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## Supplemental Materials

for

### The Development and Implementation of an Instrument to Assess Students' Data Analysis Skills in Molecular Biology

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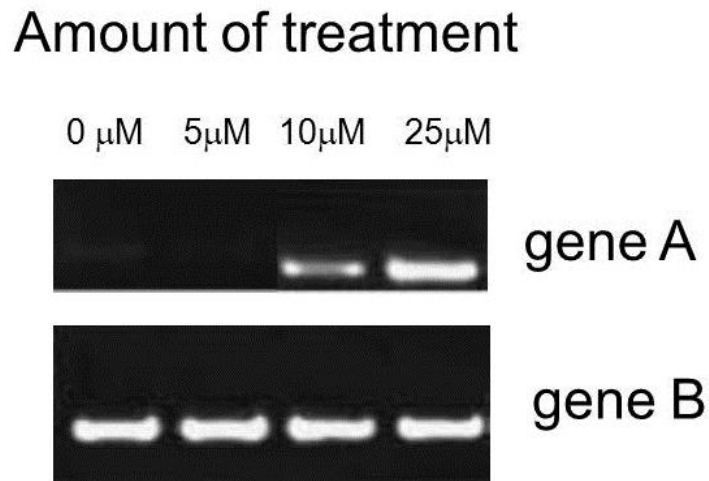
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**Appendix 1:** Molecular biology data analysis test – instrument and answer key.

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Dr. Smith studies many genes that are involved in the development of lung cancer. She uses an *in vitro* system with cultured mouse lung cells. First, she hypothesizes that both the mRNA levels from *gene A* and mRNA from *gene B* will decrease with increasing amounts of treatment. Below are the results of one reverse transcription PCR assay measuring amounts of mRNA of *genes A* and *B*. Equal amounts of total mRNA were loaded in each lane.



- 1) What is this assay measuring?
  - a) number of cells producing mRNA
  - b) amount of gene expression
  - c) the size of genes A and B
  - d) amount of protein expression
  - e) I don't know
  
- 2) Which statement BEST describes the data above?
  - a) both *gene A* and *gene B* mRNA levels increase with increasing amounts of treatment
  - b) *gene A* mRNA levels increase over time and *gene B* mRNA levels stay the same over time
  - c) *gene A* and *gene B* mRNA levels increase to the same level with the highest amount of treatment
  - d) *gene A* mRNA levels increase while *gene B* mRNA levels stay the same as treatment levels increase
  - e) I don't know

- 3) Which of the following is the BEST negative control for this experiment?
- a) amount of mRNA of *gene B*
  - b) total number of cells which express *genes A* and *B*
  - c) amount of mRNA from cells without treatment
  - d) total number of cells used in the experiment under all conditions
  - e) I don't know
- 4) Which of the following would NOT be a next logical experiment to perform?
- a) determine the amount of mRNA of *genes A* and *B* in brain cells
  - b) determine if *genes A* and *B* are expressed at similar levels in live mice with lung cancer
  - c) determine if the amount of mRNA of *genes A* and *B* are similar in human lung cancer cells
  - d) measure the amount of proteins *A* and *B* in lung cancer cells
  - e) I don't know
- 5) Do the results of the experiment support Dr. Smith's hypothesis? Why or why not?
- a) Yes, the results match with what she proposed would happen
  - b) Yes, the results indicate an increase in *gene A*
  - c) No, since *gene A* increases over time, and *gene B* stays the same
  - d) No, since the genes are interacting with each other
  - e) I don't know
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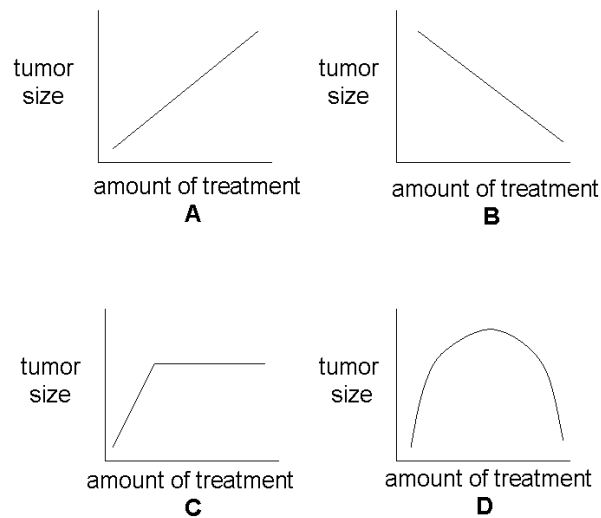
Dr. Smith is also interested in how Proteins C and D may be involved in lung cancer. The data was taken from an experiment using human lung cells. From the data below, answer the following questions.

<b>Protein C</b>		<b>Protein D</b>	
<b>Time (hours)</b>	<b>Amount of C (ng)</b>	<b>Time (hours)</b>	<b>Amount of D (ng)</b>
0	0	0	0
2	4	2	10
4	10	4	12
6	4	6	14
8	11	8	10
10	4	10	5
12	12	12	0

- 6) What statement describes the data above most accurately?
- a) The amount of protein C and protein D increase at the same rate
  - b) At 12 hrs, there is more protein D than protein C
  - c) The greatest amount of protein C occurs at time 12 hrs whereas the greatest amount of protein D occurs at time 4 hrs
  - d) The amount of protein C fluctuates from high amounts to lower amounts more often than D
  - e) I don't know
- 7) Which of the following would NOT be an appropriate control for this experiment?
- a) measure the amounts of protein C and D between 12 and 24 hrs
  - b) compare the data against known amounts of a different protein to ensure the assay provides accurate measurements
  - c) repeat the same experiment for consistency
  - d) I don't know

8) Which of the following is the best conclusion from the data above?

- a) genes C and D interact in human cells
  - b) proteins C and D interact in human cells
  - c) proteins C and D are regulated in a cyclic manner but with different rates
  - d) genes C and D cause lung cancer but at different times
  - e) I don't know
- 



Which graph best describes the following statements?

9) As the amount of treatment increases, the size of the tumor decreases

- a) A
- b) B
- c) C
- d) D
- e) None of the above

10) As the amount of treatment increases, the size of the tumor increases up to a certain point. With more treatment, the size of the tumor remains the same.

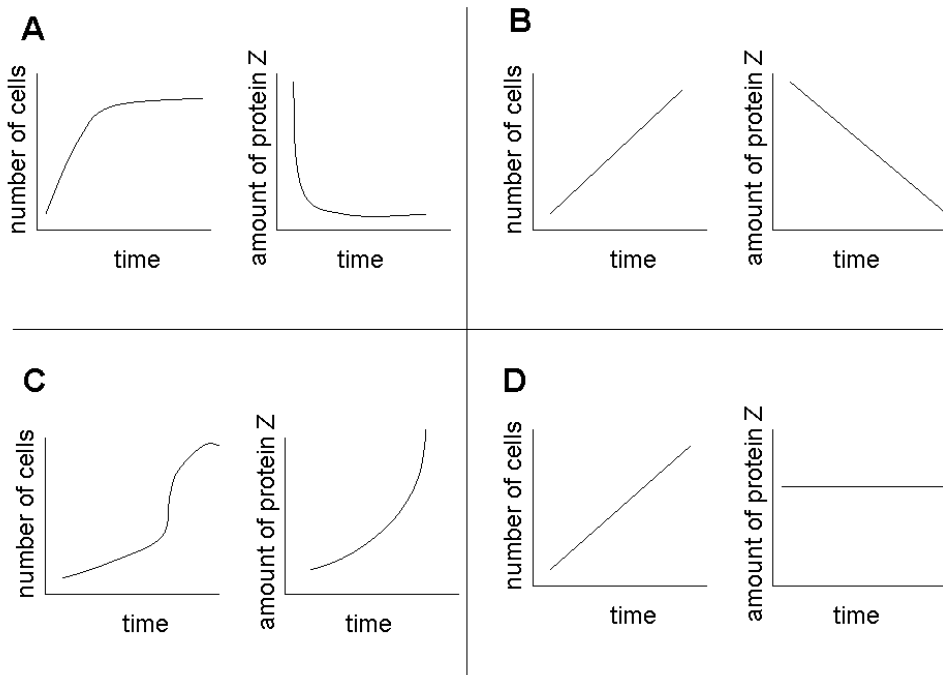
- a) A
- b) B
- c) C
- d) D
- e) None of the above

11) As the amount of treatment increases, the tumor size decreases and then levels off

- a) A
- b) B
- c) C
- d) D
- e) None of the above

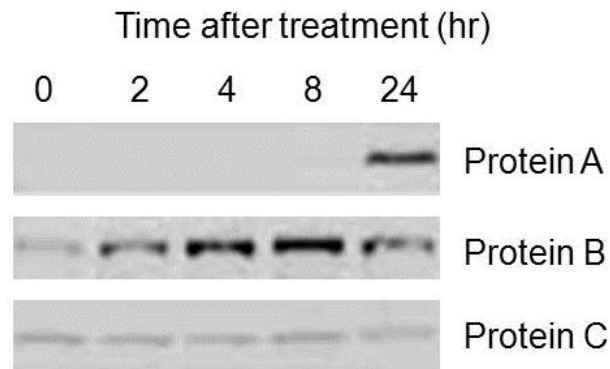
12) Sue studied breast cancer cells over a 24 hour period. She measured the amount of protein Z produced by the cells. She concluded that as the number of cells increased, the amount of protein Z decreased.

Which pair of graphs best support her conclusion?



- a) A
- b) B
- c) C
- d) D
- e) I don't know

Mary hypothesizes that proteins A and B inhibit the growth of cells, and that a treatment causing increased amounts of proteins A and B leads to decreased cell division. The following Western blot shows the results of a preliminary experiment.



13) Which of the following is true?

- a) protein A is larger than B and C since it is above proteins B and C
- b) protein B is larger than A and C since there is more of it present during the time course
- c) protein C is larger than A and B since it is below proteins A and B
- d) the weight of the proteins cannot be determined from the figure
- e) I don't know

14) Which of the following pieces of data is needed to further support Mary's hypothesis?

- a) the number of cells measured at each time point
- b) the amount of mRNA from the cells for proteins A, B, and C
- c) the total amount of protein collected at each time point
- d) amount of proteins A, B, and C measured at 48 hrs after treatment
- e) I don't know

15) If cell division is measured and decreases over time, which of the following is a valid conclusion?

- a) the amount of gene expression of A, B, and C will be similar to their protein levels
- b) the more cells divide, increased amounts of proteins A and B will be produced
- c) the original hypothesis is supported

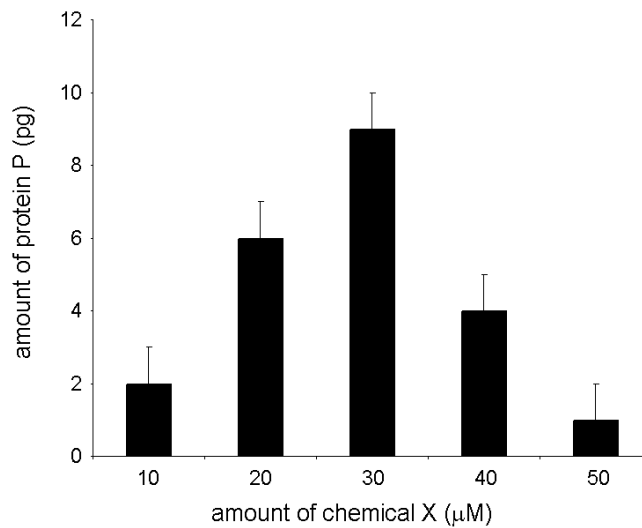
- d) only protein A causes a decrease in cell division
- e) I don't know

16) Which of the following is the BEST follow-up experiment?

- a) genetically manipulate cells to express high amounts of proteins A and B, and measure cell division in these cells
- b) measure cell division rates after 48 hrs treatment
- c) block expression of protein C and measure amounts of proteins A and B
- d) measure the amount of proteins A, B, and C in cells that are not dividing
- e) I don't know

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David treated cells with different amounts of chemical X. He measured the amount of protein P after 48 hrs of treatment.



17) One group of cells was given 35  $\mu\text{M}$  of chemical X, what would be the expected amount of protein P produced?

- a) 3 pg
- b) 7 pg
- c) 9 pg



- d) 11pg
- e) I don't know

18) If the cells produce exactly 4 pg of protein P, how much of chemical X was added?

- a) 2  $\mu\text{M}$
- b) 30  $\mu\text{M}$
- c) 40  $\mu\text{M}$
- d) 50  $\mu\text{M}$
- e) I don't know

19) The following statements describe the relationship between the amount of chemical X and the amount of protein P produced. What is the BEST description?

- a) As the amount of chemical X increased to 30  $\mu\text{M}$ , the amount of protein P decreased. With amounts greater than 30  $\mu\text{M}$ , the amount of protein P increased.
- b) Both the amount of chemical X and the amount of protein P increased up to 30  $\mu\text{M}$ . Then they both decreased.
- c) As the amount of chemical X increased to 30 $\mu\text{M}$ , the amount of protein P increased quickly. After 30  $\mu\text{M}$  of chemical X, the amount of protein P increased more slowly.
- d) As the amount of chemical X increased to 30  $\mu\text{M}$ , the amount of protein P increased. With amounts greater than 30  $\mu\text{M}$ , the amount of protein P decreased.
- e) I don't know

20) How much protein P would most likely be produced if the cells were given 60  $\mu\text{M}$  of chemical X?

- a) 0 pg
- b) 2 pg
- c) 4 pg

d) 20 pg

e) I don't know

## ANSWER KEY

1) B

2) D

3) C

4) A

5) C

6) D

7) A

8) C

9) B

10) C

11) E

12) B

13) D

14) A

15) C

16) A

17) B

18) C

19) D

20) A