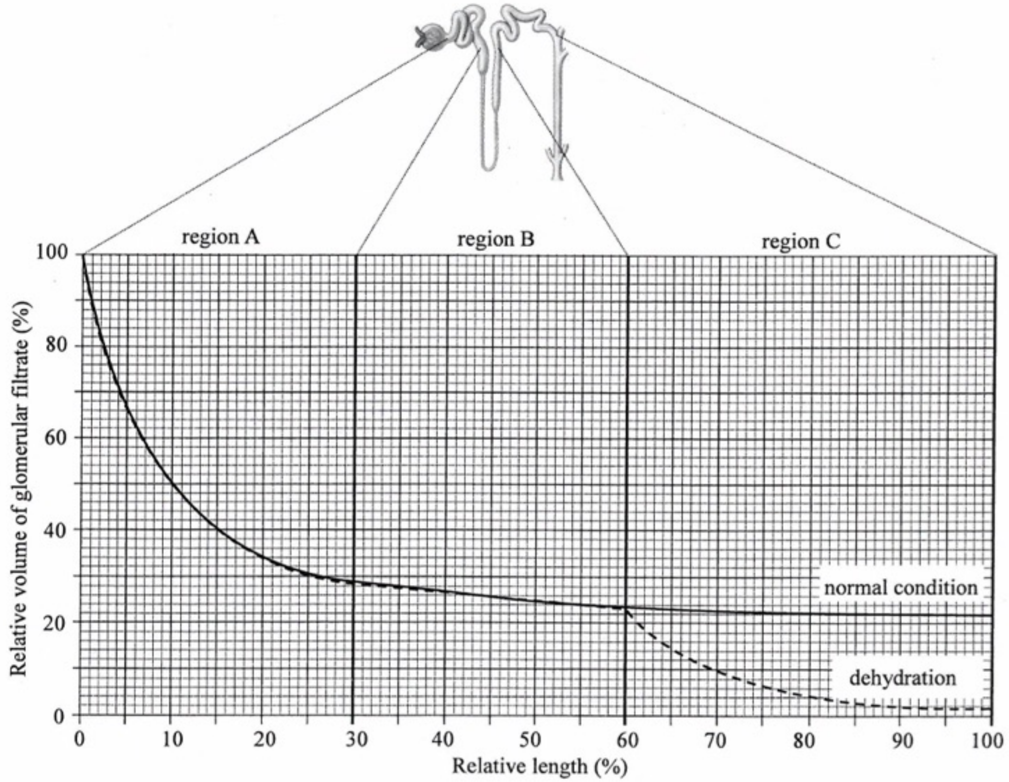
Biology Paper 2 Electives BY TOPIC AL CE DSE 1980-2022	TOPIC
Human Physiology	**Regulation of water content**
	Regulation of body temperature
	Regulation of gas content in blood
	Hormonal control of the reproductive cycle

2022

SECTION A **Human Physiology: Regulation and Control**

Answer **ALL** parts of the question.

1(a) The graph below shows the change in volume of the glomerular filtrate along different regions of the kidney tubule under normal and dehydrated conditions:



(i) Describe how the glomerular filtrate is formed in the Bowman's capsule. (2 marks)

(ii) With reference to the above graph, state the region of the kidney tubule in which most water is reabsorbed. (1 mark)

(iii) If the average volume of the glomerular filtrate formed each day is 180 L, what is the volume of water reabsorbed daily in the region stated in (ii)? (1 mark)

(iv) Explain how water is reabsorbed into the blood from the glomerular filtrate within the region stated in (ii). (3 marks)

(v) With reference to the hormonal control of osmoregulation, explain the difference in the relative volume of the glomerular filtrate at the end of region C of the kidney tubule under the two different conditions mentioned above. (4 marks)

1(b) An experiment was conducted to investigate the respiratory responses during exercise in healthy persons and in patients with hardening of lung tissue. They were asked to ride a cycling machine set at the same resistance, holding a slow constant speed for ten minutes. Their breathing rates, breathing depths and plasma gas levels were continuously monitored throughout the experiment. The results are shown in the table below:

Time (min)	Breathing rate (breath min^{-1})		Breathing depth (L)		Plasma oxygen level (arbitrary unit)		Plasma carbon dioxide level (arbitrary unit)	
	Healthy persons	Patients	Healthy persons	Patients	Healthy persons	Patients	Healthy persons	Patients
0	14	20	0.9	0.7	82.5	75.8	42.5	42.0
2	16	29	1.8	1.0	83.9	70.2	43.2	42.4
4	18	35	2.2	1.1	84.0	67.1	43.3	43.5
6	19	37	2.3	1.2	84.3	63.2	43.8	43.6
8	20	40	2.4	1.2	84.3	62.0	43.9	43.7
10	20	44	2.4	1.2	84.3	60.5	43.9	43.7

(i) State how the breathing depth of the patients was different from that of the healthy persons. (2 marks)

(ii) Based on the condition of the patients, suggest an explanation for the difference stated in (i). (2 marks)

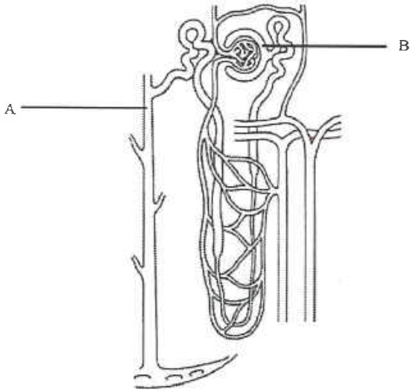
(iii) With reference to the data shown, deduce with reasons which parameter, plasma oxygen level or plasma carbon dioxide level, was more significant in bringing about changes in the breathing rate of the patients after six minutes. (3 marks)

(iv) With reference to the plasma gas levels, explain why patients would feel dizzy if the experiment continued for another ten minutes. (2 marks)

Human Physiology: Regulation and Control

Regulation of water content
2012sp (1b)

1.(b) The diagram below shows the structure of a nephron:



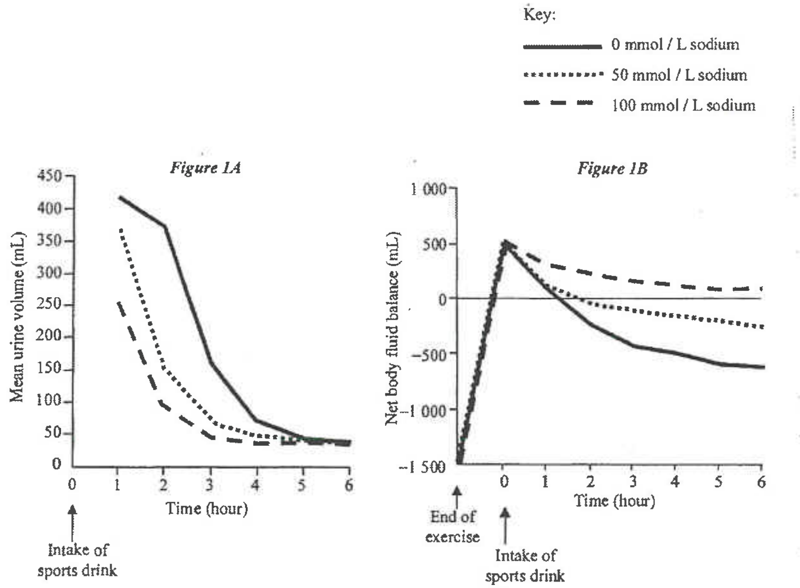
(i) Explain why the fluid in A has a lower percentage of glucose but a higher percentage of urea than that in B. (2 marks)

(ii) Explain the change in the concentration of the fluid in A after heavy sweating. (5 marks)

(iii) Patients suffering from kidney failure may need to receive treatments involving a dialysis machine which works on similar biological principles as the kidney. State ***one*** similarity and ***one*** difference between the functioning of the artificial membrane in the dialysis machine and that of the wall of nephrons. (2 marks)

2012(1a)

1.(a) In a study about the replenishment of water after exercise, participants performed exercise until they lost 1 500 mL water. They were then divided into 3 groups and asked to consume a 2 000 mL sports drink containing 0, 50 and 100 mmol / L sodium respectively. Urine samples were collected at 1-hour intervals for 6 hours and the net body fluid balance throughout the course of the experiment was determined. The results are respectively shown in the Figures 1A and 1B below:



(i) Describe the general patterns of the urine output after consuming drinks with different sodium concentrations. (4 marks)

(ii) Account for the high urine output of the participants who consumed sports drink with 0 mmol / L sodium. (4 marks)

(iii) In terms of the replenishment of water, which sports drink would you recommend for athletes to consume after exercise? Explain your answer. (3 marks)

2014(1a)

1(a) The table below shows the amounts of different substances handled by the kidneys:

	Amount filtered into the kidney tubules	Amount reabsorbed into blood capillaries	Amount excreted along with urine
Glucose (g day^{-1})	180	180	0
Hydrogencarbonate (mEq day^{-1})	4 320	4 318	2
Sodium (mEq day^{-1})	25 560	25 410	150
Chloride (mEq day^{-1})	19 440	19 260	180
Potassium (mEq day^{-1})	756	644	92
Urea (g day^{-1})	47	23.5	23.5

(i) With reference to the mechanisms involved in reabsorption, account for the differences in the amount of glucose and urea handled by the kidneys. (4 marks)

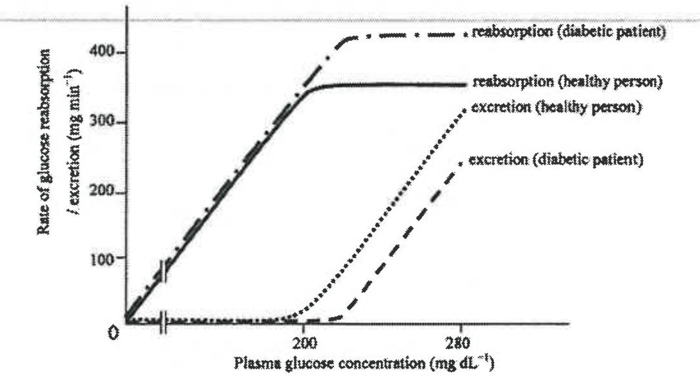
(ii) Of the total amount of water reabsorbed by the kidneys, only a small amount is regulated by a hormone.

(1) Using the information provided in the table, explain how most of the water is reabsorbed regardless of hormonal control. (3 marks)

(2) State the hormone which is responsible for regulating the reabsorption of water and state how it works. (2 marks)

2016(1b)

1(b) The graph below shows the renal glucose handling capability (reabsorption and excretion) in a healthy person and in a patient suffering from non-insulin-dependent (type II) diabetes:



(i) Describe the change in the renal handling of glucose in the healthy person if the plasma glucose concentration increases from 0 to 280 mg dL^{-1}. (4 marks)

(ii) It is noted that there is an increased expression of a gene coding for membrane glucose carriers in the kidney tubules of type II diabetic patients.

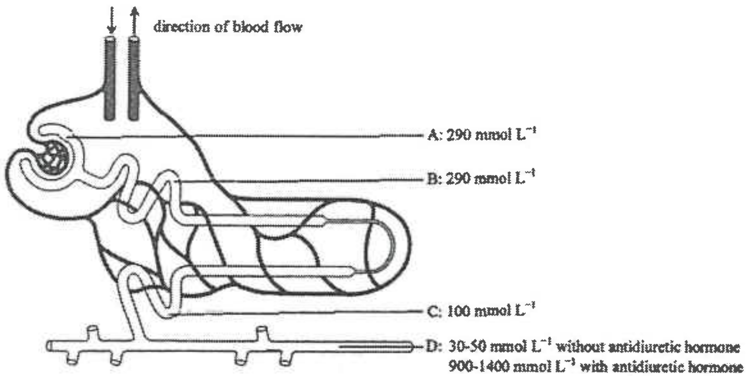
(1) In which region of the kidney tubules are these membrane glucose carriers located? (1 mark)

(2) Suggest why the type II diabetic patient has a higher glucose reabsorption capability. (2 marks)

(iii) If the diabetic condition of the patient is not properly managed, the plasma glucose concentration can rise to a level beyond 300 mg dL^{-1}. Explain why diabetic patients urinate more frequently than healthy persons. (4 marks)

2017(1b)

1(b) The diagram below shows a nephron and its associated structures. The solute concentration of the fluid at different positions in the tubules are indicated:



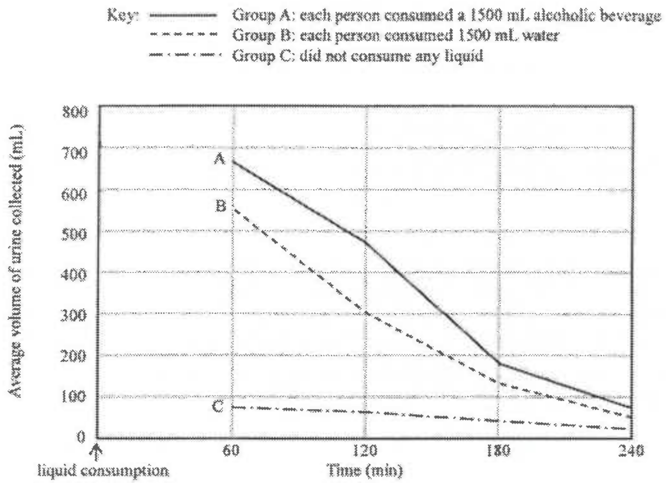
(i) With reference to the physiological processes involved, explain why there is no change in the solute concentration of the fluid inside the tubule as the fluid flows from point A to point B. (4 marks)

(ii) Account for the difference in the solute concentration of fluid in point D with or without antidiuretic hormone (ADH). (3 marks)

(iii) If protein is present in the fluid in point D, which part of the nephron is most likely damaged? Explain your answer. (2 marks)

2018(1a)

1(a) In a study of the effect of consuming different liquids on urine production, three groups of healthy persons were asked to follow the same pattern of physical activity and dietary intake. After that, Group A consumed a 1500 mL alcoholic beverage, Group B consumed 1500 mL water and Group C did not consume any liquid. Their urine was collected and its volume measured at 60-minute intervals over a period of 240 minutes. The results are shown in the graph below:



(i) With reference to the hormonal control of osmoregulation, explain why Group C had a much lower average volume of urine produced than Group A and Group B. (5 marks)

(ii) (1) With reference to the results of Group A and Group B, what is the overall effect of consuming alcoholic beverages on urine production? (1 mark)

(2) Based on (ii) (1), deduce *one* possible effect of alcohol on the hormonal control of osmoregulation. (1 mark)

(iii) Explain why the participants should avoid doing vigorous physical activity during the study. (2 marks)

2019(1b)

1(b) To investigate the effects of dehydration on cardiovascular functions, professional cyclists were divided into two groups (dehydrated group and hydrated group) and asked to ride a cycling machine set at the same resistance for 120 minutes. The dehydrated group did not drink any fluid throughout the course of the experiment, while the hydrated group drank an isotonic fluid to compensate for the water loss during cycling. The table below shows the changes in their cardiovascular functions:

Duration of exercise (min)	Heart rate (beat min^{-1})		Stroke volume (L)		Cardiac output (L min^{-1})	
	Dehydrated group	Hydrated group	Dehydrated group	Hydrated group	Dehydrated group	Hydrated group
10	138	139	0.138	0.136	19.0	18.9
60	155	148	0.120	0.129	18.6	19.1
110	168	150	0.093	0.128	15.7	19.2

(i) Over the course of the experiment, the cycling speed of the hydrated group was constant while that of the dehydrated group dropped slowly. With reference to the data on cardiac output, explain the performance of the two groups of cyclists in terms of the cycling speed. (5 marks)

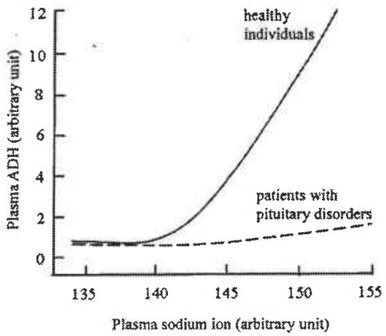
(ii) (1) With reference to the data on heart rate and stroke volume in the dehydrated group, which parameter led to the change in their cardiac output? (1 mark)

(2) With reference to water balance in the dehydrated group, explain the change in the parameter stated in (1) during the course of the experiment. (2 marks)

(iii) Suggest why there was a greater increase in heart rate in the dehydrated group as compared to the hydrated group. (2 marks)

2020(1a)

1(a) In a study, the plasma antidiuretic hormone (ADH) level and plasma sodium ion level of two groups of individuals were compared. They were healthy individuals and patients with disorders of the pituitary gland. The graph below shows the relationship between the levels of the two substances in their bodies:



(i) With reference to the above graph, describe the change in the plasma ADH level in these two groups of individuals. (3 marks)

(ii) According to your answer in (a) (i), explain how the volume and concentration of urine produced by the patients would be different from that produced by healthy individuals. (3 marks)

(iii) Explain how the increase in plasma sodium ion level leads to changes in plasma ADH level in healthy individuals. (3 marks)

(iv) Some female patients with pituitary disorders do not menstruate. Based on your knowledge of the function of the pituitary gland, propose a possible explanation for this phenomenon. (3 marks)

DSE21_01(b)(iv)

(iv) The effect described in (iii) is beneficial in regulating water balance in the hypertonic group of volunteers. Explain why. (2 marks)

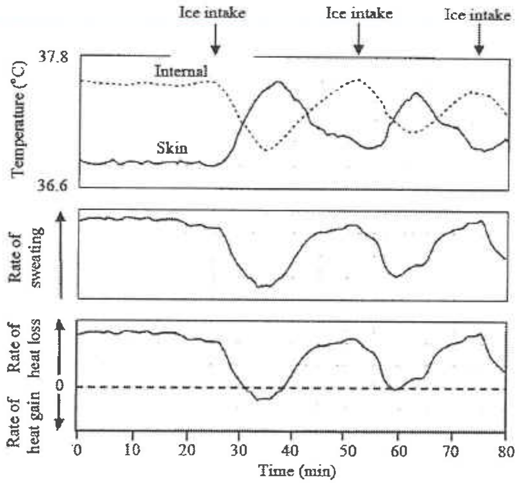
Regulation of body temperature
2012sp (1a)

1.(a) In an experiment conducted in a room with an air temperature of 45℃, a healthy man was asked to consume a large quantity of crushed ice (about 500 g) from time to time. Measurement of the following parameters were taken from the man during the course of the experiment:

- internal body temperature (taken at the eardrum which indicates the temperature of the blood supplying the hypothalamus)
- skin temperature
- rate of sweating
- rate of body heat loss / gain

(N.B. It was noted that the metabolic rate of this person ***remained unchanged*** throughout the experiment.)

The data are presented in the following graphs:



(i) Describe the changes in the man's internal body temperature and the skin temperature within the five minutes after the crushed ice was consumed. (2 marks)

(ii) Explain how the consumption of crushed ice had brought about the change in the internal body temperature you stated in (i). (2 marks)

(iii) The change in skin temperature within five minutes after the consumption of crushed ice was the result of homeostatic response. Explain the mechanisms involved in bringing about this change in skin temperature with reference to the graphs. (4 marks)

(iv) According to the findings of this experiment, the following deduction can be made: environmental temperature plays a less dominant role in causing sweating when compared to internal body temperature.
What evidence supports this deduction? (3 marks)

2012(1b)

1.(b) In the study described in (a), the participants performed exercise in a room maintained at 34°C and 60-70% relative humidity.

(i) State ***two*** major ways in which participants lost water during exercise. (2 marks)

(ii) If the temperature and relative humidity in the room had been set higher, it would have been dangerous to the participants. Explain why this is so. (4 marks)

(iii) After the exercise, the breathing rate of the participants remained at a fairly high level. Explain the significance of this. (3 marks)

2018(1b)

1(b) Nowadays, many weather forecast apps list 'real feel' temperature in addition to air temperature. The real feel temperature is the temperature which takes into account multiple factors influencing the effectiveness of heat loss from the human body. The higher the effectiveness, the lower is the real feel temperature. The table below shows the real feel temperatures at different air temperatures and relative humidities (other environmental conditions remain the same):

		Air temperature (°C)			
		24	*28*	*32*	*36*
Relative humidity (%)	*40*	24	29	34	39
	50	24	29	35	41
	60	25	30	36	41
	70	26	31	37	42
	80	26	32	37	44
	90	27	32	38	45
	100	27	33	39	46

Note: Real feel temperatures are highlighted in grey.

(i) Describe the effect of relative humidity on the real feel temperature. Explain this phenomenon with reference to the effectiveness of heat loss from the body. (3 marks)

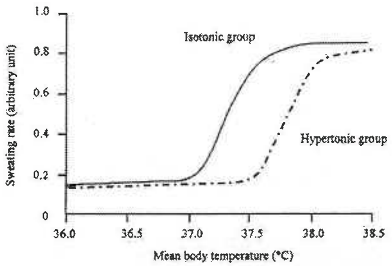
(ii) How does the effect described in (i) change at higher air temperatures? Explain this phenomenon with reference to the effectiveness of heat loss from the body. (3 marks)

(iii) Other than relative humidity and air temperature, suggest ***two*** environmental factors that may affect the real feel temperature. Explain your answer. (4 marks)

(iv) People who are engaged in outdoor work or activities are advised to drink plenty of water when the Hong Kong Observatory issues the Very Hot Weather Warning. Based on your biological knowledge, suggest an explanation for this advice. (1 mark)

DSE21_1(b)(i)-(iii)

1(b) An investigation was carried out to study the effect of the water content of blood on the thermoregulatory response. Volunteers were divided into two groups with the blood water content of one group maintained at isotonic condition while the other group at hypertonic condition. They were asked to immerse their bodies in hot water to mid-chest level for 30 minutes. The rate of sweating at the forehead and the body temperature of the volunteers were continuously monitored throughout the experiment. The relationship between these two parameters of the groups is shown in the graph below:



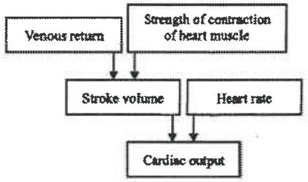
(i) State the receptor and effector involved in the thermoregulatory response of the isotonic group. (2 marks)

(ii) With reference to the thermoregulatory response of the isotonic group shown in the above graph, explain why the change brought about by this response is regarded as an example of negative feedback. (4 marks)
(Note: The nervous coordination of the response is *not* required.)

(iii) With reference to the above graph, deduce the effect of the hypertonic condition of blood on the negative feedback mechanism of the thermoregulation of the volunteers. (2 marks)

Regulation of gas content in blood
2012pp(1b)

1(b) Cardiac output refers to the blood volume supplying to the systemic circulation. The diagram below shows some factors that affect cardiac output:



(i) The contraction of which heart chamber determines the stroke volume? (1 mark)

(ii) Explain how the stroke volume is affected by the venous return and strength of the contraction of heart muscle. (2 marks)

(iii) Explain *one* way in which the venous return is increased when a person is doing exercise. (3 marks)

(iv) The average running speed in a marathon is usually much lower than that in a 100 m race. Explain why it is not possible for marathon runners to run at the same average speed as a 100 m runner throughout a marathon. (5 marks)

2014(1b)

1. (b) The table below shows the data of some parameters of the cardiovascular and respiratory systems of a healthy untrained person at rest, during light exercise and during vigorous exercise:

	At rest	Light exercise	Vigorous exercise
Heart rate (beats / min)	75	145	190
Stroke volume (dm^3)	0.07	0.09	0.11
Breathing rate (breaths / min)	14	24	40
Tidal volume (dm^3)	0.86	1.67	2.50

(i) Using the data provided, calculate the cardiac output (dm^3 / min) and ventilation rate (dm^3 / min) of this person when he is at rest, when he is doing light exercise and when he is doing vigorous exercise respectively. (2 marks)

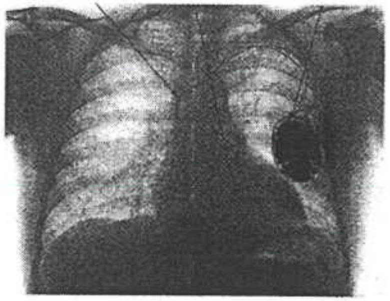
(ii) State the changes in this person's cardiac output and ventilation rate with the increasing level of exercise. What is the importance of these changes? (4 marks)

(iii) Describe how the person's sympathetic nerve brings about the change in the cardiac output during exercise. (2 marks)

(iv) Explain why the volume of urine produced by this person after vigorous exercise is less than usual. (4 marks)

2013(1a)

1(a) The X-ray photograph below shows a small electronic device that has been surgically implanted into the chest cavity of a patient suffering from heart disease. This device maintains the proper rhythm of the patient's heart.



(i) Which structure of the heart does the device replace functionally? (1 mark)

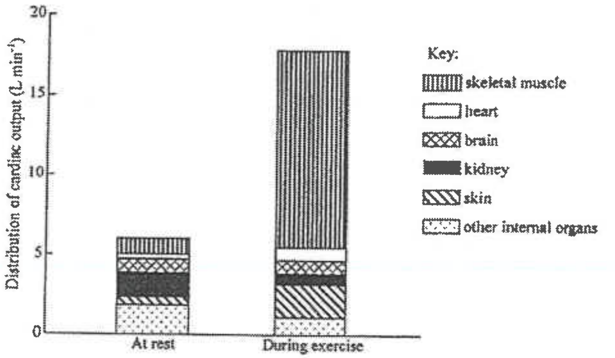
(ii) The structure mentioned in (i) triggers a series of events that lead to the proper functioning of the heart. Describe these events. (4 marks)

(iii) During the cardiac cycle, there is a period of time in which both atria and ventricles are in a relaxed state. Briefly describe the pathway of blood flow returning from the lungs to the heart chambers during this period. (3 marks)

(iv) With reference to a hormone, describe how it can bring about an increase in cardiac output. (3 marks)

2015(1b)

1(b) The diagram below shows the distribution of cardiac output to various parts of the human body at rest and during exercise:



(i) With reference to the control of heart beat, briefly describe *two* regulatory ways in which the cardiac output can be increased during exercise. (2 marks)

(ii) Explain the importance of skeletal muscles having the greatest increase in blood supply during exercise. (3 marks)

(iii) Explain why there is an increase in blood flow to the skin during exercise. (4 marks)

2016(1a)

1(a) The table below shows how the relative percentages of energy contribution from anaerobic and aerobic respiration change with different durations of vigorous exercise:

Duration of vigorous exercise	Relative percentage of energy contribution	
	Anaerobic respiration	Aerobic respiration
10 seconds	95	5
30 seconds	85	15
1 minute	70	30
2 minutes	50	50
8 minutes	30	70
12 minutes	15	85
30 minutes	5	95

(i) What is the relationship between the duration of vigorous exercise and the energy contribution from the two respiratory pathways? (1 mark)

(ii) For vigorous exercise of short duration (10-30 seconds), energy mainly comes from the breakdown of the food store in muscles.

(1) Use a flowchart to show the two major steps in converting this food store to a usable form of energy through the anaerobic pathway. (2 marks)
(Note: Details of the intermediates in the pathway are not required.)

(2) Even though energy mainly comes from the anaerobic pathway, athletes who have just performed vigorous exercise for short duration still need to breathe fast for a while. Explain the importance of this phenomenon. (2 marks)

(iii) During exercise, our sympathetic nervous system is stimulated. Explain how this will bring about physiological changes to sustain the exercise. (4 marks)

2017(1a)

1(a) Ellen went swimming with her friends on a windy day. They competed to hold their breath under water for the longest time. Ellen finally won the competition by holding her breath for 2 minutes.

(i) When Ellen was holding her breath, which part of her brain was controlling the breathing actions? (1 mark)

(ii) When Ellen left the water, she breathed rapidly and heavily.

(1) What was the stimulus leading to this response? How was this stimulus brought about when Ellen was holding her breath under water? (3 marks)

(2) Describe the nervous coordination leading to this response. (4 marks)

(iii) After Ellen had left the water, she felt cold in the wind. Give *one* physiological response her body would exhibit to help her regulate the body temperature. State the significance of this response. (3 marks)

2019(1b)

1(b) To investigate the effects of dehydration on cardiovascular functions, professional cyclists were divided into two groups (dehydrated group and hydrated group) and asked to ride a cycling machine set at the same resistance for 120 minutes. The dehydrated group did not drink any fluid throughout the course of the experiment, while the hydrated group drank an isotonic fluid to compensate for the water loss during cycling. The table below shows the changes in their cardiovascular functions:

Duration of exercise (min)	Heart rate (beat min^{-1})		Stroke volume (L)		Cardiac output (L min^{-1})	
	Dehydrated group	Hydrated group	Dehydrated group	Hydrated group	Dehydrated group	Hydrated group
10	138	139	0.138	0.136	19.0	18.9
60	155	148	0.120	0.129	18.6	19.1
110	168	150	0.093	0.128	15.7	19.2

(i) Over the course of the experiment, the cycling speed of the hydrated group was constant while that of the dehydrated group dropped slowly. With reference to the data on cardiac output, explain the performance of the two groups of cyclists in terms of the cycling speed. (5 marks)

(ii) (1) With reference to the data on heart rate and stroke volume in the dehydrated group, which parameter led to the change in their cardiac output? (1 mark)

(2) With reference to water balance in the dehydrated group, explain the change in the parameter stated in (1) during the course of the experiment. (2 marks)

(iii) Suggest why there was a greater increase in heart rate in the dehydrated group as compared to the hydrated group. (2 marks)

2020(1b)

1(b) In an investigation, a volunteer stayed at rest and breathed in air containing different concentrations of carbon dioxide. Some parameters related to breathing were measured. The results are shown in the table below:

Concentration of carbon dioxide in the inspired air (%)	Breathing rate (min^{-1})	Breathing depth (L)	Ventilation rate ($L\ min^{-1}$)
0.04	14	0.5	7.0
0.80	14	0.6	8.4
1.50	14	0.8	11.2
2.70	14	1.2	16.8
3.50	15	1.6	24.0
4.30	17	1.7	28.9
5.60	24	1.7	40.8
6.50	29	1.7	49.3

(i) State the parameter which contributed most to the change in ventilation rate in different ranges of carbon dioxide concentrations. (2 marks)

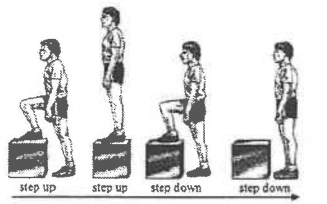
(ii) Suggest why the breathing depth remained steady as the carbon dioxide concentration exceeded 4.3%. (1 mark)

(iii) Describe the effect of an increase in carbon dioxide concentration on the volunteer's ventilation rate. (1 mark)

(iv) Explain how the increased concentration of carbon dioxide led to a change in the ventilation rate. (4 marks)

DSE21_01(a)

1(a) Two young students, Alice and Billy, carried out a series of step-up exercises of increasing intensity. Each exercise lasted for three minutes by stepping up and down on a wooden box at a fixed speed (i.e. 2, 6 or 10 step-ups per 10 seconds) as shown in the diagram below:



Their heart rates and blood lactate concentrations were measured at rest and immediately after each exercise. Before the start of the next exercise, the students were allowed to rest until their heart rate and blood lactate concentration returned to their levels at rest. The results are shown in the table below:

Intensity of exercise (No. of step-ups per 10s)	Heart rate (beat min^{-1})		Blood lactate concentration ($mmol\ L^{-1}$)	
	Alice	Billy	Alice	Billy
0 (at rest)	58	80	0.42	0.43
2	64	91	0.63	0.82
6	94	132	0.82	2.40
10	130	178	1.20	5.80

(i) Describe the overall effects of increasing the intensity of exercise on the heart rate and blood lactate concentration. (1 mark)

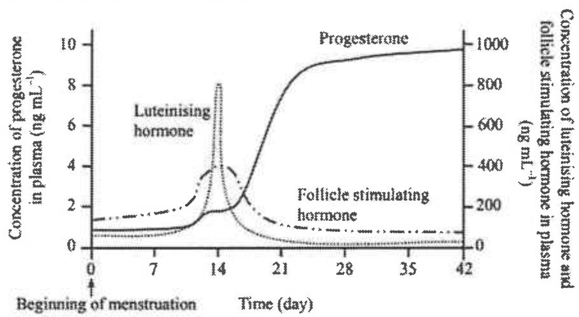
(ii) According to your answers in (i), explain the change in blood lactate concentration during the exercise. (3 marks)

(iii) According to your answer in (i), describe how the nervous system brings about the change in heart rate during the exercise. (4 marks)

(iv) Alice is a trained athlete. Give *two* pieces of supporting evidence from the data. (2 marks)

Hormonal control of the reproductive cycle
2012pp(1a)

1. (a) The following graph shows the plasma concentrations of progesterone, luteinising hormone and follicle stimulating hormone of a woman over a period of time:



(i) Name the process that took place in the ovary on day 14. (1 mark)

(ii) Account for the change in the plasma concentration of progesterone from day 14 to day 42. (3 marks)

(iii) What would happen to the woman if the progesterone level dropped significantly on day 35? (1 mark)

(iv) With reference to the changes in the concentration of the hormones shown in the above graph, explain why progesterone can be used as a drug for contraception. (3 marks)

2013(1b)

1(b) Kathy has been married for two years. In the first year, she took a progesterone-containing contraceptive pill. Then she stopped taking it and got pregnant. Three months later she noticed bleeding from her vagina. Her doctor gave her progesterone to stop the bleeding.

(i) Explain how progesterone in the contraceptive pill prevented Kathy from becoming pregnant. (5 marks)

(ii) (1) What was the possible cause and consequence of the bleeding from Kathy's vagina? (2 marks)

(2) How did the progesterone prescribed by the doctor help Kathy in this case? (2 marks)

2015(1a)

1(a) A young couple, John and Judy, wanted to have a baby. After a year of trying, Judy had still not become pregnant. They consulted their family doctor on this issue. The doctor suggested that both of them should undergo some tests to check their fertility.

(i) The doctor requested a semen sample from John for microscopic examination. Suggest *two* items in the sample that should be checked. (2 marks)

(ii) After collecting information about Judy's menstrual cycle, the doctor requested blood samples from Judy to monitor her levels of LH and FSH.

(1) Why should the levels of LH and FSH be checked? (3 marks)

(2) The doctor also checked the condition of Judy's oviducts. What is the importance of this examination? (2 marks)

(iii) All the test results were normal. Three months later, Judy did not experience menstruation on the expected day.

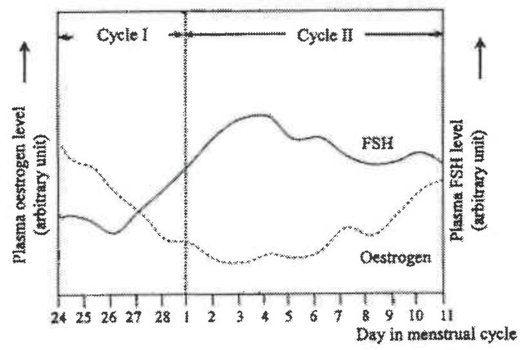
(1) Explain why the absence of menstruation can be a sign of pregnancy. (2 marks)

(2) A hormone named HCG was detected in Judy's blood and urine. HCG prevents the degeneration of the yellow body. Based on the action of HCG, explain why Judy did not experience menstruation. (2 marks)

2019(1a)

1(a) To investigate the interaction between oestrogen and follicle stimulating hormone (FSH), the plasma levels of the two hormones in a group of females were measured over a period of time. Graph 1 below shows the change in the plasma levels of the two hormones throughout the course of the study:

Graph 1



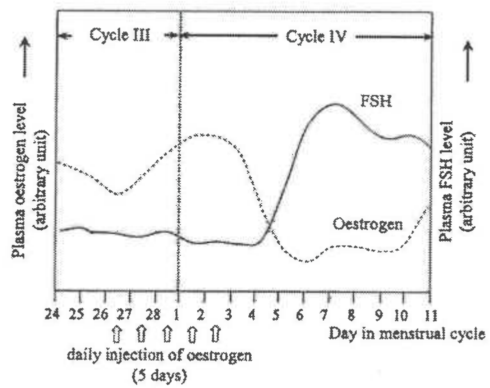
(i) With reference to the events occurring in the ovaries, explain the changes in plasma oestrogen level during the following periods of time:

(1) from day 24 of cycle I to day 3 of cycle II (2 marks)

(2) from day 5 to day 11 of cycle II (2 marks)

(ii) The same group of females received an additional daily oestrogen injection from day 26 of cycle III for 5 consecutive days. Graph 2 below shows the changes in the plasma levels of the two hormones over the same period of time:

Graph 2

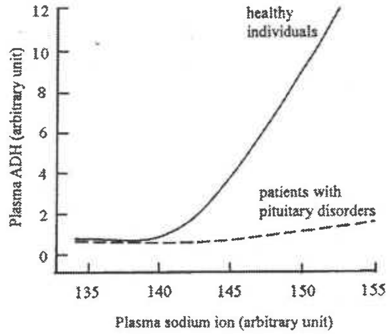


(1) The pattern of the change in plasma FSH level in Graph 2 was modified by the injection of additional oestrogen. With reference to graphs 1 and 2, deduce the effect of oestrogen on FSH. Explain your answer. (4 marks)

(2) Contraceptive pills usually contain oestrogen and progesterone. With reference to your answer in (1), explain the function of oestrogen in these contraceptive pills. (2 marks)

2020(1a,iv)

1(a) In a study, the plasma antidiuretic hormone (ADH) level and plasma sodium ion level of two groups of individuals were compared. They were healthy individuals and patients with disorders of the pituitary gland. The graph below shows the relationship between the levels of the two substances in their bodies:



(i) With reference to the above graph, describe the change in the plasma ADH level in these two groups of individuals. (3 marks)

(ii) According to your answer in (a) (i), explain how the volume and concentration of urine produced by the patients would be different from that produced by healthy individuals. (3 marks)

(iii) Explain how the increase in plasma sodium ion level leads to changes in plasma ADH level in healthy individuals. (3 marks)

(iv) Some female patients with pituitary disorders do not menstruate. Based on your knowledge of the function of the pituitary gland, propose a possible explanation for this phenomenon. (3 marks)

Regulation of water content

2012sp (1b)

1.(b) (i)
- when the fluid passes from B to A, all glucose will be reabsorbed in the first / proximal coiled tubule (1), so no glucose is present in the fluid in A (2)
- the percentage of water reabsorbed is higher than that of urea (1), so the percentage of urea in A is higher than that in B

(ii)
- after the loss of much water in heavy sweating, the water potential of the blood decreases (1) (5)
- this stimulates the release of ADH from the pituitary (1)
- ADH increases the permeability of the second / distal coiled tubule and the collecting duct to water (1)
- thus a greater proportion of / more water will be reabsorbed (1) from the fluid in A into the blood by osmosis
- as a result, the concentration of the fluid in A increases (1)

(iii) Similarity: (2)
- both the dialysis membrane and the wall of the nephron allow small molecules such as urea and other waste materials to pass through but not plasma proteins and blood cells (1)

Difference:
- the cells of the wall of the nephron actively reabsorb useful substances (e.g. glucose) into the blood, while the dialysis membrane has no such function (1)

Total: 9 marks

2012(1a)

1. (a) (i)
- regardless of the sodium concentration of the drinks, the greatest urine output occurred over the 1st hour (1) (1)
- the urine output then dropped continuously (1) until the 5th hour. (1)
- the urine output became more or less the same (1) (1)
- the urine output of the participants who consumed drinks with higher sodium content were usually smaller than those participants who consumed drinks with lower sodium content (1), or vice versa (1)

(ii)
- after drinking the sports drink with 0 mmol / L sodium, the hypothalamus detected an increased in the water potential of the blood (1) (1)
- the pituitary gland released less ADH into the blood circulation (1) (1)
- as a result, the wall of the collecting ducts of the kidney tubule became less permeable to water (1) (1)
- thus, a smaller proportion of water was reabsorbed (1) (1)
  and hence, the volume of urine output increased

(iii)
- sports drink with 100 mmol / L sodium (1) (1)
- smaller urine output, indicating that the body retains more water (1) (1)
- the net fluid balance remains high than 0 throughout the study (1) (1)

2014(1a)

1. (a) (i)
- all glucose filtered in the kidney tubules is reabsorbed into the blood (1)
- because it is reabsorbed by means of active transport (1) (4)
- however, only half of the urea is reabsorbed back into the blood (1)
- as urea is reabsorbed by means of diffusion only (1)

(ii) (1)
- as most of the substances in the glomerular filtrate are reabsorbed into the blood (1)
- the water potential of blood is much lower than the remaining fluid in the kidney tubules (1) (3)
- hence, there is a net flow of water from the filtrate in the kidney tubules to the blood in the blood capillaries by osmosis (1)

(2)
- antidiuretic hormone / ADH (1)
- it increases the permeability of the collecting duct to water (1) so more water will be reabsorbed (2)

2016(1b)

(b) (i)
- glucose reabsorption increases with the plasma glucose concentration (1) if it increases between 0 - 200 (± 20) mg dL^{-1}
- while no glucose is excreted (1)
- beyond 200 (± 20) mg dL^{-1} (i.e. the threshold), reabsorption of glucose remains unchanged / levels off / remains constant (1) (4)
- and excretion of glucose in urine begins and increases with the rise in plasma glucose concentration (1)

(ii) (1)
- the first coiled tubule / first convoluted tubule / proximal convoluted tubule (1) (1)

(2)
- because the expression of the gene resulted in greater number of glucose transporters at the kidney tubule (1)
- hence, rate of glucose reabsorption is higher / more glucose can be reabsorbed per unit time / more glucose can be absorbed for the same length of kidney tubule (1) (2)

(iii)
- they fails to reabsorb all glucose from the glomerular filtrate / glucose reabsorption is incomplete / some glucose remains in the glomerular filtrate (1)
- hence the glomerular filtrate of diabetic patients has a lower water potential than that of healthy people (1) (4)
- as a result, less proportion of water can be reabsorbed back at the collecting duct (1)
- larger volume of urine will be produced (1), and they need to urinate more frequently

2017(1b)

(b) (i)
- useful solutes, e.g. glucose, sodium ion, amino acids, are reabsorbed back into the capillary by active transport along the first coiled tubule (1)
- hence, water potential of the blood surrounding the tubule decreases / water potential of the filtrate increases (1)
- as a result, water moves out of the first coiled tubule along the water potential gradient by osmosis / water molecules move along with solutes (1) (4)
- the amount of water reabsorbed is proportional to the amount of solutes reabsorbed (1)
  hence, solute concentration remains the same as the fluid flow from point A to point B

(ii)
- fluid at point D without ADH has a lower solute concentration than that with ADH (1)
- ADH increases the permeability of the second coiled tubule and the collection duct (D) to water (1) (3)
- as a result, a larger proportion of water is reabsorbed (1), resulting in a higher solute concentration

(iii)
- glomerulus (1)
- the wall of glomerulus is impermeable to plasma protein / protein molecules are too large to pass through the wall of glomerulus (1) (2)
  if protein is present in the kidney tubule, it is most likely that the wall of glomerulus is damaged

2018(1a)

1. (a) (i)
- Group C did not drink any liquid in the experiment, therefore the water potential of the blood in persons in group C was lower than that of the groups A and B (1)
- this was detected by the osmoreceptors / the hypothalamus (1)
- which then stimulated the pituitary gland to release more ADH (1) into the blood (5)
- more ADH resulted in higher permeability of collecting duct of the nephron to water (1)
- as a result, a larger proportion of / more water was reabsorbed at the collecting duct (1), i.e. less urine was produced

(ii) (1)
- alcohol consumption resulted in the production of more urine (1) (1)

(2)
- more urine production suggested that the release / production of ADH might have been inhibited by alcohol (1) (1)

(iii)
- to prevent the participants from losing water through sweating (1) (2)
- as this may reduce the urine production (1) and interfere with the results

Regulation of body temperature

2012sp (1a)

1.(a) (i)
- shortly after the consumption of ice, his internal body temperature fell (1) with a concomitant rise in the skin temperature (1) (2)

(ii)
- the consumption of the large quantity of ice had a cooling effect on the blood in the gut (1) (2)
- as blood circulated to the hypothalamus (1), a fall in internal body temperature was registered

(iii)
- as the hypothalamus registered a fall in internal temperature (1), homeostatic mechanism would be switched on to conserve heat / to reduce heat loss so as to restore the internal temperature to normal (1) (4)
- a nervous signal was sent to the skin / sweat glands to reduce sweating (1)
- skin temperature increased as less heat is lost to the surroundings by evaporation of sweat (1)

OR
- as the hypothalamus registered a fall in internal temperature (1)
- a nervous signal was sent to the skin / sweat glands to reduce sweating (1)
- less heat was lost to the surroundings by evaporation of sweat (1)
- skin temperature increased as the rate of heat loss is lower than the rate of heat gain (1)

(iv)
- since the room temperature was kept at 45℃, skin thermoreceptors would have constantly detected this (1) and sent signals to the hypothalamus to bring about heat loss by sweating (1) (3)
- but the findings of this experiment showed that sweating fluctuated with changes in internal body temperature (1), indicating that environmental temperature plays a less dominant role in the control of sweating

2012(1b)

(b) (i) during exercise, water is lost mainly
- through sweating (1) (1)
- as water vapour during expiration / exhalation / breathing (1) (1)

(ii) heat is continuously produced during exercise (1) but the participants will experience difficulty in temperature regulation / may suffer from heat stroke / overheating (1) because (1) (1)
- heat can not be lost effectively through evaporation of sweat when the humidity is too high (1) (1)
- heat lost through convection / radiation is hindered / body may gain heat from the environment (1) when the environmental temperature is high / higher than the body temperature (1)

(iii)
- more oxygen is taken in (1) (1)
- to breakdown lactic acid in the liver / provide additional amount of energy for converting lactic acid in blood to glycogen (1) (1)
- so as to restore blood pH to normal (1) (1)

2018(1b)

(b) (i)
- increased humidity increases the real feel temperature (1)
- sweat evaporation will be hindered at higher relative humidities (1)
- as a result, heat cannot be lost to surrounding effectively by sweat evaporation (1), leading to a feeling of higher temperature at lower relative humidities (3)

(ii)
- the effect intensifies / is stronger / is more serious at at higher temperatures (1)
- because gradient between body temperature and air temperature is narrower at a higher temperature (1) (3)
- therefore, heat loss through conduction / convection / radiation is less effective (1), resulting in a feel of an even higher temperature

(iii) Any *two* sets of the following, mark the first two sets if more than two sets:
- wind speed / air movement (1), higher wind speed increases evaporation of sweat (1)
- sunshine / light intensity / sunny / cloudiness (1), skin absorbs more heat radiation when the intensity is higher (1) (4)
- precipitation (1), wetted skin loses heat to water faster through conduction and evaporation (1)

(iv)
- to compensate for the water loss due to continuous sweating (1)

OR
- if the body does not have sufficient water, sweating may be cut down and heat stroke may occur (1) (1)

Regulation of gas control in blood

2012pp(1b)

1.(b) (i)

	At rest	Light exercise	Vigorous exercise	
Cardiac output (dm^3 / min)	5.25	13.05	20.9	1
Ventilation rate (dm^3 / min)	12.04	40.08	100	1

(ii) Both the cardiac output and ventilation rate increase with the increasing level of exercise. 1
These changes enable a greater supply of oxygen and glucose to reach the skeletal muscles 1
for respiration to produce more energy for contraction. 1
and speed up the removal of carbon dioxide and lactic acid to prevent their accumulation in the body and muscles respectively. 1

(iii) During exercise, the sympathetic nerve innervating the heart is more active and increases its output (releases more noradrenaline) / stimulates the adrenal gland to release more adrenaline. 1
This stimulates the SA node to increase its activity. 1
thus increasing both the heart rate and stroke volume and hence the cardiac output.

(iv) During vigorous exercise, the person sweats more to prevent overheating of the body. 1
The water loss due to sweating results in a decrease in the water potential of the blood. 1
The pituitary gland is stimulated to secrete more ADH into the blood. 1
which makes the collecting ducts of the nephrons in the kidneys more permeable to water so that a greater proportion of water is reabsorbed along the collecting ducts. 1
Hence, a smaller volume of urine is produced.

2013(1a)

1. (a) (i)
- sinoatrial (SA) node / pacemaker (1) (1)

(ii)
- the structure initiates electrical impulses that spread through the walls of both atria (1)
- prompting the atria to contract at the same time (1) (4)
- the impulses then pass to atrioventricular (AV) node (1)
- which relays signals to the ventricular walls to initiate contraction of both ventricles after the contraction of the atria (1)

(iii)
- blood flows from lungs via the pulmonary vein (1)
- and then enters into left atrium (1) (3)
- as the bicuspid valve is open at this stage, the blood flows further into the left ventricle (1)

(iv)
- adrenal gland secretes more adrenaline (1)
- which stimulates the heart muscle to contract more rapidly (1) and more strongly (1) (3)

2014(1b)

(b) (i) • left ventricle (1) (1)

(ii) • venous return determines the volume of blood available inside the ventricle (1)
• while the strength of contraction determines the amount of blood pumped out (1) (2)

(iii) • contraction of skeletal muscles especially in the limbs squeezes the veins (1)
• increasing the blood flow from veins (1)
• thus, more blood is returning to the heart via the vena cava (1) (3)

Or
• breathing depth increases during exercise (1)
• the thoracic pressure becomes more negative (1)
• to assist the upward movement of blood along the vena cava (1)

(iv) • because marathon runners have to run a long distance than 100 m runners, their muscles need to sustain contractions for a longer time (1)
• if they run at the speed of 100 m race, the oxygen supply to muscles will be insufficient (1) (5)
• muscles will carry out anaerobic respiration (1) to produce lactic acid
• as a result, lactic acid accumulates in the muscles (1)
• leading to muscle fatigue (1), i.e. the muscles fail to contract any more

2015(1b)

(b) (i) • increase the nervous output from cardiovascular centre of the brain to the pacemaker (1) (2)
• increase the secretion of adrenaline from adrenal glands (1)

(ii) increase blood flow to skeletal muscles can
• supply more oxygen and nutrients to the muscles (1) (3)
• for respiration to provide energy (1) for muscle contractions
• and to remove carbon dioxide (1) from muscle at adequate speed

(iii) • muscle contractions/exercise produce heat (1)
• thermoreceptors in the hypothalamus / skin detect the increase in body temperature (1)
• heat loss centre in the hypothalamus is stimulated to send out nerve impulses (1) (4)
• to cause vasodilation of the arterioles near the skin surface (1) to increase the blood flow to promote heat loss

2016(1a)

1. (a) (i) • The longer the duration of vigorous exercise, the more the contribution of energy from aerobic respiration / the shorter the duration of vigorous excise, the more the contribution of energy from anaerobic respiration (1) (1)

(ii) (1) • $\underbrace{\text{glycogen} \rightarrow \text{glucose}}_{(1)} \rightarrow \underbrace{\text{lactic acid / lactate} + \text{ATP}}_{(1)}$ (2)

(2) • to provide extra oxygen (1)
• for the breakdown of lactic acid / lactate produced (1) during the exercise period (2)

(iii) • more sympathetic nerve impulses will be sent to the intercostal and diaphragm muscles (1)
• for faster and stronger contractions (1)
• that increases the breathing depth and rate / ventilation (1)
• for rapid gas exchange / loading of oxygen to the blood (1)

OR (4)
• more sympathetic nerve impulses will be sent to the SA node (1)
• for faster and stronger contraction of heart (1)
• that increases the heart rate and stroke volume (1)
• for rapid supply of more blood to the muscle (1) for continuous contraction

2017(1a)

1. (a) (i) • motor area of the cerebrum (1) (1)

(ii) (1) • high / increased concentration of carbon dioxide in blood (1)
• when she held her breath in water, the body cells continued to produce carbon dioxide through respiration (1) (3)
• however, the carbon dioxide could not be excreted through exhalation during the breath holding (1)
as a result, carbon dioxide accumulated in the blood

(2) • the high concentration of carbon dioxide was detected by the chemoreceptors at medulla / carotid body / aortic arch (1)
• this, in turn, stimulated the respiratory centre in the medulla (1) (4)
• more nerve impulses were then sent to the respiratory muscles (i.e. intercostal muscles and diaphragm muscles) (1)
• the respiratory muscles contracted faster and more powerfully (1)

(iii) • vasoconstriction of arterioles in her skin occurs (1)
• this reduces blood flow to the skin surface (1), thus lower skin temperature
• to reduce heat loss to the surrounding / to conserve core body temperature (1) (3)

Or
• shivering (1)
• the respiration rate of muscle increases (1)
• to produce more heat (1) to increase body temperature

2019(1b)

(b) (i)
- cardiac output remained more or less the same / slightly increase in the hydrated group over the course of experiments but dropped continually in the dehydrated group (1)
- as cardiac output indicates the amount of nutrients and oxygen supply (1) to skeletal muscles
- for respiration to release energy (1) (5)
- to support the muscle contractions (1)
- therefore, the constant supply of energy to muscles in the hydrated group allows them to maintain the cycling speed while the decreased energy supplied to muscles in the dehydrated group resulted in their failure in maintaining the cycling speed (1)

(ii) (1)
- stroke volume (1) (1)

(2)
- without replenishment, there was a net water loss in the dehydrated group because of continuous sweating / breathing during the course of experiment (1) (2)
- this leads to the drop in their total blood volume (1), hence stroke volume

(iii)
- the stroke volume of the dehydrated group was lower than that of the hydrated group (1)
- thus, the heart rate increases to compensate the decrease in stroke volume / the heart needs to pump faster to keep a high cardiac output for supporting the exercise (1) (2)

Hormonal control of the reproductive cycle

2012pp(1a)

1 (a) (i) ovulation* 1

(ii) A high LH level stimulates the ruptured follicle to develop into a corpus luteum (yellow body) after day 14. 1
The production of progesterone by the corpus luteum accounts for the continuous rise in plasma concentration of progesterone from day 14 onwards. 1
The high level of progesterone (after day 28) indicates that this woman is pregnant and the corpus luteum continues to produce progesterone. 1

(iii) A significant drop in the progesterone level will cause miscarriage / cause the detachment of the uterine lining / trigger menstruation. 1

(iv) A high progesterone level after day 14 causes the levels of both FSH and LH to become low. 1
At a low level of FSH and LH, there is no follicular development / no maturation of egg. 1
and hence no ovulation will take place. 1
Thus, progesterone can be used as a drug for contraception.

2013(1b)

(b) (i)
- high level of progesterone inhibits the secretion of FSH (1) and LH (1) from the pituitary
- the low level of FSH is not sufficient to stimulate follicular development (1) (5)
- the low level of LH is not sufficient to stimulate ovulation (1)
- as a result, no fertilization takes place (1)

(ii) (1)
- breakdown of uterine lining (1) which may lead to possible miscarriage / abortion (1) (2)

(2)
- progesterone maintains the thickness / thickening of the uterine lining / increases vascularisation / blood supply (1) (2)
- so that the placenta / embryo can attach to the uterine lining more securely (1)

2015(1a)

1\. (a) (i) Any *two* of the following:

- sperm count (1) / abundance
- appearance of sperm (1) for abnormality
- motility of sperm (1)

(2)

(ii) (1)

- there should be a surge / an increase in the levels of FSH and LH before ovulation (1)
- such that there are enough FSH to stimulate the development of follicles in the ovaries (1)
- and enough LH to trigger ovulation (1)

both are essential to the fertility of a woman

(3)

(2)

- to make sure that the oviducts are not blocked (1)
- so that the ovum and sperm can go through for fertilization (1)

(2)

(iii) (1)

- this shows that the uterine lining has not broken down in the last cycle (1)
- which indicates possible implantation of embryo (1)

(2)

(2)

- the yellow body continues to secrete progesterone and oestrogen (1)
- these hormones maintain / further increase the thickness of the uterine lining (1)

therefore, there is no menstruation

(2)

2019(1a)

Marks

1\. (a) (i) (1)

- the corpus luteum / yellow body in ovaries degenerates (1)
- leading to a decrease in the production of oestrogen (1)

(2)

(2)

- oestrogen is secreted by the developing follicle in ovaries (1)
- resulting in an increased oestrogen level during this period (1)

(2)

(ii) (1)

- in Graph 1, the level of FSH increased as the level of oestrogen decreases in the later period in the first cycle, which corresponds to the oestrogen treatment in the 3rd cycle (1)
- following treatment with additional oestrogen shown in Graph 2, FSH level remained low (1) as long as the women received oestrogen injections
- FSH level started to rise again after the oestrogen treatment was stopped / discontinued (1)
- this showed that oestrogen has a negative feedback on FSH level / inhibits the production / release of FSH (1)

(4)

(2)

- oestrogen in contraceptive pills inhibits FSH production, as a result, there will be no follicle development (1)
- therefore, there will be no mature egg for ovulation / no ovulation (1)

(2)