Science, Technology and Society for our century

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Abstract

The links between science and technology, on the one hand, and wider society, on the other, have been the focus of growing attention over the past two generations. This inaugural lecture by Sean Johnston, Professor of Science, Technology and Society at the University of Glasgow's School of Interdisciplinary Studies, will explore the recent history of this relationship and discuss why the social implications of science and technology have become increasingly contentious. Illustrated by career experiences as a participant and researcher in emerging fields, his session will highlight the advantages of an interdisciplinary approach for creating new knowledge and opportunities. The lecture will describe how current research and postgraduate teaching seek to identify and tackle issues at the heart of our current century.

Inaugural lectures have become less common in recent times, but they have a long tradition. They bring together friends and family, academic colleagues, and the wider community to celebrate a field and to focus on its value. Indeed, the mathematician G. H. Hardy observed about seventy years ago that 'It is one of the first duties of a Professor, in any subject, to exaggerate a little both the importance of his subject and his own place in it'.[1] I'll try not to exaggerate my case, but I will sketch how my own enthusiasm for the subject developed. As a backdrop for it, I'll focus on the twentieth century – the century during which all of us here were born. And, as I hope to show, my subject will be even more important for this century, and for our children and grandchildren.

[1] G. H. Hardy (1877-1947), *A Mathematician's Apology* (1940, First Electronic Edition), pp. 3-4. Accessed 26 Feb 2013 at http://www.math.ualberta.ca/mss/.

Besides promoting a field, it's also traditional at events like this to acknowledge those who have contributed to this trajectory, and I'll be doing that as I go along. But to begin along those lines, when I was preparing for this event, I recalled a couple of inaugural lectures that I'd attended myself – both by people who had an important influence on my working life.

The first was by my PhD supervisor, Geoffrey Cantor at the University of Leeds, who became the first professor of history of science at Leeds. History and philosophy of science had been studied there, as an offshoot of the Philosophy Department, for some forty years, so this was tardy but well-deserved recognition for the subject.

The second inaugural was by Colin Divall, who provided my postdoctoral research fellowship at the University of York, and who became the first professor there of history of technology. His post was funded partly by the history department at York, and partly by the National Museum of Science and Industry, and specifically the National Railway Museum. So Geoff and Colin found distinct niches and allegiances in the wider academic community.

Both Geoff and Colin were important to me because the work I did with them is still a touchstone for my research and teaching. And, in retrospect, that research explains my own career experiences, as I'll describe.

My PhD topic, supervised by Geoff, had explored how an everyday skill had turned into a scientific field. I had become intrigued by a forgotten corner of physics, and with a forgotten group of people: those who had first tried to measure the brightness of light. I was curious about why they didn't get around to doing this until about a century ago. Now if you've ever tried to judge brightness – perhaps to decide what wattage of light bulb to buy – you've probably come to one of two conclusions. Either you thought it was trivially easy – an inbuilt and automatic ability you had from birth – or else you decided that it was very difficult to decide, and gave up trying to do it carefully. In the same way, it left Victorian scientists and engineers divided. I investigated how this simple act of assessing the brightness of light was wrestled and pummelled and forced into a quantity that could be measured.

Electrical Industries, 21 Sep 1909.

And that wasn't the only division. This was a subject that didn't fit pigeon-holes. Physicists, physiologists and psychologists each had different approaches to it. For fifty years, international commissions argued about appropriate methods of measuring light and colour.

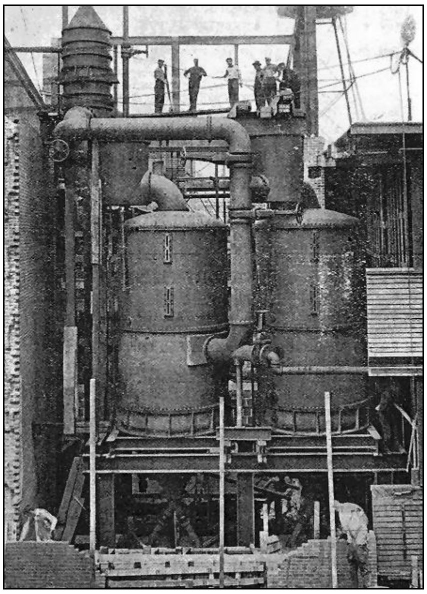
So this was an awkward in-between field. No single group of experts could gain authority over it, and careers could not be built reliably upon it. As this Edwardian cartoon shows, they struggled for status amongst other experts and even found themselves arguing with home-owners about the best place to put lamps. The new specialists never really found stable careers. They were always on the edge, working at institutions or companies without a comfortable niche, never quite secure with a widely recognised job title, and never benefiting from established textbooks or university programmes that would train their successors. It was a specialism without authority.

And yet this would-be science became important socially and economically – for everything from monitoring the quality of beer to standardising the colour of traffic signals, even to assessing slum dwellings by how dimly they were lit.

So along the way, I was drawn into an ever-expanding domain of questions: general scientific problems of judging intensity; the philosophical dimensions of measurement; the economics of light bulbs versus gas lamps; cultural questions about why quantifying – producing numbers and measurements – became so important a fashion in the modern world. And how these various experts made a place for themselves.

I dubbed such problematic technical fields 'peripheral sciences'. And, in common with French sociologist Terry Shinn, I explored these in-between specialists that became known as research-technologists. They proved to be an overlooked body of specialists who had been operating in the cracks, as it were, between more established sciences. It became apparent that such interdisciplinary experts were in fact numerous, and growing, and that they lubricated the mechanics of the modern world.

Now, to some extent, that's also the story of the field that I'll talk about today – the 'in-between', or interdisciplinary field of Science and Technology Studies, or 'Science, Technology and Society'. Both those labels, abbreviated to the acronym STS, were coined about half a century ago. That makes the field about a few academic generations old. And that would make me part of the second or third wave, trained by scholars who had been part of the creation of the field in the 1960s and 70s.



'Scotts, The Chemical Engineers', *The Chemical Age Year Book* 1923

Let me give another example of how this new field relates to other new fields. My postdoctoral fellowship, with Colin, was to co-write a monograph – a scholarly book – on the history of chemical engineering. It's a field that emerged in the early twentieth century, and which today has become one of the big four engineering professions in the UK. But chemical engineers had their own problems. A century ago, they were seen by their contemporaries as upstarts – poorly trained non-specialists trying to take jobs that could be better accomplished by teams of industrial chemists, on the one hand, and mechanical engineers on the other. The chemical engineers had to struggle to be accepted as a new breed of in-between expert. Only after the Second World War did they become a viable occupation, a reputable intellectual discipline, and a recognised profession. It took them some 40 years – a couple of working generations – to establish stable jobs, university programmes, and the respect of their peers. So chemical engineers, too, have some resonances with my subject today of science, technology and society.

Getting back to the subject of inaugural lectures, both Geoff and Colin, in their own inaugurals, identified a biographical thread as being traditional, and both sought to get across what they, as scholars, hoped to add to their subjects. So let me return briefly to my own history, to further explain the field and my own attraction to it.

I've mentioned my PhD and postdoc periods, but I had an earlier career, too, before my PhD, and working experiences that gave me a perspective on emerging sciences and how they relate to interdisciplinarity.

All of us are shaped by our time and place, our backgrounds and opportunities. My father was a plasterer and amateur photographer with a lifelong enthusiasm for history, politics and scientific progress. My mother and father were both frugal, but generous; and principled, but undemanding, people. They provided an environment of second-hand books, magazines, tools and camera junk. It encouraged an interest in eclectic reading and building gadgets, and I tuned in to the spirit of the age, which emphasised do-it-yourself technologies for everything from light shows to geodesic domes.

This was also the period when the limits of science and technology were first coming to public consciousness. Pollution, ecology and overpopulation were hot topics, and the limits of energy resources were underlined by the OPEC oil crisis. In that context, popular programmes like *Tomorrow's World* began to look increasingly simplistic as windows on the science and technology of the future.

The upshot was that, like many of my contemporaries, I became interested in the wider implications and direction of science. And I was fortunate during my undergraduate physics days to have stimulating summer jobs that provided new perspectives.

The first two were at State-funded national labs. One was Canada's principal particle accelerator, which was conveniently some 15 miles from home in Vancouver. The second was at the National Research Council in Ottawa. Both of them planted interests that stayed with me.

First, they involved emerging technologies: at the cyclotron, I worked on fluidics, a technology that appeared promising for high-radiation environments. And at the NRC, I assisted scientists on a mixture of pure and applied research. Their work ranged from studies of aerial surveying to measurements of the northern lights. And at both sites, I got first-hand experience at how science and technology mesh with industry. Both labs had a fertile mix of scientists and engineers, technicians and administrators cooperating in what seemed a remarkably non-hierarchical way. I felt almost like the acolyte of a religious sect, seduced by the social atmosphere, working culture and commitment to national problem-solving, as much as by the scientific interest of the work itself.


National Research Council, Ottawa, July 1977

Those experiences resonated in subsequent jobs and during a research master's degree over the next couple of years. I left university, returning to it only much later. I had enjoyed working at the national labs, and – naïve as it may sound – my goal was to be part of those seemingly harmonious interdisciplinary teams, and genuinely wanting to 'pay back' for my state-funded education.

So, I opted to work first as a scientific analyst and programmer at another national lab – the Canada Centre for Remote Sensing. There, I found a variety of technical people – quite a few of them without any meaningful occupational label – working in the new field of satellite imagery, and its national implications. How could one sense and map the pollution of waterways or urban sprawl? How could crop yields be predicted? How could navigable channels be found through arctic ice? But despite the satisfying link between science, technology and social application, the working environment was very unlike the other national labs. The field of digital image processing was so new – less than a decade old – that the experts came from a motley assortment of backgrounds. And those differing scientific and technological cultures bristled. Amongst the technical staff there was a constant jostling for position and status – a phenomenon that sociologist Andrew Abbott later dubbed 'the ecology of the professions'.[2]

So, from there, I moved to Quebec to take a post as a design engineer for new kinds of scientific instrument. And I interacted there with a growing number of experts and organisations: research scientists, government technologists, NASA administrators, scientific customers and engineering personnel in other companies – all of them dealing with new technical fields. I was able to see first-hand how other scientific groups became organised and worked. On the whole, these varied practitioners gave me a more hopeful perspective on 'the ecology of professions'.

And while there, I married my wife Libby. And she nurtured further change: first, because her own training as a British midwife encouraged us to move to the UK where she, too, could practise her career; and second, because she encouraged me to pursue a PhD. So, more than anyone else, I have Libby to thank for being here today.

We moved to England and to Leeds University, where I worked as a physicist at an interdisciplinary research centre, which brought together chemists, physicists and engineers to study polymers. I designed computer-controlled experiments, and came to appreciate how lab automation could have unanticipated side effects. It could imperceptibly turn people into scientific robots – ironically adapting them to their equipment (rather than the other way around), and channelling and restricting their actions and their understandings. I came to appreciate that research workers, their equipment and administrative organisation could be understood only as a 'socio-technical' system, a topic just then emerging as a focus for historians of technology.

[2] A. D. Abbott, *The System of the Professions: An Essay on the Division of Expert Labor* (Chicago: University of Chicago Press, 1988).

Now, I suppose the principal link between this string of technical posts and my later historical and sociological research is that all of these working environments and occupations were relatively new, insecure and un-established. And that meant a ferment of job roles and institutional goals, and a lack of clarity about the new knowledge itself.

In these evolving environments, I found practitioners creating new knowledge and mutating their working relationships. Within and between technical organisations, there was a constant interplay and friction. In some, the new working cultures and social relations were productive and benevolent. In others, they were abrasive and sterile. The participants constantly reassessed their expertise and knowledge. These questions about my working environments continued as I moved from science to *meta*-science – that is, changing from a practising scientist to someone who studies scientists.

And it was a time of satisfying transitions. In Yorkshire we started a family; I completed my PhD and did my postdoctoral research. So, when the University of Glasgow created its new Crichton campus, I applied for the post of lecturer in Science Studies – and we moved to Scotland.

The Crichton Campus was stimulating from the start. It was a novel experiment by one of Britain's oldest universities, founded four decades before Columbus sailed to America. With age can come conservatism, but, despite its long traditions and entrenched academic culture, the University's initiative in Dumfries sought to achieve something bold: to serve the people of southwest Scotland and beyond with a new style of academic organisation. The campus was to be interdisciplinary. It would reduce the artificial boundaries between established disciplines – precisely the boundaries that had been so irrelevant in the environments in which I had worked. Instead, students would study a joined-up selection of perspectives drawn from social studies, history, philosophy, literature and environmental studies.

Now, in some ways, this was anything but new: the University, over 500 years earlier, had begun with something like this approach. The mediaeval 'liberal arts' included broad and inter-related subjects deemed to be valuable for educated people of that age. But by the end of the 19th century, as shown by George Davie in his book *The Democratic Intellect*,[3] specialization had become more popular. New disciplines – ranging from history itself to physics – adopted new methods and, importantly, established professorships to 'pin down' and teach those subjects. By the first world war, most human knowledge had been 'disciplined' – doctors and engineers were now taught at institutions rather than by apprenticeships; new specialisms like psychology and industrial management and home economics all tried to emulate physics by measuring, tabulating and calculating information. We had become a thoroughly scientific culture.

But with that careful definition of disciplines and boundaries, something that had been valued by the mediaeval scholars was lost: the sense of interconnectedness, or holism. In the divided-up modern world, problems that crossed boundaries became more difficult to pursue; complicated questions increasingly had to be categorised and distinguished.

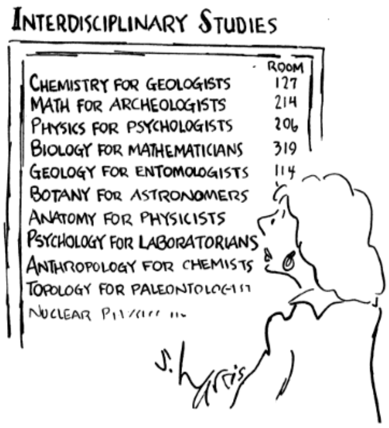
Now, admittedly, this strategy of 'divide and conquer' has strong attractions – and I'd suggest that it has been the overriding and irresistible seduction of the 20th century. The technique is *reductionism* – reducing problems to sub-problems, which can be more easily understood and solved; and then recombining those separate insights to tackle the original complex problem. So physicists over the past century have homed in very successfully to explain the structure of matter;

[3] G. E. Davie, *The Democratic Intellect: Scotland and Her Universities in the Nineteenth Century* (Edinburgh: Edinburgh University Publications, 1961).

our health service has advanced via an ever-more sophisticated combination of discrete skills and technologies; and government economic policy monitors a growing number of numerical indicators.

Yet reductionism isn’t the full answer, either. Until the 1970s, Scottish universities were the last bastion of those experts who had been known since the time of the Greeks as ‘natural philosophers’. Physicists have now given up this earlier identity, and indeed seldom have dialogue with professional philosophers today. And historians of science have sometimes found themselves at odds with practising scientists. This division between bodies of knowledge – especially between the humanities and the sciences – was dubbed ‘the two cultures’ by physicist and novelist C. P. Snow. For scholars of the humanities, science often seemed intimidating and alien; and for many scientists, literature and history seemed irrelevant to modern concerns. But as Snow argued in the 1950s, this mutual incomprehensibility was a tragedy for both sides. It restricted their vision and limited their capacity to understand.

These drawbacks of reductionism have been noticed periodically. Early in the twentieth century the so-called ‘machine age’ offered rapid progress by rationalizing industry. But by mid-century, it was becoming clear that workers were increasingly disenchanted by these socio-technical systems. So-called ‘scientific management’ had reduced many jobs to routine motions and increasing division of labour. The effects of this extreme reductionism were felt in lowered job satisfaction and even in declining productivity. Narrowly-defined progress proved self-limiting.



Sidney Harris, *Physics Today,* 1998.

So the interdisciplinary approach adopted at the Crichton Campus was a refreshing one for the new staff who took up posts here. This cartoon, by the way – appearing in a physics journal at about the time the campus was founded – is not how to be interdisciplinary! It’s not meant to be a little bit of something for everyone; instead, interdisciplinarity requires active cooperation: a working culture in which different kinds of expert can learn from each other while working on a common problem.

The photo below was taken in the first year of the campus, and shows eight of the new faculty highlighted in yellow, including the founding Director, Prof Rex Taylor. Like me, several of my colleagues had varied backgrounds and – even more importantly – were eager to teach and research in joined-up, interdisciplinary ways. And like me, they would probably see themselves as having wider competences that aren’t adequately described by disciplinary labels.


Crichton Campus faculty and students, 2000.

This mixing of different kinds of academic in one place – cooperating on developing and teaching courses, co-supervising students – is very productive. And that variety is a strength. It provides a pool of expertise and approaches that are amenable to a wide class of questions and problems. To illustrate that, let me spend my remaining time talking more directly about Science, Technology and Society.

I've sketched how I grew into this field, and I've hinted at how it accommodates a wide range of questions about the nature of modern science and what we do with it. This campus was founded at a favourable time and in an opportune place. British society over the past fifteen years has witnessed a variety of events that provided a unique engagement with science. They've provoked a dialogue between scientists, engineers, government and the public that is unparalleled in other developed nations. I'd argue that this context has encouraged discussion and evaluations that are different from the national experiences of North America and continental Europe, for example. So, let me list a few of them in chronological order.

The first was the BSE controversy of the 1990s. What began as a limited concern about the safety of agricultural practices developed into a national, and then international debate. Little by little, the public and government were drawn into examining experts and their scientific evidence that linked the spread of a neurological illness – Bovine Spongiform Encephalitis – to the feeding practices of British farm animals and regulation of our food supplies. When international concerns about British beef banned its export, it highlighted the interdependence of biology, veterinary science, government policy, modern agricultural industries and consumer demand. In short, it revealed how science and society intersect.

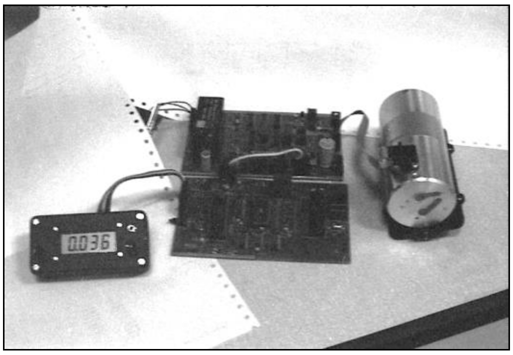
Much more positively, the creation of Dolly the sheep by cloning was a success story for Scotland. As a world first, it spawned tremendous confidence in scientific advance, and the ability of a relatively small country to lead the world. But simultaneously it started a national and international conversation about the ethics of science. And that exchange had a new tone: it didn't concern established notions of 'bad' science, or 'bad' scientists. In the recent past, for example, thoughts about ethics would probably have centred on examples such as the Nazi doctor Josef Mengele, or perhaps – more contentiously – on the development of the atomic bomb during the Second World War. But now it concerned whether we – the public, and society as a whole – should in any way control the speed or direction of 'good' or 'neutral' science. This is still a potent subject for teaching: this ice-breaker of a topic has now triggered seminar discussions for a generation of undergraduates at the campus.

Another cautionary tale unravelled during 1999, the summer the campus opened. GM food protests were taking place in the UK that year, a response to the promotional activities of corporations such as Monsanto. Those public misgivings about genetically modified organisms were expressed by vocal protests and – eventually – by government responses. The public concern about the commercial availability of GM foodstuffs was distinctly unlike the response in America. For some, genetic modification equated simply to progress and the future – something that should not, and could not be influenced by non-specialists. But the perspective that developed in this country was identifying genetic engineering as a new variant of conventional engineering – with all its hopes and promises, but also the likelihood of unforeseen side effects from at least some of those biological designs.

Ethical issues surrounding modern technologies concern not just experts, but all of us. Think of applications of genetic profiling, or how we manage the use of life support machines, or ensure the security of personal information on the internet. These are questions for all of us. The key dimensions of each of these topics is not technological capability, but ethical decision-making; not what we're able to do, but what we want to do. Over the past decade, my colleagues and I have expanded ethics teaching as a growth industry at this campus, and one that has been woven productively into our courses. I'd argue that ethical thinking can be stifled in institutions that regiment an insular, disciplinary consensus. But moral questioning can flower in an interdisciplinary environment, where ideas mingle.

During the lifetime of the Crichton Campus, a rising scientific topic has been climate change. A growing fraction of the general public has become sensitized to the multiple dimensions of this debate which has become highly politicized. As the topic emerged to wider attention, it has provoked a public dialogue about the reliability of scientific methods and conclusions. And forecasting – much harder than historical assessments – now occupies multidisciplinary research teams. Social scientists are equally engaged. How can effective responses be organised? How can personal and collective actions, and changes in lifestyle, be encouraged? What population movements and economic repercussions can be expected? And, even more generally, what is the appropriate way of managing our planet sustainably in the long term?

As I've been speaking I've gradually moved away from my career experiences towards more generic concerns. But let me illustrate them with a personal dimension to climate change issues. Twenty years ago, while completing my PhD, I was also designing commercial instruments for monitoring greenhouse gases, such as the prototype shown here for measuring carbon dioxide. And on the display, you can read a concentration: 0.036 per cent carbon dioxide, or 360 parts per million.



CO_2 measurement, Laser Monitoring Systems Ltd, 1992

Back in 1992, the global average CO_2 concentration was indeed about 360 parts per million. Today, the average is over 390 parts per million – a rise of about 8%. And if you compare today's value with the global average when I was born, it turns out to be about 25% higher. For scientists measuring to one part per million, that's one heck of a calibration shift. And it's not the instrument that has changed – it's the planet. This is a significant and global shift in a chemical concentration.

It's not limited to one habitat, or one region, or even one continent: it's the entire planet. This rate of change, and its universality, highlight good reasons for sober reflection. Its human causes, and its likely effects, are even more sobering.

Well, I've sketched a few examples of contemporary concerns that fall squarely into the domain of 'science, technology and society'. These various illustrations share some common factors:

- First of all, controversy and questioning of expertise: my field has often focused on controversy. Not because it's trying to criticise, but because that's where the action is, and it's often the point at which people engage most closely with a subject. It's newsworthy and emotive and often spurs careful examination and action.
- These episodes also reveal a growing public and policy engagement with science. The UK has seen growing demand for a wider voice in what were once seen as activities for specialists alone.
- The third factor is the focus on environments in their broadest sense: natural environments; and human-made environments, ranging from how we work to solve problems to how we construct the better world.
- And the episodes also reveal the profound sensitivity of our society to technological choices. And underlying all of this are questions of appropriate choices: the ethics of science and technology.

I've argued that the study of science, technology and society is a field for our times. I've described how contributors came from a variety of backgrounds. Some were historians who had become attuned to social history, and its perspective on social groups. Others were philosophers, studying the foundations of scientific activities. And yet others were scientists and engineers who knew first-hand the ponderous economic and political dimensions of post-war science. To some extent my own background is an amalgam of these things. But STS has also attracted literary scholars studying how writings express cultural views of science, and economists and political philosophers exploring how to yoke the power of this potent force.

Together, these perspectives give a holistic view, and a collective expertise well suited to tackling contemporary problems.

STS has the potential to flourish in an interdisciplinary environment like the one we've established here in Dumfries. And STS can underpin that interdisciplinarity further.

So as a final point, I'll sketch a new initiative in STS. That is our Master of Science degree in Environmental STS. It's based on the following claims:

- For the environmental problems we face, single-discipline solutions aren't enough. Neither economic nor technological fixes appear adequate to face the future. We cannot solve our environmental problems via tax incentives and clever engineering alone. The complexity of our problems demands interdisciplinary solutions.
- As the field of STS has shown since its origin, environmental problems must consider the social alongside the technical. The two cannot be from each other.
- And this is not a mere 'academic' exercise: my own research focus has been on new experts, new practitioners. And what this degree seeks to produce are experts trained in the relevant interdisciplinary perspectives. Our aim is that they will have the expertise and eventually wisdom to steer our world through the century.

The focus for the degree is thus threefold: the nature and importance of environment (in its broadest sense); developing new expertise; and founding that expertise on new ethical sensibilities.

I'll end with a quotation attributed to Albert Einstein, although sadly it appears to be a bogus quotation. As I tracked the documentary trail I discovered that it ended with a Californian screenwriter who coined it during the 1990s for a character played by Jeff Goldblum:

> It has become appallingly clear that our technology has exceeded our humanity.[4]

Attributing pithy quotations and aphorisms to Einstein, by the way, has exploded with the internet, and it's a worthy subject for cultural historians or ethnologists to pursue! As a society, we continue to admire science, and we make icons out of individuals like Einstein. So, if the gravitas of Einstein encourages you to ponder this statement a bit longer, so much the better.

Genuine or not, it does encapsulate some of what I've been saying today. I've suggested that science and technology have always been dependent on society – and vice versa – but that relationship has been strained in the modern world. We've increasingly stressed the technological, but forgotten the social dimension.

The challenge for STS, and for all of us in the century ahead, is to reverse the judgement expressed in this quotation, to reconnect the two. And I think it's something that is within our grasp:

We have to ensure that our science and technology live up to our human ideals, while protecting us from our human ambitions.

[4] Victor Salva (screenplay), voiced by the character Donald Ripley in *Powder* (Dir V. Salva, 1995). On the other hand, a genuine quotation is 'Our entire much-praised technological progress, and civilization generally, could be compared to an axe in the hand of a pathological criminal', A. Einstein to H. Zangger, letter (1917), quoted in Albrecht Fölsing, *Albert Einstein: A Biography* (1997), p. 399, and in Alan Lightman, *A Sense of the Mysterious: Science and the Human Spirit* (2005), p. 110. It should be noted that, there, Einstein is referring specifically to the atrocities of the First World War.