HELEN NEWTON TURNER MEDALLIST ORATION

G. A. Carnaby – 2001 Medal Recipient

I am both delighted and honoured to receive the Helen Newton Turner Medal, which has been awarded for my contributions to the wool industry, and especially for the application of mathematics and physics to the wool industry.

I got into wool quite by chance. The Foundation Director of WRONZ was an Australian, Norman Roberts, who came to New Zealand to set up WRONZ after working as a physicist at CSIRO, Ryde. Norman used to play tennis at the same club and he rang me one day and said that WRONZ was providing a scholarship for someone to go to the University of New South Wales in Sydney to study textile technology and would I consider applying for it. I was 17 at the time and didn't really consider going because I was set on doing physics at Canterbury, but my father was more worried about what he regarded as an unsuitable attachment to a young lady who lived on the other side of the city than he was about losing me to Sydney. Due to a process which I understand better now as a parent, than I did at the time, I went to Sydney.

I loved my time as a student in Australia, forgot the young lady, and got more interested in textile mechanics. I had a wonderfully inspirational teacher at the University of New South Wales. It was Professor Ron Postle who got me interested in the mechanics of fibrous assemblies for which we shared a passion over many years. Mechanics is a beautiful subject but when applied to the products which can be made out of wool it becomes very challenging because assemblies of fibres are actually, from a structural point of view, very complex materials. Unlike a simple structure such as a bridge or an aeroplane, they are comprised of literally millions of fibres held together in self-locking structures simply by friction. The structural elements, the fibres, are not just linear Hookean solids, they exhibit highly visco-elastic responses and both they and the structures made from them undergo extremely large deformations as a quite normal part of their use. If a bridge bends through 900 you've got a problem, so most of the classical literature in mechanics is concerned with stiff structures and the design of them so that they will not deform.

In contrast, wool textiles made from the finest wool are amongst the most sensuous and sophisticated products that you can buy, and the engineering of them so as to achieve softness of touch, comfort as you move, and elegance so that the three dimensional shell of your suit hides the worst features of your physique – these are the topics of mechanics in relation to textiles. I realize that the Trustees, in offering this award to me, have knowingly departed from the tradition of presenting it to Australian geneticists, a qualification to which I make no claim on either criterion.

However, I was never content just to be a theoretician in the field of mechanics and I have interacted with geneticists and animal production scientists throughout my career and so I would like, in the context of accepting this award, to refer to that interaction, too. It began through my involvement with linear programming and various applications of finite mathematics to wool marketing. We found in New Zealand that for our wool types, which are mainly woollen spun, you need to measure six principal physical features to provide a necessary and sufficient description of their processing potential. We had

to define some of these parameters, such as 'bulk' and Length After Carding, and develop our own tests for them. And here, particularly in the case of bulk, we developed a direct relationship to the subsequent work led by Roland Sumner on developing a new breed, the Growbulk Sheep.

The other connection which emerged here related to the application of finite mathematics to wool space. By wool space I mean the geometrical representation of the wool supply. Wool space can be treated as a six-dimensional vector space in which the price and quantity of clean wool at any given set of the six technical vector coordinates can be regarded as scalar quantities.

The analysis of the gradient of the price in this vector space provides the relative economic values needed in the equations which drive economic gain in classical genetics. And, by combining wools of differing prices from different parts of the space, we are now able to produce blends which just exceed defined technical limits for the six parameters, but which do so at least overall cost.

It was about this time in my life that I did discover that I had an unexpected connection to Australia. My father's father was an Australian but he had left 50 years before for my father to be brought up by my grandmother in Auckland. Imagine our surprise when my grandfather's second wife contacted us, having come across my name in the Sydney Morning Herald. We had a wonderful series of family reunions where everyone heard the other side of the story, with great reconciliations all round. It was a bit like a story from Dickens really, but for those geneticists amongst you I can provide some genuine, albeit anecdotal evidence here that if you split siblings early and bring them up in a different environment you will get different results. The New Zealand based Carnabys and my half uncles and their kids in Australia are all the spitting image of each other, but on our side we tend uniformly towards selfish pursuits, atheism and hedonism in various forms.

By way of complete contrast both of my uncles in Australia turned out to be Anglican parsons and they and their families lived lives as pure as the driven snow. When preaching, one of my uncles looks exactly like me speaking to an audience about mechanics – this is something which has caused me quite significant concern. In more recent times my own professional interests have been directed almost entirely to the task of leading WRONZ through the crisis which has confronted the wool industry since 1992. The formation of the stockpile coincided with the withdrawal of Russia, formerly a big user of bread and butter wool types, from the market. They have not yet returned.

For the most part of the last ten years the demand for wool has been insufficient to maintain farms in Australia and New Zealand at a sustainable level of profitability. And, in the resulting political upheavals, maintaining and growing the industry's research infrastructure has been something of a challenge. At last, now, after a period of fragmentation and disorder some cohesion and commitment has returned to the issue of wool R&D funding. So we as scientists supporting the industry have the chance to recommit ourselves to making it once again a great industry – and not just a by-product sector of the meat industry.

But to do that we need to focus on the new opportunities emerging both off-farm and on-farm. Firstly, we have to fix some problems with the fibre just to stay where we are. In carpets that means moths and the light stability of wool dyes. In clothing it's prickle. Prickle is inescapably bound up with fibre diameter

and it is definitely an on-farm issue for the geneticists to fix. Nothing much that can be done off-farm can disguise the bending stiffness of coarser fibres since their stiffness increases as the fourth power of their radius. And we need to keep making productivity gains on-farm and in converting wool to products.

Above all though, if the wool industry is to really go ahead again we need to find some new value chains for wool – new uses which ensure that wool is once again vital to wealthy customers. Only if we succeed with that will it be worthwhile for farmers to grow wool and for us to try to improve farm productivity and wool quality. But encouraging scientists to try and do this high risk work in an unstructured environment is not easy. Many of us prefer to work in lower risk areas that we know will make incremental change to what is known.

But what an exciting period we are in now. In wool, a new team of scientists led by Dr Bryson at WRONZ is revisiting the science of the structure of the fibre using the latest methodology. This has shown that, at the highest level of internal structure, wool can be regarded as comprising three main structural components, all of which have distinct mechanical behaviour. Firstly, it is now clear that the fibrils in the orthocortex are twisted like a yarn – whereas those in the paracortex are parallel. You can still model the paracortex as being rods in a jelly, as espoused by another of my mentors at the University of New South Wales, Professor Feughelman, but the orthocortex needs to be viewed as being an assembly of twisted strands. This results in a quite different mechanical stiffness in the two main cortical components – and it also explains the observed variation in crimp with moisture content. We also now know that the cuticle is about five times stiffer than the two main cortical components.

This new knowledge about the physical structure and the mechanical behaviour of them is now also being linked to protein composition through our proteomics research unit. So all in all there's some pretty exciting new knowledge about the expression of the genes in the wool fibre – and hopefully some opportunity with modern genetics to escape the tyranny of the follicle, which has constrained our ability to engineer the fibres in the way you can with man-made fibres. And perhaps we are not even talking about fibres at all. In our Keratec project we have essentially given up on the limitations of the follicle. If follicles can't produce wool fine enough, maybe we should start all over again by dissolving the coarser, cheaper fibres and re-extruding them as finer, more expensive ones. And if we find that the new uses for wool are in totally new sectors, non-fibrous uses such as personal grooming products, pharmaceuticals or medicine, then perhaps we will need different targets for genetic improvement of the sheep and their wool.

So, in conclusion, let me say that I receive this high honour with humility and with the acknowledgement that my management style in science has been described as 'promise and then delegate'. In this regard, I have been supported by a great number of highly talented and long-suffering individuals who have worked with me, and many of who still are. I accept this Award on their behalf, too. And in accepting it, I would like to acknowledge, too, the respect of all of us here for the life's work of Helen Newton Turner, a life devoted to genetics and the wool industry, and to her as a great scientist, communicator and inspirational leader. Her fame was international and her contributions are admired here in New Zealand today, as they are, and always have been in Australia.