SL Paper 2

a. Outline **two** possible consequences of global warming for organisms living in arctic ecosystems. [2]

b. The changes that result from global warming may lead to evolution. Define *evolution*. [2]

c. Explain how sexual reproduction promotes variation in a species. [3]

Markscheme

a. reduced space/habitat (for ice-dwelling species) / valid example;

increased competition (from temperate species);

arctic species forced to migrate (in search of suitable habitats/food);

changes in patterns of (seasonal) migration;

extinction of some species due to inability to adapt quickly/compete successfully;

increased activity of decomposers;

increased success of pest species including pathogens;

changes in the distribution of prey species;

b. (cumulative) change in heritable/genetic characteristics of a population;

new species arise from pre-existing species;

change/adaptation of a population due to natural selection / descent with modification;

c. sexual reproduction involves interbreeding/genetic material from two parents;

new combinations of paternal and maternal chromosomes/alleles/genes / (random) fertilization;

which leads to new genetic combinations/greater variation;

meiosis creates a great variety of gametes;

by crossing-over / by random orientation of alleles (during meiosis);

Examiners report

a. Most candidates performed well here, but a significant number of candidates lacked the appropriate vocabulary (habitat, competition, and extinction). Some poor answers focused on the effect of warming on the environment rather than the organisms in the arctic. Others focused only on the problems posed for polar bears. Answers that did not earn credit were release/increase in greenhouse gases, rising water levels, and references to animals “dying out” which was vague.

b. Given the pivotal position of evolution in biology, it is disturbing that so many definitions missed the mark. Candidates who did well were familiar with the Teacher's notes in the Biology syllabus (p. 66) which accompany A.S. 5.4.1. The concept of change in the heritable characteristics of a population was often expanded to include adaptation through natural selection. Others candidates expanded their answer with the idea of species arising from pre-existing species. Candidates who performed poorly did not specify change in terms of heritable/genetic characteristics. Many weak answers stressed mutation rather than natural selection as the basis for adaptation.

c. Among all candidates as a group, every marking point for the question about the promotion of variation in a species through sexual reproduction was eventually awarded. However, most candidates could only produce one or two creditable ideas in their answers. Most common was the involvement of two parents leading to new genetic combinations which cause variation in offspring. Many candidates mentioned crossing-over and/or random orientation during meiosis. A few candidates mentioned random fertilization. Some weak answers talked about interbreeding of different species because the candidates misread the question and overlooked “in a species.” Also, many candidates talked about the genes of an organism or adaptation of an organism when the discussion should have been on a species or population. Finally, some candidates mixed up meiosis with mitosis while other made irrelevant comparisons to asexual reproduction.

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a. Draw a labelled diagram of a prokaryotic cell. [5]

b. Bacteria are prokaryotes that sometimes act as pathogens. Describe how the body can defend itself against pathogens. [7]

c. Explain the evolution of antibiotic resistance in bacteria. [6]

Markscheme

a. a. cell wall – *uniformly thick and drawn outside the plasma membrane*;

b. plasma membrane – *a continuous single line*;

c. cytoplasm/cytosol;

d. nucleoid/(naked) DNA – *shown as a tangle of thread or irregular shape without a nuclear membrane*;

e. (70S) ribosomes – *drawn as a small circle or dark dot*;

f. pili – hair like structures / flagellum – *shown to be longer than any pili*;

g. plasmid – *circular ring of DNA*;

h. capsule – *drawn outside the cell wall*;

*Award **[1]** for each structure clearly drawn and labelled which conforms to the italicized guidelines given above.*

b. **Remember, up to TWO “quality of construction” marks per essay.**

a. skin/mucus membranes act as barrier (to pathogens);
b. sebaceous glands secrete lactic acid/fatty acids/sebum / make surface of skin acidic;
c. (skin/stomach) acid prevents growth of many pathogens;
d. lysozyme in mucus can kill bacteria;
e. pathogens caught in sticky mucus and removed from body;
f. inflammatory response/inflammation can cause swelling/redness/fever (to inhibit the pathogen);

g. phagocytes/macrophages/leucocytes/white blood cells (non-specifically) identify (pathogens/bacteria/fungi/viruses) as foreign;
h. (phagocytes macrophages/leucocytes/white blood cells) ingest pathogens;
i. specific lymphocytes recognize one specific antigen;
j. (antigen-specific) lymphocytes clone themselves;
k. lymphocytes/leucocytes produce antibodies;
l. antigen-antibody complex formed and stimulates destruction of pathogen;

c. a. antibiotics (are chemicals) used to treat bacterial diseases;

b. within populations, bacteria vary in their (genetic) resistance to antibiotics/fitness;

c. resistance arises by (random) gene mutation;

d. when antibiotics are used antibiotic-sensitive bacteria are killed;

e. (natural) selection favours those with resistance;

f. resistant bacteria survive, reproduce and spread the gene / increase allele frequency of resistant bacteria;

g. the more an antibiotic is used, the more bacterial resistance/the larger the population of antibiotic-resistant bacteria;

h. genes can be transferred to other bacteria by plasmids;

i. doctors/vets use different antibiotics but resistance develops to these as well;

j. multiple-antibiotic resistant bacteria evolve/it becomes difficult to treat some infections;

*(Plus up to **[2]** for quality)*

Examiners report

a. Those that drew a prokaryotic cell did well but there were also quite a few eukaryotic cells as the diagram showed and labeled organelles such as mitochondria, lysosome and endoplasmic reticulum.

b. There were a generous number of marking points for this question. However, candidates were expected to earn some of them describing the first and second lines of defence as well as some of them from the immune response. This answer was generally done well when students weren't confused by extra material, many students had been over taught this area and confused the functions of macrophages / B cells / T cells / memory cells. Terminology and concepts found in HL were presented by students. Those were not accepted in the mark scheme as there were sufficient marks allotted to show understanding of the broad picture expected at SL. Those who used the HL material successfully generally had most of the marks in the mark scheme plus HL information. Unfortunately many got muddled as stated above.

c. Capable candidates answered this question very well and with clear explanation. The best responses extended their answers to include the occurrence of multiple-antibiotic resistant bacteria. Weaker and mid-range candidates mentioned that bacteria evolve to gain resistance to antibiotics but rarely that it occurs through gene mutation or suggested that mutations that give resistance occurred because bacteria required them rather than randomly. There were many vague answers as candidates seemed to have some grasp of the mechanism but difficulty explaining it.

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a. List **two** factors that could cause an increase in the size of an animal population. [2]

1. .....
2. .....

b. Outline how overpopulation of a species in a given environment may lead to evolution. [4]

Markscheme

a. a. natality / increased birth rate;

b. immigration;

c. extra food/water / breeding sites;

d. expanding habitat;

e. lack of predators/disease/parasites / reduced death rate;

b. a. more are born than can survive;

b. there is variety/variability in the offspring;

c. competition for resources / struggle for survival / selection pressure;

d. only the most able/adapted survive / survival of the fittest;

e. the survivors reproduce and pass on genes;

f. genes of less able/adapted are eliminated / change in the gene pool;

g. natural selection occurs;

Examiners report

a. Most of the candidates obtained both marks. Expanding habitat was hardly mentioned.

b. Many candidates failed to receive points because they often wrongly implied the following: "..competition between species", "survival of the fittest species".

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a. Distinguish between bryophyta and coniferophyta. [5]

b. Outline the consequences of a global temperature rise on arctic ecosystems. [6]

Markscheme

a.

bryophyta	*coniferophyta*
(reproduced by) spores	(reproduced by) seeds;
(carried in) capsules	(carried in) cones;
non-woody stems	woody stems;
smaller (less than 2 cm)	larger (meters tall);
rhizoids	roots;
no cuticle on leaves	cuticle on leaves;
no xylem/phloem	have xylem/phloem;

Responses do not need to be shown in a table format.

b. increasing rates of decomposition of detritus previously trapped in permafrost;

expansion of the range of habitats available to temperate species;

loss of ice habitat;

changes in water salinity;

changes in distribution of prey species affecting higher trophic levels;

increased success of pest species;

loss of ice increases absorption of solar radiation increasing warming of atmosphere;

extinction of species adapted to arctic/cold conditions;

humans can/should take steps to reduce/slow losses in habitat / given example of measure taken;

statement applying the precautionary principle to this issue;

Examiners report

a. Many answered this question very poorly. They did not identify bryophytes as mosses, liverworts or hornworts instead they identified them as angiosperms. They could write about conifers but not distinguish between the two.

b. The knowledge of consequences of a global temperature rise on arctic ecosystems tended to be very general and simplistic (certainly not specific enough). Many candidates wrote in great length about how the polar bear population is decreasing but forgot to mention any other consequence of global warming on the arctic ecosystem. As well, many candidates incorrectly wrote about increasing sea levels as this applies to all coastal ecosystems not just the arctic. Many candidates believed that penguins were arctic.

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a. Plants are a diverse group of eukaryotic organisms. Describe the different characteristics of the bryophyta, filicinophyta, coniferophyta and angiospermophyta. [9]

b. Plants store carbohydrate in the form of starch. Explain the reasons for starch being digested by the human digestive system. [4]

c. Compare the structure of prokaryotic and eukaryotic cells. [5]

Markscheme

a. (*At least one characteristic from each group is needed for maximum credit*.)

bryophyta have no roots / only have rhizoids;

bryophyta have simple leaves/stems / only a thallus;

bryophyta produce spores in capsule;

byrophyta are nonvascular;

bryophyte exhibit (pronounced) alternation of generations / a significant gametophyte generation;

filicinophyta have roots, stems and leaves;

filicinophyta (often) have divided/pinnate leaves;

filicinophyta produce spores in sporangia/spores on the undersides of leaves;

filicinophyta exhibit alternation of generations;

filicinophyta have primitive vascular tissue / no true xylem and phloem;

coniferophyta have woody stems;

coniferophyta (often) have narrow leaves/needles/scales;

coniferophyta produce seeds in cones/unenclosed seeds;

angiospermophyta have flowers;

angiospermophyta have ovules in ovaries;

angiospermophyta produce seeds (with hard coats) in fruits;

b. starch is a large molecule;

large molecules/starch cannot be absorbed by the intestine/villi/epithelial cells;

glucose produced by digestion of starch can be absorbed;

starch/glucose is a useful source of energy;

starch is not used in humans;

glucose is stored as glycogen not starch;

starch is not soluble/could not be transported by blood;

c. (In the table below, information from both boxes on same line is needed for 1 mark.)

*Differences **[max 4]**:*

Prokaryotic cells	Eukaryotic cells
no nucleus	nucleus;
naked DNA	DNA associated with histone/protein;
loop of DNA	strands of DNA;
no mitochondria	mitochondria;
70S/ smaller ribosomes	80S/ larger ribosomes;
no/few internal membranes / no organelles	internal membranes/organelles/ Golgi/ER/lysosomes;
smaller in size (approx. 1-10μm)	larger in size (approx. 10-100μm);
cell wall (glycoprotein) present	sometimes present/not in animal cells;

Similarities: (*Award 1 mark for any combination of two different items* ***[max 2]***)

cytoplasm/plasma membrane/contains DNA/contains ribosomes

Examiners report

a. Only a few candidates could mention more than one distinguishing characteristic for each plant group. Within this category, there were a few elite candidates who earned maximum or close to maximum marks. They wrote comprehensive answers, full of detailed knowledge. For example, in terms of reproduction, they stated that bryophyta produce spores in capsules, that filicinophyta produce spores on the undersides of leaves (in sporangia), that coniferophyta produce seeds in cones or that angiospermophyta produce seeds in fruits.

b. That starch is useful for energy was the only idea candidates seemed to know about starch. Few candidates realized that starch molecules are large and must be digested to the size of glucose before being absorbed in the intestines of humans.

c. There were some good attempts to distinguish the types of cells, but all points were not described to gain full marks. Sometimes diagrams were drawn with no differences pointed out. There was general confusion about bacteria having a cell wall while eukaryotes not having it.

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b. Describe how natural selection leads to evolution. [6]

c. Explain the consequences of altering a DNA base in the genome of an organism. [8]

Markscheme

b. populations produce more offspring than can survive;

individuals show variation;

limited resources;

create a struggle for survival/competition;

survival of the fittest / some are better suited to the environment and survive;

variation/characteristic must be heritable;

best fitted individuals survive to reproduce;

advantageous variation/characteristic/allele passed on;

over time advantageous variation/characteristic/allele increases in the population;

c. altering a base (in DNA) is a (point) mutation;

only has an effect if base is in a gene;

when mRNA is produced by transcription one mRNA base is different;

one codon in mRNA is different;

one amino acid is different in the polypeptide;

polypeptide produced by translation of mRNA;

some base changes do not change the amino acid coded for;

structure of polypeptide /protein may be altered;

usually the polypeptide/protein does not function as well;

example given:
disease: sickle cell anemia;
mutation: GAG to GTG;
consequence in translation: glutamic acid to valine;
consequence for protein: hemoglobin altered so sickle cell formed;
consequence for individual: less oxygen can be carried;

Examiners report

b. The role of natural selection in evolution was not well answered even though it is a fundamental concept in biology. The best answered laid out a step-wise sequence of events that lead to evolution with real life examples to illustrate the explanation such as Galapagos Island Finches.

c. The consequences of altering a base in the genome of an organism should be a straightforward question to answer but many candidates rambled without giving specifics. The best answers laid out a step-wise sequence of events that explain the consequences with real life examples to illustrate the explanation such as Sickle cell anaemia.

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a. Living organisms have been placed in three domains: archaea, eubacteria and eukaryote. Distinguish archaea from eubacteria. [3]

Archaea	Eubacteria

b. List **two** types of evidence used to determine which species belong in the same clade. [2]

Markscheme

a.

archaea	*eubacteria*
DNA with proteins/histones	DNA with no proteins/histones
usually have introns	seldom have introns
cell walls lack peptidoglycan/glycoprotein	cell walls with peptidoglycan/glycoprotein
lipids different/cell membrane with glycerol-ether	lipids different/cell membrane with glycerol-esters
found in extreme environments	not in extreme environments
ribosomes are different (than eubacteria)	ribosomes are different (than archaea)

*Award **[1]** for each correct row.*
Award reasonable distinctions even if not strictly contrasted.

b. a. DNA/base sequences (of a gene/genes)

b. amino acid sequences (in a protein/proteins)

Do not credit references to morphology.

Examiners report

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

Mutations are the ultimate source of genetic variation and are essential to evolution.

Lice are wingless insects that belong to the phylum arthropoda.

a.i. State **one** type of environmental factor that may increase the mutation rate of a gene. [1]

a.ii. Identify **one** type of gene mutation. [1]

b. State **two** characteristics that identify lice as members of the arthropoda. [2]

1.

2.

b.ii. Some lice live in human hair and feed on blood. Shampoos that kill lice have been available for many years but some lice are now resistant to [3]

those shampoos. Two possible hypotheses are:

Hypothesis A	Hypothesis B
Resistant strains of lice were present in the population. Non-resistant lice died with increased use of anti-lice shampoo and resistant lice survived to reproduce.	Exposure to anti-lice shampoo caused mutations for resistance to the shampoo and this resistance is passed on to offspring.

Discuss which hypothesis is a better explanation of the theory of evolution by natural selection.

Markscheme

a.i. a. radiation

b. chemical mutagens/carcinogens/papilloma virus/cigarette smoke

a.ii. base substitution/insertion/deletion/frameshift

b. a. jointed appendages

b. «chitinous» exoskeleton

c. segmented body
OR
bilateral symmetry
OR
mouth ***AND*** anus
OR
paired appendages

b.ii a. «scientists would accept» hypothesis A as the better one as mutations are random

b. scientists would reject hypothesis B because characteristics acquired during the lifetime of the individual being inherited is Lamarckian/not part of the evolution by natural selection theory/not all mutations are heritable

c. «the resistance» mutation would be present in the population initially and not caused by the shampoo «as hypothesis B states»

d. both hypotheses include variation in the population of lice «resistant and non-resistant»

e. variation is necessary for natural selection to occur

f. frequency of the best adapted increases and these individuals reproduce/pass on resistance to their offspring, so the resistant population increases «so hypothesis A is better»

OWTTE can be used for any of the answers in this part.

Examiners report

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

b.ii. [N/A]

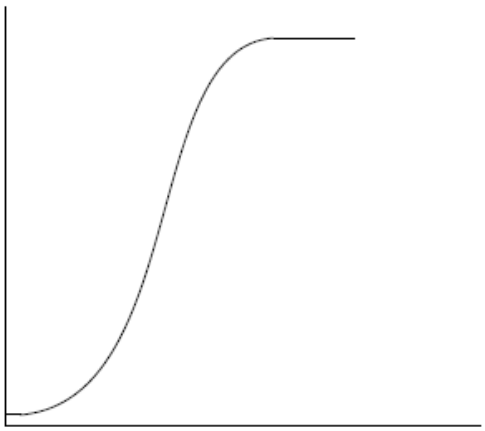
a. Reproduction can cause populations to increase rapidly. Draw a labelled graph showing a sigmoid population growth curve. [4]

b. Explain the various possible consequences of overproduction of offspring. [6]

c. Outline the role of hormones in the menstrual cycle. [8]

Markscheme

a. (a)



S-shaped curve correctly drawn; } *(eg does not fold back on itself)*

y-axis labelled as population/number of individuals and *x*-axis labeled as time/ years etc; } *(both axes must be correctly labelled)*

exponential/log growth indicated at point where rate is increasing;

transitional phase indicated at point where rate is decreasing;

plateau phase; *Do not accept carrying capacity* ***[4 max]***

b. overpopulation/overproducing (of offspring) leads to competition for limited resources/struggle for survival;

example of limited resource; *(eg water/space/food)*

not all can survive / less adapted will die/migrate;

some varieties/individuals more suited for environmental conditions;

they are more likely to survive and reproduce;

this is natural selection;

increase chances/spread of disease in population;

waste products of the population may reach toxic levels;

may exceed carrying capacity leading to population crash;
Do not accept references between species.

c. FSH (released from pituitary) stimulates follicle growth (in ovary);

oocytes/egg cells mature;

cells of growing follicle produce estrogen;

estrogen signals endometrium/lining of uterus to thicken;

causes final maturation of follicle;

high levels of estrogen stimulate secretion of LH;

LH spike stimulates ovulation/follicle ruptures releasing oocyte/ova/egg cells;

LH stimulates follicle (left behind in ovary) to develop into corpus luteum;

LH stimulates corpus luteum to secrete progesterone/estrogen;

progesterone/estrogen stimulates continued development/maintenance of lining of uterus (in preparation for implantation of embryo);

if no pregnancy then corpus luteum disintegrates;

drop in progesterone/estrogen hormone levels causes breakdown in uterine lining/menstruation;

progesterone/estrogen inhibit FSH/LH release;

(Plus up to [2] for quality)

Examiners report

a. Growth curves often showed an S shape but, in some cases, the curve folded over itself. (Some even drew a log-linear plot.) Labelling was generally poor. Surprisingly, errors/omissions were seen in the X and Y labels. Although the plateau phase was usually clearly labelled, the exponential/log growth stage and the transitional phase were often vague. Many candidates did not earn full marks.

b. As consequences of overproduction of offspring, many answers only mentioned competition, limited resources, and survival problems. A common incorrect answer was ‘competition between species’. The spread of disease in a population, the accumulation of waste products to toxic levels, and exceeding the carrying capacity were infrequently mentioned. An increase in predators was not awarded a mark. Some answers digressed in the direction of evolution without gaining marks.

c. The role of hormones in the menstrual cycle was badly answered by many. The role of FSH was known but only partial knowledge of LH, estrogen, and progesterone was seen. Regarding estrogen and progesterone, candidates generally knew they are involved in the maintenance of the lining of the uterus but that was all. Often, the various hormones were stated but without any description of their effect.

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a. Describe the movement of energy and nutrients in an ecosystem. [6]

b. Explain how sexual reproduction can eventually lead to evolution in offspring. [8]

c. Using simple external recognition features, distinguish between the plant phyla bryophyta and angiospermophyta. [4]

Markscheme

a. ecosystem is a community and its abiotic environment;

solar energy collected by autotrophs/plants (via photosynthesis);

moves through trophic levels via food;

only 5 to 20% transferred from one trophic level to next / never 100% efficient;

lost as metabolic heat/organic waste;

energy flow can be illustrated by pyramid shape;

organisms absorb nutrients from food/environment;

nutrients occur as complex organic matter in living organisms;

after death, saprotrophic bacteria and fungi (decomposers) breakdown complex organic matter;

breakdown products are simpler substances;

absorbed into plants for resynthesis into complex organic matter/recycled;

b. offspring vary in traits;

variation results from sexual reproduction;

independent assortment of alleles (during meiosis of spermatogenesis/ oogenesis) contributes to variation;

meiosis is the cellular process that produces gametes;

crossing over (during meiosis) increases variation;

fertilization (combination of different genomes) contributes to variation;

more offspring may be produced than the environment can hold;

struggle for existence can occur;

offspring whose traits best adapt them to environment will survive/survival of fittest;

change in environment will lead to survivors with new/different traits;

correct use of term natural selection/selective pressure;

variation is heritable / over time more offspring born with new trait;

change in gene pool;

when entire population (of a species) exhibits new trait, evolution has occurred;

c.

bryophyta	angiospermophyta
nonvascular/unspecialized tissue / no veins	vascular/specialized tissue / veins;
small / height up to 7 cm	tall / height up to 100 m;
exist as organized masses of cells / "leafy" appearance	contain water-conducting cells (tissue)/food-conducting tissue/ support tissue;
reproductive structures / capsules appear on stalks	have flowers;
microscopic spores	covered seeds/fruits;
sometimes hair-like extensions below growing surface/rhizoids	roots;

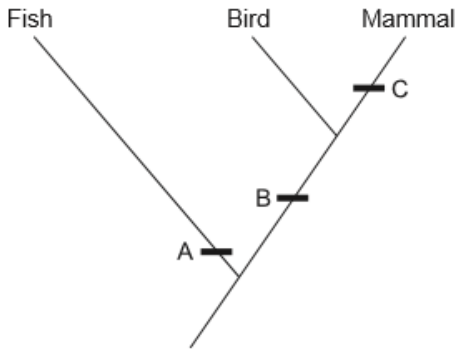
Examiners report

a. Candidates demonstrated a good understanding of the movement of both energy and nutrients in ecosystems. The best responses were illustrated with energy pyramids or nutrient diagrams.

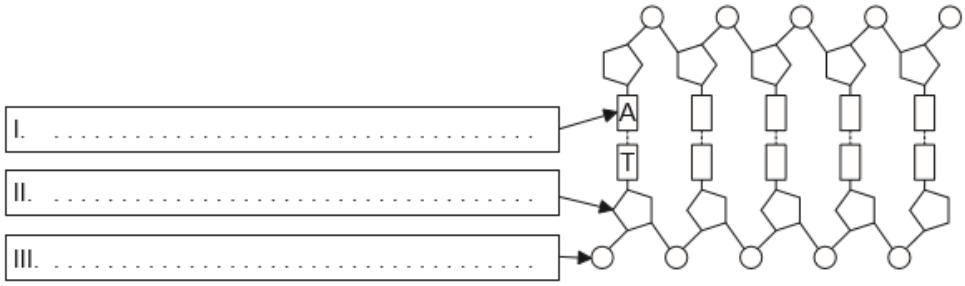
b. The role of sexual reproduction in evolution was well answered in general. The best answered laid out a step-wise sequence of events that explained how sexual reproduction leads to evolution with real life examples such as Galapagos Island Finches.

c. Few candidates could recall any detail of the characteristics of the plant phyla bryophyta and angiospermophyta. Many did use a table to distinguish between the two phyla, which was an appropriate way to approach the answer, however the lack of detail let most candidates down.

The image shows part of a cladogram.



a. Label the parts of two paired nucleotides in the polynucleotide of DNA. [3]



b. Using the cladogram, identify **one** diagnostic feature that characterizes the given groups of vertebrates at A, B and C. [3]

A: .....
B: .....
C: .....

c. State the name of the domain to which these organisms belong. [1]

Markscheme

a. *I*: nitrogenous base

OR

adenine

OR

purine base

II: deoxyribose

III: phosphate

b. A: gills ***or*** fins ***or*** scales ***or*** no limbs ***or*** external fertilization

B: homeothermic ***or*** endothermic ***or*** warm-blooded ***or*** lungs ***or*** tetrapod ***or*** four limbs ***or*** pentadactyl limbs ***or*** internal fertilization

C: hair ***or*** fur ***or*** mammary glands ***or*** milk

c. Eukaryotes

Examiners report

a. Most candidates gained two marks, the most common mistake being to label the deoxyribose as ‘sugar’ or ‘ribose’

b. Again this seems to be an area that escaped some teachers in their reading of the new specification and resulted in a large number of G2 comments, most of which seemed to think that the oversimplification of the cladogram led to confusion. In the end better prepared candidates had no problem with the question, managing to state a fish characteristic for A, something in common between birds and mammals, e.g. homeothermic for B and a general mammalian feature for C (but not forgetting the monotremes)

c. If candidates had been taught this section, they knew that the domain was eukaryotes.

b. Outline the process of gas exchange necessary for aerobic respiration in a unicellular eukaryotic organism. [3]

c. Explain how the process of evolution occurs. [8]

Markscheme

b. Oxygen must be taken up ***AND*** carbon dioxide must be released (*Both needed*)

Gases pass through a cell membrane by simple diffusion

Require a concentration gradient
OR
pass from high concentration to low concentration

Without requiring energy
OR
passive process

Large SA: vol ratio

c. Evolution is «cumulative» change in population/species over time

OR

change in allele frequency

A population has variations amongst the individuals

Due to meiosis
OR
sexual reproduction

Due to mutations

Certain variations give an advantage to some organisms over others in certain environments

Populations/species produce more offspring than the environment can support

Individuals of the species compete for the same resources

The better-adapted organisms tend to survive and reproduce
OR
less adapted organisms tend to die or reproduce fewer offspring

Individuals «that reproduce» pass on their «heritable» characteristics/alleles/genes to their offspring (*"Traits" is an acceptable alternative to "characteristic"*)

Natural selection increases the frequency of «heritable» characteristics/alleles/genes of the better-adapted organisms (*Accept "genes"*)

Specific example described (*Example must be "described" to award marks*)

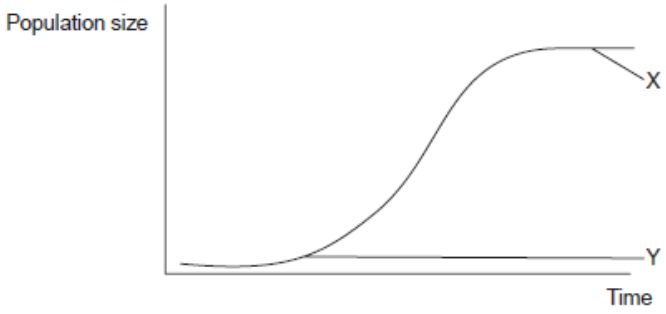
*Award **[7 max]** if no reference to heritable characteristics or alleles.*

Examiners report

b. Gas exchange and simple diffusion – Most candidates knew what aerobic respiration was, but could not apply it to the question. Perhaps under the pressure of the examination, candidates many did not progress to the second line and therefore missed the expression 'unicellular eukaryotic organism'. Detailed knowledge of the alveoli and the Krebs cycle did not gain marks.

c. Evolution – Several G2 comments were made which questioned whether the candidates should be answering a question on evolution. It is a topic that has appeared on the examination many times and well prepared candidates had no trouble answering it. The number of 'Lamarckian' answers where individuals instead of populations or species were evolving showed the continued decrease shown over the last few years.

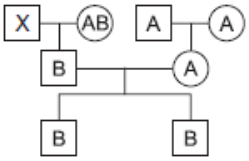
The graph shows a sigmoid population growth curve.



The table summarizes the genome size of several organisms.

Organism type	Organism	Genome size / base pairs
Bacterium	*Helicobacter pylori*	1667867
Fruit fly	*Drosophila melanogaster*	130000000
Rice	*Oryza sativa*	420000000
Human	*Homo sapiens*	3200000000

The figure shows a pedigree chart for the blood groups of three generations.



a. Identify the phases labelled X and Y. [1]

X:

Y:

b. Outline how fossil records can provide evidence for evolution. [2]

c(i). Distinguish between the terms genotype and phenotype. [1]

c(ii). Outline a structural difference between the chromosomes of *Helicobacter pylori* and *Homo sapiens*. [1]

c(iii). Deduce the percentage of adenine in *Oryza sativa* if the proportion of guanine in that organism is 30 %. [1]

d(i). Deduce the possible phenotypes of individual X. [1]

d(ii). Describe ABO blood groups as an example of codominance. [1]

Markscheme

a. X: plateau phase

Y: exponential growth / log phase

(both needed)

b. a. the sequence in which fossils appear matches the expected sequence of evolution;

b. comparisons with fossils and living organisms (morphology) shows change in characteristics from an ancestral form / *OWTTE*;

Vestigial organs and homologous structures are acceptable answers.

c. fossils of extinct species show that (evolutionary) change has occurred;

d. fossils can be dated with radioisotopes / geological depth/strata indicates (relative) age/date of organism;

e. can yield DNA for molecular clock analysis;

f. example of any of the above can earn one mark (*eg*: reptiles follow amphibians);

c(i). genotype is the genetic make-up/set of alleles (of an organism) while phenotype is the characteristics (expressed/shown in an organism)

c(ii). chromosome from bacteria has no protein associated/naked DNA / bacteria is circular, H. sapiens is linear / (chromosomes of) H. sapiens are much bigger/have many more base pairs than bacteria

N.B.: Answer must refer to "chromosomes" not genomes of the two organisms.

c(iii). 20 %

d(i). A, B, AB and O

All four phenotypes must be shown to award the mark.

d(ii). allele I^A and the allele I^B are (co)dominant as they are both expressed in the heterozygote/AB type blood / *OWTTE*

Examiners report

a. Well prepared candidates could state ‘plateau phase and exponential growth or log phase’. A surprising number reversed the answers, probably due to carelessness.

b. There were many convoluted answers without substance. Most gained the marks by stating that fossils can be compared with living organisms with an example.

c(i). Most managed to give a reasonable explanation of genotype and phenotype.

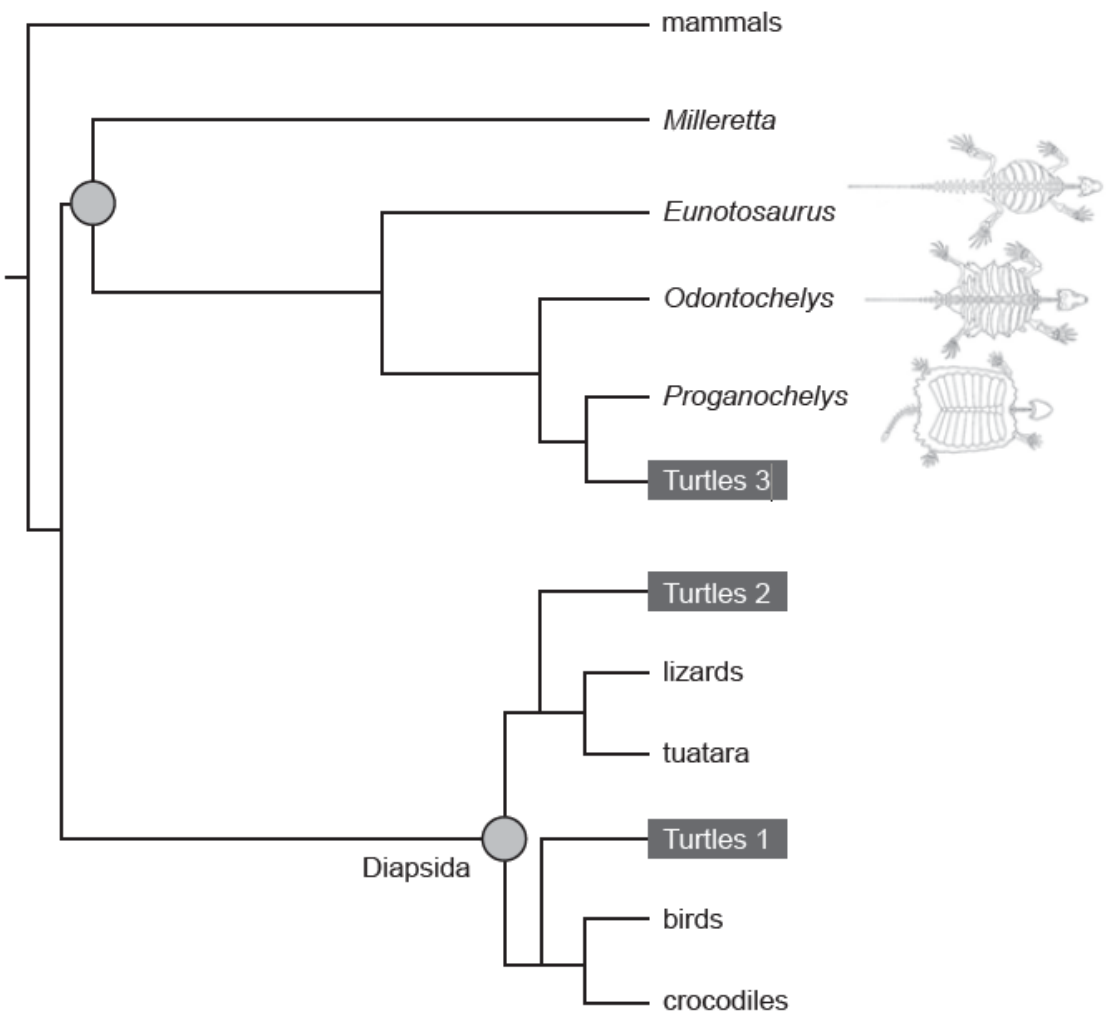
c(ii). Many missed the word 'chromosomes' in the stem. The knowledge of naked v proteins or circular v linear was expected from the core. Using the data it was expected that the candidates could state that the human chromosomes were much bigger (divide by 46) or that there were many more base pairs as there was about 3×10^3 difference.

c(iii). Considering that everyone on the IB diploma course studies maths at some level, a surprising number left (iii) blank or gave answers that did not make sense.

d(i) A pleasing number were able to state that all 4 blood groups were possible in (i), and most had a reasonable attempt at explaining codominance in part (ii).

d(ii) A pleasing number were able to state that all 4 blood groups were possible in (i), and most had a reasonable attempt at explaining codominance in part (ii).

The following cladogram shows three possible evolutionary routes for the turtle (Turtles 1, Turtles 2 and Turtles 3). The taxa in italics are extinct.



[Source: Tyler R. *et al*., Transitional fossils and the origin of turtles, *Biology Letters* 6, Dec 23, 2010, pages 830–833, by permission of the Royal Society.]

a.i. State the organism most closely related to the lizards. [1]

a.ii. Based on the taxa shown, deduce a difficulty in gathering data to study turtle ancestry. [1]

b.i. Molecular evidence is often used to construct a cladogram. Describe **one** type of molecular-based evidence to identify members of a clade. [2]

b.ii. Suggest **one** type of additional evidence that could provide strong support for Turtles 3 as the evolutionary route for turtles rather than Turtles 1 or Turtles 2. [1]

c. Taxonomists aim to place species into genera, families and higher taxa according to their evolutionary origins. This is known as natural classification. [2]

Explain the usefulness of natural classification in biodiversity research.

Markscheme

a.i. Tuatara

a.ii. some «taxa» are extinct

OR

convergence «of body form» could have occurred (confusing interpretation of the data)

b.i. a. base sequences of a gene/DNA/mtDNA

OR

amino acid sequences of a protein

b. species with the most similarities «in base sequence/amino acid sequence/genomes» have recently diverged/a common ancestor/are closely related
OR
members of a clade accumulate the fewest mutations on same base sequences/ *vice versa* / OWTTE

b.ii. fossils / comparative anatomy / homologous structures / vestigial structures

c. a. «because» it allows easier identification of a species

b. «because» it can help identify common ancestors/evolutionary paths/close relationships (showing degree of biodiversity) / OWTTE

c. «because» it is universal/cross-cultural language that avoids problems of local names of organisms
OR
«because» it promotes international collaboration
OR
«because» it facilitates access to the history/background of the species /indexing for retrieval of relevant «taxonomic» information / OWTTE

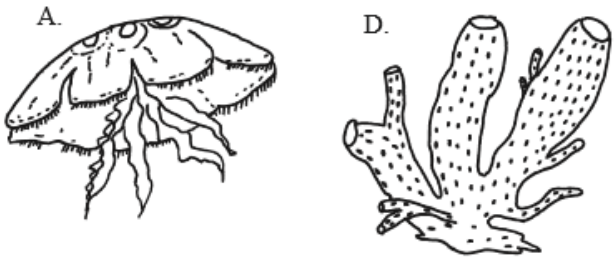
d. «because» it allows «biodiversity» research of larger taxa «*ie* examination of a family of large cats rather than one species»

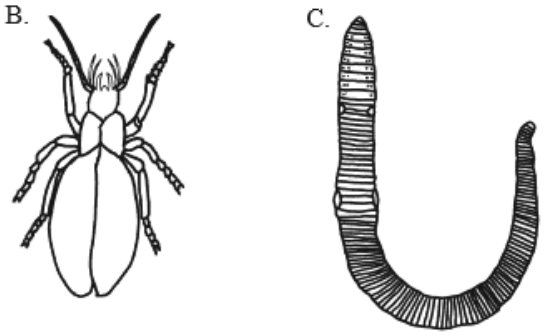
Examiners report

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

---

a. Parts of a dichotomous key to organisms A, B, C and D are shown. Design missing parts of the key using features visible in the following diagrams. [2]





1.

Body with tentacles .....A

Body without tentacles ..... go to 2

2.

.....B

.....go to 3

3

.....C

.....D

b. All of these organisms belong to the animal kingdom. State **two** structural differences between animal cells and plant cells [2]

Markscheme

a. any <u>visible</u> characteristic that distinguishes between B and the rest; (*eg. three pairs of legs/no legs*)

characteristic that distinguishes between C and D; (*eg. body divided into many segments / body not divided into many segments*)

characteristic specific to C <u>and</u> different characteristic specific to D; (*eg. C had cylinder shape and D has pores*)

b. cell wall only in plant cells;

starch granules only in plant cells;

chloroplasts only in plant cells;

centrioles only in animal cells;

(large) vacuole in plant cells;

Examiners report

a. Despite the simplicity of 2(a), this dichotomous key question drew out some remarkable weaknesses. Too often, answers included internal or physiological characteristics as opposed to visible features of the organisms. Those candidates who did not have the proper knowledge of how to design a dichotomous key were the ones who gave a varied range of incorrect answers. Exoskeleton was accepted.

b. Most candidates correctly answered question 2(b). Some sloppy answers that gained no credit were: “Plant cells have chloroplasts. Animal cells have mitochondria” or just “Plant cells have chloroplasts” and nothing said about animal cells.

---

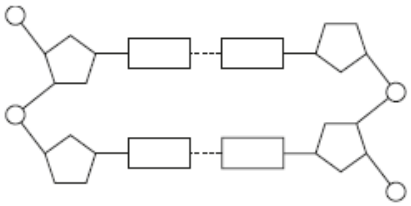
a. Draw a labelled diagram of a section of DNA showing four nucleotides. [5]

b. Outline a technique used for gene transfer. [5]

c. Explain how evolution may happen in response to an environmental change. [8]

Markscheme

a. Award [1] for each labelled item shown correctly connected.



a. phosphate;

b. deoxyribose;

c. (nitrogenous) base / specific name *eg*: adenine/thymine/guanine/ cytosine shown connected to carbon-1;

d. covalent bond / phosphodiester bond;

e. hydrogen bond;

f. nucleotide shown to include phosphate, sugar and base by (shape or label);

g. diagram shows complementary base pairing or A bonded to T, C with G.

*Award **[3 max]** if the nucleotides are shown in a single strand.*
*Award **[4 max]** if antiparallel structure is not shown.*

b. a. plasmid used for gene transfer/removed from bacteria;

b. plasmid is a small/extra circle of DNA;

c. restriction enzymes/endonucleases cut/cleave DNA (of plasmid);

d. each restriction enzyme cuts at specific base sequence/creates sticky ends;

e. same (restriction) enzyme used to cut DNA with (desired) gene;

f. DNA/gene can be added to the open plasmid/sticky ends join gene and plasmid;

g. (DNA) ligase used to splice/join together/seal nicks;

h. recombinant DNA/plasmids inserted into host cell/bacterium/yeast;

c. a. (genetic) variation in population;

b. (variation is) due to mutation / sexual reproduction;

c. valid example of variation in a specific population;

d. more offspring are produced than can survive / populations over-populate;

e. competition / struggle for resources/survival;

f. example of competition/struggle for resources;

g. survival of fittest/best adapted (to the changed environment)/those with beneficial adaptations / converse;

h. example of changed environment and adaptation to it;

i. favourable genes/alleles passed on / best adapted reproduce (more) / converse;

j. example of reproduction of individuals better adapted to changed environment;

k. alleles for adaptations to the changed environment increase in the population;

l. example of genes/alleles for adaptations increasing in a population;

m. evolution by natural selection;

n. evolution is (cumulative) change in population/species over time / change in allele frequency;

Suitable examples are antibiotic resistance and the peppered moth but any genuine evidence-based example of adaptation to environmental change can be credited.

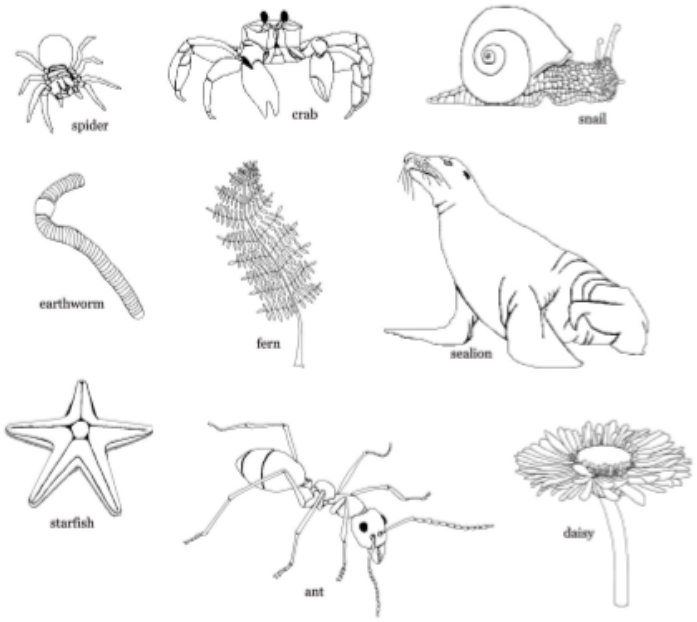
Examiners report

a. Most gained some marks for the diagram. As it was DNA the nucleotides should be in two strands joined by H bonds. Many drew only one strand.

b. Marks were lost through lack of precision. The names of the enzymes were expected. Few stated that the same restriction enzyme was required for the plasmid and gene.

c. This was answered well by the better candidates. There were also disappointing numbers of Lamarkian answers from weaker candidates trying to explain the adaptation of individuals. Many answers were very general and would have benefitted from concrete examples.

The diagrams below show different organisms (not drawn to scale).



a. State **all** the organisms shown above that belong to the following phyla. [3]

Filicinophyta:
Arthropoda:
Mollusca:

b (i) Construct a possible food chain using **three** of the organisms shown opposite, stating the trophic level to which they belong. [2]

b (ii) State the initial energy source of the food chain constructed in (b)(i). [1]

Markscheme

a. *filicinophyta:* fern;

arthropoda: spider, ant, crab; *(all three needed to award the mark)*

mollusca: snail;

b (i) e.g.

daisy/fern → ant → spider;
daisy/fern → snail → crab/sea lion/ant;
producer primary consumer secondary consumer;
*Award **[1 max]** for correct trophic levels. Award **[1]** for the correct sequence of organisms which includes a producer.*

b (ii) sun / solar energy/light

Examiners report

a. Widespread weakness was seen as many candidates could not identify which organisms belonged to which phyla (A.S. 5.5.3, 5.5.4). One correctly matched organism was often mixed with one that didn't belong, resulting in no mark.

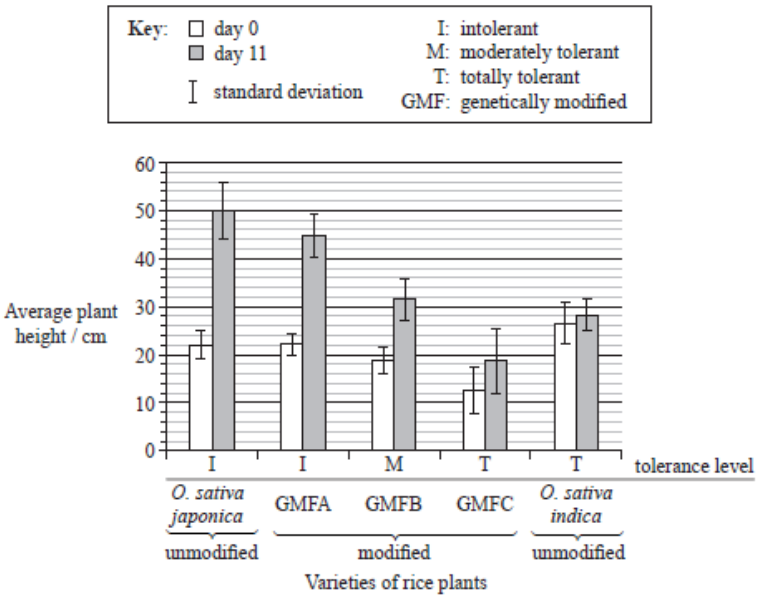
b (i) Unrealistic food chains were given; for example, daisy→ant→snail. Arrows showing energy flow did not always lead from producer to primary consumer etc. or were shown leading in both directions. Finally, the food chain had to include a producer, a primary consumer and a secondary consumer.

b (ii) Although the food chain in 3(b)(i) had to begin with either daisy or fern, the initial source of energy should have been (sun)light. Either plant was unacceptable for the mark.

Rice (*Oryza sativa*) is usually intolerant to sustained submergence under water, although it grows rapidly in height for a few days before dying. This is true for one variety, *Oryza sativa japonica*. The variety *Oryza sativa indica* is much more tolerant to submergence.

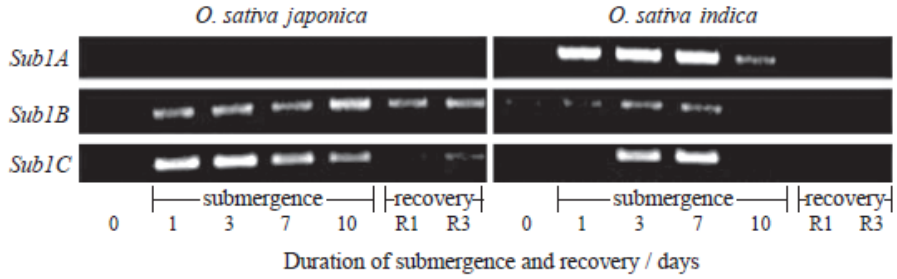
Three genetically modified forms of *O. sativa japonica*, GMFA, GMFB and GMFC, were made using different fragments of DNA taken from *O. sativa indica*.

The plants were then submerged for a period of 11 days. The heights of all the plants were measured at the beginning and at the end of the submergence period.



[Source: Adapted from "Sub1A is an ethylene-response-factor-like gene that confers submergence tolerance to rice" (2006) Kenong Xu, Xia Xu, Takeshi Fukao, Patrick Canlas, Reycel Maghirang-Rodriguez et al. Nature, 442, pp. 705—708. Adapted by permission from Macmillan Publishers Ltd (c) 2006.]

In the same experiment, the researchers hypothesized that the capacity to survive when submerged is related to the presence of three genes very close to each other on rice chromosome number 9; these genes were named *Sub1A*, *Sub1B* and *Sub1C*. The photograph below of part of a gel shows relative amounts of messenger RNA produced from these three genes by the submergence-intolerant variety, *O. sativa japonica*, and by the submergence-tolerant variety, *O. sativa indica*, at different times of a submergence period, followed by a recovery period out of water.



[Source: Adapted from "Sub1A is an ethylene-response-factor-like gene that confers submergence tolerance to rice" (2006) Kenong Xu, Xia Xu, Takeshi Fukao, Patrick Canlas, Reycel Maghirang-Rodriguez et al. Nature, 442, pp. 705—708. Adapted by permission from Macmillan Publishers Ltd (c) 2006.]

a(i). State which group of rice plants were the shortest at the beginning of the experiment. [1]

a(ii). Calculate the percentage change in height for the *O. sativa japonica* unmodified variety during the submergence period. Show your working. [2]

c. Deduce the general relationship between the growth of all the *japonica* varieties and their stated tolerance level. [1]

d. Outline the use of the binomial system of nomenclature in *Oryza sativa*. [2]

e(i). Determine which gene produced the most mRNA on the first day of the submergence period for variety *O. sativa japonica*. [1]

e(ii). Outline the difference in mRNA production for the three genes during the submergence period for variety *O. sativa indica*. [2]

e(iii). Compare the mRNA production for the three genes during the submergence period between the two varieties. [2]

f. Deduce, using all the data, which gene was used to modify GMFC. [2]

g. Evaluate, using all the data, how modified varieties of rice could be used to overcome food shortages in some countries. [2]

Markscheme

a(i). (GMF) C

a(ii). $\frac{(50-22)}{22} \times 100$;
$= 127\%$; *(units required) (allow answers in the range of 127 to 127.3)*

c. inversely proportional / the higher the tolerance, the less the growth / *vice-versa*

d. a. first name/*Oryza* for genus / second name/*sativa* for species;

b. (all) members of *Oryza satica* share special/unique features;

c. two names make a unique combination to designate species / worldwide recognizable nomenclature;

d. varieties (*japonica* and *indica*) have some (consistent) differences (in tolerance);

e(i). *Sub1C*

e(ii). a. *Sub1A* is expressed strongly/the most / *Sub1A* produces the most RNA;

b. *Sub1B* (always) has the lowest expression/produces least mRNA;

c. *Sub1A* expressed/produces mRNA for the longest time/days 1 to 10;

d. *Sub1C* expressed/produces mRNA for the shortest time/days 3 to 7;

e(iii) a. *Sub1A* only expressed/produces mRNA in *indica* / not/never expressed/ never produces mRNA in *japonica*;

b. *Sub1C* expressed/produces mRNA from day 1 in *japonica*, but not *indica*;

c. *Sub1B* has lower expression/production of mRNA than *Sub1C* in both varieties;

*Award **[1 max]** for other accurate comparisons between japonica and indica*.

f. a. *Sub1A*;

b. is only expressed in *indica*;

c. *indica* is the variety showing submersion tolerance;

g. a. genetically modified rice/rice with *Sub1A* is more tolerant to submersion;

b. can withstand seasonal flooding/torrential rain;

c. GMF/tolerant rice ensures greater harvest/provides more food during flooding;

Examiners report

a(i). Generally well done. A few wrote only GMF.

a(ii). Little understanding shown. Many divided the difference in height by 50 instead of 22.

c. Many candidates worded generalized relationships such as the higher the tolerance, the less the growth or growth and tolerance were inversely proportional. Sometimes “height” was given rather than “growth”.

d. The designation of *Oryza* as genus and *sativa* as species was the only marking point that many candidate got correct in this question, although some candidates mixed up the terms calling *Oryza* the species and *sativa* the genus. Very few candidates went beyond to mention that *O. sativa* shared special features. Even fewer candidates mentioned that the varieties *japonica* and *indica* had differences in tolerance. Occasionally, a candidate mentioned that binomial nomenclature helps scientists communicate about the same plant or the worldwide acceptance for the terminology.

e(i). Some candidates did not appreciate that the actual production of each gene was indicated by the intensity of the bands shown on the photograph of electrophoresis.

e(ii). Since the question asked for differences in mRNA production for the three genes, it was important that candidates used quantitative wording such as *Sub1A* produces the “most” mRNA or that *Sub1B* produces the “lowest” or “least” mRNA to convey a sense of comparison. A few candidates noted that *Sub1A* produced mRNA for the “longest” time/days 1 to 0 and/or that *Sub1C* produced mRNA for the “shortest” time/days 3 to 7.

e(iii). Many valid comparisons could be made comparing the mRNA production for the three genes. Most often given was that *Sub1A* only produced mRNA in *japonica* and/or never in *indica*. The two mark maximum was achieved frequently.

f. The question was poorly answered. Though *Sub1A* was sometimes correctly identified as the gene to modify GMFC, reasoning to support that answer was usually incorrect or missing.

g. Many candidates missed the question by trying to relate GMFs to drought conditions rather than flooding. GMFs offered tolerance to submersion enabling them to withstand flooding so that greater harvests/food production were ensured during flooding.

The diagram shows a leaf from Dryopteris arguta.

[https://commons.wikimedia.org/wiki/File:E20161208-0001%E2%80%94Dryopteris_arguta_(Reverse)%E2%80%94RPBG_(30698925004).jpg, E20161208-0001—Dryopteris arguta (Reverse)—RPBG Source: https://www.flickr.com/photos/john_d_rusk/30698925004/ (https://www.flickr.com/photos/john_d_rusk/30698925004/) Author: John Rusk from Berkeley, CA, United States of America, licensed under Creative Commons licence: https://creativecommons.org/licenses/by/4.0/legalcode]

a.i. State the phylum of this plant. [1]

a.ii. State **two** characteristics of plants from the phylum you stated in (a)(i). [2]

b. Outline why the number of trophic levels is limited in a food chain. [1]

Markscheme

a.i. Filicinophyta/Filicinophytes/Pteridophytes

Reject "ferns"

a.ii a. have roots, stem and leaves

All three, roots, stem and leaves required

b. pinnate leaves/leaves divided «repeatedly» into leaflets

c. have vascular tissue/xylem and phloem

d. produce spores/sporangia

OR

no flowers/fruits/seeds

[Max 2 Marks]

b. energy losses between trophic levels

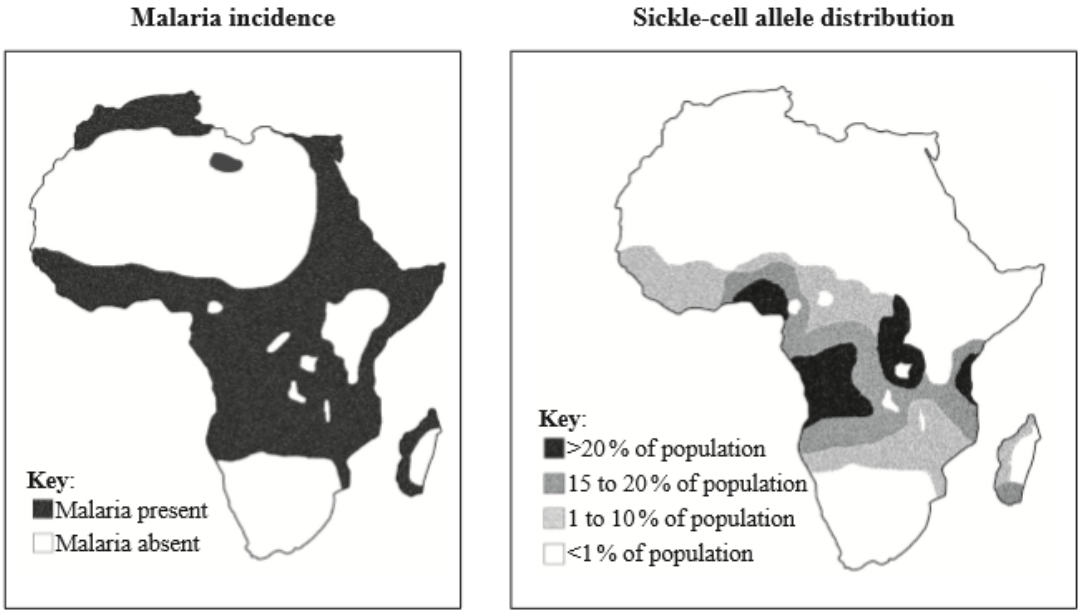
OR

only part of the energy in one trophic level will become part of the next trophic level

Examiners report

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

Sickle-cell anemia is a disease caused by a base substitution mutation, where GAG has changed to GTG. The distribution of the sickle-cell allele is correlated with the incidence of malaria in many places, as shown by the map of Africa.



[Source: Image courtesy of Anthony Allison; image source: Wikimedia Commons]

a. The correlation shown in the data above can be explained by natural selection. Outline how the process of natural selection can lead to evolution. [3]

b. Explain how a base substitution mutation, such as GAG to GTG, can lead to a disease like sickle-cell anemia. [2]

c. Using a Punnett grid, determine the possible genotypes and phenotypes of a cross between a man and a woman who are both carriers of the sickle-cell allele. Use the symbol Hb^S for the sickle-cell allele and Hb^A for the normal allele. [2]

Phenotypes:

Markscheme

a. offspring compete/environment cannot support all offspring;

(genetic) variation in the offspring;

natural selection /survival of better adapted/fittest organisms;

reproduction passes characteristics to other generations;

allele frequencies change;

malaria causes selection pressure (in Africa/worldwide);

different hemoglobin/sickle-cell genotypes exist / normal hemoglobin and sicklecell alleles exist;

natural selection/resistance to malaria of sickle-cell heterozygotes/allele;

survivors pass on sickle-cell allele to offspring; (*do not accept sickle-cell anemia*)

frequency of sickle-cell allele highest in areas of high malaria incidence;

b. change in the codon (of the mRNA);

tRNA with a different anticodon attaches;

(if codon changed) wrong/different amino acid is joined to peptide/glutamic acid replaced by valine;

distorted hemoglobin molecule alters red blood cell shape/reduces ability to carry oxygen;

c. (*genotypes shown in a Punnett grid eg*)

	Hb^A	Hb^S
Hb^A	$Hb^A Hb^A$	$Hb^A Hb^S$
Hb^S	$Hb^A Hb^S$	$Hb^S Hb^S$

;

(*phenotypes*)
(Hb^A Hb^A) normal and (Hb^A Hb^S) normal carrier/intermediate/sickle-cell trait and (Hb^S Hb^S) sickle-cell anemia/diseased / (Hb^A Hb^A and Hb^A Hb^S) normal /symptomless and (Hb^S Hb^S) sickle-cell anemia/diseased;
To award the mark all phenotypes must be mentioned.

Examiners report

a. Much stimulus material is given about malaria and sickle-cell anemia in the stem for 4(a), yet the final question can be answered without any reference to the stem. This may have caused uncertainty among candidates. An effort was made to accommodate general answers about natural selection leading to evolution as well as those that included the malaria information given in the stem. Some candidates inaccurately used the term “sickle-cell anemia” when they should have written “sickle-cell allele.”

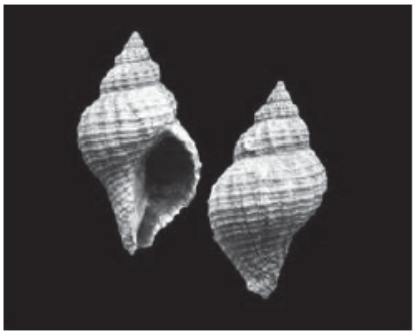
b. Few candidates recognized that a base substitution mutation causes the structural defect in hemoglobin which causes sickle-cell anemia for 4(b). Hemoglobin was rarely mentioned. A change in the codon of mRNA and the consequent attachment of a tRNA with a different anticodon and amino acid was just not given. There was almost no reference to codon or anticodon. Candidates proffered less detailed answers such as “a different amino acid is joined to the peptide” or “glutamic acid is replaced by valine”.

c. A few candidates confused sickle-cell anemia and Hb inheritance with sex-linkage in 4(c), perhaps because of wording in the stem. Some listed genotypes instead of describing phenotypes for the second part of the answer. All phenotypes had to be given for the mark. Since the guide (4.3.12) regards Hb^A and Hb^S as codominant alleles, describing or stating the phenotype of the carrier is problematic since carrier status "appears" the same as homozygous normal. This problem was covered by the mark scheme as each of the following was accepted to describe the carrier phenotype: normal, normal carrier, intermediate, sickle-cell trait and symptomless. Regardless of how the carrier phenotype was described the phenotype of sickle-cell anemia/diseased had to be mentioned. Those who drew a correct Punnett grid usually did well in describing the phenotypes.

Native oyster populations are decreasing where rivers meet the ocean along the northwest coast of North America. These oyster populations are being attacked by a gastropod.

Adult oyster, *Ostrea lurida*

[Source: © International Baccalaureate Organization 2017]



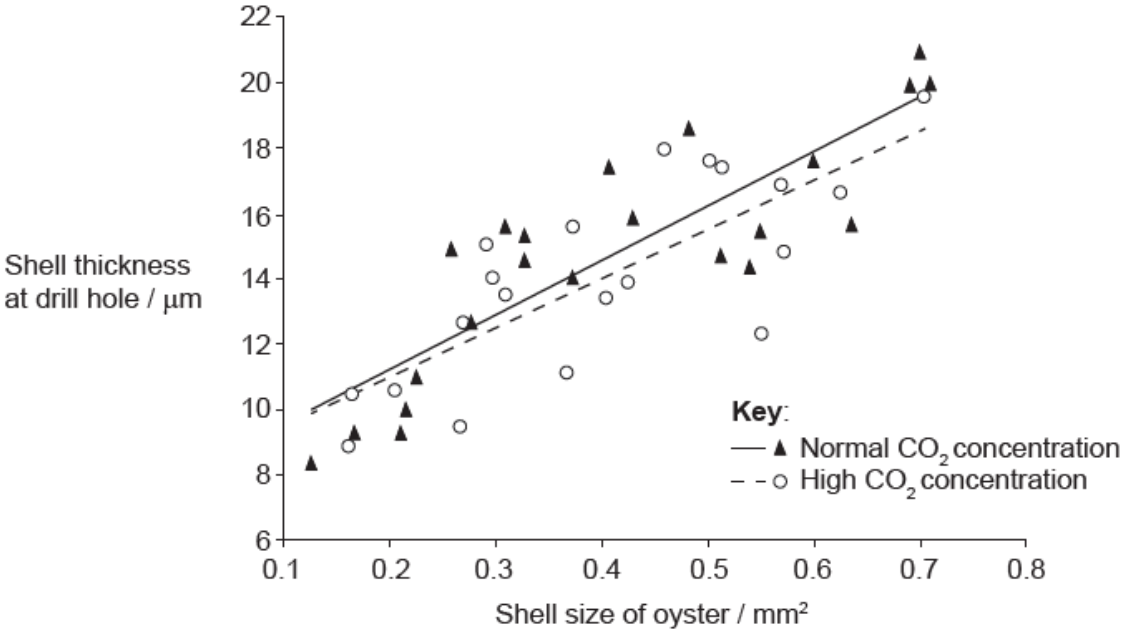
Adult gastropod shell, *Urosalpinx cinerea*

[Source: © International Baccalaureate Organization 2017]

It is known that oysters and gastropods have hard parts composed of calcium carbonate and that ocean acidification is increasing. Studies were carried out using juvenile oysters and gastropods to investigate the effects of acidification on the decrease in the population of oysters.

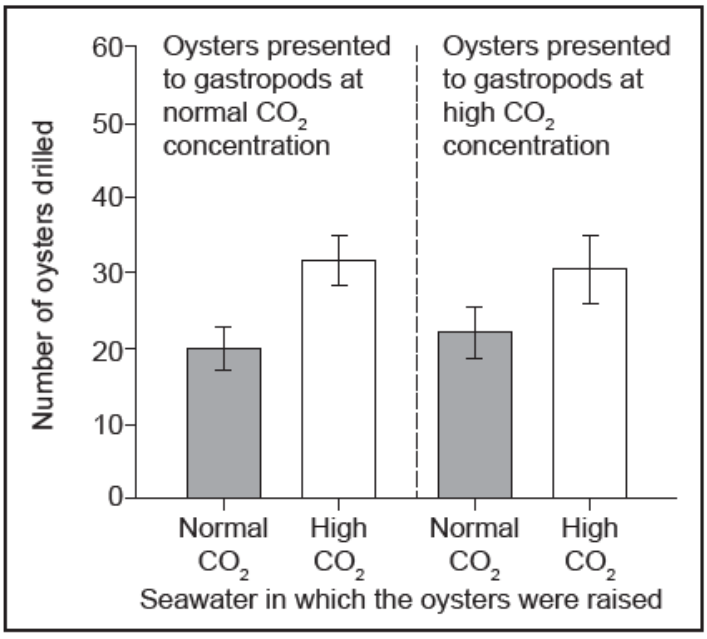
The first step was to raise oysters in two different mesocosms. One had seawater at a normal concentration of CO_2 and the other had sea water with a high concentration of CO_2. Gastropods were raised in two further mesocosms with normal and high CO_2 concentrations respectively.

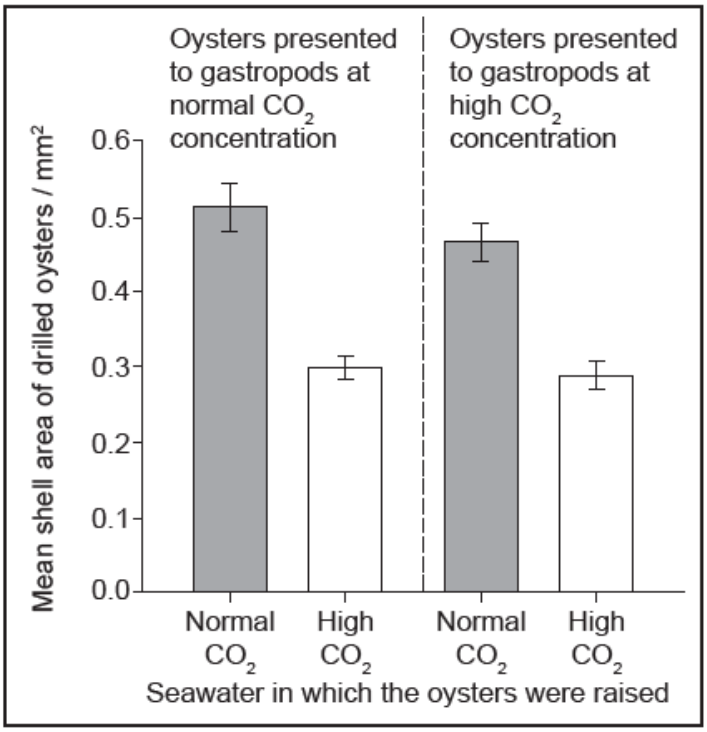
A juvenile gastropod will attack a juvenile oyster by using its tongue-like structure (radula) to drill a hole through the oyster shell. Once the hole has been drilled, the gastropod sucks out the soft flesh. Researchers investigated the shell thickness at the site of the drill hole in relation to the size of the oyster. The results are seen in this graph.



[Source: E Sanford *et al*. (2014) *Proceedings of the Royal Society B*, 281, by permission of the Royal Society.]

Equal numbers of oysters raised in seawater with a normal CO_2 concentration and in seawater with a high CO_2 concentration were then presented together to the gastropod predators in seawater with a normal CO_2 concentration. The same numbers of oysters from the two groups were also presented together to the gastropods in seawater with a high CO_2 concentration. The bar charts show how many of the oysters were drilled by the gastropods and the mean size of drilled oysters.





[Source: © International Baccalaureate Organization 2017]

a. Outline how acidified sea water could affect the shells of the oyster. [1]

b. Outline the trends shown in the data in the graph. [2]

c. Estimate how much smaller drilled oysters raised in seawater at a high CO_2 concentration were than drilled oysters raised in seawater at a normal CO_2 concentration. [1]

d.i. Deduce from the data in the bar charts which factors were and were not correlated significantly with the number of oysters drilled by the gastropods. [2]

d.ii. Suggest reasons for the differences in the numbers of oysters drilled, as shown in the bar charts. [2]

d.iii. The radula in a gastropod is hard but not made of calcium carbonate. Outline how this statement is supported by the drilling success of the gastropods in seawater with normal or high CO_2 concentrations. [2]

e. Using all the data, evaluate how CO_2 concentrations affect the development of oysters and their predation by gastropods. [2]

Markscheme

a. Shells might dissolve/deteriorate / become smaller/thinner/weaker / OWTTE

OR

shell formation reduced / more difficult

b. a. positive correlation between shell thickness and shell size

OR

as shell thickness increases, shell size «also» increases

b. (positive correlation) occurs at two different CO_2 concentrations / both high and normal concentrations

c. trend for thickness is «slightly» lower with high CO_2

c. «approximately» 0.2 mm^2

OR

«approximately» 40 % «smaller»

unit required

d.i. a. significant factor: concentration of CO_2 in which oysters were raised

b. insignificant factor: concentration of CO_2 at which oysters were presented to gastropods

d.ii. a. (because) shells are thinner/smaller when the oyster is raised in high CO_2/lower pH

OR

«because» lower pH/higher acidity prevents/reduces deposition of calcium carbonate

b. gastropods target smaller/thinner-shelled oysters more

c. gastropods can eat/drill thin-shelled/smaller oysters at a faster rate (and move onto another)

d. eating smaller oysters «from high CO_2 environments» means given population of gastropods require more oysters for same food intake

d.iii. a. data shows that similar numbers are drilled regardless of conditions

b. since radulas are not affected by acidification

OR

radulas not made of calcium carbonate so (remain) strong/successful at drilling

e. a. the data/trend lines indicate that a higher CO_2 concentration diminishes the shell thickness, making gastropod predation more successful

OR

the bar graphs suggest that oysters raised in a higher CO_2 concentration are smaller, making gastropod predation more successful

b. CO_2 concentrations «during feeding» do not change the occurrence of drilling/predation «by gastropods»

c. «limitation» no information about how exaggerated the CO_2 concentrations were
OR
«limitation» no information about numbers of gastropods used «in each setting»

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
d.i. [N/A]
d.ii. [N/A]
d.iii. [N/A]
e. [N/A]