Past-paper walk-through

Proteins ▪ 1.7

eXercise

Questions in this set

- 2025 Q1
- 2017 Q3

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 1

2025 ▪ Q1

Most proteins that are secreted from a cell must be transported to the endoplasmic reticulum (ER) either during translation or after translation.

(a) Describe the function of ribosomes.

For proteins transported during translation, this process begins in the cytosol and pauses when a specific sequence of amino acids is translated. The translation complex is then transported to the surface of the ER where translation continues. Proteins that are transported after translation are translated entirely in the cytosol and then transported to the ER. In both instances, the translated proteins enter the ER through a protein channel in the membrane of the ER.

Researchers studying the two types of protein transport identified that the ER membrane protein SR is necessary for transport during translation, while the ER membrane protein Sec62 is necessary for transport after translation. To investigate

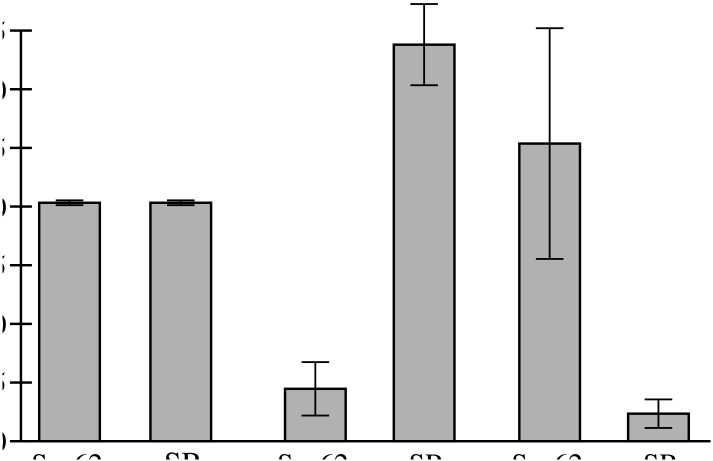
Question 1

which transport mechanism is used for different proteins, researchers first created small interfering RNAs (siRNAs) that reduce expression of either SR or Sec62. They then treated groups of cells with either the SR siRNA or the Sec62 siRNA and determined the relative amount of SR and Sec62 protein in each group of cells compared with cells treated with a control siRNA (Figure 1).

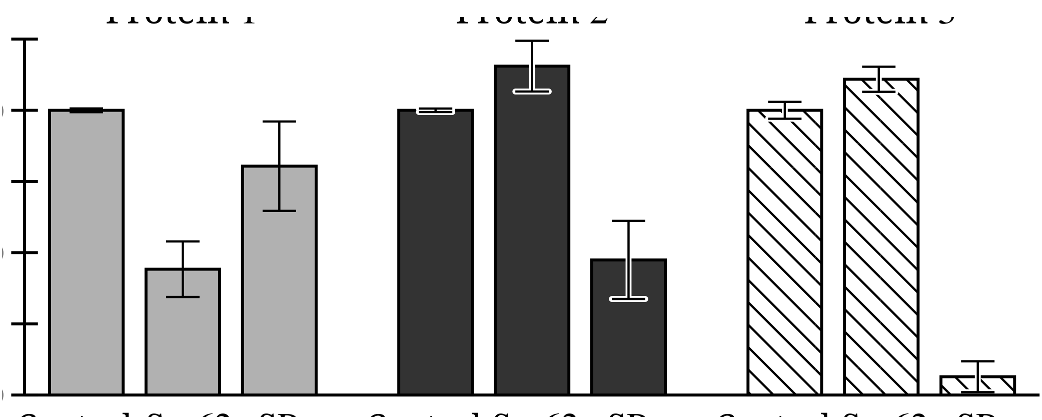
Figure 1. Average relative amounts of Sec62 and SR proteins in cells treated with control siRNA, Sec62 siRNA, or SR siRNA. Error bars represent $\pm SE_{\bar{x}}$.

[Bar graph; y-axis "Relative Protein Content (

Question 1



Question 1



Question 1

2025 ▪ Q1

Most proteins that are secreted from a cell must be transported to the endoplasmic reticulum (ER) either during translation or after translation.

(b)(i) Identify the dependent variable in the experiments shown in Figure 1.

(b)(ii) Justify why the researchers included the control of measuring the relative amounts of both Sec62 and SR proteins in cells that were treated with Sec62 siRNA only (data shown in Figure 1).

(b)(iii) Based on Figure 1, describe the effect on the production of SR protein when cells are treated with Sec62 siRNA.

Question 1

2025 ▪ Q1

Most proteins that are secreted from a cell must be transported to the endoplasmic reticulum (ER) either during translation or after translation.

(c)(i) The researchers then measured the amount of each of three different proteins that was transported to the ER in cells treated with Sec62 siRNA or SR siRNA. The researchers calculated the percent transported relative to the cells treated with control siRNA (Figure 2).

Figure 2. Average relative amounts of three proteins that were transported to the ER when treated with control siRNA, Sec62 siRNA, or SR siRNA. Error bars represent $\pm SE_{\bar{x}}$.

[Bar graph; y-axis "Relative Amount of Protein Transported to the ER (

Identify the independent variable in the researchers' second experiment (data shown in Figure 2).

Question 1

(c)(ii) Based on Figure 2, identify the protein(s) that when treated with Sec62 siRNA showed an increase in percent transport to the ER compared with the control.
(c)(iii) Protein 1 is encoded by 234 nucleotides, while protein 2 is encoded by 495 nucleotides. Assuming all nucleotides for both proteins encode amino acids, calculate the difference in the number of amino acids between the two proteins.

Question 1

2025 ▪ Q1

Most proteins that are secreted from a cell must be transported to the endoplasmic reticulum (ER) either during translation or after translation.

(d)(i) Researchers claim that protein 1 is the only tested protein that is transported to the ER following its complete translation in the cytosol. Using data from Figure 2, support the researchers' claim.

(d)(ii) For any protein that enters the ER, researchers claim that amino acids close to the protein's amino terminus determine how likely the protein is to pass through the protein channel within the ER membrane. Justify the researchers' claim based on your understanding of factors that affect the transport of proteins across membranes.

Solution 1

(a)

Mark scheme

- Ribosomes synthesize polypeptides/proteins by carrying out translation; ribosomes are the sites of polypeptide/protein synthesis.

Solution 1

(b)(i)

Mark scheme

- The dependent variable is the (relative) amount of protein / protein content — i.e., the relative amounts of Sec62 protein and SR protein measured in each treatment group in Figure 1.

Solution 1

(b)(ii)

Mark scheme

- Measuring both Sec62 and SR protein levels in cells treated with Sec62 siRNA only let researchers determine whether the Sec62 siRNA reduced/affected the content of both proteins (i.e., acted nonspecifically), or reduced/affected only Sec62 protein content (i.e., acted specifically on its target), relative to protein content in cells treated with the control siRNA.

Solution 1

(b)(iii)

Mark scheme

- SR protein production increased when cells were treated with Sec62 siRNA (Figure 1 shows SR protein content rising to roughly 170% of control, an increase of about 65%; accept any answer describing an increase in the 50–80% range).

Solution 1

(c)(i)

Mark scheme

- The independent variable in the second experiment (Figure 2) is the type of siRNA added to the cells (control siRNA, Sec62 siRNA, or SR siRNA) — equivalently, which protein pathway (Sec62-dependent vs SR-dependent) was being disrupted for each of the three tested proteins.

Solution 1

(c)(ii)

Mark scheme

- Protein 2 and/or Protein 3 showed an increase in percent transport to the ER when cells were treated with Sec62 siRNA, compared with the control (Protein 1 instead showed a decrease).

Solution 1

(c)(iii)

Mark scheme

- 87 amino acids. Protein 1: $234/3 = 78$ amino acids. Protein 2: $495/3 = 165$ amino acids. Difference $= 165 - 78 = 87$ amino acids. Full credit requires the numeric answer 87 with a correct division-by-3 (codon-to-amino-acid) setup shown.

Solution 1

(d)(i)

Mark scheme

- Only protein 1 showed a reduced amount/percentage of transport to the ER when cells were treated with Sec62 siRNA (Figure 2); proteins 2 and 3 did not show a comparable reduction with Sec62 siRNA, but did drop sharply with SR siRNA — supporting that protein 1 alone depends on the post-translational (Sec62) pathway after complete cytosolic translation, while proteins 2 and 3 depend on the co-translational (SR) pathway.

Solution 1

(d)(ii)

Mark scheme

- Amino acids near the amino terminus that have similar polarity to — or opposite charge to — the R groups lining the ER protein channel are more likely to pass through the channel, compared with an amino terminus whose amino acids have dissimilar polarity or similar (like) charge to the channel lining, since like charges repel and dissimilar polarity resists favorable interactions needed to move through the channel.

Question 3

2017 ▪ Q3

Gibberellin is the primary plant hormone that promotes stem elongation. GA 3-beta-hydroxylase (GA3H) is the enzyme that catalyzes the reaction that converts a precursor of gibberellin to the active form of gibberellin. A mutation in the *GA3H* gene results in a short plant phenotype. When a pure-breeding tall plant is crossed with a pure-breeding short plant, all offspring in the F_1 generation are tall. When the F_1 plants are crossed with each other, 75 percent of the plants in the F_2 generation are tall and 25 percent of the plants are short.
Second Base in Codon

First \ Second	**U**	**C**	**A**	**G**	**Third**
U	UUU, UUC = Phe; UUA, UUG = Leu	UCU, UCC, UCA, UCG = Ser	UAU, UAC = Tyr; UAA = Stop; UAG = Stop	UGU, UGC = Cys; UGA = Stop; UGG = Trp	U, C, A, G
C	CUU, CUC, CUA, CUG = Leu	CCU, CCC, CCA, CCG = Pro	CAU, CAC = His; CAA, CAG = Gln	CGU, CGC, CGA, CGG = Arg	U, C, A, G
A	AUU, AUC, AUA = Ile; AUG = Met or Start	ACU, ACC, ACA, ACG = Thr	AAU, AAC = Asn; AAA, AAG = Lys	AGU, AGC = Ser; AGA, AGG = Arg	U, C, A, G
G	GUU, GUC,	GCU, GCC, GCA, GCG =	GAU, GAC	GGU, GGC,	U, C, A, G

Question 3

Figure 1. The universal genetic code

(a) The wild-type allele encodes a GA3H enzyme with alanine (Ala), a nonpolar amino acid, at position 229. The mutant allele encodes a GA3H enzyme with threonine (Thr), a polar amino acid, at position 229. **Describe** the effect of the mutation on the enzyme and **provide reasoning** to support how this mutation results in a short plant phenotype in homozygous recessive plants.

(b) Using the codon chart provided, **predict** the change in the codon sequence that resulted in the substitution of alanine for threonine at amino acid position 229.

(c) **Describe** how individuals with one (heterozygous) or two (homozygous) copies of the wild-type *GA3H* allele can have the same phenotype.

Question 3

Second Base in Codon

First Base in Codon	U	C	A	G	Third Base in Codon
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met or Start	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

Solution 3

(a)

Mark scheme

- Description (1 point): the amino acid substitution (Ala$\rightarrow$Thr, nonpolar$\rightarrow$polar) changes the shape/structure/function of the GA3H protein. Reasoning (1 point): the altered/less-functional enzyme decreases or eliminates gibberellin production, and because gibberellin promotes stem elongation, low gibberellin in homozygous recessive plants results in the short phenotype.

Solution 3

(b)

Mark scheme

- Any one correctly stated codon-change representation earns the point: G$\leftrightarrow$A in the first position of the second base of the codon, i.e., 5'-GCN-3' (Ala) $\leftrightarrow$ 5'-ACN-3' (Thr); equivalently on the DNA template strand, 5'-NGC-3' $\leftrightarrow$ 5'-NGT-3'.

Solution 3

(c)

Mark scheme

- Enough active GA3H enzyme is produced from just one wild-type/dominant allele (the wild-type allele is dominant), so enough gibberellin is produced in both heterozygotes and homozygous-dominant plants, giving them the same (tall) phenotype.