Mark schemes

1

(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 deathrate from breast cancer;
2. But number of points off line / anomalies.

2

[8]

2

(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% to15.2%;

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 somepatients;
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]

3

(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/process3.

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 ofdamaged/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 ORslows 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]

4

(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 toreceptors.

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]

(a) 1. Sugar-phosphate (backbone) / double stranded / helix **so** provides strength / stability

5

/ 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 foramino 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 cellsreplaced / 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]

6 (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] (a) (i) 1. Sex;

7

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 oneinvestigation / 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]

8 (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]

(a) Given only saline;

9

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 <u>Mitosis</u>;

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

10

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] (a) RNA polymerase;

11

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 RNApolymerase / 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]

Essay Using DNA in science and technology

12

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.

13

(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]

14

(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 beinvolved;

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]

15

(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]

16

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

1

(b) Yes – curve on graph with bromelain present remains approximately constant / risesvery 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] (a)

17

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]

(a) 1 Cut gene out of cell / make gene using mRNA / obtain gene with restriction enzymes;

18

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] (a) (i) benign does not cause cancer /

19

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 protectsagainst u.v. radiation;

1

(iii) because cancer has genetic component / may have inherited (onco)gene / gene which gives predisposition to / causes cancer;

1

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

20

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

max 6

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

2

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

2

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

2

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

3

[15]

21 (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]

22 (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]

(a) mass of undifferentiated / unspecialised / totipotent cells;

23

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 cancertriggered 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] (i) smoking and drinking increase risk;

24

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] (a) Daughter (C) does not have the condition / one child doesn't have it;

25

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]

26

(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 / <u>after</u> methylation; 5. Tumour formation occurs (after 10 weeks) <u>after</u> p16 falls / <u>after</u> suppressor gene activity falls;

4 max

[11]