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# FABRICS GO SMART

For the first time, UNSW biomedical engineers have woven a ‘smart’ fabric that mimics the sophisticated and complex properties of one of nature’s ingenious materials, the bone tissue periosteum. **Bindu Gopal Rao** unearths the science behind this unique innovation through a chat with Prof Melissa Knothe Tate, Professor and Inaugural Paul Trainor Chair of Biomedical Engineering, University of New South Wales, Sydney, Australia.





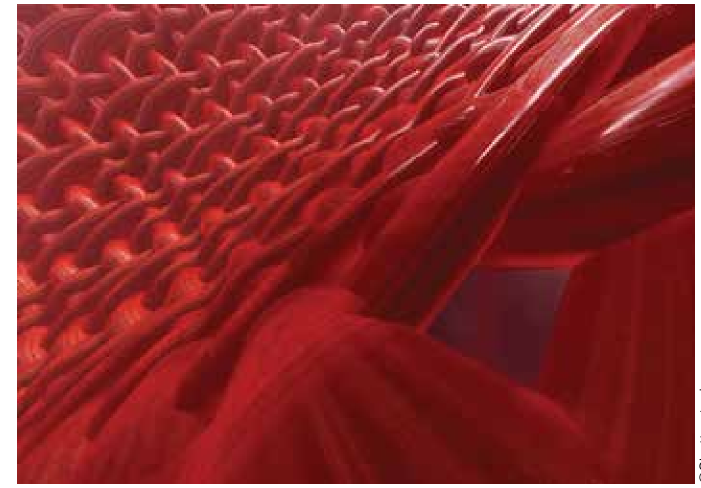
Having achieved proof of concept, the researchers are now ready to produce fabric prototypes for a range of advanced functional materials that could transform the medical, safety and transport sectors. Patents for the innovation are pending in Australia, the United States and Europe.

**PLEASE EXPLAIN ABOUT THE INNOVATION OF SMART FABRIC.**

University of New South Wales (UNSW) biomedical engineers have developed a ‘smart’ fabric, similar to bone tissue, that is hoped to transform the facets of the safety, medical and transport industries. The fabric imitates periosteum, a soft tissue which covers bony parts of the body. Periosteum is made of a structure of elastin, collagen and other proteins that provide added strength and resilience against high impact. To produce the fabric, the UNSW research team visualised the tissue’s structure in 3D on a computer, scaled up each section, and made prototypes using weaving loom technology. The fabric could be used for a range of applications including compression bandages, that respond to the wearer’s movement, safer steel-belt radial tyres, and protective suits for astronauts and, skiers that stiffen under high impact.

**HOW WILL IT HELP THE APPAREL INDUSTRY?**

The material can be used for clothing, wearables (multifunctional devices that interact with the body, typically when worn on the body) and next generation implants, which are wearables for the inside of the body. The material can be made from threads as diverse as titanium or the silk of the golden orb spider. Depending on the pattern and composition of the textile, fabrics can be made, that become incredibly tough under impact loads or materials that never develop residual stresses. The aim is to emulate natural tissues that exhibit support and protective functions in novel ways. For example, the periosteum is super-stretchy and soft if you tug on it gently. If you remove the soft sheath from a bone and load that bone until it breaks, it will break at a much lower force without the periosteum. This means that the soft sheath of the periosteum confers super-strength to our relatively hard bones. Potential future applications range from protective suits that stiffen under high impact for skiers, racing-car drivers and astronauts, through to ‘intelligent’ compression bandages for deep-vein thrombosis that respond to the wearer's movement and safer steel-belt radial tyres. The researchers have also



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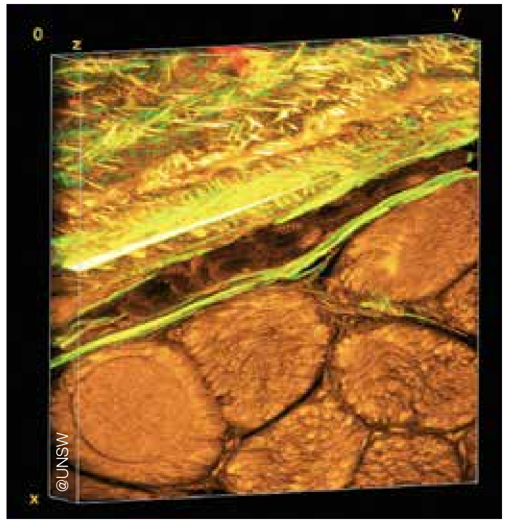
demonstrated the feasibility of using this technique to test other fibres to produce a whole range of new textiles.

**WHAT MAKES THE FABRIC 'SMART'?**

One of the researcher’s main aim was to use the fabric to fix human body parts. The long term goal is to weave biological tissues, essentially human body parts in the lab to replace and repair failing joints that reflect the biology, architecture and mechanical properties of the periosteum. The fabric imitates periosteum, a soft tissue which covers bony parts of the body. The result was a series of textile swatch prototypes that mimic periosteum’s smart stress-strain properties.

**PLEASE EXPLAIN THE TECHNOLOGY USED TO DEVELOP THIS FABRIC.**

The team had for the first time mapped the complex tissue architectures of the periosteum, visualised them in 3D on a computer, scaled up the key components and produced prototypes using weaving loom technology. The result was a series of textile swatch prototypes that mimic periosteum’s smart stress-strain properties. The team also demonstrated the feasibility of using this


technique to test other fibres to produce a whole range of new textiles. In order to understand the functional capacity of the periosteum, the team used an incredibly high fidelity imaging system to investigate and map its architecture. They then tested the feasibility of rendering periosteum's natural tissue weaves using computer-aided design software. The computer modelling allowed the researchers to scale up nature's architectural patterns to weave periosteum-inspired, multi dimensional fabrics using a state-of-the-art computer-controlled jacquard loom. The loom is known as the original rudimentary computer, first unveiled in 1801. The technique has significant implications for the development of next generation advanced materials and mechanically functional textiles.

### HOW DID YOU THINK OF BONE TISSUE PERIOSTEUM?

Many animal and plant tissues exhibit 'smart' and adaptive properties. One such material is the periosteum, a soft tissue sleeve that envelops most bony surfaces in the body. The complex arrangement of collagen, elastin and other structural proteins gives periosteum an amazing resilience and provides bones with added strength under high impact loads. The team can use the new technology to replicate many natural weaves, focusing on periosteum to start with, given its novel smart properties and the team's experience with imaging this tissue.

### WHAT ARE THE CHALLENGES YOU FACED?

The biggest challenge was reducing a big concept to a series of hands-on tasks to 'reduce the concept to practice'. This is the difference between being a visionary and being an inventor. Both are important steps in creating so called 'disruptive technologies' that open up new markets. The challenge with using collagen and elastin, is their fibres that are too small to fit into the loom. So the team used elastic material that mimics elastin and silk that mimics collagen. The loom can actually accommodate up to 5000 different types of fibres.

### TELL US MORE ABOUT THE JACQUARD LOOM.

The team tested the feasibility of rendering periosteum's natural tissue weaves using computer-aided design software. The computer modelling allowed the researchers to scale up nature's architectural patterns to weave periosteum-inspired, multidimensional fabrics using a state-of-the-art computer controlled jacquard loom. The loom is known as the original rudimentary computer, first unveiled in 1801. While the materials produced by the jacquard loom have potential manufacturing applications – one tyremaker believes a titanium weave could spawn a new generation of thinner, stronger and safer steel belt radials.

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Prof Melissa Knothe Tate, Professor and Inaugural Paul Trainor Chair of Biomedical Engineering, University of New South Wales, Sydney, Australia.

### WHAT ADVANTAGES DO YOU SEE IN THIS FABRIC OVER TRADITIONAL ONES?

The fabric will help the team achieve its longer-term goal to weave biological tissues – essentially human body parts, in the lab to replace and repair failing joints that reflect the biology, architecture and mechanical properties of the periosteum. The smart properties of the textile include that it is mechanically active, for instance can harness the movement of the arm to send pressure waves up the arm, helping fluid movement from the fingers back up to the shoulder and the heart, the body's most efficient pump.

### WHAT ARE THE FUTURE PLANS FOR THIS INNOVATION?

An NHMRC development grant received in November will allow the team to take its research to the next phase. The researchers will work with the US based Cleveland Clinic and the University of Sydney's Professor Tony Weiss to use the 'smart' technology to develop and commercialise prototype bone implants for pre-clinical research within three years. The fabric could also be used for a range of applications including compression bandages that respond to the wearer's movement, safer steel belt radial tyres, and protective suits for astronauts and skiers that stiffen under high impact. There has also been a lot of interest in the textile from athletic and garment manufacturers too.

### ANYTHING ELSE THAT YOU WOULD LIKE TO TELL US ABOUT THIS FABRIC.

We are entering an exciting new phase where, our clothes will become extensions of our bodies! Recently we had put in a proposal with a manufacturer of fibres made in India and we look forward to expanding our base with the renowned textile sector in India. ■