SL Paper 3

a. State the names of the **three** domains, giving a microbial example of each. [3]

b. Traditional classification separates organisms into two groups: prokaryotes and eukaryotes. Explain the reasons for reclassification of life into three domains. [2]

c. Distinguish between the **two** domains of prokaryotes. [2]

Markscheme

a. Eubacteria/Bacteria: *E. coli* / *Pneumococcus* / another suitable example; (*scientific/common name acceptable*)

Archaea: methanogens / thermophiles / another suitable example;

Eukaryota: *Paramecium* / yeast / another suitable example;

b. large diversity of the group categorized as prokaryotes prompted division into two domains;

similarities between Archaea more similar to Eukaryota than to Eubacteria;

facilitates study of origin/evolution of eukaryotes;

c. Archaea have different rRNA to Eubacteria;

Eubacteria have no proteins associated with DNA whereas Archaea have / *vice versa*;

introns are present in some genes of Archaea, but are rare/absent from Eubacteria;

cell walls are made of peptidoglycan in Eubacteria but not in Archaea;

cell membranes are made of different molecules / Eubacteria have glycerol-ester lipids whereas Archaea have glycerol-ether lipids;

Examiners report

a. N/A

b. F2 (b) was another difficult explanation question, although many candidates knew that the great diversity in prokaryotes prompted the new classification.

c. N/A

Using the mammalian pentadactyl limb as an example, outline the process of adaptive radiation.

Markscheme

limb bone pattern of mammals shows the same basic arrangement;

derived from common ancestor/homologous structures;

common ancestral pattern adapted to different environment conditions;

suitable example; (*eg wing of bat adapted for flight and limbs of mole for digging*)

Examiners report

Part (a) was poorly answered in general. Candidates could have obtained the 2 marks if they had known what adaptive radiation was without any reference to pentadactyl limbs. Although this very common example is not actually specified in the SL syllabus, this question was thus not compromised.

Outline the process of adaptive radiation.

Markscheme

new species evolve from one ancestral species;

species evolve in different ways to become adapted to different ecological roles;

divergent evolution / homology;

different environments provide different selection pressures/new niches become available;

valid example e.g. *Galapagos finches*/vertebrate pentadactyl limb;

Examiners report

There were some good answers to this question, with many students quoting the Galapagos finches as an example. On the lighter side, some candidates thought that the question was referring to ways of adapting to radiation, having completely misunderstood the wording.

Outline **two** processes needed for the spontaneous origin of life on Earth.

Markscheme

non-living synthesis of organic molecules;

formation of polymers;

origin of self-replicating molecules;

packing of molecules into membranes/protobionts;

(*Do not accept reference to reducing atmosphere unless part of a process)*

Examiners report

This question proved easy for candidates with most earning 2 marks.

Explain the reasons for the reclassification of Prokaryotes and Eukaryotes into Eubacteria, Archaea and Eukaryota.

Markscheme

studies of (base sequences of) rRNA provided evidence for three domain classification;

differences in cell walls / Archaea and Eukaryotes have no peptidoglycan in cell wall, Eubacteria do have peptidoglycan in cell wall;

differences in membrane bonding compared to Eubacteria and Eukaryotes / Archaea have ether bonds in lipid membranes whereas others do not;

presence or absence of histone proteins / histone proteins present in all Eukaryotes, present in some Archaea, none in Eubacteria;

Examiners report

The answers to this question were very vague. Most candidates only mentioned that studies of rRNA provided evidence for a new classification.

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a. Outline the process of adaptive radiation. [3]

b. There has been a change of thinking; moving from gradualism to punctuated equilibrium demonstrates the changing nature of science. Discuss these two ideas about the pace of evolution. [4]

Markscheme

a. varied members of a single species occupy a variety of niches / migration of a species to an area with a variety of niches;

natural selection/selection pressure will be different in various niches causing adaptation of groups to the varied niches;

results in many species from one ancestral species;

reproductive isolation enhances adaptive radiation;

adaptive radiation results in speciation;

b. in gradualism evolution occurs at a constant pace;

fossil records of gradual change with intermediate forms support this theory;

evolution of modern horse/another suitable example seems to support this view;

in punctuated equilibrium evolution proceeds rapidly for short periods of time intermittent with long periods of little change/stability;

gaps in the fossil record/lack of intermediate forms support the idea of punctuated equilibrium;

strata in the fossil record with appearance of many new species following a mass extinction supports the idea of punctuated equilibrium;

Examiners report

a. Adaptive radiation was very poorly answered.

b. Quite a few candidates got the two definitions right, but not the discussion part.

Discuss the definition of the term **species**.

Markscheme

a species is a group of organisms with similar characteristics, which can interbreed <u>and</u> produce fertile offspring;

sibling species may show similar characteristics but cannot interbreed (e.g. Pipistrelle bat in Britain);

some pairs of species are different but can interbreed (e.g. ruddy duck and white headed duck/many plant species);

some species always reproduce asexually so definition may not apply;

some breed in zoos/captivity, but will not interbreed in nature;

difficult to classify fossils as cannot decide if they could interbreed;

Unfamiliar examples should be checked for accuracy using the internet.

Examiners report

Many candidates could not give an accurate definition of the term species, so few went on to discuss the limitations of such a definition with appropriate examples.

Outline the process of adaptive radiation.

Markscheme

a. ancestral species occupies new environment / survives natural disaster;

b. different members of the species are exposed to different selection pressures;

c. gives rise to new species that share common structures adapted to new environment / occupy all niches;

d. example of divergent evolution/homology;

e. accept valid example *eg* Galapagos finches, vertebrate pentadactyl limb;

Examiners report

There were poor explanations in general for adaptive radiation, although many candidates could use Darwin's finches as an example.

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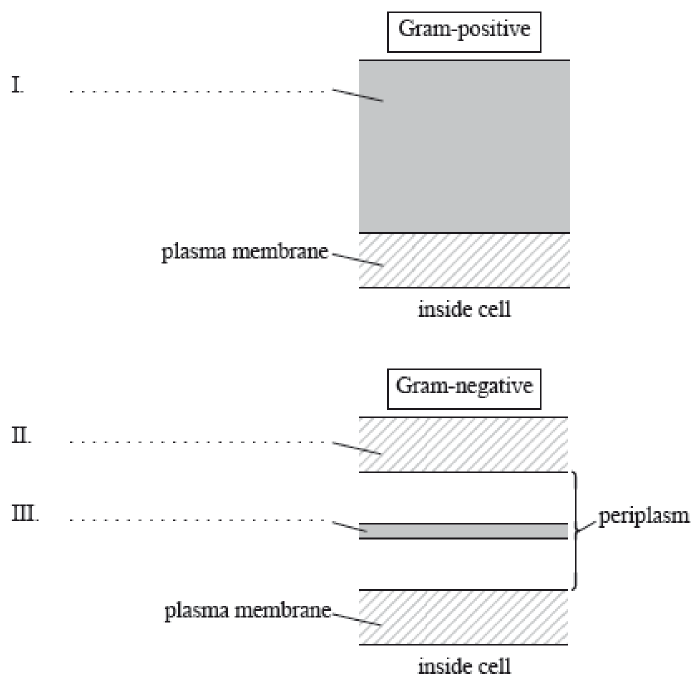
a. Distinguish between Archaea and Eukarya. [2]

b. Label the parts of the cell walls in Gram-positive Eubacteria and Gram-negative Eubacteria shown below. [3]



Markscheme

a. a. membrane-bound organelles present in Eukarya but absent in Archaea;

b. 70S ribosomes in Archaea whereas 80S ribosomes in (cytoplasm of) Eukarya;

c. nuclear envelope in Eukarya, not in Archaea;

d. introns are present in Eukarya but only in some genes of Archaea;

e. histone proteins present in all Eukarya but only in a few Archaea;

f. the membrane lipid structure is unbranched in Eukarya but branched in Archaea;

g. Archaea can inhabit extreme habitats while Eukarya cannot;

b. I. peptidoglycan;

II. <u>outer</u> membrane/layer of lipopolysaccharide and protein;

III. peptidoglycan;

Examiners report

a. Many candidates were not able to distinguish between Archaea and Eukarya. A few mentioned the different size ribosomes but that was all.

b. Labelling the part of the Gram-positive and Gram-negative cell walls was a problem as many candidates did not know the names of the layers.

Antibiotics are sometimes given orally to poultry to prevent disease that may lead to reduced growth. Antibiotic resistance of bacteria from turkeys and chickens bred for meat and from egg laying hens was measured.

Excrement was collected and *Escherichia coli* bacteria were isolated. These bacteria were tested for resistance to a range of antibiotics and the results are shown below.

Number of antibiotics to which *E. coli* are resistant	Turkeys $n = 43$	Chickens $n = 45$	Egg laying hens $n = 20$
0	7	9	13
1	8	5	3
2	7	7	0
3	2	7	3
4	5	7	1
≥5	14	10	0

[Source:Antibiotic resistance of faecal _Escherichia coli_ in poultry, poultry farmers and poultry slaughterers. A. E. van den Bogaard, N. London, C. Driessen, E. E. Stobberingh. _Journal of Antimicrobial Chemotherapy_, 47, June 1, 763--771. 2001, Oxford University Press.]

a. Calculate the percentage risk of bacteria becoming resistant to more than five kinds of antibiotics in turkeys and egg laying hens. [1]

Turkeys:

Egg laying hens:

b. Compare the incidence of drug resistance in bacteria from chickens and egg laying hens. [2]

c. Discuss the hypothesis that giving antibiotics increases antibiotic resistance in poultry bacteria. [2]

d. Suggest how antibiotic-resistant bacteria are passed from animals to humans. [1]

Markscheme

a. *turkeys:* 33/32.6/32.56 %

egg laying hens: 0 %

Both needed to award the mark.

b. a. none of the egg laying hens have bacteria resistant to 5 or more antibiotics while (10) chickens have bacteria resistant to 5 or more antibiotics;

b. 13/65 % of the egg laying hens have no resistant bacteria while 9/20 % of the chickens have no resistant bacteria;

c. both have approximately same percentage/number of *E. coli* resistant to 1 or 3 antibiotics;

d. egg laying hens have less incidence of antibiotic-resistant bacteria than chickens;

c. a. hypothesis supported for poultry raised for meat but not for egg-laying;

b. turkeys and chickens always have bacteria resistant to more antibiotics than egg laying hens;

c. antibiotic-resistant bacteria are still found in egg laying hens even though antibiotics are rarely given;

d. antibiotic-resistant strains (of bacteria) may have arisen by other means/other than by poultry being given oral antibiotics;

d. from fecal matter to man handling the chickens / by accidental hand to mouth contact / contaminated dust / eating raw meat;

Examiners report

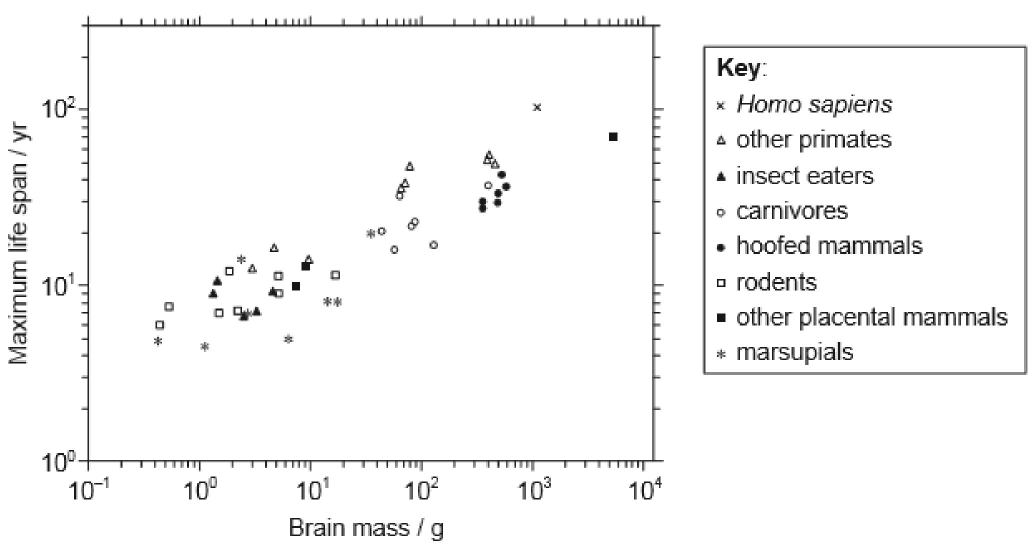
a. The few candidates who attempted this option struggled with this data analysis question. There was quite a bit of confusion about the poultry being resistant to bacteria rather than the bacteria found in the poultry being drug resistant. This caused problems in all parts of this question except (a).

b. Few received more than 1 mark for this section. The only point that was made was that egg-laying hens had a lower incidence of antibiotic-resistance bacteria than chickens.

c. Inability to understand what the table indicated meant that few were able to discuss the hypothesis given.

d. Many were able to get the 1 mark here for accidental contaminated hand to mouth contact. Those who indicated humans received the bacteria from animals when eating meat did not mention this was caused from raw meat.

The evolution of increased body size in mammals has been accompanied by an increase in life span. Another variable that could affect life span is brain size. Data was analysed from 47 mammalian species.



[Source: Hofman, M. A. (1993), Encephalization and the evolution of longevity in mammals. *Journal of Evolutionary Biology*, 6: 209–227. doi: 10.1046/j.1420-9101.1993.6020209.x]

a. State the relationship between brain mass and maximum life span. [1]

b. Identify the group with the widest range of brain mass. [1]

c. Compare the brain mass and life span of primates and marsupials. [3]

d. Discuss how a larger brain size and longer life span might have contributed to the evolution of these species. [2]

Markscheme

a. As brain mass increases life span increases / positive/direct relationship/correlation.

b. Other placental mammals.

c.

	primates	*marsupials*
a.	larger range of brain mass	(smaller);
b.	(generally) greater brain mass	(generally less);
c.	larger range of life span	(smaller);
d.	(generally) with greater life span	(generally with lesser life span);
e.	both with positive relationship between brain mass and life span;	
f.	both overlap (with the primates higher);	

Do not accept answers stating only numerical values without comparative wording.

d. a. larger brain size allows for higher intelligence/better cognition/more complex brain functions;

b. more efficient food finding / escape from predators;

c. longer life span favours parental care/survival for more reproduction;

d. (these advantages) favour natural selection which leads to evolution;

Examiners report

a. Option D data was a scatter graph showing the relationship between brain mass and life span for various groups of mammals. The question was fairly well answered, though, being a log graph, may have confused some candidates.

b. Option D data was a scatter graph showing the relationship between brain mass and life span for various groups of mammals. The question was fairly well answered, though, being a log graph, may have confused some candidates.

c. Option D data was a scatter graph showing the relationship between brain mass and life span for various groups of mammals. The question was fairly well answered, though, being a log graph, may have confused some candidates.

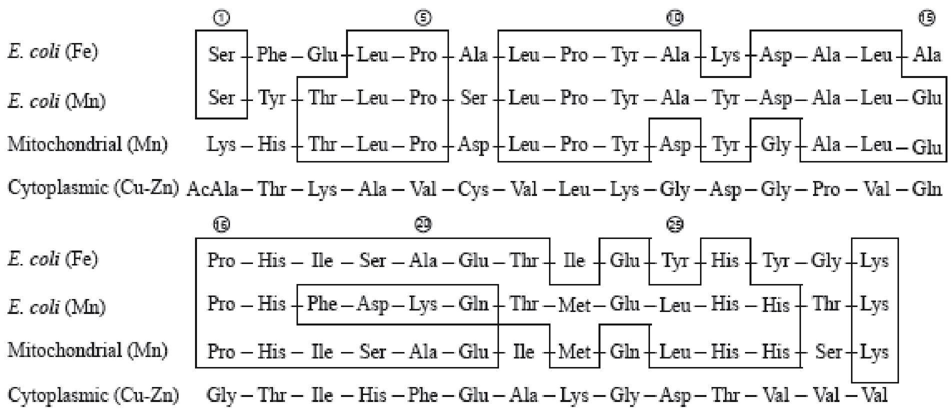
d. Option D data was a scatter graph showing the relationship between brain mass and life span for various groups of mammals. The question was fairly well answered, though, being a log graph, may have confused some candidates.

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

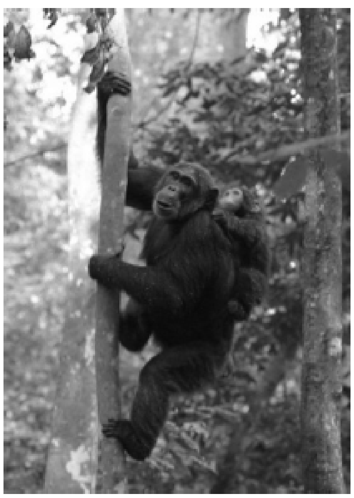
a. Almost all indicated correctly that 11 amino acids were in the same position in the three dismutase sequences.

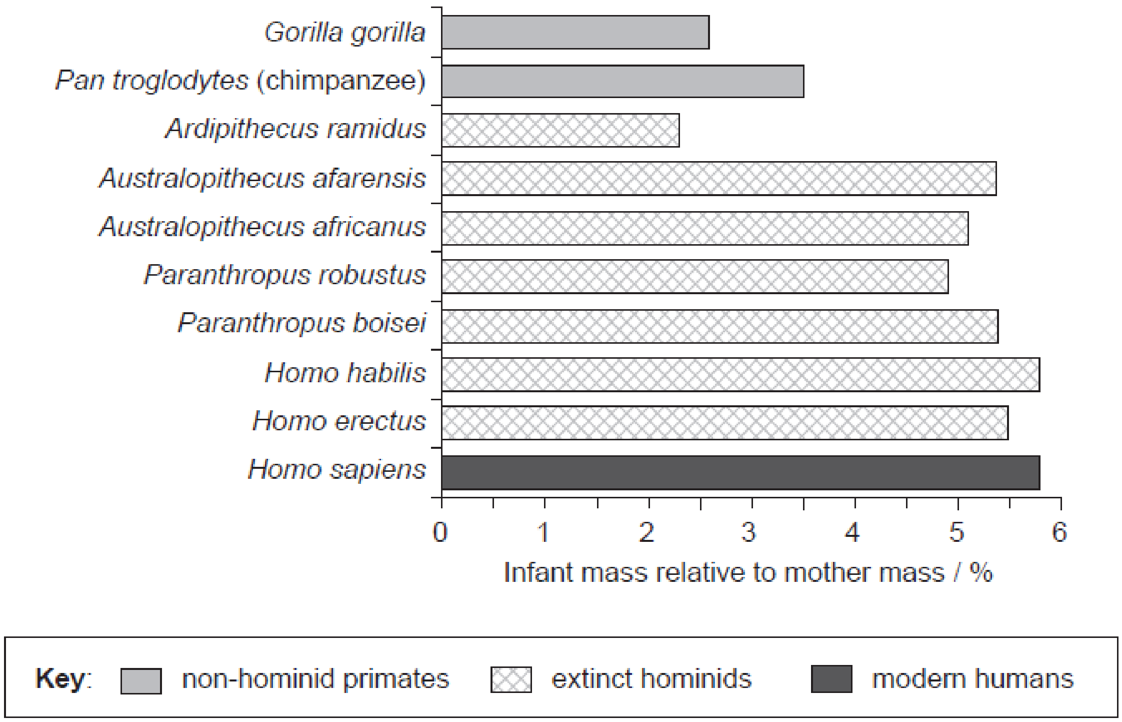
b. Most were able to correctly identify Ile and Glu as present in the same position.

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.

Modern human mothers give birth to proportionately larger infants than apes do, but it is not clear when this change occurred over the course of human evolution. The graph shows the infant mass relative to mother mass in primates, extinct hominids and modern humans.





[Source: adapted from J DeSilva, (2011), *Proceedings of the National Academy of Science*, **108** (3), pages 1022–1027]

a. State the infant mass relative to mother mass of *Homo sapiens*. [1]

b. Outline the difference in infant mass relative to mother mass in extinct hominids and modern humans. [1]

c. Suggest a hypothesis, based on evidence in the data, for when the shift to giving birth to larger infants occurred in the evolution of humans. [2]

d. Suggest **one** disadvantage of infants being born with a relatively large size in humans. [1]

Markscheme

a. 5.8(%)

Accept answers in the range of 5.7(%) and 5.9(%).

b. slightly less/similar (infant mass relative to mother mass) in extinct hominids than modern humans / *vice versa*

c. a. shift (to birthing larger infants) occurred with *Australopithecus afarensis*/after *Ardipithicus ramidus*;

b. infant mass relative to mother mass ratio lower in *Ardipithecus ramidus* than *Australopithecus afarensis*;

c. evidence limited since time lines not indicated/may be overlap;

d. a. obstetric problems / difficulty giving birth / prenatal problems;

b. carrying/transporting a large infant could be difficult;

c. larger infants require more food;

Examiners report

a. Most candidates scored well in their interpretation of the data.

b. Most candidates scored well in their interpretation of the data.

c. Most candidates scored well in their interpretation of the data.

d. Most candidates scored well in their interpretation of the data.