AQA A-LEVEL · 7402

# BIOLOGY



## MARK SCHEME

### 3.4.4 GENETIC DIVERSITY AND ADAPTATION

| SCORE | PERCENTAGE |
| --- | --- |
| /490 | % |

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## Q1.

(a) 1. Add 1 part (bacteria) culture to 9 parts (sterile) liquid (to make $10^{-1}$ dilution);
*Accept water / nutrient / broth for liquid*

2. Mix (well);
*Accept stir*

3. Repeat using 9 parts fresh (sterile) liquid and 1 part of $10^{-1}$ and $10^{-2}$ dilutions to make $10^{-3}$ dilution;
**OR**
Add 1 part $10^{-1}$ (suspension) to 99 parts (sterile) liquid (to make $10^{-3}$ dilution);
*Accept water / nutrient / broth for liquid*
*Reject 1 part (undiluted) culture added to 999 parts liquid*

**3**

(b) $3.75 \times 10^9$ / 3 750 000 000;;
*Accept for 1 mark: 3750 000 / $3.75 \times 10^6$ (cells per $mm^3$)*
*OR*
*$3.75 \times 10^{12}$ (wrong volume conversion)*
*OR*
*3750 (cells per $mm^3$ of diluted culture)*
*OR*
*Evidence of using correct dilution conversion and correct volume conversion, i.e., × 1000 and × 1000*

**2**

(c) 1. **Count** unlikely to be accurate / repeatable / reproducible / reliable;

2. Because too many cells;
**OR**
Because cells overlapping / not spread out;

**2**

(d) 1. Tetracycline used more often / in higher doses;

2. Resistant bacteria more likely to (survive and reproduce and) pass on allele/gene for (tetracycline) resistance;
**OR**

3. More / higher frequency of mutations (for tetracycline resistance);
*Reject reference to mutation being caused by use of antibiotic*

4. (so) gene passed on to more bacteria;
**OR**

5. Tetracycline used over longer time period;

6. More time for (chance) mutation to occur / for selection to occur;
*Ignore reference to resistant animals*
*Ignore reference to immunity*

**2**

(e) No selection against resistant bacteria / resistance gene/allele;
**OR**
Bacteria pass on (resistance) gene / allele when they reproduce;
**OR**
Bacteria resistant to tetracycline are passed on from one generation of farm animals to the next (probably via faeces);
**OR**
Environment does not change, so stabilising selection occurs;

*Accept no selection to get rid of it*

*Reject reference to mitosis or immunity*

**1**

**[10]**

## Q2.

(a) 1. 1 long and 1 short chromosome, each made up of 2 chromatids held (by centromere), in each cell of 1st division;

2. 1 long and 1 short (separate) chromosome in each cell of 2nd division;

*Allow ECF for correct chromosomes shown in each cell from candidate's 1st division cells.*

*Ignore drawing of centromere.*

**2**

(b)

| | |
|---|---|
| 52 | 4 |

;;

Allow 1 mark for numbers totalling 56 except 14/42 - repetition of observed values.

If table is blank, award 1 mark for evidence of 56.

*Both 52 and 4 required in table for two marks, do not credit 52 or 4 for one mark.*

*Award 1 max for answers not given as whole numbers.*

**2**

(c) 1. There is a less than 0.05/5% probability that the difference(s) (between observed and expected) occurred by chance;

*Reject 'results (without reference to difference) occurring by chance'. Overall max 1 with this statement.*

*Accept 'there is a greater than 0.95/95% probability that the difference did **not** occur by chance'.*

*Ignore 'difference is significant'*

2. Calculated value is greater than critical value so the null hypothesis can be rejected;

*Ignore 'difference is significant'*

*Do not accept 'P value' for 'critical value'.*

3. (The scientists can conclude that) the proportion of plants that produce 2n gametes does change from one breeding cycle to the next;

**2 max**

(d) 1. The scientists selected/used for breeding plants that produced 2n gametes;

*Answer must be in context of the scientists selecting plants to breed. Accept 'artificial selection' or 'selectively bred'.*

2. (So these plants) passed on their alleles (for production of 2n gametes to the next generation);

*Both mark points can be awarded if one correct reference is made to alleles (in either context).*

3. The frequency of alleles for production of 2n gametes increased (in the population).

*Both mark points can be awarded if one correct reference is made to alleles (in either context).*

*For 'production of 2n gametes' accept 'abnormal meiosis'.*

*Do not accept 'number' for frequency.*

*Accept converse answers linked to plants that produce n gametes.*

**3**

**[9]**

## Q3.

(a) 1. LP due to mutation
**OR**
Allele due to mutation;

*Reject mutation caused by drinking milk.*

*Reject (LP) gene*

2. Milk provides named nutrient;

*Accept any correct named nutrient e.g. glucose, galactose, protein*

*Ignore 'sugar' 'lactose' as named nutrient*

3. Individuals with LP more likely to survive **and** reproduce
**OR**
Individuals with advantageous allele more likely to survive **and** reproduce;

*Reject (LP) gene*

*Accept 'individuals who produce lactase' for 'LP individuals'*

*Accept 'pass on allele/LP/characteristic' for reproduce.*

4. Directional selection;

5. Frequency of allele increases (in the offspring/next generation);

*Accept description of increasing frequency of allele e.g. 'higher proportion', 'more common' but ignore increase in **number** of allele*

**4 max**

(b) 1. Dominant allele;

2. (Always) expressed/shown (when present in phenotype/offspring)
**OR**
Expressed when only one (dominant allele) present;

**2**

(c) 1. Mutation in promoter (DNA/gene) for transcription factor
**OR**
Mutation in promoter (region/DNA) for the gene
**OR**
Mutation in gene for transcription factor;
*Accept mutation in an epistatic gene*

2. Lactase gene continues to be transcribed/active;

**2**

**[8]**

## Q4.

(a) 1. (µg because) very little ammonia (in soil);

2. (µg because) avoids use of (lots of) decimal places (in their results) / avoids the use of powers of 10 / avoids the use of standard form;
*Accept makes numbers more manageable*
*Accept makes easier to plot graph*

3. ($g^{-1}$) to allow comparisons (between samples);

**2 max**

(b) Answer between 4.5 and 4.6 µg $g^{-1}$ $day^{-1}$;;

Award 1 mark for correct number but wrong / no units
*Ignore plus or minus signs*
*Accept 'per gram'* ***AND / OR*** *'per day'*

**2**

(c) 1. pH 4.3 / B has fastest rate of breakdown (of ammonia);

2. A + B / mixture at pH 6.9 slowest / slower (than A or B);
*Not just ref. to A and then B on their own*

3. Suggests (community / bacteria at) pH 4.3 / B doesn't work (well) at pH 6.9 / pH of mixture;
*Accept converse that only (community / bacteria at) pH 6.9 / A is working in the mixture*

**3**

(d) (Species **S** because) no mark

1. Species **S** change of 990,000 (per gram of soil);
*Award MP1 and 2 OR MP3 and 4*
*Accept standard forms $9.9 \times 10^5$ and $9.9 \times 10^3$ for either*
*Accept for 1 mark for 100 times greater in correct context with no other calculations shown*

2. Species **T** change of 9,900 (per gram of soil);
*Accept standard forms $9.9 \times 10^5$ and $9.9 \times 10^3$ for either*

**OR**

(Species **T** because) no mark

3. Species **S** has 99% change;

4. Species **T** has 9900% change;

**2**

(e) 1. They didn't count bacteria / cells / population(s);

*Ignore ref. to other factors / other named factors affecting growth*

2. Copies / number of mRNA related to amount of enzyme / amoA produced / translated;

3. Don't know how much mRNA / amoA produced by each cell;

*Accept some bacteria produce more mRNA / amoA than others*

4. Don't know if amoA (mRNA / enzyme) is linked to cell division / growth (of population);

*Amount of amoA does not show cell division / growth*

*Reject references to mitosis / meiosis*

**4**

(f) 1. Suitable method;
eg in boiling water / steam / autoclave / wash in disinfectant / wash in alcohol

*Ignore heat unqualified*

*Ignore flaming of bottle*

*Accept radiation*

2. (Reason) to remove / kill other bacteria / organisms that might break down ammonia;

*Ignore ref to removing bacteria that 'affect the result'*

*Accept other bacteria producing amoA*

*Accept other bacteria compete with / kill bacteria that produce amoA*

*Ignore contamination unqualified*

**2**

**[15]**

## Q5.

(a) 1. So no contamination / other bacteria;
2. So same number of bacteria transferred **<u>to</u>** allow comparison;

*1. Accept sterilisation / kills all (bacteria)*

*2. Allow amount / concentration for number*

**2**

(b) 6 000 000
**OR**
$6 \times 10^6$;

*1 mark for 3 000 000*

***OR***

*$3 \times 10^6$*

*Allow 1 mark for 600 (in $1cm^3$ of diluted culture)*

**2**

(c) 1. (Several) values between 10 and 15 (units);
2. Repetitions of each;

*1. Accept descriptions of this*

*Ignore repeat the investigation / repeat at 10 and 15 units.*

**2**

**[6]**

## Q6.

(a) 1. Person (infected with HIV) has HIV DNA (in their DNA);
2. New HIV (particles) still made;
3. (AZT) inhibits reverse transcriptase;
4. (AZT) stops these (new HIV particles) from forming new HIV DNA;
**OR**
Slows / stops replication of HIV;
5. Stops destruction of more / newly infected T cells;
6. So immune system continues to work (and AIDS does not develop);

*4. Context is important*

*4. Allow slows / stops (re)production of HIV*

*4. Reject (AZT) prevents DNA replication*

**4 max**

(b) 1. Slows / stops the development of AIDS;
2. Because HIV **resistant to AZT** is damaged / destroyed / prevented from replicating (by other drugs);
**OR**
3. AZT continues to work as a drug;
4. Because HAART prevents the spread of AZT-resistant HIV to rest of the human population;
**OR**
5. No new HIV particles made;
6. Because HAART might interfere with viral protein synthesis;

*Mark in pairs.*

*Do not mix and match.*

*2. Neutral HIV killed*

*2. Accept other drugs prevent HIV resistant to AZT from infecting new / more cells*

*6. Accept blocks transcription / translation / synthesis of lipid envelope / aspect of viral structure*

**4 max**

(c) 1. (Fewer mitochondria so) less (aerobic) respiration;
2. (Muscles receive) less ATP (so waste);

*1. Ignore no respiration*

*2. Reject less energy produced*

*2. Ignore no ATP is made*

**2**

**[10]**

## Q7.

(a)

| | |
|---|---|
| $ATP \longrightarrow ADP + P_i + H_2O$ | |
| $ATP + H_2O \longrightarrow ADP + P_i$ | |
| $ADP + P_i \longrightarrow ATP + H_2O$ | ✓ |
| $ADP + P_i + H_2O \longrightarrow ATP$ | |

**1**

(b) 1. Human ATP synthase has a different tertiary structure to bacterial ATP synthase
**OR**
Human ATP synthase has a different shape active site to bacterial ATP synthase
**OR**
Antibiotic cannot enter human cells/mitochondria
**OR**
Antibiotic not complementary (to human ATP synthase);

**1**

(c) 0.75;
One mark for showing 30 g = 0.03 kg;
One mark for showing 0.025 mg $g^{-1}$

**2**

(d) Answer in range 97.0 − 97.8%;
**OR**
Answer in range 3288 − 4368%;

*2. 1 mark for correct $log_{10}$ readings from graph converted to actual numbers*

*(16.98 − 19.50 **and** 660.7 − 758.6)*

**2**

(e) 1. (From the graph in part c) New / old antibiotic does not kill all bacteria;
**OR**
(From the graph in part c) Some bacteria are resistant to the new / old antibiotic;
2. Resistant bacteria will reproduce to produce (more) resistant bacteria;
3. (Use of both) one antibiotic will kill bacteria resistant to the other antibiotic;
**OR**
Unlikely that bacteria are resistant to both the new and the old antibiotic;
**OR**
Use of both antibiotics (likely to) kill all / most bacteria;

*Accept use of '**A**' for 'new antibiotic' and '**R**' for 'old antibiotic'.*

*1. Must relate to the bacteria that are still present – 'some bacteria are killed' or 'the bacteria number is reduced ' is insufficient.*

*2. Accept 'resistant bacteria reproduce to pass on resistance gene / allele'*

*3. 'Use of both antibiotics will be more effective' is*

*insufficient.*

3

**[9]**

## Q8.

(a) 1. Contents of phloem vessel pushed into insect's mouth by high pressure;

2. (High pressure in phloem vessel) caused by loading of sugars into phloem in leaf;

3. And (resulting) entry of water by osmosis.

3

(b) 1. Polysaccharides are insoluble;

2. So do not affect water potential of gut.

2

(c) 1. (Only few bacteria passed from parent, so) only a few (copies of) genes passed on (in bacteria);

2. May not / does not include all alleles (of genes, so diversity reduced)
**OR**
Small number of bacteria transmitted means unrepresentative sample.

2

(d) 1. Number / mass / density of insects per plant;

2. Stage of development / size of plants / insects;
*Ignore any abiotic factor*

2

(e) Draw around leaf on graph paper **and** count squares;

1

**[10]**

## Q9.

(a) Binary fission;
*Reject mitosis*

1

(b) 1. Keep lid on Petri dish
**OR**
Open lid of Petri dish as little as possible.

2. To prevent unwanted bacteria contaminating the dish.
**OR**
*L. monocytogenes* may be dangerous / may get out.

**OR**

3. Wear gloves
**OR**
Wear mask
**OR**
Wash hands;

4. To prevent contamination from bacteria on hands / mouth
**OR**
Prevent spread of bacteria outside the lab;

**OR**

5. Use sterile pipette
**OR**
Flame the loop
**OR**
Flame the neck of the container of the culture;

6. To maintain a pure culture of bacteria

**4 max**

(c) Cinnamon;

**1**

(d) 1. Thyme is the most effective / best (at 4 °C);

2. Clove and cinnamon same effectiveness at 4 °C as 35 °C (so suitable);

3. Bay and nutmeg are less effective at 4 °C than 35 °C (so unsuitable).

**3**

(e) Less kinetic energy
**OR**
Less movement of oil molecules / of phospholipid molecules

**1 max**

**[10]**

## Q10.

(a) Phylum;

**1**

(b) **M** placed correctly between zygote and zygospore;

**1**

(c) Any valid reasons, e.g.

**Asexual**

Fewer stages so quicker
**OR**
Only one parent involved so can colonise new environment
**OR**
Produces clone so successful (geno / pheno)type maintained;

**Sexual**

increases genetic diversity so greater chance of survival / success.

**2**

(d) Spores spread / dispersed further;

**1**

(e) 1. Measure diameter of large number of spores;

2. Divide measured values by 700 (to find true diameter);

3. Reference to using volume of sphere.

**3**

**[8]**

## Q11.

(a) 1. Antigen / epitope on surface of *N. meninigitidis* / bacterium binds to surface protein / surface receptor on a (specific / single) B cell.

*If answered in context of T cell, allow Antigen binds to (specific / single) T cell*

2. (Activated) B cell divides by mitosis / produces clone;

*If answered in context of T cell, allow (Activated) T cell releases cytokine.*

3. (Division) stimulated by cytokines / by T cells;

*If answered in context of T cell, allow (Cytokine) stimulates production of plasma cells;*

4. B cells / plasma cells release antibodies;

5. (Some) B cells become memory cells;

6. Memory cells produce plasma / antibodies faster

**6**

(b) 1. Mutation

*Allow horizontal gene transfer*

2. Results in Nm cell with allele for resistance to <u>one</u> antibiotic / to named antibiotic

3. (This) cell survives <u>and</u> passes the allele for resistance to offspring;

*2. and 3. If gene for resistance, penalise once*

4. Process repeated with different genes conferring resistance to each of the other (two) antibiotics

*If reference made to 'resistant gene', 2 max for MP2, 3 and 4*

**4**

(c) Any **five** contrasting statements, e.g.

1. Bacterial cell is <u>much</u> smaller than a human cell;

2. Bacterial cell has a cell wall but human cell does not;

3. Bacterial cell lacks a nucleus but human cell has a nucleus;

4. Bacterial cell lacks <u>membrane-bound</u> organelles but human cell has membrane-bound organelles;

*Accept any named membrane-bound organelle*

5. Bacterial ribosomes smaller than human ribosomes / bacteria have 70S ribosomes whereas humans have 80S ribosomes;

6. Bacterial DNA is circular but human DNA is linear;

7. Bacterial DNA is 'naked' whereas human DNA is bound to histones / proteins

*Since contrast is required, both parts of each statement must be present to gain the mark.*

**5 max**

**[15]**

## Q12.

(a) PKNJ.

**1**

(b) *Lutra lutra.*

**1**

(c) Bone / skin / preserved remains / museums.

**1**

(d) 1. (Hunting) reduced population size(s), so (much) only few alleles left;

*Accept bottleneck*

2. Otters today from one / few surviving population(s);

*Accept founder effect*

3. Inbreeding.

*Allow any **two***

**2 max**

(e) 1. Population might have been very small / genetic bottleneck;
2. Population might have started with small number of individuals / by one pregnant female / founder effect;
3. Inbreeding.

*Allow any **two***

**2 max**

**[7]**

## Q13.

(a) (No – no mark)
Graph / bar chart only shows number of species, not the name of the species.

**1**

(b) (No – no mark)
1. Mutations are spontaneous / random;
2. Only the rate of mutation is affected by environment;
3. Different species do not interbreed / do not produce fertile offspring;
4. So mutation / gene / allele cannot be passed from one species to another.

*Ignore references to correlation does not prove causation*

**4**

(c) 1. Initially one / few insects with favourable mutation / allele;
2. Individuals with (favourable) mutation / allele will have more offspring;
3. Takes many generations for (favourable) mutation / allele to become the most common allele (of this gene).

**3**

**[8]**

## Q14.

(a) 1. Kingdom, Phylum, Class, Order, Family;
2. *Luscinia svecica.*

*1 mark for each correct column*

*Allow Genus and Species if both placed in box for species but not if both placed in genus box*

**2**

(b) Number of different alleles of each gene.

*Accept number of different base sequences (found) in each gene*

**1**

(c) 1. Has greater proportion of genes / percentage of genes showing diversity;
2. Percentage is 35% compared with 28% / proportion is 0.35 compared with 0.28.

*Allow correct figures that are not rounded up, i.e., 34.9% / 0.349 and 27.8% / 0.278*

**2**

**[5]**

## Q15.

(a) 0.32.

*Correct answer = 2 marks*

*Accept 32% for 1 mark max*

*Incorrect answer but identifying 2pq as heterozygous = 1 mark*

**2**

(b) 1. Mutation produced *KDR minus* / resistance allele;
2. DDT use provides selection pressure;
3. Mosquitoes with *KDR minus* allele more likely (to survive) to reproduce;
4. Leading to increase in *KDR minus* allele in population.

**4**

(c) 1. Neurones remain depolarised;
2. So no action potentials / no impulse transmission.

**2**

(d) 1. (Mutation) changes shape of sodium ion channel (protein) / of receptor (protein);
2. DDT no longer complementary / no longer able to bind.

**2**

**[10]**

## Q16.

(a) 1. Size of cotton swab;

2. Dampness of cotton swab;

3. Size of area of skin;

4. Time rubbed on skin;

5. Part of the body / skin sampled;

6. Volume of agar / nutrient concentration of agar;

7. Incubation time;

8. Incubation temperature;

**3 max**

(b) 99.8;

**OR**

57 271;

*1 mark for writing out correct calculation: (401.6 – 0.7)/401.6 × 100* ***OR*** *(401.6 – 0.7)/0.7 x 100*

*1 mark max for incorrect rounding*

*Accept answers to any number of significant figures as long as rounding is correct*

**2**

(c) 1. Spread here greater above the mean than below;

2. Some / many Petri dishes had no colonies;

*Accept idea that data are not normally distributed / is skewed.*

**1 max**

(d) 1. Treatment **C** / treatment normally used at the time;

2. (Because) using untreated / soap and water / treatment **A** / treatment **B** would have too great a risk of infection;

*Accept C has least / lower risk of infection*

*Accept description of 'infection'*

**2**

**[8]**

## Q17.

(a) Hydrolysis (reaction);

**1**

(b) 1. (Phosphate required) to make RNA;
2. (Phosphate required) to make DNA;

*1 and 2. If neither DNA or RNA are named allow one mark for nucleotide/nucleic acid/phosphodiester bonds/sugar-phosphate backbone.*

3. (Phosphate required) to make ATP/ADP;
4. (Phosphate required) to make membranes;

*Ignore: phospholipids without reference to membranes.*

5. (Phosphates required) for phosphorylation;

*Accept: as additional mark points any named biological molecule containing phosphate e.g. NADP, AMP, RuBP.*

**2 max**

(c) Accept answer in range from 3.7 : 1 to 4.1 : 1;

*Reject any ratio not : 1.*

**1**

(d) 1. Seeds/embryo remain dormant/inactive in winter/cold
**OR**
Growth/development of seed/embryo during winter/cold;

*Ignore: hibernate.*

*Accept: 'seed survives winter/cold'.*

*Reject: plant develops or seed germinates during winter/cold.*

2. Seeds/plants develop in spring/summer
**OR**
Seeds/plants develop when temperature/light increases;

*Accept: seeds/plants develop when more light or when temperature is higher.*

*Accept: seed germinates/'sprouts' during spring/summer or when temp/light increases.*

3. Plant photosynthesise (in spring/when warm);
4. Produce (more) seeds/offspring in spring/growing season;

**3 max**

**[7]**

## Q18.

(a) 1. Change in <u>DNA</u> base/nucleotide (sequence);

*Accept: mutation in <u>DNA</u> base (sequence).*

*Accept: deletion/substitution/addition of a <u>DNA</u> base/nucleotide.*

2. Change in amino acid (sequence)/primary structure;

*Reject: different amino acid formed.*

*Ignore: change in code for amino acid.*

3. Alters (position of) hydrogen/ionic/disulfide bonds;
4. Change in <u>tertiary</u> structure (of receptor);

*Reject: any reference to active site.*

*Ignore: 3°.*

**4**

(b) 1. (Receptor) is not <u>complementary</u>
**OR**
(HIV) cannot bind/attach <u>and</u> enter/infect (helper) T cell;

*Accept: 'complimentary'.*

*Accept: invade as alternative to infect.*

2. No replication (of virus)
**OR**
No destruction of (helper) T cell;

*Accept: reproduction (of virus).*

**2**

(c) 1. Low/lower exposure to HIV (in Europe)
**OR**
Low/lower number of HIV/AIDS (infections/cases);

*Accept: converse.*

2. (HIV) has only been present for a short time period
**OR**
(HIV relatively) recently evolved;
3. Mutation/CCR5 has been around for many years;
*Accept: frequency of mutation has always been high.*
4. Mutation/CCR5 is advantageous (for something else);

**2 max**

**[8]**

## Q19.

(a) Bacteria killed;

*Ignore: no growth or growth of bacteria prevented.*

*Accept: bacteria destroyed.*

*Accept: no living bacteria.*

**1**

(b) Clear zone would be too large
**OR**
Clear zones would overlap/merge
**OR**
Could kill all bacteria (on the plate);

*Must convey idea of too large.*

**1**

(c) 1. (Same) size;

*Accept: any measure of size e.g. thickness, area, diameter.*

*Ignore: 'same shape' as shape shown on the diagram.*

2. (Same) material/absorbency;
3. In solution for same time period;

*Ignore: reference to volume of disinfectant.*

**2 max**

(d) Any number between 2.5 to 3.2 = **two** marks;;

*Allow **one** mark for an incorrect answer but shows method of calculating how many times more effective D is than B*

*e.g. 22 divided by 13/14*

*or 11 divided by 6.5/7*

*or 1.57/1.6/1.69/1.7.*

**2**

**[6]**

## Q20.

(a) Locus;

*Accept: loci*

**1**

(b) Differences in DNA / differences in base sequence of DNA;

*Accept: number of different alleles / size/variation in gene pool*

*Reject: genes*

**1**

(c) 1. Jack Russell (genetic) diversity is (significantly) greatest;
2. Bull terrier (genetic) diversity is (significantly) smallest / is most inbred;
3. Miniature terrier and Airedale terriers are similar;

*1-3: do not credit just a list of values*

4. Standard deviations do not overlap / do overlap with correct ref to significance;

*Reference to significance must be relevant to examples given*

**Max 3**

(d) 1. (Bull terrier) breeding has included a genetic bottleneck/ small population/more inbreeding/ greater selection (pressure);

*Accept: founder effect*

2. Reduced number of different alleles/size of gene pool;

*Reject: decrease in number of genes*

*Ignore ref to mutations*

OR

3. Miniature (terrier) breeding has included more outbreeding/less selection (pressure);
4. Increased number of different alleles/larger gene pool/more variety of alleles;

*Reject if genes used instead of alleles*

*Reject: lower frequency of alleles*

*Ignore ref to mutations*

**2**

**[7]**

## Q21.

(a) 1. Type of feed affects (antibiotic) <u>resistant</u> bacteria (in animals);

*Accept: null hypotheses*

*Accept predictions, for example*

*More antibiotic resistant bacteria form in animals fed with antibiotics in their food*

2. (Antibiotic) resistant <u>resistant</u> infect /are passed on to animals/farmer / resistant <u>resistant</u> are passed between animals;

*Accept: bird to bird/bird to human/human to human*

*Accept: a link (exists) between (antibiotic) resistance in animals and their keepers/farmers – as lowest level QWC*

3. Incidence of (antibiotic) resistant <u>resistant</u> differs in chickens and turkeys;

*Accept: a comparison, eg 'more resistant bacteria in chickens than turkeys'*

4. Incidence of (antibiotic) resistant <u>resistant</u> differs in chicken farmers and turkey farmers;

*Accept: a comparison, eg 'more resistant bacteria in chickens than turkeys'*

**Max 2**

(b) (i) 1. Large(r) percentage of resistant bacteria in turkeys/low(er) percentage of resistant bacteria in chickens;

*Accept: E coli for bacteria*

*Ignore: number, eg. ignore 'more'/'fewer' turkeys/chickens*

2. Large(r) percentage of resistant bacteria in turkey farmers/low(er) percentage of resistant bacteria in chicken farmers;

**2**

(ii) 1. (More) antibiotic in turkey feed kills (more) non-resistant bacteria / resistant bacteria survive;

*Accept: antibiotic creates selection pressure*

*Survive must be explicit, not implied by 'reproduce'*

2. (Resistant bacteria) reproduce / pass on gene for resistance;

**2**

(c) (Human) faeces contain pathogens;

*Accept: harmful organisms*

**1**

(d) 1. Large number of farms / farmers (surveyed) / 46;

*'Reliable' is used in the question stem*

2. So results are (likely to be) representative / can identify anomalous results;

*Ignore: reproducible / accurate / valid / reliable*

*Accept valid explanation of replicates minimising effects of chance*

**2**

(e) 1. (DNA) hybridisation (of gene for resistance in bacteria taken from bird and farmer);

2. (Identical) strands separate at high(est) temperature;

OR

3. Compare base/nucleotide sequence (of gene for resistance in bacteria taken from bird and farmer);

4. (Identical strains) have identical/same base sequences

*Mark in pairs, do not mix and match.*

*Accept: bacteria in bird and farmer/both types of bacteria have identical base sequences = 2 marks*

**2**

(f) 1. (Antibiotic use has) increased cases of bacterial resistance;

*Accept: number*

2. Transfer/horizontal transmission of (resistance) gene to pathogens/harmful bacteria;

*Accept: conjugation*

3. (Antibiotic) resistant bacteria cause harm / medical treatments less effective;

*Accept: superbug*

4. Avoids side effects on animals;

5. Increased demand for organic food;
6. Antibiotic/resistant bacteria could be present in human food;
7. High cost of antibiotics;
8. Legislation has controlled antibiotic use;

*Accept: EU/government guidelines*

**4 max**

**[15]**

## Q22.

(a) 1. Change / mutation in base / nucleotide sequence (of DNA / gene);

*Q.*

*Ignore: references to changing base-pairing*

*Accept: affect for change, if in correct context*

*Accept: changes triplets / codons*

2. Change in amino acid sequence / primary structure (of enzyme);

*Accept: different amino acid(s) coded for*

***Q** Reject: different amino acids produced / formed / made*

3. Change in hydrogen / ionic / disulfide bonds;

*Accept: references to sulfur bonds*

4. Change in the <u>tertiary</u> structure / shape;

*Neutral: alters 3D structure / 3D shape*

5. Change in <u>active site</u>;

6. Substrate not complementary / cannot bind (to enzyme / active site) / no enzyme-substrate complexes form.

*Accept: no E S complexes form*

**6**

(b) 1. Non-SR strain falls more / SR strain falls less / up to 10(µg / cm−3);

*Must include 10 but only required once in either MP1 or MP2*

*Ignore: units or absence of*

*This must be a comparative statement*

2. Above 10(µg / $cm^{-3}$), SR strain levels out / off <u>and</u> non-SR strain continues to decrease;

3. Greater difference between strains with increasing concentration of antibiotic.

*This must be a comparative statement*

**2 max**

(c) 1. Division stopped (of both strains by scientist);

*Reject: references to mitosis stopping*

2. SR strain still more resistant / fewer die / none die (at higher concentrations of antibiotic).

*Accept: SR strain and non-SR strain would be similar if resistance is due to only stopping division*

*Need some comparison with non-SR*

**2**

(d) 1. Make a competitive / non-competitive inhibitor;

*Mark in pairs*

*either MP1 <u>and</u> MP2 OR MP3 <u>and</u> MP4*

2. Competitive competes with / blocks active site / non-competitive inhibitor affects / changes <u>active site</u>;

*Do not mix and match*

OR

3. (Make a drug) that inhibits / denatures / destroys enzyme / stringent response;

*Accept: drug that 'knocks out' / destroys enzyme*

4. Give at the same time as / before an antibiotic.

**2 max**

(e) (SR strain)

1. Fewer free radicals (than non-SR);

*Note: has to be comparative statement*

2. Produces more catalase (than non-SR);

*Accept converse statements for non-SR.*

3. Catalase (might be) linked to production of fewer free radicals / breaking down / removing free radicals.

*Accept: hydrolysis of radicals by catalase.*

**3**

**[15]**

## Q23.

(a) 1. Sugar-phosphate (backbone) / double stranded / helix **so** provides strength / stability / protects bases / protects hydrogen bonds;

*Must be a direct link / obvious to get the mark*

*Neutral: reference to histones*

2. Long / large molecule **so** can store lots of information;

3. Helix / coiled **so** compact;

*Accept: can store in a small amount of space for 'compact'*

4. Base sequence allows information to be stored / base sequence codes for amino acids / protein;

*Accept: base sequence allows transcription*

5. Double stranded **so** replication can occur semi-conservatively / strands can act as templates / complementary base pairing / A-T and G-C so accurate replication / identical copies can be made;

6. (Weak) hydrogen bonds **for** replication / unzipping / strand separation / many hydrogen bonds **so** stable / strong;

*Accept: 'H-bonds' for 'hydrogen bonds'*

**6**

(b) 1. (Mutation) in **E** produces highest risk / 1.78;

2. (Mutation) in **D** produces next highest risk / 1.45;

3. (Mutation) in **C** produces least risk / 1.30;

*Must be stated directly and not implied*

***E*** > ***D*** > ***C*** = *3 marks*

*Accept: values of 0.78, 0.45 and 0.30 for MP1, MP2 and MP3 respectively*

*If no mark is awarded, a principle mark can be given for the idea that all mutant alleles increase the risk*

**3**

(c) **180**;

**1**

(d) **(Similarities):**

1. Same / similar pattern / both decrease, stay the same then increase;

2. Number of cells stays the same for same length of time;

*Ignore: wrong days stated*

**(Differences):**

(Per unit volume of blood)

3. Greater / faster decrease in number of healthy cells / more healthy cells killed / healthy cells killed faster;

*Accept: converse for cancer cells*

*Accept: greater <u>percentage</u> decrease in number of cancer cells / greater <u>proportion</u> of cancer cells killed*

4. Greater / faster increase in number of healthy cells / more healthy cells replaced / divide / healthy cells replaced / divide faster;

*Accept: converse for cancer cells*

*For **differences**, statements made must be comparative*

**3 max**

(e) 1. More / too many healthy cells killed;

2. (So) will take time to replace / increase in number;

*Neutral: will take time to 'repair'*

3. Person may die / have side effects;

**2 max**

**[15]**

## Q24.

(a) 250 000;

**1**

(b) (i) Loss of 3 bases / triplet = 2 marks;;

*'Stop codon / code formed' = 1 mark max unless related to the last amino acid*

Loss of base(s) = 1 mark;

*eg triplet for last amino acid is changed to a stop codon / code = 2 marks*

*3 bases / triplet forms an intron = 2 marks*

*Accept: descriptions for 'intron' eg non-coding DNA*

*'Loss of codon' = 2 marks*

**2**

(ii) 1. Change in tertiary structure / active site;

*Neutral: change in 3D shape / structure*

2. (So) faulty / non-functional protein / enzyme;

*Accept: reference to examples of loss of function eg fewer E-S complexes formed*

**2**

**[5]**

## Q25.

(a) 1. No interbreeding / gene pools are separate / geographic(al) isolation;

*Accept: all marks if answer written in context of producing increased diversity of plants*

*1 Do not award this mark in context of new species being formed and then not interbreeding*

*1 Accept reproductive isolation as an alternative to no interbreeding*

2. Mutation;

*2 Accept: genetic variation*

3. Different selection pressures / different foods / niches / habitats;

*3 Accept: different environment / biotic / abiotic conditions or named condition*

*3 Neutral: different climates*

4. Adapted organisms survive and breed / differential reproductive success;

5. Change / increase in allele frequency / frequencies;

**5**

(b) Similar / same environmental / abiotic / biotic factors / similar / same selection pressures / no isolation / gene flow can occur (within a species);

*Accept: same environment*

**1**

**[6]**

## Q26.

(a) (i) (We should maintain biodiversity to)

*Prevent extinction / loss of populations / reduction in populations / loss of habitats / save organisms for future generations (idea of);*

*Neutral: references to 'playing God' / animal rights*

**1**

(ii) A suitable example of how some species may be important financially e.g.

1. medical / pharmaceutical uses;

2. commercial products / example given;

3. tourism;

4. agriculture;

5. saving local forest communities;

**1 max**

(b) 1. Fewer plant species / decrease in plant diversity;

*Accept: converse arguments for islands with a high percentage of forest remaining*

*1. Neutral: fewer plants*

2. Fewer habitats nesting sites / niches / food sources / varieties / less protection from predators / hunters / environment;

*2. Neutral: fewer homes*

*2. Neutral: less food*

**2**

(c) 1. Number of (individuals / birds of) each species;

*1. Neutral: number of species*

2. Total number of individuals / birds of all species;

*2. Accept: 'total number of birds' as given context for 'all species' in the investigation*

**2**

(d) 1. (Larger birds have) a low(er) SA:VOL;

*Neutral: reference to fat / feathers*

2. (So) less heat loss / more heat retained;

*MP2 is independent of MP1*

**2**

**[8]**

## Q27.

(a) 2 of the following pairs:

*Mark for explanation must be paired with correct change in structure*

1. Larger leaves;

2. Photosynthesis;

***OR***

*Accept converse descriptions of leaves, root and stem: longer root, taller stem, smaller leaves*

3. Larger / bigger / thicker root;

4. Storage;

***OR***

5. Stem shorter / absent;

*Accept converse correct explanation*

6. Less energy used in stem growth / more energy for producing sugar;

**4 max**

(b) Beet ready quicker / less time required / allows land to be used again / harvested earlier;

*Allow more crops / many harvests. Ignore references to yield / profit*

**1**

(c) 1. (Diversity) reduced / fewer different alleles / less variation / smaller gene pool;

2. As alleles have been chosen / rejected;

**2**

**[7]**

## Q28.

(a) (i) 4;

**1**

(ii) 1. Change in amino acid / (sequence of) amino acids / primary structure;

*1. Reject = different amino acids are 'formed'*

2. Change in hydrogen / ionic / disulphide bonds alters tertiary structure / active site (of enzyme);

*2. Alters 3D structure on its own is not enough for this marking point.*

3. Substrate not complementary / cannot bind (to enzyme / active site) / no enzyme- substrate complexes form;

**3**

(b) 1. Lack of skin pigment / pale / light skin / albino;

2. Lack of coordination / muscles action affected;

**2 max**

(c) Founder effect / colonies split off / migration / interbreeding;

*Allow description of interbreeding e.g. reproduction between individuals from different populations*

**1**

**[7]**

## Q29.

(a) (i) (Human cells) don't have a cell wall;

*Accept "they" refers to human cells.*

**1**

(ii) (Affects) protein synthesis;

*Allow description e.g. 'amino acids not joined together / translation.*

*Reject: affects transcription.*

**1**

(b) 1. Mutation present / occurs;

*Ignore antibiotic causes mutation.*

2. Resistance gene / allele;

*1. or 2.*

*Reference to immunity disqualifies first credited marking point.*

3. Resistant bacteria (survive and) reproduce;

*Reference to mitosis negates marking point 3.*

**2**

**[4]**

## Q30.

(a) Difference in DNA / base sequence / difference in alleles / genes / gene pool;

*Neutral: 'fewer alleles' unless qualified e.g. fewer different alleles.*

**1**

(b) Environmental;

*Accept: Environment*

**1**

(c) Reduced (genetic diversity);

As fewer different / varied alleles / genes / reduced gene pool;

**2**

**[4]**

## Q31.

(a) (i) Antibiotics kill other bacteria / *Clostridium* is resistant;

Less / no competition so (*Clostridium*)
reproduces / replicates / multiplies / increases in number;

*Reference to bacteria being 'immune' negates first marking point.*

*Reference to mitosis negates second marking point.*

**2**

(ii) Immune system less effective / more likely to have other infections / been in hospital;

*Accept: 'Weak / lower' immune system'.*

**1**

(b) Attaches to <u>active</u> <u>site</u> (of enzyme);
(Methicillin) is a competitive inhibitor / prevents monomers / substrate attaching (to enzyme);

*'Competes for active site' = 2 marks.*

*Neutral: 'Prevents monomers joining / attaching to each other'.*

*Allow one mark max for answers relating to non-competitive inhibitor changing active site / preventing substrate attaching.*

*Do not penalise Methicillin forms an enzyme / substrate complex.*

**2**

(c) (i) Have other illness / medical condition / 'weak' immune system / disease / infection;

*Reject: Due to 'other factors', 'are smokers', 'are obese' unless related to disease or illness.*

**1**

(ii) Increase up to 2006 / 20 (per 100 000) then decreases;

**1**

(iii) Correct answer in range of 52 – 59.1% = two marks;

Incorrect answer but shows change as between 4.8 – 5.2 / shows correct subtraction giving this change e.g. 14 – 9 = one mark.

**2**

**[9]**

## Q32.

(a) Same number of ryegrass seedlings in distilled water;

**1**

(b) (i) Produce null hypothesis;

Carry out Spearman Rank correlation test / find correlation coefficient;

Use values to show P < critical value / find probability of results being due to chance;

*Accept valid example*

*E.g. There is no correlation between inhibition of germination and the concentration of the extract.*

**2 max**

(ii) May be another factor / named factor (that also inhibits germination);

*e.g. amount of water in extract*

**1**

(c) (i) Extract inhibits ryegrass germination / extract stops ryegrass starting to grow;

Inhibition of root length / causes ryegrass to have shorter roots;

**2**

(ii) Scientists crushed plants to get extract;

Plants might not secrete substances in the extract into the soil;

These substances might get broken down in the soil;

Wheat and ryegrass might not grow at the same time / wheat plants might not produce substance when ryegrass is growing;

Concentration of extract in the soil might be different from that in solution;

**3 max**

**[9]**

## Q33.

(a) Banding pattern changes as cheetah gets older / difficult to judge as tail is short / fluffy;

**1**

(b) (i) Mean not (always) a whole number;
Standard deviation not (always) zero;

**2**

(ii) Movement of tail / angle of sight / confused it with another band / subjective estimation;

*Accept reference to **Figure 1***

*E.g. Bands 2 and 3 have same thickness but look different*

**1**

(c) Band width not the same on both sides of tail;

**1**

(d) Offspring of the same family will be more similar genetically;
As have same mother (and father) / parent;
Expect to see more differences in randomly chosen cheetahs;

**3**

**[8]**

## Q34.

(a) (i) 22;

**1**

(ii) 1. Odd number of chromosomes / 33 chromosomes (in leaf cell);

2. Chromosomes cannot pair / cannot undergo meiosis / would result in half chromosomes / cannot form haploid cells;

**2**

(b) (i) Fast growth / produces crop fast / produces large crop;

*Do not insist on relative statement.*

*Accept similar terms for fast. E.g. "better" growth*

*Do not accept unqualified references to profit.*

**1**

(ii) Leaves less likely to break / higher breaking strength;

**1**

(c) Low genetic diversity because they are produced by mitosis;

Will all have the same DNA / genes / alleles / will be genetically identical / will be clones;

***OR***

Low genetic diversity because they are not produced by meiosis;

No crossing over / independent segregation / will not be genetically different;

*Independent segregation is the specification term. Accept other such as random assortment.*

**2**

**[7]**

## Q35.

(a) **Shape**

1. Different penicillin has different shape / structure / enzyme / active site has specific shape / structure;

*Not different*

**Binding**

2. No longer fits / binds to active site / not complementary to active site / does not form E-S complex;

**Consequence**

3. (Different) penicillin not broken down;

**3**

(b) (i) 1. Kills pathogenic / harmful bacteria / pathogens;

2. Disease less likely / improves health / animals healthier / reduces spread of infection;

3. Faster growth / more productive animals / more food converted to meat / greater survival / lower vet's bills / increased yield / less energy (for "fighting infection");

*Principles:*

*Action of antibiotic. Do not accept stops all disease*

*Action on health*

*Effect on production*

**2 max**

(ii) 1. (Adding antibiotics) selects in favour of antibiotic resistance / resistant bacteria more likely to survive;

2. Increase in numbers / higher proportion of resistant bacteria;

*Penalise immune only on the first occasion it occurs in this part of the question.*

**2**

**[7]**

## Q36.

(a) (So results) can be compared / so measurement is the same each time / because eye is not perfectly round / uniform;

*Accept eye opens to different amounts*

**1**

(b) (i) 1. Eye (diameter) is smaller and antennae longer;

2. Antennae detecting touch;

3. Data only refers to shrimps / data may not apply to all animals / only in one area;

*The principle here is that candidate has recognised that both features confirm suggestion. Exact wording does not matter.*

**2 max**

(ii) 1. Standard deviation gives a measure of spread / variation;

2. More standard deviations overlap, the less likely it is that differences are real / significant / the more likely they are caused by chance;

*Do not accept range*

*Accept converse.*

*Although we are looking for the idea of significance, we cannot require this term.*

**2**

(c) (i) Qualitative statement about

difference in size /

difference in variation /

overlap in size;

Quantitative statement about

difference in size /

difference in variation /

overlap in size;

Supported by relevant two sets of figures from graph;;

*Note simplistic answer involving a quantitative statement gains 1 mark.*

*More specific answer involving quantitative information gains 2 marks.*

**2**

(ii) (No) for same body length, antenna are longer / antenna are shorter / some with longer body have short antennae / some with shorter body length have longer antennae;

***OR***

(Yes) positive correlation in open / in cave;

*Habitat not critical as a term.*

*Must refer to idea of same habitat*

*Accept description*

**1**

(d) More alleles of each gene / shrimps in open have all the alleles;

*Candidates are required to use the information from the table. Must therefore refer to alleles.*

**1**

(e) 1. A small number of shrimps were / went into the cave;

2. All / high proportion of shrimps had allele L;

3. Cave population descended from these / these reproduce;

**3**

(f) (i) 1. Cross shrimps from two sites / watch courtship;

2. Breed young together / observe mating;

3. Allow 1 mark for any method of improving quality of results e.g. carry out reciprocal crosses / large number of crosses / isolate beforehand;

*Other valid equivalent suggestions should be accepted.*

(ii) If same species the shrimps would breed, producing fertile young / courtship species specific;

*Accept any form of evidence – mating / laying eggs / giving birth to young.*

**3**

**[15]**

## Q37.

(a) Isolation / quarantine / 'kept separate';

Screening / testing (of patients / doctors etc);

Sterilisation of wards / equipment / method to improve hygiene;

*Do not allow improve 'hygiene' or 'cleanliness' without named example such as 'washing hands' use of gloves etc.*

**2 max**

(b) May not all be absorbed;

May be broken down / metabolised / excreted quickly;

To kill the microorganisms / bacteria;

Reference to antibiotic resistance;

*Reference to becoming 'immune' negates last marking point.*

**2 max**

(c) (i) P;

**1**

(ii) S;

**1**

(d) (i) Prevents bias;

Vested interest (of scientists);

Prevents 'placebo' / positive / negative / psychological effects / 'demand characteristics' (in volunteers);

**2 max**

(ii) Age;

Ethnicity;

Lifestyle;

Body mass;

Health;

Sex of person;

*Ignore references to same or different*

**2 max**

(e) Gradual / slight increase followed by rapid / greater increase;

*Allow more detailed descriptions which describe similar trend of gradual increase followed by rapid increase.*

**1**

**[11]**

## Q38.

(a) (i) Faster / greater / more effective response in children;

*Do not accept children have more haemoglobin*

**1**

(ii) Use line of best fit;

**1**

Extrapolate / extend line (and read from graph);

*Allow calculation using rate of increase per day = one mark. However for both marks this must be linked to line of best fit.*

**1**

(iii) More than one polypeptide chain;

*Allow many polypeptide chains.*

*'Haemoglobin has four polypeptide chains' must be in correct context to gain mark.*

**1**

(b) (i) Has same water potential;

*Allow converse for effect of using distilled water or a concentrated solution.*

**1**

No (net) water movement / osmosis;

**1**

Cells will not swell / burst / change size;

*No osmotic lysis = two marks*

**1**

(ii) Pernicious anaemia (cells) greater range / spread / variation of diameters

/ widths;

Some pernicious anaemia (cells) wider than 9 (µm) / some less than 5.5 (µm) / without pernicious anaemia none more than 9 (µm) / none less than 5.5 (µm);

Pernicious anaemia (cells) peak / most frequent at 8.5 (µm) / peak / most frequent at higher diameter / / without pernicious anaemia peak / most frequent at 7 (µm) / peaks at lower diameter;

*There are several alternatives for marking points 2 and 3*

**2 max**

**[9]**

## Q39.

(a) Shows trend of mean temperature rise;
Higher temperatures more frequent since 1984 (in January and February);
Considerable variation in temperature from year to year;
Which may be due to chance;

*No mark for yes or no Do not penalise candidates who state there is no trend*

**2 max**

(b) Construct null nypothesis;
Use Spearman rank (and calculate test statistic);
Look up in table (to find critical value of P = 0.05 / 5 %);
Use figure (in table) to accept or reject null hypothesis;

**3 max**

(c) (i) (Particular daylength) always occurs at same time of year / valid example;
Birds do not start laying eggs when period of warm weather occurs early in year;
Synchronises breeding behaviour;
Sufficient foraging time for food collection for young;

**2 max**

(ii) Birds able to respond to changing climate;
Food availability (mainly) determined by temperature;
As insect / invertebrate development temperature-dependent;

**2 max**

(d) A correlation does not indicate a causal relationship;
As may be due to another factor / named factor;

**2**

(e) Visits could be up to 5 days apart;
Date of egg-laying may be inaccurate by 5+ days;

**2**

**[13]**

## Q40.

(a) Recognition of same species;

Stimulates release of gametes;

Recognition of mate / opposite gender;

Indication of sexual maturity / fertility;

**2 max**

(b) (i) Internal fertilisation / fertilisation occurs in pouch / limited area;

***Q*** *The term fertilisation is not required in the answer but must be implied.*

**1**

(ii) Protection from predators (developing in pouch);

**1**

(c) (i) Less stress caused to seahorse / quicker / more accurate method / body is curved / head is linear;

***Q*** *Do not accept "easier" unless qualified.*

**1**

(ii) Head length proportional to body length / or described;

**1**

(d) Positive correlation between head / body lengths of male and female / female and male with similar head / body lengths pair together;

**1**

(e) Use line of best fit;

And extrapolate / extend line as required;

**2**

(f) (Compare) DNA;

Sequence of bases / nucleotides;

Compare same / named protein;

Sequence of amino acids / primary structure;

Immunological evidence – not a mark

Inject (seahorse) protein / serum into animal;

(Obtain) antibodies / serum;

Add protein / serum / plasma from other (seahorse) species;

Amount of precipitate indicates relationship;

***Q*** *The marks awarded for reference to DNA and sequence of bases / nucleotides must be in a different context to DNA hybridisation.*

**6 max**

**[15]**

## Q41.

(a) group of organisms with similar features;
can (interbreed to) produce fertile offspring;

**2**

(b) directional selection;

*any TWO from*
selection against one extreme / for one extreme;
against broadest beaks in B and narrowest beaks in **A** / for narrowest in **B** and broadest in **A**;
whole distribution / range / mean / mode / median is shifted towards favoured extreme;

**3 max**

**[5]**

## Q42.

(a) Excitation of chlorophyll molecule / electrons / energy of (pairs of) electrons raised to higher energy level;

Electron(s) emitted from chlorophyll molecule;

Electron(s) to electron transport chain;

Loss of energy by electron(s) along electron transport chain;

Energy lost by electron(s) is used to synthesise ATP;

From ADP + Pi;

*"By electrons" need not be stated in each marking point if it can be reasonably inferred that the candidate is referring to electrons*

**max 5**

(b) Little green light reaches bottom as absorbed by surface dwellers / water;
Red and blue not absorbed and so penetrate;
Variation in pigments of sediment dwellers;
Bacteria with chlorophyll at an advantage as chlorophyll absorbs red and blue;
(Survive to) reproduce in greater numbers and pass on advantageous alleles / genes in greater numbers / increase in frequency of advantageous alleles in subsequent generations;
Increase in frequency / numbers of bacteria with chlorophyll;

**6**

**[11]**

## Q43.

(a) 1. frequent use of antibiotic creates selection pressure / antibiotic kills bacteria;
2. bacteria with mutation / resistance have (selective) advantage over others / described;
3. (survive to) reproduce more than other types pass on advantageous allele / mutated allele in greater numbers;
4. frequency of (advantageous) allele increases in subsequent generations;

*(penalise use of "gene" instead of allele once only)*

5. frequency of resistant types increases in subsequent generations;

**5**

(b) correct answer = 0.18;
And three marks for three of:
$p + q = 1$ and $p^2 + 2pq + q^2 = 1$;
$0.01 = q^2$ ;
$q = 0.1$;
$p = 0.9$

frequency of heterozygotes = 2pq = 2 × 0.1 × 0.9 / 2 × candidates
p × candidates q;

**4 max**

**[9]**

## Q44.

(a) (i) Continuous variation – range of values / not discrete categories / many categories / no gaps;

**1**

(ii) Crossing over / chiasmata;
Random segregation / independent assortment;
In meiosis I and meiosis II;

**max 2**

(b) Range influenced by single 'outlier' (*accept anomaly*) /
converse for S.D.;
S.D. shows dispersion / spread about mean / range only shows highest and lowest values / extremes;
Or
S.D. allows statistical use;
Tests whether or not differences are significant;

**max 2**

**[4]**

## Q45.

(a) 1. Occurs in an unchanging environment;

**1**

+

2. Selection against extremes / selection for the mean / mean / median / mode unaltered
3. Range / S.D is reduced
4. Increasing proportion of populations becomes well adapted to environment;

**4**

(b) 1. All plants are acyanogenic below –4 °C and (most) cyanogenic above +10 °C;
2. Cyanogenic plants' cells freeze below –4°;
3. Releasing cyanide (into their own tissues) / damaging / killing plants / disrupting metabolism;
4. Selective advantage not to produce cyanide at –4 °C;
5. Slugs present at higher temperatures / not usually present / inactive at lower temperatures and cyanide production kills / deters slugs;

**5**

**[10]**

## Q46.

(a) (i) to ensure that no unwanted bacteria will be present;

**1**

(ii) to check that bacteria cells do not die anyway / to show water / solvent has no effect on growth;

**1**

(b) some bacteria are resistant / some areas of dish have no antibiotic / antibiotic not spread evenly;

**1**

**[3]**

## Q47.

(a) (i) EITHER: Correct answer: 3.45 / 3.44 / 3.4 = 2 marks
OR: Understanding of ∑n(n-1) / use of 134 / (2 + 90 + 12 + 30)
+ wrong answer = 1 mark

**max 2**

(ii) Takes account of number of individuals / abundance / population size (as well as number of species);

**1**

(b) The species at A / *F.spiralis* loses less water / loses water less rapidly / loses less mass;

The species at A / *F.spiralis* better adapted to / can survive where exposed for longer / to drier conditions;

The species at A / *F.spiralis* avoids competition For named aspect – e.g. light / substratum / space / $CO_2$;

*ACCEPT converse argument re. F. serratus*

**3**

**[6]**

## Q48.

(a) Tapes / string / axes laid out at right angles / grid area;
Method of obtaining random co-ordinates;
*Do not allow "Use random number generator"*

**2**

(b) (i) Decrease then remain constant;
From 200 cm / over 150 cm;

**2**

(ii) Oxygen decreasing because soil becomes more compacted / not replaced;
Decrease in oxygen leads to fewer aerobes surviving;

**2**

(c) Anaerobic bacteria replace aerobic as oxygen decreased by aerobic bacteria;
Remove competition;
Aerobic bacteria no longer able to survive in these conditions;

**3**

(d) (i) Near the surface / in top 50 cm;
Table shows decrease with time at greater depths;

**2**

(ii) Decrease;
Fewer aerobic bacteria with depth;
Oxygen concentration decreases / less oxygen at depth;

**3**

(e) Probability greater than 95% / 0.95;
Results are not due to chance / results are significant;
Because bars do not overlap;

3

(f) Plot as graph;
Draw line of best fit;
Read off appropriate value;

3

**[20]**

## Q49.

(a) greater environmental influence than genetic;

1

(b) identical twins have same genotype / converse for non-identical;
compare identical and non-identical twins / identical twins who have been separated / non-identical twins in same environment;
if genetic - similarity between identical twins / converse;
large sample required / use a statistical test;

4

**[5]**

## Q50.

(a) mitosis;
genetically / genes / genotype identical;
*(reject same genes)*
*(ignore references to asexual reproduction)*

2

(b) (different)
environmental conditions / named environmental factor / mutation;

1

(c) dispersal / prevent overcrowding / competition / colonise ;
increased number of (proven) offspring; *(not quicker)*

2

**[5]**

## Q51.

(a) breed together;
if fertile offspring, then same species;

2

(b) <u>isolation</u> of two populations;
variation already present due to mutations;

different environmental conditions / selection pressures leading to selection of different features and hence different alleles;
different frequency of alleles;
separate gene pools / no interbreeding;

4

(c) selection of mate dependent on colour pattern;
prevents interbreeding / keeps gene pools separate;

**2**

**[8]**

## Q52.

(a) lower enzyme activity;

decrease in rate of photosynthesis so less carbohydrate formed / named carbohydrate / lower translocation of sucrose / to growing point;
lower respiration;
lower rate of nutrient uptake / protein synthesis / cell division;

**4**

(b) (i) differ in height when plants from different altitudes grown in same environment;

**1**

(ii) plants from 1500 / 3000m differ in height when grown at different altitudes;

**1**

**[6]**

## Q53.

(a) zooplankton nearer surface at night;
algae only found at surface;
photosynthetic;
no / little light below 30 / 40m;

**3**

(b) (i) with increasing time predators have been present in the lake, the greater the depth at which the zooplankton occur during the day;

**1**

(ii) variation in migration behaviour;
vertical migration reduces chance of predation / prey can't be seen in low light intensity;
those that migrated more likely to reproduce;
genes / alleles (for behaviour) passed to next generation;
increase in frequency of gene / allele in population;

**3 max**

**[7]**

## Q54.

(a) sections of chromatids exchanged;
sections have different alleles;
new combinations of (linked) alleles;

*(allow 1 mark for idea that 'genes' are exchanged, if no other marks gained)*

**3**

(b) (i) length controlled by many genes / polygenes;
each gene may have different alleles / idea of additive effects;
OR
environmental factors / or named factor;

how named factor may affect growth of seeds;

**2 max**

(ii) 1. selection of large seeds for sowing;
2. higher proportion of alleles for long length / loss of alleles for short seeds from population;
3. (possible appearance of) new alleles through mutation;
4. process repeated over many generations;

*(G - allow 1 mark idea for that 'largeness' selected, survives and inherited)*

**4**

**[9]**

**QWC 1**

## Q55.

(a) description of interspecific competition / competition between <u>species</u> / birds with beaks of different lengths;
link <u>length</u> of beaks to different <u>positions</u> of prey / reference to named bird with particular prey e.g. curlews with longer beaks able to feed on ragworms;

**2**

(b) variation in beak length in curlews / one species;
longer / more curved beaked curlews outcompete / at advantage / suggested advantage e.g. larger / curled beaks access more food;
reproduction;
genes passed on (to offspring);

**4**

(c) body has lower water potential;
water diffuses along a water potential gradient / by osmosis;

**2**

**[8]**

## Q56.

(a) <u>generation</u> of random co-ordinates;
use of 10 or more quadrats;
<u>collection</u> of all dog whelks in quadrat;

**3**

(b) greater variation for sheltered population / population A;
range / spread around the <u>mean</u>;

*(or converse)*

**2**

(c) (i) smaller ratio means relatively larger foot / population B has relatively large foot;
better able to grip;
larger / longer shells have greater area exposed / are subject to greater force;

(ii) wave action limits the max. L / A ratio / extremes;
valid point about age, e.g. greater age range on sheltered shore / live longer on sheltered shore;

*(allow shell size marking point in either (c)(i) or (c)(ii) but only credit once)*

**4 max**

**[9]**

## Q1.

Question (a) was designed to test the ability of students to apply their understanding of how to produce a dilution series in a new context, so building on the demand of required practical 3. Not many students (3.2%) achieved all three marks, mainly because most failed to 'mix' the diluted suspension, which is a key part of a dilution series technique. The correct procedure to prepare 1 in 10 dilutions was given by the majority of students although a significant number failed to score this mark by adding 10 units of liquid to 1 unit of original culture. Quite a few students did not use the suspensions in their correct proportions to produce 1 in 1000 dilutions: adding 1 unit of the 1 in 10 dilution to 999 units of water was a common error. Some students expressed the dilution series as a set of equations, and rarely gave enough information about the volumes to use in these equations for examiners to award marks. Quite a lot of students (14.5%) made no attempt to answer this question which suggested to examiners that some schools/colleges had not carried out this kind of practical work.

Relatively few students in (b) demonstrated the ability to perform this multi-step mathematical problem set in a microbiology context to gain both marks. Many missed a single step and achieved one mark. They often gave 375 in the answer, but the number of zeros associated with it varied enormously. Examiners noted some examples where mathematical working was signposted clearly. In poorly presented answers, however, students failed to gain marks because they hid their solution in a jumble of figures. A significant number of students (10.6%) did not attempt to answer this question.

In question (c), students were asked to apply an understanding of the dilution series technique to a context of counting cells in different suspensions. Many did not appreciate the 1 in 10 dilution was a low dilution and so suggested the number of cells in this suspension would be too low. Of those who scored one mark, some suggested there would be too many cells without reference to counting and, if they did count the cells, mention was infrequently made to the idea of accuracy. 'Time consuming' or 'too difficult' to calculate were often the main reasons for not using the dilution, for which no mark was awarded. Again, a high proportion of students (16.2%) failed to attempt this question.

Most answers to (d) achieved one mark, usually for suggesting animals were given more tetracycline or that it was used over a longer time period. Few students went on successfully to explain a reason. Those who were successful addressed the context of why more tetracycline- resistant bacteria than streptomycin-resistant bacteria occurred, occasionally by referring correctly to differences in selection pressure or differences in directional selection. Most students, however, did not make this comparison so failed to get a mark. In explanations of natural selection, reference to gene or allele transfer during reproduction was often omitted. Examiners noted misconceptions in many answers, such as "antibiotics mutate", "antibiotics cause mutations", "tetracycline reproduced" and "bacteria develop immunity".

In (e), only 16.7% of students accurately applied what they knew about selection to make a logical suggestion for explaining the scientists' results. The most frequent correct answer described bacteria passing on the resistance gene in their reproduction, and occasionally a clear explanation of stabilising selection was provided, which also gained the mark. Examiners reported many instances where the animals' immune response was incorrectly suggested as being a contributing factor.

## Q2.

47.2% of students achieved both marks for question (a). Many did not use the parent cell

in **Figure 1** as their starting point, so did not include one long and one short chromosome in their cells (an 'error carried forward' was allowed if the correct daughter cells were then drawn from the student's own cell as shown after the first division of meiosis).

Question (b) tested students' understanding of the chi-squared test. The null hypothesis stated 'the proportion of plants will not change from one breeding cycle to the next'. Students, therefore, needed to maintain the proportions from breeding cycle 0 into breeding cycle 1, taking into account that the total number of plants had changed from 54 to 56. 22.3% of students could successfully combine this understanding of chi-squared with their maths skills, using proportions to achieve both marks.

Question (c) showed that questions relating to P values are still not being answered well. Too many students still write that the 'results' are due to chance, omitting the essential aspect of it being the 'difference' in the results that is or isn't due to chance. It was rare to see the concepts of probability and chance being appropriately applied. It may be that students have only used chi-squared in relation to genetic crosses and this novel context caused confusion, but students should be introduced to the use of all three required statistical tests in a range of contexts.

Question (d) tested section 3.4.4 of the specification, specifically 'students should be able to use unfamiliar information to explain how selection produces changes within a population of a species'. Although the instruction to 'use your knowledge of directional selection' was intended to help students focus their answer, it led to many answers that simply described the outcome of directional selection with no explanation of how it comes about. When attempts were made to give explanations, they were often not linked to this example. Many students suggested that the environment had changed, so that the plants producing 2n gametes had a selective advantage, instead of using the information provided that the scientists used only these specific plants for breeding. The term 'allele', used in the correct context, was seen infrequently.

## Q3.

(a) Despite less than 13% of students obtaining more than two marks, this question proved to be an excellent discriminator. The most frequently awarded marking point was that the frequency of the *LP* allele would increase in the offspring generation. Many students who gained this mark often gained credit for stating that individuals with the advantageous allele would survive and reproduce. However, poor terminology, particularly referring to 'gene' rather than 'allele', prevented a significant number of students from gaining this mark. There were also many references to 'alleles surviving and reproducing'. Although many students realised that drinking milk gave a nutritional advantage, a named nutrient was not always included to gain a mark. Similarly, mutation was mentioned by some students but this was often not credited as many of these responses suggested that drinking milk had caused the mutation. Directional selection was only included in a minority of responses. A significant minority of students thought that *LP* occurred in cattle and suggested that cattle were selectively bred to continue lactase production. Some students also suggested that the allele for *LP* was obtained from cow's milk.

(b) Approximately 50% of students gained a mark on this question, invariably for referring to *LP* as a dominant allele. Half of these students obtained the second mark by explaining that dominant alleles were expressed (in the phenotype). Many students who scored zero simply suggested that selection for the *LP* allele caused its rapid rise, indicating they had not carefully read the question. Perhaps of greater concern was the number of students who suggested that the recessive allele of the *LP* gene had reverted to its dominant form either via mutation, methylation or acetylation.

(c) As expected, this proved difficult for many students with only 18% obtaining at least one mark and 5% gaining both marks. Many students had no idea how a mutation in DNA could cause lactase persistence. There was often confusion between lactase and lactose. Misconceptions included: mutations in proteins, mutations causing new genes to code for lactase and epigenetic changes/methylation/acetylation initiating lactase production. Some responses described deletion mutations in a different gene on the same chromosome, resulting in a frameshift which affected the lactase gene. Students who had some idea did write about mutations in a gene that codes for the protein that switches off lactase. Others mentioned transcription factors, but the mutations were often in the transcription factor rather than in the gene coding for it.

## Q4.

On reflection, in question (a), it would have been better not to try and 'help' students by splitting the answer space into µg and $g^{-1}$ and just let them answer as they saw fit. In any event, the question discriminated well. Some 22% obtained both marks, 44% one mark and 31% failed to score. All three marking points appeared with roughly equal frequency. Quite a few students seemed to miss the point entirely, writing about µg being used because ammonia is a small molecule.

Question (b) proved much more difficult than expected. Many students appeared to have difficulty extracting data from the graph, often apparently mis-reading the scale. 20% of students obtained both marks. Another 13% obtained one mark because they calculated the correct number but made a mistake with the units. The commonest error was to use a solidus to represent 'per'; so, /day instead of $day^{-1}$. For many years, AQA has followed the convention of using a solidus to separate units from the name of whatever is being presented. In this case, that would mean, "Difference in rate / µg $g^{-1}$ $day^{-1}$". The question did discriminate reasonably well.

Question (c) proved too challenging for most students. They were asked to identify evidence that supported the idea of different communities of bacteria in soils A and B. This would suggest that the bacteria (bacterial populations) in each soil would be those adapted to a certain soil pH. Many misinterpreted the graph at the start and thought that ammonia was being made; thus thinking A+B gave the fastest rate. Others focused almost entirely on how much ammonia was left at the end of 20 days and/or described the lines on the graph. Some 29% did note that the mixture of A and B had the slowest rate of breakdown of ammonia and obtained one mark. Another 15% obtained a further mark by deducing that it must be bacteria from soil B that weren't working well at pH 6.9; or that only bacteria from soil A were working. Only 3% obtained all three marks by linking their deductions to bacteria from soil B having the fastest rate of ammonia breakdown in their own soil condition (pH 4.3).

Question (d) discriminated quite well and showed which students were able to use data presented in logarithmic form. The examiners allowed calculations of changes in numbers of copies of mRNA, or calculation of percentage changes. 42% of students obtained both marks. Some 7% of students obtained one mark for calculating one correct change. Some who failed to score used the 'power' numbers as simple numbers; so, for species S they said the fall was 2 and it was the same for species T. One mark was awarded if they gave an answer of 100 times with no further explanation.

Question (e) was the worst answered on the paper and 11% did not attempt it. This might indicate that more guidance should have been included in the stem of the question, or it should have been worth only three marks. All four marking points were seen but students often focused on one or two at great length. Since the command word was 'explain', there were only four marking points, for four marks. Few students noted that the population growth could not be determined using the method outlined because at no point were the

bacteria counted. The method simply gives an indication of the amount of amoA enzyme produced. About 28% obtained one mark, usually for noting that the number of mRNA molecules produced might well vary from cell to cell. Some 8% obtained two marks, often for the previous point and suggesting that it is not known if there is a link between expression of *amoA* and population/cell growth/division.

Question (f) tested knowledge of aseptic technique and its use in the context used in the question. The examiners expected students to suggest methods for sterilising whole bottles before use. Many students wrote about flaming the necks of the bottles, ignoring the inside (and outside). Others made vague references to 'heating the bottles', with no detail about how or to what sort of temperature. The mark scheme gave acceptable examples such as autoclaving, using boiling water and washing in alcohol. 36% of students obtained one mark, usually for suggesting a suitable method for sterilisation. The explanations of the reason for sterilising were usually very weak and did not link directly to this investigation. So, most explanations were restricted to statements about getting rid of contaminants or bacteria. The examiners were looking for ideas relating to the removal of bacteria that might compete with or kill the bacteria being studied, or removal of other bacteria that might produce amoA. Only 4% of students made these sorts of statements.

## Q5.

For question (a), only 7.6% of students scored two marks. Most students were able to explain the purpose of boiling the agar, though the most common error was to copy the stem and state "so it could be poured". Explaining the purpose of transferring the same volume of liquid culture onto each agar plate was beyond most students. Some did not understand the term 'culture', thinking it just meant food. There were many generic answers, such as "to make it a fair test", "to control variables", and "so only the independent variable affects the dependent variable". The words valid, reliable, accurate and precise were also thrown at the answer.

Question (b) was not a difficult maths question; it simply involved multiplying three numbers together. Despite this, only 15.6% of students scored two marks.

For question (c), over half of the students were able to access the first marking point, but very few scored the second. There were not any real mistakes with mark point two; it was just omitted.

## Q6.

The whole of question 10 proved to be very challenging for students. This question is a test of comprehension: students must use the passage to be able to answer the questions. Some clearly tried to respond without reading the passage and scored poorly. The mean score on each question part was less than one.

In answers to question (a), there was a clear lack of understanding of the mechanism of HIV infection. Common mistakes included stating that HIV is a bacterium, stating HIV is killed, stating there is no cure for HIV, stating HIV binds to reverse transcriptase, only discussing the action of enzyme inhibition, or simply repeating phrases from the passage. Only 1.4% of students scored four marks, with 45% scoring zero marks.

In answers to question (b) the lack of understanding of the mode of infection and of how the immune system responds was evident. Common mistakes included stating the body or virus becomes immune to AZT, that HIV becomes AIDS, that HAART prevents HIV becoming resistant to AZT and that there would be no need for new antibiotics. Students also tried to include the idea that lower doses of AZT could be taken to prevent muscle wastage, but the passage already stated that AZT is taken in low doses because it causes muscle wasting. Only 0.2% of students scored four marks, with 49% scoring zero marks.

(c) was a simpler question, especially mark point one, but students mostly failed to address the question. Common mistakes included stating less energy is **produced**, less energy **for** respiration, **no** respiration and **no** ATP. Some thought oxygen is released during respiration; there was confusion with protein synthesis, and reverse transcriptase and some simply stated the role of mitochondria. As a result, only 9% of students scored two marks, and 58% scored zero marks.

## Q7.

This question revealed some confusion between antibiotics and vaccines, with many answers discussing immune responses as a result of taking antibiotics.

(a) 72.5% of students gained this mark.

(b) Some good understanding was demonstrated of how this universal enzyme could be different in different species. Some students demonstrated understanding but their responses were insufficiently precise to fulfil the marking criteria; they failed to reference the 'tertiary' structure or the 'shape' of the active site. Some students successfully suggested that the human enzyme would be found in the mitochondria and so be inaccessible to the antibiotic.

(c) 67% of students scored 2 marks. Those who did not, usually could not convert 30 g to 0.03 kg.

(d) There were two ranges of correct answer here, crediting a percentage difference compared with either group A or group R. Ranges were calculated to allow for a tolerance of half a 2x2 mm square when reading from the graph, and for rounding at different stages. It was pleasing to note that 46% of students could correctly complete this calculation. Some clearly were unfamiliar with using the $10^{x}$ function on their scientific calculators. 14% of students could correctly read from the graph and convert these values into actual numbers of bacteria, but then could not calculate the percentage difference.

(e) Only 6% of students achieved all 3 marks here. Those who did were those who fully understood that the significant aspect of the data was that **neither** antibiotic killed all the bacteria and then went on to **explain** the consequences of this. As with question (b), some students wrote extensive descriptions of the data; this is not creditworthy in this 'explain' question. Those who wrote extensive descriptions often then forgot the instruction to use their knowledge of the evolution of antibiotic resistance. Mark point 3 was commonly achieved for the idea that bacteria resistant to one antibiotic would be killed by the other antibiotic. There was a disappointing number of references to 'immune' bacteria. Some students tried to evaluate the information (not requested here), with statements relating to this investigation being in mice rather than humans.

## Q16.

(a) This was generally very well answered with students able to study the resource material and pick out relevant factors to be kept constant. Unqualified references to temperature and time were seen and these were not specific enough to this investigation to be creditworthy.

(b) This calculation was successfully completed by the vast majority and both options of answer were seen although 99.8 was more common. As with other calculations in this series, rounding errors were seen and these could only be awarded 1 max.

(c) Although many students could define standard deviation, few could apply that

knowledge to suggest what was going on here.

(d) Most students achieved mark point 1, appreciating that the control group should be treated and not given a standard placebo, although fewer could clearly explain why this was important. Unqualified references to “ethics” were not creditworthy.

## Q17.

(a) The vast majority of students correctly named the type of reaction as hydrolysis. Common errors were ‘condensation’ and ‘phosphorylation’.

(b) Approximately 50% of students gained a mark in this question. The most common scoring points referred to phosphate being required for the formation of ATP, DNA, RNA or phospholipids in cell membranes. Many students stated that phosphate was used as a ‘nutrient’, ‘for energy’ or to ‘form protein’.

(c) Approximately 40% of students were able to calculate a correct ratio. A significant number of students did not gain the mark as they provided the ratio the wrong way round or they simply transcribed their readings from the graph as a ratio, most commonly, 4.1:1.1.

(d) This question proved difficult for most students with almost 60% scoring zero. The most common misconception was that the chilling requirement of seeds would enable plants to grow during the winter so that they would be fully grown by spring and could outcompete other plants. Some students also referred to plants carry out photosynthesis and reproducing during the winter. A significant number of students misinterpreted the question and answered it in terms of natural selection for plants with a chilling requirement. Students who did gain credit often referred to growth of the seed/embryo during the winter followed by photosynthesis in the spring/summer. Very few students referred to seed production in the spring or summer.

## Q18.

(a) It was disappointing that less than 50% of students obtained two or more marks out of the four available on this question. Although the context of the question was novel the knowledge and understanding required have been regularly assessed on previous AS Biology papers with students achieving better outcomes. The fact that a mutation involves a change in the DNA base/nucleotide sequence was only appreciated by a minority of students, often the 5% of students who obtained maximum marks. Although most students appreciated that a different amino acid sequence would be coded for, a number of students incorrectly stated that different amino acids would be formed. Better answers did gain credit for references to changes in hydrogen, ionic or disulfide bonds. However, many students failed to gain a mark for a change in the tertiary structure as they incorrectly suggested that this changed ‘the active site’ of a receptor. 30% of students obtained no marks. These students often provided detailed accounts of translation or outlined the consequence of having a non-functional receptor which was required in the following question.

(b) Approximately half the students obtained at least one of the two marks available for this question. Usually this mark was awarded for appreciating that HIV would not be able to attach to the protein receptor and therefore could not enter the cell. Many other students omitted the latter part of this description. Again, many students referred to an active site on the receptor. Approximately 10% of students gained both marks by further explaining that HIV would not be replicated or that the T cells would not be destroyed.

(c) As expected, this question proved very difficult for the vast majority of students with less than 5% obtaining both marks. The most frequent correct response related to the low number of HIV infections in Europe compared with other parts of the world. A number of students did gain credit for outlining that HIV has only been present in humans for a relatively short time period. The other mark points were rarely awarded. A significant number of students appreciated that natural selection often occurs over a long time period but did not relate this information to the context of the question.

## Q19.

(a) Approximately two thirds of students correctly explained that the clear zone was due to the disinfectant killing the bacteria. Answers which only referred to the growth of bacteria being prevented were not credited as the stem of the question outlined that a culture of bacteria had already been grown on the agar.

(b) Slightly over half the students gained this mark. Most referred to the clear zones being too large or merging. A significant minority did refer to all the bacteria being killed. Students failing to gain credit often provided vague responses relating to the clear zones, concentrations of disinfectants, enzyme denaturation or safety concerns.

(c) Almost 90% of students obtained at least one mark, usually related to controlling the size of the paper disc. Approximately 40% of students gained the second mark for outlining that the discs should be soaked in each disinfectant for the same time period. A common response was to suggest that the same volume of each disinfectant should be used but as the information stated that the discs were soaked, this was not credited.

(d) 30% of students obtained both marks for his question. A similar percentage obtained a single mark for an incorrect answer but a valid method of calculating how many times more effective disinfectant D was than disinfectant B. Most students did this by dividing the diameters or the radii of the clear zones.

## Q20.

(a) Over three quarters of students correctly identified ‘locus’ as the position of a gene on a chromosome with ‘allele’ and ‘exon’ given frequently as incorrect answers.

(b) Most students correctly defined the term ‘genetic diversity’, usually by referring to the number of different alleles. ‘Genes’ was used instead of ‘alleles’ by more than a few and some tried to hedge their bets by quoting ‘genes/alleles’. Imprecise expressions like ‘the range of alleles’, ‘variation of alleles’ or ‘number of alleles’ were not credited, but often seen.

(c) This question tested students’ ability to select and translate appropriate information from tabulated form and it differentiated well. Most achieved two marks and many got all three. Concise reference was often made to ‘overlapping standard deviations showing no significant difference between mean values’ and demonstrated that there is sound awareness of this principle. Nevertheless, some misread the table and quoted Airedale as being the most diverse and others failed to make a comparison, but relied simply upon using a list of numbers. Occasionally, students failed to identify the breed of dog in the comparison they made, leaving the onus on the examiner to decipher what they really meant. Some commented correctly on ‘low values of standard deviations showing that there was high reliability’, but this did not answer the question. Misconceptions, such as ‘high diversity shows more genes are involved’ and ‘overlapping standard deviations show breeds are closely

related' were not uncommon.

(d) This question proved beyond most students because they did not link the data to human involvement in the selective breeding of domesticated animals. Many thought incorrectly that frequent mutations caused the changes in genetic diversity, and many thought speciation had occurred which involved isolating mechanisms such as island populations or river barriers. Some put the changes down to environmental causes. Reproducing Miniature terriers with other breeds was often correctly given to indicate that they were more outbred, and 'selection of specific traits in Bull terriers' was accepted at the lowest level for inbreeding. References to a gene pool or to changes in the number of different alleles were rare. Some students referred to the terriers as different species, but then bred them and their offspring successfully, which suggested there is a misconception with the concept of species.

## Q21.

(a) Most students demonstrated a sound understanding of the principle that a hypothesis is a statement that is tested by an investigation. Predictions were most often given and many gave null hypotheses. Marks were missed when students failed to make any reference to 'resistance' in the context of bacteria, and it was not uncommon for the resistance to be linked to the animal or human rather than to *Escherichia coli*.

(b) (i) Many students showed good skill and precision by selecting the right information from the table and made careful references to 'percentages' and 'resistance' to gain full marks.

(ii) The principle of natural selection is well understood, but often marks were missed because of a misconception that antibiotics cause mutations. Imprecise expressions were common, such as 'bacteria thrive' or they 'grow' rather than they 'reproduce'.
Occasionally, students wrote that 'resistant alleles survived', with no role implied for the bacteria that contained them.

(c) Approximately a quarter of students achieved the mark on this question because they made a clear link between human faeces and contaminating pathogens. Many mentioned *Escherichia coli*, which the question explicitly told them not to do, and poor written communication was evident in answers suggesting that what is spread is a 'disease' rather than an 'agent of disease'.

(d) The principle of measuring the reliability of the design of an investigation is very well understood, with the majority of answers gaining two marks. Some students misread the question because they suggested changes in the design to increase reliability, and others did not notice 'reliability' was given in the question's stem so it should not have been included as an answer.

(e) This question differentiated well. Students made appropriate suggestions using either DNA hybridisation or nucleotide sequencing to address the context of this question; some wrote at length about both of these techniques. A minority of responses discussed using antibodies to compare the similarities, possibly they think DNA is a kind of protein.

(f) Few students achieved more than three marks on this question because many tended to dwell far too long on giving a full explanation of how natural selection increased cases of resistance; they did not look to give broader reasons relating to society's view. Contamination of the human food chain, avoiding adverse side

effects, the generation of superbugs, and high costs were common answers, although students giving more than any two of these was rare. Very few answers contained suggestions about changes in legislation and, although prevention of the horizontal and vertical transmission of genes conferring resistance was often cited, it was rare for students to make clear the principle of avoiding transmission of resistance into other harmful bacteria, so this marking point was not often awarded.

## Q22.

(a) There were many good answers to this part, with 25% of students obtaining all 6 marks. For the rest, it was a matter of how much of the story they gave. Some students failed to gain one of the marks because the examiners rejected references to changes in base sequences leading to different amino acids being produced or made. The most commonly missed point related to changes in bonding within the structure, due to a different primary structure. The examiners were also looking for changes in tertiary structure of the protein, rather than just changes in shape.

(b) In this part, many obtained one mark for noting the difference in response of SR and non-SR above 10 μg $cm^{-3}$. Fewer, about a third, noted the greater effect on the non-SR up to 10 μg $cm^{-3}$ and obtained a second mark.

(c) The logic in this part defeated many students and nearly half failed to score. In the main stem, it says that the scientists stopped cell division before exposing the bacteria to the antibiotic. Despite stopping cell division in both SR and non-SR, the SR bacteria remained more resistant. This suggests something other than stopping cell division is involved. There were some very good answers (13%) that did follow the logic and obtained 2 marks. Some obtained 1 mark, usually for noting that cell division had been stopped.

(d) Many students obtained 1 mark for suggesting the development / use of either a competitive or non-competitive inhibitor of an enzyme involved in the stringent response. Surprisingly few were able to explain successfully how either of these would stop an enzyme working and thus obtain a second mark. A minority of students obtained a mark for just suggesting the use of an inhibitor (type unspecified) to block the enzyme pathway.

In this part, students illustrated something that is frequently seen in answers to exam questions. Information is provided in the question, students are instructed to use this information, but then go off on a different tangent. Students who did use the information often produced very good and very clear answers along the following lines. The SR bacteria contain fewer harmful free radicals. They also contain more of the enzyme catalase. (Perhaps) the catalase breaks down the free radicals (before they cause harm). Other students did not make comparisons between SR and non-SR but often tried explanations based around comparisons between free radicals and catalase within strains but with no sensible explanation of how this would help the bacteria. Some invented hypothetical effects of free radicals, or catalase, or both on antibiotics, or on bacterial cells.

## Q23.

Parts (a), (b) and (d) proved to be good discriminators.

(a) It was disappointing that only just below 40% of students scored at least half marks. This was mainly due to simply describing the structure of DNA, without explaining how these features relate to its functions. Some students wrote about DNA structure and function in different paragraphs. This made it unclear which feature went with which function, as no direct links had been made. In contrast, there were some truly

excellent responses, which had clearly been well planned before putting pen to paper. The most common mark points awarded were for the sugar-phosphate backbone providing strength or protecting bases, the helix allowing the molecule to be compact, weak hydrogen bonds allowing strand separation or replication and the two strands acting as templates or allowing semi-conservative replication. Relatively few students linked complementary base pairing with accurate replication or the production of identical copies of DNA. Similarly, few students referred to DNA as a large molecule that can store lots of information, or the base sequence coding for amino acids. Weaker responses often mentioned this in the context of the genetic code being degenerate. Indeed, some students thought that the base sequence causes amino acids to be *produced*. The ability to convey that *many* hydrogen bonds provide stability was rarely seen. It was also unfortunate that a number of students wasted their time by writing about irrelevant topics such as the differences between prokaryotic and eukaryotic DNA and the role of histones. There were also some lengthy accounts of DNA replication, enzyme structure and the different levels of protein structure.

(b) Many students scored at least two marks for stating that a mutation in gene **E** produces the highest risk and a mutation in gene **C** produces the lowest risk. However, only the best responses also referred to gene **D**. Students who did not mention any of the genes usually picked up one mark for noting that all of the mutant alleles increase the risk of lung cancer. Surprisingly, some thought that a mutation in gene **D** produces the highest risk.

(c) Just fewer than 40% of students gave the correct answer of **180**.

(d) Two-thirds of students scored at least two marks. Many were able to identify the decrease, plateau and increase for healthy cells and cancer cells. However, relatively few made reference to the plateau occurring for the same length of time. Students who failed to gain a mark for a similarity usually ignored the plateau. Most students spotted that a greater number of healthy cells were killed or that they experienced a faster decrease in number. Similarly, it was impressive to see that some used data from the graph to calculate that a greater *proportion* of cancer cells were killed. Many students also noted the faster increase in the number of healthy cells.

(e) Half of students scored full marks. This was usually for mentioning that too many healthy cells would be killed, which could kill the patient or cause side effects. However, relatively few appreciated that it would take time to replace the healthy cells that had been killed.

## Q24.

(a) Nearly all students gave the correct answer of **250,000**.

(b) (i) One-third of students gained at least one mark. This question required students to apply the principle that three bases code for one amino acid to an unfamiliar context. However, other creditworthy approaches were used to explain why the faulty protein has one amino acid missing. This said, many students simply defined the term ‘mutation’ or repeated information given in the question stem. Consequently, there were many references to a *change* in the base sequence or amino acid sequence. Only the best responses mentioned a loss of bases. Students who took a different approach fell into one of two camps. Some suggested that a stop codon had formed for one mark. However, it was rare to see this related to the final amino acid of the protein. Similarly,others were clearly aware of introns but rarely mentioned that three bases may form an intron. Unfortunately, a minority of students provided

a good response to (c) (ii) for this question part.

(ii) One-third of students gained full marks. Many were aware that the protein produced could be faulty or non-functional. However, the ability to explain this in terms of a change in tertiary structure or active site discriminated well. Unfortunately, some students went no further than to state that the protein would have a different primary structure. This was given in the question stem and therefore not credited.

## Q25.

(a) This question was the most effective discriminator on the entire paper. The best answers used all the information provided to describe how geographic isolation could cause a very high diversity of bird species. At the other extreme, speciation was ignored and a description of succession was given. Most answers did attempt to explain speciation but often did not make sufficient use of the information provided to gain high marks. Usually these accounts only gained the marks for geographic isolation and for describing differential reproductive success. Poor use of terminology was also clearly evident in these weaker responses. References to different selection pressures and changes in allele frequency were often only mentioned in better responses.

(b) Surprisingly, almost fifty percent of students failed to gain this mark. Common incorrect response referred to a climax community being formed, or mutations not occurring. Students gaining this mark often mentioned no ‘isolation☐ or ‘a similar environment☐.

## Q26.

(a) (i) 40% of students gave one ethical argument for maintaining biodiversity that was of A-level standard. This was the idea of preventing extinction or loss of habitats. References to animal rights, or ‘playing God’ were classed as neutral.

(ii) Just under half of students gave one economic argument for maintaining biodiversity. The most common responses that gained credit referred to medicine, tourism or agriculture.

(b) This proved to be a good discriminator. Nearly two-thirds of students gained at least one mark usually for the answer ‘fewer habitats’. Very few students mentioned that a lower percentage of the original forest meant that fewer plant species would be present. The ability to express the idea of ‘fewer food sources’ discriminated well. This was often conveyed in weaker responses as ‘less food’, which was not credited.

(c) 85% of students scored at least one mark. This was usually for ‘number of each species’. It should be noted that the specification requires students to be able to calculate one specific index of diversity. The ‘number of species’ is not required to calculate this index of diversity. Consequently, this response was classed as neutral

(d) 70% of students scored full marks. Students who did not typically referred to surface area only, a *larger* SA:VOL, a *smaller* VOL:SA, fat or feathers.

## Q27.

(a) This question was generally answered well, although some students had not appreciated the significance of the statement that the drawings were to the same

scale. The lateral roots on the sugar beet were incorrectly referred to as root hairs and led students to structure answers around the uptake of water and minerals. The weakest answers came from students who had ignored the information in the stem of the question about the role of the root in the storage of the sugar.

(b) Only a minority of students answered this question well. The commonest mistake was to write about profit in terms of more plants rather than the faster rate of growth. Others failed to gain marks by, apparently, intending to write about the 'sugar beet plant' but shortening this to 'sugar' and thereby making their answer nonsensical.

(c) Most students understood that selective breeding would reduce genetic diversity but fewer were able to explain that this was because of the deliberate selection of a few alleles during the selective breeding process.

## Q28.

(a) (i) Over 90% of students correctly determined that base sequence could code for a maximum number of four amino acids.

(ii) The vast majority of students gained at least one mark, often by mentioning a change in the sequence in amino acids. However, a significant number of students incorrectly referred to 'different amino acids being formed'. Most students gained a second mark for explaining that the active site/ tertiary structure would be altered. Over 50% of students gained maximum marks either by linking this to enzyme-substrate complexes not being formed or to changes in hydrogen bonds.

(b) Most students had little difficulty in using the information to give two symptoms of phenylketonuria and gained both marks.

(c) The majority of students obtained this mark, often by referring to migration or by describing interbreeding. However, over a third of students failed to gain credit and often accounted for the spread of phenylketonuria by horizontal or vertical gene transfer.

## Q29.

(a) (i) Over 90% of students correctly explained that vancomycin does not affect human cells as these cells do not contain a cell wall.

(ii) Approximately two thirds of students gained this mark by outlining the role of ribosomes in protein synthesis.

(b) This proved to be an effective discriminator. Most students obtained at least one mark often by referring to vertical gene transmission. Many students then referred to the reproduction of resistant bacteria to gain a second mark. Over a third of students gained maximum marks by explaining that a mutation leads to resistant strains or by stating that a resistant gene or allele is produced. Unfortunately, some weaker students incorrectly referred to bacteria becoming 'immune' or to bacteria reproduction by 'mitosis'.

## Q30.

(a) Over seventy percent of candidates were able to explain what is meant by genetic diversity. Weaker candidates confused genetic diversity with species diversity. A significant number referred to fewer alleles rather than fewer different alleles.

(b) Very few candidates did not refer to the environment as the other type of factor causing variation in a species.

(c) Very few candidates scored zero and fifty percent gained both marks in this question. Most candidates realised that genetic diversity would be reduced and many could explain this in terms of a genetic bottleneck or reduction in the variety of alleles in the population.

## Q31.

(a) (i) This caused little difficulty for most candidates with the vast majority gaining at least one mark for suggesting that *C. difficile* is resistant to antibiotics. Although many candidates realised that the other bacterial species would be killed, they failed to gain a second mark by not stating that there would be an increase in the number of *C. difficile*.

(ii) Most candidates gained this mark by suggesting that the immune system would be less effective. There were several answers linked to older people taking lots of antibiotics. These responses were not credited.

(b) Although the majority of candidates obtained at least one of the two marks available, there was still some confusion, particularly with weaker candidates, about the precise role of methicillin. Most candidates realised it was a competitive inhibitor but a significant number referred to it possessing an active site. Approximately forty percent of candidates provided a clear accurate explanation of competitive inhibition by methicillin.

(c) (i) The majority of candidates had little difficulty explaining that some of these patients were already ill and this illness could be the cause of death.

(ii) The vast majority of candidates gained this mark by describing the increase in the number of deaths up to 2006 followed by a decrease.

(iii) Less than a third of candidates could correctly calculate the percentage increase in the number of deaths caused by MRSA in Wales from 1996 to 2006. A small percentage of candidates obtained a single mark for reading figures from the graph but almost sixty percent scored zero.

## Q32.

(a) Almost all candidates referred to carrying out the procedure using distilled water but very few indicated that the same number of ryegrass seedlings would be required.

(b) Maximum credit was usually scored in part (a) with candidates correctly choosing the Spearman rank correlation test and indicating either that they would use this to test a null hypothesis or determine the probability of obtaining results by chance. Part (b) was, almost without exception, answered correctly.

(c) Most candidates scored at least one of the two available marks for part (a) by identifying either the reduced germination of ryegrass or the reduced root growth. There were few convincing answers to part (b), however, and most candidates approached this question by unjustified criticism of the experimental approach.

## Q33.

(a) There was widespread recognition that tail band width would be likely to change with age.

(b) In part (a), many candidates lacked the mathematical understanding to appreciate that a mean which had a value with decimal places suggested that measurements of the same band must differ. Likewise, they did not appreciate that a standard deviation with a value other than zero indicated variation in the measurements of the same band. However in part (b), having read the description of the procedure, most recognised that viewing an animal's tail through binoculars from a moving vehicle was likely to give rise to inconsistent data.

(c) Most candidates correctly used the data about the width of bands from the left and right sides of the tail as evidence that rings of equal width were not found.

(d) The most frequently awarded mark was for showing an understanding that unrelated animals would be expected to show more variation than animals from the same family. It was less usual to find a link to the idea that members of one family are genetically closely related, or a reference to the animals' parentage.

## Q34.

(a) Most candidates correctly identified the number of chromosomes in a male gamete in part (i) and appreciated in part (ii) that a chromosome number of 33 could not lead to viable gametes. Not all were certain as to the reason for this, however. One frequent misconception was that it is not possible to have a gamete with an odd number of chromosomes. Weaker candidates often attempted to explain why the gametes that would be produced were unable to form a zygote. Their answers were often further marred by poor use of technical language. There was much confusion between the terms chromosome, gamete and zygote.

(b) There were some excellent answers to both parts of this question. Both parts again required candidates to use the data in the table and it was clear that some failed to take sufficient care with this. The breaking strength of the leaf, for example, was not uncommonly expressed as the strength of the plant or even the breaking strength of the banana fruit. Candidates should be advised to use the wording provided in table headings and graph labels wherever possible.

(c) It was clear that some candidate's knowledge of cell division failed to extend to the use of such terms as mitosis and meiosis. The quality of many answers was also influenced by poor understanding of technical terms. Thus different varieties of bananas were not infrequently referred to as species and genetic diversity was equated with species diversity. Consequently what should have been a simple answer linking mitosis to genetically identical offspring not often involved irrelevant accounts of competition and speciation.

## Q35.

(a) Better candidates accessed the full mark range and there were some excellent logical accounts based on the information provided. Less able candidates were generally able to recognise that they were expected to draw on their knowledge of enzymes. They experienced considerable difficulties, however, in identifying the enzyme and its substrate in the context of this question. Thus the enzyme was often incorrectly given as the penicillin molecule or equated with the gene encoding it. The substrate on the other hand was identified as either an antigen or an antibody or, more commonly, as a bacterium. Elsewhere, there were a number of answers which offered convincing detail of enzyme action but were totally unrelated to the situation presented in the question.

(b) Although part (i) revealed a general understanding that the addition of antibiotics would result in fewer cows becoming ill, candidates did not always link this to

bacterial infection or could indicate with sufficient clarity how famers would benefit financially. In part (ii), the concept of selection proved to be very poorly understood by all but the best candidates. Where the concept was invoked, there was a widespread failure to appreciate that, in the context of this question, selection referred to antibiotic resistance in bacteria, not in cattle. Other candidates resorted to ethical considerations, many of which implied a total lack of consideration of animal welfare by farmers.

## Q36.

(a) Although a considerable number of candidates gained credit for their answers to this part of the question, others offered inappropriate suggestions. Many of these were yet again centred on the converse and attempted to explain why they did not measure the minimum diameter.

(b) There was evidence from the answers to part (i) that many candidates still fail to absorb material presented in the stem of a question or look critically at data in tables and graphs. Thus, although most appreciated that shrimps that lived in caves had smaller eyes and longer antennae than those that lived in the open, they were unable to point out either that the antennae were responsible for detecting touch or that these data only referred to shrimps. More limited candidates often suggested that shrimps either had eyes or sense organs. Those candidates who avoided explaining standard deviation in terms of range, generally gained at least one mark for part (ii). Better candidates were also aware that overlap in the values of standard deviation was important in indicating whether differences were attributable to chance or were significant.

(c) In part (i), most candidates made an appropriate qualitative statement about the body lengths of the shrimps concerned but few supported this with data from the graph. Some appeared distracted by antennal length and failed to identify the thrust of the question. Part (ii) was generally well answered.

(d) Most candidates appeared to have understood the information in the graph but could not always explain this with sufficient clarity to gain credit. Thus, although an answer relating to cave shrimps and ocean shrimps (interpreted as shrimps living in open streams) could be awarded credit, one that merely referred to shrimps in streams could not. There were also many sweeping statements such as that “the percentage of shrimps was higher in the open for all alleles”. This was clearly not correct. More credit might have been awarded had candidates based their wording more carefully on that supplied in the column headings in the table.

(e) One of the key phrases in this question was “Use your knowledge of the founder effect”. This should have indicated that candidates were required to apply this concept to the example provided in the question. A significant number failed to do this and opted instead to discuss the difference in percentages in terms of either natural selection or genetic bottlenecks. Such approaches rarely gained credit. Others offered extremely general explanations that made no reference either to shrimps or to allele L. These accounts often incorporated volcanic eruptions and hunting to extinction. Answers were further marred by imprecise language with the term “species” used in a variety of ways that had an adverse effect on the sense of the argument presented. Some candidates again turned the question round and attempted unsuccessfully to use their knowledge of the founder effect to explain the percentage of shrimps with the allele L in the open.

(f) Candidates who answered this question successfully either suggested breeding cave shrimps with those living in the open to see if fertile offspring were produced, or looking at whether courtship behaviour led to successful mating. Although both of

these approaches were acceptable, those based on DNA hybridisation and protein analysis were not. Those candidates who chose to discuss crossing shrimps often suggested procedures that would not have guaranteed the relevant parentage. Attempts were made to add detail and there were some valid comments about repeats and carrying out reciprocal crosses. However, there was much discussion about the ethics of experimental work and the perceived cruelty of such experiments that could not be given credit.

## Q37.

(a) The vast majority of candidates gained at least one mark often by describing a method to improve hygiene. The failure of many candidates to gain both marks was often due to providing two methods of improving hygiene rather than two distinct ways of reducing transmission of MRSA. Approximately a third of candidates did obtain a second mark, usually by referring to isolation of infected patients.

(b) Approximately two thirds of candidates obtained at least one mark by suggesting that higher doses than the minimum inhibitory concentration of antibiotic would kill microorganisms. Better candidates referred to the need to prevent antibiotic resistant bacteria surviving. Weaker candidates often incorrectly referred to bacteria 'becoming immune'. There were few correct answers relating to some of the antibiotic not being absorbed or being broken down in the body.

(c) (i) The vast majority of candidates, almost 90 %, correctly named drug P as being most effective against Enteroccus faecalis.

(ii) A similar percentage of candidates correctly named drug S as being most effective against all the species of bacteria used.

(d) (i) The vast majority of candidates obtained at least one mark often by referring to the prevention of bias. Over a third of candidates gained a second mark usually by commenting on the 'placebo effect'.

(ii) This was well answered with almost 95 % of candidates gaining at least one mark and two thirds of candidates gaining both points. Age, sex and health were the most common responses. Failure to obtain both marks was often due to two health-related factors being provided.

(e) Conversely, this was not well answered with almost nine out of ten candidates failing to describe the results shown on the graph. Most candidates simply stated that there was an increase without referring to a gradual, followed by a rapid, increase.

## Q38.

(a) (i) Most candidates gained this mark by indicating that the response was more effective in children. However, a significant minority of candidates interpreted the graph as showing that adults had a more effective response to the treatment.

(ii) Considering a similar question was asked on the January 2010 paper it was disappointing to note that less than half the candidates gained both marks. Most candidates did refer to a line of best fit but many then failed to explain that the line should be extended to predict the haemoglobin content after 40 days. Credit was also given for detailed answers using the rate of increase per day to predict haemoglobin content.

(iii) Only a third of candidates clearly explained what is meant by a quaternary

structure. Most candidates suggested that it meant four polypeptide chains or many proteins were present.

(b) (i) Almost a third of candidates obtained zero on this question, suggesting these candidates had not revised relevant principles from unit 1. A significant number of candidates interpreted isotonic as meaning a constant pH. Candidates who did know what isotonic meant were often able to provide a suitable explanation to gain at least two out of the three marks. However, there was still some confusion over the term osmosis with weaker candidates referring to salt moving by this process.

(ii) Most candidates were able to describe one difference between the two blood samples, often in relation to the variation in diameters. Many incorrectly referred to a difference in number of red blood cells, or their descriptions were too vague to gain a second mark point.

## Q39.

(a) Candidates recognised that temperatures were generally higher and also suggested that the temperature fluctuated. This question was usually marked at the correct level. It was less common for candidates to identify that the trend in the data may have been due to chance.

(b) This was well understood with the vast majority scoring two or more marks. It was marked at the correct level by most centres. Most commonly the null hypothesis was absent in responses. Many accounts provided extensive unnecessary detail about calculating the test statistic. This was often incorrectly given credit.

(c) (i) Only a very small number of candidates established valid links between egg-laying and daylength. Very few candidates realised that daylength was related to a particular time of year. Too many answers which did not correspond to points on the marking guidelines were credited by centres. Credit was also often incorrectly given for synchronising egg-laying rather than breeding behaviour.

(ii) Candidates had more success with the relationship of egg-laying and temperature. They established links with availability of food and an increase in insect numbers. Many candidates, however, discussed body temperature and survival of young and this was incorrectly credited by some centres. Others answered in terms of temperature affecting egg hatching.

(d) This was well answered by the vast majority and marked at the correct level.

(e) Many candidates were able to use the data supplied to suggest that the date of egg-laying would be imprecise. Many answers were linked to the collection of data by volunteers, candidates considering that as a consequence the data were unreliable and the conclusions that could be drawn were debatable. Again answers not meeting the requirements of those in the marking guidelines, such as ‘don’t know when the eggs were laid’, were credited.

## Q40.

(a) Most candidates had little difficulty obtaining at least one mark often for stating that courtship behavior enables recognition of the same species. Over a third of candidates gained a second mark. These candidates often linked courtship behaviour to sexual maturity or to the release of gametes. Most candidates failing to gain two marks often provided only one suggestion or there was a lack of clarity in

their answers.

(b) (i) Almost two thirds of candidates gained this mark. Most candidates used the information in the stem of the question to explain that fusion between gametes would be more likely within a limited area.

(ii) Less than half the candidates obtained this mark by indicating that developing within the pouch protected young seahorses from predators.

(c) (i) Most candidates gained this mark often by stating that the curved tail made it difficult to obtain an accurate measurement of body length.

(ii) This proved slightly more difficult with a number of candidates providing the same answer as in (c)(i). Nevertheless, over 60% of candidates did obtain the mark by suggesting that body length is proportional to head length.

(d) The vast majority of candidates obtained this mark by describing the trend of seahorses with similar head/body lengths pairing together.

(e) This was generally well answered with most candidates obtaining the first marking point by referring to drawing a line of best fit. Over 50% of candidates gained the second mark by explaining how extrapolation of the graph could be used to predict the total head length of selected mate.

(f) This question proved an excellent discriminator. The vast majority of candidates described how DNA hybridisation could be used to find out if the two species of seahorses are closely related. Not surprisingly, the quality of the descriptions of DNA hybridisation varied considerably and a variety of alternative methods were credited. Most candidates gained a couple of marks for naming the technique and for the principle of mixing the DNA strands of the two species. Many candidates also appreciated that a higher temperature would be required to separate hybrid strands from closely related species. A maximum of four marks was available for a full description of DNA hybridisation.

Other methods described included; comparing DNA base sequences, comparing amino acid sequences and immunological studies. There was considerable confusion between the first two methods with many candidates referring to ‘amino acid sequences of DNA’. Few candidates appreciated that the same or a named protein should be studied when comparing amino acid sequences. Descriptions of immunological investigations were relatively infrequent and apart from some notable exceptions, were generally of poor quality displaying little understanding of even the basic principles. Nevertheless, over a third of candidates obtained four or more marks for this question with many providing outstanding detailed descriptions of the various methods involved.

## Q41.

(a) Nearly all candidates knew that members of the same species can reproduce to produce fertile offspring. Fewer, made the additional point that they shared similar features.

(b) Responses to this question were disappointing and were most likely due to candidates not really looking carefully at the evidence and realising that the means and ranges of beak depth of the two species on island 3 had shifted in opposite directions. A majority of candidates thought that the changes in distribution of beak depths of the two species on island 3 were an example of disruptive selection. It is likely that these candidates focused on the third graph, saw two distributions and

assumed that there had been selection in favour of the two extremes of one distribution. Some even went as far as to say that sympatric speciation had occurred.

## Q42.

(a) Nearly all candidates were able to described photophosphorylation accurately and many scored full marks.

(b) A good number of candidates recognised the benefit of sediment-dwelling bacteria being able to absorb wavelengths of light that were not absorbed by the surface-dwelling bacteria. However they often then went on to suggest that the bacteria with this ability would out-compete the surface dwellers, rather than sediment dwellers without the ability to synthesise chlorophyll. As a result, some of the points they made about the process of natural selection were in the wrong context.

## Q43.

(a) Although most candidates recognised this as a question about natural selection, many did not gain marks by failing to identify the nature of the selection pressure (use of the antibiotic) or to explain how resistance would become widespread. Some candidates answered in a completely different way and, effectively, answered part (ii) by describing the nature of mutations and how they could affect the ability of an antibiotic to bind with receptors in the bacterial membrane. This said, however, there were quite a number of very good responses scoring full marks or nearly full marks.

(b) Many candidates, of all abilities, were familiar with the Hardy-Weinberg equations and were able to apply them to the data given to calculate the frequency of the heterozygotes (0.18/18%). The most common error was to assume that the frequency of those homozygous recessive (0.01) in the population is represented by q, rather than by q2. Some then used this wrong value to find p and, from that, 2pq and so were able to gain some credit for showing elements of a correct method, even though they arrived at an incorrect answer.

## Q44.

(a) Most candidates suggested crossing over in prophase I and independent assortment of chromosomes in anaphase I of meiosis. Some correctly suggested independent assortment of chromatids in anaphase II of meiosis.

(b) Explanations of standard deviation and range sometimes suffered as a result of vague and imprecise language. It is not helpful to use the term ‘range’ when trying to explain what range means. It is incorrect to say that standard deviation relates *each value* to the mean, as a good number of candidates suggested, and it is not enough to say that standard deviation describes the spread of data; it describes the dispersion or spread *about the mean*. Candidates need to be more precise in their answers.

## Q45.

Much of the material in this question was unfamiliar and required careful analysis to score highly. Even so, candidates across the ability range scored highly on the question, although it was mainly able candidates who did so.

(a) Many answers to this question, which demanded only straight recall, were disappointing. Most candidates did not get beyond saying that stabilising selection

acts against the extremes and results in a smaller range or standard deviation. They often cited the example of human birth mass. Better candidates were able to explain that this occurred because those individuals showing the mean value were best adapted to the environment and that, as a consequence, the mean would not change as the process repeated itself generation after generation. However, only a few of those took notice of the question and explained that stabilising selection occurs in an unchanging or stable environment.

(b) Candidates who made the link between temperature, the activity of slugs and the proportions of cyanogenic and acyanogenic clover plants usually went on to score well by explaining the selective advantage of producing cyanide when slugs are active and not producing cyanide when temperatures are so low that the cyanide would be released into the plant's own tissues.
Those who did not make this link often pursued an inappropriate line of reasoning concerning the effect of temperature on enzyme kinetics and developed highly teleological answers.

## Q46.

(a) In part (i) there were many imprecise answers referring to the prevention of contamination without explaining that there might be bacteria present in the agar. A few candidates thought that sterilisation would get rid of unwanted substances rather than microorganisms. Part (ii) also produced many vague answers. It was common to read "so that you can compare them" and the inevitable references to "fair tests". However, the better candidates were well aware of the need to show that the bacteria grew well without the antibiotic present.

(b) There were many references to the bacteria becoming immune, rather than resistant. Some thought that the bacteria had grown before the antibiotic was applied, or that the antibiotic was "not strong enough".

## Q47.

(a) Most candidates were able to substitute the data in the formula and calculate the index of diversity correctly. There were occasional arithmetical errors. Many appreciated that the numbers of individuals had been used in the calculation of the index of diversity, or pointed out that the influence of rare species would be minimised. Weaker candidates frequently thought the index of diversity was good for comparing two areas (although why this should be an advance on just comparing the numbers of species present was not made apparent).

(b) Some candidates were confused and seemed to regard the results as having been derived *in situ* on the shore rather than being produced using a balance in a laboratory. Many confused cause and effect and ignored information provided earlier in the question, insisting that *Fucus spiralis* must have been located on the lower shore as it lost less water due to having been exposed for a shorter time. Those who did realise that *Fucus spiralis* in fact lost less water because it was better adapted to life on the upper shore, very rarely went on to suggest that living in this location (seemingly rather hostile) would result in reduced competition between it and the other species.

## Q48.

(a) Most candidates clearly appreciated that the samples would best be obtained by using random numbers to determine co-ordinates, although they were not always specific as to how these numbers would be generated. There were, however, frequent references to "throwing" a quadrat, a technique which does not give rise to

a genuinely random distribution.

(b) In part (i), candidates revealed considerable difficulty in recognising the trend of a decrease followed by stabilisation from a depth of around 200 cm. The most frequent response was to ignore the change in gradient and refer simply to the population falling. Where a genuine attempt was made to offer an explanation for the difference in numbers in part (ii), answers were usually correctly related to the decreasing concentration of oxygen available for respiration.

(c) There was obvious confusion in the minds of some between the concepts of ecological succession and natural selection. While some of those who made this distinction produced excellent answers, others lost their way in rambling anthropomorphic accounts of bacteria “not finding conditions to their liking” or being “happier” with conditions at other depths. There were also many general references to “bacteria”. These lacked the necessary precision to gain significant credit.

(d) Part (i) was generally well answered and there were many accounts based on correct references to the surface layers being the only ones where numbers of aerobic bacteria increased. Part (ii) also produced some sound responses although candidates were inclined to embellish their answers with irrelevant detail relating to the anticipated change with time. Once again, a failure to gain marks most commonly stemmed from imprecise use of the word “bacteria”. In both parts (c) and (d) there was a need to refer them as being either aerobic or anaerobic.

(e) There was encouraging evidence of a good understanding of standard error and many candidates were able to show some appreciation of this demanding concept. However, answers were seldom targeted at explaining what the error bars revealed about the difference in activity at the times given. In spite of the wording of the last sentence of the question, the terms probability and chance were seldom incorporated into the explanation.

(f) The most frequent approach to this part of the question was to produce a mass of figures supporting a complex but inappropriate calculation. With these data the best approach was to construct a graph and draw a line of best fit. The likely number of bacteria could then have been established by reading off the appropriate value from the curve.

## Q49.

This question was generally well answered by the majority of candidates although few candidates gained maximum marks.

(a) Almost invariably correct. Candidates who did not gain this mark often failed to compare the importance of both factors in determining intelligence.

(b) The vast majority of candidates gained two marks often for comparing data from identical and non-identical twins and providing a valid conclusion. A common error was to suggest that non-identical twins have ‘different genes’ or ‘share 50% of their genes’. Few candidates suggested a large sample size would be needed or that a statistical test could be used.

## Q50.

Most candidates were able to apply their knowledge and gained credit but some failed to gain marks through failure to answer the question as set in part (c).

(a) There were many well rehearsed descriptions; some weaker candidates failed to gain marks through poor use of terminology.

(b) This question was very well answered, most candidates naming a specific environmental factor. Very few answers referred to mutation.

(c) Many candidates failed to use the information in the stem of the question and answered in terms of one or the other method rather than the advantage in having two methods. Some candidates were over elaborate, not recognising the seeds are produced asexually and therefore gave ‘variation’ as one advantage.

## Q51.

Most candidates had little difficulty obtaining at least half the available marks for this question.

(a) The vast majority of candidates gained both marks, almost invariably for indicating that organisms of the same species would breed together to produce fertile offspring. A few weaker candidates referred to DNA but these answers were only credited when a specific method of comparing the DNA, e.g. DNA sequencing, was mentioned.

(b) Most candidates were able to gain at least one or two marks, often for referring to variation being present in each population and the different selection pressures in the different environments. Better candidates had little difficulty obtaining maximum marks by explaining that organisms with favourable alleles would survive and pass these alleles on to future generations, resulting in a change in the frequency of alleles. However, some weaker candidates provided descriptions akin to Lamarckism, although these were not as prevalent as in previous years.

(c) Unfortunately, a significant number of candidates considered colour and camouflage rather than colour and mate selection. However, candidates making the correct link usually obtained both marking points.

## Q52.

(a) Most candidates correctly described the effect of reduced temperature on enzyme activity. Many of these failed to develop their answer further to explain the effect on physiological processes and growth. Those that did often limited their answer to photosynthesis, and so were not able to score full marks. Some failed to read the question carefully and described the effect of factors other than temperature.

(b) Poor expression and incomplete answers were both a major feature, with many candidates having the right idea, but not expressing their answer with sufficient clarity to score the marks.

## Q53.

(a) The majority of candidates scored at least two marks. Some confused algae with zooplankton or had problems expressing themselves when describing the different depths by using terms such as .higher depth.

(b) Part (i) was answered correctly by most candidates but some misread the data and referred to number of fish rather than time present. Many candidates tried to answer

part (ii) in terms of geographical isolation, so there were many references to zooplankton living in deep water, rather than selection acting on the variation in depth of migration during the day. Candidates that linked parts (i) and (ii) together generally scored well, although a significant number of candidates stated that zooplankton had the capacity to learn.

## Q54.

(a) This question revealed an unexpected lack of understanding of how crossing over actually results in variation, despite the fact that is regularly cited as a cause. Very few referred to the exchange of parts of chromatids, and even fewer pointed out that variation resulted when sections with different alleles were recombined. Crude diagrams often indicated that it was thought that alleles of the same gene were at different loci. The only mark obtained by the majority was for the general principle that 'genes' are exchanged, which was credited despite the lack of precision. Many candidates revealed major misconceptions, such as that genes are exchanged at the point where 'chromosomes' cross over, and that as a result of crossing over cells 'contain genes from different gametes'.

(b) (i) Most candidates did not appreciate that the question was asking about variation within each store, rather than the change over time. Many, therefore, gave mutation as an answer. Those who did try to explain continuous variation within a store of seeds explained it more often in terms of an environmental factor, which was credited, than there being several genes controlling length. Those who mentioned an environmental factor rarely went on to explain how it would result in variation.

(ii) Because only a few candidates understood that the variation involved many genes, each possibly with two or more alleles, there were few explanations which referred to the longer seeds having a higher proportion of alleles favouring length, with this proportion increasing as a result of regular selection. Most gave a vague general account of selection, often couched in terms which indicated scant regard for the role of seeds in the life of plants. It was frequently suggested that the seeds adapted to conditions, reproduced and then passed on their genes. A significant number of candidates misinterpreted the graph, and thought that the mean length of the seeds increased up to AD 1000 and then decreased again.

## Q55.

(a) Although most candidates clearly understood the question, many failed to gain marks by poorly explaining interspecific competition or failing to refer adequately to the diagram, giving vague references to different birds feeding on different prey. A few suggested that interspecific competition referred to the different species of prey, with a small minority discussing intraspecific competition.

(b) This question produced a range of answers from clearly linked explanations of natural selection to poorly expressed ideas which paid more credence to Lamarckism than Darwinism, suggesting that the long beak was produced in response to a need to develop one. Marks were frequently lost by referring to competition between species or discussing godwits rather than restricting their descriptions to the curlew. Variation within the curlew species was rarely given and this aspect of evolution seems poorly understood with a number of candidates suggesting that a single mutation had produced a bird with a longer beak. The weakest answers discussed the evolution of godwits into curlews or of interbreeding between species.

(c) This question was usually well answered with many candidates gaining full marks. Only a few candidates failed to refer to water potential or incorrectly described the movement of water in terms of water potential. Most clearly understand the concept but some discussed differences in water potentials on the seashore, which was beyond the scope of the question.

## Q56.

(a) This question proved a good discriminator with a surprising range of answers being produced. Candidates appeared not fully to appreciate the question, with many having difficulty applying a standard technique to an unfamiliar situation. A number of candidates described setting up transects without reference to the random nature of the sample to be obtained, references to counting were common and many failed to suggest a sufficient number of quadrats. A few resorted to throwing the quadrats over their shoulder, some doing so even after describing how to produce random co-ordinates.

(b) This question was generally well answered with most candidates gaining two marks. Weaker answers confused the data with probability values.

(c) (i) This was generally poorly answered. Most gained a mark for linking the foot or aperture size with grip but few answers were clearly expressed, with only the best candidates discussing both aperture and shell size. There were confused ideas attributing smaller shell size to erosion by waves.

(ii) Answers to this question were disappointing with few candidates being able to amplify their understanding of standard deviation. Only the better candidates recognised the point of the question and were able to appreciate the effect of wave action on limiting the range of sizes. The idea of size being age-related and linked to situation was rarely given.