

Urinary System

Part A – Multiple Choice

1. D
2. B
3. C
4. B
5. B
6. C
7. B
8. C
9. C
10. C
11. A
12. D
13. B
14. B
15. B
16. D
17. C
18. B
19. D
20. C
21. D
22. A
23. A
20. D
21. B

Part B – Written Answers

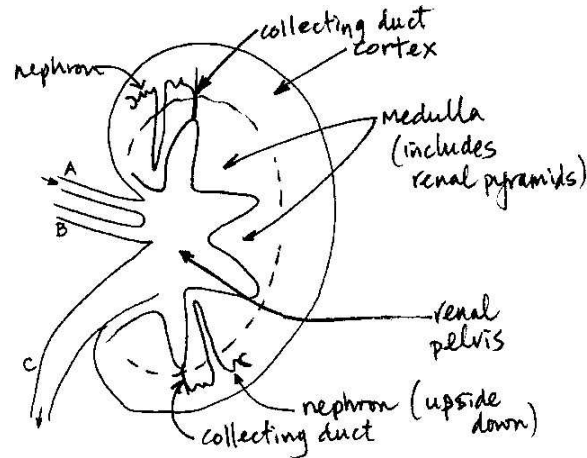
Note: The answers provided here are correct, but they may NOT be the only possible answers.

1. It is critical for survival that the pH of blood remains relatively constant at about 7.35. This pH is adjusted and regulated at the distal convoluted tubule by the movement of hydrogen and bicarbonate ions between the forming urine and the blood in the peritubular capillary bed. If the pH is low, more H^{1+} will be added to the urine and less HCO_3^{1-} will be absorbed. Alternatively, if the pH of blood is too high, less H^{1+} will be excreted and more HCO_3^{1-} will be recovered from urine.
2. W (adrenal gland) – produces hormones such as adrenalin (from the medulla) and aldosterone (from the cortex).
X (kidney) – filters wastes (such as urea) from blood and produces urine for excretion.
Y (ureter) – uses peristalsis to conduct urine to the urinary bladder for excretion.
Z (urinary bladder) – stores urine until excretion occurs.
3. a. A = renal artery
B = renal vein
C = ureter

b. A and B both contain blood. The blood in these blood vessels is different in composition in several ways. For example, blood in A is oxygenated, whereas in B it is deoxygenated. Also, the blood in A contains urea, whereas the blood in B contains significantly less urine. The blood also differs in terms of the stability of the pH, and the content of histamines and penicillin and so on.

c. B contains deoxygenated blood and C contains urine. These fluids are different in their compositions as well. Blood contains blood cells, whereas urine will not normally contain blood cells. The same is true of globulins and other blood components that are too large to pass through the glomerulus. The concentration of urea in the fluid in C is much higher than in B.

d. and e.



f. The renal pelvis accumulates and temporarily stores the urine that comes down the collecting ducts. This urine has to be transported along the ureter via peristalsis.

4. R = afferent arteriole

S = glomerulus

T = Bowman's capsule

U = proximal convoluted tubule

V = loop of Henle

W = peritubular capillary bed

X = distal convoluted tubule

Y = collecting duct

5. Urine is formed by a fairly complex sequence of events that occurs simultaneously in each of the millions of nephrons that are located in each kidney. Structurally, a nephron is a narrow tube that has a cup-shaped end called Bowman's capsule. This structure, situated in the cortical region, encloses a tuft of capillaries called a glomerulus. From Bowman's capsule, the tubule bends and folds (proximal convoluted tubule) before leaving the cortex and going down into the medulla and back up to the cortex. This portion of the nephron is called the loop of Henle. Once back in the cortex, the tubule twists and folds once more (distal convoluted tubule) before joining the collecting duct. Many nephrons can be attached to the same collecting duct. This common duct transports the almost fully formed urine to the renal pelvis.

It is important to note a few things in order to explain urine formation. Namely, the folding of the tubule in the cortex regions provides more surface area and time for certain processes to occur. Also, the tubule is very thin and has walls that are one cell thick. These features also contribute to function. The thinness facilitates the movement of materials in and out of the nephron in order to make urine. It is also notable that the ascending side of the loop of Henle is specifically designed to pump Na^+ out of the tubule and into the medullary region of the kidney, making the salt concentration of this region higher than that of the cortex.

Urine formation begins at the Bowman's capsule with the filtration of blood through the glomerulus. This blood is under blood pressure and small molecular components of blood are forced into the tubule through Bowman's capsule and into the nephron tubule. This fluid is called the filtrate. As the filtrate is pushed (by the ongoing filtration) along the proximal convoluted tubule, the cells of the tubule recover useful components in the filtrate, such as glucose, and pump them back into the blood of the peritubular capillaries. As the filtrate moves down the loop of Henle into the medulla of the kidney, it encounters the high salt concentration, which draws water out of the forming urine and increasing its concentration. This water subsequently moves by osmosis into the blood (which was made hypertonic by the filtration process). The permeability of the cells of the nephron changes on the ascending side and no longer is water able to leave the nephron. By the time the filtrate arrives in the distal convoluted tubule it no longer has nutrients in it, still has the urea and is much more concentrated than it was before. The cells of the distal tubule are specialized to make adjustments to the composition of the blood. It is here that the pH of the blood is adjusted and that penicillin and histamines are added to the urine. Once in the collecting duct, the urine again encounters the salty regions of the medulla as it travels to the renal pelvis. This causes even more water to be reabsorbed, concentrating the urine even more.

6.
 - a. ADH is produced by the hypothalamus and released into blood by the posterior pituitary gland in response to a decreased volume of blood, such as during times of dehydration. This may or may not be associated with low blood pressure as well, depending on the body's activity level at the time. ADH increases the porosity of the collecting duct to water, thus additional water escapes from urine to be recovered by the blood. This increases the concentration of the urine and decreases its volume.
 - b. aldosterone is produced and secreted into blood by the adrenal cortex. This hormone affects the distal convoluted tubule and increases the retention of sodium (and secretion of potassium). Retaining sodium causes more water to be retained as well. This hormone increases the concentration of urine and decreases the volume of the urine (same as ADH, though the mechanism is different).