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Chapter 1 Cellular Biology, Regulation, and Control Mechanisms

1. Which structure(s) is/are common feature(s) of all cells regardless of cellular function or degree of maturity?
A. Cilia
B. Nuclear envelope
C. Plasma membranes
D. Smooth endoplasmic reticulum

Correct Answer: C
Rationale:
All human cells have a plasma membrane, although it may have other names in skeletal muscles and neurons. Other features, such as a nucleus, rough and smooth endoplasmic reticulum, mitochondria, and others, are not present in every cell type.

2. Why are most positive feedback mechanisms harmful if allowed to continue to function indefinitely?
A. They amplify the effects of the initiating stimulus, increasing the undesirable response.
B. They require additional energy in the form of ATP and impair normal cellular uptake of nutrients.
C. They misinterpret the input from homeostatic monitoring centers and delay control response time.
D. They decrease the range of normal for most parameters, negating the need for homeostasis.

Correct Answer: A
Rationale:
Positive feedback mechanisms have the same responses as the initiating change, which results in an amplification of the changed parameter, often increasing its rate of change. They can be helpful in the very short run until other interventions or mechanisms can correct the initiating problem. However, when they continue uncorrected, they lead to exhaustion of the system.

3. Which property of plasma membranes contributes to a cell's longevity?
A. Unlimited size
B. Lack of covalent bonds
C. Hydrophilic outer surface
D. High concentration of lipids

Correct Answer: B
Rationale:
An important feature of plasma membranes is flexibility or fluidity, which allows cells to change shape or "deform" without breaking. This feature is a result of the phospholipids composing plasma membranes not having covalent bonds that would make them more rigid and more easily

ruptured when squeezing through small capillaries or when pressure is applied.

4. Which cell type is most likely to have the characteristic of polarity of orientation?
A. Red blood cell (erythrocyte)
B. Bronchial epithelium
C. Skeletal muscle
D. Lysosome

Correct Answer: B
Rationale:
Some cells are symmetrical on all sides, whereas others are asymmetrical and have polarity with regard to orientation. This is related to differences in plasma membrane surface anatomy for a cell's specific function. For example, a respiratory epithelial cell has cilia on the luminal surface and none on the apical surface that is in contact with the basement membrane. The same is true about the epithelial lining of the intestinal tract with the luminal surfaces expressing villi.

5. Why does the lack of a nucleus in a mature erythrocyte fail to affect its function?
A. Function of these cells is independent of a constant oxygen supply.
B. Their membranes are more rigid than those of other cell types.
C. These cells no longer produce intracellular proteins.
D. Erythrocytes do not require energy for locomotion.

Correct Answer: C
Rationale:
Without a nucleus, a cell can neither divide nor produce proteins. In the case of mature erythrocytes, all cell division and protein production, including hemoglobin, are performed at an earlier, less mature stage. Thus, a mature erythrocyte is already equipped with everything it needs for function (transport of oxygen, acting as a buffering system) and no longer needs a nucleus.

6. What is the purpose of "chaperone" proteins?
A. Completing the degradation of intracellular debris
B. Transporting newly synthesized proteins for exocytosis
C. Adding a ligand to the plasma membrane for endocytosis
D. Ensuring the correct folding of newly synthesized proteins

Correct Answer: D
Rationale:
Newly synthesized protein strands are released into the lumen of the RER with their amino acids in linear order. However, protein function is based on its final structure, which includes how it is folded. In the smooth ER (SER), "chaperone" proteins serve as guides that help fold the new protein into its correct conformation (shape) for final function.

7. Why are hydrolases confined to lysosomes?
A. The pH of lysosomes optimizes hydrolase activity.
B. They ensure degradation products are recycled appropriately.
C. They maintain a constant regeneration of transmembrane proteins.
D. Lysosomes have a direct connection to the nucleus where hydrolase is synthesized.

Correct Answer: A
Rationale:
The hydrolases within a lysosome are most effective at a pH of 4, which is the pH maintained within lysosomes.

8. Why is it necessary to limit the intracellular presence of reactive oxygen species (ROS)?
A. High levels of ROS slow cellular locomotion.
B. ROS inhibit the activity of lysosomal catalase and hydrolase.
C. ROS contribute to an overly acidic intracellular environment.
D. They can damage/inhibit the function of intracellular components.

Correct Answer: D
Rationale:
Because ROS can also oxidize almost anything and cause oxidative stress and damage to other organelles, tissues, and organs, preventing ROS from coming into contact with other normal cell structures is critical.

9. Under normal physiologic conditions, which cell type has the highest concentration of mitochondria?
A. Dermal skin cells
B. Intradermal skin cells
C. Mature erythrocytes
D. Skeletal muscle cells

Correct Answer: D
Rationale:
Mitochondria are the “powerhouses” for ATP production under aerobic conditions. They are highly concentrated in tissues that are most metabolically active, such as skeletal muscle, heart muscle, and liver cells, and they are only present in minimal or basal concentrations in less metabolically active cells, such as skin cells and erythrocytes.

10. Why is glucose inhibited from entering most cells through simple passive diffusion even though it is a nonpolar molecule?
A. The molecule expresses an overall negative charge.
B. Glucose is highly hydrophilic.
C. The molecule is too large for unaided diffusion.

D. Glucose is devoid of lipid-soluble components.

Correct Answer: C
Rationale:
Simple passive diffusion allows small, hydrophobic, uncharged (*nonpolar*) molecules to diffuse across plasma membranes easily. Although glucose is a nonpolar molecule, it is composed of 24 molecules linked together covalently, making it too large to move across most plasma membranes by simple diffusion.

11. Which factor regarding the generation of action potentials (AP) is true?
A. The speed of depolarization is determined by the number of Na^+-K^+ ATPase pumps present in the membrane.
B. Action potentials can only be generated in cells that normally express a high degree of polarity when the membrane is at rest.
C. Although an AP may be initiated at any area of an excitable membrane, propagation of the AP is unidirectional within one cell.
D. Excessive amounts of extracellular calcium enhance the capacity of an excitable membrane to generate an action potential.

Correct Answer: B
Rationale:
All cells have an ICF that is more negative than the ECF, with nonexcitable membranes having an electrical resting membrane potential of between -5 and -10 mv, and the ICF is only slightly more negative than the ECF. Cells with excitable membranes have a much greater charge difference between the ICF and the ECF, usually between -70 and -85 mv, which is required to generate an action potential that can be transmitted to other cells within the tissue.

12. In any excitable membrane, what is the trigger for opening of the potassium channels during the process of depolarization?
A. Rising intracellular ATP concentration
B. Loss of intracellular fluid protein content
C. Increased flexibility of plasma membranes
D. Closure of the voltage-regulated sodium channels

Correct Answer: D
Rationale:
A stimulus for depolarization causes a small portion of the excitable membrane to be more permeable to Na^+, which allows Na^+ to influx down its concentration gradient into the cell. Movement of Na^+ into the cell increases ICF positivity. When ICF positivity reaches threshold level (about +55 mv), all voltage-gated Na^+ channels along the plasma membrane open at the same time, allowing Na^+ to rapidly enter the cell until the Na^+ concentrations in the ICF and the ECF surrounding the cell are the same and depolarized with regard to Na^+. At this time, the voltage-regulated Na^+ channels close. Closure of these channels triggers K^+ channels to open, allowing intracellular K^+ molecules to rapidly leave the cell down its concentration gradient until

the K^+ gradient disappears. At this time, the membrane is completely depolarized for both ions, and an action potential (AP) has been generated.

13. A new drug being tested for use as an antihypertensive exerts its effects by moving extracellular chloride ions (Cl^-) into nerve cells and all other tissues with excitable membranes. What changes would you expect to see as a result of this action?
A. Membrane hypopolarization; increased rate of depolarization
B. Membrane hypopolarization; decreased rate of depolarization
C. Membrane hyperpolarization; increased rate of depolarization
D. Membrane hyperpolarization; decreased rate of depolarization

Correct Answer: D
Rationale:
When polarity is increased, the membrane is hyperpolarized, with a greater charge difference between the two fluid compartments and reduced excitability. Such a condition requires a larger, stronger, or more sustained stimulus to cause a threshold level Na^+ influx and a responding depolarization. Classic ways that true hyperpolarization occurs most often are a reduction of positively charged ions, especially K^+ ions in the ICF, or an increase in ICF concentration of negatively charged ions, especially chloride ion levels.

14. Why does increasing the voltage difference between the ECF and the ICF of excitable tissues slow the rate of depolarization?
A. A greater number of cations must enter the cell to reach the depolarization threshold.
B. The sodium-potassium ATPase pump requires additional ATP molecules for activation.
C. Affected membranes are more rigid and suppress movement of voltage-regulated gates.
D. Increased intracellular negativity causes intracellular proteins to inhibit membrane activity.

Correct Answer: A
Rationale:
When polarity is increased, the membrane is hyperpolarized, with a greater charge difference between the two fluid compartments and reduced excitability. Such a condition requires a larger, stronger, or more sustained stimulus to cause a threshold level Na^+ influx and a responding depolarization. Classic ways that true hyperpolarization occurs most often are a reduction of positively charged ions, especially K^+ ions in the ICF, or an increase in ICF concentration of negatively charged ions, especially chloride ion levels.

15. What can be expected for the activity of a drug when the receptor sites that usually bind the drug in its target tissue have “down-regulated”?
A. More drug will be required to achieve the normal effect (response).
B. Less drug will be required to achieve the normal effect (response).
C. Drug clearance by enzymatic degradation will be enhanced.
D. Drug clearance by enzymatic degradation will be reduced.

Correct Answer: A
Rationale:
For a drug that affects tissue function by binding to specific cellular receptors, when the number of receptors in/on the cells within that tissue have down-regulated, fewer are available for binding, which is a chance event. Thus, more drug will be needed to ensure drug molecules actually reach enough receptors to change activity.

16. How does hypercalcemia decrease action potential generation in excitable membranes?
A. Inhibiting the binding of adenosine triphosphate
B. Competing with sodium ions at sodium fast channels
C. Hyperpolarizing the intracellular side of the plasma membrane
D. Enhancing intracellular potassium diffusion into the extracellular fluid environment

Correct Answer: B
Rationale:
Calcium is a divalent cation that competes with sodium at sodium fast channels on excitable membranes, inhibiting inward flow of sodium and reducing or delaying depolarization even when extracellular sodium channel levels are normal.

17. What is the expected response to autocrine signaling?
A. Stimulation of receptor down-regulation
B. Blunting of signaling cell's response
C. Stimulation of receptor up-regulation
D. Enhancement of the signaling cell's response

Correct Answer: D
Rationale:
Autocrine signaling generates a more widespread and rapid response that is self-perpetuating because not only is the signal transmitted to other cells, the signaling cell also has receptors for the signal that can trigger the signaling cell to enhance its own response.

18. Which condition most represents the "all or none" principle of excitable membranes?
A. Direction of action potential propagation varies by cell type.
B. Subthreshold level stimuli have weaker propagation of the action potential.
C. Threshold level stimuli result in whole membrane depolarization with conduction.
D. Threshold level stimuli result in whole membrane depolarization with propagation.

Correct Answer: D
Rationale:
When a stimulus is strong enough to result in depolarization of an action potential in the stimulated cell, the action potential is propagated at the same strength to the next cell in the line. A weaker stimulus only results in local depolarization that does not generate a full action potential even though it may be conducted throughout the membrane of the stimulated cell. It is not propagated to the next cell in the line.

19. By which process do tyrosine kinases stimulate an increase in cellular activity?
A. Antagonizing membrane receptors
B. Agonizing ligand-associated receptors
C. Causing molecular phosphorylation
D. Dephosphorylating cyclic guanosine monophosphate

Correct Answer: C
Rationale:
Tyrosine kinases are intracellular stimulatory enzymes that activate other molecules by attaching a phosphate group to them (phosphorylation).

20. By which mechanism does a G protein-coupled receptor affect cellular responses in a specific tissue?
A. Increasing intracellular concentration of a second messenger; altering nuclear gene expression
B. Increasing intracellular concentration of a second messenger; maintaining nuclear gene expression
C. Decreasing intracellular concentration of a second messenger; maintaining nuclear gene expression
D. Decreasing intracellular concentration of a second messenger; altering nuclear gene expression

Correct Answer: A
Rationale:
A ligand (first messenger), first binds to a membrane-bound G protein-coupled receptor (GPCR). Binding of the ligand to this receptor results in activation of a G protein that then binds with and activates the adenylate cyclase enzyme system present on the inner aspect of the plasma membrane, resulting in a greatly increased intracellular concentration of cAMP, which then alters gene expression.

21. Why are lipid-based signaling actions independent of a “first messenger”?
A. They are synthesized as active molecules and do not need further activation.
B. Lipid-based substances enter the ICF without a membrane receptor.
C. Lipid-based structures express an overall positive charge.
D. Lipid-based structures express an overall negative charge.

Correct Answer: B
Rationale:
Lipid structures are soluble in the plasma membrane and do not require the use of a membrane-bound first messenger.

22. What is the most important characteristic or feature of “gap junctions” for intercellular communication?
A. Unidirectional
B. Open to larger molecules

C. Rapid signal transmission
D. Confines signals to a single cell

Correct Answer: C
Rationale:
Gap junctions are very small proteins assembled into tiny tunnel-like channels through the plasma membrane connecting adjacent cells for the purpose of allowing very rapid transfer or exchange of small molecules for signaling from the cytosol of one cell to its neighboring cells.

23. How do lower-than-normal concentrations of sodium ions in the extracellular fluid lead to slower rates of depolarization?
A. Decreasing the positivity of the ICF negates the RMP
B. Increasing the negativity of the ICF reduces its osmolarity
C. Inward flow of sodium ions requires more time to reach threshold levels
D. Outward flow of potassium and calcium ions hyperpolarizes excitable membranes

Correct Answer: C
Rationale:
Depolarization requires sufficient inward flow of ECF sodium to the ICF to raise the ICF to +55 mv. With less ECF sodium available, more time or a much stronger stimulus is needed to allow sufficient sodium ions to enter the cell and raise the positivity to threshold levels.

24. What is the major pathologic mechanism responsible for the clinical manifestation of hepatomegaly of Gaucher disease?
A. Excessive accumulation of large precursor molecules in liver macrophages
B. Failure of liver cells to respond to growth-inhibiting signals, resulting in organ hyperplasia
C. Failure to activate intracellular proteins critical to essential liver function
D. Inhibition of hepatocyte mitochondrial activity leading to intracellular swelling

Correct Answer: A
Rationale:
Gaucher disease is an inborn error of metabolism of lysosomal storage in which the enzyme beta-glucocerebrosidase is deficient. As a result, the lysosomes cannot break down beta-glucocerebroside and it accumulates in liver lysosomes, greatly enlarging the lysosomes and leading to hepatomegaly.