Letters

Information Age and Overload

Information overload, although not a new phenomenon, has become commonplace in today's rapidly evolving technological society ever since computers began spewing out more data and information at us than we can handle. A sinister facet of this overload now appears to be surfacing, one that carries serious economic and social implications. This is the lag time between data and information gathering, storage, and retrieval and the proportion of such data and information that can be analyzed, interpreted, and used.

Our data-collecting technologies have far outstripped not only our cognitive abilities but also the computerized management systems we have created to help us deal with the information.

A good example of the latter is the earth surveillance program Landsat, which has collected far more data in its 17 years than can be either analyzed or even properly archived at present levels of support (News & Comment, 16 June, p. 1250). Another example is the case of last year's Federal Aviation Administration proposal to control air traffic around our major airports. Already burdened with heavy traffic and signal data, the air traffic controllers joined forces with private pilots to oppose requirements that all planes transmit altitude data when operating near these airports. It was feared that the extra data would overwhelm the control system and actually *decrease* safety.

An insidious condition occurs when the pace of economic and social forces outruns not only the analysis and use of data but its production as well. This is seen in airline security systems, where the development of detection systems has lagged behind terrorist tactics such that the volume of traffic precludes adequate screening for potential danger. Until automated detection systems are developed and employed that can cope with the massive flow of people and baggage traffic, ones that can analyze the data and respond to suspicious elements, the flying public will remain at risk.

The nuclear accident at Three Mile Island has been described (*1*) as an example of both information deficiency and of overload. Operators were unaware of previous accidents that likely would have enabled them to avoid a core meltdown. Overload occurred when the control room operators were deluged with too much system monitoring data to analyze and act upon.

Technology is often seen to advance out of step with law, ethics, or economic feasibility. Society needs time to wrestle with the issues generated by scientific discoveries and technological developments. Our systems for data and information collection, storage, and analysis should be brought into harmony with one another so that they are regarded as equally important, are funded accordingly, and are developed in concert.

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High School Science Education

Recently, a group of high school students who were participating in the Department of Energy's (DOE's) High School Science Honors Program at Oak Ridge National Laboratory (ORNL) were asked a series of questions concerning science education. The participants expected to major in virtually all scientific and engineering fields in college, with a large portion going into pre-professional curricula.

The students were asked questions in three areas: (i) why he or she had developed an interest in science, including identification of any special person who was instrumental in exciting an interest; (ii) how high school science education could be improved; and (iii) how students become interested, or lose interest, in science as a career.

With regard to the first question, 74% of the students identified a teacher (or teachers), generally at the secondary school level, as the key person who ignited an interest in science; 45% also indicated that a family member played a critical role. Many described specific examples of events in science classes as occasions that sparked an interest. Approximately 15% identified a science fair or special project as a significant event.

Responses to the second question reaffirmed the observation from the first: teaching plays a critical role in science education. Almost 75% of the students identified the need for better science teachers to improve high school science education. (Their definition of "better" included both academic qualifications and enthusiasm for the subject.) The second most frequent suggestion (30%) was for more "hands-on" teaching (labs and field trips), followed closely by the proposal that special study programs in the sciences be developed. Approximately 15% of the students indicated that courses should include more teaching of concepts and less memorization of facts.

The importance of teaching qualifications and attitude appeared again in the answers to the third question. Almost 50% of the students said that poor and unenthusiastic teaching is a major factor in turning people away from science, while about 33% indicated that there is a general perception among their peers that science is too difficult. About 20% felt that others see science as boring, and an equal number suggested that the lack of funding for science education at the secondary level made it difficult to attract students. Not surprisingly, the single factor that the students said kept their interest in science was excellence in teaching.

Perhaps the message for improved instruction in the classroom is familiar, but the overwhelming consistency of this message from such a diverse group of talented and motivated students who had no previous communication with one another is remarkable. We should listen to these answers if we wish to reverse the staggering decline in the number of students pursuing science and engineering careers.

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O'Toole on O'Toole's Charges

Herman N. Eisen's characterization (Letters, 15 Sept., p. 1166) of my 1986 objection to the *Cell* paper by Weaver *et al.* (*1*) as entirely a matter of interpretation is simply incorrect. My 6 June 1986 memo to him told of experiments described in the paper that were not, in fact, done and of the authors' admission that the experiments were not done. Eisen refused to recommend disclosure and, when I asked him to reconsider, said my continuing pursuance of the matter indicated vindictiveness. The three principal authors said that the misstatements in the paper were due to errors, and I had little evidence with which to challenge that explanation. I have since raised questions about the authenticity of some of the raw data subsequently submitted to and relied upon by the National Institutes of Health investigating panel.

Eisen states that he never examined the raw data because such a drastic process is reasonably reserved for cases where a serious charge, such as fraud, has been made. However, the Provost of the Massachusetts Institute of Technology, John Deutch, testified at the congressional hearing (2) that the MIT "inquiry went forward in conformance with our policy of investigating suspicion of fraud, even though Dr. O'Toole chose not to characterize her concerns as [fraud]." The statements of Eisen and of Deutch cannot both be true.

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2. J. Deutch, statement before the Subcommittee on Oversight and Investigations Committee on Energy and Commerce, U.S. House of Representatives, 9 May 1989.

Oil Spill Health Effects

Marcia Barinaga's article "Alaskan oil spill: Health risks uncovered" (News & Comment, 4 Aug., p. 463) captured the flavor of the Conference on the Alaskan Crude Oil Spill and Human Health very well.

A matter that could cause some misunderstanding, however, is the misstatement in the middle of the article labeled "the good news," that the highly toxic polycyclic aromatic compounds "evaporated from the spilled oil within several days." The lightest fractions of the oil, the single ring compounds that are of most concern for inhalation exposures, did evaporate rapidly. The polycyclic aromatic hydrocarbons, on the other hand, tend to concentrate in the weathered oil and may be of significant long-term concern for health, since we know that some of these compounds are hazardous and some are associated with cancer.

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Management at DOE

Readers of the article by Mark Crawford about Robert O. Hunter (News & Comment, 15 Sept., p. 1182) may obtain the impression that Hunter is a man of vision who is meeting opposition from a stodgy bureaucracy. The article quotes Hunter as saying that his "most ambitious activity" is "to maintain the flow of new ideas and . . . the quality of research." The impression one gains from the article and from the quote, however, is inconsistent with my experience.

Like Hunter, I came to Washington "just over a year ago." Unlike Hunter, I came, not to "head the Department of Energy's [DOE] $1.7-billion" Office of Energy Research, but to work in the "tiny geophysical research program" referred to in the article. The Geosciences Program is part of the Office of Basic Energy Sciences (OBES) within the Office of Energy Research. The program has an annual budget of about $18 million and supports the basic geoscience research of about 90 investigators at eight national labs and 70 investigators at almost 40 universities. Research grants are given on the basis of a peer-review system similar to that used at the National Science Foundation. The Geosciences Program office consists of one DOE employee, a portion of a secretary, a rotator from academia, and a detailee from one of the national labs—the position I have occupied on a half-time basis for the past 15 months. Thanks to Hunter, it has been a most exciting year—exciting, exasperating, but mostly, frustrating.

One particularly frustrating task was to help my colleagues decide how to take back