Mechanics and Conventions for Graphing Data

Graphing is not a “one-shot” deal. That’s one reason to use pencil or why it’s helpful to have a graphing calculator or computer terminal. Because, we graph and re-graph until patterns become evident. The patterns offer clues to understand the biological mechanisms.

Determining the outer limits
Inspect the number you obtain. Consider the outer limit the next 100^{th}, 10^{th}, 5^{th} or 2^{nd}.

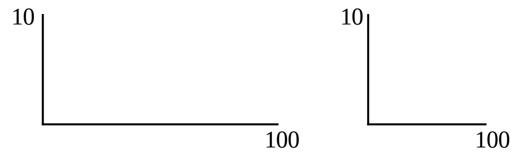
Largest X = 85, use 100 as the outer limit
Largest Y= 7.8, use 10 as the outer limit

Intervals help your eyes to focus better on the patterns the data form.
Choose intervals of 1’2s. 5’s, 10’s etc. even if you have numbers like 7.5 and 3.8, because looking at an interval of 5 or 10 may help you see the patterns better.

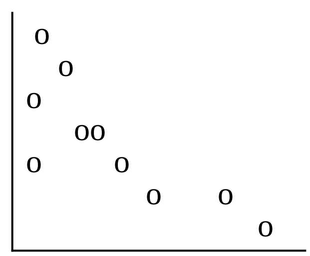
If outer limit is 100, use intervals of 10

If outer limit is 10, use intervals of 1

Squaring off. A squared-off graph has the least distortion of the data pattern. Your scales may and generally will be different on the X and Y axes because of the independent and dependent variables that were chosen for analysis.



Scatter, error bars. Sometimes the data is better visualized with scatter plots and sometimes with error bars. Inspect your graph to determine which best presents the results, even if the results are poor. Sometimes the scatter is due to poor technique, which, of course, you should correct during the next round of experimentation, but sometimes the scatter is inherent to the tissue you are studying, like an organ or whole plant that has several different cell types.

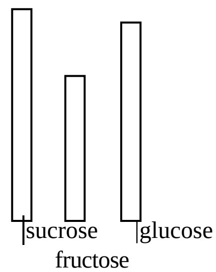


Connecting, fitting. Blindly using regression fitting on your graphing calculator may not give you the true result. Inspect the graph pattern to see if the results really are linear, log-linear, exponential or otherwise. You may be seeing a maximum, or optimum, which will give you straight lines only in the early phases or for short segments of the concentrations you are studying.
Often, excess substrate, or product build-up, can become inhibitory instead of stimulating an enzyme reaction.

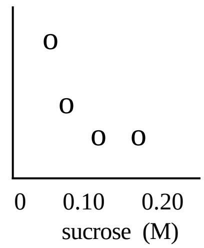
Does the graph above show data that go sharply up, then down, or does the data form a downward sloping line with some scatter? You may have to conduct more experiments to distinguish these states.

Line graph or histogram? Do not “connect the dots” to show the effects of different sugars on yeast catalase even if each is at the same concentration. These are different, not an interval or continuum of one condition. Show results comparing different sugars as a histogram. On the other hand, to show what happens as you increase the concentration of one sugar, say sucrose, you can use a continuous line graph, though you will find that you need to do curve-fitting instead of simply connecting dots.

histogram/bar graph



line graph



Graphing… *continued*.

Students will make a scatter plot of reaction time v. concentration, will plot means with error bars for each concentration and will fit a curve to the data.

Students can also work on this first part on their own once you show them how to set up the graph.

Give students a sheet of graph paper. We want to make a square graph that takes up most of the paper.

We'll put concentration on the x-axis. The independent variable is always graphed on the x-axis. The highest concentration will be 3%. We want to divide the x-axis into equal intervals from 0 to 3 Label the x-axis concentration of hydrogen peroxide (%).

What is the longest time on the data table? This will define the range for the y-axis. Now, set up equal intervals on the y-axis, spacing the intervals with approximately the same amount of space used by the x-axis. Label the y-axis time (seconds).

Make a scatter plot of the data. This is the way a computer graphs data entered from a spreadsheet. Students model this so that they have an understanding of what computer or calculator graphing programs do. That is, make a point on the graph for each data entry on the spreadsheet. See sample. Students can do this at home.

When done, ask students to verbally describe the graph.

Graphical analysis programs can "fit" a line (or curve) through the data points. The fit is calculated so that the same number of points are the same average distance above the line or curve as below the line or curve.

Ask students to "estimate a fit" for this line or curve using a different color pencil or pen.

Discuss the way the curve goes. Why is it not a straight line? Why does the curve go down as the concentration of peroxide goes up?

Students will plot of 1/mean reaction time vs. H_2O_2 concentration, with error bars.

Explain that times were recorded when a disc reached the top of a well containing hydrogen peroxide. Presumably, this required the same amount of oxygen to be produced in each well. When there was enough oxygen to lift the disc to the top, times were recorded. It took longer to generate that much oxygen at lower concentrations of peroxide. This means that the rate reaction producing oxygen was lower in those wells. The rate of the reaction is related to a constant divided by the time that it took to reach the endpoint. Plotting 1/time will give a curve that goes up as the concentration goes up.

Less time to reach the top means faster reaction

Give students a second piece of graph paper. The title of the graph will be “Rate of reaction vs. concentration of hydrogen peroxide.” Ask students to set up the graph the same way as the last one, but, this time label the y-axis as 1/mean time (sec). Use a third color to graph the means for each concentration. Now fit a curve through the means. This will be much easier.

Put in error bars that extend one SD above and below each mean.
See example.