therefore, are not independent, thus casting doubt about the validity of the interval as an estimate of the proportion of workers who wash their hands.

**9.3.1** $\hat{p}$=0.037. Thus y ≈ (848)(0.037) = 31.376, so y must be 31.

Thus, $\tilde{p} = \frac{31+0.5(1.645^2)}{848+1.645^2} = 0.0380$ and $SE = \sqrt{\frac{0.038(1-0.038)}{848+1.645^2}} = 0.0066$.

90% confidence interval: 0.0380 ± (1.645)(0.0066) or (0.0271,0.0489) or $0.0271 < p < 0.0489$.

**9.3.2** (a) y = (959)(0.157) = 150.56, so y must be 151.

Thus, $\tilde{p} = \frac{151+0.5(1.645^2)}{959+1.645^2} = .158$ and $SE = \sqrt{\frac{0.158(1-0.158)}{959+1.645^2}} = 0.012$.

90% confidence interval: 0.158 ± (1.645)(0.012) or (0.138,0.178) or $0.138 < p < 0.178$.

(b) The confidence interval from part (a) is a confidence interval for the probability of interference with the pacemaker for that type of cellular telephone.

**9.3.3** n = 180; y = 23; $\tilde{p} = \frac{y+0.5(1.645^2)}{n+1.645^2} = 0.133$.

$SE = \sqrt{\frac{\tilde{p}(1-\tilde{p})}{n+1.645^2}} = 0.025$.

The 90% confidence interval is 0.133 ± (2.576)(0.025) or 0.133 ± 0.064 or (0.069,0.197).

• **9.3.4** $\tilde{p} = \frac{40+0.5(1.645^2)}{53+1.645^2} = 0.7423$ and $SE = \sqrt{\frac{0.7423(1-0.7423)}{53+1.645^2}} = 0.0586$.

90% confidence interval: 0.7423 ± (1.645)(0.0586) or (0.646,0.839) or $0.646 < p < 0.839$.

Note: In hypothesis testing problems involving the $\chi^2$ statistic, expected frequencies are shown in parentheses.

• **9.4.1** The hypotheses are

$H_0$: The model is correct (the population ratio is 12:3:1)
$H_A$: The model is incorrect (the population ratio is not 12:3:1)

More formally, we can state these as

$H_0$: Pr{white} = 0.75, Pr{yellow} = 0.1875, Pr{green} = 0.0625
$H_A$: At least one of the probabilities specified by $H_0$ is incorrect

We calculate the expected frequencies from $H_0$ as follows:

| | | | | |
|---|---|---|---|---|
| White: | E = | (.75)(205) | = | 153.75 |
| Yellow: | E = | (.1875)(205) | = | 38.4375 |
| Green: | E = | (.0625)(205) | = | 12.8125 |



The observed and expected frequencies (in parentheses) are:

| White | Yellow | Green | Total |
|---|---|---|---|
| 155 (153.75) | 40 (38.4375) | 10 (12.8125) | 205 |

The $\chi^2$ test statistic is

$$\chi^2_s = \frac{(155-153.75)^2}{153.75} + \frac{(40-38.4375)^2}{38.4375} + \frac{(10-12.8125)^2}{12.8125} = 0.69.$$

There are 3 categories, so we consult Table 9 with df = 3 - 1 = 2. From Table 9, we find $\chi^2_{2,0.20} = 3.22$. Because $\chi^2_s < \chi^2_{0.20}$, the P-value is bracketed as

$P > .20$.

At significance level .10, we would reject $H_0$ if $P < 0.10$. Since $P > 0.20$, we do not reject $H_0$. There is little or no evidence ($P > .20$) that the model is not correct; the data are consistent with the model.

• **9.4.2** $H_0$ and $H_A$ are the same as in Exercise 9.4.1. Because the sample is 10 times as large, the value of $\chi^2_s$ is 10 times as large as in Exercise 9.4.1. Thus,

$\chi^2_s$ = (10)(0.69) = 6.9.

From Table 9, with df = 3 - 1 = 2, we find $\chi^2_{2,0.05} = 5.99$ and $\chi^2_{2,0.02} = 7.82$; thus, the P-value is bracketed as

$0.02 < P < 0.05$.

At significance level 0.10, we reject $H_0$ if $P < 0.10$. Since $0.02 < P < 0.05$, we reject $H_0$. There is sufficient evidence ($0.02 < P < 0.05$) to conclude that the model is incorrect; the data are not consistent with the model. (Note that, because $H_0$ is a compound hypothesis, the conclusion for the $\chi^2$ test is nondirectional.)

**9.4.3** The hypotheses are

$H_0$: The bee could not distinguish the patterns (Pr{Flower 1} = 0.5)
$H_A$: The bee could distinguish the patterns (Pr{Flower 1} > 0.5)

| Flower 1 | Flower 2 |
|---|---|
| 20 (12.5) | 5 (12.5) |

$\chi^2_s = 9.00$. With df = 1, Table 9 gives $\chi^2_{0.01} = 6.63$ and $\chi^2_{0.001} = 10.83$, so $0.0005 < P < 0.005$ and we reject $H_0$. There is sufficient evidence ($0.0005 < P < 0.005$) to conclude that the bee could distinguish the patterns.

**9.4.4** (a) $\chi^2_S = 13.3$

(b) $H_0$:Timing of births is random (Pr{weekend = 2/7}); $H_A$:Timing of births is not random

(Pr{weekend ≠ 2/7})

**(c)** We reject $H_0$ because the P-value is smaller than 0.05. We have sufficient evidence (P=0.0003) to conclude that the timing of births is not random; rather, there are fewer weekend births than would be expected by chance.

**9.4.5** Let WF and DF denote white and dark feathers; let SC and LC denote small and large comb.

$H_0$: The model is correct (Pr{WF,SC} = 9/16, Pr{WF,LC} = 3/16, Pr{DF,SC} = 3/16, Pr{DF,LC} = 1/16)
$H_A$: The model is incorrect (probabilities are not as specified by $H_0$)

| WF,SC | WF,LC | DF,SC | DF,LC |
|---|---|---|---|
| 111 (106.875) | 37 (35.625) | 34 (35.625) | 8 (11.875) |

$\chi^2_s = 1.55$. With df = 3, Table 9 gives $\chi^2_{0.20} = 4.64$. We do not reject $H_0$. There is little or no evidence (P > 0.20) to conclude that the model is incorrect; the data are consistent with the Mendelian model.

**9.4.6 (a)**

| Boy | Girl |
|---|---|
| 510 (500) | 490 (500) |

$\chi^2_s = 0.4$. With df = 1, Table 9 gives $\chi^2_{0.20} = 1.64$, so P > 0.20.

**(b)**

| Boy | Girl |
|---|---|
| 2550 (2500) | 2450 (2500) |

$\chi^2_s = 2$. With df = 1, Table 9 gives $\chi^2_{0.20} = 1.64$ and $\chi^2_{0.10} = 1.71$, so 0.10< P < 0.20.

**(c)**

| Boy | Girl |
|---|---|
| 5100 (5000) | 4900 (5000) |

$\chi^2_s = 4$. With df = 1, Table 9 gives $\chi^2_{0.05}$= 3.84 and $\chi^2_{0.02}$= 5.41, so 0.02< P < 0.05.

**9.4.7 (a)** $H_0$: Pr{normal} = 0.75 and Pr{shriveled} = 0.25; $H_A$: $H_0$ is false.

**(b)** $e_1 = 0.75 \times 149 = 111.75$; $e_2 = 0.25 \times 149 = 37.25$

**(c)** We reject $H_0$ because the P-value is smaller than 0.01. We have sufficient evidence (P=0.0015) to conclude that the model does not hold; the ratio of normal to shriveled progeny is not 3:1.

• **9.4.8** The hypotheses may be stated informally as



$H_0$: The drug does not cause tumors
$H_A$: The drug causes tumors

Consider only the 20 triplets in which at least one tumor occurred. Let T denote the event that a tumor occurs in the treated rat before a tumor occurs in a control rat. If the drug does not cause tumors, then each rat is equally likely to be the first to develop a tumor, so that Pr{T} would be 1/3. On the other hand, if the drug does cause tumors, then the treated rat is at higher risk, so that Pr{T} would be greater than 1/3. Thus, the hypotheses can be stated formally as

$H_0$: $\Pr\{T\} = \frac{1}{3}$
$H_A$: $\Pr\{T\} > \frac{1}{3}$

Because $H_A$ is directional, we begin by checking the directionality of the data. The estimated probability of T is

$$\hat{\Pr}\{T\} = \frac{12}{20} = 0.6.$$

We note that

$$\hat{\Pr}\{T\} > \frac{1}{3}.$$

Thus, the data do deviate from $H_0$ in the direction specified by $H_A$. We proceed to the calculation of the test statistic. The following are the observed and expected frequencies (in parentheses):

| Tumor first in treated rat | Tumor first in control rat |
|---|---|
| 12 (6.67) | 8 (13.33) |

The expected frequencies are calculated as $\frac{1}{3}(20)$ and $\frac{2}{3}(20)$. The $\chi^2$ statistic is

$$\chi^2_s = \frac{(12-6.67)^2}{6.67} + \frac{(8-13.33)^2}{13.33} = 6.4.$$

There are 2 categories, so we consult Table 9 with df = 2 - 1 = 1. From Table 9, we find $\chi^2_{1,0.02} = 5.41$ and $\chi^2_{1,0.01} = 6.63$, so $\chi^2_{1,0.01} < \chi^2_s < \chi^2_{1,0.02}$. Because $H_A$ is directional, the column headings (0.02 and 0.01) must be cut in half to bracket the P-value; thus P-value is bracketed as

0.005 < P < 0.01.

At significance level 0.01, we reject $H_0$ if P < 0.01. Since 0.005 < P < 0.01, we reject $H_0$. There is sufficient evidence (0.005 < P < 0.01) to conclude that the drug does cause tumors.

**9.4.9 (a)** The hypotheses are

$H_0$: The animals cannot discriminate between the two colors (Pr{red} = 1/3)
$H_A$: The animals can discriminate between the two colors (Pr{red} > 1/3)

| Red | White |
|---|---|
| 45 (25) | 30 (50) |

$\chi^2_s = 24$. With df = 1, Table 9 gives $\chi^2_{0.0001} = 15.14$, so $P < 0.00005$ and we reject $H_0$.

(b) There is sufficient evidence ($P < 0.00005$) to conclude that the animals can discriminate between the two colors.

(c) A directional alternative is appropriate because the animals had been trained, so that they could be expected to do better than choosing at random. That is, the researchers believed, before conducting the experiment, that if $H_0$ were false, the data would deviate in the direction of yielding an excess number of red selections.

**9.4.10** (a) $\chi^2_S = 3.81$

(b) We do not reject $H_0$. There is little or no evidence (P=0.149) to conclude that the model is incorrect; the data are consistent with the 1:2:1 ratio predicted by the model.

**9.4.11** (a) The hypotheses are

$H_0$: The men are guessing (Pr{correct} = 1/3)
$H_A$: The men have some ability to detect their partners (Pr{correct} > 1/3)

| Correct | Wrong |
|---|---|
| 18 (12) | 18 (24) |

$\chi^2_s = 4.5$. With df = 1, Table 9 gives $\chi^2_{0.05} = 3.84$ and $\chi^2_{0.02} = 5.41$, so $0.01 < P < 0.025$ and we reject $H_0$. (Note that no $\alpha$ level was specified, but a P-value less than 0.025 is generally considered to be small.) There is sufficient evidence ($0.01 < P < 0.025$) to conclude that the men have some ability to detect their partners by touching them on the forehead.

(b) There is sufficient evidence ($0.01 < P < 0.02$) to conclude that the men have some ability to detect their partners by touching them on the forehead.

**9.4.12** $H_0$: The model is correct (Pr{I} = 12/16, Pr{II} = 3/16, Pr{III} = 1/16)
$H_A$: The model is incorrect (probabilities are not as specified by $H_0$)

| I | II | III |
|---|---|---|
| 179 (184.5) | 44 (46.125) | 23 (15.375) |

$\chi^2_s = 4.04$. With df = 2, Table 9 gives $\chi^2_{0.20} = 3.22$ and $\chi^2_{0.10} = 4.61$. We do not reject $H_0$. There is little or no evidence ($0.10 < P < 0.20$) to conclude that the model is incorrect; the data are consistent with the probabilities stated.



**9.4.13** $H_0$: The model is correct (Pr{Red} = 1/4, Pr{Pink} = 1/2, Pr{White} = 1/4)
$H_A$: The model is incorrect (probabilities are not as specified by $H_0$)

| I | II | III |
|---|---|---|
| 54 (58.5) | 122 (117.0) | 58 (58.5) |

$\chi^2_s = 0.5641$. With df = 2, Table 9 gives $\chi^2_{0.20} = 3.22$. Thus, P-value > 0.20. We do not reject $H_0$. There is little or no evidence (P > 0.20) to conclude that the model is incorrect; the data are consistent with the probabilities stated. *Note to students*: This experiment (or a similar one involving crossing fruit flies) is a common experiment performed in college biology courses. Many of these courses have students conduct this chi-square test to "validate" or "confirm" Mendelian segregation. Can these data (or data from a similar experiment) actually achieve this goal? What does a lack of evidence for $H_A$ tell us here?

**9.S.1** Let Y denote the number of Rh positive people in a sample of size 10 from a population for which 83% are Rh positive.

(a) $\Pr\{\tilde{P} = 0.714\} = \Pr\{Y = 8\} = {}_{10}C_8(0.83)^8(0.17)^2 = 0.2929$.

(b) $\Pr\{\tilde{P} = 0.786\} = \Pr\{Y = 9\} = {}_{10}C_9(0.83)^9(0.17)^1 = 0.3178$.

• **9.S.2** (a) For this population, p = 1/5 = 0.20. Letting Y = the number of adults in a random sample of size 16 flatworms we have $\Pr\{\tilde{P} = p\} = \Pr\{\tilde{P} = 0.20\} = \Pr\{Y = 2\} = {}_{16}C_2(0.20)^2(0.80)^{14} = 0.2111$.

(b)

$$\begin{aligned}\Pr\{p - 0.05 \le \tilde{P} \le p + 0.05\} &= \Pr\{0.15 \le \tilde{P} \le 0.25\} = \Pr\{1 \le Y \le 3\}\\ &= {}_{16}C_1(0.20)^1(0.80)^{15} + {}_{16}C_2(0.20)^2(0.80)^{14} + {}_{16}C_3(0.20)^3(0.80)^{13}\\ &= 0.1126 + 0.2111 + 0.2462\\ &= 0.5700\end{aligned}$$

• **9.S.3** $\tilde{p} = (97+2)/(123+4) = 0.780$.
The standard error is

$$SE = \sqrt{\frac{\tilde{p}(1-\tilde{p})}{n+4}} = \sqrt{\frac{0.780(1-0.780)}{123+4}} = 0.037.$$

The 95% confidence interval is
$\tilde{p} \pm 1.96 SE_{\tilde{p}}$

$0.780 \pm (1.96)(0.037)$

$0.780 \pm 0.073$

$(0.707, 0.853)$ or $0.707 < p < 0.853$.

**9.S.4** The data may not be a random sample because it is easier to capture pregnant females than others.

**9.S.5 (a)** $\tilde{p} = \frac{2+0.5(1.645^2)}{32+1.645^2} = 0.0966$ and $SE = \sqrt{\frac{0.0966(1-0.0966)}{32+1.645^2}} = 0.0501$.

90% confidence interval: $0.0966 \pm (1.645)(0.0501)$ or $(0.014, 0.179)$ or $0.014 < p < 0.179$.

**(b)** We require that the infants are randomly sampled from a large population. That is, all infants from the population had the same chance of being selected, and the infants are chosen independently.

**(c)** We are 90% confident that between 1.4% and 17.9% of breastfed infants from the sampled population have iron deficiency.

**9.S.6** Assuming that a 95% confidence interval will be eventually constructed, we solve the following inequality (from Section 9.2) for n:

$$0.01 \geq \sqrt{\frac{0.04(1-0.04)}{n+4}}$$

Solving for n we obtain $n \geq 380$. Sampling 380 bottles will ensure that SE is at most 0.01 or 1%.

**9.S.7 (a)** Following the solution to 9.S.6 with $p = 0.10$ we must solve the following equation for n:

$$0.01 \geq \sqrt{\frac{0.10(1-0.10)}{n+4}}$$

Solving for n we obtain $n \geq 896$. Sampling 896 bottles will ensure that SE is at most 0.01 or 1% when $p = 0.10$.

**(b)** $SE_{\tilde{p}}$ is largest when $p = 0.5$. Thus, when p is unknown, we will solve the following equation for n for the worst case scenario, when $p = 0.50$:

$$0.01 \geq \sqrt{\frac{0.50(1-0.50)}{n+4}}$$

Solving for n we obtain $n \geq 2496$. Sampling 2496 bottles will ensure that SE is at most 0.01 or 1% regardless of the value of p.

**9.S.8** Let p denote the probability that the uninfected mouse in a cage becomes dominant.

$H_0$: Infection has no effect on development of dominant behavior ($p = 1/3$)
$H_A$: Infection tends to inhibit development of dominant behavior ($p > 1/3$)

Uninfected mouse



| Dominant | Not dominant |
|---|---|
| 15 (10) | 15 (20) |

$\chi^2_s = 3.75$. With df = 1, Table 9 gives $\chi^2_{0.10} = 2.71$ and $\chi^2_{0.05} = 3.84$, so $0.025 < P < 0.05$ and we reject $H_0$. There is sufficient evidence ($0.025 < P < 0.05$) to conclude that infection tends to inhibit development of dominant behavior.

**9.S.9** The validity of the analysis depends on the condition that the 16,000 observations are independent of each other. Because of the hierarchical structure in the data (50 observation per mouse), the observations are <u>not</u> independent of each other.

**9.S.10 (a)** $\chi^2_s = 1.25$

**(b)** We do not reject $H_0$. There is little or no evidence (P=0.26) to conclude that the plants occur with different frequencies.

**9.S.11** The data deviate from $H_0$ in the right direction. Thus the P-value is 0.01191/2 = 0.005955. There is sufficient evidence (P=0.006) to conclude that the mortality rate has decreased.

**9.S.12 (a)** $H_0$: The 11:5 theory is correct (Pr{glandular} = 11/16)

$H_A$: The 11:5 theory is not correct (Pr{glandular} $\neq$ 11/16)

| Glandular | Glandless |
|---|---|
| 89 (85.94) | 36 (39.06) |

$\chi^2_s = 0.35$. We have df = 1; Table 9 gives $\chi^2_{1,0.20} = 1.64$. Thus, $P > 0.20$ and we do not reject $H_0$. There is little or no evidence ($P > 0.20$) that the 11:5 theory is incorrect; the data are consistent with the 11:5 theory.

**(b)** $H_0$: The 13:3 theory is correct (Pr{glandular} = 13/16)
$H_A$: The 13:3 theory is not correct (Pr{glandular} $\neq$ 13/16)

| Glandular | Glandless |
|---|---|
| 89 (101.56) | 36 (23.44) |

$\chi^2_s = 8.28$. We have df = 1; Table 9 gives $\chi^2_{1,0.01} = 6.63$ and $\chi^2_{1,0.001} = 10.83$. Thus, $0.001 < P < 0.01$ and we reject $H_0$. There is sufficient evidence ($0.001 < P < 0.01$) that the 13:3 theory is incorrect. The data are not consistent with the 13:3 theory; rather, Pr{glandular} < 13/16.

**9.S.13 (a)** If there are only two theories to consider, then finding compelling evidence against one theory (i.e., statistically significant evidence) would provide compelling evidence for the other. In 9.S.12 there was compelling evidence ($P < 0.01$) to reject the 13:3 theory, thus we could consider this as evidence for the 11:5 theory. Note that failing to reject the 11:5 theory (in part (a)) would not in itself serve as evidence for that theory.

**(b)** As noted in part (a), failing to reject the 11:5 theory does not constitute significant evidence for that theory. And, if there are multiple possible theories, rejecting the 13:3 theory also would not provide enough evidence to conclude that the 11:5 theory is true. There may be another ratio that differs from both 13:3 and 11:5 that is true. For example, these data are also consistent with an 11:4 theory with P-value = 0.590 (from statistical software).

• **9.S.14 (a)** The hypotheses are

$H_0$: Directional choice under cloudy skies is random (Pr{toward} = 0.25, Pr{away} = 0.25, Pr{right} = 0.25, Pr{left} = 0.25)
$H_A$: Directional choice under cloudy skies is not random

The expected frequencies, under $H_0$, are

Toward: E = (0.25)(50) = 12.5
Away: E = (0.25)(50) = 12.5
Right: E = (0.25)(50) = 12.5
Left: E = (0.25)(50) = 12.5

The observed and expected frequencies (in parentheses) are

| Toward | Away | Right | Left | Total |
|---|---|---|---|---|
| 18 (12.5) | 12 (12.5) | 13 (12.5) | 7 (12.5) | 50 |

The $\chi^2$ statistic is

$$\chi^2_s = \frac{(18-12.5)^2}{12.5} + \frac{(12-12.5)^2}{12.5} + \frac{(13-12.5)^2}{12.5} + \frac{(7-12.5)^2}{12.5} = 4.88.$$

There are four categories, so we consult Table 9 with df = 4 - 1 = 3. From Table 9, we find $\chi^2_{3,0.20} = 4.64$ and $\chi^2_{3,0.10} = 6.25$. Because $\chi^2_{0.20} < \chi^2_s < \chi^2_{0.10}$, the P-value is bracketed as

$0.10 < P < 0.20$.

At significance level $\alpha = 0.05$, we reject $H_0$ if $P < 0.05$. Since $0.10 < P < 0.20$, we do not reject $H_0$. There is insufficient evidence ($0.10 < P < 0.20$) to conclude that directional choice is not random.

**(b)** The hypotheses are

$H_0$: Directional choice under cloudy skies is random (Pr{toward})
$H_A$: Directional choice under cloudy skies is not random

The expected frequencies, under $H_0$, are

Toward: E = (0.25)(50) = 12.5
Away or along: E = (0.75)(50) = 37.5

The observed and expected frequencies (in parentheses) are



| Toward | Away or along | Total |
|---|---|---|
| 18 (12.5) | 32 (37.5) | 50 |

$\chi^2_s = 3.23$; df = 1. From Table 9, we find $\chi^2_{1,0.10} = 2.71$ and $\chi^2_{1,0.05} = 3.84$. Thus, $0.025 < P < 0.05$ and we reject $H_0$. There is sufficient evidence ($0.025 < P < 0.05$) to conclude that directional choice is not random; the direction toward shore is preferred.

**9.S.15 (a)** Let E denote the event that the "enriched" rat has the larger cortex.

$H_0$: Environment does not affect cortex size (Pr{E} = 0.5)
$H_A$: Enriched environment tends to increase cortex size (Pr{E} > 0.5)

| Enriched rat | | |
|---|---|---|
| Larger | Smaller | Total |
| 10 (6) | 2 (6) | 12 |

$\chi^2_s = 5.33$; df = 1. From Table 9, we find $\chi^2_{1,0.05} = 3.84$ and $\chi^2_{1,0.02} = 5.41$. Thus, $0.01 < P < 0.025$ and we reject $H_0$. There is sufficient evidence ($0.01 < P < 0.025$) to conclude that the enriched environment tends to produce a larger cortex.

**(b)** Yes; the expected frequencies (6 and 6) both exceed 5.

• **9.S.16** The null and alternative hypotheses are

$H_0$: The probability of an egg being on a particular type of bean is 0.25 for all four types of beans
$H_A$: $H_0$ is false (at least one of the probabilities is not 0.25)

Under $H_0$, the expected number of eggs for each type of bean is (0.25)(Total), which is (0.25)(711) = 177.75. The observed and expected frequencies are

| Pinto | Cowpea | Navy | Northern |
|---|---|---|---|
| 167 (177.75) | 176 (177.75) | 174 (177.75) | 194 (177.75) |

The test statistic is

$$\chi^2_s = \frac{(167-177.75)^2}{177.75} + \frac{(176-177.75)^2}{177.75} + \frac{(174-177.75)^2}{177.75} + \frac{(194-177.75)^2}{177.75} = 2.23.$$

There are 4 categories, so df = 4 - 1 = 3. Table 9 gives $\chi^2_{3,0.20} = 4.64$, so $P > 0.20$ and we do not reject $H_0$. There is insufficient evidence ($P > 0.20$) to conclude that cowpea weevils prefer one type of bean over the others.

**9.S.17 (a)** $\chi^2_s = 2.97$

**(b)** We do not reject $H_0$. There is little or no evidence (P=0.23) to conclude that the model is incorrect; the data are consistent with the 1/2, 1/4, 1/4 probabilities model.

**9.S.18** The hypotheses are

$H_0$: The men are guessing (Pr{correct} = 1/3)
$H_A$: The men have some ability to detect their partners (Pr{correct} > 1/3)

| Correct | Wrong |
|---|---|
| 16 (12) | 20 (24) |

$\chi^2_s = 2$. With df = 1, Table 9 gives $\chi^2_{0.20} = 1.64$ and $\chi^2_{0.10} = 2.71$, so $0.05 < P < 0.10$ and we do not reject $H_0$. There is insufficient evidence ($0.05 < P < 0.10$) to conclude that the men have some ability to detect their partners by touching the backs of their hands; the data are consistent with guessing.

**9.S.19** **(a)** There are 58 + 26 = 84 total plants. The expected number of resistant plants is 84*0.75 = 63 and the expected number of susceptible plants is 84*0.25 = 21.

**(b)** We do not reject $H_0$. There is little or no evidence (P=0.21) to conclude that the hypothesized 3:1 ratio is wrong.

**(c)** No. While the results are consistent with the 3:1 ratio, the data do not confirm the null hypothesis, they only fail to refute it.

**9.S.20** $\tilde{p} = (103+2)/(1438+4) = 0.073$; $SE = \sqrt{\frac{0.073(1-0.073)}{1438+4}} = 0.0069$.

The 95% confidence interval is $0.073 \pm (1.96)(0.0069)$ or $(0.059, 0.087)$ or $0.059 < p < 0.087$.

**9.S.21** **(a)** Yes, there is compelling evidence of a difference. The confidence interval excludes 0.10 so a claim that p = 10% would be rejected at the 0.05 significance level.

**(b)** The hypotheses are

$H_0$: Pr{STD} = 0.10
$H_A$: Pr{STD} ≠ 0.10

| STD | No STD |
|---|---|
| 103 (143.8) | 1335 (1294.2) |

$\chi^2_s = 12.86$. With df = 1, Table 9 gives $\chi^2_{0.001} = 10.83$ and $\chi^2_{0.0001} = 15.14$, so $0.0001 < P < 0.001$ and we reject $H_0$. There is strong evidence ($0.0001 < P < 0.001$) to conclude that the probability of contracting an STD is not 10% for counseled individuals.

**(c)** Yes, the two answers agree.