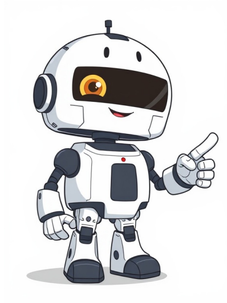
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Chordates are bilaterally symmetrical animals, making up the third largest and the most diverse phyla in the animal kingdom, Chordata. They are distinguished by five characteristics: an elastic, rod-like notochord, a dorsal hollow nerve cord, an endostyle or thyroid gland, pharyngeal slits, and a post-anal tail. These features are present at some stage in their life cycle and are integral to their classification. Presently, around 81,000 extant chordate species are divided into three subphyla: cephalochordates (Cephalochordata), tunicates (Tunicata), and vertebrates or craniates (Vertebrata). Chordates possess five characteristics that distinguish them from other animal phyla. Notochord: A stiff but elastic rod running along the body’s central axis, made of collagenous helices. In vertebrates, the notochord is replaced by hyaline cartilage or bone, with remnants reduced to intervertebral discs that allow spinal vertebrae to twist and bend against each other. Dorsal Hollow Nerve Cord: Located dorsal to the notochord, this neural tube forms the spinal cord. In vertebrates, the rostral end of this tube enlarges into vesicles that develop into the brain during embryonic development. Pharyngeal Gill Slits: These slits line the tubular pharynx. In fish, they develop into gills, while in other chordates, they are modified for filter feeding. In tetrapods, these slits are present only during embryonic stages. Post-Anal Tail: A muscular tail extending beyond the anus. This tail is present only during embryonic development in some tetrapods, including humans. Endostyle: A deep groove in the ventral wall of the pharynx that stores iodine and is considered a precursor to the thyroid gland. Tunicates and vertebrates have a distinct heart that circulates blood throughout the body. In contrast, cephalochordates use specialized blood vessels for circulation. Deoxygenated blood flows into a series of branchial arteries in the gills via the ventral aorta, and after gas exchange, oxygenated blood returns through the dorsal aorta. While vertebrates have a complex network of capillaries for blood distribution, such networks are absent in tunicates and cephalochordates. While tunicates, cephalochordates, and aquatic vertebrates possess gills for respiration, terrestrial vertebrates have evolved to use lungs as their primary respiratory organ. Their digestive system is a simple tube consisting of a ciliated pharynx, a sac-like stomach, and specialized gland-like structures found only in vertebrates, such as the liver and pancreas. Although nitrogenous waste is typically expelled through the kidneys in terrestrial vertebrates, the gills serve as the primary excretory organ in fish and other aquatic vertebrates. In contrast, cephalochordates and tunicates use different organs for excretion. Cephalochordates possess specialized protonephridia, while tunicates expel waste by diffusing ammonia across their body tissues. Although the anterior part of the dorsal nerve cord in tunicates and cephalochordates enlarges into a brain-like structure, a well-developed brain is only found in vertebrates. Both cephalochordates and vertebrates are characterized by segmentally repeated nerves arising from the nerve cord, but this segmentation is not observed in tunicates. Tunicate larvae possess simple light-sensitive organs and other sensory structures that detect the direction of gravity. Similarly, cephalochordates have pigment spots and light receptors within their nerve cord, whereas vertebrates are far more complex and sensitive to external stimuli. Several DNA sequencing efforts to determine the interrelationships among chordates have produced various hypotheses, but the current consensus supports the monophyly of chordates. This means that all chordates have descended from a single common ancestor. Recent phylogenetic data found two conserved signature indels (CSIs) in cyclophilin-like protein and mitochondrial inner membrane protease ATP23, shared by vertebrates, tunicates, and cephalochordates. This discovery reinforces the monophyletic nature of chordates. Vertebrates and tunicates share two additional CSIs in the exosome complex protein RRP44, indicating that vertebrates are more closely related to tunicates than cephalochordates. Consequently, the subphylum Cephalochordata is considered a sister group to Olfactores, which includes vertebrates and tunicates. Chordates share several features with their closest non-chordate relatives, hemichordates and echinoderms. Hemichordates possess branchial openings resembling gill slits and stomochords similar in composition to the notochord. Echinoderms share the tube-within-tube deuterostomic body plan and are believed to share a common ancestor with chordates. Based on the above studies, over 81,000 living chordate species are classified into three subphyla and ten classes. Subphylum: Cephalochordata Class: Leptocardii (lancelets) Clade: Olfactores Subphylum: Tunicata (Tunicates) Class: Ascidiacea (sea squirts) Class: Thaliacea (salps, doliolids, and pyrosomes) Class: Appendicularia (larvaceans) Class: Sorberacea Subphylum: Vertebrata (Vertebrates) Superclass: Agnatha (jawless vertebrates) Class: Cyclostomata Infraclass: Myxinoidea or Myxini (hagfish) Infraclass: Petromyzontida or Hyperoartia (lampreys) Class: Conodonta (Extinct) Class: Myllokunmingiida (Extinct) Class: Pteraspidomorphi (Extinct) Class: Thelodonti (Extinct) Class: Anaspida (Extinct) Class: Cephalaspidomorphi (Extinct) Infraphylum: Gnathostomata (jawed vertebrates) Class: Placodermi (Extinct) Class: Chondrichthyes (cartilaginous fish) Class: Acanthodii (Extinct) Class: Osteichthyes (bony fish) Subclass: Actinopterygii (ray-finned fish) Subclass: Sarcopterygii (lobe-finned fish) Superclass: Tetrapoda (four-limbed vertebrates) Cephalochordata1. Fish-like, filter-feeding animals lacking distinct heads or brains.Tunicata1. They exist in two major forms: sea squirts and salps. Both forms retain the characteristics of a chordate only in their larval stages.2. While sea squirts are sessile filter-feeders, salps float passively and possess a two-generation life cycle (solitary and colonial).3. The third group, larvaceans, resemble tadpole larvae and swim actively throughout their lives.Vertebrata1. As their name suggests, they have modified their notochords into an ossified vertebral column. They also possess a distinct cranium.2. The vertebral column consists of a series of bony or cartilaginous cylindrical vertebrae. However, hagfish lack vertebrae and possess an incomplete cranium, placing them under the group Craniata, which includes all vertebrates. Although fossil records of early chordates are sparse, several biochemical techniques based on RNA sequences have been used to study the evolution of this phylum. It is suggested that deuterostomes evolved as early as 900 million years ago, with the first chordates appearing around 896 million years ago. Nearly all the earliest chordate fossils have been discovered in China’s Chengjiang Fauna from the Early Cambrian Period. The two broad groups of animals, the protostomes and deuterostomes, are believed to have diverged at least 558 million years ago, well before the beginning of the Cambrian (538.8 million years ago). The fossil, Haikouella lanceolata, is possibly a chordate with remnants of a heart, arteries, gill filaments, and a neural chord with a brain at the anterior part. It also has eyes and tentacles around its mouth. While Haikouichthys and Myllokunmingia are believed to be fish fossils unearthed from the Chengjiang Fauna, Pikaia from the Mid Cambrian Burgess Shale in Canada is also considered a primitive chordate. Both tunicates and cephalopods filter-feed on suspended food particles in the water. They draw the water current into the mouth by using their gill slits. The food is then coated using mucus secreted by the endostyle, which is then brushed into the posterior part of the gut using the cilia lining the pharynx. Chordates move from one place to the other by the movement of muscles. While tunicate larvae propel themselves by moving their muscular tail, cephalopods undulate their entire bodies during movement. Although vertebrates, like fish, use their fins for locomotion, some mammals and birds use their wings (modified limbs) to fly. Most chordates are gonochoric, meaning they exist as either males or females. However, some fish and tunicates are hermaphrodites, possessing both male and female sex organs in a single individual. Typically, males and females produce gametes (sperm and ova) that fertilize internally to form embryos. In contrast, primitive chordates released gametes outside their bodies, with fertilization occurring externally. Additionally, some fish and lizards can reproduce asexually, completely bypassing fertilization. Tunicates and vertebrates are often viviparous, giving birth to live young. On the other hand, cephalochordates are oviparous, laying eggs that sometimes undergo a larval stage before reaching adulthood. Chordates encompass a diverse and fascinating group of animals, characterized by a set of unique anatomical features that define their evolutionary lineage. From the mighty blue whale to the unassuming lancelet, chordates span a wide range of species, inhabiting diverse ecosystems across the globe. What sets chordates apart is their possession of a notochord, a flexible rod-like structure that provides support and serves as a foundation for their body plan.The following article from thedailyECO explains what chordates are, including their classification, feeding behaviors, and reproductive habits. You may also be interested in: What Are Sea Lilies (Crinoids)? Contents Chordates are a group of animals that belong to the phylum Chordata. They have some special features that help identify them.One important feature is the presence of a notochord, which is like a precursor to the spinal cord. It helps give them support, determines their body shape, and helps with the development of their nervous system. Some chordates, like certain types of fish, keep their notochord their whole lives, while others, like humans, only have it when they are still developing inside their mother's womb.Chordates also have a special nerve cord that runs along their back, close to the notochord. This nerve cord can develop into a brain in more advanced chordates. It helps them sense things from their environment and move their bodies in response. Chordates, especially mammals like us, have well-developed nervous systems and relatively big brains.Another interesting thing about chordates is that they have pharyngeal slits. These slits appear during their early development and are found in the area near the throat. In some chordates, like fish, these slits turn into gills, which they use to breathe underwater. In others, like humans, these slits change and develop into different structures like parts of the ears.Lastly, many chordates have tails at some point in their lives. Some keep their tails throughout their whole lives, while others only have them for a short time during their development.These are just some of the characteristics that make chordates special. They also have things like a symmetrical body shape, a segmented body, and different layers of cells that make up their bodies. Chordates have evolved to have closed circulatory systems with a heart that pumps blood, and most of them have skeletons made of bone or cartilage. Chordates can be classified into three main subphyla, which are:Cephalochordates: These chordates, also known as lancelets, are small, fish-like animals that live in the sea. They keep the notochord, a flexible rod that runs along their back, throughout their entire lives. Think of lancelets as aquatic creatures resembling tiny fish.Urochordates or Tunicates: Urochordates, often called tunicates or sea squirts, are marine animals that come in different shapes and sizes. Some look like colorful barrels or blobs with a tough outer covering. While they start their lives with a notochord, they only keep it during their early stages of development. Tunicates are fascinating creatures that attach themselves to rocks or other surfaces in the ocean.Vertebrate Animals: Vertebrates are chordates that belong to the largest group and include familiar animals we know. Here are some examples of vertebrate classes:Fish: fish such as goldfish, salmon, and clownfish are part of the vertebrate group. They have backbones made of bone or cartilage and breathe using gills.Amphibians: Animals like frogs, toads, and salamanders are amphibians. They start their lives in water and then grow legs to live on land, but they still need water for reproduction.Reptiles: Reptiles include animals such as lizards, snakes, turtles, and crocodiles. They are cold-blooded and have scaly skin. Reptiles lay eggs, and some can live both on land and in water.Birds: Birds like eagles, sparrows, and penguins are part of the bird class. They have feathers, lay hard-shelled eggs, and most of them can fly.Mammals: Humans, cats, dogs, and elephants are all mammals. Mammals have hair or fur on their bodies, and most of them give birth to live young ones. They also produce milk to feed their babies.You might be interested in this other article, where we discuss the difference between unicellular and multicellular. Chordates exhibit a wide range of habitat adaptations, allowing them to inhabit diverse environments across the world. These adaptations include physiological and morphological characteristics that enable them to survive and thrive in their specific habitats. Here are some examples of chordates based on their habitats:Aquatic: some chordates are fully aquatic and can be found in marine or freshwater environments. They have adaptations such as filter feeding mechanisms, gills for extracting oxygen from water, and some may have lung-like structures called spiracles to supplement their respiration.Semi-aquatic: certain chordates are capable of spending time both in water and on land. They may have adaptations that allow them to submerge for extended periods, and their skin often relies on moisture to prevent dehydration.Terrestrial: chordates that inhabit terrestrial environments have evolved pulmonary respiration, breathing air directly into their lungs. Their skin is adapted to withstand exposure to sunlight, and they have various adaptations for life on land.Air-terrestrial: some chordates, such as certain birds and bats, have the ability to fly and take off from the ground. While they are not entirely aerial, they have adaptations for powered flight. However, they still require periods of rest on land for activities like reproduction, feeding, and regaining strength.These examples demonstrate the remarkable adaptability of chordates to different habitats, allowing them to colonize various ecosystems across the globe. Chordates play important roles within ecosystems. They can occupy various positions within the trophic chain as both prey and predator, which contributes to regulating population dynamics and resource consumption.Chordates, particularly birds and mammals, have the ability to generate internal heat and maintain a constant body temperature, which is known as endothermy. This allows them to be more active and adapt to a wider range of environments.Other chordates, such as fish and amphibians, are ectothermic or cold-blooded, meaning they rely on external heat sources, such as sunlight, to regulate their body temperature and carry out metabolic processes.In terms of feeding, chordates exhibit a range of dietary preferences:Filter feeders: Some aquatic chordates, like certain types of fish and marine mammals, utilize the water current to capture small organisms and particles for feeding.Herbivores: These chordates feed exclusively on plants and algae. Due to the lower caloric content of plant matter, herbivores typically need to consume large quantities of food to meet their energy requirements.Omnivores: Chordates with an omnivorous diet consume both plants and animal matter, exhibiting a flexible feeding behavior.Carnivores: These chordates primarily consume other animals. Compared to herbivores, carnivores generally require less frequent feeding. Within the category of carnivores, there are additional subtypes such as cannibalistic animals (feeding on members of their own species), scavengers (feeding on carcasses of other animals), and piscivorous animals (those that primarily consume fish). In terms of fertilization, chordates can engage in either external or internal fertilization:External fertilization: this occurs when gametes (sperm and eggs) are released into the external environment, typically water, where fertilization takes place. External fertilization is common among aquatic organisms, as it allows the gametes to meet and fertilize outside the body.Internal fertilization: in this process, the male deposits sperm directly inside the female, usually through copulation or mating. Internal fertilization is more prevalent in terrestrial and certain aquatic chordates, providing a higher chance of successful fertilization.Chordates also display various reproductive modes:Oviparity: with the exception of mammals, most vertebrates are oviparous, meaning they lay eggs. These eggs are typically laid in the environment, and embryonic development occurs externally.Viviparity: mammals exhibit viviparity, where embryonic development takes place inside the mother's body. Nourishment is provided to the developing embryos either through the placenta (in placental mammals) or through specialized pouches (in marsupials). Fertilization in mammals is internal, occurring through copulation. However, there are a few exceptions among mammals, such as monotremes like platypuses, which exhibit a unique form of ovoviviparity. In ovoviviparous species, the eggs are retained within the female's body until hatching, but there is no direct placental connection.The number of offspring produced by a species is often inversely proportional to the amount of parental care provided. Species with numerous offspring, like many fish, typically do not exhibit extensive parental care. They produce numerous offspring, relying on the survival of a few to perpetuate the population. In contrast, species that invest more in parental care, such as mammals, tend to have fewer offspring. Through their care, they ensure the survival and well-being of their offspring.While these statements outline general patterns in chordate reproduction, it's important to recognize that exceptions and variations exist among different species and individuals within the chordate group.You might be interested in this other article about asexual reproduction in plants and animals. Chordates, a diverse group of animals, exhibit a wide range of characteristics, reproductive strategies, and adaptations to different habitats. Let's explore some examples of chordates in evolutionary order to understand the diversity within this group.Amphioxus (subphylum Cephalochordata)Amphioxus, also known as lancelets, are marine animals that belong to the subphylum Cephalochordata. They have a slender, elongated body, and throughout their lives, they possess key chordate features such as a notochord, pharyngeal slits, and a postanal tail.Tunicates (subphylum Urochordata)Tunicates, or sea squirts, belong to the subphylum Urochordata. They are immobile marine animals with a barrel-shaped body. They are surrounded by a protective tunic and have a unique system of siphons that allow them to intake water for feeding and respiration. Despite their appearance, they possess all the diagnostic characteristics of chordates.Great white shark (Carcharodon carcharias)The great white shark (Carcharodon carcharias) is a species of large predatory shark. It is a cartilaginous fish belonging to the class Chondrichthyes. It has constantly renewing teeth and is one of the largest predators in the world.Koi carp (Cyprinus carpio)Koi carp (Cyprinus carpio) is a species of fish belonging to the family Cyprinidae. They are a popular ornamental fish known for their vibrant colors and patterns. They have a bony skeleton, various fins, and utilize gills for aquatic respiration.Lungfish (Genus Protopterus)Lungfish, belonging to the genus Protopterus, are a group of fish characterized by their ability to breathe air using lungs. They can survive in oxygen-depleted environments and are found in Africa.Common frog (Rana temporaria)The common frog (Rana temporaria) is a species of frog found in Europe. They lay eggs in water, and the tadpoles possess a tail, a characteristic of chordates. As they mature, they lose the tail and transition to a terrestrial lifestyle.Gulls (Genus Larus)Gulls belong to the genus Larus and are a group of seabirds found worldwide. They are known for their scavenging behavior and ability to adapt to various habitats. They are birds with lightweight skeletons and hollow bones that aid in flight. Furthermore, they exhibit thermoregulation abilities and are found in various habitats.Human (Homo sapiens)Humans, scientifically known as Homo sapiens, are the only surviving species of the genus Homo and belong to the family Hominidae. They are mammals and exhibit advanced cognitive abilities. During embryonic development, humans exhibit pharyngeal arches that differentiate into various structures, but not into gills.These examples showcase the remarkable diversity within the chordate group and highlight the unique adaptations that have allowed them to thrive in different environments throughout evolutionary history. If you want to read similar articles to What Are Chordates?, we recommend you visit our Biodiversity category. Bibliography Lundberg, J. (1995). Chordata . Available at: R., Beer, A., & Deeming, C. (2010). The book of nature. Great Britain: Dorling Kindersley.Myers, P. (2001). Chordata . Available at: Home Zoology Chordates Phylum Chordata – Characteristics and Classification The phylum Chordata represents a diverse and highly organized group of animals that share four key anatomical features at some stage of their life cycle. These features include the notochord, a dorsal nerve cord, pharyngeal slits, and a post-anal tail. Though these characteristics may not all persist into adulthood, they are crucial during development, especially in the embryonic stage of most chordates.The notochord is a flexible, rod-like structure that serves as a supportive axis in the early stages of development. In vertebrates, it is typically replaced by a more rigid spinal column (or vertebral column), but its presence in other chordates is an important feature that differentiates them from non-chordates. The dorsal nerve cord, which runs along the back of the animal, is hollow and provides the foundation for the central nervous system. This feature is essential for the coordination of body movements and sensory functions. Pharyngeal slits, located in the region of the throat, are openings that allow water to flow through the mouth and exit the body, a function most notably associated with aquatic species. Finally, the post-anal tail, which extends beyond the anus, is present in all chordates at some point in their development, although it is reduced or absent in many adult forms, particularly in humans.In addition to these defining traits, chordates exhibit several other features, such as bilateral symmetry, a true coelom (body cavity), and metameric segmentation. These characteristics enhance their ability to adapt to various environments. A notable example is the diverse range of habitats where chordates thrive—from marine and freshwater ecosystems to terrestrial environments and even extreme conditions like polar regions.Chordates are subdivided into three main subphyla based on their morphological and developmental characteristics. The subphylum Vertebrata includes animals with a backbone, such as fish, amphibians, reptiles, birds, and mammals. Vertebrates possess an internal skeleton made of bone or cartilage, which provides structural support and protects vital organs. The subphylum Tunicata (or Urochordata), commonly referred to as tunicates or sea squirts, retains the chordate features only during their larval stage. As adults, most tunicates lose these features and become sessile filter feeders. The third subphylum, Cephalochordata (lancelets), are small, fish-like organisms that retain all four chordate characteristics throughout their life. They are significant for their primitive structure and are often used in studies on the evolutionary origins of vertebrates.Chordata is a major phylum within the superphylum Deuterostomia, which also includes echinoderms, such as starfish and sea urchins. These two groups share a similar embryonic development pattern, but they differ significantly in their adult forms. In addition to these morphological and genetic traits, the analysis of chordate genomes has revealed conserved signature indels (CSIs), which provide further molecular evidence supporting the evolutionary relationships among chordates.The phylum Chordata is not only ancient but also vast in its diversity, with over 60,000 known species. These species range from simple, small lancelets to complex, large mammals. The fossil record of chordates dates back to the Cambrian period, more than 500 million years ago, indicating that the lineage of chordates has evolved through numerous stages to produce the vast array of species we see today.Chordates are one of the most prominent groups in the animal kingdom, second only to arthropods in terms of diversity and numbers. While the majority of living chordates are ray-finned fishes, which represent half of the species within this group, tetrapods (land-dwelling vertebrates) make up a significant portion of the remaining species. The transition of these fishes to terrestrial environments was a pivotal moment in evolutionary history, with the development of air-breathing lungs and limbs capable of supporting weight on land.Phylum ChordataBelow are the main characteristics of chordates:Notochord: The notochord is a fundamental structure in chordates, serving as a longitudinal, cartilaginous rod that lies between the dorsal nerve cord and the digestive tract. This rod provides support and rigidity during the early stages of development. In vertebrates, the notochord is eventually replaced by the vertebral column (spine) as the organism matures, thus facilitating greater structural complexity and movement.Dorsal Nerve Cord: This feature consists of a hollow bundle of nerves that runs along the back of the organism, dorsal to the notochord. It serves as the central nervous system’s main conduit, eventually splitting into the brain and spinal cord. The presence of a hollow nerve cord is a defining characteristic that sets chordates apart from many other animal phyla.Pharyngeal Slits: Present in all chordates at some stage of their development, pharyngeal slits are openings that allow water to flow into the mouth and out through the throat, bypassing the digestive tract. These slits play a significant role in feeding and respiration in aquatic species, contributing to the efficient transfer of water and nutrients.Post-Anal Tail: The post-anal tail is an extension of the body that extends beyond the anus. In chordates, this tail is composed primarily of skeletal muscle and aids in locomotion, particularly in fish-like species. While present in the embryonic stages of many chordates, it is often reduced or absent in most adult forms, such as in humans.In addition to the primary characteristics listed above, chordates share several other notable features:Bilateral Symmetry: Chordates exhibit bilateral symmetry, meaning their body can be divided into two equal halves along a single plane. This symmetrical design is a key aspect of their body plan, facilitating organized movement and development.Triploblastic Organization: Chordates are triploblastic, possessing three primary germ layers: ectoderm, mesoderm, and endoderm. This arrangement leads to the formation of specialized tissues and organs, enhancing complexity.Coelomic Body Plan: Chordates have a true coelom, a body cavity lined with mesodermal tissue. This feature allows for the development of a more complex organ system and the separation of internal organs from the body wall.Segmented Body: The body structure of chordates is segmented, allowing for greater flexibility and control of movement. This segmentation is often evident in the organization of muscles and the vertebral column.Organ System Level of Organization: Chordates possess a higher level of biological organization, characterized by well-developed organ systems. These systems work together to perform vital functions, ensuring the survival and efficiency of the organism.The anatomy of chordates encompasses a unique set of features that distinguishes them from other animal phyla. These anatomical characteristics manifest at various life stages and are fundamental to understanding the evolutionary biology of this group. Chordates share several critical anatomical structures that play significant roles in their physiology and development.Anatomy of Chordates | Image Source – Anatomical Features of ChordatesNotochord:A notochord is a stiff yet elastic rod composed of glycoprotein wrapped in two helices of collagen, extending along the central axis of the body.In vertebrates, the notochord is typically replaced by hyaline cartilage or bony structures (osseous tissue) in the spine.Remnants of the notochord develop into intervertebral discs, which facilitate bending and twisting between adjacent vertebrae.In aquatic species, the notochord aids in efficient swimming by allowing the tail to flex side-to-side.Hollow Dorsal Nerve Cord:Also known as the neural tube, this structure develops into the spinal cord, serving as the primary communication pathway of the nervous system.During embryonic development in vertebrates, the rostral end of the neural tube enlarges to form several vesicles, which give rise to the brain.Pharyngeal Slits:The pharynx is located immediately behind the mouth, where pharyngeal slits can form.In fish, these slits are modified into gills for respiration, while in some other chordates, they serve as components of a filter-feeding system that extracts food from water.In tetrapods, these slits are present only during the embryonic stages.Post-Anal Tail:A muscular tail that extends posteriorly beyond the anus characterizes many chordates.In certain species, such as hominids, this tail is typically present only during embryonic development.Endostyle:This groove situated in the ventral wall of the pharynx is crucial for filter-feeding species. It produces mucus that captures food particles, aiding their transport to the esophagus.The endostyle also stores iodine and is thought to be a precursor to the vertebrate thyroid gland.Additional Anatomical ConsiderationsWhile the above features define chordates, there are additional characteristics that differentiate them from other animal groups but are not part of the formal definition:Deuterostome Development: All chordates are classified as deuterostomes, meaning the anus develops before the mouth during embryonic stages.Bilateral Symmetry: Chordates exhibit a bilateral body plan, which contributes to their complex body structures and functions.Coelomate Organization: Chordates are coelomates, possessing a fluid-filled body cavity (coelom) lined with a serosal layer derived from mesoderm, known as mesothelium.Anatomy of Chordates. 1 = bulge in spinal cord (“brain”), 2 = notochord, 3 = dorsal nerve cord, 4 = post-anal tail, 5 = anus, 6 = digestive canal, 7 = circulatory system, 8 = atriopore, 9 = space above pharynx, 10 = pharyngeal slit (gill), 11 = pharynx, 12 = vestibule, 13 = oral cirri, 14 = mouth opening, 15 = gonads (ovary / testicle), 16 = light sensor, 17 = nerves, 18 = metapleural fold, 19 = hepatic caecum (liver-like sack) (Piotr Michał Jaworski; PioM EN DE PL, CC BY-SA 3.0, via Wikimedia Commons)Classification of Phylum ChordataThe phylum Chordata is characterized by a variety of distinct features that contribute to its classification and understanding within the animal kingdom. This phylum can be divided into two primary groups: Acrania (Protochordata) and Craniata (Euchordata). Each group exhibits contrasting characteristics that are crucial for recognizing their biological and evolutionary significance.Group A: Acrania (Protochordata)The Acrania consists of primitive, marine chordates that lack a cranium, jaws, vertebral column, and paired appendages. This group encompasses about 2,000 species and is further divided into three subphyla:Subphylum I: HemichordataThe Hemichordata is characterized by a body divided into three regions: proboscis, collar, and trunk. The notochord is either doubtful or short, located only in the proboscis and is not homologous with that of other chordates.Class 1: EnteropneustaThis class includes large, worm-like organisms with numerous paired gill slits and a straight alimentary canal. Common examples are Balanoglossus, Saccoglossus, and Ptychodera.Class 2: PterobranchiaPterobranchs are small, compact organisms with one pair or no gill slits. Their U-shaped alimentary canal distinguishes them. Examples include Cephalodiscus and Rhabdopleura.Class 3: PlanctosphaeroideaThis class features transparent, round organisms with specialized tornaria larvae possessing extensively branched ciliary bands. An example is Planctosphaera pelagica.Class 4: GraptolitaGraptolites are fossil organisms considered an extinct colonial class of Hemichordata, known for their tubular chitinous skeletons. An example includes Dendrograptus.Subphylum II: Urochordata (Tunicata)Urochordates possess a notochord and nerve cord only in their free-swimming tadpole larvae. The adult form is sac-like and covered with a tunic, often transparent, with a reduced nerve cord and no coelom or segmentation.Class 1: AscidiaceaThese sessile tunicates are characterized by well-developed, permanent tunics. They can be solitary, colonial, or compound, and have numerous gill slits. Examples include Herdmania, Ciona, and Molgula.Class 2: ThaliaceaFree-swimming tunicates with circular muscle bands, these organisms include salpians and chain tunicates. Examples are Salpa, Doliolum, and Pyrosoma.Class 3: Larvacea (Appendicularia)Tiny, transparent, free-floating organisms retain many larval features, including tails. They have only two gill slits. Examples include Oikopleura and Appendicularia.Subphylum III: CephalochordataCephalochordates have a notochord and nerve cord that are present throughout their entire life. They possess a fish-like, segmented body with numerous gill slits and are free-swimming and burrowing. An example is Branchiostoma (also known as Amphioxus).Group B: Craniata (Euchordata)The Craniata comprises higher chordates or vertebrates, which can be either aquatic or terrestrial. They typically have a distinct head, a vertebral column, jaws, and a brain protected by a cranium or skull. This group includes a single subphylum, Vertebrata.Subphylum IV: VertebrataThe Vertebrata is characterized by a notochord that is supplemented or replaced by a vertebral column comprising overlapping vertebrae. The body is divided into the head, neck, trunk, and tail, and vertebrates are usually dioecious. This subphylum is the largest within the phylum Chordata, encompassing about 45,000 species.Division I: AgnathaAgnatha includes jawless, fish-like vertebrates lacking true jaws and paired limbs.Class 1: OstracodermiThis class includes several extinct orders of heavily armored, primitive vertebrates known as ostracoderms. Examples include Cephalaspis and Pteraspis.Class 2: CyclostomataCharacterized by an eel-like body, these organisms have a rounded, suctorial mouth without scales. They possess 5 to 16 pairs of gills and include parasitic and scavenging species like lampreys and hagfishes.Division II: GnathostomataGnathostomata consists of jawed vertebrates with true jaws and paired limbs, further divided into two superclasses:Superclass 1: PiscesThis group includes all fish and fish-like aquatic gnathostomes, characterized by paired and median fins, gills, and scaly skin.Class 1: PlacodermiThese are primitive, jawed fishes known for their bony head shields and are extinct.Class 2: ChondrichthyesThese cartilaginous fishes, such as sharks and rays, are characterized by a cartilaginous endoskeleton and minute placoid scales.Class 3: OsteichthyesBony fishes with a bony endoskeleton, these organisms possess various types of scales and are the most numerous class of vertebrates.Superclass 2: TetrapodaTetrapods are land vertebrates with two pairs of pentadactyl limbs and specialized skin.Class 1: AmphibiaAmphibians have a dual life cycle, with a larval stage that is usually aquatic and an adult stage that is typically terrestrial. They possess moist glandular skin and a heart with three chambers.Class 2: ReptiliaReptiles have dry skin covered with scales, typically possess four limbs, and have a heart that is incompletely four-chambered.Class 3: AvesBirds are characterized by feathers, modified forelimbs as wings, and a heart with four chambers. They are warm-blooded and exhibit a variety of adaptations for flight.Class 4: MammaliaMammals are warm-blooded vertebrates with hair or fur and mammary glands for nursing their young. They possess a heart with four chambers and various specialized skin glands.Reproduction and Life Cycle of Phylum ChordataThe phylum Chordata exhibits a variety of reproductive strategies and life cycle patterns across its diverse subphyla, which include both invertebrates and vertebrates. Reproduction in chordates typically involves two main processes: internal fertilization and external fertilization, each adapted to specific ecological niches.Reproduction in ChordatesChordates generally employ either internal fertilization or external fertilization, with the specific method often dependent on the organism’s habitat and evolutionary lineage. Both methods involve the union of male and female gametes (sperm and eggs), but the location of fertilization differs between the two.Internal Fertilization:In this process, fertilization occurs within the body of the female, where the sperm and egg unite. This form of reproduction is more common among terrestrial organisms and some aquatic species, particularly vertebrates.External Fertilization:External fertilization occurs outside the body, typically in aquatic environments. In this case, males and females release their gametes into the surrounding water, where sperm fertilizes eggs externally. This process is common among aquatic chordates, including many fish, amphibians, and some invertebrates.Reproduction and Life Cycle in Subphylum Cephalochordata (Lancelets)Lancelets are small, fish-like creatures in the subphylum Cephalochordata, which possess a notochord and a nerve cord along the entire length of their body, supported by the notochord instead of a vertebral column. The reproductive process in lancelets typically involves external fertilization.During the mating season, lancelets release gametes into the surrounding water.Males and females release their sperm and eggs, respectively, in synchrony, causing the gonads to rupture and expel the gametes.Fertilization occurs when sperm meets the eggs in the surrounding water, leading to the development of offspring.This external method of fertilization ensures the continuation of the species, although it relies on a large release of gametes to compensate for the potential loss of fertilization.Reproduction and Life Cycle in Subphylum Urochordata and VertebrataIn the subphyla Urochordata (tunicates) and Vertebrata, reproduction can be either sexual or asexual, depending on the species.Urochordata (Tunicates):Tunicates, or sea squirts, often exhibit sexual reproduction, though some species may also reproduce asexually through budding. During sexual reproduction, fertilization can be either external or internal, depending on the specific group within Urochordata.Vertebrata (Vertebrates):Vertebrates, which include fish, amphibians, reptiles, birds, and mammals, generally reproduce sexually. The method of fertilization varies:Fish: Reproduction in many fish species occurs through external fertilization, with males and females releasing large numbers of gametes into the water to ensure successful fertilization.Amphibians: Like fish, amphibians reproduce through external fertilization. Males and females typically gather at breeding sites such as ponds or moist areas, where females lay eggs and males release sperm over them to facilitate fertilization.Life Cycle of ChordatesThe life cycle of chordates varies significantly across the different subphyla but often involves both larval and adult stages, with some species undergoing metamorphosis.In the case of lancelets (Cephalochordata), fertilized eggs develop into free-swimming larvae, which later mature into adult lancelets that burrow into the sand.In tunicates (Urochordata), the larval stage is free-swimming, but the adult form is sessile and attached to substrates, such as rocks or seaweed.Vertebrates, including fish and amphibians, typically go through a series of developmental stages, including juvenile forms that may undergo metamorphosis in some species, like amphibians, to transition from aquatic larvae to terrestrial adults.Evolutionary HistoryThe evolutionary history of phylum Chordata reveals a complex narrative of adaptation and diversification that spans hundreds of millions of years. Fossil evidence indicates that the origins of chordates date back approximately 530 million years, during the Cambrian period, when jawless fish first emerged. This period marked a significant milestone in the evolutionary timeline of chordates.Early Fossils and Origin of ChordatesFossil records show that the earliest known chordates appeared around 530 million years ago. The discovery of jawless fish fossils during this era provides a crucial insight into the anatomical and ecological characteristics of early chordates.The oldest fossil attributed to the family of Chordata was unearthed in 1995 in China, identified as Yunnanozoon lividum. This fossil serves as a key piece of evidence in understanding the early morphology of chordates.Evolutionary Timeline of Major GroupsExtensive research into the evolution of chordates has revealed important timelines for various subgroups:The earliest fossils of tetrapods appeared around 363 million years ago. Tetrapods represent a crucial transition from aquatic to terrestrial life.Fossils of early mammals date back to approximately 208 million years ago, marking the emergence of mammalian characteristics in chordates.The first birds are believed to have evolved around 80 million years ago, leading to the expansion of avian diversity and adaptations for flight.Habitat Adaptations and Evolutionary ProgressionsThe evolution of chordates is closely linked to significant changes in habitat. The earliest chordates, such as tunicates and lancelets, were predominantly aquatic organisms.As chordates evolved, they began to occupy freshwater environments, gradually making their way onto land. This transition exemplifies the adaptability of the phylum to new ecological niches.Amphibians as Transitional SpeciesAmphibians represent a key transitional group in the evolutionary history of chordates. They exhibit both aquatic and terrestrial adaptations, illustrating the intermediate phase of chordates moving from water to land.Amphibians are characterized by their dual life cycle, typically starting in water as larvae and transitioning to land as adults, which further emphasizes their role in this evolutionary shift.Diversity in Aerial HabitatsThe evolution of birds introduced significant diversity within the phylum Chordata. Birds adapted to aerial habitats, showcasing a range of morphological and behavioral traits that facilitate flight, such as lightweight bones and specialized respiratory systems.Theoretical Models of Chordate EvolutionResearchers have proposed several hypotheses to explain the evolutionary history of chordates, presenting four major scenarios:Paedomorphosis Hypothesis: This hypothesis investigates whether the ancestors of chordates were free-living or sessile, suggesting different evolutionary pathways based on their lifestyles.Inversion Hypothesis: This theory discusses the potential inversion of body plans that may have influenced chordate development.Aboral-Dorsalization Hypothesis: This model examines the orientation of chordates in relation to their evolutionary predecessors, focusing on how body structure may have changed over time.Auricularia Hypothesis: This hypothesis offers insights into the common ancestry of chordates and how certain larval forms may relate to adult chordate structures.Interconnectedness of HypothesesThese four hypotheses are interconnected, with overlapping arguments supporting each model. The combined insights from these theories provide a comprehensive understanding of chordate evolution and underscore the complexity of their developmental history.The phylogeny of the phylum Chordata presents an intricate evolutionary tree that reveals how this diverse group evolved from common ancestors and is closely related to other deuterostome groups. This topic covers the classification of chordates into distinct subphyla and explores their evolutionary history in relation to other metazoans. The current understanding of chordate phylogeny largely arises from molecular and traditional biological analyses.Subphyla of ChordataThe phylum Chordata is classified into three primary subphyla:Urochordata (Tunicata): These organisms are commonly referred to as tunicates, which are primarily marine invertebrates.Cephalochordata: These include lancelets, small fish-like creatures that exhibit features of the chordate body plan.Vertebrata (Craniata): This subphylum comprises vertebrates, including fish, amphibians, reptiles, birds, and mammals, all of which possess a backbone or vertebral column.All three subphyla exhibit certain key features, including:Notochord: A flexible rod that provides structural support.Nerve Cord: A dorsal, hollow nerve cord.Branchial Slits: Openings in the pharyngeal region that are involved in feeding and respiration.Endostyle: A mucous-secreting groove used in feeding.Postanal Tail: A tail that extends beyond the anus.Myotome: Muscular segments along the body.Phylogenetic Classification and Evolutionary RelationshipsChordata belongs to the superphylum Deuterostomia, which also includes the phyla Hemichordata and Echinodermata. These three groups share a common deuterostome ancestry, meaning that their embryonic development follows the deuterostome pattern of mesodermal and ectodermal development.The evolutionary relationship between Chordata and other deuterostomes suggests that all chordates evolved from a common deuterostome ancestor. Within this broader context, the evolutionary lineage of chordates can be traced back through a series of stages:Urochordata: The earliest of the chordates to evolve, these organisms were likely the most primitive form.Cephalochordata: Evolving after Urochordata, these small, fish-like creatures were important in the transition of chordates toward vertebrate development.Vertebrata: The final group to evolve, vertebrates developed the backbone, enabling a wide range of adaptations and diversification.Protochordates and Molecular PhylogenyThe term “protochordate” is often used to describe early, non-vertebrate chordates, which are thought to represent the evolutionary precursors of modern vertebrates. The concept of protochordates plays a significant role in understanding chordate phylogeny.Molecular phylogeny, which involves the analysis of DNA and protein-coding genes, has become essential in reclassifying the metazoan groups. It allows researchers to classify organisms more accurately based on genetic sequences rather than traditional morphological features