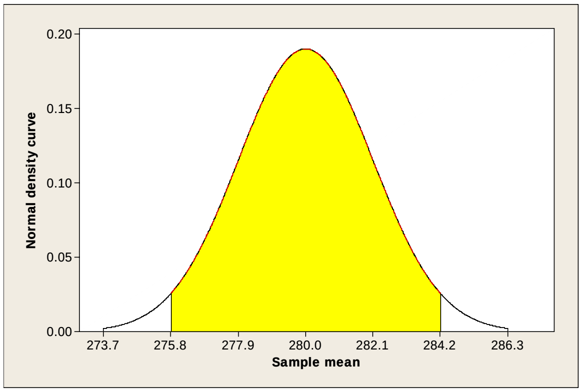
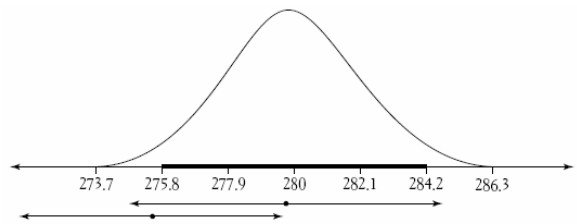
Chapter 10

10.1 (a) The sampling distribution of $\overline{x}$ is approximately normal with mean $\mu_{\overline{x}} = 280$ and standard deviation $\sigma_{\overline{x}} = \dfrac{\sigma}{\sqrt{n}} = \dfrac{60}{\sqrt{840}} \doteq 2.0702$. (b) The mean is 280. One standard deviation from the mean: 277.9 and 282.1; two standard deviations from the mean: 275.8 and 284.2; and three standard deviations from the mean: 273.7 and 286.3. Two different sketches are provided below.



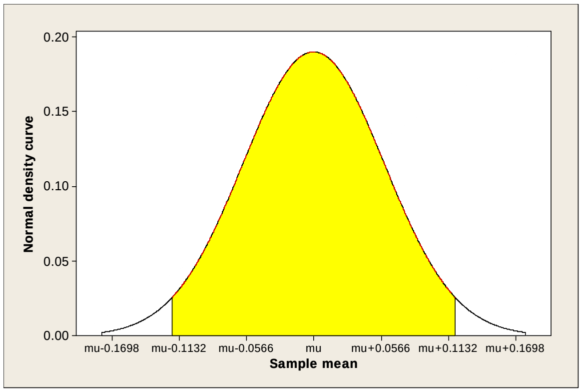


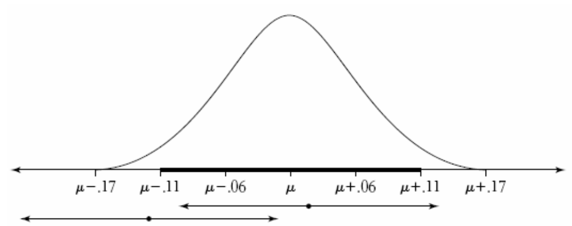
(c) 2 standard deviations; $m \doteq 4.2$. (d) The confidence intervals drawn will vary, but they should all have length $2m \doteq 8.4$. See the sketch above on the right. (e) About 95% (by the 68-95-99.7 rule).

10.2 (a) Incorrect; the probability is either 0 or 1, but we don't know which. (b) Incorrect; the general form of these confidence intervals is $\overline{x} \pm m$, so $\overline{x}$ will always be in the center of the confidence interval. (c) Incorrect; the different samples will yield different sample means, and the distribution of those sample means is used to provide an interval that captures the population mean. (d) Incorrect; there is nothing magic about the interval from this one sample. Our method for computing confidence intervals is based on capturing the mean of the population, not a particular interval from one sample. (e) Correct interpretation.

10.3 No. The student is misinterpreting 95% confidence. This is a statement about the mean score for all young men, not about individual scores.

10.4 (a) The sampling distribution of $\overline{x}$ is approximately normal with mean $\mu_{\overline{x}} = \mu$ and standard deviation $\sigma_{\overline{x}} = \dfrac{\sigma}{\sqrt{n}} = \dfrac{0.4}{\sqrt{50}} \doteq 0.0566$. (b) The mean is μ. One standard deviation from the mean: $\mu - 0.0566$ and $\mu + 0.0566$; two standard deviations from the mean: $\mu - 0.1132$ and $\mu + 0.1132$; and three standard deviations from the mean: $\mu - 0.1698$ and $\mu + 0.1698$. Two different sketches are provided below.





(c) 2 standard deviations; $m \doteq 0.1132$. (d) About 95% (by the 68-95-99.7 rule). (e) The confidence intervals drawn will vary, but they should all have length $2m \doteq 0.2264$. See the sketch above on the right.

10.5 (a) $51\% \pm 3\%$ or (48%, 54%). (b) 51% is a statistic from one sample. A different sample may give us a totally different answer. When taking samples from a population, not every sample of adults will give the same result, leading to *sampling variability*. A margin of error allows for this variability. (c) "95% confidence" means that this interval was found using a procedure that produces correct results (i.e., includes the true population proportion) 95% of the time. (d) Survey errors such as undercoverage or non-response, depending on how the Gallup Poll was taken, could affect the accuracy. For example, voluntary response will not base the sample on the population.

10.6 (a) Let $\bar{x}_G$ denote the sample mean for the 10 girls and $\bar{x}_B$ denote the sample mean for the 7 boys. The distribution of $\bar{x}_G - \bar{x}_B$ is Normal with mean $\mu_{\bar{x}_G - \bar{x}_B} = 54.5 - 54.1 = 0.4$ and standard deviation $\sigma_{\bar{x}_G - \bar{x}_B} = \sqrt{\frac{2.7^2}{10} + \frac{2.4^2}{7}} \doteq 1.25$. Thus,

$P(\bar{x}_G > \bar{x}_B) = P(\bar{x}_G - \bar{x}_B > 0) = P\left(z > \frac{0 - 0.4}{1.25}\right) = P(z > -0.32) = 0.6255$. (b) Generate 10 observations from a Normal distribution with mean 54.5 inches and standard deviation 2.7 inches. Store the average in a list, say L3. Generate 7 observations from a Normal distribution with mean 54.1 and standard deviation 2.4 inches. Store the average in another list, say L4. Repeat the previous steps 200 times. Store the 200 differences L3−L4 in list L5. Count how many of the differences in list L5 are greater than zero. The estimated probability is the count divided by 200. Clear lists L1 to L5. Generate the means of the 200 samples of 10 girls but the following commands:

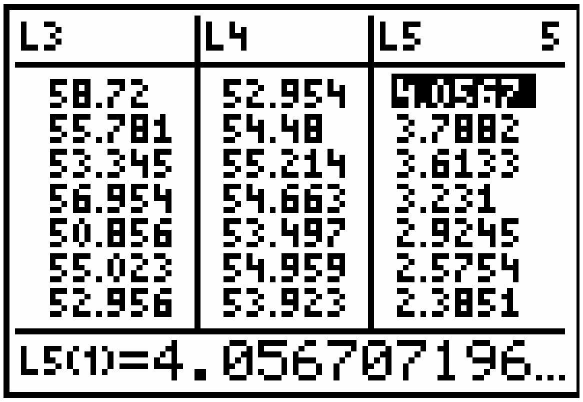
```
1 → C
randNorm(54.5,27,10)→L1: mean(L1)→L2(C): 1+C→C
```

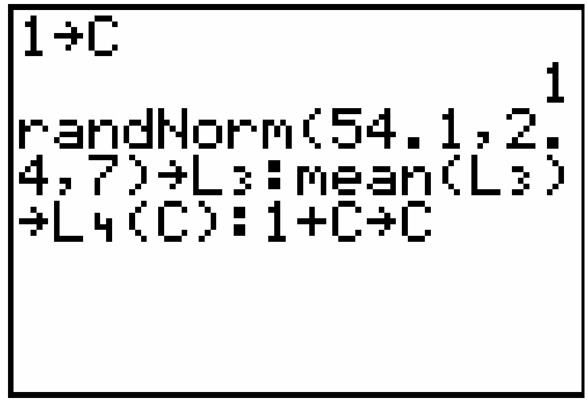
Continue to press Enter until the counter reaches 200. Now generate the means of the 200 samples of 7 boys:

```
1 → C
randNorm(54.1,2.4,7)→L3: mean(L3)→L4(C): 1+C→C
```

Continue to press Enter until the counter reaches 200.

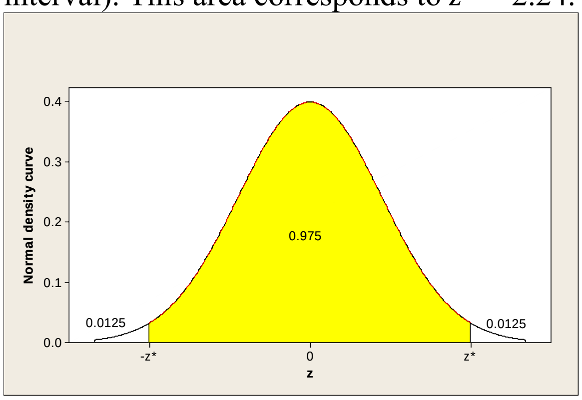
Highlight L5 and let L5 = L2 – L4. To make it easier to count the number of differences in L5 that are greater than zero, sort L5: `SortD(L5)`and look to see when the sign changes.

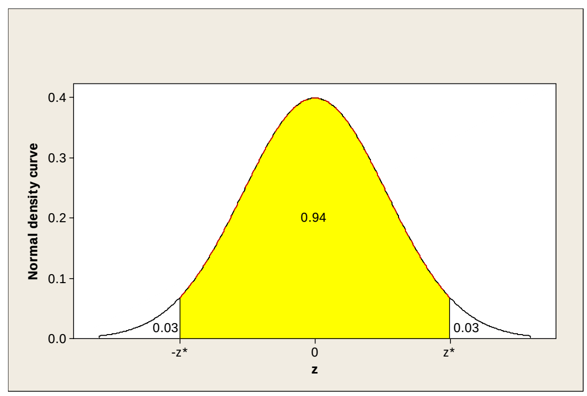




In this simulation 115 out of 200 were greater than zero, or 0.575.

10.7 The figure below (left) shows how much area is in each tail and the value z^* you want to find. Search Table A for 0.0125 (half of the 2.5% that is *not* included in a 97.5% confidence interval). This area corresponds to $z^* = 2.24$.





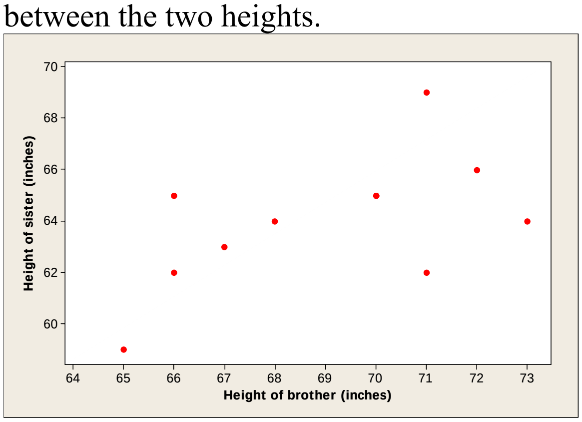
10.8 The figure above (right) shows how much area is in each tail and the value z^* you want to find. Search Table A for 0.03 (half of the 6%% that is *not* included in a 94% confidence interval). This area corresponds to $z^* = 1.88$.

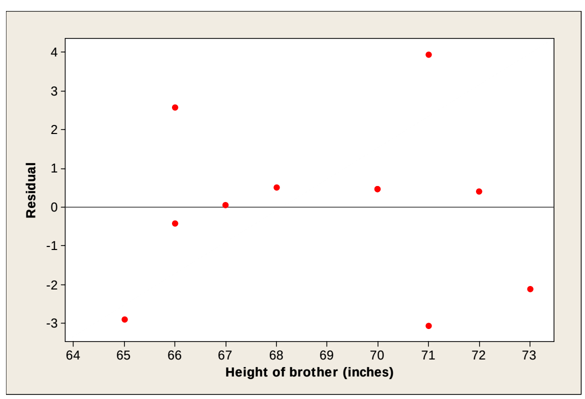
10.9 (a) The parameter of interest is μ = the mean IQ score for all seventh-grade girls in the school district. The low score (72) is an outlier, but there are no other deviations from Normality. In addition, the central limit theorem tells us that the sampling distribution of $\bar{x}$ will be approximately Normal since $n = 31$. We are told to treat these 31 girls as an SRS. The 31 measurements in the sample should be independent if there are at least 10×31 = 310 seventh-grade girls in this school district. $\bar{x} = 105.84$, the 99% confidence interval for μ, is $105.84 \pm 2.576\left(\frac{15}{\sqrt{31}}\right) \doteq 105.84 \pm 6.94 = (98.90, 112.78)$. With 99% confidence, we estimate the mean IQ score for all seventh-grade girls in the school district to be between 98.90 and 112.78 IQ points. (b) Unless the class was representative of the whole school district, we would not have been able to generalize our conclusions to the population of interest.

10.10 (a) A pharmaceutical product is a medication or device used to treat patients. This analysis is important to make sure that the production process is working properly and the medication contains the correct amount of the active ingredient. (b) The parameter of interest is μ = the true concentration of the active ingredient in this specimen. The repeated measurements are clearly not independent because they are taken on the same specimen. However, we are told that these repeated measurements follow a Normal distribution and the analysis procedure has no bias. The sample mean is $\bar{x} = 0.8404$ and the 99% confidence interval for μ, is $0.8404 \pm 2.576\left(\frac{0.0068}{\sqrt{3}}\right) \doteq 0.8404 \pm 0.0101 = (0.8303, 0.8505)$. With 99% confidence, we estimate the true concentration of the active ingredient for this specimen to be between 0.8303 and 0.8505 grams per liter. (c) "99% confident" means that if we repeated the entire process of taking three measurements and computing confidence intervals over and over a large number of times, then 99% of the resulting confidence intervals would contain the true concentration of the active ingredient.

10.11 (a) We want to estimate μ = the mean length of time the general managers have spent with their current hotel chain. The sample of managers is a SRS (stated in question) and the sample size is large enough $(n = 114)$ to use the central limit theorem to assume normality for the sampling distribution. The managers' length of employment is independent and so the conditions for a confidence interval for a mean are met. 99% C.I. for μ = $11.78 \pm 2.576\left(\frac{3.2}{\sqrt{114}}\right) \doteq 11.78 \pm 0.77 = (11.01, 12.55)$. With 99% confidence, we estimate that the mean length of time the general managers have spent with their current hotel chain is between 11.01 and 12.55 years. (b) 46 out of 160 did not reply. This nonresponse could have affected the results of our confidence interval considerably, especially if those who didn't respond differed in a systematic way from those who did.

10.12 (a) A scatterplot is shown below (left). There is a very weak, positive association between the two heights.





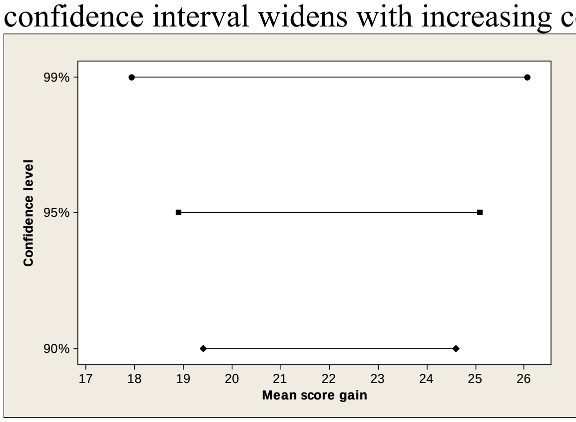
(b) Let y = sister's height and x = brother's height. The least squares regression line is $\hat{y} = 26.74 + 0.5270x$. The slope indicates that the sister's height will increase on average by

0.527 inches for every one inch increase in the brother's height. (c) Tonya's predicted height is $\hat{y} = 26.74 + 0.5270 \times 70 \doteq 63.63$ inches. (d) No, the residual plot above (right) shows a clear quadratic pattern and $r^2 = 0.311$, so only 31.1% of the variability in the heights of sisters is explained by the linear regression line using brother's height as the explanatory variable.

10.13 For 80 video monitors the margin of error is $m = 1.645\frac{43}{\sqrt{80}} \doteq 7.9$, which is half of 15.8, the margin of error for $n = 20$.

10.14 (a) A 98% confidence interval for μ = the mean scale reading for a 10 gram weight is $10.0023 \pm 2.33\left(\frac{0.0002}{\sqrt{5}}\right) \doteq 10.0023 \pm 0.0002 = (10.0021, 10.0025)$. We are 98% confident that the mean scale reading for a 10 gram weight is between 10.0021 and 10.0025 grams. Notice that 10 is not in the 98% confidence interval, so there is some evidence that the scale might need to be adjusted. (b) To meet the specifications, we need $n \geq \left(\frac{2.33 \times 0.0002}{0.0001}\right)^2 \doteq 21.7156$ or n = 22 measurements.

10.15 (a) A 95% confidence interval for μ = mean score gain on the second SAT Mathematic exam is $22 \pm 1.96\left(\frac{50}{\sqrt{1000}}\right) \doteq 22 \pm 3.1 = (18.9, 25.1)$. With 95% confidence we estimate the mean gain for all Math SAT second try scores to be between 18.9 and 25.1 points. (b) The 90% confidence interval is (19.4, 24.6) and the 99% confidence interval is (17.93, 26.07). (c) The confidence interval widens with increasing confidence level. See the figure below.



10.16 (a) When n = 250, a 95% confidence interval for μ is $22 \pm 1.96\left(\frac{50}{\sqrt{250}}\right) \doteq 22 \pm 6.2 = (15.8, 28.2)$. (b) (a) When n = 4000, a 95% confidence interval for μ is $22 \pm 1.96\left(\frac{50}{\sqrt{4000}}\right) \doteq 22 \pm 1.55 = (20.45, 23.55)$. (c) The margins of error are 3.099, 6.198, and 1.550, respectively. The margin of error decreases as the sample size increases (by a factor of $1/\sqrt{n}$). (d) To meet the specifications, we need $n \geq \left(\frac{1.96 \times 50}{2}\right)^2 = 2401$, so take $n = 2401$ students.

10.17 (a) The computations are correct. (b) Since the numbers are based on a voluntary response, rather than an SRS, the methods of this section cannot be used; the interval does not apply to the whole population.

10.18 (a) We don't know if this interval contains the true percent of all voters who favored Kerry, but it is based on a method that captures the unknown parameter 95% of the time. (b) Since the margin of error was 2%, the true value of p could be as low as 49%. Thus, the confidence interval contains some values of p which suggest that Bush will win.
(c) The proportion of voters that favor Kerry is not random—either a majority favors Kerry, or they don't. Discussing probabilities about this proportion has little meaning: the "probability" the politician asked about is either 1 or 0 (respectively).

10.19 (a) We would want the sample to be a SRS of the population under study and the observations to be independently sampled. As the sample size is only 25, the population should be approximately normally distributed. (b) A 95% confidence interval for μ is 76 ± 12 = (64, 88). We are 95% confident that the population mean is between 64 and 88, within a range of 12 on either side of the sample mean. (c) When using this method for repeated samples, 95% of the resulting confidence intervals will capture μ.

10.20 (a) A SRS of all seniors was obtained and the sample size (n = 500) is large enough so that the distribution of the sample mean will be approximately Normal. The population size is also clearly greater than 500×10 = 5000, so the conditions for using the confidence interval for a mean are satisfied. A 99% confidence interval for μ is

$461 \pm 2.576\left(\frac{100}{\sqrt{500}}\right) \doteq 461 \pm 11.52 = (449.48, 472.52)$. We are 99% confident that the mean SAT Math score for all California seniors is between 449 and 473 points. (b) In order to estimate the mean within 5 points, the margin of error needs to be ± 5 so the sample size must be

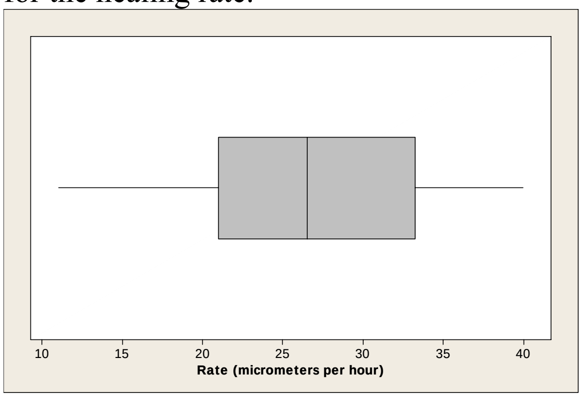
$n \geq \left(\frac{2.576 \times 100}{5}\right)^2 \doteq 2654.31$. Take n = 2,655 students.

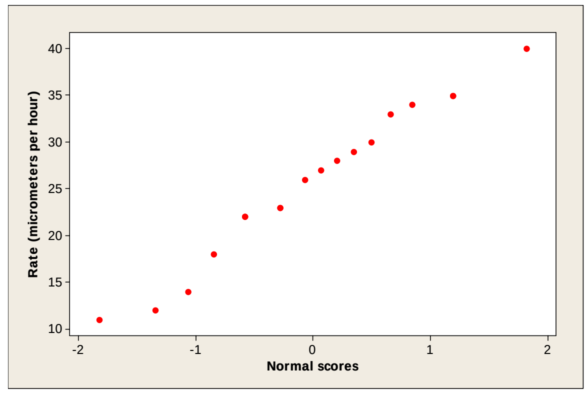
10.21 No. A confidence interval describes a parameter, not an individual measurement.

10.22 The sample sizes and critical values are the same, but the variability in the two populations is different. The margin of error for the 3rd graders will be smaller because the variability in the heights of 3rd graders is smaller than the variability in the heights of children in kindergarten through fifth grade.

10.23 (a) We can be 99% confident that between 63% and 69% of all adults favor such an amendment. Solve the equation $z^*\sqrt{\frac{0.66\times 0.34}{1664}}=0.03$ to find the critical value z^*. The critical value is $z^*\doteq 2.58$, which means that the confidence level is 99%. (b) The survey excludes people without telephones, a large percentage of whom would be poor, so this group would be underrepresented. Also, Alaska and Hawaii are not included in the sample.

10.24 (a) A boxplot (left) and a Normal probability plot (right) are shown below. The median is almost exactly in the center of the box and the left whisker is only slightly longer than the right whisker, so the distribution of healing rate appears to be roughly symmetric. The linear trend in the Normal probability plots indicates that the Normal distribution provides a reasonable model for the healing rate.

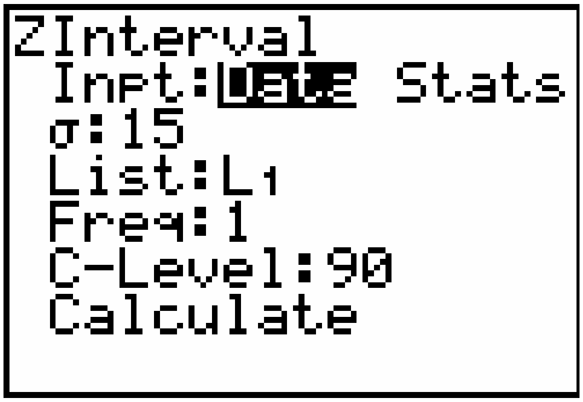


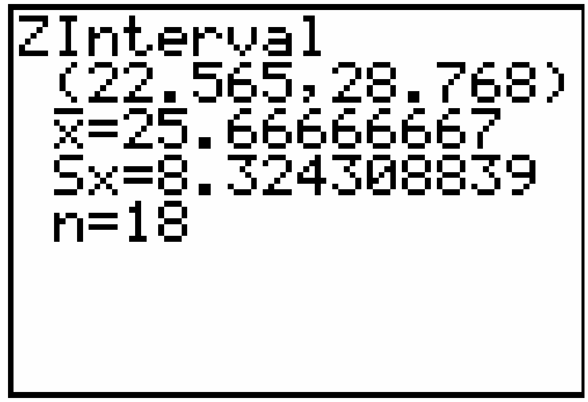


(b) A 90% confidence interval for μ is $25.67\pm 1.645\left(\frac{8}{\sqrt{18}}\right)\doteq 25.67\pm 3.10=(22.57,28.77)$. We are 90% confident that the mean rate of healing is between 22.57 and 28.77 micrometers per hour. (c) Her interval is wider. To be more confident that an interval contains the true population parameter, we must increase the length of the interval, which means allow a larger margin of error. The margin of error for 95% confidence is larger than for 90% confidence.

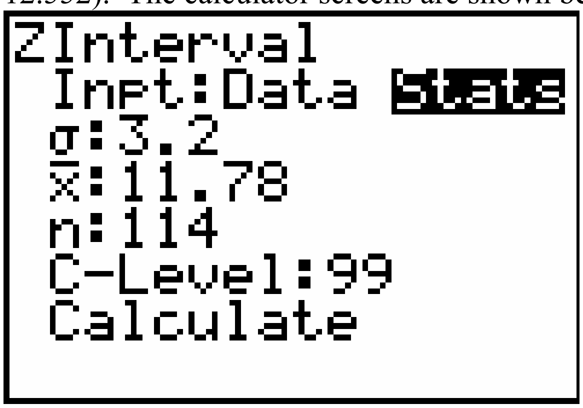
10.25 We want $z^*\frac{8}{\sqrt{n}}\leq 1$, so we need $n\geq\left(\frac{1.645\times 8}{1}\right)^2=173.19$ or n = 174 newts.

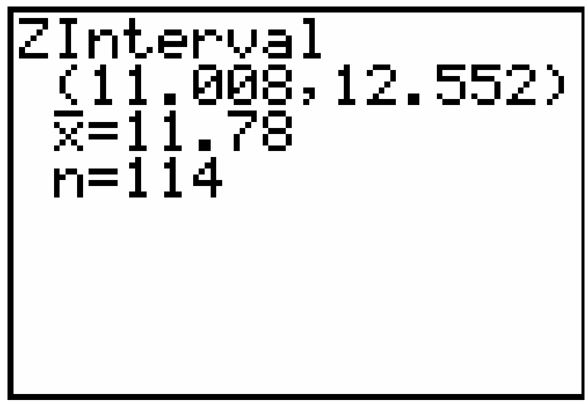
10.26 (a) The 90% confidence interval for the mean rate of healing for newts is (22.565, 28.768). The calculator screens are shown below.





(b) For steps 1, 2, and 4 in the Inference Toolbox, see the solution to Exercise 10.11 (a). The 99% confidence interval for the mean number of years for the hotel managers is (11.008, 12.552). The calculator screens are shown below.





10.27 (a) $SEM = \frac{9.3}{\sqrt{27}} \doteq 1.7898$. (b) Since $SEM = \frac{s}{\sqrt{3}} = 0.01$, the standard deviation is $s \doteq 0.0173$.

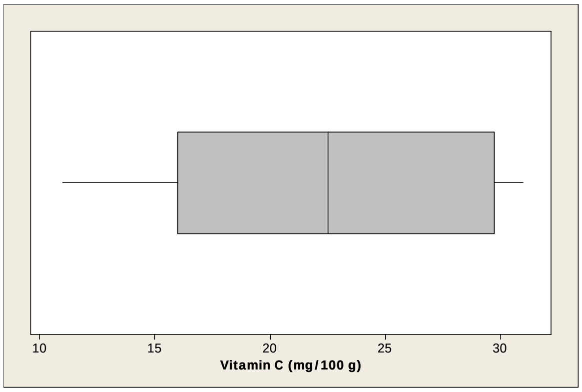
10.28 (a) df = 11, $t^* = 1.796$. (b) df = 29, $t^* = 2.045$. (c) df = 17, $t^* = 1.333$.

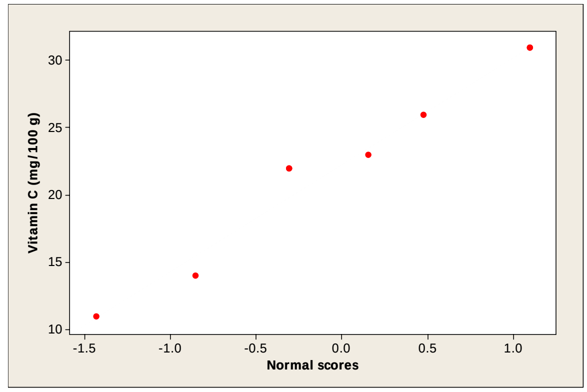
10.29 (a) 0.0228. (b), (c), and (d):

df	$P(t > 2)$	Absolute difference
2	0.0917	0.0689
10	0.0367	0.0139
30	0.0273	0.0045
50	0.0255	0.0027
100	0.0241	0.0013

(e) As the degrees of freedom increase, the area to the right of 2 under the *t* distributions gets closer to the area under the standard normal curve to the right of 2.

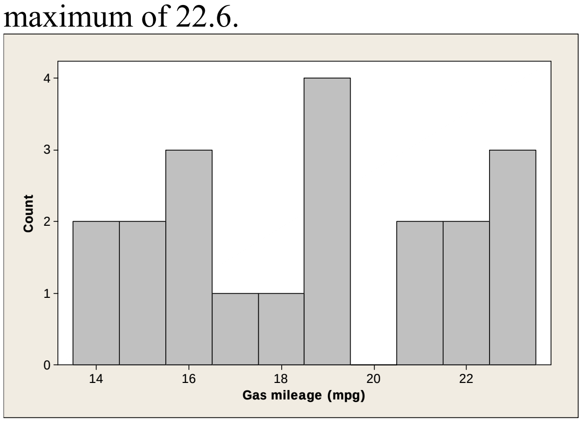
10.30 (a) The conditions are: SRS, Normality, and Independence. A random sample of $n = 8$ was taken from a production run. A boxplot (left) and Normal probability plot (right) are shown below. Even though the left whisker is a little longer than the right whisker, the distribution of vitamin C level appears to be roughly symmetric. The linear trend in the Normal probability plots indicates that the Normal distribution is reasonable, even though the sample size is very small.





Since the observations are taken from the same production run, they are not independent. However, they are representative of the vitamin C content of the CSB produced during this run, so we will proceed as if the conditions are satisfied. (b) Since $n = 8$, df = 7 and $t^* = 2.365$. A 95% confidence interval for μ is $22.5 \pm 2.365\left(\frac{7.1913}{\sqrt{8}}\right) \doteq 22.5 \pm 6.013 = (16.487, 28.513)$. We are 95% confident that the mean vitamin C content of the CSB produced during this run is between 16.487 and 28.513 mg/100 g.

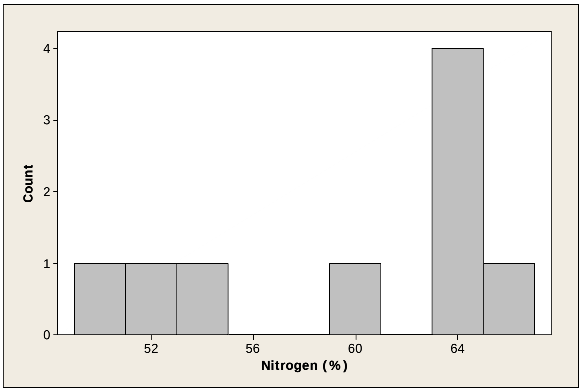
10.31 (a) A histogram (left) and a stemplot (right) are shown below. The distribution is slightly left-skewed with a center around 19. The gas mileages range from a minimum of 13.6 to a maximum of 22.6.




```
Stem-and-leaf of mpg  N  = 20
Leaf Unit = 0.10


 1   13  6
 4   14  368
 7   15  668
 7   16
 8   17  2
10   18  07
10   19  144
 7   20  9
 6   21  05
 4   22  4566
```

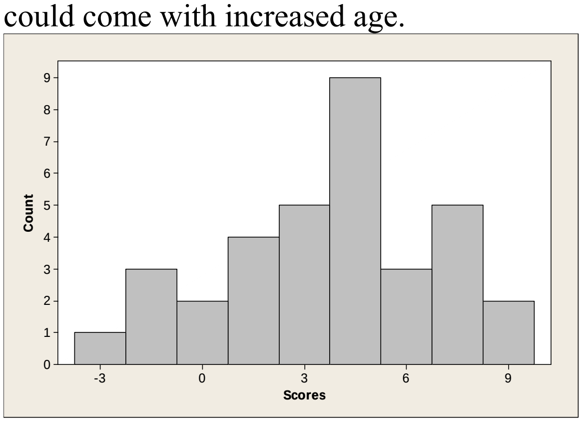
(b) Yes. The sample size is not large enough to use the central limit theorem for Normality. However, there are no outliers or severe skewness in the sample data that suggest the population distribution isn't Normal. (c) $\bar{x} = 18.48$, $s = 3.12$ and $n = 20$, so standard error is 0.6977. Since n = 20, df = 19 and $t^* = 2.093$, so the margin of error is 1.46. (d) The 95% confidence interval for μ is $18.48 \pm 1.46 = (17.02, 19.94)$. With 95% confidence we estimate the mean gas mileage for this vehicle to be between 17.02 and 19.94 mpg. (e) No, gas mileage depends on driving habits, and it is unlikely that this one vehicle will be representative of other similar vehicles.

10.32 (a) The histogram (left) and stemplot (right) below show some left-skewness; however, for such a small sample, the data are not unreasonably skewed. There are no outliers. (b) With $\bar{x}$ = 59.59% and s = 6.26% nitrogen, and t^* = 2.306 (df = 8), we are 95% confident that the mean percent of nitrogen in the atmosphere during the late Cretaceous era is between 54.78% and 64.40%.



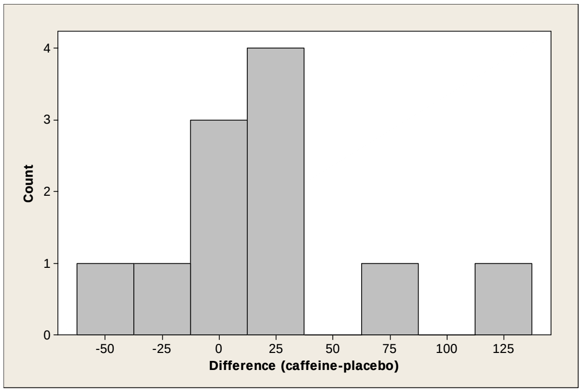

```
Stem-and-leaf of nitrogen  N  = 9
Leaf Unit = 1.0


 1   4  9
 2   5  1
 2   5
 3   5  4
 3   5
 3   5
 4   6  0
(2)  6  33
 3   6  445
```

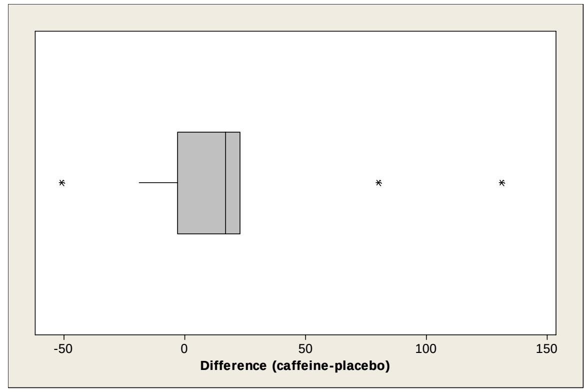
10.33 (a) The histogram (left) and stemplot (right) below show that the distribution is roughly symmetric with mean $\bar{x} = 3.62$ and standard deviation s = 3.055. (b) Using df = 30, t^* = 2.042, and the interval is (2.548, 4.688). Software and the TI calculator gives (2.552, 4.684) using df = 33. With 95% confidence we estimate the mean change in reasoning score after 6 months of piano lessons for all pre-school children is between 2.55 and 4.68 points. (c) No. We don't know that students were assigned at random to the groups in this study. Also, some improvement could come with increased age.




```
Stem-and-leaf of scores  N  = 34
Leaf Unit = 0.10
 1   -3  0
 3   -2  00
 4   -1  0
 5   -0  0
 6   0   0
 7   1   0
 10  2   000
 15  3   00000
(7)  4   0000000
 12  5   00
 10  6   000
 7   7   00000
 2   8
 2   9   00
```

10.34 (a) Neither the subjects getting the capsules nor the individuals providing them with the capsules knew which capsules contained caffeine and which were placebos. (b) The differences (number with caffeine − number with placebo) in the number of beats for the 11 subjects are 80, 22, 17, 131, −19, 3, 23, −1, 20, −51, and −3. The histogram (left) and boxplot (right) below show that the distribution is not symmetric and there are 3 outliers. The mean difference $\bar{x}_d$ = 20.2 is greater than the median difference of 17, and the standard deviation of the differences s_d = 48.75 is much larger than the IQR of 26. (c) No, the t procedure should not be used because the sample size is small (n = 11) and the differences in beats per minute are clearly not Normal.



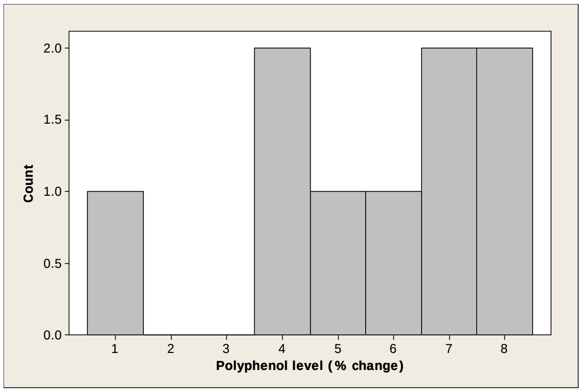


10.35 (a) Taking d = number of disruptive behaviors on moon days – number on other days, we want to estimate μ_d = the mean difference for dementia patients. We don't know how the sample was selected. If these patients aren't representative of the population of interest, we won't be able to generalize our results. The sample size is too small (n = 15) for the central limit theorem to apply, so we examine the sample data. The distribution is roughly symmetric with no outliers, which gives us no reason to doubt the Normality of the population of differences. We assume that these 15 difference measurements are independent. $\bar{x}_d = 2.43$, $s_d = 1.46$, $n = 15$, and t^* for df =14 is 2.145. Thus, the 95% confidence interval for μ_d is $2.43 \pm 2.145\left(\frac{1.46}{\sqrt{15}}\right)$ = (1.62, 3.24). On average, the patients have between 1.62 and 3.24 more episodes of aggressive behavior during moon days than other days. (b) No, this is an observational study; there could be any number of reasons that there is increased aggressive behavior.

10.36 (a) With data on all U.S. presidents formal inference makes no sense. (b) The 32 students in an AP Statistics class are not a SRS of all students, so the t interval should not be used to make an inference about the mean amount of time all students spend on the internet. (c) The stemplot is strongly skewed to the left and the sample size is n = 20, so we cannot trust the t interval.

10.37 (a) df = 9, $t^* = 2.262$. (b) df = 19, $t^* = 2.861$. (c) df =6, $t^* = 1.440$.

10.38 (a) The histogram (left) and stemplot (right) below show one observation is somewhat smaller than the others, but it would not be classified as an outlier. The plots do not show severe skewness or any outliers, so the Normal condition appears to be reasonable based on this small sample.




```
Stem-and-leaf of levels  N  = 9
Leaf Unit = 0.10

 1   0  7
 1   1
 1   2
 2   3  5
 4   4  09
(1)  5  5
 4   6
 4   7  04
 2   8  14
```

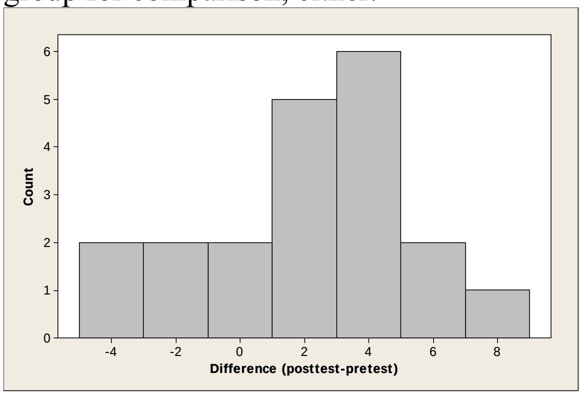
(b) The population of interest is all adults, but since only healthy men were used for this study, the results can only be generalized to the population of healthy men. In fact, these healthy men were not randomly selected, so we need to restrict the inference to other healthy men with characteristics similar to the men in the study. In short, the limitations of inferences based on observational studies with small samples (of volunteers) are clearly illustrated with this exercise. The mean of the nine observations is $\bar{x} = 5.5$ percent, while $s = 2.517$ and $s/\sqrt{9} \doteq 0.839$. With df = 8, the critical value is $t^* = 1.860$ and 90% confidence interval is $5.5 \pm 1.860 \times 0.839 = 3.939$ to 7.061. We are 90% confident that the mean percent change in polyphenol level for healthy men with characteristics similar to those in this study is between 3.9% and 7.1%. (c) The data are paired because the polyphenol level for each man is collected before and after the wine drinking period, so the observations are clearly dependent. However, this is not a matched-pairs experiment because this group of men only received one treatment.

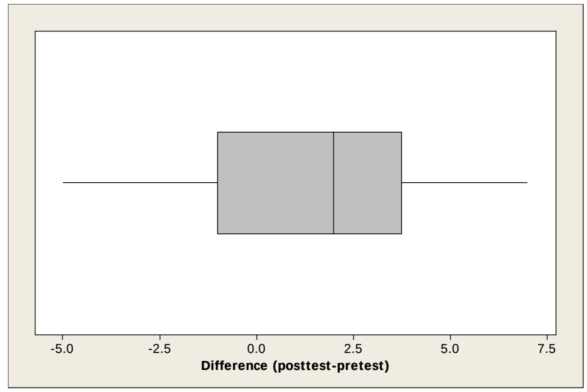
10.39 Let μ = the mean HAV angle in the population of all young patients who require HAV surgery. The *t* interval may be used (despite the outlier at 50) because *n* is large (close to 40). The patients were randomly selected and it is assumed independent. The mean and standard deviation of the angle of deformity are $\bar{x} = 25.42$ and s = 7.475. Using df = 30 and t* = 2.042, the 95% confidence interval for μ is $25.42 \pm 2.042\left(\frac{7.475}{\sqrt{38}}\right)$ = (22.944, 27.896). Software and the TI calculators use df = 37 and give the interval 22.9642 to 27.8779. With 95% confidence we estimate the mean HAV angle for all young patients who require HAV surgery to be between 23° and 28°.

10.40 (a) Dropping the outlier at 50, we have $\bar{x} = 24.76$ and s = 6.34. Using df = 30 and t* = 2.042, the 95% confidence interval for μ is $24.76 \pm 2.042\left(\frac{6.34}{\sqrt{37}}\right)$ = (22.632, 26.888). Software and the TI calculators use df = 36 and give the interval 22.6431 to 26.8704. (b) The interval in part (a) is narrower than the interval in Exercise 10.39. Removing the outlier decreased the standard deviation and consequently decreased the margin of error.

10.41 (a) The histogram (left) and boxplot (right) below show that the differences are slightly left-skewed, with no outliers, so the Normal distribution is reasonable and the *t* interval should be reliable. (b) The mean of the differences is $\bar{x}_d = 1.45$, the standard deviation is $s_d = 3.203$, and the standard error of the mean is SEM = 0.716. Using df = 19 and t* = 1.729, the 90%

confidence interval is $1.45 \pm 1.729\left(\frac{3.203}{\sqrt{20}}\right)$ = (0.212, 2.69). We are 90% confident that the mean increase in listening score after attending the summer institute improves by between 0.212 and 2.69 points. (c) No, their listening skills may have improved for a number of other, for instance by studying every night or by living with families that only spoke Spanish. There was no control group for comparison, either.





10.42 (a) The distribution cannot be normal, because all values must be (presumably) integers between 0 and 4. (b) The sample size (282) should make the *t* methods appropriate, because the distribution of ratings can have no outliers. (c) The margin of error is $t^* \frac{s}{\sqrt{282}}$, which is either 0.1611 (Table C) or 0.1591 (software):

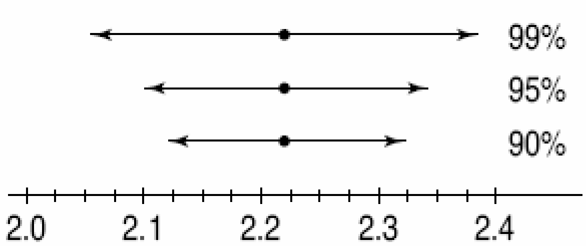
	df	t^*	Interval
Table C	100	2.626	2.22 ± 0.1611 = 2.0589 to 2.3811
Software	281	2.5934	2.22 ± 0.1591 = 2.0609 to 2.3791

We are 99% confident that the mean rating for boys with ADHD is between 2.06 and 2.38 for this item. (d) Generalizing to boys with ADHD in other locations is not recommended. These boys were clearly not a random sample from the population of all boys with ADHD.

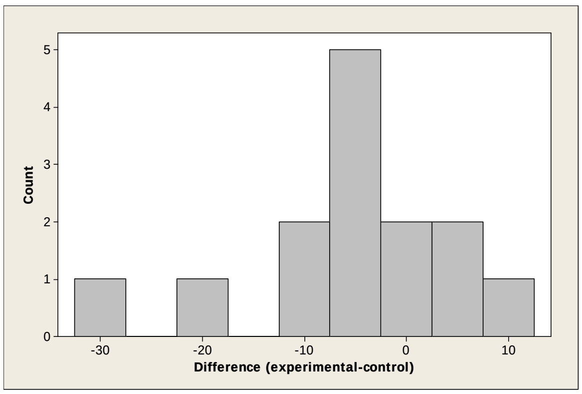
10.43 These intervals are constructed as in the previous exercise, except for the choice of t^*.

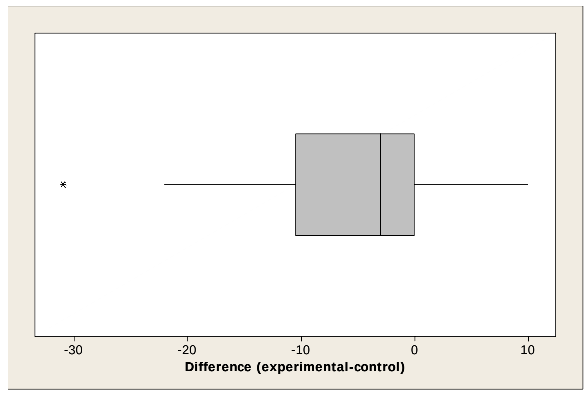
		df	t^*	Interval
90% confidence	Table C	100	1.660	2.22 ± 0.1018 = 2.1182 to 2.3218
	Software	281	1.6503	2.22 ± 0.1012 = 2.1188 to 2.3212
95% confidence	Table C	100	1.984	2.22 ± 0.1217 = 2.0983 to 2.3417
	Software	281	1.9684	2.22 ± 0.1207 = 2.0993 to 2.3407

As the confidence level increases, the width of the interval increases.



10.44 (a) The mean difference for these 14 newts is $\bar{x}_d = -5.71$, the standard deviation is $s_d = 10.56$, and the standard error of the mean is $SEM = \frac{10.56}{\sqrt{14}} \doteq 2.82$. (b) Using df = 13 and t^* = 1.771, the 90% confidence interval is $-5.71 \pm 1.771\left(\frac{10.56}{\sqrt{14}}\right)$ or from −10.71 to −0.71 micrometers per hour. If a large number of samples were obtained and the confidence intervals were computed, then approximately 90% of the intervals would contain the true mean difference in healing rates. (c) No. A histogram (left) and boxplot (right) are shown below. Since the sample size (n = 14) is small and the distribution of the difference is skewed to the left with an outlier, the Normal distribution is not appropriate. The t interval should not be used to make inferences about $\mu_{\text{experimental-control}}$.





10.45 (a) The population is the 175 residents of Tonya's dorm and p is the proportion of all the residents who like the food. (b) The sample proportion is $\hat{p} = \frac{14}{50} = 0.28$. (c) No, the population is not large enough relative to the sample (N = 175 < 500 = 10×50).

10.46 (a) The population is the 2400 students at Glen's college, and p is the proportion who believe tuition is too high. (b) The sample proportion is $\hat{p} = \frac{38}{50} = 0.76$. (b) Yes—we have an SRS, the population is 48 times as large as the sample, and the success count (38) and failure count (12) are both greater than 10.

10.47 (a) The population is all adult heterosexuals and p is the proportion of all adult heterosexuals who have had both a blood transfusion and a sexual partner from a high risk of AIDS group. (b) The sample proportion is $\hat{p} = 0.002$. (c) No, there are only 5 or 6 "successes" in the sample.

10.48 (a) The standard error of $\hat{p}$ is $SE_{\hat{p}} = \sqrt{0.87 \times 0.13/430{,}000} \doteq 0.0005129$. For 99% confidence, the margin of error is $2.576 \times SE_{\hat{p}} \doteq 0.001321$. (b) One source of error is indicated by the wide variation in response rates: We cannot assume that the statements of respondents represent the opinions of nonrespondents. The effect of the participation fee is harder to predict, but one possible impact is on the types of institutions that participate in the survey: Even though the fee is scaled for institution size, larger institutions can more easily absorb it. These other sources of error are much more significant than sampling error, which is the only error accounted for in the margin of error from part (a).

10.49 (a) The population is all college undergraduates and the parameter is p = the proportion of college undergraduates who are abstainers. (b) Example 10.15 states that the sample is an SRS. The population (all undergraduates) is at least 10 times the sample size of 10,904. The number of successes $n\hat{p} = 2105$ and the number of failures $n(1-\hat{p}) = 8799$ are both at least 10, so the conditions for constructing a confidence interval are satisfied. (c) A 99% confidence interval for p is $0.193 \pm 2.576\sqrt{0.193 \times 0.807/10{,}904} = (0.183, 0.203)$. (d) With 99% confidence, we estimate between 18.3% and 20.3% of all college undergraduates are classified as abstainers.

10.50 The report should include the sample proportion $\hat{p} = \dfrac{1127}{1633} \doteq 0.6901$ or approximate sample percent = 69% and the margin of error $\pm 1.96\sqrt{0.6901(1-0.6901)/1633} \doteq \pm 0.022$ or ±2.2 percentage points for 95% confidence. News release: In January 2000, the Gallup Organization discovered that approximately 69% of adults were satisfied with the way things are going in the United States. A random sample of 1633 adults participated in the poll and the margin of error is about 2.2 percentage points. Do you think our readers are still satisfied with the way things are going in the United States? The results of our local survey will be printed next Wednesday!

10.51 (a) The proportion is $\hat{p} = \dfrac{15}{84} \doteq 0.179$ and the standard error is $SE_{\hat{p}} = \sqrt{\dfrac{0.179 \times 0.821}{84}} \doteq 0.042$. (b) A 90% confidence interval is $0.179 \pm 1.645 \times 0.042 = (0.110, 0.247)$. With 90% confidence, we estimate that between 11.0% and 24.7% of all applicants lie about having a degree.

10.52 (a) The standard error is $SE_{\hat{p}} = \sqrt{\dfrac{0.54 \times 0.46}{1019}} \doteq 0.0156$, so the 95% confidence interval is $0.54 \pm 1.96 \times 0.0156 = (0.509, 0.571)$. We are 95% confident that the proportion of adults who would answer "Yes" is between 50.9% and 57.1%. Notice that 50% is not in the confidence interval. The margin of error is 1.96×0.0156 or about 3%, as stated. (b) The sample sizes for men and women are not provided. (c) The margin of error for women alone would be greater than 0.03 because the sample size for women alone is smaller than 1019.

10.53 (a) The margins of error are $1.96 \times \sqrt{\hat{p}(1-\hat{p})/100} = 0.196 \times \sqrt{\hat{p}(1-\hat{p})}$. See the table below. (b) With n = 500, the margins of error are $1.96 \times \sqrt{\hat{p}(1-\hat{p})/500}$. The new margins of error are less than half their former size (in fact, they have decreased by a factor of $\dfrac{1}{\sqrt{5}} \doteq 0.447$).

	$\hat{p}$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
(a)	m.e.	0.0588	0.0784	0.0898	0.0960	0.0980	0.0960	0.0898	0.0784	0.0588
(b)	m.e.	0.0263	0.0351	0.0402	0.0429	0.0438	0.0429	0.0402	0.0351	0.0263

10.54 (a) To meet the specifications, we need $1.96\sqrt{\frac{0.44\times0.56}{n}} \le 0.03$ or $n \ge \left(\frac{1.96}{0.03}\right)^2 \times 0.44\times0.56 \doteq 1051.74$. Take a sample of n = 1052 adults. (b) With the conservative guess, we need $n \ge \left(\frac{1.96}{0.03}\right)^2 \times 0.5\times0.5 \doteq 1067.11$ or 1068 adults. The conservative approach requires 16 more adults.

10.55 (a) The 95% confidence interval for *p* is $0.64 \pm 1.96\sqrt{0.64\times0.36/1028} \doteq (0.61, 0.67)$. With 95% confidence we estimate that between 61% and 67% of all teens aged 13 to 17 have TVs in their rooms. (b) Not all samples will be the same, so there is some variability from sample to sample. The margin of error accounts for this variability. (c) Teens are hard to reach and often unwilling to participate in surveys, so nonresponse bias is a major "practical difficulty" for this type of poll. Teens can also be sensitive so response bias associated with the wording of the question or the verbal emphasis by the interviewer may be a problem.

10.56 Our guess is $p^* = 0.7$, so we need $1.645\sqrt{\frac{0.7\times0.3}{n}} \le 0.04$ or $n \ge \left(\frac{1.645}{0.04}\right)^2 \times 0.7\times0.3 \doteq 355.17$. Take an SRS of *n* = 356 students. (b) With $\hat{p} = 0.5$ and *n* = 356, the margin of error is $1.645\sqrt{\frac{0.5\times0.5}{356}} \doteq 0.0436$.

10.57 (a) The sample proportion is $\hat{p} = \frac{171}{880} \doteq 0.1943$ and the 95% confidence interval is $0.1943 \pm 1.96\sqrt{0.1943\times0.8057/880} \doteq (0.1682, 0.2205)$. We are 95% confident that between 16.82% and 22.05% of all drivers would say that they had run at least one red light. (b) More than 171 respondents have run red lights. We would not expect very many people to claim they *have* run red lights when they have not, but some people will deny running red lights when they have.

10.58 (a) Our guess is $p^* = 0.2$, so we need $2.576\sqrt{\frac{0.2\times0.8}{n}} \le 0.015$ or $n \ge \left(\frac{2.576}{0.015}\right)^2 \times 0.2\times0.8 \doteq 4718.77$. Take an SRS of *n* = 4719 customers. (b) With $\hat{p} = 0.1$ and *n* = 4719, the margin of error is $2.576\sqrt{\frac{0.1\times0.9}{4719}} \doteq 0.0112$.

10.59 (a) The population of interest is all bicyclists aged 15 or older who were fatally injured and p is the proportion of all fatally injured bicyclists aged 15 or older who tested positive for alcohol. We do not know that the examined records came from an SRS, so we must be cautious. Both $n\hat{p} = 542$ and $n(1-\hat{p}) = 1169$ are at least 10. There are more than 10×1711 = 17,110 fatally injured bicyclists in the United States. A 99% confidence interval for p is $0.317 \pm 2.576\sqrt{\frac{0.317 \times 0.683}{1711}} = (0.288, 0.346)$. With 99% confidence, we estimate that between 28.8% and 34.6% of all fatally injured bicyclists aged 15 or older would test positive for alcohol. (b) No. For example, we do not know what percent of cyclists who were not involved in fatal accidents had alcohol in their systems. Many other factors, such as not wearing a helmet, need to be considered.

10.60 Our guess is $p^* = 0.75$, so we need $1.96\sqrt{\frac{0.75 \times 0.25}{n}} \le 0.04$ or $n \ge \left(\frac{1.96}{0.04}\right)^2 \times 0.75 \times 0.25 \doteq 450.19$. Take an SRS of n = 451 Americans with at least one Italian grandparent.

10.61 (a) The sample proportion is $\hat{p} = \frac{390}{1191} \doteq 0.3275$ and a 95% confidence interval for p is $0.3275 \pm 1.96\sqrt{0.3275 \times 0.6725/1191} \doteq (0.3008, 0.3541)$. (b) Only 45 congregations did not participate in the study, so the nonresponse rate is 45/1236 = 0.0364 or about 3.6%. This nonresponse rate is quite small, which suggests that the results should be reliable: If we had information for the few congregations that failed to respond, our conclusions would probably not change very much. (c) Speakers and listeners probably perceive sermon length differently (just as, say, students and teachers have different perceptions of the length of a class period). Listeners tend to exaggerate and report that the sermons lasted longer than they actually did, while speakers are more likely to report shorter sermons. Since the key informants provided the information, the estimate of the true population proportion may be too low.

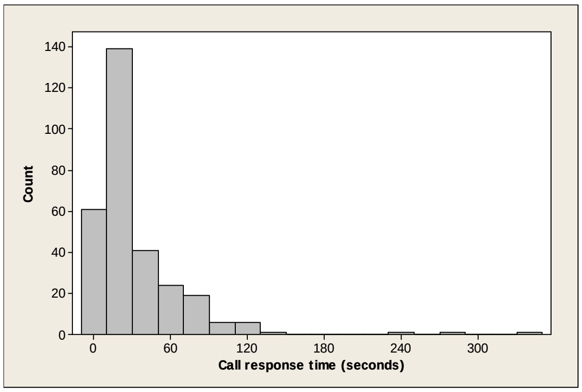
10.62 (a) The sample proportion is $\hat{p} = \frac{3547}{5594} \doteq 0.6341$. The standard error is $SE_{\hat{p}} = \sqrt{\frac{\hat{p}(1-\hat{p})}{5594}} \doteq 0.00644$, so the margin of error for 90% confidence is $1.645 \times SE_{\hat{p}} \doteq 0.0106$, and the interval is 0.6235 to 0.6447. This interval was found using a procedure that includes the true proportion 90% of the time. (b) Yes, we do not know if those who *did* respond can reliably represent those who did not.

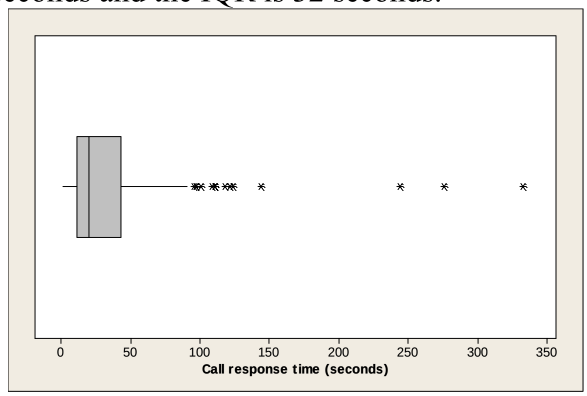
10.63 No, the data are not based on an SRS, and therefore inference procedures are not reliable in this case. A voluntary response sample is typically biased.

10.64 (a) The sample proportion is $\hat{p} = \frac{107}{127} \doteq 0.8425$ and a 99% confidence interval for p is $0.8425 \pm 2.576\sqrt{0.8425 \times 0.1575/127} \doteq (0.7592, 0.9258)$. With 99% confidence, we estimate that between 76% and 93% of all undergraduate students pray at least a few times a year. (b) No, the fact that these students were all in psychology and communications courses makes it seem unlikely that they are truly representative of all undergraduates.

CASE CLOSED!

1. Graphical summaries of the call response times are shown below. The histogram (left) and boxplot (right) clearly show that the distribution of the call response times is strongly skewed to the right with several outliers. The Normal distribution is certainly not appropriate for these response times. The mean response time is 31.99 seconds and the median response time is 20 seconds. The large outliers clearly have an impact on the mean, and they will also influence the standard deviation. The standard deviation is 37.2 seconds and the IQR is 32 seconds.



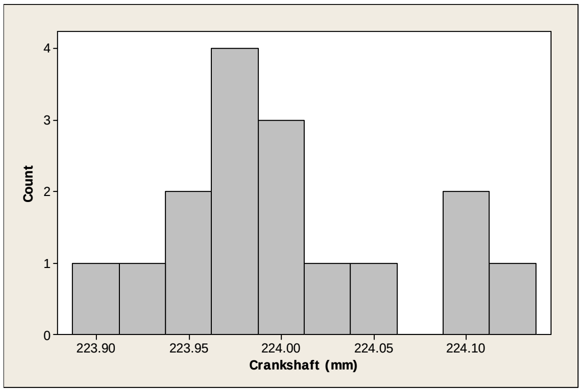


2. Let μ denote the mean call response time at the bank's customer service center. Using df = 100 and $t^* = 1.984$, a 95% confidence interval for μ is $31.99 \pm 1.984 \frac{37.2}{\sqrt{300}} \doteq (27.73, 36.25)$. Software and the TI calculators give the interval from 27.7673 to 36.2194 seconds.

3. Let p denote the proportion of call response times that are at most 30 seconds at the bank's customer service center. The sample proportion is $\hat{p} = \frac{203}{300} \doteq 0.6767$ and the 95% confidence interval for p is $0.6767 \pm 1.96\sqrt{0.6767 \times 0.3233/300} \doteq (0.6238, 0.7296)$.

4. The distribution of response times clearly does not follow a Normal distribution. The major conditions regarding random sampling and independence are satisfied for the inferences below. However, it is worth noting that we are relying on the central limit theorem and the robustness of the t procedures for the inference regarding the mean call response time because the sample size ($n = 300$) is large. We are 95% confident that the mean call response time is between approximately 28 and 36 seconds. The large call response times, which unfortunately occur in this business, clearly have an impact on the mean. With 95% confidence, we estimate the proportion of calls answered within 30 seconds to be between 62% and 73%. The intervals reported above are based on methods that will include the true mean and true proportion for all calls to your customer service center 95% of the time. (P.S. As you know, there is another way to describe the center of the call waiting times. This statistic is known as the median and it is very useful for skewed distributions. If you would like to learn more about inferences based on the median, we can schedule another meeting.)

10.65 (a) The histogram below shows that the distribution is slightly skewed to the right, but the Normal distribution is reasonable.



(b) The sample mean is $\bar{x} = 224.002$ mm and the standard deviation is $s = 0.062$, very close to the known standard deviation in the population. A 95% confidence interval for μ is $224.002 \pm 1.96\frac{0.060}{\sqrt{16}} \doteq (223.973, 224.031)$. With 95% confidence, we estimate the mean critical dimension for auto engine crankshafts of this type are between 223.973 mm and 224.031 mm.
(c) In repeated samples of this size, 95% of the intervals obtained will contain the true mean.
(d) The specification is $1.96\frac{0.06}{\sqrt{n}} \leq .02$, so we need $n \geq \left(\frac{1.96 \times 0.06}{0.02}\right)^2 \doteq 34.57$ or 35 crankshafts.

10.66 (a) If we take a different sample, then we will probably get a different estimate. There is variability from sample to sample. (b) The sample proportion is $\hat{p} = 0.37$ and the 95% confidence interval for p is $0.37 \pm 1.96\sqrt{0.37 \times 0.63/1000} \doteq (0.3401, 0.3999)$. (c) Yes, the margin of error is $1.96\sqrt{0.37 \times 0.63/1000} \doteq 0.0299$ or about 3 percentage points. (d) Yes, most people are not thinking about football during June so the proportion would probably decrease and more people would say that baseball, tennis, soccer, or racing was their favorite sport to watch.

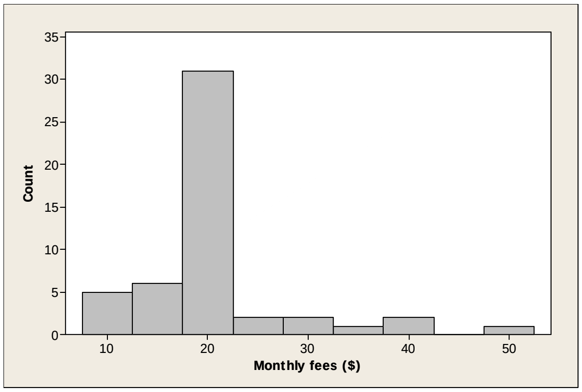
10.67 (a) Using df = 26 and $t^* = 2.779$, a 95% confidence interval for μ is $114.9 \pm 2.779\frac{9.3}{\sqrt{27}} \doteq (109.93, 119.87)$. With 95% confidence we estimate that the mean seated systolic blood pressure of all healthy white males is between 109.93 and 119.87 mm Hg. (b) The conditions are SRS, Normality, and Independence. The most important condition is that the 27 members of the placebo group can be viewed as an SRS of the population. The Normality condition requires that the distribution of seated systolic BP in this population is Normal, or at least not too nonNormal. Since the sample size is moderate, the procedure should be valid as long as the data show no outliers and no strong skewness. We must assume that these 27 measurements are independent.

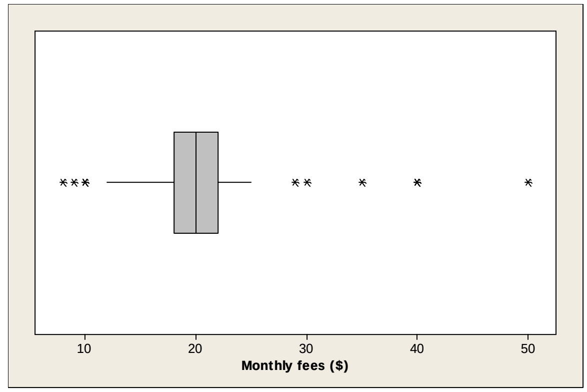
10.68 (a) For each subject, subtract the weight before from the weight after to determine the weight gain. For example, the weight gain for Subject 1 is 61.7 – 55.7 = 6 kg. The mean weight gain for all 16 adults is $\bar{x}_d = 4.7313$ kg, the standard deviation is $s_d = 1.7457$ kg, and the standard error of the mean is $SEM = \frac{1.7457}{\sqrt{16}} \doteq 0.4364$ kg. Using df = 15 and $t^* = 2.131$, the 95% confidence interval is $4.7313 \pm 2.131\left(\frac{1.7457}{\sqrt{16}}\right)$ or from 3.8013 to 5.6613 kg. Software and the TI calculators give the interval (3.8010, 5.6615). (b) Because there are 2.2 kg per pound, multiply the value in kilograms by 2.2 to obtain pounds. The confidence interval from software and the calculators becomes 8.3622 to 12.4553 lbs. (c) No, the value 16 is not in our 95% confidence interval. The data suggest that the excess calories were not converted into weight. The subjects must have used this energy some other way.

10.69 (a) The sample proportion is $\hat{p} = \frac{660}{1500} = 0.44$ and the 95% confidence interval for p is $0.44 \pm 1.96\sqrt{0.44 \times 0.56/1500} \doteq (0.4149, 0.4651)$. With 95% confidence, we estimate that between 41.5% and 46.5% of all adults would use alternative medicine. (b) The news report should contain the estimate and the margin of error (0.0251 or 2.51%). A brief, nontechnical explanation of "95% confidence" might also be included. News Release: A nationwide survey discovered that 44% of adults would use alternative medicine if traditional medicine was not producing the results they wanted. A random sample of 1500 adults participated in the survey and the margin of error is about 2.5 percentage points. What percent of our readers do you think would turn to alternative medicine? The results of our local survey will be printed next Monday!

10.70 (a) The sample proportion is $\hat{p} = \frac{221}{270} \doteq 0.8185$ and $SE_{\hat{p}} = \sqrt{\frac{0.8185 \times 0.1815}{270}} \doteq 0.02346$, so the margin of error for a 99% confidence interval is $2.576 \times 0.02346 \doteq 0.0604$. (b) Using the estimate from part (a) as our guess $p^* = 0.82$, we need $2.576\sqrt{\frac{0.82 \times 0.18}{n}} \le 0.03$ or $n \ge \left(\frac{2.576}{0.03}\right)^2 \times 0.82 \times 0.18 \doteq 1088.27$. Take an SRS of $n = 1089$ doctors. In order to guarantee that the margin of error is less than 3 percentage points, the conservative approach with $p^* = 0.5$ should be used. Thus, we would need $n \ge \left(\frac{2.576}{0.03}\right)^2 \times 0.5 \times 0.5 \doteq 1843.27$ or 1844 doctors.

10.71 (a) The histogram below shows that the distribution is skewed to the right and the boxplot below shows three low and five high outliers.





(b) The data are from a random sample, and the sample size is large ($n = 50$), so the central limit theorem tells us that the sampling distribution of $\bar{x}$ is approximately Normal. The population of commercial Internet service providers is also much larger than $10\times50 = 500$ users. (c) The sample mean is $\bar{x} = 20.9$, the standard deviation is $s = 7.6459$ and the standard error of the mean is $SEM = \frac{7.6459}{\sqrt{50}} \doteq 1.0813$. Using df = 40 and $t^* = 1.684$, the confidence interval for μ is $20.9 \pm 1.684\left(\frac{7.6459}{\sqrt{50}}\right) = (19.08, 22.72)$. Software and the TI calculators give $(19.0872, 22.7128)$, using df = 49. With 90% confidence, we estimate the mean cost for users of commercial Internet service providers in August 2000 to be between \$19.08 and \$22.72.

10.72 (a) The sample mean is $7.5\times60 = 450$ minutes. The margin of error is 20 minutes, so $1.96\frac{s}{\sqrt{40}} = 20$ minutes. Thus, the standard deviation is $s = \frac{20\times\sqrt{40}}{1.96} = 64.5363$ minutes. (b) This interpretation is incorrect. The confidence interval provided gives an interval estimate for the mean lifetime of batteries produced by this company, not individual lifetimes. (c) No, a confidence interval provides a statement about an unknown population mean, not another sample mean. (d) We are 95% confident that the mean lifetime of all AA batteries produced by this company is between 430 and 470 minutes. This interval is based on a method that will capture the true mean lifetime 95% of the time.

10.73 (a) The sample proportion is $\hat{p} = \frac{750}{1785} \doteq 0.4202$ and $SE_{\hat{p}} = \sqrt{\frac{0.4202\times0.5798}{1785}} \doteq 0.011683$, so a 99% confidence interval for p is $0.4202 \pm 2.576\times0.011683 \doteq (0.390, 0.450)$. With 99% confidence, we estimate that between 39% and 45% of all adults attended church or synagogue within the last 7 days. (b) Using the conservative guess $p^* = 0.5$, the specification is $2.576\sqrt{\frac{0.5\times0.5}{n}} \le 0.01$, so we need $n \ge \left(\frac{2.576}{0.01}\right)^2 \times 0.5\times0.5 = 16589.44$. Take an SRS of n = 16,590 adults. The use of $p^* = 0.5$ is reasonable because our confidence interval shows that the actual p is in the range 0.3 to 0.7.

10.74 (a) The differences are spread from −0.018 to 0.020 g, with mean $\bar{x} = -0.0015$ g and standard deviation $s = 0.0122$ g. A stemplot is shown below, but the sample is too small to make judgments about skewness or symmetry.

```
Stem-and-leaf of diff  N  = 8
Leaf Unit = 0.0010
 2  -1  85
 2  -1
 4  -0  65
 4  -0
 4  0   2
 3  0   55
 1  1
 1  1
 1  2   0
```

(b) Using df = 7 and $t^* = 2.365$, a 95% confidence interval for μ is

$$-0.0015 \pm 2.365\left(\frac{0.0122}{\sqrt{8}}\right) = -0.0015 \pm 0.0102 = (-0.0117, 0.0087)$$ We are 95% confident that the mean difference in TBBMC readings is between −0.0117 and 0.0087 g. (c) The subjects from this sample may be representative of future subjects, but the test results and confidence interval are suspect because this is not a random sample.