

17. **Egg Incubation Times** The mean incubation time of fertilized chicken eggs kept at 100.5°F in a still-air incubator is 21 days. Suppose that the incubation times are approximately normally distributed with a standard deviation of 1 day.

Source: University of Illinois Extension

- (a) What is the probability that a randomly selected fertilized chicken egg hatches in less than 20 days?
 - (b) What is the probability that a randomly selected fertilized chicken egg takes over 22 days to hatch?
 - (c) What is the probability that a randomly selected fertilized chicken egg hatches between 19 and 21 days?
 - (d) Would it be unusual for an egg to hatch in less than 18 days? Why?
18. **Reading Rates** The reading speed of sixth-grade students is approximately normal, with a mean speed of 125 words per minute and a standard deviation of 24 words per minute.
- (a) What is the probability that a randomly selected sixth-grade student reads less than 100 words per minute?
 - (b) What is the probability that a randomly selected sixth-grade student reads more than 140 words per minute?
 - (c) What is the probability that a randomly selected sixth-grade student reads between 110 and 130 words per minute?
 - (d) Would it be unusual for a sixth-grader to read more than 200 words per minute? Why?

19. Chips Ahoy! Cookies The number of chocolate chips in an **NW** 18-ounce bag of Chips Ahoy! chocolate chip cookies is approximately normally distributed with a mean of 1,262 chips and standard deviation 118 chips according to a study by cadets of the U.S. Air Force Academy.

Source: Brad Warner and Jim Rutledge, *Chance* 12(1): 10–14, 1999

- (a) What is the probability that a randomly selected 18-ounce bag of Chips Ahoy! contains between 1,000 and 1,400 chocolate chips, inclusive?
- (b) What is the probability that a randomly selected 18-ounce bag of Chips Ahoy! contains fewer than 1,000 chocolate chips?
- (c) What proportion of 18-ounce bags of Chips Ahoy! contains more than 1,200 chocolate chips?
- (d) What proportion of 18-ounce bags of Chips Ahoy! contains fewer than 1,125 chocolate chips?
- (e) What is the percentile rank of an 18-ounce bag of Chips Ahoy! that contains 1,475 chocolate chips?
- (f) What is the percentile rank of an 18-ounce bag of Chips Ahoy! that contains 1,050 chocolate chips?

20. Wendy's Drive-Through Fast-food restaurants spend quite a bit of time studying the amount of time cars spend in their drive-throughs. Certainly, the faster the cars get through the drive-through, the more the opportunity for making money. In 2007, *QSR Magazine* studied drive-through times for fast-food restaurants and Wendy's had the best time, with a mean time spent in the drive-through of 138.5 seconds. Assuming drive-through times are normally distributed with a standard deviation of 29 seconds, answer the following.

- (a) What is the probability that a randomly selected car will get through Wendy's drive-through in less than 100 seconds?
- (b) What is the probability that a randomly selected car will spend more than 160 seconds in Wendy's drive-through?
- (c) What proportion of cars spend between 2 and 3 minutes in Wendy's drive-through?
- (d) Would it be unusual for a car to spend more than 3 minutes in Wendy's drive-through? Why?

21. Gestation Period The lengths of human pregnancies are approximately normally distributed, with mean $\mu = 266$ days and standard deviation $\sigma = 16$ days.

- (a) What proportion of pregnancies lasts more than 270 days?
- (b) What proportion of pregnancies lasts less than 250 days?
- (c) What proportion of pregnancies lasts between 240 and 280 days?
- (d) What is the probability that a randomly selected pregnancy lasts more than 280 days?
- (e) What is the probability that a randomly selected pregnancy lasts no more than 245 days?
- (f) A “very preterm” baby is one whose gestation period is less than 224 days. Are very preterm babies unusual?

23. Manufacturing Steel rods are manufactured with a mean length of 25 centimeter (cm). Because of variability in the manufacturing process, the lengths of the rods are approximately normally distributed, with a standard deviation of 0.07 cm.

- (a) What proportion of rods has a length less than 24.9 cm?
- (b) Any rods that are shorter than 24.85 cm or longer than 25.15 cm are discarded. What proportion of rods will be discarded?
- (c) Using the results of part (b), if 5,000 rods are manufactured in a day, how many should the plant manager expect to discard?
- (d) If an order comes in for 10,000 steel rods, how many rods should the plant manager manufacture if the order states that all rods must be between 24.9 cm and 25.1 cm?

24. Manufacturing Ball bearings are manufactured with a mean diameter of 5 millimeters (mm). Because of variability in the manufacturing process, the diameters of the ball bearings are approximately normally distributed, with a standard deviation of 0.02 mm.

- (a) What proportion of ball bearings has a diameter more than 5.03 mm?
- (b) Any ball bearings that have a diameter less than 4.95 mm or greater than 5.05 mm are discarded. What proportion of ball bearings will be discarded?
- (c) Using the results of part (b), if 30,000 ball bearings are manufactured in a day, how many should the plant manager expect to discard?
- (d) If an order comes in for 50,000 ball bearings, how many bearings should the plant manager manufacture if the order states that all ball bearings must be between 4.97 mm and 5.03 mm?

- 27. Chips Ahoy! Cookies** The number of chocolate chips in an 18-ounce bag of Chips Ahoy! chocolate chip cookies is approximately normally distributed, with a mean of 1,262 chips and a standard deviation of 118 chips, according to a study by cadets of the U.S. Air Force Academy.

Source: Brad Warner and Jim Rutledge, *Chance* 12(1): 10–14, 1999

- (a) Determine the 30th percentile for the number of chocolate chips in an 18-ounce bag of Chips Ahoy! cookies.
- (b) Determine the number of chocolate chips in a bag of Chips Ahoy! that make up the middle 99% of bags.

- 28. Wendy's Drive-Through** Fast-food restaurants spend quite a bit of time studying the amount of time cars spend in their drive-through. Certainly, the faster the cars get through the drive-through, the more the opportunity for making money. In 2007, *QSR Magazine* studied drive-through times for fast-food restaurants, and Wendy's had the best time, with a mean time a car spent in the drive-through equal to 138.5 seconds. Assume that drive-through times are normally distributed, with a standard deviation of 29 seconds. Suppose that Wendy's wants to institute a policy at its restaurants that it will not charge any patron that must wait more than a certain amount of time for an order. Management does not want to give away free meals to more than 1% of the patrons. What time would you recommend Wendy's advertise as the maximum wait time before a free meal is awarded?

- 29. Speedy Lube** The time required for Speedy Lube to complete an oil change service on an automobile approximately follows a normal distribution, with a mean of 17 minutes and a standard deviation of 2.5 minutes.
- (a) Speedy Lube guarantees customers that the service will take no longer than 20 minutes. If it does take longer, the customer will receive the service for half-price. What percent of customers receive the service for half price?
 - (b) If Speedy Lube does not want to give the discount to more than 3% of its customers, how long should it make the guaranteed time limit?

Central Limit Theorem:

21. Gestation Period The length of human pregnancies is approximately normally distributed with mean $\mu = 266$ days and standard deviation $\sigma = 16$ days.

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- (a) What is the probability a randomly selected pregnancy lasts less than 260 days?
- (b) Suppose a random sample of 20 pregnancies is obtained. Describe the sampling distribution of the sample mean length of human pregnancies.
- (c) What is the probability that a random sample of 20 pregnancies has a mean gestation period of 260 days or less?
- (d) What is the probability that a random sample of 50 pregnancies has a mean gestation period of 260 days or less?
- (e) What might you conclude if a random sample of 50 pregnancies resulted in a mean gestation period of 260 days or less?
- (f) What is the probability a random sample of size 15 will have a mean gestation period within 10 days of the mean?

22. Upper Leg Length The upper leg length of 20- to 29-year-old males is normally distributed with a mean length of 43.7 cm and a standard deviation of 4.2 cm.

Source: "Anthropometric Reference Data for Children and Adults: U.S. Population, 1999–2002; Volume 361, July 7, 2005.

- (a) What is the probability that a randomly selected 20- to 29-year-old male has an upper leg length that is less than 40 cm?
- (b) A random sample of 9 males who are 20 to 29 years old is obtained. What is the probability that the mean upper leg length is less than 40 cm?
- (c) What is the probability that a random sample of 12 males who are 20 to 29 years old results in a mean upper leg length that is less than 40 cm?
- (d) What effect does increasing the sample size have on the probability? Provide an explanation for this result.
- (e) A random sample of 15 males who are 20 to 29 years old results in a mean upper leg length of 46 cm. Do you find this result unusual? Why?

23. Reading Rates The reading speed of second grade students is approximately normal, with a mean of 90 words per minute (wpm) and a standard deviation of 10 wpm.

- (a) What is the probability a randomly selected student will read more than 95 words per minute?
- (b) What is the probability that a random sample of 12 second grade students results in a mean reading rate of more than 95 words per minute?
- (c) What is the probability that a random sample of 24 second grade students results in a mean reading rate of more than 95 words per minute?
- (d) What effect does increasing the sample size have on the probability? Provide an explanation for this result.
- (e) A teacher instituted a new reading program at school. After 10 weeks in the program, it was found that the mean reading speed of a random sample of 20 second grade students was 92.8 wpm. What might you conclude based on this result?

24. Old Faithful The most famous geyser in the world, Old Faithful in Yellowstone National Park, has a mean time between eruptions of 85 minutes. If the interval of time between eruptions is normally distributed with standard deviation 21.25 minutes, answer the following questions:

Source: www.unmuseum.org

- (a) What is the probability that a randomly selected time interval between eruptions is longer than 95 minutes?
- (b) What is the probability that a random sample of 20 time intervals between eruptions has a mean longer than 95 minutes?
- (c) What is the probability that a random sample of 30 time intervals between eruptions has a mean longer than 95 minutes?
- (d) What effect does increasing the sample size have on the probability? Provide an explanation for this result.
- (e) What might you conclude if a random sample of 30 time intervals between eruptions has a mean longer than 95 minutes?

25. Rates of Return in Stocks The S&P 500 is a collection of 500 stocks of publicly traded companies. Using data obtained from Yahoo!Finance, the monthly rates of return of the S&P 500 since 1950 are normally distributed. The mean rate of return is 0.007233 (0.7233%), and the standard deviation for rate of return is 0.04135 (4.135%).

- (a) What is the probability that a randomly selected month has a positive rate of return? That is, what is $P(x > 0)$?
- (b) Treating the next 12 months as a simple random sample, what is the probability that the mean monthly rate of return will be positive? That is, with $n = 12$, what is $P(\bar{x} > 0)$?
- (c) Treating the next 24 months as a simple random sample, what is the probability that the mean monthly rate of return will be positive?
- (d) Treating the next 36 months as a simple random sample, what is the probability that the mean monthly rate of return will be positive?
- (e) Use the results of parts (b)–(d) to describe the likelihood of earning a positive rate of return on stocks as the investment time horizon increases.

29. Insect Fragments The Food and Drug Administration sets Food Defect Action Levels (FDALs) for some of the various foreign substances that inevitably end up in the food we eat and liquids we drink. For example, the FDAL for insect filth in peanut butter is 3 insect fragments (larvae, eggs, body parts, and so on) per 10 grams. A random sample of 50 ten-gram portions of peanut butter is obtained and results in a sample mean of $\bar{x} = 3.6$ insect fragments per ten-gram portion.

- (a) Why is the sampling distribution of \bar{x} approximately normal?
- (b) What is the mean and standard deviation of the sampling distribution of \bar{x} assuming that $\mu = 3$ and $\sigma = \sqrt{3}$.
- (c) What is the probability that a simple random sample of 50 ten-gram portions results in a mean of at least 3.6 insect fragments? Is this result unusual? What might we conclude?

31. Watching Television The amount of time Americans spend watching television is closely monitored by firms such as A. C. Nielsen because this helps to determine advertising pricing for commercials.

- (a) Do you think the variable “weekly time spent watching television” would be normally distributed? If not, what shape would you expect the variable to have?
- (b) According to the American Time Use Survey, adult Americans spend 2.35 hours per day watching television on a weekday. Assume that the standard deviation for “time spent watching television on a weekday” is 1.93 hours. If a random sample of 40 adult Americans is obtained, describe the sampling distribution of \bar{x} , the mean amount of time spent watching television on a weekday.
- (c) Determine the probability that a random sample of 40 adult Americans results in a mean time watching television on a weekday of between 2 and 3 hours.
- (d) One consequence of the popularity of the Internet is that it is thought to reduce television watching. Suppose that a random sample of 35 individuals who consider themselves to be avid Internet users results in a mean time of 1.89 hours watching television on a weekday. Determine the likelihood of obtaining a sample mean of 1.89 hours or less from a population whose mean is presumed to be 2.35 hours. Based on the result obtained, do you think avid Internet users watch less television?

32. ATM Withdrawals According to ATMDepot.com, the mean ATM withdrawal is \$60. Assume that the standard deviation for withdrawals is \$35.

- (a) Do you think the variable “ATM withdrawal” is normally distributed? If not, what shape would you expect the variable to have?
- (b) If a random sample of 50 ATM withdrawals is obtained, describe the sampling distribution of \bar{x} , the mean withdrawal amount.
- (c) Determine the probability of obtaining a sample mean withdrawal amount between \$70 and \$75.

Normal Approximation for the Binomial Distribution

21. On-Time Flights According to American Airlines, Flight **NW** 215 from Orlando to Los Angeles is on time 90% of the time.

Randomly select 150 flights and use the normal approximation to the binomial to

- (a) approximate the probability that exactly 130 flights are on time.
- (b) approximate the probability that at least 130 flights are on time.
- (c) approximate the probability that fewer than 125 flights are on time.
- (d) approximate the probability that between 125 and 135 flights, inclusive, are on time.

22. Smokers According to *Information Please Almanac*, 80% of adult smokers started smoking before they were 18 years old. Suppose 100 smokers 18 years old or older, are randomly selected. Use the normal approximation to the binomial to

- (a) approximate the probability that exactly 80 of them started smoking before they were 18 years old.
- (b) approximate the probability that at least 80 of them started smoking before they were 18 years old.
- (c) approximate the probability that fewer than 70 of them started smoking before they were 18 years old.
- (d) approximate the probability that between 70 and 90 of them, inclusive, started smoking before they were 18 years old.

- 23. Migraine Sufferers** In clinical trials of a medication whose purpose is to reduce the pain associated with migraine headaches, 2% of the patients in the study experienced weight gain as a side effect. A random sample of 600 users of this medication is obtained. Use the normal approximation to the binomial to
- (a) approximate the probability that exactly 20 will experience weight gain as a side effect.
 - (b) approximate the probability that 20 or fewer will experience weight gain as a side effect.
 - (c) approximate the probability that 22 or more patients will experience weight gain as a side effect.
 - (d) approximate the probability that between 20 and 30 patients, inclusive, will experience weight gain as a side effect.
- 24. Murder by Firearms** According to the *Uniform Crime Report, 2005*, 67.8% of murders are committed with a firearm. Suppose that 50 murders are randomly selected. Use the normal approximation to the binomial to
- (a) approximate the probability that exactly 40 murders are committed using a firearm.
 - (b) approximate the probability that at least 35 murders are committed using a firearm.
 - (c) approximate the probability that fewer than 25 murders are committed using a firearm.
 - (d) approximate the probability that between 30 and 35 murders, inclusive, are committed using a firearm.
- 25. Males Living at Home** According to the *Current Population Survey* (Internet release date: September 15, 2004), 55% of males between the ages of 18 and 24 years lived at home in

2003. (Unmarried college students living in a dorm are counted as living at home.) A survey is administered at a community college to 200 randomly selected male students between the ages of 18 and 24 years, and 130 of them respond that they live at home.

- (a) Approximate the probability that such a survey will result in at least 130 of the respondents living at home under the assumption that the true percentage is 55%.
- (b) Does the result from part (a) contradict the results of the *Current Population Survey*? Explain.

26. Females Living at Home According to the *Current Population Survey* (Internet release date: September 15, 2004), 46% of females between the ages of 18 and 24 years lived at home in 2003. (Unmarried college students living in a dorm are counted as living at home.) A survey is administered at a community college to 200 randomly selected female students between the ages of 18 and 24 years, and 110 of them respond that they live at home.

- (a) Approximate the probability that such a survey will result in at least 110 of the respondents living at home under the assumption that the true percentage is 46%.

- (b) Does the result from part (a) contradict the results of the *Current Population Survey*? Explain.

27. Boys Are Preferred In a Gallup poll conducted June 11–14, 2007, 37% of survey respondents said that, if they only had one child, they would prefer the child to be a boy. You conduct a survey of 150 randomly selected students on your campus and find that 80 of them would prefer a boy.

- (a) Approximate the probability that, in a random sample of 150 students, at least 75 would prefer a boy, assuming the true percentage is 37%.
- (b) Does this result contradict the Gallup poll? Explain.

28. Liars According to a *USA Today* “Snapshot,” 3% of Americans surveyed lie frequently. You conduct a survey of 500 college students and find that 20 of them lie frequently.

- (a) Compute the probability that, in a random sample of 500 college students, at least 20 lie frequently, assuming the true percentage is 3%.
- (b) Does this result contradict the *USA Today* “Snapshot”? Explain.