Observational Studies	Experimental Studies
no intervention	Experiments
	intervention
Surveys	

Experiments vs. Samples

Though some concepts are similar, don't confuse experimentation with sampling.

Purpose of sampling: estimate a parameter by measuring a representative subset of the population, created by selecting subjects randomly using an appropriate technique.

Purpose of an experiment: demonstrate a cause and effect relationship by controlling extraneous factors. Experiments are rarely performed on random samples because both ethics and practicality make that impossible. Thus, there's always concern for how far we can generalize an experiment's results.

The vocabulary of experiments

Experimental Units: Objects on which an experiment is done.

Subjects: Human experimental units.

Factor = Explanatory/Independent Variable that you manipulate

Level = value, amount, or subdivision of each Factor (a Factor *can* have an absent level)

Treatment = A separate Factor/Level combination, specific experimental condition applied to the units

Outcome = Dependent Variable (what you measure on units)

Placebo = a treatment that, in the case of medical studies, contains no medication.

Placebo Effect = Occurs when a response variable is affected by the use of a placebo.

Example   ActivStats III. 11.2 Basic Concepts
If we were testing the effectiveness of a blood pressure medication (the factor), we might randomly assign either one of three doses (levels) of the medication or a placebo (thus we have 4 treatments) to patients (our subjects) and then take their blood pressure (to measure the outcome).

Another example

Soybeans need nitrogen-fixing bacteria to make use of nitrogen in the soil. These bacteria live in nodules like the ones shown in the picture at the right. My dad bought two strains of inoculant and wants to see which strain best aids the soybean growth and yield.

I suggest that he divide a field into four sections, knowing that two quarters tend to be wet and two other sections tend to be dry. I would randomly assign strains so that one strain is tested on both a wet and a dry section and the other strain is tested on both a wet and a dry section.

What are the experimental units?
What's the treatment?
What is/are the factor(s)?

D	W
D	W

A **control group** often receives no treatment or a placebo so that we can control the effect of outside variables. Without control, our work is open to **experimental bias**, favoring a particular outcome. We sometimes say that the design of a study is biased if it favors a certain outcome.

Example
To improve upon the experiment I set up for my dad, I should have two control groups: areas that receive no inoculant. It *is* possible, after all, that the native bacteria could crowd out the inoculant strain. The experiment now would have my dad consider 6 areas of the field. The 3 wet areas would each be assigned to one inoculant, no treatment, or the other inoculant. The 3 dry areas would likewise be assigned. This would control for the native strains existing in the soil.

controlling and comparing

D	w
D	w
D	w

To control bias, we try to balance groups as much as possible. We try to match subjects or units for each treatment.

controlling and comparing

examples
1. I suggested using one bacteria strain in each field condition.
2. Doctors researching drugs will administer treatments to subjects while considering gender, health, age, smoking history, etc.
3. Marketing researchers field test new products in various parts of the country, with men and women, of all ages and races.

But, that's not enough-- we need to assign treatments randomly! When all experimental units are assigned at random among all treatments, the experimental design is **completely randomized**.
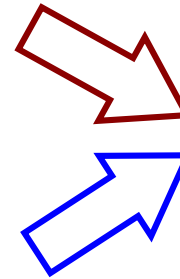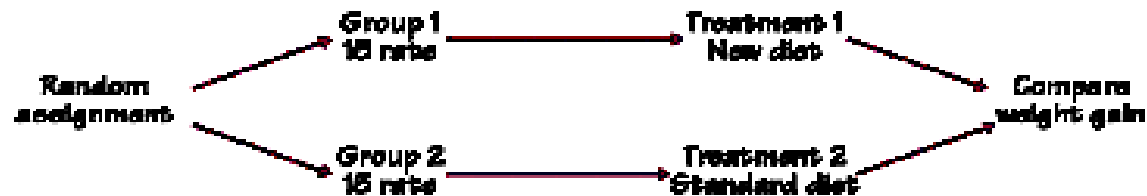
Randomization produces groups that should be similar in all respects before treatment is applied.

Comparative design ensures that outside influences operate equally on each group.

Differences among groups must be due to <u>treatment</u> or due to the play of <u>chance</u> in the random assignment to groups.

Random assignment

Group 1
15 rats → Treatment 1
New diet

Group 2
15 rats → Treatment 2
Standard diet

Compare weight gain

Would we trust a pain medication that was tested for safety and effectiveness on just two subjects?

Would McDonald's put a Basil-Okra Sundae on its menu if a market research study involving only 5 people found that all 5 liked them?
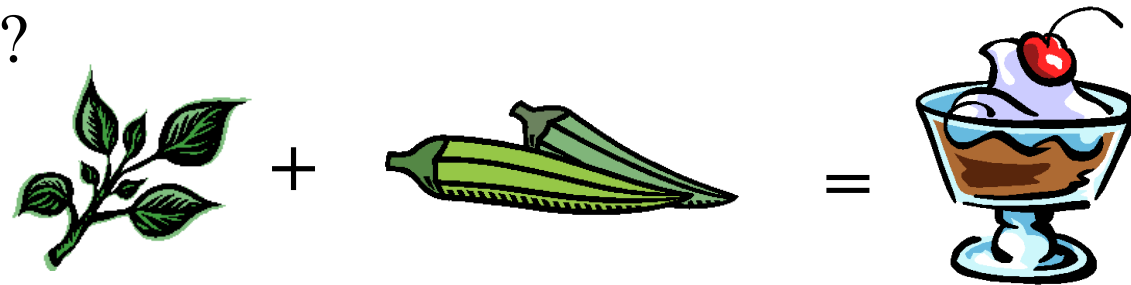
The issue:
It's unlikely that 2 or 5 people adequately represent the varied physiology and tastes of the entire population. We have to use enough experimental units to reduce chance variation.

Replicate

Principles of Experimental Design

1. Control the effects of lurking variables on the response, most simply by comparing two or more treatments.

2. Randomize-- use impersonal chance to assign experimental units to treatments.

3. Replicate each treatment on many units to reduce chance variation in the results.

An observed effect so large that it would rarely occur by chance is called **statistically significant**.

ActivStats III. 11.1 Review the 3 rules

Other experimental designs

In a **double-blind experiment**, neither the subjects nor the people who have contact with them know which treatment a subject received.

In a **block design**, the random assignment of units to treatments is carried out separately within each block.

A **block** is a group of experimental units or subjects that are known before the experiment to be similar in some way that is expected to affect the response to the treatments.

In a **matched pairs design**, we compare just two treatments. We then either

a. choose *blocks* of two units that are as closely matched as possible and randomly assign treatments to each unit in the pair/block, or

b. choose *blocks* of just one unit each and apply both treatments to each unit but in a random order.

Blocking vs. Stratification:

Blocking (experiments) and stratifying (samples) both divide subjects before random assignment or selection, but the words are definitely not interchangeable.

Blocking is separating units into similar groups in an <u>experiment</u> to minimize any effect of some variable and to help detect a difference in levels of the independent variable.	Stratification is separating units into similar groups during the process of <u>sampling</u>

Why block?

Blocking results in homogeneous experimental units to which you then randomly assign treatments.

Homogeneous means that units in the same block tend to produce the same response while blocks may produce, on the average, different responses. Units within blocks are correlated.

Blocking may reduce unwanted variation and thus allow us to see differences more clearly. This happens only if the blocks have more variation between them than within them.

Blocking is used to control the factors you can see; randomization helps balance the ones you can't see.

Blocking divides subjects in advance based on some factor we know or believe is relevant to the study and then we randomly assign treatments within each block. The key things to remember:

1. Don't just block for the heck of it, but rather based on some factor we think will impact the response to the treatment.

2. Blocking isn't random. The randomization occurs within each block essentially creating 2 or more miniature experiments.

3. Blocks should be homogenous (i.e. alike) with respect to the blocking factor.

example:

Mrs. Teacher wonders if playing classical music during tests will result in higher mean scores. She could randomly assign half the students to a room with the music and the other half to a normal room, but she knows that her juniors consistently score higher than her seniors, and she want to account for this source of variation in the results.
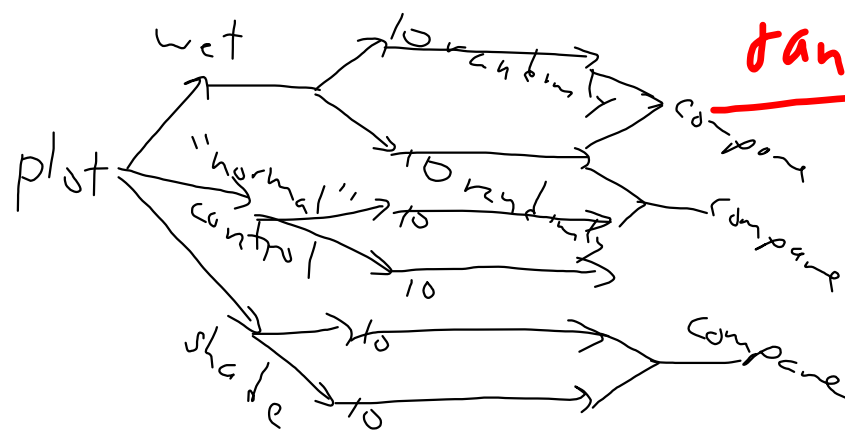
She blocks according to grade, separating juniors and seniors, then randomly assigns half the juniors to the music room and the other half to the normal room. She does the same with the seniors.

For this design to be valid, she has to expect that each grade will respond to the music similarly. In other words, she knows that juniors will score higher, but she expects to see a similar improvement or decline in both groups as a result of having the music.
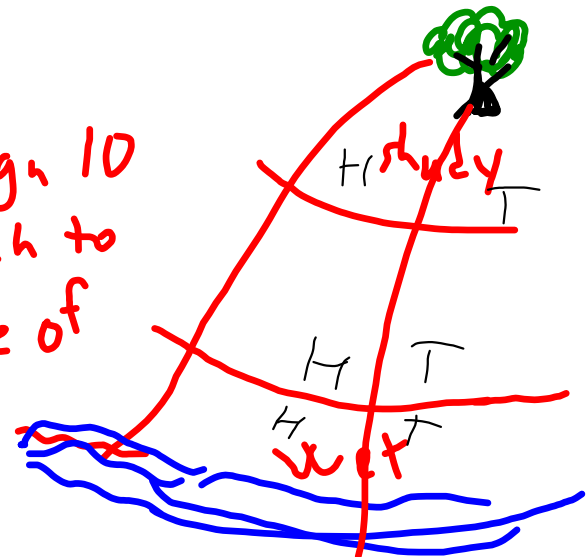
To analyze the results of one special type of blocked design, matched pairs, we subtract each pair of values, which eliminates the variation due to the subject.

Renowned agricultural geneticist, P.P. Pumpkineater, produced two new pumpkin varieties, ScaryFace and CandleBreath. To decide which variety is most "jack-o-lanternable", he plans a test. He has a hillside plot of land available with a large number of trees on top and a stream near the bottom. He is quite concerned about the effects of sunlight and water and has 30 seeds of each variety available.
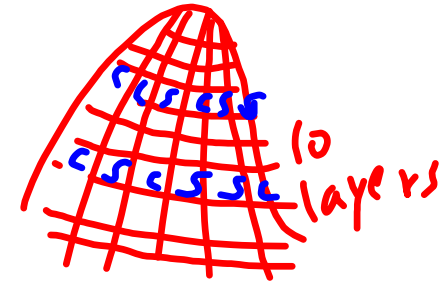
Design an experiment that will help P.P. determine which strain to market.

randomly assign 10 of each to each type of plot.

wet

plot

"normal" control

shade

low humidity

10

compare

10 humidity

10

10

10

compare

compare

dry

H T

H T

wet H T

There are at least two possible answers.

Block Design:
Create 60 plots of land in blocks parallel to the trees/river in 10 blocks of 6 each. Three plots in each row would be chosen at random for one variety, the remaining plots would be the other. Growth is compared.

Matched Pairs Design:
Split the field into 30 plots, and each plot gets one seed of each variety. Randomly assign one seed in each plot to the hill side and the other to the river side.