AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.5.3 ENERGY AND ECOSYSTEMS

SCORE	PERCENTAGE
/402	%

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Q1.

(a) 1. Method of randomly determining position (of quadrats) e.g. random numbers table/generator;

Ignore line/belt transect

2. Large number/sample of quadrats;

Accept many/multiple

Ignore point quadrat

If a specified number is given, it must be 20 or more

3. Divide total percentage by number of quadrats/samples/readings;

3

(b) 1. Beach grass is the pioneer (species);

2. Pioneers/named species change the (abiotic) environment/habitat/conditions/factors;

Must convey idea of change being caused by a species

Accept example of change e.g. more humus

3. (So) less <u>hostile</u> for named species
OR
(So) more <u>suitable</u> for named species;

4. Conifer/hardwood trees represent climax community;

4

(c) Trees block/reduce (sun)light;

Reject 'blocks' all of the light

1

(d) 1. (NPP) remains constant;

2. GPP/photosynthesis **and** respiration constant;

Accept GPP/photosynthesis equals respiration

OR

3. (NPP) low/decreases;

4. Less light so less photosynthesis/GPP;

Reject no photosynthesis

Mark in paired statements

1 and 2 or 3 and 4

2

[10]

Q2.

(a) Used to produce <u>named</u> phosphate compound in cells;
e.g. ATP / ADP / phospholipids / DNA / RNA / RuBP / TP /GP etc.

1

(b) Example of a carbon-containing biological compound e.g. carbohydrate / amino acid / vitamin;

Accept: sugars / organic (compounds).

Ignore: products of photosynthesis.

Ignore: starch.

1

(c) 1. Represents dry mass / mass of carbon;
2. Represents gross production minus respiratory losses;

2. Accept: NPP = GPP −R.

2. Accept: Chemical energy minus respiratory losses.

1 and 2. Chemical energy store minus respiratory losses = 2 marks.

2

(d) 1. For the control an increase in phosphate increases (plant) growth;
2. For *Entrophospora* an increase in phosphate reduces (plant) growth;
3. *Scutellospora* reduces (plant) growth (compared to control);
4. *Entrophospora* and *Glomus* increases (plant) growth (compared to control);
5. No SD / statistical test to determine significance;
6. Only 20 weeks of growth;
7. Underground / root growth not known;

5. Accept: no error bars.

7. Accept: only shows shoot growth.

4 max

(e) 1. Answer in range 0.07 to 0.09 = **2 marks**;
2. Answer in range 9.97 to 12.2
OR
Shows division by 140 or 20 × 7 = 1 mark;

2

[10]

Q3.

(a) Two suitable examples;
Examples
1. amino acid / protein / polypeptide / peptide;
2. nucleic acid / nucleotide / base;
3. DNA;
4. RNA;
5. ATP / ADP;
6. NAD / NADP (reduced or not);
7. Cyclic AMP / cAMP;
8. Chlorophyll;

List rule applies

Reject for either point nitrates / nitrites / ammonia / ammonium / urea

4. Accept pre-mRNA / mRNA / rRNA / tRNA

2 max

(b) Correct answer in the range 90 to 133.2 scores 2 marks;

1 mark for answers where yield calculated correctly for 1970 **OR** 2005;
(1970 in range) 170.8 to 176.4
OR
(2005 in range) 266.4 to 304.0;

Accept positive or negative values

2

(c) 1. Using more but getting less response over time;
2. The graph shows correlation but doesn't prove changes in yield due to fertiliser / but there could be other factors;
3. Becomes less cost effective with time;

Idea of over time is important

1. accept fertiliser becomes less effective over time

1. Accept use of figures from graph

1. Accept the idea of less grain / crop over time

2. Ignore whether correlation is positive or negative

2 max

[6]

Q4.

(a) 1. 35.22 or 35.23% = 2 marks;

Award 1 mark if only fresh and dry masses correct, 1335.59 and 865.13 g;

2

(b) (After 24 hours)

1. Record mass and reheat;

Accept return to oven = reheat

2. Until constant mass recorded;

2

(c) 1. Positive correlation (between diameter and biomass);

2. Not linear / geometric / exponential / gradient gets steeper;

2

(d) 1. Calculate a mean diameter;

2. (Use this to) estimate / determine the mean fresh biomass of trees;

3. Use the percentage water content to find the dried biomass;

4. Use the dried density to calculate the mass of tree;

5. Count / estimate the number of trees in plantation and multiply by (mean) carbon content (to find total carbon);

4 max

[10]

Q5.

(a) 1. Oxygen produced in light-dependent reaction;
2. The faster (oxygen) is produced, the faster the light-dependent reaction.

2

(b) 35–36 µmol Oxygen per mg chlorophyll.

Correct difference at 500 µmol photons m^{-2} s^{-1} or incorrect difference but division by 4 shown = 1 mark.

2

(c) At all light intensities, chloroplasts from mutant plants:
1. Have faster production of ATP and reduced NADP;
2. (So) have faster / more light-independent reaction;
3. (So) produce more sugars that can be used in respiration;
4. (So) have more energy for growth;
5. Have faster / more synthesis of new organic materials.

Accept converse points if clear answer relates to non-mutant plants

4 max

[8]

Q6.

(a) 1. To kill any fungus / bacteria on surface of seeds or in soil;
2. So only the added fungus has any effect.

2

(b) So that only nitrate or ammonia / type of fertiliser affects growth.

1

(c) 1. So that effects of nitrate or ammonium alone could be seen;
2. So that effects of fungus can be seen.

2

(d) 1. Weigh samples at intervals during drying;
2. To see if weighings became constant (by 3 days).

2

(e) With live fungus – showing effects of the fungus:
1. Fungus increases growth of roots and shoots in both;
2. Produces greater growth with nitrate.

With heat-treated fungus – showing effects of fertiliser:

3. Similar dry masses for roots and shoots;
4. (Probably) no significant difference because SDs overlap.

4

(f) 1. Dry mass measures / determines increase in biological / organic material;
2. Water content varies.

2

(g) 1. Fungus with nitrate-containing fertiliser gave largest shoot: root ratio;
2. And largest dry mass of shoot;
3. 6.09:1 compared with ammonium-containing fertiliser 4.18:1

2 max

[15]

Q7.

(a) 1. (Use) coordinates / number the rocks/sites/squares;

Ignore: references to grid, tape measures, metre rulers etc.

2. Method of generating/finding random numbers e.g.

calculator/computer/random number generator/random numbers table;

Accept: numbers out of a hat / use of dice.

2

(b) Difficult/too many to count / individual organisms not identifiable / too small to identify/count / grows in clumps;

Ignore: easier/quicker/representative/ more accurate, unless qualified.

1

(c) Any suitable factor with valid explanation = 1 mark

1. Wave action - firmer grip on rock is necessary (at either site);
2. Wind/air movement/less humid - more evaporation at site A / more (physical) damage;
3. Light – (linked to) photosynthesis (at either site);
4. Temperature – (linked to) photosynthesis/respiration/enzymes/ evaporation (at either site);
5. pH – (linked to) enzymes/proteins;

Note: other common factors include salt (salinity) linked to water potential / named nutrient e.g. nitrate linked to protein/DNA.

Ignore: carbon dioxide/oxygen/pollution/rainfall/food/nutrients.

Reject: biotic factors e.g. predation.

2 max

(d) 1. Greater variety of food / more food sources;

Ignore: more food.

2. More/variety of habitats/niches;

Ignore: homes/shelters.

Accept: different habitats.

2

(e) (i) 1. (So they were) hungry/not full;

Accept: description of hunger e.g. appetite / 'empty stomach'/'so they eat'.

2. (Allows) comparison;

2

(ii) 1. Alga without consumer/named consumer/animal;

Accept: repeat experiment without consumer.

Accept: in separate tank / in tank where not eaten.

2. (Find change in mass) in dark;
3. For 50 hours;

Accept: 'same time as in experiment'.

Accept: For lower time period then scaled up to 50.

3

(iii) 1. For *Laurencia pacifica* **and** *Cystoseira osmondacea* (difference in results) significant /reject null hypothesis / not due to chance / less than 5%/0.05 probability due to chance;

Accept: for Laurencia pacifica 'less than 1%/0.01 probability'.

2. For *Egregia leavigata* **and** *Microcystis pyrifera* no significant (difference in results)/accept null hypothesis / is due to chance/more than 5%/0.05 probability due to chance;

Accept: 'insignificant' for 'no significant difference'.

3. (Difference in results) for *Laurencia pacifica* is the most significant;

Note: reference to probabilities on their own is not sufficient.

1, 2 and 3. Accept: abbreviations for all species.

3

[15]

Q8.

(a) (i) Unit of energy / mass, per area, per year.

1

(ii) 1. Less light / more shading / more competition for light;

Neutral: references to animals

2. Reduced photosynthesis.

Accept: no photosynthesis

2

(b) 1. Pioneer species;

2. Change in abiotic conditions / less hostile / more habitats / niches;

Accept: named abiotic change or example of change e.g. formation of soil / humus / organic matter / increase in nutrients

Neutral: reference to change in environment unqualified

Neutral: more hospitable / habitable / homes / shelters

3. Increase in number / amount / diversity of species / plants / animals.

Accept: other / new species (colonise)

3

(c) 1. Net productivity = gross productivity minus respiratory loss;

2. Decrease in gross productivity / photosynthesis / increase in respiration.

2

(d) 1. Conserving / protecting habitats / niches;

2. Conserving / protecting (endangered) species / maintains / increases (bio) diversity;

3. Reduces global warming / greenhouse effect / climate change / remove / take up carbon dioxide;

4. Source of medicines / chemicals / wood;

5. Reduces erosion / eutrophication.

Accept: tourism / aesthetics / named recreational activity

1 max

[9]

Q9.

(a) (i) 1. Amino acid / protein / enzyme / urea / nucleic acid / chlorophyll / DNA / RNA / / ATP / ADP / AMP / NAD / NADP;

2. DNA / RNA / nucleic acid / ATP / ADP / AMP / NADP / TP / GP / RuBP / phospholipids;

1. and 2. Accept any named equivalent examples e.g. nucleotides.

Neutral: ammonia / nitrite / nitrate / phosphate.

2

(ii) 1. Saprobiotic (microorganisms / bacteria) break down remains / dead material / protein / DNA into ammonia / ammonium;

Accept: saprobionts / saprophytes / saprotrophs

Neutral: decomposer

2. Ammonia / ammonium ions into nitrite and then into nitrate;

Allow correct chemical symbols.

Accept: correct answers which use incorrect bacteria e.g. nitrogen-fixing but then reject m.p. 3.

3. (By) Nitrifying bacteria / nitrification;

3

(b) 1. Nitrate / phosphate / named ion / nutrients for growth of / absorbed / used by plants / algae / producers;

2. More producers / consumers / food **so** more fish / fish reproduce more / fish grow more / fish move to area;

Must have idea of more plants related to some increase in fish.

2

[7]

Q10.

(a) Succession;

Ignore any word in front of succession e.g. secondary / ecological succession.

Neutral 'forestation'.

1

(b) 1. Greater variety / diversity of plants / insects / more plant / insect species;

Neutral: more plants.

2. More food sources / more varieties of food;

Neutral: more food / more / greater food source (singular).

3. Greater variety / more habitats / niches;

Accept: more nesting sites.

***Q** Neutral: more homes / shelters.*

3

(c) (i) Temperature and carbon dioxide;

Neutral: water, chlorophyll.

1

(ii) Shows (gross) photosynthesis / productivity minus respiration / more carbon dioxide used in photosynthesis than produced in respiration;

Correct answers are often shown as: net productivity = (gross) photosynthesis – (minus) respiration.

1

(iii) 1. (Shade plant) has lower (rate of) respiration / respiratory losses / less CO2 released at 0 light intensity / in dark;

Accept use of figures.

Accept: lower compensation point.

2. Greater (net) productivity / less sugars / glucose used / more sugars / glucose available;

Neutral: any references to rate of photosynthesis.

2

[8]

Q11.

(a)

Part of ecosystem	**Mean rate of carbon dioxide production / $cm^3\ m^{-2}\ s^{-1}$**	**Percentage of total carbon dioxide production measured by the scientists**
Leaves of plants	0.032	25.0
Stems and roots of plants	0.051	**39.8**
Non-photosynthetic soil organisms	0.045	**35.2**

2 correct = 2 marks;;

Adding rates to get 0.128 = 1;

If rounded to 40 and 35 in table;

- *but working shows decimal points, then award 2 marks*
- *but no working shown, then 1 max*

2 max

(b) 1. Data only include (heterotrophic) soil organisms;

2. Doesn't include animals (above ground) / other (non-soil) organisms;

3. Doesn't take into account anaerobic respiration;

Award points in any combination

Accept for 1 mark idea that CO_2 for leaves doesn't take into account photosynthesis – not told in dark until part (d)

2 max

(c) **All three** of following = 2 marks;;

Two of them = 1 mark;

Volume of carbon dioxide given off

(From known) area / per m^2 / m^{-2}

In a known / set time

Ignore 'amount' / concentration of CO_2

Accept per second / per unit time

2

(d) 1. (In the light) photosynthesis / in the dark no photosynthesis;

2. (In light,) carbon dioxide (from respiration) being used / taken up (by photosynthesis);

2

(e) (i) (Rate of respiration)

Assume "it" means soil under trees

1. In soil under trees (always) higher;

Accept converse for soil not under trees

Accept 'in the shade' means under the trees

2. In soil under trees does not rise between 06.00 and 12.00 / in the middle of the day / peaks at 20:00-21.00 / in the evening;

3. In soil **not** under trees, peaks at about 14:00-15:00 / in middle of day;

2. and 3. No mm grid, so accept 'between 18.00 and 24.00' or 'between 12.00 and 18.00'

2 max

(ii) <u>(Between 06.00 and 12.00</u>, (No Mark))

Respiration higher in soil under tree, (No mark)

Do not mix and match mark points

No list rule

1. Tree roots carry out (a lot of) respiration;

2. More / there are roots under tree;

Accept converse for soil not under trees

OR

3. More food under trees;

4. So more active / greater mass of / more organisms (carrying out respiration);

Accept converse for soil not under trees

OR

Soil not under trees respiration increases (No mark)

5. Soil in sunlight gets warmer;

6. Enzymes (of respiration) work faster;
Accept converse for soil under trees

2 max

(f) (i) 1. Photosynthesis produces sugars;

2. Sugars moved to roots;
Do not penalise named sugars other than sucrose

3. (Sugars) are used / required for respiration;

2 max

(ii) Takes time to move sugars to roots;
Look for movement idea in (i) – can carry forward to (ii)

1

[15]

Q12.

1. Growth of algae / surface plants / algal bloom blocks light;

2. Reduced / no photosynthesis so (submerged) plants die;

3. Saprobiotic (microorganisms / bacteria);
3. Accept: Saprobiont / saprophyte / saprotroph
3. Neutral: decomposer

4. Aerobically respire / use oxygen in respiration;

5. Less oxygen for fish to respire / aerobic organisms die;

[5]

Q13.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with

		appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects covered but they are unrelated	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question. Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
6 – 10	Unistructural Only one or few aspects covered	Response predominantly deals with only one or two topics that relate to the question. Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
1 – 5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level. May contain a large number of errors and, or, irrelevant topics.
0		Nothing of relevance or no response.

Commentary on terms and statements in the levels mark scheme

The levels mark scheme for the essay contains a number of words and statements that are open to different interpretations. This commentary defines the meanings of these words and statements in the context of marking the essay. Many words and statements are used in the descriptions of more than one level of response. The definitions of these remain the same throughout.

Levels mark scheme word/statement	**Definition**
Holistic	Synoptic, drawing from different topics (usually sections of the specification)
A fully integrated answer which makes clear links between several different topics and the theme of the question	All topics relate to the title and theme of the essay; for example, explaining the biological importance of a process.

	When considering, for example, the importance of a process, the explanation must be at A-level standard. 'Several' here is defined as at least four topic areas from the specification covered. This means some sentences, not just a word or two. It does not mean using many examples from one topic area.
Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of the many different types of relationships and interactions between organisms**.

Topics

1.P	Pathogens and effects on host
2.T	Taxonomy

2.C	Classification and evolution.
2.I	Inheritance and evolution
2.Gc	Genetic code, universal
2.B	Behaviour
2.Ev	Populations and evolution, variation between individuals within a species
3.BP	Relationships within ecosystems − eg predator / prey
3.E	Energy transfer in ecosystems
3.N	Nutrient cycles, the organisms involved
3.S	Succession, biodiversity, species and individuals in a community
4.H	Human impacts on the environment and its effect on relationships between organisms − including farming
4.Gt	Gene technology and GMO and selective breeding
4.Ar	Antibiotic resistance

Examiners are free to select other letters if they wish

The emphasis in answers should be on the relationships and interactions between organisms not just the topics themselves

Breadth, one mark for use of an example from each of the following approaches − 3 max:

1. Pathogen and host

2. Evolution (related topics)

3. Ecological

4. Human intervention in relationships

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

Note, other topics from beyond the specification can be used, providing they relate to the title and contain factually correct material of at least an A-level standard. Credit should not be given for topics beyond the specification which are below A-level standard.

[25]

Q14.

(a) 1. Chlorophyll absorbs light energy;

Accept light energy 'hits' chlorophyll

Accept photon for light energy

2. Excites electrons / electrons removed (from chlorophyll);
Accept higher energy level as 'excites'

3. Electrons move along carriers / electron transport chain releasing energy;
Accept movement of H^+ / protons across membrane releases energy

4. Energy used to join ADP and Pi to form ATP;
Negate 'produces energy' for either mark but not for both
Accept energy used for phosphorylation of ADP to ATP
Do not accept P as Pi

5. Photolysis of water produces protons, electrons and oxygen;
3. and 4.

6. NADP reduced by electrons / electrons and protons / hydrogen;
Accept NADP to NADPH (or equivalent) by addition of electrons / hydrogen
Do not accept NADP reduced by protons on their own

5 max

(b) 1. Variation / variety;

2. Mutation;
Do not accept answers which suggest the mutation is caused by copper

3. Some plants have allele to survive / grow / live in high concentration of copper / polluted soils;
Reference to immunity disqualifies this mark
Do not disqualify mark for references to allele providing resistance to copper

4. (Differential) reproductive success / adapted organisms reproduce;

5. Increase in frequency of allele;

6. No interbreeding (with other populations) / separate gene pool / gene pool differs (from other populations);
Accept reproductive isolation

5 max

[10]

Q15.

(a) 1. Is widely / commonly used;

2. Provides a standard / benchmark / reference;
Allow a variety of descriptors for marking point 2 e.g. 'provides a base line',
'produces known amount of carbon dioxide'
Mark point 2, do not accept 'for comparison' on its own as 'comparison' is in stem of question

3. Produces large amount of carbon dioxide;

4. Is a decreasing resource / could be replaced by biofuel;

Ignore reference to a control

2 max

(b) 1. Independent / no bias / trustworthy;

2. Non-profit making;

3. (Focused on) effect on environment / climate;

2 max

(c) 1. CO_2 taken up in photosynthesis;

2. More taken up than produced (when it is used) with less CO_2 produced than petrol;

2

(d) 1. (These microorganisms) don't have (cellulose-digesting) enzymes;

Accept 'don't make enough of these enzymes' for mark point 1

2. (Cellulose) is a polysaccharide / polymer / long (molecule / chain);

Accept 'large' for mark point 2

3. (Cellulose) is insoluble / glucose / product of digestion is soluble;

4. Broken down into glucose / monomers / monosaccharides;

Ignore (alpha) glucose for mark point 4.

Do not accept sugars for mark point 4

5. Sugars / glucose used in glycolysis / glucose can be converted to pyruvate;

6. Produces more ethanol / fuel produces ethanol / fuel quicker;

Accept 'speeds up process' for mark point 6

3 max

(e) 1. Removes species / fewer species / growth of single crop / single plant species / monoculture;

Deforestation or removal of hedges on its own should not be credited

2. Removes habitats / fewer habitats / niches / only one habitat;

3. Removes variety of food sources / fewer food sources / only one food source;

2 max

[11]

Q16.

(a) (i) Non-living / physical / chemical factor / non biological;

Do not accept named factor unless general answer given.

1

(ii) Accept an abiotic factor that may limit photosynthesis / growth;

Reject altitude / height

Water

Named soil factor

Not "soil" / "weather"

Light

Carbon dioxide

Accept Oxygen

Incline / aspect

Wind / wind speed

1

(b) 1. Correct explanation for differences between day and night e.g. photosynthesises only during the daytime / no photosynthesis / only respiration at night;

2. Net carbon dioxide uptake during the day / in light

OR

No carbon dioxide taken up at night / in dark / carbon dioxide released at night / in dark;

3. At ground level more respiration / in leaves more photosynthesis;

4. Carbon dioxide produced at ground level / carbon dioxide taken up in leaves;

Principles

Comparing day and night / light and dark

1. Explanation in terms of photosynthesis / respiration

2. Effect on carbon dioxide production / uptake

Comparing leaves with ground level

3. Explanation in terms of photosynthesis / respiration

4. Effect on carbon dioxide production / uptake

2 and 4 must relate to why the change occurs

4

(c) 1. Variation in original colonisers / mutations took place;

2. Some better (adapted for) survival (in mountains);

2. Allow "advantage so able to survive"

3. Greater reproductive success;

4. Allele frequencies change;

4. Reject gene / genotype

3 max

[9]

Q17.

(a) (i) 1. Same breed so similar alleles;

1. Allow different alleles have different effects

2. Controls / removes variable / so genes not a factor / only temperature affects results / rate of growth affected by genes;
2. Accept idea worded in such terms as inherited.

2

(ii) 1. Different growth rates / gained different biomass / grew different amount;
Allow "more food for growth"
Ignore references to efficiency of conversion.

2. Not due to temperature / the independent variable;

2

(b) (i) Rise then fall with peak at 20 C;
Do not accept 0.85 as alternative to 20.

1

(ii) 1. Temperature may be between 10 and 30 / 10 and 20 / 20 and 30;
No mark for yes or no.

2. Intervals are 10°C / large / not small / should be smaller / should be intermediates;

2

(c) (i) 1. Growth rate decreasing / conversion staying same / decreasing;

2. (Scientists would be) looking for high growth rate / conversion / data shows unlikely to improve growth / yield;

3. Wastes time / resources / would not relate to farming conditions;
3. Ignore cruelty to pigs

2 max

(ii) 1. Will lose more heat / not as much energy used to maintain body temperature;
1. Must be a comparative statement
Accept energy as equivalent to heat in the context of this question

2. Heat resulting from respiration / more respiration;
2. Do not credit answers relating to energy made in respiration

3. More food used in respiration;

2 max

(d) **In support**
Read standard deviation as standard error

1. Food **B** produces greater mass than control / greater than 100%;
1. Must refer to control

But

2. Error bars for **B** mean **B** could be no better / not different from control;

3. Overlap of error bars for **B** and **A**;

4. A no better than / not different from **B**;

*4. Neutral: "Results not significant". Mark must compare **A** to **B***

Experimental limitations

5. Experiment only ran for 10 days;

6. Experimental conditions / breed of pig may not be the same as on the farm;

7. No information about cost;

4 max

[15]

Q18.

(a) 1. High temperature allows enzymes to work faster / allows more collisions / allows more e-s complexes to be formed

OR

A lot of light so light not limiting;

2. Photosynthesis reactions are faster / more photosynthesis;

Accept enzymes more effective. Ignore references to respiration. Ignore references to optimum (temperature or light).

2

(b) (i) Gross productivity = net productivity + respiratory loss / respiration;

Accept any correct rearrangement of this equation

Accept recognisable abbreviations

Reject respiratory rate.

1

(ii) 1. Respiration slower / less respiration;

Unspecified references refer to August. Allow converse of respiration faster but must specify July / higher temperature

2. Light-dependent reaction / photosynthesis less affected by temperature increase;

3. Lower (energy) loss;

Unspecified references refer to August. Allow converse of higher loss but must specify July

"Lower respiratory losses (in August)" can meet both points 1 and 3 and gain 2 marks.

2 max

(c) 1. Stored as fat / glycogen / biomass;

Reject stored energy. Ignore respiration

2. Used for growth / movement / reproduction / process involved in growth /

movement / reproduction;

2 max

(d) 1. More heat / energy is lost (in March) / colder (in March);

2. Maintain / regulate body temperature / more heat generated;

Accept keep warm.

3. By respiration / metabolism;

2 max

[8]

Q19.

(a) (i) Reduced cost;

Less feed / less land use / more growth rate with same amount of food;

Allow is 'cost effective'

2

(ii) Amount of food taken in less than expected.

Allow 'expected food intake is higher,

Allow 'food intake is lower than it should be'

1

(b) Type of food (not a mark)

1. May vary in protein / fat / carbohydrate / fibre / roughage / vitamins / minerals;

2. May affect absorption / digestibility / energy value / tastiness / growth / overall food intake;

For mark point 1 allow appropriately named food compound e.g. cellulose, glucose

For mark point 2 it must be clear that these factors are affected by the type of food.

Temperature (not a mark)

3. Will affect heat loss / gain / respiration / metabolism;

4. More food / energy can be used for growth;

Note: two maximum marks for effect of temperature.

4

(c) RFI does not affect methane production /

There is no difference in the rate of methane production for low and high RFI values /

The difference between the rates of methane production is due to chance /

No correlation / relationship / link between RFI and methane production;

Any clear statement that there is no link between RFI and methane production should be credited.

1

(d) (i) Sulfate without straw;

1

(ii) 1. May affect yield / damages rice crop;

2. Substance / treatment may affect other organisms / environment;

3. Cost of substance / application / labour;

4. Method / frequency / timing of application / amount of substance required;

2 max

(iii) Not flooded aerobic conditions / more oxygen / with flooding anaerobic conditions / less oxygen;

Not flooded fewer / less active anaerobic microorganisms / respiration / not flooded more / more active aerobic microorganisms / respiration;

2

[13]

Q20.

(a) Heat at 100°C / heat to temp to evaporate water;
Value which would not burn material

Weigh and heat until no further change in mass;

2

(b) Amount of water present will vary;

This will affect fresh mass / will not affect dry mass;

2

[4]

Q21.

(a) To see if a difference in hours of sunshine was present / because it is necessary to monitor factors which cannot be controlled;
So that they could eliminate this factor from affecting the yield (with /without extra carbon dioxide);
OR
Duration of light influences length of time for photosynthesis / temperaturein glasshouse;
Higher photosynthesis results in higher yield / more carbohydrates /sugars / proteins produced;

2 max

(b) Named factor;
Explanation of why the factor is important;
E.g.
Density of planting;
Competition for named resource;
or
Same variety of tomato;
Yield will vary with different varieties / with different genotypes;
or
Water (application);

Water needed for expansion of fruit / maintain leaf turgidity / maintain stomatal opening / replace water lost in transpiration / water used in photosynthesis;

For named resourceaccept 'nutrient' but not 'food'

2

[4]

Q22.

(a) (i) Yield increases by 0.6 kg m^{-2} (when extra carbon dioxide present);

1

(ii) Temperature / light intensity so could be lower in these weeks (as temperature / light insensity not fully controlled / monitored) (over period 1998 – 2000);

1

(b) Two marks for correct answer of 50.6%;;
One mark for incorrect answer in which candidate has shown clearly that calculation based on an increase / 0.42 and original mass / 0.83

2

(c) Cost of supplying carbon dioxide;
Price of (very early) tomatoes;

2

(d) Lowest price paid for tomatoes;
Some carbon dioxide lost as windows open in summer;
Little / no mean increase in yield in summer;

2 max

(e) Grow with extra carbon dioxide in one glasshouse and without carbon dioxidein other glasshouse at same time;
So all environmental conditions / light and temperature same for experiment and control;

2

[10]

Q23.

(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]

Q24.

(a) (i) decomposers convert (nitrogen in organic compounds) into ammonia / ammonium; suitable example of "organic nitrogen" - protein / urea / amino acid etc. (e.g. linked to process); nitrifying bacteria / correctly named convert ammonium to nitrate; via nitrite;

3

(ii) convert nitrogen (gas) into ammonium / ammonia / amino acids;
add usable / available nitrogen to an ecosystem / eq.;

2

(b) (i) 1. numbers of dispersed bacteria increase as they <u>feed</u> on organic matter;

2. numbers of free-swimming protoctistans increase because number of bacteria increase;

3. dispersed bacteria decrease as amount of dispersed organic matter decreases / due to lack of food / as organic matter is converted to flocs / are preyed on by free-swimming protoctistans;

3

(ii) 1. (in a succession) organisms (enter an area and) change the environment / conditions creating new niches / habitats;

2. allows different species / different types of organisms to enter / be successful;

3. dispersed bacteria change dispersed organic matter to flocs;

4. presence of flocs allows crawling protoctistans to enter / to increase / to be successful;

4

[12]

Q25.

(a) (variation in) temperature will affect the solubility of oxygen / rate of respiration / use of oxygen by cells / diffusion / gas exchange;
to gain credit point made must concern oxygen

1

(b) (i) there is no difference between the partial pressure of oxygen in the two groups / the partial pressure of oxygen is the same in each group;

1

(ii) results may have been due to chance and statistical test allows us to determine the probability of this / of the difference between results being significant;
enables acceptance or rejection of null hypothesis;
The key points here are chance and probability used in the correct context.

2

(c) **A**;
because partial pressure of oxygen only reduced when zinc in water / in **Y** / because when injected zinc / in **X** has no effect on partial pressure of oxygen in blood;

2

(d) less oxygen transport to cells / in fish / in blood;
anaerobic respiration;
lactic acid produced / less carbon dioxide removed (from gills);
more H^+;

3 max

(e) (i) copper;
calculation based on comparing concentration in woodlice with that in leaves;
accept any suitable method here, giving marks for the method and explanation. For example, calculating ratio of concentration in woodlice to concentration in leaves.

2

(ii) not absorbed from gut / passes out in faeces / egested / urine / excreted;

1

(iii) woodlice eat large amount of leaves;
copper stored / accumulates in body;

2

(f) (i) mutation;

1

(ii) (as a component of) nucleic acids / DNA / RNA / nucleotides;
phospholipids;
ATP / ADP;

2 max

(iii) arsenic-tolerant plants would not be able to take up phosphates / take up a little phosphate;
since likely to involve same mechanism / same carrier / protein;
(process of) growth would be poorer than non-tolerant plants;

3

[20]

Q26.

(a) (i) **P** = 3;
Q = acetylcoenzyme A;

2

(ii) 36 ATP, however derived = 2 marks
30 ATP, however derived = 1 mark

2

(iii) *Correct statement in the context of aerobic respiration or anaerobic respiration concerning*:
Oxygen as terminal hydrogen / electron acceptor allowing operation of electron transport chain / oxidative phosphorylation;
Fate of pyruvate;
Significance of ATP formed in glycolysis;

3

(b) (i) Thick walls exclude oxygen;
Produced by photosynthetic cells (of fern and *Anabaena*);
Contain no chlorophyll so do not photosynthesise;
Do not produce oxygen;
Oxygen would inhibit nitrogen fixation process;

max. 3

(ii) Decomposers / bacteria / fungi / saprobionts (in fields);

Convert protein / organic nitrogen (in cells of fern) into ammonium ions (*allow ammonia*);
Ammonium ions (ammonia) converted to nitrite, then converted to nitrate;

Allow 1 mark for NH_3 / $NH_4^+ \rightarrow NO_3^-$
By nitrifying bacteria / correctly named;
Nitrate used to form protein / amino acids in rice;

5

[15]

Q27.

(a) collect a sample (of insects in each area) and mark unobtrusively / in a way not harmful to insects;
release and allow time to re-integrate with rest of population / eq.;
collect second sample and count number marked;
number in population estimated by:

$$\frac{S1 \times S2}{\text{Number marked in } 2^{nd} \text{ sample}} \quad /$$

$$\frac{\text{Total marked}}{\text{Number marked in } 2^{nd} \text{ sample}} = \frac{\text{Population}}{\text{second sample}} ;$$

4

(b) (i) 1;

1

(ii) (p =) 0.05 / 5%;
(ignore 95%)

1

(iii) value for χ^2 exceeds critical value / 125.8 > 10.8 ;
Results unlikely to be due to chance / have a biological cause;
P < 0.1% / < 5% ;

2 max

(c) (i) biomass respired / GPP – respiration = NPP;

biomass lost as CO_2;

2

(ii) more food for insects;

1

[11]

Q28.

(a) Fertilisers / detergents / slurry / manure / sewage / faeces;

1

(b) (31 – 5) / 31 x 100% / single error in otherwise correct method;
83.87 / 83.9 / 84%;

2

(c) Have continuous data for phosphate but not for biomass;
Effect of named factor explained;

2

(d)
1. Increased phosphate causes increase in plant growth / algal bloom;
2. Plants (cover surface and) block out light so plants (under surface) die;
3. Increase in (aerobic) bacteria / decomposers (which break down plants);
4. Bacteria / decomposers use up oxygen / reduce oxygen conc. in water;
5. In respiration;
6. Plants unable to photosynthesise so less oxygen produced;

max 6

[11]

Q29.

(a) Samples collected at random;
Method for choosing random sites – random coordinates / position from tables / calculator / other suitable means;

Other named factor constant e.g.:

Same size of net / same width of opening of net / use of one quadrat / Quadrats of same size / of stated size / same area disturbed / collect each
Sample for same time;

3

(b) *Caenidae* in deep water – because highest standard deviation / 'S.D.= 7.92'

1

(c) (i) An organism's role / in the ecosystem / community;
[ALLOW refs. To trophic levels / named]
(IGNORE refs. To habitat)

1

(ii) *Caenidae* found mainly in deep water AND *Baetidae* in shallow water / one family mainly in deep water AND the other in shallow water;

1

(iii) Reduces competition for named factor – e.g. food / shelter / O_2 ;
To ensure both types survive / otherwise better adapted type displaces other type;
OR
Ref. to 'Competitive exclusion principle' = 2 marks

max 2

[8]

Q30.

(a) (i) mass produced increases then levels off at 17.1 kg m^{-2} / concentrations above 40 kg ha^{-1};

1

(ii) replaces nutrients removed;
fertiliser provides nitrate needed for protein / amino acid production; as more fertiliser added, there is more growth / protein / amino acid / yield;

2

(iii) plants already have enough nitrate / nitrate no longer limiting;
another named factor / element is limiting growth;

2

(b) because cattle excreted / produced faeces / droppings / cowpats / manure; in field B crop used elements / minerals / nitrates / nutrients last year;

2

[7]

Q31.

(a) (i) P = C – R – U– F / C – (R + U + F) / eq;

1

(ii) 3.74;

1

(b) Correct answer: 2.18
(Accept 2.19 or 2.2)

/ correct for candidate's (a)(ii) ;; = 2 marks

Correct use of data but wrong answer:

$$\frac{(a)(i) \times 10^6 \times 100}{21135 \times 8100}$$

= 1 mark

2

(c) Less energy lost as heat / in maintaining body temperature / in movement

1

[5]

Q32.

(a) use of random numbers;

large number of quadrats;
count number of dead and live mussels in unit area;

3

(b) (i) different size organisms / different composition (of carbohydrate / fat / protein) / low digestability / not all eaten;

1

(ii) 14;

1

[5]

Q33.

(a) (i) change in community over time;
either due to change environmental / abiotic factors / change is due to species present;

2

(ii) stable community / no further succession / final community;

1

(b) (increased) interspecific competition;
for light / nutrients / named nutrient / water;

2

(c) fewer leaves / lower surface area / shading of leaves so less photosynthesis to produce new biomass / glucose / growth; competition with other species for nitrates / named nutrients so reduced synthesis of protein or named compound; ratio of leaves to woody parts and roots decreases so higher respiration relative to photosynthesis;

3

[8]

Q34.

(a) less nitrate taken up;
less amino acid / protein synthesis;

OR

parts of plant higher in protein die;
higher proportion of cellulose / non-protein components in diet;

2

(b) (wildebeest) selective feeders / only some species / parts of plant eaten;
choose to eat species / part of plant with high protein content;

2

(c) named protein;
consequences of lack of protein related to failure to escape from predators;

examples:

myosin / actin;
(skeletal) muscles weak / less muscular tissue so slower movement;

OR

relevant named enzyme;
why deficiency of enzyme increases chance of being caught;

OR

haemoglobin;
insufficient oxygen for muscle contraction;

2

[6]

Q35.

(a) prevents disease / pest organisms from reaching crop plants / prevents herbicides from reaching hedgerow / enables machinery to manoeuvre without damaging crop / hedgerow;

1

(b) some weeds provide habitats / niche for (beneficial) insects / animals:
allow (insect) pest predators to survive;
conserve (common) weed plants;
weeds are producers in food chains / food source;

2 max

(c) decomposers / saprophyte / bacteria / fungi / micro organisms (organisms) excrete / produce nitrogenous waste / e.g.; bacteria convert to nitrate / nitrifying bacteria;
(increased) nitrates(in soil) taken up / used by plants;
release of phosphate / potassium;
organisms respire and produce carbon dioxide which is used by plants in photosynthesis;

4

[7]

Q36.

(a) lactate / lactic acid / pyruvate; ATP;

2

(b) (i) energy demand is very high / high respiration rate;
unable to supply enough oxygen to muscles / tissues / cells /
insufficient time for oxygen to reach muscles / tissues / cells /
insufficient oxygen in muscles / tissues / cells;

2

(ii) break down with oxygen / oxidise lactate into pyruvate / glucose / glycogen / $CO_{2 + water;}$
by <u>aerobic</u> respiration;

2

[6]

Q37.

(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]

Q38.

(a) transmission / reflected / misses chlorophyll / chloroplasts / wrong wavelength;

1

(b) (larger area) to absorb light;
(larger surface area) to absorb carbon dioxide;
short diffusion pathway for gases / oxygen / CO_2;
light able to penetrate to all cells;

2 max

(c) effect;
detail;
effect on photosynthesis;
some effects are less light / light absorbed by water
different wavelength of light
temperature
availability of carbon dioxide
availability of water

(more than one effect award 1 mark only)

3

[6]

Q39.

(a) source of pests / animals, and effect on crop;
source of weeds / no longer taking nutrients, hence competition / reduced yield; creation of larger fields / leaving room,
hence more efficient use of machinery / grow more crops;
hedgerows have to be maintained, so removal saves time / money;

2 max

(b) allows beetles to remain / survive / over winter in the middle of the field / strip of grass;
effect on distribution, e.g. do not normally reach the centre of the field / can reach all parts;

2

(c) increases biodiversity;
source of food for animals;
habitat / nest for animals;
reduce need for insecticides / attracts insects away from crop;
windbreaks / prevent erosion / run-off / leaching;

migratory corridors;

2 max

[6]

Q40.

(a) (i) respiration;

1

(ii) decomposers;
(*accept bacteria / fungi*)

1

(b) $\frac{87402}{1.7 \times 10^6} \times 100 = 5.14 / 5.1\%$;
(correct answer = 2 marks)
(principle: energy in producers ÷ energy of light absorbed = 1 mark)

2

(c) excites chlorophyll / electrons;
release electron(s);

2 max

(d) reduced NADP;
reduces GP / to change GP to TP;
ATP;
provides the energy to reduce GP / convert GP to TP / TP to RuBP /
provides phosphate to convert TP to RuBP;

4

[10]

Q41.

With hormone (third column) cadmium produces large /
significant / 45% fall in enzyme production;
without hormone (second column) no significant effect
on enzyme production with cadmium;.

2 max

[2]

Q42.

(a) (i) presence of grass causes less nutrients / minerals / nitrates / ammonium ions to be leached;
(do not allow references to less nitrogen)

1

(ii) clover contains nitrogen-fixing bacteria;
(do not allow references to nitrifying bacteria)

decomposition (of ploughed clover) introduces nitrates /
ammonium ions into soil;

2

(b) (i) minimal effect / no significant effect on yield / small increase up to 25 kg ha^{-1};

increase in protein content of grain with all fertiliser applications;

2

(ii) (37 ÷ 44 =) 0.84 : 1.0

(allow 0.8 : 1);

1

[6]

Q43.

(a) 10

(reject: 9.76)

1

(b) isolation (on islands);
variety of habitats / conditions different from origin / other islands;
differing pathways of natural selection;
leading to organisms too different to interbreed.

3 max

[4]

Q1.

(a) This question proved to be more demanding than expected, with less than 7% of students obtaining maximum marks. Most of the students did not appreciate that a large number of quadrats should be used. Reference to a method of randomly determining the position of quadrats was the most frequently credited marking point. However, a significant number mentioned randomly positioning quadrats without suggesting a method for this. There were some responses which suggested randomly throwing quadrats! Students often spent time describing how the percentage cover in a single quadrat could be determined without explaining how the mean percentage could be calculated. A significant number referred to counting numbers rather than determining percentages.

(b) This question proved to be an effective discriminator in terms of students using the information provided in **Figure 1**. Just over 20% of students scored zero as they often provided a description of succession with little, if any, reference to the information provided on the exam paper. Only 7% of students gained maximum marks. Students who did gain credit usually identified beach grass as the pioneer species. Students varied considerably on how they progressed from this point. The idea of the pioneer (or named) species changing the abiotic environment in some way was often understood, though not always stated clearly enough to gain the mark. The idea of a 'less hostile' environment was not often stated and, if it was, it was not often linked to a named species. There were extensive descriptions of competition between species without linking this to the changes in the biotic environment. There were also descriptions of secondary succession which is not on the specification. Surprisingly, relatively few students suggested that the hardwood and confer trees represented the climax community. In fact, a significant minority of students suggested the conifers and hardwood trees were the pioneer species and seemed to be reading the x-axis of the graph from right to left.

(c) Two-thirds of students were able to explain that the conifer and hardwood trees reduced the percentage of light reaching the ground. Incorrect answers either omitted to mention trees or just referred to plants or larger species reducing the light.

(d) Approximately 72% of students stated that the NPP would decrease or remain constant to gain one mark. Less than a third of these students could explain why. The most common response to gain two marks linked the low/decreased NPP with reduced light for photosynthesis. Students who suggested that NPP would remain constant usually did not gain a second mark for explaining that photosynthesis/GPP would equal respiration. A significant number of students thought the NPP would increase, either because there were more plants photosynthesising or because there was more light absorbed by the trees for photosynthesis, with the same respiratory losses.

Q2.

(a) Over 80% of students obtained this mark, often for referring to the use of phosphate to produce ATP or DNA, although a variety of other correctly named compounds such as RNA, ADP, TP and NADP were mentioned. A common error was to refer to proteins.

(b) Almost 60% of students obtained this mark, usually for referring to carbohydrate or sugars. Incorrect responses often mentioned nutrients, water or oxygen.

(c) Very few students, slightly more than 5%, obtained both mark points for this question. Most students did not refer to biomass as representing the dry mass or mass of carbon in a plant. Alternatives such as the chemical energy store were also rarely credited. However, over 40% of students did provide a definition of net primary productivity in terms of gross productivity minus respiratory losses. This was often provided as an equation. Unfortunately, weaker responses also included loss due to faeces as part of this equation.

(d) This question produced a good spread of marks and some very extensive answers, often continued on additional pages. Over 90% of students obtained at least one mark and over 10% of students gained all four marks. The most common marking points credited related to directly comparing the effect of AMF or phosphate on plant growth, although a significant minority did refer to the lack of a statistical test. Generally, more marks were awarded for describing the effect of increased phosphate concentration on plant growth than the effect of AMF species on plant growth. References to only twenty weeks of growth, or to only shoot growth being considered, were infrequent. A number of students referred to the AMF as plant species and others confused the results between *Scutellospora fulgida* and *Entrophospora infrequens*, probably as a result of the similarity of the hatching on the graph for these two species.

(e) It was pleasing to note that over 50% of students demonstrated a good understanding of the $\log_e$ scale and obtained both marks for this question. Over 25% percent of students obtained a single mark, often by realising that the calculated $\log_e$ value had to be divided by 140 to determine the rate of shoot biomass production in grams per day.

Q3.

(a) Just over half of students scored both marks. Those who failed to score one or both marks usually gave one or two inorganic ions containing nitrogen as answers. It may be that the references to nitrates and nitrogen in the stem of the question caused some students to think about the nitrogen cycle, rather than biological molecules.

(b) About 30% of students calculated a difference within the accepted range (depending on where, exactly, they placed the points on the graph).

(c) This appeared to be an example of where students failed to appreciate the relevance of all the information in the stem of the question. Very many students appeared to interpret the data as what happens if crops are given different concentrations of fertiliser in experiments performed at the same time, rather than changes in response to fertiliser over time. This produced statements along the lines that “more fertiliser produces less crops”. It is worth noting that the data include the *fertiliser response ratio*. Historically, students have always tended to perform poorly on any question involving ratios.

Q7.

(a) This question caused few difficulties for students with 95% obtaining one mark and 85% both marks. The process of generating random numbers either via a computer, calculator or out of a hat was well understood. The vast majority of students used these numbers as coordinators or to choose rocks which had been previously numbered. A minority of students referred to incorrect methods involving line transects or randomly thrown quadrats.

(b) 70% of students obtained this mark usually by suggesting that there would be too many algae to count, that algae are too small to identify or that they grow in clumps.

Incorrect responses often suggested that using percentage cover was easier, more accurate or quicker without providing any explanation of these statements.

(c) Approximately, two thirds of students gained a mark on this question but only 20% obtained both marks. Students failing to gain any credit either gave unsuitable factors such as oxygen or carbon dioxide concentrations or named suitable factors but provided inadequate explanations. A significant minority named a biotic factor, most frequently predators. Explanations related to light, temperature and pH proved to be the most accessible marking points for students. Explanations related to salinity, wave action, wind and named nutrients were often too vague to gain credit.

(d) Approximately 75% of students obtained at least one mark, usually for relating the greater diversity of algae to a greater variety of food sources for consumers. One in four students obtained two marks as they also referred to an increase in number or variety of habitats at site B. Incorrect responses tended to focus on the abiotic conditions being different on the lower shore or the seawater providing more nutrients.

(e) (i) Over 80% of students obtained at least one of the two marks available. This mark was most often credited for stating that the consumers would be hungry or have an appetite. The idea of this allowing a comparison to be made was only appreciated by a minority of students. Consequently, only 11% of students obtained both marks. Most students suggested that the results would be more accurate, reliable or representative if both consumers were hungry.

(ii) This proved to be the most challenging question on this exam paper in terms of achieving marks. Less than 1% of students obtained all three marks and less than 10% achieved two marks. Many students incorrectly suggested the use of a respirometer to determine the loss of mass due to respiration. Weighing the consumers before and after the experiment to find their gain in mass and subtracting this from the loss of mass of the alga was another method suggested by a number of students. Very few students appreciated that any chosen method would have to be conducted in the dark to prevent photosynthesis. Fortunately, students were able to gain a mark for conducting an experiment with only the algae present, even if the method was invalid. Similarly, conducting an experiment for the same time period of 50 hours was also credited. Despite these allowances on the mark scheme, more than 75% of students failed to obtain a mark.

(iii) This also proved to be a challenging question in terms of gaining maximum marks, with less than 4% of students gaining all of the three marks available. However, almost 50% of students obtained two marks almost invariably for explaining that the difference between the results (mass eaten by the two consumers) for *Laurencia pacifica* and for *Cystoseira osmondacea* were significant (or less than a 0.05 probability of being due to chance or reject the null hypothesis) and for stating that the difference between the results for *Egregia leavigata* and for *Microcystis pyrifera* were not significant. The mark point for understanding that the difference in results was most significant for *L. pacifica* was very rarely credited. Frequent errors included a complete misunderstanding of probability values, culminating in incorrect conclusions and no marks, confusion between accepting and rejecting the null hypothesis, and a misunderstanding of what the symbols < and > represent.

Q8.

(a) (i) Approximately twenty five percent of students could suggest appropriate units for gross productivity, the majority of correct answers being kJ m^{-2} $year^{-1}$. There

were many different incorrect answers, including units of mass and energy per year, just energy, just mass and incorrect attempts at outlining areas; m^{-1}, cm^{-3} and arbitrary units.

(ii) Most students obtained one mark by linking reduced gross productivity to reduced photosynthesis. Only a third of students gained a second mark by relating the increased competition for light with reduced photosynthesis. Incorrect responses often referred to competition for a variety of other factors including carbon dioxide and food. A number of students confused net productivity with gross productivity and attempted to provide an explanation in terms of increased respiratory losses. An increase in losses of energy between trophic levels as food chains became longer was another incorrect explanation.

(b) The process of succession was well known with many students gaining full marks. The pioneer species dying, decaying and making the conditions less hostile by forming humus and enabling new species to colonise was the most common explanation. References to more habitats / niches or more animals were infrequent. Students who failed to gain maximum marks often omitted reference to pioneer species.

(c) There were many students who did not know what was required with many responses only explaining that the woodland had reached a stable climax community and no new organisms could grow so biomass did not increase. Unfortunately, other students discussed productivity without specifying whether it was net or gross. However, at least half the students gained one mark, often for recognising the decrease in gross productivity / photosynthesis. Fewer students described the relationship between gross productivity, net productivity and respiration.

(d) This caused few problems with almost ninety percent of students obtaining the mark. The most common correct responses referred to conserving species / habitats, maintaining biodiversity or reducing global warming. The importance of woodlands as a source of medicines and for tourism was also often credited.

Q9.

(a) (i) Over two thirds of students correctly identified two molecules containing nitrogen or phosphorus, most often DNA and ATP. The commonest answers were DNA, proteins and amino acids for a nitrogen-containing molecule and ATP and DNA for a phosphorus-containing molecule. Ammonia and nitrate were not accepted as biological molecules as they do not contain carbon. Fewer students could name a phosphorus-containing molecule, with lipids being a common incorrect response.

(ii) Although slightly more than 50% of students obtained all three marks, this question proved to be a fairly good discriminator. It was pleasing to note that fewer students than on previous papers were confusing nitrifying and nitrogen-fixing bacteria. Most students did appreciate that nitrification involved the conversion of ammonia to nitrate via nitrite. However, a significant number of students simply referred to ‘decomposers’ rather than providing any reference to saprobionts or saprobiotic nutrition.

(b) Almost half the students failed to gain a mark in this question. Many of these students stated that the nutrients were used as a food source by fish. Students who did gain credit often did so by linking the increase in nitrates / nutrients to an increase in producers. Approximately half of these students then linked the increase

in producers to some increase in the productivity of fish, usually increased growth or number.

Q10.

(a) Over 95% of students correctly named the process as succession. Speciation was the most common incorrect response.

(b) Most students obtained at least one mark, usually for stating that more habitats would be available. Many of these students also referred to a greater variety of food sources although a significant minority simply stated there would be more food, which was not credited. Approximately a third of students gained all three marks by also indicating that as the woodland developed there would be an increase in the variety of plants.

(c) (i) 50% of students correctly gave temperature and carbon dioxide as the two limiting factors. Most who did not referred to water rather than temperature. However, humidity, mineral ions / nutrients, oxygen, pH, light intensity and chlorophyll were also given as limiting factors. Only rarely were two incorrect factors selected.

(ii) Most students referred to the uptake of carbon dioxide in photosynthesis and its release during respiration but did not fully explain net productivity. Some students got the use / production of carbon dioxide in photosynthesis / respiration the wrong way round. Almost a third of students did gain this mark, almost invariably by stating that net productivity = gross productivity minus respiration.

(iii) This question was not answered well. Very few students were able to use the information in **Figure 2** to explain how the shade plant is better adapted to gain both marks. The lower rate of respiration was recognised but the lower release of carbon dioxide was usually described at low light intensities rather than at 0 or in the dark. The idea of greater productivity in the shade plant was less frequently described. Most answers related to photosynthesis and many students gained no marks. As in part (ii), the uptake and release of carbon dioxide was sometimes wrongly assigned to respiration and / or photosynthesis. The surface area of the leaves, amount of chlorophyll and number of stomata were also incorrectly used as part of some students' explanations.

Q11.

(a) About three quarters of students obtained both marks for the calculation in this part. Some students only scored one mark because of incorrect rounding of numbers in their calculations or answers.

(b) This part proved far more challenging than intended. It was hoped that students would note that only (plants and) non-photosynthetic soil organisms are mentioned in the study and point out that there are lots of other organisms / animals that are not mentioned. The examiners accepted statements that carbon dioxide from leaves did not take into account effects of photosynthesis, because students were not told until (d) that measurements were taken in the dark. Quite a few students treated the leaves of plants and the stems and roots of plants as separate organisms, rather than different parts of the same organisms. Nearly three quarters of students failed to score any marks.

(c) To obtain two marks in this part, students had to identify three measurements:

volume of carbon dioxide, from a given / known area, in a set time. If they identified two of these, they obtained one mark. A quarter of students obtained two marks and about half failed to score. There were many vague references to *amount* of carbon dioxide and *time* unqualified and many students missed out area altogether.

(d) This part was done well by many students and three quarters obtained both marks. They were able to state that there is no photosynthesis in the dark and photosynthesis would take up carbon dioxide. Some students were confused about whether it was photosynthesis or respiration that produces carbon dioxide, or uses it.

(e) (i) Most students noted that respiration in soil under trees is always higher in this part. Over a third went on to describe a difference in the peak times of respiration in soil under trees and soil not under trees. Although a 2 mm grid was not given on the graph, the examiners expected some attempt to describe time frames, rather than just *earlier* or *later*.

(ii) Correct answers to this part usually revolved around respiration in soil not under trees increasing because the soil gets warmer in sunshine and this leads to faster enzyme activity. Very few looked back to the table and noted the high rate of respiration in roots of plants, of which there would be a lot under trees. Many students thought that photosynthesis by the trees would make more oxygen available in the soil under the trees. Others thought that photosynthesis by the soil not under the trees would increase during the day.

(f) As the final interpretive question on the final paper, this part was intended to be challenging and so it proved. Very few students appear to appreciate the relationship between photosynthesis and respiration in plants in terms of respiratory substrate. This was tested last year and proved challenging then. Students should appreciate that plants make their own respiratory substrates via photosynthesis. Those students who did score in this part did understand this. Given that many students treated leaves and roots of plants as separate organisms in (b), it was perhaps not surprising that very few students suggested it takes time for sugars to travel from leaves to roots. Some got ‘close’ by suggesting it took time for oxygen from photosynthesis to travel to the roots.

Q12.

Not surprisingly this question produced a lot of good answers but still discriminated well despite forty percent of students scoring four or more marks out of the five available. Weaker responses lacked the appropriate level of scientific terminology, omitted essential details or confused ideas. Most students referred to an algal bloom and its effect on penetration of light. However, some students omitted any reference to photosynthesis, or related a reduced oxygen concentration solely to the activity of plants. Some students referred to fish dying due to lack of food with no reference to oxygen or respiration. The best responses were often clear and concise and read as the mark scheme. These answers referred to saprobiotic microorganisms rather than simply ‘decomposers’ and clearly related the death of fish to a decrease in oxygen for respiration.

Q13.

Large numbers of good and excellent essays were seen.

The vast majority of students appeared to understand that this is a synoptic exercise, where they have to draw on a wide range of examples to obtain a high mark. Some students only dealt with one or two topics but in great detail and depth. Unfortunately, this severely limited the mark they could obtain.

Essays with a narrow scope were more common with this question about relationships and interactions. Many of these just went on endlessly about food chains and webs. Attempts at extension material were common. However, the use of examples that any member of the public might use did not gain any extra credit; for example, vague accounts of the plight of polar bears as ice caps melt. Extension material has to be at least of A-level standard and accurately described using appropriate scientific terminology.

There are many different types of relationships and interactions between organisms.

There were some good accounts of the interactions between pathogen and host. These usually focused on the reaction of the immune system to a pathogen. Some looked more at how a pathogen may harm the host. This was a topic area where extension material was quite often included, usually relating to detailed accounts of the effects of a pathogen not named in the specification. Cholera was used as a specific example by many, together with varying amounts of detail on how it interacts with the host. Tuberculosis was quite often cited but relevant detail appeared to be rare.

Only the best essays tended to contain detailed and relevant accounts of taxonomy, classification and evolution. These included accounts of principles of phylogenetic classification, DNA hybridisation and immunological comparisons of proteins. These essays often contained good accounts of evolution of populations and speciation. Weaker essays often contained rambling accounts of competition and evolution of new species but used little or no correct terminology and often confused populations and species.

Behaviour was a very popular topic. There were good accounts of its importance during reproduction to identify individuals of the same species, in order to produce fertile offspring. Some accounts went on to explain its role in identifying individuals in breeding state, or even its role in promoting gamete production or release. There were a lot of vague descriptions of behaviour showing who was ready to mate, with no A-level content.

Many essays had very long and rambling accounts of relationships within ecosystems. Some consisted of little else. There were some very good accounts of the concepts of food chains and food webs and the inter-dependence of populations of different species within a community. These often went on to consider energy transfers within ecosystems, between different trophic levels. Weak accounts were at GCSE level or below, with references to plants making their own food, or energy, and this being passed on to all the animals. The predator-prey relationship was often described but infrequently with references to populations, inter and intra-specific competition or time lags.

Succession was another frequently seen topic. The best accounts wrote about pioneer species and communities, resultant changes in abiotic and biotic factors and the ensuing competition from other species that (may) out-compete the pioneers. They also wrote about communities and biodiversity changing over time until a climax community was established. Many accounts contained little or no scientific terminology or concepts.

Human impacts on the environment were as commonly written about as relationships within ecosystems. Unfortunately, many accounts were at or below GCSE standard and were often at the level of humans causing global warming which was bad for polar bears. There were good accounts that used, for example, deforestation as an example and contained references to habitat destruction, loss of niches, loss of diversity and the reasons for this. Others wrote about farming and the simplification of food webs, loss of diversity, use of pesticides and selective breeding. Nutrient cycles were written about by most students. The specification rather limits what they can be expected to know about the carbon cycle but some failed to include any relevant detail. The nitrogen cycle was well done by some but there were common misconceptions about what happens in the root nodules of leguminous plants. Many thought that *Rhizobium* converts nitrogen to nitrates for the plants. There was also considerable confusion between nitrifying and

denitrifying bacteria. Many students went on to write about eutrophication and it was pleasing to see many correct accounts of the process.

Gene technology in various forms was a popular topic. Most wrote about genetically engineering microorganisms to produce useful substances such as insulin. Others wrote about genetically engineered crop plants with herbicide resistance, or that produced an insecticidal protein. The quality of the accounts varied a great deal. Many who wrote about this also wrote about evolution of antibiotic resistance in bacteria. Good accounts included horizontal transmission of genes for resistance between species of bacteria, involving plasmids. Relatively few students made any mention of antibiotics as a selection pressure, or random mutations as the source of resistance.

Q14.

(a) This question was well answered by students with over eighty percent of students obtaining three or more marks. The most commonly awarded marks were; electrons becoming ‘excited’, energy being released from the ETC, energy being used to form ATP from ADP and Pi and details of the photolysis of water. Marks were often not awarded because of references to chlorophyll absorbing light rather than light energy (or photons), or for referring to NAD being reduced rather than NADP. However, it was clearly evident that this topic is well understood by most students, with many answers including factual details well beyond the requirements of the specification.

(b) This question proved to be a relatively good discriminator and provided a good spread of marks. There were some excellent answers where students provided a detailed account of speciation, clearly linking this process to the context of the question. At the other end of the range, there were references to plants becoming ‘immune to copper’ and considerable confusion between genes and alleles. Most students referred to a mutation, to an allele providing ‘resistance to copper’ and to differential reproductive success. Better answers mentioned the ‘allele for copper resistance’ and often appreciated that the frequency of the allele would increase in future generations. Far fewer students mentioned ‘variation’. A significant minority of students provided a description of succession, often in addition to explaining speciation.

example change

Q15.

(a) Most students were able to suggest one reason why petroleum is used as a comparison when evaluating NLPs of biofuels. This usually related to petroleum being the most commonly used fuel. Far fewer students provided a valid second reason but, when they did, this was often linked to the large amount of carbon dioxide produced from using petroleum. Common responses which were not credited included that petroleum ‘is a control’, ‘is a fossil fuel’ or ‘is cheap’.

(b) Most students gained at least one mark for the idea that environment agency scientists were unbiased. Relatively few students went on to make a valid second comment about their interest in the environmental effects of using biofuels or that the agency was non-profit making. Often students simply suggested that the environment agency would have unlimited funding or that their scientists would be experts.

(c) Many students failed to gain a mark on this question. There was often considerable confusion in the answers provided by these students. Many of their explanations focused on anaerobic respiration and ethanol production rather than uptake and

production of carbon dioxide. However, students who understood ‘negative percentage change’ had little difficulty relating this to the greater uptake of carbon dioxide during photosynthesis compared with its production when biofuels are used.

(d) Many students had difficulty applying the biological principles from unit 2 to gain marks in this question. The most common scoring mark was that ethanol could be produced quicker or in greater amounts following pretreatment. Better students did appreciate that cellulose would be broken down to glucose which could then be used in glycolysis. The mark points relating to cellulose being a polysaccharide and being insoluble were credited less frequently.

(e) The majority of students obtained at least one mark usually for referring to the removal of other species during changes in land use. Half these students then mentioned the removal of habitats or food sources to gain the second mark.

Q16.

(a) Part (i) was correctly answered by many as a non-living factor, and most students gave a suitable example for part (ii).

(b) Answers to this question were frequently very disorganised, with students wasting many lines describing the data before attempting an explanation. The first marking point was often gained, usually for no photosynthesis at night, but students did not then develop the idea and explain that this resulted in no carbon dioxide being taken up at night. The production of carbon dioxide in respiration, and therefore that the uptake in the light was a net movement, was also very rarely mentioned. A few students tried to include the detail of the Calvin cycle to explain the reduction in carbon dioxide levels. Marking point 4 was often awarded for carbon dioxide taken in by leaves. The higher concentration of carbon dioxide at ground level was sometimes explained as being because it is denser than oxygen.

(c) There were many excellent answers where all four marking points were clearly understood and explained using the correct terminology. Many students could clearly explain that advantageous characteristics allowed trees to survive and reproduce successfully. They gained two marks. The change in allele frequency was also often correctly explained with fewer incorrect references to genes. There was some apparent misunderstanding of germination which seemed to be taken by some students to mean reproduction. There was the occasional account of succession or descriptions of features advantageous to survival in the mountains. Weaker students could say little more than that the trees with an advantage were more likely to survive. There were frequent references to directional and stabilising selection.

Q17.

(a) In part (i), most students gained the second marking point. Very few mentioned alleles and so the first marking point was rarely awarded.

In part (ii), most students gained the first marking point and around half gained the second. There were a lot of references to efficiency of conversion and to variables not being controlled.

(b) Most students gained this mark for part (i), although a surprising number thought the peak was at 30°C. Some only described either an increase or a decrease with temperature. Others described the increase up to 20°C and then a decrease from 30-35°C. A few thought that as temperature increases, growth rate decreases.

Marking point 1 for part (ii) was given by a majority of students, around half of whom gained credit for the second point, with answers being expressed in a variety of ways.

(c) In part (i), most students gained the first mark; relatively few gained either the second or third mark, usually by stating that growth was unlikely to increase beyond 35°C or that it would have been a waste of time to investigate higher temperatures. A large number of students were under the apparent impression that as soon as environmental temperature exceeded 35°C all of the pigs' enzymes would immediately denature.

A significant minority of students did not gain marks in part (ii) because they failed to make comparative statements. However, most gained the first marking point. Around a quarter gained the second. The third was rarely seen. A significant minority of students wrote about the effect of the external temperature on the pigs' enzymes in terms of collisions and enzyme-substrate complex formation.

(d) The label on the y-axis gave many students the reference to the control that they needed for the first marking point and most used the error bars in their discussion, but many failed to gain marks by referring to the smaller error bar on food **B** rather than identifying the overlap between **A** and **B**. All of the marking points were seen, but it was very rare for any one candiate to have looked beyond the first idea that caught their attention and develop enough points to gain all four marks. A significant minority of answers gave generic 'How Science Works' responses involving repeats, validity, correlation not proving casuation and reliability, failing to contextualise their answers.

Q18.

(a) Weaker candidates gave superficial answers that referred to optimum temperatures for photosynthesis, rather than using the data in the table to explain that, as July had the highest temperature, the enzyme-catalysed reactions would be taking place more rapidly. Some candidates explained the effect of increasing temperature on enzyme reactions very well, but then failed to gain the second mark by going on to show that this would result in faster photosynthesis and therefore increased productivity.

(b) In part (i), the equation was well known and written in conventional terms or abbreviations, although some candidates failed to gain this mark because they referred to energy loss without linking it to respiration. A significant number of candidates gained both of the marks for part (ii) by explaining that respiratory losses were lower in August, but those who tried to explain the stem by writing a comparative account of the effects of temperature on photosynthesis and respiration did not do so clearly. Very few candidates realised that increasing temperatures had a greater effect on the rate of respiration than on the rate of photosynthesis. A worrying number explained that the plants were using up energy in maintaining their body temperature in the cooler month.

(c) Most candidates gained this mark.

(d) Few candidates were able to suggest that increased respiration would replace the heat lost to the environment, but most realised that more heat would be lost in March and that the horse would use energy in maintaining its body temperature. Although temperature control is not a requirement for this unit, credit was given to those candidates who showed understanding of the energy implications of the process.

Q19.

(a) (i) Generally well answered with most candidates realising that this would reduce cost. Almost half the candidates also referred to less food being required.

(ii) Almost half the candidates obtained this mark. Although some candidates showed no understanding of a negative value, many who failed to gain credit did so because of imprecise language. For example, a common incorrect response was 'they eat less than they need to' rather than the credited response 'they eat less than expected'.

(b) This was generally well answered although very few candidates gained all four marks. Most candidates gained credit for explaining that different types of food could have different energy values or could affect the growth rate. However, few candidates related this to the content of the food in terms of fat, carbohydrate, etc. The effect of environmental temperature on heat loss/gain/respiration was generally appreciated and many candidates referred to the need to maintain body temperature.

(c) Most candidates suggested a correct null hypothesis. Candidates who failed to gain the mark often provided a hypothesis or their null hypothesis did not refer specifically to RFI and methane production.

(d) (i) Most candidates correctly referred to sulfate without straw. A common incorrect response was sulfate.

(ii) Over three quarters of candidates gained at least one mark usually for referring to the effect of the treatment on crop yield. A second mark was obtained by many for referring to the cost of the treatment or its effect on the environment.

(iii) Most candidates were able to describe how the oxygen content would be affected by the rice field being flooded or not flooded. Better candidates then described how methane production was reduced in fields that were not flooded due to fewer anaerobic microorganisms being present.

Q20.

This question was generally answered well.

Q21.

(a) Considerable confusion was evident between light duration and light intensity in candidate responses. There seemed to be little appreciation that light intensity would affect the rate of photosynthesis and light duration would only affect the time available for photosynthesis. It was not possible to credit references to light intensity although many centres did so.

Many candidates correctly recognised that it was essential to monitor the number of hours of sunshine to check that both crops were experiencing similar levels.

(b) All factors were seen in responses. The explanations were often weak and were not sufficiently precise to award the mark correctly. Light intensity, light and carbon dioxide were regularly seen but were ~~these~~ often incorrectly awarded marks by the centre.

Q22.

(a) (i) This was correctly answered by the vast majority, although some candidates simply stated that the yield increased. This was incorrectly given credit by some centres.

(ii) This was well understood by the vast majority and marked at the correct level. Some candidates did not answer the question and wrote about differences in mean monthly values rather than in some weeks of the year.

(b) This was well answered and marked at the correct level, two marks being scored frequently. Centres tended to be over-generous in awarding one mark, accepting either of the figures in the marking guidelines instead of requiring both to be present. Incorrect responses usually involved candidates expressing a response based on 0.42 / 1.25, giving an answer of 33.6%.

(c) Most candidates indicated that the addition of extra carbon dioxide would incur costs and realised that the price of tomatoes would also have to be taken into account. A smaller but significant number of candidates realised that customer demand would also be important. This question was generally marked at the correct level.

(d) Many candidates realised that the lowest price was paid for tomatoes during this period. They also observed that there were weeks when there were decreased yields. The more discerning candidates recognised that the yield showed little or no increase in the summer. These candidates also successfully linked the opening of windows to reduce temperature and improved ventilation with the reduced carbon dioxide levels.

(e) Most candidates failed to appreciate that the control would be improved if the experiment took place at the same time. When candidates did appreciate that it would be sensible to ensure that the plants experienced the same growing or environmental conditions, they unfortunately did not express this clearly enough, or failed to mention specific conditions of light and temperature. This question was often too generously marked, with credit being awarded for answers which were below the standard expected by the marking guidelines.

Q23.

(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.

Q24.

(a) In this question, it was a relatively common failing for candidates to be unable to write about the relevant part of the nitrogen cycle without also trying to include other aspects. In (i), some candidates failed to distinguish between the roles of decomposers and nitrifying bacteria in their answers, phrasing their responses along the lines of “the decomposers and nitrifying bacteria convert the organic substances into ammonia and then to nitrates”. It was also disappointing to read the number of answers that included references to lightning and the Haber process. However, candidates who understood the nitrogen cycle well usually had little problem with this question. There was a general understanding in (ii) that nitrogen-fixing bacteria convert nitrogen gas into a form that is more readily available; however, there was also a widespread misconception that they convert the gas directly into nitrate ions.

(b) In (i), a disappointing number of candidates did not read the question carefully and described changes in the populations of both types of bacteria and both types of protoctistans, usually without really explaining the reasons for any of the changes. Good candidates recognised the predator-prey relationship between the dispersed bacteria and the free-swimming protoctistans in the way the numbers increased and then declined slightly out of phase with each other. In (ii), candidates who understood the process of succession were generally able to recognise the changes in the environment in the treatment tank that resulted in changes in the community inhabiting that environment. A common failing was not to make clear that it is the activities of the organisms that inhabit an area that change the environment and so make it suitable for colonisation by other species.

Q25.

Unit 8

(a) Most candidates were able to explain that an increase in water temperature would influence a relevant feature such as oxygen solubility or respiration. Answers based on the effect of temperature on the rate of enzyme activity or on metabolism were, however, a little too general, failing to relate to the specific investigation described in the question. There were a few references to ensuring “a fair test”, an entirely inappropriate response at this level.

(b) The responses to this section formed a sharp contrast to the high marks frequently awarded for statistical analysis in coursework. Answers to part (i) were often centre-dependent, some candidates being able to produce a sound null hypothesis; others clearly had little idea. These candidates frequently lacked understanding of the purpose of the investigation or of the concept of a null hypothesis. The weakest responses usually involved equating the expression with an inappropriate statistical formula. In part (ii), many candidates were aware that statistical tests are related to chance, but fewer were able to explain that such tests give a measure of the probability that chance might account for the results obtained.

(c) Most candidates correctly identified A as the more likely explanation and were able to justify their choice.

(d) Better candidates were able to produce in a logical account in which they successfully linked a lower oxygen concentration to anaerobic respiration and the production of lactic acid. Others revealed a disturbing lack of understanding of respiratory biochemistry, suggesting that the evolution of carbon dioxide was entirely independent of the consumption of oxygen. They inevitably based their answers on an argument that, despite reduced oxygen, fish must continue to respire aerobically, so there would be an increase in carbon dioxide. There were occasional references to supposed chemical effects of zinc.

(e) The best candidates used common sense in part (i) and, realising that the only elements that were concentrated were copper and cadmium, calculated appropriate ratios for these ions. Credit was also given to those who supported their conclusions by calculating the inverse. A significant number, however, merely subtracted the relevant values from each other, an approach which inevitably led to an incorrect answer. The examiners were instructed to be generous in marking the calculations and undertook much work in interpreting confusing presentation. Centres would do well to advise candidates that it is their responsibility to present material sufficiently clearly that the logic of the response can be followed. In part (ii), most recognised that lead ions would be egested or excreted, although there was some incorrect usage of these terms. Most candidates were aware, in part (iii), that woodlice would concentrate copper. The principle of bioaccumulation was often correctly described but not always related to eating a large number of leaves. Weaker candidates frequently referred to additional sources of copper ions or to the intriguing possibility of copper ions multiplying within the body of the woodlouse.

(f) Mutation figured widely in the responses to part (i), although there were occasional incorrect references to natural selection or to the presence of arsenic causing the allele to first arise. Although there were a number of rather vague references to growth and formation of new cells, the majority of candidates were able to identify two specific effects of phosphates in part (ii). Answers to part (iii) were frequently marred by a failure to answer the question and explain why arsenic-tolerant plants were unable to compete in the conditions described. Candidates referred to both arsenic-tolerant and non-tolerant plants as “they” and it was often far from clear as to which they were referring. However, it was encouraging to note that, although this question was targeted specifically at Grade A candidates, many others were able to suggest that arsenic-tolerant plants would not grow as well because they were unable to take up sufficient phosphates.

Unit 9

(a) Candidates offered a range of explanations, suggesting that the air mixed the water, that it affected the zinc, and that it was needed to make the test fair. Few candidates earned a mark; those that did suggested that oxygen would no longer be a limiting factor. Links were rarely made with the effect it would have on the saturation of the haemoglobin.

(b) (i) A large number of individuals know from their coursework that the term ‘null hypothesis’ implies ‘no difference’, but they did not always recognise where this lack of difference might lie. Weaker candidates made comments about chance. The commonest error was to devise a hypothesis relating to gas exchange and respiration.

(ii) Many commented on the need to look for effects that are due to chance. Some quoted significance levels, but failed to mention probability. Many referred to

establishing levels of accuracy, and a few made statements about the null hypothesis. It was disappointing to note that large numbers of candidates are able to suggest null hypotheses in their coursework but are unable to apply these statistical skills to material presented in an unfamiliar context.

(c) Most candidates recognised the answer as A, and were able to use the graph to explain their choice. Those that could not were vague in their answers.

(d) Unless candidates recognised that there was less oxygen available to the cells they were inclined to answer irrelevantly. The best recognised the anaerobic respiration that would ensue, and therefore lactic acid would be produced. Some wrote of haemoglobin as a buffer, but failed to recognise that it would be the extra hydrogen ions which affected the pH not those absorbed through the buffer. Weaker candidates were confused over the numbering of the pH scale. They thought that zinc affected the pH of the water, or that zinc caused haemoglobin to pick up fewer hydrogen ions from the water.

(e) (i) The calculations were absent in some cases, and very varied where present. Simple ratios were the best idea, but some even calculated standard deviations. Subtractions were also fine. Many candidates had no idea what to calculate. The commonest response was to find the mean concentration of cadmium and copper in shrews, without any reference to the levels in the source of food. Many gave calculations without saying what they were, leaving the examiner to guess. The weakest candidates mis-read the data as numbers of shrews or numbers of ions. Despite poor performances on the supporting mathematics, many candidates could comment on the relative concentrations.

(ii) The fate of the ions was mixed. There appears to be widespread confusion over egestion and excretion and the fact that ions have to be absorbed before they can be used appears to have escaped some. Weaker candidates were of the opinion that the copper ions could be broken down.

(iii) Candidates had little understanding of the ways in which ions accumulate through diet.

(f) (i) Most candidates correctly identified mutations as the cause of the allele arising, but some offered a choice to the examiner regarding natural selection.

(ii) Likewise, most candidates were able to name two functions of phosphates. A few were confused with protein synthesis. Some answered too vaguely with ‘membranes’, iii). This part of the question presented difficulties to many and only the better candidates directed their responses appropriately. There were many vague references to “fogs” and inappropriate set-piece answers on inheritance.

Q26.

(a) Too many candidates saw two empty boxes in the flowchart in (i) and either wrote the names of both substances in the boxes or the number of carbon atoms in each substance. This clearly is the result of not reading the question carefully. Those who did answer the question set, usually scored both marks. In part (ii) good candidates realised that all ATP is produced in mitochondria, except that produced in glycolysis. They therefore arrived at the correct answer of 36 ATP by deducting 2 from the net total yield of 38 ATP per molecule of glucose, or by deducting 4 from the total production of 40 ATP. Others did arrive at the correct answer by working out where each molecule of ATP was produced, but many attempting this method did so in a disorganised way and so made errors in calculation. In (iii) most candidates knew

that, in the absence of oxygen, some of the reactions of respiration could not take place, but many were unable to describe the extent of anaerobic respiration. Well prepared candidates were able to state clearly that only glycolysis would take place and, therefore, the ATP production of the Krebs cycle and electron transport chain would be lost. They also often

(b) Despite being given specific information in part (i) concerning the features of the heterocysts (thick walls and the absence of chlorophyll), and the requirements of nitrogen fixation (anaerobic conditions) candidates too often invented other features and reasons other than maintaining anaerobic conditions for those features. Disappointingly few candidates confined themselves to answers based on excluding oxygen and not producing oxygen, which would inhibit the process of nitrogen fixation. There were some excellent answers to part (ii) from candidates who appreciated that nitrogen-containing compounds in the rice plants would be the starting point for the reactions of the nitrogen cycle, and duly described the roles of decomposition and nitrification accurately and logically. Some realised that the decomposers would produce carbon dioxide as a result of their respiration and that this could be used in photosynthesis by the leaves of the rice plants. However, too many just assumed that the ammonia produced by the heterocysts would be released into the soil, apparently unused by the fern and, in their answers, took this as the starting point for the nitrogen cycle. This clearly shows less appreciation of the situation as described.

Q27.

(a) Most candidates knew the mark-release-recapture technique, and were able to describe the various steps. However, they did not always explain the reasons behind the steps. For example, they did not always explain that the released insects should be left for a suitable period of time to allow them to re-integrate with the rest of the population.

(b) (i) Nearly all candidates knew that there would be only one degree of freedom.

(ii) Most candidates knew that the 0.05 level of probability is that most commonly used in biological analysis to judge statistical significance.

(iii) Responses to this section were generally disappointing. Most candidates were unable to reason that, because the value for χ^2 is greater than the critical value, then there is a probability of less than one in one thousand that the results are due to chance. They were uncertain as to whether the difference in values of χ^2 implied that the differences in results are due to chance or due to some biological cause. They wrote about rejecting a null hypothesis which had not been stated and also merely that ‘the results are statistically significant’. Candidates should be aware of the logic that, if χ^2 is greater than the critical value, there is only a probability of (usually one in twenty) that the results are due to chance as the basis for rejecting any null hypothesis and accepting the experimental hypothesis.

(c) (i) A number of candidates realised that some of the biomass produced in photosynthesis would be respired by the plant, but very few actually explained that biomass is lost in the form of carbon dioxide. Most of those who involved respiration in their answers suggested that energy is lost, which is true, but loss of energy does not account for the difference in biomass between gross primary production and net primary production.

(ii) Nearly all knew that a higher net primary production would lead to more dead plants and so more food for the detritivorous insects.

Q28.

(a) Fertiliser was the most frequently seen answer but many attributed dying plants with the ability to release significant volumes of phosphate.

(b) The calculation was well done by many and some credit was given even to those who chose the wrong denominator or misread the graph. Some used the wrong graph or calculated the 1995 level as the difference.

(c) It was good to see most candidates attempting this question, many appreciating that other factors might be involved. The second mark was only rarely given, usually for a comment on the validity of the information or for an explanation of the effect of the factor.

(d) Whilst many candidates were easily able to gain maximum credit here, a number performed badly and failed to recognise the idea of the question. References to phosphate killing fish directly or to plants giving out lethal levels of carbon dioxide were often seen. The main points missed were reference to *increased* phosphate and development of the lack of light aspect in reducing photosynthesis and thus oxygen output.

Q29.

(a) In this section, candidates often concentrated on either the method of achieving randomness in the sampling or on how other variables might have been controlled: both aspects were required for a complete answer.

(b) Most realised that mayfly nymphs belonging to the family Caenidae and living in the deep water showed the greatest variation as this sample had the highest standard deviation. Some were less specific.

(c) A simple definition in terms of an organism's role in the ecosystem or community was required to explain the meaning of the term *ecological niche*. Some candidates' answers could equally well have been applied to the term 'habitat'. However, there were few problems in recognising that one family of mayfly nymphs living mainly in deep water and the other in shallow water indicated that they occupied different ecological niches. Also, most candidates appreciated that the occupancy of different niches would result in reduced competition for some environmental resource (food being the most common correct suggestion), although some should have thought more carefully about the given situation before suggesting competition for 'light' of for 'mates' (the two groups of mayflies were from different families). Some confused *intraspecific* and *interspecific* competition – only the latter being applicable here.

Q30.

(a) Many descriptions lacked precision through not supplying figures or giving only part of the pattern. Weak explanations failed to refer to the nitrate and its use in the plant. In the third part only a few realized that the nitrate would no longer be limiting and many offered no alternative limiting factors which might be operating. In this part, and elsewhere in the question, answers would have attained higher marks if the word 'nutrient' had been replaced by a more exact term.

(b) This section scored highly although a surprising number overlooked the output of the cattle and concentrated on the paucity of their input. The idea of a crop clearing a field of a particular mineral was seen in many scripts and removal on harvesting

was well known.

Q31.

(a) Some candidates disregarded the instruction in the question that only the letters C, F, R and U should be used in their equation. These inevitably scored zero marks. Most candidates were, however, successful in producing an expression for the productivity of the cattle. Most also achieved a correct numerical answer for this from the data.

(b) Very few candidates were able to perform this step in the calculation. Many ignored the area of grassland (8100 m^2); others forgot that their answer to (a)(ii) was in kJ × 10^6. Many simply made no attempt to answer this section.

(c) Nearly all candidates appreciated that keeping the cattle in barns would reduce heat loss or would restrict movement, thus leading to less wastage of energy. Some made sweeping, inaccurate statements suggesting that *no* heat would be lost or that the cattle did *not* move at all.

Q32.

This question discriminated well, producing the full range of marks.

(a) Only a minority of candidates gave a complete answer and scored all three points. Although most candidates correctly described how random coordinates would be obtained, fewer mentioned the number of samples and only a minority stated that the number of empty and live mussels would need to be recorded. The majority only counted the number of empty shells and confused percentage cover with percentage of mussels eaten. Transects were used by a significant number of candidates rather than random sampling.

(b) About half the candidates related the low energy content to size or indigestibility of the barnacle. Many tried to explain the point by referring to energy used in metabolic processes or inefficiency of energy transfer through food chains. About half also correctly calculated the number of barnacles eaten.

Q33.

Failure to use the correct ecological terms was a major problem in this question.

(a) Succession was only explained well by a minority of candidates. The term ‘community’ was seldom used – instead candidates referred to one species replacing another, or just stated that the ‘plants’ or ‘organisms’ would change. Many candidates described succession purely in terms of an increase in the number of species. Specific changes in environmental factors or the role of species in changing these factors were seldom mentioned. Climax community was described more accurately with most candidates stating that it was the end point of succession.

(b) Most candidates correctly explained the changes in the number of other species in terms of interspecific competition for light or nutrients. There were many vague references to ‘resources’ or ‘space’ which could not be given credit.

(c) Only a minority of candidates answered in terms of biomass production, i.e., the

balance between photosynthesis and respiration. Most did not use the information given in the table about the appearance of the heather, and just discussed the changes in terms of competition.

Q34.

(a) This was poorly answered as few candidates referred to the loss of high protein parts of the plants in dry conditions or the reduced uptake of nitrates. Most stated that, as the process of photosynthesis required water, there would be less energy or less carbohydrate for protein synthesis.

(b) Only a minority of candidates correctly explained the higher protein content in the food by selective eating of the high protein species/parts. Many stated that wildebeest had another source of protein, such as animals.

(c) There was a very wide variety of acceptable answers, although most candidates described the effect of a lack of actin or myosin. A significant number of candidates gave non-protein examples such as glucose, starch and acetylcoenzyme A or did not name a protein.

Q35.

(a) This was well answered and most candidates were able to suggest a reason for leaving a strip of bare ground between the hedgerow and the conservation headland.

(b) This question was generally poorly answered with vague responses and poor terminology. Only the best candidates discussed ideas like habitats for pest predators. Weaker candidates refered to ‘homes for insects’, or stated increased diversity with no explanation.

(c) This was well answered by many, with candidates gaining three marks for a discussion of the nitrogen cycle. Few candidates discussed the carbon cycle, and those that did were rather vague.

Q36.

(a) Most candidates scored full marks, identifying lactate and ATP as the products. Carbon dioxide was a common error.

(b) Most of the marks missed in this question were in part (i) with candidates failing to explain why muscle tissue becomes deprived of oxygen or to relate the high energy demand to respiratory rate. A frequent approach was an explanation of anaerobic respiration as a rapid process, which was not credited. Part (ii) was well answered.

Q37.

(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.

Q38.

This question was generally well answered although a significant number of candidates failed to read the question carefully enough and described what might happen to the energy that had **not** fallen on the producers.

Most candidates were able to suggest one appropriate reason for the seaweed having a large surface area. Many failed to give a second reason with some giving vague answers in terms of ‘gaseous exchange’ rather than explaining it in terms of the ease of absorption of carbon dioxide. A number of weaker candidates responded in terms of respiration rather than photosynthesis.

Many candidates included some good detail as to how their chosen environmental factor might affect the rate of photosynthesis. Appropriate references to the light dependent or light independent stages were included.

Q39.

(a) Many candidates failed to explain the advantages of removing hedgerows in sufficient detail, many just stating that this leaves ‘more space’ with no further qualification. Good candidates included detail about the effect on the crop, or the cost of labour in maintaining hedgerows.

(b) Although most candidates scored at least one mark, many did not refer back to the stem of the question. Some suggested that it might be easier for the farmer to destroy the beetles if they were all in one place, or that the strip of grass might become a source of humus. Relatively few candidates explained that the strip of grass would allow the beetles easier access to pests throughout the crop.

(c) Most candidates scored well on this question, with the most popular responses describing the effect of hedgerows in preventing erosion, or promoting biodiversity.

Q40.

(a) Most candidates were able to identify process **A** as respiration and the group of organisms represented by box **B** as decomposers. Common incorrect answers included ‘consumers’ and ‘detritivores’.

(b) The calculation was performed well with most candidates realising that to work out the percentage efficiency, the energy in the producers had to be divided by the energy they had absorbed. However, the main error was understanding ‘standard form’; the number 1.7×10^6 caused problems, with students finding it difficult to work out how many zeros should be placed after the decimal point.

(c) It was pleasing to see so many candidates realising that the effect of light energy was to excite electrons in chlorophyll but few gave any more information as to what happened to the electron once excited. Vague answers were seen with reference to

the production of carbon dioxide and glucose.

(d) Some candidates could name the two end products of the light-dependent reaction as reduced NADP and ATP, but only the very best could explain their function. Usual mistakes were writing reduced NAD or just NADP.

Q41.

Most obtained one mark for noting that cadmium reduced the amount of enzyme produced with the hormone present. Few made any reference to the data without the hormone, showing that cadmium has an effect on the action of the hormone.

Q42.

(a) (i) Most candidates achieved this mark.

(ii) The presence of nitrogen-fixing bacteria in leguminous plants is well known, but the process by which the fixed nitrogen is made available to a future crop is not. Very few candidates referred to the role of decomposition in recycling nitrogen and many implied that the fixed nitrogen was automatically made available. Nitrifying bacteria were incorrectly given as having the ability to fix nitrogen and a surprising number of candidates believe clover is able to fix it.

(b) (i) The effect of increasing fertiliser application on the protein content of grain was usually described adequately, but only the most able candidates identified the small effect that fertiliser applications had on grain yield. Many candidates ignored the small increase in yield at low doses of fertiliser by stating that fertiliser had no effect on yield, without any indication that the yield increase might not be statistically significant.

(ii) This was well answered by the majority of candidates.

Q43.

(a) A surprisingly high proportion of candidates failed to calculate the percentage correctly, and those who did often did not round off their answer, thus suggesting that a fraction of a species existed.

(b) Few candidates showed appreciation of the role of isolation in the production of new species that would be unique to the Solomon Islands. Most focused on one aspect only. For example, some described adaptation to the range of habitats without discussing speciation. Others pointed out the problems of interbreeding without considering how the endemic species might have arisen in the first place.