Chapter 9 – Producing Data: Experiments

9.1 (a) The explanatory variable is the level of education. The response variable is the rate of motor vehicle crashes. **(b)** Age of car, crash test rating, and presence of safety features are lurking variables, as they are neither the primary explanatory nor response variables. **(c)** Without an experiment, no causal relationship can be made.

9.2 This is an experiment: Each subject is (presumably randomly) assigned to a group, each with its own treatment (Arial or Brush font). The explanatory variable is the font, and the response variables are then perceived effort (in minutes) and willingness to make the exercise part of his or her daily routine.

9.3 This is an observational study, so it is not reasonable to conclude any cause-and-effect relationship. At best, we might advise smokers that they should be mindful of potential weight gain and its accompanying ailments after smoking cessation.

9.4 Subjects: the 50 obese adolescents. Factor: type of intervention. Treatments: gastric banding operation or supervised lifestyle intervention. Response variables: weight loss.

9.5 Subjects: the students. Factors: price of item and type of discount. Treatments: the four combinations of low/high price and the amount off or percentage off discount. Response variables: rating on each of the two questions.

		Discount used	
		Fixed amount	Percentage
Price	48 pesos	1	2
	480 pesos	3	4

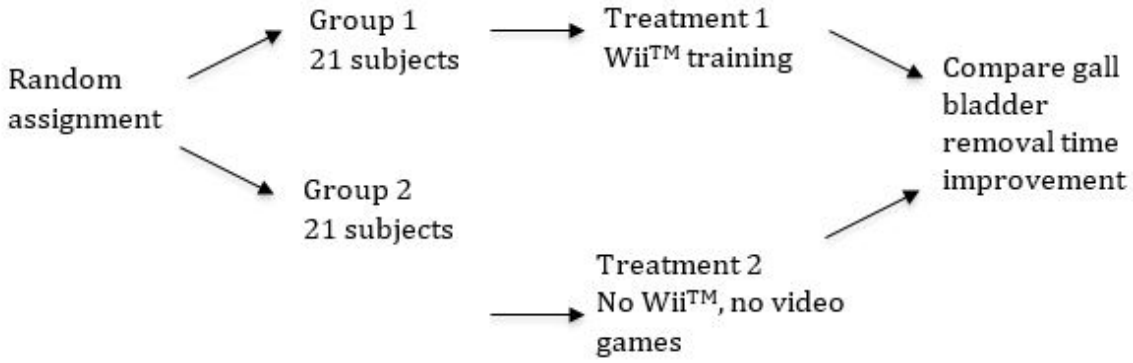
9.6 (a) Factors: harvest time and storage temperature. Treatments: for harvest time: 80, 95, and 110 days after fruit setting; for storage temperature: 20, 30, and 40 degrees centigrade. The treatment combinations are shown below. Response variable: time to ripening.

	Storage temperature (°C)		
Days after fruit set	20	30	40
80	1	2	3
95	4	5	6
110	7	8	9

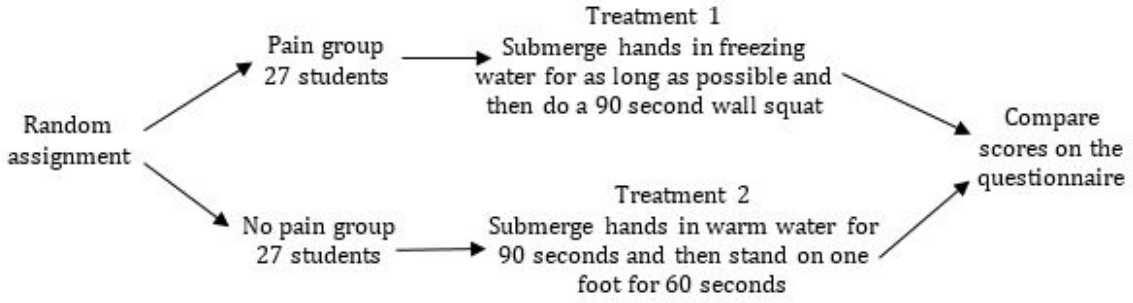
(b) This would probably not be a good way to assign mangoes; if a tree was diseased, for example, its fruit would most likely not withstand any treatment and would indicate that the treatment was not good, regardless of the treatment's effect.

9.7 Making a comparison between the treatment group and the percent finding work *last year* is not helpful. Over a year, many things can change: the state of the economy, hiring costs (due to an increasing minimum wage or the cost of employee benefits), etc. (In order to draw conclusions, we would need to make the $500 bonus offer to some people and not to others during the same time period, and compare the two groups.)

9.8 (a) The scenario in Example 9.1 was an observational study—the surgeons had played video games (or not) on their own. This is an experiment with treatments deliberately imposed. **(b)** The outline is provided. The response variable is improvement in the time needed to perform a virtual gall bladder removal. **(c)** Those selected for the Wii™ are labeled 05, 16, 17, 40, 20, 19, 32, 41, 04, 25, 29, 37, 39, 31, 18, 07, 13, 33, 02, 36, and 23.



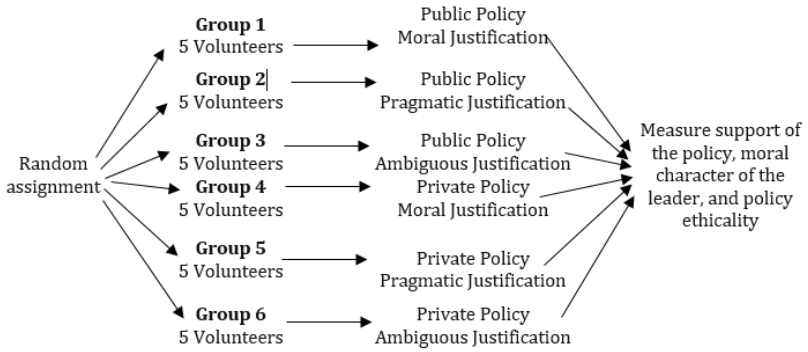
9.9 (a) The diagram is provided below.



(b) Label the subjects 01 to 54, and use either a random number generator or Table B to generate 27 two-digit numbers from 01 to 54. Using Table B, beginning at line 125, the first few subjects selected are: 21, 49, 37, 18, 44, 23, 51, …. **(c)** The experiment used similar tasks to control for bonding that may result from certain tasks regardless of whether there is pain. This is important because if the tasks are dissimilar, we cannot conclude whether a difference in bonding is attributed to pain or to the particular activity.

9.10 Assign 30/6 = 5 subjects to each treatment. The diagram is shown below. We assign labels 01 through 30, then use the first five two-digit numbers in this range for Group 1, the next five for Group 2, etc. Starting at line 133 in Table B, the assignments are given below (presuming that you numbered down each column and then left to right in the list of names). Note that with this many assignments, you will run through many lines of Table B. Once you've filled out members for five groups, the sixth group contains all the remaining, unassigned subjects.

Group 1: 04 Long, 18 Disbro, 07 Anthony, 13 Brower, 02 Gold
Group 2: 05 Bernstein, 19 Cressie, 23 Linder, 20 Kessis, 27 Stanley
Group 3: 16 Santner, 21 Lahr, 26 Leatherman, 08 Pearl, 10 Shi
Group 4: 11 Weingold, 15 Cohen, 12 Blake, 14 Hepler, 09 Baker
Group 5: 24 Minor, 22 Kruger, 17 Delp, 28 Tory, 29 Verducci
Group 6: 01 Hain, 03 Knab, 06 Abramson, 25 Carson, 30 Walsh



9.11 In a controlled scientific study, the effects of factors other than the nonphysical treatment (such as the placebo effect and differences in the prior health of the subjects) can be eliminated or accounted for, so that the differences in improvement observed between the subjects can be attributed to the differences in treatments.

9.12 If this year is considerably different in some way from last year, we cannot compare electricity consumption over the two years. For example, if this summer is warmer, the customers may run their air conditioners more. The possible differences between the two years would confound the effects of the treatments.

9.13 (a) The researchers simply observed the diets of subjects; they did not alter them. (That is, no treatments were assigned.) **(b)** Such language is reasonable because, with observational studies, no "cause-and-effect" conclusion would be reasonable.

9.14 "Double-blind" means that the treatment (testosterone supplement or placebo) assigned to a subject was unknown to both the subject and to those responsible for assessing the effectiveness of that treatment. "Randomized" means that patients were randomly assigned to receive either the testosterone supplement or a placebo. "Placebo-controlled" means that some of the subjects were given placebos. Even

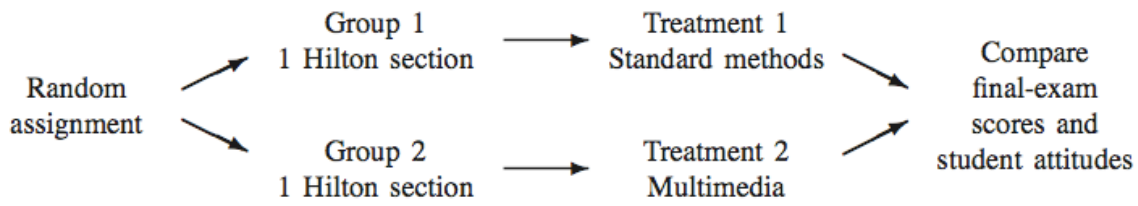
though placebos possess no medical properties, some subjects may show improvement or benefits just as a result of participating in the experiment; the placebos allow those doing the study to observe this effect.

9.15 In this case, "lack of blindness" means that the experimenter knows which subjects were taught to meditate. The experimenter may have some expectation about whether or not meditation will lower anxiety; this could unconsciously influence the end-of-month assessment.

9.16 (a) Each swimmer swims one time using each breathing technique (B2 and B4). A coin is tossed to determine the order in which these techniques are used. **(b)** In a completely randomized design, the 10 male collegiate swimmers would be assigned randomly to the two treatments: 5 swimmers using technique B2 and the other 5 using technique B4. A completely randomized design would not allow us to observe the differences in breathing technique for individual swimmers and eliminate any variability caused by different swimming abilities among the swimmers. **(c)** If swimmers select their own technique, it would be an observational study.

9.17 (a) The explanatory variable is whether or not they are using a hands-free cell phone; the response variable is the reaction time. **(b)** Completely randomized design: 20 students are randomly assigned to each of the two treatments (cell phone or no cell phone), and then they measure the reaction time. **(c)** Agree with the first experimenter. Otherwise, students may become familiar with the experiment and have a faster reaction time, regardless of having a cell phone in the next phase of the experiment. **(d)** Yes, the matched pairs experiment is a better choice, because it allows the researchers to compare the effect of having a cell phone instead of having results being highly influenced by the variation among the subjects.

9.18 For each block (pair of lecture sections), randomly assign one section to be taught using standard methods and the other to be taught with multimedia. Then (at the end of the term) compare final-exam scores and student attitudes. The diagram below is *part* of the whole block diagram; there would also be three other pieces like this (one for each of the other instructors). The randomization will vary with the starting line in Table B—or the randomization can be done by flipping a coin for each block.



9.19 (a) an observational study. Victimization is observed; no treatments were imposed.

9.20 (c) lurking variables. Sex and previous emotional and behavioral problems are lurking variables, since they are not the primary explanatory variable.

9.21 (b) an uncontrolled experiment. All participating students had the same treatment.

9.22 (c) experiment with two factors, luxury/mass market and condescending/neutral. There are two factors and four treatments, where the treatments consist of each combination of the factors.

9.23 (c) limited because of lack of realism.

9.24 (c) the aspiration measure towards the product.

9.25 (a) Because this is an observational study, living in a zip code near an airport may or may not be causing the increase in the proportions of admissions for cardiovascular disease. The researchers did not randomly assign where the people lived, so no treatments were actively imposed.

9.26 (b) a matched pairs experiment. The communities are paired up, then one is randomly chosen to have the advertising campaign.

9.27 (a) toss a coin. The choice should be made randomly.

9.28 (b) results from students may not generalize to the older and richer customers who might buy a Mercedes. This was a (matched pairs) experiment, but to give useful information, the subjects should be chosen from those who might be expected to buy this car.

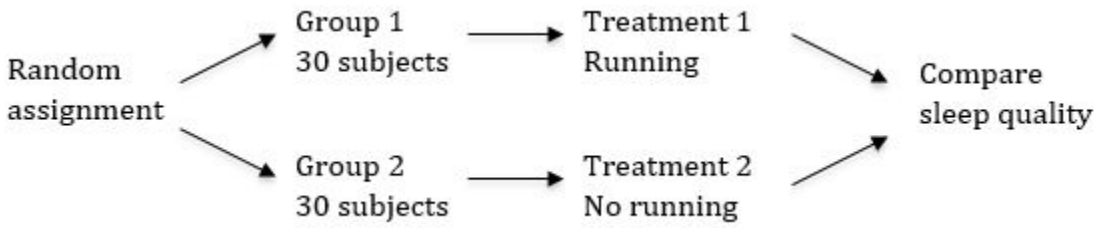
9.29 (a) This is an observational study; the subjects chose their own "treatments" (how much red meat to eat). The explanatory variable is red meat consumption, and the response variable is whether or not a subject dies. (There may have been other variables, but these are the only ones mentioned in the problem.) **(b)** Many answers are possible. For example, smoking is known to increase the risk of cancer. These variables are called lurking variables. **(c)** Many answers are possible. For example, how many servings of fruits and vegetables were consumed along with the red meat?

9.30 Many answers are possible. For example, it may take time to adjust to a new neighborhood or to be brought up to the academic performance level of students already in the new neighborhood.

9.31 (a) This is a matched pairs design. The explanatory variable is the activity level and the response variables are body fat percentage, endurance level, and insulin sensitivity. **(b)** This is an observational study, because no treatment is assigned. **(c)** "Blind" means the person taking the measurements did not know whether they

were measuring the active or inactive twin. This is important because the person recording this information will not be able to influence the results.

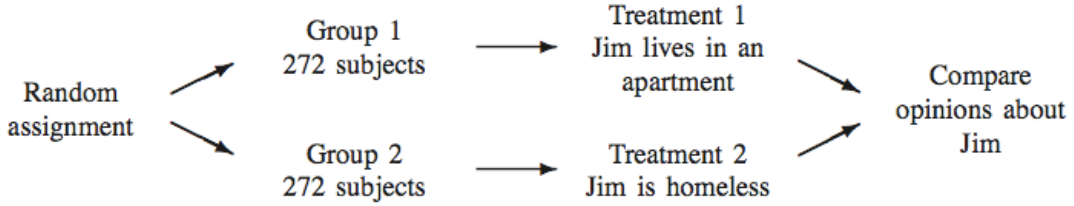
9.32 (a) Explanatory variable: running or not. Response variable: sleep quality. **(b)** The design is provided.



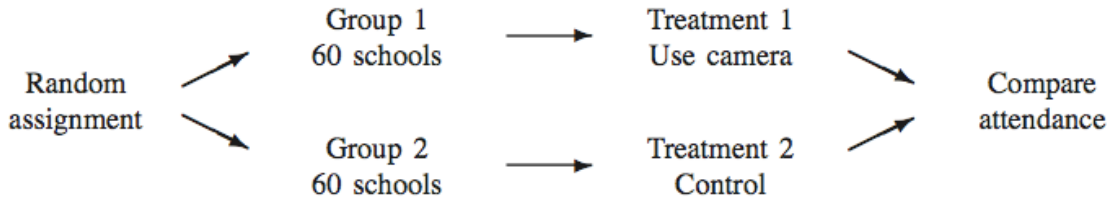
(c) The control group was treated like the treatment (running) group, in terms of these variables, in an attempt to eliminate lurking variables. It is very important, in experiments with human subjects, that they all be treated as "alike" as possible in order to make valid conclusions. **(d)** Before-and-after scores for the same subjects would be a matched pairs design, because we only have two groups—those who ran and those who did not run. The researchers were trying to see if the "program" made a difference. Perhaps the discipline of getting up early and doing homework before breakfast made those in the nonrunning group sleep better as well.

9.33 (a) In an observational study, we simply observe people who underwent cardiac surgery. In an experiment, we would assign some individuals to receive surgery and others to not have surgery. **(b)** Answers will vary. For example, those who are divorced, separated, or widowed may not have anyone assisting with their recovery; whereas those who are married have the support of a spouse. Access to care would be a variable that might be confounded. Another example is that those who are divorced, separated, or widowed may have greater financial strain and not be able to afford high quality post-surgical care. Money would also be a confounding variable. **(c)** This study is limited because it is an observational study and does not control for confounding variables. It is not possible to make a causal relationship in this case. However, it still provides useful information to researchers, in that doctors know to consider the marital status of a patient when developing a recovery plan.

9.34 In the diagram below, equal numbers of subjects are assigned to each treatment.



9.35 (a) The diagram follows.



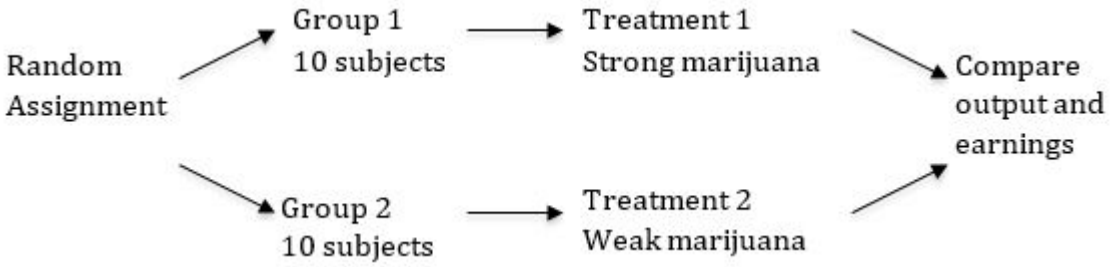
(b) Assign labels 001 to 120. If using Table B, line 108 gives 090, 009, 067, 092, 041, 059, 040, 080, 029, and 091.

9.36 (a) The diagram is shown below. The outline randomly assigns participants to each treatment and compares the anxiety level of each consumer after having them evaluate several products.

		Ambient Scent		
		Seashore	Firewood	No Scent
Product Density	Jam-packed	1	2	3
	Nearly Empty	4	5	6

(b) Assign 30/6 = 5 consumers for each of the six treatments. Label the subjects from 01 through 30. Randomly select 5 numbers for treatment 1, then 5 of the remaining consumers for treatment 2, and so on. Using Table B, at line 130, the consumers assigned to treatment 1 are those numbered 05, 16, 17, 20, and 19.

9.37 (a) The outline is shown.



(b) From line 126, assuming we label 01 to 20 down the columns, we choose subjects corresponding to the numbers 19, 03, 06, 08, 11, 15, 13, 09, 18, and 05 for the first group, and the rest for group 2. Thus, the strong marijuana group consists of Wilson, Birkel, Fleming, Giriunas, Mani, Sawant, Reichert, Kennedy, Williams, and DeVore. All other subjects are assigned to the weak marijuana group. **(c)** This could be a double-blind experiment, assuming that subjects can't distinguish between the types of marijuana smoked, and that the persons measuring output and earnings of subjects don't know what kind of marijuana a subject smoked. Ensuring these conditions is very unlikely.

9.38 (a) Explanatory variable: text method used. Response variable: WRAT score.

(b) This is observational; researchers did not assign "text method usually used." **(c)** "No significant difference" means that the observed differences could be due to chance. There was no systematic difference in spelling ability among the three groups.

9.39 (a) There are two factors. The first factor is type of granola, and it has two levels (regular and low-fat). The second factor is serving size label, and it has three levels (2 servings, 1 serving, and no label). There are six treatment combinations (regular granola at 2 servings, regular granola at 1 serving, regular granola with no serving label, low-fat granola with 2 servings, low-fat granola with 1 serving, and low-fat granola with no serving label). At 20 subjects per treatment, there were 120 subjects in the experiment. **(b)** A diagram is given.

	Granola type	
Serving size label	Regular	Low-fat
2 servings	20 subjects	20 subjects
1 serving	20 subjects	20 subjects
No label	20 subjects	20 subjects

9.40 (a) This is an observational study. Shoppers were not assigned which stores to walk by. The explanatory variable is the type of window display. The response variable is whether or not shoppers entered the store. **(b)** Statistical significance means it would be rare to observe a difference in the proportions who entered the two store types (creative or less creative window displays) such as that observed in this study based on chance alone. **(c)** The authors are acknowledging, since this was an observational study and not a controlled experiment, that they were unable to control for confounding variables that may be contributing to the difference in the proportion who entered the stores. For example, the particular articles of clothing displayed in the window vary. If the articles of clothing displayed in the more creative windows are more desirable to consumers, then it may be the clothing and not the window display that influenced shoppers to enter the store. (Answers may vary.)

9.41 (a) The factors are pill type and spray type. "Double-blind" means that the treatment assigned to a patient was unknown to both the patient and to those responsible for assessing the effectiveness of that treatment. "Placebo-controlled" means that some of the subjects were given placebos. Even though placebos possess no medical properties, some subjects may show improvement or benefits just as a result of participating in the experiment; the placebos allow those doing the study to observe this effect. **(b)** "No significant difference" does *not* mean the groups are identical. While there almost certainly were *some* differences in these variables among the four groups, those differences were no bigger than we might expect from true random allocation. For example, the proportions of smokers in the four groups were sufficiently similar that the effect of smoking on sinus infections would be nearly the same in each group.

9.42 (a) This is an experiment, since the subjects are assigned an image to view. The explanatory variable is the window display (more or less creative), and the response variable is the desire to enter the store. **(b)** The drawbacks in Exercise 9.40 were that it was an observational study and that it did not control for confounding variables (such as variations in merchandise). The second study addresses these drawbacks by using the same retailer and the same merchandise, and by only changing the creativity of the window display. Both studies suffer from a lack of realism, because the study design does not duplicate the conditions of all retailers. Rather, we can only appropriately draw conclusions for similar retailers within this same geographic region.

9.43 (a) The subjects are randomly chosen (preferably people who like flavored water). Each subject tastes two cups of flavored water, in identical unlabeled cups. One contains MiO; the other, the ready-to-drink product. The cups are presented in random order: half the subjects get MiO, then the ready-to-drink; the other half get the ready-to-drink, then MiO. Each subject says which cup he or she prefers; preference is the response variable. **(b)** We must assign 10 customers to MiO first. Label the subjects 01 to 20. Starting at line 138, the "MiO first" group is: 16, 08, 15, 13, 17, 04, 10, 19, 12, and 18.

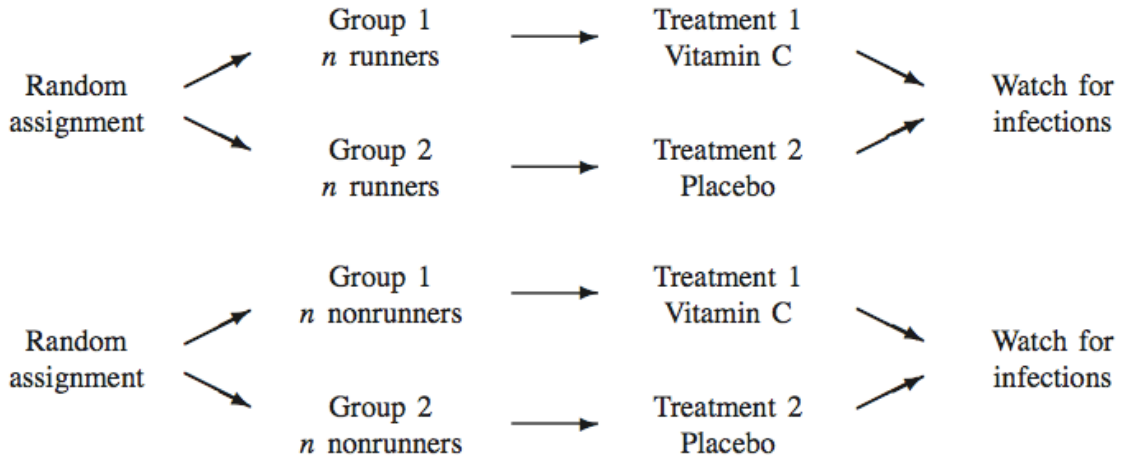
9.44 (The sketches requested in the problem are not shown here; random assignments will vary among students.) **(a)** Label the circles 1 to 6, then randomly select three (using Table B or simply by rolling a fair, six-sided die) to receive the extra CO_2. Observe the growth in all six regions, and compare the mean growth within the three treated circles with the mean growth in the other three (control) circles. **(b)** Select pairs of circles in each of three different areas of the forest. For each pair, randomly select one circle to receive the extra CO_2 (using Table B or by flipping a fair coin). For each pair, compute the difference in growth (treated minus control).

9.45 (a) The subjects are all consumers who are recruited and assigned a combination of program and advertisement. The factors are the energy saving programs (Conservation or Peak Shaving) and advertisement (save money, save energy, or save both). The treatments are the six combinations of program and advertisement (see part [b]). The response variable is whether the consumer decided to enroll in the program after reading the advertisement. **(b)** The diagram is below.

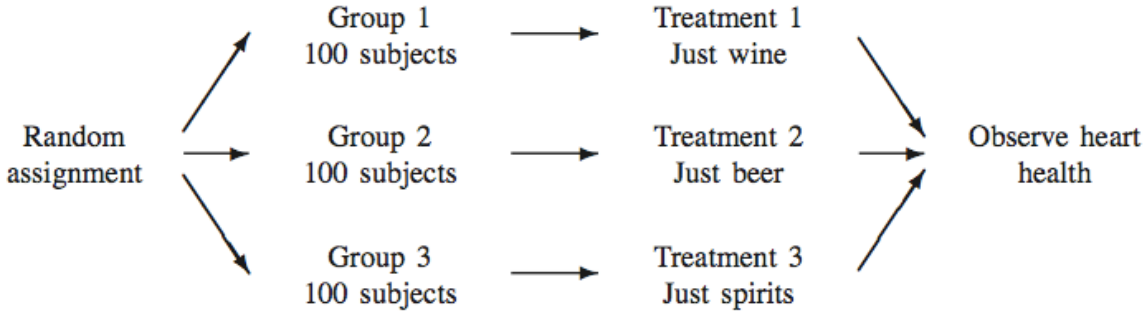
		Advertisement		
		Save money	Save energy	Save both
Program	Conservation	1	2	3
	Peak shaving	4	5	6

9.46 (a) This is a randomized block design. **(b)** The diagram might be similar to the

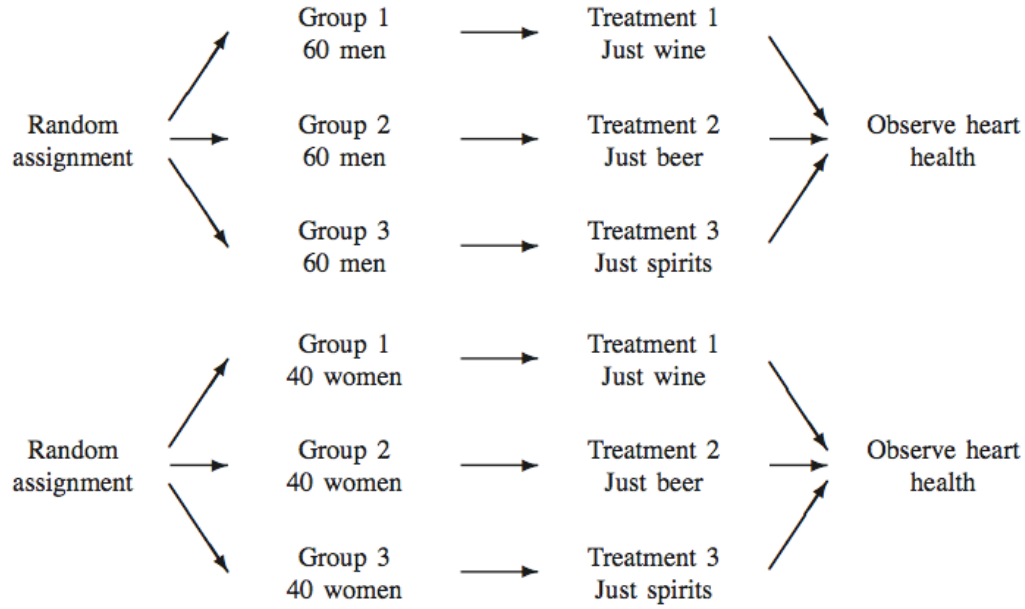
one below (which assumes equal numbers of subjects in each group).



9.47 The diagram is shown. The last stage ("Observe heart health") might be described in more detail.

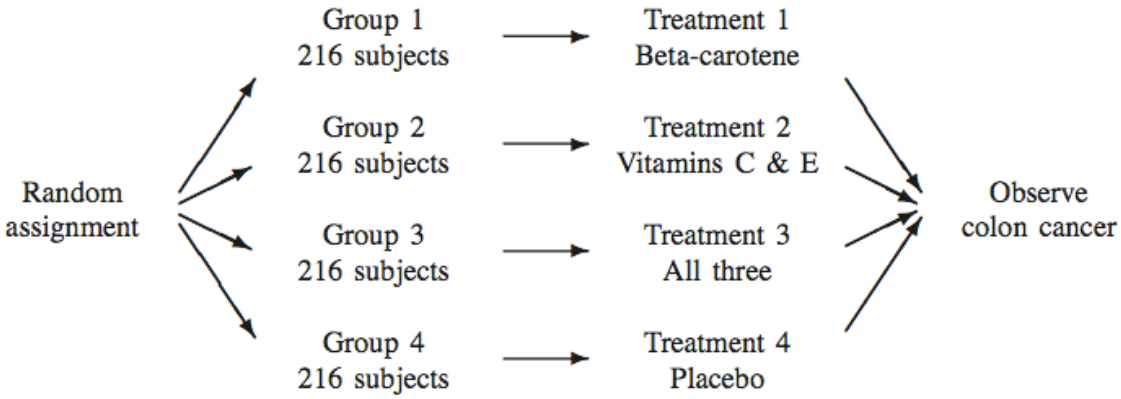


9.48 Divide the men and women into three groups of equal size. The diagram is below.



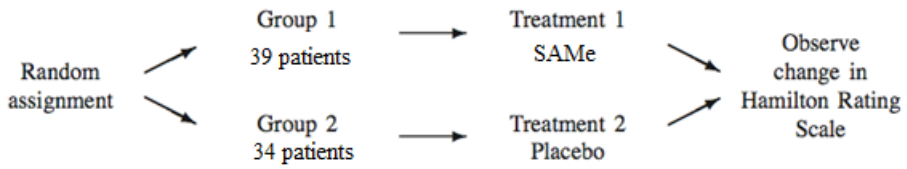
9.49 Any experiment randomized in this way assigns all the women to one treatment and all the men to the other. That is, sex is completely confounded with treatment. If women and men respond differently to the treatment, the experiment will be strongly biased. The direction of the bias is random, depending on the coin toss.

9.50 (a) The explanatory variable is the beta-carotene or vitamin(s) taken each day; the response variable is whether or not colon cancer develops. **(b)** The diagram is shown below; equal group sizes are convenient, but not necessary.



(c) Neither the subjects nor the researchers who examined them knew who was getting which treatment. **(d)** The observed differences were no more than what might reasonably occur by chance, even if there is no effect due to the treatments. **(e)** Fruits and vegetables contain fiber; this could account for the benefits of those foods. Also, people who eat lots of fruits and vegetables may have healthier diets overall (such as less red meat).

9.51 (a) "Randomized" means that patients were randomly assigned to receive either SAMe or a placebo. "Double-blind" means that the treatment assigned to a patient was unknown to both the patient and to those responsible for assessing the effectiveness of that treatment. Even though placebos possess no medical properties, some subjects may show improvement or benefits just as a result of participating in the experiment; the placebos allow those doing the study to observe this effect. **(b)** Statistical significance means that the SAMe group had a greater difference in response (more had a positive response) than could be attributed to chance. This means that it appears SAMe helps reduce depression when used with standard treatment. **(c)** The diagram is below.



9.52 (a) We expect half of the sample to be made up of older students, so we expect 12.5 (half of 25) older students in the sample. **(b)** Results will vary, but probability computations reveal that more than 97.7% of samples will have 9 to 16 older employed subjects (and 99.6% of samples will have 8 to 17 older employed subjects). Additionally, if students average their 20 samples, nearly all students (more than 99%) should find that the average number of older employed subjects is between 11.3 and 13.7. Note: X, the number of older employed subjects in the sample, has a hypergeometric distribution with parameters $N = 50$, $r = 25$, $n = 25$, so that $P(9 \le X \le 16) = 0.977$. The theoretical average number of older employed subjects in the sample is 12.5.

9.53 and **9.54** are Web-based exercises.