How do journalists who act as the information interface between science and its clients do their job today? We do it, most of us, with varying success. We try to separate science and technology in our writing for the public, and we succeed, I think, more often than not. We try to present news about scientific developments in the context of science as a continuing process, and when space and deadlines permit, at times we succeed. We try to avoid political bias or advocacy when we cover the interaction between science and public affairs, and here we almost always do. We aim for accuracy and try to shun sensationalism, but here our critics say we too often fall short.

Let us look at a recent example of reporting on fundamental science and technology combined: the long voyage of Pioneer 10 to Jupiter, which climaxed December 3, 1973 with the spacecraft’s precisely executed fly-by, 81,000 miles above the planet’s cloud tops. There was no political controversy here (although there may be doubters among the public who cry “boondoggle” at a $50 million spacecraft measuring fields and particles, and photographing Jovian moons that Galileo spotted more than 350 years ago).

The Pioneer mission was a major event in planetary astronomy, a superb feat of technology, a collector of fundamental scientific data about important physical phenomena, and a forerunner of other interplanetary missions that will tell us much about how our solar system was formed.

For science writers, Pioneer offered an opportunity to treat the public to something quite unique: a glimpse of science in its moment of pursuit. As the spacecraft’s radio data poured in to the Missions Operations Center at the Ames Research Center of the National Aeronautics and Space Administration in Mountain View, California, the thirteen principal investigators joined reporters to engage in daily colloquies of considerable depth. More than 130 reporters, photographers and television crew members were registered in the special press room set up at Ames. At least two dozen reporters—many of them specialized science writers from major newspapers, magazines and wire services—attended every briefing by the scientific teams. Those briefings began a week before Pioneer’s rendezvous with Jupiter, and continued each day until a week after encounter. Some of the discussions were relatively brief hour-long progress reports on the functioning of Pioneer’s array of instruments; others lasted up to three hours, and offered detailed interpretations of complex data.

Among the scientists some, like James Van Allen of the University of Iowa, who was investigating Jovian radiation, were veterans of press encounters; others, like Tom Gehrels of the University of Arizona, who directed Pioneer’s imaging
photopolarimetry experiments, had rarely, if ever, met experienced science writers before. During the briefings, the reporters pressed for details on what the data from Pioneer meant. The scientists, elated at the mission's continuing success and the near-perfect functioning of their instruments, were eager to answer. They covered blackboards with speculative diagrams; they built magnetic field models out of wire; and pushed the wires into new shapes with each new set of readings from Pioneer. They interpreted S-band occultation readings on the spot. They likened the huge planet's magnetic field to a soggy, leaky, bulging doughnut. They debated whether it rotated with the planet, or not; whether its dipole center was offset from Jupiter's equator or not; whether its trapped radiation extended 4 billion miles out, or only 2 million miles. Energetic electron fluxes rose predictably; proton fluxes less so. With every new batch of data, the experimenters devised new models, or altered old ones.

This was 'instant science,' as the reporters dubbed it, and somehow, we felt, we were able to capture for our readers the legitimate excitement of the instant in terms of its purely scientific content. We were able to help our readers share the sense of wonder which Victor Weisskopf contends is implicit in science as "the greatest cultural achievement of our time." We didn't have to write about plastic flags on the moon, or talking satellites, or photograph astronauts floating upside-down like the men of 2001. We could report a purely scientific mission to explore man's home solar system, and the new concepts it was generating. We could try to convey in dramatic terms the magnitude of the universe as Pioneer headed out beyond Jupiter, beyond the solar system, to fly, perhaps, forever—"It." As one journalist reminded his readers, "there is such a thing as forever."

This sense of excitement, of discovery, of questioning, imbued much of the Pioneer news coverage with a flavor that commanded front-page attention. Newspapers all over the country featured the Pioneer story prominently for days, and even science writers who were not sent personally to California to cover the story wrote interpretive commentaries as Jupiter yielded up its secrets. The television networks carried news reports on the mission every day, with interviews, charts and models to explain the data. The Johnny Carson Show featured Carl Sagan for half an hour speculating on pre-biotic chemicals in the Jovian atmosphere. Time and Newsweek both published detailed articles on Jupiter, its moons, and its magnetic field.

Editorial comment in major newspapers accurately identified the mission's meaning:

**Pioneer 10 is an extension of mankind, a probing of the unknown. We treasure the facts we gather, but mankind's glory is the questions it asks.**

_ Houston Chronicle, December 14, 1973

**Pioneer 10 is a triumph of technology, but it is more than that, it is another successful attempt by endlessly curious man to puzzle out the secrets of the endless universe and then, some day, turn them to his own use.**

_ Los Angeles Times, December 5, 1973

Now the data from Pioneer 10 inaugurate a qualitatively new stage in man's knowledge of this giant planet and in his understanding of how its physical and other properties relate to the larger problem of the origin of the solar system and of the universe.

_ New York Times, December 4, 1973

Yet despite occasions such as these, when a scientific event captures the public imagination, it seems clear that only a small fraction of the public understands science as scientists or science reporters might hope they would. Amaiti Etzioni reports, elsewhere in this volume, that while public confidence in the institutions of science has declined in recent years, the decline has not reached crisis proportions. Perhaps not. But there is no evidence that public confidence is growing.

A gifted, mystical friend recently sent me a poster bearing a picture, a tarot card of The Fool. The poster's message is this:


There is no indication here that any thought has been given to how "simple truth" is really reached: no thought of Newton's calculus, of the desperately painstaking observations by Brahe, of Darwin's years aboard Beagle amidst the armadillos and iguanas, of Michelson's and Morley's mirrors upon mirrors that sought to detect the luminiferous ether, of the x-ray crystallography (and high-spirited chickencoop, too, if we are to believe Watson) that pinned down the double helix of molecular genetics. What seems to be new in science's problem of public understanding is an unexpectedly swift shift in public attitudes as reflected not only in Congressional budgets and Nixonian impoundments, but also in fundamentalist textbook rewriters; growing bands of seekers after instant satori; and growing numbers of citizens who seem to equate all physics with nuclear holocaust, all biology with DDT all psychiatry with mind control, all electronics with Big Brother and the end of privacy.

This development has led to a response from the scientific community. The American Association for the Advancement of Science and the National Science Foundation, and the National Science Foundation, are at this moment intensifying their programs aimed at increasing the public understanding of science. Experimental conferences, briefings, and community education ventures are underway. The efforts are promising, and in my judgment soundly directed. Some will suggest, as Daniel Greenberg does in Science and Government Reports, that this activity is a Pavlovian response to the drying up of real dollars in federal support for science. Greenberg contends that these new programs are "essentially a public relations campaign designed to allay public fears of science and drum up support for increased spending on research." Even if this were the case—and I believe Greenberg oversimplifies it—there is an urgent need to increase the general public's understanding of the processes, the motives, and the results of scientific inquiry.

In 1868, Thomas Henry Huxley offered this statement to an audience of ordinary English workingmen in Norwich:

I weigh my words well when I assert that the man who should know the true history of the bit of chalk which every carpenter carries about in his breeches pocket, though ignorant of all other history, is likely, if he will think his knowledge out to its ultimate mudds, to have a truer, and therefore a better conception of this wonderful universe and of man's relation to it than the most learned student who is deep-read in the records of humanity and ignorant of those of nature.

It is this kind of quasi-missionary sense about the search for the universe's truths that the communicators of science—be they scientists or reporters—believe is fun-
damental to a public understanding of science today. Communication is essential not because Huxley’s “humanity” and “nature,” or C. P. Snow’s “Two Cultures” are antithetical, but because they co-exist and are interdependent.

My colleagues and I, as science writers, believe the public’s understanding of science can and must be improved for reasons that should be self-evident. The scientific enterprise is expensive; it requires financial support and knowledgeable overseeing by the public. Science yields practical consequences that require public decision-making: to fluorescent or not to fluorescent; to finance dialysis centers or not to finance them; to build breeder reactors, or fund fusion research, or both; to engineer genes, abort after amniocentesis, or screen universally for sickle-cell trait. And above all, science is and has been mankind’s greatest intellectual adventure, as much a part of our culture as music or art or literature. Surely the mass media have as much business reporting and interpreting science as they do ballet or baseball.

In a newspaperman’s terms science can be a Good Story. My own editors, for example, have no particular bias in favor of science, yet they have headlined on our front pages such varied subjects as the discovery of distant pulsars; the paleomagnetic evidence for polar reversal; the concept of a sea-floor spreading and continental drift; the historical emergence of theories in molecular evolution, from Opalin to Fannamperum; and the synthesis of biologically active viral DNA.

Recently, the comet Kohoutek made headline news, first because it was coming in all its brilliance as “the comet of the century,” and later because it failed miserably to live up to its advance billing. Was there a backlash from Kohoutek? Was science generally, or astronomy in particular, diminished in the public mind as a result? Did the astronomers or the press fail the public? I think not.

David Coulaback, of the University of California at Berkeley, concludes that he and his fellow astronomers probably erred in their early public discussions of Kohoutek by not noting clearly enough that predictions of comet magnitude are notoriously uncertain, and that Kohoutek itself might, in fact, barely attain naked-eye brightness at all.

Nevertheless, the backlash appears to have been minimal. There have been few letters to the editor ridiculing the fallibility of science, and no editorial denunciations of astronomy. The only real ridicule, in fact, has been against cultists and astrologers who saw Kohoutek as the portent of the century. Kohoutek T-shirts lay in shops unsold, and a paperback book, The Comet Kohoutek: Greatest Fiery Charlot of All Time, which proclaimed that “the harbinger of God is coming” sold briskly for a while, then vanished from bookstores.

II

That not all those people “out there” beyond the laboratory are cultists or cluck Bunkers is evident from the high level of public interest in science. The two major American newsmagazines, Time and Newsweek, devote significant space to their sections on Science and Medicine. Jerry Bishop, the Wall Street Journal’s perceptive chief science writer, frequently publishes long articles on scientific topics far removed from the day-to-day interests of stockbrokers or investors. Meetings of the American Physical Society, the Federation of Societies for Experimental Biology, the American College of Surgeons, the American Chemical Society, the American

Geophysical Union and the American Association for the Advancement of Science are widely covered by the press. Reports in scientific journals are regular sources of news, and often lead to personal interviews with investigators.

Nor are the mass media the only avenues for communicating science to the public. Huxley has been updated with enormous success. For example, in the summer of 1972, a thirteen-week lecture series entitled, “Cosmic Evolution: Man’s Descent from the Stars” was held in San Francisco. Its sponsors rented a 500-seat auditorium and worried about filling all the seats, even though the series was opened by Ray Bradbury and featured such luminaries as Geoffrey Burbidge, Melvin Calvin, Sherwood Washburn, Freeman Dyson, and Philip Morrison. On the first night 3000 people showed up. Bradbury gave his lecture twice, the audience was crammed into every aisle, and the overflow listened from the lobby and the floor of the “Explorerarium,” a science museum next door. A thousand people still had to be turned away, and the same thing occurred at the next five lectures. The total audience for the series was more than 26,000. The following summer a similar lecture series, called “The Next Billion Years: Our Future in a Cosmic Perspective,” was even more successful. This time a larger hall was rented in San Francisco, and the series was repeated in Los Angeles, San Diego and Cupertino, a suburb of San Francisco with a junior college. Total attendance was over 100,000, and educational television stations in each city broadcast the entire series from videotapes. A third series is projected for the summer of 1974, focusing more specifically on the interaction of science and society in solving major problems during the coming century.

Much of the attraction of the series, I am convinced, has lain in the intelligent public’s eagerness to understand the processes by which science asks questions of nature. All the speakers shared with the public their own curiosity about the universe and man’s place in it, including both the insights and the ignorance that mark scientific knowledge as of today.

III

Science journalists face many problems as they confront audiences on one side, scientists on another, and the traditions of the media in the middle.

The current directory of the National Association of Science Writers lists some 400 active members, engaged, by definition, primarily in the dissemination of science information directly to the public. “Public” is a broad term, for active members include writers and editors at such specialized publications as Science, Chemical and Engineering News, Medical World News, Physics Today, and the Journal of the American Medical Association. There are also many free-lance writers, a tiny handful of television workers, and a few staffers on general magazines. But among the nation’s 1750 daily newspapers and two major wire services, there are fewer than seventy-five full-time science writers all told. The New York Times, by latest count, has a science and medical staff of eleven, including two in Washington. The Boston Globe has four. The Washington Post and Los Angeles Times have three each. A handful of other papers, no more than a dozen, boast two science reporters, who usually divide their work so that one covers the biomedical sciences and health care, while the other does the “hard” science and technology, including everything from physics to manned space flight. Lately, some papers have assigned specialized
reporters to cover the "environment" beat, the "energy" beat, and "consumer affairs," each of which includes significant components of science and technology.

Until the 1980s, science writing was a virtually unknown specialty in journalism. The NASW was conceived in 1934 in the bar of a Philadelphia hotel during the annual meeting of the American Philosophical Society; its three founders were David Dietz, science editor of the Scripps Howard Newspapers, William Laurence of the New York Times, and Robert D. Potter of the New York Herald Tribune. A more formal meeting in Washington during that year's meeting of the National Academy of Sciences launched the organization. The first eleven active members included virtually all the full-time science writers in the country. By 1938 there were 15; by 1945 there were 61; by 1963 there were 200; and today there are about 400.

Very few science journalists have any specialized training in the sciences; fewer than one-quarter were science majors in college. Most are college-educated in the liberal arts, and, according to a 1973 survey, nearly half majored in either English or journalism and spent several years in more general newspaper reporting before specializing in science. Younger science writers today are beginning to come from the ranks of undergraduate science majors, but there is little formal training in the field. A few university journalism departments offer seminars or single courses in science writing; one or two provide "internships" with experienced science writers in major metropolitan centers. But, by and large, entry into the field is unsystematic at best. I am not sure this is all bad. I, for one, am without formal scientific training, but I think of my own rather typical job in science writing as a full-time, perpetual fellowship to a graduate school with an endlessly varied and endlessly challenging curriculum. And all I have to produce each year, instead of a dissertation with footnotes, is a file of 100 to 150 newspaper articles, most of them written under a daily deadline, and each running in length from 500 to 1200 words.

Most newspaper editors, it is fair to say, still cling to the journalistic tradition that names make news, that "human interest" is essential, and that any good reporter can cover any story. So specialists like science writers are not always considered team players. They demand expensive reference books and shelf room for journals. They disappear on out-of-town trips to meetings, rocket-launchings, and laboratories. They insist that their stories cannot be written in less than two columns. They balk at explaining what a proton or a molecule is every time they use such words. They argue—all too often in vain—with the copy editors who incorrigibly top their carefully qualified stories with headlines heralding "cure" and "breakthrough."

Science writers are not always loved by scientists, either. And if we are inaccurate, or we sensationalize, we deserve our lumps. But Edward Shils, for example, is also concerned that the press air controversies where, as he puts it, scientists publicly attack their own colleagues for such sins as "not serving society." Shils has said:

"Journalists, especially those involved in reporting and commenting on science policy, pick up all these criticisms. They delight in finding the "establishment" of science in the wrong. Their animosity against government makes them critical of governmental science and of the scientists who perform it. They like to catch them in contradiction or impugn the veracity of their statements."

We specialized journalists who cover science and science policy consider ourselves reporters with a particular mission. We are in business to report on the activities of the house of science, not to protect it, just as political writers report on politics and politicians. At times these activities may seem ignoble. If "politically adroit and accomplished senior academicians" edge out promising young investigators in the scramble for limited grant funds, as the President of the American Federation for Clinical Research has alleged,9 that is legitimate news in a story analyzing the funding problems of science.

In 1971, research teams at the University of Southern California and Georgetown University simultaneously announced the discovery of what the New York Times called "two candidates for the ominous title of human cancer virus." Neither group had as yet published its report in a refereed journal, but each group summoned a press conference for its announcement. Six months earlier a group at the M.D. Anderson Tomlinson Institute in Houston had also reported a possible "candidature" for the virus, publishing in Nature and subsequently in a press release.10 It seems to me fully appropriate that a perceptive and knowledgeable science reporter should comment on the background of such races for priority and note: "The development of the controversy also reflects the pressure of the present political maneuverings to legislate a cure for cancer."

Surely it is an obligation for science writers to report most carefully on the qualifications of those who claim scientific expertise, and at times to seek to balance their controversial statements. An eminent physicist may expatiate on his theories linking race and I.Q. When he does, however, the conscientious science writer will note the physicist's track record in genetics, and place his conclusions in the context of the ongoing controversy over race as a definable concept and I.Q. as a measurable culture-free entity; the reporter may even solicit comments from the physicist's message to geneticists known to oppose his views.

No formalized code of journalistic ethics covers this kind of reporting. But reporters who specialize in any field—be it science, politics, labor, or education—are expected on most newspapers to interpret the background of complex issues in their field. Their responsibility goes beyond the traditional "who-what-where-when" of elementary police-court reporting.

Science writers, in short, are now exercising "clinical judgment" on many of the stories they cover. A virologist, for example, reported in 1973 that virus-like particles had been found in the breast milk of nursing mothers with a family history of breast cancer. "Look," he said in response to questions during a press conference at the National Academy of Sciences, "if a woman has a familial history of breast cancer in her family and if she shows virus particles, and if she was my sister, I would tell her not to nurse the child." Here was a story, from a most eminent source, in a vitally important area of human interest, that could have alarmed millions of women. How did the press handle it? In the New York Times Harold Schneck discussed the research that led to the finding of the virus particles; he mentioned the scientist's reservations about nursing in the fourth paragraph of his story, and immediately added: "He and other scientists emphasized, however, that the particles had not been proved to be viruses related to the cause of breast cancer in humans." In the New York Daily News Edward Edelson wrote this interpretive paragraph: "There is no definite proof that the suspected virus causes breast cancer. Even if the milk agent does cause breast cancer, there is no definite proof that transmission of the particle in human milk is responsible." And for the Associated Press Frank Carey wrote this lead: "A
Columbia University cancer researcher said Tuesday new findings suggest a conceivable though wholly unproven danger that some breast-nursing mothers may transmit a potential for breast cancer to their female babies."

Whether we science reporters are backgrounding the technological problems of the energy crisis, the biological activity of synthetic DNA, the cosmological questions of quasars, or the Hunting of the Quark, we try never to forget our basic role as journalists. Our stories must be compellingly told, for if they are not, neither our editors nor our readers will accept them. We try to point out how every event the most fundamental and arcane research has its relevance to human purposes. Yet, since the rubric of "science news" covers such an unbelievably broad range of topics, it is no wonder that science writers often feel frustrated by their inability to remain familiar with it all, to translate it all, to convey the nature and implications of scientific progress promptly yet accurately.

There are aids and obstacles to covering the science beat. The organizers of most major meetings have long since learned to retain experienced public information staff to distribute texts or abstracts of papers to the press in advance, and to help arrange interviews and press conferences when science writers request them or the organizers feel that particular papers are especially noteworthy. The major scientific institutions—government agencies, universities, medical centers, "think tanks," and technically based corporations—employ professional public relations staff. Most science writers read or scan regularly as many major scientific journals as they can. And all science writers, wherever they are based, try to enlist the best scientists in their neighborhoods to help them simplify formidable journal language and focus appropriately on the significance of new developments. I do not often encounter a scientist who, when he understands the kind of help I need, refuses to discuss his work or to help me interpret the work of others in his field. If I am reporting results of a scientist's own research, I am perfectly willing, when asked, to hold up my story until the research has been published in a journal or presented at a meeting. "Refereeing" is at least tentative assurance that the story is valid. If the story is complex and technically difficult (and deadlines permit), I am eager to have a scientist's help in checking the facts in my account. I may show him my piece, or read it over the phone, but always with the most careful prior understanding that only the facts are at issue, never my personal interpretative comments, my emphasis, or my writing style.

After a few years of experience, most science writers find they have developed personal contacts among the professionals in the fields they cover. Walter Sullivan of the New York Times is virtually a card-carrying geophysicist by now, he has written so often on the subject; because of his personal interest in it, he has developed a wide circle of scientific friendships ever since he first covered the International Geophysical Year in 1957-1958. Among my own personal friends—first encountered because I covered news stories involving them—I can number a radio astronomer, a neurophysiologist, a cardiac surgeon, a biophysicist, a biochemist, a nuclear physicist, a radiologist, a population biologist, and a number of environmental activists who also happen to be good scientists. Any one of these men and women is willing to help me when I need a guide—anonymously or not—through some scientific thicket.

Many scientists, however, still flatly refuse to cooperate with reporters—some because they have in fact been misquoted or misinterpreted in the past; others because they mistrust the press generally; still others because they really do cling to the outmoded idea that science is none of the public's business. Similarly, those who cover the interface between science and political affairs from Washington often encounter public information officers in federal agencies who withhold information or distort it through mistaken zeal.

In some scientific institutions—a few grant-hungry universities and high-technology corporations are the worst offenders—public relations writers exaggerate the achievements of their scientists and proclaim "breakthrough" in wholesale press releases. I recall one handout from a university in Texas, dealing with a very minor development in accelerator design, where the writer did not quite have the nerve to use the word "breakthrough." The development, he wrote, was a "major ripple" in the world of physics.

There are, of course, always the problems of competition—among the mass media for "exclusive" stories, and among the varied happenings world-wide that mark each day's news budget. More than a million words a day will pour onto the desks of a major newspaper's editors; only a fraction can be printed. In the scramble for space or air time, does the overthrow of parity outrank the overthrow of a Latin American government? Does the synthesis of growth hormone overshadow The French Connection? Are Kohoutek and Pioneer 10 more spell-binding than the after shocks of Watergate? The science drama in the skies—despite Kohoutek's poor performance—achieved prominence last winter partly because many editors decided with canny news judgment that it would provide welcome front-page relief from a depressing spate of aircraft hijackings, White House tape erasures, stock market plunges, and energy brown-out. The public learned a lot of astronomy last winter, as well as politics. In a less ominous time the science might not have been as welcome.

There are no orderly rules for this kind of decision-making in journalism, for journalism deals with news, and news is ad hoc; it happens and it must be reported now. True, there are Sunday sections, and a few papers feature weekly science pages where background articles, sometimes written by scientists themselves, are published. There is a strong suspicion among many reporters, however, that these special pages and sections, because they are dull, wind up pinned to high school bulletin boards, largely ignored.

Newsmagazines have time to be more reflective, and their science and medicine sections frequently produce extremely well-backgrounded accounts of new developments. But this country does not boast a single broadly based popular magazine of science with a wide circulation. Science News, a sixteen-page weekly magazine, is published in Washington by the nonprofit Science Service, Inc.; according to E. G. Sherburne, the magazine's publishers, it has a circulation of about 100,000, made up largely of "scientists and engineers, science teachers, students and interested citizens," and is now in "pretty good shape" financially. The New Scientist, published in England, fares somewhat better; it has a circulation of 70,000, only half of which is in the United Kingdom. It is part of the profitable International
Scientific American is superb in its rather special field, that of communicating primarily to scientists, engineers, executives in technical management, and scientifically literate laymen. Since it crosses all disciplines, however, its publisher, Gerard Piel, argues that every reader of the magazine is a "layman" in every field the magazine covers except his own. Popular Science and even Popular Mechanics occasionally publish articles about scientific and technological developments, but hardly do much to convey the true spirit of science or the nature of scientific work. The National Geographic ranges now and then into astronomy, geophysics and oceanography, but not much further. The women's magazines present clear and accurate information at times on developments in clinical medicine, but their style is breathless and their focus is heavily biased toward nutrition, contraception, sexuality and new approaches to breast and cervical cancer. Harper's, the Atlantic Monthly and The New Yorker carry occasional excellent science articles, but these magazines have such small circulations that "mass media" becomes a misnomer.

Television, the newest of the media, has been called "the chief popular form of discourse in a technological society" by Michael Ambrosino, producer of science documentaries for WGBH, the Boston educational TV station. But in terms of continuing discourse between scientist and citizen, American commercial television is the most bankrupt of the mass media. Except for major developments that make the front pages of virtually every daily, TV networks pay little attention to science news; they seem to save their talents for the spectacular.

When Apollo 11 carried three astronauts to the moon, for example, commercial television truly shone: for nearly two weeks the American public was saturated with coverage every step of the way. Lunar scientists, armed with magnificent mockups and models and animated drawings, discussed on maria and craters, meteoroids and volcanism, gravity and the whole history of the solar system. Every network dedicated itself to the enterprise. At CBS, no fewer than 1000 employees were involved in the Apollo coverage; behind Walter Cronkite and Eric Severeid stood 37 correspondents, 9 researchers assigned from the regular CBS news research staff, 6 special scientific and technical consultants, 22 producers, 13 directors, 16 engineers and 65 guest discussants who ranged all the way from Lyndon Johnson and Spiro Agnew to Sir Bernard Lovell, Harold Urey, James D. Watson, Buckminster Fuller and Gloria Steinem! Four corporate sponsors—Western Electric, General Foods, International Paper, and Kellogg's—helped pay for the effort, although the network will not disclose cost and revenue figures. And all that was only CBS. The efforts of NBC and ABC were equally valiant. Apollo 11 was covered like the great human adventure it truly was; and if anyone in America failed to learn at least a little about space flight, selenology and Newtonian physics along the way, it was not television's fault.

But what of the prime-time hours since? Television news programs do indeed cover new developments in science from time to time, occasional interviews on talk shows do try to elucidate complex technical controversies. But Ambrosino has noted that during the 1972-1973 TV season—leaving out coverage of the Apollo 17 flight—fewer than 25 of 4,368 prime-time commercial network hours were devoted to science documentaries which explored topics in depth. There is, then, virtually no biology, no behavioral science, no physical science on everyday television.

According to records from the networks, when Pioneer 10 flew past Jupiter last December, ABC television carried three three-minute reports on three successive evening news programs. CBS News presented five successive spots of two to three minutes each. NBC did better: the Today Show featured two discussions of Pioneer's flight results—one six minutes long, the other nine minutes. At encounter time, NBC News described the event in five reports both morning and night, while NBC's syndicated service fed daily stories of two to three minutes each to some 200 independent TV stations. United Press International, whose Telemedia service feeds film to 700 client TV stations, covered the Jupiter encounter with two three-minute news spots.

From personal experience I can testify how less spectacular science news may typically reach the public. A major meeting takes place in a large city—a meeting, say, on geophysics. A press conference is held at which scientists from Columbia University, California Institute of Technology, and the U.S. Geological Survey discuss efforts at earthquake prediction. They explain a new theory of crustal dilatation, and describe how they and Soviet geophysicists have used such parameters as changes in strain gauges, changes in water levels, and changes in the radioisotope content of ground water to foretell earthquakes. They contend that a few quakes have been predicted—although not yet with precision at this time, magnitude or exact epicenter—and that new analyses of old records before the 1971 San Fernando quake show how that devastating temblor might have been forecast. This press conference lasts, perhaps, an hour. Science writers for a handful of newspapers and the two wire services take notes, ask questions, and prepare to write articles that may run between a few hundred words and a thousand. Their deadlines will come in a very few hours, but some reporters will later write more reflective, interpretive, longer feature articles based on further interviews and fresh background reading.

At the end of the press conference, the television reporters will seek out the scientist whose explanations have seemed the most colorful and articulate, and ask him if he can please explain the whole matter in two or three minutes. The scientist, if he is adroit and cooperative, may take four or five minutes. On the six o'clock news that night his explanation will be cut down to thirty seconds or a minute, with another minute for the TV reporter's summary, often rewritten from a press release prepared earlier by the public relations office of the scientist's institution. Nor is such coverage surprising when one considers that a major local television station in a big city could announce with pride recently that its new chief newscaster "is well known for his services as master of ceremonies at a wide variety of banquets and civic functions, and has served as singing 'emcee' at 70 beauty pageants..." The News Department's catch-phrase is "never a dull moment—and they mean it." says this station.

In England, where the BBC is entirely financed by a tax on radio and television receivers, the quality of science coverage is very different. BBC's science department is advised by a nine-member committee of scientists (six are Fellows of the Royal Society) which meets twice a year with the network's science producers and writers. The BBC's Features Group, a close-knit and independent team with a $20 million
yearly budget, produces some 600 programs a year in 32 different series covering every area of interest. Ten of these series involve science, and three, notably, the Horizon science documentary series, have been among the finest ever made. Several Horizon programs have been purchased and shown in the United States.

The most recent BBC science series, and one of the most successful, is The Ascent of Man, a highly personal view of the history of man's continuing discovery about his world and his universe, conceived and narrated by Jacob Bronowski. The budget for its 13 installments was $3 million. As of last February, Time-Life Films, its American distributors, had not yet sold it to a commercial American network, although Bronowski's book with the same title has already been published and the films have been released for educational use. "It is filled with passion and visual excitement. It's a personal, idiosyncratic view of science. It's Bronowski's view, and a noble one."

Except for a few outstanding films on nature like those of Jacques Yves Cousteau and Jane van Lawick-Goodall, it is outrageous that commercial American television 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. Fortunately, the outlook for more effective TV communication of science, at least via the public channels, is improving right now. In 1975-1976 two major projects were launched. The more ambitious is that of Ambrosino's "Science Program Group for Public Television" at WGBH in Boston. Its initial series of 13 weekly documentaries, entitled Nova, opened in March, 1974, over the 234 stations of the Public Broadcasting Network. The series deals imaginatively with varied aspects of science, research, and technology: the origins of life in the solar system, intelligence in cetaceans, a stone-age Brazilian culture, the history of anesthesia, reactors and the prospects of fusion power, astrophysics and the Crab Nebula in history. Some of the programs were produced at WGBH, some were made jointly by the BBC and the Boston group; and some were purchased from other documentary film makers.

The Boston group's initial planning was financed by a $40,000 grant from AAAS Funds for the first year's films, totaling $1.5 million, came from the Carnegie Corporation of New York, the Corporation for Public Broadcasting, the National Science Foundation and the Polaroid Corporation. For the future, given adequate funding, the Science Group plans a separate series in the behavioral sciences; a series for children involving activities that can lead to scientific questions ("we would climb a mountain, build a flying machine, predict the weather, study a cubic yard of dirt, excavate a site, plant a garden," says Ambrosino); a series on archeology, anthropology, linguistics, and history; and a special film project to provide expert up-to-date backgrounding of topical and controversial issues arising from science and technology.

The second science project of interest this year has been a five-part series, also on public television, called the Killers, financed by the Bristol-Myers Company and produced by David Prowitt at WNET in New York. Prowitt enlisted a team of twenty-three medical consultants to assure the accuracy of programs that dealt with research, clinical advances and prevention in five medical problem areas: heart disease, cancer, inborn genetic defects, trauma, and pulmonary disease.

Surveys of newspaper content show that far more science information and science news is being conveyed to the public today, and with greater accuracy and science sophistication, than was the case in the years before Sputnik symbolized the opening of a space age. Newspaper journalism, with its primary focus on immediate events, is not designed as an educational venture; by and large, newspaper publishers are in business to record the day's news and to make a profit doing so—not to serve as an extension of school and college. Even the best of newspaper science articles are ephemeral, though they can still be informative and interesting without sensationalism.

Yet I see real possibilities that science writers and the scientific community can, together, bring about major improvements in the reporting of science news. We science writers, I believe, can and should be more aggressive in persuading our managers that the scientific enterprise merits even fuller coverage because of its drama, mystery, human relevance, successes, failures and newsworthiness. We can, in our writing, show our readers more effectively that science is a continuing process by which the laws and workings of the universe are uncovered step by step, and that each step, however small, is potentially crucial. We need to develop more skill in reporting the full social significance of technological developments. We should show how these developments flow from the basic science that preceded them, and we should more energetically enlist thoughtful scientists who can point out, as quickly and fully as possible, what the social effects—both intended and unintended—are likely to be of new science and technology.

We should report more thoroughly than we do now on the political institutions of science and technology—on the complex processes of public funding, the internal operations of the great science-supporting agencies like the National Institutes of Health, the National Aeronautics and Space Administration, and the Atomic Energy Commission. We should be covering the ebb and flow of power among the scientists who advise, or should advise, the White House and the governors of the states. Science and Daniel Greenberg's Science and Government Reports do this effectively for their limited audiences, and occasionally their reporting is picked up by the more general press. But many a Science story on an AEC reorganization or an impoundment of HEW funds has direct repercussions on academic communities around the nation, and we "provincial" science writers should become far more alert to these issues in our own regions.

If this kind of depth reporting is to be done thoroughly, accurately, fairly, and interestingly, however, it will require a new level of assistance from scientists and technological leaders. These people will have to make themselves far more accessible to the public, not as apologists or propagandists, but as explainers and interpreters.

I see no reason why every component organization in the house of science, from astronomers to zoologists, should not develop cadres across the country to serve as guides when science news needs translation or local scientific developments warrant public notice. The Scientists Institute for Public Information (SIPI) has developed an effective nation-wide network for communication on environmental issues. But where are the physicists? the immunologists? the molecular biologists? Would it be undignified if an astronomer at a local state college were to telephone the news
director of a local television station and volunteer to spend a few minutes explaining why Kohoutek fizzled, and to provide some good photographs of earlier comets that didn't? Would an assistant professor of physiology risk refusal of tenure if he invited a newspaper reporter to watch the operation of a scanning electron microscope, and made available some photomicrographs of virus particles for a Sunday feature article? For five years, from 1966 to 1971, Joshua Lederberg wrote his personal interpretations of scientific developments in a column syndicated by the Washington Post. Right now two faculty members at the University of California-Steinbeck School of Public Health in Los Angeles contribute a weekly column on scientific nutrition to the Los Angeles Times, and Jean Mayer's Boston Globe column is widely syndicated. The kind of effort by scientists who like to write would be welcomed by scores of newspapers in small cities everywhere. It requires only three elements: the ability to write simply and clearly, the ability to sense what interests the public as well as the scientific community; and a commitment to publish for the public as well as to "publish or perish" for the rewards of tenure and promotion.

Scientists may not always succeed, however, when they try to improve communication with the public. Editors may trim their contributions to meet space requirements. Headline writers may miss their major points. In interviews, scientists may find themselves misunderstood and sometimes bruised by encounters with journalists and the public (although the bruising will prove healthy if it impels scientists to become activists for science education in their local school districts). They may often find their work described in the press with less than academic completeness, and even at times, inaccurately; reporters, after all, can make errors, although they do not knowingly commit malpractice more often than physicians would.

Happily, the American Association for the Advancement of Science and the National Science Foundation are at this moment intensifying their programs aimed at the public understanding of science. Experimental conferences between local government officials and scientists have been held to underscore the contributions science and technology can make to community problems in states and cities. Community education ventures have begun which bring scientists into personal contact with small local communities. On several university campuses in recent years, editors, news executives, and other "opinion leaders" have been brought face to face with scientists in small working conferences that explore both the processes of basic science and the relevance of applied science.

The Council for the Advancement of Science Writing, a small offshoot of the National Association of Science Writers, whose members include both scientists and science writers, sponsors a most valuable series of briefings for journalists—usually three a year—in the physical sciences, health and medicine, and the social sciences. These briefings attract fifty to seventy-five science writers from all over the country, and recruit leaders in the various scientific fields for programs that last from two to five days. Costs are borne by research institutions, foundation grants, and technological industries whose sustaining memberships keep CASW functioning.¹⁰

To do the urgent job of science writing more and more effectively, to assure an increasingly constructive interaction between the scientific community and the public, we need an unimpeded flow of information. We need scientists who are willing to explain their work, to interpret its significance, to defend its relevance without special pleading. Scientists, in turn, have every right to expect that reporting

REFERENCES

2. Science and Government Reports, December 1, 1972, p. 5.
5. This series came into being under the initial stimulus of Dr. Hans Mark, Director of the Ames Research Center. Both this series and the one given the following summer were cosponsored by the National Aeronautics and Space Administration, the Astronomical Society of the Pacific, and local educational institutions.
13. The Council's 1974 membership includes: Alton Blakeney, Science Editor, Associated Press, New York; Melvin Calvin, Professor of Chemistry, University of California, Berkeley; Victor Cohn, Science Reporter, Washington Post, I. W. Cohn, Danil School of Journalism, Northwestern University, Evanston, Illinois; William J. Cronin, Director of Research and Development, Field Enterprises Educational Corporation, Chicago; René Dubos, Professor Emeritus of Microbiology, The Rockefeller University, New York; Nancy A. Hicks, Science Reporter, New York Times; Donald C. Kirkman, Science Writer, Scripps-Howard Newspapers, Washington, D.C.; Samuel L. Konetz, M.D., Professor and Chairman, Department of Surgery, Downstate Medical Center, State
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