Scientific Method; Measurement & Data Analysis

Lab 1
Science

- Science is a process of learning about the natural world.

- Doing experiments that involve gathering repeated and unbiased measurements (data) is the heart of testing hypotheses and answering questions.
The typical steps in the process of science

- Make insightful observation
- Pose and clarify testable questions
- Formulate hypotheses (Karl Popper)
- Do experiments to gather data
- Quantify the data
- Test the hypotheses
- Refine hypotheses and re-test
- Answer the questions and make conclusions
Nutrient Use in Yeast

Control
Low Nutrient
High Nutrient
Background

- Yeast obtains energy by breaking up large nutrient organic molecules called fermentation.

- The products of yeast fermentation including Ethanol, CO₂ (gas) and energy.

- To generate one unit of energy, it will produce certain units of CO₂ gas.
Investigation yeast nutrition

- Observation:

- Questions:
Investigation yeast nutrition

Hypotheses:

Prediction: the height change of the liquid in the “protein” tube should be same as the height change in the “sugar” tube.

H₀: CO₂ production by yeast fed sugar is not significantly different from CO₂ the production by yeast fed protein.
Investigation yeast nutrition

H₀: Yeast produces more CO₂ when fed sugar than when fed protein.

Prediction: the height change of the liquid in the “sugar” tube should be larger than the height change in the “protein” tube.
Investigation yeast nutrition

- Design experiment*: 
  - Repeat experiment multiple times 
  - Calculate the mean and standard deviation 
  - Test the hypotheses
The metric system

- Standard system of measurement in science

- Length, weight, volume, temperature
Metric units of length

- Length: meter (m), centimeter (cm), millimeter (mm), micrometer (µm), nanometer (nm)

1 m = 100 cm
1 cm = 10 mm
1 mm = 1,000 µm
1 µm = 1,000 nm

\[ 1 \text{m} = 1 \times 10^2 \text{cm} = 1 \times 10^3 \text{mm} = 1 \times 10^6 \text{µm} = 1 \times 10^9 \text{nm} \]

\[ 1 \text{nm} = 1 \times 10^{-3} \text{µm} = 1 \times 10^{-6} \text{mm} = 1 \times 10^{-7} \text{cm} = 1 \times 10^{-9} \text{m} \]
Metric units of length
Metric units of mass

- Weight: kilogram (kg), gram (g), milligram (mg)

\[
\begin{align*}
1\text{kg} &= 1000\text{g} = 1 \times 10^3 \text{g} \\
1\text{g} &= 1,000\text{mg} = 1 \times 10^3 \text{mg} \\
1\text{mg} &= 0.001\text{g} = 1 \times 10^{-3} \text{g} \\
1\text{g} &= 0.001\text{kg} = 1 \times 10^{-3} \text{kg}
\end{align*}
\]
Metric units of volume

- Volume: liter (l), milliliter (ml)

  \[ 1 \text{l} = 1,000 \text{ml} = 1 \times 10^3 \text{ml} \]
  \[ 1 \text{ml} = 0.001 \text{l} = 1 \times 10^{-3} \text{l} \]
Meniscus Reading

Low Reading

Correct Line of Volume

High Reading
Temperature scales

- Fahrenheit (F) & Celsius (C)
  
  \[
  C = \frac{F - 32\degree}{1.8}
  \]
  
  \[
  F = 1.8 \times C + 32\degree
  \]
Understanding numerical data

- Statistics
- Mean: the arithmetic average of a group of measurements
- Median: the middle value of a group of measurements
- Standard deviation (SD): how measurements vary about the mean

sample1: 25, 35, 32, 28
sample2: 15, 75, 10, 20
Test the hypotheses

- Only determining if one mean is higher than the other is not an adequate test because natural variation will always make the two means at least lightly different, even if the two treatments have the same effect on yeast growth. Therefore, the means and the variation about the means must be compared to determine if the means are not just different but significantly different.
Mean, variance and standard deviation

- $X_{\text{mean}} = (X_1+X_2+X_3+X_4+X_5...)/N$

- Variance = $\frac{1}{N} \sum_{i=1}^{N} (x_i - \bar{x})^2$

- SD = $\sqrt{\frac{1}{N} \sum_{i=1}^{N} (x_i - \bar{x})^2}$
Mean, variance and standard deviation

- Nutrient use in yeast data:

<table>
<thead>
<tr>
<th>Replicate</th>
<th>Control CO2 Production (mm)</th>
<th>Replicate</th>
<th>Glucose CO2 Production (mm)</th>
<th>Replicate</th>
<th>Protein CO2 Production (mm)</th>
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<td>G1</td>
<td>9</td>
<td>P1</td>
<td>4</td>
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<tr>
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<td>G2</td>
<td>8</td>
<td>P2</td>
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<td>10</td>
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Mean, variance and standard deviation

\[ C_{\text{mean}} = 1.00 \quad C_{\text{SD}} = 0.41 \]

\[ G_{\text{mean}} = 9.50 \quad G_{\text{SD}} = 1.29 \]

\[ P_{\text{mean}} = 5.125 \quad P_{\text{SD}} = 0.85 \]
Lab work

1. measure tubes of yeast fermentation and calculate the mean and standard deviation
2. Procedure 2.1 (p13)
3. Procedure 2.3 (p14) marbles, rocks
4. Procedure 2.4 (p14)
5. Procedure 2.5 (p15) rocks, marbles, coins, paper clips
6. Procedure 2.6 (p16) room temp, refrigerated, & hot water
7. Procedure 2.7 (p18-19) test on average, the height of female adults is lower than the height of male adults in human???
<table>
<thead>
<tr>
<th></th>
<th>group1</th>
<th>group2</th>
<th>group3</th>
<th>group4</th>
<th>group5</th>
<th>Group6</th>
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<td>4.0</td>
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