matical equations that produced orderly strings of numbers that gradually gave way to disorderly ones. He noticed that certain patterns began to emerge in the breakdown. Describing them in mathematical terms consistently produced certain numbers—now known as "Feigenbaum numbers." The physicist even discovered a new universal constant (like pi): 4.669201609 . . . , which expresses how rapidly all systems undergo something called "period doubling" on their way to chaos.

Although Feigenbaum could not at first get his work published in professional journals, word spread quickly along the scientific grapevine. Gradually, it became apparent that Feigenbaum had approached in a general way what researchers in other fields were exploring in particular cases. For example, Feigenbaum's discoveries coincided with MIT meteorologist Edward N. Lorenz's work on what is sometimes fancifully called "the Butterfly Effect"—how "a butterfly flapping its wings today in Peking might affect the weather next month in New York," or, in other words, how a tiny variation in a system can produce chaos.

As it turns out, the Feigenbaum numbers do seem to be universal. Their existence, Gleick writes, shows that "of all the possible paths to disorder, nature favors just a few."

It is too soon to tell whether Feigenbaum's findings will have any practical applications. It could be that they will help scientists understand manifestations of chaos such as earthquakes, economic trends, and the sometimes deadly fibrillation of the human heart. Today, that possibility is real enough to have awakened the interest of people as various as Pentagon analysts and Wall Street stockbrokers.

The Fallacy of Computer Literacy

"The Underside of Computer Literacy" by Douglas Noble, in *Raritan* (Spring 1984), 165 College Ave., New Brunswick, N.J. 08901.

"A computer in every classroom and a floppy disk in every book bag" could well be America's slogan for the 1980s. But Noble, a schoolteacher and former computer programmer, thinks that today's fad for "computer literacy" in the public schools and elsewhere is pure hokum.

True, he says, computers will be everywhere before long: One estimate is that there will be 80 million computers in use in the United States by the end of the century. But "literacy" in computer languages (e.g., BASIC, FORTRAN) and the ability to program will be no more needed to operate a computer than a knowledge of auto mechanics is needed to drive a car—especially as the new devices become more and more "user friendly."

Behind the push for computer literacy is the notion that it will be a prerequisite in the job market of the future. But it is absurd to believe that the mere presence of a computer "will transform the skills required and radically raise the level of intellect needed" in most jobs, Noble contends. Far from requiring *greater* skills, Noble fears, comput-

erization will strip many jobs—especially clerical ones—of any remaining opportunities for human creativity. Whatever computer skills will be needed, he adds, will be easily acquired on the job. In 1990, there will be well over 100 million Americans at work, and only about two million of them will be in true computer occupations (e.g., programmers and systems analysts).

A computer literate citizenry is also often cited as the best defense against the triumph of Big Brotherism, Noble observes. But only the most sophisticated programmers can prevent computerized invasion of privacy. And knowing BASIC is beside the point. It would not give ordinary Americans any greater political voice in determining what role computers will play in U.S. society.

Computer literacy has nearly "created its own necessity," as it becomes a requirement for jobs in which it will never be used. Dazzled by the technology and afraid of being left behind, Noble says, too many Americans fail to recognize a pernicious fad for what it is.

Futuristic Ceramics

"High-Tech Ceramics" by Howard J. Sanders, *Chemical and Engineering News* (July 9, 1984), American Chemical Society, 1155 16th St. N.W., Washington, D.C. 20036.

Ceramics is a pleasant hobby, a nice way to make personalized gifts such as ashtrays, coffee cups, and vases. Ceramics is also a rapidly expanding $4-billion high-technology industry, reports *Chemical and Engineering News*'s Sanders.

The heat-resistant tiles layered on the skin of the space shuttle *Challenger* are made of "high-tech" ceramics, as are some artificial human heart valves and a variety of electronic devices. High-tech ceramics may help make the Pentagon's long-planned Stealth bomber invisible to radar. Obviously, these are no ordinary ceramics. They have names such as silicon carbide and cubic boron nitride. They are valued because of their extreme resistance to heat, their strength (diamonds are ceramics), and their peculiar electrical properties. Their chief drawback is the same as that of a homemade coffee cup: brittleness.

Ceramics, high-tech or low-tech, are made by subjecting a base material (such as clay) to extreme heat or pressure. Scientists are now working to find ways to reduce brittleness in the high-tech ceramics, manufactured by pressing or heating superfine powders. The researchers are focusing on purifying the powders and making the particles extremely small and regular in shape so that they fit tightly together. Also under study are new ways of mixing ceramic fibers with other materials.

The chief impetus behind much of this work is the prospect of developing ceramic gas turbine automobile engines to replace today's metal piston ones. Because ceramics can withstand higher temperatures than even the most advanced metal alloys, engines built mostly of ceramic parts could run hotter than their conventional counterparts, thereby burning fuel more efficiently and leaving fewer pollut-