Learning Goals:

- Identify confounding variables and identify features in experiment design that control the effects of confounding variables.
- Explain the purpose of random assignment in an experiment.

Introduction:

In our previous discussion of the hormone replacement studies, we examined how an experiment can control the effects of confounding variables better than an observational study. For this reason, an experiment can provide evidence of a cause-and-effect relationship between the explanatory variable and the response variable.

In an experiment, researchers attempt to control the effects of confounding variables using *direct control* and *random assignment.*

Direct controls address potential confounding variables up front. For example, if we think a family history of cancer will increase cancer rates, we can remove people with a family history of cancer from the experiment. But what if we do not know about the confounding variable ahead of time? For example, if a gene influences cancer rates, but we do not know that. This is why a well-designed experiment uses random assignment.

How does random assignment control the effects of confounding variables?

Here is how it works. Random assignment creates treatment groups that are similar to each other. It does not eliminate the effect of the confounding variable; instead it equalizes the effect across the treatment groups.

When we have similar groups relative to the confounding variable at the start of the experiment, then we can assume that the confounding variable is not explaining the differences we see in treatment groups at the end of the experiment. Therefore, we can conclude that the observed differences are the result of the treatments which are associated with the explanatory variable. This allows us to say that the explanatory variable is responsible for differences in the responses. This is what we mean by a cause-and-effect relationship.

Like random sampling in observational studies, random assignment in an experiment is also necessary for statistical inference. Why? Because statistical inference is based on probability and probability is based on random events. If an experiment does not use random assignment, the data from that experiment cannot be used to draw conclusions about the relationship between the variables for a larger group of subjects.

Check your understanding:

1) This diagram is adapted from Ramsey and Schafer's *The Statistical Sleuth*.

<table>
<tr><th colspan="5">Conclusions Permitted by Different Study Designs</th></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">How are individuals assigned to groups?</td><td rowspan="2"></td></tr>
<tr><td>Random assignment</td><td>Not random</td></tr>
<tr><td rowspan="2">How are individuals selected?</td><td>Random selection</td><td>Select a random sample from one population. Randomly assign individuals to treatment groups.</td><td>Select random samples from existing populations or groups.</td><td>Make an inference about population(s). Draw a conclusion about the population(s).</td></tr>
<tr><td>Not random</td><td>Find a group of individuals. Randomly assign them to treatment groups.</td><td>Examine available individuals from different populations or groups.</td><td></td></tr>
<tr><td></td><td></td><td>Make an inference about a treatment effect. Draw cause-and-effect conclusions.</td><td></td><td></td></tr>
</table>

a) In the diagram, which descriptions correspond to experiments? Which to observational studies? Label these.

b) How does this diagram highlight key ideas from Unit 6 (Modules 13-15)?

c) In the diagram, add the phrase "potential for sampling bias" and the phrase "potential for confounding by other variables" in the empty boxes where it makes sense.

d) In the diagram, circle the description of a study that produces data that cannot be used in statistical inference. Is there more than one?

Group work:

2) A high school student named David Merrell did an experiment to examine if music affects the time it takes rats to run a maze. (If you are curious, you can watch a conference presentation by Merrell https://www.youtube.com/watch?v=78QtW_AxWFU (21:16)).

   The explanatory variable was exposure to music. He had three treatment groups: *one group* listened to heavy metal music by the group Anthrax. A *second group* listened to Mozart. The *third group* never heard music.

   a) Which group is the control group? What is the purpose of a control group in this experiment?

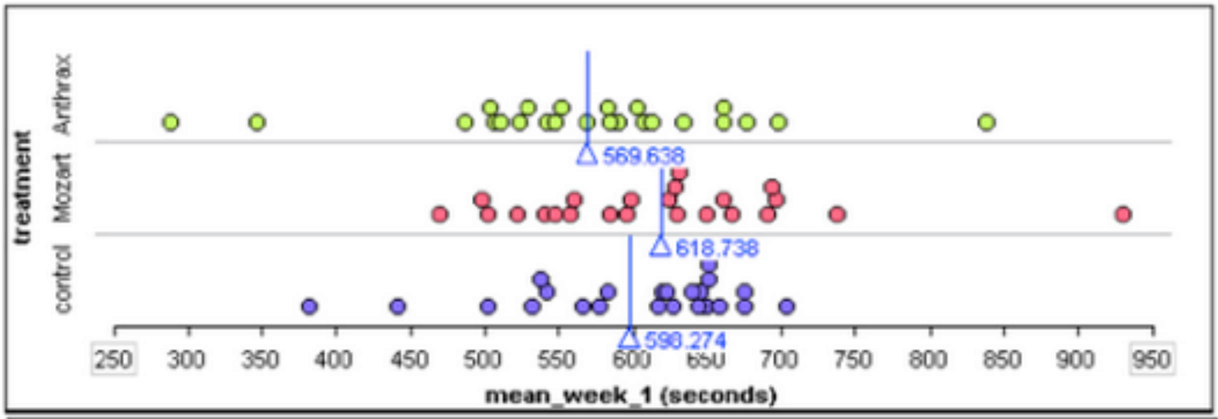
   The response variable was the average time (in seconds) to complete three runs. Every week each rat ran the maze three times. Merrell recorded each rat's average time for the week.

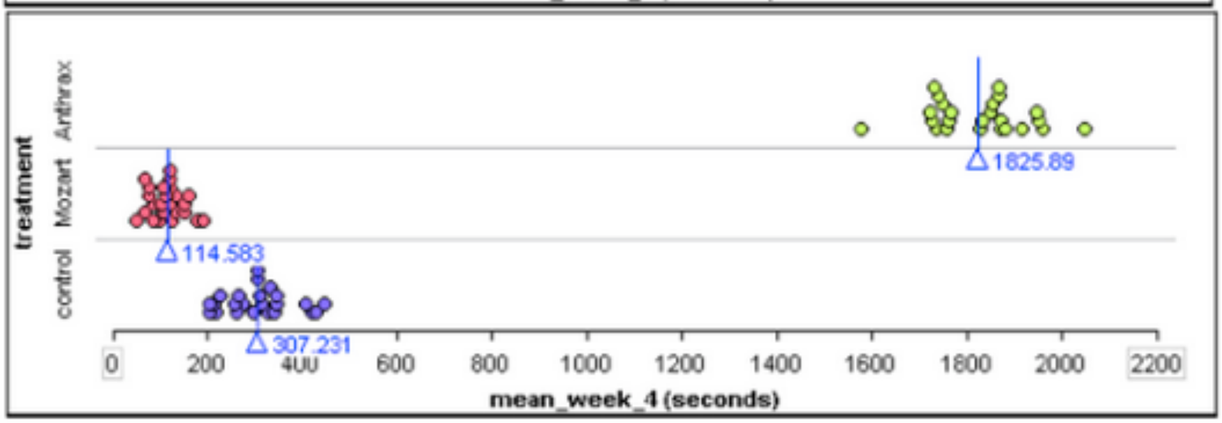
   Merrell included many direct controls in an attempt to minimize the impact of confounding variables on the rats' performance.

   b) Match each confounding variable with the direct control that addresses it. Circle confounding variables that cannot be addressed by one of the direct controls listed.

Confounding variable	Direct control
Some rats may be faster learners.	Use rats with born on the same day. At the start of the experiment remove rats with weights outside the normal range.
Overweight rats or old rats may be slower.	House all rats in identical individual cages and give them the same amount of food and light.
Living conditions may affect a rat's performance.	Train all of the rats to run the same maze before the experiment begins.
Some rats may be faster due to hereditary factors.	In the treatment groups, rats listen to music at 70 decibels for 10 hours a day for a month.
The volume of the music rather than the type of music may affect a rat's performance.	Blinding: the person measuring the run times does not know which treatment the rat received.

Here are the average run times (3 runs) for the 1st week (start of the experiment) and the 4th week (end of the experiment.) Each dot represents one rat. Blue lines mark the overall mean for all rats.





c) Merrell claims that he randomly assigned rats to treatment groups. Does the data support his claim? Why or why not?

d) Does exposure to music affect the rats' performance in the maze? How does the data support your answer?