NU-Bone: Antler BioDesign for structural tissue engineering and cellular agriculture

Supervised by Dr James Henstock & Professor Martyn Dade-Robertson
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Summary: This PhD will develop *in vitro* biotechnologies to create living bone structures for applications in cellular agriculture (cultivated meat), bio-machine interfaces, engineering, design and architecture.

Background: By combining research in regenerative antler biology with cutting-edge techniques from tissue engineering and cellular agriculture, it is now possible to design and create 3D structures from lab-grown living bone. Deer antler is one of the fastest growing mammalian tissues and can form at a rate of 2.5cm per day to produce 25kg bone in under 20 weeks – a fully regenerative process which is repeated annually. Developing from a stem cell-filled cranial pedicle, antler bone grows rapidly to create a complex 3D structure with a solid outer cortex and an interior strengthening meshwork of organised trabecular struts and plates. Like all bone, the 3D structure of antler is highly responsive to biomechanical forces and becomes stronger in alignment to the stresses it experiences, generating a strong and lightweight mineralised organic composite material which can be biomechanically shaped as it grows.

The project: In this PhD, you will develop a methodology to grow human-designed 3D structures from deer antler stem cells in bioreactors, combining cutting edge research in stem cell culture, cellular agriculture, bioprocessing, bioreactor engineering, nanotechnology, mechanobiology and design engineering. Our objectives are to establish methodologies to grow multiple kilograms of highly structured bone which you will evaluate using an array of analytical methods including mechanical resilience, advanced fluorescence and 3D microscopy, X-ray microtomography (microCT) and quantified biochemical analysis. You will also engage with our ongoing interests in extraplanetary biomanufacturing to determine how these engineered tissues could be grown in microgravity, and how the internal trabecular structure can be organised by design to strengthen the material using nanotechnology and field-based electromagnetic mechanical stimulation. You will also explore the downstream applications of this new material, from current market opportunities as cultivated meat scaffolds and bio-machine interfaces to larger scale structural applications in luxury goods, engineering and 'grown' architecture. You will also determine how far these antler-inspired biotechnologies can be translated to revolutionise human healthcare technologies, and if some of the two million bone transplants performed every year can be grown from human stem cells through a similar process.

Antler BioDesign Bioreactor (AI-generated image)

Supervision: You will be supervised by Dr James Henstock (Associate Professor of Bioengineering) and Professor Martyn Dade-Robertson (Professor of Emerging Technology). James has a track record in translational musculoskeletal tissue engineering using advanced nanotechnology and bioreactors, including having launched tissue engineered human muscle to the International Space Station to better understand how living tissues behave in microgravity, and an industry career developing the large-scale biotechnologies needed to create cultivated meat. Martyn is an interdisciplinary academic with a career spanning architectural design and synthetic biology with projects exploring new material possibilities for architecture through morphogenesis and biomineralization, and is co-director of the £8M Hub for Biotechnology in the Built Environment held between Newcastle and Northumbria Universities.

Northumbria University's BioFutures Interdisciplinary Research Theme (IDRT) explores innovating new biotechnological approaches to replace our fossil fuel-based economy with more sustainable alternatives. Together with our other IDRTs including Space (biomanufacturing in extreme environments, e.g. enabling transplanetary habitation) and UrbanFutures, Northumbria is leading the way in addressing the challenges and opportunities presented by the need for global change.