Science Shepherd

Science Shepherd BIOLOGY

3rd Edition, Revised

Science Shepherd

BIOLOGY

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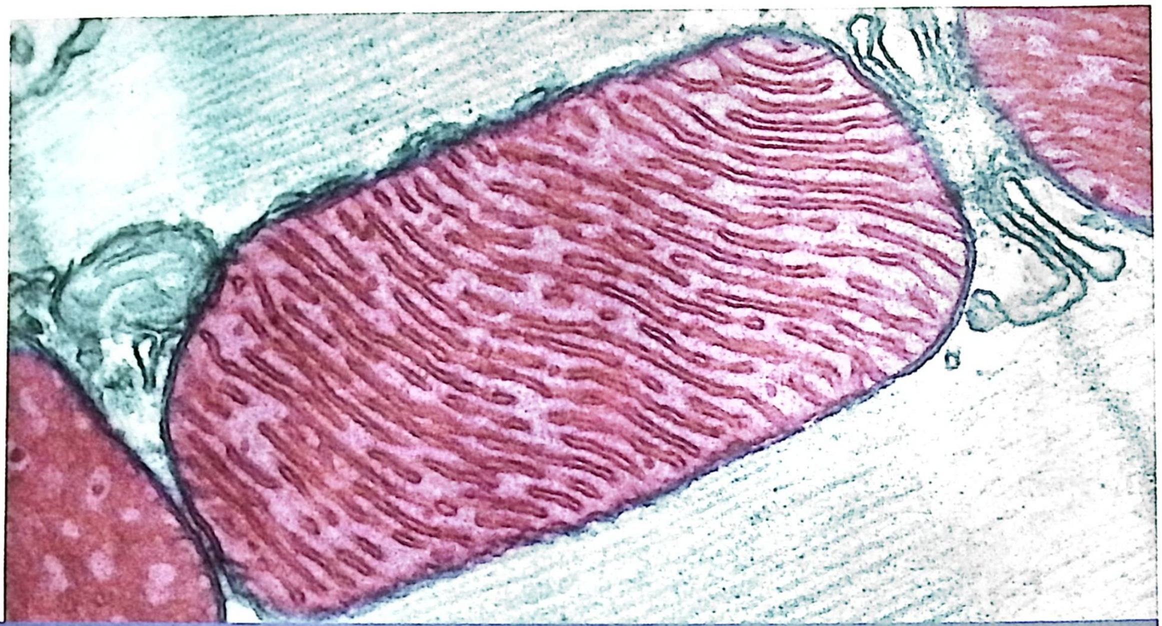

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1.0 CHAPTER PREVIEW

In this chapter we will:

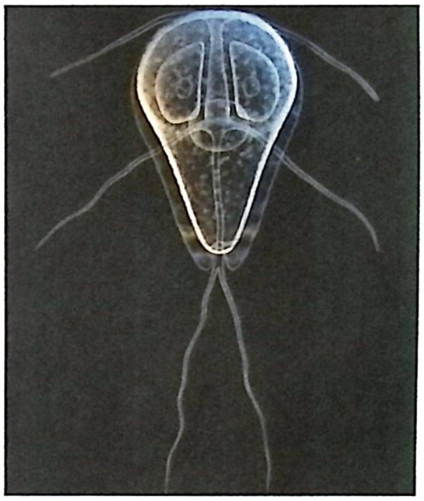
- Discuss the following properties that all living things have in common:
  - They are made up of one or more cells.
  - They contain DNA.
  - They reproduce.
  - They are complex and organized.
  - They respond to their surroundings.
  - They extract energy from their environment.
  - They maintain homeostasis.
  - They grow.
  - They can be systematically classified.
- Explore the principles and practice of the scientific method.
- Discuss the SI measurement units.
- Discuss properties of light and electron microscopes.

1.1 INTRODUCTION TO BIOLOGY

Biology is the study—or science—of life and how that life interacts with the environment and other life forms. This first chapter will serve as an introduction to all of the concepts we will be exploring during this year. In order to understand more clearly what is meant by "life," we will explore the following properties, which all living things have in common: they are made up of one or more cells; they contain DNA; they reproduce; they are complex and organized; they are responsive to their environment; they extract energy from their surroundings; they maintain homeostasis; they grow; and they can be systematically classified.

Figure 1.1.1

Giardia lamblia
This is a picture of *G. lamblia*, an organism which causes infectious diarrhea. It is a unicellular organism.



1.2 CELLS

All life forms are made up of cells. Therefore, the cell is the basic functional unit of all life. Some life forms—or **organisms**—are made up of only one cell. They are called **unicellular organisms**. Other organisms are made up of many cells and are called **multicellular organisms**.

Figure 1.2.1

DNA
This deer, and all of the plants visible in this picture, are composed of millions, billions, or trillions of cells, depending on the size of the organism. Like all living things, deer grow to look and act like deer because of its DNA. DNA is called the blueprint of life because it contains all of the information a cell, and organism, needs to function properly. DNA instructs the cell, and organism, how it is to look and function. Without DNA, life would not exist.

1.3 DEOXYRIBONUCLEIC ACID (DNA)

All life forms **contain DNA, or deoxyribonucleic acid**. DNA is a very complex molecule which instructs the cells which proteins to produce and when to produce them. It also contains the information the cell needs to duplicate, or **reproduce.** DNA contains all of the information the cell needs to work properly. Proteins are used to communicate and carry out the instructions. These same proteins then take part in almost all of the chemical reactions which the cell performs. Finally, the proteins that are made, as directed by DNA, determine the characteristics of the cell and of the multicellular organism as a whole.

DNA is passed from parents to offspring, and this serves as the basis for heredity, which will be discussed more in the genetics section of this course. In short, DNA is the material inside all living organisms that tells the organism how it is supposed to function, what kind of cell it is, and when to reproduce itself. There will be much, much more about DNA later in our book.

1.4 REPRODUCTION

All life forms make more of themselves, or reproduce, for the purpose of generating more organisms like themselves. This assures the survival of that life form. No non-living things reproduce themselves. There are two kinds of reproduction—**sexual and asexual.** Some organisms reproduce asexually, some reproduce sexually, and some are able to reproduce both sexually and asexually. The way the cell and organism reproduce is controlled by the DNA.

Asexual reproduction is typically performed by single-celled organisms, fungi, and some plant and algae species. It is accomplished by a single cell splitting into one or more cells exactly like it. In usual circumstances, this type of reproduction does not cause a change in the genetic material from the parent to the offspring, so the offspring that result from asexual reproduction are genetically identical to the parent and any other offspring from the same parent. This process is similar to making photocopies in that all of the copies (offspring) are an exact copy of the original (parent).

Sexual reproduction requires a male and a female organism to mate—or to combine their genetic material—resulting in offspring that are genetically different from each parent. The offspring's traits—how the organism looks and acts—are a mixture of the **traits** of the male and female parent. Offspring reproduced asexually always look exactly the same, but offspring produced sexually are rarely identical.

1.5 COMPLEX AND ORGANIZED

All life forms are **highly organized** and **complex** structures. Even what some biologists may call "simple life forms" are actually complex organisms. This is proven by the utter inability of any scientist to create life from only the basic molecules which make up a living organism. Life is both organized and complex as directed by its DNA. This complexity occurs on a multi-level basis. Life forms are organized specifically in regard to their atoms, atoms are specifically arranged into molecules, molecules are organized into cells, cells are organized into tissue, tissue is organised into organs, and organs are specifically arranged into organisms.

But it doesn't stop there. Organisms are grouped into **populations** (a collection of similar organisms), and populations are organized at an **ecosystem** level. An ecosystem is a group of populations interacting in their environment. At all levels, living organisms are highly organized.

1.6 RESPONSIVE

All living things are responsive to their environments. This means that they have various ways to sense changes in their environment and react to those changes. The ability to respond is controlled by varied **receptors**. Receptors are specialized molecules, structures, or chemicals that allow the organism to sense and respond to its environment. These sensing and responsive abilities of an organism help it to locate food, find shelter, and find a mate. Eyes, ears, chemical receptors in a snake's mouth, and the lateral line system of fish are all types of receptors that help organsisms sense and respond to the environment.

1.7 ENERGY EXTRACTION

Staying alive requires energy. Countless chemical reactions occur every minute in all cells and these reactions require energy to occur. All living organisms extract the energy they need from their environment and have specific ways to utilize the extracted energy in order to reproduce, obtain nutrients, etc. **Metabolism** is the process by which an organism extracts energy from its surroundings and uses it to sustain itself.

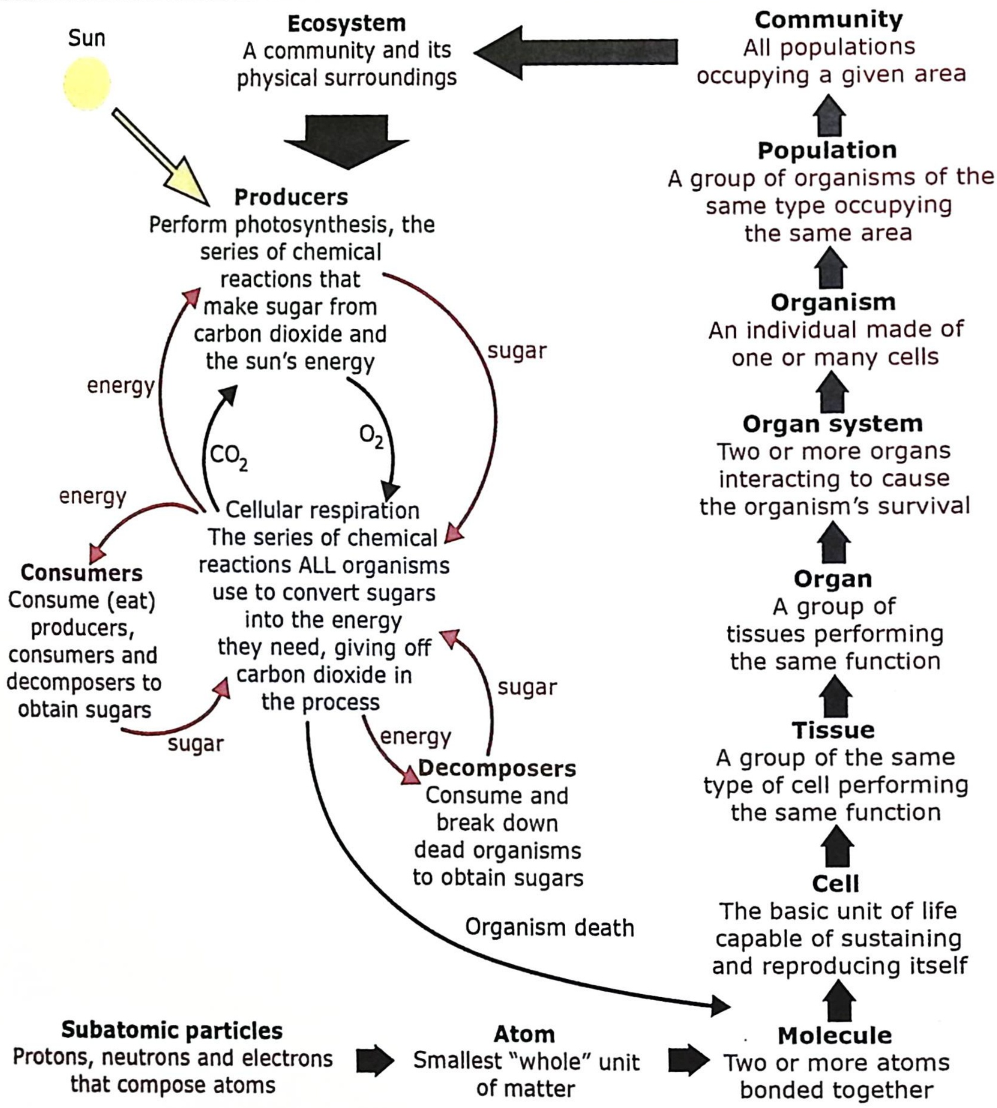
The majority of the energy on earth which all living organisms use for their sustenance ultimately comes from the sun. Plants, through the metabolic process of **photosynthesis**, are able to capture the energy from the sun and use it to grow and reproduce. Photosynthesis is a series of chemical reactions that plants use to make sugar molecules using energy from the sun. Plants then use the sugar molecules to make energy molecules. The energy molecules are used to run vital chemical reactions. Animals are not able to make their own sugar molecules, though. Animals make their energy molecules from the food they eat. Animals eat plants or other animals to obtain sugar molecules. The sugar molecules are then used to make energy moelcules that fuel the animal's vital chemical reactions. The biological process of an animal or plant using sugar molecules to make energy molecules is called **cellular respiration**.

Animals that are only able to derive their energy from plants and do not eat other animals are called **herbivores**. Some examples of herbivores are giraffes, elephants, and gerbils. Animals that can only derive their energy from other animals are called **carnivores**. Examples of these are tigers, lions, and wolves. Finally, there are organisms that are able to derive energy from either plants or animals; these are called omnivores. Humans and bears, for example, are **omnivores**.

Another way to view the energy extraction situation in nature is through a food chain in which the energy passes from **producers** (plants, by and large) to **consumers** (herbivores, carnivores, and omnivores) and finally to the **decomposers**. Decomposers are organisms like certain bacteria and fungi that break down the remains of other organisms. Decomposers can either be carnivores (who "decompose" by eating the remains of animals), or herbivores (who break down the remains of plants). This transfer of energy from producer to consumer to decomposer is called **the food chain**.

Figure 1.7.1

The Complexity and Flow of Atoms, Molecules, and Organisms in the Circle of Life.
This graphic illustrates the complexity and highly organized structure of living organisms. It also demonstrates the dependence organisms have upon one another. Start the figure by looking at the sub-atomic particles way down in the lower left hand corner. The first series of lines from subatomic particles to "multicelled organism" indicate the increasing complexity of how cells are organized within life forms. A group of organisms makes up a population of the same organisms. Populations of different organisms make up a community, and communities are organized into ecosystems. Then, moving downward from ecosystem, the relationship of energy transfer is indicated. The sun is the ultimate source of energy for almost all organisms on earth. Producers release oxygen (O_2) when they make sugar from the sun's energy. Animals use that oxygen for their survival and release carbon dioxide (CO_2). The carbon dioxide is then taken up by the plants. The remainder of the flow of energy and molecules is as indicated. This is simply to be used as a tool to begin understanding how complex nature is. We will be discussing all of these issues much more in this course.



1.8 HOMEOSTASIS

All life forms have the need to maintain a stable internal environment within the single cell or multi-cellular organism to ensure that the metabolic needs of the organism are able to be met.

This means the organism needs a way to ensure its temperature, hydration, acidity, and other physiologic needs are maintained within the strict limits necessary for the organism to carry out its metabolic needs. This is called **homeostasis**. Generally speaking, if homeostasis is not maintained properly within an organism, it becomes quite sick, or even dies.

Maintaining proper body temperature is a good example of homeostasis. Humans, as mammals, are able to maintain a fairly constant internal temperature. When a mammal is too hot, it begins to sweat to cool itself. If a mammal is too cool, it is able to increase its internal temperature. Reptiles, such as snakes, on the other hand, have a different way to maintain a normal body temperature. If a reptile is too cold, it moves into the sun to warm itself up. If it is too hot, it moves into the shade. This is because reptiles are not able to maintain a constant body temperature on their own. Their body temperature is dependent on the outside temperature. They still need to maintain a "normal" body temperature but have a different way of doing it than mammals.

Figure 1.8.1

Homeostasis
Organisms have many different ways of maintaining homeostasis. Dogs maintiain temperature homeostasis by panting. Reptiles maintain homeostasis by changing their environment. If a snake is cold, it moves into the sun. If it is hot, it moves into the shade.

1.9 GROWTH

All living organisms grow. Whether the organism is a one-celled bacterium or a trillion-celled human, all organisms grow at some point in their life cycle. Single-celled organisms grow as the cell gets larger. However, a single-celled organism can only grow so big. Multicellular organisms grow by cell reproduction. Cell reproduction increases the number of cells making up the organism. As the number of cells increases, the organism gets larger.

1.10 CLASSIFICATION

The final common property of life forms is that they have been assigned to groups based on their common properties. It is important to remember that not all life forms have been studied or classified yet. It has been estimated that there are 40 million species on earth and we have only studied about 2 million of them.

Figure 1.10.1

The Six Kingdoms and Representative Examples

Kingdom	Example
Archaea	Methanogens
Bacteria	*Escherichia coli*
Protista	Protozoa
Fungi	Molds and Fungus
Plantae	Moss, Trees, Flowers, Bushes
Animalia	Mammals, Birds, Reptiles, Amphibians, Insects

We have already discussed two possible ways to classify all life forms on earth: 1) the producers, consumers, and decomposers system, and 2) the herbivores, carnivores, and omnivores system. However, these systems do not allow for a great deal of specificity when classifying life forms. Another system is used that has been in place—though modified from time to time—for almost 300 years, since it was first devised by Linnaeus in the 16^{th} century.

The **taxonomy** (or classification) system in use today is a seven level, six kingdom system. Life forms are first divided into kingdoms based upon common characteristics, then divided further into other groupings as indicated in the next paragraph until the organism has been placed into the appropriate seven levels.

The levels of classification in the binomial six kingdom taxonomy system are (moving top to bottom, from the more general to the more specific):

Kingdom
Phylum (or Division)
Class
Order
Family
Genus
Species

The levels of classification listed above are the same for plants as they are for animals, with the exception of one level. In the kingdoms of Plantae and Fungi, instead of using phylum, the term division is often used. As can be seen in Figure 1.10.1, all of the over two million already classified organisms are grouped into six kingdoms.

As an example of how this system works, the specific classification breakdown for humans is the following:

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Hominidae
Genus	Homo
Species	sapiens
Sub-species	sapiens

As you read down the classification for humans, the kingdom is the least specific. That means there are many organisms classified in the Kingdom Animalia. As you move down the levels, the classes become more specific. That means there are fewer and fewer organisms in each level of classification as the one above it. For example, there are fewer organisms classified in the Order Primates as there are in the Class Mammalia.

Once you reach the genus and species, you have reached the most specific classification level. For example, there are only a few types of bacteria classified in the *Clostridium* genus. However, there is only one organism classified as the species *Clostridium botulinum*. Occasionally, two organisms are so similar that they have the same genus and species name and are further classified as sub-species. For example, there are two organisms classified as *Homo sapiens—Homo sapiens sapiens* (modern humans) and *Homo sapiens neanderthalensis* (a now extinct group of humans). Most organisms are not classified as sub-species, but simply as a species.

Per convention, organisms are referred to by scientists using their genus and species name. This is a two-part name called the **binomial name.** Note that binomial names are written either with the genus and the species name underlined or in italics as I have done. The genus is always written starting with a capital and the species is started with a lower case letter. Look at Figure 1.1.1 and see the binomial name for the bacteria shown. Organisms are always referred to using their binomial name because this avoids any confusion since there is only one organism on the planet with that name. In the case of species which are classified into a sub-species, then the name is written with all three names. For example, humans are referred to as *Homo sapiens* sapiens, or *H. sapiens sapiens*.

This classification system allows for a great deal of specificity to name any potential life form is encountered on the planet. In addition, there is an infinite number of species that can be classified in this manner due to the seven-level system. Even today, though, as we learn more about particular species, they are sometimes reclassified by scientists into different levels of classification. We will discuss much more about classification systems as the year goes on. Do not get bogged down on this subject now.

1.11 SCIENTIFIC METHOD

All disciplines that are classified as "science" conform to a systematic way of obtaining and methodically analyzing data or observations about a subject called **scientific method**. The scientific method, quite simply, explains how scientists ask questions or answer questions.

The scientific method begins with a question regarding any subject. Then the process of **observation** begins. Observation is the collection of data—or facts—related to the question that needs to be answered. Once some data has been collected, a **hypothesis** is able to be formed. A hypothesis is an educated statement that explains the observations made up to the point the hypothesis statement is formed. A good hypothesis not only explains the data collected, but also predicts what future data will be collected.

Following the formation of the hypothesis statement, the **experimentation** stage of the scientific method begins. During the experimentation period, more and more data is collected and analyzed to test the hypothesis statement.

There are different types of experiments that can be performed. The most simple is the **observation experiment**. Data is collected by using the five senses—taste, touch, vision, smell, and hearing. The observations are written down and assessed after the experiment is completed.

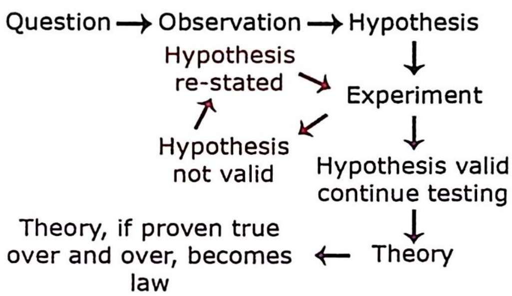


Figure 1.11.1

The Scientific Process.
This is a continually changing process that takes into account the meaning of all information acquired. At times, hypotheses (or even entire theories) have to be re-thought, re-stated,or tested further because of new information obtained in the scientific process.

Most experiments, though, are **controlled experiments.** This type of experiment is designed to test the effects of changing one **factor** on the hypothesis. A variable is anything in an experiment which may affect the outcome. In a controlled experiment, two groups are studied to assess the effects of changing one variable on the outcome of the experiment. This is done to test whether or not the hypothesis is accurate in predicting the outcome of future data.

One group in a controlled experiment is called the **control group**, and the other is the **experimental group**. The control group is exposed to certain factors, and the results are collected. The experimental group is exposed to the exact same factors as the control group, except that one factor is changed. The factor that is changed is called the **variable.** At the end of the experiment, the effects of the variable are evaluated in the experimental group as compared to the control group.

For example, you make the observation that plants almost always grow straight up out of the ground. You hypothesize that the reason they do so is because they grow toward the sun. Since the sun is above the plants, they naturally grow straight up from the earth. The implication in this hypothesis is that if plants are not exposed to the sun, they will not grow straight up. Now you need to devise an experiment to test that hypothesis. The variable that is very easy to control is whether or not the plants are exposed to sun. You devise an experiment in which the control plants are grown in the presence of full sunlight and the experimental plants are grown in the dark. If your hypothesis is correct, then the plants that are grown in the dark should not grow straight up in the air. You plant seeds in pots, water the two groups the same amount, and monitor their growth. You are surprised to find that both sets of plants grow straight upward. That means that your hypothesis is incorrect. You now know that plants grow straight up regardless of their exposure to the sun and you need to revise or restate your hypothesis statement and then design a new experiment to test the new hypothesis.

1.12 THEORY

During the experimental phase, more and more data is collected and evaluated as to whether it is consistent with the experimental hypothesis, or not. If the data is consistent, then there is further experimentation performed in multiple controlled experiments to continue to test the hypothesis. When a large amount of data is collected and remains consistent with the hypothesis statement, then the hypothesis becomes a **theory.** A scientific theory comes as close to a complete explanation of a question as possible. A theory also accurately explains experimental data which is collected. However, if the data collected does not accurately predict the next batch of data which is collected, one of two things needs to occur: either the hypothesis needs to be reformulated, or it needs to be discarded.

1.13 MEASUREMENTS

Finally, there needs to be a way for the scientific experiments to be reported. This is accomplished through scientists discussing their results in scientific journals, at scientific meetings, and on the Internet. By sharing their experimental design and results, other scientists are able to further test the hypothesis and report their findings. This method ensures that strict experimental conditions are maintained, and that results from one scientist are able to be reproduced by other researchers.

In order for the scientific method to be meaningful and universal, scientists have devised a way of expressing results in measurements that any scientist can understand. This is done by using a single standard of measurement called the **International System of Measurement**, or **SI units**, for short. This system is also called the metric system. Figure 1.13.1 lists units that are directly measurable. They serve as the basis for the rest of the SI units' values.

Not all units are measurable units. Some units need to be calculated, such as those for surface area, temperature, volume, and velocity. These are called **derived units** and are the result of mathematical relationships between two base units, or other derived units. These are listed in Figure 1.13.3

Figure 1.13.1

SI Base Units

Base Unit	Name	Abbreviation
Time	second	s
Length	meter	m
Mass	kilogram	kg
Electric current	ampere	A
Amount of substance	mole	mol
Luminous intensity	candela	cd
Thermodynamic temperature	kelvin	K

Figure 1.13.2

SI Modifiers/Prefixes

Prefix	Abbreviation	Factor of base unit	Example
pico-	p	10^{-12}	1 picometer = .000000000001 meters
nano-	n	10^{-9}	1 nanogram = .000000001 grams
micro-	μ	10^{-6}	1 microamp = .000001 amperes
milli-	m	10^{-3}	1 millimole = .001 moles
centi-	c	10^{-2}	1 centimeter = .01 meters
deci-	d	10^{-1}	1 decisecond = .1 seconds
deka-	da	10	1 dekamole = 10 moles
hecto-	h	10^{2}	1 hectogram = 100 grams
kilo-	k	10^{3}	1 kiloamp = 1000 amps
mega-	M	10^{6}	1 megacandela = 1,000,000 candelas
giga-	G	10^{9}	1 gigasecond = 1,000,000,000 seconds

Figure 1.13.3

Derived Units

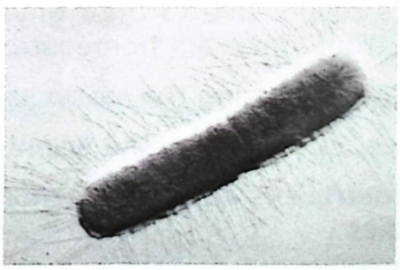
Unit	Name	Abbreviation
Area	square meter	m^2
Volume	cubic meter	m^3
Mass density	kilogram per cubic meter	kg/m^3
Specific volume	cubic meter per kilogram	m^3/kg
Celsius temperature	degree Celsius	°C

1.14 MICROSCOPY

One of the most common instruments used in the study of biology is the **microscope.** A microscope is an instrument that produces large images of even incredibly small objects. A **light microscope** is the standard microscope in scientific use. It is a made of a series of lenses through which light is passed to obtain an image of a small object. The light source can be direct light (such as from a light bulb) or reflected light (such as from a mirror) to **illuminate**—or "light up"—the small object so that the enlarged image can be viewed. The image of the object is then viewed through a lens or a television/computer screen. The amount that the image is enlarged is called the **magnification**. Most light microscopes are capable of magnifying an image up to 2000 times (or 2000x) its normal size.

Figure 1.14.1

Microscopic, TEM and SEM Views of Escherichia coli.
This figure demonstrates the different abilities of three different types of microscopes. The image on the left is taken through a regular light microscope. This type of picture is called a light micrograph. This organism is a unicellular animal called an amoeba. This is magnified approximately 400x. The middle picture is taken from a type of electron microscope called a transmission electron microscope (TEM). This type of picture is called an electron micrograph. This is of a bacterium called *E. coli* and it is magnified approximately 5000x. The image on the right is an electron micrograph taken with a scanning electron microscope (SEM). Notice the SEM gives a three dimensional image, whereas the TEM gives a two dimensional image. This is an image of a tick, magnified approximately 500x.


1.15 ADVANCED

The light microscope is limited to magnifying an image to 2000x because magnifying the image any larger makes the image too blurry to see detail. The ability to see detail well under magnification is called **resolution**. The light microscope has a resolution that is limited to magnifying an image 2000 times its normal size (or 2000x).

In order to further our knowledge of biology and other sciences, a way was devised to magnify images much larger without affecting their resolution. This method is called electron microscopy. An **electron microscope** bounces a beam of electrons off of an object instead of light. Instead of the image of the object being collected in a lens to be viewed, the image from an electron microscope is collected in magnetic lenses. The image is then converted into a signal and is usually displayed on a screen like a television or computer monitor. An electron microscope allows for magnification of an object up to 200,000x. This means an electron microscope can enlarge things 200,000 times their original size. Electron microscopes also give excellent resolution. That means that even though it enlarges objects to thousands of times their normal size, the detail of the image is not distorted. Unfortunately, the use of electron microscopes is limited due to their cost (several million dollars each).

There are two main types of electron microscopes. The **transmission electron microscope (TEM)** allows for the study of non-living objects by embedding the object in a frozen block and slicing it into extremely thin pieces. The electron beam is passed through the object in one plane. This method of study of microscopy has been crucial in advancing our knowledge of the interiors of cells. Like light microscopy, the TEM gives a 2D image.

The **scanning electron microscope (SEM)** is an excellent tool for studying living small things. In SEM, the electron beam is swept across an intact, rather than thinly sliced, sample and gives a 3D image of the object. It does not allow for as much magnification as the TEM does, though.

1.16 PEOPLE OF SCIENCE

Anton van Leeuwenhoek (1632–1723) It is a hard call regarding who should be the first person listed in the People of Science section. Mr. van Leeuwenhoek was chosen for several reasons. First of all, he had absolutely no training in biology. He was a janitor and owned his own dry goods store in Holland. Second, he did things no one expected could be done at the time, which raised him to great prominence. In his spare time, he liked to grind lenses used for eye glasses. However, van Leeuwenhoek was able to grind lenses smaller than any else ever had—some as small as a pinhead. He was able to hand grind lenses 300 years ago which are still the envy of microscope makers. It was this hobby that led him to discover the microscope. Due to his perfection of grinding high optic lenses, he was able to see things never before seen. He was the first human to ever see bacteria, yeast, muscle fibers, and blood flowing through blood vessels. The scientific community rapidly adopted his technology, and his observations led to a revolution in biology that lasted several hundred years. His determined approach to a hobby led to one of the most significant contributions to science.

1.17 KEY CHAPTER POINTS

- Every organism which is alive shares the following properties: they are made up of one or more cells; they contain DNA; they reproduce; they are complex and organized; they are responsive to their environment; they extract energy from their surroundings; they maintain homeostasis; and they grow.
- All organisms are classified using the seven level, six kingdom, taxonomic system.
- Biology, as a science, is subject to the scientific method.
- SI units (i.e. the "metric system") are standardized units of measurements used in all scientific studies.

- Many instruments are used to make scientific observations. One of the most important in biology is the microscope.
- Electron microscopes have much better resolution than light microscopes.

1.18 DEFINITIONS

asexual reproduction
The production of a new organism that only requires one parent. This type of reproduction normally does not cause any change in the genetic material from parent to offspring.

binomial
The two-part name of an organism that has been classified using the six kingdom system.

biology
The study—or science—of life.

carnivore
An animal that extracts its energy from other animals. Simply put, a meat eater.

cellular respiration
The process by which producers produce their energy from the sugars they make during photosynthesis or the way that consumers produce their energy from the food they eat.

consumer
An organism that uses a producer or other consumers for its energy source. All animals are examples of consumers.

controlled experiment
A type of experiment in which two sets of groups are studied—a control group and an experimental group—to understand the effect of changing one condition.

control group
The group in a controlled experiment that is not subjected to a changed variable.

decomposers
Organisms that derive their energy from dead organisms.

DNA (deoxyribonucleic acid)
The molecule that contains the genetic material in all life forms.

ecosystem
The relationship between more than one population and the environment in which they live.

electron microscope
A microscope which bounces a beam of electrons off of an object to acquire the image.

environment
The surroundings in which an organism lives. This can refer to an external (outside) environment (such as a rain forest) or an internal environment (such as a human being when discussing a bacteria that is making someone ill).

experiment
A careful method of testing a hypothesis.

experimental group
The group in a controlled experiment that is exposed to a variable.

food chain
The process of the transfer of energy from the sun, to the producers, to the consumers, to the decomposers.

herbivore
An animal that extracts its energy only from plants. Simply put, a plant-eater.

homeostasis
The maintenance of a stable internal environment in order for an organism to live.

hypothesis
An educated statement that explains observations. A hypothesis statement is made early on in the scientific method.

International System of Measurement, or SI Units
A standard set of units that are used by all scientists around the world.

light microscope
A system of connected lenses which acquires an image by reflecting light off of, or shining light through, the object.

magnification
The amount by which an image is enlarged by a microscope.

metabolism
The process by which an organism extracts energy from its surroundings and uses it to sustain itself.

microscope
An instrument that produces enlarged images of very small objects.

offspring
The organism that receives the genetic material and is formed as a result of reproduction.

omnivore
An animal that can extract its energy from either plants or animals.

organism
The resulting structure that is formed when one or more cells are grouped together to carry on the activities of life. Examples range from a one-celled bacterium to a trillion-celled human being or tree.

parent
The organism(s) that supplies the genetic material during reproduction.

photosynthesis
The process by which the energy of the sun is captured and used to make sugar molecules.

population
A group of similar organisms that live in the same area.

producer
An organism that uses photosynthesis to produce its own energy source. All plants are examples of a producer.

receptor
Specialized molecules or organs that all life forms possess that allow them to sense and respond to changes in their environments.

resolution
The ability to see an image's fine detail.

reproduction
The formation of a new organism or cell from already living organisms or cells in order to propagate—or spread—the species or make new cells.

scientific method
The systematic collection and analysis of data.

sexual reproduction
The production of one or more offspring as a result of a male and female of the species combining their genetic material. This type of reproduction results in changes in genetic material from parent to offspring and requires two parent organisms.

taxonomy
The orderly classification of plants and animals according to their observed natural relationships to one another as well as similarities in structure and function.

theory
A hypothesis which has undergone extensive experimentation and has been found to completely explain a question.

STUDY QUESTIONS

1. Describe or list the common properties that all life forms share.
2. What is a food chain?
3. How do plants obtain their sugar molecules?
4. How does an herbivore obtain its daily energy? Where does a carnivore obtain its daily energy?
5. How is an omnivore different from a carnivore?
6. What is the process of a producer, consumer, or decomposer making energy molecules from sugar molecules called?
7. Describe homeostasis and explain why it is important.
8. List three ways that organisms can be scientifically classified.
9. Describe the taxonomy system most commonly used to classify organisms today.
10. What is a hypothesis statement?
11. What is the next step of the scientific method after the hypothesis statement is formulated?
12. Is the experimental group or control group exposed to the variable in a controlled experiment?
13. What must a scientist do if the data collected during hypothesis testing does not support the hypothesis statement?
14. What is important about the units used in the SI system?
15. Define magnification and resolution.
16. Which type of electron microscope provides a three dimensional image of an object?