AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.1.5 NUCLEIC ACIDS

SCORE	PERCENTAGE
/ 310	%

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Q1.

(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.*

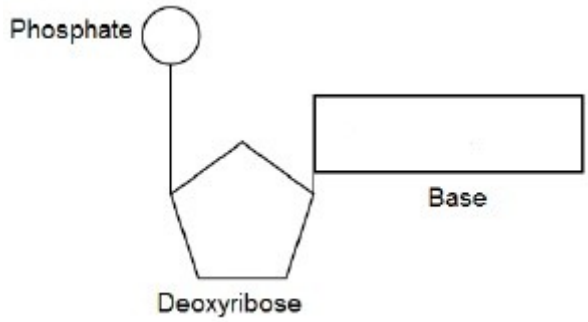
Ignore references to sugar.

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]

Q2.

(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]

Q3.

(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]

Q4.

(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 <u>nucleotides</u> or forms H bonds.

Reject if joining RNA nucleotides or forming RNA.

3. Forming <u>phosphodiester</u> 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 <u>allele</u>
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]

Q5.

(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]

Q6.

(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]

Q7.

(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]

Q8.

(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]

Q9.

(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]

Q10.

(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]

Q11.

(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]

Q12.

(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]

Q13.

(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]

Q14.

(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]

Q15.

(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]

Q16.

(a) 1. Sugar-phosphate (backbone) / double stranded / helix **so** provides strength / stability / protects bases / protects hydrogen bonds;
Must be a direct link / obvious to get the mark
Neutral: reference to histones

2. Long / large molecule **so** can store lots of information;

3. Helix / coiled **so** compact;
Accept: can store in a small amount of space for 'compact'

4. Base sequence allows information to be stored / base sequence codes for amino acids / protein;
Accept: base sequence allows transcription

5. Double stranded **so** replication can occur semi-conservatively / strands can act as templates / complementary base pairing / A-T and G-C so accurate replication / identical copies can be made;

6. (Weak) hydrogen bonds **for** replication / unzipping / strand separation / many hydrogen bonds **so** stable / strong;
Accept: 'H-bonds' for 'hydrogen bonds'

6

(b) 1. (Mutation) in **E** produces highest risk / 1.78;

2. (Mutation) in **D** produces next highest risk / 1.45;

3. (Mutation) in **C** produces least risk / 1.30;
Must be stated directly and not implied
E > ***D*** > ***C*** = *3 marks*
Accept: values of 0.78, 0.45 and 0.30 for MP1, MP2 and MP3 respectively
If no mark is awarded, a principle mark can be given for the idea that all mutant alleles increase the risk

3

(c) **180**;

1

(d) **(Similarities):**

1. Same / similar pattern / both decrease, stay the same then increase;

2. Number of cells stays the same for same length of time;
Ignore: wrong days stated

(Differences):

(Per unit volume of blood)

3. Greater / faster decrease in number of healthy cells / more healthy cells killed / healthy cells killed faster;
Accept: converse for cancer cells
Accept: greater <u>percentage</u> decrease in number of cancer cells / greater <u>proportion</u> of cancer cells killed

4. Greater / faster increase in number of healthy cells / more healthy cells replaced / divide / healthy cells replaced / divide faster;
Accept: converse for cancer cells
*For **differences**, statements made must be comparative*

3 max

(e) 1. More / too many healthy cells killed;

2. (So) will take time to replace / increase in number;
Neutral: will take time to 'repair'

3. Person may die / have side effects;

2 max

[15]

Q17.

(a) 1. Separates / unwinds / unzips strands / helix / breaks H-bonds;
*1. **Q** Neutral: strands / helix split*
1. Accept: unzips bases

2. (So) <u>nucleotides</u> can attach / are attracted / strands can act as templates;
*2. **Q** Neutral: bases can attach*
2. Neutral: helix can act as a template

2

(b)

Sample	Type(s) of DNA molecule present in each tube		
	$^{15}N/^{15}N$	$^{15}N/^{14}N$	$^{14}N/^{14}N$
1	✓		
2		✓	
3		✓	✓

One mark for each correct row

3

(c) (i) 1. Similar shape / structure (to cytosine) / added instead of cytosine / binds to guanine;

1. Accept: idea that <u>only</u> one group is different

1. Reject: same shape

2. Prevents (complementary) base pairing / prevents H-bonds forming / prevents formation of new strand / prevents strand elongation / inhibits / binds to (DNA) polymerase;

2. Accept: prevents cytosine binding

Neutral: 'prevents DNA replication☐ as given in the question stem

Neutral: 'competitive inhibitor☐ unqualified

Neutral: inhibits DNA helicase

2

(ii) (Cancer cells / DNA) divide / replicate fast(er) / uncontrollably;

Accept: converse argument for healthy cells

1

[8]

Q18.

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

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

1. Accept: strands unzip

2. DNA helicase (involved);

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

4. (Free) nucleotides attach;

4. Neutral: bases attach

4. Accept: nucleotides attracted

5. Complementary / specific base pairing / AT <u>and</u> GC;

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

6. Reject: if wrong function of DNA polymerase

7. H-bonds reform;

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

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

6 max

(b) (i) 18;

Do not accept 17.5

1

(ii) 10;

1

(iii) 1. Horizontal until 18 minutes;

Allow + / - one small box

2. (Then) decreases as straight line to 0 μm at 28 minutes;

2. Allow lines that start from the wrong place, ending at 0 at 28 minutes

2

(c) (i) Two marks for correct answer of 19.68 or 19.7;;

Accept 19hrs 41mins

One mark for incorrect answers in which candidate clearly multiplies by 0.82;

Allow one mark for incorrect answers that clearly show 82% of 24 (hours)

2

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

1

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

1. Lower % (of cells) in interphase / higher % (of cells) in mitosis / named stage of mitosis;

1. Accept: 'less' or 'more' instead of '%'

1. Do not accept: higher % (of cells) in each / all stage(s)

2. (So) more cells dividing / cells are dividing quicker;

2. Accept: uncontrolled cell division

*2. Do not award if Tissue **C** is chosen*

2

[15]

Q19.

(a) (i) Repeating units / nucleotides / monomer / molecules;

Allow more than one, but reject two

1

(ii) 1. C = hydrogen bonds;

2. D = deoxyribose;
Ignore sugar

3. E = phosphate;
Ignore phosphorus, Ignore molecule

3

(iii)

Name of base	Percentage
Thymine	34
Cytosine / Guanine	16
Adenine	34
Cytosine / Guanine	16

Spelling must be correct to gain MP1
First mark = names correct
Second mark = % correct, with adenine as 34%

2

(b) (i) 153;

1

(ii) Some regions of the gene are non-coding / introns / start / stop code / triplet / there are two DNA strands;
Allow addition mutation
Ignore unqualified reference to mutation
Accept reference to introns and exons if given together
Ignore 'junk' DNA / multiple repeats

1

[8]

Q20.

(a) (i) Anaphase

1

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

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

2

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

2. 4.2 = DNA not replicated / (early) interphase / telophase / cell just

divided / finished mitosis;

2

(ii) 2.1;

1

[6]

Q21.

(a) (i) Spindle formed / chromosome / centromere / chromatids attaches to spindle;

Chromosomes / chromatids line up / move to middle / equator (of cell);

Do not award second mark for answers referring to chromosomes 'pairing up'.

Ignore reference to homologous chromosomes unless context suggests pairing which negates second mark.

Neutral: Details on nuclear membrane.

Accept: Diagram for second marking point.

2

(ii) Chromosome / centromere splits / chromatids / 'chromosomes' separate / pulled apart;

To (opposite) sides / poles / centrioles (of cell);

Reject: Homologous chromosomes separate for first marking point.

Accept: Diagram for second marking point.

Chromatids / 'chromosomes' move to poles / sides / centrioles = 2 marks.

2

(b) (i) Form / replace cells quickly / rapidly / divide / multiply / replicate rapidly;

Neutral: Repair cells.

Answers must convey idea of 'speed'.

1

(Ii) Correct answer = 774 minutes / 12 hours 54mins = 2 marks;;

Incorrect answer but indicates 3 cell cycles involved = one mark;

2

(c) Prevents / slows DNA replication / doubling / prevents / slows mitosis;

New strand not formed / nucleotides (of new strand) not joined together / sugar-phosphate bonds not formed;

First marking point must be in context of DNA replication not cell replication.

Do not negate first marking point if role of DNA polymerase is described incorrectly e.g. Reject: 'joins bases / strands together'.

Role of DNA polymerase must be correct for last marking point.

2

[9]

Q22.

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.

Please note that to obtain full credit, students must use information to show **the importance of Using DNA in science and technology**.

Topics

DNA and classification	
2.2	Structure of DNA
2.3	Differences in DNA lead to genetic diversity
2.9	Comparison of DNA base sequences
Genetic engineering and making useful substances	
2.5	Plasmids
5.8	The use of recombinant DNA to produce transformed organisms that benefit humans
Other uses of DNA	
2.5	Cell cycle and treatment of cancer
5.8	Gene therapy; Medical diagnosis and the treatment of human disease; The use of DNA probes to screen patients for clinically important genes.

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]

Q23.

(a)

✓	✓	✓	
			✓
		✓	✓

One mark for each correct column

Mark ticks only and ignore crosses

4

(b) 1. Two marks for box round two hydrogens and one of the oxygens from OH groups on carbons 1 and 4;;

2. One mark from incorrect answer involving any two hydrogens and an oxygen from carbons 1 and 4;

Do not award marks if all atoms concerned are on same carbon atom or are on carbon atoms other than 1 and 4 or where the answer does not have two hydrogen and one oxygen

2

(c) (i) 1. Holds chains / cellulose molecules together / forms cross links between chains / cellulose molecules / forms microfibrils, providing strength / rigidity (to cellulose / cell wall);

2. Hydrogen bonds strong in large numbers;x

Principles here are first mark for where hydrogen bonds are formed and second for a consequence of this.

Accept microfibres

2

(ii) Compact / occupies small space / tightly packed;

Answer indicates depth required. Answers such as "good for storage", "easily stored" or "small" are insufficient.

1

[9]

Q24.

(a)

DNA	✓	2
mRNA	✗	1
tRNA	✓	1

One mark for each correct column

Regard blank as incorrect in the context of this question

Accept numbers written out: two, one, one

2

(b) (i) Marking principles

1 mark for complete piece transcribed;

Correct answer
UGU CAU GAA UGC UAG

1 mark for complementary bases from sequence transcribed;

but allow 1 mark for complementary bases from section transcribed, providing all four bases are involved

2

(ii) Marking principle
1 mark for bases corresponding to exons taken from (b)(i)

Correct answer
UGU UGC UAG
If sequence is incorrect in (b)(i), award mark if section is from exons. Ignore gaps.

1

[5]

Q25.

(a) (i) Deoxyribose;

pentose / 5C sugar = neutral

1

(ii) Phosphate / Phosphoric acid;

phosphorus / P = neutral

1

(b) Hydrogen (bonds);

1

(c) 381 / 384 / 387;

1

(d) (Gln) Met Met Arg Arg Arg Asn;

1

(e) Change in (sequence of) amino acids / primary structure;

Change in hydrogen / ionic / disulfide bonds leads to change in tertiary structure / active site (of enzyme);

Substrate cannot bind / no enzyme-substrate complexes form;

***Q** Reject = different amino acids are formed*

3

[8]

Q26.

(a) (i) base / named bases;

reject nucleotide or uracil

1

(ii) it has been produced by semi-conservative replication / one old strand and one new;
One strand has ^{15}N bases and the other ^{14}N;

Accept light / heavy N (therefore) it is less dense / lighter;

2

(iii) one band is in same position as generation 1;
one band higher;
accept a line. N.B. need a visible gap

2

(b) (i) A = 31 and JT = 31;
C = 19;

2

(ii) viral DNA single-stranded / not double-stranded;
evidence from table e.g. not equal amount of A and T / C and G / all different;

2

*ignore no base-pairing In this **Question** assume It' means viral DNA*

[9]

Q27.

(a) nucleotide;

1

(b) (i) 21.4, 21.4; 28.6;

2

(ii) amounts of A and T / C and G / complementary bases different;
therefore no base-pairing;

2 max

[5]

Q28.

(a) (i) (Molecule) made up of many identical / similar molecules / monomers / subunits;

Not necessary to refer to similarity with monomers.

1

(ii) Cellulose / glycogen / nucleic acid / DNA / RNA;

1

(b) (i) To keep pH constant;
A change in pH will slow the rate of the reaction / denature the amylase / optimum for reaction;

2

(ii) Purple / lilac / mauve / violet;
Do not allow blue or pink.

1

(iii) Protein present / the enzyme / amylase is a protein;
Not used up in the reaction / still present at the end of the reaction;

2

[7]

Q29.

(i) sugar or phosphate / S-P / nucleotide chain / backbone /

original / parent DNA;

1

(ii) X thymine; Y guanine; Z adenine;
(Allow T, G and A) Reject: thiamine

3

[4]

Q30.

(a) Presence of resistant and non-resistant varieties / mutation produces resistant variety;
Resistant ones survive / non-resistant ones killed by treatment;
These will reproduce and produce more resistant parasites / pass on resistance allele;

3

(b) Likelihood of being infected (by strain resistant to both drugs) is less;
1/500 × 1/500/1/250 000;
Drug has longer effective life;

max 2

(c) (i) As comparison / to show that nothing else in the treatment was responsible;

1

(ii) Given injections of saline / injection without SPf66;
(otherwise) treated the same as experimental group;

2

(d) (i) 100%;

1

(ii) 10%;

1

(e) (i) Different lengths of DNA have different base sequences / cut at specific sequence;
Results in different shape / different shape of active site;
Therefore (specific sequence) will only fit active site of enzyme;

3

(ii) Recognition sites contain only AT pairs;
Which would occur very frequently;

2

[15]

Q31.

(a) each strand copied / acts as a template;
(daughter) DNA one new strand and one original / parent strand;

2

(b) (i) ^{15}N / tube **B** (DNA), more / greater density;
(reject heavier)

1

(ii) DNA with one heavy and one light strand;
new / synthesised strand, made with ^{14}N / light strand;

2

(c) 32;
28 32 26;

2

[7]

Q32.

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

4 max

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

7 max

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

2

[13]

Q33.

(a) (i) ATA;

1

(ii) AUA;

1

(b) tRNA 'clover leaf' shape; (allow reference to loop / folded structure)
tRNA standard length;
tRNA has an amino acid binding site;
tRNA has anticodon available / three exposed bases;
tRNA has hydrogen bonds (between base pairs);

2 max

[4]

Q34.

(a) different form of a gene;

1

(b) hydrogen bonds broken;
semi-conservative replication / both strands used (as templates);
nucleotides line up complementary / specific base pairing / A and T / C and G;
DNA polymerase;

4

(c) deletion causes frame shift / alters base sequence (from point of mutation);
changes many amino acids / sequence of amino acids (from this point);
substitution alters one codon / triplet / one amino acid altered / code degenerate / same amino acid coded for;

3

[8]

Q35.

(a) appropriately placed box;

1

(b) (i) B;

(ii) A;

2

(c) (i) determines (sequence of) amino acids / specific protein produced / mRNA formation;

1

(ii) hydrogen bonds;

1

(iii) stability / protects bases / replication;

1

[6]

Q36.

(a) **X**, phosphate;
Y, deoxyribose / pentose / 5-carbon sugar;
Z, (nitrogenous) base;
(accept named base)

3

(b) (specific) hydrogen (bonds);

1

(c) thymine 28% so adenine 28%
therefore 44% cytosine and guanine;
therefore 22% cytosine;
(idea of equal amounts T and A, C and G – 1 mark, correct answer 2 marks)

2

[6]

Q37.

(a) (i) substances / molecules have more (kinetic) energy / moving faster;
(reject vibrate)

increased collisions / enzyme substrate complexes formed;

2

(ii) causes denaturation / tertiary structure / shape change / H^+ / ionic bonds break;
(shape) of <u>active site</u> changed;
substrate no longer binds / not complementary to (active site);

3

(b) all substrate changed into product / reaction is complete;
same amount of product formed as same initial substrate concentration;

2

[7]

Q1.

Question (a) required students to draw a diagram that is included in the specification. Just under half (46.3%) were able to do this successfully. The main issues were bonds drawn in the wrong place, and the use of the word pentose, rather than deoxyribose. Most were able to recognise that it was supposed to be a pentagonal molecule.

Again, question (b) should have been simple recall of knowledge; however, only 9.2% scored two marks. Features were simply described and not explained. Students did not give the idea that the hydrogen bonds between bases were weak or easily broken, and, for mark point 2, most students said there were two strands, so one acts as a template, rather than both being templates.

32.3% of students scored the mark for question (c), with many appearing simply to guess, as demonstrated by no working appearing on their scripts.

Q2.

Generally, the comprehension was far better answered than in 2017. This may be partly due to the specification content included this year compared with last. The main issue, as with last year, is that students attempted to answer the question without using the passage. However, these are true comprehension questions. This was the main issue with question (a), though 70.7% of students did score at least one mark. Many students appreciated that the presence of an antigen caused the production of more T cells which resulted in increased amounts of cytokines being produced. Other students appreciated the former but attributed the swelling to the accumulation of T cells. There were some spurious arguments based on alteration of water potential resulting in accumulation of water, and hence swelling.

(b) was similarly well answered, but those students who failed to score (28.8%) gave vague responses, such as ‘it is passed on’ and also thought that those with Crohn’s disease had genes to make bacteria pathogenic instead of normal.

(c) was poorly answered, with nearly 80% scoring zero marks. Students failed to get from the passage that 5-ASA is a drug that reduces swelling. Incorrect answers centred round “the body seeing the drug as foreign”, “being immune to the drug”, “making antibodies against the drug”, “digesting the drug”, “having no receptors for the drug” or, as 5-ASA is an acid, it “denaturing protein/cytokines”. A significant number of students attempted to relate their argument to an allergy to the drug, but many expressed this in terms of suffering side-effects.

(d) was better answered, with the majority of students able to follow the idea that DNA replication will slow, meaning fewer T cells and less cytokine. The question gave guidance not to include details of enzyme inhibition or protein synthesis. This was to help guide students to the correct answer; many based their arguments on a failure to form enzyme-substrate complexes, despite the advice. There was some confusion of cytokine and cytosine, and some students thought that 6-MP would have stopped bacteria or “Crohn’s” reproducing, not T cells.

Q3.

This question was loosely based on the skills students would have developed when completing required practical activity 2 – “Preparation of stained squashes of cells from plant root tips; set-up and use of an optical microscope to identify the stages of mitosis in

these stained squashes and calculation of a mitotic index". Students should have observed cells undergoing mitosis surrounded by many cells that were not and, therefore, should have considered why they looked different.

Many incomplete answers were seen to question (a). Students were required to give evidence **and** to explain that piece of evidence, but often only gave half the story. Some students used **Figure 2** rather than **Figure 1** and some tried to explain which stage of mitosis was shown, rather than simply that it was happening. Confusion was demonstrated here and in question (e) between a homologous pair of chromosomes and a pair of chromatids in a single chromosome. Worryingly, 62% of students failed to score on this opening question; only 5.8% gained both marks.

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

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

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

Q4.

Despite question (a) testing recall (AO1) from section 3.1.5.2 of the specification, only 24.4% of students achieved all three marks. Many answers included DNA helicase 'hydrolysing' hydrogen bonds, which was not given credit. Answers often also included DNA polymerase catalysing the formation of complementary base pairs, or hydrogen bonding between bases; this statement negated mark point 2.

Question (b) was another that required explanations of results, so the students were expected to use some knowledge within each marking point. Able students responded with clear explanations about the effects of the antibody and how the RNA could prevent translation using correct technical language and an appropriate level of knowledge for an A-level question. Some answers were very good indeed. Many answers, however, were descriptions of the data without any explanation. A very high proportion of students (15.4%) made no attempt at this question.

Q5.

Students found questions (a) and (b) accessible, with the majority scoring the marks.

Answering question (c) should have involved only simple recall, however only 28% of students scored two marks. When describing the role of DNA helicase, many used very simple language, such as ‘unwinds’ or ‘unzips’. Such terms were not accepted at GCE level. When describing the role of DNA polymerase, the most common mistake was stating that it forms hydrogen bonds between bases. There was also confusion with protein synthesis; many students stated that DNA polymerase forms pre-mRNA.

For question (d), 25% of students failed to score any marks, usually because they did not follow the command word and thus failed to give a contrasting statement; for example, ‘ATP has ribose, DNA has deoxyribose.’ Many thought adenosine is a base.

Q6.

It was hoped that this would provide a reasonably straightforward start to the paper, assessing AO1 on topics 3.1.5.1 and 3.4.2.

(a) Only 22% of students could correctly name the types of molecule that make up a ribosome.

(b) This question was answered much more successfully than (a), with 48% of students gaining all three marks.

(c) This question proved to be very accessible, with 96.3% of students gaining the mark.

(d) Although 83% of students scored 2 marks for this question, there were some incorrect answers, e.g., indicating that the introns removed from the pre-mRNA were made of DNA.

Q7.

(a) It was pleasing to see that nearly all students could name two enzymes involved in DNA replication; 92% got both marks.

(b) This question discriminated well. 40% of students obtained one mark, usually by noting that phosphorylation of the enzyme caused the active site to be formed, or to become complementary to the substrate. About 38% of students obtained two marks, usually by also noting that phosphorylation changed the tertiary structure of the enzyme (which caused the change to the active site). Some students’ terminology was poor and confused, and some referred, wrongly, to phosphate as a competitive, or non-competitive inhibitor. Some failed to mention the active site at all, even though the question asks why enzymes become able to bind to their substrates.

(c) About 50% of students obtained the mark, by reference to the substrate becoming more reactive, or phosphorylation (of the substrate) lowering the activation energy for the reaction. Quite a few made vague references to kinetic energy changes that were not credited. Some wrongly continued to focus on phosphorylation of the enzyme.

(d) This was well done by many, with 47% obtaining 3 marks, but still discriminated quite well. Most students appeared to be able to follow the story in the stem of the question and apply some basic principles, such as the mutation leading to a form of ATM unable to bind to broken DNA. Only 3% of students failed to score.

Q14.

(a) (i) Only a quarter of students obtained the mark. DNA polymerase catalyses the reactions that make the polymer, DNA. It does this by catalysing the formation of bonds between nucleotides that have already undergone complementary base-pairing to an exposed template strand. Many students described DNA polymerase as making nucleotides base-pair and this was not given credit.

(ii) Many students appeared to ignore 'DNA' in the question and included various differences between prokaryotic and eukaryotic cells, including differences in how they divide. As a result, only a quarter obtained 2 marks.

(b) (i) About 40% of students obtained 2 marks in this part. This was usually for references to different sequences of bases resulting in different proteins being made. Some failed to obtain one of these marks because they referred to different sequences on DNA making or producing different amino acids. Few students noted that different species have different genes, reflected in different base sequences.

(ii) About half of students failed to score in this part. The question did discriminate, in that students who did well on the whole paper tended to do well on this question. Most commonly, correct responses referred to the differences in percentages of C and G and A and T and then went on to suggest there was no base-pairing. A few students correctly suggested the DNA was single-stranded. Weaker responses simply restated the numbers from the table.

Q15.

(a) The examiners noted that many students approached this part as 'describe mitosis' and proceeded to do so in various degrees of correct detail. The question asked for an explanation of how events in mitosis lead to the production of genetically identical cells. Some students focused on DNA replication but ignored chromatid movements and others only discussed chromatids. Many obtained 1 or 2 marks for references to DNA replication and / or chromatids moving to the poles (of the spindle).

Some students clearly got confused between sister chromatids and homologous pairs of chromosomes.

The examiners were looking for replication of DNA, involving complementary base-pairing, in order to produce exact copies of genetic information. Then, how this is linked to sister chromatids and how their separation during mitosis leads to genetically identical cells.

(b) (i) About 60% of students correctly suggested that the sections had to be thin to allow light to pass through but few went beyond that. The examiners were looking for the idea that thin sections would allow individual cells, or layers of cells, to be seen (and the chromosomes within them, if present). Only about 20% obtained a second mark.

(ii) Many students wrote about the size of the mitotic index in this part, simply describing the graph and not explaining growth. The examiners were looking for answers relating the rate of mitosis at the tip of the root to growth. A third of students did this and obtained both marks.

Q16.

Parts (a), (b) and (d) proved to be good discriminators.

(a) It was disappointing that only just below 40% of students scored at least half marks. This was mainly due to simply describing the structure of DNA, without explaining how these features relate to its functions. Some students wrote about DNA structure and function in different paragraphs. This made it unclear which feature went with which function, as no direct links had been made. In contrast, there were some truly excellent responses, which had clearly been well planned before putting pen to paper. The most common mark points awarded were for the sugar-phosphate backbone providing strength or protecting bases, the helix allowing the molecule to be compact, weak hydrogen bonds allowing strand separation or replication and the two strands acting as templates or allowing semi-conservative replication. Relatively few students linked complementary base pairing with accurate replication or the production of identical copies of DNA. Similarly, few students referred to DNA as a large molecule that can store lots of information, or the base sequence coding for amino acids. Weaker responses often mentioned this in the context of the genetic code being degenerate. Indeed, some students thought that the base sequence causes amino acids to be *produced*. The ability to convey that *many* hydrogen bonds provide stability was rarely seen. It was also unfortunate that a number of students wasted their time by writing about irrelevant topics such as the differences between prokaryotic and eukaryotic DNA and the role of histones. There were also some lengthy accounts of DNA replication, enzyme structure and the different levels of protein structure.

(b) Many students scored at least two marks for stating that a mutation in gene **E** produces the highest risk and a mutation in gene **C** produces the lowest risk. However, only the best responses also referred to gene **D**. Students who did not mention any of the genes usually picked up one mark for noting that all of the mutant alleles increase the risk of lung cancer. Surprisingly, some thought that a mutation in gene **D** produces the highest risk.

(c) Just fewer than 40% of students gave the correct answer of **180**.

(d) Two-thirds of students scored at least two marks. Many were able to identify the decrease, plateau and increase for healthy cells and cancer cells. However, relatively few made reference to the plateau occurring for the same length of time. Students who failed to gain a mark for a similarity usually ignored the plateau. Most students spotted that a greater number of healthy cells were killed or that they experienced a faster decrease in number. Similarly, it was impressive to see that some used data from the graph to calculate that a greater *proportion* of cancer cells were killed. Many students also noted the faster increase in the number of healthy cells.

(e) Half of students scored full marks. This was usually for mentioning that too many healthy cells would be killed, which could kill the patient or cause side effects. However, relatively few appreciated that it would take time to replace the healthy cells that had been killed.

Q17.

(a) This proved to be a good discriminator. Most students were aware that DNA helicase separates strands or breaks hydrogen bonds. However, only better responses went on to state that this allows nucleotides to attach or the strands to act as templates. Unfortunately, poor expression or a lack of precision let down some students. This was usually for DNA ‘splitting’, or ‘bases’, rather than nucleotides, attaching.

(b) Just under half of students gained full credit.

(c) (i) This proved to be a good discriminator. A quarter of students scored full marks. Most were aware that cytarabine has a similar structure to cytosine. However, weaker responses were often vague regarding the subsequent effect of this, eg ‘prevents DNA replication’ or ‘inhibits helicase’. Similarly, there were many unqualified references to cytarabine acting as a competitive inhibitor. It was only the best responses that suggested cytarabine may prevent base pairing, prevent the formation of a new strand or act as an inhibitor of DNA polymerase.

(ii) Just over seventy percent of students were aware that cancer cells divide faster than healthy cells.

Q18.

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

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

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

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

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

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

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

Q19.

(a) (i) Students were aware that polymers were made of many monomers, but in many cases went on to include descriptions in their answers that implied they did not understand what the monomers in this case were. A number of answers suggested that each strand was a monomer or that the monomers were amino acids.

(ii) Most students knew the names of the parts of the diagram; the most common mistake was giving ‘sugar’ or ‘ribose’ instead of deoxyribose.

(iii) In order to gain both marks, students had to show that they knew the names of the bases. This proved very revealing in that almost all knew the initial letters of the four bases but only a minority could write down the names correctly. About half were able to complete the simple calculation to give the percentage of the other three bases.

(b) (i) Those who failed to gain credit often did so because they were, apparently, of the opinion that one base coded for three amino acids.

(ii) Introns, non-coding DNA, start and stop codes were all known to be non-coding DNA and, thus, adding to the length of the gene without contributing to the polypeptide. Some students also mentioned addition mutations or the fact that there are two strands. A minority of students incorrectly linked the degeneracy of the genetic code to the difference in number of bases.

Q20.

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

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

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

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

Q21.

(a) (i) It was clearly evident that the vast majority of candidates had a good understanding of what happens in metaphase with two thirds of candidates gaining both marks and only ten percent scoring zero. Most candidates gained credit for mentioning chromosomes moving to the equator of the cell. A number of candidates, however, referred to homologous chromosomes aligning in pairs and described metaphase I of meiosis.

(ii) Almost seventy five percent of candidates gained two marks often by stating that ‘chromatids move to opposite poles’. Again, approximately ten percent of candidates scored zero.

(b) (i) Although most candidates appreciated that the cells lining the human intestine needed to be replaced only half of the candidates conveyed the idea that this occurs quickly. A significant number of candidates simply stated that the cells needed to be repaired.

(ii) Almost half the candidates gained both marks for 774 minutes or 12 hours 54 minutes. A small number of candidates provided an incorrect answer but correctly indicated three cell cycles for one mark. Many of the remaining candidates used four cell cycles to obtain an incorrect answer of 1032 minutes.

(c) There were some excellent detailed answers to this question which gained both marks. These were, however, in the minority. Most candidates gained at least one mark usually for stating that DNA replication would be inhibited. Generally, there was considerable confusion over the role of DNA polymerase, with many candidates believing it to be involved in breaking hydrogen bonds or in complementary base pairing.

Q22.

Using DNA in science and technology

The very best essays from candidates who selected this option were outstanding. They reviewed, often in great detail, the relevant aspects of the specification although not always incorporating the role of DNA in the classification of organisms. Considering that much of the content of this essay could be drawn from this unit, it was surprising how poor many answers were. Understanding of techniques was often extremely limited, particularly *in vivo* gene cloning and the use of markers. Many essays presented no more than a broad overview either emphasising ethical issues at the expense of biological detail or failing to distinguish established practice from wishful thinking.

Q23.

(a) Although this question produced an even spread of marks across the entire ability range, the overall marks were disappointing for a question largely targeted at Grade E candidates. Many appeared uncertain as to the distribution of starch and glycogen, the identity of deoxyribose as a carbohydrate or of DNA helicase as an enzyme.

(b) Most candidates were able to gain some credit for recognising that condensation involved the elimination of a molecule of water, although there were some who apparently failed to appreciate that water molecules contained two hydrogen atoms and an oxygen atom, or that condensation involved linking the molecules shown. The better candidates selected the appropriate atoms and gained both of the available marks.

(c) In part (i), candidates were usually able to make an appropriate reference to the role of hydrogen bonds in strengthening either cellulose or the cell wall. Many, however, were uncertain as to the location of these bonds and produced answers referring to linking the β-glucose residues. Part (ii) was usually well answered and most candidates were able to discuss the compact shape of starch molecules. There were, however, some answers incorrectly based on the idea of a large surface area to volume ratio.

Q24.

(a) This part of the question was often poorly answered. While errors in the first column were perhaps predictable, those not infrequently given in the second column suggested confusion between polynucleotide strands and bases or even chromosomes.

(b) This question was marked in such a way that a candidate who made a single error

was still able to gain some credit. The answers to both parts were generally sound although there were occasional errors involving giving the base sequence on the complementary DNA strand, or resulting from uncertainty over splicing.

Q25.

(a) (i) Most candidates correctly named part **R** as deoxyribose. Answers identifying part **R** as pentose or as a five carbon sugar were considered too imprecise due to the question clearly identifying the molecule as being DNA.

(ii) Most candidates correctly named part **Q** as a phosphate group or as phosphoric acid. Unfortunately, some candidates incorrectly named parts **R** and **Q** the wrong way round.

(b) Almost every candidate correctly stated 'hydrogen bonds'.

(c) Approximately fifty percent of candidates obtained this mark. Although there was a wide range of incorrect answers, the most common error was to divide, rather than multiply the number of amino acids by three.

(d) Over 90 % of candidates were able to correctly work out the sequence of amino acids.

(e) This question proved to be an effective discriminator. Most candidates gained at least one mark, often by mentioning a change in the sequence in amino acids. However, a significant number of candidates incorrectly referred to 'different amino acids being formed'. Many of these candidates gained a second mark for describing that the active site or tertiary structure would be altered. Better candidates gained maximum marks either by linking this to enzyme-substrate complexes not being formed or to changes in hydrogen/disulfide bonds.

Q26.

Unit 2

(a) In (i), this was known by most, though a few failed to gain marks by suggesting 'nucleotide' 'amino group' or even 'phosphate'.

Part (ii) was often poorly answered by repeating the given part, that ^{14}N is lighter than ^{15}N. Better answers recognised that semi-conservative replication would mean that one of the strands would contain the heavier isotope, and one the lighter isotope. A few candidates thought that the bands were bacteria or nitrogen.

Candidates often scored one mark for (iii), usually for the higher band, but it was rare for candidates to score both marks.

(b) In (i), most candidates scored both marks.

Many scored full marks for (ii). However, the weakest candidates thought that viral DNA had different base-pairing rules.

Unit 3

(a) Specifically, nitrogen is part of the organic base. The chemical understanding of some was shown to be poor with suggestions of phosphates or amino acids. From the responses provided, it would seem that few candidates were familiar with semi-conservative replication. Few were able to express this concept and explanations

were not convincing.

(b) Candidates were familiar with base pairing and most calculated the appropriate percentages. Fewer recognized, from the evidence provided from the different percentages of all the bases, that viral DNA is single stranded.

Q27.

Unit 2

(a) Surprisingly few gave the correct response of nucleotides. Many gave one or all of the parts of a nucleotide, or amino acids.

(b) (i) Virtually all candidates gained two marks for calculating the missing figures.

(ii) Though most candidates had the right idea, many found it difficult to explain that the bases did not show a 1:1 ratio and were therefore not paired. The concept of base pairing was often omitted.

Unit 3

(a) A wide variety of answers was seen here ranging from no response to amino acids, assorted sugars, a list of the components of DNA and, in a disappointingly small number of scripts, nucleotides.

(b) A pleasing number of candidates scored two marks here but several went astray as a result of poor maths or weak biology. Part (ii) proved a test of expression and many spent time explaining that the virus DNA was double-stranded or used much of the margin to fit in all their ideas.

Q28.

(a) Imprecise expression frequently limited the marks awarded for part (i). Care clearly needed to be taken to avoid suggesting too few components, with answers such as that a polymer consisted of ‘two or more’ monomers. Those who did not make use of the term ‘monomer’ needed to indicate, in some way, the similarity of the constituents. They did not always do this. The most frequent reason for failing to gain credit for part (ii) was where candidates gave substances, such as haemoglobin and amylopectin, which were excluded by the wording of the question. Nevertheless, many candidates gave correct answers.

(b) In part (i), most candidates recognised the importance of buffers in maintaining pH, although some associated them with temperature. Better candidates could generally develop the idea and usually gained a second mark through reference to denaturation. Unfortunately, some saw parts (ii) and (iii) as a trick and pointed out that since starch was not a protein, it would give a negative result. Others made the same error by simply failing to focus on the right component of the mixture. Perhaps more disturbing is the continued failure of so many candidates at this level to learn the relevant information relating to basic biochemical tests. There was again much confusion over test and result, apparent both here and in the answers to Question **4** (b).

Q29.

BYA2

Some candidates found it difficult to see what was required here but any appropriate

answer was accepted. The second part was generally well answered although some failed to gain marks as a result of poor spelling.

BYA3

In part (i) there were some vague answers which did not gain credit. Although examiners allowed a variety of correct responses, some candidates simply offered nucleotide. This was not specific enough. A small number referred to the phosphate chain or deoxyribose backbone, showing a lack of understanding of the structure of DNA. In part (ii), X and Y were usually correct, but Z was sometimes named as uracil. Examiners were amazed at the number of spelling variants offered for thymine.

Q30.

(a) Many candidates understood the basic principles of natural selection underlying this part of the question and better answers related these to the development of resistance in malarial parasites. Responses, however, were frequently marred by imprecise use of terms. Thus malarial parasites were variously described as developing resistance, immunity or, in some cases, allergies to the drugs concerned, while resistance was described as taking place in bacteria, the disease or even in the human population.

(b) Evidence from BYA5 suggests that many candidates understand that probabilities are combined by multiplication. However, they were unable to apply this principle to the example in this part of the question. The most frequent response was to add the two figures. The resulting value of 1/250 then proved difficult to explain, and the simple idea that the probability of being infected by a strain of malarial parasite resistant to both drugs was much lower eluded most.

(c) The concept of a control proved surprisingly unfamiliar to most candidates and even the best seldom progressed beyond explaining that a control offered a standard against which to compare the effectiveness of the vaccine. This idea should have given rise, in part (ii), to injection with saline only in an otherwise identically treated control group. Answers ranged from those who clearly failed to appreciate the nature of a control and discussed issues which were largely ethical in nature, to responses which were in varying degrees incomplete. Such responses included making sure that both groups “lived in the same place” or “were the same age”, ignoring the fact that these were only part of a whole range of factors which should have been kept constant. Evidence from this question and from the coursework suggests that the issue of controls is one that needs to be addressed by centres.

(d) Better candidates experienced little apparent difficulty in identifying the correct percentages here. Incorrect answers fell into no set pattern and most responses which could conceivably be given arose at least once.

(e) Many candidates were obviously of the opinion that restriction enzymes function in a way that is totally different from other enzymes, and attempted to explain their specificity in part (i) in terms of base pairing. Others clearly understood the principles involved but neglected to relate their understanding of enzyme action to this particular question. A lack of precision characterised many of the answers to part (ii). Thus there were frequent references to adenine and thymine but not to these bases forming the restriction sites. However, most candidates were able to equate the frequency of cutting to the small size of the resulting fragments.

Q31.

This question produced a large spread of marks. Inaccurate use of terminology

compromised the marks gained by many candidates in parts (a) and (b).

(a) Generally this part was poorly done. Most candidates seemed unaware that both strands were replicated. Answers lacked clarity because candidates used the word 'strand' loosely when trying to explain DNA replication. They seemed aware that DNA is a double helix but not that this is a double polynucleotide or that the polynucleotides are the strands and the double helix a molecule.

(b) Again, the imprecise use of the word 'strand' revealed a lack of understanding of DNA replication. The most common error described half the new DNA strand as ^{14}N and half ^{15}N.

(c) The vast majority of candidates could apply their knowledge of base pairing to complete the table correctly.

Q32.

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

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

(b) There were some good answers but very few examples of full marks. Most candidates described chromosomes shortening, referred to movement to the equator and had some knowledge of the cause of chromatid separation. Beyond this there was confusion over the involvement of homologous pairs and many candidates failed to mention the identical nature of chromatids. Only the very able candidates alluded to the significance of the movement to opposite poles. Weaker candidates could not put the events of the process into order. It was disappointingly rare to read a logically presented, coherent full answer. The majority of the candidates could use the information in the stem of the question and gained both marks.

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

Q33.

Although only a few candidates obtained maximum marks on this question, most candidates were able to gain between two and four marks.

Better candidates had little difficulty in providing the correct responses for parts (i) and (ii). Weaker candidates often correctly identified the DNA triplet for tyrosine but gave an incorrect tRNA anticodon for the same amino acid.

The most frequent correct responses referred to the 'clover leaf' or folded structure of tRNA, the presence of an amino acid binding site or the anticodon. Incorrect responses included references to tRNA consisting of two strands, possessing three anticodons or

possessing thymine rather than uracil.

Q34.

There were some excellent answers to this question with the most able candidates gaining maximum marks. Weaker candidates were often able to obtain some marks in parts (b) and part (c).

Surprisingly, explaining what is meant by an allele proved to be quite difficult for many candidates. There were many vague references to an allele 'being part of a gene' or 'being a gene for eye colour'. The context provided by candidates often suggested that alleles were different genes.

As in previous years a significant number of candidates confused DNA replication with transcription. It was often difficult to give credit in these answers, except for the first mark point referring to hydrogen bonds being broken. As in previous years, there was considerable confusion concerning the role of DNA polymerase. However, naming the enzyme itself was credited in this answer to avoid a double penalty for incorrectly describing its role in question 6(b). There was also some confusion between bases and nucleotides. Nevertheless, better candidates had little difficulty obtaining maximum marks, some answers displaying knowledge well beyond the requirements of this specification. Weaker candidates often gained marks for referring to semi-conservative replication and complementary base pairing.

In part (c) the effects of a mutation involving a deletion or a substitution were generally well known. Most candidates referred to 'frame shifts' and appreciated the degenerate nature of the genetic code. However, some weaker candidates referred to 'amino acids in the DNA' being deleted or substituted. Better candidates had little difficulty gaining maximum marks.

Q35.

This question was very well answered and the majority of candidates gained at least half the marks available. A significant number of candidates gained maximum marks.

(a) Very few candidates failed to draw correctly a box round one nucleotide on the diagram.

(b) In part (i), most candidates gained the mark for indicating that **B** (deoxyribose), is different in a RNA molecule. Slightly fewer candidates obtained the mark for part (ii) by indicating that molecule **A** (an organic base) contains nitrogen.

(c) In part (i), many candidates correctly described the role of the sequence of bases on DNA in protein synthesis. However, a number of candidates referred to tRNA formation rather than to mRNA. Almost every candidate gained the mark for hydrogen bonds in part (ii). Although many candidates gained a mark in part (iii), vague statements simply referring to 'protection' were not credited.

Q36.

(a) Many candidates had learnt the material needed to answer this question and many obtained full marks. When marks were not gained it was usually because of references to phosphoric acid for **X**, sugar or ribose for **Y** or amino acid for **Z**.

(b) It was pleasing to find that almost all candidates correctly identified these as hydrogen bonds.

(c) There were many correct answers, demonstrating that most candidates understood that A binds to T in equal amounts, as does C to G. Some candidates obtained one mark for stating these relationships, even though they went on to make some error in their calculation of the percentage of cytosine.

Q37.

(a) Many candidates gained full marks, although some referred to breaking of disulphide bridges. A common error, caused by misinterpretation of the graph axes, was to attribute the levelling off to a maximum rate of reaction, with all the active sites being used.

(b) Many candidates appreciated that all the substrate had been used up but most were reluctant to relate this to the same amount of product or that the initial substrate was the same.