1. A study of king penguins looked for a relationship between how deep the penguins dive to seek food and how long they stay underwater. For all but the shallowest dives, there is a linear relationship that is different for different penguins. The study report gives a scatterplot for one penguin titled "The relation of dive duration (DD) to depth (D)." Duration DD is measured in minutes and depth D is in meters. The report then says, "The regression equation for this bird is: DD = 2.69 + 0.0138D."

(a) What is the slope of the regression line? Explain in specific language what this slope says about this penguin's dives.

(b) According to the regression line, how long does a typical dive to a depth of 200 meters last?

(c) The dives varied from 40 meters to 300 meters in depth. Plot the regression line from D = 40 to D = 300.

2. **Does social rejection hurt?** An exercise in our textbook gives data from a study that shows that social exclusion causes "real pain." That is, activity in an area of the brain that responds to physical pain goes up as distress from social exclusion goes up. A scatterplot shows a moderately strong linear relationship. The figure below shows Minitab regression output for these data.

Regression Analysis: Brain versus Distress

The regression equation is
Brain = -0.126 + 0.0608 distress

Predictor	Coef	SE Coef	T	P
Constant	-0.12608	0.02465	-5.12	0.000
distress	0.060782	0.009979	6.09	0.000

S = 0.0250896 R-Sq = 77.1% R-Sq (adj) = 75.1%

(a) What is the equation of the least-squares regression line for predicting brain activity from social distress score? Use the equation to predict brain activity for a social distress score of 2.0.

(b) What percent of the variation in brain activity among these subjects is explained by the straight-line relationship with social distress score?

(c) Use the information in Figure 5.10 to find the correlation r between social distress score and brain activity. How do you know whether the sign of r is $+$ or $-$?

3. An exercise in our textbook gives data on beak heat loss, as a percent of total body heat loss from all sources, at various temperatures. The data show that beak heat loss is higher at higher temperatures and that the relationship is roughly linear. The figure below shows Minitab regression output for these data.

Regression Analysis: Percent heat loss versus Temperature

The regression equation is
Percent heat loss = 0.92 + 2.06 Temperature

Predictor	Coef	SE Coef	T	P
Constant	0.919	5.613	0.16	0.872
distress	2.0647	0.2444	8.45	0.111

S = 4.50655 R-Sq = 83.6% R-Sq(adj) = 82.4%

(a) What is the equation of the least-squares regression line for predicting beak heat loss, as a percent of total body heat loss from all sources, from temperature? Use the equation to predict beak heat loss, as a percent of total body heat loss from all sources, at a temperature of 25 degrees Celsius.

(b) What percent of the variation in beak heat loss is explained by the straight-line relationship with temperature?

(c) Use the information in the above figure to find the correlation r between beak heat loss and temperature. How do you know whether the sign of r is $+$ or $-$?

4. **Husbands and wives.** The mean height of American women in their twenties is about 64.3 inches, and the standard deviation is about 3.9 inches. The mean height of men the same age is about 69.9 inches, with standard deviation about 3.1 inches. Suppose that the correlation between the heights of husbands and wives is about $r = 0.5$.

(a) What are the slope and intercept of the regression line of the husband's height on the wife's height in young couples?

(b) Draw a graph of this regression line for heights of wives between 56 and 72 inches. Predict the height of the husband of a woman who is 67 inches tall, and plot the wife's height and predicted husband's height on your graph.

(c) You don't expect this prediction for a single couple to be very accurate. Why not?

5. **What's my grade?** In Professor Krugman's economics course the correlation between the students' total scores prior to the final examination and their final-examination scores is $r = 0.5$ The pre-exam totals for all students in the course have mean 280 and standard deviation 40. The final-exam scores have mean 75 and standard deviation 8. Professor Krugman has lost Julie's final exam but knows that her total before the exam was 300. He decides to predict her final-exam score from her pre-exam total.

(a) What is the slope of the least-squares regression line of final-exam scores on pre-exam total scores in this course? What is the intercept?

(b) Use the regression line to predict Julie's final-exam score.

(c) Julie doesn't think this method accurately predicts how well she did on the final exam. Use r^2 to argue that her actual score could have been much higher (or much lower) than the predicted value.

6. **Sisters and brothers**. How strongly do physical characteristics of sisters and brothers correlate? Here are data on the heights (in inches) of 12 adult pairs.

Brother	71	68	66	67	70	71	70	73	72	65	66	70
Sister	69	64	65	63	65	62	65	64	66	59	62	64

(a) Use your calculator or software to find the correlation and the equation of the least-squares line for predicting sister's height from brother's height. Make a scatterplot of the data and add the regression line to your plot.

(b) Damien is 70 inches tall. Predict the height of his sister Tonya. Based on the scatterplot and the correlation r, do you expect your prediction to be very accurate? Why?

7. **Keeping water clean**. Keeping water supplies clean requires regular measurement of levels of pollutants. The measurements are indirect—a typical analysis involves forming a dye by a chemical reaction with the dissolved pollutant, then passing light through the solution and measuring its "absorbence." To calibrate such measurements, the laboratory measures known standard solutions and uses regression to relate absorbence and pollutant concentration. This is usually done every day. Here is one series of data on the absorbence for different levels of nitrates. Nitrates are measured in milligrams per liter of water.

Nitrates	50	50	100	200	400	800	1200	1600	2000	2000
Absorbence	7.0	7.5	12.8	24.0	47.0	93.0	138.0	183.0	230.0	226.0

(a) Chemical theory says that these data should lie on a straight line. If the correlation is not at least 0.997, something went wrong and the calibration procedure is repeated. Plot the data and find the correlation. Must the calibration be done again?

(b) The calibration process sets nitrate level and measures absorbence. The linear relationship that results is used to estimate the nitrate level in water from a measurement of absorbence. What is the equation of the line used to estimate nitrate level? What does the slope of this line say about the relationship between nitrate level and absorbence? What is the estimated nitrate level in a water specimen with absorbence 40?

(c) Do you expect estimates of nitrate level from absorbence to be quite accurate? Why?

8. **Sparrowhawk 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:

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

In a previous exercise we saw that there is a moderately strong linear relationship, with correlation $r = -0.748$.

(a) Find the least-squares regression line for predicting y from x. Make a scatterplot and draw your line on the plot.

(b) Explain in words what the slope of the regression line tells us.

(c) An ecologist uses the line, based on 13 colonies, to predict how many new birds will join another colony, to which 60% of the adults from the previous year return. What is the prediction?