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 minute 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 taken as 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 commonly used by scientists 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 comprises 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 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 tests may prove the hypothesis incorrect, or new information may require that the hypothesis be modified. Clearly the accuracy of a prediction in the green apple example or 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. Take the case of testing drugs for their effectiveness in treating disease. If one set of observations erroneously indicates that the drugs are risky but very effective, such a conclusion could lead to the death of the subsequent drug recipients. This illustrates two points: (1) Repeated testing of scientific ideas is important, particularly because scientists working on the same problem do not always agree on their conclusions. The studies on the use of saccharin and aspartame as sweeteners are only two examples. (2) Conclusions drawn from scientific tests are only as accurate as the information on which they are based; therefore, careful observation is essential, even at the very outset of a study.

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. Because man is a social animal influenced by culture, these two characteristics tend to promote biased thinking. 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 verify or disprove their hypotheses—that is, they test their hypotheses. Data are accumulated 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 made.

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. The color of an object, its texture, the relationship of one part to another, and its relative size (large versus small) may all be part of a qualitative description. For some quick practice in qualitative observation, compare and contrast* an orange and an apple.

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, and data must be derived from measurements made by a variety of scientific equipment. 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 and other chemicals in urine.

*Compare means to emphasize the similarities between two things, whereas contrast means that the differences are to be emphasized.

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 performing chemical measurements of the relative amounts of sugar and water in a given volume of fruit flesh, by analyzing 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 verify 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 experimenter manipulates the independent variables and observes the effects of this manipulation on the dependent (or response) variable. For example, if the goal is to determine the effect of body temperature on breathing rate, the value measured (breathing rate) is called the dependent variable because it "depends on" the value chosen for the independent variable (body temperature). 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. It is essential to know how the system you are investigating works under normal circumstances before you can be sure that the results obtained from experimentation are due solely to the manipulation of the independent variable(s). 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 control group would provide the "normal standard" against which all other samples would be compared relative to the dependent variable.

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 pain-killing effects was successful after having tested it on only one postoperative patient would be scientifically 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 acceptance or rejection of many hypotheses.

During experimentation and observation, data must be carefully recorded. Usually, such initial, or raw, data are recorded in tabular (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 average 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). What is the range of the set of numbers just provided?

1. ____________________________

The average, or mean, is obtained by summing the items and dividing the sum by the number of items. Compute the average for the set of numbers just provided:

2. ____________________________

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.

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:

\[
\frac{0.25 \times 100}{1} = 25\% \\
5 \div 100 = 0.05 = 5\% \\
\]

Change the following numbers to percents:

3. 38.2 = ____________ 5. 1.6 = ____________ 4. 402 = ____________

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 a whole number (or decimal), remove the percent sign, and move the decimal point two places to the left. Change the following percents to whole numbers or decimals:

6. 36% = ____________ 8. 25777% = ____________

7. 800% = ____________ 9. 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 large numbers of statistical data can be visualized 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 and vertical 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 techniques is

Answers are given on page xviii.
only slightly more accurate than that provided by a crystal ball!

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

10. What was the respiratory rate at a body temperature of 96°F? ___________

11. Between 98° and 102°F, the respiratory rate increased from _____ to ____ breaths per minute.

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

13. Are the intervals on each scale uniform?

---

**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, several questions may need to be answered. 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 hastily and inaccurately? If you did record it accurately, is it possible that the subject was emotionally upset about something, which (even though the matter of concern had nothing to do with the experiment) 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. There is now a greater probability that the hypothesis is correct.

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. (Okay, 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

---

**Scientific Notation and Metrics**

No matter how highly developed our ability to observe, observations have scientific value only if they can be communicated to others. This necessitates the use of scientific notation and the widely accepted system of metric measurements.
Scientific Notation

Because quantitative measurements often yield very large or very small numbers, you are quite likely to encounter numbers such as \(3.5 \times 10^{12}\) or \(10^{-5}\). It is important that you understand what this scientific notation means.

Scientific notation is dependent on the properties of exponents and on the movement of the decimal point when multiplying or dividing by 10. When you multiply 10 by itself, you get a product that is one followed by zeros. The number of zeros (two, in this case) in the product is equal to the number of times you have used 10 as a factor and is shown as an exponent. Thus, the notation \(10^2\) has these parts:

\[
\text{base} \rightarrow 10^2 \leftarrow \text{exponent}
\]

and translates to “the base 10 multiplied by itself \((10 \times 10)\).”

The powers of 10 are represented as follows:

\[
10^0 = 1 \quad (\text{Any number followed by a zero exponent is one.})
\]

\[
10^1 = 10 \quad (10 \times 1 = 10)
\]

\[
10^2 = 100 \quad (10 \times 10 = 100)
\]

\[
10^3 = 1000 \quad (10 \times 10 \times 10 = 1000)
\]

\[
10^4 = 10,000 \quad (10 \times 10 \times 10 \times 10 = 10,000)
\]

As you can see, each time the exponent is increased by one, another zero \((\times 10)\) is added to the answer.

When you multiply any number by a power of 10 written with exponents, the decimal point is moved to the right the number of times shown in the exponent. Thus:

\[
3.25 \times 10^1 = 3.25 \times 10 = 32.5
\]

\[
3.25 \times 10^2 = 3.25 \times 100 = 325
\]

\[
3.25 \times 10^3 = 3.25 \times 1000 = 3250
\]

By using such exponential notation, very large numbers may be written in a far simpler form.

Write the following numbers using the proper scientific notation:

14. \(140,000 = 1.4 \times \underline{\phantom{1000}}\)

15. \(9,650,000 = 9.65 \times \underline{\phantom{1000000}}\)

16. \(852 = 8.52 \times \underline{\phantom{100}}\)

17. \(10 = 1.0 \times \underline{\phantom{10}}\)

Notice that proper scientific notation entails only one number to the left of the decimal point. Thus \(1.03 \times 10^3\) is correct, but \(10.3 \times 10^2\) is not.

In the above examples, all of the numbers used were greater than one. Scientific notation can also be used to report numbers less than one. To do this, negative exponents are used. For example, in

\[
3.25 \times 10^2
\]

the positive exponent means that the decimal point is to be moved two places to the right, and the number designated is \(325 \times 10 \times 10\). However, in

\[
3.25 \times 10^{-2}
\]

the negative exponent means that the number is to be divided by the power of 10 indicated by the exponent and the decimal point is to be moved two places to the left. The number so designated is \(0.0325 \div (10 \times 10)\).

Thus, the rule for converting scientific notation (using powers of 10) to decimal notation is to move the decimal point the number of places indicated by the exponent. When the exponent is positive (with or without a plus sign), the decimal point is moved to the right. When the exponent is negative (always indicated with a minus sign), the decimal point is moved to the left.

For a little practice, write the following numbers in scientific notation: \((18–23)\)

\[
140,000 = 1.4 \times \underline{\phantom{1000}} \quad 45,000 = 4.5 \times \underline{\phantom{1000}}
\]

\[
0.0000063 = 6.3 \times \underline{\phantom{1000000}} \quad 0.265 = 2.65 \times \underline{\phantom{1000}}
\]

\[
0.00054 = 5.4 \times \underline{\phantom{1000000}} \quad 0.10 = 1.0 \times \underline{\phantom{10}}
\]

Metrics

Without measurement, we would be limited to qualitative description. However, with a system of measurement, quantitative description becomes possible.

Anyone can establish a system of measurement. All that is required is a reference point; and historically, much of our common (the British) system of measurement evolved from units based on objects everyone knew. For example, horses were measured in “hands,” and a “fathom” was the distance between outstretched arms. However, the variability in such measurements is immediately apparent—for example, an infant’s hand is substantially smaller than that of an adult. Therefore, for precise and repeatable communication of information, the agreed-upon system of measurement used by scientists is the metric system, a nonvarying standard of reference.

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. Table G.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 millillon (milli = one thousandth), such as a millimeter or milliliter, is one step smaller than a centiliter (centi = one hundredth), such as a centimeter or centiliter. Thus to change milliliters to centiliters, 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 (because there will be more of the smaller units). A partial scheme for conversions between the metric units is shown below.

Students studying a science or preparing for a profession in the health-related fields find that certain of the metric units are encountered and dealt with more frequently than others. Thus, the objectives of the sections that follow are to provide a brief overview of these most-used measurements and to help you gain some measure of confidence in dealing with
Table G.1  Commonly Used Units of the Metric System, and Their Fractions and Multiples

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Unit</th>
<th>Fraction or multiple</th>
<th>Prefix</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Meter (m)</td>
<td>$10^6$ one million</td>
<td>mega</td>
<td>M</td>
</tr>
<tr>
<td>Volume</td>
<td>Liter (L, 1 with prefix)</td>
<td>$10^3$ one thousand</td>
<td>kilo</td>
<td>k</td>
</tr>
<tr>
<td>Mass</td>
<td>Gram (g)</td>
<td>$10^{-1}$ one tenth</td>
<td>deci</td>
<td>d</td>
</tr>
<tr>
<td>Time*</td>
<td>Second (s)</td>
<td>$10^{-2}$ one hundredth</td>
<td>centi</td>
<td>c</td>
</tr>
<tr>
<td>Temperature</td>
<td>Degree Celsius (°C)</td>
<td>$10^{-3}$ one thousandth</td>
<td>milli</td>
<td>m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$10^{-6}$ one millionth</td>
<td>micro</td>
<td>µ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$10^{-9}$ one billionth</td>
<td>nano</td>
<td>n</td>
</tr>
</tbody>
</table>

* 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 prefixes used in the designation of units of length, mass, and volume are also used in specifying units of time. However, because minutes and hours are terms that indicate multiples of seconds, the only prefixes generally used are those indicating fractional portions of seconds; for example, millisecond and microsecond.

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

29. A match (in a matchbook) is (0.3, 3, 30) cm long.
30. A standard-size American car is about 4 (mm, cm, m, km) long.
31. John pole-vaults a height of 5 meters, whereas Gerry vaults a height of 5 yards. Does John or Gerry make the more difficult vault?

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 products measured in liters are becoming more common, and laboratory solutions often come in 1-liter quantities. 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 just slightly more than 360 ml.
A cup of coffee is approximately 180 ml.
A fluid ounce is 30 ml (cc).
A teaspoon of vanilla is about 5 ml (cc), and many drug injections are given in 5-ml volumes.

\[
\begin{align*}
\text{microliter} & \xrightarrow{\times 1000} \text{milliliter} & \xrightarrow{+10} \text{centiliter} & \xrightarrow{+100} \text{liter} & \xrightarrow{+1000} \text{kiloliter} \\
\text{smallest} & & & & \text{largest}
\end{align*}
\]
Compute the following:

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

33. A 450-ml volume of alcohol is ______ L.

34. The volume of one grape is approximately 0.004 L. What is the volume of the grape in milliliters?

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, at sea level, on a mountain top, 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.

The metric unit of mass is the gram (g), and most objects weighed in the laboratory will be measured in terms of this unit or fractions thereof. 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:

35. 300 g = ______ mg = ______ μg

36. 4000 μg = ______ mg = ______ g

* 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.

37. 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 boiling point of water is 100°C and 212°F.
The freezing point of water is 0°C and 32°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 and 37°C.

To convert from the Fahrenheit scale to the Celsius scale (or vice versa), the following equation is used:

\[ ^\circ C = \frac{5}{9}(^\circ F - 32) \]

For example, to convert 180°F to °C:

\[ 180 = 5(\circ F - 32) \]
\[ 180 = 5(\circ F - 32) \]
\[ 180 = 5(\circ F - 32) \]
\[ 180 = 5(\circ F - 160) \]
\[ 180 = 5(\circ F) \]
\[ 356 = ^\circ F \]

and to convert 72°F to °C:

\[ ^\circ C = \frac{5}{9}(^\circ F - 32) \]
\[ ^\circ C = \frac{5}{9}(-1) \]
\[ ^\circ C = \frac{5}{9}(0) \]
\[ ^\circ C = \frac{5}{9}(22) \]
\[ ^\circ C = 22.2 \]

Perform the following temperature conversions:

38. Convert 38°C to °F: ______

39. Convert 158°F to °C: ______
**Answers**

1. range of 94–64: 30 beats/min
2. average 77.5
3. 3820%
4. 40200%
5. 160%
6. 0.36
7. 8
8. 257.77
9. 0.0005
10. 10 breaths/min
11. 12 to 36
12. interval between 100–102° (went from 22 to 36 breaths/min)
13. yes
14. \(10^3\)
15. \(10^6\)
16. \(10^2\)
17. \(10^1\)
18. \(1.4 \times 10^5\)
19. \(6.3 \times 10^{-6}\)
20. \(5.4 \times 10^{-2}\)
21. \(4.5 \times 10^5\)
22. \(2.65 \times 10^{-1}\)
23. \(1.0 \times 10^{-1}\)
24. cm = 3520 mm
25. km = 150,000 m
26. \(\mu m = 2\) mm
27. cm = 120 mm
28. mm = 0.001 m
29. 3 cm
30. m long
31. John
32. 200
33. 0.45 L
34. 4 ml
35. 300 g = \(3 \times 10^3\) mg = \(3 \times 10^3\) \(\mu\)g
36. 4000 \(\mu\)g = \(4\) mg = \(4 \times 10^{-3}\) g (0.004)
37. 0.32 g
38. 100.4°F
39. 70°C