Lord Broers

Reith Lectures 2005: The Triumph of the Technology

Lecture 3: Innovation and Management

When Ralph Waldo Emerson reputedly and memorably said that the world would beat a path to the door of a person who made a better mousetrap, he was perhaps being unduly optimistic, but at least he realised that the mousetrap had to be made and that it would not be sufficient merely to have an idea, or even a patent, for a better mouse trap. Ideas have to be proven to be useful, and the world told about them, before any paths are beaten. Profound changes have taken place in the development of ideas and their translation in to the market place and in my third Reith lecture I argue that this innovation revolution demands a new approach to research and product development.

To illustrate this story I go back to the beginning of my research career. I was drawn to Britain from the sunshine of Australia in 1959 because Britain led the world in making the best domestic electronics, especially the high fidelity sound systems that had fascinated me since I was a boy. I had formed a little company in Melbourne - today we would call it a start-up - that made hi fi systems for rich farmers, and all the equipment that we used was British, including the electronic components, so my ambition was to come to England and work on their further development.

But by the time I had finished my PhD in 1965 the excitement in electronics had moved to transistors and the newly emerging integrated circuits, and my PhD research had taken me strongly in this direction. Some of the important concepts for integrated circuits had emerged in Britain, in particular at the Royal Signals and Radar Establishment in Malvern, but the most exciting research was being pursued in the laboratories of the large American technology companies. There was a great demand for PhD graduates in electronics and related fields and the 'brain drain' from the UK to the USA was at full flow. There was no doubt in anybody's mind at that time that the ideal model for technology development was the large, well funded, industrial research laboratory staffed with talented PhD graduates from the world's leading universities. Fundamental research could go on in universities but it was only in the large industrial or government funded research laboratories that the really important practical advances were made. If I wanted to work on the creation of new technologies - on the evolution of the better mousetrap - then I would have to go to such a laboratory. This was not only the case in computers and communication but in the transport, chemical and pharmaceutical industries also.

The most famous of the industrial research laboratories was the great A T & T Bell Telephone Laboratory that had dominated the world of communications for decades, but there were many other fine laboratories. General Electric, Hewlett Packard, Hughes Aircraft, Westinghouse, General Motors and so on, all maintained large research facilities and relied on them to provide the ideas and technologies for their new products. I chose the new IBM Research Laboratory because IBM led in computer technology and they were running some projects where I could apply my PhD research directly. And besides the IBM laboratory was housed in a magnificent new Eero Saarinen building surrounded by 70 acres of beautiful grounds in the country 50 minutes north of New York City and everyone was talking about it. As I

have said this was the era when the industrial research laboratories dominated the world of innovation.

But that was forty years ago and much has changed since then, and it is the way things have changed that I discuss this evening. The domination of the large industrial research laboratory has largely come to an end, and in all fields except perhaps pharmaceuticals, those that remain no longer operate in the same manner. They have become far more focussed on product development. It is the way this has happened, and what has replaced these large institutions which once seemed so dominant and impregnable, that interests me.

Industrial research laboratories were, and are, extraordinarily expensive, and to an extent, speculative. The payback is the new products that they enable. Their task is to take advances in science, or novel uses and combinations of existing technologies, and demonstrate that they can be used to produce useful commercial products. In the larger companies the research laboratories were not required to produce finished products - that was left to 'development' laboratories - their task was to demonstrate that it was in principle possible to make the product. But they did much more than this. They were also charged with carrying out fundamental research to underpin the activities of the parent company. They provided the reservoir from which most, if not all, of the fundamental advances from which products were to be developed, would be drawn.

By no means all innovative research carried out in industrial laboratories succeeded commercially - who has now heard of Remington-Rand computers. Neither was everything taken up by the parent company - the ubiquitous icons that we see on personal computer screens were first proposed by workers in Xerox' research laboratory and yet Xerox never made computers in large volumes. But up until the 1980s it was the industrial research laboratories that acted as the well-springs from which most successful new products were drawn. In addition to providing the scientific underpinning to a range of products, researchers were rewarded for making contributions to fundamental science, even if it was unrelated to the company's business. I remember scientists in the IBM Research laboratory working on gravity waves, the formation of galaxies, and fractals, subjects of importance to science, but that bore little relation to IBM's products. Achievements in science were considered as important as solutions that enabled new products to be successful.

In retrospect it becomes obvious that this support of fundamental science was in effect a philanthropic activity and could be afforded because the companies that practiced it on a significant scale were in fact monopolies. Some thought that they owed it to society. This has now changed. Very little fundamental research remains in corporate research laboratories.

The world has become more competitive and there are now few, if any, companies in any country that exercise an effective monopoly. The world of technology and science has also expanded so much that it is no longer possible, even for the largest companies, to sustain a research effort that can cover all the disciplines used in their products. Finally, leading research is going on all over the world and it is less and less likely that the important new ideas will emerge in a company's own laboratory. It is better to put in place mechanisms that draw on the global research output, which

incidentally is no longer confined to Europe, Japan and North America but is emerging rapidly in the East. The aim must be to draw upon the entire world of science and technology.

So given this transformation, where is it best to pursue basic research and how should companies manage and organize the creation of new products? It is relatively easy to answer the first of these questions. Fundamental research is best carried out in universities. Universities allow researchers to set long-range goals - they are free to further humankind's understanding of the universe. It also makes them good at the type of research that used to be the domain of the industrial research laboratory. They have critical mass through the support of governments and can sustain breadth across the disciplines including the social sciences, and in some cases also the arts and humanities. Successful academics are active participants in the international community and are in a position to discuss their work without constraint with their peers around the world. They live in an environment that is continually refreshed by the intake of new students, and provided the faculty are motivated to remain active in areas of current interest, they remain agile and creative. It is the scope and variety of interdisciplinarity and the constant renewal brought by new, young minds, which underpin the achievements of university research. Government funded research laboratories are also in a good position to sustain strong fundamental research, although they are more likely to lose creativity as their membership ages.

The principal challenge for any research organization, when their aim is to pursue research which underpins technology, is to find ways to transfer their ideas into practical advances - in other words to be effective in technology transfer. This is especially the case for universities. Universities have made significant advances in recent years through the setting up of what are called 'incubators' and by supporting work that takes ideas to the point of initial feasibility. They have shown that they can be effective in providing the input to the product development process, especially when new scientific concepts are involved.

When it comes to product development, however, academics have difficulty in being sufficiently single-minded. They have to teach and examine, and tend nowadays to be evaluated on their output of original research. The product development process, on the other hand, requires focused dedication to product aims. Important scientific advances are made along the path to the product but these usually become valuable intellectual property and their creators will not be motivated, nor even allowed, to publish them. Academics who have been involved in the research phase of technology development, however, make valuable consultants and their involvement in the product development process is hugely beneficial.

The creation of new products is therefore only effectively carried out by dedicated teams who can devote one hundred percent of their time to the activity. To be successful the innovators will almost certainly need an intimate knowledge of the science that underlies the technology, but their aim will not be to further the science. They will use their knowledge to break down the barriers that stand in the way of practical application. The resources needed to innovate are typically greater than those needed in research: As Thomas Edison famously said, the process is 'one per cent inspiration and ninety-nine per cent perspiration', and the energy and effort called for to take the idea of our better mousetrap successfully through to the sales floor is

immense. This is partly because the process becomes a race against competitors, and the team must be large enough to get to their goal in time; and partly because there is an over-riding need to demonstrate that there are means reliably to manufacture the product in high volumes.

Although there will be different ways to organize the creation of products in different industries some general needs can be identified. Innovation today is global so innovators must be familiar with what is going on all over the world - they should be members of the international community in their subject, or at least be in close contact with those who are, such as leading academics. For large companies with adequate resources this can be accomplished through collaborative research programmes with universities. In such programmes the goals of the research should be jointly set by the academics and industrialists so that everyone is familiar with the needs of the product or process programmes as well as with the research agenda. Such joint projects are also effective in transferring technology that has had its origins in universities. It is not effective for industry merely to 'contract out' their research needs to universities.

In small and medium sized companies, where the resources are not great enough to fund large-scale research in universities, technology is best transferred by the academics moving out of their universities and devoting their full energies to the product development process. Many venture capitalists require this before they will fund a start-up. If they are not prepared to devote full time to the project themselves they will have to find others who will, and then act as advisors. This is not the best way to do things but it is a common model.

It is also important to realize that the original ideas of the founding entrepreneurs usually only form the core of the what will be required. The rest of the creative input will have to come from all over the world. It is therefore important for small companies to be in touch with all sources of expertise; with universities, large companies, government funded establishments etc.... feeding off their ideas and using the larger organisations' resources to lever their own activities. In recent years in Britain it has been the small companies that have worked alongside large companies in a complementary way, such as ARM whose microprocessors power more than three quarters of the world's mobile phones, that have succeeded. Competing with the technological giants head-on normally ends in failure, or in selling out at their terms as the giants turn their blow-torch on the small company's niche.

To understand the degree to which product development has changed and become global, one only has to examine the aerospace, mobile telephone or automobile industries. The components that make up these systems are no longer made by single companies. Technologies are brought together from around the world and integrated in to the final product. The indispensable modern cellular telephone drew on technology developed in Finland, Sweden, Japan, and the United States, and many of the most advanced phones are designed in the UK. The components of a modern airliner like the Airbus 380 have been drawn from hundreds of locations in Europe, the USA and the Far East as are the components of modern cars. The innovation is distributed and international and perhaps the most powerful minds of all are those at the centre who have to decide which technologies to select and how they will be brought together. The situation is similar in the chemical and pharmaceutical industries and in the building of large computer software systems.

In cases where the product is to be mass-produced, as with most consumer products, the development of a commercially competitive manufacturing process is similarly global and takes even greater resources And again there is an interface, this time between development and manufacturing, where collaboration and the transfer of people is once more the key to success. As already mentioned, the resource needed to develop the manufacturing process can be ten times greater than that in development, or one hundred times that in research.

Throughout all of what I have been talking about, the handling of intellectual property is key. The intellectual property must be sound and the ownership of patents clear and capable of withstanding challenge. Multiple ownership makes patents difficult to manage internationally and should, if possible, be avoided. Professionalism is essential. This is not the territory of the gifted amateur, even if many still cling to this romantic idea. Losing one's own and everyone else's money through unprofessional protection of intellectual property is not romantic.

Leadership in the creation of new technology, is of prime importance and nobody will be surprised to hear that there are tensions between the ambitions of the creative engineer, the demands of the market, and the availability of resources. This is one area where the vast increase in the technology base and the spreading of this base around the globe has not changed things. I believe that technology based businesses should always be led by those who understand and have most experience of the market. Creative technologists provide the ideas for the new products and the expertise for manufacturing them, and may of necessity have to carry a new company through its early stages, but only the exceptional amongst them are able to develop a realistic view of the market for their ideas. In a small company, the ideal leadership team consists of a chief executive who has extensive experience of the market and good business sense, the creative engineer who stands at the chief executive's right hand and provides knowledge and contacts that spread throughout the entire technical spectrum, and the chief financial officer who acts as the disciplinarian. In large companies the team should retain the same characteristics and hierarchy although the capabilities will be distributed over the layers of the organisation. What has changed over the last few years is that everyone now has to have an international perspective, and preferably international working experience.

The world of product and process creation has become wholly international. To be only nationally competitive is to be not competitive. The pace has also accelerated to the extent that those who do not thrive in a stressful environment had better find something else to do. In the oft quoted words of Andy Grove, the past head of Intel - "Only the paranoid survive". This is a fast moving and ultra-competitive world. In the last decade of the 20th century we lived through what was in effect a new industrial revolution. Companies ceased to make entire products themselves and became assemblers of the world's best, and to do this they had to know the world - both its technologies and its peoples. And these trends are only going to accelerate as the emerging powers of India and China enter the world of innovation as powerfully as they entered high technology manufacturing. It is immensely exhilarating to be a player but there are no places reserved for amateurs.