



THE IMPORTANCE OF BEING SCIENTIFIC

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By Walter Boas*

THE IMPORTANCE OF BEING SCIENTIFIC

Science and Technology.

"Science has an enormous impact on every aspect of human affairs". "Science has changed our way of life dramatically". How often do we read sentences like these? How often do people treat these statements as wild exaggerations, and as a result, discount them completely? On the one hand, it is fashionable these days to believe in science as the possible cure for many evils, and every community prides itself on the large sums spent on science. On the other hand, many quarters pay only lip service to science, belittle its importance and attack claims which, in fact, have never been made by scientists. It may, therefore, be worthwhile to give a few examples, firstly of the influence science has already had on our way of life and can be foreseen to have in the near future, and secondly of problems raised by these developments whose solution is not in the domain of science and therefore cannot be expected from scientists. This will lead to a discussion of the interaction between science and politics and of the rôle scientists have to play in a modern society. These matters have frequently been discussed amongst scientists but less often been brought to the notice of others.

Speaking of the interaction between science and politics is not strictly correct. It is the application of science in modern technology which changes our material environment, our material conditions of life. This widespread confusion of technology with science has recently been pointed out by Vice-Admiral Rickover.¹ "By boring into the secrets of Nature, scientists discover keys that can be used to unlock powerful forces. Technology is concerned with putting these forces to practical uses. Science has to do with discovering the facts and relationships of observable phenomena in Nature. . . . Because of the care scientists take to verify the facts . . . science has great authority. What the scientific community accepts as proved is not questioned by the public. . . . But technology cannot claim the

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¹ H. G. Rickover, "A Humanistic Technology", *Nature*, Vol. 208, p. 721 (Nov. 20, 1965).

authority of science. It is properly a subject of debate, not alone by experts, but by the public as well".

Clearly, in this article we are concerned with technology rather than with science and in many instances the word "science" may be replaced by "technology". On the other hand, modern industrial technology is largely based on science, whereas "earlier techniques, arts, skills were almost entirely empirical". Further, there has hardly been any discovery in physics and chemistry which has not, sooner or later, found an industrial application, and the time interval between the discovery and its application has steadily become shorter. Moreover, the boundaries between pure and applied research have become less and less well defined and frequently the scientist who made the original discovery has seen the project through to its application. This may explain the origin of the confusion of terms to which Rickover refers.

The Effects of Technology.

Although the economic benefits of the application of science for the community have been elaborated often, a few examples may act as a reminder.

The developments of the electronic, aircraft, chemical and pharmaceutical industries are probably the most frequently quoted: T.V., transistors, plastics are among the products which owe their existence to science. Some firms have stated that 90% of their output is products which did not exist ten years ago; in U.S.A. the semiconductor industry which was non-existent in 1950 has reached an output of the order of a billion dollars per year. In consequence, employment has been created in these new industries.

In primary industries, the effects of fertilizers, pesticides, weed killers, to improve crops are well known; the population of some countries would be starving without these improvements. The 90 mile desert in South Australia has been made fertile, and carries 4 to 5 sheep per acre, by the addition of traces of copper and zinc. Rabbit control by myxomatosis has increased the productivity of the land. In Australia, the number of persons employed in agricultural industries decreased by over 20% in the last 30 years, although the volume of production increased considerably. This increased efficiency could not have been achieved without the development of specialized equipment by the engineering industry. All these developments have brought greater comfort and prosperity to the community. In 1956 Lord Casey, then Minister in Charge of CSIRO, estimated that the Australian economy benefited yearly

by an amount equal to more than three times the total sum spent by CSIRO in the thirty years of its existence.² In an assessment made in June, 1960, he gave the yearly benefit as more than 3.5 times the total costs since CSIRO's inception.

In addition to these effects on the economy, the use of new products has changed our way of life; of spending our leisure (T.V. against picture theatres), of travelling (aircraft against railways, motor cars against public transport), of communication (telephone against letters or messengers), of home life (washing machines, etc., against domestic help), of eating (the can against home cooking).

In the field of health, medical research has achieved control of infectious diseases and almost eliminated epidemics by the development of drugs (antibiotics, etc.) and inoculations. Diseases due to nutritional deficiencies (e.g. lack of vitamins) can be treated. There is a general improvement in health. As consequences of the large number of children surviving the first year after birth and of the average life span being much greater—for instance in U.K.³ it is now 70 years instead of 41 years a hundred years ago—the population of the earth is increasing rapidly. The following table of the estimates of the growth in population shows the increase we can expect and its distribution over the continents. The developing countries in Asia, notably China and India, will grow from 56% to 62% of the world population by the year 2000, whereas the population of Europe (including U.S.S.R.) will be 50% larger than now, but have only 15% of the world population, compared with 22% now.

Estimates of World Population Growth, 1960-2000 (in millions)

| | World | Africa | North America | Latin America | Asia | Europe incl. USSR | Oceania |
|-----------------------------|-------|--------|---------------|---------------|-------|-------------------|---------|
| 1960 | 2,910 | 237 | 197 | 206 | 1,620 | 639 | 16 |
| 1970 | 3,478 | 278 | 225 | 265 | 1,980 | 711 | 19 |
| 1980 | 4,220 | 333 | 254 | 348 | 2,470 | 792 | 23 |
| 1990 | 5,135 | 410 | 283 | 455 | 3,090 | 871 | 26 |
| 2000 | 6,267 | 517 | 312 | 592 | 3,870 | 947 | 29 |
| Increase 1960-2000: | | | | | | | |
| (a) Numbers | 3,357 | 280 | 115 | 386 | 2,250 | 308 | 13 |
| (b) Ratio, 1960 = 100 | 215 | 218 | 158 | 287 | 239 | 148 | 181 |
| Distribution of Population: | | | | | | | |
| (a) 1960 | 100 | 8.1 | 6.8 | 7.1 | 55.7 | 21.9 | 0.4 |
| (b) 2000 | 100 | 8.2 | 5.0 | 9.4 | 61.8 | 15.1 | 0.5 |

From: United Nations, Dept. of Economic and Social Affairs, Population Studies No. 28, 1958: "The Future Growth of World Population".

² Speech in the Federal Parliament on June 20th, 1956.

³ Similar increases have occurred in the other countries.

The statement that the application of science had an enormous impact on our economy, health and way of life, is therefore well justified. However, there is another aspect of the problem. The effects of science are not necessarily beneficial. Here again Rickover's distinction between science and technology is important. "Much harm has been done to man and nature because technologies have been used with no thought for the possible consequences of their interaction with Nature. Science, being pure thought, harms no one. . . . But technology is action, and often potentially dangerous. Unless it is made to adapt itself to human interests, needs, values, and principles, more harm than good will be done. Never before, in all his long life on Earth, has man possessed such enormous power to injure his human fellows and his society as has been put into his hands by modern technology".

Again, the harmful effects of the application of science have been publicized so frequently that only a few examples need be cited. The noise in cities due to motor cars, amplifiers, portable radios, etc., has risen to a level dangerous for ear and nerves.

One of the greatest dangers is that we change our environment with consequences for the future of man we can only guess at now. Modern technology has made fishing so efficient that we are likely to exterminate whales. R. A. Piddington⁴ considers that, since the sperm whale is the only creature eating the giant squid, its extermination may lead to a tremendous increase in the squid population which may penetrate close to our shores. The whole balance of marine life will be disturbed as the million whales are removed in a single generation.

Rachel Carson⁵ has drawn attention to the danger that pesticides and weed killers will poison soil and crops, kill animals and, at least, injure man. The fact that insecticides sprayed on orchards killed the bees fertilizing the blossoms and thus indirectly reduced the production of fruit and honey is now well known. So are the consequences of pollution of our environment. The pollution of the air by the exhaust of motor cars and factories has led to smog, resulting in many deaths: about 4000 in the London smog of 1952 and about 200 in the New York smog of 1953.⁶ The chemical fumes from industrial operations have killed the trees on

⁴ R. A. Piddington, "The Limits of Mankind", Macmillan, London, 1956.

⁵ R. Carson, "Silent Spring", Hamish Hamilton, London, 1963. See also the symposium of the Australian Academy of Science "New Perspectives in Insect Control", *Austr. J. Science*, Vol. 218, p. 217 (December, 1965).

⁶ *Science*, Vol. 150, p. 467 (Oct. 22, 1965).

the hills near Queenstown (Tasmania). The use of detergents instead of soap has set new problems for sewage disposal. Industrial wastes pollute our rivers and lakes, kill useful bacteria and fish, necessitate chlorination of water for use in the home. This pollution by chemical effluents of industry has become a national emergency in many countries and has generated powerful corrective efforts.

Problems Created by Technology.

The question has been asked whether the beneficial effects of technology outweigh the harmful ones or whether the balance swings in the opposite direction. There is no clear cut answer to this question and one has to weigh the private interest in exploiting technology economically and efficiently against considerations of long-range consequences and public interest.⁷ Whatever the answer, the question is, in my opinion, irrelevant. The changes brought about by modern technology are with us and we have to learn to live with them. We cannot turn back the clock. In fact, we must think now of the next step and anticipate the problems which result from present developments and with which we will have to deal probably sooner than some of us realize and like.

A most significant group of problems results from the population explosion. Firstly, the problem of food production; for the next thirty or forty years the food production in the well-developed countries will keep up with the population increases. In the under-developed countries the food supply is deficient already, and since these are countries with a high rate of population increase, the difference between them and the well-developed countries will increase. To keep a man in good health he has to be provided not only with the sufficient number of calories but also with sufficient animal proteins. The high mortality of children and the poor development of those who survive in the under-developed countries is largely due to protein deficiency. Unless the food production in those countries is increased markedly and in a short time, the additional food will be consumed by the natural increase in the population. There is little prospect that conventional methods of providing more food (improved agricultural practices, fertilizers, etc.) can "produce enough food to provide a minimum adequate diet for the ever-hungry half of the world's population, and at the same time feed the

⁷ See the remarks on this subject by Rickover, loc. cit.

rapidly mounting numbers. The ultimate solution of the problem must lie in a totally new source of food that will relieve the world's population from virtually sole dependence on agriculture".⁸ Several non-conventional methods of food production have been suggested, amongst them that of synthesis from hydrocarbons with the help of micro-organisms, and there should be no difficulty in giving synthetic food the same odour, taste and consistency as the "natural" food to which we are used. It may well be that at the end of the century the question of the type of political system of a country which at present dominates international relations is of no interest and the most important problem is that of feeding our fellow men.

A second aspect has recently been stressed by Lord Florey in his Address to the Royal Society of London.⁹ "There is now overwhelming evidence that rapid population growth is bringing with it dire consequences not only in the great Asian countries, but probably even here. Evidence is slowly accumulating that the question is not simply whether food can be supplied for an ever-increasing population, but whether overcrowding *per se* does not lead to obscure and so far ill defined difficulties of mental and social adjustment to a crowded and rapidly changing environment. Observations on animals are certainly pointing to some such possibility. Perhaps we should be paying more attention to the generally unpleasing form that life is assuming in great cities.

"It may be that to relate population to environment optimally is the greatest technological task of the end of this century. Its solution will not depend on biological science or medicine alone. It will involve every discipline from economics to psychology."

A third aspect which has to be considered results from the facts that people not only live to higher age, but also remain capable of doing useful work beyond what is at present considered to be "normal" retiring age. Are we going to increase the compulsory retiring age with the consequence of slowing the rate of advancement of the younger people? Or are we going to create new jobs for the aged and thereby lose the benefit of their experience? Or are we to increase the number employed in a certain field even if there is no immediate demand on greater output? These are questions resulting from scientific and technological developments

⁸ A. T. McPherson "Synthetic food for tomorrow's billions" *Bull. Atom. Scientists*, Sept. 1965, p. 7. See also—H. W. Mattson, "Food for the world", *International Science and Technology*, December, 1965, p. 28.

⁹ Lord Florey, Address of the President, Proceedings Royal. Soc. London, Vol. A289, p. 141 (1966).

which cannot be answered by the scientists who created the questions, but have to be answered by economists, social scientists and ultimately by politicians.

Another group of problems arises when the establishment of new industries creates a new type of work while employment in some of the older industries becomes drastically smaller than before. This shift in the type of occupation has often been associated with a shift in the locality of the workers and necessitated their retraining in the skills required for the new job. Obviously, problems of providing housing and training facilities are involved: the associated costs are, in U.S.A., usually borne by the Government since this re-zoning of industry reduces unemployment. In Germany, Krupp has adapted the training of apprentices to the new standards required by the evolution of engineering and technology.¹⁰ "The main characteristic of the new plan is adaptation to the principle of change. It is no longer possible to calculate far in advance the changing requirements of industrial work. Therefore the aim of training can no longer be a qualification in the traditional sense: it will be much more important to reach a level of knowledge and skill that guarantees a quick adaptation to new working conditions."

An important group of problems, the solution of which does not lie in the realm of science, arises from mechanisation and automation in industry. The general trend in the new methods of production and, in fact, quite generally in the house, on the wharves, and in the services to the community, is towards the elimination of hard physical labour. This means that more and more tradesmen are required with higher and higher skills to produce, maintain, and operate complex and sophisticated equipment. This has created an increased demand for training and education at all levels, and we witness at present, all over the world, this increased demand which has led to the crowding of schools, technical colleges and universities. There is the possibility that the scarcity of educated and skilled labour will constitute a bottleneck in an expanding economy, a problem that was discussed by the Kennedy administration.¹¹ The Vernon Report¹² states: "Skilled labour in our view, is likely to be Australia's scarcest resource. Everything possible

¹⁰ U.K. Dept. of Education & Science, Bonn Newsletter No. 6, October, 1965.

¹¹ Arthur M. Schlesinger Jr., *A Thousand Days*, A. Deutsch Ltd., London, 1965, pp. 545-7.

¹² Report of the Committee of Economic Enquiry. *Commonwealth of Australia*, Vol. 1, May, 1965, Chapter 17-36, p. 436.

must be done to increase the supply of this resource and to make the most economical use of what is available."

Whereas mechanisation creates a demand for skilled labour, it makes employment of unskilled men more difficult. There are, in every community, people whose intelligence is too low to make it possible for them to be trained for a skilled job. At present they find employment in manual jobs. As these become more scarce it may well happen that such people are not just temporarily unemployed, but unemployable. What are we going to do to give them some purpose in life, some feeling that they are useful to the community? Are we going to leave them permanently on unemployment relief, dissatisfied with life and open to the propaganda by extreme political parties? The many desperate unemployed were the first to support Hitler.

Finally, we should mention problems for which science or technology has provided a solution and where enacting the solution has economic and social implications which make the action, logical as it is from the purely scientific aspect, difficult to accept by a part of the community. Some of these are subject to public controversy and the decision on any action to be taken is clearly one to be made by politicians who have to weigh the pros and cons of the scientific, economic and social arguments.

There is strong scientific evidence for the relation between cigarette smoking and lung cancer. To what extent should advertising cigarettes be restricted by law? To what extent should government funds be used for research on growth of tobacco plants?

The pollution of air by the exhaust from motor cars has been mentioned in a previous section. The technology to reduce exhaust pollutants substantially now is at hand. On 1st October, 1965, the U.S. Congress passed legislation directing the Secretary of Health, Education and Welfare to prescribe emission standards for new vehicles. It is intended to apply standards to 1968-model automobiles.¹³ Research in France¹⁴ has shown that exhaust fumes of motor cars are most noxious when the engine is idling, and this occurs during 56 per cent. of the average time of a journey in Paris, owing to traffic blocks and traffic lights. A simple carburettor adjustment improves the situation considerably. The adjustment has been tried out successfully over a year and a half

¹³ See *Science*, Vol. 150, p. 467-8 (Oct. 22, 1965).

¹⁴ U.K. Dept. of Education & Science, Paris Newsletter No. 5, December, 1965.

on the 1,300 vehicles of the Police Force in Paris. A check is now to be carried out and vehicles that are found to emit fumes in excess of the limits laid down will have to be taken, after adjustment, for checking by the authorities. Should this procedure be followed here?

The number of deaths due to motor car accidents has reached alarming proportions. Engineers have proposed changes in the design which would make the motor car safer in driving and in accidents. The proceedings of the U.S. Senate sub-committee investigating car safety show the reaction of interested parties to the changes in design. Can we afford these engineering modifications, or, better, can we afford not to make them?

Similarly, it is well known that injuries in minor accidents of aircraft (those not leading to fire and complete destruction) are reduced if the passengers are seated facing backwards. In military air transport this way of seating was already current ten years ago. Civilian airlines still insist in seating their passengers facing the front of the aircraft: the passengers are used to that way of seating and should not be irritated by the possibility of danger. Thus psychological reasons override safety precautions. This problem of human behaviour occurs again and again in the application of technical advances.

It has been stated that the problem of pesticides in the human environment is 95 per cent. a problem in the scientific knowledge of human behaviour. "It is a combination of apathy and organized stupidity motivated by the market place."¹⁵

The Rôle of the Scientist in Government.

It has become clear from the previous section that the application of science has created many problems whose solution lies outside the domain of science. Hence their solution cannot be expected from scientists alone. Outside his own field the scientist is not any less qualified than others who speak on subjects outside their domain. The ultimate decision will often be made on political grounds, and the politician will seek the advice of the economist, the social scientist and the lawyer, but too rarely does he ask the scientist. The scientist should take his place as an adviser, and no longer be debarred from this rôle. Therefore lines of communication should be opened up between the politicians, economists,

¹⁵ I. McT. Cowan, "Conservation and Man's Environment", *Nature*, Vol. 208, p. 1145 (Dec. 18, 1965).

lawyers and the scientists. At present, they often don't speak the same language and ignorance and mutual misunderstanding are frequent. How difficult it can be for a scientist to communicate even with a most intelligent and well informed statesman, is perhaps best illustrated by the "disastrous interview" (an expression used by Sir Henry Dale, then President of the Royal Society of London), which Niels Bohr had with Mr. Churchill (as he was then) on May 16th, 1944.¹⁶ Bohr was concerned with the political implications of the atomic bomb for the future of the world and the consequences of this new source of power for industry in the years after the war. He was convinced that a form of international control must be devised. Sir Henry Dale, Field Marshal Smuts and Lord Cherwell combined, persuaded Mr. Churchill to see Bohr. However, "The main point was never reached: Professor Bohr was unable to bring the Prime Minister's mind to bear on the implications of the bomb or to tell him of his belief that the President (of U.S.A.) himself was giving the subject such serious thought. When he asked as he left if he might address a memorandum on the subject to Mr. Churchill, the Prime Minister replied that he would always be honoured to receive a letter from Professor Bohr but hoped that it would not be about politics. Bohr came away greatly disappointed at the way the world was apparently governed, with small points exercising a quite irrational influence. 'We did not speak the same language', said Bohr afterwards. Churchill retained a very disagreeable memory of the interview."

The advice of the scientist should be sought not only because he created the problem and, as a responsible citizen, has given considerable thought to its solution, but because his training has made the scientist particularly suitable to suggest solutions of the problem. As already said above, the development of technology is irreversible. We are confronted with a new type of problem, and the scientist has been trained to meet a new situation with new ideas. He will have to know, of course, the background of previous decisions in similar circumstances, but his way of thinking will not be restricted or inhibited by precedents.

There is widespread antagonism against having scientists sitting together with those who by tradition are consulted when political decisions are being made.¹⁷ In the discussion of the place

¹⁶ M. Gowing, *Britain and Atomic Energy, 1939-1945*, Macmillan & Co., London, 1964, pp. 353-59, 371.

¹⁷ L. F. Audrieth, *Bull. Atom. Scientists*, September, 1965, p. 24.

of the scientist in public affairs, the main point is obscured by the smoke screen of traditionalism. The real issue is¹⁷ "To determine in what way science and technology, both now and in the future, can contribute to our goals and objectives as a nation and to the welfare of mankind as a whole". "The traditional 'four hundred' whose business it has been to analyze trends in government and politics constitute those who are presumed to have inherited the right to do so by training. They do resent the intrusion of the come-lately scientist. They have invoked the two cultures polemic in defending their traditional positions." But the real issue is clouded because of their inability or unwillingness to comprehend the changes which are taking place through scientific discovery and technological innovation. "The scientist has not only fostered change, but has also lived with change. He is acclimated to change in his thinking processes. We live in a world where the status quo is accepted by no individual or nation. Our political scientists would do well to pay more attention to these new parameters that affect so markedly our relations with our fellow man, rather than insist that the past alone is the guide to the future." On the other side, "The physical scientist must descend from his ivory tower and realize that his achievements affect the life and living of people and nations, both on a national and international scale. The scientist must develop a greater awareness of the sociological and economic changes wrought by what he has done—and participate actively in the solution of the resulting political problems".

The need for government officials and employees to become better acquainted with problems of science has recently been recognized in Western Germany where the Ministry for Scientific Research arranged for the first time a ten days' seminar on natural science and technology.¹⁸ "The members were lawyers and economists whose work in the administration is connected with furthering scientific research and technical development or who need to be acquainted with the importance of the progress in natural science and technology for the legal, economic, financial or political sphere. The seminar was to give them information which they neither received during their training nor obtained during their work. In the first part of the seminar well-known scientists held lectures on physics, chemistry, biology, medicine, cybernetics and power supply. Visits were paid" to various research centres. Similar seminars

¹⁸ U.K. Dept. of Education & Science, Bonn Newsletter No. 7, January, 1966.

are planned for each spring and autumn. This example may be worth following in other countries.

There is an urgent need to provide members of Parliament with authoritative scientific information and ensure closer contact between Members and scientists. It is the despair of an increasing number of scientists that there is little intelligent or informed discussion on science from either side in Parliament.¹⁹ The same complaint has been made in other countries. An editorial in a German newspaper remarks on a recent debate in the Federal Parliament: "If cultural policy is to be debated, not more than 40 M.P.s will appear, but 21 university chancellors will be in the visitors' gallery. There is no lobby for science."²⁰ Recently, Mr. C. W. Bridges-Maxwell, M.P., has proposed the formation of a national liaison committee on science.²⁰ This committee could include M.P.s and Senators from Government and Opposition parties and representatives of research organizations and State Governments. Some of the aims of such a committee would be to inform members of Parliament and Government departments about scientific research and technological development, to examine science legislation and to watch the financing of scientific and technological research, education and development.

A Parliamentary and Scientific Committee of the U.K. House of Commons has been in existence since 1939 and has fulfilled much the same functions most satisfactorily.

Advice on scientific and technological matters is frequently required by governments. This advice should often be given by an independent group rather than by scientists in government service. The U.S. Government therefore makes regular use of the National Academy of Sciences at Washington, and in 1965 this Academy became a formal adviser to Congress, while continuing in its long-established rôle of adviser to the Executive Branch. The U.K. Government makes similar use of the Royal Society of London. These bodies have a high reputation among the scientists, the public and the governments. They can speak with authority and they do so, not only when asked for advice, but also on their own initiative if any scientific matter demands public attention.

The Australian Academy of Science was formed in 1954 along lines almost identical with those of the Royal Society of London.

¹⁹ G. B. Gresford, Secretary of C.S.I.R.O., reported in *The Australian*, Sept. 20th, 1965.

²⁰ *Aust. Parliament Debates*, House of Representatives, p. 2032, Oct. 20, 1965.

It now consists of about 110 Fellows who have been elected because of their high individual distinction. There is no reason why the Academy should not be used by the Government in the same way as the corresponding societies are being used by the U.K. and U.S.A. governments.

These examples indicate what has been suggested, or found workable in other countries. Whether the Australian Government will adopt any of these possibilities, or develop other means of communication between scientists and politicians and of obtaining advice on scientific matters, remains to be seen. However, the first, and most urgent, step to be taken before specific questions can be asked is the formulation of a national scientific policy.²¹ "If we are to advance science for the progress of our society, we must have a broad conception of the most suitable directions of attack at the frontiers of knowledge and an understanding of how the application of knowledge may effectively be achieved."²² Scientific research and technological change are expensive. Technology has to be considered in decision making at all levels. What is the limit to the amount which a nation can wisely expend on scientific research? How is this limit determined, and how should the amount available be distributed among the different fields?²³

The application of science for the benefit of our society is a matter of national importance. Hence, the formulation of a national scientific policy should be above party politics. The development of Australia should not depend on which party is in power and everyone qualified should contribute to the formulation of the national policy. We cannot afford not to make use of the brain power available in Australia when it is a matter of our future.

²¹ France has the most formalized structure for national planning in the Western world and is integrating science and technology into national plans. See J. B. Quinn, "National Planning of Science and Technology in France", *Science* Vol. 150, p. 993, Nov. 19th, 1965.

²² F. W. G. White, *Aust. J. Science*, Vol. 26, p. 191 (1964).

²³ *The Impact of Science on Technology, Seminar on Technology and Social Change*. Columbia University Press, New York & London, 1965.