

## 4.2 GENETIC INFORMATION, VARIATION AND RELATIONSHIP – DNA AND PROTEIN SYNTHESIS (2) – MARK SCHEMES

### Q1.

(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]**

### Q2.

- (a) Phosphate;

Deoxyribose;

*Q Candidates must specify deoxyribose. This term is a specification requirement.  
Ignore anything that is not incorrect.*

2

- (b) 4;

1

- (c) (i) 14;

1

- (ii) 36;

*If (c)(i) incorrect accept [50 – (c)(i)]*

1

- (d) Different genes;

Different (DNA) base sequences;

2

[7]

**Q3.**

(a) RNA polymerase;

*DNA polymerase is incorrect*  
*Ignore references to RNA dependent or DNA dependent*  
*Allow phonetic spelling*

1

(b) (i) (Receptor / transcription factor) binds to promoter which stimulates RNA polymerase / enzyme X;

Transcribes gene / increase transcription;

2

(ii) Other cells do not have the / oestrogen / ER $\alpha$  receptors;  
*But do not accept receptors in general.*

1

(c) Similar shape to oestrogen;

Binds receptor / prevents oestrogen binding;

Receptor not activated / will not attach to promoter / no transcription;

*Accept alternative*  
*Complementary to oestrogen;*  
*Binds to oestrogen;*  
*Will not fit receptor;*

2 max

[6]

**Q4.**

(a) (i) ACG;

1

(ii) serine;

1

(b) idea that DNA contains introns / mRNA is only exons / mRNA is "edited";  
*(allow junk / non-sense DNA)*

1

(c) binds to / blocks codon / triplet on mRNA so anticodon / tRNA will not fit in / base-pair;  
amino acids not delivered / joined;

*Accept translation will not occur for 1 mark*

2

[5]

**Q5.**

(a) GCAAUG; ;

*Allow one mark if T instead of U, i.e. GCAATG*

2

- (b) (i) DNA is edited / introns present in DNA;  
*Allow reference to 'junk' or non-coding DNA* 1
- (ii) 220; allow 218 or 219-allow 2  
Three bases / nucleotides code for one amino acid;  
Correct explanation for 218 or 219; 2
- (c) mRNA has no base-pairing, tRNA has base-pairing / mRNA linear,  
tRNA cloverleaf shape; mRNA has no binding site for amino acids,  
tRNA has; mRNA different for each gene / many kinds, only few / 20 / 64  
kinds of tRNA; accept mRNA longer / larger / more nucleotides than tRNA max 2
- [7]

### Q6.

- (a) Protein made of (chain of) amino acids;  
Each amino acid has its own base / triplet code; 2
- (b) UCA = 2 marks  
TCA – 1 mark; 2
- (c) CCG;  
GGG GGG; 2
- (d) (i) Changes base sequence;  
Of later triplets / amino acid codes; 2
- (ii) S-phase / interphase; 1
- (e) 1. mRNA leaves (nucleus) through nuclear pore;  
2. To ribosome;  
3. tRNA molecules bring amino acids (to ribosome);  
4. Specific tRNA molecule for specific amino acid;  
5. Anticodon of tRNA corresponds / complementary to codon on mRNA;  
6. Peptide bonds form between amino acids;  
7. tRNA detaches and collects another amino acid;  
8. Ribosome moves along mRNA; max 6
- [15]

### Q7.

- (a) antibiotic has diffused / spread / moved into agar;  
killed / inhibited bacteria; 2
- (b) largest clear area / inhibition zone / killed the most bacteria; 1
- (c) disrupts cell wall / prevents cell wall synthesis;  
stops DNA replication; 2
- [5]

**Q8.**

- (a) (i) C → B → E → F → A → D

Mark links: 5 correct = 2, 4 correct = 1, <4 correct = 0

2

- (iii) nucleus;

1

- (iii) A, D, F; (
- ignore E if evident*
- )

1

- (b) (i) Isoleucine;

1

- (ii) TGG;

1

**[6]****Q9.**

- (a) 387;

1

- (b) (i) CCAG;

1

- (ii) 5;

1

- (c) high energy radiation / X rays / ultraviolet light / gamma rays;  
 high energy particles / alpha particles / beta particles;  
named chemical mutagens e.g. benzene / caffeine / pesticide /  
 mustard gas / tobacco tar / free radicals;  
*(two named examples of any of the above = 2 marks)*  
 length of time of exposure (to a mutagen);  
 dosage (of mutagen);

2 max

- (d) (i) UAC UUA UGG;

1

- (ii) addition and deletion (of bases / nucleotides);  
 thymine added;  
 adenine deleted;  
*(addition of thymine and deletion of adenine = 3 marks)*  
*(allow addition of adenine (RNA) and deletion of uracil (RNA)*  
*= 2 marks)*

3

**[9]****Q10.**

- (a) memory B / T cells do not recognise (new antigens);  
 antibodies previously produced are not effective  
 as shape not complementary to new antigen;

2

- (b) (i) antigen in membrane presented to lymphocytes /  
 produce cytokinins;

1

- (ii) mitochondria provide (more) ATP / energy;  
 (more) RER / ribosomes synthesise proteins;  
 (more) Golgi body secretes / modifies or packages proteins /  
 produces glycoproteins;  
 (B lymphocytes) produces antibodies;

4

[7]

**Q11.**

- (a) mutation changes the amino acid sequence / primary structure of Factor VIII protein;  
 changes the tertiary structure / 3D shape; 2
- (b) (mutant) Factor VIII protein is non-functional / does not work with Factor IX;  
 so no conversion of Factor X to active form and pathway blocked; 2
- (c) boy's blood contains (active) Factor VIII;  
 Factor VIII haemophiliac's blood contains (active) Factor IX;  
 the mixture has both Factors and so the pathway can  
 complete / blood clots;

2 max

[6]

**Q12.**

change in base / nucleotide (in DNA);  
 change in base sequence of mRNA / change in codons / idea of  
 frameshift following deletion or addition / incorrect tRNA / anticodon;  
 incorrect amino acids / different primary structure / formation of new  
 stop codon;  
 different tertiary structure / different 3D structure / different  
 polypeptide / shortened polypeptide;  
 different shape of active site / no active site present;

[5]

**Q13.**

- (a) (i) join / attach nucleotides, to form a strand / along backbone / phosphodiester  
 bonds;  
*(reject reference to H bonds, complementary base pairing)* 1
- (ii) ribosome / RER; 1
- (b) (i) CGTTACCAA; 1
- (ii) CGU UAC CAA; 1
- (c) substitution; 1
- (d) (i) alanine; 1
- (ii) (mutation 1)

no change(to sequence of amino acids);  
codon for alanine / degenerate codon / same amino acid coded for;

2

(mutation 2)  
(change in sequence) valine replaced by alanine / codon for alanine;  
folding / shape / tertiary structure / position of bonds may change;  
(reject peptide bonds)

2

[10]

### Q14.

- (a) (i) number of bases = 4440  
*allow 4446 if they refer to start / stop*

each amino acid coded for by triplet / three bases  
(so three times more bases than amino acids);

2

- (ii) deletion;  
(deletion) of three bases;  
because substitution / addition would change amino acid(s);

2 max

- (b) codon on mRNA;  
specific / complementary base pairing with;  
anti-codon on tRNA;  
specific tRNA for each amino acid;  
protein formed by condensation reactions /  
peptide bonds formed;

4 max

[8]

### Q15.

- (a) side effects / allergic reactions / low toxicity to cells;  
interaction with other drugs / effective in conditions of use / reasonably stable;  
should only act on the problem bacteria / narrow spectrum;  
how much resistance the bacteria have built up;

2 max

- (b) (i) tetracycline  
prevents tRNA binding to ribosomes / amino acid / mRNA;

1

amino acids not available / brought / picked up;

1

chloramphenicol  
prevents amino acids being joined / prevents primary structure forming;

1

no enzymes / no structural proteins formed;  
*(accept cell wall formation if qualified) (prevents protein  
synthesis gains one mark in either section, once only)*

1

- (ii) only prevents tRNA binding to 70S / prokaryotic / bacterial  
ribosomes / human ribosomes are different sizes / shapes / structure;

**Q16.**

- (a) chloroplast, so cell photosynthesises and moves to optimum / best light intensity for photosynthesis;  
avoids damage due to bright light; 2
- (b) (i) 2700 1
- (ii)  $\frac{242 \times 7500 \times 900}{60} = 27\,225\,000 / 27 \times 10^6 = 2 \text{ marks}$   
(allow 1 mark for principle:  $\frac{\text{amino acids} \times \text{proteins}}{\text{time}}$ ) 2
- (c) (i) rate slightly slower / not affected in first 20 / 30 minutes / lower peak than control;  
then decreases / much lower (than control);  
(allow 1 mark for increase in first 20 / 30 minutes, then decreased, if not compared with control / normal)  
(disqualify flagellum grows longer) 2
- (ii) 1. actinomycin has no effect (on growth of flagella);  
even though mRNA production / transcription prevented;  
(accept references to 'expt 1')
2. (re)growth little affected by puromycin at first;  
protein synthesis inhibited, so likely to be using proteins present; 4

[11]

**Q17.**

- (a) high energy radiation / ionising particles;  
named particles /  $\alpha$ ,  $\beta$ ,  $\gamma$ ;  
colchicine;  
x rays / cosmic rays;  
uv (light);  
carcinogen / named carcinogen;  
mustard gas / phenols / tar (qualified); 1 max
- (b) (i) removal of one or more bases / nucleotide;  
frameshift / (from point of mutation) base sequence change; 2
- (ii) sequence of bases in mRNA would change;  
(sequence of) amino acids different / different primary structure;  
(active site / enzyme 1) changed tertiary shape / changed active sites;  
white pigment does not bind;  
lilac pigment not produced / white pigment remains unchanged /  
enzyme 1 does not function; 4 max

(iii) blue and lilac; white;

<i>colour of petal</i>
<i>(white)</i>
blue
lilac;
white;

2

[9]

### Q18.

- (a) (Gene 1) allele A makes enzyme converting J to K / colourless to red;  
Allele a produces no / non-functional enzyme;  
(Gene 2) allele B makes enzyme converting K to L / red to purple;  
Allele b produces no / non-functional enzyme;  
("Recessive alleles produce no / non-functional enzyme" = 2)  
White flowers result from genotype aa;  
... regardless if B or b / even if aaB\_ ;  
Colourless (substance) / J produces white;  
Red flowers when A\_ bb / enzyme 1 only;  
Purple flowers when A\_ B\_ / enzymes 1 and 2;

6 max

- (b) (i) (1) (red parent) AAbb;  
(2) (white parent) aaBB;

2

- (ii) F<sub>1</sub> are AaBb;  
F<sub>2</sub> ratio of 9 : 3 : 4;  
Purple : red : white;  
Suitable working shown;

4

- (c) (i) aabb, aaBb, and aaBB; (allow aabb & aaB\_)

1

- (ii) (Crush each type of white petal to make an extract, and) add some of the (red) pigment / K, to petal OR incubate with K;  
(extract becoming) purple is identified as aaBB OR that staying red, after K is added, is aabb;

2

[15]

### Q19.

- (a) AGC; TTC;

2

- (b) anticodon complementary to codon / reads message on mRNA;  
specific amino acid;  
carried / transferred (to ribosome);  
correct sequence of amino acids along polypeptide;

3 max



(c)

(Met)	Phe	Gln	Gln	Lys	Gln	Phe
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*(three / four / five correct 1 mark; six correct 2 marks)*

2

[7]

**Q20.**

(a) Two suitable differences between DNA and RNA;

*1 mark per correct row to 2 max*

e.g.

DNA is double stranded, RNA is single stranded;  
DNA has thymine present, RNA has Uracil present;

*Accept T and U*

DNA is larger/heavier/longer, RNA is smaller/lighter/shorter;  
DNA has a deoxyribose sugar, RNA has a ribose sugar;  
DNA stays in the nucleus, RNA leaves the nucleus;

2 max

(b) Three suitable examples;

e.g.

Carries coded information about the sequence of amino acids;  
Copied from DNA/gene;  
Code is in sequence of bases / triplet / three bases / a codon codes  
for one amino acid;  
Moves out of nucleus/goes into cytoplasm;  
To ribosomes;

*Accept codons allow anticodons / tRNA to bind*

*Accept carries 'start' and 'stop' codes*

*Accept moves through ribosomes*

3 max

[5]

**Q21.**

(i) mRNA attaches to ribosome;  
codon on mRNA;  
binds to an anti-codon on tRNA;  
each tRNA brings a specific amino acid;  
sequence of codons / bases on mRNA determines order of amino acids;  
formation of peptide bonds / amino acids joined by condensation  
reactions;

4 max

(iii) inserted gene / mRNA complementary to normal gene / mRNA;  
binds to it to prevent protein synthesis / form double strand / prevents  
mRNA binding to ribosomes;  
will not stop all translation, some mRNA reaches ribosomes /  
because not all mRNA is bound by inserted gene mRNA;

2 max

[6]

**Q22.**

(a) Any two of:

DNA	RNA
Large molecule	Smaller
Double stranded	Single stranded
Contains Thymine (T)	Contains Uracil (U)
Contains deoxyribose	Contains ribose

2 max

(b) Base sequence (on DNA/in gene);  
Determines sequence of amino acids;  
By determining base sequence on (messenger) RNA;  
Code is a triplet code/three base code for an amino acid;

2 max

(c) Pairs of chromosomes/two chromosomes;  
With genes for same features / with same genes;  
At same loci / in same sequence;

*Accept same alleles*

2 max

[6]

**Q23.**

(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]

**Q24.**

(a) Will replace themselves / keep dividing / replicate;

Undifferentiated / can differentiate / develop into other cells / totipotent / multipotent / pluripotent;

*Accept tissues*

2

(b) Reverse transcriptase;

*Allow phonetic spelling*

1

(c) (i) Alters base / nucleotide sequence / causes frame shift;

Different sequence of amino acids in polypeptide / protein / primary structure alters the tertiary structure;

*Accept any reference, such as adding bases, to changing the base sequence of the gene. Reject deletion / substitution.*

*Idea of sequence essential so not makes different amino acids.*

*Accept answers involving stop / start codons and effect on protein.*

2

(ii) Affects tumour suppressor gene;

Inactivates (tumour suppressor) gene;

Rate of cell division increased / tumour cells continue to divide;

*Ignore answers relating to oncogenes. May gain third point.*

2 max

(d) Yes

SCID patients unlikely to survive / quality of life poor unless treated;  
Cancer that develops is treatable / only affects 25% / five children;

No

Risk of developing cancer is high / 25%;

Cancer may recur / may not be treated successfully in future / only short time scale so more may develop cancer;

*No mark for yes or no. Marks are for supporting argument based on biological reasoning.*

*Accept any points*

2 max

[9]