**The Cell: A Microcosm of Life**

**Multiple-Choice**

**Key Page(s)**

a 2 1. Membrane lipid bilayers consist primarily of \_\_\_\_\_.

a. phospholipids

b. cholesterol

c. proteins

d. saturated fatty acids

b 2 2. Membrane proteins serve as all of the following EXCEPT \_\_\_\_\_.

a. pumps

b. detoxifiers

c. receptors

d. enzymes

b 4 3. What is the role of cholesterol in plasma membrane structure?

a. produce bile

b. regulate fluidity

c. reduce stability

d. produce hormones

a 2-3 4. Which of the following is NOT an attribute common to all membranes?

a. Membranes are symmetrical.

b. Membranes form sheet-like structures.

c. Membranes are fluid structures.

d. Membranes protect cellular components.

a 4 5. The carbohydrate moieties of the plasma membrane glycoproteins and glycolipids are oriented \_\_\_\_\_.

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

c 4 6. Proteins attached to the membrane through hydrophobic interactions and embedded in the membrane are called \_\_\_\_\_.

a. peripheral proteins

b. rough endoplasmic reticulum

c. integral proteins

d. Golgi apparatuses

c 4, 5 7. In the cell structure the \_\_\_\_\_ provides support and controls the movement of cell organelles.

a. endoplasmic reticulum

b. mitochondrion

c. cytoskeleton

d. matrix space

b 6 8. Enzymes of metabolic pathways that are associated with the cytoplasmic matrix so that the product of one enzyme is released in close proximity to the next enzyme for which it is a substrate to facilitate velocity of the overall pathway include enzymes of \_\_\_\_\_.

a. beta-oxidation

b. glycolysis

c. ketone production

d. the Krebs cycle

d 6 9. The organelle responsible for production of most of the metabolic energy (ATP) is the \_\_\_\_\_.

a. Golgi apparatus

b. endoplasmic reticulum

c. nucleus

d. mitochondrion

a 7 10. All components of the electron transport chain are embedded in the \_\_\_\_\_.

a. mitochondrial inner membrane

b. mitochondrial outer membrane

c. mitochondrial matrix

d. cytoplasmic matrix

d 7-8 11. In which organelle do the TCA cycle and fatty acid oxidation occur?

a. Golgi apparatus

b. nucleus

c. microsomes

d. mitochondrion

a 7 12. What is the major route for ATP production?

a. oxidative phosphorylation

b. hydrolysis

c. peroxidation

d. transformation

c 8 13. Genes contained in mitochondrial DNA are inherited only from the mother and code for

a. all proteins functioning within the mitochondrial matrix.

b. non-functional ancient proteins considered remnants of evolution.

c. proteins vital to the production of ATP.

d. antioxidant proteins.

d 8 14. What type of cell depends solely on energy produced through anaerobic mechanisms?

a. hepatocyte

b. enterocyte

c. glucocyte

d. erythrocyte

b 8 15. The cell organelle responsible for most of the initiation and regulation of cellular activity is the \_\_\_\_\_.

a. cytoplast

b. nucleus

c. mitochondrion

e. nucleolus

a 10 16. Encoded within the nuclear DNA of each cell is

a. the entire genome for that organism.

b. the genes coding for proteins needed by that particular cell in the organism.

c. chromatin.

d. a cell-specific histone.

b 8 17. Which of the following nitrogenous bases is unique to RNA?

a. guanine

b. uracil

c. thymine

d. cytosine

d 10 18. Translation is the process by which

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 of the protein product is extended.

d. genetic information in an mRNA molecule specifies the sequence of amino acids in the protein product.

a 11 19. The smooth endoplasmic reticulum (SER) is associated with

a. lipid synthesis.

b. protein synthesis.

c. the calcium ion pump necessary for the contractile process.

d. ribosomes and cytochrome P450 enzymes.

d 12 20. What structural body made up of flattened cisternae flanked by tubular networks is thought to be an extension of the endoplasmic reticulum?

a. nucleus

b. cytoplasm

c. lysosome

d. Golgi apparatus

b 12 21. The Golgi apparatus is prominent in neurons and secretory cells and functions

a. to stop the synthesis of proteins that may need carbohydrate additions.

b. to add polysaccharide or lipid moieties to polypeptides.

c. only for constitutive secretion of proteins.

d. only for regulated secretion of proteins.

c 12 22. The organelle that serves as the digestive system for the cell is the \_\_\_\_\_.

a. polysome

b. endosome

c. lysosome

d. ribosome

a 13 23. The organelle that detoxifies by oxidizing molecules such as hydrogen peroxide and ethanol is the \_\_\_\_\_.

a. peroxisome

b. endosome

c. lysosome

d. ribosome

b 13 24. Leader sequences attached to the amino end of newly synthesized proteins that remain within the cell are required for proteins

a. destined for degradation.

b. to move to the appropriate site for proper function.

c. to function within lysosomes and peroxisomes.

d. requiring post-translational activation.

c 13 25. Highly specialized membrane proteins that modify the cell's response to its environment are \_\_\_\_\_.

a. transport proteins

b. enzymes

c. receptors

d. peroxisomes

e 15 26. For active transport (e.g., of glucose), you need:

a. ATP.

b. a Na-K pump.

c. Na.

d. an integral protein.

e. all of the above

b 9, 17-18 27. If you measure the abundance of an enzyme (or any other protein) and it increases, that increase is most likely due to:

a. decreased transcription.

b. increased translation.

c. posttranslational modification.

d. allosteric regulation.

e. two of the above

a 18 28. Most human enzymes are synthesized intracellularly and function

a. within the same cell.

b. in another location after secretion.

c. in the bloodstream due to leakage from the synthesizing cell.

d. to promote tumors unless quickly degraded.

a 17 29. Maintaining balance in the regulation of metabolic pathways necessary for life of the organism includes all of these catalytic regulatory mechanisms EXCEPT \_\_\_\_\_.

a. increasing the synthesis of constitutive enzymes

b. covalent modification through hormone stimulation

c. modulation of allosteric enzymes

d. increasing adaptable enzyme concentration by induction

a 16 30. A high Km means \_\_\_\_\_ affinity and is stated in units of \_\_\_\_\_.

a. low; concentration (e.g., M; mM; μM)

b. high; rate (e.g., molecules/sec; moles/min)

c. high; time (e.g., hours; min; sec)

d. low; does not have any units

b 17 31. Substances that bind with allosteric sites and alter the activity of regulatory enzymes are called \_\_\_\_\_.

a. transport proteins

b. modulators

c. Na pumps

d. sarcoplasmic reticula

b 18 32. Diagnostic enzymology focuses 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.

c 18 33. Which of the following enzymes has diagnostic value for disease?

a. isocitrate dehydrogenase

b. ornithine carbomoyl transferase

c. isozymes of lactate dehydrogenase

d. isozymes of phosphofructokinase

d 20 34. One trigger of apoptosis is

a. overexpression of Bcl-2.

b. inactivation of *Casp-9*.

c. swelling of the cell.

d. release of mitochondrial cytochrome c.

a 22 35. The quantity of energy released in an exothermic reaction is \_\_\_\_\_ the quantity required for the reverse endothermic reaction.

a. the same as

b. greater than

c. less than

d. not related to

c 23 36. The energy needed to raise the energy of a reactant sufficiently to cause an exothermic reaction to occur is referred to as the

a. transition state.

b. barrier state.

c. activation energy.

d. free energy.

d 23 37. The net energy transformation when nutrients are systematically oxidized to carbon dioxide and water is \_\_\_\_\_.

a. reversible

b. catalytic

c. endothermic

d. exothermic

c 25 38. The energy pool that serves as the major linking intermediate between energy-yielding and energy-demanding chemical reactions is:

a. activation energy.

b. NAD.

c. ATP.

d. free energy.

a 25-26 39. If an exothemic reaction releases -3,300 cal/mol of energy, how much energy is required for the reaction to be reversed?

a. +3,300

b. -3,300

c. +6,600

d. -6,600

b 24-25 40. Phosphorylation of ADP is an example of \_\_\_\_\_.

a. an exothermic reaction

b. an endothermic reaction

c. an energy-releasing reaction

d. a downhill reaction

b 25-26 42. When the terminal phosphate group of ATP is removed by hydrolysis, forming ADP and inorganic phosphate, the type of reaction that occurs is \_\_\_\_\_.

a. endothermic

b. exothermic

c. standard

d. free

a 26 43. In electron transfer, an electron donor reduces the electron receptor and in the process becomes

a. oxidized.

b. transformed.

c. reduced.

d. flavin mononucleotide.

**True/False**

Indicate whether each of the following statements is true or false. If the statement is false, explain why it is false.

**Key Page(s)**

F 2 1. The plasma membrane is a sheet-like structure composed solely of lipids.
***Explanation:*** *Also composed of proteins (transporters, receptors).*

F 2 2. The lipid bilayer determines the function of the plasma membrane while the proteins are primarily responsible for the structure of the membrane.
***Explanation:*** *The lipid bilayer determines the STRUCTURE of the plasma membrane while the proteins are primarily responsible for the FUNCTION of the membrane.*

T 4-5 3. The various components within a cell (e.g., mitochondria) are not “free-floating” in the cytosol, but rather are held in place by the cytoskeleton.

T 4 4. Peripheral proteins are involved in cell-cell recognition, whereas integral proteins function primarily as receptors/ transporters.

F 10 5. The reason different cells express different proteins is because they contain different sequences of DNA in the nucleus.
***Explanation:*** *All cells contain the same DNA; however, not all genes are expressed in all cells.*

F 10 6. Polysomes function to transcribe mRNA into proteins.
***Explanation:*** *Translate, not transcribe.*

F 16 7. When discussing enzyme kinetics, Km refers to the substrate concentration at which the enzyme is saturated and functioning at maximal velocity.
***Explanation:*** *Km is substrate concentration at half of maximal velocity.*

T 16 8. If two enzymes (e.g., pyruvate dehydrogenase and pyruvate carboxylase) compete for the same substrate (pyruvate), the one with the higher Km has less affinity and will be more active when pyruvate concentrations are high.

F 16-17 9. Most cellular reactions are irreversible since the same enzyme that catalyzes the conversion cannot catalyze the reverse reaction.
***Explanation:*** *Most cellular reactions are reversible and catalyzed by the same enzyme. The rate-limiting enzymes tend to be irreversible to contribute to regulation of the pathway.*

F 17 10. Allosteric regulation of enzymes is carried out by modulators, other proteins that bind to the enzyme to inhibit its activity.
***Explanation:*** *Modulators are substrates, intermediates, and products in the relevant pathway, not proteins.*

**Matching**

***Enzyme Classification:*** Match the correct enzyme classification with the examples provided.

|  |  |  |  |
| --- | --- | --- | --- |
| **Key** | **Page(s)** | **Classification** | **Examples** |
| c | 18 | 1. oxidoreductases | a. Enzymes that catalyze cleavage of C-C, C-S, and certain C-N bonds (excluding peptide bonds) without hydrolysis or oxidation-reductionb. Enzymes forming bonds between carbon and other atoms, such as acetyl-CoA carboxylase, which adds bicarbonate to acetyl-CoA to initiate fatty acid synthesis in the cytoplastc. Enzymes in the election transport chain in the mitochondriad. Enzymes that catalyze cleavage of bonds by addition of water, such as digestive enzymese. Enzymes that catalyze reactions, not oxidation or reduction, in which a functional group is moved from one substrate to another, such as transaminases |
| d | 18 | 2. hydrolases |
| e | 18 | 3. transferases |
| a | 18 | 4. lyases |
| b | 18 | 5. ligases |

**Fill-in-the-Blank**

**Page(s)**

4 1. Membrane fluidity and permeability are regulated and controlled by the fat-soluble compound \_\_\_\_\_.
***Key:*** *cholesterol*

4 2. The lipid bilayer determines the \_\_\_\_\_ of the plasma membrane while the proteins are primarily responsible for the \_\_\_\_\_ of the membrane.
***Key:*** *structure, function*

13 3. The catabolic enzyme that degrades hydrogen peroxide into water and molecular oxygen is \_\_\_\_\_ and it is located in the \_\_\_\_\_.
***Key:*** *catalase, peroxisome*

***Enrichment*** *(these questions are related to but go beyond the text chapter)*

2, 141 4. The melting temperature of the lipids in the lipid bilayer of the plasma membrane is \_\_\_\_\_ than normal mammalian body temperature because it generally contains a relatively large proportion of \_\_\_\_\_ fatty acids. Explain the physiological significance for human beings of this statement by relating structure to function.
***Key:*** *lower, polyunsaturated. Significance: the PUFA remain fluid at body temperature due to their low melting temperature and this fluidity allows carrier mechanisms to operate effectively.*

**Short Answer** (with suggested answer key)

**Page(s)**

17-18 1. List the three mechanisms that can be used to regulate the function of a protein (e.g., an enzyme) and briefly (1-2 sentences) describe their key features.

***Key:***

*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. What are these things that bind to enzymes to affect their activity? NOT other proteins or enzymes—they are typically substrates, intermediates, or products along the pathway in which the enzyme participates. 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 these same enzymes, but the result is not inhibition of their activity, but rather ADP stimulates them to be more active (and thus make more energy). Then, when ATP levels begin to rise again... we’re back where this paragraph 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, etc. 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 & 2 are fast, whereas mechanism 3 is slower.]*

6-11, 19-20 3. Choose THREE (3) of the following terms and in ONE SENTENCE per term, provide a concise definition of that term: nucleus, mitochondria, RER, transcription, translation, apoptosis, replication.

***Key:*** *Here are a couple of examples:*

*Mitochondria is the organelle in virtually all cells that is 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.*

*Transcription is the nuclear process of copying one strand of DNA into single-stranded mRNA and substituting the base uracil in place of thymine.*

2-4 4. Why is cholesterol important in plasma membrane function?

***Key:*** *Grading rubric – answer should include the following items:*

* *The steroid rings containing the hydroxyl groups of cholesterol align near the polar head groups of the membrane phospholipids and the hydrocarbon tail aligns with the hydrophobic fatty acids on the phospholipid.*
* *This alignment allows cholesterol to stabilize the membrane and regulate fluidity.*
* *Changes in membrane fluidity alter the permeability of the membrane and control entrance and exit of molecules into and out of the cell.*
* *Membrane fluidity also affects the location and function of membrane proteins.*

4-6 5. Describe the cytoskeleton (microtrabecular lattice) and its role as an intercommunication system of proteins and other macromolecules.

***Key:*** *Grading rubric – 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).*
* *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*
* *Provides mechanism for cell locomotion in certain cells such as phagocytes*
* *Vital for cell activation and survival*

11-12 6. Describe the process by which the cytochrome P450 system contributes to the detoxification and metabolism of different drugs.

***Key:*** *Grading rubric – answer should include the following items:*

* *Located on the liver rough endoplasmic reticulum*
* *Oxidizes lipophilic drugs and steroid hormones, thus making them hydrophilic*
* *System called mixed-function oxidase system because other molecules are simultaneously oxidized*
* *Detoxifies the drugs by enabling excretion in bile or urine*

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

***Key:*** *Grading rubric – answer should include the following items:*

* *The high Km 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 red blood cells.*
* *After a meal, when a lot 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 quickly after a meal.*

19-20 8. Describe the process of apoptosis in relation to the life span of the cell.

***Key:*** *Grading rubric – 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 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.*

22-23 9. Describe the uphill-downhill concept.

***Key:*** *Grading rubric – answer should include the following items:*

* *Pushing a boulder uphill represents endothermic reactions, which require input of energy to occur. The products of such a reaction will contain greater potential energy than the reactants. It will be the sum of the energy in the reactants plus the energy put in to create the products.*
* *The boulder falling downhill represents exothermic reactions, which release energy as they occur. The products of such a reaction will contain less potential energy than the reactants because free energy, which can be used for work, is released.*
* *Whenever carbohydrates or fats are metabolized completely to carbon dioxide and water, free energy is partly released as heat and partly captured in ATP for use in work.*
* *In the case of downhill reactions, although the overall metabolic pathway is exothermic (energy-releasing), it is not spontaneous and some activation energy needs to be added to the potential energy in the reactants to allow the reaction to proceed. In the uphill-downhill concept, the activation energy is represented by adding energy to push the boulder up a short distance so it is in a position to fall and release some of the potential energy in the reactants as they become products.*

24-26 10. Discuss the concept of coupled reactions in the transfer of energy.

***Key:*** *Grading rubric – 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.*
* *So 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.*

**Perspective – Nutritional Genomics:
A New Perspective on Food**

**Multiple-Choice**

**Key Page(s)**

d 29-30 1. The discipline of nutritional genomics studies \_\_\_\_\_.

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. all of the above

d 29 2. A common mutation in the 5,10-methylenetetrahydrofolate reductase enzyme (MTHFR) \_\_\_\_\_.

a. prevents the individual from activating the B vitamin folate

b. diminishes the activity of the enzyme

c. increases the activity of the enzyme

d. both a and b

b 30 3. The primary mechanism by which gene expression is modified by bioactive factors in food appears to be \_\_\_\_\_.

a. mutations causing cancer

b. interactions with transcription factors

c. production of SNPs

d. downregulation of translation

c 29, 30 4. What lifestyle change would be most important to individuals with a common variant in the *GST* gene that impairs protections 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