

**Statistics and Data Display Assignment**  
**ABE 304: Bioprocess Engineering Laboratory**

**Due:** January 26, 2018

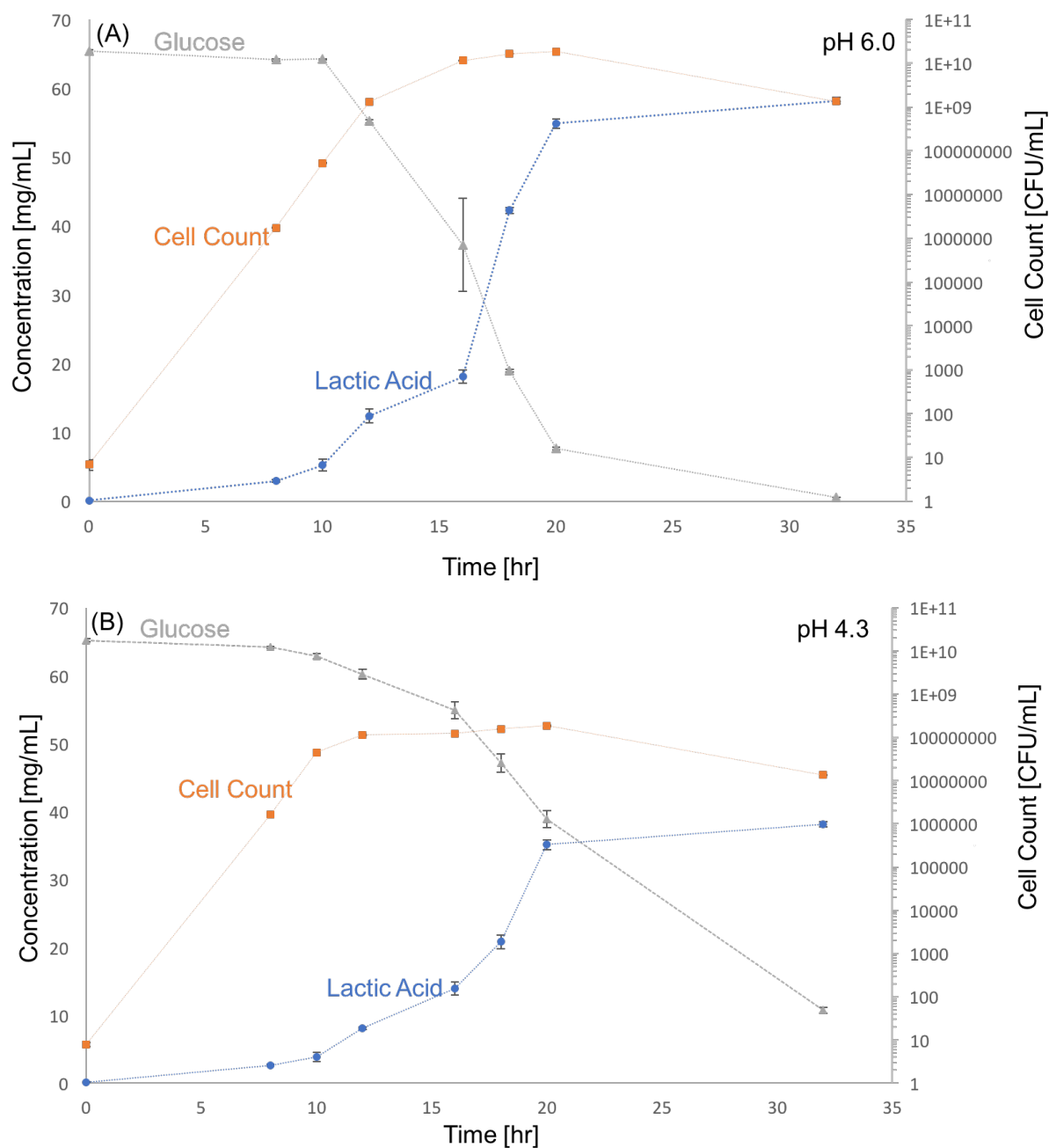
**Points:** 25

You will work with your lab group to complete this assignment, which will count towards your pre-lab grade.

1. Analyze the data in the excel spreadsheet to show the effect of pH on lactic acid fermentation
  - a. Calculate the mean and standard deviation at each time point.
  - b. Graph the means as shown in Figure 1.
  - c. Add in standard deviation error bars as shown in Figure 1. Note that the error is generally small so it may not be apparent at each time point.
2. Use the data to check for any outliers in your data. Generally, a point beyond two standard deviations of the mean is considered an outlier. You can use whatever method you think is best to determine the outlier, you will need to explain your reasoning.
  - a. If you have outliers, exclude them from your data and re-graph.
3. What to hand in? A document with
  - a. A short introduction as to what you did. Did you find outliers, if so how and what did you do with them?
  - b. The final graphs you made – try to make them as close to Figure 1 in this document as possible.
  - c. A table showing the means and standard deviation of each of the time points for each pH studied (again, try to make it look close to Table 1).
  - d. A descriptive figure caption.
  - e. A conclusion as to the effect of pH on lactic acid fermentation. What can you draw from the graphs you made?

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**Note:** Figure 1 shows the results of six fermentations. The data displayed is the mean of the six fermentations and the error bars are included to show the spread of the data. The means are connected by dotted lines. For experimental data, the points should generally not be connected because the points are not continuous and you cannot assume what is happening between sampling. Lines are allowed for a plot of model data, because the points in the model are all known. For this example, lines have been added to allow the reader to better follow the data along the x-axis and to make a better visual comparison between the two pH fermentations.



**Figure 1:** Viable cell counts (■), glucose (▲) and lactic acid (●) concentrations, during two pH-controlled batch culture fermentations – (A) at pH 6.0 and (B) at pH 4.3 – with *Lactococcus lactis*. Means and standard deviations are for six fermentations.

**Table 1:** Means and standard deviation for each time point for both pH measured. Both glucose and lactic acid concentration as well as cell counts are shown.

	Time [h]	Glucose Concentration [mg/mL]	Lactic Acid Concentration [mg/mL]	Cell Counts [CFU/mL]
pH 6	0	65.28 ± 0.25	0.06 ± 0.08	5.83 ± 2.07
	8	64.03 ± 0.17	3.06 ± 0.22	1.75E+06 ± 2.81E+04
	10	63.15 ± 0.37	5.38 ± 0.8	5.24E+07 ± 3.20E+05
	12	52.61 ± 2.06	12.48 ± 0.54	1.31E+09 ± 4.78E+07
	16	36.85 ± 6.1	17.85 ± 0.73	1.15E+10 ± 3.12E+08
	18	18.9 ± 0.28	42.11 ± 0.96	1.64E+10 ± 3.43E+08
	20	7.55 ± 0.56	54.6 ± 0.49	1.86E+10 ± 2.88E+08
	32	0.64 ± 0.13	57.96 ± 0.33	1.36E+09 ± 3.37E+07
pH 4.3	0	65.08 ± 1	0.06 ± 0.08	5.01 ± 2.77
	8	63.85 ± 1.28	2.63 ± 0.43	1.66E+06 ± 2.27E+04
	10	62.95 ± 0.68	4.75 ± 0.32	4.49E+07 ± 2.02E+06
	12	59.3 ± 0.48	7.8 ± 0.57	1.15E+08 ± 2.80E+06
	16	54.55 ± 0.94	14.36 ± 0.96	1.27E+08 ± 4.82E+06
	18	47.2 ± 1.18	20.32 ± 0.92	1.56E+08 ± 4.06E+06
	20	39.25 ± 3.96	34.88 ± 1.04	1.87E+08 ± 3.52E+06
	32	10.69 ± 0.33	38.35 ± 0.54	1.34E+07 ± 3.38E+05