## Statistical Comparisons of Measured Data

Is my measured mean different from an accepted value?

$$
\begin{aligned}
& \text { ensured mean different from an accepted value? } \\
& H_{0}: \mu=\text { value } \quad t \text { stat compare to normal } \\
& \\
& \text { * assume } \sigma \text { of }
\end{aligned}
$$

Is my measured mean different from a different measured mean?

$$
\begin{array}{r}
\text { Ho } \mu_{1}=\mu_{2} \quad \begin{array}{l}
\text { compare to Gauss distr. } \\
\text { assume or know } \stackrel{\sigma}{=} \text { true pop. } \\
\text { better: } \quad t \text { distribution } t \text { pooled std der. } \\
t=\frac{\mu_{1}-\mu_{2}}{s_{1-4}} \quad s=\text { std of meas } f
\end{array}
\end{array}
$$

What if you want to compare 3 or more samples?

Which seems best?
A) Compare each pair of samples to each other and evaluate whether they are "the same"

$$
\begin{array}{llll}
\text { e.g., } & \mathrm{x}_{1} \text { VS } \mathrm{X}_{2} & \mathrm{x}_{1} \text { VS } \mathrm{X}_{3} & \mathrm{x}_{1} \text { VS } \mathrm{X}_{4} \\
& & \mathrm{x}_{2} \text { VS } \mathrm{X}_{3} & \mathrm{x}_{2} \text { VS } \mathrm{X}_{4} \\
& & \mathrm{x}_{3} \text { VS Xt }
\end{array}
$$

B) Compare the samples as a set to determine whether they are all "the same"

Analysis of Variance (ANOVA)
Compare 3 or more samples from 3 or more populations

For example:
3 different instrumental methods measure the same thing.
Are all of the resultant values "the same"??

We want to compare three means: $\mu_{1}, \mu_{2}, \mu_{3}$

What is the correct null hypothesis?
A) $\mu_{1}=\mu_{2}=\mu_{3}$ one possibility $\quad \mathrm{Null}=\mathrm{NO}$
B) $\left.\mu_{1} \neq \mu_{2} \neq \mu_{3}\right]_{D}^{\text {lots possiblite }}$
C) $\mu_{1}>\mu_{2}>\mu_{3}$
D) $\mu_{1}<\mu_{2}<\mu_{3}$
E) $\mu_{1}>\mu_{2}=\mu_{3}$

Uar example:
4 groups of pigs are given different types of feed, and the pigs are weighed.


$$
=\frac{\left(x_{i}-x_{i}\right)^{2}}{N} \quad s^{2}=\frac{\left(x_{i}-x_{i}\right)^{2}}{N-1} \quad \text { all the data } \quad \text { has a } \quad \text { mean } \quad \text { }
$$

* Assumptions:

1) each group from a normally-distr. population
d) all groups have the same true $\sigma$

Two major types of variation
I. variation within a group
$S S=\sum\left(x_{i}-X_{i}\right)^{2}$ (deviation from the mean in a group
sum of squares
for all groups: $\sum_{i=1}^{k} \underbrace{\sum_{j=1}^{n_{i}}\left(x_{i j}-x_{i}\right)^{2}}=$ Degrees of freedom

$$
N-k
$$

Degrees of all groups
II. variation between groups $2=N-1$

$$
\begin{aligned}
& F=164 \\
& F_{\text {crit }}=3.2 \\
& F>7 F_{\text {cit }}
\end{aligned}
$$

So
$H_{0}$ is rejected rejected as ${ }^{\text {aswan- }}$ Tukey Test StetsTukey Test (igor) if diff $\mathrm{hig} \Rightarrow$ diff

$$
\frac{X_{\text {large }} X, X, X_{\text {small }}}{2}
$$


total variation $=\underset{\text { vithingion }}{\text { virus }}+\underset{\text { variation }}{\text { betuea groups }}$

between groups ms

Test!
If $H_{0}\left(\mu_{i}=\mu_{2}=\mu_{3}\right)$ true, the true $\sigma$ is the same b/c come from pore pop.

If not, variation between groups $>$ within

$$
F=\frac{\text { variance between groups }}{\text { variance withingroups }}=\frac{m s}{m s \epsilon}
$$

look up $F_{\text {crit }}$
If $F>F_{\text {crit }}$ reject $H_{0}$

