Section 3.1 Exercises

1. **Coral reefs** How sensitive to changes in water temperature are coral reefs? To find out, measure the growth of corals in aquariums where the water temperature is controlled at different levels. Growth is measured by weighing the coral before and after the experiment. What are the explanatory and response variables? Are they categorical or quantitative?

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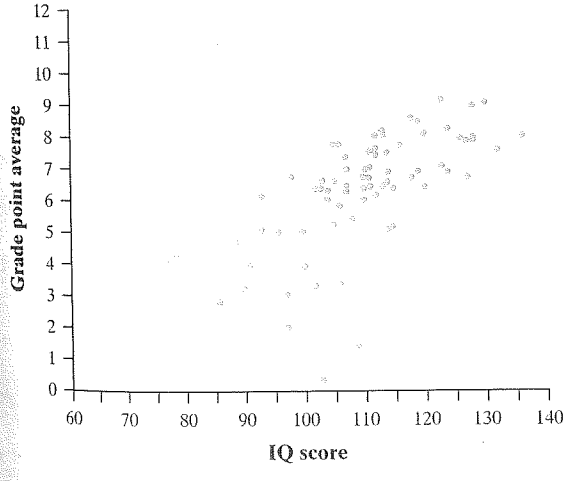
2. **Treating breast cancer** Early on, the most common treatment for breast cancer was removal of the breast. It is now usual to remove only the tumor and nearby lymph nodes, followed by radiation. The change in policy was due to a large medical experiment that compared the two treatments. Some breast cancer patients, chosen at random, were given one or the other treatment. The patients were closely followed to see how long they lived following surgery. What are the explanatory and response variables? Are they categorical or quantitative?

3. **IQ and grades** Do students with higher IQ test scores tend to do better in school? The figure below shows a scatterplot of IQ and school grade point average (GPA) for all 78 seventh-grade students in a rural midwestern school. (GPA was recorded on a 12-point scale with A+ = 12, A = 11, A− = 10, B+ = 9, . . . , D− = 1, and F = 0.)[5]

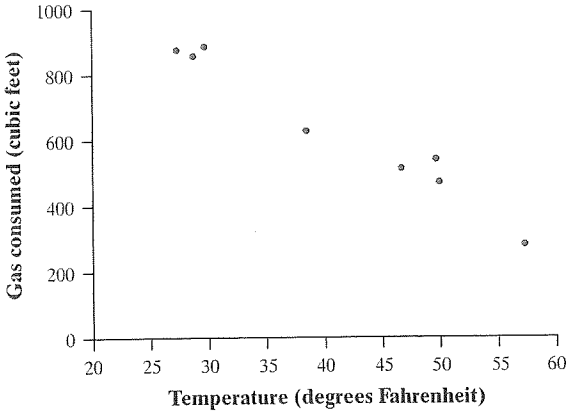


(a) Does the plot show a positive or negative association between the variables? Why does this make sense?

(b) What is the form of the relationship? Is it very strong? Explain your answers.

(c) At the bottom of the plot are several points that we might call outliers. One student in particular has a very low GPA despite an average IQ score. What are the approximate IQ and GPA for this student?

4. **How much gas?** Joan is concerned about the amount of energy she uses to heat her home. The graph below plots the mean number of cubic feet of gas per day that Joan used each month against the average temperature that month (in degrees Fahrenheit) for one heating season.



(a) Does the plot show a positive or negative association between the variables? Why does this make sense?

(b) What is the form of the relationship? Is it very strong? Explain your answers.

(c) Explain what the point at the bottom right of the plot represents.

5. **Heavy backpacks** Ninth-grade students at the Webb Schools go on a backpacking trip each fall. Students are divided into hiking groups of size 8 by selecting names from a hat. Before leaving, students and their backpacks are weighed. The data here are from one hiking group in a recent year. Make a scatterplot by hand that shows how backpack weight relates to body weight.

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Body weight (lb):	120	187	109	103	131	165	158	116
Backpack weight (lb):	26	30	26	24	29	35	31	28

6. **Bird colonies** One of nature's patterns connects the percent of adult birds in a colony that return from the previous year and the number of new adults that join the colony. Here are data for 13 colonies of sparrowhawks:[6]

Percent return:	74	66	81	52	73	62	52	45	62	46	60	46	38
New adults:	5	6	8	11	12	15	16	17	18	18	19	20	20

Make a scatterplot by hand that shows how the number of new adults relates to the percent of returning birds.

pg 147 7. **Heavy backpacks** Refer to your graph from Exercise 5.

(a) Describe the relationship between body weight and backpack weight for this group of hikers.

(b) One of the hikers is a possible outlier. Identify the body weight and backpack weight for this hiker. How does this hiker affect the form of the association?

8. **Bird colonies** Refer to your graph from Exercise 6.

(a) Describe the relationship between number of new sparrowhawks in a colony and percent of returning adults.

(b) For short-lived birds, the association between these variables is positive: changes in weather and food supply drive the populations of new and returning birds up or down together. For long-lived territorial birds, on the other hand, the association is negative because returning birds claim their territories in the colony and don't leave room for new recruits. Which type of species is the sparrowhawk? Explain.

9. **Does fast driving waste fuel?** How does the fuel consumption of a car change as its speed increases? Here are data for a British Ford Escort. Speed is measured in kilometers per hour, and fuel consumption is measured in liters of gasoline used per 100 kilometers traveled.[7]

Speed (km/h)	Fuel used (liters/100 km)	Speed (km/h)	Fuel used (liters/100 km)
10	21.00	90	7.57
20	13.00	100	8.27
30	10.00	110	9.03
40	8.00	120	9.87
50	7.00	130	10.79
60	5.90	140	11.77
70	6.30	150	12.83
80	6.95		

(a) Use your calculator to help sketch a scatterplot.

(b) Describe the form of the relationship. Why is it not linear? Explain why the form of the relationship makes sense.

(c) It does not make sense to describe the variables as either positively associated or negatively associated. Why?

(d) Is the relationship reasonably strong or quite weak? Explain your answer.

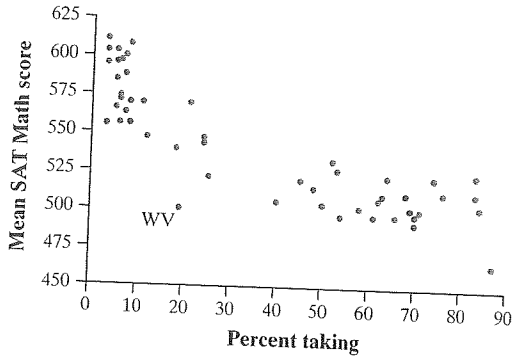
10. **Do heavier people burn more energy?** Metabolic rate, the rate at which the body consumes energy, is important in studies of weight gain, dieting, and exercise. We have data on the lean body mass and resting metabolic rate for 12 women who are subjects in a study of dieting. Lean body mass, given in kilograms, is a person's weight leaving out all fat. Metabolic rate is measured in calories burned per 24 hours. The researchers believe that lean body mass is an important influence on metabolic rate.

Mass:	36.1	54.6	48.5	42.0	50.6	42.0	40.3	33.1	42.4	34.5	51.1	4
Rate:	995	1425	1396	1418	1502	1256	1189	913	1124	1052	1347	12

(a) Use your calculator to help sketch a scatterplot to examine the researchers' belief.

(b) Describe the direction, form, and strength of the relationship.

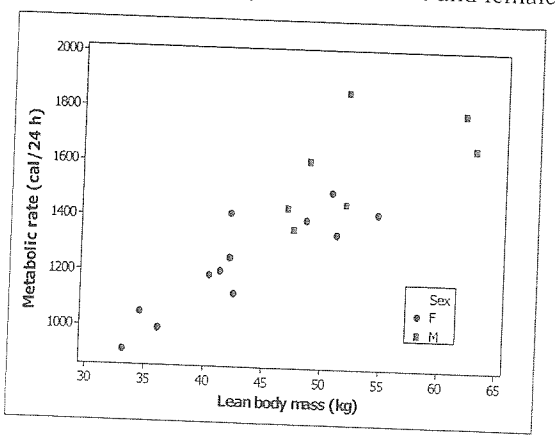
11. **Southern education** For a long time, the South has lagged behind the rest of the United States in the performance of its schools. Efforts to improve education have reduced the gap. We wonder if the South stands out in our study of state average SAT Math scores. The figure below enhances the scatterplot in Figure 3.2 (page 145) by plotting 12 southern states in red.



(a) What does the graph suggest about the southern states?

(b) The point for West Virginia is labeled in the graph. Explain how this state is an outlier.

12. **Do heavier people burn more energy?** The study of dieting described in Exercise 10 collected data on the lean body mass (in kilograms) and metabolic rate (in calories) for 12 female and 7 male subjects. The figure below is a scatterplot of the data for all 19 subjects, with separate symbols for males and females.



Does the same overall pattern hold for both women and men? What difference between the sexes do you see from the graph?

pg 148 13. **Merlins breeding** The percent of an animal species in the wild that survives to breed again is often lower following a successful breeding season. A study of

merlins (small falcons) in northern Sweden observed the number of breeding pairs in an isolated area and the percent of males (banded for identification) that returned the next breeding season. Here are data for seven years:[8]

Breeding pairs:	28	29	29	29	30	32	33
Percent return:	82	83	70	61	69	58	43

Make a scatterplot to display the relationship between breeding pairs and percent return. Describe what you see.

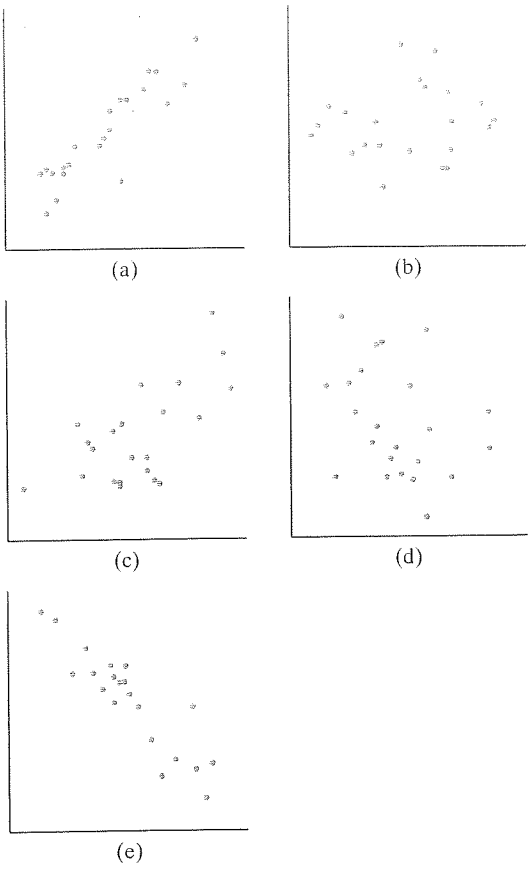
14. **Does social rejection hurt?** We often describe our emotional reaction to social rejection as "pain." Does social rejection cause activity in areas of the brain that are known to be activated by physical pain? If it does, we really do experience social and physical pain in similar ways. Psychologists first included and then deliberately excluded individuals from a social activity while they measured changes in brain activity. After each activity, the subjects filled out questionnaires that assessed how excluded they felt. The table below shows data for 13 subjects.[9] "Social distress" is measured by each subject's questionnaire score after exclusion relative to the score after inclusion. (So values greater than 1 show the degree of distress caused by exclusion.) "Brain activity" is the change in activity in a region of the brain that is activated by physical pain. (So positive values show more pain.)

Subject	Social distress	Brain activity
1	1.26	−0.055
2	1.85	−0.040
3	1.10	−0.026
4	2.50	−0.017
5	2.17	−0.017
6	2.67	0.017
7	2.01	0.021
8	2.18	0.025
9	2.58	0.027
10	2.75	0.033
11	2.75	0.064
12	3.33	0.077
13	3.65	0.124

Make a scatterplot to display the relationship between social distress and brain activity. Describe what you see.

15. **Matching correlations** Match each of the following scatterplots to the r below that best describes it. (Some r's will be left over.)

$r = -0.9$ $r = -0.7$ $r = -0.3$ $r = 0$
$r = 0.3$ $r = 0.7$ $r = 0.9$



16. **Rank the correlations** Consider each of the following relationships: the heights of fathers and the heights of their adult sons, the heights of husbands and the heights of their wives, and the heights of women at age 4 and their heights at age 18. Rank the correlations between these pairs of variables from largest to smallest. Explain your reasoning.

17. **Correlation blunders** Each of the following statements contains an error. Explain what's wrong in each case.

(a) "There is a high correlation between the gender of American workers and their income."

(b) "We found a high correlation ($r = 1.09$) between students' ratings of faculty teaching and ratings made by other faculty members."

(c) "The correlation between planting rate and yield of corn was found to be $r = 0.23$ bushel."

18. **Teaching and research** A college newspaper interviews a psychologist about student ratings of the teaching of faculty members. The psychologist says, "The evidence indicates that the correlation between the research productivity and teaching rating of faculty members is close to zero." The paper reports this as "Professor McDaniel said that good researchers tend to be poor teachers, and vice versa." Explain why the paper's report is wrong. Write a statement in plain language (don't use the word "correlation") to explain the psychologist's meaning.

19. **Dem bones** Archaeopteryx is an extinct beast having feathers like a bird but teeth and a long bony tail like a reptile. Only six fossil specimens are known. Because these specimens differ greatly in size, some scientists think they are different species rather than individuals from the same species. We will examine some data. If the specimens belong to the same species and differ in size because some are younger than others, there should be a positive linear relationship between the lengths of a pair of bones from all individuals. An outlier from this relationship would suggest a different species. Here are data on the lengths in centimeters of the femur (a leg bone) and the humerus (a bone in the upper arm) for the five specimens that preserve both bones:[10]

Femur (x):	38	56	59	64	74
Humerus (y):	41	63	70	72	84

(a) Make a scatterplot. Do you think that all five specimens come from the same species? Explain.

(b) Find the correlation r step by step, using the formula on page 154. Explain how your value for r matches your graph in part (a).

20. **Data on dating** A student wonders if tall women tend to date taller men than do short women. She measures herself, her dormitory roommate, and the women in the adjoining rooms. Then she measures the next man each woman dates. Here are the data (heights in inches):

Women (x):	66	64	66	65	70	65
Men (y):	72	68	70	68	71	65

(a) Make a scatterplot of these data. Based on the scatterplot, do you expect the correlation to be positive or negative? Near ± 1 or not?

(b) Find the correlation r step by step, using the formula on page 154. Do the data show that taller women tend to date taller men?

21. **Hot dogs** Are hot dogs that are high in calories also high in salt? The figure below is a scatterplot of the calories and salt content (measured as milligrams of sodium) in 17 brands of meat hot dogs.[11]

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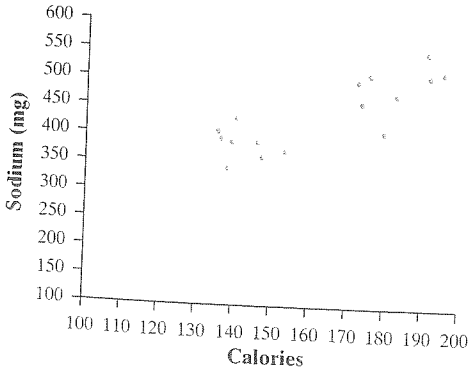


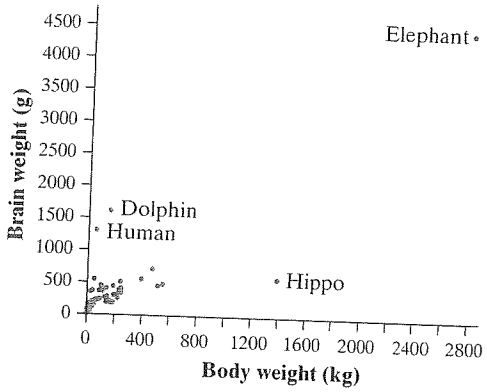
(a) The correlation for these data is $r = 0.87$. Explain what this value means.

(b) What effect does the hot dog brand with the lowest calorie content have on the correlation? Justify your answer.

22. **All brawn?** The figure below plots the average brain weight in grams versus average body weight in kilograms for 96 species of mammals.[12] There are many small mammals whose points overlap at the lower left.

(a) The correlation between body weight and brain weight is $r = 0.86$. Explain what this value means.

(b) What effect does the elephant have on the correlation? Justify your answer.



23. **Dem bones** Refer to Exercise 19.

(a) How would r change if the bones had been measured in millimeters instead of centimeters? (There are 10 millimeters in a centimeter.)

(b) If the x and y variables are reversed, how would the correlation change? Explain.

24. **Data on dating** Refer to Exercise 20.

(a) How would r change if all the men were 6 inches shorter than the heights given in the table? Does the correlation tell us if women tend to date men taller than themselves?

(b) If heights were measured in centimeters rather than inches, how would the correlation change? (There are 2.54 centimeters in an inch.)

25. **Strong association but no correlation** The gas mileage of an automobile first increases and then decreases as the speed increases. Suppose that this relationship is very regular, as shown by the following data on speed (miles per hour) and mileage (miles per gallon).

Speed:	20	30	40	50	60
Mileage:	24	28	30	28	24

(a) Make a scatterplot to show the relationship between speed and mileage.

(b) Calculate the correlation for these data by hand or using technology.

(c) Explain why the correlation has the value found in part (b) even though there is a strong relationship between speed and mileage.

26. What affects correlation? Here are some hypothetical data:

x:	1	2	3	4	10	10
y:	1	3	3	5	1	11

(a) Make a scatterplot to show the relationship between x and y.

(b) Calculate the correlation for these data by hand or using technology.

(c) What is responsible for reducing the correlation to the value in part (b) despite a strong straight-line relationship between x and y in most of the observations?

Multiple choice: Select the best answer for Exercises 27 to 32.

27. You have data for many years on the average price of a barrel of oil and the average retail price of a gallon of unleaded regular gasoline. If you want to see how well the price of oil predicts the price of gas, then you should make a scatterplot with _____ as the explanatory variable.

(a) the price of oil (c) the year (e) time

(b) the price of gas (d) either oil price or gas price

28. In a scatterplot of the average price of a barrel of oil and the average retail price of a gallon of gas, you expect to see

(a) very little association.

(b) a weak negative association.

(c) a strong negative association.

(d) a weak positive association.

(e) a strong positive association.

29. The following graph plots the gas mileage (miles per gallon) of various cars from the same model year versus the weight of these cars in thousands of pounds. The points marked with red dots correspond to cars made in Japan. From this plot, we may conclude that

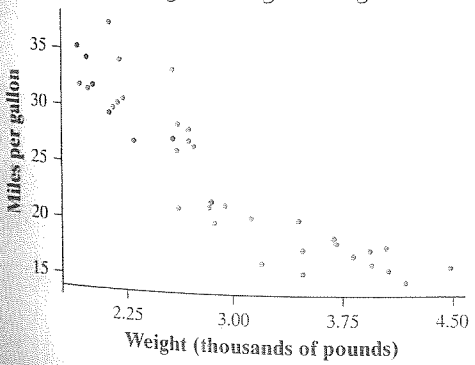
(a) there is a positive association between weight and gas mileage for Japanese cars.

(b) the correlation between weight and gas mileage for all the cars is close to 1.

(c) there is little difference between Japanese cars and cars made in other countries.

(d) Japanese cars tend to be lighter in weight than other cars.

(e) Japanese cars tend to get worse gas mileage than other cars.



30. If women always married men who were 2 years older than themselves, what would the correlation between the ages of husband and wife be?

(a) 2

(b) 1

(c) 0.5

(d) 0

(e) Can't tell without seeing the data

31. The figure below is a scatterplot of reading test scores against IQ test scores for 14 fifth-grade children. There is one low outlier in the plot. What effect does this low outlier have on the correlation?

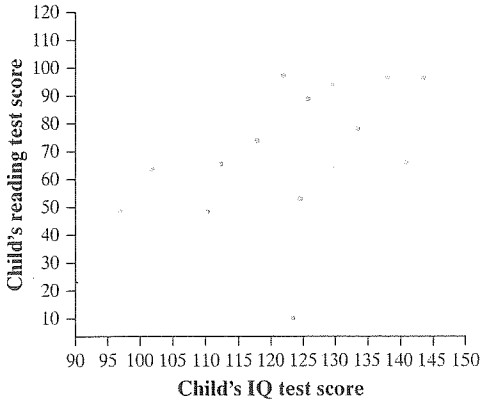
(a) It makes the correlation closer to 1.

(b) It makes the correlation closer to 0 but still positive.

(c) It makes the correlation equal to 0.

(d) It makes the correlation negative.

(e) It has no effect on the correlation.



32. If we leave out the low outlier, the correlation for the remaining 13 points in the preceding figure is closest to

(a) −0.95. (c) 0. (e) 0.95.

(b) −0.5. (d) 0.5.

33. **Big diamonds** (1.2, 1.3) Here are the weights (in milligrams) of 58 diamonds from a nodule carried up to the earth's surface in surrounding rock. These data represent a population of diamonds formed in a single event deep in the earth.[13]

13.8	3.7	33.8	11.8	27.0	18.9	19.3	20.8	25.4	23.1	7.8
10.9	9.0	9.0	14.4	6.5	7.3	5.6	18.5	1.1	11.2	7.0
7.6	9.0	9.5	7.7	7.6	3.2	6.5	5.4	7.2	7.8	3.5
5.4	5.1	5.3	3.8	2.1	2.1	4.7	3.7	3.8	4.9	2.4
1.4	0.1	4.7	1.5	2.0	0.1	0.1	1.6	3.5	3.7	2.6
4.0	2.3	4.5								

Make a graph that shows the distribution of weights of these diamonds. Describe what you see. Give appropriate numerical measures of center and spread.