Additional Assessment Materials
Summer 2021

Pearson Edexcel GCE in A Level Biology

Topic 9: Control Systems

(Public release version)

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

1 Mammals produce urea as a nitrogenous waste product.

(a) Describe how urea is produced in mammals.

(2)

Ammonia is formed via deamination of excess amino acids in the liver. Ammonia is combined with carbon dioxide in the ornithine cycle and converted to urea.

(b) Bowman's capsule (renal capsule) in the kidney is involved in the excretion of urea in mammals.

Name the cluster of blood capillaries enclosed by Bowman's capsule.

(1)

Glomerulus

(c) The table shows the concentrations of molecules and ions in the blood plasma of the kidney, in the filtrate produced in Bowman's capsule and in the bladder.

Molecule or ion	Blood plasma of kidney (%)	Filtrate produced in Bowman's capsule (%)	Urine in the bladder (%)
Water	90 to 93	94 to 96	96
Protein	7 to 9	0.0	0.0
Glucose	0.10	0.10	0.0
Urea	0.03	0.03	2.0
Sodium	0.32	0.32	0.30 to 0.35
Chloride	0.37	0.37	0.60

(i) Name the process by which this filtrate is produced in Bowman's capsule.

(1)

Ultrafiltration

(ii) Analyse the data to explain the difference between the protein and the other molecules or ions in the filtrate in Bowman's capsule.

(3)

No protein is present in the filtrate because proteins are too large to pass through the basement membrane of the glomerulus. The concentrations of glucose, urea, sodium and chloride are equal in the blood and glomerular filtrate because they are small enough to pass into the Bowman's capsule. The percentage of water in the filtrate is slightly higher than in the plasma.

(iii) Urea and chloride ions both become more concentrated as they pass from Bowman's capsule to the urine in the bladder.

Calculate how many more times urea becomes concentrated compared with chloride ions.

(3)

urea : $\frac{2.00}{0.03} = 66.67$ $\qquad \frac{66.67}{1.62} = 41.2$

Cl^- : $\frac{0.60}{0.37} = 1.62$

Answer 41.2 times more

(iv) Analyse the data to explain the glucose concentration in the bladder.

(2)

No glucose is present in the bladder. All glucose is selectively reabsorbed into the blood from the filtrate in the proximal convoluted tubule.

(v) Explain how the loop of Henlé is involved in the production of concentrated urine.
(5)

Loop of Henle acts as a countercurrent multiplier. The descending and ascending limbs pass close together with their fluids flowing in opposite directions, enabling content exchange. Na^+ and Cl^- are actively transported out of the ascending limb. This decreases the water potential of the medulla so water moves out of the descending limb via osmosis and is reabsorbed by the capillaries. Water potential of the filtrate decreases and ion concentration increases. As the filtrate returns through the ascending limb, Na^+ and Cl^- diffuse into tissue fluid in the medulla. The ascending limb is impermeable to water resulting in a low water potential in the medulla. Fluid entering the collecting duct has a high water potential. It is permeable to water so water diffuses from the collecting duct into the medulla and blood capillaries via osmosis. Concentrated urine is therefore produced.

2

The retina contains rod cells and bipolar neurones.

Rod cells contain large numbers of mitochondria.

(a) Explain the role of mitochondria in the functioning of rod cells.

(2)

Mitochondria produce ATP for active sodium-potassium pumps in the membrane of rod cells which pump $3Na^+$ out for $2K^+$ in.

(b) Rod cells release glutamate, an inhibitory neurotransmitter.

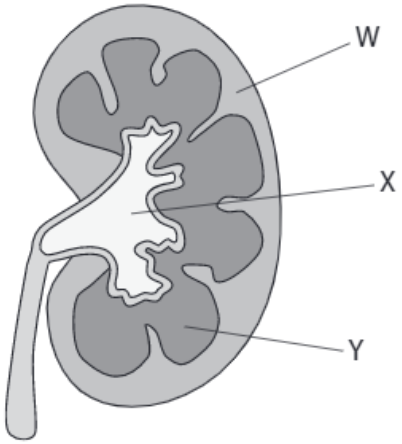
Describe how light causes a change in the release of glutamate from rod cells.

(4)

When rod cells absorb light, retinal within rhodopsin changes from cis to trans isomer. Na^+ channels close and the presynaptic membrane of the rod cell becomes hyperpolarised. Voltage-gated Ca^{2+} channels close and Ca^{2+} levels fall. This causes less glutamate to be released.

3

The diagram shows a section through a mammalian kidney.



(a) Which row of the table names the parts of the kidney labelled in the diagram?

(1)

	W	X	Y
☐ **A**	cortex	medulla	pelvis
☒ **B**	cortex	pelvis	medulla
☐ **C**	medulla	pelvis	cortex
☐ **D**	medulla	cortex	pelvis

(b) The table shows information about substances found in the blood and in the filtrate in the renal (Bowman's) capsule.

Substance	Relative molecular mass	Ratio of concentration in the filtrate in the renal (Bowman's) capsule : concentration in blood
sodium ions	23	1.00
water	18	1.00
urea	60	1.00
glucose	180	1.00
myoglobin	17 000	0.75
plasma proteins	69 000	<0.01

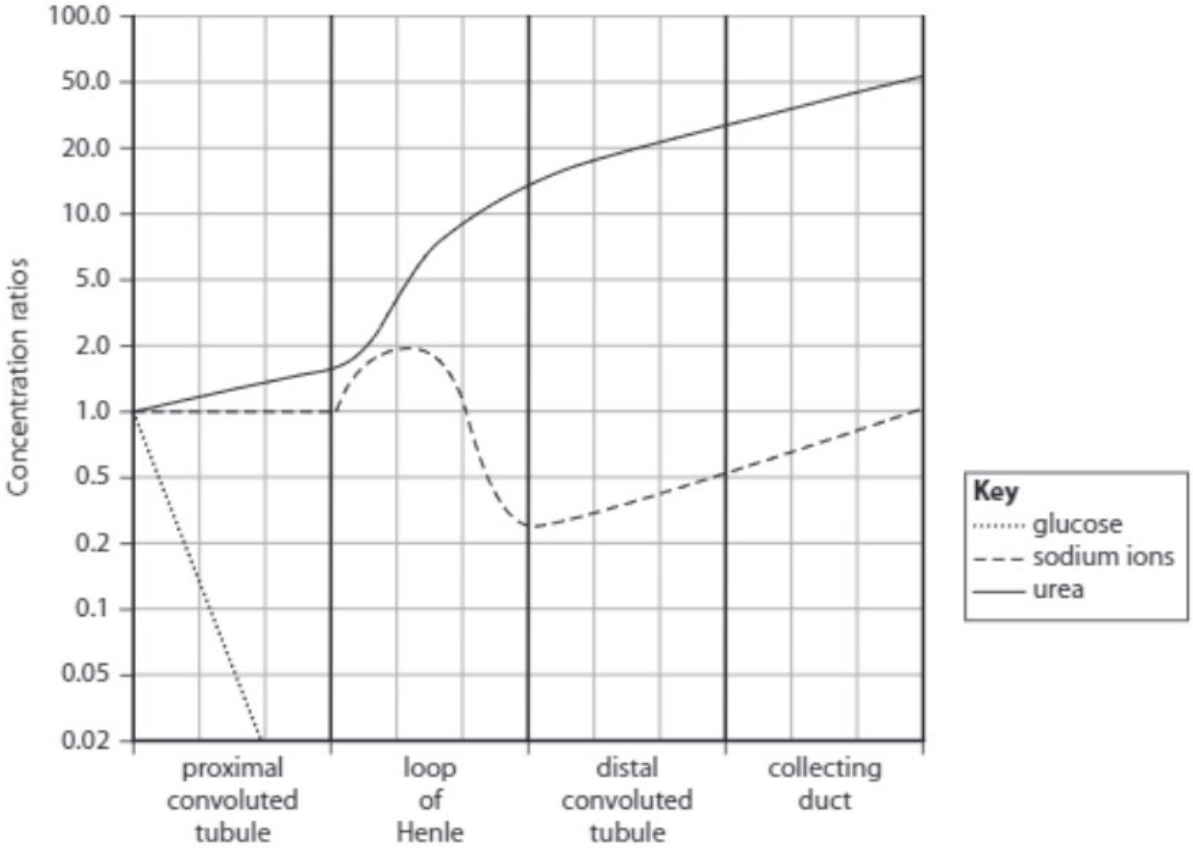
Analyse the data to explain the ratios of these substances.

(3)

Substances with a smaller molecular mass have a ratio of 1·00. This is because they are small enough to pass through the basement membrane of the glomerulus into the Bowman's capsule. Myoglobin and plasma proteins which have a larger relative molecular mass have a ratio less than 1·00 as they are too large to pass through the basement membrane so remain in the blood. Plasma proteins have a larger molecular mass than myoglobin, therefore their concentration in the filtrate is significantly lower.

*(c) The renal (Bowman's) capsule is part of each nephron found in the kidney.

The graph shows the concentration ratios of three solutes in different parts of the nephron compared with their concentrations in the renal capsule.



Explain the changes in the concentration ratios of these solutes in the different parts of the nephron.

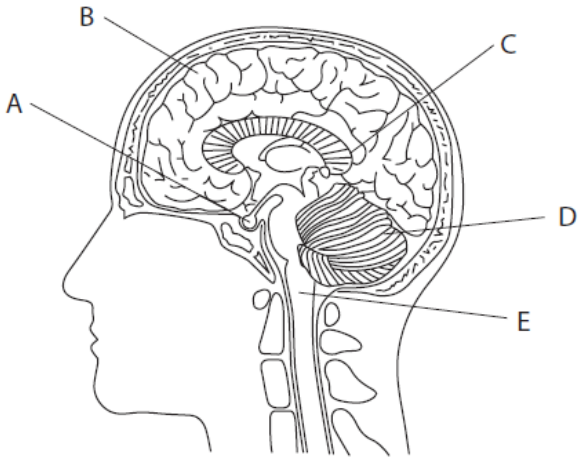
(6)

Glucose concentrations decrease in the proximal convoluted tubule (PCT) from a ratio of 1·0 to 0·02 because all glucose is selectively reabsorbed by active transport. Urea concentration rises from 1·0 to 1·7 because 85% of water is reabsorbed in the PCT. The concentration of Na^+ remains 1·0 because Na^+ and water are reabsorbed in equal proportions in the PCT. The concentration of Na^+ initially rises in the loop of Henle as water diffuses out of the descending limb via osmosis causing the water potential of the filtrate to decrease. Na^+ concentration then falls in the ascending limb as ions passively diffuse down their concentration gradient into tissue fluid in the medulla. This limb is impermeable to water. Na^+ are also actively transported out of the loop of Henle at the top of the ascending limb. Urea concentrations also rise more rapidly in the loop of Henle to approximately 15·0 as water diffuses out of the permeable descending limb. In the distal convoluted tubule and collecting duct, the concentrations of urea and Na^+ both rise as water diffuses by osmosis into the blood capillaries. The permeability of the collecting duct to water can be altered by ADH.

4

The human brain controls many functions.

The diagram shows a section through a human brain with parts labelled A to E.



(a) Which letter labels the part of the brain that controls heart rate?

(1)

E

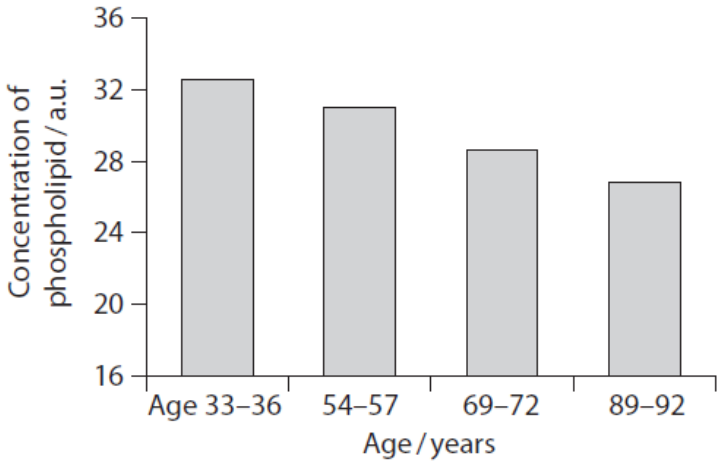
(b) The human brain consists of 100 billion neurones.

The function of these neurones is affected by many factors.

The concentration of phospholipid in neurones from one part of the brain was measured.

This was carried out in people from different age ranges.

The graph shows the results.



Explain how age might affect the structure of a neurone and the speed of transmission of an impulse.

(3)

As age increases, the concentration of phospholipid decreases. The myelin sheath consists of many fused phospholipid bilayers, therefore as age increases, the myelin sheaths of neurones will degenerate. This will affect saltatory conduction and increase current 'leakage', reducing the speed of impulse transmission.

(c) Poisons can also affect the function of neurones in the brain.

The photograph shows a pufferfish, a traditional food delicacy in Japan.

Pufferfish have to be carefully prepared by a chef to remove a poison called tetrodotoxin. This poison causes muscle paralysis.

Neurones were placed in a solution containing tetrodotoxin and in a control solution.

The neurones were stimulated and the potential difference across the axon membrane was measured.

The table shows the results.

Solution	Potential difference after stimulation / mV
tetrodotoxin	−70
control	+40

Analyse the data to explain the effect of tetrodotoxin on the neurone.

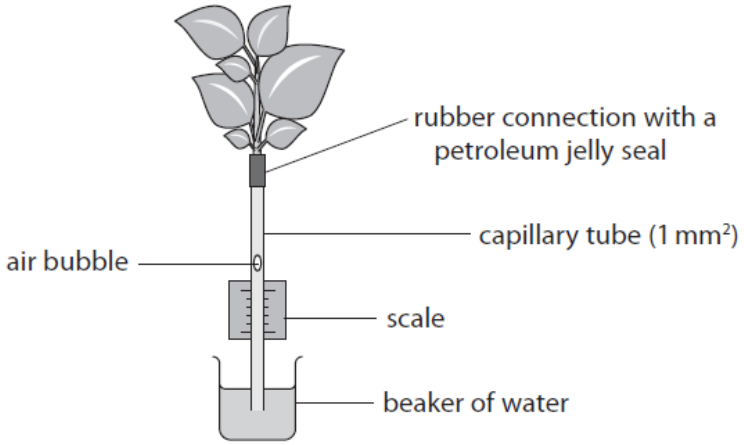
(4)

In neurones placed in a solution containing tetrodotoxin, the potential difference after stimulation is approximately the same as at resting potential. This may be because tetrodotoxin blocks the opening of voltage-gated Na^+ channels, preventing the diffusion of Na^+ into the the axon. This prevents depolarisation of the membrane which remains at resting potential.

5

A student investigated the effect of moving air on transpiration in a leafy shoot.

The diagram shows the potometer used by the student.



(a) In this investigation, a leafy shoot was cut from a plant.

The leafy shoot was then put under water and the stem inserted into the rubber connection.

Explain how this procedure should be modified to produce accurate readings.

(2)

The leafy shoot should be cut underwater to ensure that air bubbles do not become trapped in the xylem. The leaves should also be dried to prevent water from obstructing the stomata and reducing diffusion.

(b) During the investigation, the air bubble moved off the scale very quickly.

Explain how this potometer could be modified to obtain repeat readings.

(2)

use a longer scale so that the air bubble remains on the scale for a longer period of time and accurate readings can be recorded.

TOTAL FOR TEST = 45 Marks