6 **You carry out a clinical trial to test whether a new drug relieves the symptoms of arthritis better than a placebo. You have four groups of participants, all of whom have mildly painful arthritis (rated 6 on a scale of 1 to 10). Each group receives a daily pill as follows: group 1 (control), placebo; group 2, 15 mg; group 3, 25 mg; group 4, 50 mg. At the end of 2 weeks, participants in each group are asked to rate their pain on a scale of 1 to 10. What is the independent variable in this experiment?**

a. the amount of pain experienced at the start of the experiment
b. the amount of pain experienced at the end of the experiment
c. the degree to which pain symptoms changed between the start and the end of the experiment
d. the drug
e. The independent variable could be a, b, or c.

Answer: d

7 **You are working on an experiment to test the effect of a specific drug on reducing the risk of breast cancer in postmenopausal women. Describe your control and experimental groups with respect to age, gender, and breast cancer status.**

Answer: Given the parameters, both the experimental and the control groups would have to be postmenopausal females. As you are looking at reducing the risk of breast cancer, all women in both groups would be free of breast cancer.

8 **Design a randomized clinical trial to test the effects of caffeinated coffee on brain activity. Design your study so that the results will apply to as many people in as many scenarios as possible.**

Answer: There are many possibilities. The independent variable will be caffeinated coffee. The dependent variable can be any measure of brain activity (for example, memory, alertness, problem-solving). The basic design will be to observe the results on two groups: caffeinated coffee drinkers and non–caffeinated-coffee drinkers. So that the results will be broadly applicable, the participants should include both sexes and a variety of ages, ethnicities, and racial groups.

DRIVING QUESTION 2

9 **In which of the following would you have the most confidence?**

a. a randomized clinical trial with 15,000 subjects
b. a randomized clinical trial with 5,000 subjects
c. an epidemiological study with 15,000 subjects
d. an endorsement of a product by a movie star
e. a report on a study presented by a news organization

Answer: a

10 **What is the importance of statistical analyses?**

a. They can reveal whether or not the data have been fabricated.
b. They can be used to support or reject the hypothesis.
c. They can be used to determine whether any observed differences between two groups are real or a result of chance.
d. all of the above
e. b and c

Answer: e

11 **You carry out a clinical trial to test whether a new drug relieves the symptoms of arthritis better than a placebo. You have four groups of participants, all of whom have mildly painful arthritis (rated 6 on a scale of 1 to 10). Each group receives a daily pill as follows: group 1 (control), placebo; group 2, 15 mg; group 3, 25 mg; group 4, 50 mg. At the end of 2 weeks, participants in each group are asked to rate their pain on a scale of 1 to 10. The mean pain rating of the participants was 6.5 for the placebo, 6.0 for 15 mg of the drug, 4.5 for 25 mg of the drug, and 4.5 for 50 mg of the drug. What is your next step?**

a. Invest in the drug company.
b. Conclude that the drug relieves arthritis pain.
c. Run a statistical analysis to determine if the differences are significant.
d. Conclude that the drug doesn't work very well (even the placebo group went down on the pain scale, and there was no difference in results between doses of 25 mg and 50 mg of the drug).
e. a and b

Answer: c

12 **Looking at Infographic 1.4 (Sample Size Matters), you see that both graphs show a positive impact of caffeine on memory. However, the data in the graph on the right carry more weight. Why is that? If you read a study that reported only the data in the left graph, would you find the relationship to be compelling? Why or why not?**

Answer: The study whose results are plotted in the graph on the left had far fewer participants. Because of the smaller sample size, the data are not as convincing as those plotted in the graph on the right, with a larger sample size. Larger sample sizes give more conclusive results.

From the abstracts, and from any other investigation you do, name the components of underarm deodorants and antiperspirants that have been identified as possible culprits in causing breast cancer.

b. Briefly comment on the strengths and weaknesses of each study (consider sample size, control groups, and overall study design).

c. From what you read in the abstracts and from other research you do (cite any additional reliable sources that you consulted), do you think that use of antiperspirants or deodorants or both is a consistent risk factor for breast cancer? Has your opinion about underarm hygiene changed? Explain how and why your opinion has either changed or remained consistent, referring to the abstracts that you have reviewed.

Answer:

a. The Darbre abstract points to aluminum, whereas the Harvey and Everett abstract points to parabens.

b. Darbre, having found breast cancer in areas of the breast near where antiperspirants are applied, implicates aluminum. There is no indication of sample size, and as the findings are simply a case of correlation, they do not suggest causation. Harvey and Everett, the parabens study, looks at levels of parabens in breast tumors from 20 patients. The sample size is small, and there does not appear to be an investigation of parabens levels in normal (control) breast tissue.

c. Answers will vary, but all should be supported by evidence.

Chapter 2 Chemistry of Life

DRIVING QUESTION 1

1 Which of the following is *not* a generally recognized characteristic of most (if not all) living organisms?

a. the ability to reproduce
b. the ability to maintain homeostasis
c. the ability to obtain energy directly from sunlight
d. the ability to sense and respond to the environment
e. the ability to grow

Answer: c

2 What is homeostasis? Why is it important to living organisms?

Answer: Homeostasis is the maintenance of a relatively stable internal environment even when the external environment changes. Homeostasis helps maintain the conditions necessary for life: many of the molecules and processes of life cannot function outside a narrow range of, for example, pH and temperature.

3 What does it mean to say that a macromolecule is a polymer? Give an example.

Answer: A polymer is a molecule made up of smaller and typically repeating subunits. Examples include proteins, which are made up of amino acids; complex carbohydrates, which are made up of simple sugars, or monosaccharides; and nucleic acids, which are made up of nucleotides.

4 A collection of amino acids could be used to build a

a. protein.
b. complex carbohydrate.
c. triglyceride.
d. nucleic acid.
e. cell.

Answer: a

5 How would you assess whether or not a possibly living organism from another planet were truly alive?

Answer: Answers will vary. In general, you should look for evidence of the characteristics of life described in the chapter, such as the ability to grow, to reproduce, and to maintain homeostasis. You could also look for molecules that make up living organisms on Earth (e.g., proteins, amino acids, sugars).

6 Which of the characteristics of living organisms (if any) allow you to distinguish between living and formerly living (that is, dead) organisms? Explain your answer.

Answer: Answers will vary. In general, dead organisms still have cells (or remains of cells) but are not growing, reproducing, obtaining or using energy, or responding to their environment.

7 You are searching for life in a sample of dirt. If you had evidence that carbon dioxide was being consumed and converted to glucose, what could you conclude about the presence of a living organism in your sample? Explain your answer.

Answer: It is possible that a living organism is present and carrying out metabolic reactions. However, it is also possible that abiotic (nonliving) reactions are occurring. Further investigation would be required: for example, you could attempt to isolate an organism from the dirt. Or you could take a sample of the dirt and sterilize it to destroy any organisms and see if carbon dioxide were still being consumed and glucose were still being produced.

23 Why do olive oil and vinegar (a water-based solution) tend to separate in salad dressing? Will added salt dissolve in the oil or in the vinegar? Explain your answer.

Answer: Olive oil and vinegar separate because the oil is hydrophobic and the vinegar is water based. The hydrophobic triglycerides in the oil tend to cluster together, and the water molecules interact with other water molecules. The salt is hydrophilic, and will dissolve in the vinegar—its charged ions (Na^+ and Cl^-) can interact with the partial charges on water molecules.

24 Which of the following is/are most likely to dissolve in olive oil?

a. a polar molecule
b. a nonpolar molecule
c. a hydrophilic molecule
d. a and c
e. b and c

Answer: b

25 Look at Infographic 2.9. For the substances drain cleaner, coffee, and soda, answer the following questions: Is the substance an acid or a base? What is the hydrogen ion concentration relative to a solution with a neutral pH?

Answer: Drain cleaner is a base. Its pH of 14 means that it has a lower hydrogen ion concentration than does a neutral solution (10^7 times lower). Coffee is an acid. Its pH of 5 means that it has a higher hydrogen ion concentration than does a neutral solution (100 times higher). Soda is an acid. Its pH of ~3 means that it has a hydrogen ion concentration that is 10,000 times higher than that of a neutral solution.

26 One approach to finding out if there is life on Mars is to bring Martian dirt samples to Earth for analysis. What are possible considerations for science and society if a Martian life form is released on Earth? Given that *Curiosity* has landed on Mars, what are the possible consequences if an Earth life form is released on Mars? What steps can mission control take to minimize these risks?

Answer: There are many possible answers. Martian life brought back to Earth could cause disease or otherwise be harmful to species and the environment on Earth (e.g., if it outcompeted Earth species or released toxic waste products). If an Earth life form on Mars survived, it could affect the Martian environment or any Martian species (if any exist). Ways to minimize the risks of introducing non-native species to other planets include careful sterilization of *Curiosity* components before launching it to Mars to ensure that *Curiosity* harbors no living Earth organisms. Similarly, risks of introducing Martian life forms to Earth can be minimized by isolating and sterilizing any material brought to Earth from Mars.

27 Your tax dollars are being invested in projects such as the *Curiosity* rover project. Investigate the NASA website to learn more about NASA's rationale for the investment in this mission. Now draft a letter to your congressional representative that expresses your opinion about this expenditure of taxpayer dollars. If you agree, state specific reasons why you think this a good investment of your money. If you disagree, state your reasons, and describe at least two other scientific programs that you would prefer to see funded, providing a rationale for why these are more important.

Answer: Letters will vary.

Chapter 3 Cell Structure and Function

DRIVING QUESTION 1

1 What does the cell theory state?

Answer: The cell theory states that all living organisms are made of cells, and that all cells arise from existing cells.

2 Which of the following statements best explains why bacteria are considered living organisms?

a. They can cause disease.
b. They are made up of biological macromolecules.
c. They move around.
d. They each consist of a cell.
e. They contain organelles.

Answer: d

3 What are the two main types of cells found in organisms?

Answer: prokaryotic and eukaryotic

4 Which of the following is/are *not* associated with human cells?

a. cell membrane
b. ribosomes
c. DNA
d. cell wall

9Our bodies cannot synthesize vitamin C, but require it. Therefore, vitamin C is

a. an essential micronutrient.
b. an essential mineral.
c. an essential macronutrient.
d. a nonessential vitamin.
e. a nonessential amino acid.

Answer: a

10 Which component of peanut butter RUTF supplies essential amino acids?

a. milk powder
b. peanut butter
c. sugar
d. vegetable oil
e. powdered vitamins and minerals
f. a and c

Answer: a

11 Corn lacks the essential amino acids isoleucine and lysine. Beans lack the essential amino acids tryptophan and methionine. Soy contains all the essential amino acids.

a. Could someone survive on a diet with a corn-based protein alone? Why or why not?
b. Why do many traditional diets combine corn (e.g., in tortillas) with beans?
c. Why did one of the home-based feeding therapies in Malawi combine soy flour with corn flour?

Answer:

a. No. A diet with a corn-based protein alone would lack the essential amino acids isoleucine and lysine, which our bodies cannot make.
b. Traditional diets that combine corn and beans (e.g., in a meal of tortillas and beans) provide all the essential amino acids. The beans provide the essential amino acids lacking in corn, and the corn provides the essential amino acids lacking in beans.
c. Corn and soy are traditional foods in Malawi, and so would be familiar. Also, whereas soy contains all the essential amino acids, the starchy corn flour adds another source of carbohydrates.

DRIVING QUESTION 3

12 The substrate of an enzyme is

a. an organic accessory molecule.
b. the molecule(s) released at the end of an enzyme-facilitated reaction.
c. the shape of the enzyme.
d. one of the amino acids that makes up the enzyme.
e. what the enzyme acts on.

Answer: e

13 Compare and contrast enzyme cofactors and coenzymes.

Answer: Both cofactors and coenzymes help enzymes speed up their reaction rates. Cofactors are typically inorganic metals, whereas coenzymes are organic molecules, such as vitamins.

14 Enzymes speed up chemical reactions by

a. increasing the activation energy.
b. decreasing the activation energy.
c. breaking bonds.
d. forming bonds.
e. releasing energy.

Answer: b

15How is folate (folic acid) best described?

a. as a substrate of an enzyme
b. as a nucleotide
c. as an organic cofactor (coenzyme)
d. as an enzyme
e. a and b

Answer: c

16 If the shape of an enzyme's active site were to change, what would happen to the reaction that the enzyme usually speeds up?

Answer: If the shape of the active site were to change, the reaction rate would likely decrease (or completely slow to 0). If the active site changes shape, the substrate cannot properly enter and bind to the active site, and the enzyme cannot catalyze the reaction.

17 Considering the function of folate (folic acid) given in Infographic 4.5, why would you say pregnant women (and women who could become pregnant) should ensure that they have adequate levels of folate in their diets?

Answer: Folate is essential for DNA replication, and DNA must be replicated every time a cell divides. An embryo (and later the fetus) grows from a single fertilized egg through many rounds of cell division, each round adding new cells to the growing embryo. If the mother is folate deficient, the embryo and fetus will not grow properly, and so folate deficiency can lead to birth defects.

DRIVING QUESTION 4

18 When vitamins are consumed:

a. Why does excess vitamin E cause problems, but excess vitamin C does not?
b. If you were to take a supplement with a high amount of vitamin C, what would happen to all that vitamin C? Would it all be used? Would some of it be stored in your body?

Answer:

a. Vitamin C is water soluble, so any excess is removed from the body in the urine. Vitamin E is fat soluble, so excess is stored in fatty tissues in the body, possibly accumulating to toxic levels.
b. Taking high levels of a vitamin C supplement will not lead to storage of vitamin C in the body. Any excess over what is needed is excreted from the body, dissolved in the urine.

19 What ingredient(s) in RUTF peanut paste specifically help bone growth? (Hint: Refer to Table 4.1.)

a. calcium
b. vitamin D
c. potassium
d. all of the above
e. a and b

Answer: e

20 Infographic 4.6 shows the results of a study examining three different home-based therapies for malnourished children in Malawi.

a. From the data shown, how many of all the children in the study reached full catch-up growth?
b. What percentage of the children in the study does this number represent? How does this compare to previous recovery rates of 25%–40% for children who had received standard hospital therapy?

The children who received the RUTF were given enough of it to supply 730 kJ of energy per kg of body weight. This is sufficient energy to meet their needs.

c. A malnourished 2-year-old girl weighs a mere 6 kg (~13 pounds; an average 2-year-old American girl weighs approximately 28 pounds). If she had been in the RUTF group in the study, how many daily kJ would she have obtained from the RUTF?
d. If the same malnourished 2-year-old had been in the RUTF supplement group, she would have received 2,100 kJ per day from the supplement. What percentage of her daily energy needs would this represent? (Hint: Use your answer to part c.)
e. Children in the RUTF supplement group ate a traditional diet of corn/soy flour to make up the rest of their diet. Corn/soy flour contains 4 kJ per gram. How many grams of the traditional mix would this 2-year-old need to consume (on top of the RUTF supplement) to meet her daily needs?

Answer:

a. (95% of 69 = 66) + (78% of 96 = 75) + (78% of 117 = 91) = 232 Overall, 232 children reached full catch-up growth.
b. 232 children reaching catch-up growth out of 282 children in the study represent ~82% of the children in this study. This rate is between two and three times higher than the 25%–40% rate for standard hospital therapy.
c. She would have received (6 kg × 730 kJ/kg) = 4,380 kJ per day of the RUTF.
d. 2,100 kJ from a supplement is only 47.9% of her daily energy needs.
e. She would need to obtain another 2,280 kJ per day from the corn/soy flour to meet her energy needs. This represents 570 g of the soy/flour per day on top of the RUTF supplement.

d. She has 3,536 Calories stored as glycogen. If she is burning 885 Calories per hour, she can run 4 hours on her glycogen stores. At this pace (9 miles per hour), she can run 36 miles on her glycogen—a distance greater than a marathon (26.2 miles).
e. She will start to burn other energy sources, which include fats and proteins.

DRIVING QUESTION 3

13 Which process is *not* correctly matched with its cellular location?

a. glycolysis—cytoplasm
b. citric acid cycle—mitochondria
c. glycolysis—mitochondria
d. electron transport—mitochondria
e. none of the above; they are all correctly matched

Answer: c

14 In the presence of oxygen we use_____to fuel ATP production. What process do plants use to fuel ATP production from their stored sugars?

a. aerobic respiration; photosynthesis
b. aerobic respiration; aerobic respiration
c. fermentation; aerobic respiration
d. fermentation; photosynthesis
e. glycolysis; photosynthesis

Answer: b

15 Given 1 g of each of the following, which would yield the greatest amount of ATP by aerobic respiration?

a. fat
b. protein
c. carbohydrate
d. nucleic acid
e. alcohol

Answer: a

16 During aerobic respiration, what molecule has (and carries) electrons stripped from food molecules?

a. NAD^+
b. NADH
c. O_2
d. H_2O
e. pyruvate

Answer: b

17 During aerobic respiration, how does NADH give up electrons to regenerate NAD^+?

a. by giving electrons to O_2
b. by giving electrons to pyruvate
c. by giving electrons to glucose
d. by giving electrons to the electron transport chain
e. by giving electrons to another NAD^+

Answer: d

18 Draw a carbon atom that is part of a CO_2 molecule such as you just exhaled. In a written description or a diagram, trace what happens to that carbon atom as it is absorbed by the leaf of a spinach plant and then what happens to the carbon atom when you eat that leaf in a salad.

Answer: The carbon atom (in the form of CO_2 in the air) will be taken up by the spinach leaf and used to make sugars (glucose) by photosynthesis, which occurs in the chloroplasts in the leaves. The sugar may be used to build cell wall material (cellulose) in the plant, or it may be used in aerobic respiration to generate ATP to power cellular functions, or it may be stored as starch (a polymer of glucose). When humans eat the spinach, they can digest the starch, and then "burn" the released glucose in aerobic respiration. The carbon atoms will be released (and exhaled) as CO_2 back into the air—so will have come full circle.

c. Fermentation cannot sustain life for humans for several reasons. First, fermentation does not produce enough ATP to sustain all our cellular and body functions. Second, the product of fermentation is lactic acid. If a substantial amount of lactic acid accumulates, our blood and tissues will acidify, disrupting the structure and function of most proteins. We cannot survive if our internal environment becomes too acidic, and a stable pH cannot be maintained in the presence of sustained lactic acid production.

26 A 60-year-old CEO wants to lose some weight, but he has bad knees, so can't work out as he used to. He is skeptical about a weight-loss plan not based on exercise. What specific activities can you suggest to him, and what information can you provide to persuade him to give a NEAT plan a try?

Answer: While engaging in intentional exercise can certainly expend many calories, so can engaging in activities known as NEAT activities. These are everyday activities such as standing (instead of sitting), walking a dog, parking farther away from the office (and walking a few extra blocks), taking stairs instead of an elevator, even jiggling your knees as you sit (fidgeting). Studies have shown that people who overeat but have higher levels of NEAT gain less fat than people with lower levels of NEAT. Similarly, lean people tend to spend more time engaging in NEAT activities compared to obese people. It is likely that this CEO can lose weight by increasing his NEAT activities, even if he can't engage in intentional exercise.

Chapter 7 DNA Structure and Replication

DRIVING QUESTION 1

1 Which of the following is *not* a nucleotide found in DNA?

a. adenine (A)
b. thymine (T)
c. cytosine (C)
d. guanine (G)
e. uracil (U)

Answer: e

2 If the sequence of one strand of DNA is AGTCTAGC, what is the sequence of the complementary strand?

a. AGTCTAGC
b. CGATCTGA
c. TCAGATCG
d. GTCGACGC
e. GCTAGACT

Answer: c

3 In addition to the base, what are the other components of a nucleotide?

a. sugar and polymerase
b. phosphate group and sugar
c. phosphate group and polymerase
d. phosphate group and helix
e. helix and sugar

Answer: b

4 The chromosomes in a typical human cell are found in the .

a. 46; cytoplasm
b. 23; nucleus
c. 24; cytoplasm
d. 46; nucleus
e. 22; nucleus

Answer: d

5 Each chromosome contains

a. DNA only.
b. proteins only.
c. DNA and proteins.
d. the same number of genes and STRs.
e. the entire genome of a cell.

Answer: c