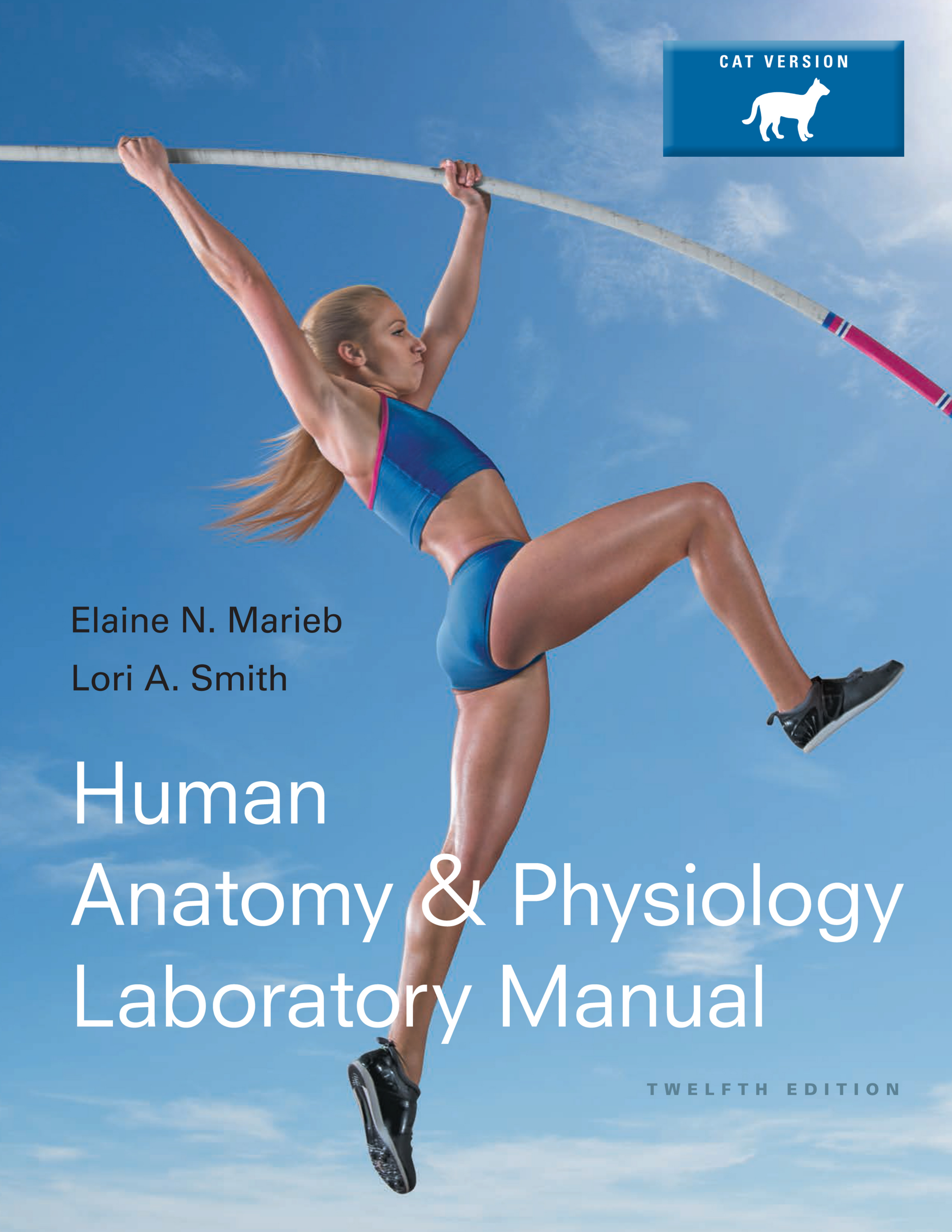


CAT VERSION

Elaine N. Marieb

Lori A. Smith

Human Anatomy & Physiology Laboratory Manual

TWELFTH EDITION

Getting Started—What to Expect, The Scientific Method, and Metrics

Two hundred years ago, science was largely a plaything of wealthy patrons, but today's world is dominated by science and its technology. Whether or not we believe that such domination is desirable, we all have a responsibility to try to understand the goals and methods of science that have seeded this knowledge and technological explosion.

The biosciences are very special and exciting because they open the doors to an understanding of all the wondrous workings of living things. A course in human anatomy and physiology (a subdivision of bioscience) provides such insights in relation to your own body. Although some experience in scientific studies is helpful when beginning a study of anatomy and physiology, perhaps the single most important prerequisite is curiosity.

Gaining an understanding of science is a little like becoming acquainted with another person. Even though a written description can provide a good deal of information about the person, you can never really know another unless there is personal contact. And so it is with science—if you are to know it well, you must deal with it intimately.

The laboratory is the setting for "intimate contact" with science. It is where scientists test their ideas (do research), the essential purpose of which is to provide a basis from which predictions about scientific phenomena can be made. Likewise, it will be the site of your "intimate contact" with the subject of human anatomy and physiology as you are introduced to the methods and instruments used in biological research.

For many students, human anatomy and physiology is an introductory-level course; and their scientific background exists, at best, as a dim memory. If this is your predicament, this prologue may be just what you need to fill in a few gaps and to get you started on the right track before your actual laboratory experiences begin. So—let's get to it!

The Scientific Method

Science would quickly stagnate if new knowledge were not continually derived from and added to it. The approach scientists commonly use when they investigate various aspects of their respective disciplines is called the **scientific method.** This method is *not* a single rigorous technique that must be followed in a lockstep manner. It is nothing more or less than a logical, practical, and reliable way of approaching and solving problems of every kind—scientific or otherwise—to gain knowledge. It includes five major steps.

Step 1: Observation of Phenomena

The crucial first step involves observation of some phenomenon of interest. In other words, before a scientist can investigate anything, he or she must decide on a *problem* or focus for the investigation. In most college laboratory experiments, the problem or focus has been decided for you. However, to illustrate this important step, we will assume that you want to investigate the true nature of apples, particularly green apples. In such a case you would begin your studies by making a number of different observations concerning apples.

Step 2: Statement of the Hypothesis

Once you have decided on a focus of concern, the next step is to design a significant question to be answered. Such a question is usually posed in the form of a **hypothesis,** an unproven conclusion that attempts to explain some phenomenon. (At its crudest level, a hypothesis can be considered to be a "guess" or an intuitive hunch that tentatively explains some observation.) Generally, scientists do not restrict themselves to a single hypothesis; instead, they usually pose several and then test each one systematically.

We will assume that to accomplish step 1, you go to the supermarket and randomly select apples from several bins. When you later eat the apples, you find that the green apples are sour but that the red and yellow apples are sweet. From this observation, you might conclude *(hypothesize)* that "green apples are sour." This statement would represent your current understanding of green apples. You might also reasonably predict that if you were to buy more apples, any green ones you buy will be sour. Thus, you would have gone beyond your initial observation that "these" green apples are sour to the prediction that "all" green apples are sour.

Any good hypothesis must meet several criteria. First, *it must be testable.* This characteristic is far more important than its being correct. The test data may or may not support the hypothesis, or new information may require that the hypothesis be modified. Clearly the accuracy of a prediction in any scientific study depends on the accuracy of the initial information on which it is based.

In our example, no great harm will come from an inaccurate prediction—that is, were we to find that some green apples are sweet. However, in some cases human life may depend on the accuracy of the prediction. For that and other reasons: (1) Repeated testing of scientific ideas is important, particularly because scientists working on the same problem do not always agree in their conclusions. (2) Careful observation is essential, even at the very outset of a study, because conclusions drawn from scientific tests are only as accurate as the information on which they are based.

A second criterion is that, even though hypotheses are guesses of a sort, *they must be based on measurable, describable facts. No mysticism can be theorized.* We cannot conjure up, to support our hypothesis, forces that have not been shown to exist. For example, as scientists, we cannot say that the tooth fairy took Johnny's tooth unless we can prove that the tooth fairy exists!

Third, a hypothesis *must not be anthropomorphic.* Human beings tend to anthropomorphize—that is, to relate all experiences to human experience. Whereas we could state that bears instinctively protect their young, it would be anthropomorphic to say that bears love their young, because love is a human emotional response. Thus, the initial hypothesis must be stated without interpretation.

Step 3: Data Collection

Once the initial hypothesis has been stated, scientists plan experiments that will provide data (or evidence) to support or disprove their hypotheses—that is, they *test* their hypotheses. They accumulate data by making qualitative or quantitative observations of some sort. The observations are often aided by the use of various types of equipment such as cameras, microscopes, stimulators, or various electronic devices that allow chemical and physiological measurements to be taken.

Observations referred to as **qualitative** are those we can make with our senses—that is, by using our vision, hearing, or sense of taste, smell, or touch. For some quick practice in qualitative observation, compare and contrast an orange and an apple. (*Compare* means to emphasize the similarities between two things, whereas *contrast* means to emphasize the differences.)

Whereas the differences between an apple and an orange are obvious, this is not always the case in biological observations. Quite often a scientist tries to detect very subtle differences that cannot be determined by qualitative observations; data must be derived from measurements. Such observations based on precise measurements of one type or another are **quantitative observations**. Examples of quantitative observations include careful measurements of body or organ dimensions such as mass, size, and volume; measurement of volumes of oxygen consumed during metabolic studies; determination of the concentration of glucose in urine; and determination of the differences in blood pressure and pulse under conditions of rest and exercise. An apple and an orange could be compared quantitatively by analyzing the relative amounts of sugar and water in a given volume of fruit flesh, the pigments and vitamins present in the apple skin and orange peel, and so on.

A valuable part of data gathering is the use of experiments to support or disprove a hypothesis. An **experiment** is a procedure designed to describe the factors in a given situation that affect one another (that is, to discover cause and effect) under certain conditions.

Two general rules govern experimentation. The first of these rules is that the experiment(s) should be conducted in such a manner that every **variable** (any factor that might affect the outcome of the experiment) is under the control of the experimenter. The **independent variables** are manipulated by the experimenter. For example, if the goal is to determine the effect of body temperature on breathing rate, the independent variable is body temperature. The effect observed or value measured (in this case breathing rate) is called the **dependent** or **response variable**. Its value "depends" on the value chosen for the independent variable. The ideal way to perform such an experiment is to set up and run a series of tests that are all identical, except for one specific factor that is varied.

One specimen (or group of specimens) is used as the **control** against which all other experimental samples are compared. The importance of the control sample cannot be overemphasized. The control group provides the "normal standard" against which all other samples are compared relative to the dependent variable. Taking our example one step further, if we wanted to investigate the effects of body temperature (the independent variable) on breathing rate (the dependent variable), we could collect data on the breathing rate of individuals with "normal" body temperature (the implicit control group), and compare these data to breathing-rate measurements obtained from groups of individuals with higher and lower body temperatures.

The second rule governing experimentation is that valid results require that testing be done on large numbers of subjects. It is essential to understand that it is nearly impossible to control all possible variables in biological tests. Indeed, there is a bit of scientific wisdom that mirrors this truth—that is, that laboratory animals, even in the most rigidly controlled and carefully designed experiments, "will do as they damn well please." Thus, stating that the testing of a drug for its painkilling effects was successful after having tested it on only one postoperative patient would be scientific suicide. Large numbers of patients would have to receive the drug and be monitored for a decrease in postoperative pain before such a statement could have any scientific validity. Then, other researchers would have to be able to uphold those conclusions by running similar experiments. *Repeatability* is an important part of the scientific method and is the primary basis for support or rejection of many hypotheses.

During experimentation and observation, data must be carefully recorded. Usually, such initial, or raw, data are recorded in table form. The table should be labeled to show the variables investigated and the results for each sample. At this point, *accurate recording* of observations is the primary concern. Later, these raw data will be reorganized and manipulated to show more explicitly the outcome of the experimentation.

Some of the observations that you will be asked to make in the anatomy and physiology laboratory will require that a drawing be made. Don't panic! The purpose of making drawings (in addition to providing a record) is to force you to observe things very closely. You need not be an artist (most biological drawings are simple outline drawings), but you do need to be neat and as accurate as possible. It is advisable to use a 4H pencil to do your drawings because it is easily erased and doesn't smudge. Before beginning to draw, you should examine your specimen closely, studying it as though you were going to have to draw it from memory. For example, when looking at cells you should ask yourself questions such as "What is their shape—the relationship of length and width? How are they joined together?" Then decide precisely what you are going to show and how large the drawing must be to show the necessary detail. After making the drawing, add labels in the margins and connect them by straight lines (leader lines) to the structures being named.

Step 4: Manipulation and Analysis of Data

The form of the final data varies, depending on the nature of the data collected. Usually, the final data represent information converted from the original measured values (raw data) to some other form. This may mean that averaging or some other statistical treatment must be applied, or it may require conversions from one kind of units to another. In other cases, graphs may be needed to display the data.

Elementary Treatment of Data

Only very elementary statistical treatment of data is required in this manual. For example, you will be expected to understand and/or compute an average (mean), percentages, and a range.

Two of these statistics, the mean and the range, are useful in describing the *typical* case among a large number of samples evaluated. Let us use a simple example. We will assume that the following heart rates (in beats/min) were recorded during an experiment: 64, 70, 82, 94, 85, 75, 72, 78. If you put these numbers in numerical order, the **range** is easily computed, because the range is the difference between the highest and lowest numbers obtained (highest number minus lowest number). The **mean** is obtained by summing the items and dividing the sum by the number of items. What is the range and the mean for the set of numbers just provided?

1. ____*

The word *percent* comes from the Latin meaning "for 100"; thus *percent,* indicated by the percent sign, %, means parts per 100 parts. Thus, if we say that 45% of Americans have type O blood, what we are really saying is that among each group of 100 Americans, 45 (45/100) can be expected to have type O blood. Any ratio can be converted to a percent by multiplying by 100 and adding the percent sign.

$$.25 \times 100 = 25\% \qquad 5 \times 100 = 500\%$$

It is very easy to convert any number (including decimals) to a percent. The rule is to move the decimal point two places to the right and add the percent sign. If no decimal point appears, it is *assumed* to be at the end of the number; and zeros are added to fill any empty spaces. Two examples follow:

$$0.25 = 0.25 = 25\%$$
$$5 = 5 \quad = 500\%$$

Change the following to percents:

2. 38 = ___________ **4.** 1.6 = ___________

3. .75 = ___________

Note that although you are being asked here to convert numbers to percents, percents by themselves are meaningless. We always speak in terms of a percentage *of* something.

To change a percent to decimal form, remove the percent sign, and divide by 100. Change the following percents to whole numbers or decimals:

5. 800% = ___________ **6.** 0.05% = ___________

Making and Reading Line Graphs

For some laboratory experiments you will be required to show your data (or part of them) graphically. Simple line graphs allow relationships within the data to be shown interestingly and allow trends (or patterns) in the data to be demonstrated. An advantage of properly drawn graphs is that they save the reader's time because the essential meaning of a large amount of statistical data can be seen at a glance.

To aid in making accurate graphs, graph paper (or a printed grid in the manual) is used. Line graphs have both horizontal (X) and vertical (Y) axes with scales. Each scale should have uniform intervals—that is, each unit measured on the scale should require the same distance along the scale as any other. Variations from this rule may be misleading and result in false interpretations of the data. By convention, the condition that is manipulated (the independent variable) in the experimental series is plotted on the X-axis (the horizontal axis); and the value that we then measure (the dependent variable) is plotted on the Y-axis (the vertical axis). To plot the data, a dot or a small x is placed at the precise point where the two variables (measured for each sample) meet; and then a line (this is called the **curve**) is drawn to connect the plotted points.

Sometimes, you will see the curve on a line graph extended beyond the last plotted point. This is (supposedly) done to predict "what comes next." When you see this done, be skeptical. The information provided by such a technique is only slightly more accurate than that provided by a crystal ball! When constructing a graph, be sure to label the X-axis and Y-axis and give the graph a legend **(Figure 1)**.

To read a line graph, pick any point on the line, and match it with the information directly below on the X-axis and with that directly to the left of it on the Y-axis. The figure below (Figure 1) is a graph that illustrates the relationship between breaths per minute (respiratory rate) and body temperature. Answer the following questions about this graph:

7. What was the respiratory rate at a body temperature of 96°F? _________________

8. Between which two body temperature readings was the increase in breaths per minute greatest? _________________

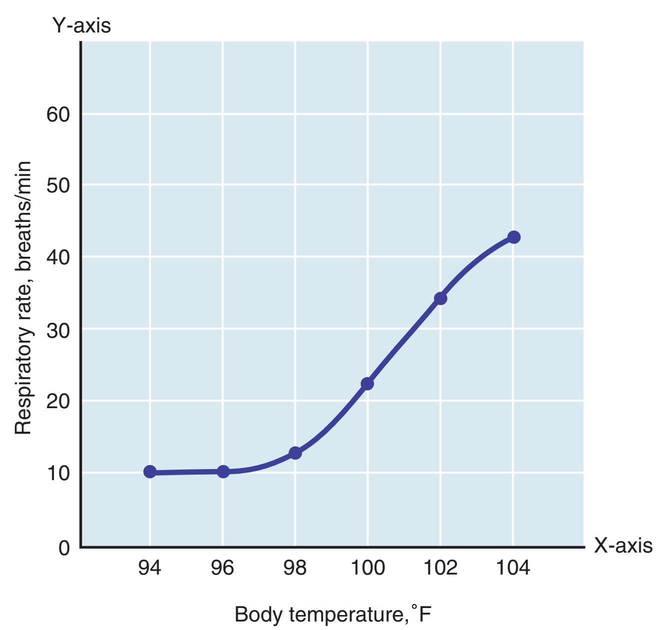


Figure 1 Example of graphically presented data. Respiratory rate as a function of body temperature.

*Answers are given at the end of this section (page xx).

Step 5: Reporting Conclusions of the Study

Drawings, tables, and graphs alone do not suffice as the final presentation of scientific results. The final step requires that you provide a straightforward description of the conclusions drawn from your results. If possible, your findings should be compared to those of other investigators working on the same problem. For laboratory investigations conducted by students, these comparative figures are provided by classmates.

It is important to realize that scientific investigations do not always yield the anticipated results. If there are discrepancies between your results and those of others, or what you expected to find based on your class notes or textbook readings, this is the place to try to explain those discrepancies.

Results are often only as good as the observation techniques used. Depending on the type of experiment conducted, you may need to answer several questions. Did you weigh the specimen carefully enough? Did you balance the scale first? Was the subject's blood pressure actually as high as you recorded it, or did you record it inaccurately? If you did record it accurately, is it possible that the subject was emotionally upset about something, which might have given falsely high data for the variable being investigated? Attempting to explain an unexpected result will often teach you more than you would have learned from anticipated results.

When the experiment produces results that are consistent with the hypothesis, then the hypothesis can be said to have reached a higher level of certainty. The probability that the hypothesis is correct is greater.

A hypothesis that has been validated by many different investigators is called a **theory.** Theories are useful in two important ways. First, they link sets of data; and second, they make predictions that may lead to additional avenues of investigation. (OK, we know this with a high degree of certainty; what's next?)

When a theory has been repeatedly verified and appears to have wide applicability in biology, it may assume the status of a **biological principle.** A principle is a statement that applies with a high degree of probability to a range of events. For example, "Living matter is made of cells or cell products" is a principle stated in many biology texts. It is a sound and useful principle, and will continue to be used as such—unless new findings prove it wrong.

We have been through quite a bit of background concerning the scientific method and what its use entails. Because it is important that you remember the phases of the scientific method, they are summarized here:

1. Observation of some phenomenon

2. Statement of a hypothesis (based on the observations)

3. Collection of data (testing the hypothesis with controlled experiments)

4. Manipulation and analysis of the data

5. Reporting of the conclusions of the study (routinely done by preparing a lab report—see page xvii)

Lab Report

Cover Page

- Title of Experiment
- Author's Name
- Course
- Instructor
- Date

Introduction

- Provide background information.
- Describe any relevant observations.
- State hypotheses clearly.

Materials and Methods

- List equipment or supplies needed.
- Provide step-by-step directions for conducting the experiment.

Results

- Present data using a drawing (figure), table, or graph.
- Analyze data.
- Summarize findings briefly.

Discussion and Conclusions

- Conclude whether data gathered support or do not support hypotheses.
- Include relevant information from other sources.
- Explain any uncontrolled variables or unexpected difficulties.
- Make suggestions for further experimentation.

Reference List

- Cite the source of any material used to support this report.

Writing a Lab Report Based on The Scientific Method

A laboratory report is not the same as a scientific paper, but it has some of the same elements and is a formal way to report the results of a scientific experiment. The report should have a cover page that includes the title of the experiment, the author's name, the name of the course, the instructor, and the date. The report should include five separate, clearly marked sections: Introduction, Materials and Methods, Results, Discussion and Conclusions, and References. Use the previous template to guide you through writing a lab report.

Metrics

No matter how highly developed our ability to observe, observations have scientific value only if we can communicate them to others. Without measurement, we would be limited to qualitative description. For precise and repeatable communication of information, the agreed-upon system of measurement used by scientists is the **metric system.**

A major advantage of the metric system is that it is based on units of 10. This allows rapid conversion to workable numbers so that neither very large nor very small figures need be used in calculations. Fractions or multiples of the standard units of length, volume, mass, time, and temperature have been assigned specific names. The metric system **(Table 1)** shows the commonly used units of the metric system, along with the prefixes used to designate fractions and multiples thereof.

To change from smaller units to larger units, you must *divide* by the appropriate factor of 10 (because there are fewer of the larger units). For example, a milliunit (*milli* = one-thousandth), such as a millimeter, is one step smaller than a centiunit (*centi* = one-hundredth), such as a centimeter. Thus to change milliunits to centiunits, you must divide by 10. On the other hand, when converting from larger units to smaller ones, you must *multiply* by the appropriate factor of 10. A partial scheme for conversions between the metric units is shown on the next page.

The objectives of the sections that follow are to provide a brief overview of the most-used measurements in science or health professions and to help you gain some measure of confidence in dealing with them. A listing of the most frequently used conversion factors, for conversions between British and metric system units, is provided on the inside back cover.

Length Measurements

The metric unit of length is the **meter (m).** Smaller objects are measured in centimeters or millimeters. Subcellular structures are measured in micrometers.

To help you picture these units of length, some equivalents follow:

One meter (m) is slightly longer than one yard (1 m = 39.37 in.).

One centimeter (cm) is approximately the width of a piece of chalk. (Note: There are 2.54 cm in 1 in.)

One millimeter (mm) is approximately the thickness of the wire of a paper clip or of a mark made by a No. 2 pencil lead.

One micrometer (µm) is extremely tiny and can be measured only microscopically.

Make the following conversions between metric units of length:

9. 12 cm = __________ mm

10. 2000 µm = __________ mm

Now, circle the answer that would make the most sense in each of the following statements:

11. A match (in a matchbook) is (0.3, 3, 30) cm long.

12. A standard-size American car is about 4 (mm, cm, m, km) long.

Table 1 Metric System

A. Commonly used units		B. Fractions and their multiples		
Measurement	**Unit**	**Fraction or multiple**	**Prefix**	**Symbol**
Length	Meter (m)	10^6 one million	mega	M
Volume	Liter (L; l with prefix)	10^3 one thousand	kilo	k
Mass	Gram (g)	10^{-1} one-tenth	deci	d
Time*	Second (s)	10^{-2} one-hundredth	centi	c
Temperature	Degree Celsius (°C)	10^{-3} one-thousandth	milli	m
		10^{-6} one-millionth	micro	µ
		10^{-9} one-billionth	nano	n

* The accepted standard for time is the second; and thus hours and minutes are used in scientific, as well as everyday, measurement of time. The only prefixes generally used are those indicating *fractional portions* of seconds—for example, millisecond and microsecond.

$$\text{microunit} \underset{\times 1000}{\overset{\div 1000}{\rightleftharpoons}} \text{milliunit} \underset{\times 10}{\overset{\div 10}{\rightleftharpoons}} \text{centiunit} \underset{\times 100}{\overset{\div 100}{\rightleftharpoons}} \text{unit} \underset{\times 1000}{\overset{\div 1000}{\rightleftharpoons}} \text{kilounit}$$

$$\text{smallest} \rightleftharpoons \text{largest}$$

Volume Measurements

The metric unit of volume is the liter. A **liter** (l, or sometimes L, especially without a prefix) is slightly more than a quart (1 L = 1.057 quarts). Liquid volumes measured out for lab experiments are usually measured in milliliters (ml). (The terms *ml* and *cc,* cubic centimeter, are used interchangeably in laboratory and medical settings.)

To help you visualize metric volumes, the equivalents of some common substances follow:

A 12-oz can of soda is a little less than 360 ml.

A fluid ounce is about 30 (it's 29.57) ml (cc).

A teaspoon of vanilla is about 5 ml (cc).

Compute the following:

13. How many 5-ml injections can be prepared from 1 liter of a medicine? ______________

14. A 450-ml volume of alcohol is ______________ L.

Mass Measurements

Although many people use the terms *mass* and *weight* interchangeably, this usage is inaccurate. **Mass** is the amount of matter in an object; and an object has a constant mass, regardless of where it is—that is, on earth, or in outer space. However, weight varies with gravitational pull; the greater the gravitational pull, the greater the weight. Thus, our astronauts are said to be weightless when in outer space, but they still have the same mass as they do on earth. (Astronauts are not *really* weightless. It is just that they and their surroundings are being pulled toward the earth at the same speed; and so, in reference to their environment, they appear to float.)

The metric unit of mass is the **gram (g).** Medical dosages are usually prescribed in milligrams (mg) or micrograms (µg); and in the clinical agency, body weight (particularly of infants) is typically specified in kilograms (kg; 1 kg = 2.2 lb).

The following examples are provided to help you become familiar with the masses of some common objects:

Two aspirin tablets have a mass of approximately 1 g.

A nickel has a mass of 5 g.

The mass of an average woman (132 lb) is 60 kg.

Make the following conversions:

15. 300 g = __________ mg = __________ µg

16. 4000 µg = __________ mg = __________ g

17. A nurse must administer to her patient, Mrs. Smith, 5 mg of a drug per kg of body mass. Mrs. Smith weighs 140 lb. How many grams of the drug should the nurse administer to her patient?

__________ g

Temperature Measurements

In the laboratory and in the clinical agency, temperature is measured both in metric units (degrees Celsius, °C) and in British units (degrees Fahrenheit, °F). Thus it helps to be familiar with both temperature scales.

The temperatures of boiling and freezing water can be used to compare the two scales:

The freezing point of water is 0°C and 32°F.

The boiling point of water is 100°C and 212°F.

As you can see, the range from the freezing point to the boiling point of water on the Celsius scale is 100 degrees, whereas the comparable range on the Fahrenheit scale is 180 degrees. Hence, one degree on the Celsius scale represents a greater change in temperature. Normal body temperature is approximately 98.6°F or 37°C.

To convert from the Celsius scale to the Fahrenheit scale, the following equation is used:

$$°\text{C} = \frac{5\,(°\text{F} - 32)}{9}$$

To convert from the Fahrenheit scale to the Celsius scale, the following equation is used:

$$°\text{F} = (9/5\ °\text{C}) + 32$$

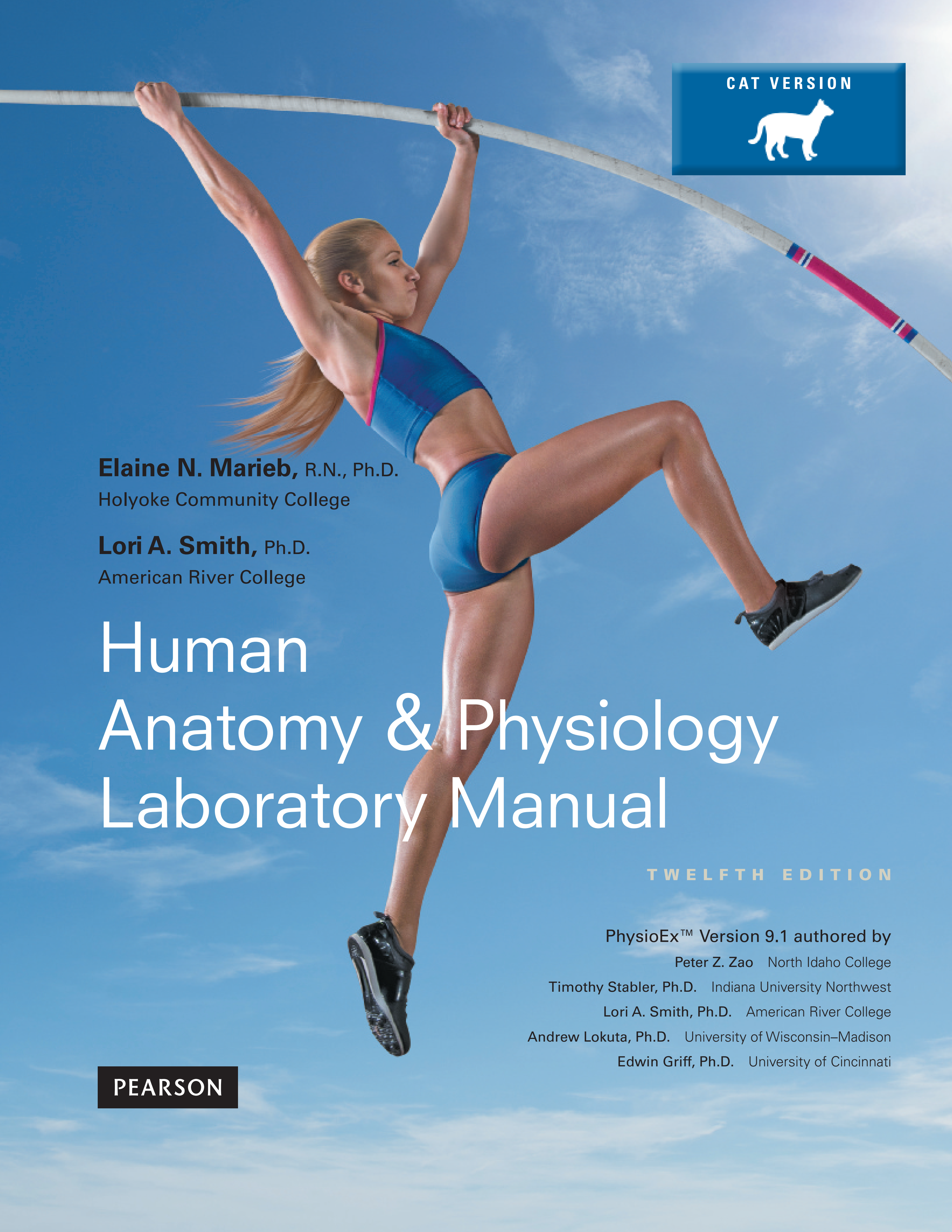
Perform the following temperature conversions:

18. Convert 38°C to °F: ______________

19. Convert 158°F to °C: ______________

Answers

1. range of 94–64 or 30 beats/min; mean 77.5 **2.** 3800% **3.** 75% **4.** 160% **5.** 8 **6.** 0.0005 **7.** 10 breaths/min **8.** interval between 100–102° (went from 22 to 36 breaths/min) **9.** 12 cm = 120 mm **10.** 2000 µm = 2 mm **11.** 3 cm long **12.** 4 m long **13.** 200 **14.** 0.45 L **15.** 300 g = $\underline{3 \times 10^5}$ mg = $\underline{3 \times 10^8}$ µg **16.** 4000 µg = $\underline{4}$ mg = $\underline{4 \times 10^{-3}}$ g (0.004 g) **17.** 0.32 g **18.** 100.4°F **19.** 70°C



CAT VERSION

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Human Anatomy & Physiology Laboratory Manual

TWELFTH EDITION

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THE DIGESTIVE SYSTEM

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The new workbook-style design makes it easy to see where sections, lab activities, and drawing activities begin and end.

6

Activity 1

Examining Epithelial Tissue Under the Microscope

Obtain slides of simple squamous, simple cuboidal, simple columnar, stratified squamous (nonkeratinized), pseudostratified ciliated columnar, stratified cuboidal, stratified columnar, and transitional epithelia. Examine each carefully, and notice how the epithelial cells fit closely together to form intact sheets of cells, a necessity for a tissue that forms linings or the coverings of membranes. Scan each epithelial type for modifications for specific functions, such as cilia (motile cell projections that help to move substances along the cell surface), and microvilli, which increase the surface area for absorption. Also be alert for goblet cells, which secrete lubricating mucus. Compare your observations with the descriptions and photomicrographs in Figure 6.3.

While working, check the questions in the Review Sheet at the end of this exercise. A number of the questions there refer to some of the observations you are asked to make during your microscopic study.

WHY THIS MATTERS | **Buccal Swabs**

A buccal, or cheek, swab is a method used to collect stratified squamous cells from the oral cavity. The cells contain DNA that can be used for DNA fingerprinting or tissue typing. DNA fingerprinting can be used in criminal investigations, and tissue typing can be used to match a recipient with a donor for organ transplant, especially a bone marrow transplant. The buccal swab procedure involves using a cotton-tipped applicator to scrape the inside of the mouth in the buccal region and remove cells at the surface. This noninvasive procedure provides an easy way to obtain the DNA profile of an individual, a unique molecular "signature." ■

Group Challenge 1

Identifying Epithelial Tissues

Following your observations of epithelial tissues under the microscope, obtain an envelope for each group that contains images of various epithelial tissues. With your lab manual closed, remove one image at a time and identify the epithelium. One member of the group will function as the verifier, whose job is to make sure that the identification is correct.

After you have correctly identified all of the images, sort them into groups to help you remember them. (*Hint:* You could sort them according to cell shape or number of layers of epithelial cells.)

Now, carefully go through each group and try to list one place in the body where the tissue is found and one function for it. After you have correctly listed the locations, take your lists and draw some general conclusions about where epithelial tissues are found in the body. Then compare and contrast the functions of the various epithelia. Finally, identify the tissues described in the **Group Challenge 1** chart, and list several locations in the body.

Group Challenge 1: Epithelial Tissue IDs

Magnified appearance	Tissue type	Locations in the body
• Apical surface has dome-shaped cells (flattened cells may also be mixed in) • Multiple layers of cells are present		
• Cells are mostly columnar • Not all cells reach the apical surface • Nuclei are located at different levels • Cilia are located at the apical surface		
• Apical surface has flattened cells with very little cytoplasm • Cells are not layered		
• Apical surface has square cells with a round nucleus • Cells are not layered		

Succeed in the Lab

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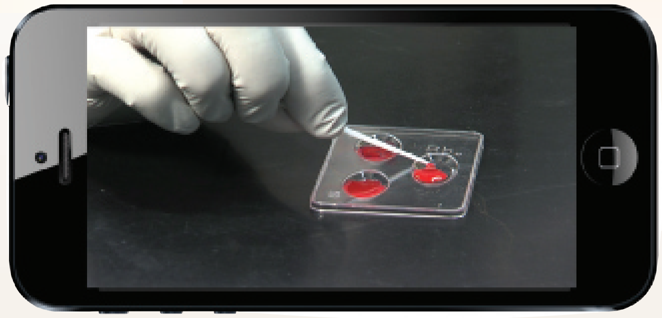

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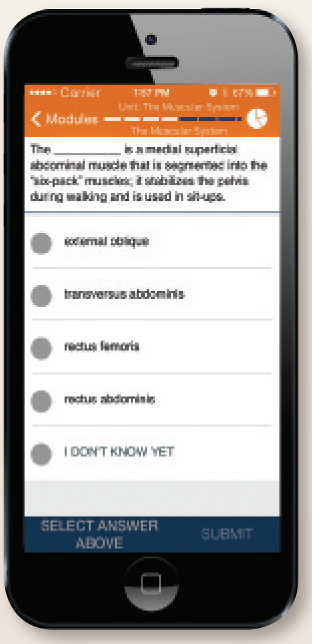

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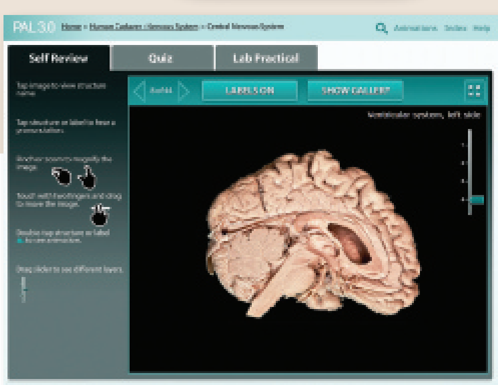
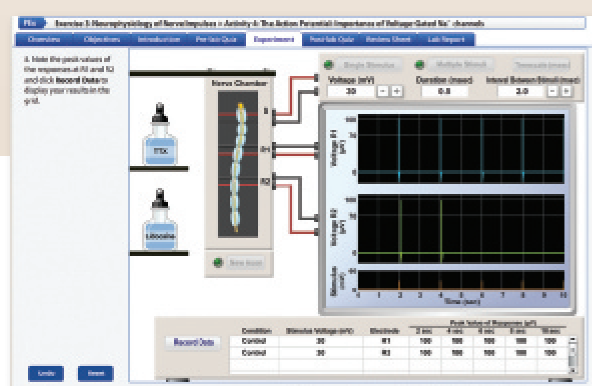
Dynamic Study Modules offer a mobile-friendly, personalized reading experience of the chapter content. As you answer questions to master the chapter content, you receive detailed feedback with text and art from the lab manual itself. The Dynamic Study Modules help you acquire, retain, and recall information faster and more efficiently than ever before.



Practice Anatomy Lab™ (PAL™) 3.0 is a virtual anatomy study and practice tool that gives you 24/7 access to the most widely used lab specimens, including the human cadaver, anatomical models, histology, cat, and fetal pig. PAL 3.0 is easy to use and includes built-in audio pronunciations, rotatable bones, and simulated fill-in-the-blank lab practical exams.



PhysioEx™ 9.1 is an easy-to-use lab simulation program that allows you to repeat labs as often as you like, perform experiments without animals, and conduct experiments that are difficult to perform in a wet lab environment because of time, cost, or safety concerns. The online format with easy step-by-step instructions includes everything you need in one convenient place.

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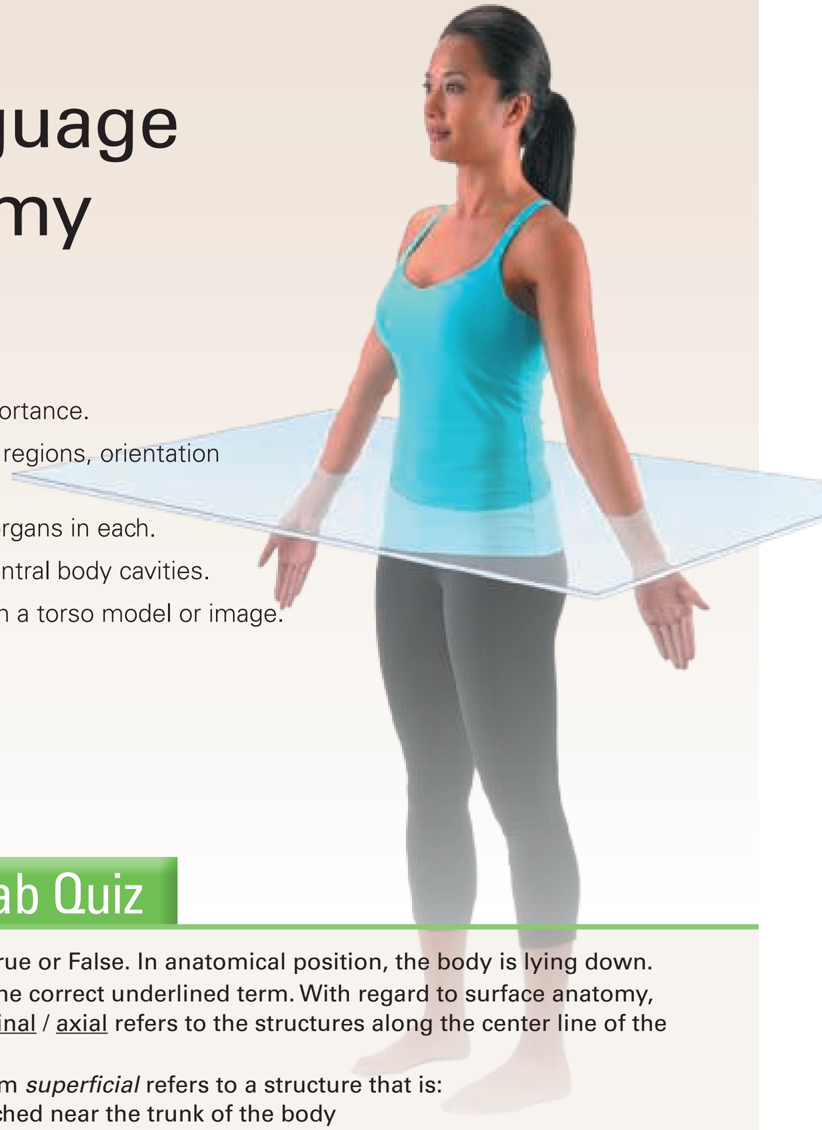
EXERCISE

1 The Language of Anatomy



Objectives

- ☐ Describe the anatomical position, and explain its importance.
- ☐ Use proper anatomical terminology to describe body regions, orientation and direction, and body planes.
- ☐ Name the body cavities, and indicate the important organs in each.
- ☐ Name and describe the serous membranes of the ventral body cavities.
- ☐ Identify the abdominopelvic quadrants and regions on a torso model or image.

Materials

- Human torso model (dissectible)
- Human skeleton
- Demonstration: sectioned and labeled kidneys (three separate kidneys uncut or cut so that [a] entire, [b] transverse sectional, and [c] longitudinal sectional views are visible)
- Gelatin-spaghetti molds
- Scalpel
- Post-it® Notes

Pre-Lab Quiz

1. Circle True or False. In anatomical position, the body is lying down.
2. Circle the correct underlined term. With regard to surface anatomy, abdominal / axial refers to the structures along the center line of the body.
3. The term *superficial* refers to a structure that is:
   a. attached near the trunk of the body
   b. toward or at the body surface
   c. toward the head
   d. toward the midline
4. The ________ plane runs longitudinally and divides the body into right and left sides.
   a. frontal **c.** transverse
   b. sagittal **d.** ventral
5. Circle the correct underlined terms. The dorsal body cavity can be divided into the cranial / thoracic cavity, which contains the brain, and the sural / vertebral cavity, which contains the spinal cord.

Most of us are naturally curious about our bodies. This curiosity is apparent even in infants, who are fascinated with their own waving hands or their mother's nose. Unlike an infant, however, an anatomy student must learn to observe and identify the dissectible body structures formally.

A student new to any science is often overwhelmed at first by the terminology used in that subject. The study of anatomy is no exception. But without this specialized terminology, confusion is inevitable. For example, what do *over, on top of, above,* and *behind* mean in reference to the human body? Anatomists have an accepted set of reference terms that are universally understood. These allow body structures to be located and identified precisely with a minimum of words.

This exercise presents some of the most important anatomical terminology used to describe the body and introduces you to basic concepts of **gross anatomy,** the study of body structures visible to the naked eye.

1

Anatomical Position

When anatomists or doctors refer to specific areas of the human body, the picture they keep in mind is a universally accepted standard position called the **anatomical position.** It is essential to understand this position because much of the directional terminology used in this book refers to the body in this position, regardless of the position the body happens to be in. In the anatomical position, the human body is erect, with the feet only slightly apart, head and toes pointed forward, and arms hanging at the sides with palms facing forward (**Figure 1.1a**).

☐ Assume the anatomical position, and notice that it is not particularly comfortable. The hands are held unnaturally forward rather than hanging with palms toward the thighs.

Check the box when you have completed this task.

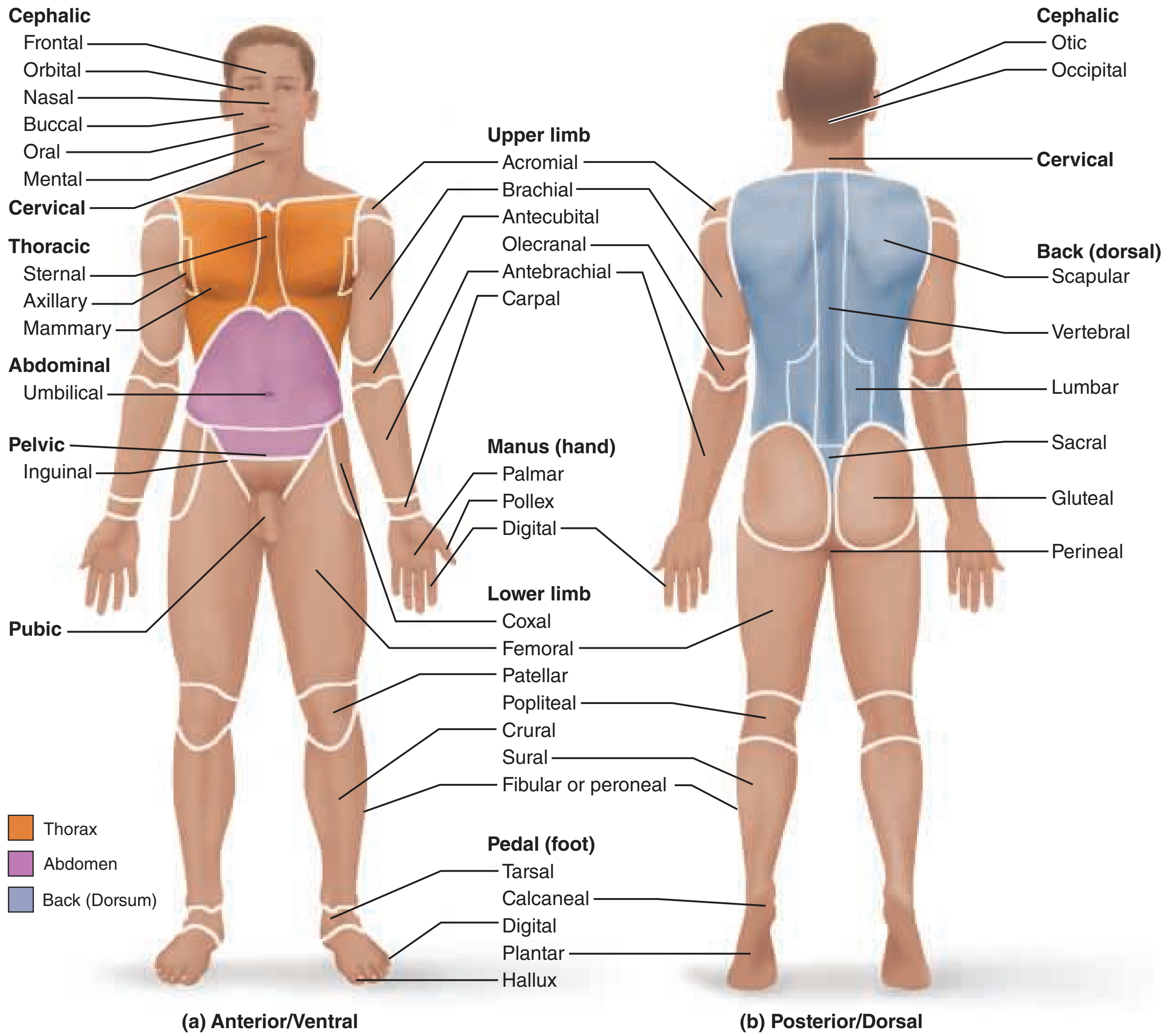


Figure 1.1 **Surface anatomy. (a)** Anatomical position. **(b)** Heels are raised to illustrate the plantar surface of the foot.

Surface Anatomy

Body surfaces provide a wealth of visible landmarks for study. There are two major divisions of the body:

Axial: Relating to head, neck, and trunk, the axis of the body

Appendicular: Relating to limbs and their attachments to the axis

Anterior Body Landmarks

Note the following regions in Figure 1.1a:

Abdominal: Anterior body trunk region inferior to the ribs

Acromial: Point of the shoulder

Antebrachial: Forearm

Antecubital: Anterior surface of the elbow

Axillary: Armpit

Brachial: Arm

Buccal: Cheek

Carpal: Wrist

Cephalic: Head

Cervical: Neck region

Coxal: Hip

Crural: Leg

Digital: Fingers or toes

Femoral: Thigh

Fibular (peroneal): Side of the leg

Frontal: Forehead

Hallux: Great toe

Inguinal: Groin area

Mammary: Breast region

Manus: Hand

Mental: Chin

Nasal: Nose

Oral: Mouth

Orbital: Bony eye socket (orbit)

Palmar: Palm of the hand

Patellar: Anterior knee (kneecap) region

Pedal: Foot

Pelvic: Pelvis region

Pollex: Thumb

Pubic: Genital region

Sternal: Region of the breastbone

Tarsal: Ankle

Thoracic: Chest

Umbilical: Navel

Posterior Body Landmarks

Note the following body surface regions in Figure 1.1b:

Acromial: Point of the shoulder

Brachial: Arm

Calcaneal: Heel of the foot

Cephalic: Head

Dorsum: Back

Femoral: Thigh

Gluteal: Buttocks or rump

Lumbar: Area of the back between the ribs and hips; the loin

Manus: Hand

Occipital: Posterior aspect of the head or base of the skull

Olecranal: Posterior aspect of the elbow

Otic: Ear

Pedal: Foot

Perineal: Region between the anus and external genitalia

Plantar: Sole of the foot

Popliteal: Back of the knee

Sacral: Region between the hips (overlying the sacrum)

Scapular: Scapula or shoulder blade area

Sural: Calf or posterior surface of the leg

Vertebral: Area of the spinal column

Activity 1

Locating Body Regions

Locate the anterior and posterior body landmarks on yourself, your lab partner, and a human torso model.

Body Orientation and Direction

Study the terms below, referring to **Figure 1.2** on p. 4 for a visual aid. Notice that certain terms have different meanings, depending on whether they refer to a four-legged animal (quadruped) or to a human (biped).

Superior/inferior *(above/below):* These terms refer to placement of a structure along the long axis of the body. For example, the nose is superior to the mouth, and the abdomen is inferior to the chest.

Anterior/posterior *(front/back):* In humans, the most anterior structures are those that are most forward—the face, chest, and abdomen. Posterior structures are those toward the backside of the body. For instance, the spine is posterior to the heart.

Medial/lateral *(toward the midline/away from the midline or median plane):* The sternum (breastbone) is medial to the ribs; the ear is lateral to the nose.

1

The terms of position just described assume the person is in the anatomical position. The next four term pairs are more absolute. They apply in any body position, and they consistently have the same meaning in all vertebrate animals.

Cephalad (cranial)/caudal *(toward the head/toward the tail):* In humans, these terms are used interchangeably with *superior* and *inferior,* but in four-legged animals they are synonymous with *anterior* and *posterior,* respectively.

Ventral/dorsal *(belly side/backside):* These terms are used chiefly in discussing the comparative anatomy of animals, assuming the animal is standing. In humans, the terms *ventral* and *dorsal* are used interchangeably with the terms *anterior* and *posterior,* but in four-legged animals, *ventral* and *dorsal* are synonymous with *inferior* and *superior,* respectively.

Proximal/distal *(nearer the trunk or attached end/farther from the trunk or point of attachment):* These terms are used primarily to locate various areas of the body limbs. For example, the fingers are distal to the elbow; the knee is proximal to the toes. However, these terms may also be used to indicate regions (closer to or farther from the head) of internal tubular organs.

Superficial (external)/deep (internal) *(toward or at the body surface/away from the body surface):* For example, the skin is superficial to the skeletal muscles, and the lungs are deep to the rib cage.

Activity 2

Practicing Using Correct Anatomical Terminology

Use a human torso model, a human skeleton, or your own body to specify the relationship between the following structures when the body is in the anatomical position.

1. The wrist is ______________ to the hand.
2. The trachea (windpipe) is ______________ to the spine.
3. The brain is ______________ to the spinal cord.
4. The kidneys are ______________ to the liver.
5. The nose is ______________ to the cheekbones.
6. The thumb is ______________ to the ring finger.
7. The thorax is ______________ to the abdomen.
8. The skin is ______________ to the skeleton.

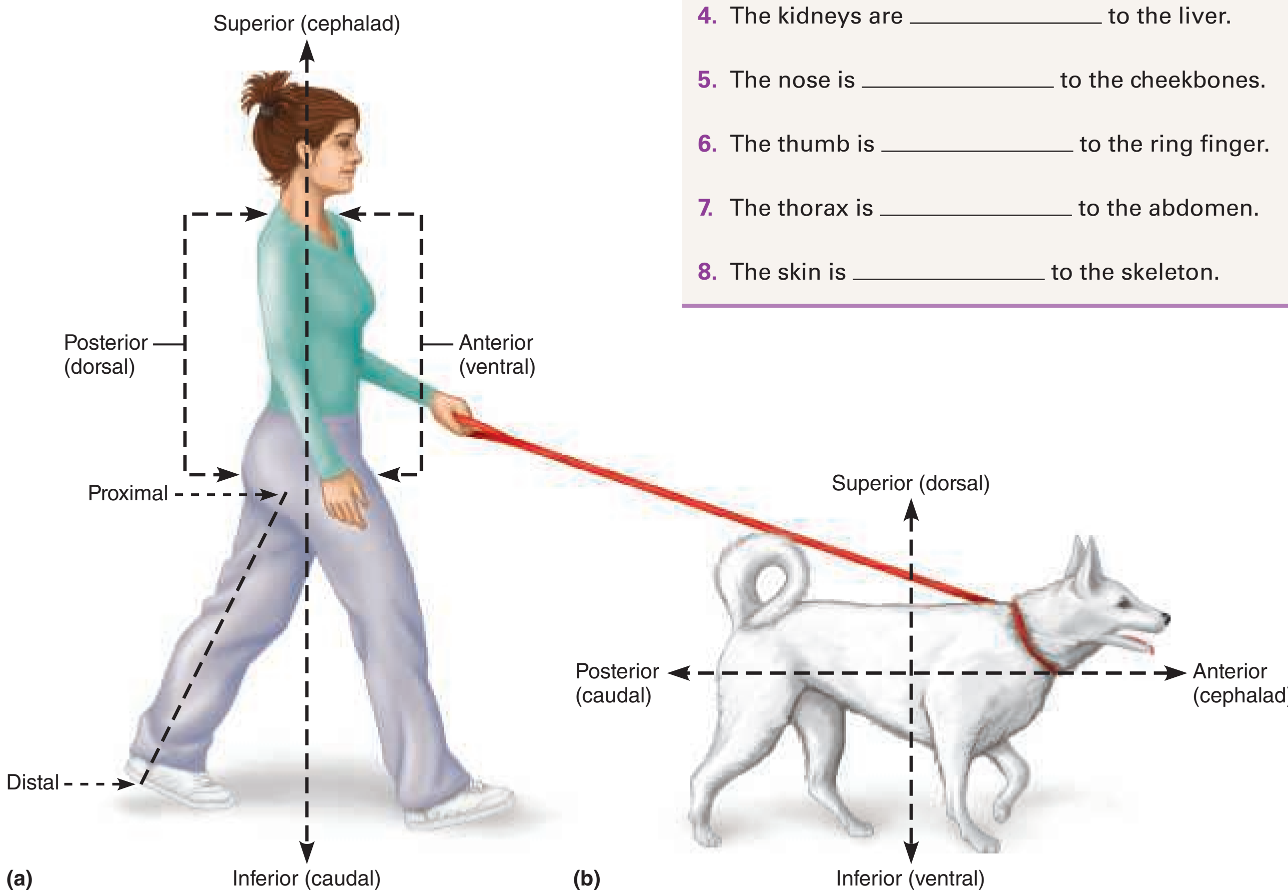


Figure 1.2 Anatomical terminology describing body orientation and direction. **(a)** With reference to a human. **(b)** With reference to a four-legged animal.

Body Planes and Sections

The body is three-dimensional, and in order to observe its internal structures, it is often necessary to make a **section,** or cut. When the section is made through the body wall or through an organ, it is made along an imaginary surface or line called a **plane.** Anatomists commonly refer to three planes (**Figure 1.3**), or sections, that lie at right angles to one another.

Sagittal plane: A sagittal plane runs longitudinally and divides the body into right and left parts. If it divides the body into equal parts, right down the midline of the body, it is called a **median,** or **midsagittal, plane.**

Frontal plane: Sometimes called a **coronal plane,** the frontal plane is a longitudinal plane that divides the body (or an organ) into anterior and posterior parts.

Transverse plane: A transverse plane runs horizontally, dividing the body into superior and inferior parts. When organs are sectioned along the transverse plane, the sections are commonly called **cross sections.**

On microscope slides, the abbreviation for a longitudinal section (sagittal or frontal) is l.s. Cross sections are abbreviated x.s. or c.s.

A median or frontal plane section of any nonspherical object, be it a banana or a body organ, provides quite a different view from a cross section (**Figure 1.4**, p. 6).

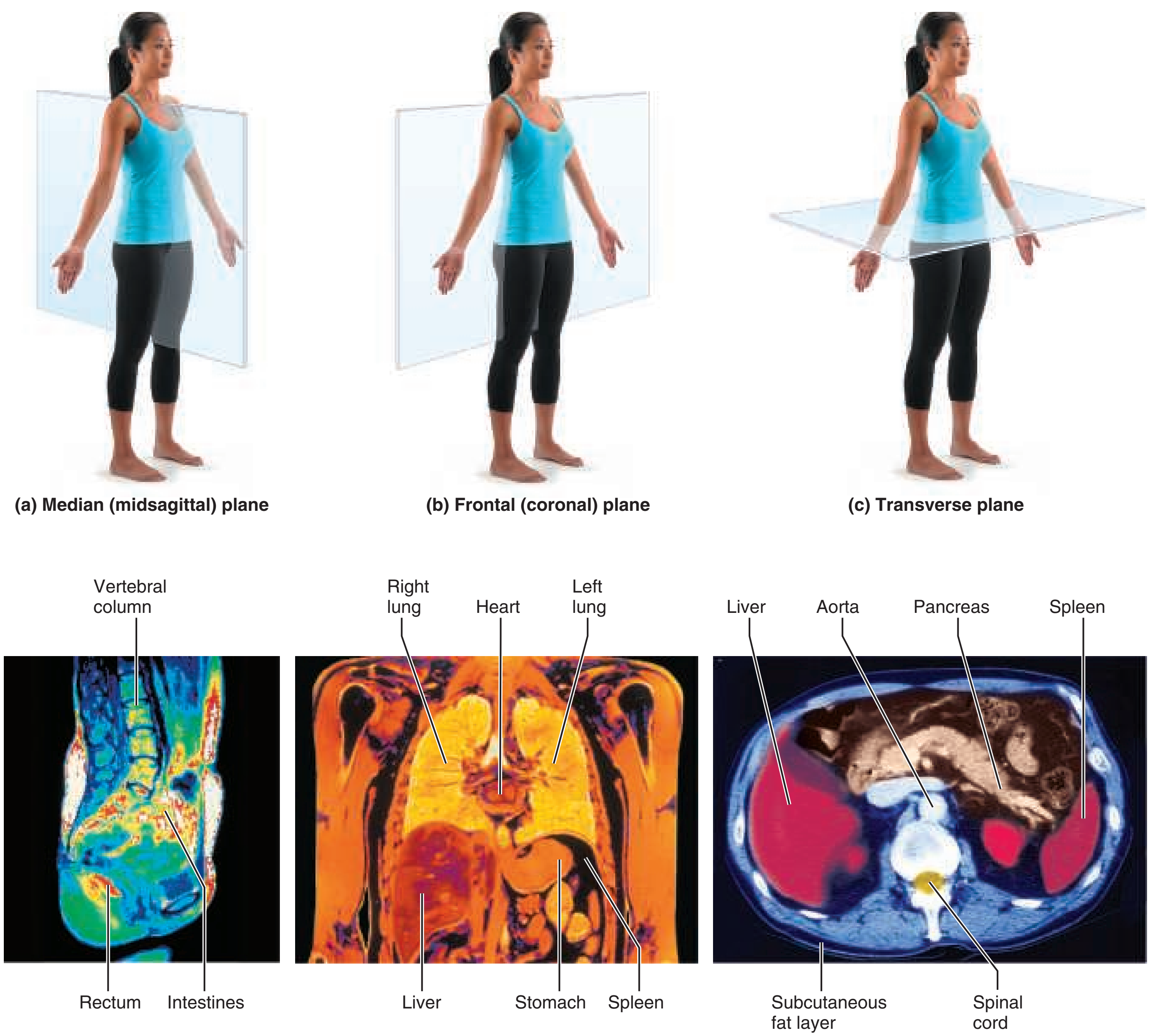


Figure 1.3 Planes of the body with corresponding magnetic resonance imaging (MRI) scans. Note the transverse section is an inferior view.

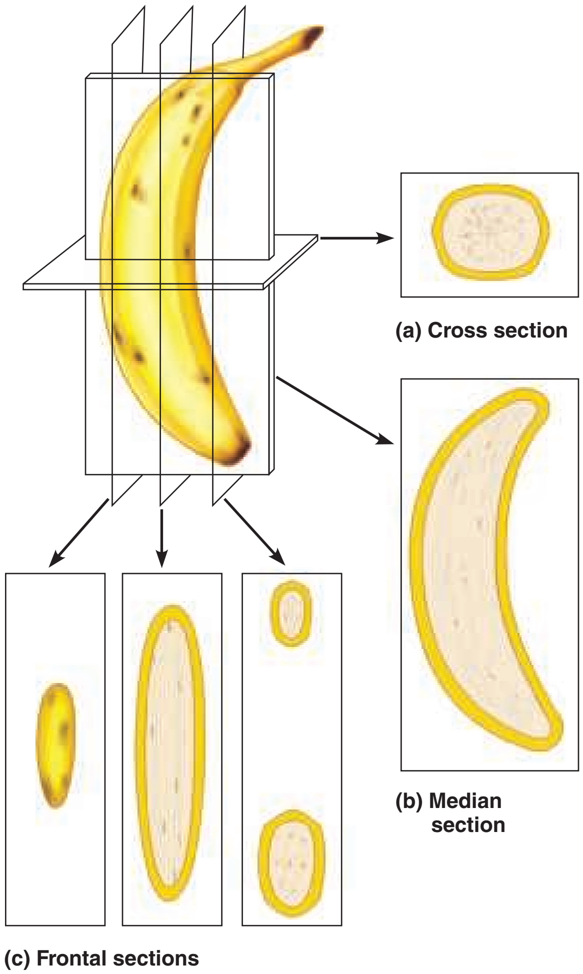


Figure 1.4 Objects can look odd when viewed in section. This banana has been sectioned in three different planes **(a–c)**, and only in one of these planes **(b)** is it easily recognized as a banana. If one cannot recognize a sectioned organ, it is possible to reconstruct its shape from a series of successive cuts, as from the three serial sections in **(c)**.

Activity 3

Observing Sectioned Specimens

1. Go to the demonstration area and observe the transversely and longitudinally cut organ specimens (kidneys). Pay close attention to the different structural details in the samples; you will need to draw these views in the Review Sheet at the end of this exercise.
2. After completing instruction 1, obtain a gelatin-spaghetti mold and a scalpel, and take them to your laboratory bench. (Essentially, this is just cooked spaghetti added to warm gelatin, which is then allowed to gel.)
3. Cut through the gelatin-spaghetti mold along any plane, and examine the cut surfaces. You should see spaghetti strands that have been cut transversely (x.s.) and some cut longitudinally.
4. Draw the appearance of each of these spaghetti sections below, and verify the accuracy of your section identifications with your instructor.

Transverse cut	Longitudinal cut

Body Cavities

The axial portion of the body has two large cavities that provide different degrees of protection to the organs within them (**Figure 1.5**).

Dorsal Body Cavity

The dorsal body cavity can be subdivided into the **cranial cavity,** which lies within the rigid skull and encases the brain, and the **vertebral** (or **spinal**) **cavity,** which runs through the bony vertebral column to enclose the delicate spinal cord. Because the spinal cord is a continuation of the brain, these cavities are continuous with each other.

Ventral Body Cavity

Like the dorsal cavity, the ventral body cavity is subdivided. The superior **thoracic cavity** is separated from the rest of the ventral cavity by the dome-shaped diaphragm. The heart and lungs, located in the thoracic cavity, are protected by the bony rib cage. The cavity inferior to the diaphragm is often referred to as the **abdominopelvic cavity.** Although there is no further physical separation of the ventral cavity, some describe the abdominopelvic cavity as two areas: a superior **abdominal cavity,** the area that houses the stomach, intestines, liver, and other organs, and an inferior **pelvic cavity,** the region that is partially enclosed by the bony pelvis and contains the reproductive organs, bladder, and rectum. Notice in Figure 1.5a that the abdominal and pelvic cavities are not aligned with each other in a plane because the pelvic cavity is tipped forward.

Serous Membranes of the Ventral Body Cavity

The walls of the ventral body cavity and the outer surfaces of the organs it contains are covered with an exceedingly thin, double-layered membrane called the **serosa,** or **serous membrane.** The part of the membrane lining the cavity walls is referred to as the **parietal serosa,** and it is continuous with a

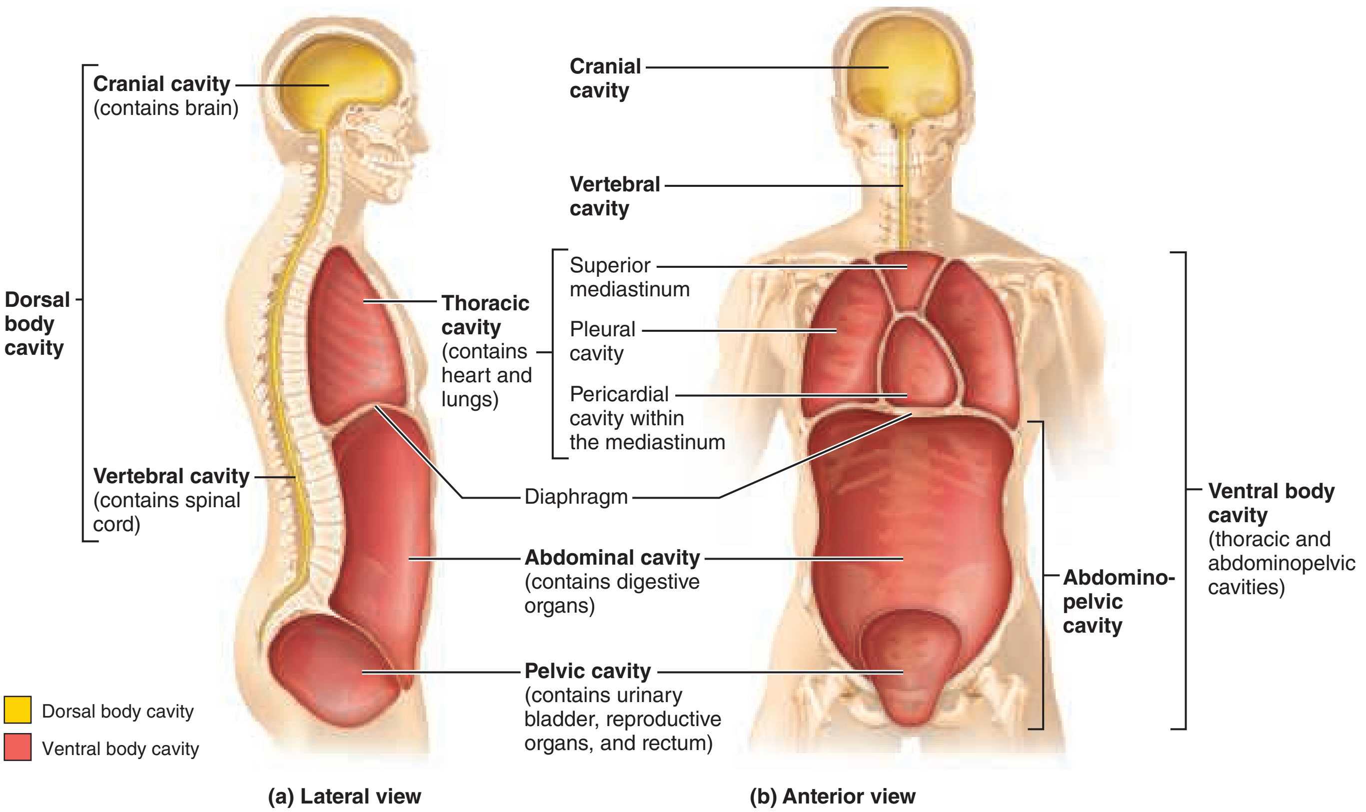


Figure 1.5 Dorsal and ventral body cavities and their subdivisions.

similar membrane, the **visceral serosa,** covering the external surface of the organs within the cavity. These membranes produce a thin lubricating fluid that allows the visceral organs to slide over one another or to rub against the body wall with minimal friction. Serous membranes also compartmentalize the various organs to prevent infection in one organ from spreading to others.

The specific names of the serous membranes depend on the structures they surround. The serosa lining the abdominal cavity and covering its organs is the **peritoneum,** the serosa enclosing the lungs is the **pleura,** and the serosa around the heart is the **pericardium** (**Figure 1.6**).

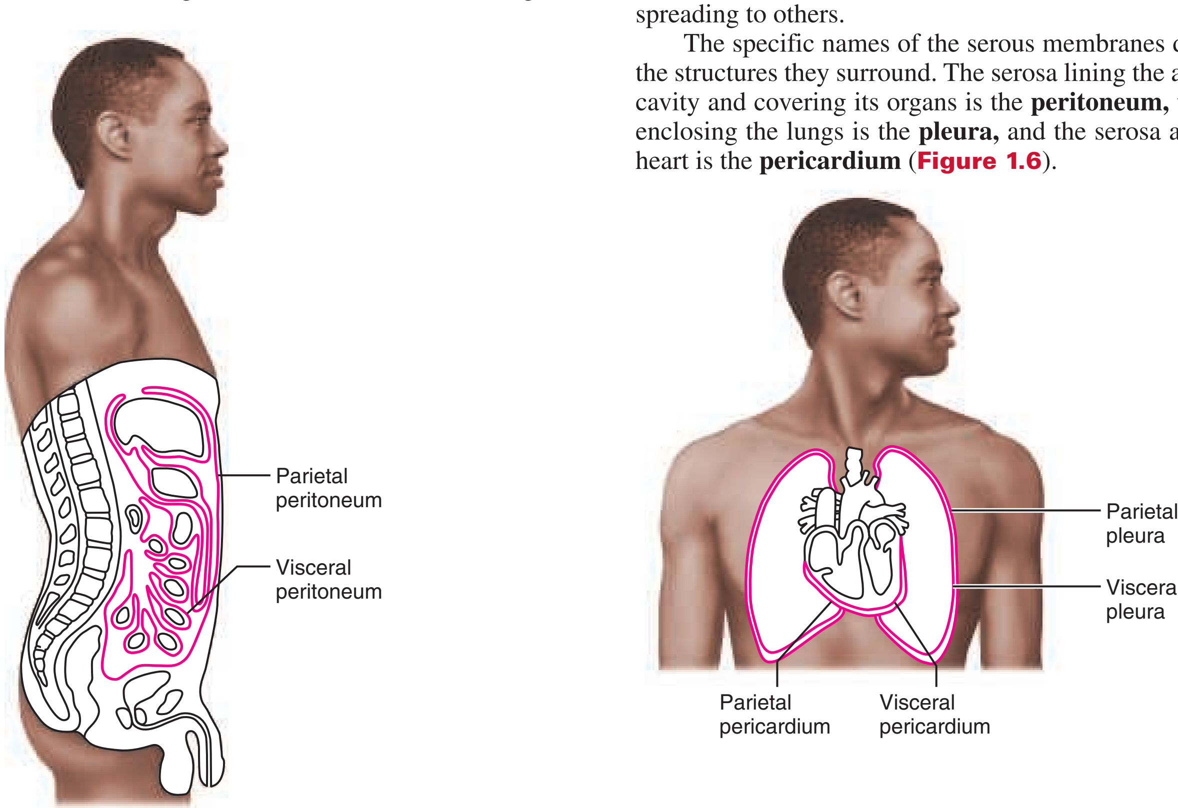


Figure 1.6 Serous membranes of the ventral body cavities.

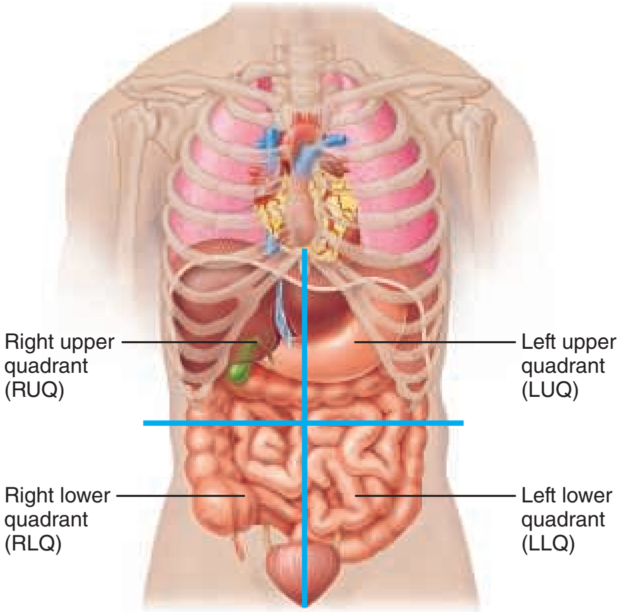


Figure 1.7 Abdominopelvic quadrants. Superficial organs all shown in each quadrant.

Abdominopelvic Quadrants and Regions

Because the abdominopelvic cavity is quite large and contains many organs, it is helpful to divide it up into smaller areas for discussion or study.

Most physicians and nurses use a scheme that divides the abdominal surface and the abdominopelvic cavity into four approximately equal regions called **quadrants.** These quadrants are named according to their relative position—that is, *right upper quadrant, right lower quadrant, left upper quadrant,* and *left lower quadrant* (**Figure 1.7**). Note that the terms *left* and *right* refer to the left and right side of the body in the figure, not the left and right side of the art on the page.

A different scheme commonly used by anatomists divides the abdominal surface and abdominopelvic cavity into nine separate regions by four planes (**Figure 1.8**). As you read through the descriptions of these nine regions, locate them in Figure 1.8, and note the organs contained in each region.

Umbilical region: The centermost region, which includes the umbilicus (navel)

Epigastric region: Immediately superior to the umbilical region; overlies most of the stomach

Hypogastric (pubic) region: Immediately inferior to the umbilical region; encompasses the pubic area

Iliac, or inguinal, regions: Lateral to the hypogastric region and overlying the superior parts of the hip bones

Lumbar regions: Between the ribs and the flaring portions of the hip bones; lateral to the umbilical region

Hypochondriac regions: Flanking the epigastric region laterally and overlying the lower ribs

Activity 4

Identifying Organs in the Abdominopelvic Cavity

Examine the human torso model to respond to the following questions.

Name two organs found in the left upper quadrant.

______________ and ______________

Name two organs found in the right lower quadrant.

______________ and ______________

What organ (Figure 1.7) is divided into identical halves by the median plane? ______________

Activity 5

Locating Abdominal Surface Regions

Locate the regions of the abdominal surface on a human torso model and on yourself.

Other Body Cavities

Besides the large, closed body cavities, there are several types of smaller body cavities (**Figure 1.9**). Many of these are in the head, and most open to the body exterior.

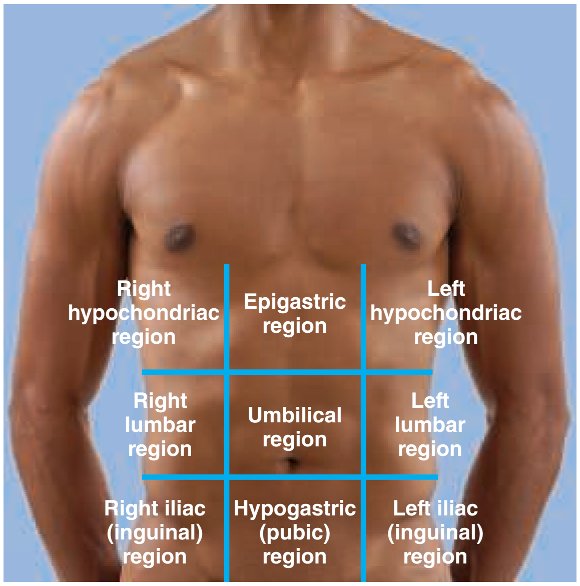
Oral cavity: The oral cavity, commonly called the *mouth*, contains the tongue and teeth. It is continuous with the rest of the digestive tube, which opens to the exterior at the anus.

Nasal cavity: Located within and posterior to the nose, the nasal cavity is part of the passages of the respiratory system.

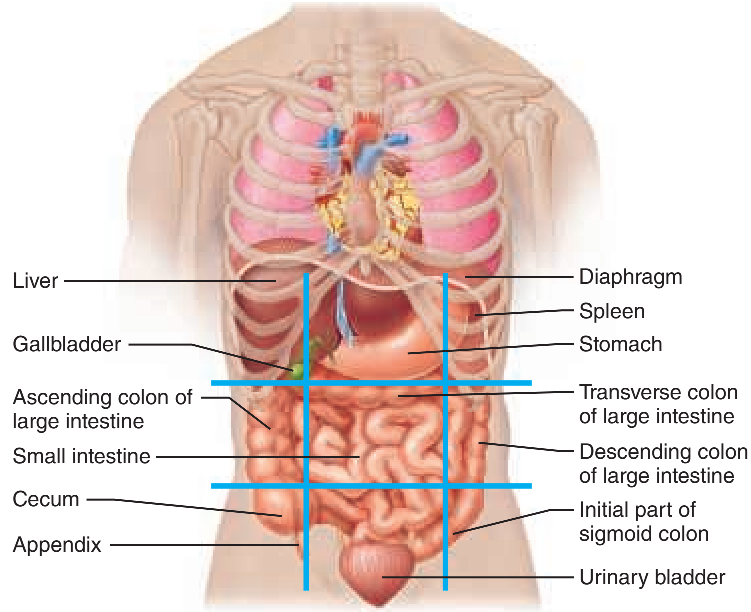
Orbital cavities: The orbital cavities (orbits) in the skull house the eyes and present them in an anterior position.

Middle ear cavities: Each middle ear cavity lies just medial to an eardrum and is carved into the bony skull. These cavities contain tiny bones that transmit sound vibrations to the hearing receptors in the inner ears.

Synovial cavities: Synovial cavities are joint cavities—they are enclosed within fibrous capsules that surround the freely movable joints of the body, such as those between the vertebrae and the knee and hip joints. Like the serous membranes of the ventral body cavity, membranes lining the synovial cavities secrete a lubricating fluid that reduces friction as the enclosed structures move across one another.

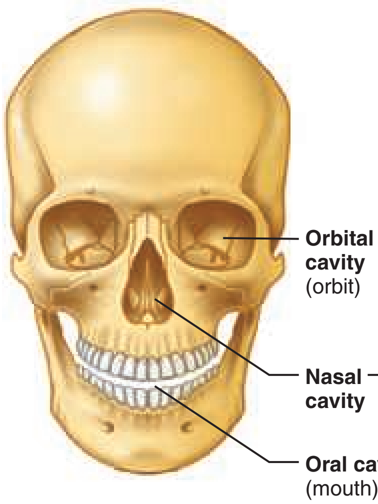


(a)



(b)

Figure 1.8 Abdominopelvic regions. Nine regions delineated by four planes. (a) The superior horizontal plane is just inferior to the ribs; the inferior horizontal plane is at the superior aspect of the hip bones. The vertical planes are just medial to the nipples. (b) Superficial organs are shown in each region.



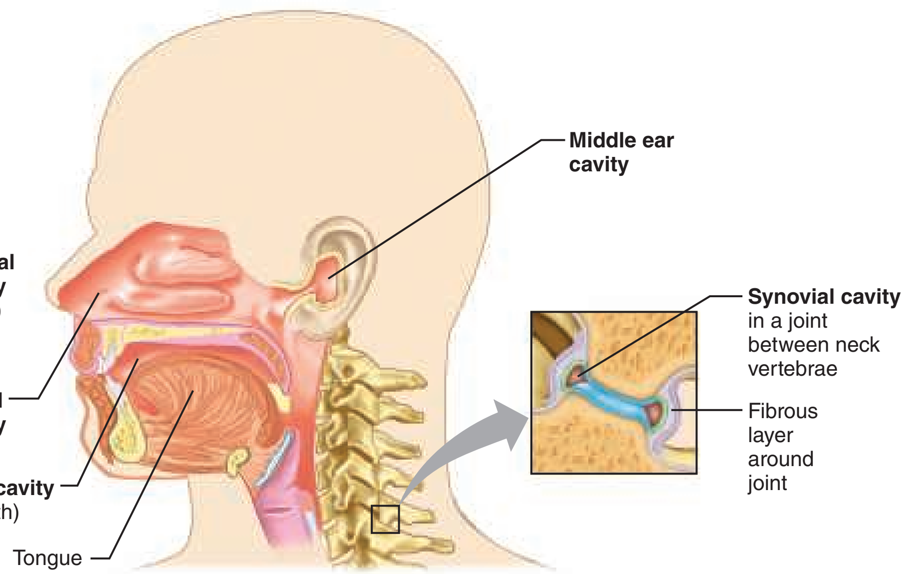


Figure 1.9 Other body cavities. The oral, nasal, orbital, and middle ear cavities are located in the head and open to the body exterior. Synovial cavities are found in joints between many bones, such as the vertebrae of the spine, and at the knee, shoulder, and hip.