# Indraprastha Institute of Information Technology Delhi (IIITD)

**Department of Computational Biotechnology**

## BIO211 – Cell Biology and Biochemistry

## ASSIGNMENT-1 (October 10, 2022)

---

**Question 1.** An electron microscope can magnify a cell almost 10,000 folds. If you are viewing a typical eukaryotic cell (spherical in shape) with diameter 50 µm using this electron microscope, how big will this cell appear? [2 marks]

Answer: Diameter of magnified cell = 500 mm

**Question 2.** Actin filaments are a major constituent of muscle cells. Assuming a muscle cell and the actin molecule to be spherical in nature with a diameter of 50 µm and 3.6 nm respectively, find the number of actin molecules this muscle cell can hold in the absence of any other organelle. [3 marks]

Answer: No. of actin molecules = Volume of cell/Volume of actin

$= [4/3 \times \pi \times (D/2)^3] / [4/3 \times \pi \times (d/2)^3]$

$= (D/d)^3 = [(50 \times 10^{-6}\ m) / (3.6 \times 10^{-9}\ m)]^3 = 2.68 \times 10^{12}$ molecules

**Question 3.** The *E. coli* chromosome is a single DNA molecule whose mass is about $3.0 \times 10^9$ Da. This macromolecule is actually a circular array of nucleotide pairs. The average molecular weight of a nucleotide pair [A-T (or) G-C] is 660 Da and each pair imparts 0.34 nm to the length of the DNA molecule.

(i) Using the given information, calculate the length of an *E. coli* DNA molecule? [3 marks]

Answer: No. of nucleotide pairs = $3.0 \times 10^9$ Da/660 Da = $4.55 \times 10^6$

Length of DNA = $4.55 \times 10^6 \times 0.34 \times 10^{-9}$ m = $1.547 \times 10^{-3}$ m = 1547 µm

(ii) What are the dimensions of a typical *E. coli* cell? How many nucleotide pairs does this DNA contain? [2 marks]

Answer: A typical *E. coli* cell is 2 µm long.

No. of nucleotide pairs = $3.0 \times 10^9$ Da/660 Da = $4.55 \times 10^6$

(iii) If an average protein in an *E. coli* is made up of 360 amino acids, what will be the maximum number of proteins that can be coded by an *E. coli* DNA molecule? (Hint: three nucleotide pairs in the DNA, called a codon, codes for one amino acid.) [3 marks]

Answer: No. of nucleotide pairs encoding for one protein = 360x3 bp = 1080 bp

$$\text{No. of proteins} = \frac{\text{Total no. of nucleotide pairs}}{\text{No. of nucleotide pairs encoding for one protein}}$$

$= 4.55 \times 10^6 / 1080 = \sim 4213$ proteins

**Question 4.** A yeast cell consists of a spherical nucleus with diameter of roughly 2.0µm. This nucleus houses 1.2 $X10^7$ bp of genome, divided amongst 16 chromosomes. This DNA is densely packed with the help of protein assemblies known as histones. Eight such histones make up a

cylindrical core around which roughly 150 bp are wrapped. This assembly is known as a nucleosome. There exists a spacer of 50 bp spacer between two nucleosomes. Using this information, estimate the number of nucleosomes present in the nucleus of the yeast cell. [5 marks]

Answer: Number of nucleosomes = $\frac{\text{Size of genome}}{\text{(bp associated with one nucleosome + spacer)}}$

$= \frac{1.2 \times 10^7 \text{ bp}}{150 \text{ bp} + 50 \text{ bp}}$

= 60,000 (approx.)

**Question 5.** Estimate the number of lipid molecules associated with the plasma membrane of a yeast cell, provided the following information:
Yeast cell is enclosed by a single lipid bilayer membrane.
Surface area of such cells is approximately 80$\mu m^2$.
Roughly half of the surface area is covered by membrane proteins rather than lipid molecules.
Area per lipid is 0.25 $nm^2$. [5 marks]

Answer: Number of lipid molecules = $\frac{2 \times 0.5 \times 80 \times 10^{-6}}{0.25}$

$= 3.2 \times 10^8$

**Question 6.** Glucose is one of the major energy-yielding molecules present inside in a cell. Assuming that an *E. coli* has a glucose concentration of 1 mM,

(i) What is the concentration of glucose, expressed as mg/ml? [3 marks]

*Answer*: Glucose concentration = 1mM = $1 \times 10^{-3}$ mol/L

Molecular mass of glucose, $C_6H_{12}O_6$ = 6x12 + 12x1.0 + 6x16 = 180

Mass concentration of Glucose = $1 \times 10^{-3}$ mol/L x 180 g/mol = 0.18 g/L = 0.18 mg/ml

(ii) How many glucose molecules will be contained the *E. coli* cell if its cellular volume is 1fL? (Hint: Avogadro's number = $6.023 \times 10^{23}$) [3 marks]

*Answer*: Moles of glucose = concentration x volume

= $1 \times 10^{-3}$ mol/L x $1 \times 10^{-15}$ L [1fL = $1 \times 10^{-15}$ L]

= $1 \times 10^{-18}$ moles

Number of glucose molecules = $1 \times 10^{-18}$ moles x $6.023 \times 10^{23}$ molecules/mole

= $6 \times 10^5$ molecules

**Question 7.** You have a 225 µM solution of a protein called bovine cytochrome c. What is the concentration of this solution expressed in g/L, mg/mL and µg/µL? The molar mass of this protein is 12327 g/mol.

*Answer*: 225 µM solution of bovine cytochrome c = 225 µmol of bovine cytochrome c in 1L.

*Conversion of molar to mass*:
225 µmol x 12327 g/mol = $225 \times 10^{-6}$ mol x 12327 g/mol = 2.77 g

Therefore, concentration of bovine cytochrome c = 2.77 g/L [2 marks]

= $2.77 \times 10^3$ mg/$10^3$ mL = 2.77 mg/mL [2 marks]

= $2.77 \times 10^6$ µg/$10^6$ µL = 2.77 µg/µL [2 marks]