19 Fossil fuels are most immediately derived from

a. organic molecules.
b. CO_2.
c. methane.
d. melting ice caps.
e. photosynthesis.

Answer: a

20 Name at least two human activities that increase CO_2 levels in the atmosphere and two natural processes that contribute CO_2 to the atmosphere.

Answer: Burning fossil fuels (e.g., by driving cars) and eating red meat increase atmospheric CO_2 levels. Decomposition increases CO_2 levels in the atmosphere, as do forest fires.

21 How is ice useful in the measurement of atmospheric levels of CO_2?

Answer: Ice traps air bubbles. The air bubbles contain dissolved CO_2 at the levels found in the atmosphere at the time the air was trapped.

22 Describe the evidence that increasing levels of greenhouse gases are responsible for global climate change. What if someone suggested to you that global climate change is due to increased intensity of solar radiation (that is, the amount of sunlight reaching Earth)? What evidence would you ask for in support of this hypothesis?

Answer: The evidence that global greenhouse gases are responsible for global climate change include the fact that current atmospheric CO_2 levels are higher than they have been in a very long time (hundreds of thousands of years); the fact that direct measurements of CO_2 in the atmosphere have shown a rapid increase in the last ~140 years; the fact that the increase in CO_2 concentrations parallels the increasing global temperatures. In order to support the hypothesis that increased solar radiation is responsible for global climate change, it would be necessary to show that worldwide levels of solar radiation are increasing at the same rate as global temperatures, particularly over the same period of time (~140 years) for which we have CO_2 data.

23 Which of the following data would you use to determine the levels of atmospheric CO_2 in 1750? Justify your choice, including an explanation of why the other choices would not be as effective.

a. historical weather records of daily temperatures
b. records for 1750 from the archives of the Mauna Loa Research Station
c. tree-ring analysis (to look for evidence of extreme fires)
d. ice cores from ice formed in 1750

Answer: d. The ideal data would be the analysis of ice cores formed in 1750. Historical temperature records do not directly measure CO_2. The Mauna Loa observatory was not recording data in 1750, and tree-ring analysis does not reveal CO_2 levels.

24 Annie is considering a new car. She is contemplating several options, and has decided that environmental impact (particularly greenhouse gas emissions) is her top priority. After all, she tries to eat primarily grains, fruits and vegetables, and regularly embraces "meatless Mondays." She is looking at a fuel-efficient gasoline powered car, a traditional hybrid (that uses gasoline, but can also run on a battery that recharges while the car is being driven), and a fully electric plug-in car. Discuss the pros and cons of her three vehicle options. What other factors (which may be beyond her control) could affect the emissions associated with owning and driving some of the vehicles she is contemplating?

Answer: Pros of the gasoline powered car include the ability to travel longer distances without a recharge (relative to most electric plug-in cars) and (generally) a lower cost. Cons are the emissions resulting from combustion of gasoline.

Pros of the traditional hybrid include the ability to recharge on the go, the flexibility to run on gasoline if necessary, and the low emissions. Cons include the cost, as well as concerns about battery life and safe disposal.

Pros of the plug-in electric care include no reliance on gasoline (and therefore no emissions from the car itself) and the ability to recharge from the electric grid. Cons include cost, the low number of recharging stations in many areas, and the relatively short distance that can be traveled on a single charge.

For the plug-in electric car, the amount of emissions associated with charging from the electric grid will depend on how the electricity is generated. If the electricity is generated through solar or wind, then there will be no emissions associated with charging from the grid. If the grid is maintained by coal-fired electric plants, then there will be associated emissions.

25 Visit an online carbon footprint or carbon emissions calculator (for example, http://www.epa.gov/climatechange/ghgemissions/ind-calculator.html) and calculate your total carbon emissions.

a. What is your largest source of emissions?
b. What steps can you take to decrease your carbon emissions?
c. Explain how drying your laundry on a clothesline rather than in the dryer can decrease your carbon emissions.

Answer:

a. Answers will vary. Common sources include fossil-fuel powered vehicles, household appliances (which typically run on natural gas or coal-fueled electricity), extensive air travel, and purchasing goods that are transported long distances by air.
b. Emissions from these sources can be reduced by taking public transportation, walking, or riding bikes. Minimizing unnecessary use of electrical appliances and unplugging appliances when they are not in use reduces electrical usage. Buying locally made goods can reduce emissions associated with transportation.
c. Air drying clothes reduces the amount of electricity (or gas) used to power the clothes dryer. Because electricity is most commonly produced at coal-fired plants, reducing electrical usage reduces the amount of coal burned for electricity.

2 Match each nitrogen conversion process with the organism that can carry out that process.

Answer:

Nitrogen Conversion Process		Organism
___b___	N_2 ➔ NH_3	a. humans
___c___	proteins ➔ NH_3	b. nitrogen-fixing bacteria
___a___	N_2 ➔ chemical fertilizer	c. decomposers

3 Which of the following is *not* a reservoir of phosphorus?

a. rocks
b. bodies of plants and animals
c. atmospheric gases
d. the soil
e. bodies of water

Answer: c

4 If phosphorus is important for bones and teeth, why do plants need phosphorus?

Answer: Phosphorus is an important component of the phospholipids that make up cell membranes, and of the nucleotides that make up DNA.

5 Why is carbon not included in industrial fertilizers?

Answer: Plants can fix their own CO_2 into organic carbon by photosynthesis, and there is abundant CO_2 in the atmosphere. Plants obtain CO_2 from the air, so adding carbon to the soil will not be helpful.

6 If you applied to the soil around your plants a chemical that kills bacteria (but not plants), why might your plants die?

Answer: If the chemical killed nitrogen-fixing bacteria in the soil, then the plants might not have enough usable nitrogen (ammonia).

7 You have five containers with specific soils and for each container you can control the composition of the surrounding air. The setup of each container is as follows:

A: sterile soil with no ammonia; limited N_2 in the air
B: sterile soil with no ammonia; abundant N_2 in the air
C: soil with no ammonia but with Rhizobium bacteria; limited N_2 in the air
D: soil with no ammonia but with Rhizobium bacteria; abundant N_2 in the air
E: sterile soil with ammonia added; abundant N_2 in the air

Which container do you predict will support the most robust growth of plants? Explain your answer.

Answer: The plants in container D will likely have the best growth. The Rhizobium bacteria will be able to fix the abundant N_2 to maintain sufficient levels of ammonia in the soil. In contrast, container E has ammonia added, but without nitrogen-fixing bacteria to replenish the ammonia, the plants will not be able to sustain robust growth. The Rhizobium bacteria in container C will not be able to generate much ammonia with limited N_2 in the air.

Chapter 26 Overview of Physiology

DRIVING QUESTION 1

1 Compare and contrast anatomy and physiology.

Answer: Anatomy is the study of the structure of living organisms. Physiology is the study of how organisms function, particularly with respect to maintaining homeostasis.

2 Organize the following terms on the basis of level of structure, from the simplest (1) to the most complex (4).

Small intestine
Mucus-secreting cell of the small intestine
Digestive system
Layer of muscle that contributes to the function of the small intestine

Answer: (1) mucus-secreting cell of the small intestine; (2) layer of muscle that contributes to the function of the small intestine; (3) small intestine; (4) digestive system

3 Which of the following groups is in the correct order of organization from most inclusive level to lowest level?

a. tissues, cells, organ systems, organs
b. organ systems, organs, tissues, cells
c. cells, organ systems, tissues, organs
d. cells, tissues, organs, organ systems
e. cells, organs, organ systems, tissues

Answer: b

4 An emergency room doctor setting a complex bone fracture is relying primarily on knowledge of

a. anatomy.
b. physiology.
c. thermoregulation.
d. homeostasis.
e. osmoregulation.

Answer: a

5 Is a personal trainer who works with clients to help them lose weight through a combination of diet and exercise focusing primarily on anatomy or physiology? Explain your answer.

Answer: The trainer is focusing on physiology. Both dietary and exercise work through a variety of metabolic processes and require homeostatic mechanisms (e.g., body temperature regulation, blood sugar regulation, ATP production, lipid storage vs. lipid utilization, heart rate, breathing rate).

6 Why is the heart considered an organ and not a tissue?

Answer: The heart is made up of more than one tissue type, all of which work together to maintain heart function. For example, the heart contains both nervous tissue and muscle tissue.

DRIVING QUESTION 2

7 What is homeostasis?

Answer: Homeostasis is the maintenance of a relatively stable internal environment, even when the external environment changes.

8 How does brown fat contribute to thermoregulation in bats?

a. by providing insulation to retain heat
b. by providing a highly vascularized tissue to release heat to the environment
c. by generating heat through shivering
d. by generating heat via cellular respiration in specialized mitochondria
e. b and d

Answer: d

overweight (but not morbidly obese) may want to consider consulting with a physician to discuss their general health, the risks associated with their current weight, the risks and challenges associated with the surgery, and nonsurgical options for weight management.

20 A 2012 study compared the impacts of medical therapy and bariatric surgery in obese people with uncontrolled type 2 diabetes. Patients were randomly assigned to receive aggressive medical therapy for their diabetes (including medications and diet and lifestyle modifications) or bariatric surgery. Several dependent variables were measured for 1 year. Two of these variables—average BMI and average number of diabetes medications—are shown in the table below.

a. Draw two graphs, one plotting the average diabetes medications over time for the group receiving medical therapy and for the group receiving surgery, and one plotting the change in BMI from baseline for the two groups (set the baseline values at 0 on the time axis because by definition no change can have taken place yet).

b. From these graphs, how does gastric bypass compare to medical therapy for diabetes management in obese patients with type 2 diabetes?

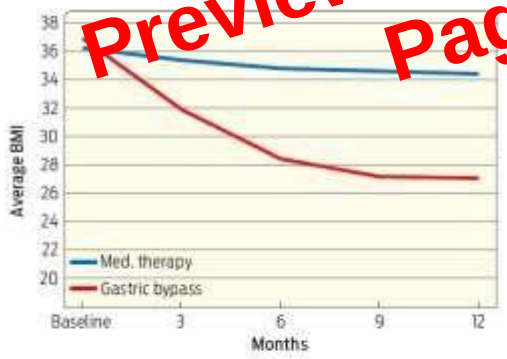
c. The data shown in the table are for 41 patients who had medical therapy and 50 patients who had gastric bypass. From this information and any other limitations you can identify, are these data sufficient to make a recommendation of surgery for diabetes management? Why or why not?

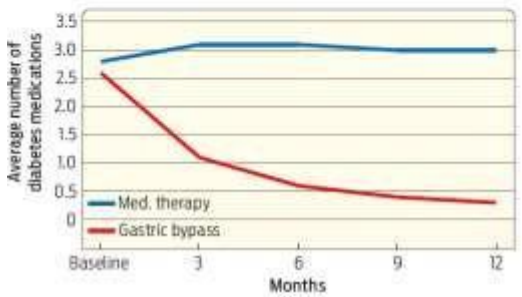
Treatment	Variable	Baseline	Time after Treatment			
			3 Mos.	6 Mos.	9 Mos.	12 Mos.
Medical therapy	Average BMI	36.3	35.4	34.8	34.5	34.4
	Average no. of diabetes medications	2.8	3.1	3.1	3.0	3.0
Gastric bypass	Average BMI	37.0	31.8	28.2	26.9	26.8
	Average no. of diabetes medications	2.6	1.1	0.6	0.4	0.3

Data from Schauer, P. R., et al. (2012) Bariatric surgery versus intensive medical therapy in obese patients with diabetes. *New England Journal of Medicine* 366(17):1567–1576.

Answer:

a.





b. Those who had gastric bypass surgery were able to reduce their average number of diabetes medications within 1 year, but those who received medical therapy were not.

c. The results are encouraging for the impact of gastric bypass on management of diabetes in obese individuals. Nevertheless, this study was small, and there has been only a 1-year follow-up. The weight loss seemed to be leveling off at the end of the study, and we don't know if participants who regain the weight will need to resume taking medications. It would be important to see this study replicated with more participants and a longer follow-up period before recommending whether or not to use gastric bypass in diabetes management.

5 Asthma is a disease that causes swelling and constriction of the airways in the lungs. Compare the predicted symptoms of asthma with the symptoms of pneumonia. Can you think of any treatments for asthma that might be different from treatments for pneumonia?

Answer: In the case of swollen and constricted airways, air may not be able to move readily between the outside of the body and the alveoli, where oxygen from fresh air enters the bloodstream. This would lead to shortness of breath, also a symptom of pneumonia. Because the air is moving through constricted passages, asthma often causes wheezing. Asthma symptoms can be treated by drugs that open the airways. Because constricted airways are not an underlying cause of pneumonia, asthma drugs that open airways would not be effective in treating pneumonia.

DRIVING QUESTION 2

6 How is O_2 transported throughout the body?

a. dissolved in the plasma of blood
b. bound to hemoglobin in plasma
c. bound to hemoglobin in white blood cells
d. bound to hemoglobin in red blood cells
e. dissolved in the cytoplasm of red blood cells

Answer: d

7 What can cause a drop in blood pH?

a. a decrease in O_2
b. an increase in O_2
c. a decrease in CO_2
d. an increase in CO_2
e. b or d

Answer: d

8 If blood pH drops, what happens to the breathing rate? Explain your answer.

Answer: If blood pH drops and the blood becomes more acidic, breathing rate will increase, removing CO_2 from the lungs more quickly. The removal of CO_2 helps restore blood pH because elevated CO_2 contributes to acidification of the blood.

9 Oxygen diffuses from the air in alveoli to the blood in lung capillaries. Diffusion occurs rapidly over short distances, but decreases dramatically with increasing distance. Pneumonia is an accumulation of fluid in the alveolar air spaces. Why does pneumonia cause shortness of breath and give a bluish tint to the skin and nails?

Answer: The accumulation of fluid in the alveoli increases the distance between the oxygen in the air in the alveoli and the capillaries underlying the alveoli. Diffusion of oxygen is not as efficient over this increased distance, and less oxygen enters the blood as it passes through the lungs. The reduction in blood oxygen causes shortness of breath, and less-oxygenated blood appears bluish under the skin.

10 Breathing in and out of a paper bag will pH and therefore ventilation.

a. not change; not change
b. increase; increase
c. increase; decrease
d. decrease; decrease
e. decrease; increase

Answer: e

DRIVING QUESTION 3

11 Relative to a tissue at rest, actively exercising tissues have

a. higher temperature, higher P_{O_2}, and higher pH.
b. higher temperature, lower P_{O_2} and lower pH.
c. higher temperature, higher P_{O_2} and lower pH.
d. lower temperature, higher P_{O_2} and higher pH.
e. lower temperature, lower P_{O_2} and lower pH.

Answer: b

DRIVING QUESTION 2

6 Name three components of the innate immune system. For each, provide a brief description of how it offers protection.

Answer: Skin provides a barrier to pathogen entry. Enzymes in tears and saliva digest components of a pathogen. Phagocytes ingest and destroy pathogens.

7 What are phagocytes, and what do they do?

Answer: Phagocytes are white blood cells that engulf and destroy invaders, including bacteria.

8 From what you know about innate immunity, would you predict different or identical innate responses to infections from *E. coli* (a bacterium) and *S. aureus* (another bacterium)? Explain your answer.

Answer: Because innate immunity is nonspecific (it does not uniquely recognize different pathogens), the innate response to *E. coli* will be the same as the innate response to *S. aureus*.

9 Neutropenia is a deficiency in a type of phagocytic cell called neutrophils. Neutrophils are among the "first responders" to an injury or infection. Would you expect someone with neutropenia to be able to mount an effective inflammatory response? Explain your answer.

Answer: Because neutrophils are important phagocytes in the inflammatory response, someone who is deficient in neutrophils will not be able to mount an effective inflammatory response.

10 Why might someone taking anti-inflammatory drugs be more susceptible than others to bacterial infections?

Answer: The inflammatory response is important in killing and containing pathogens at their sites of entry. Someone taking anti-inflammatory drugs will be more vulnerable to infections because the drugs suppress an important component of his or her innate defenses.

DRIVING QUESTION 3

11 Compare and contrast the features of innate and adaptive immunity.

Answer: Innate immunity is present since birth, always active and nonspecific. It does not have "memory." Adaptive immunity is specific for a particular pathogen and must be turned on when that pathogen is encountered—it is not always "on." Adaptive immunity exhibits "memory": it strengthens with repeated exposures to the same pathogen.

12 B cells, plasma cells, and antibodies are all related. Describe this relationship, using words, a diagram, or both.

Answer: B cells are lymphocytes that are activated during an adaptive response. Upon activation, they become antibody-producing plasma cells specialized to act against a specific pathogen. The antibodies produced specifically bind to and inactivate their targets.

13 Anti–hepatitis C antibodies present in a patient's blood indicate

a. that the patient is mounting an innate response.
b. that the patient has been exposed to HIV.
c. that the patient was exposed to hepatitis C within the last 24 hours.
d. that the patient was exposed to hepatitis C at least 2 weeks ago.
e. that the patient has hepatitis.

Answer: d

14 Vaccination against a particular pathogen stimulates what type of response?

a. innate
b. primary
c. secondary
d. autoimmune
e. b and c

Answer: b

15 Will someone who has been exposed to seasonal influenza in the past

a. have memory B cells?
b. still be at risk for seasonal influenza next year? Why?
c. still be at risk for pandemic swine flu? Why?

Answer:

a. Yes. He or she will have memory B cells specific for the influenza virus they were exposed to.
b. Yes. He or she is still at risk for next year's seasonal flu. Flu varies seasonally as a result of mutations, so his or her memory cells may not recognize the strain of seasonal flu circulating next year.

c. Yes. He or she is still at risk for H1N1 swine flu because that strain of flu is substantially different from seasonal flu. Prior exposure to seasonal flu will not protect against H1N1.

16 *Staphylococcus aureus* can cause a bacterial skin infection that can become very serious.

a. Why does the body exhibit innate and adaptive responses to *Staphylococcus aureus* but not to its own skin cells?

b. Will the innate response to *Staphylococcus aureus* be equally effective against *Streptococcus pyogenes*, another bacterium that can cause skin infections? Explain your answer.

c. Will the adaptive response to *Staphylococcus aureus* be equally effective against *Streptococcus pyogenes*? Explain your answer.

Answer:

a. *S. aureus* is foreign, or nonself. Both innate and adaptive immunity act against foreign invaders.

b. Yes. Because the innate response does not specifically recognize individual pathogens, the innate response to *S. aureus* will be equally effective against *S. pyogenes*.

c. No. The adaptive response to *S. aureus* will not be effective against *S. pyogenes*. The adaptive response to *S. aureus* is specific to *S. aureus* and is not effective against other bacteria.

17 HIV is a virus that infects and eventually destroys helper T cells. Why do people with AIDS (that is, with advanced HIV infections) often die from infections by other pathogens?

Answer: Helper T cells are critical in mounting an effective adaptive response. In the absence of helper T cells, the ability to mount an adaptive immune response is compromised, leaving someone with AIDS vulnerable to a variety of infections.

18 In 2008, there was an outbreak of measles in San Diego. The first patient was a 7-year-old unvaccinated boy who had returned home from a family trip to Switzerland. He began to develop a cough, sore throat, and fever, but continued to attend school. He was taken to his pediatrician when he developed a rash, and then was sent to the emergency room because of a very high fever. Blood tests revealed antimeasles antibodies. Eleven other children ended up developing measles; none had been vaccinated. The other cases were the 2 siblings of the first patient, 4 children in his school and 5 children who were in the pediatrician's office at the same time as the patient. Of the 11 additional cases, 3 children were less than 1 year old. (Data are from Outbreak of measles—San Diego, California, January—February 2008 (2008) *Morbidity and Mortality Weekly Report* 57(8): 203–206.)

a. Why was the presence of antimeasles antibodies in the first case an important finding?

b. What can you infer about how easily measles spreads?

c. What does this case suggest about the importance of measles vaccinations?

d. Were all the unvaccinated children necessarily behind on their vaccination schedule? (Hint: Look up the recommended measles vaccination schedule on the Centers for Disease Control and Prevention website, www.cdc.gov.)

Answer:

a. Because the boy had not been vaccinated, the only way he would have antimeasles antibodies would be if he had been exposed to the measles virus. This circumstance helped make the diagnosis of measles.

b. Children in the doctor's office and in the school developed measles by simply being in the same place as the patient; this suggests that measles spreads very easily.

c. All of the children who developed measles were unvaccinated, suggesting that unvaccinated children are vulnerable to developing measles.

d. The first measles shot should be given around the first birthday, at 12–15 months of age. Thus, the youngest children (those less than a year old) were not behind on their vaccination schedule—they were too young to be vaccinated, and therefore vulnerable to contracting measles.

19 Almost 10% of the children in the school attended by the original patient described in the Mini Case were unvaccinated because their parents had filed Personal Belief Exemptions stating that they did not want to vaccinate their children. What is your local school district or state policy on vaccinations for enrolled students? This information is typically available at the school district website or the state's health department website. From the policies in place (and whether they permit any exemptions), do you think it is possible that a measles outbreak could occur in a local school?

Answers will vary. Some states allow exemptions for personal beliefs, and some allow exemptions for religious reasons; exemptions can be requested because of allergies to the components of a vaccine. If a substantial proportion of students in a school is unvaccinated, vaccine-preventable diseases such as measles can spread throughout the unvaccinated population.

DRIVING QUESTION 4

20 What is the difference between antigenic shift and antigenic drift?

Answer: Antigenic shift occurs when viruses exchange genes, such that a virus can have genes from a completely different virus. A virus resulting from antigenic shift tends to be very different from either starting virus. Antigenic drift describes small changes, caused by mutations, in the viral genome.