



Animal

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Animals are multicellular, eukaryotic organisms of the kingdom **Animalia** (also called **Metazoa**). The animal kingdom emerged as a basal clade within Apoikozoa as a sister of the choanoflagellates. Sponges are the most basal clade of animals. Animals are motile, meaning they can move spontaneously and independently at some point in their lives. Their body plan eventually becomes fixed as they develop, although some undergo a process of metamorphosis later on in their lives. All animals are heterotrophs: they must ingest other organisms or their products for sustenance.

Most known animal phyla appeared in the fossil record as marine species during the Cambrian explosion, about 542 million years ago. Animals can be divided broadly into vertebrates and invertebrates. Vertebrates have a backbone or spine (vertebral column), and amount to less than five percent of all described animal species. They include fish, amphibians, reptiles, birds and mammals. The remaining animals are the invertebrates, which lack a backbone. These include molluses (clams, oysters, octopuses, squid, snails); arthropods (millipedes, centipedes, insects, spiders, scorpions, crabs, lobsters, shrimp); annelids (earthworms, leeches), nematodes (filarial worms, hookworms), flatworms (tapeworms, liver flukes), cnidarians (jellyfish, sea anemones, corals), and sponges. The study of animals is called zoology.

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Animals

Temporal range: Cryogenian – Present, 670–0 Ma

Had'n	Archean	Proterozoic	Pha.

Scientific classification

(unranked): Filozoa

Kingdom: **Animalia**
Linnaeus, 1758

Phyla

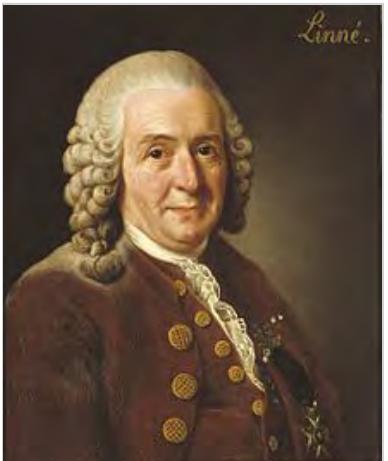
- **Subkingdom Parazoa**
 - Porifera
 - Placozoa
- **Subkingdom Eumetazoa**
 - **Radiata (unranked)**
 - Ctenophora
 - Cnidaria
 - Trilobozoa †
 - **Bilateria (unranked)**

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Etymology

The word "animal" comes from the Latin *animalis*, meaning *having breath, having soul or living being*.^[2] In everyday non-scientific usage the word excludes humans – that is, "animal" is often used to refer only to non-human members of the kingdom Animalia; often, only closer relatives of humans such as mammals and other vertebrates, are meant.^[3] The biological definition of the word refers to all members of the kingdom Animalia, encompassing creatures as diverse as sponges, jellyfish, insects, and humans.^[4]

History of classification



Carl Linnaeus, known as the father of modern taxonomy

Aristotle divided the living world between animals and plants, and this was followed by Carl Linnaeus, in the first hierarchical classification.^[5] In Linnaeus's original scheme, the animals were one of three kingdoms, divided into the classes of Vermes, Insecta, Pisces, Amphibia, Aves, and Mammalia. Since then the last four have all been subsumed into a

single phylum, the Chordata, whereas the various other forms have been separated out.

In 1874, Ernst Haeckel divided the animal kingdom into two subkingdoms: Metazoa (multicellular animals) and Protozoa (single-celled animals).^[6] The protozoa were later moved to the kingdom Protista, leaving only the metazoa. Thus Metazoa is now considered a synonym of Animalia.^[7]

Characteristics

Animals have several characteristics that set them apart from other living things. Animals are eukaryotic and multicellular,^[8] which separates them from bacteria and most protists. They are heterotrophic,^[9] generally digesting food in an internal

- Proarticulata †
- Xenacoelomorpha
- **Mesozoa (unranked)**
 - Orthonectida
 - Rhombozoa
 - Monoblastozoa
- **Nephrozoa (unranked)**
 - **Superphylum Deuterostomia**
 - Chordata
 - Hemichordata
 - Echinodermata
 - Vetulicolia †
 - **Protostomia (unranked)**
 - Chaetognatha (incertae sedis)^[1]
 - **Superphylum Ecdysozoa**
 - Kinorhyncha
 - Loricifera
 - Priapulida
 - Nematoda
 - Nematomorpha
 - Onychophora
 - Tardigrada
 - Arthropoda
 - **Superphylum Platyzoa**
 - Platyhelminthes
 - Gastrotricha
 - Rotifera
 - Acanthocephala
 - Gnathostomulida
 - Micrognathozoa
 - Cycliophora
 - **Superphylum Lophotrochozoa**
 - Sipuncula
 - Hyolitha †
 - Nemertea
 - Phoronida

chamber, which separates them from plants and algae.^[10] They are also distinguished from plants, algae, and fungi by lacking rigid cell walls.^[11] All animals are motile,^[12] if only at certain life stages. In most animals, embryos pass through a blastula stage,^[13] which is a characteristic exclusive to animals.

- Bryozoa
- Entoprocta
- Brachiopoda
- Mollusca
- Annelida

Structure

With a few exceptions, most notably the sponges (Phylum Porifera) and Placozoa, animals have bodies differentiated into separate tissues. These include muscles, which are able to contract and control locomotion, and nerve tissues, which send and process signals. Typically, there is also an internal digestive chamber, with one or two openings.^[14] Animals with this sort of organization are called metazoans, or eumetazoans when the former is used for animals in general.^[15]

All animals have eukaryotic cells, surrounded by a characteristic extracellular matrix composed of collagen and elastic glycoproteins.^[16] This may be calcified to form structures like shells, bones, and spicules.^[17] During development, it forms a relatively flexible framework^[18] upon which cells can move about and be reorganized, making complex structures possible. In contrast, other multicellular organisms, like plants and fungi, have cells held in place by cell walls, and so develop by progressive growth.^[14] Also, unique to animal cells are the following intercellular junctions: tight junctions, gap junctions, and desmosomes.^[19]

Reproduction and development



Some species of land snails use love darts as a form of sexual selection^[20]

Nearly all animals undergo some form of sexual reproduction.^[21] They produce haploid gametes by meiosis (see Origin and function of meiosis). The smaller, motile gametes are spermatozoa and the larger, non-motile gametes are ova.^[22] These fuse to form zygotes, which develop into new individuals^[23] (see Allogamy).

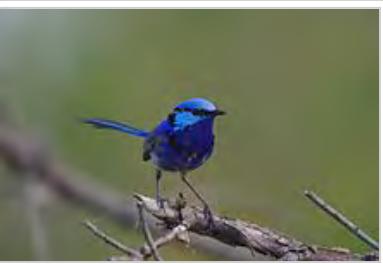
Many animals are also capable of asexual reproduction.^[24] This may take place through parthenogenesis, where fertile eggs are produced without mating, budding, or fragmentation.^[25]

A zygote initially develops into a hollow sphere, called a blastula,^[26] which undergoes rearrangement and differentiation. In sponges, blastula larvae swim to a new location and develop into a new sponge.^[27] In most other groups, the blastula undergoes more complicated rearrangement.^[28] It first invaginates to form a gastrula with a digestive chamber, and two separate germ layers—an external ectoderm and an internal endoderm.^[29] In most cases, a mesoderm also develops between them.^[30] These germ layers then differentiate to form tissues and organs.^[31]

Inbreeding avoidance

During sexual reproduction, mating with a close relative (inbreeding) generally leads to inbreeding depression. For instance, inbreeding was found to increase juvenile mortality in 11 small animal species.^[32] Inbreeding depression is considered to be largely due to expression of deleterious recessive mutations.^[33] Mating with unrelated or distantly related members of the same species is generally thought to provide the advantage of masking deleterious recessive mutations in progeny.^[34] (see Heterosis). Animals have evolved numerous diverse mechanisms for avoiding close inbreeding and promoting outcrossing^[35] (see Inbreeding avoidance).

As indicated in the image of chimpanzees, they have adopted dispersal as a way to separate close relatives and prevent inbreeding.^[35] Their dispersal route is known as natal dispersal, whereby individuals move away from the area of birth.



DNA analysis has shown that 60% of offspring in splendid fairywrens nests were sired through extra-pair copulations, rather than from resident males.^[35]

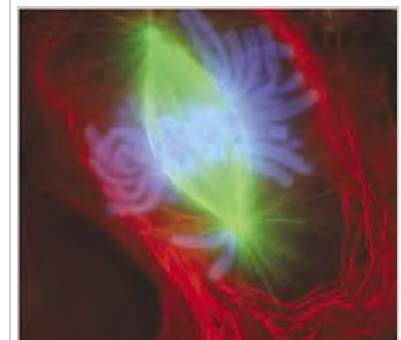
In various species, such as the splendid fairywren, females benefit by mating with multiple males, thus producing more offspring of higher genetic quality.

Females that are pair bonded to a male of poor genetic quality, as is the case in inbreeding, are more likely to engage in extra-pair copulations in order to improve their reproductive success and the survivability of their offspring.^[36]

Food and energy sourcing

All animals are heterotrophs, meaning that they feed directly or indirectly on other living things.^[37] They are often further subdivided into groups such as carnivores, herbivores, omnivores, and parasites.^[38]

Predation is a biological interaction where a predator (a heterotroph that is hunting) feeds on its prey (the organism that is attacked).^[39] Predators may or may not kill their prey prior to feeding on them, but the act of predation almost always results in the death of the prey.^[40] The other main category of consumption is detritivory, the consumption of dead organic matter.^[41] It can at times be difficult to separate the two feeding behaviours, for example, where parasitic species prey on a host organism and then lay their eggs on it for their offspring to feed on its decaying corpse. Selective pressures imposed on one another has led to an evolutionary arms race between prey and predator, resulting in various antipredator adaptations.^[42]



A newt lung cell stained with fluorescent dyes undergoing the early anaphase stage of mitosis



In Gombe Stream National Park, male chimpanzees remain in their natal community while females disperse to other groups

Most animals indirectly use the energy of sunlight by eating plants or plant-eating animals. Most plants use light to convert inorganic molecules in their environment into carbohydrates, fats, proteins and other biomolecules, characteristically containing reduced carbon in the form of carbon-hydrogen bonds. Starting with carbon dioxide (CO₂) and water (H₂O), photosynthesis converts the energy of sunlight into chemical energy in the form of simple sugars (e.g., glucose), with the release of molecular oxygen. These sugars are then used as the building blocks for plant growth, including the production of other biomolecules.^[44] When an animal eats plants (or eats other animals which have eaten plants), the reduced carbon compounds in the food become a source of energy and building materials for the animal.^[43] They are either used directly to help the animal grow, or broken down, releasing stored solar energy, and giving the animal the energy required for motion.^{[44][45]}

Animals living close to hydrothermal vents and cold seeps on the ocean floor are not dependent on the energy of sunlight.^[46] Instead chemosynthetic archaea and bacteria form the base of the food chain.^[47]

Origin and fossil record

Life timeline

Animals are generally considered to have emerged within flagellated eukaryota.^[49] Their closest known living relatives are the choanoflagellates, collared flagellates that have a morphology similar to the choanocytes of certain sponges.^[50] Molecular studies place animals in a supergroup called the opisthokonts, which also include the choanoflagellates, fungi and a few small parasitic protists.^[51] The name comes from the posterior location of the flagellum in motile cells, such as most animal spermatozoa, whereas other eukaryotes tend to have anterior flagella.^[52]

The first fossils that might represent animals appear in the Trezona Formation at Trezona Bore, West Central Flinders, South Australia.^[53] These fossils are interpreted as being early sponges. They were found in 665-million-year-old rock.^[53]

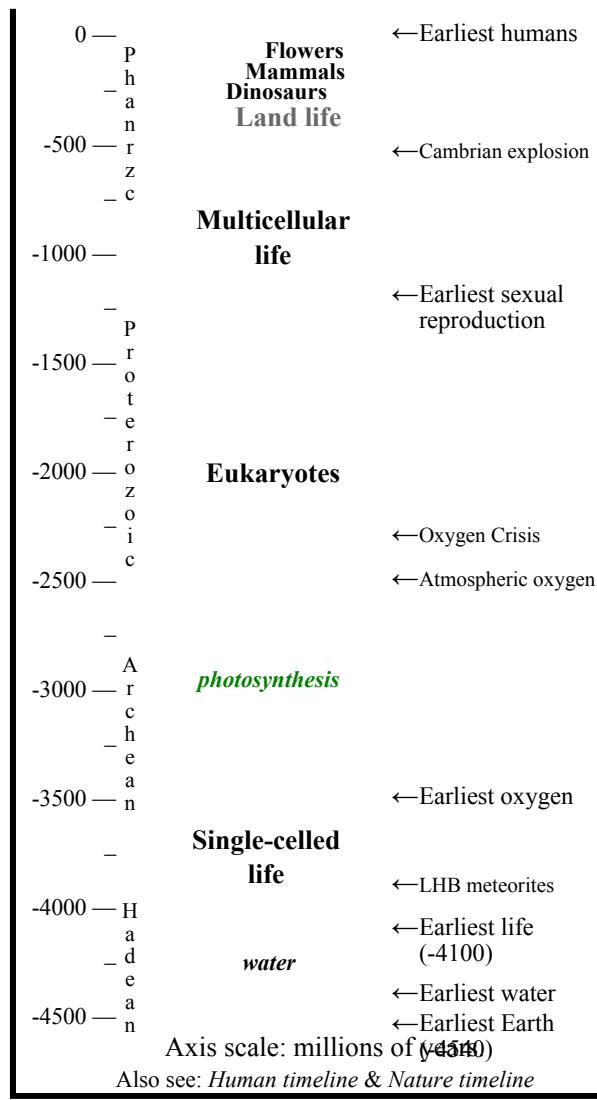
The next oldest possible animal fossils are found towards the end of the Precambrian, around 610 million years ago, and are known as the Ediacaran or Vendian biota.^[54] These are difficult to relate to later fossils, however. Some may represent precursors of modern phyla, but they may be separate groups, and it is possible they are not really animals at all.^[55]

Aside from them, most known animal phyla make a more or less simultaneous appearance during the Cambrian period, about 542 million years ago.^[56] It is still disputed whether this event, called the Cambrian explosion, is due to a rapid divergence between different groups or due to a change in conditions that made fossilization possible.

Some palaeontologists suggest that animals appeared much earlier than the Cambrian explosion, possibly as early as 1 billion years ago.^[57] Trace fossils such as tracks and burrows found in the Tonian period indicate the presence of triploblastic worms, like metazoans, roughly as large (about 5 mm wide) and complex as earthworms.^[58] During the beginning of the Tonian period around 1 billion years ago, there was a decrease in Stromatolite diversity, which may indicate the appearance of grazing animals, since stromatolite diversity increased when grazing animals became extinct at the End Permian and End Ordovician extinction events, and decreased shortly after the grazer populations recovered. However the discovery that tracks very similar to these early trace fossils are produced today by the giant single-celled protist *Gromia sphaerica* casts doubt on their interpretation as evidence of early animal evolution.^{[59][60]}

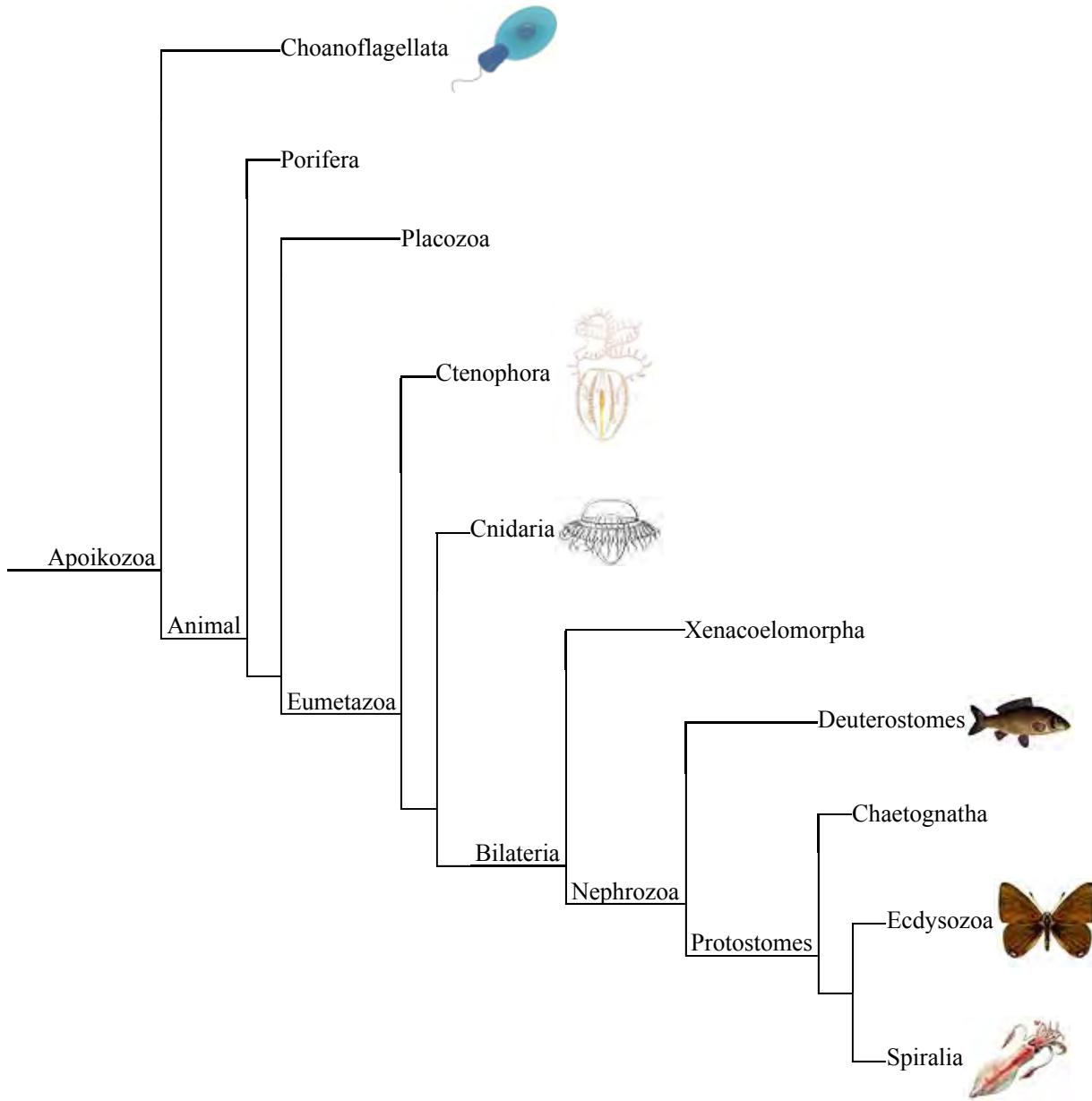
Groups of animals

Traditional morphological and modern molecular phylogenetic analysis have both recognized a major evolutionary transition from "non-bilaterian" animals, which are those lacking a bilaterally symmetric body plan (Porifera, Ctenophora, Cnidaria and Placozoa), to "bilaterian" animals (Bilateria) whose body plans display bilateral symmetry. The



Dunkleosteus was a 10-metre-long (33 ft) prehistoric fish.^[48]

latter are further classified based on a major division between Deuterostomes and Protostomes. The relationships among non-bilaterian animals are disputed, but all bilaterian animals are thought to form a monophyletic group. Current understanding of the relationships among the major groups of animals is summarized by the following cladogram.^[61]



Non-bilaterian animals: Porifera, Placozoa, Ctenophora, Cnidaria

Several animal phyla are recognized for their lack of bilateral symmetry, and are thought to have diverged from other animals early in evolution. Among these, the sponges (Porifera) were long thought to have diverged first, representing the oldest animal phylum.^[62] They lack the complex organization found in most other phyla.^[63] Their cells are differentiated, but in most cases not organized into distinct tissues.^[64] Sponges typically feed by drawing in water through pores.^[65] However, a series of phylogenomic studies from 2008-2015 have found support for Ctenophora, or comb jellies, as the basal lineage of animals.^{[66][67][68][69]} This result has been controversial, since it would imply that sponges may not be so

primitive, but may instead be secondarily simplified.^[66] Other researchers have argued that the placement of Ctenophora as the earliest-diverging animal phylum is a statistical anomaly caused by the high rate of evolution in ctenophore genomes.^{[70][71][72][73]}

Among the other phyla, the Ctenophora and the Cnidaria, which includes sea anemones, corals, and jellyfish, are radially symmetric and have digestive chambers with a single opening, which serves as both the mouth and the anus.^[74] Both have distinct tissues, but they are not organized into organs.^[75] There are only two main germ layers, the ectoderm and endoderm, with only scattered cells between them. As such, these animals are sometimes called diploblastic.^[76] The tiny placozoans are similar, but they do not have a permanent digestive chamber.

The Myxozoa, microscopic parasites that were originally considered Protozoa, are now believed to have evolved within Cnidaria.^[77]



Orange elephant ear sponge, *Agelas clathrodes*, in foreground. Two corals in the background: a sea fan, *Iciligorgia schrammi*, and a sea rod, *Plexaurella nutans*.

Bilaterian animals

The remaining animals form a monophyletic group called the Bilateria. For the most part, they are bilaterally symmetric, and often have a specialized head with feeding and sensory organs. The body is triploblastic, i.e. all three germ layers are well-developed, and tissues form distinct organs. The digestive chamber has two openings, a mouth and an anus, and there is also an internal body cavity called a coelom or pseudocoelom. There are exceptions to each of these characteristics, however—for instance adult echinoderms are radially symmetric, and certain parasitic worms have extremely simplified body structures.

Genetic studies have considerably changed our understanding of the relationships within the Bilateria. Most appear to belong to two major lineages: the deuterostomes and the protostomes, the latter of which includes the Ecdysozoa, and Lophotrochozoa. In addition, there are a few small groups of bilaterians with relatively similar structure whose relationships with other animals are not well-established. These include the Acoelomorpha, Rhombozoa, and Orthonectida.

Deuterostomes and Protostomes

Deuterostomes differ from protostomes in several ways. Animals from both groups possess a complete digestive tract. However, in protostomes, the first opening of the gut to appear in embryological development (the archenteron) develops into the mouth, with the anus forming secondarily. In deuterostomes the anus forms first, with the mouth developing secondarily.^[78] In most protostomes, cells simply fill in the interior of the gastrula to form the mesoderm, called schizocoelous development, but in deuterostomes, it forms through invagination of the endoderm, called enterocoelic pouching.^[79] Deuterostome embryos undergo radial cleavage during cell division, while protostomes undergo spiral cleavage.^[80]



Superb fairy-wren, *Malurus cyaneus*

All this suggests the deuterostomes and protostomes are separate, monophyletic lineages. The main phyla of deuterostomes are the Echinodermata and Chordata.^[81] The former are radially symmetric and exclusively marine, such as starfish, sea urchins, and sea cucumbers.^[82] The latter are dominated by the vertebrates, animals with backbones.^[83] These include fish, amphibians, reptiles, birds, and mammals.^[84]

In addition to these, the deuterostomes also include the Hemichordata, or acorn worms, which are thought to be closely related to Echinodermata forming a group known as Ambulacraria.^{[85][86]} Although they are not especially prominent today, the important fossil graptolites may belong to this group.^[87]

Ecdysozoa

The Ecdysozoa are protostomes, named after the common trait of growth by moulting or ecdysis.^[88] The largest animal phylum belongs here, the Arthropoda, including insects, spiders, crabs, and their kin. All these organisms have a body divided into repeating segments, typically with paired appendages. Two smaller phyla, the Onychophora and Tardigrada, are close relatives of the arthropods and share these traits. The ecdysozoans also include the Nematoda or roundworms, perhaps the second largest animal phylum. Roundworms are typically microscopic, and occur in nearly every environment where there is water.^[89] A number are important parasites.^[90] Smaller phyla related to them are the Nematomorpha or horsehair worms, and the Kinorhyncha, Priapulida, and Loricifera. These groups have a reduced coelom, called a pseudocoelom.



Yellow-winged darter, *Sympetrum flaveolum*

Lophotrochozoa

The Lophotrochozoa, evolved within Protostomia, include two of the most successful animal phyla, the Mollusca and Annelida.^{[91][92]} The former, which is the second-largest animal phylum by number of described species, includes animals such as snails, clams, and squids, and the latter comprises the segmented worms, such as earthworms and leeches. These two groups have long been considered close relatives because of the common presence of trochophore larvae, but the annelids were considered closer to the arthropods because they are both segmented.^[93] Now, this is generally considered convergent evolution, owing to many morphological and genetic differences between the two phyla.^[94] The Lophotrochozoa also include the Nemertea or ribbon worms, the Sipuncula, and several phyla that have a ring of ciliated tentacles around the mouth, called a lophophore.^[95] These were traditionally grouped together as the lophophorates.^[96] but it now appears that the lophophorate group may be paraphyletic,^[97] with some closer to the nemerteans and some to the molluscs and annelids.^{[98][99]} They include the Brachiopoda or lamp shells, which are prominent in the fossil record, the Entoprocta, the Phoronida, and possibly the Bryozoa or moss animals.^[100]



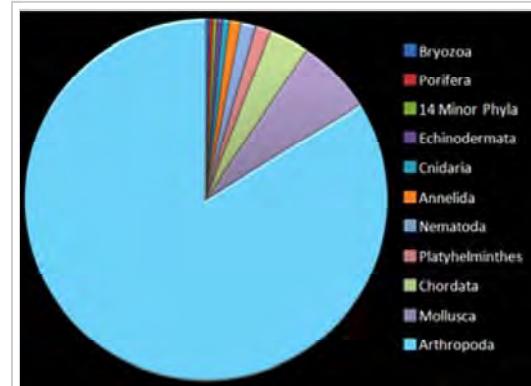
Roman snail, *Helix pomatia*

The Platyzoa include the phylum Platyhelminthes, the flatworms.^[101] These were originally considered some of the most primitive Bilateria, but it now appears they developed from more complex ancestors.^[102] A number of parasites are included in this group, such as the flukes and tapeworms.^[101] Flatworms are acoelomates, lacking a body cavity, as are their closest relatives, the microscopic Gastrotricha.^[103] The other platyzoan phyla are mostly microscopic and pseudocoelomate. The most prominent are the Rotifera or rotifers, which are common in aqueous environments. They also include the Acanthocephala or spiny-headed worms, the Gnathostomulida, Micrognathozoa, and possibly the Cycliophora.^[104] These groups share the presence of complex jaws, from which they are called the Gnathifera.

The Chaetognatha or arrow worms have been traditionally classified as deuterostomes, though recent molecular studies have identified this group as a basal protostome lineage.^[105]

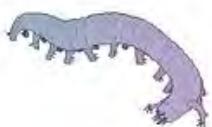
Number of extant species

Animals can be divided into two broad groups: vertebrates (animals with a backbone) and invertebrates (animals without a backbone). Half of all described vertebrate species are fishes and three-quarters of all described invertebrate species are insects. The following table lists the number of described extant species for each major animal subgroup as estimated for the IUCN Red List of Threatened Species, 2014.3.^[106]



The relative number of species contributed to the total by each phylum of animals

Group	Image	Subgroup	Estimated number of described species ^[106]
Vertebrates		Fishes	32,900
		Amphibians	7,302
		Reptiles	10,038
		Birds	10,425
		Mammals	5,513
	Total vertebrate species: 66,178		
Invertebrates		Insects	1,000,000
		Molluscs	85,000
		Crustaceans	47,000
		Corals	2,000
		Arachnids	102,248

		
	Velvet worms	165
	Horseshoe crabs	4
	Others	68,658
	Total invertebrate species: 1,305,075	
	Total for all animal species: 1,371,253	

Over 95% of the described animal species in the world are invertebrates.

Model organisms

Because of the great diversity found in animals, it is more economical for scientists to study a small number of chosen species so that connections can be drawn from their work and conclusions extrapolated about how animals function in general. Because they are easy to keep and breed, the fruit fly *Drosophila melanogaster* and the nematode *Caenorhabditis elegans* have long been the most intensively studied metazoan model organisms, and were among the first life-forms to be genetically sequenced. This was facilitated by the severely reduced state of their genomes, but as many genes, introns, and linkages lost, these ecdysozoans can teach us little about the origins of animals in general. The extent of this type of evolution within the superphylum will be revealed by the crustacean, annelid, and molluscan genome projects currently in progress. Analysis of the starlet sea anemone genome has emphasized the importance of sponges, placozoans, and choanoflagellates, also being sequenced, in explaining the arrival of 1500 ancestral genes unique to the Eumetazoa.^[107]

An analysis of the homoscleromorph sponge *Oscarella carmela* also suggests that the last common ancestor of sponges and the eumetazoan animals was more complex than previously assumed.^[108]

Other model organisms belonging to the animal kingdom include the house mouse (*Mus musculus*) and zebrafish (*Danio rerio*).

See also

- Animal attacks
- Animal coloration
- Biological classification
- Ethology
- Fauna
- List of animal names
- Lists of animals
- Lists of organisms by population

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- The Animal Kingdom (http://logic-law.com/index.php?title=Kingdom_Animalia/Metazoa)
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