Observational Studies no intervention Surveys	Experimental Studies Experiments intervention

Experiments vs. Samples

sampling
purpose: estimate parameter
how: measure a representative subset of the population, created by randomly selecting subjects by some appropriate method

experiment
purpose: demonstrate a cause and effect relationship
how: control other variables and randomly assign volunteers to treatments
(rarely performed on random samples because of ethics & practicality)
Always question generalizability.

The vocabulary of experiments

Experimental Units: Objects we experiment on.

Subjects: Human experimental units.

Factor = Explanatory/Independent Variable you manipulate

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

BA BN BC LA LN LC

Treatment = Each Factor/Level combination, specific experimental condition applied to units

Outcome = Dependent Variable (what you measure on units)

Placebo = treatment (in medical studies) contains no medication.

Placebo Effect = when placebo affects response variable

Example
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).

ActivStats III. 11.2 Basic Concepts

Another example controlling and comparing

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

control group: receives no treatment or a placebo
(to control effect of outside variables)

avoids **experimental bias**
(favoring a some 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.

D	W
D	w
D	w

controlling and comparing

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

controlling and comparing

examples

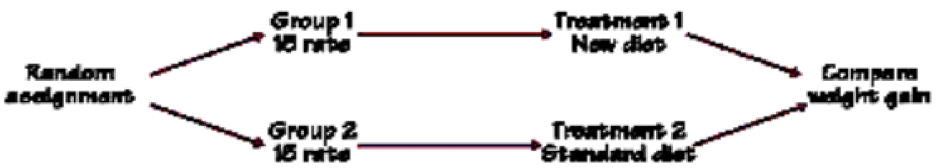
1. I suggested using one bacteria strain in each field condition.
2. Doctors researching drugs will administer treatments to subjects while considering gender, health, age, smoking history, etc.
3. Marketing researchers field test new products in various parts of the country, with men and women, of all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

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.



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. This reduces bias.

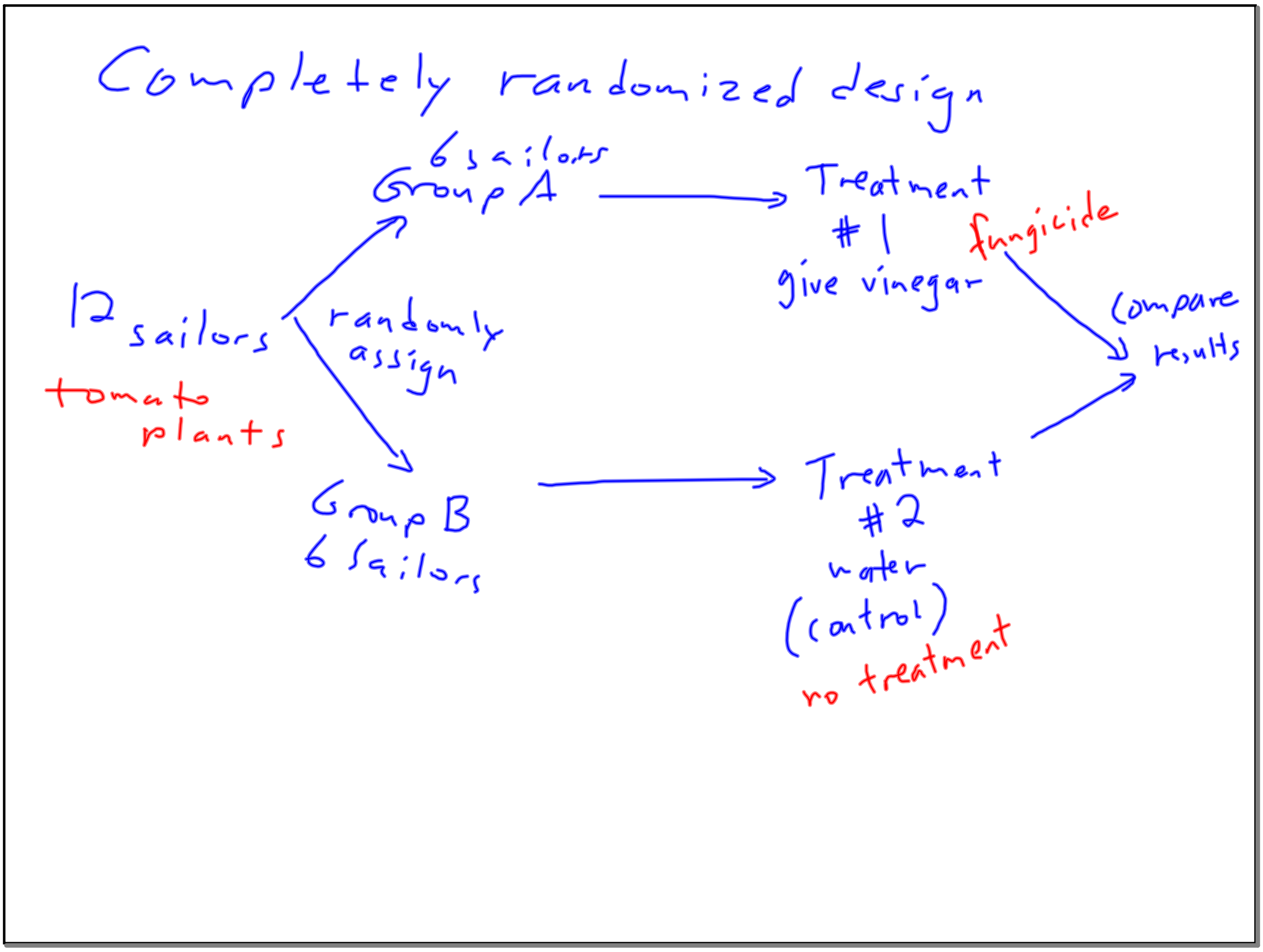
In a **block design**, the random assignment of units to treatmen is carried out separately within each block. This reduces variation.

> 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.

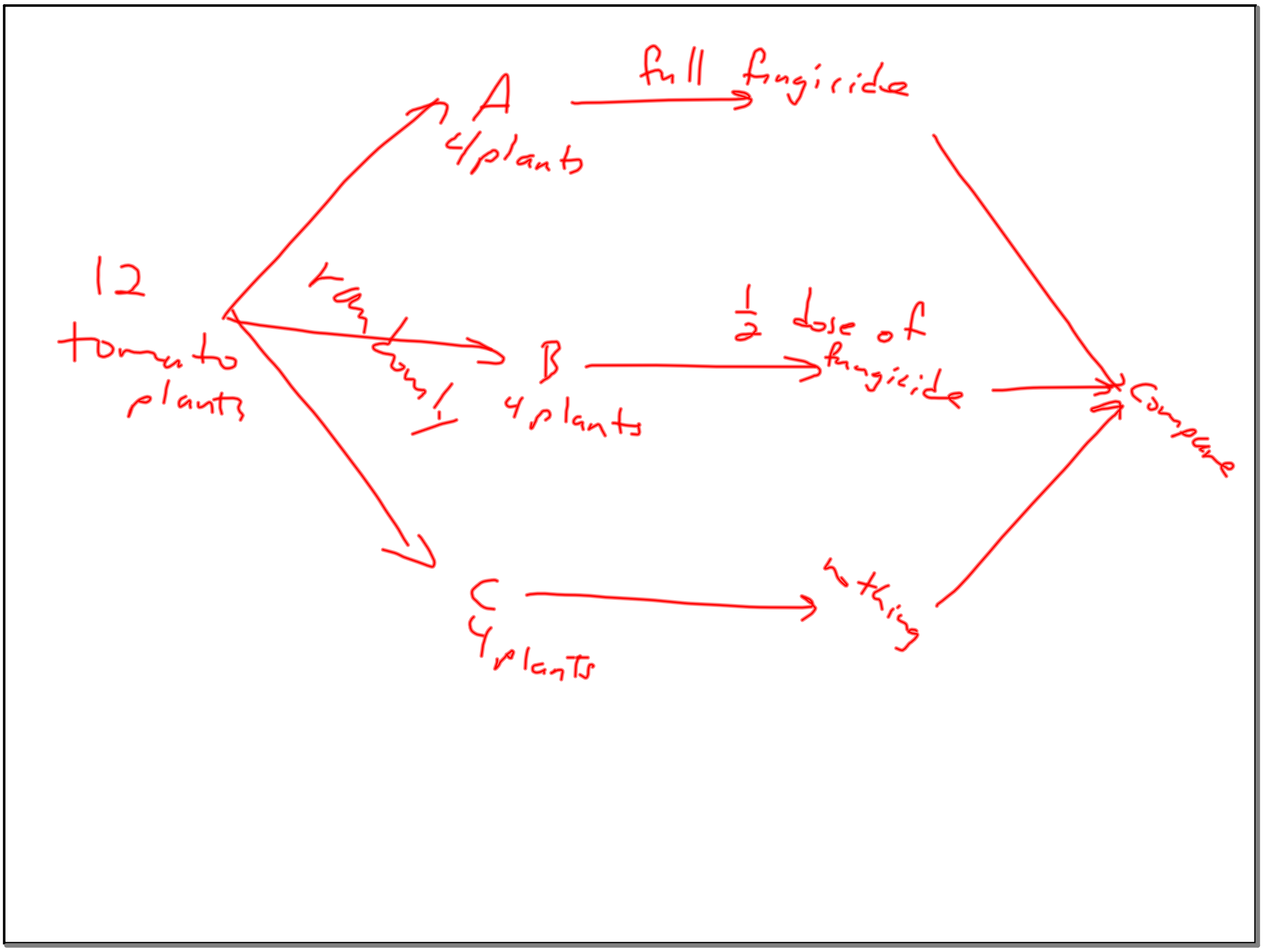
In a **matched pairs design**, we compare just two treatments. We then either

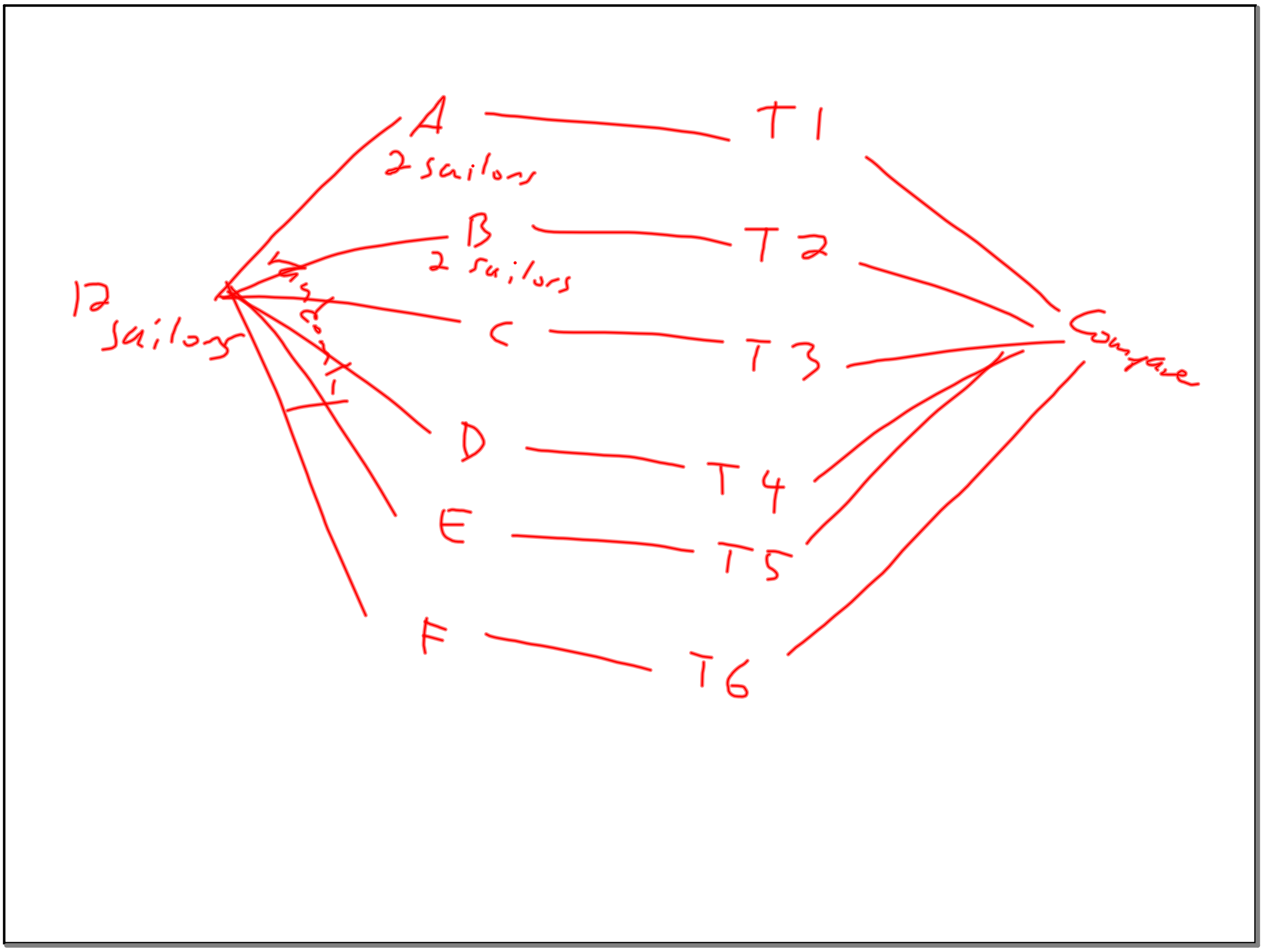
a. choose *blocks* of two units that are as closely matched as possible and randomly assign treatments to each unit in the pair/block, or

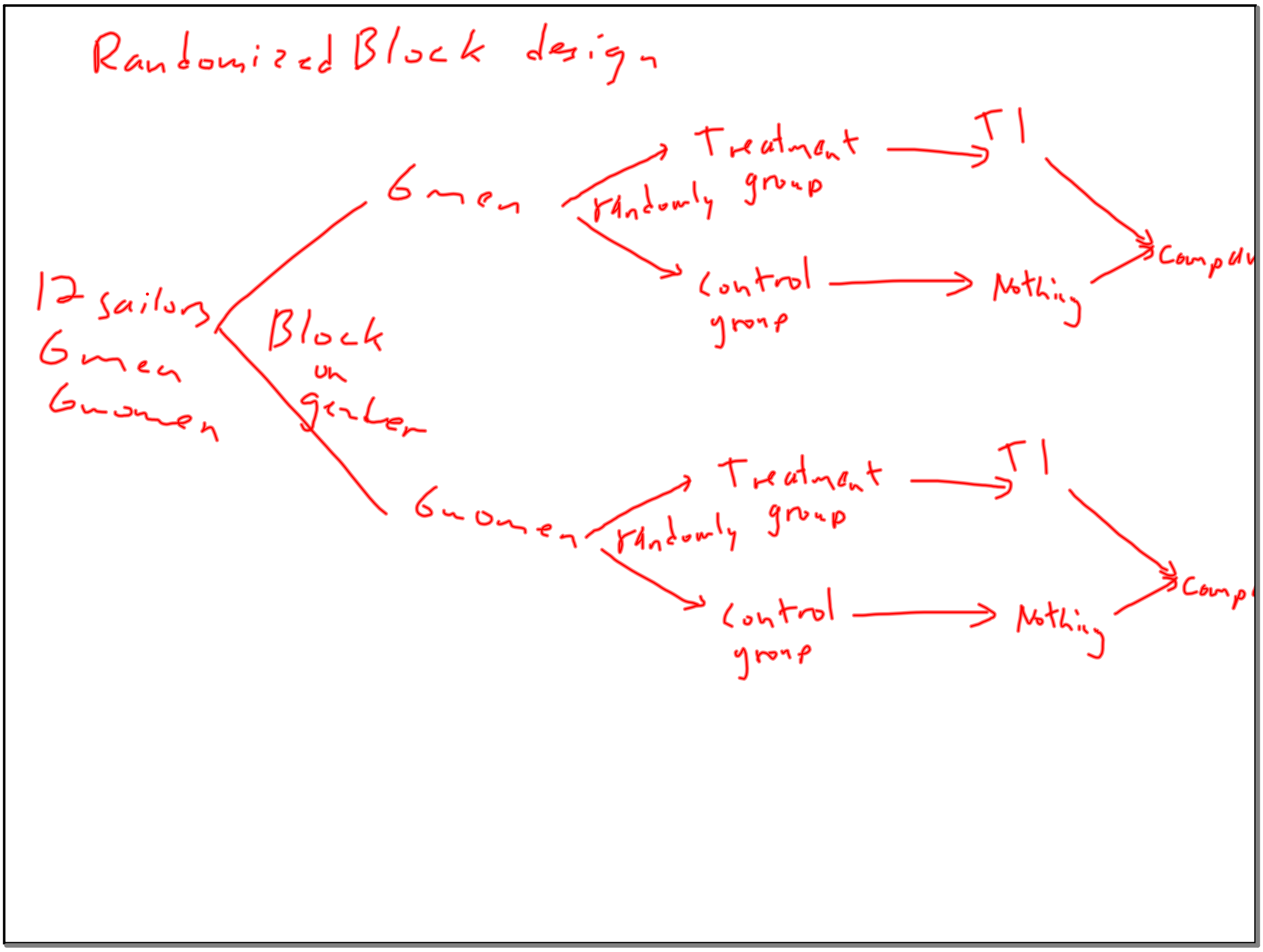
b. choose *blocks* of just one unit each and apply both treatments to each unit but in a random order.

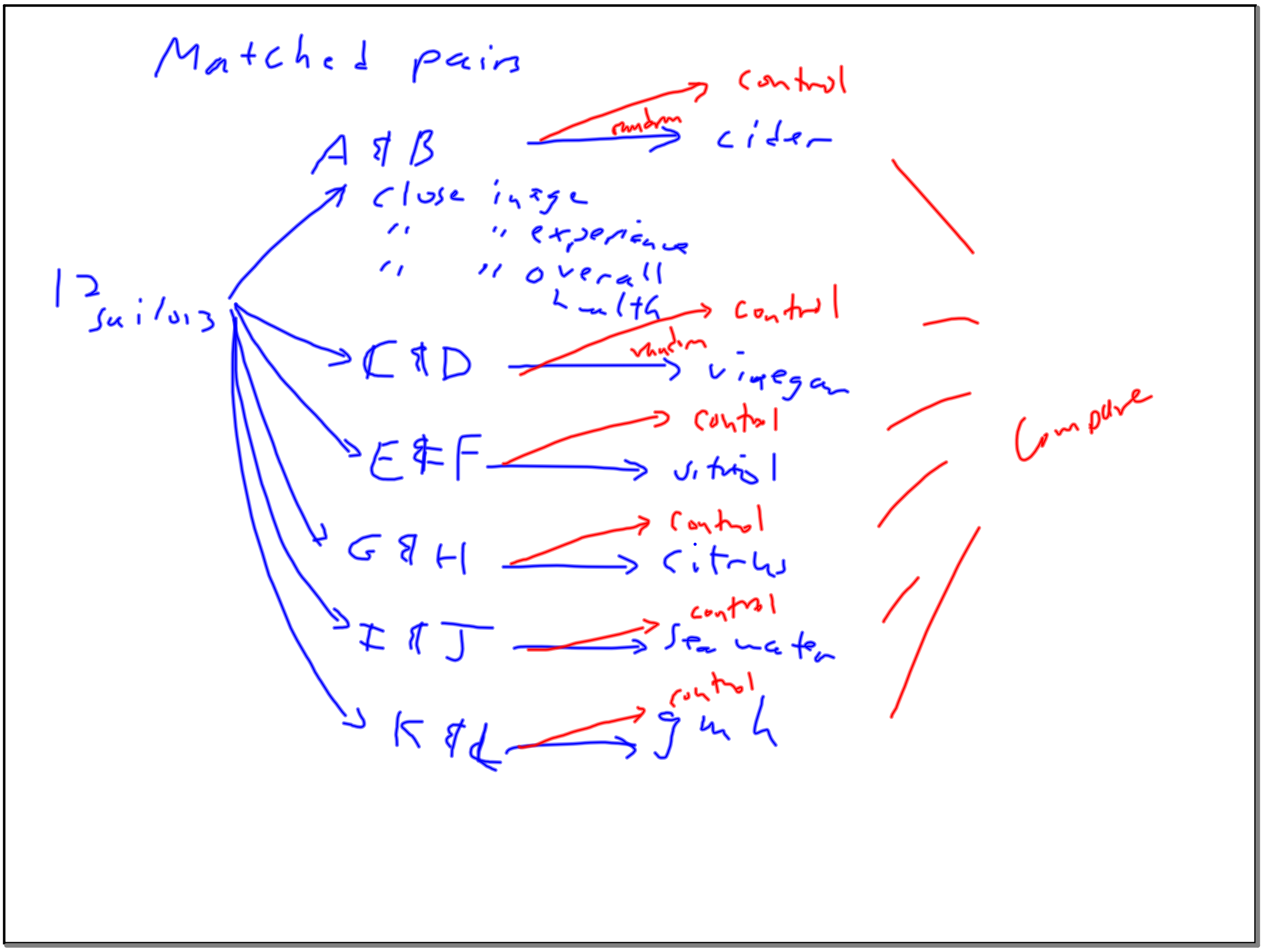

Completely randomized design
6 sailors
Group A
Treatment #1
give vinegar
fungicide
12 sailors
tomato plants
randomly assign
compare results
Group B
6 Sailors
Treatment #2
water
(control)
no treatment

In 1747, while serving as surgeon on HM Bark Salisbury, James Lind, the ship's surgeon, carried out a controlled experiment to develop a cure for scurvy.
Lind selected 12 men from the ship, all suffering from scurvy, and divided them into six pairs, giving each group different additions to their basic diet for a period of two weeks. The treatments were all remedies that had been proposed at one time or another. They were
A quart of cider per day
Twenty five gutts of elixir vitriol three times a day upon an empty stomach,
Half a pint of seawater every day
A mixture of garlic, mustard and horseradish, in a lump the size of a nutmeg
Two spoonfuls of vinegar three times a day
Two oranges and one lemon every day.
The men who had been given citrus fruits recovered dramatically within a week. One of them returned to duty after 6 days and the other became nurse to the rest. The others experienced some improvement, but nothing was comparable to the citrus fruits, which were proved to be substantially superior to the other treatments.
In this study his subjects' cases "were as similar as I could have them", that is he provided strict entry requirements to reduce extraneous variation. The men were paired, which provided replication. From a modern perspective, the main thing that is missing is randomized allocation of subjects to treatments.


12
tomato
plants
random
A
4 plants
full fungicide
B
4 plants
1/2 dose of
fungicide
C
4 plants
nothing
Compare


12 sailors
A
2 sailors
B
2 sailors
C
D
E
F
T1
T2
T3
T4
T5
T6
Compare


Randomized Block design
12 sailors
6 men
6 women
Block on gender
6 men
randomly
Treatment group
T1
Control group
Nothing
Compare
6 women
randomly
Treatment group
T1
Control group
Nothing
Comp


Matched pairs
A & B
close in age
" " experience
" " overall health
12 sailors
C & D
E & F
G & H
I & J
K & L
control
random
cider
vinegar
vitriol
citrus
sea water
Compare

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 experiment 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 sampling.

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.

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.