion. Though there are some issues that are hotly contested by opposing theories, many do not fulfill this requirement. Scientists, for example, would not be eager to have the “flat-earth theory” included in reports
about the shape of the earth, simply to provide a sense of balance, and a journalist's rendition with the extremist theory included is, to the scientists, as harmful as an outright lie.

Ironically, scientists also believe that accuracy, within the domain of science, requires an unwillingness to take a position. "Being neutral" is a requisite characteristic of scientific investigation and subjective views are not worthy of consideration. This perception, erroneous as it may be, is common to many members of both the scientific and journalistic guilds. The contention that journalists should not be balanced is typical of the hypocritical fault-finding in either community. But more importantly, both views are outwardly wrong. Though the perceptive desire of objectivity is strong in each camp, the real issue is, as Joann Rodgers astutely explains, that "... the processes of both science and science writing take some guts and some willingness to commit to a point of view or a conclusion, on paper or on the airwaves" (emphasis added) (Flatow et. al., 1986). In my opinion, journalists need to stop worrying so much about being biased in their presentations of science and concentrate on producing more subjective, stimulating, and intriguing pieces and allowing the public to make judgments for themselves. Though this may be reworking the definition of a journalist, I believe it is necessary. Science writers need to undergo a catharsis of sorts, focusing on the primary receptivity of science by the public rather than the overall absolutist idea of increased scientific literacy. Most newspapers are openly politically biased, in one way or another, and the fact that the public is aware of this fact allows them to pick and choose freely those opinions that they feel are well founded. But in scientific writing, the belief that every written piece is objective, that everything pronounced by the institution of science is sacred, can
only lead to the glorification and hence, unintended disillusionment of the process when it turns out to be wrong. Open debate, or open expression of opinions, can, in the long run, bolster the public's interest and confidence in science.

As a resolution to the impasse facing scientist-journalist relationships, two other deficiencies need to be addressed. The first is a deficiency in the scientific system - the second, a deficiency in the journalism league. William Bennet (1986) summarizes the problem in the scientific camp:

The underlying problem is that scientists have professional goals and rules that keep them from wanting to make their work truly accessible to a popular audience... Professional jargon, just to take one obvious example, helps to serve this purpose.

Of even further concern is, as described by Sharon Dunwoody (1985), the fact that "...most scientific training does not adequately teach those who go through it to communicate with media representatives." Scientists need to begin to realize that they must concern themselves with the communication of science to the public and that science journalists are there to facilitate the transfer. They must be able to help the journalist cope with the increased specialization in science, as most science reporters fill the role of jack-of-all-trades. And more importantly, they must begin to train themselves, along with their developing pupils, how to communicate with the public and how to assist science journalists in the same process. A slow change in attitude is required, if they are to survive in the presence of the public and if society is to survive in their hands. It will not be easy, as scientists resent the need to change and oftentimes are highly conservative (Jones, 1978). But it must happen nonetheless.

The press must also take steps to effect a change in its attitude. Science reporters must begin to understand the constraints of the scientific system and
how difficult it is for scientists to go public (in timing and detail). For some reason, the media and communications people either fail to recognize the professional price to be paid or won't admit to it. Even AAAS meetings, the largest efforts of journalists and scientists to disseminate scientific information, attract the least significant scientists and research results in most fields - if only because they are generalists' meetings and implied "press conferences" for research. At a recent AAAS meeting of science communicators in Boston, I brought up the point that scientists who actively cooperate with the media suffer in reputation and their work is sullied by the exposure - and I was met by a seemingly concerted front that this just wasn't so. Scientists, they argued, are simply retreating from the issue and need to be prodded into action. They are the ones that need to change, not us. But in this case, compromise is in order. Scientists can strengthen their efforts to communicate to the public; the press can soften their approach.

What makes science "news"?

The business of reporting science news in mass media may be characterized in several ways. First, science stories are often very cursory examinations of topics. Science news, both on television and radio is limited to extremely short time-spans (generally one to three minutes for television - thirty seconds to three minutes for radio). In written form, science reports are crammed into ever smaller spaces, as the demand for "real" news presses on editorial decision-makers. Scientific articles for newspapers are generally used as Sunday
supplements, or at best, daily, single columns. They have been relegated to filler stories or "by the way"-type news, with limited space and random placement.

The science reported focuses on human related issues or those with some technological ramifications. The public is concerned with science only as it pertains to them. "Does this affect my life?" and "What can it do for me?" are questions the public is seeking to answer each time it comes upon a science story. Accordingly, the media direct their attention to stories that challenge accepted beliefs held by scientists (or the public for that matter), looking for something "new" and exciting. "Science in the mass media has remained primarily a sales contest in which the goal is to come up with the newest newness." (Jerome, 1983) "New" and "different" often translate directly into "timely" and "important", giving the impression that vital information always follows the phrase, "Scientists have discovered that...."

Reporters also favor science stories that stir up controversy. An argument or fight, be it on a grade school playground or intellectual battlefield, attracts attention, and ultimately, a paying audience. The nature/nurture controversy continues to surface in the media, often overemphasizing the opposing viewpoints, simply because it sells, pitting one side against another (though most scientists would argue otherwise). For the most part, the controversies are limited to the loop of conceptualization of scientific ideas in the inner circle of scientists - cliques - to the documentation and spread of the research into the journals for peer review and further knowledge conceptualization and generation. This loop continues endlessly, in the "inner sanctum" of the scientific circles, occasionally popping out an important public idea needing to be communicated to the general public or generating the all-out battle for intellectual control of a theory. These
science ideas and controversies are selected by three groups in particular - the “promoter” scientists themselves, the PR departments of larger institutions, or the science journalist. Press releases, news conferences, and research grazed from the science journals by the journalists are the sources. The stories are timed to coincide with the publication of a researcher’s results, playing on the “news” aspect. Each week, with the publication of the New England Journal of Medicine and the Journal of the American Medical Association (and often Nature and Science), a flood of science stories inundates the mass media. (Foreman 1986)

Science journalists (and hence the outside world) do not often concern themselves with the conversations and theorizing that goes on within the normal procedures of the scientific loop. Once in a while, a particular item may strike their eye but generally, science journalists are “presented” with the news. They are interested primarily in the “news flash” and involve themselves very little with the everyday proceedings of the scientists. As an end result, their focus is on the communication of an important breakthrough idea, not the communication of the process of science. Journalists ordinarily abide by this credo - “call me when you come up with something important - otherwise, leave me out of it” - and the public is left in the dark when it comes to coverage of regular events in scientists’ lives. Press release are an important source of information for a science reporter. “Because time is short and information complex, most reporters rely most heavily on press releases, often adopting their language as well as their content.” (Molony, 1992) To the public, science is seen as a series of continual breakthroughs and accordingly, a reporter’s emphasis is not on depth in a story but the new angle - especially in television due to time and costs (Friedman,
and "All too often, the 'Eureka!' approach to reporting science prevails" (Jerome, 1986). As the adage goes, "Americans are suckers for good news."

Then, what makes science "news"? In a national study of science writers in 1973, most journalists reported that the primary criterion for a good science story was relevance to or application for the reader. Health-oriented stories are generally a good sell, particularly if they involve good news, a cure, or actions to be taken. AIDS is far and away the most commonly covered science-related issue of the day. Some estimate that one in every four science-related articles in U.S. newspapers is connected in some way to the AIDS issue. Environmental concerns are now beginning to gain prominence in the media under the new administration and as conditions continue to deteriorate across the planet, they may continue to rise in popularity. Most science articles are focused on the drama and human interest aspects of scientific investigation. Research for research's sake, or unrelated advancements in knowledge (e.g., the discovery of a new neutron star or improvements in the field of animal behavior) are not of major concern in people's lives and are relegated to the "tid-bit" information sections, ordinarily not more than a brief paragraph - if they are covered at all. Though these types of stories may play major roles in distinct scientific disciplines, "...what a scientist calls interesting is worlds apart from what the general public calls interesting" (Wheeler, 1986).

It is the sparcity of science stories covered in the media, not the narrow selection of topics, that tends to shock most science educators and communicators. There is an enormous amount of coverage devoted directly to pseudo-scientific activities, particularly horoscopes and science fiction, in major metropolitan newspapers but generally one must look high and low to come
across an article with any scientific merit. Why is it that astrology is such a popular field, but not astronomy? "Every newspaper in America has a daily astrology column. How many even have a weekly science column?" (Sagan, quoted in Playboy 1991) It may be the media's tendency to expand the types of coverage that they feel the public is interested in and reduce those that don't play well to large audiences. But as William Bennet (1986) observes, "I think there is a large and avid audience for science stories." I would have to agree with this simple, yet challenging statement, but with the amended clause "interesting" science stories. Much of the science news that is presented to popular audiences today is quite bland and uninteresting. Journalists tend to note that the system is simply that way and that it will not change, no matter how high the ideals. But I think it can be attacked and altered if approached in the correct manner. As Hunsaker (1979) found in a study comparing the relationship between enjoyment and information gain in the reading of science articles, the less difficult science writings elicited more enjoyment than complex accounts. Not only that, Funkhouser and Maccoby (1971, 1973) found that the simplest scientific coverage is enjoyed by all levels of readers, including the most well-educated audiences. Clearly, accessible science writing should be the ultimate goal for science writers, not overloading quantity. Teach them a little and don't bury them under a lot. But if we are to address the real sector of the media in need of change to improve the quality of science communication, we must address the deficiencies of the commercial television industry - journalistic endeavors should follow accordingly. As Jon Miller (1986) notes, the interested public is far more likely to use broadcast media than print media when learning about science -
commercial television far more than public television. This exigency is what I will attempt to redress in the following chapters.
CHAPTER III
The Art of Television

Eventually, television will, I suggest, become our new Homeric form, (told around an electronic campfire) the way we can and must speak to succeeding generations. It seems too easy to dismiss its cruder aspects, to turn away from its clearly manipulative elements, or cave in to its seductive power. We must learn how to use it, make it speak our truths and tell our stories, our his-stories, in an honorable fashion.

- Ken Burns (producer of The Civil War) to the National Press Club in Washington.

This instrument can teach, it can illuminate; yes, and it can even inspire. But it can do so only to the extent that humans are determined to use it to those ends. Otherwise it is merely lights and wires in a box.

- Edward R. Murrow

Commercial television does so well doing its worst, it can’t afford to do its best.

- Fred W. Friendly

Entertainer, painkiller, vast wasteland, companion to the lonely, white noise, thief of time... What is this thing, this network of social relations, called television?

- Todd Gitlin

Why television is popular

Television has radically altered our lives in this country. There is little way around the effects - it has infiltrated almost all aspects of our world. Television sets are in shopping malls, in hospitals, on screens high above baseball fields; every direction that we turn, our gaze cannot help falling on another vehicle of the medium. It has invaded our homes and wrenched large chunks of our personal
lives for its use. The average American spends thirty hours a week watching television, a third of that is prime-time narrative (Gerbner, 1981). Why have we become so dependent on this form of entertainment? Why do large masses of people sit in their living rooms transfixed on the changing light-patterns falling across a small screen? What is it about television that makes it so intriguing?

If we can begin to answer these questions we may begin to gain an insight on how to produce more enticing science programming. Science programs are like any other kinds of programs. Those factors that make a successful program, those qualities that enable shows to capture large audiences, are normally equally relevant and utilitarian in science production. Many critics may scoff at the methods used by popular television programming, that they are not educational or enlightening and thereby should be avoided, but formal, educational television has simply failed to gather the mass audience primetime narrative and other programming formats have managed to sustain. Though producers should strive to maintain technical excellence, intellectual excellence need not be the highest concern. Entertainment is the most important factor. If quality is shunted at the price of popularity, then so be it. As Neil Postman (1985) notes:

*The best things on television are its junk, and no one and nothing is seriously threatened by it... television is at its most trivial and, therefore, most dangerous when its aspirations are high, when it presents itself as a carrier of important cultural conversations. The irony here is that this is what intellectuals and critics are constantly urging television to do.*

Commercial television is concerned with drawing the largest possible audience but we cannot blame corporate capitalism for television's mediocrity. He continues:
The high road simply doesn't pay, and the fault lies with us, not with those who provide the money for television programming... whatever aesthetic potential it may have will always be sacrificed to the requirements of the corporate sponsors intent on transforming us all into docile consumers. For my own part, I sometimes find this critical baying at the heels of commercial television just a little shrill - after all, no one forces us to watch TV...

In effect, if a tree falls on an educational channel that no one is watching, it does fail to make a sound (an impact on an audience).

But what is it about television that seems to fascinate us so? Jack Solomon (1988), author of the book *The Signs of Our Times*, a semiotic analysis of the impact of culture and television, believes that the lure of television is actually lodged in our genes - that constant changes of scene, rapid pacing, infinite variety provide the sensory stimulation and change we all need. Our behavioral norms require an ever-changing environment and without the visual stimulation, we eventually lose our attentions to the events of our surroundings. Like toads, whose visual systems prevent them from seeing any object remaining stationary, we cannot stimulate our cortexes unless some action is taking place. We thrive on action and television, though two-dimensional and contained, provides us with that requirement. It is, as Solomon puts it, “the most profound invention of the age” and gives us a view on life that is rather like a disorganized carnival of arresting images in a frame - basically it is one long episode of Monty Python (Solomon, 1988). Television cuts into our most important sense - sight. Humans lean toward their sense of sight when taking in any particular situation or observing intricate details. Most humans would feel lost without their visual acuity, even if only for a day, and relish any chance to flood their sights with visual stimuli. People love the flashing lights of Las Vegas casinos, drawn in to the seductive deluge of neon. People love strobe lights, fireworks, lightning
strikes - anything with strong visual impact and bright colors or contrast. Television is even beginning to catch on to this pull of moving images and flashing patterns. MTV is built upon that principle and hand-held camera moves are now the norm in many programs - as the images sway from side to side. Look has become everything, not necessarily the character underneath (e.g., Miami Vice). Television gives us conversation in images, not words (Postman, 1985) and good television has little to do with what is really good but rather what looks good.

We can also see how humans enjoy this quality of television in how they watch it. Television viewing is often a casual affair and fully forty percent of the time a television set is on, no one is even watching it. In a study done by time-lapse filming family room television-viewing episodes, researchers found that twenty percent of the time a set was on, no one in the room was looking at the set and another twenty percent of the time, no one was even in the room itself. Most people do not turn on their television sets to watch carefully; they turn it on simply to have it on. Most people claim that they do not sit down to view a particular program but engage in the activity to “watch television” (Allen, 1965). It is the visual stimulation that becomes important, not the intellectual stimulation of the programming content. This is supported by the infrequent use of VCRs in relation to overall viewing time. If individuals were clearly driven to watch only the programming they wanted to watch, they would elect to use their VCRs more often. But most people do not have this intention when they sit down. The first five minutes of viewing is generally spent “roaming” the channels, gathering information of what is available (Chagall, 1981). Viewers typically avoid intellectually demanding programs and now, spend a great deal of their time
“channel surfing” or “grazing” - scanning continually the channels available with their remote control, staying on one channel long enough to get a basic idea of the programming. Males are more likely to do this than females and there is almost always one person in a household that controls the use of the remote. Many people claim to be able to watch several programs at once and others, incapable of following at such a quick pace, resort to other sets in the house.

As a result, television viewing has switched from a primarily family-oriented activity to a more individual and solitary exercise. “Channel surfing” has resulted in an enormous switch in programming tactics for networks. The visual impact and “grab” of a program must now be held throughout each show not just in the first five minutes or else the viewer will move on. Programs have lost their content depth for more visually stimulating demands. Solomon (1988) describes it as the “peek-a-boo world” of disappearing and flashing images - the average length of any shot being 3.5 seconds. Television networks and producers have had to modify their styles drastically, concentrating on how they show something rather than what they actually say in a program. Jim Duffy, President of Communications for ABC Television, notes that this has empowered the viewer but enslaved the producer. “Nobody could watch it all - and that's the point. There is a choice. Your choice.” In the words of Marshall McLuhan: “the medium is the message.” Television has begun to recognize that fact - with the change in technology. Before, we were at the mercy of the dial - now we are in control of the medium. But it has reflected what we find most intriguing about the medium - the visual flash and stimulation. There is no going back, and probably no chance to change the direction we have taken. "What the mass media offer is not popular
art, but entertainment which is intended to be consumed like food, forgotten, and replaced by a new dish" (Auden quoted in Goodfield, 1981).

Television also appeals to humans because, like other primates, we are social by nature and it allows us to communicate with others in our species (though one-way), no matter their location. We want to know about other human beings - what they’re doing, what they have to say, who they’re with, etc. “In a certain sense, TV is the ultimate form of gossip,” notes Solomon (1988). It is in other ways, instant communication and we only have to flick on the set to find out what is going on in all parts of the globe. People have begun to inform themselves on, and included themselves in, the lives of other human beings scattered all over the planet. Evinced by the recent events in Bosnia, Waco, and the Persian Gulf, humans have found a technology that allows them to invade other people’s affairs (and even gossip about them among themselves). As Solomon notes, without news of the day there is no news. Old news is not news at all; it is simply historical information. If we are to find out about the activities of other human beings, we must turn to television. “Television is our culture’s principal mode of knowing about itself” (Postman, 1984). It gives us a common world view and normalizes all forms of human activity - we are all alike, particularly in the United States, because we watch the same images day in and day out.

In a sense, Americans need to watch television. When asked in a national survey which medium they would choose to give up if they had to go without one, 49% chose magazines, 22% each for radio and newspapers, but only 8% would relinquish television (Tan, 1977). Most television viewing is done at night and serves as a release for the tensions of everyday life. Watching television has
displaced sleep, socializing, and other types of diversions - because it eases psychic pressures of daily activities and our personal lives (Fowles, 1992). This form of entertainment is more than a simple diversion. For us, it has become a means of survival. "Escapism" is the term most often associated with this idea but, as Neil Postman (1984) points out, "Its emotional power is the one not to be taken lightly." For most Americans, watching television is enjoyable. In a recent national survey, Americans reported that they enjoyed watching television more than sex, eating, hobbies, religion, and marriage (Kubey & Csikzentmihalyi, 1990). David Marc (1987) poignantly summarizes the situation when he notes: "Americans look askance at television, but look at it nonetheless."

Ingredients of popular television programming

There have been many books and theses describing the technical direction and production techniques necessary to provide maximum quality in television production. The fact that television production can be ascribed to a series of procedures and stylized formats does little to illuminate the approach that should be taken to improve science television production. We can assume that the technical aspects of science programming are not to be blamed for the failure of the discipline to attract larger audiences. Most of the science programming is done quite well and is technically superb in both presentation and production. But what needs to be examined is not how to produce high-quality television programs (qualified camerapersons and technicians can accomplish this quite easily) but rather how to produce successful television programming. Strong
technical work does not translate directly to popular television programming.
Successful aspects are something altogether different. As Edson (1988) notes:

_If the language of science is unfamiliar and the message often esoteric to begin with, television's inherent limitations complicate the problem. Television is visual and it moves fast, which is great for news events, but is that enough for capturing science? Can it do justice to a scientific principle, to a story that is partly cerebral? Can it show science at work as it is, an uncertain, time-consuming negotiation among probabilities, rather than a high road to certain truth? And can it do all this and be entertaining at the same time?_

In my experience, most producers of successful television programs, series, and Hollywood films were told that their ideas would never work and would fail miserably. Most of the projects were done by individuals too pigheaded, too obstinate, and sometimes, just too dumb to listen to reason. No one, absolutely no one, knows what makes a particular film or show successful and no one could ever hope to predict whether a project will succeed or not. The highest paid television executives and production companies continually and consistently put out clunkers that for one reason or another, never reached the expectations of the forces behind them.

Most Americans will tell you that the majority of television programming is quite lousy, though they seem to enjoy it, and that their number one desire would be to improve the overall quality of the programming slightly rather than produce a few more programming gems. Success and popularity are funny things. When an artist, photographer, or producer produces a particular piece, each has no way of knowing whether it will translate beyond personal preference. One way to have any idea is to compare it to past experiences - the doomed programs and the remarkable shows. We know that programs like *NOVA* have not caught on and spread into the general public's scope of interest. We also know that the
natural history programs have attracted small, devoted followings but have also failed to become widely popular. The problem, explains Richard Zoglin, is inherent in the programming.

Another common complaint about many science programs on television, such as the highly regarded "Nova" series, is that they are "preaching to the converted" - people already interested in science. At the same time, shows that try to reach a wider audience, especially in the popular magazine format, are frequently criticized for superficiality. (Zoglin, 1981)

Some other approach must be taken if we are to ensure that people will at least begin to follow science programming to a greater extent. A speech without an audience can have no impact. So we must look to other, more successful ventures on television and determine what format, style, and additional elements are used to capture mass audiences.

**Popular television is: funny**

One of the most popular forms of television programming today is the sit-com. Humor was important in early television history and formed the foundation for many of the network shows. In the late seventies and early eighties, the sit-com lost its popular force on network television and many people predicted its eventual demise before the beginning of the next decade. But within the past ten years, sit-coms and other humor-related programs have undergone a resurrection, largely due to the overwhelming success of *The Cosby Show*, *Cheers*, and *M*A*S*H*. Since the early eighties, sit-coms have consistently ranked amongst the top ten highest rated programs on television. The format has proliferated and audiences have responded quite favorably to their reintroduction.
Humor seems to be one of the best mechanism for capturing larger audiences. "...The fact remains that comedy - entertainment of a primarily humorous nature - has always been an essential, even dominant, ingredient of American commercial television programming... Television is America's jester," wrote David Marc in his 1987 essay on the influence and comeback of the commercial sit-com style. Through the years, the format has proven its popularity over and over again and in today's primetime market, comedy programming fills over half the available time slots. Americans seem to enjoy laughing and seem to rely on their televisions to provide that laughter. Stand-up comedy is particularly suited to television viewing (Marc, 1987) and currently there is an entire cable channel devoted solely to stand-up comedy programming (The Comedy Channel).

If science programming wishes to capture larger audiences, I believe it must begin to include humor in its programs. Science has always been seen as a mundane affair and an overly complicated, unattached enterprise that has little to do with everyday life. If people are to make a connection with science and scientists, the programming must begin to reflect those qualities that individuals can most readily identify with. The most important, in my opinion, is humor. Humor brings science down from its lofty perch high above the heads of normal mortals and shows the "humaness" of the endeavor. Humor allows people to believe that they can possibly relate to the ideas of science because if the scientific community doesn't take itself so seriously, then maybe, after all, the system is not so serious. If the public laughs at something, it is far more likely to accept it than if it fears it or is intimidated by its actions.
Intimate

Popular television programming is also intimate in that it invites viewers to experience the action taking place directly rather than separate the two worlds. Television does its best at pretending it is not television at all and inveigles the audience to accompany it along on its journey. The images seem natural - an "electronic bulletin board" of our lives - hoping that the viewer does not notice the difference between real life and television. As Neil Postman (1985) describes:

...commercial television is not in the business of representing reality: its job is pushing products. And the best way to push them, American television has assumed from almost its inception, is to substitute a televised reality for a lived one, to turn the entire world into one big TV show...

Television acts as if it is our friend, continually inviting the viewer to "join us again next time" or to "sit right back and watch a tale". It directs us, leads us on, and tells us what to think and do. Television demands accession to its wishes, all the while cooing softly in the viewer's ears. Television has become our surrogate lover, companion, and friend.

Popular television shows strive to present the illusion of intimacy. The viewer is led to believe that it has walked in on a private scene and has become the fabled "fly on the wall." Some shows have gone so far as to address the viewer personally but generally, the audience is given the impression it is watching an isolated scene. The over-the-shoulder camera shots give the feeling of looking into a scene, as a person that has just walked by the episode and decided to stop to observe for a minute. For most people, intimacy translates to easily comprehensible concepts and situations. It has been shown that audience
size decreases as technical level increases (Friedman, 1986). Complexity does not inspire intimacy.

According to Solomon (1988), “Entertaining television tends to be fast-paced, gossipy, and sensually stimulating... Educational TV... does not try to create an illusion of intimacy. There’s a lot of talk on educational TV, while entertaining TV presents action and emotion.” It is in this aspect that science programming needs to change its approach. Science programs need to begin to express feelings and to talk to audiences rather than at them. Science producers should start by inviting viewers into scientists’ lives and allowing them to take part in their normal behaviors. Hill Street Blues, St. Elsewhere, and L.A. Law brought viewers into the actor’s realm, showing the emotional qualities and personal conflicts present in the police officers’, doctors’, and lawyers’ lives. Scientists laugh, cry, argue with their wives, have bitter family fights, and trip over skateboards just like the rest of the world. Intimate details of scientists’ lives need to be transmitted through science programming - showing scientists as they really are. Scientists are human beings and science is a human activity. The public needs to begin to see this side of the enterprise before it can accept the system as normal. To date, science programs have tried to isolate scientists from the “real world”, placing them as far out of reach as possible. Science was not tainted with human emotive qualities or vagrancies. It was pure, unadulterated truth. Unfortunately, this is not the reality of science and the public has responded accordingly by walling themselves off from the pursuit. This barrier needs to be taken down and can be done only by allowing the public to peek in on the private lives of scientists.
Story-oriented

Almost all successful television programming revolves around a story of some type. Drama, sit-coms, and even news programming each have their own format style but rely heavily on the presentation being molded into a formal narrative context. Most subject matter is presented as entertaining and is given form by the traditional use of a beginning, middle, and end. Almost all television programming follows the dramatic narrative curve as described by Rabiger (1992) (see figure 3) and is done for single scenes, sequences between intervening commercials, and the program as a whole. Sometimes life doesn't have a beginning, middle, and end, but we do need it (Solomon, 1988). Television molds our perception of reality and bestows us with the defined border of a logical narrative. Though television on the whole may be a collection of random images and flashes, individual programs are not. They are distinctive in their use of story lines and without the thread of a plot to wind their way through a program, most people cannot readily enjoy the visual images. We look to find a "story" in everything we do. "Television creates reality as much as records it" (Solomon, 1988) and by doing so, allows us to intake the medium's messages accurately.
The focus of much of television programming is on the plotline of a particular story - in that the actions and the characters themselves may be secondary to the baseline of the story. Characters cannot wander in and out of scenes without any semblance of a sequential plot or continuity in the action. One scene must lead to another and serve as the prerequisite foundation for the story's progression. Two programming formats that are the exception to this rule
are television news coverage and soap operas. News formats cover prescribed sequences that, though they may not follow plotlines or formulated half-hour stories, the rigidity of the format belies the public's need for detailed story structure. The nightly news is a "story" in a sense, for each night we are presented with the daily national news, local news, sports, weather, and entertainment - and in that particular order. Each topic must have the required story line (news is not simply "information blurbs") and the order must not be deviated from. If suddenly, the national news coverage started with the weather, then sports, and finally international news, the public's response would be very dramatic indeed. And soap operas, for all their discontinuity and jumping from scene to scene, remain faithful to the narrative style - they are simply five stories progressing simultaneously. Each sub-story follows the natural progression of a narrative and without the continual advancement of a plot, the soap operas would lose their appeal.

Remarkably, science programming does not consistently follow this format. Science productions do not often include distinctive story lines and in making sense of a senseless world, science productions actually blur the rationality behind scientific progress. The "story" of science is rarely followed. The only hints of a story we get in most science programming are the story of "nuclear fission" or "fractal geometry" - and these are not truly narratives but expositions of a particular subject. Layered facts about scientific concepts do not make for interesting television fare. There is no beginning, middle, and end to an exploration of particle physics. Science production needs to begin by focusing on the process of science (or the story), following the developments of a particular scientist or illuminating a sequence of events in research. Without a narrative,
science has only facts to tell... and audiences have made it clear that they are not interested in watching these types of dispatches.

**Extreme**

Popular television production exploits situational extremes - either as far-fetched distortions of reality or as bland representations of the extreme normalcy in human affairs. Successful formats follow one or the other and steer clear of the middle ground. Television audiences need to engage themselves in programs, becoming active members of the story, and to do that they must be either fooled into believing that they are viewing real life or they must be asked to suspend their disbelief completely and launch themselves into a world of fantasy. But the public cannot be asked to do both - i.e., believe that what is happening is real and yet suspend their disbelief at the appropriate times. Television normally declares itself to be one of these versions (reality or fantasy) and sets a tone for the entire progression of a show.

Human routine can be quite successful, if done correctly, and has reached enormous popularity in commercial primetime programming. Four of the top five primetime rating spots (for the month of March 1993) belonged to typified day-in and day-out behaviors of average American citizens (*Cheers, Seinfeld, Home Improvement, and Roseanne*) and it is the inclusion of audience members as “one of the gang” that is attributed to their enormous popularity. People can relate to the characters and often see themselves in the cast, reflecting the typical capricious behaviors that most of us exhibit. These types of programs typify the normal lives of most citizens and in so doing, invite viewers to join their realities with little or no alteration demanded of them. The other extreme represents the
complete suspension of reality and allows the viewer to escape to other
existences far removed from the pressures and stresses of daily life. Most of
these programs are so extreme that they actually become (and appear)
transposed into variable forms of reality. *Star Trek*, for example, is so successful
because it represents science fiction as normality. The extremes are so extreme,
they are rendered into alternative norms (Banks & Tankel, 1990). Once the
viewer has agreed not to pass judgment on the subjective extremes, the
programs are free to explore endless possibilities, taking the viewer along for the
ride. Seventy-five percent of primetime programming is fantasy programs.

Science production, again, has failed in this aspect. Science programs
typically represent their actions as normalized behaviors but make it clear that
these are not ordinary pursuits of average citizens. They play the middle ground.
The audience is asked to accept the science and research of central characters
but not include themselves in the same company. Scientists are human but are
not doing “average” types of procedures. Their realm is as unattainable as the
realm of science fiction for ordinary viewers but they are invited along to watch
the progress of science as it takes place. Viewers are continually asked to
suspend their disbelief (because they do not have the background to understand
the concepts and principles of science fully) and accept the data as given, but at
the same time, are asked to embrace the endeavor as a common affair. When
the process of science is left out, viewers must rely on the word of the program or
scientists in the program. This leads to the exclusion of the audience and
effectively, their disinterest.
American culture

Popular television is American culture. Most people rarely talk about television but rather what is on television. We like to watch ourselves in action and we especially like to relate to the characters. Those programs that include bits of Americana - bars, dingy apartments, sporting events, anything that illustrates our way of life - usually capture the largest audiences. Successful shows are not about families living in Germany or events happening in southeast Asia. They are programs with the "girl-next-door" and the "guy-just-down-the-street." They represent places where "everybody knows your name" and the times when "those were the days." The ability to relate to television programming should not be readily brushed aside. Americans like their culture and this enjoyment translates directly to the small screen. Though "escapism" always underlies the desire to watch, it only goes so far. Escapism to somebody else's life must be to another individual that we can relate to. If they behave differently than we do or react to certain circumstances in strange ways, the public is not inclined to accept the role and shies away. We watch television to see others doing things that we would like to do or act in ways that we wish we could. Unpredictable or irrational actions are simply too hard to envision.

Science programming has also failed in this manner, for it has revered its own activities as "above" the activities of the rest of society. Scientists behave in manners different from those of average citizens. They think differently (on different planes), conduct their work in uncorrupted manners (free from the pollution of subjective actions), and pursue incredible facets of the natural world that are not open to the rest of us (to be introduced only by their translators). Science has not become part of the American culture. Though technology is part
and parcel of our lives, we do not see its development as normalized human activity - only its results. In a way, society is partly to blame for this misjudged observation. But science, and science production, has done little to alleviate the problem. If scientists were introduced as people, American citizens, and shown conducting their lives outside of the scientific system, then possibly the public's perception would begin to shift. Science production needs to show scientists doing their daily activities: jogging in their spare time, playing with their kids, loving their families, whatever it takes to dissolve the illusion that scientists are non-humans. Once this approach is included, the public may be able to relate to the people pursuing scientific endeavors and perhaps, even relate to the science itself. Television is, after all, the "theater for the masses" (Postman, 1985).

**Advocacy**

One final characteristic of popular programming that is almost entirely ignored by scientific productions is the establishment of a viewpoint or conviction toward a singular belief. Scientific productions have continually emphasized the objective, even-handed approach and consequently have lost the ability to capture larger audiences. Viewers are not interested in objective programming. They require shows that elicit particular responses and advocate specific ideas. Television programming on the whole, is a very "preachy" type of curriculum. Some shows advocate political points of view and there are others that clearly state their biases to personal behaviors. Sit-coms and series are well-known vehicles for political and social "messages." It is either *Murphy Brown* advocating single parenthood and equal rights for women or *Coach* advocating abstention from sex and athletic superiority. All successful programs advance some form of political
or social ideal and the biases are generally not hidden. One of the most popular programs on television today, 60 Minutes, is infamous for extolling their personal doctrine while at the same time, disparaging the behaviors of others. The public is not interested in watching objective programming. They demand to know the opinions and beliefs of their shows - “What’s your point” and “Give me the bottom line.”

Science programs have avoided this pretense at all costs. They address all sides of an issue but never really attack them in any significant fashion. Jerome (1983) states, “If anything, most reporters are guilty not of being too critical but of not being critical enough. They tend to accept what their official sources tell them, and they rarely seek out additional sources who might provide them with more accurate information or a different perspective.” Additionally:

Coverage of technology stories has typically swung from claims of miracle science to visions of apocalypse. Why? Because reporters look for the dramatic angle to gain and hold readers’ attention. And... they do so at the expense of asking the right questions. They report the facts, and sometimes even all contending sides, but often they fail to reach the bottom of the problem with questions that will provide the public with insight and the information necessary to analyze underlying issues. (Molony, 1992)

Science productions need to begin to accentuate the virtues of a particular viewpoint or criticize the attentions of others. Whatever the case, science programs need to take sides. Normally, the programs come off as “wishy-washy” or “uncentered” and the audience reacts to this feeling by turning the programs off. No one wants to watch an hour of science, or any other subject for that matter, without coming to any sort of conclusion. In a panel discussion of science producers and writers entitled “Science, Technology, and the Media”, Ellen Shell explained the dilemma:
There are two common notions about science journalists: that they should be spokespeople for science, and that they should be objective reporters of science. But to my mind, neither of these views is adequate or even appropriate.

She goes on to explain that:

Even if we overlook the impossibility that a human being could remain objective on an issue about which he or she feels strongly enough to investigate, neither science nor the public is served if science journalists aspire to this saintly frame of mind... The job of science journalists, and of all journalists, is to listen to as many views on an issue as possible. It is also their job to report these views. But to my mind, the ultimate and most important job of science journalists is analysis. (Shell, quoted in Technology Review 1992)

Most Americans have learned not to accept everything that is presented to them via the media, but instead, accept those judgments it deems reasonable and reject those it does not give credence. The best teachers are those that take a stand and state their opinions - anybody who wants to reach their audience must believe in what they are presenting. Lecturers and instructors can give counter evidence to allow their audience to reach their own conclusions but ultimately, the speaker must advocate a particular side. If we are to teach the public about science through the televisual medium, producers must begin to ally themselves (and their programs) with a singular viewpoint. If enough subjective programs are shown, the public will be allowed to come to their own conclusions... and most importantly, their interest will follow.

An additional consideration

An additional minor consideration that is often overlooked by science productions (and in fact, a lot of television programming) is the concentration on audio
aspects of program. Soundtracks and sound effects can play major roles in engaging the viewer. We tend to forget, as television producers, that a television set not only includes a visual screen but a sound speaker as well. As Michael Rabiger (1992) recounts:

... good cinematography and good action help create a series of moods. When they are effective, this predisposes viewers to enter the movie wholeheartedly and opens them to the film's more abstract values. Once a film is freed from the tyranny of the interview-with-illustrations it can become more sensual, more lyrical, and more sensitive to atmospheres and lighting and to small but significant details that build up the strong aura of subjectivity that is for the viewer inseparable from personally felt experience... (the best way) to plan a series of moods through your film is to deliberately design a sound composition... Much of a film's power to enter the imagination lies not in the visuals but in the use of sound.

The recent educational series *The Civil War* best demonstrates the power of the audio portion of a program. Though the series was shown on PBS (not known for drawing mass audiences), it managed to become one of the highest rated, primetime programs each week, simply through its extraordinary use of sound and narration. In fact, each program, stated Ken Burns, the executive producer, was originally scripted from the sound and then the visuals were laid over the composition to match its intentions. If science production can tap this rich vein, simply by concentrating on the audio aspects of a program, the ability to involve the viewer in the process of science will become even greater. This involvement is what science production so desperately needs.
CHAPTER IV
Science on Television

No matter how exotic human civilization becomes, no matter the developments of life and society nor the complexity of the machine/human interface, there always comes interludes of lonely power when the course of humankind, the very future of humankind, depends upon the relatively simple actions of single individuals.

- Frank Herbert

I cannot say whether things will get better if we change; what I can say is they must change if they are to get better.

- G.C. Lichtenberg

The portrayals of science on television

Until now, televisual representation of the process of science employed by researchers has been one portraying the pure, unfettered pursuit of truth - with an accumulation of all sides of an issue - then, ultimately a conclusion. The medium has tried to force-feed comprehensive understanding of scientific endeavors by utilizing a purely objective program covering all bases (like the "all you need to know about cold fusion" NOVA-type programs). But this is not how science works, or for that matter, any discipline, so why should it be shown in this manner? Science is an amalgam of biased and subjective views scrutinized by a consortium of peers, that when taken as a whole, may be judged for conclusion. Individual programs do not need to fulfill this role in a single, grand synthesis. What is needed are several subjective programs - allowing viewers to make their own value judgments.
Generally, science programs are series of talking heads, chattering away on some oblique aspect of triviality or the ever-popular, cue-card soliloquy. After enough talking heads, droning voice-over narration and flashes of demonstrative illustrations, the audience is expected to have learned the subject with some minimum degree of understanding. The “If we throw enough at them, they’re bound to catch something” attitude taken by most science programming has resulted in the opposite effect - an “all-or-none” outcome. Instead of absorbing a portion of the material presented, the audience often fails miserably, like a juggler trying to keep too many balls in the air at once. This of course, is assuming the viewer has watched the entire program without changing the channel or falling asleep. Even Paula Apsell has noted the dismal state of affairs: “A lot of science journalism, both in print and on television, is simply awful.” (Apsell, quoted in Technology Review 1992) Even though, as Christopher Doman (1990) notes, “The task of science communication is to transmit as much information as possible with maximum fidelity”, care must be taken when considering exactly how this ideal translates into modern communicative programming. “Maximum fidelity” is the key issue in the transmission of scientific information to the populace and though maximum generally entails the inclusion of vast quantities, in this case it does not. Irrespective of the amount of information being disseminated to the citizenry, if the public is not listening or not even tuning their dials to the particular programs, no level of increase in the bulk of scientific programming is going to help. What needs to be addressed is the quality of current programming, not the quantity. Adding more to the system, like adding more information to a specific program, may actually have the effect of
overloading the viewer, so much so that the end result is an overall decrease in science viewership.

By looking at all sides of an issue, single programs often fail to explore the issue itself. Ken Burns once wrote, "Issues and ideas are merely pushed around the plate, never digested, by the same people, always the same people, engaged more with subtle one-upmanship among themselves and their TV alter egos than with the advancement of our understanding." Purely propagandistic routes are not the answer, but the films need a singular point of view, reflective of the story presented. Individuals in our society do not wish to hear all sides of an issue from a single source and then extract the best option. Rather, they prefer to hear a medley of opinions and pick the one that sounds best to them (a repercussion of our democratic ideology). Programs with a single point of view may seem like attempts to sway an audience - in fact they are - but the presentation of those viewpoints is what determines the persuasive power of the message. If the audience is preached to, assaulted, or even disparaged into supporting a particular point of view, the average viewer, like the average teenager, will resent the directive and reject the program's message. However, if the story is told in a straightforward fashion and the viewer is allowed to come to a conclusion of their own accord (which may be the only possible conclusion), their acceptance is generally assured. The best politicians and religious spokesmen have utilized this method for centuries. George Bush, Martin Luther King Jr., John F. Kennedy - these are all great story-tellers, not preachers of a directed message. People will listen to stories, but not speeches. In this manner, television production should begin to focus on "docudramas" of particular science stories - not all-encompassing objective programs or flagrant propagandistic films.
Current overall programming reflects the same ideology that singular science programs employ, trying to attack all sides of the literacy problem at once. The call has gone out to teach them everything and teach them now - unconcerned with the question if it will even have an observable effect on the public audience. Current science television programming, as an agent of the scientific literacy campaigns, needs to focus on achieving a singular, primary goal before moving on to address the issue of programming volume. That goal, in my opinion, should be to engage the uninterested audience in science programming and science in general through the use of non-traditional, commercial television programs aimed at elucidating the process of science and the everyday features of scientist's lives. "The real mission of science programming," says Robert Cremer, director of media projects for the Lawrence Hall of Science at the University of California, Berkeley, "should be to enable people to come to grips with the ways science is increasingly influencing their lives." (quoted in Zoglin 1981)

However, those of us trying to produce quality scientific programming for commercial television are faced with an enormous dilemma. Though the public is anxious to hear of scientific progress, particularly how technology affects their lifestyles, the image of science and scientists for the public is forbidding and strange, a giant cloud that looms over the heads of all involved. On the one hand, audiences thrill to new adventures and pushing the limits of our frontiers; yet on the other, cringe at the complexity and confusion normally associated with scientific endeavors. Graham Chedd, a former NOVA producer who was also co-producer of the magazine show Omni says:

*Science is difficult. It takes a lot of thought to grasp, and television is not a medium that induces thought in people. That limits the sort*
of science you can do. You look for stories that are containable, both intellectually and temporally - stories that are neat, intriguing, perhaps with a bit of mystery. I wouldn't want to do a story on the omega particle, for example, or neutrinos, because you're not doing science justice. You're just hand-waving at the subject. (quoted in Zoglin 1981)

The public has continually been given mixed messages about science. They are taught to respect the pursuits of scientists as they seek to uncover the mysteries of nature but at the same time are shown the diabolical results of those studies. Science has been granted immunity status, free from the invading influences of external critique, but has also been vilified on television to such an extreme, ultimately the public is hesitant to accept their declarations. The messages go even further.

Dorothy Nelkin, professor in the Cornell University Program on Science, Technology, and Society, described this state of science affairs in the television industry:

While the images of science as the source of modern day Frankensteins persist, the message is mainly that science is arcane. Television documentaries, in an effort to personalize science, make the scientist a star; the tweed and turtleneck chic of Carl Sagan and Jonathan Miller represents a contrast with the eccentric and dangerous figures on entertainment programs, but these scientists are equally idealized. Many documentaries, such as those produced by NOVA, are thick with awe and reverence; while explaining science carefully, with elegant visual images, they, too, perpetuate the image of science as arcane.

In this respect, does television have to show exactly how science works or only a fractured image of it - and to what extent do televisual representations preserve the distinction between science and the everyday?

Though, as discussed previously, the press typically celebrates the scientific community and its members as exalted constituents of a prophetic
The television industry, particularly the public broadcasting sector, has elevated the image of science to even higher dimensions. Scientists have become the only individuals in society capable of translating the natural phenomena of our world, capable of dictating ethical objectivity on matters of social concern, and serving as unbiased judges in a community locked in a bitter battle with unscrupulous individuals and agenda-following sects. Television has served to heighten the prestige and honor bestowed upon the pursuit of unencumbered knowledge by the public - presenting far more laudatory programming than investigations into the scandalous nature, or misdirected technologies, of the enterprise (as compared to journalistic accounts of the same). It is a rare televisual experience to see attacks on the enterprise or examinations into the underlying processes or faults in the system. "Cornell Professor Dorothy Nelkin, a board member of the Council for the Advancement of Science Writing, says that far from being overly negative about science, most science writers tend to glamorize it. 'While newspapers employ critics of art, theater, music, and literature, science is by and large spared from this critical approach.'" (quoted in Jerome, 1983)

NOVA, one of the most prominent and successful science programs of the day, best exemplifies this reverential attitude taken by the television industry. As described by Susanna Homig in her critical examination of the ideological portrayals utilized by the program, "NOVA appears as a product of the postindustrial elite celebrating itself, rather than a persuasive vehicle directed from one group toward another." NOVA would by most standards be considered an extremely in-depth exploration of scientific issues prevalent in modern scientific endeavors. The coverage afforded to the community of science is not
(as I’m sure the producers would readily admit) directed toward the uninterested sector of the public. The type of programming presented on *NOVA* is normally not even directed toward the interested portion of the audience, though occasional attempts to speak to this component of the viewing public are conducted. *NOVA* is the communication of scientific processes from the research community directly to the attentive segment of society. It is the scientific “haves” talking to the other portion of the scientific “haves”, with little concern for including the “have-nots”. This communicative cycle is the least imposing mechanism for breaking the primary scientific communication cycle (as described in Chapter 1), without actually having to sacrifice complexity, accuracy, or context in order to more efficiently converse with the audience. *NOVA* is the quintessential version of what most scientists would consider to be “going public”. They can actively participate in the dissemination of scientific information without having to forfeit the sanctity of their communication style and without having to worry about the possibility of oversimplification. The programs are complex treatises of scientific subjects. It is inconsequential that the uninformed or inattentive audiences are left out of the loop.

Surprisingly, *NOVA* still demands reverential consideration by those individuals closest to the scientific system. The attentive sector of the audience (i.e., those who watch *NOVA*) is called upon to follow unquestioningly the dictates of the enterprise. Those viewers who are most familiar with science and its procedures are asked to turn their critical abilities off during the programs. The scientists portrayed in *NOVA* programming represent rationality (Homig, 1990). They are the “explainers of mysterious phenomena” and oversee the examinations and discoveries of intellectual pursuits. As opposed to journalistic
accounts, scientists are used to present their story rather than professional interpreters. Most NOVA programming involves the identification of a mystery followed by a close-up of a man (scientist) who explains it (Homig, 1990). The demagogic narrator (more commonly known as the “voice of God” narrator), normally ascribed to the role of rationality in television programming, gives way to the enlightened and incisive explanations of the scientist. If other players are included in the program, they are generally only offered cursory parts and do not involve themselves in intellectual activities. Lay people are shown doing things whereas scientists are almost always shown explaining things (Homig, 1990). They are the only ones capable of explaining natural phenomena - idealized as the messengers of holy scientific scriptures. Their status is formalized by the placement of charts and blackboards, white coats and complex apparatus in their natural environment (Homig, 1990).

Most scientists are portrayed as actively pursuing intellectual endeavors, physically manifested by the indecipherable scribblings across the blackboard behind them or the bubbling chemical reactions at their side. The scientist may rarely enter the laboratory (or not even at all) but no matter the normal procedure, they must be taken to a visually enticing environment. There are two reasons for this type of filming procedure. One is exactly as described - complex laboratory apparatus and spewing chemicals are visually stimulating. Science can be terribly boring and without the creation of televisual interest, the viewer may be inclined to turn away. However, the primary reason for putting scientists in white lab coats and in front of complex mathematical formulae is because that is what scientists are expected to do. Not only does it create the sense of normalized proceedings but it reinforces the image of scientists as separate from the natural
realm inhabited by the rest of society. When a NOVA crew initially enters the scientist's environment, they may find him/her munching away happily on a sandwich and casually chatting with students and colleagues. But the scientist is immediately pulled from that "unnatural" scene and placed against the backdrop of a more "typical" scientific scene. It is not important that the true, natural environment of the scientist may be casually dressed and roaming the halls of the institution. The perceived image of a scientist must be maintained. If not, the producers are taking a chance that the viewer will dismiss the credibility of the individual as a "real" scientist. (Ironically, not only may television be perpetuating this myth, it may be responsible for its original creation.)

Though many may see this form of directed advertisement for the scientific community as an agenda-setting move by the scientific establishment, in reality it may have little to do with what the scientists would have the public believe about their enterprise. Scientists have not consciously determined that a formalized spin on the public's perception of their practice is in order but have simply gone along with the social shift because it is much easier for them. If the public believes them without critical analysis, all the better. The belief of scientists is that they have been "elected" in a way to perform the communal task of knowledge exploration and technological development. There is no need to ask for a recount every day - they should be trusted in their well-founded pursuit of objective research. But most would agree that controls are needed and that they should not be exempt from public scrutiny; it just makes their jobs much easier. So they have held with the social perception of science and have not demanded that changes be instituted.
It is society that has drifted away from the conceptual foundations of science - aided by the prevailing winds of the media. Much of the United States populace has lost interest in the pursuit of scientific endeavors and the press is only happy to accommodate the change. With less science in the media, mediocre presentations when science is addressed, and constraints of the evolving journalistic styles, science has pretty much admitted defeat and packed its bags for the weary trip home to oblivious prestige. This snowball effect, with the media abetting the social shift and the science community withdrawing from engagement, has left the country in a state of declining interest and literacy and everyone maintaining that their systems are not to blame.

Looking back at past television events about science, there are two prominent examples of programming that have directly influenced the "image" of science. Probably the biggest impacts on social attitudes toward science were the result of the Apollo missions (in the positive direction) and the Challenger explosion (in the negative direction). Both were about real science stories (though they were science "news" and largely based on technological advances - news of technological advances translates to scientific advances for most of the general public) and nothing in science has ever captured our attention so forcefully, affecting our nation as a whole. Unfortunately, we have been left with the legacy of the shuttle disaster and I believe science, and in particular technology, has suffered accordingly. In the end, almost all of the films that incorporate scientific topics or themes have had a major influence on social attitudes. Alas, it has been in the negative direction. The films have propagated the myth of an overly complex discipline, the nerdy, evil or deranged scientist, and backfiring technology.
Television, in its non-apologetic manner, has further managed to impede the attempts of anyone trying to modify the situation. Most attempts at rectifying the dismal quality of science programming on television have either sought to overhaul the system entirely or simply to add more bulk to the already unwanted load of scientific shows. Both have failed miserably. Television, as Neil Postman (1985) observed, does not need to be revamped or eliminated. Changing the entertainment concept behind modern programming cannot be accomplished. Television is bad and will always be bad. Intellectual attempts at refashioning the medium will not succeed, he contends. The public simply doesn’t want it (and probably never will). The programming will probably never reflect a more enlightened manner of transmitting images - but it can be modified to transmit the images that we carefully control. Senseless dissemination of programs is counterproductive but painstakingly constructing a visual context that both entertains the audience and transmits desired messages can be achieved.

Television has a preferred reading built into the context of the programs (Morley, 1980) and it is that preferred reading that can be modified to achieve the necessary results. Television can only set the stage for increased scientific literacy in this country - it will not ultimately correct the deficiency. Television should not hope to alleviate the woes of scientific literacy but should focus on changing attitudes toward science that will eventually augment scientific learning. Peter Jennings once noted that “television has the capacity to massage the agenda, to have a measure of impact on it and, if it really decides to be tenacious, to shift it. But rarely to set it.” Banks and Tankel (1990) noted the same impression: “Television... is more like a map maker than an agenda setter.” Television can function as a teaching tool - not of data and information, but of
perception and interest. It cannot set the national agenda - to increase scientific literacy - but can support and construct the foundations for such a change. Representation of the process of science should act as the trigger for this shift.

To date, television science production has managed to obscure, rather than reveal, the real nature of science (Homig, 1990). The belief is that showing science as it truly works would somehow make it less acceptable for the public (Pinch & Collins, 1984), primarily because it is believed that “… accounts that describe the day-to-day character of scientific activity threaten the privileged status of scientific conclusions” (Homig, 1990). Television has served as the principal agent for the protection of this exalted status. Most science programs aimed at the interested or inattentive portions of the viewing audience generally leave scientists out of the process altogether - thereby not tainting it with error-prone and biased human activity. Those that do include scientists in some manner don’t show the ad hoc procedural methods of scientists (Homig, 1990) - instead portraying them as unswerving, straight-line investigations. Most producers however rely on the “gee-whiz” aspects of science research (Jerome, 1986) or the “fluffy/cute” versions of natural phenomena.

Because most science television producers must initially rely on scientific sources, scientists influence the public definitions and perceptions of science heavily (Jones, 1978). Unfortunately, scientists are probably the most unqualified individuals to be making these types of decisions. Christopher Dornan (1990) notes that “… without the narrative artifice that comes with press handling, science makes for unfortunately dreary subject matter." Scientific investigation, at least the purely intellectual pursuit of knowledge, is not well suited for transmission via television. The televisual aspects are far more important when
producing science programs than the actual program content itself (Jones, 1978). Neil Postman poignantly describes the problem associated with televising science when he states, "... the act of thinking... is as disconcerting and boring on television as it is on a Las Vegas stage. Thinking does not play well on television, a fact that television director discovered long ago. There is not much to see in it." But most science television producers, dependent upon the direction of scientist-sources, are not inclined to follow this illuminating advice. Gerald Wheeler (1986), scientist-turned-television producer, explains:

"I tried to change television to match science rather than change my style to match television. Television styles conflict with the ways of science. Television moves fast. Success in front of the camera means moving at a high pace. There's nothing like it in science."

As a result, most television science fails miserably - fails to capture large audiences and hence, fails to fulfill expectations of teaching the public about science.

**Constraints of television**

The constraints of science news reporting may set rigid limitations on how science coverage is determined and created in this country but producing science programs for television has further restrictions that make informative, intriguing, and entertaining science programs almost unattainable. The need for fast-paced action and a visually stimulating flow of images prevents most producers from even attempting to devise methods and styles for communicating
scientific concepts - science is just too boring to make for enticing and lively programming. Science is an intellectual exercise. Television is normally the opposite. Held down by the demanding styles of television, science producers have frozen like a deer in the beam of a car's headlights, not knowing which way to turn and not knowing just what to do.

The majority of science programming is either limited to public broadcasting venues or if presented on commercial networks, is generally in the form of science news. The constraints of science news only exaggerate the problems of communicating science to the public in other media. June Goodfield (1981) describes the particular bind television science has fallen into:

...fast moving, predigested news effectively prevents the viewer from going through the process of thought and assimilation that is provoked by the printed word. The fact that television is our single most potent and widespread form of communication, and also the most influential by virtue of the numbers of people reached, only compounds the problem one faces when trying to communicate science, or any complicated topic, as it really is.

The resulting distorted image conveyed to the public is far from what most individuals involved directly with the process would call "reflective" of the true nature of the beast. The need to find new all the time coupled with the emphasis on applied technologies leaves the viewer with the distinct impression that science has only results to offer.

Science television producers are faced with a bevy of demands, restrictions, and pressures from all sides of the industry - in addition to the limits set by the scientific community (as discussed before). Of most concern to those responsible for bringing science news coverage to the world is the utter lack of time to present the story. The average length of any network television news story is just under three minutes (Friedman, 1986) and science news is generally
given an even shorter segment to work with - if it is given any time at all. Science news is almost always low in the running order during commercial newscasts (Jones, 1978) and even lower in priority. Science stories are the first to be cut from news broadcasts - they are the shorter pieces that can be eliminated to trim the time budget down to the required size but more importantly, they just aren't considered "hard" or important news. Michael Guillen, science spokesman and editor for ABC News, commented that he is the first person the director turns to when there is a need for additional time in the telecast. He is often called upon to cut his three minute pieces down to forty-five seconds or less and has had innumerable segments axed from the running order - approximately ten times more frequently than other segment producers.

Robert Bazell, science correspondent for NBC News, described the current state of network news production and the frantic compulsion to synthesize more and more news into smaller and smaller time intervals. He noted:

... that he usually gets no more than ninety seconds for a story. He jokingly said that if the Ten Commandments were to be delivered in the contemporary world, network news would report, 'The Lord issued ten commandments today. The three most important were...’ (quoted in Friedman, 1986)

The demand to produce such bite-sized fragments of news has a devastating effect on science news coverage on the commercial networks. How is it possible to explain the problems of chemical dumping, a bit of scientific background to understand the issue better, and probable implications of the story, all in a forty-five second clip? Science is an extremely technical and complex discipline and if there is no time to lay out the simplified, but insightful, reasoning behind the issues, the public has little opportunity to appreciate or understand the functions
and consequences of scientific endeavors. Everything must be neatly packaged, complete in itself, and no prior knowledge must be needed in order to understand the concepts fully (Postman, 1985). Very few science subjects, if any at all, can be accurately conveyed to an audience under these exacting conditions.

The three major networks (ABC, NBC, & CBS) have a single science/medical correspondent that appears infrequently during the week (unless there is some medical or scientific crisis that demands their explanations) but most other networks and almost all local stations cannot afford to maintain a science communicator on staff. CNN is the only other national network that currently has a science correspondent, along with several feature science reporters, serving as full-time staff members. Even their involvement is limited on twenty-four hours a day news telecast to daily twenty-minute segments and weekly one-hour specials. This calculates to two percent of their entire news coverage devoted to scientific coverage, a remarkably low percentage for a major intellectual pursuit of human society. The reporters are also under rigid news deadlines - as much as other news segments. They must be able to research scientific issues, gather footage from widely varying locations, and edit it into a cohesive, comprehensive, and understandable product - all within a twenty-four hour schedule (Russell, 1986).

These obstacles inevitably lower the accuracy and clarity of the final science segments (Wheeler, 1986), in one sense due to the short time period to research and produce the piece and in another sense due to the cursory aspect of news segments. Most pieces also have very fast explanations of complex issues (if at all) and the majority of the allotted segment time is spent simply announcing the results of research or technological advancements. The public is
afforded little opportunity to explore a subject and misunderstandings, as well as
misperceptions, are bound to crop up. Those issues are left to the longer science
productions, science series and the like, to delve further and conceptually
deeper, with critical evaluation of the topic. Ironically, most half-hour or hour-long
science programs fail to address these subjects at length. Science news normally
covers technology, hard results, breakthroughs, applications and medicine. The
procedural underpinnings of the research are almost never touched upon. Only
longer format programs have the luxury of including examinations of the process
or discussions of the approach scientists take to complex problems yet,
surprisingly, they do not. A large proportion of the science programs feature
subjects such as the natural sciences and biology (Jones, 1978) - very little
attention is given to the topics discussed in the news. The only exception might
be the topic of AIDS but I would think it hard to uncover more than two or three
programs that deal with the issue at some length and detail. In a way, the public
is not taught about those things that it needs to understand and taught those
things that are generally irrelevant to their everyday lives and concerns (i.e., cute,
furry animals or Antarctic living conditions).

Not that these programs do not have their value. But what is most
important if we are to redirect the downward slide of scientific literacy is to
engage the audience in scientific pursuits, particularly through subjects that are
relevant to their lives. The problem facing most science producers (and the
reason they have turned to producing programs that do not pertain to the daily
lives of people or scientists) is that most scientific subjects are not televisible. On
television, the visual image is everything - without it, television just becomes a
larger version of the radio - and the continual need to present fascinating visual
subjects overwhelms all other constraints of the medium. No matter how fascinating the topic or how intellectually stimulating the concept involved, without strong visual images to support the story, the program is doomed to failure. So most producers, in their desire to present stimulating images to the public, have moved away from the harder contextual issues to areas of what is benevolently referred to as “fluff” - the visually entertaining, light-hearted looks at simplistic aspects of science. In scientific research, there is a general lack of visual effects and story and so one must either be created (which can be quite difficult for disciplines such as particle physics or molecular genetics) or the producer must turn to other, more visually oriented endeavors. In the case of subjects without visual effects, most are created via a special effects crew or through animation. But these things cost money, and lots of it - something the science productions do not have in their budgets. Most science programming on television is produced at a cost around $150,000 - $400,000 per televised hour - about a tenth of that for made-for-television movies and about twice as much as for soap operas or “reality” programs (such as Cops, Code 3, or America’s Funniest Home Videos). Reality programs are spreading across the airwaves because they are cheap to produce. Television movies continue to be made because they capture large audiences. Science programming has neither benefit.

Most critics claim that television contains poor quality programming not because the audience demands it and wouldn’t watch more intellectually stimulating programs, but because the “powers that be” behind television have taken the low road to programming and the public has only followed their lead. They point to the relative success of British television and the abundance of high-caliber programs produced and aired (with large viewshipers) on their networks.
They have not pandered to the baser desires of human behavior and have forced the audience not to "turn on and tune out" but to challenge their analytical and critical abilities by giving them quality shows - and the audiences have responded quite favorably. The BBC system regularly produces scientific series and singular programs, averaging over six hundred hours of new programming each year (Perlman, 1974). The same goes for the other networks - the related Channel 4 and ITV, the independent commercial network. All three networks even have separate science production departments with forty to fifty full-time staff members. The BBC has consistently produced excellent, multiple-part specials such as *The Trials of Life, Life on Earth, The First Eden,* and *The Living Planet,* all hosted by David Attenborough, *The Day the Universe Changed, Corridors of Time, The Making of a Continent, Planet Earth,* a third of the programs televised through NOVA in the United States, and numerous others. Almost all of them are widely considered to be spectacular programs and the intellectual level of each remains high. British television science series such as *Horizon* continue to capture over half of the viewing audience (11-13 million viewers & 1/6 of the country's total population) (Jerome, 1986) - a feat rarely accomplished by any form of American programming.

This state of affairs in Britain seems to point to the actual ability of television to bring quality science programming to the masses and the apparent lack of effort on the part of American producers to get it done. But even if there were an enormous push to increase the quality of scientific programming (intellectually) in this country, ignoring for a minute the visual constraints of the discipline, American television would not be able to accomplish successfully such high ideals without entirely restructuring the broadcast system. British television
was set up quite differently from the system employed in the United States, particularly when it comes to the financing of programs. British television networks were given free reign over program content but "...American commercial television is based on the premise of delivering not a program to the audience, but a mass audience to the sponsor, at once" (Goodfield, 1981). The BBC gained funds for program production through tax levies imposed upon television viewers by the British government that were then passed on to the network as programming grants. The BBC was basically a government-funded enterprise, like the U.S. postal or national park systems, and had the flexibility of internally funneling the funds to whatever projects it deemed necessary (though this is all now changing as the BBC focus has shifted to the privatization of funding in recent years). Even ITV operated in basically the same fashion, except the funds were derived from fees collected through corporate sponsors and advertisers. These sponsors simply paid into the system of ITV, as donations or paid advertisements, but had no choice in the programs they actually sponsored. The fees were generally the same for each advertiser, irrespective if their commercials were aired during the World Cup Soccer Matches or during late-night cooking programs. As a result, sponsors may have paid less for the advertisements (as compared to $3 million thirty-second spots during the Super Bowl on U.S. networks) but the network had final control over the programming curriculum. Lower quality programs or those needing a little more time to catch on were in effect cross-subsidized by more successful programs. A television program did not live or die solely on its own success, but enjoyed the success of the network as a whole. This is not to say that programs did not need to be at all successful, but the ones executives (or even the producers) believed in, could be
given the time to grow and develop an audience before they were driven off the air. British programs did not have to be “overnight successes” like those in the U.S. As the network has begun to swing toward privatization, the British system will soon fall more and more into the form taken by American programming.

In the United States, the network systems are run quite differently. Corporate advertisers sponsor individual programs, even specific parts of a show, and have ultimate control on whether the programs will live or die. Television shows are utilized to capture large audiences (so that they may view the commercials) and for nothing else. Most Americans believe that commercial television is in the business of providing television programs to their viewing audience and, out of necessity, includes advertisements to pay the bills. What they don’t realize is that commercial networks are called that for a very good reason; they are in the business of televising commercials and it is the programs that are inconsequential, added in as a means of gathering an audience. Ratings are the authoritative forces behind American television. Ratings are numbers by which the networks prove to a sponsor that large audiences are watching their commercials (and hence, more sales for the sponsoring agent). Without high ratings, sponsors don’t pay - and without payments, programs don’t get produced. So there is an extraordinary pressure put on producers and their shows to become successful and to do it fast. Corporate sponsors will line up to support proven, successful programs but hesitate to jump the gun for newly emerging productions.

Each new production is forced to seek sponsorship before it even can begin production and the sponsor that eventually decides to back the program can pull their support at any time, leaving the program caught in mid-air. Since
television production has become such a costly affair and it is only the rare production company or group that can afford to prefinance the program, producers must continually turn to the sponsors for their approval. Sponsors, interested in capturing the largest audience possible, do not concern themselves with the detailed quality of the programs, but rather anticipate the effect changes or concepts will have on the audience draw. As a result, the program's emphasis cannot but be on the attractive characteristics of the program - what the sponsors believe will pull viewers to the program - and little concern is given to the intellectual qualities or conceptual complexities of the program. Simple, fast-moving, action-filled programs have historically drawn the larger audiences and future success can only be judged against the backdrop of previous programs. Some types of programs have always been successful - sporting events, soap operas, etc. - and sponsors are generally willing to front the money to produce such events. But science programming has not been a great draw for the industry and so sponsors are hesitant to invest in their production. Paula Apsell notes:

Science on television is very much the orphan child. There's no legacy of science on television in this country, whereas in England at the BBC, and among other European broadcasters, management has been enthusiastic about science for years. (Apsell, quoted in Technology Review 1992)

Science programs, by virtue of the previous science programming failures, are extremely difficult to fund. Independent television science producers spend more of their time looking for money than actually producing programs. Typically, a production may take three to four years to complete with over three-fourths of the time being spent trying to secure funds for production. Even those involved with producing programs in well-established series such as National Geographic or Audubon
specials can spend equal amounts of time searching for financing and developing their programs. Throughout the program's development, there is always the possibility that the funds will be pulled. Consequently, there is often an enormous amount of turnover in a particular production company as the company must hire and rehire personnel when the funds become available. Even a single program's staff may change throughout the four-year process - producers may get the money to start scripting and pre-production, later secure the funds for production, and eventually collect enough to complete post-production - all the while feeding personnel in and out of the company as the monies come in. This discontinuity of staff can have drastic effects on the quality of the series or single programs. The only constant in the production may be the producer and programs in series can become disjointed, lacking continuity in style or format. Single programs can be modified dramatically as directive forces (i.e., writers, directors, etc.) change over to new staffs and the lack of communication between sources can have profound results on the final product.

The creativity of science programming also lags behind the British system due to the lack of production control by those individuals directly involved with the production. Production staffs may be fully qualified (and fully intending) to produce high-caliber science programs but with the controlling influence held by the higher-ups and the sponsors, the production may only reflect the ideals of the upper hierarchy. As opposed to the British system where production decisions and program direction are dictated by those individuals involved with their creation, American science programs are influenced from the top down. By having to pander to the whims and demands of the upper tier - producers, directors and writers may have as little influence in the outcome of the production
as the photographers, grips, and lighting personnel. Sponsors have ultimate veto power and with the limited opportunity in terms of available programming slots and financial resources, production staffs have little choice but to comply with their wishes. Sponsors continue to insist that they do not interfere in the creative process but inevitably the desire to direct is too powerful. In the end, science programs reflect more what the sponsors consider to be attractive to the masses than what producers consider will communicate important scientific concepts.

Producers looking to change the way science is conveyed via the television medium are faced with enormous obstacles imposed by this system. Sponsors are generally unwilling to invest in risky projects and science programs as a whole are not the normal profitable fare of the commercial networks. Even those producers acting under the financial umbrella of network sponsorship (i.e., ABC fronts the money for production of the program) have little chance to push the creative limits. In today's overcompetitive climate of cable television, where the "Big Three" networks have more competition than just each other, the networks have discontinued their ventures into unknown, risky territories - charting the same, well-worn and proven courses that they have always followed over the years. Formerly, the major networks were more willing to take chances, to step out on a limb for new types of programming, but alas those days are long since gone. So science production, limited as it may be, continues on in its obscured, infrequent programming - afraid to look back and afraid to look ahead - stuck in its unsuccessful rut.

Since commercial television has been eminently hostile to science programming, the majority of science programs have traditionally been relegated to the public broadcasting system. Public broadcasting may be thought to be
exempt from these financial influences (because they are governmentally funded) but public broadcasting science producers have to worry about "sponsors" almost as much as those in commercial television.

In the United States, Nova was for a long time the only science program on television. Commercial broadcasters simply considered science a complete impossibility - that the audience would just not buy into it. They were willing to gamble with health and medical programming because of its personal angle - after all, people were interested in their own health - but commercial broadcasters were afraid of science. Even in public television, which has long supported Nova and other science series, funding is always a struggle. (Apsell, quoted in Technology Review 1992)

Public broadcasting services do not come cheap and though local stations are partially sponsored by private donations, PBS as a whole is not. Funds come from both government grants and sponsor "donations" - the larger part coming from sponsors. When a science producer wishes to fund a program, he/she must seek monies from PBS funds and directly from the sponsors. Sponsorship of a program is based almost exactly on the principles of commercial television - i.e., popularity means money. Though technically, companies only donate to particular programming, most productions provide promotional consideration to the funding corporation. These promotional considerations are nothing more than commercials for the companies; the only difference is that they are placed at the beginning and end of the program rather than interspersed throughout the hour. Even PBS funds are transferred to the most popular shows and the Corporation for Public Broadcasting acts as an agent for subsidizing costs, determined for the most part by how much the programs can "sell". Accordingly, science producers must maintain interest and capture large audiences in the same way as
commercial programmers, due to the dependency of productions on the financing and support of sponsoring entities.

The financial demands of science production (and the ensuing loss of productive control by the creative teams) may impede the progress of science programming but these are not the only obstacles facing those of us attempting to change the current status of science on television. Many other factors also influence the distortion of scientific concepts on television and help to maintain the status quo of poor quality programming. First of all, as an offshoot of the financial demands, there is a formidable need to catch and hold viewer attention in the first few minutes of a program, leading to distortion or exaggeration of the subject matter. Sensationalism, though in the visual form, is more prevalent in science television programming than in journalistic accounts. Visual appeal, capable of attracting the large audiences required by sponsors, can result in the oversimplification of scientific endeavors or more commonly, the misdirected emphasis on controversial or irrelevant actions. Everyday science lacks drama and the need to entertain often overrides the need to educate (Friedman, 1986).

With sponsors controlling the program format and substance, and scientists controlling the presentation, television producers can be restricted to singular methods more than any other medium or subject matter. Public broadcasting producers (as well as commercial producers to some degree) are subservient to the cooperation of scientists. Scientists are their subjects. Scientists are their translators and messengers. They must avoid upsetting the scientists or painting a bad picture of their research and consequently, programs such as NOVA have more constraints than other commercial productions as well as any other form of science communication (Hornig, 1990). Most people think of
Hollywood stars as being fickle and demanding in their roles on television productions but scientists are far worse. Scientists not only have personal reputations to look after but professional ones as an added limitation. If a general producer has problems with a particular actor or actress, there are many others waiting in the wings to take their place. But if a scientist is eliminated from the project, the entire program material may revolve around their work and the whole thing would have to be scrapped. And as Gerald Wheeler (1986) notes, "On television, scientists are translators, and a good translator must know both languages well." Those types of individuals are hard to come by - in effect, they must be both accomplished actors and skilled scientists. Few scientists have any idea what it takes to produce an interesting science television program (Goodfield, 1981) and fewer still that have the communication skills to accomplish those goals.

Science programs do not follow the normal pattern of production for most television shows - "Good science programs do not just happen; they must be carefully planned," to quote Neal Miller (1986). There is a difficulty in capturing scientists at work implicit in their normal behaviors (Homig, 1990). For the most part, scientists are not busily scurrying about their laboratories mixing chemicals in their everyday affairs. A great deal of their time may be spent behind a microscope, in conferences, or typing away at a computer. This, unfortunately, makes for awfully tedious television. No one wants to watch another individual think or stare transfixedly at a computer screen - viewers want action, excitement, and adventure. Most scientists never experience what people would consider "ground-shaking" thrills, and those who do, do so only occasionally. Indiana Jones might have been a great explorer and scientist - charting the
unknown regions of the world and continually facing situations of danger and intrigue. But what was not shown in the movies is the other ninety-five percent of his life, situated behind his desk in his office, pouring over books and ancient inscriptions. Falling off a cliff is exciting stuff; reading is not. If a producer sets out to document the action-filled life of a scientist, he/she must wait a long time or stage a synthesized version.

With science programs, more time may be needed to explain background information fully and with limited air time, simplicity becomes all-important. Some critics claim that science on television has become oversimplified, so much so that detailed knowledge is either lost in the simplistic analogies and explanations or foregone completely. Though this may lower substantially the amount of scientific information transmitted to the viewer, this is exactly what the medium demands. Television is not designed as a vehicle for quantities of information or in-depth concepts. The pacing is too fast and the medium does not allow for closer scrutiny. Ira Flatow (1986) explains the circumstances: “There is no way to go back and ‘hear’ a sentence again as one might reread it in a newspaper or magazine. That’s why broadcast writing is as simple as possible.” Also, most producers lack the formal education to depict complex scientific concepts accurately and must either rely on scientist to translate for them (and they are notoriously bad as television communicators) or focus only on the most basic of ideas. Jones et. al. (1978) noted in their study of British television science that most producers felt comfortable with their lack of formal education and if anything, thought it important not to have functional insights. On the contrary; they felt that if they could understand the ideas presented to them, then any viewer would be equally capable.
Producers must stick to the simpler aspects of the story for not only reasons of clarity but also because of the severe time restrictions placed on their production schedules. Even NOVA, known for its density in subject matter, tries to be as simplistic in its approach as possible.

*Whether commercial or public, television is quite inadequate for some things. It's not good, for example, at presenting abstract ideas. We're constantly amazed by how little we can actually say, even when we have a lot of time to work with. Our rule of thumb at Nova is to limit ourselves to three difficult concepts in an hour. That's because television is less a communicator of ideas than it is a teller of stories through pictures. On television, the narrative that's expressing the ideas is the subtext; the pictures are the real text. (Apsell, quoted in Technology Review 1992)*

Normally, producers are under the gun to complete production before their funds run out and this leaves them little time to research and write the story formally (Russell, 1986). Writing and research stages of the production are short in comparison with other parts of the process and though producers would like to commit more time to improving these components, the money crunch simply won't allow it. Scientists must be taken at their face value and scientific research unquestionably accepted. The result is absolute reliance upon the scientist-sources and the same mystification, god-like portrayals of scientists, so prevalent in journalistic activities.
The mysticism of science on television

The mysticism of science has reached its greatest heights in the televisual medium. Almost all of the science production currently gracing the airwaves of the United States has taken the singular role of serving science, increasing its economic power in the process and maintaining the distinction between those things "scientific" and those things "normal". The medium has presented itself as a factor in the demystification of science, illuminating the research and applications, but what it has done, in reality, is the exact opposite. Television and television journalists contend that they are a challenge to authority - the "groundshakers" of unscrupulous foundations - but for science, the effect of discourse concerning the affairs of the scientific community runs counter to this assertion. Banks and Tankel (1990) describe a situation in which images are used as acts of containment, encouraging continued scientific advancement and drumming down any thoughts counter to this opinion. It is their contention that almost all of scientific programming is self-promoting - that science shows are basically one big commercial for science.

In their thesis, they state that the television convention mitigates against depictions of technology as socially destructive. Science applications are generally positivistic and television turns to scientists as agents of social correction when problems of community concern arise. Science is what we turn to when looking for a way to fight AIDS; the scientists will come up with a cure very soon. What is rarely mentioned is the fact that AIDS is a one hundred percent preventable disease - humans need simply to change their behavioral habits. Science is what we turn to when looking for a way to clean up the environment; technology will allow us to rectify the planet's problems. Again,
what is not mentioned is that behavioral changes are easier to institute and can interdict in the downward spiral faster than technological advances. If you want to stop pollution, the medium implies, turn to technology to provide the means - not pointing out that cutting it off at the source is a far better method. Ironically, technological advances are what put us in the position of needing help and we are turning back to them to solve their own problems.

Technology on television, they note, is a conservative act and as a basis for social solution, it reinforces the imperative of technology in an industrial society. The solution to technology is more technology, not less. Technology is portrayed as the vehicle for positive social change. This perception is what determines public inhibition or encouragement of technology and television has done its best to depict technology as ultimately equivalent to progress. In the end, television images are not acts of liberation but containment - not stimuli for intellectual challenges but prevention. Television, in a sense, acts as a cultural brake - reinforcing contemporary hierarchies and allaying contemporary fears of technology. Science is signified by its technology rather than activities (Hornig, 1990) and this ultimately, prevents viewers from seeing scientists as they are - as real human beings.

This demagogic portrayal of scientists comes about as a result of the medium’s structure, particularly amongst the contingency of science producers. Most broadcasters involved with the production of scientific programs will normally hold the same views and ideals about science as the scientists themselves, referred to by Jones et. al. (1978) as the “reciprocity of perspectives”. This tendency produces the image of complicity in the final product, where scientific research is shown as a series of “mystical images of a
distant, unknowable, sacred truth, the unreachable goal toward which science gropes" (Homig, 1990). Even the documentary formats considered to be objective perspectives allow scientists to explain their work, basically as a lecturer to dutiful pupils (Doman, 1992). NOVA dramatizes science for an elite audience, the "learned" communicating to the "interested", where scientists are defined as a special type of person (Homig, 1990), not like you and me. Since the scientist-sources are the dominant partner in communication efforts through television, the tendency is even more pronounced. Even when scientists are seen in dispute or in contention from critical analyses, the antagonisms are seldom of a fundamental nature (Jones et. al., 1978) (i.e., they simply don't have a fact straight or are missing some vital piece of information). They are not shown as bickering or argumentative humans but more like robots engaged in polite discussion.

All of this may seem to be an inevitable result of the restrictions imposed by the television medium, with its need for fast-moving scenes and its inability to examine critically complex ideas at any length. Television can only be used to show the results of science and accordingly, act to preserve the distinction between scientific events and normal human activity. Television simply does not have the time to examine in-depth scientific concepts or to evaluate their results critically. It is difficult enough to achieve this to a minor degree in written form and any hope for that type of treatment must be left to the newspapers and magazines. Television does not have the luxury of explaining detailed facts or research and people would not be interested in those forms of programs even if they could be produced. I would be inclined to agree with this argument to a
certain extent, but I do not think that it is as inevitably discouraging as some would have us believe.

I believe, quite frankly, that it is entirely feasible to teach science to the disinterested public via television. Science, if communicated properly, can capture the attention of individuals that are not only disinterested but somewhat defensive to scientific insight. The emphasis should not be on complex scientific issues; it should be on the ways in which science functions - particularly the ways in which scientists work. Scientists should not be shown doing activities that are elevated and beyond the mortal realm of average human beings but how scientists go about their jobs, how they approach specific scientific problems, and most importantly, how they behave in the same fashion as all of us do. Science is not a pursuit by individuals that are far above our heads but by people, interested in answering questions in a practical manner. What turns most people away from science is the belief that scientists are doing activities beyond the average person's comprehension. If the lay person can make the connection to the scientists' lives, their interest in the subject invariably follows. But I also realize, as Gerald Wheeler most notably explains, that outside experience is a "necessary but hardly sufficient background for getting science on television."

**Science programming audience goals**

Insightful scientific programming is popular for limited audiences. Mass programming lacks scientific insight or content. Where, in the changeover, is the loss occurring and is it a prerequisite for popularity? Dunwoody (1986) notes that
"... when nonscientists are looking for scientific information, they turn to the mass media" and polls show that most Americans get their news from television (Miller, N.E., 1986), so why then aren't scientifically oriented programs more popular? Who exactly is watching the programming already available and what can be done to draw in those who are not tuned in?

Those individuals viewing science programming on public broadcasting are, as Jon Miller (1986) describes, in the attentive or interested sector of the population. Combined, they represent about forty percent of the non-scientific audience but they do not watch science programming equally. The attentive audience is far more likely to watch detailed programs such as NOVA, approximately four times as frequently as the interested segment of the population (see Table 2). Only about one-fifth of the total attentive segment watches NOVA, a small fraction of the overall viewing public. Even the attentive sector of the population does not seem to be overwhelmingly interested in watching the more difficult programs; Susanna Homig (1990) points out that, "The NOVA audience is not a typical television audience, not even a typical PBS audience." Attentive segments of the population seem to be drawn to the less intense forms of television portrayals, demanding to be entertained as well as informed. But are these even the segments of the public that need to be informed?
First we must define the audience that mass programming will appeal to. If the attentive and interested segments are the sector that could use an increase in scientific programming, then clearly something different must be produced. The current science format appeals only to a limited portion of the "scientifically intuned" audience (though programs such as NOVA and Innovation seem to have devout followings) and as detailed by Gerald Wheeler (1986), in science it's the data but in television it's the people. When we concern ourselves with bringing science to the public via television, the make-up of the audience and the definition of "public" become important. June Goodfield (1981) outlines what the focus for science producers should be when they seek to communicate to the community: "...the public out there, whose influence is increasingly felt, is made up of young people less and less likely to be in sympathy with elitist points of view... the public are those whose science teachers are the media." Science production needs to move away from the traditional audience to which it has

### Table 2 Pattern of television viewing (1981)
(from Miller, J.D. 1986)

<table>
<thead>
<tr>
<th>Attentive Public</th>
<th>Interested Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Geographic Specials</td>
<td>45%</td>
</tr>
<tr>
<td>Walter Cronkite's Universe</td>
<td>24</td>
</tr>
<tr>
<td>NOVA</td>
<td>22</td>
</tr>
<tr>
<td>At least one of the above</td>
<td>59</td>
</tr>
<tr>
<td>Evening news</td>
<td>72</td>
</tr>
<tr>
<td>Morning news</td>
<td>24</td>
</tr>
<tr>
<td>ABC's Nightline</td>
<td>22</td>
</tr>
<tr>
<td>At least one of the above</td>
<td>78</td>
</tr>
<tr>
<td>60 Minutes</td>
<td>61</td>
</tr>
<tr>
<td><strong>N =</strong></td>
<td><strong>637</strong></td>
</tr>
</tbody>
</table>
historically directed its programming and to move towards communicating with the largest, most partial to influence, sector of the general viewing public - the inattentive segment.

The goal for the viewing audience should be to reach the lowest common denominator of viewers, the largest audience, and the widest age and socioeconomic range as possible. Sixty percent of the population in this country is not attentive to science (as described by Jon Miller) and it is that enormous proportion we should be striving to reach. The current need of science production is to transform the inattentive (of science) in this nation to the attentive - basically... spark their interest in science. Individuals in this category fit all walks of life but the "average" television viewer is often described as young (20s to 30s), middle-class, and white. This descriptor is not truly reflective of the viewing audience, so the attempt must be made to incorporate the broadest appeal. The "average American" is a non-entity and in the end, the initiative's success can only be grasped post-hoc. (If I had to choose the most important element, I would concentrate on the younger generation.)

The reality, however, is dictated by a particular program's carrier. If TBS funds a project, it will be a national audience of the type described above (though it would certainly be limited to individuals who receive cable). If the carrier is an entity such as the Discovery Channel, WGBH, or the like, the audience will be accordingly reduced and specialized. With these carriers, science production can extend its message only to those individuals who are inclined to watch such "science-like" or educational programming (and possibly some others captured by advertisement). But as a rule, science programming needs to shift away from the rigors and limitations of public broadcasting and move to the arena where
people have traditionally congregated. Most people don't even tune in to PBS and they certainly are not likely to view a program aimed at them if they do not even watch the channel. The message must be brought to them, on their own territory - not the other way round. The messages must be simple, entertaining, and illuminate science as it is actually conducted rather then enshrouding it in the mystical features that have prevented inattentive viewers from following science all along. Science production must realize that:

> If the television-watching public is presented with and influenced by television representations of science, then it is the cumulative overall picture on which we should focus attention, not to mention the input of the audience's earlier education and the parallel inputs of other media” (Jarvie, 1990).

The mountain must go to Mohammed... for Mohammed does not seem to be willing to go to the mountain right now.

“Walter Cronkite’s Universe” - A Valiant Attempt

One of the best attempts to date to address this concern was a series of programs that ran in the early 1980s on CBS entitled, “Walter Cronkite’s Universe”. The series was produced by Jonathan Ward, a long-time veteran of CBS News and was slotted in primetime programming as a trial run for scientific shows that might appeal to the masses. The series seemed to have everything going for it - one of the most popular, if not the most popular, television personality of the decade as host of the series; an award-winning producer with a clear interest in the communication of science; and a $3 million budget for the
thirteen program series. But the show was dropped quite dramatically by CBS after only two lackluster seasons. What had gone wrong?

Some blamed the failure of the series on the economy of the times. The thought that market-driven programming couldn’t be sustained without a powerful message and mass appeal was the initial explanation for the show’s failure. The supposition was that without instant success, a television program was ultimately doomed to failure. But other critics have suggested that the series’ downfall was most likely caused by other, more subtle forces at work. Jerome notes that:

[T]he disappointing Nielsen ratings for Universe and Omni cannot be blamed on the economy. (A “30-share” has long been considered the minimum for survival of a prime-time series, although this figure has been lowered recently as network audiences have declined. In November 1981, a typical month, the Omni rating in Los Angeles, one of its better markets, showed an 18-share. Universe did better, but not enough to satisfy network decision makers.) The cancellations may have resulted from the networks’ own action and inaction—specifically, the failure to promote the programs adequately combined with poor time-slotting. (Jerome, 1983)

He goes on to explain:

Universe staffers were not surprised by the network’s decision to drop the series. They point out, with some bitterness, that CBS never seriously publicized the program and relegated it to summer evenings—the rerun season—almost certainly sealing its fate. Also, the first Universe segment, which drew 34 percent of the audience, was aired on a Sunday evening following 60 Minutes. The series was then switched to midweek and the ratings, as might well have been expected, plummeted some ten points in one week and never recovered. Pointing out that audience mail for Universe was unusually large and enthusiastic, Cronkite argued— in vain—to move the program back to Sunday evenings. (Jerome, 1983)

The fact that “Universe” was never widely publicized and was relegated to the summer, mid-week programming slot may be viewed as the single force in
the destruction of the series but this view is certainly both exaggerated and overly simplified. Many lesser programs have survived similar ordeals and have gone on to prosper. The initiation of the program after "60 Minutes" had done what it was supposed to do - capture the initial attention of viewers through the inertia of television's most popular program. No matter how much advertising was done prior to this initiation, nothing is a better introduction to the viewing public than a post-"60 Minutes" slot. Not many programs have the luxury of being introduced immediately after a wonderfully popular program sequence but despite this, many have managed to succeed in capturing large audiences, without massive advertising campaigns.

Additionally, having a $3 million dollar budget and one of the most popular television personalities is certainly a formula for success that is hard to argue. If any science show was going to have a head-start down the road to success, "Universe" was it. The money and talent were behind the show and other programming introduced during the same season had managed to thrive. There must have been something more to the story than the lack of publicizing the program.

"Universe" was to be the grandest effort on the part of the television community to communicate science to the general public. It was science, writ large, and the producers had the best of intentions for the series. Jonathan Ward described the goal of the program by noting "in view of their importance to our everyday lives, science and technology should be more widely represented on TV, which, after all, is the most powerful tool of communication ever invented" (quoted in Edson, 1988). Underlying that goal were all of the tools for success: money, talent, and an extremely prominent star. No matter how exciting and
enthralling the subject matter may be in a television program, without one of these components backing that subject matter, the program is destined for oblivion. “Universe” understood this fully and had not one, but all three aspects. The producers were fighting an uphill battle, for not only was science viewed by the general public as an intrinsically boring subject but most, disdained the field.

So CBS brought all its guns to bear on the problem and went with the best thing possible - Walter Cronkite.

*Television’s strongest point is that it brings personalities into our hearts, not abstractions into our heads. That is why CBS’ programs about the universe were called “Walter Cronkite’s Universe." One would think that the grandeur of the universe needs no assistance from Walter Cronkite. One would think wrong. CBS knows that Walter Cronkite plays better on television than the Milky Way. (Kleiner, 1987)*

But even “Uncle Walt” was not enough to save the series. After some initial popularity, the program slipped in the ratings and continued that slide until its ultimate demise. Although it lasted several seasons, the show was near the bottom before it was eventually canceled. The New York Times (1982) announced the series’ cancellation:

*Low ratings may not mean the end of the world for Walter Cronkite, but they did mean the end of his “Universe” last week. His award-winning CBS-TV science series was in its third year when ratings placed it 60th of 69 prime-time programs earlier this month. Van Gordon Sauter, the president of CBS News, denied the show was dumped in a belt-tightening move. He said that despite its “merit and distinction," its audience base appeared "insufficient to sustain it in a prime-time environment." Mr. Cronkite, who formerly anchored "The CBS Evening News," had called the science show "a noble experiment." (New York Times, 1982)*

It seemed as if science was simply an impossible subject to broach on national commercial television. Other science programs were collapsing at about the
same time and many proclaimed that the subject matter was destined for limited audiences on public television programming.

In the electronic arena, the most significant reflections of this sudden change of fortune were the back-to-back cancellations of Omni and Universe, the two prime-time network efforts at popularizing science. The bright, new day of science coverage by the mass media had turned decidedly cloudy. If Walter Cronkite couldn't make it work, who could? (Jerome, 1983)

“Universe” was the best that CBS had to offer and its failure apparently signified the ultimate impracticality of trying to popularize science for the general viewing public. But was it truly the best that CBS could offer?

As it turns out, the strengths of the “Universe” series may be what actually caused its unfortunate failure. Both the series’ star and the executive producer had been pulled from the CBS News division and represented the elite in the news field. Jonathan Ward had a multitude of awards and years of experience before he ventured into “Universe”. Walter Cronkite was somewhat of a living legend in the broadcast community - the closest thing to a supreme being that the television news world had to offer. Everyone in the United States knew his face and respected his character. His visage was also known around the globe and was admired by many. Both Ward and Cronkite brought this legacy to the program’s production - and they did what they did best - produce a news program. This time however, it was not a news program about world events or tragic stories but a news program about science.

The programs were compiled like hour-long news programs straight from the CBS News division. The stories were brief and skimmed the issues and were presented in the fashion of “Today in the world of science....” They had forgotten their own agenda - to concentrate on the process of science and the people
behind that process - and instead went with what they knew best. Jonathan Ward noted the program's flaw in its tendency to trivialize science.

I was the one responsible for cutting down some of the longer reports.... I trivialized the shows. Even though I have always argued that science should be covered on TV better than it is covered on the spot-news shows, I threw the segments on like evening news pieces. It's fine to tell 23 million people any valid science news . . . in a three-minute spot. But that's not how science works, and we really should be doing more on this show. We're spending more time on researching and reporting. (quoted in Unger, 1981)

Even the show's star, Walter Cronkite was aware of the problem in retrospect after the first program of the series, but even so, the producers failed to correct the problem.

The problem is a kind of strange psychotechnical one that is built into television. I noticed it when we made the pilot for the one-hour evening news a couple of years ago. You just cannot do pilots of news programs, and "Universe" would be a news program because the whole geewhiz aspect of it is that each program would be tied to something that happened in the news that week.

Now when you make a pilot in advance, you find that the bits and pieces get worked and reworked and put together and reworked again, until boredom sets in. You end up with no touch of the unexpected, and executive viewers become jaundiced about the whole project. (Shales, 1979)

In the end, "Universe" was most likely master of its own fate. The short segments on different scientific stories managed to keep the pacing of the show upbeat but failed to deliver in terms of the "story behind the story" - the truly interesting aspect of science for the general public. Unlike modern television news programs, most of the stories on "Universe" were old news - the creation of the universe, historical scientific discoveries and the like. Their impact on people's lives had either long passed or were tenuous at best. The general public watches
the news because it is happening today and affects their world and oftentimes their lives. Television news programming is the modern equivalent of neighborly gossip or word-of-mouth storytelling. Few people gossip about science, and as a result, science news is not often passed along unless it has a major impact on people's lives or is a momentous discovery (as evidenced by the noticeable lack of it in the news in print or televised). For most people, scientific results are simply uninteresting and unappealing. Though "Universe" was a valiant attempt at conveying science to the general public in an interesting and informative manner, as Unger (1980) notes, "My tears are shed for 'Universe,' a show that tries to cram too much into too little time and ends up no more than a scattering of science filler items." Cullington put it more precisely when he observed, "People want more interesting, but not necessarily less, science on television... 'Universe' had many attributes, one of the being Cronkite. But 'Universe' was boring" (quoted in SIPlscope, 1982).

The current status of science programming on television

The current status of science programming on American television is one in which science portrayals are, in the words of Carl Sagan, "...dreary, inaccurate, ponderous, grossly caricatured, or openly hostile to science" (quoted in Goodfield, 1981). The dismal state of affairs science programs have fallen into on the public broadcasting system is only surpassed by the overwhelming vacuum of programming on commercial television. Science is, and always has been, one
of mankind’s most prominent disciplines but for some reason, American television has either recently forgotten its importance or skirted over it entirely. The fact is that:

... no major effort is being made to provide serious science programming for the vast majority of scientifically illiterate Americans who depend on the television networks for most of their information. For some, it is comfortable to rationalize that there is simply no mass audience for science policy, that the tens of millions of television viewers are “inattentive” to science - “tube-boobs” desiring nothing more after a hard day’s work than to settle into the oblivion of a can of beer and “Dallas”. (Jerome, 1986)

The rationale behind this poverty of science programs is apparent when talking to television executives. Even though there may be a strong push by the science literacy programs to include more science programming, television executives have not responded. “Science,” they claim, “has not done well on television in the past and no matter the format, it will never do well.” Though the public seems to be interested in more scientific topics and coverage, the networks are unwilling to accede to faint inclinations.

As described by Gerbner et. al. (1981), “Science news and science programs are few and far between, and most Americans avoid them.” This trend is not likely to change without turning the methods of science communication to issues of interest and attention. The network programmers are correct when they resist the call to add more scientific programming to their schedules - the most popular science programs to date have only captured seven to 10 percent of the viewing audience. Typically, the greater amount of television a person watches, the greater their confidence in the people who run institutions. Only two show negative associations between television viewing and confidence - major companies and the scientific community (even though it is the second highest
rated institution). Television viewing has a strong, consistent, and significant negative association with confidence in science among those individuals with more confidence in general (Gerbner, 1981) (see figures 3 and 4). Another study suggests that the quantity of coverage of a risk event may have more influence on public perceptions than the actual content of the coverage (Mazur 1987). Additional programming of the type currently produced will only reinforce the same negative feelings. Science on television is successfully alienating the audiences and confirming their mistrust of scientists and technology, and as they conclude in their study, "television, on the whole, seems to make few friends for science…"

According to the survey of science programs on U.S. television networks by Gerbner et. al. (1981), science and technology appear in about half of all dramatic network programs. Six out of ten primetime and seven out of ten weekend-daytime programs contain a theme of science, technology, or engineering but remarkably scientists are rare primetime characters. No more than one percent of all primetime characters are scientists (an average appearance of once every two weeks), which is about half as much as in the actual working force. On the other hand, doctors and health care personnel are seven times more likely to appear as primetime characters than are represented in the population. Of the scientists portrayed, more were shown as negative portrayals and could be comparatively characterized as "less attractive, fair, sociable, warm, tall, young, or peaceful - but very smart... fewer are youthful and involved in romance or family, and more are dangerous and headed for ultimate failure". Programs involving science were more likely to occur outside of the United States or in the future than other types of programming.
Television entertainment is the major daily source of information for most Americans. This is where attitudes about science are formed. "By their selection of newsworthy events, journalists identify pressing social or policy issues." (Lang and Lang 1983). These attitudes are far more important than actual information conveyed via the medium. "Surveys—and straightforward experience—reveal that most people (53 per cent) glean their knowledge of science from television. Newspapers (25 per cent), books (24 per cent) and radio (a paltry 5 per cent—which is sad because it is doing a good job these days) cannot hold a candle to the box." (Couper, 1992) Americans are exposed to more science in the dramatic form than ever before but sadly, it is in the form of bad news. Science is a negative aspect in most television programming in that it produces negative feelings towards the discipline, even as it glorifies the institution at the same time. Pressing the wonderful qualities of science results in the audience turning away. Most of us do not seem easily persuaded by the "Try this, you'll like it" messages of science-oriented programs. Even more damaging is the absolute poverty of programs focusing on science, not just incorporating the theme into other subjects. Surveys of television science coverage discovered that only 25 of 4,368 primetime commercial network hours were science documentaries (Perlman, 1974). A more recent survey discovered the shocking fact that, not given to the documentary format, US commercial television does not have one program that deals explicitly and exclusively with science (Doman, 1992). Science fiction seems to be the only form of science coverage that has maintained a minimal portion of the programming curriculum.
Figure 4

Relationship between Amount of Television Viewing and Degree of Confidence in the Scientific Community
(adapted from Gerbner et al., 1981)
Figure 5
Relationship between Amount of Television Viewing and Degree of Confidence in the Scientific Community
(adapted from Gerbner et. al., 1981)
In 1963, E.G. Sherburne Jr., director of Studies on the Public Understanding of Science for the AAAS, surveyed the primetime coverage of science on television in the San Francisco area for the month of March. His results showed that only about six percent of the primetime hours for five stations (the three major networks, an educational network, and a local station) were devoted to science. What is remarkable is that his definition of "science" was extremely generous in that he included medicine, science fiction, and anything remotely related to the disciplines involved with scientific pursuits - no matter how much they were detailed in the program. For example, *Ben Casey* and *The Twilight Zone* were defined as scientific programming. Still, only 35 hours during the entire month of primetime coverage included such themes. Over seventy-five percent of this coverage was devoted exclusively to medicine or psychological behavior, leaving only eight hours of actual scientific topics. Most of the programming was presented in dramatic form and science was generally included as a sub-theme of the show. Twenty-two percent of the science programs were aired by the educational channel, which were relatively rare commodities at the time. The educational channel also presented the same bias in science presentation by choosing to concentrate on primarily topics of medicine.

But what is the situation thirty years later? With the proliferation of channels by cable television and the inclusion of science-oriented networks such as the Discovery Channel, the circumstances must surely have changed. I have surveyed the television science programming available to viewers for an entire year, including both daytime and primetime programming for the entire cable spectrum available in a midwestern region of the country (through analysis of
daily programming schedules provided by a cable provider). Tables 3 and 4 show the science programming available in Columbus, Ohio (a widely used test market) for the year spanning April 1992 to April 1993.

Table 3  Science on television  
Columbus, Ohio (April 1992 - April 1993)

<table>
<thead>
<tr>
<th>Percentage of each station's hours devoted to science</th>
<th>Non-Primetime Hours</th>
<th>Primetime Hours</th>
</tr>
</thead>
</table>
| **Public Broadcasting Station**                      | 12%  
(599 total hours) | 33%  
(365 total hours) |
| **Discovery Channel**                                | 23%  
(1798 total hours) | 47%  
(521 total hours) |
| **Major Network Commercial Stations**                | 3%  
(1173 total hours) | 8%  
(362 total hours) |
| **Independent Commercial Stations**                  | .4%  
(756 total hours) | .7%  
(208 total hours) |

Total hours for year  
4,326  
1,456

Of the total air hours for the year (273,932.5), only 2% were devoted to science-related topics (I have included science fiction, cartoons, and other types of indirect programming similar to Sherburne's original survey) and only 4.5% of the total primetime hours (35,040) were devoted to science-related topics. With a six-fold increase in the number of stations available to viewers from the 1963 data, (one of them claiming to be devoted to science programming) the primetime science programming has actually decreased over the years. Medical programming has been replaced by wildlife programming in popularity (medicine dropping from 59% to 6.5% and wildlife programs rising from 6% to 40% of the total science coverage) and science fiction has also taken up a great deal of the
percentage. PBS has fallen off slightly in their science coverage (dropping from 22% to 16%) but their format bias has remained relatively constant.

Table 4  Analysis of topics and total formats

<table>
<thead>
<tr>
<th>Topic</th>
<th>Percentage of Total Science Programs</th>
<th>Percentage of All Primetime Science Programs</th>
<th>Original Programming (Non-repeatDuring a Week)</th>
<th>Presented on Independent or Commercial Networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science fiction</td>
<td>21%</td>
<td>16</td>
<td>8</td>
<td>96</td>
</tr>
<tr>
<td>Medical programming</td>
<td>6.5%</td>
<td>10</td>
<td>52</td>
<td>74</td>
</tr>
<tr>
<td>Wildlife programming</td>
<td>40%</td>
<td>66</td>
<td>42</td>
<td>68</td>
</tr>
<tr>
<td>Environmental</td>
<td>7%</td>
<td>6</td>
<td>79</td>
<td>76</td>
</tr>
<tr>
<td>All other general science</td>
<td>25.5%</td>
<td>2</td>
<td>43</td>
<td>52</td>
</tr>
</tbody>
</table>

The Discovery Channel, proclaiming to be the “science-devoted” network, has, upon closer inspection, a substantially “science-bereft” programming format. Analysis of network format types shows that only twenty-six and a half percent of their total coverage actually deals with scientific topics. These numbers should also be compared to other types of programming now available on their channel, particularly the “paid program” format now spreading over the airwaves. One quarter of the programs (25%) aired by the Discovery Channel were “paid programs” - a percentage equal to that of science topics. The Discovery Channel is, in reality, no more devoted to airing science shows than it
is in airing paid programming. Though this may not be an intended fault of their channel (they are simply trying to earn enough money to stay in business), viewers cannot automatically assume their goals are what the executives state. Even aside from the paid programming factor in their format, fully fifty percent of their shows have nothing to do with science or technology, a fact of which most people are not aware. On the whole, television airs more than twice as many paid-program hours as it does science programs (4.6% of the total hours).

One must also place science programming into perspective by examining the numbers a little more closely, for the situation is even bleaker than it seems. Several factors are worth noting as they tend to distort the numbers somewhat. Fourteen hours of the total programming in a week (representing 12% of the total science programming) is a series of programs aired each Sunday by the Lifetime network that are specialized medical programs aimed solely at medical professionals. These types of shows are in no way intended for audiences outside of the disciplines (their use of technical jargon and methods is intense) and even attentive audiences would be very unlikely to watch them. They are primarily training videos and visual journals for health-care professionals. Twenty percent of all science programming is represented by the series Star Trek and its spin-offs (Star Trek: The Next Generation and Star Trek: Deep Space Nine) and without these two forms of programs, the total science percentage drops to a mere one and a half percent of the overall programming. One further factor complicating matters is the newly acquired habit of networks and syndications airing repeated material during the week. Of the entire science programming available to viewers each week, only thirty-eight percent of it is original programming (though even most of that is ultimately a repeat - particularly
programs on the Discovery Channel). As a result, the truly original scientific programming menu for most viewers is paltry indeed.

So where do we stand? Thirty years and several efforts to increase public scientific literacy later, we are no further along in television science production than we were when Mr. Sherburne (1963) stood at the head of both worlds and put forth:

*The challenge, properly put, is to make the entertainment, the everyday, every hour, ordinary run-of-the-mill programs more significantly involved and widely representative of the dramatic, exciting themes of today's world of science... And my concern is not so much that the image of science be rectified, but that the entertainment of Americans be filled with subject matter that reflects honestly and genuinely the drama and grandeur, the understandings and insights of the age of science in which they live.*

We are no closer to accepting his challenge today than we were those thirty years ago - if anything we have actually lost ground in the process. Television programming has proliferated and science, though its overall coverage has increased, has not even kept pace with that rate of inflation. Some critics claim that it is the fault of promotion. Science programming has not been afforded the same emphasis as other, increasingly popular, formats. But I would argue that this is only a reflection of the faulty state of affairs scientific programming has fallen into. Networks promote those programs that will interest audiences, not the unpopular shows. Advertisement does not save a particular program (it may delay its demise somewhat) - the people decide its fate. The same goes for programming formats. Science programs are not successful because they have not attracted audiences and kept them. Promotion has never done them any good.
Jon Miller (1986) cites the solution to the current state of science programming when he states: "An increase in the volume of science programming or articles will have little effect on the nonattentive citizen until he or she first develops an interest in the subject area." It is this deficiency that science producers must solve before increased scientific programming will even be accepted. This void cannot be filled by simply increasing the quantity of scientific programs available - the quality (in interest) must be altered. As an example, television executives sought to increase the amount of science fiction programming available this year by introducing four new science fiction series to the market. Of the four, *Time Trax, Babylon 5*, and *Space Raiders* all died a quick death (three weeks on average) and have been passed on even in syndication. The only one to survive the year was the *Star Trek* spin-off, *Deep Space Nine*. Network spokespersons claimed that the other series failed because the science fiction market had been oversaturated by the *Star Trek* group of programs (there are currently three running) and they stood little chance in competition with the well-established series. The truth of the matter is that the three programs all failed to capture an audience because they were, to put it quite mildly, bad. Increasing the volume of science fiction programs did not enhance the market because those that were introduced could not maintain an audience. What is needed is not more science programs but ones that will stay.

The television science situation has changed little since 1963. We are still faced with a virtual void of scientific programming that elucidates the true process of science - the type of programming that will capture and audience and entreat them to stay with the program. To date, the science television industry has
sought to capture an audience by presenting the "interesting" aspects of science, be they medical issues of the sixties or wildlife programs of today:

Commercial television, the only truly mass medium in this country, continues to be a vacuum tube when it comes to science policy issues. The few network science 'specials' continue to focus on the wonders of nature and the miracles of modern technology. Certainly those are valid and valuable areas to cover, and they lend themselves beautifully to the graphics needed by television; but gee whiz, is that all there is? (Jerome, 1986)

Jerome goes on to note that not only is this trend prevalent in commercial television but public broadcasting as well. "Even the Public Broadcasting System, which seems, by default, to have cornered the television science market, appears to be infatuated with 'wow' programming." This "wow" programming has captured a segment of the population that seems to be fascinated with observing animal behavior and wildlife habits. But most people in society are not interested in birdwatching and though birdwatchers are typically ardent in their activities, the rest of society has not been pulled into that fold. What is needed is a new approach - one that includes the examination of the process of science. Perlman (1974) echoes this sentiment:

But in terms of continuing discourse between scientist and citizen, American commercial television is the most bankrupt of the mass media... it is outrageous that (it) should be so bereft of material in an area that can produce so much visually satisfying, entertaining, and enlightening information on a most vital aspect of human culture.

"Surely, the creative genius of American communication could find a way to capture the public's enthusiasm by presenting the excitement, the challenge, and the risk-benefit choices involved in virtually all current science policy debates as regular, primetime fare" (Jerome, 1986). But how?
Some examples

There are four examples in current commercial television programming worthy of examination. They serve as beginnings in a process of science programming change that needs to be implemented in order to address the entertainment demands of the inattentive audience. Though I intend these to be in no way used as exemplars of what scientific programming should become, they are the only four science programs (that I am aware of) currently being shown on national commercial television venues. Two of them are programs that have been around for years and therefore are only indicative of the qualities in programming that have been successful. The remaining programs have only been recently introduced to American commercial television, but they represent a new (and so far successful) approach to capturing the attention of commercial audiences.

The first is the long-running science news series Tomorrow’s World, produced in Britain under the auspices of the BBC. Tomorrow’s World has been running for over twenty-five years in Britain and is one of the highest rated shows on British television. The weekly show is an examination of the leading-edge innovations in technology and incorporates non-scientist actors as the narrators. Several features of the program distinguish it from other unsuccessful programs - notably the use of humor. Most of the segments are straight-forward discussions of the applications of technology but they are conducted in informal manners, typical of a personal conversation. The program has even spawned a successful spin-off on Australian television, which has been picked up by the Discovery Channel in this country. Beyond 2000 is the Australian version, immensely popular “down under" but has failed to entice similarly massive audiences in the
U.S. Part of the reason for its inability to capture the inattentive sectors of this country is that the carrier, Discovery Channel, has not been very successful at attracting those segments of the population. But more likely, it is the difference in culture that has prevented the program from carrying over to U.S. audiences. The narrators speak in strange British accents (really Australian accents) and Americans find it difficult to accept such differences when it comes to voice-over narrators. On screen, British and Australian actors have been reasonably accepted, but off screen, the focus shifts to their voice and use of language. American citizens have also not had the benefit of the British broadcasting systems, where programs are developed slowly and audiences acculturated to their styles (due to the differing financial mechanisms).

Probably the best example of distinguished American television programming that has not pandered to the masses entirely, but rather, has captured the public's attention and then brought the masses to them, is 60 Minutes. Though they are not a "scientific" program by any stretch of the imagination, they have included several science feature stories that have changed public attitudes and promoted awareness. Just recently, they produced expository pieces on the dangers of mercury dental fillings and the environmental effects on the post-Chemobyl landscape. For 60 Minutes, content does not have to be lost in the interest of style. The program focuses on the process behind the rhetoric (though it is generally the scandalous aspects of the process) and shows how scientists, human in form and manner, can make mistakes and follow their biases. One would have to agree that 60 Minutes has not built its reputation on scientific reporting but their inclusion of science issues and problems has not effected a downfall in their ratings. Most of science programming need not
include such extreme forms of critical analysis, but a modified version (where scientists and science are seen as they are actually conducted) would do the field wonders.

One of the new science programs that has attempted to break through the commercial television barrier is a series of programs called *World of Discovery*. The series is not actually a continuing sequence of programs but occasionally preempts primetime commercial programming (normally *As Life Goes On* on Sunday nights) as programs become available. The series is produced by ABC/Kane and is basically, a watered-down version of *National Geographic*. The specials do not follow consistent subject matter and have ranged from tall ship exploration to salt water crocodiles of Australia. Most of the programs have focused on wildlife themes (snakes, crocodiles, home pests, Amazonian fish, and killer whales) and are filled with stunning visual photography typical of programs on *Nature* or *National Geographic*. The series tries to bring science down to the level of the inattentive audience by approaching subjects in the simplest of manners. Most of the language used is simple and direct and the concepts shown are often related to the average American’s experience.

I mention it not because it has done a marvelous job at presenting science to the public but because it is one of the few attempts of science programming being made to address the inattentive segments of the population and capture their interest. For that I commend it. Unfortunately it undertakes the task in the same fashion as most typical science programming does - pretty pictures, nifty effects, and "gee-whiz" concepts. The show has not managed to break into a regular programming slot, not because it cannot produce enough programs to fill a regular spot, but because it has not achieved the popularity hoped for by the
network. The programs do well, but only well enough to justify the occasional "special". The specials have become less and less frequent as their ratings have gradually dropped. The show panders to the audience and treats science as a "wow" aspect of life - but still, unattainable.

The best new show to reach the commercial airwaves is a Saturday morning program known as Beakman's World. Beakman's World is a program intended for a children's audience but I am aware of several adults that watch it without fail. (This, believe it or not, is actually very common. Over forty percent of regular Sesame Street viewers are over the age of thirty and thirty percent of them do not even have children.) Beakman's World was introduced less than a year ago but has risen in the ratings each week and has recently been given a high-priority time slot. The program is basically a "scientist-explains-the-world" program, where viewer questions are answered in lay terminology and descriptions. It is the 90s' version of Mr. Wizard, utilizing the MTV-style prevalent in much of today's programming (in tempo, language, and color). The star of the show is a man in his late twenties (or possibly early thirties) known as Beakman, a scientist of unknown qualifications but who seems eminently knowledgeable in all facets of science. The star is accompanied by a young woman called Josie, who, for lack of an appropriate description, is a cross between Twiggy and Punky Brewster on amphetamines. Josie acts as the intermediary between the viewing audience and Beakman, posing questions to the scientist originally formulated by the viewers (like, "Why are bubbles round?", "Do toilets ever explode?", "How does a submarine get its power?", etc.). The third member of the group, Lester, is, for all intents and purposes, a six-foot, walking, talking, tattooed rat with a
flatulent propensity. Lester serves as the surrogate "airhead" viewer, asking the inanely dumb questions most viewers were asking themselves.

Though *Beakman's World* is designed to address a younger audience, there are several features of the program that are both innovative and effective (and would be equally so for adult entertainment). The first striking feature is the program's use of humor, almost unknown for a science show (particularly one that seeks to explain concepts). The use of humor is not infrequent and is oftentimes quite sophisticated. As a result, the program does not "talk down" to children, bringing them instead to the same level as the actors and their behaviors. The way in which the characters interact is very casual and their mannerisms speak to the features of young schoolchildren's actions. The program uses simple analogies to explain difficult scientific concepts but shows the concepts at work, through examples using everyday items. Mouse traps are used to explain nuclear fission. Bowling balls on pendulums are used to evince Newton's Third Law. Exploding soda containers are used to show how rockets are propelled. All of these demonstrations are tangible to viewers and often, the audience is shown how to complete them at home.

The other factor that accounts for *Beakman's World*'s enormous success and popularity is the producer's attention to sound. Sound is normally overlooked when programs are developed but *Beakman's World* has paid particular attention to filling the background with intensive music and sound effects. I have yet to count more than a five-second interval between sound effects on the program and the result is more like a cartoon soundtrack than a studio production (almost all of them are post-production inlays). It is wonderfully successful in capturing the audience's interest. The ear is continually involved in the show and it
becomes difficult to avoid the effects attention. Generous use of animation effects also increases the eye-catching appeal of the show. They are simple (and hence, cheap) and enormously illuminating for complex technical concepts or circumstances too difficult to film.

Though *Beakman's World* is a step in the right direction, I still have several qualms with the program that prevent it from becoming a perfect model for other programs of its type. I also think that if the show did not rely upon the inquisitive nature of children to feed into the program's popularity, it would not be as successful as it has become. First, the program falls back to the old stereotypes of scientists - wacky, eccentric, and all-knowing. Beakman always knows the answer to each question and is the only one who explains any information throughout the entire half-hour. Beakman even wears the requisite lab coat of scientists (though in his case it is green) and looks as if he has just stepped out of a laboratory experiment gone wrong. Science, he contends, is the answer to every question and one only has to send in the query to be guaranteed a response. The program also concentrates on technological concepts, physics problems or medical issues and relegates other disciplines to the back burner (natural history questions are normally only given ten-second responses for example). The same bias of science communication present in other media presentations has not changed. Most of this bias may be the result of visual restrictions of the studio (i.e., physics demonstrations are far easier to manage in the confines of the studio) and the difficulty of obtaining other types of footage. It is hard, for example, to show "behavior" or "ecology" experiments. Part of it may also be from the types of questions received from the viewers. If viewers concentrate on those sorts of issues, the program will follow accordingly. But I
also believe that the bias is partially the underlying bias of the medium - medicine and technology sell and therefore, these are what the program concentrates their efforts on.

The final problem I have with the show is the complete lack of the process of science. Answers are given and demonstrations are shown but never once is the manner in which a scientist derives the answer exhibited. The only incident where such a direction was taken was a case where Beakman showed how he ascertained the responses to their questions. He showed how he looked through source material, made personal contact with researchers, and even visited the library, but did not show how the original conclusions were determined. Science is shown, again, as a series of results, not a series of progressive steps.

Solutions

I would first like to offer humble suggestions to both the scientific community and the creators of mass media science programs (including news) before addressing the larger issue of improving scientific television communication as a whole.

The scientific community needs to begin by realizing the enormous importance of communicating their ideas and issues to the outside world. Isolating themselves from the rest of society does the public little good, but more importantly, does their own enterprise even more damage. Public perceptions
have become increasingly important in the financial support for scientific endeavors, controlling the pursestrings of large sums of public research monies. Without public support, the scientific community will be incapable of pursuing the concepts it wishes to follow, in both depth and scope. Money makes the world go round - even the scientific world - and without it, their world will slowly stop revolving. Bob Cowen pointed out that:

"Public perception of science and technology has become crucial both to the health of the scientific enterprise and to the technological strength our nation derives from it. If we are serious about preserving that strength, building a bridge between the scientific community and the media should be a national priority. (quoted in Jerome, 1983)"

But of far greater concern is the public's reliance upon scientific information to illuminate and support important social issues that need to be decided. One of them will be whether or not to fund science. But others, like recombinant DNA controls, will be left in the hands of those not fully aware of their implications or applications. Public policy decisions are now enveloping scientific issues and unlike earlier times, scientists are not the ones in control of the direction or limits of emerging technologies. Society will be the one to determine if science will be able to go forward will genetic research or what types of environmental technologies need to be studied further... and they need to make educated decisions. Science must step forward to fill the role of educator, because no one is more fully qualified.

Scientists and the scientific community as a whole also need to realize that educating themselves, on the thinking processes of non-scientists and the methods of public communication, is of vital importance and should be done by their own community. Scientists are formally educated on how to complete
scientific research, rarely on how to communicate scientific results to their
colleagues, and almost never on how to communicate to the public. As Lievrouw
(1990) notes:

*Scientists as a subculture share very similar values about their work
and can persuade one another of the value of their research based
on a reasonably consistent set of standards and conventions. It is a
more difficult task, however, to persuade the general public of the
value of an idea. To do this scientists must tap into the social
themes and values that are shared by most of the general public...*

Courses in public communication should be added to formal scientific training
and emphasis within the community should be shifted towards engaging in just
such communication. Professional communicators can assist in the process but
scientists must first take it upon themselves to become better informed. Until the
scientific community has managed this feat, the media and other communicators
will only have their hands tied.

The creators of mass media science programming, on the other hand,
need to come to the realization that scientists are often unable to communicate
their ideas sensibly to the media or the public because of the limitations imposed
by their community structure or by their lack of formal training and awareness.
Not only must scientists take steps to become better educated on the methods
and styles of the unfamiliar discipline of media but media personnel must take the
same steps in involving themselves in the community of scientists.

Communicators need to approach science stories not only from their own point of
view (which represents the public) but also from the point of view of the
scientists. Mass media communicators must begin to "walk a mile in their
footsteps" in order to understand the restrictions and methods of the scientific
discipline better.
Communicators should take it upon themselves to restructure their opinions and portrayals of science by beginning to elucidate the scientific process as it actually is, on behalf of the public. They need to start by science "story-telling", not simply "science reporting". Science journalists, uncomfortable and unpopular as it may be, should forget the common practices of their discipline and focus on sparking the interest in scientific subjects of their readerships. Society does not need to see glorification of science or its practitioners - it is actually detrimental to their understanding of the institution. The media need to evaluate critically their own stance on science and the scientific community and become more objective in their examinations and stories involving the practice of science. Neither the public nor the scientific community benefit from the separation, by idealization, of the two communities.

Americans are not hostile to the idea of science television programming. Television is a major force in constructing public consciousness (Jones, 1978) but "its potential for education has only been partially realized." (Miller, N.E., 1986). To date, nothing has truly captured their attention and won them over to the guiles of scientific exploration. There have been successful series about the lives of doctors, police, and lawyers - professions that have often had image problems - but science has been left behind. Probably what has hurt science television programming the most is the fallacy or myth of impartiality... objectivity... the calculated collection of truth. Science has been seen as a discipline where little else goes on; no politics, no human tragedies, no social connections - just the pure accumulation of facts. In a field such as this, what excitement could possibly take place? What interest would it hold? This attitude,
more than any other factor, has relegated science to the back room, to come out only when it has some important news to tell. “Just the facts ma’am, and only the facts.”

I think that once viewers awaken to this and see scientists as they really are; as human beings with joys and sorrows, loves and hatreds, passions and weaknesses, they will accept science programming with little resistance. AS Jerome (1988) notes, “If television can make hairsprays--and Wall Street--interesting, it can do the same for science.” It may not be the entity we call television that has failed to use quality programming, stooping to the wanton desires of a hungry public, but us, as producers and directors, who have failed to create quality programs that both intrigue and educate the populace on important issues and disciplines. It is important to realize that “all public understanding... is shaped by the biases of television” (Postman, 1985). We are the ones who must, as William Laurence decreed, “...take the fire from the scientific Olympus, the laboratories and universities, and bring it down to the people.”

It may be true that we cannot solve the problems in our world through television, particularly documentaries, but we are not out to solve a problem with process of science. We should be out to change the image of science in the mind of the public - to break down the communication barriers between the two worlds - and if television is defined by any merits, it is those two: communication and perception. June Goodfield (1981) notes the power of science on television:

...the biggest single impact on the problem of mass science communication could be made through television... we must really begin to get good science programs in reasonable quantity available on the commercial networks... There are rich veins of material and interest to be utilized, if only enough interest and
money can be mobilized... what is the rationale that ignores thereby one enormous area of human creativity?

As of 1990, 98.2% of households had television sets, with an average of two per household. (Borow, 1993) According to the Nielsen reports, from 1983 to 1987 American households watched an average of more than seven hours of television a day. (Jerome, 1988) With so much time spent in front of the electronic god, we now have the power to shape societal belief systems. Political campaigns are now won by the best “actor”, not the best politician. John F. Kennedy credited his victory over Richard Nixon in the 1961 presidential election entirely to the workings of television. Image has become the most important element in any proper campaign, and television wears the sorcerer’s hat, conjuring up hero and villain, winner and loser. This effect is distinctly enunciated by the televangelist Billy Graham:

*Television is the most powerful tool of communication ever devised by man. Each of my primetime specials is now carried by nearly 300 stations across the U.S. and Canada, so that in a single telecast I preach to millions more than Christ did in his lifetime.* (quoted in Postman, 1985)

Science, however, has fallen victim to this system. I feel we are the ones who have created our own monster. Some may say that television cannot solve the image problem of science, but I contend that television is the cause of the problem. To date, television has promoted the myth of scientific hubris. The menu of science programs has been filled with the likes of elitist and abstruse “NOVA”-programs or patronizing “Wild America” shows, both of which are hard for the public to swallow. Substance without style or style without substance. Sacrifice in science programming continues to be the norm. It is little wonder that the public turns away.
Even if we cannot change the social attitude of our nation toward science, we, as G.C. Lichtenberg put it, must try. The surest way of not progressing is standing still. I believe however, that it can be done. We should hope to find the formula to raise public interest in science without trying to destroy accuracy completely, as Indiana Jones attempted to do for archaeology and Jurassic Park for genetic engineering, though both were in the film industry. As Gerald Wheeler (1986) describes:

... television can be a part of a larger conduit for reaching the public... increasing the scientific literacy of (the) audience is not a continuous process, but, rather, a layered one. Television naturally lends itself as a springboard to other layers, or conduits, which strengthen, deepen, and expand the superficial layer initially presented.

Some individuals have argued that television is incapable of rectifying the woes of science and scientific understanding. William Bennet (1986) declares that: “Television and other electronic novelties have done little to convey an understanding of science to the viewing public. They may, indeed, prove incapable of doing so.” But this fatalistic attitude is indicative of the previous failures to reach the public on issues of scientific and social importance. Television, they claim, has not done well because it is destined to fail; the medium simply isn’t designed to communicate those types of ideas. In a way, they are right. But the concern has always been on the results and data of science, not the process of science. This information can be relayed. The approach cannot simply be a unilateral directive by the television community. It must be advanced by the scientific community, print media and, as Jon Miller (1986) describes:
The best long-term solution to both increasing scientific literacy and increasing the size of the attentive public for science policy is the improvement of science education in the pre-college and college years. If an interest in science can be stimulated early in life and an understanding of the basic processes of scientific study conveyed, there will be a higher level of receptivity to scientific communication. Once these formative years have passed and no interest in science, or a fear or dislike of it, has been created, the effectiveness of later communication efforts will be very low.

It is possible to produce a quality commercial television program about science, even, I believe, a truly magnificent science program, but it is so rarely achieved. Television in general (but particularly scientific programming) has sold its soul, creating a pact with the Faustian audience to produce programs that neither cause the viewer to deal with involved or complicated issues nor, to all intents and purposes, think. Many critics have described television as the antithesis of intellectualism. Producers, writers, and television executives may long to produce and air quality programming that stimulates the mind and investigates critical issues, but are enslaved by the sheer power of the dollar, the ultimate power of popularity, and must grudgingly telecast the demanded placebos - all the while, yeaming to superimpose the words, as Fred Friendly once put it: “Due to circumstances beyond our control, the broadcast originally intended for this time will not be seen”.

Concentrating only on the entertainment aspect of popular science communication will do little to improve scientific literacy. All too often this “gee-whiz” science serves merely the same soothing function of soap operas, baseball games, and “I Love Lucy” re-runs, but for a different audience. (La Follette, 1982)

In order to change the game, one must play by the rules. You can either fight the system, creating your own format and industry (as done by Ted Turner with CNN - an individual with enough power to change the rules) or you can
infiltrate the system and use it to your advantage, playing off the powers instilled by commercial television, yet never fully relinquishing your humility, virtue, and integrity. Funding poses the biggest threat to any innovative programming. Commercial networks have erected barriers against any change in their systems, against an onslaught of cable competition. Commercial networks are losing their hold on America's viewership and any change in the status quo, any new venture, is, for them, a risk not worth taking. Personally, I think it will be the ultimate death knell for the major networks if they continue on such paths, but likely, they will soon awaken to the trend and call for sweeping revisions. This may be a few years away because of the current recession. Million dollar gambles give any executive the jitters, but eventually, they will be forced by their cable competitors to take the leap forward.

In designing a successful television program about science, you can do one of two things. You can either mold your program around the science and then look for ways to make it successful (i.e., popular) or you can look at ways of producing a successful program and then mold the science to fit your formula. The first method is utilized by exemplars such as NOVA and their constituents; the second, by Nature shows and Hollywood films. NOVA, Innovation, and other programs manage to maintain the integrity of science in the program, but the secondary, post hoc attempts to make the shows more attractive to a general viewing audience fail to capture the average television viewer. Nature programs such as Wild America, Jacques Cousteau, and Lorne Green's New Wilderness and Hollywood films such as Gorillas in the Mist, Young Einstein, and Emerald Forest capitalize on successful formats that pander to the whims of a pop culture
society, but in the process, the scientific integrity of the program disintegrates into flashy pictures and anthropomorphisms.

But what is called for is a combination of the two, and also, a departure from the convention. Television is rich visual information, free from the constraints of print conventions, and it invites us to experience science directly, the process of science, as nothing else can (Homig, 1990). The first priority must be given to the medium. Science on television cannot survive unless it is good television. Nothing short of this will suffice. "Unless you entertain the audience sufficiently you can't begin to inform them (Hill, 1961). The audience's attention must be solicited and actively sustained. With cable television and the technology of remote control, viewers are apt to "channel surf", so the program must be constantly stimulating - or else the audience will not return to the show or even stop in the first place. Science programs must begin to concentrate on the factors that increase viewing interest in other programming venues - particularly the use of humor, stimulating sound backgrounds, and rapid pacing. Science, like all other human endeavors, is not exempt from these televisual requirements. With the lack of visually enticing images inherent in the enterprise, the need for their use becomes all the more important. The final chapter shows an example of the type of creative programming style needed to restructure the scientific television production industry to better fit this need. It is a program proposal for a project to be shown on national commercial television. I would hold it as an example of science production that should be presented to the public as a response to their increasing apathy towards current programming styles. It exhibits, I believe, all the qualities needed in a program to fulfill my proposed solution and though it
may only be a written program proposal, it can be used as a concrete exemplar of the resolvent methods described above.

Finally, the orthodoxy of science programming needs to be dramatically altered. Traditionally, science programs have been seen as vehicles to render information stimulating. The job of science producers has usually been to take the facts and straight information and render them intelligible and interesting, attempting to inform, and point out significances (Jones, 1978). But this role, to date, has failed in almost every attempt. Science producers need to see television as a mechanism for elucidating the process of science - for sparking an interest in science in the general public - not for transmitting streams of dressed-up information. "... Science presented on television has the greatest impact on the general public" (Jones, 1978) and it is this quality that we must rely on. Science programming has to serve only one function - to excite the public about the process of science, nothing else. It does not have to tackle the entire scientific illiteracy problem in our society. It should only take the first step in the learning process... to stimulate interest. As Michael Guillen once commented, "You have to get people into the tent if you're going to preach to them."
CHAPTER V
Conclusion

Scientific research was the lifeblood of civilization; it was the one investment that could be guaranteed to pay dividends for eternity...
- Arthur C. Clarke  Earthlight

Miracles are never a stumbling-block to the realist.
- Fyodor Dostoyevsky
The Brothers Karamazov

Any path which narrows future possibilities may become a lethal trap. Humans are not threading their way through a maze; they scan a vast horizon filled with unique opportunities. The narrowing viewpoint of the maze should appeal only to creatures with their noses buried in the sand.
- Frank Herbert  Children of Dune

We are at a critical juncture in the evolution of the relationship between members of the scientific community and the outside world. Lay audiences are growing increasingly weary of the insular behavior of scientists and their cadre, in both the procedures and directions the scientific community is following. The scientific enterprise on the other hand, has become a dramatically specialized industry in which individuals competent in particular areas of a discipline find it hard to communicate effectively with members of other scientific specialties, let alone the general public. The two communities are growing farther and farther apart (in understanding and awareness) at a time when the exact opposite is required. Though both the scientific community and science communicators have their own weaknesses and are partly responsible for the lack of communication to the general public, the blame belongs to the entity that remains unwillingly to change
and compromise. Let this study serve as a notice or call to action for the scientific and journalism communities to begin the process of revision in their procedures and attitudes.

Science journalists, I believe, feel caught in a situation between two warring factions in which the demands of one side are mutually exclusive to the demands of the other. Science communicators feel that they are under strict charge by the public to produce entertaining and intellectually unexacting pieces but at the same time are beholden to the scientific community to maintain the high standards of accuracy and satiation of content reflective of scientific practices. They feel caught in a Catch-22, and in a sense they are, but the time has come for them to follow the course of least resistance and strive to correct the situation - for, as the colloquialism goes, “The surest way of losing ground is by standing still.” Changing public attitude is an enormous undertaking and a task to be completed with the efforts of all parties involved but the primary impetus must come from the communicators and scientists.

Science journalists must begin by refusing to acquiesce in the demands of the scientific community and the traditions of the journalistic discipline by providing the public with intriguing and vivid accounts of scientific endeavors. Content may have to suffer slightly at the hands of style but interest of the audience must be the first and foremost concern of the communicators. A message without an audience is, as Don Marquis notes, “like dropping a rose-petal down the Grand Canyon and waiting for the echo.” I do not think that intellectual content has to be dismissed en toto (in fact, I think the general public is much more accepting of demanding material than the trade generally gives them credit for) but science communicators must concentrate on the
interest-capturing aspects of their production pieces before all else. They must redirect their attentions to capturing the larger, disinterested audiences and enticing them into the process of science rather than better educating the already advanced populace. Preaching to the converted does very little good to anyone. Scientific literacy must begin by creating scientific interest. Literacy will ultimately follow.

Science journalists must, to put it bluntly, damn the common practices of their profession and align themselves into a new standard of journalism - that of involved, creative writing or production and taking a stand on scientific issues that are never, and should never be, completely objective. Subjective reporting is not one of the initial stages in the downfall of society and need not be avoided at all costs. The public is fully capable of making informed decisions by weighing subjective accounts but informed is the key word. The public must be exposed to science and important scientific issues and they cannot be informed if they are eternally turning the channel or skipping articles.

Science on television has, I believe, the most room for improvement, largely due to the depauperate state of current science programming. Television may never be the powerful tool of education most critics would like it to be - the medium is not well suited for heavy-handed instruction - but it can be a tremendously powerful mechanism for creating interest in education, fostering further pursuit of intellectually demanding subjects. The public (particularly the disinterested public) should be asked to “tune in and turn on” to science and this act may be as much as we can ask of the medium. This single step is of such critical importance that we should not scoff at it simply because it seems to be setting our sights low. It is certainly much more than the medium is doing today.
The way to capture that interest in science is by showing the process of science. By "humanizing" science and scientists, the general public will be able to relate to the issues and concepts and not feel like passersby peering in through glass windows at the movements of a distant and strange performance. Once this barrier is broken, the connection between science and the public can begin to be reinforced. The lay community needs to understand how science works and the procedures by which it functions. This is important not only in the decisions citizens will be required to make on complex and crucial scientific issues but also, as June Goodfield (1981) most notably remarks, "... what is the rationale that ignores thereby one enormous area of human creativity?"

Understanding, however, is a two-way street and though science journalists are the entities necessary to pave the way, bridging the distance between the communities of scientists and the lay public is not solely their responsibility. As Goodfield (1981) continues,

...the burdens must be shared, for responsibility is a dual one. It does little good to conduct historical post mortems, and in any case, mere understanding is not enough. Maintaining a level of scientific literacy in the public is as difficult a task as doing science itself, and the media cannot do this alone.

The scientific community needs to begin by first changing its attitudes towards the communication of ideas to the general public, either formally or informally. Scientists must accept those efforts by their colleagues to communicate and educate lay audiences as valid practices essential to science. If the general shift in attitudes cannot be accomplished merely by the informal redirection of beliefs of scientists, procedural mandates must be imposed by the scientific community at large. The role of science popularizer must not be frowned upon if done in the proper manner (i.e., subsequent to peer review, not distorting data or
conclusions, etc.) and must be recognized as a requisite part of some researchers' activities.

Those individuals who do not have the oratory or communication skills possessed by the more vocal members of the scientific community must take it upon themselves to become better educated in the mechanisms and methods of public communication and begin to reach out actively, initiating and fostering relationships with science journalists - those who are trained to translate such information properly. Once this preliminary adjustment to attitude takes place, the more refined aspects of scientific literacy can be invoked, simply due to the open channels of communication between those who possess the information and those who do not. I would not hazard a guess as to how long a shift in demeanor by the scientific community will take - it certainly will not happen overnight. But the pendulum must begin to swing the other way if progress is to be made. Once efforts pick up some momentum, the snowball effect realized can create change at a very rapid pace. Thomas Kuhn (1970), among others, has noted that science proceeds by a series of saltations - by large shifts in attitudes and thought conventions rather than by new specific discoveries or theories. It is a revolution of this magnitude that is presently called for within the scientific community.

We can no longer put our heads in the sand and assume that the problem will either go away or solve itself. If changes in attitude and practice are not effected in both the scientific and science communications communities, we are in for dramatic and detrimental results indeed. Plainly speaking, if scientists wish to pursue the activities that they have enjoyed over the years, if they wish to be funded, supported, or even trusted - if the public wishes to preserve the incorporation of democratic ideals into scientific or technological decision-making,
if they wish to enjoy the continued benefits of technological, scientific, and intellectual progress - and if the science communicators wish to remain as that, communicators of science - then changes in the system must occur. We are proceeding down a path of probable trouble. As the gap between science and the public widens, so too does the potential for crisis increase. I not only believe that this situation can be rectified but that it is imperative that we do it and do it soon. We must move ahead and attempt to institute change - for we, like our ancestors, must evolve or perish.
CHAPTER VI
Sample Television Production

I'm sure they will turn up their noses and say this is a popularization. Sure, every bit of science that I know I've learned from print. But in most cases I was inspired to spend time with print by pictures -- movies, comic books, things like that. So maybe you won't learn any science from "Universe." But maybe you'll see some stuff that will tickle and entrance you, and maybe even inspire you to go to books to learn more about it. That's no small thing.

- Jonathan Ward

I began to imagine this silent and unmoving jungle as it would look and sound if it were wired to record the terror of the plants and if it were filmed in those techniques that Walt Disney perfected to show in a few seconds the opening of a rosebud. And it seemed a real probability that the shrieks of dying plants and the snakelike lashing of a million vines - all at a deadly war with one another in their writhing, choking, killing, as they strained and clawed toward the sun - would simply be too awful, too horrifying for a man to watch.

- Moritz Thomsen
The Farm on the River Emeralds

Building the Green Cathedral
(approx. running time: 53 min.)

From the murky depths of an ancient lake, hidden deep within the maze of an Amazonian rain forest, a slab of mud slowly makes its way towards the surface. It is a giant punch taken from the skin of the Earth, holding twenty thousand years of history, extracted by a hollow, hundred-foot syringe. And like a freshly-caught prize fish, it is placed on the floor of the open boat for safe-keeping, glistening in the mid-day sun. The great cathedral of the Amazon forest, with buttressed columns and green stained-glass, towers round the small lake. Research
scientists stand about and stare at the lifeless form, wondering if hidden deep within its innards is the key that may unlock the answer to a mystery that has haunted them for years. Somewhere in the grey ooze may be a cache of pollen grains that unravels the mystery of a prehistoric Amazon - tell-tale traces of the forest that has come and gone before, like fingerprints that give away a crime.

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Our goal is to make a film that communicates three brief ideas. 1) Science is immensely exciting and fascinating. 2) Science is a process that is familiar to us all. 3) Scientists are human beings pursuing interests we all have, especially as children.

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Building the Green Cathedral is a mystery story, an adventure into intriguing and exotic locations, a personal tale of human endeavor. Everyone loves a good mystery story and the search for clues to the history of the Amazon during the last great ice age provides us with the opportunity to encounter the unexpected... the unknown... and to follow a scientific detective uncovering clues to a puzzle on a grand scale.

The exotic appeal of the Amazon rain forest provides a unique "hook" to draw in the program's viewer. Trudging through uncharted and unexplored portions of the world fascinates and captures the adventurer within us all. Since the days of "Tarzan" and continuing through to contemporary awareness of tropical deforestation, the jungle has held our imagination.
These hooks are not novel ideas. They have been used in other science programs. But the approach of our program is unique in three ways.

First, we will utilize a semi-documentary format. The story is developed in four parts, in the manner of a television narrative drama. Two thirds of the story will be fully scripted while the remaining third will be based on actual expedition coverage. Though it is our absolute intention to accurately document the normal scientific studies, scripting a portion of the story will allow consolidation of humorous, uncommon, and unpredictable events that have occurred during previous expeditions - without the enormously time-consuming and challenging affair of trying haphazardly to capture them on film.

Secondly, our story will incorporate humor. The television community has viewed scientists as individuals working in a field that is intrinsically complex and serious. Consequently, the foibles, mishaps, and blunders that permeate our everyday lives are excluded. The most successful way to capture an audience in programs dealing with other professional fields (i.e. doctors, lawyers, and the police) has been to utilize humor. In those cases, the use of humor has not trivialized the importance of the work being done. Somehow, science has gotten lost in the shuffle.

Finally, the film will stress the "humaness" of scientists and their activities. Successful dramas, sit-coms, and feature films are those in which the audience gets to know a character (or a small group of individuals) in a very personal manner. It is important to show the personal side of the researchers. Scientists are human and just like us all, exhibit the vices and virtues of human behavior. It is essential to create vignettes, allowing the viewer to relate to the scientists.
We are all scientists. Everyday we unwittingly use the scientific method during the course of normal activities. Whether it is the mechanic trying to figure out exactly what is wrong with a malfunctioning car or the baker who seeks to improve his recipe with a new combination of ingredients, each of us utilizes the identical procedures used by a nuclear physicist or genetic engineer. The process of guessing, trying new ways, noting the outcome, and reshaping original guesses has simply been formalized by scientists into hypotheses, experimentation, data collection, and reformulation of hypotheses.

We have recruited an exceptional scientist for the film, but more importantly, an exceptional personality. Dr. Paul Colinvaux, a paleoecologist at the Smithsonian Institution, is a humorous, personable, and somewhat eccentric man with an enormous passion for his work and a remarkable, verbal ability to communicate it to others. Considered to be one of the top five ecologists in the nation, his ecology textbooks have been on the market since 1973 and his current edition is one of the top two sellers in the field. His popular book Why Big Fierce Animals Are Rare, published in 6 languages, has been called the only literate ecology book to describe the natural world and how it works. He is a member of the Explorers Club Committee on Scientific Research and is in demand to lecture to audiences all over the world. Dr. Colinvaux is currently studying the history of the Amazon during a period between 10,000 and 50,000 years ago - the time of the last great ice age.

The Amazon past is one of the great unknowns of exploration. Researchers know how the forests of North America and Europe were built, even much about ice-age Africa and Asia. But the ice-age Amazon is, in the purest sense of the word, unexplored. In this unknown past lie the origins of the
biodiversity of the richest ecosystem on earth. Long prevalent was the view of an unchanging Amazon, where the past was like the present. Species gathered in the warm and humid environment, avoiding the perils of freezing ice-age temperatures and the danger of extinction. This has been challenged by those who imagine an arid and decimated ice-age Amazon, with forests taking refuge in a few wet spots. Only after it warmed did the protected patches of plants and animals radiate back out. But Colinvaux’s work is uncovering evidence of cooling rather than drying, of a forest shattered by moderate cold with each passing ice age. Pollen, and mud, and his discourse of science, will show how this green cathedral was built. His theories are extremely important in today’s world because he is reading the past in order to look ahead to the future. By discovering how the green cathedral was built, perhaps we can predict whether the structure can be rebuilt after the great fire which is close upon it. Our program will concentrate on the man behind the science, his views, and their ramifications, rather than all aspects of research within the field of Amazonian history reconstruction.

THE STORY

In the tradition of a conventional epic, *Building the Green Cathedral* will begin "*in medias res*". Flying low over the endless green canopy of an Amazon rain forest, helicopters rush toward an unexplored lake deep in the heart of Yanomami territory. Reaching a small clearing a mile south of the lake, the helicopters set themselves down and expel their cargos of scientists, support staff, and a mountain of supplies. After everything is unloaded, the helicopters
rise and draw away, leaving the circle of boxes and humans standing alone in a vast unbroken forest.

Part One of our story focuses on the set-up of camp and a personal introduction to the characters involved in the project. Here we will meet Dr. Colinvaux and begin to see his fervor in his work, along with his dynamic personality and odd-ball set of habits. We will meet the graduate students working under Colinvaux - who share his passion for exploration and excitement with science. We are introduced to the two Yanomami Indians who serve as guides and porters during the expedition. Though they do not speak English, we get a sense of their stand-offish attitudes and genuine perplexity at this bizarre situation. Finally, we meet the young Earthwatch student - a non-scientist thrust into the midst of one of the world's most mysterious places. Through him, the audience is transported to this world, seeing the rain forest and the process of science through his eyes. He is the connection for all of us to relate to the story. We will develop his story as the sub-plot (how he encounters the rain forest, how he views this world and the science, etc.) His presence serves as a means for Colinvaux to explain, in the simplest of terms, the purpose of the expedition, the mystery behind it all, and the science involved.

Part Two illustrates the various activities of life around camp. Daily deluges of rain. The odd assortment of animal visitors. Swarms of bugs and biting insects. The preparation of daily meals. Sleeping in the cacophony of nighttime screeches, squeaks, and croaks. Exploring the rain forest at night. And we will focus on an early morning activity of Colinvaux - his travels on the nearby river in his rowing shell.
As a non-scientist, the young Earthwatch student's perspective will allow us to view the rain forest in a fresh manner. Fleeing from the outhouse as a flock of roosting fruit bats streams from the entrance of the hole, quickly reminds him (and us) that he is not camping in the woods of central Ohio.

In Part Three we follow the expedition to the research site. Canoeing upriver and tirelessly hacking our way through the forest, we eventually reach the lake where core samples are to be taken. It is an ancient lake, pristine and stained black like tea, scooped out of the dense forest. The launching of boats and the set up of the coring rig leads us to the purpose of the entire expedition - the collection of mud.

Around the campfire that night, Colinvaux tells tales of previous adventures and then breaks off into a prediction of the Amazon past and its future. During his row the following morning, the silence of dawn is broken by the sound of returning helicopters. The adventure has ended for now.

But the mystery is still there.

In Part Four we return to civilization and the analysis of the cores begins. In the lab, the search for the tell-tale signs of the past races on. Colinvaux, with his new data in hand, forms a clearer picture of the Amazon during the last of the great ice ages. Using film footage of comparable landscapes or through computer animation, Colinvaux will "reconstruct" the Amazon, describing his views of the past.

The Amazon has often been described as an ancient ecosystem - a cradle of evolution. It has been conjectured that the stable climate of the region has allowed it to evolve slowly, producing the fantastic biodiversity present today. Colinvaux's work describes a much different ice-age Amazon. It was much
cooler, a full thirteen degrees (F.) colder than today (enough to kill an average houseplant). Environmentalists concerned with the possible dramatic effects of global warming speak of a five degree increase in temperature. The effects of a drop in temperature almost three times that value would have overwhelming results. The immense biodiversity of the Amazon may consequently be a result of catastrophic events. Rather than a stable and static system, the Amazon may be in a continual process of rejuvenation and change. This is one controversial new answer to our Amazon mystery.

The film closes as Colivaux and his crew load into Soviet helicopters to go off and study the history of the Russian Siberia and the Bering Land Bridge - another of the first chapters in the Earth's mystery story.
In the fall of 1992, we attempted to run through the process of filming such a work as described above but without doing it on a grand scale - a trial run if you will - where we would document a similar expedition project. This venture however, would be on a very limited budget, with limited crew, and would not be scripted. The object of this was to see if such a project could be managed in the remote areas of the Amazon and to discover what technological, political, or artistic obstacles we would face on a larger scale when the full program was filmed. With a budget of only $10,000 dollars and a crew of two, we set out to document a scientific expedition to the Hill-of-Six-Lakes region of northern Brazil.

The result was a learning experience in terms of feasibility problems, technical glitches, and the demands of filming in such a difficult locale and an insight into what would be required if the larger project was to be accomplished without disaster. Not only was the film crew faced with the problems of working in the difficult environment but the scientists on the expedition faced other unexpected difficulties that made for trying times. A large contingent of their labor force that had been hired to do a great deal of the portering, never showed up, forcing the scientists to delay their venture for several days and to spend extensive periods of time carting equipment back and forth through the rain forest, rather than concentrating on the work at hand. Additionally, since they were unable to keep all of their equipment together by using a large labor force, much of it was ransacked, unavailable, or stolen by the locals.

Conducting scientific investigation in the Amazon is very demanding and the problems we encountered in filming the expedition were both unexpected and unfortunate. Much of the videotape was ruined because of faulty cameras - a
technological hitch that wasn't discovered until our return. The high humidity and heat had caused the electrical system in one of our cameras to short out and though the camera could still film, the end result was devoid of sound and the picture had interference running through most of it. In the other, the microphone became inoperative. Without an expensive monitor to view the progress of the filming each day (due to the limited budget), it was impossible to detect the problems in the field. Additionally, the fact that we could not script the action and sequences meant that we were literally following the scientists around to the best of our abilities, hoping to capture the proper sequences and trying to stay out of their way. Obviously, this problem would not occur with a docudrama production. With the lack of the footage from the one camera and only visual images from the other, most of the action continuity and much of the trip was lost and could not be used in editing together the sample preview for the final production. The result was more of a travelogue than any other type of program and parted from the original intent of the sample preview, and certainly from the intent of the final production.

The sample piece was forced to utilize voice-over narration, since almost all of the natural sound had not been recorded during the trip. This meant that without the original people in the film available for post-production, it was necessary to change our entire outlook on the venture. We were well aware that the sample preview would not simply be a smaller version of the larger program, but the idea was that it would at least resemble the general concept to a limited degree. Without the opportunity to acquire actors for the parts, the inability to script the action and dialogue, and the uncertain nature of the events that would unfold, our ultimate control over the final appearance of the sample piece would
be dramatically limited. What we did not plan however, was the inability to use those segments that we would be able to capture in roughly the same form as they were taken.

This forced the final editing of the sample piece to utilize both voice-over narrations and music overlays quite extensively. Additionally, a great deal of stock footage had to be used to fill in missing pieces for those segments of the trip that were only covered by a single camera unit (which turned out to be the one that failed to record both the sound and video portions). Stock natural sound was utilized to give the piece some semblance of naturalness, but the final effect was a rather disjointed and stilted piece.

In theory, scientific television can be put together in the same fashion and utilizing the same techniques as any other form of production - it is simply a different subject and storyline. However, in reality, working with scientists (real or fictional) in the field is a much more arduous undertaking. Science often does not proceed as the scientists expect it to and for the television producer, this unpredictability can spell trouble. Coupled with the throes of working in the Amazon, several thousand miles away from the nearest production facility or repair firm, we soon found that it increases the problems associated with film production exponentially. Either the entire process should be moved to production studios or minimally, to a controlled location with easy access to modern facilities, or a great deal of preparation and backup must be included in the production plan. Shooting footage in the rain forests of the Amazon is comparable to shooting footage on the moon - once you are there, you are on your own and you can't just pop back to the studio to view the dailies or hammer out production problems.
The problem with shooting scientific ventures then is a tradeoff between becoming too stilted and artificial, seeking to eliminate the vagaries of the wild, and not having any control when filming beyond the reach of modern technology. Unfortunately, much of the great scenery and quite a bit of the "true" scientific action happens in those unexplored places - at least much of the exciting and camera-worthy scientific ventures appear to follow this paradigm. We are then placed in a difficult position in order to capture scientific endeavors - and generally the easier approach is taken and the endeavor is either moved to the lab or accomplished through the use of a talking-head discourse. The only departures from this have been similar "travelogue" type of documentaries that have utilized the same methods as ours and have resulted in virtually the same form of programming product.

The learning experience of this venture has taught us several important factors when approaching the final piece. First, a complete backup system and plan must be implemented before the excursion into the out-of-the-way places is initiated. Without it, the production will inevitably fall to the whims of the unknown forces at work in these locales and will be compelled to take a reactive stance to the ensuing difficulties rather than taking proactive action. Under these strenuous conditions, a proactive approach is by far the better method. This means that the production costs will escalate far above those for a normal production effort of similar scale. Each vital piece of equipment will require a backup system, or minimally, a way to determine the problem on the spot and the capabilities to deal with it as it happens. Not only will this necessitate much more equipment to be taken into the field, but will also require further technical assistance from personnel capable of repairing or analyzing the equipment.
Secondly, the production will have to be as fully scripted as possible, with as much detail as can be elicited from the circumstances. Little should be left to the ways of chance and more than likely, the entire production will have to be a recreation of events, rather than a current experience of them. This means that a scout party will have to be sent on location long before the actual production to ensure that most of the intricacies of the filming are managed and under control. Obviously, in dealing with such tenuous situations as the Amazonian environment presents, this will not be a perfect process, but improvement of the odds will ultimately be of great value.

Finally, we must be ready to deal with the problems that present themselves in remote locations by working with the difficulties rather than against them. The tendency in dealing with these hardships is to eliminate the hardship by going back to the production studio or "faking" many of the environmental conditions. Scientists do not go over well to the general public simply sitting in laboratories amongst their equipment or before chalkboards strewn with complex writings. This must be remembered before taking the shortcut of working in the controlled production facility. Even though a great deal of our footage was lost due to the technical glitches, most of them could have been rectified or at least, lessened through the use of backups and better technology. Nothing can replace the essence of "being there" and the natural world goes over, even with its many problems, far better than any studio setting. Local Indians are always better and more appropriate for general audiences than are imported or counterfeit ones. The atmosphere of a rain forest can never be reproduced, no matter how extensive a film's budget is, and this shows through
in the final product. Though the general public may not be connoisseurs of science, they are fully versed in the textures of motion pictures.
The following is the resulting narration script for the sample preview piece:

We are flying into the heart of the Amazon basin. The forest is home to over half of the known species on the planet. And directly in the middle of this vast green savanna - at the confluence of the Rio Negro and Amazon river - lies a city of over a million people. Former home to rubber barons, frontier traders, and a hodge-podge of Indians, forest settlers, and river people, it is now a city stuck somewhere between the 16th and 20th centuries. The rubber barons are now gone - but they have left behind them a legacy of opulence and desperate poverty - a symbol of the Amazon's promised treasures and broken dreams. Until recently, the only ways into Manaus were by river or by air. And it is here where our journey begins. In the city of Manaus, Brazil.

The remnants of the former glory Manaus once enjoyed, during the years of the rubber boom, abound throughout the city. The most prominent of which is the Manaus opera house. Built in the latter part of the 19th century, it was constructed from materials brought over from Europe. Each brick, every item in its construction was meticulously shipped from the master craftsmen of Europe, across the Atlantic Ocean and up the Amazon river, 1,000 miles to the city of Manaus. Some local residents still consider the structure sacred. But to most, it is a symbol of the rich days of long ago. the rubber empire fell in the 1920s - when rubber seeds from the Amazonian region were smuggled out of Brazil and transplanted in the British colony of Malaysia. Not long thereafter, the price of rubber fell dramatically - and along with it - the city of Manaus.
It is here that we find an international group of scientists preparing for an arduous journey up the Rio Negro and into the Amazon rain forest. Their first task is to gather supplies they will need to get them through the 6-week expedition. First on the list is hammocks for the long boat journey upriver. The trip will take them 700 miles from Manaus; deeper into the rain forest. They will travel by boat, bus, car, truck, canoe, and finally on foot - just to reach the destination of their research... isolated lakes on a mountain jutting from the rain forest. With them, they will have to carry about three tons of supplies, equipped for both their research and survival. It will take them over two weeks to reach the lakes, where they will have about a week and a half to complete their work; and another two weeks just to return.

As they walk through the streets of Manaus, the signs of luxury and poverty are all around. People living on the streets without shelter or even clothes. Some are forced to sleep wherever they can find a place to lie down. Others must use the fountains built by the city's rubber barons, as places to bathe.

They collect supplies for several days and then finally, head off with it all to the port of Manaus. There they will load the food and equipment into a cargo boat for the long journey upriver.

The harbor is a very busy place and it doesn't take long to gather enough people to help carry supplies from the truck to the dock - for the equivalent of about a dollar a person.
At the docks, the leader of the expedition, Dr. Paul Colinvaux of the Smithsonian Institute, joins the group, along with a smaller group of Brazilian scientists. Dr. Colinvaux explains why they have all come to the Amazon.

<interview with Dr. Paul Colinvaux>

Their equipment is loaded onto the boats. They must bring everything that they will need for the next 6 weeks. Every bit of food, medicine, and equipment that they might require. There are no local grocery stores in the forest. No cozy motels. There's no going to the local pharmacy just down the way for medicine if an emergency occurs. They will be on their own and out of contact until they return to Manaus.

Finally, all the supplies are on board, the gangplank is pulled in, and they begin upriver, to the lakes so very far away.

The next morning at dawn, the forest awakens slowly from a deep fog that has enclosed the river. The sun peers through the canopy of the jungle that runs all the way up to the river's edge. It is rather peaceful and mystical - sun, fog, trees, and gently rolling waves.

Some of the expedition members find it hard to wake up despite the hum of the cargo boat's engine. Others are already up, passing the early hours by shaving, taking a bath in the wake of the boat, or simply eating breakfast and reading a book as the miles slip by. There is no hurry, no rush - the sights along the bank
rarely change. It is almost always the same green wall of vegetation sliding by - like a record player stuck in the same groove of a record - playing the same thing over and over.

It will take eight days traveling upriver. the waters of the river are low right now, making some passages particularly difficult to navigate. It will slow their journey even more, so there is nothing to do for the expedition crew except to pass the time idly as the river rolls by. Some spend the time chatting. Others find time to unpack and repack their supplies, making sure everything is in perfect working order. Writing is a favorite pasttime, as journals are filled with impressions of the forest or memories of loved ones at home. Dr. Mike Miller of the University of Cincinnati uses the time to test the chemical composition of the dark waters of the Rio Negro. Some use the time to sketch or draw while others birdwatch in the trees along the bank as they continue to slip by.

Fishermen bring their catch of two days into one of the small towns along the bank of the Negro. The diversity of the fish in the Amazon is so great, biologists are unable to catalogue or identify 30 percent of they catch they find in these local markets.

At least once a day, the crew pulls alongside one of the many white sand beaches that lines the shore of the river for a recreational swim and other activities. It is a nice break from sitting on the boat all day long. Crew members take time-out to play soccer on the spit of sand while others practice their
**capoeira** - a Brazilian sport that combines martial arts and dance - usually performed to the rhythms of drumming music.

After 8 days, the mountain where they are going to search for the ancient lake, looms ahead in the distance. This is as far as the boat can take them. rapids prevent them from going any further upriver. From here it is another 4 days to reach their destination.

Everything must again be unloaded from the boat and onto a bus. The trip seems to be one long experience of loading and unloading cargo.

Even though the mountain is visible just over the forest, it is still a very long way away.

A bus takes them down a highway cut through the middle of the forest. Before the start of the rainy season, the dirt road is in excellent condition but as soon as the rains begin, it will become one, big muddy quagmire - impassable for over half of the year. Bridges in the Amazon are made of nothing more than logs and planks stretched across small rivers. With the rainy season, any bridge would be swept away in the flood waters, no matter how well it is built, so the locals only put up temporary bridges in each year at the beginning of the dry season, knowledgeable of the fact that they will only last about 6 months.

The expedition reaches the boundary of a Brazilian national park. In the interior lies the mountain and lakes they are looking for. From here, they must travel by
canoe and on foot. Their destination is still some 10 miles away - through the dense forest and some of the hardest going so far. But as far as Colínvaux and his group are concerned, it is some of the best.

At last, through the tangled vines and dense trees, the expedition reaches their ultimate goal - the ancient lakes.

Their equipment and boats are set up and hauled out into the middle of the lake. It has been two long weeks and finally the group can begin their work. Colínvaux explains why they have come.

<interview with Dr. Paul Colínvaux>

Their research is also done on some of the smaller lakes in the area. This one, a swampy region no more than a hundred yards across, provides them another opportunity to collect more data. The drill is lowered into the mud to core for samples, but this small lake proves to take a little more effort in order to get what they are after.

Later that evening, research samples collected and time to go home once again, Colínvaux finds, in the relief, a reason to sing.
I wish to thank Melissa Carter (no relation) for her role as the other camera person during the trip to the Hill-of-Six-Lakes region. Unfortunately, it was her camera that shorted out during the early part of the trip and most of her footage was unusable. In the end, none of her shots were used to put together the edited sample preview but her efforts have not gone unappreciated.
BIBLIOGRAPHY


Albrecht, B.E. (1992). Beakman will dig up all the answers. *Plain Dealer* (Cleveland), November 7, 1992, 1D.


Donlon, B. (1993). Beakman will be educating kids on CBS. USA Today, March 18, 1993, 3D.


Kaufman, J. (1989). There are reasons for the 'fusion confusion' when scientists announce they've solved the world's problems, not everyone in the news business reacts the same way. *Boston Globe, April 16, 1989*, 78.


Williams, S. (1993). Beakman's World' answers all questions but one most asked. *Plain Dealer (Cleveland), October 23, 1993*, 10D.
