

## Section 9.5: The Excretory System

### Mini Investigation: Treating Lead Poisoning, page 453

**A.** In Step 5, when the “lead” solution was added to the “blood” solution, it turned cloudy and a white solid was apparent. This happened because the calcium in the “lead” solution reacted with the sodium bicarbonate in the “blood” solution and came out of solution (precipitated). This is similar to what happens when lead enters the bloodstream. The lead in the bloodstream would then be freely available to react with and poison parts of the body.

**B.** In Step 6, when the EDTA was poured into the “blood” solution, it turned clear again and the white solid disappeared. This happened because the EDTA binds with the calcium, preventing it from reacting with the sodium bicarbonate. This allows the calcium (or the lead) to stay in solution and ultimately be excreted in the urine.

**C.** The excretory system plays a very important role in the treatment of lead poisoning. Once the victim has been treated with a chelating agent, the lead remains dissolved in the blood stream. The kidneys then filter the blood and the lead is removed from the body with the excretion of urine.

**D.** The process of filtration is involved in the removal of lead from the blood. This occurs in Bowman’s capsule and the glomerulus.

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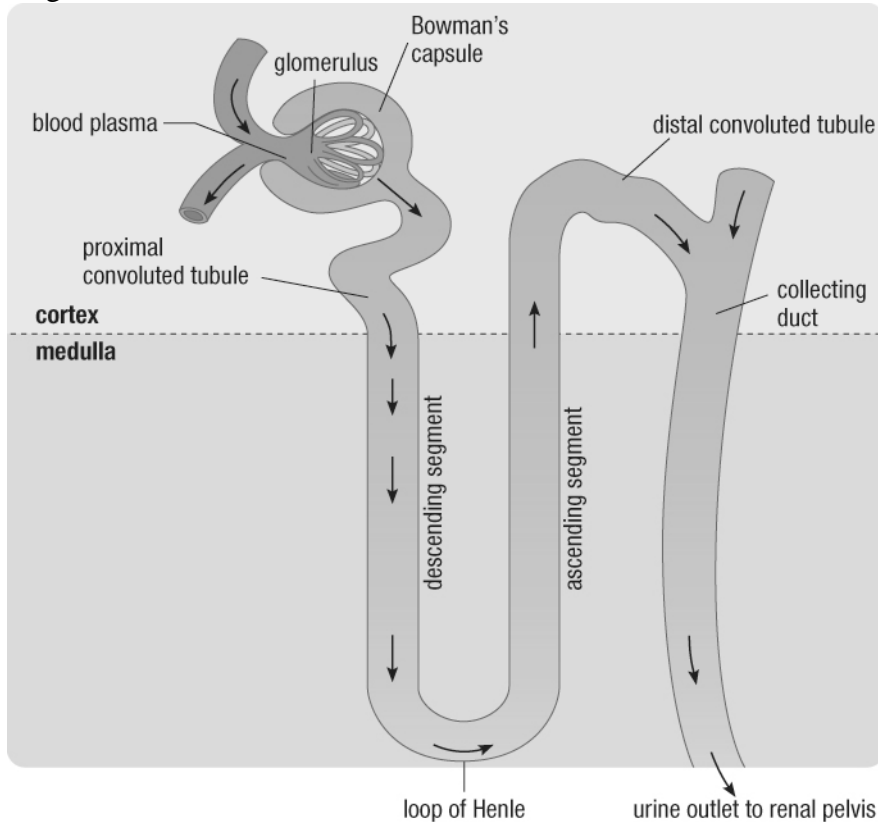
**1. (a)** In both the excretory organs of insects and the kidneys, molecules are reabsorbed and water is returned to the body fluids by osmosis. In addition, the Malpighian tubules and the kidneys use active transport proteins to remove ions.

**(b)** Conversely, the kidney is a much more complex organ than the excretory organs of insects, and there are a greater number of steps involved in the process of urine formation and excretion. Also, the end form of the nitrogenous waste is different for the two groups. Kidneys produce urine and the excretory organs of insects produce uric acid crystals.

**2.** Answers may vary. Sample answer: The body normally uses two kidneys because the kidneys perform such an essential function that it may have been evolutionarily advantageous to have a “spare” kidney. Also, the amount of blood and bodily fluids that must be filtered by the kidneys is large, and it is beneficial to “share the load” between two kidneys.

**3.** Blood flows into the nephrons through the afferent arteriole. It is supplied to the glomerulus where it is filtered by the Bowman’s capsule. The remaining blood exits the glomerulus via the efferent arteriole and flows through the peritubular capillaries, where it reabsorbs ions and nutrients. When blood enters the kidneys it contains metabolic wastes and other substances that must be eliminated from the body. When blood leaves the kidneys, these wastes have been removed. At the same time, the nephrons maintain an appropriate water and pH balance. The water balance is achieved through osmosis, depending on the concentrations of solutes in the fluids. The pH balance is achieved by the secretion of  $H^+$  ions.

4. Fluid is first filtered through the glomerulus and Bowman's capsule. It then enters the proximal convoluted tubule, and flows down into the loop of Henle. It continues up into the distal convoluted tubule and into the collecting ducts. From here, it flows to the renal pelvis and enters the bladder through the ureter. It is then excreted to the environment via the urethra. See diagram below.



5. It is beneficial for nephrons to be folded to increase the surface area available to filter blood and reabsorb water, nutrients, and ions in a smaller space.

6. Nitrogenous waste is not concentrated because the blood is filtered about 65 times every day. This constant filtering of urea, even with 50 % of the urea being reabsorbed, never builds up to a dangerous level.

7. Answers may vary. Sample answer: To prevent the build up of calcium (i.e., kidney stones), it is best to drink more water, take in fewer minerals, and avoid foods containing oxalates (e.g., spinach, rhubarb) and high phosphate concentrations.

8. Answers may vary. Sample answer: Diabetes has negative effects on kidney function.

Diabetes is the leading cause of kidney failure. Diabetics often have high blood glucose levels due to their inability to produce insulin or the inability of their tissues to take up blood glucose. This osmotic imbalance eventually damages the blood vessels of the kidney causing proteins to spill into the urine from the blood. Without treatment, the kidneys will eventually fail and the patient will require either a transplant or dialysis to remove wastes from the blood.

9. If  $\text{Na}^+$ ,  $\text{K}^+$ , and  $\text{Cl}^-$  were not reabsorbed in the kidneys, the body would excrete the minerals, causing muscles to not operate properly. The body would have to take in copious amounts of salts in order to maintain optimal levels of  $\text{Na}^+$ ,  $\text{K}^+$ , and  $\text{Cl}^-$ .

**10.** Running in hot temperatures like Ray Zahab did is an extreme condition that would dehydrate the body rapidly causing a much higher concentration of nitrogenous waste in the urine.

**11.** Answers may vary. Sample answer: In normal circumstances, protein remains in the blood and is not excreted as waste. Proteinuria is a condition in which protein escapes the blood and enters the urine. The three main causes of proteinuria are disease (i.e., diabetes), excessive levels of protein in the blood, and low reabsorption in the proximal tubule. The most obvious symptom is discovering protein in the urine, which is detected using a simple dipstick test. In addition, high protein levels in the urine often produce foamy urine, which can also be a symptom. If proteinuria is not treated, this condition will ultimately lead to impaired function of the nephrons, leading to kidney failure and eventually requiring either a kidney transplant or dialysis.

**12. (a)** The most common causes of chronic kidney disease are diabetes mellitus, hypertension (high blood pressure) and glomerulonephritis (inflammation of the glomerulus). There are 5 stages of the disease. Stage 1: slightly reduced kidney function, including abnormal blood and urine tests. At this stage, the glomerular filtration rate (i.e., how quickly blood is filtered through the glomerulus) is normal or relatively high. Stage 2: The rate of blood filtration through the glomerulus is mildly reduced. Kidney damage becomes apparent as shown by blood and urine tests. Stage 3: Reduction in the glomerular filtration rate becomes more moderate. Stage 4: The rate of blood filtration through the glomerulus is severely reduced. Stage 5: The kidneys fail.

**(b)** The two types of dialysis are hemodialysis and peritoneal dialysis. Hemodialysis is usually given in a clinic three times a week, which therefore requires the patient to regularly attend clinics for treatment. Conversely, peritoneal dialysis can be done at home with little to no support. Peritoneal dialysis gives the patient more freedom and flexibility and does not require the patient to visit a clinic. However, peritoneal dialysis is less efficient than hemodialysis and for this reason this type of dialysis has to be carried out over a longer period of time to be as effective as hemodialysis.

**(c)** Answers may vary. Sample answer: The criteria for eligibility for kidney transplants can vary from program to program and country to country. Ultimately, to be a candidate for kidney transplant, a patient must be in end-stage renal disease (kidney failure). Usually, the person must be in good health (e.g., no heart, lung, or liver disease; no cancer; and no mental illness) and sometimes the person is required to be under a certain age. Also, candidates must be able to tolerate their medications. That is, they are screened to determine if they react negatively to any of the medications that will be required for a successful transplant.

**(d)** Answers may vary. Sample answer: For live donor transplants, the donors must be screened to ensure that the donor is physically and mentally fit to donate the kidney. This is not required in cadaveric transplants. Additionally, in countries where selling organs is illegal, the case must first be investigated to ensure that the donor has not been “bullied” or paid to donate the kidney. For both types of transplants, it is important that the recipient and donor have matching blood types and have as many antigens in common as possible to prevent rejection of the kidney.

**13.** Answers may vary. Sample answer: Camels and other desert animals are able to conserve water and maintain proper kidney function because they have the ability to produce concentrated urine. That is, they retain the water in their blood and excrete urine that has a very high concentration of salt (almost as high as sea water salt concentrations). Because they produce urine with a high level of salt, they have an expanded range of available water sources. That is, they can drink salty water and eat succulent plants that have a high salty water content.