11. **(a)** False. **(b)** True. **(c)** False (the population proportion and the limits 0.12 and 0.28 are all constants, so no probability is involved). **(d)** False.

12. **(a)** The larger number (25.4) must be the standard deviation and the smaller (2.54) must be the standard error of the mean. **(b)** $N = 100$, because $\mathrm{SE}_{\bar{Y}} = s/\sqrt{n}$, and here $2.54 = 25.4/\sqrt{100}$.

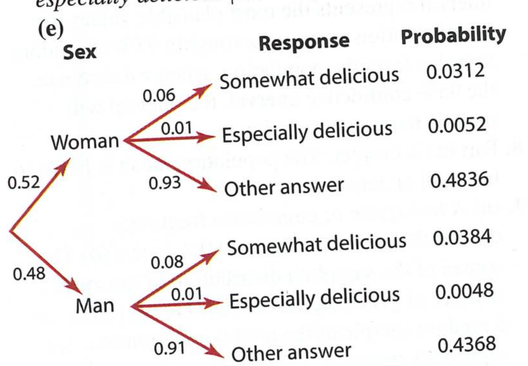
13. The estimates of the mean are consistently too high, meaning that the estimation of mean height was done by a process that caused bias. Perhaps the people were measured with their shoes on, or perhaps the measurement device was poorly calibrated.

14. Increase the sample size.

Chapter 5

1. **(a)** They are mutually exclusive because each respondent can select only one answer. Therefore, two cannot occur. **(b)** Pr[*very repulsive or somewhat repulsive*] = Pr[*very repulsive*] + Pr[*somewhat repulsive*] = 0.30 + 0.20 = 0.50. **(c)** Pr[not *especially delicious*] = 1 − Pr[*especially delicious*] = 1 − 0.01 = 0.99.

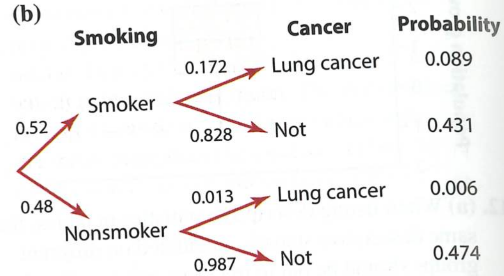
2. **(a)** 0.48. 0.52. (Probability tree is below.) **(b)** Events are mutually exclusive: 0.08 + 0.01 = 0.09. **(c)** Pr[*somewhat delicious* or *especially delicious* | *man*] = 0.09. **(d)** Pr[*somewhat delicious* or *especially delicious* | *woman*] = 0.06 + 0.01 = 0.07.
(e)



(f) Pr[*somewhat delicious* or *especially delicious*] = Pr[*woman*] Pr[*somewhat delicious* or *especially delicious* | *woman*] + Pr[*man*] Pr[*somewhat delicious* or *especially delicious* | *man*] = (0.52)(0.07) + (0.48)(0.09) = 0.0796.

3. **(a)** Pr[*HPV* or *Chlamydia*]. **(b)** Pr[*HPV* or *Chlamydia*] = Pr[*HPV*] + Pr[*Chlamydia*] − Pr[*HPV* and *Chlamydia*]. **(c)** Pr[*HPV*] = 0.24 + 0.04 = 0.28. Pr[*Chlamydia*] = 0.02 + 0.04 = 0.06. Pr[*HPV* or *Chlamydia*] = 0.28 + 0.06 − 0.04 = 0.30.

4. **(a)** Pr[*cancer* | *smoker*] = 0.172.
(b)



(c) Pr[*smoker* and *cancer*] = (0.52)(0.172) = 0.089. **(d)** Pr[*smoker* and *cancer*] = Pr[*smoker*] Pr[*cancer* | *smoker*] = (0.52)(0.172) = 0.089. Yes. **(e)** Pr[*nonsmoker* and *no cancer*] = Pr[*nonsmoker*] Pr[*no cancer* | *nonsmoker*] = (0.48)(0.987) = 0.474.

5. **(a)** Pr[*smoker* | *cancer*] = Pr[*cancer* | *smoker*] Pr[*smoker*] / Pr[*cancer*] **(b)** Pr[*cancer*] = 0.089 + 0.006 = 0.095. **(c)** Pr[*smoker* | *cancer*] = 0.089/0.095 = 0.937.

6. **(a)** 5/8. **(b)** 1/4. **(c)** 7/8 ("either" in this case means pepperoni or anchovies or both). **(d)** No (some slices have both pepperoni and anchovies). **(e)** Yes. Olives and mushrooms are mutually exclusive. **(f)** No. Pr[*mushrooms*] = 3/8; Pr[*anchovies*] = 1/2; if independent, Pr[*mushrooms* and *anchovies*] = Pr[*mushrooms*] × Pr[*anchovies*] = 3/16. Actual probability = 1/8. Not independent. **(g)** Pr[*anchovies* | *olives*] = 1/2 (two slices have olives, and one of these two has anchovies). **(h)** Pr[*olives* | *anchovies*] = 1/4 (four slices have anchovies, and one of these has olives). **(i)** Pr[*last slice has olives*] = 1/4 (two of the eight slices have olives; you still get one slice—it doesn't matter whether your friends pick before you or after you). **(j)** Pr[*two slices with olives*] = Pr[*first slice has olives*] × Pr[*second slice has olives* | *first slice has olives*] = 2/8 × 1/7 = 1/28. **(k)** Pr[*slice without pepperoni*] = 1 − Pr[*slice with pepperoni*] = 3/8. **(l)** Each piece has either one or no topping.

7. Pr[*encounter* and *success*] = Pr[*encounter*] Pr[*capture* | *encounter*] = (0.035)(0.40) = 0.014.

8. Of 273 trees, 45 trees have cavities, so the probability of choosing a tree with a cavity is $45/273 = 0.165$.

9. **(a)** $\Pr[vowel] = \Pr[A] + \Pr[E] + \Pr[I] + \Pr[O] + \Pr[U] = 8.2\% + 12.7\% + 7.0\% + 7.5\% + 2.8\% = 38.2\%$.
(b) $\Pr[$*five randomly chosen letters from an English text spell "STATS"*$] = \Pr[S] \times \Pr[T] \times \Pr[A] \times \Pr[T] \times \Pr[S] = 0.063 \times 0.091 \times 0.082 \times 0.091 \times 0.063 = 2.7 \times 10^{-6}$. (Each draw is independent, but all must be successful to satisfy the conditions, so we must multiply the probability of each independent event.)
(c) $\Pr[$*2 letters from an English text* = "*e*"$] = 0.127 \times 0.127 = 0.016$.

10. **(a)** $\Pr[A_1 \text{ or } A_4] = \Pr[A_1] + \Pr[A_4] = 0.06 + 0.03 = 0.09$. **(b)** $\Pr[A_1 \text{ and } A_1] = \Pr[A_1]\ \Pr[A_1] = 0.06 \times 0.06 = 0.0036$. **(c)** $\Pr[A_1\ A_3] = (0.06)(0.84) + (0.84)(0.06) = 0.1008$. **(d)** $\Pr[\text{not } (A_1 \text{ and } A_1)] = 1 - \Pr[A_1 \text{ and } A_1] = 1 - 0.0036 = 0.9964$. **(e)** $\Pr[$*two individuals not* $A_1\ A_1] = \Pr[\text{not } A_1\ A_1]\ \Pr[\text{not } A_1\ A_1] = (0.9964)\ (0.9964) = 0.9928$. **(f)** $\Pr[$*at least one of two individuals is* $A_1\ A_1] = 1 - \Pr[$*neither is* $A_1\ A_1] = 1 - 0.9928 = 0.0072$. **(g)** $\Pr[$*three individuals have no* A_2 *or* A_3 *alleles*$] = \Pr[$*six alleles are not* A_2 *or* $A_3] = (1 - 0.84 - 0.03)^6 = (0.13)^6 = 0.0000048$.

11. **(a)** $\Pr[$*no dangerous snakes*$] = \Pr[$*not dangerous in the left hand*$] \times \Pr[$*not dangerous in the right hand*$] = 3/8 \times 2/7 = 6/56 = 0.107$.
(b) $\Pr[bite] = \Pr[bite \mid 0\ dangerous\ snakes]\ \Pr[0\ dangerous\ snakes] +$
$\Pr[bite \mid 1\ dangerous\ snake]\ \Pr[1\ dangerous\ snake] +$
$\Pr[bite \mid 2\ dangerous\ snakes]\ \Pr[2\ dangerous\ snakes]$.
$\Pr[0\ dangerous\ snakes] = 0.107$ [from part (a)].
$\Pr[1\ dangerous\ snake] = (5/8 \times 3/7) + (3/8 \times 5/7) = 0.536$.
$\Pr[2\ dangerous\ snakes] = 5/8 \times 4/7 = 0.357$.
$\Pr[bite \mid 0\ dangerous\ snakes] = 0$.
$\Pr[bite \mid 1\ dangerous\ snake] = 0.8$.
$\Pr[bite \mid 2\ dangerous\ snakes] = 1 - (1 - 0.8)^2 = 0.96$.
Putting these all together:
$\Pr[bite] = (0 \times 0.107) + (0.8 \times 0.536) + (0.96 \times 0.357) = 0.772$.

(c) $$\Pr[defanged \mid no\ bite] = \frac{\Pr[no\ bite \mid defanged]\Pr[defanged]}{\Pr[no\ bite]}$$
$\Pr[no\ bite \mid defanged] = 1$; $\Pr[defanged] = 3/8$;
$\Pr[no\ bite] = \Pr[defanged]\ \Pr[no\ bite \mid defanged] + \Pr[dangerous]\Pr[no\ bite \mid dangerous]$
$= (3/8 \times 1) + [5/8 \times (1 - 0.8)] = 0.5$
So, $[defanged \mid one\ snake\ did\ not\ bite] = (1.0 \times 3/8) / (0.5) = 0.75$.

12. **(a)** $\Pr[$*all five researchers calculate 95% CI with the true value*$]$? Each one has a 95% chance, all samples are independent, so $\Pr = (0.95)^5 = 0.774$. **(b)** $\Pr[$*at least one does not include true parameter*$] = 1 - \Pr[$*all include true parameter*$] = 1 - 0.774 = 0.226$.

13. **(a)** 0.99. **(b)** $\Pr[$*cat survives seven days*$] = \Pr[$*cat not poisoned one day*$]^7 = (0.99)^7 = 0.932$.
(c) $\Pr[$*cat survives a year*$] = \Pr[$*cat not poisoned one day*$]^{365} = (0.99)^{365} = 0.026$.
(d) $\Pr[$*cat dies within year*$] = 1 - \Pr[$*cat survives year*$] = 1 - 0.026 = 0.974$.

14. **(a)** Of the 1347 people who did not have HIV, 129 tested positive. Therefore, the false-positive rate is $129/1347 = 0.096$. **(b)** Of the 170 people with HIV, 4 tested negative. The false-negative rate is $4/170 = 0.024$.
(c) Use Bayes' theorem: $\Pr[HIV \mid positive\ test] = \Pr[positive\ test \mid HIV]\ \Pr[HIV]/\Pr[positive\ test] = (166/170)\ (170/1517)/[(129 + 166)/1517] = 0.56$.

15. **(a)** 0.976. **(b)** 0.904.

16. Sampling a *Wnt*-responsive cell has probability 0.09, whereas the probability of a nonresponsive cell is 0.91.
(a) $\Pr[\text{WWLWWW}] = 0.09^5 \times 0.91 = 5.4 \times 10^{-6}$. **(b)** $\Pr[\text{WWWWWL}] = 0.09^5 \times 0.91 = 5.4 \times 10^{-6}$.
(c) $\Pr[\text{LWWWWW}] = 0.09^5 \times 0.91 = 5.4 \times 10^{-6}$. **(d)** $\Pr[\text{WLWLWL}] = 0.09^3 \times 0.91^3 = 5.5 \times 10^{-4}$.
(e) $\Pr[\text{WWWLLL}] = 0.09^3 \times 0.91^3 = 5.5 \times 10^{-4}$. **(f)** $\Pr[\text{WWWWWW}] = 0.09^6 = 5.3 \times 10^{-7}$.
(g) $\Pr[$*at least one nonresponsive cell*$] = 1 - \Pr[\text{WWWWWW}] = 1 - 0.09^6 = 0.9999995$.

ANSWERS

17. **(a)** $\Pr[\textit{next person will wash his/her hands}] = \Pr[\textit{wash} \mid \textit{man}] \times \Pr[\textit{man}] + \Pr[\textit{wash} \mid \textit{woman}] \times \Pr[\textit{woman}] = 0.74 \times 0.4 + 0.83 \times 0.6 = 0.794$.

18. **(a)** $\Pr[\textit{one person not blinking}] = 1 - \Pr[\textit{person blinks}] = 1 - 0.04 = 0.96$.
(b) $\Pr[\textit{at least one blink in 10 people}] = 1 - \Pr[\textit{no one blinks}] = 1 - (0.96)^{10} = 0.335$.

Chapter 6

1. False. The Type 1 error rate is set by the experimenter, and it will be accurate provided the sample is a random sample.

2. **(a)** Failing to reject a false null hypothesis. **(b)** The probability (α) used as a criterion for rejecting the null hypothesis; if the *P*-value is less than or equal to α, then the null hypothesis is rejected, otherwise the null hypothesis is not rejected. **(c)** Setting a higher significance level, α, such as raising it to 0.05 instead of 0.01, decreases the probability of failing to reject a false null hypothesis.

3. **(a)** False. **(b)** False.

4. **(a)** H_0: The rate of correct guesses is $1/6$.
(b) H_A: The rate of correct guesses is not $1/6$.

5. **(a)** Alternative hypothesis. **(b)** Alternative hypothesis. **(c)** Null hypothesis. **(d)** Alternative hypothesis. **(e)** Null hypothesis.

6. **(a)** Lowers the probability of committing a Type I error. **(b)** Increases the probability of committing a Type II error. **(c)** Lowers power of a test.
(d) No effect.

7. **(a)** No effect. **(b)** Decreases the probability of committing a Type II error. **(c)** Increases the power of a test. **(d)** No effect.

8. **(a)** $P = 2 \times (\Pr[15] + \Pr[16] + \Pr[17] + \Pr[18]) = 0.0075$. **(b)** $P = 2 \times (\Pr[13] + \Pr[14] + \cdots + \Pr[18]) = 0.096$. **(c)** $P = 2 \times (\Pr[10] + \Pr[11] + \Pr[12] + \cdots + \Pr[18]) = 0.815$.
(d) $P = 2 \times (\Pr[0] + \Pr[1] + \Pr[2] + \Pr[3] + \cdots + \Pr[7]) = 0.481$.

9. Failing to reject H_0 does not mean H_0 is correct, because the power of the test might be limited. The null hypothesis is the default and is either rejected or not rejected.

10. Begin by stating the hypotheses. H_0: Size on islands does not differ in a consistent direction from size on mainlands in Asian large mammals (i.e., $p = 0.5$); H_A: Size on islands differs in a consistent direction from size on mainlands in Asian large mammals (i.e., $p \neq 0.5$), where *p* is the true fraction of large mammal species that are smaller on islands than on the mainland. Note that this is a two-tailed test. The test statistic is the observed number of mammal species for which size is smaller on islands than mainlands: 16. The *P*-value is the probability of a result as unusual as 16 out of 18 when H_0 is true: $P = 2 \times (\Pr[16] + \Pr[17] + \Pr[18]) = 0.00135$. Since $P < 0.05$, reject H_0. Conclude that size on islands is usually smaller than on mainlands in Asian large mammals.

11. **(a)** Not correct. The *P*-value does not give the size of the effect. **(b)** Correct. H_0 was rejected, so we conclude that there is indeed an effect.
(c) Not correct. The probability of committing a Type I error is set by the significance level, 0.05, which is decided beforehand. **(d)** Not correct. The probability of committing a Type II error depended on the effect size, which wasn't known. **(e)** Correct.

12. Their test almost certainly failed to reject H_0, because the 95% confidence interval includes the value of the parameter stated in the null hypothesis (i.e., 1).

13. **(a)** H_0: Subjects pick the mother correctly one time in two ($p = 1/2$); H_A: Subjects pick the mother correctly more than one time in two ($p > 1/2$).
(b) One-sided, because the alternative hypothesis considers parameter values on one side of the parameter value stated in the null hypothesis. This seems justified here because it is not feasible that sons would resemble their mothers less than randomly chosen women. **(d)** $P = 0.1214 + 0.1669 + \cdots + 0.000004 = 0.881$ (it is quicker to calculate as $1 - [0.000004 + 0.00007 + \cdots + 0.0708] = 0.881$).
(e) Since $P > 0.05$, do not reject the null hypothesis.
(f) Calculate a 95% confidence interval for *p*.

14. Statement (a) is correct. If the estimate that the test is based on is biased, the estimate will on average be different from the true value. As a result, the probability of rejecting the (true) null hypothesis is increased, and therefore the Type I error rate is increased.

15. **(a)** 0.25. **(b)** 0.2. **(c)** 0.69. **(d)** 0.8.