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*Human Perspectives ATAR Units 3 & 4*

# Answers: Chapter 5 Homeostasis controls blood glucose and body temperature

## Questions 5.1

### RECALL KNOWLEDGE

**1** Define 'homeostasis'.

*Answer:* The maintenance of a relatively constant internal environment despite fluctuations in the external environment.

**2** Fill in the blanks for the negative feedback loop.

*Answer:* Stimulus → Receptor → Modulator → Effector → Response → feedback

**3** List four characteristics that are maintained by homeostasis.

*Answer:* Core body temperature, Blood glucose levels, Body fluid pH and concentrations of dissolved substances, concentration of oxygen and carbon dioxide in the blood and other body fluids, blood pressure, concentration of metabolic wastes.

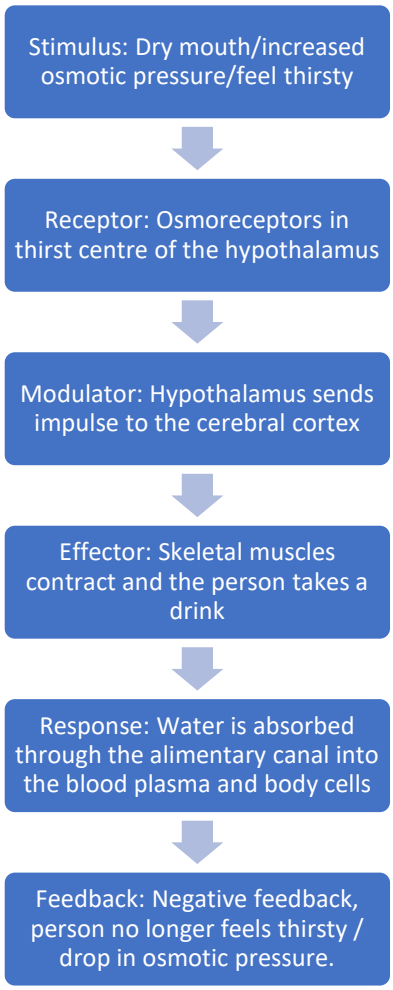
**4** Describe two positive feedback systems.

*Answer:* Childbirth is one example. During childbirth oxytocin is secreted to cause contractions of the uterus. These contractions push the baby's head against the cervix which in turn sends messages to the brain to release more oxytocin. The increase in oxytocin causes stronger uterine contractions, pushing the baby's head more forcibly against the cervix, which send more impulses to the brain to secrete more oxytocin.

Blood clotting is a second example. When a blood vessel is damaged substances released by the mast cells begin the process of blood clotting. Platelets will cling to the damaged site and release chemicals that attract additional platelets. As the platelets continue to build more chemicals are release and more platelets are attracted to the site. This positive feedback accelerates the process of clotting until the clot is large enough to stop the bleeding.

**5** Use a flow chart to model the feedback loop when drinking water maintains fluid levels in the body on a very hot day.

*Answer:*




### APPLY KNOWLEDGE

**6** Explain the difference between the set point and tolerance limit.

*Answer:* The set point is the level at which substances or concentrations can fluctuate above or below. The degree of fluctuation is defined at the tolerance limits, the upper and lower limits that allow the body to function normally.

**7** Explain why a positive feedback system would not achieve homeostasis.

*Answer:* Positive feedback acts to reinforce and increase the stimulus. Negative feedback acts to reduce or oppose the stimulus. Homeostasis can only be achieved when negative feedback is applied, as positive feedback will continue the stimulus beyond the tolerance limits.

## Questions 5.2

### RECALL KNOWLEDGE

**1** List the organs that play key roles in glucose homeostasis.

*Answer:* Liver, pancreas, adrenal glands.

**2** Define ‘glycogenesis’, ‘glycogenolysis’ and ‘gluconeogenesis’.

*Answer:*

| Term | Definition |
|---|---|
| Glycogenesis | The formation of glycogen from other carbohydrates, especially glucose. |
| Glycogenolysis | The breakdown of glycogen to glucose. |
| Gluconeogenesis | The creation of glucose from fats or proteins |

**3** Describe what happens to glucose from ingestion to it passing through the liver.

*Answer:* Glucose is actively absorbed at the villi in the small intestine into the blood capillaries. From there, the capillaries join to form the hepatic portal vein which delivers blood to the liver from the small and large intestine, stomach, spleen and pancreas. At the liver the glucose is either:

- Removed from the blood by the liver to provide energy for liver functioning
- Removed from the liver and converted into glycogen for storage
- Continues through the liver to circulate in the blood for body cells to absorb and use as a source of energy
- Converted into fat for long-term storage.

**4** Blood glucose levels increase after eating carbohydrates.

**a** What is the key hormone that will initially be released?

*Answer:* Insulin

**b** What organ produces this hormone?

*Answer:* Pancreas

**c** What cells within the organ produce this hormone?

*Answer:* The beta cells in the Islets of Langerhans

**d** What responses does the hormone lead to?

*Answer:* Glycogenesis, protein synthesis, lipogenesis, increased in uptake of glucose by body cells, overall decrease in blood glucose levels.

**5** Describe the role of the adrenal glands in controlling the level of glucose in the blood.

*Answer:* The adrenal glands contain two distinct parts; the outer part called the cortex and the inner part called the medulla.

The adrenal cortex will secrete glucocorticoid hormones (cortisol) in response to low blood glucose levels. Cortisol regulate carbohydrate metabolism, stimulates glycogenolysis and the transfer rate of amino acids to the liver for gluconeogenesis.

The adrenal medulla secretes adrenaline and noradrenaline, which mimics the sympathetic nervous system and elevates blood glucose levels. In particular, adrenaline promotes glycogenolysis and counteracts the effects of insulin. Adrenaline also stimulates the production of lactic acid which can be used by the liver to manufacture glucose (gluconeogenesis).

### APPLY KNOWLEDGE

**6** Write a word equation for cellular respiration and explain its significance in relation to glucose homeostasis.

*Answer:*

Glucose + Oxygen → Carbon dioxide + Water + Energy in the form of heat and ATP.

Increased rates of cellular respiration will increase the use of glucose by body cells and as such will reduce blood glucose levels. Increased rate of cellular respiration is influenced by thyroxine, as such, elevated thyroxine can also act to reduce blood glucose levels.

**7** Use the stimulus–response–feedback model to summarise how the pancreas responds after strenuous activity.

*Answer:*

Stimulus: Reduced blood glucose levels

Receptor: Chemoreceptors in the alpha cells of the Islets of Langerhans

Modulator: Alpha cells secrete glucagon into bloodstream

Effector: Liver, skeletal muscle cells and adipose tissue

Response: Liver – glycogenolysis and gluconeogenesis, Skeletal muscle cells – glycogenolysis, Adipose tissue – lipolysis

Feedback: Negative feedback, blood glucose levels increase.

## Questions 5.3

### RECALL KNOWLEDGE

**1** Define 'thermoregulation' and state the set point for body temperature.

*Answer:* Thermoregulation is the regulation of body temperature. The set point for body temperature in humans is 37°C.

**2** List the methods of heat loss.

*Answer:* Evaporation, radiation, conduction and convection.

**3** Define 'metabolic rate' and list the reasons that the metabolic rate would:

*Answer:* Metabolic rate is the rate at which energy is released by the breakdown of foods.

**a** increase

*Answer:* Exercise, stress, stimulation of the sympathetic nervous system, rising body temperature

**b** decrease.

*Answer:* Age, reduced physical activity, not getting enough sleep, loss of muscle mass

**4** State the location of thermoreceptors.

*Answer:* Peripheral thermoreceptors are located in the skin and mucous membranes. Central thermoreceptors are located in the hypothalamus.

**5** Why is the skin such an important organ in regulating body temperature?

*Answer:* The skin provides a large surface area and is located between the internal and external environments. Heat loss can occur by evaporation, conduction, convection and radiation, so changes in the

skin can speed up or slow down the rate of heat loss from the body.

**6** Other than sweating, what other modes of evaporation occur in the body?
*Answer:* Evaporation of water from breathing out, evaporation from urine and faeces.

**7** List five responses that the hypothalamus would trigger on a hot day. For each, classify them as responses from the nervous system or endocrine system.
*Answer:*

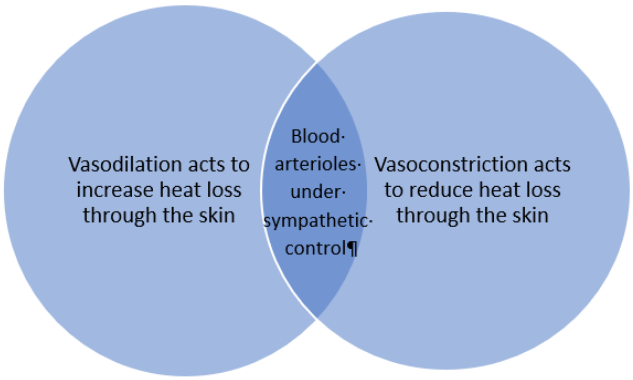
- Vasodilation of skin arterioles: Nervous response
- Sweating: Nervous response
- Conscious behaviour of reducing clothing or turning on a fan: Nervous response
- Increase surface area by sprawling/spreading out: Nervous response
- Decrease in voluntary activity: Nervous response
- Decrease in metabolic rate as a long-term response: Endocrine response

**8** Which is more dangerous – heat stroke or heat exhaustion? Explain why.
*Answer:* Heat stroke is more dangerous as it results in the increase in body temperature and regulatory mechanisms stop. It can be fatal is brain cells are affected. Increased body temperatures denature enzymes

## APPLY KNOWLEDGE

**9** Heat will flow from areas of high temperature to low temperature until the temperatures are equal. Considering this process, explain how the body is able to maintain a temperature above that of the surrounding environment.
*Answer:* If the environmental temperature falls the cold thermoreceptors in the skin sends messages to the hypothalamus. The hypothalamus then sends out impulses aimed at reducing further heat-loss and increasing heat production so that body temperature is maintained.

**10** Use a Venn diagram to compare and contrast vasodilation and vasoconstriction.
*Answer:*




**11** Explain why sweating is more effective at cooling the body when the humidity is low.
*Answer:* Humidity is a measure of water vapour in the air. In high humidity there is a higher concentration of water vapour in the air, as such evaporation of water from the skin surface is impaired. When relative humidity is low, sweat can evaporate more readily and the body can lose heat more effectively.

**12** Imagine that you forgot to take your sleeping bag on a camping trip in winter. Draw a flow chart to show the process that would occur as the temperature dropped overnight.
*Answer:*
Stimulus: Drop in core body temperature due to drop in environmental temperature
Receptor: Cold peripheral thermoreceptors
Modulator: Hypothalamus – send impulse to cerebrum. Hypothalamus stimulates sympathetic nerves
Effector: Skeletal muscles and skin arterioles
Response: Skeletal muscles tremor – shivering. Conscious decision to curl up or find warmth/fire. Skin arterioles constrict to reduce blood flow to the skin surface.
Feedback: Negative feedback, increase in core body temperature.

**13** People who live in cold climates don't seem to 'feel' the cold as much as visitors to the area. Explain why this happens.
*Answer:* The production of thyroxine is a long-term response to increase metabolic rate. It is effective in cold climates, people who live in cold climates will have elevated thyroxine levels in comparison to someone who lives in warmer climates. As such they will not feel the effects of cold as much as visitors.

# Chapter 5 Activities

## ACTIVITY 5.1 Investigating thermoregulation

**You should consider:**

**1** What characteristics can you measure to determine the effect of changing the temperature?
*Answer:* Skin colour (flushing or paleness), sweating or shivering, skin temperature. Other characteristics may be appropriate.

**2** What changes occur in core body temperature when the skin temperature is changed?
*Answer:* Students should find that when skin temperature changes, the core body temperature stays the same (due to the adjustments made by the hypothalamus to maintain homeostasis).

**3** What changes are evident at the surface of the body when the environment is very hot or very cold?
*Answer:* Students should be able to demonstrate that in very hot conditions the skin becomes red and sweat is secreted.
In very cold conditions the skin should become pale, or even bluish, and no sweat is secreted. Goosebumps may appear as the hairs on the arms and legs are raised in an attempt to trap an insulating layer of air above the surface of the skin.

**4** Do changes in environmental temperature affect breathing rate, heart rate or blood pressure?
*Answer:* Results will depend on how carefully students do the experiments. At the temperatures achievable in a school laboratory one would not expect any effect on breathing rate, heart rate or blood pressure.

**5** What factors were you able to control?
*Answer:* Students should provide a list of controls including diet of the subjects, method of taking temperature, limiting physical exercise, age of the subjects, body mass of the subjects.

**6** What conclusion can you make from your investigation?
*Answer:* Conclusion needs to relate to the aim of the investigation and state whether the hypothesis is supported or not.

### ACTIVITY 5.2 Investigating experiments conducted in a heated room

**1** Beef is mostly muscle tissue from a cow or a bull. Explain how the men's muscles were unharmed after 45 minutes in the hot chamber, while the muscle from the cow was cooked.
*Answer:* Humans have mechanisms, controlled by the hypothalamus, that maintain body temperature so that their muscles do not 'cook'. Skin vasodilation and sweating occur to keep the body temperature as close to normal as possible (approximately 37°C). Cows (and therefore beef) have no such mechanisms for maintaining its temperature.

**2** Would you expect to see any changes in the appearance of the men after they had been in the hot chamber? Explain your answer.
*Answer:* The men would look very red, due to the vasodilation of blood vessels in their skin, and they would be dripping with sweat.

**3** The men were in the hot chamber for 45 minutes. Do you think they would be able to survive for a much longer period? Explain.
*Answer:* It is unlikely that at such a high temperature the men would survive for much longer. There would be a limit to the amount of sweat they could produce, and limited air circulation would reduce evaporation.

**4** Do you think the men (and the dog) would have had anything to drink while in the chamber? Explain.
*Answer:* It is very likely that they would have had a drink, because the amount of sweat being secreted would have been very high, and the water lost would have to be replaced – otherwise their core temperature would have increased more rapidly.

**5** A sauna is a small room where people can experience heating in dry or humid conditions. The temperature in the room can vary from 60°C to 120°C. High humidity is used at lower temperatures, but at higher temperatures only dry heat is used. Explain why a high humidity sauna should not be set to a high temperature.
*Answer:* High humidity would decrease the effectiveness of sweating. Sweating is only effective if there is high evaporation because heat is removed from the skin when the liquid changes into a vapour. If humidity is high, there is too much water in the air for evaporation to be effective, and heat stroke could occur.

**6** Suggest some precautions that should be taken when using a sauna.
*Answer:* The environmental temperature inside the sauna should be monitored at all times. The humidity should be decreased if the person is sweating, but not being cooled. Minimal clothes should be worn, so that the maximum surface area of skin can be exposed to air for cooling. Water should be consumed.

## Chapter 5 Review questions

### Recall

**1 a** What is homeostasis?
*Answer:* Homeostasis is the maintenance of a constant environment inside the body.

**b** What aspects of the internal environment need to be regulated?
*Answer:* The following aspects of the internal environment need to be regulated:
• Internal body temperature
• pH of body fluids
• Concentration of substances dissolved in the body fluids
• Concentration of glucose in the blood
• Concentration of oxygen and carbon dioxide in the body fluids, including the blood
• Blood pressure
• Concentration of metabolic wastes in the body fluids.

**2** Define 'tolerance limits'.
*Answer:* Homeostasis aims to keep the internal environment constant, but variations do occur. Tolerance limits are the upper and lower limits for factors in the internal environment. Above or below these limits the body cannot function normally.

**3** Describe the role of the liver in regulating blood sugar concentration.
*Answer:* The liver is able to convert glucose to glycogen for storage, or glycogen to glucose for release into the blood. The liver stores glucose as glycogen, so the liver can either take up glucose from the blood or can add glucose to the blood according to the body's needs.

**4** Distinguish between glycogenesis, glycogenolysis and gluconeogenesis.
*Answer:*
• Glycogenesis is where glucose molecules are chemically combined in long chains to form glycogen molecules.
• Glycogenolysis is the process of converting glycogen to glucose.
• Gluconeogenesis is the production of glucose molecules from fats or amino acids.
See also Table 5.1 on page 111 of the student book.

**5** Which gland is involved in the secretion of insulin and glucagon? Identify the location of the gland.
*Answer:* The islets of Langerhans of the pancreas (pancreatic islets) secrete insulin and glucagon. These are small islands of tissue within the pancreas – a pale grey gland that lies partly in the curve of the duodenum.

**6** Describe the influence of the hormones of the adrenal glands on blood sugar concentration.
*Answer:* The hormones secreted by the adrenal cortex are glucocorticoids. These hormones ensure that enough energy is provided to the cells by stimulating the conversion of glycogen to glucose. They also increase the rate at which amino acids are removed from cells (mainly muscle cells) and are transported to the liver. Some of these amino acids may be converted to glucose by the liver if glycogen levels are low, a process called gluconeogenesis.
The adrenal medulla synthesises adrenaline and noradrenaline. These hormones prepare the body for increased physical activity. In particular, adrenaline brings about a rise in blood glucose levels and, in so doing, counteracts the effects of insulin. It stimulates breakdown of glycogen in the liver and the release into the blood of the glucose that is formed.

**7** Describe the ways in which the body can gain heat.
*Answer:* The body can gain heat by:
• shivering (skeletal muscle contraction produces heat)
• increased metabolic rate (a long-term response)
• absorption of heat radiation (for example, from a heater or the sun)
• conduction from hot surrounding air
• consumption of hot food or drink.

**8** What are the two types of thermoreceptors, and in what parts of the body are they located?
*Answer:* Thermoreceptors in the skin and in some mucous membranes are called peripheral thermoreceptors. Those located in the hypothalamus are called central thermoreceptors.
Some students may say (but in doing so, have not answered the question): There are two types of peripheral thermoreceptors. Cold receptors are stimulated by environmental temperatures lower than normal, and heat receptors detect temperatures higher than normal.

**9 a** What responses are likely to occur if core body temperature begins to fall?
*Answer:* If the core temperature falls, the following responses may occur:
• vasoconstriction in the skin
• reduction in sweating
• increase in cellular metabolism that leads to an increase in heat production (a long-term response)
• shivering
• increase in voluntary activity
• conscious behaviour, such as putting on a jumper or turning on a heater
• reducing surface area from which heat can be lost.

**b** What responses are likely to occur if core body temperature begins to rise?
*Answer:* If body temperature tends to rise, the following responses may occur:
• vasodilation of skin blood vessels to increase blood flow through the skin
• sweating
• a decrease in metabolic rate (in the longer term)
• behavioural responses such as turning on a fan or air conditioner, removing external clothing and reducing physical activity
• increasing surface area
• decreasing voluntary activity.

## Explain

**10** Explain what the following terms mean and their relevance to homeostasis:
**a** dynamic equilibrium
*Answer:* Dynamic equilibrium is the fluctuation of internal environmental factors around the normal level.

**b** set point.
*Answer:* The set point is the point around which internal environmental factors fluctuate.

**11** Why is the stimulus–response–feedback mechanism referred to as a model?
*Answer:* A model, in scientific terms, is a simple way of representing a complex idea. The stimulus-response-feedback model describes in a simple way how homeostasis is achieved.

**12 a** Using examples, explain the difference between positive and negative feedback.
*Answer:* When the response to a stimulus has the effect of reducing or eliminating the stimulus it is known as negative feedback. For example, if you feel thirsty you have a drink. Your response, drinking, reduces the original stimulus of thirst.
Positive feedback is where the response to a stimulus reinforces and intensifies the stimulus. The intensified stimulus results in an even greater response, and so the response keeps on getting greater and greater.
An example of positive feedback occurs during childbirth when contractions of the uterus push the baby's head against the mother's cervix. This stimulation of the cervix causes the uterus to contract more strongly and the baby's head is pushed even more forcibly against the cervix. Uterine contractions become even more intense and so the process continues.

**b** Why would a negative feedback loop be able to achieve homeostasis?
*Answer:* Homeostasis aims to achieve a steady state inside the body. Positive feedback continually intensifies a response, so that the response gets stronger and stronger. In such a situation, a steady state could not be achieved.

**13** After a meal, the blood glucose level often rises well beyond the normal level. Explain why this occurs.
*Answer:* After consuming a meal, especially one containing a high proportion of carbohydrates, the breakdown products of carbohydrate digestion, mainly glucose, are absorbed into the blood capillaries of the villi of the small intestine. Thus, blood glucose concentration following a meal may rise sharply until homeostatic mechanisms take effect and return blood glucose to normal levels.

**14** Explain how insulin and glucagon regulate the concentration of glucose in the blood.
*Answer:* When blood glucose levels rise, insulin is secreted from beta cells in the pancreatic islets. Insulin decreases blood sugar levels in the following ways:
• It speeds up the transport of glucose from the blood into the cells, especially those of the skeletal muscles.
• It accelerates the conversion of glucose into glycogen.
• It stimulates the conversion of glucose to fat which is stored in adipose tissue (fat storage tissue).
• It causes an increase in protein synthesis in some cells.
When blood glucose levels fall, glucagon is secreted from alpha cells in the pancreatic islets. Glucagon causes an increase in blood sugar levels by:
• stimulating the conversion of glycogen to glucose (glycogenolysis) in the liver. The glucose formed is then released into the blood
• stimulating the liver to produce new glucose molecules from fats and amino acids (gluconeogenesis).

**15** Explain why heat loss must equal heat gain.
*Answer:* A balance between heat gain and heat loss results in a relatively constant body temperature. If heat loss was more than heat gain, body temperature would fall; if heat loss was less than heat gain, body temperature would rise.

**16** The skin plays an important role in thermoregulation. Explain how it is able to achieve this function.
*Answer:* Skin contains both hot and cold thermoreceptors so is able to detect changes in external temperature quickly. Skin also provides a large surface area for heat loss via conduction, convection, evaporation and radiation. Arterioles are located close to the skin's surface, so when they vasodilate or vasoconstrict, that can impact of heat retention or heat loss rates.

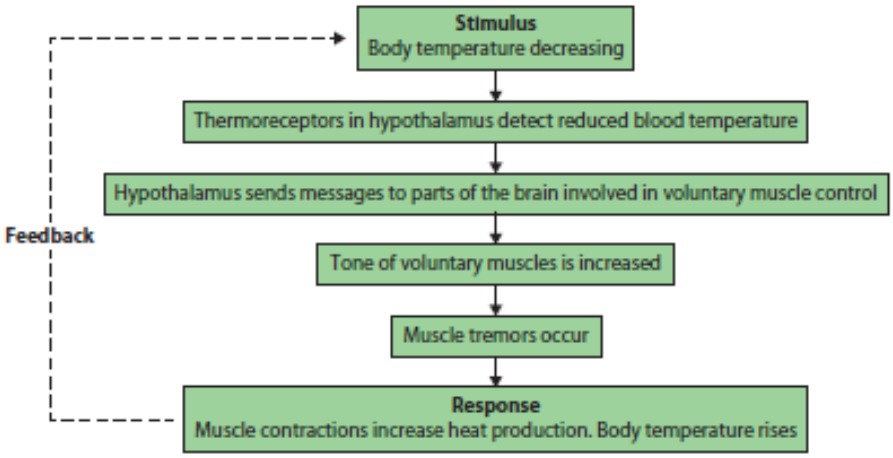
## Apply

**17** Apply the stimulus–response–feedback model to the response of the pancreas after a chocolate bar is eaten.
*Answer:*
• Stimulus = blood sugar levels rise above normal
• Receptors = chemical sensors in the beta cells of the Islets of Langerhans
• Modulator = beta cells of the Islets of Langerhans secrete insulin
• Effectors = liver, muscles
• Response = liver and muscles take up glucose from the blood and convert it into glycogen
• Feedback = the level of blood sugar decreases so that the beta cells are no longer stimulated and production of insulin is reduced.

**18** Compile a table that summarises the role of each of the following systems in regulating blood glucose level: nervous system, digestive system, endocrine system, circulatory system, muscular system, excretory system.
*Answer:*

| **System** | **Role in regulating blood glucose level** |
|---|---|
| Nervous system | Regulates food intake through control of appetite |
| Digestive system | Responsible for the breakdown of food, especially carbohydrates to glucose; absorbs glucose and supplies |
| Endocrine system | Alpha and beta cells in pancreas monitor glucose level in blood |
| Circulatory system | Transports glucose from digestive system to liver, and the rest of the body where glucose is taken up by cells for respiration or stored as glycogen. Transports the hormones involved in blood sugar regulation around the body |
| Muscular system | Cells use glucose to release energy; stores glucose as glycogen |
| Excretory system | Kidneys reabsorb filtered glucose to maintain levels. Excretion of hormone molecules |

**19** Draw a stimulus–response model to show the processes involved with shivering.
*Answer:*




Students may combine some of the above points.

**20** In very cold weather, it is our fingers and toes that often feel coldest.

**a** Why are fingers and toes affected by cold more than other parts of the body?

*Answer:* Fingers and toes have a higher surface area-to-volume ratio and therefore tend to lose heat more quickly than the torso and therefore feel colder. They are also more likely to be in contact with cold surfaces than other parts of the body are.

**b** The fingers and toes may appear white when very cold. Explain why.

*Answer:* Fingers and toes have a higher surface to volume ratio than other parts of the body and therefore tend to lose heat more rapidly. To reduce heat loss, vasoconstriction (to restrict blood flow through arterioles) occurs in fingers and toes. Heat loss is then minimised. Because there is little blood flowing through the skin of the fingers and toes, they appear white.

**21** Alcohol increases blood flow through the skin. If a person suggested 'a stiff drink' would warm them up, what would you advise them, and why?

*Answer:* Increasing blood flow through the skin will allow more heat to be transferred from the body to the environment by radiation and conduction. An alcoholic drink would not be useful if a person is feeling cold, because it will increase heat loss and make the person feel even colder.

**22** As a first aider at a sports carnival, it is important that you know the difference between heat stroke and heat exhaustion. Explain how you will distinguish between the two conditions.

*Answer:* Heat exhaustion symptoms include: heavy sweating, heat cramps, paleness, weak or dizzy, nausea or vomiting, fast, weak pulse, headache. Their body temperature remains normal, due to the heat loss through evaporation of sweat.

Heat stroke includes all of heat exhaustions symptoms plus worsening mental condition, slurred speech, poor coordination, seizures or losing consciousness. Sufferers of heat stroke have an elevated body temperature.

**23** A thermogram shows the temperature at the surface of an object or body. Examine the thermogram shown in Figure 5.17.

**a** What parts of the ballerina's skin are the hottest? The coolest?

*Answer:* The hottest parts are the head and neck, the shoulders and arms and the lower legs.

The coolest parts are the fingers, toes and soles of the feet.

**b** Explain the reasons for the differences in skin temperature that you have described in your answer to part **a** of this question.
*Answer:* The hottest parts are where muscles are actively contracting. Muscle contraction requires energy, which comes from cellular respiration and some of the energy released in respiration is in the form of heat. The coolest parts are where muscles are not contracting so actively and, where there is a large surface to volume ratio, which allows more heat loss.

## Extend

**24** People with type 1 diabetes are unable to produce insulin.
**a** Explain why patients have an increased blood glucose level.
*Answer:* Insulin acts to reduce blood glucose levels by increasing uptake of glucose into cells, promoting glycogenesis, promoting lipogenesis and promoting protein synthesis. If insulin is not being produced than glucose will not be used up or converted, as such a person will have high blood glucose levels.

**b** One symptom of type 1 diabetes is tiredness. Explain why this occurs.
*Answer:* As glucose is not being taken up into cells as effectively, less cellular respiration will occur, and a reduced level of ATP will be produced. As such a person will feel fatigued or tired.

**25** Vasoconstriction in the skin occurs when a person's body temperature is low, or when a person is very scared or very angry. (We say that someone is 'white with fear' or 'white with anger'.)
**a** Apply the feedback model to each of these responses. Do they both fit the model? Explain your answer.
*Answer:* Stimulus = decreased body (blood) temperature; receptor = thermoreceptors in hypothalamus; modulator = hypothalamus; effector = arterioles in skin; response = vasoconstriction in skin so that skin appears pale; feedback = increased body temperature
Stimulus = scary event; receptor = senses such as eyes (photoreceptors) and hearing; modulator = cerebral cortex; effector = arterioles in skin; response = vasoconstriction in skin and increased blood flow to vital organs; feedback = the person either confronts the threat or removes themselves from the threatening situation (fight or flight) and so the stimulus is decreased

**b** What is the advantage to a person of vasoconstriction in the skin:
**i** when their body temperature is tending to fall?
*Answer:* Vasoconstriction causes the skin to retain heat because with less warm blood flowing near the surface heat loss by radiation is reduced.
**ii** when they are scared or angry?
*Answer:* Vasoconstriction in the skin allows for blood to be redirected to the muscles and organs that will be needed for a fight-or-flight response.

**26** In the arms and legs there is exchange of heat between the arteries carrying blood to the limbs and the veins taking blood away from the limbs. This is called a countercurrent heat exchange. Find out how countercurrent heat exchange operates and describe its significance in maintaining core body temperature.
*Answer:* In the arms and legs the arteries run parallel to a set of deep veins. As warm blood passes down the arteries, the blood will give up some of its heat to the cooler blood returning from the extremities in these veins. This will ensure that the blood returning to the core is not significantly cooler. A drop in core body temperature will be detected by the central thermoreceptors in the hypothalamus, which will trigger other physiological responses including vasoconstriction in the skin and extremities and shivering.