

THE UNIVERSITY OF NORTH CAROLINA
SCHOOL OF MEDICINE



MERRIMON LECTURE

by

SIR PETER B. MEDAWAR, F.R.S.

OCTOBER TWENTIETH, NINETEEN HUNDRED AND SEVENTY-ONE

THE MERRIMON LECTURE

Science and Civilization

SIR PETER B. MEDAWAR, F.R.S.
Nobel Laureate in Physiology and Medicine

THE UNIVERSITY OF NORTH CAROLINA SCHOOL OF MEDICINE
CHAPEL HILL

1972

THE MERRIMON LECTURESHIP IN MEDICINE

This Lectureship, which was established by the late Dr. Louise Merrimon Perry "in respect and honour of the Great Traditions of the Science and Practice of Medicine," was inaugurated in 1966. Dr. Perry's idea was that the lectures be open to all, but that they be concerned with "the Origins, Traditions and History of the Medical Profession and of that Ethical Philosophy which must dominate this Field of Human Endeavor." It was her intent that the Merrimon Lecturers be distinguished both for scientific or clinical skills and a notably humane attitude toward Medicine.

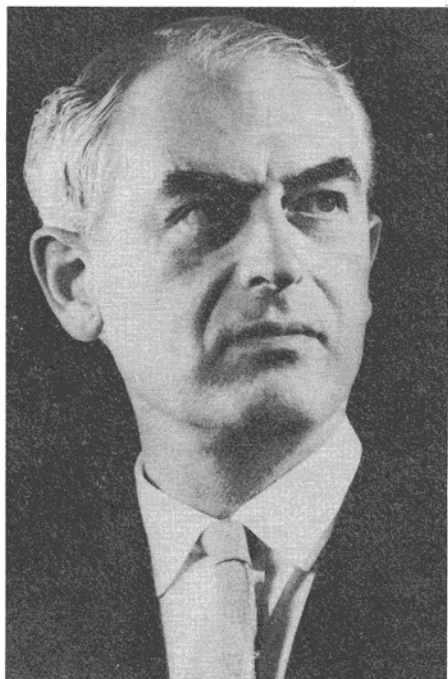
Previous Merrimon Lecturers

DR. NICHOLSON JOSEPH EASTMAN

DR. WILLIAM BOSWORTH CASTLE

DR. RENÉ JULES DUBOS

DR. JOHN HILTON KNOWLES



SIR PETER BRIAN MEDAWAR was born in Brazil in 1915 and educated in England, graduating from the University of Oxford in 1935. He began his career in the Sir William Dunn School of Pathology at Oxford and was a fellow of Magdalen College. He became head of Zoology at the University of Birmingham in 1947 and was elected Fellow of the Royal Society in 1949. Moving to London as head of Zoology at the University College in 1951, he shared the Nobel prize in Physiology and Medicine with F. M. Burnet in 1960. He was appointed head of the National Institute for Medical Research at Mill Hill in 1962 and was knighted by Queen Elizabeth in 1965. He served as president of the British Association for the Advancement of Science in 1969. In 1972 he was made Companion of Honour, one of Britain's highest awards.

Sir Peter has been a continuously productive scholar, devoting himself particularly to studying the processes of growth and aging and transplantation immunity, and was the discoverer of acquired immunological tolerance. He has also sketched on a broader canvas, having written several widely read books, including *The Uniqueness of the Individual* (1956), *The Future of Man* (1960), and *The Art of the Soluble* (1967).

Recently he has once again demonstrated his virtuosity. He has resigned the directorship at Mill Hill and is beginning a new career as director of a small biomedical research unit at the Clinical Research Center of the Medical Research Council at Northwick Park Hospital outside London.

Science and Civilization

An attempt to evaluate the place of science in civilized life and the ways in which science could or should uphold it might well begin with a statement of what was originally expected of the New Science in the early decades of the 17th century when modern science began. In those days most thoughtful people were still deeply perturbed and oppressed by ancient superstitions and by what may loosely be described as a 'fear of the dark.' (By 'fear of the dark,' I mean of course fear of the unknown. The imagery of light and dark plays a most important part in the writings of Francis Bacon. Pascal seems to attribute the same significance to silence as Bacon does to darkness. Silence for Pascal symbolizes the loneliness of incomprehension, as we shall see.) They were ignorant of the world, much of which had yet to be discovered, and of the nature of the people who might live in it. They were ignorant of the universe and fearful of the complete indifference of its motions to all matters of human concern. They accepted the long-standing traditional belief that the world would come shortly to an end—perhaps even within the lifetime of their own grandchildren, so that all aspiration was futile. Much of the philosophic thought of the period is permeated by a sense of hopelessness and impending doom.

Forgetting Shakespeare—if such an amazing feat is possible—though not forgetting that the darker Shakespeare of *Lear*, *Macbeth* and *Timon* was an early 17th Century and not an Elizabethan playwright, let me remind you of some of the famous passages in literature which tell us of the imminent end of the world and of the tragedy of human bewilderment and ignorance. These passages are probably familiar to you already—indeed, I hope they are—but there is no harm in repeating them. Thomas Browne, the author of *Religio Medici*, spoke of himself as one whose generation was 'ordained in the setting part of time': 'The great mutations of the world are acted. . . . It is too late to be ambitious.'

Thomas Burnet said, 'We are almost the last posterity of the first men, and are fallen into the dying age of the world.' In one of the most famous of all passages of apocalyptic prose in English, Thomas Burnet in his *Sacred Theory of the Earth* describes the end of the world as he conceives it: the immolation of the entire earth in a storm of fire as it might be in a nuclear holocaust: 'Where are the Great Empires of the World and their great Imperial Cities, their pillars, their trophies and their Monuments of Glory? Show me where they stood, read the Inscription and tell me the Victor's name.' 'Who won?' is a good question and one that could be asked after any modern war. 'Rome itself,' he goes on, 'eternal Rome, the great city, the empress of the world, whose domination and superstition ancient and modern make a great part of the history of this earth. What has become of her now? She gloried in herself and lived deliciously and said in her heart, I sit a Queen and shall see no sorrow. But her hour is come, she is wiped away from the face of the earth and buried in everlasting oblivion. Here stood the Alpes, a prodigious range of stone, the load of the Earth that covered many countries and reached their arms from the ocean to the Black Sea. This huge mass of stone is softened

and dissolved as a tender cloud into rain. There was frozen Caucasus and Taurus and Imaus and the mountains of Asia. Yonder towards the north stood the Rhiphaean hills clothed in ice and snow. All these are vanished, dropped away as the snow upon their heads and swallowed up by the red sea of fire.' 'Hallelujah,' he adds in a pious *non sequitur*.

The greatest spokesman of the trait I described as fear of the dark was of course the French mathematician Blaise Pascal (but notice also the imagery of silence). Pascal the great geometer wrote with perfect composure about infinity and the infinitesimal, but when he was about thirty he gave up the secular sciences for pursuits commonly considered more lofty, and it was during this latter part of his life that he dwelt upon and composed those dark and deeply troubled thoughts upon which his literary fame rests. 'Those devoid of faith and grace find in nature only darkness and obscurity,' he tells us. 'When I see the blindness and misery of man, when I gaze upon the whole silent world, and upon man without light abandoned to himself, lost, . . . I become terrified. . . . For what after all is man in nature? A mere nothing when compared with the infinite. We sail within a vast sphere, ever drifting uncertain. The eternal silence of infinite space terrifies me.'

I myself believe that philosophical moods have a much more profound effect upon human behaviour than is generally realised, and that philosophy is not, or not merely, a matter of learned pedants poring in their private rooms upon matters having no relevance whatsoever to human affairs. I therefore think it quite possible (and am not the first to do so) that part of the motive force which led to the great emigrations from England to America in the period I am speaking of was the desire to find a land in which a new world could be made and in which hopes and ambitions for the future would not be regarded as essentially futile. It was with special pleasure that I learned from Dr. John Graham that the Chapel which gave its name to Chapel Hill was the 'Chapel of New Hope.'

But not all philosophers were moping, and Francis Bacon, the self-proclaimed 'trumpeter' of the New Science, began to write with the air of a man determined to put a stop forever to all the nonsense about human incapability and moral infirmity. Bacon must have realised instinctively that a main cause of despondency and discontent was fear of the dark—because the imagery of light and the notion of kindling a light in nature permeates his works from end to end.

Consider for example his passionate advocacy of 'Experiments of Light'—experiments that truly enlarge the understanding—as opposed to 'Experiments of Use'—experiments directed toward immediate practical purposes. Consider also his strange poetic notion of the 'Merchants of Light' as the men who transact the business of his own special Utopia *The New Atlantis*. Bacon's distinction between experiments of light and of use may well be the first sign of the unhappy class distinction that has grown up between Pure and Applied Science.

Today it is a little difficult not to look back rather sadly upon Bacon's sanguine expectations. In the heyday of Science towards the end of the 19th century it was taken for granted that science and civilised society were firm

allies, the one the agency of the other. Today antiscientific and antirational propaganda encourage us to believe that science and civilised society are incompatible or even antithetical. Science and technology (we learn from our professional Doomniks) lurch forward like some mythical monster, like some great Behemoth trampling down in its pathway everything that makes life worth living, and bringing with it gifts that people did not ask for and would prefer to be without.

This misconception of science is rapidly achieving the status of a new superstition as disheartening as any that Bacon dispelled, so I should like to spend a little time discussing some of the factors that enter into it.

I am afraid that scientists themselves cannot be acquitted of a fairly substantial share of the blame—both senior and junior scientists.

When senior scientists have reached the level of distinction at which they may be invited to give Commencement Addresses and other such elevating public declarations, they are often rather hard put to know what to say, but a mischievous instinct has sometimes prompted them to believe that a spirited denunciation of science and technology will fall upon grateful ears and will be found acceptable by the younger members of their audience, with whom they try to curry favour by pretending either that they share their views or that they were once young themselves.

Unfortunately for these speakers, the denunciation of science and technology is becoming too well known an alternative to having anything original to say, and I look forward to a very lean period for them when their audiences get wise to this and demand something a little more appropriate to the occasion than the fashionable wringing of hands.

Younger scientists are also very much to blame. To say or do something or profess to hold beliefs *pour épater le Bourgeois* is a characteristic of many young academics, and young scientists who study reproductive physiology seem to be specially afflicted by a desire to shock the middle classes out of their complacent slumbers. What often seems to happen is that a newspaper reporter or radio interviewer asks, 'Now what exactly is the purpose of your enquiries, Dr. So-and-So?' Dr. So-and-So feels that by implication he is being accused of whiling away his time in an ivory tower dealing with matters having no relevance to human life so in a moment of panic he says the first newsworthy and arresting thing that comes into his head; it is often something very unfortunate like: 'We hope one day to be able to produce carbon copies of human beings and alter the genetic structure of the human germ cell nucleus in such a way that we shall be able to populate the world with Newtons and Mozarts.' He can hear himself speaking while wishing he wasn't because in his heart he knows he is talking the most frightful rot, but unfortunately his audience does not know this and slowly the picture is built up of scientists as ectoparasites of society, inhuman creatures who deliberately and gratuitously meddle with natural processes in a dangerous and altogether uncalled-for way with unpredictable and possibly malignant consequences.

One of the things that makes it almost impossible to get science technology a fair hearing before the general public, is that nearly all the jurors have already been suborned. They carry with them a conception of science

that is built upon a childhood perusal of Gothick strip cartoons or TV serials of the same intellectual stature. The wicked scientist, like the Mad Genius, has joined the roster of those fictional characters whose real existence everybody takes for granted (they have become just like the members of the family). Shortly after the second world war an English bishop wrote to the *London Times* exhorting all nations to destroy the formula of the atomic bomb. If there indeed were a formula it would, of course, have been a splendid thing to destroy it—perhaps ceremonially. But one's flesh creeps at the thought that the guidance of human opinion is in the hands of people who retain such an infantile conception of modern science.

I am sorry to say that in England many senior citizens have no conception of science at all—not even a mistaken one. In England ignorance of science had become like the Mandarin's fingernails—a sign of high cultural status and of distant removal from vulgarly practical pursuits.

A second important factor that enters into the modern reaction against science and technology is a tendency, first pointed out to me by Professor S. Toulmin, to blame science and technology for the malefactions of 19th century *laissez faire* capitalism in its more predatory aspects. The despoliation of the countryside, and what Goronwy Rees calls the looting and plundering of the planet are not necessary consequences of the advance of science and technology—though they follow very naturally from a creed according to which profitability is a characteristic that excuses any mercantile enterprise from social censorship.

Karl Friedrich Engels' work *The Condition of the Working Class in England in 1844* is one of the works that helped to change the history of the world. Unfortunately, the environment has not yet found its Engels, and certainly not its Marx. The preparation of a comparable treatise on the condition of the human environment in the world right now might have an equally salutary effect. The United Nations has exactly such a project in mind.

Another more subtle element that enters into the modern distrust of science is the general repugnance of right-thinking people to the notion of the 'mastery' or 'domination' of nature. The idea that the purpose of scientific learning is to achieve the mastery of nature is attributed—and I fear quite rightly attributed—to Francis Bacon. I won't go into the technical reasons why this was a perfectly reasonable view for him to entertain in his day—it had to do with the special way in which he used the word 'experimentation'; the notion of 'mastery' as the goal of Natural Science also appears in Freud and in Marx. Both should have known better. However, the important thing is that it should not be an acceptable figure of speech today. We are not at war with nature and most natural processes are no longer inimical to us. The 'Conquest of Disease' is fair enough but I always get a very disagreeable impression from reading about, for example, the 'Conquest of Space.' What harm did space ever do to us?

The most unfortunate consequence of the notion of domination or mastery is that it seems to condone, or even in a perverse way to justify the despoliation of the environment. Travelling by railroad south of New York City or north of Birmingham, England, is very like visiting an old battlefield:

the scene of some terrible victory of technology over Nature. I think it important, therefore, consciously to repudiate this notion of mastery or warfare and substitute for it the gentler notion of understanding.

When I first thought about the theme of this Lecture I had intended to call it 'Some doctors' dilemmas,' because I thought I would discuss a number of therapeutic or biomedical advances through which it might appear to the uninformed layman that an individual's elementary human rights were being violated or disregarded. This appealed to me because transplantation, on which I work, is the area of modern medical treatment which has given rise to the gravest suspicions on the part of those who believe that they are unique in possessing a social conscience. The last time I attended a meeting of the Transplantation Society in New York the conference hall was picketed by people bearing placards saying, 'These men are creating Frankensteins!' This charge dismayed the delegates very greatly, because it betrayed such a shocking ignorance of English literature. I need not tell you that the Frankenstein of Mary Shelley's famous Gothick novel was not the monster but the man who created him.

Malicious and utterly uninformed propaganda to the effect that organs are removed from patients who have consented to be transplant donors before they are really dead has had the paradoxical effect of denying a normal life to quite a number of people who might otherwise have enjoyed it. One of the leading transplant surgeons in England tells me that donors are now so reluctant to come forward that a shortage of transplant organs is putting a serious brake upon carrying out the successful and in many cases life-giving operation of transplanting kidneys.

The transplantation of kidneys is an alternative to death for those whose kidneys have ceased to work and who cannot afford or cannot for logistic reasons be provided with an artificial kidney. Methods of hemodialysis are being steadily improved, and it is now possible to conduct the process at home. Unfortunately it has many drawbacks: the obligation to undergo hemodialysis restricts freedom seriously and infection is a constant threat. For this and other reasons the transplantation of a kidney is a better remedy when the right conditions for its performance can be fulfilled. A person with a working kidney transplant lives a close approximation to a normal life. It is willfully mischievous to contend that such a person is a surgical artifact or monster, a latterday Chimera compounded of tissue from different individuals, and being kept alive by some sort of surgical conjuring trick. Before anyone insists too vehemently upon the right of a human being to die it should be remembered that a very decided preference for being alive is a manifestation in human beings of one of the great motive forces of evolutionary change over the past several million years. At a conference in London dealing with a patient's right to die and the degree to which he might be victimized by being, so to speak, forcibly kept alive, a physician at our greatest centre for the treatment of nerve injuries remarked how rare it was to find even a person paralysed in all four limbs who did not wish to remain alive.

Let me now turn briefly to another subject which I have been practically interested in and have some theoretical understanding of: the project, applauded by an eminent French literary biologist, to keep a person alive in a state of suspended animation in a very deep freeze until medicine finds cures for the mortal or all-but-mortal illnesses that afflicted them, whereupon they can be thawed out, cured and restored to the bosom of society.¹ Whatever M. Jean Rostand may have thought about the matter, I should like you to be in no doubt about my own opinion, which is that the entire project is impracticable, socially disruptive and a gross affront to our sense of the fitness of things. I say 'socially disruptive' because only a very limited number of people could enjoy the privilege of remaining in a state of suspended animation. Upon what grounds then will the choice be made between one candidate for immortality and another? Presumably it can only be upon the grounds of their ability to afford the necessary capital endowment and running expenses to maintain their own refrigerated mausoleum. It is hard to believe that the ambition to leave oneself as a legacy to posterity even when combined with the possession of such a degree of wealth, coupled with such an ambition, justifies the issue of a passport to immortality. And I describe it as a gross affront to our sense of the fitness of things because there is indeed a natural order of things in the course of which people grow up and have children and eventually die and are succeeded by their children. If this succession did not take place there would have been no evolution and no *Homo sapiens*. Moreover, it is very difficult to think of any process of social regeneration which would not ultimately depend on the succession of an older generation by a younger one, with new ideas and new ambitions.

The second example I shall choose is one upon which I hold a very different opinion indeed, viz, the proposal that a human ovum might sometimes be fertilized outside the body and implanted into the womb of a woman who would not otherwise have a child. This proposal has caused an outcry which I attribute to a real failure of human understanding. The project should be thought of as a process of adoption except that, inasmuch as the mother will actually bear and rear the child, it is a process of adoption that will give the adoptive mother a deeper sense of affection and kinship than is made possible by, for example, the more conventional procedure of adopting what might be called a 'readymade' child.

The next example I shall choose from the repertory of medico-biological extravaganzas is one which is sometimes called 'genetic engineering,' in the rather special sense of a modification of heredity in some foreknown and predetermined direction by a modification or replacement of the DNA in the fertilized egg. For example, the victim of a genetic deficiency disease like phenylketonuria could in theory have his defective gene replaced by a normal gene. I share with my friends Sir MacFarlane Burnet and Dr. Jacques Monod the gravest doubts about the practicability of this scheme even for the simple genetic defects which its proponents must originally have had in mind.

1. See *The Prospect of Immortality* by Herbert W. Ettinger, with an introduction by Jean Rostand. New York: Doubleday, 1964.

I should like to pursue the genetic train of thought a little further, to illustrate how severely and unjustly science may be blamed for supposedly putting into our hands a destructive weapon which in fact we already possess. You probably remember that H. G. Wells, in what is surely the most imaginative and best written of science fiction, **The Time Machine**, foretold that in the distant future the human race would have divided itself into two classes, namely a privileged, pampered and effete higher class, the Eloi, and an inferior class of drudges and slaves, the Morlochs. Morlochs are rather like characters in Wagner. As I remember it, the latter fed upon the former—which served them right, I remember thinking as a radically-minded boy. It has come to be quite widely believed that it is modern science that has put it into our power to breed different ‘makes’ or ‘models’ of human beings, as different one from another as toy poodles from great danes or greyhounds from dachshunds. It is of course not science that has put it in our power to realise this frightful possibility. On the contrary, the enterprise that could have been put in train any time within the past two or three thousand years, simply by applying to human beings the familiar empirical arts of the stock-breeder. Of course it would have needed a particularly ruthless tyrant, or rather a dynasty of tyrants, to put it into effect. But the point is that it *could* have been done: science has nothing to do with it. Nor, until comparatively recent years, has science had very much to do with stockbreeding itself. Human beings are perfectly susceptible to the process of selective breeding, because we are quite unspecialised animals, i.e., we are not committed as ant-eaters are to some one particular way of life which would prejudice our exploring new avenues of evolution. Human beings have, moreover, a very great range of inborn diversity, that is to say there are an enormous number of genetically different kinds of human beings. If selection were to have been embarked upon, there would have been a great variety to choose from. The element of horror in Wells’s fantasy was not that science had put it into anybody’s power to bring about this dichotomy of the human species, but that the people existed who wished to bring it about and actually did so.

I shall now turn from a fictional example to a dilemma that is far from fictional and indeed deadly earnest. The original doctor’s dilemma as George Bernard Shaw described it in the Preface to his famous play was not so much medical as socio-political and moral. It is that which is implicit in any system of medical care in which it is financially worthwhile for a surgeon to remove one or more limbs or part or all of the insides (‘Except,’ Shaw notes, ‘when he does it on a poor person for practice’). ‘I cannot knock my shins severely,’ he continues, ‘without forcing upon some surgeon the difficult question: could I not make better use of a pocketful of guineas* than this man is making of his leg? Could he not write just as well, or even better, on one leg than on two?’ There is a genuine dilemma behind Bernard Shaw’s outrageous fun and it has been resolved, or at least partially resolved in the United Kingdom by the institution of a National Health Service. Don’t let anybody

* The guinea is an obsolete British coin worth about 3 dollars.

con you into believing that the National Health Service doesn't work. It does work—not superlatively well, maybe, but few human schemes do, even the best laid. It has, however, removed from ordinary people, particularly older people, the almost self-destructive dread of being ill and unable to pay for adequate medical treatment.

I chose the Morlocks and the Eloi as an example of how science may be arraigned for empowering us to do what we can do anyway. Let me give another example. Many fearful and rather credulous people believe that modern psychology has put it in our power systematically to corrupt and deprave the minds of children by filling them with unsound principles and erroneous beliefs, and generally shaping their minds and wills at the entire discretion of their teachers. But, of course, it is not science, let alone psychology, that has made this process possible. It has been in progress for thousands of years and is called 'Education.' (A literary critic would discern here the influence of Bernard Shaw.) If psychology had any such power we might be more confident about its use for therapeutic purposes.

I should like to end with one further case history which has to do with the population problem and the practice of family limitation. It is quite widely felt that the practice of family limitation may ultimately damage the human species, for is it not 'flying in the face of nature'? I have looked carefully into this possibility in both its aspects, that is reduction of family size and the completion of families earlier in life, and can assure you that there is no good reason to suppose that either of these practices is genetically deleterious though propagandists against birth control might be deeply gratified if they were so.² My last case history is a truly fine specimen of the kind of propaganda I have in mind. It embodies a fallacy which for reasons that will soon be clear I propose to call the 'Beethoven Fallacy.' I can remember its being used with dramatic effect in a public lecture in America by an English Catholic politician, Mr. St. John-Stevas.³ We have to imagine a family doctor's discussing with an obstetrician the advisability of terminating a certain pregnancy. The story (Maurice Baring's), which I shall recount to you just as St. John-Stevas did, runs as follows:

(One doctor to the other:) 'About the terminating of pregnancy, I want your opinion. The father was syphilitic, the mother tuberculous. Of the four children born, the first was blind, the second died, the third was deaf and dumb, the fourth was also tuberculous. What would you have done?'

'I would have ended the pregnancy.'

'Then you would have murdered Beethoven.'

2. An expert committee of the American Society of Human Genetics has recently reported that the genetical effects of family planning are either beneficial or neutral (Am. J. Human Genet., 1972).
3. See N. St. John-Stevas in *Life or Death—Ethics and Options*, p. 9. Univ. of Washington Press, 1968.

It is because they make remarks like this that we all love politicians. Let us try to discern what the message in this odious anecdote can be. It cannot just be that the termination of pregnancy may have the ill fortune to deprive the world of a genius because it is obvious that the world might equally well be deprived of a Beethoven by chaste abstention from intercourse. The message could be that thanks to the mysterious working of Providence there is a specially high likelihood of giving birth to a musician of towering genius if one parent is syphilitic and the other tubercular. I do not suppose for a moment that Mr. St. John-Stevas believes this to be the case. So what remains of the anecdote except the echo of a rabble-rousing appeal to the emotions?

I think that most people now recognise that the population problem is the worst of all the unintended side effects of medical treatment: everyone understands, and nowhere more clearly than at Chapel Hill, that it is a consequence of the increase in the mean expectation of life made possible by advances in medicine and sanitary engineering of the past hundred years or so. But put yourself in the position of someone called upon a hundred years ago to pass judgment on the desirability of these advances. Who, I wonder, would have been callous enough to say that these scientific and technical advances were intrinsically undesirable, and that for every life saved another life should have been forfeited?—for that is the only method by which the population problem could have been prevented from arising in the first place. To put the same question in another way, let us ask ourselves from what nation or race the benefits of modern medical advances should have been withheld in order to have spared us our present embarrassments? These questions I think illustrate the intrinsic absurdity of blaming medical science for the population problem. By 1945 when penicillin and drugs like sulfanilamide were coming into common use it might have been possible for a very far-seeing demographer to have issued a warning about the population explosion which they and modern sanitation would ultimately help to bring about. Instead of that we find that the greatest demographer in the world at that time, Alfred J. Lotka of the Metropolitan Life Insurance Company, was writing with unfeigned sadness about the very strong likelihood that the peoples of the Western world would die out through infertility. How strange it was, he said to himself, that the human species would be the first to be clever enough to foresee its own doom. Even in a highly quantified subject such as demography it is not possible to predict future population trends over long periods anything like accurately. This is because the behavioural variables on which the growth of a population ultimately depends cannot themselves be predicted—I mean, marriage rates, marriage ages, and married couples' preferences about completed family size. It is true that one can make generalizations about all these matters at a sort of pop sociology level, but that does not provide a foundation firm enough for demographic prediction.

It is entirely possible that the practice of family size limitation over many generations would ultimately diminish the fecundity or 'innate' fertility of the population that practiced it. This is because the practice of family limitation reduces the selective differential between the most fecund and the least

fecund human beings. The mother who *could* produce 14 children but has only three is no longer at a high selective advantage with respect to the mother who can and does produce three children. If such a decline of innate fertility were to occur, we should applaud the phenomenon and regard it as a manifestation in human beings of an adjustment that has occurred repeatedly in the evolution of animals, as we have learned from David Lack's⁴ scrupulous studies of clutch size in nidicolous birds—studies which show conclusively that animals in nature are not under some mysterious compulsion to reproduce flat out, i.e., at the extreme limit of their physical capability. On the contrary, the fertility level of a species is adjusted by natural selection to the value best suited to propagating it. The 'best' value is not in general likely to be the upper biological limit. The human species illustrates this as clearly as any other. How did the fallacy of obligatory maximal fertility arise? I believe it is part of the spin off from the insidiously fallacious syllogism in terms of which we were first introduced to the notion of Natural Selection. It runs as follows:

1. Animals produce young in numbers vastly in excess of their requirements.
2. Only a tiny minority of these survive.
3. The survivors are the best adapted to their environments.

The fallacy lies in premise (1), of course. It is only by neglecting mortality and infertility that we can suppose that animals produce young in vastly excessive numbers. In reality they produce just about the numbers that are sufficient and necessary to propagate their kind. Incidentally it is a tendency to disregard mortality and infertility that makes people think it obvious that the population replacement value for human beings is a family size of 2 per married couple. It cannot be less than two of course (unless someone discovers the secret of immortal life) and will in general be more. The figure will vary from one population to another in accordance with the prevailing pattern of mortality and of impediments to reproduction.

It is perfectly well understood that the solution of the over-population problem depends upon concerted political, administrative, scientific and educational action. The scientific contribution is necessary, but of course it is not by itself sufficient—obviously a remedy is useless unless it is actually applied. I have much greater faith in the scientist's ability to solve his share of the problem than in the administrators or the politicians to solve theirs. This is because the scientific objective is much more clearly defined and its achievement less distracted by irrelevant considerations. The scientific problem is in any case very much easier to solve than the political, educational or administrative problems. I suspect that what I have said of the population problem is true also of other misadventures and malefactions associated with the growth of science and technology without special censorship, including

4. See D. Lack in *The Natural Regulation of Animal Numbers*, Clarendon Press, Oxford, 1954.

the pollution problem in its various aspects. Here, too, the solution of a pollution problem involves not merely the discovery of methods of, for example, purifying toxic effluents but also the enactment and enforcement of legislation to make sure that these methods are actually used. In all such cases to cut off the services of science is to spite one's own face, because only science and technology can remedy the consequences of their own misuse.

Although I have been defending science in this Lecture, I am of course not trying to contend that science showers unmixed blessings in profusion upon us. On the contrary, I regard the cornucopial conception of science as hardly less foolish than that which sees in the relations between science and civilization a re-enactment of the fable of the Sorcerer's Apprentice. My purpose has, above all, been to contest the view that there is some *essential* malefaction about the progress of science and technology, so that a society founded upon science and technology must of necessity be engaged in doing itself in.

I began this Lecture by comparing the philosophic gloom of the seventeenth century with our state of mind today. A well-known English historian of the seventeenth century described the despondent and gloom-ridden state of mind of the philosophers and thinkers of that day as evidence of a 'failure of nerve.' We are suffering a comparable failure of nerve today—a loss of hope in progress, in our ability to make the world a better place to live in through our own exertions and by making use of every possible resource at our disposal, including of necessity, science itself. It is this failure of nerve more than any other single factor which, if anything, will eventually do us in.

But consider what progress we have made in the last few hundred years. The darkness of ignorance and superstition has receded all around us. No ordinary man now thinks himself at the mercy of occult malevolent forces; we can see everything much more clearly, including our own imperfections. We were never more clearly aware than we are today of the degree to which we fall short of having achieved a just and humane society. But we have this at least to distinguish us from the seventeenth century: we know that our predicaments are remediable given the will to seek and apply remedies. 'But by far the greatest obstacle to the progress of science and the undertaking of new tasks and improvements is that men despair and think things impossible. I am now therefore to speak of Hope,' said Bacon in 1620.⁵ He and a few others managed to give their contemporaries a confidence in their power to better their condition. It is something of the Baconian spirit that we need today, for without the hope of progress or of the possibility of progress we lack the principal motive force of human betterment.

5. F. Bacon. *Novum Organum* XCII.

THE MERRIMON COMMITTEE

Dr. John B. Graham, Chairman

Mr. Cecil M. Farrington

Dr. Charles H. Hendricks

Mr. Thomas G. Irons

Dr. Margaret C. Swanton

ARRANGEMENTS:

Miss Maria A. Leon

Miss Lucia W. Hudson