Mark schemes

1

(a) 1. (If injected into egg), gene gets into all / most of cells of silkworm;

2. So gets into cells that make silk.

2

(b) 1. Not all eggs will successfully take up the plasmid;2. Silkworms that have taken up gene will glow.

2

(c) Promoter (region / gene).

1

(d) 1. So that protein can be harvested;2. Fibres in other cells might cause harm.

2

2

[7] (a) 1. Cut (DNA) at same (base) sequence / (recognition) sequence;

Accept: cut DNA at same place

2. (So) get (fragments with gene) **R** / required gene.

Accept: 'allele' for 'gene' / same gene

2

(b) 1. Each has / they have a specific base sequence;2. That is complementary (to allele r or R). *Accept description of 'complementary'*

2

(c) 1. Fragments L from parent rr, because all longer fragments / 195 base pair fragments;

Ignore: references to fragments that move further / less, <u>require</u> identification of longer / shorter or 195 / 135 Accept: (homozygous) recessive

2. Fragments N from parent RR, because all shorter fragments / 135 base pairfragments;

1 and 2 Accept: A3 for 195 and A4 for 135

2. Accept: (homozygous) dominant

3. (M from) offspring heterozygous / Rr / have both 195 and 135 base pairfragments.

Accept: have both bands / strips

Reject: <u>primer</u> longer / shorter

3

(d) 1. (Cells in mitosis) chromosomes visible;
2. (So) can see which chromosome DNA probe attached to.

2

(e) (i) 1. For comparison with resistant flies / other (two) experiments / groups;

Ignore: compare results / data / no other factors

2. To see death rate (in non-resistant) / to see effect of insecticide in non-resistant / normal flies. *Accept: 'pesticide' as 'insecticide'*

Accept to see that insecticide worked / to see effect of enzyme

2

(ii) (PM must be involved because)

1. Few resistant flies die (without inhibitor);
2. More inhibited flies die than resistant flies;
3. (PM) inhibited flies die faster (than resistant flies);

(Other factors must be involved because)

4. Some resistant flies die;
5. But (with inhibitor) still have greater resistance / die slower thannon-resistant flies.

Accept: (with inhibitor) die slower than non-resistant flies

4 max

[15] (a) (i) Restriction endonuclease;

3 **1**

(ii) (DNA) ligase;

1

(b) (For those plants that contained the desired gene in thenucleus/plant DNA)

1. (DNA of desired gene) copied/replicated with host DNA/insidenucleus;
2. Passed on by mitosis/plant grows by mitosis;
3. Produces genetically identical cells/clones;

Ignore references to protein synthesis or plasmids not taking up the gene

1. Accept DNA replication during mitosis

1. and 2. Accept converse for plants with the gene in the cytoplasm

3. Neutral 'identical unqualified'

3. Accept description, e.g., DNA is the same

3

(c) 1. Genetic code is universal/triplets in DNA always code forsame amino acid;

2. It/insect DNA can be transcribed;
3. Can be translated (process/mechanism same in allorganisms/cells);

2. Accept (basic) transcription (process/mechanism) same in all organisms/cells;

2. Accept descriptions of process

3. Accept descriptions of process

3

[8]

(a) Reverse transcriptase;

4 **1**

(b) 1. Probe (base sequence) complementary (to DNA of allele A / where A is (and) binds by forming base pairs / hydrogen bonds; *Accept gene A*

2. So (only) this DNA labelled / has green dye / gives out (green) light;*Accept glows for green light*

2

(c) (i) 1. More probe binding / more cDNA / mRNA / more allele / gene A meansmore light;

2. DNA (with **A**) doubles each (PCR) cycle;

3. So light (approximately) doubles / curve steepens more and more (eachcycle) / curve goes up exponentially / increases even faster;

3

(ii) (**G** because)

1. (Heterozygous) only has half the amount of probe for **A** attaching / only half the amount of DNA / allele A (to bind to); *Accept only one A to bind to*

2. (So,) only produced (about) half the light / glow / intensity (of **H**) (per cycle of PCR);

If reference to 'half' for point 1, allow 'less light' in 2.

2

[8] (a) 1. Adenylate cyclase activated / cAMP produced / second messenger produced;

5

3. Activates enzyme(s) (in cell so) glycogenolysis / gluconeogenesis occurs /glycogenesis inhibited;

2. Neutral: 'glucose produced' as given in the question stem

Accept: correct descriptions of these terms

2

(b) (i) 1. Glucose / sugar in food would affect the results;

1. Accept references to starch / carbohydrateOr

2. Food / eating would affect blood glucose (level);

Or

3. (Allows time for) blood glucose (level) to return to normal;

3. Neutral: allows time for insulin to act

1 max

(ii) Type 2 diabetes is a failure to respond to insulin / still produces insulin / is notinsulin-dependent;

1

(iii) (For) – 3 max

A maximum of three marks can be awarded for each side of the argument

1. Avoids injections / pain of injections;

2. Long(er) lasting / permanent / (new) cells will contain / express gene;*Ignore references to methodology e.g. sample size not known*

3. Less need to measure blood sugar / avoids the highs and lows in bloodsugar;

4. Less restriction on diet;

(Against) – 3 max

5. Rats are different to humans;

6. May have side effects on humans;

6. Accept: virus may be harmful / disrupt genes / cause cancer

7. Long(er) term effects (of treatment) not known / may have caused effectsafter 8 months;

8. (Substitute) insulin may be rejected by the body;

4 max

[8] (a) Restriction / endonuclease;

6

Ignore specific names of restriction enzymes e.g. EcoR1

1

(b) (i) 1. (Acts as a) marker gene to show that the (human) gene has been takenup / expressed;

1. Accept: gene marker

2. (Only) implant cells / embryos that show fluorescence / contain thejellyfish gene;

2

(ii) 1. Factor IX present in / extracted from milk;

2. Gene only expressed in mammary glands / udder / gene not expressed elsewhere;

2. Ignore references to milk

The 'only' aspect is important here.

3. Do not need to kill sheep (to obtain Factor IX);

2 max

(c) (i) 1. Mutation / nucleus / chromosomes / DNA may be damaged / disruptsgenes;

1. *Neutral: cell may be damaged*

2. May interfere with proteins (produced) / gene expression / translation;*Ignore references to hormone levels or time of implantation*

OR

3. Embryo / antigens foreign;
3. Neutral: antigens change

4. Embryo is rejected / attacked by immune system;
4. sNeed idea that the immune system is involved if mark point 3 has not been given
'Embryo foreign so rejected' = 2 marks
'Embryo rejected by immune system' = 1 mark
'Embryo is rejected' = 0 marks

2 max

(ii) 1. Saves time / money for others;

2. Same work is not repeated / methods can be compared / improved / amended / same errors are not made;

2

[9]

7 (a) 1. No effect at 25°C

The question only refers to plants <u>with</u> GB

1. Reject same mass

2. Keeps growing at 30°C and 35°C / up to 35°C (more than without GB);

3. Above 35°C, falls but grows more than plant without GB;
3. Accept at all temperatures above 25°C more growth than without GB

2 max

(b) (i) <u>Significantly</u> different / SEs do not overlap ;
Accept converse without GB

1

(ii) (As temperature increases,)

1. Enzyme activity reduced / (some) enzymes denatured;

2. Less photosynthesis, so fewer sugars formed;

3. Less respiration / less energy / ATP for growth;

4. Less energy for named function associated with growth

4. Eg mitosis, uptake of mineral ions

4

(c) 1. (Rubisco activase attaches to thylakoid and) this changes shape / tertiarystructure (of enzyme) / blocks active site / changes active site;

Note - question states enzyme stops working when it attaches to thylakoid, not before

1. Accept rubisco in this context

2. (This) prevents substrate / RuBP entering active site / binding;

2. Accept prevents ES complex forming

2. Accept no longer complementary to substrate / RuBP

2

(d) 1. GB prevents / reduces binding of rubiscoactivase to (thylakoid membrane);

1. Accept enzyme instead of rubiscoactivase. Accept rubisco

2. (Prevents it) up to 35°C;

3. (So) rubiscoactivase / enzyme remains active;

4. (So) photosynthesis / light-independent stage still happens;

4. Accept descriptions of light-independent stage

5. Above 35°C, some binding still occurs but less than without GB, so lessreduction in growth;

4 max

(e) 1. Looked for information / journals, on crop plants that grow at high temperatures;

1. "other research" is minimum accepted

1. Accept previous experiments research with temperature resistantcrops

Ignore simple references to looking at previous studies / other plants - need to relate to this context

2. (Crop plants cited in this research) contain / make GB;

3. So assumed making plants produce GB makes them resistant to hightemperatures;

2 max

[15] (a) restriction (enzyme) / endonuclease / named example;

8 **1**

(b) unpaired bases / sticky ends / staggered;complementary / explained;

2

(c) *1 mark for each correct outcome* plasmid with foreign DNA joined in ring; ring with plasmid only; ring of foreign DNA only; *ignore linear structures*

3

[6]

9 (a) 1. Closer the (amino acid) sequence the closer the relationship;

2. (Protein structure) related to (DNA) base / triplet sequence;

Amino acid sequence is related to (DNA) base / triplet sequence = two marks;

2

(b) 1. Reference to base triplets / triplet code / more bases than amino acids / longer base sequence than amino acid sequence;

Different (base) triplets code for same amino acids = 2 marks;

Degeneracy of triplet code = 2 marks

2. Introns / non-coding DNA / degeneracy of code / more than one code for each amino acid;

Ignore reference to codon.

2

[4]

10 (a) (i) 1. Negative correlation;

Accept: description for 'negative correlation'

Neutral: 'correlation'

Reject: positive correlation

2. Wide range;

3. Overlap;

4. (Graph suggests that) other factors may be involved (in age of onset);

2 / 3 Accept the use of figures from the graph

2 / 3 Can refer to age of onset or number of CAG repeats

Ignore references to methodology

3 **max**

(ii) 1. Age of onset can be high / symptoms appear later in life;

Accept: 'gene' for 'allele'

2. (So) individuals have already had children / allele has been passed on;

OR

3. Individuals have passed on the allele / already had children;

4. Before symptoms occur;

2 max

(b) (i) 1. Person **K**;

2. (As has) high(est) band / band that travelled a short(est) distance / (er) so has large(st) fragment / number of CAG repeats; *Must correctly link distance moved and fragment size*

2

(ii) Run fragments of known length / CAG repeats (at the same time);

Accept: references to a DNA ladder / DNA markers

Do not accept DNA sequencing

1

(iii) Homozygous / (CAG) fragments are the same length / size / mass;

Accept: small fragment has run off gel / travelled further

1

[9]

Essay Using DNA in science and technology

11

DNA and classification

2.2 Structure of DNA

2.3 Differences in DNA lead to genetic diversity

2.9 Comparison of DNA base sequences

Genetic engineering and making useful substances

2.5 Plasmids

5.8 The use of recombinant DNA to produce transformed organisms that benefit humans

Other uses of DNA

2.5 Cell cycle and treatment of cancer

5.8 Gene therapy;

Medical diagnosis and the treatment of human disease;

The use of DNA probes to screen patients for clinically important genes.

(a) (i) protein / immunoglobulin;

12

specific to antigen;
idea of 'fit' / complementary shape;

2 max

(ii) 1. virus contains antigen;
2. virus engulfed by phagocyte / macrophage;
3. presents antigen to B-cell;
4. memory cells / B-cell becomes activated;
5. (divides to) form clones;
6. by mitosis;
7. plasma cells produce antibodies;
8. antibodies specific to antigen;
9. correct reference to T-cells / cytokines;

6 max

(b) 1. antibody gene located using gene probe;
2. cut using restriction enzyme;
3. at specific base pairs;
4. leaving sticky ends / unpaired bases;
5. cut maize / DNA / vector using same restriction enzyme;
6. join using DNA ligase;
7. introduce vector into maize / crop / recombinant DNA into maize;

4 max

(c) passive / person is not making own antibodies / antibodies not replaced;memory cells not produced;

2

(d) fewer ethical difficulties / less risk of infection;

1

[15]

13

(a) Restriction (enzyme / endonuclease);

1

(b) Move towards anode / move because charged;

Different rates of movement related to charge / size;

2

(c) (i) Piece of DNA;
Single stranded;
Complementary to / binds to known base sequence / gene;

max 2

(ii) DNA invisible on gel / membrane;
Allows detection;

2

[7]

14

(a) (i) Reverse transcriptase;

1

(ii) Idea that mRNA is present in large amounts in cell making the protein / mRNA has been edited / does not contain introns / mRNA codes for single protein;

1

(b) (Ligase) splices / joins two pieces of DNA / “sticky ends”;

1

[3] (a) (i) Sticky ends / description;

15

Reference to complementary base-pairing

2

(ii) Ligase;

1

(b) Carrier of DNA / gene; *(context of foreign DNA)*
Into cell / other organism / host;

2

(c) Act as marker gene;
Allows detection of cells containing plasmid / DNA;

2

[7]

(a) (i) Different genes / characteristics / features;

16

Reference to mutations;
Or
Base sequence determines protein;
Different species have different protein sequences;

max 2

(ii) Primer has different DNA sequence;
DNA specific / complementary base-pairing;

2

(iii) Electrophoresis separates DNA;
(So they can be) identified by position on gel;
Smaller / shortest fragments travel furthest / quicker / or reverse argument;

3

(b) (*conventional*) Many lengths / all DNA / (*new*) one length;
Each rung is DNA of one / specific length;

2

(c) 1 Heat DNA;
2 Breaks hydrogen bonds / separates strands;
3 Add primers;
4 Add nucleotides;
5 Cool;
6 (to allow) binding of nucleotides / primers;
7 DNA polymerase;
8 Role of (DNA) polymerase;9 Repeat cycle many times;

max 6

[15] (a) (i) Sticky ends / description;

17

Reference to complementary base-pairing

2

(ii) Ligase;

1

(b) Carrier of DNA / gene; *(context of foreign DNA)*
Into cell / other organism / host;

2

(c) Act as marker gene;
Allows detection of cells containing plasmid / DNA;

2

[7] (a) Mother and father both heterozygotes / Tt / carriers;

18

Probability of thalassaemia 1/4 and female 1/2;
Probability of both 1/8;

3

(b) (i) Cut at same base sequence as same enzyme used;
Fragments are same length / size / have same charge;

2

(ii) Single base occurs many times;
Sequence of 20 unlikely to occur elsewhere;
Allow one mark for establishing the principle where neither marking point clearly made.

2

[7] (a) Endonuclease / restriction enzyme;

19

1

(b) DNA made of base pairs;
Each base pair is same length / occupies same distance along backbone;

2

(c) (i) Second blank box from left labelled 6;

1

(ii) Distance moved depends on length / number of base pairs / second longest fragment / second shortest distance identified;

1

(d) 5;

1

[6] (a) 1 (DNA altered by) mutation;

20

2 (mutation) changes base sequence;
3 of gene controlling cell growth / oncogene / that monitors cell division;
4 of tumour suppressor gene;
5 change protein structure / non-functional protein / protein not formed;
6 (tumour suppressor genes) produce proteins that inhibit cell division;7 mitosis;
8 uncontrolled / rapid / abnormal (cell division);
9 malignant tumour;

max 6

(b) cancer cells die / break open;releasing DNA;

2

(c) normal DNA and changed DNA have different sequences;
DNA only binds to complementary sequence;

2

(d) fewer abnormal / cancerous cells / smaller tumours;less cell damage / less spread / fewer locations to treat;

2

(e) mRNA base sequence has changed;gene / DNA structure is different / has mutated; cancer gene active / tumour suppressor gene inactive;

3

[15]

(a) Presence of resistant and non-resistant varieties / mutation produces resistant variety;

21

Resistant ones survive / non-resistant ones killed by treatment;
These will reproduce and produce more resistant parasites / pass on resistance allele;

3

(b) Likelihood of being infected (by strain resistant to both drugs) is less;
1/500 × 1/500/1/250 000;
Drug has longer effective life;

max 2

(c) (i) As comparison / to show that nothing else in the treatment was responsible;

1

(ii) Given injections of saline / injection without SPf66;
(otherwise) treated the same as experimental group;

2

(d) (i) 100%;

1

(ii) 10%;

1

(e) (i) Different lengths of DNA have different base sequences / cut at specificsequence;
Results in different shape / different shape of active site;
Therefore (specific sequence) will only fit active site of enzyme;

3

(ii) Recognition sites contain only AT pairs;
Which would occur very frequently;

2

[15] (a) (i) contains genes / nucleotides / sections of DNA / artificial

22

DNA from two species / 2 types of organisms;

1

(ii) carries gene / DNA (into the other organism / gene carrier);

1

(iii) expose cells to the fungus;non-resistant ones die, resistant ones survive;
OR identify by adding marker gene / gene probe / (qualified) marker probe; description of positive result
e.g. radioactivity / fluorescence / complementary base pairing;

2

(b) EITHER 1 cut desired gene (from DNA) of oat plant;
2 using restriction endonuclease / restriction enzyme;
OR 1 use mRNA from oat which will code for resistance;
2 and use reverse transcriptase to form desired DNA;
OR 1 make artificial DNA with correct sequence of bases;
2 using DNA polymerase;
3 cut plasmid open;
4 with (same) restriction endonuclease / restriction enzyme;
5 ref. sticky ends / unpaired bases attached;
6 use (DNA) ligase to join / ref. ligation;
7 return plasmid to (bacterial) cells;
8 use of Ca^{2+} / calcium salts / electric shock; (if ref. to 'insulin' allow 5 max.)

max 6

[10] (a) 1 macrophages present antigens to B lymphocytes;

23

2 antigen binds to / is complementary to receptors on lymphocyte;
3 binds to a specific lymphocyte;
4 lymphocytes become competent / sensitised;
5 (B) lymphocytes reproduce by mitosis / (B) lymphocytes cloned; 6 plasma cells secrete antibodies;

4 max

(b) 1 restriction enzyme / endonuclease;
2 to cut plasmid / to form sticky ends in plasmid;
3 (use) ligase(to join) gene to plasmid;
4 culture bacteria with (in medium containing) plasmids

5 to allow uptake of plasmids / transformation;
6 use of cold shock / chemical treatment (to enhance uptake) / heat shock;
(ignore bullets / electroporation / microinjection)

3 max

[7] (a) probe will attach (to mutant allele);

24

attaches to <u>one</u> DNA strand; as a result of complementary base <u>pairing</u>; radioactivity detected on film / X-ray / by autoradiography (if mutant allele present);

4

(b) *<u>for</u>* gene is only active in mammary cells / only affects milk / easy to obtain product / product produced in large amounts / gene passed to offspring;

1

<u>against</u> long term effects not known / qualified reference to animal exploitation e.g. use of embryos / effect of inserted gene on other sheep tissues / genes;

1

[6] (a) (i) transfer / carry genes from one organism to another / into

25 bacteria / cells;

1

(ii) cut open plasmid; cut donor DNA, to remove gene / length of DNA; cut donor DNA and plasmid with the <u>same</u> enzyme / enzyme that cuts at the <u>same</u> base sequence; sticky ends / (overhanging) ends with, single strand / bases exposed; association / attachment / pairing of complementary strand;

2 max

(iii) annealing / splicing / backbones joined / phosphodiester bonds;

1

(b) (i) L and M;

1

(ii) fragments 64 and 36(kilobases obtained)

1

[6] (a) (i) <u>restriction</u> (endonuclease) enzyme;

26

<u>cuts</u> DNA at specific / restriction points / after specific base sequence;

2

(ii) PCR / polymerase chain reaction;

1

(b) isolated cells divide by mitosis; can get many plants
(producing toxin) / rapid production of
(toxin producing) plants;
all cells (in the new plant / clone) will produce the toxin;

3

[6]

27

(a) introduction of healthy gene / 'replacement' of defective gene;

1

(b) can enter cells / infect cells / inject DNA into cells;targets specific cells; replicates (in cells);

2

(c) reproductive cells / gamete cells do not contain ADA allele / gene;

1

(d) (i) to 'prevent' rejection / immune response;

1

(ii) T lymphocytes have a limited life span / die off / do not reproduce;
bone marrow provides continual supply of T lymphocytes /
(ADA) gene enzyme;

2

[7] (a) (cut out gene using an) endonuclease / restriction enzyme;

28

reference to specificity / recognition site; sticky ends; use the
same enzyme to cut; plasmid / virus / potato DNA; fixed by ligase;
method of introducing vector e.g. micropipette / virus injects DNA
/ remove plant cell wall;

6 max

(b) different genes are expressed;
producing different enzymes / proteins;

2

[8] (a) isolate wanted gene / DNA from another organism / mRNA from cell / organism;

29

using restriction endonuclease / restriction enzyme / reverse transcriptase to get DNA
and produce sticky ends; use ligase to join wanted gene to plasmid; also include marker
gene e.g. antibiotic resistance; add plasmid to bacteria to grow (colonies)then (replica)
plate onto medium where the marker gene is expressed; bacteria / colonies not killed
have antibiotic resistance gene and (probably) the wanted gene;

6

(b) (i) injection, rapid rise and fall; virus, slower rise and longer in
effective / harmful range; capsule slowest rise, longest in
effective / harmful range; injection and virus give harmful
concentrations but capsule does not;

3 max

(ii) advantage e.g.:
substance never reaches harmful levels / no side effect / less likely to harm the organism, longer relief from symptoms / less frequent treatment needed / longer effective range / longer but without harmful side effects;

1 max

disadvantage e.g.: takes longer to take effect;

1

[11] (a) use restriction enzyme / endonuclease / named, e.g. Bam / Eco;

30 to cut DNA in specific place / base sequence;

2

(b) heat DNA to 90 – 95 °C;strands separate; add primers; and <u>nucleotides</u>;
cool so that primers bind to DNA;
(DNA) polymerase forms new strands / joins nucleotides;

4 max

(c) (i) virus is inhaled / sprayed into the lungs;gets into cells, inserting the healthy gene;

2

(ii) makes DNA from RNA
rather than other way round

1

[9] (a) (i) plasmid;

31 **1**

(ii) the bacteria divide / grow, producing many copies of desiredgene / plasmid;
OR
the bacteria divide / grow to cover the agar;

1

(iii) plant tissue that has antibiotic resistance survives;identifies plant tissue which has desired gene / plasmid;

2

(iv) to <u>clone</u> plants / produce <u>genetically</u> identical plants with gene / characteristic;
and produce large numbers / quickly;

2

(b) (i) (*one reasonable suggestion*),
e.g. toxin present all the time; save costs of buying / application of spray; no spray drift onto other fields / insects;

1 max

(ii) (*one reasonable suggestion*),
e.g. killing of harmless / useful insects that feed on wild plants;
damage to food chains starting with wild plants;

1 max

[8] (a) Restriction enzyme / restriction endonuclease;

32 **1**

(b) (i) A-G-C-T / T-C-G-A;
Allow A-G-C-T-T / T-T-C-G-A

1

(ii) Joining two pieces of DNA;

By complementary binding/complementary base-pairing;

2

(c) (i) 4943;

1

(ii) 3;

1

(iii) 2 bands disappear / only 3 bands;

New band formed at heavier position/nearer to origin/higher up;

2

[8] (a) Cocaine (binding) changes shape of transporter/prevents dopamine binding;

33

Reject references to active site

Transporter cannot move (bound) dopamine (through membrane / protein / into cell);
Dopamine remains / builds up in synapses (leading to feelings of pleasure);

3

(b) (i) Polymerase chain reaction / PCR;

1

(ii) Single-stranded DNA;
Reject reference to a single strand of DNA

Bases / sequence complementary to DNA / gene to be identified;

(Radioactively / fluorescent) labelled so that it can be detected;

2 max

(c) Mutation changes base sequence of gene / DNA;
Accept references to active site

(Thus) changing amino acid sequence;

Changes tertiary structure / shape of protein/transporter;
Cocaine binding site changes/cocaine cannot bind;
Dopamine can still bind (and be transported);

3 max

[9] (a) (i) Amount of mRNA > amount of DNA / multiple copies of mRNA;

34

Insulin mRNA/the specific mRNA is found in pancreas cells;

Introns / non-coding information present in DNA / these removed in mRNA / corr. ref. post-transcriptional modification;

2 max

(ii) Enzyme 1 = reverse transcriptase;

Enzyme 2 = (DNA)-polymerase;

2

(iii) Hydrogen (bonds) / H-(bonds);

1

(b) (i) Primers;

1

(ii) To allow H-bond re-formation / to allow joining of primers/P(and Q) to (single-stranded) DNA / converse re. high temp. breaks H-bonds / prevents joining;

1

(iii) To mark region of DNA to be 'copied' / to show enzyme whereto start;

(Enzyme) needs starting strand onto which to attach nucleotides;

Allow idea of extending pre-existing chain

2

(iv) 32;

1

[10]