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Some Negative Feedback to the Unstable Amplifier

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The Annenberg School of Communications gives us reassuring evidence that great American wealth still finds its way to the University in support of rational enquiry. Under the leadership of George Gerbner, this School writes its mission large: as the fish lives in water so modern man lives in an all-surrounding sea of communication. For men to comprehend their media is as difficult as for the fish.

This conference is called by a timely concern taken up by the School. Our country is once again troubled by the deplorable state of the teaching of science and mathematics in our secondary and elementary schools. Nearly 30 years ago Philip Morrison, from whom you will hear tonight, led the organization of the Physical Science Study Committee that reformed the science curricula in our schools for two generations of students. We are acutely conscious that whatever we succeeed in doing now about the situation in the schools must be strongly conditioned by what the media may or may not be doing about science. As Harry Gray observed, the average U.S. high school graduate will have spent more hours in front of the TV screen than in the classroom.

By way of coaxing the media into constructive action Cecily Selby has suggested, among other stratagems, that science might serve as the appropriate topic for the intermission talk during symphony hour. I am sure she spoke from the same nostalgia I have for the intermission in the New York Philharmonic broadcasts during the late 1940's, when scientists were heard describing their work in lucid, literate five-minute talks. Those scientists were recruited and their copy was vetted for the understanding of the radio audience by Warren Weaver. Then

director for the natural sciences of the Rockefeller Foundation, Weaver has gone down in history as the canny, humble statesman-servant of science who, more than any other single man launched the contemporary revolution in the life sciences. He coined the term molecular biology; of the first 18 Nobel Prizes awarded in this new field before 1967, 17 winners had worked on Weaver's Rockefeller grants, bestowed an average of 18 years earlier. As the time and zeal he gave to the Philharmonic talks suggest, Weaver was deeply concerned by the need to promote wider popular understanding of science:

"It has become a simple and plain necessity that people in general have some understanding of science. We must appreciate its strength and value, and we must be aware of its limitations. We must realize what conditions of freedom and flexibility of support must be maintained for pure scientific research in order to assure a flow of imaginative and basic new ideas. Without some of this understanding we simply cannot be intelligent citizens of a modern free democracy, served and protected by science. Without this we will not know how to face the modern problems of our home, our school, our village, state or nation."

With his sunny, generous outlook on the world, Weaver would argue a still more deeply held motive for knowing science:

"The true significance of science rests not on its practical achievements, be they trivial or great, but rather on the fact that the scientific mind, approaching the wildly tangled confusion of nature, accomplishes an act of artistic creation when it discerns, displays, and illuminates, amid all the apparent complexity, hitherto-unsuspected relationships of

simplicity. This is the moment when man justifies his role as the culmination of all nature, justifies the cerebral machinery which evolution was so long in providing him with.

The wintry spirit of James B. Conant held a dimmer view of the possibility of curing the prevailing scientific illiteracy. He said, "...the remedy does not lie in a greater dissemination of scientific information among nonscientists. Being well informed about science is not the same thing as understanding science..." He despaired of "short-cut methods," for "'science' is the sum total of the potential findings of the worker in the laboratories; it is their plans, hopes, ambitions in the process of realization, week after week, year after year, that is the essence of modern science."

By way of emphasizing his doubt that what we now call the media could help, Conant proposed a fanciful project in science instruction for the layman:

"One way to proceed would be to require every person to take a few years off and become a visitor to scientific institutions. He might spend six months, let us say, at the elbow of a group leader in a research laboratory of some large chemical company; then move to a corresponding vantage point in the electrical industry, then to a university laboratory of physics or chemistry, finally to a hospital or to the engineering operations of those who are studying new ways of utilizing coal."

Conant was careful to discount this vision, lest any one take it seriously. "Unfortunately, there are grave difficulties quite apart from the time involved," he said. "Visitors are proverbial nuisances in any laboratory..."

A few years earlier, in 1947, I had consulted Mr. Conant on my plans for a magazine of science. "That's a terrible idea," he said. He thought the magazine was not so terrible when it appeared. That was because my collegues and I took the easy way; we published a magazine for people who are interested in science. The task for this conference is the more difficult one: How can the media take the story to people who are not interested?

We would have warm encouragement for our effort from J. Bronowski if he could be with us today. His Ascent of Man remains the best demonstration that significant ideas can be portrayed in images and conveyed with clarity on the television screen. Bronowski, it is worth recalling, was moved to this enterprise by his outrage at the Kenneth Clark 13-part TV spectacular called Civilization; Lord Clark mentioned science once, in a subordinate clause.

Bronowski defined the most compelling motive for our concern to elevate popular understanding of science. The new high technologies yielded by science beset, haunt and threaten us, he said, because we are trying to buy the body of science without its soul. "Science is not a loose-leaf notebook," and we cannot live our lives by values chosen for the occasion at hand from the "rag bag" of the past. As man's understanding grows and his technological competence increases, man's values change. "Such concepts as justice, humanity, and the full life have not remained fixed in the last hundred years, whatever churchmen and philosophers may pretend... A civilization cannot hold its activities apart or put on science like a suit of clothes -- a workday suit which is not good enough for Sundays."

In the Ascent of Man and all his other writings about science to laymen Bronowski argued that science bears as much upon the ends as upon the means of human existence. To begin with, he rejected the dichotomy of ends and means that has done so much mischief in history, permitting men to justify evil acts by claims for high purpose. The values of science stem, he said, from truth -- truth not as dogma but as a William James pragmatic process: the habit of truth. The habit of truth requires independence, for its practitioner can accept no authority but his own judgement and conscience. Science as a public practice must, therefore, protect independence and with it the right of dissent. Accordingly, science must cherish freedom: free enquiry, free thought, free speech, tolerance. "These values are self-evident, logical needs," Bronowski said, "only where men are committed to seek the truth; that is in a scientific society."

We have the good fortune to live in a society which fosters science. The postwar present in which we are living -- the last 36 years in which I have enjoyed the particular good fortune of practice as a science journalist -- stands as the most momentous era in intellectual history. Of the transformations in human understanding that have blazed in every field I choose just two for consideration here, for their relevance to J. Bronowski's thesis and the insights they offer into our progress with the task of promoting the wider public understanding of science.

Until our time tool-making has been held to be the type-trait, the status symbol, of membership in the genus Homo. If fossil bones were found with tools, those bones were man. But now, as we all know, tools have been found with two-million and

even three-million year-old bones, and these bones cannot by any stretch of the imagination be labeled man. They are the bones of a little 90-pound primate that still used its hands for walking. The fossil record of our forerunners is incomplete; their bones are hard to find because they bivouaced on streamsides and seashores. Their stone tools have been called, however, the most common fossil of Pleistocene. The elaboration, diversification and refinement of those tools give us a sensitive index of the progress of our biological evolution. Long before sapiens appears, the record clearly shows, our forerunners had begun social organization and were teaching their children not only new hand-skills but the values and purpose taking shape in their heads. In sum, we now know that purpose and value had their role in the shaping of our biological evolution. At least with respect to their tool-making our forerunners were already engaged in the habit of truth. The record of our evolution shows that the natural locus of value, which men have sought everywhere else in the Universe, sits inside the human head.

At the other end of the spectrum of the scientific enterprise the dust is just now settling on an earthquake at the foundations of mathematics. This is the catastrophe for the old order in academic philosophy that is associated with the names of Gödel, Turing, Church and a new, younger generation of computer scientists. It used to be argued we had two ways of knowing, two kinds of knowledge: by logical deduction, we discovered the absolutes of truth and beauty and right and wrong; by induction, we found our way to uncertain and new, but practical truths. To explain what happened at the foundations of knowledge, I call

upon a trenchant paragraph of Willard Quine:

"What Gödel proved," Quine said, "...was that no deductive system, with axioms however arbitrary, is capable of embracing among its theorems all the truths of the elementary arithmetic of positive integers unless it discredits itself by letting slip some falsehoods too." Finality, the absolute, is not to be had even in mathematices and logic.

The Gödel proof does not imply, however, that logic and mathematics lose their role in the structuring of the thinking process. On the contrary, any deductive system may be cured of its bankruptcy in paradox by appropriate amendment or expansion of its premises. This stratagem, of course, engenders new paradox. But now mathematics adopts the toolmaker's strategy; it looks away from first things and forward to last things, results and consequences. Mathematics, empowered by the computer, has become an experimental science.

We have found, in these momentous years, that we have only one way of knowing. It is the habit of truth: the fiercely individualistic and intensely social enterprise of science.

If we now look for signs that these insights have percolated into the popular consciousness we find disheartening evidence of an opposite state of affairs. J. B. Conant's bleak view would appear to prevail. Society persists in its hopeless attempt to possess the body of science without its soul. Absolutes and finalities from the rag bag of history are invoked to justify destructive and dangerous national policy. Scientists are called upon, as if they were authorities privy to some secular source of revelation, to repeal the laws of physics. The triumph of

science is celebrated and deplored as an information explosion, with no more than uneasy suggestion that a transformation in human understanding has been proceeding through these years. Far from the beauty in science that Warren Weaver called us to celebrate, science is known to the wide public principally through the artifacts of the new technologies and as the sometimes promising, sometimes threatening exotic enterprise of the Federal government. Among the industrial nations of the world, the U.S. is distinguished by the nearly complete shutdown of its nuclear power enterprise brought on by public anxiety that no politician dares to challenge. The Federal support of the scientific enterprise has faltered through the last decade, and is blighted now by tampering with the freedom of scientific communication in the name of national security.

In my gloomy assessment of the state of public understanding of science, I have not mentioned some of the undoubted occasions for cheer and even hope. The most hopeful I take to be the arrival of the personal computer and its installation in the American household. As children master this tool for learning, no one can take their independence from them.

I hope no one will think I am saying that the media are to be held responsible for the public's failure to understand and love science. I have to say, however, that in my judgement our mass media have hindered more than they have helped. If we wish to harness media power to the objective of public understanding of science we had best consider the nature of the instrument.

I have called the media an unstable amplifier. The metaphor fits; the media habitually listen to their own output, feed it

back into their input, and, with each regenerative positive feedback cycle, tell the story louder and with greater distortion. Such treatment is not, of course, restricted to science stories. Three Mile Island and the panic over recombinant DNA give us, however, archetypical episodes of the performance of the system. Less seriously, consider what is meant by celebrity. A celebrity is one who has been celebrated by the media and, because celebrated, is celebrated some more. Woe to the scientist caught in this vortex! The truly successful celebrity is handed around, like the souls in Dante's first circle, in perpetual exchange from one medium to the next; in the word from the editorial sanctum of Time, Inc., names make news. More seriously, consider the confounding of our political life by the media processing of candidates that we have not managed yet to read and comprehend and discount.

Further, I have to declare that our unstable amplifier has a narrow bandwidth. It is narrower relative to the spectrum of human concern than the visible spectrum, itself less than an octave in the twenty or so orders of magnitude of the useful electromagnetic spectrum. With respect to our concern here, the prevailing definition of "news" lets little science through; satellite launchings and test-tube fertilizations, indeed, but when it comes to science, Nobel Prizes and similarly contrived events must serve. By contrast, Uri Geller, UFO fans and clairvoyants find readier access to space and time in the media; for, it may be said, claims make news.

Finally, I call your attention to the low signal to noise ratio that characterizes our unstable amplifier. In the language

of information theory, so well popularized by Warren Weaver upon its first publication in 1949, the term information is the measure of your freedom to communicate -- how much you can say and how variously. It is a function of the capacity of the channel and, inversely, of the noise in the channel. I have mentioned the narrowness of the bandwidth; sadly, I have to say the capacity of the media is still further constricted by noise. One form of noise is the cliche to which an out-of-the-way bit of news must be attached. For science, the cliches are familiar; new hope, new comfort, new gadget, and so on, for you constitute one category. There is also the new threat, new anxiety, etc. for you. For pure science a creative new headline declares "Scientists Astonished," and the lead paragraph goes on to show what scientists themselves know perfectly well, that scientists can be wrong. In the entertainment hours, it is the mad scientist or the absent-minded one, both serving to displace or relieve the same anxiety.

The most totally interfering and destructive noise however is introduced by the equal-time principle. While I hold with Milton the sanctity of the minority of one, I do not think he or she is owed equal time. The principle goes into action not from fairness, but from the abdication of responsibility that takes the easy way out. On all the major issues of policy -- starting with nuclear fission power -- the public must think the experts, the scientists, are about equally divided. In fact, the negative side had enlisted only a few scientists with special concerns and histories of their own. This would not be a world we could live in at all if reasonable men in possession of the same set of

facts did not come to the same conclusion. That the community of science has a true consensus on all the important questions is concealed from the public by noise on the amplifier.

As your keynote speaker, I have not thought that I am expected to follow my diagnosis with prescription. That is your task over the next 36 hours. If you are to take our concern past the point where Weaver, Conant and Bronowski left it, you must show us how to get around or cure the frailties of the media. If you are to generate negative feedback to the unstable amplifier, stretch wider its bandwidth and reduce the noise on its channels, you could not find a better setting for your labors than the Annenberg School of Communications under the deanship of George Gerbner.