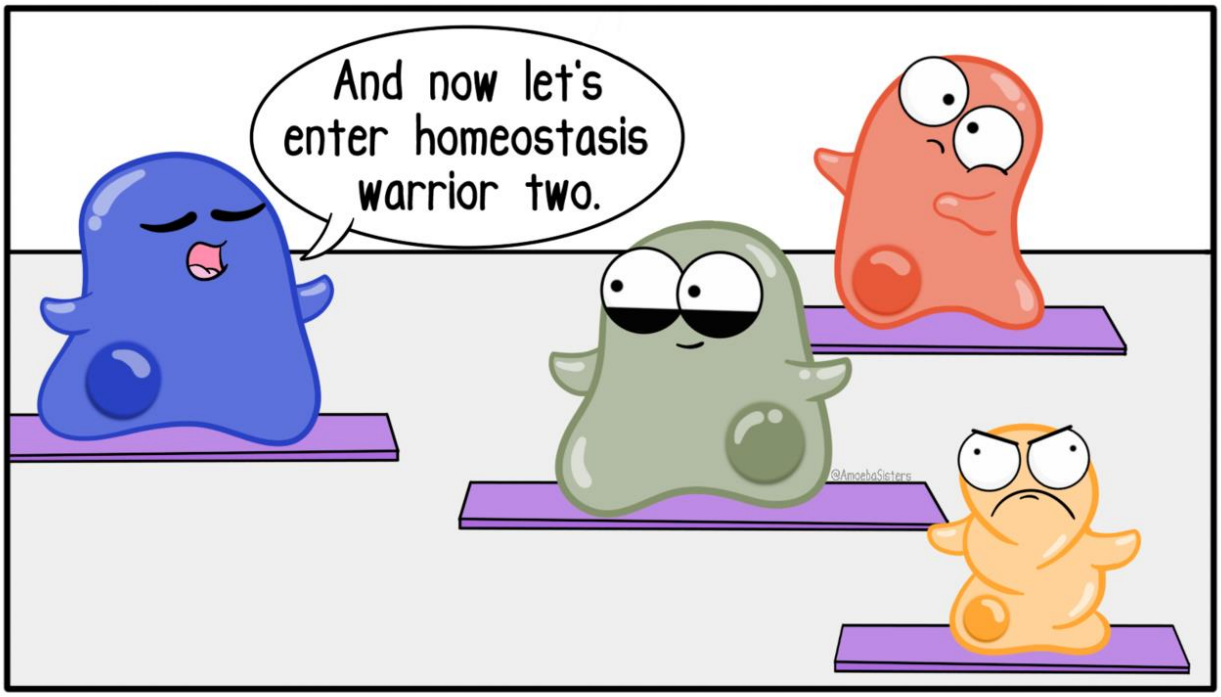
YEAR 12 HUMAN BIOLOGY
ATAR UNIT 3
2022

Homeostasis

Chapters 5 & 6



Cell membranes working hard to maintain homeostasis.

Pages	Due Date	Initialised
Temperature and Osmoregulation Science Inquiry:		
Homeostasis Test:		

ANSWERS

Syllabus Points

- homeostatic processes involve nerves and hormones in maintaining the body's internal environment within tolerance limits through the control of metabolism and physiological and behavioural activities (SU 3.11)
- thermoregulation occurs by the control of heat exchange and metabolic activity through physiological and behavioural mechanisms (SU 3.12)
- blood sugar levels are maintained by controlling of sugar uptake, its storage and release by cells and use in metabolism; these processes involve the hormones of the pancreas and adrenal glands (SU 3.13)
- body fluid concentrations are maintained by balancing water and salts via the skin, digestive system and the kidneys, which involve the actions of antidiuretic hormone and aldosterone on the nephron, and the thirst reflex (SU 3.14)
- gas concentrations are controlled by balancing the intake of oxygen and the removal of carbon dioxide via the lungs, through the actions of the medulla oblongata and the autonomic nervous system (SU 3.15)

Learning Objectives	☺	😐	☹
1. Define homeostasis			
2. Explain tolerance limits and steady state control			
3. Identify feedback loop components; stimulus, receptor, modulator, effector, response, feedback			
4. Distinguish between positive and negative feedback loops			
5. Explain the need to regulate the composition of body fluids			
6. Explain the relationship between cytoplasm, tissue fluid and plasma in terms of concentration of substances			
7. Describe the role of skin, digestive system and kidneys in osmoregulation			
8. Explain the effects of ADH and aldosterone on the activities of the nephron and construct feedback loops for both			
9. Describe the thirst reflex and construct feedback loop			
10. Distinguish between physiological and behavioural activitites / responses			
11. Define thermoregulation and explain the importance of maintaining a constant body temperature			
12. Describe the following methods of heat transfer and ways in which the body uses them to lose or gain heat - conduction, convection, radiation and evaporation			
13. Explain the following physiological mechanism of thermoregulation and construct negative feedback loops for each- TSH secretion, vasoconstriction/vasodilation, sweat production, shivering, adrenaline			
14. Explain the following behavioural mechanisms of thermoregulation and construct appropriate negative feedback loops			
15. Explain how the actions of the medulla oblongata and the ANS regulate gas exchange			
16. Describe the relationship between blood CO_2, Hydrogen ions and pH			
17. Describe how CO_2, Hydrogen ions and O_2 concentration are involved in the regulation of breathing rate and depth			
18. State that the nervous control of breathing (rate and depth) by the respiratory muscles is by the breathing centre in medulla oblongata			
19. Construct a negative feedback look for breathing			
20. Explain why it important to have consious control over breathing			
21. Describe the risk of hyperventilation			
22. Describe the role of the liver, skeletal muscle, pancreas and adrenal glands in glucose regulation			
23. Differentiate between • chemicals involved in blood sugar regulation (glucose, glycogen) • the processes of regulation (glycogenolysis, glycogenesis, gluconeogenesis, lipolysis) • the hormones controlling blood sugar levels (insulin, glucagon, cortisol, adrenaline/epinephrine) • alpha and beta cells in the Islets of Langerhans of the pancreas			

Learning Objectives:

Homeostatic processes involve nerves and hormones in maintaining the body's internal environment within tolerance limits through the control of metabolism and physiological and behavioural activities (SU 3.11)

- Define homeostasis
- Explain tolerance limits and steady state control
- Identify feedback loop components; stimulus, receptor, modulator, effector, response, feedback
- Distingusih between positive and negative feedback loops

Homeostasis (pages 105 - 108)

1. Define homeostasis and list the aspects of the internal environment that the body needs to regulate.

The maintenance of a relatively constant internal environment despite fluctuations in the external environment. Eg glucose, oxygen, temperature etc

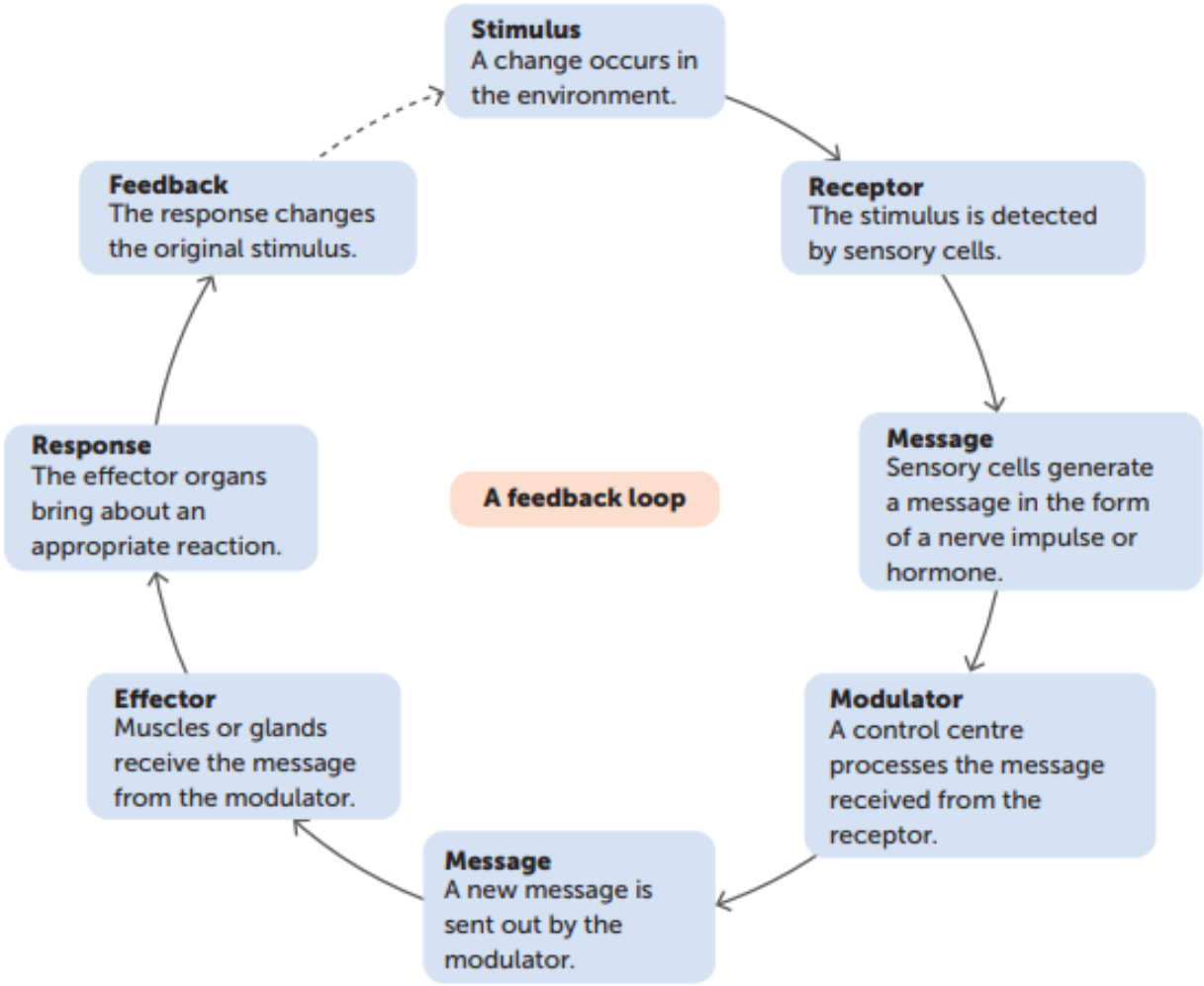
2. Define the following terms
   a. Feedback system

A Feedback system is a circular situation in which the body responds to a stimulus

   b. Negative feedback system

A feedback system in which the feedback is in the opposite direction to the stimulus.

3. Fill in the blanks below to define each component of a negative feedback system.



4. Why is the stimulus-response-feedback mechanism referred to as a model?

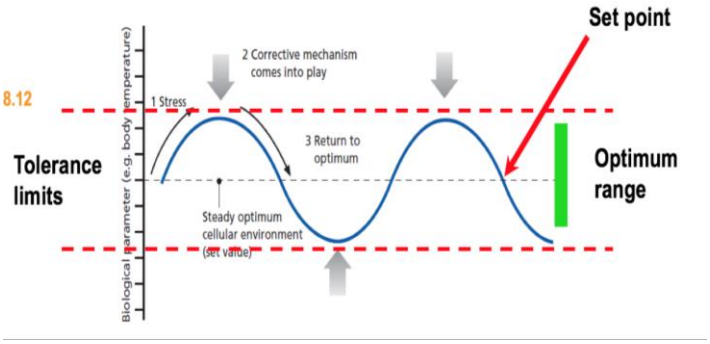
Models are a simplifies representation of something that is fairly complex. Stimulus-response-feedback-models (feedback loops) are a simplistic way of explaining how homeostasis mechanisms work

5. What is meant by the terms 'dynamic equilibrium', 'set point' and 'tolerance limits' and of what significance are these terms in homeostasis?

Set point: optimum level

Dynamic equilibrium: fluctuations above and below set point

Tolerance limit: The upper and lower limits to the a range of factors. Within these limits the body functions normally. Exceeding these limits, dysfunction will occur.



6. Describe steady state control.

Negative feedback.

7. Using examples, explain the difference between positive and negative feedback.

Positive: Does not maintain homeostasis. Intensifies or reinforces the initial stimulus. It controls process that must be completed quickly eg contractions during labour.

Negative feedback maintains homeostasis. Reduces or eliminated the stimulus

8. Why would a positive feedback loop be unable to achieve homeostasis?

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

9. Indicate whether the following are examples of positive or negative feedback.

Example	Positive	Negative
Drinking water when thirsty until your thirst is quenched		X
Calcium is released and stored in the bones according to the concentration in body fluids		X
Oxytocin is released when the baby's head reaches the cervix at a certain force and causes the uterus to contract further, releasing additional oxytocin	X	
After releasing the ovum, oestrogen is secreted to prevent any new eggs from maturing and being released	X	
In lactation more milk is produces the more the baby suckles	X	

10. State the name and location of the receptors for each of the factors listed below.

Factor	Receptor	Location(s)
Oxygen	Chemoreceptor	Aortic and carotid bodies and medulla oblongata
Carbon dioxide	Chemoreceptor	Aortic and carotid bodies and medulla oblongata
Body fluid concentration	Osmoreceptors	Hypothalamus
Glucose	Chemoreceptors	Islets of Langerhans (alpha and beta cells)
pH	Chemoreceptor	Aortic and carotid bodies
Temperature	Thermoreceptors	Hypothalamus and skin

11. What are the normal operating ranges for the following in the human body?
    a) Temperature 36.1-37.8°C
    b) Glucose 4.4-6.1mmol/L
    c) pH 7.35-7.45

Complete 5.2 Review question 1-6 on page 109 of your textbook.

Complete Chapter 5 Review Question 1, 2, 10 – 12 on page 127 of your textbook.

Learning Objectives:

Thermoregulation occurs by the control of heat exchange and metabolic activity through physiological and behavioural mechanisms (SU 3.12)

- Define thermoregulation and explain the importance of maintaining a constant body temperature
- Describe the following methods of heat transfer and ways in which the body uses them to lose or gain heat - conduction, convention, radiation and evaporation
- Explain the following physiological mechanism of thermoregulation and construct negative feedback loops for each- TSH secretion, vasoconstriction/vasodilation, sweat production, shivering, adrenaline
- Explain behavioural mechanisms of thermoregulation and construct appropriate negative feedback loops

Thermoregulation (pages 114 - 1)

1. Define thermoregulation.

Regulation of body temperature.

2. State the optimum internal body temperature. 36.8°C
3. Explain why a constant body temperature is important.

Too low: slowed rate of reactions (cellular respiration → ↓ energy production)

Too high: denature of enzymes (→ ↓rate of reactions)

4. Describe the following four mechanisms of heat loss / gain.

Method	Description
Conduction	direct contact with heat source eg swimming in pools or standing on hot ground particles collide passing energy from particles with higher energy to particles with lower energy until equilibrium is reached
Convection	Occurs when air or water passes over a body eg fan
Radiation	Indirect heating / cooling, no direct contact with source via infrared waves eg sun or a fire Heat moves from objects with high levels of heat energy to objects with low levels of heat energy
Evaporation	Conversion of water from liquid to gas of the surface of skin. Energy required for water molecule to change from liquid to gas

5. Compare peripheral and central thermoreceptors.

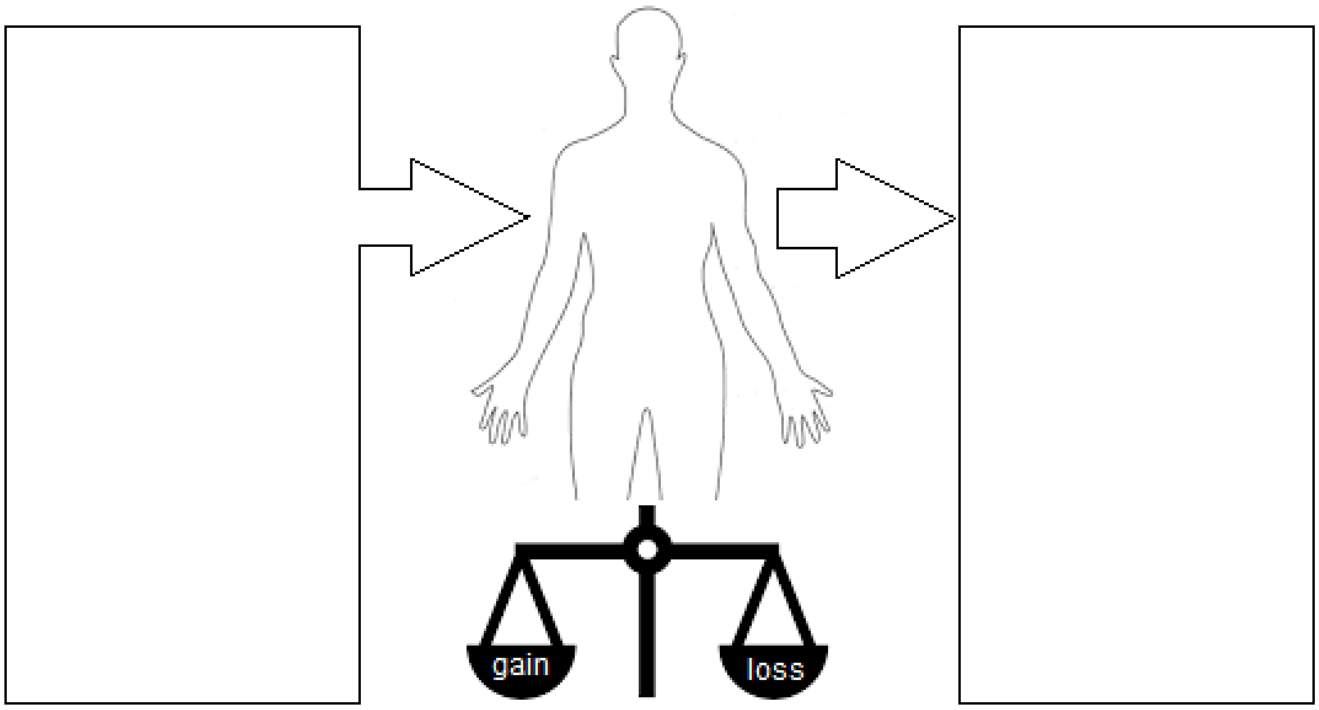
	Central	Peripheral
Location	Hypothalamus	Skin
Detects	Hot and cold stimuli	Hot OR cold stimuli
Stimuli	Detects internal temperature (blood)	detects external temperature

Both detects temperature

6. Explain the role of the hypothalamus in thermoregulation.

_____
_____
_____
_____

7. List the ways the human body gains and loses heat in the diagram below.



8. Define the following terms.

Term	Definition
Metabolism	
Basal Metabolic Rate	

9. Write the word equation for cellular respiration in the space below.

Preventing body temperature from falling

If the cold receptors in the skin detect a drop in environmental temperature and a message is sent to the hypothalamus, the hypothalamus sends out impulses aimed at reducing heat loss and increasing heat gain.

In the table below, describe how the following mechanisms **prevent heat loss** from the body and identify if they are either physiological or behavioral responses.

Decrease heat loss		
Change	**Description**	**Physiological or Behavioural**
Vasoconstriction	Blood vessels carry heat to the skin from the core of the body Impulses from the hypothalamus stimulate nerves from the ANS that cause blood vessels in the skin to constrict reducing their diameter & decreasing the flow of warm blood to the skin from the internal organs The skin becomes cooler therefore less heat will be lost from the body surface by convection and radiation	P
Shelter	Insulates the body by trapping a layer of warm air and thus slowing the rate of heat loss by radiation, conduction and convection	B
Clothing	Reduces wind and therefore decreases the rate of evaporation and heat loss. May be a warmer environment that decreases temp. gradient and therefore rate of heat loss	B
Reduce surface area	Curl up so as reduce surface area and therefore less area over which to lose heat via radiation	P

In the table below, describe how the following mechanisms **increase heat production** from the body and identify if they are either physiological or behavioral responses.

Increase heat production		
Change	**Description**	**Physiological or Behavioural**
Shivering	The increase in skeletal muscle tone resulting in oscillating, rhythmic muscle tremors. Produces heat via increasing metabolic activity Under the primary control of the hypothalamus, but conscious input from cerebral cortex can suppress	P
Stimulation of adrenal medulla	Sympathetic nerves stimulate the adrenal medulla to secrete adrenaline and noradrenaline which brings about an increase in cellular metabolism that leads to an increase in heat production. Occurs when there is rapid heat loss.	P
Increase in voluntary activity	Muscle tremors that lead to an increase rate of respiration and therefore heat production	B
Increase thyroxine (long-term response)	Hypothalamus produces TSHrf which stimulates anterior lobe of pituitary to release TSH which causes thyroid gland to secrete thyroxine. Thyroxine increases M.R. which increases heat production and therefore body temperature. Response is slow but long lasting.	P

Preventing body temperature from rising

When the outside temperature is warm, or when we exercise, the heat produced by metabolism is greater than that needed to maintain a constant body. To prevent core temperature rising, excess heat needs to be lost. Most heat loss occurs through the skin with smaller amounts of heat loss through exhalation, urine and faeces.

In the table below, describe how the following mechanisms **increase heat loss** from the body and identify if they are either physiological or behavioral responses.

Increase heat loss		
Change	**Description**	**Physiological or Behavioural**
Vasodilation	Blood vessels carry heat to the skin from the core of the body Impulses from the hypothalamus stimulate nerves from the ANS that cause blood vessels in the skin to dilate increasing their diameter & increasing the flow of warm blood to the skin from the internal organs. More heat will be lost from the body surface via convection and radiation	P
Seeking shade / fan	Fan on – increase heat loss via convection Shelter – lower temp therefore higher temp gradient and higher rate of heat loss / less heat gain via radiation	B
Clothing	Less insulation therefore higher rate of heat loss by convection and radiation	B
Sweating	Increase heat loss from the body as energy is required for the sweat to evaporate (liquid to gas). Heat energy from the body is used thus having a cooling effect. Not effective in high humidity	P

In the table below, describe how the following mechanisms **prevent heat production** from the body and identify if they are either physiological or behavioral responses.

Decrease heat production		
Change	**Description**	**Physiological or Behavioural**
Decrease physical activity	Decreased cellular respiration and then less energy produces as a byproduct	B
Decrease thyroxine (long term response)	Hypothalamus produces TSHif which inhibits anterior lobe of pituitary to release TSH. Decrease TSH leads to thyroid gland reducing secretion of thyroxine. Thyroxine decreases M.R. which decreases heat production and therefore body temperature. Response is slow but long lasting.	P

Activity: Temperature Control

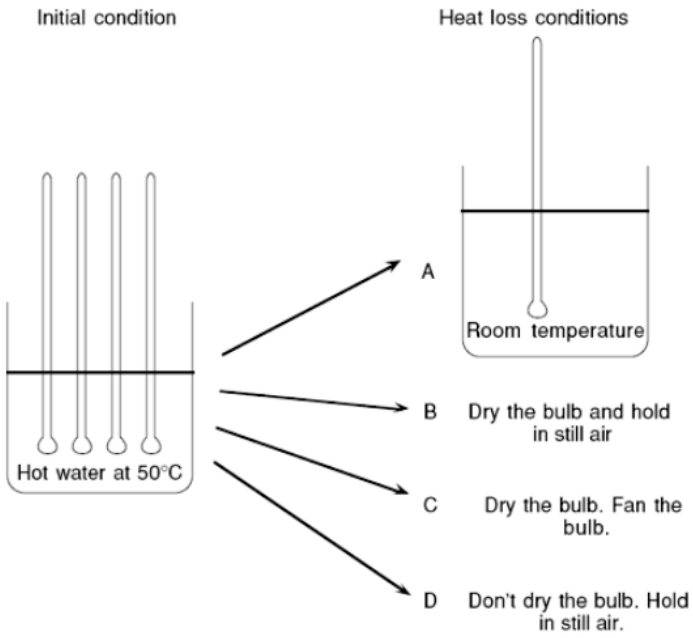
Purposes: to measure heat loss in different solutions and to explore factors affecting heat loss

Materials

- 4 thermometers
- Boiling water
- Timer
- Cotton wool
- 2 x 600ml beakers
- Card for fanning

Procedure

1. Join a team of 4 students. Make one member of the team responsible for each condition and if a fifth member is available, they will be the timekeeper.
2. Fill one beaker with hot water at about 50°C
3. Put the four thermometers into the hot water until their temperature's readings become steady (they may not all read the same temp)
4. When the timekeeper says "Go"



Experimenter A: transfer the thermometer quickly to the beaker of water at room temperature

Experimenter B: take the thermometer out and quickly wipe the bulb dry with cotton wool. Hold the thermometer by the end opposite the bulb in air without moving it

Experimenter C: take the thermometer out and quickly wipe the bulb dry with a piece of cotton wool. Hold the thermometer and fan it in the air with the piece of card

Experimenter D: take the thermometer out. Do not dry the bulb. Hold the thermometer by the end opposite the bulb in the air without moving it.

5. When the timekeeper says "time" at exactly one minute, read and record the temperature for each.

Treatment	Initial Temperature (°C)	Final temperature (°C)	Change in temp (°C)
Experiment A (room temp water)			
Experiment B (dry in still air)			
Experiment C (dry in moving air)			
Experiment D (wet in still air)			

Treatment	Change in temperature (°C)					
	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Experiment A (room temp water)						
Experiment B (dry in still air)						
Experiment C (dry in moving air)						
Experiment D (wet in still air)						

Discussion

1. Did all the thermometers produce the same temperature reading when placed in the hot water? Explain your answer. Will this affect the outcome of the investigation?

Small differences corrected for by finding the difference in temperature rather than using the final temperature value. A % difference could also have been used.

2. Was the temperature of the hot water the same for each trial? Will this affect the investigation?

No, the hot water is constantly losing heat energy to the environment via radiation. This should not affect the investigation as the difference in temperature is calculated.

3. Which thermometer (A, B, C or D) showed the greatest temperature drop after one minute? What heat loss process was responsible for this change?

A – conduction

4. Compare the wet and dry bulbs in still air. Outline the causes of any difference.

Both bulb underwent heat loss via radiation. The wet bulb also underwent heat loss via evaporation. The wet bulb results show a greater temperature difference than the dry bulb in still air.

5. What heat loss process would be affected if the wet bulb was placed in moving air? What effect would it have on the magnitude of the heat loss?

Convection – resulting in a great rate of heat loss.

6. Explain at the molecular level:
   a. how evaporation removes heat from a surface.

Water particles need energy to overcome forces of attraction to become a gas. The energy is taken from the thermometer. Therefore the thermometer loses heat energy.

   b. how heat is transferred between skin and a solid surface

hotter particles have more kinetic energy passed to cooler objects as there are more collisions between particles and therefore heat transfer from particles with more heat energy to particles with less heat energy until equilibrium is reached.

   c. how heat is gained by radiation

Electromagnetic radiation in the infrared section of the spectrum travels in a vacuum. Radiant heat transfers from objects with more heat energy to objects with less heat energy.

7. On a hot day student come into the science lab and turn the ceiling fans on high.
   a. Explain why this makes students feel cool.

Increase heat loss via convection.

   b. After a few minutes the students are not getting the same cooling effect from the fan. Why is this?

Heat has been lost from the person and their temperature s now closer to that of the room (particles of air) Therefore rate of heat loss has slowed.

c. When the fan is on a lower setting, students feel the cooling effect of the fan for a longer period of time. Why is this?

There would be the same amount of heat loss but the rate of heat loss is slower, thus prolonging the cooling effect.

8. On hot days, people with loose, long hair complain of being hotter than those with short hair or long hair tied up. Explain why this happens.

Hair does not conduct hear well and is therefore an insulator. Hair reduce heat loss via radiation. Hair also traps air therefore reducing heat loss convection. Hair also prevents sweat evaporating from the neck, therefore preventing heat loff via evaporation.

9. When people are cold, they tend to sit with their arms close by their sides and legs close together. How would this affect heat loss from the body?

This will decrease surface area therefore reducing heat loss via radiation.

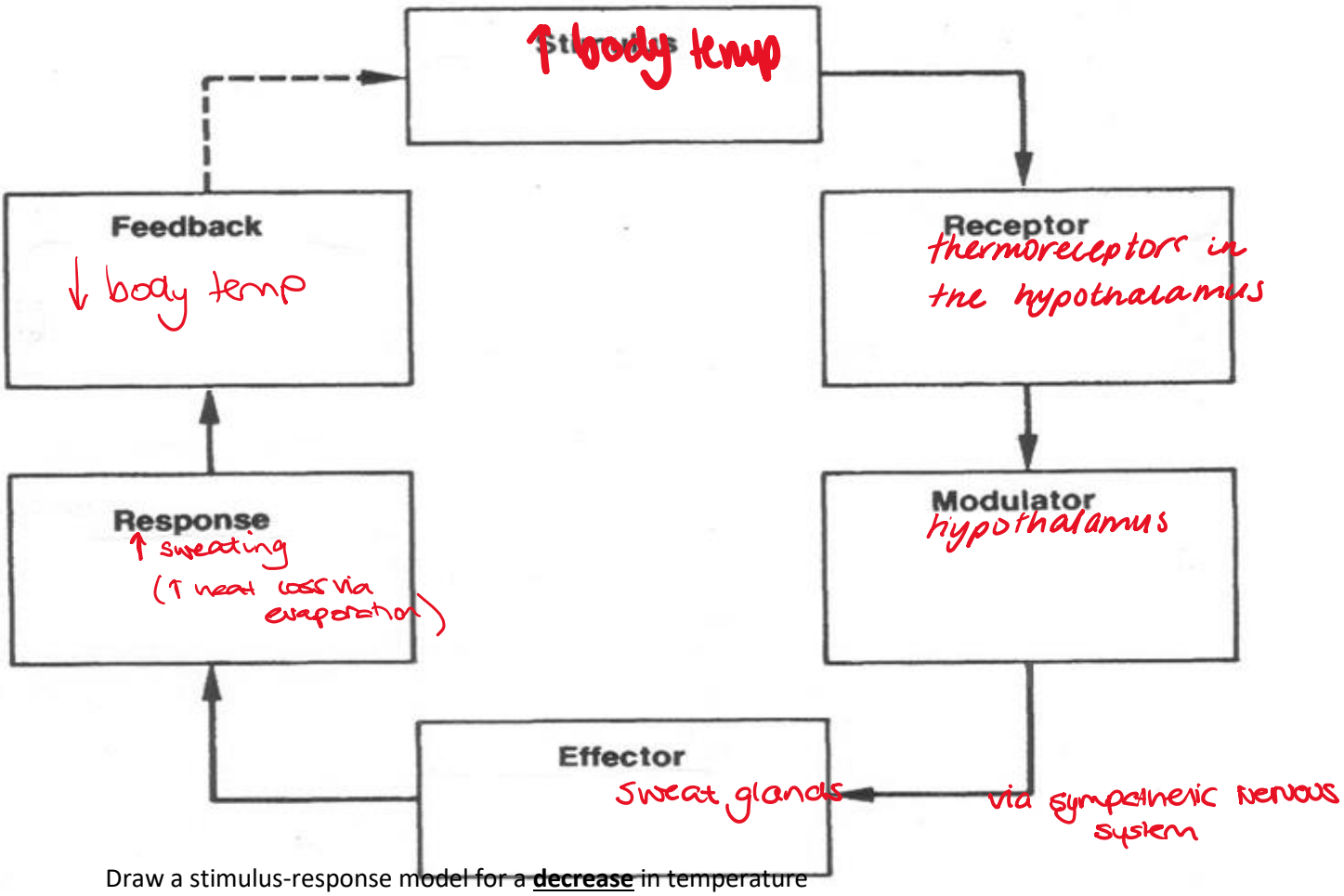
10. When a person has a blood nose, ice packs are often placed on the forehead and the back of the neck. The result is that blood flow is reduced quickly, allowing clotting to occur. How does applying ice packs to the forehead and back of the neck change the blood flow to the nose.

Cooler blood temperatures result in blood going to brain being cooler. This causes vasoconstriction. thermoreceptors in the skin → autonomic nerves to blood vessels (smooth muscle) →vasoconstriction of arterioles at skin surface. Decreased diameter of arterioles results in less blood flow.
Back of the neck: cools blood going to the hypothalamus cuasing the respnse of vasoconstriction of arterior to the skin

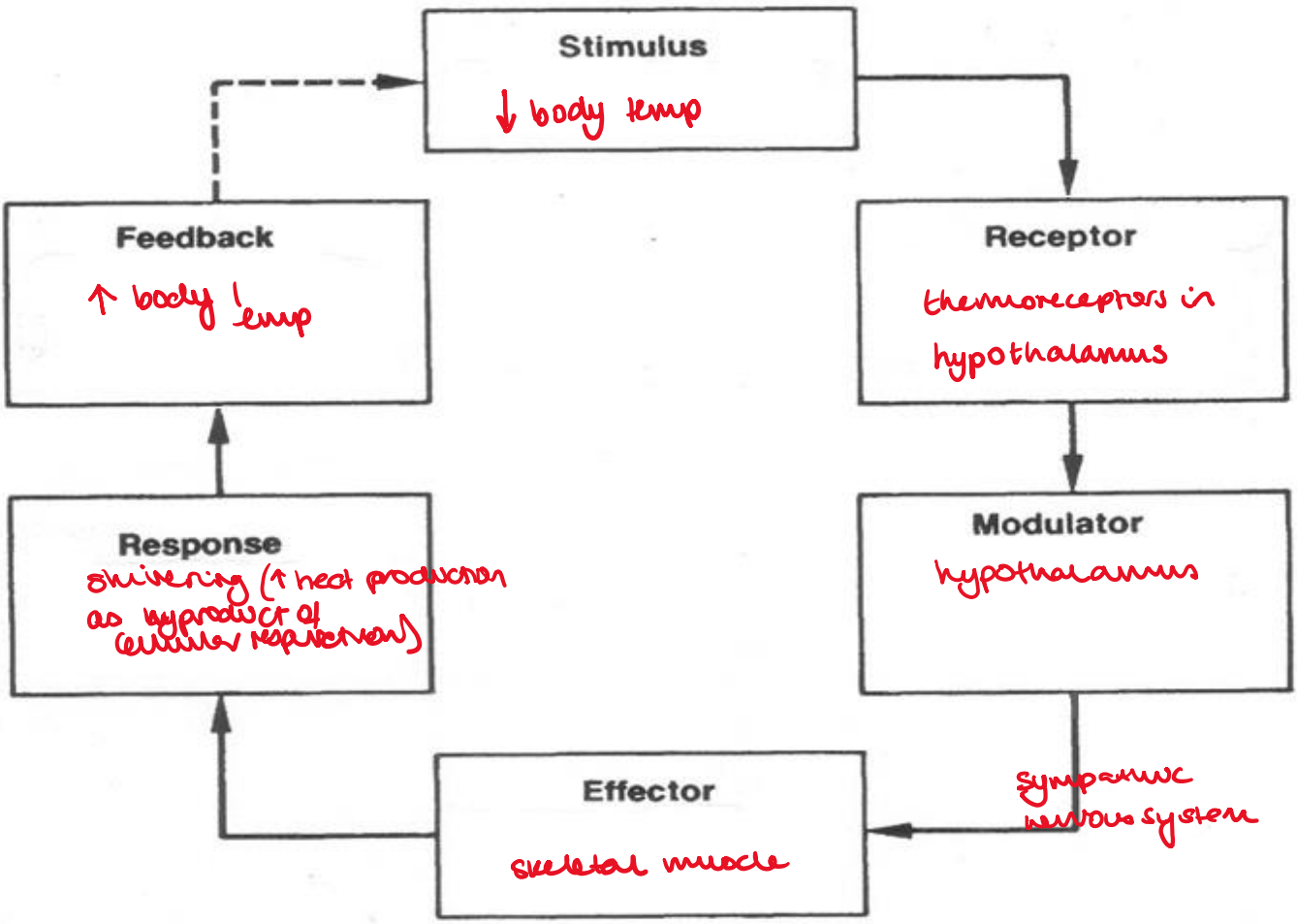
Forhead: local vasocnstriction of arteriole to the nose

Both results in less blood flow an allows for clotting

Draw a stimulus-response model for an **increase** in temperature

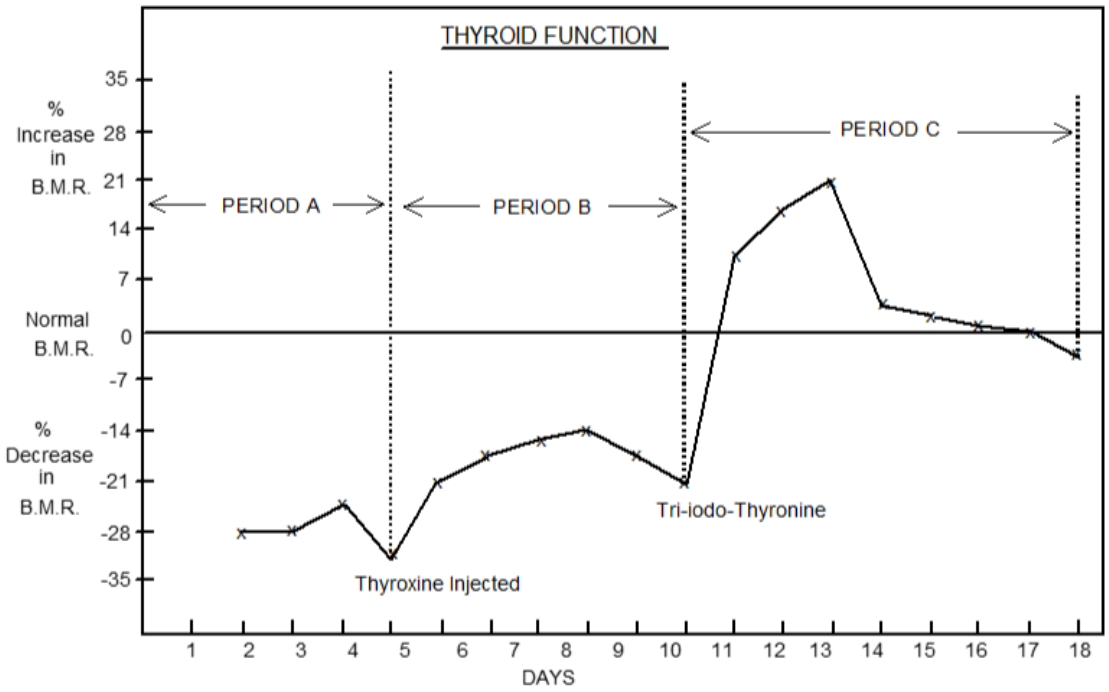


Draw a stimulus-response model for a **decrease** in temperature



Practice Questions

1. The fundamental function of thyroxine is to maintain body temperature at 37°C to provide for essential body processes. The basal metabolic rate (BMR) is the amount of energy expended when a person is in a steady state of rest. It represents the energy needed to maintain a constant body temperature. The following graph shows the BMR of an adult whose thyroid gland in not working.



a) How much less than normal is this persons BMR?

28%

a) What symptoms would you expect the patient to display?

Low energy / fatigue, weight gain, unable to stay warm, goitre

b) What was the effect on BMR of the injection of thyroxine at the beginning of period B?

Slight increase in in BMR ~14%

c) What was the effect on BMR of the injection of tri-ido-thyroxine at the beginning of period C?

There was a substantial increase in BMR ~40%

d) What symptoms would a person with hyperthyroidism display?

Low body weight, high energy, high body temp / sweating

e) Discuss how thyroid gland secretions are controlled.

- There must be a stimulus: low metabolic rate / low body temperature
- This stimulus is detected by central thermoreceptors in hypothalamus
- hypothalamus secretes TSH- releasing factor which travels through the hypophyseal portal system to the anterior pituitary where it stimulates the secretion of TSH (thyroid-stimulating hormone)
- TSH secreted into blood which travels to thyroid which stimulates the production and secretion of thyroxine into the blood

1. Summaries how the body can conserve and increase heat production when body temperature is falling and rising by completing the tables blow.

Core Temp. <37°C	Heat Conservation	Behavioural	Decrease surface area of body (curl up)
		Physiological	Vasoconstriction of arteriole to skin leading to more blood being in core circulation
	Increased heat Production	Behavioural	Putting on additional clothing
		Physiological	Shivering and increase thyroxine [long term]. Both of which increase metabolic rate and heat production as a byproduct

Core Temp. >37°C	Heat Loss	Behavioural	decrease surface area (spreading out), taking off additional clothing
		Physiological	Sweating and vasodilation of arteriole to the skin
	Decreased heat Production	Behavioural	Less physical activity
		Physiological	Decrease thyroxine (decrease metabolic rate) [long term]

2. How will change in temperature affect the rates of reactions in cells?

Increase temperature = increase reaction rate
Decrease temperature = decrease reaction rate

3. There have been several cases of people surviving for long periods of time submerges in cold water. Early 2009 in England (during winter), a two year old girl made a complete recovery after spending 20 minutes at the bottom of a pool. In 2008, a 35 year old man was found floating in the cold water off Cape Town. It was thought he had been without a pulse for about an hour. Explain how low body temperature could allow these people to survive, when at normal body temperature they would die.

Decreased body temperature slows rates of reactions therefore decreases metabolic rate, leading to a reduction in oxygen consumption and a reduced accumulation of toxic waste. Therefore less energy is required to maintain metabolism

4. In the USA, on average 38 people, mainly infants, have died each year over the last 8 years from being left in a hot vehicle. Children thermoregulatory systems are not as efficient as adults and their body temperatures warm 3-5 times faster than adults. Use this information to describe why it is dangerous to leave young children in a vehicle on a mild day, especially a dark coloured car.

Children have a large surface area to volume ration and therefore have a greater rate of heat gain in warm environments. Dark coloured cars absorb heat at a greater rate than light coloured cars. So internal temperature rapidly increases.

2. Complete 5.3 Review Questions 1-13 on page 122 of your textbook.

Complete Chapter 5 Review Questions 7-9, 15, 16, 19 – 21 and 23 on page 127 of your textbook.

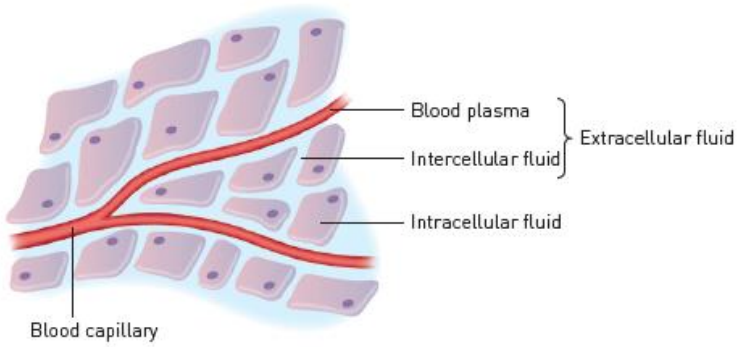
Learning Objectives:

Homeostatic processes involve nerves and hormones in maintaining the body's internal environment within tolerance limits through the control of metabolism and physiological and behavioural activities (SU 3.11)

- Explain the need to regulate the composition of body fluids
- Explain the relationship between cytoplasm, tissue fluid and plasma in terms of concentration of substances
- Describe the role of skin, digestive system and kidneys in osmoregulation
- Explain the effects of ADH and aldosterone on the activities of the nephron and construct feedback loops
- Describe the thirst reflex and construct feedback loop

Osmoregulation (pages 130 – 137)

1. Label the diagram below.



2. Distinguish between intercellular and extracellular fluid and explain the relationship between cytosol, tissue fluid and plasma in terms of concentration of substances.

Type of body fluid	Proportion of total body fluid	Components of the body fluid
Intracellular fluid	2/3 of total body water	Fluid inside the cell – the cytosol
Extracellular fluid	1/3 of total body water	Fluid that is outside the cells
Plasma	1/4 of extracellular fluid	The fluid part of the blood
Intercellular fluid	3/4 of extracellular fluid	Lymph, cerebrospinal fluid, synovial fluid in joints, fluids of eyes and ears, fluid in the chest and abdominal cavities and around the heart, fluids of the alimentary canal, kidney filtrate

3. Define metabolic water.

Water produced via cellular respiration

4. Explain the need to regulate the composition of body fluids.

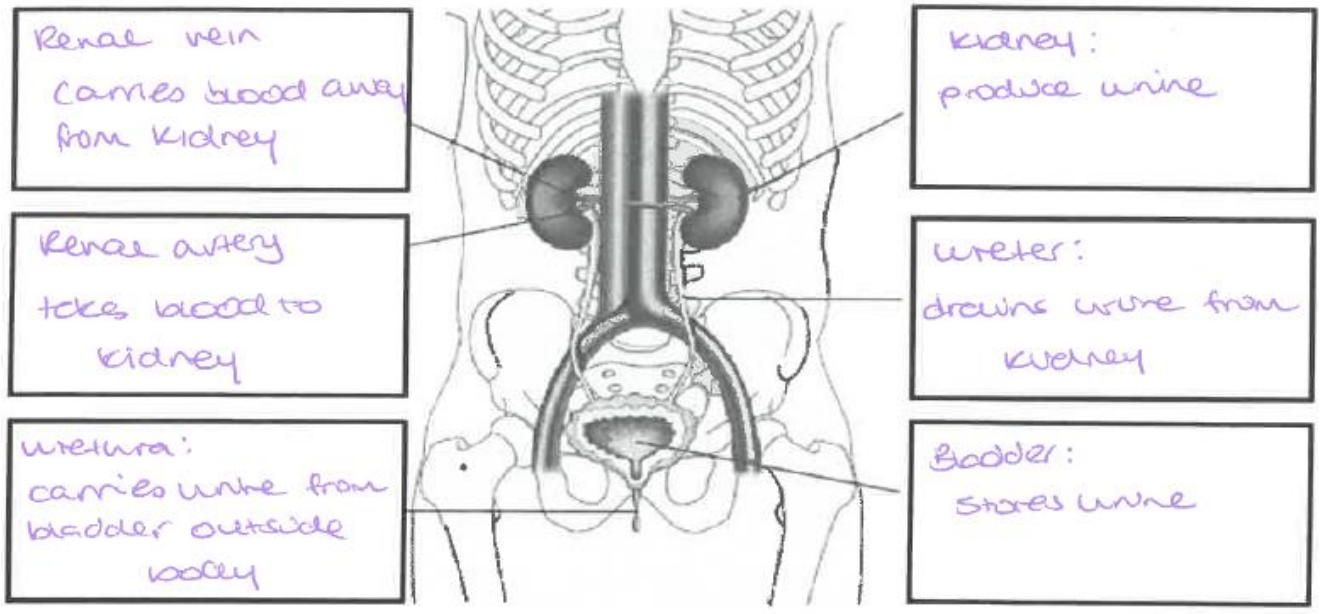
High osmotic pressure means that there is low water in blood plasma, therefore water moves from intercellular fluid into the blood. Now intercellular fluid is more concentrated, so water begins to move out of cells leading them to shrink

5. Define the term osmolarity.

The concentration of solute relative to solvent within a solution
High osmotic pressure = high solute relative to solvent
Low osmotic pressure = low solute relative to solvent

6. Explain why the kidneys is the only organ in which water loss can be regulated.

Excretion from lungs, sweat and alimentary canal are all passive. Kidneys are controlled via hormones to alter active transport of water into filtrate and thus urine

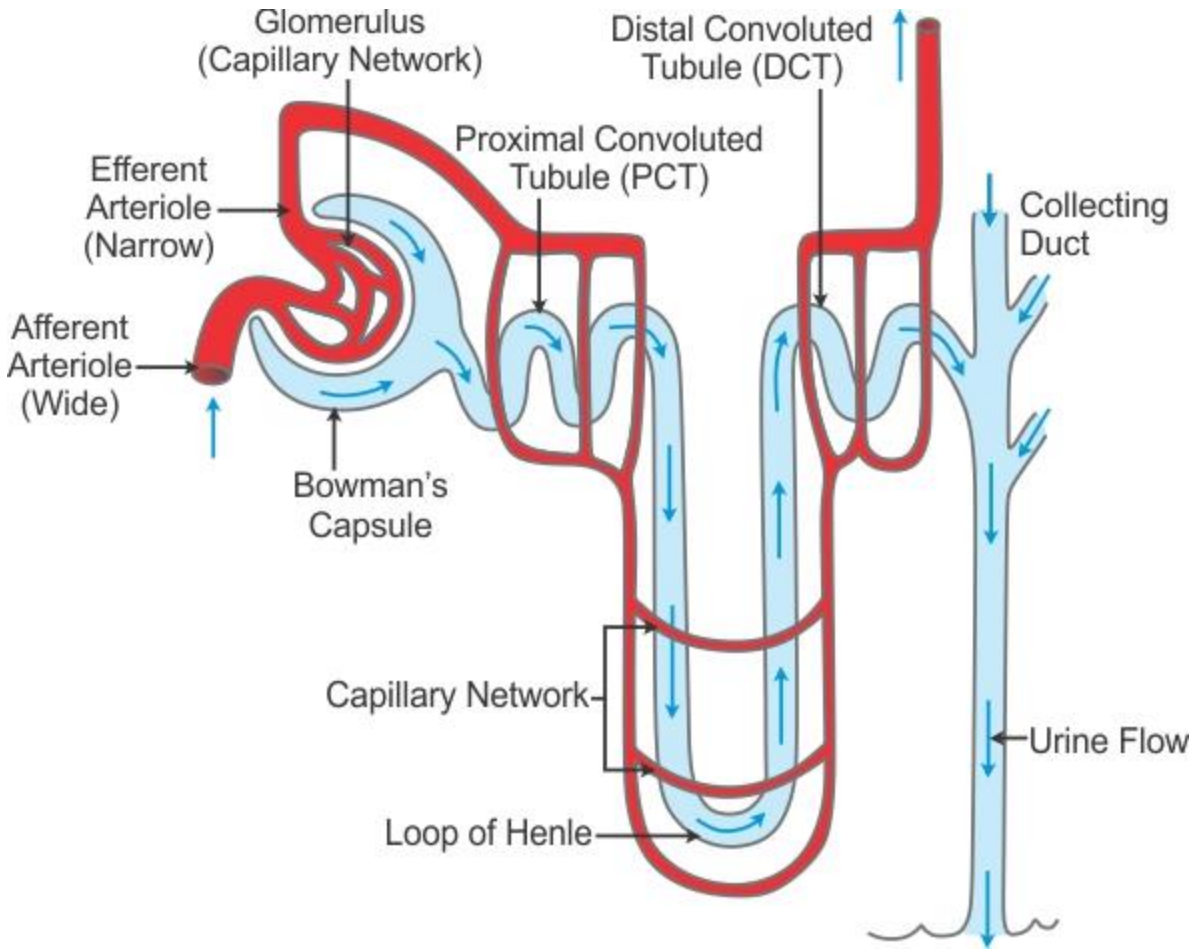


7. In the image below, identify each structure and describe it structure / function.
8. Describe the function of the nephron.

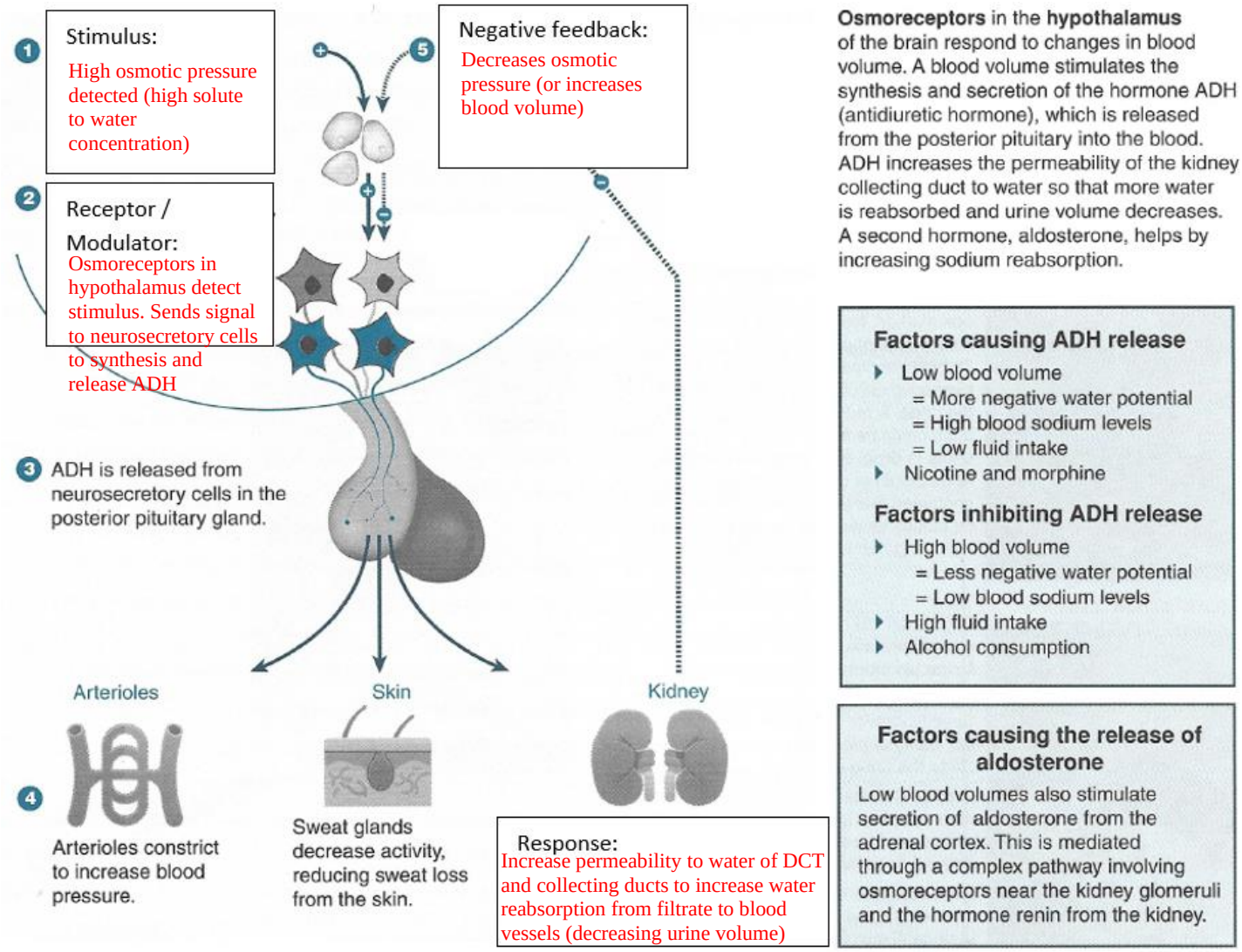
Each kidney contains 1.2 million nephrons (the functional unit of the kidney). Here water regulation occurs and excretion of waste occurs

9. Label the following structures on the diagram below:

afferent arteriole *glomerular capsule* *proximal convoluted tubules* *distal convoluted tubules*
efferent arterioles *loop of Henle* *glomerulus* *collecting duct* *peritubular capillaries*



10. Recall the three processes of urine formation; filtration, reabsorption and secretion.
    1. Filtration: occurs in the renal corpuscle (glomerulus and Bowmans capsule). High pressure forces water and dissolved substances our of the vessels and into the nephron
    2. Selective reabsorption: 180L of filtrate is produced every day, 99% of which is reabsorbed. Occurs in PCT, Loh, DCT and collecting ducts. Movement from nephron back into capillaries
    3. Secretion: occurs in PCT and DCT. Certain wastes, neurotransmitters are left behind in capillaries. They are actively transported into filtrate to be removed



ADH

1. Discuss in detail the effect of ADH on fluid balance.

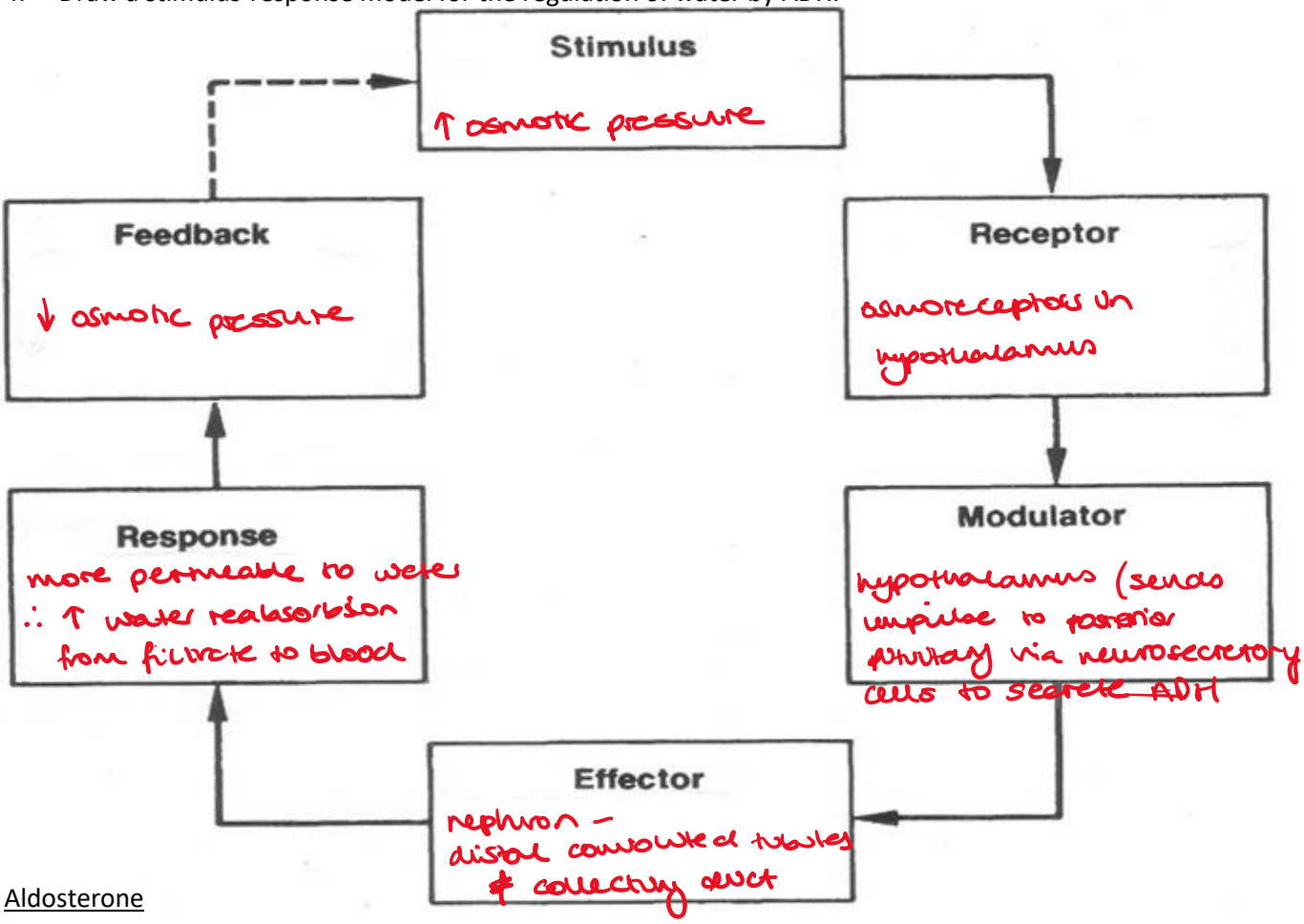
Antidiuretic hormone (ADH) is produced in the hypothalamus and released from the posterior pituitary. Osmoreceptors in the hypothalamus are stimulated by high osmotic pressure. Hypothalamus stimulates posterior pituitary to secrete ADH. ADH acts on the walls of the DCT and collecting duct, making them more permeable to water, therefore increasing the amount of water reabsorbed from filtrate into the blood

2. Fill in the boxes in the diagram above to illustrate the release of ADH.

3. Describe how the posterior pituitary is influenced by the hypothalamus to release ADH.

High blood osmolarity is detected by osmoreceptors in the hypothalamus. The hypothalamus sends an impulse along the neurosecretory cells to the posterior pituitary to secrete ADH into the blood. Note: posterior pituitary did not produce ADH, it was produced by the hypothalamus and travels down to the PP along neurosecretory cells where it was stored.

4. Draw a stimulus-response model for the regulation of water by ADH.



Aldosterone

1. Discuss the part played by aldosterone in the regulation of water output.

Aldosterone is produced and secreted by the adrenal cortex in response to low blood pressure, low sodium ions, or nigh potassium ion concentration in the blood Aldosterone acts on the DCT and collecting duct to increase the amount of sodium ions reabsorbed from the filtrate into the capillaries. Water follows sodium (thus increasing water reabsorption) and increasing blood pressure

2. Aldosterone regulates the amount of sodium in the blood. Explain why:

(a) aldosterone influences the amount of water excreted from the body.

Aldosterone acts on the DCT to reabsorb sodium ions into the bloodstream. More sodium ions in the bloodstream will increase the osmotic pressure of the blood, therefore water molecules will diffuse into the blood from the nephron by osmosis.

(a) aldosterone affects blood pressure.

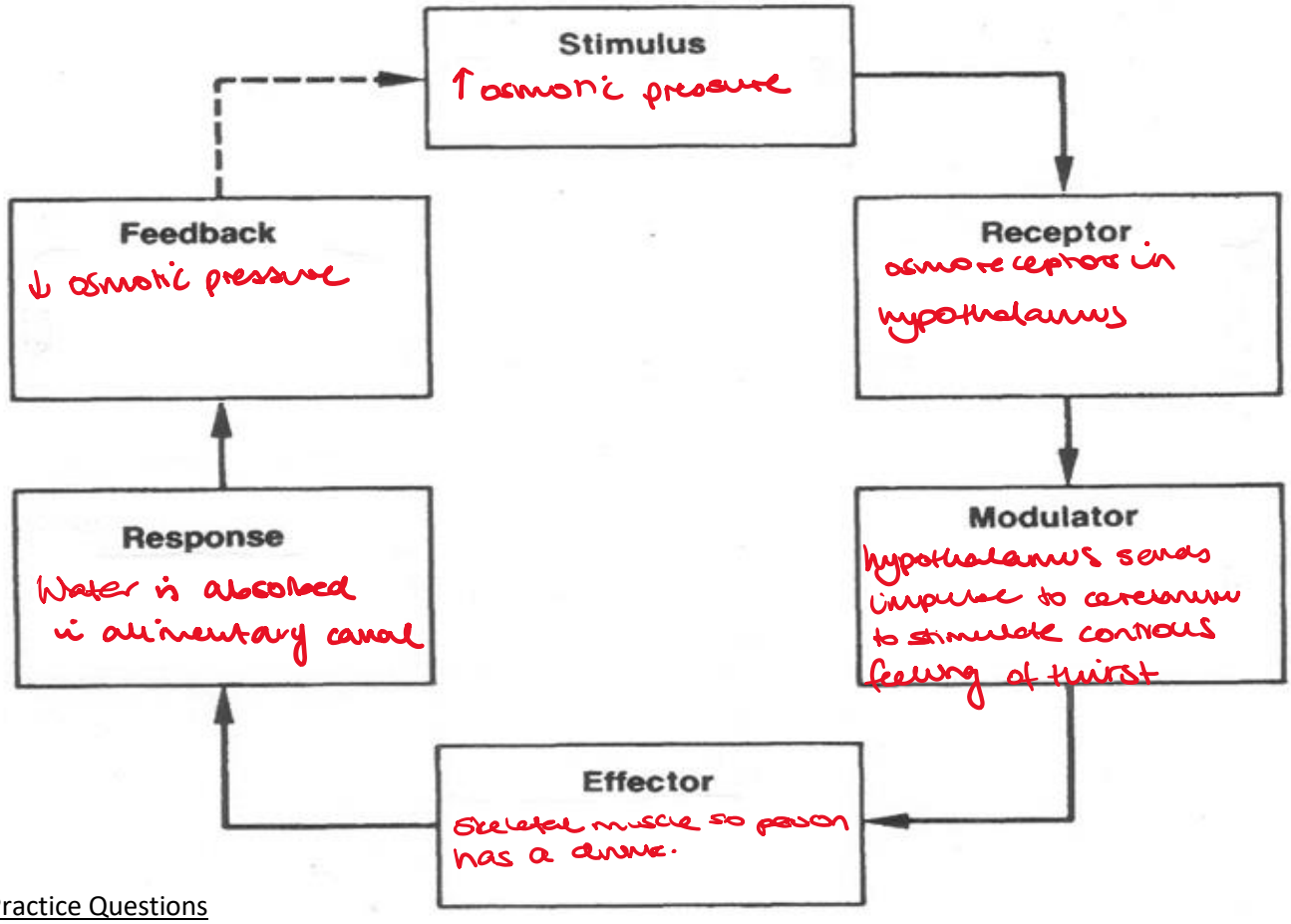
An increase in sodium in the bloodstream will increase the blood pressure, as the osmotic pressure of the blood increases and therefore by osmosis, more water enters. This will increase the blood volume in blood vessels, thus increasing blood pressure.

Thirst

1. Describe the events that bring about the intake of water (thirst reflex).

Osmoreceptors in the hypothalamus detect the change in osmotic concentration which stimulus the thirst centre in hypothalamus . The conscious feeling of thirst stimulates a person to drink. Fluid absorbed form alimentary canal into blood, decreasing osmotic pressure

2. Draw a stimulus-response model for the regulation of water intake by the thirst mechanism.



Practice Questions

1. Explain why excretion is closely related to maintaining fluid balance.

If blood water volume is too high, a higher volume of water is excreted via the nephrons (increase volume of urine). This will remove excess water from the bloodstream and maintain fluid balance.

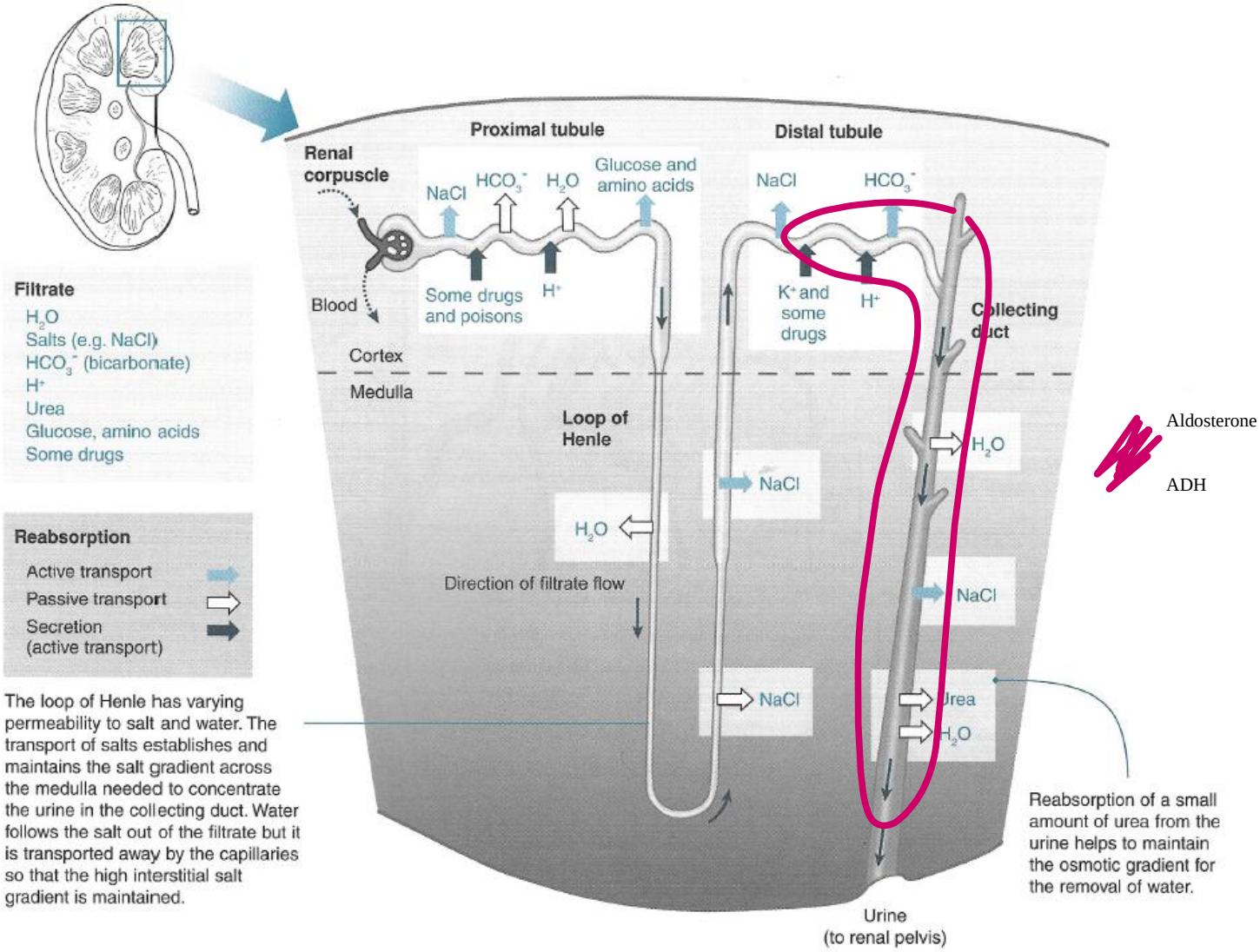
2. The table below shows the water loss from a person's skin and kidneys under different conditions. Use the data in the table to explain the relationship between the regulation of body temperature and regulation of fluid content of the body.

	Water lost (mL/hour)		
Organ	At room temperature	In hot weather	With lengthy vigorous exercise
Skin	19	73	225
Kidneys	58	50	20

A significantly larger volume of water is lost from the skin in hot weather and under vigorous exercise compared to the kidneys. This is because the skin plays a major role in cooling the body down through the volume of water lost via sweat production and evaporation.

The kidneys work in the opposite way: when it is hot, or during vigorous exercise, less water is lost from this organ, as it works to reabsorb water back into the bloodstream and prevent excessive water loss via excretion.

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.



3. On the diagram above, indicate the parts of the nephron that are influence by ADH and aldosterone.
4. Why does the kidney receive blood at a higher pressure than other organs?

High pressure is required to force small molecules (such as water, glucose, amino acids, sodium chloride, urea etc) through the capillaries of the glomerulus into the Bowmans capsule (to become filtrate).

5. Describe the difference between water reabsorption in the loops of Henle and the distal convoluted tubules.

PCT: 60-70% of water reabsorbed here via osmosis (passive)
LoH: additional 25% reabsorbed via osmosis (passive)
DCT: final fine tuning of water and salt – active transport

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

Reduce rate of sweating – this will reduce the volume of water lost from the body
Reduce the volume of urine produced – a high concentration and low volume of urine is produced to conserve water volume.

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

The rate of water loss via sweat production increases on a hot day, therefore a low volume of urine is produced to ensure that homeostasis is maintained in relation to water blood volume. To produce a low volume of concentrated urine, high levels of ADH would be secreted from the posterior pituitary which acts on the DCT and CD to increase water reabsorption from filtrate to blood.

On a cold day, the rate of sweat production is far less, therefore less water is lost from the body so a high volume of dilute urine is produced to ensure that water volume of the blood is maintained within tolerable limits. Low osmotic pressure is detected by the chemoreceptors in the hypothalamus which inhibits the secretion of ADH from the posterior pituitary. Less water is therefore reabsorbed from the filtrate to blood in the DCT and CD therefore there is a high volume of water in urine – thus high volume and low concentration of solute.

9. 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.

ADH is secreted when the blood osmotic pressure is high (low amount of water compared to solute in blood). On a hot day, more water is lost from the body through metabolic processes e.g. sweating, higher rate of respiration etc, therefore a higher concentration of ADH is produced and secreted to ensure that a higher volume of water is retained within the body.

10. People suffering from heat exhaustion or a hangover share a symptom; a headache. Alcohol inhibits the production of ADH. Heat exhaustion is caused when the body loses fluid due to heat. The headache is caused by the effect of very concentrated blood on the brain cells.

    a) Explain how low ADH can cause dehydration.

ADH acts on the distle convoluted tubes and the colleting ducts to increase water reabsorption from filtrate to blood. Low ADH means that less water is being reabsorbed into the blood and more is lost as urine. This can lead to dehydration

    a) How could you avoid a hangover after drinking alcohol?

Headaches are a result of dedration (increased omotic pressure)
Drnking water while drinking alchol will aid in replenilsihing of lost water and will re-establish water walance and decrease osotic pressure

    b) Explain why dehydration is common in hot environments.

Water is lost as sweat (to maintain body temperture and lose heat form the body)
There is therefore an increase in osmotic pressure (dehydration)

    c) In industries located in hot dry climates eg Pilbara area, there is usually a urine colour chart at the back of the door of the toilet. Why is it important to know if you are dehydrated?

To ensure / remind people to drink water. As more water is lost as sweat in hot climates, dehydration is common. People are able to identify they are dehydrated by low volume, dark urine

d) The volume of urine production by Student A was measured every half hour for several hours. Student A drank a litre of tap water 1 hour after the measurements started and then stayed quiet watching movies during the time the data was collected. The results are shown below.

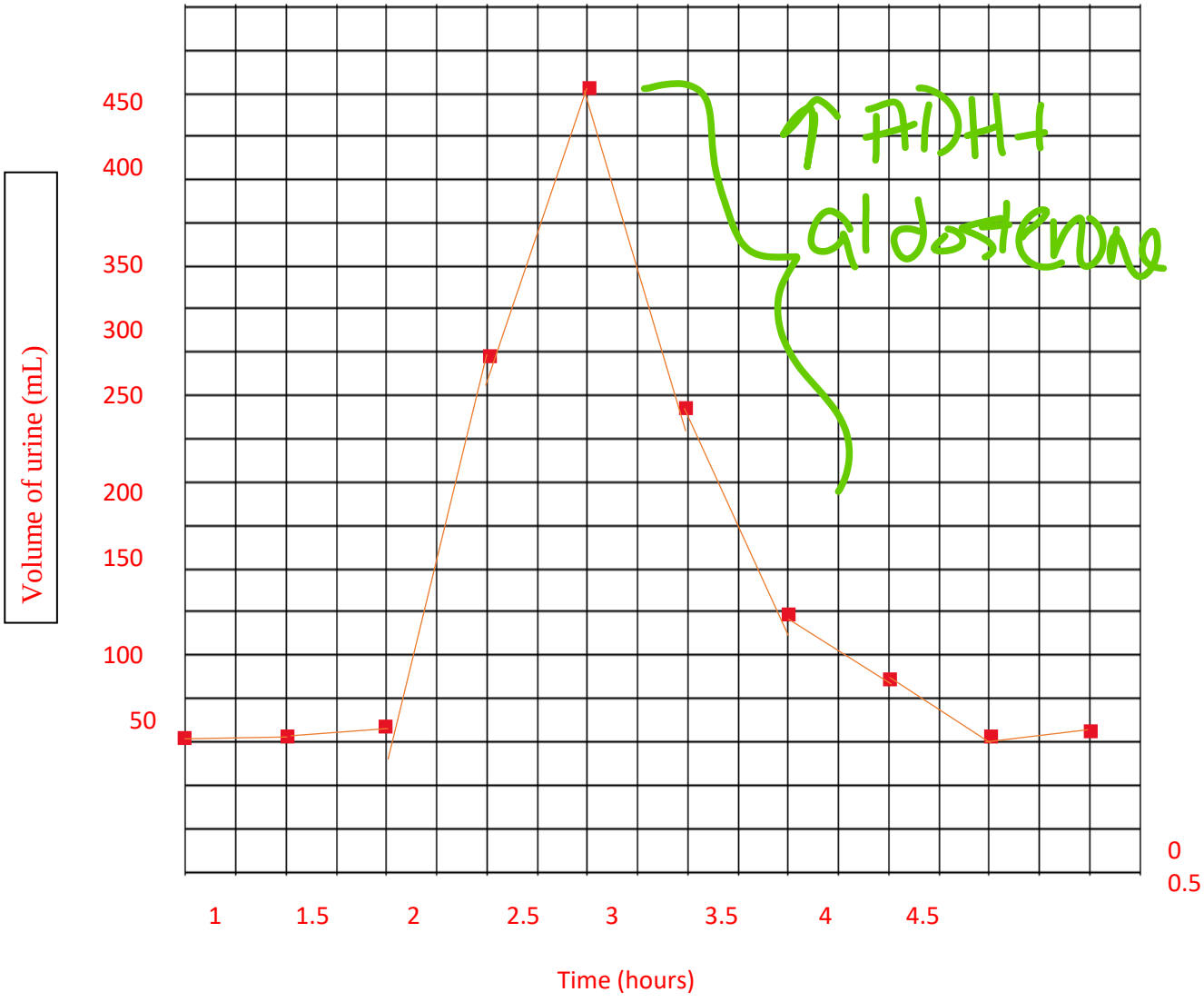
Time (h)	Volume of urine (mL)
0	45
0.5	40
1	50
1.5	280
2	450
2.5	250
3	120
3.5	80
4	45
4.5	50

a) Why were urine volumes collected before the person drank water?

To determine a base line / act as a control / to be able to compare

b) Graph the data on the grid below.

Title linking variables. Eg: The effect of 1 litre of tap water consumption on volume of urine production over 4.5 hours



2. How long did it take for the water to affect urine volume? Explain why.

~30 min. It needed to be absorbed by the alimentrary canal. Then change in osmotic pressure detected, hormones to be relseased, travel in blood and then act on nephone

3. Indicate on the graph expected times of increased levels of ADH and aldosterone.

Complete 6.1 Review Questions on page 138 of your textbook.
Complete Chapter 6 Review Question 1a, 2, 3, 6, 7, 10, 12-16 on page 152 of your textbook.

Learning Objectives:

Gas concentrations are controlled by balancing the intake of oxygen and the removal of carbon dioxide via the lungs, through the actions of the medulla oblongata and the autonomic nervous system (SU 3.15)

- Explain how the actions of the medulla oblongata and the ANS regulate gas exchange
- Describe the relationship between blood CO_2, Hydrogen ions and pH
- CO_2, hydrogen ions and O_2 concentration are involved in the regulation of breathing rate and depth
- State that the nervous control of breathing (rate and depth) by the respiratory muscles is by the breathing centre in medulla oblongata
- Construct a negative feedback look for breathing
- Explain why it important to have consious control over breathing
- Describe the risk of hyperventilation

Regulation of gas concentration (pages 139 – 142)

1. Explain how both the respiratory system and the circulatory system are involved in the regulation of gas concentrations.

All cells need a constant supply of oxygen for respiration & need to remove carbon dioxide, a product of respiration. The respiratory system is responsible taking in oxygen & excreting carbon dioxide – the lungs are the organs in which the exchange of these gases occur
Changes in breathing change the amount of oxygen taken in and carbon dioxide excreted. The circulatory system carries oxygen from the lungs to the cells & takes away carbon dioxide and delivers it to the lungs for excretion

2. Identify the muscle involved in breathing and state the nerve the innervates them.

The diagram is supplied by the phrenic nerve
The intercostal muscles are supplied by the intercostal nerve

3. Briefly explain the mechanisms involved in inspiration and expiration. This is a review of Year 11 work and will help your understanding.

When you inhale, the following occurs:

- The diaphragm contracts and flattens down.
- The external intercostal muscles contract and move the rib cage up & out.
- The volume of the chest cavity increases.
- The lungs inflate with air
- Lungs are now a large, empty space so air pressure in lungs is less than air pressure outside.
- Air flows into the lungs to equalise the pressure.

When you exhale, the following occurs:

- The diaphragm relaxes & bulges into chest cavity.
- The external intercostal muscles relax and move the rib cage down and in.
- The volume of chest cavity decreases.
- The lungs are compressed and deflate.
- Lungs are now a small, tight space so air pressure in lungs is greater than air pressure outside.
- Air flows out of lungs to equalise the pressure.

4. Explain how the concentration of carbon dioxide in the blood plasma affects the concentration of hydrogen ions. Write a word and formula equation in the space below.

Concentration of carbon dioxide in blood plasma affects the concentration of hydrogen ions.
CO2 dissolves in water to form carbonic acid (H_2CO_3) which rapidly breaks down to form Hydrogen ions and bicarbonate ions. Note increase in hydrogen ions is what causes the decrease in blood pH. See equation below:
$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$

5. Name and describe the function of the two regions within the respiratory centre.

Inspiratory Centre – controls breathing in
Expiratory Centre – controls breathing out

To coordinate breathing, messages need to pass back and forth between the neurons in these two regions.

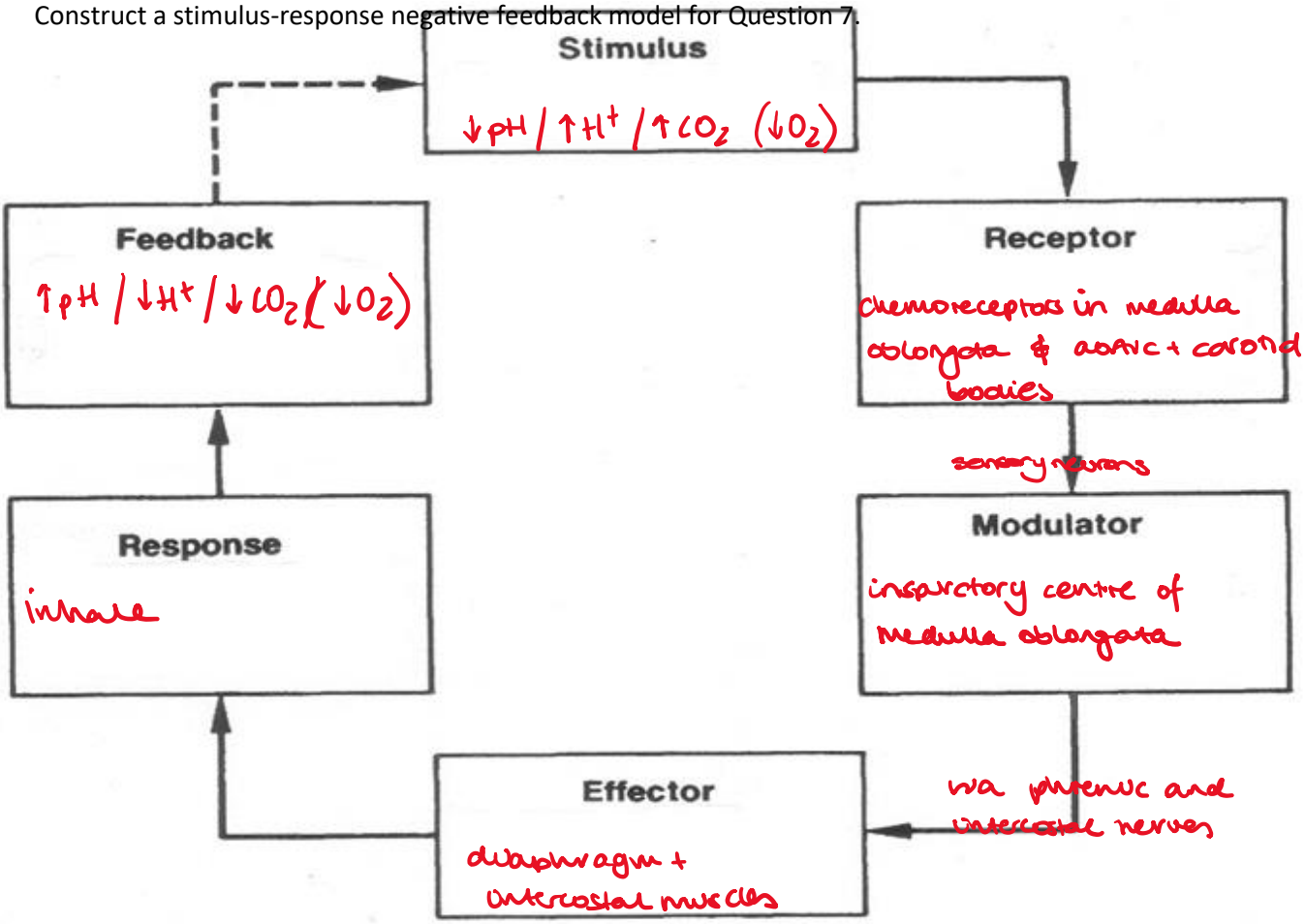
6. List the three chemicals that are carried in the blood that affect breathing rate.

Oxygen, carbon dioxide, H+

7. Describe the effect of a low pH on the rate and depth of breathing.

Normal pH is 7.35-7.45
As hydrogen ions increase, blood pH decreases. This change is detected by chemoreceptors in the aortic and carotid bodies. This send impulse to medulla which will increase rate and depth of breathing to remove CO_2

8. Construct a stimulus-response negative feedback model for Question 7.



9. Discuss the role of oxygen concentration on breathing rate.

Oxygen is a very weak stimulus

10. Suggest why blood pH is a good mechanism by which to regulate breathing rate.

Blood pH is a good indicator of blood carbon dioxide levels (therefore the need to increase respiratory rate).

11. Identify other receptors that can influence breathing rate.

Stretch receptors in airways (lung tissue and thoracic cavity) prevent over / under inflation (protective mechanism)
Receptors in nose, larynx, pharynx, bronchi react to irritants and trigger cough / sneeze reflex

12. Discuss the importance of voluntary breathing.

It is important for speech and to protect from irritants eg swimming / gas

13. Explain how a person can breathe voluntarily.

Voluntary control of breathing originates in the cerebra cortex and bypasses the medualla oblongata and enters descending tracts of the spinal cord. BUT we cannot hold our breath forever. Build up of carbon dioxide in the blood plasma will result in stimulation of receptors and the medulla oblongata to override conscious control

14. Define hyperventilation.

Extreme rapid, deep breathing. be voluntary or in response to stress

15. When hyperventilation occurs, a person breathes faster and more deeply the normal.
    i) What effect would this have on the level of oxygen in the blood? A very small increase

    ii) What effect would this have on the level of carbon dioxide in the blood? A large decrease

    iii) Where in the brain would this change in carbon dioxide level be detected? Medulla oblongata

16. Some divers will hyperventilate before diving in order to hold their breath for a longer period of tie. Explain why hyperventilation before diving can be extremely dangerous.

Hyperventilation allows for a significant decrease in carbon dioxide (and increase in pH) but does not have a large impact on increase oxygen levels. The decrease in carbon dioxide therefore reduces the stimulus to take a breath. But due to decreased oxygen, cells become oxygen deprived, resulting in passing out. The conscious decision to hold ones breath therefore is overridden by the unconscious stimulus to take a breath. Under water this means the lungs fill with lungs instead of air, which can result in drowning.

17. A girl had the pH levels in her blood taken immediately before and after swimming 500 meters in a pool. The results showed a drop in pH from 7.4 to 7.3 What caused this drop in to occur?

Breath holding and increase cellular respiration results in a build up of carbon dioxide. Carbon dioxide dissociates in blood plasma to for hydrogen ions and bicarbonate ions. The build up of hydrogen ions results in a decrease in her blood pH

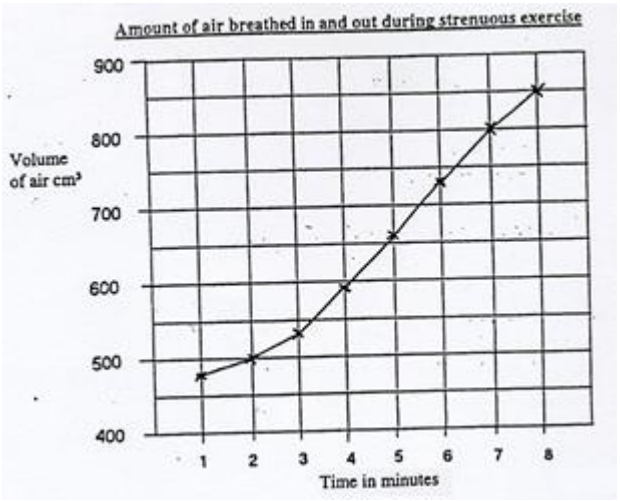
18. Why is plasma concentration of carbon dioxide a useful indicator of the body's energy requirement?

Carbon dioxide increases when the body requires energy. Energy is made through cellular respiration. Carbon dioxide is also a product of cellular respiration. Therefore CO2 increases when energy is required.

19. Summarise the three stimuli for breathing.

	Oxygen	Carbon dioxide	pH (H^+)
Stimulus	Must be a large ↓	↑	↑
Strength of stimuli	Weak	Strong	Strong
Receptor system	Chemoreceptor	Chemoreceptor	Chemoreceptor
Receptor location	Central and peripheral	Central (medulla oblongata)	Peripheral (aortic and carotid bodies)
Modulator	Respiratory center in medulla oblongata sends out nerve impulses	Respiratory center in medulla oblongata sends out nerve impulses	Respiratory center in medulla oblongata sends out nerve impulses
Effector	Diaphragm and intercostal muscles	Diaphragm and intercostal muscles	Diaphragm and intercostal muscles
Response	Increase rate of breathing	Increase rate of breathing	Increase rate of breathing
Negative Feedback	↑ O2	↓ CO2	↓ H+ ↑pH

20. Use the graph below to answer the following questions.



a) From the graph above – how much more air is taken in at 7 minutes compared to 1 min? (Show all your working)

800 – 480 = 320 cm3

b) Explain why more air is taken in at 7 minutes.

Increase demand for oxygen through aerobic respiration in muscles during exercise

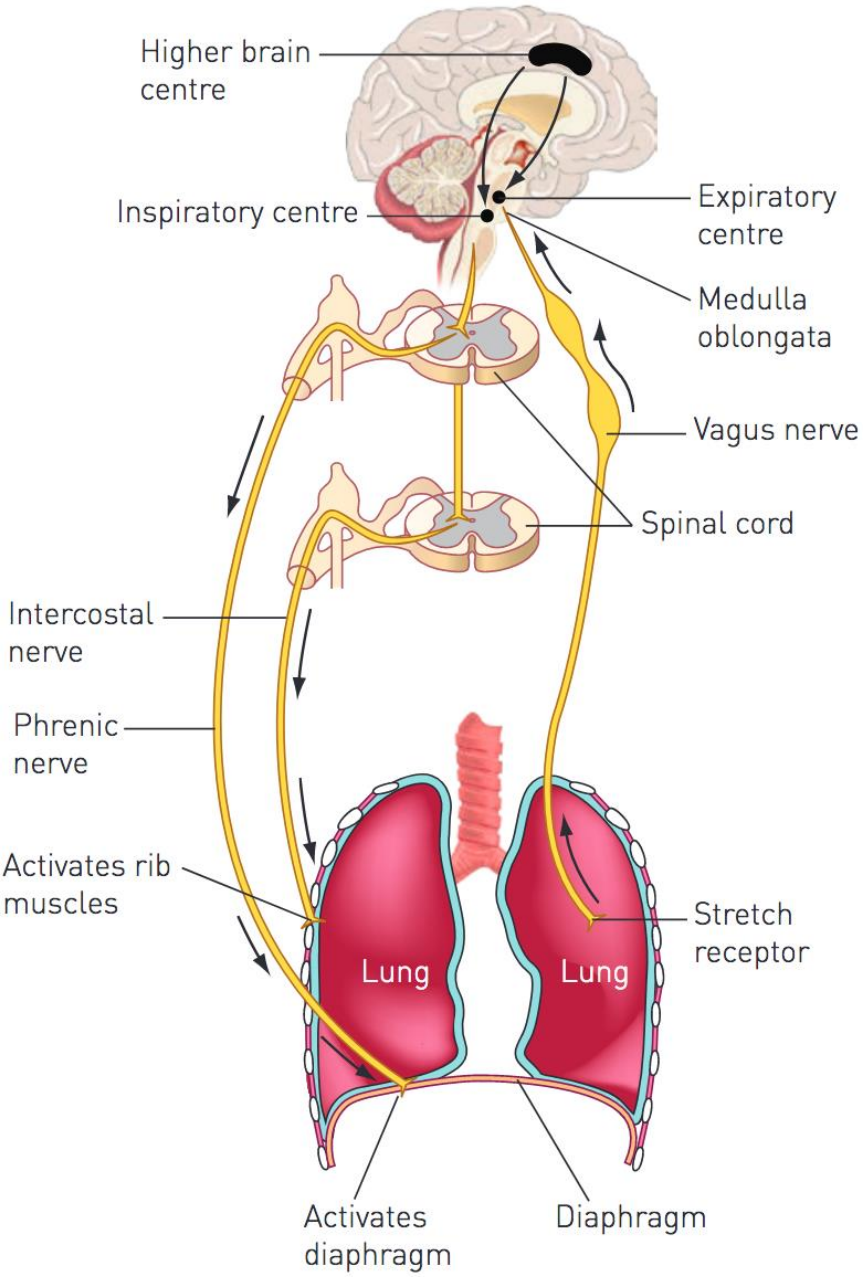
c) Where is the respiratory centre that controls breathing situated?

Medulla oblongata

d) List three stimuli that may affect breathing other than conditions in the blood.

Oxygen, carbon dioxide, pH (hydrogen ions)

21. Label and annotate the image below to summarise how breathing rate is regulated.



Complete 6.2 Review Question on page 143 of your textbook.
Complete Chapter 6 Review Question 1b, 4, 5, 8, 9, 11, 17 – 19 on page 152 - 153 of your textbook.

Learning Objectives:

Body fluid concentrations are maintained by balancing water and salts via the skin, digestive system and kidneys, which involve the actions of antidiuretic hormone and aldosterone on the nephron, and the thirst reflex (SU 3.14)

- Describe the role of the liver, skeletal muscle, pancreas and adrenal glands in glucose regulation
- Differentiate between
  - chemicals involved in blood sugar regulation (glucose, glycogen)
  - the processes of regulation (glycogenolysis, glycogenesis, gluconeogenesis, lipolysis)
  - the hormones controlling blood sugar levels (insulin, glucagon, cortisol, adrenaline/epinephrine)
  - alpha and beta cells in the Islets of Langerhans of the pancreas

Regulation of blood sugar (pages 109 – 114)

1. Describe the difference between glucose and glycogen.

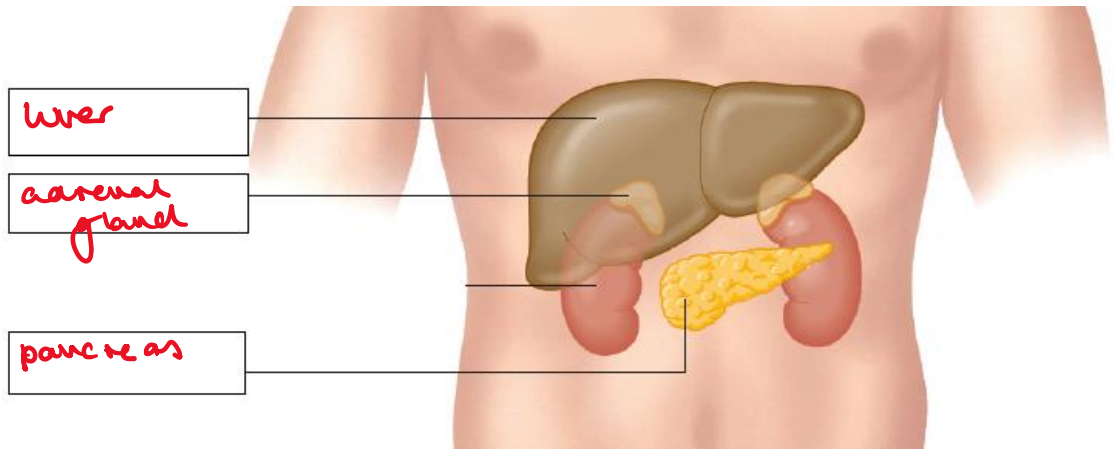
Glycogen is a chain of glucose molecules which can be stored.

Glucose is a smaller molecule which can be used for cellular respiration but cannot be stored.

2. Define the following terms.

Term	Definition
Glycogenesis	Glucose → glycogen
Glycogenolysis	Glycogen → glucose
Gluconeogenesis	Lipids and amino acids → glucose
Lipogenesis	Glucose → lipids

Glucose regulation is under the control three organs in the body: liver, pancreas and adrenal glands. Label each on the diagram below.



Role of the Liver

Explain the role of the liver in glucose regulation.

A number of things may occur in the liver

- Glucose can be removed from the blood to provide energy for liver functioning
- Glucose can be removed from the blood and / or muscles and converted to glycogen for storage – glycogenesis (stimulated by insulin) – after meals
- Glucose can continue to circulate and be used by body cells
- Glucose in excess of normal blood glucose & glycogen can be converted to fat for long-term storage
- Glycogen in liver can be converted to glucose to maintain blood sugar levels (glycogen in muscle cells provides the glucose for muscle activity) – glycogenolysis (stimulated by glucagon) – most likely b/w meals or during exercise

Use page 110 to label the diagram below.

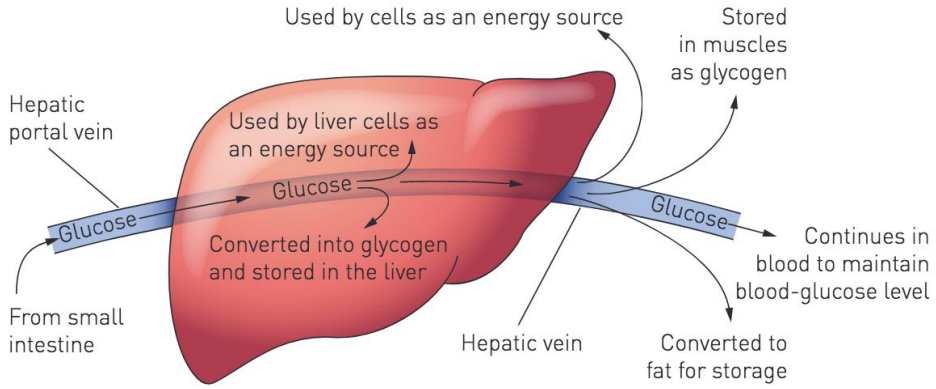


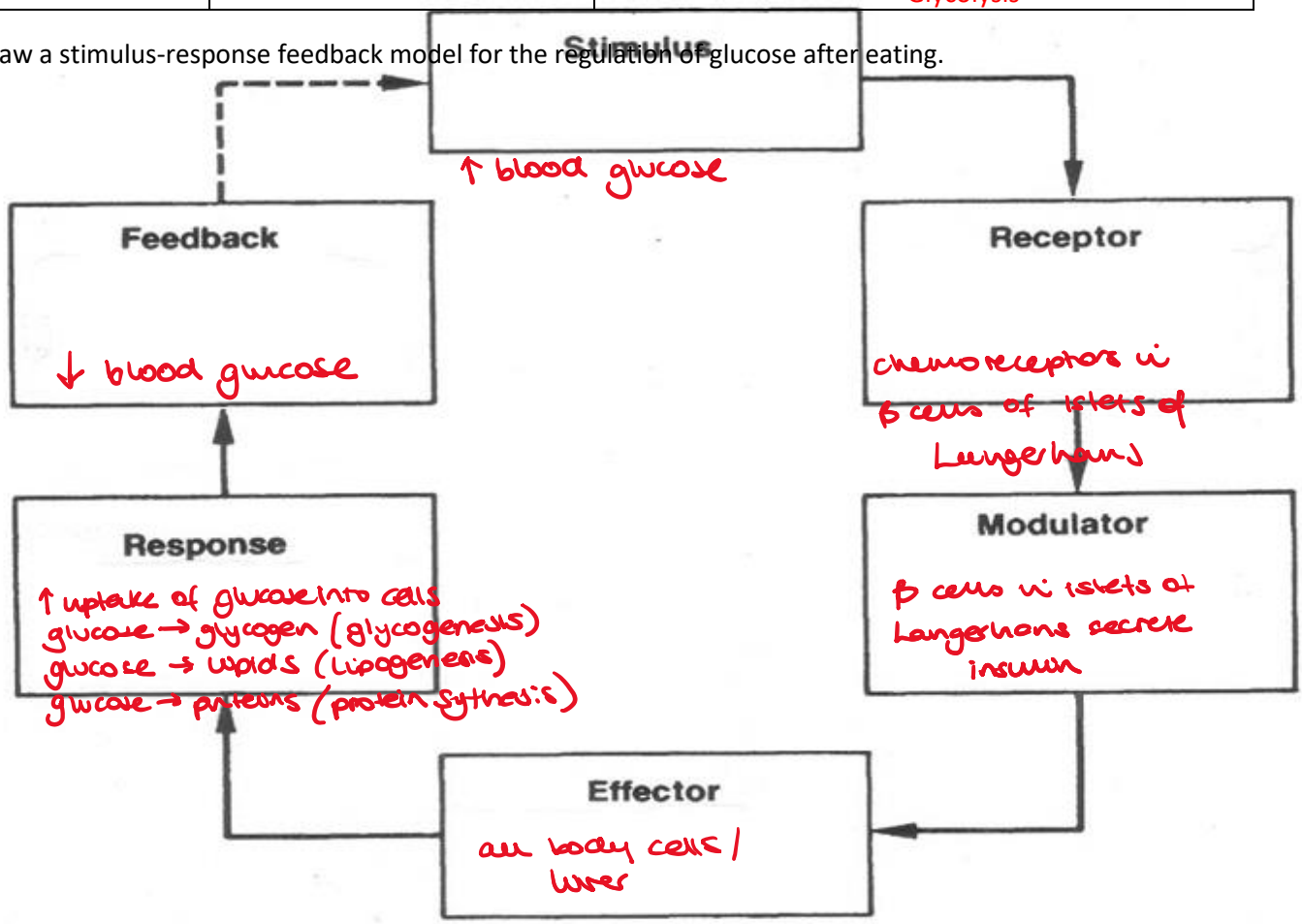
Figure 8.5 The fate of glucose absorbed in the small intestine

Role of the pancreas

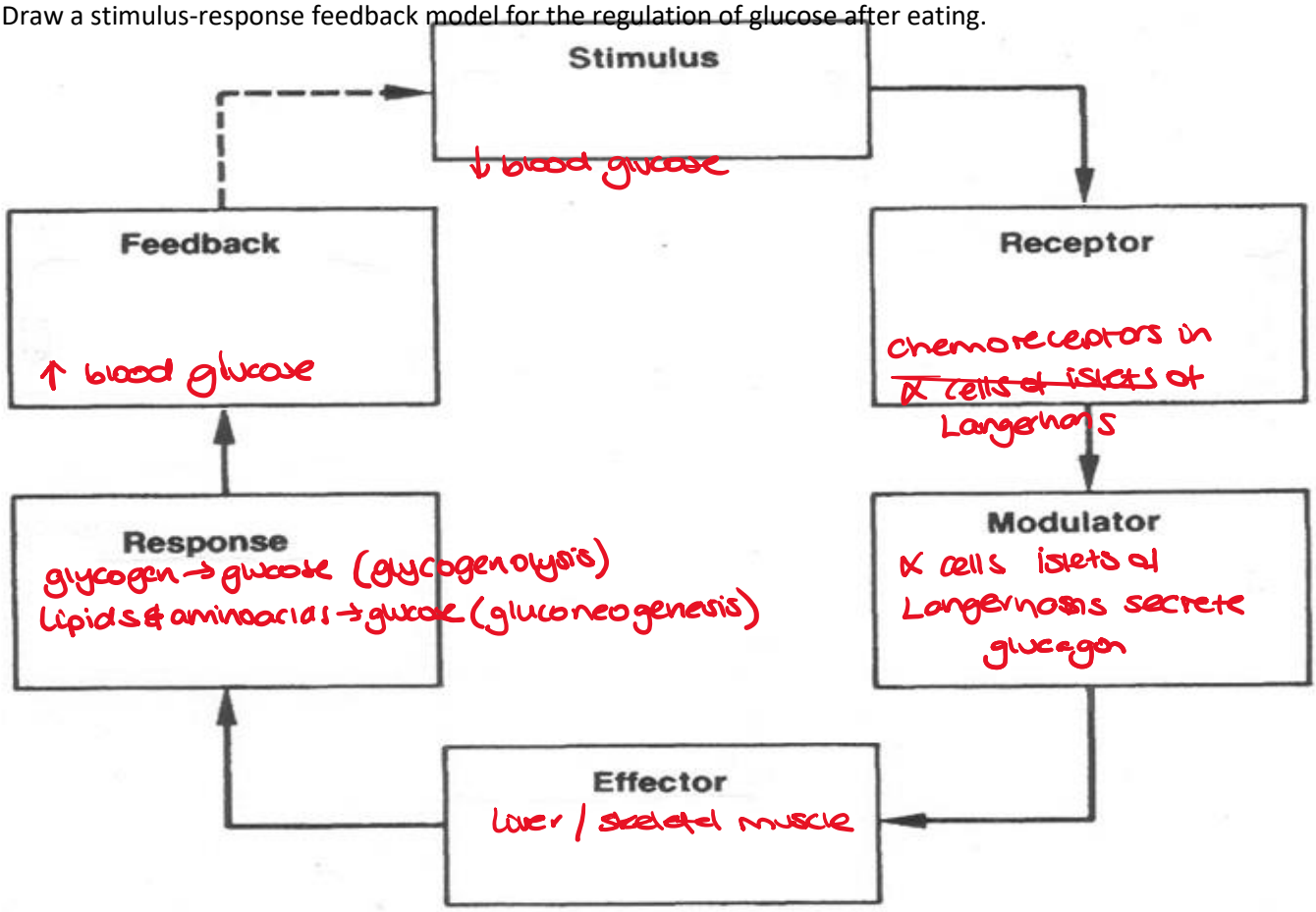
Scattered throughout the pancreas are small masses of endocrine tissue called islets of Langerhans.

Hormone	Secreted from	Effect
Insulin	Beta cells of Islets of Langerhans	Decrease glucose levels in the blood: - Increase movement of glucose into cells - Lipogenesis - Glycogenesis
Glucagon	Alpha cells of islets of Langerhans	Increase glucose levels in the blood: - Glycogenolysis - Glycolysis

Draw a stimulus-response feedback model for the regulation of glucose after eating.



Draw a stimulus-response feedback model for the regulation of glucose after eating.



Role of the adrenal glands

1. Explain how adrenaline and noradrenaline are stimulated to be secreted from the adrenal cortex.

Under stress (fight and flight), the adrenal gland is stimulated by the sympathetic nervous system to secrete adrenaline and noadrenaline.

2. Describe the effect of adrenaline and noradrenaline of glucose blood levels.

Adrenaline and noradrenaline promote the movement of lipids to the liver to be converted to glucose, and acts on the liver to convert glycogen to glucose. Both of these actions increase blood glucose levels.

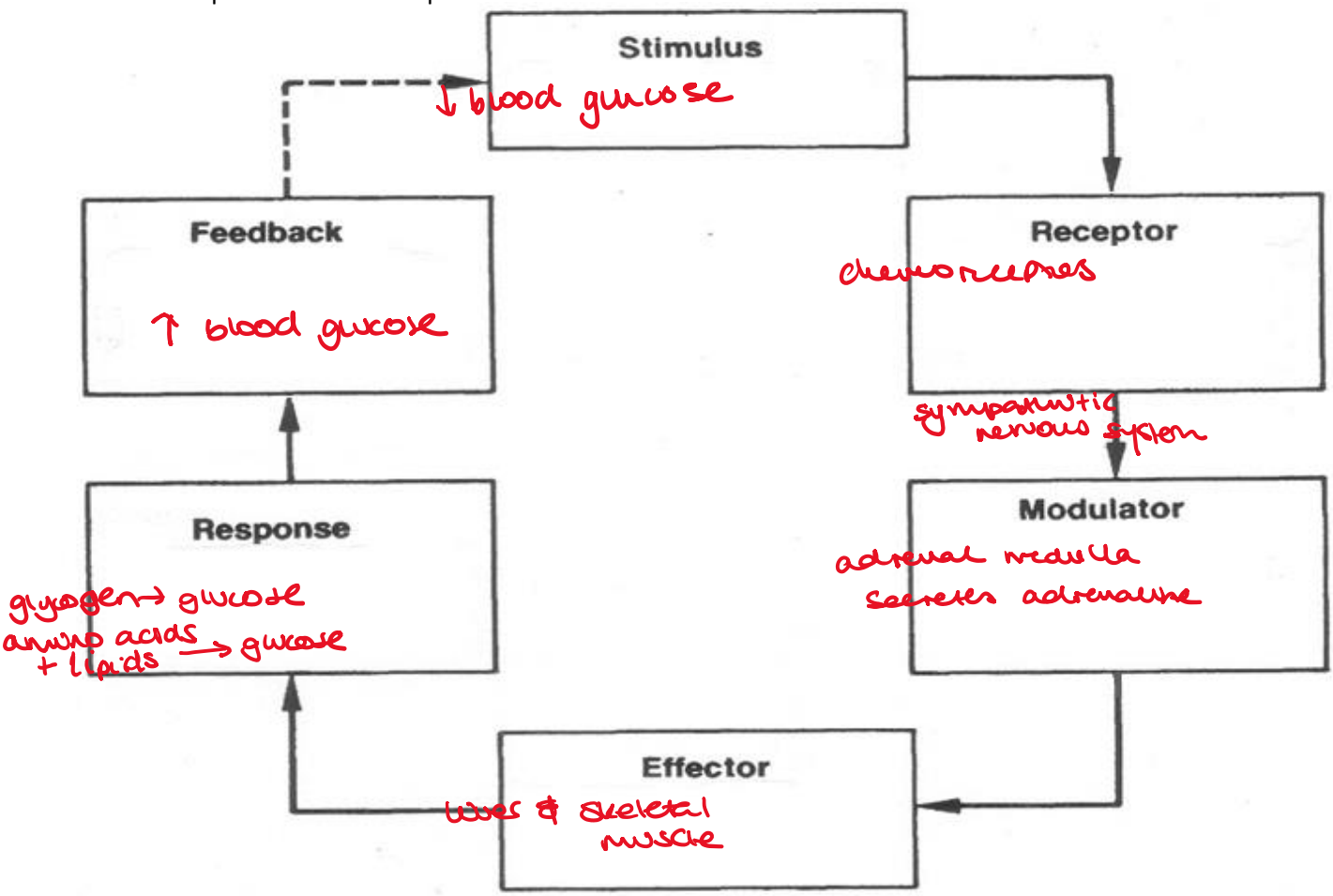
3. Explain how cortisol is stimulated to be secreted from the adrenal cortex.

Under long term stress adrenocroticotrophic (ACTH) releasing factor is secreted from the hypothalamus into the blood vessels fo the infundibulum (hypophyseal portal system) and acts on the anterior pituitary to secrete ACTH into the blood which acts on the adrenal cortex to secrete cortisol.

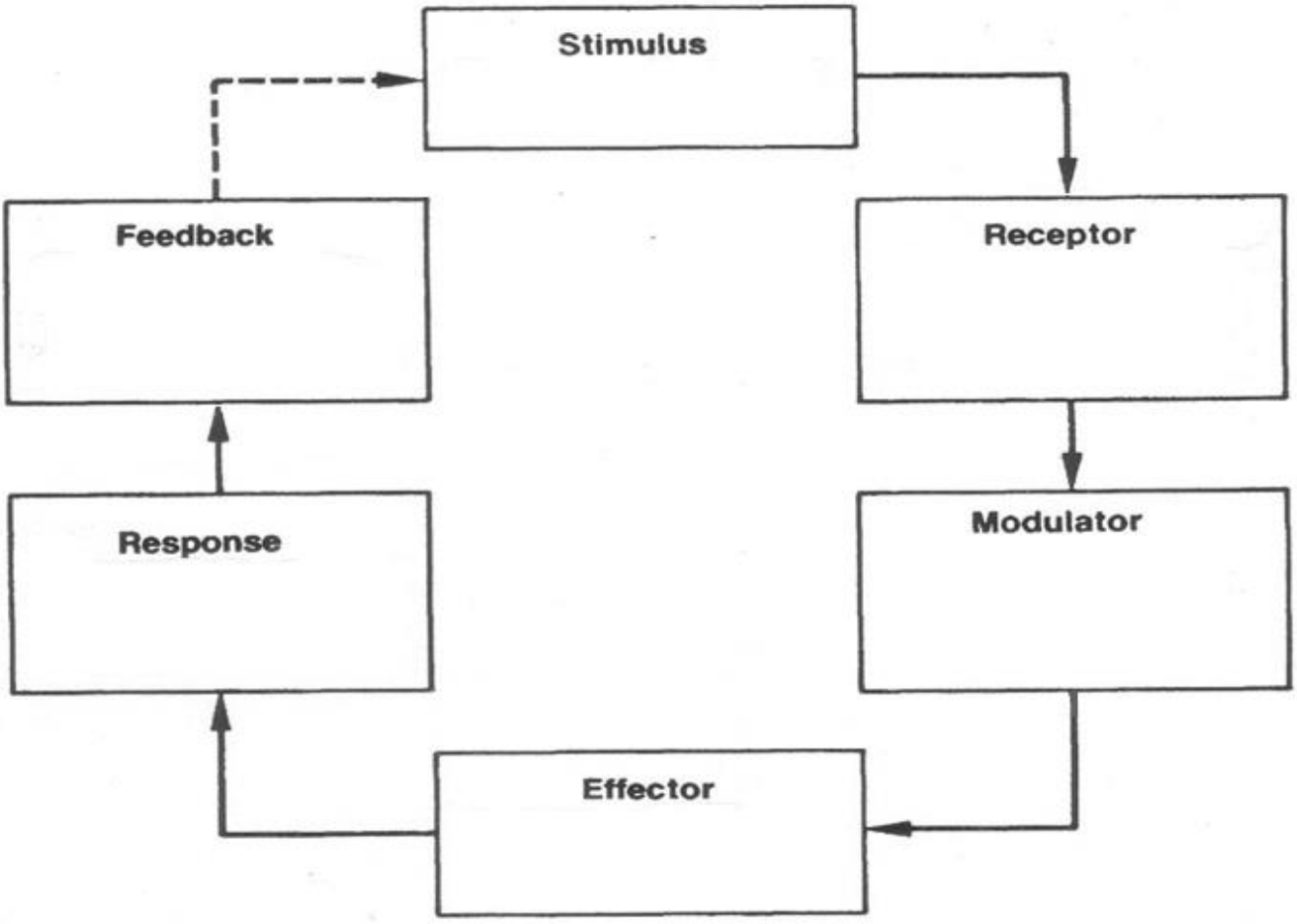
4. Describe the effect of cortisol of glucose blood levels.

Increase conversation of proteins and fat to glucose (gluconeogenesis) therefore increasing blood glucose levels.

5. Compose a stimulus-response feedback model for adrenaline.

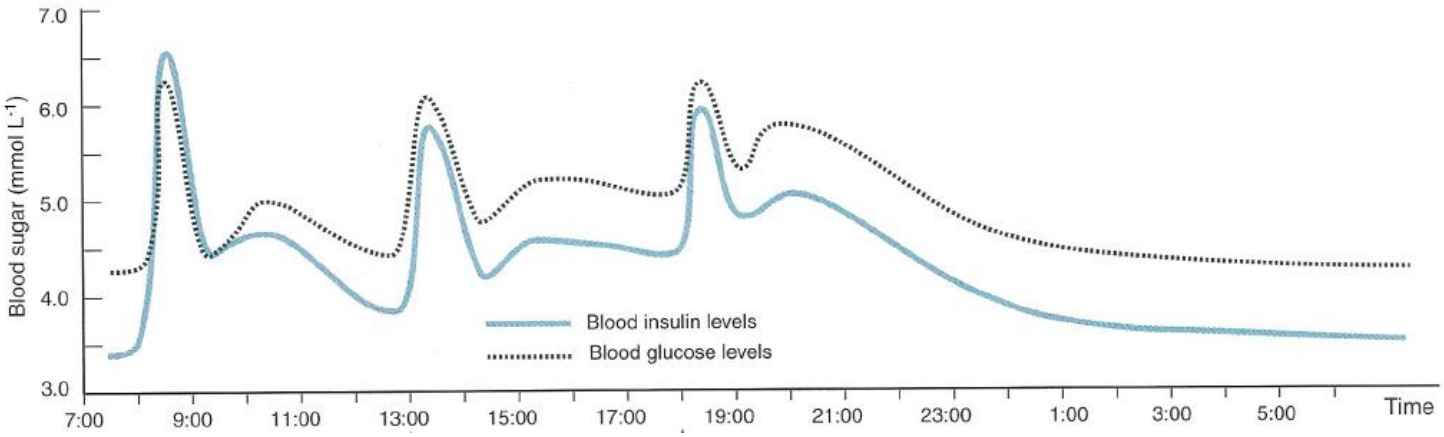


6. Compose a stimulus-response feedback model for cortisol.



Practice Questions

The endocrine portion of the **pancreas** (the α and β cells of the **islets of Langerhans**) produces two hormones, **insulin** and **glucagon**, which maintain blood glucose at a steady state through **negative feedback**. Insulin promotes a decrease in blood glucose by promoting cellular uptake of glucose and synthesis of glycogen. **Glucagon** promotes an increase in blood glucose through the breakdown of glycogen and the synthesis of glucose from amino acids. When normal blood glucose levels are restored, negative feedback stops hormone secretion. Regulating blood glucose to within narrow limits allows energy to be available to cells as needed. Extra energy is stored as glycogen or fat, and is mobilized to meet energy needs as required. The liver is pivotal in these carbohydrate conversions. One of the consequences of a disruption to this system is the disease **diabetes mellitus**. In type 1 diabetes, the insulin-producing β cells are destroyed as a result of autoimmune activity and insulin is not produced. In type 2 diabetes, the pancreatic cells produce insulin, but the body's cells become increasingly resistant to it.



1. What is the normal blood glucose level? 4-6mmol/L
2. State how the body detects blood glucose levels. Chemoreceptors in islets of langerhans
3. Identify on the graph the time(s) of day the individual ate a meal. 8:15am, 12:45pm, 6pm
4. Describe the process that led to a change in blood glucose level after a meal was eater.
   - After a meal was eaten, initially there is an increase in blood glucose as glucose is absorbed form the alimentary canal.
   - This increase in blood glucose is detected by chemoreceptors in Beta cells of the Islets of Langerhans
   - This results in the secretion of insulin from the beta cells of the Islets of Langerhans
   - Insulin results in the reduction of glucose in the blood by:
     1) Increase glucose uptake by all body cells
     2) Converting glucose to glycogen in the liver and muscle cells (glycogenesis)
     3) Converting glucose to amino acids in adipose tissue

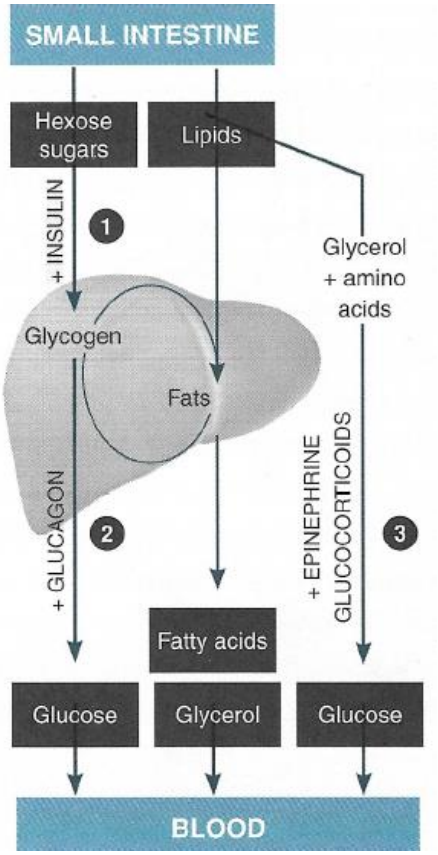
5. Label times of glucagon secretion on the graph. 9:15am, 2:15pm, 7pm
6. Describe the process that led to the change in blood glucose levels that you identified in Q5.
   - Low blood glucose is detected by alpha cells of the Islets of Langerhans
   - Glucagon is secreted from the alpha cells of the Islets of Langerhans
   - Glucagon acts to increase blood glucose by:
     1) Converting glycogen to glucose in the liver (glycogenolysis)
     2) Converting lipids and amino acids to glucose in the liver (gluconeogenesis)

7. Propose why blood glucose levels plateaued from ~1am.

The person is asleep therefore there is a low energy requirement, so glucose is not required. Plus the person is not eating so there is no glucose entering the body.

The liver plays a central role in carbohydrate metabolism, specifically the production of glucose from non-carbohydrate sources, and the interconversion of glucose and glycogen. These processes ensure carbohydrates are stored or are made available to cells as required and are regulated by hormones.

The role of the liver is illistrated in the adjacent picutre.



1. Name and describe the processes labelled as 1, 2 and 3 in the diagram.

1 = Glycogenesis: the conversion of glucose to glycogen. This is caused by the presence of insulin in the body when there is high blood glucose.

2 = Glycogenolysis: the conversion of glycogen to glucose. This is caused by the presence of glucagon in the body when there is low blood glucose.

3 = Gluconeogenesis: the conversion of lipids and amino acids to glucose. This is caused by the presence of glucagon in the body when there is low blood glucose.

2. Explain why it is important that the body can readily convert and produce different forms of carbohydrates.

Interconversion of carbohydrates is essential to regulating blood glucose levels and maintaining a readily available supply of glucose to cells for cellular respiration without incurring the homeostatic problems of high circulating levels of glucose.

Complete 5.2 Review Questions on page 14 of your textbook.

Complete Chapter 5 Review Questions 3-6, 13, 14, 17, 18 and 24 on page 127 of your textbook.

Question 1 – 2013 **(26 marks)**

A recent study investigating the effects of MDMA (ecstasy) on human thermoregulation. The research team selected 10 individuals (male and female) ages between 18 and 35 years. Each participate attended two sessions, one week apart. At the first session participants receives, in tablet form, either a placebo or 2 mg/kg of MDMA. If at the first session participants received a placebo, at the second session they received MDMA and visa versa.

At each session, participates assembled in a room at 10 am with the room temperature at 23°C. After 30 minutes, the room was changed to 30°C, which took about 2 minutes. Data collection began at 11 am, when the drug or placebo tablet wad given with a small amount of water. Recordings of core temperature were taken every hour for the next 4 hours, when the session concluding at 3pm. Data for each of the five time periods were averaged and recorded (in order of time starting at 11am) in a notebook as follows.

MDMA: 36.9°C, 37.1°C, 37.5°C, 37.6°C, 37.6°C Placebo: 36.9°C, 37°C, 37°C, 37.1°C, 37.1°C

a) Present the above data in a table. (5 marks)

Core body **temperature** following administration of **placebo** and **MDMA**

Time (min)	Core body temperature with MDMA (°C)	Core body temperature with placebo (°C)
0	36.9	36.9
60	37.1	37.0
120	37.5	37.0
180	37.6	37.1
240	37.6	37.1

Description	**Marks**
Title linking variables	1
First column is time (as minutes or time of day)	1
Appropriate column headings	1
Correct units in headings	1
Data correctly inputted	1
	5

b) Formulate a hypothesis for this experiment. (1 mark)

Description	Marks
Any statement that includes directional change between the independent variable (MDMA) and the dependant variable (core body temp) Eg the consumption of MDMA will increase core body temperature above normal levels	1
TOTAL	1

c) Explain why each participant did not receive the same amount of MDMA: that is, they received 2 mg of MDMA per kilogram of body mass of the participant. (1 mark)

Description	Marks
Control for the effect of body mass	1
All received the same relative amount of the drug	
To make it a valid investigation	
TOTAL	1

d) i) Describe two variables that were controlled adequately in the experiment. (2 marks)

Description	Marks
Number of times MDMA and placebo administered	1-2
Same method of administration	
All people are in the same environmental temperature	
Same amount of time from administration to recording body temperature	
Period to time in which participants assembled / core body temperature recordings were taken	
TOTAL	2

ii) For one of the variables described in part di) explain why it is needed to be controlled. (1 mark)

Description		Marks
Describing the effect of the stated variable on core body temperature (either increase or decrease core body temperature)		1
number of times MDMA and placebo administered	as increasing frequency of MDMA administration could increase core body temperature	
same method of administration of MDMA and placebo (tablet)	as injecting MDMA could increase core body temperature more/faster than ingesting MDMA/ action of the drug may be affected by digestion	
room temperature	as a hotter room could increase core body temperature / a cooler room could decrease core body temperature	
same amount of time from administration of MDMA/placebo to recording core body temperature	to allow core body temperature values at each time period to be validly compared/averaged	
period of time over which participants were assembled / core body temperature recordings were taken	to allow comparison as core body temperature of participants could increase/decrease over different time periods	
all participants had both MDMA and placebo	to control any effect of participants' health, diet, etc on core body temperature	
	Total	**1**

e) The research team also recorded the oxygen consumption of participants over the same time period. They found that oxygen consumption after administration of the placebo remain constant, they found that it increased significantly after the administration of MDMA. Using this information and data from the table, suggest what caused the observed effect of MDMA on core body temperature. (1 mark)

Description	Marks
Increased rate of cellular respiration / increased metabolic rate / increase metabolism	1
TOTAL	1

f) During both sessions, the research team took recordings of skin temperature for 5 hours from 10 am. Between 10:30 and 11 am, the skin temperature increased 1°C to administration of the placebo and MDMA. Explain why this occurred. (1 mark)

Description	Marks
Heat gained from warm / warmer / ambient / external / room temperature	1
TOTAL	1

g) After 12:30 pm, the skin temperature, following administration of MDMA, steadily at 0.5 °C above the skin temperature following administration of the placebo. Account for what might have caused the difference in skin temperature between the two treatments. (1 mark)

Description	Marks
Delayed / decreased sweating after MDMA	1
TOTAL	1

h) In 2009, 17 year old Gemma Thoms attended the Big Day Out (BDO) at Claremont showgrounds in Perth. It was a 35°C day and Gemma spent most of the day dancing. Gemma consumed one MDMA tablet before leaving home and swallowed two more tablets while lining up to enter the event because she was concerned police at the BDO would charge her with possession of an illegal substance. She collapsed at the concert and died in hospital 12 hours later.

i) MDMA has been shown to increase metabolic rate as well as result in vasoconstriction of blood vessels to the skin and reduce sweating. Describe how MDMA and the environment in which it was taken, contributed to Gemma's death. (3 marks)

Description	Marks
Increase metabolic rate led to an increase in body temperature (as heat is a byproduct of cellular respiration).	1
Reduced sweating and vasoconstriction to the skin means less heat is lost from body from radiation, convection, conduction and evaporation.	1
This, in addition to a 35-degree day, would have all resulted in hyperthermia / heat exhaustion.	1
TOTAL	1

ii) Increase body temperature usually results in increase sweating and vasodilation of the blood vessels to the skin. Select one of these cooling mechanisms and explain why and how it occurs. (4 marks)

Description	Marks
	1
	1
	1
TOTAL	1

iii) MDMA has also been linked to water intoxication (hyponatremia) as a result of increased ADH levels. Describe how increase ADH can lead to water intoxication. (4 marks)

Description	Marks

Antidiuretic hormone (ADH) acts on the distal convoluted tubes and collecting ducts n the nephron	1
to increase their permeability to water,	
resulting in increased water reabsorption from filtrate to blood.	1
This leads to additional water being in the blood which can result in decreased osmotic pressure (water intoxication).	1
TOTAL	1

iv) Describe why water intoxication is so dangerous. (2 marks)

Description	**Marks**
Water intoxication can lead to water moving into cells (intracellular fluid) as a result of decreased osmotic pressure in the blood. This can result in cells swelling and potentially bursting.	1
This can occur in the cells I the brain resulting in increased pressure within the cranium which can result in fainting / falling unconscious.	1
TOTAL	1

Question 2 - 2009 (20 marks)

Brad was part of a research group investigating the control of blood glucose levels in different people. The graph below shows the changes in his blood glucose levels over a period of 24 hours.

a) Explain the changes in Brads blood glucose concentration between 16 hours and 24 hours. (8 marks)

Description	Marks
Meal / digestion of carbohydrates produced glucose	1
Glucose from meal is absorbed into the blood increase blood glucose levels	
Alpha cells in pacres detect low / decreasing glucose levels	1
Glucagon converts glycogen to glycose / glycolysis in the liver / muscle	1
Glucagon converts lipids to glucose / gluconeogenesis	1
When no glucose input from diet blood glucose levels decrease	1-4
Glucose being used in metabolism / activity	
Beta cells in pancreas detect high blood glucose levels	
Insulin moves glucose into cells	
Insulin converts glucose to glycogen / glycogenesis	
Glycogen stored in liver / skeletal muscle	
TOTAL	8

b) Tony (Brads fellow researcher) also monitored his blood glucose concentration in the investigation. Tony is a diabetic and requires insulin: they had their meals and exercised together. From the graph, state when Tony would need to have his insulin injections and explain why these times. (6 marks)

Description	Marks
Breakfast/ lunch/ evening meal / meals (times are allowed instead 8:30 / 12:30 / 17:00)	1-2
Insulin promotes uptake of glucose into cells	1-4
Meals provide source of glucose	
Blood glucose levels increase after a meal	
Due to absorption from digestive system	
Need to remove excess blood glucose to maintaing within tolerance limit	
TOTAL	6

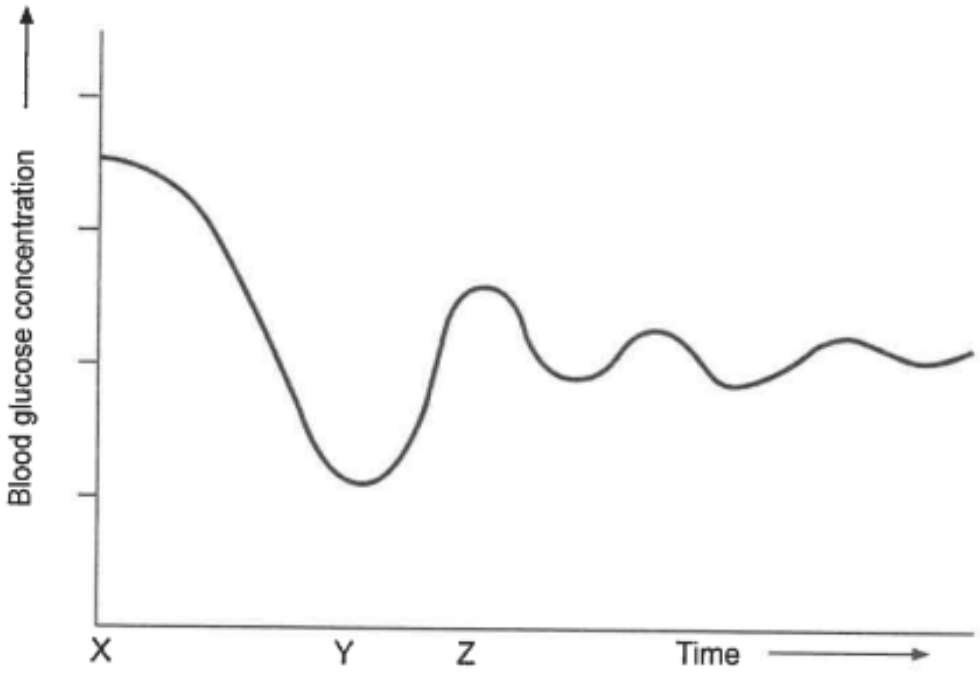
c) Before Tony was diagnosed with diabetes, he was always thirsty, urinated frequently and was always tired. Explain how these symptoms link to high blood glucose caused by diabetes. (6 marks)

Description	Marks
High blood glucose levels increase osmotic pressure	1-2
Water moves from cells into blood	
This stimulates thirst reflex	
High blood volume caused by excess water from cells causes kidney to remove large amounts of water from body	1
Increase blood pressure increases urine production	1
Low / no glucose is being absorbed by cells causing low metabolic rate	1
Less energy being produced	1
TOTAL	6
TOTAL	1

Question 3 – 2013 **(12 marks)**

The following question refers to the information and the graph below.

Prior to having a morning operation, a patient was told to fast (go without food) after an evening mean the night prior. The graph below shows changes to the blood glucose concentration throughout the night, which the patient was resting, starting 30 minutes after the evening meal.



a) Describe how the graph illustrates a negative feedback model. (2 marks)

Description	Marks
Negative feedback produces a response in a direction opposite to the stimulus	1
Appropriate description with reference to the graph	1

b) The following questions refer to the changes in the blood glucose concentration between Points Y and Z.

(i) Name the hormone that causes the change in blood glucose concentrations between times Y and Z on the graph. (1 mark)

Description	Marks
Glucagon	1
TOTAL	1

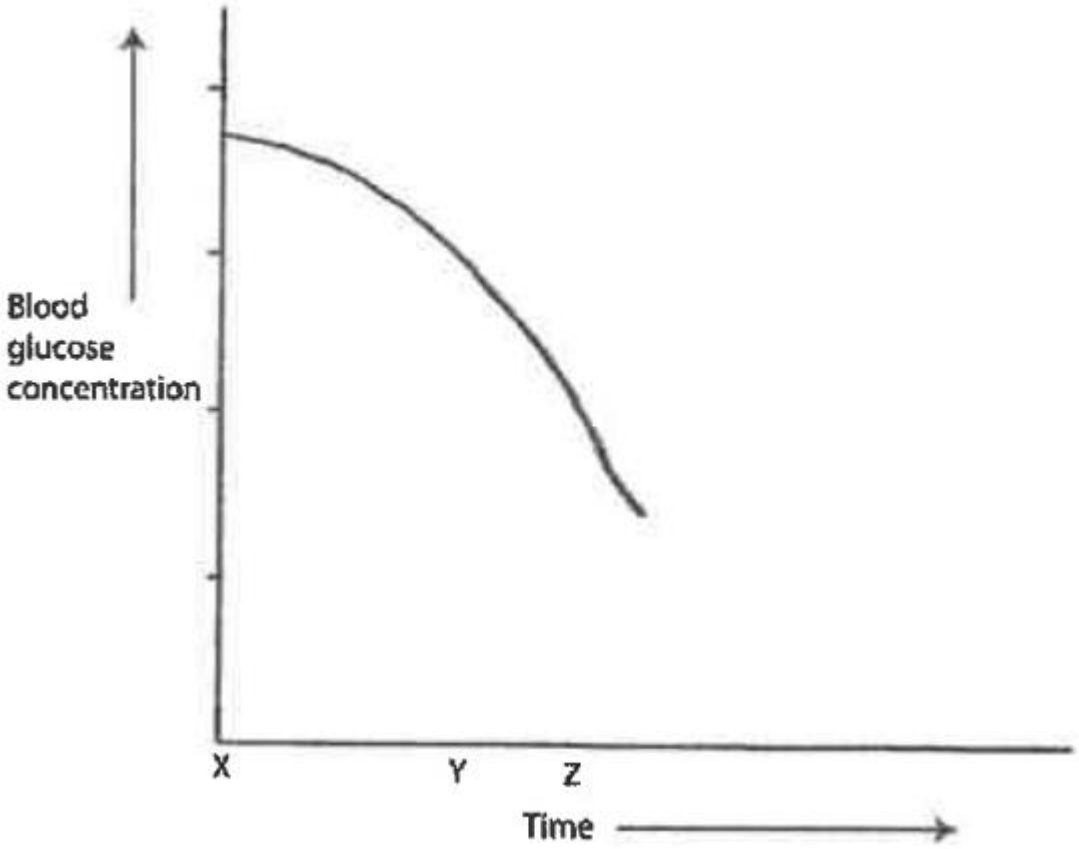
(ii) Name the cell type and the specific location within the organ from which the hormone state in part b)(i) was secreted. (2 marks)

Description	Marks
Alpha cells	1
Islets of Langerhans	1
TOTAL	2

(iii) Describe two responses that led to the change in blood glucose concentration between times Y and Z o the graph. (2 marks)

Description	Marks
Glycogen conversation to glucose / glycogenolysis	1-2
Conversation of fat to glucose / gluconeogenesis (of lipids / fats)	
Production of glucose from proteins / gluconeogenesis (of proteins / amino acids)	
TOTAL	2

a) (i) On the axes below, draw the blood glucose levels of a person suffering Type 2 diabetes (untreated) over the same time period. (1 mark)



Example graph shown above. Note that the start of the line should technically be above the start point of the original for a person suffering type 2 diabetes. However, no marks deducted if line is started at the same point as the original.

Description	Marks
Line shows that the level remains higher for longer and slowly decreases (must decrease slower than original)	1
Total	**1**

(ii) Explain the shape of your graph above in terms of glues regulation. (4 marks)

Description	**Marks**
Insulin is present / produced	1-4
Cells don't response to insulin	
Cells unable to uptake glucose	
Failure to convert glucose to glycogen	
Failure to convert glucose to fat	
Cells unable to use glucose for energy	
Glucose levels remain higher for longer	
TOTAL	4

WACE Past Paper Questions

Extended Response Practise

1. A person got stranded on a desert island after their boat hit some rocks and capsized. There was limited fresh water and they were unsure of what plants they could eat. They had set off a rescue beacon, but the closest community was a day's boat ride away.

a) Outline what would happen to their body fluid and sugar levels in the first 24hours. (10 marks)

Description	Marks
Initially water level would be within normal range, urination and sweat would be normal.	1
Over time, as fluid consumption decreased, fluid loss increased through sweating and urination, increasing osmotic pressure and reducing blood volume	1
As osmotic pressure increases, fluid will move from within cells into extracellular fluid, causing cells to begin to shrink.	1
Urination volume will reduce to try and retain water.	1
Low blood volume and high osmotic pressure results in dehydration.	1
Sugar levels would initially be as normal.	1
Throughout the day, as not glucose is ingested, blood glucose levels initially drop	1
This will be regulated by converting glycogen to glucose in order to maintain blood glucose levels required for cellular respiration	1
Through the 24 hours there will be a steady decline in blood glucose levels, but it will not reach zero as the body converts other fuels to glucose.	1
This will occur through the action of insulin	1
TOTAL	10

b) Describe the homeostatic mechanisms to control the change in fluid and sugar levels. (10 marks)

Description	Marks
Stimulus: osmotic pressure increased	1-5
Receptors: osmoreceptors in hypothalamus detect change (this will stimulate the thirst reflex giving conscious sensation of thirst but as no water, this will not be replenished	
Modulator: neurosecretory cells from hypothalamus into posterior pituitary secrete and release antidiuretic hormone (ADH) into blood	
Effector: ADH acts on the distal convoluted tubes and collecting ducts to increase permeability to water	
Response: increased water reabsorption from filtrate to blood	
Negative feedback: deceasing osmotic pressure and increase blood volume	
Stimulus: decrease blood glucose	1-5
Receptors: chemoreceptors in alpha cells in Islet of Langerhans	
Modulator: alpha cells secrete glucagon into the blood	
Effector: liver and adipose tissue	
Response: glycolysis (conversion of glycogen to glucose) and gluconeogenesis (conversion of fat and amino acids to glucose) in liver. In adipose tissue transport of fat to liver.	
Negative feedback: increase blood glucose level	
TOTAL	10

2. On a hot day you spend several hours working or playing sport and notice that your skin becomes red and your clothes wet with sweat. You feel thirsty and you have several large drinks of water. When you get home you notice that your urine is darker than normal and you recall with some surprise that you hadn't felt the need to empty your bladder since you left home that morning. Outline the way in the sweating, the thirst and the low volume of concentrated urine produced, can be related to the physiological process of homeostasis. (20 marks)

Temperature regulation:

Stimulus: Body temperature increase (1)
due to Hot day/Metabolic heat production. (1)
Receptor/Modulator: Thermo receptors (1)
Hypothalamus (1)
Effector/Response: Sweat glands will increase sweating (1)
Body will cool by 'evaporation' (1)
max. = 6 marks

Thirst: regulation of body fluids

Stimulus: Osmotic pressure of the blood is increased (1)
due to Water loss from sweating (1)
Receptor/Modulator: Osmoreceptors (1)
Hypothalamus (1)
Effector/Response: Thirsty/dry throat (1)
Drinking behaviour activated. (1)
(max. = 6 marks)

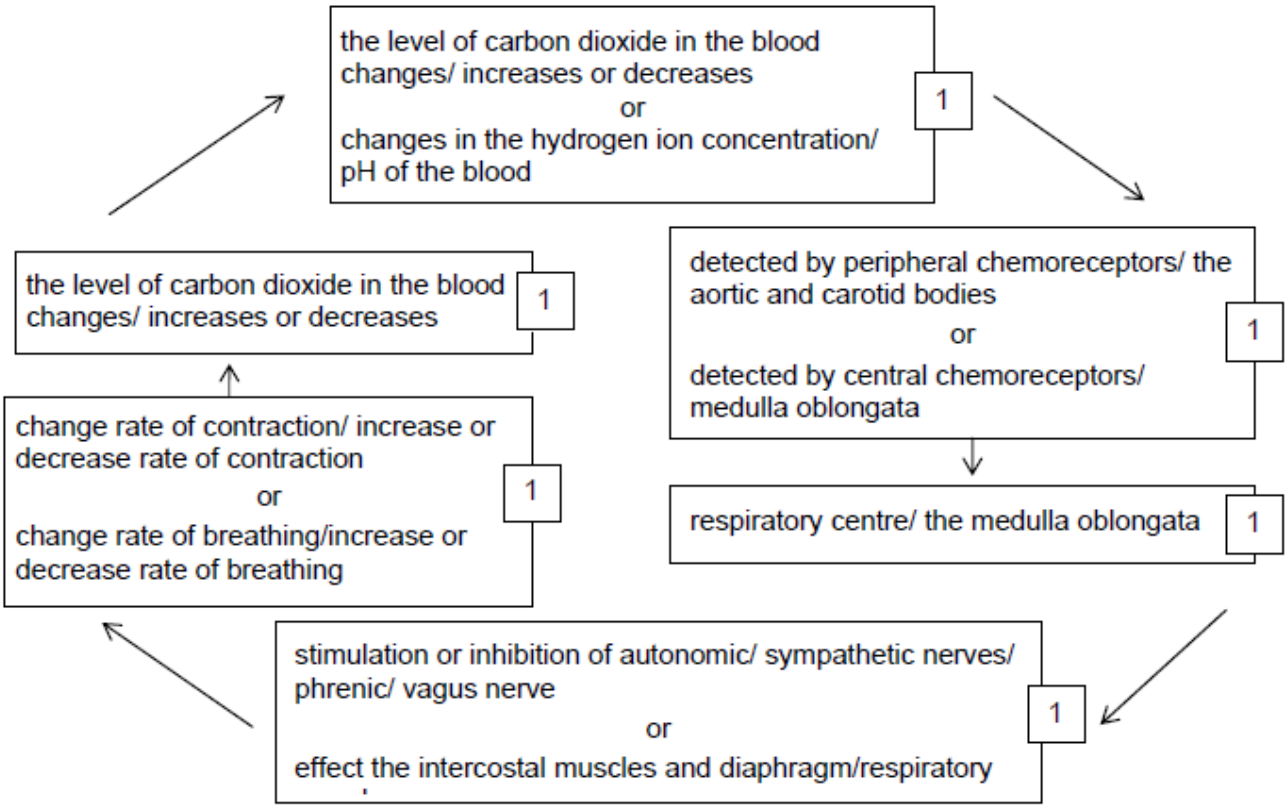
The low volume of strong urine

Stimulus: Osmotic pressure of the blood is increased (1)
due to Water loss from sweating (1)
Receptor/Modulator: Osmoreceptors (1)
Hypothalamus Effector/Response Posterior pituitary (1)
Increase ADH (1)
ADH acts on the DCT/Collecting duct (1)
Permeability increases (1)
More water is returned to the bloodstream (1)
Less water enters the urine – causing a low volume of strong urine (1)
(max. = 8 marks)

3. A patient was in a coma for a long period of time due to damage to his cerebrum. He was able to maintain some crucial functions such as breathing, within the normal tolerance limits without the use of medical intervention. Use your knowledge of the function of the brain and negative feedback models to explain how he was able to continue breathing normally even though part of his cerebrum was damaged.

(7 marks)

Description	Marks
• the cerebrum is not involved (in the control of breathing and blood pressure) • breathing and blood pressure are controlled by the medulla and not affected by damage to the cerebrum	1
Breathing	
• the level of carbon dioxide in the blood changes/increases or decreases • changes in the hydrogen ion concentration/pH of the blood	1
• detected by peripheral chemoreceptors/the aortic and carotid bodies • detected by central chemoreceptors/medulla oblongata	1
• respiratory centre/ the medulla oblongata	1
• stimulation or inhibition of autonomic/sympathetic nerves/ phrenic/ vagus nerve • effect the intercostal muscles and diaphragm/respiratory muscles	1
• change rate of contraction/increase or decrease rate of contraction	1
• change rate of breathing/increase or decrease rate of breathing • negative feedback/the level of carbon dioxide in the blood changes/increases or decreases	1



4. Glucose is required in body cells for the production on energy during cellular respiration. To maintain glucose levels in a cell, negative feedback mechanisms are necessary for more glucose to be released into the bloodstream and to enter the cell. Identify, name the source and describe the role of three hormones in increasing glucose levels in the blood. (12 marks)

Description	Marks
Any three hormones: **Glucagon**	1
• Produced by the alpha cells/Islets of Langerhans/pancreas/endocrine pancreas/pancreatic islets	1
• Enters the liver • Glycogenolysis/breakdown of glycogen to glucose • Promotes gluconeogenesis/breakdown of lipids/amino acids • Into glucose which enters the bloodstream	1–2
Cortisol	1
• Produced by adrenal cortex	1
• Amino acids to liver for gluconeogenesis/amino acid to glucose • Glycogenolysis/breakdown of glycogen to glucose • Glucose enters the blood stream • Removal of amino acids from muscle cell	1–2
Adrenaline/ noradrenaline	1
• Produced by adrenal medulla	1
• Glycogenolysis/breakdown of glycogen to glucose • Glucose enters the bloodstream • Glycogen in muscles is acted on • Lactic acid is produced • Lactic acid is converted to glucose in the liver • Increased insulin receptor numbers on cell surface • Increased sensitivity of insulin receptors • Promotes gluconeogenesis/breakdown of lipids/amino acids	1–2
	Total 12