Looking into the middle ground

When someone says they are studying soft materials, you may think of cuddly toys or velvet cushions, but to MacDiarmid researchers it means the long chains of molecules that make up cellulose fibres, dairy-based casein micelles and protein filaments in hair or food.

These biomaterials form an intermediary hierarchy between the atomic and single molecule arena at the nano-end of the scale and the real-world mass and form of everyday objects.

Take a very, very close look at an ordinary glass of milk, for example, and you'll find it made up of hydrogen and oxygen, calcium, phosphorus and other elements. Pull back a little and you'll see these organised into molecules of proteins, fats, carbohydrates, which can, in turn, agglomerate into highly complex structures such as the roughly spherical globules of casein micelles, composed of thousands of large protein molecules.

The biomaterials field has looked at the properties of individual polymers, as well as examining the properties of the bulk materials they produce, but the area of the intermediate states remains a tad fuzzy.

"Hair, for example, is not just individual proteins stuck together in a lump," says MacDiarmid Theme 4 Soft Materials research leader Dr Bill Williams. In hair, as in many biological structures, long chains of proteins are arranged together in filaments, which then assemble into fibrils. Even though this self-assembly is somewhat ubiquitous in living systems, how it occurs remains something of a puzzle, and predicting what happens and how it affects the resulting soft material so formed is equally unclear.

"Just because you know the molecule doesn't mean you're going to understand the properties of the material," says Bill. It's this area of the "mesocule", as he puts it, which has formed the focus of a new MacDiarmid collaborative project that aims at gaining a better understanding of this area and its implications when designing new biomaterials.

"If you want to understand soft materials, you really do need to look in the mesocule space. If you look at just one single molecule, you'll never understand how it works."

Gaining that greater understanding could point the way to being able to optimise the desired properties of biomaterials, leading the way to potentially huge improvements in medical applications such as artificial joints; foods with improved taste and texture qualities; or a more environmentally friendly means of oil extraction.

Getting that work under way involves tapping into a broad range of expertise and requires an equally broad variety of specialist equipment. Bill is based at Massey University, being an Associate Professor in the Physics, Chemistry and Biophysics Group. Working with him are MacDiarmid Principal Investigators, Dr Juliet Gerrard, Professor of Biochemistry at Canterbury University and co-director of their Biomolecular Interaction Centre;

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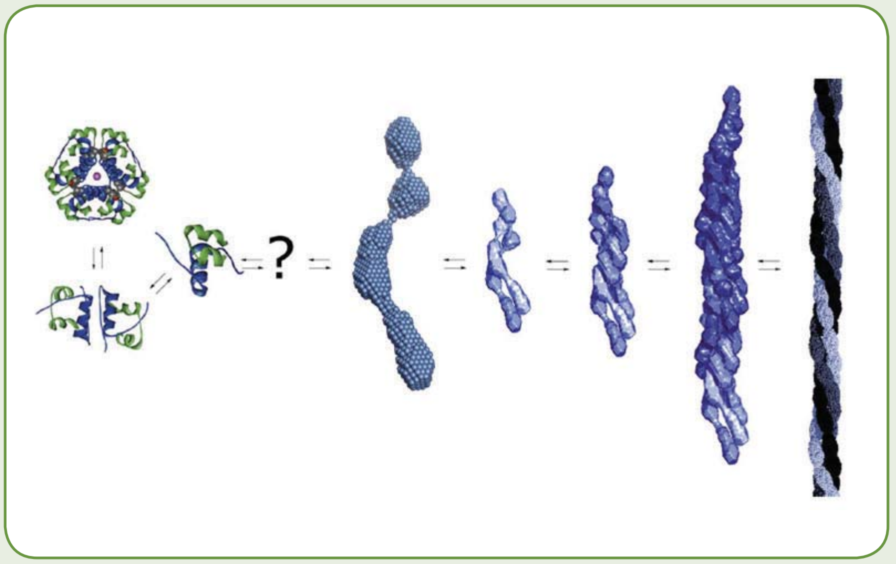

Insulin forms fibrils of about 7-10 nm in diameter, however lengths of fibrils vary hugely due to the complex nature of the fibril mechanism. These fibrils form rapidly when subjected to elevated temperature, low pH and in the presence of salt. Varying these growth conditions, along with native protein concentration, time and also the way in which the mature fibrils are stored are shown to have varying effects on the length of the fibril formed.

and Dr Kate McGrath, Professor of Chemistry at Victoria University.

"Together we've got the opportunity to do this," says Bill, adding that it wouldn't be possible any other way.

The team is settling into place across the three institutions. In Palmerston North, working alongside Bill, is postdoctoral fellow Sandy Suei, born in Taiwan, brought up in New Zealand and recently returned from postdoctoral work from Canada. The other postdoctoral fellow is Luigi Sasso, an Italian who is travelling from Denmark to work at Canterbury with Juliet. Two research students from Spain and Greece, the former supported by the Riddet Institute, fill out the initial group.

Bill expects further travel to be on the cards for everyone, as the plan is for researchers and students to get together at the different campuses as the project proceeds.

"I'm excited about the ability to bring together different skills and different expertise. The success of the project will depend a lot on how these guys work together."

Bill sees strong value in taking advantage of complementary expertise, as well as making use of complementary facilities and equipment. Trying to gain a better understanding of what is happening in the intermediate level between individual molecules and soft materials requires a variety of steps.

It starts at Canterbury, where the on-site expertise in protein engineering will be utilised in attaching micro-sized beads at either end of fibrils made from a common protein found in whey, beta-lactoglubulin. Luigi's job will be to make controlled lengths of these beta-lactoglubulin fibrils, stretching them between the beads.

The team at Massey will then take these and use that institution's Optical Tweezers to measure the mechanical properties of the fibrils, or, as Bill puts it rather more colourfully, "they stick the handles on them so we can do the prodding and pulling."

At Victoria, the project team will use a range of techniques – rheology, cryo-scanning electron microscopy and small-angle X-ray scattering – to study the resulting networks of macroscopic gels and develop models that will allow predictions of the bulk properties to be made from what is known about the individual fibrils.

Having specialist equipment available every step of the way is vital to the project's success, not just in the lab itself but also via generating interest further afield from researchers and students keen to work with such gear.

"It's really a very powerful way of bolstering collaborations." Bill believes that funding support for equipment and joint students provides two very strong reasons for why the CoRE system has been so successful in development collaborations throughout New Zealand research institutions.

"I can't think how else you could fund this without [something like] the MacDiarmid. Collaborations are really awesome."