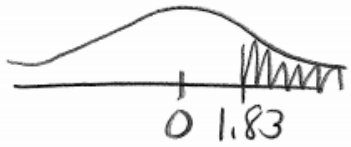
1. a. 3.36%
   b. 6.68%
   c. 4.39504
   d. 5.88694

2. a. 18.75%
   b. 18,750
   c. 54.05%
   d. 12.648 mpg
   e. 34.99838 mpg

1. Based on long-term investigation, researchers have suggested that the acidity (pH) of rainfall in the Shenandoah Mountains can be described by the Normal model N(4.9, 0.6).

a. What percent of storms produce rainfall with pH over 6?

$$z = \frac{6 - 4.9}{.6} = 1.83$$



$P(z > 1.83) = .0336 = 3.36\%$

b. What percent of storms produce rainfall with pH under 4?

$$z = \frac{4 - 4.9}{.6} = -1.5$$

$P(z < -1.5) = .0668 = 6.68\%$

c. The lower the pH, the more acidic the rain. What is the pH level for the most acidic 20% of all storms?

$\text{invNorm}(.2) = -.8416$

$$-.8416 = \frac{x - 4.9}{.6}$$

$-.50496 = x - 4.9$ → $x = 4.39504$

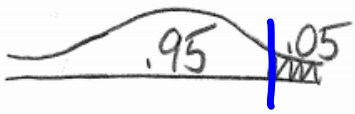
d. What is the pH level for the least acidic 5% of all storms?

$\text{invNorm}(.95) = 1.6449$

$$1.6449 = \frac{x - 4.9}{.6}$$

$.98694 = x - 4.9$

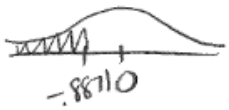
$x = 5.88694$



2. Environmental Protection Agency (EPA) fuel economy estimates for automobile models tested recently predicted a mean of 24.8 mpg and a standard deviation of 6.2 mpg for highway driving. Assume that a Normal model can be applied.

a. About what percent of autos should get less than 19.3 mpg?

$z = \frac{19.3 - 24.8}{6.2} = -.8871$



$P(z < -.8871) = .1875$

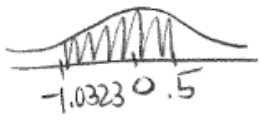
b. If they tested 100,000 autos, how many autos would have had less than 19.3 mpg?

$100{,}000(.1875) = 18{,}750$

c. About what percent of autos should get between 18.4 and 27.9 mpg?

$z = \frac{18.4 - 24.8}{6.2} = -1.0323$

$z = \frac{27.9 - 24.8}{6.2} = .5$



Prob = .5405

d. What's the gas mileage of the worst 2.5% of all cars?

invNorm(.025) = -1.96

$-1.96 = \frac{x - 24.8}{6.2}$

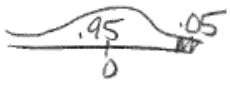
$-12.152 = x - 24.8$ → $x = 12.648$ mpg

e. What's the gas mileage of the best 5% of all cars?

invNorm(.95) = 1.6449

$1.6449 = \frac{x - 24.8}{6.2}$

$10.19838 = x - 24.8$ → $x = 34.99838$ mpg



Types of Statistical Studies

You want to know what proportion of the population likes rock music. You carefully consider three ways to conduct a study. What are the similarities and differences between the following three alternatives? Do any display clear advantages or disadvantages over the others?

a. You could pick a random sample of people and ask them the question, "Do you like rock music?" and record their answers. People may not be truthful
b. You could pick a random sample of people and follow them for a period of time, noting their music purchases, both in stores and online. Stalker!
c. You could pick a random sample of people, separate it into groups, and have each group listen to a different genre of music. You would collect data on the people who display an emotional response to the rock music.

Match the above 3 situations with the following types of studies:

1. Observational Study B
2. Experiment C
3. Survey A

*A statistical study begins by asking a question that can be answered with data. The next steps are to collect appropriate data, organize and analyze it, and arrive at a conclusion in the context of the original question.

1. **Observational Study:** values of one or more variables are observed with no attempt to affect the outcome. (No treatment given)

   a. For example, researchers investigated the link between use of cell phones and brain cancer. There are two variables in this study: One is the extent of cell-phone usage, and the second is whether a person has brain cancer. Both variables were measured for a group of people. This is an observational study. There was no attempt to influence peoples' cell-phone usage to see if different levels of usage made any difference in whether or not a person developed brain cancer.

   Why would studying any relationship between asbestos exposure and lung cancer be an observational study and not an experiment?

   Unethical to impose a dangerous treatment on people.

   Example: assigning them to smoke a pack of cigarettes/day or exposing them purposely to asbestos.

b. In an **observational study** (just as in surveys), the **people or objects to be observed would ideally be selected at random from the population of interest. This would eliminate bias and make it possible to generalize from a sample to a population.** For example, to determine if the potato chips made in a factory contain the desired amount of salt, a sample of chips would be selected randomly so that the sample can be considered to be representative of the population of chips.

Random selection

Discuss how a random sample of 100 chips might be selected from a conveyor belt of chips.

- Pick a (few) ~~chip~~ chip every 5 sec
- Pick every ___ chip
- Use Random # Generator to randomly select chips \ R.N Table

c. Suppose that an observational study establishes a link between asbestos exposure and lung cancer. Based on that finding, can we conclude that asbestos exposure causes lung cancer? Why or why not?

Observational studies can't conclude cause & effect r'ships.
Could be other factors that are creating the outcome.

2. Survey: asking a group to respond to one or more questions. (A poll is one example of a survey.) Surveys are a type of observational study.

a. Surveys can be flawed in several ways. Questions may be confusing. For example, consider the following question:

What kind of laptop do you own? (*Circle one*) Dell HP

How do you answer that question if you don't own a laptop? How do you answer that question if you own a different brand? A better question would be:

Do you own a laptop? (*Circle one*) Yes No
If you answered yes, what brand of laptop is it? _____

Now consider the question, "Do you like your school's cafeteria food?"

Rewrite the question in a better form. Keep in mind that not all students may use the school's cafeteria, and even if they do, there may be some foods that they like and some that they don't like.

Do you buy lunch from the school cafe? yes/ no

If you answersed yes,

what is your favorite food? _____

what is your least favorite food? _____

b. Something else to consider with surveys is **how survey participants are chosen**. If the **purpose of the survey is to learn about some population, ideally participants would be randomly selected from the population of interest.** If people are not randomly selected, misleading conclusions from the survey data may be drawn. There are many famous examples of this. Perhaps the most famous case was in 1936 when *The Literary Digest* magazine predicted that Alf Landon would beat incumbent President Franklin Delano Roosevelt by 370 electoral votes to 161. Roosevelt won 523 to 8. Random selection

Ten million questionnaires were sent to prospective voters (selected from the magazine's subscription list, automobile registration lists, phone lists, and club membership lists), and over two million questionnaires were returned. Surely such a large sample should represent the whole population. How could *The Literary Digest* prediction be so far off the mark?

The sample was biased towards the wealthy. 1936 had the Great Depression, so the wealthy wasn't a representation of the whole population of votes. Not everyone who got the survey chose to return it (Voluntary Response Bias)

**Observational Studies and Surveys do NOT conclude a cause-and-effect relationship.

3. **Experiment:** subjects are assigned to treatments for the purpose of seeing what effect the treatments has on some response

a. Suppose that an observational study indicated that a certain type of tree did not have as much termite damage as other trees. Researchers wondered if resin from the tree was toxic to termites. They decided to do an experiment where they exposed some termites to the resin and others to plain water and recorded whether the termites survived. The explanatory variable (treatment variable) is the exposure type (resin, plain water), and the response variable is whether or not the termite survived. We know this is an experiment because the researchers imposed a treatment (exposure type) on the subjects (termites).

Is the following an observational study or an experiment? Why? If it is an experiment, identify the treatment variable and the response variable. If it is an observational study, identify the population of interest.

A study was done to answer the question, "What is the effect of different durations of light and dark on the growth of radish seedlings?" Three similar growth chambers (plastic bags) were created in which 30 seeds randomly chosen from a package were placed in each chamber. One chamber was randomly selected and placed in 24 hours of light, another for 12 hours of light and 12 hours of darkness, and a third for 24 hours of darkness. After three days, researchers measured and recorded the lengths of radish seedlings for the germinating seeds.

Experiment b/c trmt was applied (diff. amts. of light) and response recorded (seed lengths)

b. In an experiment, random assignment of subjects to treatments is done to create comparable treatment groups. For example, a university biologist wants to compare the effects of two weed killers on pansies. She chooses 24 plants. If she applies weed killer A to the 12 healthiest plants and B to the remaining 12 plants, she won't know which plants died due to the type of weed killer used and which plants subjected to weed killer B were already on their "last legs." Randomly selecting twelve plants to receive weed killer A and then assigning the rest to B would help ensure that the plants in each group are fairly similar.

How might the biologist go about randomly assigning 12 plants from the 24 candidates to receive weed killer A? Could she be sure to get exactly 12 plants assigned to weed killer A and 12 plants to weed killer B by tossing a fair coin for each plant and assigning "heads up" plants to weed killer A and "tails up" to weed killer B? If not, suggest a method that you would use.

Flipping coin 24 times does not ensure 12 in each group.

the plants from 1-24. Use random # generator to assign 1st 12 #'s to group A. Rest to group B.

*Experiments are the ONLY TIME you can conclude a cause - and - effect relationship.

Random Selection: randomly **SELECTING** a sample from a population
↳ allow generalization of results to the population

Random Assignment: randomly **ASSIGNING** the subjects in an experiment to treatments
↳ creates similar treatment groups

Examples:

1. For each of the following study descriptions:
   - identify whether the study is a survey, observational study, or experiment, **and** give a reason for your answer.
   - For observational studies, identify the population of interest.
   - For experiments, identify the treatment and response variables.

   a. A study investigated whether boys are quicker at learning video games than girls. Twenty randomly selected boys and twenty randomly selected girls played a video game that they had never played before. The time it took them to reach a certain level of expertise was recorded.

Observational Study-Children were observed & no treatment was imposed

Pop. of Interest- all boys & girls who would play the video game they'd never played before

*Study was to see who is quicker at achieving a certain level of expertise.

b. The local Department of Transportation is responsible for maintaining lane and edge lines on its paved roads. There are two new paint products on the market. Twenty comparable stretches of road are identified. Paint A is randomly assigned to ten of the stretches of road and paint B to the other ten. The department finds that paint B lasts longer.

Experiment- diff. paint is assigned to roads

Treatment- 2 types of paint assigned to stretches of road

Response Variable- longevity of the paint

c. As your statistics project, you collect data by posting five questions on poster board around your classroom and recording how your classmates respond to them.

Survey- questions were asked of classmates.

*May question if it's really a sample survey since all classmates participated; they weren't chosen randomly.

2. A researcher wants to find out whether higher levels of a certain drug given to experimental rats would decrease the time it took them to complete a given maze to find food.
    a. Why would the researcher have to carry out an experiment rather than an observational study?

To make cause & effect conclusions requires an experiment to be done. Cause & effect can't be concluded from an observational study.