

2.2 THE CELL CYCLE, INCLUDING MITOSIS 1 – MARK SCHEMES

Q1.

- (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) $12 / 200 \times 24$ / single error in otherwise correct method; 1.44 hours (1 hour 26 min); 2

[7]

Q2.

- (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]

Q3.

(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]

Q4.

(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 out 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]

Q5.

(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]

Q6.

- (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:

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

2

[6]

Q7.

- (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]

Q8.

- (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]**Q9.**

- (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]**Q10.**

- (a) Centromere; 1
- (b) Same size;
Same shape;

Same genes;

In same sequence/locus/loci;

2 max

(c) Chromatids separate;

(Chromatids) pulled to opposite ends of cell;

By spindle fibres;

Become part of new nuclei;

2 max

[5]

Q11.

(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]

Q12.

(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

Q13.

(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]

Q14.

- (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]

Q15.

- (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]

Q16.

- (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
- (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);
- (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

2

2 max

[6]

Q17.

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

1

4

2

[9]

Q18.

- (a) (i) prophase;
chromosomes thickening / becoming visible;
- (ii) anaphase;
chromatids / chromosomes moving to opposite poles / ends of spindles;
- (b) DNA replication;
synthesis or proteins / build-up of energy stores / growth / increase in cytoplasm;
replication of organelles / named example;

2

2

2 max

[6]

Q19.

- (a) Later fertilisation / cell fusion; (NOT just 'sexual reproduction')
Restoring diploid / original number / not doubling chromosome number;
ALLOW ref '1/2 + 1/2'
- (b) Any three pairs from:
need comparison of meiosis and mitosis each time

2

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;
<u>Genetically</u> different (product)	Genetically identical (product);

IGNORE refs. To location

max 3

[5]

Q20.

- (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]

Q21.

- (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]

Q22.

- (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;
- (ii) because fair skin has little melanin which protects
against u.v. radiation;
- (iii) because cancer has genetic component / may have inherited
(onco)gene / gene which gives predisposition to / causes cancer;

2

1

1

[7]

Q23.

- (a) produced by mitosis;
genetically identical;
*(accept identical genes / same genotype / WNA / genetic
information)(reject same genes, same genetic code)*
- (b) cells lost ability to control development / no longer totipotent /
cells have differentiated / become specialised;
- (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

1

2 max

[5]

Q24.

- (a) mitosis;
genetically / genes / genotype identical;
*(reject same genes)
(ignore references to asexual reproduction)*
- (b) (different)
environmental conditions / named environmental factor / mutation;
- (c) dispersal / prevent overcrowding / competition / colonise ;
increased number of (proven) offspring; *(not quicker)*

2

1

2

[5]

Q25.

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

- (ii) metaphase; 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]

Q26.

- (a) Sequence: C,A,D,B;
1 mark per correct box to 3 max 3 max
- (b) (i) Q; 1
- (ii) Cell/nucleus has divided / is dividing (into two);
Accept – mitosis (occurring)
Ignore refs to chromosomes dividing 1

[5]

Q27.

- (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 aerobic 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]

Q28.

- (a) DNA replicated/two DNA strands/molecules;
 Coiled/condensed/wound up (to make visible);
 Giving/made of (two) chromatids;
 Attached at centromere;
Accept linear so eukaryote; with histone;
Accept have become shorter and fatter
- 2 max
- (b) (i) Stage **A**, anaphase/prophase;
 Chromatids/chromosomes moving to poles/chromosomes condensed/
 coiled/wound up;
Points not linked but need correct description with stage in this case.
Accept prophase because the image could be interpreted as such
- 2
- (ii) Stage **B**, metaphase;
 Chromosomes on equator/attaching to spindle;
Points not linked
Accept equator of cell
Reject centre of cell
Accept chromatids for chromosomes
- 2

[6]