ME445/BioEN440 Spring 2016

Introduction to Biomechanics

Homework 4

1. A small cubic tissue specimen of dimension h = 1cm is tested to determine its elastic properties. If we assume that the material can be modeled as linear, isotropic and homogeneous.

a) The sample is placed between two rigid surfaces and compressed by 5% of its initial height (Fig. 1a). If the material were incompressible and has a Young's modulus of 10^6 Pa, how much force would need to be applied?

b) A shearing force is applied as in Fig. 1b. What is the shear modulus of the specimen, based on your measurements in (a) and the stated assumptions? How great would a shear force need to be applied to displace the top surface a distance of 0.1*h?

c) If, in the process of conducting the experiment in (a), it is observed that the lateral dimensions of the specimen increase from h to 1.02*h, what is the final volume of the specimen? Is the specimen incompressible? What is the Poisson ratio?

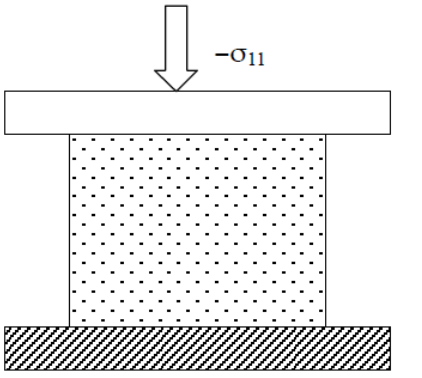


Fig. 1a

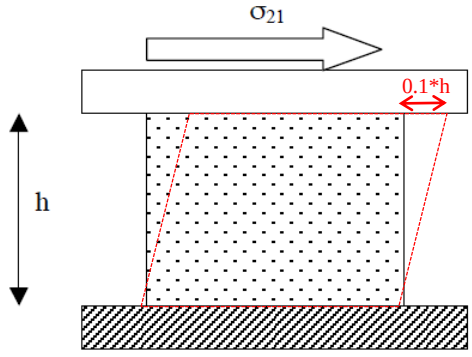
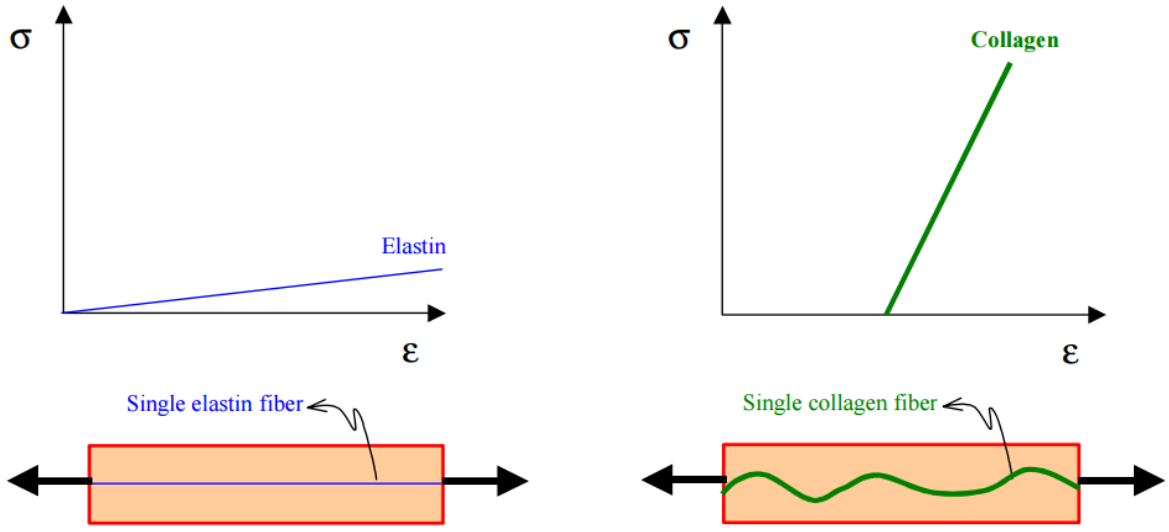


Fig. 1b

2. If we have tissue made of a single elastin fiber and tissue made of a single collagen fiber, the stress-strain curves are similar to Figures below, within a linear strain region.



How would you plot the stress-strain curves for (a) tissue made of one elastin and one collagen fiber? (b) and for tissue made of 3 elastin fibers and 3 collagen fibers? (hint: there is one point of stiffness change in (a) and three points in (b))

(c) The major ECM components in large elastic arteries are the proteins elastin and collagen. Find Figure 4 in the paper by Jessica E. Wagenseil (2012) Elastin in large artery stiffness and hypertension and discuss the graph in Figure 4 with respect to what you draw in (a) and (b). No need to consider circular-shaped, you may consider it in 1D.

3. We studied four types of tissue, but the detail of the basement membrane was not covered in class. What is the basement membrane? And what functions do they perform? Which type of tissue does the basement membrane belong to?

You may just search the web or read any textbook of tissue mechanics. However, please list at least two references for your answers.