

Can a picture predict strength? Learning how collagen architecture sets the mechanics of living tissue.

Project ID: 3601

Supervisory team

Lead supervisors: Dr Ben Sherlock (University of Exeter) & Dr Daniela Oehring (University of Plymouth)

Other supervisors: Dr Ben Gardner (University of Exeter) & Dr Matt Jones (University of Plymouth)

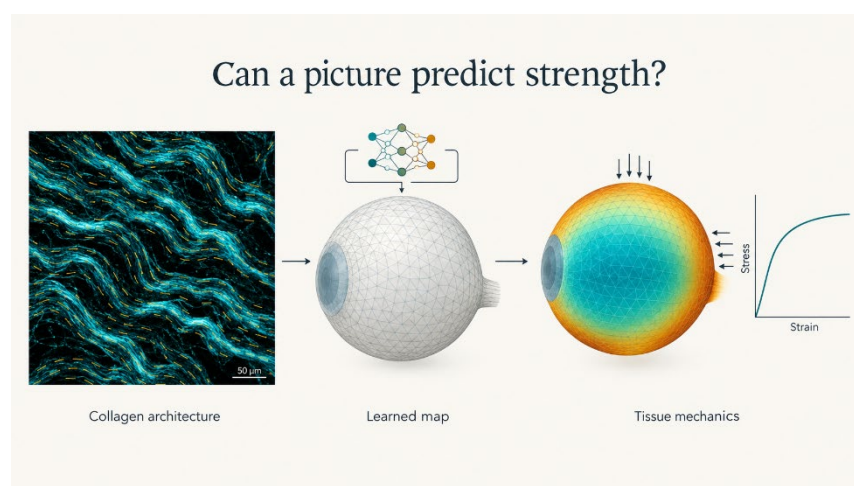
Collaborators: Dr Craig Boote (Cardiff University) & Prof Ahmed Elsheikh (University of Liverpool)

Registered institution: University of Plymouth

Host institutions: University of Exeter/University of Plymouth

Project description: Collagen makes connective tissue strong, and the direction its fibres run makes it stiff one way and compliant another, like grain in wood. What is unknown is whether an image of that structure predicts mechanical behaviour better than the two or three numbers we boil it down to: a mean fibre direction and how neatly the fibres line up. If the image wins, every model of soft tissue in use is leaving information behind. If not, a long-running argument closes. Either way it matters beyond the eye: such

models borrow their material properties from other specimens. You will answer that in two tissues from the same eye. Cornea and sclera are continuous and built from the same collagen, arranged very differently: cornea in ordered lamellae of uniform fibrils, sclera interwoven and variable. Any difference in predictive performance comes from the arrangement. So there is a prediction you can be wrong about: the summary numbers should work on the ordered tissue and fail on the disordered one. At Exeter you will image collagen architecture in viable and freshly excised tissue by label-free, polarisation-resolved multiphoton microscopy. At Plymouth you will measure how the same specimens carry load. Generating that paired dataset, two architectures within one eye, is the project's first half. You will then learn the map from architecture to mechanics twice over: classically, fitting an established model to fibre orientation and dispersion, and with a neural network reading the whole image, constrained so thermodynamics holds by construction. Comparison on unseen specimens answers it. The last question is the most interesting. Living tissue rebuilds itself in response to load. Does tissue held under sustained load drift from what its architecture predicts? If so, mechanics depend on biological history in a way no current model captures. You will finish able to image tissue microstructure, measure its mechanics, and build machine-learning models that respect physics and report uncertainty. Few people can do all three. Backgrounds in physics, engineering, mathematics, biology or biomedical science all fit; you need mathematical confidence and willingness to code, but no machine learning. You will belong to two groups, a biophotonics laboratory at Exeter and an eye and vision group at Plymouth, time split equally and worked in blocks, with no weekly commuting, alongside a doctoral cohort across the South West. Cardiff contributes an X-ray scattering archive of corneal and scleral collagen. Continued on next page.....



Our aim as the SWBio DTP is to support students from a range of backgrounds and circumstances. Where needed, we will work with you to take into consideration reasonable project adaptations (for example to support caring responsibilities, disabilities, other significant personal circumstances) as well as flexible working and part-time study requests, to enable greater access to a PhD. All our supervisors support us with this aim, so please feel comfortable in discussing further with the listed PhD project supervisor to see what is feasible.