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Human Perspectives ATAR Units 1 & 2

Answers

Chapter 7 The excretory system removes waste products

Questions 7.1

Recall knowledge

1 List the organs involved in excretion.

Answer: Lungs, liver, sweat glands, kidneys, alimentary canal

2 Describe how the alimentary canal is involved in excretion.

Answer: The alimentary canal passes out bile pigments. Bile pigments are the products from the breakdown of haemoglobin from red blood cells.

3 Summarise how amino acids are broken down and removed from the body.

Answer: Amino acids go through a process of deamination, a byproduct of which is urea, which is filtered out by the kidneys and is present in urine.

Apply knowledge

4 Some people are living donors. This means that they are alive when they donate an organ such as a kidney to someone else. Explain how they are able to do this and still remain healthy.

Answer: The living donor still retains one kidney, and that kidney will increase in size to compensate for the loss of the second kidney. Blood is filtered through the kidney and the waste products are removed to form urine.

5 People who consume excess alcohol have a higher risk of liver problems. Suggest why this is so.

Answer: The liver detoxifies alcohol, in doing so, undergoes oxidative stress. This is where the product from the detoxifying damages the liver cells causing inflammation and scarring.

Questions 7.2

Recall knowledge

1 Define ‘deamination’.

Answer: The removal of an amino group from an amino acid molecule.

2 Name the functions of the skin in excretion.

Answer: The skin contains sweat glands that secrete sweat containing mostly water, but also salts urea and lactic acid, which are all byproducts of metabolism.

3 List three substances that the liver processes for excretion.

Answer: Proteins, alcohol, antibiotics, drugs, hormones, haemoglobin

4 Describe what happens to proteins that are broken down.

Answer: Proteins are broken down into amino acids. These amino acids (provided they are not recycled in the body) undergo deamination. Deamination is the removal of an amino group from an amino acid with the aid of an enzyme. The product formed is ammonia and a carbohydrate. Ammonia is highly toxic to cells, as such the liver converts the ammonia into urea which can be excreted in urine.

Apply knowledge

5 Patients with liver disease have higher than normal levels of ammonia in their blood. Explain why this occurs.

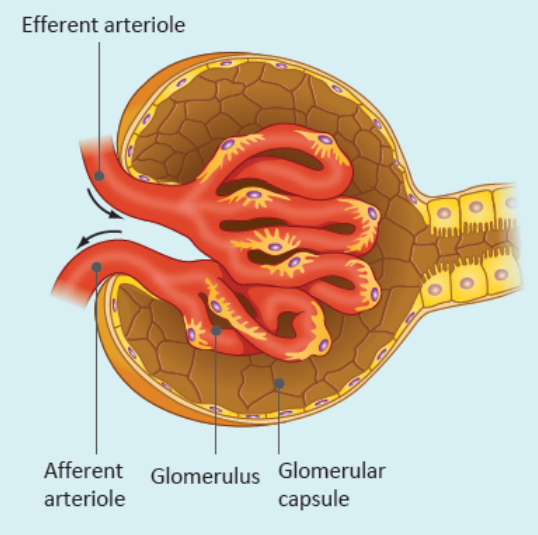
Answer: A patient with liver disease will not have a fully functioning liver. The liver will not be able to complete the process of converting ammonia into urea for safe excretion form the body. Therefore, the levels of ammonia would be higher than normal in that person.

Questions 7.3

Recall knowledge

1 Label the diagram of a renal corpuscle.

Answer:



2 List the components of the filtrate that are reabsorbed.

Answer: Water, glucose, sodium ions, chloride ions, potassium ions, bicarbonate ions, urea, uric acid

3 State where each of the following processes occurs:

a filtration *Answer:* Renal corpuscle

b secretion *Answer:* Distal convoluted tubule

c reabsorption *Answer:* Proximal convoluted tubule, loop of Henle, distal convoluted tubule, collecting duct

d storage of urine *Answer:* Bladder

e drainage of urine from the nephrons. *Answer:* Renal pelvis

4 Draw a diagram of a cross-section of the kidney and label the:

a renal artery and renal vein **b** renal medulla

c renal cortex **d** renal pyramids

e renal capsule **f** renal columns

g renal pelvis.

Answer: Refer to Figure 7.6 on page 172 of the student book.

Apply knowledge

5 Explain the importance of reabsorbing glucose.

Answer: Glucose is vital for cellular respiration, without it the body cannot produce ATP ,which is required for all vital functions.

6 Explain why the active reabsorption of water is vital in maintaining the correct fluid levels in the body.

Answer: The kidneys produce 180 L of filtrate each day. Active reabsorption is needed to maintain blood volume and blood plasma concentrations. If active reabsorption did not occur, we would be required to drink 180 L to replace what is being lost in the urine.

7 Describe how the kidney is able to have a large surface area for the processes involved in excretion.

Answer: The large surface area is produced by the millions of microscopic nephrons found in each kidney. Each nephron also has two convoluted tubules, and a loop of Henle to provide a large surface area for reabsorption to occur along.

8 Compare and contrast the process of glomerular filtration with the movement of fluid from capillaries in other body tissues.

Answer: Compare: Fluid will leave capillaries
Contrast: Glomerular filtration is enhanced by the increased blood pressure to force more fluid to be filtered at the renal corpuscle.

Questions 7.4

Recall knowledge

1 List the types of dialysis.

Answer: Peritoneal dialysis and haemodialysis

2 List the causes of liver disease.

Answer: Infection, autoimmune problems, genetic disorders, cancer, lifestyle factors including excessive alcohol consumption and a fatty diet.

3 Describe kidney stones.

Answer: Kidney stones are formed from solid crystals that build up inside kidneys when urine has become too concentrated. Crystals may combine to form stones that may get stuck in the ureter, bladder or urethra.

Apply knowledge

4 Explain how dialysis allows patients with kidney disease to live relatively normal lives.

Answer: Dialysis helps keep your body fluids in balance by removing wastes, salts and extra water to prevent them from building up to unsafe levels. Dialysis will help remove chemicals, drugs and toxins from the bloodstream. Dialysis can help control blood pressure as well.

5 Some patients with kidney stones require surgery to remove them. Explain what might happen if the kidney stones were not removed.

Answer: If kidney stones are not removed, there is an increased chance of urinary and kidney infection. Stones may block urine flow and cause permanent kidney damage.

Chapter 7 Activities

Activity 7.1 Examining the structure of the kidneys: a dissection

Recording your observations

1 Describe the texture and external appearance of the kidney.

Answer: Texture: smooth, encased in the renal capsule; Appearance: Reddish brown in colour

2 Draw a sketch, or take a photo, of the intact kidney. Label the hilum and any vessels that were present.

Answer: Students should draw a simplified diagram of a kidney with the hilum and relevant vessels labelled.

3 Describe the renal capsule.

Answer: The renal capsule is a tough and fibrous layer surrounding the kidney.

4 Draw a sketch, or take a photo, of the longitudinal section of the kidney. Label any structures that you were able to identify.

Answer: Students should draw and label the renal capsule, renal pyramid, renal column, cortex, medulla, ureter, renal artery, renal vein and hilum. Refer to Figure 7.6 on page 172 of the student book.

5 Describe the pathway of the urine from the collecting duct of the nephrons to the ureter.

Answer: Urine exits the collecting duct, moves to the minor calyces, then the major calyces before entering the renal pelvis. From the renal pelvis the urine flows into the ureter.

Activity 7.3 Investigating kidney output

Questions

1 If 180 L of water are filtered out of the blood in 24 hours, why don't we produce 180 L of urine per day?

Answer: Most of the water that is filtered out of the blood in the glomerular capsule is reabsorbed into the blood through the walls of the kidney tubule.

2 Why is there no protein in the fluid that is filtered out of the blood?

Answer: There is no protein in the fluid filtered out of the blood because protein molecules are very large and do not fit through the differentially permeable membrane of the glomerular capsule.

3 A large quantity of glucose is filtered out of the blood, but there is none in the urine. What happens to the glucose that is filtered out of the blood?

Answer: The glucose filtered out of the blood is totally reabsorbed as the filtrate passes along the kidney tubule.

4 Of the substances listed in the table (Table 7.2, page 178 of student book), which ones would be considered wastes? That is, for which of the substances does a high proportion of the filtered amount end up in the urine?

Answer: The wastes include urea and creatinine with small amounts of uric acid and ions.

5 Suggest how the figures in the table might change if the person drank a large volume of water.

Answer: If a person drank a large volume of water, body fluids would be diluted and the volume of water in the urine would increase.

6 Table salt is sodium chloride. If a person ate very salty foods, what changes might be seen in the figures in the table?

Answer: Intake of salt would cause an increase in the concentration of body fluids. This would result in less water being excreted (decreased volume of urine) and an increase in the amount of sodium and chloride ions excreted.

7 Urea is formed when proteins are broken down in the liver. Suggest how the figures in the table might change if the person had a high-protein diet.

Answer: A high-protein diet would result in more proteins being metabolised in the liver and more urea being formed. This would result in an increased amount of urea in the urine.

Activity 7.4 Investigating urine concentration

Analysis of results

1 Using an appropriate format, draw a graph of these results.

TIME	URINE MASS (g)
6.30 a.m.	1073
8.45 a.m.	1026
10.30 a.m.	1049
1.00 p.m.	1062
3.15 p.m.	1078
5.00 p.m.	1033
7.00 p.m.	1014
10.15 p.m.	1022

Answer: Students should draw a column graph with 'time' on the horizontal axis and 'urine mass' on the vertical axis.

2 For each of the measurements taken during the day, explain why the urine concentration has increased or decreased.

Answer:

Time	Urine mass (g)	Explanation for change
6.30 a.m.	1073	Urine concentration high caused by no fluid intake and accumulation of wastes during the night
8.45 a.m.	1026	Bladder emptied after the night and drink at breakfast reduces concentration
10.30 a.m.	1049	Concentration rises caused by some physical activity and perhaps some sweating
1.00 p.m.	1062	Loss of moisture through sweating, and muscle activity producing waste, increases concentration
3.15 p.m.	1078	Loss of moisture through sweating, and muscle activity producing waste, increases concentration
5.00 p.m.	1033	Becoming cooler so less sweating and reduction in physical activity
7.00 p.m.	1014	Cooler, less activity and possible fluid intake reduces concentration
10.15 p.m.	1022	Some fluid intake with dinner, but deamination of protein in evening meal so some rise in concentration

Activity 7.5 Modelling kidney function

Discussion

1 Which portion of the nephron were you modelling in this procedure? Explain.

Answer: Students modelled the glomerulus by passively filtering particles from blood based on size and a concentration gradient. The glomerulus is the only part of the nephron in which particles travel from blood to filtrate solely along a concentration gradient without active transport.

2 Why was it necessary to test the water for salt before you added the dialysis tubing?

Answer: The salt content is tested before the dialysis tubing is added to serve as a control for the procedure. The first test results serve as a baseline.

3 Imagine you left the tubing model in the cup for two days; how would the salt content in the filtrate change?

Answer: While the salt concentration in the tubing is higher than in the filtrate, then the salt content in the filtrate would be expected to increase until equilibrium is reached. Once equilibrium is reached, whether in the first 30 minutes or at some other time over the two days, the salt content in the filtrate would not change, as no further change is expected once equilibrium is reached between the tubing contents and filtrate.

4 Compare the dialysis tubing model and kidneys. Examine how the model you created functioned like a kidney and the ways in which it did not.

Answer: The glomerulus separates substances based on particle size and characteristics. In the model, the dialysis tubing functions to filter particles based on size. Any substances that are too large to pass through, such as blood cells or large flecks of debris in water are retained. In a kidney, other characteristics of the particle such as charge and affinity of ions will impact whether it is allowed to pass through, whereas the model only filters based on particle size and concentration gradients. Comparatively, the filtration that occurs within the kidney is far more controlled. Filtration within the kidney enables the body to reabsorb required substances as well as removing unwanted substances, such as waste, excess water and toxins.

5 What did the dialysis tubing retain? What was able to pass through the membrane?

Answer: Students should identify that the tubing retained the simulated blood cells, while salt was able to pass through the membrane, along with the yellow dye.

6 Explain the difference between the solution within the dialysis tubing and surrounding water that allowed substances to travel through the membrane.

Answer: The solution within the dialysis tubing contains a much higher concentration of salt and dye than the surrounding water. This produces a concentration gradient that causes the salt and dye to move passively from an area of high concentration to one of low concentration. The membrane, which is only permeable under a concentration gradient, does not allow salt and dye to pass through it until placed in water. The 'cells' in the blood do not pass through despite the difference in concentration, because they are too large.

Taking it further

1 Kidney disease can be described as a systemic disease despite directly affecting the kidneys. In what ways can the whole body be affected by kidneys that do not adequately function?

Answer: Kidneys remove waste and toxins from the body and regulate pH, salt and mineral levels. Damaged kidneys can affect the blood system leading to anaemia. Fluid build-up or toxins around the heart can create the risk of heart attack. Unbalanced minerals cause skin problems, and calcium may be taken from bones to compensate for reduced levels elsewhere.

2 Explain how the following systems interact with the urinary system.

a Circulatory

Answer: Blood passes through the kidneys where toxins and excess water are removed. Nutrients required by the body are reabsorbed into the blood after having been filtered by the kidneys. The kidney controls production of red blood cells and regulates blood pressure by the release of hormones. The blood provides oxygen and nutrients to the cells of the kidneys.

b Nervous

Answer: The bladder will send signals via the nervous system to the brain to indicate that it is full, and the nervous system controls the movement of the muscles to empty it.

c Digestive

Answer: Molecules from digestion pass through the filtering system of the kidneys and are either removed or put back into circulation for use by the cells of the body. Kidneys use the energy derived from the digestive system to undertake their work.

d Respiratory

Answer: Lungs and kidneys both regulate blood pH. The hormone angiotensin is converted in the lungs, into a form that helps the kidneys with their regulatory processes.
The respiratory system oxygenates the blood that supplies the urinary system.

3 When blood is present in urine, it can be an indication of several disorders, such as high blood pressure. How could high blood pressure be responsible for these results?

Answer: High blood pressure can damage the arteries around the kidneys so the cells do not receive the oxygen and nutrients required to function. If the filtering function is damaged, then they may fail to prevent blood from entering the urine. Or if the thin walls of the glomerulus burst, blood cells may be released into the urine.

4 Explain the interaction that occurs between the circulatory system and kidneys to create urine.

Answer: Blood passes through the kidney to be filtered, and excess water removed. The excess fluid, carrying waste products, passes through the nephrons and collecting ducts into the renal pelvis and funnelled into the ureter through to the bladder.

Chapter 7 review questions

Recall

1 a What is meant by the term ‘excretion’?

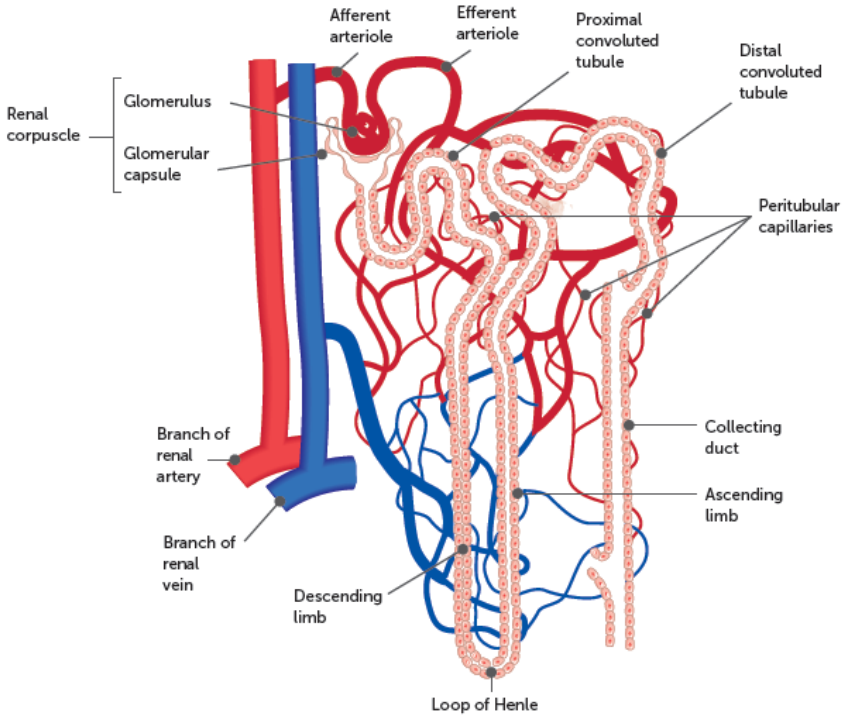
Answer: Excretion is the removal from the body of the wastes of metabolism.

b Which organs of the body are involved in excretion?

Answer: The organs involved in excretion are the lungs, sweat glands, alimentary canal, kidneys and liver.

2 a Draw a nephron and its associated blood vessels. Label the afferent and efferent arterioles, glomerulus, glomerular capsule, distal and proximal convoluted tubules, loop of Henle, collecting duct and peritubular capillaries.

Answer: Refer to Figure 7.7 on page 173 of the student book:



b Use arrows on your diagram to indicate the direction of blood flow and the direction in which the filtrate flows.

Answer: Blood flow starts at afferent arteriole and passes through the glomerulus out through the efferent arteriole, through the peritubular capillaries and out through the renal vein.
Filtrate flows from the glomerular capsule through the kidney tubule into the collecting duct.

3 a Define 'deamination'.

Answer: Deamination is the removal of an amine group from an amino acid.

b Describe where deamination occurs.

Answer: Deamination occurs in the liver.

c Describe what happens to the ammonia produced in deamination.

Answer: The cells of the liver rapidly convert ammonia to the less toxic molecule urea. Moderate amounts of urea are harmless to the body. It is easily excreted by the kidneys and is eliminated from the body in the urine. Small amounts of urea are also lost in sweat from the sweat glands.
energy + carbon dioxide + ammonia → urea + water

4 Describe the role of the skin in excretion.

Answer: Sweat glands in the skin excrete about 500 mL of water per day (about 20% of the body's water loss). Dissolved in the water secreted as sweat by the skin are sodium chloride, lactic acid, urea and some drugs.

5 Describe what happens in the nephron during:

a filtration

Answer: This process takes place in the renal corpuscle when fluid is forced out of the blood due to the blood pressure and is collected by the glomerular capsule.
When blood enters the glomerulus, the high pressure forces water and dissolved blood components through the differentially permeable cell membranes and into the glomerular capsule. The resultant fluid, the filtrate, consists of water, salts, amino acids, fatty acids, glucose, urea, uric acid, creatinine, hormones, toxins and various ions.

b reabsorption

Answer: Reabsorption is carried out by the cells that line the renal tubule. Materials that are reabsorbed include water, glucose and amino acids. In addition, ions such as sodium, potassium, calcium, chloride and bicarbonate are also reabsorbed. Some wastes, such as urea, are partially reabsorbed as well (refer to Figure 7.10 on page 176 of the student book).

c secretion.

Answer: Substances that the body does not require can be removed from the blood and secreted into the tubule. Materials secreted in this way include potassium and hydrogen ions, creatinine and drugs such as penicillin. Tubular secretion can be either active or passive.

6 Describe kidney failure.

Answer: If the kidneys lose their ability to excrete waste and control the level of fluid in the body, it is known as kidney failure. Sometimes failure occurs suddenly, but more commonly it develops over a period of years.
Kidney failure results from destruction of the nephrons by factors such as high blood pressure, diabetes or kidney disease. After kidney failure, the only way to maintain life is by dialysis or a kidney transplant.

Explain

7 Explain why ammonia must not accumulate in the tissues.

Answer: Ammonia is extremely soluble in water and must not be allowed to accumulate because, in large quantities, it is highly toxic to cells.

8 a Explain the process of dialysis.

Answer: Dialysis is a method of removing wastes from the blood when kidney failure occurs.

b Explain the difference between peritoneal dialysis and haemodialysis.

Answer: In peritoneal dialysis, a fluid is passed into the abdominal cavity through a catheter. The fluid contains glucose and other substances at concentrations similar to those found in the blood. There are no wastes in the fluid, which means that because of the concentration difference, wastes will diffuse out of the blood into the fluid in the abdominal cavity. Useful substances stay in the blood because there is no concentration difference between the blood and the fluid. After a time, the fluid that was placed in the abdominal cavity is drained out through the catheter, along with any wastes and extra water that have diffused from the blood. Peritoneal dialysis is usually done each day.

An artificial kidney, known as a dialysis machine, is used for haemodialysis. The patient's blood is passed through thousands of fine tubes, made of a differentially permeable membrane. The tubes are immersed in a bath of fluid that has concentrations of substances similar to those in the blood, except that the fluid has no waste. Because of the concentration differences, wastes diffuse from the blood into the fluid. Patients spend about four to five hours attached to the machine and haemodialysis is normally done three times per week.

9 Make a list of ways in which the structure of the kidney is suited to the functions that it performs. For each structural feature on your list, explain how that feature is related to the working of the kidney.

Answer: Kidney structure is related to its function by:

- being well supplied with blood under high pressure because the renal arteries branch from the aorta.
- each kidney having a vast number of blood vessels, including capillaries, which allow for maximum blood flow and exchange of materials.
- having over a million nephrons in each kidney, so the total surface area available for reabsorption and secretion is extremely large.
- having clumps of capillaries, the glomeruli, each with a capsule surrounding it so that the fluid filtered out of the blood capillaries is collected.
- the arteriole leading out of the glomerulus having a smaller diameter than the arteriole leading in. This raises the blood pressure in the glomerulus so that more fluid is filtered out of the blood.
- each tubule having two sets of convolutions and a long loop so that there is a large surface area for reabsorption and secretion.

Apply

10 Compare and contrast the filtrate and the blood entering the glomerulus.

Answer:

Compare: Both contain water, glucose, ions, urea, uric acid

Contrast: The filtrate does not contain blood cells or large amounts of proteins

11 What lifestyle measures should you adopt to make sure that your kidneys remain healthy?

Answer:

- Drink water instead of sugary drinks.
- Limit salt intake.
- Regulate diet to maintain a healthy weight.
- Don't smoke.
- Drink alcohol in moderation.
- Do not use performance enhancing drugs.

12 To be effective, an organ where materials are taken into the body, or passed out of the body, must have a very large surface area. How is a large surface area achieved in the kidney?

Answer:

- There are over a million nephrons in each kidney.
- Each nephron has two sets of convolutions that serve to increase the length.
- Each nephron has a long loop, which also increases the length.

13 In this chapter, you were told the approximate length of a renal tubule and also the approximate number of tubules in a kidney. Using these figures, calculate the total tubule length for an average person, remembering that most people have two kidneys. Express your answer in appropriate units.

Answer:

- Length of renal tubule = 5 cm
- 1.2 million nephrons/kidney
- Two kidneys
- Therefore, approximate length = $5 \times 1\,200\,000 \times 2$ = 12 million cm, or 120 000 m, or 120 km.

14 The kidneys have a very important function in maintaining the composition of body fluids at a constant level. Describe the kidney's role in maintaining a constant internal environment for the cells.

Answer: Answers should include the following points about the kidneys' role in homeostasis.

The kidneys:

- excrete nitrogenous and other wastes: urea, uric acid, creatinine and salts
- regulate blood concentration by regulating the amount of water lost as urine
- maintain the pH of the blood at 7.4 by regulating the amount of water in tissue fluids.

15 What effects would you expect the following to have on urine production?

a A high-salt diet

Answer: Lower volume of urine with a higher concentration of salts (more salt)

b A low-protein diet

Answer: Normal volume of urine with a lower concentration of nitrogenous waste (less urea)

c A large intake of water

Answer: Higher volume of urine with low concentration of salts (dilute urine)

16 a Suggest why we tend to urinate more frequently in cold weather than in hot weather.

Answer: In hot weather, we tend to sweat, so that more fluid is lost through the skin rather than in urine. In cold weather, less water is lost as sweat, so it has to be removed as urine. During cold weather blood vessels in the skin constrict to conserve body heat. This raises blood pressure and increases filtration rate so the kidneys excrete more water because more fluid is being filtered out of the blood.

b Suggest why urine is often more darkly coloured in hot weather than in cold weather.

Answer: In hot weather more fluid is lost in sweat. To balance this loss more fluid is reabsorbed in the kidneys so that urine is more concentrated. The dark colour is due to the increased concentration of salts and other wastes. In cold weather the opposite occurs: little water is lost in sweat, and a less concentrated (or more diluted) urine is produced, with little colour.

Extend

17 The desert hopping mouse lives on dry seeds and never drinks water. It has extremely long kidney tubules. How is it able to reduce water loss in urine to a minimum?

Answer: It has extremely long tubules that maximise the amount of surface area available to reabsorb water. It probably doesn't sweat and keeps cool by living in a burrow and being nocturnal.

18 Explain how the circulatory system forms a link between the respiratory, digestive and excretory systems.

Answer: The circulatory system transports all the substances needed by the cells; for example, glucose and amino acids from the digestion of foods, and oxygen from breathing. It also transports wastes away from cells to be excreted, for example, carbon dioxide through the lungs, and salts via the kidneys. Thus, it connects all the systems to deliver inputs and outputs to where they are required.

19 Why do doctors sometimes order a urine test for a patient? What information about a person's health can be gained from an analysis of their urine?

Answer: Urine analysis can be used to help diagnose many different diseases. For example, glucose in the urine can indicate diabetes, presence of certain compounds in the urine may be a sign of liver problems and blood or plasma proteins in urine could indicate a problem with the kidney itself. Too much water being excreted could be a result of hormonal imbalance and too much urea may indicate excessive protein in the diet.

20 Kidney disease causes protein to be excreted in the urine. The loss of protein from the blood causes fluid to accumulate in the tissues and there may be swelling of the hands, feet and face. Conduct research to find out why loss of protein from the blood causes swelling of the tissues.

Answer: Loss of the proteins from your blood allows fluid to leak out of the blood vessels into the nearby tissues, causing swelling. The proteins (specifically albumin) help hold salt and water inside the blood vessels. When the levels of proteins in the blood get too low, fluid is retained in the body tissues causing swelling.

21 Countercurrent exists between the two limbs of the loop of Henle and between each nephron tubule and surrounding capillaries. Conduct research to find out:

a what a countercurrent is

Answer: Countercurrent is the process to use energy to generate a concentration gradient. In the nephron it is used to generate an osmotic gradient that will enable more water to be reabsorbed from the filtrate and to produce concentrated urine.

b the importance of the countercurrents that exist in the kidney

Answer: The countercurrent mechanism that exists between the two limbs of the loop of Henle ensures that the osmotic gradient is maintained over the length of the loop of Henle so that a large amount of water can be reabsorbed. Without this mechanism, not enough water would be removed from the filtrate in the given space.

c how changes in the concentration of the filtrate would affect the countercurrent exchange mechanisms

Answer: If the filtrate has less solutes (is more dilute) then less solute (sodium chloride) can be actively reabsorbed. If the filtrate is more concentrated, then more solute can be actively reabsorbed. Changes in concentration of the filtrate will generate more or less of the countercurrent exchange mechanism.

d other places in the body, apart from the kidney, where countercurrent exchanges operate.

Answer: Humans do operate countercurrent heat exchange in our extremities, but this is not as well developed as in other animals which are routinely exposed to cold climates.