Chapter 32: An Introduction to Animal Diversity

Overview: Welcome to Your Kingdom

- The animal kingdom extends far beyond humans and other animals we may encounter
- **1.3 million living species of animals** have been identified
  (How many could you name?)

What makes an Animal?

- There are always exceptions, but several characteristics together define the group

1. Ingest their food (**heterotrophic**), digestion is internal
2. **Multicellular** eukaryotes **lacking cell walls**
3. Bodies held together by **structural proteins**: e.g., collagen
4. Possession of **nervous and muscular tissues** (movement)
5. Most animals reproduce sexually, **2N stage dominant**

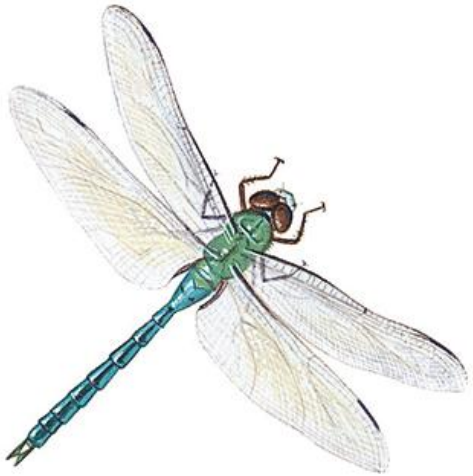
What else makes an Animal?

6. After fertilization, the zygote undergoes rapid cell division called **cleavage**, leading to the formation of a **blastula**
   (multicellular stage: cell division occurs without growth)

7. The **blastula undergoes gastrulation**, forming a gastrula with different layers of embryonic tissues

8. Many animals have **at least one larval stage**

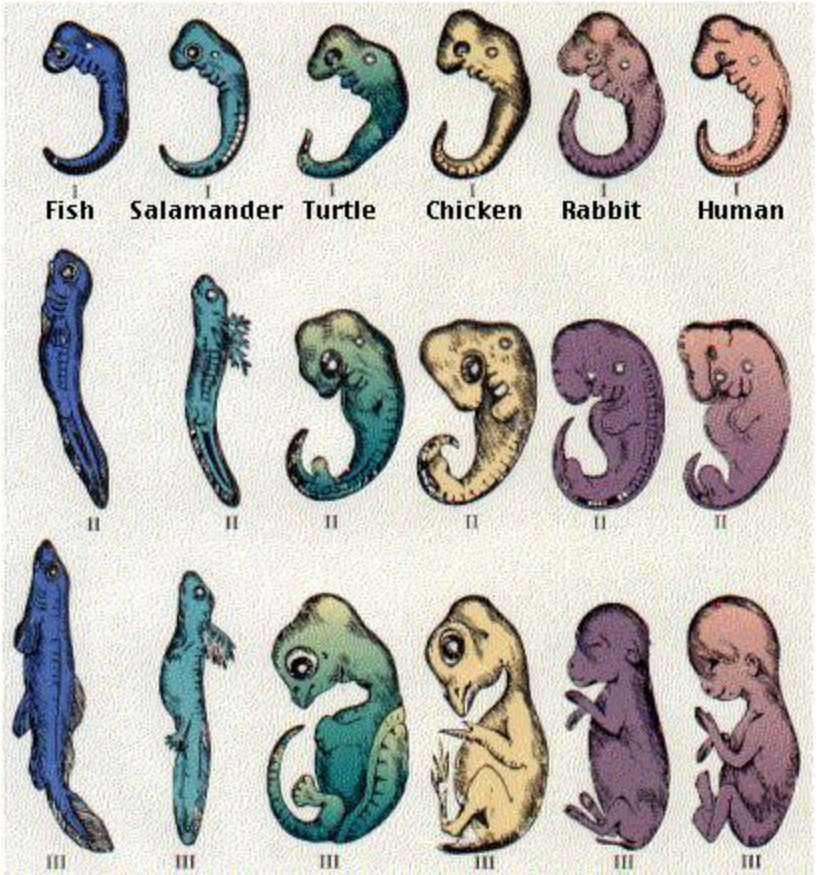
9. A larva is **sexually immature and morphologically distinct** from the adult; it eventually undergoes **metamorphosis**



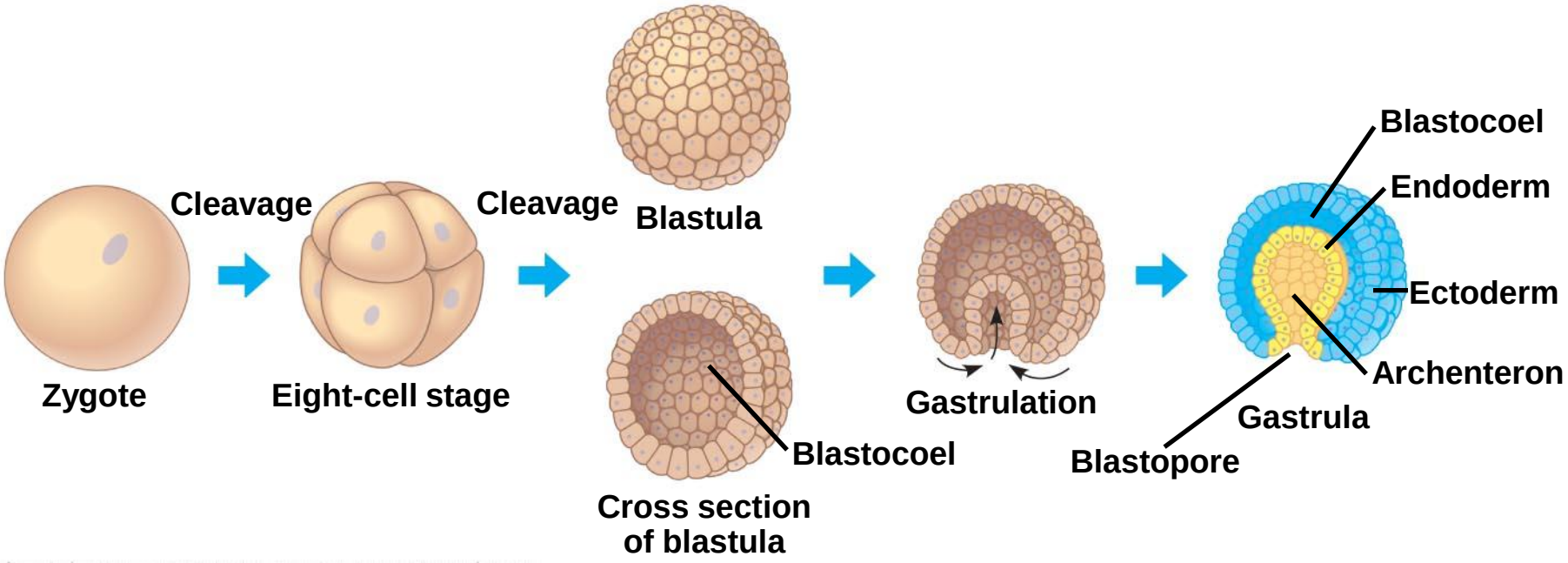
What else makes an Animal?

10. All animals, and only animals, have **Hox genes that regulate the development of body form** **(They control expression of other genes)**

11. Although the Hox family of genes has been highly **conserved**, it can produce a wide **diversity of animal morphology**

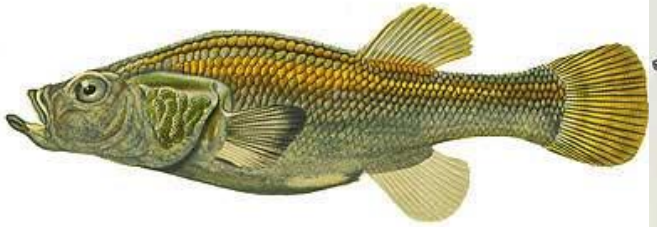


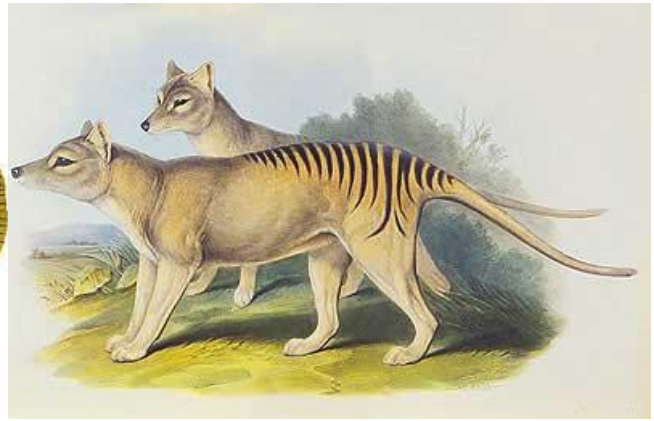
Zygote → Cleavage → Blastula → Gastrulation



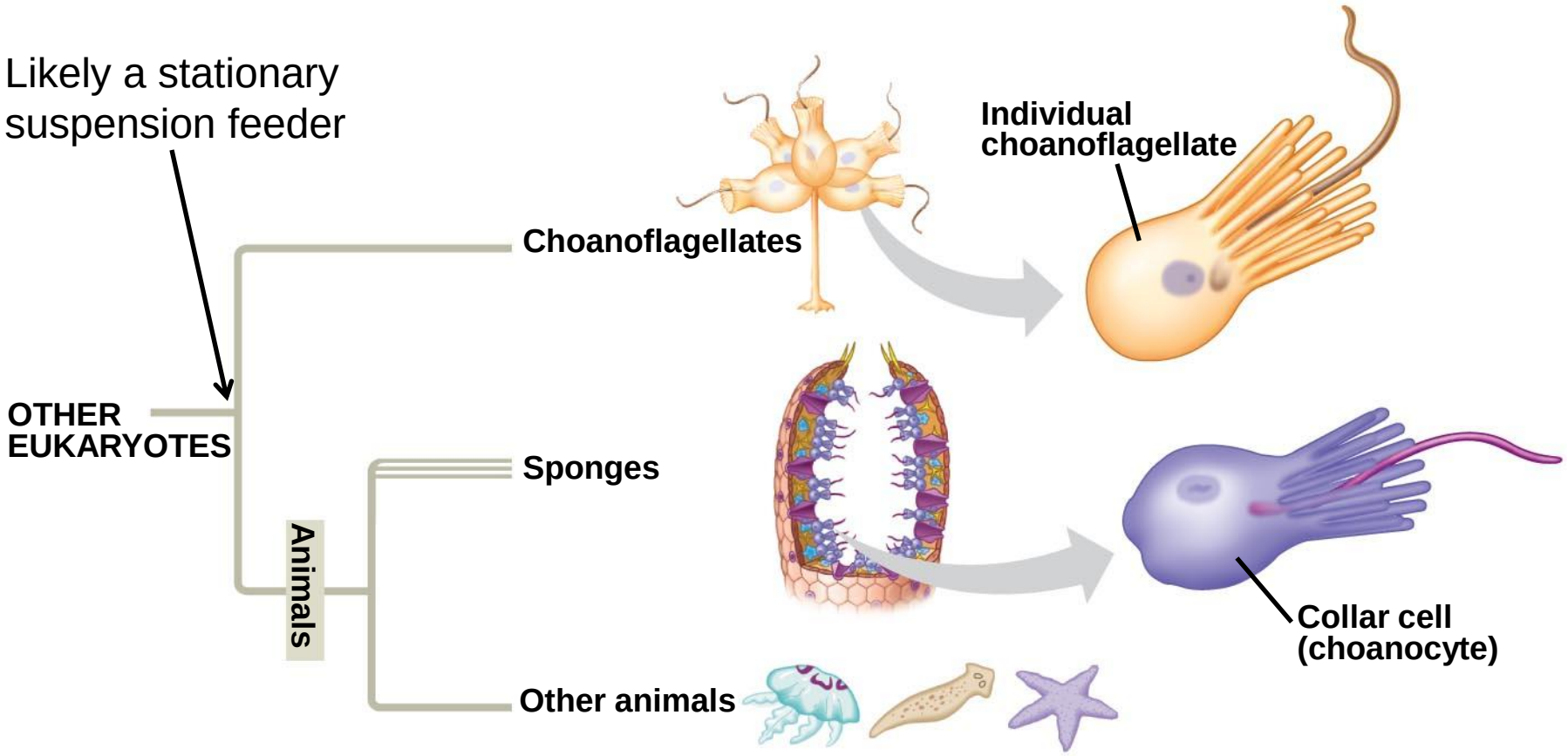
The history of animals

- There are **more extinct animals than living ones** **(that means more than 1.3 million species are gone)**
- The **common ancestor of living animals** may have lived between 675 and 875 million years ago
- This ancestor may have resembled modern **choanoflagellates, protists** that are the closest living relatives of animals





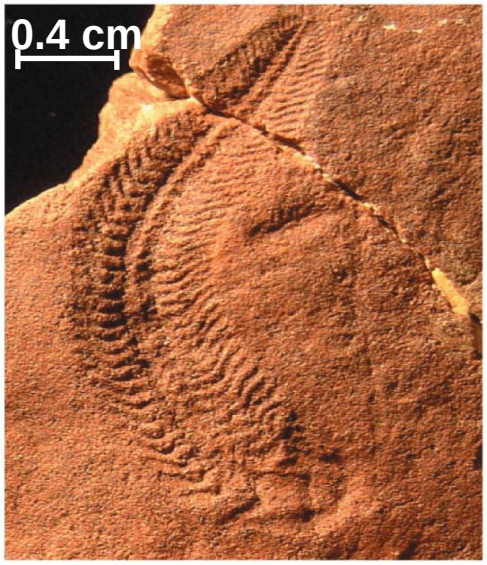
The history of animals



Neoproterozoic Era (1 Billion–524 Million Years Ago)

- Early members of the animal fossil record include the **Ediacaran biota** (565 to 550 million years ago)

(a) ***Mawsonites spriggi***



(b) ***Spriggina floundersi***

Paleozoic Era (542–251 MYA)

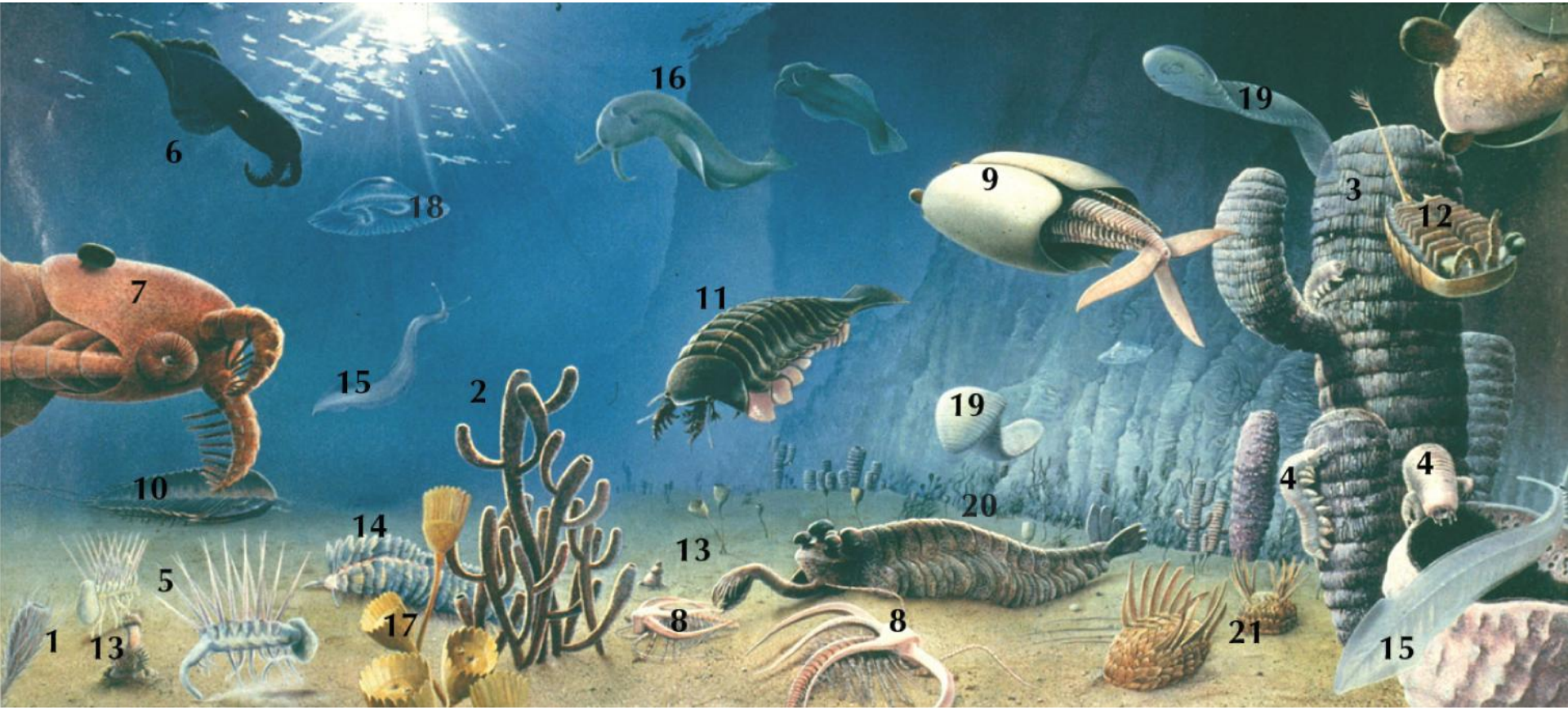
- The Cambrian explosion (535-525 mya) marks the earliest fossil appearance of many major groups of living animals
- There are several hypotheses regarding the cause of the Cambrian explosion

1. New predator-prey relationships **(Why would this help?)**
2. A rise in atmospheric oxygen
3. The evolution of the Hox gene complex

Most of our info on this came from Canada!

The Burgess Shale in Yoho National Park

Most of our info on this came from Canada!



The Burgess shale contains fossils from as many as 20 Extinct phyla of invertebrates (Where is the Burgess Shale?)

Paleozoic Era (542–251 MYA)

- 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**

Mesozoic Era (251–65.5 Million Years Ago)

- **Coral reefs emerged**, becoming important marine ecological niches for other organisms
- During the Mesozoic era, dinosaurs were the **dominant terrestrial vertebrates**
- The **first mammals** emerged during this time, diversification of form occurred as well

Cenozoic Era (65.5 MYA to Present)

- The beginning of the Cenozoic era followed **mass extinctions** of both terrestrial and marine animals
- These extinctions included the **large, nonflying dinosaurs and the marine reptiles**
- Modern **mammal** orders and **insects** diversified during the **Cenozoic**

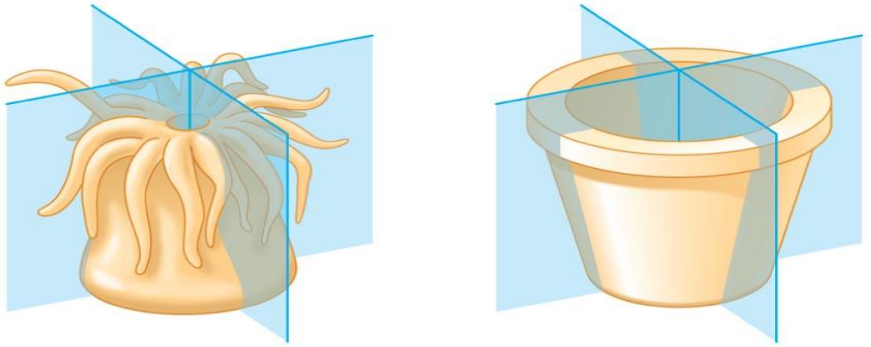
Animals can be characterized by “body plans”

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

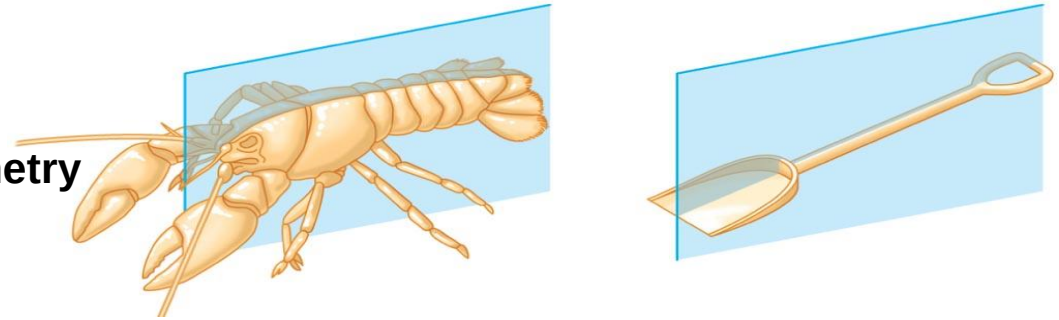
Symmetry

- Animals can be categorized according to the **symmetry of their bodies, or lack of it**
- Some animals have **radial symmetry**, some **bilateral**

(a) Radial symmetry



(b) Bilateral symmetry



Symmetry Pop Quiz

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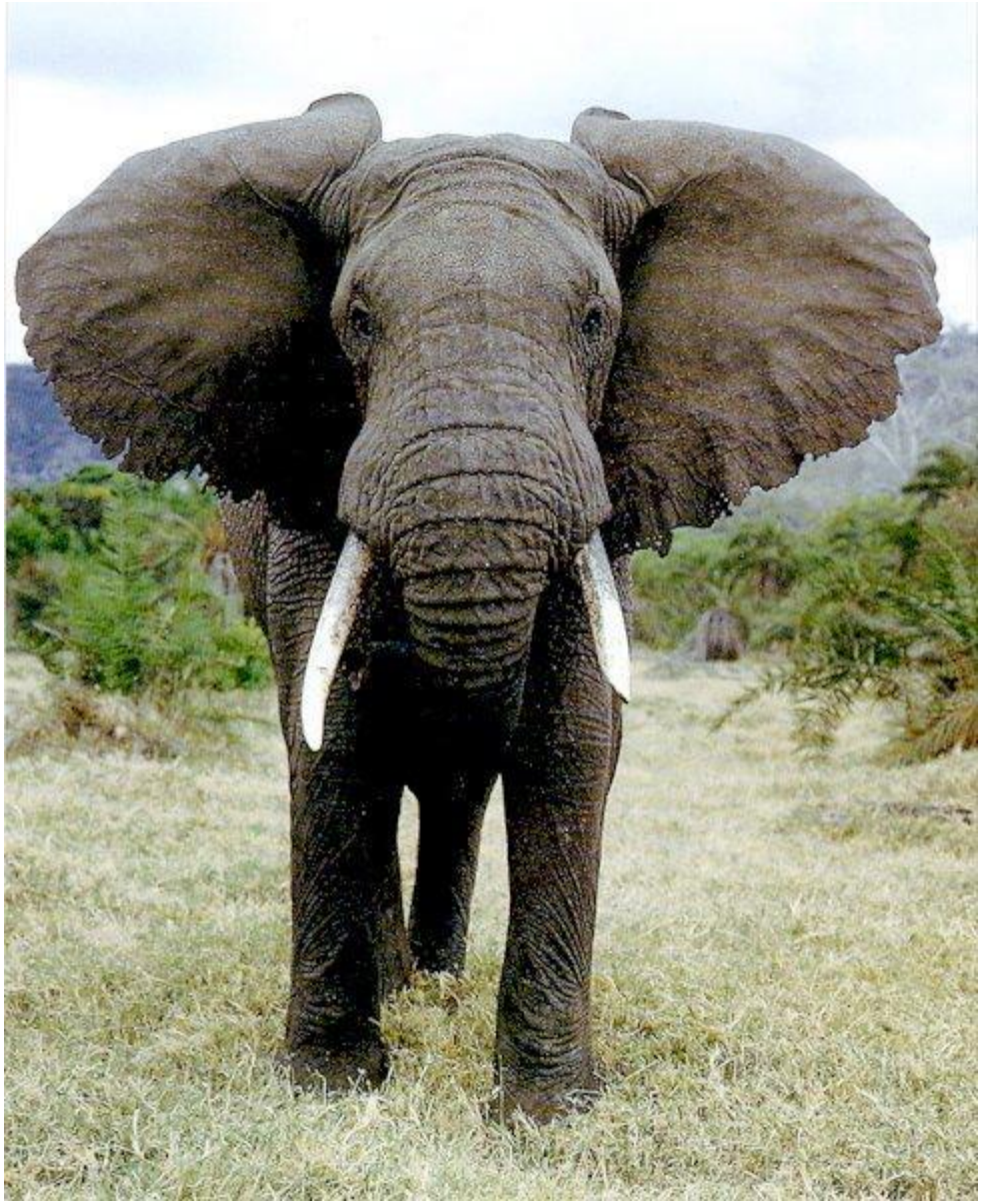

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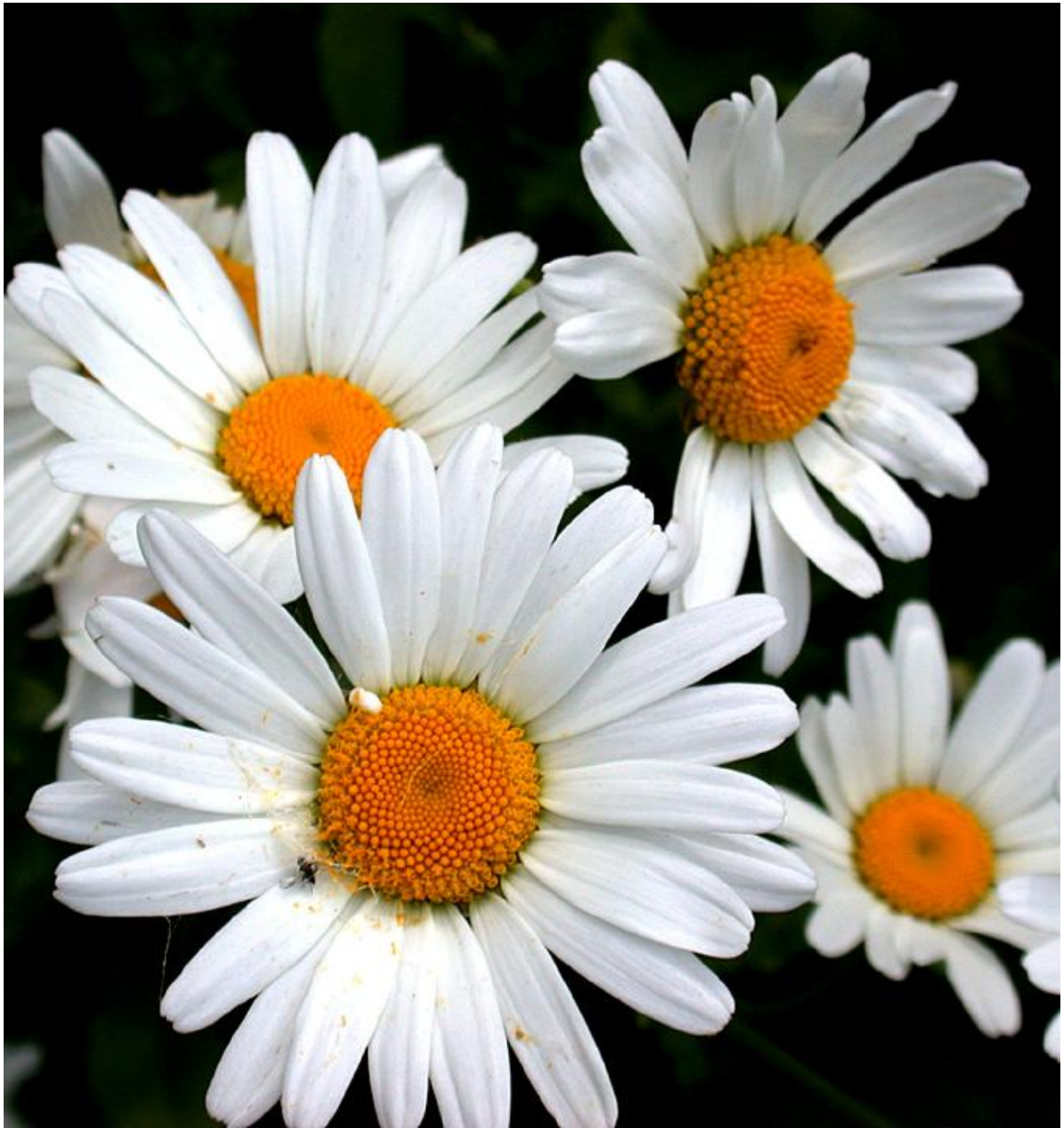

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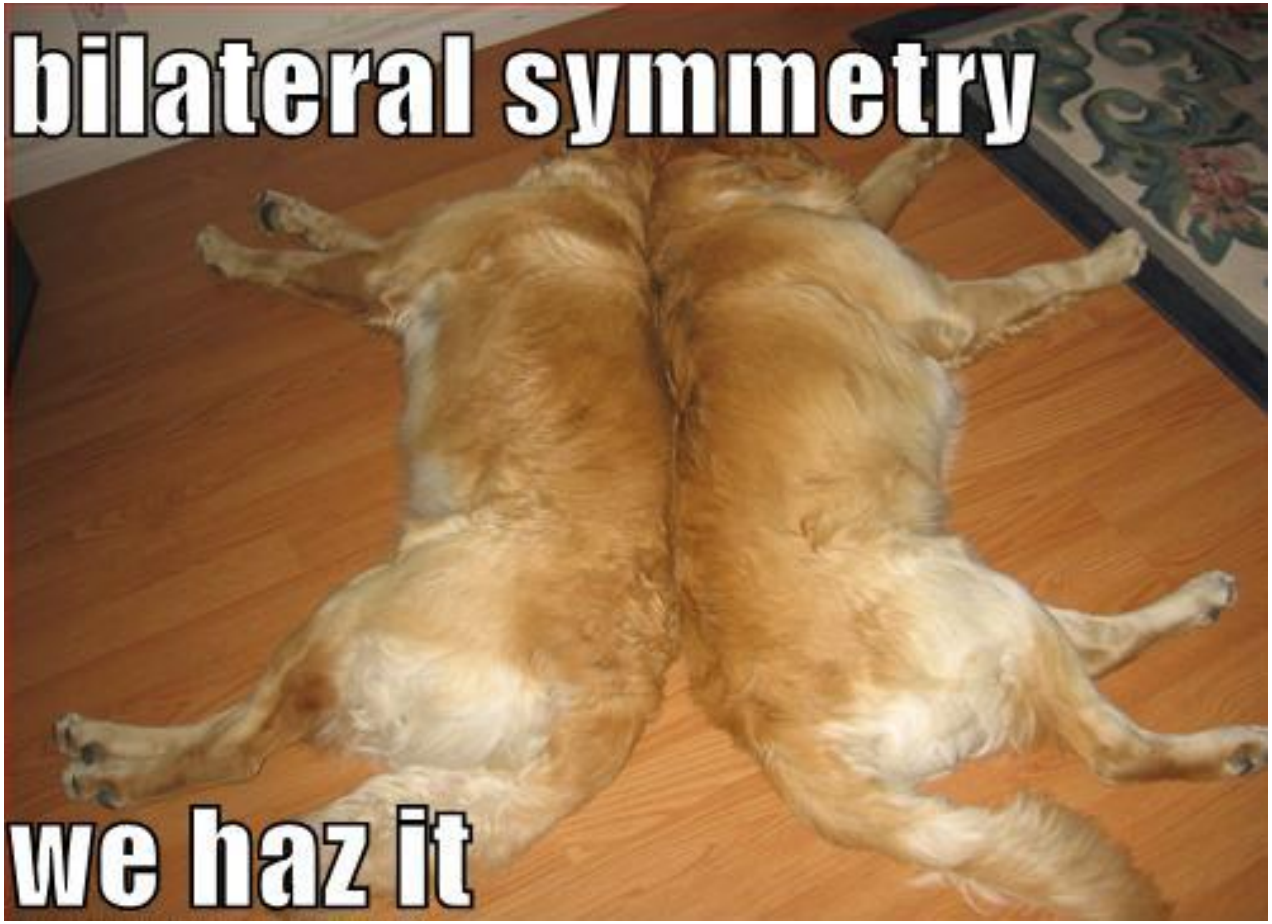
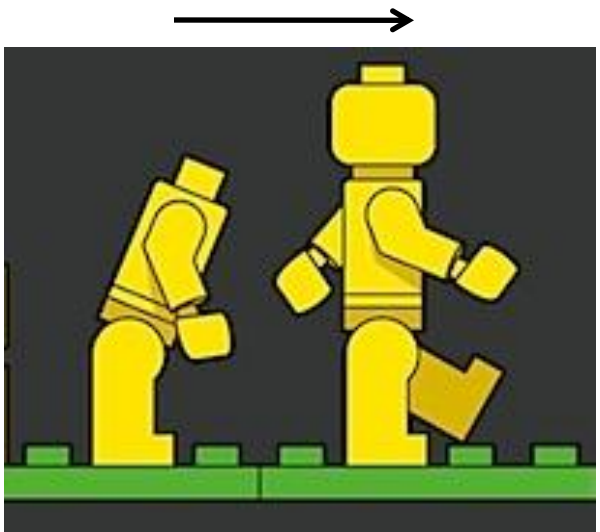


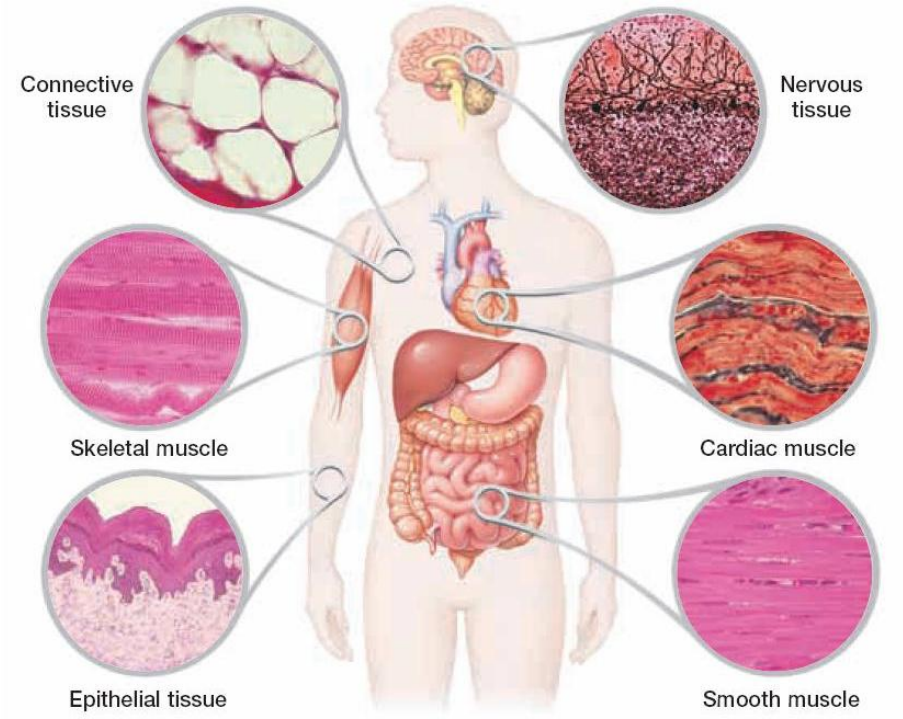
Symmetry

- Bilaterally symmetrical animals have:
  1. **Dorsal** (top) side and a **ventral** (bottom) side **(Are we bilaterally symmetrical? Where's our dorsal side etc.?)**
  2. **Right** and **left** side **(most of us know this one)**
  3. **Anterior** (head) and **posterior** ends (tail/butt)
  4. **Cephalization**, the development of a head



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** **(What is a tissue?)**
- During development, **three germ layers** give rise to the tissues and organs of the animal embryo

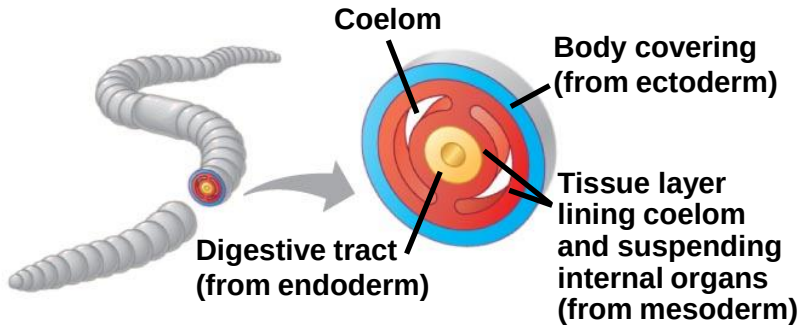


The Germ Layer

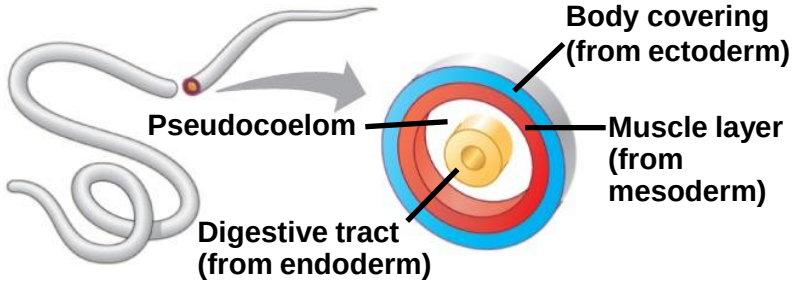
- **Ectoderm** is the germ layer covering the embryo's surface
- **Endoderm** is the **innermost germ layer** and lines the developing digestive tube, called the archenteron
- **Diploblastic animals** have ectoderm and endoderm
- **Triploblastic animals** also have an intervening mesoderm layer; these include **all bilaterians** **(arthropods/vertebrates)**

Body Cavities

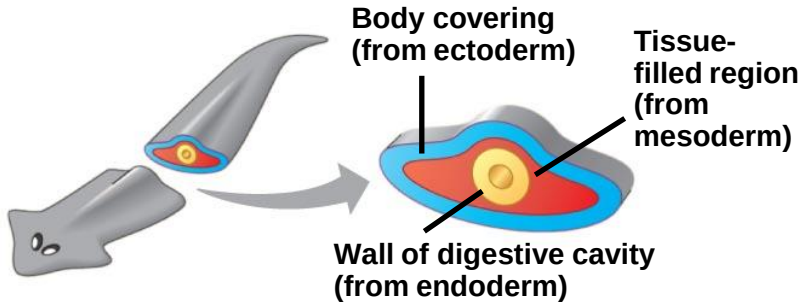
- Most **triploblastic animals possess a body cavity**
- A true body cavity is called a **coelom** and is derived from mesoderm
- **Coelomates** are animals that possess a true coelom



(a) Coelomate



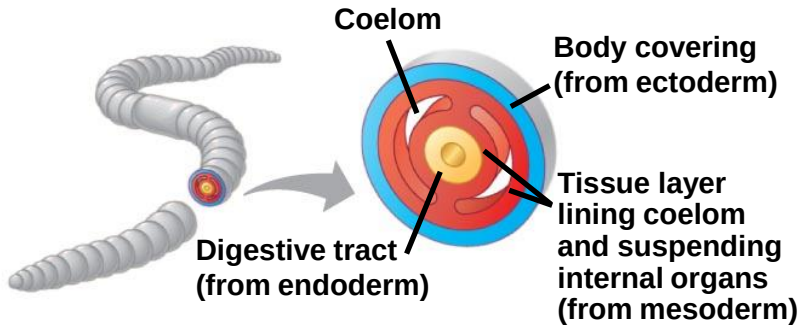
(b) Pseudocoelomate



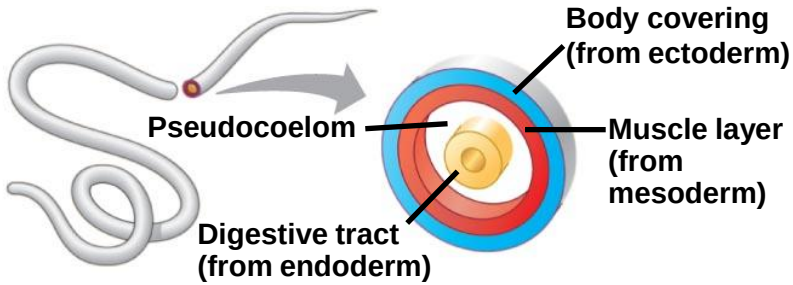
(c) Acoelomate

Body Cavities

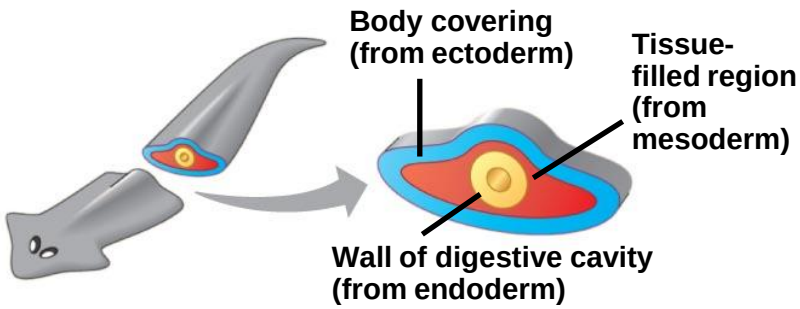
- A **pseudocoelom** is a body cavity derived from the mesoderm and endoderm
- **Pseudocoelomates** are triploblastic animals that possess a pseudocoelom
- **Acoelomates** are triploblastic animals that lack a body cavity
- Without a coelom, every heart beat of movement of your gut would register on your surface



(a) Coelomate



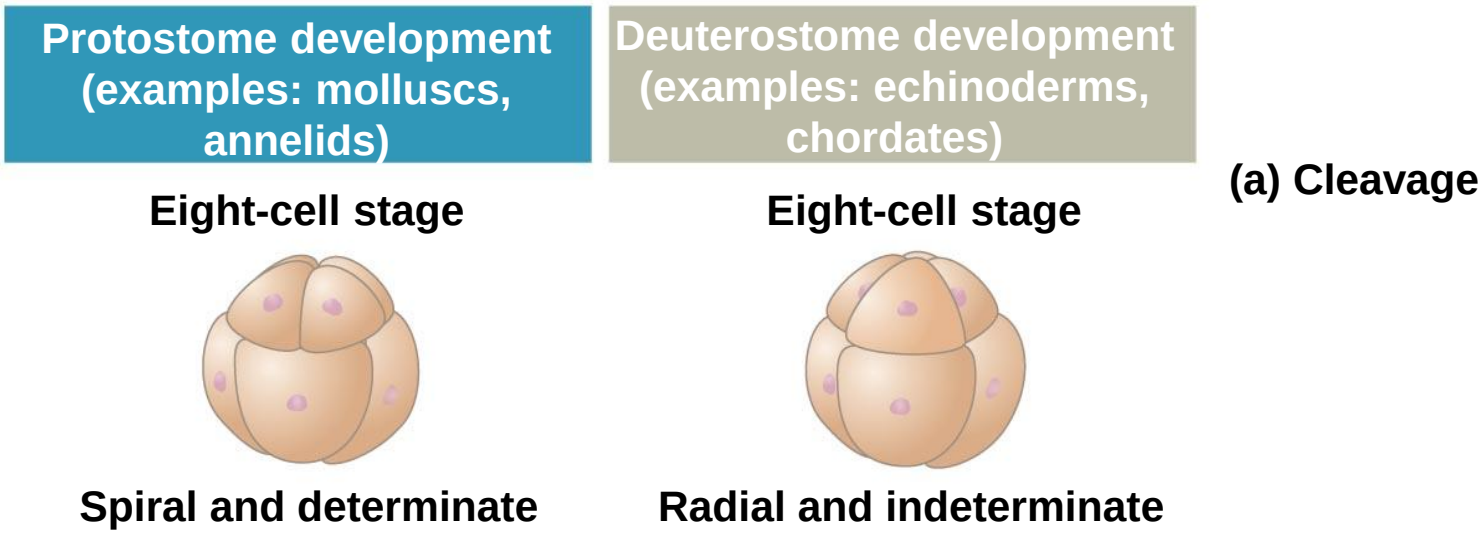
(b) Pseudocoelomate



(c) Acoelomate

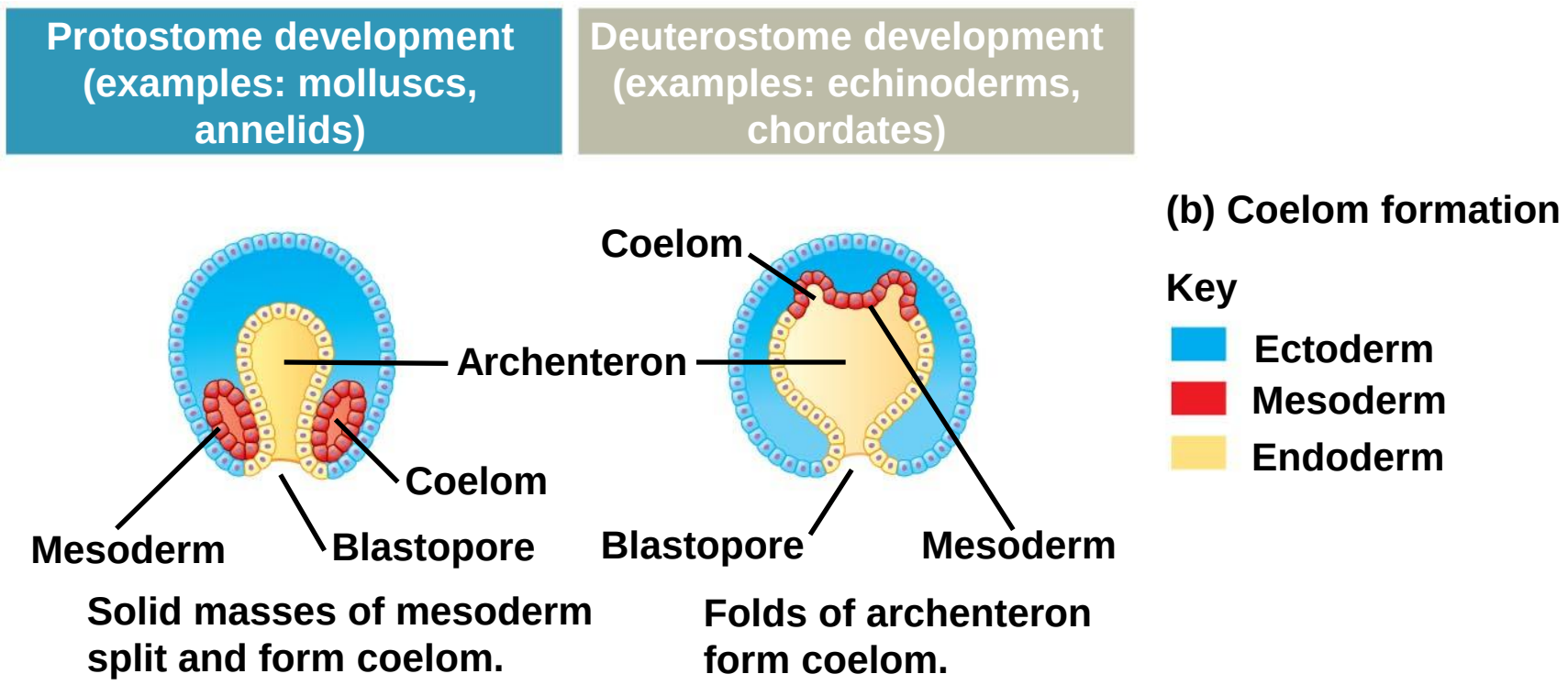
Protostome and Deuterostome Development

- Based on early development, many animals can be categorized as having **protostome development** or **deuterostome development** **(Which are we?)**
- With **indeterminate cleavage**, each cell in the early stages of cleavage can develop into a complete embryo
- **Indeterminate cleavage** makes possible identical twins, and embryonic stem cells **(Explain this)**



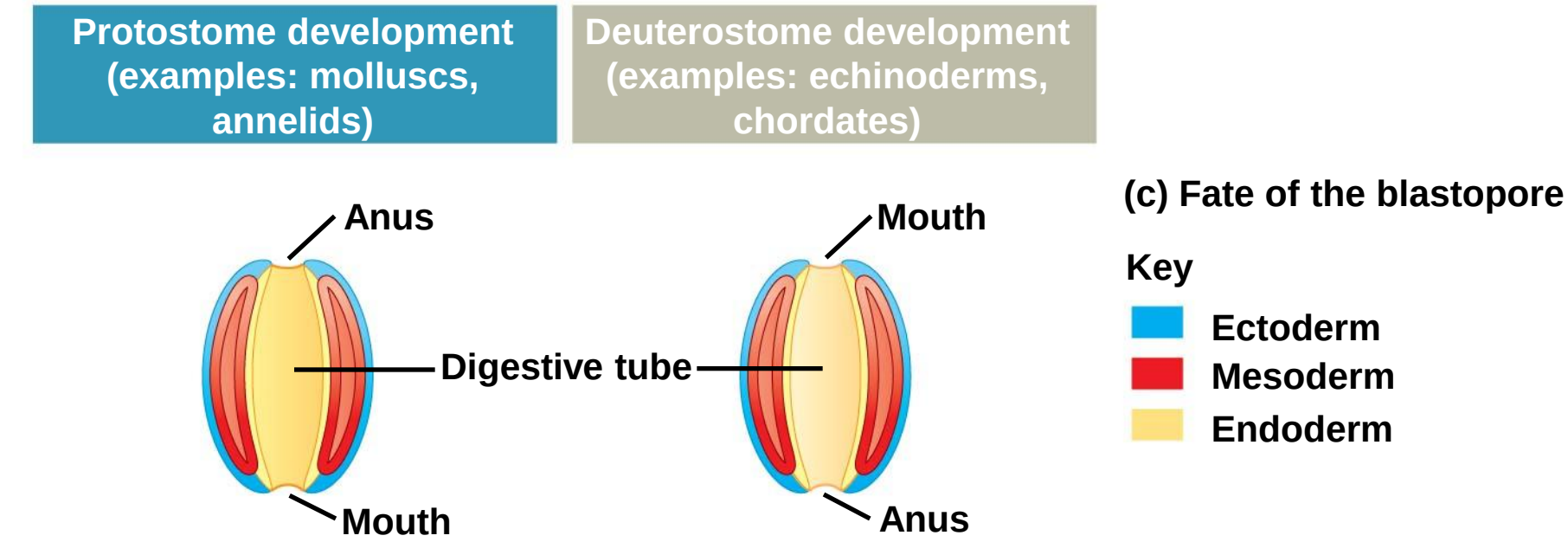
Coelom Formation

- In **protostome** development, the **splitting of solid masses of mesoderm forms the coelom**
- In **deuterostome** development, the **mesoderm buds from the wall of the archenteron to form the coelom**



Fate of the Blastopore

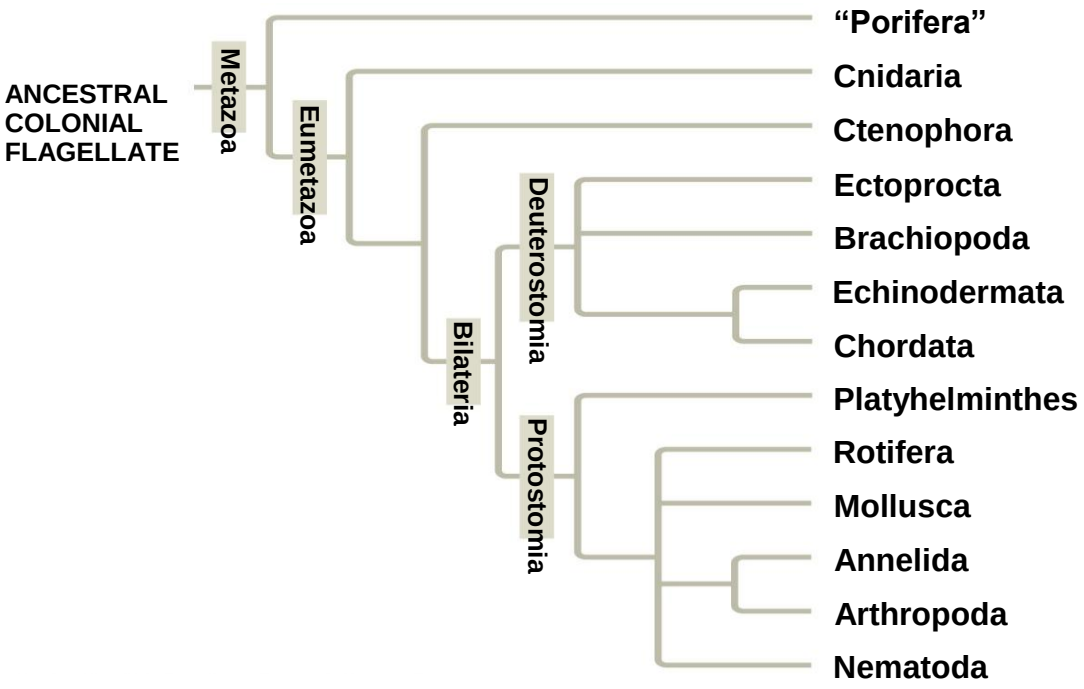
- The **blastopore** forms during gastrulation and **connects the archenteron to the exterior of the gastrula**
- **Protostome** development: **blastopore becomes the mouth**
- **Deuterostome** development: **blastopore becomes the anus**



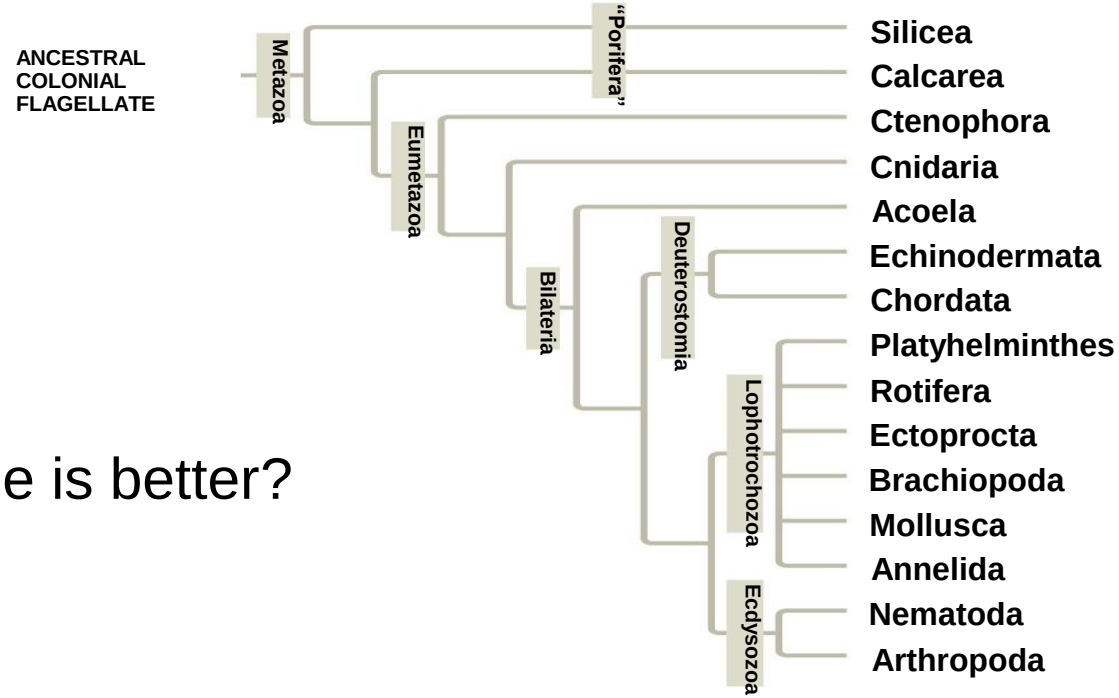
New views of animal phylogeny are emerging

- Zoologists recognize about **three dozen animal phyla**
- Current debate has led to the development of **two phylogenetic main hypotheses for animals** **(but there are other fringe hypotheses)**
- So basically there's a lot we don't know about the evolutionary history of animals



based on Morphological & developmental data



based on molecular data

So which one is better?

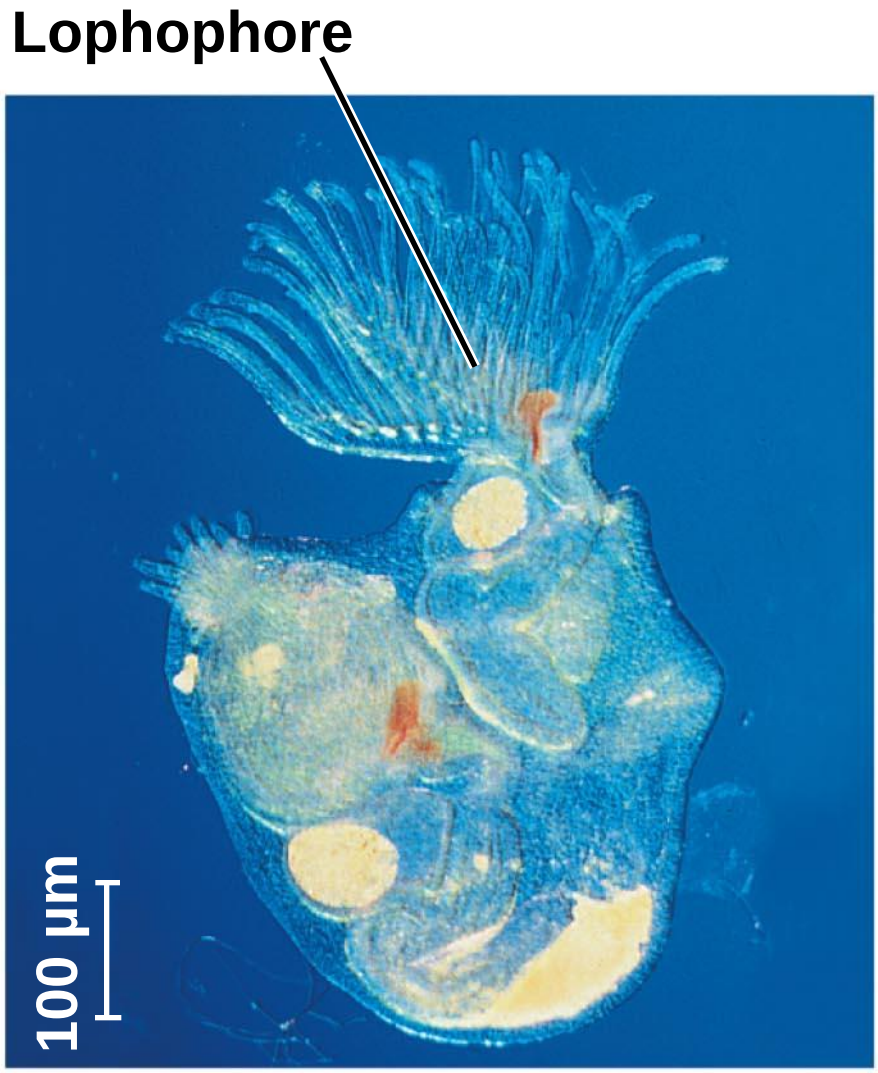
Points of Agreement

- All animals share a **common ancestor**
- **Sponges are basal** animals **(What does 'basal' mean in this context?)**
- **Eumetazoa is a clade of animals** with true tissues
- Most animal phyla belong to the **clade Bilateria**, and are called **bilaterians**
- **Chordates** and some other phyla belong to the clade **Deuterostomia** **(Where does the word chordates come from?)**

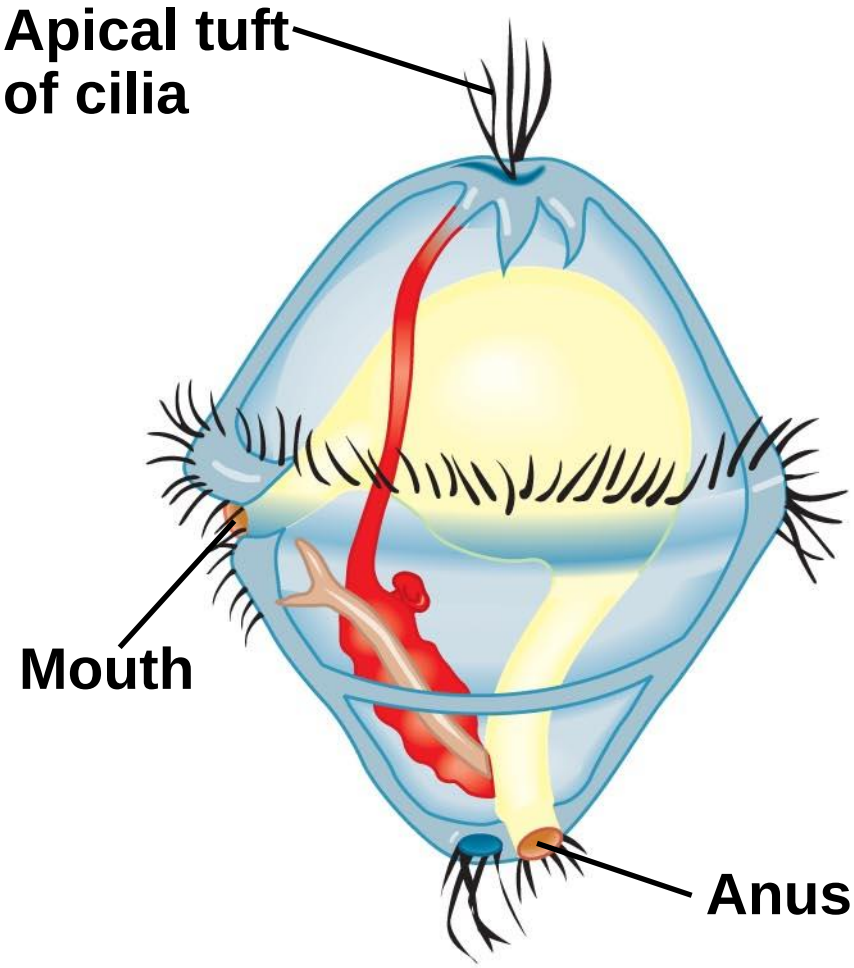
Progress in Resolving Bilaterian Relationships

- The morphology-based tree divides bilaterians into two clades: **deuterostomes** and **protostomes**
- In contrast, recent molecular studies indicate three bilaterian clades: **Deuterostomia, Ecdysozoa,** and **Lophotrochozoa**
- **Ecdysozoans** shed their exoskeletons through a process called ecdysis
- Some **Lophotrochozoans** have a feeding structure called a lophophore
- Other phyla go through a distinct developmental stage called the **trochophore larva**

An example of Ecdysis, the shedding of an exoskeleton by a cicada



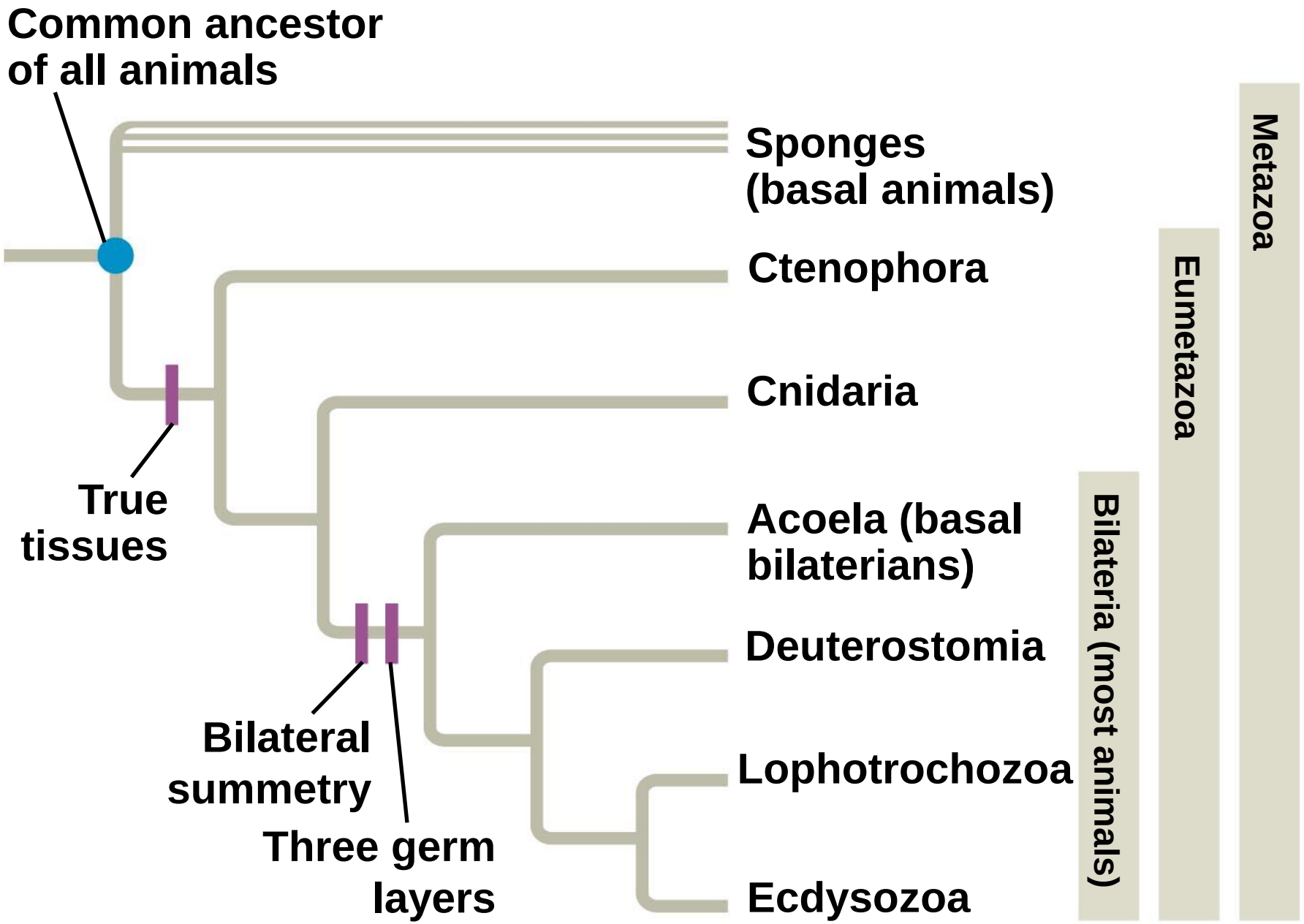
(a) An ectoproct



(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
- Will we likely make faster progress with this phylogeny work compared to that in other groups like the **protists and bacteria**? **(Why?)**


Common ancestor of all animals
Sponges (basal animals)
Ctenophora
Cnidaria
True tissues
Acoela (basal bilaterians)
Deuterostomia
Bilateral summetry
Lophotrochozoa
Three germ layers
Ecdysozoa
Bilateria (most animals)
Eumetazoa
Metazoa

You should now be able to:

1. List the characteristics that combine to define animals
2. Summarize key events of the Paleozoic, Mesozoic, and Cenozoic eras
3. 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
4. Compare the developmental differences between protostomes and deuterostomes
5. Compare the alternate relationships of annelids and arthropods presented by two different proposed phylogenetic trees
6. Distinguish between ecdysozoans and lophotrochozoans