AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.8.2 GENE EXPRESSION AND CANCER

SCORE	PERCENTAGE
/360	%

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Q1.

(a) Box 2.

An inversion will result in a change in the number of DNA bases.

Reject if more than one box with tick. Ignore crossed-out ticks

1

(b) 1. (Increased) methylation (of tumour suppressor genes);

Accept abnormal methylation or hypermethylation

Ignore decreased acetylation of histones

2. Mutation (in tumour suppressor genes);

3. Tumour suppressor genes are not transcribed/expressed
OR
Amino acid sequence/primary structure altered;

Accept mRNA for transcription/transcribed

Accept tertiary structure altered

Accept different amino acid

Ignore reference to protein not being formed

4. (Results in) rapid/uncontrollable cell division;

Accept cell division cannot be regulated

Ignore growth

3 max

(c) 1. Correct answer of $1.9/1.93 \times 10^{25}$ = **2 marks**;;

Accept 2×10^{25} = 2 marks

Ignore any numbers after 1.93

2. Incorrect answer but shows 84 = **1 mark**
OR
28 × 3 = **1 mark**
OR
Incorrect answer but shows 672 divided by 8 = **1 mark**;

2

[6]

Q2.

(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]

Q3.

(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]

Q4.

(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

[15]

Q5.

(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.

3

(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]

Q6.

(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]

Q7.

(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]

Q8.

(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]

Q9.

(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]

Q10.

(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 <u>percentage</u> decrease in number of cancer cells / greater <u>proportion</u> 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]

Q11.

(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;

2

(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

[8]

Q12.

(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]

Q13.

(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 × 100 000;

2. No. of deaths from breast cancer divided by all deaths × 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]

Q14.

(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

[9]

Q15.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects covered but they are unrelated	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question. Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
6 – 10	Unistructural Only one or few aspects covered	Response predominantly deals with only one or two topics that relate to the question. Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
1 – 5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level.

		May contain a large number of errors and, or, irrelevant topics.
0		Nothing of relevance or no response.

Commentary on terms and statements in the levels mark scheme

The levels mark scheme for the essay contains a number of words and statements that are open to different interpretations. This commentary defines the meanings of these words and statements in the context of marking the essay. Many words and statements are used in the descriptions of more than one level of response. The definitions of these remain the same throughout.

Levels mark scheme word/statement	Definition
Holistic	Synoptic, drawing from different topics (usually sections of the specification)
A fully integrated answer which makes clear links between several different topics and the theme of the question	All topics relate to the title and theme of the essay; for example, explaining the biological importance of a process. When considering, for example, the importance of a process, the explanation must be at A-level standard. 'Several' here is defined as at least four topic areas from the specification covered. This means some sentences, not just a word or two. It does not mean using many examples from one topic area.
Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word.

	Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of Using DNA in science and technology**.

Topics

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.

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

Note, other topics from beyond the specification can be used, providing they relate to the title and contain factually correct material of at least an A-level standard. Credit should not be given for topics beyond the specification which are below A-level standard.

[25]

Q16.

(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 / ERα 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]

Q17.

(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]

Q18.

(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

[9]

Q19.

(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]

Q20.

(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]

Q21.

(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]

Q22.

(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]

Q23.

(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]

Q24.

(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]

Q25.

(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]

Q26.

(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

(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]

Q27.

(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]

Q28.

(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;

1 max

[4]

Q1.

(a) The vast majority of students (94%) realised that an inversion would not result in a change in the number of DNA bases.

(b) This question proved to be a very effective discriminator with one in three students gaining maximum marks. Nearly all students (91%) gained at least one mark, often for referring to mutation or methylation of tumour suppressor genes. Mutation was the most frequently credited marking point, although a significant number of students mentioned both alterations for two marks. Weaker students who provided further details on mutations often limited their descriptions to a non-functional protein being produced. Better answers included changes in primary or tertiary structure. Many students describing methylation did appreciate that this could prevent transcription of tumour suppressor genes. A significant minority of students referred to uncontrollable cell growth rather than uncontrollable or rapid cell division. There were also irrelevant, and often incorrect, references to oncogenes.

(c) Over 83% of students gained at least one mark, almost invariably for showing 84 cell divisions. Slightly more than half of these students provided further calculations leading to a correct answer for two marks. Common errors included 84^2 and 28^3.

Q2.

(a) It was pleasing to see that nearly all students could name two enzymes involved in DNA replication; 92% got both marks.

(b) This question discriminated well. 40% of students obtained one mark, usually by noting that phosphorylation of the enzyme caused the active site to be formed, or to become complementary to the substrate. About 38% of students obtained two marks, usually by also noting that phosphorylation changed the tertiary structure of the enzyme (which caused the change to the active site). Some students' terminology was poor and confused, and some referred, wrongly, to phosphate as a competitive, or non-competitive inhibitor. Some failed to mention the active site at all, even though the question asks why enzymes become able to bind to their substrates.

(c) About 50% of students obtained the mark, by reference to the substrate becoming more reactive, or phosphorylation (of the substrate) lowering the activation energy for the reaction. Quite a few made vague references to kinetic energy changes that were not credited. Some wrongly continued to focus on phosphorylation of the enzyme.

(d) This was well done by many, with 47% obtaining 3 marks, but still discriminated quite well. Most students appeared to be able to follow the story in the stem of the question and apply some basic principles, such as the mutation leading to a form of ATM unable to bind to broken DNA. Only 3% of students failed to score.

Q7.

(a) 44% obtained one mark, usually for noting that binding of interferon gamma activated/switched on the enzyme inside the cell. 28% obtained a second mark, usually for reference to there being a second messenger process involved, or describing this. A few noted that ATP would be used in the phosphorylation of STAT1.

(b) It was pleasing to find that 33% could correctly identify the transcription factors. Those who obtained one mark (42%) usually referred to STAT1, rather than phosphorylated STAT1 in their answer.

(c) 37% obtained two marks for reference to interferon gamma leading to more helper T cells, which then produced more interferon gamma. Some students (41%) only wrote about more of one or the other and scored 1. Poor answers usually consisted of generalised statements about, or definitions of, positive feedback.

(d) 70% of students obtained one mark, usually for stating that the *IRF* gene would slow/stop cell division; essentially stating what a tumour suppressor gene is. Only 20% obtained a second mark for noting that the *IRF* gene leads to the formation of IRF protein that binds to gene B. Very few went on to get the third mark by noting that this binding leads to the death of damaged or mutated (potential tumour) cells.

Q8.

(a) This part was most notable for the very large number of students who misread the stem of the question. The stem states that the substrate of aromatase was injected into mice. The majority of students wrote about injecting aromatase, the enzyme. This made it unlikely that they could score 2 marks. About 50% did obtain one mark, almost always for noting that removing the ovaries removed a major source of oestrogen. The 20% who obtained a second mark usually did so by noting that this allowed the scientists to control oestrogen (concentration by injecting the substrate).

(b) About 25% scored both marks. These students recognized that one drug reduces oestrogen production and the other stops any remaining oestrogen binding to its receptors. Obviously, this makes the drugs more effective together. Weaker answers just re-stated information about what each drug does from the stem. Others marred their answers by writing about competition by fulvestrant for ‘active sites’, rather than binding sites or receptors.

(c) This required students to explain their answer. Weaker answers were often just observations without explanations. For example, noting that there are only a few mice in each group but not going on to explain that this means the results may not be very representative / reliable. A large number of students incorrectly wrote about standard deviations, when it clearly states that Figure 2 includes ranges. For those who did attempt explanations, it was a case of how many valid points they made; there were 10 on the mark scheme. Only 5% scored all 5 marks but the question did discriminate well, in the sense that students who did well on the whole paper tended to do well on this question.

(d) Many students (about 60%) obtained 1 mark in this part for suggesting a more reliable measurement of tumour size. Only a quarter noted that tumour area gives no idea of depth of the tumour and went on to get a second mark.

(e) This part produced quite a large number of generic ‘How Science Works’ attempts at answers and these did not score any marks. Many good answers were seen, where students noted that the extra time allowed tumours to develop and thus the chance to see how effective the drugs are on already-developed tumours.

(f) Nearly half of students failed to score any marks in this part. Perhaps most worrying were the students who wanted to give human cancer patients no treatment, or inactive forms of the drugs. The other students often obtained 1 mark for referring to it being unethical not to treat people with cancer. About half of these then went on to suggest the use of existing treatments for cancer; often suggesting chemotherapy or radiotherapy.

Q9.

(a) (i) The examiners wanted a statement that a mutation could make the gene inactive and that this would lead to uncontrolled, or very rapid, cell division. About half of students obtained both marks. Some students did not mention cell division but just stated that a tumour would grow; apparently taking 'growth' to mean cell division. The examiners did not accept these terms as equivalent. Some students got into long explanations of how a mutation could lead to a faulty protein and eventually got the first mark point for an inactive gene. Some of these failed to score because they wrote about mutations leading to the production of faulty amino acids.

(ii) A large majority of students managed to convey the idea of the genetic code being degenerate.

(b) Very few students obtained all three marks in this part. This was because they didn't address the reference to 'this antibody' in the stem. The examiners were looking for an observation that 'this antibody' will have a specific tertiary structure, or binding site, or variable region. Some of those who did consider this aspect, failed to score because they referred to a specific 'active site'. Many students obtained two marks for suggesting that the antibody binds either to the receptor (protein), or growth factor, and this prevents growth factor binding to its receptor.

Q10.

Parts (a), (b) and (d) proved to be good discriminators.

(a) It was disappointing that only just below 40% of students scored at least half marks. This was mainly due to simply describing the structure of DNA, without explaining how these features relate to its functions. Some students wrote about DNA structure and function in different paragraphs. This made it unclear which feature went with which function, as no direct links had been made. In contrast, there were some truly excellent responses, which had clearly been well planned before putting pen to paper. The most common mark points awarded were for the sugar-phosphate backbone providing strength or protecting bases, the helix allowing the molecule to be compact, weak hydrogen bonds allowing strand separation or replication and the two strands acting as templates or allowing semi-conservative replication. Relatively few students linked complementary base pairing with accurate replication or the production of identical copies of DNA. Similarly, few students referred to DNA as a large molecule that can store lots of information, or the base sequence coding for amino acids. Weaker responses often mentioned this in the context of the genetic code being degenerate. Indeed, some students thought that the base sequence causes amino acids to be *produced*. The ability to convey that *many* hydrogen bonds provide stability was rarely seen. It was also unfortunate that a number of students wasted their time by writing about irrelevant topics such as the differences between prokaryotic and eukaryotic DNA and the role of histones. There were also some lengthy accounts of DNA replication, enzyme structure and the different levels of protein structure.

(b) Many students scored at least two marks for stating that a mutation in gene **E** produces the highest risk and a mutation in gene **C** produces the lowest risk. However, only the best responses also referred to gene **D**. Students who did not mention any of the genes usually picked up one mark for noting that all of the mutant alleles increase the risk of lung cancer. Surprisingly, some thought that a mutation in gene **D** produces the highest risk.

(c) Just fewer than 40% of students gave the correct answer of **180**.

(d) Two-thirds of students scored at least two marks. Many were able to identify the decrease, plateau and increase for healthy cells and cancer cells. However, relatively few made reference to the plateau occurring for the same length of time. Students who failed to gain a mark for a similarity usually ignored the plateau. Most students spotted that a greater number of healthy cells were killed or that they experienced a faster decrease in number. Similarly, it was impressive to see that some used data from the graph to calculate that a greater *proportion* of cancer cells were killed. Many students also noted the faster increase in the number of healthy cells.

(e) Half of students scored full marks. This was usually for mentioning that too many healthy cells would be killed, which could kill the patient or cause side effects. However, relatively few appreciated that it would take time to replace the healthy cells that had been killed.

Q11.

(a) Generic answers that included ideas such as improved accuracy, reliability, validity and so on did not gain marks in this question. A few students clearly understood what the units meant and the way in which they would ensure comparability between results at different temperatures. The majority of the rest of the students who did gain these marks gave rather unconvincing responses and apparently hit the target by accident.

(b) This calculation of percentage increase gave a significant number of students difficulty. The majority selected the correct figures from the table but then had little idea of how to use them, and many scripts showed much crossing out and re-writing. Quite a large number of students did not attempt the calculation. Some students with correct calculations did not do as instructed and give their answer to 1 decimal place.

(c) (i) A number of students did not answer the question as set. Many wrote about the effect of increasing temperature on the kinetic energy available in the system, rather than comparing the data for the two different temperatures. Some read ‘rate of uptake’ as the concentration of imatinib inside the cells and so gave movement up the concentration gradient as the evidence for active transport.

(ii) This was another question that was quite frequently not attempted. Some students had a good understanding of active transport as a process involving trans-membrane carrier proteins and could apply this to the rate of uptake in the cells levelling off at 37°C. Others appeared to be guessing, suggesting that enzymes had been denatured, or that the imatinib had all been used up.

Q12.

(a) (i) Over 80% of students had little difficulty obtaining both marks in this question. Students who obtained one mark often provided two examples of lifestyles or referred to age which was excluded in the stem of the question.

(ii) This was also well answered with over 70% of students gaining both marks. Most students referred to the large sample size and that the study took place over a long period of time. Some weaker students incorrectly answered the question in terms of additional features which may have been desirable in this investigation.

(b) Approximately half the students obtained both marks for this calculation. 20% of

students obtained a single mark for their method of calculation or provided an answer of 210 rather than 209 / 209.1.

(c) Most students made the link between age and the risk of getting cancer. Answers which linked age to caffeine consumption were not credited.

(d) The majority of students obtained at least two marking points often for stating that a correlation does not mean a causal relationship and for mentioning that tea /coffee contains other substances. All the other marking points were seen by examiners but surprisingly few responses included a reference to the lack of a control group in this investigation.

(e) (i) The vast majority of students gained at least one mark by stating that the control group would be treated in exactly the same way as the experimental group. Over 50% of these students gained a second mark by mentioning that the control group should not have caffeine. Answers which were limited to using a placebo without mentioning lack of caffeine were not credited.

(ii) Almost two thirds of students gained this mark often by referring to different rates of absorption, different sources of caffeine or to people having different blood volumes.

(iii) Slightly less than half the students obtained this mark usually by referring to a lack of oxygen supplied to the cancer cells or to the spread of cancer cells being reduced.

Q13.

(a) Candidates often failed to appreciate that point A referred to just one of the 24 countries represented on the graph. The graph showed two points with 35% fat that had different death rates. A number thought that 20 in 100 000 was the same as 200 000.

(b) This question proved to be challenging for many with only the more able gaining the mark. Some suggested a suitable method but then failed to multiply their answer by 100 000. There were many vague answers such as use hospital records, or reading the answer from the graph.

(c) The majority gained two marks for evaluating the data on the graph, although many simply repeated a stock answer along the lines of there being „a positive correlation but correlation does not mean causation". Unfortunately, some candidates failed to gain the first mark by failing to state that the correlation was positive. The better candidates actually looked at the data and gave examples which did not fit in with the pattern – for example, the widely differing death rate with 35% fat in the diet.

Q14.

(a) (i) It was clearly evident that the vast majority of candidates had a good understanding of what happens in metaphase with two thirds of candidates gaining both marks and only ten percent scoring zero. Most candidates gained credit for mentioning chromosomes moving to the equator of the cell. A number of candidates, however, referred to homologous chromosomes aligning in pairs and described metaphase I of meiosis.

(ii) Almost seventy five percent of candidates gained two marks often by stating that 'chromatids move to opposite poles'. Again, approximately ten percent of candidates scored zero.

(b) (i) Although most candidates appreciated that the cells lining the human intestine needed to be replaced only half of the candidates conveyed the idea that this occurs quickly. A significant number of candidates simply stated that the cells needed to be repaired.

(ii) Almost half the candidates gained both marks for 774 minutes or 12 hours 54 minutes. A small number of candidates provided an incorrect answer but correctly indicated three cell cycles for one mark. Many of the remaining candidates used four cell cycles to obtain an incorrect answer of 1032 minutes.

(c) There were some excellent detailed answers to this question which gained both marks. These were, however, in the minority. Most candidates gained at least one mark usually for stating that DNA replication would be inhibited. Generally, there was considerable confusion over the role of DNA polymerase, with many candidates believing it to be involved in breaking hydrogen bonds or in complementary base pairing.

Q15.

Using DNA in science and technology

The very best essays from candidates who selected this option were outstanding. They reviewed, often in great detail, the relevant aspects of the specification although not always incorporating the role of DNA in the classification of organisms. Considering that much of the content of this essay could be drawn from this unit, it was surprising how poor many answers were. Understanding of techniques was often extremely limited, particularly *in vivo* gene cloning and the use of markers. Many essays presented no more than a broad overview either emphasising ethical issues at the expense of biological detail or failing to distinguish established practice from wishful thinking.

Q16.

(a) The answers to this question and to Question 6 (b) suggested that many candidates were uncertain as to the roles of various enzymes used in gene technology.

(b) Although the majority of candidates clearly understood the basic idea of transcription, they tended to gain limited credit for part (i) of this question. This was largely because they failed to make effective use of the material with which they had been provided. There were few references either to binding to the promoter or to stimulation of the enzyme. In part (ii), most candidates recognised the specificity of the receptors but were not always able to address the question of why oestrogen does not affect other cells. There was much discussion of oestrogen binding to receptors, but relatively little about receptors being confined to the cells of target organs.

(c) Most candidates recognised the molecular structures as being either complementary or similar and used this information to construct sensible suggestions about reduction in growth of breast tumours. The terminology used by many, however, suggested confusion with enzyme action.

Q17.

(a) While most candidates recognised that stem cells are undifferentiated, many failed to point out that they were capable of replacing themselves. A reference to totipotency ensured this first mark, but a second could not be awarded for simply explaining what the term meant.

(b) The examiners were of the opinion that many candidates had encountered the word but had very little understanding of its meaning.

(c) In part (i), only the better candidates recognised and were able to describe the relationship between the altered sequence of nucleotide bases and the consequent change in the sequence of amino acids affecting the tertiary structure of the protein. There were many general answers that offered little more information than that the "gene was disrupted" or that a "different amino acid was made." Many candidates found part (ii) challenging and, although they were able to gain credit for a general statement relating to the uncontrolled division of cancer cells, they attributed this to insertion of the gene in the base sequence of either the tumour suppressor gene or into a proto-oncogene, thereby converting it into an oncogene.

(d) Many candidates had clearly given careful thought to their answers and made effective use of the data provided. They usually came to the conclusion that 25% was either an unacceptably high cancer risk or that 75% of children were unaffected by cancer. Many took the view that, as the cancer could be treated, whereas SCID was likely to prove fatal, this was an acceptable trial. Answers that adopted a more general approach, describing the trial as unethical, accusing the scientists concerned of "playing God" or commenting on children being unable to make informed judgement did not gain credit.

Q18.

(a) (i) Most candidates gained one mark for describing that the rate of reaction increased and then remained constant. Unfortunately, a minority of candidates disqualified this mark by stating that the plateau was where the reaction had stopped or the rate had decreased. Surprisingly, very few candidates correctly identified the substrate concentration at which the rate of reaction started to level off. Many simply referred to point **B** on the graph, or typically gave a value from 20-25. A minority of candidates gave an explanation for the shape of the curve.

(ii) Most candidates were aware that substrate concentration was limiting the rate of reaction. Many then went on to explain correctly how this could be determined from the graph. A minority of candidates did not read the question stem carefully and referred to the curve **after** point **B**. References to temperature as the limiting factor were not credited as this could not be determined from the graph.

(iii) This proved to be a good discriminator. Just less than half of candidates gained this mark for explaining that all active sites were occupied or that enzyme concentration was a limiting factor. Weaker candidates were often let down by poor expression or a lack of detail e.g. 'enzymes working flat out', 'all enzymes are active', 'enzymes are at saturation point' and 'maximum number of collisions'. As was the case for (a)(i), a minority of candidates thought that the reaction had stopped between points **C** and **D**. Other incorrect explanations seen included reference to enzyme denaturation and the presence of an inhibitor.

(b) Almost half of candidates scored one mark. Many candidates who failed to score were aware that the initial rate of reaction would be lower. However, they usually confused the two types of enzyme inhibitor and drew the plateau below that of the original curve.

(c) (i) Most candidates gained at least one mark for stating that the drug would bind to the active site. Weaker candidates sometimes missed out on this mark

through a lack of detail e.g. ‘the drug binds to the enzyme’. Better candidates usually went on to score full marks for the idea that less enzyme-substrate complexes would form. References to the drug having a similar shape to the substrate were less frequent. However, some candidates disqualified this for stating that the drug was the same shape as the substrate or active site.

(ii) Just less than half of candidates gained the mark for explaining that the drug could only fit the active site of folate reductase. This was expressed in a variety of ways but typically in terms of the complementary shapes of drug and active site. Very few candidates gained the mark for explaining that the drug was a similar shape to only one substrate. Weaker candidates often wrote in general terms about enzyme specificity, without reference to the drug. Similarly, as in (c)(i), poor expression prevented some candidates from scoring. This was usually for referring to the enzyme rather than active site or for stating that the drug was the same shape as the active site.

Q19.

(a) Most candidates gained at least one mark by stating that the control group would be treated in exactly the same way as the experimental group apart from being injected with taxol. Less than 10% of candidates gained the second mark by indicating that the control group would be injected with saline.

(b) Although most candidates were able to suggest two factors relating to the number of mice used in the investigation the explanations provided were not always worthy of credit. A common scoring point was the suggestion that a large number of mice would increase the reliability of the results. However, answers relating to ethical considerations often lacked sufficient detail to gain a mark.

(c) Slightly less than half the candidates gained this mark often by indicating that growth of tumours vary in shape. There was a wide variety of incorrect responses.

(d) It was disappointing to note that over half the candidates obtained zero on this question. Approximately 30% of candidates gained both marks. The mark scheme allowed for a variety of approaches but it was clearly evident that many candidates had difficulty calculating a growth rate.

(e) This question proved a very effective discriminator. Most candidates gained one mark for suggesting that mitosis would be affected, although a small minority referred to meiosis. A good proportion of these candidates then explained how taxol could specifically inhibit the separation of chromatids during mitosis. However, only the most able candidates used the results to explain that mitosis was not completely inhibited by taxol as shown by the increase in the volume of the tumour with this treatment. Candidates who stated that ‘mitosis was stopped’ did not gain this third mark.

(f) (i) Less than 50% of candidates were able to provide a clear definition of standard deviation. Most incorrect answers simply stated that it provided the ‘spread of results’ with no reference to the mean.

(ii) This question also proved a very effective discriminator. Most candidates gained one mark for suggesting the combined treatment seemed to be the most effective treatment. The vast majority of these candidates also noted that taxol is more effective than OGF. However, far fewer candidates clearly explained that both these chemicals on their own were effective in slowing growth of the tumour. Although better candidates also considered the standard deviation only the most able candidates clearly explained how the overlap of

standard deviations indicated that the taxol and combined treatments could have been equally effective.

(ii) As expected this proved to be a difficult question. Most candidates had difficulty understanding the flow chart and gave a variety of incorrect responses. Despite the information provided in the stem of the question many candidates suggested that the *Giardia* antigen would remain on the plate and cause a positive result. Other misconceptions related to the enzyme reacting with the antigen or with the antibodies. Approximately forty percent of candidates obtained one mark for realising that the second antibody with the attached enzyme would remain on the plate. Far fewer of these candidates went on to explain that the enzyme would react with the substrate to provide a yellow colour.

Q20.

(a) The first column in the table was intended to test the basic idea that chromosome number is unchanged in mitosis but is halved during meiosis. Many candidates attempted to halve the chromosome number in mitosis and then halve this number again to produce the number of chromosomes in a sperm cell. Unfortunately they failed to recognise the impossibility of an answer involving half a chromosome. Completing the second column correctly proved more challenging but better candidates clearly understood the principles involved.

(b) There were some excellent answers to this part of the question that were not only factually correct but expressed the essential points clearly and logically. Others were limited by poor use of technical language, the most common failing being to describe the protein rather than the gene as mutating. Once again, there was considerable evidence of over-teaching leading to confusion. Almost invariably candidates who introduced the topics of Hayflick limit, oncogenes and tumour suppressor genes lost sight of the underlying theme. They frequently produced contradictory answers that gained little credit.

(c) Both parts of this question were usually answered correctly.

Q22.

(a) Some candidates found the context of this question too complex to be able to give the well practised story of gene transfer. Examiners dealt with many answers that were set in the contexts of transferring *Clostridium* into a bacterium or transferring the enzyme into *Clostridium*. These answers were often still able to gain some credit for the steps involved despite the overarching context being misunderstood. Some candidates failed to reinsert the vector into the bacteria after modification.

(b) Generally well answered, although quality of written communication let down those who used the term "cancer" rather than "tumour".

(c) Few candidates correctly understood the passage and, therefore, most did not realise that the enzyme activated the prodrug. Therefore the examiners found many responses where the enzyme and/or the antibody directly attacked the cancer cells.

(d) Unfortunately the confusions apparent in part (c) carried over to this question. Many candidates correctly identified that there would be an issue related to cell division. However, because they had failed to understand the activation of the prodrug by the enzymes, their responses were confused and became more so as more was written.

Q23.

(a) Many candidates gave a good account of the changes a mutation could produce and those with clear expression achieved full marks; many scored three or four marks. Uncontrolled cell division and malignant tumors were frequently referred to and some appreciated that genes which controlled cell division could have changed. References to benign tumours or cell mutations were irrelevant in the context of this question.

(b) Very few candidates achieved marks here, mainly because they did not read the question. Whole cells in the blood were not required, but the understanding that cancer cells could burst or die and release their DNA was.

(c) Few seemed to understand this and restated the question without reference to the changed base sequences to which the strip would bind.

(d) This was generally well known. The main reason for failing to gain marks was a reference to an undefined 'it' which would be growing, dividing or spreading, causing undefined damage.

(e) Here too some candidates who understood the problem found it hard to explain that changes in the mRNA would reflect mutations in the DNA and would show that a cancer gene was active.

Q24.

(a) In part (i) a minority of candidates commented about a malignant tumour without referring to the benign tumour, e.g. "malignant tumours spread throughout the body". A large number of candidates failed to understand part (ii) properly, and gave one cause of harm for each type of tumour. Even when the question was correctly interpreted, answers were often vague. Tumours were frequently thought to cause blood clots in arteries.

(b) In part (i) the fact that u.v. radiation causes cancer was well known, but few gained credit for establishing a link with the genes controlling cell division. Many candidates believe that u.v. radiation interacts with melanin to cause skin cancer. In part (ii) there was confusion between melanin and melanoma. There were frequent references to the amount of melanoma in the skin. Again, examiners were intrigued by the various spellings of melanin, of which melamine was popular. A common misconception was that dark-skinned people have a darker pigment than light-skinned people, rather than *more* pigment. In part (iii) there were many imprecise answers. A large number of candidates simply mentioned that cancer could be inherited, with no reference to genes. A significant minority thought that cancer cells could be passed on.

Q25.

In part (i) most candidates were aware that there are differences in the figures for men and women. However, despite being asked to use an example from the tables, many failed to do so. In part (ii) many candidates were aware that percentages lead to ease of comparison, but few referred to differing sample sizes.

Q26.

This question produced a wide range of marks and discriminated well between candidates.

(a) Most candidates described the role of bile in digestion but failed to refer to the site of production, or to recognise the distinction between the small intestine and the colon.

(b) The concept of significance was well rehearsed by many candidates. However, few could then use the evidence effectively to support the hypothesis. Most simply related high incidence to high levels of both factors, without drawing a comparison with the control patients. Weaker candidates confused cause and effect, assuming percentage quoted indicated risk of contracting cancer, rather than patients found to have the factor present.

(c) There were a lot of good answers with a significant minority of candidates gaining full marks. Very few mentioned changes to mRNA resulting from mutations, referring only to the influence on the process of translation. Weaker candidates interchanged base sequence of DNA with amino acid sequence of polypeptide.

Q27.

This question was also answered well, but very few scored full marks due to incomplete or poorly expressed answers to part (a).

(a) Nearly all candidates obtained at least one mark but only a few scored all three marks, as the majority did not refer to undifferentiated cells. Cell division was often described as rapid rather than uncontrolled, and many just referred to the growth of the tumour without mentioning cell division. Although most candidates realised that tumours would develop in other regions of the process, the process of metastasis was often poorly described, with many candidates stating that the tumour moved around the body.

(b) Most candidates were able to give a valid reason, with the immune system being less effective, accumulation of genetic error and longer exposure to UV being the most common answers.

(c) Most candidates appreciated that melanin or dark skin protects against the effect of UV. However, some then failed to link this to the decreased chance of developing malignant tumours. Some candidates confused melanoma with melanin, and some stated that dark skin absorbs more UV and then failed to complete their answer or stated that people with dark skin were therefore more susceptible to skin cancer.

Q28.

Many candidates failed to gain one or two marks because they were unable to describe in detail information given in a chart.

(i) Most candidates scored one mark for the general observation that smoking and drinking increase the chance of cancer. Many candidates obtained a second mark for some point of detail; for example, that over forty cigarettes per day and four or more drinks gives the greatest risk. Few obtained a third mark for another valid observation based upon the data.

(ii) Most candidates obtained this mark, usually by reference to some other environmental risk.

Q1.

(a) 1. No (functional) cones
OR
Only rods;

2. Cones are connected to a single neurone
OR
Several rods connected to a single neurone;

Accept correct reference to retinal convergence

Accept 'bipolar/nerve cell' for neurone

Accept 'many' 2 or more for 'several'

3. (Cones) Separate (sets of) impulses to brain
OR
(Rods) Single (set of) impulse/s to brain;

Accept 'optic nerve' for brain

Reject 'signals', 'messages' for 'impulses'

Accept 'action potential'

3

(b) 1. Correct answer in range 42 – 44% = 2 marks;;

2. Incorrect answer but shows that understanding that 2pq = heterozygous/carriers = 1 mark;

Accept 1 – (p^2 + q^2)

Accept understanding of 2pq by using calculation involving 2 × two different numbers

2

(c) 1. (Gene/allele) is on the X chromosome;

2. Females require two alleles/females can be heterozygous/carriers **and** males require one allele;

Reference to allele is essential but only required once

*Reference to females **and** males required*

Reject dominant allele

2

(d) 1. Green sensitive pigment/cones non-functional
OR
Cones that detect green light non-functional;

2. Three different types of pigment/cone;

3. Other/different colours ('seen') due to stimulation of more than one cone/pigment;

1, 2 and 3. Reject reference to 'green cones'/ 'blue cones / 'red cones' but once only

1, 2 and 3. Reject reference to 'green pigment'/ 'blue pigment/ 'red pigment but once only and only if 'green cones' etc, (see above) has not been rejected.

3

(e) 1. (iPS cells) divide;

2. (iPS cells) develop/differentiate into (green sensitive) cones;

Accept 'produce'/'specialise' 'turn in to' / 'genes switched on' / 'turned on' for 'develop' but ignore 'grow'

Reject develop into 'green cones'/blue' cones'/'red cones'

Ignore develop/differentiate into (blue/red sensitive) cones;

Reject reference to develop in to 'green pigment'/ 'blue pigment/ 'red pigment

2

(f) 1. (Use of iPS cells) long-term;

Accept 'gene therapy short-term' or 'only two years'

Accept 'permanent'

2. (Use of iPS cells) less chance of rejection/immune response;

3. (Use of iPS cells) single treatment;

Accept 'gene therapy 'regular/frequent treatment"

4. Harm/side effects from using viruses (in gene therapy);

3 max

[15]

Q2.

(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]

Q3.

(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

[15]

Q4.

(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]

Q5.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects covered but they are unrelated	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question. Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology.

		Some significant errors and, or, more than one irrelevant topic.
6 – 10	Unistructural Only one or few aspects covered	Response predominantly deals with only one or two topics that relate to the question. Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
1 – 5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level. May contain a large number of errors and, or, irrelevant topics.
0		Nothing of relevance or no response.

Commentary on terms and statements in the levels mark scheme

The levels mark scheme for the essay contains a number of words and statements that are open to different interpretations. This commentary defines the meanings of these words and statements in the context of marking the essay. Many words and statements are used in the descriptions of more than one level of response. The definitions of these remain the same throughout.

Levels mark scheme word/statement	**Definition**
Holistic	Synoptic, drawing from different topics (usually sections of the specification)
A fully integrated answer which makes clear links between several different topics and the theme of the question	All topics relate to the title and theme of the essay; for example, explaining the biological importance of a process. When considering, for example, the importance of a process, the explanation must be at A-level standard. ‘Several’ here is defined as at least four topic areas from the specification covered. This means some sentences, not just a word or two. It does not mean using many examples from one topic area.
Biology is detailed and comprehensive A-level content, uses appropriate	Detailed and comprehensive A-level content is the specification content.

terminology, and is very well written and always clearly explained.	Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of Using DNA in science and technology**.

Topics

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.

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

Note, other topics from beyond the specification can be used, providing they relate to the title and contain factually correct material of at least an A-level standard. Credit should not be given for topics beyond the specification which are below A-level standard.

[25]

Q6.

(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]

Q1.

(a) Despite only 8% of students obtaining maximum marks, this question proved to be an effective discriminator. 90% of students obtained at least one mark, often for stating that only rods or no (functional) cones are present. Slightly more than half of these students gained a second mark, usually for correctly describing the connections of rods and/or cones to a single neurone. However, poor terminology prevented some of these students from obtaining maximum marks. Some students used terms such as 'messages' and 'signals' rather than impulses. Even when students did refer to impulses, they often omitted reference to the optic nerve or brain, resulting in incomplete explanations.

(b) The majority of students (70%) gained at least one mark for recognising that 2pq represented the heterozygous genotype. 39% of students successfully completed the calculation to obtain both marks. Many students scoring zero simply provided the Hardy-Weinberg equation with no annotation. Students obtaining one mark often thought that 0.1 was q rather than q^2, resulting in $2pq = 2 \times 0.9 \times 0.1$. This mark was not awarded when students (commonly) suggested that pq represented the heterozygous genotype.

(c) Almost 70% of students obtained at least one mark for this question, with both of the marking points being awarded in similar numbers. Students who scored zero often correctly stated that red-green colour blindness is sex-linked but did not mention the X chromosome in their explanation. These students often realised that males only required one recessive allele to express the condition, but did not explain that females require two alleles. Some students did refer to males and females, but omitted the term allele. Sex-linked alleles were sometimes said to be on an unspecified sex chromosome, on both X and Y, or just on the Y chromosome preventing females being affected. Females were sometimes thought to be XY and males XX.

(d) The answers to this question were extremely disappointing. Less than 1% of students gained maximum marks and only about a third of students obtained any of the three marks available. The trichromatic theory is a new topic on the specification and many students displayed a poor understanding of how different colours are distinguished. Many students incorrectly referred to green/red/blue cones/pigments rather than green-/red-/blue-'sensitive' cones/pigments. Consequently, fewer than 5% gained a second mark. Although better students did appreciate that 'other colours' were mixtures of different wavelengths of light, they failed to explain that 'other colours' resulted in the stimulation of more than one type of cone at the same time. Students who did gain a mark invariably referred to non-functional green-sensitive pigments or cones. However, this point was often negated as many students suggested that red-sensitive cones were also non-functional or absent, or that all cones were non-functional or absent. It was not uncommon to read answers that provided details on the breakdown of pigments which were not only beyond the requirements of the specification, but were also often inaccurate.

(e) Only 3% of students gained both marks in this question as it was a rarity to see responses that mentioned that iPS cells would divide. Although most students did understand that iPS cells would differentiate, many suggested they formed the 'green-sensitive pigment' rather than cone cells. A significant proportion of students referred to the iPS cells developing into green/red/blue cones, again failing to gain the mark for omitting the term 'sensitive'. There were also answers which referred to iPS 'growing' into cone cells with no indication of development or differentiation.

Some students suggested that rod cells were produced or confused this method with gene therapy and referred to genes being injected into stem cells. Consequently, 48% of students scored zero on this question.

(f) Most students (70%) obtained at least one mark for this question. Usually, this mark was awarded for stating that iPS is a long-term treatment or that gene therapy would only last two years. An additional mark was available if students realised that iPS would be a single treatment or that gene therapy would require regular treatments. However, this idea was rarely conveyed in students' answers. Far more students appreciated that one advantage of iPS was that rejection or an immune response was less likely. Although many students mentioned that gene therapy could cause 'harm' or 'side effects', this was often in the context of the 'injection' rather than due to using viruses. Consequently, only 8% of students obtained maximum marks and only 33% gained two or more marks. Many students also mentioned ethical issues, cost and/or the idea that results on monkeys were not necessarily transferable to humans. However, these constraints could also have applied to the use of iPS cells as a treatment.

Q2.

(a) This was generally well answered, with over 40% of students obtaining both marks and over 80% gaining one mark. Most students stated that type II diabetics produce insulin, although a number of them simply stated that the pancreas is not damaged. The lack of responsiveness to insulin was not always linked to cells or receptors, or was described as a 'resistance' or 'immunity' to insulin. Although students often understood that diet and lack of exercise may be involved in causing type II diabetes, they did not always suggest that exercise and diet may be used in treating type II diabetes.

(b) 85% of students understood that insulin does not activate enzymes involved in the conversion of glycerol to glucose.

(c) The idea of a transcription factor binding to a gene / DNA / promoter region, which then stimulates transcription by allowing RNA polymerase to bind, was clearly understood and described in the best responses. The inhibition of transcription by transcription factors was referred to less often. Over 50% of students gained at least one mark, often related to the binding process. Many students who did not gain credit limited their explanations to genes being switched on or expressed. Translation to form the proteins linked with pluripotency was often included in these answers. However, a number of students confused transcription and translation.

(d) This question produced a good spread of marks and proved to be an effective discriminator. Over 90% of students gained at least one mark, and almost a third of students gained three out of the four marks available. Most students correctly compared the results of group A with group C. Fewer compared group A with group B. A significant minority of students mistakenly took group B results to be those of group A due to not carefully looking at the key provided for the graph; this restricted their maximum mark to two. Mice often became rats during the explanations but this was not penalised! Most students appreciated that the results could be different for humans, and stated that 12 weeks was not long enough to determine long-term effects. Some students referred to the lack of a statistical test, but this was not credited in this question. Similarly, for this investigation, thirty mice was not considered to be a small sample size.

Q4.

(a) Most candidates were able to explain that totipotent cells were able to differentiate

but could not link this satisfactorily to the evidence in the table. Many of the less able candidates either attempted to link totipotency to callus, or considered callus, leaves and plantlets to be different sorts of cells.

(b) Simple numbers and a generous mark scheme should have enabled most candidates to gain full credit for their answers to this question. The fact that only just over half did so emphasises the difficulty candidates have in working with ratios.

(c) Part (i) was answered very poorly and many candidates ignored the reference to reproducing sexually in the question to write about mutation and environmental factors. Many of those who did approach the question appropriately demonstrated confusion between seeds and gametes and between mitosis and meiosis. The answers to part (ii) were rather better with many pointing out that plants derived from tissue culture would be clones or would be genetically identical. However, there were inappropriate responses relating to the procedure being “quicker” or “less expensive”.

Q5.

Using DNA in science and technology

The very best essays from candidates who selected this option were outstanding. They reviewed, often in great detail, the relevant aspects of the specification although not always incorporating the role of DNA in the classification of organisms. Considering that much of the content of this essay could be drawn from this unit, it was surprising how poor many answers were. Understanding of techniques was often extremely limited, particularly *in vivo* gene cloning and the use of markers. Many essays presented no more than a broad overview either emphasising ethical issues at the expense of biological detail or failing to distinguish established practice from wishful thinking.

Q6.

(a) While most candidates recognised that stem cells are undifferentiated, many failed to point out that they were capable of replacing themselves. A reference to totipotency ensured this first mark, but a second could not be awarded for simply explaining what the term meant.

(b) The examiners were of the opinion that many candidates had encountered the word but had very little understanding of its meaning.

(c) In part (i), only the better candidates recognised and were able to describe the relationship between the altered sequence of nucleotide bases and the consequent change in the sequence of amino acids affecting the tertiary structure of the protein. There were many general answers that offered little more information than that the “gene was disrupted” or that a “different amino acid was made.” Many candidates found part (ii) challenging and, although they were able to gain credit for a general statement relating to the uncontrolled division of cancer cells, they attributed this to insertion of the gene in the base sequence of either the tumour suppressor gene or into a proto-oncogene, thereby converting it into an oncogene.

(d) Many candidates had clearly given careful thought to their answers and made effective use of the data provided. They usually came to the conclusion that 25% was either an unacceptably high cancer risk or that 75% of children were unaffected by cancer. Many took the view that, as the cancer could be treated, whereas SCID was likely to prove fatal, this was an acceptable trial. Answers that adopted a more general approach, describing the trial as unethical, accusing the scientists concerned of “playing God” or commenting on children being unable to make

informed judgement did not gain credit.