

Ladies

Welcome to AP Biology! As you may know this is my second year teaching the course, and I'm excited to have you. One thing I noticed last year is that many students come in needing a little bit of "brushing up" on graphing! The ability to construct and interpret graphs is fundamental to AP Bio and to science in general. To that end, your summer assignment is all about graphing!

There are three tasks, each worth 5 points for a total of 15 points (in the assessment category so this is basically your first quiz grade). For each, your points are:

- I'll give you one just for doing it on graph paper, ***NEATLY BY HAND***, so that's practically a freebie.
 - You can print graph paper for free here: <https://print-graph-paper.com/details/10-squares-per-inch>
 - You can buy graph paper at just about any general store
 - You can order it off Amazon for about 7 bucks here <https://www.amazon.com/Zaviko-Blueprint-Quadrille-Notebook-Sheets/dp/B0CWDRD3CR2>
- Axes are properly scaled. This means that your domain (X values) and range (Y values) don't extend beyond the axis, but also that your graph takes up most of the paper. Certainly enough to see the shape of the graph, vs taking up a small corner of the graph paper.
- The correct variable is on the correct axis. The independent variable is always on the X and the dependent is on the Y. The independent variable is the variable that is either manipulated or observed independently of anything else (for example, time is often an independent variable because time ticks along regardless of anything else). The dependent variable, as the name suggests, depends on something else. It's the "output" or "result" that the scientist is measuring. For a simple example, in a drug trial for a cholesterol lowering drug, the independent variable is the dosage of the drug, and the dependent variable would be the patient's cholesterol, since the cholesterol level is affected by the drug.
- The data matches the graph. In other words, your points are plotted correctly. Error bars are correctly included if applicable. Hopefully you learned what error bars in in math, but if not this YouTube video has you covered: <https://www.youtube.com/watch?v=RO1O58XnwWY>
- Analysis. Each problem contains a question requiring you to interpret your results. You can hand-write these on the back of your graph paper. **This entire assignment should be done entirely by hand.**

Finally, a word on checking your work since you're doing this over the summer. I'm totally OK if you use an AI Tool, such as Google Gemini to check your work. You can literally take a picture of the problem, and your work, and ask Gemini if it's done properly. You have my permission to use it in this regard! But that's why I'm making you do the actual work by hand :)

Bring them in hard copy the first day of school. I'd recommend taking pictures of them too just in case you misplace them.

Problem 1: Students are testing the effectiveness of four different household disinfectants against *E. coli*. They measure the zone of inhibition (in mm) on agar plates after 24 hours. Each disinfectant is tested 10 times.

Data Table

Disinfectant	Mean Zone of Inhibition (mm)	Standard Error (SEM)
Control (Water)	0.0	0.0
Brand A (Alcohol-based)	14.2	1.1
Brand B (Bleach-based)	22.5	0.8
Brand C (Plant extract)	9.8	1.5

Protip - We'll discuss this in class, including the theory behind it, but in AP Biology error bars are always $\pm 2 \times \text{SEM}$ where SEM is the "standard error of the mean". Use the Youtube video on the introductory page if you need help!

- 1 **Graph:** Construct a bar graph representing the mean zone of inhibition for each group.
- 2 **Error Bars:** Add error bars representing $\pm 2 \text{ SEM}$ for each disinfectant.
(Note: Calculate the error bar length by multiplying the SEM by 2. For Brand A, the bar will extend 2.2 mm above and below the mean).
- 3 **Analysis:** Based on your error bars, can you definitively conclude that Brand B is more effective than Brand A? Explain using the concept of error bar overlap.

Problem 2: An experiment measures the rate of an enzyme-catalyzed reaction at various substrate concentrations. Because multiple trials were run at each specific concentration, the standard error for the reaction rate was calculated for each data point.

Data Table

Substrate Concentration (mM)	Mean Reaction Rate ($\mu\text{mol}/\text{min}$)	Standard Error (SEM)
0	0.0	0.0
2	15.1	1.2
4	28.4	1.9
6	38.2	2.1
8	42.0	1.8
10	43.5	1.5

- 1
- Graph: Create a scatter plot of the data.
- 2
- Error Bars: Draw vertical error bars (± 2 SEM) for each plotted data point.
- 3
- Trendline: Sketch a smooth, best-fit curve that represents the enzyme kinetics (Michaelis-Menten style curve) passing through the error ranges.
- 4
- Analysis: Identify the substrate concentration where the reaction rate begins to plateau. Why do the error bars get smaller or stay relatively consistent at high substrate concentrations?

Problem 3: Ecologists are monitoring the population growth of a specific aquatic protist under two different temperature conditions (20 and 25 degrees C) over the course of 5 days to study climate impacts.

Day	20°C Mean Population (per mL)	20°C Error (± 2 SEM)	25°C Mean Population (per mL)	25°C Error (± 2 SEM)
1	50	± 5	52	± 4
2	120	± 12	180	± 15
3	290	± 25	410	± 30
4	430	± 31	520	± 35
5	450	± 28	530	± 40

- 1 **Graph:** Plot a line graph featuring *both* temperature treatments on the same axes. Use distinct symbols or colors for each line, and include a clear legend.
- 2 **Error Bars:** Plot the given ± 2 SEM values directly onto each data point.
- 3 **Analysis:** * On which days is the population size statistically indistinguishable between the two temperatures?
 - On which days is the population size statistically different? Justify your answers by citing the overlap (or lack thereof) of the error bars.