E3 Scholarship Project Description

Passive Skeletal Muscle Form and Function: Engineering Insights from Zoology

Principal Investigator:  Ciaran Simms (School of Engineering, Mechanical and Manufacturing Engineering)

Official Collaborator:  Paula Murphy (School of Natural Sciences, Zoology)

Brief Description of the Research

This PhD position is in the area of musculoskeletal biomechanics. The passive mechanical properties of muscle tissue are important for many biomechanics applications, including impact biomechanics, surgical simulation and rehabilitation engineering. However, significant gaps remain in our understanding of the three-dimensional response of skeletal muscle tissue to applied loading. Apart from the nonlinearity, anisotropy and viscoelasticity associated with soft biological tissues, it has recently been observed that the stress response of skeletal muscle to stretching in both the fibre and cross-fibre directions is two orders of magnitude stiffer for tension than for compression (see Figure). Conventional fibre-reinforced composite theory fails to capture this. Instead, the work proposed here will test the novel hypothesis that the passive mechanical behaviour of skeletal muscle tissue is dominated by soft but incompressible muscle fibres surrounded by stiff but initially wavy collagen fibres of the connective tissues. This hypothesis will be examined using a micro-structural and mechanical study of different muscles from a variety of animal species. This will provide comparative data across a number of systems naturally adapted to different functions, in order to corroborate or falsify this hypothesis.

Figure: Passive skeletal muscle stress-strain response for a load applied at different angles (α) to the main muscle fibre direction; (A) compression and (B) tension; note the magnitude differences between (A) and (B).
The research will lead to an understanding of why skeletal muscle takes the form observed, and how this determines the deformation behaviour of the tissue. The project will be supervised by Ciaran Simms, Assistant Professor in Mechanical and Manufacturing Engineering, in collaboration with Paula Murphy, Associate Professor in Zoology, School of Natural Sciences. The expertise within Natural Sciences will provide cross-species insight and depth in biological analysis. Engineering principles will guide the testing of functional properties, and the development of models of muscle response. The research will benefit biomedical engineering applications ranging from impact protection devices and drug delivery systems, to tissue engineering.

Applicant Profile and Procedure

Applicants should be first-class honours graduates in biomedical engineering or a cognate discipline, with interest and/or experience in the natural sciences.

This E3 Scholarship covers full annual PhD tuition fees, and provides an annual stipend of €8000, for three years, in line with TCD’s Postgraduate Research Studentships. Additional income may be gained from occasional service as a postgraduate teaching assistant.

To apply, please send (1) a letter of motivation, (2) a full curriculum vitae (CV) with details of qualifications and experience, and (3) the contact details of two referees, to Ciaran Simms (csimms@tcd.ie), who may also be contacted for further information and enquiries about this E3 Scholarship opportunity.

The closing date for applications is 31st August 2013. The successful candidate should be available to commence their PhD studies at Trinity College Dublin in late September 2013.