NEET PG Physiology Sample Paper-7

Duration: 15 Minutes **Maximum Marks: 68**

Instructions

- This paper contains **17** Multiple Choice Questions.
- Each correct answer carries **+4** mark. Incorrect answer: **−1** marks. Only **one** correct option.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A medical student is participating in a research study on cell membrane dynamics. The study uses fluorescence recovery after photobleaching (FRAP) to measure the lateral diffusion coefficient of a newly discovered integral membrane glycoprotein. If the temperature of the experimental chamber is lowered from 37°C to 4°C, which of the following changes in the cell membrane structure or behavior is most likely to occur?

(A) The transition of the lipid bilayer into a gel-like state, significantly decreasing the rate of fluorescence recovery.

(B) An increase in the number of double bonds within the fatty acid tails of phospholipids to maintain fluidity.

(C) Enhanced activity of flippases, leading to a rapid randomized scrambling of phosphatidylserine to the outer leaflet.

(D) A significant decrease in the activation energy required for the passive flip-flop of transmembrane proteins.

Q2. A 56-year-old male with a history of chronic alcoholism and malnutrition is admitted with severe generalized weakness and paresthesias. Laboratory evaluation reveals a serum potassium concentration of 2.1 mEq/L. Which of the following statements best describes the effect of this electrolyte abnor-

mality on the resting membrane potential (RMP) of skeletal muscle cells, as calculated by the Nernst equation?

(A) The RMP becomes less negative (depolarized) due to a reduction in the chemical driving force pushing potassium out of the cell.

(B) The RMP becomes more negative (hyperpolarized) because the concentration gradient for potassium efflux is increased.

(C) The RMP remains unchanged because the Goldman-Hodgkin-Katz equation dictates that sodium permeability dominates the resting state.

(D) The RMP shifts exactly to 0 mV because the absolute intracellular potassium concentration falls to match the extracellular concentration.

Q3. A basic science researcher is studying cellular transport mechanisms using synthetic liposomes that lack membrane proteins. She introduces a specialized carrier protein into the liposome membranes that couples the transport of solute X down its electrochemical gradient to the movement of solute Y against its electrochemical gradient. This transport mechanism does not consume ATP directly or indirectly through an established sodium gradient. Which type of transport is being modeled in this experiment?

(A) Primary active transport

(B) Facilitated diffusion

(C) Secondary active co-transport

(D) Tertiary active transport

Q4. A 58-year-old male with a long-standing history of heavy cigarette smoking presents with progressive exertional dyspnea and a chronic productive cough. Pulmonary function testing shows a forced expiratory volume in 1 second to forced vital capacity (FEV1/FVC) ratio of 0.45. A high-resolution CT scan of the chest demonstrates extensive destruction of alveolar walls distal to the terminal bronchioles. Which of the following physiological parameters is most likely increased in this patient compared to a healthy individual?

(A) Pulmonary diffusing capacity for carbon monoxide (DL_{CO})

(B) Elastic recoil of the lungs

(C) Static lung compliance

(D) Functional residual capacity (FRC) measured by body plethysmography is decreased

Q5. During a routine medical checkup, a healthy 28-year-old female undergoes a spirometric evaluation. The physician asks her to inhale as deeply as possible and then exhale maximally into the spirometer. The total volume of air exhaled during this maneuver represents which of the following lung volumes or capacities?

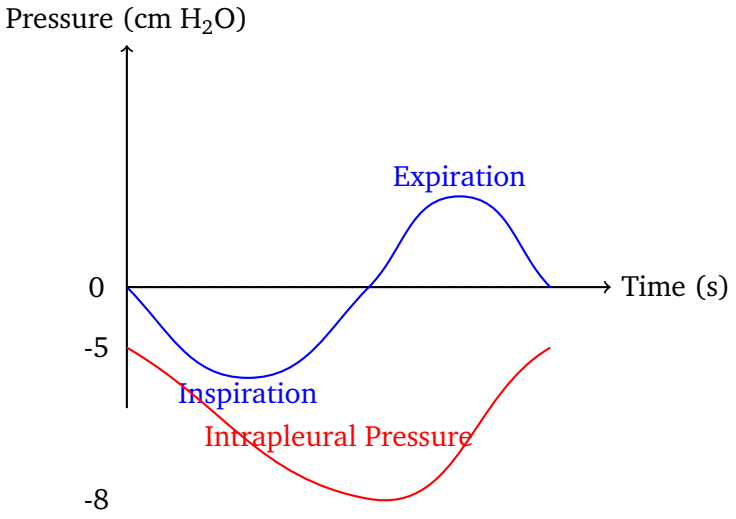
(A) Functional Residual Capacity

(B) Inspiratory Capacity

(C) Vital Capacity

(D) Total Lung Capacity

Q6. An experimental setup measures the changes in intrapleural and alveolar pressures during a normal, quiet respiratory cycle in a healthy volunteer. The diagram below illustrates the relationship between these pressures and the lung volume during inspiration and expiration.



Based on the standard physiological principles represented in the diagram, which of the following events occurs precisely at the transition point from inspiration to expiration (at Time = 4 seconds)?

(A) Alveolar pressure reaches its most negative value.

(B) Airflow into the lungs reaches its maximum velocity.

(C) Alveolar pressure is exactly equal to atmospheric pressure, and lung volume is at its peak.

(D) Intrapleural pressure reaches its least negative value.

Q7. A 62-year-old male with chronic kidney disease secondary to long-standing diabetes mellitus presents to the clinic for a routine evaluation. His laboratory results reveal a serum creatinine of 3.2 mg/dL and an estimated glomerular filtration rate (eGFR) of 22 mL/min/1.73 m^2. Which of the following substances would show a clearance rate that most closely approximates the patient's actual glomerular filtration rate without requiring an absolute correction for tubular secretion or reabsorption?

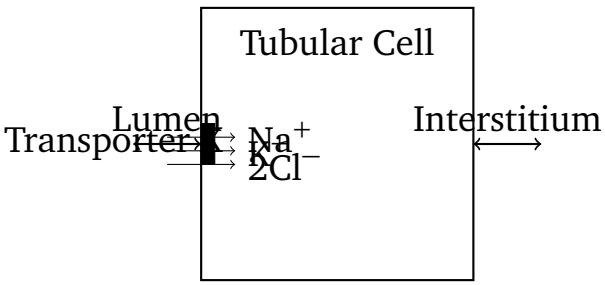
(A) Urea

(B) Para-aminohippuric acid (PAH)

(C) Inulin

(D) Glucose

Q8. A pharmacology research team is testing a new loop diuretic that acts exclusively on the thick ascending limb of the loop of Henle. The drug binds to and inhibits a specific luminal membrane transporter. The schematic diagram below demonstrates the cellular transport mechanisms in this segment of the nephron.



By directly inhibiting Transporter X, this novel diuretic will lead to which of the following immediate physiological changes within the renal tubule?

(A) An increase in the positive lumen-potential, driving greater paracellular reabsorption of calcium and magnesium.

(B) Disruption of the corticomedullary osmotic gradient, reducing the kidney's maximum concentrating ability.

(C) A dramatic increase in intracellular sodium concentration within the thick ascending limb cells.

(D) Marked alkaline shift in the luminal fluid due to compensatory upregulation of the Na^+-H^+ exchanger.

Q9. A 33-year-old female presents to the emergency department with profound weakness and recurrent muscle cramps. Her laboratory panel reveals severe hypokalemia, metabolic alkalosis, and elevated plasma renin and aldosterone levels. Urinary analysis shows significantly elevated levels of calcium excretion. Genetic testing confirms a loss-of-function mutation in the gene encoding the thiazide-sensitive Na^+-Cl^- cotransporter (NCCT) in the distal convoluted tubule. What is the most likely diagnosis for this patient?

(A) Bartter syndrome

(B) Gitelman syndrome

(C) Liddle syndrome

(D) Syndrome of Inappropriate Antidiuretic Hormone (SIADH)

Q10. A 42-year-old female presents with a 15-pound weight gain over the past three months, progressive proximal muscle weakness, and new-onset easy bruising. On physical examination, her blood pressure is 155/96 mmHg. She exhibits central obesity, a prominent dorsocervical fat pad, and wide purple striae across her abdomen. Laboratory evaluation reveals elevated early morning serum cortisol levels that are not suppressed following a low-dose (1 mg) dexamethasone suppression test. ACTH levels are found to be markedly elevated. Which of the following underlying pathologies is most consistent with these clinical findings?

(A) An autonomous cortisol-secreting adenoma of the adrenal cortex.

(B) An ACTH-secreting pituitary microadenoma (Cushing's disease).

(C) Primary adrenal insufficiency (Addison's disease).

(D) Iatrogenic Cushing's syndrome due to exogenous glucocorticoid use.

Q11. A research group is studying the intracellular signaling cascades triggered by various peptide hormones. They isolate endocrine target cells and expose them to a newly discovered hormone, Hormone Z. Following hormone-receptor binding, they observe a rapid increase in intracellular inositol 1,4,5-trisphosphate (IP_3) and diacylglycerol (DAG) concentrations, alongside an influx of intracellular calcium from the endoplasmic reticulum. Which of the following endogenous hormones utilizes this identical signal transduction pathway?

(A) Glucagon

(B) Antidiuretic hormone acting on V_2 receptors

(C) Growth Hormone

(D) Gonadotropin-releasing hormone (GnRH)

Q12. During a medical physiology lab experiment, students study the response of a single mammalian alpha-motor neuron to continuous intracellular electrical depolarization. They apply a sustained depolarizing current that remains well above the threshold potential for 200 milliseconds. The recording shows a rapid burst of action potentials that gradually decreases in frequency over time. Which physiological property of excitable membranes explains this decrease in firing frequency during a sustained stimulus?

(A) Saltatory conduction

(B) Accommodation and adaptation

(C) Spatial summation

(D) Temporal summation

Q13. A 67-year-old male is brought to the neurology clinic by his wife, who notes that he has developed a resting tremor in his left hand that disappears during purposeful movement. On examination, the neurologist notes a "pill-rolling" quality to the tremor, generalized cogwheel rigidity, bradykinesia,

and a festinating gait. The fundamental physiological defect underlying this patient's clinical presentation involves a loss of dopaminergic input from the substantia nigra pars compacta to which component of the basal ganglia circuit?

(A) Globus pallidus externus

(B) Subthalamic nucleus

(C) Striatum (Caudate and Putamen)

(D) Thalamic ventral anterior nucleus

Q14. A 55-year-old male with a history of hypertension and hyperlipidemia presents to the emergency room with sudden-onset chest pain radiating to his left shoulder. An electrocardiogram (ECG) reveals ST-segment elevation in leads II, III, and aVF. Which region of the myocardium is affected by this acute infarction, and which coronary artery is most likely occluded?

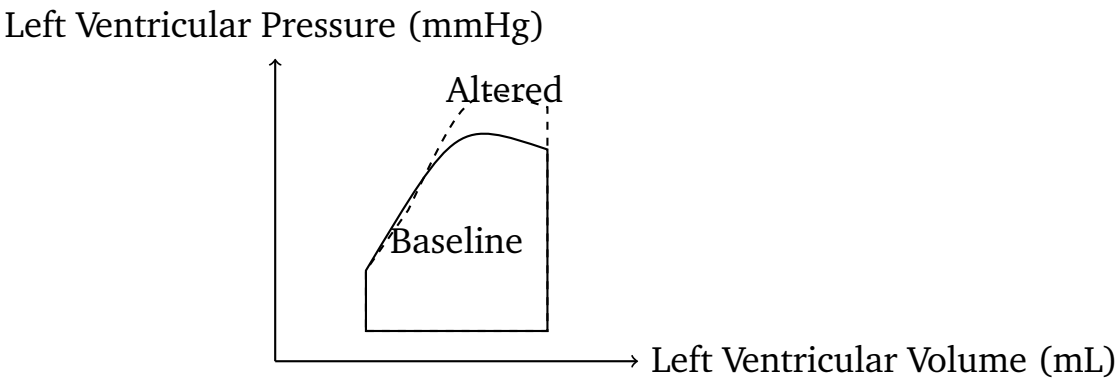
(A) Anterior wall; Left anterior descending artery

(B) Lateral wall; Left circumflex artery

(C) Inferior wall; Right coronary artery

(D) Posterior wall; Left main coronary artery

Q15. An experimental study analyzes the pressure-volume loop of the left ventricle in a healthy canine model. The baseline loop is recorded, and then an intervention is performed that abruptly increases the systemic arterial resistance (afterload) while maintaining constant preload and contractility. The diagram below illustrates the baseline loop (Solid line) and the altered loop (Dashed line).



Based on the pressure-volume relationships shown, what is the primary consequence of this isolated increase in afterload on left ventricular performance?

(A) An increase in stroke volume and a decrease in end-systolic volume.

(B) A decrease in stroke volume and an increase in end-systolic volume.

(C) An increase in ejection fraction with no change in end-diastolic volume.

(D) A decrease in end-diastolic volume with an increase in stroke volume.

Q16. A 19-year-old college athlete is undergoing a high-intensity treadmill exercise stress test. As her total cardiac output increases from a resting value of 5 L/min to a peak exercise value of 25 L/min, multiple cardiovascular adjustments occur simultaneously. Which of the following changes is expected to happen within the systemic vascular bed during this strenuous exercise session?

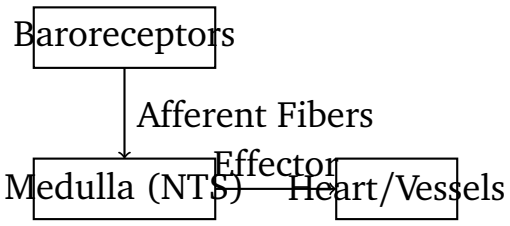
(A) Total peripheral resistance increases significantly due to generalized alpha-1 adrenergic vasoconstriction.

(B) Blood flow to the renal and splanchnic circulations decreases due to sympathetic vasoconstriction, while local metabolic factors cause profound vasodilation in active skeletal muscle.

(C) Skeletal muscle blood vessels constrict under the influence of increased circulating epinephrine acting on beta-1 receptors.

(D) Cerebral blood flow increases five-fold in direct proportion to the increase in cardiac output.

Q17. A 72-year-old female is admitted to the intensive care unit with severe septic shock. Her arterial blood pressure is 78/42 mmHg. The body attempts to compensate for this severe hypotension via the arterial baroreceptor reflex mechanism. The schematic diagram below demonstrates the standard response pathway of the medullary cardiovascular centers to changing afferent inputs.



In this patient's profoundly hypotensive state, which of the following alterations in the baroreceptor reflex arc firing rate and downstream autonomic output is occurring?

(A) Increased firing rate of afferent fibers in the glossopharyngeal and vagus nerves, leading to increased parasites sympathetic output to the SA node.

(B) Decreased firing rate of afferent fibers in the glossopharyngeal and vagus nerves, resulting in disinhibition of the sympathetic pressor area and increased sympathetic outflow.

(C) Increased firing rate of afferent fibers, causing direct inhibition of the rostral ventrolateral medulla (RVLM).

(D) Constant firing rate of afferent fibers because the baroreceptors reset completely within minutes of any change in MAP.

Detailed Solutions

Q1.

Solution

Concept:

Cell membrane fluidity is heavily governed by temperature and lipid composition. According to the fluid mosaic model, lipid bilayers undergo a phase transition from a flexible, fluid state to a rigid, highly ordered gel crystalline state when temperatures drop below a characteristic threshold. Lateral diffusion rates of integral proteins and lipids are directly linked to this physical state.

Solution:

(a) Fluorescence recovery after photobleaching (FRAP) measures the rate at which unbleached fluorescently tagged molecules diffuse laterally into a laser-bleached area, serving as a direct index of membrane fluidity.

(b) Lowering the experimental temperature from 37°C to 4°C deprives the phospholipid molecules of thermal energy, drastically decreasing their kinetic movement and causing tight packing of the hydrophobic fatty acid tails.

(c) This thermal drop induces a phase transition into a highly viscous, gel-like state. Because the structural rigidity increases, the lateral movement of the newly discovered integral membrane glycoprotein is profoundly restricted.

(d) Consequently, the rate at which unbleached glycoproteins migrate into the photobleached zone is severely slowed down, resulting in a significantly prolonged or decreased rate of fluorescence recovery.

(e) Other options describe long-term adaptive cellular changes or non-physiological protein kinetics that do not occur acutely or passively within an isolated physical experimental chamber.

Final Answer: The transition of the lipid bilayer into a gel-like state, significantly decreasing the rate of fluorescence recovery.

Answer: (A)

Go Back to Question 1

Q2.

Solution

Concept:

The resting membrane potential (RMP) of excitable cells is highly dependent on the transmembrane concentration gradient of potassium ions, because resting cell membranes exhibit a predominant permeability to potassium via leak channels. The equilibrium potential for a specific single ion is mathematically modeled using the classical Nernst equation.

Solution:

(a) The Nernst equation calculates the equilibrium potential for potassium (E_K) as $61 \times \log([K^+]_{out}/[K^+]_{in})$. Under baseline physiological conditions, intracellular potassium is approximately 140 mEq/L and extracellular potassium is 4 mEq/L, giving a negative RMP.

(b) In this patient, chronic alcoholism and severe malnutrition have induced profound hypokalemia, driving the serum potassium concentration down to an extremely low value of 2.1 mEq/L.

(c) This drastic drop in extracellular potassium significantly widens the ratio between the intracellular and extracellular compartments, thereby increasing the chemical driving force that favors the outward efflux of potassium ions.

(d) As more positively charged potassium ions leave the cell down this amplified concentration gradient, the interior of the skeletal muscle cell becomes increasingly negative relative to the exterior.

(e) This shift toward a more negative electrical state represents hyperpolarization of the resting membrane potential, which shifts the RMP further away from the threshold potential required to trigger an action potential.

Final Answer: The RMP becomes more negative (hyperpolarized) because the concentration gradient for potassium efflux is increased.

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept:

Cellular transport mechanisms are broadly classified into passive and active processes based on their energy expenditure and direction of movement relative to an electrochemical gradient. Carrier-mediated transport that moves substances across membranes without utilizing high-energy phosphate bonds or existing ion gradients represents a unique class of diffusion.

Solution:

(a) Passive transport relies solely on the inherent kinetic energy of solutes moving down an established concentration or electrical gradient. When a specialized membrane protein assists this movement without energy expenditure, it is termed facilitated diffusion.

(b) Active transport processes require a metabolic energy source to pump solutes against an unfavorable electrochemical gradient. Primary active transport hydrolyzes ATP directly, while secondary active transport utilizes a pre-established sodium or ion gradient.

(c) In this liposome experiment, the introduced carrier protein couples the transport of two solutes. However, the prompt notes that solute X moves strictly down its electrochemical gradient.

(d) Crucially, the experimental parameters explicitly state that this mechanism does not consume ATP directly, nor does it rely indirectly on an established sodium gradient or any other external energy reservoir.

(e) Because the thermodynamic driving force is derived entirely from solute X moving down its own gradient, no net metabolic energy is inputted. This system demonstrates a complex model of facilitated diffusion acting via a structural carrier.

Final Answer: Facilitated diffusion.

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept:

Pulmonary emphysema is a chronic obstructive pulmonary disease (COPD) characterized by the irreversible destruction of alveolar walls and the loss of pulmonary elastic connective tissue. These structural alterations profoundly modify the mechanical characteristics of the lungs, specifically affecting compliance, recoil dynamics, and total volumes.

Solution:

(a) Cigarette smoke triggers an inflammatory influx of neutrophils and macrophages that release elastase, an enzyme that degrades the structural elastin network within the pulmonary parenchymal architecture.

(b) The extensive destruction of alveolar septa leads to a permanent loss of the lung's natural elastic recoil. Elastic recoil and static compliance share an inverse mathematical relationship in pulmonary mechanics.

(c) Because the structural forces opposing lung expansion are severely compromised due to the tissue degradation, the diseased lungs become highly distensible, which translates to a marked increase in static lung compliance.

(d) The loss of radial traction also causes micro-airway collapse during expiration, trapping large volumes of air inside the chest cavity and causing pathological hyperinflation.

(e) Consequently, parameters like total lung capacity, residual volume, and functional residual capacity increase, whereas the total surface area available for gas exchange drops, leading to a diminished carbon monoxide diffusing capacity (DL_{CO}).

Final Answer: Static lung compliance.

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept:

Spirometry is a fundamental clinical tool utilized to assess pulmonary function by measuring the specific volumes of air an individual can inhale or exhale. Lung capacities are combinations of two or more anatomical lung volumes that change dynamically depending on the respiratory effort and structural integrity of the respiratory system.

Solution:

(a) During a standard spirometric evaluation, a full maximal respiratory excursion requires the subject to transition between the absolute extremes of their total pulmonary containment boundaries.

(b) When the 28-year-old female patient inhales as deeply and fully as possible, her lungs are filled to their absolute maximum limit, which is anatomically defined as the Total Lung Capacity (TLC).

(c) From this point of maximal inspiratory inflation, she is instructed to drive out every milliliter of mobilizable air through a forceful, maximum expiratory effort down to her residual volume.

(d) The collective volume of air swept out of the respiratory tract during this complete maneuver from full inspiration to full expiration is defined as the Vital Capacity (VC).

(e) Vital Capacity represents the maximum usable volume of the lungs and is composed of the mathematical sum of the inspiratory reserve volume, the tidal volume, and the expiratory reserve volume.

Final Answer: Vital Capacity.

Answer: (C)

Go Back to Question 5

Q6.

Solution

Concept:

The mechanics of ventilation require dynamic fluctuations in alveolar and intrapleural pressures relative to atmospheric pressure to establish a driving pressure gradient for airflow. Understanding the precise temporal coordination between these pressure changes, airflow, and lung volume is crucial for assessing normal respiratory physiology.

Solution:

(a) During inspiration, expansion of the chest wall causes intrapleural pressure to become more negative, which pulls the alveoli open and drops alveolar pressure below 0 cm H2O, generating inward airflow.

(b) As air enters the lungs, the pressure difference equilibrates. At the exact end of inspiration (Time = 4 seconds in the diagram), inward airflow ceases completely because the alveolar pressure returns to exactly 0 cm H2O.

(c) Because air has been flowing into the respiratory tree throughout the entire inspiratory phase, the total volume of air within the lungs reaches its peak value at this precise transition point.

(d) At this identical moment, the intrapleural pressure reaches its most negative value (approximately -8 cm H2O) due to the maximum elastic recoil stretch of the fully inflated pulmonary tissue.

(e) Immediately after this point, passive expiration begins, causing alveolar pressure to become positive and forcing air out of the lungs. Thus, the transition marks the apex of volume and zero airflow.

Final Answer: Alveolar pressure is exactly equal to atmospheric pressure, and lung volume is at its peak.

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept:

Glomerular filtration rate (GFR) is the gold standard index for evaluating global renal function. To accurately measure GFR via renal clearance calculations, a substance must possess highly specific physiological properties such that its excretion rate matches its filtration rate perfectly.

Solution:

(a) The ideal marker for measuring glomerular filtration rate must be freely filtered across the glomerular capillary basement membrane, completely un-bound to plasma proteins, and chemically inert.

(b) Crucially, the substance must not undergo any form of reabsorption along the length of the renal tubules, nor should it be secreted by the peritubular capillaries into the tubular lumen.

(c) Inulin, an exogenous plant carbohydrate polymer, meets all of these criteria perfectly. The mass of inulin filtered per unit time equals the mass excreted, making its clearance rate exactly equal to the GFR.

(d) Creatinine is used clinically but undergoes minor tubular secretion, overestimating GFR slightly. Urea is heavily reabsorbed, while glucose is completely reabsorbed under normal transport maximum limits.

(e) Para-aminohippuric acid (PAH) is both filtered and completely secreted, meaning its clearance rate reflects renal plasma flow rather than the glomerular filtration rate. Thus, inulin remains the definitive reference standard.

Final Answer: Inulin.

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept:

The thick ascending limb (TAL) of the loop of Henle plays an indispensable role in urinary concentration and dilution. The cellular mechanisms of this segment are dominated by a specialized luminal transporter that drives the movement of electrolytes from the tubular fluid into the renal epithelial cells.

Solution:

(a) Transporter X in the provided diagram represents the electrogenic Na-K-2Cl (NKCC2) cotransporter located on the apical membrane of TAL cells, which moves one sodium, one potassium, and two chloride ions simultaneously.

(b) Loop diuretics, such as furosemide, act by specifically binding to and blocking the chloride-binding sites of this NKCC2 cotransporter, halting all secondary active transport in this segment.

(c) Inhibiting this transporter prevents the accumulation of sodium chloride within the medullary interstitium. This process directly disrupts the hypertonic corticomedullary osmotic gradient.

(d) Without this crucial hypertonic medullary gradient, the collecting ducts lose their osmotic driving force to reabsorb water, even in the presence of high circulating antidiuretic hormone levels.

(e) This failure to concentrate urine results in profound diuresis. Additionally, blocking this transporter suppresses the positive lumen potential, leading to wasting of calcium and magnesium rather than increasing it.

Final Answer: Disruption of the corticomedullary osmotic gradient, reducing the kidney's maximum concentrating ability.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept:

Inherited tubulopathies are genetic disorders that disrupt specific ion channels or transporters along the nephron, mimicking the chronic effects of various diuretic classes. Differentiating these clinical syndromes requires an analysis of serum electrolytes, acid-base status, and urinary divalent cation excretion patterns.

Solution:

(a) The patient presents with classic features of renal salt-wasting, including activation of the renin-angiotensin-aldosterone axis, which promotes downstream potassium and hydrogen ion secretion, causing hypokalemic metabolic alkalosis.

(b) Genetic analysis reveals a loss-of-function mutation in the NCCT gene within the distal convoluted tubule. This exact molecular defect mirrors the lifelong pharmacological blockade of this channel by thiazide diuretics.

(c) A hallmark clinical feature that distinguishes Gitelman syndrome from Bartter syndrome is the handling of calcium. Gitelman syndrome causes significant hypocalciuria due to upregulated calcium reabsorption in the proximal segments.

(d) However, Bartter syndrome presents with hypercalciuria (elevated urinary calcium excretion), matching the presentation of this patient. Bartter syndrome stems from mutations in the TAL transporters like NKCC2 or ROMK.

(e) Liddle syndrome is an autosomal dominant condition characterized by an ENaC gain-of-function mutation, which causes severe hypertension, low renin, and low aldosterone levels, completely contradicting this patient's presentation.

Final Answer: Bartter syndrome.

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept:

Hypercortisolemia, or Cushing's syndrome, can arise from primary adrenal dysfunction, ectopic hormone production, exogenous steroid use, or pituitary hypersecretion. Deciphering the exact etiology requires sequential biochemical suppression tests alongside plasma adrenocorticotropic hormone (ACTH) measurements.

Solution:

(a) The patient exhibits definitive physical features of glucocorticoid excess, including proximal muscle wasting, central adiposity, truncal purple striae, easy bruising from dermal collagen breakdown, and systemic arterial hypertension.

(b) The failure of early morning cortisol to suppress below baseline levels following a low-dose dexamethasone suppression test confirms the definitive presence of an autonomous, non-reactive hypercortisolemic state.

(c) The subsequent laboratory measurement demonstrating markedly elevated plasma ACTH levels indicates that the hypercortisolemia is entirely driven by an upstream, ACTH-dependent pathophysiological mechanism.

(d) An autonomous cortisol-secreting adrenal adenoma would instead secrete massive amounts of cortisol that exert powerful negative feedback, lowering plasma ACTH levels to near zero.

(e) Therefore, an ACTH-secreting pituitary microadenoma, formally classified as Cushing's disease, represents the correct underlying pathology. This pituitary tumor continuously secretes ACTH, over-stimulating the adrenal cortex despite the high cortisol levels.

Final Answer: An ACTH-secreting pituitary microadenoma (Cushing's disease).

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept:

Hormones and neurotransmitters trigger physiological changes in target cells by binding to specific receptors. Peptide hormones, which cannot cross the lipid bilayer, rely on transmembrane receptors coupled to intracellular secondary messenger systems. The major pathways include the cyclic adenosine monophosphate (cAMP) pathway, the tyrosine kinase pathway, and the phosphatidylinositol (IP_3/DAG) pathway.

Solution:

(a) The experiment describes a classic signaling cascade involving the activation of phospholipase C (PLC). Upon hormone binding to a Gq-protein-coupled receptor, PLC cleaves membrane-bound phosphatidylinositol 4,5-bisphosphate (PIP_2) into two secondary messengers: inositol 1,4,5-trisphosphate (IP_3) and diacylglycerol (DAG).

(b) The liberated IP_3 binds to specific ligand-gated calcium channels on the membrane of the smooth endoplasmic reticulum, triggering a rapid release of stored intracellular calcium into the cytoplasm.

(c) Concurrently, DAG remains within the plasma membrane where it acts alongside the newly released calcium ions to activate protein kinase C (PKC), leading to downstream protein phosphorylation.

(d) Among the choices provided, Gonadotropin-releasing hormone (GnRH) utilizes this exact Gq-protein-coupled IP_3/DAG mechanism to exert its physiological actions on gonadotrophs in the anterior pituitary gland.

(e) In contrast, glucagon and antidiuretic hormone acting on V_2 receptors utilize the Gs-protein cAMP pathway, while growth hormone operates via a single-transmembrane receptor coupled directly to the JAK-STAT tyrosine kinase intracellular signaling cascade.

Final Answer: Gonadotropin-releasing hormone (GnRH).

Answer: (D)

Go Back to Question 11

Q12.

Solution

Concept:

Excitable tissues like nerve and muscle cells display specialized biophysical adjustments when exposed to prolonged electrical stimulation. When a sustained depolarizing current is continuously applied to a neuronal membrane, the initial high-frequency burst of action potentials undergoes a progressive decline over time, a physiological process essential for sensory and motor regulation.

Solution:

(a) The generation of an action potential requires the rapid opening of voltage-gated sodium channels when the membrane potential reaches a critical threshold. This allows a sudden influx of positive charge that rapidly depolarizes the excitable cell.

(b) Under a sustained, continuous depolarizing current, these voltage-gated sodium channels enter a prolonged, inactive structural state. This inactivation occurs via a specialized inactivation gate (the h-gate) that closes shortly after channel opening.

(c) As long as the membrane remains continuously depolarized, these inactivated sodium channels cannot transition back to their resting, closed-but-activatable conformation, effectively reducing the pool of channels available to fire subsequent spikes.

(d) Simultaneously, voltage-gated potassium channels open in a delayed fashion and remain active, causing a persistent outward repolarizing potassium current that fights against the continuous external depolarizing stimulus.

(e) The combined effect of progressive sodium channel inactivation and persistent potassium channel activation raises the effective threshold potential of the neuron, leading to the observed accommodation and adaptation where the firing frequency slows down.

Final Answer: Accommodation and adaptation.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:

The basal ganglia constitute a complex subcortical network that modulates voluntary motor control, cognitive functions, and procedural learning. Proper motor coordination requires a precise regulatory balance between the direct pathway (which promotes movement) and the indirect pathway (which inhibits unwanted movement) via localized neurotransmitter signaling.

Solution:

(a) The clinical presentation described—including a pill-rolling resting tremor, cogwheel muscle rigidity, generalized bradykinesia, and a characteristic festinating gait—is the classic diagnostic hallmark of Parkinson's disease.

(b) The central pathophysiology of Parkinson's disease centers on the progressive, idiopathic degeneration of melanin-containing dopaminergic neurons located within the substantia nigra pars compacta (SNc), a core structure of the midbrain.

(c) Under normal physiological conditions, these SNc dopaminergic neurons project extensively to the striatum, which is composed of the caudate nucleus and the putamen, via the well-established nigrostriatal pathway.

(d) Within the striatum, released dopamine binds to excitatory D1 receptors on neurons of the direct pathway and inhibitory D2 receptors on neurons of the indirect pathway, net-favoring the execution of smooth voluntary movements.

(e) The profound loss of this dopaminergic input leads to an under-active direct pathway and an over-active indirect pathway, causing excessive inhibition of the thalamus and generating the characteristic motor deficits seen in this patient.

Final Answer: Striatum (Caudate and Putamen).

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept:

An electrocardiogram (ECG) records the spatial and temporal summation of cardiac electrical vectors. Because specific ECG leads face distinct anatomical surfaces of the thick ventricular myocardium, localized patterns of ischemia, injury, or infarction can be map-linked directly to corresponding regional coronary arterial distributions.

Solution:

(a) The patient presents with classic signs of an acute myocardial infarction, marked by ischemic chest pain radiating to the left upper extremity along dermatomal distributions, alongside specific localizing electrical changes on his ECG.

(b) The presence of significant ST-segment elevation in leads II, III, and aVF indicates an acute transmural injury pattern localized exclusively to the inferior anatomical wall of the left ventricle.

(c) In the vast majority of the human population (approximately 85 percent), the inferior wall of the left ventricle is supplied by the posterior descending artery, which arises directly from the right coronary artery, denoting a right-dominant circulation.

(d) Therefore, acute thrombotic occlusion of the proximal or mid-portion of the right coronary artery results in localized transmural tissue ischemia and subsequent infarction across this specific inferior diaphragmatic zone.

(e) Conversely, an occlusion of the left anterior descending artery leads to an anterior wall MI (leads V1-V4), while a left circumflex artery occlusion results in a lateral wall MI (leads I, aVL, V5-V6).

Final Answer: Inferior wall; Right coronary artery.

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept:

Left ventricular performance can be comprehensively evaluated using a cardiac pressure-volume (PV) loop diagram, which charts intraventricular pressure against volume throughout a single complete cardiac cycle. The structural dimensions of the loop dynamically adjust to changes in core mechanical parameters: preload, afterload, and myocardial contractility.

Solution:

(a) Afterload represents the total mechanical resistance or tension that the ventricular myocardium must generate and overcome to successfully eject blood into the systemic aorta during the systolic phase of the cardiac cycle.

(b) The experimental intervention introduces a sudden, isolated increase in systemic arterial resistance. This forces the left ventricle to develop a much higher peak systolic pressure to force open the aortic valve.

(c) Because a greater portion of the total contractile energy is spent simply building pressure to open the valve against higher resistance, the velocity and duration of myocardial fiber shortening are compromised.

(d) Consequently, the aortic valve closes prematurely at a higher residual volume than baseline. This leads to a distinct increase in the end-systolic volume (ESV), shifting the left edge of the PV loop to the right.

(e) Since the end-diastolic volume (preload) is held experimentally constant, this increase in end-systolic volume results in a smaller horizontal width of the loop, which represents a direct, significant decrease in stroke volume ($SV = EDV - ESV$).

Final Answer: A decrease in stroke volume and an increase in end-systolic volume.

Answer: (B)

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Q16.

Solution

Concept:

Sustained, strenuous physical exercise demands a massive, highly coordinated redistribution of total cardiac output to fulfill the metabolic requirements of actively contracting skeletal muscle groups while simultaneously preserving systemic perfusion pressure and cerebral homeostatic blood flow.

Solution:

(a) During high-intensity treadmill exercise, a massive surge in generalized sympathetic nervous system activity triggers a widespread release of norepinephrine and epinephrine into the circulation, targeting alpha-1 and beta receptors.

(b) This sympathetic activation induces robust alpha-1 mediated vasoconstriction within non-essential vascular beds, notably the renal and splanchnic mesenteric circulations, substantially diverting blood volume away from these internal reservoirs.

(c) Within the active skeletal muscle beds, this systemic neural vasoconstriction is completely overridden by a powerful local phenomenon known as active hyperemia or metabolic autoregulation.

(d) The rapidly contracting muscle tissue releases high local concentrations of vasodilator metabolites, including potassium ions, hydrogen ions, lactic acid, adenosine, and nitric oxide, driving profound local arteriolar vasodilation.

(e) This local vasodilation dramatically drops resistance in the skeletal muscle beds, allowing muscle blood flow to increase up to twenty-fold, while total peripheral resistance decreases despite widespread visceral vasoconstriction.

Final Answer: Blood flow to the renal and splanchnic circulations decreases due to sympathetic vasoconstriction, while local metabolic factors cause profound vasodilation in active skeletal muscle.

Answer: (B)

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Q17.

Solution

Concept:

The high-pressure arterial baroreceptor reflex serves as the body's primary, rapid neural mechanism for stabilizing acute fluctuations in systemic mean arterial pressure (MAP). Mechanoreceptors located within the carotid sinuses and the aortic arch continuously monitor mechanical vascular stretch to adjust autonomic outflow.

Solution:

(a) The patient is presenting in a state of severe septic shock, characterized by systemic vasodilation and a dangerously low blood pressure of 78/42 mmHg, which induces a profound reduction in total intravascular pressure.

(b) This severe arterial hypotension drastically decreases the physical stretch exerted against the mechanoreceptive walls of the carotid sinus and aortic arch baroreceptor regions.

(c) Because these baroreceptors are stretch-activated structures, a lack of mechanical distension causes a sharp reduction in their baseline electrical firing rate along their afferent neural pathways (glossopharyngeal and vagus nerves).

(d) These afferent inputs normally terminate in the nucleus tractus solitarius (NTS) of the medulla, where they provide tonic excitation to parasympathetic pathways and tonic inhibition to the sympathetic pressor centers.

(e) The dramatic drop in afferent firing removes this normal inhibitory constraint on the rostral ventrolateral medulla (RVLM), resulting in a powerful reflex disinhibition that maximizes sympathetic outflow to increase heart rate and systemic vasoconstriction.

Final Answer: Decreased firing rate of afferent fibers in the glossopharyngeal and vagus nerves, resulting in disinhibition of the sympathetic pressor area and increased sympathetic outflow.

Answer: (B)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	B	3	B	4	C	5	C
6	C	7	C	8	B	9	A	10	B
11	D	12	B	13	C	14	C	15	B
16	B	17	B						