Goals for the day:

1. Words: null and alternate hypotheses
2. R: t.test
3. Big idea: One reason for gathering data is to test a hypothesis about a population parameter

A hypothesis is a statement about the population, usually about the value of some population parameter. In this activity all our hypotheses will be hypotheses about $\mu$.

**Null hypothesis:** The hypothesis of no change (null). It might be the hypothesis that is generally accepted. It’s the hypothesis that we will continue to live with unless the data provide strong evidence against it. The null hypothesis is denoted $H_0$.

**Alternate hypothesis:** Usually the reason why we are collecting data. It is the hypothesis that we are prepared to adopt but only if we see strong evidence in its favor. The alternate hypothesis is denoted $H_1$ or $H_a$.

**Raisin Bran**

Kellogg’s labels Raisin Bran boxes with the net weight. For example, they market boxes that are labeled 11 oz. Periodically, samples are taken to determine whether the boxes do in fact have 11 oz.

\[
H_0: \quad \text{______________} \\
H_1: \quad \text{______________}
\]

What about our sample would count as strong evidence that $H_1$ is true?

**Body Temperature**

The generally accepted figure for average body temperature of humans is 98.2 degrees Fahrenheit (taken orally). We would like to see whether this is true by taking a sample of 130 Calvin students.

\[
H_0: \quad \text{______________} \\
H_1: \quad \text{______________}
\]

What about our sample would count as strong evidence that $H_1$ is true?

What about this particular sample should give us caution in using it to test these hypotheses?
Length of Baseball games

Major league baseball says that the average baseball game last 2.5 hours. Having sat through many three hour games, you doubt this. You happen to have the length in minutes of all baseball games played in 2003 (there are 2430 of them).

\[ H_0: \quad \text{ } \]
\[ H_1: \quad \text{ } \]

If all the games played in 2003 are a sample, what might the population be?

What would count as evidence that \( H_1 \) is true?

The speed of light

In 1887, Michelson and Morley did their classic experiment to measure the speed of light. We now know that the speed of light is 299,792,456 m/s, exactly. Are the 100 measurements of Michelson and Morley consistent with this number?

\[ H_0: \quad \text{ } \]
\[ H_1: \quad \text{ } \]

What is the population here?
How strong is the evidence for $H_1$ over against $H_0$?

The logic of hypothesis testing is this: we assume that $H_0$ is true and we ask whether our data is sufficient evidence to abandon that assumption in favor of believing $H_1$.

There are a lot of misunderstandings of hypothesis testing – here are some things that we are not doing.

1. We are not trying to prove $H_0$ is true. We assume it is true and try to find sufficient evidence that it is false.
2. We do not ask whether the evidence merely favors $H_1$ over $H_0$. We ask whether it is sufficient to abandon $H_0$ in favor of $H_1$.

Steps in testing hypotheses about $\mu$ (illustrated with temperature data)

1. Compute a test statistic that measures how far away $\bar{x}$ is from the hypothesized value of $H_0$.
   We could use $\bar{x} - 98.2$ in this case but it is far better to use
   
   $$T = \frac{\bar{x} - 98.2}{s/\sqrt{n}}$$

   because “far away” is relative to the variation in $\bar{x}$.

   > xbar=mean(normtemp$Temp)
   > s=sd(normtemp$Temp)
   > n=length(normtemp$Temp)
   > T = (xbar-98.2)/(s/sqrt(n))
   > T
   [1] 0.76559

2. Ask this question: if $H_0$ is true how likely is it that we will get a value of $T$ at least this far away from what $H_0$ hypothesizes.
   If $H_0$ is true, then $T$ has a $t$-distribution with $n - 1$ degrees of freedom.
   > 1-pt(T,n-1)
   [1] 0.22266

   Even if $H_0$ is true, 44% of the time we would get a value of $T$ at least this far away from what is expected if $H_0$ is true.

   All this computation can be done by `t.test`:
   > t.test(normtemp$Temp, mu=98.2)
   
   One Sample t-test
   
   data: normtemp$Temp
t = 0.7656, df = 129, p-value = 0.4453
   alternative hypothesis: true mean is not equal to 98.2
   95 percent confidence interval:
   98.122 98.376
   sample estimates:
   mean of x
   98.249

3. Draw a conclusion. We don’t have sufficient evidence to abandon $H_0$ in favor of $H_1$. These data would not be at all surprising if $H_0$ were true.