**Animals**

**Animal**, any member of the kingdom Animalia, which comprises all multicellular organisms that obtain energy by ingesting food and that have cells organized into tissues. Unlike plants, which manufacture nutrients from inorganic substances by means of photosynthesis, or fungi, which feed by absorbing organic matter in which they are usually embedded, animals actively acquire their food and digest it internally. Associated with this mode of nutrition are many of the additional features that readily distinguish most animals from other life forms. Specialized tissue systems permit animals to move about freely in search of food or, for those that are fixed in place during most of their lives (sessile animals), to draw the food toward themselves. The well-developed nervous systems and complex sense organs that have evolved in most animals enable them to monitor the environment and, in association with specialized movements, to respond rapidly and flexibly to changing stimuli.

Almost all animal species, in contrast with plants, have a limited growth pattern and reach a characteristically well-defined shape and size at maturity. Reproduction is predominantly sexual, with the embryo passing through a blastula phase .

The conspicuous differences between plants and animals first led to a formal division of all life into two kingdoms, Plantae and Animalia. When the world of microorganisms was later investigated, some were seen to be clearly plantlike, with walled cells and chlorophyll-containing bodies that conducted photosynthesis, whereas others resembled animals in that they moved about (by means of flagella or pseudopodia) and digested food. The latter type, protozoa, was categorized as a subkingdom of Animalia. Difficulties arose, however, with many forms that showed mixed characteristics and with groups in which some organisms were plantlike but had close relatives that were animal-like. Eventually, classification schemes with several kingdoms were proposed, in which the definitions of Plantae and Animalia became more restricted. What constitutes an animal, therefore, depends on the scheme followed.

In the five-kingdom system used in this encyclopedia , animals are limited to organisms with differentiated tissues, and the protozoan groups are assigned to the kingdom Protista. The separation of the protozoa from the higher animals is not entirely satisfactory, however, because classification systems should reflect evolutionary relationships, and multicellular forms are believed to have evolved from protozoan ancestors more than once. Moreover, some protozoans form colonies that are difficult to distinguish from simple multicellular animals. The problem in deciding on the limits of the Animalia is a reflection of the natural world, in which boundaries are blurred and evolution leaves intermediates between major groups in its path.

***Origins and Relationships***

The multicellular animals (metazoa), as stated, evidently arose from animal-like, unicellular creatures (protozoa). Precise relationships are unclear because of the poor fossil record and the extinction of intermediate forms, but several evolutionary routes are possible. For example, certain animal-like flagellates occur as colonies and could readily have evolved into more elaborate organisms. In addition, the embryonic stages of some animals display a sequence of changes that provides a reasonable evolutionary model: a unicellular stage, followed by an undifferentiated colonylike stage, a hollow ball of cells (blastula), and then a gut (gastrula stage). Other theories suggest different transitional forms, such as a protozoan with many nuclei in one cell.

Since its uncertain beginnings, the animal kingdom has diversified into several major lineages or branches, which in turn have subdivided into phyla, classes, and smaller groups. The old notion that a single series of organisms has progressed from lower to higher forms, in a so-called chain of life, has long since been rejected. The course of evolution is more comparable to a tree or bush, with many branches undergoing diversification or adaptive radiation, and with some progressive evolution occurring throughout the kingdom. Thus, insects, cephalopods, and vertebrates followed different evolutionary routes, but all of them can be described as “higher” animals.

Much of the diversification within the kingdom probably occurred more than 600 million years ago, before the Cambrian era, because a wide variety of fossils, representing most major animal groups (phyla), already appear in the oldest Cambrian rocks. Because the phyla arose in earlier times for which the fossil record is poorer, relationships between them have to be inferred on the basis of conservative features, including embryology, and are often conjectural. Better evidence usually exists for subdivisions within each phylum, partly because most of these originated more recently.

***Body Organization***

The various kinds of animals have body plans that can be interpreted both historically and functionally. Thus, comparative anatomy enables scientists to sort animals into major groups and to trace and explain their evolution.

**Gut**

One basic body part is the gut, which must have arisen early in the evolution of the metazoans. The simplest animals, sponges, have internal cavities that function in feeding, but the openings are not comparable to a mouth or anus. Furthermore, they have tissues but no real organs or nerves, and they lack symmetry. The more complex jellyfish and their allies, more active animals that generally feed with tentacles, have a gut with a mouth but no anus. A nervous system is present, but no brain or head. A jellyfish body also has no bilateral symmetry—that is, no left or right side—as have the bodies of more advanced animals, including humans. Instead, the animals exhibit radial symmetry, or symmetry around a central axis.

**Symmetry**

Symmetry thus provides a basis for further dividing most animals into two grades: Radiata and Bilateria. The tissues of the Radiata have only two major layers, whereas the Bilateria have three. This came about through the addition of a middle layer (mesoderm) between the outer layer (ectoderm) and inner layer (endoderm). (In the embryological development of animals in general, the ectoderm gives rise to the skin and nervous system, the endoderm to the lining of the gut and some of its derivatives, and the mesoderm to the remaining structures, such as muscles.) Bilateral symmetry is also an evolutionary development linked with an increasing capability of active locomotion, although such locomotion has often been lost in later lines of evolution. Movement in one direction is facilitated by the development of a head, with brain and sense organs at the leading end.

**Protostomia and Deuterostomia**

Within the Bilateria, a number of phyla that differ as adults have been linked on the basis of early embryology. Such groups are founded on the basis of how the cells divide and how various organs are formed. For example, one such basic division is into the Protostomia, in which the embryonic mouth persists, and Deuterostomia, in which a new mouth is formed. (Until the Deuterostomia are reached, below, the animals discussed henceforth are Protostomia.)

**Coelom**

The ancestral bilaterian had a gut but no other body cavity; because of the absence of such a cavity, or coelom, the animal could be called an acoelomate. It also lacked an anus and a circulatory system but probably had a simple excretory system. Among extant animals, this stage is represented by the flatworms (phylum Platyhelminthes). Lack of a circulatory system and anus makes for an inefficient distribution of materials in the body. The nemertean worms (phylum Rhynchocoela) have a circulatory system and anus, but their locomotion remains slow and clumsy.

A major advance occurred with the origin of a coelom in addition to the gut. This added body cavity allowed for the movement of internal organs. In some animals it may also double as a circulatory system and as a skeleton, if its contents are under pressure. Two basic types exist. A true coelom is a cavity within the mesoderm, covered with a layer of tissue called an epithelium. A pseudocoelom, however, lacks such a covering. A number of phyla of mainly wormlike animals have this latter kind of body cavity and hence are called pseudocoelomates. Such animals generally are of modest size and have poor locomotion. They lack a circulatory system and are simple in various other respects. Nevertheless, they are quite successful in some habitats. The remaining organisms have a true coelom and are called eucoelomates.

**Manner of Coelom Formation**

Eucoelomates can be subdivided (but not rigorously) on the basis of how the coelom forms in embryology. The Schizocoela form a coelom by splitting the mesoderm, whereas the Enterocoela form it as an outgrowth of the gut. Transitional between these two are the lophophorates, or Tentaculata. Members of this small group have a crown of tentacles, or a lophophore, used in feeding, and are modified to a sedentary way of life.

The true Schizocoela are related to the annelid worms (phylum Annelida). Metamerism, or segmentation (a serial repetition of groups of body parts), arose in this group, an arrangement that is thought to have allowed better locomotion. The arthropods (phylum Arthropoda) retain segmentation but add a hard external skeleton (exoskeleton) that improves locomotion and provides support and protection. The mollusks (phylum Mollusca) have reduced coeloms and little indication of segmentation, but they have a characteristic shell and soft body.

**Deuterostomia**

The Deuterostomia comprise the enterocoels—echinoderms, arrowworms, hemichordates, and chordates—the rest of the animal kingdom. These phyla are united mainly by developmental characteristics and may be related to the lophophorates, some of which also have an enterocoelous manner of forming the coelom. In addition, no segmentation exists of the sort found in annelids. Another important link of the deuterostomes to the lophophorates is the presence, in some members of both groups, of three pairs of coelomic cavities and three corresponding body regions. Adult deuterostomes have become quite modified. Thus, arrowworms are equipped for floating and swimming; echinoderms have lost their bilateral symmetry and reverted to radial symmetry (often with five rays, as in most starfish); the wormlike hemichordates have a very simple structure; and such advanced features as a complex brain and the capability for rapid locomotion evolved within the chordate lineage.

 What follows is a brief summary of the phyla, which are grouped into some of the larger assemblages discussed above. Further information is given in separate articles under the common name of the phyla or superphyla. The number of known animal species, about 1 million, is approximate and does not include fossil species.

***The Parazoa***

Only one phylum exists in this most primitive division of the animal kingdom.

**Phylum Porifera (sponges)**

Sponges are simple, multicellular animals with tissues but no distinct organs. Most are marine, but a few occur in fresh water. They live attached to a substrate and feed by drawing water into the body through pores, then extracting food particles with flagellated cells. Most of the activities of the body are carried out by cells acting independently or in small groups. Sponges have no nervous system but do react to stimuli. A skeleton that consists of fibers, minerals, or both is usually present. 4800 species.

***The Mesozoa***

This group consists of two minor phyla of simple, parasitic worms of uncertain relationships: Orthonectida and Dicyemida. Mesozoa, which means “middle animals,” suggests that they are living fossils, but they may be degenerate forms of unknown ancestors. 50 species.

***The Radiates***

Animals with radial symmetry (except when secondarily modified), radiates have a body with two cell layers: endoderm and ectoderm.

**Phylum Coelenterata (true jellyfish and hydroids, corals, and sea anemones)**

The phylum is also called Cnidaria, especially when extended to include the Ctenophora (see below). The stages of a coelenterate’s life history include an attached polyp (as in sea anemones), a free-swimming medusa (as in jellyfish), or both. Prey is taken with stinging capsules, generally located on the tentacles. The animals are marine, except for a few freshwater forms such as *Hydra.* 3 classes and 5300 species.

**Phylum Ctenophora (comb jellies)**

These marine animals resemble true jellyfish but have no polyp stage, and they swim using bands of hairlike cells resembling combs. Prey is usually taken with sticky tentacles. 80 species.

***The Acoelomate Bilateria***

The two major phyla consist of small to moderate-sized worms with bilateral symmetry and no coelom.

**Phylum Platyhelminthes (flatworms)**

These worms have no anus or circulatory system and are structurally simple, although the generally hermaphroditic reproductive system is often quite intricate. Their flat shape is necessary because the tissues must be near the surface to facilitate gas and nutrient exchange with the environment. The free-living class Turbellaria is abundant in the sea and fresh water and rare on land. Two classes are parasitic: Trematoda (flukes) and Cestoda (tapeworms). An obscure marine group, Gnathostomulida, is sometimes put here and sometimes made a separate phylum. 13,000 species.

**Phylum Nemertina, or Rhynchocoela (ribbon worms)**

Elongate worms with a circulatory system and an anus, ribbon worms are common in the sea and rare on land. Prey is taken with an extensible proboscis. 800 species.

***The Pseudocoelomates***

The body cavity of these usually small to microscopic, worm-shaped animals is a pseudocoelom, and they lack a circulatory system. Most pseudocoelomates are often grouped into a single phylum, Aschelminthes, with several classes. Alternatively, as here, each class is a phylum, and Aschelminthes is a superphylum. This leaves one wormlike group (Acanthocephala) and one group of “moss animals” (Endoprocta) outside the aschelminths proper.

**Phylum Nematoda (roundworms)**

 These elongate worms have a firm covering called a cuticle and a body supported by fluid under pressure. They generally feed by sucking fluid or taking in small particles or soft materials. Abundant but inconspicuous, they live in soil and marine and freshwater sediments. Some, as parasites, cause serious diseases. 10,000 species.

**Phylum Gastrotricha**

These are tiny (less than 1 mm/0.04 in long), short-bodied, marine and freshwater worms. 170 species.

**Phylum Nematomorpha**

Worms of this minor group resemble roundworms. They are parasitic in arthropods when young and briefly free-living and aquatic as adults. 230 species.

**Phylum Acanthocephala (spiny-headed worms)**

Parasitic as adults in the guts of vertebrates, and as juveniles in the tissues of various animals, these worms lack a gut and have a spiny attachment organ on the head. They superficially resemble tapeworms. 500 species.

**Phylum Kinorhyncha**

These tiny (less than 1 mm/0.04 in), short-bodied marine worms have spiny bodies and a spiny proboscis. 100 species.

**Phylum Rotifera (wheel animalcules)**

Rotifers are so named because of the wheel-shaped organ on the head, used in feeding and swimming. Often microscopic, these animals are abundant in fresh water. 1500 species.

**Phylum Priapulida**

These free-living marine worms have spiny heads. 8 species.

**Phylum Endoprocta (moss animal)**

Very small, stalked, marine or freshwater animals, endoprocts feed with tentacles. 75 species.

**Phylum Loricifera**

This phylum, established in 1983, consists of marine sediment dwellers only 0.5 mm (0.02 in) long. Free-swimming larvae and sedentary adults have mouth cones that can be retracted into a spiny head, itself retractable.

***Eucoelomates: the Tentaculata***

These coelomate animals have a short body and a crown of tentacles called a lophophore.

**Phylum Phoronida**

Phoronids have a U-shaped gut because the lower part of the body is greatly elongated. They live in tubes, with the lophophore and anus at the open end. Adults are about 1 to 10 cm (about 0.4 to 4 in) long, and all phoronids are marine. 18 species.

**Phylum Ectoprocta, or Bryozoa (moss animal)**

The ectoprocts, polyzoans, or true bryozoans are small, colonial animals that resemble simplified phoronids. Almost all inhabit a hardened covering and are primarily marine. 3500 species.

**Phylum Brachiopoda (lampshells)**

These animals superficially resemble clams but have upper and lower shells rather than left and right ones. All are marine. 230 species.

***Eucoelomates: the Trochozoa***

The following phyla frequently possess a juvenile stage called a trochophore larva. They all may be derived from an annelidlike ancestor, judging from their widespread metamerism (segmentation) and the frequent occurrence of paired nerve cords ventral to the gut.

**Phylum Annelida**

Annelids have a well-developed coelom, a soft body, and (as a rule) well-developed metamerism. Bristlelike structures (setae) used in crawling are often present. The group includes earthworms (class Oligochaeta), leeches (class Hirudinea), and the less familiar bristle worms (class Polychaeta). Some animals of uncertain position, here treated as classes of annelids, are sometimes made separate phyla: Echiura and Pogonophora (beardworms). Two minor groups within the polychaetes, Archiannelida and Myzostomida, are often considered independent classes. 8700 species.

**Phylum Sipuncula (peanut worms)**

These moderate-sized (about 3 cm/1.2 in) marine worms have a saclike body and a long proboscis. They may be simplified annelids. 250 species.

**Phylum Mollusca**

The second largest animal phylum, including snails and clams, mollusks typically have a hard shell and a soft body. Few traces of metamerism are observed, and the coelom is small; the main body cavity is part of the circulatory system. Some forms, such as octopuses and squid, attain considerable size. The seven mollusk classes are Aplacophora, Polyplacophora (chitons), Monoplacophora, Gastropoda (snails and slugs), Bivalvia (clams and allies), Cephalopoda (octopuses, squid, and allies), and Scaphopoda (tusk shells). 50,000 species.

**Phylum Arthropoda**

The body of an arthropod is covered with a hard, jointed skeleton. This is the largest animal phylum, partly because so many kinds of insects exist. Arthropods are abundant and successful in almost all habitats. The body remains segmented, and the coelom has been reduced. Three small, transitional groups are sometimes included in the Arthropoda and sometimes made independent phyla: Onychophora, Tardigrada, and Pentastomida. The classes of higher arthropods can be grouped into assemblages. Those with jaws (mandibulates) include the Crustacea (lobsters, crabs, and allies), the allied Myriapoda (centipedes and millipedes), and Insecta (insects). Arthropods with mouthparts called chelicerae include the Pycnogonida (sea spiders), Merostomata (horseshoe crabs), and Arachnida (spiders and their allies). 838,000 species.

***Eucoelomates: the Deuterostomia***

This large group includes all the remaining animals. The group’s name indicates that the mouth is produced secondarily, as a new formation, in embryological development.

**Phylum Chaetognatha (arrowworms)**

These animals are small, active, exclusively marine swimmers of uncertain relationship. 50 species.

**Phylum Echinodermata**

 Echinoderms derive their name from their spiny skins. The group includes starfish and sea cucumbers. They are slow moving and rely mainly on small processes called tube feet for locomotion. All are marine. The five extant classes are as follows: Crinoidea (feather stars), Asteroidea (sea stars), Ophiuroidea (brittle stars), Echinoidea (sea urchins), and Holothuroidae (sea cucumbers). 6000 species.

**Phylum Hemichordata (acorn worms)**

These simple, wormlike marine animals have a few characteristics linking them to chordates. Among these are traces of what may be a notochord (see discussion under Phylum Chordata) and a dorsal nerve cord, as well as a system of gill slits. The larval body of the worms, however, indicates a link to the echinoderms. 230 species.

**Phylum Chordata**

Chordates include vertebrates (animals with backbones) and some related invertebrates. At some time in their lives, all possess a stiff rod, called a notochord, that lies above the gut. In vertebrates, a series of bones (vertebrae) replaces the notochord.

Two subphyla of invertebrate chordates exist. The Tunicata (tunicates, or sea squirts) become highly modified as adults and attach to a substrate, feeding with gill slits. Only the free-swimming larvae retain a notochord. All are marine, and about 1300 species exist. The Cephalochordata (lancelets) resemble very simple fish. They live in the sea and extract food from the water with their gill slits. About 25 species exist.

The remaining Chordata belong to the subclass Vertebrata and have a backbone. Half of the 42,000 species are fish. Thus, although the group is very successful, it is outnumbered by arthropods and mollusks. Seven classes are generally recognized. The old class Pisces (fish) has long since been broken down into three classes: Agnatha (jawless fish such as lampreys), Chondrichthyes (cartilaginous fish such as sharks and rays), and Osteichthyes (bony fish). The class Amphibia contains such semiaquatic forms as salamanders, toads, and frogs. The class Reptilia is better adapted to life on land; it includes turtles, lizards, and crocodilians. The class Aves (birds) is noteworthy not only for flight but also for warm blood and an insulating layer of feathers. The class Mammalia is characterized by the possession of hair and of mammary glands that secrete milk. This group also is warm-blooded.

***Animals in the Ecosystem***

Animals have diversified so as to occupy many ecological niches. Herbivores form a basic link in the food chain, or food web. They are eaten by carnivores, which in turn are eaten by other carnivores. Many animals are parasites or scavengers or feed on sediments. Every animal has adaptations, such as sense organs and teeth, that enable it to find and utilize food. Some use a wide variety of foods; others specialize. Features such as camouflage and protective shells enable them to cope with predators.

Animals compete with one another for scarce resources, including food and a place to live. The interactions between predator and prey have involved a coevolution of these different parts of the ecosystem—that is, the evolution of prey is affected by the evolution of predators. Parasites, which are harmful but usually do not kill their hosts, must be able to overcome defensive adaptations. On the other hand, mutualists have cooperative arrangements with other organisms. Plants and animals can also cooperate, in the sense that food is provided by plants, and various animals effect pollination or seed distribution.

A great variety of strategies enable animals to survive and reproduce. When food in an ecosystem is abundant, the animals involved generally tend to reproduce in quantity. When intense competition for food is involved, however, the animals have to develop a more effective use of resources and tend to care for the young for a prolonged period. Where the ecosystem is stable, as in the Tropics, competition leads to complex life cycles and intricate adaptations, both structural and behavioral.

Animals often move from place to place. This enables them to locate food, avoid predators, and reproduce effectively. Through migration, birds and other animals can feed and reproduce where food is seasonally abundant. The movement of animals is limited only by the food supply, the terrain, and their individual capabilities for locomotion, and each local area and habitat has tended to evolve its own distinctive fauna.

***Animals in the Human Community***

 Ever since true humans appeared on earth, they have lived in close association with other animals. Throughout most of that time, humans existed as hunter-gatherers who depended on wild animals for food and clothing. They also found a source of aesthetic pleasure and spiritual strength in the animal life about them. Evidence of this exists in the remarkable paintings of Paleolithic people in the caves of southern France. The religious practices of Native North Americans involved the veneration of certain animals, such as the bear, wolf, and eagle, in an attempt to acquire the power, wisdom, courage, and speed that these animals supposedly possessed.

Human societies have continued to exhibit traces of these relationships. The aesthetic appeal of animals is expressed in the mosaics and frescoes of ancient Greece, Rome, and Egypt; in the paintings of the Renaissance masters; and in countless works of more recent artists. Mystical feelings toward animals are reflected in myths and folktales, moralistic fables involving animals, and anthropomorphic animal stories for children, as well as the adoption of animal names for cars, sports teams, and so on.

Despite highly developed technology and agriculture and the domestication of many species, modern humans still depend on wild stocks of a variety of other animals, such as fish and shellfish, for food. Unmanaged commercial exploitation, however, has greatly reduced this resource and has driven some species to the edge of extinction . In addition, wild animals provide recreation in the form of sport hunting and sportfishing, bird-watching, and visits to zoos and wildlife refuges.

As humans advanced from a hunting to an agricultural existence, relationships between humans and animals changed. Animals that preyed on livestock or that destroyed crops were reduced or exterminated, and the alteration of the landscape eliminated habitats for many other species. As humans became more concentrated in cities, however, animals such as rats multiplied and became important carriers of disease.

Humans domesticated some animals for food, clothing, power, and companionship. How this came about is a matter of speculation. Through protection and selective breeding, humans changed early domesticated forms into highly productive dairy and beef cattle, sheep, swine, and poultry. Also contributing to human welfare are the dogs, cats, white rats and mice, guinea pigs, and rhesus monkeys that medical research has used to gain an understanding of human physiology and to develop drugs and procedures to combat human illnesses.

As humans continue to spread across the earth, however, they encroach on or pollute the environments of many animals, reducing remaining habitats to smaller and smaller areas. Unless this trend is reversed, much of the world’s animal life faces extinction.