Past-paper walk-through

Gene control ▪ 16.3

eXercise

Questions in this set

- 9700/24 N25 Q3 ▪ 10 marks
- 9700/41 N25 Q1 ▪ 9 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

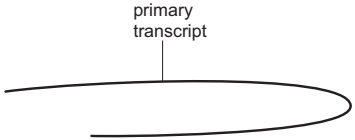
Question 3

9700/24 N25 ▪ Q3 ▪ 10 marks

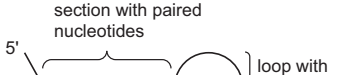
3 Small interfering RNA (siRNA) is a short length of double-stranded RNA (dsRNA), approximately 21 to 25 nucleotides long. siRNA helps to regulate protein synthesis in cells.

(a) Fig. 3.1 is an outline summary of one way in which a primary transcript can be processed to produce a molecule of siRNA. The transcript does **not** code for a sequence of amino acids.

step 1: a primary transcript is synthesised from one strand of DNA



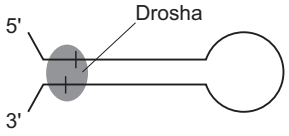
step 2: the primary transcript loops and a section of the RNA becomes



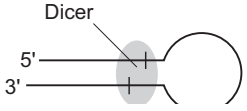
Question 3

a section of the RNA becomes double stranded

step 3: the enzyme Drosha attaches and cleaves (cuts) the RNA to produce a shorter length



step 4: in the cytoplasm, the enzyme Dicer attaches and cleaves the RNA



Question 3

Question 3

and has 2 unpaired nucleotides at each 3' end, is produced

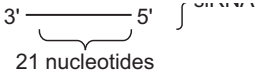


Fig. 3.1

(i) In **step 2** in Fig. 3.1, the single-stranded primary transcript loops and forms a section where dsRNA is present.

Explain how it is possible for the double-stranded section of RNA to be held together in **step 2** and maintained this way in **steps 3**, **4** and **5**.

Question 3

(ii) After **step 3**, the shorter dsRNA produced by the action of Drosha is transported to the cytoplasm, where it is cleaved further by Dicer to produce ds siRNA.

Suggest why two different enzymes, Drosha and Dicer, are needed to cut dsRNA into shorter lengths.

Question 3

(b) From 2018, siRNA has been used as a therapeutic drug to treat a number of diseases.

The presence of molecules of siRNA in the cytoplasm can result in the cleavage of messenger RNA (mRNA) molecules coding for a protein involved in the disease. This prevents the synthesis of the protein.

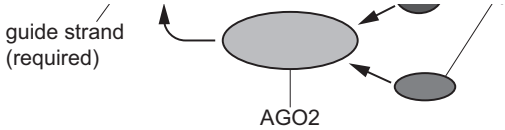
Describe the differences between a molecule of mRNA and a molecule of siRNA, such as the siRNA shown in **step 5** in Fig. 3.1.

Question 3

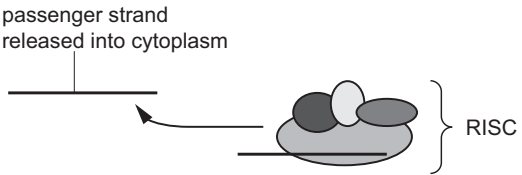
(c) Fig. 3.2 summarises how mRNA coding for a protein involved in disease can be targeted and cleaved by siRNA.

Question 3

siRNA and other proteins to form a complex known as RISC



passenger strand is separated from RISC



RISC uses guide strand to

Question 3

Question 3

for cleavage

Fig. 3.2

(i) With reference to Fig. 3.2, state why the passenger strand needs to be separated and released from the RISC.

Question 3

(ii) The aim of siRNA therapy is to prevent or decrease the synthesis of a protein involved in the disease being treated.

A target mRNA molecule can be cleaved in a different location by a RISC with a different siRNA.

Suggest how cleaving mRNA in different locations will have different effects on protein synthesis **and** explain how these different effects can result in a lack of functioning protein.

Question 3

[Total: 10]

Solution 3

(a)(i) Mark scheme

- if DNA or thymine stated within response, allow only H-bond mark (ecf)
- any two from:
- (paired section) contains, complementary nucleotides / complementary bases / base pairs ;
- adenine-uracil and guanine/cytosine ; A A/U and G/C
- (paired by) hydrogen / H, bonds ; I strong (bonds) ecf from mp1
- R if another bond also named
- I phosphodiester bonds between, adjacent / AW, nucleotides

Solution 3

- 2

Solution 3

(a)(ii) Mark scheme

- any two from:
- (enzyme / Drosha / Dicer) active site is specific (to site on dsRNA) ;
- can apply in context of specific shaped active site or active site specific to a particular location
- detail of different active sites of Drosha and Dicer ;
- site to be cleaved / AW, (only), fits into / can bind with / is complementary to (the specific) active site
- forms enzyme-substrate complex at a particular site

Solution 3

- Drosha and Dicer require different, conditions / cell locations, to function ;
- AVP ; e.g. suggestion that Dicer too large to enter nucleus
- Drosha exposed to degradation in cytoplasm
- 2
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Solution 3

(b) Mark scheme

- any two from:
- mRNA is single-stranded and siRNA is double-stranded ;
- A polynucleotide / chain, for strand
- siRNA has paired and unpaired nucleotides
- or
- mRNA has, only unpaired nucleotides / no base pairing ;
- mRNA codes for a, sequence of amino acids / protein ; ora for siRNA
- mRNA has a longer sequence of nucleotides ;

Solution 3

- A mRNA, is longer / has more nucleotides
- AVP ; e.g. ref. to siRNA antiparallel / mRNA only 5' to 3'
- mRNA has no H bonds
- 2

Solution 3

(c)(i) Mark scheme

- any one from:
- RISC must, align with / attach to / form H bonds with, (target) mRNA ;
- (passenger strand needs to be, separated / released) to allow guide strand to, be exposed / bind to mRNA ; AW
- ora e.g. (otherwise) guide strand cannot bind to mRNA
- passenger strand prevents guide strand binding
- guide strand has complementary sequence to target sequence of mRNA ;
- ora passenger strand does not ….

Solution 3

- 1
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Solution 3

(c)(ii) Mark scheme

- allow protein for polypeptide
- points need the correct context of cleaved mRNA
- any three from:
- no protein formed
- 1 idea that mRNA may be degraded in cell before attaching to ribosome ;
- 2 mRNA may not (be able to) attach to ribosome so no, polypeptide formed / translation ;
- 3 cleaved mRNA results in loss of start, sequence / codon ;

Solution 3

- abnormal polypeptide formed
- 4 polypeptide chain is not released from ribosome ;
- A cleaved mRNA results in loss of stop codon
- 5 polypeptide chain degraded within cytoplasm / AW ;
- 6 cleaved mRNA results in short(er) (polypeptide) chain being produced ;
- 7 polypeptide does not, fold up / form correct tertiary structure / form correct 3D shape ; I tertiary structure changes
- 8,9 AVP ; e.g. (results in) different R-group interactions / change in number of bonds that can form
- active site / site of activity, changed / lost
- 3

Solution 3

- 9700/24
- October/November 2025

Question 1

9700/41 N25 ▪ Q1 ▪ 9 marks

1 Guinea pigs, *Cavia porcellus*, vary in the length and colour of their fur.

Fig. 1.1 shows a guinea pig with short black fur.

Fig. 1.1

Question 1

Two genes that determine the length and colour of the fur occur at the **A**/**a** locus and the **B**/**b** locus. These two gene loci are on separate autosomal chromosomes.

- The allele **A** results in short fur.
- The allele **a** results in long fur.
- **A** is dominant to **a**.

- The allele **B** results in black fur.
- The allele **b** results in chocolate fur.
- **B** is dominant to **b**.

(a) **(i)** List **all** the possible genotypes of a guinea pig with short black fur.

Question 1

(ii) A test cross could be used to determine the genotype of a female guinea pig with short black fur.

Describe the **phenotype** of the male guinea pig that could be used to carry out this test cross.

Question 1

(b) A black guinea pig with long fur that was homozygous at both loci was crossed with a chocolate guinea pig with short fur that was homozygous at both loci. The F1 offspring of this cross had short black fur. F1 offspring were mated together to produce the F2 offspring.

Complete the Punnett square to:

- show the cross between the F1 offspring
- predict the F2 offspring genotypes.

You should include the gametes in your answer.

State the ratio of F2 offspring phenotypes. You should include a key to link phenotypes to genotypes.

Question 1

Question 1

ratio of F2 offspring phenotypes:

Question 1

Question 1

[4]

(c) Some genes in guinea pigs are structural genes and some are regulatory genes.

Describe the difference between a structural gene and a regulatory gene.

Question 1

[Total: 9]

Solution 1

(a)(i)

Mark scheme

- AABB AABb AaBB AaBb ; ;
- 2

(a)(ii)

Mark scheme

- long chocolate ;
- 1

Solution 1

(b) Mark scheme

- ;
- AB
- Ab
- aB
- Ab
- AB
- AABB
- AABb

Solution 1

- AaBB
- AaBb
- Ab
- AABb
- AAbb
- AaBb
- Aabb
- aB
- AaBB
- AaBb

Solution 1

- aaBB
- aaBb
- Ab
- AaBb
- Aabb
- aaBb
- aabb ;
- F2 offspring phenotype number ratio:
- 9 : 3 : 3 : 1 ;
- short short long long

Solution 1

- black chocolate black chocolate ;
- Mp 4 need phenotypes linked to genotypes by colour, symbol or initials
- 4

Solution 1

(c) Mark scheme

- 1
- structural gene codes for, (named) structural / functional, protein / polypeptide ;
- 2
- regulatory gene codes for, transcription factor / repressor protein
- or
- regulatory gene, controls / helps / restricts, expression of (other) genes ;
- 2
- A

Solution 1

- b
- A
- B
- a
- B
- a
- b
- A
- b
- A

Solution 1

- B
- a
- B
- a
- b
- 9700/41
- October/November 2025