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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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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.

Amount of treatment

0 µM   5µM   10µM   25µM
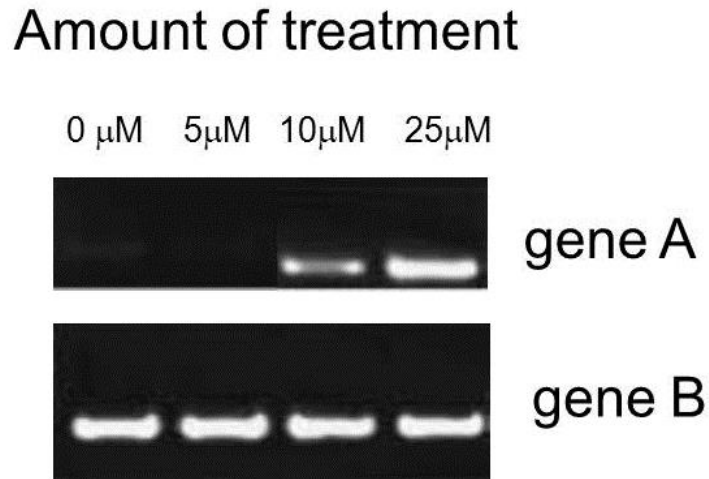
gene A

gene B

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
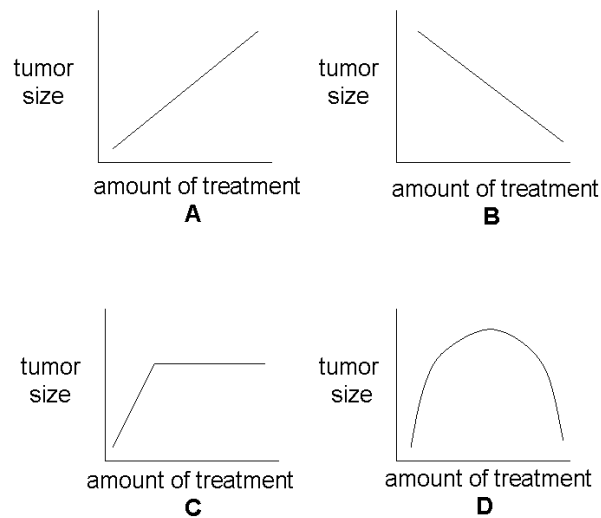
    e) I don't know

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.

Protein C		**Protein D**	
Time (hours)	**Amount of C (ng)**	**Time (hours)**	**Amount of D (ng)**
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

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tumor size / amount of treatment — A

tumor size / amount of treatment — B

tumor size / amount of treatment — C

tumor size / amount of treatment — D

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

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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

B

C

D
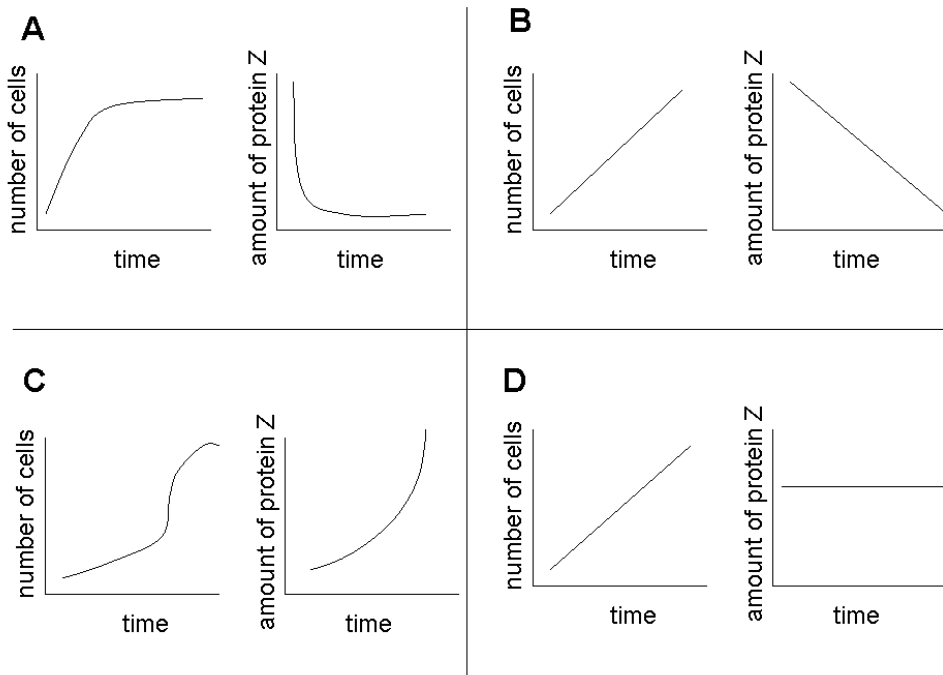
a) A

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.
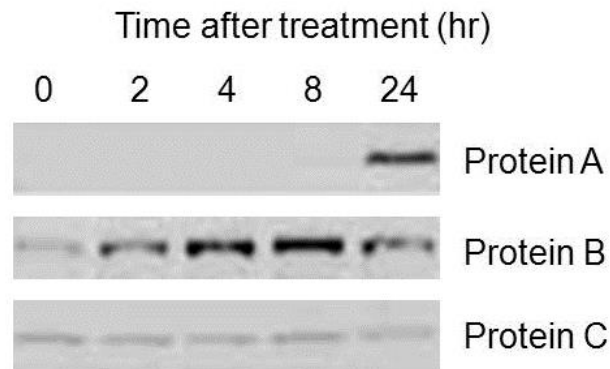
13) Which of the following is true?

    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

David treated cells with different amounts of chemical X. He measured the amount of protein P after 48 hrs of treatment.
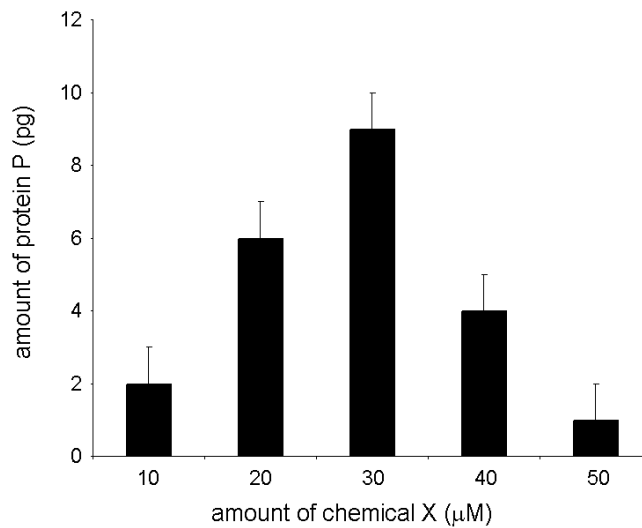
17) One group of cells was given 35 μM of chemical X, what would be the expected amount of protein P produced?

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 μM

    b) 30 μM

    c) 40 μM

    d) 50 μM

    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 μM, the amount of protein P decreased. With amounts greater than 30 μM, the amount of protein P increased.

    b) Both the amount of chemical X and the amount of protein P increased up to 30 μM. Then they both decreased.

    c) As the amount of chemical X increased to 30μM, the amount of protein P increased quickly. After 30 μM of chemical X, the amount of protein P increased more slowly.

    d) As the amount of chemical X increased to 30 μM, the amount of protein P increased. With amounts greater than 30 μM, 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 μM 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