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Name:_____ Class:_____ Date:_____

Chapter 01: The Cell: A Microcosm of Life

1. Membrane lipid bilayers consist primarily of ____.
   a. phospholipids
   b. cholesterol
   c. proteins
   d. saturated fatty acids
   e. enzymes

ANSWER: a

2. Which of the following is a common function of membrane proteins?
   a. receptors
   b. detoxifiers
   c. purifier
   d. neutron transporter
   e. storage proteins

ANSWER: a

3. What is the role of cholesterol in plasma membrane structure?
   a. to produce bile
   b. to regulate fluidity and permeability
   c. to reduce stability
   d. to produce hormones
   e. to catalyze chemical reactions

ANSWER: b

4. Which of the following is not a usual function of the cytoskeleton?
   a. locomotion
   b. generation of ATP
   c. structural support
   d. positioning of organelles
   e. transfer of DNA and RNA

ANSWER: b

5. Which cellular component enables signal transmission to various parts of the cell due to interconnections within the cytosol?
   a. glycoproteins
   b. microfilaments
   c. glycolipids
   d. integral proteins
   e. nucleic acids

ANSWER: b

6. How are the carbohydrate moieties of the plasma membrane glycoproteins and glycolipids oriented?

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a. outwardly, away from the cytoplasmic matrix
b. inwardly, toward the lumen
c. equally inwardly and outwardly to maintain symmetry
d. between the bilayers of the membranes
e. interlinked with each on both sides of the membrane

ANSWER: b

7. Which of the following describes proteins attached to the membrane through hydrophobic interactions and embedded in the membrane?
a. peripheral proteins
b. rough endoplasmic reticula
c. integral proteins
d. Golgi apparatus
e. apoproteins

ANSWER: c

8. Which structure in the cell provides support and controls the movement of cell organelles?
a. endoplasmic reticulum
b. mitochondrion
c. cytoskeleton
d. cytosolic matrix
e. nucleus

ANSWER: c

9. Cytochalasin is a fungal toxin that prevents the polymerization of actin. Which cellular structure is the target?
a. nucleus
b. cytoskeleton
c. lysosomes
d. mitochondria
e. plasma membrane

ANSWER: b

10. Which of the following is not normally found in the cytoplasmic matrix of a typical cell?
a. amino acids
b. glucose-6-phosphate
c. carbon dioxide
d. urea
e. lipids

ANSWER: d

11. Enzymes of which metabolic pathway can be found in the cytoplasmic matrix?
a. beta-oxidation

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b. glycolysis
c. ketone production
d. the Kreb's cycle
e. cholesterol synthesis

ANSWER: b

12. Which organelle is responsible for the production of most of the metabolic energy (ATP)?
a. Golgi apparatus
b. endoplasmic reticulum
c. nucleus
d. mitochondrion
e. lysosome

ANSWER: d

13. Which of the following can freely diffuse across the inner mitochondrial membrane?
a. glucose
b. oxygen and carbon dioxide
c. fatty acids
d. NADH
e. protons

ANSWER: b

14. Where are the majority of the components of the electron transport chain embedded?
a. mitochondrial inner membrane
b. mitochondrial outer membrane
c. mitochondrial matrix
d. cytoplasmic matrix
e. plasma membrane

ANSWER: a

15. In which organelle do the TCA cycle and fatty acid oxidation occur?
a. Golgi apparatus
b. nucleus
c. microsomes
d. mitochondrion
e. endoplasmic reticulum

ANSWER: d

16. What is the major route for ATP production in the cell?
a. oxidative phosphorylation
b. hydrolysis
c. peroxidation

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d. transformation
e. substrate-level phosphorylation

ANSWER: a

17. Which organelle is capable of performing both fission and fusion?
a. Golgi apparatus
b. mitochondria
c. rough endoplasmic reticulum
d. nucleus
e. lysosome

ANSWER: b

18. What do the genes contained in the mitochondrial DNA code for?
a. all proteins functioning within the mitochondrial matrix
b. nonfunctional ancient proteins considered remnants of evolution
c. proteins vital to the production of ATP
d. antioxidant proteins
e. immune proteins

ANSWER: c

19. Which cell organelle is responsible for the initiation and regulation of most cellular activity?
a. peroxisome
b. nucleus
c. mitochondrion
d. Golgi body
e. endoplasmic reticulum

ANSWER: b

20. In addition to the mitochondria, which organelle possesses an inner and outer membrane?
a. lysosome
b. peroxisome
c. Golgi apparatus
d. nucleus
e. endoplasmic reticulum

ANSWER: d

21. Microtubule organization centers (MTOCs) on the outer nuclear membrane are associated with which cellular process?
a. oxidative phosphorylation
b. electron transport
c. mitosis
d. protein synthesis

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e. lipid synthesis

ANSWER: c

22. What information does the DNA in the nucleus contain?
    a. the entire genome for that organism
    b. the genes coding for proteins needed only by that particular cell
    c. chromatin
    d. all components of the cytoskeleton
    e. components of the electron transport chain

ANSWER: a

23. What is the DNA in the nucleus found wrapped around?
    a. proteins called histones
    b. the nucleolus
    c. the nuclear envelope
    d. ribosomal RNA
    e. the inner membrane

ANSWER: a

24. What is the best description of transcription?
    a. the genetic information in a single strand of DNA is copied onto a specific sequence of bases in a messenger RNA (mRNA) chain
    b. genetic information in an mRNA molecule specifies the sequence of amino acids in the protein product
    c. amino acids are linked together to form the primary structure of a protein
    d. the information of one DNA strand is copied onto another DNA strand
    e. the primary structure of a protein is folded several times to become the quaternary structure

ANSWER: a

25. What is the best description of translation?
    a. the genetic information (base sequence) in a single strand of DNA is used to specify a complementary sequence of bases in an mRNA chain
    b. a daughter duplex DNA molecule that is identical to the parental duplex DNA is synthesized
    c. the polypeptide chain is degraded
    d. information in an mRNA molecule is used to build a sequence of amino acids to form the protein product
    e. mRNA strand is modified in the nucleus

ANSWER: d

26. What is the best description of elongation?
    a. the mRNA strand is formed
    b. peptide bonds are formed between aligned amino acids after the amino acids are positioned
    c. amino acids are activated by ATP at their carboxyl end
    d. activated amino acids are transferred to their specific tRNAs that contain the anticodon complementary to

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each amino acid's codon

e. amino acids are activated by ATP at their amino terminal end

ANSWER: b

27. What are the microtubule organization centers (MTOCs) at the outer nuclear membrane composed of?

a. sugars
b. proteins
c. fatty acids
d. NADH
e. glycolipids

ANSWER: b

28. What is the role of transcription-level control mechanisms?

a. to determine the path by which mRNA can be translated into a polypeptide
b. to determine whether a particular mRNA is actually translated
c. to determine the effect on the transcription of a gene
d. to drive the interaction between tRNA and mRNA
e. to drive the interaction between mRNA and RNA Polymerase

ANSWER: c

29. What are microRNAs?

a. small noncoding RNAs that enhance gene expression by activating mRNA expression
b. small noncoding RNAs that silence gene expression by binding to mRNA to inhibit translation
c. small noncoding RNAs that modify gene expression by replacing specific nucleotides in mRNA
d. small noncoding RNAs that mediate DNA production in a reverse direction
e. small noncoding RNAs that enhance the interaction between DNA and DNA binding proteins

ANSWER: b

30. What are defined as the nucleotide sequences that are part of a gene but do not code for the protein product?

a. exons
b. introns
c. histones
d. promoters
e. enhancers

ANSWER: b

31. Which organelle is composed of an extensive network of membranous channels that connects the nuclear membrane, the Golgi apparatus, and the plasma membrane?

a. the lysosome
b. the nucleolus
c. the centrioles
d. the endoplasmic reticulum

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e. centrosome

ANSWER: d

32. What is the smooth endoplasmic reticulum (SER) associated with?
a. lipid synthesis
b. protein synthesis
c. the calcium ion pump necessary for the contractile process
d. ribosomes and cytochrome P450 enzymes
e. production of glycoproteins

ANSWER: a

33. Which enzyme complex, used in metabolizing many drugs, is located on the rough endoplasmic reticulum in liver cells?
a. chromatins
b. lysozymes
c. cytochromes
d. polymerases
e. hydrolases

ANSWER: c

34. What cellular structure is made up of flattened cisternae flanked by tubular networks and thought to be an extension of the endoplasmic reticulum?
a. nucleus
b. cytoplasm
c. lysosome
d. Golgi apparatus
e. mitochondrion

ANSWER: d

35. What is the prominent function of the Golgi apparatus in neurons and secretory cells?
a. to stop the synthesis of proteins that may need carbohydrate additions
b. to add polysaccharide or lipid moieties to modify polypeptides
c. to regulate the constitutive secretion of proteins
d. to inhibit the regulated secretion of proteins
e. to synthesize polypeptides from mRNA

ANSWER: b

36. Which organelle is involved in maintaining quality control of synthesized proteins in the cell?
a. the endoplasmic reticulum
b. the Golgi apparatus
c. the nucleus
d. the mitochondrion

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e. the lysosome

ANSWER: a

37. Which organelle serves as the digestive system for the cell?

a. polysome
b. endosome
c. lysosome
d. ribosome
e. liposome

ANSWER: c

38. Which organelle is involved in detoxification by oxidizing molecules such as hydrogen peroxide and ethanol?

a. peroxisome
b. endosome
c. lysosome
d. ribosome
e. polysome

ANSWER: a

39. Destruction of which organelle(s) would cause the cell to cease to function due to a total loss of energy?

a. the nucleus
b. the Golgi apparatus
c. the ribosomes
d. the mitochondria
e. the lysosomes

ANSWER: d

40. Pancreatic cells produce many digestive enzymes necessary for digestion in the small intestine. Which organelle(s) is/are necessary for the delivery of digestive enzymes by the pancreatic cells?

a. endoplasmic reticulum and Golgi apparatus
b. lysosomes
c. ribosomes
d. peroxisomes
e. cytoplasm

ANSWER: a

41. Damage to MTOCs will interfere with which cellular process?

a. oxidative phosphorylation
b. mitosis
c. electron transport
d. synthesis of an mRNA molecule
e. synthesis of DNA

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ANSWER: b

42. What are the molecular stimuli that bind specifically to receptors known as?
    a. ligands
    b. enzymes
    c. allosteric enzymes
    d. hydrolases
    e. transcription factors

ANSWER: a

43. To which category do most receptor proteins belong?
    a. peripheral proteins
    b. internal proteins
    c. integral proteins
    d. glycoproteins
    e. nucleoproteins

ANSWER: a

44. Which of the following best describes the interaction between LDL and its receptor?
    a. Receptor that internalizes stimuli
    b. Receptor that functions as an ion channel
    c. Receptor that plays a catalytic role
    d. Receptor that generates internal chemical signals
    e. Receptor that is G-protein

ANSWER: a

45. What would be the effect of a glucokinase enzyme with a low K_m?
    a. There will be no effect.
    b. Glucose will be removed from blood even at low glucose concentrations by the liver.
    c. The liver will not be able to synthesize adequate glycogen.
    d. Glucagon will not be secreted.
    e. Appetite will be reduced.

ANSWER: b

46. What does diagnostic enzymology focus on?
    a. enzymes that are widely distributed among many tissues
    b. intracellular enzymes that express their activity in the blood abnormally due to a disease process
    c. secreted enzymes such as clotting proteins in blood
    d. nuclear enzymes
    e. receptor enzymes

ANSWER: b

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Chapter 01: The Cell: A Microcosm of Life

47. What is one possible trigger of apoptosis?
    a. overexpression of Bcl-2
    b. inactivation of *Casp-9*
    c. swelling of the cell
    d. release of mitochondrial cytochrome c
    e. inactivation of tumor necrosis factor

ANSWER: d

48. Malformed Apaf-1 molecules in a cell might ____.
    a. cause rapid apoptosis of the cell
    b. inactivate cytochrome c
    c. lead to the development of a tumor
    d. terminate all protein synthesis in the cell
    e. have no effect on the cell

ANSWER: c

49. Which of the following is not a form of energy?
    a. oxygen
    b. heat
    c. kinetic
    d. Chemical
    e. mechanical

ANSWER: a

50. In muscle cells, creatine phosphate is used to replenish which substance?
    a. glucose
    b. pyruvic acid
    c. ATP
    d. calcium
    e. glycogen

ANSWER: c

51. What category of enzymes function in the electron transport chain in the mitochondria?
    a. hydrolases
    b. oxidoreductases
    c. transferases
    d. lyases
    e. ligases

ANSWER: b

52. What category of enzymes function as digestive enzymes?
    a. hydrolases

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b. oxidoreductases
c. transferases
d. lyases
e. ligases

ANSWER: a

53. What category of enzymes catalyze reactions in which one functional group is moved from one substrate to another such as transaminases?
a. hydrolases
b. oxidoreductases
c. transferases
d. lyases
e. ligases

ANSWER: c

54. Which term describes a higher energy level or barrier at which the exothermic conversion to products takes place in a chemical reaction?
a. Free energy
b. Activation energy
c. Cellular energy
d. Transition state
e. Standard reduction potential

ANSWER: d

55. Which term describes the potential energy released from chemical bonds upon oxidation?
a. Free energy
b. Activation energy
c. Cellular energy
d. Transition state
e. Standard reduction potential

ANSWER: a

56. Which term describes the energy required to raise the reactants in a chemical reaction to their transition state?
a. Free energy
b. Activation energy
c. Cellular energy
d. Transition state
e. Standard reduction potential

ANSWER: b

57. Which term describes the tendency of a compound to donate or receive electrons in a chemical reaction?
a. Free energy

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b. Activation energy
c. Cellular energy
d. Transition state
e. Standard reduction potential

ANSWER: e

58. What is a researcher in the field of nutritional genomics *least* likely to study?
a. the interactions among genes and bioactive components in food that change gene expression without changing the DNA nucleotide sequence (nutritional epigenetics)
b. inborn changes in DNA nucleotide sequences or gene variants (nutrigenetics)
c. genetic alterations that can be compensated for by increasing or decreasing specific nutrients (nutrigenomics)
d. the interaction between genetically engineered enzymes and their substrates
e. interaction between enzymes and pollutants in the atmosphere.

ANSWER: d

59. A common mutation in the 5,10-methylenetetrahydrofolate reductase enzyme (MTHFR) ____.
a. prevents the individual from activating the B vitamin folate
b. has no effect on the activity of the enzyme
c. increases the activity of the enzyme
d. modifies the folate molecule directly
e. increases the activity of vitamin B12

ANSWER: a

60. What lifestyle change would be most important to individuals with a common variant in the *GST* gene that impairs protection against toxins?
a. increasing levels of daily exercise
b. eating a low-fat diet
c. increasing ingestion of cruciferous vegetables
d. increasing intake of omega-3 fats
e. reducing fiber in the diet

ANSWER: c

61. Which organelle do bioactive molecules need to travel to have effects on gene expression?
a. Golgi apparatus
b. plasma membrane
c. nucleus
d. mitochondrion
e. lysosome

ANSWER: c

62. Which term describes energy-releasing reactions?

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a. free reactions
b. activated reactions
c. endothermic reactions
d. transition reactions
e. exothermic reactions

ANSWER: e

63. What can be triggered by defects in the apoptotic process?
a. hypertension
b. cardiovascular disease
c. osteoporosis
d. autoimmune disease
e. viral disease

ANSWER: d

64. What is the term that refers to pathological cell death?
a. cellulosis
b. nephrosis
c. apoptosis
d. necrosis
e. oncosis

ANSWER: d

65. Which are highly specialized membrane proteins that modify the cell's response to its environment?
a. transport proteins
b. enzymes
c. receptors
d. peroxisomes
e. filamentous proteins

ANSWER: c

66. Receptors are the only type of protein found in the plasma membrane of cells.
a. True
b. False

ANSWER: False

67. The lipid bilayer determines the function of the plasma membrane, while the proteins are primarily responsible for the structure of the membrane.
a. True
b. False

ANSWER: False

68. Flagella and cilia are structural elements that are part of the cytoskeleton of the cell.

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a. True
b. False
ANSWER: True

69. Glycoproteins with their carbohydrate moieties facing the outer cell surface provide asymmetry to the plasma membrane.
a. True
b. False
ANSWER: True

70. Different cells express different proteins because the DNA contained in their nucleus is made up of different genes.
a. True
b. False
ANSWER: False

71. Polysomes function to transcribe mRNA into proteins.
a. True
b. False
ANSWER: False

72. When discussing enzyme kinetics, K_m refers to the substrate concentration at which the enzyme is saturated and functioning at maximal velocity.
a. True
b. False
ANSWER: False

73. If two enzymes (e.g., pyruvate dehydrogenase and pyruvate carboxylase) compete for the same substrate (pyruvate), the one with the higher K_m has less affinity and will be more active when pyruvate concentrations are high.
a. True
b. False
ANSWER: True

74. Most cellular reactions are irreversible because the same enzyme that catalyzes the conversion cannot catalyze the reverse reaction.
a. True
b. False
ANSWER: False

75. Regulation of enzyme activity by increasing the synthesis and thereby the concentration of the enzyme is an example of regulation by induction.
a. True
b. False
ANSWER: True

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Chapter 01: The Cell: A Microcosm of Life

76. Most of the metabolic energy produced in cells is made in the mitochondria.
    a. True
    b. False
ANSWER: True

77. The nuclear envelope consists of a single membrane layer that separates the nucleus from the rest of the cell.
    a. True
    b. False
ANSWER: False

78. Transcription of DNA cannot be altered.
    a. True
    b. False
ANSWER: False

79. An increase in the concentration of a substrate will increase the rate of the enzyme-catalyzed reaction.
    a. True
    b. False
ANSWER: True

80. Oncosis results from cell injury and is associated with cellular swelling and swelling of the mitochondrial nucleus.
    a. True
    b. False
ANSWER: True

81. List the three mechanisms that can be used to regulate the function of a protein (e.g., an enzyme) and briefly (in one to two sentences) describe their key features.
ANSWER: Mechanism 1: Covalent modification—no change in the abundance of a protein. Here, preexisting protein is made active or inactive by covalently modifying it (involves making or breaking covalent bonds). Examples include phosphorylation, carboxylation, glycosylation, or proenzyme activation by breaking a peptide bond.
Mechanism 2: Allosteric regulation—here we also are not changing the abundance of the protein (in this case an enzyme), but we are inhibiting or stimulating its activity—not by covalently modifying the protein, but by having something bind to it, resulting in a change in its conformation that affects its enzymatic activity. Typically, substrates, intermediates, or products along the pathway in which the enzyme participates bind to the enzyme. The book calls them modulators. A good example is ATP—ATP is the end point of a lot of pathways (glycolysis, TCA cycle) and as such, when it is abundant, that is a good sign that we have enough ATP/energy. Once the concentration of ATP reaches a certain level, it begins to bind some of the key enzymes in glycolysis and the TCA cycle and inhibits them. Why continue to make ATP if we have enough? Conversely, when ADP levels are higher than ATP (a sign we need energy), ADP binds to some of the same enzymes, with the result that ADP stimulates them to be more active (and thus make more energy). Then, when ATP levels begin to rise again... we are back to the beginning of the process when it all started.
Mechanism 3: Induction—inducing a gene to be expressed, thereby ultimately resulting in an increase in the abundance of a protein. This is accomplished by increasing transcription and/or translation of the corresponding gene/mRNA. [By definition, induction means to increase abundance; writing “increase and/or decrease” would be incorrect.]
[Note: For mechanism 1 or 3, the proteins we are talking about can be enzymes, transporters, and so forth.

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For 2, we are only talking about enzymes. Don't let the term active confuse you—we use it mostly when we talk about enzymes, but an "active protein" means it is carrying out its function, be it catalytic or transport or anything else. Also note that mechanisms 1 and 2 are fast, whereas mechanism 3 is slower.]

82. Briefly describe the three levels in which gene expression is regulated.

ANSWER: Gene expression can be regulated at three levels that covers the process of gene expression.
Transcription-level: This involves the role of proteins or other molecules such as metals and vitamins that can play a role in regulating transcription by way of transcription factors. Transcription factors are the factors that can influence gene transcription. Effects of transcription factors can be seen in how they may enhance, inhibit or alter the frequency at which the gene is being expressed. In this manner, the environment is able to elicit a response from the cell through an effect on the transcription of the gene. Signal transduction mechanisms mediate this effect from the environment.
Processing-level: Processing level effects are directed toward the transcript or mRNA that is the result of gene transcription. Alternate ways of processing the mRNA can result in regulatory effects that can enhance, inhibit or alter the amount of mRNA available for the next step. One example of this level of activity is splicing effects.
Translation-level: These are control mechanisms that affect the translation of the protein. The various mechanisms at play here include localization of mRNA, interactions with other small RNAs or microRNAs. These types of interactions can influence the amount of protein being made as well as the degradation of the protein.

83. Choose three of the following terms and in one sentence per term, provide a concise definition of that term: cytoskeleton, mitochondria, Golgi apparatus, transcription, translation, apoptosis, and cell signaling.

ANSWER: The **cytoskeleton** is a system of filaments and fibers that makes up the supportive structure of the cell. The cytoskeleton helps the cell with locomotion, localization of organelles. Maintenance of cell shape, transfer of molecules and intercellular communication.
Mitochondria are the organelles in virtually all cells that are responsible for the major portion of energy (ATP) production, utilizing metabolic processes including the TCA cycle, β-oxidation, parts of gluconeogenesis, and the electron transport chain.
The **Golgi apparatus** consists of a system of a system of stacked cisternae that work in close coordination with the endoplasmic reticulum in protein synthesis. The Golgi apparatus is more involved in the modifications and processing changes made to newly synthesized proteins such as glycosylation that are necessary for proteins to be sorted and/or secreted.
Transcription is the nuclear process of copying one strand of DNA into a single-stranded mRNA and substituting the base uracil in place of thymine.
Translation is the process by which the genetic information carried by a molecule of mRNA becomes the sequence of amino acids in a protein.
Apoptosis is programmed cell death brought about by several different mechanisms designed to regulate the number of cells in a tissue.
Cell Signaling is the process whereby a cell communicates with its environment and responds to the signal by altering its activities such an gene expression.

84. Briefly explain the structure of a phospholipid and its role in the plasma membrane?

ANSWER: The answer should include the following items:

- A phospholipid has two fatty acids and a charged head group attached to a glycerol molecule.
- The charged head group provides a polar side to the molecule that balances the hydrophobic nature of the fatty acids

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- Amphipathic molecules have the advantage of aligning at the lipid-water interphase and to spontaneously assemble in a manner that keeps the hydrophobic portions of together and away from the aqueous environments.
- Formation of a lipid bilayer is advantageous in that it acts a barrier and allows selective permeability depending on the proteins that are associated with the bilayer.

85. Describe the cytoskeleton (microtrabecular lattice) and its role as an intercommunication system of proteins and other macromolecules.

ANSWER: The answer should include the following items:

- The cytoskeleton (microtrabecular lattice) consists of microtubules (hollow structures), microfilaments (made of actin), and intermediate filaments (found in cells like neurons and in muscle and epithelial cells that are subjected to physical stress).
- It provides a structure for organization of organelles and proteins such as enzymes to facilitate interactions with substrates such as glucose and oxygen, thus facilitating metabolic pathways in all cells.
- The cytoskeleton provides a mechanism for cell locomotion in certain cells such as phagocytes.
- The microtrabecular lattice is vital for cell activation and survival.

86. Define and describe diagnostic enzymology.

ANSWER: Diagnostic enzymology studies intracellular enzymes that, due to a problem within the cell, escape and act within the serum where they do not normally exist. The serum activity of these now displaced enzymes is measured, which allows for a determination of the site and extent of the cellular damage. An accurate determination of the site of the damage requires that the enzyme being measured must exhibit a high degree of organ or tissue specificity.

87. Describe the important implications of the high K_m for glucokinase in terms of maintaining normal blood glucose after a meal and during fasting.

ANSWER: The answer should include the following items:

- The high K_m for glucokinase means that it requires a high concentration of glucose in the blood to be active.
- Thus, it is not very active during fasting and so the glucose that comes into the liver during fasting can easily return to the blood for use by the brain and other cells.
- After a meal, when a high concentration of glucose enters the liver, the glucose concentration is high enough that glucokinase phosphorylates glucose, trapping it inside the liver.
- This action is important for lowering blood glucose and making sure that the excess glucose can be converted to glycogen in liver.

88. Describe the process of apoptosis in relation to the life span of the cell.

ANSWER: The answer should include the following items:

- Apoptosis refers to programmed cell death as distinguished from pathological cell death, which causes inflammation and possibly autoimmune reactions.
- Apoptosis can be beneficial during development of an organism when cells are no longer needed as

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development progresses.

- Apoptosis is thought to be detrimental when it leads to degenerative diseases such as Alzheimer's. Thus, active research seeks to understand triggers and methods by which it might be controlled.
- DNA damage, hypoxia, or other intracellular insults can cause release of mitochondrial factors, especially cytochrome c, which activates caspases and results in the beneficial apoptosis (death) of that damaged cell.
- The mitochondrial membrane protein Bcl-2 can prevent apoptosis by blocking the release of cytochrome c. If Bcl-2 is upregulated, it can cause cell survival. Survival of a damaged cell can allow it to continue to grow and cause cancer.
- Both the retinoic acid form of vitamin A and the active form of vitamin D are involved in these cell death and survival pathways. Research is needed to completely understand the beneficial control of cell death and survival.

89. Briefly describe how energy is harnessed from macromolecules as compared to combustion.

ANSWER: The answer should include the following items:

- The macronutrients contain energy in their chemical bonds.
- Release of energy by combustion of these molecules would result in the oxidation of the molecules and conversion to carbon dioxide, water and heat energy as seen in the example of a candle burning.
- The difference between simple combustion and metabolic oxidation lies in the conversion of part of the heat energy into chemical energy in the form of ATP.
- During oxidative phosphorylation, the energy is converted into the high energy phosphate bonds of ATP to be stored and released upon future hydrolysis. Some energy is still lost as heat and only about 40% is captured as ATP.

90. Discuss the concept of coupled reactions in the transfer of energy.

ANSWER: The answer should include the following items (note that students may provide other examples such as the coupling of phosphocreatine to creatine with the formation of ATP from ADP):

- Coupled reactions allow metabolism to proceed because exothermic reactions that release energy are capable of driving endothermic reactions that require the energy released.
- In metabolism, ATP is involved as the ideal intermediate because the breakdown of high-energy phosphate compounds such as creatine phosphate can drive the formation of the intermediate-energy bond that creates ATP from ADP.
- In turn, ATP can be hydrolyzed to form ADP and release the intermediate amount of energy in the bond in order to provide energy to, for example, add phosphate to glucose to form glucose-6-phosphate, the first step in the glycolytic breakdown of glucose.
- The breakdown of ATP to ADP to release energy is said to be coupled to the input of energy required to add phosphate to glucose to create glucose-6-phosphate.

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