AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.2.2 CELL CYCLE AND MITOSIS

SCORE	PERCENTAGE
/357	%

STEMUP

These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner reports in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

(a) 1. Where dividing cells are found / mitosis occurs;
OR
No dividing cells / mitosis in tissue further away / more than 5 mm from tip;
OR
To get (soft) tissue that will squash;
OR
Length that will fit under cover slip;

Accept most dividing cells

2. Single / thin layer of cells / spread out cells **so** light passes through (making cells / nuclei visible);

Accept thin layer of tissue

Ignore to see cells clearly

2

(b) 3.57 / 3.6 / 3.7 / 3.71 / 3.8 (%);;

If the answer includes additional decimal places, award the marks if it would round to a correct answer

There are 3 cells in anaphase

Accept for 1 mark, 101.25 / 101 (students estimate in minutes)

OR

3.75 (difference between scientist estimate and student's estimate in minutes)

Ignore plus or minus signs

2

(c) Cytokinesis;

1

(d) Description;

Explanation;

E.g,

1. Examine large number of fields of view / many cells;

Mark as pairs only

Accept large number / 20 or more for many

2. To ensure representative sample;

Accept typical / reliable

OR

3. Repeat count;

4. To ensure figures are correct;
OR

5. Method to deal with part cells shown at edge /count only whole cells;

6. To standardise counting;

2 max

(e) 1. Stops anaphase / cell division / mitosis;

Accept prevents telophase / cytokinesis

2. (By) stopping / disrupting / spindle fibres forming / attaching / pulling;

Ignore affects anaphase

3. Preventing separation of (sister) chromatids;

Ignore chromosomes separate / split

Accept chromatids split

4. (So) no new cells added (to root tip);

3 max

[10]

Q2.

(a) 1. The (individual) chromosomes are visible because they have condensed;

Both parts of each answer are required – evidence and explanation.

For 'they' accept 'chromosomes/chromatin/DNA'

Accept 'tightly coiled' or 'short and thick' for condensed but do not accept 'contracted'.

Ignore references to nucleus/nucleolus/nuclear membrane.

2. (Each) chromosome is made up of two chromatids because DNA has replicated;

Both parts of each answer are required – evidence and explanation.

Accept 'sister chromatids' for 'two chromatids'.

Ignore references to nucleus/nucleolus/nuclear membrane.

3. The chromosomes are not arranged in homologous pairs, which they would be if it was meiosis;

Both parts of each answer are required – evidence and explanation.

Accept not meiosis because bivalents/chiasmata/crossing over not seen.

Ignore references to nucleus/nucleolus/nuclear membrane.

2 max

(b) Automarked q – ✔ prophase

1

(c) 1. Water moves into the cells/cytoplasm by osmosis;

Reject water moving into chromosomes/nucleus.

2. Cell/cytoplasm gets bigger;

Accept idea of cell/cytoplasm has greater volume/swells/expands.

Ignore references to pressure changes, turgidity and chromosomes being more dilute.

Ignore references to changing water/fluid contents of the cell.

Allow ECF for 'nucleus expands' but not for 'chromosomes expand'.

2

(d) Differences in base sequences

OR

Differences in histones/interaction with histones

OR

Differences in condensation/(super)coiling;

Answer must be in context of differences in arrangement of chromosomes not just related to the properties of the stain.

Accept spec section 8 ideas e.g. different methylation/acetylation

Accept different genes

Reject different alleles

1

(e) (Two chromosomes that) carry the same genes;

Reject 'same alleles'

Accept 'same loci' (plural) or 'genes for the same characteristics'

1

(f) (Prokaryotic DNA) is

1. Circular (as opposed to linear);

2. Not associated with proteins/histones ;

3. Only one molecule/piece of DNA
OR
present as plasmids;

Max 1 if prokaryotic DNA only found as plasmids OR if prokaryotic DNA is single stranded.

Ignore references to nucleus, exons, introns or length of DNA. Do not credit converse statements.

Ignore descriptions of eukaryotic DNA alone.

2 max

[9]

Q3.

(a) Three of chromosome 13 / an extra chromosome 13;

Accept trisomy 13

*Accept circle around three chromosomes or any other correct indication on **Figure 1***

Do not allow references to any other chromosomes.

Do not accept chromatids for chromosomes.

1

(b) 1. In meiosis;
2. Homologous chromosomes / sister chromatids do not separate;

2. Accept non-disjunction

2 max

(c) 1. Mutation / extra chromosome in gamete / egg / sperm (that formed zygote);
2. All cells derived (from a single cell / zygote) by mitosis;
OR
3. All cells derived from a single cell / zygote by mitosis;
4. Mitosis produces genetically identical cells / a clone;

*Mark points 1 and 2 **OR** 3 and 4*

4. Accept: have same DNA / same alleles

2

(d) 1. (Some) oxygenated blood (from the aorta) flows into pulmonary artery;
OR
Less oxygenated blood flows out through aorta;
OR
Lower blood pressure in aorta;
2. Less oxygen delivered to cells / tissues / organs / named organ / via named blood vessel;
3. So less / not enough oxygen for <u>aerobic</u> respiration (in cell / tissue / organ);
4. Tissue / organ doesn't grow / develop properly (causing death);
OR
Tissue dies / organ stops working (causing death);

1. Accept mixing of deoxygenated with oxygenated blood in pulmonary artery

2. Do not accept "no oxygen"

3. Do not accept "produce energy"

3 max

[8]

Q4.

(a) 1. Binary fission;
2. Replication of (circular) DNA;
3. Division of cytoplasm to produce 2 daughter cells;
4. Each with single copy of (circular) DNA;

1. Ignore reference to 'chromosome'

2. Ignore 'copy'.

4. Ignore references to number of plasmids.

2 max

(b) 1. Both denatured (by high temperature);
2. Denaturation faster at 60 °C due to more (kinetic) <u>energy;</u>
3. Breaks hydrogen / ionic bonds (between amino acids / R groups);
4. Change in shape of the active site / active site no longer complementary **so** fewer enzyme-substrate complexes formed / substrate does not fit;

3. Ignore references to disulphide bonds

*3. Accept (at 60 °C) Change in shape of the active site / active site no longer complementary **so** no enzyme-substrate complexes formed / substrate does not fit;*

4

(c) 1. To digest protein;
2. (So) they can absorb <u>amino acids</u> for growth / reproduction / protein synthesis / synthesis of named cell component;
OR
(So) they can destroy a toxic substance / protein;

1. For 'digest' accept 'break down' here.

2. Accept '(so) they can destroy antibodies / antibiotics / viral antigens / bacterial antigens'

2

(d) 1. <u>Hydrolyse</u> (peptide bonds) to release amino acids;
2. Amino acids can cross (cell) membrane;
OR
Dipeptides cannot cross (cell) membrane;
OR
Maintain concentration gradient of amino acids for absorption;
OR
Ensure (nearly) maximum yield from protein breakdown;

2. Ignore references to crossing gut membranes.

2. Accept 'there are carrier proteins for amino acids'

2. Accept 'no carrier proteins for dipeptides'

2

[10]

Q5.

(a) Binary fission;

Reject mitosis

1

(b) 1. Keep lid on Petri dish
OR
Open lid of Petri dish as little as possible.

2. To prevent unwanted bacteria contaminating the dish.
OR
L. monocytogenes may be dangerous / may get out.

OR

3. Wear gloves
OR
Wear mask
OR
Wash hands;

4. To prevent contamination from bacteria on hands / mouth
OR
Prevent spread of bacteria outside the lab;

OR

5. Use sterile pipette
OR
Flame the loop
OR

Flame the neck of the container of the culture;

6. To maintain a pure culture of bacteria

4 max

(c) Cinnamon;

1

(d) 1. Thyme is the most effective / best (at 4 °C);

2. Clove and cinnamon same effectiveness at 4 °C as 35 °C (so suitable);

3. Bay and nutmeg are less effective at 4 °C than 35 °C (so unsuitable).

3

(e) Less kinetic energy
OR
Less movement of oil molecules / of phospholipid molecules

1 max

[10]

Q6.

(a) (During prophase)

1. Chromosomes
coil / condense / shorten / thicken / become visible;

2. (Chromosomes) appear as (two sister) chromatids joined at the centromere;

(During metaphase)

3. Chromosomes line up on the equator / centre of the cell;

4. (Chromosomes) attached to spindle fibres;

5. By their centromere;

(During anaphase)

6. The centromere splits / divides;

7. (Sister) chromatids / chromosomes are pulled to opposite poles / ends of the cell / separate;

(During telophase)

8. Chromatids / chromosomes
uncoil / unwind / become longer / thinner.

No marks for naming the stages

Reject references to homologous chromosomes / pairing of chromosomes

Ignore references to spindle formation during prophase

5 max

(b) 1. Homologous chromosomes pair up;

2. Independent segregation;

3. Maternal and paternal chromosomes are re-shuffled in any combination;

4. Crossing over leads to exchange of parts of (non-sister) chromatids / alleles between homologous chromosomes;

5. (Both) create new combinations of alleles;

5

[10]

Q7.

(a) 1. Push hard – spread / squash tissue;
2. Not push sideways – avoid rolling cells together / breaking chromosomes.

Neutral – to see cells clearly

2

(b) No (no mark)
Yes (no mark)

1. Chromosomes / chromatids are (in two groups) at poles of spindle / at ends of spindle;

Do not accept 'ends of cell'

2. V-shape shows that (sister) chromatids have been pulled apart at their centromeres / that centromeres of (sister) chromatids have been pulled apart.

2

(c) 28.8 / 29.

If incorrect, allow:

$\frac{6}{200} \times 960$ *= 1 mark*

2

[6]

Q8.

(a) (D)CBEA.

1

(b)

Step	Reason
(Taking cells from the root tip)	Region where mitosis / cell division occurs;
(Firmly squashing the root tip)	To allow light through / make tissue layer thin;

2

(c) (Increase)

1. Chromosomes / DNA replicates;
(First decrease)

2. Homologous chromosomes separate;
(Second decrease)

3. Sister chromatids separate.

3

(d) 1. (DNA would) double / go to 2 (arbitrary units).

1

[7]

Q9.

(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]

Q10.

(a) **C**

Auto mark

1

(b) 1. No separation of chromatids/chromosomes/centromeres;

Accept anaphase prevented

Accept nondisjunction

Reject homologous pairs

2. Chromatids/chromosomes all go to one pole/end/sides of cell/not pulled to opposite poles;
3. Doubles chromosome number in cell/one daughter cell gets no chromosomes or chromatids;

Accept DNA for chromosomes

Accept ploidy

Ignore references to 'genetic information'

Ignore simple descriptions of what normally happens in mitosis

2 max

(c) 1. (No, because) at 100 there are still **some** (7%) cancer cells dividing/undergoing mitosis;

Accept idea that all division stops only at 1000

2. So, cancer not destroyed/may continue to grow/spread/form tumours;

Must refer to cancer spreading not cells dividing

3. Best concentration may be between 100 and 1000/need trials between 100 and 1000;
4. This research in culture, don't know effect of KI on people;

Reject 'not tested on humans'

Reject 'done in animals'

5. (Yes, because) above 100 produces little increase in % of cells not dividing/undergoing mitosis/at 100, **most** (93%) cancer cells unable to divide/dead;

Must clearly link lack of monopolar mitotic spindles with cell division

6. Above 100 may be harmful (to body);

*Accept '**above 100/high concentrations** produce harmful side effects/named effects'*

7. Higher concentrations more expensive;
8. (Above 100) will have more effect on (rapidly dividing) cancer cells;

Must relate to 100

4 max

(d) 1. 10 cm^3 of 10 000 nmol dm^{-3}/ (original) solution;
2. 90 cm^3 of water;

If ratio correct but make wrong volume e.g. 1 litre, award 1 mark

2

[9]

Q11.

(a)

	Cell B	Cell C	Cell D
homologous chromosomes are present	✔	✔	
a stage of mitosis		✔	

Mark horizontally

1 mark for each correct row

2

(b) Mark as pairs, do not mix and match

1. (Chromosomes consist of) two chromatids connected at centromere;

   Accept: sister chromatids for two chromatids

2. (Because) DNA has replicated;

   OR

3. K is on equator of spindle;

   Ignore: 'middle'

4. (because) attached at centromere;

   Ignore reference to meiosis / bivalents / homologous pairs

2

(c) 1. Crossing over / exchange of alleles /lengths of DNA / recombination;

   Accept: description of crossing over eg sections of chromatids break and re-join

   Accept: reference to chiasma/ chiasmata

2. Between (chromatids of) homologous chromosomes;

   Accept: 'between non-sister chromatids'

   Accept: 'bivalent' for homologous

   Ignore: genes exchanged

2

(d) Separation/segregation of pairs/homologous chromosomes;

Accept: result of meiosis I / result of division of cell B

Accept: pulled to opposite poles for 'separation'

Ignore ref to chromatids

1

(e) (DNA) replication taking place/not finished;

Accept: they are cells in S phase

1

[8]

Q12.

(a) Variable that is changed;

Reject 'the variable that changes'.

1

(b) 1. Idea of a confounding variable;

2. (So) genetically similar;

   2. Do not accept 'genetically identical / same DNA'.

3. (So) have similar salt tolerance / response to salt water / response to watering treatment;

4. (So) have similar yield / mass of seeds;

   Do not accept 'amount / number of seeds' or 'growth rate'.

2 max

(c) Mitosis;

Ignore cell division

1

(d) 1. Irrigation with sea water / **C** / **D** increased yield compared with no irrigation / **A**;

For 'yield' accept 'mass of seed' throughout.

2. Yield was lower when irrigated with sea water / **C** / **D** compared with fresh water / **B**;

Only penalise once for use of 'amount / number of seeds'.

3. Yield was lower when watered with sea water throughout growth and seed formation / **C** than when watered with sea water just at seed formation / **D**;

Accept use of figures from table.

'It' refers to watering with seawater / mixture.

2 max

(e) 1. Irrigation with sea water / **C** / **D** increases concentration of salt in soil;

Ignore reference to standard deviation / quality of the data.

2. Lower water potential in the soil linked to reduced uptake of water;

3. Salt concentration in the soil might / might not increase in the future;

Mark point 3 includes the principle for mark point 1 so mp3 gains 2 marks (for mp1 and mp3)

4. Might decrease plant growth / yield in the future;

5. Less food / fewer seeds for future planting;

Mp 3 and 4. Allow 'further' for the idea of 'in the future'.

3 max

[9]

Q13.

(a) (i) Centromere;

Accept: if phonetically correct

Reject: centriole

1

(ii) 1. Holds chromatids together;

2. Attaches (chromatids) to spindle;

3. (Allows) chromatids to be separated / move to (opposite) poles / (centromere) divides / splits at metaphase / anaphase;

*3. **Q** Neutral: chromosomes or chromatids split / halved / divided*

3. Reject: reference to homologous chromosomes being separated

Accept 'chromosomes' instead of 'chromatids'

*Ignore incorrect names for **X***

2 max

(iii) (Homologous chromosomes) carry different alleles;

Accept alternative descriptions for 'alleles' eg different forms of a gene / different base sequences

Neutral: reference to maternal and paternal chromosomes

1

(b) (i) (In **Figure 2**)

1. Chromatids have separated (during anaphase);

*1. **Q** Neutral: split / halved / divided*

1. Reject: reference to homologous chromosomes being separated

or

2. Chromatids have not replicated;

1. & 2. Accept 'chromosomes' instead of 'chromatids'

or

3. Chromosomes formed from only one chromatid;

*Accept converse arguments for **Figure 1***

Ignore references to the cell not dividing as in the question stem

Ignore: named phases

1 max

(ii) 1. Three chromosomes;

Ignore shading

2. One from each homologous pair;

Only one mark for three chromosomes shown as pairs of chromatids

2

(iii) Crossing over / alleles exchanged between chromosomes or chromatids / chiasmata formation / genetic recombination;

Accept: description of crossing over eg sections of chromatids break and rejoin

Neutral: random fertilisation

Reject: reference to sister chromatids

***Q** Neutral: genes exchanged*

Neutral: mutation

1

[8]

Q14.

(a) 1. (Phosphate) changes shape of TK / changes shape of enzyme / changes the active site;

It = phosphate

Accept 'alters' for changes

Reject that phosphate is an inhibitor

Accept adding energy / affecting charged / affects polar groups (on amino acids)

2. Active site forms / becomes the right shape / can bind to substrate / complementary to substrate / E-S complex can form;

Reject similar / same shape as substrate

2

(b) 1. Faulty TK has functional active site without phosphate;

Accept 'works without phosphate'

2. (So, faulty) TK functional all the time / TK not controlled (by phosphate);

2

(c) 1. Non-competitive inhibitor / binds to site other than active site;

Accept allosteric site

Do not accept 'changes shape' unqualified

2. Causes TK to be in non-functional form / active site not formed / wrong shape / E-S complex not formed;

3. So, (uncontrolled) cell division stopped / slowed / controlled;

2 max

[6]

Q15.

(a) 1. Strands separate / H-bonds break;

*1. **Q** Neutral: strands split*

1. Accept: strands unzip

2. DNA helicase (involved);

3. Both strands / each strand act(s) as (a) template(s);

4. (Free) nucleotides attach;

4. Neutral: bases attach

4. Accept: nucleotides attracted

5. Complementary / specific base pairing / AT and GC;

6. DNA polymerase joins nucleotides (on new strand);

6. Reject: if wrong function of DNA polymerase

7. H-bonds reform;

8. Semi-conservative replication / new DNA molecules contain one old strand and one new strand;

8. Reject: if wrong context e.g. new DNA molecules contain half of each original strand

6 max

(b) (i) 18;

Do not accept 17.5

1

(ii) 10;

1

(iii) 1. Horizontal until 18 minutes;
Allow + / - one small box

2. (Then) decreases as straight line to 0 µm at 28 minutes;
2. Allow lines that start from the wrong place, ending at 0 at 28 minutes

2

(c) (i) Two marks for correct answer of 19.68 or 19.7;;
Accept 19hrs 41mins

One mark for incorrect answers in which candidate clearly multiplies by 0.82;
Allow one mark for incorrect answers that clearly show 82% of 24 (hours)

2

(ii) 1. No visible chromosomes / chromatids / visible nucleus;

1

(iii) **D** (no mark)

1. Lower % (of cells) in interphase / higher % (of cells) in mitosis / named stage of mitosis;
1. Accept: 'less' or 'more' instead of '%'
1. Do not accept: higher % (of cells) in each / all stage(s)

2. (So) more cells dividing / cells are dividing quicker;
2. Accept: uncontrolled cell division
*2. Do not award if Tissue **C** is chosen*

2

[15]

Q16.

(a) 1. Growth / increase in cell number;
Ignore growth of cells

2. Replace cells / repair tissue / organs / body;
Ignore repair cells
Reject bacteria

3. Genetically identical cells;
'Produces 2 genetically identical cells' does not reach MP1 as well as MP3

4. Asexual reproduction / cloning;
Allow example or description

2 max

(b) (i) (Ensures) representative (sample);
Accept find some cells in mitosis / not in interphase.
Accept 'more reliable' only if linked to percentage (of cells).'Improves reliability' on its own does not gain this mark
Neutral: Large sample

1

(ii) 1. A = metaphase;

2. Chromosome / chromatids lie on equator;
Reject homologous chromosomes Allow centre / middle

3. B = anaphase;

4. Chromatids / chromosomes separating / moving apart / moving to poles;
Reject homologous chromosomes

4

(c) 2 hours / 120 minutes;
Allow 1 mark if working shows candidate understood that mitosis would take 10%

2

[9]

Q17.

(a) (i) Anaphase

1

(ii) 1. Sister / identical chromatids / identical chromosomes;
Reject: Homologous chromosomes separate.
Allow any reference to chromatids / chromosomes being identical e.g. same DNA

2. To (opposite) poles / ends / sides;

2

(b) (i) 1. 8.4 / cells with twice DNA content = replicated DNA / late interphase / prophase / metaphase / anaphase;
Any reference to interphase must suggest towards end of interphase.
'Chromosomes replicate' is not enough for DNA replicates.

2. 4.2 = DNA not replicated / (early) interphase / telophase / cell just divided / finished mitosis;

2

(ii) 2.1;

1

[6]

Q18.

(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]

Q19.

(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]

Q20.

(a) (i) 22;

1

(ii) 1. Odd number of chromosomes / 33 chromosomes (in leaf cell);

2. Chromosomes cannot pair / cannot undergo meiosis / would result in half chromosomes / cannot form haploid cells;

2

(b) (i) Fast growth / produces crop fast / produces large crop;

Do not insist on relative statement.

Accept similar terms for fast. E.g. "better" growth

Do not accept unqualified references to profit.

1

(ii) Leaves less likely to break / higher breaking strength;

1

(c) Low genetic diversity because they are produced by mitosis;

Will all have the same DNA / genes / alleles / will be genetically identical / will be clones;

OR

Low genetic diversity because they are not produced by meiosis;

No crossing over / independent segregation / will not be genetically different;

Independent segregation is the specification term. Accept other such as random assortment.

2

[7]

Q21.

(a) (i) Cells are in interphase;

Accept G phase / S phase.

1

(ii) Cells undergoing mitosis / in telophase / cytokinesis;

Accept all named stages but reject prophase, metaphase or anaphase on their own.

1

(b) 1. 3 hours;

2. Time between beginnings / endings DNA replication / Increases / levelling outs of DNA concentration / for shape (of curve for replication) to be repeated;

3. (DNA) replication takes place once per cell cycle;

Allow close approximation where candidate attempts to be more accurate.

Principle
What is shown on the graph

3

[5]

Q22.

(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]

Q23.

(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]

Q24.

(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]

Q25.

(a) Chromosomes: **C** = 8 *and* **D** = 4;
DNA: **C** = 300 *and* **D** = 150;

2

(b) (i) testis / ovary;
accept anther / carpel / stamen / testicle

1

(ii) to make chromosomes / chromatids / DNA / genetic material visible;

1

[4]

Q26.

(a) Interphase / S-phase;

1

(b) **A D C E B;**

1

(c) Attachment of centromeres / chromosomes / chromatids; Separation of centromeres / chromatids / chromosomes;

2

(d) Halves chromosome number / haploid;

Diploid / full number restored at fertilisation;
Allow correct reference to variation

max 2

[6]

Q27.

(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]

Q28.

(a) (i) where mitosis / division / growing / occurs
(reject growing cells)

1

(ii) to distinguish chromosomes / chromosomes not visible without stain;

1

(iii) to let light through / thin layer;

1

(b) (i) 74 + 18 / 982;
= 9.4% / 9%;

2

(allow 1 mark for identifying prophase & metaphase i.e.92 or correct method using wrong figures*)*

(ii) genetic differences / different types of garlic;
time of day;
chance;
age of root tip;

water availability;
temperature;
nutrient availability;

(environmental factors = 1 but cannot be awarded in addition to a named environmental factor)

2 max

[7]

Q29.

(a) (i) Prophase;

1

(ii) Chromosomes / chromatids moved apart;

1

(iii) *A wide range of processes occurs during interphase. This list is by no means exhaustive, but we would expect to see answer such as:*

Increase in volume of cell / volume of cytoplasm / increase in mass / cell bigger; increase in number of organelles;
synthesis of protein / named protein;
DNA replication / increase / chromosomes copied;
ATP synthesis / respiration;

max 2

(b) Divide real length of bar (in mm) / 10 by 0.02;

1

(c) 12 / 200 × 24 / single error in otherwise correct method;
1.44 hours (1 hour 26 min);

2

[7]

Q30.

(a) Chromosomes attach to equator / middle of cell / spindle;
Prophase;
Anaphase;
DNA replication / synthesis / chromosome copying / duplication;
Telophase;

5

(b) (i) Meiosis;

1

(ii) 32;

1

[7]

Q31.

(a) Later fertilisation / cell fusion; (NOT just ‘sexual reproduction’)
Restoring diploid / original number / not doubling chromosome number;

ALLOW ref '½ + ½'

2

(b) Any three pairs from:

need comparison of meiosis and mitosis each time

Meiosis	Mitosis
(Homologous) chromosomes associate in pairs	(Homologues) independent / do not pair (IGNORE ref. separation
Crossing-over / chiasmata formation	No crossing-over;
Two / (nuclear stages) divisions / → 4 offspring cells	One / (nuclear stage) division / → 2 offspring cells;
Genetically different (product)	Genetically identical (product);

IGNORE refs. To location

max 3

[5]

Q32.

(a) replication / duplication / doubling of chromosomes / replication of DNA / transcription of DNA;

1

(b) (i) cell to show correct number of chromosomes;
correct shape and position of centromere;

2

(ii) as (i) except everything halved – *Ignore crossing over*;
(if mitosis and meiosis reversed, allow 1 if otherwise correct)

2

(c) to replace cells;

1

[6]

Q33.

(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]

Q34.

(a) produced by <u>mitosis</u>;
genetically identical;

(accept identical genes / same genotype / WNA / genetic information)(reject same genes, same genetic code)

2

(b) cells lost ability to <u>control</u> development / no longer totipotent /
cells have differentiated / become specialised;

1

(c) (many) offspring with favourable characteristics / high meat / milk yield;
pedigree embryos into non-pedigree mothers / not risking pedigree mothers / rare breeds conserved;
sex / gender selection;

2 max

[5]

Q35.

(a) (i) (D) B E A C;

1

(ii) <u>metaphase</u>;

1

(b) interphase / S phase;

1

(c) (i) 0.06 × 100;
6(%);

(correct answer 2 marks)

2

(ii) more(cancer cells) killed, cancer cells divide more (often)
(so are more likely to be killed, more susceptible);

1

(iii) longer time to recover;
reduced rate of mitosis / divide more slowly /
increased doubling time;

2

[8]

Q36.

(a) mitosis;

genetically / genes / genotype identical;
(reject same genes)
(ignore references to asexual reproduction)

2

(b) (different)
environmental conditions / named environmental factor / mutation;

1

(c) dispersal / prevent overcrowding / competition / colonise ;
increased number of (proven) offspring; *(not quicker)*

2

[5]

Q37.

(a)
1 two strands therefore semi-conservative replication (possible);
2 base pairing / hydrogen bonds holds strands together
3 hydrogen bonds weak / easily broken, allow strands to separate;
4 bases (sequence) (exposed so) act as template / can be copied;
5 A with T, C with G / complementary copy;
6 DNA one parent and one new strand;

4 max

(b)
1 chromosomes shorten / thicken / supercoiling;
2 chromosomes (each) two identical chromatids / strands / copies (due to replication);
3 chromosomes / chromatids move to equator / middle of the spindle / cell;
4 attach to individual spindle fibres;
5 spindle fibres contract / centromeres divide / repel;
6 (sister) chromatids / chromosomes (separate) move to opposite poles / ends of the spindle;
7 each pole / end receives all genetic information / identical copies of each chromosome;
8 nuclear envelope forms around each group of chromosomes / chromatids / at each pole;

7 max

(c) cancer cells killed, normal body cells survive;
cancer cells low oxygen (as blood supply cannot satisfy demand);

2

[13]

Q38.

(a) (i) anaphase;

1

(ii) sister / identical chromatids (separate);
move to opposite poles / ends / sides;

2

(b) (i) interphase;

1

(ii) ATP production / protein synthesis / replication of centrioles;

1

(iii) 1.2;

1

(c) short duration of interphase;

1

[7]

Q39.

(a) (i) 8 ‘chromatids’ each side;
spindle drawn;

2

(ii) 4 chromosomes;
1 from each homologous pair;

2

(b) produces haploid cells / chromosome number halved;
fertilisation maintains the diploid / chromosome number (in next generation);

2

[6]

Q40.

(a) genetically identical cells / individuals;

1

(b) mitosis;

1

(c) no differentiation at this stage / same genes being expressed;

1

(d) brown - genes / DNA / genetic ‘information’ from the nucleus (expressed);

1

(e) embryo cell diploid, egg cell haploid;
contain different alleles / forms of the colour gene;

2

(f) damage to nucleus / cells during transfer;

1

[7]

Q41.

(a) (cut out gene using an) endonuclease / restriction enzyme;
reference to specificity / recognition site;
sticky ends;
use the same enzyme to cut;
plasmid / virus / potato DNA;
fixed by ligase;
method of introducing vector e.g. micropipette / virus injects DNA /
remove plant cell wall;

6 max

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

2

[8]

Q42.

(a) (i) prophase;
chromosomes thickening / becoming visible;

2

(ii) anaphase;
chromatids / chromosomes moving to opposite poles /
ends of spindles;

2

(b) DNA replication;
synthesis or proteins / build-up of energy stores / growth /
increase in cytoplasm;
replication of organelles / named example;

2 max

[6]

Q43.

(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]

Q44.

(a) (i) **A** anaphase;

1

(ii) (**C**) **B**,**A**,**D**;

1

(iii) (original) chromosome / DNA has been replicated;
each chromosome consists of two chromatids /
chromatids attached at centromere;

(accept reference to condensed state of chromosomes)

2

(b) (i) it has doubled / now 8;

1

(ii) chromosome / DNA replication but no separation / anaphase / cell division;

1

[6]

Q45.

(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.

It was evident that many students had practical experience of the procedure in question (a) as answers tended to be well-explained. Most students achieved at least one mark, usually for stating mitosis occurred at the root tip. A significant number described mitosis as being the cell cycle, or “most stages of the cell cycle occur at the tip” when, in fact, all stages occur there. Another misconception was observed in answers where meiosis happened in root cells. The reason for pressing down firmly was not well known and explanations were left short by not mentioning cells/tissue or that light passed through. To remove air bubbles or to distribute stain were frequent alternatives, but ignored by examiners.

Question (b) discriminated well. Many students successfully calculated the time spent by cells in anaphase and a significant proportion took this one step further and calculated the correct percentage difference. Their workings were usually well presented and demonstrated logical thinking. Quite a few students did not know how to calculate the mitotic index, even though it is part of required practical activity 2 (section 7.2 of the specification). Many (8%) made no attempt at all to answer the question.

The vast majority of students (93.9%) correctly identified cytokinesis in (c).

For (d), most students gave a description of a relevant technique to check the accuracy of a cell count and often followed this with an appropriate explanation. Examiners sensed that the explanations were based on students’ first-hand experience – gained by doing the required practical. Some students misinterpreted the question and gave, often in long accounts, a step by step procedure to calculate the mitotic index. Others went off track by describing the calculation of mean values, which would improve accuracy of mitotic index scores, but not the accuracy of cell counts. Some students mistakenly believed that the root cells would continue to go through mitosis after staining and squashing. A few failed to notice that the stem of the question referred to ‘this root tip’ and wrote about using other root tips to check their count.

In (e), many students demonstrated sound knowledge of mitosis and applied it well to give a sensible suggestion of how the chemical affected root growth. Most suggested the chemical affected spindle fibres, and went on to identify correctly the stage of mitosis inhibited by it, and developed a line of reasoning to its logical conclusion, in which new cells did not form. Almost as many students referred to chromosome separation as to chromatid separation. Some confused meiosis with mitosis by referring to homologous chromosome pairs and crossing over.

Q2.

This question was loosely based on the skills students would have developed when completing required practical activity 2 – “Preparation of stained squashes of cells from plant root tips; set-up and use of an optical microscope to identify the stages of mitosis in these stained squashes and calculation of a mitotic index”. Students should have observed cells undergoing mitosis surrounded by many cells that were not and, therefore, should have considered why they looked different.

Many incomplete answers were seen to question (a). Students were required to give evidence **and** to explain that piece of evidence, but often only gave half the story. Some students used **Figure 2** rather than **Figure 1** and some tried to explain which stage of mitosis was shown, rather than simply that it was happening. Confusion was demonstrated here and in question (e) between a homologous pair of chromosomes and

a pair of chromatids in a single chromosome. Worryingly, 62% of students failed to score on this opening question; only 5.8% gained both marks.

In part (b), 69.3% of students correctly identified that these cells were in prophase.VWithin required practical activity 2, students needed to spread the cells out to gain a clear view; question (c) was based on a similar principle, but using a different method. It required standard knowledge of osmosis, but the novel context threw many students. The majority could state that the water would move into the cells by osmosis, but then often referenced increased pressure, rather than the idea of the volume of the cells increasing. Some complex, incorrect answers were seen in which students attempted to describe changes in polar interactions between the chromosomes and water, and how these would change.

Question (d) tested Assessment Objective 2 (application of knowledge) and there were several parts of the specification from which students could select material to support their answer. 42.2% did this successfully; those who did not often did not describe sufficiently how a feature would be different along the length of the chromosome to result in the striped appearance. For example, mentioning “histones” or “bases” alone was not creditworthy.

In question (e), only 36.9% of students could define the term ‘homologous chromosome’. It is likely that more students could have written about independent segregation or crossing over of homologous chromosomes, but this question revealed that they did not fully understand this biological term. Many students only referred to the origin of the chromosomes as paternal and maternal.VFor question 01.6, most students (83.2%) scored at least one mark, but there were many good answers limited to one out of two by demonstration of fundamental misunderstanding. The most common of these was that only eukaryotic DNA is a double helix and that prokaryotic DNA is single-stranded.

Q3.

Almost 60% of the students correctly identified the trisomy of chromosome 13 in question (a). Most of the incorrect answers referred to there being no Y chromosome.

In answers to question (b), there was evidence that students are less confident in their knowledge of mutation involving a change in chromosome number. There was an assumption made by some that, as this was a mutation, it must involve a change in the base sequence – answers of this type gained no marks. At the other end of the spectrum, some excellent answers were seen in which students wrote about non-disjunction during meiosis.

Most students knew, in question (c), that body cells are produced by mitosis and often gained a mark for explaining that all cells are derived from a single cell, the zygote. Relatively few (17%) gained a further mark either for pointing out that the mutation would have been present in one of the gametes used in the formation of the zygote, or that mitosis produces genetically identical cells.

In answers to question (d), it was again evident that some students did not use the information given in the diagram, which clearly showed the direction of the blood flow. Some students wasted a lot of time writing about the functions of the aorta and pulmonary artery. The vast majority gained at least one mark for stating that there would be less oxygen delivered to the tissues, but fewer went on to explain that there would be less oxygen available for aerobic respiration, which would reduce growth or development of the tissue or organ.

Q4.

(a) There were many excellent answers to this question, with over 50% of students

achieving both marks. The majority of students knew that bacteria divide by binary fission, but often did not include sufficient, or specific enough, detail in their description of what happens during this process to score the second mark. There were several statements about mitosis and some descriptions of viral replication.

(b) This question required an **explanation** and so there were no marks for a description of the graph. Many students gave lengthy descriptions and, even if they went on to write creditworthy statements after this, they had wasted much time and energy. The first requirement was for students to realise that, since the 30 °C line stays at 100%, both lines at 50 °C and 60 °C show denaturation of the enzymes. Many students got this far, but their explanations of what happens to the protein during denaturation were often incomplete or imprecise. For example, some stated that 'bonds' would be broken or that 'hydrogen, ionic, disulfide and peptide bonds' would be broken, so not achieving mark point 3. The mark least often awarded was for the explanation that a temperature of 60 °C would denature the enzyme more quickly because of the increased (kinetic) energy at this temperature.

(c) / (d) Both of these questions required careful reading of the question stems to access the mark points; many students got half-way through their answers, but gave insufficient detail to score full marks. For question (c), many students appreciated that the extracellular proteases would digest protein and this might protect the bacteria in some way, but their answers were not specific enough to gain credit for this idea. Similarly, many appreciated that extracellular protein digestion would provide useful products for the bacteria but did not go on to state that these products would be amino acids that could be used for growth / protein synthesis within the bacteria. For question (d), it was pleasing to see how many students could state that the dipeptidases would hydrolyse bonds in dipeptides, but many were not confident what these bonds were, or what the products of this hydrolysis would be. Many did not continue their answer to state the importance of this hydrolysis with reference to the passage of amino acids across the cell-surface membrane into the cells for absorption.

Q10.

Most students managed to score marks on (b). Most (about 45%) noted that the chromatids would not separate and obtained one mark. Many (39%) went on to deduce that this would mean all of the chromatids/chromosomes would go to one pole of the dividing cell and obtained both marks. Some students got confused between sister chromatids and homologous chromosomes.

Question (c) was about the same context as (b), where the kinesin inhibitor was linked to prevention of successful mitosis. It was hoped that students would appreciate that slowing or stopping mitosis would be a good thing when treating cancer (section 3.2.2). Most students made no reference to slowing or stopping mitosis when considering the results in (c). As a result, few went on to discuss the prevention of spread of cancer with KI at 100 nmol dm^{-3}. Some even suggested that a low KI dose would be better because it would allow more cell division. Many students *described* the results at length. Students can usually be relied upon to comment on the method used in an experiment, but here almost none of them noted that the doses of the drug were being tested on cells grown in culture, not on people.

Question (d) tested a basic experimental skill. Broadly, 41% could describe how to make the required volume of the required solution and 49% could not. A minority had the correct proportions of solutions but the wrong volumes.

Q11.

(a) Approximately half of all students achieved one mark on this question and about a fifth achieved both.

A lack of awareness of homologous chromosomes and their role in cell division was a common feature throughout the different parts of this question.

(b) Some students gave a concise description for, and explanation of, the appearance of chromosome K, although few made a reference to DNA replication for the presence of two chromatids. Some students offered two points of description without giving an explanation of either.

(c) The idea of 'crossing over' is well understood, although not what structures it occurs between. Few stated that homologous chromosomes are involved (some referred vaguely to maternal and paternal chromosomes), although occasionally references to bivalent or non-sister chromatids demonstrated that there is an awareness of the principle. Independent assortment and crossing over are biological processes which some students confused.

(d) Some sensible suggestions gained credit, like cell D is the product of division in cell B, or cell D is the result of Meiosis I, but many answers included long and tortuous accounts that confused fundamental differences between mitosis and meiosis. Structures were inaccurately referred to as chromatids and the idea that a homologous chromosome 'is split' is a fairly common misconception.

Q12.

(a) Very few students failed to score the mark on this question.

(b) Very few students scored two marks here. Few used the term 'confounding variable', which made it necessary to explain the concept; weak powers of expression meant that these explanations often failed to be creditworthy. Better answers often scored on marking points 3 and / or 4.

(c) Very few students failed to score the mark on this question. It was rare to come across a spelling error.

(d) This question produced a full range of marks. Some students referred to the effect of watering on the concentration of salt in the soil, rather than the effect on yield. It was clear from the responses which students had carefully studied the resource and clearly understood the effects of the different watering treatment.

(e) This question produced the whole range of marks. Some students simply repeated what they had written in the previous question. Many students could come up with the fact that irrigation with sea water increases the salt concentration in the soil. A few students correctly went on to relate this to lower water potential in the soil and linked this to a reduction in water uptake. Only a small number of students then considered the effects of this watering being repeated every year. This resulted in fewer responses relating to marking points 3, 4 and 5.

Q13.

Given that this question was targeted at grade E, it is surprising that all parts proved to be good discriminators.

(a) (i) Over three-quarters of students gained full marks. The most common incorrect response was 'centriole'.

(ii) Most students gained at least one mark for stating that the centromere attaches chromosomes to the spindle. However, the ability to tell the rest of the story, in terms of allowing the chromatids to be separated, discriminated well. Unfortunately, some students failed to read the question stem carefully enough. They instead described the role of the centromere in allowing homologous chromosomes to be separated during meiosis.

(iii) Many students were aware that homologous chromosomes carry different alleles. However, some failed to score through a lack of detail or poor expression. They typically mentioned maternal and paternal chromosomes, crossing over of alleles or thought that the sequence of genes on each homologous chromosome is different.

(b) (i) It was disappointing that sixty percent of students failed to score. This was usually for simply repeating information from the question stem, in terms of the cell having finished cell division. However, some students did not appreciate that an explanation was required. They simply stated that the chromosomes in **Figure 2** lack a centromere. Only the best responses mentioned that the chromosomes had not replicated, or had separated.

(ii) Just over half of students gained full marks. However, it was disappointing that nearly one-third failed to score. A vast range of incorrect responses was seen, in relation to the number of chromosomes drawn in the cell. It was evident that some students did not realise that meiosis produces haploid cells. Similarly, some students drew chromosomes consisting of two chromatids joined by a centromere.

(iii) Most students gained this mark for 'crossing over' or 'genetic recombination'. The most common response that failed to score was 'random fertilisation'.

Q14.

This was a question where many students failed to use the information given, or were let down by poor expression of ideas.

(a) Sixty percent of students obtained both marks and thirty percent obtained one mark. Those who obtained one mark frequently stated that phosphate was a non-competitive inhibitor and then went on to say that it made the enzyme active. Some students made more considered observations along the lines of, 'Like a non-competitive inhibitor, phosphate binds to a site other than the active site, changes the shape of the enzyme and causes the active site to form'. These answers were given full credit.

(b) This proved very difficult for the majority of students. Many failed to make any use of the information or diagrams in the question and resorted to vague statements about cancer and uncontrolled division. Some wrote about TK as though it was a cancerous cell, rather than an enzyme. Many got confused between faulty and non-functional forms of TK.

(c) This proved to be accessible, with marks awarded being very similar to those for (a). The context was obviously more familiar to students. Weaker answers often involved references to there being two active sites on the faulty TK. It has been noted in many papers that some students think any binding site, on any protein, is an active site.

Q15.

(a) This proved to be an excellent discriminator. Just over 70% of students scored at least half marks. Many were aware of the breaking of hydrogen bonds, the role of DNA helicase and complementary base pairing. However, it was only better responses that referred to the attachment of free nucleotides (as opposed to free bases) and both strands acting as templates. DNA polymerase was frequently mentioned but its role was often confused in weaker responses. This enzyme joins nucleotides on the newly formed strand, it does not cause complementary base pairing. Some students negated the mark for semi-conservative replication through poor expression. The most common examples of this included 'each new DNA molecule contains half of the original strand' and 'new strands contain half of the original strand'. Very few students wrote about hydrogen bonds reforming.

(b) (i) Two-thirds of students correctly gave the duration of metaphase as **18** minutes.

(ii) 80% of students correctly calculated the duration of anaphase as **10** minutes.

(iii) This proved to be a good discriminator. Most students gained one mark for extending the horizontal line to 18 minutes, or decreasing this line to 0 μm at 28 minutes. Weaker responses often showed the horizontal line increasing.

(c) (i) 70% of students correctly calculated the time the cells were in interphase as **19.7** hours. Very few students gained the principle mark for multiplying by 0.82.

(ii) Just under half of students were aware that cells in interphase could be detected by a visible nucleus or the inability to see chromosomes. Weaker responses typically referred to the inability to see *DNA* or that the cells in interphase would contain twice the amount of chromosomes.

(iii) This proved to be a good discriminator. Most students were aware that cancer cells divide more rapidly than healthy cells. However, it was only better responses that referred to data in the table and correctly linked this to tissue **D**. Some students wrongly thought that more cells in interphase meant more rapid cell division due to increased DNA replication.

Q16.

(a) The role of mitosis in growth was generally well known and clearly expressed. Some responses did not give precise enough wording to distinguish between replacement or repair of individual cells, the former gaining credit but the latter not.

(b) (i) Inappropriate answers often related to reliability or other aspects of general experimental design. Some very good answers demonstrated practical experience of finding cells undergoing the division process, but many disappointed with references, in particular, to the identification of anomalies.

(ii) This question was generally answered well; most incorrect responses identified **A** as prophase. Descriptions of evidence were generally good. Sometimes references were made to the spindle moving to opposite poles. Some answers referred to pairs of chromosomes, suggesting a confusion with meiosis.

(c) While quite a high proportion of students made little or no attempt at this calculation, the majority of those that did gained at least one mark. Some students clearly spent a lot of time in very lengthy compution; they would benefit from understanding that, for a maximum of two marks, they would not be expected to have to carry out such a

procedure. The main mistake was to regard stages **A+B** as being all of mitosis giving 3 + 1 as 4% of the total time, rather than taking 90% of the time in interphase, so 10% in mitosis.

Q17.

(a) (i) Over 80% of students correctly named this stage of mitosis as anaphase. A common incorrect response was telophase.

(ii) Most students gained one mark for describing the separation of the chromatids to opposite sides of the cell. However, less than 30% of students explained that the chromatids would be identical in terms of their genetic content. Most students simply stated that the cells being produced would be identical. This was in the stem of the question and, therefore, did not gain credit.

(b) (i) This proved to be a very effective discriminator. The most common mark was for linking cells containing 8.4 units with DNA replication. It was only better students who correctly explained how cells with 4.2 units were produced. A third of students gained no credit, often referring to meiosis, gametes and haploid cells in their explanations.

(ii) Two thirds of students correctly showed that a gamete formed in this animal would contain 2.1 units of DNA.

Q18.

(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.

Q19.

(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”.

Q20.

(a) Most candidates correctly identified the number of chromosomes in a male gamete in part (i) and appreciated in part (ii) that a chromosome number of 33 could not lead to viable gametes. Not all were certain as to the reason for this, however. One frequent misconception was that it is not possible to have a gamete with an odd number of chromosomes. Weaker candidates often attempted to explain why the gametes that would be produced were unable to form a zygote. Their answers were often further marred by poor use of technical language. There was much confusion between the terms chromosome, gamete and zygote.

(b) There were some excellent answers to both parts of this question. Both parts again required candidates to use the data in the table and it was clear that some failed to take sufficient care with this. The breaking strength of the leaf, for example, was not uncommonly expressed as the strength of the plant or even the breaking strength of the banana fruit. Candidates should be advised to use the wording provided in table headings and graph labels wherever possible.

(c) It was clear that some candidate’s knowledge of cell division failed to extend to the use of such terms as mitosis and meiosis. The quality of many answers was also influenced by poor understanding of technical terms. Thus different varieties of bananas were not infrequently referred to as species and genetic diversity was equated with species diversity. Consequently what should have been a simple answer linking mitosis to genetically identical offspring not often involved irrelevant accounts of competition and speciation.

Q21.

(a) Candidates who answered this question well followed the instructions and referred either to interphase in part (i) or to telophase or cytokinesis in part (ii). A significant number of others confined themselves to general descriptions, often related to the concentration of DNA rather than to the number of cells as required.

(b) In order to gain full credit here, candidates were simply required to recognise that the curves repeated themselves at 3 hourly intervals and to explain how they arrived at their answer. It was not uncommon to see a reasonable explanation but this was all too often incorrectly related to a 4 hour cycle. Some candidates had annotated

the graph on the opposite page. This practice should be discouraged as such answers may not be picked up.

Q22.

(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.

Q23.

(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.

Q25.

Unit 2

(a) Very few scored two marks for this question. Most missed the fact that the mass of DNA given was for a cell just before cell division and it had therefore already replicated its DNA. C = 600 and D = 300 was a common incorrect response.

(b) In (i), some good answers were found when candidates realised that the process was meiosis. Many just gave any organ where cell division takes place, misinterpreting the process as mitosis. So liver, skin or even roots were given by many. Part (ii) was again well answered when candidates realised that the purpose was to see the chromosomes. Poorer answers gave general purposes for staining, such as ‘to show the process’ or ‘to show up the cell/organe lles’.

Unit 3

(a) The accurate completion of the table proved challenging for all but a few candidates. ‘Immediately before division’ should have allowed the interpretation that chromosomes had replicated and would exist as a pair of chromatids. The chromosome number of an organism is not altered but the mass of DNA within the cell is temporarily doubled, and shown in the table. Few appreciated this and almost the whole cohort failed to link correctly change in chromosome number with mass of DNA.

(b) Weaker candidates failed to name an appropriate organ, or thought that meiosis might occur within the liver or skin, and many misinterpreted the question by identifying cells. Where, perhaps, candidates had investigated stages of cell division first-hand, the use of a stain to make chromosomes visible was appreciated more readily.

Q26.

Unit 2

(a) Most candidates knew that DNA replication occurs during interphase, or the S-phase, and could put the stages of mitosis in the right order.

(b) The commonest error here was to give ACDEB, i.e. failing to recognise that stage D came before stage C. Nevertheless, a few who did not read the question properly simple wrote ”Interphase, prophase, metaphase’ etc on the lines.

(c) The role of the spindle was well known although expression was clumsy.

(d) Many demonstrated full understanding. The terms haploid and diploid were confused by some and so fusion was described as producing the full set of haploid chromosomes. Variation was mentioned by some, but often vaguely suggesting that it occurred at fertilisation rather than during gamete formation. Confusion exists between meiosis and mitosis and a significant number of candidates explained that gametes were identical as a result of being formed by mitosis.

Unit 3

(a) This question was well answered with very few incorrect responses.

(b) Most candidates correctly identified the sequence of events. The most common error was to place **B** as the second event. Unfortunately some candidates did not follow the rubric and gave the stage names in sequence rather than the sequence of diagrams.

(c) Weaker candidates tended to confuse centrioles and centromeres and this led to some unacceptable responses. The idea that the spindle makes chromosomes move was well understood though some candidates did not appear to appreciate that the chromosomes are separated or moved to opposite poles.

(d) As is usual in January, there were many resit candidates who used information from module BYA5 in their answers to this question. Where correct, this was credited by the examiners.

Q27.

(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.

Q28.

Unit 2

(a) (i) Many identified the root tip as the region or area where mitosis was taking

place.

(ii) Too many did not know the reason for using a stain and often thought it was to stain the organelles, the nucleus or the cell. Only the better candidates identified its role as staining the chromosomes.

(iii) Many had the correct idea of producing a single layer of cells so that light could pass through.

(b) (i) Only the best candidates gave the correct answer here, as few recognised that only during prophase and metaphase would chromosomes be visible as chromatids.

(ii) Most candidates found this question very difficult and often just repeated the stem, stating that a different root tip had been used. Only the better candidates gave some idea that the garlic may have been growing in different conditions or that it might be genetically different.

Unit 3

(a) Most candidates were able to explain that the tip was the site of root growth and cell division but fewer knew that a stain was required to distinguish the DNA or chromosomes rather than cells, nuclei or organelles. In part (iii), while many correctly described the cells being separated or formed into a single layer to allow light through, some thought it necessary to remove air bubbles or to break open cells to release the contents.

(b) Credit was given for correct recognition of the two stages involved; many candidates were unsure of these or were unable to complete the calculation. In the second part, only the very best candidates could supply suitable ideas about genetic variation, differing environmental factors or the role of chance. Many others suggested the differences would be due to the size of the tip, the area of the slide or the stage in mitosis at which the slide was made. Some blamed the observer for miscounting or the poor quality of the microscope.

Q29.

Unit 2

(a) Most candidates correctly identified the stage in mitosis with appropriate evidence in (ii) although some suggested spindle fibres or centrioles. These were not visible. In (iii), most provided one example but suggested a similar process as a second, for example replication of DNA and of chromosomes. The difference between processes and events was not often understood.

(b) Few candidates gained this mark since they did not apply the standard formula to this question. Use of the scale bar appeared to be unfamiliar to many.

(c) While the majority of entrants produced a correct answer, several confused 1.44 hours with 1h 44 min, or gave 1.26 hours as their answer. The examiners gave credit to those who made a reasonable attempt here and whose calculations were set out clearly enough to be understood.

Unit 3

In (a)(i), most candidates could identify cell **A** correctly as being in prophase, although a significant minority thought it was in interphase. In (a)(ii), most candidates could give

suitable evidence for the cell being in anaphase, such as the chromatids moving to the poles. However, some candidates referred to being able to see the spindle fibres. In (a)(ii), there was some confusion with cytokinesis or telophase, with many references to the nuclear envelope reforming and the cytoplasm dividing. In (b), very few candidates seem to have noticed the scale bar. Many simply gave the formula that magnification = measured size divided by actual size. In a few cases, where candidates did notice the scale bar, they invalidated their answers by dividing 1cm by 0.02mm, instead of using the same units for both measurements. In (c), many candidates calculated the time correctly as 1.44, but a significant proportion of these went on to interpret this as 1 hour 44 minutes. Where the calculated answer was wrong, it was often difficult for examiners to award a mark for correct method. Many candidates simply offered a random collection of numbers, making it difficult to decide upon which method had been used.

Q30.

BYA2

The stages of mitosis were well known in part (a). Some candidates lost marks by referring to 'replication' in the S-phase, without stating what was being replicated. In part (b) (i), most candidates recognised that meiosis was involved in producing the spores, though the spellings were extremely varied. Examiners allowed phonetic misspellings, but had to reject "hybrid" spellings such as 'meitosis'. In part (ii), about half the candidates gave the correct answer of 32. The commonest error was 16, though many gave 23.

BYA3

(a) A range of responses was seen here, with many completely correct.

(b) The examiners agreed to accept alternative spellings of 'meiosis' provided they were phonetically unambiguous. Had they demanded an exact spelling, the number gaining the mark would have plummeted. Various numbers of chromosomes were offered, 16, 32 and 64 being common, but many gave 23.

Q31.

(a) Many candidates presumably misinterpreted the question because, instead of explaining the biological importance of *reducing the chromosome number* in meiosis, they discussed the importance of the variation which meiosis produced. However, most answered appropriately with reference to fertilisation and the need to prevent doubling of the chromosome number from generation to generation.

(b) Relatively few candidates were able to make three correct comparisons between meiosis and mitosis. One problem was the belief that the two rounds of division in meiosis and the production of four cells from the original constituted *two* different features. Some candidates also repeated the example given in the table. The points most commonly missed were the association of homologous chromosomes (or formation of bivalents) in meiosis and the production of *genetically* different cells by meiosis. Candidates were required to make a comment on both the meiosis and on the mitosis side of the table in order to score each mark.

Q32.

BYA2

(a) Whilst replication of the genetic material was given in some form by many candidates, several failed to relate their answers to the nucleus or were unaware that most organelles are reproduced in the cytoplasm.

(b) A few candidates confused mitosis and meiosis but the majority failed to gain marks through careless drawing even when they had identified the correct number of chromosomes. A surprising number drew chromosomes in part (ii) which had been bisected so they had the centromere with one 'arm' attached.

(c) Many correctly discussed replacing cells although some thought they could be repaired by this process.

BYA3

(a) This was known by most candidates, though a small number referred to chromosomes appearing or to events, such as protein synthesis or production of organelles, happening outside the nucleus.

(b) Many students gained the mark for the correct number of chromosomes in (i) and (ii), showing that the basic ideas behind mitosis and meiosis are well understood. However, fewer gained the mark for drawing the chromosomes correctly: many drew all chromosomes as identical.

(c) Many candidates realised that mitosis would allow damaged cells to be replaced, although the less able referred to repair of cells damaged by acid or enzymes.

Q33.

(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.

Q34.

There were very few maximum marks in this question with most candidates scoring two or three marks.

(a) The majority of candidates gained one mark for the idea of genetically identical embryos but imprecise descriptions of 'same genes' or 'identical genetic code' failed to gain credit. Only a minority of candidates named mitosis.

(b) Weaker candidates often described the failure to develop in terms of the 'cells being too small' or 'not having enough chromosomes to allow the process to continue'.

(c) Most candidates gained one mark for recognising the production of offspring with favourable characteristics but very few could describe a second advantage.

Q35.

This proved to be a discriminating question with only the very best candidates gaining maximum marks.

(a) Only very weak candidates failed to gain both marks.

(b) A specification term well answered.

(c) A small number of candidates could not read the figure from the graph, 0.6 being the most common error. As in the past, some students did not know to calculate the percentage. This inability did not necessarily correlate to the performance on the rest of the paper. Parts (ii) and (iii) were often answered very superficially, in terms of more cells being killed, without reference to the stem of the question or any interpretation of information given in the graph.

Q36.

Most candidates were able to apply their knowledge and gained credit but some failed to gain marks through failure to answer the question as set in part (c).

(a) There were many well rehearsed descriptions; some weaker candidates failed to gain marks through poor use of terminology.

(b) This question was very well answered, most candidates naming a specific environmental factor. Very few answers referred to mutation.

(c) Many candidates failed to use the information in the stem of the question and answered in terms of one or the other method rather than the advantage in having two methods. Some candidates were over elaborate, not recognising the seeds are produced asexually and therefore gave ‘variation’ as one advantage.

Q37.

This question gave candidates the opportunity to display their knowledge of factual material from the specification. Answers were often marred by inaccurate recall and poor expression. Once again, weaker candidates failed to select the appropriate information to answer the question set.

(a) Generally this section was poorly done with little reference to the question. Most candidates attempted to describe DNA replication without explanation as to how the structure of the molecule allows this to happen. Base pairing, often quoted, was well understood.

(b) There were some good answers but very few examples of full marks. Most candidates described chromosomes shortening, referred to movement to the equator and had some knowledge of the cause of chromatid separation. Beyond this there was confusion over the involvement of homologous pairs and many candidates failed to mention the identical nature of chromatids. Only the very able

candidates alluded to the significance of the movement to opposite poles. Weaker candidates could not put the events of the process into order. It was disappointingly rare to read a logically presented, coherent full answer. The majority of the candidates could use the information in the stem of the question and gained both marks.

(c) Targeting of the cells as a concept was only implied, but not referred to, so restricting some candidates to one mark.

Q38.

Although this question produced a wide range of marks, many candidates were able to obtain at least three of the marks available.

(a) (i) The vast majority of candidates correctly named this stage as anaphase.

(ii) Although most candidates described the separation of the chromatids towards the two poles of the cell, only better candidates referred to 'sister chromatids' or indicated that the chromatids would be identical. A significant minority of candidates mistakenly referred to the separation of homologous pairs of chromosomes.

(b) (i) Most candidates correctly identified stage X as interphase.

(ii) This proved more difficult with many candidates simply referring to the replication of 'cell organelles'. Correct responses required specific references to the processes during interphase, which enable nuclear division to occur, such as ATP synthesis, protein synthesis and, in animal cells, replication of cell organelles.

(iii) It was surprising to find so many candidates giving the incorrect answer of 1.1, having read the graph as 2.2 units rather than 2.4. Another common incorrect response was 23 (i.e. chromosomes), due to candidates not reading the question carefully.

(c) Although as expected a number of candidates suggested that the short time spent in anaphase was significant, it was pleasing to find that many candidates correctly referred to the short duration of interphase.

Q39.

This question was generally well answered by the majority of candidates, although few candidates gained maximum marks.

(a) In part (i), many candidates incorrectly drew a total of eight rather than sixteen chromatids. However, the vast majority did gain one mark for drawing a spindle. In part (ii), most candidates gained one mark by drawing four separate chromosomes. Only better candidates obtained the second mark by clearly showing that the four chromosomes represented one from each homologues pair.

(b) This caused few problems for the majority of candidates, many obtaining both marks. Candidates who obtained a single mark usually referred to the importance of meiosis in maintaining the chromosome number from generation to generation, but failed to mention that meiosis results in the production of haploid cells.

Q40.

This question proved to be an effective discriminator providing a wide range of marks.

(a) This caused few problems with the majority of candidates correctly explaining that a clone consists of genetically identical cells or individuals.

(b) This was also well answered with most candidates giving mitosis as the correct answer. However, a significant number of candidates gave the answer meiosis.

(c) Approximately half the candidates obtained this mark, usually by explaining that the embryo cells had not yet become specialised. Incorrect answers often referred to the ease of separating cells at this stage.

(d) Although many candidates gained this mark, a significant number failed to explain that the gene determining the brown colour would be present in the transferred nucleus.

(e) Very few candidates obtained both marks for this question. Many appreciated that the egg cells would be haploid but failed to mention that the embryo cells would be diploid. Only the very best candidates appreciated that these cells would contain different alleles of the colour gene.

(f) Again, only better candidates gained this mark, by suggesting that the low success rate was due to damage to the nucleus during transfer. Most candidates provided vague statements such as, 'the nucleus didn't work'.

Q41.

Generally this question was well answered with most candidates obtaining at least four marks. However, part (b) proved difficult for the majority.

(a) Answers to this question provided the full range of marks. Better candidates gave a detailed description of genetic engineering and had little difficulty in obtaining five of the six marks available. A significant number obtained maximum marks. Weaker candidates referred to the use of a restriction endonuclease and the production of 'sticky ends'. Many of these candidates also referred to the use of a plasmid but, unfortunately, not always in the correct context. There was also some confusion over the use of the enzyme ligase. Many candidates failed to realise that the gene was inserted into a plant cell but did not take the cell wall into consideration when describing the method of transfer. Nevertheless, the quality of answers to this question was pleasing.

(b) This proved to be an effective discriminator, with only better candidates suggesting how different cells could be produced by different genes being expressed. The best candidates then linked this to the production of different enzymes or proteins. Many candidates referred to the use of hormones without displaying any understanding of how these may initiate gene expression.

Q42.

(a) Most candidates correctly identified the stages in the photographs as prophase and anaphase. Many went on to gain further credit for their descriptions of what was happening to the chromosomes. This was especially pleasing since this was the first time for some years that photographs rather than diagrams have appeared in a question on this topic. Some weaker candidates appeared to be unsure whether mitosis or meiosis was shown, leading to suggestions that homologous pairs of chromosomes were separating in B.

(b) Candidates generally displayed rather weak knowledge of events during interphase. Even the best candidates tended to be restricted to one correct statement. Surprisingly few appreciated that DNA replication occurs during interphase, despite the fact that this a prerequisite for cell division.

Q43.

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.

Q44.

The vast majority of candidates appeared to be familiar with the stages of mitosis and were able to relate their knowledge to the diagrams in the question.

(a) (i) A large majority of candidates correctly identified stage A as anaphase.

(ii) A similar majority correctly gave the order of the stages.

(iii) Most candidates obtained one mark for describing the chromosomes as consisting of two chromatids, or being in a highly coiled state. Relatively few obtained a second mark by explaining that the chromatids resulted from replication of DNA. A minority confused the chromatids joined at the centromere with homologous pairs of chromosomes.

(b) (i) A large majority correctly noted that the chromosome number had doubled. A minority thought that the number had halved.

(ii) Few candidates put together the idea that DNA had replicated but without anaphase (or separation) being possible. Many got one half of the answer so could not be awarded the one mark available for a complete answer.

Q45.

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.