

Indian Institute of Technology Kharagpur
Mid-Spring semester examination 2016
Subject: Science of living system (BS20001)

NAME _____

Roll # _____

Part – I (Total 18 marks) Choose (tick) ALL correct answers. Each question carries 0.5 mark.

1. If one DNA sample has 40% GC contents, what will be the percentage of Adenine base in that DNA sample? 30%
2. During DNA replication, which of the following enzyme unwinds DNA strands?
(A) DNA polymerase ☒ (B) Helicase (C) Ligase (D) Primase
3. Which enzyme removes RNA primers during DNA replication
(A) Primase (B) Ribonuclease
☒ (C) DNA polymerase III ☒ (D) DNA polymerase I
4. Which of the following enzyme is routinely used for polymerase chain reaction
(A) DNA polymerase I (B) Primase
☒ (C) Taq polymerase (D) DNA polymerase I and Primase
5. Which one of the following is in correct order:
(A) Transcription, Translation, mRNA Splicing, Protein folding
☒ (B) Transcription, mRNA Splicing, Translation, Protein folding
(C) Transcription, Translation, poly-adenylation Protein folding
(D) Transcription, Translation, 5' capping of mRNA, Protein folding
6. Function of RNA polymerase's sigma factor is the recognition of
(A) translational stop sequence ☒ (B) transcriptional start sequence
(C) translational start sequence (D) translational start sequence
7. Which of the following is NOT TRUE for codon?
(A) Contains three nucleotides (B) Contains multiple stop codons
☒ (C) Contains multiple start codons (D) Complementary to tRNA anti-codon
8. Which one of the following is TRUE
☒ (A) DNA is more stable than RNA (B) DNA is only right handed helix
(B) DNA is less stable than RNA ☒ (D) Both DNA and RNA can be synthesized from each other
9. The linkage between sugar and base is called
(A) Phosphodiester ☒ (B) Glycosidic (C) Hydrogen bond (D) Vander-Wall

10. In E. coli. Lac operon gene regulation, lactose induces gene expression
 (A) through the binding of Lac repressor to promoter
 (B) through the binding of Lac repressor to operator
☒ (C) through the release of bound Lac repressor from the operator
 (D) through the release of bound Lac repressor from the promoter
11. Arrange the following in the increasing order of protein structure hierarchy:
 a: α -helix
 b: amino acid sequence
 d: quaternary structure
 c: folded structure
 (A) a, d, c, b
☒ (B) b, a, c, d
 (C) b, c, a, d
 (D) a, c, d, b
12. When both C-alpha atoms are on the same side of a peptide bond, it is called a cis isomer.
13. Which terminus (N or C) of an α -helix is most likely to interact with a DNA backbone? N terminal
14. Which of the following CAN NOT be close (adjacent) in primary structure
 (A) two α -helices
☒ (B) parallel β -strands
 (C) anti-parallel β -strands
 (D) an α -helix and a β -strand
15. Which of the following can fold independently in to a stable three-dimensional structure
 (A) β -strands
 (B) α -helices
 (C) motifs
☒ (D) domains
16. Which of the following amino acid residues have two covalent linkages with the backbone and side chain atoms.
 (A) Glycine (B) Alanine ☒ (C) Proline (D) Phenyl alanine
17. In a helical wheel each residue can be plotted every 100° degree around a spiral path.
18. An enzyme that breaks a bond by adding water is called hydrolase
19. In a Lock and Key model of enzyme action, the part of the enzyme that recognizes the substrate is known as
 (A) Enzyme-substrate complex
 (B) Product-substrate complex
☒ (C) Active site
 (D) Co-enzyme

20. Which of the following is TRUE for a tRNA.

- Both C & D*
- (A) Its gene is transcribed by RNA polymerase II.
 - (B) It is normally composed of about 20 monomers.
 - ☒ (C) During translation it interacts with mRNA.
 - ☒ (D) Brings amino acid into the translating ribosome.

21. DNA and RNA polymerase differ in

- A, B, D (any 2)*
- ☒ (A) the nucleotide substrates they incorporate.
 - ☒ (B) their requirement for a primer.
 - (C) the type of chemical reaction they catalyze.
 - ☒ (D) their processivity

22. Which enzyme is depicted in the following schematic drawing?



- (A) DNA polymerase
- ☒ (B) RNA polymerase
- (C) Primase
- (D) Helicase

23. During DNA replication in the cell, Primase makes short primers that are then extended by the DNA polymerases. These primers ...

- Both A & D*
- ☒ (A) are made up of ribonucleotides.
 - (B) are made more frequently in the leading strand than the lagging strand.
 - (C) are joined to the neighboring DNA by DNA ligase.
 - ☒ (D) provide a 3'-OH group for the DNA polymerases to extend.

24. Which of the following is TRUE

- B, C, D (any 2)*
- (A) Protein folding takes place inside the nucleus.
 - ☒ (B) Naturally occurring proteins are made of L amino acids.
 - ☒ (C) Both the ribosomal subunits are necessary for protein synthesis.
 - ☒ (D) Proteins always start with methionine amino acid.

25. How many turns will be there in a 18 amino acid long helix? 5 (18/3.6)

26. A 100 amino acid long protein will be encoded by a mRNA containing 101 number of codons.

27. Which of the amino acids has maximum possible combinations of phi (ϕ) and psi (ψ) angles in its Ramachandran plot?

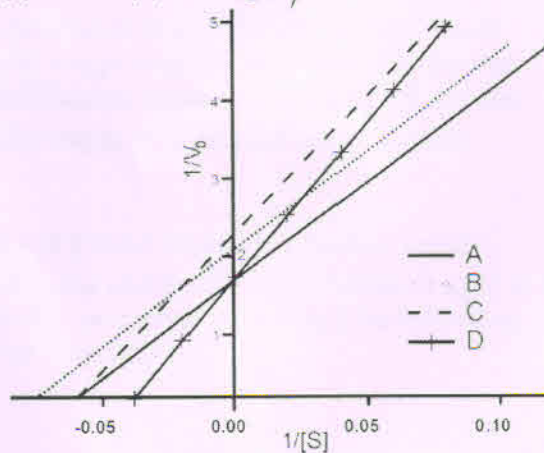
- ☒ (A) Glycine (B) Lysine (C) Alanine (D) Tyrosine

28. On which of the following molecules would you find an anticodon?

- (A) rRNA (B) mRNA ☒ (C) tRNA (D) small nuclear RNA

29. The curve which shows competitive inhibitor, the line 'A' belongs to uninhibited enzyme kinetics (symbols has their usual meaning) [Choose correct answer]

- (a) B (b) C ☒ (c) D (d) None



30. Pepsin, a digestive enzyme which is secreted in stomach, and acts best at pH _____

- (A) 10 (B) 7 (C) 6 ☒ (D) 1

31. Once a primary structure is formed, which of the following is not required to get the tertiary structure?

- (A) H-bond (B) Salt bridges (C) vander Waals interactions ☒ (D) Peptide bond

32. The diameter of B-form of DNA is (P) and the distance between two adjacent bases in any of the DNA strands is (R). What are the correct values of 'P' and 'R'?

- ☒ (A) P=2.0 nm, R= 0.34 nm (B) P=20 nm, R= 3.4 nm
(C) P=2.0 mm, R= 0.34 mm (D) P=2.0 nm, R= 3.4 nm

33. Melting of DNA at high temperature means

- (A) Cleavage of DNA into nucleotides (B) Separation of base from the sugar
(C) Separation of phosphate from the sugar ☒ (D) Separation of two strands of DNA

34. Which one of the followings sequence of events occurred during DNA amplification by PCR

- (A) Extension / synthesis, Annealing, Denaturation
- ✓ (B) Denaturation, Annealing, Extension/ synthesis
- (C) Annealing, Extension/synthesis, Denaturation
- (D) Renaturation, Annealing, Extension/synthesis

35. In prokaryotes transcription and translation is

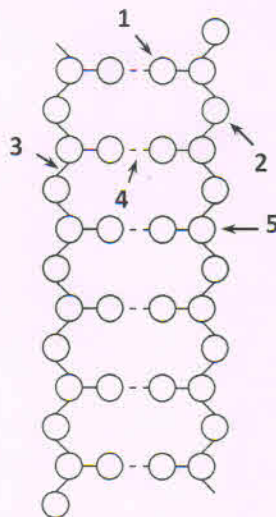
- ✓ (A) A coupled process that occurs in same compartment
- (B) A coupled process that occurs in different compartments
- (C) Not a coupled process that occurs same compartment
- (D) Not a coupled process that occurs in different compartments

36. *E. coli* bacterial DNA is

- (A) Double stranded, right handed, linear
- (B) Single stranded, right handed, circular
- ✓ (C) Double stranded, right handed, circular
- (D) Single stranded, left handed, linear

Part – II (Total 12 marks) Answer briefly.

1. Indicate which numbered feature (1 to 5) in the schematic drawing below of the DNA double helix corresponds to each of the following. For your answer match the numbers (1 to 5) with the letters (a to e) (1 Mark)



- 1 - nitrogen base
- 2 - phosphate group
- 3 - covalent linkage
- 4 - hydrogen bonding
- 5 - sugar

- (a) Hydrogen-bonding 4
- (b) Covalent linkage 3
- (c) Phosphate group 2
- (d) Nitrogen-containing base 1
- (e) Deoxyribose sugar 5

2. In a double-stranded DNA molecule, one of the chains has the sequence CCCATTCTA when read from the 5' to the 3' end. Indicate true (T) and false (F) statements below regarding this chain. (1 mark)

(A) The other chain is heavier, i.e. it has a greater mass. *True*
 (B) There are no C base in the other chain. *True*
 (C) The 5'-terminal base of the other chain is G. *False*
 (D) The other chain is pyrimidine-rich. *False*

(A, G - purines)

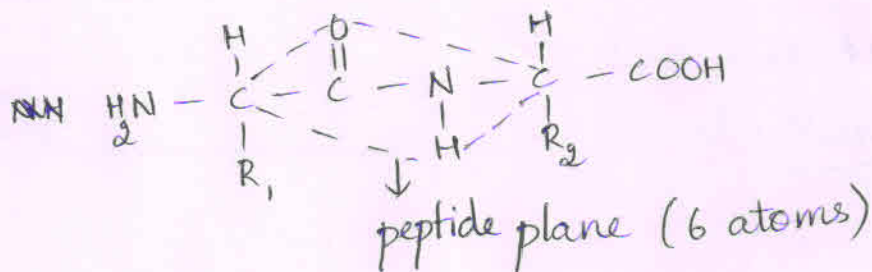
3. How many DNA molecules are present in the nucleus of one normal human somatic cell and in the nucleoid of one *E. coli* bacteria? (1 mark)

Human - 23 pairs (46)
E. coli - 1

4. As part of an ambitious student research project you create a short synthetic protein consisting of 30 amino acids. However, instead of linking the amino acids in the intended order of Trp - Gly - - Val - Ile, you accidentally synthesize protein in the reverse order, Ile - Val - - Gly - Trp. One of your classmates says the two protein must be identical, and bets you Rs 500 that the protein are structurally and functionally equivalent. What do you think? Explain briefly. (1 mark)

Not identical
 - Different -COOH & -NH₂ sides → ~~different~~ ~~changes~~
 - ~~di~~ reverse order → different folding / 3D structure
 → function differs.

5. Draw the structure of a dipeptide. You can show the sidechains as R1 and R2. Also show all the atoms involved in the peptide plane. (1 mark)



6. Given $\Delta G_{\text{cat}} = 25 \text{ kJ/mol}$, $\Delta G_{\text{uncat}} = 65 \text{ kJ/mol}$, $R = 8.413 \text{ JK}^{-1} \text{ mol}^{-1}$ and room temperature condition, calculate the rate enhancement by this enzyme. (1 mark)

$$\Delta G = -RT \ln K$$

$$K = e^{-\Delta G/RT}$$

$$\text{Rate enhancement} = \frac{K_{\text{cat}}}{K_{\text{uncat}}} = e^{(65-25) \times 10^3 / (8.413 \times 298)} \quad \text{or } 300$$

$$= e^{15.95}$$

$$\approx 10^7$$

7. Write down the Michaelis-Menten equation. (2 marks)

Using this equation determine the reaction rate when the substrate concentration $[S]$ is equal to

- i) saturation condition i.e. $[S] = \text{infinity}$
- ii) K_m
- iii) $K_m/2$

Michaelis - Menten equ.:

$$V_o = \frac{V_{\text{max}} \cdot [S]}{K_m + [S]}$$

(i) $V_o = V_{\text{max}}$

(ii) $V_o = \frac{V_{\text{max}}}{2}$

(iii) $V_o = \frac{V_{\text{max}}}{3}$

8. Estimate the V_{max} and K_m values by inspecting the following data (1 mark)

$[S] \text{ (M)}$	$V_0 \text{ (}\mu\text{M/min)}$
2.5×10^{-6}	28
4.0×10^{-6}	40
1×10^{-5}	70
2×10^{-5}	95
4×10^{-5}	112
1×10^{-4}	128
2×10^{-3}	139
1×10^{-2}	140
2×10^{-2}	140

$$V_{\text{max}} = 140 \mu\text{M/min}$$

$$K_m = 10^{-5} \text{ M}$$

↳ substrate concentration
at $\frac{V_{\text{max}}}{2}$

DNA helix

- (i) Double stranded
 - (ii) Intermolecular H_2 bonding
 - (iii) Pitch: 34 \AA
9. Mention two structural differences between a DNA helix and a protein helix. (1 mark)
- (iv) Diameter: 20 \AA
 - (v) Bases/twist: 10.5

Ptn. helix

- (i) Single strand/chain
 - (ii) Intramolecular H_2 bonding ($n \rightarrow (n+4)$)
 - (iii) Pitch: 5.4 \AA
- (iv) Diameter: 12 \AA
 - (v) Residues/twist: 3.6

10. Imagine that 1 L of a solution containing each of the 20 naturally occurring amino acids at 50 mM concentration each (total concentration of 1 M) is allowed to polymerize in a perfectly stepwise fashion such that at each step, a random amino acid can be incorporated into a growing polypeptide. The steps are repeated, until eventually the solution is only composed of 40-mers (and virtually all of the monomers have been used). What fraction of all 40-mers can possibly be present in this solution? Round your number to four decimal places.

Avogadro's number is 6×10^{23} .

(1 mark)

$$\text{No. of all possible 40mers} = 20^{40} = 10^{52}$$

$$\text{Total amino acids present} = 1 \text{ M} = 6 \times 10^{23}$$

$$\text{40mers synthesized} = \frac{6 \times 10^{23}}{40} = 1.5 \times 10^{22}$$

$$\text{Fraction} = \frac{\text{Synthesized}}{\text{Possible}} = \frac{1.5 \times 10^{22}}{10^{52}} \approx 10^{-30}$$

$$\text{4 decimal rounding} = 0.0000$$

11. What transcript (RNA) will be produced from the coding DNA sequence (5'-

ATGCGTAGGTAGCT-3') of a double stranded DNA molecule?

(0.5 mark)

5'-AUGCGUAGGUAGCU-3'

Coding strand is given. Hence mRNA is same sequence, only $T \rightarrow U$.

12. Name the enzyme which helps to attach the appropriate amino acid to its tRNA. (0.5 mark)

Aminoacyl tRNA synthetase