# 1

# The triumph of technology

Around 4,000 years ago, just 5 miles north of what is now the Norfolk town of Thetford, our Neolithic ancestors began what may have been the largest early industrial process in these British Isles. This is the site that the Anglo-Saxons called 'Grimes Graves' and it contains nearly 400 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 12 metres to reach the buried flints. It has been calculated that the miners needed to remove 1,000 tonnes of waste to produce 8 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 into 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.

Humankind's way of life has depended on technology since the beginning of civilisation. It can indeed be argued that civilisation 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 Grimes 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. For example, a recent poll asked the British 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 and Watson demonstrates in my mind a

profound misunderstanding of the contribution of advanced technologies to our lives, and of the manner in which the vast pyramid of scientific and technical achievement that underlies these technologies was built.

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 have become defensive about it and would rather retreat into the past, or into funda-

mental science, than 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 throughout the world, through plant breeding; to monitor and find the means for avoiding global warming so that we can safeguard 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 can 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 demystification 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 build upon itself as it does today because there were no means to pass information reliably 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 on its precious knowledge.

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 [WWW] makes – in principle – all 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. The World Wide Web Consortium, an independent group at the Massachusetts Institute of Technology headed by Tim Berners-Lee (who is credited with first developing the WWW), 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 arm

ourselves against such falsehood by teaching people to be intelligent critics and helping them to judge whether a source is reliable.

The ready availability of even objective truth does not 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. This chapter was delivered as a lecture 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 folklore in medicine began to crumble in the light of advances in understanding made by William Harvey and others, based on systematic observation and recording. Harvey