**Photosynthesis**

Photosynthesis is the process by which green plants and certain other organisms transform light energy into chemical energy. During photosynthesis in green plants, light energy is captured and used to convert water, carbon dioxide, and minerals into oxygen and energy-rich organic compounds.

It would be impossible to overestimate the importance of photosynthesis in the maintenance of life on Earth. If photosynthesis ceased, there would soon be little food or other organic matter on Earth. Most organisms would disappear, and in time Earth’s atmosphere would become nearly devoid of gaseous oxygen. The only organisms able to exist under such conditions would be the chemosynthetic bacteria, which can utilize the chemical energy of certain inorganic compounds and thus are not dependent on the conversion of light energy.

Energy produced by photosynthesis carried out by plants millions of years ago is responsible for the fossil fuels (i.e., coal, oil, and gas) that power industrial society. In past ages, green plants and small organisms that fed on plants increased faster than they were consumed, and their remains were deposited in Earth’s crust by sedimentation and other geological processes. There, protected from oxidation, these organic remains were slowly converted to fossil fuels. These fuels not only provide much of the energy used in factories, homes, and transportation but also serve as the raw material for plastics and other synthetic products. Unfortunately, modern civilization is using up in a few centuries the excess of photosynthetic production accumulated over millions of years. Consequently, the carbon dioxide that has been removed from the air to make carbohydrates in photosynthesis over millions of years is being returned at an incredibly rapid rate. The carbon dioxide concentration in Earth’s atmosphere is rising the fastest it ever has in Earth’s history, and this phenomenon is expected to have major implications on Earth’s climate.

An intriguing area in the study of photosynthesis has been the discovery that certain animals are able to convert light energy into chemical energy. The emerald green sea slug (Elysia chlorotica), for example, acquires genes and chloroplasts from Vaucheria litorea, an alga it consumes, giving it a limited ability to produce chlorophyll. When enough chloroplasts are assimilated, the slug may forgo the ingestion of food. The pea aphid (Acyrthosiphon pisum) can harness light to manufacture the energy-rich compound adenosine triphosphate (ATP); this ability has been linked to the aphid’s manufacture of carotenoid pigments.

**Plants**

A plant (kingdom Plantae) is any multicellular eukaryotic life-form characterized by (1) photosynthetic nutrition (a characteristic possessed by all plants except some parasitic plants and underground orchids), in which chemical energy is produced from water, minerals, and carbon dioxide with the aid of pigments and the radiant energy of the Sun, (2) essentially unlimited growth at localized regions, (3) cells that contain cellulose in their walls and are therefore to some extent rigid, (4) the absence of organs of locomotion, resulting in a more or less stationary existence, (5) the absence of nervous systems, and (6) life histories that show an alteration of haploid and diploid generations, with the dominance of one over the other being taxonomically significant.

Plants range in size from diminutive duckweeds only a few millimetres in length to the giant sequoias of California that reach 90 metres (300 feet) or more in height. There are an estimated 390,900 different species of plants known to science, and new species are continually being described, particularly from previously unexplored tropical areas of the world. Plants evolved from aquatic ancestors and have subsequently migrated over the entire surface of Earth, inhabiting tropical, Arctic, desert, and Alpine regions. Some plants have returned to an aquatic habitat in either fresh or salt water.

In nature all food chains begin with photosynthetic autotrophs (primary producers), including green plants and algae. Primary producers, represented by trees, shrubs, and herbs, are a prolific source of energy in the form of carbohydrates (sugars) stored in the leaves. These carbohydrates, produced in photosynthesis, are broken down in a process called respiration; the smaller units of the sugar molecule and its products fuel numerous metabolic processes.

The daily existence of human beings is also directly influenced by plants. Plants furnish food and flavourings; raw materials for industry, such as wood, resins, oils, and rubber; fibres for the manufacture of fabrics and cordage; medicines; insecticides; and fuels. More than half of Earth’s population relies on the grasses rice, corn (maize), and wheat as their primary source of food. Apart from their commercial and aesthetic value, plants conserve other natural resources by protecting soils from erosion, by controlling water levels and quality, and by producing a favourable atmosphere.

**Zoology**

Zoology is a branch of biology that studies the members of the animal kingdom and animal life in general. It includes both the inquiry into individual animals and their constituent parts, even to the molecular level, and the inquiry into animal populations, entire faunas, and the relationships of animals to each other, to plants, and to the nonliving environment. Though this wide range of studies results in some isolation of specialties within zoology, the conceptual integration in the contemporary study of living things that has occurred in recent years emphasizes the structural and functional unity of life rather than its diversity.

The emergence of animal biology has had two particular effects on classical zoology. First, and somewhat paradoxically, there has been a reduced emphasis on zoology as a distinct subject of scientific study; for example, workers think of themselves as geneticists, ecologists, or physiologists who study animal rather than plant material. They often choose a problem congenial to their intellectual tastes, regarding the organism used as important only to the extent that it provides favourable experimental material. Current emphasis is, therefore, slanted toward the solution of general biological problems; contemporary zoology thus is to a great extent the sum total of that work done by biologists pursuing research on animal material.

Second, there is an increasing emphasis on a conceptual approach to the life sciences. This has resulted from the concepts that emerged in the late 19th and early 20th centuries: the cell theory; natural selection and evolution; the constancy of the internal environment; the basic similarity of genetic material in all living organisms; and the flow of matter and energy through ecosystems. The lives of microbes, plants, and animals now are approached using theoretical models as guides rather than by following the often restricted empiricism of earlier times. This is particularly true in molecular studies, in which the integration of biology with chemistry allows the techniques and quantitative emphases of the physical sciences to be used effectively to analyze living systems.

**Physiology**

Physiology is the study of the functioning of living organisms, animal or plant, and of the functioning of their constituent tissues or cells.

The word physiology was first used by the Greeks around 600 BC to describe a philosophical inquiry into the nature of things. The use of the term with specific reference to vital activities of healthy humans, which began in the 16th century, also is applicable to many current aspects of physiology. In the 19th century, curiosity, medical necessity, and economic interest stimulated research concerning the physiology of all living organisms. Discoveries of unity of structure and functions common to all living things resulted in the development of the concept of general physiology, in which general principles and concepts applicable to all living things are sought. Since the mid-19th century, therefore, the word physiology has implied the utilization of experimental methods, as well as techniques and concepts of the physical sciences, to investigate causes and mechanisms of the activities of all living things.

The publication in 1628 of Harvey’s *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus* (*An Anatomical Dissertation upon the Movement of the Heart and Blood in Animals*) usually is identified as the beginning of modern experimental physiology. Harvey’s study was based only on anatomical experiments; despite increased knowledge in physics and chemistry during the 17th century, physiology remained closely tied to anatomy and medicine.

Physiology as a distinct discipline utilizing chemical, physical, and anatomical methods began to develop in the 19th century. Claude Bernard in France; Johannes Müller, Justus von Liebig, and Carl Ludwig in Germany; and Sir Michael Foster in England may be numbered among the founders of physiology as it now is known. At the beginning of the 19th century, German physiology was under the influence of the romantic school of Naturphilosophie. In France, on the other hand, romantic elements were opposed by rational and skeptical viewpoints. Bernard’s teacher, François Magendie, the pioneer of experimental physiology, was one of the first men to perform experiments on living animals. Both Müller and Bernard, however, recognized that the results of observations and experiments must be incorporated into a body of scientific knowledge, and that the theories of natural philosophers must be tested by experimentation.

**Botany**

*Botany* is a branch of biology that deals with the study of plants, including their structure, properties, and biochemical processes. Also included are plant classification and the study of plant diseases and of interactions with the environment. The principles and findings of botany have provided the base for such applied sciences as agriculture, horticulture, and forestry.

*Areas of Study*

For convenience, but not on any mutually exclusive basis, several major areas or approaches are recognized commonly as disciplines of botany; these are morphology, physiology, ecology, and systematics.

*Morphology*

Morphology deals with the structure and form of plants and includes such subdivisions as: cytology, the study of the cell; histology, the study of tissues; anatomy, the study of the organization of tissues into the organs of the plant; reproductive morphology, the study of life cycles; and experimental morphology, or morphogenesis, the study of development.

*Physiology*

Physiology deals with the functions of plants. Its development as a subdiscipline has been closely interwoven with the development of other aspects of botany, especially morphology.

*Ecology*

Ecology deals with the mutual relationships and interactions between organisms and their physical environment. The physical factors of the atmosphere, the climate, and the soil affect the physiological functions of the plant in all its manifestations, so that, to a large degree, plant ecology is a phase of plant physiology under natural and uncontrolled conditions; in fact, it has been called “outdoor physiology.”

*Systematics*

Systematics deals with the identification and ranking of all plants; it includes classification and nomenclature (naming) and enables the botanist to comprehend the broad range of plant diversity and evolution.

*Other subdisciplines*

In addition to the major subdisciplines, several specialized branches of botany have developed as a matter of custom or convenience. Among them are bacteriology, the study of bacteria; mycology, the study of fungi; algology or phycology, the study of algae; bryology, the study of mosses and liverworts; pteridology, the study of ferns and their relatives; and paleobotany, the study of fossil plants.

**vertebrates**

*A vertebrate*, also called Craniata is any animal of the subphylum Vertebrata, the predominant subphylum of the phylum Chordata. They have backbones, from which they derive their name. The vertebrates are also characterized by a muscular system consisting pimarily of bilaterally paired masses and a central nervous system partly enclosed within the backbone.

The subphylum is one of the best known of all groups of animals. Its members include the classes Agnatha, Chondrichthyes, and Osteichthyes (all fishes); Amphibia (amphibians); Reptilia (reptiles); Aves (birds); and Mammalia (mammals).

Although the vertebral column is perhaps the most obvious vertebrate feature, it was not present in the first vertebrates, which probably had only a notochord. The vertebrate has a distinct head, with a differentiated tubular brain and three pairs of sense organs (nasal, optic, and otic). The body is divided into trunk and tail regions. The presence of pharyngeal slits with gills indicates a relatively high metabolic rate. A well-developed notochord enclosed in perichordal connective tissue, with a tubular spinal cord in a connective tissue canal above it, is flanked by a number of segmented muscle masses. A sensory ganglion develops on the dorsal root of the spinal nerve, and segmental autonomic ganglia grow below the notochord. The trunk region is filled with a large, bilateral body cavity (coelom) with contained viscera, and this coelom extends anteriorly into the visceral arches. A digestive system consists of an esophagus and a gut. A distinct heart, anteroventral to the liver, is enclosed in a pericardial sac. A basic pattern of closed circulatory vessels is largely preserved in most living forms. Unique, bilateral kidneys lie retroperitoneally (dorsal to the main body cavity) and serve blood maintenance and excretory functions. Reproductive organs are formed from tissue adjacent to the kidneys; this original close association is attested by the tubular connections seen in males of living forms. The ducts of the excretory organs open through the body wall into a cloacal chamber, as does the anus of the digestive tract. Reproductive cells are shed through nearby abdominal pores or through special ducts. A muscular tail continues the axial musculature of the trunk.

Approximately 45,000 living species constitute the vertebrates.

**carnivores**

A carnivore is any member of the mammalian order Carnivora (literally, “flesh devourers” in Latin), comprising more than 270 species. In a more general sense, a carnivore is any animal (or plant; see carnivorous plant) that eats other animals, as opposed to a herbivore, which eats plants. Although the species classified in this order are basically meat eaters, a substantial number of them, especially among bears and members of the raccoon family, also feed extensively on vegetation and are thus actually omnivorous.

Two carnivores are probably the animals most familiar to people: the domestic dog and cat, which are both derived from wild members of this order. On the other hand, various bears, felines, canines, and hyenas are among the few animals that occasionally attack humans. These large, dangerous carnivores are often the objects of hunters, who kill them for display as trophies. Most luxurious natural furs (ermine, mink, sable, and otter, among others) come from members of Carnivora, as do many of the animals that attract the largest crowds at circuses and zoos. Producers of livestock worldwide are concerned about possible depredations upon their herds and flocks by this group of mammals.

Being meat eaters, carnivores are at the top of the food chain and form the highest trophic level within ecosystems. As such, they are basic to maintaining the “balance of nature” within those systems. In areas of human settlement, this precarious balance has frequently been upset by the extermination of many carnivores formerly considered undesirable because of their predatory habits. Now, however, carnivores are recognized to be necessary elements in natural systems; they improve the stability of prey populations by keeping them within the carrying capacity of the food supply. As a result, the surviving animals are better fed and less subject to disease. Many of these predators dig dens and provide burrows in which other forms of wildlife can take refuge. Digging also results in the mixing of soils and the reduction of water runoff during rains. The carnivores best known for their burrow building are badgers and skunks, but bears, canines, and felines regularly engage in this behaviour as well.

Carnivore numbers are limited by food, larger predators, or disease.

Carnivores are found worldwide, although Australia has no native terrestrial members except for the dingo, which was introduced by aboriginal man. Terrestrial forms are naturally absent from most oceanic islands, though the coastlines are usually visited by seals. However, people have taken their pets, as well as a number of wild species, to most islands.

**TYPES AND LAYERS OF FORESTS**

A forest is made up of many layers.

Each layer has a different set of plants and animals depending upon the availability of sunlight, moisture and food.

Forest floor contains decomposing leaves, animal droppings, and dead trees. Decay on the forest floor forms new soil and provides nutrients to the plants. The forest floor supports ferns, grasses, mushroom and tree seedlings.

Understory is made up of bushes, shrubs, and young trees that are adapted to living in the shades of the canopy.

Canopy is formed by the mass of intertwined branches, twigs and leaves of the mature trees. The crowns of the dominant trees receive most of the sunlight. This is the most productive part of the trees where maximum food is produced. The canopy forms a shady, protective "umbrella" over the rest of the forest.

Emergent layer exists in the tropical rain forest and is composed of a few scattered trees that tower over the canopy.

*Classification*

Forests can be classified in different ways. One such way is in terms of the biome in which they exist, combined with leaf longevity of the dominant species (whether they are evergreen or deciduous). Another distinction is whether the forests are composed predominantly of broadleaf trees, coniferous trees, or mixed.

Boreal forests occupy the subarctic zone and are generally evergreen and coniferous.

Temperate zones support both broadleaf deciduous forests (e.g., temperate deciduous forest) and evergreen coniferous forests (e.g., temperate coniferous forests and temperate rainforests). Warm temperate zones support broadleaf evergreen forests, including laurel forests.

Tropical and subtropical forests include tropical and subtropical moist forests, tropical and subtropical dry forests, and tropical and subtropical coniferous forests.

Forests can also be classified more specifically based on the climate and the dominant tree species present, resulting in numerous different forest types (e.g., Ponderosa pine/Douglas-fir forest).

The number of trees in the world, according to a 2015 estimate, is 3 trillion, of which 1.4 trillion are in the tropics or sub-tropics, 0.6 trillion in the temperate zones, and 0.7 trillion in the coniferous boreal forests. The estimate is about eight times higher than previous estimates, and is based on tree densities measured on over 400,000 plots. It remains subject to a wide margin of error, not least because the samples are mainly from Europe and North America.

**Taiga**

Taiga, also called boreal forest is a biome (major life zone) of vegetation composed primarily of cone-bearing needle-leaved or scale-leaved evergreen trees, found in northern circumpolar forested regions characterized by long winters and moderate to high annual precipitation. The taiga, “land of the little sticks” in Russian, takes its name from the collective term for the northern forests of Russia, especially Siberia.

The taiga, which is also known as the boreal (meaning northern) forest region, occupies about 17 percent of Earth’s land surface area in a circumpolar belt of the far Northern Hemisphere. Northward beyond this limit, the taiga merges into the circumpolar tundra. The taiga is characterized predominantly by a limited number of conifer species – i.e., pine (Pinus), spruce (Picea), larch (Larix), fir (Abies) – and to a lesser degree by some deciduous genera such as birch (Betula) and poplar (Populus). These trees reach the highest latitudes of any trees on Earth. Plants and animals in the taiga are adapted to short growing seasons of long days that vary from cool to warm. Winters are long and very cold, the days are short, and a persistent snowpack is the norm. The taiga biomes of North America and Eurasia display a number of similarities, even sharing some plant and animal species.

The taiga regions of North America and Eurasia are broad belts of vegetation that span their respective continents from Atlantic to Pacific coasts. In North America the taiga occupies much of Canada and Alaska. Although related transition forest types are present in the northern tier of the lower 48 United States, true taiga stops just north of the southern Canadian border. The vast taiga of Asia extends across Russia and southward into northeastern China and Mongolia. In Europe most of Finland, Sweden, and Norway are covered with taiga. A small, isolated area of boreal forest in the Scottish Highlands lacks some continental species but does contain the most widespread conifer of the Eurasian taiga, Scotch pine (Pinus sylvestris).

Taiga occupies the Russian and West Siberian plains north of latitude 56°–58° N together with most of the territory east of the Yenisey River. The western taiga, where the climate is less extreme, is often distinguished from the eastern taiga beyond the Yenisey. In the western section forests of spruce and fir in moister areas alternate with shrubs and grasses interspersed with pine on lighter soils. These species also are present in the east, but the larch becomes dominant there.

**Birds**

A bird is any of the more than 10,400 living species unique in having feathers, the major characteristic that distinguishes them from all other animals. A more-elaborate definition would note that they are warm-blooded vertebrates more related to reptiles than to mammals and that they have a four-chambered heart (as do mammals), forelimbs modified into wings (a trait shared with bats), a hard-shelled egg, and keen vision, the major sense they rely on for information about the environment. Their sense of smell is not highly developed, and auditory range is limited. Most birds are diurnal in habit. More than 1,000 extinct species have been identified from fossil remains.

Birds arose as warm-blooded, arboreal, flying creatures with forelimbs adapted for flight and hind limbs for perching. This basic plan has become so modified during the course of evolution that in some forms it is difficult to recognize.

Among flying birds, the wandering albatross has the greatest wingspan, up to 3.5 metres (11.5 feet), and the trumpeter swan perhaps the greatest weight, 17 kg (37 pounds). In the largest flying birds, part of the bone is replaced by air cavities (pneumatic skeletons) because the maximum size attainable by flying birds is limited by the fact that wing area varies as the square of linear proportions, and weight or volume as the cube. During the Pleistocene Epoch (2.6 million to 11,700 years ago) lived a bird called Teratornis incredibilis. Though similar to the condors of today, it had a larger estimated wingspan of about 5 metres (16.5 feet) and was by far the largest known flying bird.

The smallest living bird is generally acknowledged to be the bee hummingbird of Cuba, which is 6.3 cm (2.5 inches) long and weighs less than 3 grams (about 0.1 ounce). The minimum size is probably governed by another aspect of the surface-volume ratio: the relative increase, with decreasing size, in surface through which heat can be lost. The small size of some hummingbirds may be facilitated by a decrease in heat loss resulting from their becoming torpid at night.

When birds lose the power of flight, the limit on their maximum size is increased, as can be seen in the ostrich and other ratites such as the emu, cassowary, and rhea. The ostrich is the largest living bird and may stand 2.75 metres (9 feet) tall and weigh 150 kg (330 pounds). Some recently extinct birds were even larger: the largest moas of New Zealand and the elephant birds of Madagascar may have reached over 3 metres (10 feet) in height.