Chapter 1-1: Characteristics of Living Things

Biology is the scientific discipline that is concerned with the study of life. Strictly speaking, it is difficult to describe any one prototypical living thing, but in this plate we will describe some characteristics that all living things possess.

As you look over the plate, you will note that it consists of seven sections, each of which shows one characteristic of a living thing.

One of the characteristics of living things is internal organization. The cell itself is characterized by internal organization, and, in the case of multicellular organisms, the organism possesses an overall internal organization.

All living things must obtain materials and energy from the environment. These are used in metabolism, which is the sum of all of the chemical reactions that occur in an organism. In this plate, we see a **plant (A)** and an **animal (B)**. Plants obtain nutrients from the soil, while animals obtain them through the ingestion of **food (C)**. In both organisms, reactions are carried out and substances are synthesized and broken down. Energy is released from the organic substances that were obtained from the environment, and this energy fuels the organism.

All living things exhibit control (see the **bird (D)** in the figure), which refers to the coordination of their body activities, as well as the regulation of their processes; internal and external. Control refers to the fact that the metabolic activities in living things occur in sequence and at specific rates. The flapping of the bird's wings, for example, requires that nerve impulses are coordinated as they travel to muscles and that muscles contract in sequence. Blood must be supplied to tissues, and waste products must be removed from them. Dynamic control is absent in nonliving things.

We have examined metabolism and control as two characteristics of living things. We now move to three additional characteristics as we continue our introduction. Continue your reading below as you color the plate.

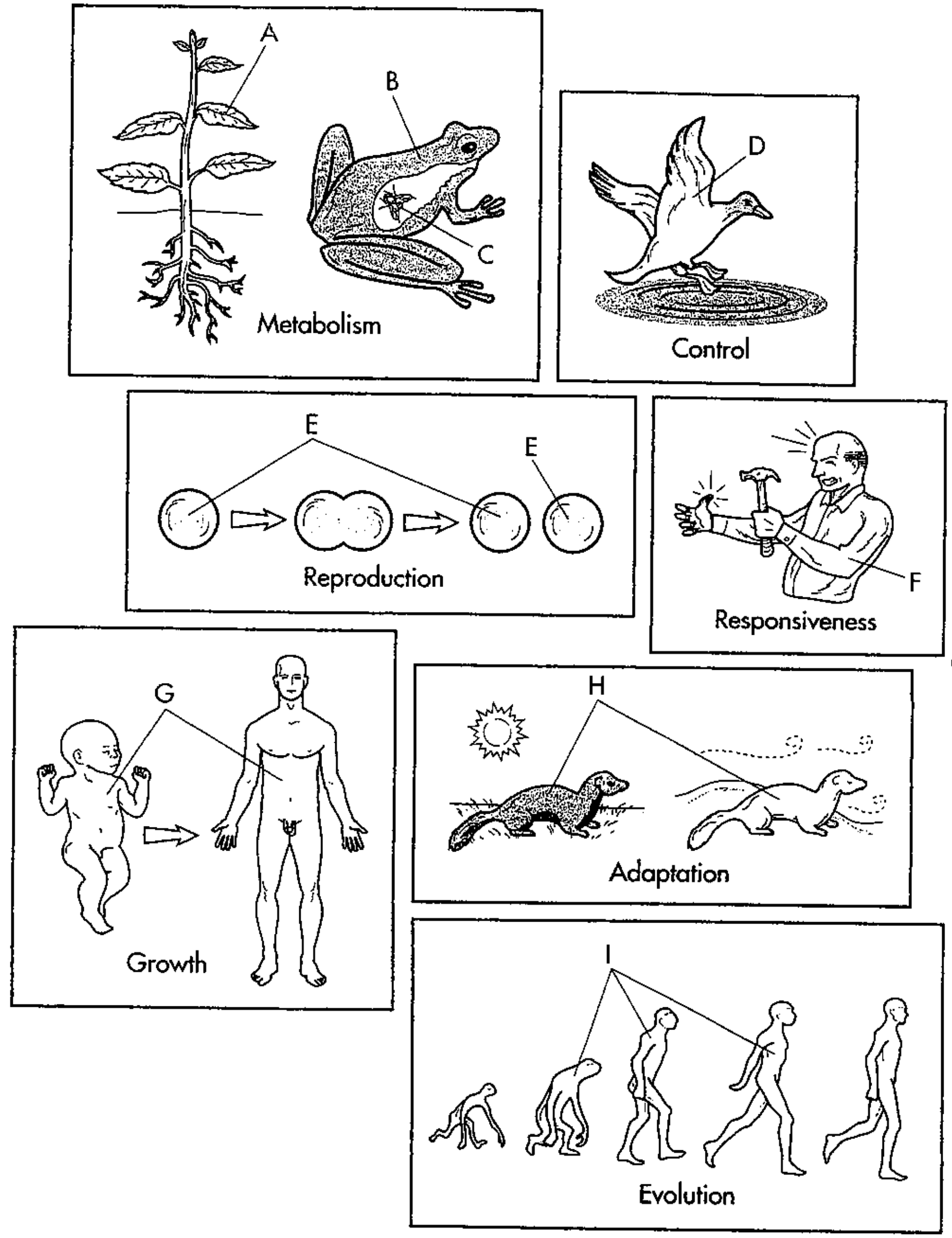
Another essential aspect of life is reproduction. Here we see a **cell (E)** undergoing binary fission to produce two identical daughter cells. Reproduction is accompanied by an increase in size called growth. In the process of growth, living things increase the size of their structures. In this plate, we see growth in a **human (G)**. Growth can also mean that cells increase in size, number, and specialization. As you can imagine, the fully formed human is much more complex than the fertilized egg cell from which it developed.

Living things also exhibit responsiveness, which means that they respond to changes in their environment. In the art, you can see a **responsive individual (F)** reacting to an injury. Hormones, nerve cells, and various other chemical substances bring about responses in humans.

We have now examined five characteristics that all living things possess. We will finish by examining adaptation and evolution, two more characteristics that are attributed to living organisms.

Adaptation refers to physical adjustments organisms make over relatively long periods of time to changes in their environments. In this plate, you can see an **adapted animal (H)**. This is an animal with a coat that blends with the brown prairie grass among which it lives in the summertime. When snows falls, the animal loses its brown coat and takes on a white one in order to blend into its new environment.

Evolution refers to populations changing over time. Evolution is a slow change in the genetic makeup of a population (rather than an individual) that enables it to survive in its environment. We show the **evolving population (I)** as the evolution of the human species. By continuing to adapt to its changing environment, the human population survived the selective pressures of the environment over thousands of years. Arguably, with evolution, our population improved its ability to live in the environment, and avoided extinction. Other populations, which failed to make these adaptations, became extinct.



Characteristics of Living Things

- ○ Plant ....A
- ○ Animal ....B
- ○ Food C
- ○ Bird ....D
- ○ Cell ....E
- ○ Responsive Individual ....F
- ○ Human ....G
- ○ Adapted Animal ....H
- ○ Evolving Population....I

1-1 Characteristics of Living Things

a. With what study is biology concerned?

b. What kind of organization characterizes living things?

c. For what do living things use materials & energy?

d. The sum of al the chemical reactions that occur in an organism:

e. Where do plants obtain nutrients? Animals?

f. The coordination of body activities:

g. How do metabolic activities occur in living things?

h. Binary fission is an example of this characteristic of life:

i. Increase in size &/or structure & specialization:

j. Responding to changes in the environment:

k. Physical adjustments organisms make over relatively long periods of time to changes in their environment:

l. Population changing over time refers to:

m. What happens to populations who fail to make adaptations?

Chapter 1-2: Biological Organization

Organization in living things exists in a hierarchical structure. Organization exists within organisms, as we will discuss in this plate, and also within environments; this will be covered in the ecology chapter.

In this plate, we will show the hierarchy of organization that exists in a human. We will begin with the most basic level of organization at the bottom of the plate, and show the increasing complexity as we move up.

The most fundamental level of organization on Earth is the atom. All matter in the universe is composed of atoms. There are ninety-two naturally occurring elements, each of which is made up of a distinct atom. About 99% of the atoms in living things are carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorous.

At the bottom of the plate we show a typical **atom** (A); you should color the bracket in a bold color such as dark red or green. The atom consists of positively charged particles called **protons** (A_1) and uncharged particles, or **neutrons** (A_2). These particles are surrounded by **electrons** (A_3), which have a negative charge. Elements vary according to the number of protons present in the nuclei of their atoms. An atom of carbon, for example, has six protons in its nucleus, while an atom of oxygen has eight protons.

Atoms join to form the **molecule** (B). A molecule consists of various kinds of atoms bonded to one another. In the plate, we show a **DNA molecule** (B_1), which is involved in heredity. It is composed of atoms of carbon, hydrogen, oxygen, and nitrogen and phosphorus. The atoms are linked and wound to form the familiar spiral staircase (double helix) of the DNA molecule. A light color should be used for it.

The most basic unit of life is the **cell** (C). In the plate, we show a muscle cell, which has both **cytoplasm** (C_1) and a **nucleus** (C_2). The cell is composed of molecules of protein, carbohydrate, lipid, and nucleic acid. It is long and slender in shape, and contracts to create movement. The human body consists of approximately 100 trillion cells.

Atoms and molecules are inert, but the cell is alive and has the properties of a living thing, which were discussed in the previous plate. We will now progress to the next level to see how cells are organized.

In some cases, cells operate independently. These are unicellular organisms, which include bacteria and protozoa. In humans, cells are generally grouped together to form tissues. In the plate, you can see one section of a typical **tissue** (D) outlined by the bracket. When muscle cells contract in unison, the entire muscle contracts. Other types of body tissues are nervous tissue, epithelial tissue, and connective tissue. They are discussed in a future plate, titled Cell Types and Tissues.

When various tissues join with one another, they can form an **organ** (E). In this plate, we show the heart as a typical organ. The heart has two pumping chambers called **ventricles** (E_1). Carrying blood to and from the ventricles are the **major blood vessels** (E_2). Arteries take blood away from the heart to the body and veins bring blood back to it. The heart contains various types of tissues: muscle tissue that allows contraction, nerve tissue that controls the contraction rate, and membranous tissue that encloses it.

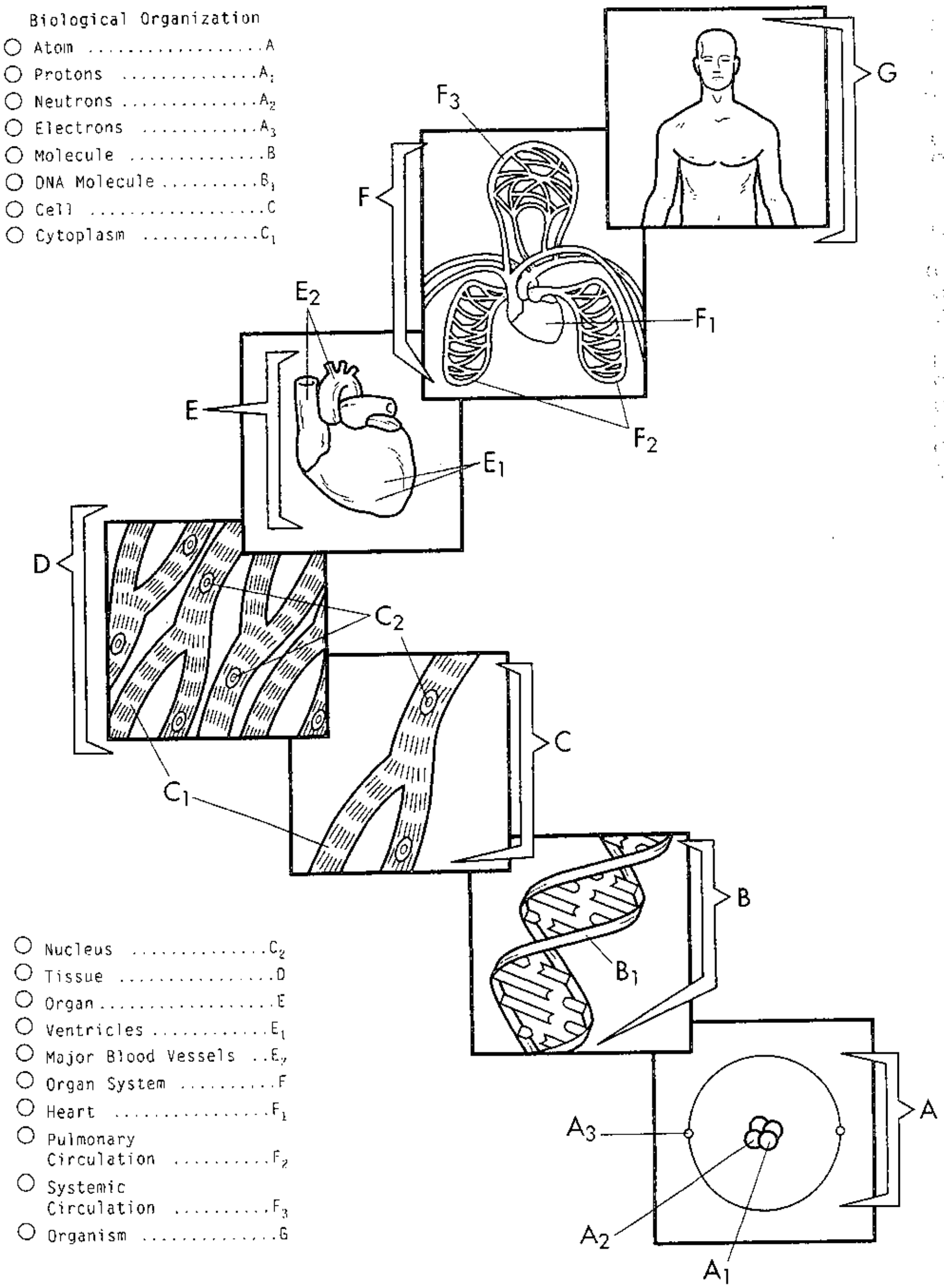
Various organs in combination are called an **organ system** (F). An example of an organ system is the circulatory system. It consists of the **heart** (F_1) and numerous blood vessels. Certain of these blood vessels carry blood to and from the lungs and compose the **pulmonary circulation** (F_2), while other vessels carry blood to and from the other sections of the body and compose the **systemic circulation** (F_3). Another organ system is the digestive system. Organs in this system include the esophagus, stomach, pancreas, small and large intestines, and liver.

The highest level of biological organization is the **organism** (G). It is composed of numerous organ systems, including the digestive, nervous, circulatory, respiratory, excretory, and reproductive systems. The organ systems work closely together.

Biological organization can also be studied at the level of ecology, which we will discuss later in the book. A number of organisms grouped together constitute a population, and various populations form a community.

Biological Organization

- ○ Atom ....A
- ○ Protons ....A_1
- ○ Neutrons ....A_2
- ○ Electrons ....A_3
- ○ Molecule ....B
- ○ DNA Molecule ....B_1
- ○ Cell C
- ○ Cytoplasm ....C_1
- ○ Nucleus ....C_2
- ○ Tissue ....D
- ○ Organ ....E
- ○ Ventricles ....E_1
- ○ Major Blood Vessels ..E_2
- ○ Organ System ....F
- ○ Heart ....F_1
- ○ Pulmonary Circulation ....F_2
- ○ Systemic Circulation ....F_3
- ○ Organism ....G



1-2 Biological Organization

a. In what type of structure does organization exist in living things:

b. What is the most fundamental level of organization of life on Earth?

c. How many naturally occurring elements exist?

d. About 99% living things are composed of what five atoms?

e. Positively charged particles are called? Uncharged particles? Negatively charged particles?

f. Atoms join to form:

g. The most basic unit of life:

h. What four compounds make up a cell?

i. How many cells does the human body contain?

j. What kind of organism has cells that operate independently?

k. Cells generally join to form:

l. When various tissues join with one another, they can form a(n):

m. Various organs in combination are called a(n):

n. The highest level of biological organization:

o. Organisms group together to form a ____, which can then form ____.

Chapter 1-3: Size Relationships in Biology

Organisms vary considerably in size. In this plate, we survey some members of the biological kingdom and point out how they relate to one another in size.

This plate displays thirteen different organisms, each of which is placed along the meter scale to show its size and relationship to other biological specimens. We will examine the specimens in three groups.

We will move from the smallest organism, which is on the left, to the largest. We begin with specimens that are too small to be viewed with any instrument, and those that can only be viewed with the **electron microscope (A)**. The arrows that group the different sized organisms should be colored in bold reds, greens, or blues.

Atoms cannot be seen under electron microscopes. An **atom (B)** measures approximately 0.1 nanometers (nm) in diameter, and a nanometer is a billionth of a meter. (So an atom is a ten-billionth of a meter in diameter.) The smallest specimen that can be viewed with an electron microscope is a **small molecule (C)**. Such a molecule measures approximately 1 nm (one-billionth of a meter) in diameter. An amino acid and a glucose molecule are examples. Slightly larger specimens are large, **folded proteins (D)**. Proteins can range in size from about 4 nm to about 10 nm in diameter, as the bracket indicates.

Within the size range of 10 to 100 nm are the **viruses (E)**. In the diagram, you can see a complex virus known as a bacteriophage. Its details are easily visible through the electron microscope. Viruses are inert particles that have the ability to replicate.

Thus far we have examined several specimens that are visible only through the electron microscope. We now turn to biological specimens that are visible with the light microscope. Continue your coloring as you read the paragraphs below.

The range of sizes of objects that is visible with the aid of the **light microscope (F)** is indicated by the arrow. The range starts at objects that are approximately 100 nm. Included in this is the **chloroplast (G)**, which is the photosynthetic organelle of the plant. Chloroplasts are approximately 1 micrometer (μm) in diameter; a micrometer is one millionth of a meter.

As the diagram shows, **bacteria (H)** range in size from slightly less than 1 μm to about 10 μm. They are smaller than **plant and animal cells (I)**, which range from approximately 10 to100 μm. Note that the electron microscope can be used to view these samples, and it is often used to view the submicroscopic structures in plant and animal cells.

Also within the realm of the light microscope is the **human egg cell (J)**. This cell measures approximately 125 μm in diameter and is almost large enough to be seen by the naked eye.

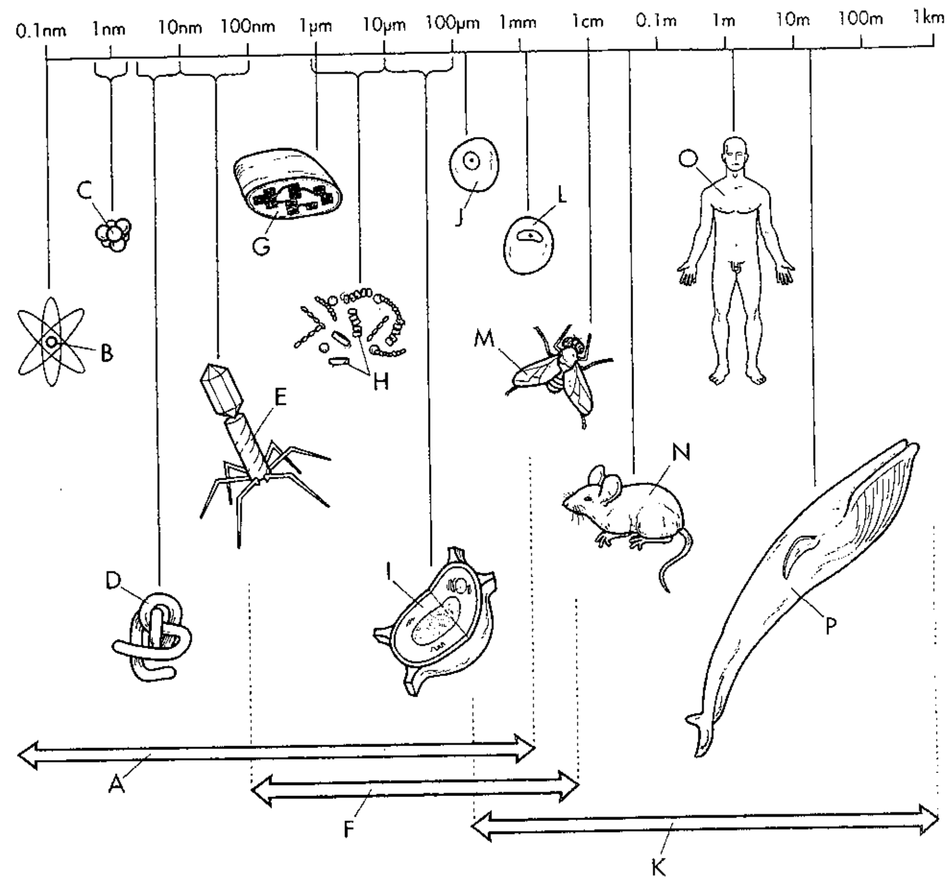
We now move to those biological specimens that can be visualized with the unaided eye. Continue your reading below as you note the various size relationships among biological objects.

The range of the **unaided eye (K)** is indicated by the arrow, which should be colored a dark color. Within this realm is the **frog egg cell (L)**. This specimen is slightly more than a millimeter (mm) in diameter. (A millimeter is a thousandth of a meter.)

The next specimen we will look at is the **insect (M)**. Although the insect is larger than the frog egg cell, the size of insects varies considerably. The insect we display is approximately a centimeter (cm) in length. The next largest organism on our chart is the **rodent (N)**, which is approximately 5 cm in length.

Now we examine the **human (O)**. The average human is taller than a meter. A meter is equivalent to 39.37 inches, or slightly larger than three feet. The human we show is approximately five feet in height, or about 1.2 m.

The largest biological organism presented is the **whale (P)**. Notice the enormous size of this animal relative to the other biological specimens. The animal is roughly 25 m in length, or approximately 75 feet. The whale is among the largest organisms known to inhabit Earth.



1-3 Size relationship in Biology

a. Smallest organisms can only be viewed with this:
b. Can atoms be seen with an electron microscope?
c. How big is an atom?
d. How big is a molecule (that can be seen with an electron microscope)?
e. What are examples of molecules this size?
f. How big are folded proteins?
g. How big are viruses?
h. What is the range of the light microscope?
i. Are bacteria smaller or larger than plant or animal cells?
j. Can a human egg be seen with a light microscope?
k. Do you need a light microscope to see a frog egg?
l. What is the largest organism know to inhabit the Earth?

Size Relationships in Biology

- ○ Electron Microscope Range ....A
- ○ Atom ....B
- ○ Small Molecule C
- ○ Folded Protein ....D
- ○ Virus ....E
- ○ Light Microscope Range ....F
- ○ Chloroplast ....G
- ○ Bacteria ....H
- ○ Plant/Animal Cell......I
- ○ Human Egg Cell ....J
- ○ Unaided Eye Range......K
- ○ Frog Egg Cell L
- ○ Insect ....M
- ○ Rodent ....N
- ○ Human ....O
- ○ Whale ....P