Supplemental Material

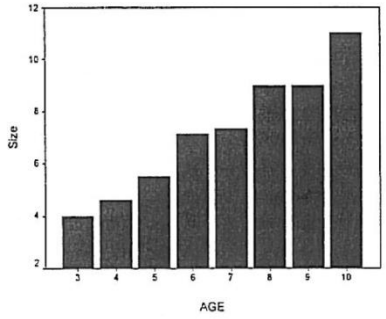
CBE—Life Sciences Education

Flanagan *et al.*

Quantitative Skills for Biology Assessment

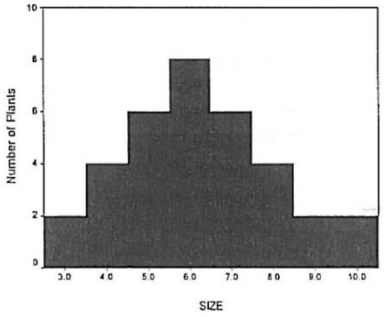
This quiz is designed to measure your quantitative skills and how they change across the semester. We are focusing on skills biologists believe to be relevant to modern biology, although some of the questions may not deal with biology directly. For the problem solving questions, if you have an idea of how to approach the problem, attempt to find the correct answer. If you have no idea where to start, select "I don't know how to approach this problem."

Use the following to answer the question below:



1. This figure supports which of the following statements:
    a. Smaller individuals grow more quickly than old individuals;
    b. Older individuals are larger than younger individuals;
    c. Younger individuals are larger than older individuals;
    d. Size and age are not related in this experiment;

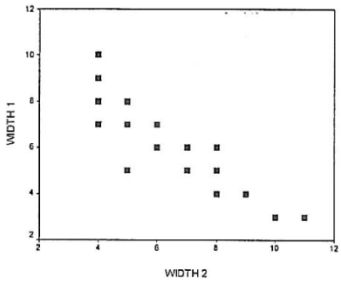
Use the following to answer the question below:



2. The figure supports which of the following statements:
    a. The largest plants measured were approximately 8 units;
    b. Most of the plants measured were about 10 units in size;
    c. The smallest plants measured were in the 0 unit size;
    d. Most plants in the population were very large;
    e. The largest number of measured plants were in the 6 unit size;

3. With the appropriate data, a hypothesis can be proven to be true:
    a. True
    b. False

Use the following to answer the question below:



4. This figure supports which of the following statements:
    a. There seems to be no relationship between Width 1 and Width 2;
    b. As Width 2 gets greater, so does Width 1;
    c. As Width 2 gets greater, Width 1 gets smaller;
    d. As Width 1 gets greater, so does Width 2;
    e. The average size of Width 1 is twice the average size of Width 2;

5. A statistical test used to determine if there is a numerically significant difference in the average values of two different groups of numbers:
    a. ANOVA;
    b. Chi-square test;
    c. Linear regression;
    d. Mean determination;
    e. T-test;

6. A descriptive statistic calculated by summing all numbers in a dataset and then dividing by the sample size:
    a. Alpha;
    b. Mean;
    c. Median;
    d. Mode;
    e. Standard deviation;

7. A certain strain of fruit flies grows exponentially, and in one week, the number of flies increases from 10 to 80. Which of the following would be a good model for the growth of this species, if you started with 10 flies? (read N_t as "number of flies at week t")
    a. $10 = N_t * t^8$
    b. $N_t = 10 * t^8$
    c. $N_t = 10 * 8^t$
    d. $N_t = 8t + 10$
    e. I don't know how to approach this problem.

8. A biologist is interested in the effect of temperature on growth in fish. She sets up 10 ponds with 5 fish in each. Temperature in the ponds is regulated to stay at a constant level of 10 degrees Celsius in the first pond, 12 degrees in the second pond, 14 degrees in the third pond, and so on. After 4 weeks, she weighs each of the fish. Which of the following describes her experiment?

a. temperature is the independent variable, amount of growth is the dependent ***variable***
b. amount of growth is the independent variable, temperature is the dependent variable
c. warm or cold is the independent variable, amount of growth is the dependent variable
d. whether temperature exceed 18 degrees (yes or no) is the independent variable and amount of growth is the dependent variable.
e. I don't know how to approach this problem.

9. In the scenario for the previous question, what type of analysis is most appropriate? (In case you've forgotten the previous question, here it is again: A biologist is interested in the effect of temperature on growth in fish. She sets up 10 ponds with five fish in each. Temperature in the ponds is regulated to stay at a constant level of 10 degrees Celsius in the first pond, 12 degrees in the second pond, and so on. After 4 weeks, she weighs each of the fish.)

    a. making a bar chart comparing final weight of fish in the 5 warmest ponds to fish in the 5 coldest ponds
    b. making a scatterplot of final weight vs. pond temperature and drawing a "best fit" line through the points
    c. doing a goodness of fit test such as chi-square to see whether final weight was randomly distributed
    d. doing a t-test to see whether fish in the 5 warmest ponds had larger final weight than fish in the 5 coldest ponds
    e. I don't know how to approach this problem.

10. A group of students measures the lengths of cockroaches found in a nearby restaurant, and calculates a mean length of 3.1 cm, with a standard deviation of 1.1 cm. Which of the following is most likely true?

    a. about 95% of the cockroaches they found were between 2.0 and 4.2 cm
    b. about 2/3 of the cockroaches they found were between 2.0 and 4.2 cm
    c. about 2/3 of the cockroaches they found were between 0.9 and 5.3 cm
    d. none of the cockroaches they found were below 2.0 or above 4.2 cm
    e. I don't know how to approach this problem.

11. A biologist measures the depth of erosion at one spot on a stream bank over time. The erosion started at 24 cm, and deepened (on average) 2.5 cm per week. Which of the following best describes the depth of erosion over time?

    a. a curved line: depth = $24 + week^{2.5}$
    b. a straight line: depth = 2.5 + 24*week
    c. a straight line: depth = 24 + 2.5*week
    d. a curved line: depth = $24*week^{2.5}$
    e. I don't know how to approach this problem.

12. During a psychology study, a researcher asks girls and boys in a second-grade class to pair up randomly. There are 10 girls and 20 boys. Assuming that the students really do pair off randomly, what fraction of pairs should be all girls, mixed pairs, and all boys? (approximately)?

    a. 1/9, 4/9, 4/9
    b. 1/3, 1/3, 1/3
    c. 1/4, 1/2, 1/4
    d. 1/9, 6/9, 2/9
    e. I don't know how to approach this problem.

13. A rainfall event may be classified as "heavy" if it exceeds 0.3 inches per hour. What is this in mm per minute?

    a. 0.3in/hr * (2.54cm/in) * (10mm/cm) * (60min/1hr)
    b. 0.3in/hr * 2.54 * 10 * 60
    c. 0.3in/hr * (2.54cm/in) * (10mm/cm) * (1hr/60min)
    d. 0.3in/hr * (1 in/2.54cm) * (1cm/10mm) * (60min/1hr)
    e. I don't know how to approach this problem.

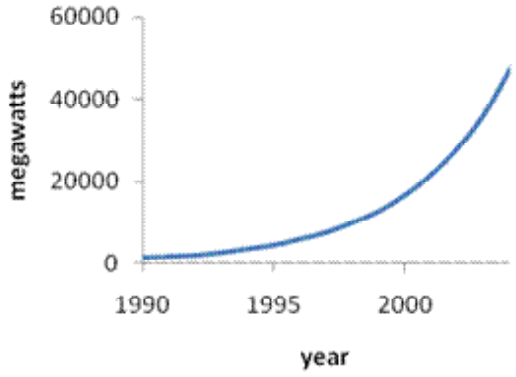
14. A researcher wants to measure the rate of cars going through an intersection. What would be appropriate units to use?

    a. time / speed
    b. cars / time
    c. time / car
    d. cars / distance
    e. I don't know how to approach this problem.

15. A medical lab uses 2 sizes of petri dishes: one has a 30-cm diameter and the other has a 60-cm diameter. How much additional area does the large dish have for cell cultures?

    a. 2 times as much
    b. 4 times as much
    c. 6.25 times as much
    d. 30 times as much
    e. I don't know how to approach this problem.

16. Wind energy has been the fastest growing renewable energy sector over the past 2 decades, with growth averaging about 30% per year, starting at about 1200 Megawatts capacity worldwide in 1990. The graph of worldwide megawatts capacity from 1990 to 2004 looks like this:



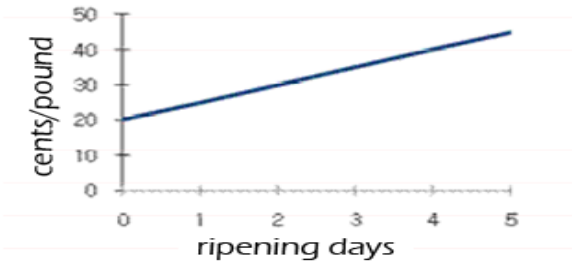
If you changed the y-axis of this graph to a log scale, which of the following would describe the graph:

    a. it would have a y-intercept between 3 and 4, and would be a straight line pointing up
    b. it would have a y-intercept 0, and would be a curved line pointing up
    c. it would have a y-intercept of 1200, and would be a straight line pointing up
    d. it would have a y-intercept between 3 and 4, and would be a curved line pointing up
    e. I don't know how to approach this problem.

17. A researcher finds that ***happiness = 0.57 log(income)***. (All incomes are assumed to be above $1000 / year). Which of the following is true?

    a. If you multiply your income by 10, you will AT LEAST multiply your happiness by 10.
    b. If you multiply your income by 10, you will EXACTLY multiply your happiness by 10.
    c. If you multiply your income by 10, your happiness increases by 0.57 units.
    d. At very high incomes, there is no increase in happiness with increasing income.
    e. I don't know how to approach this problem.

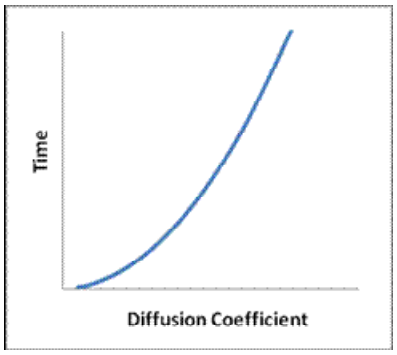
18. The graph below expresses the relationship between price per pound of apples, and the number of days the apples were allowed to ripen. Which of the following statements is supported by the graph?

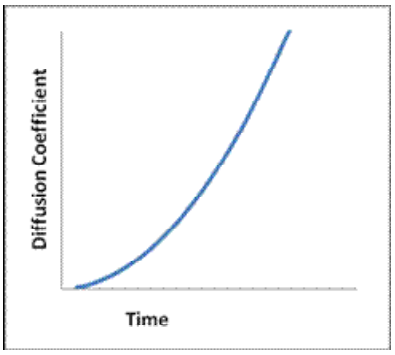


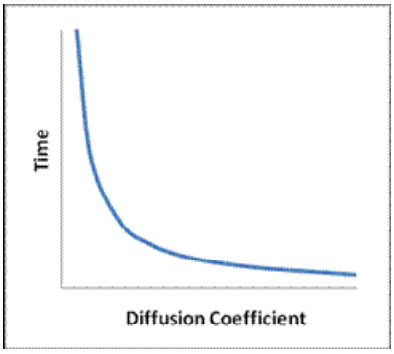
    a. The y-intercept of the graph is 20 cents/pound, meaning that apples increase in value by 20 cents/pound for every day they are allowed to ripen.
    b. The y-intercept of the graph is 20 cents/pound, meaning that the average cost of apples is 20 cents/pound.
    c. The slope of the graph is 0.5 cents/pound per day, meaning that apples increase in value by 0.5 cents/pound for every day they are allowed to ripen.
    d. The slope of the graph is 5 cents/pound per day, meaning that apples increase in value by 5 cents/pound for every day they are allowed to ripen.
    e. I don't know how to approach this problem.

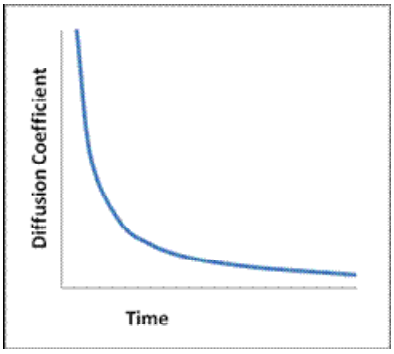
19. A gaseous toxin has been accidentally released in the center of a room. Over time, the toxin diffuses farther and farther from the center of the room, obeying the following equation:
    time to diffuse = (distance^2)/2D,
    where D is the "diffusion coefficient", measuring the speed of diffusion.

If you graphed time it takes for the toxin to diffuse to the door of the room as a function of the diffusion coefficient, what shape would the graph be?

a.


b.


c. 

d. 

e. I don't know how to approach this problem.

20. Imagine that the probability that Hogwarts will win the Quidditch championship in any given year is 30%, and the probability that they will come in second is 20%. What is the probability that they will get one first and one second place over 2 years?

    a. 50%
    b. 12%
    c. 10%
    d. 6%
    e. I don't know how to approach this problem.

21. The time *t* required for carbon dioxide to diffuse through a plant cell is approximately $t = x^2 / (2D)$, where *x* is the width of the cell, and D is a positive constant. Assuming you measured *t* and *x*, which of the following would allow you to (correctly) estimate D?

    a. $D = x^2 / (2t)$
    b. $D = 2t / (2x^2)$
    c. *x* = Square root (2**t**D)
    d. $x = t^2 / (2D)$
    e. I don't know how to approach this problem.

22. What year of your program are you in?
    a. 2
    b. 3
    c. 4
    d. 5+

23. What is your gender?
    a. Male
    b. Female

Here are a number of statements that may or may not apply to you. For the most accurate score, when responding, think of how you compare to most people -- not just the people you know well, but most people in the world. There are no right or wrong answers, so just answer honestly!

24. I'm no good in math.
    a. Strongly agree
    b. Agree
    c. Neither agree nor disagree
    d. Disagree
    e. Strongly disagree

25. For some reason even though I study, math seems unusually hard for me.
    a. Strongly agree
    b. Agree
    c. Neither agree nor disagree
    d. Disagree
    e. Strongly disagree

26. I can get good grades in mathematics.
    a. Strongly agree
    b. Agree
    c. Neither agree nor disagree
    d. Disagree
    e. Strongly disagree

27. New ideas and projects sometimes distract me from previous ones.
    a. Very much like me
    b. Mostly like me
    c. Somewhat like me
    d. Not much like me
    e. Not like me at all

28. Setbacks don't discourage me.
    a. Very much like me
    b. Mostly like me
    c. Somewhat like me
    d. Not much like me
    e. Not like me at all

29. I have been obsessed with a certain idea or project for a short time but later lost interest.
    a. Very much like me
    b. Mostly like me
    c. Somewhat like me
    d. Not much like me
    e. Not like me at all

30. I am a hard worker.
    a. Very much like me
    b. Mostly like me
    c. Somewhat like me
    d. Not much like me
    e. Not like me at all

31. I often set a goal but later choose to pursue a different one.
    a. Very much like me
    b. Mostly like me
    c. Somewhat like me
    d. Not much like me
    e. Not like me at all

32. I have difficulty maintaining my focus on projects that take more than a few months to complete.
    a. Very much like me
    b. Mostly like me
    c. Somewhat like me
    d. Not much like me
    e. Not like me at all

33. I finish whatever I begin.
    a. Very much like me
    b. Mostly like me
    c. Somewhat like me
    d. Not much like me
    e. Not like me at all

34. I am diligent.
    a. Very much like me
    b. Mostly like me
    c. Somewhat like me
    d. Not much like me
    e. Not like me at all

Quantitative Resources

Logarithmic help

http://www.biology.arizona.edu/biomath/tutorials/log/Definition.html

More logs

http://www.faculty.biol.ttu.edu/strauss/stats/handouts/07_logarithms.pdf

Stats and Probability

http://www.biostathandbook.com/probability.html

General Math Bio Resource

http://www.biology.arizona.edu/biomath/BioMath.html

PLEASE DO NOT WRITE ON THIS EXAM. USE THE SCRAP PAPER PROVIDED.

Quantitative Skills for Biology Assessment

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1. A certain strain of fruit flies grows exponentially, and in one week, the number of flies increases from 10 to 100. Which of the following would be a good model for the growth of this species, if you started in week 0 with 6 flies? (read N_t as "number of flies at week t")

    a) $N_t = 10t + 6$
    b) $6 = N_t * t^{10}$
    c) $N_t = 6 * t^{10}$
    d) $N_t = 6 * 10^t$
    e) I don't know how to approach this problem

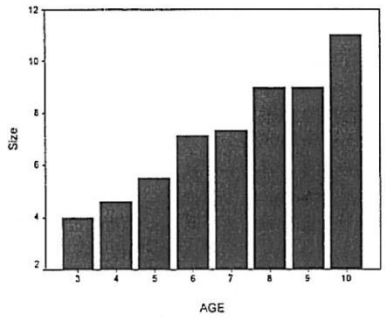
2. A biologist is interested in the effect of sugar concentration in a food source on size of mold populations. She sets up 10 Petri dishes with 10 mold spores in each. Initial sugar concentration of the food source in the dishes is established – 10% sugar in the first dish, 20% in the second dish, 30% in the third dish, and so on. After 4 days, she calculated the amount of dish area covered by mold. Which of the following describes her experiment?

    a) amount of mold is the independent variable, sugar concentration is the dependent variable
    b) sugar concentration is the independent variable, amount of mold is the dependent variable
    c) high sugar and low sugar is the independent variable, amount of growth is the dependent variable
    d) whether sugar concentration exceeds 50% (yes or no) is the independent variable and amount of mold is the dependent variable
    e) I don't know how to approach this problem.

3. In the previous question, what type of analysis is most appropriate?
    a) making a bar chart comparing final mold coverage in the 5 dishes with lowest sugar concentration to mold coverage in the 5 dishes with highest sugar concentration
    b) doing a goodness of fit test such as chi-square to see whether final size of mold populations was randomly distributed
    c) making a scatterplot of final mold coverage vs. sugar concentration and drawing a "best fit" line through the points
    d) doing a t-test to see whether mold populations in the 5 dishes with lowest sugar concentration were larger than the mold populations in the 5 dishes with highest sugar concentration
    e) I don't know how to approach this problem.

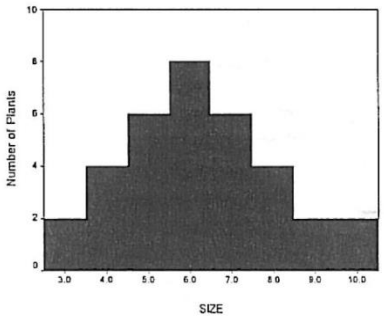
4. With the appropriate data, a hypothesis can be proven to be true:
    a) True
    b) False

Use the following to answer the question below:



5. This figure supports which of the following statements:
    a) Smaller individuals grow more quickly than old individuals;
    b) Older individuals are larger than younger individuals;
    c) Younger individuals are larger than older individuals;
    d) Size and age are not related in this experiment;

Use the following to answer the question below:



6. The figure supports which of the following statements:
    a) The largest plants measured were approximately 8 units;
    b) Most of the plants measured were about 10 units in size;
    c) The smallest plants measured were in the 0 unit size;
    d) Most plants in the population were very large;
    e) The largest number of measured plants were in the 6 unit size;

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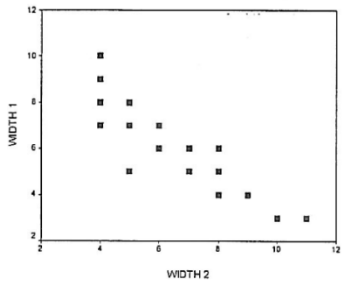


7. This figure supports which of the following statements:
    a) There seems to be no relationship between Width 1 and Width 2;
    b) As Width 2 gets greater, so does Width 1;
    c) As Width 2 gets greater, Width 1 gets smaller;
    d) As Width 1 gets greater, so does Width 2;
    e) The average size of Width 1 is twice the average size of Width 2;

8. A statistical test used to determine if there is a numerically significant difference in the average values of two different groups of numbers:
    a) ANOVA;
    b) Chi-square test;
    c) Linear regression;
    d) Mean determination;
    e) T-test;

9. A descriptive statistic calculated by summing all numbers in a dataset and then dividing by the sample size:
    a) Alpha;
    b) Mean;
    c) Median;
    d) Mode;
    e) Standard deviation

10. A group of students measures the masses of cockroaches found in a nearby restaurant, and calculates a mean mass of 14.5 g, with a standard deviation of 1.3 g. Which of the following is most likely true?

    a) About 95% of the cockroaches they found were between 13.2 and 15.8 g.
    b) About 2/3 of the cockroaches they found were between 13.2 and 15.8 g.

c) About 2/3 of the cockroaches they found were between 11.9 and 17.1 g.
d) None of the cockroaches they found was below 13.2 or above 15.8 g.
e) I don't know how to approach this problem.

11. A biologist measures the height of sediment deposits at one spot on a stream bank over time. The height of the deposits started at 15 cm, and grew (on average) 1.2 cm per week. Which of the following best describes the height of sediment deposit over time?

a) a curved line: depth= 15 + $week^{1.2}$
b) a curved line: depth= 15*$week^{1.2}$
c) a straight line: depth= 1.2 + 15*week
d) a straight line: depth= 15 + 1.2*week
e) I don't know how to approach this problem.

12. During a psychology study, a researcher asks girls and boys in a 2nd-grade class to pair up randomly. There are 15 girls and 5 boys. Assuming that the students really do pair off randomly, what fraction of pairs should be all girls, mixed pairs, and all boys? (approximately)?

a) 1/2, 1/4, 1/4
b) 9/16, 6/16, 1/16
c) 3/5, 1/5, 1/5
d) 9/20, 7/20, 4/20
e) I don't know how to approach this problem.

13. A researcher wants to measure the rate of people passing through the front door of the Student Union building. Which would be appropriate units to use?

a) time / speed
b) time / people
c) people/speed
d) people / time
e) I don't know how to approach this problem.

14. A dripping faucet can waste up to 30 gallons of water per day. What is this in liters per year? (1 gal = 3.8 L)

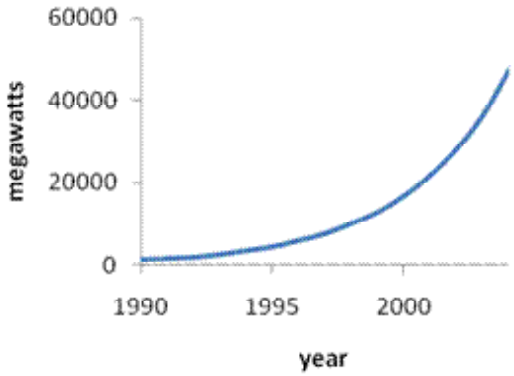
a) 30gal/day * (3.8L/yr)
b) 30gal/day * (1gal/3.8L) * (1yr/365day)
c) 30gal/day * (3.8L/gal) * (365day/yr
d) 30gal/day * (24hr/day) * (365day/yr) * (3.8L/gal)
e) I don't know how to approach this problem.

15. A restaurant is advertising a new monster-sized version of its best-selling pizza: 20 inches in diameter instead of the usual 10 inches. How much more area will they have to cover with cheese on the larger pizza than on the smaller one?

a) 0.5 times as much
b) 2 times as much

c) 4 times as much
d) 6.25 times as much
e) I don't know how to approach this problem.

16. Wind energy has been the fastest growing renewable energy sector over the past 2 decades, with growth averaging about 20% per year, starting at about 1600 MW capacity worldwide in 1995. The graph of worldwide capacity from 1995 to 2009 looks like this:



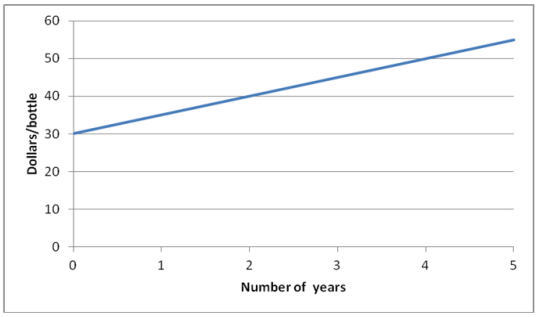
If you changed the y-axis of this graph to a log scale, which of the following would describe the graph?

a) It would have a y-intercept between 3 and 4, and would be a straight line pointing up.
b) It would have a y-intercept 0, and would be a curved line pointing up.
c) It would have a y-intercept of 1600, and would be a straight line pointing up.
d) It would have a y-intercept between 3 and 4, and would be a curved line pointing up.
e) I don't know how to approach this problem.

17. Market research found that the amount individuals were willing to donate to charity = 0.55 log(income), and quantified this willingness by means of a particular scale. Which of the following is true?

a) If you double your income, you will AT LEAST double your willingness to donate to charity.
b) If you double your income, you will EXACTLY double your willingness to donate to charity.
c) If you multiply your income by 10, your willingness to donate to charity increases by 0.55 units.
d) At very high incomes, there is no increase in willingness to donate to charity with further increasing income.
e) I don't know how to approach this problem.

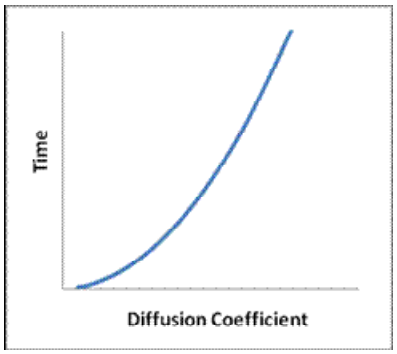
18. The graph below expresses the relationship between price (dollars per bottle) for bottles of fine wine, and the number of years the bottles of wine are allowed to age in a wine cellar. Which of the following statements is supported by the graph?

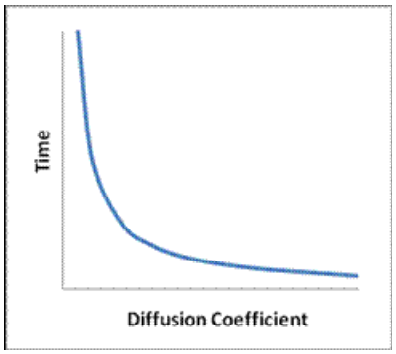


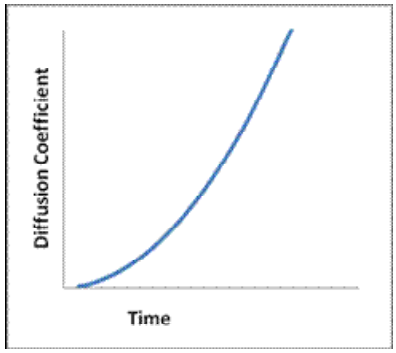
a) The y-intercept of the graph is 30 dollars/bottle, meaning that wine increases in value by 30 dollars per bottle for every year the wine is stored.
b) The y-intercept of the graph is 30 dollars/bottle, meaning that the average cost of a bottle of wine is 30 dollars per bottle.
c) The slope of the graph is 0.5 dollars/bottle per year, meaning that the wine increases in value by 50 cents per bottle for every year the wine is stored.
d) The slope of the graph is 5 dollars/bottle per year, meaning that the wine increases in value by 5 dollars per bottle for every year the wine is stored.
e) I don't know how to approach this problem.

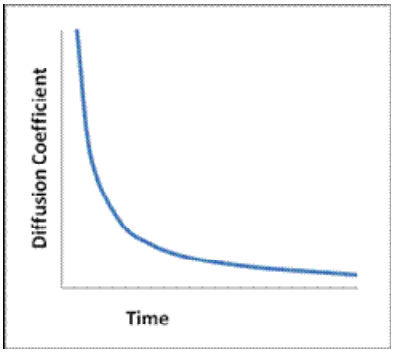
19. A gaseous toxin has been accidentally released in the center of a room. Over time, the toxin diffuses farther and farther from the center of the room, obeying the following equation:
time to diffuse = (distance^2)/2D,
where D is the "diffusion coefficient", measuring the speed of diffusion.

If you graphed time it takes for the toxin to diffuse to the door of the room as a function of the diffusion coefficient, what shape would the graph be?

a.


c.


b.


d.


e. I don't know how to approach this problem.

PLEASE DO NOT WRITE ON THIS EXAM. USE THE SCRAP PAPER PROVIDED.

20. Imagine that the probability that your college team will win the basketball championship in any given year is 20%. The probability that they will come in second is 40%. What is the probability that they will get one first and one second place over 2 years?

    a) 16%
    b) 24%
    c) 60%
    d) 80%
    e) I don't know how to approach this problem.

21. The time *t* required for carbon dioxide to diffuse through a plant cell is approximately $t = x^2 / (2D)$, where *x* is the width of the cell, and D is a positive constant. If you already knew D and *t*, which of the following would allow you to calculate the cell width?

    a) $D = x^2 / (2t)$
    b) $D = 2t / (2x^2)$
    c) *x* = Square root (2**t**D)
    d) $x = t^2 / (2D)$
    e) I don't know how to approach this problem

22. How would you rate your effort while taking this quiz?

    a) A great deal of effort
    b) Moderate effort
    c) Little effort
    d) No effort

23. In your opinion, which statement best describes the relationship between math and biology?

    a) Math is not relevant to biology.
    b) Math can be useful in biology but it's not really necessary.
    c) Math is helpful in biology.
    d) Math is essential in biology if you want to do cutting-edge work.
    e) Math is essential for doing any biology, cutting-edge or not.

24. It is important for biologists to know math.

    a) Strongly agree
    b) Agree
    c) Neither agree nor disagree
    d) Disagree
    e) Strongly disagree

25. I like math.

    a) Strongly agree
    b) Agree
    c) Neither agree nor disagree
    d) Disagree
    e) Strongly disagree

26. As a result of your enrollment in this course so far, please indicate the level of IMPROVEMENT you made in your **scientific content knowledge**.

    a) A great deal of improvement
    b) Moderate improvement
    c) Little improvement
    d) No improvement

27. In this course, which class activity or component most helped you improve your **scientific content** knowledge?

    a) Lectures
    b) Labs
    c) SIMBIO labs
    d) Exams
    e) Lab reports

28. As a result of your enrollment in this class, please indicate the level of IMPROVEMENT you made in your **quantitative skills** (mathematical and statistical reasoning).

    a) A great deal of improvement
    b) Moderate improvement
    c) Little improvement
    d) No improvement

29. In this course, which class activity or component most helped you improve your **quantitative skills** (mathematical and statistical reasoning)?

    a) Lectures
    b) Labs
    c) SIMBIO labs
    d) Exams
    e) Lab reports