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Gradients, Osmotic & Oncotic Pressure

Study Guide — Cell Membrane

Comprehensive Pre-med style questions on gradients, osmotic and oncotic pressure, Starling forces, and physiological examples (edema, capillaries, IV fluids).

28 items — Study Guide with Answers

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1 **In physiology, a gradient is best defined as:**

A Any difference in size between two cells

B **A difference in the value of a variable (such as concentration or pressure) between two points, often across a membrane** ✓

C A constant level of a substance throughout a tissue

D The total amount of a substance in the body

E The rate at which a membrane protein works

▶ **Explanation:** A gradient is a spatial difference in a parameter (concentration, pressure, electrical potential) that can drive movement of substances.

2 **An electrochemical gradient across a cell membrane for an ion consists of:**

A Only the concentration difference for that ion

B Only the electrical potential difference across the membrane

C **The sum of a chemical (concentration) gradient and an electrical gradient** ✓

D The difference in water concentration across the membrane

E The difference in plasma protein concentration between blood and interstitium

▶ **Explanation:** An electrochemical gradient combines the tendency of ions to move down a concentration gradient and the influence of membrane voltage on charged particles.

3 **Osmotic pressure of a solution is best defined as:**

A The hydrostatic pressure generated by the heart to drive blood flow

B **The pressure that must be applied to a solution to prevent net movement of water across a semipermeable membrane** ✓

C The force required to push ions through an open channel

D The pressure inside a cell due to cytoskeletal tension

E The total pressure exerted by blood in arteries

▶ **Explanation:** Osmotic pressure is the pressure that exactly counterbalances osmosis; it depends on the number of osmotically active particles in a solution.

4 **Which property of a solute most strongly determines its contribution to osmotic pressure of a solution?**

A Its molecular weight

B Its chemical nature (for example, glucose versus NaCl)

C **The number of dissolved particles it produces per unit volume** ✓

D Its ability to cross the plasma membrane rapidly

E Its colour and taste

▶ **Explanation:** Osmotic pressure is a colligative property: it depends mainly on the number of particles, not their size or identity.

5 **Which statement best distinguishes osmolarity from tonicity of a solution?**

A Osmolarity describes only impermeant solutes; tonicity describes all solutes

B **Osmolarity describes the total number of solute particles; tonicity describes the effect of a solution on cell volume** ✓

C Osmolarity is measured only inside cells; tonicity only outside cells

D They are identical terms and interchangeable

E Osmolarity is expressed as a percentage, whereas tonicity is not

▶ **Explanation:** Osmolarity counts all solute particles; tonicity reflects only the effect of impermeant solutes on water movement and cell volume.

6 **A red blood cell is placed in a solution containing 300 mOsm of urea. Urea is freely permeable across the RBC membrane. Which outcome is most likely after equilibrium is reached?**

A The solution is isotonic; the cell retains its normal volume

B The solution is hypertonic; the cell shrinks and crenates

C The solution is initially iso-osmotic but effectively hypotonic; the cell swells and may lyse ✓

D The solution is hypotonic; the cell immediately shrinks

E No water movement occurs because only urea moves

▶ **Explanation:** Urea enters the cell, raising intracellular osmolarity and drawing water in; the solution is iso-osmotic but hypotonic because the solute is permeant.

7 **A red blood cell is placed in 0.9 percent NaCl solution (about 300 mOsm). What happens to the cell?**

A It swells and bursts

B It shrinks and crenates

C It maintains its normal volume and shape ✓

D It loses only Na^+ but not water

E It gains K^+ and loses Na^+

▶ **Explanation:** Normal saline is approximately isotonic to plasma; NaCl is largely impermeant, so there is little net water movement and cell volume remains stable.

8 **A patient receives a large intravenous infusion of isotonic saline (0.9 percent NaCl). Which statement best describes the immediate effect on body fluid compartments?**

A Both extracellular and intracellular volumes increase equally

B **Extracellular volume increases; intracellular volume is largely unchanged** ✓

C Intracellular volume increases; extracellular volume decreases

D Total body osmolarity decreases, causing cells to swell

E Total body osmolarity increases, causing cells to shrink

▶ **Explanation:** Isotonic saline remains in the extracellular space and does not change osmolarity, so water does not shift significantly into or out of cells.

9 **A patient receives an intravenous infusion of a hypertonic saline solution. What is the immediate effect on cell volume and plasma osmolarity?**

A Cell volume increases; plasma osmolarity decreases

B **Cell volume decreases; plasma osmolarity increases** ✓

C Both cell volume and plasma osmolarity decrease

D Cell volume and plasma osmolarity are unchanged

E Cell volume increases; plasma osmolarity remains constant

▶ **Explanation:** Hypertonic saline raises extracellular osmolarity, pulling water out of cells. Cells shrink and plasma osmolarity rises.

10 **Oncotic (colloid osmotic) pressure of plasma is mainly generated by:**

A Glucose

B Na^+ and Cl− ions

C **Plasma proteins, especially albumin** ✓

D Dissolved oxygen and carbon dioxide

E Cholesterol in cell membranes

▶ **Explanation:** Oncotic pressure is the component of osmotic pressure due to large, relatively impermeant proteins in plasma, mainly albumin.

11 **Which statement best distinguishes total osmotic pressure from oncotic pressure in capillaries?**

A Osmotic pressure is due only to proteins; oncotic pressure is due only to ions

B **Osmotic pressure includes all solute particles; oncotic pressure refers specifically to the contribution of plasma proteins** ✓

C Osmotic pressure is irrelevant for water movement; only oncotic pressure matters

D Oncotic pressure is always larger than osmotic pressure

E They are identical terms in physiology

▶ **Explanation:** Total osmotic pressure reflects all solutes; oncotic pressure refers specifically to the osmotic effect of large colloids such as proteins.

12 **At the arterial end of a typical systemic capillary, which Starling forces usually cause NET filtration of fluid OUT of the capillary?**

A Capillary hydrostatic pressure is low; plasma oncotic pressure is high

B **Capillary hydrostatic pressure exceeds plasma oncotic pressure** ✓

C Plasma oncotic pressure exceeds capillary hydrostatic pressure

D Interstitial hydrostatic pressure is always greater than capillary hydrostatic pressure

E Interstitial oncotic pressure dominates and pulls fluid into capillaries

▶ **Explanation:** At the arterial end, capillary hydrostatic pressure is relatively high and tends to push fluid out, while oncotic pressure pulls fluid in; the net effect is usually outward filtration.

13 At the venous end of a typical systemic capillary, which statement is generally TRUE in classic Starling physiology?

A Capillary hydrostatic pressure is still much higher than oncotic pressure, so filtration is maximal

B **Capillary hydrostatic pressure falls below plasma oncotic pressure, favouring reabsorption of fluid** ✓

C Both hydrostatic and oncotic pressures fall to zero

D Plasma oncotic pressure becomes negligible

E Interstitial oncotic pressure becomes higher than plasma oncotic pressure

▶ **Explanation:** As blood flows along the capillary, capillary hydrostatic pressure falls; oncotic pressure remains relatively constant, so the balance shifts towards net reabsorption at the venous end.

14 Which change would most clearly INCREASE net filtration of fluid out of systemic capillaries into the interstitial space?

A Decreased capillary hydrostatic pressure

B Increased plasma oncotic (colloid osmotic) pressure

C **Increased capillary hydrostatic pressure, for example due to venous congestion** ✓

D Decreased capillary permeability to water

E Increased lymphatic drainage

▶ **Explanation:** Raising capillary hydrostatic pressure pushes more fluid out of capillaries; if lymph drainage cannot keep up, edema can result.

15 **Peripheral edema in a patient with severe liver cirrhosis is largely due to:**

A Increased plasma albumin concentration

B **Reduced plasma albumin leading to decreased plasma oncotic pressure** ✓

C Reduced capillary permeability to water

D Marked decrease in capillary hydrostatic pressure

E Excessive lymphatic drainage

▶ **Explanation:** Liver failure reduces albumin synthesis, lowering plasma oncotic pressure, so fluid tends to leave the vasculature and accumulate in tissues and body cavities (ascites).

16 **A patient with right-sided heart failure develops ankle edema. Which mechanism best explains this finding in terms of Starling forces?**

A Decreased capillary hydrostatic pressure in the legs

B **Increased venous and capillary hydrostatic pressure in the lower limbs** ✓

C Increased plasma oncotic pressure due to hemoconcentration

D Reduced lymphatic capillary permeability

E Primary increase in interstitial oncotic pressure due to more plasma proteins

▶ **Explanation:** Right-sided heart failure raises venous pressure, increasing capillary hydrostatic pressure in dependent tissues and promoting filtration and edema.

17 **Lymphatic vessels help prevent edema primarily by:**

A Increasing capillary hydrostatic pressure

B **Returning excess filtered interstitial fluid and proteins back to the circulation** ✓

C Producing plasma proteins such as albumin

D Blocking plasma filtration at the arterial end of capillaries

E Reducing intracellular fluid volume

▶ **Explanation:** Lymphatic vessels drain excess fluid and leaked proteins from interstitium; lymphatic obstruction can therefore cause edema.

18 **A patient with nephrotic syndrome loses large amounts of albumin in the urine. Which combination of changes would you most expect in the capillary–interstitial fluid exchange?**

A Increased plasma oncotic pressure and reduced filtration

B **Decreased plasma oncotic pressure and increased net filtration into tissues** ✓

C Increased capillary hydrostatic pressure and decreased filtration

D No change in Starling forces

E Increased interstitial hydrostatic pressure and reduced edema

▶ **Explanation:** Loss of plasma proteins lowers oncotic pressure, so the inward pull on fluid is reduced and net filtration from capillaries into tissues increases, favouring edema.

19 **Intravenous infusion of concentrated albumin solution in a patient with hypoalbuminaemic edema is expected to:**

A Decrease plasma oncotic pressure and worsen edema

B Increase plasma oncotic pressure and draw water from the interstitial space into the vascular compartment ✓

C Directly lower capillary hydrostatic pressure

D Prevent further lymph drainage

E Only expand intracellular volume

▶ **Explanation:** Raising plasma oncotic pressure increases the inward pulling force on water, promoting movement of interstitial fluid back into the circulation.

20 Mannitol, an osmotic diuretic, is sometimes given intravenously to reduce cerebral edema. Its main mechanism is to:

A Lower plasma osmolarity so water leaves blood and enters brain tissue

B Increase plasma osmolarity, drawing water from brain interstitial and intracellular spaces into the blood ✓

C Increase plasma oncotic pressure by acting like a plasma protein

D Decrease capillary hydrostatic pressure in the brain

E Act as a primary active transporter of Na^+ out of neurons

▶ **Explanation:** Mannitol stays in the extracellular compartment and raises plasma osmolarity, creating an osmotic gradient that removes water from brain tissue, lowering intracranial pressure.

21 A patient with severe hyperglycaemia (very high blood glucose) is most likely to have which immediate effect on body water distribution?

A Decreased extracellular osmolarity, causing cells to swell

B Increased extracellular osmolarity, causing water to leave cells and making them shrink ✓

C Decreased intracellular osmolarity, causing water to enter cells

D No osmotic effect because glucose is osmotically inactive

E Immediate equilibration of glucose across cell membranes with no water shift

▶ **Explanation:** If glucose cannot enter cells effectively (for example, due to lack of insulin), it acts as an effective extracellular osmole, raising ECF osmolarity and pulling water out of cells.

22 In the pulmonary circulation, left-sided heart failure commonly leads to pulmonary edema because:

A Pulmonary capillary hydrostatic pressure falls below oncotic pressure

B Pulmonary capillary hydrostatic pressure increases, favouring filtration into lung interstitium and alveoli ✓

C Plasma oncotic pressure increases markedly

D Lymphatic drainage from lungs becomes excessive

E Alveolar epithelium becomes completely impermeable to water

▶ **Explanation:** Left heart failure raises pulmonary venous and capillary pressures, increasing hydrostatic pressure and promoting fluid movement into lung tissue and air spaces.

23 Which statement best describes the main driving force for O2 diffusion from alveolar air into pulmonary capillary blood?

A A gradient in total gas pressure between alveoli and blood

B A gradient in oxygen partial pressure between alveoli and blood ✓

C A gradient in nitrogen partial pressure

D A gradient in blood hydrostatic pressure

E A gradient in plasma oncotic pressure

▶ **Explanation:** Gases diffuse according to partial pressure gradients; alveolar PO2 is higher than venous PO2, so O2 diffuses into blood.

24 **In a typical neuron at rest, the K^+ concentration is higher inside than outside, and the inside of the cell is negatively charged relative to the outside. How do these gradients influence K^+ movement if K^+ channels open?**

A Both the chemical and electrical gradients drive K^+ inward

B The chemical gradient drives K^+ outward, while the electrical gradient tends to pull K^+ inward ✓

C Both gradients drive K^+ outward

D Neither gradient acts on K^+ because it is uncharged

E The gradients cancel completely, so K^+ never moves

▶ **Explanation:** High intracellular K^+ creates a chemical gradient outward, while the negative interior attracts positive K^+ inward; the combined electrochemical gradient determines net K^+ movement.

25 **Which situation is most likely to cause cellular swelling due to osmotic water movement?**

A Infusion of large volumes of isotonic saline

B Acute ingestion of large volumes of pure water without solutes ✓

C Infusion of hypertonic saline

D Loss of water without solute (for example, sweating without replacement)

E Increase in plasma oncotic pressure due to albumin infusion

▶ **Explanation:** Excess pure water intake lowers extracellular osmolarity, causing water to move into cells down the osmotic gradient, making them swell and potentially causing hyponatraemic symptoms.

26 **Which statement best describes Gibbs–Donnan equilibrium across a semipermeable membrane separating two compartments when one side contains impermeant negatively charged proteins?**

A All permeant ions distribute equally on both sides, regardless of charge

B **Permeant ions distribute unequally so that electroneutrality is maintained in each compartment, creating both electrical and osmotic gradients** ✓

C Water cannot move across the membrane, so no osmotic gradient develops

D Impermeant proteins cross the membrane to equalise charge

E It has no relevance to real biological systems

▶ **Explanation:** Fixed negatively charged proteins attract cations and repel anions, leading to unequal ion distribution that maintains electroneutrality and creates an osmotic difference, relevant to plasma proteins and cells.

27 **Which of the following changes would tend to REDUCE the tendency for edema formation in peripheral tissues?**

A Marked increase in capillary hydrostatic pressure

B Decrease in plasma oncotic pressure due to low albumin

C Obstruction of lymphatic drainage

D **Decrease in capillary permeability to proteins and water** ✓

E Increase in interstitial oncotic pressure due to protein leakage

▶ **Explanation:** Lower capillary permeability reduces leakage of fluid and proteins into interstitium, diminishing net filtration and thus reducing edema risk.

28 **Which statement correctly links oncotic pressure and hydrostatic pressure in the context of capillary fluid exchange?**

A Oncotic pressure pushes fluid out of capillaries; hydrostatic pressure pulls fluid in

B Both oncotic and hydrostatic pressures always push fluid out of capillaries

C Capillary hydrostatic pressure tends to push fluid out, whereas plasma oncotic pressure tends to pull fluid into capillaries ✓

D Neither oncotic nor hydrostatic pressures affect fluid exchange

E Hydrostatic pressure is constant along the capillary, while oncotic pressure changes rapidly

▶ **Explanation:** Hydrostatic pressure is a pushing force that favours filtration, while plasma oncotic pressure pulls water into capillaries; the balance of these determines net movement.