GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2004

BIOENGINEERING

EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

* Please sign your **name** on the back of this page —

Woodruff School of Mechanical Engineering
Bioengineering Qualifying Exam
Fall 2004

1. A. Identify at least four different types of fluid mechanic phenomena that occur in the human body and indicate where in the human body it occurs and if there are specific conditions required for it to occur.

   B. As a red blood cell passes through a small capillary, describe the nature of the flow and the time history of the wall shear stress.

   C. For a large blood vessel, sketch the curve for diameter as a function of pressure. Indicate how this curve changes with the age of the individual.

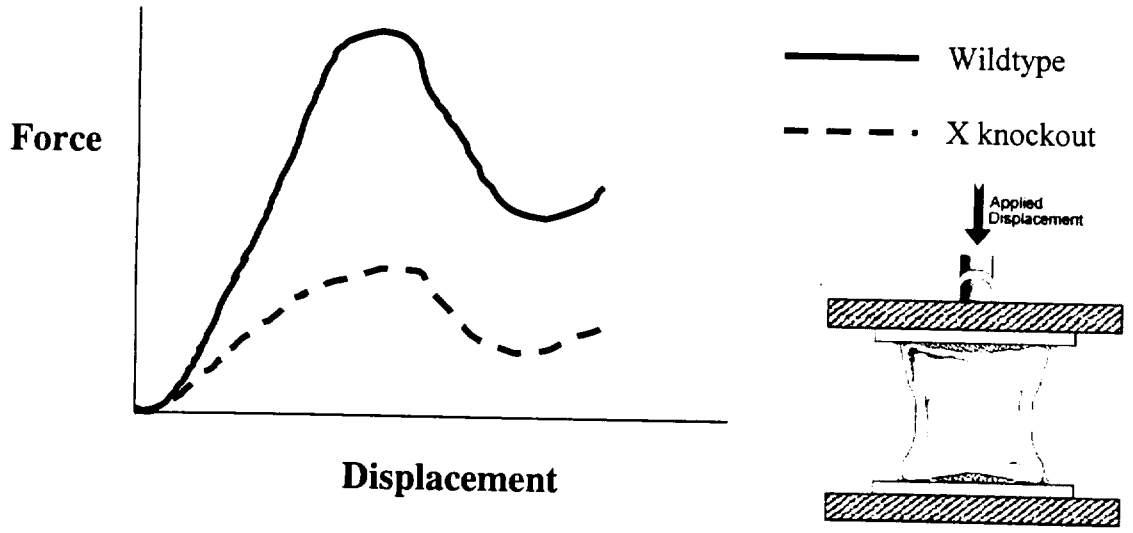
2. A colleague in biology has generated a Protein X knockout mouse and would like take advantage of your biomechanics expertise to investigate whether Protein X plays a role in bone and particularly trabecular bone. Because of the limited amount of trabecular bone volume in the bones of mice, you decide to analyze the compressive mechanical properties of vertebral bodies in the knockout mice and wildtype control mice. The vertebral bodies consist of a thin cortical shell filled with trabecular bone. You find significant differences in the mechanical behavior of bones from Protein X knockout mice relative to wild type control mice. The force-displacement plots below are representative of these observed differences. Your colleague is intrigued and would like to know more about why the mechanical behavior of the knockout mouse bones is so different.

A. What parameters can you measure from the plots below?

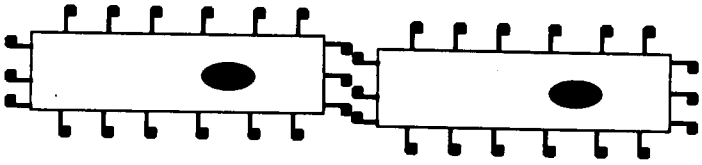
B. Describe the differences in mechanical behavior between the wildtype and knockout vertebrae.

C. Discuss all possible reasons for the observed differences in mechanical behavior.

D. What additional measurements or analyses would you propose to do to better understand the underlying mechanisms responsible for these differences?



3. Consider the E-cadherin-mediated adhesion of two identical epithelial cells. Assuming that 10% of the total number of receptors in each cell participates in the adhesive interaction at the interface, derive time-dependent governing equations and steady state solutions for the number of bonds. State all assumptions clearly.



R_T = total number of E-cadherin/cell (#/cell)
k_f = forward reaction rate ((#/cell)$^{-1}$s^{-1})
k_r = reverse reaction rate (s^{-1})