The Rise of Animal Diversity

What are the main features of animals?

- Like the plant kingdom, the Animal Kingdom is made up of only multicellular organisms.
- Most animals are mobile and use traits such as strength, speed, toxins, or camouflage to detect, capture, and eat other organisms (heterotrophs). The chameleon captures insect prey with its long, sticky, fast-moving tongue.

Animals originated more than 700 million years ago:

- More than 1.3 million animal species have been named to date; the actual number of species is estimated to be nearly 8 million.
- Most animals will go extinct before they are even discovered.

Earliest-Diverging Animal Groups:

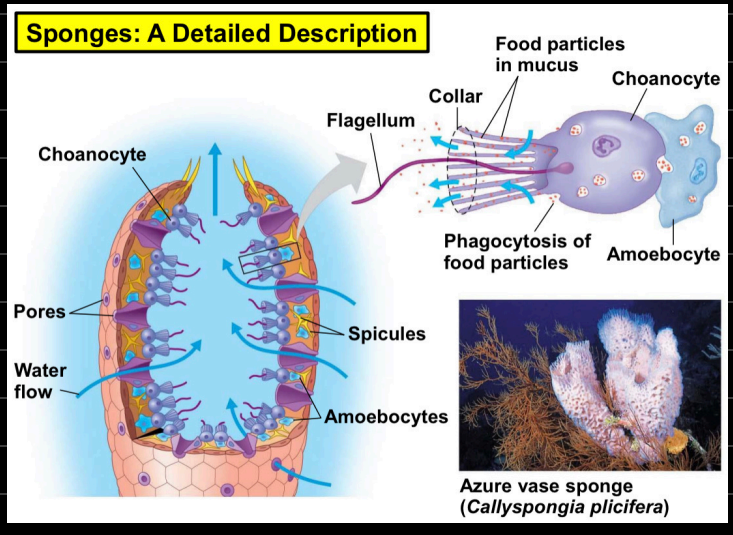
- Sponges and cnidarians are early-diverging groups of animals.
- Sponges are considered to be the very first animals, but were not always classified as animals.

More Details About Sponges:

- Animals in the Phylum Porifera are known informally as sponges.
- Sponges are suspension feeders, capturing food particles suspended in the water that passes through their body.
- Water is drawn through pores into a central cavity and out through and opening at the top.
- Sponges lack true tissues, groups of cells that function as a unit. They are simple, having only 2 or 3 types of cells in many cases.

Cnidarians:

- Like most animals, members of the Phylum Cnidaria have true tissues.
- Cnidarians are one of the oldest groups of animals, dating back to 680 million years ago.
- Cnidarians have diversified into a wide range of both sessile and motile forms. Include jellyfish and sea anemones.

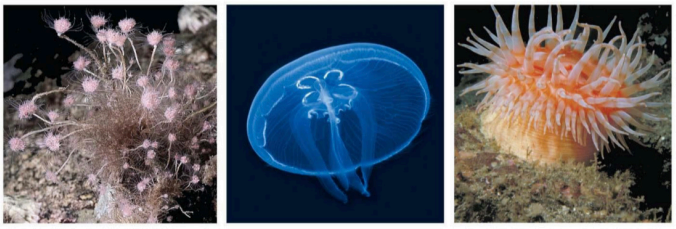


Characteristics of Cnidarians:

- The basic body plan of a cnidarian is a sac with a centra digestive compartment, the gastrovascular cavity.
- A single opening functions as the mouth and the anus.
- Cnidarians are carnivores (heterotrophs) that use tentacles to capture prey.
- Have stinging cells called cnidocytes used to kill their prey.
- They have a non-centralized nerve net associated with sensory structures throughout the body.

The Cambrian explosion (535 to 525 million years ago) marks the earliest fossil appearance of many major groups of living animals.

Examples of Cnidarians



(a) Hydrozoa (b) Scyphozoa (c) Anthozoa

Early Animal Fossils

There are several hypotheses regarding the cause of the Cambrian explosion and the appearance in more complicated animal species:

- New predator-prey relationships.
- A rise in the atmospheric oxygen.
- The evolution of the Hox gene complex: A group of genes critical in the layout of organismal development.

Diverse Animal Groups Radiated in Aquatic Environments

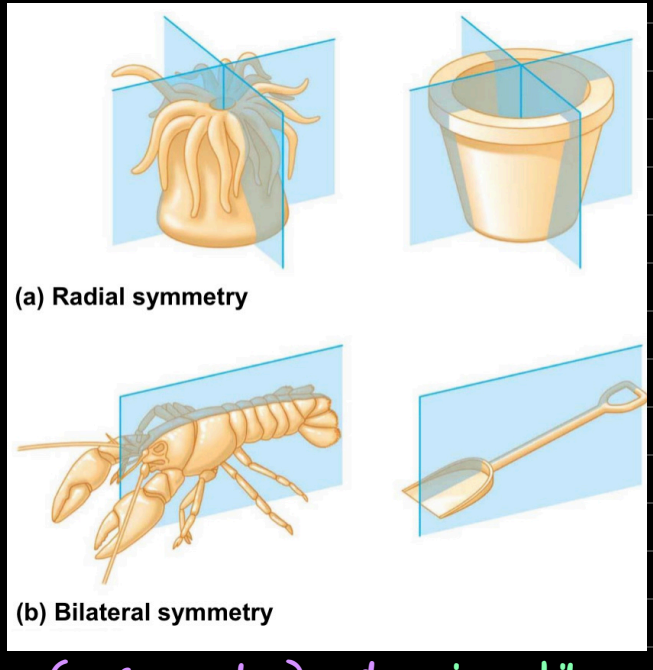
- The oceans were teaming with animal life.
- Similar to our prior discussion of plants, animals originated in relation with a water-based environment.
- Animals in the early Cambrian oceans were very diverse in morphology, way of life, and taxonomic affiliation.

Ways to Define Animals: Animal Body Plans

- Body plans, sets of integrated morphological and developmental traits, provide a basis for comparing key animal features.
- There are 3 important aspects of animal body plans: Symmetry, Tissues, Body Cavities.

Types of Symmetry

- Animals can be categorized according to the symmetry of their bodies, or lack of it (asymmetrical).
- Some animals have radial symmetry. Humans, when you cut in half, you have mirror images.



(a) Radial symmetry

(b) Bilateral symmetry

Bilaterally symmetrical animals have:

- A dorsal (top) side and a ventral (bottom) side.
- A right and left side which are mirror images.
- Anterior (front) and posterior (back) ends.
- Most have sensory equipment, including a central nervous system ("brain"), concentrated at the anterior end.

The Correlation Between Symmetry and Mobility

- Many radial animals are not very mobile or are attached to a substrate.
- Bilateral animals often move actively; their central nervous system enables coordinated movement and they are much more mobile.
- Most sponges (Phylum Porifera) are asymmetrical (no symmetry) and are immobile.

Animal Tissues

- Tissues are collections of specialized cells that act as a functional unit, isolated from other tissues (nervous tissue, muscle tissue, etc.).
- Animal body plans vary with regard to tissue organization. The earliest animals such as sponges, did not have tissues.
- During development, germ layers give rise to the tissues and organs of the animal embryo.

Ectoderm and Endoderm

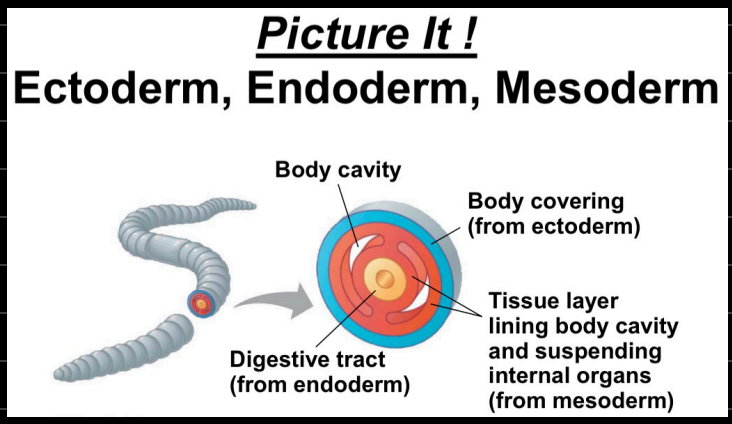
- Ectoderm, the outer germ layer, gives rise to the outer covering and, in some phyla, the central nervous system.
- Endoderm, the innermost germ layer, gives rise to the digestive tract and organs including the liver and lungs in vertebrates.
- These layers are present in all animals that have true tissues.

Mesoderm

- Mesoderm fills the space between the ectoderm and the endoderm and gives rise to muscles and most other organs.
- Cnidarians and a few other phyla lack mesodermal structure; all bilaterally symmetric animals have mesoderm.

Protostomes and Deuterostomes

- In protostomes the first opening in the embryo (blastopore) becomes the mouth.
- In deuterostomes the first opening (blastopore) becomes the anus and the mouth forms as the second opening.



Most Invertebrates are Protostomes!

Body Cavities

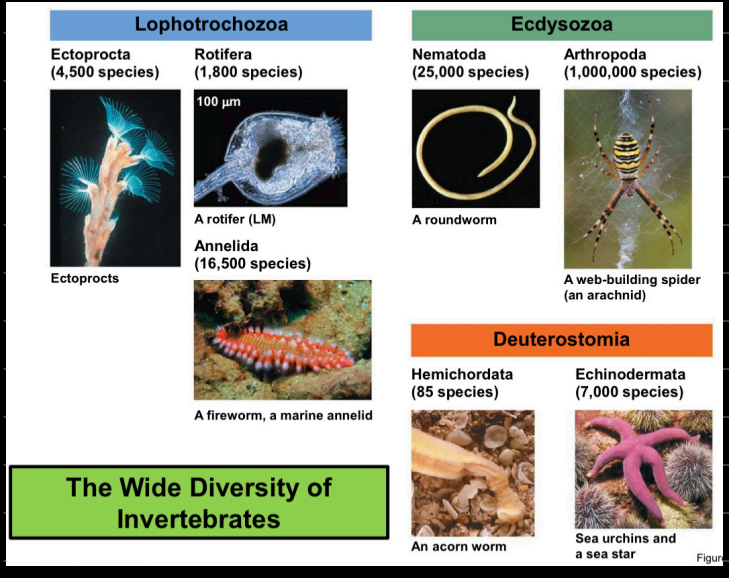
- Most animals with bilateral symmetry posses a body cavity (coleus), a fluid-filled or air-filled space between the digestive tract and the outer body wall.

The body cavity may:

- Cushion suspended organs
- Act as a hydrostatic skeleton
- Enable internal organs to move independently of the body wall

The Diversification of Animals

- Phylogenies now combine molecular data from multiple sources with morphological data to determine the relationships among the many animal phyla.



Animals are split into two main classification avenues:

- Invertebrates: (animals without a backbone) The overwhelming majority of animals (95%) are invertebrates.
- Vertebrates: (animals with a backbone); the Chordata; 5% of all animals.

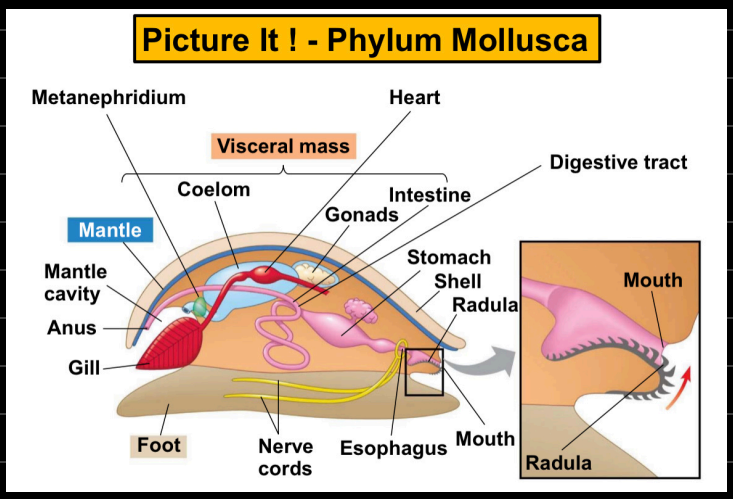
Phylum Mollusca:

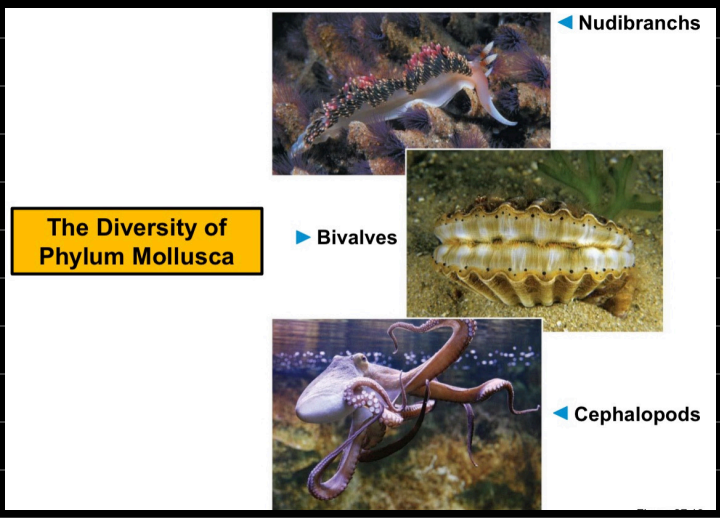
- The invertebrate Phylum Mollusca includes 100,000 species.
- REMEMBER, Phylum Porifera (sponges) and Phylum Cnidaria (jellyfish); these are also

invertebrates.

The body of a Mollusca has three main parts that vary in size and form:

- A muscular foot, usually used for movement.
- A visceral mass containing most of the internal organs.
- A mantle, a fold of tissue that drapes over the visceral mass and secretes a shell (if present).





Phylum Arthropoda

- More than 1 million arthropod species have been described; about 10^18 are estimated to exist on Earth!!! (Scorpions, crustaceans, insects).
- Members of the Phylum Arthropoda are found in nearly all habitats of the biosphere.
- The diversity and success of this group are attributed to their body plan.

Characteristics of Phylum Arthropoda

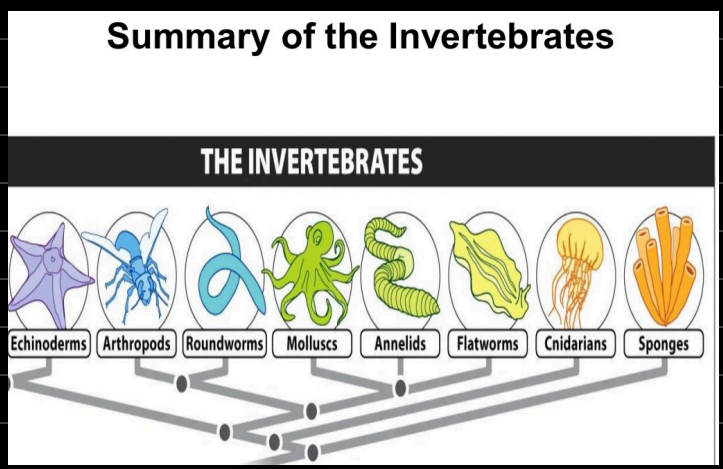
- The arthropod body plan consists of a segmented body, hard exoskeleton, and jointed appendages.
- The exoskeleton is made of a polysaccharide called chitin, which as we mentioned before, also composes the cell wall of fungi.
- Early arthropods show little variation from segment to segment.

Arthropod Evolution

- Arthropod evolution is characterized by degreasing number of body segments and increasing appendage specialization.
- Increasing complexity of the body plan likely resulted from changes in the sequence or regulation of existing Hox genes (genes involved in development).

Other Invertebrates

- Echinoderms-starfish
- Roundworms (Phylum Nematoda)- Can cause disease in humans.
- Flatworms (Phylum Platyhelminthes)- Can cause disease in humans.
- Annelids-earthworms, do not cause disease in humans.



Vertebrates are named for vertebrae, the series

of bones that make up their backbone. So that means all animals are either invertebrates or vertebrates. One of the earliest close relatives of the vertebrates, Myllokunmingia fengjiaoa, evolved in the ocean during the Cambrian period.

Aquatic Vertebrates

- Vertebrates are members of Phylum Chordata.
- Chordates are used to describe the earliest vertebrates.
- The first vertebrates were in an aqueous environment. This is similar to when we look at plant evolution-they also evolved from water to land-based environments due to the development of vascular tissue.
- Chordates are bilaterian animals that belong to the animal clade Deuterostomia.
- So, they have bilateral symmetry (if you cut them in half, each half is a mirror image of the other half).
- So, the first opening in development is that of the anus and the mouth develops after that (deuterostomes).

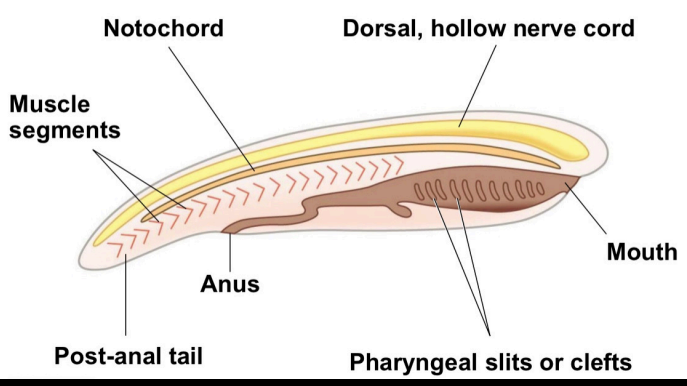
Early Chordate (Vertebrate) Evolution- 4 Common Features!

- All chordates share four derived characters, some of which are present only during embryonic development in many species- Remember these from the fetal pig lab.

Four key characters of chordates:

- Notochord, a flexible rod providing support.
- Dorsal, hollow nerve cord, which develops into the brain and spinal cord.
- Pharyngeal slits or pharyngeal clefts, which function in suspension feeding as gills, or as parts of the head.
- Muscular, post-anal tail (this disappears in normal human development).

PICTURE IT! –
Early Chordate (Vertebrate) Evolution – 4 Common Features!



Early Groups of Aquatic Vertebrates

- Lancelets are a basal group of extant, blade-shaped animals that closely resemble the idealized chordate.
- Tunicates are another early diverging chordate group, but they only display the 4 key chordate traits during their larval stage.
- The ancestral chordate may have looked similar to a lancelet.

More Details about Early Chordates (Vertebrates)

- In addition to the features of all chordates, early vertebrates had a backbone, a skull, and a well-defined head with a brain and sensory organs.
- Fossils representing the transition to vertebrates formed during the Cambrian explosion.

PICTURE IT! – Early Vertebrates

(a) Lancelet

(b) Tunicate

The Rise Of Vertebrates

- Vertebrates originated about 500 million years ago.
- Early vertebrates were more efficiency at capturing food and evading predators than their ancestors; heterotrophic.
- The earliest vertebrates in the fossil record lacked jaws.
- There are only two extant (living) lineages of jawless vertebrates (cyclostomes), the hagfishes and lampreys.
- Today, jawed vertebrates, or gnathostomes, far outnumber jawless vertebrates.
- Early gnathostomes success is likely due to adaptations for predation including paired fins and tails for efficient swimming and jaws for grasping prey.

The Gnathostomes

- Gnathostomes diverged into 3 surviving lineages, chondrichthyans, ray-finned fishes, and lobe-fins.
- Humans and other terrestrial animals are included in the lobe-fin gnathostomes.

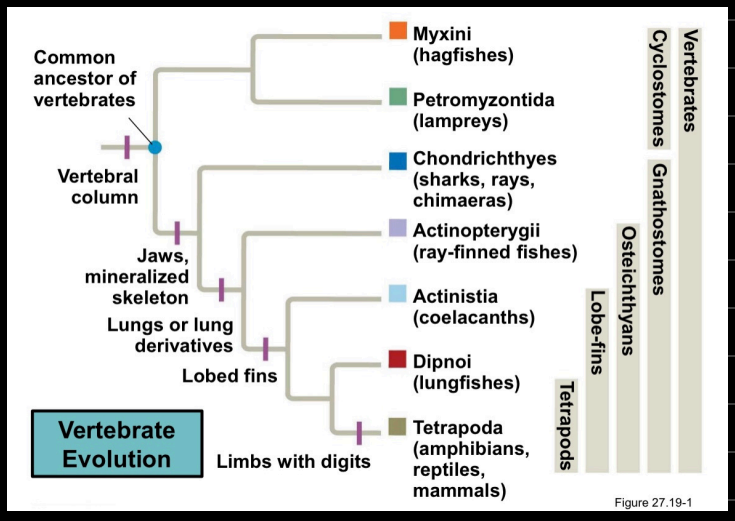
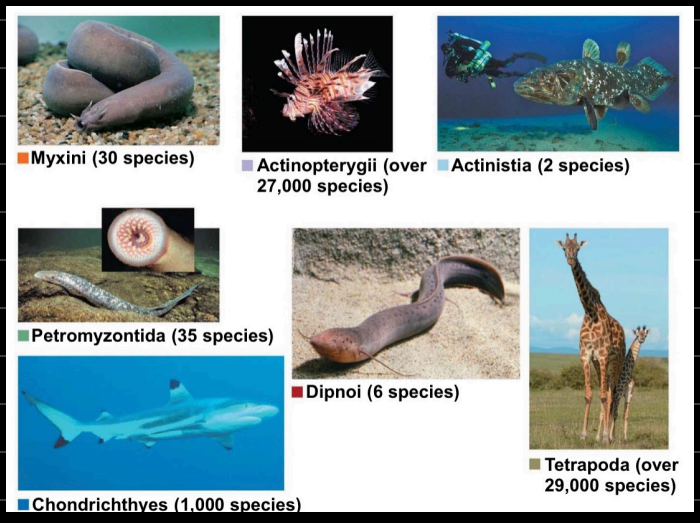


Figure 27.19-1



The Chondrichthyans

- Chondrichthyans include sharks, rays, and their relatives.
- The skeletons of chondrichthyans are composed primarily of cartilage.
- This group includes some of the largest and most successful vertebrate predators, such as sharks.

The Osteichthyes

- Ray-finned fishes are a major lineage of Osteichthyes, the clade of gnathostomes that included the vast majority of vertebrates.
- Nearly all living osteichthyans have a bony endoskeleton and lung, or lung derivatives.
- Most familiar aquatic osteichthyans are ray-finned fishes.
- Lobe-fins are the other major lineage of osteichthyans.
- A key derived trait in the lobe-fins is the prescience of rod-shaped bones surrounded by a think layer of muscle in their pectoral and pelvic fins.
- Three lineages survive today: the coelacanths, lungfishes, and tetrapods, terrestrial vertebrates with limbs and digits.

Summary

- The first large marine eukaryotes were slow-moving and soft-bodied.
- Large and diverse invertebrate predators and well-defended prey evolved during the

Cambrian period.
- Vertebrates, particularly gnathostomes, have been the dominant marine predators for over 400 million years.

The Colonization of Land By Animals

- Some animals colonized land following the Cambrian explosion, causing profound changes in terrestrial communities.

Early Land Animals

Life on land provided advantages and posed challenges to early colonizers:

- The atmosphere had higher oxygen concentration than aquatic environments.
- There were new sources of food and fewer competitors.
- Water was scarcer.
- Temperatures fluctuated between greater extremes.
- There was no support against gravity.
- Members of many animal groups made the transition to terrestrial life, both invertebrate and vertebrate.
- Arthropoda (invertebrates) were among the 1st animals to colonize the land about 459 million years ago.
- Vertebrates (chordates) colonized land 365 million years ago.

Colonization of Land by Invertebrates: The Arthropods

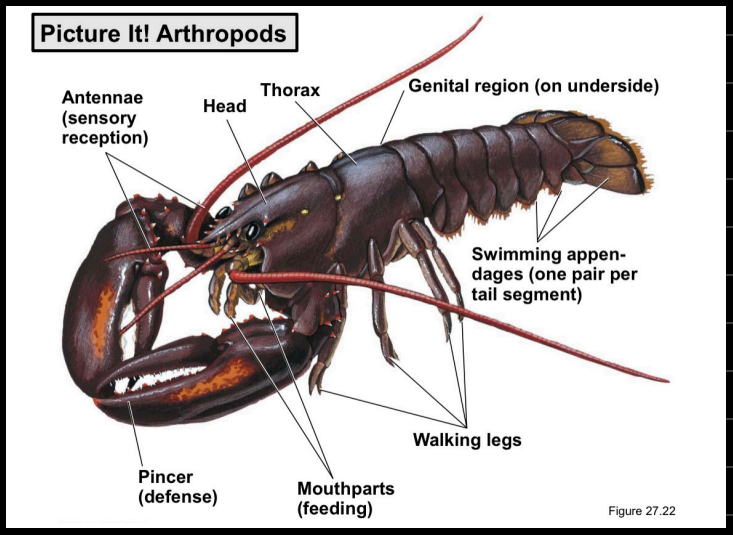
- Terrestrial lineages have arisen in several different arthropod groups, including millipedes, spiders, crabs, and insects.

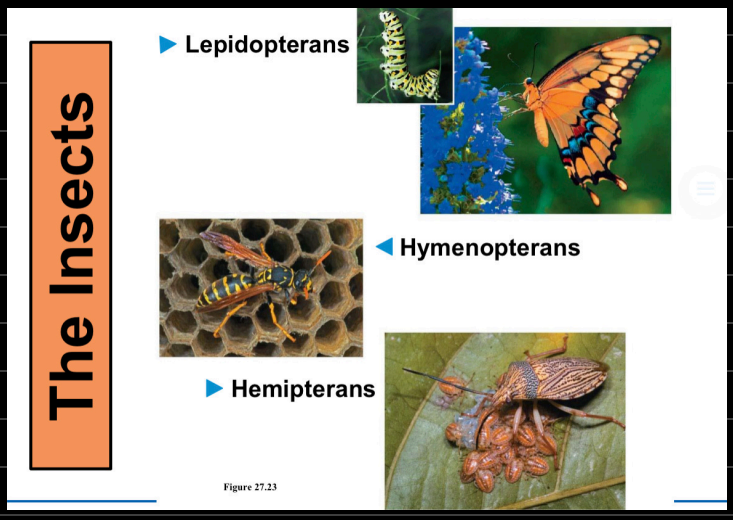
General Characteristics of Arthropods

- The appendages of some living arthropods are modified for function such as walking, feeding, sensory reception, reproduction, and defense.
- Like the appendages from which they were derived, these structures are jointed and paired.
- The body of an arthropod is completely covered by the cuticle, an exoskeleton made of layers of protein and chitin (a polysachaccharide).
- The exoskeleton provides structural support, attachment points for muscles, and protection from physical harm and desiccation.
- A variety of organs specialized for gas exchange have evolved in arthropods.

Types of Arthropods- The Insects

- The insects and their relatives include more species than all other eukaryotic groups combined.
- They live in almost every terrestrial habitat and in fresh water.
- The oldest insect fossils dat to about 416 million years ago.
- Insects diversified several times following the evolution of flight, adaptation to feeding on gymnosperms, and the expansion of angiosperms.
- The evolutions of flight is one key to the great suzzes of insect.
- An animal that can fly can escape predators, find food, and disperse to new habitats much faster than organisms that can only crawl.
- Because wings are extensions of the cuticle, insects did not lose any walking legs when wings evolved.



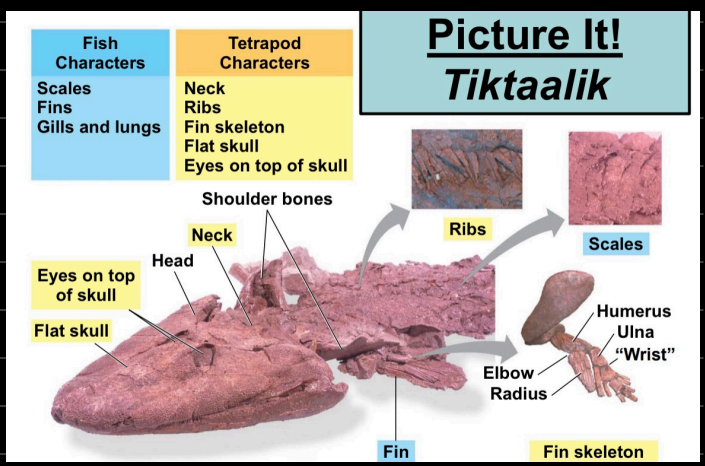


The Colonization of Land: Terrestrial Vertebrates

- A key event in the colonization of land occurred when the fins of some lob-fins evolved into the limbs and feet of tetrapods.

The Origin of Tetrapods (Terrestrial Vertebrates)

- Tiktaalik, nicknamed a "fishapod", is a fossils animal with both fish and tetrapod characteristics.
- It is the earliest ancestor of the true tetrapods.



Tiktaalik had:

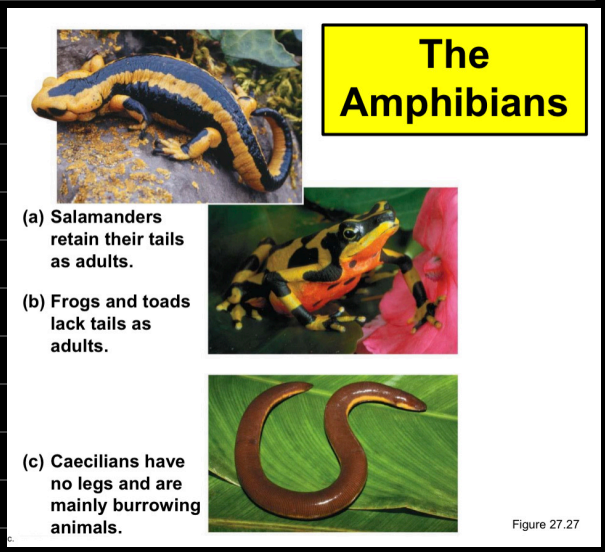
- Fins, gills, lungs, and scales
- Ribs to breathe air and support its body
- A neck ad shoulders
- Fins with the bone pattern of a tetrapod limb.

Details: Tiktaalik

- Tiktaalik could likely prop itself up on its fins in water, but could not walk on land.
- Tiktaalik predated the oldest tetrapod, and its traits were ancestral to the tetrapod lineage.
- Fins became progressively more limb-like over evolutionary time, leading to the 1st appearance of tetrapods 365 million years ago.

The Amphibians

- Amphibians are represented by about 6,150 species including salamanders, frogs, and caecilians.
- Many amphibians have gill-breathing aquatic larvae that undergo metamorphosis into lung-breathing adults that live on land.
- Amphibians are vertebrates!
- Amphibians, including those without an aquatic larval state, are restricted to damp habitats.
- Their eggs lack a shell and are vulnerable to desiccation.
- Their skin must also be kept moist to facilitate gas exchange.

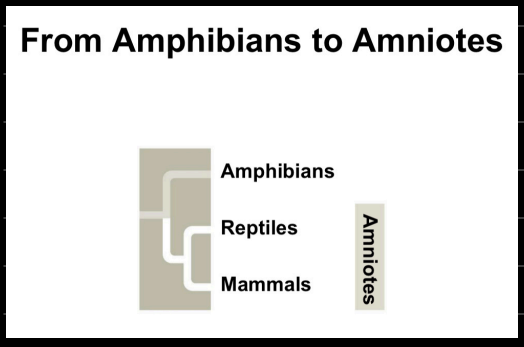


Amphibian Populations are Declining

- Today, amphibian populations are rapidly declining worldwide due to a disease caused by a chytrid fungus, habitat loss, climate change, and pollution.
- At least 9 amphibian species have gone extinct in the past 40 years; more than 100 others may have been lost in that time.

From Amphibians to Amniotes

- Amniotes colonized a more extensive range of dry habitats than did amphibians.
- Amniotes are a group of vertebrate tetrapods whose living members are the reptiles (including birds) and mammals.



Terrestrial Adaptations in Amniotes

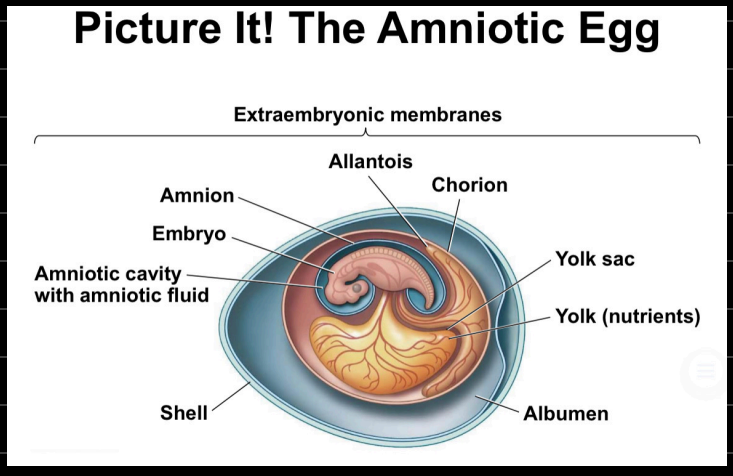
- Amniotes are named for the major derived character, the amniotic egg, which contains four membranes that protect the embryo.
- The specialized membrane are the amnion, chorion, yolk sac, and allantois.

The Amniotic Egg

- The amniotic eggs of most reptiles and some mammals have a shell.
- The shell slows dehydration of the egg in air.
- Most mammals have lost the eggshell; the embryo develops within the amnion inside the mother's body (placental development).

The Rib Cage of Amniotes

- Another important adaptation of the amniotes is the use of a rib cage to ventilate their lungs.
- The efficient ventilation of the rib cage allowed for less permeable skin and better water conservation.



The Origin and Radiation of Amniotes

- Early amniotes lived in warm moist habitats; they adapted to expand into a wide range of environments.
- Amniotes include 2 large, terrestrial Claude's: Reptiles and Mammals.

The Reptiles

- The earliest reptiles lived about 310 million years ago; they are vertebrates.
- Living members of the reptiles include lizards and snakes, turtles, crocodilians, and birds.
- Birds originated from a common ancestor with the dinosaurs.

Characteristics of Reptiles

Reptiles share several derived characters:

- They have scales that create a waterproof barrier.
- Most have internal fertilization and lay shelled eggs on land.
- Most are ectothermic, absorbing external heat to regulate body temperature; birds are endothermic, maintaining body temperature throughout metabolism.

Birds are Reptiles

- Birds are a diverse group of flying reptiles that evolved around 160 million years ago.

Birds have weight-saving adaptations for flight:

- They lack a urinary bladder.
- Females of most species have one ovary.
- They have small gonads, except during breeding season.
- They lack teeth.

Other characteristics aiding bird flight are:

- Wings and feathers.
- Large pectoral (breast) muscles.
- A keel on the sternum (breastbone) that anchors the pectoral muscles.
- Efficient respiratory and circulatory systems, including a four-chambered heart.
- Color vision and accurate eyesight.
- Well-developed visual and motor areas of the brain.

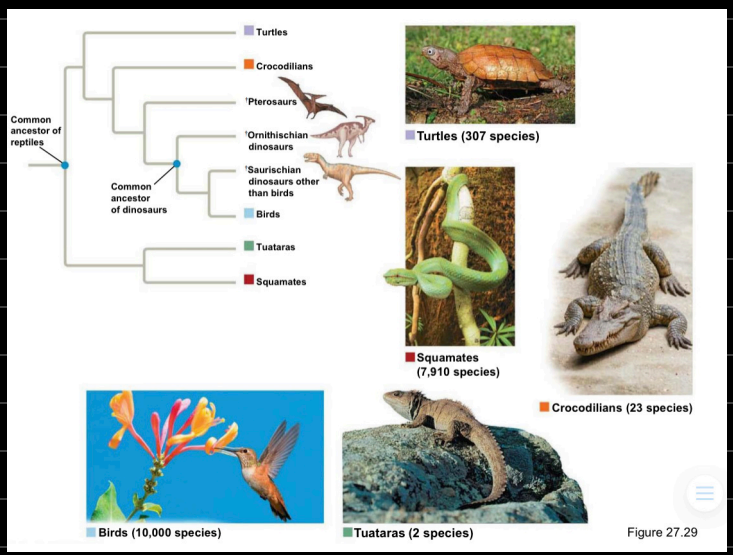
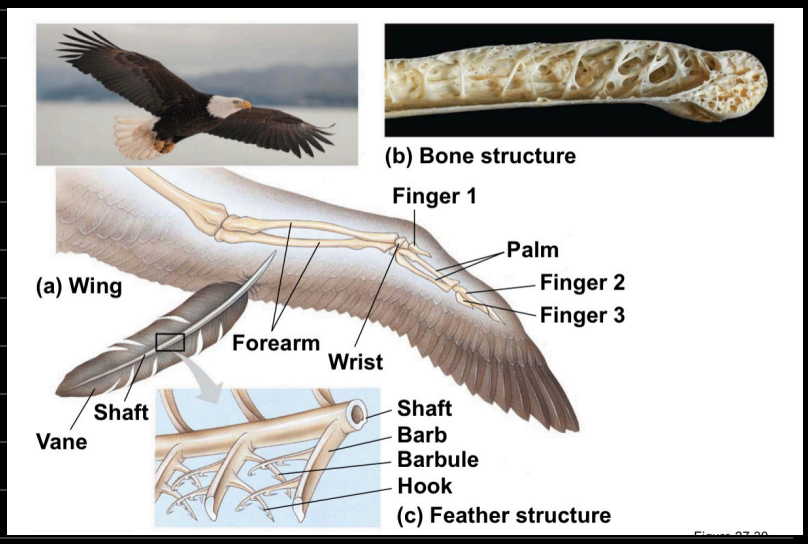


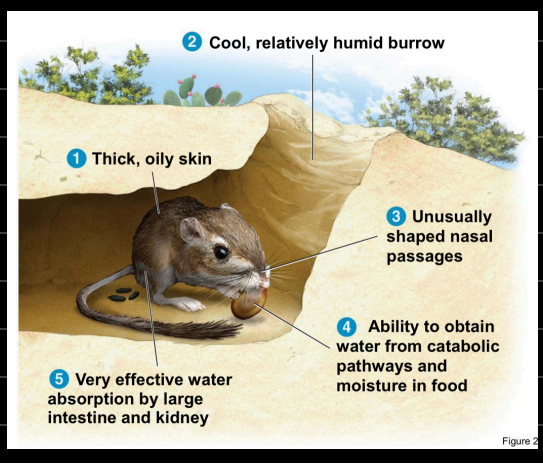
Figure 27.29



The Mammals

Mammals, the other extant (living) lineage of vertebrate amniotes, have many derived traits:

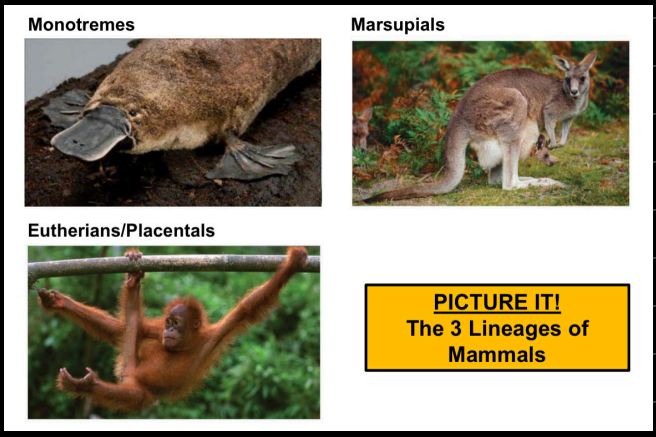
- Mammary glands that produce milk
- Hair
- A fat layer under the skin
- The kidney, which conserves water during waste removal
- A high metabolic rate, due to endothermy
- A relatively large brain
- Differentiated teeth



The 3 Lineages of Mammals

- The first true mammals arose around 180 million years ago.
- By 140 million years ago, the three living lineages of mammals had emerged.
- Monotremes: egg-laying mammals
- Marsupials: mammals with a pouch
- Eutherians/Placentals: placental mammals

Humans Are Eutharians/Placentals



Primates Are a Type of Eutherians/Placentals

- Primates are a group of eutherians that includes lemurs, tarsiers, monkeys, and apes.
- Humans are members of the ape group.

Characteristics of Primates

Many derived traits of primates are adaptations to life in trees:

- Grasping hands and feet
- A separate, movable thumb; monkeys and apes have opposable thumbs
- Large brains and short jaws
- Forward-looking eyes with good depth perception

Human Evolution

- Humans (Homo sapient) are primates, nested within a group informally called apes.

Characteristics of Humans

A number of characters distinguish humans from other apes:

- Upright posture and bipedal locomotion
- Larger brains capable of language, symbolic thought, artistic expression, and the use of complex tools.

Early Human Ancestors

- Chimpanzees, the closest living relatives to humans, have genomes 99% identical to our own.
- The lineage leading to humans diverged from chimpanzees and other apes 6-7 million years ago.
- Humans and their extinct human ancestors comprise the hominins.

Bipedalism & Brain Size

- The evolution of bipedalism preceded the evolution of increased brain size in early human ancestors.
- Brain size, body size, and tool use increased over time in Homo species.

Homo sapient

- The oldest H. sapiens fossils are from 2 specimens in Ethiopia.
- They date to about 195,000 and 160,000 years ago.
- All living humans have ancestors that originated as H. sapiens in Africa.

The Biodistribution of Humans (Homo sapiens)

- Humans dispersed out of Africa into Asia and then to Europe, Australia, and the New World.
- Shared morphological characters and analysis of DNA extracted from a fossil human jawbone indicate that humans interbred with Neanderthals.

Key Summary Points

- All animals are invertebrates or vertebrate
- The Chordates are vertebrates
- The evolution of animals moved from water to land and allowed for the development of several adaptations
- Mammalian evolution included a change in where the offspring developed.