1. Which stage of mitosis is most characterized by the shortening of kinetochore microtubules?

   A. Prometaphase  
   B. Metaphase  
   C. Anaphase A  
   D. Anaphase B  
   E. Telophase

2. MPF phosphorylates all but which of the following substrates:

   A. Histone H1  
   B. Microtubule-associated proteins  
   C. Nuclear lamins  
   D. Cyclin B

3. All of the following substances move across the plasma membrane of cells by passive diffusion EXCEPT

   A. palmitic acid  
   B. aldosterone  
   C. Na+  
   D. testosterone  
   E. estrogen

4. Loss of function mutations (involving a single allele) that affect the production on an enzyme are usually autosomal _______, while loss of function mutations that affect structural proteins are usually autosomal _______.

   A. recessive, recessive  
   B. recessive, dominant  
   C. dominant, dominant  
   D. dominant, recessive  
   E. huh?
5. Rb and p53 both are genes that function in regulating the cell cycle transition from ___ to ___.

A. S to G2  
B. M to G1  
C. G2 to M  
D. M to G2  
E. G1 to S

QUESTIONS #6-#11

Indicate whether the following statements regarding translation are true in ;
a) Prokaryotes ONLY  
b) Eukaryotes ONLY  
c) Both  
d) Neither

6. Multiple ribosomes can be bound to and translating a single mRNA
7. Genes for multiple proteins may be encoded on the same mRNA
8. Ribosomes use a 50S subunit
9. Ribosome may bind to an mRNA and initiate translation from either end
10. Proteins are targeted to their destination through interaction with the endoplasmic reticulum and golgi apparatus.
11. Proteins enter the golgi apparatus at its trans face.

QUESTIONS #12- #15

Match the molecule to the mechanism:

12. SRP  
a) assist in protein folding
13. KDEL Sequence  
b) brings proteins and the ribosomes that are translating them from the cytosol to the rough ER
14. Chaperones  
c) help configure ribosome and mRNA to start translation
15. eIFs  
d) targets proteins emerging from the golgi apparatus to rough ER

16. Which type of Genetic Analysis method can detect the presence of a gene but is not useful for single base pair changes?
17. The term that describes different mutations at the same locus that lead to the same phenotype is:

a. Allelic heterogeneity  
b. polygeneity  
c. Locus heterogeneity

18. All of the following are true of an individual’s DNA except:

a. Environmental mutagens can cause the expression of a recessive allele that otherwise would not be expressed in a heterozygous individual.  
b. Somatic mutations, like germline mutations, are passed on to progeny.  
c. Tumors can result from spontaneous translocations affecting proto-oncogenes.

19. True or False: The majority of cancers involve an inherited predisposition?

20. FOS, JUN and MYC are:

a. genes coding for surface proteins expressed on cancerous cells.  
b. genes coding for protein kinases that phosphorylate transcription factors regulating cancer genes.  
c. genes coding for transcription factors that induce growth-dependent genes.  
d. unfortunate third-grade spellings of three months of the year.

21. At what stage in development are human oocytes arrested between fetal life and puberty? When does the second meiotic division occur in the oocyte?

a. zygotene, at ovulation  
b. dictyotene, after fertilization  
c. dictyotene, at ovulation  
d. zygotene, after fertilization

22. Order the following events in eukaryotic gene expression:
I. Binding of the 40S subunit
II. Creation of a 2’-5’ phosphodiester bond
III. Exporting RNA from the nucleus
IV. Binding of DNA Polymerase to the template strand

A. IV, I, II, III
B. IV, II, III, I
C. I, IV, II, III
D. IV, II, I, III
E. None of the above

23. Which of the following abnormal base pairings might be found in “wobble” codon-anticodon binding?
   A. adenosine-uracil
   B. guanine-uracil
   C. cytosine-inosine
   D. guanine-thymine

24. Which of the following statements about the 3’ poly(A) tail of mRNA is FALSE?
   A. It helps align eukaryotic mRNA on the ribosome during translation.
   B. It is added to the primary transcript in the nucleus.
   C. It is not essential for protein synthesis
   D. It helps contribute to the stability and lifespan of the mRNA.

25. Which of the following proteins is NOT essential in the synthesis of eukaryotic proteins from DNA templates?
   A. RNA Polymerase I
   B. TATA binding protein (TBP)
   C. aminoacyl tRNA synthetases
   D. TFIID

26. The property of resonance as applied to protein structure is responsible for:
   a. the prevention of rotation about the alpha carbon
   b. the partial double bond character of the side chain-alpha carbon bond
   c. the planar nature of the peptide bond
   d. the ability of cochlear cells to detect sound waves by mechanotransduction

27. Which of the following statements is TRUE?
a. hydrophobic forces are due to the intrinsic attraction between hydrophobic side chains  
b. β-sheets can be stretched relatively more than α-helices  
c. chaperones increase the rate of protein denaturing  
d. β-sheets are formed from inter-chain hydrogen bonding

28. Match the characteristic side chain group with the corresponding amino acid category:

- Acidic amino acids: Hydrocarbons (CH, CH₂, CH₃, benzene rings)  
- Nonpolar amino acids: (+) charged Nitrogen atom  
- Basic amino acids: (-) charged COO⁻ (carboxyl)  
- Polar amino acids: Uncharged Oxygen or Nitrogen atoms

29. Enzyme Q can catalyze the conversion of molecule A to A’ and the conversion of molecule B to B’. Both of these conversion reactions follow Michaelis-Menten kinetics and both have the same $V_{max}$. However, the $K_M$ for the $A \rightarrow A’$ conversion is three times as large as the $K_M$ for the $B \rightarrow B’$ conversion. What is the relationship between the substrate concentrations, $[A]$ and $[B]$, when both of these reactions are proceeding at a reaction velocity equal to $\frac{1}{2}*V_{max}$?

a. $[A] > [B]$  
b. $[B] < [A]$  
c. $[A] = [B]$  
d. not enough information

30. Imagine a beaker containing only molecules H and H’, which are in dynamic equilibrium with each other. A significant amount of enzyme Z, which catalyzes the conversion of $H \rightarrow H’$, is then added to the beaker. The presence of enzyme Z will result in:

a. an increase in the amount of $H$ in the beaker  
b. an increase in the amount of $H’$ in the beaker  
c. an increase in the production rates of both $H$ and $H’$ with no change in the actual amounts of $H$ and $H’$ in the beaker  
d. no changes in either the production rates or the amount of $H$ and $H’$ in the beaker.

31. Which if the following statement about the apoptotic process is TRUE?
a. Anti-apoptotic protein BCL-2 is located in the mitochondrial inner membrane
b. Apoptotic protein Bax resides in cytosol and translocates into the mitochondria in response to death stimuli
c. Cytochrome C is released from lysosome into cytosol to kill the cell
d. During apoptosis, there is an increase in osmotic pressure inside the cell, causing the cell to swell and burst and results in cell death

32. Mitochondrial DNA is inherited from:
e. Paternal only
f. Maternal only
g. Both paternal and maternal
h. The offspring’s own DNA

33. Matching
Endocrine Cell responds to its own secreted molecules
Autocrine Cell secretes molecules to act on neighboring cells
Paracrine Cell secretes molecules to act on distant cells

34. Which of the following is TRUE about G-protein signaling?
I. During activation of G-protein, subunit of the G-protein dissociates from the activated G-protein to activate adenylyl cyclase
II. During activation of G-protein, the active $\alpha$ subunit is terminated by the hydrolysis of the bound GTP caused by GTPase
III. Testosterone can bind to the cell membrane receptor to activate G-protein
IV. The ratio of G-protein coupled receptor to G-protein is 1:1

A. I only
B. II only
C. III only
D. II and IV
E. II and III

35. What is/are the consequences of the activation of phospholipase C (PLC) by G protein mechanism?
i. Cleavage of phosphotidylinositol 4,5-bisphosphate (PIP$_2$) into IP$_3$ and protein kinase C (PKC)
j. Decrease of Ca$^{2+}$ level in the cell causes cell mobility
k. IP$_3$ binds to receptor on the membrane of endoplasmic reticulum to stimulate the release of Ca$^{2+}$
l. Diacylglycerol (DAG) alone activates protein kinase C (PKC)
ANSWERS TO MULTIPLE CHOICE QUESTIONS

1. C
2. D
3. C

Palmitic acid is a C-16 fatty acid, while aldosterone, testosterone, and estrogen are all steroid derivatives and therefore hydrophobic. These cross membranes by passive diffusion. Na+, a charged molecule, crosses membranes through channels, since it is hydrophilic: facilitated transport (non-energy requiring) or active transport (energy-requiring).

4. B
A loss of function mutation involving an enzyme can usually be compensated by the corresponding normal allele. Most inborn errors of metabolism fit into this category. A loss of function mutation affecting a key structural protein like collagen or fibrillin, however, is usually expressed in a dominant fashion.

5. E
6. C
7. A

“Polycistronic” mRNAs occur only in prokaryotes. In eukaryotes, there are no internal ribosome binding sites, only the 5’ methylguanosine cap.

8. A -- a target of antibiotics
9. D
10. B
11. D
12. B
13. D
14. A
15. C
16. C
17. A
18. B
19. False - Most develop sporadically.
20. C - Fos and Jun form a heterodimer prior to binding DNA, and all three are potential oncogenes.
21. B
22. E

RNA Polymerase (usually RNA Pol II) is involved in gene transcription; DNA Polymerase is involved in DNA replication. After RNA Pol transcription of the template strand, the 2’-5’ phosphodiester bond is formed when the lariat structure is spliced out of the primary transcript. Next, the RNA is exported from the nucleus before the 40S ribosomal subunit binds to initiate translation.
23. B.  
Codon-anticodon base pairing is relaxed at the third codon position which can allow G to pair with C, U, or I. A-U base pairing isn’t an abnormal base pairing. Cytosine does not base pair with inosine. Thymine is not found in mRNA or tRNA (and it wouldn’t base pair to guanine anyways).

24. A  
The 7-methylguanosine cap helps align mRNA on the ribosome. The poly(A) tail (along with the 7-methylguanosine cap) is involved in the mRNA’s stability and lifespan.

25. A  
RNA Polymerase I is involved in the synthesis of various rRNA subunits, not protein products (that is done by RNA Polymerase II).

26. C  
Resonance of the double bond between the carbonyl (C=O) and amide (C-N) bonds imparts a partial double bond character to the peptide (or amide) bond. Atoms that are bound even by a partial double bond cannot rotate with respect to each other, so the C, O, N, and H atoms of the peptide bond are restricted within a single plane. The alpha carbon of each amino acid residue in a polypeptide, however, is allowed to rotate with respect to the adjacent carbonyl and amino groups.

27. D  
β-sheets are formed from inter-chain hydrogen bonding, whereas α-helices are formed from intra-chain hydrogen bonding. β-sheets are already relatively stretched out in their natural state, and thus cannot be stretched further. α-helices are naturally compact and spring-like, and stretch considerably. Chaperones are proteins the increase the rate of protein folding into their native state. Hydrophobic forces are actually due to the increase in entropy resulting from the formation of solvation shells with decreased surface areas (For example, three non-polar amino acids each with their own solvation shell of water molecules will come in close proximity with each other. In the areas where they contact each other, water will no longer have to coat their surfaces in a highly ordered arrangement. This increased disorder is energetically favorable).

28. Matching:  
Acidic amino acids <---------> (-) charged COO⁻ (carboxyl)  
Nonpolar amino acids <-----------> Hydrocarbons (CH, CH₂, CH₃, benzene rings)  
Basic amino acids <-------------> (+) charged Nitrogen atom  
Polar amino acids <-------------> Uncharged Oxygen or Nitrogen atoms

29. A  
Don’t let the question confuse you. The larger Kₘ for the A → A’ conversion means that enzyme Q has a lower affinity for molecule A. Thus, there needs to be relatively more of A than B to get the conversion reaction to proceed at the same speed (of ½*Vₘₐₓ). Another way to figure this out is to remember that at Vₒ = ½*Vₘₐₓ, the substrate concentration, [S], is equal to the Kₘ. So if the Kₘ for the A → A’ conversion is three
times as large as the $K_M$ for the $B \rightarrow B'$ conversion, the $[A]$ must be three times as large as the $[B]$ when $V_o = \frac{1}{2}V_{max}$.

30. C
Enzymes lower the activation energy required to bring the reactants to the transition state. Thus, they will increase both the forward and reverse reactions in an equilibrium reaction. However, they do not affect the equilibrium state of a reaction because the forward and reverse reaction rates remain perfectly balanced.

31. B
A is incorrect because BCL-2 protein is located in the mitochondrial outer membrane, not the inner membrane. C is incorrect as well because cytochrome C is released from the mitochondria during apoptosis. Once cytochrome C is released into the cytosol, it associates with adaptive protein and caspase to execute cell death. Lysosome releases hydrolytic enzymes that digest materials endocytosed by the cell. Finally, D is incorrect because during apoptosis, the cell shrinks and breaks up into membrane-enclosed fragments called apoptotic bodies.

32. B
Correct answer is B. Mitochondrial DNA is of maternal origin. This is because during fertilization, only the genetic materials inside the nucleus (or the head) of the sperm will be preserved to fuse with the egg nucleus. The tail and the neck of the sperm, which contains the mitochondria, will be destroyed.

33.

<table>
<thead>
<tr>
<th>Endocrine</th>
<th>Cell responds to its own secreted molecules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autocrine</td>
<td>Cell secretes molecules to act on neighboring cells</td>
</tr>
<tr>
<td>Paracrine</td>
<td>Cell secretes molecules to act on distant cells</td>
</tr>
</tbody>
</table>

34. B
Correct answer is B. Statement I is wrong because it is the $\alpha$ subunit of the G-protein, not the $\beta\gamma$ subunit, that activates adenylyl cyclase to form cAMP, which acts as a second messenger of the signaling transduction process. Statement III is incorrect because testosterone is a steroid hormone, and it enters the cell and the nucleus via diffusion to bind with receptors of transcription factors and to act upon the regulation of DNA transcription. Statement IV is also incorrect because G protein signaling has the ability to amplify signals. Activation of one receptor can activate multiple G proteins in the cytoplasm.

35. C
C is the correct answer. A is wrong because cleavage of PIP$_2$ results in IP$_3$ and DAG. DAG, along with the Ca$^{2+}$ released from the ER membrane by IP$_3$, will then activate PKC. B is wrong because cleavage of PIP$_2$ produces both DAG and IP$_3$, and IP$_3$ will cause an increase in the level of intracellular Ca$^{2+}$. D is wrong as well because as mentioned above, the activation of PKC requires both DAG and Ca$^{2+}$ released from ER.