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 $C^rC^r \times C^wC^w$;
gametes C^r, C^w;

F_1 genotypes and phenotypes 1 mark:

F_1 genotypes (all) C^rC^w
F_1 phenotypes (all) pink;

F_2 genotypes and phenotypes 1 mark:

gametes C^r, C^wC^r, C^w;
F_2 genotypes C^rC^r C^rC^w C^rC^w C^wC^w
F_2 phenotypes red pink (pink) white;

F_2 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, HCO_3^-;
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:*
<u>transcription</u>;
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:
<u>translation</u>;
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
                       Mg^{2+}

[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

$(90 – 50 = 40)$ $40 / 50 \times 100$;
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 <u>in</u> artery walls/atherosclerosis;
<u>coronary</u> arteries;
narrows lumen;
reduces, blood/oxygen, delivered to <u>heart muscle</u>;
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 <u>*standards*</u> *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, <u>roots/root hairs</u>;
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) <u>sympatric</u>;   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 <u>alleles</u>/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) <u>crossing over</u>; *treat chiasma(ta) as neutral*   1

     (ii) <u>prophase</u>;   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 <u>and</u> 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 <u>intensity</u>;
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;

              F_1 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 <u>callus</u>;
subdivided;
different (nutrient) medium to encourage differentiation;
detail of either medium; e.g. *named nutrient or plant growth substance*
grows to <u>plantlet</u>;
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 <u>DNA</u>;   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 <u>quadrats</u>;
    5   use of appropriate sized quadrat;
    6   details of <u>regular</u> 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 <u>ulna</u>;
       extensor (muscle)/straightens arm/pulls lower arm down;   *2 max*   3 max

[9]

45. (calcium ions/Ca^{2+}) 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 <u>short term</u> 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** CO_2 1

    (ii) *Desulfovibrio*, uses sulphur (S)/makes hydrogen sulphide (H_2S);
    green sulphur bacteria, use H_2S/make S;
    colourless sulphur bacteria use H_2S;   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 <u>and</u> 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 ($\times$ 100)
18.4%;;

ecf applied for minor addition errors +/- 2   2

(b) 1 lay, tape / string, <u>across</u> 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* – $C^{Ch}C^{Ch}$ $C^{Ch}C^{H}$ $C^{Ch}C^{a}$;

agouti – $C^{A}C^{A}$ $C^{A}C^{Ch}$ $C^{A}C^{H}$ $C^{A}C^{a}$;   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   <u>aseptic</u> 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;

$\dfrac{32}{200} \times 100$;

$=16\%$;   max 2

(iii)   1,2 $\dfrac{A \quad B}{a \quad b}$ $\times$ $\dfrac{a \quad b}{a \quad b}$;; **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 <u>alleles</u> / AW;
by <u>artificial selection</u>;
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   <u>artificial selection</u>;
- 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   <u>natural selection</u>;
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 <u>synovial</u> 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)   <u>semi-conservative</u> 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* $NH_4^{(+)}$; **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)   <u>restriction</u> (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 <u>alleles</u> ; 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 <u>crossing over</u> ;
4 chiasma(ta) occur ;
5 DNA / alleles, exchanged ; **A** linked genes separated ;
6 metaphase 1 ;
7 <u>independent / random, assortment</u> ;
8 bivalents line up on equator, independent of each other / randomly ;
9 metaphase 2 ;
10 independent assortment of <u>chromatids</u> ;
11 <u>chromosome</u> 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

$I^OI^O \times (I^OI^O)$ <u>O</u> ;   *mark across each line in table*

$I^AI^B \times I^OI^O$ <u>B</u> ;   *if no marks gained mark down columns*

$I^A I^O / I^AI^A \times I^OI^O$ <u>A</u> ;   *max 2 marks if baby blood groups correct*

$I^AI^B \times I^AI^O / I^AI^A$ <u>AB</u> ;

[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 <u>action potential</u> (*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 <u>presynaptic</u> <u>membrane</u> ;
 12   named neurotransmitter ;
 13   secretion / exocytosis (from presynaptic membrane) ; **R** release
 14   <u>diffusion</u> across synaptic cleft ;
 15   receptors on <u>postsynaptic</u> 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 ;
<u>genetically</u> 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 <u>re</u> 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

goldfish	common carp	crucian carp	hybrid goldfish x crucian carp	hybrid goldfish x common carp	hybrid common carp x crucian carp
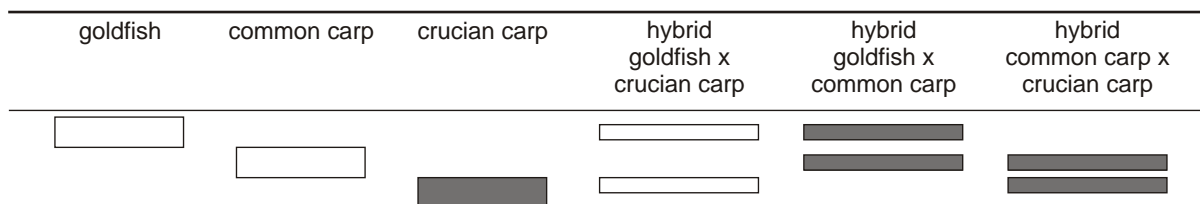
[15]

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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 ;
<u>callus</u> formed ;
subdivided ;
appropriate hormone to stimulate differentiation ;
<u>plantlet</u> formed ;
hardening medium / sterile soil   4 max

(iv) <u>genetically</u> 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 ;
<u>concentration</u> 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** $CuSO_4$ 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
<u>energy</u> 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 / Ca^{2+}) ;
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 <u>sarcoplasmic reticulum</u> ;
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 Q_{10} 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 / NADH$_2$;
     luciferin, synthesis / regeneration, stops ;
     AVP ;   3 max

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

(g) <u>mRNA</u> (coding for luciferase) ; **A** DNA   1

                                                                             [13]

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

         (ii) <u>role</u> 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 <u>species</u>
          and community = more than one / all, species / population;   1

                                                                             [4]

112. (i) **1**   some <u>food</u> 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   <u>energy</u> lost**,** as heat / in movement / in metabolism;

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

(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 <u>replicate</u> ;   2 max

[8]

114. (i) Individual 2 - $X^H Y$;

Individual 5 - $X^h Y$;

Individual 6 - $X^H Y$;

Individual 9 - $X^H X^h$;

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 <u>limiting factors</u> ;   2

                                                                 [10]

116. (a) form of <u>a</u> 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 <u>alleles</u> / ora ;
10 reproduce ;
11 pass <u>alleles on</u> (to, offspring / next generation) ;
12 ref to <u>stabilising selection</u> (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 = V_G / V_P ;
              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** <u>both</u> result from changes in allele frequencies ;
  2 selective breeding often faster than evolution / ora ;
  3 <u>both</u> 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 ; ($\times$ 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 <u>two</u> 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 <u>protein</u> / <u>polypeptide</u> / 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;
　　　　<u>callus</u>;
　　　　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 $\equiv$ 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 <u>later</u> / 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…;
    <u>quadrat</u> used;
    suitable size / actual size stated (minimum 0.25m^2);   **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 CO_2 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)

difficulty maintaining a constant temperature ;⎫   one mark for ref to difficulty of
difficulty maintaining a constant pH ;   ⎭   controlling environmental factors

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, $A\beta42$ / beta amyloid 42
/ abnormal $A\beta$; **R** $A\beta40$ 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 <u>post</u>-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 G^1 and G^2
        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 $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$;
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;
<u>secondary response</u>;
more mitosis (of antibody producing cells);
second injection of toxin would result in <u>clonal expansion</u>;
ref <u>memory cells</u>;
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   <u>photosynthesis</u>;
4   not all energy trapped <u>and</u> 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 1° consumer / herbivore, eats, producer / plant;
10   some producer, not edible / not accessible / e.g.;

11   some, not digested / egested / lost as faeces;

12 2° consumer / carnivore / omnivore, eats, 1° 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 <u>heat</u> 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;
<u>complementary</u>;
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) <u>allele</u> / cannot have two
             (coat colour) <u>alleles</u>;
             need black and orange <u>alleles</u> for tortoiseshell colour;   max 2

                                                                            [5]

155. **1** ref to <u>operon</u>;
    2 normally <u>repressor</u> substance bound to <u>operator</u>;
    3 prevents RNA polymerase binding (at promoter) / prevents transcription;
    4 lactose binds to <u>repressor</u>;
    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 <u>lactose permease</u>;
    9 production of <u>beta – galactosidase</u>;

                                                                [5]

156. (a) $R^R R^R$ - low,   do not have enough vitamin K in diet / ref to figures;

          $R^R R^S$ - high,   (warfarin resistant) and have enough vitamin K
                                  / ref to figures;

          $R^S R^S$ - 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 <u>allele</u>, 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 / R^R, will decrease **and**, susceptible allele / R^S, will
          increase;
          $R^R R^R$ at a disadvantage due to vitamin K requirements / $R^S R^S$ 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*

$24 \times 60 = 1440 \div 55$;

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) <u>active transport</u>;
(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;
<u>complementary</u> 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 <u>significant difference</u>;
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 <u>significant difference</u> between the means at the two sites;
the <u>difference</u> 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 <u>*Rhizobium*</u> bacteria;
which are nitrogen-fixing;
convert nitrogen (gas), to nitrate ions / ammonium compounds; **A** NO_3^- / NH_4^+
 R ammonia / NH_3
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, <u>water</u>;
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 <u>lower</u> 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** CO_2 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 <u>aerobic</u> 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, <u>cells</u> / <u>neurones</u>;
performing, similar / same / named, function;
brain is made of, more than one / different <u>tissue(s)</u>;
carrying out more than one function / AW;

[3]

172. <u>planning a task</u>;

[1]

Ü

À**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 <u>aerobic</u> 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 <u>1.2</u> or linear inversely proportional after <u>1.5</u>;
R length decreases   max 3

(ii) *mark first three factors*
temperature;
age of stems;
light, <u>intensity</u> / 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), O_2 concentration, CO_2 concentration

R 'amount of'   max 3

(b) <u>cell</u>, 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 / <u>endocrine</u> 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 <u>and</u> translation (or described);
enzyme is <u>globular</u> (protein);
3 bases ≡ 1 amino acid;
sequence of bases / triplets, determines, sequence of amino acids /
primary structure;
coiling / α helix / β-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 / NH_4^+, to, nitrate III / nitrite / NO_2^-;
A *ammonia / NH₃*

nitrite, converted to, nitrate (V) / NO_3^-;

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) <u>and</u> peptide (bonds) (in correct context);
condensation;
ref. OH groups;
ref. NH_2 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]

PMT

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. <u>primary</u> consumer / herbivore; ignore e.g.s **R** vegetarian   1

[1]