crush and open the hard seeds. Unfortunately, finches that have beaks that are neither long nor dense may slowly begin to decline in number because they are limited in their ability to obtain nutrients. Finches that obtain food can put energy into reproduction and survival needs. When those finches reproduce, they pass along those adaptations that allow them to be successful in their respective feeding environments. Over time two distinct groups may arise, those with thick, dense beaks and those with longer skinnier beaks (Figure 1.5). If these individuals genetically change in such a way that they no longer can interbreed with one another, a speciation event will have occurred.

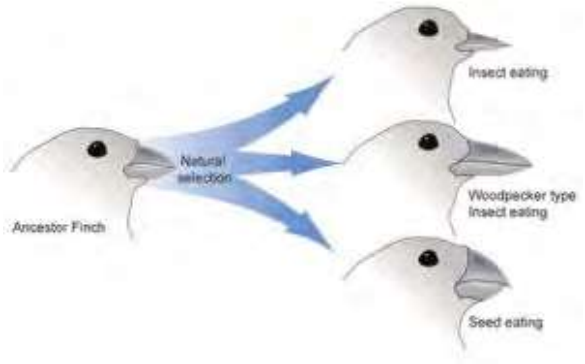

Figure 1.5 Different finch phenotype variations due to environmental changes. (credit: National Human Genome Research Institute's Talking Glossary/Wikimedia Commons)

Growth and Development

Development is often described as the processes that an individual goes through as it grows and matures. For example, in humans, development begins once the sperm fertilizes the egg. Human development can be broken down into different stages including embryonic development, fetal development, infancy, childhood, puberty, and adulthood. Development can also be observed in many other organisms. For example, butterflies go through a developmental process called metamorphosis that begins at the egg stage and then proceeds to the larva, pupa, and adult stages.

Both multicellular and single-celled organisms grow and develop according to specific instructions encoded in their DNA. DNA is organized into genes that provide information for cellular growth and development. An individual's DNA ensures that a species' young (Figure 1.6) will grow up to exhibit many of the same traits as its parents.

Figure 1.6 Although no two looks alike, these kittens have inherited genes from both parents and share many of the same characteristics. (credit: Pieter & Renée Lanser/ Concepts of Biology OpenStax)

Homeostasis

Even the smallest organisms are complex and require multiple regulatory mechanisms to coordinate internal functions, such as the transport of nutrients (Figure 1.7), response to stimuli, and coping with environmental stresses. **Homeostasis** or "steady state" is the ability of an organism to regulate and maintain constant internal conditions.

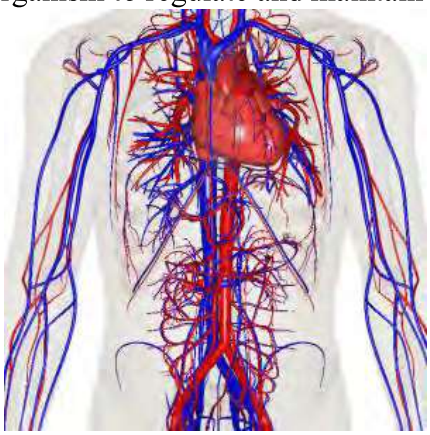

Figure 1.7 Human circulatory system plays an important role in transporting oxygen, removal of waste, and delivering nutrients to every cell. (credit: Public domain/Wikimedia Commons)

Cells require appropriate conditions such as proper temperature, pH, and concentrations of nutrients to function correctly. Although these conditions may change, organisms can maintain internal conditions within a narrow range. For example, many organisms regulate their body temperature in a process known as thermoregulation. Organisms that live in cold climates, such as the polar bear (Figure 1.8), have body structures such as thick layers of fur or fat, which help them withstand low temperatures and conserve body heat. In hot climates, plants carry out unique versions of photosynthesis to reduce water loss and optimize their potential of making sugar.

a

b

Figure 1.8a. Polar bears and other mammals living in ice-covered regions keep their body temperature relatively constant, even though the environment can be very hot during the day and cold at night. (credit: "longhorndave"/Flickr) b. Polar bear maintain their body temperature by generating heat and reducing heat loss through thick fur and a dense layer of fat under their skin. In this infrared image the polar bear's body heat hardly registers; only the uninsulated eyes and mouth show temperatures significantly warmer than the environment. (credit: Arno/Coen/Wikimedia Commons)

Organisms like humans (Figure 1.9), use their skeletal muscles to generate heat. The contraction of skeletal muscles helps humans maintain stable internal body temperature as environmental conditions fluctuate. If body temperature drops below a certain point, metabolism begins to slow and may even stop, leading to death. Conversely, if body temperature rises above a certain point, it can lead to the destruction of key molecules called proteins. Students that continue and take Anatomy and Physiology classes will spend time discussing how the body works to maintain homeostasis. Students will also look at what occurs when the body loses its ability to maintain stable internal conditions, otherwise referred to as a homeostatic imbalance.

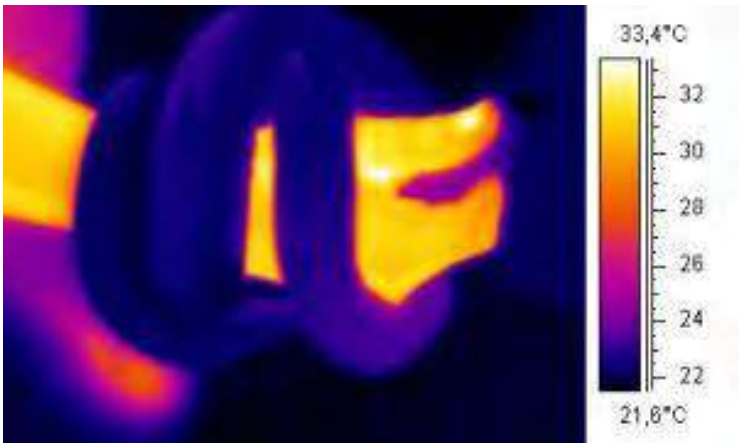

Figure 1.9 Thermogram of a snake wrapped around a human arm. (credit: Arno/Coen/Wikimedia Commons)

Energy Processing

All organisms, including the California condor shown in Figure 1.10, use a source of energy for their metabolic activities. Some organisms can obtain energy through metabolic pathways such as photosynthesis. Photosynthesis is a process where light energy can be captured and converted into chemical energy. Organisms that are capable of making their own chemical energy are referred to as **autotrophs**. Others must obtain their chemical energy by consuming other organisms. These individuals are referred to as **heterotrophs**. Regardless of whether an organism is an autotroph or a heterotroph, all living cells must have energy to drive metabolism.

Figure 1.10 A lot of energy is required for a California condor to fly. (credit: Pacific Southwest Region U.S. Fish and Wildlife/ Concepts of Biology OpenStax)

Levels of Organization of Living Things

Living things are highly organized and structured. The **atom** is the smallest and most fundamental unit of matter. It consists of a nucleus surrounded by electrons. Atoms form molecules. A **molecule** is a chemical structure consisting of at least two atoms held together by a chemical bond. Many biologically important molecules are macromolecules. A **macromolecule** is a large molecule that is typically formed by combining smaller molecules. For example, nucleotides are small molecules linked together to form the macromolecule, DNA (deoxyribonucleic acid) (Figure 1.11). DNA contains the instructions necessary for cells and organisms to maintain homeostasis.

Figure 1.11 A molecule, like this large DNA molecule, is composed of atoms. (credit: "Brian0918"/Wikimedia Commons)

CONCEPTS IN ACTION- To see an animation of this DNA molecule, click here.

Some cells contain collections of macromolecules surrounded by membranes; these are called organelles. **Organelles** are small structures that exist within cells and perform specialized functions. For example, in some cells, DNA is enclosed within a membrane-bound organelle called the nucleus (plural: nuclei). All living things are made of cells; the **cell** is the smallest fundamental unit found in living organisms. Cells exhibit all of the properties of life discussed above. Viruses are often not considered living because they are not made of cells, nor are they capable of reproducing on their own. To make new viruses, they must invade and take over a living cell.

Some **organisms** consist of a single cell, while others are multicellular. In most multicellular organisms, cells combine to make **tissues**, which are groups of similar cells carrying out the same function. **Organs** are collections of tissues grouped based on a common function. Organs are present not only in animals but also in plants. An **organ system** is a higher level of organization that consists of functionally related organs. For example, vertebrate animals have many organ systems, such as the circulatory system that transports blood throughout the body; it includes organs such as the heart and blood vessels. **Organisms** are individual living entities. For example, each tree in a forest is an organism. Single-celled prokaryotes and single-celled eukaryotes are also considered organisms and are typically referred to as microorganisms.

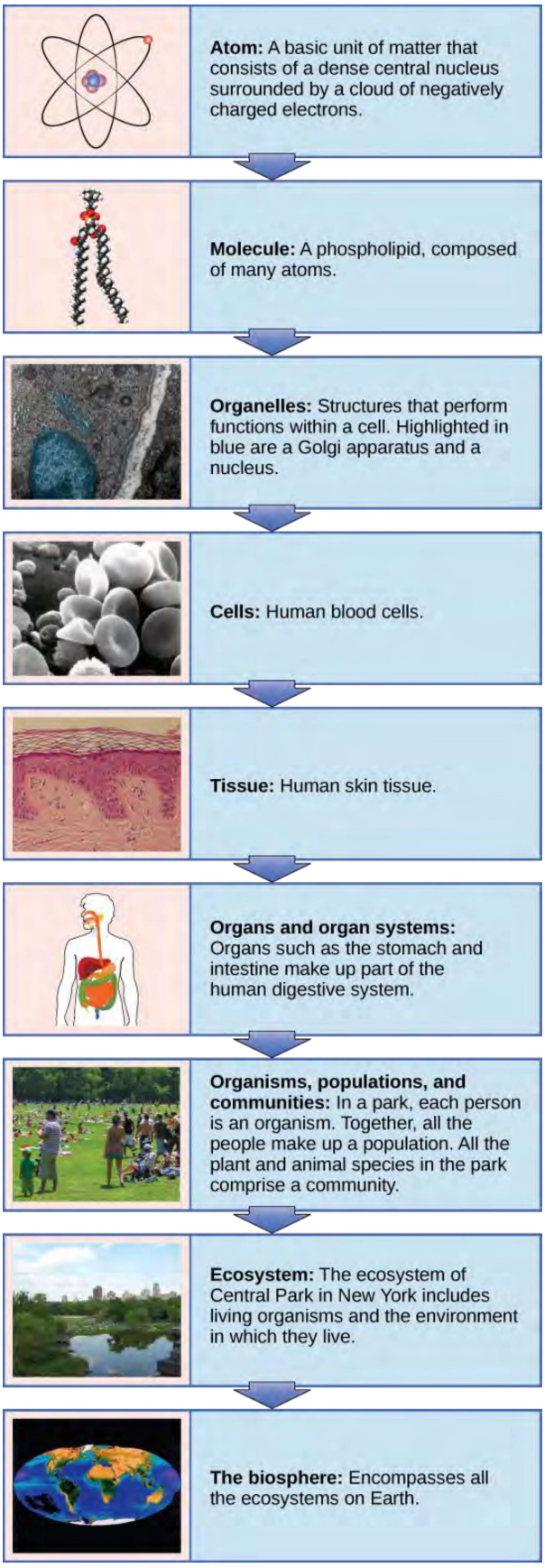

Figure 1.12 From an atom to the entire Earth, biology examines all aspects of life. (credit "molecule": modification of work by Jane Whitney; credit "organelles": modification of work by Louisa Howard; credit "cells": modification of work by Bruce Wetzel, Harry Schaefer, National Cancer Institute; credit "tissue": modification of work by "Kilbad"/Wikimedia Commons; credit "organs": modification of work by Mariana Ruiz Villareal, Joaquim Alves Gaspar; credit "organisms": modification of work by Peter Dutton; credit "ecosystem": modification of work by "gigi4791"/Flickr; credit "biosphere": modification of work by NASA/ Concepts of Biology OpenStax)

All the individuals living within a specific area are collectively called a **population**. For example, a forest may include many white pine trees. All these pine trees represent the population of white pine trees in this forest. Different populations may live in the same area. The forest with the pine trees includes populations of flowering plants, insects, and microbial populations. A **community** is the set of populations inhabiting a particular area. For instance, all the trees, flowers, insects, and other populations in a forest form the forest's community. The forest itself is an ecosystem. An **ecosystem** consists of all the living things in a particular area together with the abiotic, or non-living, parts of that environment, such as nitrogen in the soil or rainwater. At the highest level of organization (Figure 1.12), the **biosphere** is the collection of all ecosystems on planet Earth. It includes land, water, and portions of the atmosphere.

Check your knowledge

Which of the following statements is false?

a. Tissues exist within organs which exist within organ systems.
b. Communities exist within populations which exist within ecosystems.
c. Organelles exist within cells which exist within tissues.
d. Communities exist within ecosystems which exist in the biosphere.

Answer: (b)

The Diversity of Life

The science of biology is very broad because there is a tremendous diversity of life on Earth. The source of this diversity is evolution. **Evolution** is the process of genetic change in a population. Evolution helps explain how new species can arise from older species. Speciation events can occur when individuals within a population are separated and begin to change or evolve independently of one another. If the individuals change to the point where they can no longer interbreed, a speciation event has occurred, and species diversity has increased. Evolution will be discussed in much greater detail in chapter 11.

In the 18th century, a Swedish scientist named Carl Linnaeus first proposed organizing living organisms into a hierarchical taxonomy. In this system, species that are most similar to each other are put together within a grouping known as a genus. Furthermore, similar genera (the plural of genus) are put together within a family. This grouping continues until all organisms are collected together into groups at the highest level. The current taxonomic system now has eight levels in its hierarchy, from lowest to highest, they are species, genus, family, order, class, phylum, kingdom, and domain (Figure 1.13).