When the objective is to compare more than two populations, the experimental design that decreases the variability within the samples is called a **randomized block design**.

Block designs in experiments are similar to stratified designs for sampling. Both are meant to reduce variation among the subjects. We use different names only because the idea developed separately for sampling and experiments. Blocking also allows more precise overall conclusions, because the systematic differences due to gender or some other characteristic can be removed.

A block is a group of experimental units that are similar in some way that affects the outcome of the experiment. In a block design, the random assignment of treatments to units is done separately within each block. Rather than treating the subjects as if they were in a single pool we split the subject population.

Blocks are used to control the effects of some extraneous variable (such as smoking, cholesterol level, weight, age, etc.) by bringing that variable into the experiment so that some of the variability in the experiment can be reduced.

**** If needed, how is a blocking variable chosen? A researcher should choose a variable that most highly correlates or has the strongest association with the response variable in the experiment.

1. An agronomist wishes to compare the yield of five corn varieties. The field, in which the experiment will be carried out, increases in fertility from north to south. Outline an appropriate design for this experiment. Identify the explanatory and response variables, the experimental units, and the treatments. If it is a block design, identify the blocks.

   ![Diagram of corn variety vs. yield]

   I will block on fertility since this will influence crop yield.

   ![Experimental units]

   Block poor: Label the plots 1-5. Put numbers 1-5 in a hat, mix well. Pick out a number and assign it seed A, the second gets seed B, etc. Do the same for the remaining blocks. Treatments are the seed types planted. Compare mean crop yield for each variety of corn. [Response variable] vs. [explanatory variable].

   By blocking on fertility we have reduced variability due to one "lurking" variable.
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**This is another option, but the diagram is huge.**

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```
<table>
<thead>
<tr>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
</table>
```

**Block on fertility from north to south**

- Block Poor — randomly — Corn Varieties
- Block Fair — randomly — Corn Varieties
- Block Good — randomly — Corn Varieties
- Block Excellent — randomly — Corn Varieties

**Compare mean # of bushels**

The explanatory variable is the corn variety and the yield in bushels will be the response variable. The experimental units are the plots of land. The treatments are the 5 different varieties of corn. Blocking on location from north to south in 4 horizontal strips will decrease variability due to the fertility of the field. In each block I will number the corn varieties 1-5, place them in a hat, mix well, then select them one by one for assignment to plots from left to right.
The **matched-pairs** method of sampling is used to compare **two** treatments. This method reduces the variability within the samples since you are trying to match subject's characteristics as closely as possible. This makes it easier to detect differences within the two populations or treatments.

Matched-pairs design is one kind of **block design**. A block is a group of experimental units that are similar in some way that affects the outcome of the experiment. In a block design, the random assignment of treatments to units is done separately within each block.

Each block consists of just two units matched as closely as possible. These units are assigned at random to the two treatments by tossing a coin or reading odd and even digits from a random number table. Alternatively, each block in a matched pair design may consist of one subject who gets both treatments one after the other. Each subject then serves as his or her own control.

2. Suppose that the experiment using fertilizer on a 20-acre farm described in the previous handout has been redesigned in the following way. Ten 2-acre plots of land scattered throughout the county are randomly selected. Each plot is subdivided into two subplots, one of which is treated with the current fertilizer and the other of which is treated with the new fertilizer. Wheat is planted and the crop yields are measured. How is this experiment different from that in example #1? What advantages are there for this method? Which treatment is acting as the control group? What information, if any, can be gained by having a control group?

This is different because there are many additional factors added in regards to geography—weather, climate, soil type, fertility, etc. However, this is beneficial because we will be able to discern the effectiveness of the new fertilizer on many different soil types.

The current fertilizer is the control group. This will help to reduce variability based on factors such as weather from last year.

I will use each plot as a block and divide it into 2 equal plots, then flip a coin:

- Heads: left plot gets new fertilizer
- Tails: left plot gets old fertilizer

The right plot gets the other treatment

⇒ Compare average wheat yield [response variable]
3. You are participating in the design of a medical experiment to investigate whether a new dietary supplement will reduce the cholesterol level of middle-aged men. Sixty randomly selected men are available for the study. It is known from past studies that smoking and weight can affect cholesterol levels in men. Describe the design of an appropriate experiment. Is blocking necessary in this case? Explain. Can this experiment be blinded?

Blocking is necessary in order to reduce the variability based on either smoking or weight. I will block on smoking because it is a more distinct classification than weight and because it possibly affects weight.

\[
\begin{align*}
\text{Men} & \quad \text{Smokers} \quad \text{(made up #5s)} \quad \text{Randomly} \quad \text{to placebo} \quad \text{Compare mean cholesterol levels} \\
& \quad \text{40 non-smokers} \quad \text{Randomly} \quad \text{to placebo} \quad \text{Compare mean cholesterol levels}
\end{align*}
\]

Give all the smokers a number (ex. 1-20), place them in a hat, mix well, and select 10 to receive the supplement. The remaining subjects will receive the placebo. The experiment should be double-blinded to prevent any intervention by the doctor or patient that would invalidate the study.

4. An educational psychologist wants to test two different memorization methods to compare their effectiveness to increase memorization skills. There are 120 subjects available ranging in age from 18 to 71. The psychologist is concerned that differences in memorization capacity due to age will mask (confound) the differences in the two methods. What would the design look like?

I will block on age by using matched pairs.

\[
\begin{align*}
\text{Experimental units} & \quad \text{Method 1} \quad \text{Comparing mean increase in memorization skills} \\
\{ \text{2 youngest} \} & \quad \text{Method 2} \quad \text{Repeat for each block} \\
\{ \text{60 groups} \} & \quad \text{Repeats for each block} \\
\{ \text{2 oldest} \} & \quad \text{Method 1 and explanatory variable} \\
\end{align*}
\]

Flip a coin to assign treatments. Heads: Younger gets method 1; Tails: Younger gets method 2; older gets the other method.