

## Answers: Chapter 6 Homeostasis controls fluid and gas levels

### Questions 6.1

#### RECALL KNOWLEDGE

1 List three functions of water in the body.

*Answer:* Containing dissolved substances, transporting substances around the body, facilitating movement across membranes and being the site of chemical reactions.

2 What organ has the greatest percentage of water?

*Answer:* Kidneys and the brain both contain up to 85% water.

3 Complete the following sentence.

The extracellular fluid is the fluid found outside the cells. It is made up of the intravascular fluid, which is also known as plasma, the interstitial fluid between the cells and transcellular fluid – for example, cerebrospinal fluid (CSF).

4 True or false? There is more fluid found in the plasma than in the cells.

*Answer:* False, there is 28 L of fluid found in the cells and only 3 L found in the plasma.

5 Describe osmosis.

*Answer:* Osmosis is the movement of water from areas of low osmotic pressure to areas of high osmotic pressure across a membrane until equilibrium is met.

6 List the ways that fluid is:

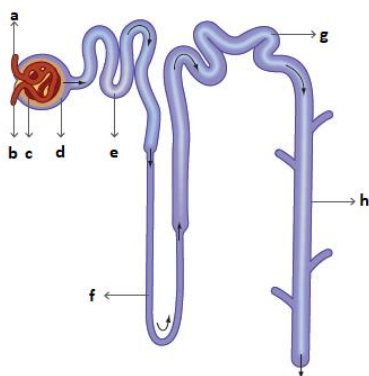
**a** gained

*Answer:* metabolic water, food and drink

**b** lost.

*Answer:* urine, skin, alimentary canal (faeces), lungs

7 Label the parts of a nephron on the diagram below.



*Answer:*

a – afferent arteriole

b – efferent arteriole

c – glomerulus

d – glomerular capsule

e – proximal convoluted tubule

f – (descending) Loop of Henle

g – distal convoluted tubule

h – collecting duct

**8** Name the receptors that detect a change in water content of the body, and state where they are located.

*Answer:* Osmoreceptors. Osmoreceptors are located in the hypothalamus.

**9 a** What does 'ADH' stand for?

*Answer:* ADH stands for antidiuretic hormone.

**b** What part of the nephrons does ADH act on?

*Answer:* ADH acts on the distal convoluted tubule and collecting ducts of the nephron.

**c** What effect does ADH have on the structures identified in **b**?

*Answer:* ADH will increase the permeability of the nephron wall to water. As such more water is reabsorbed into the peritubular capillaries.

**d** Is ADH secreted due to a high or low osmotic pressure?

*Answer:* ADH is secreted due to high osmotic pressure in the peritubular capillaries.

**10** Describe the role of aldosterone in maintaining the concentration of sodium ions in the blood. Identify any relevant structures in your description.

*Answer:* Aldosterone acts on the distal convoluting tubule and collecting ducts to increase the sodium ions reabsorbed into the bloodstream. Aldosterone is secreted by the adrenal cortex in response to a decrease in sodium ions in the blood plasma, a decrease in blood volume, a decrease in blood pressure and an increase in potassium concentration in the blood plasma.

### APPLY KNOWLEDGE

**11** What is the mass of water in an adult female weighing 62 kg?

*Answer:* There would be approximately 31L of water.

**12** Suggest why the proportion of water in a baby's body is larger than in their grandparent's body.

*Answer:* Muscles atrophy with age and seniors/grandparents will consequently have less water in the body than younger adults and infants. The kidney's ability to reabsorb water decreases with age, so water is lost in greater amounts as well.

**13** Explain why water toxicity can cause cells to swell.

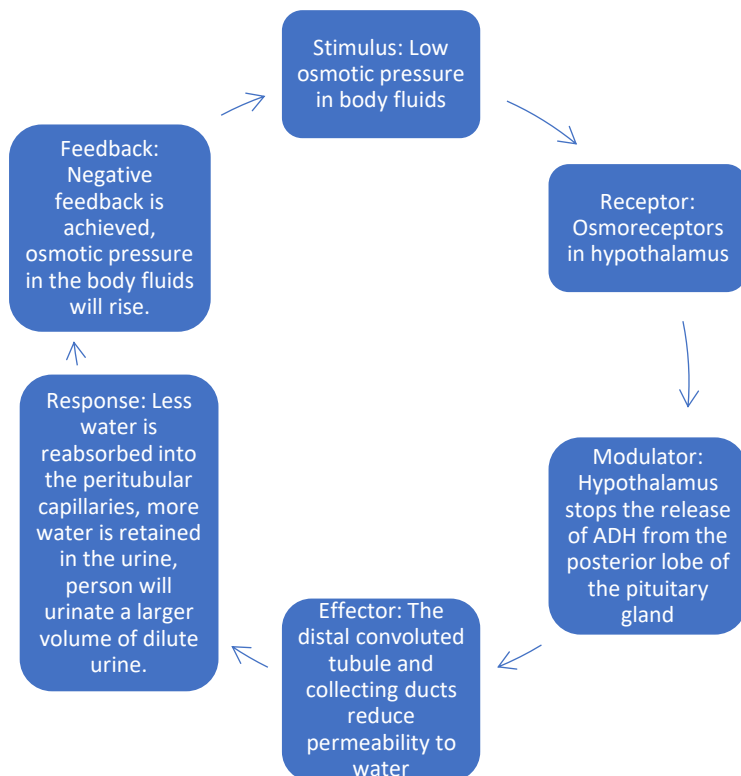
*Answer:* Water toxicity occurs when a person, who has lost a lot of water and salts through sweating, replaces fluid with pure water only. The osmotic concentration gradient between the extracellular and intracellular fluid will be high, therefore water will enter the cells and they will swell.

**14** Explain why the homeostatic mechanisms that control body fluids are focused on the kidneys and not the alimentary canal, lungs or skin, even though water is also lost through these organs.

*Answer:* Water lost through the alimentary canal, lungs and skin is deemed insensible water loss. It is not able to be measured accurately and occurs through normal body processes. The kidneys are able to be influenced by ADH and aldosterone when osmotic concentrations change. As such the homeostatic mechanisms for body fluid focusses on the kidneys.

**15** Draw a feedback loop to show what would happen if you drank more water than you lost.

*Answer:*



**16** Explain why, after running a cross-country course, Alex had a dry throat and was very thirsty.

*Answer:* During the cross-country race, Alex would have been increasing his body temperature by running and would have been sweating to prevent his body overheating. A larger amount of water would have been lost through evaporation from the skin's surface. In order to maintain blood volume, due to excessive sweating, water would have moved from the intracellular fluid, into the interstitial and then extracellular fluid (plasma). This would have caused Alex's cells to shrink, sending an impulse to the hypothalamus indicating dehydration and thirst.

While running Alex is likely to have been breathing in and out through his mouth, increasing the water loss from the mucous membranes in his throat. This would lead to his dry throat.

## Questions 6.2

### RECALL KNOWLEDGE

**1** What is the name of the peripheral chemoreceptors that influence breathing?

*Answer:* Aortic and carotid bodies

**2** Write the word equation for cellular respiration.

*Answer:* Glucose + Oxygen → Water and Carbon dioxide + energy in the form of heat and ATP

**3** Describe the relationship between carbon dioxide and the concentration of hydrogen ions in the blood.

*Answer:* Carbon dioxide will dissolve in the blood plasma forming carbonic acid. This acid will dissociate one of its hydrogen ions, increasing the concentration of hydrogen ions in the blood plasma and reducing the pH level. And increased level of carbon dioxide will result in an increased concentration of hydrogen ions in the blood plasma.

4 Which nerve sends impulses to:

a the diaphragm?

*Answer:* The phrenic nerve.

b the intercostal muscles?

*Answer:* The intercostal nerves.

5 Which chemoreceptors detect changes in:

a oxygen?

*Answer:* Peripheral chemoreceptors in the aortic and carotid bodies.

b carbon dioxide?

*Answer:* Peripheral chemoreceptors and central chemoreceptors in the medulla oblongata.

c hydrogen ions?

*Answer:* Peripheral chemoreceptors and central chemoreceptors in the medulla oblongata.

6 Explain how an increased rate and depth of breathing is able to decrease the concentration of carbon dioxide in the blood.

*Answer:* By increasing the rate (and depth) of breathing, more carbon dioxide will be exchanged with oxygen at the alveoli, reducing the concentration of carbon dioxide in the blood plasma.

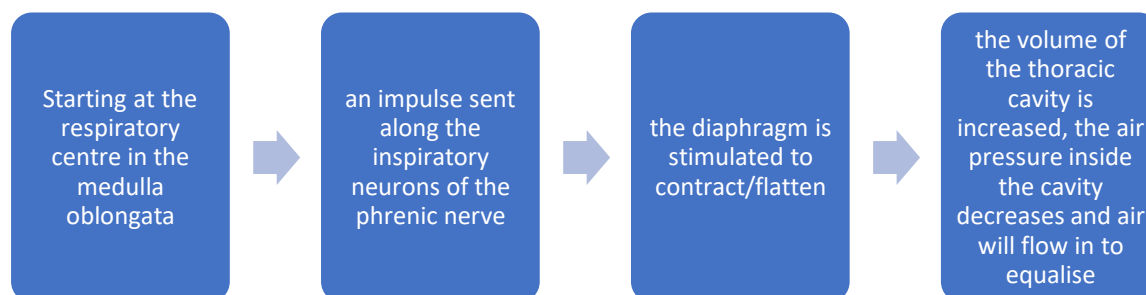
7 Explain why it is not possible to die from holding your breath unless you are under water.

*Answer:* Due to the build-up of carbon dioxide in the blood plasma, the peripheral and chemoreceptors will send an impulse to the inspiratory centre in the medulla oblongata and to the inspiratory muscles forcing you to take a breath. Unless you are underwater, or in a space with irritating or toxic gases, you will not die. If you are underwater, you will inhale water and possibly drown.

### APPLY KNOWLEDGE

8 Use a flow chart to show the pathway of messages from the respiratory centre to the diaphragm during inspiration.

*Answer:*



9 Why is it important that the muscles responsible for breathing are skeletal muscles, and not smooth or cardiac muscles?

*Answer:* Skeletal muscles can be controlled voluntarily as the medulla oblongata can be bypassed in the case of being underwater or if you are at risk of inhaling irritating gases. If the diaphragm and intercostals were involuntary (like the smooth and cardiac muscles are) there would not be an opportunity to voluntarily control breathing.

**10** Draw a feedback loop to show what would happen in the body if the concentration of oxygen decreased by a:

**a** small amount

*Answer:*

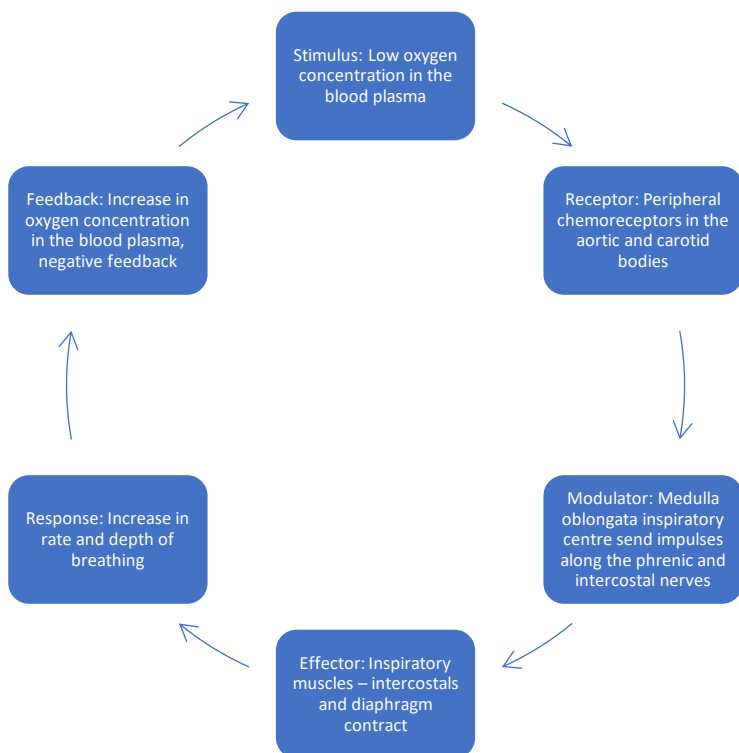
Stimulus: Slightly lower oxygen concentration in the blood plasma

Receptor: Peripheral chemoreceptors in the aortic and carotid bodies is unlikely to detect or signal a change

Modulator: will not be required to change breathing rate or depth

**b** large amount.

*Answer:*



**11** Both central and peripheral chemoreceptors respond when there is an increase in carbon dioxide levels. Explain why it is important that both of these receptors are stimulated.

*Answer:* The peripheral chemoreceptors detect the carbon dioxide levels in the blood plasma circulating around the entire body. If carbon dioxide levels are too high in the blood plasma it may indicate hypocapnia. The central chemoreceptors detect high carbon dioxide concentration levels in the cerebrospinal fluid. If these levels are high, it may indicate a lack of oxygen to the brain. It is important both are sensitive to carbon dioxide levels as they are triggered from different sources in the human body.

**12** People with chronic obstructive pulmonary disease have inflamed airways that make it difficult to breathe. This can lead to a condition known as hypercapnia, an increased level of carbon dioxide.

**a** One symptom of hypercapnia is that the blood becomes acidic. Explain why this would occur.

*Answer:* High levels of carbon dioxide will result in an increased level of carbonic acid and an increase in the hydrogen ion concentration. pH is a measure of available hydrogen ions in solution, high hydrogen ions indicates a lowered pH and an increase in acidity.

**b** Explain why giving oxygen to patients with hypercapnia could be dangerous.

*Answer:* Hypercapnia is a result of an increased level of carbon dioxide, which needs to be removed by increasing the rate and depth of breathing (perhaps through use of a ventilator). If you give a person oxygen, they may not be stimulated to increase the rate and depth of breathing and gas exchange in the lungs, so carbon dioxide levels could continue to rise. Hypocapnia also results in the constriction of the bronchioles to decrease ventilation, this mechanism is meant to counteract hyperventilation and to decrease the amount of oxygen coming into the lungs, which would be counterintuitive if the person is given oxygen therapy.

## Chapter 6 activities

### ACTIVITY 6.1 Simulated urinalysis

#### Discussion

**1** What information regarding patient health does examining urine under a microscope provide?

*Answer:* Microscopic analysis provides insight into the cells that are present in the urine. This is useful when attempting to determine whether red colouration in urine has been caused by the presence of red blood cells. The presence of an infection is indicated by increased white blood cells numbers or bacterial cells in the urine.

**2** Describe how urinalysis results may change for an individual over a 24-hour period. Consider daily activities and how test results may be different in urine samples collected earlier or later in the day.

*Answer:* Medication and perspiration levels, along with water and food consumption can impact urinalysis results over a 24-hour period. Urine is generally slightly acidic in the morning due to the lack of food and water consumption overnight. Urine becomes more alkaline as the day progresses as different foods are consumed.

**3** In Table 3, describe the urinalysis results that you would expect to see from 'Patient A' and provide reasoning for each factor. Patient A has been diagnosed with strep throat and has been prescribed amoxicillin to be taken twice a day. They are under instruction to get lots of bed rest and drink plenty of fluids.

*Answer:*

Factor	Result	Reasoning
Colour	Yellow-orange to orange	Amoxicillin is an antibiotic. Antibiotics are known to change urine to colours in the yellow-orange to orange range.
pH	6.0–8.0	pH should be normal. There are no known issues with diabetes or anaemia. Note: Students may say that the pH is <6 .0 because the patient may be drinking a lot of cranberry juice, a clear

		liquid. This answer is acceptable as long as the student connects low pH specifically to cranberry juice.
Glucose	Negative	There should not be any glucose in the urine. This is the normal condition. There are no known issues with diabetes.
Protein	Negative	There should not be any protein in urine. This is the normal condition. There are no known issues with anaemia, and there is no indication of a large meal having been consumed.
Specific gravity	<1.010	Specific gravity should be lower than normal, since this person is drinking lots of fluids.

**4** What side-effect warning would be appropriate for an anti-inflammatory medication used to treat the symptoms of arthritis?

**Answer:** Taking common anti-inflammatory medications including those used to treat arthritis can cause individuals to have dark (wine-coloured) urine.

**5** Why do doctors order a urinalysis when attempting to diagnose diabetes? Can these urine tests be used to definitively diagnose diabetes? Discuss.

**Answer:** Doctors use urinalysis as a first step in a diagnosis for diabetes as they are quick and easy to perform, inexpensive, non-invasive and relatively reliable. However, urine test results cannot be relied upon for a full diagnosis, as the factors for diabetes such as the presence of glucose in urine can be the result of diet and other factors. Doctors will conduct additional testing before making a conclusive diagnosis.

### Taking it further

**1** Investigate other types of urine tests, such as drug and pregnancy tests. Describe how each test works.

**Answer:**

- Pregnancy tests work by testing urine for a hormone called human chorionic gonadotropin (hCG). When pregnant, the body produces this hormone and the presence of hCG in your urine is considered a positive sign of pregnancy. A qualitative hCG test tests for the presence of hCG, while a quantitative hCG test (beta hCG) measures the exact amount of hCG in your blood.
- There are two types of urine drug screens. Immunoassay are the most common type of urine drug screening. These tests detect how the drug interacts with the body's immune system and its ability to form antigen-antibody complexes rather than measuring the drug itself. Any result below the (ng/mL) cut-off number is a negative screen and any number above the cut-off number is a positive screen. If your first test

comes back positive, a follow-up test known as gas chromatography/mass spectrometry (GC/MS) is ordered for confirmation. This type of test is more accurate, but also more expensive and take longer to give results.

**2** Although rare, false positive results can occur in both pregnancy and certain drug tests. This can be due to diet, medications and other factors. Describe how false positive pregnancy and drug tests occur.

**Answer:** False positive pregnancy tests are rare but can occur due to a variety of reasons:

- Presence of protein or blood in urine.
- Recent birth, miscarriage or chemical pregnancy.
- User error or faulty equipment.
- Some fertility, antihistamines, anti-anxiety and diuretic medications.
- hCG-producing growth such as an ovarian tumour.

False positive drug tests are more common and can occur due to:

- Consumption of poppy seeds can cause false-positive results for opium.
- Consumption of Coca tea, Coca leaf, Coca flour, Coca oil can cause false-positive results for cocaine.
- Consumption of Hempseed Oil (Cannabis Seed/Hemp Oil) can cause false-positive results for cannabis.
- Prescription medicines containing opioids, amphetamines etc.
- Many different medications including specific pain medications, antidepressants, cold medications, antihistamines and blood pressure tablets can produce false positive results for different drugs.

**3** Compare urine and blood testing. Identify the advantages and disadvantages of the two tests.

**Answer:** Urine pregnancy tests are convenient, inexpensive, immediate and relatively accurate. Blood pregnancy tests are more accurate and can detect a much lower amount of hCG than urine pregnancy tests, meaning they can detect pregnancy at an earlier stage. However, the results for these tests take longer and must be performed by a medical professional.

Urine drug tests are cost-effective and give results fairly quickly. However, this test does not detect all opioids, sometimes gives false positives and can fail to capture same-day drug use. Blood tests are more accurate, but also more expensive and invasive.

**4** Investigate how urinalysis differs between animals and humans as a result of physiological differences.

**Answer:** Human urine and animal urine have different compositions. Therefore, the 'normal ranges' for particular substances are different. Invasive urine collection methods such as cystocentesis, urethral catheterisation is used more frequently in animals, as it can be difficult to collect a voluntary sample. Urine pH is typically acidic in dogs and cats and alkaline in horses and ruminants, but varies depending on diet, medications, or presence of disease. Animals consuming milk diets tend to have acidic urine.

## ACTIVITY 6.2 Investigating breathing rate

### Studying your results

**1** How did your breathing rate change after holding your breath and after breathing into the paper bag?

**Answer:** After holding the breath the breathing rate would be expected to be higher than when breathing normally.

After breathing into a paper bag the breathing rate would be expected to be higher than when breathing normally.



**2** Suggest reasons for the changes in breathing rate.

*Answer:* While the breath is being held the level of carbon dioxide in the blood will slowly rise because no exchange of gases is taking place.

While breathing into a paper bag the level of carbon dioxide in the blood will also rise because the subject is re-breathing the same expired air, which will contain higher and higher levels of carbon dioxide.

In both cases the increased concentration of carbon dioxide in the blood stimulates chemoreceptors, which send impulses to the respiratory centre which increases breathing rate.

**3** What could be the stimulus that regulates a person's rate of breathing?

*Answer:* Possible stimuli involved in regulation of breathing rate include the following (these are possibilities only and are not necessarily involved):

- Oxygen concentration in the blood
- pH of the blood/concentration of hydrogen ions
- Carbon dioxide concentration in the blood
- Anxiety
- Anger
- Conscious control of breathing rate

**4** How does the evidence from the activity you have just done support your answer to Question 3?

*Answer:* Responses will vary, but you would expect students to suggest that carbon dioxide concentration and possibly oxygen concentration could be involved and they may be able to offer plausible reasons.

Some students may say that the results of the activity do not enable one to say what stimulus is involved in regulation of breathing rate.

## ACTIVITY 6.3 Investigating behaviour and homeostatic mechanisms

### Planning your investigation

Some of the questions that you will need to answer in your planning are as follows.

- What hypothesis will you test? The hypothesis should link the behaviour you are going to test with the aspect of homeostasis that you are going to investigate. Make sure your investigation really will test your hypothesis.

*Answer:* The student's hypothesis should be brief, a definite statement, have a single idea that can be tested and it should link behaviour with the aspect of homeostasis to be investigated.

- What data will you collect? How will you make your observations objective? Quantitative measurements are the best option, if possible.

*Answer:* Students responses will vary; however, teachers should ensure that the responses are practical and achievable. If students are collecting qualitative data, the teacher could suggest a scale to convert qualitative responses into a quantitative data set that can then be presented and analysed. Students should also show repeat trials in order to gain multiple data sets for averaging, identifying outliers and ensuring their investigation is more reliable.

- What variables will you control, and how will you go about controlling them?

*Answer:* Students should devise ways of controlling all factors that could possibly affect the aspect of homeostasis being tested (except the behaviour under investigation).

- How will you make sure that your results are valid and reliable? How many repetitions will you perform?

*Answer:* The proposed experiment will be valid if it tests what it is supposed to test.

The experiment will be reliable if it gives the same result each time it is carried out. Students should have

sufficient repetitions of their experiment to determine reliability.

- How will you record your results? Will it be possible to present the results as a table and/or a graph?

*Answer:* Answers will depend on the actual results to be measured or observed. Students may suggest drawing up a table to record their results. If the results are in a tabular form, a graph should be able to be drawn.

### Conclusions

Write a conclusion discussing the relationship between your results and your hypothesis.

*Answer:* Answers will depend on what hypothesis is tested.

## Chapter 6 Review questions

### Recall

**1** State whether the nervous system, endocrine system, or both, are responsible for:

**a** body fluid homeostasis

*Answer:* Both nervous and endocrine system

**b** gas concentration homeostasis.

*Answer:* Only the nervous system

**2 a** What are nephrons?

*Answer:* Nephrons are the functional units of the kidney; they carry out the kidney's role in excretion and water regulation.

**b** Draw a diagram of a nephron and label the places where filtration, reabsorption and secretion occur.

*Answer:* See Figure 6.6 on page 134 of the student book. Filtration occurs between the capillaries of the glomerulus and the capsule that surrounds it. Reabsorption takes place along the length of the tubule and in the collecting duct. Secretion occurs from the kidney tubule into the peritubular capillaries.

**c** Describe the role of nephrons in homeostasis.

*Answer:* The nephron is able to reabsorb or secrete substances into the peritubular capillaries depending on the requirements of the body or depending on the concentration levels of substances dissolved in the body fluids. As such, the nephron is responsible for maintaining water concentrations in the blood plasma, levels of sodium and potassium in the blood plasma, and the maintenance of blood volume and blood pressure.

**3** Describe the role of antidiuretic hormone (ADH) in regulating water output.

*Answer:* The permeability of the walls of the distal convoluted tubules and collecting ducts of the kidney nephrons are controlled by ADH. When the concentration of ADH in the blood plasma is high, the tubules are very permeable to water, and water leaves the tubule and enters the surrounding capillary network. On the other hand, when the concentration of ADH in the plasma is low, the tubules are not very permeable to water, and little water is reabsorbed into the plasma of the blood.

**4** Describe the effects of the following factors on breathing rate:

**a** concentration of oxygen in the blood

*Answer:* Oxygen normally plays little part in the regulation of breathing. The concentration of oxygen has to fall to very low levels before it has a major stimulatory effect on the rate of breathing.

**b** concentration of carbon dioxide in the blood

*Answer:* The concentration of carbon dioxide in the plasma is very important in the regulation of breathing rate. Any increase in the concentration of CO<sub>2</sub> in the blood results in the stimulation of the central and peripheral chemoreceptors. These send nerve impulses to the respiratory centre, which increases breathing rate.

**c** hydrogen ion concentration (pH) in the blood.

*Answer:* Carbon dioxide in the blood plasma combines with water to form carbonic acid, which dissociates into hydrogen ions and bicarbonate ions. Thus any increase in carbon dioxide in the plasma will result in an increase in hydrogen ion concentration. The increase in CO<sub>2</sub> concentration and hydrogen ion concentration in the blood stimulates the central and peripheral chemoreceptors. These send nerve impulses to the respiratory centre in the medulla oblongata, which increases breathing rate.

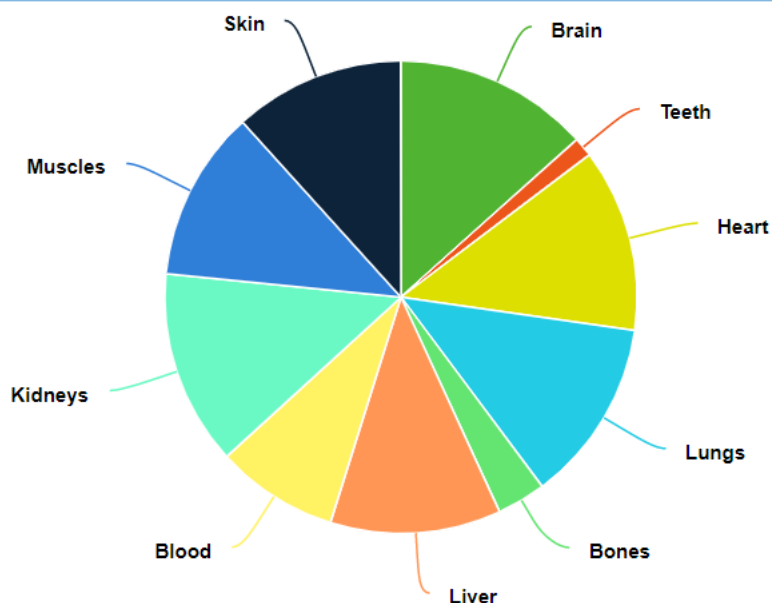
**5** Describe the role of the aortic and carotid bodies in regulating breathing rate.

*Answer:* The aortic and carotid bodies contain chemoreceptors that are sensitive to the concentration of CO<sub>2</sub> and hydrogen ions in the blood plasma. When stimulated by rising concentrations of these substances, the bodies send messages to the respiratory centre in the medulla oblongata, which in turn increases breathing rate.

**6** Draw a pie chart to demonstrate the distribution of body fluids.

*Answer:*

Distribution of body fluids in humans



**7** Define 'metabolic water'.

*Answer:* Metabolic water is a small amount of water produced as a by-product of chemical processes occurring within the cells. For example, cellular respiration uses oxygen and glucose and releases carbon dioxide and water.

**8** Name and describe the receptors that play a role in the control of:

**a** body fluid

*Answer:* Osmoreceptors

**b** gas concentrations.

*Answer:* Chemoreceptors

### Explain

**9** Explain how the respiratory centre controls the rate of breathing.

*Answer:* The respiratory centre in the medulla oblongata of the brain receives information about the carbon dioxide concentration of the blood from the aortic and carotid bodies and from receptors in the medulla itself. The aortic and carotid bodies are sensitive to increases in the concentration of hydrogen ions and CO<sub>2</sub>. They stimulate the respiratory centre to bring about an increase in breathing rate if CO<sub>2</sub> levels rise. Negative feedback occurs as CO<sub>2</sub> levels fall due to the increase in breathing rate.

**10** Aldosterone regulates the amount of sodium in the blood. Explain why aldosterone influences the amount of water excreted from the body.

*Answer:* Aldosterone is a hormone that increases the amount of sodium reabsorbed into the kidney tubules. Water is reabsorbed with the sodium so aldosterone indirectly affects the amount of water excreted.

**11** We cannot voluntarily control our heart rate or blood sugar level, yet we can voluntarily control our breathing.

**a** Explain why it is important for us to be able to voluntarily decide when to take a breath and how deep the breath should be.

*Answer:* Voluntary control of breathing is essential for speech. It is also a protective device to prevent food, water or irritating gases from entering the lungs. Voluntary control is also important in activities like blowing up a balloon, blowing out candles, swimming and many other actions.

**b** We cannot voluntarily stop breathing indefinitely. Explain why.

*Answer:* If we stop breathing, the build-up of carbon dioxide in the plasma stimulates the inspiratory centre to send impulses to the inspiratory muscles. The reflex contraction of the inspiratory muscles due to carbon dioxide build-up eventually overcomes any voluntary effort and we are forced to take a breath – whether we want to or not.

**12** Explain why excretion is closely related to maintaining fluid balance.

*Answer:* Wastes excreted by the kidneys must be dissolved in water, so that removal of wastes inevitably involves loss of water. By regulating the amount of water reabsorbed, and thus the concentration of wastes in the urine, fluid balance can be maintained.

### Apply

**13** A person lost in the desert would suffer extreme dehydration. Although the thirst receptors would try to initiate drinking behaviour, the lack of available water would not allow this requirement to be met.

Describe the mechanisms the body would employ to conserve water while getting rid of metabolic wastes.

*Answer:* The person would be losing water through sweating but would be unable to replace that water.

This means that the osmotic pressure of the blood would be raised. Osmoreceptors in the hypothalamus detect the increased osmotic pressure of the blood. The hypothalamus stimulates the posterior lobe of the pituitary gland to release ADH into the bloodstream. ADH affects its target organs, which are the nephron

tubules in the kidney. The permeability to water of the distal convoluted tubules and the collecting ducts is increased. More water is then reabsorbed into the blood plasma from the tubules and ducts. This response will cause a dramatic decrease in the volume of urine produced and an increase in the concentration as less water is available to dilute the salts/wastes being excreted. Small quantities of highly concentrated urine will be produced.

**14** A student made the following observations. On a very hot day, the volume of urine produced was small and it was dark in colour. On a cold day, urination occurred more frequently, and the urine was pale in colour. Explain these observations.

*Answer:* On a very hot day, the student will sweat in order to cool the body and maintain homeostasis. This results in an increase in water loss from the body, which raises the osmotic pressure of the blood. More ADH will be released from the posterior pituitary. This causes the nephron to become more permeable to water, so water is retained in the blood and only small quantities of urine are produced. The urine would be dark in colour because the metabolic wastes are concentrated due to the excretion of less water. On a cold day, the opposite occurs. The student will not lose as much fluid through sweat. Less ADH will be released from the posterior pituitary. This causes the nephron to become less permeable to water, so water is retained in the collecting tubule and is lost as urine. It is light or pale in colour because the metabolic wastes are diluted by the larger volume of water being lost.

**15** An athlete had blood samples taken before and after a vigorous training session on a hot, dry day. The sample taken after training had a much higher concentration of ADH than the sample taken before training. Explain why there would be a difference in concentrations.

*Answer:* A vigorous training session on a hot, dry day will result in the athlete sweating profusely to maintain homeostasis of body temperature. Thus, if there is a decreased amount of water in the blood, the water concentration of the blood plasma would decrease. This means that the osmotic pressure of the blood is raised. Osmoreceptors in the hypothalamus detect this and stimulate the posterior lobe of the pituitary gland to release ADH into the bloodstream. ADH causes permeability to water of the distal convoluted tubules and the collecting ducts to increase. Thus, less water is lost in the urine to compensate for the increased loss of water through sweating.

**16** Moderate dehydration occurs when the body loses 7–10% of the body weight in fluid. What is the minimum mass an 80 kg male would need to lose in fluid to be considered moderately dehydrated?

*Answer:* An 80 kg male would need to lose 5.6 kg as a minimum.

**17** Why is it dangerous to hyperventilate before swimming under water?

*Answer:* Hyperventilation is rapid, deep breathing. It has the effect of removing much of the CO<sub>2</sub> from the blood. When a person swims under water after hyperventilating there is no urge to breathe because the CO<sub>2</sub> concentration is very low. Oxygen concentration could become so low that the person loses consciousness.

**18** People sometimes hyperventilate in stressful situations. The hyperventilation may cause dizziness and tingling of the fingers and toes. In such cases, the person may be advised to breathe into a paper bag and re-breathe the same air that was breathed out. How would such a procedure help to overcome the problems of hyperventilation?

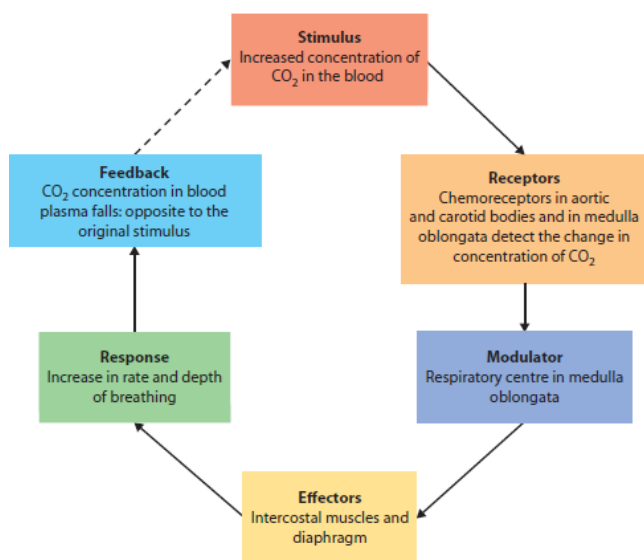
*Answer:* Rapid, deep breathing can provide more oxygen than required and remove more carbon dioxide than necessary. By breathing in air that has been breathed out (into a paper bag), the person is breathing

air that has a higher concentration of CO<sub>2</sub> than atmospheric air. As CO<sub>2</sub> in the blood builds up, the chemoreceptors will be stimulated and a normal breathing pattern should resume.

**19** Draw a stimulus–response–feedback diagram, labelling the receptor, modulator, effector and feedback, to show what happens to breathing rate when:

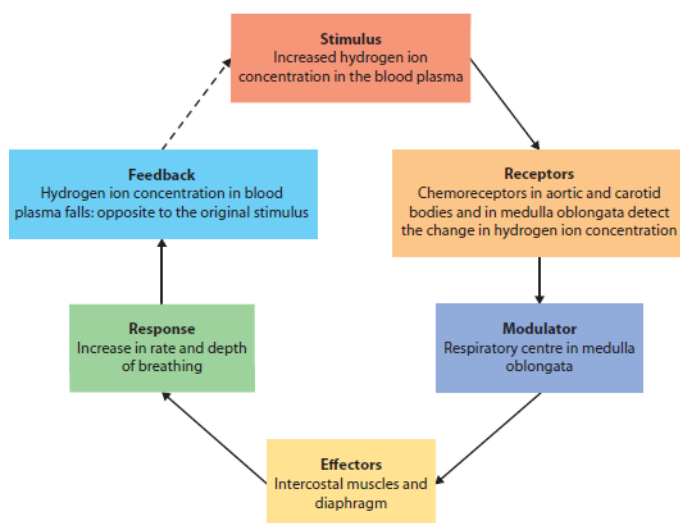
**a** the concentration of carbon dioxide in the blood increases

*Answer:*



**b** the hydrogen ion concentration of the blood increases.

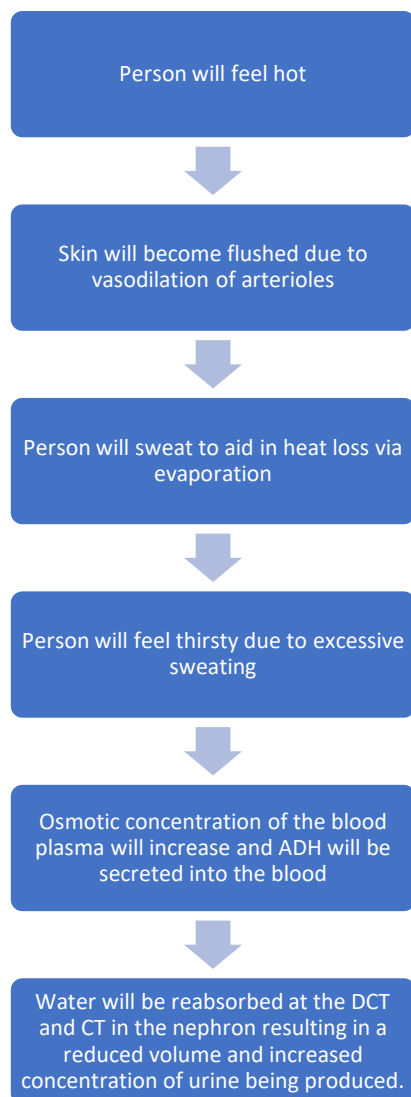
*Answer:*



### Extend

**20** Use a flow chart to summarise all the changes that would occur in the body while playing basketball during a hot day.

*Answer:*



**21** The table shows the water loss from a person’s skin and kidneys under different conditions. Use the data to explain the relationship between regulation of body temperature and regulation of fluid content of the body.

ORGAN	WATER LOST (ML/HOUR)		
	AT ROOM TEMPERATURE	IN HOT WEATHER	WITH LENGTHY VIGOROUS EXERCISE
Skin	19	73	225
Kidneys	58	50	20

*Answer:* At room temperature a person sweats very little, so only a small volume of water is lost from the skin as sweat. This means that more water circulates in the plasma to the kidneys and, with less ADH released from the pituitary gland, more water will be lost as urine.

In hot weather, a person sweats to help cool the body, so a larger volume of water is lost from the skin as sweat. This means that less water circulates in the plasma to the kidneys and, with more ADH released from the pituitary gland, smaller amounts of water will be lost as urine.

With lengthy vigorous exercise, a person sweats profusely, so a large volume of water is lost from the skin as sweat. This means that osmotic pressure of the blood is raised significantly. Greater amounts of ADH will

be released from the pituitary gland, so that as much water as possible will be retained by the kidneys. This results in a very small volume of urine being formed.

**22** Elderly people are much more likely to suffer from water regulation problems than the young. The gradual decline in the effectiveness of the thirst reflex has already been mentioned, but there is also a decline in the effectiveness of the kidneys.

Find out the changes in kidney function that occur with age, and describe some of the conditions that can occur in elderly people due to poor kidney function.

*Answer:* Changes in the kidney that occur with age include

- Amount of kidney tissue decreases
- Number of nephrons decreases and the filtration of the blood decreases
- Blood vessels supplying the kidneys can become hardened, this will slow the rate of filtration down.
- Kidneys may decrease in size

Some kidney dysfunction and conditions that occur due to age include urinary tract infections, urinary incontinence, renovascular disease, high blood pressure.