**Writing a Results Section**

Purpose

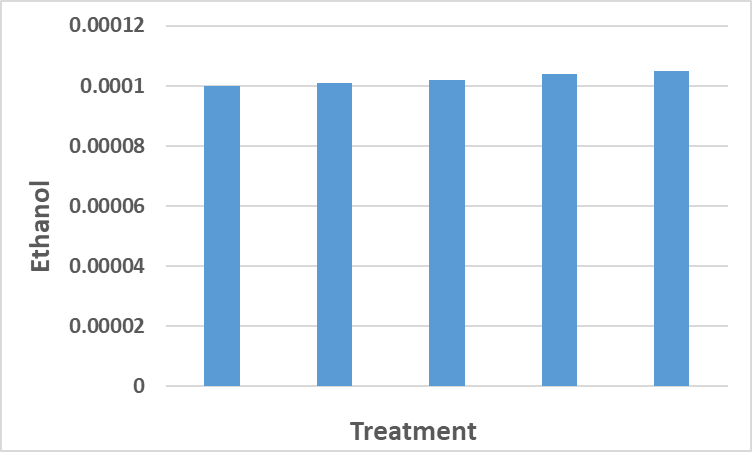
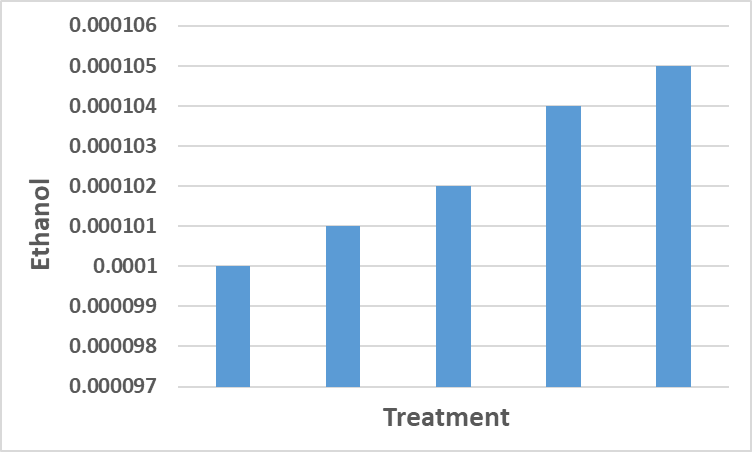
* Present your data to the readers in a manner that is:
  + Clear - You want the reader to fully understand your data.
  + Concise - You want to communicate your data with as few words as possible.
  + Easy to Follow - You want the reader to be able to understand your results with as little effort on their part as possible.

Writing the Text

* Provide a description of the **trends** you observed in your data.
  + The description should indicate how your treatment levels compared to each other. You should only have ~**one sentence per dependent variable**.
  + “On average, yeast utilizing glucose produced more carbon dioxide than yeast using sucrose.”
  + “Yeast given sucrose produced nearly two times the amount of ethanol than yeast given lactose.”
* Talk about your data as a whole, not trial-by-trial or week-by-week.
* Make sure to reference your figures in the text.
  + Referencing figures is similar to how you would include a citation.
  + “As shown in Figure 1,……”
  + “Yeast produced carbon dioxide twice as fast when exposed to heat (Figure 2).”
* Avoid these common mistakes:
  + Reporting raw data - Do not provide the actual values that you are showing in you graphs.
  + Interpreting the data - Do not say that the independent variable *caused* the difference observed in the dependent variable, and do not reference your hypothesis.
  + Including too much information - Your Results section should be concise; remember, you only want ~one sentence per dependent variable.
  + Including material that belongs in other sections - Don’t include number of trials (Methods), trial lengths (Methods), anything about your hypothesis (Introduction and Discussion).

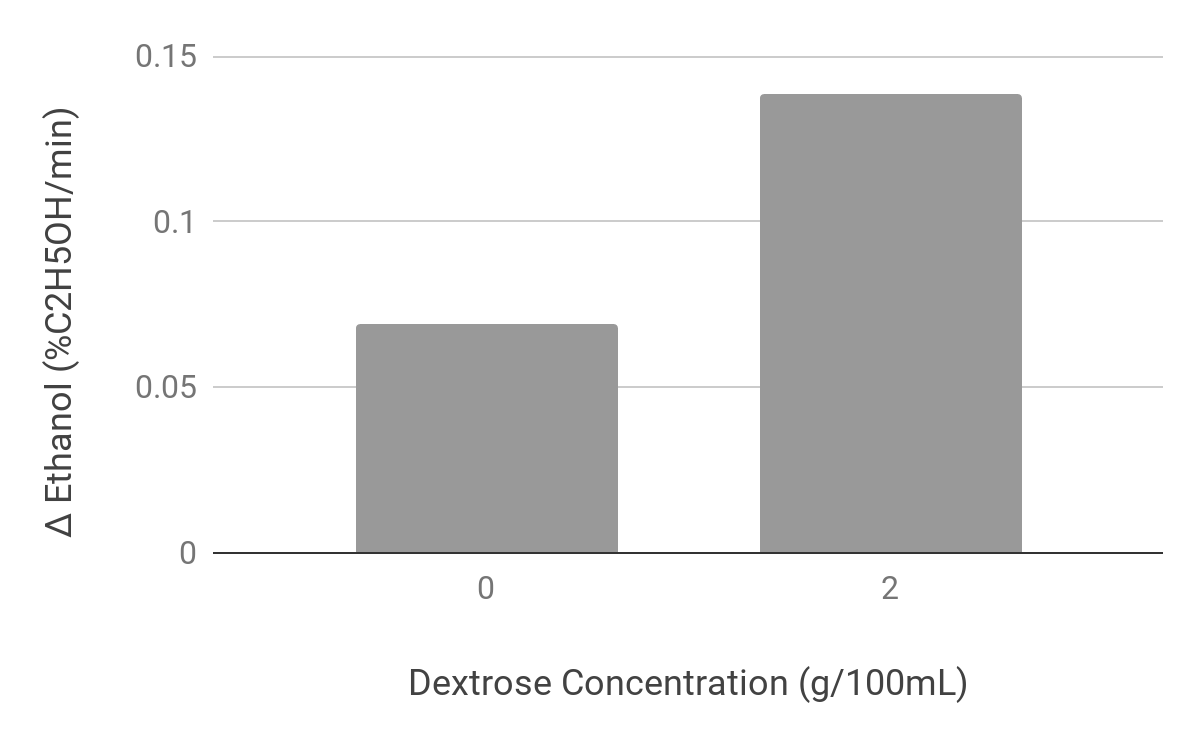
Creating Graphs

* Make sure to follow these rules when making your graphs:
  + **Do not** include titles on your graphs - You should use a figure caption to describe the graph instead of a title.
  + Include a descriptive figure caption - The figure caption should describe the independent and dependent variables depicted on the graph, as well as some relevant information that can be quickly summarized, such as sample size.
    - “Figure 1: Average change in carbon dioxide for yeast given glucose and sucrose over the course of five 10 minute trials.”
    - “Figure 2: Average ethanol production for yeast using lactose vs. rice sugar for six 15 minute trials. Bars denote standard error.”
  + Label the axes - Your axis labels should be concise but descriptive, and should include appropriate units.
  + Only include a legend if necessary - This typically occurs when you have more than one independent variable (for example, different concentrations of two or more sugars).
  + Include error bars if possible on bar charts - Error bars should be either **standard deviation**, **standard error**, or **95% confidence interval**. Do NOT use Excel’s default error bars; you must calculate these yourself and use the custom error bar setting.
  + Ensure the y-axis begins at zero - Starting your y-axis at a point other than zero can give the reader the impression that there is more of a difference between the treatments than there actually was.



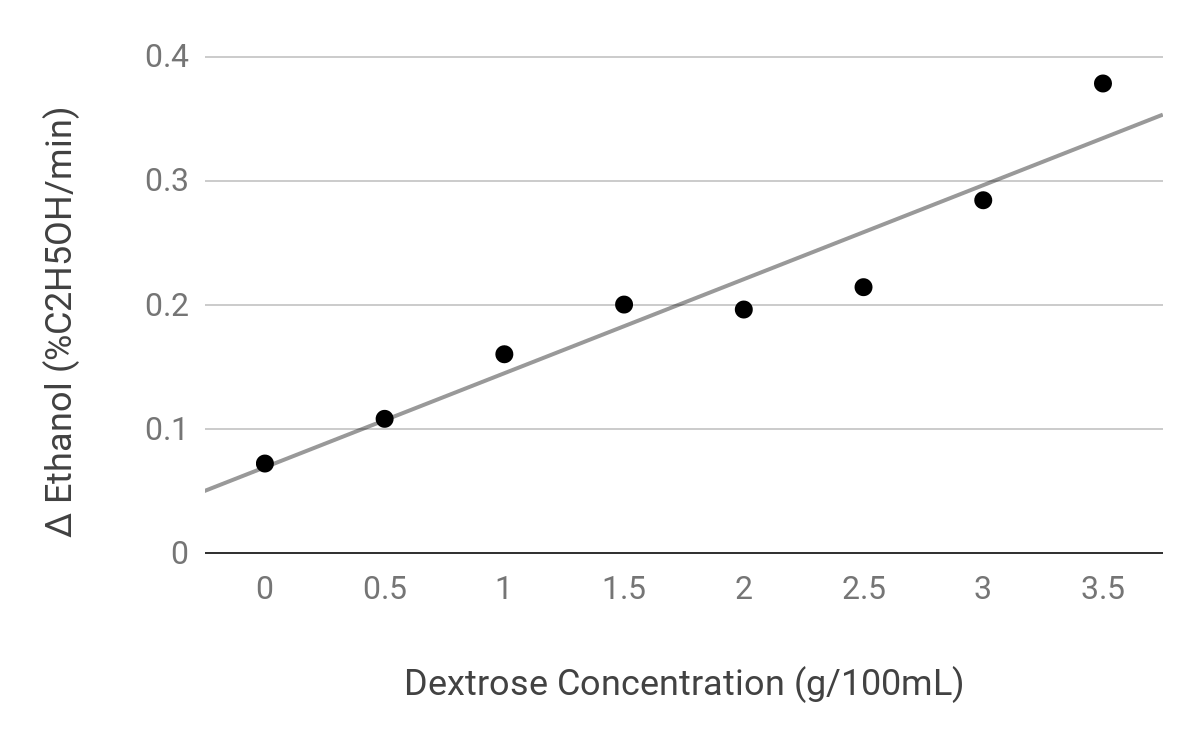
*Figure 1. These two graphs depict the same data. Figure 1.a does not start the y-axis at zero, which causes the reader to assume that the difference between treatments is larger than it actually is, whereas Figure 1.b starts the y-axis at zero, which more honestly reflects the data.*

* Make sure that you are using an appropriate graph for your data:
  + **Categorical Data** is when your independent variable can be broken into discrete categories (such as different types of sugar, or when you use only a few different concentrations of one sugar).
    - Categorical data should be depicted using a **bar chart**.



*Figure 2. An example of a bar chart.*

* + **Continuous Data** is when your independent variable can be any value within a range (such as many different concentrations of sugar, which can be any value from 0% to 100%).
    - Continuous data should be depicted using an **x-y scatter plot**.



*Figure 3. An example of an x-y scatter plot with a trendline.*

Statistics

* *Statistics are not required*, but will make reviewers regard your manuscript more favorably.
* Statistical test provide additional support for your hypothesis by telling you how confident you can be that your independent variable is affecting your dependent variable.
* Depending on the type of data you have, you should use a different type of statistical test.
  + When comparing exactly two different treatment levels, you should use a **t-test** (R8.3).
    - Example: You are comparing which of two sugars (sucrose and dextrose) causes yeast to produce the most ethanol.
  + When comparing three or more different treatment levels, you should use an **ANOVA** (R8.6).
    - Example: You are comparing which of 4 different pH buffers (pH 4, 5, 6, and 7) causes the yeast to produce the most ethanol.
  + When determining if there is a relationship between two continuous variables, you should use a **correlation analysis** (R8.8).
    - Example: You are determining if increasing the concentration of sugar (from 0% to 5%) is related to the amount of ethanol produced by yeast.
* You should calculate the **p-value**; this value will be between 0 and 1.
  + In biology, a p-value of **less than 0.05** indicates **significance** (that there is a meaningful difference between groups in a t-test or ANOVA, or that there is a meaningful relationship between variables in a correlation).
  + You should *only* use the words “significant” or “significance” if you’ve done a statistical test and found a p-value less than 0.05.
  + You should indicate that you found significant or insignificant results in the text of the results, and cite the p-value.
    - “As shown in Figure 1, the yeast treated with sucrose produced significantly more ethanol than the yeast treated with lactose (p=0.003).”
    - “There was no significant relationship between pH and ethanol production (Figure 1, p=0.543).”
    - “There was a significant positive correlation between between the concentration of sucrose added to the yeast and the ethanol produced (Figure 2, p=0.038).”
* You should state the statistical test performed in the Methods section.