# SL Paper 3

a. The spontaneous origin of life on Earth is thought to have involved the non-living synthesis of simple organic molecules. [2]

List **two** other processes needed for the spontaneous origin of life.

c. Outline the role of prokaryotes in the development of an oxygen-rich atmosphere on the Earth. [2]

# Markscheme

a. simple molecules must polymerize/assemble into polymers;

origin of self-replicating molecules / formation of self-replicating molecules;

simple molecules must become isolated from the surroundings/enclosed in membranes;

c. early atmosphere was oxygen free;

some prokaryotes could carry out chemosynthesis;

cyanobacteria (and other varieties) developed the ability to photosynthesize;

used water as hydrogen source so released oxygen;

oxygen began to accumulate in the atmosphere;

more photosynthesis than respiration;

# Examiners report

a. This was well answered by some candidates, but often answers referred to *organisms* rather than *molecules*.

c. This was either well answered or poorly done, with the weaker candidates thinking that oxygen came from carbon dioxide rather than water. Few gave the idea of more photosynthesis than respiration helping to build up the amount of oxygen in the atmosphere.

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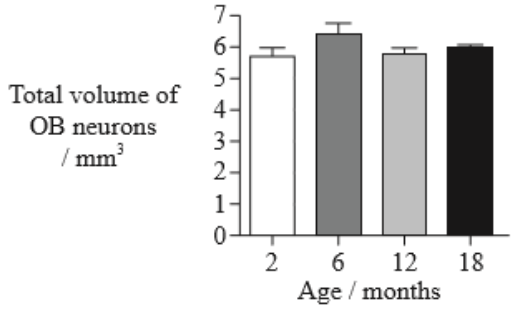
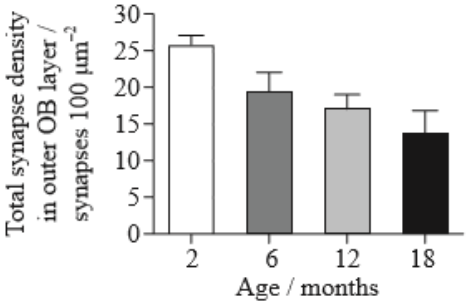
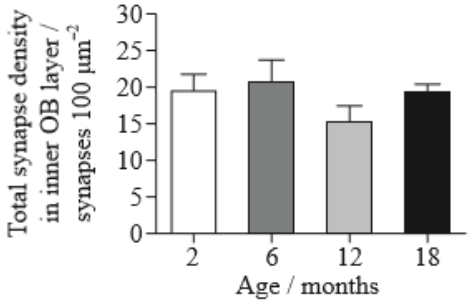
The hypothesis that aging involves loss of brain cells was investigated in mice. The olfactory bulb (OB) of the brain was studied because its layered arrangement of neurons resembles large regions of the human brain. Sensory input about smell is sent to the OB by axons of receptor cells that line the upper nasal cavity. These axons synapse with relay neurons in the OB where interpretation of smell perception begins. The bar charts show the total volume of neurons in the OB and the density of synapses (number of synapses per unit area) in two regions of a mouse's OB.




[Source: Marion Richard et al., "Age-induced disruption of selective olfactory bulb synaptic circuits", *PNAS* 107 (35), 15,613–15,618. Copyright 2010, National Academy of Sciences, USA.]

a. State when the total volume of OB neurons is the greatest. [1]

b. Compare the total synapse density of neurons in the outer and inner OB layers. [2]

c. Evaluate, using the data in the bar charts, the hypothesis that aging involves loss of brain cells. [2]

d. Suggest the implications of the data for humans. [2]

# Markscheme

a. 6 months

b. a. no clear trend in the inner layer whereas there is a decrease in the outer layer;

b. outer layer is higher (than inner layer) at 2 months and lower at 18 months;

(*do not accept statements that are not comparisons*)

*Accept any other correct comparisons.*

c. a. volume of neurons remains the same;

b. synapse density in the outer but not the inner layer decreases with age;

c. number of neurons may not be reduced even with fewer synapses;

d. a. smell perception may fall in aging humans;

b. changes in smell perception may change food eating habits/reduce quality of life;

c. ageing human brains may lose synapses but not neurons (as previously thought);

d. losing synapses in one part of the brain may be repeated in other parts of the brain;

# Examiners report

a. Most were able to state that the total volume was greatest at 6 months.

b. Most were able to gain a mark for spotting that there is no clear trend in the inner layer but a decrease in the outer. Few gained the second mark. There were many correct statements, but few correct comparisons.

c. In c most were able to state that the volume of neurons remains the same and that the synapse density in outer but not inner decreases with age.

d. In d most were able to gain the mark for loss of synapses, but not neurons, but only the more astute candidates could link it back to the introduction and talk about smell perception.

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Discuss the endosymbiotic theory for the origin of eukaryotes.

# Markscheme

a. microorganisms/prokaryotes taken into cell by endocytosis;

b. kept inside cell and perform respiration/photosynthesis;

c. developing into mitochondria/chloroplasts;

d. mitochondria/chloroplasts have double membranes (as expected in cells taken in by endocytosis);

e. mitochondria/chloroplasts have (circular naked) DNA (as prokaryotes);

f. mitochondria/chloroplasts have 70S ribosomes (as prokaryotes);

g. mitochondria/chloroplasts grow and divide like (prokaryotic) cells;

# Examiners report

Most candidates scored some points in questions 11 and 12 with the top candidates achieving full marks.

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Discuss the endosymbiotic theory for the origin of eukaryotes.

# Markscheme

(both) mitochondria and chloroplasts have evolved from independent prokaryotic cells;

endocytosis originally led to symbiotic relationship;

(mitochondria and chloroplasts) grow and divide like cells;

naked loop of DNA, like prokaryotes;

have 70S ribosomes, like prokaryotes;

have double membranes as would expect when taken in by endocytosis;

# Examiners report

The general idea of the endosymbiotic theory for the origin of eukaryotes was understood by many for part (b) but few described this well; candidates were still able to gain 2 of the 3 marks.

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Discuss the evidence supporting the endosymbiotic theory for the origin of eukaryotes.

# Markscheme

a. chloroplasts, mitochondria and prokaryotes are a similar size;

b. all have 70S ribosomes;

c. double membrane suggests engulfing by endocytosis;

d. all contain naked DNA;

e. all divide by binary fission;

f. chloroplasts and mitochondria cannot survive on their own;

g. theory cannot be repeated/falsified;

# Examiners report

This question discriminated well with most candidates scoring some marks and the stronger candidates achieving full marks.

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Outline the contribution of prokaryotes to the creation of an oxygen-rich atmosphere.

# Markscheme

(prokaryotes) used hydrogen from water in synthesis and released oxygen;

(prokaryotes) produced oxygen during photosynthesis;

atmosphere changed from a reducing atmosphere to an oxidizing atmosphere;

current life forms depend upon an oxygen-rich atmosphere;

# Examiners report

D2 (b) presented a problem for many candidates who could not outline the contribution of prokaryotes to an oxygen rich atmosphere.

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Outline **two** pieces of evidence that support the endosymbiotic theory for the origin of eukaryotes.

# Markscheme

smaller/70S ribosomes in mitochondria/chloroplasts (as in prokaryotes);

circular DNA in mitochondria/chloroplasts (as in prokaryotes);

mitochondria/chloroplasts have double membrane;

similar size/shape of mitochondria/chloroplasts to prokaryotes;

# Examiners report

Some very good answers, but, most often, candidates only explained the endosymbiotic theory, without outlining the pieces of evidence for it.

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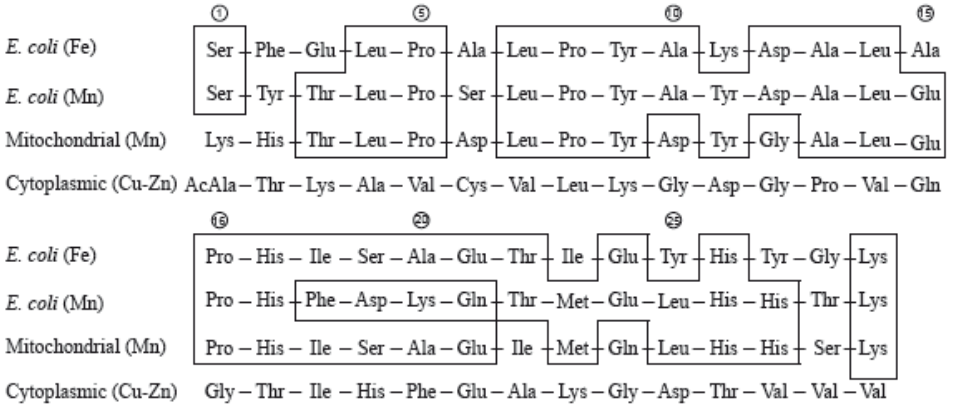
Superoxide dismutase is an enzyme used by cells to protect themselves against oxidative damage. These enzymes can have different metals as part of their structure.

A study to compare two dismutases from *Escherichia coli* bacteria and two dismutases from eukaryotic cells was undertaken. The following enzymes were used:

- *E. coli* dismutase with iron (Fe)
- *E. coli* dismutase with manganese (Mn)
- eukaryotic mitochondrial dismutase with manganese (Mn)
- eukaryotic cytoplasmic dismutase with copper-zinc (Cu-Zn).

The following shows part of the amino acid sequences of these enzymes. Boxes enclose identical amino acids in the sequence of the two *E. coli* and mitochondrial dismutases.




[H. M. Steinman and R. L. Hill (1973) "Sequence homologies among bacterial and mitochondrial superoxide dismutases". PNAS journal (USA), 70 (12), pp. 3725—3729. Used with the permission of the authors.]

a. State how many amino acids are in the same position in the *E. coli* (Fe), *E. coli* (Mn) and the mitochondrial dismutase sequences shown. [1]

b. State the amino acids which are present in the same position in at **least one** bacterial dismutase and in **both** eukaryotic dismutases. [1]

c. Compare the *E. coli* (Mn) and the mitochondrial dismutases. [2]

e. The sequences of the two bacterial dismutases and the mitochondrial dismutase show a high degree of homology. Discuss how this supports the endosymbiotic theory for the origin of mitochondria. [2]

# Markscheme

a. 11

b. Ile and Glu *(need both to award the mark)*

c. a. share 17 (out of 29) amino acids in common / more amino acids similar than different;

b. both have Mn in the enzyme (as cofactor);

c. greatest difference between them is from amino acid 18 to 22;

d. mitochondrial has Gly (position 12) while *E. coli* (Mn) never has Gly;

e. Leu is most common amino acid in both appearing four times / other valid comparison;

e. a. endosymbiotic theory states bacteria were engulfed by organisms to become mitochondria;

b. sequence comparison between mitochondrial and bacterial dismutase supports this hypothesis;

c. more similarity in the amino acid sequence between mitochondrial and bacterial dismutase than between mitochondrial and cytoplasmic dismutase;

# Examiners report

a. Almost all indicated correctly that 11 amino acids were in the same position in the three dismutase sequences.

b. Most were able to correctly identify Ile and Glu as present in the same position.

c. Most were able to get two correct comparisons. Some carelessly indicated that the common element was magnesium rather than manganese despite the fact this was stated in the stem.

e. Most candidates received 2 marks for this section. Good descriptions of the endosymbiotic theory were often given.

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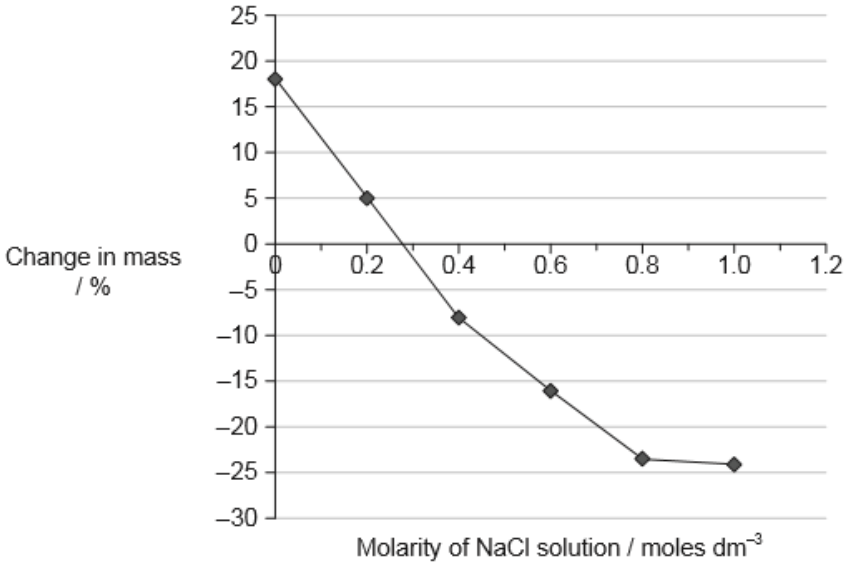
a. Solutions of ions, for example NaCl dissolved in water, can be used to investigate the concentration of solutes in plant tissues. After immersion in solutions of varying concentration, the percentage changes in mass of potato samples were measured. The graph shows the results. [3]



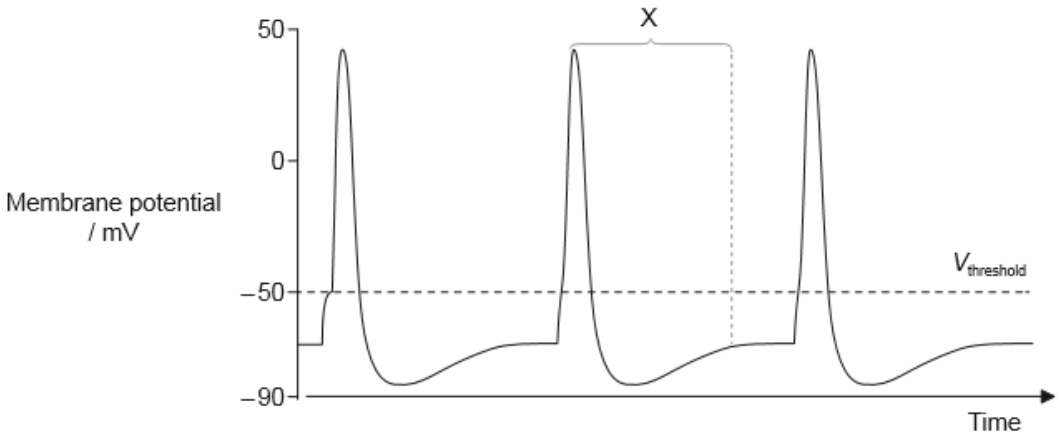

(i) Estimate the osmolarity of the plant tissue.

.....moles $dm^{-3}$

(ii) Identify which part of the graph represents samples measured in a hypotonic solution.

(iii) State **one** possible source of error when collecting data during this experiment.

b. Ions move across the plasma membrane of a neuron during an action potential. The oscilloscope trace shows voltage changes generated in a neuron during three action potentials. [3]




Explain the movement of ions which causes the voltage changes observed during the interval labelled X on the graph.

# Markscheme

a. (i)

0.28 «moles $dm^{-3}$» (*Allow answers in the range of 0.27 to 0.29 «moles $dm^{-3}$»*)

0.56 «osmoles $dm^{-3}$» (*Allow answers in the range of 0.55 to 0.57 «osmoles $dm^{-3}$»*)

(ii)

«Any» part of the line above 0 percent change in mass (*Allow ECF for upper value of molarity.*)

0 to 0.28 molarity of NaCl solution

(iii)

Too few samples weighed

Not dried before weighing

Samples from different sources

Not cut all same way so different surface area

Temperature of each sample not the same

Potatoes not left for the same time in the solutions

Error due to the limitation of the apparatus/equipment

*Differentiate between errors and mistakes eg: do not accept "balance read incorrectly"*

*Do not accept mass/weight differences*

b. At the peak the sodium channels close

The potassium channels open

Potassium ions flow out

Repolarization occurs

Delay in closing of potassium channels

Hyperpolarization results

Sodium and potassium pump re-starts to restore ions to resting/previous potentials/concentrations

*Accept $Na^+$ and $K^+$ ions*

*Award **[2 max]** if answer refers to part of graph before X*

# Examiners report

a. (i) and (ii): Most candidates could estimate the osmolarity of the plant tissue though fewer could identify the samples in hypotonic solution. Credit was given to candidates whose answers considered the dissociation of sodium chloride in water.

(iii) Candidates had difficulty differentiating between a source of error and a mistake through carelessness or improper technique.

b. Discriminated well with only good candidates scoring full marks. Many referred to ion movement before the interval labelled X on the graph.

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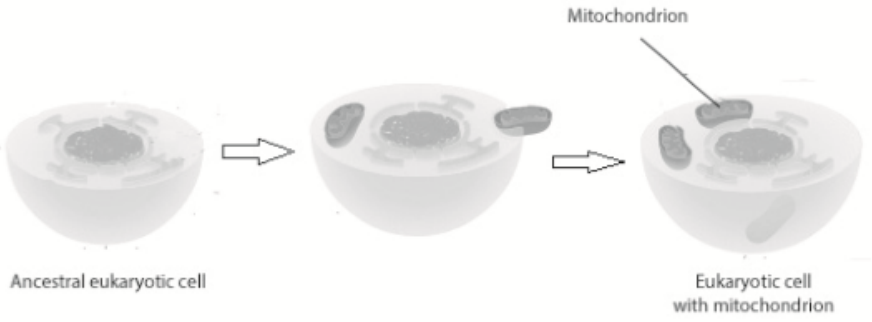
The diagram shows some of the later stages in the origin of eukaryotic cells according to the endosymbiotic theory.




[Source: "Serial endosymbiosis" by Kelvinsong - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Serial_endosymbiosis.svg#/media/File:Serial_endosymbiosis.svg]

Discuss the endosymbiotic theory including the evidence for the process shown in the diagram.

# Markscheme

a. ancestral eukaryote cell engulfs free living prokaryote;

b. free living prokaryote not digested;

c. symbiotic relationship develops between ancestral eukaryote cell and engulfed prokaryote;

d. ancestral eukaryote cell and engulfed prokaryote reproduce as a unit;

e. the engulfed prokaryote provides energy by aerobic respiration for the eukaryote;

f. prokaryote gains protection/nutrition;

g. organelles have double membranes;

h. organelles have DNA/ribosomes;

i. theory cannot be falsified/tested;

# Examiners report

There was sound knowledge of endosymbiosis

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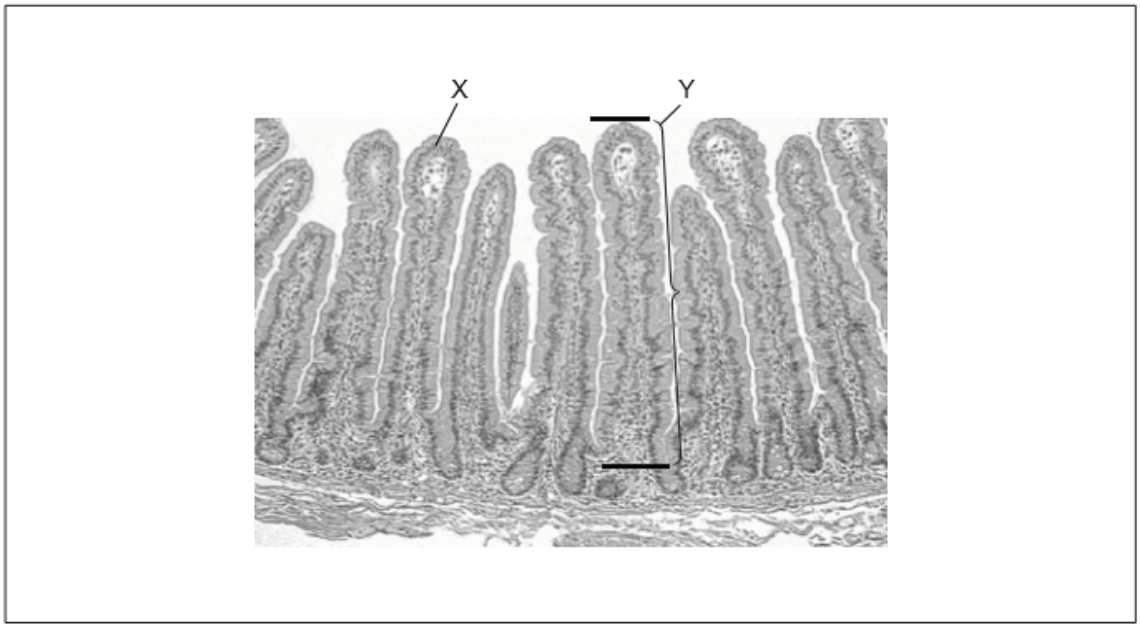
The micrograph shows a section of an organ in the human body.




[Source: adapted from Stacey E. Mills (ed.), *Histology for Pathologists*, 3rd Edition, Copyright ©2007, Lippincott Williams & Wilkins.]

a. State from which organ the section was taken. [1]

b. Identify the layer of tissue found at X. [1]

c. The actual length of the structure labelled Y is 0.8 mm between the two black lines. Calculate the magnification of the micrograph. [2]

Working should be shown.

c. The actual length of the structure labelled Y is 0.8 mm between the two black lines. Calculate the magnification of the micrograph. Working [2]

should be shown.

. . . . . .

# Markscheme

a. small intestine

*Do not accept villi/villus or intestine alone.*

b. epithelium

*Do not accept microvilli/brush border.*

c. a. calculation shown with accurate measurement of length of villus

OR

*For the first marking point to be awarded, the measurement must be between 53 and 55 mm.*

*b. 67* ***or*** *68* ***or*** *68*

*Allow any value between 67 and 69 inclusive.*
*Accept decimals e.g. 68.75.*
*Allow ECF from first marking point.*

c. a. calculation shown with accurate measurement of length of villus

***OR***

$\frac{53}{0.8}$ ***or*** $\frac{54}{0.8}$ ***or*** $\frac{55}{0.8}$ «mm»

*For the first marking point to be awarded, the measurement must be between 53 and 55 mm.*

b. 67 ***or*** 68 ***or*** 68

*Allow any value between 67 and 69 inclusive.*
*Accept decimals e.g. 68.75.*
*Allow ECF from first marking point.*

# Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
c. [N/A]

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The micrograph shows a transverse section through blood vessels of a mammal.

[Source: This book was originally published by OpenStax College, released under the CC-By license: https://creativecommons.org (https://creativecommons.org/) The eBook was adapted by Frank Lee.]

a. Identify the vein by labelling it with the letter V. [1]

b. Distinguish between the vein and the artery with reference to structures visible in the micrograph. [2]

# Markscheme

a. label pointing to the upper of the two blood vessels in the micrograph

*Note: check the answer carefully as the scan of the diagram is not always clear for candidates writing in pencil*

b. a. vein has larger lumen

b. vein has less elastic tissue

c. vein has less muscular/thinner walls/tunica media

***OR***

ratio of wall thickness to lumen is less in the vein

d. vein less rounded/squashed more easily

*Accept inverse for artery*

*Do not accept non-visible differences such as valves*

*No ECF*

***[Max 2 Marks]***

# Examiners report

a. [N/A]
b. [N/A]