HL Paper 3

b. Outline the endosymbiotic theory. [2]

c (ii) Define *gene pool*. [1]

Markscheme

b. a. mitochondria/chloroplasts were once (independent) prokaryotes;

b. taken in by (larger) heterotrophic/host cell (through endocytosis);

c. new living arrangement mutually beneficial / depend on each other to exist as single organism;

c (ii) all the alleles/genes of a population (at a particular time)

Examiners report

b. While many candidates were able to get 1 mark, and some 2, few wrote clearly or accurately about the endosymbiotic theory. The question was not asking for evidence of the theory which is what some candidates wrote about.

c (ii) The definition of gene pool in (ii) was answered better than in previous years.

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b. Define analogous characteristics using **one** example to illustrate your answer. [1]

c. Outline **two** pieces of evidence that support the endosymbiotic theory for the origin of eukaryotes. [2]

d. List **two** anatomical features that define humans as primates. [2]

Markscheme

b. analogous structure similar in appearance/function but with different evolutionary history *e.g.* wing of bat and wing of bird;

c. 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;

d. opposable thumb;

large range of shoulder movement;

good vision / stereoscopic vision / overlapping field view;

large brain relative to body size;

tailless primate;

Y-5 cusps of molars;

Examiners report

b. Those that knew the correct definition did well.

c. The main pieces of evidence supporting the endosymbiotic theory for the origin of eukaryotes seen were double membranes and the presence of circular DNA.

d. The most popular answers here were those of humans having an opposable thumb and stereoscopic vision. Many though only gained one mark point here with the answer of opposable thumb.

Discuss the endosymbiotic theory for the origin of eukaryotes.

Markscheme

eukaryotes evolved from prokaryotes;

mitochondria/chloroplasts evolved from (independent) prokaryotic cells;

taken in by larger (heterotrophic) cell by endocytosis;

theory supported by characteristics of chloroplasts/mitochondria;

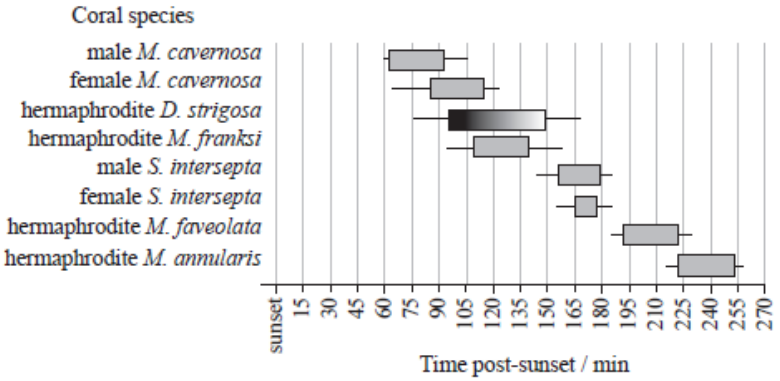
[2 max] *for mitochondria/chloroplast characteristics:*
mitochondria/chloroplasts have naked DNA;
mitochondria/chloroplasts divide/carry out fission;
mitochondria/chloroplasts have 70S ribosomes / synthezise own proteins;
mitochondria/chloroplasts have double membranes;
cristae similar to mesosomes / thylakoid have similar structures in prokaryotes;

but theory cannot be falsified as it predicts something occurring in the past;
theory does not explain the origins of cilia/flagella/linear chromosomes/meiosis;
weaker evidence that cilia/flagella evolved from attached bacteria/spirochetes;

Examiners report

Many candidates were able to score four or more marks on this question on the endosymbiotic theory by describing it and looking at the supporting evidence shown by the structure of chloroplasts or mitochondria. However, even those candidates scoring well seldom „discussed" the fact that evidence was weak for evolution of other organelles such as cilia or flagella and that the theory cannot be falsified.

Corals can be male, female or hermaphrodite (both male and female) and the release of their gametes is called spawning. Data was collected to study the spawning behaviour in the Gulf of Mexico of three genera of coral: *Montastraea*, *Stephanocoenia* and *Diploria*. The spawning behaviour is expressed in minutes post-sunset. Peak spawning windows are shown as grey bars and the range as black bars.



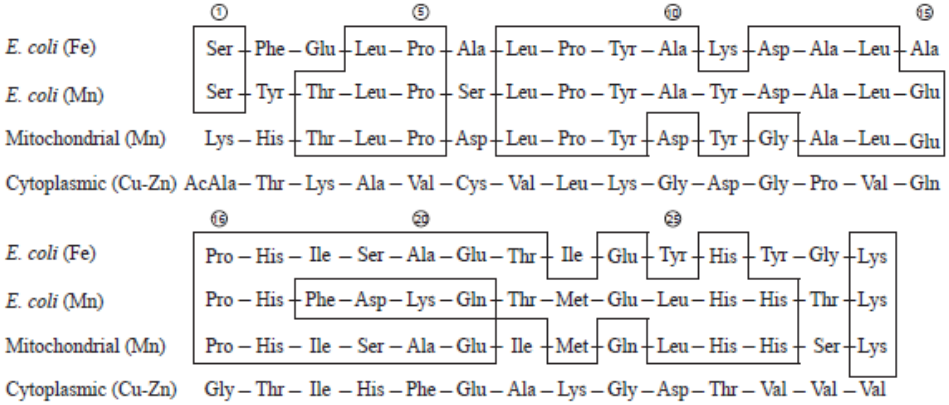
[Adapted from P. D. Vize, J. A. Embesi, M. Nickell, D. P. Brown and D. K. Hagman (2005) "Tight temporal consistency of coral mass spawning at the Flower Garden Banks, Gulf of Mexico, from 1997–2003." _Gulf of Mexico Science_, 1, pp. 107–114. © 2005 by the Marine Environmental Sciences Consortium of Alabama. Used with permission.]

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 the range of the time of spawning for the male *M. cavernosa*. [1]

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. from 60 to 105 minutes (post-sunset) / 45 minutes

a. 11

b. Ile and Glu *(both needed 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. Most candidates performed well in the data analysis with (e) being the best discriminator of the better candidates.

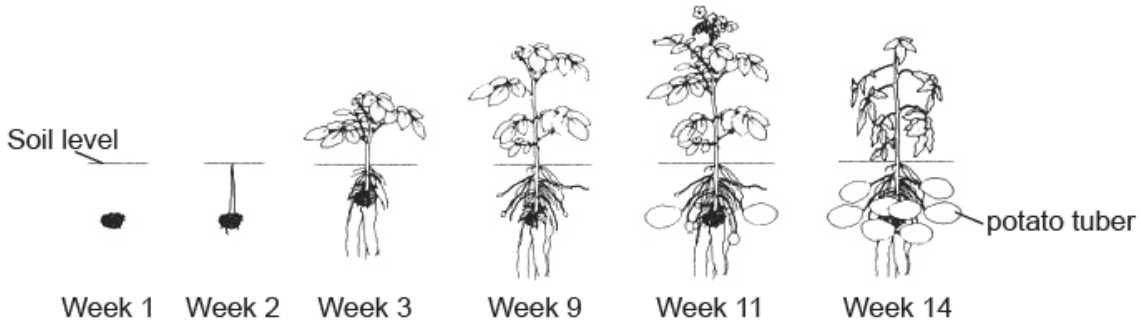
a. Many candidates responded correctly to (a).

b. Many candidates responded correctly to (a) and (b), although some candidates only stated one of Ile and Glu.

c. [N/A]

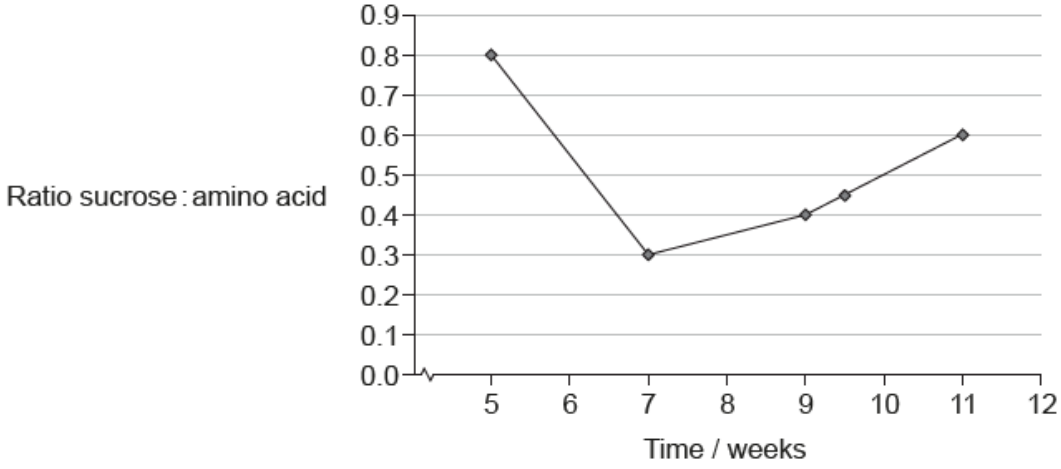
e. Many candidates were familiar with the endosymbiotic theory and gained marks in (e).

The diagram shows the development of potato plants (*Solanum tuberosum*) over 14 weeks. New tubers start growing from week 9. These are modified underground stems serving as a starch reserve and bearing buds from which new plants arise.



[Source: adapted from http://humanitiespotato.weebly.com/potato-production.html]

Scientists planted several potato plants in a greenhouse. The sucrose and amino acids in potato plant phloem exudates were measured during several weeks.



[Source: adapted from A. J. Karley, A. E. Douglas, W. E. Parker, Amino acid composition and nutritional quality of potato leaf phloem sap for aphids. *Journal of Experimental Biology* 2002 205: 3009-3018.© The Company of Biologists Limited 2002.]

a. Describe briefly how scientists obtained leaf phloem sap from the potato plants. [2]

b. Suggest reasons for different amounts of sucrose in the leaf phloem sap of the potato plants. [3]

Markscheme

a. a. aphids insert stylet in «potato» plants/feed from «potato» plants

"Aphids" is essential for the mark.

b. phloem exudates/sap obtained from severed stylets

"Stylets" is essential for the mark.

b. a. sucrose produced by leaves during photosynthesis

b. sucrose moves/translocates from source/leaves to sink/roots/tubers
OR
sucrose carried by phloem to tuber

c. «wk 5» high sucrose with increased leaf growth/photosynthesis / OWTTE

d. «wk 5-7» more sucrose used for general plant growth / OWTTE

e. «wk 7-11» concentration sucrose increases due to greater production/photosynthesis «than usage/storage» / OWTTE

f. sucrose transformed into starch in tuber «from week 9»

g. contribution of amino acids unknown so difficult to know about different amounts of sucrose / OWTTE

Award the mark for realizing that amino acids play a role in the ratio

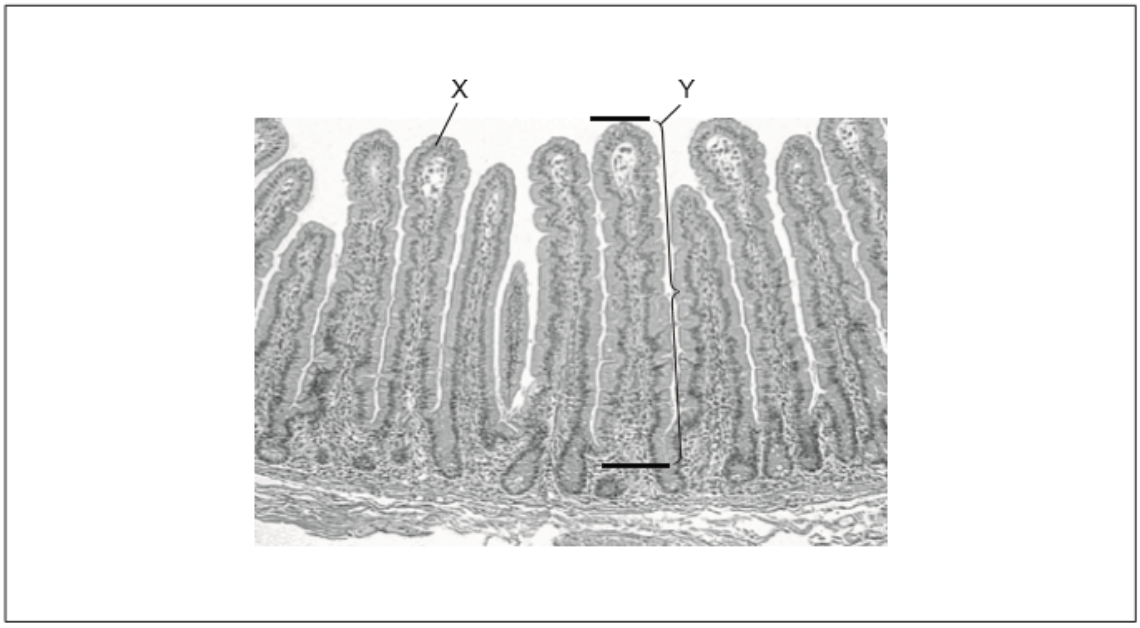
h. «abiotic» conditions in greenhouse may vary over time / OWTTE

Accept abiotic factors only if variation through time is explicit.

Examiners report

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

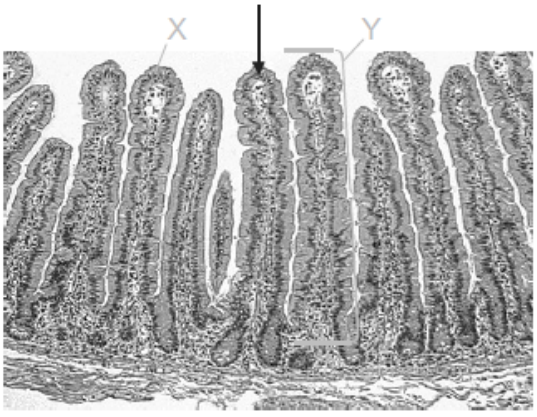
The micrograph shows a section of an organ in the human body.



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

One of the functions of this organ is absorption. On the micrograph, draw an arrow showing the direction of absorption.

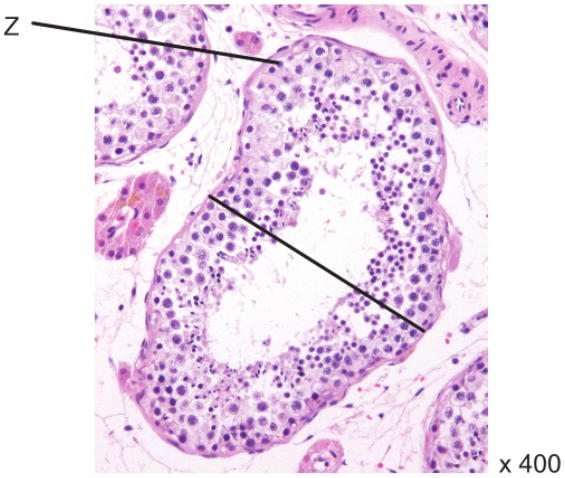
Markscheme



Examiners report

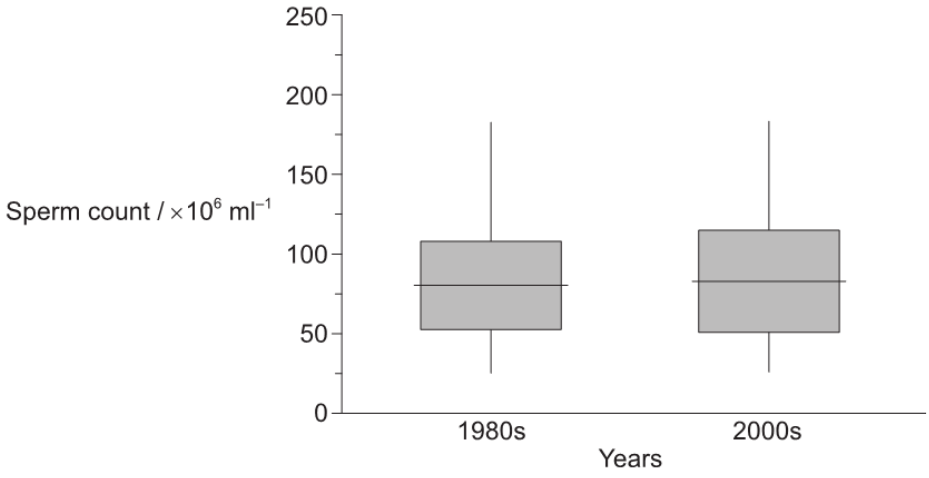
[N/A]

The light micrograph shows a cross section of seminiferous tubules.



[Source: Micrograph of a seminiferous tubule with sperm by Nephron (https://commons.wikimedia.org/wiki/File:Seminiferous_tubule_and_sperm_low_mag.jpg)]

a. Concerns have been raised about the effect of rising pollution levels on sperm production in men. To investigate the possible effects of pollution on spermatogenesis, sperm samples from men of similar ages were collected in Kolkata in the 1980s and 2000s. The box plot represents the mean and range of sperm counts in the 1980s and 2000s. [3]



[Source: Republished with permission of Elsevier Science and Technology Journals, from 'Semen quality and age-specific changes: A study between two decades on 3729 male partners of couples with normal sperm count and attending an andrology laboratory for infertility-related problems in an Indian city', Dyutiman Mukhopadhyay, Alex C. Varghese, Manisha Pal, Sudip K. Banerjee, Asok K. Bhattacharyya, Rakesh K. Sharma, and Ashok Agarwal, Fertility and Sterility, 93 (7), 2009; permission conveyed through Copyright Clearance Center, Inc]

A hypothesis has been suggested that pollution may have a negative effect on spermatogenesis. Evaluate whether the data support this hypothesis.

b.i. Calculate the actual size of the seminiferous tubule in the area indicated by the line across it, giving the units. [1]

b.ii. Identify the type of cell labelled Z. [1]

Markscheme

a. a. hypothesis not supported as there is a «slight» increase/not much difference in sperm count between the 1980s and the 2000s

OR

hypothesis not supported as similar means/values for both groups

b. no information on sample size

c. no information/data provided on pollution levels/types of pollution

d. other factors affecting sperm count not considered

OR

other elements than sperm count could be affected

e. data limited to Kolkata/one country/one city

OR

pollution may affect spermatogenesis elsewhere

[Max 3 Marks]

b.i. 62 mm Y400 = 0.155 mm/155 μm/micrometers/10^{-6} m

OR

61 mm Y400 = 0.153 mm/153 μm/micrometers/10^{-6} m

Calculation and units required. Accept correct answers expressed in cm

b.ii. spermatogonium

OR

primary spermatocyte

Examiners report

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