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Nephron Structure & Basic Renal Physiology

Study Guide — Renal Physiology

High-school/pre-med-level questions on nephron anatomy, transport mechanisms, SGLT, glucose handling, medullary gradients and urine concentration.

35 items — Study Guide with Answers

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1 **The nephron is best defined as:**

A The whole kidney including its blood vessels

B **The microscopic functional unit of the kidney that forms urine** ✓

C Only the glomerulus without tubules

D The blood supply of the kidney

E The capsule surrounding the kidney

▶ **Explanation:** Each kidney contains about a million nephrons; each nephron filters blood and modifies the filtrate to produce urine.

2 **Which sequence correctly lists the parts of a nephron in the order that filtrate/urine flows through them?**

A Bowman's capsule → distal convoluted tubule → loop of Henle → proximal convoluted tubule → collecting duct

B **Glomerulus → Bowman's capsule → proximal convoluted tubule → loop of Henle → distal convoluted tubule → collecting duct** ✓

C Afferent arteriole → collecting duct → glomerulus → proximal tubule → loop of Henle

D Collecting duct → loop of Henle → proximal tubule → glomerulus → Bowman's capsule

E Glomerulus → loop of Henle → proximal tubule → distal tubule → Bowman's capsule

▶ **Explanation:** Filtrate forms in Bowman's capsule around the glomerulus and then flows PCT → loop of Henle → DCT → collecting duct.

3 **The main process occurring at the glomerulus/Bowman's capsule is:**

A Selective secretion of waste into the tubule

B **Bulk filtration of plasma to form an ultrafiltrate** ✓

C Fine-tuning of water reabsorption under ADH

D Active transport of glucose into the blood

E Production of erythropoietin

▶ **Explanation:** At the glomerulus, blood plasma (minus cells and large proteins) is filtered under pressure into Bowman's capsule to form the initial filtrate.

4 Which substance is normally present in blood plasma but almost completely ABSENT from the initial glomerular filtrate in a healthy person?

A Na^+ ions

B Glucose

C **Large plasma proteins such as albumin** ✓

D Urea

E Cl— ions

▶ **Explanation:** The filtration barrier prevents cells and most large proteins from entering the filtrate, but small solutes (Na^+, glucose, urea) are freely filtered.

5 Which combination best describes the normal composition of fluid in Bowman's capsule COMPARED with plasma?

A Same as plasma including cells and proteins

B **Similar to plasma but lacking cells and most large proteins** ✓

C Only water with no solutes

D Contains only waste products like urea, no useful substances

E Contains only proteins and no ions

▶ **Explanation:** Filtrate is essentially plasma minus cells and most proteins; it still contains ions, glucose and other small molecules.

6 Which vessels bring blood TO and FROM the glomerulus respectively?

A Efferent arteriole → afferent arteriole

B Renal vein → renal artery

C Afferent arteriole → efferent arteriole ✓

D Peritubular capillary → vasa recta

E Bowman's capsule → collecting duct

▶ **Explanation:** The afferent arteriole supplies blood to the glomerular capillaries; the efferent arteriole drains them.

7 Which region of the nephron reabsorbs the LARGEST fraction of the filtered water, Na^+, and glucose under normal conditions?

A Bowman's capsule

B Proximal convoluted tubule (PCT) ✓

C Loop of Henle

D Distal convoluted tubule (DCT)

E Collecting duct

▶ **Explanation:** The PCT is the 'bulk reabsorption' site, reclaiming most filtered water, Na^+, and nearly all filtered glucose and amino acids.

8 **Which statement about fluid leaving the proximal convoluted tubule (PCT) is MOST accurate?**

A It is usually more concentrated (hypertonic) than plasma

B It is usually more dilute (hypotonic) than plasma

C **Its osmolarity is similar to plasma, because water and solutes are reabsorbed together (iso-osmotic reabsorption)** ✓

D It contains no Na^+ at all

E It no longer contains any urea

▶ **Explanation:** The PCT reabsorbs water and solutes in roughly equal proportions, so the filtrate remains approximately isotonic to plasma.

9 **Glucose reabsorption from the filtrate in the proximal tubule primarily occurs by:**

A Simple diffusion directly through the lipid bilayer

B Primary active transport directly using ATP on the luminal membrane

C **Secondary active cotransport with Na^+ via SGLT (sodium–glucose transporters)** ✓

D Endocytosis of whole glucose molecules

E Filtration only, with no reabsorption

▶ **Explanation:** SGLT proteins on the luminal side use the Na^+ gradient (created by Na^+/K^+ pumps on the basolateral side) to bring glucose into the cell against its gradient.

10 **After glucose enters the proximal tubule cell via SGLT, how does it usually exit the cell into the peritubular capillary blood?**

A Via a Na^+/glucose symporter on the basolateral membrane

B Via facilitated diffusion through GLUT transporters on the basolateral membrane ✓

C Via simple diffusion across the lipid bilayer

D By exocytosis in vesicles

E It is not transported; it accumulates in the tubular cell

▶ **Explanation:** Once inside the cell, glucose leaves down its concentration gradient via GLUT (facilitated diffusion) into the interstitial fluid and then blood.

11 In a healthy person, why is there normally NO glucose in the urine?

A Glucose is not filtered at the glomerulus

B Glucose is filtered but completely reabsorbed in the proximal tubule below its transport maximum (Tm) ✓

C Glucose is destroyed in the kidney

D Glucose is secreted back into the blood in the collecting duct

E Glucose is too large to pass through any membrane transporters

▶ **Explanation:** Glucose is freely filtered but under normal plasma levels the SGLT transporters in the PCT reabsorb essentially all of it.

12 In uncontrolled diabetes mellitus, glucose appears in the urine mainly because:

A The glomerular filter becomes leaky to glucose

B Plasma glucose is so high that filtered load exceeds the transport maximum (Tm) of SGLT transporters ✓

C The kidneys stop filtering glucose

D The collecting duct secretes glucose into the urine

E Glucose channels open only in the presence of insulin

▶ **Explanation:** When plasma glucose is very high, the PCT transporters are saturated; extra glucose cannot be reabsorbed and is excreted (glycosuria).

13 Which best describes the DIFFERENCE between tubular reabsorption and tubular secretion?

A Reabsorption moves substances from blood into filtrate; secretion moves substances from filtrate into blood

B Reabsorption moves substances from filtrate into blood; secretion moves substances from blood into filtrate ✓

C Reabsorption occurs only in the PCT; secretion only in the glomerulus

D They are identical processes with different names

E Reabsorption applies only to water; secretion only to ions

▶ **Explanation:** Reabsorption recovers useful substances back into the blood; secretion actively adds additional substances (like drugs, H^+, K^+) from blood into the tubular fluid.

14 Which relationship between filtration (F), reabsorption (R), secretion (S), and excretion (E) of a substance is correct?

A $E = F + R - S$

B $E = F - R + S$ ✓

C $E = R - F + S$

D $E = F - S - R$

E $E = F + R + S$

▶ **Explanation:** What ends up in the urine (E) is what was filtered minus what was reabsorbed plus anything additionally secreted into the tubule.

15 **A substance is freely filtered and not reabsorbed or secreted anywhere in the nephron. How does its amount excreted in urine compare with the amount filtered?**

A Excreted amount is zero

B Excreted amount is less than filtered

C **Excreted amount equals the filtered amount** ✓

D Excreted amount is greater than filtered

E Excreted amount depends only on secretion

▶ **Explanation:** If there is no reabsorption or secretion, all filtered substance ends up being excreted: E = F.

16 **Which segment of the nephron descends into the medulla, is highly permeable to water, but has low permeability to NaCl?**

A Proximal convoluted tubule

B **Descending limb of the loop of Henle** ✓

C Thick ascending limb of the loop of Henle

D Distal convoluted tubule

E Collecting duct

▶ **Explanation:** The descending limb allows water to leave into the increasingly salty medulla, concentrating the tubular fluid.

17 **Which segment is often called the 'diluting segment' because it reabsorbs NaCl but is essentially impermeable to water?**

A Proximal convoluted tubule

B Descending limb of the loop of Henle

C **Thick ascending limb of the loop of Henle** ✓

D Early distal convoluted tubule

E Collecting duct

▶ **Explanation:** The thick ascending limb pumps NaCl out but does not allow water to follow, so the tubular fluid becomes more dilute.

18 **The medullary osmotic gradient (increasing osmolarity from cortex to inner medulla) is mainly generated by:**

A Active water pumping in the collecting duct

B **NaCl reabsorption in the ascending limb of the loop of Henle and urea recycling** ✓

C Glucose secretion in the proximal tubule

D Protein filtration in Bowman's capsule

E Bulk flow of blood through afferent arterioles

▶ **Explanation:** Active transport of NaCl out of the ascending limb and recycling of urea into the medulla create a high solute concentration deep in the medulla.

19 **The ability of the kidney to produce CONCENTRATED urine (small volume, high osmolarity) depends most directly on:**

A **The presence of long juxtamedullary nephrons and a medullary osmotic gradient** ✓

B The absence of any gradient in the medulla

C Complete impermeability of collecting ducts to water

D The lack of ADH (antidiuretic hormone)

E Only cortical nephrons with very short loops of Henle

▶ **Explanation:** Juxtamedullary nephrons with long loops help create the medullary gradient needed for water reabsorption in the presence of ADH.

20 **Antidiuretic hormone (ADH) mainly increases water reabsorption by:**

A Making the proximal tubule more permeable to water

B Increasing water permeability of the late distal tubule and collecting duct via insertion of aquaporins ✓

C Blocking Na^+ reabsorption in the thick ascending limb

D Raising glomerular filtration rate

E Reducing medullary osmolarity

▶ **Explanation:** ADH causes collecting duct cells to insert water channels (aquaporins) into their luminal membranes, allowing water to leave the tubule into the hyperosmotic medulla.

21 **In the ABSENCE of ADH, which of the following is TRUE?**

A Collecting ducts are highly permeable to water and urine is concentrated

B Collecting ducts are relatively impermeable to water and a large volume of dilute urine is produced ✓

C Glomerular filtration stops

D No Na^+ is reabsorbed in the nephron

E The medullary osmotic gradient disappears immediately

▶ **Explanation:** Without ADH, water cannot follow the medullary gradient in the collecting ducts, so relatively dilute urine is excreted in a larger volume.

22 **Most students assume 'most water is reabsorbed in the collecting duct because ADH acts there'. Which correction is MOST accurate?**

A **Most water is actually reabsorbed in the proximal tubule, regardless of ADH** ✓

B No water is reabsorbed in the proximal tubule

C ADH acts mainly on the glomerulus

D All water reabsorption is optional and ADH-dependent

E Water is reabsorbed only in the loop of Henle

▶ **Explanation:** The PCT always reabsorbs a large, fixed fraction of filtered water (obligatory reabsorption). ADH controls the variable, extra water reabsorbed later.

23 **Which nephron segment is MOST responsible for fine-tuning Na^+ and K^+ balance under the influence of aldosterone?**

A Proximal convoluted tubule

B Descending limb of loop of Henle

C Thick ascending limb

D **Late distal convoluted tubule and collecting duct (principal cells)** ✓

E Bowman's capsule

▶ **Explanation:** Aldosterone acts on principal cells in the late DCT and collecting duct to increase Na^+ reabsorption and K^+ secretion.

24 **Which of the following is a common example of a substance that is SECRETED into the nephron rather than primarily filtered and reabsorbed?**

A Glucose

B Na^+

C Urea

D **Many drugs and H^+ ions** ✓

E Water

▶ **Explanation:** Certain organic acids/bases and hydrogen ions are actively secreted from peritubular capillaries into the tubule, aiding drug clearance and pH regulation.

25 **Which part of the nephron lies mainly in the cortex?**

A **Glomerulus, Bowman's capsule, proximal and distal convoluted tubules** ✓

B Descending and ascending limbs of juxtamedullary loops only

C Collecting ducts only

D Vasa recta only

E Entire loop of Henle and papillary ducts

▶ **Explanation:** The renal cortex contains the renal corpuscles (glomerulus + Bowman's capsule) and convoluted tubules.

26 **The vasa recta (capillaries running alongside the loops of Henle of juxtamedullary nephrons) mainly function to:**

A Generate the medullary osmotic gradient by active Na^+ pumping

B **Carry away reabsorbed water and solutes while preserving the medullary gradient (countercurrent exchange)** ✓

C Filter plasma into Bowman's capsule

D Act as the main site of glucose reabsorption

E Secrete ADH into the nephron

▶ **Explanation:** The vasa recta pick up reabsorbed water and solutes without washing out the medullary gradient, thanks to their countercurrent flow.

27 **The macula densa is a specialised region of cells located in the:**

A Proximal convoluted tubule near the glomerulus

B **Thick ascending limb/distal tubule where it contacts its own glomerulus** ✓

C Collecting duct opening into the renal pelvis

D Bowman's capsule wall facing the ureter

E Vasa recta in the medulla

▶ **Explanation:** The macula densa senses NaCl in the tubular fluid and is part of the juxtaglomerular apparatus that helps regulate GFR and renin release.

28 **Which statement best describes the osmolarity of tubular fluid at the END of the thick ascending limb (entering the distal tubule) in normal conditions?**

A More concentrated (hypertonic) than plasma

B Similar to plasma (isotonic)

C **More dilute (hypotonic) than plasma** ✓

D Contains no solutes at all

E Is always an exact copy of plasma

▶ **Explanation:** Because the thick ascending limb removes NaCl but is impermeable to water, the tubule fluid becomes more dilute than plasma.

29 In which situation would the kidney most likely produce a LARGE volume of DILUTE urine?

A High levels of ADH and a strong medullary gradient

B **Low or absent ADH (e.g. central diabetes insipidus)** ✓

C Very high plasma oncotic pressure

D Severe dehydration with high ADH

E Reduced NaCl reabsorption in the ascending limb

▶ **Explanation:** Without ADH, the collecting ducts remain water-impermeable, so the dilute fluid leaving the thick ascending limb remains dilute and is excreted in excess.

30 Which of the following best explains why plasma proteins (like albumin) normally stay in the blood and do NOT appear in the filtrate?

A They are too small to pass through the filtration barrier

B **The filtration barrier is both size- and charge-selective, restricting large and negatively charged proteins** ✓

C They are actively secreted back into the blood in Bowman's capsule

D They are trapped by SGLT transporters

E They are bound to red blood cells and follow them into the filtrate

▶ **Explanation:** Fenestrated endothelium, basement membrane and podocyte slits form a filter that largely excludes big, negatively charged proteins.

31 **Which of the following combinations is correct regarding LOCATION and MAIN ROLE?**

A Proximal tubule – fine-tuning of Na^+ under aldosterone

B **Loop of Henle – creating the medullary osmotic gradient** ✓

C Collecting duct – main site of glucose reabsorption

D Bowman's capsule – secretion of drugs

E Distal tubule – bulk reabsorption of water and Na^+

▶ **Explanation:** The loop of Henle (especially juxtamedullary loops) is key for establishing the cortex-to-medulla osmotic gradient.

32 **Which statement about SGLT (sodium–glucose cotransporters) is TRUE and often misunderstood?**

A SGLT uses ATP directly to move glucose

B **SGLT uses the Na^+ gradient created by the Na^+/K^+ pump, so it is a form of secondary active transport** ✓

C SGLT is found on the basolateral membrane facing the blood

D SGLT moves glucose out of the blood into the filtrate

E SGLT only works when urine volume is very high

▶ **Explanation:** SGLT is driven by the Na^+ electrochemical gradient (maintained by ATP-dependent Na^+/K^+ pumps), not by its own ATP hydrolysis.

33 **Which of the following would MOST likely lead to an INCREASE in water reabsorption from the collecting ducts?**

A Decreased ADH secretion

B **Increased ADH secretion and an intact medullary gradient** ✓

C Destruction of the medullary gradient

D Blockade of all aquaporin channels

E Infusion of a large volume of hypotonic fluid

▶ **Explanation:** High ADH plus a salty medulla allow water to leave the collecting duct, concentrating the urine.

34 **Which statement about cortical vs juxtamedullary nephrons is correct?**

A Cortical nephrons have very long loops of Henle deep into the medulla; juxtamedullary nephrons have very short loops

B **Juxtamedullary nephrons with long loops are more important for concentrating urine** ✓

C Only cortical nephrons produce filtrate

D Juxtamedullary nephrons have no glomeruli

E Both types are functionally identical with identical loop lengths

▶ **Explanation:** Cortical nephrons are more numerous but have short loops; juxtamedullary nephrons have long loops and are crucial for generating a strong medullary gradient.

35 **Which change would most likely IMPAIR the kidney's ability to concentrate urine?**

A Loss of glomerular fenestrations

B **Loss of thick ascending limb NaCl reabsorption (no salt pumping)** ✓

C Increased glucose reabsorption in the PCT

D Mild reduction in GFR only

E Slight increase in aldosterone

▶ **Explanation:** Without NaCl reabsorption in the ascending limb, the medullary gradient collapses and water has no driving force to leave collecting ducts, so urine cannot be concentrated effectively.