CAREER ENDEAVOUR
Best Institute for IIT-JAM, NET & GATE

CSIR-UGC-NET/JRF LIFE SCIENCES
TEST : MOLECULAR BIOLOGY

Time : 90 Minutes **Date : 18-10-2019**
M.M. : 90

INSTRUCTION:

1. **There are two parts. Part-B contains 15 objective type questions, each question carry 2 marks and Part-C contains 15 objective type questions, each question carry 4 marks.**
2. **There is negative marking, @ 25% will be deducted for each wrong answer.**
3. **Attempt all the questions, use of calculator is not allowed.**

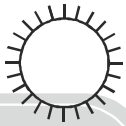
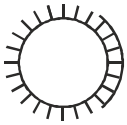
PART-B

1. Which of the following are INCORRECT regarding the structure of DNA?
   (a) Watson-Crick geometry is the most stable mode of base pairing in the double helix, even though non-Watson-Crick base pairs are theoretically possible
   (b) The intrinsic stability of Watson-Crick base pairs is due to the bases in Watson-Crick pairs have a higher mutual affinity than those in a non-Watson-Crick pair
   (c) Hydrogen bonding contributes to the stability of nucleic acid structures as during denaturation the H-bonds between the base pairs are replaced by energetically similar H-bonds between the bases and water.
   (d) The stacking interactions between the base pairs of the double helix are results of hydrophobic forces
2. It is essential that RNA primers at the ends of Okazaki fragments be removed and replaced by DNA because otherwise
   (a) The RNA might not be accurately read during transcription, thus interfering with protein synthesis
   (b) The RNA would be more likely to contain errors because primase lacks a proofreading function
   (c) The stretches of RNA would destabilize and begin to break up into ribonucleotides, thus creating gaps in the sequence
   (d) The RNA primers would be likely to H-bond to each other forming complexes that might interfere with proper formation of DNA Helix
3. Usually two functional replication forks are found at each origin of replication. What would happen if a mutant arose having only one functional replication fork per replication bubble?
   (a) No change at all in replication
   (b) Replication would occur only on one half of the chromosome
   (c) Replication would be complete only on the leading strand
   (d) Replication would take twice as long

4. What would happen if DNA synthesis were discontinuous on both strands?
   (a) The DNA fragments from the two new strands could become mixed, producing possible mutations
   (b) DNA synthesis would not occur because the appropriate enzyme to carry out discontinuous replication on both strands would not be present
   (c) DNA synthesis might take longer, but otherwise there would be no noticeable difference
   (d) DNA synthesis would not occur as the entire length of the chromosome would have to be unwound before both strands could be replicated in a discontinuous fashion

5. One form of a plasmid shows a twist of Tw = 48 and a writhe of Wr = 3. What would be the value of writhe of a form with Tw = 50 if none of the phosphodiester bonds are broken while changing the twist.
   (a) 3 (b) 50 (c) 51 (d) 1

6. A reaction mixture contains DNA polymerase, the four dNTPs and one of the DNA molecules whose structure is represented below. Which reaction mixture would generate PP_i?

   (a)
   (b) 
   (c) 
   (d) 

7. If replication has to be accomplished in an 8-hour S-phase and the replication fork moves at 50ntd/sec, what would be the minimum number of origins required to replicate the human genome of 6.4×10^9 nucleotides on 46 chromosomes?
   (a) 1111 (b) 2222 (c) 4444 (d) 8888

8. A gene contains eight sites where alternative splicing is possible. Assuming that the splicing pattern at each site is independent of that at all other sites, how many splicing products are possible
   (a) 256 (b) 64 (c) 8 (d) 16

9. Suppose the specific activity of a ligand is 10^{12} cpm per millimole and the maximal specific binding is 10^4 cpm per milligram of membrane protein. If there are 10^{10} cells per milligram of membrane protein and only one ligand binds per receptor. Find the number of receptor molecules present per cell.
   (a) 1000 (b) 800 (c) 600 (d) 400

10. Suppose that each β-adrenergic receptor bound to epinephrine converts 100 molecules of $G_{\alpha s}$ into their GTP bound forms and that each activated adenylate cyclase produces 1000 molecules of cAMP per second. With assumption of a full response, how many molecules of cAMP will be produced in a second after formation of a single complex between epinephrine and the β-adrenergic receptor?
    (a) 10^5 (b) 6×10^6 (c) 10^3 (d) 5×10^5

11. Glucose is mobilized for ATP generation in muscles in response to epinephrine, which activates $G_{\alpha s}$. cAMP phosphodiesterase is an enzyme that converts cAMP into AMP. How would the inhibitors of cAMP phosphodiesterase affect glucose mobilization in muscles?
    (a) The glucose mobilization will stop after some time
    (b) The glucose mobilization will continue even after the epinephrine level drops
    (c) The glucose mobilization will be observed only when epinephrine level is increased in presence of the inhibitor
    (d) The inhibitor will favour the synthesis of glycogen

12. A mutated form of α-subunit of the heterotrimeric G protein has been identified, which readily exchanges nucleotides even in absence of an activated receptor. What would be the effect on a signaling pathway containing the mutant α-subunit.
    (a) The signaling pathway will be immediately inhibited and will not transduce signal to target effectors even in presence of the ligand
    (b) The signaling pathway will become constitutively active and the signal will be transduced to the effectors even in absence of ligand
    (c) The signaling pathway will be conditionally active and will transduce the signals to the effectors with reduced efficiency in presence of ligand
    (d) The signaling pathway will be conditionally activated and will transduce the signals to the effectors with increased efficiency in absence of ligand
13. Suppose that the circulating level of hormone is 10^{-10} M and the K_d for binding to its receptor is 10^{-8} M. What fraction of receptors will have hormone bound? If the meaningful physiological response occurs when 50% of the receptors are bound to hormone, how much concentration of hormone have to be raised to elicit a response?
    (a) 10%, 100 fold (b) 1%, 10 fold (c) 10%, 10 fold (d) 1%, 100 fold
14. Which of the following pairs are correctly represented?

	Binding domains	**Binding targets**
(a)	PH domain	Proline rich sequence
(b)	PTB domain	Phosphorylated inositol phospholipids
(c)	SH2 domain	Phosphorylated tyrosine
(d)	SH3 domain	Phosphorylated inositol phospholipids

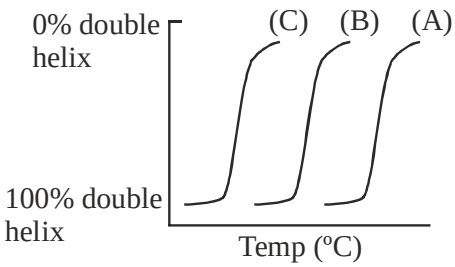
15. You are trying to purify adenylyl cyclase from brain. The assay is based on the conversion of α-^{32}P-ATP to cAMP. You can easily detect activity in crude brain homogenates stimulated by isoproterenol, which binds to β-adrenergic receptors, but the enzyme loses activity when low molecular weight cofactors are removed by dialysis. What single molecule do you think you could add back to the dialyzed homogenate to restore activity?
    (a) ATP (b) cAMP (c) GTP (d) cGMP

PART-C

16. Monitoring the changes in absorbance at 260 nm as the temperature increases reveals that the increase in the absorbance occurs over a narrow range of temperature, usually represented in terms of hyperchromic shift. Different statements are made regarding the melting/denaturation of DNA
    I) It is a co-operative phenomenon in which the collapse of one part of the structure destabilizes the remainder
    II) The viscosity of DNA solution decreases drastically due to denaturation
    III) The conformationally single stranded DNA chains gives more viscosity to the DNA solution than the duplex DNA molecules

    Find the CORRECT pair of statements
    (a) I and II only (b) II and III only (c) I and III only (d) I, II and III

17. Three different salt solutions of a DNA molecule is prepared having salt concentrations 0.02 M NaCl, 0.1 M NaCl and 0.6 M NaCl. The three solutions were denatured by heating and the melting curve was plotted as



Find the correct explanation

(a) Curve (A) corresponds to 0.02 M NaCl solution of DNA
(b) Curve (B) corresponds to 0.6 M NaCl solution of DNA
(c) Curve (C) corresponds to 0.02 M NaCl solution of DNA
(d) Curve (C) corresponds to 0.6 M NaCl solution of DNA

18. Analyse the following statements about the DNA molecule

I) A + T = G + C
II) A/T = C/G
III) T/A = C/G
IV) A = T within each single strand
V) Once separated, the two strands of a double helix are identical

Find the correct pair of statements

(a) I, II only
(b) III, IV, V only
(c) I, II, III only
(d) II and III only

19. The nucleic acids from various viruses were extracted and examined to determine their base composition. The results are given as

Virus A : 35% A, 35% T, 15% G, 15% C
Virus B : 35% A, 15% T, 25% G, 25% C
Virus C : 35% A, 30% U, 30% G, 5% C

Find the correct interpretation of the results

(a) Virus A has a double stranded DNA while virus C has a double stranded RNA
(b) Virus A has a double stranded DNA while virus B has a single stranded DNA
(c) Virus B has a double stranded DNA while virus C has a single stranded RNA
(d) Virus C has a single stranded DNA while virus B has a single stranded RNA

20. In normal strain of *E. coli*, σ^{70} stimulates the transcription of "typical genes" at 30°C. The level of σ^{32} at 30°C is too low to allow the transcription of heat shock genes. When the temperature is raised to 42°C, however the level of σ^{32} rises to stimulate the transcription of "heat shock genes". On the other hand, σ^{70} heat denaturates and therefore, the transcription of the "typical genes" is shut off at 42°C. A mutant strain of *E. coli* is generated in which the promoter regions of "typical genes" has been altered such that σ^{32} binds in place of σ^{70}. In this mutant, the level of two sigma factors behaves as in the normal strain i.e., σ^{70} is

high at 30ºC and σ^{32} is high at 42ºC. Which of the following correctly predicts the transcriptional status of "typical genes" in the mutant strain of *E. coli*.

	Transcription at 30ºC	**Transcription at 42ºC**
(a)	activated	activated
(b)	activated	silent
(c)	silent	silent
(d)	silent	activated

21. A high rate of base substitution mutations can result from a polymerase's tendency to incorporate a mispaired nucleotide or from its poor ability to incorporate the correct nucleotide. The following table provides the information about the catalytic efficiency (K_{cat}/K_m) of two error prone polymerases to compare their ability to generate substitution mutations.

Polymerase	Template nucleotide	Incoming nucleotide	K_{cat}/K_m (10^3)
Polymerase η	T	A	420
	T	G	22
HIV Reverse Transcriptase	T	A	800
	T	G	0.07

Which enzyme can generate substitution mutations more efficiently?

(a) Polymerase η
(b) HIV reverse transcriptase
(c) Both can generate substitution mutations with almost equal efficiency
(d) The data is insufficient to conclude

22. Different statements are given regarding the replication of DNA

I) When read in the same direction (5'→3') the sequence of nucleotides in a newly synthesized DNA strand is same as in the parental strand used as the template for its synthesis

II) Each time the genome is replicated, half the newly synthesized DNA is stitched together from Okazaki fragments

III) In *E. coli*, where the replication fork travels at 500 base pairs per second, the DNA ahead of the fork must rotate at nearly 3000 revolutions per minute.

Find the correct combination of statements?

(a) I and II (b) I and III (c) II and III (d) I, II and III

23. Conditional lethal mutations have proven indispensible in genetic and biochemical analyses of complex processes such as DNA replication. Temperature sensitive (ts) mutations are one such mutations. A large number of temperature sensitive replication mutants have been isolated in *E. coli*. These mutant bacteria are defective in DNA replication at 42ºC but not at 30ºC. "Quick stop" mutations halt DNA synthesis immediately, whereas the "slow-stop" mutants stop DNA synthesis only after many minutes at 42ºC. Suppose extract from a temperature sensitive DNA helicase mutant and a temperature sensitive DNA ligase mutant were mixed together at 42ºC. The mixture would show

(a) Quick-stop phenotype (b) Slow-stop phenotype
(c) Both quick-stop and slow-stop phenotype (d) Non-mutant phenotype

24. Consider following statements

I) The consequences of errors in transcription are less than those of errors in DNA replication

II) The σ-subunit is a permanent component of RNA polymerase holoenzyme from *E. coli,* allowing it to initiate at appropriate promoters in the bacterial genome

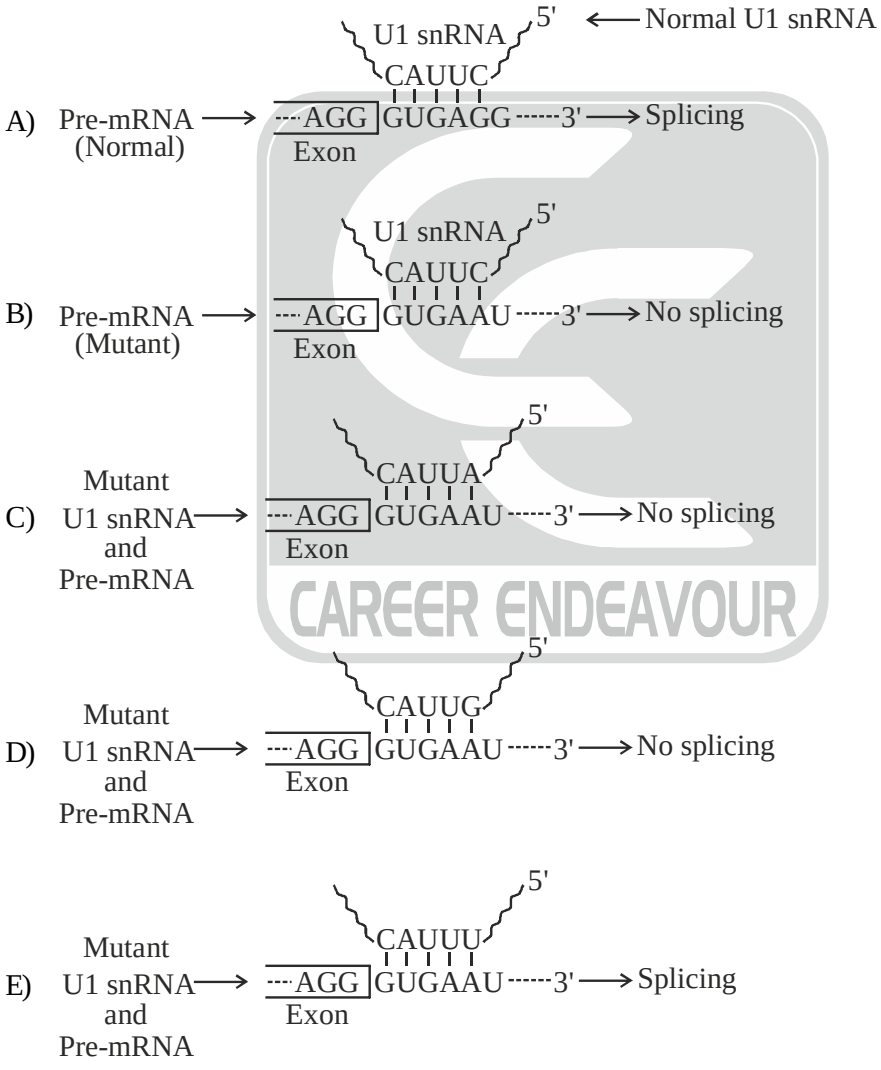
III) Eukaryotic mRNA molecules carry 3'-OH groups at both their 3' and 5' ends

IV) RNA polymerase II generates the end of a pre-mRNA transcript when it ceases transcription and releases the transcript; a poly (A) tail is then quickly added to the free 3'-end.

Find the CORRECT combination of statements

(a) I and III (b) II and IV (c) I and II (d) III and IV

25. The interaction of U1 snRNP with the 5' ends of introns is known to be critical for the splicing on introns. A series of mutants of U1 snRNA and the pre-mRNA are generated and assayed for catalysing splicing of introns. Following results were observed



Different interpretations are made based upon the above results such as

I) The base pairing occurs between the pre-mRNA and U1 snRNA at 5' end of intron

II) A mutation in the U1 snRNA or the pre-mRNA at 5' end of intron disrupts the base pairing and hence inhibits splicing.

III) A compensatory base change in the U1 snRNA suppresses a 5' splice site mutation

Which of the interpretations are wrong?

(a) I, III (b) II, III (c) I, II, III (d) None

26. Total RNA was isolated from human cells growing in culture. The RNA was mixed with

A) Non-template strands of human gene encoding thymidine kinase

B) Template strands of thymidine kinase gene

In both cases the RNA-DNA mixture was incubated for 12 hours under renaturation conditions. What would be expected in the two cases?

(a) The RNA-DNA duplex would be formed in case (A) as well as in case (B)

(b) The RNA-DNA duplex would be formed in case (A) but not in case (B)

(c) RNA-DNA duplex would be formed only in case (B)

(d) RNA-DNA duplex will not be formed in any of the two cases

27. Two preparations of RNA polymerase from *E. coli* are used in separate experiments to catalyze RNA synthesis *in vitro* using a purified fragment of DNA carrying the *arg H* gene as template DNA. One preparation catalyzes the synthesis of RNA chains that are highly heterogeneous in sizes. The other preparation catalyzes the synthesis of the RNA chains of same length. The most suitable explanation of the differences in the outcomes of the two reactions is

(a) The RNA polymerase preparation synthesizing heterogeneous lengths of RNA molecules contained the σ-factor bound RNA polymerase holoenzyme

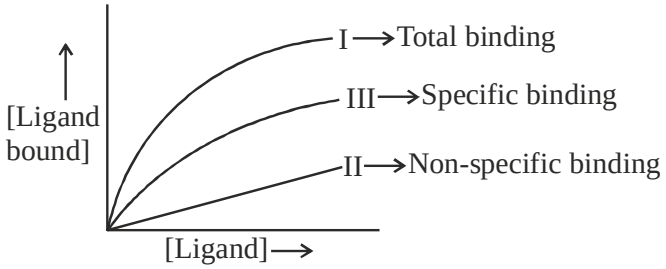
(b) The RNA polymerase preparation synthesizing RNA molecules of equal lengths lacked σ-factor

(c) The RNA polymerase preparation synthesizing heterogeneous lengths of RNA molecules lacked the σ-factor

(d) The reaction mixture synthesizing heterogeneous lengths of RNA molecules lacked the dNTPs

28. You wish to determine the number of receptors specific for a ligand X, which you have in both radioactive and non-radioactive form. In one experiment you add increasing amounts of radioactive X and measure how much of it is bound to the cells. In another experiment you include 1000 fold excess of non-radioactive X along with radioactive X and measure the radioactive X bound to cell.

The results of the two experiments are shown as



Different conclusions are made from the data

1) The total binding curve shows the specific binding and the non-specific binding of the ligand

2) The total binding curve is produced when radioactive ligand is mixed with 1000 fold non-radioactive ligand

3) The specific binding curve is generated by calculating the difference in the radioactivity bound to the cells of total binding curve and non-specific binding curve

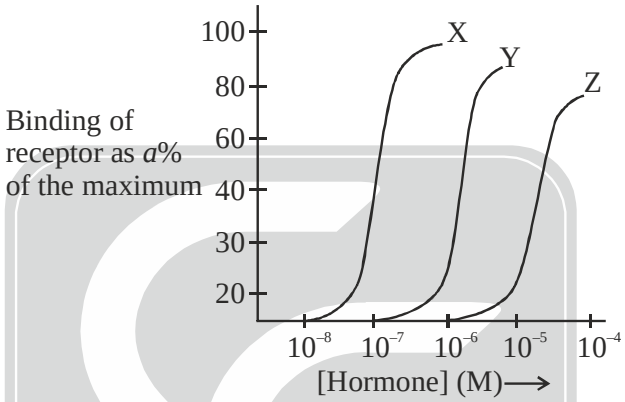
4) The non-specific binding curve is generated in presence of 1000 fold higher non-radioactive ligand X as the non-radioactive ligand can bind to receptors in higher proportion as compared to the radioactive ligand

5) The saturation of the curves shows that all the receptors are bound to the ligand and receptor binding sites are limited

Which of the conclusions correctly explain the results

(a) 1, 2, 3, 4 (b) 2, 3, 4, 5 (c) 1, 2, 4, 5 (d) 1, 3, 4, 5

29. You wish to determine the hormone binding specificity of a newly identified membrane receptor. Three different hormones X, Y and Z were mixed with the receptor in separate experiments and the percentage of binding capacity of the receptor was determined as a function of hormone concentration as shown in the graph



Which hormone shows the highest binding affinity for the receptor?

(a) X (b) Y

(c) Z (d) All of them have equal affinity

30. Carefully read the following statements with respect to PKA.

1) Any mutation that generate a regulatory subunit incapable of binding to the catalytic subunit would produce a permanently active PKA

2) Any mutation that generate a regulatory subunit that can bind to catalytic subunit but not bind cAMP would lead to a permanently inactive PKA

3) A mutant regulatory subunit that can bind cAMP but does not undergo conformational change to release catalytic subunit would lead to a permanently active PKA.

Find the correct combination of statements

(a) 1 and 2 only (b) 2 and 3 only (c) 1 and 3 only (d) 1, 2, 3

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[ANSWER KEY]

PART-B

1. (c)	2. (b)	3. (b)	4. (c)	5. (d)	6. (c)	7. (b)
8. (a)	9. (c)	10. (a)	11. (b)	12. (b)	13. (d)	14. (c)
15. (c)						

PART-C

16. (a)	17. (c)	18. (d)	19. (b)	20. (d)	21. (a)	22. (c)
23. (d)	24. (a)	25. (d)	26. (c)	27. (c)	28. (d)	29. (a)
30. (a)						