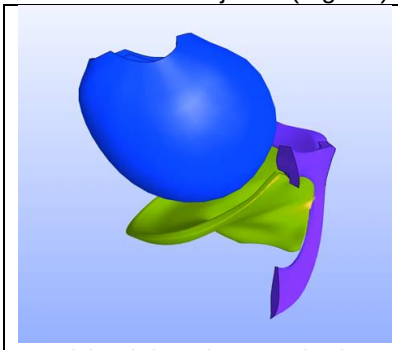
QUB - Mechanical and Aerospace Engineering
PhD Project Description

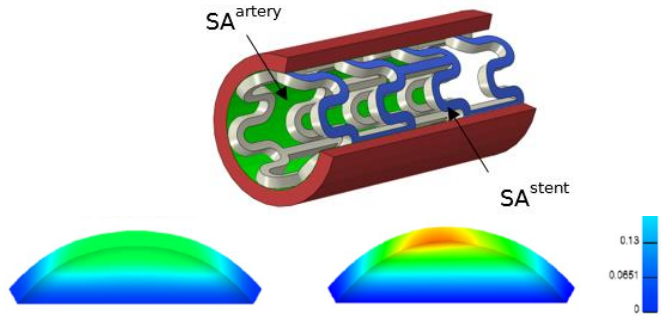
Title:	**Research Opportunities in Soft Matter Biomechanics**
Theme:	**Bioengineering**

Project description:
Very flexible (soft) materials exist at multiple length scales within the body, from muscle and connective tissue down to the membranes of cells. Understanding their role in disease, injury, and regeneration provides numerous exciting challenges for biomechanics research. A range of possible topics in which there has been recent or active research include

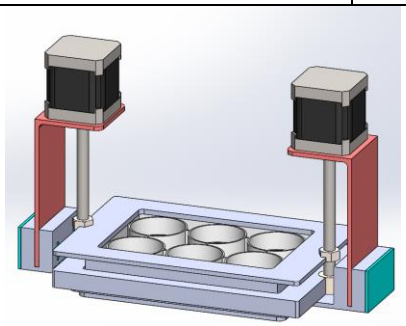
- investigating properties of pelvic floor muscles to understand injury risk during childbirth (Fig. 1a),
- investigating deployment of bioresorbable stents within diseased arteries and their subsequent resorption (Fig. 1b-top),
- modelling cornea biomechanics to help understand cornea degradation and/or improve laser eye surgery (Fig. 1b-bottom)
- experimental and/or numerical investigation of response of human airway cells to chronic coughing in respiratory disease,
- multiphysics modelling to investigate how biological cells interpret mechanical loads induced by their environment, e.g. within deforming muscle tissue or the highly loaded regions of cartilage and bone within our joints (Fig. 1d).



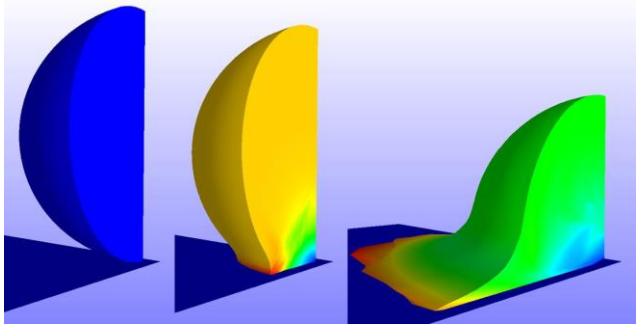
(a) Finite element (FE) model of childbirth



(b) FE models of a stent (top) and healthy and degenerated cornea subjected to normal intraocular pressure (bottom)



(c) Mechanical testing device to exert radial stretching on flexible cell culture plates to simulate stretch experienced during coughing



(c) Passive FE model of a cell spreading

Fig. 1: Examples of potential activities within suggested research topics.

Other opportunities may exist, depending on the candidate's interests and whether relevant collaborators exist or can be readily identified.

Aims and Objectives:

Depending on the chosen topic a typical project may attempt to

- characterise mechanical properties of the tissue of interest,
- develop/adapt material models for use in FEA of devices (e.g. stents) and/or surrounding tissues (e.g. arterial tissue),

- perform testing and/or develop material models for time-dependent behaviour of biomaterials or tissues (e.g. during device degradation, disease progression, or healing after injury),
- develop mathematical models of cell population behaviour and integrate them with either experiments or simulations of cell populations within mechanically loaded environments,
- develop multiphysics models of individual cells that link biochemistry with the cell to mechanical loading within the cell's structural elements

Key skills required for the post:

- A minimum upper second class bachelor degree in Mechanical/Aerospace/Biomedical Engineering, Physics, Applied Mathematics, or relevant degree
- For all topics:
  - Have, or be willing to develop, awareness of anatomy and physiology relevant to the topic.
- For topics with an experimental testing emphasis:
  - Experience with general design and manufacturing (CAD, appropriateness of manufacturing techniques, etc.)
  - Understanding of mechanics of materials and mechanical testing principles
- For topics with a modelling emphasis:
  - applicants with an interest in computational mechanics are preferred. Experience in using finite element analysis (FEA) software such as Abaqus, MSC.Marc, or FEBio is an advantage but strong candidates with good understanding of general computational methods as well as general mechanical principles (e.g. continuum mechanics) are also encouraged.
  - Have, or be willing to develop, the ability to code novel algorithms; knowledge of at least one compiled (e.g. C++/Fortran) and one interpreted (e.g. Python/Julia) programming language would be an advantage.

Key transferable skills that will be developed during the PhD:

Training will be targeted towards securing employment in medical device companies, academic institutions, and national & international government agencies. Training areas will include four domains encompassing knowledge & intellectual abilities, personal effectiveness, research governance & organisation, engagement influence & impact. Opportunities will also exist to avail of both general and technical training activities provided by the Bioengineering Research Group.

Specific technical skills referred to in the key skills for the post will also be highly transferrable to careers in research and development within academia, medical device companies, and any industries requiring understanding of soft matter deformation (e.g. polymer processing) and advanced FEA (consultant engineering, developers and support for FEA companies).

Lead supervisor:	Dr Alex Lennon (Lecturer, Bioengineering Research Group) a.lennon@qub.ac.uk
Other supervisor(s):	A range of collaborators are available to develop research programmes in the topics highlighted above.
Funding mechanism:	Yet to be secured.
Application closing date:	Dependent on funding mechanism
Guaranteed stipend:	Basic stipend and any top-up will depend on funding mechanism. N.B. Stipend for 20-21 is not yet confirmed. Base stipend for 19/20 is £15,009.
Conditional top-up available:	Dependent on funding mechanism, applicant CV, and applicant performance

PhD students in the School may have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.