BIOLOGICAL MOLECULES

Nucleic Acids – Genes Part 1 EXAM Q&A

Q1.

(a) Describe how a phosphodiester bond is formed between two nucleotides within a DNA molecule.

_____

_____

_____

_____

_____

_____

(2)

(b) The two DNA strands of a particular gene contain 168 guanine bases between them. The relationship between the numbers of guanine bases (G), adenine bases (A), thymine bases (T) and cytosine bases (C) in these two strands of DNA is shown in the following equation.

$$G = 4(A + T) – C$$

Use this information and your understanding of DNA structure to calculate the maximum number of amino acids coded by this gene.

Show your working.

Answer _____

(2)

(c) Name the protein associated with DNA in a chromosome.

_____

(1)

(d) In the process of semi-conservative DNA replication, the two strands within a DNA molecule are separated. Each then acts as a template for the formation of a new complementary strand.

Describe how the separation of strands occurs.

_____

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

Q2.

(a) Describe the role of DNA polymerase in the semi-conservative replication of DNA.

_____

_____

_____

_____

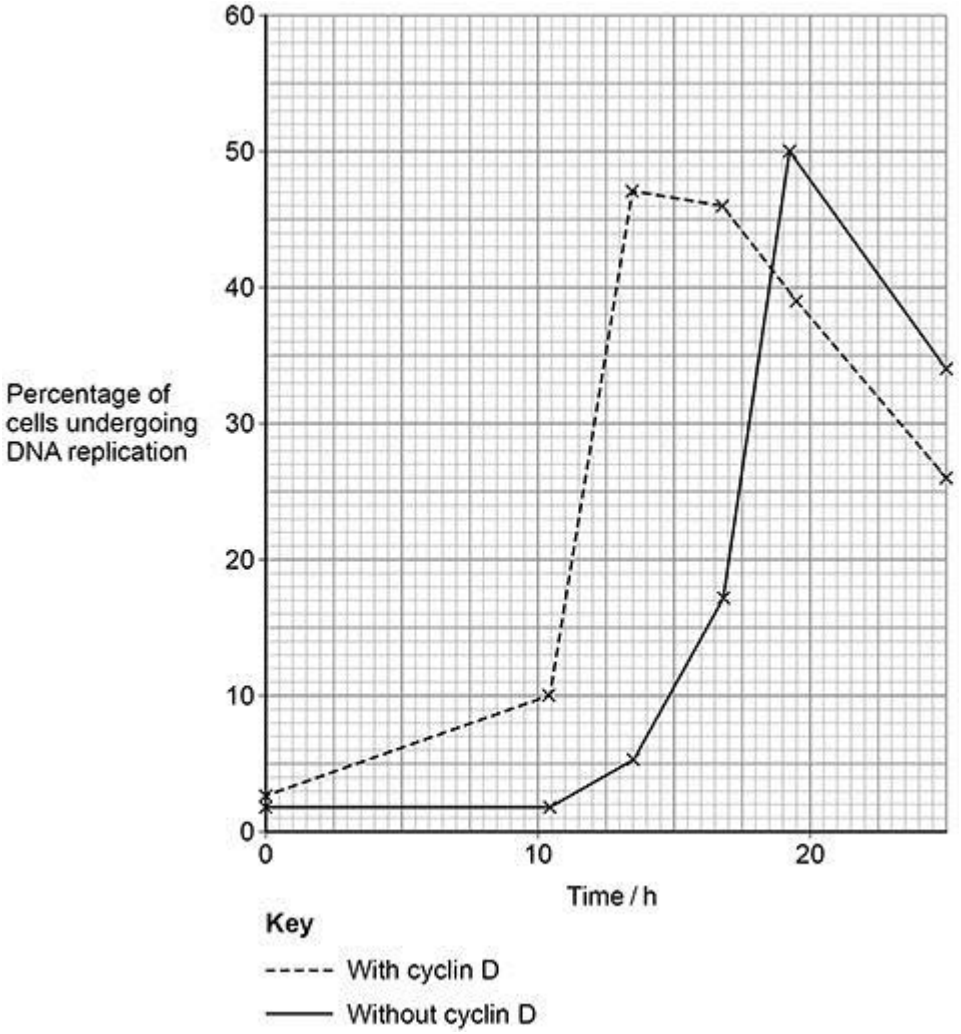
_____

_____

_____

(2)

The graph below shows the percentage of rat cells undergoing DNA replication. Some cells contained a protein called cyclin D and some cells did not contain cyclin D. All cells were in early interphase at time 0



(b) It took less time for 25% of cells with cyclin D to be undergoing DNA replication than for 25% of cells without cyclin D.

Use the graph above to calculate this time difference as a percentage decrease.

Show your working.

Answer _____ %

(2)

(c) Cyclin D stimulates the phosphorylation of DNA polymerase, which activates the DNA polymerase.

Describe how an enzyme can be phosphorylated.

(2)

(d) Some tumour cells contain higher than normal concentrations of cyclin D.

Use the graph above to suggest why higher than normal concentrations of cyclin D could result in a tumour.

(2)

(Total 8 marks)

Q3.

(a) Describe how mRNA is formed by transcription in eukaryotes.

(5)

(b) Describe how a polypeptide is formed by translation of mRNA.

(6)

(c) Define ‘gene mutation’ and explain how a gene mutation can have:

- no effect on an individual
- a positive effect on an individual.

_____

(4)

(Total 15 marks)

Q4.

(a) The nucleus and a chloroplast of a plant cell both contain DNA.

Give **three** ways in which the DNA in a chloroplast is different from DNA in the nucleus.

1 _____

_____

_____

2 _____

_____

_____

3 _____

_____

_____

(3)

(b) Some DNA nucleotides have the organic base thymine, but RNA nucleotides do not have thymine. RNA nucleotides have uracil instead of thymine.

Give **one** other difference between the structure of a DNA nucleotide and the structure of an RNA nucleotide.

_____

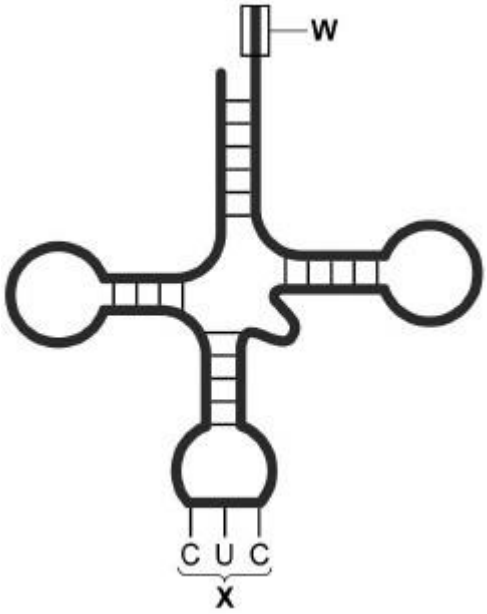
_____

_____

_____

(1)

The diagram shows a tRNA molecule.



(c) Name the structures labelled **W** and **X** in the diagram.

W _____

X _____

(1)

(d) Not all mutations in the nucleotide sequence of a gene cause a change in the structure of a polypeptide.

Give **two** reasons why.

1 _____

_____

_____

_____

2 _____

_____

_____

_____

(2)

(Total 7 marks)

Q5.

(a) Name the **two** scientists who proposed models of the chemical structure of DNA and of DNA replication.

_____

(1)

A scientist replicated DNA in a test tube. To do this, he mixed an enzyme with identical single-stranded DNA fragments and a solution containing DNA nucleotides.

(b) Name the enzyme used in this DNA replication.

_____

(1)

(c) Use your knowledge of semi-conservative replication of DNA to suggest:

1. the role of the single-stranded DNA fragments _____

_____

_____

_____

_____

2. the role of the DNA nucleotides. _____

_____

_____

_____

_____

(3)

(Total 5 marks)

Q6.

(a) Describe the roles of iron ions, sodium ions, and phosphate ions in cells.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(b) The movement of substances across cell membranes is affected by membrane structure. Describe how.

(5)

(Total 10 marks)

Q7.

Scientists investigated the cell cycle in heart cells taken from mice 6 days before their birth and then at 4, 14 and 21 days after their birth.

Their results are shown in the table. Age 0 days = day of birth.

Age / days	Percentage of heart cells undergoing mitosis	Percentage of heart cells undergoing DNA replication
−6	13.9	8.5
4	8.5	2.6
14	1.6	0.2
21	0.6	0.0

(a) Describe and explain the data in the table above.

(2)

The scientists determined the percentage of heart cells undergoing DNA replication by using a chemical called BrdU. Cells use BrdU instead of nucleotides containing thymine during DNA replication.

(b) Describe how BrdU would be incorporated into new DNA during semi-conservative replication.

(5)

(c) Cells with BrdU in their DNA are detected using an anti-BrdU antibody with an enzyme attached.

Use your knowledge of the ELISA test to suggest and explain how the scientists identified the cells that have BrdU in their DNA.

(3)
(Total 10 marks)

Q8.

(a) Draw **and** label a single DNA nucleotide.

(2)

(b) Give **two** features of DNA **and** explain how each one is important in the semi-conservative replication of DNA.

1. _____

2. _____

_____

_____

_____

_____

(2)

(c) Replication of mitochondrial DNA (mtDNA) is different from that of nuclear DNA.

The replication of the second strand of mtDNA **only** starts after two-thirds of the first strand of mtDNA has been copied.

A piece of mtDNA is 16 500 base pairs long and is replicated at a rate of 50 nucleotides per second.

Tick (✓) the box that shows how long it would take to copy this mtDNA.

A 330 seconds ☐

B 440 seconds ☐

C 550 seconds ☐

D 660 seconds ☐

(1)

(Total 5 marks)

Q9.

Read the following passage.

Sizes of populations of normal intestinal bacteria are usually controlled by T cells that are produced slowly and in small numbers by the immune system. These T cells do not normally survive for very long. As a result, they do not release large amounts of cytokines. Cytokines are chemicals that can cause swelling of the lining of the intestines. 5

Crohn's disease is a long-lasting disease that causes swelling of the lining of the intestines. It is believed that Crohn's disease can be caused by a loss of tolerance to normal intestinal bacteria, as shown by an unusually large response by T cells. This response can be triggered by pathogenic bacteria in the intestines of people with a genetic tendency to Crohn's disease. 10

Some people's Crohn's disease can be controlled by a drug called 5-aminosalicylic acid (5-ASA) that reduces swelling. Another drug called

6-mercaptopurine (6-MP) may also be used. 6-MP inhibits an enzyme required to make adenine and guanine. This is effective because most cells can recycle nucleotides, but T cells are not able to do so. 15

Use information from the passage and your own knowledge to answer the questions.

(a) The Crohn's disease symptom of swelling of the lining of the intestines could be triggered by pathogenic bacteria in the intestines (lines 6–10).

Suggest how.

(3)

(b) Suggest the meaning of 'a genetic tendency to Crohn's disease' (line 10).

(2)

(c) Suggest why 5-ASA is only effective in controlling the swelling of the lining of the intestines in **some** people with Crohn's disease (lines 11–12).

(2)

(d) Suggest why 6-MP can be used to control the symptoms of Crohn's disease (lines 13–15).

Do **not** include details of enzyme inhibition or protein synthesis in your answer.

(3)

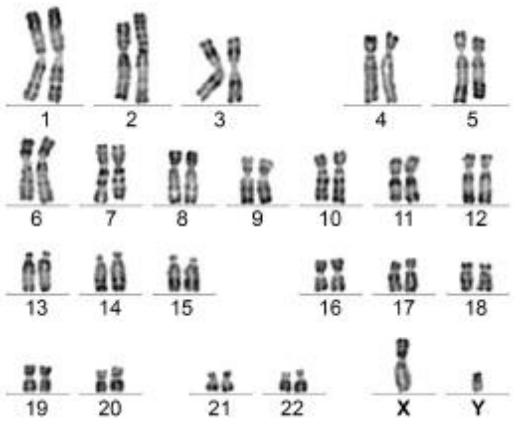
(Total 10 marks)

Q10.

Figure 1 shows all the chromosomes present in one human cell during mitosis. A scientist stained and photographed the chromosomes. In **Figure 2**, the scientist has arranged the images of these chromosomes in homologous pairs.

Figure 1

Figure 2



(a) Give **two** pieces of evidence from **Figure 1** that this cell was undergoing mitosis. Explain your answers.

1.

2. _____

(2)

(b) Tick (✓) **one** box that gives the name of the stage of mitosis shown in **Figure 1**.

A Anaphase ☐

B Interphase ☐

C Prophase ☐

D Telophase ☐

(1)

(c) When preparing the cells for observation the scientist placed them in a solution that had a slightly higher (less negative) water potential than the cytoplasm. This did not cause the cells to burst but moved the chromosomes further apart in order to reduce the overlapping of the chromosomes when observed with an optical microscope.

Suggest how this procedure moved the chromosomes apart.

(2)

(d) The dark stain used on the chromosomes binds more to some areas of the chromosomes than others, giving the chromosomes a striped appearance.

Suggest **one** way the structure of the chromosome could differ along its length to result in the stain binding more in some areas.

(1)

(e) In **Figure 2** the chromosomes are arranged in homologous pairs.
What is a homologous pair of chromosomes?

(1)

(f) Give **two** ways in which the arrangement of prokaryotic DNA is different from the arrangement of the human DNA in **Figure 1**.

1.

2.

(2)

(Total 9 marks)

Q11.

(a) Describe the role of **two** named enzymes in the process of semi-conservative

replication of DNA.

(3)

(b) Scientists investigated the function of a eukaryotic cell protein called cyclin A. This protein is thought to be involved with the binding of one of the enzymes required at the start of DNA replication.

The scientists treated cultures of cells in the following ways.
C – Control cells, untreated
D – Added antibody that binds specifically to cyclin A
E – Added RNA that prevents translation of cyclin A
F – Added RNA that prevents translation of cyclin A **and** added cyclin A protein

They then determined the percentage of cells in each culture in which DNA was replicating.

Their results are shown in the table.

Cell treatment	**Percentage of cells where DNA was replicating**
C Control	91
D Antibody that binds specifically to cyclin A	11
E RNA that prevents translation of cyclin A	10
F RNA that prevents translation of cyclin A **and** added cyclin A protein	92

Suggest explanations for the results in the table.

(3)

(Total 6 marks)

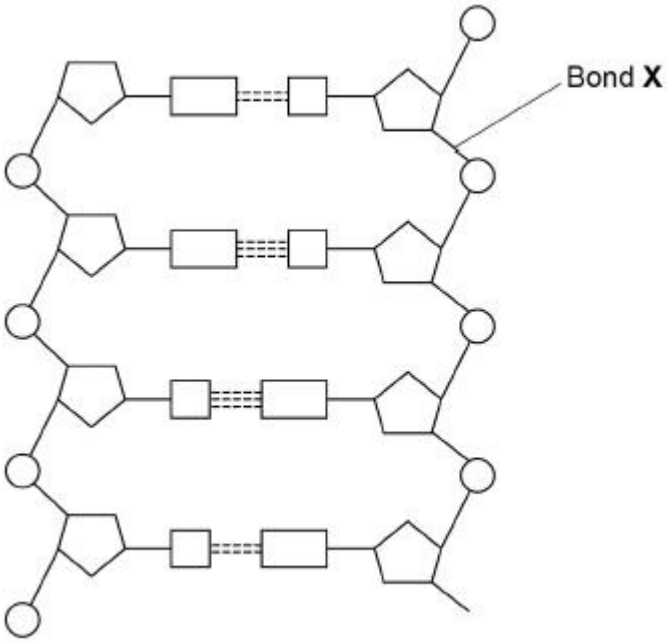
Q12.

Write an essay on the importance of the control of movement in cells and organisms.

(Total 25 marks)

Q13.

The diagram shows part of a DNA molecule.



(a) How many nucleotides are shown in the diagram above?

_____

(1)

(b) Name the type of bond labelled **X** in the diagram.

_____

(1)

(c) The enzymes DNA helicase and DNA polymerase are involved in DNA replication.

Describe the function of each of these enzymes.

DNA helicase _____

_____

_____

_____

DNA polymerase _____

_____

_____

_____

(2)

(d) Adenosine triphosphate (ATP) is a nucleotide derivative.

Contrast the structures of ATP and a nucleotide found in DNA to give **two** differences.

1. _____

_____

_____

_____

2. _____

_____

_____

_____

(2)

(Total 6 marks)

Q14.

(a) Give the **two** types of molecule from which a ribosome is made.

_____

_____

(1)

(b) Describe the role of a ribosome in the production of a polypeptide. Do **not** include transcription in your answer.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(c) The table below shows the base sequence of part of a pre-mRNA molecule from a eukaryotic cell.

Complete the table with the base sequence of the DNA strand from which this pre-mRNA was transcribed.

									DNA
A	**C**	**G**	**C**	**A**	**U**	**U**	**A**	**U**	pre-mRNA

(1)

(d) In a eukaryotic cell, the base sequence of the mRNA might be different from the sequence of the pre-mRNA.

Explain why.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

Q15.

(a) Name **two** enzymes involved in the semi-conservative replication of DNA.

1. _____

2. _____

(2)

(b) Sometimes, damage occurs during DNA replication. One enzyme involved in repairing damage to DNA is called ATR.

ATR works as follows.

- ATR phosphorylates other enzymes involved in repairing DNA.
- ATR **also** phosphorylates substrates required to repair DNA.

When ATR phosphorylates other enzymes, these enzymes become able to bind to their substrates.

Use your knowledge of enzyme structure to suggest why.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

(c) The enzyme-catalysed reactions activated by ATR only occur if the substrates have

been phosphorylated.

Use your knowledge of energy changes in enzyme-catalysed reactions to suggest why.

(1)

(d) Sometimes, a mutagenic agent causes DNA to break. A different enzyme called ATM binds to the broken DNA. This leads to the activation of a protein coded for by a tumour suppressor gene. The effect of ATM binding is to stop cell division until DNA is repaired.

A mutation could result in a person having non-functional forms of the gene that produces ATM.

What can you predict about the possible effects of having a non-functional form of ATM?

(3)

(Total 8 marks)

Q16.

Write an essay on the importance of nitrogen-containing substances in biological systems.

(Total 25 marks)

Q17.

(a) The genetic code is **degenerate** and **non-overlapping**.

Explain the meaning of:

Degenerate _____

_____

Non-overlapping _____

_____

(2)

The table shows a short section of a messenger RNA (mRNA) molecule and the section of a polypeptide for which it codes.

mRNA	G G G	G C U	U C A	C C G	G C A	A C G
Polypeptide	glycine	alanine	serine	proline	alanine	threonine

(b) Name the bases represented in the table by:

A _____

C _____

G _____

U _____

(2)

(c) Use information in the table to give the sequence of bases in **DNA** that codes for serine.

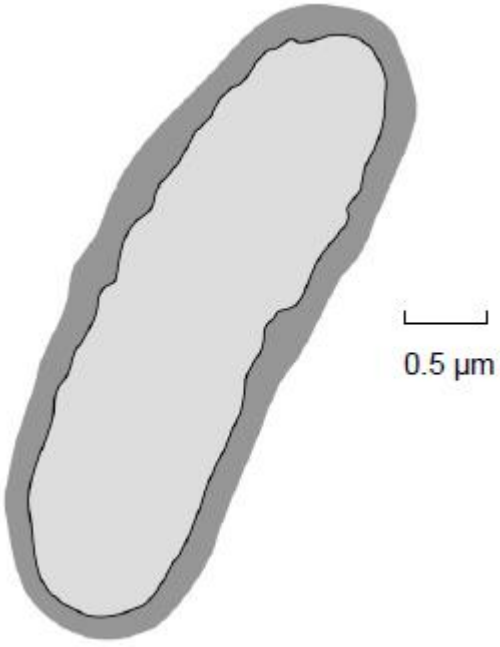
_____

(1)

(Total 5 marks)

Q18.

A bacterium is shown in the diagram.



(a) Calculate the magnification of the image.

Magnification = _____

(1)

(b) Complete the table to show the features of a bacterium and a virus.

Put a tick (✔) in the box if the feature is shown.

Surface	**Bacterium**	**Virus**
Cell-surface membrane		
Nucleus		
Cytoplasm		
Capsid		

(2)

(c) DNA and RNA can be found in bacteria.

Give **two** ways in which the nucleotides in DNA are different from the nucleotides in RNA.

1. _____

2. _____

(2)

(Total 5 marks)

Q19.

(a) DNA is a polymer of nucleotides. Each nucleotide contains an organic base.

Explain how the organic bases help to stabilise the structure of DNA.

_____

_____

_____

_____

_____

(2)

(b) Triplets of bases in a DNA molecule code for the sequence of amino acids in a polypeptide. The genetic code is frequently written as the three bases on mRNA that are complementary to a triplet on DNA. **Table 1** shows what different combinations of bases on mRNA code for. The names of amino acids are abbreviated. For

example, ‘Ala’ stands for alanine.

Table 1

First base	Second base				Third base
	Guanine (G)	**Adenine (A)**	**Cytosine (C)**	**Uracil (U)**	
G	GGG Ala	GAG Glu	GCG Ala	GUG Val	**G**
	GGA Gly	GAA Glu	GCA Ala	GUA Val	**A**
	GGC Gly	GAC Asp	GCC Ala	GUC Val	**C**
	GGU Gly	GAU Asp	GCU Ala	GUU Val	**U**
A	AGG Arg	AAG Lys	ACG Thr	AUG Met	**G**
	AGA Arg	AAA Lys	ACA Thr	AUA Iso	**A**
	AGC Ser	AAC Asn	ACC Thr	AUC Iso	**C**
	AGU Ser	AAU Asn	ACU Thr	AUU Iso	**U**
C	CGG Arg	CAG Gln	CCG Pro	CUG Leu	**G**
	CGA Arg	CAA Gln	CCA Pro	CUA Leu	**A**
	CGC Arg	CAC Hist	CCC Pro	CUC Leu	**C**
	CGU Arg	CAU Hist	CCU Pro	CUU Leu	**U**
U	UGG Trp	UAG **stop**	UCG Ser	UUG Leu	**G**
	UGA **stop**	UAA **stop**	UCA Ser	UUA Leu	**A**
	UGC Cyst	UAC Tyr	UCC Ser	UUC Phe	**C**
	UGU Cyst	UAU Tyr	UCU Ser	UUU Phe	**U**

Suggest **one** advantage of showing the genetic code as base sequences on mRNA, rather than triplets on DNA.

_____

_____

_____

(1)

(c) What name is given to a group of three bases on mRNA that codes for an amino acid?

_____

(1)

(d) Use information from **Table 1** to explain why the genetic code is described as degenerate.

_____

(2)

(e) Suggest the role of the mRNA base triplets UGA, UAG and UAA.

(2)

(f) **Table 2** shows the sequence of mRNA bases forming part of a single gene.

Table 2

Base on DNA template									
Base on mRNA	G	U	G	U	A	C	U	G	G
Encoded amino acid									

Complete **Table 2** to show the base sequence of the DNA template from which this mRNA was transcribed and the encoded amino acid sequence.

(2)

(Total 10 marks)

Q20.

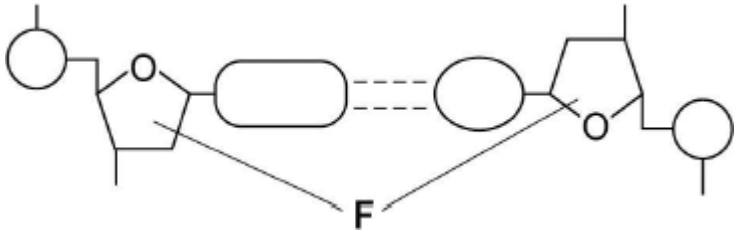
Write an essay on the importance of nucleotides, molecules derived from nucleotides and nucleic acids in keeping organisms alive.

(Total 25 marks)

Q21.

Figure 1 shows one base pair of a DNA molecule.

Figure 1



(a) Name part **F** of each nucleotide.

_____

(1)

(b) Scientists determined that a sample of DNA contained 18% adenine.

What were the percentages of thymine and guanine in this sample of DNA?

Percentage of thymine ☐

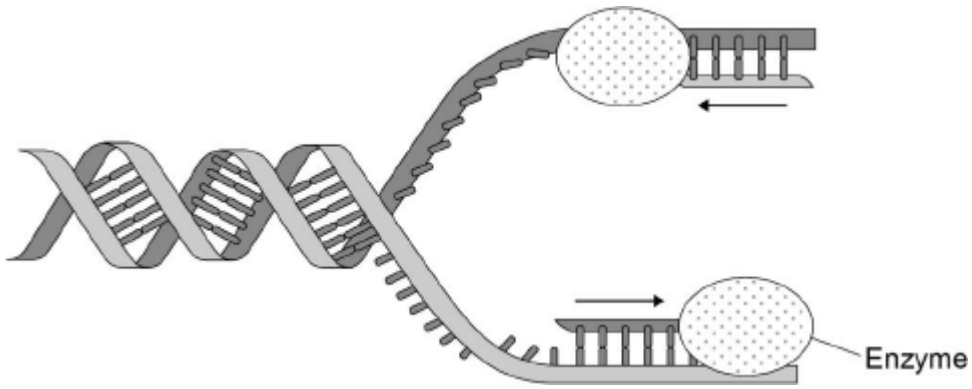
Percentage of guanine ☐

(2)

During replication, the two strands of a DNA molecule separate and each acts as a template for the production of a new strand.

Figure 2 represents DNA replication.

Figure 2



(c) Name the enzyme shown in **Figure 2**.

_____

(1)

The arrows in **Figure 2** show the directions in which each new DNA strand is being produced.

(d) Use **Figure 1, Figure 2** and your knowledge of enzyme action to explain why the arrows point in opposite directions.

_____

(4)

(Total 8 marks)

Q22.

Read the following passage.

Herpes simplex virus (HSV) infects nerve cells in the face, including some near the lips. Like many other viruses, HSV can remain inactive inside the body for years. When HSV becomes active, it causes cold sores around the mouth.

Human cells infected with a virus may undergo programmed cell death. While HSV is inactive inside the body, only one of its genes is transcribed. This gene is the latency-associated transcript (*LAT*) gene that prevents programmed cell death of an infected nerve cell.

Scientists have found that transcription of the *LAT* gene produces a microRNA. This microRNA binds to some of the nerve cell's own mRNA molecules. These mRNA molecules are involved in programmed cell death of nerve cells. The scientists concluded that production of this microRNA allows HSV to remain in the body for years.

Use information from the passage and your own knowledge to answer the following questions.

(a) HSV infects nerve cells in the face (line 1). Explain why it infects **only** nerve cells.

(3)

(b) HSV can remain inactive inside the body for years (lines 2–3). Explain why this virus can be described as **inactive**.

(2)

(c) Suggest **one** advantage of programmed cell death (line 4).

(1)

(d) The scientists concluded that production of this microRNA allows HSV to remain in the body for years (lines 10–12).

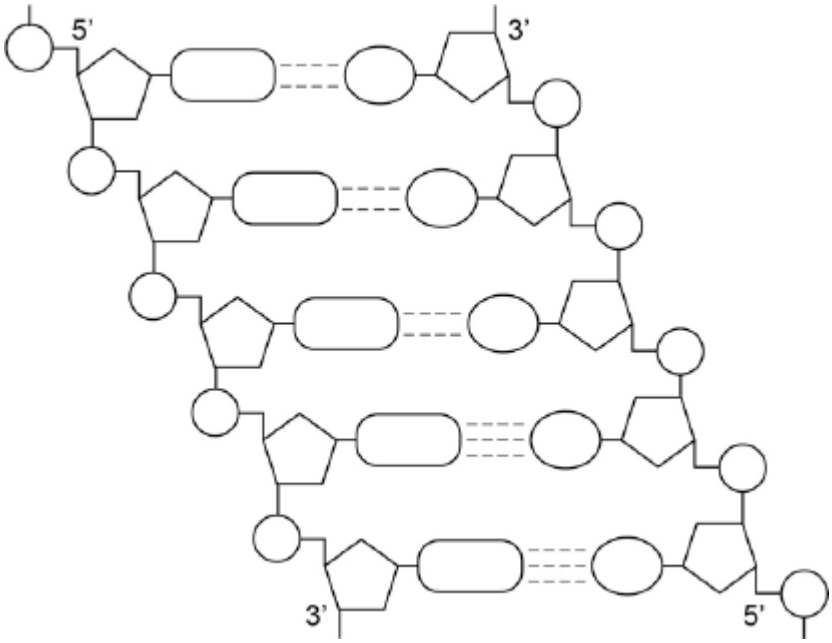
Explain how this microRNA allows HSV to remain in the body for years.

(4)

(Total 10 marks)

Q23.

The following figure represents part of a DNA molecule.



(a) Draw a box around a single nucleotide.

(1)

The table below shows the percentage of bases in each of the strands of a DNA molecule.

DNA strand	**Percentage of each base**			
	A	**C**	**G**	**T**
Strand **1**	16			
Strand **2**		21	34	

(b) Complete the table by adding the missing values.

(2)

(c) During replication, the two DNA strands separate and each acts as a template for the production of a new strand. As new DNA strands are produced, nucleotides can only be added in the 5' to 3' direction.

Use the figure in part **(a)** and your knowledge of enzyme action and DNA replication to explain why new nucleotides can only be added in a 5' to 3' direction.

_____

_____

(4)

(Total 7 marks)

Q24.

Write an essay on the importance of movement in living organisms

(Total 25 marks)

Q25.

(a) (i) Describe the role of DNA polymerase in DNA replication.

_____

_____

(1)

(ii) Other than being smaller, give **two** ways in which prokaryotic DNA is different from eukaryotic DNA.

1. _____

2. _____

(2)

(b) The table shows the percentage of each base in the DNA from three different organisms.

Organism	**Percentage of each base in DNA**			
	Adenine	Guanine	Thymine	Cytosine
Human	30.9	19.9	29.4	19.8
Grasshopper	29.4	20.5	29.4	20.7
Virus	24.0	23.3	21.5	31.2

(i) Humans and grasshoppers have very similar percentages of each base in their DNA but they are very different organisms.

Use your knowledge of DNA structure and function to explain how this is possible.

_____

_____

_____

_____

_____

(2)

(ii) The DNA of the virus is different from that of other organisms. Use the table above and your knowledge of DNA to suggest what this difference is. Explain your answer.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

Q26.

(a) The events that take place during interphase and mitosis lead to the production of two genetically identical cells. Explain how.

_____

_____

_____

_____

_____

_____

_____

_____

_____

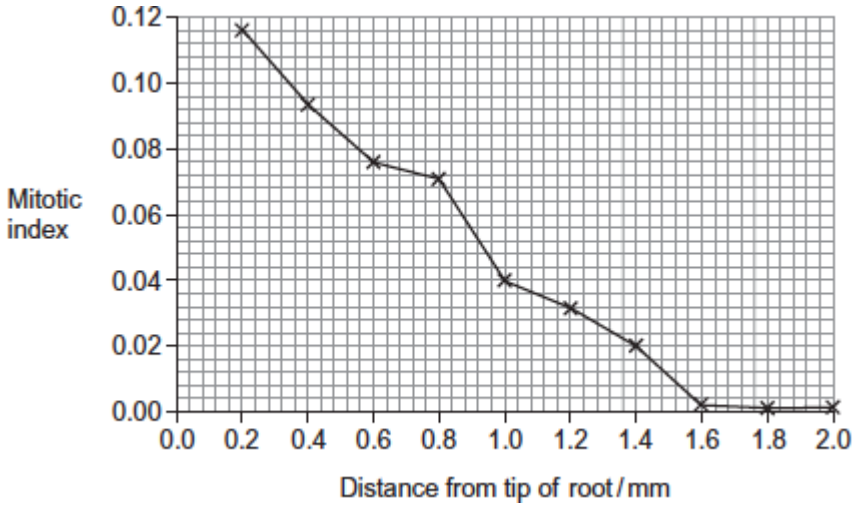
(4)

(b) A student cut thin sections of tissue at different distances from the tip of a root. She stained the sections and viewed them with an optical microscope.

For each section, the student counted the number of cells in mitosis and the total number of cells in each field of view. She then calculated a **mitotic index** for each section using the equation:

$$\text{mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}}$$

The student's results arer shown in the graph.



(i) The student cut thin sections of tissue to view with an optical microscope.
Explain why it was important that the sections were thin.

(2)

(ii) What does the graph show about the growth of roots?
Use the data to explain your answer.

(2)

(Total 8 marks)

Q1.

(a) 1. Condensation (reaction)/loss of water;

2. (Between) phosphate **and** deoxyribose;

3. (Catalysed by) DNA polymerase;

Reject if DNA polymerase joins AT/GC OR complementary nucleotides/bases OR forms hydrogen bonds

2 max

(b) Correct answer for 2 marks = 70;;

Accept for 1 mark,

A = 42 **and** T = 42

OR

420 (total bases in gene)

OR

210 (bases in template strand)

2

(c) Histone;

1

(d) 1. DNA helicase;

2. Breaks hydrogen bonds between base pairs/ AT and GC/complementary bases

OR

Breaks hydrogen bonds between <u>polynucleotide</u> strands;

Reject <u>hydrolysis</u> of hydrogen bonds

2

[7]

Q2.

(a) 1. Joins (adjacent DNA) nucleotides;

Reject suggestions that it forms hydrogen bonds or joins complementary bases.

Reject 'nucleotide bases'.

2. (Catalyses) condensation (reactions);

3. (Catalyses formation of) phosphodiester bonds (between adjacent nucleotides);

2 max

(b) Final answer with 2sf or 3sf in range 31.8 to 34.7%;;

1 mark for

5.5 to 6.1 hours

OR

Final answer with 2sf or 3sf in range 46.6 to 53.0%

OR

Correct final answers rounded to more than 3sf

OR

Final answer with 2sf or 3sf in range 30.8 to 31.7 or 34.8 to 35.6%.

2

(c) 1. Attachment/association of (inorganic) phosphate (to the enzyme);

For 'phosphate/Pi' accept PO_4^{3-} and P in a circle.

Accept 'phosphate goes to the enzyme'.

Ignore named bonding or position of phosphate attaching to enzyme but reject formation of E-S complex.

2. (Released from) hydrolysis of ATP

OR

(Released from) ATP to ADP + Pi;

For ATP accept adenosine triphosphate.

For ADP accept adenosine diphosphate.

2

(d) 1. Shortens interphase

OR

Cells begin DNA replication earlier OR

DNA replication (starts) faster;

*Accept '**starts** mitosis earlier'.*

2. Fast(er) **cell** cycle/division/multiplication/mitosis

OR

Uncontrolled cell division/mitosis;

Accept '(May result in) mutation in a tumour suppressor gene' OR '(May result in) mutation in an oncogene'.

Ignore uncontrolled growth;

3. (Resulting in) a mass/group of abnormal/excessive cells;

Ignore uncontrolled growth;

*Accept '(Resulting in) **a** growth of abnormal/excessive cells'.*

2 max

[8]

Q3.

(a) 1. Hydrogen bonds (between DNA bases) break;

Ignore DNA helicase.

Reject hydrolysing hydrogen bonds.

2. (Only) one DNA strand acts as a template;

3. (Free) RNA nucleotides align by complementary base pairing;

For 'align by complementary base pairing', accept 'align to complementary bases' or 'align by base pairing'.

4. (In RNA) Uracil base pairs with adenine (on DNA)

OR

(In RNA) Uracil is used in place of thymine;

Do not credit use of letters alone for bases.

5. RNA polymerase joins (adjacent RNA) nucleotides;

Reject suggestions that RNA polymerase forms hydrogen bonds or joins complementary bases.

6. (By) phosphodiester bonds (between adjacent nucleotides);

7. Pre-mRNA is spliced (to form mRNA)

OR

Introns are removed (to form mRNA);

5 max

(b) 1. (mRNA attaches) to ribosomes

OR

(mRNA attaches) to rough endoplasmic reticulum;

2. (tRNA) anticodons (bind to) complementary (mRNA) codons;

3. tRNA brings a specific amino acid;

4. Amino acids join by peptide bonds;

5. (Amino acids join together) with the use of ATP;

6. tRNA released (after amino acid joined to polypeptide);

7. The ribosome moves along the mRNA to form the polypeptide;

6 max

(c) (Definition of gene mutation)

1. Change in the base/nucleotide (sequence of chromosomes/DNA);

For 4 marks at least one mark must be scored in each

section of the answer.
Accept named mutation for 'change'.

2. Results in the formation of new allele;

(Has no effect because)

3. Genetic code is degenerate (so amino acid sequence may not change);

OR

Mutation is in an intron (so amino acid sequence may not change);
Accept description of 'degenerate', eg some amino acids have more than one triplet/codon.

4. Does change amino acid but no effect on tertiary structure;

5. (New allele) is recessive so does not influence phenotype;

(Has positive effect because)

6. Results in change in polypeptide that positively changes the properties (of the protein)

OR

Results in change in polypeptide that positively changes a named protein;
For 'polypeptide' accept 'amino acid sequence' or 'protein'.

7. May result in increased reproductive success

OR

May result in increased survival (chances);

4 max

[15]

Q4.

(a) **In chloroplasts**

Must be comparative statements.
Accept alternatives in context of nuclear DNA

1. DNA shorter;
Accept smaller

2. Fewer genes;

3. DNA circular not linear;
Accept DNA in a loop not linear
Accept no chromosomes (in chloroplast) unlike nucleus

4. Not associated with protein/histones, unlike nuclear DNA;

5. Introns absent but present in nuclear DNA;

Ignore references to double and single stranded DNA

3 max

(b) Deoxyribose in DNA **and** ribose in RNA;

1

(c) W = amino acid binding site **and** X = anticodon;

W *Idea of binding site needed*

1

(d) 1. Triplets code for same amino acid

Accept: DNA/code/triplets are degenerate

Reject: codons (as question states within genes)

2. Occurs in introns /non-coding sequence;

Reject: codons (as question states within genes)

Ignore junk DNA

Reject: multiple repeats

2

[7]

Q5.

(a) Watson **and** Crick
OR
Crick **and** Watson;

Correct spelling

Ignore first/given/fore names

1

(b) DNA polymerase;

Correct spelling

1

(c) **Role of single-stranded DNA fragments**

1. Template;
2. Determines order of nucleotides/bases;

Role of DNA nucleotides

3. Forms complementary pairs / A – T, G - C
OR
Forms complementary (DNA) strand;

Ignore forms complementary bases

Accept sequence/ chain for strand

3

[5]

Q6.

(a)

Must have MP1 for 5 max

3 max for sodium and 3 max for phosphate

Iron ions

1. Haemoglobin binds/associates with oxygen
OR
Haemoglobin transports/loads oxygen;
Ignore reference to 2^+ or 3^+ in Fe^{2+} or Fe^{3+}

Sodium ions

2. Co-transport of glucose/amino acids (into cells);

3. (Because) sodium moved out by active transport/Na – K pump;

4. Creates a sodium concentration/diffusion gradient;

5. Affects osmosis/water potential;

Phosphate ions

6. Affects osmosis/water potential;
*Accept 5. OR 6. – **not** both*

7. Joins nucleotides/in phosphodiester bond/in backbone of DNA/RNA/in nucleotides;

8. Used in/to produce ATP;
Reject 'energy produced'

9. Phosphorylates other compounds (usually) making them more reactive;

10. Hydrophilic/water soluble part of phospholipid bilayer/membrane;
Accept for 1 mark,
Sodium ions cause water reabsorption in kidneys
OR
Sodium ions establish resting potential (in neurones)
OR
Sodium ion diffusion creates action potential

5 max

(b) 1. Phospholipid (bilayer) allows movement/diffusion of non-polar/lipid-soluble substances;
1. and 2. Accept correct named examples
1. and 2. Ignore water
Accept phospholipid (bilayer) allows movement/diffusion of O_2/CO_2
Accept water-insoluble

2. Phospholipid (bilayer) prevents movement/diffusion of polar/ charged/lipid-insoluble substances
OR
(Membrane) proteins allow polar/charged substances to cross the membrane/bilayer;
Accept water-soluble

3. Carrier proteins allow active transport;

4. Channel/carrier proteins allow facilitated diffusion/co-transport;

Accept aquaporins allow osmosis

5. Shape/charge of channel / carrier determines which substances move;

6. Number of channels/carriers determines how much movement;

7. Membrane surface area determines how much diffusion/movement;

6. and 7. Accept correct reference to faster/slower/rate for 'how much movement'

Accept microvilli / Golgi (apparatus) / ER / rER

Accept surface area to volume for 'surface area'

8. Cholesterol affects fluidity/rigidity/permeability;

Accept cholesterol affects vesicle formation/ endocytosis/exocytosis/phagocytosis;

5 max

[10]

Q7.

(a) 1. (Trend of) slowing growth from before birth to 21 days
OR
(Trend of) decreasing percentage undergoing mitosis from before birth to 21 days
OR
(Trend of) decreasing percentage undergoing DNA replication from before birth to 21 days;

Accept 'day -6' for 'before birth'.

For '21 days' accept 'until the end of the investigation'.

2. DNA replication happens before mitosis
OR
Heart growth slowing **until** (fully) developed
OR
These cells lost the **ability to** divide;

*Accept 'Heart growing/developing before birth **and** becomes (fully) developed'.*

Accept reference to only unipotent cells/cardiomycetes dividing (at 21 days).

2

(b) 1. DNA helicase;

2. Breaks hydrogen bonds (between 2 DNA strands);

Reject 'hydrolyses hydrogen bonds'

Accept H bonds for hydrogen bonds.

3. BrdU complementary to <u>adenine</u> (on template strand)
OR
BrdU forms hydrogen bonds with <u>adenine</u> (on template strand);

Accept H bonds for hydrogen bonds.

4. DNA polymerase joins (adjacent) <u>nucleotides</u> (to incorporate BrdU into the new DNA strand);

Reject if DNA polymerase catalyses complementary base pairing

or if DNA polymerase catalyses nucleotides joining to template strand.

5. <u>Phosphodiester bonds</u> form (between nucleotides);

5

(c)

All mark points must relate to procedure.

Do not negate any mark point for use of additional antibodies.

1. Add antibody (anti-BrdU with enzyme attached) to cells/DNA
OR
Add cells/DNA to antibody (anti-BrdU with enzyme attached);

2. Wash (cells/DNA) **to** remove excess/unattached antibody
OR
Wash (immobilised antibody) **to** remove excess/unattached cells/DNA;

Allow ECF for absence of cells/DNA.

3. Add substrate **to** cause colour change;

For 'substrate' accept description in context of enzyme.

3

[10]

Q8.

(a) 1. Phosphate, deoxyribose and base correctly labelled;

Accept P in a circle / P_i / PO_4^{3-} for phosphate.

Do not accept phosphorus for phosphate.

*Do not accept **only** pentose for deoxyribose.*

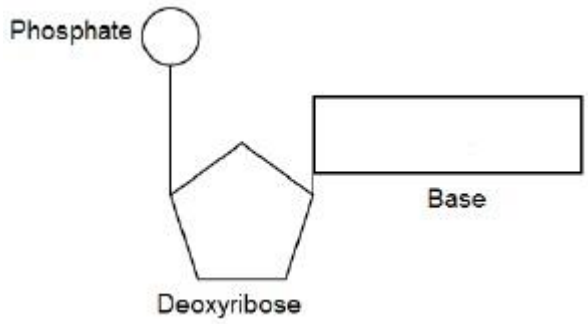
Ignore references to sugar.

Accept a named base, (eg adenine, thymine, guanine, cytosine).

*Do not accept uracil or **only** letters (eg A, T, G or C).*

Ignore labelled bonds

2. Correct shapes **and** bonds in the correct positions (as shown below);



Accept correct shapes with incorrect labels

Accept any orientation of diagram, eg inverted / mirror image

Accept any pentagon for deoxyribose

2

(b) 1. Weak / easily broken hydrogen bonds between bases allow two strands to

separate / unzip;
may appear in the same feature

2. Two strands, so both can act as templates;
may appear in the same feature

3. Complementary base pairing allows accurate replication;
Allow description of complementary base pairing and accurate replication.

2 max

(c) C. 550 seconds;

1

[5]

Q9.

(a) 1. (Presence of) antigen of the (pathogenic) bacteria;
Assume bacteria are pathogenic unless otherwise stated

2. (Causes) more T cells produced / faster T cell production;

3. Against (the pathogen and) normal bacteria;

4. (Long lasting as) cells do not die / live for longer;

5. (More) cytokines / chemicals causing swelling are produced;

3 max

(b) 1. (Some people) have a mutation / allele / gene;

2. (That) increases the chances / risk / makes it more likely for / causes them to have an unusually large T cell response;
OR
(That) lowers / removes tolerance to (normal) intestinal bacteria;

2

(c) 1. (Some people might) produce (very) large amounts of cytokine / have large amounts of swelling;

2. (That) 5-ASA drugs cannot control / reduce;

OR

3. Some people may be allergic to / cannot tolerate 5-ASA;

4. So cannot take it;
Award 1 and 2
OR
Award 3 and 4

2

(d) 1. (Lack of adenine and guanine) will slow / stop DNA synthesis / replication (in T cells);

2. Affects T cells **more** as they cannot recycle nucleotides;
Needs idea of more / greater effect.

Accept converse idea that 'other' cells not as affected as they can recycle nucleotides.

3. (6-MP therefore) suppresses / slows the (unusually large) T cell / immune response
OR
(6-MP causes) fewer / no T cells (to be) produced;

Accept (6-MP) acts as an immunosuppressant drug

4. (So) less cytokine is produced (and therefore less swelling);

3 max

[10]

Q10.

(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]

Q11.

(a) 1. (DNA) helicase causes breaking of hydrogen/H bonds (between DNA strands);

Reject 'helicase hydrolyses hydrogen bonds'.

2. DNA polymerase joins the (DNA) nucleotides;

Reject if suggestion that DNA polymerase joins the complementary nucleotides or forms H bonds.

Reject if joining RNA nucleotides or forming RNA.

3. Forming phosphodiester bonds;

3

(b) 1. (Treatment **D** Antibody binds to cyclin A so) it cannot bind to DNA/enzyme/initiate DNA replication;

For 'bind to enzyme' accept 'activate'.

Idea of 'initiate DNA replication' must be linked to start not just less replication.

For 'enzyme' accept named enzyme.

2. (Treatment E) RNA interferes with mRNA/tRNA/ribosome/polypeptide formation (so cyclin A not made);

3. In Treatment **F** added cyclin A can bind to DNA/enzyme (to initiate DNA replication)
OR
Treatment **F** shows that it is the cyclin A that is being affected in the other treatments
OR
Treatment **F** shows that cyclin A allows the enzyme to bind (to DNA)
OR
(Some cells in **D** or **E**) can continue with DNA replication because they have a different cyclin A allele
OR
(Some cells in **D** or **E**) can continue with DNA replication because the antibody/RNA has not bound to all the cyclin A protein/mRNA
OR
(Some cells in **E**) can continue with DNA replication because they contain previously translated cyclin A;

Context needed for Treatment F but it does not need to be named.

For 'enzyme' accept named enzyme.

3

[6]

Q12.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.

	covered but they are unrelated	Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
6 – 10	Unistructural Only one or few aspects covered	Response predominantly deals with only one or two topics that relate to the question. Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
1 – 5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level. May contain a large number of errors and, or, irrelevant topics.
0		Nothing of relevance or no response.

Commentary on terms and statements in the levels mark scheme

The levels mark scheme for the essay contains a number of words and statements that are open to different interpretations. This commentary defines the meanings of these words and statements in the context of marking the essay. Many words and statements are used in the descriptions of more than one level of response. The definitions of these remain the same throughout.

Levels mark scheme word/statement	Definition
Holistic	Synoptic, drawing from different topics (usually sections of the specification)
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Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and

	use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (eg importance) at A-level standard.

The importance of the control of movement **in** cells and organisms.

Suitable topic areas

- 3.1.4.2 Enzymes and control of action
- 3.1.5.2 DNA replication
- 3.2.2 Mitosis, binary fission
- 3.2.3 Transport across membranes
- 3.2.4 Cell recognition and the immune system
- 3.3.2 Gas exchange
- 3.3.3 Digestion and absorption
- 3.3.4.1 Mass transport in animals
- 3.3.4.2 Mass transport in plants
- 3.4.2 DNA and protein synthesis
- 3.4.3 Meiosis
- 3.5.1 Photosynthesis
- 3.5.2 Respiration
- 3.6.1.1 Survival and response
- 3.6.1.2 Receptors
- 3.6.1.3 Control of heart rate
- 3.6.2.1 Nervous impulses
- 3.6.2.2 Synaptic transmission
- 3.6.3 Muscle contraction
- 3.6.4.2 Control of blood glucose
- 3.6.4.3 Control of blood water potential
- 3.7.1 Inheritance
- 3.8.2.2 Regulation of transcription and translation
- 3.8.2.3 Gene expression and cancer

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the

essay.

Students may be able to show the relevance of other topics from the specification.

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[25]

Q13.

(a) 8;

Accept eight

1

(b) Phosphodiester (bond);

Accept phonetic spellings

1

(c) 1. DNA helicase – (unwinding DNA and) breaking hydrogen bonds / bonds between chains / bases / strands;

2. DNA polymerase – joins (adjacent) nucleotides **OR** forms phosphodiester bond / sugar-phosphate backbone;

1. Accept H bonds.

1. Accept hydrolyses for breaks

2. Reject forms hydrogen bonds (between nucleotides / bases)

2

(d) 1. ATP has ribose **and** DNA nucleotide has deoxyribose;

2. ATP has 3 phosphate (groups) **and** DNA nucleotide has 1 phosphate (group);

3. ATP – base always <u>adenine</u> **and** in DNA nucleotide base can be different / varies;

Both parts of each MP needed

3. Reject Uracil / U

3. Accept C, T or G for different bases

Accept annotated diagram for any of the three marks

2 max

[6]

Q14.

(a) 1. **One of** RNA / ribonucleic acid(s) / nucleotide(s)/nucleic acid(s) / rRNA / ribosomal RNA / ribosomal ribonucleic acid
and
one of protein(s) / polypeptide(s) / amino acid(s) / peptide(s) / ribosomal protein;

Reject DNA, deoxyribonucleic acid, tRNA, transfer RNA, transfer ribonucleic acid, mRNA, messenger RNA, messenger ribonucleic acid.

Ignore enzyme(s), base(s).

1

(b) 1. mRNA binds to ribosome;
2. Idea of <u>two</u> codons / binding sites;
3. (Allows) tRNA with <u>anticodons</u> to bind / associate;
4. (Catalyses) formation of <u>peptide</u> bond between **amino acids** (held by tRNA molecules);
5. Moves along (mRNA to the next codon) / translocation described;

Assume 'it' refers to ribosome.

3 max

(c) TGCGTAATA;
Any errors = 0 marks

1

(d) 1. Introns (in pre-mRNA);
2. Removal of sections of (pre-mRNA) / splicing;

Introns removed' scores 2 marks.

Reference to 'introns present in mRNA' disqualifies mp1 but allow ECF for mp2.

Accept for 1 mark mRNA contains <u>only</u> exons.

2

[7]

Q15.

(a) 1. (DNA) helicase;
2. (DNA) polymerase;

List Rule Applies

Accept (DNA) ligase / Primase / telomerase / Topoisomerase / DNA gyrase

Reject RNA

Accept phonetic spellings

2

(b) 1. Changes tertiary structure of the enzyme;
2. (Enzyme) <u>active site</u> formed / able to be formed / <u>active site</u> becomes complementary;

1. Accept tertiary symbol 3 °

1. Ignore 3D

2. Reject refs to inhibition / inhibitors

2. Ignore refs to E-S complexes form

2. Ignore refs to substrate phosphorylation

2

(c) (Phosphorylation / phosphate) makes substrates more reactive / raises their energy level(s) / lowers activation energy for the reaction;

Ignore provides energy unqualified

Ignore refs to kinetic energy unqualified

1

(d) 1. ATM will not bind to (broken) DNA;
2. DNA not repaired / cell still has broken DNA;
3. Cell division continues / tumour forms;
4. Tumour suppressor (gene) not effective / not activated;
5. May have no effect in diploid / heterozygous (organism);

6. (Which) still has a functional ATM / ATM gene;

3 max

[8]

Q16.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects covered but they are unrelated	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question. Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
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Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
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	accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of nitrogen-containing substances in biological systems**.

Specification Reference	Topic Area
3.1.4 and 3.1.4.2	proteins and enzymes
3.1.5	nucleic acids
3.1.5.2	DNA replication
3.1.6	ATP
3.2.1.1	ribosomes
3.2.2	cell division
3.2.3	transport across membranes
3.2.4	immune response
3.3.3	digestion and absorption
3.3.4.1	haemoglobin
3.4.1	genes and chromosomes
3.4.2	protein synthesis
3.4.3	mutation
3.4.7	investigating diversity
3.5.1	photosynthesis
3.5.2	respiration

3.5.4	nitrogen cycle
3.6.2	nervous coordination
3.6.3	muscles
3.6.4.2	control of blood glucose (and peptide / protein hormones)
3.7.1	inheritance
3.8.1	alteration of DNA sequences
3.8.2.2	regulation of transcription and translation

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

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[25]

Q17.

(a) 1. Degenerate: more than one (base) triplet for each amino acid;

2. Non-overlapping: each base is part of only one triplet.

Accept codon (as would be applicable to mRNA code)

2

(b) A = adenine

C = cytosine

G = guanine

U = uracil

All four correct = 2
One error = 1
Two or more errors = 0

2 max

(c) AGT;

1

[5]

Q18.

(a) × 20 000

Accept range from 18 000 to 22 000

1

(b)

✔	
✔	
	✔

1 mark for each correct column

2

(c) 1. DNA contains thymine **and** RNA contains uracil;

2. DNA contains deoxyribose **and** RNA contains ribose.

2

[5]

Q19.

(a) 1. Hydrogen bonds between the base pairs holds two strands together

2. Many hydrogen bonds provides strength

Reject strong hydrogen bonds

2

(b) (Because) ribosomes assemble polypeptides using mRNA code
OR
DNA has two strands each with a different (complementary) base sequence;

1

(c) Codon;

1

(d) 1. (Because) some amino acids have more than one codon / mRNA code;

2. Correct example from table.

2

(e) 1. Stop translation;

2. Result in detachment of polypeptide chain from ribosome.

2

(f)

CAC	ATG	ACC
Val	Tyr	Trp

Mark each row

2

[10]

Q20.

21–25	Extended Abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16–20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11–15	Multistructural Several aspects covered but they are unrelated	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question. Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
6–10	Unistructural Only one or few aspects covered	Response predominantly deals with only one or two topics that relate to the question. Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
1–5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level. May contain a large number of errors and, or, irrelevant topics.

0		Nothing of relevance or no response.

Commentary on terms and statements in the levels mark scheme

The levels mark scheme for the essay contains a number of words and statements that are open to different interpretations. This commentary defines the meanings of these words and statements in the context of marking the essay. Many words and statements are used in the descriptions of more than one level of response. The definitions of these remain the same throughout.

Levels mark scheme word/statement	Definition
Holistic	Synoptic, drawing from different topics (usually sections of the specification)
A fully integrated answer which makes clear links between several different topics and the theme of the question	All topics relate to the title and theme of the essay; for example, explaining the biological importance of a process. When considering, for example, the importance of a process, the explanation must be at A-level standard. 'Several' here is defined as at least four topic areas from the specification covered. This means some sentences, not just a word or two. It does not mean using many examples from one topic area.
Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.

For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

How nucleotides, molecules derived from nucleotides and nucleic acids are important in keeping organisms alive.

In order to fully address the question and reach the highest mark bands, students must include at least five topics in their answer, to demonstrate a synoptic approach to the essay.

Specification reference	**Topic area**
3.1.6	ATP
3.1.4.2	Enzymes – ATP, phosphorylation and activation energy
3.1.5	Nucleic acids – information carrying molecules
3.2.2	Mitosis
3.2.3	Transport across membranes – active transport and co-transport
3.3.3	Absorption
3.4.1	DNA, genes and chromosomes
3.4.2	DNA and protein synthesis – ribosomes as nucleic acids – mRNA, tRNA – etc.
3.4.3	Genetic diversity – mutations
3.4.	Meiosis
3.4.4	Diversity and adaptation
3.5.1	Photosynthesis
3.5.2	Respiration
3.6.2	Nerve impulses
3.6.3	Muscle contraction
3.6.4.2	Control of blood glucose – second messenger and cAMP
3.6.4.3	Control of blood water potential
3.8.1	Control of gene expression – Mutations

3.8.2	Gene expression
3.8.2.2	Regulation transcription and translation

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

Note, other topics from beyond the specification can be used, providing they relate to the title and contain factually correct material of at least an A-level standard. Credit should not be given for topics beyond the specification which are below A-level standard.

[25]

Q21.

(a) Deoxyribose.

1

(b) 1. Thymine 18 (%);
2. Guanine 32 (%).

2

(c) DNA polymerase.

1

(d) 1. (**Figure 1** shows) DNA has antiparallel strands / described;
2. (**Figure 1** shows) shape of the nucleotides is different / nucleotides aligned differently;
3. Enzymes have active sites with specific shape;
4. Only substrates with complementary shape / only the 3' end can bind with active site of enzyme / active site of DNA polymerase.

4

[8]

Q22.

(a) 1. Outside of virus has antigens / proteins;
2. With complementary shape to receptor / protein in membrane of cells;
3. (Receptor / protein) found only on membrane of nerve cells.

Accept converse argument

3

(b) 1. No more (nerve) cells infected / no more cold sores form;
2. (Because) virus is not replicating.

2

(c) Prevents replication of virus.

1

(d) MicroRNA binds to cell's mRNA (no mark)
1. (Binds) by specific base pairing;
2. (So) prevents mRNA being read by ribosomes;
3. (So) prevents translation / production of proteins;
4. (Proteins) that cause cell death.

4

[10]

Q23.

(a) Box around single nucleotide.

1

(b)

DNA strand	Percentage of each base			
	A	**C**	**G**	**T**
Strand **1**	(16)	**34**	**21**	**29**
Strand **2**	**29**	(21)	(34)	**16**

2 rows correct = 2 marks;
1 row correct = 1 mark.

2

(c) 1. Reference to DNA polymerase;
2. (Which is) specific;
3. Only complementary with / binds to 5' end (of strand);

Reject hydrogen bonds / base pairing

4. Shapes of 5' end and 3' end are different / description of how different.

4

[7]

Q24.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with appropriate use of terminology.

		Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects covered but they are unrelated	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question. Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
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1 – 5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level. May contain a large number of errors and, or, irrelevant topics.
0		Nothing of relevance or no response.

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	'Several' here is defined as at least four topic areas from the specification covered. This means some sentences, not just a word or two. It does not mean using many examples from one topic area.
Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of movement**.

Specification Reference	**Topic Area**
3.1.4.2	Enzyme-catalysed reactions
3.1.5.2	DNA replication
3.1.6	ATP
3.2.2	Cell division

3.2.3	Transport across membranes
3.2.4	Immune response
3.2.2	Gas exchange
3.3.3	Digestion and absorption
3.3.4.1, 4.2	Mass transport
3.4.2	DNA and protein synthesis
3.4.3	Meiosis
3.5.1	Photosynthesis
3.5.2	Respiration
3.6.1	Survival and response
3.6.1.2	Receptors
3.6.1.3	Control of heart rate
3.6.2.1	Nerve impulses
3.6.2.2	Synapses
3.6.2.2	Synaptic transmission
3.6.3	Skeletal muscle
3.6.4.2	Control of blood glucose concentration
3.6.4.3	Control of blood water potential
3.7.3	Evolution (population isolation and movement between)
3.8.2.2	Regulation of transcription and translation
3.8.2.3	Gene expression and cancer

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

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[25]

Q25.

(a) (i) Joins nucleotides (to form new strand).

Accept: joins sugar and phosphate / forms sugar-phosphate backbone

Reject: (DNA polymerase) forms base pairs / hydrogen bonds

1

(ii) (Prokaryotic DNA)

1. Circular / non-linear (DNA);

Accept converse for eukaryotic DNA

Ignore: references to nucleus, binary fission, strands and plasmids

2. Not (associated) with proteins / histones;

Accept does not form chromosomes / chromatin

3. No introns / no non-coding DNA.

Accept only exons

Q *Neutral: no 'junk' DNA*

2 max

(b) (i) 1. Have different genes;

Reject: different alleles

2. (Sobases / triplets) are in a different sequence / order;

Accept: base sequence that matters, not percentage

3. (So) different amino acid (sequence / coded for) / different protein / different polypeptide / different enzyme.

Unqualified 'different amino acids' does not gain a mark

Reject: references to different amino acids formed

Ignore: references to mutations / exons / non-coding / introns

2 max

(ii) (Virus DNA)

1. A does not equal T / G does not equal C;

Accept: similar for equal

Accept: virus has more C than G / has more A than T

2. (So) no base pairing;
3. (So) DNA is not double stranded / is single stranded.

2 max

[7]

Q26.

(a) 1. DNA replicated;

Reject: DNA replication in the wrong stage

2. (Involving) specific / accurate / complementary base-pairing;

Accept: semi conservative replication

3. (Ref to) two identical / sister chromatids;

4. Each chromatid / moves / is separated to (opposite) poles / ends of cell.

Reject: meiosis / homologous chromosomes / crossing over

Note: sister chromatids move to opposite poles / ends = 2 marks for mp 3 and mp 4

Reject: events in wrong phase / stage

4

(b) (i) 1. To allow (more) light through;

Accept: transparent

2. A single / few layer(s) of cells to be viewed.

Accept: (thin) for better / easier stain penetration

2

(ii) 1. More / faster mitosis / division near tip / at 0.2 mm;

Neutral: references to largest mitotic index

2. (Almost) no mitosis / division at / after 1.6 mm from tip;

Accept: cell division for mitosis

Penalise once for references to meiosis

3. (So) roots grow by mitosis / adding new cells to the tip.

Accept: growth occurs at / near / just behind the tip (of the root)

Accept: converse arguments

2 max

[8]