MASSACHUSETTS INSTITUE OF TECHNOLOGY

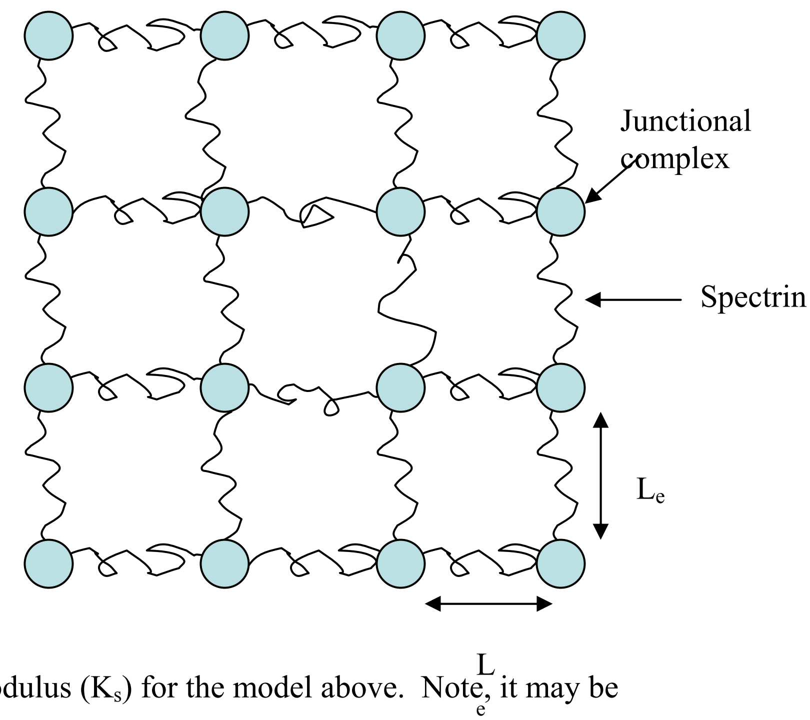
Molecular, Cellular and Tissue Biomechanics
BEH.410 / 2.978J / 6.524J / 10.537J

Problem Set #8 Issued: 4/30/03

Problem #1: Red Blood Cell Membrane Mechanics

Below is a picture of the cortex of a red blood cell. Our goal is to develop a model to predict the membrane mechanics of this 2-dimensional array of crosslinked spectrin polymers. A simple model is to consider a 2-D rectangular array of polymers (spectrin) which are connected at defined nodes (the circles). Each one of the polymers has a persistence length L_p, contour length of L and diameter d.

Photo removed due to copyright considerations. (Spectrin structure in red blood cell.)



a) Calculate the membrane shear modulus (K_s) for the model above. Note, it may be helpful to consider the deformation of one unit cell. Also, for simplicity you can assume that the spectrin is not strongly stretched ($L_e \ll L$).

b) Using optical tweezers researchers have found that the persistence length of spectrin is 10nm. Furthermore, the contour length of each spectrin molecule is 200 nm and L_e is approximately 70nm. Calculate the K_s for the cortex using your model from part a). Comment on how this compares to the value mentioned in class for a red blood cell.

c) Now derive an expression for the membrane area expansion modulus K_e for the model.

d) Calculate the value of K_e using the optical tweezer data. Comment on how this compares to the value of K_e for a red blood cell.

Problem #2

R.D. Kamm Manuscript, Chapter 2.1 Problem #1

Problem #3

R.D. Kamm Manuscript, Chapter 2.2 Problem #4

Problem #4

R.D. Kamm Manuscript, Chapter 2.3 Problem #1

Problem #5

R.D. Kamm Manuscript, Chapter 2.3 Problem #3