Metazoa

Defining characteristics of animals
- Nutritional mode
- Multi-cellularity
- Sexual reproduction with dominant diploid stage (usually)
- Developmental genes

Animals are a pretty old group...100MY older than the first plants

Origins of animal multicellularity

Fossil record shows vivid and consistent picture of animal evolution

Cambrian explosion led to great animal diversity

Animal body plans
- Symmetry? Tissues? Body cavities?

Most animals are just tubes...how the tube forms matters (Developmental Biology)

What did the first animal look like?

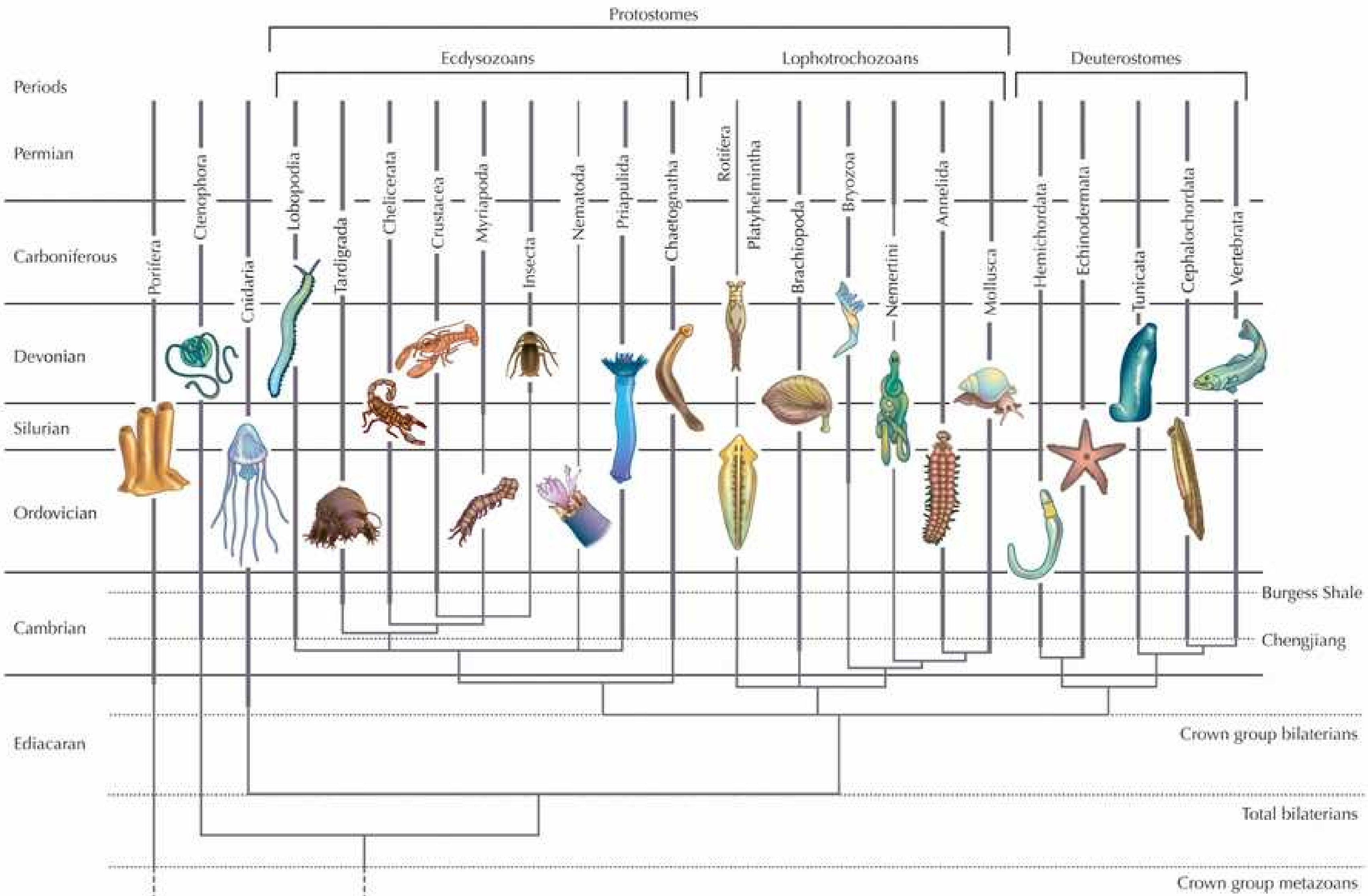


FIGURE 10.16. The fossil record and metazoan phylogeny. *Dark lines* represent the temporal range of phyla from their first appearance in the fossil record to the present. Extrapolation into the Ediacaran is based on molecular clock data. Some relationships, particularly among the arthropods, remain controversial (see Fig. 10.17).

10.16, adapted from original drawing by Susan Butts, based on design by Matthew Wills

Common Traits

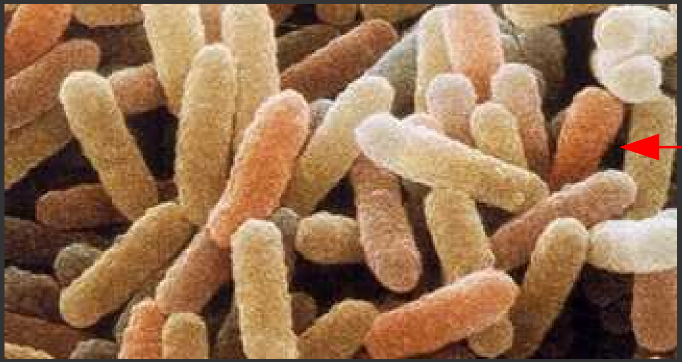
For ALL metazoans:

- **Eat food**
- **Multi-cellular**

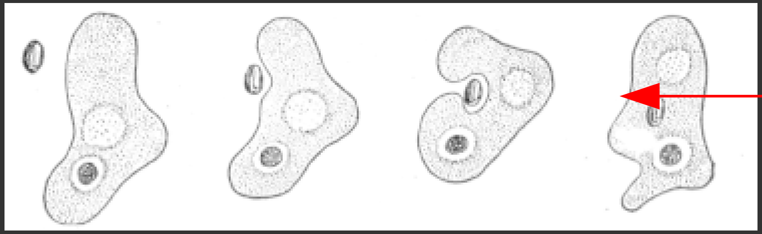
For MOST metazoans:

- **Sexual life cycle dominated by diploid stage**
- **Have differentiated tissues**
- **Gastrulation of embryo**

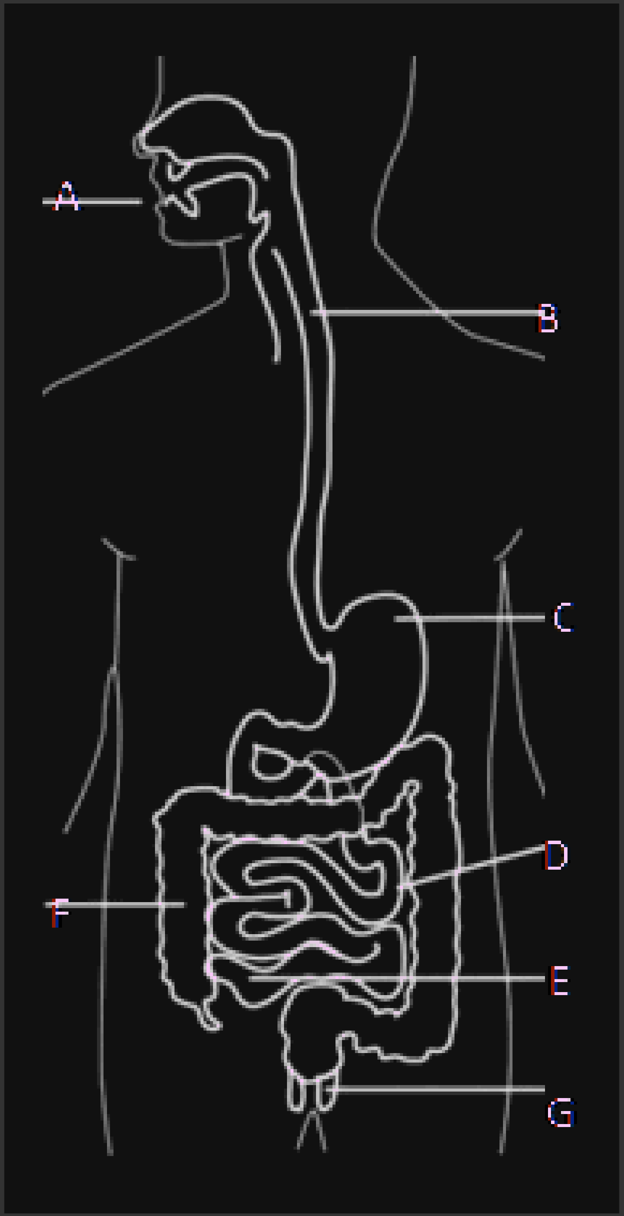
Heterotrophic



Lysotroph

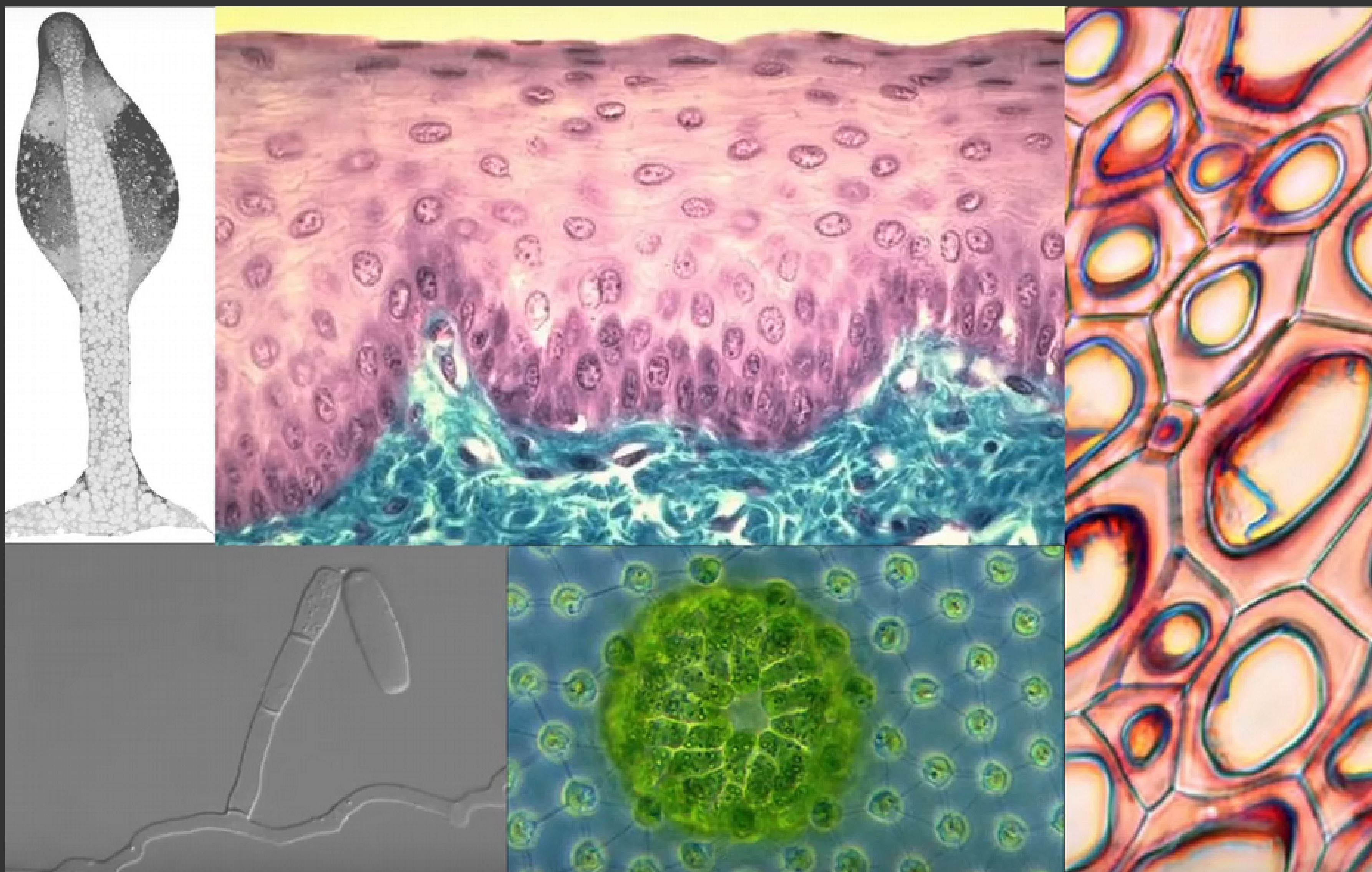


Phagotroph

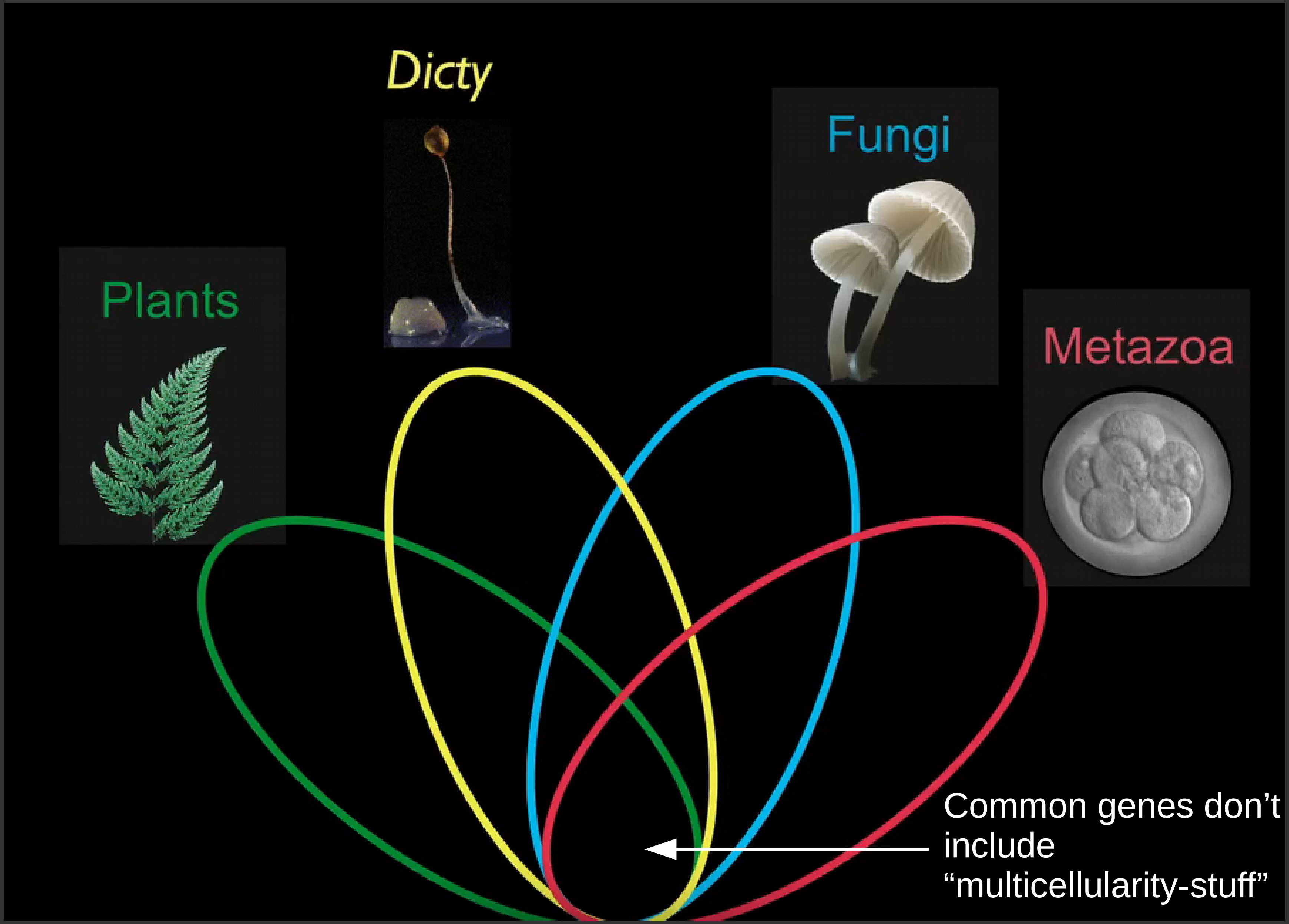


Multicellularity isn't super special

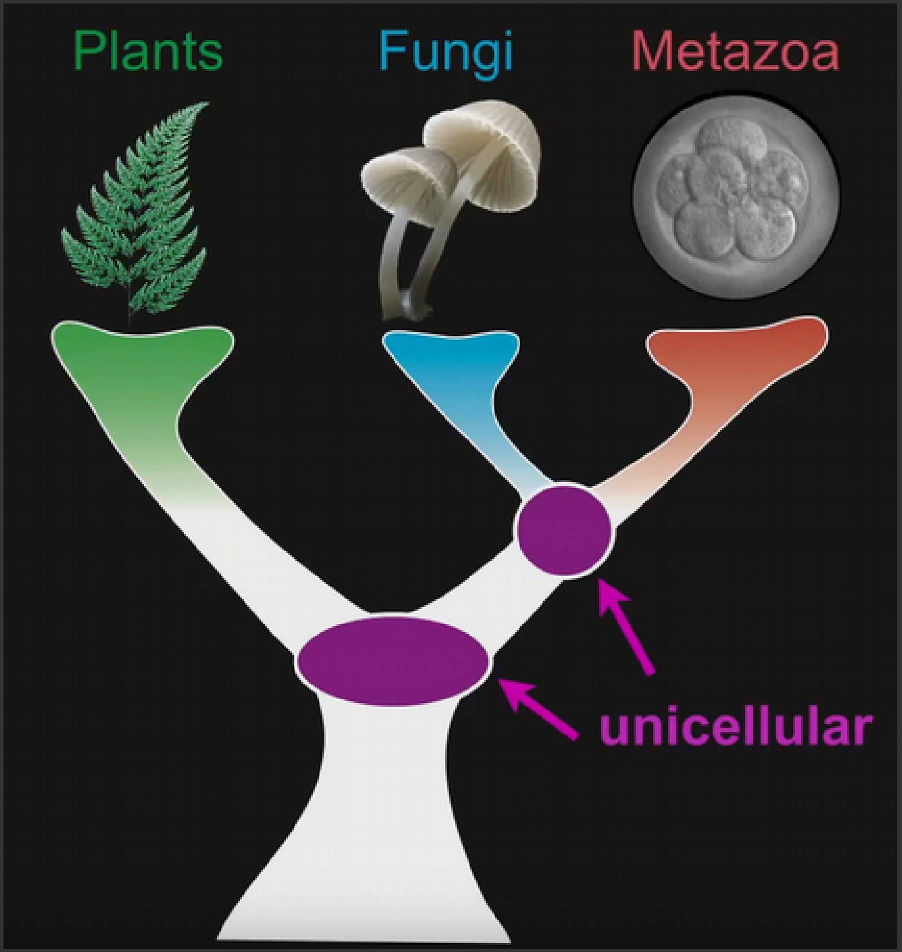
Distinct mechanisms underlie multicellular diversity



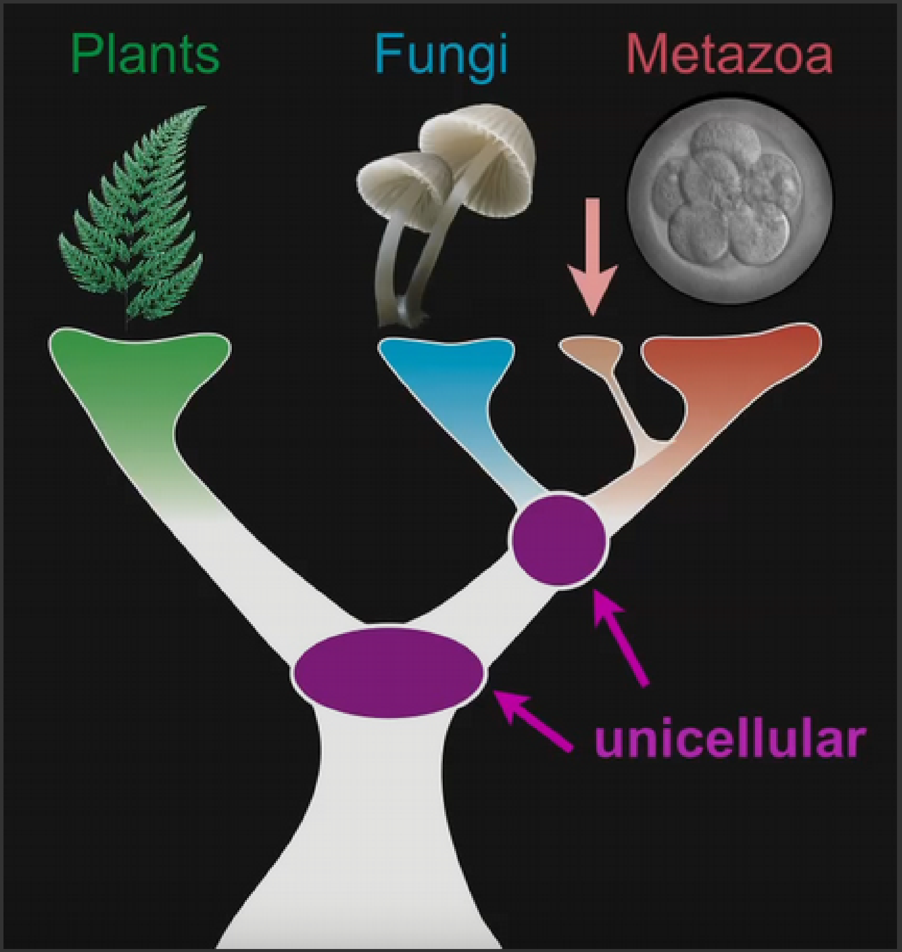
Multicellularity has evolved independently in these lineages



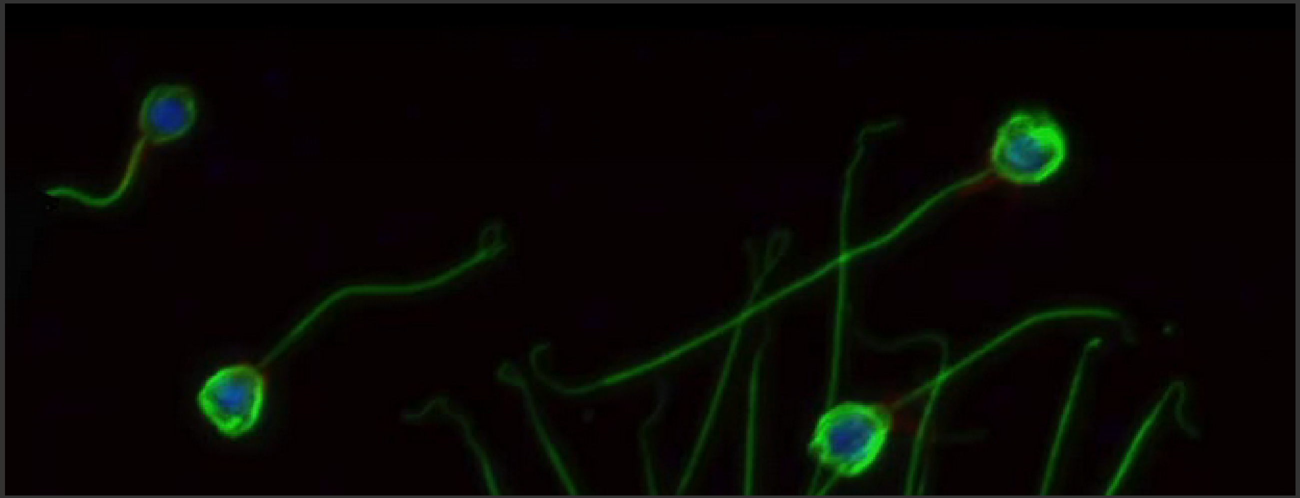
Common ancestor was unicellular

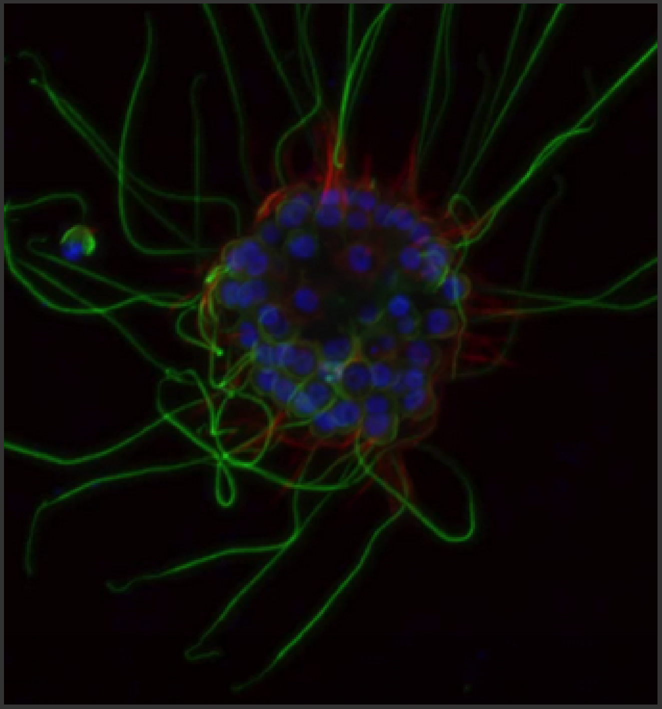


Common ancestor was unicellular



Choanoflagellates



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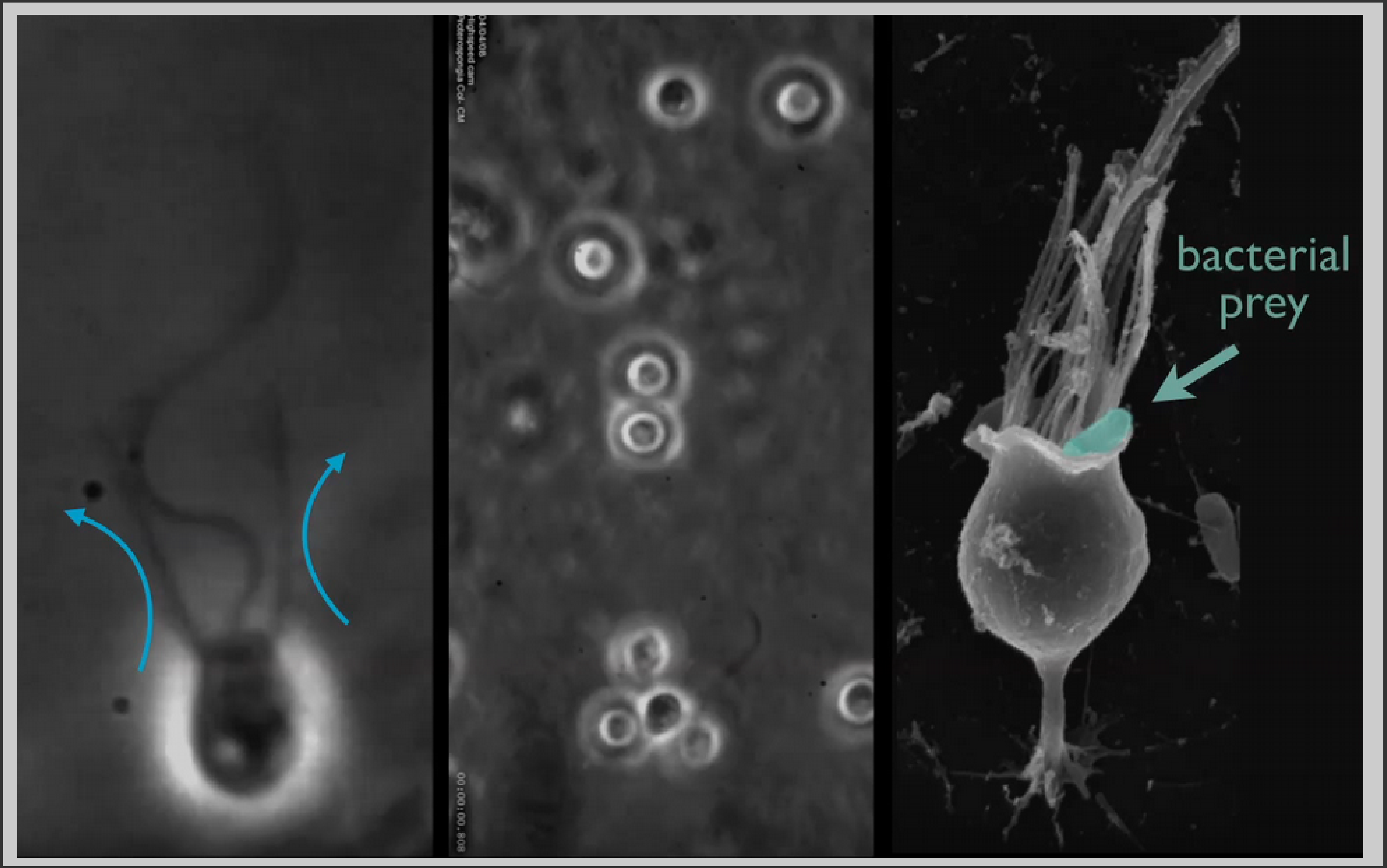
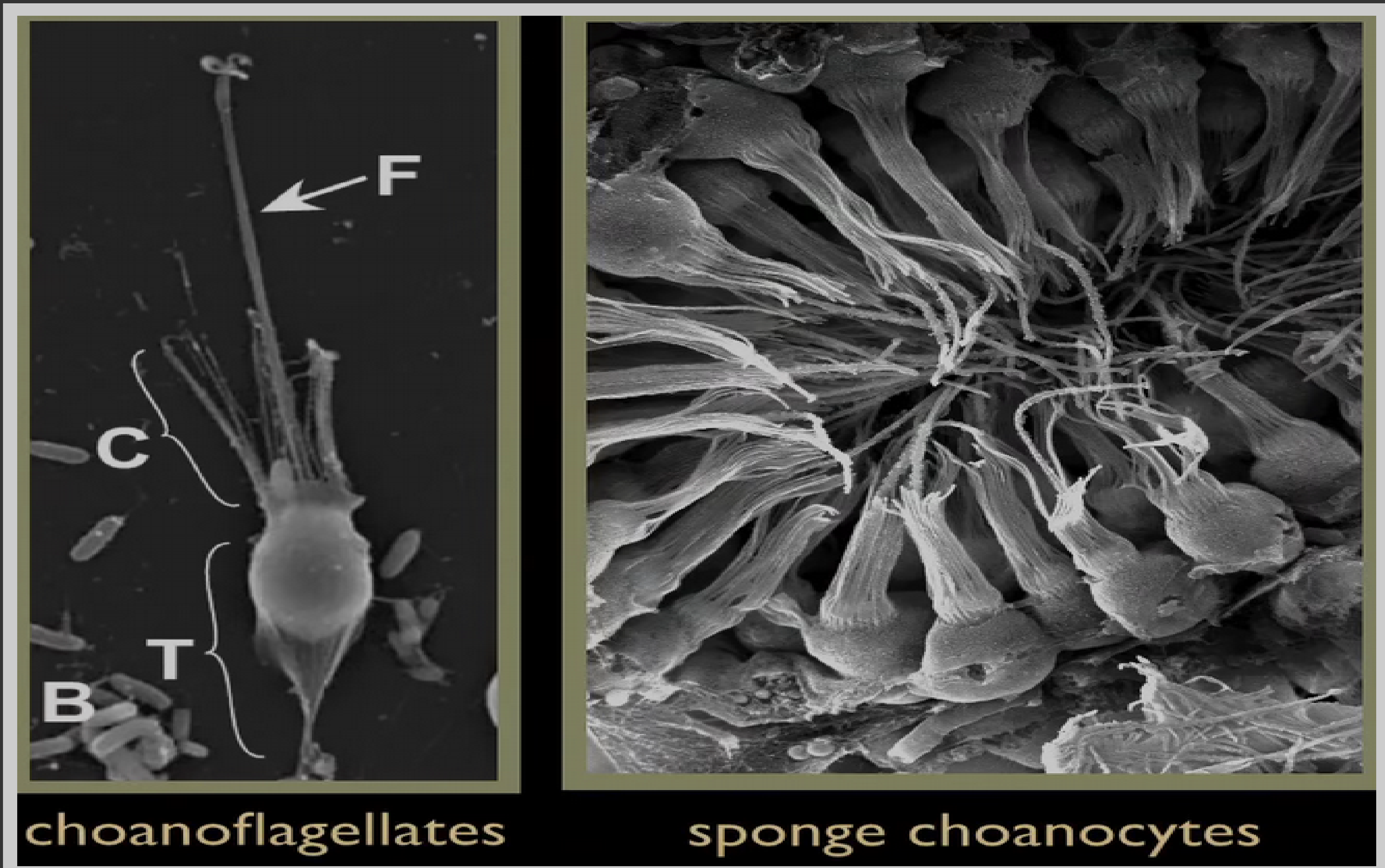
Choanoflagellates

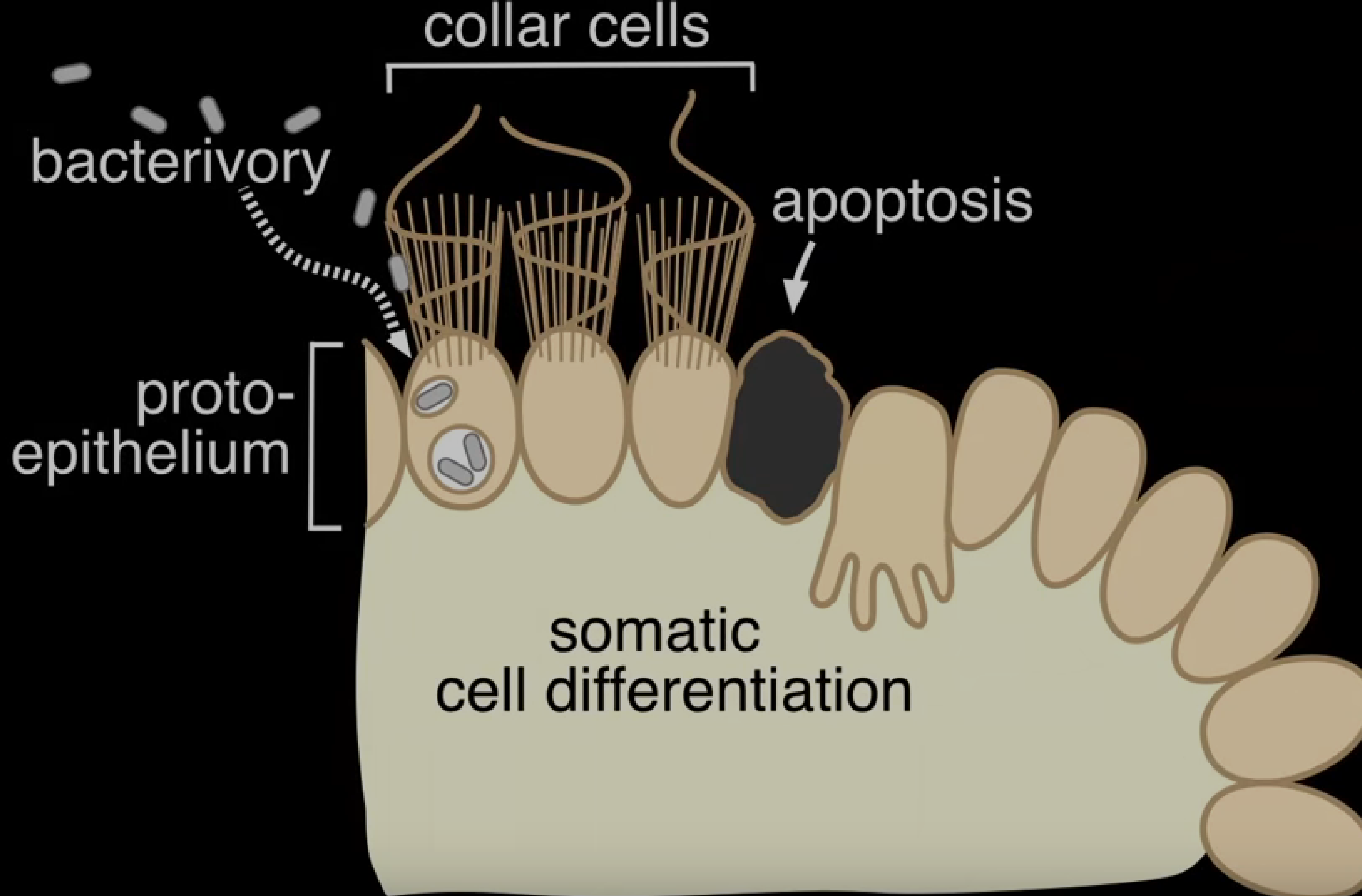


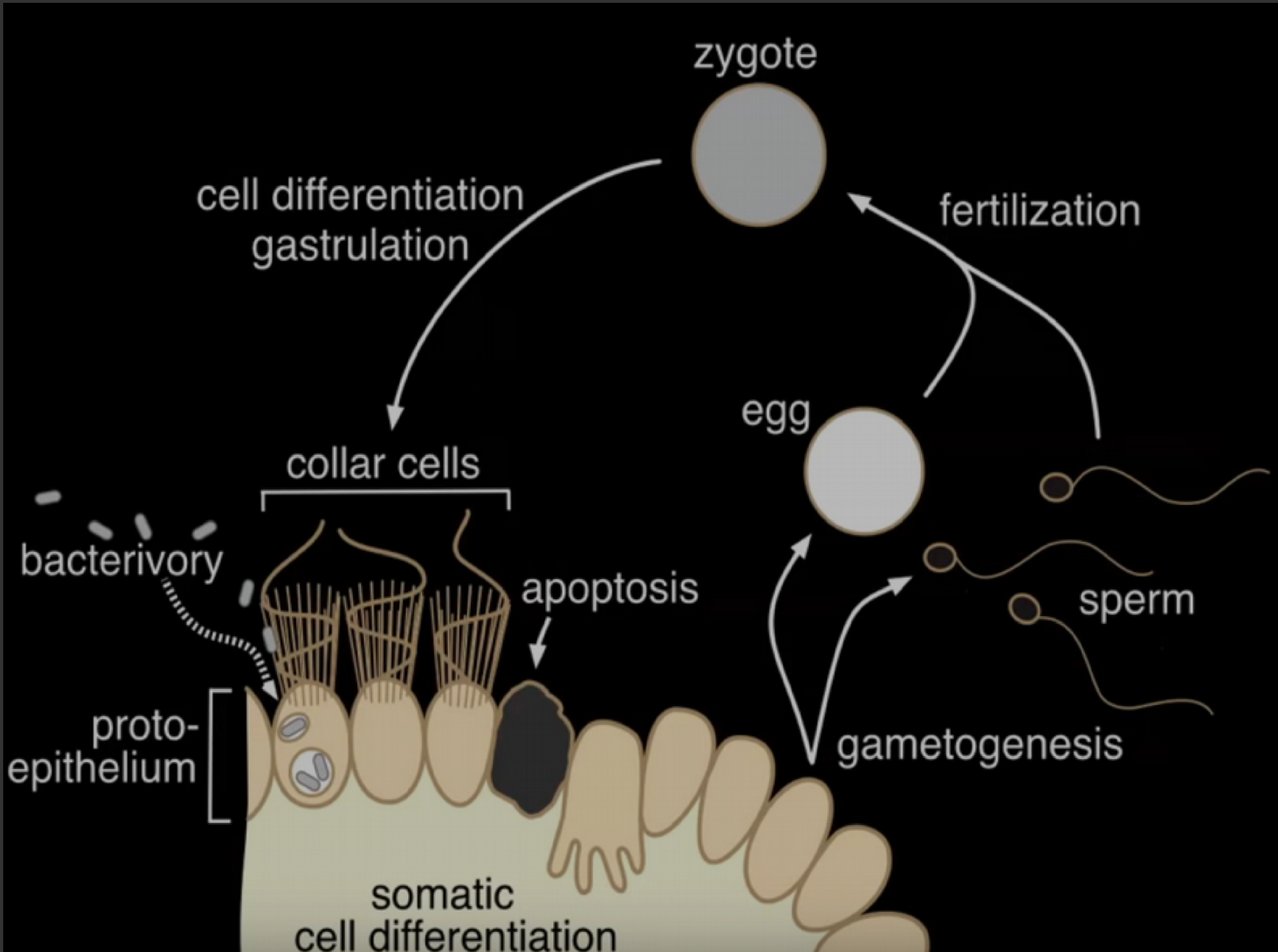
Choanoflagellates



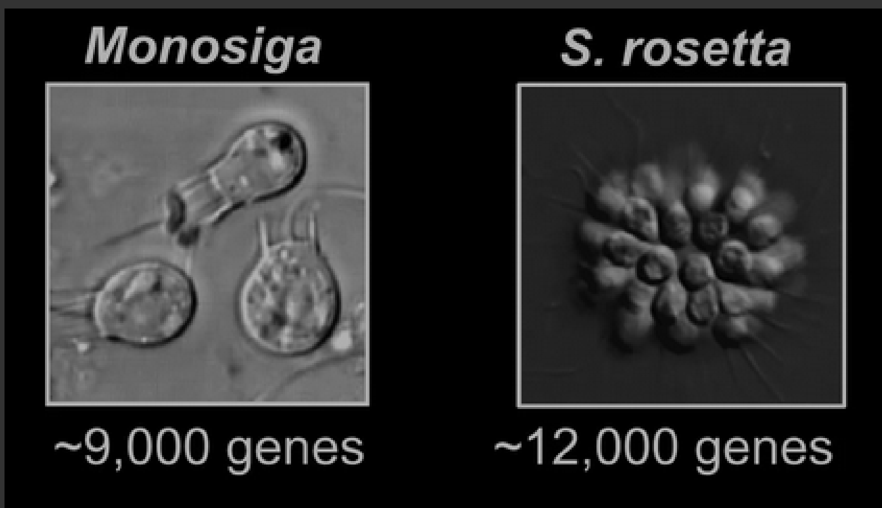
Ever wondered how sponges filter water?

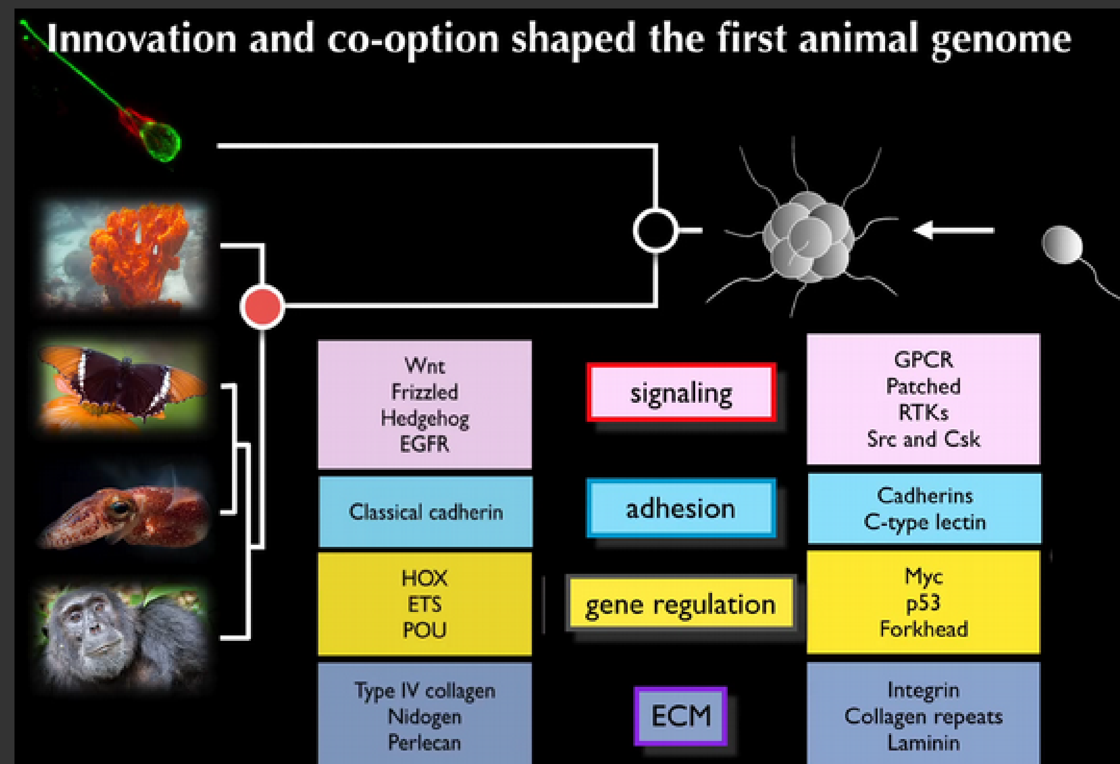
Cell biology and life history of the first animals




zygote
cell differentiation
gastrulation
fertilization
egg
collar cells
bacterivory
apoptosis
sperm
proto-
epithelium
gametogenesis
somatic
cell differentiation

Genomics for reconstructing animal multicellularity

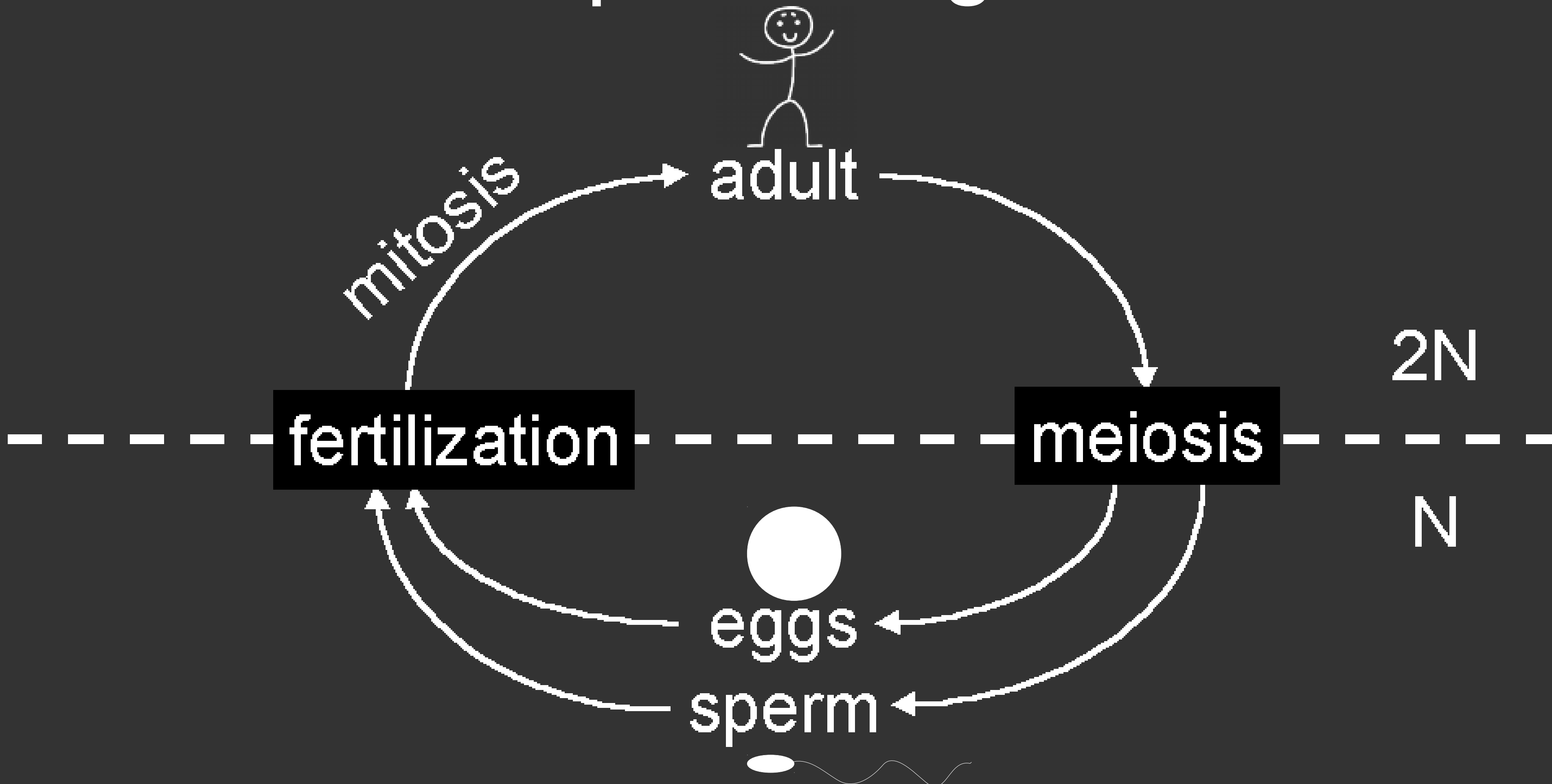




Choanoflagellates can tell us about the cell biology and genome of the common ancestor of animals

Genes for animal cell adhesion and signaling evolved before the transition to multicellularity

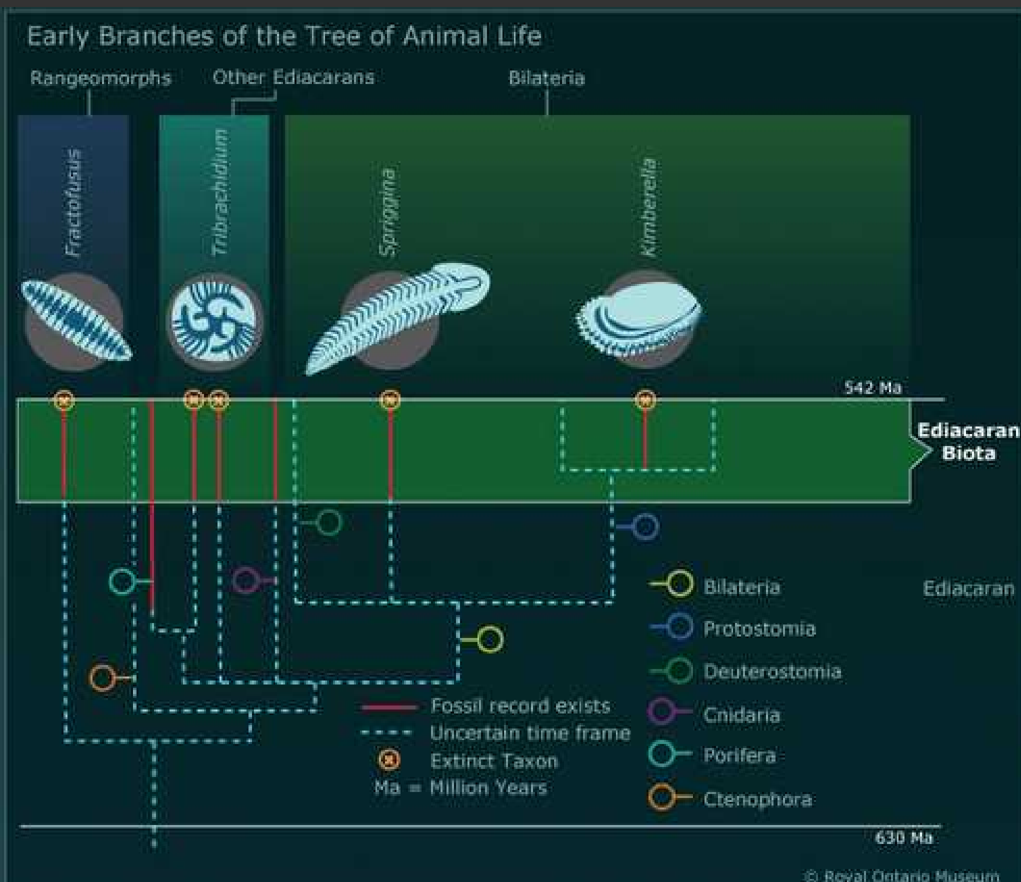
Typically sexual with dominant diploid stage

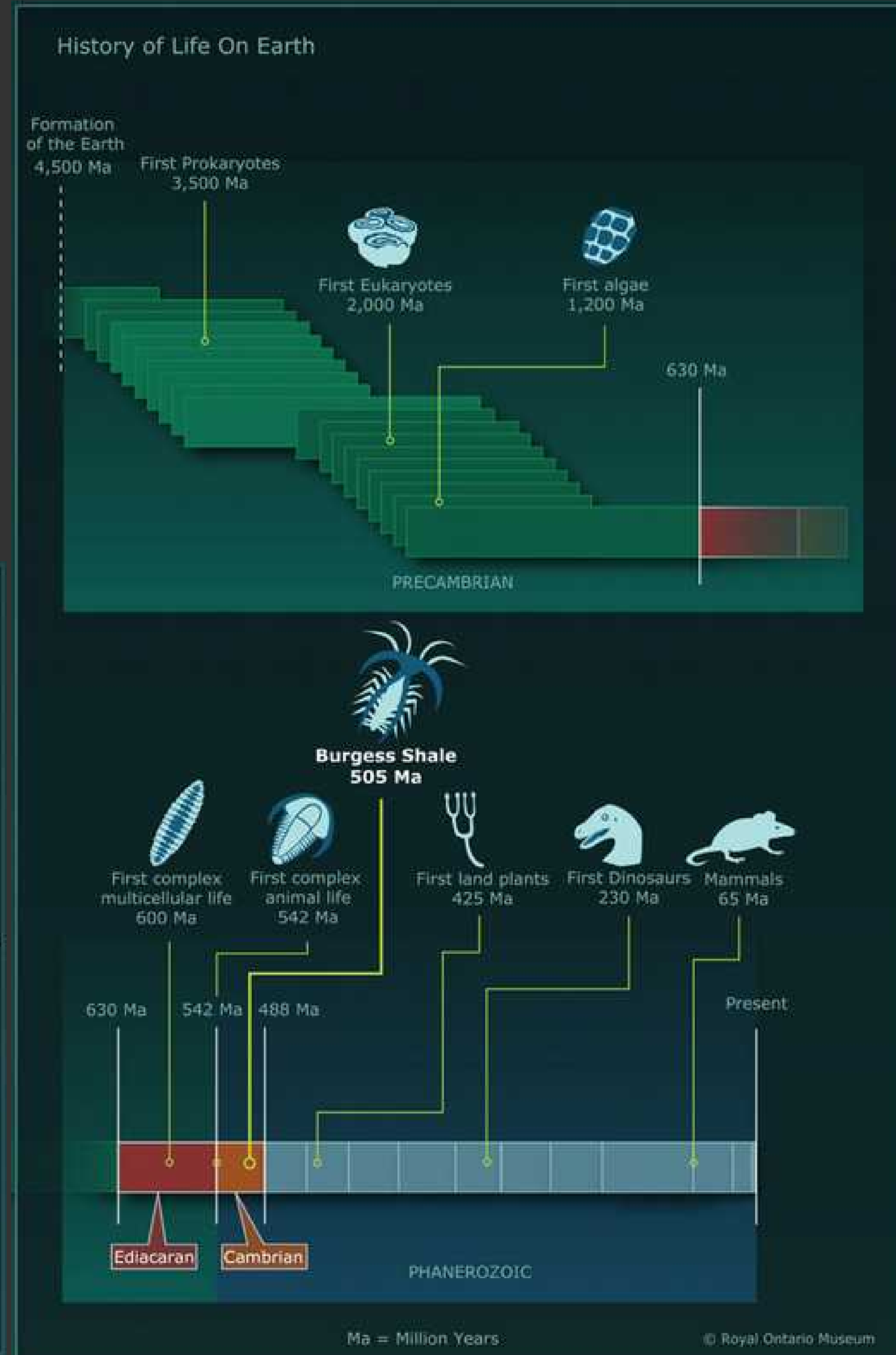


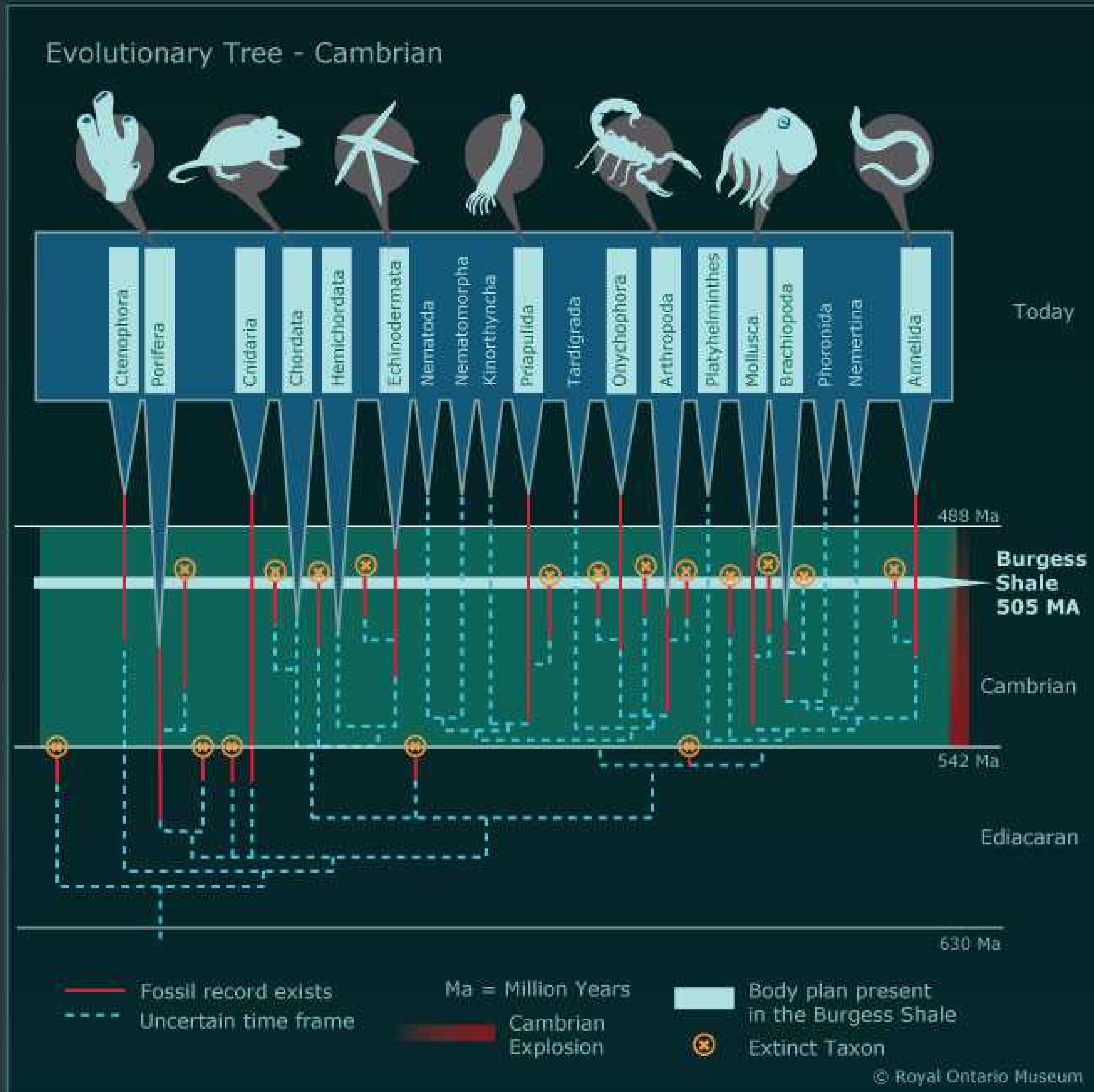
Asexual animals exist

What type of trait is asexuality in metazoans?

Animals have been around for quite a while







Evolutionary Tree - Cambrian
Ctenophora
Porifera
Cnidaria
Chordata
Hemichordata
Echinodermata
Nematoda
Nematomorpha
Kinorhyncha
Priapulida
Tardigrada
Onychophora
Arthropoda
Platyhelminthes
Mollusca
Brachiopoda
Phoronida
Nemertina
Annelida
Today
488 Ma
Burgess Shale 505 MA
Cambrian
542 Ma
Ediacaran
630 Ma
Fossil record exists
Uncertain time frame
Ma = Million Years
Cambrian Explosion
Body plan present in the Burgess Shale
Extinct Taxon
© Royal Ontario Museum

You can kind of classify animals based on “body plans”

Do they have symmetry? If so, what kind?

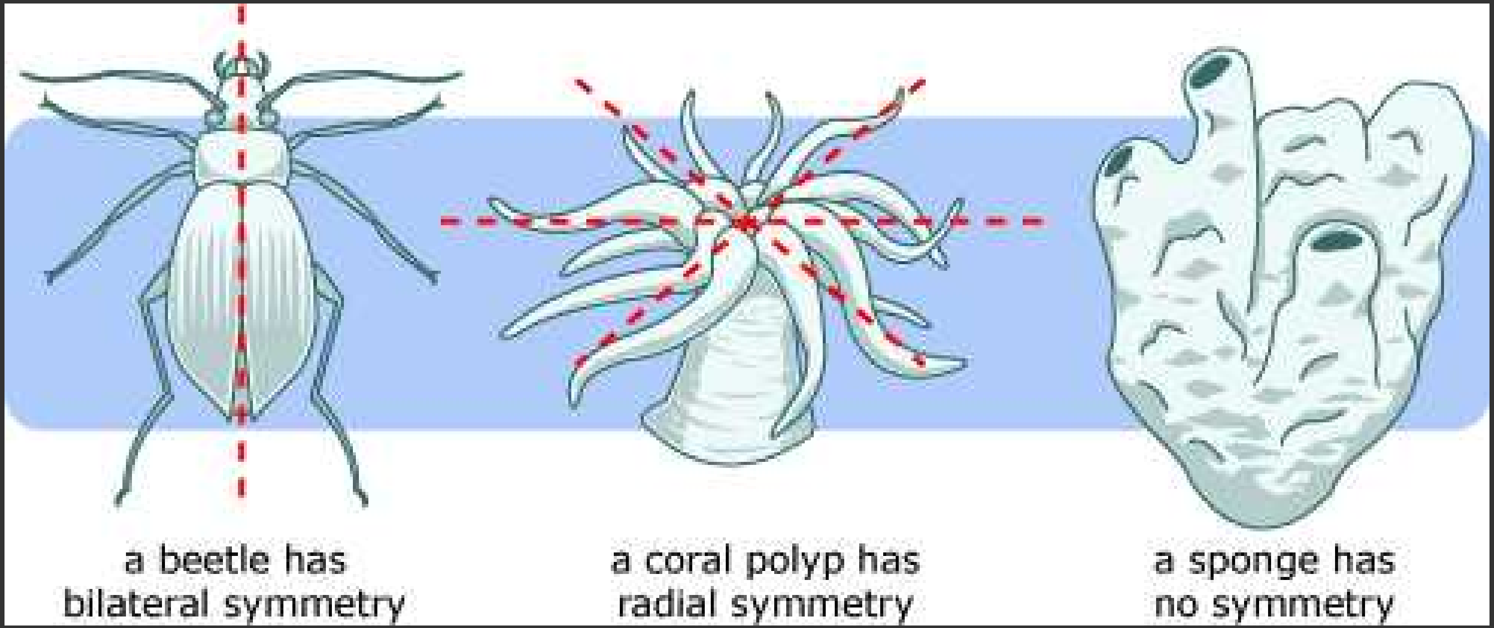
Do they have true tissues (collections of specialized differentiated cells)?

Do they have a “body cavity?” If so, how was it formed?

How does development proceed?

These do not always reflect evolutionary clades though. How can this be?

Symmetry

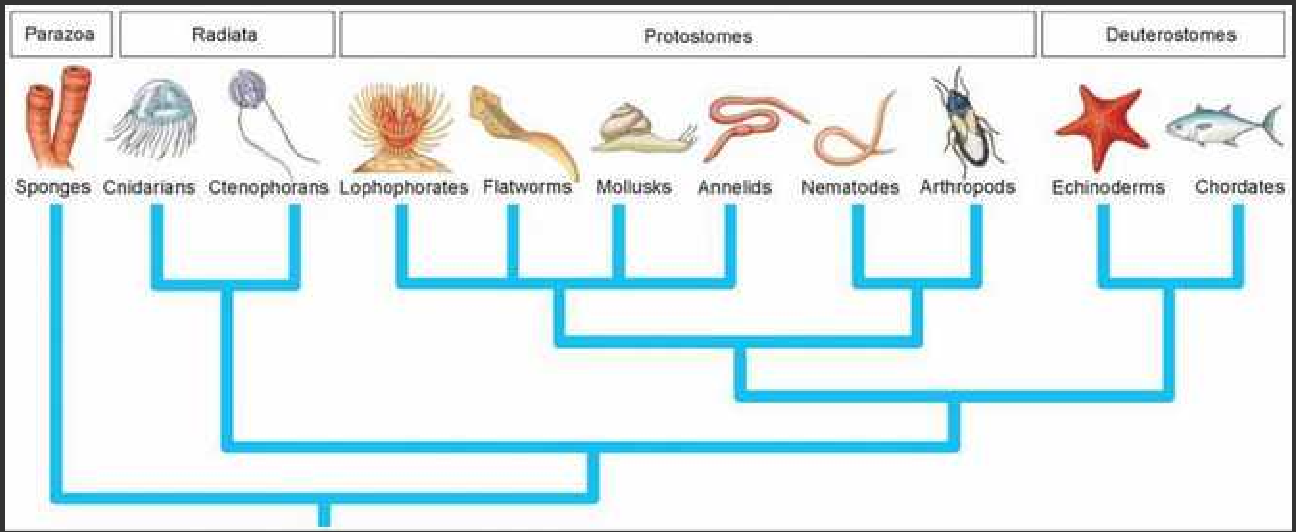

a beetle has
bilateral symmetry
a coral polyp has
radial symmetry
a sponge has
no symmetry

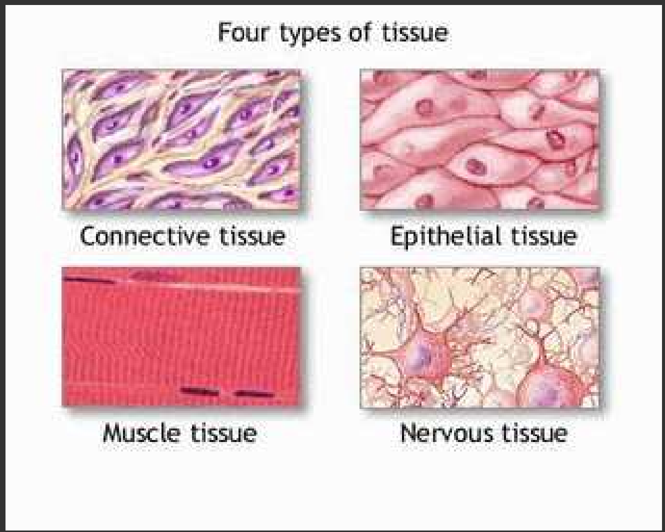
Tissues?
(specialized groups of cells)

Animal body plans also vary according to the organization of the animal's tissues.

Tissues are isolated from other tissues by membranous layers.

During development, three germ layers give rise to the tissues and organs of the animal embryo.





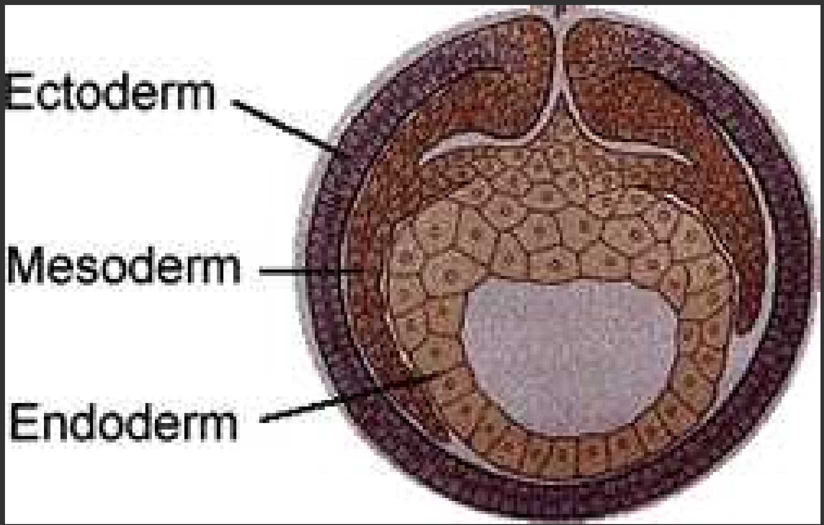
Embryonic germ layers

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 a *middle* ***mesoderm*** layer; these include all bilaterians.

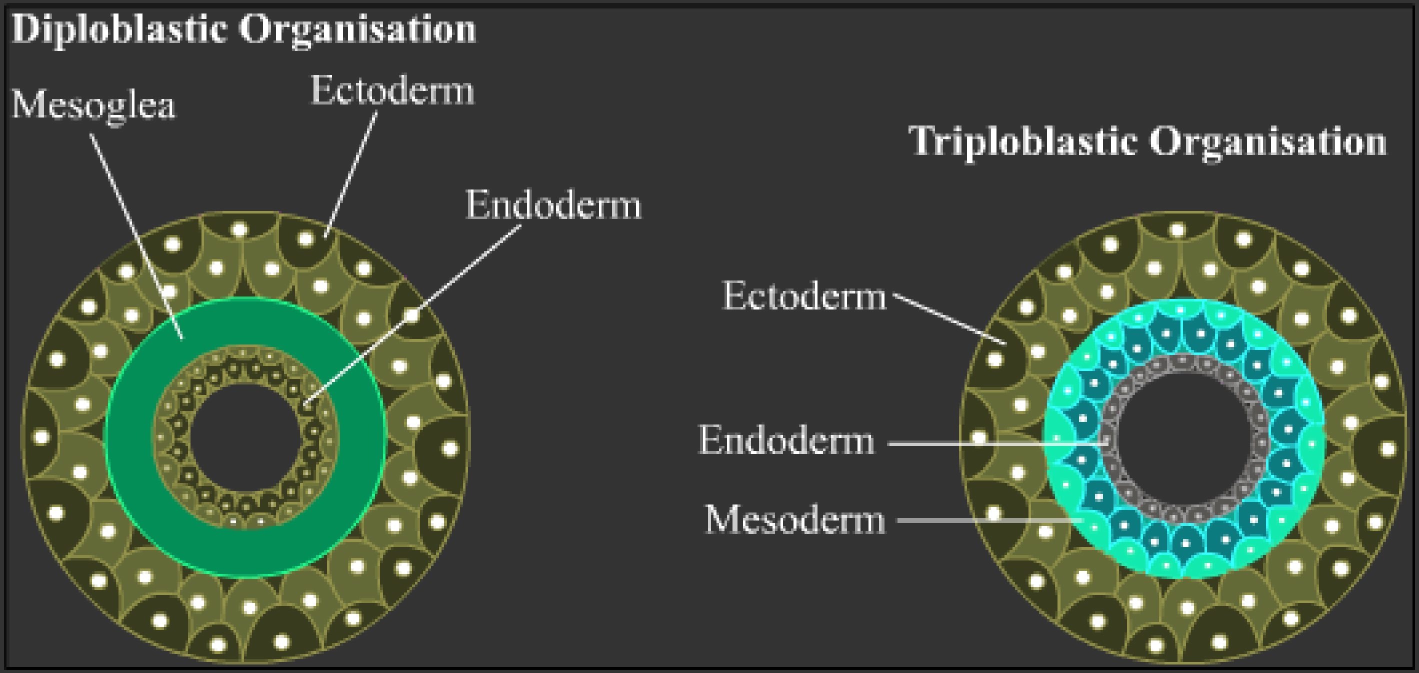


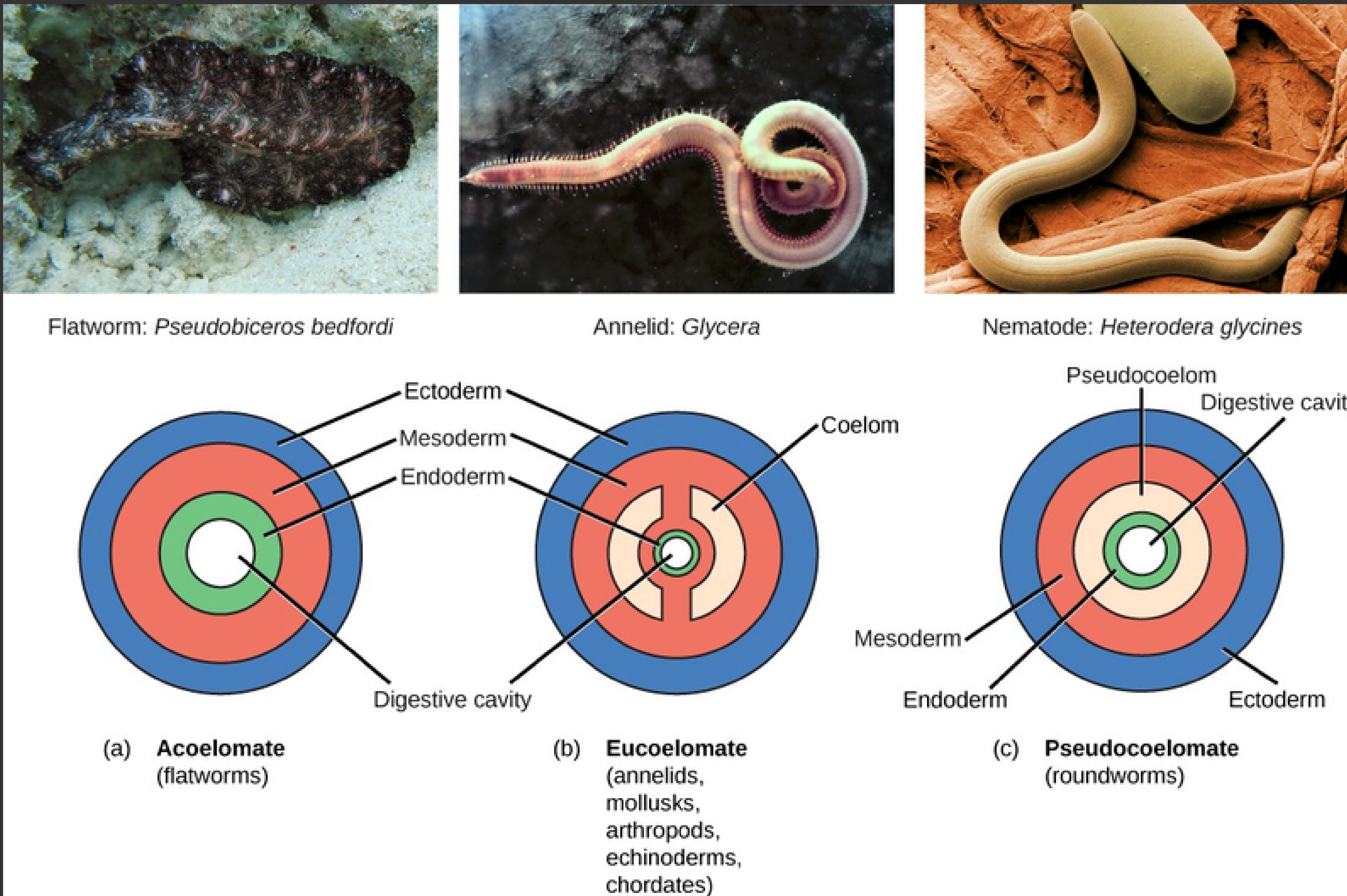
Most triploblastic animals have a body cavity

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

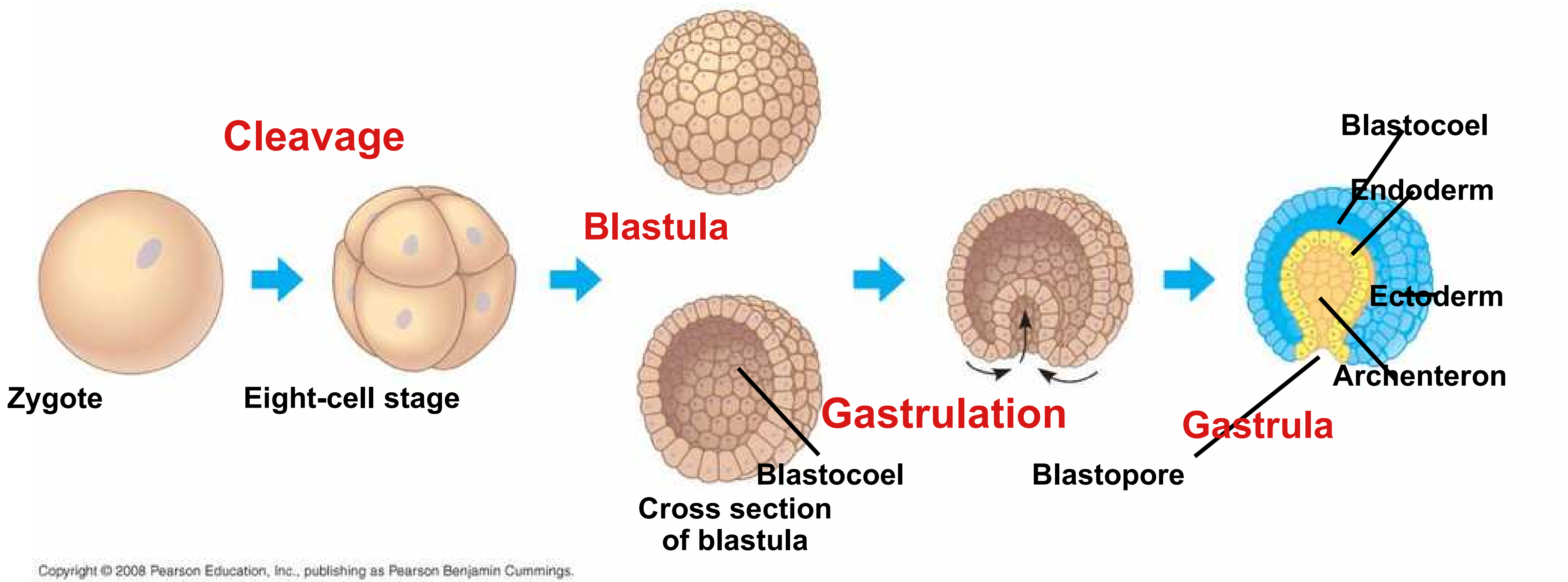
A pseudocoelom is *a body cavity derived from the mesoderm and endoderm*. Triploblastic animals that possess a pseudocoelom are called ***pseudocoelomates*****.**

Triploblastic animals that *lack a body cavity* are called ***acoelomates*****.**

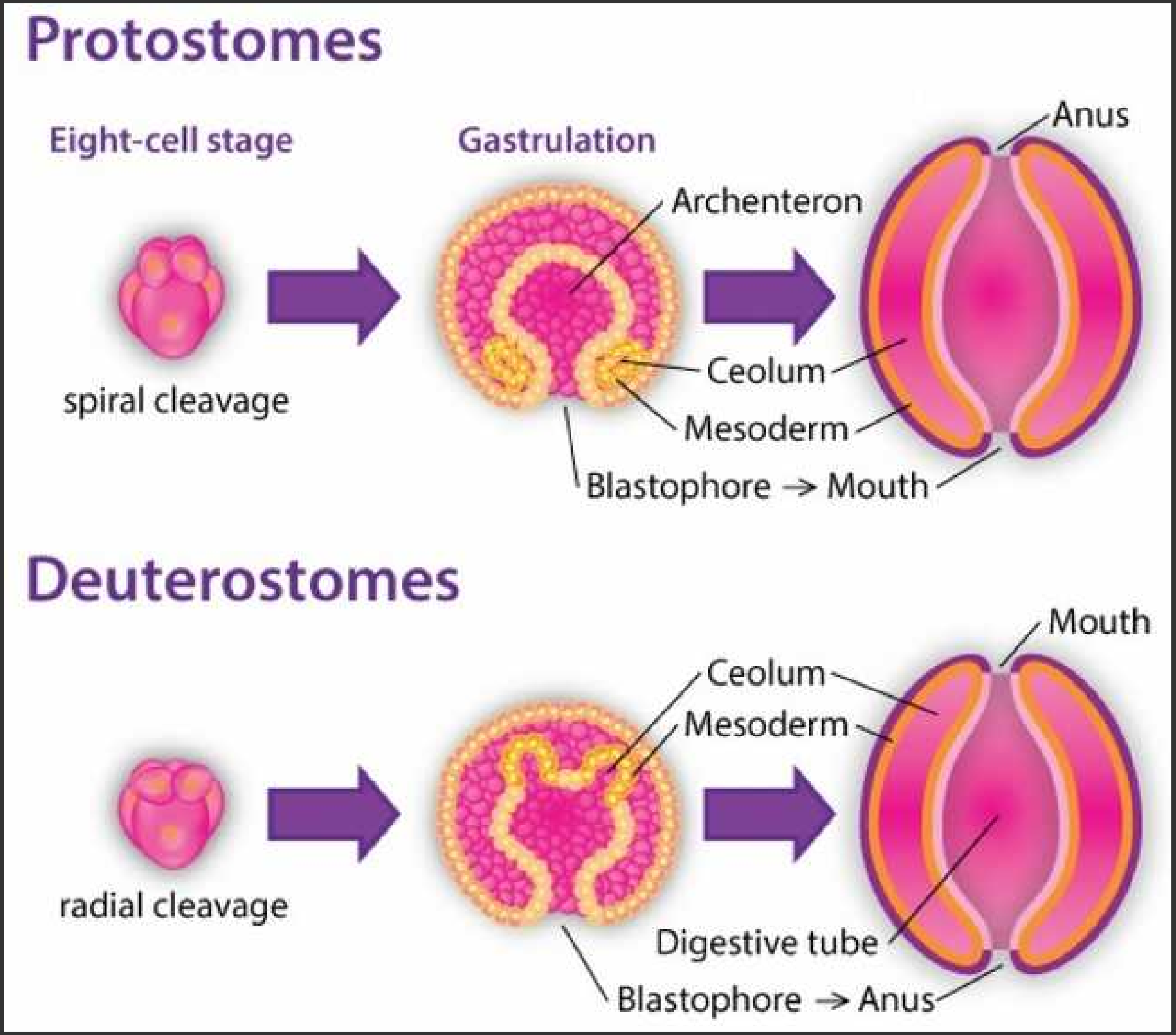



Flatworm: *Pseudobiceros bedfordi*
Annelid: *Glycera*
Nematode: *Heterodera glycines*
Ectoderm
Mesoderm
Endoderm
Coelom
Digestive cavity
Pseudocoelom
Digestive cavity
Mesoderm
Endoderm
Ectoderm
(a) **Acoelomate** (flatworms)
(b) **Eucoelomate** (annelids, mollusks, arthropods, echinoderms, chordates)
(c) **Pseudocoelomate** (roundworms)

Animal Early Embryonic Development

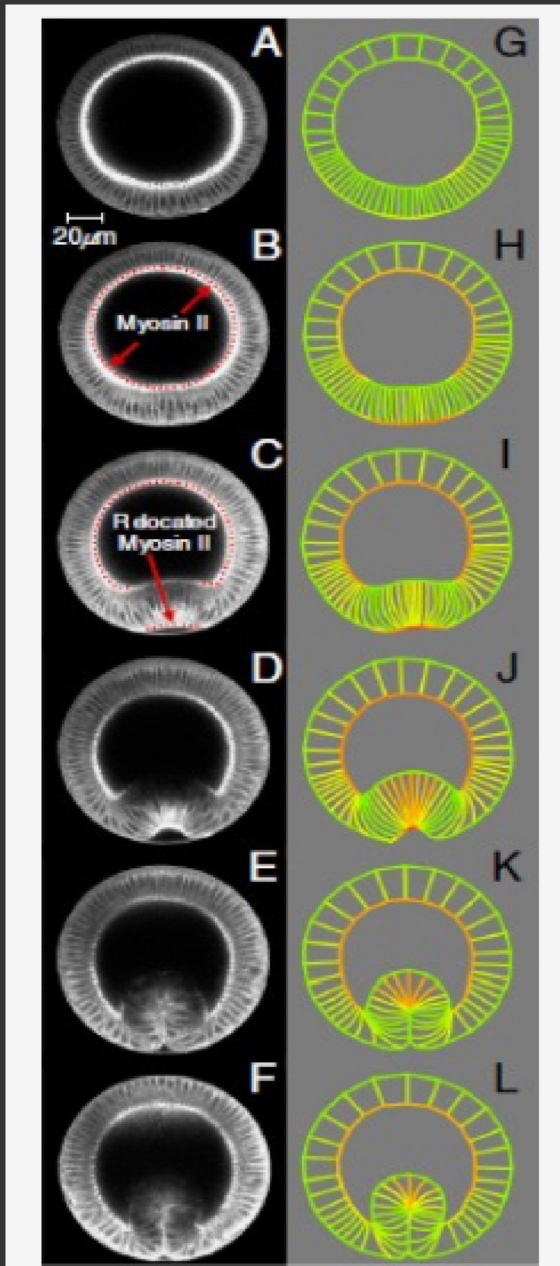


Tube formation: Mouth first or butt first?




SYSTEMS

Mechanical mechanism of gastrulation



22 minute time-lapse

$$\frac{2K}{A_0}(A-A_0)R_S - k_C\left(\frac{2}{R_S}-C_0\right)C_0 R_S + \frac{2k_r}{A_0}(\overline{C}-\overline{C_0}) - \Delta p R_S^2 = 0 \qquad (10)$$

By drawing on earlier conclusions about the stability of spherical vesicular objects the authors of Ref. [3] have formulated the criterion for the stability of a spherical vesicle thus delimiting the region in the parameter phase space where spherical vesicular objects become unstable.

6

$$c_0 - 2\frac{k_r}{k_c}(\bar{c}-\bar{c}_0) - \frac{\Delta p R_S^3}{2k_c} - 6 < 0\,. \qquad (11)$$

The two middle terms follow directly from the last two terms in Eq. (10). The first two terms represent the features of the vesicle and the third one represents the reduced pressure. We could interpret the inequality as suggesting that the difference in magnitude between the bending force and force due to non-local deformation should be smaller than the magnitude of the force due to pressure difference, although this statement is only vaguely appropriate. Figure 6 shows the parameter phase space and its division into the stable and unstable region for spherical vesicular objects.

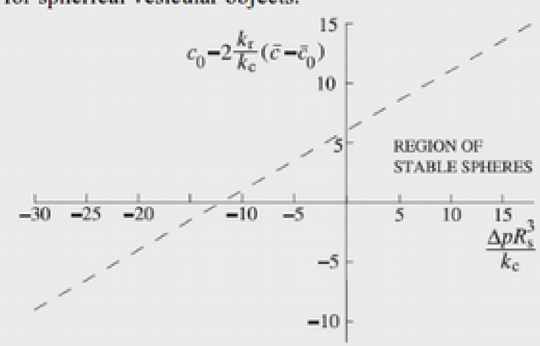
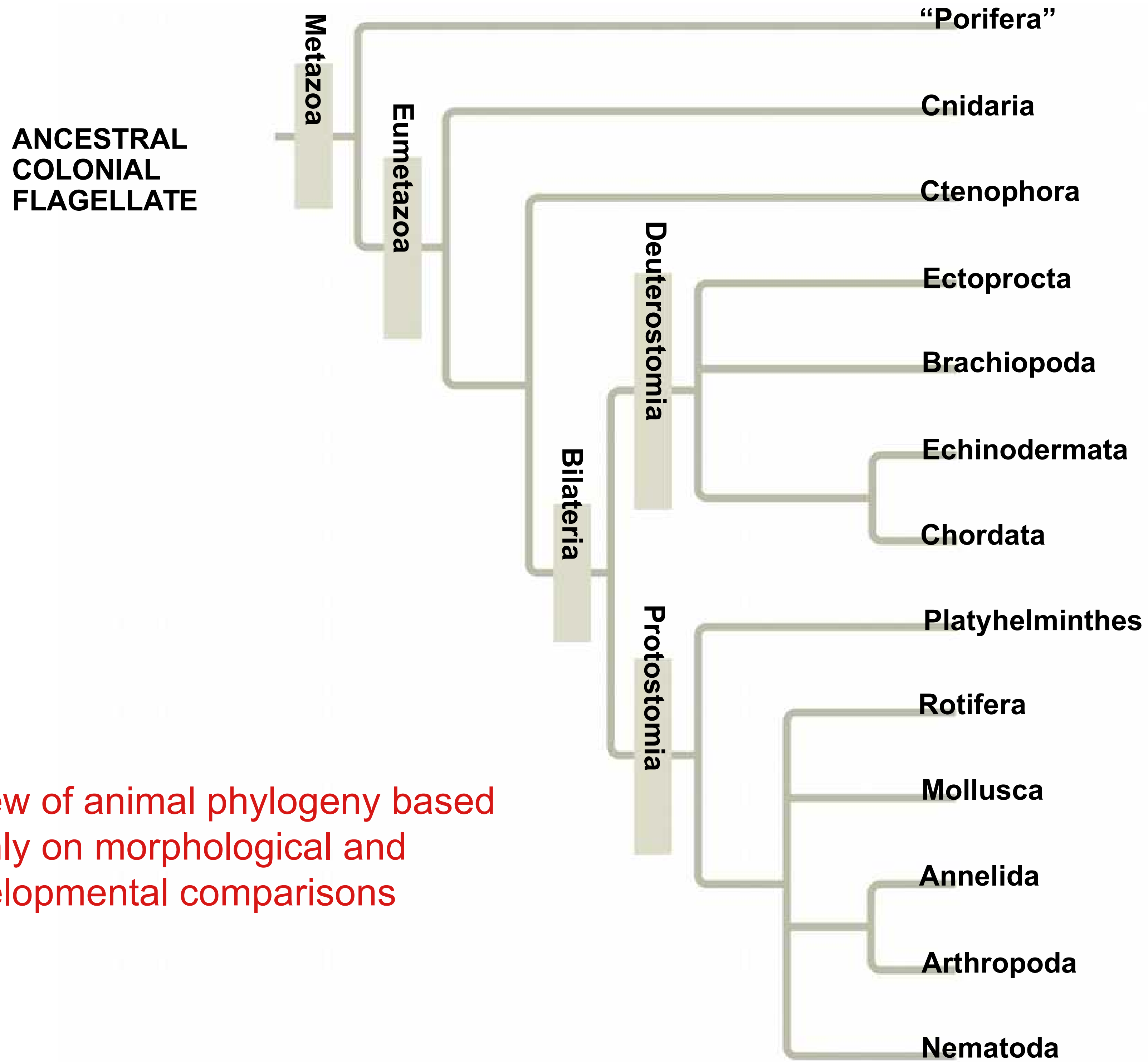
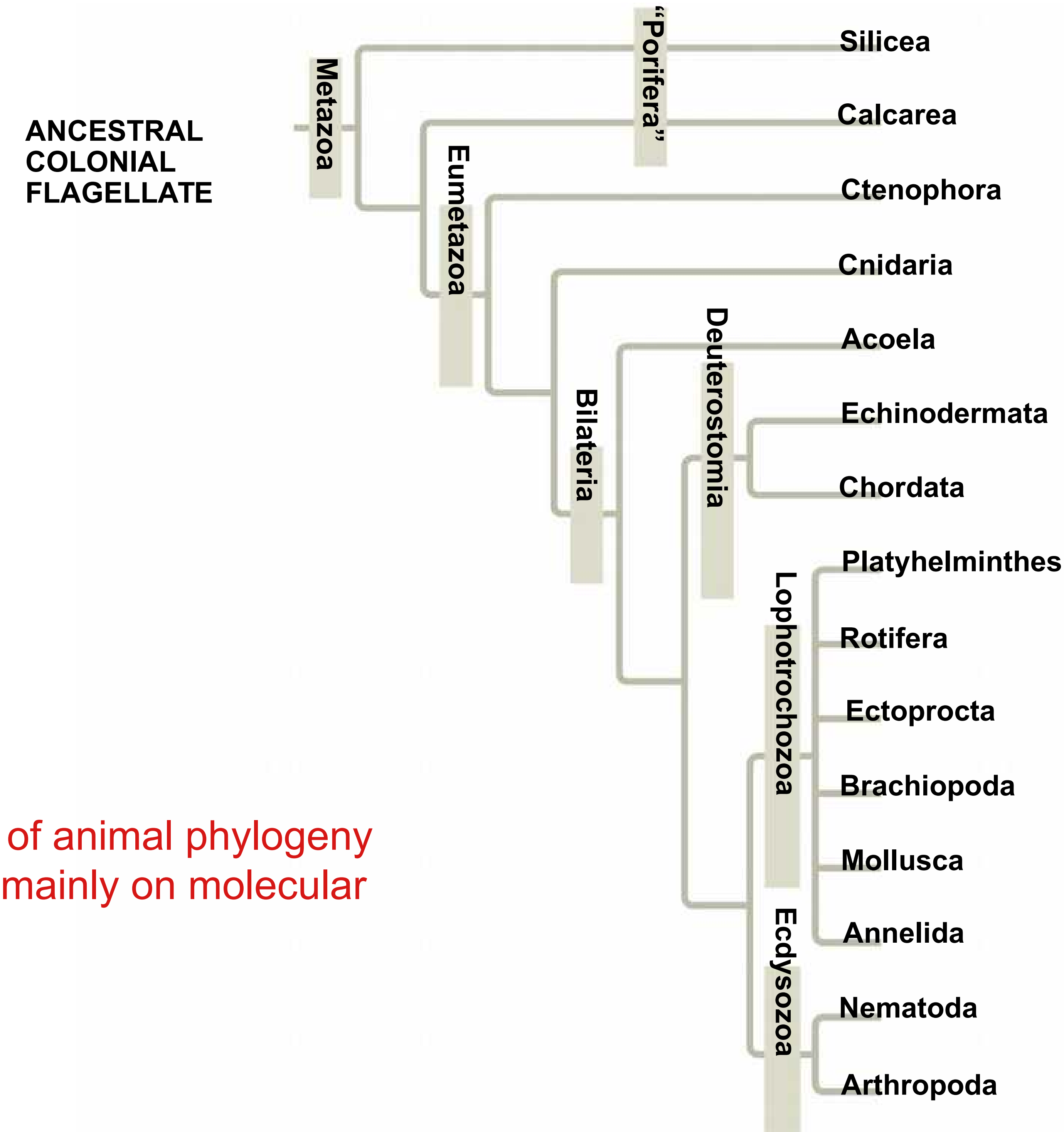


Figure 6: Stability of spherical vesicles. The dashed line represents the border of the instability region for spherical vesicular objects. Below it there is the region of stable spheres, above it the conditions are fulfilled in order for a metamorphosis of the spherical shape to occur. The material constants of the



A view of animal phylogeny based mainly on morphological and developmental comparisons



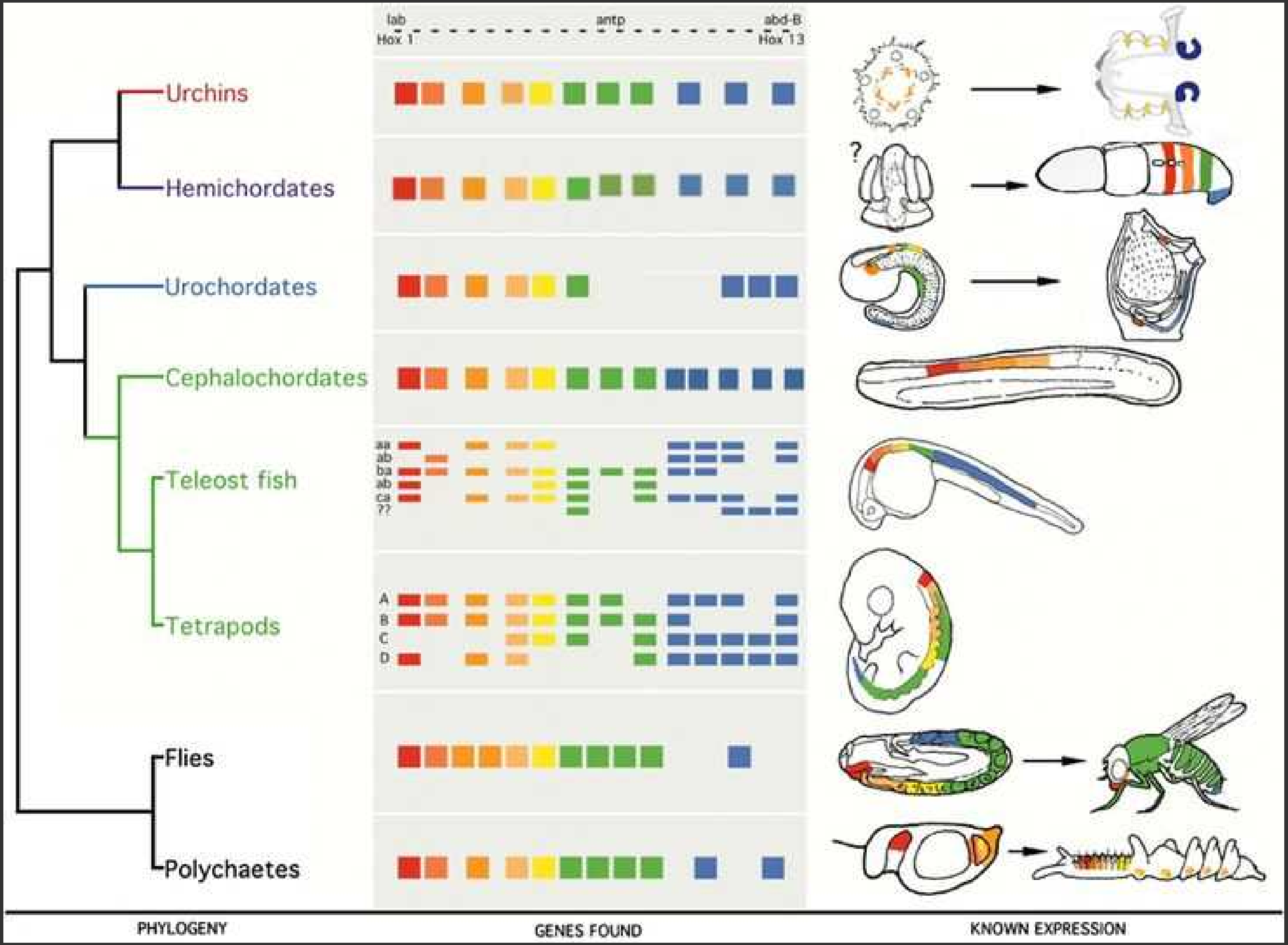
A view of animal phylogeny based mainly on molecular data

Points of Agreement

- All animals share a *common ancestor*.
- Sponges are basal animals.
- Eumetazoa is a clade of animals - ***eumetazoans*** 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.

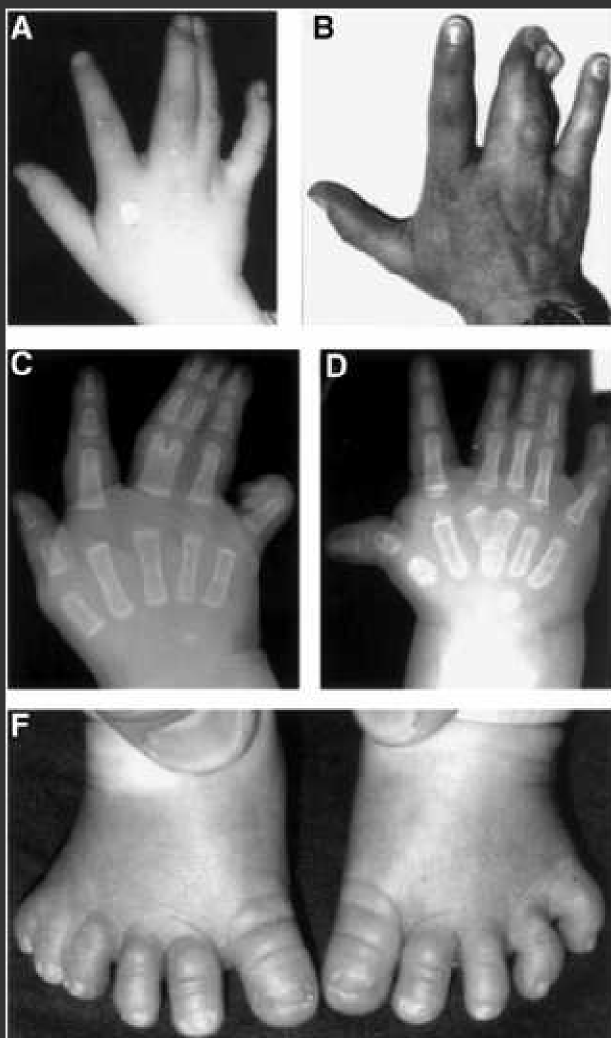
- Many animals have at least one larval stage.
- A *larva* is sexually immature and morphologically distinct from the adult; it eventually undergoes *metamorphosis*.
- *All animals*, and only animals, have ***Hox* genes** that *regulate* the development of *body form*.
- Although the *Hox* family of genes has been highly conserved, it can produce a wide diversity of *animal morphology*.
- *Hox* genes control body development along "head-to-tail" axis

Hox genes across some animal groups



Hox genes code for transcription factors

Mutation



Duplication