8.4 The control of gene expression (A-Level Only) - Gene technologies 1 – Mark schemes

Q1.

(a) Produces (c)DNA using (m)RNA;

Accept: 'converts' (m)RNA to (c)DNA.

Reject: tRNA

1

(b) Joins nucleotides to produce (complementary strand/s of) DNA;

Accept: 'joins DNA nucleotides'.

1

(c) 1. To remove any DNA present;
2. As this DNA would be amplified / replicated;
   1. *Must be idea of removal / destruction.*
   2. *Accept: idea of DNA not being used as template.*

2

(d) 1. Ratio in range of 1.4 :1 to 1.5 :1 = **2 marks**;
2. One mark for answers which shows incorrect ratio but
Shows 0.24 as a number or line on the graph
OR
Ratio in correct range, but the wrong way round
OR
Ratio in correct range but not expressed to 1
OR
Ratio shown the other way round in range
1: 0.67 to 1:0.71;

Note: ratio not expressed to 1 in correct range may be shown in different ways, for example as:

3:2 or simply as 1.5 for one mark.

2

(e) Limited number of primers / nucleotides;

Accept: DNA polymerase (eventually) denatures

Accept: primers / nucleotides 'used up'.

1

(f) 1. Base sequences differ;
2. (Different) complementary primers required;
   1. *Accept: reference to either RNA or DNA base sequences but reject reference to DNA base sequence in viruses.*

2

[9]

Q2.

(a) 1. Human DNA / human gene / HGH gene contains introns
OR
Methods 2 and 3 produce DNA / *HGH* without introns;

2. *E. coli* cannot remove introns / cannot splice mRNA / cannot splice pre-mRNA;

2

(b) Faster to use gene machine than all the enzyme-catalysed reactions (involving reverse transcriptase);

Accept extra step / more steps involved in isolating mRNA

1

(c) 1. Cut the plasmid with a restriction endonuclease;

Allow 'add base sequences to blunt ends of plasmid and HGH gene'

2. (So that) both have complementary / sticky ends;

3. (Mix together) and add ligase to join the complementary / sticky ends;

3

(d) Can quickly identify transformed bacteria using UV light;

1

(e) 1. Arabinose alters structure of araC protein / reduces effect of araC protein;

2. So stops / reduces inhibition of promoter gene and GFP gene is transcribed;
OR
So stops / reduces inhibition of promoter gene and GFP is produced;

2

[9]

Q3.

(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

[7]

Q4.

(a) (i) Restriction endonuclease;

1

(ii) (DNA) ligase;

1

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

1. (DNA of desired gene) copied/replicated with host DNA/inside nucleus;
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 for same amino acid;
2. It/insect DNA can be transcribed;
3. Can be translated (process/mechanism same in all organisms/cells);

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

2. Accept descriptions of process

3. Accept descriptions of process

3

[8]

Q5.

(a) (i) Does not code for amino acid/tRNA/rRNA;

Accept 'does not code for production of protein/polypeptide'

Reject 'that produces/makes amino acid'

1

(ii) Deletion mutation;

Accept 'deletion'

Ignore references to splicing

1

(b) (The) polymerase chain reaction;

Accept PCR

1

(c) 1. Probes are single stranded / have a specific base sequence;
2. Complementary base sequence on (specific) spacer

OR

3. Complementary/specific to (particular) spacer;
4. (In white squares probe) binds (to single-stranded spacer) and glows/produces light/fluoresce;

2. Need idea of complementary to spacer

3. Accept converse for dark squares

3

(d) 1. To see if strain is resistant to any antibiotics;
2. So can prescribe effective/right antibiotic;

OR

3. To see whether (any) vaccine works against this strain/ see which vaccine to use/ to produce specific vaccine;
4. (So) can vaccinate potential contacts/to stop spread;

OR

5. Can test other people to see if they have the same strain/ to trace where people caught TB;
6. Allowing control of spread of disease/vaccinate/treat contacts (of people with same strain) before they get TB;

Do not allow mix and match of points from different alternative pairs

2 max

[8]

Q6.

(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, require identification of longer / shorter or 195 / 135

Accept: (homozygous) recessive

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

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 pair fragments.

Accept: have both bands / strips

Reject: primer 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 than non-resistant flies.

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

4 max

[15]

Q7.

(a) Reverse transcriptase;

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 means more light;

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

3. So light (approximately) doubles / curve steepens more and more (each cycle) / 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]

Q8.

(a) 1. Carriers are heterozygous / have one normal copy and one mutant copy of gene / have one recessive allele / don't have the condition;

2. Both have DNA that binds (about) half / 50% amount of probe (that non-carrier does);

3. Probe binds to dominant / healthy allele so only one copy of exon in their DNA / have one copy of gene without exon / base sequence for probe to bind to;

3. Accept normal and gene

3. Accept have <u>a</u> deletion mutation

3

(b) 1. Introns not translated / not in mRNA / (exons) code for amino acids / introns do not code for amino acids;

1. Accept not expressed

1. Accept polypeptide / protein for amino acids

2. Mutations of these (exons) affect amino acid sequences (that produce) faulty protein / change tertiary structure of protein;

2. Accept deletion leads to frameshift

2. In this context, accept affects protein made

3. So important to know if parents' exons affected, rather than any other part of DNA / introns;

Accept converse arguments involving - eg introns do not code for amino acids / proteins

Reject references to making amino acids, once

3

(c) 1. Restriction mapping / described;

2. DNA / base sequencing (of fragments) / description / name of method;

2

[8]

Q9.

(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 / tertiary structure (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 less reduction 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 resistant crops

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 high temperatures;

2 max

[15]

Q10.

(a) Restriction / endonuclease;

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 taken up / expressed;

1. Accept: gene marker

2. (Only) implant cells / embryos that show fluorescence / contain the jellyfish 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 / disrupts genes;

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]

Q11.

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

2. 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 / carbohydrate

Or

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 not insulin-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 blood sugar;

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 effects after 8 months;

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

4 max

[8]

Q12.

(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]

Q13.

(a) restriction (enzyme) / endonuclease / named example;

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]

Q14.

(a) a length of DNA;
that codes for a single protein / polypeptide;

2

(b) by heating;
to break the H-bonds (between complementary bases);

2

(c) (i) to allow the DNA polymerase to attach / start addition of nucleotides / mark start and end of sequence to be copied / prevents strands re-joining;

1

(ii) because the sequences at the ends of the target sequence are different / one is at the beginning and one at the end;

1

(d) 8;
accept 7

1

[7]

Q15.

(a) 1 DNA is cut;

2 Using restriction enzyme;

3 Use electrophoresis;

4 Separates according to length / mass;

5 Southern blotting / transfer to (nylon) membrane;

6 Make single-stranded;

7 Apply probe;

8 Radioactive / fluorescent;

9 Reference to tandem repeats / VNTRs / minisatellites;

10 Autoradiography / eq;
8 and 10 should be consistent

max 6

(b) (i) All bands in cub which don't come from mother;

Must be in father's DNA fingerprint;

Principle that all bands in cub must come from mother and father = 1

2

(ii) Select pairs with dissimilar DNA fingerprints;

1

(c) (i) Cells (from panda) in faeces / gut cells / blood cells;

1

(ii) To increase amount of DNA / only small amount present;

1

(iii) DNA / primer has specific base-sequence;
Reference to specific / complementary base-pairing;

2

(d) Taking samples from animals causes stress / injury to animal;

Difficult to find animals;

Pandas are dangerous / threat to human;

max 2

[15]

Q16.

(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]

Q17.

(a)
1. DNA is cut;
2. using restriction enzyme;
3. electrophoresis;
4. separates according to length / mass / size;
5. DNA made single-stranded;
6. transfer to membrane / Southern blotting;
7. apply probe;
8. radioactive / single stranded / detected on film / fluorescent;
9. reference to tandem repeats / VNTRs / minisatellites;
10. pattern unique to every individual;

6 max

(b) cells on toothbrush;
DNA present in cell;

2

(c) (i) toothbrush gives small sample of DNA / need more DNA for analysis;
PCR gives many copies;

2

(ii) uses heat;
to separate strands;
OR
PCR replicates pieces of DNA;
because DNA has been cut;
OR
primer added in PCR;
to initiate replication

2 max

(d) (i) PCR / amplification needed;

1

(ii) other DNA present; need to identify 'required' DNA from rest;

2

[15]

Q18.

(a) (i) protein / immunoglobulin;
specific to antigen;
idea of 'fit' / complementary <u>shape</u>;

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]

Q19.

(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]

Q20.

(a) Endonuclease / restriction enzyme;

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]

Q21.

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

Q22.

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

Q23.

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

Q24.

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

Q25.

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

Q26.

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

Q27.

(a) only small amounts obtained / PCR increases the amount / mass of DNA;
so enough DNA available for genetic fingerprinting;

2

(b) (i) to separate the two strands of the DNA /
to break the hydrogen bonds;
(Reject "unzip")

1

(ii) short lengths / fragments of DNA / nucleotides /
single stranded DNA;

1

(iii) to mark beginning and / or ends of the part of DNA needed /
for attachment of enzymes or nucleotides / initiator /
keeps strands apart;

1

(iv) would not be denatured;
must be heated to 95 °C / must withstand high temps;

2

(c) 1 DNA extracted from sample;
2 DNA cut / hydrolysed into segments using restriction endonucleases;
3 must leave minisatellites / required core sequences intact;
4 DNA fragments separated using electrophoresis;
5 detail of process e.g. mixture put into wells on gel and electric current passed through;
6 immerse gel in alkaline solution / two strands of DNA separated;
7 Southern blotting / cover with nylon / absorbent paper (to absorb DNA);
8 DNA fixed to nylon / membrane using uv light
9 radioactive marker / probe added (which is picked up by required fragments) / complementary to minisatellites;
10 (areas with probe) identified using X-ray film / autoradiography;

max 6

(d) adult 3;
this is only one which, (with number 1), can provide (all) the DNA fragments which children have / all bars match;

(Reject 'genes')

2

[15]