

Decide which is the BEST answer and blacken the corresponding brackets. (1 MARK EACH)

1. Van der Waals forces

- a) are the result of interactions between any two atoms which are covalently linked to each other.
- b) have higher energies (kcal/mole) in an aqueous environment than in a vacuum
- \*c) are weak bonding interactions between any two atoms due to fluctuating electric charges.
- d) have no effect on driving the possible conformations of a macromolecule.
- e) are only observed between atoms which are positively or negatively charged.

2. Hydrogen bonds

- a) are only observed in macromolecular structures between atoms making up a-helical secondary structure elements.
- b) have distances of 0.4nm (4.0Ångstrom).
- \*c) occur when a hydrogen atom is shared between two electronegative atoms.
- d) never involve water molecules.
- e) are much weaker in a vacuum than in an aqueous environment.

3. A polypeptide's backbone conformation is determined by the following torsion angles:

- a) phi (F) about C<sub>a</sub>- N.
- b) psi (y) about C<sub>a</sub>- C.
- c) theta (q) about C - N.
- d) (a) and (b) above.
- \*e) (a), (b) and (c) above.

4. The dipole moment of an a-helix

- a) is a result of the fact that peptide bonds exhibit different polarities for the NH and the CO groups.
- b) results in a net positive charge at the amino termini of the helix and a net negative charge at the carboxyl termini.
- c) is utilized by proteins to attract opposite charged ligands, such as phosphate groups, at the amino termini of the helix.
- d) is aided by the fact that the peptide units are all aligned in the same orientation along the helical axis.
- \*e) all of the above.

5. Beta sheet structures:

- a) are made up of a single, continuous region of the polypeptide chain.
- b) are made up of beta strands which are always oriented parallel to each other.
- \*c) most often form the central core of globular protein structures.
- d) adopt a left handed twist when viewed along their strands.
- e) all of the above.

6. Proteins adopt their native functional conformation

- a) by randomly exploring all conformations available to the peptide chain.
- b) by folding in such a way as to create a hydrophilic core and a hydrophobic surface.
- c) in a time frame of approximately 10<sup>100</sup> seconds.
- \*d) through an ordered pathway where the approach to the native state is accompanied by increasing conformational stability.
- e) none of the above.

7. A protein motif

- a) is never related to the biological function of the molecule.
- \*b) can be described as a geometric arrangement of certain secondary structure elements in a protein molecule.
- c) can never be predicted by an analysis of the amino acid sequence of a protein.
- d) (a) and (b) above.
- e) none of the above.

8. Glycine residues are often strategically positioned within the amino acid sequence of a protein molecule (BOTH ANSWERS CORRECT)

- a) to add variety to the sequence.
- b) to enable the polypeptide chain to maintain an a-helical structure.
- c) because the bulky side chain of a glycine residue will create important van der Waals interactions within the protein structure and thus stabilize the overall fold of the molecule.
- \*d) because the lack of a side chain on a glycine residue allows the polypeptide chain to adopt conformations which would not normally be accessible to other amino acid residues.
- \*e) none of the above.

9. The SH2 domain is a protein module found in a large number of signal transduction molecules.

- a) The structure specifically binds peptide substrates which adopt a-helical conformations.
- b) The specificity for the peptide substrate is mediated solely through interactions with a phospho-tyrosine residue.

- \*c) The binding site for the phospho-tyrosine side chain consists of a small cleft formed, in part, by three highly conserved positively charged residues with which it makes specific contacts.
- d) The binding site for the phospho-tyrosine side chain consists of a small cleft, the base of which is occupied by a calcium ion involved in interactions with the phospho-tyrosine moiety.
- e) Comparison of the structures of the complexed and the uncomplexed forms of the Src SH2 domain show that no conformational change occurs upon ligand binding.

10. The molecular structure bacteriorhodopsin

- a) contains 10 transmembrane  $\alpha$ -helices.
- b) has a retinal molecule bound at the cytoplasmic surface of the protein molecule.
- \*c) contains a retinal molecule which undergoes a conformational change when it absorbs light.
- d) contains a channel through which iron atoms are pumped from the cytosolic to the extracellular side of the membrane.
- e) none of the above.

11. One answer is incorrect

Glucose transport across the small intestinal epithelium:

- \*a) Occurs through junctional complexes between epithelial cells
- b) Involves a sodium:glucose symport
- c) Involves a metabolically driven sodium potassium ATPase
- d) Involves a potassium leak channel
- e) Involves a glucose carrier

12. One answer is incorrect:

Membrane fluidity:

- a) Certain phospholipids must flip across the bilayer during their biosynthesis
- b) Phospholipids spin with ease
- \*c) Phospholipids are usually prevented from moving laterally
- d) Cholesterol preserves the fluid nature of the membrane
- e) The lipid portion of the membrane is a continuous phospholipid bilayer

13. One answer is incorrect:

Proteins which span the membrane:

- \*a) Must readily flip-flop during carrier mediated transport of water soluble substances
- b) Have extracellular domains which are often decorated with carbohydrate groups
- c) May act as receptors for extracellular ligands
- d) May link structures outside the cell to structures inside
- e) Different membrane proteins may have various numbers of spanning domains

14. Select the incorrect answer:

For the insertion of membrane proteins through the phospholipid bilayer:

- \*a) Multipass membrane proteins are inserted post-translationally
- b) Multipass membrane proteins are usually N-glycosylated
- c) Multipass membrane proteins may be linked by a fatty acid to the membrane
- d) Multipass membrane proteins may be synthesized with a cleaved N-terminal signal sequence
- e) The location of  $\alpha$ -helical membrane spanning segments in multipass membrane proteins is predicted by hydrophathy plots.

15. Which statement is incorrect?

Membrane fusion:

- a) Is best understood for the influenza fusion protein which catalyzes lipid bilayer fusion at low pH.
- b) Is regulated in membranes of the secretory pathway by the apposition of v and t-SNARES
- c) In membranes of the secretory and endocytic pathways is regulated by Rabs.
- \*d) In axonal endings consists of the clathrin catalyzed fusion of neurotransmitter containing synaptic vesicles with the pre-synaptic plasma membrane.
- e) Requires the priming of SNARES by NSF and SNAPs

16. One statement is incorrect:

Integral membrane proteins associate with the bilayer:

- a) As single pass membrane proteins
- b) As multipass membrane proteins
- 3) And include proteins attached to the bilayer by covalently attached lipid

- 4) Via an oligosaccharide covalently linked to phosphatidylinositol  
\*5) By non-covalent interactions with other membrane proteins

17. Only one answer is correct

The "all or none" property of the Action Potential raises from:

- a) opening of voltage-gated  $K^+$  channels which their conformation changes by a change in the membrane voltage from  $-70\text{mV}$  to  $-50\text{mV}$ .  
b) the electrogenic pumping of  $Na^+$  out of the membrane by the  $Na^+ / K^+$  exchanger.  
\*c) a conformational change and opening of the voltage dependent  $Na^+$  channels as a result of a change in the membrane potential from  $B70\text{mV}$  to  $B52\text{mV}$ .  
d) the refractory period that voltage-gated  $Na^+$  channels enter after membrane depolarization.  
e) a conformational change of the voltage-gated  $Na^+$  channels that results from hyperpolarization of the plasma membrane.

18. Only one answer is correct

Delayed voltage-gated  $K^+$  channels function to:

- a) balance the electrochemical gradient of  $K^+$  across that membrane that was created by the  $Na^+ / K^+$  exchanger.  
\*b) reduce the duration of the Action Potential by increasing  $K^+$  concentration outside the cell.  
c) preserve a constant resting potential by pumping  $K^+$  into the cell.  
d) depolarize the membrane of the post-synaptic cell by  $K^+$  influx into the cell.  
e) delay the hyperpolarization produced by ligand-gated ion channels.

19. Select the best answer

To create a membrane potential the plasma membrane must ...

- \*a)  
1. contain electrogenic  $Na^+ / K^+$  pumps  
2. be impermeable to  $Na^+$  ions  
3. contain  $K^+$  channels
- b)  
1. be permeable to  $Na^+$  ions  
2. contain voltage-gated  $K^+$  channels
- c)  
1. contain a  $Na^+ / K^+$  pump that changes its conformation with depolarization  
2. contain  $Na^+$  channels that induce efflux of these ions out of the cell  
3. contain a machinery to induce influx of  $K^+$  into the cell
- d)  
1. contain a  $Na^+ / K^+$  exchanger that pumps  $Na^+$  into the cell and  $K^+$  out  
2. contain an open voltage-dependent  $Na^+$  channels
- e)  
1. contain open voltage-dependent  $Ca^{2+}$  channels  
2. be impermeable to  $K^+$  ions

20. Which of the following did NOT contribute to the creation of the field of biological chemistry in the 1950's?

- a) Studies on urea and other organic compounds.  
\*b) Development of DNA cloning techniques.  
c) Studies on microorganisms and their ability to produce alcohol by fermentation.  
d) Identification of the peptide bond.  
e) Description of the structure of DNA.

21. Which of the following statements is FALSE? Provide the most accurate answer.

- a) Chromatin is comprised of DNA, histones, and other proteins.  
\*b) Chromatin is formed at mitosis during chromosomal condensation.  
c) Chromatin contains DNA in 'loop domains' of 5000 to 150,000 base pairs.  
d) Chromatin associates with nuclear lamina at matrix associated regions (MAR).  
e) All of the above statements are true.

22. Which of the following statements is FALSE?

- a) Nuclear matrix associates with specific regions of DNA, termed "matrix association regions" or MARs.

- b) Nuclear matrix contains at least three major classes of lamins.
- c) Nuclear matrix forms a highly branched network structure.
- \*d) Nuclear matrix maintains cellular chromatin in a highly compacted state.
- e) The interactions between DNA and nuclear matrix is altered during the cell cycle by phosphorylation of lamins.

23. The CHARGE on histones is affected by which of the following. Provide the most accurate answer.

- A. phosphorylation
- B. methylation
- C. acetylation
- \*D. all of the above (A-C)
- E. none of the above (A-C)

24. In which order should the following be carried out to identify the histone components of chromatin?

- A. Separate components by SDS-polyacrylamide gel electrophoresis.
- B. Treat with high salt.
- C. Digest with DNase to remove DNA.

- 1) ABC
- 2) ACB
- 3) BCA
- 4) CAB
- \*5) CBA

25. Which of the following scenarios is INCORRECT following fusion of mammalian cells?

- a) G2 x M - the M cell nucleus continues mitosis and the G2 nucleus goes into mitosis.
- \*b) G1 x M - the M cell nucleus continues mitosis and the G1 nucleus first synthesizes DNA and then goes into mitosis.
- c) G1 x S - the S-phase nucleus continues DNA synthesis and the G1 nucleus starts DNA synthesis.
- d) G2 x S - the S-phase nucleus continues DNA synthesis and the G2 nucleus remains in G2.
- e) G1 x G2 - the G1 nucleus proceeds through G1 and into S whereas the G2 proceeds through G2.

26. Which factor is NOT associated with density-dependent growth inhibition?

- a) high cell density
- b) low concentration of nutrients or growth factors
- \*c) high levels of cyclin D
- d) high levels of p130 and pRB
- e) low levels of p107

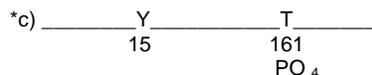
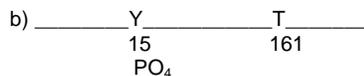
27. Which of the following statements about telophase cells is FALSE?

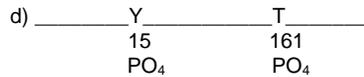
- \*a) cyclin B levels rise
- b) chromosomes de-condense
- 4) membranes surround chromosomes and reform the nuclear membrane
- d) the nucleolus is reformed
- e) vesicle movement restarts

28. Which of the following properties is NOT a difference between G1 and mitotic chromosomes? Provide the most accurate answer.

- a) Mitotic chromosomes contain twice the amount of DNA as G1 chromosomes.
- b) G1 chromosomes are less condensed than mitotic chromosomes.
- c) Mitotic chromosomes become attached to spindles, G1 chromosomes do not.
- d) Chromatin in G1 nuclei is more highly acetylated than that in mitotic cells.
- \*e) All the above statements are true.

29. Which of the following forms of yeast cdc2 kinase are active? Y denotes a tyrosine residue and T a threonine residue. PO4 if shown below indicates phosphorylation of the residue.





e) all of the above

30. The primary goal of chromosome condensation in mitosis is to:

- A. inhibit gene expression
- \*B. facilitate division of chromosomes into daughter cells
- C. facilitate attachments to spindle bodies
- D. promote cyclin B degradation
- E. promote breakdown of the nuclear membrane

31. What do p21, p16, p15 and p27 all have in common?

- a) All are activated by p53.
- b) All dephosphorylate RB family members.
- \*c) All bind to and inactivate Cdks.
- d) All are regulated by E2F.
- e) All of the above are true.

32. In late S-phase in yeasts what cyclins are present at significant levels. Provide the most accurate answer.

- a) only Cln1 and Cln2
- b) all cyclins
- c) only cyclin B
- d) only Cln3
- \*e) only cyclin B and some Cln3

33. Which is the correct order of events in mating factor signalling?

- A. degradation of G1 cyclins
- B. activation of a kinase cascade
- C. binding of mating factor to receptor
- D. activation of a G protein

- 1) A to B to C to D
- 2) D to C to A to B
- 3) C to D to A to B
- 4) C to B to D to A
- \*5) none of the above

34. Transcriptional repression of some promoters containing E2F binding sites does NOT involve which one of the following?

- A. Binding of E2F
- B. Binding of RB members to E2F
- C. Histone deacetylases
- \*D. The activation domain of E2F
- E. The 'pocket' of RB members

35. Which of the following approaches has NOT contributed to the discovery of cellular oncogenes? Provide the most accurate answer.

- a) study of animal retroviruses
- b) the 3T3 mouse cell assay
- c) study of chromosomal break points found in tumours
- d) detection of amplified genes in tumours
- \*e) all of the above have contributed

36. Overexpression of what number of the genes in the list below could lead to growth arrest?

RB, cyclinD, E2F1, Cdk4

- a) none
- \*b) one
- c) two
- d) three
- 5) four

37. Order the following steps in the identification of human oncogenes using the mouse 3T3 cell assay.

- A. isolation of DNA from human tumours

- B. introduction of transformed cell DNA into bacteriophage library and transformation of 3T3 cells
- C. identification of clones containing human Alu repeat sequences
- D. transfection of mouse 3T3 cells
- E. isolation of transformed cell clones

- 1) AEDCB
- \*2) ADEBC
- 3) ABEDC
- 4) ABCDE
- 5) ADCBE

38. If a growth factor present on the cell surface of one cell binds to a receptor on an adjacent cell, this results in

- a) Exocrine growth stimulation
- \*b) Juxtacrine growth stimulation
- c) Autocrine growth stimulation
- d) Paracrine growth stimulation
- e) Endocrine growth stimulation

39. Members of the steroid receptor gene family

- a) are localized only in the cytoplasm
- b) activate a kinase cascade
- c) have intrinsic enzymatic activity
- \*d) bind hydrophobic ligands
- e) none of the above

40. Signal transduction requires a series of protein:protein interactions. Proteins containing an SH3 domain interact with proteins containing

- a) SH3 domains
- b) kinase domains
- \*c) proline rich domains
- d) phosphotyrosine residues
- e) none of the above

41. Activation of Raf kinase-

- a) is mediated only by receptor tyrosine kinases.
- b) is mediated by receptor tyrosine kinases through phospholipase C
- c) requires activation of protein kinase A.
- d) always requires activation of Ras.
- \*e) is mediated by G-protein linked receptors through protein kinase C.

42. Binding of a growth factor to a receptor tyrosine kinase, promotes receptor dimerization, activates the receptor and leads to -

- a) phosphorylation of the receptor on tyrosine and serine residues
- b) association of the receptor with trimeric G proteins
- c) activation of protein kinase A
- \*d) phosphorylation of some SH2 domain containing proteins on tyrosine residues
- e) none of the above

43. Activation of G-protein linked receptors following binding of ligand can lead to-

- a) activation of the RasGTPase.
- b) activation of the intrinsic GTPase activity of the receptor.
- c) formation of a complex between the receptor and protein kinase A.
- d) formation of a complex between the receptor and protein kinase C.
- \*e) none of the above

44. The src tyrosine kinase is:

- a) Is activated through interaction of its SH2 domain with a proline rich domain on a receptor tyrosine kinase.
- \*b) Is maintained inactive through an interaction of its SH2 domain with a tyrosine residue in its carboxyterminus.
- c) A transmembrane protein
- d) Is recruited to the plasma membrane by an activated G protein coupled receptor.
- e) None of the above

45. Protein tyrosine phosphatases

- a) share extensive homology at the amino acid level with phospho -serine phosphatases within the active site
- b) bind ATP
- c) require a metal ion for activity

- d) dephosphorylate threonine residues
- \*e) none of the above

46. In which one of the following transcription factors are the recognition helices separated by 3.4 nm?

- 1) Helix-loop-helix
- 2) Zinc finger
- \*3) Helix-turn-helix
- 4) Leucine zipper
- 5) None of the above

47. Which one of these transcription activation examples could serve as a model of transcription factor cooperativity?

- 1) Steroid receptors
- \*2) albumin gene transcription
- 3) myogenin and myoD
- 4) Gal4 and galactose catabolism
- 5) none of the above

48. In which one of the following examples is transcriptional regulation NOT modulated by DNA recombination?

- 1) alpha mating
- 2) immunoglobulin gene
- 3) H1 flagellar protein
- \*4) Myf5
- 5) None of the above

49. Which one of the following enzymes is not part of the mRNA capping mechanism?

- a) RNA triphosphatase
- b) mRNA guanylyltransferase
- c) mRNA (guanine-7) methyltransferase
- d) mRNA (nucleoside 2' -) methyltransferase
- \*e) none of the above

50. Based on the following hnRNA sequence what is the size of the expected intron presented:

---AAGCAAGGUAACUGGAUCGGAUGGCAGAAACAGGCCAAAA---

- \*a) 27
- b) 18
- c) 22
- d) 35
- e) 29

51. During the splicing event a unique RNA structure is made named a Lariat. What is the linkage in the hnRNA that creates this structure?

- a) between the 3' end of exon II and the 5' end of exon I.
- \*b) between the branch point and the 5' end of the intron
- c) between the 5' end of intron and the 3' end of exon II
- d) between the 5' end of the exon II and the branch point
- e) between the 5' end of the intron and the 3' end of the intron

52. What is the enzymatic reaction that produces one of the RNA editing process?

- a) phosphorylation of adenine
- b) methylation of thymidine
- \*c) deamination of cytosine
- d) ubiquitination of guanine
- e) dephosphorylation of ADP ribose

53. In which of the following functions does cytosolic aconitase (CA) regulate iron metabolism?

- a) in excess iron CA binds the 5' non coding sequence of the ferritin message.
- \*b) during iron starvation CA binds the 3' non coding sequence and stabilize the transferrin receptor mRNA.
- c) in excess iron CA binds the 3' non coding sequence of the ferritin message.
- d) during iron starvation CA binds the 5' non coding sequence and stabilize the transferrin receptor mRNA.
- e) in excess iron CA binds iron and promotes its interaction with the ferritin mRNA.

54. Which one of the following embryo manipulation techniques cannot be performed on morula?

- a) freezing
- b) splitting

- c) embryo typing
- d) es cocultivation
- \*e) DNA microinjection

55. By which one of the following techniques can one detect the multiple initiation start sites of mRNA using initiator sequences.

- \*a) Primer extension
- b) Gel shift assay
- c) Foot-printing
- d) Reporter gene assay
- e) None of the above

56. If the following message was translated how long would the most translated peptide be?  
CCAAAUGACACAUGCCGCGCCAUGAAACCGGUGAAGUAAGAAGUAGGG-

- a) 12 amino acids
- \*b) 5 amino acids
- c) 10 amino acids
- d) 4 amino acids
- e) 8 amino acids

57. How does the sxl protein control the expression of the tra gene?

- a) by binding to its 5' promoter
- b) by targeting the poly A site of the tra mRNA
- \*c) by specifically blocking the exon 2 acceptor splicing site of the tra gene.
- d) By promoting splicing of exon 2 at its donor site.
- e) None of the above

58. What is a bicistronic message?

- a) A mRNA that encodes a dimeric protein.
- b) A mRNA that contains two overlapping open reading frames.
- \*c) A mRNA that encodes two subsequent open reading frame separated by a ribosome landing pad.
- d) A mRNA that can be spliced into two independent messages.
- e) None of the above

59. How many GTP molecules are required for the elongation stage of a protein of 20 amino acids.

- a) 20
- b) 10
- c) 40
- \*d) 38
- e) 19