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Reith Lectures 2005: The Triumph of the Technology

Lecture 1: Technology will Determine the Future of the Human Race

Four thousand years ago, just 5 miles north of present day Thetford, our Neolithic ancestors began what may have been the largest early industrial process in these islands. This is the site that the Anglo-Saxons called 'Grimes Graves' and it contains nearly four hundred mine-shafts, built to extract high-quality flints, which could be chipped to produce sharp cutting edges. Using nothing but tools of bone and wood and presumably the flints themselves, these ancient people excavated to a depth of up to twelve metres, to reach the buried flints. It has been calculated that the miners needed to remove 1000 tonnes of waste to produce eight tonnes of flint. The site covers nearly 40 hectares and the whole project is astonishing.

Whilst more advanced technologies had developed elsewhere - for instance in China - our ancestors' task was anything but easy. They needed timbers to shore up their excavations and ladders to get down in to them, lighting was required in the deeper pits and they needed tools, which they made from deer antlers, so they had to manage the local herds of red-deer. A separate and skilled industry was required to work the extracted flints and to market and distribute them. The flints were used as axe heads, as agricultural implements, as arrow-heads, and no doubt there were countless other applications that we have lost track of. The Grimes Graves operation underpinned the foundations of a new sort of society. The timescale was quite different from our own. Excavation at Grime's Graves lasted more than five centuries, whereas, for example, valve electronics lasted about fifty years.

Humankind's way of life has depended on technology since the beginning of civilization. It can indeed be argued that civilization began when humans first used technologies, moving beyond the merely instinctual and into an era when people began to impose themselves on their environment, going beyond mere existence, to a way of life which enabled them to take increasing advantage of their intellect. A visit to Grime's Graves at its peak would have created as much wonder as was created by flight or the telephone when they first appeared.

Ranking in importance such early developments as the techniques of flint extraction against subsequent developments, such as the use of metals, is not easy, especially as the primitive technologies were independently developed in widely separated societies. But any such ranking is fraught with difficulties as was the recent poll that asked the public how they would rank Britain's greatest inventions; electricity generation, which is the foundation of almost every current technology, the jet engine, which made possible our international mobility, the invention of vaccination that saved millions of lives, the discovery of the structure of DNA, which underpins biotechnology, the possibilities seemed endless. Well, the public chose none of these, but instead…..the safety bicycle. And it was that choice which confirmed my subject for these lectures.

The bicycle is of course an ingenious, practical, and sustainable invention, which brought new opportunities for people in every stratum of society, and which continues

to offer benefits today. But to place it ahead of the fundamental accomplishments of Faraday, Stephenson, Maxwell, Thomson, Whittle, and Crick & Watson demonstrates in my mind a profound misunderstanding of the contribution of advanced technologies to our lives, and of the vast pyramid of scientific and technical achievement that underlies these technologies.

The means to control plagues, to travel in hours to parts of the world which once took months to reach, to be able to access billions of written words from one's desk, to instantly conjure up high-quality images of distant objects and events - these are just a few of the technologies which we take almost for granted and which rest upon the accomplishments of generations of British engineers and scientists. Compared with these, I am afraid I cannot view the safety bicycle as a significant contender. But the fact that so many of our compatriots thought that it was of such paramount significance surely indicates a failure - of serious dimensions - in communication and understanding. I needed at least to try in these lectures, to correct that failure.

My contention is that technology is sidelined and undervalued - we become defensive about it and would rather retreat into the past, or into fundamental science, than to strive to stay in the race. The cost of this major social failure will progressively disadvantage all of us. Technology is determining the future of the human race. We need it to satisfy our appetite for energy, perhaps through nuclear power; to help us address hunger through plant breeding throughout the world; to monitor and find the means for avoiding global warming so that we can rescue our planet for future generations. Technology can improve our health, and lengthen our lives. I want this lecture series to act as a wake up call to all of us. Technology, I repeat, will determine the future of the human race. We should recognise this and give it the profile and status that it deserves.

The most straightforward explanation for the lack of appreciation is that modern technologies are too complex to be understood by anyone but the experts. But this is only true if the details are to be understood. It is up to the engineers and scientists who create these technologies to explain what they have done in language that can be understood by non-experts. We are very much to blame. Mind you matters were no better in days gone by when those responsible for the developments were purposefully obscure about their discoveries. The boundary between science and what for the sake of simplicity we call 'magic' was blurred. Even when the Royal Society, Great Britain's leading scientific academy, was founded in 1662 its objectives included matters we would now class as 'alchemy' rather than science. Knowledge was power and potentates were anxious to restrain its diffusion. Galileo was condemned and confined to house arrest for the latter part of his life for seeking to promulgate theories we now know to have been broadly correct. Worse perhaps than that, he wrote in the vernacular language (Italian) which could be understood by ordinary people, rather than the Latin of the scholars. And even the humdrum mining at Grimes Graves seems to have been associated with mystical rituals and ceremonies. The de-mystification of science is another change of the last few centuries, but it is evidently one which remains incomplete.

One of the reasons that the earliest significant advances were few and far between was that the technologies of communication had yet to be created, and communication of any kind could be rigidly controlled. While there was only word of mouth,

information must frequently have been lost, and the process of innovation forced to repeat itself over and over again. Innovation could not advance exponentially as it does today because there were no means reliably to pass information from generation to generation, or between widely-separated societies. The difficulty of transportation compounded the problem: it was only the wealthy and powerful who could travel to distant sources of information. It was through primitive paintings and tablets of stone, and eventually hand-written manuscripts, that each generation first began to preserve and reliably to pass its precious knowledge on.

Progress remained slow because it was only through tedious hand copying that more than a single record could be produced, and replication in large numbers was impossible. It was the printing press that began to solve this problem. Printing was the first and perhaps the greatest of the communication technologies. It was followed four centuries later by the telegraph and then the telephone, the radio, the television and now, and perhaps as important in its influence as the early printing presses, the electronic media, especially the Internet. Electronic networks provide the ability to communicate instantaneously anywhere in the world and the World Wide Web of Tim Berners Lee makes - in principle - all of the information possessed by anyone available to everyone.

This previously inconceivable connectivity enables people to contribute to the process of innovation, or perhaps more importantly, to avoid the mistakes of others. Yet every advance in communication technology has facilitated the dissemination of both misinformation and disinformation; the more advanced the technology the greater the potential for misuse. The Internet is especially vulnerable as it is less controlled than its predecessors, and the World Wide Web Consortium is fighting to keep it this way for reasons I support, but the inevitable consequence is that it carries a plethora of falsehood, which any surf of the web will speedily demonstrate. We must arms ourselves against such falsehood - teach people to be intelligent critics and help them judge whether a source is reliable.

The ready availability of even objective truth doesn't mean that objective truth will be believed or absorbed. For example, the difficulty the public has in understanding science in some respects grows rather than shrinks in the age of unlimited information. We are gathered today in the Royal Institution of London, 205 years old, and specifically founded - mainly by non-scientists - to 'diffuse the knowledge, and to facilitate the general introduction, of useful mechanical inventions and improvements, and to teach the application of science to the common purposes of life'. Those rotund eighteenth-century phrases contain a mighty truth which we need to heed no less today.

Advances in technology accelerated as efforts to understand the world around us bore fruit. For instance, inherited folk lore in medicine began to crumble in the light of advances in understanding made by William Harvey and others, based on systematic observation and recording. Newton put to flight so many of the myths about the universe. Newton's 'laws' introduced systematic and (on the face of things) simple rules which helped to explain the Universe, and helped to solve previously insoluble problems. This was the beginning of a new era. Perversely, it was also when intellectual advances began to become so complex that it became difficult and eventually impossible for the non-specialist to understand them.

In the course of these lectures I shall look at some of the ways in which technologies have grown more complex, and yet how - despite hugely expanded public education - understanding of them has diminished. The idea of a straight-line development towards an ideal is attractive, but it is alas untrue. There have been mistakes in judgement, mistakes sometimes compounded by secrecy. In health-related issues there is the tragedy of Thalidomide, to mention one example. Engineers, whilst making immense leaps in so many directions, have failed always to predict other consequences of operating in hitherto unknown regimes: the amazingly-innovative British jet airliner, the Comet, ahead of all its competitors at the time, was aborted because of insufficient understanding of materials and stress induced fatigue.

Such lapses have tended to engender a sense of mistrust and suspicion on the part of the general public, and there is an ever-more pressing need for scientists and engineers openly to communicate what they are doing and to be candid over the likely consequences of their work. This is a subject I will discuss at greater length in my final lecture when I will also examine our responsibilities towards the developing world.

I have found that the possession of an understanding of technology, just as with an understanding of music, literature, or the arts, brings with it great personal satisfaction and pleasure. I still pause to wonder at the achievements of humankind, for example, when I am flying in comfort at 40,000 feet and look down on the white caps and spume of a turbulent sea so far distant below me, and realize the difficulties there were in crossing it only a couple of lifetimes ago. I know that I can safely drink the water that runs out of the tap in the majority of places I visit in the world, and can talk with my family or even hold in my hand a real-time picture of them wherever I am. How remarkable it is to gaze up at the moon and the planets and realise that we have already walked on that great sphere and have sent intelligent machines to those planets, even to their satellites, and received high-quality pictures and data from those remote surfaces.

My appreciation is all the greater because I know enough to realise how difficult it has been to accomplish these things, enough in fact to know how little - after a lifetime in science and technology - I actually know myself. I sometimes play the game of wondering how much I would be able to recreate if by some cataclysmic disaster I were to be the only person left with knowledge of how these wonders were accomplished. I am afraid that it would only be a small and specialized fraction of electronics.

I was born in Calcutta. My father was an insurance business man, but his great passion was for technology, especially wireless and photography. Indeed, he spent enough time on these hobbies that his expertise was close to that of professionals. His interest in radio is recorded in a series of articles that he wrote for the Calcutta Statesman in the late 1930s discussing radio and reviewing the latest receivers. He was one of the first to receive the BBC on short-wave radio and he wrote under the pseudonym 'Superhet'. Radios and TVs still use superheterodyne receivers but that will have to be the subject of another series of lectures.

By happy coincidence, but perhaps not surprisingly, he wrote twice about Sir John Reith, describing him in 1938, the year I was born, as, "building up the BBC from its beginnings to the mighty machine which today transmits music, entertainment, and information to no less than 8,600,000 homes in Great Britain", and later pointing out that he had behaved as a virtual dictator in his management style.

That so many people are able to hear this lecture today is itself the consequence of a whole series of inventions and coincidences. Whilst some of the basic principles of radio were understood, the fundamental roots of broadcasting arrived partly by chance, as a technology thought of as the opportunity for 'messages without wires' turned unintentionally into a system of diffusion to multiple audiences. The development of the valve, 'the magic lamp of radio', was the decisive step, as I will describe in my next lecture, but so were the governmental and regulatory attitudes that followed and which for a time seemed likely to snuff out infant broadcasting.

No-one could anticipate the effects of the radio, on the printed word, on politics, on social behaviour, …on advertising even following that fateful day in 1922 when the first radio commercial was broadcast. The future US President, Herbert Hoover, said of this afterwards that it was "inconceivable that we should allow so great a possibility for service…to be drowned out by advertising chatter". We all know what happened to that good intention, but at least the BBC and National Public Radio in the USA hold out against that chatter.

There was, you can be sure, no lack of commentators eager to predict the worst outcomes of radio broadcasting, that it would destroy theatres and newspapers, that it would vulgarise culture, things which turned out either to be untrue or which were outweighed by the benefits. Through radio and later television, and subsequently the internet, societies beyond the metropolitan circle - and beyond the 'rich' world - have access to music, literature, drama, information, and news, in a way which was previously impossible.

Perhaps because we have yet to come fully to terms with their implications and possibilities, the potentialities of modern technology tend to be thought of in terms of advances brought about by computers and electronic communications, and indeed those potentialities are awesome. But is it not developments in transport, medicine, energy and weaponry that have produced the greatest impact upon our lives?

It is surely by developments in medicine that the greatest numbers of the world's people have been most immediately affected. Changed techniques for travel have had revolutionary social consequences, at least in the first world. And some of the technologies of energy generation are threatening the planet's eco-system (and their profligate use of scarce non-renewable resources presents still greater threats in the future). Finally, we are unlikely to overlook the implications of weaponry and its delivery. These have shifted centres of power and have had unpredictable and as yet unforeseen effects on the relative success of different countries and societies. The twentieth century, the seed-bed of so many advanced sciences, was also the century of previously unimaginable atrocities based on advances in technology and the capacity for yet-greater atrocity clearly still exists.

I would argue, though, that most new technologies, with the exception of those associated with weaponry, have had hugely beneficial effects for most people extending our capabilities and indeed our lives to an extent that our ancestors could not have imagined and I believe that we are only at the beginning.

We began this evening in the empty landscape of East Anglia, four millennia ago. The basis of the highest achievement in their day, flints were superseded as a fundamental technology by metals of increasing sophistication. Now they are but historic artifacts. Other, far more complex, technologies have followed a similar course, passing from the mainstream into recreation, heritage, and history. One thinks of the sailing ship and the steam locomotive, although Ellen MacArthur's heroic sailing triumphs suggest that technology developments in sailing are still alive and well. And many were superseded by superior alternatives before they reached their full potential, such as the airship.

The cycle of technological change grows faster. Compared with the sailing ship how brief was the longevity of the steam engine, let alone the vinyl gramophone record. What will be the next cycle, and how will it emerge? I hope it is clear by now that I am convinced that it is technology that shapes our lives and that its influence is paramount and is only going to increase as time passes. It is time that we in Britain, so good at fundamental science also came fully to appreciate the intellectual challenge behind product development. We seem culturally unable to realise that this can be more challenging than fundamental science and requires the very best minds. In my view this has already been grasped in India and China which in my view is pleasing because after all technology is the means by which the developing world can increase its standard of living but if we do not join the race to advance technology we face serious consequences not least that we will fall behind in our own intellectual, social and material development.