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Effects of World War II on education in science

BY LORD BOWDEN

University of Manchester Institute of Science & Technology

I would like to begin by returning to some of the points that have already been made by Professor Jones. It is difficult in retrospect to remember the very small budgets which were available for university research in physics before the war. The Cavendish was the largest and most celebrated laboratory in England but Rutherford never spent more than £2500 a year on his research programme. He resisted suggestions that an industrial appeal might provide him with more money and he did not believe in the economic significance of any of the work he was doing. He used to boast that 'we have no money, so we shall have to think'.

When I went to the Cavendish there were ten Nobel Prizemen and future Prizemen on the staff. Most of our apparatus was crude and simple. I don't think any other university will ever produce so many Nobel Prizemen so cheaply. The foreman of the Laboratory, Mr Lincoln, was extraordinarily mean; he used to give me tungsten wire by the inch at a time when it cost a few pence a yard. I used to measure radioactive sources with a home made electroscope which I charged by rubbing my fountain pen in my back hair. I remember going with W. B. Lewis to buy a valve for 15s. from Bailey, Grundy & Barrett's and we were so elated by our good fortune that we celebrated the event on the way back to the Laboratory. A few years later both of us were using valves by the million. Cockcroft was the first engineer I knew who made an impact on research and the teaching of physics. Rutherford asked him to design a magnet which was built by Metropolitan Vickers for Lewis and me to use. It weighed a couple of tons and it was much admired. It was evacuated by the first of C. R. Burch's famous oil diffusion pumps; we used a couple of dozen valves and half a dozen thyratrons, so we were thought to be very much ahead of current practice, but although our apparatus was so simple, the work of the Laboratory was remarkably good and the teaching was superb.

Anyone who was exposed as I was to the lectures of J. A. Ratcliffe must count himself fortunate as long as he lives. Ratcliffe had already developed his technique of sending his audience happily out of the room under the impression that they understood him, only to realize when it was too late that they still had many hours' work to do before they mastered his apparently simple ideas. I always suspected him of palming magnets to make certain his demonstrations worked. I am delighted that he is here among us today and that he seems to be as persuasive as ever.

When I took a group of twenty Englishmen to America in the middle of the war, I was able to compare their academic standards with those of contemporary

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Americans. I am sure that undergraduate teaching in Cambridge was as good as, if not better, than any to be found anywhere else in the world, but in those days some of the ordinary pass degrees were of a standard which was so low that one can hardly imagine it today. I think some of the most scholarly and some of the most unscholarly men of their generation graduated as Bachelors of Arts from Cambridge in my time. The idea of a scholarly elitist population had never been heard of in those days.

The intimate association between American academics and Englishmen which was produced by the war probably did as much as the war itself to change the teaching of science in this country. Americans were used to teaching much larger classes than ours. The Morrill Act which established the Land Grant Colleges in 1862 ensured that their universities were involved in most of the problems of the local community. American universities had a profound effect on the industrial development of the whole Continent.

When the Tizard Committee went to America to explain the secrets of radar to American scientists, President Roosevelt asked Alfred Loomis to entertain them. Loomis was a wealthy and very successful amateur scientist, he was a member of the Corporation of M.I.T. and he knew about its Department of Industrial Cooperation and its contracts branch. He suggested that American research in radar should not be done in Service establishments such as Wright Field, which was very much like Farnborough or T.R.E., but that it should be concentrated in a special laboratory to be built in and administered by M.I.T. This was the beginning of the Radiation Laboratory which dominated the American research programme in this field. Many other universities afterwards joined the work, but the main work began and remained in Cambridge, Massachusetts. Radar research in America was dominated by academic scientists just as it was in England, but it was conducted in Universities and not in establishments controlled by the Services. This was a source of great strength to the universities at the time, but, as I shall show in a moment, it nearly ruined them twenty years later.

After the war, Vannevar Bush wrote a notable report called 'Science the endless frontier' for President Roosevelt. He pointed out that American industry had always depended on fundamental research done in Europe. Europe was in ruins so America would have to embark on a major expansion of fundamental research. The details of the atomic energy project were still a closely guarded secret, but he referred to the enormous achievements of science during the war, particularly in the fields of radar and medicine. Bush hoped for further developments in medicine, but above all he hoped that the Government would develop both undergraduate and postgraduate schools of science and engineering in all the major universities of America. Several university presidents travelled with a bag of gold to buy the best of the European scientists who had survived the war. I talked to some of them about the difficulty of buying and transporting an institution as distinct from an individual, but they were perfectly confident that they could do this if they had to. As a result of Bush's initiative and the actions of the American

Government the centre of gravity of scientific research moved across the Atlantic, where it has been ever since.

When President Truman tried to implement Bush's proposals he encountered grave constitutional difficulties and he could not create a National Science Foundation of adequate size, so for twenty years or more the Armed Services had to sponsor most of the American research programme; even the purest research, in the Ivy League Universities. It is an extraordinary thing that some of the best fundamental research in the world has been paid for because it was ostensibly 'important to the defence of the Continental United States'. Astonishing though it may appear, this is why so many of the best graduate schools in the world are in the United States today. This extraordinary system worked because everyone was determined that it should and because the Pentagon recruited academic scientists to help them to negotiate research contracts. The Chief Engineer of the American Army became Vice-President of M.I.T. in charge of industrial liaison and government contracts.

The system was supremely successful for many years. It received a tremendous stimulus after Sputnik, which shocked the Americans as nothing else has ever done. They believed it was an unnatural and almost sacrilegious event and one poor teacher was dismissed for telling her class that the Russians had sent up a satellite before the Americans. Everyone in her town believed that the whole thing must have been an elaborate hoax. I happened to be there at the time and I remember the hysteria with which the announcement was greeted. After Sputnik the panic stricken Government poured enormous sums of money into universities and schools; funds were available for every conceivable research project, good or bad. The waste and inefficiency which resulted may have caused some of the troubles which beset American universities today.

The scale on which American universities developed is still not understood or even comprehended in this country. For many years M.I.T. disposed of greater resources for its research programme than all the English universities put together and the reputation of M.I.T. did a great deal to force our own Government into action.

The tradition that American universities must engage in research which is important to the community has always been their greatest source of strength. But after the Vietnamese War began the interest of the community became identified by the financial controllers and politicians with the interests of the Pentagon. The Defence Department was paying for so many research programmes that it was in a position to exert pressure on the universities and make them concentrate on research projects which might be of use to the Army. Senator Mansfield moved his famous amendment which forbade the Pentagon to fund any research programme which was not directly associated with a particular military requirement. Mansfield's amendment and the change in the Pentagon's policy distorted the wonderful American tradition of university involvement in community affairs and devastated many of the best universities in the United

States. The tradition which had created them seemed likely to destroy them. A great organization had within itself the seeds of its own decay.

Furthermore the use of science in the Vietnamese War appalled and estranged the young. In particular the use of napalm and even worse of defoliants, destroyed the confidence of a whole generation in the values of science. The defoliants themselves were discovered as the result of very beautiful fundamental research, but their large scale manufacture and their use by the Army depended entirely on political decisions. Nevertheless the number of would-be students of chemistry dropped almost by half in the year after the effect of defoliants was first publicized. Young men refused to study a subject which could produce such results.

At this moment almost every undergraduate school of chemistry in England is half empty and I suspect that our young people have been influenced profoundly by Americans. The decline in the recruitment of chemists in such firms as I.C.I. cannot be ignored, but I do not believe it is the only cause of the difficulties in undergraduate schools of chemistry today. I suspect, furthermore, that some young men are intimidated by the elaborate measuring devices which have proliferated to such an extraordinary extent since the war and seem to me to have converted organic chemistry into a branch of applied electronics.

I must now pass to another problem which interests me very greatly and that is the effect of the war on the scientists as distinct from science.

The extraordinary thing about wartime science is that most of it was done by very young men. Many of those who are present in this room worked on radar during the war in their twenties or their very early thirties. It would be invidious of me to mention names, but there is no doubt that men who are here with us now developed techniques without which we should probably have lost the War. Our own defence against German air attack, the bombing offensive against Germany, and the battle against submarines in the Bay of Biscay, all depended completely on the skill and the enterprise of men who are here this afternoon. Some of them associated on terms of equality with the Chiefs of the Armed Services and attended meetings of the Cabinet where they sometimes had to argue a case against the sustained opposition of the Prime Minister's official advisers. No young man who has ever done that will ever be intimidated by a Professor or by any Vice-Chancellor I have ever met!

Great responsibilities can have a profound effect on very young men. I wonder how much of the success of many of the scientists who distinguished themselves after the war was due to their understanding and mastery of men and not, as they fondly believe, to their mastery of fundamental scientific principles or even the new techniques which the war did so much to encourage. Some men seem to have burned themselves out during the war and done little or nothing since. Others might never have made their mark had it not been for the tremendous stimulus of the war. There was no one for young men to turn to for advice, so they were forced to do the most astonishing things, some of which their elders knew to be impossible. Many of us had to carry more real responsibility than we have

ever had in our maturity. I often wonder how young men can be given similar opportunities today. We used to think that a man was too old at 35. Now we are apt to assume that men of 35 are too young to be appointed senior lecturers. There are few professors of less than 40, and an old man is still someone who is more than three years older than we are! Does lack of opportunity embitter some of our potential heroes; men like those who in another context were once described as 'mute, inglorious Miltons'? Perhaps some things are only possible in wartime. Alexander the Great died sighing for new worlds to conquer before he was 30; Napoleon Bonaparte had conquered Italy before he was old enough to become an established lecturer in an English university and Nelson was a post captain responsible for the lives of hundreds of men at the age of 20. No English undergraduate of that age can do more than cox an eight. But during the war young men rose to high ranks in all the fighting services in every belligerent country.

An enterprising statistician has discovered that the average age of men who graduated as Ph.D.s from Harvard increased by two or three months every year during the fifteen years from 1950 to 1965. He also discovered that the average age at which Harvard men retire has been falling steadily at about the same rate during the same period. If one extrapolates these two curves, and even Fellows of this Ancient Society have confidently extrapolated much less reliable data, it appears that they will intersect before the end of the century, and after that men may graduate when they have retired or retire before they graduate.

It is easy for us to be too nostalgic, and perhaps even nostalgia isn't what it was! But we must remind ourselves that most of us were young men during World War II and that we have been growing old gracefully or disgracefully ever since. We shall never know what the war really did for us, but there is no doubt that it changed our lives and those of all our fellow scientists; it changed our attitude to science and it changed our attitude to authority. Which of these changes has had the greatest effect on science itself, I do not know.