AN INTRODUCTION TO TABLES AND GRAPHS

Tables and graphs provide a concise summary of data and relationships. If they are well-constructed, titled, and labeled, they are self-explanatory and can stand alone. However, if they are poorly constructed, either the reader will not understand them or they will have to be described in detail in the text, defeating the purpose.

Construction of Tables:

Clear and concise tables convey a wealth of information in a convenient, easy-to-understand way.

1. Each table should have a number and a title that briefly states what data are involved.
2. Tables should be constructed so they read down, not across. Compare Table A and Table B, below:

Table A. Common Characteristics of Serveral Domestic Cats

	Siamese	**Calico**	**Tiger**	**Burmese**	**Pursain**
Fur Color	grey	calico	orange	brown	white
Eye Color	blue	brown	green	brown	blue
Stripes?	no	no	yes	no	no
Average Weight	5 lb	6 lb	6 lb	5 lb	5 lb

Table B. Common Characteristics of Serveral Domestic Cats

	Fur Color	**Eye Color**	**Stripes**	**Average Weight**
Siamese	grey	blue	no	5 lb
Calico	calico	brown	no	6 lb
Tiger	orange	green	yes	6 lb
Burmese	brown	brown	no	5 lb
Pursian	white	blue	no	5 lb

Table A reads across, and Table B reads down. It is obvious which table is easier to read. This construction is even more important when numbers are involved because we are trained to add numbers vertically, not horizontally.

Construction of Graphs:

Graphs are a very effective method of describing results. They depict a relationship between values plotted on the y-axis (the **ordinate**, or vertical axis) and the x-axis (the **abscissa**, or horizontal axis). The y-axis should always list the **dependent** variable and the x-axis the **independent** variable.

1. Imagine that you want to show the relationship between the level of photosynthesis and light intensity. The photosynthetic level is the **dependent** variable, to be plotted on the y-axis, since it *depend*s on the x variable, light intensity. If you plotted light intensity as the dependent variable, the graph would not make sense -- you would be saying that if you increase the photosynthetic level of the geranium on your windowsill, the sun will shine brighter! An excellent example of an independent variable is time. It is one variable we have no control over, and all processes are a function of it. Therefore, it will always be plotted on the x-axis

Table A

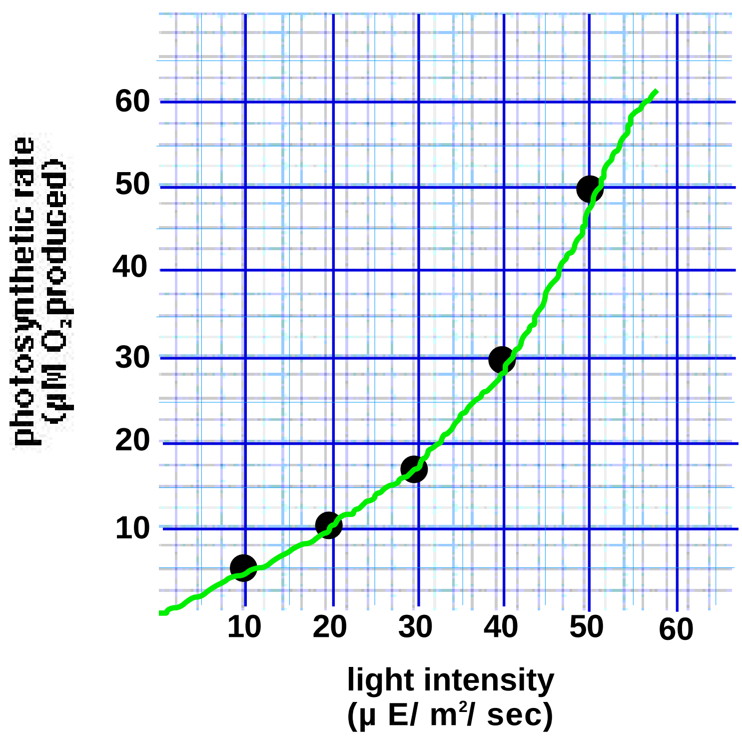
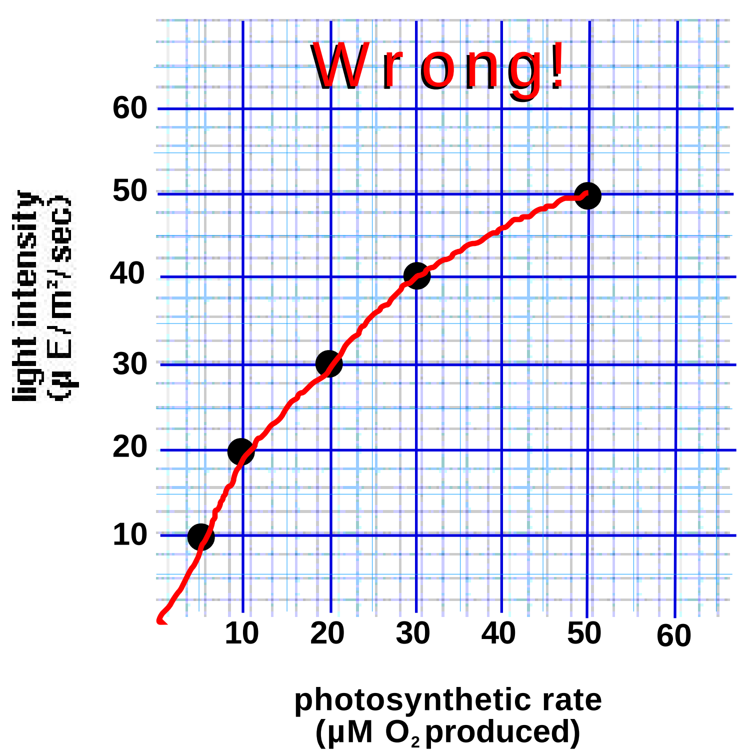


Table B



2. You must construct your graph so that it tells the whole story of what happened during the experiment in the simplest and most logical manner.
   a. ***Titl***e.
   b. ***Axe***s. These should be labeled as to magnitude, direction, and unit, using a logical format. For example, if your data set goes from 2 to 23, do not label your axis from 0 to 100, thereby“scrunching” the points into a small corner; 0 to 25 would be much more practical. Also, each square on the graph must always equal a constant amount.
   c. ***Multiple graph***s. If 2 or more data sets are included on a single graph, each must be identified.
      This is done by using a **ke**y, which identifies what the symbols representing different experiments mean.

3. “Best-fit” vs. “point-by-point” graphs. A graph is accurate if the data points are each connected with a line. However, if there is a consistent relationship, this should be shown by means of a best-fit line or curve. Not only does a best-fit line or curve illustrate the trend, but it also enables one to make predictions.

The following graphs show 2 different ways of graphing the relationship between the length of a mammal’s femur and running velocity. Both show that velocity increases with an increase in femur length. However, if we found a 25 cm femur and wanted to estimate how fast the animal could run, we could not use graph a. The only way to make a proper estimate is to draw a best-fit curve (graph b). These are some complicated statistical and regression techniques that must be used to produce a truly accurate best-fit line, but we will leave those explanations to the statisticians for now. and draw the best-fit curve by eye. You can see that it is possible to predict the running velocity of the mammal with the 25 cm femur (10.0 m/sec).

Table A

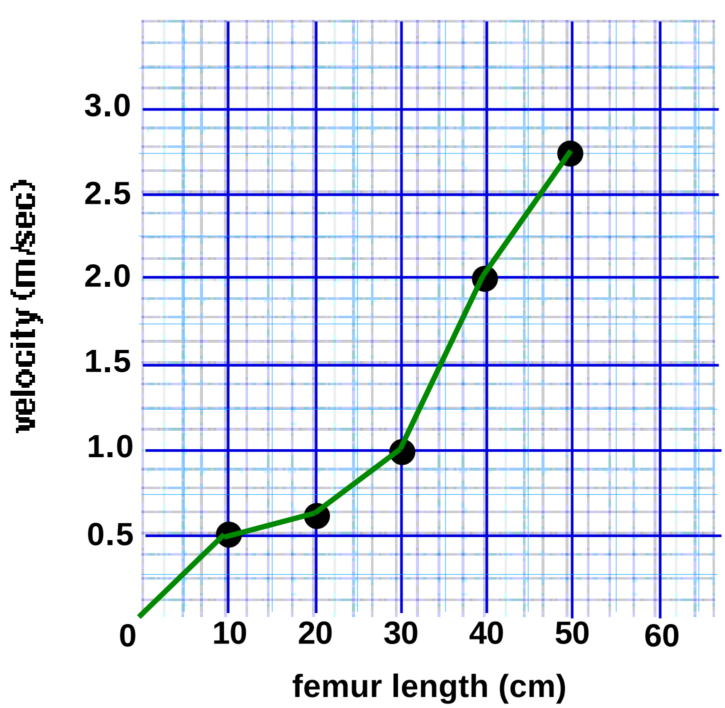
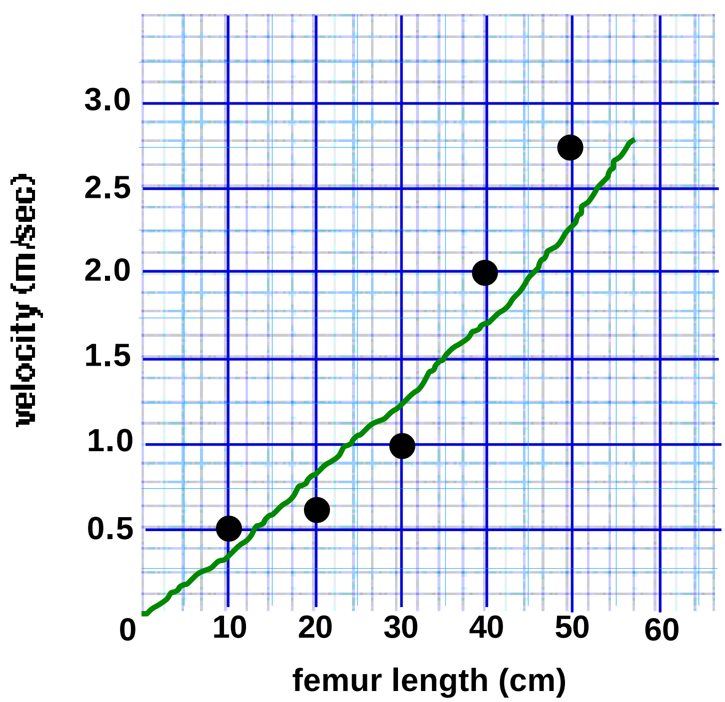


Table B



<u>Examples of the "Dos" and "Don'ts" of Graphing</u>:

Of the graphs appearing on the next page, some have been done correctly, others incorrectly. study them so that you do not make the errors that are illustrated.

Graph A: A good graph. All the information is there and the reader can immediately understand that the number of glurks almost doubled every day.

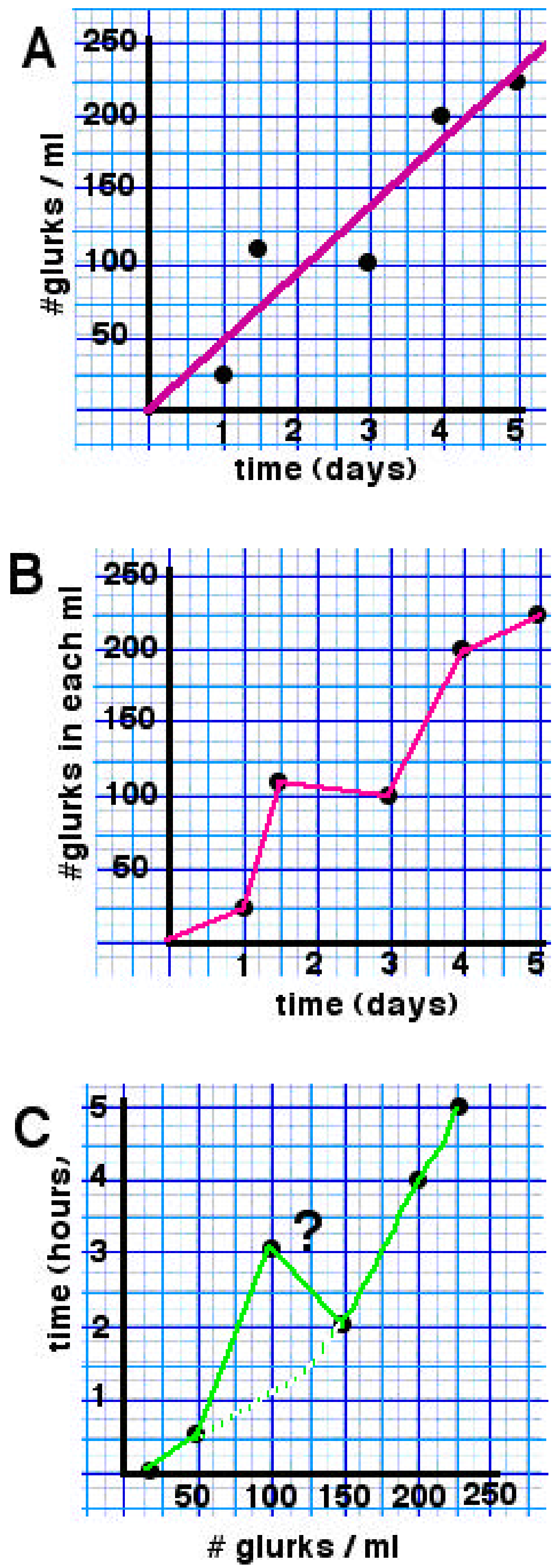
Graph B: This graph is acceptable but is an example of the "truth" but not the "whole truth"! If you hypothesize that the growth rate of glurks is usually constant, the discrepancy in numbers of glurks between Day 2 and Day 3 probably does not represent a "real" phenomenon. It is more likely due to experimental error, inaccurate counting, choosing a sample haphazardly, etc. A best-fit line would five a more accurate description.

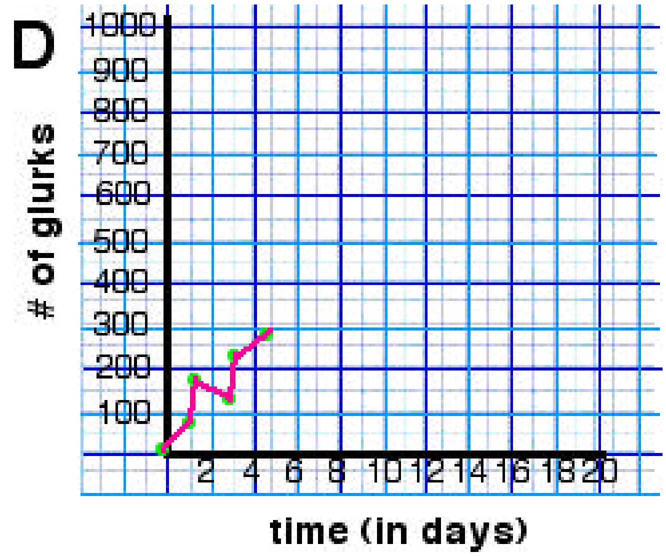
Graph C: This is graphed backwards and therefore it is totally wrong! Nothing we or the glurks do will affect the steady marching on of time, and to say that an increase in glurks causes time to speed up is obviously absurd. To add insult to injury, this student labeled the time incorrectly (hours).

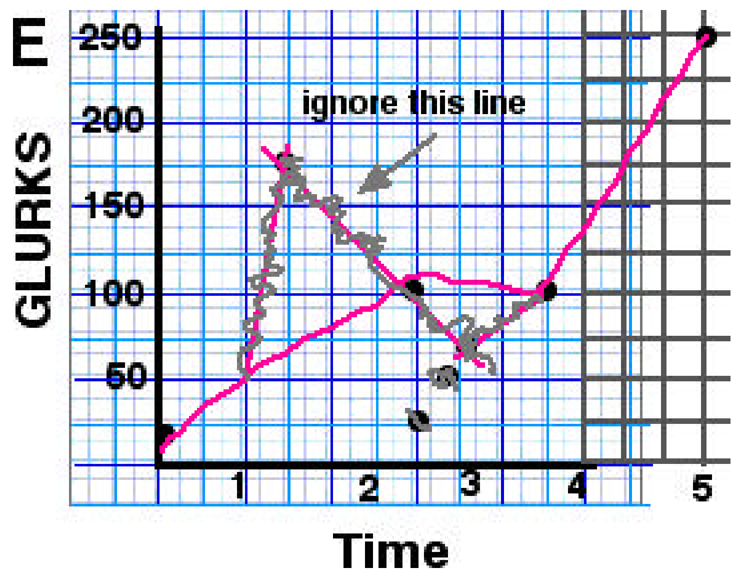
Graph D: Unnecessarily "scrunched".

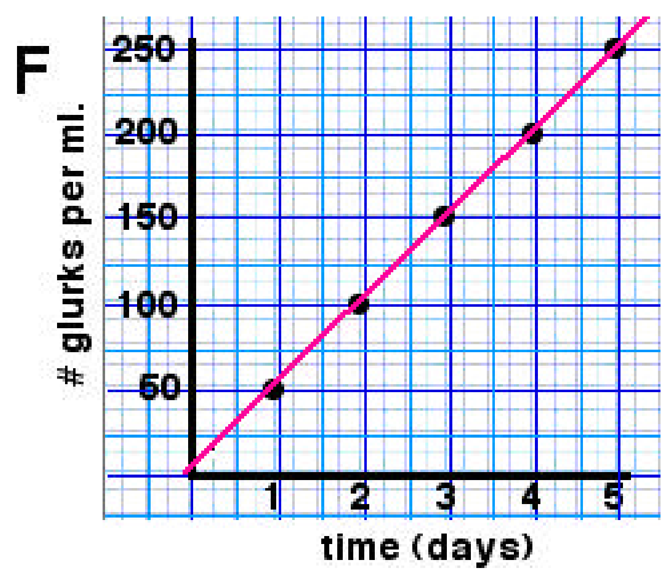
Graph E: Inexcusably messy. The student used a pen and had to cross out incorrect data. The units are not given. Poor planning made extra graphing lines necessary. The line is partially best-fit and partially point-to-point. It must be one or the other, never a combination. The time scale is not linear (sometimes a large square represents 1 day, sometimes it represents 2 days). The data points are too small. The name of the organism is misspelled. This is a terrible graph!

Graph F: This is the worst graph! This student knew that the number of glurks was expected to double every day and "fudged" the data accordingly. This graph is dishonest.


A
250
200
150
100
50
#glurks / ml
1
2
3
4
5
time (days)
B
250
200
150
100
50
#glurks in each ml
1
2
3
4
5
time (days)
C
5
4
3
2
1
time (hours)
?
50
100
150
200
250
glurks / ml


D
1000
900
800
700
600
500
400
300
200
100
# of glurks
2 4 6 8 10 12 14 16 18 20
time (in days)


E
250
200
150
100
50
GLURKS
ignore this line
1 2 3 4 5
Time


F
250
200
150
100
50
glurks per ml.
1 2 3 4 5
time (days)

The graphs shown on the next page emphasize multiple data sets and best-fit curves. In this experiment, various nutrients were used to test their effects on the growth of glurks.

Graph A: A good graph. The reader can immediately see that the number of glurks almost doubled each day in the control experiment. When nutrient X was added, the growth rate increased (the number doubled in less than a day). When nutrient Y was added, the growth rate decreased (it took 2 days for the number to double).

Graph B: Difficult to read. All the data points look the same, so the individual curves cannot be followed easily. Also, there is no information stating what each curve represents. The reader would have to search back into the methods section of the paper to find out what experiments 1, 2, and 3 represent.

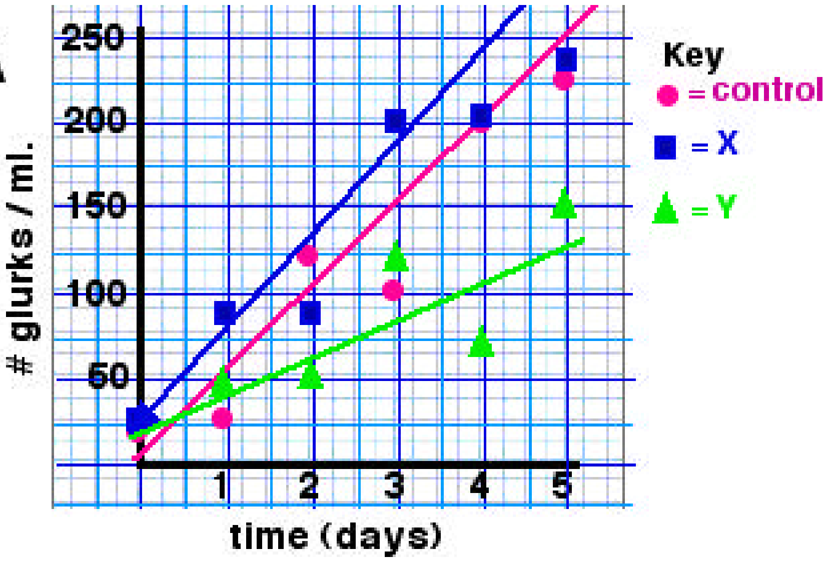
Graph C: This graph illustrates common errors in making a best-fit curve. Curve 1 is incorrect because the student tried to combine the 2 methods (best-fit curve and point-to-point) by making a wiggly line somewhere near some of the data points. Curve 2 is incorrect because it starts with the point-to-point method and ends up with a best-fit curve. The student who drew curve 3 felt that a line going through the first 3 data points would be accurate, but that meant ignoring data points 4 and 5. In this case, it would make the doubling time with nutrient Y 6 days, instead of the 2 days portrayed on graph A. It is often difficult for students to decide whether a straight line or a curve should be fitted to data. Remember that a graph illustrates a relationship between the variables; that relationship may be linear or may be curvilinear. In research, the scientist would have to justify logically such a relationship. For our purposes, you should draw whichever relationship incorpor-ates most of the data points the best.

Graph D: Although the information is here, the reader must try to connect the points mentally to understand the results.

Graph E: Here, 2 experiments are combined in 1 set of data points. The student added an inhibitor towards the end of the experiment. The data could be illustrated with a graph that uses point-to-pont method. Alternatively, the best-fit line or curve method could be used, but to do so, the student needs to fit 1 line/curve for the data points before the inhibitor was added, and a different line/curve for the data points after the inhibitor was added.. The dotted line shown in the graph ignores this information.

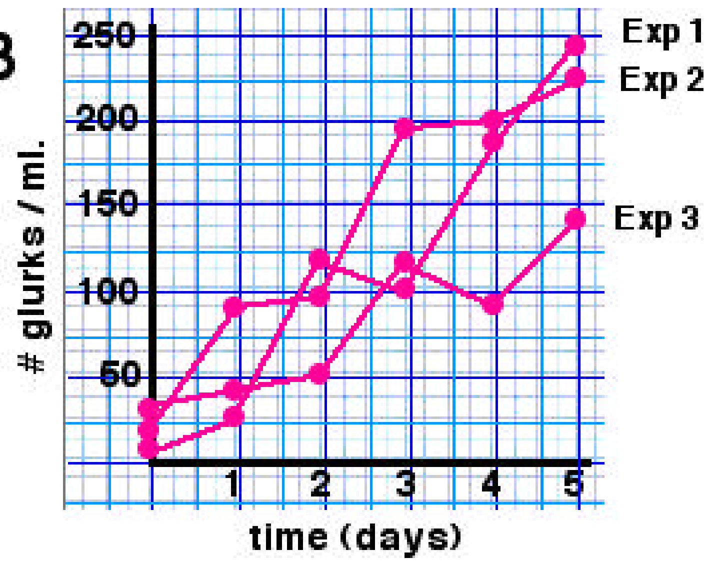
Graph F: Occasionally, the data points from an experiment are so scattered that even the most vivid imagination cannot see a trend in the results. In such a case, the student must use the point-to-point method..

A



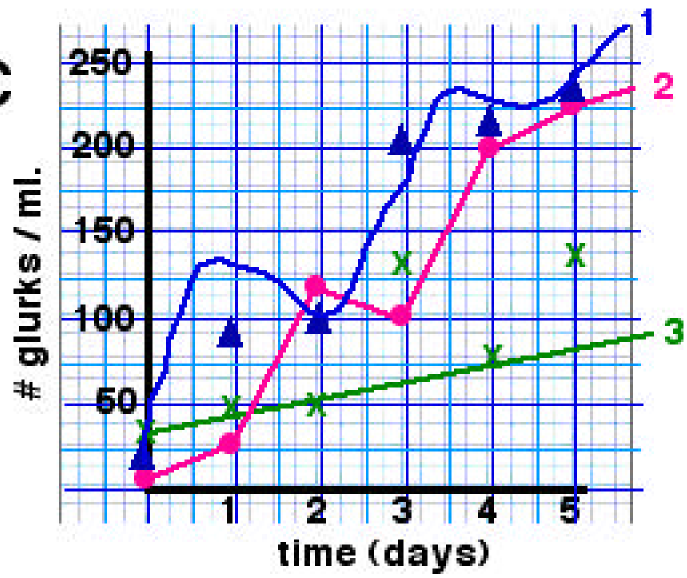
250
200
150
100
50
1
2
3
4
5
glurks / ml.
time (days)
Key
= control
= X
= Y

B

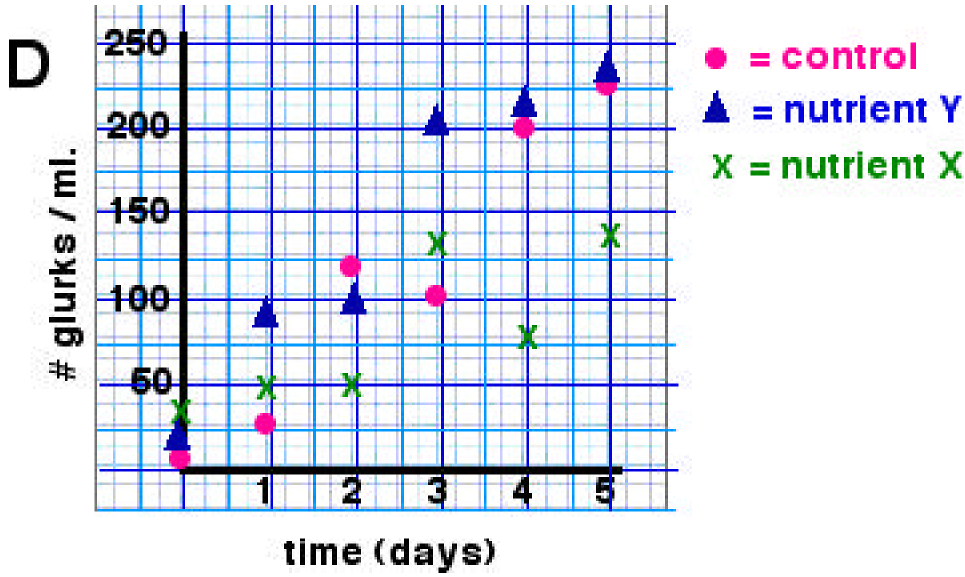


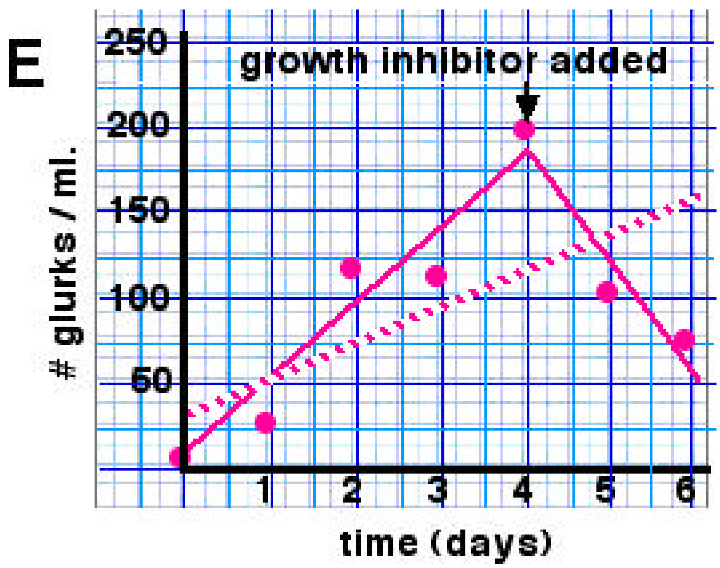
250
200
150
100
50
1
2
3
4
5
glurks / ml.
time (days)
Exp 1
Exp 2
Exp 3

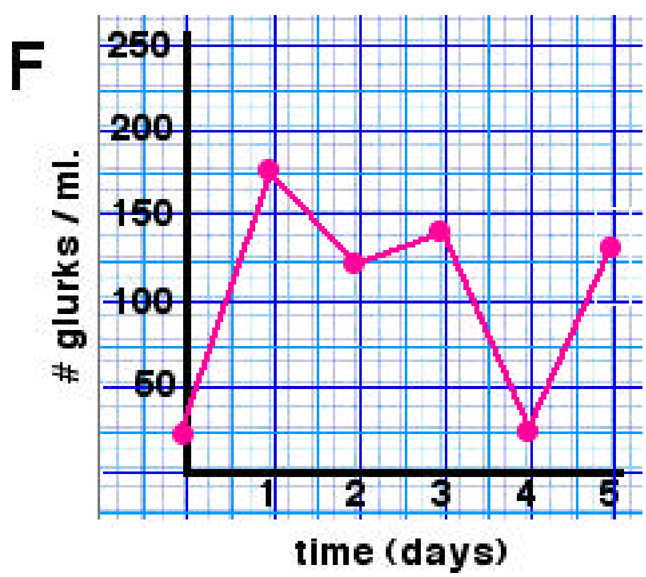
C



250
200
150
100
50
1
2
3
4
5
glurks / ml.
time (days)
1
2
3


D
250
200
150
100
50
glurks / ml.
1
2
3
4
5
time (days)
= control
= nutrient Y
X = nutrient X


E
growth inhibitor added
250
200
150
100
50
glurks / ml.
1
2
3
4
5
6
time (days)


F
250
200
150
100
50
glurks / ml.
1
2
3
4
5
time (days)