50 YEARS OF CURRENT SCIENCE—GLEANINGS

SCIENCE AND MANKIND*†

NUCLEAR physics, including particle physics, remains the principal frontier of advance in physics to-day. It presents a greater challenge to theoretical investigation than any other branch of science and within its field basically new concepts are needed to explain the phenomena observed. But nuclear physics is now the basic science of nuclear energy and of nuclear explosives. It receives greater support from all governments than any other branch of investigation in science. Motives less admirable than the pure search for knowledge of the structure of matter now ensure a continuing and growing interest in nuclear physics. The explosion of the first nuclear weapon did more than usher in a new era in warfare and in the provision of industrial power. It blew to pieces the world of pure research in which Rutherford had spent his life and in which he believed so passionately.

In a less spectacular manner, almost all branches of science are assuming increasing social importance. It seems that all knowledge is applied, sooner or later, both for the benefit of man and for his destruction in war. Mankind is faced with a choice; to use natural knowledge to solve the manifold problems of his continued existence with an increasing standard of living, or to use it to destroy men, the works of their hands, and, worse still, the products of their minds.

Science is the search for truth through natural knowledge. The danger is that in the face of the destruction which can be the fruit of that knowledge, men will turn away from the endeavour to understand nature and seek protection in enforced ignorance. World war with atmoic, chemical and bacteriological weapons, waged as all-out conflict, could well provoke a revolt from science and a return to the primitive bliss of ignorance. Men of science could be wiped out as socially dangerous and the accumulated wisdom of three hundred years could be destroyed overnight.

It is uncomfortable to face up to these problems, perhaps the crucial problems of our time. The great American essayist, Emerson, has written:

> 'God offers to every mind its choice between truth and repose. Take which you please—you can never have both.... He in whom the love of repose predominates...gets rest, commodity and reputation; but he shuts the door to truth. He in whom the love of truth predominates... will abstain from dogmatism.... He submits to the inconveniences of suspense and of imperfect opinion, but he is a candidate for truth, as the other is not, and respects the highest law of his being.'

These words reflect the conflict in men's minds today. What matters most? The survival of mankind, with his precious heritage of culture and learning, or the victory in war of one ephemeral ideology over another, a hollow victory from which little of value can ever be salvaged? In the name of a cold war men commit all the crimes of their adversaries. Is there any reason to believe that in a shooting war with nuclear and other weapons of mass destruction, men will preserve any moral scruples whatever?

What is Science?

The problems we face to-day have been created by technological applications of scientific knowledge. It is worthwhile, then, to examine the meaning of science and how it affects mankind.

Until about 300 years ago, the normal course of science was the patient observation of nature. Man in general remained a passive agent in the process. With few exceptions the results of such observations were not recorded, although they were incorporated into the lore of the countryside or became part of the traditional knowledge of the craftsmen. Because knowledge was confined almost exclusively to natural events observed by chance, attempts to weave from it any coherent natural philosophy produced intricate, rigid and generally completely erroneous conceptions. These false ideas so obsessed men that they deliberately distorted many elementary observations so that the results fitted into the philosophy popular at the time, or they avoided any conclusions not in accord with belief. For instance, from his very beginnings man must have had a very complete knowledge of the anatomy of animals and men. He dissected both for food or to embalm the dead. Yet it was less than food or to embalm the dead. Yet it was less than 300 years ago that the English medical man, Harvey, showed that the blood circulated in the body as a result of the pumping action of the heart. Similarly, the Persians made suprizingly accurate observations of the apparent motions of the planets and stars, but were unable to produce other than mystical explanations because they lacked knowledge of mechanics.

---

* Abstract of Rutherford Lecture 1955, delivered by Professor M. L. Oliphant, at Madras, on 25th March 1955.

† Published in *Current Science*, 1955, Vol. 24, p. 107.

The pursuit of knowledge changed its character and was accelerated through the adoption of the experimental method. As a result of this revolution, man became an active participant in the phenomena he observed. The revolution was not without bloodshed, for ancient beliefs had been woven into religion and social behaviour. Many of the revolutionaries paid with their lives for their love of the truth. On the whole, mankind is logical and has an inherent respect for integrity, so that the enormous power of the experimental approach was soon recognised. Experiments were devised to test all hypothesis and any theory which did not accord with the results of experiment was discarded. The habits arose of free and open discussion of scientific problems and the results of scientific investigations were published. An ethic of science developed which made discussion and publication obligatory. Thus, as Sir Henry Dale has pointed out to me, Benjamin Franklin, who founded in Philadelphia a society for the discussion of the problems of his time, imposed upon its members an oath, part of which may be paraphrased as follows: "I swear diligently to seek the truth, and having found it, to impart it to others." Scientific knowledge was no longer guarded jealously and recorded in code or in Latin, but became the property of all.

One result of the development of the experimental approach, and of complete openness in science, was that many more men became interested. Science rapidly became a branch of learning with all the dignity and depth of the older disciplines but with far greater vitality. It flowed across national boundaries. There grew up, throughout the civilized world, a body of men devoted to science who, in this matter, were true internationals.

Basic and Applied Science

Scientific activity stretches over a whole spectrum of work, from basic science at one end to the applied sciences like engineering, agriculture and medicine, at the other. There is no sharp division between basic and applied science but rather a gradual merging of one into the other. What is more, applied science is often able to provide tools and ideas for use in research in basic science. The real difference between the ends of this spectrum lies in the motives behind them. Knowledge of nature is sought in basic science which is an activity carried on for its own sake. Applied science, or technology, has an immediate end in view and an investigation is pursued or dropped according to the practical resutls and profit which can result. Basic and applied sciences are complementary activities and both are essential for increasing knowledge of nature and for the improvement of industry.

In general a considerable period elapses between the making of a fundamental discovery and its successful application for practical purposes. The technological problems associated with the industrial development of a discovery nearly always require more effort and expenditure for their solution than did the original basic research. Thus there are few basic problems remaining to be solved in that part of nuclear physics fundamental to atomic energy, but it will require a decade or two to find solutions to the many technological problems which stand between the fundamental principles and the commercially successful atomic power station

Use and Misuse of Scientific Knowledge

Science and technology have wrought such a revolution in our way of life that through familiarity with changes we are often indifferent to the full implications of what is happening. For instance, there can be little doubt about the positive benefits which mankind has gained from the development of communications—travel by sea, land and air, printing and the press, the telegraph and telephone, the cinema, radio and television. When properly used, all these modes of communication aid commerce and technological advance, bring peoples of the world closer toegether, so promoting international understanding and goodwill, and, above all, enable men to share directly their cultural activities and ideas.

The application to medicine of the discoveries of biological science has practically eliminated the threat of death from infectious diseases; technological advances based upon searches in basic science have reduced hard labour and drudgery in almost every walk of life, from the home to the factory and the farm; the yields of produce from agriculture and animal husbandry have increased greatly, the quality has improved and land formerly unfit for farming has come into production; large-scale production methods have brought to the ordinary man much improved standards of housing and of comfort, beauty and entertainment; leisure has increased and education to the highest levels is open to all.

For all these things, which are part of present-day life, men and women who are not blase, disillusioned or soured will give thanks to science and technology. The processes of improvement of knowledge, and hence of its applications, will go on. Already we have before us the prospects of the complete conquest of disease in the very near future, of enormously increased agricultural production and of unlimited energy for all purposes from nuclear processes. Knowledge is available or is being sought which will bring these benefits to all men and help remove hunger, poverty, degradation and despair from the inhabitants of all parts of the world.

These same advances in knowledge, which set so fair a prospect before the eyes of men, bring with them also the possibility of destruction of man and of his civiliza-

tion. Science, used for individual gain without thought for the consequences, can bring disaster. At the present time we face a crisis in the use of science which is of far greater immediate importance and which must be surmounted if our present civilization is to endure. This is the threat of war which has been for mankind a sort of undulant fever of increasing malevolence which now threatens his very existence. Man stands on the brink of a precipice of his own devising.

Before the advent of the atomic bomb the increasing mechanization of war had introduced new and inhuman characteristics into fighting. The development of "push-button" warfare, whereby a guided torpedo may be launched, a load of bombs dropped or a pilotless guided missile be sent on its deadly mission, had made of war an impersonal and immoral business. A warrior of the past experienced a peculiarly personal relationship with his adversary; skill, physical fitness and bravery were the hallmarks of the victor. What Professor Julius Stone calls the "dehumanizing" of warfare through mechanization has made these qualities of negligible importance. In a future war a girl, sitting at a telephone in a deep dug-out, may misinterpret a message over a bad line with the result that she launches a missile, which will destroy a city and its million inhabitants. An electrical fault in a complex control network may release such a weapon by accident. Problems of navigation of a high-flying aircraft moving in bad weather to eliminate an industrial target of strategic importance, can lead to the destruction of a neutral city, its inhabitants and priceless treasures. The kind of mistake which occurred again and again in the last war can now have incalculable consequences and in the atmosphere of war is inevitable.

The banning of weapons of mass destruction offers no solution, for any nation facing defeat abandons all scruples and uses every weapon which could decimate the enemy. Excuses can always be found for the use of any diabolical weapon in retaliation. Both sides in the last war were fully armed with the banned weapons of gas and chemical warfare. The only reason that these were not used was that they were not good weapons; it paid to use aircraft to carry explosive and incendiary bombs rather than gas. Atomic weapons were used, and by us.

The wonderfully fruitful field of human endeavour, nuclear physics, which has led to such insight into the structure of matter and which for 50 years had been the preserve of the pure scientist, has assumed overriding importance as the basis of both unlimited power for the future of man and unlimited powers of destruction of all that he holds dear. The nuclear scientist has come into the limelight in two guises, as the saviour of the Western world from Communist domination and at the same time as the inventor of the diabolic weapons which may destroy civilization.

It is an unfortunate fact that scientific advances yield guns as well as butter. Almost every discovery can be used for evil as well as for good. Even the medical sciences have produced the spectre of bacteriological warfare.

The Responsibilities of the Scientist

The part played by science and applied science in the modern community is so great that the control of activities in these fields can no longer be left to the scientist alone. This statement will sound like heresy to many men of science who believe sincerely in the established conception of complete freedom in the search for truth. In the realm of basic science investigations must continue in an atmosphere of complete freedom, for no one can know from one day to the next, where, how or when the next major discovery will be made, or in what direction the seekers for knowledge will turn tomorrow. Complete freedom does not imply freedom to injure other human beings, to commit acts of cruelty or to neglect the interests of others. The pursuit of knowledge must be governed by the ordinary rules of social conduct.

However, in the applied sciences—and we have seen how difficult it is to draw a line between basic and applied science—the social consequences of development are all important. Ruthless exploitation of men and of raw materials has followed many developments in applied science. Grave dangers can arise to life and to health through the adoption of new equipment or processes which have not been tested thoroughly or which produce unexpected side effects. The deliberate design and development of weapons of destruction is an activity unworthy of science, essential though it may be until a stable state of the world has been established. Activities in these fields must be subjected to social controls.

Technological development proceeds so rapidly that dangers and difficulties arise before external social controls can be established or made effective. Proper supervision can then come only from within the ranks of scientists and technologists. Men of science can no longer deny all responsibility for the uses which may be made of their discoveries or developments. The ethic of social responsibility must be made an integral part of the spirit of the search for knowledge and its applications. Such a feeling is growing rapidly, but it needs to be established on a stronger and more formal basis so that some restraints are imposed upon the ruthless, the cruel or the foolish scientist comparable with those exercised, in theory at least, in the practice of law and medicine.

Finally, it must be recognised that, except in his pursuit of knowledge, the man of science differs in no way from other reasonably intelligent men and women. He is as full of prejudices and failings. He is as

much a creature of contradictions, for while he hates the misuse and misrepresentation of science and is irritated and alarmed by secrecy, he is in general passionately loyal. When his country is in danger he is as ready to sacrifice his work and many of his cherished ideals in order to defend her with his knowledge. He is often quite naive and sometimes irresponsible in matters of politics and business. He recognises the greatness and the integrity of men like Rutherford, but does not often reach those heights.

Nevertheless, the real man of science, the seeker after truth, is aware of the paucity of his real knowledge, but has an infinite faith in the ability of man to know and to understand. He experiences humility in the contemplation of the immensity of nature, but he is impressed deeply by the capacity of the human mind. He knows that he is part of nature, but feels that because man can comprehend it, even partially, he must be superior, in some subtle way, to this environment. For him nature has a beauty, a dignity and a reality which transcends even that sensed by the artist, for he apprehends not only with his senses, but with his mind. He knows that knowledge is never certain but that it grows with the efforts of men and so, ultimately, some men may find the truth.

ANNOUNCEMENTS

ALL INDIA SYMPOSIUM ON WILD LIFE BIOLOGY

The Wild Life Biology Division of the Department of Zoology, Farook College will be conducting an All India Symposium on Wildlife Biology during 27th, 28th and 29th December, 1982. The Symposium is sponsored by the University Grants Commission. Fifty scientific papers will be presented at the Symposium in different branches of Wildlife Biology – Conservation of Reptiles, Birds and Mammals; Wildlife Management; Population status, Ethology, and Sociobiology, Diseases, Epidermics and Pathology; Zoo Management; Tourism and Wild Life, Wildlife law and practices etc. More than 60 Scientists from different parts of India are expected to participate in the sessions. Many experts also will be addressing the forum.

It is proposed to publish and present the research papers as a Fest-schrift Volume to Dr. Salim Ali, the veteran Naturalist Conservationist of India on his 85th birthday.

As a part of the Symposium it is planned to take the participants to Silent Valley, the controversial biosphere reserve of evergreen tropical forest, to the Kuttiady Hydro-electric project at Kakkayam deforested damste and through the Chaliyar river polluted by the effluents of Mavoor Gwalior Rayons, in order to impress upon the scientists on the extent of damage done to the environment including the soil, virgin forest, clean air and water and the rich wildlife heritage of this part of the country.

Further details may be had from: Dr. N. B. Elayidom, Professor and Head of the Department of Zoology, Farook College, Farook College P.O., Calicut 673 632.

THE INSTITUTE OF PHYSICS AWARDS FOR 1982

The Council of the Institute of Physics has made the following awards for 1982; the presentation of the awards will be made in London on 5 May 1982.

Charles Vernon Boys Prize – to Dr. B. J. Isherwood of the GEC Hirst Research Centre, Wembley, for his development and use of X-ray topography and multiple diffraction in diagnosis of surface behaviour and crystalline quality in materials and devices of importance in the electronics industry; *Duddell Medal and Prize* – to Mr. S. van der Meer of CCERN, Geneva, for the conception, design and construction of many experimental devices in the field of high energy physics and particularly the development of Stochastic Cooling of Particle Beams; *Glazebrook Medal and Prize* – to Professor J. M. A. Lenihan of the West of Scotland Health Boards, Department of Clinical Physics and Bio-Engineering, Glasgow, for his outstanding contributions to the orgnization and application of physics to the practice of medicine; *Guthrie Medal and Prize* – to Sir Charles Frank of the University of Bristol, for his extensive contributions to the physics of solids; *Maxwell Medal and Prize* – to Dr. J. R. Ellis, of CERN, Geneva, for his contributions to elementary particle physics, particularly on the implications of gauge theories of strong and electro-weak interactions; *Rutherford Medal and Prize* – to Dr. D. M. Brink of the University of Oxford, for his contributions to the understanding of nuclear structure and nuclear reactions.

Further information about the awards may be had from Dr. L. Cohen F. Inst. P., The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.