Introduction to Animal Diversity

Chapter 32

- Objectives
  - List the characteristics that combine to define animals
  - Summarize key events of the Paleozoic, Mesozoic, and Cenozoic eras
  - Distinguish between the following pairs or sets of terms: radial and bilateral symmetry; grade and clade of animal taxa; diploblastic and triploblastic; spiral and radial cleavage; determinate and indeterminate cleavage; acoelomate, pseudocoelomate, and coelomate grades
  - Compare the developmental differences between protostomes and deuterostomes

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- Compare the alternate relationships of annelids and arthropods presented by two different proposed phylogenetic trees
- Distinguish between ecdysozoans and lophotrochozoans

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What is an Animal?

- The animal kingdom extends far beyond humans and other animals we may encounter
- Several characteristics of animals sufficiently define the group

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Nutritional Mode

- Animals are heterotrophs that ingest their food

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Cell Structure and Specialization

- Animals are multicellular eukaryotes
  - Their cells lack cell walls
  - Their bodies are held together by structural proteins such as collagen
  - Nervous tissue and muscle tissue are unique to animals

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Reproduction and Development

- Most animals reproduce sexually with the diploid stage usually dominating the life cycle
  - After a sperm fertilizes an egg the zygote undergoes cleavage, leading to the formation of a blastula
  - The blastula undergoes gastrulation resulting in the formation of embryonic tissue layers and a gastrula
- Many animals have at least one larval stage
  - A larva is sexually immature and morphologically distinct from the adult; it eventually undergoes metamorphosis

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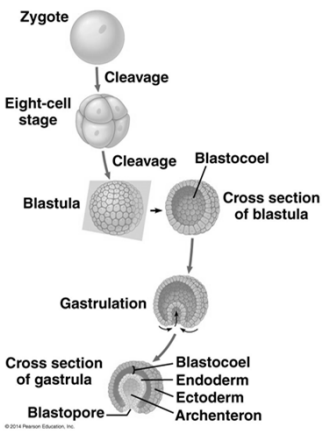

- All animals, and only animals have Hox genes that regulate the development of body form
  - Although the Hox family of genes has been highly conserved it can produce a wide diversity of animal morphology

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Animal Phylogeny

- The animal kingdom includes not only great diversity of living species but the even greater diversity of extinct ones as well
- The common ancestor of living animals may have lived 1.2 billion–800 million years ago
  - May have resembled modern choanoflagellates, protists that are the closest living relatives of animals
  - Was probably itself a colonial, flagellated protist

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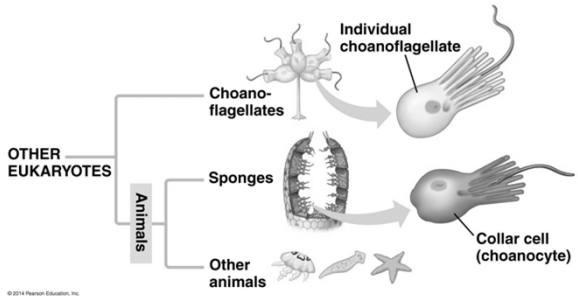

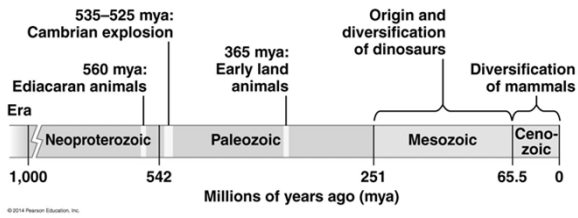

Neoproterozoic Era (1 Billion–524 Million Years Ago)

- Early members of the animal fossil record include the Ediacaran fauna

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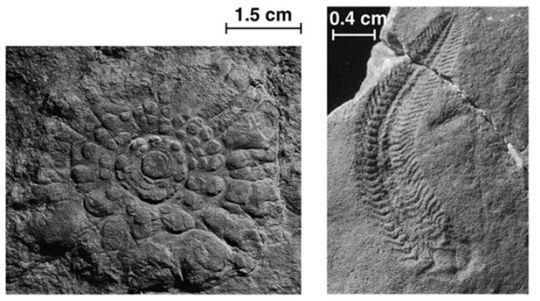

(a) *Mawsonites spriggi* (b) *Spriggina floundersi*

Paleozoic Era (542–251 Million Years Ago)

- The Cambrian explosion marks the earliest fossil appearance of many major groups of living animals
- There are three main hypotheses for what caused the diversification of animals
  - Ecological Causes:
    - The emergence of predator-prey relationships led to a diversity of evolutionary adaptations, such as various kinds of protective shells and diverse modes of locomotion

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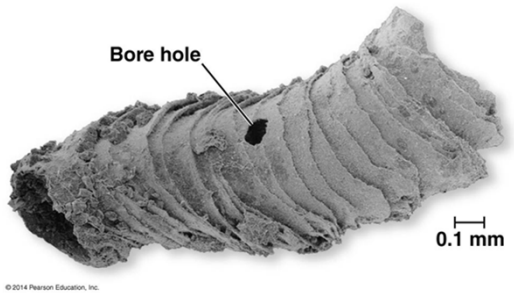

- Geological Causes:
  - Atmospheric oxygen may have finally reached high enough concentrations to support more active metabolism
- Genetic causes:
  - Much of the diversity in body form among animal phyla is associated with variations in the spatial and temporal expression of Hox genes within the embryo
- These three hypotheses are not mutually exclusive

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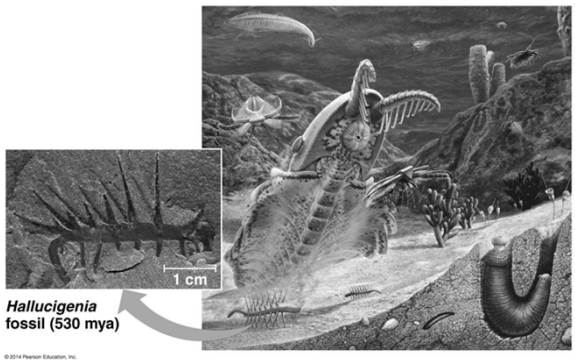

- Animal diversity continued to increase through the Paleozoic, but was punctuated by mass extinctions
  - Animals began to make an impact on land by 460 million years ago
  - Vertebrates made the transition to land around 360 million years ago

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Mesozoic Era (251–65.5 Million Years Ago)

- During the Mesozoic era dinosaurs were the dominant terrestrial vertebrates
  - Coral reefs emerged, becoming important marine ecological niches for other organisms

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Cenozoic Era (65.5 Million Years Ago to the Present)

- The beginning of this era followed mass extinctions of both terrestrial and marine animals
  - Modern mammal orders and insects diversified during the Cenozoic

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Animal “Body Plans”

- Zoologists sometimes categorize animals according to a body plan, a set of morphological and developmental traits
- A grade is a group whose members share key biological features
  - A grade is not necessarily a clade, or monophyletic group

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Symmetry

- Animals can be categorized according to the symmetry of their bodies, or lack of it
  - Some animals have radial symmetry like in a flower pot
  - Some animals exhibit bilateral symmetry or two-sided symmetry

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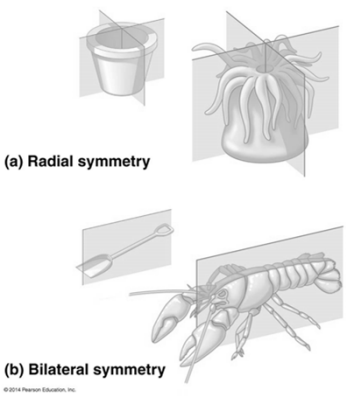

- Bilaterally symmetrical animals have:
  - A dorsal (top) side and a ventral (bottom) side
  - A right and left side
  - Anterior (head) and posterior (tail) ends
  - Cephalization, the development of a head

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Tissues

- Animal body plans also vary according to the organization of the animal's tissues
  - Tissues are collections of specialized cells isolated from other tissues by membranous layers
- Animal embryos form germ layers, embryonic tissues, including ectoderm, endoderm, and mesoderm
  - Diploblastic animals have two germ layers
  - Triploblastic animals have three germ layers

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Body Cavities

- In triploblastic animals a body cavity may be present or absent
  - A true body cavity is called a coelom and is derived from mesoderm
  - A pseudocoelom is a body cavity derived from the blastocoel, rather than from mesoderm
- Organisms without body cavities are considered acoelomates

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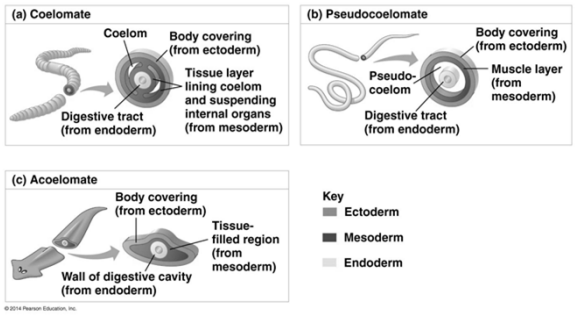

Protostome and Deuterostome Development

- Based on certain features seen in early development many animals can be categorized as having one of two developmental modes: protostome development or deuterostome development

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Cleavage

- In protostome development cleavage is spiral and determinate
- In deuterostome development cleavage is radial and indeterminate

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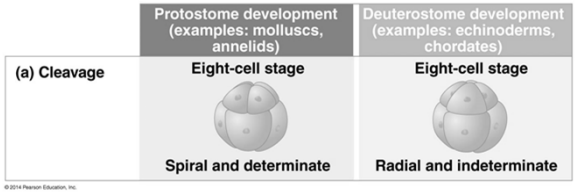

Coelom Formation

- In protostome development the splitting of the initially solid masses of mesoderm to form the coelomic cavity is called schizocoelous development
- In deuterostome development formation of the body cavity is described as enterocoelous development

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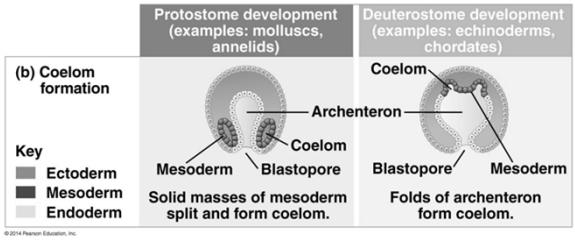

Fate of the Blastopore

- In protostome development the blastopore becomes the mouth
- In deuterostome development the blastopore becomes the anus

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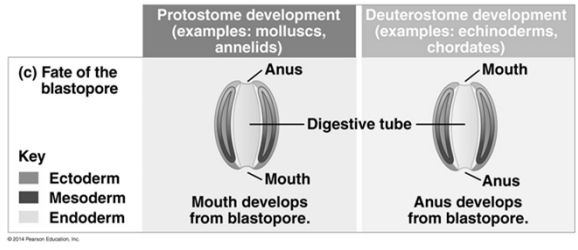

Animal Diversity

- Zoologists currently recognize about 35 animal phyla
- The current hypothesis of animal phylogeny is based mainly on morphological and developmental comparisons

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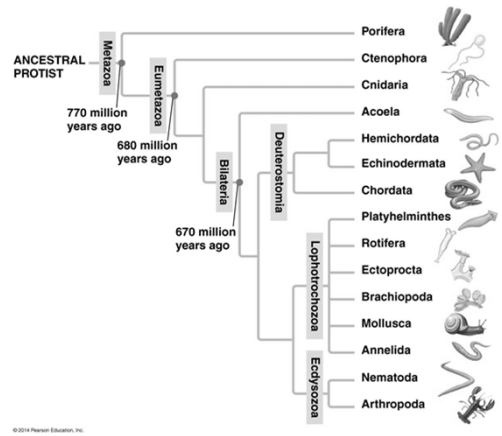

Key Points of the Hypothesis

- All animals share a common ancestor
- Sponges are basal animals
- Eumetazoa is a clade of animals with true tissues
- Most animal phyla belong to the clade Bilateria
- Chordates and some other phyla belong to the clade Deuterostomia

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- Several recent molecular studies generally assign two sister taxa to the protostomes rather than one:
  - the ecdysozoans and the lophotrochozoans
- Ecdysozoans share a common characteristic
  - They shed their exoskeletons through a process called ecdysis

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- Lophotrochozoans share a common characteristic called the lophophore, a feeding structure
  - Other phyla go through a distinct larval stage called a trochophore larva

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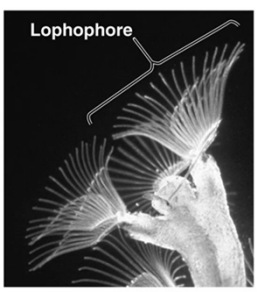
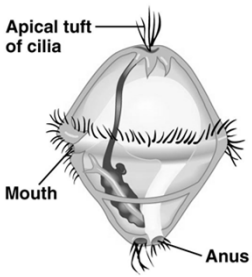


(a) Lophophore feeding structures of an ectoproct



(b) Structure of a trochophore larva

Future Directions in Animal Systematics

- Phylogenetic studies based on larger databases will likely provide further insights into animal evolutionary history

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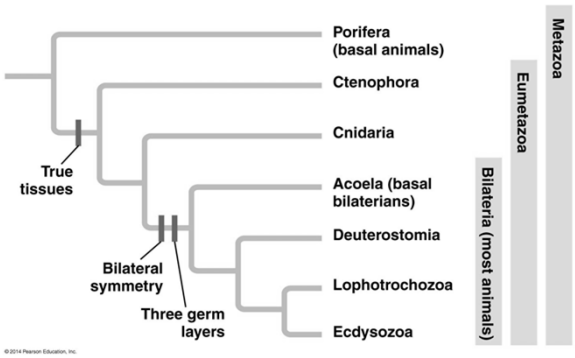

Blastopore Fate	Phyla
Protostomy (P)	Platyhelminthes, Rotifera, Nematoda; most Mollusca, most Annelida; few Arthropoda
Deuterostomy (D)	Echinodermata, Chordata; most Arthropoda; few Mollusca, few Annelida
Neither (N)	Acoela

Source: A. Hejnol and M. Martindale, The mouth, the anus, and the blastopore—open questions about questionable openings. In *Animal Evolution: Genomes, Fossils and Trees*, eds. D. T. J. Littlewood and M. J. Telford, Oxford University Press, pp. 33–40 (2009).