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The Computer Issue

I learned the other day that wind tunnels are essentially obsolete for testing airplane designs. Modern understanding of aerodynamics and the ability to alter multiple variables of wind, size, airflow, and so on by computer mean that structural designs can be more efficiently examined by computer than by old-fashioned experiments. My immediate reaction was to travel by train. Although I have bowed to the onward march of modern science and continue to use airplanes, this development indicates the enormous, sometimes unknown, change in all of our lives occasioned by the computer. In this issue some ways in which computers are being used are described by authors recruited for *Science* by Philip H. Abelson.

The development from calculating machine to computer involved many scientists and engineers among whom Alan Turing and John von Neumann are usually mentioned. It is instructive to realize that since von Neumann's studies in the 1940's, computers have increased in speed by a factor of 1 billion and have become cheaper per computation by a factor of 10 million. Larry Smarr describes a problem in which there are 25,600 variables at each step and a single experiment makes use of at least 10,000 steps. The solution involves 1.25 billion numbers. Problems of this complexity could not even be planned, let alone solved, just a few years ago. This increase in complexity has, moreover, altered the thinking of scientists. Old-fashioned types, like me, have a feeling that the true answer to a scientific problem lies in an analytical equation; numerical calculations are only approximations to the real answer. Modern computer experts are frequently dealing with problems with so many variables that the true visualization requires a numerical solution; the analytical equation is only an approximation.

These articles also reveal a second change in our lives. The handheld pocket calculator now lies on laboratory benchtops, so cheap that theft is no longer considered a serious problem, and personal computers are being given to college students at the beginning of their college careers. What will happen to students, as M. Mitchell Waldrop asks, if the ease of push-button access to information eliminates the normal interactions occasioned by meeting at the library or attending classes? What will happen to the character of a student who has never had to wait in line for a book?

Entire sciences are being changed, as described in the article by E. J. Corey *et al.* on the use of computers to design organic syntheses. Will the computer really replace the cerebellums of the great organic chemists with their incredible storehouses of individual reactions? Similar revolutions may be in store for the humanities, agriculture, and economics, in which the ability to examine many variables and to have access to large amounts of data will change problem-solving.

Communication between scientists and the education of students will also be affected. Knowledge of electronic databases will be as important as keeping up with the latest journals. *Science*, for example, will soon add software reviews to the book reviews. Teaching may be enhanced by machines and allow students to progress at their own pace.

Although the enormous power of computers brings joy to many, this power can have a destructive element as well. The elimination of routine jobs by computerization will have a fundamental effect on society. It is not enough to say to individuals who are displaced that a new productivity will allow you to be supported all your lives. Humane understanding and a generous effort must motivate those who will benefit from these wonderful machines to help those who are displaced by them. The promise of computers may best be realized in approaching solutions to that most complex multivariate problem, the establishment of a fully productive and satisfying society.

For the good of society, we may have to enact laws to protect some endangered species. Already computers are being used to design musical scores. When they start writing editorials, they will have gone too far.

—DANIEL E. KOSHLAND, JR.