Biology

Biology is a [natural science](https://en.wikipedia.org/wiki/Natural_science) concerned with the study of [life](https://en.wikipedia.org/wiki/Life) and living [organisms](https://en.wikipedia.org/wiki/Organism), including their structure, function, growth, [evolution](https://en.wikipedia.org/wiki/Evolution), distribution, identification and [taxonomy](https://en.wikipedia.org/wiki/Taxonomy_(biology)). Modern biology is a vast and eclectic field, composed of many [branches and sub disciplines](https://en.wikipedia.org/wiki/Biology#Branches). However, despite the broad scope of biology, there are certain general and unifying concepts within it that govern all study and research, consolidating it into single, coherent field. In general, biology recognizes the [cell](https://en.wikipedia.org/wiki/Cell_(biology)) as the basic unit of life, [genes](https://en.wikipedia.org/wiki/Genes) as the basic unit of [heredity](https://en.wikipedia.org/wiki/Heredity), and [evolution](https://en.wikipedia.org/wiki/Evolution) as the engine that propels the synthesis and creation of new [species](https://en.wikipedia.org/wiki/Species). It is also understood today that all the organisms survive by consuming and transforming [energy](https://en.wikipedia.org/wiki/Energy) and by [regulating](https://en.wikipedia.org/wiki/Homeostasis) their internal environment to maintain a stable and vital condition known as [homeostasis](https://en.wikipedia.org/wiki/Homeostasis).

Sub-disciplines of biology are defined by the scale at which organisms are studied, the kinds of organisms studied, and the methods used to study them: [bio chemistry](https://en.wikipedia.org/wiki/Biochemistry) examines the rudimentary chemistry of life; [molecular biology](https://en.wikipedia.org/wiki/Molecular_biology) studies the complex interactions among biological [molecules](https://en.wikipedia.org/wiki/Molecule); [botany](https://en.wikipedia.org/wiki/Botany) studies the biology of plants; [cellular biology](https://en.wikipedia.org/wiki/Cellular_biology) examines the basic building-block of all life, the [cell](https://en.wikipedia.org/wiki/Cell_(biology)); [physiology](https://en.wikipedia.org/wiki/Physiology) examines the physical and chemical functions of [tissues](https://en.wikipedia.org/wiki/Tissue_(biology)), [organs](https://en.wikipedia.org/wiki/Organ_(anatomy)), and [organ systems](https://en.wikipedia.org/wiki/Organ_system) of an organism [evolutionary biology](https://en.wikipedia.org/wiki/Evolutionary_biology) examines the processes that produced the diversity of life; and [ecology](https://en.wikipedia.org/wiki/Ecology) examines how organisms interact in their [environment](https://en.wikipedia.org/wiki/Environment_(biophysical)).

History

The term [biology](https://en.wiktionary.org/wiki/biology) is derived from the [Greek](https://en.wikipedia.org/wiki/Greek_Language) word  bios, [life](https://en.wikipedia.org/wiki/Life) and the suffix logia, study of. The Latin-language form of the term first appeared in 1736 when Swedish scientist [Carl Linnaeus](https://en.wikipedia.org/wiki/Carl_Linnaeus) (Carl von Linné) used biologi in his Bibliotheca botanica. It was used again in 1766 in a work entitled Philosophiae naturalis sive physicae: tomus III, continens geologian, biologian, phytologian generalis, by [Michael Christoph Hanov](https://en.wikipedia.org/wiki/Michael_Christoph_Hanow), a disciple of [Christian Wolff](https://en.wikipedia.org/wiki/Christian_Wolff_(philosopher)). The first German use, Biologie, was in a 1771 translation of Linnaeus' work. In 1797, Theodor Georg August Roose used the term in the preface of a book. [Karl Friedrich Burdach](https://en.wikipedia.org/wiki/Karl_Friedrich_Burdach) used the term in 1800 in a more restricted sense of the study of human beings from a morphological, physiological and psychological perspective. The term came into its modern usage with the six-volume treatise Biologie, oder Philosophie der lebenden Natur (1802–22) by [Gottfried Reinhold Treviranus](https://en.wikipedia.org/wiki/Gottfried_Reinhold_Treviranus), who announced the objects of our research will be the different forms and manifestations of life, the conditions and laws under which these phenomena occur, and the causes through which they have been effected. The science that concerns itself with these objects we will indicate by the name biology [Biologie] or the doctrine of life Lebenslehre.

Although modern biology is a relatively recent development, sciences related to and included within it have been studied since ancient times. [Natural philosophy](https://en.wikipedia.org/wiki/Natural_philosophy) was studied as early as the ancient civilizations of [Mesopotamia](https://en.wikipedia.org/wiki/Mesopotamia), [Egypt](https://en.wikipedia.org/wiki/Egypt), the [Indian subcontinent](https://en.wikipedia.org/wiki/Indian_subcontinent), and [China](https://en.wikipedia.org/wiki/China). However, the origins of modern biology and its approach to the study of nature are most often traced back to [ancient Greece](https://en.wikipedia.org/wiki/Ancient_Greece). While the formal study of [medicine](https://en.wikipedia.org/wiki/Medicine) dates back to [Hippocrates](https://en.wikipedia.org/wiki/Hippocrates) (ca. 460 BC – ca. 370 BC), it was [Aristotle](https://en.wikipedia.org/wiki/Aristotle) (384 BC – 322 BC) who contributed most extensively to the development of biology. Especially important are his [History of Animals](https://en.wikipedia.org/wiki/History_of_Animals) and other works where he showed naturalist leanings, and later more empirical works that focused on biological causation and the diversity of life. Aristotle's successor at the [Lyceum](https://en.wikipedia.org/wiki/Lyceum), [Theophrastus](https://en.wikipedia.org/wiki/Theophrastus), wrote a series of books on [botany](https://en.wikipedia.org/wiki/Botany) that survived as the most important contribution of antiquity to the plant sciences, even into the [middle Ages](https://en.wikipedia.org/wiki/Middle_Ages).

Scholars of the [medieval Islamic world](https://en.wikipedia.org/wiki/Science_in_the_medieval_Islamic_world) who wrote on biology included [al-Jahiz](https://en.wikipedia.org/wiki/Al-Jahiz) (781–869), [Al-Dīnawarī](https://en.wikipedia.org/wiki/Al-D%C4%ABnawar%C4%AB) (828–896), who wrote on botany, and [Rhazes](https://en.wikipedia.org/wiki/Muhammad_ibn_Zakar%C4%ABya_R%C4%81zi" \o "Muhammad ibn Zakarīya Rāzi) (865–925) who wrote on anatomy and [physiology](https://en.wikipedia.org/wiki/Physiology). [Medicine](https://en.wikipedia.org/wiki/Medicine) was especially well studied by Islamic scholars working in Greek philosopher traditions, while natural history drew heavily on Aristotelian thought, especially in upholding a fixed hierarchy of life.

Biology began to quickly develop and grow with [Anton van Leeuwenhoek](https://en.wikipedia.org/wiki/Anton_van_Leeuwenhoek)'s dramatic improvement of the [microscope](https://en.wikipedia.org/wiki/Microscope). It was then that scholars discovered [spermatozoa](https://en.wikipedia.org/wiki/Spermatozoa), [bacteria](https://en.wikipedia.org/wiki/Bacteria), [infusoria](https://en.wikipedia.org/wiki/Infusoria) and the diversity of microscopic life. Investigations by [Jan Swammerdam](https://en.wikipedia.org/wiki/Jan_Swammerdam) led to new interest in [entomology](https://en.wikipedia.org/wiki/Entomology) and helped to develop the basic techniques of microscopic dissection and [staining](https://en.wikipedia.org/wiki/Staining).

Advances in [microscopy](https://en.wikipedia.org/wiki/Microscopy) also had a profound impact on biological thinking. In the early 19th century, a number of biologists pointed to the central importance of the [cell](https://en.wikipedia.org/wiki/Cell_(biology)). Then, in 1838,[Schleiden](https://en.wikipedia.org/wiki/Matthias_Jakob_Schleiden) and [Schwann](https://en.wikipedia.org/wiki/Theodor_Schwann) began promoting the now universal ideas that the basic unit of organisms is the cell and that individual cells have all the characteristics of [life](https://en.wikipedia.org/wiki/Life), although they opposed the idea that all cells come from the division of other cells. Thanks to the work of [Robert Remak](https://en.wikipedia.org/wiki/Robert_Remak) and [Rudolf Virchow](https://en.wikipedia.org/wiki/Rudolf_Virchow), however, by the 1860s most biologists accepted all three tenets of what came to be known as [cell theory](https://en.wikipedia.org/wiki/Cell_theory).

Meanwhile, taxonomy and classification became the focus of natural historians. [Carl Linnaeus](https://en.wikipedia.org/wiki/Carl_Linnaeus) published a basic [taxonomy](https://en.wikipedia.org/wiki/Taxonomy_(biology)) for the natural world in 1735 (variations of which have been in use ever since), and in the 1750s introduced [scientific names](https://en.wikipedia.org/wiki/Binomial_nomenclature) for all his species. [Georges-Louis Leclerc, Comte de Buffon](https://en.wikipedia.org/wiki/Georges-Louis_Leclerc,_Comte_de_Buffon), treated species as artificial categories and living forms as malleable—even suggesting the possibility of [common descent](https://en.wikipedia.org/wiki/Common_descent). Though he was opposed to evolution, Buffon is a key figure in the [history of evolutionary thought](https://en.wikipedia.org/wiki/History_of_evolutionary_thought); his work influenced the evolutionary theories of both [Lamarck](https://en.wikipedia.org/wiki/Lamarck) and [Darwin](https://en.wikipedia.org/wiki/Charles_Darwin).

Serious evolutionary thinking originated with the works of [Jean-Baptiste Lamarck](https://en.wikipedia.org/wiki/Jean-Baptiste_Lamarck), who was the first to present a coherent theory of evolution.[[15]](https://en.wikipedia.org/wiki/Biology#cite_note-Gould_2002_187-15) He posited that evolution was the result of environmental stress on properties of animals, meaning that the more frequently and rigorously an organ was used, the more complex and efficient it would become, thus adapting the animal to its environment. Lamarck believed that these acquired traits could then be passed on to the animal's offspring, who would further develop and perfect them.[[16]](https://en.wikipedia.org/wiki/Biology#cite_note-Lam1914-16) However, it was the British naturalist [Charles Darwin](https://en.wikipedia.org/wiki/Charles_Darwin), combining the biogeographical approach of [Humboldt](https://en.wikipedia.org/wiki/Alexander_von_Humboldt), the uniformitarian geology of [Lyell](https://en.wikipedia.org/wiki/Charles_Lyell), [Malthus's](https://en.wikipedia.org/wiki/Thomas_Malthus) writings on population growth, and his own morphological expertise and extensive natural observations, who forged a more successful evolutionary theory based on [natural selection](https://en.wikipedia.org/wiki/Natural_selection); similar reasoning and evidence led Alfred to independently reach the same conclusions. Although it was the subject of [controversy](https://en.wikipedia.org/wiki/Creation%E2%80%93evolution_controversy) (which continues to this day), Darwin's theory quickly spread through the scientific community and soon became a central axiom of the rapidly developing science of biology.

The discovery of the physical representation of heredity came along with evolutionary principles and [population genetics](https://en.wikipedia.org/wiki/Population_genetics). In the 1940s and early 1950s, experiments pointed to [DNA](https://en.wikipedia.org/wiki/DNA) as the component of [chromosomes](https://en.wikipedia.org/wiki/Chromosomes) that held the trait-carrying units that had become known as [genes](https://en.wikipedia.org/wiki/Genes). A focus on new kinds of model organisms such as [viruses](https://en.wikipedia.org/wiki/Viruses) and [bacteria](https://en.wikipedia.org/wiki/Bacteria), along with the discovery of the double helical structure of DNA in 1953, marked the transition to the era of [molecular genetics](https://en.wikipedia.org/wiki/Molecular_genetics). From the 1950s to present times, biology has been vastly extended in the [molecular](https://en.wikipedia.org/wiki/Molecular_Biology) domain. The [genetic code](https://en.wikipedia.org/wiki/Genetic_code) was cracked by [Har Gobind Khorana](https://en.wikipedia.org/wiki/Har_Gobind_Khorana" \o "Har Gobind Khorana), [Robert W. Holley](https://en.wikipedia.org/wiki/Robert_W._Holley) and [Marshall Warren Nirenberg](https://en.wikipedia.org/wiki/Marshall_Warren_Nirenberg) after DNA was understood to contain [codons](https://en.wikipedia.org/wiki/Codons). Finally, the [Human Genome Project](https://en.wikipedia.org/wiki/Human_Genome_Project) was launched in 1990 with the goal of mapping the general human [genome](https://en.wikipedia.org/wiki/Genome). This project was essentially completed in 2003, with further analysis still being published. The Human Genome Project was the first step in a globalized effort to incorporate accumulated knowledge of biology into a functional, molecular definition of the human body and the bodies of other organisms.

Foundations of modern biology

Cell theory

Human [cancer cells](https://en.wikipedia.org/wiki/Cancer_cell) with nuclei (specifically the DNA) stained blue. The central and rightmost cell are in [interphase](https://en.wikipedia.org/wiki/Interphase), so the entire nuclei are labeled. The cell on the left is going through [mitosis](https://en.wikipedia.org/wiki/Mitosis) and its DNA has condensed.

[Cell theory](https://en.wikipedia.org/wiki/Cell_theory)

Cell theory states that the [cell](https://en.wikipedia.org/wiki/Cell_biology) is the fundamental unit of [life](https://en.wikipedia.org/wiki/Life), and that all living things are composed of one or more cells or the [secreted](https://en.wikipedia.org/wiki/Secretion) products of those cells (e.g. [shells](https://en.wikipedia.org/wiki/Animal_shell), hairs and [nails](https://en.wikipedia.org/wiki/Nail_(anatomy)) etc.). All cells arise from other cells through [cell division](https://en.wikipedia.org/wiki/Cell_division). In [multicellular organisms](https://en.wikipedia.org/wiki/Multicellular_organisms), every cell in the organism's body derives ultimately from a single cell in a fertilized egg. The cell is also considered to be the basic unit in many pathological processes. In addition, the phenomenon of [energy flow](https://en.wikipedia.org/wiki/Energy_transfer) occurs in cells in processes that are part of the function known as [metabolism](https://en.wikipedia.org/wiki/Metabolism). Finally, cells contain hereditary information ([DNA](https://en.wikipedia.org/wiki/DNA)), which is passed from cell to cell during cell division.

Evolution

A central organizing concept in biology is that life changes and develops through evolution, and that all life-forms known have a [common origin](https://en.wikipedia.org/wiki/Common_descent). The theory of evolution postulates that all [organisms](https://en.wikipedia.org/wiki/Organism) on the [Earth](https://en.wikipedia.org/wiki/Earth), both living and extinct, have descended from a common ancestor or an ancestral [gene pool](https://en.wikipedia.org/wiki/Gene_pool). This organisms is believed to have appeared about [3.5 billion years ago](https://en.wikipedia.org/wiki/Timeline_of_evolution). Biologists generally regard the universality and ubiquity of the [genetic code](https://en.wikipedia.org/wiki/Genetic_code) as definitive evidence in favor of the theory of universal common descent for all [bacteria](https://en.wikipedia.org/wiki/Bacterium), [archaea](https://en.wikipedia.org/wiki/Archaea), and [eukaryotes](https://en.wikipedia.org/wiki/Eukaryote) (see: [origin of life](https://en.wikipedia.org/wiki/Origin_of_life)).

Introduced into the scientific lexicon by [Jean-Baptiste de Lamarck](https://en.wikipedia.org/wiki/Jean-Baptiste_de_Lamarck) in 1809, evolution was established by [Charles Darwin](https://en.wikipedia.org/wiki/Charles_Darwin) fifty years later as a viable scientific model when he articulated its driving force: [natural selection](https://en.wikipedia.org/wiki/Natural_selection). ([Alfred Russel Wallace](https://en.wikipedia.org/wiki/Alfred_Russel_Wallace) is recognized as the co-discoverer of this concept as he helped research and experiment with the concept of evolution.) Evolution is now used to explain the great variations of life found on Earth.

Darwin theorized that species and breeds developed through the processes of [natural selection](https://en.wikipedia.org/wiki/Natural_selection) and [artificial selection](https://en.wikipedia.org/wiki/Artificial_selection) or [selective breeding](https://en.wikipedia.org/wiki/Selective_breeding). [Genetic drift](https://en.wikipedia.org/wiki/Genetic_drift) was embraced as an additional mechanism of evolutionary development in the [modern synthesis](https://en.wikipedia.org/wiki/Modern_synthesis) of the theory.

The evolutionary history of the [species](https://en.wikipedia.org/wiki/Species)—which describes the characteristics of the various species from which it descended—together with its genealogical relationship to every other species is known as its [phylogeny](https://en.wikipedia.org/wiki/Phylogeny). Widely varied approaches to biology generate information about phylogeny. These include the comparisons of sequences conducted within [molecular biology](https://en.wikipedia.org/wiki/Molecular_biology) or [genomics](https://en.wikipedia.org/wiki/Genomics), and comparisons of [fossils](https://en.wikipedia.org/wiki/Fossil) or other records of ancient organisms in [paleontology](https://en.wikipedia.org/wiki/Paleontology). Biologists organize and analyze evolutionary relationships through various methods, including [phylogenetic](https://en.wikipedia.org/wiki/Phylogenetics), phonetics, and [cladistics](https://en.wikipedia.org/wiki/Cladistics). (For a summary of major events in the evolution of life as currently understood by biologists, see [evolutionary timeline](https://en.wikipedia.org/wiki/Evolutionary_timeline).)

Genetics

A [Punnett square](https://en.wikipedia.org/wiki/Punnett_square) depicting a cross between two pea plants heterozygous for purple and white blossoms

[Genes](https://en.wikipedia.org/wiki/Gene) are the primary units of inheritance in all organisms. A gene is a unit of [heredity](https://en.wikipedia.org/wiki/Heredity) and corresponds to a region of [DNA](https://en.wikipedia.org/wiki/DNA) that influences the form or function of an organism in specific ways. All organisms, from bacteria to animals, share the same basic machinery that copies and translates DNA into [proteins](https://en.wikipedia.org/wiki/Protein). Cells [transcribe](https://en.wikipedia.org/wiki/Transcription_(genetics)) a DNA gene into an [RNA](https://en.wikipedia.org/wiki/RNA) version of the gene, and a [ribosome](https://en.wikipedia.org/wiki/Ribosome) then [translates](https://en.wikipedia.org/wiki/Translation_(biology)) the RNA into a protein, a sequence of [amino acids](https://en.wikipedia.org/wiki/Amino_acid). The [translation code](https://en.wikipedia.org/wiki/Genetic_code) from RNA codon to amino acid is the same for most organisms, but slightly different for some. For example, a sequence of DNA that codes for [insulin](https://en.wikipedia.org/wiki/Insulin) in humans also codes for insulin when inserted into other organisms, such as plants.

DNA usually occurs as linear [chromosomes](https://en.wikipedia.org/wiki/Chromosome) in [eukaryotes](https://en.wikipedia.org/wiki/Eukaryote), and circular chromosomes in [prokaryotes](https://en.wikipedia.org/wiki/Prokaryote). A chromosome is an organized structure consisting of [DNA](https://en.wikipedia.org/wiki/DNA) and [histones](https://en.wikipedia.org/wiki/Histone). The set of chromosomes in a cell and any other hereditary information found in the [mitochondria](https://en.wikipedia.org/wiki/Mitochondria), [chloroplasts](https://en.wikipedia.org/wiki/Chloroplasts), or other locations is collectively known as its [genome](https://en.wikipedia.org/wiki/Genome). In eukaryotes, genomic DNA is located in the [cell nucleus](https://en.wikipedia.org/wiki/Cell_nucleus), along with small amounts in [mitochondria](https://en.wikipedia.org/wiki/Mitochondrion) and [chloroplasts](https://en.wikipedia.org/wiki/Chloroplast). In prokaryotes, the DNA is held within an irregularly shaped body in the cytoplasm called the [nucleoid](https://en.wikipedia.org/wiki/Nucleoid).[[32]](https://en.wikipedia.org/wiki/Biology#cite_note-32) The genetic information in a genome is held within genes, and the complete assemblage of this information in an organism is called its [genotype](https://en.wikipedia.org/wiki/Genotype).

Homeostasis

The [hypothalamus](https://en.wikipedia.org/wiki/Hypothalamus) secretes [CRH](https://en.wikipedia.org/wiki/Corticotropin-releasing_hormone), which directs the [pituitary gland](https://en.wikipedia.org/wiki/Pituitary_gland) to secrete [ACTH](https://en.wikipedia.org/wiki/ACTH). In turn, ACTH directs the adrenal cortex to secrete glucocorticoids, such as [cortisol](https://en.wikipedia.org/wiki/Cortisol). The GCs then reduce the rate of secretion by the hypothalamus and the pituitary gland once a sufficient amount of GCs has been released.

Homeostasis is the ability of an [open system](https://en.wikipedia.org/wiki/Open_system_(systems_theory)) to regulate its internal environment to maintain stable conditions by means of multiple [dynamic equilibrium](https://en.wikipedia.org/wiki/Dynamic_equilibrium) adjustments controlled by interrelated regulation mechanisms. All living [organisms](https://en.wikipedia.org/wiki/Organism), whether [unicellular](https://en.wikipedia.org/wiki/Single_celled) or [multicellular](https://en.wikipedia.org/wiki/Multicellular), exhibit homeostasis.

To maintain dynamic equilibrium and effectively carry out certain functions, a system must detect and respond to perturbations. After the detection of a perturbation, a biological system normally responds through [negative feedback](https://en.wikipedia.org/wiki/Negative_feedback). This means stabilizing conditions by either reducing or increasing the activity of an organ or system. One example is the release of [glucagon](https://en.wikipedia.org/wiki/Glucagon) when sugar levels are too low.

Energy

The survival of a living organism depends on the continuous input of [energy](https://en.wikipedia.org/wiki/Energy). Chemical reactions that are responsible for its structure and function are tuned to extract [energy](https://en.wikipedia.org/wiki/Chemistry#Energy) from substances that act as its food and transform them to help form new cells and sustain them. In this process, [molecules](https://en.wikipedia.org/wiki/Molecule) of [chemical substances](https://en.wikipedia.org/wiki/Chemical_substance) that constitute [food](https://en.wikipedia.org/wiki/Food) play two roles; first, they contain energy that can be transformed for biological [chemical reactions](https://en.wikipedia.org/wiki/Chemical_reaction); second, they develop new molecular structures made up of biomolecules.

The organisms responsible for the introduction of energy into an ecosystem are known as producers or [autotrophs](https://en.wikipedia.org/wiki/Autotroph). Nearly all of these organisms originally draw energy from the sun. Plants and other [phototrophs](https://en.wikipedia.org/wiki/Phototroph) use solar energy via a process known as photosynthesis to convert raw materials into organic molecules, such as [ATP](https://en.wikipedia.org/wiki/Adenosine_triphosphate), whose bonds can be broken to release energy. A few [ecosystems](https://en.wikipedia.org/wiki/Ecosystems), however, depend entirely on energy extracted by [chemotropism](https://en.wikipedia.org/wiki/Chemotroph) from [methane](https://en.wikipedia.org/wiki/Methane), [sulfides](https://en.wikipedia.org/wiki/Sulfides), or other non-[luminal](https://en.wikipedia.org/wiki/Solar_energy) energy sources.[[38]](https://en.wikipedia.org/wiki/Biology#cite_note-38)

Some of the captured energy is used to produce [biomass](https://en.wikipedia.org/wiki/Biomass) to sustain [life](https://en.wikipedia.org/wiki/Life) and provide energy for growth and development. The majority of the rest of this energy is lost as heat and waste molecules. The most important processes for converting the energy trapped in chemical substances into energy useful to sustain life are [metabolism](https://en.wikipedia.org/wiki/Metabolism) and [cellular respiration](https://en.wikipedia.org/wiki/Cellular_respiration).

Study and research

Structural

Main articles: [Molecular biology](https://en.wikipedia.org/wiki/Molecular_biology), [Cell biology](https://en.wikipedia.org/wiki/Cell_biology), [Genetics](https://en.wikipedia.org/wiki/Genetics) and [Developmental biology](https://en.wikipedia.org/wiki/Developmental_biology)

Schematic of typical animal [cell](https://en.wikipedia.org/wiki/Cell_(biology)) depicting the various [organelles](https://en.wikipedia.org/wiki/Organelle) and structures.

[Molecular biology](https://en.wikipedia.org/wiki/Molecular_biology) is the study of biology at a molecular level. This field overlaps with other areas of biology, particularly with [genetics](https://en.wikipedia.org/wiki/Genetics) and [biochemistry](https://en.wikipedia.org/wiki/Biochemistry). Molecular biology chiefly concerns itself with understanding the interactions between the various systems of a cell, including the interrelationship of DNA, RNA, and protein synthesis and learning how these interactions are regulated.

[Cell biology](https://en.wikipedia.org/wiki/Cell_biology) studies the structural and [physiological](https://en.wikipedia.org/wiki/Physiology) properties of [cells](https://en.wikipedia.org/wiki/Cell_(biology)), including their [behaviors](https://en.wikipedia.org/wiki/Behavior), interactions, and [environment](https://en.wikipedia.org/wiki/Natural_environment). This is done on both the [microscopic](https://en.wikipedia.org/wiki/Microscope) and molecular levels, for unicellular organisms such as [bacteria](https://en.wikipedia.org/wiki/Bacterium), as well as the specialized cells in multicellular organisms such as [humans](https://en.wikipedia.org/wiki/Human). Understanding the structure and function of cells is fundamental to all of the biological sciences. The similarities and differences between cell types are particularly relevant to molecular biology.

[Anatomy](https://en.wikipedia.org/wiki/Anatomy) considers the forms of macroscopic structures such as [organs](https://en.wikipedia.org/wiki/Organ_(biology)) and organ systems.

[Genetics](https://en.wikipedia.org/wiki/Genetics) is the science of [genes](https://en.wikipedia.org/wiki/Gene), [heredity](https://en.wikipedia.org/wiki/Heredity), and the variation of [organisms](https://en.wikipedia.org/wiki/Organism). Genes encode the information necessary for synthesizing proteins, which in turn play a central role in influencing the final [phenotype](https://en.wikipedia.org/wiki/Phenotype) of the organism. In modern research, genetics provides important tools in the investigation of the function of a particular gene, or the analysis of [genetic interactions](https://en.wikipedia.org/wiki/Genetic_interaction). Within organisms, genetic information generally is carried in [chromosomes](https://en.wikipedia.org/wiki/Chromosome), where it is represented in the structure of particular [DNA](https://en.wikipedia.org/wiki/DNA) [molecules](https://en.wikipedia.org/wiki/Molecule).

[Developmental biology](https://en.wikipedia.org/wiki/Developmental_biology) studies the process by which organisms grow and develop. Originating in [embryology](https://en.wikipedia.org/wiki/Embryology), modern developmental biology studies the genetic control of [cell growth](https://en.wikipedia.org/wiki/Cell_growth), [differentiation](https://en.wikipedia.org/wiki/Cellular_differentiation), and "[morphogenesis](https://en.wikipedia.org/wiki/Morphogenesis)," which is the process that progressively gives rise to [tissues](https://en.wikipedia.org/wiki/Biological_tissue), [organs](https://en.wikipedia.org/wiki/Organ_(anatomy)), and [anatomy](https://en.wikipedia.org/wiki/Anatomy). [Model organisms](https://en.wikipedia.org/wiki/Model_organism) for developmental biology include the round worm [Caenorhabditis elegant](https://en.wikipedia.org/wiki/Caenorhabditis_elegans), the fruit fly [Drosophila melanogaster](https://en.wikipedia.org/wiki/Drosophila_melanogaster), the zebrafish [Danio rerio](https://en.wikipedia.org/wiki/Danio_rerio), the mouse [Mus musculus](https://en.wikipedia.org/wiki/Mus_musculus), and the weed [Arabidopsis thaliana](https://en.wikipedia.org/wiki/Arabidopsis_thaliana). (A model organism is a [species](https://en.wikipedia.org/wiki/Species) that is extensively studied to understand particular biological [phenomena](https://en.wikipedia.org/wiki/Phenomena), with the expectation that discoveries made in that organism provide insight into the workings of other organisms.)[[51]](https://en.wikipedia.org/wiki/Biology#cite_note-51)

Physiological

Main article: [Physiology](https://en.wikipedia.org/wiki/Physiology)

Physiology studies the mechanical, physical, and biochemical processes of living organisms by attempting to understand how all of the structures function as a whole. The theme of structure to function is central to biology. Physiological studies have traditionally been divided into [plant physiology](https://en.wikipedia.org/wiki/Plant_physiology) and [animal physiology](https://en.wikipedia.org/wiki/Animal_physiology), but some principles of physiology are universal, no matter what particular [organism](https://en.wikipedia.org/wiki/Organism) is being studied. For example, what is learned about the physiology of [yeast](https://en.wikipedia.org/wiki/Yeast) cells can also apply to human cells. The field of animal physiology extends the tools and methods of [human physiology](https://en.wikipedia.org/wiki/Human_physiology) to non-human species. Plant physiology borrows techniques from both research fields.

Physiology studies how for example [nervous](https://en.wikipedia.org/wiki/Nervous_system), [immune](https://en.wikipedia.org/wiki/Immune_system), [endocrine](https://en.wikipedia.org/wiki/Endocrine_system), [respiratory](https://en.wikipedia.org/wiki/Respiratory_system), and [circulatory](https://en.wikipedia.org/wiki/Circulatory_system) systems, function and interact. The study of these systems is shared with [medically](https://en.wikipedia.org/wiki/Medicine) oriented disciplines such as [neurology](https://en.wikipedia.org/wiki/Neurology) and immunology.

Evolutionary

[Evolutionary research](https://en.wikipedia.org/wiki/Current_research_in_evolutionary_biology) is concerned with the origin and descent of [species](https://en.wikipedia.org/wiki/Species), as well as their change over time, and includes scientists from many taxonomically oriented disciplines. For example, it generally involves scientists who have special training in particular [organisms](https://en.wikipedia.org/wiki/Organism) such as [mamma logy](https://en.wikipedia.org/wiki/Mammalogy), [ornithology](https://en.wikipedia.org/wiki/Ornithology), [botany](https://en.wikipedia.org/wiki/Botany), or [herpetology](https://en.wikipedia.org/wiki/Herpetology), but use those organisms as systems to answer general questions about evolution.

Evolutionary biology is partly based on [paleontology](https://en.wikipedia.org/wiki/Paleontology), which uses the [fossil](https://en.wikipedia.org/wiki/Fossil) record to answer questions about the mode and tempo of evolution, and partly on the developments in areas such as [population genetics](https://en.wikipedia.org/wiki/Population_genetics). In the 1980s, [developmental biology](https://en.wikipedia.org/wiki/Developmental_biology) re-entered evolutionary biology from its initial exclusion from the [modern synthesis](https://en.wikipedia.org/wiki/Modern_synthesis) through the study of [evolutionary developmental biology](https://en.wikipedia.org/wiki/Evolutionary_developmental_biology).[[54]](https://en.wikipedia.org/wiki/Biology#cite_note-54) Related fields often considered part of evolutionary biology are [phylogenetic](https://en.wikipedia.org/wiki/Phylogenetics), [systematics](https://en.wikipedia.org/wiki/Systematics), and [taxonomy](https://en.wikipedia.org/wiki/Alpha_taxonomy).

Systematic

A [phylogenetic tree](https://en.wikipedia.org/wiki/Phylogenetic_tree) of all living things, based on [rRNA](https://en.wikipedia.org/wiki/RRNA) [gene](https://en.wikipedia.org/wiki/Gene) data, showing the separation of the three domains [bacteria](https://en.wikipedia.org/wiki/Bacterium), [archaea](https://en.wikipedia.org/wiki/Archaea), and [eukaryotes](https://en.wikipedia.org/wiki/Eukaryote) as described initially by [Carl Woese](https://en.wikipedia.org/wiki/Carl_Woese). Trees constructed with other genes are generally similar, although they may place some early-branching groups very differently, presumably owing to rapid rRNA evolution. The exact relationships of the three domains are still being debated.

The hierarchy of [biological classification](https://en.wikipedia.org/wiki/Biological_classification)'s eight major taxonomic ranks. Intermediate minor rankings are not shown. This diagram uses a 3[Domains](https://en.wikipedia.org/wiki/Domain_(biology))  6 [Kingdoms](https://en.wikipedia.org/wiki/Kingdom_(biology)) format

Main article: [Systematics](https://en.wikipedia.org/wiki/Systematics)

Multiple [speciation](https://en.wikipedia.org/wiki/Speciation) events create a tree structured system of relationships between species. The role of systematics is to study these relationships and thus the differences and similarities between species and groups of species. However, systematics was an active field of research long before evolutionary thinking was common.

Traditionally, living things have been divided into five kingdoms: [Monera](https://en.wikipedia.org/wiki/Monera" \o "Monera); [Protista](https://en.wikipedia.org/wiki/Protist); [Fungi](https://en.wikipedia.org/wiki/Fungus); [Plantae](https://en.wikipedia.org/wiki/Plant" \o "Plant);[Animalia](https://en.wikipedia.org/wiki/Animal). However, many scientists now consider this five-kingdom system outdated. Modern alternative classification systems generally begin with the [three-domain system](https://en.wikipedia.org/wiki/Three-domain_system): [Archaea](https://en.wikipedia.org/wiki/Archaea) (originally Archaebacterial); [Bacteria](https://en.wikipedia.org/wiki/Bacterium) (originally Eubacteria) and [Eukaryote](https://en.wikipedia.org/wiki/Eukaryote) (including [protests](https://en.wikipedia.org/wiki/Protist), [fungi](https://en.wikipedia.org/wiki/Fungi), [plants](https://en.wikipedia.org/wiki/Plants), and animals) These domains reflect whether the cells have nuclei or not, as well as differences in the chemical composition of key biomolecules such as [ribosomes](https://en.wikipedia.org/wiki/Ribosome).

Further, each kingdom is broken down recursively until each species is separately classified. The order is: [Domain](https://en.wikipedia.org/wiki/Domain_(biology)); [Kingdom](https://en.wikipedia.org/wiki/Kingdom_(biology)); [Phylum](https://en.wikipedia.org/wiki/Phylum); [Class](https://en.wikipedia.org/wiki/Class_(biology)); [Order](https://en.wikipedia.org/wiki/Order_(biology)); [Family](https://en.wikipedia.org/wiki/Family_(biology)); [Genus](https://en.wikipedia.org/wiki/Genus); [Species](https://en.wikipedia.org/wiki/Species).

Outside of these categories, there are obligate intracellular [parasites](https://en.wikipedia.org/wiki/Parasite) that are on the edge of life in terms of [metabolic](https://en.wikipedia.org/wiki/Metabolism) activity, meaning that many scientists do not actually classify these structures as alive, due to their lack of at least one or more of the fundamental functions or characteristics that define life. They are classified as [viruses](https://en.wikipedia.org/wiki/Virus_(biology)), [viroids](https://en.wikipedia.org/wiki/Viroid" \o "Viroid), [prions](https://en.wikipedia.org/wiki/Prion), or [satellites](https://en.wikipedia.org/wiki/Satellite_(biology)).

The scientific name of an organism is generated from its genus and species. For example, humans are listed as [Homo sapiens](https://en.wikipedia.org/wiki/Homo_sapiens). Homo is the genus, and sapiens the species. When writing the scientific name of an organism, it is proper to capitalize the first letter in the genus and put all of the species in lowercase. Additionally, the entire term may be italicized or underlined.

The dominant classification system is called the [Linnaean taxonomy](https://en.wikipedia.org/wiki/Linnaean_taxonomy). It includes ranks and [binomial nomenclature](https://en.wikipedia.org/wiki/Binomial_nomenclature). How organisms are named is governed by international agreements such as the [International Code of Nomenclature for algae, fungi, and plants](https://en.wikipedia.org/wiki/International_Code_of_Nomenclature_for_algae,_fungi,_and_plants) (ICN), the [International Code of Zoological Nomenclature](https://en.wikipedia.org/wiki/International_Code_of_Zoological_Nomenclature) (ICZN), and the [International Code of Nomenclature of Bacteria](https://en.wikipedia.org/wiki/International_Code_of_Nomenclature_of_Bacteria) (ICNB). The classification of [viruses](https://en.wikipedia.org/wiki/Viruses), [viroid’s](https://en.wikipedia.org/wiki/Viroids), [prions](https://en.wikipedia.org/wiki/Prions), and all other sub-viral agents that demonstrate biological characteristics is conducted by the International (ICTV) and is known as the International Code of Viral Classification and Nomenclature (ICVCN). However, several other viral classification systems do exist.

A merging draft, [BioCode](https://en.wikipedia.org/wiki/BioCode" \o "BioCode), was published in 1997 in an attempt to standardize nomenclature in these three areas, but has yet to be formally adopted. The BioCode draft has received little attention since 1997; its originally planned implementation date of January 1, 2000, has passed unnoticed. A revised BioCode that, instead of replacing the existing codes, would provide a unified context for them, was proposed in 2011. However, the [International Botanical Congress](https://en.wikipedia.org/wiki/International_Botanical_Congress) of 2011 declined to consider the BioCode proposal. The [ICVCN](https://en.wikipedia.org/wiki/International_Committee_on_Taxonomy_of_Viruses) remains outside the BioCode, which does not include viral classification.

## Branches

These are the main branches of biology:

[Aerobiology](https://en.wikipedia.org/wiki/Aerobiology)  the study of airborne organic particles

[Agriculture](https://en.wikipedia.org/wiki/Agriculture)  the study of producing crops and raising livestock, with an emphasis on practical applications

[Anatomy](https://en.wikipedia.org/wiki/Anatomy) the study of form and function, in plants, animals, and other organisms, or specifically in humans

[Histology](https://en.wikipedia.org/wiki/Histology)  the study of cells and tissues, a microscopic branch of anatomy

[Astrobiology](https://en.wikipedia.org/wiki/Astrobiology) (also known as exobiology, xenopaleontology, and bio astronomy) – the study of evolution, distribution, and future of life in the universe

[Biochemistry](https://en.wikipedia.org/wiki/Biochemistry)  the study of the [chemical reactions](https://en.wikipedia.org/wiki/Chemical_reactions) required for life to exist and function, usually a focus on the cellular level

[Bioengineering](https://en.wikipedia.org/wiki/Bioengineering)  the study of biology through the means of engineering with an emphasis on applied knowledge and especially related to biotechnology

[Biogeography](https://en.wikipedia.org/wiki/Biogeography)  the study of the distribution of species spatially and temporally

[Bioinformatics](https://en.wikipedia.org/wiki/Bioinformatics)  the use of information technology for the study, collection, and storage of genomic and other biological data

[Biomathematics](https://en.wikipedia.org/wiki/Biomathematics) (or Mathematical biology) – the quantitative or mathematical study of biological processes, with an emphasis on modeling

[Biomechanics](https://en.wikipedia.org/wiki/Biomechanics)  often considered a branch of medicine, the study of the mechanics of living beings, with an emphasis on applied use through [prosthetics](https://en.wikipedia.org/wiki/Prosthetics) or [orthotics](https://en.wikipedia.org/wiki/Orthotics)

[Biomedical research](https://en.wikipedia.org/wiki/Biomedical_research)  the study of health and disease

[Pharmacology](https://en.wikipedia.org/wiki/Pharmacology)  the study and practical application of preparation, use, and effects of drugs and synthetic medicines

[Bio musicology](https://en.wikipedia.org/wiki/Biomusicology)  the study of music from a biological point of view.

[Biophysics](https://en.wikipedia.org/wiki/Biophysics)  the study of biological processes through physics, by applying the theories and methods traditionally used in the physical sciences

[Biosemiotics](https://en.wikipedia.org/wiki/Biosemiotics) – the study of biological processes through [semiotics](https://en.wikipedia.org/wiki/Semiotics), by applying the models of meaning-making and communication

[Biotechnology](https://en.wikipedia.org/wiki/Biotechnology) – the study of the manipulation of living matter, including genetic modification and [synthetic biology](https://en.wikipedia.org/wiki/Synthetic_biology)

[Synthetic biology](https://en.wikipedia.org/wiki/Synthetic_biology) – research integrating biology and engineering; construction of biological functions not found in nature

[Building biology](https://en.wikipedia.org/wiki/Building_biology) – the study of the indoor living environment

[Botany](https://en.wikipedia.org/wiki/Botany) – the study of plants

[Cell biology](https://en.wikipedia.org/wiki/Cell_biology) – the study of the cell as a complete unit, and the molecular and chemical interactions that occur within a living cell

[Cognitive biology](https://en.wikipedia.org/wiki/Cognitive_biology) – the study of [cognition](https://en.wikipedia.org/wiki/Cognition) as a biological function

[Conservation biology](https://en.wikipedia.org/wiki/Conservation_biology) – the study of the preservation, protection, or restoration of the natural environment, natural ecosystems, vegetation, and wildlife

[Cryobiology](https://en.wikipedia.org/wiki/Cryobiology) – the study of the effects of lower than normally preferred temperatures on living beings

[Developmental biology](https://en.wikipedia.org/wiki/Developmental_biology) – the study of the processes through which an organism forms, from zygote to full structure

[Embryology](https://en.wikipedia.org/wiki/Embryology) – the study of the development of embryo (from fecundation to birth)

[Ecology](https://en.wikipedia.org/wiki/Ecology) – the study of the interactions of living organisms with one another and with the non-living elements of their environment

[Environmental biology](https://en.wikipedia.org/wiki/Environmental_biology) – the study of the natural world, as a whole or in a particular area, especially as affected by human activity

[Epidemiology](https://en.wikipedia.org/wiki/Epidemiology) – a major component of public health research, studying factors affecting the health of populations

[Evolutionary biology](https://en.wikipedia.org/wiki/Evolutionary_biology) – the study of the origin and descent of species over time

[Genetics](https://en.wikipedia.org/wiki/Genetics) – the study of genes and heredity.

[Epigenetics](https://en.wikipedia.org/wiki/Epigenetics) – the study of heritable changes in gene expression or cellular phenotype caused by mechanisms other than changes in the underlying DNA sequence

[Hematology](https://en.wikipedia.org/wiki/Hematology) (also known as Hematology) – the study of blood and blood-forming organs.

[Integrative biology](https://en.wikipedia.org/wiki/Integrative_biology) – the study of whole organisms

[Limnology](https://en.wikipedia.org/wiki/Limnology) – the study of inland waters

[Marine biology](https://en.wikipedia.org/wiki/Marine_biology) (or Biological oceanography) – the study of ocean ecosystems, plants, animals, and other living beings

[Microbiology](https://en.wikipedia.org/wiki/Microbiology) – the study of microscopic organisms (microorganisms) and their interactions with other living things

[Bacteriology](https://en.wikipedia.org/wiki/Bacteriology) - the study of bacteria

[Mycology](https://en.wikipedia.org/wiki/Mycology) – the study of fungi

[Parasitology](https://en.wikipedia.org/wiki/Parasitology) – the study of parasites and parasitism

[Virology](https://en.wikipedia.org/wiki/Virology) – the study of viruses and some other virus-like agents

[Molecular biology](https://en.wikipedia.org/wiki/Molecular_biology) – the study of biology and biological functions at the molecular level, some cross over with biochemistry

[Nano biology](https://en.wikipedia.org/wiki/Nanobiology) - the study of how [nanotechnology](https://en.wikipedia.org/wiki/Nanotechnology) can be used in biology, and the study of living organisms and parts on the [nanoscale](https://en.wikipedia.org/wiki/Nanoscale) level of organization

[Neurobiology](https://en.wikipedia.org/wiki/Neurobiology) – the study of the nervous system, including anatomy, physiology and pathology

[Population biology](https://en.wikipedia.org/wiki/Population_biology) – the study of groups of conspecific organisms, including

[Population ecology](https://en.wikipedia.org/wiki/Population_ecology) – the study of how population dynamics and extinction

[Population genetics](https://en.wikipedia.org/wiki/Population_genetics) – the study of changes in gene frequencies in populations of organisms

[Paleontology](https://en.wikipedia.org/wiki/Paleontology) – the study of fossils and sometimes geographic evidence of prehistoric life

[Pathobiology or pathology](https://en.wikipedia.org/wiki/Pathology) – the study of diseases, and the causes, processes, nature, and development of disease

[Physiology](https://en.wikipedia.org/wiki/Physiology) – the study of the functioning of living organisms and the organs and parts of living organisms

[Phytopathology](https://en.wikipedia.org/wiki/Phytopathology) – the study of plant diseases (also called Plant Pathology)

[Psychobiology](https://en.wikipedia.org/wiki/Psychobiology) – the study of the biological bases of [psychology](https://en.wikipedia.org/wiki/Psychology)

[Quantum biology](https://en.wikipedia.org/wiki/Quantum_biology) - the study of [quantum mechanics](https://en.wikipedia.org/wiki/Quantum_mechanics) to biological objects and problems. Sociobiology – the study of the biological bases of [sociology](https://en.wikipedia.org/wiki/Sociology)

[Structural biology](https://en.wikipedia.org/wiki/Structural_biology) – a branch of [molecular biology](https://en.wikipedia.org/wiki/Molecular_biology), [biochemistry](https://en.wikipedia.org/wiki/Biochemistry), and [biophysics](https://en.wikipedia.org/wiki/Biophysics) concerned with the molecular structure of biological macromolecules

[Zoology](https://en.wikipedia.org/wiki/Zoology) – the study of animals, including classification, physiology, development, and behavior, including:

[Ethology](https://en.wikipedia.org/wiki/Ethology) – the study of animal behavior

[Entomology](https://en.wikipedia.org/wiki/Entomology) – the study of insects

[Herpetology](https://en.wikipedia.org/wiki/Herpetology) – the study of reptiles and amphibians

[Ichthyology](https://en.wikipedia.org/wiki/Ichthyology) – the study of fish

[Mamma logy](https://en.wikipedia.org/wiki/Mammalogy) – the study of mammals

[Ornithology](https://en.wikipedia.org/wiki/Ornithology) – the study of birds