Aromatics, Automotive, Aspire and Ambiguity:

40 Years of Applied Research and Why It Matters

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Introduction

I started my PhD in 1978, so 40 years have now elapsed since I began my research career. This evening, I want to celebrate that with you, attempt to find the common thread running through many diverse activities, and relate them to current Government policy and how Solent University and its researchers might benefit from such work.

As you probably know, I am coming to the end of my main career and retire from my substantive post at the end of February. I am very pleased to have been awarded the title of Emeritus Professor, with effect from 16 February, and I am most grateful to Solent University for this conferment. I shall stay active as a PhD Supervisor and I shall touch on a little of that towards the end of this lecture.

Since I have had a rather generalist career, I shall canter through several different subjects and do not intend to dwell too long on any specifics or technicalities.

Aromatics

Now, I'll move to my first subject – Aromatics - has anyone got any idea what I might mean by this? Any chemists here tonight?

It's about the study of aromatic compounds: they were named as such because the early ones discovered as natural products had a sweet, or pleasant smell. Aromatics later came to mean something about a structural component – the benzene ring of six carbon atoms at the heart of the structures.

We're talking here about the study of organic chemistry. So, what does 'organic' mean in this context?

It's about matter in its various forms – animal or vegetable – that contains chains of carbon atoms linked together and then linked to hydrogen and other atoms.

Indeed, my PhD was about synthetic organic chemistry. What do you think 'synthetic' means here? How can it be 'synthetic' and 'organic' – surely that's a contradiction?

My PhD was entitled 'Novel Syntheses of Polyketide Aromatics'. I developed laboratory routes to an important class of fungal metabolites, known as polyketides, which could be adapted to produce candidates for active pharmaceuticals (Carpenter et al, 1984). These could then be tested for therapeutic properties (by others – probably commercially) and close analogues

produced, varying the chemical structure slightly to improve the balance of properties. This overall process has been the basis for pharmaceutical and plant protection chemistry for many years. So, this is properly applied research, with important potential consequences for people and crops. The skills and ideas learnt during the PhD are directly applicable to the industrial workplace. Indeed, several Cambridge colleagues from that period – a lecturer, PhD and Post Doc Students joined ICI Plant Protection at Jealott's Hill (now Syngenta) and carried on in much the same vein for most of their careers. I therefore take slight issue with Professor Chudley's comment in an earlier lecture in this series that a PhD is not a direct education or training for a career. It rather depends on the PhD and career!

Eventually, I synthesised the polyketide metabolite Citrinin – a compound that had been isolated in the same laboratory from fungi (Barber et al, 1986). The synthesis, and its strategy, later enabled Regan, also in Cambridge, to perform an asymmetric synthesis of (+)-Citrinin, the active stereoisomer (Regan and Staunton, 1983). That simply means the correct version of the compound that is active in nature. Typically only one 'mirror image' of the 3-dimensional structure occurs in nature and has the biochemical properties ascribed to it. So the synthesised (synthetic) compound is not different in any way from the natural product as long as the right 'mirror image' is produced. So simply put, but difficult to achieve in the laboratory and my route paved the way to that I am pleased to say.

Why did I find this work attractive? It was practical, applied, but came from an analysis of a 'puzzle'. How to work backwards from a target compound by conceptually 'cutting up' the compound into smaller molecules where known

reactions could move forward, using a given strategy to make it in the lab? So, a puzzle: intellectually challenging like Sudoku or Chess, but with practical verification. In fact, a perfect blend of theory and practice. Now, where have I heard that before? Of course, in a research-intensive university, such as Cambridge, the impetus is also to publish papers in world-leading journals. I'm glad to say that this was also possible, with two from my PhD.

Later developments have enabled computer programmes to solve such puzzles and suggest how to synthesise complex natural molecules. Automated laboratory apparatus is also used to carry out many parallel reactions on a micro-scale at the same time. This is more efficient but rather less fun than our old approach, which involved frequent use of the fume cupboard, with bespoke apparatus, and some colleagues creating frequent fires.

Later, it has been found that natural enzymes are much more efficient at complex stereoselective synthesis than humans (Chem@cam, 2003). The best way of creating rapidly a library of novel polyketide molecules is a combination of synthesis and biosynthesis as pioneered by a company founded as a result of discoveries by my PhD Supervisor, Jim Staunton.

I'll now briefly tell you where a few of my colleagues from that time ended up.

<u>The UK Industrial Strategy</u>

The Government has developed a strategy with the goal of stimulating growth and improving productivity through innovation. There are five foundations: ideas (innovation), people, infrastructure, business environment and places (HM Government, 2017).

The strategy sets out to develop local industrial strategies, linked to the strengths in sub-regional areas, such as the Solent. In this area that will probably major on marine and maritime firstly and secondly computing and artificial intelligence. Nationally, there will be additional investment in research, innovation and knowledge transfer to industry through a variety of measures.

The strategy (and prior consultation) also makes it clear that applied research is vital in taking ideas to market. This positions it very well against our University vision. It also sets 'four grand challenges' for the UK in rapidly developing areas of technology. The aim is to 'drive partnerships between the best minds in science and business throughout Britain.'

This links neatly to the theme of my lecture this evening, illustrated by this slide. Clearly, the 'Grand Challenges' have moved on since my efforts in these areas but, nevertheless, there are some pointers which can always be found for the future by examining the past. The Industrial Strategy also provides an excellent opportunity for Solent University and its researchers to continue to gain funding as the 'applied University for Southampton'. Close attention to the Government's developing Knowledge Excellence Framework (KEF) will be needed to maximise funding (Cyrus, 2017).

There are some encouraging recent signs that there has been an export-led revival in manufacturing. In my opinion, a stronger manufacturing sector is essential for a more balanced UK economy and some stimulus from the Industrial Strategy packages will certainly be needed if this is to continue.

At the beginning of the period of my research in 1978, manufacturing in the UK provided 25% of UK jobs, compared with only 8% in 2014 and 10% of GVA (ONS, 2014). However, it still employs 2.7 million people here and accounts for 45% of total exports and 68% of UK R&D (The Manufacturer, 2018; EEF, 2017/18). Therefore, it is still important to UK plc! We are still the ninth biggest manufacturing nation. Figures are no longer directly comparable as ancillary services to industry such as cleaning, catering and building services which were once counted in the figures are now allocated to other parts of the economy.

Nevertheless, total manufacturing output has increased since 1978, despite a 60% fall in the workforce. Labour productivity is now 6 times more than in 1948 for UK manufacturing and three times that in 1978. This is most likely a result, in part, of improved qualifications in the workforce. 15% of employees now have first degrees and another 5% Masters or PhDs. Services productivity, in contrast, has increased by less than three times since 1948.

This all suggests that the UK's productivity issues lie more with service sectors than manufacturing. Perhaps more research is needed in those areas as automation moves to increase productivity by replacing routine jobs?

In terms of chemical sales by country, China leads the world with sales of €1,331 billion in 2016 – ahead of the USA (476 bn) and Germany (145 bn). The UK is now outside the top ten producers (Cefic, 2017). Over 60% of chemical and pharmaceutical jobs have disappeared since 1979, about the same as the average reduction for all of manufacturing industry. However, the UK still has a sizable chemical industry (Chemical Industries Association, 2018) with 160,000 employed in chemicals and pharmaceuticals and another 500,000 indirect jobs supporting these. This is the UK's largest manufacturing export sector. Since I started my career there, I am pleased to say that 30,000 people are still employed in chemical R&D in the UK.

Automotive

I, however, desired something nearer to the market and even more inter-disciplinary than synthetic organic chemistry would give me. I therefore joined the chemical industry in a Development (the 'D' of 'R&D') role. I soon discovered how near to market this was! On being allocated to a team within a business working to supply the automotive industry the challenge soon became clearer. This was now the autumn of 1981, in the depths of the biggest recession before 2007. Industry was in the doldrums and this applied equally to the car industry. Sales had dipped and Ford, for example, was storing thousands of new cars on the marshes at Rainham near its Dagenham factory. This was for periods well in excess of a year, with foundry fall-out (acid) and seagull droppings (alkali) attacking the paintwork. To combat this, they started spraying new cars with wax in white

spirit. Once the car was delivered to the dealer, the wax was stripped off using a hot water washer mixed with white spirit. This protected the paint but gave two large problems: potential fire hazard and toxic solvents mixing with water effluent.

So, my employer had 'sold' a new product to Ford – a waterborne emulsion coating, sprayed onto the car paintwork, drying quickly, protecting the paint and stripped off by waterborne detergents that would not harm the environment. This great innovation was called 'Tempro 20' and a trial was booked with Ford at Dagenham. Only one problem: the product had not yet been developed in the lab! That's what my job was – no pressure then!

This was precisely the mix of near market innovation, practical work, trials and economic decisions I was wanting.

Aided by my excellent technicians – Danny and Patricia – we trialled various formulations with known ingredients; developed a new potential latex resin, 'Aquersymer' (Bromley et al, 1983) with our research chemists; formulated a waterborne detergent remover and went to Dagenham to test it. Donning boiler suits, we sprayed it on real cars at the end of the production line and waited with baited breath.

Astonishingly, Ford (and other manufacturers – we repeated this with Rover, Leyland, Jaguar and others) did not know where or when these vehicles would get to dealers. In the early eighties, there was no just-in-time manufacture or

selecting your own vehicle trim and accessories before it was built. Later, there was 'The Second Revolution in the Car Industry', with lean manufacturing (Womack et al, 1992). Producers intensified Total Quality Management with the Pursuit of Quality (Whitford and Bird, 1996) and developed Excellence in Manufacturing (Goldratt and Cox, 1984).

In 1981, only the Japanese seemed to know about such things. So, we had 'phone calls, through Ford, from all the Ws – Warrington, the Wirral, Walton-on-the-Naze and Wakefield. Cars had turned up covered in 'funny' wax and no-one knew how to get it off. So, off we popped and successfully removed the coating.

Early on we trialled a batch of Jaguar cars being exported to Germany and travelled to Bremerhaven to get the Tempro off. That worked, so a fiendish trial was devised to coat several Jaguars, then for me to travel to Dammam on the Gulf in Saudi Arabia to remove the temporary coating. But disaster : the coating and paint softened in the 40-degree heat, the desert sand fell on top and I supervised a poor Indian worker doing his best to remove this sandpaper-like mess from the cars!

We reformulated with harder resins, tests by sending panels to Florida to bake in the sun, and continued successful trials in several countries. All went well, we optimised formulations and sold literally tonnes of product and variants to car manufacturers, earth moving equipment companies, fork lift truck providers and so on.

Of course, all products have a downside and even waterborne removable resins have organic matter content that in aggregate can do harm to watercourses. Also, as just-in-time manufacture came in, the need to store cars for months before sale 'as new' decreased. Also, paintwork improvements helped cars resist corrosive agents better. So now, manufacturers use a combination of shrink-wrap plastic or shaped covers and storage under cover – as for export vehicles at Southampton.

After a few years, I transferred to a different business unit supplying high-specification paints and coatings for coils of metal. These are huge coils of metal sheet – steel or aluminium – about 1.5 m wide, up to 800 m long and weighing often 15 tonnes. The paint is applied by roller on a line that uncoils the metal, bakes the paint layers in ovens, then recoils them. They are then formed (already painted) into objects such as roof or wall cladding, domestic appliances, caravans or car parts. This is the most technical end of paint and coatings as the paints must adhere well enough and be hard enough to bond with the metal on forming into finished objects. I'm still amazed that it works.

In 1988, my family and I were seconded to Germany – Hannah and Rhian came with me and Rachel was born there in 1989. I was European Technical Manager for these coatings. We developed there some excellent technology – Bonazinc – to apply a zinc-rich paint to vehicle bonnets (before forming and the rest of the painting process). This improved stone-chip resistance and salt corrosion in winter. The old red-rusting became a thing of the past. It was expected that zinc would protect steel or iron in this way and later car body steel was made with

galvanised (zinc coated) steel. That's why modern cars last so much longer and don't red rust like they did in the seventies.

Surprisingly, a variant of Bonazinc also worked on aluminium car parts, such as bonnets, helping the standard car paint layers to stick. Aluminium was introduced with such a coating by higher end manufacturers such as Mercedes, BMW and Audi. Being based in Germany, I visited all these manufacturers and others, such as Ford, for trials and discussions. This was part of that 'Second Revolution in the Automobile Industry' of which I am very proud. In a decade, the quality management improved hugely and these benefits saw their way back to the UK. I'm not sure that I agree with the statement in the UK Industrial Strategy to the effect that our country had a strategy to attract investment from abroad. However, I do agree that the ailing giants, such as British Leyland, were taken over by German and other firms who had better quality, using innovations such as Bonazinc. This led to a resurgence in UK motor production, including by new Japanese factories exporting within the EU. The challenge has now moved on from the fabric of the car to environmental impact, driverless and Smart technology. That is one of the Grand Challenges in the UK industrial strategy: 'the future of mobility' (HM Government, 2017).

International and Globalisation

In the chemical industry I was lucky enough to begin trips with the automotive projects and work in Germany, Saudi Arabia and Ireland. This gave me a real taste for different cultures and languages. The four-year secondment to Germany, from

1988, was hugely enjoyable for me and my enlarged family, with an opportunity to drive to almost all the adjacent countries and Scandinavia on business or pleasure. I also had customers behind the Iron Curtain in Czechoslovakia and East Germany. Whilst we were there, the Berlin Wall and the Curtain came down, providing a unique opportunity to witness the transition. It also presented me with a chance to visit Russia to set up a new coil coating line there.

Globalisation was already a theme in the 1980s and by the late part of the decade in our organisation, we regionalised so that we could better service customers in each region of the world. This led later to a Global Product Organisation (Howard and Jeannet, 1993). This was driven by three factors: the need to service customers with international manufacturing operations – can, vehicle, coil etc; the need to service customers dealing with aftercare of internationally traded products such as vehicles or ships; and, thirdly, the need to amortise the costs of R&D and marketing over a broad base.

In my business, I was the technical lead for Europe, but also co-ordinator for the World Group, since we had coil coatings laboratories also in the USA, Australia and New Zealand. I was therefore fortunate to travel to all these places and meet our staff there. I also visited associate companies in Asia – Indonesia, India, Malaysia, Singapore and, in 1987, the year Hannah was born, made two trips to China. This was a revelation! At that time entry was exclusively via Hong Kong and I travelled to Guangzhou, Shanghai and Wuhan. This involved seeking potential paint companies to partner with. In the event, discretion was the better part of valour

and we later invested in our own manufacturing plants built from new with JV partners, such as Swire, which owned Cathay Pacific Airlines.

In Wuhan we negotiated the set-up of the first coil coating line in China at the Wuhan Iron and Steel Company (WISCO). I led the technical part of discussions – specifications and such like. Operating through translators with a, then, collective management system, was a fascinating challenge. Perhaps it prepared me for my much later dealings with universities and the consultative style needed. It certainly prepared me for my future 18 university visits to China. I do think that this early international exposure, in my late twenties and early thirties, paved the way for my later title of Professor of International Education, once I had switched sectors.

In this role, my dealings with the National Academy of Education Administration (NAEA) in Beijing, China, have been one of the most instructive and pleasurable parts. I have been Visiting Professor there since 2008, in my time at London South Bank University. During this time, I have given many lectures in Beijing and the UK to cohorts of Chinese University Chairs, Presidents and Vice-Presidents and also presented various topics to international conferences in China. Perhaps the most remarkable was when I presented to NAEA staff in Beijing on Government reforms in UK Higher Education as a result of the credit crunch (Wilkinson, 2009). When it became clear how often UK Government changes rules, regulations and funding, the NAEA Vice-President remarked that perhaps he was glad that he lived in a one-party state where plans tend to have a 5-10-year duration!

A paper on Leadership Development was also published in NAEA's journal and presented at a UK Conference (Wilkinson and Jing, 2012). I also undertook a three-week exchange with that Vice-President, getting to see Tsinghua University (the 'Cambridge' of China) and others. Two post-doctoral students also came to London for three months each to produce dissertations on Organisation, Governance and Power in UK Higher Education and a comparative perspective with China (Hu, 2008; Si 2008). One of those post-docs was promoted following his visit and he and the Vice-President later came to Solent University as part of NAEA delegations.

I am also delighted that several of you have benefitted from joint research with our Chinese partners. Long may this continue.

And that reminds me of one of the great pleasures of this job – to teach and develop students. Much of my work in this regard has been with mature staff looking to advance in their careers and I have also coached university and school staff. This has all been particularly enjoyable.

I would like to pay tribute to the team, formerly at South Bank, who helped me get into this hugely satisfying international work and forged our contacts with NAEA. We also founded a hugely successful Confucius Institute, teaching Chinese language, culture and medicine of the traditional sort. I was very honoured to be founding Chair of this Institute and receive an award for Confucius Institute of the Year in 2009. This was from Madame Liu Yandong, still the most senior woman in the Chinese Government and now Vice-Premier. I was recently able to see her

speak in Oxford about People Exchange and Boosting Development (Liu, 2017). Indeed, she emphasised that this is now considered the 'Golden Era' in China and that the UK is a key partner. How things have developed!

Madame Liu mentioned that it is 40 years since she, herself, was one of the first mainland Chinese students to visit Europe after the rapprochement with the West. Her tour then culminated in a first visit to Oxford. I can also say that early in my PhD – 1978/1979 – a delegation from mainland Chinese visited our laboratory with our Professor. Again, this was remarkable as part of the first outbound delegation since the time of Mao. Little did I know then how much I would personally have to do with China!

Aspire

This was the name given to the local Aimhigher partnership in South East London. Aimhigher was a key Government-funded initiative to raise children's aspirations and results in order to get more students from diverse backgrounds into Higher Education. This type of activity has been known as widening participation for some years. It involved student ambassadors going into local schools and inspiring children.

In our research, survey and other data and semi-structured interviews were analysed by a post-doc social scientist, Dr David Chilosi, from the London School of Economics. Each of three participant universities supervised the various strands – myself, Margaret Noble, then Deputy Vice-Chancellor, University of Greenwich and

Philip Broadhead, then Pro-Warden of Goldsmiths, Univesrity of London. In summary, from four papers written (Chilosi et al, 2008, 2009 (a) and (b), 2010), the results showed that:

- Student ambassadors (SAs – about 400 were employed in SE London), identified positively with education and higher education and saw the role as providing high levels of satisfaction and confidence as well as work experience.
- To a lesser extent, students also reported that the role helped them develop their study skills.
- The type of institution to which SAs belonged shaped attitudes towards the scheme – the 'institutional habitus' of new (post – '92) universities disciplines them towards endorsing utilitarian/vocational, as well as academic, values.
- Evaluation of such short-term initiatives is difficult. Some pointers were given to ways forward to improve this. Realist evaluation, as practised at Solent University, is a potential strategy in future.
- The partnership generated mutually beneficial links between educational institutions and between sectors. It did, however, lead to some conflict.
- Using a new method of multiple regression analysis, it was shown that Aimhigher had a positive impact on GCSE results and, especially, HE applications. Being targeted by Aimhigher was associated with an increase in probability of entering HE by about four percentage points.

The thrust behind this work was firstly to show that the Government money was spent beneficially, secondly to demonstrate exactly what the benefits were and to

whom, and thirdly to continue the research careers of the three supervisors with a view to successful submission in the Research Excellence Framework (REF), 2014.

The first two objectives were successful, but in the third we were in part thwarted. Although the strategy of using a high-calibre post-doc to prepare the papers worked well with these placed in good journals and conferences, rule changes for the REF to omit research led by management meant the work was not submitted for any of our universities.

So, some tips for your future REF work: yes, use a post-doc with the necessary skills and knowledge of the right journals, but be aware of the exact REF rules and that they do change from time to time.

In the event, although this applied research showed that Aimhigher provided multiple benefits, Governments come and Governments go. A new administration after 2010 discontinued Aimhigher and later, as fees were raised and loans increased, even grants for the most disadvantaged students were stopped. This has led to concerns that progress made in increasing Higher Education participation among such communities will eventually stop, giving potential impact on Government ambitions for social mobility. Some of this may be a theme for the recently announced Review of Funding in Tertiary Education in England. Meanwhile, new funding for widening participation has been granted by recent Governments and we receive some of this here as part of the Southern Universities Network (SUN).

I shall now say something about my background, education and how this has affected my own attitudes and led me to work very happily in a university with the mission of Solent.

Ambiguity

I am talking here particularly about Strategic Ambiguity. Is it better to have a detailed five-year strategic document including classically: mission, vision, strategic imperatives and objectives, which then translates to annual plans and personal objectives? Or is it better to have a higher level, more ambiguous document, perhaps limited to mission, vision and objectives for a five year plus period? Which might lead to better outcomes? This university has had both types over the last ten years. In industry, I was more used to working with the former and at a point in my career when I was General Manager, Strategy and Planning for Europe, we indeed used the methodology of Arnoldo Hax, Professor of Management at MIT. This used familiar methodology – Mission, Business Scope and Challenges; Environmental Scan; Opportunities and Threats; Strengths and Weaknesses; Portfolio Analysis; Business Strategic Priorities. Significantly, it then developed clear priorities against budgets through a set of broad action plans (3-5 years) mapped to specific actions plans (6-18 months). Those from ICI, Unilever and other Corporates will be very familiar with all this. It later developed into Hax's Delta model, centred on the customer (Hax, 2010).

But suppose the strategy is being developed for a voluntary organisation where leaders are in place for only a year before passing over the reins? Would a

broader, more ambiguous strategy be more effective in that situation? What if it were backed-up by clear values, triggering the right behaviours in volunteers?

This is a very interesting set of questions and our PhD student, Caroline Millman, is aiming to transfer to the research part of her programme using realist evaluation methods to answer these points for her case study of Rotary International as organisation.

Conclusion

It has been an honour and a privilege to work on a succession of fascinating projects in industry and universities with brilliant, co-operative colleagues. I have worked across disciplinary, geographical and cultural boundaries. I will be continuing a bit of this as a research supervisor and I am pleased with that. I have satisfied my passion for applied research in research-intensive and teaching-oriented universities.

I hope that these examples show you that applied research of widely differing types is hugely interesting and enjoyable. It also matters to the relevant industry or sector in benefitting consumers or clients for products and services by doing things in novel ways. In some cases, it also enhances the public good. In all cases, it can improve people's lives. The UK industrial strategy calls for more applied research and it is essential that such research interacts with 'Blue Skies' research to take completely new ideas into the market, or evaluate projects and initiatives. Solent University is well-placed to work collaboratively on such initiatives for the

future. The benefits should include knowledge transfer, consultancy, papers scoring highly in the Research Excellence Framework and ultimately new or better curriculum to teach. It is important to choose the part of this that suits your personality and background as far as the usual constraints allow. You are then much more likely to excel in your endeavours.

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