Chapter 9: Review Answers

Student Textbook page 328–329

Answers to Understanding Concepts Questions

1.

Label	Structure	Function
A	Renal artery	carries blood from the aorta into the kidney for filtration
B	Renal vein	carries filtered blood from the kidney to the inferior vena cava

Label	Structure	Function
C	Aorta	brings oxygen-rich blood from left side of heart to organs of lower body, including the kidneys via the renal arteries
D	Kidney	filters blood; reabsorbs nutrients, water and other useful molecules; removes metabolic waste products; helps regulate blood volume; helps maintain pH of blood
E	Ureter	carries urine from kidney to the urinary bladder
F	Urinary Bladder	temporarily stores urine
G	Urethra	carries urine to the external environment

2. The active transport of Na^+ ions out of the ascending limb of the loop of the nephron and into the renal medulla controls the volume of urine produced. Na^+ pumping in the ascending loop of the nephron establishes an osmotic gradient that is used to regulate volume of water. This water is then returned to the cardiovascular system.

3. Antidiuretic hormone (ADH) plays a role in water absorption. When ADH is present, more water is reabsorbed (blood volume and pressure rise), and a decreased amount of urine results.

One example of ADH release occurs on a warm day. The hypothalamus will be stimulated to release ADH if an individual does not drink much water. The release of ADH causes more water to be reabsorbed and less urine is formed.

4. Proteins and blood cells are not normally found in the urine because these molecules are too large to pass through the capillary walls of the glomerulus. Because they do not enter the glomerular filtrate, they cannot become part of the urine.

5. If blood pH is too acidic, H^+ ions are actively transported from the blood into the urine. This process takes place in the distal tubule.

The kidneys also help regulate the levels of bicarbonate ions in the blood. Bicarbonate ions pass freely through the capillary walls in the glomerulus and enter the glomerular filtrate. The concentration of bicarbonate in the glomerular fluid is equivalent to that of plasma. If bicarbonate ions are not reabsorbed, the buffering capacity of the blood will be rapidly depleted. The process of reabsorption of the bicarbonate ions primarily occurs in the proximal tubule, although some can be reabsorbed from the distal tubule.

6. The following is a partial list.

- Blood leaving the kidney has a much lower concentration of urea (nitrogenous waste).
- Blood leaving the kidney has a much lower concentration of uric acid (nitrogenous waste).
- Blood leaving the kidney has a lower concentration of potassium ions (under hormonal control).
- Blood leaving the kidney will have a lower concentration of metabolites (drugs, products of metabolic reactions in the body) (tubular secretion).
- Blood leaving the kidney has the same concentration of glucose (glucose actively reabsorbed).
- Blood leaving the kidney has the same concentration of amino acids (amino acids actively reabsorbed).
- Blood leaving the kidney has less ammonia (tubular excretion).

7. Four types of dissolved substances found in the filtrate include nitrogenous wastes (urea, uric acid), glucose, amino acids, and salts (Na^+, Cl^-, K^+, HCO_3^-). Accept any four of the answers.

8. If the bladder has a bacterial or viral infection, the disorder is called cystitis; if only the urethra is involved, the condition is called urethritis. Urinary tract infections are more common in women than in men, primarily because of the differences in anatomy. In females, the urethral and anal openings are closer together, making it easier for bacteria from the bowels to enter the urinary tract and start an infection.

Symptoms of a urinary tract infection include a painful burning sensation during urination; a need to urinate frequently, even if no urine is present; and bloody or brown-coloured urine. The upper abdomen or lower back may be tender, and other symptoms may include chills, fever, nausea, or vomiting.

9. The following flow chart is one way to show how the kidneys control water levels in this situation.

blood plasma dilute → osmoreceptors signal to stop releasing ADH → distal tubule and collecting duct less permeable to water → more water excreted in the urine

10. Filtration occurs when whole blood enters the glomerulus. Due to blood pressure in the glomerulus, water and small molecules move from the glomerulus to the inside of the glomerular capsule. This is a filtration process because large molecules and formed elements in the blood are unable to pass through the capillary wall.

Tubular Reabsorption occurs as molecules and ions are both passively and actively reabsorbed from the nephron into the blood of the capillary network that surrounds the nephron. When sodium ions are actively reabsorbed, chloride ions follow passively. The reabsorption of salt (NaCl) increases the concentration of solutes in the blood, and water will move from the tubule into the blood by osmosis.

Tubular secretion of salt along the thick portion of the ascending limb produces an osmotic gradient. Because of the osmotic gradient within the renal medulla, water leaves the collecting duct and moves into the capillary bed surrounding the nephron.

Osmosis is the diffusion of water across a semi-permeable membrane. Tubular secretion and reabsorption establishes osmotic gradients in the kidney, which, in turn, regulates the balance of water in the body.

11. Serious dehydration would have the following effects.

(a) Glomerular filtration would be less (dehydration would reduce blood pressure). Angiotension released by the adrenal glands is a vasoconstrictor that increases blood pressure.

(b) Tubular reabsorption would create increased levels of ADH, resulting in increased reabsorption of water in the collecting duct. Aldosterone stimulates the distal tubule and collecting ducts to reabsorb sodium ions, which allows more water to reabsorb.

(c) ADH secretion would increase the permeability of the distal tubule and collecting duct, resulting in more water being removed from the urine (increased concentration of urine).

12. (a) A: renal cortex

B: renal medulla

C: renal artery

D: renal vein

E: ureter

(b) The functions of sections of the human kidney are as follows.

(i) Cortex: the processes of filtration (glomerulus). Tubular reabsorption (proximal tubule) of materials required by the body are removed from the filtrate and returned to the bloodstream. Tubular secretion (distal tubule) involves the active transport of materials out of the blood and into the distal tubule.

(ii) Medulla: cells of the medulla have an increased concentration of Na^+ ions. The high levels of Na^+ are the result of active transport of sodium ions out of the ascending limb of the nephron. Reabsorption of water (osmosis) occurs in the collecting ducts as they pass through this region.

(iii) Collecting duct: reabsorption of water by osmosis as urine moves through. Collecting ducts pass through renal medulla.

(iv) Renal pelvis: a central space that is continuous with the ureter. The collecting ducts deliver urine to the renal pelvis.

13. The following chart identifies the structures in the diagram shown.

Label	Structure
A	Bowman's capsule
B	renal artery
C	renal vein
D	loop of the nephron
E	capillary network
F	proximal tubule
G	glomerulus
H	distal tubule
I	renal cortex
J	renal medulla
K	collecting duct

(b) The following chart summarizes the function of the different parts of the nephron.

Label	Part of the Nephron	Function
i	glomerulus	Filtration ■ Glomerular blood pressure forces some of the water and dissolved substances from the blood plasma through the pores of the glomerular walls
ii	Bowman's capsule	Receives filtrate from the glomerulus
iii	proximal tubule	Reabsorption ■ Active reabsorption of all nutrients, including glucose and amino acids ■ Active reabsorption of positively charged ions such as sodium, potassium, calcium ■ Passive reabsorption of water by osmosis ■ Passive reabsorption of negatively charged ions such as chloride and bicarbonate by electrical attraction to positively charged ions Secretion ■ Active secretion of hydrogen ions
iv	Descending loop of Henle	Reabsorption ■ Passive reabsorption of water by osmosis

Label	Part of the Nephron	Function
v	Ascending loop of Henle	Reabsorption ■ Active reabsorption of sodium ions ■ Passive reabsorption of chloride and potassium ions
vi	Distal tubule	Reabsorption ■ Active reabsorption of sodium ions ■ Passive reabsorption of negatively charged ions such as chloride and bicarbonate ■ Passive reabsorption of water by osmosis Tubular Secretion ■ Active secretion of hydrogen ions ■ Passive secretion of potassium ions by electrical attraction to chloride ions
vii	Collecting duct	Reabsorption ■ Passive reabsorption of water by osmosis

Answers to Applying Concepts Questions

14. Alcohol stimulates urine production partly by decreasing ADH release, which decreases the permeability of the distal tubule and collecting ducts to water. More dilute urine (lighter colour) is expelled from the body.

15. (a) water—180 L of water are filtered into the capsules each day; only 1.8 L of urine are produced; 99% of the water that is filtered is reabsorbed into the bloodstream from the proximal tubules, the descending loop of Henle, the distal tubule, and the collecting ducts.

(b) sodium—630 g of sodium enter the filtrate; 3.2 g of sodium are excreted in the urine; 99.5% of the sodium entering the filtrate is reabsorbed into the bloodstream from the proximal tubule, the loop of Henle, and the distal tubule

(c) glucose—180 g of glucose enter the filtrate; theoretically 0.0 g of glucose is excreted in the urine; all of the glucose is reabsorbed into the bloodstream in the proximal and distal tubules.

(d) urea—54 g of urea enter the filtrate; 30.0 g of urea are excreted in the urine; only 44% of the urea is reabsorbed through all regions of the nephron.(56% of the urea in the blood is excreted).

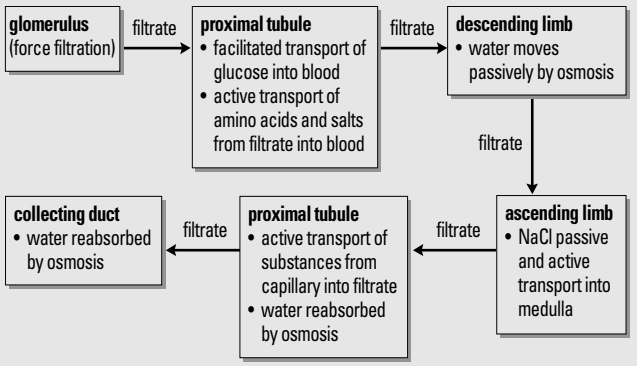
16. The following are potential answers:

- A kidney transplant using a living donor generally has a higher success rate because the kidney is usually a better genetic match and therefore is not as likely to be rejected.
- The time between the donor and recipient surgeries is usually minimal, which may improve long-term graft survival. The recipient does not have to wait for a cadaveric organ, which can take as long as 2–5 years.

17.

Function	Human Kidney	Dialysis Machine
Filtration of Blood	Glomerulus (force filtration).	Blood passes through dialysis tubing; small molecules pass through this membrane by diffusion.
Tubular Reabsorption	Glucose and amino acids are actively reabsorbed from the filtrate in the proximal tubule.	Substances can be added to the blood by increasing their concentration in the diasylate; these molecules will diffuse from the diasylate into the blood.
Tubular Secretion	Certain molecules are actively secreted from the capillary network into the distal tubule.	This process cannot be duplicated in a dialysis machine.

18.



Answers to Making Connections Questions

19. (a) As blood filtering becomes impaired, urine output decreases, water and waste products accumulate in the blood, and blood then appears in the urine.

(b) Students need to associate the inability of the glomerulus to filter blood properly, due to nephritis, with the resulting presence of blood cells in the filtrate. Thus, students might suggest that the presence of red blood cells causes a change in urine colour. (This response is partly correct, but incomplete. As unfiltered red blood cells break down, hemoglobin—the red pigment in such cells—is released, leading to the colour change.)

20. Students should indicate that artificial kidney dialysis uses the same chemical principles as the kidneys do to

maintain the chemical composition of the blood. The processes of diffusion across semi-permeable membranes, polarity, and concentration gradients are central to the dialysis process for both natural and artificial kidneys. Dialysis machines, however, cannot excrete unwanted substances such as medication or excess H^+ ions. Therefore, one would expect to find higher concentrations of metabolites in healthy urine than you would find in dialysis filtrate.

21. (a) Student answers will depend on their point of view. Accept answers that are well thought out and address the issue of cost of transplants vs. the cost of dialysis. (In Alberta, the cost of ongoing dialysis over a few years is considerably higher than the cost of transplant surgery and follow-up medical care.)

(b) Students may want to know the long-term implications of being on dialysis, the impact on daily routines, the inability to travel, the inability to do a regular job due to continued ill health etc.