

## Chapter 11: Animal Diversification

### Learning Goals

- ❑ Define an animal and the key distinctions that divide the species.
- ❑ Define and describe the invertebrates, including sponges, cnidarians, flatworms, mollusks, arthropods, and echinoderms.
- ❑ Define and describe vertebrates and their evolution.
- ❑ Define and describe the terrestrial vertebrates, including amphibians, birds, and mammals.

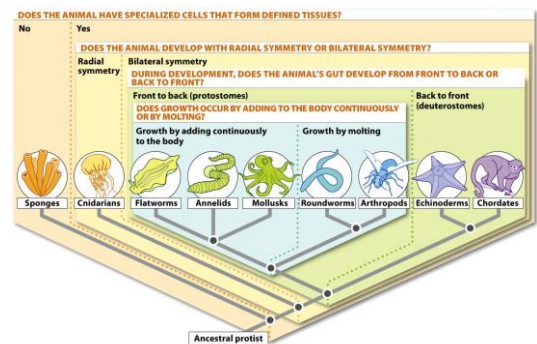
### What is an animal?

#### Three Key Characteristics

Animals are one branch of the Eukarya domain.



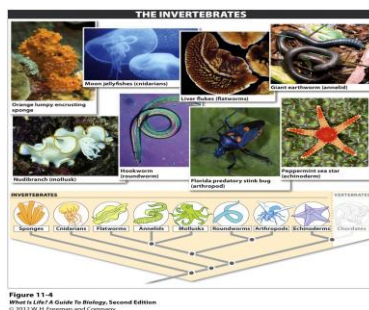
#### Four key distinctions divide the animals.



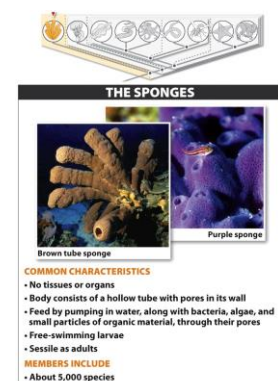
1. Does the animal have defined tissues, with specialized cells?
2. Does the animal develop with radial symmetry or bilateral symmetry?
3. During development, does the animal's gut develop from front to back or back to front?
4. Does growth occur by molting or by adding continuously to the skeletal elements?

### Invertebrates are the largest and most diverse group of animals.

Invertebrates are animals without a backbone.



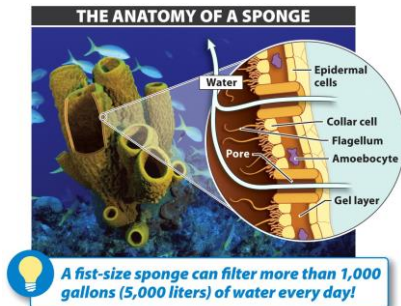
### Sponges are animals that lack tissues and organs.



A collar cell's flagellum creates a current that carries water upward and out through the opening at the top of the sponge. Food particles taken in too.

Amoebocyte cells, picks up some of the food particles from the collar cells

Epidermal cells, outer protective layer.



## Sponge Reproduction

- How do they do it?
- Hermaphrodites
  - Male and female sexual reproductive organs
  - Free-swimming larvae become sessile adults
- Asexual reproduction
  - Budding

**Jellyfish and other cnidarians are among the most poisonous animals in the world.**

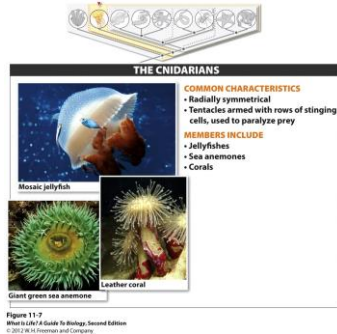


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## Cnidarians

- Two types of cnidarian bodies:
  - A sessile polyp
  - A free-floating medusa
- Reproduce both sexually and asexually
- Carnivores that use cnidocysts
  - Stinging cells

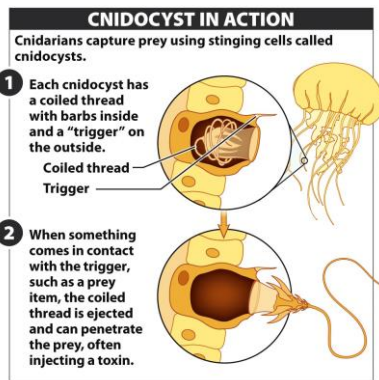


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## 3 Major Groups of Cnidarians

- Corals
- Sea anemones
- Jellyfishes

## The Corals

- ❑ Small, soft-bodied polyps living in large colonial groups
- ❑ Secrete calcium carbonate
- ❑ Stinging tentacles surrounding a mouth
- ❑ Sexual and asexual reproduction

## The Sea Anemones

- ❑ Resemble flowers
- ❑ Free-swimming larval stage
- ❑ Adult stage settles
  - But may crawl slowly

## The Jellyfishes

- ❑ Range tremendously in size
- ❑ Some species deadly

## The Flatworms

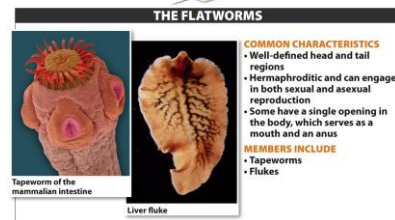
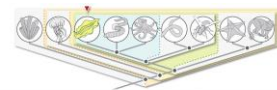


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## The Roundworms

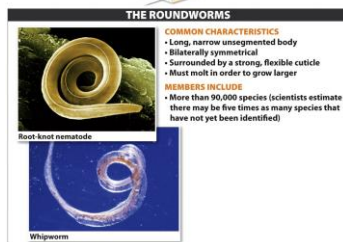


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## The Segmented Worms (Annelids)

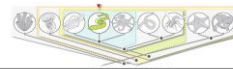


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## Annelids: Polychaetes

- ❑ Marine worms
- ❑ “Many bristles”
- ❑ Some are burrowing.
- ❑ Some are tube dwelling.

## Annelids: Earthworms

- ❑ “Few bristles”
- ❑ Bulk feeders
  - Consume particles of soil and organic material
- ❑ Castings are valued by gardeners.

## Annelids: Leeches

- ❑ The saliva of blood-sucking leeches contains an anticoagulant substance that prevents blood from clotting.
- ❑ Not all leeches are blood suckers.
  - More than half the species of leeches are predators.

## Worm Summary

- ❑ Flatworms include parasitic flukes and tapeworms, many of which infect humans.
- ❑ Many roundworms are parasites of plants or animals and are responsible for several widespread human diseases.
- ❑ Earthworms are annelids that play an important role in recycling dead plant material.

## Mollusks

- ❑ Mollusks are protostome invertebrates that do not molt.
- ❑ They are the second most diverse phylum of animals and include snails and slugs, clams and oysters, and squids and octopuses.

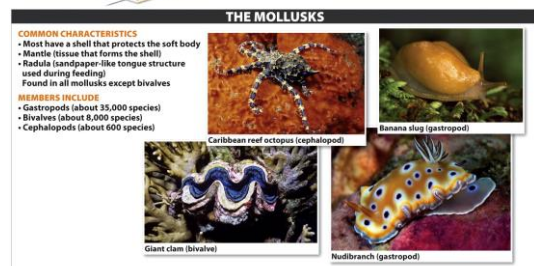


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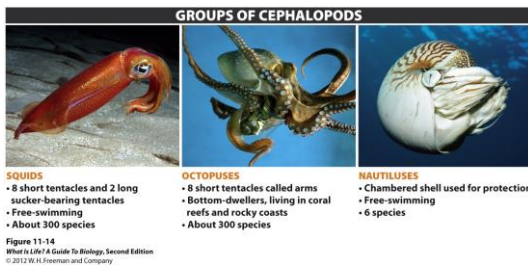
## Gastropods

- ❑ Snails and slugs are called **gastropod** mollusks.
- ❑ “stomach foot”
- ❑ Found in both aquatic and terrestrial environments, snails and slugs account for three-quarters of all mollusks.

## Bivalve Mollusks

- ❑ Clams, scallops, oysters, and mussels have a pair of shells that clamp together.
- ❑ Roughly 8000 species of bivalves—most of them live in the ocean.
- ❑ All are filter feeders.

## Cephalopods

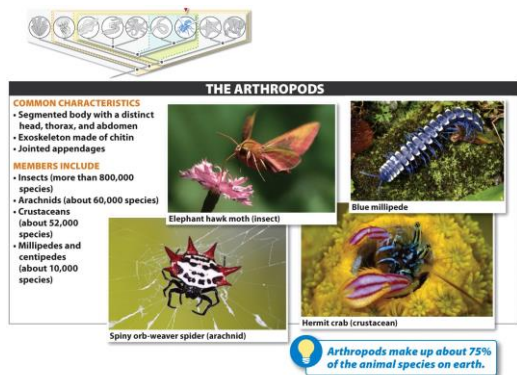


## Octopuses are smart

- ❑ The predatory behavior of octopuses involves exploration and manipulation.
- ❑ These behaviors are considered as intelligent by humans.



**An external skeleton and metamorphosis produced the greatest adaptive radiation ever.**



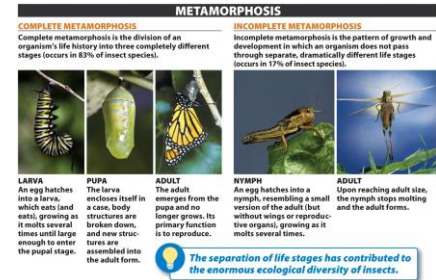


## Insects Rule

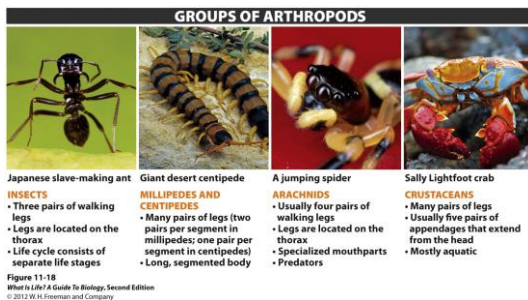
- The ability to fly and the development of a body with a rugged exoskeleton have contributed to the enormous ecological diversity of insects.
- The life cycle of most insects includes a larval stage that is devoted to feeding and growth, a pupal stage during which metamorphosis occurs, and an adult stage in which the insect reproduces.

## Metamorphosis

- Complete
- Incomplete



**Other arthropods include arachnids, crustaceans, millipedes, and centipedes.**



## Millipedes and Centipedes

- “A thousand feet” and “a hundred feet”
- Long, segmented bodies
- Millipedes feed on decaying plant material.
- Centipedes are predators; they use venomous fangs to kill insects and even small mammals.

## Arachnids

- Land-dwelling arthropods
- Include spiders, scorpions, mites, and ticks
- Usually have four pairs of walking legs
  - And a specialized feeding apparatus
- Only have legs on the thorax

## Spider Venom

- Arachnids are predators
- **Black widow spider**
- **Brown recluse spider**

## The Crustaceans

- Lobsters, crayfish, crabs, and shrimps
- All have five pairs of appendages extending from their heads.
- Many pairs of legs modified for many purposes
- Most are aquatic.

## Echinoderms

- Are deuterostomes (as are vertebrates), echinoderms are the invertebrates that are the closest evolutionary relatives to the vertebrates (and other chordates).
- Their aquatic larvae are bilaterally symmetrical and share some anatomical features with chordates, but adult echinoderms are radially symmetrical.

## Evolutionary Specialization

- Radial symmetry in adults
- An evolutionary specialization associated with their locomotor mode and feeding specializations

## Echinoderms are vertebrates' closest invertebrate relatives

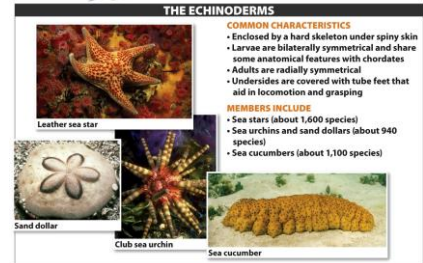
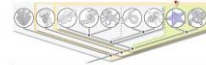


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## Echinoderms and Chordates

- Bilateral symmetry in larvae
- The larvae have anatomical characteristics in common with the larvae of primitive chordates.

## All vertebrates are members of the phylum Chordata.

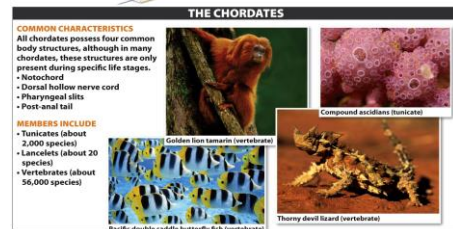


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## Four distinct features of chordates

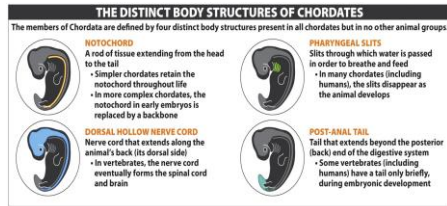


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## A Dorsal Hollow Nerve Cord

- Extends from head to tail
- In vertebrates, forms the central nervous system (spinal cord and brain)
- In other animals, lies in lower portion of ventral part of body (and is solid instead of hollow)

## Pharyngeal Slits

- Pharyngeal region
  - The area between the back of the mouth and the top of the throat
- **Pharyngeal slits** are present in the embryos of all chordates.
- Originally used for breathing and feeding

## A Post-Anal Tail

- Extends back beyond the end of the trunk

The phylum Chordata contains three sub-phyta:



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## The Tunicates



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## The Lancelets

### GROUPS OF CHORDATES



#### LANCELETS

- Filter-feeding marine animals
- Live in coastal waters

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## The Vertebrates: The Most Diverse Subphylum of Chordates

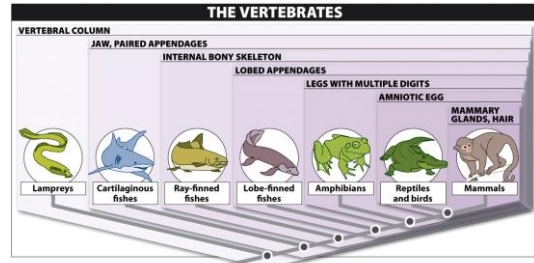


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Vertebrates differ from the other chordates in two important ways:

1. They have a backbone.
2. They have a head.

The evolution of fins paralleled the evolution of jaws because the two structures work together.

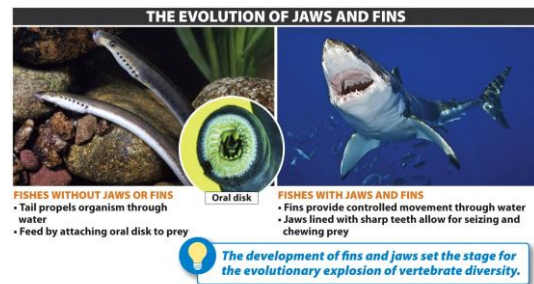


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Fins get you to the organism you are going to eat.

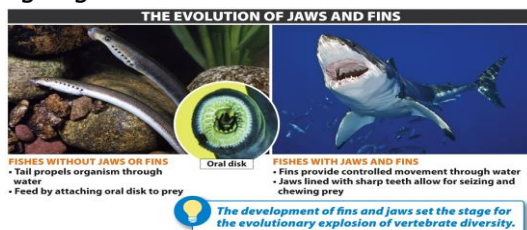


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Jaws capture and kill it.



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**The movement onto land required lungs, a rigid backbone, four legs, and eggs that resist drying.**

□ In the transition of vertebrates from life in water to life on land:

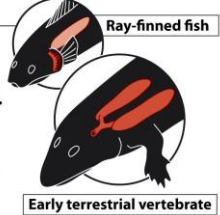
- Fins were modified into limbs.
- Vertebrae were modified to transmit the body weight through the limbs to the ground.
- The site of gas exchange was transferred from gills and swim bladders to lungs.

### FROM WATER TO LAND

The transition of vertebrates from life in water to life on land required overcoming three main obstacles. Four major evolutionary innovations allowed for this transition.

**PROBLEM: RESPIRATION**  
Aquatic animals use gills to acquire dissolved oxygen from water. The transition onto land required the ability to breathe air.

**SOLUTION: LUNGS**  
Gas exchange was transferred from gills to lungs, which evolved from the swim bladder found in ray-finned fishes.



Ray-finned fish

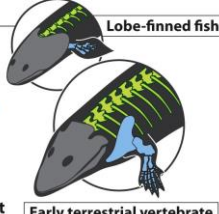
Early terrestrial vertebrate

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### FROM WATER TO LAND

**PROBLEM: GRAVITY**  
The transition onto land required structural support to resist the pull of gravity.

**SOLUTIONS: LIMBS and MODIFIED VERTEBRAE**  
Limbs evolved from the jointed fins found on the underside of lobe-finned fishes. Vertebrae were modified to transmit the body weight through the limbs to the ground.



Lobe-finned fish

Early terrestrial vertebrate

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### FROM WATER TO LAND

**PROBLEM: EGG DESICCATION**  
The transition onto land required an egg that resisted drying out when exposed to air.

**SOLUTION: AMNIOTIC EGG**  
Terrestrial animals developed a water-proof eggshell, which prevents eggs from drying out before they hatch.

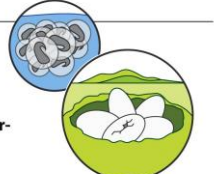


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All terrestrial vertebrates are tetrapods.




*Amniotes and non-amniotes*

## Amphibians live a double life.

### THE AMPHIBIAN LIFE CYCLE

Amphibians, such as frogs, toads, and salamanders, are terrestrial vertebrates (tetrapods) with non-amniotic eggs. Most species live on land as adults, but develop in water.



**EGGS**  
Amphibians have non-amniotic eggs, which must be laid in water to prevent desiccation.

**JUVENILES**  
Amphibians spend their juvenile stage underwater and undergo metamorphosis to develop legs and lungs.

**ADULTS**  
Only the adults are true land animals; however, most of the species in this group stay close to water to lay their eggs.

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## Birds are reptiles in which feathers evolved.

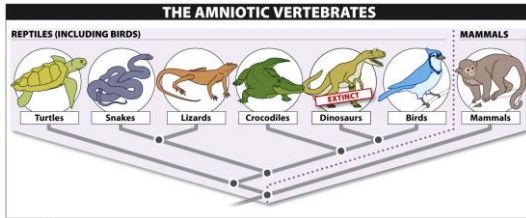




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**REPTILES VS. BIRDS**



**REPTILES**

- Skin is covered in scales
- Body temperature is controlled by external conditions, such as air temperature (exothermic)
- Include snakes and lizards (about 8,000 species), turtles (about 300 species), crocodiles and alligators (23 species), and tuatara (2 species)



**BIRDS**

- Skin is covered in feathers, enabling flight and providing insulation
- Body temperature is maintained by heat generated from cellular respiration (endothermic)
- Include about 9,700 species

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## Feathers



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## Mammals are animals that have hair and produce milk.

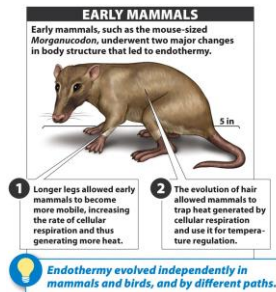



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## Are all mammals viviparous?

- ❑ **Viviparity**—giving birth to babies rather than laying eggs
- ❑ **Monotremes** lay eggs, but also produce milk.


**GROUPS OF MAMMALS**

Mammals are endothermic vertebrates that have hair and produce milk for their young.




**MONOTREMES**

- Females lay eggs
- Females produce milk, but do not have nipples—babies suck milk from the hairs on their mother's chest
- Only 5 species survive—the platypus and 4 species of spiny animals called echidnas



**MARSUPIALS**

- Females give birth after a short period of development
- Females of most species have a pouch where the young complete their development
- About 300 species, including kangaroos, koalas, wallabies, and possums



**PLACENTAL MAMMALS**

- Females have a placenta that provides oxygen and nutrients to embryos in the uterus
- About 4,500 species

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## Humans tried out different life styles.

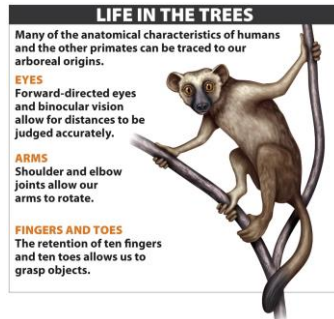


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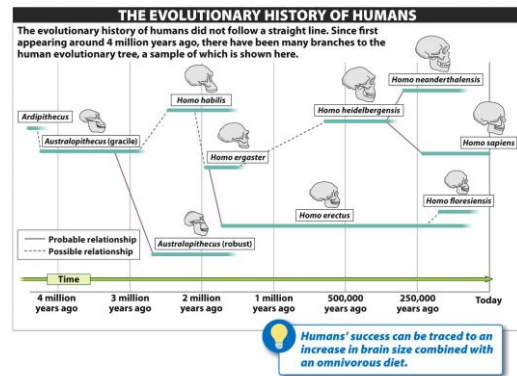


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### Chimpanzee and Modern Human Lineages

- Separated only 5 or 6 million years ago

Humans differ from chimpanzees in three major anatomical characteristics:

- Humans are bipedal.
- Humans are bigger than chimpanzees.
- Humans have a brain that is about three times the size of the brain of a chimpanzee.

### What are the advantages of walking on two feet rather than four?

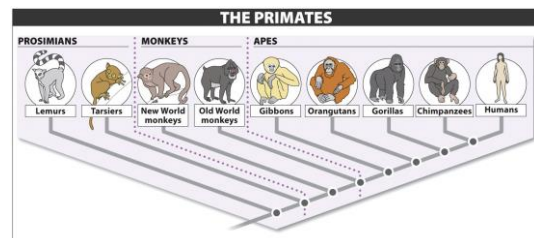


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### How did we get here?

*The past 100,000 years of human evolution*

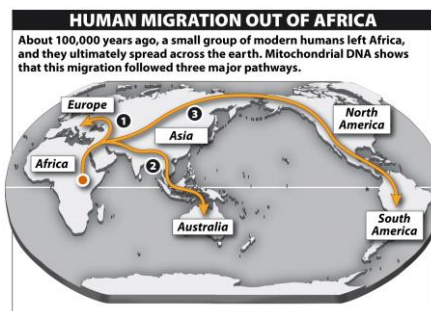


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## Humans

Modern humans (*Homo sapiens*) evolved in Africa between 200,000 and 100,000 years ago, and all living humans are descended from that evolutionary radiation

- About 100,000 years ago, a small group of modern humans moved out of Africa, and the descendants of this group ultimately populated Europe, Asia, and the Americas.
- Three other species of humans were living at this time.



## Neandertals, *Homo neanderthalensis*

- About the same size as modern humans
- More robust and muscular
- Lived in organized groups
- Probably hunted large mammals

Became extinct between 30,000 and 12,000 years ago, after modern humans had spread into the areas where they were living.

## The Indo-Australian Archipelago

- *Homo erectus*
- *Homo floresiensis*

## Learning Objectives

- Describe why flowering plants are the most diverse and successful plants.
- Describe the love-hate relationship between plants and animals.
- Discuss the relationship between fungi and plants.

## Most Plants Make Their Own Food

- Nitrogen, phosphorus, and salts
- Roots and shoots



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## Chapter 12: Diversification of the Eukaryotes: Plants and Fungi

### Learning Objectives

- Explain what a plant is.
- Describe the characteristics of the first plants.
- Explain what a seed is as well as the significance of its evolution.

## What is a plant?

Plants a branch of the eukarya.

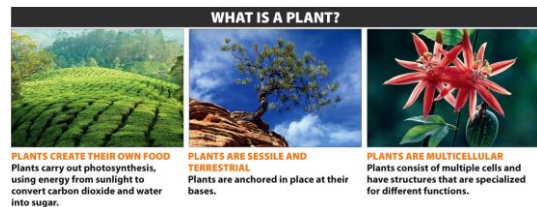


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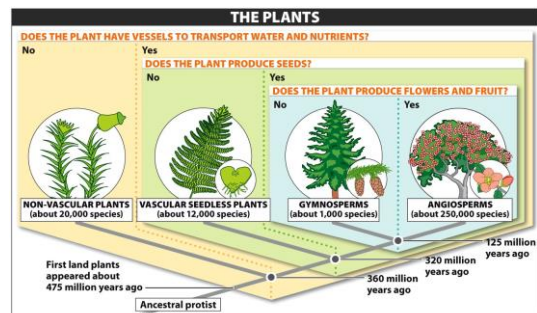


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What characteristics do Gymnosperms (pine trees) have that are absent in nonvascular plants (moss)?

1. Vascularity and flowers
2. Seeds and flowers
3. One is multicellular while the other is not.
4. Vascularity and seeds

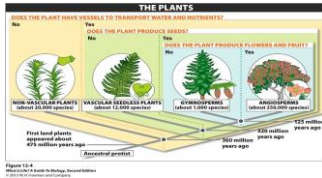


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## The First Land Plants Appeared About 475 Million Years Ago



- 1 PROBLEM: GRAVITY**  
SOLUTION: The earliest plants grew very close to the ground, as mosses do today, in order to resist the pull of gravity.
- 2 PROBLEM: DESICCATION**  
SOLUTION: Plants developed an outer waxy layer called a cuticle that covers their entire surface.

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Mosses and other non-vascular plants lack vessels for transporting nutrients and water.

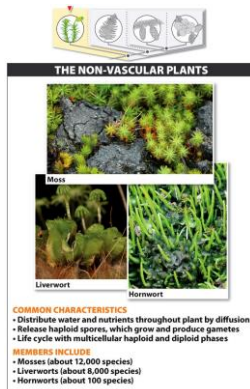


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## Colonizing land brings new opportunities and challenges for plants.

Coleochaetes, a type of green alga, are the closest relative to plants. They can withstand exposure to air when water levels fall.



Ancestors of plants began the transition from water to land with the evolution of resistance to drying.

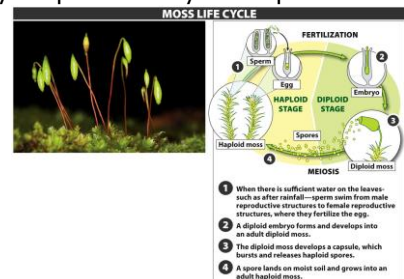
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## Non-vascular plants

- Non-vascular plants—mosses, liverworts, and hornworts
- They lack roots and vessels to move water and nutrients from the soil into the plant.
- They reproduce with spores that form when a sperm from a male reproductive structure “swims” through a drop of rainwater to the egg in a female reproductive structure.

## Alternation of Generations

- A life cycle of alternating haploid and diploid generations in which the diploid embryo is protected by the haploid female



- 1 When there is sufficient water on the leaves, such as after rain fall—sperm swim from male reproductive structures to female reproductive structures, where they fertilize the egg.
- 2 A diploid embryo forms and develops into an adult diploid moss.
- 3 The diploid moss develops a capsule, which bursts and releases haploid spores.
- 4 A spore lands on moist soil and grows into an adult haploid moss.

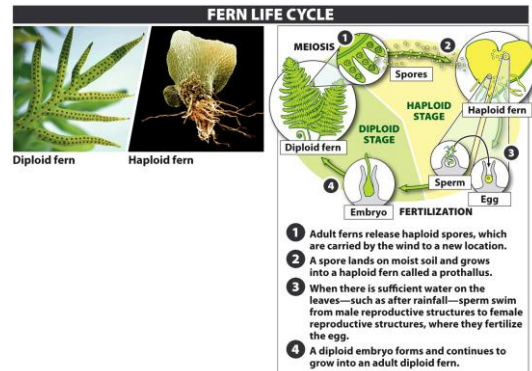
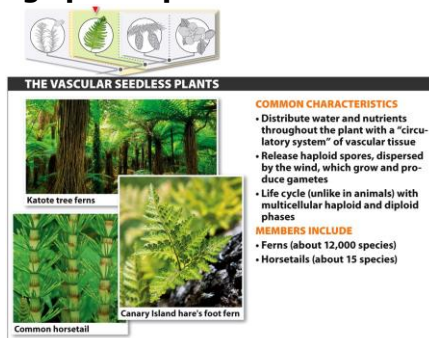




Bryophytes are characterized by all the following except...

1. Multicellular diploid stage
2. Multicellular haploid stage
3. Alternation of generations
4. Obtaining water and nutrients through diffusion
5. Diploid spores

The evolution of vascular tissue made large plants possible.



**Figure 12-12**  
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Differences between a moss and a fern include...

1. Alternation of generations
2. Multicellular diploid stage in the life cycle
3. Multicellular haploid stage in the life cycle
4. Presence of a vascular system
5. Use of chlorophyll for harvesting light energy

What chemical property of water allows transpiration to occur in a tree?

1. Equal sharing of electrons between oxygen and hydrogens
2. Unequal sharing of electrons between oxygen and hydrogens
3. Water molecules sticking to each other
4. 1 and 3
5. 2 and 3

## Seeds

- DNA, RNA, a few proteins
- A multicellular embryo and a store of nutrients
- Endosperm
- Gymnosperms and angiosperms



Figure 12-13  
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## Seed Dispersal

- Only opportunity most plants have to send their offspring away from home
- Seeds and seed pods have many ways to do this:
  - Forceful send-off of exploding seed pods
  - Seeds that hitch rides on passing animals
  - Seeds that float in water or almost fly

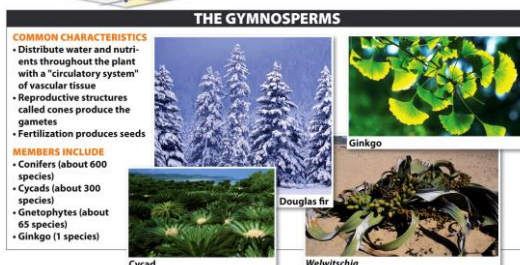


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## Do plants have sex? How are seeds formed?

- The **gametophyte**
  - A life stage that produces haploid gametes
- Pollen grains and ovules
  - Pollen produces a pollen tube that grows into the ovule.
- The external layer of the ovule forms the seed coat.

## When you eat corn, most of the nutrients you are getting are from the seed's...

1. Endosperm
2. Embryo
3. Protective coating
4. Sporophyte

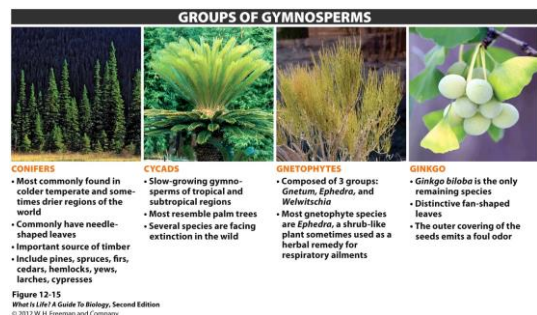
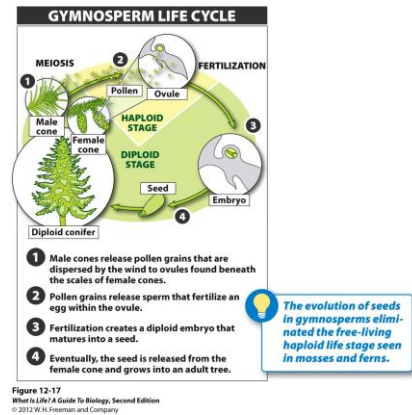
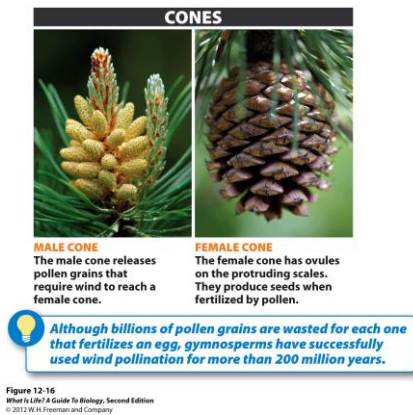


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Which answer below is not true for gymnosperms?

1. Their life cycle displays alternation of generations.
2. Seed dispersal occurs via the wind.
3. The male and female gametophytes (cones) look the same.
4. They can be extremely long lived.

Conifers include the tallest and longest-living trees.



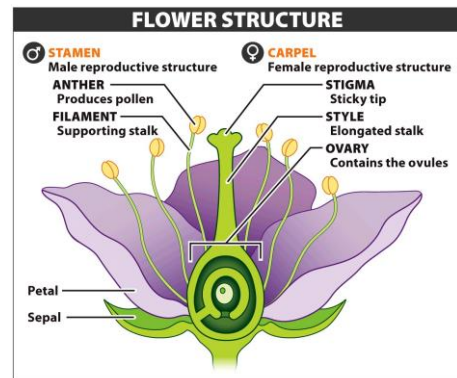
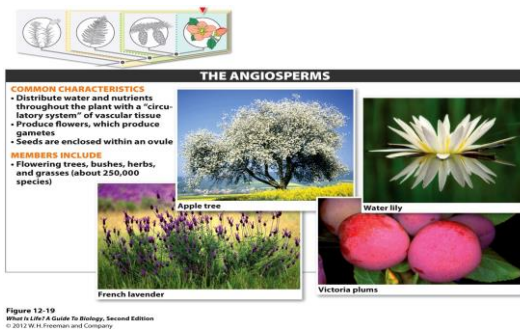
How can trees grow large and live to great ages?

- ☐ Woody plants can be exceptionally strong and resistant to attack by herbivores.
- ☐ Heartwood
- ☐ Bark
- ☐ Exuding a sticky pine pitch

Which answer below is not true for gymnosperms?

1. Their life cycle displays alternation of generations.
2. Seed dispersal occurs via the wind.
3. The male and female gametophytes (cones) look the same.
4. They can be extremely long lived.

## Angiosperms are the dominant plants today.



## What characteristics do angiosperms share with gymnosperms?

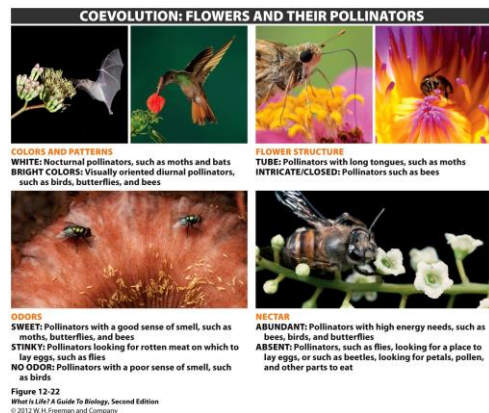
1. Both produce a seed.
2. Both are sporophyte dominant.
3. Both have a vascular system.
4. Both produce flowers.
5. 1, 2, and 3
6. All of the above

## A flower needs a pollinator



## Trickery and Bribery

- Plant deceit!
  - Orchid species
    - Flowers that resemble female wasps
    - Male wasps "riding a bucking bronco"
  - Plants offer something of value for pollen transport.
- Requires:**
- a) A sticky pollen
  - b) A flower that catches the attention of the pollinator
  - c) Something of value to the pollinator.





Which answer below is an example of coevolution between two species?

1. A flower gets pollinated through wind dispersal.
2. Seeds get dispersed by sticking to passing animals.
3. A flower develops into a fruit for animals to eat.
4. Yucca moths can only enter yucca plant flowers that provide a place for the moths to lay their eggs.

Which answer below is “Bribery” by the plant?

1. A flower gets pollinated through wind dispersal.
2. Seeds get dispersed by sticking to passing animals.
3. A flower develops into a fruit for animals to eat.
4. Yucca moths can only enter yucca plant flowers that provide a place for the moths to lay their eggs.
5. 3 and 4
6. All of the above

## Angiosperms improve seeds with double fertilization.

### Two Advantages of Double Fertilization

- Initiates formation of endosperm only when an egg is fertilized
- Smaller gametes can be produced.
  - Ensures that seeds are produced quickly

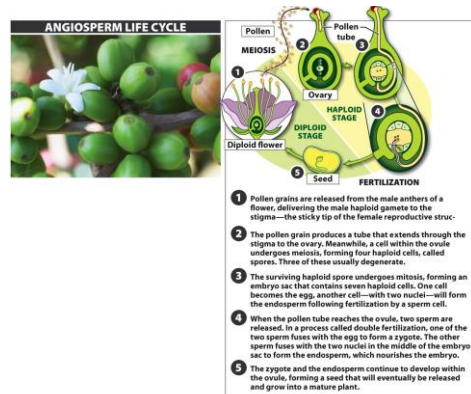


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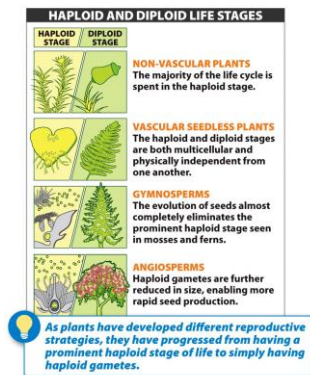


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## Do flowers fertilize themselves?

### *Outbreeding versus Inbreeding*

- Angiosperms have also developed methods to reduce the occurrence of self-fertilization, thereby ensuring greater genetic variation among offspring than occurs through inbreeding.

## What is an advantage of double fertilization in angiosperms?

1. Production of endosperm
2. Larger seeds
3. Increase in energy used to make the seed
4. 1 and 2
5. All of the above

## Fleshy fruits are bribes that flowering plants pay animals to disperse seeds.

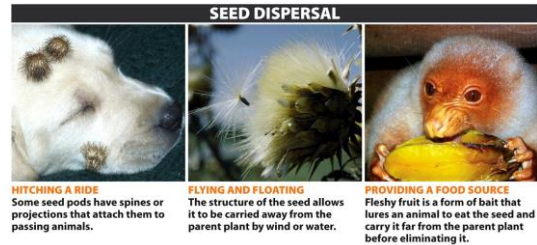


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## How does this system work?

- Fruits are colorful.
- Fruits taste good.
- Fruit is good for animals.

## What is an advantage to making a fleshy fruit (for the plant)?

1. A large amount of energy is used to make the fruit.
2. The seed is dispersed by the animal that eats the fruit.
3. When defecated, the seed will be inhibited from germinating.
4. The nutrients in the fruit help keep the animal healthy.

## Unable to escape, plants must resist predation in other ways.

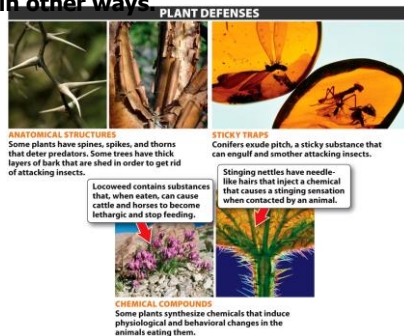


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## Chemical Defenses as Medicines?

- Medicinal plants
- Salicin, opium, digitalin, ipecac
- Bioprospecting



## Insect Attack!

- Volatile chemicals
- Plants can also warn nearby plants!

- Methyl jasmonate (MJ)
- Chemical carried by air
- Insect prey might respond

• Example: caterpillars eating cotton, MJ released, attracts wasps that lay eggs in caterpillars. Wasp larvae eat caterpillars from inside out.



Some plants living in nitrogen-deficient soil have turned the tables, becoming predators on insects.

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**Fungi are closer to animals than they are to plants.**

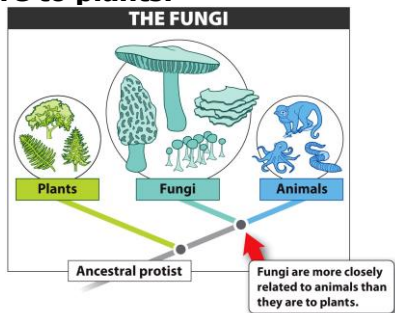


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## Fungi

- Fungi are decomposers, and all they need to thrive is organic material to consume and a moist environment, so their hyphae don't dry out.
- Fungi can grow almost anywhere that is moist, and they can attain enormous sizes.

## Fungi

- Fungi are eukaryotes with the same internal cellular elements as other eukaryotes...
- ...and one distinctive feature: a cell wall formed from the carbohydrate chitin.
- Some fungi, the yeasts, live as individual cells; most other fungi are multicellular.

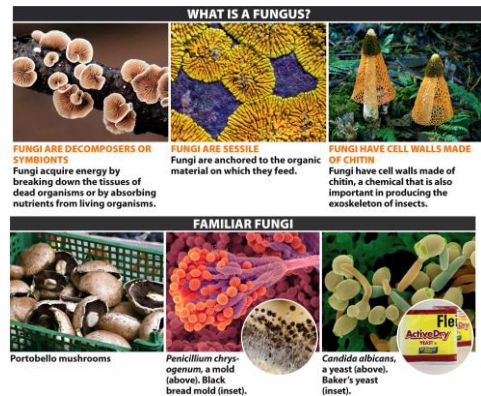
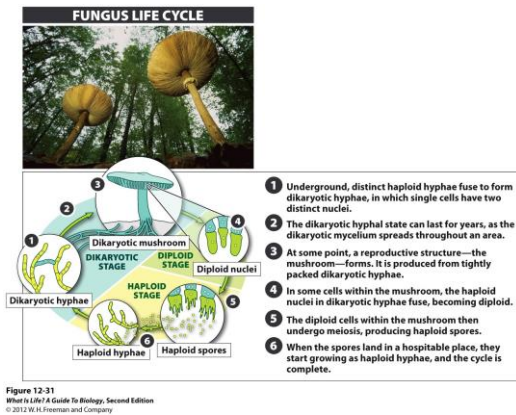


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## Fungi

- Fungi have complex life cycles, with both sexual and asexual phases; the parts of fungi that are most often visible are their temporary spore-producing bodies.
- Fungi can cause a variety of health problems but also are responsible for antibacterial medicines such as penicillin.



How can fungi grow in so many habitats?

□ Advantages of being a **decomposer**

□ Don't need light

□ **Important ecological role!**

## Fungal Invasion!

*Sick-building Syndrome*



Molds can contaminate poorly ventilated buildings, causing a variety of irritating and potentially dangerous health problems.

Figure 12-33  
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## Fungal Parasites

□ On humans?!

□ Mycosis

## Beneficial Fungi

□ *Penicillium*

□ Penicillin

□ Wonder drug!

## How are fungi and plants similar?

1. Both are sessile.
2. Both use photosynthesis to produce food.
3. Both use chitin for building cell walls.
4. Both have a dikaryotic state in their life cycle.
5. Both have a prominent multicellular haploid state in their life cycle.

## Most plants have fungal symbionts

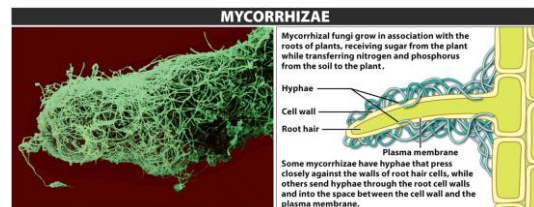


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What percentage of the offspring from parents with mycorrhizal fungi were surviving after 47 days? What was the percentage surviving from parents without mycorrhizal fungi?

Mycorrhizae:	+	-
1.	100%	100%
2.	59%	25%
3.	38%	18%
4.	25%	59%
5.	18%	38%

