BMT-72106 Cellular Interactions
Exercise 3, 5.4.2019

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Exercise 1.
Please, describe shortly

a) Tight junctions

b) Differences between adherens junctions and desmosomes

c) Tensegrity model in the context of mechanobiology

Exercise 2. *Microtubule stiffness*
Bending stiffness measures the flexural rigidity of a rod-like structure such as a microtubule. Flexural rigidity is calculated as $E \times I$, where E is the Young's modulus and I is the geometrical moment of inertia. Microtubule can be approximated as hollow tube as shown in Figure 2, whose geometrical moment of inertia about the axis through the middle of its cross-section is

$$I_z = \pi \frac{D_o^4 - D_i^4}{64}, \tag{1}$$

where D_o and D_i are the outer and inner diameter of the hollow cylinder, which for microtubules are around 25 nm and 17 nm, respectively. If microtubules are compressed, they will buckle when the

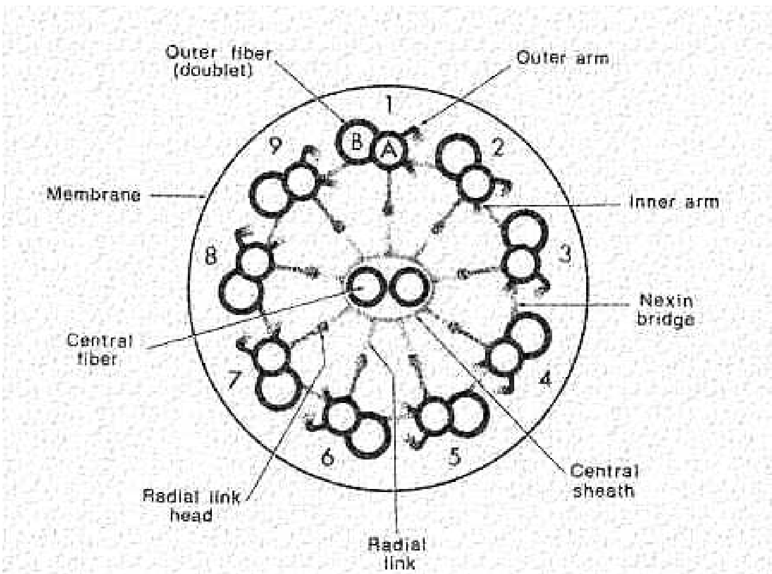

Figure 1: Cross-sectional view of a microtubule.

compression force reaches critical force P_{cr}, which can be calculated with Euler's formula:

$$P_{cr} = \frac{\pi^2 EI}{L^2}, \tag{2}$$

where L is the cylinder length. Table below gives critical forces measured of microtubules with varying lengths. Based on these results, calculate the mean flexural rigidity and Young's modulus for microtubules.

Microtubule	Length (μm)	Critical force (pN)
1	7.5	2.6
2	10.5	2.9
3	22.0	2.1
4	20.0	2.0
5	10.0	3.8
6	30.5	1.1
7	18.0	1.7
8	19.0	1.1
9	9.0	3.7
10	28.0	1.4

Exercise 3. *Nerst potential*
Nernst potential can be written as:

$$E = \frac{RT}{zF} \ln \frac{[\text{ion outside cell}]}{[\text{ion inside cell}]} \tag{3}$$

a) What phenomena does the equation above describe? What do the symbols denote?

The table below lists typical concentrations and permeabilities of the ions in a mammalian neuron.

b) Calculate the Nernst potentials for K^+, Na^+ and Cl^- at 37 °C using the values in the table.

Ion type	Intracellular concentration (mM)	Extracellular concentration (mM)	Permeability of the membrane
K^+	140	5	1
Na^+	10	145	0.05
Cl^-	6	110	0.40

Exercise 4. *Goldman equation*
The Goldman equation can be written for K^+, Na^+ and Cl^- in form

$$E_{K^+,Na^+,Cl^-} = \frac{RT}{F} \ln \left(\frac{P_{Na^+}[Na^+]_{\text{out}} + P_{K^+}[K^+]_{\text{out}} + P_{Cl^-}[Cl^-]_{\text{in}}}{P_{Na^+}[Na^+]_{\text{in}} + P_{K^+}[K^+]_{\text{in}} + P_{Cl^-}[Cl^-]_{\text{out}}} \right) \tag{4}$$

a) What does the Goldman equation describe? What are Ps?

b) Given the values in the above table, calculate the membrane potential in 37 °C using the values in the table above. Compare this to the values of the previous exercise.

c) What would happen to the membrane potential, if the membrane suddenly became 100 times more permeable to sodium? Is this scenario realistic?