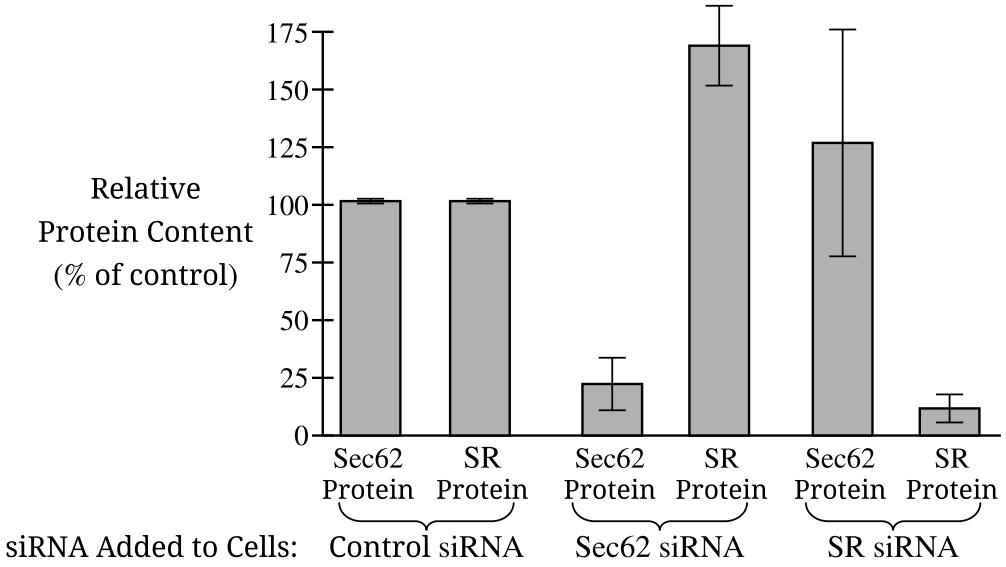
1. Most proteins that are secreted from a cell must be transported to the endoplasmic reticulum (ER) either during translation or after translation.

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 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 $\pm SE_{\bar{x}}$.



B.

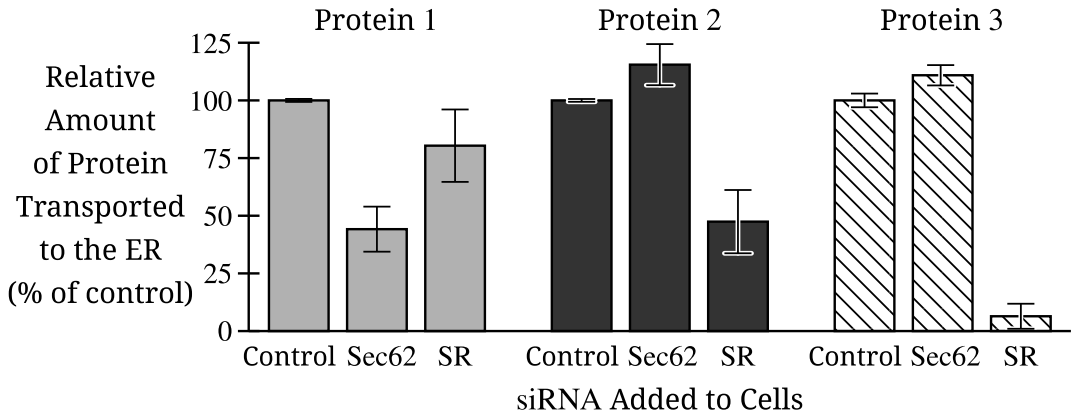
i. **Identify** the dependent variable in the experiments shown in Figure 1.

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).

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

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 $\pm SE_{\bar{x}}$.



C.

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

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.

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.

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.

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.

Question 1: Interpreting and Evaluating Experimental Results 9 points

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

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 which transport mechanism is used for different proteins, researchers first created small interfering RNAs (siRNAs) that reduce expression of either SR or Sec 62. They then treated groups of cells with either the SR siRNA or the Sec62 siRNA and determined the relative amount of SR and Sec 62 protein in each group of cells compared with cells treated with a control siRNA. (Figure 1).

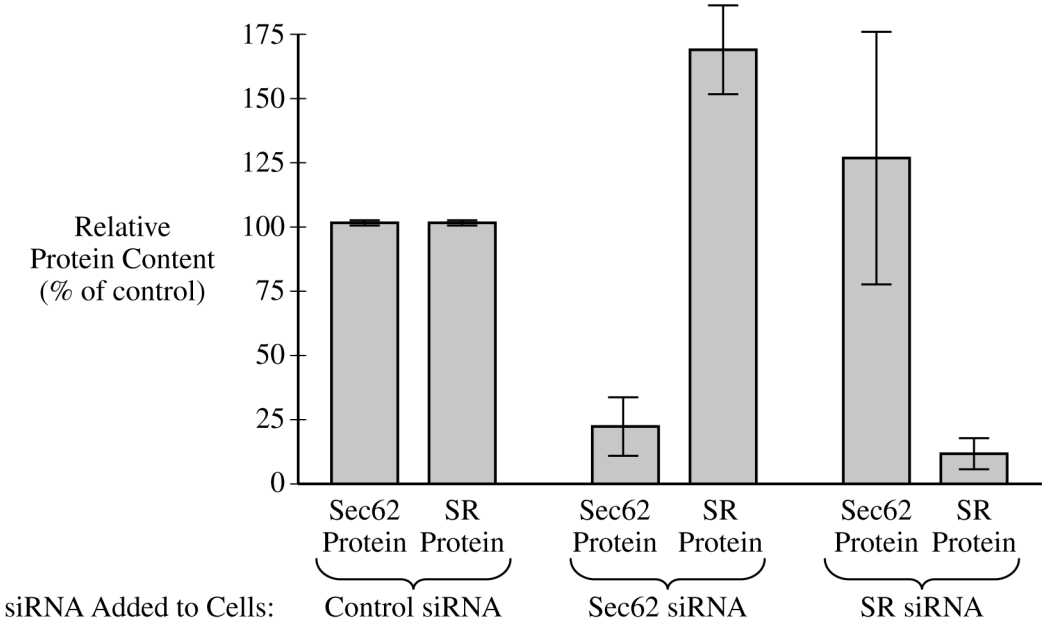


Figure 1. Average relative amounts of Sec62 and SR proteins in cells treated with control siRNA, Sec62 siRNA or SR siRNA. Error bars represent $\pm SE_{\bar{X}}$.

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).

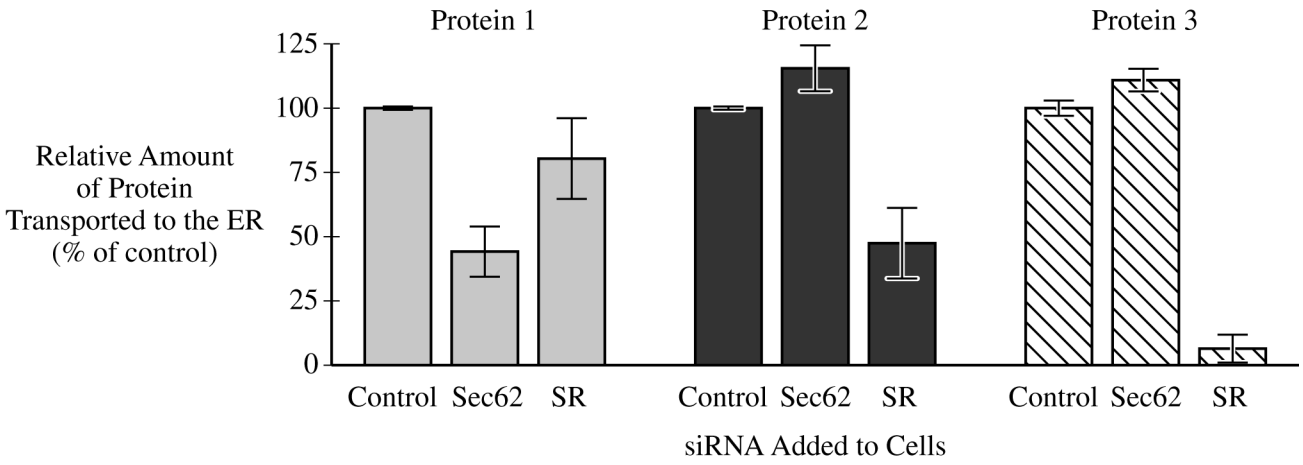


Figure 2. Average relative amounts of three proteins that were transported to the ER when treated with control siRNA, Sec62 siRNA, or SR siRNA. Error bars represent $\pm SE_{\bar{X}}$.

A	**Describe** the function of ribosomes. Examples of acceptable responses may include the following: • Ribosomes synthesize polypeptides/proteins. • Ribosomes perform translation. • Ribosomes are sites of polypeptide/protein synthesis.	**Point A1**
B	(i) **Identify** the dependent variable in the experiments shown in Figure 1. • The (relative) amount of protein/protein content	**Point B1**
	(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). Examples of acceptable responses may include the following: • (The control allowed the researchers) to determine whether the (Sec62) siRNA reduced/affected the content of both proteins (relative to protein content in the presence of the control siRNA). • (The control allowed the researchers) to determine whether the (Sec62) siRNA reduced/affected Sec62 (protein content) only.	**Point B2**
	(iii) Based on Figure 1, **describe** the effect on the production of SR protein when cells are treated with Sec62 siRNA. Examples of acceptable responses may include the following: • (SR protein production) increased. • (SR protein production) increased by 65% (accept 50–80%).	**Point B3**

A	Based on Figure 1A, **identify** the fly genotype in which the average percent of metaphase cells with ALD-associated filaments is close to 12%. • *ald1/del*	**1 point**
B	Based on Figure 1B, **describe** the difference in ALD protein production between gamete-forming metaphase cells of flies with the genotype *ald3*/*ald23* and flies with the genotype *ald23*/*del*. Examples of acceptable responses may include the following: • More ALD protein is produced by *ald3*/*ald23* cells (than by *ald23*/*del* cells). • Less ALD protein is produced by *ald23*/*del* cells (than by *ald3*/*ald23* cells). • No ALD protein is produced by *ald23*/*del* cells (whereas it is produced by *ald3*/*ald23* cells).	**1 point**
C	Scientists hypothesize that gamete-forming metaphase cells can produce a normal amount of ALD-associated filaments even when they produce about half as much ALD protein as the wild-type cells produce. Use the data in Figures 1A and 1B to **support** the scientists' hypothesis. Examples of acceptable responses may include the following: • (With half as much protein) the *WT/del* cells show no difference in percent of (gamete forming metaphase cells with) ALD-associated filaments. • The data for the *WT/del* relative to/in comparison with the *WT/WT* cells support the scientists' hypothesis.	**1 point**
D	For gamete-forming metaphase cells of the *WT*/*del* and *ald1*/*del* flies, **explain** why the phenotypes observed in Figure 1A differ even though the amount of ALD protein produced (Figure 1B) does not. Examples of acceptable responses may include the following: • (The phenotypes) differ because only the *WT*/*del* flies produce enough functional (ALD) protein to generate a wild-type phenotype. • When one allele encodes functional ALD protein (in *WT/del* flies), the flies can generate a wild-type phenotype/produce ALD-associated filaments in a similar amount as *WT/WT* flies. • Both genotypes produced ALD protein, but the *ald1* mutation resulted in a protein with reduced function (compared with *WT*, resulting in a different phenotype).	**1 point**