

THE COMPUTER, THE EYE, THE SOUL

By fortunate coincidence, three unusual new books on robots are available in this month of September. Two come from the University of Illinois Press, one from the University of Washington Press. The last, titled Of Molecules and Men, originated as the fifth in the series of John Danz Lectures, delivered on the University of Washington campus at Seattle by Sir Francis Crick, British biochemist and co-discoverer of the spiral stairway pattern of DNA, the nucleic acid since proclaimed as a prime mover in inheritance. The text below is excerpted from Of Molecules and Men.

By SIR FRANCIS CRICK

HOWEVER we compare a computer with the brain, we find that even the most complex of today's computers are far, far simpler than the human brain. This can easily be shown by counting up the number of elements in the two. There are about a thousand times more nerve cells in the brain than there are elements in even our largest computers. Again, the brain has an enormous advantage in that it is packed into a small space and works on very little power. However, modern computers are getting rather smaller in physical size because of the increasing use of transistors and of printed circuits. Although it will not be possible in the near future to make elements as small as neurons, at least the difference in size is not as apparent as it was a few years ago.

It is most important to realize that modern computers are based on quite a different system of operation from anything we can see in the brain. Such computers work on a binary system and are extremely accurate. Our brains, on the other hand, show no signs of working on a binary system, and in addition are very inaccurate. However, the brain is able to work with the loss of quite a fair number of its nerve cells (every day some die as we grow older) and is presumably made to be inaccurate in order that the loss of one particular element will not upset the functioning of the brain as a whole. Computers, on the other hand, are usually designed in such a way that, as far as possible, all their elements function satisfactorily.

The great advantage a computer has over the brain is that its basic rate of

working is very much quicker. Its "pulse rate" is on the order of a thousand times faster than the corresponding rate of sending signals in the brain. Consequently, even a rather small computer can undertake a task that the brain cannot tackle in any reasonable time. On the other hand, the brain is a multiple-input device. Over a million nerve fibers go from the eye to the brain, and many of these can be carrying signals at the same time. Thus the elements of the brain act to some extent in parallel, whereas much of the working of computers occurs in series. A computer is made in such a way that it can concentrate on doing one particular job at a time, or at the most a small number of different jobs. It is for these reasons that computers can do straight calculations more rapidly than we can with our brains, whereas our brains can do certain complex jobs, like the recognition of a friend's face, surprisingly quickly.

It is amusing to note the sort of things modern computers can do. One, for example, has been programmed to play checkers. This is a type of program in which the machine evaluates each game after it has been played and then adjusts the strategy of play to optimize chances of winning. For a time, it was even able to beat the man who wrote the program. Several people have written programs that allow a computer to play chess, which is a far more difficult game. So far such machines can play only very average chess.

Programs are also actively being written for teaching purposes. One of these, for example, will give a young medical doctor a problem, instruct him what (imaginary) tests to carry out, cross-examine him on what he has done, and

criticize his diagnosis, telling him sometimes to try again, or to go back and examine different sorts of evidence.

A very amusing program written recently simulates the behavior of a psychiatrist talking to a patient. The great advantage of this situation is that the "patient" is not supposed to ask the "psychiatrist" a question, whereas the "psychiatrist" can always initiate a new topic if he does not wish to continue along the lines of the previous one. Below is an example of an exchange that occurred between a real person and an IBM computer, following instructions written by Joseph Weizenbaum, visiting associate professor of electrical engineering at the Massachusetts Institute of Technology. The interview took place by typewriter. The "patient"—a "distraught young lady"—typed out what she wished to say in lower-case letters, and then pressed a button twice, whereupon the machine replied, also by typewriter, but in upper-case letters. According to the *Harvard Review*, the conversation went as follows:

men are all alike

IN WHAT WAY

they're always bugging us about something or other

CAN YOU THINK OF A SPECIFIC EXAMPLE

well, my boy friend made me come here

YOUR BOY FRIEND MADE YOU COME HERE

he noticed that i'm depressed much of the time

I AM SORRY TO HEAR YOU ARE
DEPRESSED

he's right. i am unhappy

DO YOU THINK COMING HERE
WILL HELP YOU NOT TO BE
UNHAPPY

i need some help, that much is clear

WHAT WOULD IT MEAN TO YOU
IF YOU GOT SOME HELP

perhaps i could learn to get along with
my mother

TELL ME MORE ABOUT YOUR
FAMILY

my mother takes care of me

WHO ELSE IN YOUR FAMILY
TAKES CARE OF YOU

my father

YOUR FATHER

you are like my father in some ways

WHAT RESEMBLANCE DO YOU
SEE

you are not very aggressive but i
don't think you want me to notice
that

WHAT MAKES YOU THINK I AM
NOT VERY AGGRESSIVE

you don't argue with me

WHY DO YOU THINK I DON'T
ARGUE WITH YOU

you are afraid of me

DOES IT PLEASE YOU TO BE-
LIEVE I AM AFRAID OF YOU

it pleases my father to think i am
afraid of him

WHAT ELSE COMES TO MIND
WHEN YOU THINK OF YOUR
FATHER

bullies

NOTICE that at one point the "patient" used the word "like." This was probably a cue for the machine to say, "WHAT RESEMBLANCE DO YOU SEE." By use of such simple clues and other tricks, it is possible to make a dialogue that sounds reasonably convincing, using a simple program. There is even speculation that it may be possible to provide a service for emotionally disturbed people, so that they can have someone "sympathetic" to talk to. However, people who have spoken with such a computer find it an emotionally unnerving experience,

partly because of the somewhat superior attitude of the machine, which is apt to ignore what one has said and simply ask a new question from time to time. Nevertheless, it is clear that with ingenuity it will be possible to extend this type of programming in a number of directions.

I THINK the really striking thing that will come from the use of computers will occur when they reach a very high degree of sophistication and one can have a computer behind a screen with which one could carry on a conversation. The standard question this possibility raises is, "How will one find out that one is talking to a computer and not to a real person? Would the computer, if questioned, say that it was conscious and describe what it meant by this?" Of course the computer might have to be "educated," but then so do human beings. There are many people who believe that it will never be possible to simulate a human being in this way, but those who work on computers tend to think that we shall see this development in our lifetime.

Even if we do not, I am sure that interaction with computers will become a common part of everyday life. After all, we can easily get the computer to type out what it has said, and then get some actor to read it. It would be quite possible to have a television program in which people spoke to the computer; their words would simply be typed down and passed to the computer by some intermediary; the machine would then reply on the typewriter, and an actor would read out what the machine had said. I prophesy that before long there will be a television program of this kind and that it will be a sensation, provided, of course, that the program is written with sufficient ingenuity.

In fact, I think writing programs of this sort will become a new literary occupation. We may have a program for, say, literary criticism, which would certainly be great fun to devise. Alternatively, someone might try to write a program for a seduction scene. Before long, I can well imagine, people will put two machines together and see how they talk to each other. It would be very amusing to get the seduction program to talk to the psychiatrist program!

Leaving aside all these fancier applications, we have to realize, as has already been stressed by a number of people, that machines are going to take on many of the functions of human beings. It is going to be quite disturbing for us to associate with machines. There are people—Fred Hoyle, for example—who believe that machines will eventually take control of our civilization. Even if that does not happen, it could be argued that what will arise is a symbiosis between machines and men, in which the

main function of the men will be to reproduce and to tend the machines. I myself doubt whether we shall reach quite such a stage; nevertheless, I am convinced that during our own lifetime we will come to associate with very complicated and sophisticated machines, and it is going to be quite upsetting.

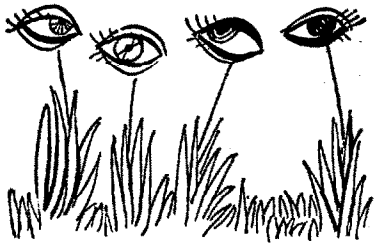
I think the people who are most disturbed by this sort of thing are those who believe in some sense in the soul. What is never very clear is what is meant by "the soul," but one of its attributes appears to be that it can associate with the body but is separate from the body, and, in particular, that it can in some circumstances exist separately from the body and especially, so many people think, after death.

One difficulty about the soul is to know when it originated in evolution. Most people would agree that all human beings have souls (though no doubt there are a few eccentrics who think that they are denied to women), but it is not at all clear whether a chimpanzee or a dog can have one. It is noticeable that philosophers who keep dogs, and are fond of them, are more inclined to attribute souls to dogs than are those who are not animal lovers. And if a dog, why not a worm?

To take another familiar difficulty: Does a baby have a soul? And if so, does it have the soul before birth, and at what moment does it get the soul? It seems hardly likely that the unfertilized egg has a soul in the sense of which we are talking. Of course, there are standard religious answers to some of these questions; but they appear to me to be arbitrary nonsense.

I MYSELF, like many scientists, believe that the soul is imaginary and that what we call our minds is simply a way of talking about the functions of our brains. The real difficulty comes from the vividness of our experience of consciousness, and even that to some extent is a matter of degree, since we can be conscious to various extents, either when we are half awake or when we are sleepwalking. I also find it disturbing that we dream every night and retain so little of our dreams. Recent work has shown quite conclusively that everybody dreams each night for quite considerable periods and that most of these dreams are forgotten unless one is awakened while they are going on.

Of course it is not true that mankind is evolving at the moment only by natural selection. Ever since man was able to communicate and form societies, another form of evolution has been taking place—social evolution, which is very much faster and in many ways more effective. Nevertheless, much in our nature has evolved under the pressure of natural selection alone, and these pres-



tures still exist today. Natural selection being a slow process and civilization being fairly recent, it follows that a lot of our behavior was evolved in a period when human beings acted rather differently from the way they act today. For example, much of our aggressiveness probably springs from behavior selected when man was living in small groups, probably in constant competition with each other. The same is probably true of much of our sexual behavior and explains many of the difficulties and dilemmas that we find in our marriage laws and in our sex laws in general.

I think it is difficult to overemphasize the importance of teaching natural selection, both in schools and in universities, so that every member of our culture has a clear and firm grasp of the principle involved. It is, I think, one of the scandals of the United States that there still are statutes on the law books of certain Southern states which formally forbid the teaching of evolution in schools.

PERSONALLY, I would go further. I think it regrettable that there is so much religious teaching. True, the situation in the United States is nothing like as bad as it is in Great Britain, where religious instruction, I am sorry to say, is compulsory in all schools supported by public money. Since much of this instruction, from the point of view of most educated men, is utter nonsense, it seems to me particularly distressing that this should be the one compulsory subject of British education.

Nor, unfortunately, are many British universities much better in this particular matter. Many of them have inherited a religious tradition, but this does not easily explain the tremendous institutional support given to religion by such a body as Cambridge University, and the colleges that form a part of it. The fact that many of the senior members of the university believe that what is taught and propagated in this way is really beneath contempt intellectually is not apparently enough to prevent the continuation of these ancient practices. Of course, if a university is founded by a number of private people, there is no reason why those people should not propagate their religious beliefs if they wish to do so, but it is quite another matter when a university is public.

The business of the university has been well stated by Lord Annan, the Provost of King's College, Cambridge, as "intellect, intellect, intellect." Whatever other functions the university may have, there is no place for the support of half-truths and falsehoods. It is remarkable that so many intellectuals are hypocritical about this matter, and either shrug their shoulders and say they are not personally involved, or feel that it is a matter of no importance.

One should perhaps state clearly why questions like this are important. When our culture was firmly based on Christian beliefs and practices, answers were provided to many fundamental questions, and it was not thought necessary that science should do more than dot the *i*'s and cross the *t*'s for those answers. The position is quite different today. Today we know that everything we knew yesterday about questions of this type is almost certainly untrue.

THE intellectual should be concerned with questions such as "What are we?" and "Why are we here?" and "Why does the world work in this particular way?" It is remarkable to me that there is not more urgency to answer questions of this kind. I think this situation can only spring from the fact that most people believe either that these questions have been answered already, in some way or another, or, alternatively, that the answers are perhaps too difficult to understand. It would be a much healthier state of affairs if, instead of competing in an arms race, the United States and Russia competed in a knowledge race; if it were to be regarded as a matter of national prestige that we could understand the nature of life, for example, rather than mounting enormous and costly space programs to go to Mars, although I would be the first to agree that going to Mars may perhaps help us a little way toward answering the question of the nature of life.

Once one has become adjusted to the idea that we are here because we have evolved from simple chemical compounds by a process of natural selection, it is remarkable how many of the problems of the modern world take on a completely new light. It is for this reason important that science in general, and natural selection in particular, should become the basis on which we are to build the new culture.

C. P. Snow was quite right when he said there were two cultures. (I do not wish to argue here whether there are two, or three, or four, but simply that there is more than one.) The mistake he made, in my view, was to underestimate the difference between them.

The old, or literary culture, which was based originally on Christian values, is clearly dying, whereas the new culture,

the scientific one, based on scientific values, is still in an early stage of development, although growing with great rapidity. It is not possible to see one's way clearly in the modern world unless one grasps this division between these two cultures and the fact that one is slowly dying and the other, although primitive, is bursting into life.

FOR this reason I believe that all university students should be taught a subject that might be called "The Map of Science." This would not only describe the broad nature of all the various sciences and the way they are related to each other (with a few selected illustrations from each to bring life to the description), but would also show how developed each science is and which areas are relatively understudied.

Such a course would clearly demonstrate that while, say, mechanics or optics are very well explored, much of biology is still almost virgin territory. It would encourage students to consider questions to which we do not yet know the answer, but which we think there is a hope of answering within the next three-score years.

Now there are some questions that affect us far more personally than others, and among these the working of the brain certainly ranks high. It can be confidently stated that our present knowledge of the brain is so primitive—approximately at the stage of the four humors in medicine or of bleeding in therapy (What is psychoanalysis but mental bleeding?)—that when we do have fuller knowledge our whole picture is bound to change radically. Much that is now culturally acceptable will then seem to be nonsense. People with training in the arts still feel that in spite of the alterations made in their lives by technology—by the internal combustion engine, by penicillin, by the Bomb—modern science has little to do with what concerns them most deeply. As far as today's science is concerned this is partly true, but tomorrow's science is going to knock their culture right out from under them.