Summary
A novel multi-laminar and anisotropic osteochondral scaffold has been developed and preliminary in vivo data obtained. This scaffold mimics the natural structure of articular cartilage, which is a highly organized, fibre-reinforced tissue with specific mechanical and biological properties. This innovative scaffold material not only provides the mechanical strength that matches the native tissue but also assists with new extracellular matrix formation enabling replacement of the natural tissue (demonstrated by studies in piglets and pigs).

Quick Info
Benefits
• Biomimetic composition with layers of varying fibre orientation, pore structure, and stiffness to closely align with natural cartilage.

• Material can be used to repair larger defects, as the material is capable of bearing dynamic load while supporting tissue growth.

• Mechanical properties provide a protective environment for the cells migrating or seeded into the scaffold. Based on scaffold design, scaffolds feature high cellular seeding efficiency and can be localized within different regions of the scaffold based on the local density, surface area and porosity; Scaffolds support long term production of cartilage like tissue as established through extensive in vitro characterization. Scaffold can be integrated with a number of bone substitutes.

Applications
• The cartilage scaffold itself could be used in conjunction with microfracture.

• It can be pre-seeded and cultured with chondrocytes.

• Fused with the bone component, and can be used as an osteochondral plug.

• Main application areas: Joint trauma or disorders (fall/impact; joint dislocation; ligament tear or meniscus tear) and osteoarthritis.
Background
Articular cartilage damage or deterioration can be caused by injury or trauma, congenital abnormalities or hormonal disorders as osteoarthritis. Ankle, digits, elbow, hip, knee, shoulder or wrist can be affected by articular cartilage disorders. If damaged cartilage is not treated, it can worsen and eventually require joint structure replacement surgery. Articular cartilage is a difficult tissue to mimic as it is a highly organized, fibre-reinforced tissue with specific mechanical and biological properties. This tissue exhibits unique anisotropic mechanical properties and organization based on structural arrangement of its extracellular matrix components retained within a collagen meshwork. The collagen fibres orientation varies throughout the depth of the tissue: parallel, random or perpendicular orientation which makes complicated to mimic the cartilage properties.

Technology
A team at Imperial College London led by Professor Molly Stevens developed the Osteochondral Scaffold. The original 3D fibrous scaffold structurally mimics articular cartilage. It enhances natural cell-extracellular matrix interactions, promote cell proliferation and cartilage-like tissue formation. It provides a template to organize the newly deposited matrix. The scaffold is a 3D laminated construct comprising various nano to micron-sized fibres with anisotropic structure and composition.

The scaffolds were tested in vivo using a porcine osteochondral defect model under four conditions; acellular osteochondral scaffold, cellularized scaffold with allogeneic chondrocytes, MaioRegen scaffold, or empty defect. The two scaffold groups (acellular and seeded) revealed strong bone ingrowth and osseointegration within the PCL open-pore lattice, which also shows strong invasion and population of the acellular scaffold with chondrocytes as visualized by the pink/red staining.
The key features of this technology are:

- The scaffolds cover defects as large as any competing Matrix-ACI approach. Scaffolds in 10 cm x 10 cm sheets are produced and cut to size. Large sheets of scaffolding can be produced and can be applied to virtually any surface covered by articular cartilage including femoral condyles, tibial plateau, hip, etc.

- The mechanical properties of the construct match those of native articular cartilage, thereby allowing it to perform mechanically from implantation and in large defects.

- With the osteochondral design option, it is possible to anchor neo-tissue to the subchondral bone in a large defect, providing greater stability.

- The scaffold has also been successfully bonded to porous bioactive glasses.

Market
The global cartilage repair/regeneration market size was valued at USD 4.2 billion in 2016 and is expected to grow at a CAGR of 5.4% during the forecast period, reaching USD 6.7 billion by 2025.

Team
Prof Molly Stevens: Professor of Biomedical Materials & Regenerative Medicine in the Faculty of Engineering, Department of Materials at Imperial College London. She was recognised by The Times as one of the top ten scientists under the age of 40 and also received various awards.

Intellectual Property
The technology is protected by a US granted patent (US9393097B2).

References

