THE HUMAN USE OF HUMAN BEINGS

This is one of the fundamental documents of our time, a period characterized by the concepts of 'information' and 'communications'. Norbert Wiener, a child prodigy and a great mathematician, coined the term 'cybernetics' to characterize a very general science of 'control and communication in the animal and machine'. It brought together concepts from engineering, the study of the nervous system and statistical mechanics (e.g. entropy). From these he developed concepts that have become pervasive through science (especially biology and computing) and common parlance: 'information', 'message', 'feedback' and 'control'. He wrote, 'the thought of every age is reflected in its technique . . . If the seventeenth and early eighteenth centuries are the age of clocks, and the later eighteenth and nineteenth centuries constitute the age of steam engines, the present time is the age of communication and control.'

In this volume Norbert Wiener spells out his theories for the general reader and reflects on the social issues raised by the dramatically increasing role of science and technology in the new age – the age in which we are now deeply and problematically embroiled. His cautionary remarks are as relevant now as they were when the book first appeared in the 1950s.

Norbert Wiener (1894–1964), Professor of Mathematics at the Massachusetts Institute of Technology from 1919 onwards, wrote numerous books on mathematics and engineering. Having developed methods useful to the military during World War Two, he later refused to do such work during the Cold War, while proposing non-military models of cybernetics.

THE HUMAN USE OF HUMAN BEINGS

CYBERNETICS AND SOCIETY

Norbert Wiener

With a new Introduction by
Steve J. Heims

FAB

'an association in which the free development of each is the condition of the free development of all'

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To the memory of my father
LEO WIENER
formerly Professor of Slavic Languages
at Harvard University
my closest mentor and dearest antagonist

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BIOGRAPHICAL NOTES

NORBERT WIENER, born in 1894, was educated at Tufts College, Massachusetts, and Harvard University, Massachusetts, where he received his Ph.D. at the age of nineteen. He continued his studies at Cornell, Columbia, in England at Cambridge University, then at Göttingen and Copenhagen. He taught at Harvard and the University of Maine and in 1919 joined the staff of the Massachusetts Institute of Technology, where he was Professor of Mathematics. He was joint recipient of the Bocher Prize of the American Mathematical Society in 1933, and in 1936 was one of the seven American delegates to the International Congress of Mathematicians in Oslo. Dr Wiener served as Research Professor of Mathematics at the National Tsing Hua University in Peking in 1935–36, while on leave from MIT. During World War II he developed improvements in radar and Navy projectiles and devised a method of solving problems of fire control.

In the years after World War II Wiener worked with the Mexican physiologist Arturo Rosenblueth on problems in biology, and formulated the set of ideas spanning several disciplines which came to be known as 'cybernetics'. He worked with engineers and medical doctors to develop devices that could replace a lost sensory mode. He analysed some non-linear mathematical problems and, with Armand Siegel, reformulated quantum theory as a stochastic process. He also became an articulate commentator on the social implications of science and technology. In 1964 Wiener was recipient of the US National Medal of Science.

His published works include *The Fourier Integral and Certain of Its Applications* (1933); *Cybernetics* (1948); *Extrapolation and Interpolation and Smoothing of Stationary Time Series with Engineering Applications* (1949); the first volume of an autobiography, *Ex-Prodigy: My Childhood and Youth* (1953); *Tempter* (1959); and *God and Golem* (1964). Wiener's published articles have been assembled and edited by P. Masani and republished in four volumes as *Norbert Wiener: Collected Works* (1985).

STEVE J. HEIMS received his doctorate in physics from Stanford University, California. He engaged in research in the branch of physics known as statistical mechanics and taught at several North American universities. In recent years he has devoted himself to studying various contexts of scientific work: social, philosophical, political and technological. He is the author of *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death* (MIT Press, 1980). Currently he is writing a book dealing with the characteristics of social studies in the USA during the decade following World War II.

INTRODUCTION

Steve J. Heims

G.H. Hardy, the Cambridge mathematician and author of *A Mathematician's Apology*, reflecting on the value of mathematics, insisted that it is a 'harmless and innocent occupation'. 'Real mathematics has no effects on war', he explained in a book for the general public in 1940. 'No one has yet discovered any warlike purpose to be served by the theory of numbers or relativity . . . A real mathematician has his conscience clear.' Yet, in fact, at that time physicists were already actively engaged in experiments converting matter into energy (a possibility implied by the Theory of Relativity) in anticipation of building an atomic bomb. Of the younger generation which he taught, Hardy wrote, 'I have helped to train other mathematicians, but mathematicians of the same kind as myself, and their work has been, so far at any rate as I have helped them to it, as useless as my own . . . '

Norbert Wiener took issue with his mentor. He thought Hardy's attitude to be 'pure escapism', noted that the ideas of number theory are applied in electrical engineering, and that 'no matter how innocent he may be in his inner soul and in his motivation, the effective mathematician is likely to be a powerful factor in changing the face of society. Thus he is really as dangerous as a potential armourer of the new scientific war of the future.' The neat separation of pure and applied mathematics is only a mathematician's self-serving illusion.

Wiener came to address the alternative to innocence – namely, taking responsibility. After he himself had during World War II worked on a mathematical theory of prediction intended to enhance the effectiveness of anti-aircraft fire, and developed a powerful statistical theory of communication which would put modern communication engineering on a rigorous mathematical footing, any pretence of harmlessness was out of the question for him. From the time of the end of the war until his death in 1964, Wiener applied his penetrating and innovative mind to identifying and elaborating on a relation of high technology to people which is benign or, in his words, to the human – rather than the inhuman – use of human beings. In doing so during the years when the cold war was raging in the United States, he found an audience among the generally educated public. However, most of his scientific colleagues – offended or embarrassed by Wiener's views and especially by his open refusal to engage in any more work related to the military – saw him as an eccentric at best and certainly not to be taken seriously except in his undeniably brilliant, strictly mathematical, researches. Albert Einstein, who regarded Wiener's attitude towards the military as exemplary, was in those days similarly made light of as unschooled in political matters.

Undaunted, Wiener proceeded to construct a practical and comprehensive attitude towards technology rooted in his basic philosophical outlook, and presented it in lucid language. For him technologies were viewed not so much as applied science, but rather as applied social and moral philosophy. Others have been critical of technological developments and seen the industrial revolution as a mixed blessing. Unlike most of these critics, Wiener was simultaneously an irrepressibly original non-stop thinker in mathematics, the sciences and high technology *and* equally an imaginative critic from a social, historical and ethical perspective of the uses of his own and his colleagues' handiwork. Because he gave rather unchecked rein to both of these inclinations, Wiener's writings generate a particular tension and have a special fascination.

Now, four decades later, we see that the tenor of his comments on science, technology and society were on the whole prophetic and ahead of his time. In the intervening years his subject matter, arising out of the tension between technical fascination and social conscience, has become a respectable topic for research and scholarship. Even leading universities have caught up with it and created courses of study and academic departments with names such as 'science studies', 'technology studies' or 'science, technology and society'. His prediction of an imminent 'communication revolution' in which 'the message' would be a pivotal notion, and the associated technological developments would be in the area of communication, computation and organization, was clear-sighted indeed.

The interrelation between science and society via technologies is only one of the two themes underlying *The Human Use of Human Beings*. The other derives as much from Wiener's personal philosophy as from theoretical physics. Although he was a mathematician, his personal philosophy was rooted in existentialism, rather than in the formal-logical analytical philosophy so prominent in his day and associated with the names of Russell, Moore, Ramsey, Wittgenstein and Ayer. For Wiener life entailed struggle, but it was not the class struggle as a means to social progress emphasized by Marxists, nor was it identical with the conflict Freud saw between the individual and society. In his own words:

> We are swimming upstream against a great torrent of disorganization, which tends to reduce everything to the heat death of equilibrium and sameness described in the second law of thermodynamics. What Maxwell, Bolzmann and Gibbs meant by this heat death in physics has a counterpart in the ethic of Kierkegaard, who pointed out that we live in a chaotic moral universe. In this, our main obligation is to establish arbitrary enclaves of order and system. These enclaves will not remain there indefinitely by any momentum of their own after we have once established them . . . We are not fighting for a definitive victory in the indefinite future. It is the greatest possible victory to be, to continue to be, and to have been . . . This is no defeatism, it is rather a sense of tragedy in a world in which necessity is represented by an inevitable disappearance of differentiation. The declaration of our own nature and the attempt to build an enclave of organization in the face of nature's overwhelming tendency to disorder is an insolence against the gods and the iron necessity that they impose. Here lies tragedy, but here lies glory too.

Even when we discount the romantic, heroic overtones in that statement, Wiener is articulating what, as he saw and experienced it, makes living meaningful. The adjective 'arbitrary' before 'order and system' helps to make the statement appropriate for many; it might have been made by an artist as readily as by a creative scientist. Wiener's outlook on life is couched in the language of conflict and heroic struggle against overwhelming natural tendencies. But he was talking about something very different from the ruthless exploitation, even destruction, of nature and successfully bending it to human purposes, which is part of the legacy, part of the nineteenth-century heroic ideal, of Western man. Wiener in his discussion of human purposes, recognizing feedbacks and larger systems which include the environment, had moved far away from that ideal and closer to an ideal of understanding and, both consciously and effectively, of collaborating with natural processes.

I expect that Wiener would have welcomed some more recent developments in physics, as his thinking was already at times tending in that direction. Since his day developments in the field of statistical mechanics have come to modify the ideas about how orderly patterns – for example, the growth of plants and animals and the evolution of ecosystems – arise in the face of the second law of thermodynamics. As Wiener anticipated, the notions of information, feedback and non-linearity of the differential equations have become increasingly important in biology.

But beyond that, Ilya Prigogine and his co-workers in Belgium have more recently made a convincing case that natural systems which are either far from thermodynamic equilibrium initially, or which fluctuate, may not return to equilibrium at all (G. Nicolis and I. Prigogine, *Self-Organization in Nonequilibrium Systems*, 1977). Instead they continue to move still further away from equilibrium towards a different, increasingly complex and orderly, but nevertheless stable pattern – not necessarily static, but possibly cyclic. According to the American physicist Willard Gibbs' way of thinking, the stable state of a system – equilibrium – is independent of its detailed initial conditions, yet that simplification no longer holds for systems finding stability far from equilibrium. This is an explicit mechanism quite different from that of a 'Maxwell demon' (explained in

Chapter 2), the mechanism assumed necessary in Wiener's day. It is more nearly related to Wiener's notion of positive feedback, which he tended to see as only disruptive and destructive, rather than as leading to complex stable structures. The results obtained by the Prigogine group show the creation of orderly patterns – natural countertrends to the tendency towards disorganization – to be stronger and more ordinary and commonplace than a sole reliance on mechanisms of the Maxwell-demon type would suggest. Sensitivity to initial conditions is also a prominent feature of 'chaos theory', currently an active field of research.

If, however, we now extend Wiener's analogy from statistical mechanics and incorporate the findings of the Prigogine group – according to which natural and spontaneous mechanisms other than just the Maxwell demon generate organization and differentiation – this suggests a shift in emphasis from 'the human fight against the increase of entropy to create local enclaves of order' to a more co-operative endeavour which to a considerable extent occurs naturally and of its own accord. It is a subtle shift that can, however, make large differences. Yet to be explored, these differences appear to echo disagreements that some modern feminists, neo-Taoists and ecologists have with classical Greek concepts of the heroic and the tragic.

Wiener's status, which he strongly prized, was that of an independent scientifically knowledgeable intellectual. He avoided accepting funds from government agencies or corporations that might in any way compromise his complete honesty and independence. Nor did he identify himself with any political, social or philosophical group, but spoke and wrote simply as an individual. He was suspicious of honours and prizes given for scientific achievement. After receiving the accolade of election to the National Academy of Sciences, he resigned, lest membership in that select, exclusive body of scientists corrupt his autonomous status as outsider *vis-à-vis* the American scientific establishment. He was of the tradition in which it is the intellectual's responsibility to speak truth to power. This was in the post-war years, when the US government and many scientists and science administrators were celebrating the continuing partnership between government and science, government providing the funds and scientists engaging in research. Wiener remained aloof and highly critical of that peacetime arrangement. More precisely, he tried to stay aloof, but he would not separate himself completely because for many years he remained a professor at the Massachusetts Institute of Technology, an institution heavily involved in that partnership. As was his nature, he continued to talk to colleagues about his own fertile ideas, whether they dealt with mathematics, engineering or social concerns.

The Human Use of Human Beings, first published in 1950, was a sequel to an earlier volume, *Cybernetics: Or Control and Communication in the Animal and the Machine.* That earlier volume broke new ground in several respects. First of all, it was a report on new scientific and technical developments of the 1940s, especially on information theory, communication theory and communications technology, models of the brain and general-purpose computers. Secondly, it extended ideas and used metaphors from physics and electrical engineering to discuss a variety of topics including neuropathology, politics, society, learning and the nature of time.

Wiener had been an active participant in pre-war interdisciplinary seminars. After the war he regularly took part in a series of small conferences of mathematicians and engineers, which were also attended by biologists, anthropologists, sociologists, psychologists and psychiatrists, in which the set of ideas subsumed under cybernetics was explored in the light of these various disciplines. At these conferences Wiener availed himself of the convenient opportunity to become acquainted with current research on a broad range of topics outside of his speciality.

Already in his *Cybernetics* Wiener had raised questions about the benefits of the new ideas and technologies, concluding pessimistically,

> there are those who hope that the good of a better understanding of

man and society which is offered by this new field of work may anticipate and outweigh the incidental contribution we are making to the concentration of power. I write in 1947, and I am compelled to say that it is a very slight hope.

The book was a rarity also in that, along with the technical material, he discussed ethical issues at length. *The Human Use of Human Beings* is a popularization of *Cybernetics* (omitting the forbidding mathematics), though with a special emphasis on the description of the human and the social.

The present volume is a reprint of the second (1954) edition, which differs significantly from the original hard-cover edition. The notable reorganization of the book and the changes made deserve attention. In the first edition we read that 'the purpose of this book is both to explain the potentialities of the machine in fields which up to now have been taken to be purely human, and to warn against the dangers of a purely selfish exploitation of these possibilities in a world in which to human beings human things are all-important.' After commenting critically about patterns of social organization in which all orders come from above, and none return ('an ideal held by many Fascists, Strong Men in Business, and Government'), he explains, 'I wish to devote this book [first edition] to a protest against this inhuman use of human beings.' The second edition, in contrast, as stated in the Preface, is organized around Wiener's other major theme, 'the impact of the Gibbsian point of view on modern life, both through the substantive changes it has made in working science, and through the changes it has made indirectly in our attitude to life in general.' The second edition, where the framework is more philosophical and less political, appears to be presented in such a way as to make it of interest not only in 1954, but also for many years to come. The writing and the organization are a bit tighter and more orderly than in the first edition. It also includes comment on some exemplifications of cybernetics (e.g., the work of Ross Ashby) that had come to Wiener's attention only during the early 1950s. Yet, even though several chapters are essentially unchanged, something was lost in going from the first to the second edition. I miss the bluntness and pungency of some of the comments in the earlier edition, which apparently were 'cleaned up' for the second.

The *cause célèbre* in 1954 in the USA was the Oppenheimer case. J. Robert Oppenheimer, the physicist who had directed the building of atom bombs during World War II, had subsequently come to disagree with the politically dominant figures in the government who were eager to develop and build with the greatest possible speed hydrogen bombs a thousand times more powerful than the atom bombs which had devastated Hiroshima and Nagasaki. Oppenheimer urged delay, as he preferred that a further effort be made to negotiate with the Soviet Union before proceeding with such an irreversible escalation of the arms race. This policy difference lay behind the dramatic Oppenheimer hearings, humiliating proceedings at the height of the anti-Communist 'McCarthy era' (and of the US Congressional 'Un-American Activities Committee'), leading to, absurdly, the labelling of Oppenheimer as a 'security risk'.

In that political atmosphere it is not surprising for a publisher to prefer a different focus than the misuse of the latest technologies, or the dangers of capitalist exploitation of technologies for profit. Wiener himself was at that time going on a lecture tour to India and was then occupied with several other projects, such as writing the second volume of his autobiography, the mathematical analysis of brain waves, sensory prosthesis and a new formulation of quantum theory. He did not concern himself a great deal with the revision of a book he had written several years earlier – it would be more characteristic of him to write a new book or add a new chapter, rather than revise a book already written – although he must have agreed to all revisions and editorial changes.

At the end of the book, in both editions, Wiener compares the Catholic Church with the Communist Party, and both with cold war government activities in capitalist America. The criticisms of America in these last few pages of the first edition (see Appendix to this Introduction) are, in spite of one brief pointed reference to McCarthyism, largely absent in the second edition. There are other differences in the two editions. The chapter 'Progress and Entropy', for example, is much longer in the first edition. The section on the history of inventions within that chapter is more detailed. The chapter also deals with such topics as the depletion of resources and American dependence on other nations for oil, copper and tin, and the possibility of an energy-crisis unless new inventions obviate it. It reviews vividly the progress in medicine and anticipates new problems, such as the increasing use of synthetic foods that may contain minute quantities of carcinogens. These and other discursive excursions, peripheral to the main line of argument of the book, are omitted in the present edition.

The Human Use of Human Beings was not Wiener's last word on the subject. He continued to think and talk and write. In 1959 he addressed and provoked a gathering of scientists by his reflections and analysis of some moral and technical consequences of automation (*Science*, vol. 131, p. 1358, 1960), and in his last book (*God and Golem, Inc.*, 1964) he returned to ethical concerns from the perspective of the creative scientist or engineer.

It was Wiener's lifelong obsession to distinguish the human from the machine, having recognized the identity of patterns of organization and of many functions which can be performed by either, but in *The Human Use of Human Beings* it is his intention to place his understanding of the people/machines identity/dichotomy within the context of his generous and humane social philosophy. Cybernetics had originated from the analysis of formal analogies between the behaviour of organisms and that of electronic and mechanical systems. The mostly military technologies new in his day, which today we call 'artificial intelligence', highlighted the potential resemblance between certain elaborate machines and people. Academic psychology in North America was in those days still predominantly behaviourist. The cybernetic machines – such as general-purpose computers – suggested a possibility as to the nature of mind: mind was analogous to the formal structure and organization, or the software aspect, of a reasoning-and-perceiving machine that could also issue instructions leading to actions. Thus the long-standing mind–brain duality was overcome by a materialism which encompassed organization, messages and information in addition to stuff and matter. But the subjective – an individual's cumulative experience, sensations and feelings, including the subjective experience of being alive – is belittled, seen only within the context of evolutionary theory as providing information useful for survival to the organism.

If shorn of Wiener's benign social philosophy, what remains of cybernetics can be used within a highly mechanical and dehumanizing, even militaristic, outlook. The fact that the metaphor of a sophisticated automaton is so heavily employed invites thinking about humans as in effect machines. Many who have learned merely the technical aspects of cybernetics have used them, and do so today, for ends which Wiener abhorred. It is a danger he foresaw, would have liked to obviate and, although aware of how little he could do in that regard, valiantly tried to head off.

The technological developments in themselves are impressive, but since most of us already have to bear with a glut of promotional literature it is more to the point here to frame discussion not in the promoters' terms (what the new machine can do), but in a more human and social framework: how is the machine affecting people's lives? Or still more pointedly: who reaps a benefit from it? Wiener urged scientists and engineers to practise 'the imaginative forward glance' so as to attempt assessing the impact of an innovation, even before making it known.

However, once some of the machines or techniques were put on the market, a younger generation with sensitivity to human and social impacts could report empirically where the shoe pinches. Even though such reports may not suffice to radically change conventional patterns of deployment of technologies, which after all express many kinds of political and economic interests, they at least document what happens and help to educate the public. As long as their authors avoid an a priori pro-technology or anti-technology bias, they effectively carry on where Wiener left off. Among such reports we note Joseph Weizenbaum's description of the human damage manifested in the 'compulsive programmer', which poses questions about appropriate and inappropriate uses of computers (*Computer Power and Human Reason*, 1976). Similarly David Noble has documented how the introduction of automation in the machine-tool industry has resulted in a deskilling of machinists to their detriment, and has described in detail the political process by which this deskilling was brought about (*Forces of Production*, 1984).

These kinds of 'inhuman' uses seem nearly subtle if placed next to the potentially most damaging use, war. The growth of communication–computation–automation devices and systems had made relatively small beginnings during World War II, but since then has been given high priority in US government-subsidized military research and development, and in the Soviet Union as well; their proliferation in military contexts has been enormous and extensive. A proper critique would entail an analysis in depth of world politics, and especially the political relations of the two 'superpowers'. Wiener feared that he had helped to provide tools for the centralization of power, and indeed he and his fellow scientists and engineers had. For instance, under the Reagan government many billions of dollars were spent on plans for a protracted strategic nuclear war with the Soviet Union. The technological 'challenge' was seen to be the development of an effective C-cubed system (command, control and communication) which would be used to destroy enemy political and command centres and at the same time, through a multitude of methods, prevent the destruction of the corresponding American centres, leaving the USA fully in command throughout the nuclear war and victorious. Some principled scientists and engineers have, in a Wienerian spirit, refused to work on, or have stopped working on, such mad schemes, or on implementing the politicians' 'Star-Wars' fantasies.

We have already alluded to Wiener's heavy use of metaphors from engineering to describe the human and the social, and his neglect of the subjective experience. In the post-war years American sociologists, anthropologists, political scientists and psychologists tried harder than ever to be seen as 'scientific'. They readily borrowed the engineers' idiom and many sought to learn from the engineers' or mathematicians' thinking. Continental European social thinkers were far more inclined to attend to the human subject and to make less optimistic claims about their scientific expertise, but it required another decade before European thought substantially influenced the positivistic or logical-empiricist predilections of the mainstream of American social scientists.

A major development in academic psychology, prominent and well-funded today, relies strongly on the concept of information processing and models based on the computer. It traces its origins to the discussions on cybernetics in the post-war years and the wartime work of the British psychologist Kenneth Craik. This development, known as 'cognitive science', entirely ignores background contexts, the culture, the society, history, subjective experience, human feelings and emotions. Thus it works with a highly impoverished model of what it is to be human. Such models have, however, found their challengers and critics, ranging from the journalist Gordon Ratray Taylor (*The Natural History of Mind*, 1979) to the psychologist James J. Gibson, the latter providing a far different approach to how humans know and perceive (*The Perception of the Visual World*, 1950; *The Senses Considered as Perceptual Systems*, 1966; *The Ecological Approach to Visual Perception*, 1979).

If we trace the intellectual history of current thinking in such diverse fields as cellular biology, medicine, anthropology, psychiatry, ecology and economics, we find that in each discipline concepts coming from cybernetics consitute one of the streams that have fed it. Cybernetics, including information theory, systems with purposive behaviour and automaton models, was part of the intellectual dialogue of the 1950s and has since mingled with many other streams, has been absorbed and become part of the conventional idiom and practice.

Too many writings about technologies are dismal, narrow apologetics for special interests, and not very edifying. Yet the subject matter is intrinsically extremely varied and stimulating to an enquiring mind. It has profound implications for our day-to-day lives, their structure and their quality. The social history of science and technology is a rich resource, even for imagining and reflecting on the future. Moreover the topic highlights central dilemmas in every political system. For example, how is the role of 'experts' in advising governments related to political process? Or how is it possible to reconcile, in a capitalist economy within a democratic political structure, the unavoidable conflict between public interest and decision by a popular vote, on the one hand, and corporate decisions as to which engineering projects are profitable, on the other?

We are now seeing the rise of a relatively new genre of writing about technologies and people which is interesting, concrete, open, exploratory and confronts political issues head-on. We need this writing, for we are living in what Ellul has appropriately called a technological society. Within that genre, Wiener's books, as well as some earlier writings by Lewis Mumford, are among the few pioneering works that have become classics. The present reissue of one of these classics is cause for rejoicing. May it stimulate readers to think passionately for themselves about the human use of human beings with the kind of intellectual honesty and compassion Wiener brought to the subject.

Steve J. Heims
Boston, October 1988

V

ORGANIZATION AS THE MESSAGE

The present chapter will contain an element of phantasy. Phantasy has always been at the service of philosophy, and Plato was not ashamed to clothe his epistemology in the metaphor of the cave. Dr. J. Bronowski among others has pointed out that mathematics, which most of us see as the most factual of all sciences, constitutes the most colossal metaphor imaginable, and must be judged, aesthetically as well as intellectually, in terms of the success of this metaphor.

The metaphor to which I devote this chapter is one in which the organism is seen as message. Organism is opposed to chaos, to disintegration, to death, as message is to noise. To describe an organism, we do not try to specify each molecule in it, and catalogue it bit by bit, but rather to answer certain questions about it which reveal its pattern: a pattern which is more significant and less probable as the organism becomes, so to speak, more fully an organism.

We have already seen that certain organisms, such as man, tend for a time to maintain and often even to increase the level of their organization, as a local enclave in the general stream of increasing entropy, of increasing chaos and de-differentiation. Life is an island here and now in a dying world. The process by which we living beings resist the general stream of corruption and decay is known as *homeostasis.*

We can continue to live in the very special environment which we carry forward with us only until we begin to decay more quickly than we can reconstitute ourselves. Then we die. If our bodily temperature rises or sinks one degree from its normal level of 98.6° Fahrenheit, we begin to take notice of it, and if it rises or sinks ten degrees, we are all but sure to die. The oxygen and carbon dioxide and salt in our blood, the hormones flowing from our ductless glands, are all regulated by mechanisms which tend to resist any untoward changes in their levels. These mechanisms constitute what is known as homeostasis, and are negative feedback mechanisms of a type that we may find exemplified in mechanical automata.

It is the pattern maintained by this homeostasis, which is the touchstone of our personal identity. Our tissues change as we live: the food we eat and the air we breathe become flesh of our flesh and bone of our bone, and the momentary elements of our flesh and bone pass out of our body every day with our excreta. We are but whirlpools in a river of ever-flowing water. We are not stuff that abides, but patterns that perpetuate themselves.

A pattern is a message, and may be transmitted as a message. How else do we employ our radio than to transmit patterns of sound, and our television set than to transmit patterns of light? It is amusing as well as instructive to consider what would happen if we were to transmit the whole pattern of the human body, of the human brain with its memories and cross connections, so that a hypothetical receiving instrument could re-embody these messages in appropriate matter, capable of continuing the processes already in the body and the mind, and of maintaining the integrity needed for this continuation by a process of homeostasis.

Let us invade the realm of science fiction. Some forty-five years ago, Kipling wrote a most remarkable little story. This was at the time when the flights of the Wright brothers had become familiar to the world, but before aviation was an everyday matter. He called this story "With the Night Mail," and it purports to be an account of a world like that of today, when aviation should have become a matter of course and the Atlantic a lake to be crossed in one night. He supposed that aerial travel had so united the world that war was obsolete, and that all the world's really important affairs were in the hands of an Aerial Board of Control, whose primary responsibility extended to air traffic, while its secondary responsibility extended to "all that that implies." In this way, he imagined that the various local authorities had gradually been compelled to drop their rights, or had allowed their local rights to lapse; and that the central authority of the Aerial Board of Control had taken these responsibilities over. It is rather a fascist picture which Kipling gives us, and this is understandable in view of his intellectual presuppositions, even though fascism is not a necessary condition of the situation which he envisages. His millennium is the millennium of a British colonel back from India. Moreover, with his love for the gadget as a collection of wheels that rotate and make a noise, he has emphasized the extended physical transportation of man, rather than the transportation of language and ideas. He does not seem to realize that where a man's word goes, and where his power of perception goes, to that point his control and in a sense his physical existence is extended. To see and to give commands to the whole world is almost the same as being everywhere. Given his limitations Kipling, nevertheless, had a poet's insight, and the situation he foresaw seems rapidly coming to pass.

To see the greater importance of the transportation of information as compared with mere physical transportation, let us suppose that we have an architect in Europe supervising the construction of a building in the United States. I am assuming, of course, an adequate working staff of constructors, clerks of the works, etc., on the site of the construction. Under these conditions, even without transmitting or receiving any material commodities, the architect may take an active part in the construction of the building. Let him draw up his plans and specifications as usual. Even at present, there is no reason why the working copies of these plans and specifications must be transmitted to the construction site on the same paper on which they have been drawn up in the architect's drafting-room. Ultrafax gives a means by which a facsimile of all the documents concerned may be transmitted in a fraction of a second, and the received copies are quite as good working plans as the originals. The architect may be kept up to date with the progress of the work by photographic records taken every day or several times a day; and these may be forwarded back to him by Ultrafax. Any remarks or advice he cares to give his representative on the job may be transmitted by telephone, Ultrafax, or teletypewriter. In short, the bodily transmission of the architect and his documents may be replaced very effectively by the message-transmission of communications which do not entail the moving of a particle of matter from one end of the line to the other.

If we consider the two types of communication: namely, material transport, and transport of information alone, it is at present possible for a person to go from one place to another only by the former, and not as a message. However, even now the transportation of messages serves to forward an extension of man's senses and his capabilities of action from one end of the world to another. We have already suggested in this chapter that the distinction between material transportation and message transportation is not in any theoretical sense permanent and unbridgeable.

This takes us very deeply into the question of human individuality. The problem of the nature of human individuality and of the barrier which separates one personality from another is as old as history. The Christian religion and its Mediterranean antecedents have embodied it in the notion of *soul*. The individual possesses a soul, so say the Christians, which has come into being by the act of conception, but which will continue in existence for all eternity, either among the Blessed or among the Damned, or in one of the little intermediate lacunae of Limbo which the Christian faith allows.

The Buddhists follow a tradition which agrees with the Christian tradition in giving to the soul a continuity after death, but this continuity is in the body of another animal or another human being, rather than in some Heaven or Hell. There are indeed Buddhist Heavens and Hells, although the stay of the individual there is generally temporary. In the most final Heaven of the Buddhists, however, the state of Nirvana, the soul loses its separate identity and is absorbed into the Great Soul of the World.

These views have been without the benefit of the influence of science. The most interesting early scientific account of the continuity of the soul is Leibnitz's which conceives the soul as belonging to a larger class of permanent spiritual substances which he called *monads*. These monads spend their whole existence from the creation on in the act of perceiving one another; although some perceive with great clarity and distinctness, and others in a blurred and confused manner. This perception does not however represent any true interaction of the monads. The monads "have no windows," and have been wound up by God at the creation of the world so that they shall maintain their foreordained relationships with one another through all eternity. They are indestructible.

Behind Leibnitz's philosophical views of the monads there lie some very interesting biological speculations. It was in Leibnitz's time that Leeuwenhoek first applied the simple microscope to the study of very minute animals and plants. Among the animals that he saw were spermatozoa. In the mammal, spermatozoa are infinitely easier to find and to see than ova. The human ova are emitted one at a time, and unfertilized uterine ova or very early embryos were until recently rarities in the anatomical collections. Thus the early miscroscopists were under the very natural temptation to regard the spermatozoon as the only important element in the development of the young, and to ignore entirely the possibility of the as yet unobserved phenomenon of fertilization. Furthermore, their imagination displayed to them in the front segment or head of the spermatozoon a minute fetus, rolled up with head forward. This fetus was supposed to contain in itself spermatozoa which were to develop into the next generation of fetuses and adults, and so on *ad infinitum.* The female was supposed to be merely the nurse of the spermatozoon.

Of course, from the modern point of view, this biology is simply false. The spermatozoon and the ovum are nearly equal participants in determining individual heredity. Furthermore, the germ cells of the future generation are contained in them *in posse,* and not *in esse.* Matter is not infinitely divisible, nor indeed from any absolute standpoint is it very finely divisible; and the successive diminutions required to form the Leeuwenhoek spermatozoon of a moderately high order would very quickly lead us down beyond electronic levels.

In the view now prevalent, as opposed to the Leibnitzian view, the continuity of an individual has a very definite beginning in time, but it may even have a termination in time quite apart from the death of the individual. It is well known that the first cell division of the fertilized ovum of a frog leads to two cells, which can be separated under appropriate conditions. If they are so separated, each will grow into a complete frog. This is nothing but the normal phenomenon of identical twinning in a case in which the anatomical accessibility of the embryo is sufficient to permit experimentation. It is exactly what occurs in human identical twins, and is the normal phenomenon in those armadillos that bear a set of identical quadruplets at each birth. It is the phenomenon, moreover, which gives rise to double monsters, when the separation of the two parts of the embryo is incomplete.

This problem of twinning may not however appear as important at first sight as it really is, because it does not concern animals or human beings with what may be considered well-developed minds and souls. Not even the problem of the double monster, the imperfectly separated twins, is too serious in this respect. Viable double monsters must always have either a single central nervous system or a well-developed pair of separate brains. The difficulty arises at another level in the problem of split personalities.

A generation ago, Dr. Morton Prince of Harvard gave the case history of a girl, within whose body several better-or-worse-developed personalities seemed to succeed one another, and even to a certain extent to coexist. It is the fashion nowadays for the psychiatrists to look down their noses a little bit when Dr. Prince's work is mentioned, and to attribute the phenomenon to hysteria. It is quite possible that the separation of the personalities was never as complete as Prince sometimes appears to have thought it to be, but for all that it was a separation. The word "hysteria" refers to a phenomenon well observed by the doctors, but so little explained that it may be considered but another question-begging epithet.

One thing at any rate is clear. The physical identity of an individual does not consist in the matter of which it is made. Modern methods of tagging the elements participating in metabolism have shown a much higher turnover than was long thought possible, not only of the body as a whole, but of each and every component part of it. The biological individuality of an organism seems to lie in a certain continuity of process, and in the memory by the organism of the effects of its past development. This appears to hold also of its mental development. In terms of the computing machine, the individuality of a mind lies in the retention of its earlier tapings and memories, and in its continued development along lines already laid out.

Under these conditions, just as a computing machine may be used as a pattern on which to tape other computing machines, and just as the future development of these two machines will continue parallel except for future changes in taping and experience, so too, there is no inconsistency in a living individual forking or divaricating into two individuals sharing the same past, but growing more and more different. This is what happens with identical twins; but there is no reason why it could not happen with what we call the mind, without a similar split of the body. To use computing-machine language again, at some stage a machine which was previously assembled in an all-over manner may find its connections divided into partial assemblies with a higher or lower degree of independence. This would be a conceivable explanation of Prince's observations.

Moreover, it is thinkable that two large machines which had previously not been coupled may become coupled so as to work from that stage on as a single machine. Indeed this sort of thing occurs in the union of the germ cells, although perhaps not on what we would ordinarily call a purely mental level. The mental identity necessary for the Church's view of the individuality of the soul certainly does not exist in any absolute sense which would be acceptable to the Church.

To recapitulate: the individuality of the body is that of a flame rather than that of a stone, of a form rather than of a bit of substance. This form can be transmitted or modified and duplicated, although at present we know only how to duplicate it over a short distance.

When one cell divides into two, or when one of the genes which carries our corporeal and mental birthright is split in order to make ready for a reduction division of a germ cell, we have a separation in matter which is conditioned by the power of a pattern of living tissue to duplicate itself. Since this is so, there is no absolute distinction between the types of transmission which we can use for sending a telegram from country to country and the types of transmission which at least are theoretically possible for transmitting a living organism such as a human being.

Let us then admit that the idea that one might conceivably travel by telegraph, in addition to traveling by train or airplane, is not intrinsically absurd, far as it may be from realization. The difficulties are, of course, enormous. It is possible to evaluate something like the amount of significant information conveyed by all the genes in a germ cell, and thereby to determine the amount of hereditary information, as compared with learned information, that a human being possesses. In order for this message to be significant at all, it must convey at least as much information as an entire set of the *Encyclopedia Britannica.* In fact if we compare the number of asymmetric carbon atoms in all the molecules of a germ cell with the number of dots and dashes needed to code the *Encyclopedia Britannica,* we find that they constitute an even more enormous message; and this is still more impressive when we realize what the conditions for telegraphic transmission of such a message must be. Any scanning of the human organism must be a probe going through all its parts, and will, accordingly, tend to destroy the tissue on its way. To hold an organism stable while part of it is being slowly destroyed, with the intention of re-creating it out of other material elsewhere, involves a lowering of its degree of activity, which in most cases would destroy life in the tissue.

In other words, the fact that we cannot telegraph the pattern of a man from one place to another seems to be due to technical difficulties, and in particular, to the difficulty of keeping an organism in being during such a radical reconstruction. The idea itself is highly plausible. As for the problem of the radical reconstruction of the living organism, it would be hard to find any such reconstruction much more radical than that of a butterfly during its period as a pupa.

I have stated these things, not because I want to write a science fiction story concerning itself with the possibility of telegraphing a man, but because it may help us understand that the fundamental idea of communication is that of the transmission of messages, and that the bodily transmission of matter and messages is only one conceivable way of attaining that end. It will be well to reconsider Kipling's test of the importance of traffic in the modern world from the point of view of a traffic which is overwhelmingly not so much the transmission of human bodies as the transmission of human information.