1 Introduction to Animal Diversity

Chapter 32

2

5 major Eukaryote Clades

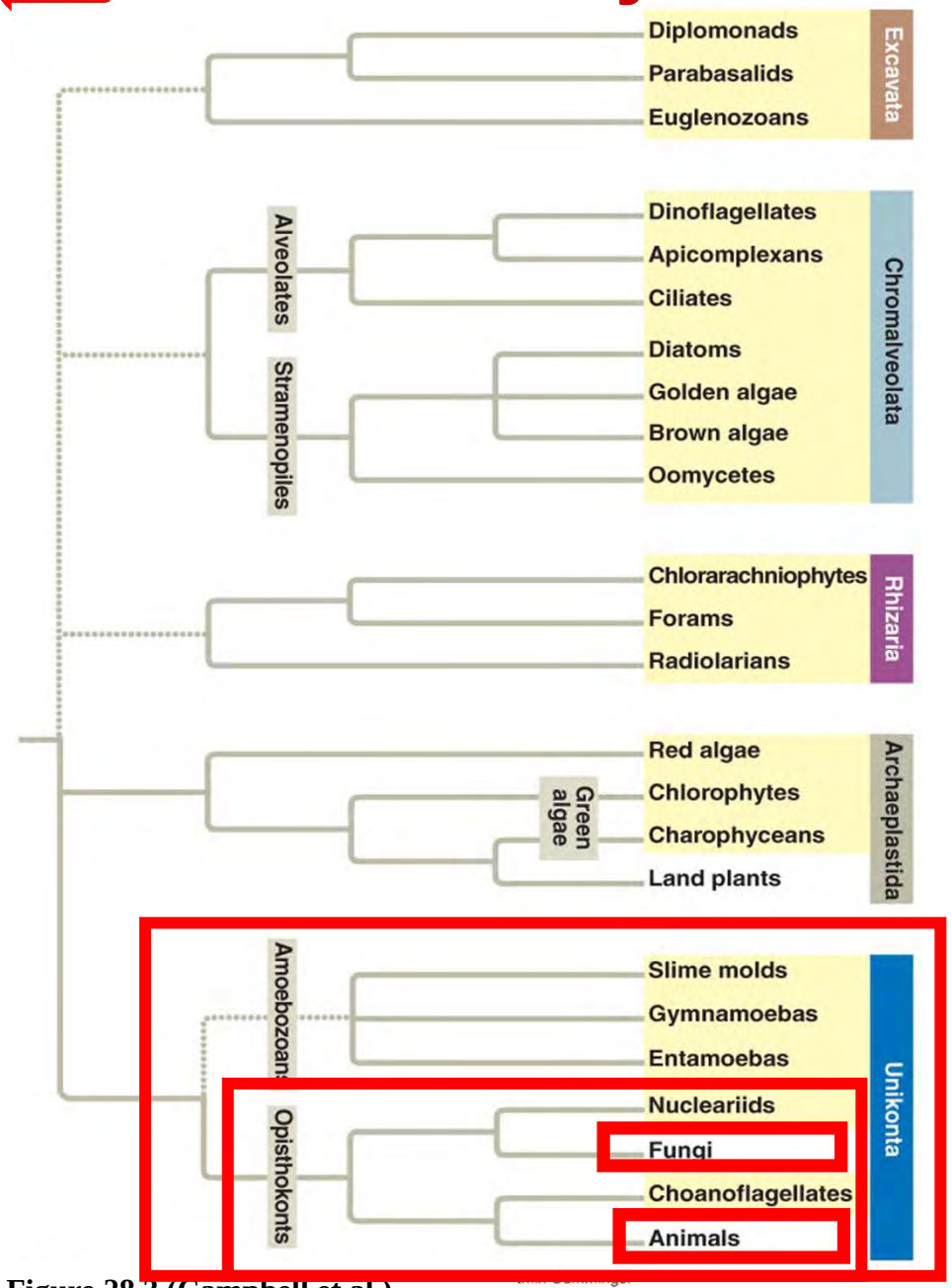


Figure 28.3 (Campbell et al.)

Unikonts

2 major subclades

1. Amoebozoans
2. Opisthokonts

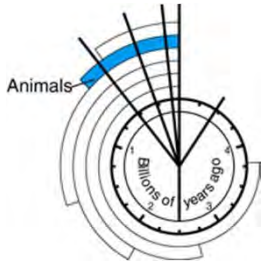
Opisthokont Synapomorphies:

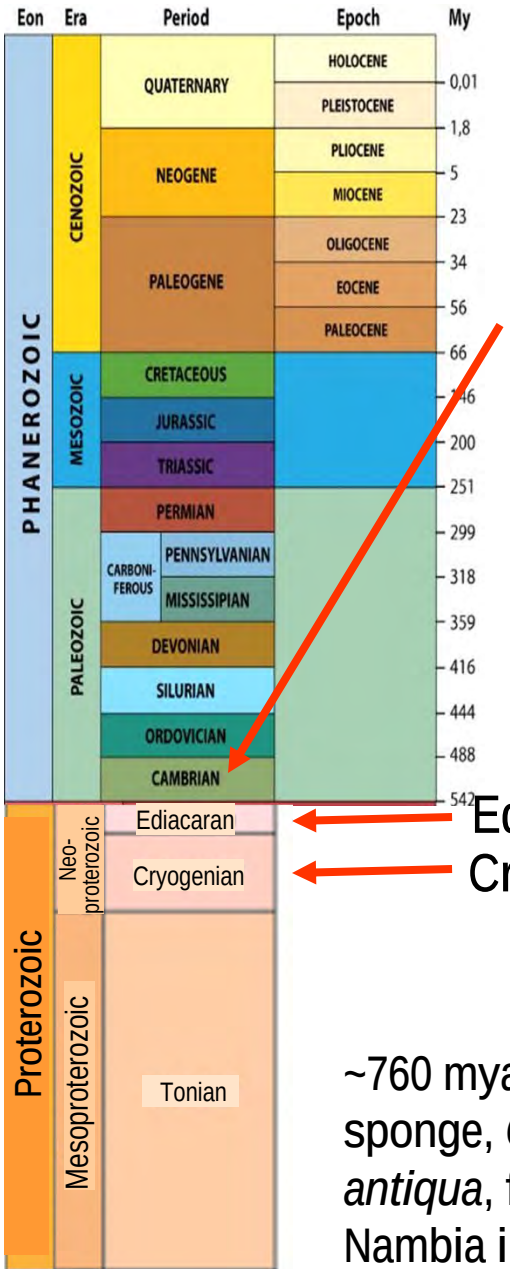
1. Molecular homologies:
   - rRNA sequences,
   - amino acid sequences
2. Morphological homologies:
   - single posterior flagellum (in chytrid fungi only)

Animals = Metazoa

3

Key Events:
Animal Diversification



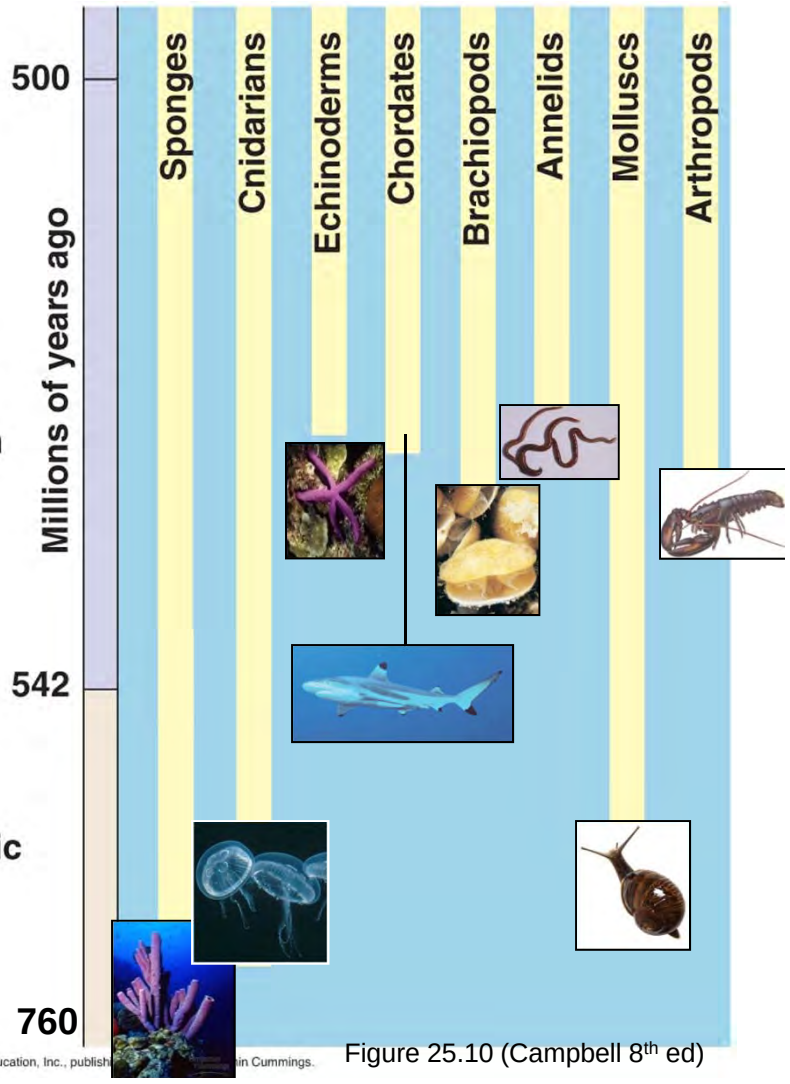


Cambrian

- ~542-522 mya
  "Cambrian explosion"
- ½ of all extant phyla appear!
- 1st animals w/ exoskeletons

Ediacaran = Animal diversification

Cryogenian = 1st animal???



~760 mya fossil sponge, *Otavia antiqua*, found in Nambia in 2010

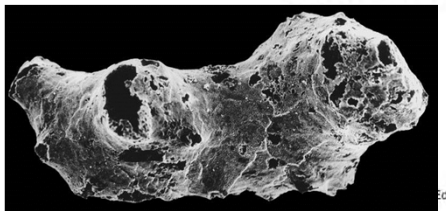


Figure 25.10 (Campbell 8th ed)

What caused the Cambrian Explosion?

Hypotheses:

1. Evolution of predation led to predator/ prey “arms race”
   - New forms of locomotion
   - 1st animals w/ exoskeletons appear
2. Increased Oxygen
   - Higher metabolic rate
   - More complex tissues
   - Larger body size
3. Origin of *Hox* genes and other developmental genes (µRNAs)
   - facilitated evolution of new body forms

Animal Characteristics

Cell Type	Eukaryotic
Cell Number	Multicellular

Cell Number

- **Protists:** Mostly unicellular, some multicellular
- **Fungi:** Some unicellular, mostly multicellular
- **Plants & Animals:** ALL multicellular

Cell Wall

- **Plants:** yes (cellulose)
- **Fungi:** yes (chitin)
- **Animals:** No
  - – cell structural support is external proteins (usually collagen)

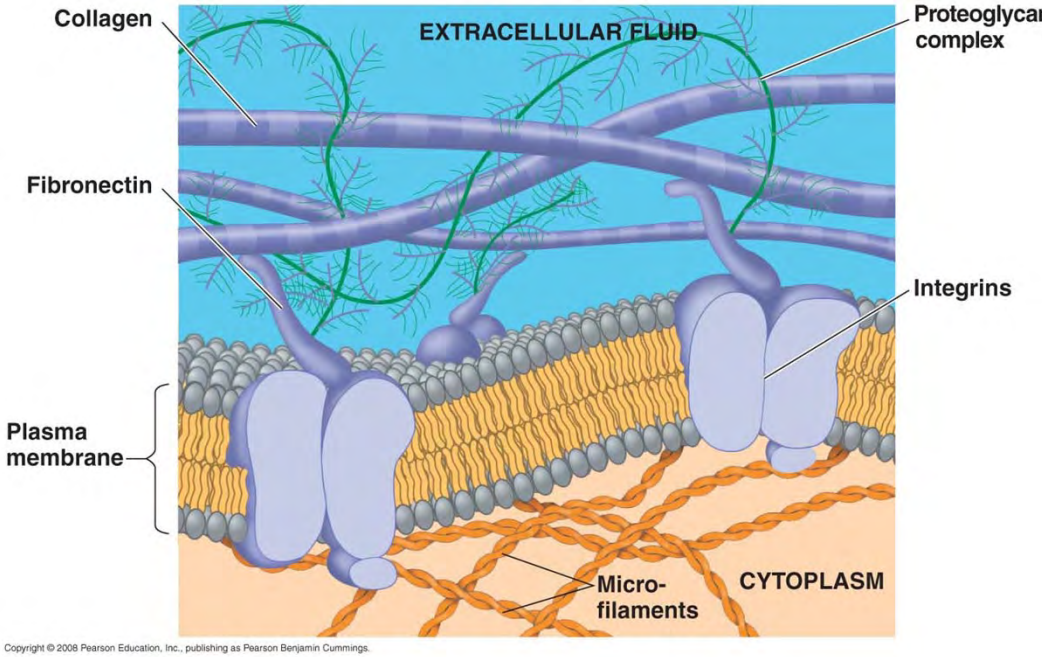


Figure 6.30 (Campbell et al)

Nutrition

- **Plants:** Autotrophic eukaryotes
- **Fungi:** Heterotrophic absorptive eukaryotes
  - w/ external digestion
- **Animals:** Heterotrophic ingestive eukaryotes
  - w/ internal Digestion

Motility

Plants: Gametes – flagellated sperm in seedless and a few seed plants
Adult - No

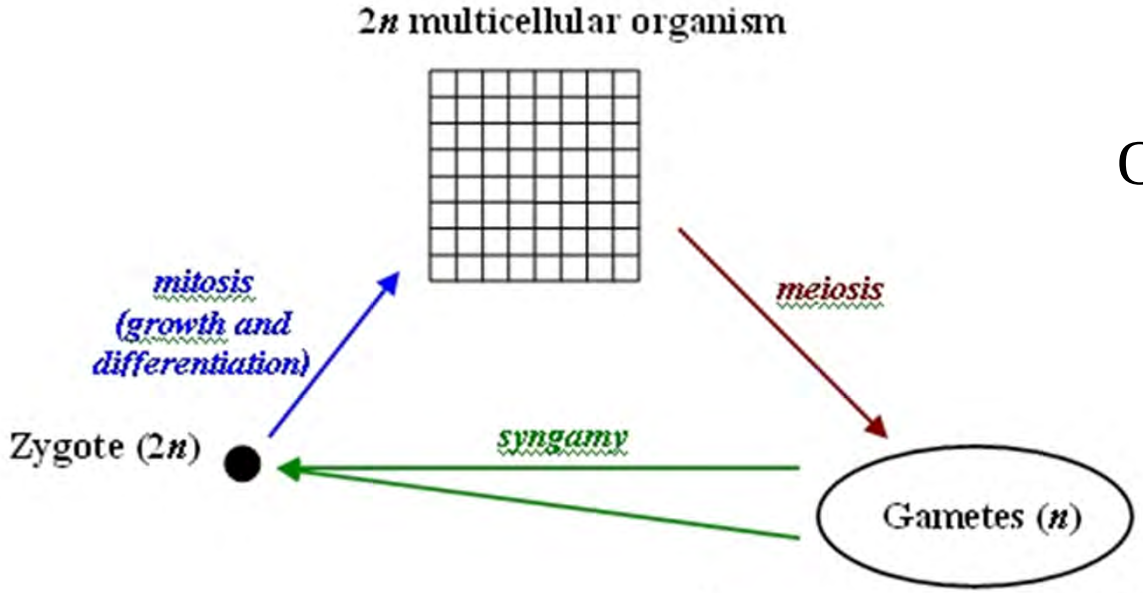
Fungi: Gametes (mating hyphae) – No
Adult - No

Animals: Gametes – all w/ flagellated sperm
Adult – some yes, some no

Animal Characteristics

Cell Type	Eukaryotic
Cell Number	Multicellular
Cell Wall	None
Nutrition	Heterotrophic (ingestive)
Mobility	Sessile & mobile
Life cycle	Diploid-dominant

Diploid Dominant

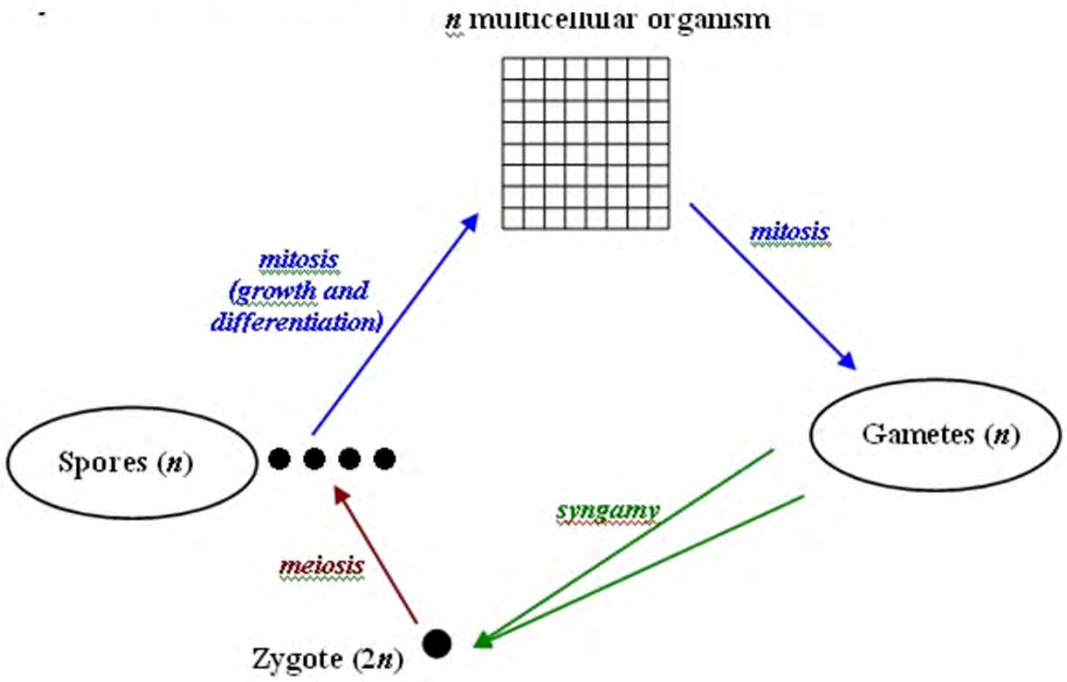


Diploid Dominant
ONE multicellular stage
w/ all <u>diploid</u> cells

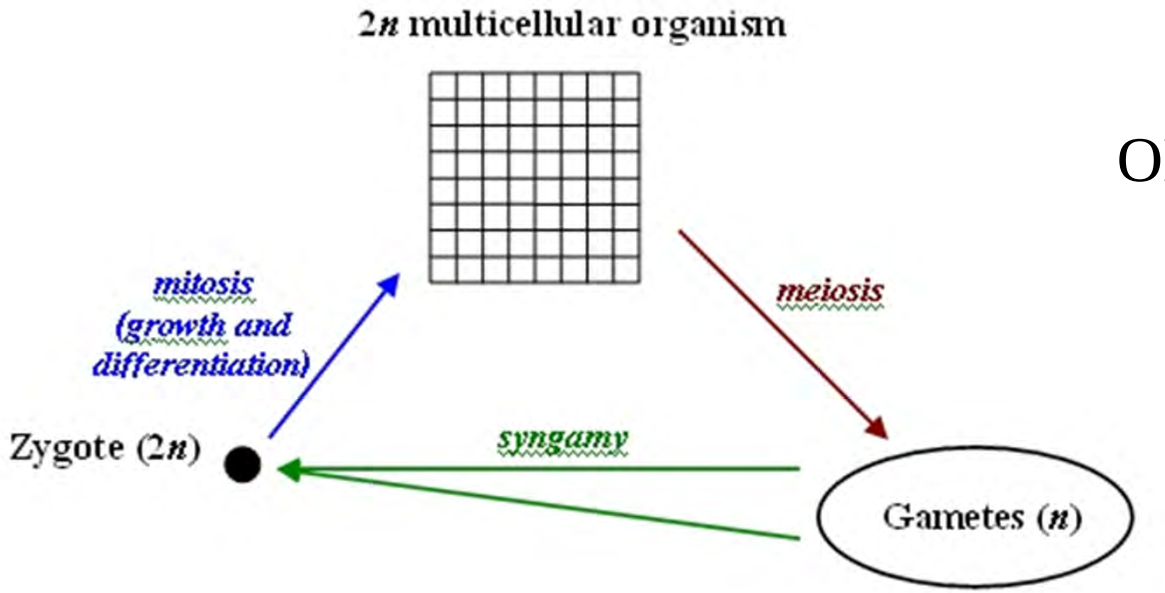
Occurs in animals
& some protists

Haploid Dominant
ONE multicellular stage
w/ all <u>haploid</u> cells

Occurs in fungi
& some protists



Diploid Dominant



Diploid Dominant

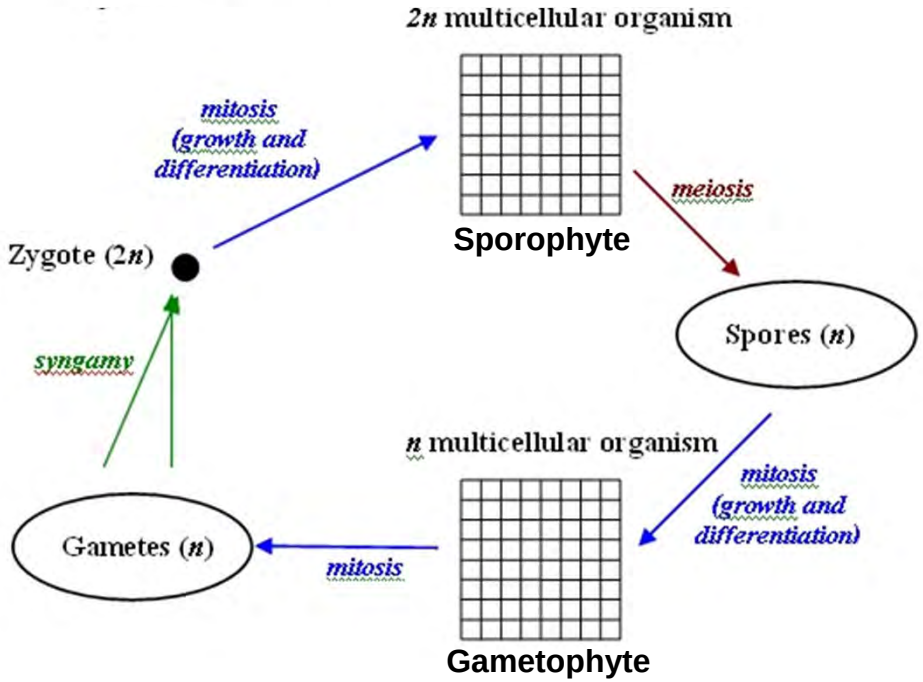
ONE multicellular stage
w/ all <u>diploid</u> cells

Occurs in animals
& some protists

Alternation of Generations

TWO multicellular stages
Gametophyte w/ haploid cells
Sporophyte w/ diploid cells

Occurs in all plants
& some protists



LARVAL STAGE

ADULT STAGE

BOTH DIPLOID

…. NOT ALTERNATION OF GENERATION!!!

Summary of Animal Reproduction

- Most (but not all) reproduce sexually;
- Flagellated sperm; large nonmotile eggs;
- Diploid stage dominates life cycle;
  - Only haploid stage is gamete;
    - Gamete produced via meiosis;
  - No alternation of generations (no multicellular (n) stage);
  - No spore stage;
- Plasmogamy and karyogamy occur nearly simultaneous thus is called syngamy.

Body plans:

Overview

Main morphological characters used to categorize animal body plans:

1. Symmetry
   a) none; b) radial; c) bilateral
2. Embryonic “germ” layers
   a) 0; b) 2; c) 3
3. Organization of body cavity
   a) acoelomate; b) coelomate; c) pseudocoelomate
4. Possession of vertebral column?
   a) no; b) yes

Body plans:

Symmetry

a) No symmetry (asymetric)

- No way to divide animal into mirror images
- Clade Porifera

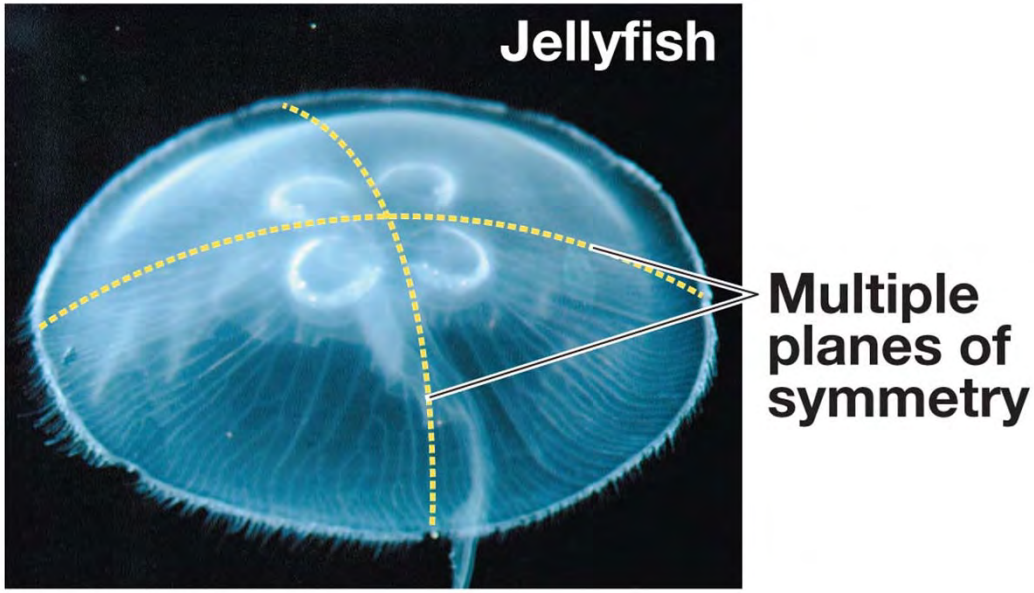
No plane of symmetry

Body plans:

Symmetry

b) Radial symmetry

- Any imaginary slice through the central axis divides the animal into mirror images
- Clade Cnidaria



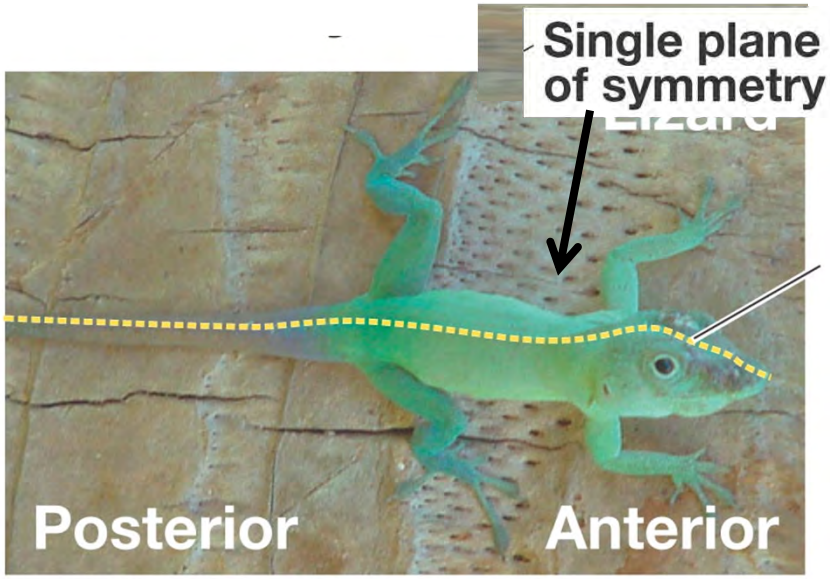
See Figure 32.7 (Campbell et al)

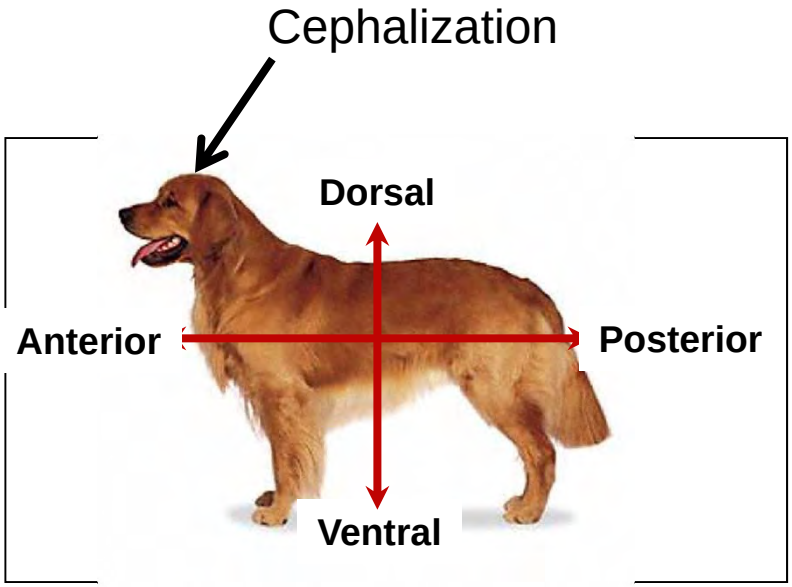
Body plans:

Symmetry

c) Bilateral symmetry

- Only 1 imaginary slice divides the animal into mirror images
- All other clades except Porifera and Cnidaria





See Figure 32.7 (Campbell et al)

Body plans:

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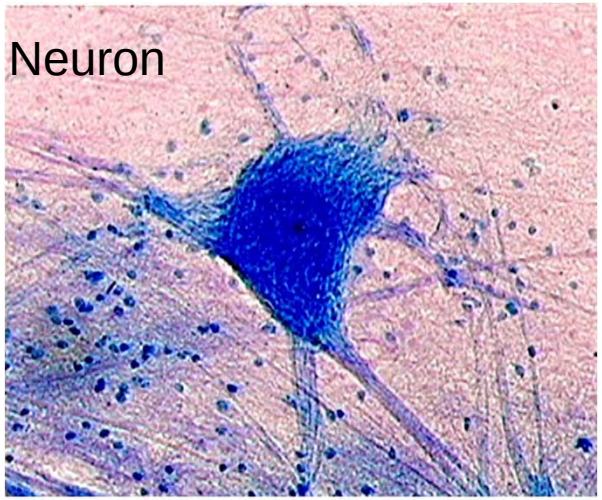
4. Possession of vertebral column?
   a) no; b) yes

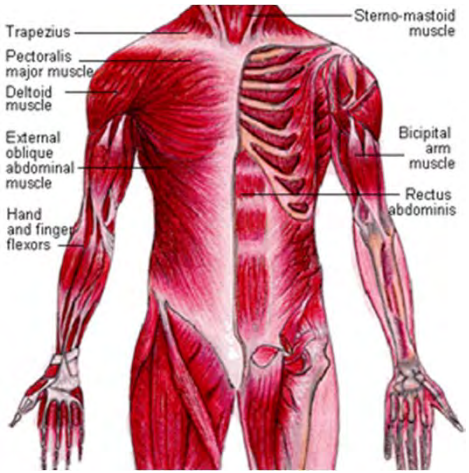
Body plans:

Embryonic "Germ" Layers

= collection of cells, formed during animal embryogenesis

- Different groups have 0, 2 or 3 layers
- "Germinate" into tissues
  - Tissues = collections of specialized cells isolated from other tissues via a membrane
    - 4 types: Epithelial, connective, muscle, and nervous tissues
    - ***Muscle & nervous tissues are unique to animals





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Formation of embryonic Germ Layers

1. Cleavage = zygote becomes multicellular blastula
   - Blastula = a hollow ball of cells (hollow center = blastocoel)
2. Gastrulation = blastula invaginates to form gastrula which results in:
   A. two layers
   - Ectoderm = outer layer
   - Endoderm = inner layer
   - (In some a 3rd layer (mesoderm) will later develop between ecto- and endoderm

   B. 2nd hollow space (archenteron) with an external opening (blastopore)
   - Archenteron: later becomes digestive tract
   - Blastopore: later becomes either the mouth or anus

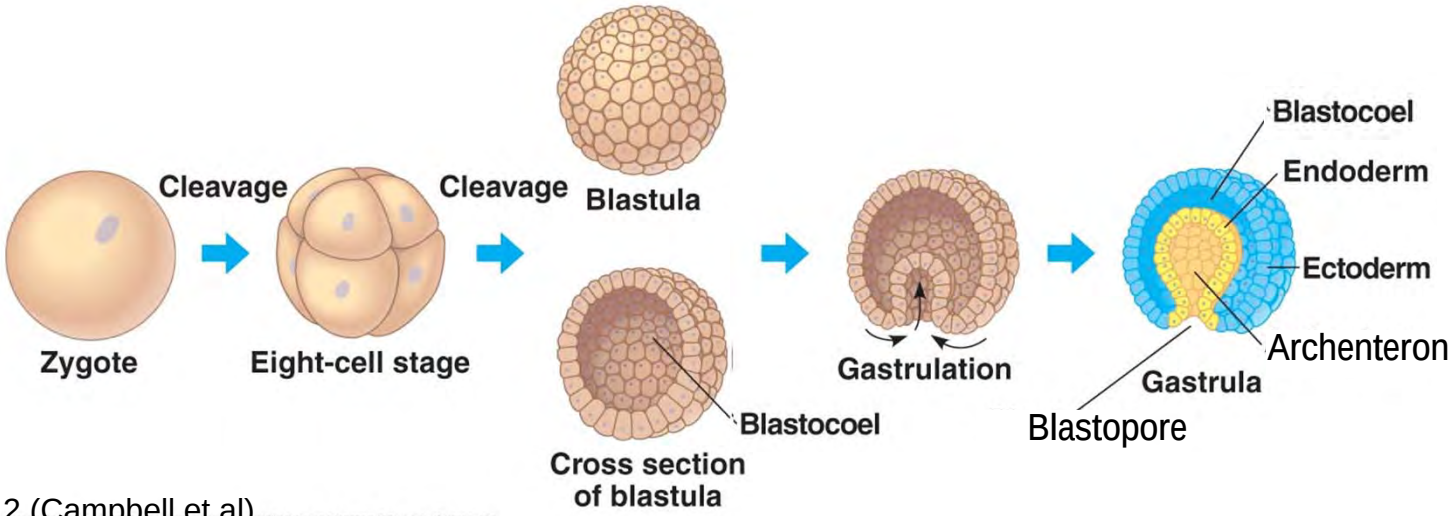


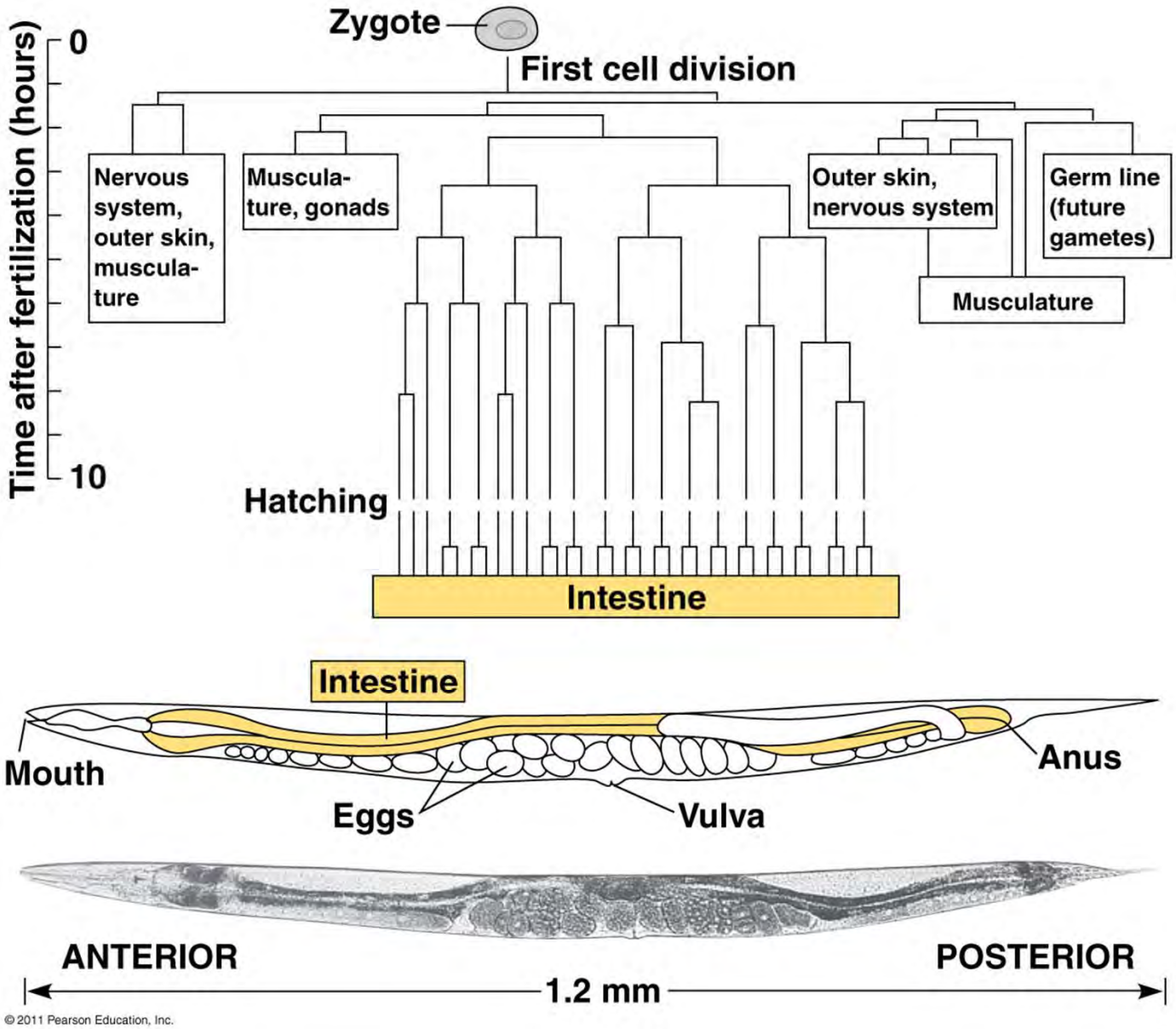
Figure 32.2 (Campbell et al)

Destiny of embryonic Germ Layers

Ectoderm	Mesoderm	Endoderm
Epidermis	Dermis	Lining of digestive system
Lining of mouth & rectum	Lining of coelom	Digestive organs (liver, thymus, pancreas)
Nervous system	Skeletal, muscular, & circul. systems	Lining of respiratory system (lungs)

Do not need to remember fate of each tissue layer

Destiny of embryonic Germ Layers



The transparent embryo of the Nematode *Caenorhabditis elegans* makes it possible to trace the lineage of every cell from zygote to adult worm.

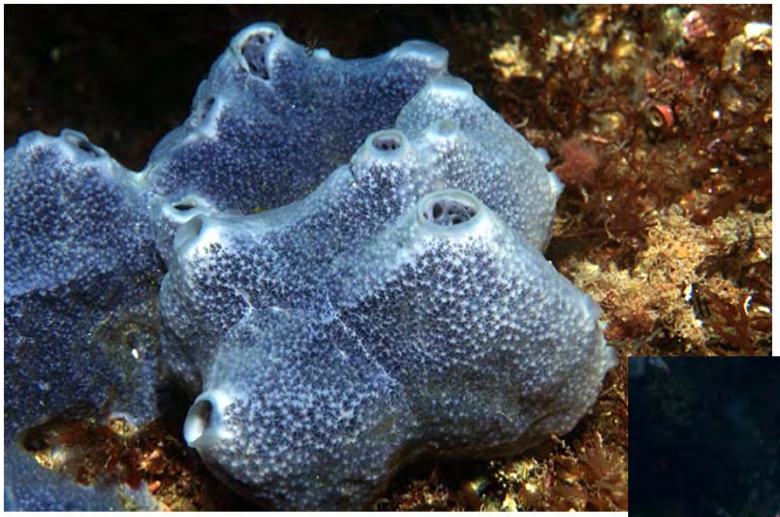
Figure 47.18 (Campbell et al)

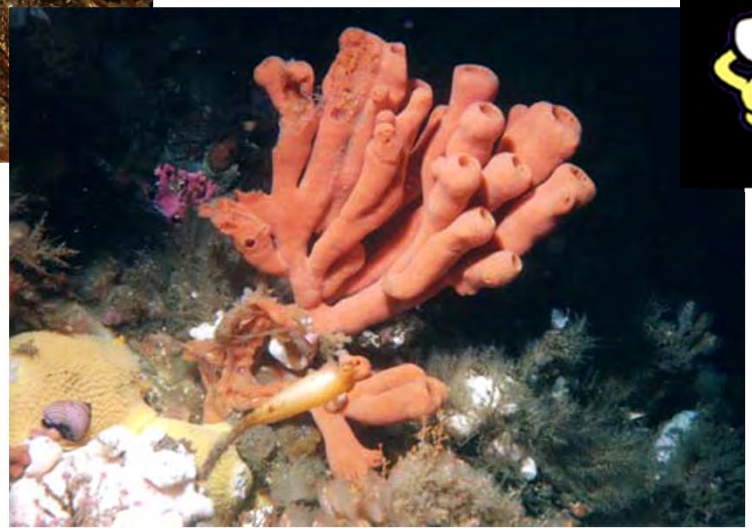
Body plans:

Embryonic Germ Layers

Sponges have ZERO tissue layers

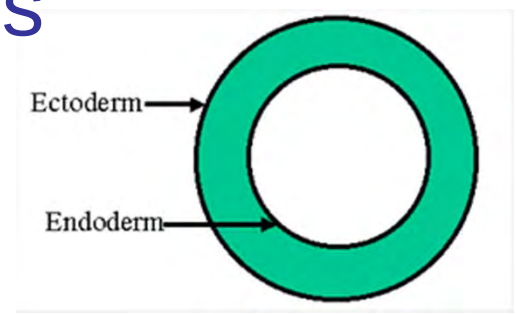
Tissues = collections of specialized cells isolated from other tissues via a membrane





Body plans:

Embryonic Germ Layers



Some animals have 2 germ layers

Diploblastic

✓ Ectoderm - ~~Mesoderm~~ ✓ Endoderm

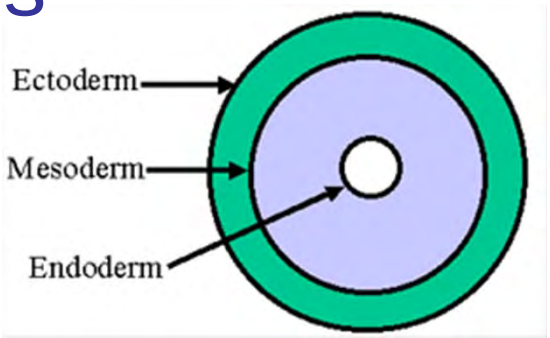
anemones

corals

jellyfish

Body plans:

Embryonic Germ Layers



Most animals have all three germ layers:

Triploblastic

✓ Ectoderm ✓ Mesooderm ✓ Endoderm

arthropods

molluscs

chordates

Body plans:

Overview

Main morphological characters used to categorize animal body plans:

1. Symmetry
   a) none; b) radial; c) bilateral
2. Embryonic “germ” layers
   a) 0; b) 2; c) 3
3. Organization of body cavity
   a) acoelomate; b) coelomate; c) pseudocoelomate
4. Possession of vertebral column?
   a) no; b) yes

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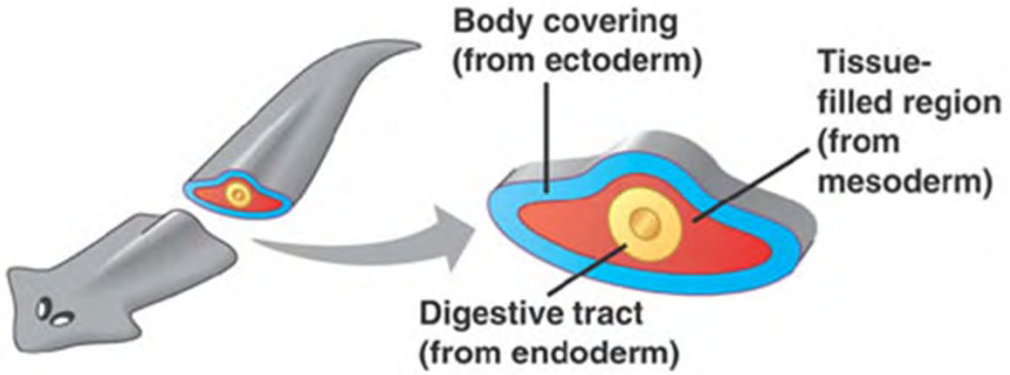
Coelom

Most triploblastic phyla have a body cavity (coelom)

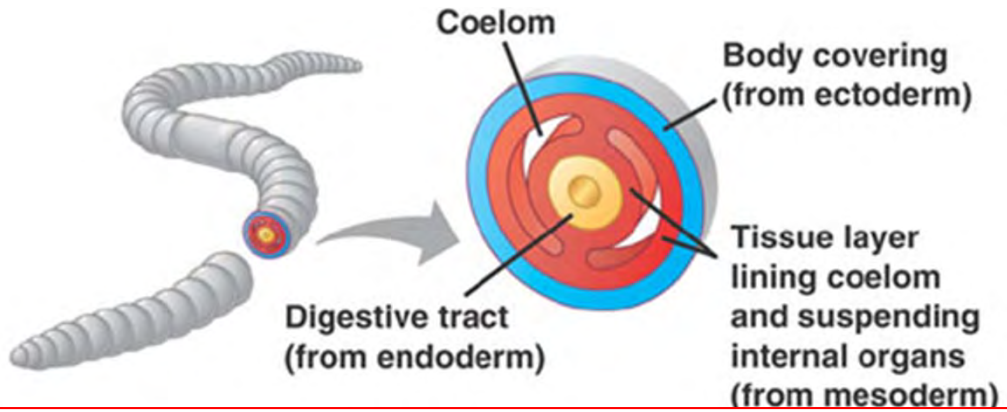
Coelom =

- Fluid or air filled space
- Separates digestive tract from outer body wall
- Fluid cushions organs
- Allows independent growth/movement of organs
- Aids in movement in invertebrates

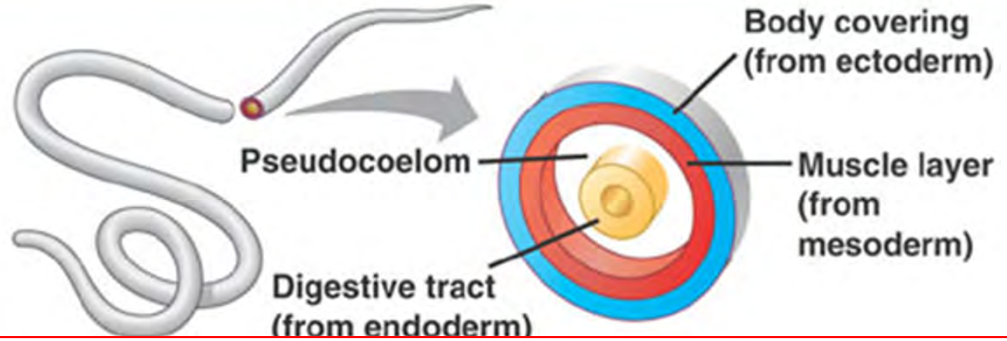
Embryologic development varies resulting in formation of 0, 1 or 2 body cavities



Acoelomates have no body cavity



Coelomates: 2 body cavities (both enclosed in mesoderm)



Pseudocoelomates: 1 body cavity (enclosed in endo- & mesoderm)

Figure 32.8 (Campbell et al)

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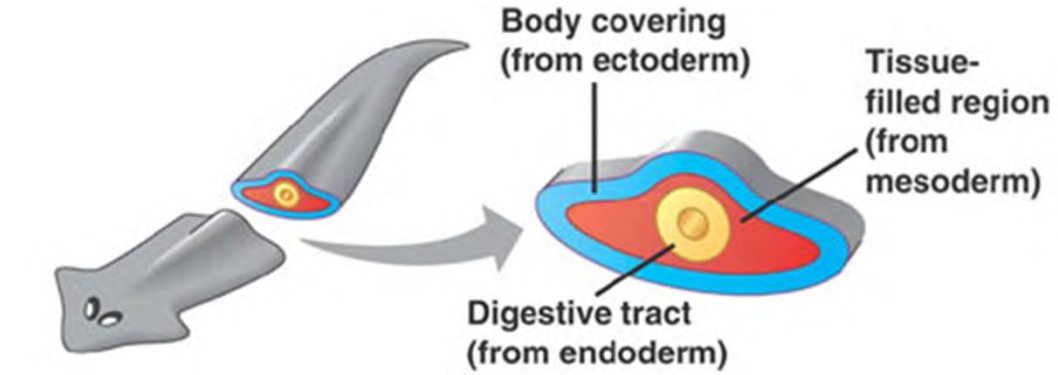
Coelom

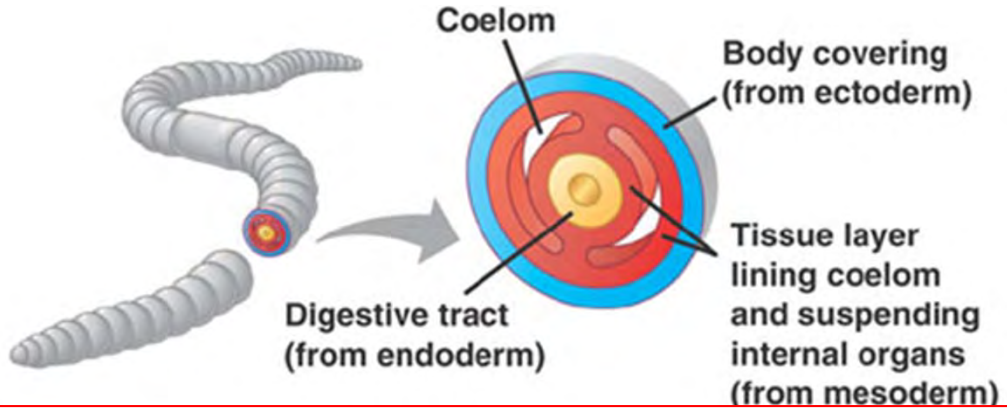
The presence/absence of a coelom does not indicate evolutionary relationships.

i.e. This character has been gained & lost multiple times in various lineages.

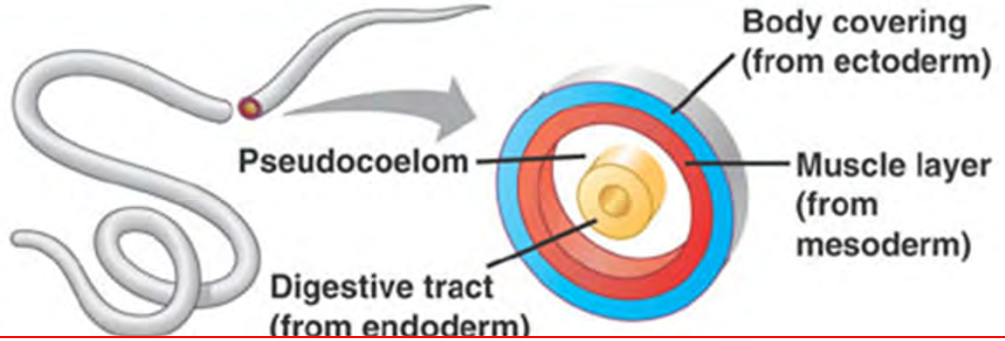
i.e. parsimony ≠ phylogeny



(c) Acoelomates have no body cavity



Coelomates: 2 body cavities (both enclosed in mesoderm)



Pseudocoelomates: 1 body cavity (enclosed in endo- & mesoderm)

Figure 32.8 (Campbell et al)

Animals can also be grouped based on 2 developmental modes

A) Protostomes B) Deuterostomes

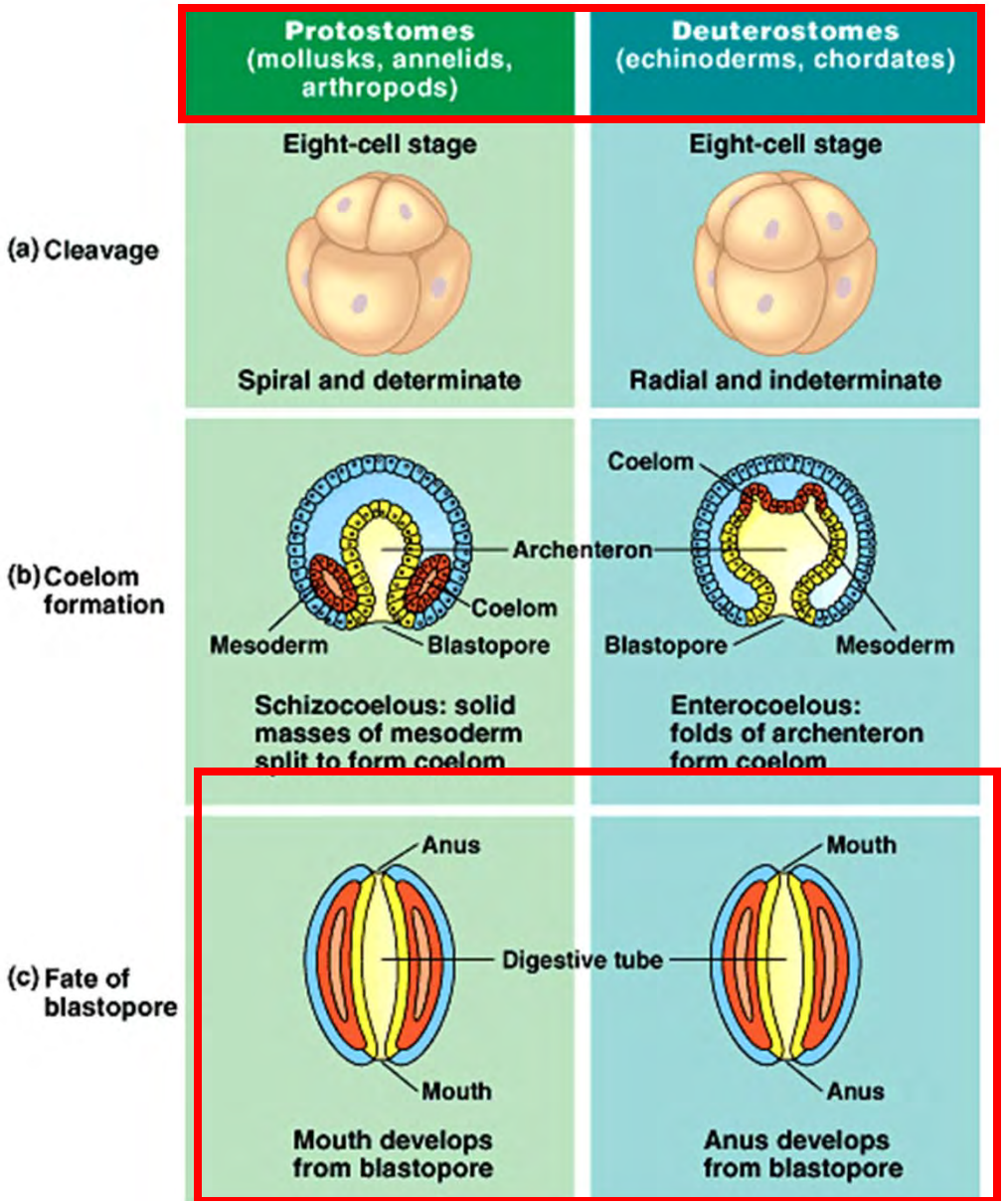
- Genetic analyses now indicate that similarity in developmental mode does not indicate evolutionary relationships

i.e. parsimony ≠ phylogeny

Figure 32.9 (Campbell et al)

Protostomes vs Deuterostomes

Grouping based on three aspects of early development

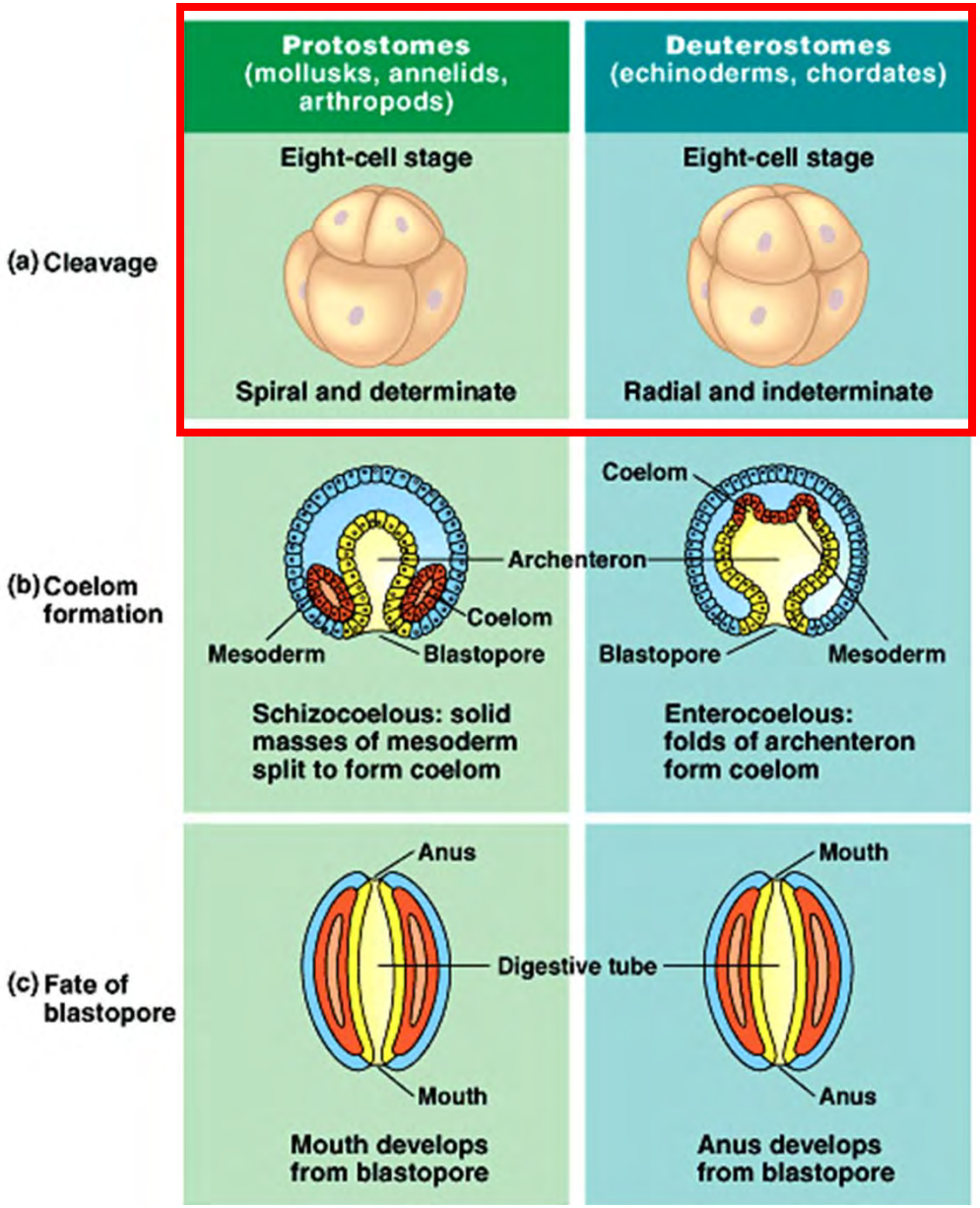


- 1. <u>Fate of blastopore</u> differs:
  - Protostomes:
    - Develops into mouth
  - Deuterostomes:
    - Develops into anus

Figure 32.9 (Campbell et al)

Protostomes vs Deuterostomes

Grouping based on three aspects of early development

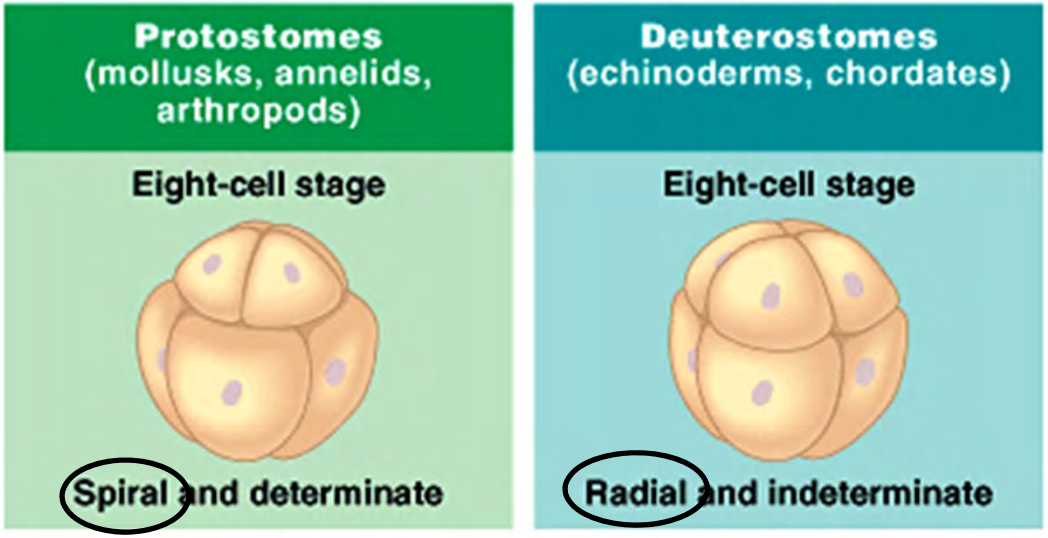


2. <u>Cleavage</u> differs
   - Angle that cells divide
   - Fate of the cells

- Protostomes:
  - Spiral and determinate
- Deuterostomes:
  - radial and indeterminate

Figure 32.9 (Campbell et al)

Protostomes vs Deuterostomes



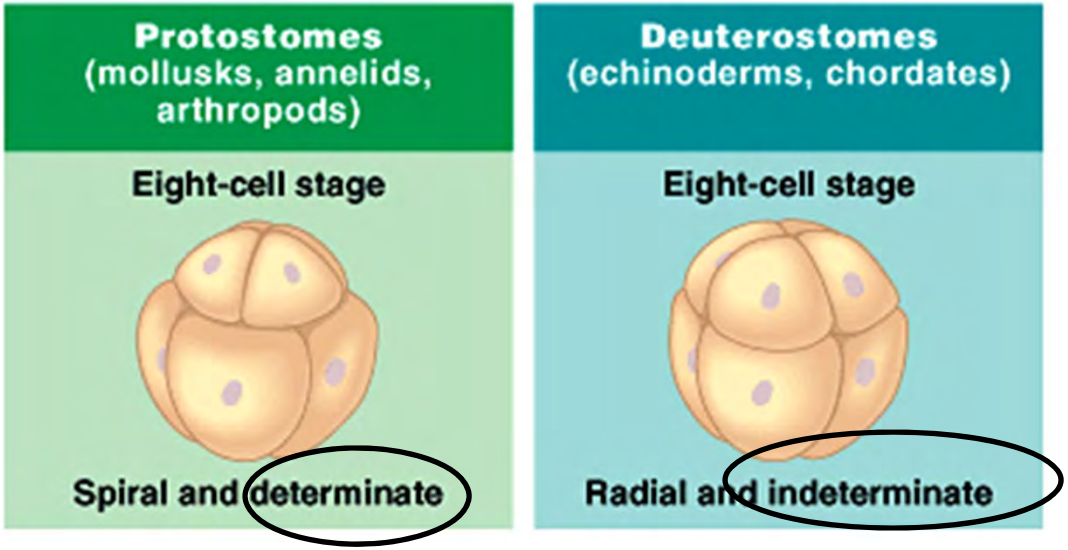
Spiral

- Cleavage planes diagonal to vertical axis
- Smaller cells centered over grooves between underlying larger cells

Radial

- Cleavage planes parallel or perpendicular to vertical axis
- Cells aligned directly over one another

Protostomes vs Deuterostomes



Determinate

- Developmental fate of each cell is determined early on (e.g. by 4-cell stage)

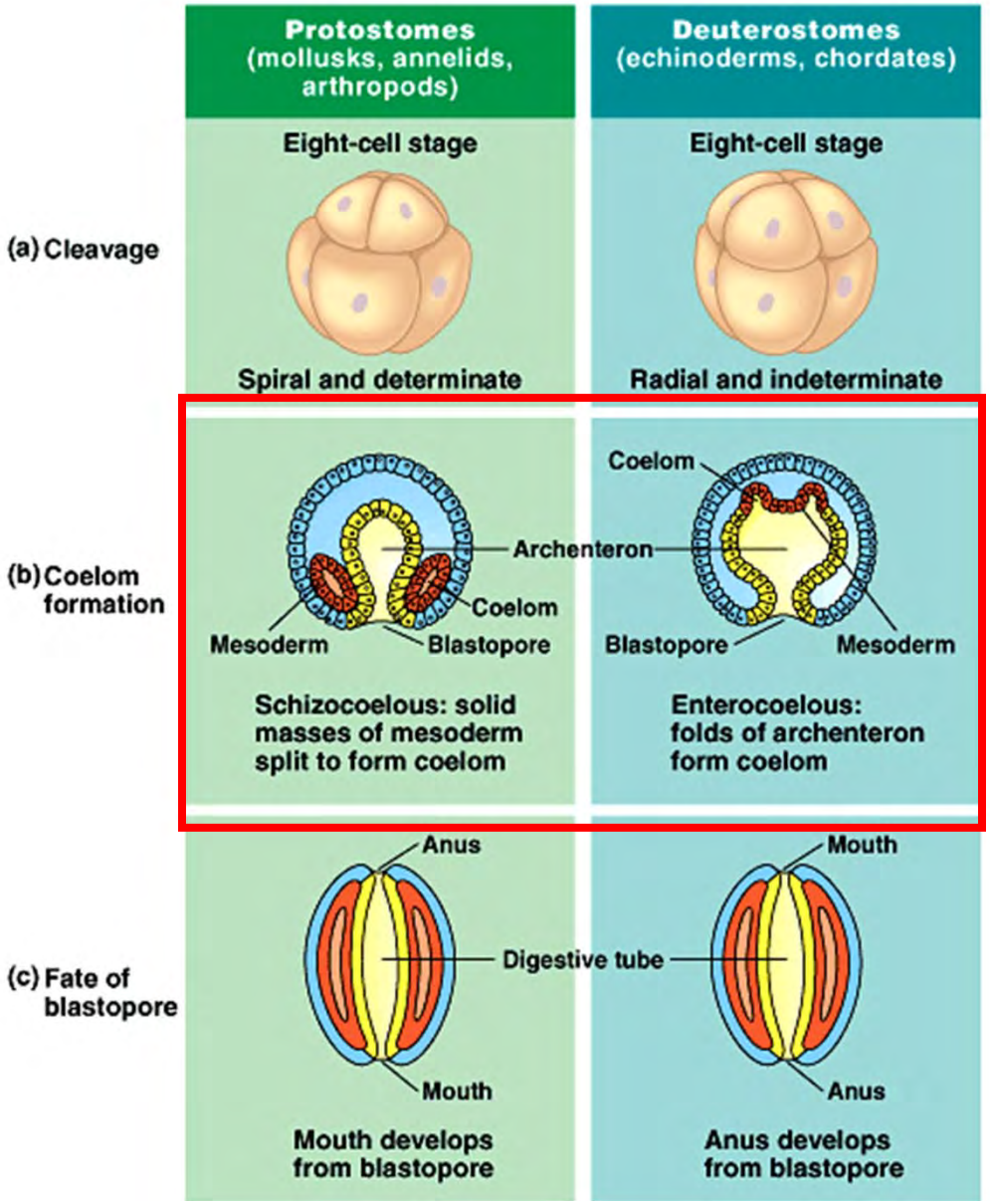
e.g. Snail: Take one cell from the 4-cell stage & it will grow into a nonviable embryo with missing parts

Indeterminate

- Developmental fate of all cells is determined much later.
  - Undifferentiated cells called embryonic stem cells

Protostomes vs Deuterostomes

Grouping based on three aspects of early development



3. <u>Coelom formation</u> differs
   - Protostomes:
     - Solid mesoderm masses hollow to form coelom
   - Deuterostome:
     - Folds of archenteron form coelom

Figure 32.9 (Campbell et al)

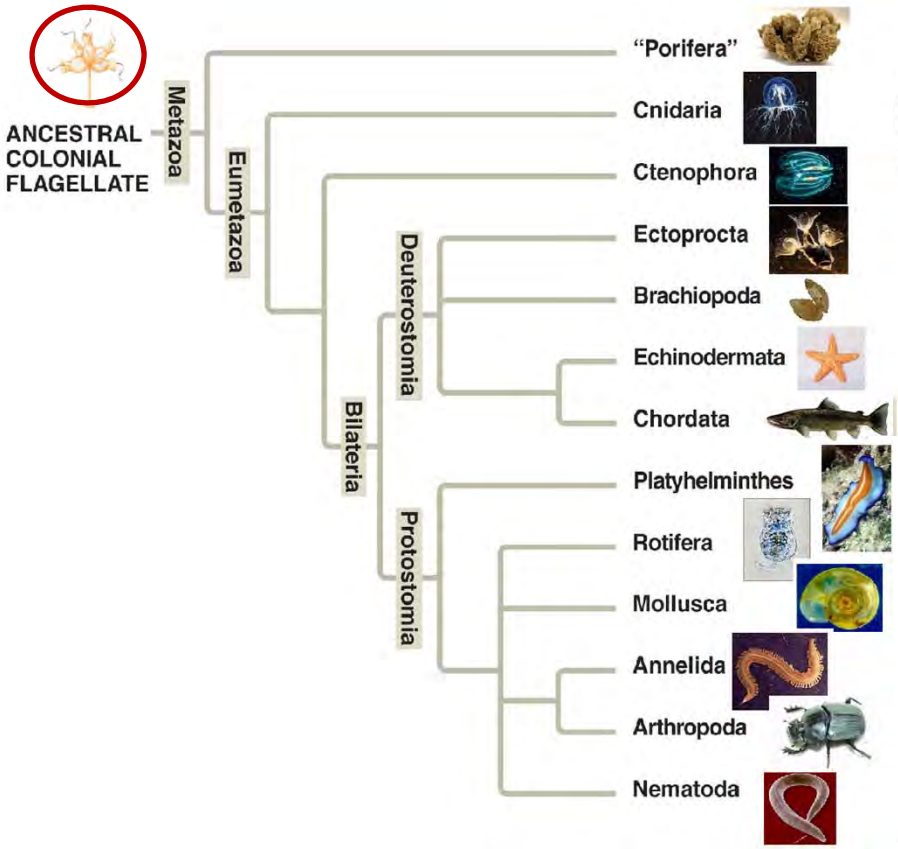
Body plans:

Overview

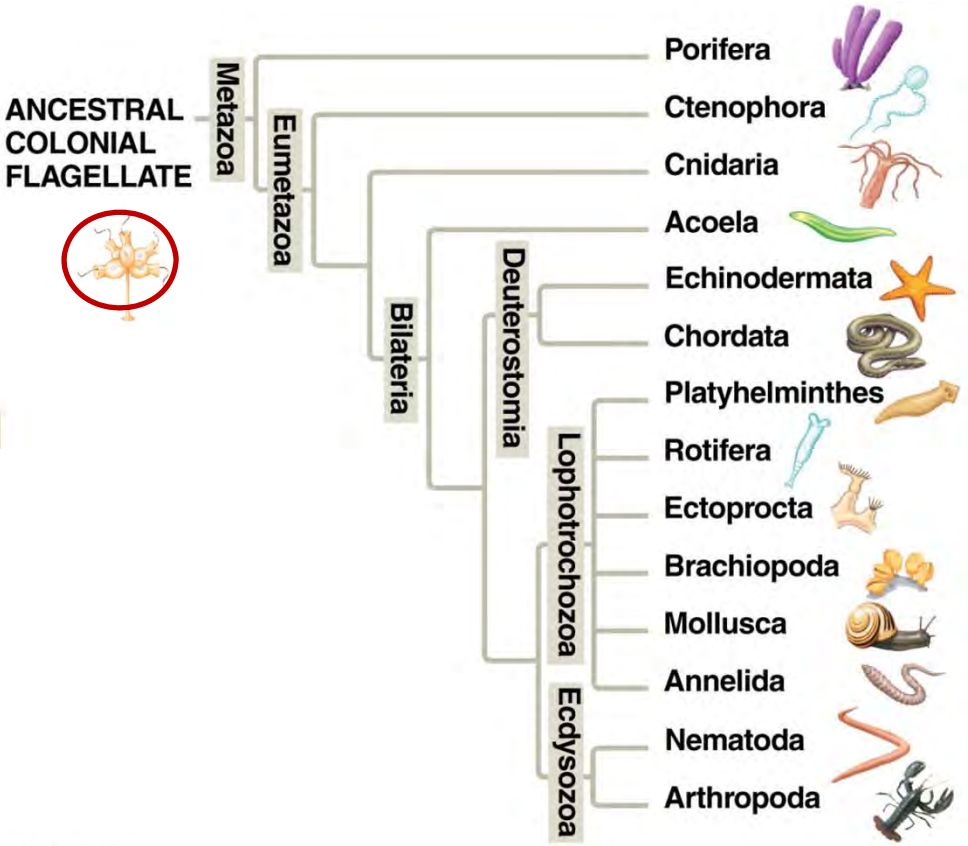
Main morphological characters used to categorize animal body plans:

1. Symmetry
   a) none; b) radial; c) bilateral
2. Embryonic “germ” layers
   a) 0; b) 2; c) 3
3. Organization of body cavity
   a) acoelomate; b) coelomate; c) pseudocoelomate
4. Possession of vertebral column?
   a) no; b) yes

Relationships are still unclear but getting clearer…



Phylogenetic Tree: Morphology



Phylogenetic Tree: Molecular

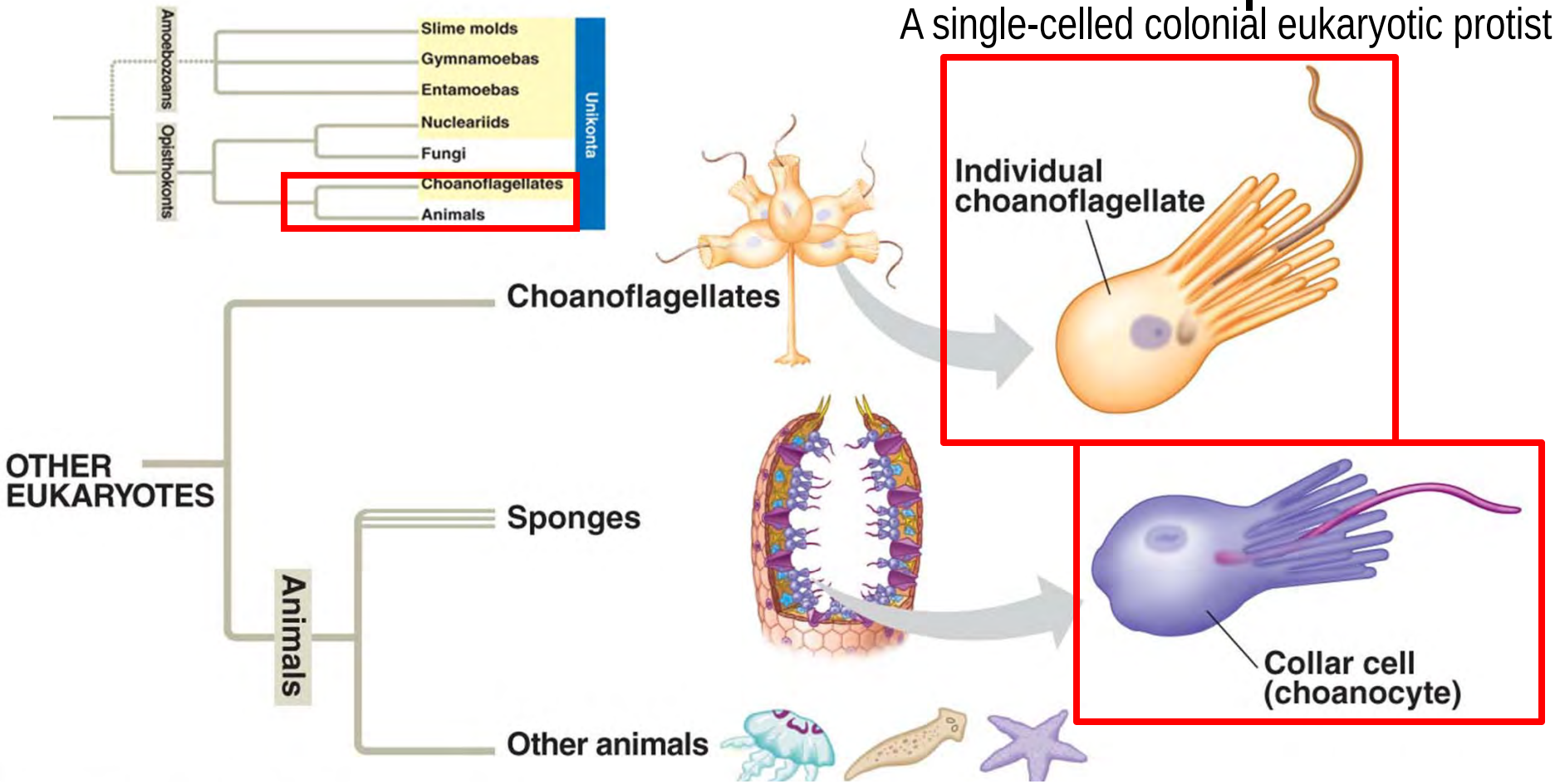
Points of agreement:

1. Metazoa (multicellular animals) are MONOPHYLETIC
   & derive from a single common ancestral colonial flagellate

Figures 32.10 and 32.11 (Campbell et al.)

44 Animal ancestor likely resembled modern choanoflagellates

A single-celled colonial eukaryotic protist



How do we know?

A. DNA sequences similar btwn choanoflagellates and Metazoa

B. Choanoflagellate and sponge choanocytes morphologically indistinguishable

- Similar cells seen in a few other animal groups too but not other protists, fungi, or plants

Figure 32.3 (Campbell et al)

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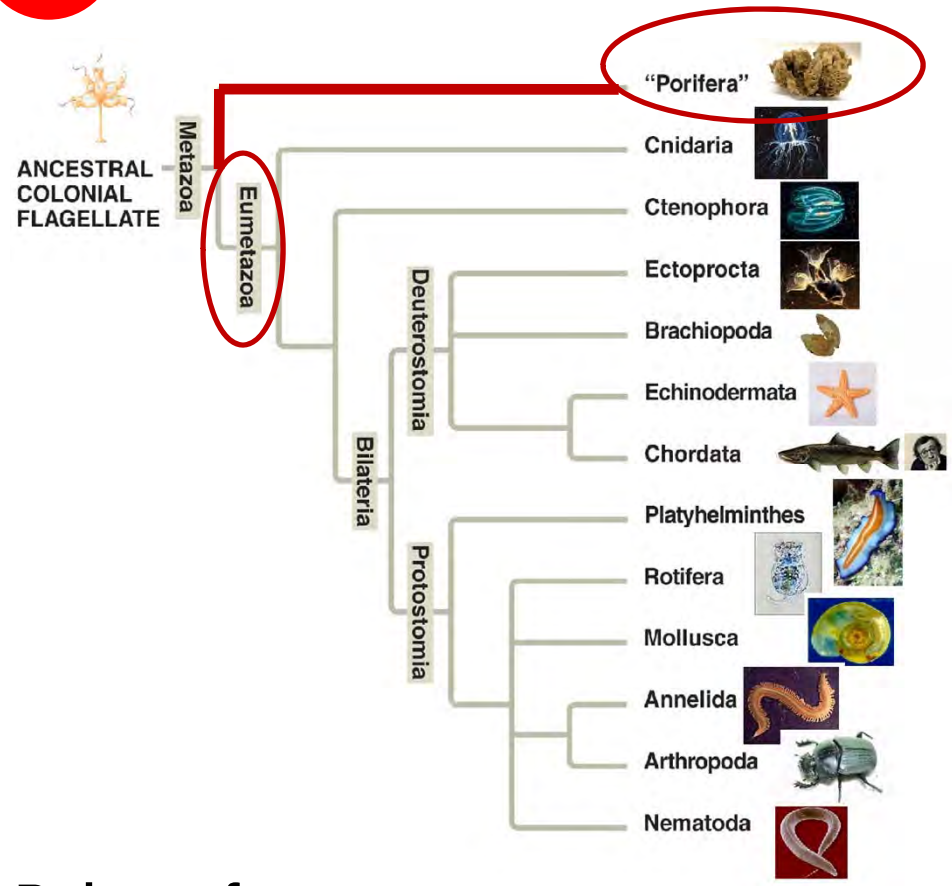
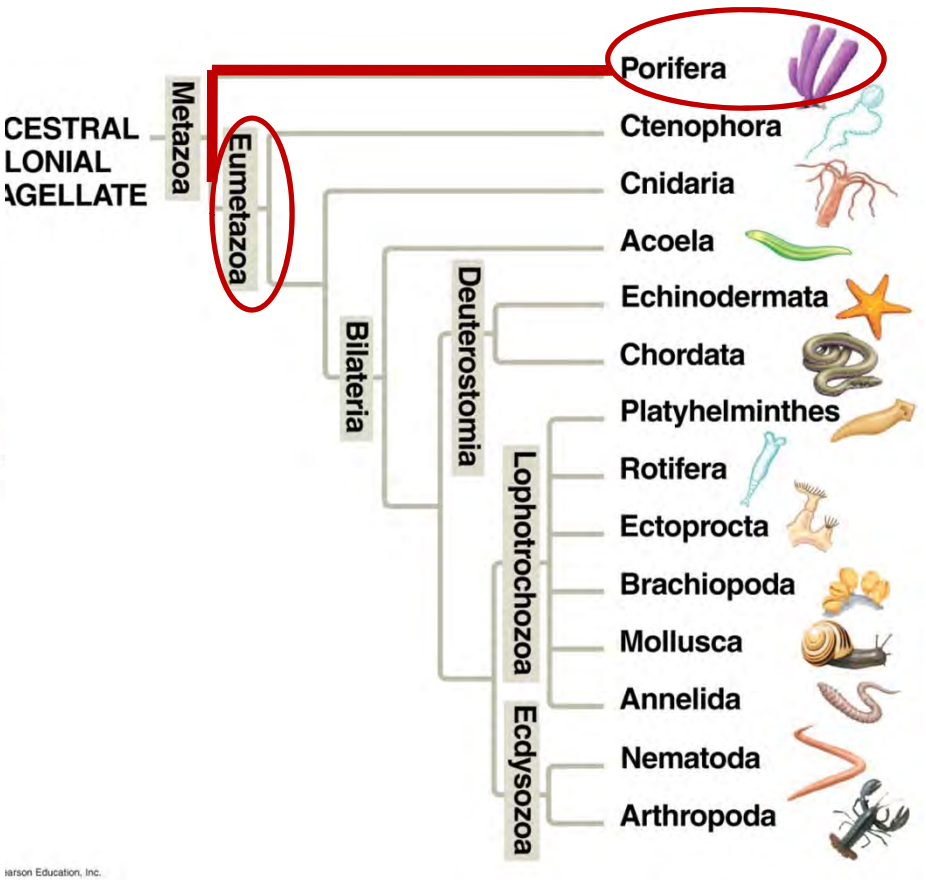
Phylogenetic Tree: Morphology



Phylogenetic Tree: Molecular



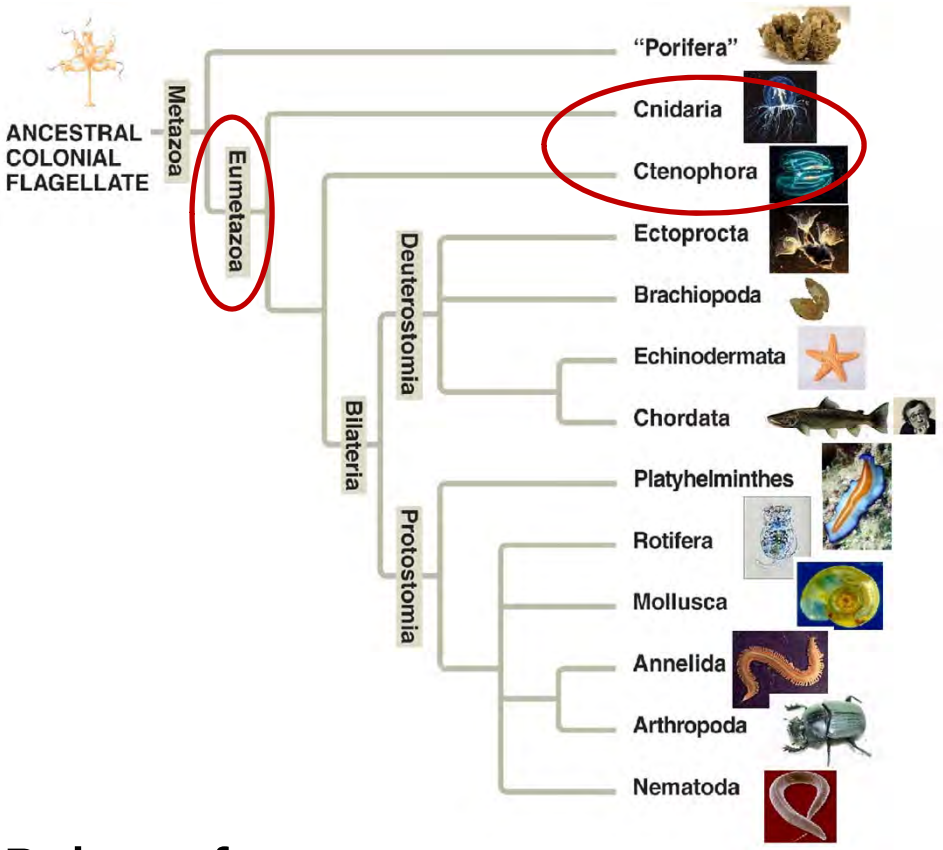
Points of agreement:

2. Sponges are *basal* group – sister taxon/a to all other animals (Eumetazoa)

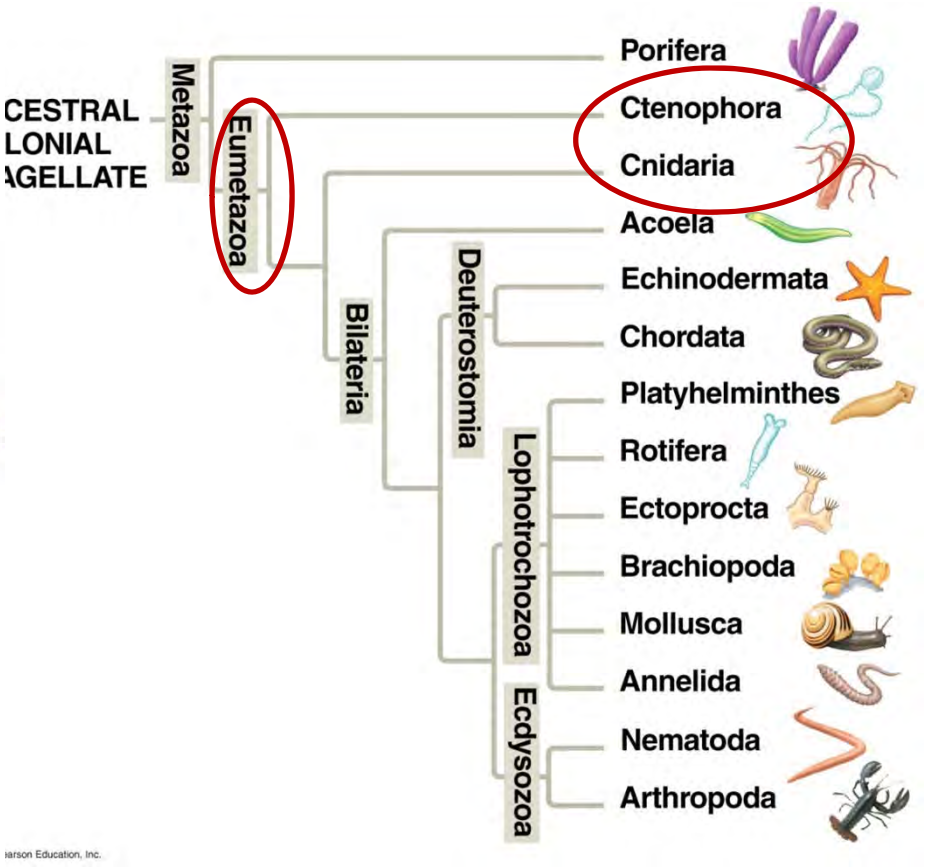
- Sponges: multicellular, NO tissues (i.e. nerves or muscles), no symmetry

Figures 32.10 and 32.11 (Campbell et al.)

Phylogenetic Tree: Morphology



Phylogenetic Tree: Molecular



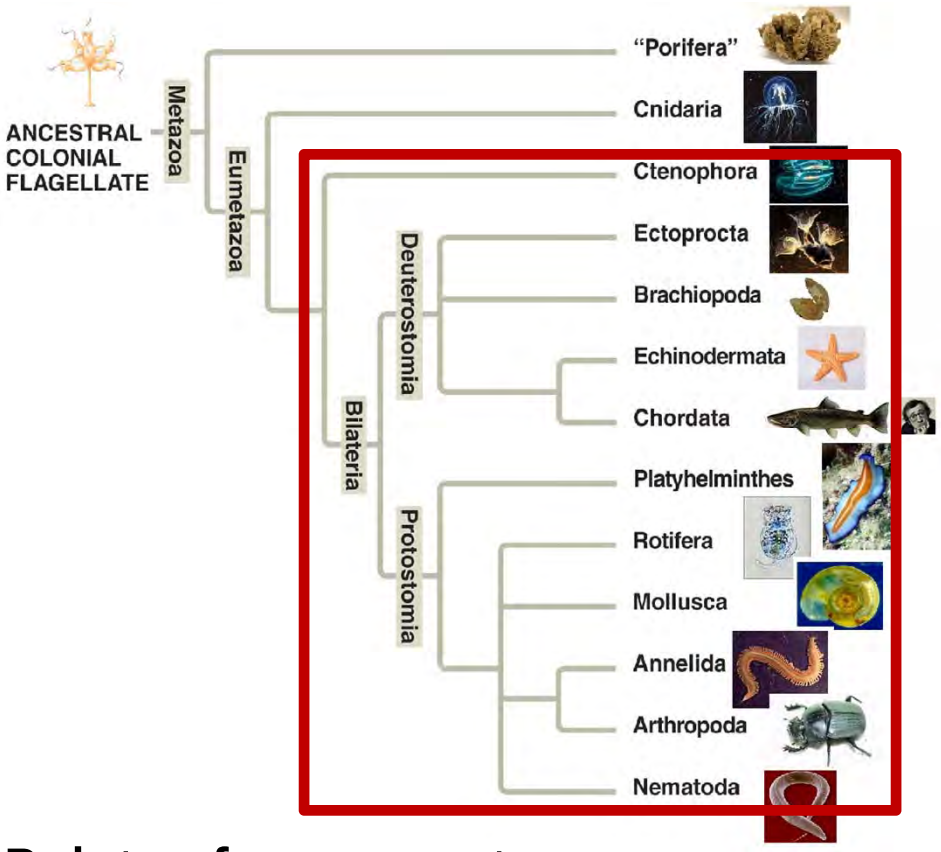
Points of agreement:

3. Eumetazoa = monophyletic clade of all animals with true tissues

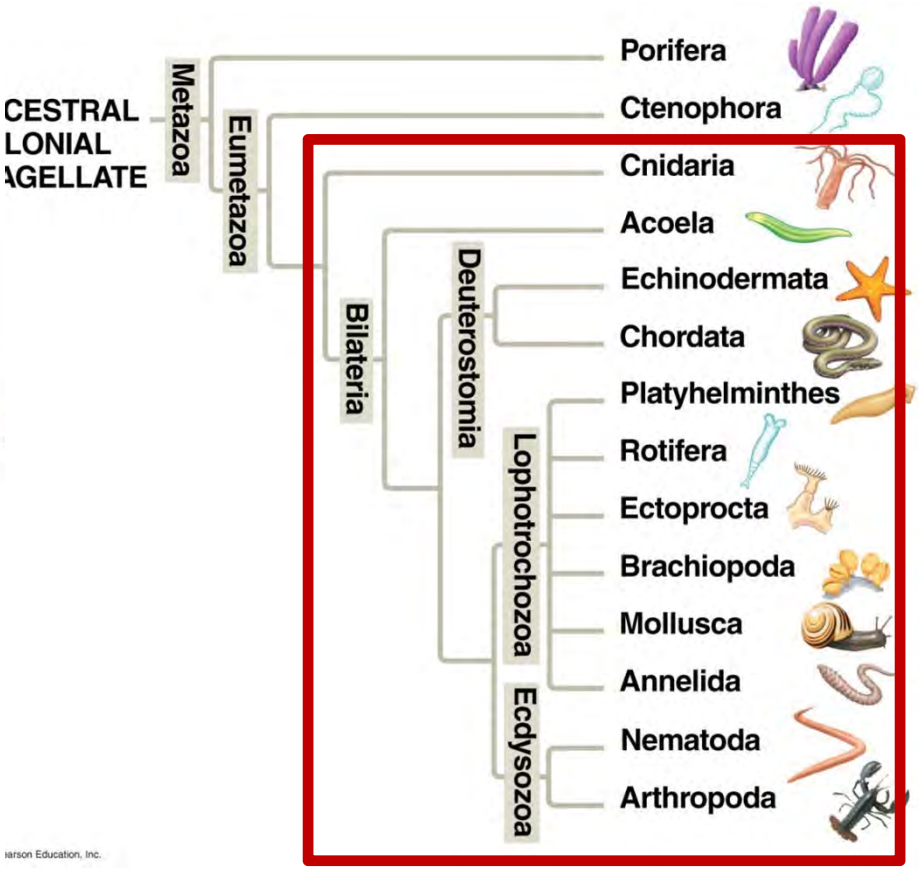
- Cnidaria and Ctenophora are early branches of the Eumetazoa

Figures 32.10 and 32.11 (Campbell et al.)

Phylogenetic Tree: Morphology



Phylogenetic Tree: Molecular

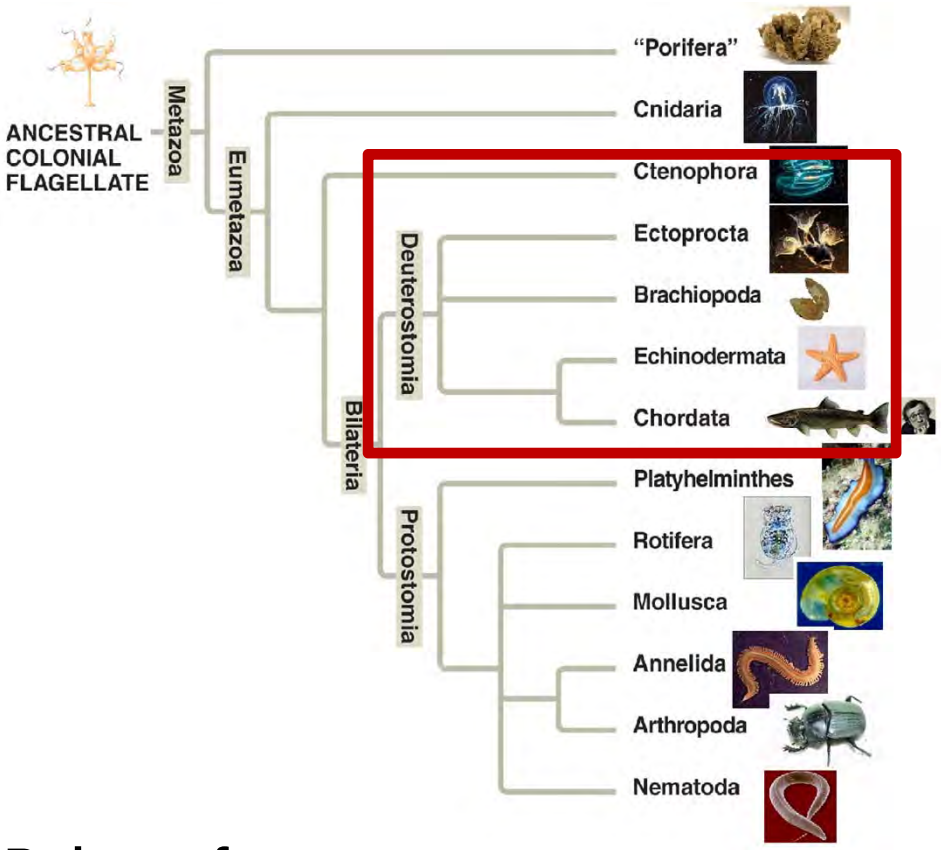


Points of agreement:

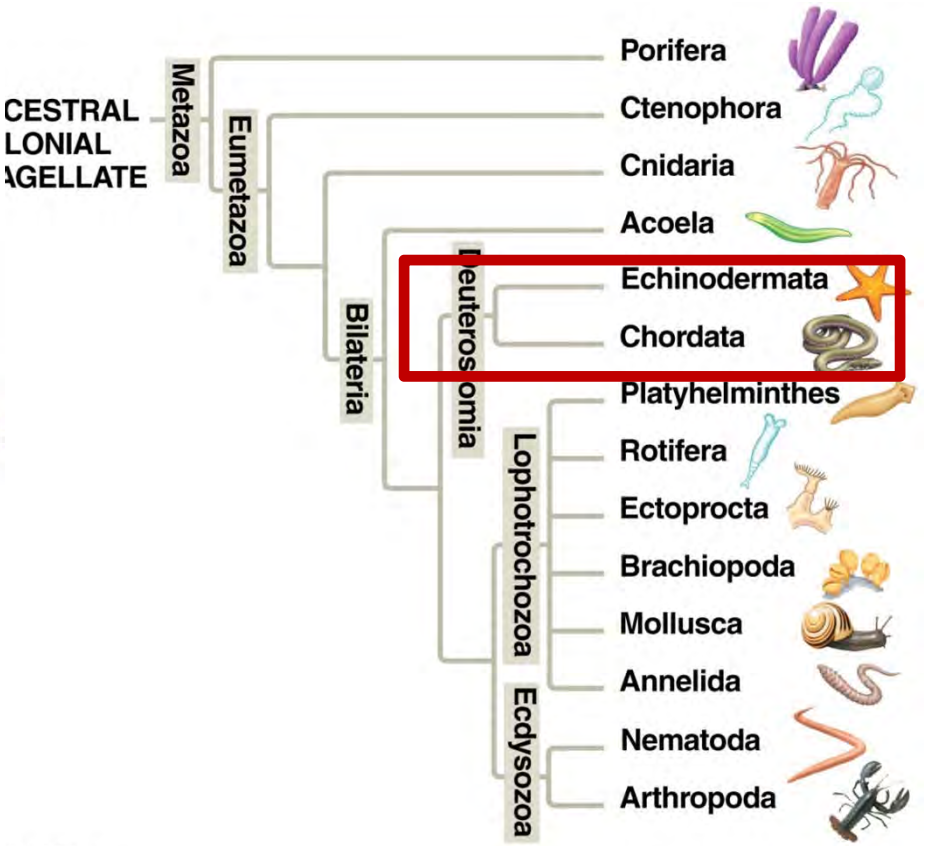
4. Bilateria – Most animal phyla belong to the clade Bilateria which have bilateral symetry

Figures 32.10 and 32.11 (Campbell et al.)

Phylogenetic Tree: Morphology



Phylogenetic Tree: Molecular

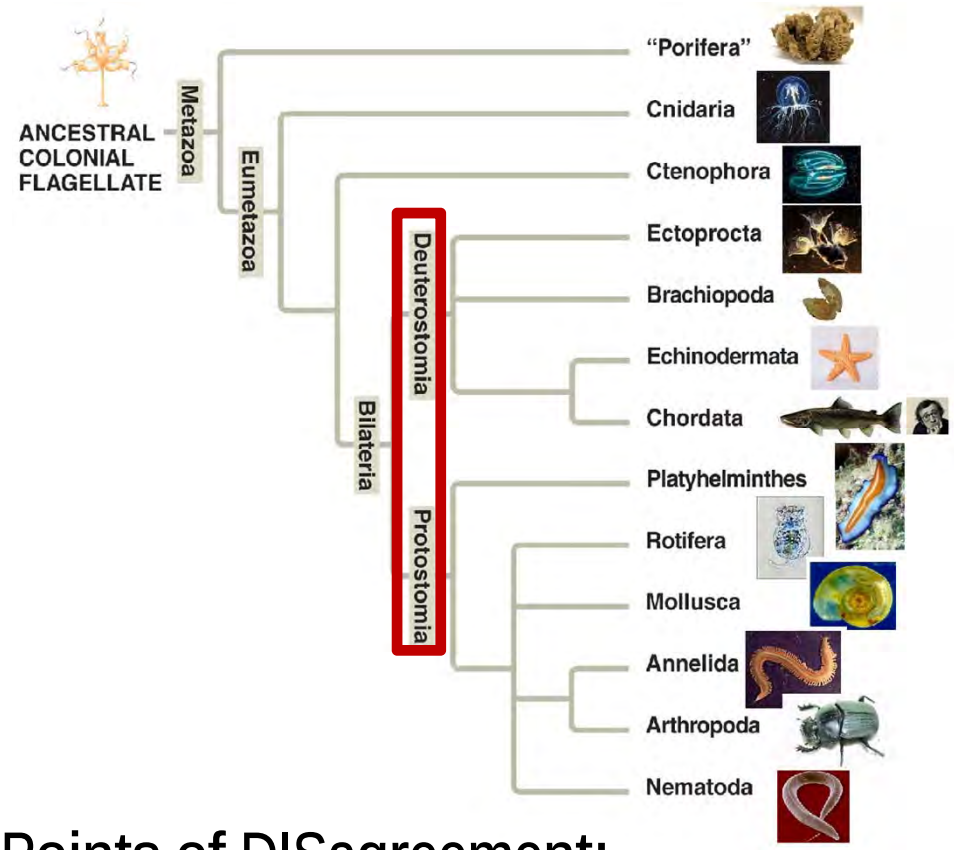


Points of agreement:

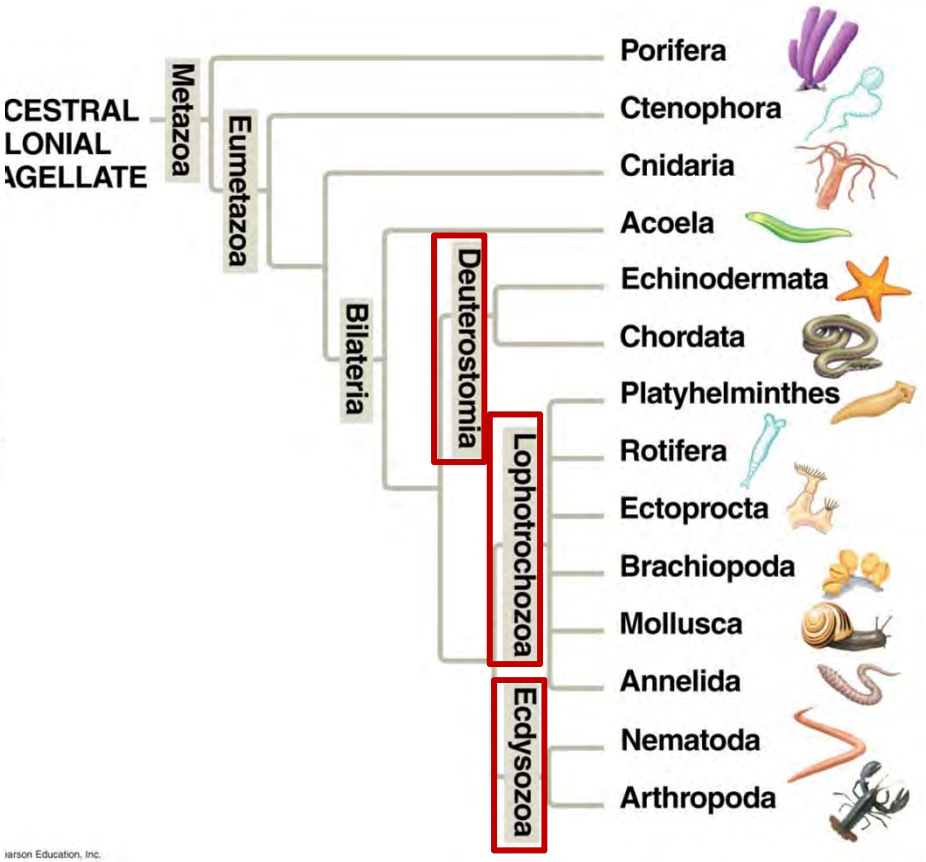
5. Chordates and Echinoderms belong to the monophyletic clade Deuterostomia

Figures 32.10 and 32.11 (Campbell et al.)

Phylogenetic Tree: Morphology



Phylogenetic Tree: Molecular

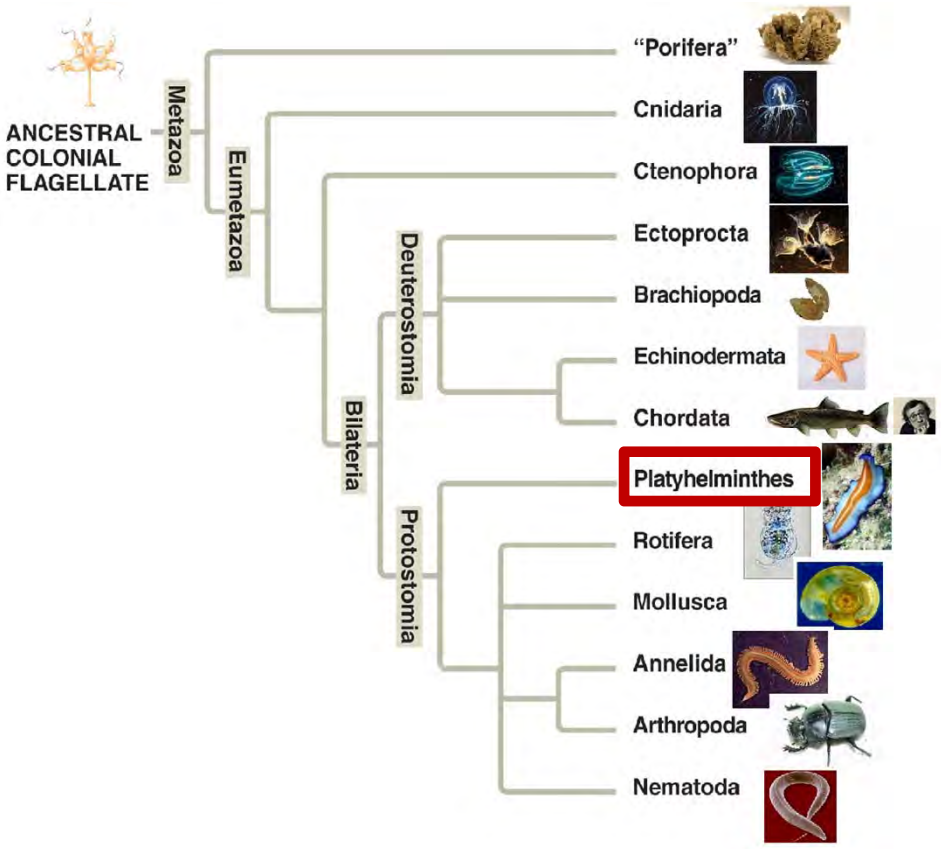


Points of DISagreement:

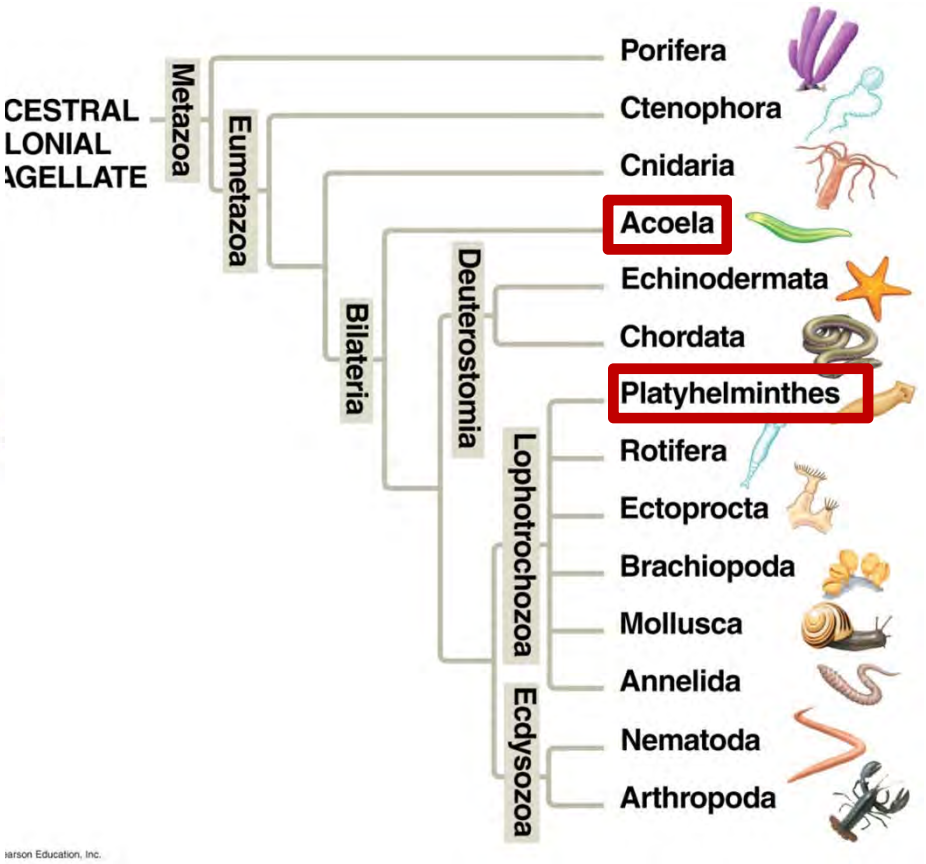
1. Morphological Tree: 2 clades: Deuterostomes vs. Protostomes
   Molecular Tree: - 3 subclades of bilataria
   - Some Deuterostomes monophyletic
   - Other Deuterostomes and nearly all Protostomes grouped into either Lophotrochozoa or Ecdysozoa

Figures 32.10 and 32.11 (Campbell et al.)

Phylogenetic Tree: Morphology



Phylogenetic Tree: Molecular



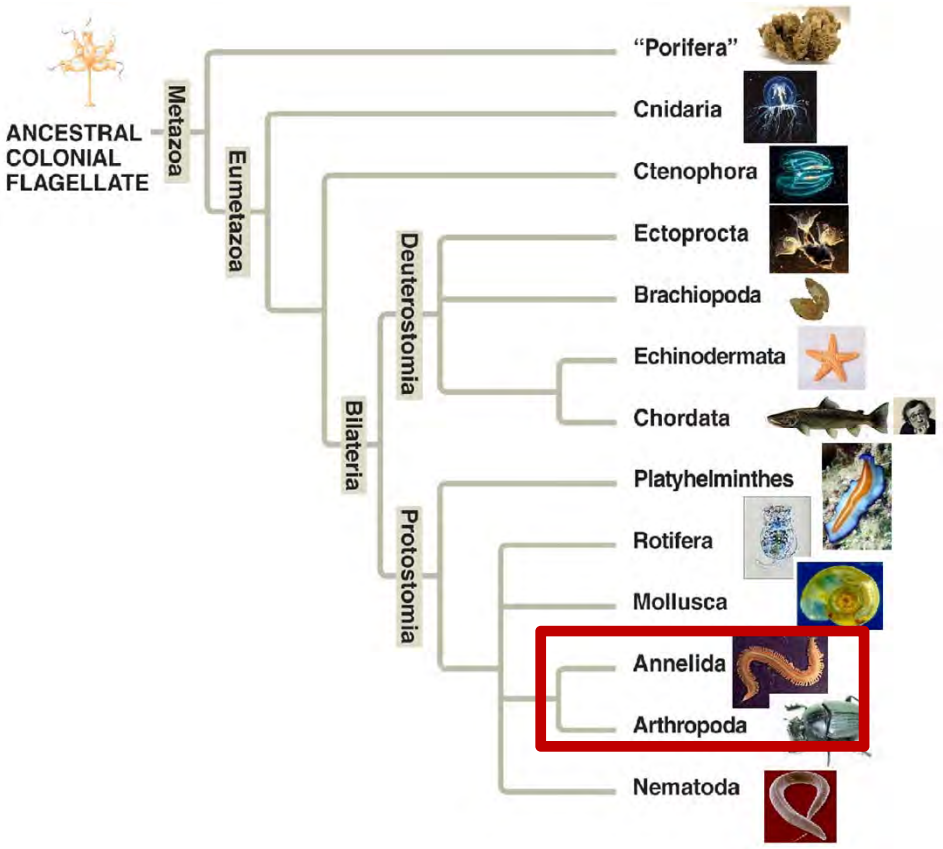
Points of DISagreement:

2. Morphological Tree: All platyhelminthes (flat worms) are one group.

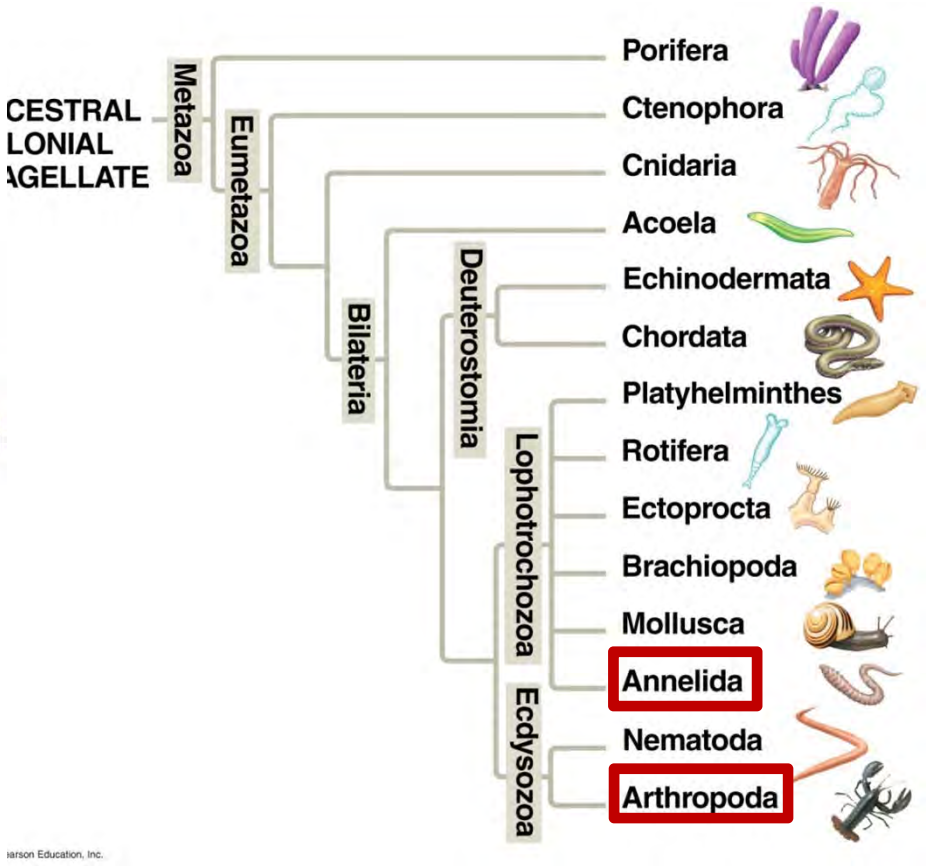
   Molecular Tree: Acoelomate Platyhelminthes separated into basal Bilateria group called Acoela

Figures 32.10 and 32.11 (Campbell et al.)

Phylogenetic Tree: Morphology



Phylogenetic Tree: Molecular



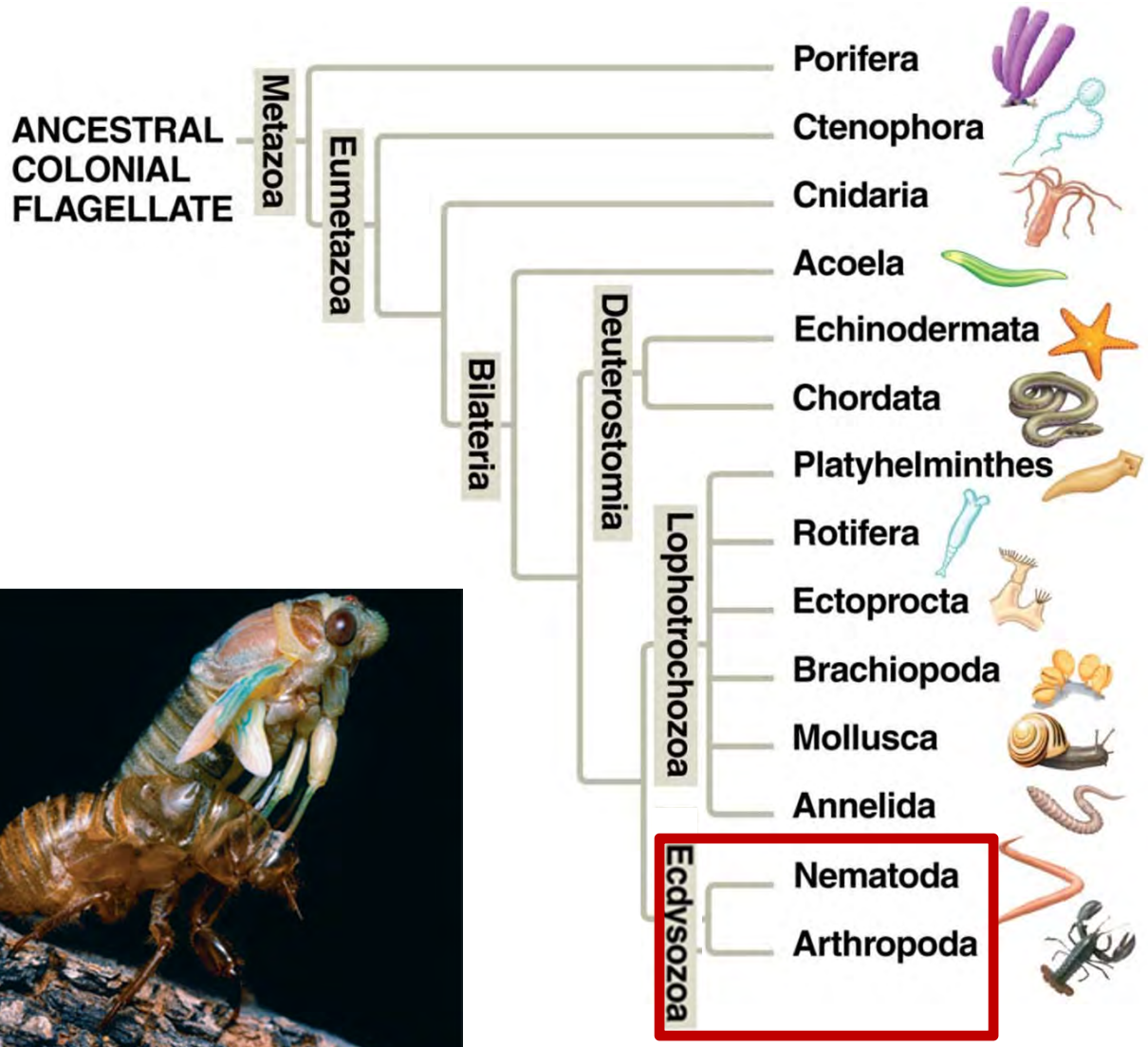
Points of DISagreement:

3. Morphological Tree: Arthropods and Annelids closely related

   Molecular Tree: - Arthropods in Ecdysozoa
   - Annelids in Lophotrochozoa

Figures 32.10 and 32.11 (Campbell et al.)

Phylogenetic Tree: Molecular



Ecdysozoa:

Bilaterians that excrete hard exoskeletons and moult them as they grow

Moulting = ECDYSIS

Figures 32.10 and 32.11 (Campbell et al.)

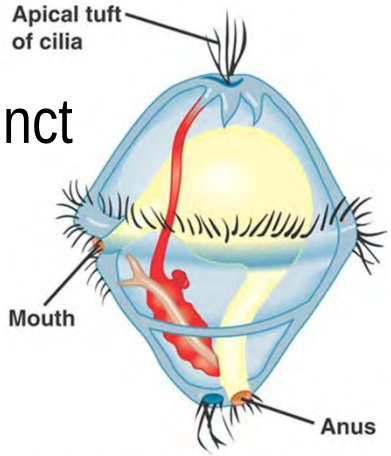
Lophotrochozoa:

Bilateria that either have a:

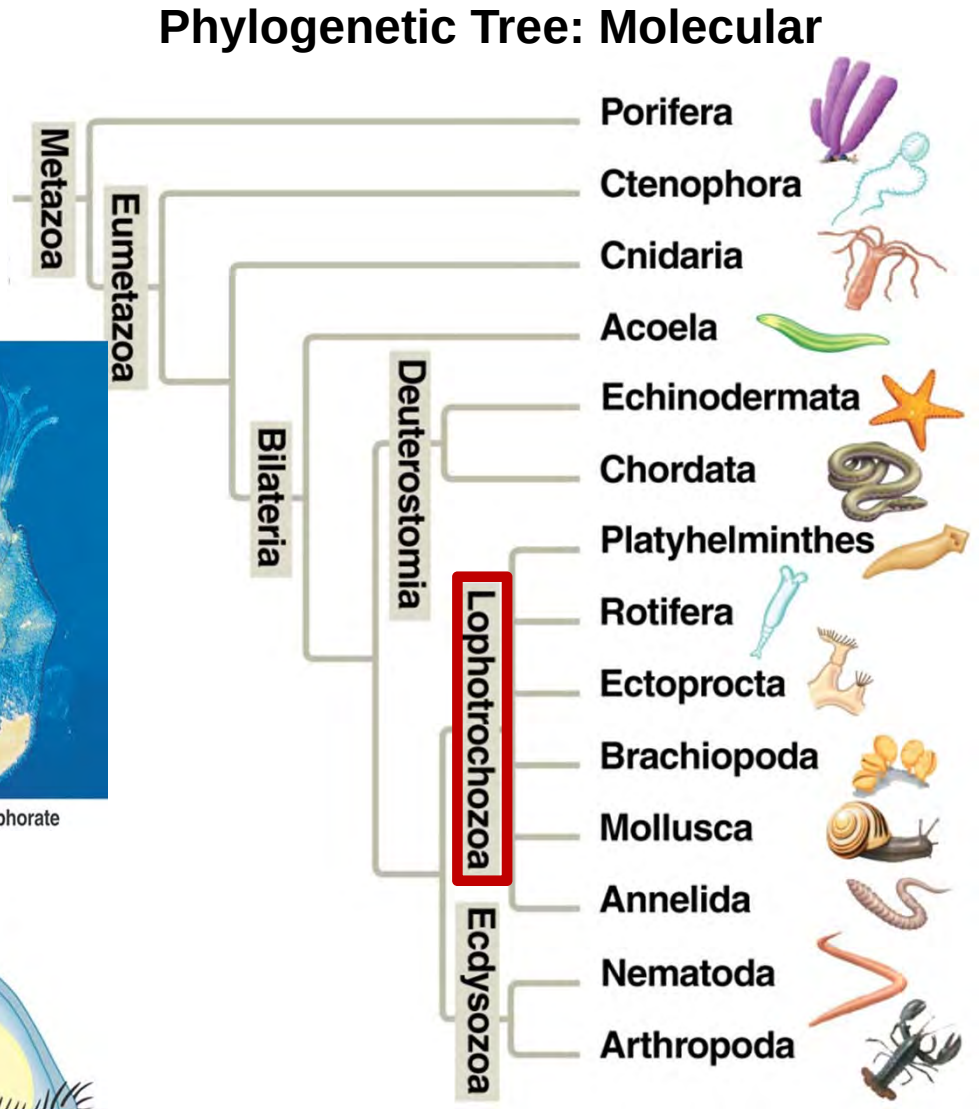
A. lophophore
= crown of ciliated tentacles used to feed

(a) An ectoproct, a lophophorate

B. trocophore
= morphologically distinct larval phase
e.g. annelids, mollusks



(b) Structure of trochophore larva



Figures 32.10 and 32.11 (Campbell et al.)

Readings on which you will NOT be tested

Figure 32.6 Inquiry

In general:

- You are NOT responsible for definitions of terms or sections included in the text but which were not discussed in lecture
- You are not responsible for the details of examples used in the text but not discussed in lecture. HOWEVER, these additional examples will help your understanding of concepts discussed and may be used on exams to test if you understand the general concepts.
- You ARE responsible for material covered in lecture but not included in the readings

Next Chapter

Chapter 33 – An Introduction to Invertebrates