funding has had an important role in how people see the Institute, in several different ways. To begin, its very existence helps establish the credibility of the Institute as an excellent research organisation. "If you're going to be a credible research institute on a world scale, then you need that sort of equipment," Sally explained. Second, the equipment, which is located at different Institute sites, is freely accessible to Institute researchers. "That is part of that whole fairness thing that comes through very strongly, about making sure that everybody is treated equally," she explained. Finally, the equipment also has an effect on attracting new people to the Institute, further contributing to the organisation's reputation for excellence.

Another interesting result is the effect that the formation of the Institute has had on collaboration between scientists within it. "Some of the people obviously had strong relationships before they went into the Institute, and others are quite new," said Sally. "Quite a lot of new young people have come in, and they have been very well integrated into the Institute quite quickly. You can tell from the co-authors of papers that there have been a lot of new collaborations formed, and there is a much more dense network of co-authorship across the whole Institute."

This collegiality - working cooperatively with others - is seen as important in the Institute. "I think Paul has imprinted some very strong values right from the start on the Institute around collegiality, and a lot of people talk about the fact that if you're not collegial - not collaborative - then this isn't the place for you. It's not a place for lone wolves trying to build up an empire. Science has always been collegial, you need everybody to be involved to actually be successful, so students have always been involved, and technicians have often been co-authors, but there was always a senior person who was the mentor of all of these people. Traditionally, it was a more pyramidal structure, whereas I think that in Centres of Research Excellence you've got so many really good researchers, it's much more flat from a hierarchy point of view."

The research project will continue until next year, and preliminary results have recently been presented at the European Group for Organizational Studies (EGOS) conference in Bergen, Norway. "The sorts of results that are coming through I think would be of interest not just to the MacDiarmid Institute, but also to other organisations trying to set up these research centres," said Sally Davenport. "It's fun, it's always interesting to go and talk to people. And we're getting to know everyone in the Institute as well which is really great."

# Mechanical Magic – Nature's 'Smart' Materials

**by Anna Meyer**

**From plants growing and flowering, to animals breathing and moving around, to DNA unwinding as it gets transcribed and copied, nature is a beehive of constant mechanical action. Many of the activities that occur in the natural world simply do not seem possible in things that are not alive – take fruit ripening, for example, which involves large-scale structural changes in a relatively short period of time. How can nature achieve such remarkable mechanical feats? A significant part of the answer lies in a unique class of materials found in biology, known as biopolymers.**

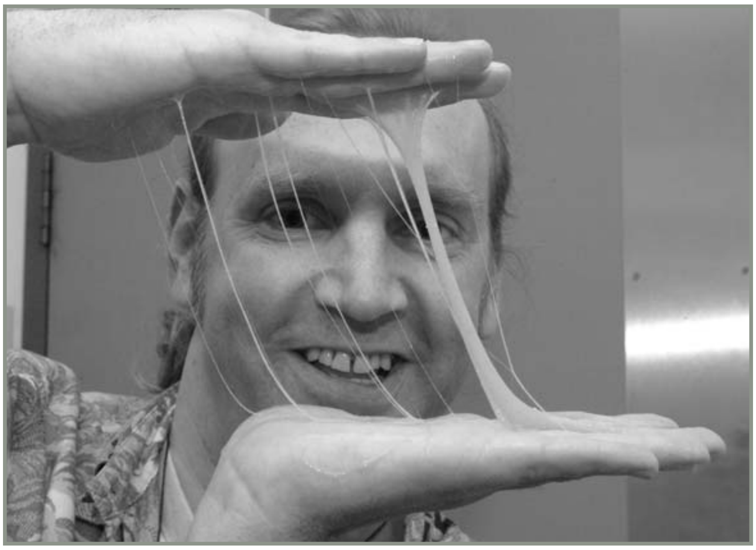
Biopolymers are long, chain-like molecules made from large numbers of smaller units joined together. Examples include proteins, polysaccharides, and DNA, and as a group, they have fascinating structural and functional properties. Materials constructed from these molecules are classified as 'soft', because they are stretchy and gel-like, neither true solids nor liquids, but somewhere in between. Biopolymers are 'smart', adaptable materials – in living things, their structures are constantly manipulated by enzymes throughout different stages of an organism's life cycle, or in response to environmental triggers. This 'molecular tinkering' can be very subtle, but can cause very large changes in an organism's structure or function, leading to the unique mechanical abilities possessed by living things.

Dr Bill Williams, a member of the Institute of Fundamental Sciences at Massey University and the MacDiarmid Institute, is working to understand how the structures of biopolymers relate to their function, and how the small changes at a molecular level can change their properties. In particular, he is interested in polysaccharides, which are a major class of structural biopolymer made from chains of linked sugar molecules. "Polysaccharides are maybe seen sometimes as a bit of a poor man's biopolymer," he joked. "When people think of polysaccharides, they tend to just think of something like starch, which they don't think is very interesting." Actually, he explained, this is not the case at all – not only are polysaccharides fascinating, but they are right at the heart of many biological structures. Plant cell walls, for example, are filled with polysaccharides, which control the mechanical properties of the walls and their ability to change in response to different environmental triggers.

To investigate the structure and function of a particular polysaccharide, Dr Williams and his team begin by extracting it from living tissue, and carefully characterising its chemical structure. Then, they manipulate the molecular structure of the polymer slightly, in a precisely known way, and examine how this affects the behaviour of the molecule, for example when it assembles into a gel – which is a useful model of how it would behave in a living system. “The aim is to understand how, when we change different features, we change the behaviour,” he explained. “The ways in which we tinker with the biopolymers are primarily ways that we think model processes that actually happen to them in nature.”

One molecule that the team has worked extensively with is pectin, a polysaccharide which is present in the cell walls of all land plants. Pectin has a particular distribution of chemical groups along its central ‘backbone’, and changes to this distribution modifies how the polymer interacts with calcium. In turn, this affects how chains of pectin crosslink together, which determines the structural properties of networks of the biopolymer. “If I have pectin in a test tube, and I play with the pattern and amount of substituents, and then introduce calcium, I get gels with various properties,” said Dr Williams. “That’s interesting, because we know that in the plant, there are enzymes which are responsible for controlling this degree of the substitution.”

**“When people think of polysaccharides, they tend to just think of something like starch, which they don’t think is very interesting.” Actually, he explained, this is not the case at all – not only are polysaccharides fascinating, but they are right at the heart of many biological structures.**



Another molecule they have been investigating is collagen, the main protein found in many body tissues, including cartilage, ligaments, bone, teeth, tendons and skin. Interestingly, collagen is found in stretchy tissues like skin, and also in more rigid tissues like cartilage. How does it manage to be both elastic and non-elastic? It has been known for some time that collagen fibrils are crosslinked by polysaccharides, and that there are slightly different forms of these in stretchy and unstretchy tissues. Could this be the key? By stretching single collagen-associated polysaccharide chains from different tissues using an atomic force microscope, Dr Williams and collaborators, Associate Professor Haverkamp and Professor Scott have shown that in tissues which are quite unstretchy, such as cartilage, collagen is crosslinked by polysaccharides that do not extend very easily. In tissues that have to be very flexible, such as skin, collagen is crosslinked with polysaccharides that are easier to extend. In an illustration of the versatility of biopolymers, the two forms of polysaccharide have an almost identical chemical structure, but have vastly different properties.

Overall, Dr Williams’ research has two aims. The first is to simply understand nature, to gain an appreciation of why the natural world uses the biopolymers it does, and how it manipulates them to achieve structural changes. The second aim is to explore the possibility of making use of nature’s methodology to make new soft materials for our own use. “Soft materials are used in absolutely stacks of stuff all the time,” said Dr Williams, “in food, and household products such as toothpaste and shower gel - more or less anything that you eat, or put on your body. Naturally occurring materials tend to be very smart materials – they can change their mechanical properties according to environmental signals, so maybe some of those properties could be used to make new soft materials that have some of those smart properties.” This area of work is known as ‘biomimetics’, involving understanding how nature comes up with solutions to problems, and mimicking them. In other words, said Dr Williams, “let’s have a look at how nature does it, pinch the ideas, and then try to apply those ideas to produce materials and devices with designed properties.” “Lots of physicists are inspired by life,” he said, “and most interesting biological problems have some aspect in them to do with biopolymers.”