5) A biologist is interested in studying the effect of growth-enhancing nutrients and different salinity (salt) levels in water on the growth of shrimp. The biologist has ordered a large shipment of young tiger shrimps from a supply house to use for the study. The experiment is to be conducted in a lab where there are 12 tanks (with equal amount of shrimp in each) in a controlled environment. The biologist is planning to use 3 different growth-enhancing nutrients (A, B and C) and two different salinity levels (high and low).

(a) List the treatments that the biologist plans to use in this experiment \((hint: \text{there are 6!})\)

- A-Low
- B-Low
- C-low
- A-high
- B-high
- C-high

(b) Using the treatments listed in part (a), describe a completely randomized design that will allow the biologist to compare the shrimps growth after 3 weeks

```
  12 tanks
  \(\text{random}\)

  Low
  6 tanks
  \(\text{random}\)

  B (2 tanks)
  C (2 tanks)

  A (2 tanks)

  High
  6 tanks
  \(\text{random}\)

  A (2 tanks)
  B (2 tanks)
  C (2 tanks)

  compare growth of shrimp after 3 weeks between the six treatments
```

OR

```
  12 tanks
  \(\text{random}\)

  B low (2 tanks)
  C low (2 tanks)

  A low (2 tanks)

  A high (2 tanks)
  B high (2 tanks)
  C high (2 tanks)

  compare growth of shrimp after 3 weeks between the six treatments
```
(c) Give one statistical advantage of having only tiger shrimp in the experiment. Explain why this is an advantage.
There will be no variability in the experimental units, and therefore we can see if the change in growth is due to the treatments, and not due to another factor (like different breed of shrimp). We can isolate the variation in the results that is due to the treatment.

(d) Give one statistical disadvantage of having only tiger shrimp in the experiment. Explain why this is an advantage.
We cannot generalize (broaden) our conclusions to all shrimp, only to Tiger shrimp. We will be limited in our conclusion.

2008 AP STATISTICS FREE-RESPONSE QUESTIONS (Form B)
4) A researcher wants to conduct a study to test whether listening to soothing music for 20 minutes helps to reduce diastolic blood pressure in patients with high blood pressure, compared to simply sitting quietly in a noise-free environment for 20 minutes. One hundred patients with high blood pressure at a large medical clinic are available to participate in this study.

(a) Propose a matched-pairs design for this study to compare these two treatments.

(b) Propose a completely randomized design for this study to compare these two treatments.
2007 AP STATISTICS FREE-RESPONSE QUESTIONS

2) As dogs age, diminished joint and hip health may lead to joint pain and thus reduce a dog’s activity level. Such a reduction in activity can lead to other health concerns. A study is to be conducted to see which of two dietary supplements, glucosamine or chondroitin, is more effective in promoting joint and hip health and reducing the onset of canine osteoarthritis. Researchers will randomly select a total of 300 dogs from ten different large veterinary practices around the country. All of the dogs are more than 6 years old and their owners have given consent to participate in the study. Changes in joint and hip health will be evaluated after 6 months of treatment.

(a) What would be an advantage of adding a control group to the design of the study?
   Adding a control group would allow us to see how the dogs’ joint and hip health changes naturally over time. It would allow us to compare the effect of the treatments to the natural (untreated) joint and hip health. If we include a control we can better assess the effect of the treatment, and reduce the possibility of confounding results or of a placebo effect.

(b) Assuming a control group is added, explain how you would assign the 300 dogs to the 3 treatment groups for a completely randomized design (do not draw the experiment!)
   1- Use a TRD and read off 3 digits at a time
   2- Assign each dog a number from 001 – 300. Ignore 000, 301-999
   3- Read off 100 numbers and ignore repeats. Assign these dogs to the “Glucosamine” treatment group. Read off another 100 numbers and ignore any repeats. Assign these dogs to the “Chondroitin” treatment group. The 100 dogs that are left should be placed in the “Control” group.

(c) Rather than using a completely randomized design, one group of researchers proposes blocking on clinics while another group of researchers proposes blocking on breed of dog. How would you decide which one of these two variables to use as a blocking variable?
   Blocks = groups of experimental units that have something in common that affects the results of the experiment.

   Due to the definition above, I would decide to block based on which variable has the most effect on joint and hip health.

   For example, if I believe that different breeds have different natural joint and hip health, then I should block the dogs based on breed. Then I can eliminate the lurking variable of breed.

   However, if I believe that different veterinary clinics treat joint and hip health differently (thus different vet clinics would have different natural joint and hip health of the animals they treat), then I should block based on clinics.
**2005 AP STATISTICS FREE-RESPONSE QUESTIONS**

3) In search of a mosquito repellent that is safer than the ones that are currently on the market, scientists have developed a new compound that is rated as less toxic than the current compound thus making a repellent that contains this new compound safer for human use. Scientists also believe that a repellent containing the new compound will be more effective (at repelling mosquitoes) than the ones that contain the current compound. To test the effectiveness of the new compound versus the current compound, scientists have randomly selected 100 people from a state. Up to 100 bins, each with an equal number of mosquitoes in the bin, are available for use in this experiment. After a compound is applied to a participant's forearm, the participant will insert his or her forearm into a bin for 1 minute, and the number of mosquito bites on the arm at the end of the minute will be recorded.

(a) Design this experiment using a completely randomized design.

(b) Design this experiment using a matched pairs design.

(c) Which of the two designs (in part A or part B) is better for testing the effectiveness of the new compound versus the current compound. Justify your answer.

The Matched Pairs design is the better design. It reduces any variability in the subjects. Each treatment is being tested on the same conditions (the same people). Therefore there will be no lurking variables that have to do with differences in subjects (like some people being more susceptible to mosquito bites). And then we can better see the effect of the treatment.
2002 AP STATISTICS FREE-RESPONSE QUESTIONS

2) A manufacturer of boots plans to conduct an experiment to compare a new method of waterproofing to the current method. The appearance of the boots is not changed by either method. The company recruits 100 volunteers in Seattle where it rains frequently, to wear the boots as they normally would for 6 months. At the end of the 6 months, the boots will be returned to the company and evaluated for water damage.

(a) Describe a design for this experiment that uses the 100 volunteers. Include a few sentences on how it would be implemented (hint: the best design here is a matched pairs design)

(b) Could your experiment be double blind? Explain.

Yes, as long as both the subjects and the people evaluating the water damage on the boots don’t know which boot is which. This seems possible since it is stated that the appearance of the boots is not changed by either method.
2008 AP STATISTICS FREE-RESPONSE QUESTIONS (Form B)

2) Four different statistics have been proposed as estimators of a population parameter. To investigate the behavior of these estimators, 500 random samples are selected from a known population and each statistic is calculated for each sample. The true value of the population parameter is 75. The graphs below show the distributions of values for each statistic.

(a) Which of the statistics appear to be unbiased estimators of the population parameter? How can you tell?
Statistics A, C and D all appear to be unbiased estimators of the parameter (75). I can tell this because the center of the sampling distributions for each A, C, and D is equal to the parameter (75).

(b) Which of statistics A or B would be a better estimator of the population parameter? Explain.
Statistic A would be a better estimator of the parameter (75) because it is unbiased. The center of sampling distribution A is at 75, while the center of sampling distributions B is approx. 85, thus making it a biased estimator.

(c) Which of statistics C or D would be a better estimator of the population parameter? Explain.
Since statistic C and D both have low bias, I would need to look at the variability. Statistic C has lower variability than statistic D, so I would choose statistic C.
3) The US Dept. of Energy is conducting an experiment to compare the heat gain in houses using two different types of windows, A and B. Six windows of each type are available for the experiment. The Dept. has constructed a house with twelve windows as shown on the floor plan below.

In the interior of the house, each window is surrounded by a window box to capture and measure the amount of heat coming in through that window and to isolate the heat gain for each window.

(a) A randomized block experiment will be used to compare the heat gain for the two types (A and B) of windows. How would you group the window boxes into blocks? (Clearly indicate your blocks using the window box numbers). Justify your choice of blocks.

Based on this definition, I would put the windows into groups that have something in common that has to do with sunlight, since this relates to heat gain in a house.

**Option 1:**
- Block 1 = #1, 12 (North)
- Block 2 = #2, 3, 4, 5 (East)
- Block 3 = #6, 7 (South)
- Block 4 = #8, 9, 10, 11 (West)

**Option 2:**
- Block 1 = #1, 12 (North)
- Block 2 = #2, 3 (North East)
- Block 3 = #4, 5 (South East)
- Block 4 = #6, 7 (South)
- Block 5 = #8, 9 (South West)
- Block 6 = #10, 11 (North West)

(b) For the design in part (a), describe how you would assign window types (A and B) to the numbered window boxes.

In each block we need to randomly assign half of the windows to A and half to B.
Use a random number generator (like a coin or calculator) where there are two outcomes (like heads = A and tails = B, or 0 = A and 1 = B).

- In blocks with two windows, use the generator once on the first numbered window, assigning it to the correct treatment (A or B). Then the other window will be the opposite treatment.
- In blocks with 4 windows, use the generator once on the first numbered window, assigning it to the correct treatment (A or B). Repeat this for the second numbered window. Continue this until you have 2 assigned to A and 2 assigned to B.

**AP Example Problem:**
An experiment to determine the effect of a fertilizer on the growth of grass is to be conducted in a controlled environment. Identical soil and seeds are placed in plots in the lab. Once the grass starts growing, some plots are to be treated with the new fertilizer, while the rest receive no fertilizer. All other conditions regarding water, temperature, etc. are identical, except for the proximity of the plots to the single light source in the room. The figure below illustrates this. Create a block design experiment below. **(Remember, BLOCKS are groups of similar experimental units, where the similarity could have an effect on the experiment)**

![Diagram of block design experiment](image-url)