**1.** (a) (i) *gene*length of DNA;  
codes for a (specific), polypeptide / protein / RNA; max 1

*allele*alternative form of a gene;  
found at a, locus / particular position on, a chromosome; max 1

(ii) *assume allele refers to coat colour allele*

(coat colour) gene / alleles, only on X chromosome;  
 **A** *no (coat colour), gene / allele, on Y chromosome*male cats, XY / only have one X chromosome;  
males have only one (coat colour) allele / cannot have two (coat colour)  
 alleles;  
need black and orange alleles for tortoiseshell colour; 2

(b) parental genotypes CrCr × CwCw;  
gametes Cr, Cw;

*F1 genotypes and phenotypes 1 mark:*

F1 genotypes (all) CrCw  
F1 phenotypes (all) pink;

*F2 genotypes and phenotypes 1 mark*:

gametes Cr, CwCr, Cw;  
F2 genotypes CrCr CrCw CrCw CwCw  
F2 phenotypes red pink (pink) white;

F2 ratio 1:2:1;  
*accept other symbols if key given*.  
*accept r and w as symbols without key.* 6

(c) (i) 65; 130; 65; 3

(ii) 0.138 + 0.007 + 0.061; (*or other suitable working*)  
0.206 – 0.208;  
*2 marks for correct value if no working shown*  
*ecf for both marks but calculated value must be to three decimal  
places* 2

(iii) support, figure lower than 5.991 / figure lower than critical value;

***R*** *‘support’ on its own.*

*ecf applies if value in (ii) is incorrect* 1

[16]

**2.** named characteristic;  
named environmental factor; *(mark first answer only)* 2

[2]

**3.** 1 ref to operon;  
2 normally repressor substance bound to operator;  
3 prevents RNA polymerase binding (at promoter) / prevents  
 transcription;  
4 lactose binds to repressor;  
5 changes shape of protein molecule;  
6 unable to bind (to operator);  
7 RNA polymerase binds (at promoter) / transcription occurs / genes  
 switched on;  
8 AVP; e.g. production of lactose permease / production of beta-  
 galactosidase; max 5

[5]

**4.** a change in the genetic material;  
unpredictable / AW;  
extra detail; e.g. addition / substitution / deletion / frame shift / small  
 part of chromosome / may code for different protein /  
 may code for no protein

[2]

**5.** *1 mark max for general effect of mutations:*mutation may give different, amino acid / primary structure;  
 **A** *ref stop codon*some mutations alter, molecular shape / tertiary structure / binding;

*max 3 for explaining data in Table:*so unable to, accept / transport, HCO3-;  
unable to bind ATP;

so increase in acidity / decrease in pH;  
effect on mucus;  
effect on enzyme(s) /ref pH optimum of enzyme(s);  
poor digestion of, protein / lipid / starch;

AVP; e.g. some mutations, give some transport / have less effect.  
 > 33% (of norm) allows normal digestive function / < 6%  
 [**A** *very low*] does not. max 3

[3]

**6.** (a) (i) *award both marks for correct answer*

10 000 / 800 000 (× 100);  
1.25 / 1.3 / 1(%); 2

(ii) **R** *any reference to energy / light missing the plant*

reflected (off plant) / only certain wavelengths of light can be, absorbed /  
used; ora  
absorbed by / hits, non-photosynthetic parts; e.g. bark  
passes through leaf / misses chlorophyll / misses chloroplasts;  
some is heat that is used in evaporation / respiration; max 2

(iii) bacteria / named bacterium decomposer; (*Nitrobacter*, *Nitrosomonas*) 1

(iv) *take the first 2 answers*:

death / dead remains;  
excretion; **R** *waste products*egestion;  
other suitable method; e.g. insects moulting  
 hatched eggs  
 moulting (fur / feathers)  
 **R** *leaves* 2

(b) *Primary consumers are eating and*…

producers have, cell walls / cellulose; ora  
difficult to digest / much material, wasted / egested;  
energy used by gut microorganisms; ora  
much material cannot be eaten (by primary consumer); ora 3

[10]

**7.** (i) plasmid cut by restriction enzyme;  
at specific sequence;  
same enzyme as used to cut (insulin) gene;  
sticky ends / described;  
ref. complementary sticky ends;  
ligase seals (sugar-phosphate) backbone / AW; max 4

(ii) *credit any two from the following*:

1 antibiotic resistance (gene) introduced and survivors have plasmid;

2 fluorescent marker (gene) introduced and glowing bacteria have plasmid;

3 identify bacteria producing insulin using antibodies; 2

[6]

**8.** *referring to pig insulin:*ethical / religious, reasons;  
incompatibility / lack of tolerance / immune response; ora  
not exactly the same as / less effective than, human insulin; ora

*referring to human insulin from bacteria:*engineered insulin is cheaper; ora  
greater supply of engineered insulin; ora 1

[1]

**9.** *allow max 5 for following:*transcription;  
DNA unzips / H bonds break;  
exposing required, gene / sequence of bases;  
RNA nucleotides align with DNA;  
U with A, A with T, C with G, **and** G with C;  
RNA polymerase;  
mRNA formed (using DNA strand as template);  
leaves nucleus through pore;

*allow max 5 for following:*translation;  
mRNA attaches to ribosome;  
tRNA brings amino acid (to, ribosome / mRNA);  
each tRNA attached to specific amino acid;  
tRNA binds to mRNA using complementary, base triplet / anticodon;  
peptide bond formed between amino acids;  
DNA / mRNA, (nucleotide / base) sequence determines sequence of  
amino acids;

AVP; e.g. 2, base triplets / codons, in ribosome  
AVP; e.g. ref. to : start / stop, codons  
 polysomes  
 large and small subunit in ribosome  
 Mg2+

[10]

**10.** (a) from below / ventral / AW; **A** **idea of brain being seen from below**  
 **R** *upside down, looking upwards* 1

(b) (i) **reject choice of answers, accept any reasonable spelling**  
**A** cerebrum / cerebral hemisphere / cerebral cortex / frontal lobe;  
 ignore refs to right or left **R** *incorrect lobe***B** pituitary (gland); **R** *hypothalamus***C** cerebellum;  
**D** medulla (oblongata) 4

(ii) control of breathing;  
control of heart rate;  
control of circulation;  
control of swallowing / salivation / vomiting reflex; 2

(c) *If blood hormone concentration rises*

inhibits output of trophic hormones by pituitary gland;  
which inhibits output of hormones by endocrine glands;  
blood hormone concentration falls to normal levels;  
ref. negative feedback;  
*ORA* max 2

[9]

**11.** (a) (apical / terminal) bud is source of auxin;  
auxin inhibits growth of side shoot / ora;  
remove bud and auxin concentration drops;  
(this allows) cell division / elongation to take place;  
*ecf – marking points 2 and 3 if growth regulator or hormone used  
instead of auxin* max 3

(b) *award two marks if correct answer (80%) is given*

*award one mark for calculation if answer is not correct*

(90 – 50 = 40) 40 / 50 × 100;  
80%;; 2

(c) no growth until day, 8 / 10;  
auxin moves out of paste / AW;  
inhibits growth;  
growth occurs after, 8 / 10, days;  
because auxin, levels fall / ‘used up’; 3

[8]

**12.** (i) *max 1 for meaning of term*attached to an insoluble material / AW;

*max 2 for description*(micro)encapsulation / (trapped) in alginate beads;  
adsorption / stuck onto, collagen / clays / resin / (porous) glass;  
cross linkage / covalent / chemical, bonding to, cellulose / collagen fibres;  
gel entrapment / trapped inside gel e.g. silica (lattice / matrix);  
partially permeable membrane (polymer) microspheres; 3

(ii) *any three from the following*:

urine can be processed / no problem of removing urine / AW;  
pure / drinkable / useable, water produced; **A** water recycled  
space saving / less water needs to be taken into space;  
payload limit / weight reduction / AW;  
no problem in separating enzyme from products / product not  
 contaminated;  
ref. to longer shelf-life of enzyme;  
no need to take more enzymes into space / enzymes reusable;  
 **A** enzymes recoverable

AVP; e.g. larger surface area of enzyme exposed, more stable at  
 extremes,  
 ref. to ease of use (of bioreactor) 3

[6]

**13.** (i) adding / using, water to break, bond / ester bond, (in molecule);  
**A** breakdown into smaller molecules 1

(ii) matrix, protects / stabilises, enzyme / lipase;

functions, at optimal rate / more efficiently, at higher temperature / 45 °C;  
 **A** *greater activity / AW*ref. to soluble lipase begins to denature (reducing activity); ora

functions, at optimal rate / more efficiently, at lower pH;  
ref. to presence of fatty acids changing pH;  
ref. to ionic bonds breaking (in soluble lipase); ora

AVP; e.g. ref to industrial uses  
 ref to effect on R groups max 4

[5]

**14.** (a) starts with previously uncolonised area / bare ground / bare rock / AW;  
ref to pioneer species / named pioneer;  
series of recognisable, seres / stages;  
progresses to, climax / final equilibrium stage; max 2

(b) stabilise environment;  
soil development / increase humus / organic material;  
change soil pH;  
hold more water;  
release more minerals or nutrients / increase N content or fix N / hold  
 ions;  
form microhabitat / reduce exposure / provide shelter / reduce erosion; max 3

(c) *any two from following*:

grazing;  
burning;  
mowing / application of fertilizer / application of selective herbicide;  
exposure to wind;  
grass able to continue to grow (linked to a statement above); 2

(d) increases;  
plants at later stages are large / plants in early stages are small;  
trees / shrubs. are woody, appear later in succession; 2

[9]

**15.** *max 1 mark from following:*1 economic definition of sustainable; e.g. similar quantities of timber  
 can be harvested year on year  
2 grants for planting forests / management schemes;  
3 planting to ensure sustainable harvest rate;

*max 3 marks for planting strategy:*4 trees not planted too closely together;  
5 support young trees to prevent damage e.g. from grazing animals;  
6 species planted that are suitable for prevailing conditions /  
 native spp;  
7 softwood sp. / conifers / named conifer / fast growing sp. planted;  
8 deciduous broadleaved species around edges for aesthetic reasons;  
9 creates different habitats / named habitat / protected habitats/ some  
 fallen trees left to rot;

*max 3 marks for felling/cropping strategy:*10 ref. to clear felling having negative effects e.g. soil erosion;  
11 only mature trees removed / selective felling / individual trees;  
12 some clearings / rides / glades in woodland / strip felling;  
13 control of, pests / diseases / fire prevention;  
14 ref to coppicing / pollarding;  
15 (deciduous trees) regrow from base/ idea of rotation/ cycle;  
16 standards / large trees not coppiced, as encourages biodiversity; 7

[7]

**16.** population;  
habitat;  
community;  
ecosystem;

(first) trophic; **R** *tropic*producers/(photo) autotrophs/autotrophic;  
(primary) consumers/heterotrophs/heterotrophic/herbivore;

**R** *carnivore/other qualified consumer* 7

[7]

**17.** *1 mark per correct row*

*Look for both ticks and crosses.*

*If a table consists of ticks ONLY or crosses ONLY, then assume that the blank spaces are the other symbol.*

*If a table consists of ticks, crosses and blanks then the blanks represent no attempt at the answer.*

Nucleotides line up along an exposed DNA strand. ;



The whole of the double helix ‘unzips’. ;



Uracil pairs with adenine. ;



A tRNA triplet pairs with an exposed codon. ;



Both DNA polynucleotide chains act as templates. ;



Adjacent nucleotides bond, forming a sugar-phosphate backbone. ;



The original DNA molecule is unchanged after the process. ;



Adenine pairs with thymine. ;



[8]

**18.** (a) (clinically) obese/obesity; **R** *morbidly obese* 1

(b) *Diet* ***B***essential fatty acids/linoleic acid/linolenic acid/fat soluble  
vitamins/A/D /E/K;

*Diet* ***C***sugars/named sugar/starch; **A** *vitamin C* 2

(c) (i) B;  
energy intake (of B) is lower ORA; 2

(ii) energy intake is less than energy used ORA; 1

(d) (no fruit may mean) scurvy/described; **R** *vitamin C deficiency unless qualified*

raised, cholesterol/LDL, levels in blood; **R** *intake*fatty substances deposited in artery walls/atherosclerosis;  
coronary arteries;  
narrows lumen;  
reduces, blood/oxygen, delivered to heart muscle;  
CHD/heart attack/angina;  
thrombosis/clot;  
raised blood pressure/hypertension;  
stroke;

stress on liver;  
stress on kidney;  
due to excess protein/amino acids/urea;

AVP;  
AVP; e.g. deposition of subcutaneous fat/AW  
 obesity  
 stress on joints  
 anorexia/bulimia/obsession on diet  
 constipation  
 bowel cancer  
 hypoglycaemia  
 giddiness  
 lethargy/fatigue/tiredness *[but* ***R ‘****lack of energy’]* 3 max

[9]

**19.** (i) tree cut, close to ground/down to its stump/AW; **R** *down to trunk*new growth forms/AW;  
harvest after a number of years/process repeated;  
rotational coppicing/AW;  
ref to how coppicing increases biodiversity  
e.g. increasing light intensity; max 3

(ii) (standards) large planks/AW; **A** used as *timber*  
**A** *standards more valuable/AW*  
(coppice) small diameter wood/fencing/hurdles/garden  
furniture/charcoal/firewood/matches;  
(coppice) continuous, source of timber/income;  
recreational use/nature reserve; **A** ref to tourism max 2

[5]

**20.** release of carbon dioxide;  
from fungal respiration;  
available for photosynthesis/carbon fixation;  
extracellular digestion;  
named enzyme(s);  
release of, inorganic substance/minerals/named mineral; **R** *nutrients, nitrogen* **A** *nitrogenous compound*uptake through, roots/root hairs;  
named use of mineral in plants;  
ref. to humus;  
ref. to beneficial role of humus in soil; e.g. increase water retention, improve soil  
 structure, stabilize soil max 4

[4]

**21.** (a) (i) sympatric; 1

(ii) ranges of two species, overlap/close together/AW;  
no geographical barrier;  
ref to behavioural/genetic/physiological/prezygotic barrier;  
correct ref to named area of map; max 2

(b) ref to mate selection by size; ie large with large or small with small  
ref to monogamy;  
ref to intermediate sizes, at disadvantage/selected against/ora;  
intermediate do not pass on alleles/ora;  
suggested reason why intermediate at disadvantage/ora max 3

(c) female produces a lot of eggs;  
selects male, that can store lots of eggs/has a large pouch/ora;  
large males fertilise many eggs/ora;  
chance of more offspring surviving;

***or***large female and small male produce intermediates/ora;  
intermediates at disadvantage/ora; max 2

[8]

**22.** (i) crossing over; *treat chiasma(ta) as neutral* 1

(ii) prophase; 1

(iii) have different, alleles/base sequence of DNA;  
**A** *sister chromatids have same alleles/non sister have different alleles* 1

[3]

**23.** two different genes represented in each gamete ie Q or q and R or r;  
four correct combinations ie Q and R, Q and r, q and R, q and r; 2

[2]

**24.** (i) (parental genotypes:) AaBb × aabb;

(gametes:) AB, Ab, aB, ab (all) ab;

(offspring genotypes:) AaBb, Aabb, aaBb, aabb;

(offspring phenotypes:) grey body/normal wing, grey body/bent wing,  
 black body/normal wing, black body/bent wing;

*[sequence of phenotypes must match genotypes for mark*]

(phenotypic ratio:) 1 : 1 : 1 : 1;

*apply ecf.*

*accept alternative symbols if a key is given, but if no key given max 4* 5

(ii) 80,80,80,80; 1

(iii) (working) 0.1125 + 0.3125 + 0.05 + 0.45;  
= 0.925; **A** *0.9/0.92/0.93*

*2 marks for correct answer with no working.*

*ecf if correctly use wrong figures from (ii)* 2

(iv) yes (*but no mark for yes on own*)

as calculated figure is smaller than 7.82;

*ecf applies to value calculated in part (iii)* 1

[9]

**25.** (a) (i) due to mutation; **A** *named mutation*  
has changed, gene/allele/base sequence/DNA;  
random;  
irradiation/other named mutagen;  
genetically engineered;  
altered, mRNA/enzyme/protein;  
selective breeding; max 2

(ii) light intensity;  
carbon dioxide;  
water/humidity;  
temperature;  
mineral content of soil/potting compost; **R** *nutrients*pH;  
lighting regime; max 2

(b) *wild type*  
no significant/very little, difference;  
those with water taller/ora;  
18 day result an anomaly;  
ref to figures from table; *need two figures at same age with correct* *units*

*dwarf*those with gibberellin taller;  
difference greater as they get older;  
still shorter than wild type;  
ref to figures from table; *need two figures at same age with correct* *units*

*only penalise lack of units once*

calculation of % difference between treatments for either wild type or  
 dwarf; max 5

(c) dwarf unable to produce (active) GA/ora;  
dwarf lacks enzyme for (active) GA formation/ora;  
details of why dwarf lacks enzyme; **A** *has, recessive/mutant allele* max 2

[11]

**26.** (i) **R** *questions*  
embryo, potential human/member of society/right to life/killed/AW;  
may be from abortion;  
scientist making decision for use of embryo/consent may not be required;  
parents may not know fate;  
religious objection;  
may involve cloning;  
some stem cells can be obtained instead from umbilical cord;  
AVP; 1 max

(ii) treat/cure for, anaemia/sickle cell anaemia/named blood disease;  
blood, for transfusion/to replace loss;  
treat, immune disorders/SCID/lupus;  
treat, non-Hodgkins lymphoma/some types of cancer/leukaemia;  
treat/cure for, Alzheimer’s disease;  
treat/cure for, Parkinson’s disease;  
treat paraplegics/repair injury to, nerves/spinal cord;  
treat, genetic disorders affecting nerves/Huntington’s/Tay Sachs/Lou  
 Gehrig’s;  
treat multiple sclerosis/motor neurone disease;  
AVP; eg. stroke/brain damage/retinal repair  
AVP; *must be relevant to use of blood cells or neurones* 2 max

[3]

**27.** (i) indicates the range of results;  
on either side of the mean;  
indicates, variability/(standard) deviation/(standard) error;  
indicates if data sets significantly different; 2 max

(ii) no/small, increase/figs. quoted;  
lag phase;  
adjust to conditions/detail of adjustment;  
produce enzymes;  
AVP; 2 max

(iii) more rapid growth in non-deficient cells/ora;  
figures in support from both axes of graph;  
low ribose in G6PD deficient cells/ora;  
less available to, parasites/*Plasmodium*;  
less production of RNA/ribonucleotides;  
less available for transcription;  
inhibited protein synthesis;  
less protein available for, reproduction/growth/cell division; 4 max

[8]

**28.** deficiency gives resistance to malaria;  
deficient/resistant, individuals more likely to survive;  
alleles, passed to next generation;  
natural selection;  
presence of *Plasmodium* is selection pressure;  
frequency of this allele increases;  
phenotype more common in population;  
AVP; e.g. others more likely to die of malaria 3 max

[3]

**29.** (a) (dominant) epistasis; 1

(b) ref. frame shift;  
ref. three extra, triplets/amino acids;  
may introduce stop code so shorter, polypeptide/protein;  
may increase length of, polypeptide/protein;  
may alter, shape/3’ structure, of, polypeptide/protein;  
affects active site;  
protein/polypeptide, may lose function;  
protein/polypeptide, may have different function; max 4

(c) (i) *Parental phenotypes: White Leghorn x Red Junglefowl*  
*Parental genotypes:* IICC x iiCC *or* IIcc x iiCC;

F1 genotype: IiCC *or* IiCc; 2

(ii) 3 white : 1 pigmented *or* 13 white : 3 pigmented; 1

[8]

**30.** gene bank;  
source of alleles;  
for future (selective) breeding;  
to counteract, genetic erosion/loss of genetic variation;  
to counteract, inbreeding/homozygosity;  
to counteract extinction;  
for changed conditions;  
example of changed conditions; e.g. *climate/environment/disease/fashion*to preserve as yet unidentified, alleles/traits; max 4

[4]

**31.** pigmented birds more likely to be damaged;  
at all percentages;  
more damage as percentage of pigmented birds increases to 23%;  
more damage as percentage of white birds increases to 24%;  
fall in damage of white birds at, 25%/highest percentage; max 3

[3]

**32.** (i) for benefit of humans;  
to improve, trait(s)/named trait;  
to produce desirable, phenotype/genotype;  
to increase number of desirable alleles;  
to increase homozygosity;  
AVP; max 2

(ii) ref. self-pollination;  
ref. inbreeding;  
limited gene pool; max 2

(iii) ref. different numbers of chromosomes;  
hybrid is 3n;  
sterile;  
gametes have 22 and 11 chromosomes/hybrid has 33 chromosomes;  
some chromosomes unpaired;  
failure of meiosis;  
ref. uneven distribution of chromosomes;  
ref. other barrier to interspecific cross; max 2

[6]

**33.** meristematic/pluripotent/totipotent/cambial/undifferentiated, tissue;  
sterile conditions;  
nutrient medium to encourage, division/mitosis;  
produces callus;  
subdivided;  
different (nutrient) medium to encourage differentiation;  
detail of either medium; e.g. *named nutrient or plant growth substance*grows to plantlet;  
hardening medium/sterile soil; max 5

[5]

**34.** stated advantage;  
detail; e.g. *particular character (not whole phenotype)/can alter one trait* *only (without affecting background genes)/can add allele from* *different taxon with which breeding may not be possible/quicker* *(than the many generations of, selective breeding/backcrossing)* 2

stated disadvantage;  
detail; e.g. *cannot precisely position insert (so) unknown/unanticipated* *effect/may pass to other species (with unknown/undesirable,* *effect)/regarded as ethically undesirable (no market/crop* *destroyed by protesters)/cannot breed from GM (requires cloning)* 2

[4]

**35.** (i) ;  
;  
 (tick);  
; 4



(ii) discontinuous; [*do* ***not*** *allow if no reason given*] 1

*reason*  
one, gene/locus; **A** *major/Mendelian*, *gene*  
discrete phenotypes/ora;  
qualitative/large effect/little environmental effect; max 1

[6]

**36.** (i) endonuclease;  
cuts DNA;  
with sticky or blunt ends;  
at, palindromic/AW/specific/4 to 6 base pair/restriction, site;  
from bacteria;  
for cutting ‘phage DNA; max 3

(ii) 2 sources DNA;  
ref. sticky ends;  
complementary binding;  
H-bonds between bases;  
A to T and C to G;  
nicks in sugar-phosphate backbone sealed/AW;  
by ligase; max 4

[7]

**37.** (a) (i) two recessive alleles/homozygous recessive/two of allele 2;  
no, normal dominant/allele 1;  
homozygous same allele as affected child; 2

(ii) deletion removes base pairs;  
shorter/lighter, pieces of DNA move further in electrophoresis;  
towards anode;  
so allele 2, shorter/lighter, than allele 1; max 3

(b) 0.25/25%/1 in 4; 1

[6]

**38.** ref to, leaching/runoff, into waterways;  
causing algal blooms;  
blocking of light for aquatic plants;  
ref to, decomposition/high numbers of decomposers;  
leading to high BOD;

reference to ‘blue-baby’ syndrome;  
links to haemoglobin; max 4

[4]

**39.** 1 ref to setting grid/area to be sampled;  
2 suitable systematic method chosen/ref to belt/line transect;  
3 ref to repetition of line transects;  
4 use of quadrats;  
5 use of appropriate sized quadrat;  
6 details of regular quadrat placing;

7 identify species/use of keys;  
8 presence or absence in quadrat;  
9 calculation of % of species frequency;  
10 measure % cover/use of appropriate scale; e.g. (Braun-blanquet/ACFOR/  
 DAFOR/DOMIN)  
11 ref to analysis of data/use of kite diagram;  
12 AVP; ref to relevant statistical analysis, e.g. Spearmans Rank Correlation max 7

**QWC - clear well-organised answer using specialist terms** 1

[8]

**40.** routeways/pathways allowing movement of (insects);  
ref to connectivity/AW;  
ref to sites of refuge/habitat; max 2

[2]

**41.** pest remains/not totally eradicated;  
slow to work/AW;  
labour intensive/AW;  
reintroduction often needed;  
predator may eat crop;  
risk of migration;  
risk to other organisms/mutation/predation of other species; max 2

[2]

**42.** pollination;  
maintain biodiversity;  
benefits to food chain/food for other organisms; max 2

[2]

**43.** increased profit for farmers/shops;  
no residues on food;  
no pesticides;  
less use of inorganic fertilizers;  
less risk of pollution;  
benefits to soils structure and quality;  
benefits to biodiversity;  
benefits to human health; max 3

[3]

**44.** (i) **A** scapula  
**B** humerus  
**C** ulna  
**D** radius; *2 or 3 correct = 1 mark, 4 correct = 2 marks* 2

(ii) *ligament*holds bones together/prevents dislocation;  
high tensile strength;  
flexible;

*cartilage*ends of bones;  
low friction/smooth/slippery;  
ref. shock absorber/stops bones rubbing together; 4 max

(iii) biceps/brachialis;  
(contraction) pulls on radius;  
flexor (muscle)/bends arm/pulls lower arm up; *2 max*

triceps;  
(contraction) pulls on end of ulna;  
extensor (muscle)/straightens arm/pulls lower arm down; *2 max* 3 max

[9]

**45.** (calcium ions/Ca2+) released from sarcoplasmic reticulum;  
bind to troponin;  
troponin changes shape;  
troponin/tropomyosin, moves;  
myosin binding site exposed;  
myosin head binds (to actin); 3 max

[3]

**46.** *(Alzheimer’s)*1 reduced uptake of isotope/less positrons emitted/less glucose in brain  
2 cells;  
3 reduced blood flow;  
4 reduced brain activity;  
5 reduced respiration in cells;  
 AVP; e.g. parts of brain *accept reverse argument for all points* 3 max

[3]

**47.** (i) control explained/AW; **R** *control without explanationf* 1

(ii) mean number of errors reduced in subsequent trials;  
in all trials rats with phenserine had fewer errors/ora;  
ref. paired data for 2 trials; 2 max

(iii) ref. trial and error;  
ref. associative learning;  
ref. operant conditioning;  
escape is reward/reinforcer; 3 max

(iv) inhibits acetylcholinesterase;  
effect on enzyme;  
in synapses;  
slows down fall in ACh concentration/keeps some ACh at synapses/slows  
breakdown of ACh;  
in parts of brain associated with memory;  
improved short term memory; 3 max

[8]

**48.** innate/instinctive/stereotypic;  
inherited/genetic/inborn;  
does not require, learning/conscious thought;  
AVP; e.g. reflex *3 max*

searches for breast/bottle/AW; 4 max

[4]

**49.** (a) plants/protoctists;  
animals/fungi/protoctists;

**A** *protoctists once only* **R** *taxa that are not kingdoms* 2

(b) *energy*  
movement/locomotion/muscle contraction/cilia/flagella;  
active transport; **A** *example*anabolic reactions/AW; **A** e.g. *protein synthesis/DNA replication*(movement of chromosomes in) mitosis/meiosis;  
nerve impulse/electrochemical gradients;  
maintain body temperature/generate heat;  
AVP; (eg bioluminescence/electrical discharge)  
AVP; (detail of any point) *3 max*

*carbon*in, biochemicals/macromolecules; **A** *in organic matter*e.g. carbohydrate/protein/lipid/nucleotide/nucleic acid;  
**A** *named examples*growth;  
repair;  
AVP; e.g. detail of any point) *3 max* max 4

(c) (nitrifying bacteria) help/increase, plant growth;  
bacteria make nitrate (available);  
plants need nitrate;  
for, amino acids/protein/chlorophyll/DNA;  
for, new cells/mitosis/new leaves; max 2

(d) (i) chemoheterotrophic; 1

(ii) photoautotrophic; 1

(e) (i) carbon; **R** *CO2* 1

(ii) *Desulfovibrio*, uses sulphur (S)/makes hydrogen sulphide (H2S);  
green sulphur bacteria, use H2S/make S;  
colourless sulphur bacteria use H2S; max 2

(f) colourless sulphur bacteria; 1

(g) *C*. *perfringens* similar to *C*. *difficile*/AW;  
(bacteria) anaerobic;  
(tissue damage/poor blood supply) decreases oxygen available;  
conditions suitable for *Clostridium* to multiply;  
AVP; max 2

[16]

**50.** (a) (i) U A C C G G A U U C A C;;

*1 error = 1, 2 errors = 0*

*allow 1 mark for giving T throughout instead of U*

*(i.e. T A C C G G A T T C A C = 1 mark)* 2

(ii) transcription / transcribed; **R** transcriptase 1

(b) (i) **J** anticodon; **R** anticodons  
**K** transfer RNA / tRNA; **L** ribosome / rRNA; **M** codon; **R** codons 4

(ii) **1** DNA triplet / codon / **M** / mRNA triplet,codes for  
specific amino acid;

**2** order of, triplets / bases, determines the order of amino acids;

**3** tRNA / K, has, corresponding / complementary,  
triplet / anticodon;

**4** (tRNA / K) attached to specific amino acid;

**5** activation of amino acid;

**6** 2 (tRNA) binding sites on the ribosome;

**7** codon and anticodon bind; **A** match

**8** A to U and C to G;

**9** adjacent amino acids join;

**10** peptide bond; 4 max

(c) **1** attaches to ribosome;

**2** removes,base / portion, of ribosome; **A** stops ribosome assembling / changes shape of ribosome

**3** prevents ribosome,attaching to / reading, mRNA;

**4** prevents codons being exposed;

**5** prevents,tRNA / anticodon,attaching to,mRNA / codon;

**6** prevents / inhibits enzyme responsible for,formation of  
peptide linkages;

**7** AVP;e.g. further detail of any of the above points 2 max

[13]

**51.** ***max 7 for the process of genetic engineering  
max 2 for the advantages***

**1** identify / find, gene (for insulin) / length of DNA coding for insulin;

**2** obtain / isolate / extract,gene / length of DNA (for insulin);obtain / isolate / extract,mRNA (for insulin);

**3** restriction enzyme / named e.g.; reverse transcriptase;

**4** cut plasmid;cut plasmid;

**5** use same restriction enzyme;use restriction enzyme / named e.g.;

**6** ref to, complementary ends / sticky ends / described;

**7** insert, gene / AW, into plasmid;

**8** recombinant DNA;

**9** plasmid uptake by bacteria;

**10** identify those bacteria that have taken up the plasmid;

**11** provide with, raw materials / nutrients;

**12** fermenter / bioreactor;

**13** bacteria produce insulin;

**14** extract and purify / downstream processing;

**15** AVP; **e.g.**. detail of uptake by bacteria  
 method of identifying those that took up plasmid  
 PCR  
 ligase *7 max*

**16** advantage 1; e.g. more reliable supply

**17** advantage 2; greater / faster, production  
 overcomes ethical problem described  
 less risk of disease  
 less risk of, rejection / side effects  
 human insulin so more effective 8 max

**QWC – clear, well organised using specialist terms**;*award QWC mark if four of the following are used* 1

gene plasmid  
restriction enzyme complementary  
named e.g. of a restriction enzyme sticky end  
reverse transcriptase recombinant DNA  
fermenter / bioreactor

[9]

**52.** (i) asexual; **A** binary fission / cloning **ignore** mitosis 1

(ii) **1** restore diploid number when gametes fuse / AW;

**2** prevents doubling of chromosome number  
(in each successive generation);

**3** without use of gametes there is less variation;

**4** no input of genetic material from more than one individual;

**5** triploid / 5n / etc, would be infertile;

**6** AVP; e.g. polyploid would result in loss of variation 2 max

[3]

**53.** (a) (i) denitrification; 1

(ii) Rhizobium; 1

(iii) active transport / diffusion; 1

(iv) nitrification; 1

(b) *max 3 for each method*

***ploughing-in***

**1** legumes / named e.g., possess, (root) nodules /  
nitrogen fixing bacteria;

**2** *Rhizobium,*performs nitrogen fixation / described;

**3** nitrogenous compounds are present in, roots / nodules /  
legumes / plants;

**4** made available to soil if, ploughed in / not removed;

**5** roots / AW,decomposed / acted on by decomposers / rot / decay;

**6** nitrogenous compounds released (by decomposers);

**7** formation of nitrate; *3 max*

***crop rotation***

**8** different, crops / plants, have different (nutrient / nitrate)  
requirements;

**9** each year,different demands made on the soil / nutrients not  
being removed at the same rate;

**10** in, 4th / fallow, year, no (little) nutrients removed / used  
for grazing animals;

**11** nutrient levels allowed to build up;

**12** use legume in rotation;

**13** tuber / root, crop to improve soil structure; *3 max* 4 max

[8]

**54.** (i) ***R*** *if refer to body muscles*

less, oxygen / nutrients / sugars / fatty acids, supplied (to heart muscle);slower removal of carbon dioxide;less, respiration / ATP made;muscle contraction is weaker / cannot pump as forcefully /  
contraction stops;death of heart muscle;makes (remaining) heart muscle work harder / hypertrophy; max 3

(ii) angina / chest pain when, exercising / exertion;reduced ability to perform exercise;breathlessness;myocardial infarction / heart attack / cardiac arrest; max 2

[5]

**55.** idea of soil development; **A** ref to depth or fertility of soil  
(increase), organic material / humus;  
(increase) in availability of water;  
minerals available; **A** nutrients  
(some pioneer species) carry out nitrogen fixation;  
photosynthesis (fixing carbon);  
create habitats / provide shelter;  
AVP; e.g. increase weathering, stabilise sand / soil 2 max

[2]

**56.** (i) final stage in succession / AW;  
(community) in equilibrium with environment; 1 max

(ii) eat / trample, seedlings (of shrubs / trees) / AW; **R** eat grass  
prevents, succession / establishment of next sere; 1 max

[2]

**57.** (a) *award two marks if correct answer (18.4) is given  
incorrect answer (or no answer) but correct working = 1 mark*

44 / 239 (× 100)  
18.4%;;

*ecf applied for minor addition errors +/- 2* 2

(b) 1 lay, tape / string, across path; **R** along the path  
2 include trampled and non trampled areas in same transect;  
3 use of quadrat;  
4 ref to how quadrat is placed; **R** random  
5 count number of plants / percentage cover of plants;  
6 plot a graph;  
7 repeat the transect;  
8 carry out statistical test (Mann-Whitney / Spearman’s rank);  
9 AVP; e.g. detail of sampling technique 5 max

[7]

**58.** *chinchilla –* CChCCh CChCH CChCa;

*agouti –* CACA CACCh CACH CACa; 2

[2]

**59.** *max 3 from points 1 to 5*

1 limited, food supply / space;  
2 competition;  
3 predation;  
4 disease;  
5 reached carrying capacity / death rate = birth rate;

*marking points 1 – 5 linked to keeping population stable*

6 individuals show variation;  
7 variation due to, combination of alleles / mutations;  
8 best adapted survive / ora; **A** *survival of fittest idea*9 reproduce;  
10 pass alleles to offspring;  
11 frequency of favourable alleles will, increase / be maintained; **A** ora 5 max

[5]

**60.** light / daylength;  
gravity;  
water / humidity;  
touch;  
chemicals; **R** carbon dioxide  
temperature; **A** heat 3 max

[3]

**61.** *tissue*1 meristematic;  
2 undifferentiated / totipotent / able to develop into any cell type /  
 unspecialised;  
3 (cells) can still divide / undergo mitosis;  
4 virus free; *max 2*

*sterilising agent*5 aseptic technique;  
6 prevent, growth of / contamination by, bacteria / fungi;  
7 could overwhelm / grow faster than / compete with, plant tissue;  
 **A** AW *max 2*

*cytokinins, auxins*8 plant growth, **regulator / promoter / hormone**;  
9 cytokinins stimulate, shoot / stem, growth / many branches;  
10 auxins stimulate growth of, root / root hairs; *max 2*

*magnesium, nitrate ions, sucrose*11 magnesium for, chlorophyll / photosynthesis;  
12 nitrate (ions) needed for, protein / enzyme / chlorophyll / named chemical;  
13 sucrose converted to, glucose / fructose / monosaccharide;  
14 used in, respiration / release energy; *max 3*

15 AVP; e.g. further detail e.g. cytokinins stimulate cell division  
 no vascular tissue therefore disease free 6 max

**QWC – clear well organised using specialist terms**; 1

*award QWC mark if three of the following terms are given in correct* *context* meristematic  
 undifferentiated  
 totipotent  
 mitosis  
 aseptic  
 contamination  
 regulator  
 promoter  
 hormone  
 chlorophyll  
 photosynthesis  
 respiration

[7]

**62.** (a) *linkage*(two or more) genes / loci, on same chromosome; **R** alleles  
do not assort independently (in meiosis) / inherited together;

*crossing over*reciprocal exchange of portions of, chromatids / DNA; **A** swapping alleles  
between (paternal and maternal) homologous chromosomes; **A** bivalent  
in prophase I (of meiosis); *max 2* max 3

(b) anthers removed (before maturity) (to produce male sterility);  
male sterilisation; *genetic or, PGS / hormone*pollen transferred by hand;  
plants isolated;  
flowers bagged (before and after pollination); max 3

(c) (i) **R** ‘chance’ alone

chance fertilisation;  
chance re picking 50 offspring;  
chance re other traits affecting survival;  
AVP; e.g. position effect, different gene interactions affecting  
expression,  
effect of crossing over on numbers of other classes max 1

(ii) *award two marks if correct answer (16%) is given without working*

recognition of recombinant classes;

× 100;



=16%; max 2

(iii) 1,2 × ;; **A** (AB)(ab) × (ab)(ab)



3 both chromatids per chromosome shown;  
4 crossover shown;

5 result of crossover shown;

6 most / 84%, gametes A B and a b [ × a b]; **A** AB and ab  
7 = parental;

8 few / 16%, gametes A b and a B [ × a b ]; **A** Ab and aB  
9 = recombinant;

10 ref 16 map units apart / close together; max 6

[15]

**63.** (i) production of desired changes in phenotype of an organism;  
selection of appropriate alleles / AW;  
by artificial selection;  
use as parents / mate, those showing desired phenotype  
(to larger degree); max 2

(ii) measure of value of individual’s genotype (for breeding);  
mate with number of proven individuals;  
assess phenotypes of offspring; **R** genotypes  
average value;  
especially useful for sex-limited traits; **R** sex-linked  
e.g. sex-limited trait; max 4

[6]

**64.** *description*D1 chosen male and female mated;  
D2 ref to desired characteristic / named desired characteristic;  
D3 ref to AI;  
D4 advantage of using AI;  
D5 offspring inspected and best mated;  
D6 several / many, generations;  
D7 ref to problem inbreeding;  
D8 ref to way of minimising inbreeding;  
D9 ref to heritability;  
D10 easier to select for traits with high heritability / ora;  
D11 easier to select for discontinuous variation / ora continuous variation;  
D12 ref to polygenes / additive effect; *max 6 ‘describe’ D marks*

*explanation*E13 selective breeding involves whole genomes;  
E14 hence other traits follow selected trait(s);  
E15 ref to linkage;  
E16 artificial selection;  
E17 selection, different from natural selection / for benefit of humans;  
E18 starter population, small / not representative;  
 **A** founder principle *max 4 ‘explain’ E marks*

AVP either D or E mark;  
 e.g. ref to use of, IVF / surrogate, with reason  
 ref to loss of alleles / genetic erosion max 8

**QWC - legible text with accurate spelling, punctuation and grammar**; 1

[9]

**65.** (a) (i) cow superovulated;  
treated with, hormone / FSH / named proprietary brand;  
washed out of oviduct (**A** uterus) / collected from ovary;  
detail washing;  
detail collection; max 3

(ii) ref to mitochondrial DNA;  
detail; e.g. circular / self-replicating  
mitochondria in cytoplasts fused with darted buffalo cell; **A** organelle  
embryo has mixture of buffalo and cow mitochondria;  
nuclear / chromosomal, DNA is buffalo;  
ref to bacterial contamination; max 2

(iii) for correct phase of cycle;  
ref to synchronisation;  
to prepare uterus for (implantation of) embryo;  
ref to increased thickness of uterine lining;  
ref to increased vascularisation of uterine lining; max 3

(b) increases rate of reproduction;  
does not require species’ eggs;  
so does not require fertile female;  
does not require female for pregnancy / uses surrogate;  
female not put at risk in, travel / mating / pregnancy;  
successfully formed embryo can be, subdivided / cloned;  
can use adult cells from all existing animals to maintain diversity; max 4

(c) sperm bank;  
oocytes / eggs; *“gametes”* = 1 mark only  
embryos;  
tissue;  
zoo / reserve / game park; max 3

[15]

**66.** (i) 4 - 6 base pairs;  
palindromic / AW;  
specific sequence; max 2

(ii) yes, same sticky ends / sticky ends shown; GATC / CTAG  
complementary (bases);  
hydrogen bond;  
A with T;  
C with G; max 3

(iii) two correct cuts;  
G| A T T C A G A A T T T C G| A A T C  
C T A A |G T C T T A A A G C T T A |G 1

[6]

**67.** 1 restriction enzyme to cut gene from genome;  
2 and, plasmid / artificial chromosome / DNA of vector;  
3 same restriction enzyme;  
4 if cut with sticky ends then join;  
5 if cut with blunt ends then, sticky ends / nucleotides, added; **R** bases  
6 with C bases one end and G bases other;  
7 requires terminal transferase;  
8 (DNA) ligase needed to seal nicks in DNA backbone;  
9 ref to join phosphate - sugar / adds phosphate;  
10 DNA may be produced by reverse transcriptase;  
11 from mRNA;  
12 single strand made double stranded by DNA polymerase;  
13 wanted DNA replicated by polymerase chain reaction (PCR);  
14 using, DNA polymerase with high optimum temperature /*Taq* polymerase;  
15 AVP; max 8

**QWC - clear, well-organised answer using specialist terms**; 1  
 *award QWC mark if three of the following are used*

endonuclease  
 terminal transferase  
 reverse transcriptase  
 (DNA) ligase  
 DNA polymerase  
 PCR  
 correct use of nucleotide and base  
 sticky ends  
 blunt ends

[9]

**68.** (a) (i) 1 mutation;  
2 random / spontaneous / chance / pre-existing;  
3 natural selection;  
4 drug / insecticide, is, selective agent / selective pressure;  
5 resistants have selective advantage;  
6 resistants survive / susceptibles die;  
7 pass, allele / mutation, to offspring; **R** gene / resistance  
8 allele frequency increases;  
9 rapid because, multiplicative phase / short generation time / large  
10 numbers offspring / many breeding sites; max 5

(ii) *Plasmodium* inside, liver cell / red blood cell;  
antibodies cannot reach target / cannot be detected by immune system;  
large genome;  
antigenic variation / AW;  
variation from meiosis;  
detail; e.g. independent assortment / crossing over  
parasite switches between different versions of proteins;  
ref *var* gene; max 3

(b) (i) *marks in pairs - one pair only*mutation; with lack of production;

*examples  
in, promoter / ‘on’ switch; so not transcribed;  
to give premature stop codon; so, no useful / shortened, product;  
deletion; with loss of allele / different product;  
frameshift; so, different / no useful, mRNA / product;  
in initiation codon; so mRNA not translated;  
AVP mutation; AVP lack of production*; max 2

(ii) *marks in pairs - one pair only*

no, membrane receptor / AW; so no, binding / internalisation;  
no, channel / carrier / pump; so lack of essential, nutrient / ion;  
do not multiply in liver; so not available to infect red blood cells;  
AVP protein; problem; max 2

(c) 100% protection with 2 boosters;  
irrespective of dosage;  
70% with 1 booster;  
no evidence with 50 000 whether works with one booster;  
ref to memory cells;  
needs large numbers of parasite / ref 10 000 x 3;  
safe / will not cause disease / does not kill mice;  
might mutate back to wild type;  
can infect liver cells even if no further development;  
may need drug to remove from liver;  
data relates only to mice / may not be applicable to humans;  
AVP; e.g. no data comparing results with standard antigenic (AW)  
 vaccine max 3

[15]

**69.** insulin is, polypeptide / protein;  
(promoter), switches on transcription *or* makes gene produce, mRNA /  
insulin;  
as blood glucose rises insulin production increases;  
ref to figures with units;  
only produced when needed;  
ref to, homeostasis / negative feedback; max 3

[3]

**70.** *benefits*avoids injections / pain of injections / children’s fear of injections;  
mimics normal pancreatic behaviour;  
more stable homeostasis / reduced highs and lows in blood sugar;  
less chance, hypoglycaemia / hyperglycaemia;  
less restriction on lifestyle;  
no need to measure blood sugar;  
AVP; *max 3*

*problems*rejection;  
cells could lodge elsewhere;  
may take longer to act;  
AVP; e.g. rat data may not be applicable to humans,  
 transgene may have unforeseen effect *max 3* max 4

[4]

**71.** genetically isolated populations;  
allopatric speciation / AW;  
ref to genetic drift;  
ref to, founder effect / founder population;  
loss of alleles / genetic erosion / reduced gene pool / loss of genetic  
diversity / AW;  
ref to, disease / population crash;  
AVP; e.g. ref to exposure to different selection pressures max 4

[4]

**72.** plot size;  
soil type;  
soil pH;  
plant cover;  
aspect / locality;  
ref to temperature linked to aspect;  
slope;  
ref to rainfall or irrigation;  
time period;  
AVP; e.g. tillage, method of cultivation, degree of compaction  
AVP; e.g. previous use of land max 3

[3]

**73.** (i) **A** cartilage;

**B** synovial fluid; 2

(ii) reduces friction / stops bones rubbing together; **R** no friction  
shock absorber / cushions bone;  
keeps (joint) lubricated / AW;  
(fluid) provides nutrients to, chondrocytes / cartilage; **A** cells 3 max

[5]

**74.** 1 cone cells absorbs light;  
2 iodopsin changes form / AW;  
3 ref to three different types of cone;  
4 hyperpolarisation / –40mV to –70mV;  
5 stops releasing transmitter;  
6 bipolar / ganglion, cells;  
7 action potentials / impulses, along optic nerve; *max 4*

8 to, visual sensory area / sensory cortex;  
9 then visual association area;  
10 ref to occipital lobe;  
11 then temporal lobe;  
12 where word is identified from memory / AW;  
13 AVP; e.g. glutamate,  
 optic chiasma,  
 inhibitory action of transmitter 6 max

**QWC – legible text with accurate spelling, punctuation and grammar**; 1

[7]

**75.** *chimpanzees*arboreal / AW;  
co-ordination of movement more complex / chimps perform more  
complicated tasks / AW; ora  
more neurones required / AW; ora  
AVP; e.g. hand-eye co-ordination 2 max

[2]

**76.** (i) red light; 1

(ii) arm withdrawn (without a shock); 1

[2]

**77.** 1 rat, investigates cage / tries to escape;  
2 presses lever by chance;  
3 food / reward, appears;  
4 ref to (positive) reinforcement;  
5 ref to repetition;  
6 associative learning;  
7 AVP; e.g. trial and error 3 max

[3]

**78.** (i) S dorsal root ganglion;  
T relay / intermediate / bipolar / internuncial, neurone; 2

(ii) 1 rapid / fast acting;  
2 short lived;  
3 automatic / involuntary / no conscious thought / brain not involved;  
4 not learned / innate / genetic / inborn / instinctive;  
5 response the same each time / stereotypical;  
6 AVP; e.g. safety / survival 3 max

(iii) 1 distortion / AW;  
2 Na+, gates / channels, open; **A** sodium / Na  
3 Na+ / sodium ions, enter; **R** sodium / Na  
4 depolarisation / –65mV to +40mV;  
5 receptor / generator, potential;  
6 ref to threshold;  
7 action potential; *allow only if linked to idea of threshold reached* 3 max

(iv) neurotransmitter only, in presynaptic knob / released from presynaptic  
membrane;  
receptors only on postsynaptic membrane;  
ref to refractory period / hyperpolarisation; 2 max

[10]

**79.** 1 eutrophication;  
2 increased growth of, algae / seaweeds;  
3 block, light / space;  
4 ref to competition;  
5 (so) alters food chain / example;  
6 decomposition of, sewage / dead organisms;  
7 ref to aerobic bacteria / increased BOD / less oxygen in water;  
8 fish / sea slugs / sponges / corals, die; (linked to oxygen loss)  
9 AVP; e.g. increased mineral nutrients increases susceptibility of corals to  
 disease,  
 increased numbers of anaerobic species, ref to heavy metal toxicity 4 max

[4]

**80.** humans are eukaryotes / *Escherichia coli* is a prokaryote;

*humans / eukaryotes have (accept ora)*larger, proteins / genes;  
introns;  
‘junk’ DNA / non-coding DNA;  
repeating sequences;  
centromeres / telomeres;  
fossil genes;

*E. coli* cell much smaller; *ora*selection for, less waste of space / more compact genome; 2 max

[2]

**81.** (i) semi-conservative replication;  
DNA, polymerase / helicase;  
breaks hydrogen bonds between two DNA strands / unzips DNA;  
each DNA strand acts as a template / both strands copied;  
complementary base-pairing (with free DNA nucleotides);  
sugar-phosphate backbone forms; 2 max

(ii) crossing-over;  
in prophase;  
recombination of, non-sister / maternal and paternal, DNA;  
AVP; e.g. matching cuts in DNA  
 DNA ligase 2 max

(iii) synapsis / to hold, (homologous) chromosomes / bivalent, together;  
(so close enough) for crossing-over;  
so can be evenly segregated;  
AVP; e.g. to package or support chromosomes,  
 avoid DNA breaking,  
 easier to move DNA 2 max

[6]

**82.** (a) (i) mRNA leaves nucleus; *ora*mRNA, translated / used to make, protein;  
DNA, transcribed / used to make, mRNA;  
mRNA short-term / DNA (long-term) store; 2 max

(ii) siRNA smaller / fewer nucleotides / only matches part of gene; *ora*siRNA double-stranded; *ora* 2

(b) (complementary) base-pairing;  
hydrogen bonding;  
between purines and pyrimidines;  
A with U; **R** A with T  
C with G;  
ref to 2 or 3 bonds (correct context); 3 max

[7]

**83.** (i) *(CCR5 / macrophages)*(siRNAs continue to work) in long-lived cells;  
only one treatment needed for macrophages / CCR5;  
(siRNAs diluted) as lymphocytes divide; *ora*repeat treatments needed for, lymphocytes / CD4; 2

(ii) *(CCR5)*because no essential function in body / absence not a problem; 1

[3]

**84.** (a) *do not credit if any incorrect answer included*

(i) fox; 1

(ii) grass / clover / legume; 1

(b) (i) nitrogen fixation / Haber (process); **A** reduction 1

(ii) lightning; **A**oxidation / combines with oxygen  
 **A *‘***lightening’  
 **R**thunderstorm / lighting 1

(iii) denitrifying; **A** correct e.g.(Pseudomonas)  
 **R** Nitrobacter / Nitrosomonas / Rhizobium 1

(iv) fixes nitrogen / provides fixed nitrogen *or* NH4(+); **R**ammonia  
ref to**,** clover / legume / named legume, making,amino acids /  
polypeptides / protein;  
(plant has) no need to rely on (fixed) nitrogen compounds in soil;  
**R***ref to fertilisers*free-living species provide,ammonium (ions) / fixed nitrogen,for nitrifying bacteria / nitrification; 2 max

[7]

**85.** (i) restriction (enzyme) / endonuclease; **A**named e.g. 1

(ii) (DNA) ligase; 1

[2]

**86.** 23 ;

6-7 ;

[2]

**87.** (i) **A**, **B** and **E** ; 1

(ii) *apply ora throughout*

produced by, sexual reproduction / fusion of gametes / fertilisation ;

ref to random mating ; *random fertilisation* *= 2 marks*

contain chromosomes from two individuals / diploid organisms ;

more alleles ; 2 max

(iii) **C** and **D** are haploid organisms ;

haploid cells have, one set of chromosomes / half the number of  
chromosomes ;

meiosis requires pairing of homologous chromosomes ;

ref to maintaining chromosome number when gametes fuse / gametes  
must be haploid ; 2 max

[5]

**88.** *marking points 1,6 and 9 must be linked to correct statements as to what is*  
*taking place in these stages to gain the mark.*

**1** prophase 1 ;

**2** synapsis / homologous chromosomes pair up / bivalents form ;

**3** crossing over ;

**4** chiasma(ta) occur ;

**5** DNA / alleles, exchanged ; **A** linked genes separated ;

**6** metaphase 1 ;

**7** independent / random, assortment ;

**8** bivalents line up on equator, independent of each other / randomly ;

**9** metaphase 2 ;

**10** independent assortment of chromatids ;

**11** chromosome mutation ;

**12** named example ; e.g. non-disjunction

**13** AVP ; e.g. ref to non-sister / non-identical, chromatids. 7 max

**QWC  clear well organised using specialist terms** ;

*award the QWC mark if four of the following are used in correct context*  
prophase, metaphase, homologous, bivalent, chiasma, crossing over,  
independent assortment 1

[8]

**89.** parent genotypes baby blood group

|  |  |
| --- | --- |
|  | O ; *mark across each line in table*  B ; *if no marks gained mark down columns*  A ; *max 2 marks if baby blood groups correct*  AB ; |

[4]

**90.** ADH / anti diuretic hormone ;

reduces blood sugar levels / correct mechanism to achieve this ;

increases blood sugar levels / correct mechanism to achieve this ;

ABA / abscisic acid ;

auxin / IAA ;

[5]

**91.** **1** ref to change in receptor ;

**2** creates, receptor potential / generator potential ;

**3** if greater than threshold value ;

**4** depolarisation / AW, (of axon / sensory / afferent, neurone) ;

**5** ref to action potential (*anywhere in answer*) ;

**6** ref to, myelin sheath / myelinated neurones ;

**7** saltatory conduction / AW ;

**8** ref to nodes of Ranvier ;

**9** synapse with, motor / effector / efferent, neurone ;

**10** ref to, calcium ions / calcium channels ;

**11** vesicles of neurotransmitter fuse with presynaptic membrane ;

**12** named neurotransmitter ;

**13** secretion / exocytosis (from presynaptic membrane) ; **R** release

**14** diffusion across synaptic cleft ;

**15** receptors on postsynaptic membrane ;

**16** depolarisation / AW, (of postsynaptic membrane / motor neurone) ;

**17** ref to, neuromuscular junction / motor end plate ;

**18** AVP ; e.g. ion movement,

refractory period

voltage-gated channels 8 max

**QWC – legible text with accurate spelling, punctuation and grammar** ; 1

[9]

**92.** (a) (i) produced by asexual reproduction ;

one parent / no gamete formation ;

genetically identical (to parent) ;

produced by mitosis ; 2 max

(ii) keeps, desirable characteristics / high productivity / AW ;

quicker / no germination time ;

stronger / more likely to survive ;

mass production / more produced ;

disease free ; 2 max

(iii) induce seedless fruit ;

increase fruit size ;

improve fruit set ;

avoid need for pollination ;

AVP ; e.g. weedkiller / inhibits sprouting in potatoes / prevents  
premature fruit drop 2 max

(iv) large surface area ;

absorbs water ;

by osmosis / down a water potential gradient ;

ions / named ion(s) ;

ions pass through cell surface membrane ;

protein, channels / carriers ;

active transport ;

help to prepare cuttings for transplanting to soil / AW ;

AVP ; 4 max

(b) sucrose ;

amino acids ;

vitamins ;

ions / named ions ;

auxins ;

cytokinins ;

water ;

agar ; 3 max

(c) labour intensive ;

sterile conditions ;

special equipment ;

trained staff ;

electricity / power, costs ;

quality control of process ;

AVP ; e.g. set up costs 3 max

(d) grafting / budding / described ;

layering / described ; 1 max

[17]

**93.** (a) (i) epistasis ;

dominant ;

correct ref to epistatic and hypostatic gene ;

ref to protein / enzyme / inhibitor, product of allele A ;

prevents, transcription / translation ;

inhibits, expression / gene action ;

blocks enzyme activity ; 3 max

(ii) small number of phenotypes ;

distinct (phenotypic) classes ;

qualitative ;

two genes / AW ;

large effect ;

different genes have different effects ;

not environmental ;

AVP ; 3 max

(b) (i) emasculate /remove stamens from / male sterility gene in, seed parent ;

bag flowers, before / after, pollination ;

grow in isolation ;

transfer pollen by hand ; 2 max

(ii) increase genetic contribution of that species / *ora* ;

keep (alleles of) background genes of that species ;

so that only A/a exchanged / AW ;

to see effect of A/a in other species ; 2 max

(iii) to produce, homozygous recessive / aa / AW ;

so that, wanted allele / desired trait, expressed ; 1 max

(c) pollinators can distinguish colour ;

bees attracted to pink ; [A refs to ‘blue’ or UV re pink]

swapping alleles reduces visits by normal pollinator ;

swapping alleles attracts wrong pollinator ;

selectively bred / aa / red *M lewisii*, decreases bumblebee visits;

but does not attract many hummingbirds ;

selectively bred / Aa / pink *M. cardinalis*, attracts bumblebees;

and decreases hummingbird visits only slightly ;

ref comparative figures ;

colour important to bees ;

colour not important to hummingbirds / some other feature important  
to hummingbirds ;

AVP ; 4 max

[15]

**94.** more transcription by QQ genotype ;

at both ages ;

in both skeletal and cardiac muscle ;

**A** *‘throughout’ / ‘in all cases’ for 1 mark of these 2*

much more in skeletal muscle / slightly more in cardiac muscle ;

in QQ genotypes expression falls with age in both skeletal and cardiac muscle ;

in qq genotypes expression rises with age in skeletal but falls in cardiac muscle ;

use of comparative figures ; 4 max

[4]

**95.** (a) **1** gene bank ;

**2** ref to wild type ;

**3** maintain genetic diversity ;

**4** ref to, loss of alleles / genetic erosion ;

**5** may have appropriate trait for breeding ;

**6** for future use ;

**7** requirements of breeders change ;

**8** in case, climate change / different conditions ;

**9** ref to, temperature / global warming ;

**10** ref to, pH tolerance / acid rain ;

**11** as yet unknown traits may be useful ;

**12** in case other named change ;

**13** may lose trait if interbred ;

**14** may form part of, food web / community ;

**15** that cannot be replaced ;

**16** adapted for, habitat / niche ;

**17** hybrids less well adapted ;

**18** ref to extinction ;

**19** AVP ; e.g. need to maintain population for leisure fishing

**20** AVP ; 8 max

**QWC – legible text with accurate spelling, punctuation and**  
**grammar**; 1

(b) (i) enzyme from bacterium ;

break down DNA of invading (bacterio)phages ;

ref to specific site of DNA ;

detail of site (4 - 6 bp / palindromic) ;

cut DNA ;

leaving blunt ends ;

or sticky ends ; 3 max

(ii) *crucian carp* 1 (thick) band in correct position (*see diagram*) ;

*hybrid goldfish x common carp 2* (thin) bands in correct position ;

*hybrid common carp x crucian carp 2* (thin) bands in correct position ; 3



[15]

**96.** (a) mRNA and its complementary RNA bind together ;

hydrogen bonding ;

A to U and C to G ; **R** ‘T’

double stranded RNA / duplex RNA ;

cannot bind to ribosome ;

tRNA cannot bind ;

cannot be translated / AW;

ref to, RNA interference / RNAi ; 4 max

(b) (i) theobromine content, reduced / approximately halved ;

no significant difference between short and long lengths of RNA ;

caffeine content reduced ;

to half by short lengths of RNA ; **A** figures

to about a third by long lengths of RNA ; **A** figures 3 max

(ii) (re caffeine) greater chance of pairing longer length with mRNA ;

AVP ; 1

(iii) explant of meristematic / cambium / totipotent / pluripotent, cells  
/ tissue ;

explant (surface) sterilised / sterile nutrient ;

appropriate hormone to stimulate, mitosis / division ;

callus formed ;

subdivided ;

appropriate hormone to stimulate differentiation ;

plantlet formed ;

hardening medium / sterile soil 4 max

(iv) genetically identical ;

genotype does not affect result ;

easily genetically engineered ;

plants derived from it identically genetically engineered / AW ;

large numbers easily obtained ;

early stages compact ; 3 max

so easily kept in identical conditions ;

[15]

**97.** (a) penetration of biofilm difficult ;

ref to diffusion of antibiotic ;

detail of diffusion ;

larger SA of separate bacteria / *ora* ;

does not reach all bacteria in film / *ora* ;

antibiotic trapped by film ;

detail of entrapment ;

dead bacteria in film form barrier ;

AVP ; e.g. horizontal transmission / conjugation, easier in biofilm

AVP ; 4 max

(b) both strains have identical sensitivity when in suspension ;

to all three antibiotics ;

both, less sensitive / more resistant, when in biofilms (*ora*) ;

strain 1 much, less sensitive / more resistant ;

comparative figures ;

C most effective / AW ;

B least effective / AW ; 4 max

(c) mutation ;

random / chance / pre-existing ;

detail of mutation ; e.g. base substitution, addition, deletion

ref to, selection / selective advantage ;

codes for different, glucan / biofilm ;

affects all three antibiotics ;

blocks antibiotic from reaching cells ;

binds antibiotics ; 4 max

(d) horizontal transmission ;

(copy of) plasmid ;

via conjugation ;

detail ; conjugation tube / ‘R’ plasmid / single strand DNA transferred

via transformation ;

transferred by (bacterio)phage ; 3 max

[15]

**98.** preservation of, organisms / environments ;

that are at risk from human activity ;

requires management ;

creation of new habitats ;

may need reclamation ;

conservation requires vigilance ;

resolving conflicts ; **A** suitable alternatives 2 max

[2]

**99.** (i) (penicillin) secondary metabolite ;

produced at start of / during stationary phase / end of growth phase ; **A** log  
phase ref to production (at maximum) when kept short of nutrients  
/ nutrients depleting / factors limiting growth ;

continuous culture maintains in, log / rapid growth, phase ; 2 max

(ii) to provide respiratory substrate / energy ; **A** for respiration

to maintain culture / keep culture alive / prevent (premature) death of  
culture ;

(limited) maintains in stationary phase / prevents rapid growth ;

AVP ; **R** glucose as carbon source 2 max

[4]

**100.** (i) type of starch ;

concentration of, starch / suspension ;

volume of, starch / suspension ; **R** amount

ref to flow rate ;

size of beads ; **A** number / mass / volume, of beads in column **R** amount  
temperature ;

length / diameter, of column ;

yeast concentration ;

pH ;

AVP ; e.g. age of culture 3 max

(ii) add Benedict’s (reagent) and, boil / heat ; **A** CuSO4 in alkaline solution

different, densities / colours (of precipitates) formed ; **A** turbidities

use of a colorimeter in correct context ;

**A** filtering and weighing precipitate

**OR**

use of Clinistix / Diastix (strips) ;

different colours obtained ;

colour compared to chart ;

*accept other valid methods e.g. reference to use of biosensors* 2 max

(iii) *agree*

not all yeast cells successfully entrapped / AW ;

(in product) yeast cells, respiring / metabolising / using sugar as an  
energy source ;

(so) lower levels of sugar (in product) ;

*not agree*

yeast cells, entrapped (in beads) / immobilised, so product not contaminated  
/ yeast not present to affect product ;

yeast cells unable to pass through, glass wool / filter ;

only very low numbers of yeast cells (so unlikely to have great effect) ; 2 max

[7]

**101.** (i) habituation / associative ; 1

(ii) no threat ;

no waste of energy ;

less stress ;

AVP ; 2 max

[3]

**102.** ref. faster / rapid / AW ;

AVP ; e.g. survival 1 max

[1]

**103.** (i) corpus callosum ; 1

(ii) cerebellum ;

medulla (oblongata) ;

hypothalamus ;

cerebrum / cerebral cortex ; 4

[5]

**104.** acetylcholine – neurotransmitter / AW ;

acetylcholinesterase – breaks down ACh / enables repolarisation of post synaptic membrane ;

[2]

**105.** (i) stimulus causes, increase in tension / twitch ;

fluctuation in tension / AW ;

overall increase in tension ;

AVP ; e.g. ref to figs (must have time units) 2 max

(ii) state of constant, contraction / tension ; **R** paralysed alone

correct ref. to heart ;

difficulty in ingestion / jaw muscles fixed ;

rib / intercostal, muscles remain contracted ;

difficulty in, lung ventilation / breathing ;

AVP ; e.g. fever / headache 3 max

[5]

**106.** **1** ATP produced ;

**2** Na+ *or* K+ pump / maintains concentration gradient / repolarisation ;

*transmission of impulses*

**3** acetylcholine / neurotransmitter formation ;

**4** vesicle formation ;

**5** movement of vesicles ;

**6** exocytosis / vesicles fuse with membrane ;

**7** ref. active transport (of ACh / Ca2+) ;

**8** AVP ; e.g. ref to microtubules / endocytosis 4 max

*muscular contraction*

**9** ATP attaches to myosin head / ATPase ;

**10** hydrolysis of ATP / ATP → ADP + P ;

**11** myosin head tilts / shortening of sarcomere ;

**12** ATP / energy, required for detachment of myosin head ;

**13** from actin ;

**14** calcium pumps in sarcoplasmic reticulum ;

**15** synthesis of protein (for repair, growth) ;

**16** AVP ; 5 max 8 max

**QWC – clear, well-organised using specialist terms** ; 1

*award the QWC mark if four of the following are used in correct* *context*  
acetylcholine, actin, myosin, sarcoplasmic reticulum, exocytosis,  
hydrolysis, repolarisation

[9]

**107.** (i) higher, number / proportion / percentage / ratio / fraction, of mounds  
have thyme ;

(c.f. quadrats) *ora*

**A** figs, e.g. ⅔ vs ½, 2:1 vs 1:1, 36 vs 24 1

(ii) *look for a statement and a reason*

use smaller quadrat ; e.g. 50 cm × 50 cm

for fair test ; AW

use grid and random numbers ;

throwing keys biased ; AW

estimate, percentage cover / abundance ; **A** point (frame) quadrat

may be single plants in some samples and many in others ;

bigger study area / more data ; (keep equal numbers mounds and quadrats)

improves reliability / AW ;

record other plants ;

could influence thyme ;

measure / note, abiotic variables ; **A** example

explanation of how named variable affects thyme ;

AVP ;

AVP ; 4 max

[5]

**108.** (a) (i) steep increase, for the first 1 - 2 hours / till 2.2 - 3.8 (a.u) ; **A** linear,  
steady became constant at, 3 hours / 4.3 (a.u) ;

*if no figs in description, e.g. ‘rose then constant’ award 1 mark max* 2

(ii) (increased as) enzyme working / rate of reaction high / reaction  
proceeding ;

(increased as) substrate converted into, drug / product ;

(levelled off / became constant, after the) enzyme, became inactive /  
was denatured;

(levelled off / became constant) because product inhibits, reaction /  
enzyme ;

**R** references to enzyme or substrate being used up **R** T ºC limiting 2

(b) pH ;

degree of mixing ;

enzyme concentration ;

AVP ; e.g. ref to concentration of inhibitors 1 max

(c) *max of 2 marks for predicting* ***or*** *explaining*

**P1** concentration of drug higher / AW ;

**P2** rate of reaction slower / AW ;

**P3** may not level off (in time scale shown on graph) ;

**P4** time taken to reach the maximum yield (approximately)  
doubles ; (c.f. 15 ºC)

**E1** not denatured ;

**E2** adapted to 5 ºC / optimum / body / usual, temperature ;

**E3** ref to Q10 of about 2 ;

**E4** ref to lower kinetic energy / AW ;

**E5** ref to E-S, collisions / complexes ;

AVP ; e.g. ref to active site 3 max

(d) (i) (shaded amino acids) form the active site ;

substrate may not attach to the active site ;

enzyme-substrate complex may not be formed / AW ; 1 max

(ii) 44 and 66 not part of active site ;

hold, active site / 3º structure / 3D structure, in shape ; **A** stop denaturing  
hydrogen bonds weak ;

easily broken by, vibration / heat ; **A** pH

disulphide bridge strong ;

not broken by heat ; 2 max

(e) nucleotide / base/ DNA, sequence codes for, protein / amino acid, sequence ;

changes DNA ; **A** change triplet

makes different mRNA ; **A** change codon

transcription ;

different tRNAs line up ; **A** change anticodon

translation ;

different (amino acid sequence in), enzyme / protein / polypeptide ; 2 max

[13]

**109.** (a) *any two of the following*

(monomer) not glucose ;

contains nitrogen ;

contains, sulphur ;

AVP ; **R** ref to branching 2 max

(b) amount of glycoprotein varies (in different cells) ;

(cells carry out) endocytosis to different extents ;

cells have different life spans / example ;

no time for polysaccharide to accumulate in short lived cells ;

number / role, of lysosomes not same in all cell types ;

AVP ; 1 max

(c) *with Hunter’s syndrome, lysosomes / vesicles, might be*

larger ;

more numerous ;

have different shape ;

stain differently ;

AVP ; e.g. granular cytoplasm 1 max

(d) (i) unaffected parents can have an affected child ; *ora*

e.g. 3, 4, 8 / 11, 12, 16, 17 ; 1 max

(ii) only males affected ; *ora*

mothers pass it on ; *ora*

on the X chromosome ;

carrier women asymptomatic / dominant normal allele masks trait ;

4 / 11 / 1, could be carriers ; 2 max

(e) there are only 3 cases / too small a sample ;

mostly female line shown ;

AVP ; e.g. pedigree of, 3 / 12, not known

progeny of, 13 / 14 / 15, not known 1 max

(f) drug must act in all cells ;

lysosomes are within cells ;

hard for drug to reach ;

if drug acts as enzyme, polysaccharide on cell membranes may be broken  
down ;

tissue mechanical support would break down ;

AVP ;

AVP ; e.g. no animal model

protein drug digested in gut

rare condition (qualified), economic argument 2 max

[10]

**110.** (a) avoid attracting a mate of a different species ; *ora*

ensure reproductive isolation ; 1 max

(b) (i) diffusion ; 1

(ii) so that they do not receive oxygen constantly ;

there are mitochondria between them and the cell surface ; 1 max

(c) mitochondria / aerobic respiration / oxidative phosphorylation, inhibited  
only briefly ;

oxygen concentration decreases again ;

preventing, action of luciferase / production of light ;

each flash short ; *ora* e.g. so not continuously lit

AVP ; 2 max

(d) active transport ; **A** e.g. Na+/K+ pump

protein synthesis ;

synthesis of named substance ;

movement of organelles ;

phosphorylation of glucose ;

AVP ; ; ; e.g. transcription, translation, anabolic reaction

**R** respiration, DNA replication, chromosome movement, mitosis 3 max

(e) cells / membranes, damaged / disrupted ;

nitrous oxide released ;

mitochondria stop using oxygen ;

oxygen, allows light production / reaches light-producing organelles ;

in unlimited quantities / continuously, so light is brighter ;

respiration / oxidative phosphorylation, ceases ;

no more, ATP / NADH2 ;

luciferin, synthesis / regeneration, stops ;

AVP ; 3 max

(f) live bacteria, respire / produce ATP ; *ora* 1

(g) mRNA (coding for luciferase) ; **A** DNA 1

[13]

**111.** (a) (i) (place) where, organism / animal / plant / population /  
community, lives; **R** *things / named organism* 1

(ii) role of organism in**,** the ecosystem / AW; **A** *habitat / environment / community / area / place***R** *population* 1

(iii) living / biotic**,** and,non-living / abiotic,components that interact; 1

(b) population = one species  
**and** community = more than one / all,species / population; 1

[4]

**112.** (i) **1** some food not, eaten / accessible; **A** *an example*

**2** some**,** food / energy,not digested / egested / lost as faeces;

**3** (some assimilated) food / energy,lost in excretion;

**4** ref to decomposers;

**5** (some assimilated) food / energy, lost in respiration;

**6** energy lost**,** as heat / in movement / in metabolism;

**7** small proportion energy used for**,** growth / material**,**and is available to next trophic level; 3max

(ii) **1** plant material difficult to digest / animal material can be digested  
easily;

**2** ref to, cellulose / lignin / wood;

**3** no cellulase;

**4** (animal) gives similar spectrum of amino acids (as consumer);

**5** less of the producer available to the 1° consumer than 1° consumer  
available to the 2° consumer;

**6** AVP;e.g. ref to gut bacteria

*ignore references to numbers of organisms eaten or size of organisms* 2 max

[5]

**113.** (i) Q, S, P, N, M, R ; 1

(ii) *accept correct names of stages*

Q ; **A** prophase 1

M ; **A** anaphase 2

Q / S ; **A** prophase 1 / metaphase 1

S ; **A** metaphase 1

R ; **A** telophase 2 5

(iii) DNA replication ;

synthesis of proteins / named protein ; **A** transcription / translation

synthesis of membrane ;

synthesis of, organelle(s) / named organelle ;

respiration ;

AVP ; e.g. centrioles replicate ; 2 max

[8]

**114.** (i) Individual 2 - XHY ;

Individual 5 - XhY ;

Individual 6 - XHY ;

Individual 9 - XHXh ;

*max 2 if sex chromosomes not shown* 4

(ii) half / 0.5 / 50% / 1 in 2 ; **A** 1:1, 50:50 **R** 1:2 1

(iii) carriers have, both / H and h / dominant and recessive, alleles ; **A** are  
heterozygous **R** two alleles

females have two X chromosomes / ora ; 2

[7]

**115.** (a) (i) curve to have peaks to right of lemming peaks and must have two  
peaks between 1994 and 1996 and 1998 and 2000 respectively ;

peaks below level of lemming peaks ; 2

(ii) plenty / AW, of food ;

few / AW, predators ;

high population of alternative prey for predators ;

no overcrowding / lots of breeding sites / AW ;

less disease ;

less competition from other species ;

low environmental resistance ; 3 max

(b) *interspecific*

between two (or more) species ;

two named species (on lemmings) ;

*intraspecific*

within species ;

named species plus resource ;

*if definitions of interspecific and intraspecific competition are the wrong*  
*way around can still gain one mark for correct examples of both types*  
*of competition* 3 max

(c) maximum, size / number, of a, population / species ;

*either*

(supported) in a particular, habitat / ecosystem / area / environment ;

*or*

determined by limiting factors ; 2

[10]

**116.** (a) form of a gene ;

position of, gene / allele on, chromosome / DNA ; 2

(b) **1** *Woodland* more, dark / unbanded, snails **or** fewer, light /

banded, snails ;

**2** better camouflaged / ora ;

**3** against, leaf litter / uniform background ;

**4** relevant woodland data quote on colour **and**

banding ;

**5** *Grassland* more, yellow / banded, snails **or** fewer, dark /

unbanded, snails ;

**6** better camouflaged / ora ; ***(only award if missed***

***point 2)***

**7** against, pale / yellow / green / variable,

background ;

**8** relevant grassland data quote on colour **and**

banding ;

**9** survivors posses advantageous alleles / ora ;

**10** reproduce ;

**11** pass alleles on (to, offspring / next generation) ;

**12** ref to stabilising selection (in both habitats) ;

**13** ref to other **named** selection pressure(s) ;

**14** not a very mobile population *or* little, immigration / emigration ;

**15** separate gene pools described ;

**16** little mutation taking place ; **A** no new camouflage method over time

**17** habitat stable ;

**18** ref to why unfavourable alleles have not disappeared ;

**19** AVP ; e.g. calculated average figures for both habitats 8 max

**QWC – clear well organised using specialist terms** ;

clear and well organised and must include marking points 4 and 8 1

[11]

**117.** (a) transmit (information) between neurones ;

ensure one way transmission of impulses ;

integration of nerve pathways ; **A** allows, convergence / divergence /  
summation filter out low level stimuli ;

prevent overstimulation and fatigue ;

ref to inhibition ; 2 max

AVP ; e.g. role in, learning / memory

(b) vesicles move to presynaptic membrane ;

vesicles fuse with presynaptic membrane ;

exocytosis / AW ;

neurotransmitter moves across synaptic cleft ;

neurotransmitter binds to receptor on postsynaptic membrane ;

recycling of neurotransmitter / channels for uptake of neurotransmitter ; 3 max

(c) **1** to allow repolarisation to occur ;

**2** by unblocking (neurotransmitter) receptor ;

**3** prevents sodium channels remaining open ;

**4** so more neurotransmitter can bind ;

**5** new action potential is generated ;

**6** to allow movement to occur ;

**7** recycling of neurotransmitter ;

**8** AVP ;

*or*

**1** permanently depolarised ;

**2** receptors (permanently) blocked ;

**3** sodium channels open ;

**4** no more neurotransmitter can bind ;

**5** no new action potential / action potentials continuously fired ;

**6** continuous contraction / AW ;

**7** no recycling of neurotransmitter ;

**8** AVP ; 2 max

[7]

**118.** (a) estimate of role of genotype in phenotypic variation / AW ;

heritability = VG / VP ;

when heritability high much of variation is, genetic / not environmental  
/ ora ;

high heritability will result in successful selective breeding / ora ; 2 max

(b) single / major / Mendelian, gene ;

large effect ;

little environmental effect ;

dominant allele T expressed in homo- and heterozygote ;

not polygenic ;

not additive ;

discontinuous variation / not continuous variation ;

qualitative / not quantitative ; 2 max

(c) (i) triplet of bases that does not code for an amino acid ;

ATT / ATC / ACT ;

code to mark end of gene ;

code to stop transcription / ref to disengagement RNA polymerase ; 2 max

(ii) transcription halted early / AW ;

protein will, be smaller / have fewer amino acids ;

tertiary structure / 3D shape different ;

binding / affinity, different ;

protein inactive ; 3 max

ref to *lac* operon ;

(iii) ref to, promoter / operator / ‘on’ switch ;

allele T is regulator ;

(protein) binds to DNA ;

(protein) binds to repressor and prevents it binding to DNA ;

allows RNA polymerase to bind ;

AVP ; e.g. enzyme affecting transcription 2 max

(d) (i) tt + T / AW, increases number of tillers per plant ;

and number of branches per tiller ;

ref to comparative figures ; 2 max

(ii) inserted into genome randomly / cannot choose where it is inserted ;

may be within a frequently expressed gene ;

may be after an ‘on’ switch ;

lacks normal controls ;

AVP ; e.g. no other alleles affecting it 2 max

different promoter

[15]

**119.** **1** both result from changes in allele frequencies ;

**2** selective breeding often faster than evolution / ora ;

**3** both require selection of parents ;

**4** to pass alleles to offspring ;

**5** selective breeding involves artificial selection ;

**6** v. evolution involves natural selection ;

**7** man selective agent in selective breeding ;

**8** v. whole environment selective agent in, natural selection / evolution ;

**9** selective breeding for benefit of man ;

**10** may be detrimental to organism / e.g. detriment ;

**11** v. fitness for environment ;

**12** single / few, trait(s) in selective breeding ;

**13** v. whole, phenotype / genotype ;

**14** AVP ;

**15** AVP ; 8 max

**QWC – legible text with accurate spelling, punctuation and grammar**; 1

[9]

**120.** (i) depends on plant growth regulators ; **A** plant growth substances / plant hormones

named plant growth regulator ;

produced in a variety of tissues ;

may have effect at a distance ;

move, cell to cell / by diffusion / by active transport / via vascular tissue

via a named vascular tissue / via plasmodesmata ;

different effects in different tissues ;

different effects when acting together ; 2 max

(ii) coordinate, growth / development / activities, of different parts ;

respond to internal changes ;

respond to, external / environmental / e.g. environmental, change ;

AVP ; e.g. comparison with animals 2 max

[4]

**121.** (i) economy of, materials / resources ;

economy of energy ;

saves unnecessary, transcription / translation ; 2 max

(ii) random / chance / preexisting, mutation (for resistance) ;

resistants survive / susceptibles die ;

natural selection ;

insecticide selective agent ; ***A*** selective pressure

resistants pass, mutation / allele for resistance, to offspring ; **R** gene

frequency of, mutation / allele for resistance, increases in population ; 5 max

[7]

**122.** plant signal used by earworms ;

**J** switches on gene coding for **E** ;

can then break down insecticide ;

effect on transcription ; (× 5.5)

reduces mortality ;

even in absence of insecticide ;

in absence of **J**, mortality, high / c. 87% ;

ref to comparative figures ;

e.g. 87 to 48% / almost halved, in presence of insecticide

16 to 7% / more than halved, in absence of insecticide

slight expression of **E** in absence of **J** caused by insecticide ; 4 max

[4]

**123.** (a) rDNA = DNA from two sources ;

both DNAs cut with, restriction enzyme / named restriction enzyme ;

giving sticky ends ;

or giving blunt ends to which sticky ends added ;

complementary binding of sticky ends ;

H bonds / e.g. A to T / e.g. C to G ;

nicks in (sugar-phosphate) backbone sealed by ligase ; 3 max

(b) percentage / proportion, of, muscle fibres with central nuclei / dying muscle

fibres, increases in control with time ;

percentage / proportion, of, muscle fibres with central nuclei / dying muscle  
fibres, reduced by treatment ;

ref to comparative figures with percentages and day ; 3

(c) *advantages*

**1** can identify presence of disorder ;

**2** removes uncertainty ;

**3** allows early treatment ;

**4** which may improve, life expectancy / quality of life ; **A** avoid  
unncessary suffering

**5** allows, informed choice about having children / planning healthy  
family ;

**6** allows IVF and, embryo screening / preimplantation genetic  
diagnosis (PGD) ;

**7** allows fetal testing and termination ;

**8** choice, re donation / adoption ;

**9** AVP ; e.g. detail of donation: AI(D) / egg donation / embryo  
donation

**maximum 5 on advantages**

*disadvantages*

**10** false, positives / negatives ;

**11** may not be test for all mutations ;

**12** only small number tests available / not available for all conditions ;

**13** simple presence may not result in condition ;

**14** confirmed presence gives stress / fear ;

**15** problem *re*, telling / testing, rest of family ;

**16** discrimination by, employers / insurers ;

**17** ethics of termination ;

**18** AVP ; e.g. detail of problem of test, risk of test procedure,  
diagnosis and elimination rather than treatment, increase  
in, intolerance / discrimination, of disabled, ‘designer’  
problem **maximum 5 on disadvantages**

8 max

**QWC – clear well organised using specialist terms**; 1

*must include both advantages and disadvantages and two terms*  
*such as*

life expectancy, quality of life,

IVF, PGD, PGH, AI(D),

amniocentesis,

CVS, karyotype,

false positive, false negative

[15]

**124.** (i) natural change in species composition (in an area) ;

ref to directional change ;

ref to named examples in the diagram (either species or category) ;

over a period of time ;

a number of recognisable stages / seres / seral stages ;

one sere changes the conditions for the next ;

e.g. depth of soil increases / soil stabilisation ;

leads to a climax community ;

creation of niches ;

ref to nitrogen fixation ;

AVP ; e.g. pioneer species 4 max

(ii) development of deeper soil ;

soil, becomes rich in humus / has more nutrients / is more fertile ;

dominant species change ;

plant species get larger / shrubs to trees / increase in biomass / larger  
root systems ;

**R** soil structure improves unqualified ;

AVP ; 2 max

(iii) **biotic** = animal species / number of soil organisms / decomposers /

detritivores / decrease in biodiversity ;

AVP ;

**abiotic** = pH of soil / nitrogen *or* mineral content of soil / soil texture

/ wind speed / humidity / shading / light intensity / soil  
water retention ;

AVP ; e.g. temperature 2 max

[8]

**125.** *award marks if diagram clearly annotated*

reservoir for storage of nutrients ;

ref to method for addition of nutrients and removal, of waste / products ;

**A** substrate

ref to more detail of, nutrient addition / product removal, at a constant rate /  
continually / throughout fermentation period ;

idea of rate of product removal equal to addition of nutrients ;

**A** keep volume constant

use of probes / sensors / monitors ; **A** thermometer (for temperature)

(to monitor) any two of, temperature / pH / oxygen levels ;

method to maintain pH e.g. use of buffers, tube to add acid / alkali ;

addition of antifoam ;

ref. to need to maintain sterility (to avoid contamination) ;

method to maintain constant temperature e.g. (thermostatically-controlled) water  
bath, cooling jacket ; **R** heat exchanger

AVP ; e.g. use of stirrer, method to avoid, clumping of cells / blocking of inlet *or*  
outlet pipe(s) 4 max

[4]

**126.** *any three acceptable e.g.*

disease / virus, free ;

genetically identical / clone ;

maintain, favourable characteristics / advantageous phenotypes ;

faster method ;

produces many plants ;

allows long-term storage of plant tissue ;

easily genetically manipulated / example of genetic manipulation ;

easier exchange between countries as no quarantine ;

enables optimal production of useful secondary products (e.g. codeine  
from poppy) ;

no external environmental influences ;

no influence of seasonal variation ;

AVP ; e.g. use for, sterile / infertile, plants,

AVP ; named example of advantageous phenotype e.g. grow more vigorously

use for rare or endangered plants

relevant example of genetic manipulation 3 max

[3]

**127.** *answers referring to insulin production can also be credited in mp 2,3,4*

**1** *Escherichia coli* ; **A** *E. coli*

*genetic engineering* 3 max

**2** amino acid sequence (of HGH), known / analysed ;

**3** gene coding for HGH synthesised ;

**4** using, triplet code / genetic code ;

*OR*

**5** mRNA (coding for insulin) from beta cells ;

**6** use reverse transcriptase ;

**7** synthesise cDNA ;

**5** plasmid (vector) ;

**6** cut using restriction (endonuclease) enzyme ;

**7** ref to gene and plasmid mixed with (DNA) ligase ;

**8** (recombinant) plasmid introduced into, bacterium / bacteria ; AW

*large scale production* 4 max

**9** genetically engineered / recombinant bacteria ;

**10** grown in fermenter / fermentation, qualified ;

**11** reproduce / replicate / multiply / undergo binary fission / form a clone

/ large numbers / millions of bacteria / gene cloning ;

**12** idea of gene expression / transcription and translation, for HGH,  
synthesis / production ; **A** *insulin when relevant*

**13** downstream processing ;

**14** separation / purification, of growth hormone ; **A** *insulin when relevant*

**15** AVP ; e.g. ref to screening using antibiotic resistance markers

**16** AVP ; scaling up to determine optimum operating conditions

bacteria killed and separated (from proteins)

by centrifugation

growth hormone separated from other, proteins / molecules

(product separated by) large scale chromatography / ultrafiltration

other detail of fermentation e.g. pH 5.5 – 8.0, temperature

20 – 45 ºC, aeration, glucose

doubling time 20 minutes 6 max

**QWC – clear, well organised with specialist terms** ; 1

*any three, used in context, from*

amino acid sequence (beta cells for insulin) / triplet (mRNA for insulin) /  
genetic code (reverse transcriptase for insulin), plasmid, vector, restriction  
enzyme, ligase, recombinant, genetically engineered, binary fission, clone,  
transcription, translation, downstream processing, screening, antibiotic  
resistance markers, centrifugation

[7]

**128.** surrounded by meninges ;

cerebrospinal fluid ;

absorbs shocks ;

brain protected by, cranium / skull ;

spinal cord protected by vertebrae ; 3 max

[3]

**129.** (i) time taken (to make choice) decreases ;

as number of trials increases / AW ;

ref to figures ;

idea chamber **B** chosen more often towards end of investigation ; 2 max

(ii) same, apparatus / conditions ;

different experimental mouse ;

*idea of* same species / same age / same gender, of (experimental) mouse ;

no companion mouse / **B** and **C** empty ;

same number of trials ;

AVP ; 3 max

(iii) time taken does not decrease significantly ;

roughly equal choice of chamber **B** or **C** / AW ; 1 max

(iv) trial and error learning / operant conditioning ;

ref to associative learning ;

companion animal is, reinforcer / reward ;

no conditioned stimulus ;

no conditioned response ;

AVP ; 3 max

[9]

**130.** (a) *plasmid DNA* *protein*

nucleotides / sugar + phosphate + base ; amino acids ;

4 different subunits ; 20 different subunits ;

phosphodiester bonds ; **A** phosphoester peptide bonds / polypeptide ;

contains P ; contains S / disulphide bonds ;

double-stranded / double helix ; may have 4º structure ;

circular ; ref to, 2º / 3º, structure / AW ;

AVP ; e.g. role of H bonds 3 max

(b) (i) stimulates, immune response / production of antibodies / T or B cells ; 1

(ii) stimulate, cell-mediated immunity / T cells ;

antigen, remains in body longer / continuously produced ;

antigens in blood only stimulate, humoral immune system / B cells ;

antigens (in blood) lost in urine / broken down in liver ;

ref to MHC ; 1 max

(c) (i) binds RNA polymerase ;

allows, transcription / production of mRNA ;

switches gene on / allows gene expression ; 2 max

(ii) (protect against) more than one, strain / disease / pathogen / AW ;

stronger immune response ;

less likely mutant form will escape immune response / AW ;

AVP ; cheaper / reduces number of vaccinations 2 max

(iii) Golgi modifies protein / polypeptide / AW ;

forms glycoproteins / add sugars *or* carbohydrate ;

Golgi forms vesicles ;

incorporated into cell membrane ; **R** exocytosis

AVP ; 2 max

(d) *cells that take up DNA vaccine might*

**1** function less well ;

**2** be killed by immune system / trigger auto-immune response ;

**3** have genes disrupted / mutation ;

**4** new gene might be inherited / AW ;

**5** plasmid could enter bacteria ;

**6** superbug / create new disease / AW ;

**7** effects unknown / new technology / no human trials ;

**8** AVP ; ref ethics, ref irreversible 3 max

[14]

**131.** U;V;Z;S; 4

[4]

**132.** (a) (i) **AaBB** white;

**aaBB** black;

**Aabb** white;

**aabb** brown; 4

(ii) (dominant) epistasis; 1

(iii) codes for inhibitor;

protein;

blocks transcription (of allele coding for pigment);

ref to, regulator / promoter;

blocks enzyme (producing pigment);

AVP; e.g. detail max 3

(b) (i) AaBb × AaBb / AaBb × Aabb;

both must have A because they are white;

\* both must, have a / not be homozygous AA, because some  
kittens coloured;

\* both must have b to give brown kittens;

• *‘must be heterozygous at both loci’ = 1 only*

at least one / one or both, must have B to give black kittens;

credit ref to Punnett square showing genotypes;

credit ref to Punnett square showing phenotypes; max 5

(ii) AaBb × AaBb 12 white : 3 black : 1 brown;;

AaBb × Aabb 6 white : 1 black : 1 brown;; max 2

[15]

**133.** (a) (i) gradual process / AW;

to improve traits;

to achieve homozygosity / AW;

best in each generation interbred;

ref to artificial selection;

ref to several traits involved / may be, additive / polygenic; max 2

(ii) ref to mitosis;

chromosomes replicated;

failure of, spindle / cell division; max 2

colchicine / other method;

(iii) self-pollination prevented;

pollination by foreign pollen prevented;

pollen transfer;

practical detail; max 2

(iv) 3n;

meiosis fails;

ref to, synapsis / homologous pairs; max 2

(b) (i) sterile explant;

sterile nutrient medium;

ref to plant growth regulators;

callus;

subdivided;

medium with different plant growth regulators;

plantlets / embryoids;

hardening medium / sterile soil;

AVP; e.g. appropriate plant growth regulators max 5

(ii) callus can be divided;

large numbers of identical plants; **A** clone

in short time;

bulk up sterile hybrid;

bulk up master hybrid lines;

no need for making more 4n; max 2

[15]

**134.** **A** / ‘marbling’;

scale 0 – 1;

measure of genetic v. environmental contribution;

high value most easily selected for;

value <0.02 results in no selective breeding;

ease of selection = ‘marbling’>growth rate>subcutaneous fat>‘rib eye’; max 3

all the traits / even ‘rib eye’, can be selected for;

[3]

**135.** increase in use of, GM crop / GE crop / Bt cotton;

no / less, insecticide needed;

reduced number of cases of pesticide poisoning;

ref to figures (e.g. by × 4.4);

reduced cost (insecticide);

ref to figures (e.g. by 0.62 US$ kg-1 / × 1.38);

ref to limitations of survey;

AVP;

**A** reverse arguments max 4

[4]

**136.** (i) ref to, rDNA / recombinant DNA;

restriction enzyme(s);

cut DNA at specific site(s);

detail site(s);

ref to viral DNA and, human DNA / DNA of gene;

ref to sticky ends;

complementary binding;

detail of binding; A = T / C = G / hydrogen bonds

ligase to seal ‘nicks’ in (sugar-phosphate) backbone; max 4

(ii) has effect when added to genome;

not masked;

no need to, remove / inactivate, recessive / mutant, allele; max 2

[6]

**137.** (i) trees are living organisms;

renewable;

ref to, growth / growing;

timber is, of use to human beings / made into products; max 2

(ii) harvested at levels which leave sufficient organisms;

to grow / reproduce, and replenish what has been harvested;

ref to, coppicing / replanting / afforestation;

can be carried on indefinitely; max 2

[4]

**138.** (a) cyclamen mite / prey populations increase;

when conditions are suitable / when predator numbers are low / no or  
few limiting factors;

provides plenty of food for predator mites;

which begin to increase later / time lag;

cyclamen mites are then eaten by (increasing numbers of) predators;

so both decline in numbers;

cycle repeated;

prey populations reach higher levels than predators; max 4

(b) (i) *start by looking at end of February*

increases with appropriate time lag;

decreases at spraying times (end of June / beginning of October);

final peak for predator numbers is the lowest; max 2

(ii) less food available / less strawberry plants;

low temperature / frost;

other predators;

disease / parasites;

ref to parasitoids;

AVP;

**R** spraying idea max 2

(c) (i) biological (pest control); 1

(ii) insecticides, are harmful to other organisms / may kill natural  
predators to the pest;

reduces species diversity / disrupts food chains;

many insecticides are, slow to biodegrade / long lasting;

concentrate along food chains / bioaccumulate / bioconcentrate;

stored in fat deposits of organisms;

ref to effects on top carnivores; e.g. egg shell thinning

poisonous to those applying them; **A** ref to humans / asthma sufferers

pests can build up a resistance;

ref to selection;

run-off from land carries them into water supplies / causes pollution /  
poisons aquatic organisms;

problems of residues in food;

AVP; e.g. pesticides need to be used repeatedly max 5

(d) crop rotation;

intercropping;

release of, irradiated / sterile, males of pest species;

AVP; e.g. fly paper max 2

[16]

**139.** (a) trees felled for wood to, sell / export;

cleared to provide land for agriculture; **A** cattle ranching

to build, housing / villages;

industrial development / mining / quarrying;

building of roads; max 3

(b) **1** high, biodiversity / species diversity;

**2** deforestation, causes extinction / reduces biodiversity;

**3** decrease in, size of gene pool / genetic diversity;

**4** act as carbon, reservoirs / sinks; **R** carbon fixation

**5** remove carbon dioxide from atmosphere;

**6** release of carbon dioxide when wood is burnt;

**7** less photosynthesis also means less oxygen production;

**8** transpiration contributes to atmospheric water content;

**9** destruction of rainforests disrupts water cycle;

**10** rainforests can be used to supply sustainable crops;

**11** example of crop; e.g nuts / rubber / fruits / plant oils

**12** drugs / other useful compounds (may await discovery), that only  
occur in rainforests;

**13** soils are nutrient deficient and cannot sustain agriculture;

**14** increased risk of soil erosion;

**15** moral responsibility to conserve for later generations;

**16** ref to indigenous populations / tribes;

**17** AVP; e.g. provision of habitats

ref to Fig. 1 max 8

**QWC – clear, well organised using specialist terms**; 1

*award the QWC mark if four of the following are used in correct*  
*context*

biodiversity transpiration

deforestation water cycle

carbon reservoirs / sinks sustainable

photosynthesis nutrient deficient

(c) ban on import of wood from, tropical rain forests / unsustainable sources;

introduce labelling system for wood;

trade sanctions on countries that continue to remove rain forests;

schemes / financial support, for setting up of sustainable use of rain forests;

development of ecotourism;

educate local population as to importance of rain forests;

forest reserves established;

AVP;

AVP; e.g. debt relief

fair trade schemes

quotas max 3

[15]

**140.** (a) *advantages (max 2)*

can be used with any species (irrespective of size);

does not require to distinguish one individual from another;

quick to assess; **R** simple

*disadvantages*

subjective / AW;

dominant species may be over-estimated; max 3

(b) (i) line established, from shore to dune slack / from… to…;

quadrat used;

suitable size / actual size stated (minimum 0.25m2); **R** if no units  
given

placed continuously / at specified intervals along line;

key to identify species;

abundance recorded in each quadrat;

bare ground recorded; max 4

(ii) **1** ACFOR scale converted to numerical scale;

**2** reading at each site recorded (on graph paper);

**3** width of diagram related to ACFOR (maybe shown on diagram);

**4** points from each site joined together;

**5** repeated for each species found present; max 3

(c) use of, thermometer / probe;

probe must be calibrated;

pushed into, sand / soil, to same depth each time;

repetitions at each sampling point; max 2

(d) (i) a stage during the process of succession; 1

(ii) sea couch / marram grass, grow in bare sand;

dune builds up / stabilised by grasses;

OR

colonisers established on bare, rock / soil;

example; (if not sand dunes)

ref to pioneer species;

organic matter builds up / humus content increases;

forming soil / depth of soil increases;

other species take over from grasses; **A** named example  
from Fig. 1

roots stabilise soil structure;

diversity of species increases;

climax eventually reached;

AVP;

AVP; e.g. reference to deflected succession,

growth of shrubs max 4

[17]

**141.** (a) (i) penicillin; **A** other named antibiotic 1

(ii) (complex organic molecules) produced after / not produced during,  
the (log / rapid / main) growth phase;

not essential for normal, cell growth / reproduction; max 1

(iii) batch / fed batch; 1

nutrients only added at start;

short / rapid, growth phase;

required product made, during stationary phase / late in life  
cycle; ora

**R** death phase

shortage / depletion of, nutrients / named nutrients;

cell division / reproduction, no longer occurring;

ref to addition of, glucose / lactose, at intervals  
(to avoid death of culture); max 2

(b) **1** air pressure will push the medium into the culture vessel;

**2** medium / nutrients, added to the culture at a constant rate / AW;

**3** algae / cells / *Chlorella*, removed / harvested, from the sample port;

**4** at the same rate as / to match, the nutrients added;

**5** so volume in fermenter remains constant;

**6** removal of, waste / toxic products;

**7** that could affect, growth / reproduction;

**8** (cells kept in) exponential / log / rapid / main, growth phase;

**9** algae are photosynthetic;

**10** light energy required;

**11** ref to use of fluorescent light to avoid overheating;

**12** ref to monitoring temperature;

**13** ref to optimum conditions; **A** ‘conditions for maximum growth’

**14** air bubbles to mix culture with nutrients / AW;

**15** air bubbles to allow algae to get sufficient light;

**16** air bubbles provide oxygen for (aerobic) respiration;

**17** and CO2 for photosynthesis;

**18** air flowing into the culture vessel flows out through an outflow tube;

**19** preventing build-up of pressure;

**20** AVP; e.g. sampling to check for mass of *Chlorella* max 6

(c)



heating / cooling, qualified;

foaming;

blocking of, inlet / outlet, tubes;

difficulties with, mixing / stirring;

contamination / keeping it sterile;

conditions need to be continuously monitored;

nutrient requirements may change;

AVP;

AVP; e.g. algal growth on glass

difficulties in providing sufficient light

errors lead to loss of several days production of *Chlorella* max 4

[15]

**142.** (i) RNA(i) combines with mRNA;

e.g. of base pairing (but not T) A-U / G-C;

stops translation;

ref to stops mRNA combining with ribosomes;

stops protein synthesis; max 3

(ii) chemicals / enzymes in, mouth / toothpaste / bacteria;

denature / degrade, RNA;

RNA not normally taken up by bacterial cells;

short life of RNA;

RNA not replicated in bacteria when bacteria reproduce;

toothpaste in mouth only for short time;

AVP;

AVP; e.g. washed away by saliva max 2

[5]

**143.** (a) (i) amylase; 1

(ii) glycosidic; R glucosidic 1

(iii) alpha / α; 1

(b) (i) encapsulation / trapped in alginate beads;

adsorption *or* stuck onto, collagen / clays / resins;

cross linkage or covalent / chemical bonding to, cellulose (fibres);

gel entrapment / trapped in silica gel;

partially permeable membrane microspheres; max 2

(ii) does not mix with / does not contaminate / stays separate from, the  
product; ref to, no / less / easier, downstream processing;

recoverable / not lost during processing;

reusable / cost effective;

matrix stabilises / protects the enzyme;

so activity not affected by changes in, temperature / pH *or* run at  
a high temperature / wider range of pH;

longer, use / shelf-life;

so suitable for continuous culture / cost effective / greater yield;

AVP;

*points can interchange if valid* max 4

(c) not necessary to start with a pure enzyme;

keeps the enzyme away from oxygen;

more enzymes involved;

cell produces enzymes;

AVP; e.g. enzyme(s) may be, expensive / difficult to isolate

simultaneous processes can occur max 2

[11]

**144.** (a) (i) *automatic*

requires no (conscious) thought / AW;

(ii) *stereotyped*

carried out by all individuals in a species / always carried out in  
same way / AW;

(iii) *conditioned*

(response) can be, modified / produced, following exposure to ‘new’  
stimulus / AW; 3

(b) **A** any response, provided correct stimulus is given;

**R** non-mammalian example **R** examples of conditioned reflexes 1

(c) **D1** time spent in box decreases as number of trials increases / AW;

**D2** greatest change in response occurs in first few trials;

**D3** little / less, change in response time;

**D4** between trials 6 and 20;

**D5** ref to supporting paired data;

**D6** ref to ‘fluctuations’; *max 4*

**E1** (at first) cat pulls, loop accidentally / AW;

**E2** ref to trial and error;

**E3** freedom is a, reward / reinforcer;

**E4** associative learning;

**E5** detail (of associative learning);

**E6** pulls loop sooner / AW;

**E7** correct ref to acclimatisation period  
(when cat placed in box) / AW;

**E8** AVP; e.g. other behaviours / inactivity, not,  
reinforced / rewarded *max 5* max 7

**QWC – legible text with accurate spelling, punctuation and**  
**grammar;** 1

(d) no reward / punishment (of behaviour), in classical; ora

one stimulus in operant / two stimuli in classical;

AVP; max 2

[14]

**145.** (a) *cerebellum*

coordination of, (voluntary) movement / skeletal muscles;

(control of) posture;

(control of) balance;

AVP; max 2

*medulla oblongata*

initiation / control of, breathing rate;

control of heart rate; **R** initiation of heart rate

control of blood pressure;

control of peristalsis (in alimentary canal);

AVP; max 2

(b) (i) build up of, tau / protein; 1

(ii) secretion of / high levels of, Aβ42 / beta amyloid 42  
/ abnormal Aβ; **R** Aβ40 1

(c) similar shape to, acetylcholine / ACh;

binds to / enters, active site;

prevents ACh entry;

competitive (inhibitor);

different shape to ACh;

enters / binds, but not at active site;

allosteric / indirect;

change in, tertiary structure / shape of active site;

non-competitive (inhibitor); max 3

(d) prevents ACh breakdown / increase ACh level;

ACh binds to, proteins / receptors;

on post-synaptic membrane;

depolarisation / action potential / impulse (produced;

activates memory circuit / AW; max 2

(e) control group;

given, placebo / tablet / injection / no drug;

idea of ‘double-blind’ trial, i.e. neither patient nor doctor aware of which  
treatment each patient receives;

random assignment of each patient to one group;

similar severity of symptoms before trial;

control of age;

control of gender;

control of diet;

control of drug, dosage / administration;

not taking any other, drug / medication;

ref to suitable sample size;

AVP; max 3

[14]

**146.** (a) 1 : 2 :1; 1

(b) **1** ref to, codominant / equally dominant (alleles);

**A** incomplete dominance but **R** genes as alternative to alleles

**2** appropriate symbols for two codominant alleles; eg G1 and G2

**R** a capital and a lower case symbol or two different letters  
such as G and Y

**3** parent plant shown or stated to be heterozygous; **A** if it is explained  
 that any sunny plant is heterozygous

**4** gamete genotypes shown appropriately;

**5** correct offspring genotypes;

**6** the ‘Sunny’ / yellow-green, were heterozygous / genotype shown  
by diagram;

**7** the dark green / the yellow, were homozygous / genotype shown  
by diagram; max 5

(c) **1** ref to, randomness / chance (sampling);

**2** ref to random fertilisation;

**3** totals are (quite) a large sample, pot **B** / single pot / six, is a small  
sample;

**4** if (only) six seeds, there is a greater chance of departing from an  
expected ratio / AW;

**5** probability of six seedlings all the same is ½ × ½ × ½ × ½ × ½ × ½;

**6** with, many seedlings / the totals, the deviations of the individual  
results cancel out;

**7** some departure from an expected ratio is always likely / idea;

**8** only the yellow number (33) deviates from the expected / 28  
is half 56;

**9** chi squared test could be used;

**10** AVP; max 3

(d) *credit ora here*

***A*** *chloroplast as alternative to chlorophyll*

yellow seedlings have, no / very little, chlorophyll;

cannot photosynthesise;

die when, energy reserve / carbohydrate (accept food), in seed is  
exhausted;

dark green grow more because they have more chlorophyll  
(than the yellow-green);

so dark green have more, photosynthetic products / named product;

ref to competition between the seedlings;

ref to, selection / selective advantage; max 3

[12]

**147.** (a) dissolve / destroy, cell membranes (idea); 1

(b) block the receptor / prevent ACh from binding;

no longer able to stimulate post synaptic membrane;

muscle fibres, not stimulated (by nerve fibres) / do not contract; **A** tetany  
idea

AVP; e.g. ref to lack of synaptic transmission max 2

(c) toxin acts too fast, for immunity / antitoxin to develop (idea);

human unlikely to have been, bitten before / exposed to toxin or antigen;

one / a / few (immature), lymphocyte(s) / stem cell(s)  
(able to bind the toxin);

these must be stimulated to divide / ref to clonal selection *or* clonal  
expansion;

mitosis takes too long;

has no memory cells;

AVP; max 2

(d) more, antibody-secreting cells / B lymphocytes, produced;

enough / more, antitoxin produced; (idea of good yield)

faster / goes on for longer;

secondary response;

more mitosis (of antibody producing cells);

second injection of toxin would result in clonal expansion;

ref memory cells;

AVP; e.g. large dose would kill the horse max 3

(e) antibody / antitoxin, only remains in, blood / body, for short time;

acquired immunity / passive immunity;

person not themselves producing any antitoxin;

no clonal selection;

no memory cells;

immune system will (soon) reject / destroy the (foreign) horse antibody;

AVP; e.g. further detail explaining why immune system not stimulated

different snakes have different toxins max 2

[10]

**148.** **1** sun is the energy source (for the system);

**2** producers / (green) plants, trap / use / absorb (sun’s energy);

**3** photosynthesis;

**4** not all energy trapped and reason;

**5** energy used for,plant metabolism / plant processes / e.g.; **A** respiration

**6** so this energy not,passed on / available, to consumer;

**7** (some energy) used for, growth / storage;

**8** so this energy is, passed on / available,to consumer;

**9** 1o consumer / herbivore, eats, producer / plant;

**10** some producer, not edible / not accessible / e.g.;

**11** some,not digested / egested / lost as faeces;

**12** 2o consumer / carnivore / omnivore, eats, 1o consumer / herbivore;

**13** some parts of animal not edible / e.g.;

**14** energy used by animal in moving (to feed);

**15** energy, used / lost, in,digestion / excretion / sweating /  
e.g.; **A**respiration

**16** transfer / loss, to, decomposers / bacteria / fungi / saprotrophs;

**17** energy lost as heat from respiration;

**18** net productivity = gross productivity – respiration;

**19** some ref to estimate of efficiency of transfer (a general statement);

**20** quote of (comparative) figures from diagram;

**21** manipulation of figures to illustrate a point; **NOT** 6612 and 14198

**22** AVP;

**23** AVP;e.g. loss out of ecosystem  
 another manipulation of figures  
 available energy limiting length of chain max 9

**QWC – legible text with accurate spelling, punctuation and grammar**; 1

[10]

**149.** cheaper;ref to compatibility / less chance of rejection / fewer side effects;stated ethical issue;e.g.don’t need to kill animals / removes religious  
objections  
ref to contamination / easier to purify / ref to disease;consistent quality;more effective (as human in origin);production level can meet demand / reliability of supply / faster production;*ignore* *greater production* 2 max

[2]

**150.** (i) restriction (enzyme) / endonuclease; 1

(ii) *this may be answered in the context of inserting into a plasmid.*

cut DNA with restriction enzyme;ref to sticky ends;complementary;base pairs / CCC and GGG / C pairing with G / alternative;(DNA) ligase / ligation;ref to bonding / AW;e.g. hydrogen *or* phosphodiester / sugar-phosphate  
AVP;e.g. add sticky ends to blunt ends  
 cut both at the same place 3 max

(iii) codes for,protein / polypeptide / enzyme; **A**ref to, protein synthesis / transcription / translation

(enzyme) catalyses / causes,condensation / formation of glycosidic  
bonds / reaction (between, mannose / sugars); 2

[6]

**151.** **1** genetic, testing / screening;

**2** for inherited disease / AW;

**3** (test to see if) individual is carrier;

**4** premarital testing / predict if (potential) offspring may inherit the disease;

**5** antenatal testing;

**6** ref to termination;

**7** embryo selection (to ensure embryo healthy); **R** selection of sex

**8** (test for genes that contribute to) diseases that develop later in life;

**9** those with genes given, advice to limit effects / counselling;

**10** faster / earlier, diagnosis;

**11** develop more, effective / efficient, drugs (to combat disease);

**12** drugs have direct effect, on genes / protein made from specific gene code;

**13** gene therapy / correct the base sequence of faulty gene;

**14** economic implications / AW;

**15** AVP;e.g. ref. to method used / use of gene probes / biopsy

**16** AVP; allows targeting of drug treatment 4 max

[4]

**152.** anxiety about (future) health / may not want to know / AW;many diseases we can test for have no treatments;discrimination by employers;discrimination by, insurance companies / banks;reliability of tests in question; **A** false, positive / negative, result  
example of disease given in context;cost to, NHS / government;rich people can benefit / poor will not benefit;AVP;; e.g. moral issues associated with embryo selection  
 eugenics  
 parents feelings towards child  
 presence of allele may not cause disease / ref to multifactorial  
 diseases  
 ref to storage of data and freedom of information / invasion  
 of privacy / question of paternity

**R** ‘playing God’ / cloning 4 max

[4]

**153.** *parental genotypes* RrBb × Rrbb;

*gametes* RB Rb rB rb Rb rb;

*offspring genotypes* RRBb RrBb (RrBb) Rrbb RRbb (Rrbb) rrBb rrbb;

*offspring phenotypes* rough black rough white smooth black smooth white;

*expected ratio* 3 : 3 : 1 : 1;

*accept correct gametes, offspring genotypes and offspring phenotypes in*  
*Punnett square*

*use ecf except for ratio* ***Reject*** *the ratio 6 : 6 : 2 : 2*

*ratio not a stand alone mark – there must be some correct working to support it*

[5]

**154.** (i) length of DNA;

codes for a (specific), polypeptide / protein / RNA;

found at a, locus / particular position on, a chromosome; 2

variety / form of a gene; **R** type of gene **A** type of a gene 1

(ii) *assume the allele = coat colour allele*

(coat colour) gene / alleles, only on X chromosome;

**A** no (coat colour), gene / allele, on Y chromosome

male cats, XY / only have one X chromosome;

(males have) only one (coat colour) allele / cannot have two  
(coat colour) alleles;

need black and orange alleles for tortoiseshell colour; max 2

[5]

**155.** **1** ref to operon;

**2** normally repressor substance bound to operator;

**3** prevents RNA polymerase binding (at promoter) / prevents transcription;

**4** lactose binds to repressor;

**5** changes shape of protein molecule;

**6** unable to bind (to operator);

**7** RNA polymerase binds (at promoter) / transcription occurs  
/ genes switched on;

**8** production of lactose permease;

**9** production of beta – galactosidase;

[5]

**156.** (a) RR RR - low, do not have enough vitamin K in diet / ref to figures;

RRRS - high, (warfarin resistant) and have enough vitamin K  
 / ref to figures;

RSRS - low, will be killed by warfarin / ref to effects of warfarin;

*If quote probabilities for survival less than 50% is low and over 50% is high* 3

(b) (i) mutation / named mutation;

change in DNA base sequence; max 1

(ii) variation within population;

some individuals produce enzyme not susceptible to warfarin;

these individuals survive / selective advantage;

reproduce / breed;

pass, resistance / advantageous allele, to offspring; **R** gene

those without resistance die;

ref to selective pressure of warfarin; max 5

(c) does not directly involve humans;

environment selects individuals that will reproduce; max 1

(d) resistant allele / RR, will decrease **and**, susceptible allele / RS, will  
increase;

RRRR at a disadvantage due to vitamin K requirements / RSRS at  
an advantage due to warfarin being removed;

**A** frequencies of both alleles will stay the same;

*must be linked to second statement*

no longer any selective pressure / no directional selection; max 2

[12]

**157.** (a) **B**;

**C**;

**D**;

**A**; 4

(b) (i) *award two marks if correct answer (26.18 / 26.2 / 26) is given*

24 × 60 = 1440 ÷ 55;

26.18; **A** 26 / 26.2 2

(ii) less oxygen / *ora*;

reduced amount of nutrients / *ora*;

ref to pH / *ora*;

competition from other bacteria / interspecific competition / *ora*;

use of antibiotics;

AVP; ref to intestinal enzymes or immune system

**R** reference to temperature

*treat toxins as neutral* max 3

[9]

**158.** (a) (i) Aabb - pink;

aaBB - green; 2

(ii) (dominant) epistasis;

ref to, epistatic / hypostatic, gene;

ref to, promoter / gene switching;

increased, transcription / expression; max 3

AVP; enzyme to alter pigment / change structure of pigment /  
make more pigment / complementary action

(b) (i) *parents* (AaBb) red spines × (aabb) green spines;

*gametes* AB Ab aB ab × ab; ***A*** *from Punnett square*

*offspring* genotypes;; *minus 1 for each of first two mistakes*

phenotypes related to genotypes; ***A*** *key*

*ratio* 1 red spines : 1 pink spines : 2 green spines; max 5

*gametes* *AB* *Ab* *aB* *ab*

*ab* *AaBb* *Aabb* *aaBb* *aabb*

*red spines pink spines green spines green spines*

(ii) many AaBb and aabb;

ref 1 : 1 ratio of these;

ref linkage;

ref parental types;

few Aabb and aaBb;

ref 1 : 1 ratio of these;

ref recombinants;

ref crossing over;

many red and green spined;

few / no, pink spined;

1 : 1 green : red / more green than red;

ref proportions depend on how close, loci / genes, are; max 5

[15]

**159.** (a) **1** prevent, self-pollination / unwanted pollination, of flowers;

**2** detail of prevention;

**3** cross-pollinate two varieties; **A** crossed / mated / hybridised

**4** detail pollination;

**5** isolate, plants / flowers;

**6** collect seeds and sow;

**7** in high salt concentration;

**8** select plants, which survive / can tolerate, high concentration;

**9** and have large, tasty tomatoes;

**10** interbreed these plants;

**11** repeat selection;

**12** ref many generations;

**13** cross with variety with large tomatoes to improve size;

**14** cross with variety with good flavour to improve taste;

**15** ref backcrossing with original variety for salt tolerance;

**16** AVP;

**17** AVP; max 8

e.g. ref background genes / hybrid vigour / heritability /

effect on vigour / ref setting up pure-breeding initial lines

**QWC – legible text with accurate spelling, punctuation**  
**and grammar;** 1

(b) (i) active transport;

(energy from), ATP / respiration;

against concentration gradient;

ref binding site for ion / AW;

ref change of shape of protein; max 3

(ii) GE quick(er) / SB slow(er);

(tolerance) in one generation (v. many generations);

ref one gene / rest of genome unaltered (v. hybridisation);

background genes intact (v. need for backcrossing);

different varieties engineered for different conditions;

no problem re interbreeding;

can select, transporter system / AW, / from, another species  
/ named taxon;

can select, transporter system / AW, / for maximum efficiency;

AVP; max 3

[15]

**160.** (i) mutation;

chance / random / preexisting;

insecticide acts as selective, agent / pressure;

susceptibles die / resistants survive;

resistants pass, mutation / allele, to offspring; **A** gene max 3

(ii) mosquito is vector; **A** carrier

obligatory / AW;

part of life cycle is in mosquito;

not killed by insecticide; max 2

[5]

**161.** (i) DNA from two different sources;

combined / joined / AW; 2

(ii) restriction enzymes cut DNA;

at specific sites;

detail of sites;

may give sticky ends;

complementary sticky ends join;

terminal transferase / enzyme, adds sticky ends;

ligase joins, gaps / nicks; max 3

[5]

**162.** (i) fewer genetically engineered mosquitoes pass parasites across midgut  
; **A** figures

fewer g e mosquitoes have parasites in salivary glands; **A** figures

fewer g e mosquitoes can infect (uninfected) mice; **A** figures

*‘less good as vectors’ instead of all of first three points = 1 only*

use of comparative figures; max 3

(ii) *benefit* one of following;

reduce use of, insecticide / drug

safer than, insecticide / drug

AVP max 1

*hazard* one of following;

parasite may develop resistance

gene may pass to other species

AVP max 1

[5]

**163.** (i) anaerobic conditions encourage denitrifying bacteria;

convert nitrate ions to (gaseous) nitrogen;

reduces available nitrogen;

sundew does not rely on, soil nitrate / soil nitrogen;

ref to, hydrolysis / digestion / use of enzymes, on insect proteins;

releasing amino acids;

ref to deamination; *max 3* max 4

(ii) Reduces amount of air in soil;

roots starved of oxygen;

respiration becomes anaerobic;

insufficient energy released;

not able to absorb (enough), ions / named ion;

via active transport; max 3

[7]

**164.** (a) set out a grid in each area *or* site / description of how the grid is  
established;

use random numbers;

how generated; e.g. random number tables / use of calculator

to give co-ordinates;

at that point / co-ordinate, measure nearest plant;

repeat (14 times); max 4

(b) (i) total heights;

divided by the number of plants (in the sample);

provides an average height for the sample; max 2

(ii) measure of, variability / spread of heights (in sample); **R** range

sum of differences from the mean;

68% of values lie within mean ± 1 S.D.;

95% of values lie within mean ± 2 S.D.; max 2

(c) greater spread from mean in site **B** / *ora*; **R** range

height of plants in site **B** is more variable / *ora*; max 1

(d) (i) that there is no significant difference;

between the mean height in site **A** and the mean height in  
site **B**; **A** results any difference is entirely due to chance; max 2

(ii) there is a significant difference between the means at the two sites;

the difference is due to something other than chance;

reject the null hypothesis;

with 28 degrees of freedom;

at the 5% confidence level; **A** p<0.05 / <0.01 / <0.001

the critical t value is, 2.05 / 2.76 / 3.67;

calculated value, exceeds / is much higher than, this;

assuming the sample shows a normal distribution; max 4

[15]

**165.** *accept reverse arguments if responses are referring to cereal plants*

both have root nodules;

with *Rhizobium* bacteria;

which are nitrogen-fixing;

convert nitrogen (gas), to nitrate ions / ammonium compounds; **A** NO3– / NH4+

**R** ammonia / NH3

plants convert these to amino acids;

which are used to make protein;

high levels of proteins stored in seeds; max 4

[4]

**166.** (i) attached to an insoluble material / AW; 1

(ii) (micro)encapsulation / (trapped) in alginate beads;

adsorption / stuck onto, e.g. collagen / clays / resin / (porous) glass;

cross linkage or covalent / chemical bonding to, e.g. cellulose /  
collagen fibres;

gel entrapment / trapped inside gel e.g. silica (lattice / matrix);

partially permeable membrane (polymer) microspheres; max 2

(iii) urine can be processed / no problem of removing urine / AW;

pure / drinkable / useable, water produced; **A** water recycled

space saving / less water needs to be taken into space;

payload limit / weight reduction / AW;

no need to take more enzymes into space / enzymes reusable; **A** enzymes

recoverable

no problem in separating enzyme from products / product not contaminated;

ref to longer shelf-life of enzyme;

AVP; e.g. larger surface area of enzyme exposed, more stable at extremes,

ref to ease of use (of bioreactor) max 3

[6]

**167.** (i) adding / using, water;

breaking, bond / ester bond (in molecule); **A** breakdown into smaller  
molecules 2

(ii) matrix, protects / stabilises, (immobilised) enzyme / lipase; *allow once*

so will function, at optimal rate / more efficiently (than soluble), at higher  
temperature / 45 °C; **A** greater activity / AW

ref to soluble lipase begins to denature (reducing activity); *ora*

continues to work, at optimal rate / more efficiently, at lower pH;

ref to presence of fatty acids changing pH;

ref to ionic bonds breaking (in soluble lipase); *ora*

AVP; e.g. ref to industrial uses, ref to effect on R groups max 4

[6]

**168.** (a) odd number of sets of chromosomes / AW;

homologous pairs not formed; **A** ref to difficulties in pairing

during meiosis; *allow point if reference made to causing problems*  
*during meiosis*

does not form seeds; max 2

(b) ref to, sterile conditions / aseptic techniques;

(small) piece of plant tissue removed; **A** take cuttings

ref to named tissue; e.g. meristem, axillary / (apical) buds

explant;

*or*

leaf removed;

enzymes / cellulases / pectinases, to remove cell wall;

protoplasts formed;

growth on nutrient medium;

plant growth regulators / named growth regulator; **R** hormones

rooting;

incubation in light;

plantlets;

subdivide;

handling, medium / sterile soil;

AVP;

AVP; e.g. remove wax from leaves

callus culture / mass of undifferentiated cells forms

ref. auxin to cytokinin ratio

Murashige and Skoog (M & S) medium

further detail of culture method / aseptic technique max 5

(c) *max 4 for either*

*advantages*

many plants;

genetically identical;

(so) all have desired, characteristics / genotypes / phenotypes;

no need for (artificial) selection;

can be obtained in short space of time / AW;

easy to, transport / store; **A** ref to space saving

easy to genetically engineer;

disease / virus, free;

*disadvantages*

genetically identical, qualified in terms of disadvantage;

susceptible to disease;

loss in genetic diversity (as cloned plants are grown exclusively);

farmers have to buy plants from suppliers / AW;

ref to economic problems for developing countries; e.g. start up costs

patented property;

AVP;

AVP; e.g. no quarantine required, ref. to cost qualified, not labour intensive (advantages), genetically unstable (disadvantage) max 5

[12]

**169.** (a) (i) temperature;

concentration of, substrate / sugars /  
carbohydrates; **R** volumes / amounts

concentration of yeast; **R** volume / amount

pH / carbon dioxide concentration;

oxygen availability;

concentration of, alcohol / ethanol / toxic waste;

AVP; max 3

(ii) carbon dioxide; **A** CO2 1

(b) (i) *one mark for slow, fast, slow / nothing*

initial gas production slow, ref to time;

rapid rate, ref to time;

little gas production, ref to time;

ref to actual volumes;

any rate calculated; max 4

(ii) ref to (aerobic / anaerobic) respiration;

*slow gas production*

transport of glucose into yeast cells takes time; **A** absorbed / taken  
up by yeast detail; e.g. ref to carriers

*rapid rate of respiration*

high substrate concentration in yeast cells;

*rate slows*

substrate runs out;

or other factor(s) / named factor, affect the rate;

AVP; e.g. increase in number of yeast cells increases rate of  
 respiration, qualified ref to time taken for adjustment to  
 conditions (in slow production) max 4

(c) *slower rate of respiration*

enzymes(s) to, metabolise / hydrolyse / digest / breakdown, maltose  
not present;

genes switched on;

time for enzymes to be synthesised;

ref to, membrane transport / ease of passing through membrane;

AVP; e.g. facilitated diffusion max 2

[14]

**170.** (a) provides oxygen for aerobic respiration;

any detail, e.g. oxidative phosphorylation;

sterile to prevent contamination;

mixes fungus with substrate / prevents settling / bubbles help stirring / AW; 2

(b) (i) carbon – glucose / lactose;

nitrogen – amino acids / nitrate ions / ammonium ions / yeast extract;

**A** corn steep liquor for either but not both 2

(ii) water is for, cooling / removing excess heat;

maintains, constant / optimum, temperature;

respiration produces heat;

which would, denature enzymes / kill cells;

heat also produced by, stirrer / motor; max 3

(iii) will affect, enzyme action / metabolic rate; **A** denature enzymes  
addition of, buffer / acid / alkali / base; 2

(c) (i) 96 hours; 1

(ii) **X** includes, rapid / exponential / main, growth phase; *ora*

when primary products are made / penicillin is a secondary  
metabolic product;

excess of nutrients in **X** *or* penicillin produced when nutrients,  
limited / depleted; 3

(d) filter (to remove fungus);

fungus washed (to remove penicillin);

continuous countercurrent / chemical extraction;

concentration;

addition of potassium ions;

precipitate crystals / (potassium) salts;

solvents used to purify penicillin;

AVP; e.g. dried, some are chemically modified, 99.5% pure max 3

(e) can genetically engineer microorganisms;

ref to risk of infection; e.g. CJD with GH

avoids problem with, side effects / allergic effects; **A** ref. to  
immune response

large amount of product;

grow microorganisms in small, area / volume; **A** less space required

can be cultured anywhere in world;

ethical advantages, qualified;

ref to cost qualified; e.g. *insulin* uses cheaper feedstock (than for  
rearing pigs)

AVP;

AVP; e.g. high replication / growth rate

extraction of GH from brains slow process max 4

[20]

**171.** (cortex is group of), specialised / similar / same, cells / neurones;

performing, similar / same / named, function;

brain is made of, more than one / different tissue(s);

carrying out more than one function / AW;

[3]

**172.** planning a task;

[1]

ÜÀ**173.** ulna;

[1]

**174.** **1** proteins needed for repair / AW;

**2** more transcription of, DNA / genes;

**3** more translation;

**4** protein synthesis;

**5** named protein; e.g. actin / myosin / troponin / tropomyosin

*ignore all refs to muscle contraction*

**6** more aerobic respiration;

**7** so more, energy released / ATP produced;

**8** (energy required for) condensation / anabolic, reactions;

**9** (energy required for) formation of peptide bonds;

**10** (energy required for) formation of extra mRNA; max 5

[5]

**175.** (a) (i) *penalise lack of units once in answer*

increase in, elongation / length, with auxin concentration up  
to, 1.4 / 1.8, μmol dm-3;

peak / maximum, at 1.4 μmol dm–3;

decrease between 1.4 and 1.8 μmol dm–3;

data quote with any 2 points;

linear / directly proportional, before 1.2 or linear inversely  
proportional after 1.5;

**R** length decreases max 3

(ii) *mark first three factors*

temperature;

age of stems;

light, intensity / wavelength;

concentration of dissolved, ions / salts;

(concentration of) other named growth substance;

AVP;;;

e.g. pH, genotype (of plant), concentration of named  
metabolite (e.g. glucose / amino acids), O2 concentration,  
CO2 concentration

**R** ‘amount of’ max 3

(b) cell, enlargement / elongation; **R** stem

enzyme synthesis;

vacuolation;

increase in plasticity of cell walls;

(cell) wall softened by, H+ / lowered pH;

high concentration of auxin causes inhibition of growth;

AVP; e.g. cell division, mitosis, replication, cytokinesis, increase in  
number of cells

**R** ref to uptake of nutrients max 2

(c) *assume answer is about plant growth substances unless stated otherwise*  
*treat refs to target, cells / tissue(s) and external stimuli as neutral*

growth substances produced by, dividing cells / meristems;

*ora* hormones produced by, islets of Langerhans / alpha cells /  
beta cells / endocrine gland / pancreas

growth substances move, in phloem / in xylem / from cell to cell;

*ora* hormones / named hormone(s), move in blood

growth substances usually produce a permanent change in the plant;

*ora* hormones produce reversible change in blood sugar

(GS) not homeostatic / no negative feedback; *ora* for hormones

**R** positive feedback **A** description of negative feedback

(GS) not protein / not polypeptide; *ora* insulin / glucagon, are proteins

AVP; max 2

[10]

**176.** *accept any three correct statements based on the data;;; for example*

populations of, mites / springtails, much greater / more than twice the  
number, in the climax forest than before trees established *ora*

number of species of springtail greatest in the climax community *ora*

small difference in numbers / no significant difference, between areas with young

trees and areas with mature trees

there were always (many) more mites than springtails in the sample

[3]

**177.** AATCCC / adenine adenine thymine cytosine cytosine cytosine; (first 6)

[1]

**178.** (a) provides sites for binding;

ref to, spindle fibres / microtubules;

ref to genes being spaced out along chromosome;

places to break and rejoin (during meiotic division); **A** chiasmata formation

‘junk’ implies no, function / purpose; *ora*

function may not yet have been discovered;

AVP; e.g. raw material for, evolution / natural selection,

required for, cell division / mitosis / meiosis max 2

(b) straight line sloping up from left to right; (does not need to start at origin) 1

(c) ATP / NAD / NADP / RNA / phospholipid / GP / TP / RuBP / ADP /

RUP / AMP / cAMP/ phosphocreatine / AVP; **R** DNA 1

[4]

**179.** DNA codes for,protein / polypeptide;transcription and translation (or described);enzyme is globular (protein);3 bases  1 amino acid;sequence ofbases / triplets, determines,sequence of amino acids /  
primary structure;coiling /  helix / -pleated sheet / particular secondary structure;determines projecting side groups;folding / bonding, for tertiary structure;3-D structure is tertiary structure;AVP;e.g. ref. active site related to shape  
 2 or more genes produce quaternary structure 4 max

[4]

**180.** *mark (i) and (ii) to max 3 each – the question to max 4*

(i) *nitrifying bacteria*  
convert,ammonium / NH4+,to, nitrate III / nitrite / NO2–; **A** *ammonia / NH3*nitrite, converted to, nitrate (V) / NO3-;

**A** *one mark for single step ‘ammonium to nitrate* (*V*)*’*

requires, aerobic conditions / oxygen / aerated soil;(nitrate (V) ions) can be,taken up / used, by plants;

(ii) *denitrifying bacteria*remove nitrate (V) (ions) / convert nitrate (V) (ions) to nitrogen (gas);in, anaerobic conditions / oxygen poor soil / non-aerated soil;recycles nitrogen / further use of nitrogen (by fixing);prevents nitrogen being trapped / AW; 4 max

[4]

**181.** (i) *look for prokaryote feature*

no nucleus / no nuclear membrane / no nucleolus / DNA free  
(in cytoplasm); **R** DNA moving  
naked DNA / DNA not associated with proteins / no chromosomes;circular / loop, DNA;no,membrane-bound organelles / e.g.;smaller / 18nm / 70S,ribosomes;no ER;cell wall, not cellulose / polysaccharide and, amino acids / murein;AVP;e.g. mesosomes / plasmids 1 max

(ii) glycosidic (link) and peptide (bonds) (in correct context);condensation;ref. OH groups;ref. NH2 and OH group;water, removed / produced / by-product;enzyme;AVP;e.g. energy required 3 max

(iii) iron / Fe;*ignore pluses / minuses* 1

(iv) *treat enzyme as neutral*

nitrogenase;leghaemoglobin;haemoglobin; 2 max

(v) (nitrogen) fixation; **A** reduction 1

(vi) type of inhibition (competitive / non-competitive / reversible / irreversible);basic mode of action (e.g. binds to active site);detail;consequence (e.g. prevents, substrate / nitrogen, from binding); 2 max

[10]

**182.** can fix nitrogen;does not deplete soil nitrogen / improves nitrogen content of soil (over time);allows cultivation of poor soil;reduces use of fertilisers;higher yield;AVP;e.g. reduce contamination of environment by fertilisers  
qualified cost ref.  
ref. leaching of nitrate 2 max

[2]

**183.** primary consumer / herbivore;ignore e.g.s **R** vegetarian 1

[1]