

Evolution of Digestive Systems

1. In terms of getting nutrition, organisms can be divided into various categories.
 - a. Those that need only CO₂ as a carbon source are called **autotrophs**.
 - b. Organisms that need organic molecules, like glucose, to make other organic compounds are called **heterotrophs**.
 - i. They can also be divided based on how they derive their energy.
 - (1) **Phototrophs** use light as their energy source.
 - (2) **Chemotrophs** get their energy from chemicals.
 - c. For all organisms, materials must be obtained from the environment to provide three things:
 - i. Molecules that can be used for energy (this wouldn't apply to autotrophs).
 - ii. Organic molecules that can be used to build other molecules. Given a source of organic carbon (like glucose) and organic nitrogen (usually from digesting protein) organisms can build many of the carbohydrates, proteins and lipids they require.
 - iii. Vitamins and minerals that cannot be synthesized by the organism.
2. Bacteria can be categorized by the way they obtain their nutrition.
 - a. Some bacteria are **photoautotrophs**. They use light energy (like plants do) and use it to make organic compounds from CO₂.
 - b. Bacteria that are **chemoautotrophs**, need CO₂ as a carbon source but they get their energy from chemicals such as hydrogen sulfide or ammonia.
 - c. **Photoheterotrophs** get their energy from light but must have a source of organic carbon.
 - d. **Chemoheterotrophs** rely on organic molecules for both energy and carbon. This is the most widely seen mode of nutrition in bacteria (as well as the mode used by most protists, fungi and animals).
3. Protists are divided into three large nutritional groups.
 - a. **Plant-like** protists are photosynthetic and include the organisms we call seaweeds. The photosynthetic capability of the green seaweeds suggests they are the ancestors of all modern plants.
 - b. **Animal-like** protists are motile and heterotrophic.
 - c. **Fungus-like** protists, commonly called slime molds, are heterotrophic and play an important role as decomposers in many ecosystems.
4. All plants are photoautotrophs, meaning they use sunlight to build organic molecules from CO₂. (See the Evolution of Circulatory and Respiratory Systems notes for a discussion on how plants transport and store food.)
 - a. Some plants (*e.g.*, Venus' Flytrap) are carnivorous – they obtain some nitrogen and minerals by killing and digesting insects and other small animals.
5. Fungi are heterotrophs that feed by absorbing nutrients from the environment.
 - a. Fungi cannot make their own food like plants can. Fungi do not ingest food, however. They secrete digestive enzymes into their surroundings that break down complex molecules into simple molecules that are small enough to be absorbed.
 - b. This mode of nutrition makes fungi important decomposers. They often live on fallen logs, animal corpses, and other dead organic material. They decompose these materials by breaking down and absorb the nutrients from them.

6. Animals cannot make all the molecules they need so they must ingest them.
 - a. An animal fits into one of three dietary categories based on what it normally eats and the adaptations it has for obtaining and digesting food. Remember that most animals are opportunistic and will eat food outside their normal category if their preferred food is unavailable.
 - i. **Herbivores** eat mainly autotrophs.
 - ii. **Carnivores** eat other animals.
 - iii. **Omnivores** regularly eat both plants and animals.
 - b. Unlike fungi, most animals digest food after eating it.
 - c. The clear trend observed in digestion in animals is that of progressing from a two-way to a one-way digestive tract. In a two-way tract, food enters the animal through an opening and waste exits through the same opening. In a one-way tract, food enters through an opening in one end of the digestive tract and continues moving in one direction through the tract. Waste exits through a separate opening at the other end of the tract.
 - d. There are four main feeding mechanisms in animals.
 - i. Suspension feeders (e.g., clams and some whales) filter particles of food from the water.
 - ii. Substrate feeders live in or on their food. For example, a caterpillar eating a leaf.
 - iii. Fluid feeders, like mosquitos and hummingbirds, suck nutrients from a living host.
 - iv. Most animals are bulk feeders which eat large pieces of food.
 - e. In most animals, some digestion occurs outside of cells in a process called **extracellular digestion**. It allows the animal to eat and digest much larger prey than could be digested inside a cell.
 - f. Simple animals have a digestive cavity with a single opening. The cavity, called a **gastrovascular cavity**, is a space where digestion occurs but also helps in the distribution of nutrients throughout the body.
 - i. This is a two-way system with one opening.
 - g. More complex animals have a digestive tube extending between a mouth and an anus. This a one-way system is called an alimentary canal.
 - i. This arrangement allows specialized digestive organs that have specific roles in digestion and nutrient absorption.
 - ii. An additional advantage of this type of system is the ability to eat more food before the last meal is digested.
7. Invertebrate animals display a wide range of digestive systems ranging from simple cavities to more complex systems with specialized organs.
 - a. Sponges in Phylum Porifera are sessile filter feeders.
 - i. They capture food particles suspended in the water that passes through their body, which resembles a sac perforated with holes.
 - ii. Water enters through these holes into a central cavity in the body and flows out of the top of the sponge through a larger hole. Food particles are filtered out of the water by cells as it passes through.
 - iii. This arrangement is not sufficient to be called a digestive system.
 - b. Cnidarians are predatory animals that capture prey by stinging it.
 - i. The body of a typical cnidarian is basically a sac with a digestive compartment in the middle called a **gastrovascular cavity**. A single opening to this cavity functions as both a mouth and anus.

- ii. They are carnivores which capture food with tentacles surrounding the mouth. **Cnidocytes** (stinging cells) on the tentacles paralyze prey which is then brought into the mouth.
- iii. Extracellular digestion occurs in the gastrovascular cavity and the resulting molecules are absorbed directly by cells.
- iv. Undigested material is egested through the mouth/anus.
- c. Recall from the Evolution of Circulatory and Respiratory Systems notes that flatworms in Phylum Platyhelminthes have a branched gastrovascular cavity.
 - i. An opening at the end of a muscular tube extending from the gastrovascular cavity functions as a mouth.
 - ii. Digestive enzymes are spilled onto the prey and the digested remains are sucked into the gastrovascular cavity through the tube. Digestion is completed in the gastrovascular cavity.
 - iii. The branching of the gastrovascular cavity provide a large surface area which helps distribute nutrients to all cells of the animal.
 - iv. Undigested material is egested through the mouth/anus.
- d. The roundworms of phylum Nematoda are the simplest animals to possess a one-way digestive tract, with a separate mouth and anus. All later phyla also have a one-way digestive tract.
- e. Animals in phylum Mollusca display a variety of feeding strategies.
 - i. Most gastropods, such as snails, have a rough feeding organ they use to scrape food off a surface.
 - ii. Bivalves like clams and scallops are filter feeders that trap tiny food particles in mucus that coats the gills. Cilia then move the food particles to the mouth.
 - iii. Cephalopods, like octopuses, are active predators, using their tentacles to capture prey. (Remember the cephalopods have a closed circulatory system which allows them to be much more active than animals with an open system.)
- f. Earthworms literally eat their way through the soil. As they burrow, they eat the soil and extract nutrients from it as it passes through the digestive tract. Undigested material is egested through the anus.
- g. Phylum Arthropoda contains a wide diversity of animals with equally diverse feeding strategies that depend on how their appendages have become specialized for feeding.
 - i. Some insects have mandibles for chewing (grasshoppers and ants) while others have mouthparts specialized for lapping (butterflies), piercing (mosquito), or sucking (wasps).
 - ii. Arachnids (spiders, scorpions and ticks) also have a variety of feeding strategies.
 - (1) Ticks are parasites that suck blood from the body surface of reptiles and mammals.
 - (2) Arachnids are generally predators. Many use webs to catch prey and fangs to inject prey with paralyzing venom. Digestive enzymes are then injected into the body of the prey and the resulting juices are then sucked up.
 - iii. Lobsters, crabs and shrimps are crustaceans. They have two or three pairs of appendages that are modified into mouthparts for grasping and chewing food.

8. Vertebrate animals all possess complex, one-way digestive systems with specialized digestive organs.
- a. Animals in class Agnatha, like the lamprey, do not have moveable jaws and feed by clamping their round mouth onto the side of a fish. They use either a rasping tongue or rows of teeth to penetrate the skin and devour the blood or flesh.
 - b. Sharks and rays belong to class Chondrichthyes while all bony fishes are in class Osteichthyes.
 - i. Many sharks are predators that use their moveable jaw to capture and eat larger prey. The teeth are sharp and pointed backward to prevent the prey escaping.
 - ii. Bony fishes display a wide range of feeding strategies.
 - c. Like the fishes, amphibians and reptiles (classes Amphibia and Reptilia, respectively) are ectotherms, requiring less food than homeotherms.
 - d. Birds and mammals (classes Aves and Mammalia, respectively) are homeotherms.
 - i. Birds eat small amounts of food often and digestion is very fast to minimize the weight during flight. Birds must consume enough food to provide the energy needed for both endothermy and flight.
 - ii. Mammals have a diversity of teeth for different kinds of foods. By contrast, the teeth of reptiles are all similar.