Sponges, Mollusks, and Worms, Oh My!
Animals

General Features of Animals

- animals share many important characteristics, such as they
  - are heterotrophs
  - are multicellular and lack cell walls
  - can move from place to place
  - have diverse forms and habitats
  - reproduce, mostly, by sexual reproduction
  - have a common pattern of development
  - unique tissues

The Animal Family Tree

- the multicellular animals 35 very different phyla
  - to judge which phyla are more closely related, taxonomists compare anatomical features and aspects of embryological development
  - the end result are **phylogenies**, which are basically like family trees
  - the main branches of the phylogenies make possible the evolutionary history of animals

- Kingdom Animalia is traditionally divided into two main branches based on tissue presence

  - **Parazoa** possess neither tissues nor organs and have no discernible symmetry
    - they are represented mostly by the phylum Porifera, the sponges

  - **Eumetazoa** have a definite shape and symmetry and, in most cases, tissues organized into organs and organ systems

- although very different, the Parazoa and Eumetazoa are thought to have evolved from a common ancestor

  - the shared ancestor was probably a choanoflagellate

    - the choanoflagellate lived over 700 million years ago and was a colonial, flagellated protist

- within the Eumetazoan phylogeny, the family tree branches on the basis of the type of embryological layering

  - **Radiata** have two embryological layers, an outer **ectoderm** and an inner **endoderm**
    - this body plan is called **diploblastic**

- **Bilateria** have a third embryological layer, the **mesoderm**, that occurs between the ectoderm and the endoderm
  - this body plan is called **triploblastic**

- additional branches to the phylogenetic tree were assigned by identifying traits that were important to the evolutionary history of phyla
  - for example, the presence or absence of a body cavity
  - the traditional phylogeny of taxonomists relies on the either-or-nature of categories

The animal family tree: the traditional viewpoint.

- the traditional animal phylogeny is being revised because some of the important characters may not be conserved to the extent previously thought
  - **molecular systematics** offers a means to construct phylogenic trees using clusters of genes as means to detect relatedness
  - this new approach has resulted into significant refinements of the traditional phylogeny
    - for example, the protostomes have a more complex evolutionary history

The animal family tree: A new look.

Five Key Transitions in Body Plan

- the evolution of animals is marked by five key transitions in body plan

1. evolution of tissues
2. bilateral symmetry
3. body cavity
4. deuterostome development
5. segmentation

- the presence of tissues is the first key transition in the animal body plan
  - only the Parazoa, the sponges, lack defined tissues and organs
    - these animals exist as aggregates of cells with minimal intercellular coordination
  - all other animals besides members of the Parazoa possess tissues
    - they belong to the Eumetazoa

- virtually all animals other than sponges have a definite shape and symmetry

  - **radial symmetry** is a body plan in which all parts of the body are arranged along a central axis
    - if a plane passing through the central axis divides the organism in halves, the halves will be mirror images

- **bilateral symmetry** is body plan with distinct right and left halves that are mirror images
  - the plan allows for specialization among body regions

- the evolution of a body cavity was an important step in animal evolution
  - this internal space allowed for the support of organs, distribution of materials, and coordination of development
  - for example, the digestive tract can be larger and longer

- the subdivision of the body into **segments** is a key transition to the animal body plan that occurs early on during development

- in highly segmented animals, each segment can develop a more or less complete set of adult organ systems

- each segment can function as a separate locomotory unit

Evolutionary trends among the animals.

Sponges: Animals Without Tissues

- **sponges**, members of the phylum Porifera

  - their bodies a little more than masses of specialized cells embedded in a gel-like matrix

  - clumps of cells disassociated from a sponge can give rise to new sponges

  - the body of a sponge is perforated by many pores
    - **choanocytes** are flagellated cells that line the body cavity of the sponge and draw in water through the pores

  - the sponge is a filter feeder which traps any food particles

Diversity in sponges.

Cnidarians: Tissues Lead to Greater Specialization

- the Radiata include two phyla
  - **Cnidaria** comprises the hydra, jellyfish, corals and anemones
  - **Ctenophora** comprises the comb jellies

- the members of the Radiata have a body plan that allows them to interact with their environment on all sides

- a major evolutionary advance in the Radiata is **extracellular digestion** of food
  - digestion begins outside the body in a gut cavity called, the **gastrovascular cavity**
  - this form of digestion allows animals to digest an animal larger than itself

Representative cnidarians.

- **cnidarians** (phylum Cnidaria) are carnivores that capture prey with tentacles that ring their mouths
  - these tentacles and, sometimes, the body surface, bear stinging cells called **cnidocytes**
  - within each cnidocyte is a harpoon-like barb, called a **nematocyst**, which cnidarians use to spear their prey and they retract towards the tentacle
  - the nematocyst can discharge so explosively that it is capable of piercing the hard shell of a crab

Solid Worms: Bilateral Symmetry

- body symmetry differs among the Eumetazoa
  - **radial symmetry** means that multiple planes cutting the organism in half will produce mirror images
  - **bilateral symmetry** means that only one plane can cut the organism in half to produce mirror images
- most bilaterally symmetrical animals have evolved a definitive head end
  - this process is termed **cephalization**
- the bilaterally symmetrical eumetazoans produce three embryonic layers
  - ectoderm will develop into the outer coverings of the body and the nervous system
  - mesoderm will develop into the skeleton and muscles
  - endoderm will develop into the digestive organs and intestine
- the **solid worms** are the simplest of all bilaterally symmetrical animals
  - the largest phylum of these worms is the Phylum Platyhelminthes, which includes the flatworms
    - flatworms lack any internal cavity other than the digestive tract
      - this solid condition is called **acoelomate**
    - they have separate organs, including a uterus and testes

Body plan of a solid worm.

Bilateral Body plans

- there are three basic kinds of body plans found in bilaterally symmetrical animals
  - acoelomates have no body cavity
  - pseudocoelomates have a body cavity located between the mesoderm and the endoderm

- coelomates have a body cavity (called a coelom) that develops entirely within the mesoderm

Flatworms

- most flatworms are parasitic but some are free-living
  - flatworms range in size from less than a millimeter to many meters long
- there are two classes of parasitic flatworms
  - flukes
  - tapeworms
- the parasitic lifestyle has resulted in the eventual loss of features not used or needed by the parasite
  - for example, the parasites lack cilia in the adult stage and do not need eye spots
  - this loss of features that lack adaptive purpose for parasitism is sometimes called *degenerative evolution*
- tapeworms are a classic example of degenerative evolution
  - the body of a tapeworm has been reduced to two primary functions
    - eating
    - reproduction
  - if flatworms have a digestive cavity, then it is incomplete
    - the gut branches throughout the body and is involved in both digestion and excretion
    - they are capable of performing some extracellular digestion
  - the parasitic flatworms lack a gut entirely and absorb food directly through their body walls
- flatworms lack a circulatory system and all cells must be within diffusion distance of oxygen and food
- flatworms have a simple nervous system
  - they use sensory pits or tentacles along the sides of the head to detect food, chemical, and movement
  - free-living forms have eyespots to distinguish light from dark
- reproduction in flatworms is complex
  - most flatworms are **hermaphroditic**, meaning that each individual contains both

male and female reproductive structures
  - some flatworms have a complex succession of distinct larval stages
  - some flatworms are capable of asexual regeneration

Roundworms: The Evolution of a Body Cavity

- a key transition in the evolution of the animal body plan was the evolution of the body cavity
- the evolution of an internal body cavity helped improve the animal body design in three areas
  - circulation
  - movement
  - organ function

- seven phyla of bilaterally symmetrical animals have a pseudocoelom
  - the pseudocoelom serves as a **hydrostatic skeleton**, a skeleton that gains its rigidity from fluids kept under pressure
  - all pseudocoelomates lack a circulatory system
  - most pseudocoelomates have a complete digestive tract

- the phylum Nematoda contains the greatest number of species among the phyla that are pseudocoelomates
  - the members of this phylum include nematodes, eelworms, and other roundworms
  - they are unsegmented, cylindrical worms covered by a flexible cuticle that is molted as they grow
  - nematodes move in a whip-like fashion

Pseudocoelomates. (a) Nematodes (phylum Nematoda)

- some nematodes are parasitic in humans, cats, dogs, and animals of economic importance
  - heartworm in dogs is caused by a nematode
  - trichinosis is an infection caused by the nematode *Trichinella* and transmitted to humans who eat undercooked pork
  - intestinal roundworms, *Ascaris lumbricoides*, live in human intestines

Coelomates

- coelomate animals are more successful than pseudocoelomates because of the nature of embryonic development
  - **primary induction** is a process in animal development in which one of the three primary embryonic tissues interacts with another
  - the interaction requires physical contact
  - in coelomates, contact is made possible between mesoderm and endoderm
    - this interaction permits localized portions of the digestive tract to become highly specialized

Annelids: The Rise of Segmentation

- one of the early innovations to body plan to arise among the coelomates was **segmentation**
  - segmentation is the building of a body from a series of similar segments
    - this body plan offers a lot of flexibility in that small changes to segments can produce a new kind of segment with different functions
  - the first segmented animals to evolve were the **annelid worms**, phylum Annelida

- the basic body plan of an annelid is a tube within a tube
  - the digestive tract is suspended within the tube of the coelom
  - the tubes run from mouth to anus

- derived from this basic organization are three characteristics
  - repeated segments
  - specialized segments
  - connections

Mollusks

- the mollusks, members of the phylum Mollusca, are the only coelomates without segmented bodies

- the basic body of a mollusk is comprised of three regions
  - a head-foot
  - a visceral mass containing the body's organs
  - a mantle that envelopes the visceral mass and is associated with the gills

- There are three major groups of mollusks
  - **gastropods—**include the snails and slugs

  - **bivalves—**include clams, oysters, and scallops

  - **cephalopods—**include the octopi and squids

Three major groups of mollusks.

Arthropods: Advent of Jointed Appendages

- the most successful of all animal groups is the phylum Arthropoda, comprising the **arthropods**
  - these animals have jointed appendages
  - in addition to joints, arthropods have an **exoskeleton** made of chitin
    - the muscles of arthropods attach to the interior of this outer shell
    - the shell offers protection against predators and water loss

- chitin cannot support much weight

- arthropod size is limited as a result

- arthropod bodies are segmented like annelids
  - segments often fuse into functional groups in the adult stage

Segmentation in insects.

Protostomes and Deuterostomes

- there are two major kinds of coelomate animals representing two distinct evolutionary lines
  - **protostomes**
    - the mouth develops from or near the blastopore
  - **deuterostomes**
    - the anus forms from or near the blastopore; the mouth forms on another part of the blastula

Figure 25.34 Embryonic development in protostomes and deuterostomes.

- deuterostomes also differ from protostomes in three other fundamental ways
  - the pattern of cleavage
    - protostomes have **spiral** cleavage while deuterostomes have **radial** cleavage
  - fating of cells
    - it occurs later in deuterostome cleavage than in protostome cleavage
  - origin of the coelom

Echinoderms: The First Deuterostomes

- echinoderms belong to the phylum Echinodermata
  - **echinoderm** means "spiny skin" and refers to the calcium-rich ossicles that protude just beneath the echinoderm's skin
  - they are entirely marine animals and include sea stars, sea urchins, sand dollars, and sea cucumbers
  - all are bilaterally symmetrical as larvae but become radially symmetrical as adults

Diversity in echinoderms.

- a key adaptation of echinoderms is the **water vascular system**
  - this system is a fluid-filled and composed of a central ring canal around which five radial canals extend out into the arms
  - from each radial canal short side branches extend to form thousands of tiny, hollow **tube feet**

- most echinoderms reproduce sexually but asexual regeneration is also common

Chordates: Improving the Skeleton

- chordates belong to the phylum Chordata and are deuterostome coelomates

- they exhibit a truly internal endoskeleton with muscles attached to an internal rod, called a notochord
- this innovation opened the door to large body sizes not possible in earlier animal forms

- the approximately 56K species of chordates share four principal features
  - notochord
  - nerve cord
  - pharyngeal pouches
  - postanal tail

- all chordates have all four of these characteristics at some time in their lives.

- not all chordates are vertebrates
  - tunicates and lancelets

- vertebrate chordates differ from tunicates and lancelets in two important respects

  - vertebrates have a backbone
    - this replaces the role of the notochord

  - vertebrates have a distinct and well-differentiated head

A mouse embryo.