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NOTES OF A BIOLOGY-WATCHER

On Artificial Intelligence

LEWIS THOMAS, M.D.

THE most profoundly depressing of all ideas about the future of the human species is the concept of artificial intelligence. The ambition that human beings will ultimately cap their success as evolutionary overachievers by manufacturing computers of such complexity and ingenuity as to be smarter than they are, and that these devices will take over and run the place for human betterment or perhaps, later on, for machine betterment, strikes me as wrong in a deep sense, maybe even evil. Until now, computers have had the look of useful, often indispensable tools; you can't run banks or hospitals or department stores without them, and we could never have placed those neat little surrogate laboratories on the surface of Mars, nosing about for evidences of life, lifting up stones and peering under them from a distance of a million miles. Without computers we could not have sent that famous plaque describing humanity off into deep space like a postcard, out beyond our solar system, carrying through the galaxy the information that we are rather an uninteresting lot, given to cliché and hardly worth invading, and for that I am grateful to computer science. There are home computers on the market, taking over the household chores, even doing the laundry and paying the bills, and I have no quarrel with these.

I am even willing to concede that any instrument capable of such things must be possessed of flashes of something like intelligence, but it is an intelligence built into the structure by extremely intelligent physicists and mathematicians. This is a different matter from what is called artificial intelligence, planned for the future. This would be, if the makers can bring it off, an actual thinking machine, a real brain, human-like but better than ours.

I do not mean just winning at chess, or composing something like music, or translating Chinese into English. I mean thinking, turning things over in the mind, selecting this rather than that on grounds of taste, maybe just wondering.

This is what the artificial-intelligence people are talking about: a mechanical brain with the capacity to look back over the past and make accurate predictions about the future, then to lay out flawless plans for changing that future any way it feels like, and, most appalling of all, capable of feeling like doing one thing or another. Machines like this would be connected to each other in a network all around the earth, doing all the thinking, maybe even worrying nervously. But being right all the time.

Leaving us with time for leisure. This part of the scenario isn't clear to me, but there it is anyway, the big gain to be made from computers: leisure time — games, I suppose, very likely games involving com-

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puters themselves; automatic, prosthetic devices for twiddling the thumbs or drumming the fingers of one's mind.

It is, in my view, an absolutely hideous prospect, and if I thought it were really something waiting ineluctably ahead of us I would spend all my days in protest. But I have just finished reading a long paper published in *Science*,[1] and my mind is, temporarily anyway, at peace. Maybe it cannot happen. There is a natural limit to the sophistication and power of a computer, recognizable already in the new generation of instruments that evolved in 1978, and it looks as though nothing can be done about it. Or I hope this is true anyway.

Computers of the size and complexity needed for real artificial intelligence are bound to fail from time to time, and there is no way to avoid this on our kind of planet; indeed, the mistakes will get worse if we try to set up the machines elsewhere in space. The accidents will be caused by cosmic-ray particles or by the muons or other particles generated at the impact of cosmic rays with our atmosphere. It is already known that radioactive materials like thorium or uranium can confuse the functioning of today's most advanced computers, causing flips in the bits of information encoded on tiny silicon chips, and the new calculations demonstrate that cosmic rays can, at least in theory, do the same thing. The errors are called "soft fails" in computer jargon; a number that ought to turn up is simply omitted, and the machine suddenly stops in puzzlement. The dimension of the error depends on the importance of that number. The mistake is transient; if you go back and repeat the same program, it will probably come out right the second time, but then a similar omission can be made somewhere else.

You cannot make a human mind with this kind of fallibility. You have to be able to design into it the capacity to make real, irrevocable, mistakes — but not this business of just dropping out a number at random and then being unable to repeat the same accident. Our kind of brain is built so that it can make great numbers of errors, all the time, for this is really the way we go about the process of thinking. We get things wrong by nature, and when we get enough things wrong we make use of that information to get things right. The process is trial and error, as we say.

It is in this sense that our brains differ so greatly from machines, and it is probably the recognition of this special gift of error that makes us feel so strongly that we are different from all the other animals of the earth. It is hard for us to imagine anything taking place in the brain of an insect that bears any resemblance to the events in our own heads. We take it for granted that insects are little whirring machines, programmed by their genes to do this or that insect-like thing, but we recoil from the notion that the bug is a conscious, thinking creature. We do this partly because we feel superior, and partly because we know that we could never do so reproducibly what beetles do.

It could be that simple animals possess the same kind of awareness as ours, but that they are conscious of fewer items and therefore the probability of error is greatly reduced. It takes some imagining, but I think I can imagine what it would be like to be an animal with only two thoughts. A termite thinks about piling pellets to a certain height and then turning an arch. Or an ant, with maybe only one thought: to fetch twigs of the right size for the construction of the hill.

Our minds work differently because they contain millions of thoughts, perhaps an infinity of thoughts. The only near analogy I can think of in biology, similar in principle to human thinking, is the behavior of the immunologic system. This is one of the prize achievements of evolution, bestowed on us hundreds of millions of years ago when vertebrate animals first made their appearance on the planet. Memory is the gift of lymphocytes, hundreds of billions in each of us, each one given the power to recognize and remember one thing, and one thing only.

Perhaps our brains work in somewhat the same fashion, except that instead of having individual receptor cells roaming around looking for something in which they are preprogrammed to be interested, we have what are called "modules" of neurons,[2] tiny columns of nerve cells, all interconnected by nerve fibers, making up the sheer bulk of the cortex of our enormous brains. Each module acts as a receptor, in the same sense that a lymphocyte knows in advance about horse-serum protein. A frog doesn't have as many of these as we do, and therefore a frog has only a few ideas to remember; the main, preoccupying thought of a frog is about a moving speck crossing his horizon against the light; the speck is a fly, and that is what a frog knows. We, in contrast, possess more than a hundred billion nerve cells arranged in modules, and the cortex of our brains is equipped for receiving and processing, and then remembering, a vast amount of information coming in from the outside by way of our various sense organs. Moreover, the modules are connected to each other, throughout our brains, by trillions of connecting fibers, and these are busy all the time passing information around — not information coming in from the outside world but information generated within the brain itself — the process we call consciousness.

There seems to be no limit to the number of impressions we are equipped to receive from the outside, and no limit to the number of ideas we can generate within our brains. There seems no limit, but we have no way of being sure of this. Obviously, if there are some things in the world for which we do not have receptors we will not see them, nor will we be able to think about them, and that is that. There does not seem to be much of a limit to what we can learn, given time, and given as well a few exceptional learners among us — Homer, Bach, and Einstein for examples. We can pick up information about the world from Bach so easily, once it is provided for us, that it is safe to assume that our cortical modules of nerve cells are already set up as receptors — for the art of fugue, for instance — so nicely and precisely that we are each

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prefabricated to be music receivers, language receivers, maybe even mathematics receivers. Still, the limits may be there. The physicists keep running into strange queernesses, things that simply do not fit with rational thought, light rays that are at the same time waves and particles, paradoxes; it is said that a Great Truth in physics is one for which the opposite is also a Great Truth. It may turn out that the cosmologists will never succeed in making sense of the universe — not because their instruments cannot obtain all the needed information, but because the human brain was not developed with modules of cells designed to receive this kind of information. If that speck seen by the frog's eye does not move, the frog does not perceive it in his brain.

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BY THE LONDON POST

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Patients First

THE government has responded to the report of the Royal Commission on the National Health Service (NHS)[1] by publishing a paper[2] summarizing its proposals for changes in the structure and management of the NHS in England and Wales. This document, with the imaginative title, "Patients First," is commendably brief, and, as the title indicates, the emphasis is on identifying the changes required to improve the standard of patient care. Thus, it is emphasized that the NHS exists to serve patients and that the main objective of the government is to establish a structure that will allow efficient planning and management of the health services and within which decisions can be made by those who are most responsive to the needs of patients.

Although the 1974 reorganization achieved the objective of integrating services for patients in the hospitals and in the community, there has been widespread criticism that it created too many administrative tiers, with too many administrators. Thus, in England there are 14 Regional Health Authorities (RHA's) and 90 Area Health Authorities (AHA's), each having one or more districts. Although it was intended that there should be maximum delegation of responsibility downward, this principle was matched by the principle of accountability upward, and the result has been an inhibition of the decision-making process and an extremely expensive administrative machine. The Royal Commission accepted all these criticisms and defects of the present system and suggested that one administrative tier might be removed. It also suggested that the accountability of RHA's should be directly to Parliament rather than mediated through the Secretary of State at the Department of Health and Social Security (DHSS) and that local government might administer the local health services. However, the government has pointed out that the proposal regarding accountability to Parliament would be inconsistent with the statutory responsibility of the Secretary of State, and that the one involving local government would not command general support.

But the government has proposed changes that it believes would improve the present unsatisfactory situation. These changes would include the strengthening of management arrangements at the local level with greater delegation of responsibility to those in the hospitals and in the local community; in addition, the structure of the NHS would be simplified by removal of the area level of administration and establishment of District Health Authorities. The government also recognizes the need for better professional advisory machinery and for simplification of the planning system to ensure that regional plans are fully sensitive to local needs. The government shares the view of the Royal Commission that there has been a decline in the quality of hospital administration and that there is a clear need to simplify and improve the management of both the hospitals and the community services. Each District Health Authority would appoint a management team to coordinate all the health-service activities of the district, but at the same time there would be maximum delegation of authority to hospital administrators. Thus, for each major hospital or group of hospitals there should be an administrator and nurse of appropriate seniority to discharge an individual responsibility in conjunction with the medical staff.

An ideal district authority would be responsible for a locality large enough to justify the range of specialties normally found in a district general hospital, but not so large as to make members of the authority remote from the services for which they are responsible or from the staff who provide them. The population of districts would normally be between 200,000 and 500,000.

RHA's would make proposals for the restructuring of districts within their regions and in the case of districts based on teaching hospitals would consult with the universities concerned. Special arrangements would be required to maintain the links between local government and the health service in respect to their related responsibilities in the fields of child health, the school health service, social services, and environmental health.

The new District Health Authorities would have a chairman appointed by the Secretary of State and about 20 members appointed by the RHA. Each district authority would include a hospital consultant, a general practitioner, a nurse, a university nominee, and a member nominated by the trade-union movement. Local government would be adequately represented, although it was not thought necessary for local

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