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Scientific Leadership in the Modern World

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One of the basic human drives is to find out more about ourselves and the world in which we live. This desire for knowledge goes back to the birth of civilisation, but it is only in relatively recent centuries that a modern scientific approach has developed. In previous civilisations in the main and in Western civilisation prior to the Renaissance, the general view of the world among educated people was a rather rigid one typically dominated by the religious philosophies of the time and era. In Western Europe, truths related to religious dogma and even in areas such as medicine arcane knowledge dating back to Hippocrates and Gallen provided a framework for understanding human disease, which from a modern perspective lacks any credibility. The great English universities of Oxford and Cambridge, well into the 19th century, existed mainly as places to prepare young people for a clerical life.

Things began to change in the Renaissance, where a human-centred view of the world was associated with a desire for new knowledge. This led to the birth of experimental science driven by figures such as Gallen, with the idea that new truths could be searched for around areas such as the place of the Earth in the cosmos by careful observation, not always readily found in a religious text. This approach expanded in the Northern European Enlightenment with the development of a widespread philosophy where experimental science involving new observations began to provide fundamental insights. Von Humboldt, when he founded the University of Berlin, set up the credo 'the freedom to teach and the freedom to learn wherever knowledge takes you', which spread to North America and now guides universities throughout the world.

On this background, the past 100 years have seen an explosion in new knowledge. This has been driven by a general cultural belief that it is appropriate for humankind to understand as much as possible about themselves and about the world and universe in which they live. There has also been an often realised expectation that advances in scientific knowledge will lead to new technologies, which will improve both the material quality of life and the general health of populations. Several factors have contributed to the explosion of new scientific knowledge that has been seen from the beginnings of the 20th century. The world's population became larger, with more educated and able people entering science. Capitalism became more entrenched in many countries, with clear evidence that new scientific knowledge led eventually to commercial benefits both for individuals and for countries and with resultant investment in science. The value of scientific knowledge and of major breakthroughs became greatly increased with the development of awards such as the Nobel Prize system, probably the highest single accolade that can be attained by a human being in the disciplines it covers. Major impetus to scientific development also came through the major wars of the 20th century, where development of more advanced technology often gave one group of nations an edge over their enemies. Examples include the development of radar, which had a pivotal role in the U-boat warfare in the Atlantic Ocean in World War II and of course the development of atomic weapons used to bring the World War II to a rapid conclusion.

The major advances in science seen in the 20th century fall into two major areas. At the start of the century the major advances were in mathematics and physics. This built on some major breakthroughs in mathematics in the previous century, but the extent of the advances in physics and to some extent chemistry would have been totally surprising to most learned people working in science in the late 19th century. Clerk Maxwell, one of the greatest of all scientists, who developed the mathematical basis for the laws of thermodynamics, felt that physics had virtually reached the end of its journey at the end of the 19th century, whereas in fact the journey was scarcely beginning. The breakthroughs that followed the development of special and general laws of relativity by Einstein and the Quantum Theory by Max Planck, Nils Bohr and various other scientists provided a basis for theoretical physics that is still expanding our knowledge. This was accompanied by very practical advances pioneered by Rotherford's discovery of the atom, which eventually led to deleterious outcomes in the form of nuclear weapons, beneficial outcomes in the forms of radioisotopes available to treat various cancers, and as yet unclear outcomes in the form of nuclear energy as a potential clean energy source.

The second area of massive advance in the 20th century has been in the field of medical science. This started as with physics in the late 19th century with the discovery of the germ theory of disease, which led sequentially to the development of antimicrobials and then antibiotics. This is probably the single major contribution to come from medical science and the pharmaceutical industry, and led to major improvements in the treatment of many major infective diseases, which prior to that time had been fatal. This was followed by advances in the treatment of vascular disease, with both improved surgical techniques and better medications to improve common things, such as high blood pressure and high cholesterol. Towards the end of the 20th century medical science received its major boost ever with the completion of the human genome project and the beginnings of a massive project that would lead over the next 20 to 30 years to a complete understanding at a cellular level of the machinery that makes cells work, both in health and in disease. Many incurable illnesses remain. Viral illness is still inadequately treated and there is still the potential, as the HIV epidemic has shown us, for new infections to arise that test the resources of modern society to the full in terms of finding adequate solutions. In the case of AIDS, major advances have now been made with the development of combinations of treatments that greatly slow the disease, although complete cures are yet elusive. There is still the potential for major new infectious diseases to arise, and the current threat of a new strain of avian flu is an example of the risks that humankind, even in this more advanced era, still faces from pandemic infections.

Medical treatment, however, still has a long way to go in terms of the range of conditions that humanity faces. Treatment for many nervous system conditions, probably the major cause of disability in more elderly people, is still largely inadequate, with poor or no useful treatments available for many causes of neurodegeneration. This includes most causes of dementia, which will be the major health problem the world faces as our populations continue to age and average life spans increase into the 90s. Treatment for many forms of cancer is also inadequate, although in both nervous-system diseases and cancer modern science is likely to see significant advances over the next decade.

As these major scientific advances occurred and continued to occur, the attitude of the general public to science merits some attention. For much of the 20th century the general public had a great faith in science, at times almost a blind faith, in terms of science's ability to improve the quality of life for themselves and their families. This belief certainly has considerable foundation, and one just has to go into any household today and look at the range of technologies available to support quality of life, and to go into a modern hospital and look at how patients are treated with common conditions, to realise how a stream of scientific breakthroughs over the past 150 years has improved both the quality and duration of life for everyone. At the same time, however, much that is not desirable has followed through scientific advances. Scientists have contributed to the development of weapons of mass destruction and other military technologies, which in most people's view have had a deleterious effect on the world at large. Occasionally scientists get it wrong in the biomedical area also, and events such as the contamination of the French blood supply with HIV early in the pandemic, which led to a large number of children with haemophilia in France being infected with HIV, caused widespread concern. Many members of the general public have become wary of scientists' assurances that new developments are safe. This is seen in areas such as the debate on the safety of genetically modified food. There has been a concern that science as a whole has been late to appreciate the importance of climate change and the need to evolve technologies that move the world towards carbon-friendly economies. In short, the past 20 years have seen a move from a culture of broad trust in science to a culture where science is often seen with some suspicion.

In this environment, it is important to keep in mind the importance of science to the future of humanity. Ongoing scientific breakthroughs with the development of both new understandings and new technologies is going to be essential to the preservation of our planet. The very large population today cannot be sustained without new scientific approaches to the development of human nutrition. What used to be called the Third World is rapidly industrialising, with massive wealth generation and improvement of living quality for its peoples. As India and China develop standards of living approximating those of Europe and the United States, the strains on the environment of the world will be enormous, and issues such as climate change can only be realistically dealt with through ongoing improvements in technology that will involve the development of new science. As our populations age with the conquering of the problems that cause illness and death in young people, namely infection in the main, and in middle-aged people, namely vascular disease, a huge burden of degenerative brain disease will fall on ageing populations, which can only be dealt with by new scientific understandings that will lead to early detection, prevention and in some cases cure. The modern world therefore has no option but to continue to invest heavily in science.

On the other hand, the days when science proceeds in a rather unfettered way are appropriately finished. Every scientific advance needs to be looked at very carefully for its overall impact on society as a whole. The economic costs and the environmental costs need to be taken into account, for major new technologies and the general public, through a more astute media and through scientific engagement with that media, need to become better educated about major scientific issues and the pros and cons of new developments. We have seen very vigorous debates around a number of issues recently, including climate control, genetically modified foods and stem-cell research to mention but a few, and it is important that this degree of public engagement in science at large continues in the years ahead, as more scientific breakthroughs lead to the development of more novel technologies that will impact on all aspects of people's lives.

Why then should a young person consider becoming a scientist in today's world? The economic benefits may not be immediately as great as in some other areas and a long period of difficult training is involved, usually involving an undergraduate degree, a doctorate in research in one's chosen discipline and then some years of postgraduate study, often in a number of institutions and universities around the world before taking a position in either a university, institute or in industry. The potential to contribute to humanity at large through a major contribution to science is probably greater than in almost any other area. Major scientific breakthroughs today are typically made by teams of people who bring their ideas together and have overlapping areas of expertise. The opportunity to be part of such a team is very real for young people today who go into science, and the gratification that emerges where major breakthroughs are made cannot be understated. There is the opportunity to contribute to almost every problem that the world faces today, including the environment, energy production, food production and health. The world faces more serious questions than ever in its history, and modern science has advanced to a stage where there is a prospect of breakthroughs being made in nearly every critical area society faces by the generation of young people who go into science today. The next 20 to 30 years will be the most exciting time ever in science in almost every discipline. This certainly pertains to my own discipline, medical research, but also applies to other areas such as climate control and energy generation. The shape of the world for the centuries ahead is likely to be written largely through scientific and technological achievement over this period.

Scientists face many difficult issues that they will have to combat, and they will need to be much more broad-looking in their vision than their colleagues in previous generations. One issue that often comes up is the issue of realism versus relativism. This is the argument that scientific truth is there waiting to be discovered whatever the views of the scientist — often called realism — or that to some extent truth is in the eye of the beholder, with a range of interpretations depending on the culture and background of the individuals looking at the data, sometimes referred to as relativism. We need to move to a position in science where both views are given credence. Respect for the individual and their right to come to their own conclusion about data is critical to freedom in today's world. Nevertheless, there are likely to be key truths in most areas, and the most important thing here is that the general public are given a sound and easily understandable information base on which to base their decisions. There will be many grey areas where new technologies have both benefits and a cost, and here it is important that there is vigorous public debate around how society wants to use these technologies and whether they should be introduced or held in abeyance. If this had happened in rather different circumstances towards the end of World War II one wonders if atom bombs would have been developed and used. On the other hand, few people would dispute the enormous benefits that have come from the development of new pharmaceutical treatments for infectious disease and for common illnesses such as high blood pressure and high cholesterol.

Even in advanced countries the budget is not unlimited, and many of the new breakthroughs have enormous cost. This tends to sort itself out in areas such as energy generation, food generation and climate control, where economic factors set natural controls for the degree of investment that can be made in certain new technologies. In health it is often a more difficult issue, where vast expense may be needed to prolong life, often in the case of significant ongoing disability. If, for example, a new treatment is developed for Alzheimer dementia, a common cause of memory loss, which prolongs a reasonable level of cognition for a period of only a few months, but which costs a huge amount to society, there needs to be processes that determine whether this treatment is resulting in sufficient benefit to warrant its cost. Modern society, with complete scientific support, is getting much better at developing processes of that type.

Science as a whole has not given sufficient regard to the environment in the past. The new technologies that have contributed to the carbon crisis have been developed by scientists, often over a very long period. Scientists are now largely aware of the critical importance of the environment, and indeed a major thrust of science generally, with the support of the university sector, is on the development of new science and new technologies that will improve the environment and make the world a liveable place for billions of people for centuries going ahead.

Science has its own politics. Political battles around different viewpoints have been fought for as long as science has existed. In recent times, however, scientific debate around scientific truths has often extended outside the scientific community. Different groups have taken a viewpoint on different scientific facts depending on their religious or ethnic background, as for example in the debate around various forms of potential stem-cell therapy, or on their industrial or financial background, as in the debate now resolved about the health risks of cigarettes and now largely resolved about the climatic risks of greenhouse-gas emissions. It is unrealistic ever to think that any major scientific breakthrough, especially something that potentially impacts on society at large, will ever not have a broader political implication in the future. It is crucial therefore that scientists become better communicators to the world at large, and also in many cases get better at listening to what other people are telling them about how they see the costs and benefits of potential new innovations. The next generation of scientists will have to be better communicators than their predecessors.

In recent times there has been a tendency for many of the brightest people in secondary schools to go towards a career in finance or in industry. Science as a whole, the most important and vital area for our young people to engage in, has become relatively neglected. This is more the case in the West than in countries such as China, where the importance of science by young people, albeit with some state encouragement, is perhaps better appreciated. It is crucial for the future of any country that a significant proportion of clever young people adopt scientific careers. There is more work to be done in science than ever before, and in any number of fields the potential for immensely satisfying careers in terms of contribution to humanity and to general wellbeing. Scientific careers are now becoming better reimbursed financially, and there is increasing recognition that scientists who play a role in major breakthroughs should get some benefit from any commercialisation of their research. The future of science is incredibly bright and the career opportunities for young people enormous. The modern scientist will have to become more and more what has been described in the past as a Renaissance man, a human being who is expert in his or her own discipline, but is also attuned to the general trends in society around them. There is no doubt that the next generation of young scientists will rise to this challenge.

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