5. The Mitotic Cell Cycle

5.1 Replication and Division of Nuclei and Cells

Paper 2

Marking Scheme

Q1.

(a)	coiling / supercoiling / condensation / becomes more compact / AW ; e.g. becomes shorter and fatter	**1**
(b)	**I** *ref. to* homologous chromosomes to describe the chromosomes in Fig. 5.1 *any* ***four*** *from:* each has two, sister / (genetically) identical, chromatids ; **R** homologous (chromatids) joined by a centromere ; each chromatid has a (single) DNA molecule ; **A** 2 chromatids and 2 DNA molecules DNA associated with, histone proteins / histones / basic proteins ; telomeres / repeating non-coding sequences, at ends of, chromatids / chromosomes ; AVP ; e.g. chromosomes, highly / most, condensed	**4**

Q2.

(a)	replacing cells that are, damaged / destroyed / worn out / old ;	1
(b)	*any **two** from:* result of mutation ; **A** example proto-oncogene to oncogene tumour suppressor gene inactive **I** mutation / mutated, *as a single term* short(er) / fast(er) / many / continuous, cell cycle(s) / cell divisions ; **A** shorter interphase **A** cells do not stop dividing **I** ref. to mitosis no contact inhibition / mitosis continues beyond space available / cell formation may spread to other nearby areas / AW ; ref. to normal (cell cycle) checkpoints not occurring ; **A** *idea that* substances needed for error checking not, available / functioning **A** errors not checked loss of (original / normal) function ; **A** example **A** non-functional (cell cycle continues because) fault in / errors in / no response to, cell signalling ; cells do not carry out apoptosis / no programmed cell death ; AVP ; e.g. different cell metabolism increase in telomerase (activity) telomeres do not shorten as quickly formation / presence, of blood vessels (feature of tumour) **A** angiogenesis lack of adhesion between cells ref. metastasis / described e.g. cells travel in, blood / lymph, to form tumours elsewhere in body **I** ref. to tumour spread in blood	2

(c)	*any **two** from:* *idea that* after each, cell cycle / cell division / DNA replication, telomeres shorten ; (long telomeres means that DNA) replication can take place more times ; **A** allows continuous (DNA) replication *context is DNA and not cell replication* *idea that* ends of chromosomes are protected ; telomeres do not contain, genes / genetic information ; **A** telomeres are non-coding detail ; e.g. *idea that* after replication nucleotides at ends of DNA are lost lagging strand replication leads to unpaired nucleotides DNA polymerase cannot continue to end on lagging strand (replication) (long telomeres) allow, long life span / many divisions to occur / many mitoses ; AVP ; e.g. prevents chromosome ends from joining otherwise, mitosis could not occur / may lead to cell death	2
(d)	*any **three** from:* differentiation has already started / AW ; **A** they are not undifferentiated **A** GMP cells are, differentiated / specialised (compared to stem cells) no self-renewal / AW ; **A** cannot produce a stem cell when they divide cannot form, all blood cell types / correct named ; (only) forms (immature) neutrophils and monocytes ;	3

Q3.

(c)	**A** = cytokinesis ; **A** division of the cytoplasm / cytoplasmic division **B** = interphase ; **C** = DNA replication ; **A** semi-conservative replication / production of sister chromatid **A** DNA, synthesis / AW **I** chromatid duplication / chromatid replication	**3**

Q4.

(c)(i)	**A** - centromere and **I** kinetochore site of attachment of, chromatids / chromosome(s) to, spindle fibres / microtubules **or** holds, sister / identical, chromatids together ; **R** daughter chromatids **B** - spindle fibres / microtubules, and orientating chromosomes at the (spindle) equator **or** separating chromatids, at end of metaphase / at start of anaphase **or** movement of, chromatids / chromosomes, to (opposite) poles ; *allow 1 mark max if functions incorrect but **A** and **B** named correctly* *allow 1 mark max if functions are correct but **A** named as kinetochore and **B** poorly misspelt attempt at microtubules*	**2**

Q5.

(a)	histones ; **A** basic / histone, proteins	**1**

Q6.

(a)(i)	S phase / synthesis phase / interphase ;	**1**

Q7.

(d) *any **four** from:* **4**

suggestion max 3	explanation
1 to replace, old / dead / damaged / injured, cells **or** to, repair / replace, damaged tissue ; **I** repair cells **I** replace old tissues	**6** *idea of* function in context of mp1 or 2 or 3 ; e.g. repair allows tissues to function specialisation / differentiation, allows, cells / tissue, to function genetically identical so cells can function as a tissue *look for other approaches e.g.* *'replace damaged cells that no longer function'* is mp1 and mp6
2 cells are produced that can, differentiate / become specialised (into intestinal cells); **I** multipotent / AW **R** if, stated / strongly implied that, all cells produced by mitosis become specialised	
3 produce cells that are genetically identical ; **A** clones **A** identical / same, DNA / genetic material / genetic information	**7** detail of function (intestines) ; e.g. absorption (of, glucose / nutrients) production of digestive enzymes pass absorbed, nutrients / AW, to blood **I** nutrition
4 growth ; **R** growth of cells	**8** idea of development during, infancy / childhood ;
5 renew / replenish / restore number of / AW, stem cells ; **I** increase in stem cells	**9** for, continued production / constant supply / AW, of intestinal cells **or** so that number of stem cells doesn't decrease ;

Q8.

(f) **I** transcription and translation stops **3**

*any **three** from:*

1 no, S phase / G_2 phase / mitosis / cytokinesis ;
A remains in (G_1) interphase
A synthesis phase *for* S phase
I named mitotic stages
look for **CON** e.g. 'no S-phase, so mitosis only has one chromatid'

2 (semi-conservative) DNA, replication / synthesis, does not occur ;
A sister / identical, chromatids, do not form
R if a phase is stated and it is not given as the S-phase

3 failure to pass checkpoints / does not reach checkpoints ;
A ref. to no error checking occurs (*in context of checkpoints)*
I proofreading / error checking, (by DNA polymerase) during DNA replication

4 cell does not, grow / increase in size / increase cytoplasm ;
(context of preparing for mitosis / cytokinesis) **A** grows to normal (non-dividing) size

5 *idea that* the cell does not, duplicate / synthesise, organelles / extra materials *(context is for, cytokinesis / new cells)* ;
A centrioles do not replicate
A microtubules not synthesised
R if stated as occurring in S phase (even if e.g. G_2 given as well)

Q9.

(a)(ii)	*any **two** from:* growth ; **R** growth of cells repair of tissues (by replacement of cells) ; replacement of, old / dead /damaged / worn out, cells ; **R** repair of cells asexual reproduction ; production of genetically identical daughter cells ;	**2**

Q10.

(a)	*any three from* *lung cancer to max 2* (tar) is a carcinogen ; acts as mutagen / causes mutations / described ; **I** mutant cells e.g. causes changes to sequence of, bases / nucleotides, in DNA detail ; **I** uncontrolled mitosis e.g. tumour suppressor genes switched off protooncogenes to oncogenes / oncogenes switched on (cell cycle) checkpoints fail to function AW cell moves from, G0 / inactive state of cell cycle, to G1 phase (for mitosis) no programmed death / AW *chronic bronchitis to max 2* (tar) paralyses / destroys / damages / AW, cilia ; **I** weakens cilia **A** damage to ciliated (epithelial) cells consequence to cilia action ; *must be related to mp1* e.g. cilia do not, waft away / AW, mucus loss of synchronous rhythm of cilia (tar causes), goblet cells / mucous glands, to, increase in size / enlarge / AW ; **A** (tar / accumulation of mucus, causes) inflammation more / excess, mucus produced (by, goblet / mucous gland cells) ; **I** mucus accumulates	**3**

Q11.

(b)(i)	*any **two** from:* allow DNA replication to continue ; *idea that* stem cell to, self renew / keep dividing ; *idea that* stem cells differentiate into (named) specialised cells ; *idea that* mitosis produces cells for, cell replacement / tissue repair ; (maintains telomeres, so) prevents the loss of genes ;	**2**

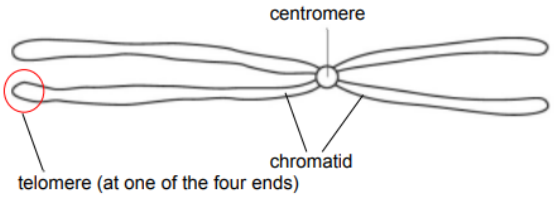
(b)(ii)	*any **one** from:* (high level of telomerase activity) allows ,continuous / uncontrolled, mitosis / cell division ; idea of allowing shorter cell cycle ;	**1**

Q12.

(a)	<table><tr><th>Stage of cell cycle</th></tr><tr><td>(G_1 phase)</td></tr><tr><td>S phase</td></tr><tr><td>G_2 phase ;</td></tr><tr><td>prophase</td></tr><tr><td>metaphase</td></tr><tr><td>anaphase ;</td></tr><tr><td>(telophase)</td></tr><tr><td>(cytokinesis)</td></tr></table> interphase ; (mitosis) *one mark for interphase* *one mark for S phase and G_2 phase in correct sequence* *one mark for prophase, metaphase and anaphase in correct sequence*	3
(b)	Vincristine: ✓ ✓ x x ; 5-fluorouracil : x x x x ;	2

(c)	*any three from* *blood smear differences* large / larger, numbers of lymphocytes ; more lymphocytes than normal blood smear ; *as blood smear or lymphocyte difference* immature / not fully developed ; *ref. to* no large nuclei / nuclei not pronounced small nuclei ; **A** nuclei not visible *lymphocyte difference* non-functional / AW ; detail of lack of function for either B-lymphocytes or T-lymphocytes ; AVP ; e.g. *ref. to* difficult to distinguish between lymphocytes and monocytes ; **A** no monocytes visible	3

Q13.

(b)(i)	*drawing* two chromatids of identical length joined at the centromere ; *labels* chromatid ; *one label line is sufficient* **R** if second line drawn to arm of sister chromatid centromere ; telomere ;  	4
(b)(ii)	histone(s) ; **A** highly basic (protein)	1

Q14.

(a)(i)	(sister) chromatids ; centromere ; histone ;	3

Q15.

(a)(i)	*in context of mutations in genes* *any **two** from:* uncontrolled, (cell) division / mitosis ; cell cycle not regulated ; programmed cell death does not occur / cell becomes immortal ; uncontrolled growth not suppressed ; *ref. to* mass of abnormal cells ; AVP ; e.g. cell cycle checkpoints impaired proto-oncogenes become oncogenes tumour suppressor genes switched off	2

Q16.

(b)	if letter used in more than one row, **R** these rows correct interphase knowledge G2 = **A**, S = **B**, G1= **blank** ; *cytokinesis* **blank** ; *prophase* **C** ; *anaphase* **E** ; *telophase* **D** ;	5

Q17.

(b)(i)	stops, cell cycle / mitosis / cell division / cell replication / AW ;	1

(c)(ii)	*three from* tobacco smoke / tar, contains (named) carcinogens ; cause, damage to DNA / mutations ; detail ; e.g. proto-oncogenes to oncogenes / tumour suppressor genes switch off (in) epithelial cells in the, trachea / bronchus / gas exchange system / lungs ; uncontrolled, mitosis / cell division ; AVP ; e.g. forms a mass of undifferentiated cells / AW cells do not respond to signals	3

Q18.

(a)	**I** maintains length of chromosomes / prevents chromosome shortening *any two from:* permit continued replication ; prevent loss of genes ; **I** prevents gene damage genetic material is neutral **A** genetic / coded, information *for genes* **A** information on DNA **A** protein coding regions of DNA **A** exons protect ends of chromosomes from being, degraded / AW ; AVP ; e.g. prevents ends of chromosomes from being attached to each other not mistaken for a break in DNA that needs repairing	**2**
(b)	*Idea that,* mitosis / cell cycle / (DNA) replication / (cell) division, occurs in both cell types (continuously / regularly / AW) ; **R** uncontrolled mitosis **R** meiosis	**1**

Q19.

(a)	*any one from:* *idea that* to provide cells that can, differentiate / divide ; for (continued) growth of the, shoot tip / (named) tissues ; **I** 'to produce more meristematic cells'	**1**

Q20.

(e)	*any three from:* *to produce, new / daughter, cells…* **1** that are genetically identical ; **2** to replace, old / damaged / dead, cells ; **A** named cells **3** to repair (damaged / injured / diseased) tissue ; **A** named tissue *if mp 2 and 3 not gained, allow 1 mark for replacing damaged tissue* **4** *ref.to* function ; *in context* **5** AVP ; *idea of* increase in number of cells / growth, to accommodate increase in size of gas exchange system in growing infants / AW	**3**

Q21.

(b)(i)	*any two from:* lymphocytes / blood cells, produced in / originate from, bone marrow ; *ref. to* stem cell(s) ; *ref. to* cell division ; e.g. bone marrow has cells that can carry out, mitosis / cell division **A** (stem cells are) multipotent	**2**

(b)(ii)	*any three from:* *measles* immune response stimulated ; detail ; e.g. **either** antigen recognition / presence / binding **or** lymphocyte / white blood cell, stimulated / triggered } **or** clonal selection / AW **plus** clonal, expansion / proliferation / cell division / mitosis **R** incorrect pathogen name **R** bacteria *CLL* result of, uncontrolled mitosis ; **A** uncontrolled, division / cell cycle **I** rapid mitosis detail ; owing to, mutation / named mutation **or** cell cycle checkpoints not working **or** cells don't respond to signals to control division	**3**

Q22.

4(c)	*one from:* not sectioned to include (nucleus) ; did not take up the stain / not stained (correctly) / AW ; AVP ; e.g. cells may be dead **I** destroyed / eliminated / AW	**1**

Q23.

(a)	*any two from* **1** (division that) produces, new / daughter, cells **A** produces more cells **or** (so) replaces, damaged / lost / dead, cells ; **2** new / daughter, cells, genetically identical ; **A** *ref. to* clone if correct context **A** genetic information not lost **I** same number of chromosomes **3** (all) new cells can retain function ; AW	**2**
(b)	*any two from* **1** cell cycle continuous / continually divide / AW ; **2** (produce cells that) can, differentiate / specialise / described ; **A** multipotent / pluripotent **I** totipotent *divide to produce a cell that can divide and a cell that differentiates = 2 marks* **3** can produce, cells / tissue, that can still function (as before) ;	**2**

Q24.

(b)(i)	*any two from* DNA , replication / AW ; **A** S phase **I** chromosome replication (early interphase) chromosome becomes two chromatids ; **A** described DNA checked for errors / errors in DNA repaired ; synthesis of, (growth) protein / enzymes (for growth) ; cell growth ; organelle synthesis ; centrioles replicate ; AVP ; e.g. *ref.* to checkpoint(s) nucleotide synthesis	**2**