



3: DNA and the mitotic cell cycle – Topic questions

The questions in this document have been compiled from past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
4	2017	May/June	21
5	2017	May/June	23
4	2017	May/June	22

The mark scheme for each question is provided at the end of the document.



[4]

3: DNA and the mitotic cell cycle

(b) Fig. 4.2 shows:

- the first seven amino acids of the β chain of haemoglobin
- the first amino acid in the sequence is valine (Val)
- the 21 base pairs in the sequence of DNA that code for these seven amino acids.

amino acid sequence	Val	His	Leu	Thr	Pro	Glu	Glu
base sequence in DNA	CAC	GTG	GAC	TGA	GGA	CTC	CTC
	GTG	CAC	CTG	ACT	CCT	GAG	GAG

Fig. 4.2

Table 4.1 shows the triplets of bases that code for seven amino acids.

Using Fig. 4.2 and Table 4.1, state what will happen to the sequence of amino acids in the first part of the β chain of haemoglobin:

(i) if the base pair at position 6 is deleted

.....
[1]

(ii) if the three base pairs at positions 7, 8 and 9 are deleted.

.....
[1]

Table 4.1

amino acid		DNA triplets
cysteine	(Cys)	TGT TGC
glutamic acid	(Glu)	GAA GAG
histidine	(His)	CAT CAC
leucine	(Leu)	CTT CTC CTA CTG
proline	(Pro)	CCT CCC CCA CCG
threonine	(Thr)	ACT ACC ACA ACG
valine	(Val)	GTT GTC GTA GTG
no amino acid	STOP	TAA TAG TGA

- (c)** DNA is involved in the processes of replication and transcription.

Complete Table 4.2 by using a tick (✓) to indicate which features apply to each of the processes. Use a cross (X) for features that do **not** apply.

The first row has been completed for you.

Table 4.2

feature	replication	transcription
a single-stranded molecule is produced	<i>x</i>	✓
hydrogen bonds are broken		
both strands of DNA act as templates		
phosphodiester bonds are formed		
DNA polymerase is used		

[4]

- (d)** Telomeres are parts of chromosomes. Describe the function of telomeres.

.....[2]

- (e)** Describe the function of ribosomes in protein synthesis.

[illegible]

...[Turn over]^[4]
[Total: 16]

5 (a) Describe the process of DNA replication.

[5]

(b) State the name of the part of the chromosome that prevents the loss of genes during DNA replication.

.....[1]

(c) During DNA replication, the use of an incorrect base in the newly synthesised strand can lead to a mutation.

(i) A transversion event is where a pyrimidine is used in the newly synthesised strand instead of a purine, or the other way round.

Name the **two** possible bases that could be used instead of cytosine in a transversion event.

.....[1]

(ii) A transition event is where an incorrect purine is used or an incorrect pyrimidine is used.

Suggest why transversion events are **less** likely to occur than transition events.

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.....

.....[2]

(d) Outline how mutations can cause healthy cells to become tumour cells.

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.....[3]

[Total: 12]

4 Meristematic tissue is found in the growing regions of plants, such as root tips.

(a) Fig. 4.1 summarises a cell cycle for a meristematic cell in the root tip. The two phases of this cell cycle are shown:

- interphase, which is divided into the G_1 , S and G_2 stages
- cell division, which is divided into stages 1–5.

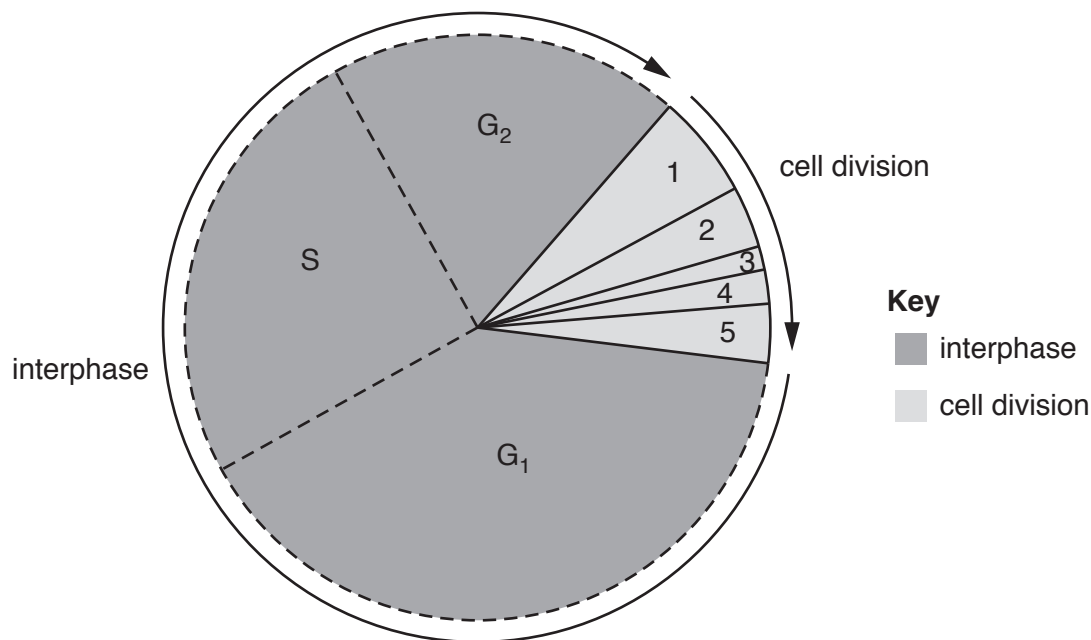


Fig. 4.1

(i) In Fig. 4.1, stage 2 is metaphase.

The stages shown in Fig. 4.1 are listed below. Draw a circle around the stage in the cell cycle that is cytokinesis **and** describe what happens in this stage in the root tip meristematic cell.

1 2 3 4 5 G_1 S G_2

.....

.....

.....

.....

.....

.....

.....

.....[3]

[Turn over

- (ii) The stages shown in Fig. 4.1 are listed below. Draw a circle around the stage in the cell cycle in which the semi-conservative replication of DNA occurs **and** state what is meant by semi-conservative replication.

1 2 3 4 5 G₁ S G₂

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.....

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.....

.....[3]

- (b) Meristematic cells have a similar role to stem cells found in animals.

Suggest the role of a meristematic cell **and** explain the features that help it to carry out its role.

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.....

.....[3]

[Turn over

(c) Meristematic regions in the plant can sometimes be described as strong sinks.

(i) State what is meant by a *sink*.

.....
.....
.....[1]

(ii) Suggest what is meant by a **strong** sink.

.....
.....
.....[1]

[Turn over

[4]

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Mark scheme abbreviations

;	separates marking points
/	alternative answers for the same point
A	accept (for answers correctly cued by the question, or by extra guidance)
R	reject
AW	alternative wording (where responses vary more than usual)
<u>underline</u>	actual word given must be used by candidate (grammatical variants accepted)
max	indicates the maximum number of marks that can be given
ora	or reverse argument
mp	marking point (with relevant number)
ecf	error carried forward
I	ignore
AVP	alternative valid point

Question	Answers	Marks
4(a)	<p><i>mRNA</i></p> <ol style="list-style-type: none"> single-stranded ; no hydrogen bonding / only DNA has hydrogen bonding ; no base pairs / only DNA has base pairs ; uracil and not thymine / DNA has thymine instead of uracil ; <i>treat as neutral T and U, look for complete term</i> ribose not deoxyribose ; detail, e.g. –H and not –OH on C2 ; short(er) / DNA is longer ; A smaller / bigger not a helix ; 	max 4
4(b)(i)	<p><i>third triplet is a stop codon so</i></p> <p>only two amino acids are joined by peptide bonds / chain only 2 amino acids long ;</p> <p>A will still have Val-His as the first two amino acids</p> <p>very short molecule is produced / chain stops after His(tidine) ;</p> <p>R frameshift / description of frameshift</p>	max 1

Question	Answers	Marks																		
4(b)(ii)	<p>a triplet is deleted so (polypeptide / sequence / β chain) has one less amino acid ; polypeptide does not have Leu (as the third amino acid) ; I Leu is not, produced / made / synthesised</p>	max 1																		
4(c)	<table border="1"> <thead> <tr> <th>feature</th><th>DNA replication</th><th>transcription</th></tr> </thead> <tbody> <tr> <td>a single-stranded molecule is produced</td><td>x</td><td></td></tr> <tr> <td>hydrogen bonds are broken</td><td></td><td>✓ ;</td></tr> <tr> <td>both strands of DNA act as templates</td><td></td><td>x ;</td></tr> <tr> <td>phosphodiester bonds are formed</td><td></td><td>✓ ;</td></tr> <tr> <td>DNA polymerase is used</td><td></td><td>x ;</td></tr> </tbody> </table>	feature	DNA replication	transcription	a single-stranded molecule is produced	x		hydrogen bonds are broken		✓ ;	both strands of DNA act as templates		x ;	phosphodiester bonds are formed		✓ ;	DNA polymerase is used		x ;	4
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phosphodiester bonds are formed		✓ ;																		
DNA polymerase is used		x ;																		
4(d)	<p>I functions of telomerase permits continued replication (in stem cells / meristematic cells) ; A ora prevents loss of, genes / genetic material / DNA ; A ora A prevents shortening of, chromosomes / DNA length of telomere determines lifespan of, cells / cell lineage ; AVP ; e.g. prevents ends of chromosomes attaching to each other prevents apoptosis / cell death / cell destruction</p>	max 2																		

Question	Question	Question
4(e)	<ol style="list-style-type: none"> 1 translation / construction of <u>polypeptide(s)</u> ; 2 provide binding site for mRNA / mRNA attaches to ribosome / AW ; A entering ribosome 3 provides binding sites for (two) tRNA molecules ; A entering ribosome 4 two amino acids are held close together ; 5 formation of <u>peptide bond(s)</u> ; R dipeptide / polypeptide, bond 6 (allows) assembly of amino acids into, sequence / primary structure ; 7 AVP ; e.g. P and A site (and E site) bond between amino acids catalysed by peptidyl transferase 	max 4
		Total: 16

Question	Answer	Marks
5(a)	<p>1 DNA (double helix) unwinds ; A uncoils I unzips R DNA strand unwinds</p> <p>2 hydrogen bonds break between, base pairs / bases / strands ;</p> <p>3 both strands used as templates ;</p> <p>4 catalysed by / AW, DNA polymerase ;</p> <p>5 <i>ref. to</i> (free) activated nucleotides / AW ;</p> <p>6 complementary (DNA) nucleotides added ; R RNA nucleotides</p> <p>A described in terms of complementary base pairing</p> <p>7 step-by-step / sequentially / AW ;</p> <p>8 <i>idea that</i> process continues, along whole DNA molecule ;</p> <p>9 replication bubbles / described</p> <p>or</p> <p><i>ref. to</i> Okazaki fragments ;</p> <p>10 replication is semi-conservative / each newly formed molecule contains one original and one newly synthesised strand</p> <p>11 AVP ; e.g. <i>ref. to</i> repair / proofreading</p> <p><i>ref. to</i>, helicase / ligase <i>in correct context</i></p>	max 5
5(b)	telomere(s) ;	1
5(c)(i)	adenine <u>and</u> guanine ;	1
5(c)(ii)	<p><i>idea that</i> purines and pyrimidines are different sizes / two rings and one ring ;</p> <p>purine normally bonds with pyrimidine (to maintain DNA double strand width) ;</p> <p><i>idea that</i> two purines or two pyrimidines will distort the double helix width (in a transversion event) ; ora</p> <p>AVP ; e.g. (transversion event) more likely to be detected by the repair mechanism ora</p>	max 2

Question	Answer	Marks
5(d)	<p><i>idea that</i> mutation occurs for a gene controlling cell division ; detail ; e.g. proto-oncogene to oncogene tumour suppressor gene switched off ; <i>ref. to</i> disruption of cell cycle / shortened interphase ; (results in) uncontrolled cell division ; I uncontrolled growth other detail of result of mutation ; e.g. divide indefinitely / no programmed cell death do not respond to signals to stop dividing loss of, specialisation / function</p>	max 3
Total: 12		

Question	Answer	Marks
4(a)(i)	<p>1 circle round 5 ; <i>to max 2 but 4 cells produced = max 1 out of 2</i></p> <p>I details of telophase leading to cytokinesis</p> <p>2 { <i>or</i> cell plate forms (across equator of cell) cell wall / cellulose, laid down ; A cell wall forms (between the two)</p> <p>3 (so) <u>cytoplasm</u> divided (into two) ; R <u>cytoplasm</u> constricts / pinches in / cleavage furrow forms / cleavage forms (<i>i.e. referring to animal cell</i>)</p> <p>4 AVP ; detail of cell plate formation e.g. <i>ref. to</i> vesicles transported to equator / involvement of cytoskeletal structures <i>idea that</i> organelles shared out</p>	max 3

Question	Answer	Marks
4(a)(ii)	circle round S ; synthesis of <u>two</u> identical DNA, molecules / double helices (from one) ; each new molecule consists of one, original / parental, strand, and one, new / newly synthesised, strand ; AW A daughter <i>for newly synthesised</i>	3
4(b)	<p><i>role</i></p> <p>1 form cells that can, differentiate / become specialised ; A can develop into other cell types / totipotent A named examples</p> <p>2 for, cell replacement / tissue repair / growth ; R for cell growth I found in growing region</p> <p>3 divides to give continuous supply of, meristematic / stem, cells ; A divides to forms more, meristematic / stem, cells</p> <p><i>feature</i></p> <p>4 (stem cells are) undifferentiated ; A not specialised / unspecialised</p> <p>5 able to divide ; <i>must be in context of mitosis</i> A able to undergo mitosis A can replicate I reproduce R uncontrolled division</p> <p>6 <i>idea that</i> genes not switched off ; ora</p>	max 3

Question	Answer	Marks
4(c)(i)	<p>growing / storage, area / region / correct named part of plant ; <i>examples of part of plant that stores / growing</i> root / shoot tip / bud / flower / maturing leaf / tuber / fruit / seed</p> <p>I where sucrose, used / used up I nutrients unqualified receives, assimilates / sucrose / AW ; A area where sucrose unloaded <i>in context of, via phloem / from source / from leaf</i></p>	max 1
4(c)(ii)	<p><i>strong</i> high requirement for assimilates ; fast growing / highly active ; AW e.g. requires a lot of energy</p>	max 1

Question	Answer	Marks
4(d)	<p><i>accept H⁺ / protons, throughout for hydrogen ions</i></p> <p>1 active process / uses ATP / requires energy ;</p> <p>2 hydrogen ions, pumped / active transport / move(d), out of companion cells ; <i>this also gets mp1 if stated as, pumped / active transport / move by proton pump</i></p> <p>3 into cell wall / apoplast ; A intercellular space R pumped into phloem sieve tube</p> <p>4 hydrogen ion gradient builds up ;</p> <p>5 hydrogen ions re-enter companion cell, down gradient / AW ; A facilitated diffusion</p> <p>6 via, cotransport protein(s) / cotransporter(s) ; A carrier protein(s) <i>'hydrogen ions diffuse back into companion cell through cotransport protein' is two marks</i></p> <p>7 <u>cotransport</u> sucrose (molecules) ; A secondary active transport A idea of bringing sucrose into companion cell if cotransport / er stated for previous mp R cotransport if into phloem sieve tube from companion cell</p> <p>8 transport of sucrose against gradient ;</p> <p>9 diffusion of sucrose into phloem sieve tube (element) ; R facilitated diffusion A moves from high to low concentration</p> <p>10 via plasmodesmata ;</p>	max 4
		Total: 15