

PHY420 Problems Class 3: DNA

Dr. Rhoda Hawkins

1. The DNA code

- (a) DNA is made up of monomers we call base pairs. Given that one base pair is 0.34 nm how many base pairs (monomers) are there in human DNA? [1]
- (b) These base pairs are the units of the DNA code and can be thought of as “letters”. Three of these units together (like “3-letter words”) code for one monomer of a protein (called an amino acid). Given that there are 4 types of base pairs (a “4-letter alphabet”) how many different amino acids (different “3-letter words”) can be described by DNA? [1]
- (c) Given that there are 20 amino acids occurring naturally, discuss the biological significance of your previous answer. [2]

2. End to end distance of a semiflexible polymer

- (a) Show that the average end to end distance squared $\langle \mathbf{R}^2 \rangle$ of a semi-flexible polymer with free ends is given by:

$$\langle \mathbf{R}^2 \rangle = 2Ll_p \left(1 - \frac{l_p}{L} (1 - e^{-L/l_p}) \right)$$

where l_p is the persistence length and L is the total contour length of the polymer. You may use the result derived in lectures for the tangent correlations: $\langle \mathbf{t}(s) \cdot \mathbf{t}(s') \rangle = e^{-|s-s'|/l_p}$. [4]

- (b) From this expression for $\langle \mathbf{R}^2 \rangle$ in (a) for a semi-flexible polymer, calculate the limits showing the end-to-end distance for a flexible polymer and a rigid polymer. [2]
- (c) Given that the length of human DNA is about 2 m and the persistence length of DNA is about 50 nm, calculate the size of unconstrained (free) human DNA using the expression in (a). [2]
- (d) Write a couple of sentences explaining the significance of this for a biological cell. i.e. what is the problem and how does a cell solve this problem? [2]