1. **Weeds Among the Corn.** The corn yield study of discussed in class also examined yields in four plots having 9 weeds per meter. The yields (bushels per acre) in these plots were

$$162.8 \quad 142.4 \quad 162.7 \quad 162.4$$

There is a clear outlier, but rechecking the results found that this is the correct yield for this plot. The outlier makes us hesitant to use t procedures because $\bar{x}$ and s are not resistant.

(a) Is there evidence that 9 weeds per meter reduces corn yields when compared with weed-free corn? Use the Wilcoxon rank sum test with the data above and part of the data from Example 26.1 to answer this question.

(b) Compare the results from (a) with those from the two-sample t test for these data.

(c) Now remove the low outlier 142.4 from the data with 9 weeds per meter. Repeat both the Wilcoxon and t analyses. By how much did the outlier reduce the mean yield in its group? By how much did it increase the standard deviation? Did it have a practically important impact on your conclusions?

2. **Perception of Life Expectancy.** A researcher asked a sample of men and women to indicate their life expectancy. This was compared with values from actuarial tables, and the relative percent difference was computed (perceived life expectancy minus life expectancy from actuarial tables was divided by life expectancy from actuarial tables and converted to a percent). Here are the relative percent differences for all men and women over the age of 70 in the sample:

Men	-28	-23	-20	-19	-14	-13	
Women	-20	-19	-15	-12	-10	-8	-5

(a) What are the null and alternative hypotheses for the Wilcoxon test? For the two-sample t test?

(b) There are two pairs of tied observations. What ranks do you assign to each observation, using average ranks for ties?

(c) Apply the Wilcoxon rank sum test to these data. Compare your result with the $P = 0.0528$ obtained from the two-sample t test.

3. Recall a previous exercise which reports the following data on the percent of nitrogen in bubbles of ancient air trapped in amber:

$$63.4 \quad 65.0 \quad 64.4 \quad 63.3 \quad 54.8 \quad 64.5 \quad 60.8 \quad 49.1 \quad 51.0$$

We wonder if ancient air differs significantly from the present atmosphere, which is 78.1% nitrogen.

(a) Graph the data, and comment on skewness and outliers. A rank test is appropriate.

(b) Test hypotheses about the median percent M of nitrogen in ancient air:

$$H_0 : M = 78.1$$
$$H_a : M \neq 78.1$$

What do you conclude?

4. **Sweetening Colas.** Cola makers test new recipes for loss of sweetness during storage. Trained tasters rate the sweetness before and after storage. Here are the sweetness losses (sweetness before storage minus sweetness after storage) found by 10 tasters for one new cola recipe:

$$2.0 \quad 0.4 \quad 0.7 \quad 2.0 \quad -0.4 \quad -1.3 \quad 2.2 \quad 1.2 \quad 1.1 \quad 2.3$$

Are these data good evidence that the cola lost sweetness?

(a) These data are the differences from a matched pairs design. State hypotheses in terms of the median difference in the population of all tasters, carry out a test, and give your conclusion.

(b) The one-sample matched pairs t test had a P-value $P = 0.0123$ for these data. How does this compare with your result from (a)? What are the hypotheses for the t test? What conditions must be met for each of the t and Wilcoxon tests?

5. Our bodies have a natural electrical field that is known to help wounds heal. Does changing the field strength slow healing? A series of experiments with newts investigated this question. In one experiment, the two hind limbs of 12 newts were assigned at random to either experimental or control groups. This is a matched pairs design. The electrical field in the experimental limbs was reduced to zero by applying a voltage. The control limbs were left alone. Here are the rates at which new cells closed a razor cut in each limb, in micrometers per hour:

Newt	1	2	3	4	5	6	7	8	9	10	11	12
Control Limb	36	41	39	42	44	39	39	56	33	20	49	30
Experimental Limb	28	31	27	33	33	38	45	25	28	33	47	23

The paired differences include an outlier, so we may choose to use the Wilcoxon signed rank test. Carry out the test and give a conclusion. Be sure to include a description of what the data show in addition to the test results.

6. **More Rain for California?** Another exercise in our text describes an experi- ment that examines the effect on plant biomass in plots of California grassland randomly assigned to receive added water in the winter, added water in the spring, or no added water. The experiment continued for several years. Here are data for 2004 (mass in grams per square meter):

Winter	Spring	Control
254.6453	517.6650	178.9988
233.8155	342.2825	205.5165
253.4506	270.5785	242.6795
228.5882	212.5324	231.7639
158.6675	213.9879	134.9847
212.3232	240.1927	212.4862

The sample sizes are small and the data contain some possible outliers. We will apply a nonparametric test.

(a) Examine the data. Show that the conditions for ANOVA are not met. What appear to be the effects of extra rain in winter or spring?

(b) What hypotheses does ANOVA test? What hypotheses does Kruskal-Wallis test?

(c) Carry out a Kruskal-Wallis test. What do you conclude?