

8.1 The control of gene expression (A-Level Only) - Gene expression - Mark schemes

Q1.

- (a) RNA polymerase;
DNA polymerase is incorrect
Ignore references to RNA dependent or DNA dependent
Allow phonetic spelling 1
- (b) (i) (Receptor / transcription factor) binds to promoter which stimulates RNA polymerase / enzyme X;
Transcribes gene / increase transcription; 2
- (ii) Other cells do not have the / oestrogen / ER α receptors;
But do not accept receptors in general. 1
- (c) Similar shape to oestrogen;
Binds receptor / prevents oestrogen binding;
Receptor not activated / will not attach to promoter / no transcription;
Accept alternative
Complementary to oestrogen;
Binds to oestrogen;
Will not fit receptor;

2 max

[6]

Q2.

- (a) (i) 1. (Tumour suppressor) gene inactivated / not able to control / slow down cell division;
Ignore: references to growth
2. Rate of cell division too fast / out of control.
1 and 2 Accept: mitosis
1 and 2 Reject: meiosis 2
- (ii) 1. (Genetic) code degenerate;
Accept: codon for triplet
Accept description of degenerate code, e.g. another triplet codes for the same amino acid
2. Mutation in intron.
Accept: mutation in non-coding DNA 1 max
- (b) 1. Antibody has specific tertiary structure / binding site / variable region;
Do not accept explanations involving undefined antigen
2. Complementary (shape / fit) to receptor protein / GF / binds to receptor

protein / to GF;
Ignore: same shape as receptor protein / GF

3. Prevents GF binding (to receptor).

3

[6]

Q3.

- (a) (i) Increases then plateaus / constant / steady / rate does not change;
Neutral: 'peaks' / 'reaches a maximum' / 'stops increasing' / 'no effect' instead of 'plateaus'
Reject: rate decreases / reaction stops

Correct reference. to 27 / 28 units;
e.g. increases up to / plateaus at 27 / 28

2

- (ii) Substrate concentration / amount of substrate;

As substrate concentration increases, rate increases / positive correlation (between rate and substrate concentration);

2

- (iii) All active sites occupied / saturated / enzyme limiting (rate of reaction) / maximum number of E-S complexes;

Reject: enzymes used up
Reject: substrate limits rate of reaction
Neutral: substrate no longer limits the reaction
Neutral: reference to temperature

1

- (b) Curve is lower and plateaus at a higher substrate concentration (it must also start at zero);

Accept: curve lower and joins existing curve at final point (with no plateau)
Reject: if curve plateaus before original
Reject: if curve plateaus lower than original

1

- (c) (i) Methotrexate / drug is a similar shape / structure to substrate so binds to / fits / is complementary to active site;

Q Reject: same structure / shape
Q Reject: reacts with active site

Less substrate binds / less enzyme-substrate complexes formed;
Accept: substrate cannot bind / enzyme-substrate complex not formed

2

- (ii) Methotrexate / drug is only similar shape to specific substrate / only fits this active site;

Assume that 'it' refers to the drug

OR

Methotrexate / drug is a different shape to other substrates / will not fit other active sites;

1

Q4.

- (a) 1. (Usually) Type II produce insulin;
 2. Cells / receptors less sensitive / responsive (to insulin)
OR
 Faulty (insulin) receptors;
 3. (Treated / controlled by) diet / exercise;
 2. *Accept: cells / receptors do not respond.*
 2. *Accept: 'fewer receptors'*
 3. *Accept: (Treated / controlled by) weight loss / medication / drugs.*
 3. *Ignore: diabetes is caused by diet / exercise.*

2 max

- (b) Tick in box 4

1

- (c) 1. Attach to gene / DNA / promoter region;
 2. Stimulate / inhibit transcription / RNA polymerase;
Note: Genes being expressed / inhibited or switched on / off is not enough on its own.

2

- (d) 1. (Effective as) group A / with iPS / treated lower than group B / with diabetes;
 2. (Effective as) group A similar to group C / without diabetes;
 3. (Investigation) done on mice not humans;
 4. Only shows results for 12 weeks / short-time period / long-term effects not known;
Ignore: Only one study / not repeated / sample size.
 2. *Accept: 'healthy' or 'normal' or control for group C.*

4

[9]

Q5.

- (a) 1. Correct answer of 19.4 / 19.41%
OR
 19.47 / 19.5% = **2 marks**;
 2. Incorrect answer but shows increase of
 1,048,320 **OR** 1,051,200 = one mark;
Accept: 19.46% for one mark.

2

- (b) 1. Less / no acetylcholine broken down;
 2. Acetylcholine attaches to receptors;
 3. (More) Na⁺ enter to reach threshold / for depolarisation / action potential / impulse;
 1. *Accept: more acetylcholine present / remains.*
 1 and 2. *Accept: remains attached for longer = 2 marks.*
 3. *Must be sodium ions.*

3

- (c) 1. Isolated **so** inbreeding / low genetic diversity / small gene pool;
 2. Allele inherited (through generations) from (common) ancestor;

1. *Ignore: Founder effect.*
 1. *Accept: no interbreeding with other populations.*
 1. *Reject: interbreeding within the population.* 2
- (d) 1. AD / symptoms develops late / at 49;
 2. Have already reproduced;
Note: 'It' is not equivalent to AD / symptom as the question stem relates to the mutation. 2
- (e) 1. Epigenetics / environment / named factor e.g. stress, alcohol, toxins, diet, exercise, smoking;
 2. methylation (of genes)
OR
 acetylation (of histones);
 1. *Ignore: gender and lifestyle.*
 2. *If further details are provided the context must be correct e.g. increased methylation or decreased acetylation inhibit gene expression / transcription.* 2
- (f) 1. One person was homozygous dominant / has two dominant alleles = 2 marks;
 2. For one mark has two alleles / chromosomes;
 1. *Accept; homozygous dominant genotype e.g. 'one person has AA' for 2 marks.*
 2. *Accept: is diploid or has two copies of the gene.* 2
- (g) 1. (GCA / triplet) is common / found in other places;
 2. Would not know if it was the mutation / allele / gene
OR
 Produces 'false positives'
 1. *Accept: Probe will bind elsewhere.* 2

[15]

Q6.

- (a) 1. (DNA) helicase;
 2. (DNA) polymerase;
List Rule Applies
Accept (DNA) ligase / Primase / telomerase / Topoisomerase / DNA gyrase
Reject RNA
Accept phonetic spellings 2
- (b) 1. Changes tertiary structure of the enzyme;
 2. (Enzyme) active site formed / able to be formed / active site becomes complementary;
 1. *Accept tertiary symbol 3°*
 1. *Ignore 3D*
 2. *Reject refs to inhibition / inhibitors*
 2. *Ignore refs to E-S complexes form*

2. *Ignore refs to substrate phosphorylation*

2

- (c) (Phosphorylation / phosphate) makes substrates more reactive / raises their energy level(s) / lowers activation energy for the reaction;

Ignore provides energy unqualified

Ignore refs to kinetic energy unqualified

1

- (d) 1. ATM will not bind to (broken) DNA;
2. DNA not repaired / cell still has broken DNA;
3. Cell division continues / tumour forms;
4. Tumour suppressor (gene) not effective / not activated;
5. May have no effect in diploid / heterozygous (organism);
6. (Which) still has a functional ATM / ATM gene;

3 max

[8]

Q7.

- (a) Correct answer 23.55 – 24 two marks;

For one mark

5.9

OR

94.2;

2

- (b) 1. Method for measuring area;
e.g. draw round (each) leaf on graph paper and count squares;
2. Of both sides of (each) leaf;
3. Divide rate (of water loss / uptake from potometer) by (total) surface area (of leaves);

3

- (c) Plant has roots

OR

xylem cells very narrow;

Ignore references to air bubbles / mass flow / photosynthesis

Accept xylem damaged when cut

1

- (d) 1. Both small / similar size (so fit channel);
2. Have a similar shape (so bind to / fit channel);
1. *Accept same height and width*
Ignore refs to polar / non-polar
2. *Accept Aquaporin complementary to oxygen(s)*

2

- (e) 1. Single-stranded RNA (has base sequence) complementary to PIP1 mRNA;
2. Binds to mRNA (of PIP1) / leads to destruction of mRNA;
3. Prevents / reduces translation (of PIP1);
4. Reduces photosynthesis/named process that uses water;
3. *Less made is insufficient*

3 max

- (f) Not all of mRNA bound to single-stranded RNA / there is more mRNA than interfering RNA

OR

Not all mRNA destroyed / disabled;

Accept mutations in transgene,

Accept not all cells with transgenes

1

- (g)
1. Loss of PIP reduces water **and** carbon dioxide movement;
 2. Differences significant because SDs don't overlap
OR
Need stats test to see whether significant differences (or not);
 3. Greater (proportional) effect on carbon dioxide transport;
 4. Not all movement through PIP;
 1. *Accept converse for wild type*
 2. *Reject references to results significant or not significant*
 2. *Accept error bars for SDs*

3 max

[15]

Q8.

- (a)
1. Heritable changes in gene function;
 2. Without changes to the base sequence of DNA;

2

(b)

Control element	Binds with DNA	Binds with protein
Oestrogen		✓
Methyl groups	✓	
Acetyl groups		✓

1 mark for each correct column.

Accept both boxes ticked in oestrogen row.

2

- (c)
1. Methyl groups (could be) added to (both copies of) a tumour suppressor gene;
 2. The transcription of tumour suppressor genes is inhibited;
 3. Leading to uncontrolled cell division.

3

(d) Cells of benign tumours cannot spread to other parts of the body / metastasise;

OR

Cells of benign tumours cannot invade neighbouring tissues.

Accept answers clearly in the context of malignant tumours.

1

[8]

Q9.

- (a)
1. (Required to) make ATP / glucose phosphate, so less respiration / less energy for growth;
 2. (Required to) make nucleotides, so less DNA / mRNA / tRNA for cell division /

production of protein (for growth);

3. (Required to) make RuBP / NADP, so less CO₂ fixed / reduced into sugar;

4. (Required to) make phospholipids for membranes;

2 max

(b) 1. Hydrolyse;

Accept digest

2. murein / glycoprotein (in cell wall);

2

(c) 1. Bind to receptor (on target plant);

2. Acts as / leads to production of a transcription factor;

3. (Which) binds to promoter

OR

stimulates transcription of genes

OR

production of mRNA (for defensive enzymes);

3

(d) 1. Direct plant-to-plant transmission;

2. (So) localised response

OR

faster response

OR

no dilution of signal protein;

2

(e) 0.278;

Accept 1 mark for 1001.7 or

$$\frac{x - 450}{450} \times 100$$

$$= 122.6$$

2

(f) Should not use:

1. Fertilisers prevent development of mycorrhizae;

2. Mycorrhizae help plants to defend themselves (causing an increase in crop yield);

3. Mycorrhizae help plants to take up nitrates / phosphates (causing an increase in crop yield);

Should use:

4. Fertilisers containing phosphate and nitrate increase gross primary production so increase yield;

5. Most soil is poor in phosphate so without fertiliser (tomato) plant might not get enough phosphate;

4 max

Q10.

- (a) 1. (ESCs) can replace any type of (heart) cell;
Accept named type of cell, e.g. heart muscle cell 1
- (b) 1. Might divide out of control;
2. Leading to tumour / cancer; 2
- (c) 1. Shows the effects of surgery;
2. Allows effects of transplants / treatment to be seen;
Allow in either order 2
- (d) 1. Other cell types cause some increase but most of increase due to cardiomyocytes;
2. Large SD, so some not much increase / no better than control;
3. Overlap of SDs indicates / suggests no significant difference; 3
- (e) 1. Greater blood supply (to damaged areas);
2. Bringing more oxygen / glucose for respiration;
3. Brings more amino acids for protein synthesis;
4. For cell repair / mitosis / division; 3 max
- (f) 1. Measure diameter of field of view and calculate area;
2. Using micrometer slide and eyepiece graticule;
Accept descriptions
3. Count number of capillaries in large number of fields of view and calculate mean;
4. Select fields of view randomly 4

Q11.

- (a) 1. Methylation prevents transcription of gene;
2. Protein not produced that prevents cell division / causes cell death / apoptosis;
3. No control of mitosis. 3
- (b) 1. Scatter graph;
2. Fat on x axis and death rate on y axis;
3. (Because) looking at relationship between two discrete / independent variables.

- (c) 1. (Trend) shows positive correlation / shows the more fat in diet, the higher death rate from breast cancer;
2. But number of points off line / anomalies.

2

[8]**Q12.**

- (a) 1. Rank all STs in ascending order;
2. Find value with same number (of people) above and below.
Accept find middle value

2

- (b) Not ethical to fail to treat cancer.

1

- (c) Yes since with ipilimumab:

1. Median ST increased by 2.1 months;
2. Percentage of patients showing reduction in tumours increased from 10.3% to 15.2%;

No because:

3. No standard errors shown / no (Student) t- test / no statistical test carried out;
4. (So) not able to tell if differences are (statistically) significant / due to chance (alone);
5. Improvement might only be evident in some patients / no improvement in some patients;
6. Quality of (extra) time alive not reported;

If answers relate only to 'Yes' or 'No', award 2 marks max

4 max

- (d) 1. Faulty protein recognised as an antigen / as a 'foreign' protein;
2. T cells will bind to faulty protein / to (this) 'foreign' protein;
3. (Sensitised) T cells will stimulate clonal selection of B cells;
4. (Resulting in) release of antibodies against faulty protein.

3 max

[10]**Q13.**

- (a) 1. Binding (of interferon gamma) changes shape/tertiary structure of receptor (protein);
2. This activates/switches on the enzyme;
3. Use of ATP (to phosphorylate STAT1);
1. Accept reference to second messenger mechanism/process
3. Context is important

2 max

- (b) 1. Phosphorylated STAT1;
2. IRF (protein);
Accept in either order
1. Must be phosphorylated but accept STAT1P
2. Ignore references to phosphorylated

2

- (c) 1. Causes more helper T cells to form;
2. (So) more interferon (gamma) production (by helper T cells);

1. and 2. require idea of more

2

- (d) 1. (Tumour suppressor gene) slows cell division/causes death of damaged/tumour/cancer cells;
2. *IRF* gene leads to formation of IRF (protein) that binds to gene B;
3. (Gene B protein) causes death of damaged/mutated cells OR slows division;

2. 'It' means IRF gene

3. Context is important

*3. If clearly stated **and** includes the protein, scores 2 marks because it subsumes point 1*

3

[9]

Q14.

- (a) 1. Removes (main / largest) source of oestrogen / (different) mice produce different amounts of oestrogen;

Accept: so oestrogen from ovaries not a confounding variable – idea of.

2. (Allows) oestrogen to be controlled / oestrogen to be made by aromatase only / only oestrogen made in lungs to be involved.

Reject: references to injection of aromatase.

2

- (b) 1. (Anastrozole) prevents / reduces oestrogen production;

2. (Fulvestrant) stops remaining oestrogen binding / less oestrogen binds to receptors.

Note: brackets around drug names.

2

- (c) (Yes for Group T)

1. Least tumours per animal (from fig. 1);

Accept: 'mean values' for tumour area.

2. Lowest (mean) tumour area / size (from fig. 2);

3. Lowest top of range;

(But)

4. Means (tumour area) are similar;

Where candidates confuse range and standard deviation, do not give credit.

5. Ranges overlap / share values so differences may not be real / treatments may be just effective in reducing tumour;

Ignore significance

6. Range affected by outliers / SD's would be better;

7. Done on mice / not done on women / humans;

8. Only 10 mice used per group / small sample size so may not be representative / reliable;

9. Might be side effects;

10. Only did for 15 weeks so maximum effect of drugs may not have been seen.

5 max

(d) 1. Tumours may be different depths / area does not take depth into account / tumours are 3-D / are not 2-D;

Neutral: different sizes

Accept: height / thickness for depth

2. (Measure) tumour volume / mass / weight.

2

(e) 1. Allows tumours to grow / develop / form;

Neutral: gives drug more time to work.

2. (So) can investigate treatment rather than prevention (of tumours) / when tumour / cancer is more advanced.

Accept: to see whether it can destroy / treat / stop growth of a tumour (that already exists) / to allow / assess treatment of a tumour

2

(f) 1. Unethical (not to treat patients) / may increase probability of patients dying / getting more ill;

Reject: references to giving people tumours

2. Use normal cancer drugs / treatment.

Accept: named type of cancer treatment, e.g. chemotherapy

2

[15]

Q15.

(a) 1. Sugar-phosphate (backbone) / double stranded / helix **so** provides strength / stability / protects bases / protects hydrogen bonds;

Must be a direct link / obvious to get the mark

Neutral: reference to histones

2. Long / large molecule **so** can store lots of information;

3. Helix / coiled **so** compact;

Accept: can store in a small amount of space for 'compact'

4. Base sequence allows information to be stored / base sequence codes for amino acids / protein;

Accept: base sequence allows transcription

5. Double stranded **so** replication can occur semi-conservatively / strands can act as templates / complementary base pairing / A-T and G-C so accurate replication / identical copies can be made;

6. (Weak) hydrogen bonds **for** replication / unzipping / strand separation / many hydrogen bonds **so** stable / strong;

Accept: 'H-bonds' for 'hydrogen bonds'

6

(b) 1. (Mutation) in **E** produces highest risk / 1.78;

2. (Mutation) in **D** produces next highest risk / 1.45;
3. (Mutation) in **C** produces least risk / 1.30;
Must be stated directly and not implied
E > D > C = 3 marks
Accept: values of 0.78, 0.45 and 0.30 for MP1, MP2 and MP3 respectively
If no mark is awarded, a principle mark can be given for the idea that all mutant alleles increase the risk

3

(c) **180;**

1

(d) **(Similarities):**

1. Same / similar pattern / both decrease, stay the same then increase;
2. Number of cells stays the same for same length of time;
Ignore: wrong days stated

(Differences):

(Per unit volume of blood)

3. Greater / faster decrease in number of healthy cells / more healthy cells killed / healthy cells killed faster;
Accept: converse for cancer cells
Accept: greater percentage decrease in number of cancer cells / greater proportion of cancer cells killed
4. Greater / faster increase in number of healthy cells / more healthy cells replaced / divide / healthy cells replaced / divide faster;
Accept: converse for cancer cells
*For **differences**, statements made must be comparative*

3 max

- (e)
1. More / too many healthy cells killed;
 2. (So) will take time to replace / increase in number;
Neutral: will take time to 'repair'
 3. Person may die / have side effects;

2 max

[15]

Q16.

- (a)
1. To allow comparison;
 2. Because different number of cells in samples / different times for incubation / numbers become easier to manipulate;

2

(b) 203.7(%);;

Allow 1 mark for 21.8 / 10.7

Allow 1 mark for correct answer (203.74) but not correctly to 1 dp

204 = 1 mark

2

- (c) (i) 1. (At every concentration) uptake is faster at 37°C / at higher temperature;
2. Due to faster respiration / ATP production;
- (ii) 1. Uptake at 37°C only small increase / levelling off / almost constant as carrier proteins full;
Accept 'no (significant) change'
Ignore use of numbers
2. Concentration of imatinib is not the limiting factor;

2

2

[8]

Q17.

- (a) Cytosine with Guanine and (Adenine) with Uracil;
Ignore G, C and U

1

- (b) Two reasons, with suitable amplification;;

Q

Only infected cells have HIV protein on surface;

So carrier only attaches to / specific to these cells / siRNA can only enter these cells;

OR

siRNA (base sequence) complementary / specific to one mRNA;
Accept idea of specificity

Only infected cells contain mRNA of HIV / this gene / stops translation of this gene / only binds to this mRNA / destroys this mRNA;

Accept could not inhibit other / non-HIV mRNA

4 max

- (c) 1. Carrier binds to (protein on) HIV;
1. Accept references to HIV membrane
2. Prevents HIV / it binding to (receptor on human) cell;
2. Reject references to binding to HIV protein on human cell

2

[7]

Q18.

- (a) (i) 1. Sex;
2. Lifestyle;
Stress, smoking, diet etc are examples of lifestyle.
3. Body mass;

3. Allow weight for mark point 3.
4. Health;
Reject: height.
 5. Ethnicity;
 6. Genetic factors / family history;
- 2 max**
- (ii) 1. Large sample / number / 410 000;
Reject: random
2. Long time period / 8.5 / many years;
 3. Different countries / more than one country;
- 2**
- (b) Correct answer of 209 / $209.1 = 2$ marks;
Answer of 210 = one mark
- Incorrect answer but multiplies by 8.5 = 1 mark;
- 2**
- (c) Age affects risk of cancer;
Must relate to cancer not just to illness
- 1**
- (d) 1. Correlation does not mean causal relationship;
1. Reject casual for point 1.
Reference to 'due to other factors' on its own is not enough for a mark
2. Tea / coffee contains other substances / different amounts of caffeine / estimated intake (of tea / coffee);
 3. No control group;
 4. Only one type of cancer studied / further studies required / only one investigation / study / group;
- 4**
- (e) (i) 1. Treated the same;
2. Accept decaffeinated
2. No caffeine;
2. Reject placebo.
- 2**
- (ii) 1. Absorb different amounts;
Reject: Different body masses
2. Broken down by enzymes / digested;
 3. Different blood volumes;
 4. Differences in metabolism;
 5. Caffeine from a different source;
- 1 max**

- (iii) 1. Less oxygen / glucose to (cancer) cells;
'Reduces cell division' on its own should not be credited.
- 2. Less carcinogens;
- 3. Reduces spread of cancer (cells);

1 max

[15]

Q19.

- (a) In one country where the percentage of fat (in the diet) is 35%, the death rate (from breast cancer) is 20 per 100 000;

Must have reference to country

Accept ... 1 per 5 000 / 0.02%

1

- (b) 1. No. of deaths from breast cancer divided by total population \times 100 000;
- 2. No. of deaths from breast cancer divided by all deaths \times 100 000;
- 3. Sample and count deaths from breast cancer in 100 000 people;
If sample not 100 000 then must scale appropriately

1 max

- (c) 1. Positive correlation;
- 2. But correlation does not show causation / some other (named) factor may be involved;
- 3. Evidence against positive correlation e.g. different death rates at same % fat / similar death rates at different % fat / some countries with higher death rate have lower fat intake;
1. Accept description of positive correlation / directly proportional.
Accept positive relationship.
2. Do not accept casual in place of causal.
3. Answer must be consistent with data.

3

[5]

Q20.

- (i) smoking and drinking increase risk;
risk increases for nonsmokers with more alcohol;
20-40 cigarettes increases risk;
at all levels of alcohol consumption;
4 or more drinks increase risk in all groups;
worst risk with combination of 40+ cigarettes and 4 or more drinks;
smoking and drinking together have a greater effect than either on its own;
over 40 cigarettes and no alcohol greater than 1 or 2 alcoholic drinks / valid comment about anomaly;

3 max

- (ii) other environmental factor / e.g. passive smoking;
genetic predisposition / inherited from parents;
mutation;

Q21.

- (a) (i) Spindle formed / chromosome / centromere / chromatids attaches to spindle;

Chromosomes / chromatids line up / move to middle / equator (of cell);

Do not award second mark for answers referring to chromosomes 'pairing up'.

Ignore reference to homologous chromosomes unless context suggests pairing which negates second mark.

Neutral: Details on nuclear membrane.

Accept: Diagram for second marking point.

2

- (ii) Chromosome / centromere splits / chromatids / 'chromosomes' separate / pulled apart;

To (opposite) sides / poles / centrioles (of cell);

Reject: Homologous chromosomes separate for first marking point.

Accept: Diagram for second marking point.

Chromatids / 'chromosomes' move to poles / sides / centrioles = 2 marks.

2

- (b) (i) Form / replace cells quickly / rapidly / divide / multiply / replicate rapidly;
Neutral: Repair cells.
Answers must convey idea of 'speed'.

1

- (ii) Correct answer = 774 minutes / 12 hours 54mins = 2 marks;;

Incorrect answer but indicates 3 cell cycles involved = one mark;

2

- (c) Prevents / slows DNA replication / doubling / prevents / slows mitosis;

New strand not formed / nucleotides (of new strand) not joined together / sugar-phosphate bonds not formed;

First marking point must be in context of DNA replication not cell replication.

Do not negate first marking point if role of DNA polymerase is described incorrectly e.g. Reject: 'joins bases / strands together'.

Role of DNA polymerase must be correct for last marking point.

2

Q22.

- (a) 1. Gives rise to new plants / plantlets;

2. So must be able to develop into different tissues / other specialised cell types / differentiate;
 1. *Ignore references to leaves / callus* 2
- (b) Two marks for 5 : 1/50 : 10/1 : 0.2;;
One mark for ratio correctly identified but expressed incorrectly as 1 : 5 / 10 : 50 / 0.2 : 1; 2
- (c) (i) 1. Meiosis / independent assortment / crossing over;
 2. (Fusion of) genetically different gametes / random fertilisation; 2
- (ii) Will be clones / produced by mitosis / will be genetically identical / less variation / all plants will have desired characteristics;
If the reference is to identical must be genetically identical, but allow less variation without the reference to genetical. 1

[7]

Q23.

Essay Using DNA in science and technology

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.

Q24.

(a) Will replace themselves / keep dividing / replicate;

Undifferentiated / can differentiate / develop into other cells / totipotent / multipotent / pluripotent;

Accept tissues

2

- (b) Reverse transcriptase;
Allow phonetic spelling 1
- (c) (i) Alters base / nucleotide sequence / causes frame shift;
Different sequence of amino acids in polypeptide / protein / primary structure alters the tertiary structure;
Accept any reference, such as adding bases, to changing the base sequence of the gene. Reject deletion / substitution.
Idea of sequence essential so not makes different amino acids.
Accept answers involving stop / start codons and effect on protein. 2
- (ii) Affects tumour suppressor gene;
Inactivates (tumour suppressor) gene;
Rate of cell division increased / tumour cells continue to divide;
Ignore answers relating to oncogenes. May gain third point. 2 max
- (d) Yes
SCID patients unlikely to survive / quality of life poor unless treated;
Cancer that develops is treatable / only affects 25% / five children;
- No
Risk of developing cancer is high / 25%;
Cancer may recur / may not be treated successfully in future / only short time scale so more may develop cancer;
No mark for yes or no. Marks are for supporting argument based on biological reasoning.
Accept any points 2 max

[9]

Q25.

- (a) Given only saline;
Otherwise treated exactly the same way; 2
- (b) Ethical consideration, e.g., leads to death / suffering of mice;
Large number to improve reliability / reduce sampling error;
Number of mice related to cost / space available / animal husbandry; 2 max
- (c) Vary in shape / do not grow uniformly;
Q Allow descriptions of variation in shape. 1
- (d) 7.44 and 1.74;;
7.42 and 1.72;;

(Ratio) 4.28 : 1;;

(Ratio) 4.31 : 1;;

(Percentage decrease) 76.6%;;

(Percentage decrease) 76.8%;;

Any of the answers shown gain two marks.

An answer of 23.4% or 23.2%

Percentage decrease gains one mark.

Correct method of calculating rate / ratio / percentage increase with an incorrect answer gains one mark.

2 max

(e) Reference to Mitosis;

As chromosomes cannot attach (to spindle) / chromatids cannot separate (on spindle);

Q Do not penalise confusion between chromosomes and chromatids in second marking point

Cell division / cell cycle slows down;

Q Mitosis slows down = 2 marks

Q Mitosis stopped = 1 mark

Q Mitosis must be spelt correctly

3

(f) (i) (Degree of) spread / variation from the mean;

1

(ii) Both chemicals (on their own) slow down growth / are effective;

Taxol is more effective than OGF;

Combined treatment (seems) most effective;

SD overlap for OGF with taxol and taxol (on its own) so not conclusive / could be chance / both treatments could be equally effective;

Q Ignore all references to significance

4

[15]

Q26.

(a) To ensure the colour is the same at the start;

1

(b) Yes – curve on graph with bromelain present remains approximately constant / rises very slightly;
Would decrease if killing of cells occurred / would increase if cells still dividing;

2

(c) Use of mouse cells (rather than human);
(Carried out) *in vitro* / not in living organisms;
Only tested on one type of cancer;
Not possible to predict effect on humans (as no data collected);

3 max

(d) The faster the rate of division the faster the cancer would grow;

By measuring rate of cell division you could see how effective the treatment was;

2

- (c) Not ethical to replace conventional treatment;
As life of patient is at risk (if bromelain not effective);

2

[10]

Q27.

(a)

Nucleus	Number of chromosomes	Mass of DNA / arbitrary units
At telophase of mitosis	26;	30;
From a sperm cell	13;	15;

4

- (b) Cancer cells often have faulty / damaged DNA;

Protein / p53 faulty / not made;

Cell (with faulty / DNA) divides / completes cell cycle;

Uncontrolled division produces cancer;

p53 refers to the protein so do not accept reference to p53 mutating.

3

- (c) (i) Interphase / S phase / synthesis phase;

1

(ii) Anaphase / A;

1

[9]

Q28.

- (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]

Q29.

- (a) (i) benign does not cause cancer /
does not invade other tissues causing damage /
with benign cancer, pieces which break off do not start new
tumours elsewhere in body / metastasis; 1
- (ii) may damage organ concerned;
may cause blockages / obstructions;
may damage / exert pressure on other organs; max 2
- (b) (i) because sun's radiation contains ultra violet radiation;
this causes mutation of genes which control division; 2
- (ii) because fair skin has little melanin which protects
against u.v. radiation; 1
- (iii) because cancer has genetic component / may have inherited
(onco)gene / gene which gives predisposition to / causes cancer; 1

[7]

Q30.

- (i) Because there are big differences;
any correct named example e.g. lung cancer / bronchitis much lower
in women than in men; 2
- (ii) easier to compare if sample size effectively the same;
different numbers of people in each group; 2

[4]

Q31.

- (a) secreted by the liver / storage / release from gall bladder into the duodenum / small
intestine;
bile passes unchanged from small intestine to colon; 2
- (b) (i) chance alone has not caused the difference (between the two patients
types);
high steroid high bacteria (significantly) higher percentage of cancer
patients / low steroids low bacteria (significantly) higher percentage of
control patients; 2

2

(ii) some patients with low levels of one / both factor(s) have cancer;

1

- (c) change in code / base sequence / structure of gene;
addition / deletion / substitution;
mRNA / transcription changed;
gene product / protein structure / amino acid sequence changed / different protein;
loss of function;
uncontrolled cell division;

4 max

[9]

Q32.

- (a) mass of undifferentiated / unspecialised / totipotent cells;
uncontrolled cell division;
(not 'repeated')

metastasis / (cells break off and) form new tumours /
spread to other parts of body;

3

- (b) cancer takes time to develop / exposure when young but cancer triggered later; other organs destroyed before death occurs / metastasis affects other organs;
immune system less effective in old people;
longer time of exposure to UV / accumulation of mutagenic effect;

1 max

- (c) dark skin / melanin / pigment stops UV light / prevents burning;
so less cancer risk in dark skinned people / less likely to develop tumours;
(allow converse)

2

[6]

Q33.

- (a) Daughter (C) does not have the condition / one child doesn't have it;
Accept converse arguments (If candidates see it purely as a genetic cross diagram) D is heterozygous because E is unaffected;

Parents must have been carriers of normal / healthy recessive/
if recessive then parents homozygous (so all children affected);
D has cancer, so the cancer allele must be dominant;

2

- (b) Father (A) would pass on X chromosome to daughter;
She is not affected;
Accept that if D's X chromosome carried 'it', then E would be affected.

2

- (c) Only 25 / young so don't know if cancer will develop;
Accept E must be homozygous recessive/have two recessive alleles;

Don't know if her father was heterozygous or homozygous;

So no chance of cancer / no more chance than rest of the population;

If heterozygous, she has a 50% chance of carrying the allele/gene;
If homozygous, she has a serious risk of cancer.

2 max

- (d) Mutation / mutagen changes DNA of cell;
Damaged DNA not repaired / cells not killed / apoptosis doesn't happen;
Mutation leads to loss of control / uncontrolled cell division;
(Some of these) cells carried to other parts of the body.

3 max

[9]

Q34.

- (a) No cadmium;
Other conditions same as cadmium-treated group;

2

- (b) (i) As a measure of the effect due to cadmium /
to make a comparison;

1

- (ii) Becoming more methylated;
Ignore later slight decrease/no change

1

- (iii) Production of more methyltransferase enzyme /
increased activity of transferase;
Extra incorrect relevant information - cancel

1

- (c) RNA-polymerase could not bind (to DNA / to promoter);
mRNA of p16 could not be made / no transcription of p16 gene;

2

- (d) Any four from:
1. Cadmium causes expression of methyltransferase gene /
increased activity transferase (from 2 to 3 weeks in);
2. Methyl groups on to promoter / p16 gene / suppressor (gene);
3. (p16) normally suppresses tumour growth;
4. p16 protein / p16 expression falls after 4 weeks / after methylation;
5. Tumour formation occurs (after 10 weeks) after p16 falls /
after suppressor gene activity falls;

4 max

[11]

Q35.

- (a) 1 Cut gene out of cell / make gene using mRNA / obtain gene with restriction enzymes;
- 2 Cut DNA using restriction enzyme / plasmid cut with restriction enzyme;
- 3 Correct reference to sticky ends;
- 4 Join DNA using ligase / insert gene into vector;
- 5 Plasmid / named vector transferred to cell;

- 6 Method of transfer e.g. heat shock;
- 7 Reference to marker gene;
- 8 Select bacteria containing new gene;

max 6

- (b) Cells can metastasise / break off / spread to other parts of the body;
Remaining cells continue to divide forming a new tumour / secondary; 2
- (c) Antibodies specific;
Normal cells have different antigen / cancer cell has particular antigen;
Enzyme **only** present in cancer cells so drug **only** activated at / near cancer cells; 3
- (d) All cells contain DNA;
Would stop / inhibit DNA replication in normal cells;
Stops / inhibits cell division;
Named example on growth / repair e.g. no new blood cells made / no wound healing; 4

[15]