The contribution of sarcomere length to the passive mechanical properties of cardiac muscles in the lobster *Homarus americanus*

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Recent research and literature has brought to light the intricacies in passive material properties of cardiac muscles in the American lobster, *Homarus americanus*; depending on the axis upon which force is applied, the mechanical responses vary between the transverse and longitudinal directions. This mechanical anisotropy is consistent throughout all mechanical tests that were applied including stress-strain curves, active length-tension curves, and passive length tension curves. These differences may have a large impact on the efficiency of pumping fluids and in a mechanism like the lobster heart, it is important to be able to effectively pump haemolymph throughout the organism. Thus, the Johnson Lab is focusing on how this anisotropy arises.

Taylor (2000) showed that sarcomere lengths dictate contractile speed and force of contraction that muscles can produce. In most vertebrates, sarcomere length amongst all muscles are quite homogenous with an average length of about 2.5 um, but crustaceans are unique in that they have variant sarcomere lengths of up to ten times that of humans. This leads to the question of whether differences in sarcomere lengths also contribute to the different mechanical properties we see in the transverse and longitudinal muscles.

Thus, my research this summer focused on whether fundamental differences in sarcomere lengths of longitudinal and transverse muscle fibers contributed to the mechanical anisotropies seen in the lobster heart. This was approached from two directions. First, using microscope histology, individually dissected cardiac muscle fibers were stained with methylene blue dye and sarcomeres were measured using ImageJ. Measurements of both transverse and longitudinal sarcomere lengths were recorded throughout the summer. Overall, the transverse sarcomere lengths were significantly larger than their longitudinal counterparts. Furthermore, within the same lobster heart sample, transverse sarcomere lengths were still bigger. Passive forces in the heart are greater in the transverse direction and thus data shows that sarcomere lengths may play a role in the mechanical anisotropy. Although microscope histology was helpful in obtaining a general idea for the structure of the heart, it is difficult to control for the contractile state of each muscle fiber. Chemicals such as MgCl and EtOH were used to control contractile states throughout all lobsters but those images did not come out favourably. Thus, a secondary approach was taken after this preliminary round of data.

Near the end of the summer, laser diffraction was used as a means of measuring sarcomere lengths. When a laser is exposed at a muscle fiber, the Z-lines that separate individual sarcomeres act as a diffraction grating and the light diffracts. This diffracted light can be measured and the distance can be used to calculate the length of each individual sarcomere. Using this method, sarcomeres can be manipulated using a force transducer and vibrator to maximally stretch and relax its state. However, this method only worked on thoracic muscles up to this point. Future research will seek to get accurate sarcomere measurements of cardiac muscles using this setup.

Ultimately, this research will point to different biomechanical processes that different organisms have perfected to cope with a ubiquitous problem living organisms face; since lobster heart evolved separately from those of vertebrates, it is intriguing to see how other organisms cope with the problem of circulating oxygen throughout their cardiovascular system.
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