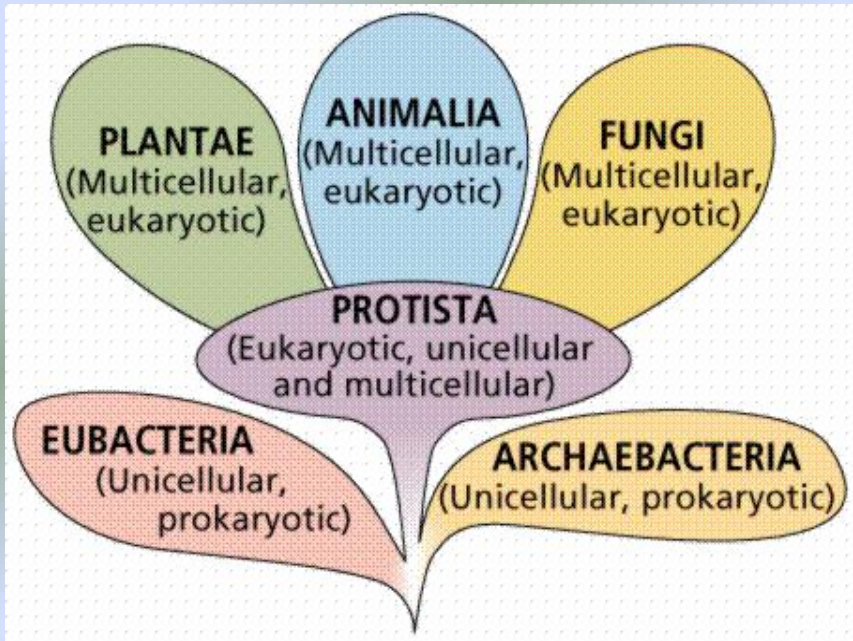
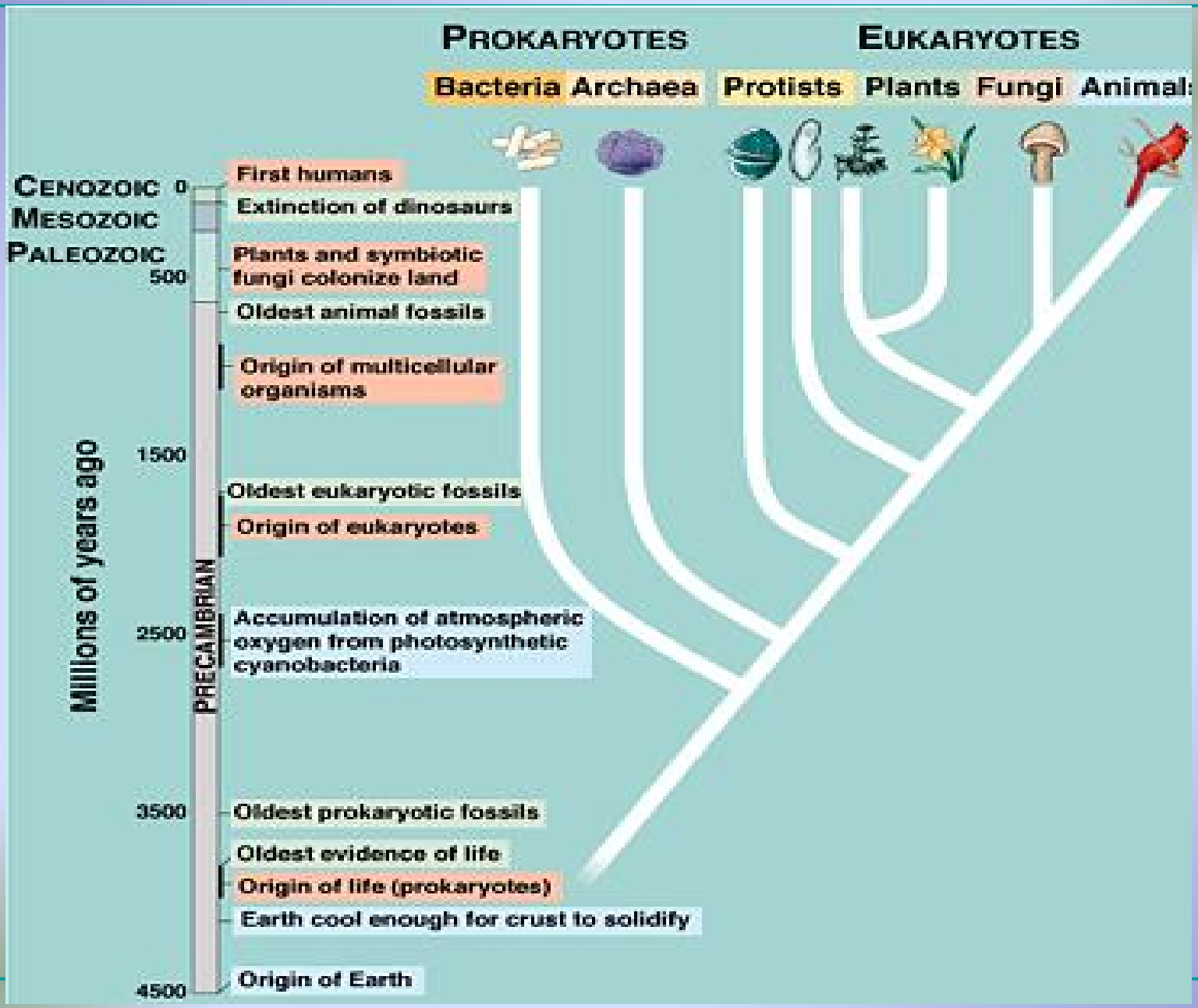
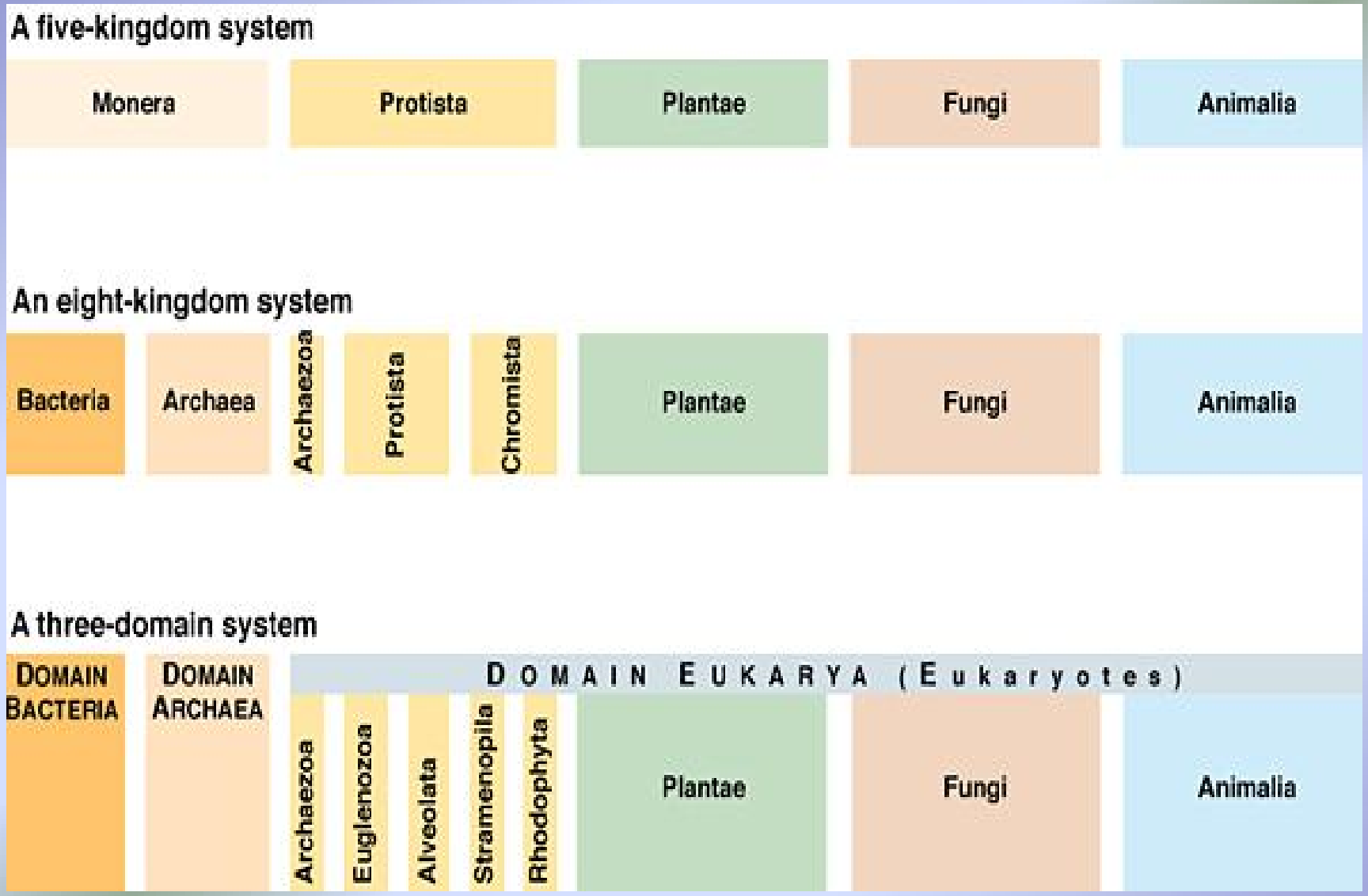
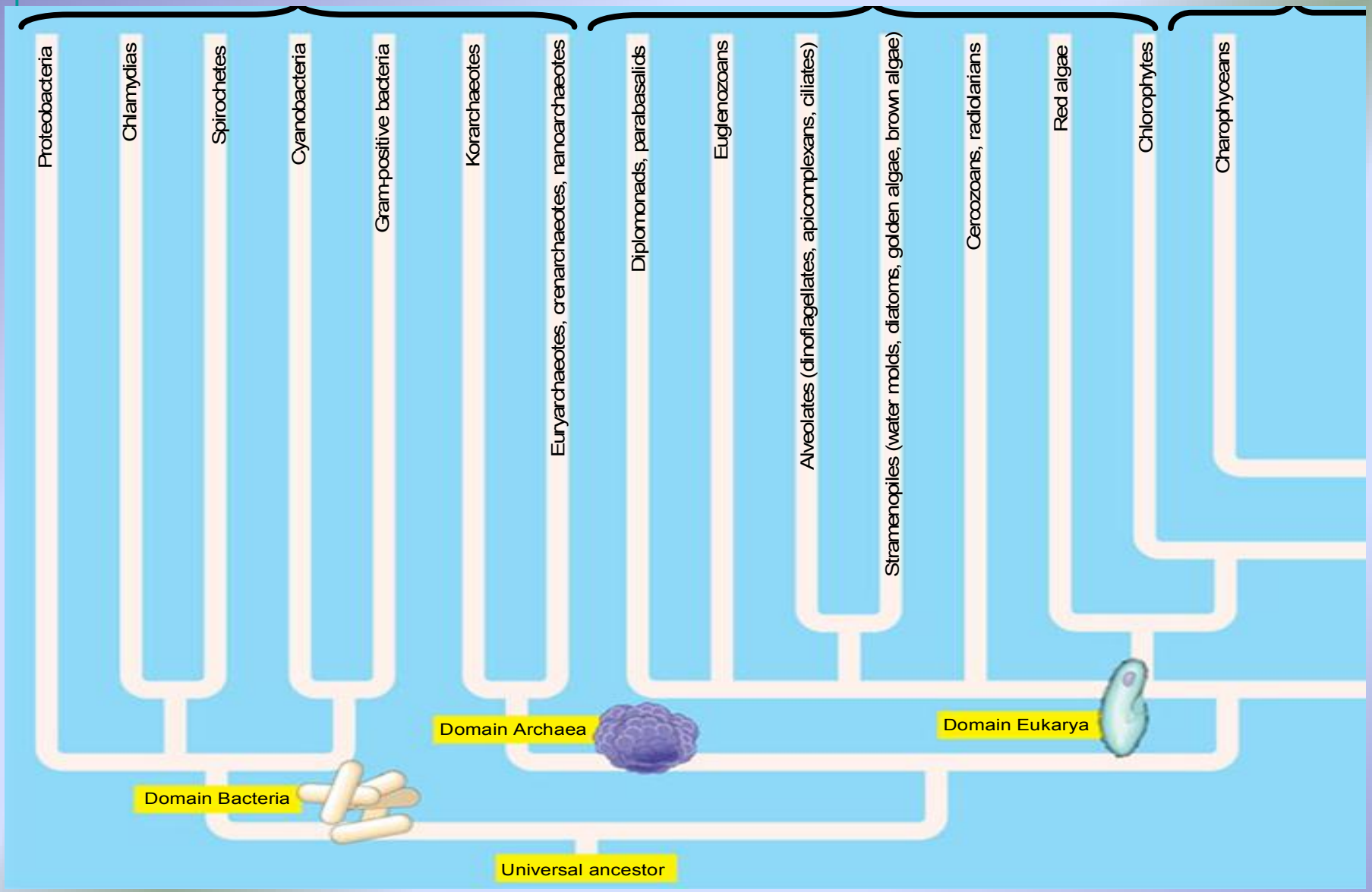
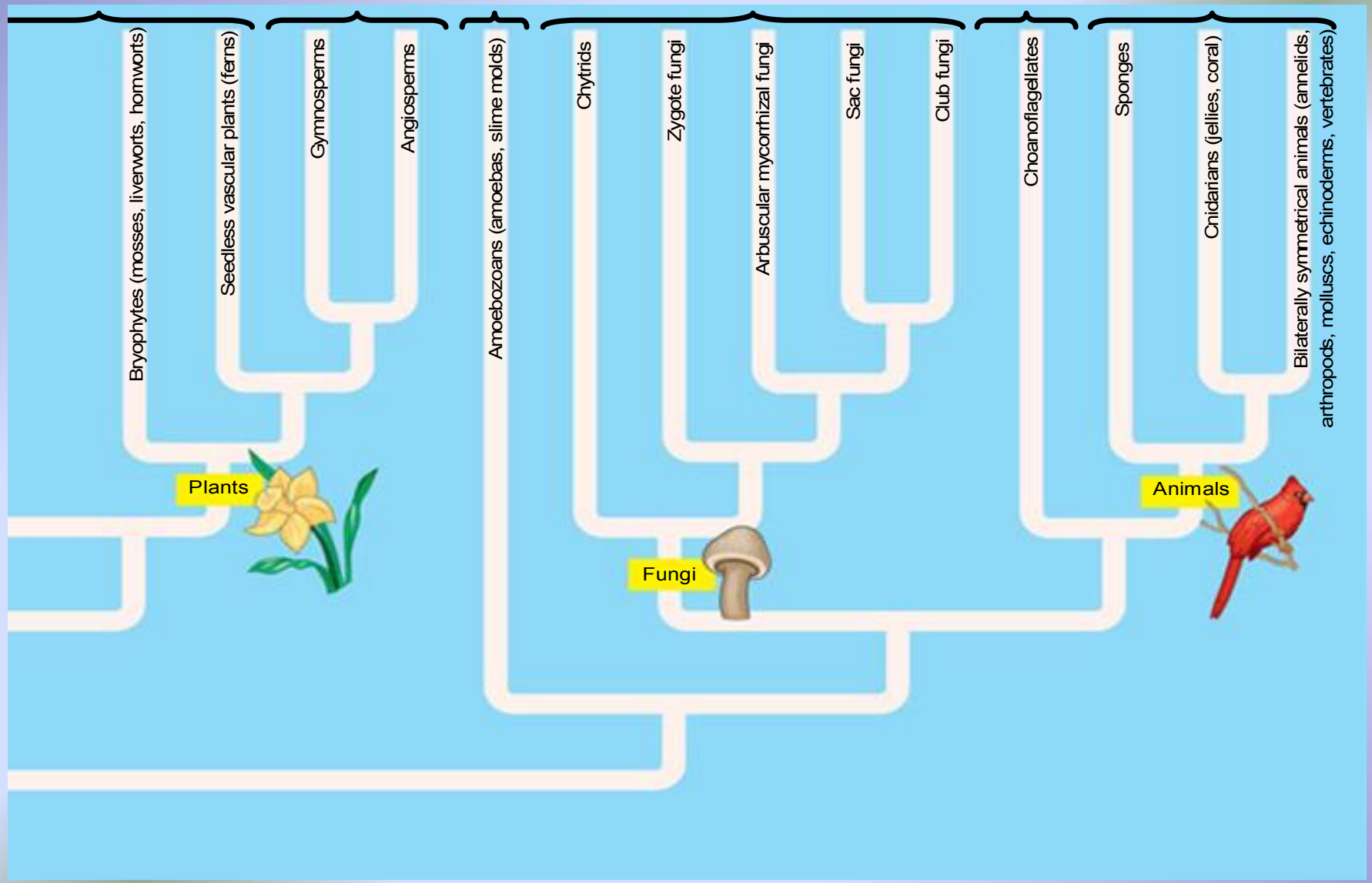
Bacteria, Protists, Fungi, Plants, Animals: Phylogeny and Diversity




PROKARYOTES
EUKARYOTES
Bacteria
Archaea
Protists
Plants
Fungi
Animals
CENOZOIC
MESOZOIC
PALEOZOIC
PRECAMBRIAN
Millions of years ago
0
500
1500
2500
3500
4500
First humans
Extinction of dinosaurs
Plants and symbiotic fungi colonize land
Oldest animal fossils
Origin of multicellular organisms
Oldest eukaryotic fossils
Origin of eukaryotes
Accumulation of atmospheric oxygen from photosynthetic cyanobacteria
Oldest prokaryotic fossils
Oldest evidence of life
Origin of life (prokaryotes)
Earth cool enough for crust to solidify
Origin of Earth


A five-kingdom system
Monera
Protista
Plantae
Fungi
Animalia
An eight-kingdom system
Bacteria
Archaea
Archaezoa
Protista
Chromista
Plantae
Fungi
Animalia
A three-domain system
DOMAIN BACTERIA
DOMAIN ARCHAEA
DOMAIN EUKARYA (Eukaryotes)
Archaezoa
Euglenozoa
Alveolata
Stramenopila
Rhodophyta
Plantae
Fungi
Animalia


Proteobacteria
Chlamydias
Spirochetes
Cyanobacteria
Gram-positive bacteria
Korarchaeotes
Euryarchaeotes, crenarchaeotes, nanoarchaeotes
Diplomonads, parabasalids
Euglenozoans
Alveolates (dinoflagellates, apicomplexans, ciliates)
Stramenopiles (water molds, diatoms, golden algae, brown algae)
Cercozoans, radiolarians
Red algae
Chlorophytes
Charophyceans
Domain Archaea
Domain Eukarya
Domain Bacteria
Universal ancestor


Bryophytes (mosses, liverworts, hornworts)
Seedless vascular plants (ferns)
Gymnosperms
Angiosperms
Plants
Amoebozoans (amoebas, slime molds)
Chytrids
Zygote fungi
Arbuscular mycorrhizal fungi
Sac fungi
Club fungi
Fungi
Choanoflagellates
Sponges
Cnidarians (jellies, coral)
Bilaterally symmetrical animals (annelids, arthropods, molluscs, echinoderms, vertebrates)
Animals

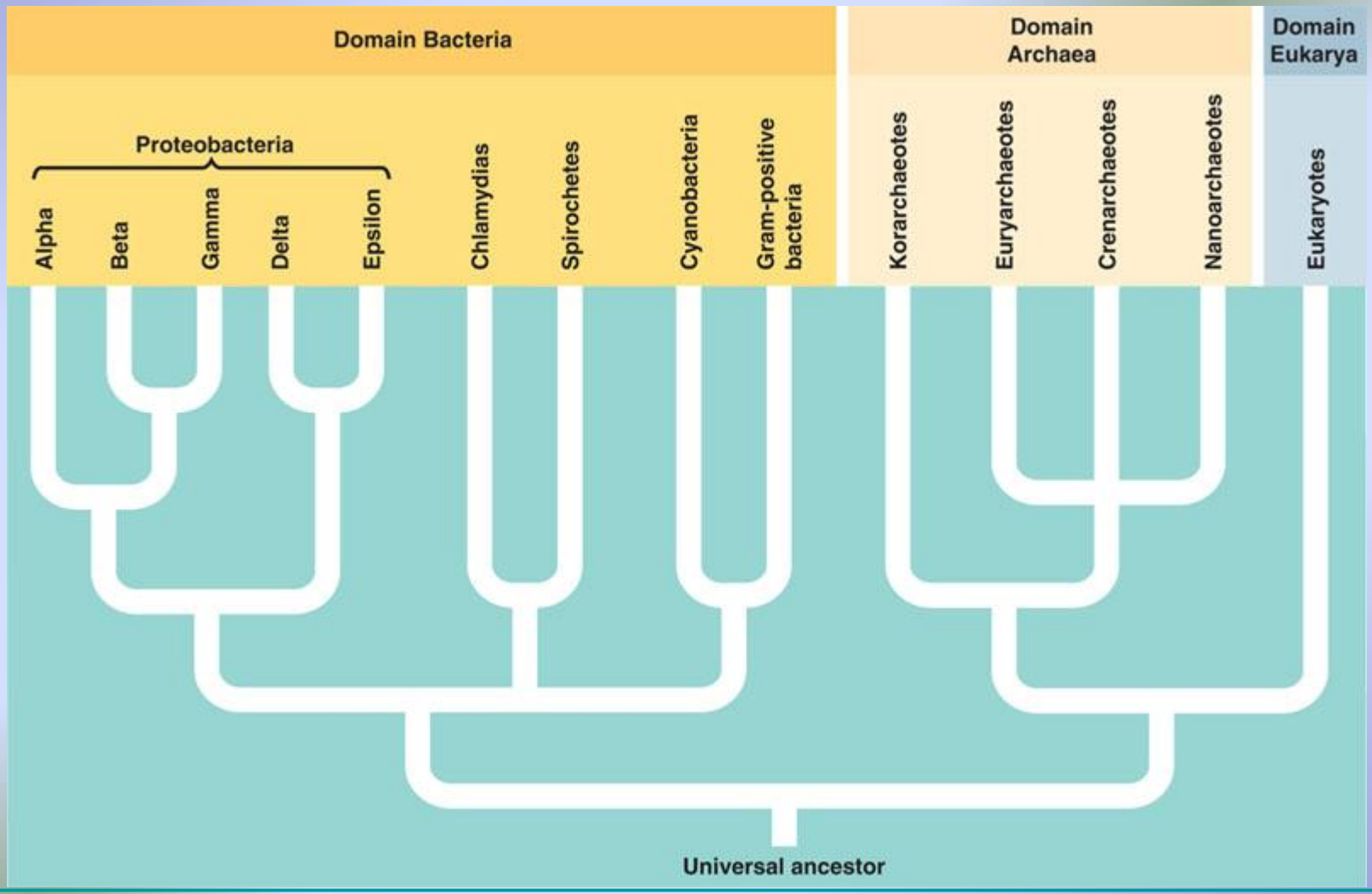
Comparing the Domains

CHARACTERISTIC	DOMAIN		
	Bacteria	Archaea	Eukarya
Nuclear envelope	Absent	Absent	Present
Membrane-enclosed organelles	Absent	Absent	Present
Peptidoglycan in cell wall	Present	Absent	Absent
Membrane lipids	Unbranched hydrocarbons	Some branched hydrocarbons	Unbranched hydrocarbons
RNA polymerase	One kind	Several kinds	Several kinds
Initiator amino acid for protein synthesis	Formyl-methionine	Methionine	Methionine
Introns (noncoding parts of genes)	Rare	Present in some genes	Present
Response to the antibiotics streptomycin and chloramphenicol	Growth inhibited	Growth not inhibited	Growth not inhibited
Histones associated with DNA	Absent	Present	Present
Circular chromosome	Present	Present	Absent
Ability to grow at temperatures > 100°C	No	Some species	No

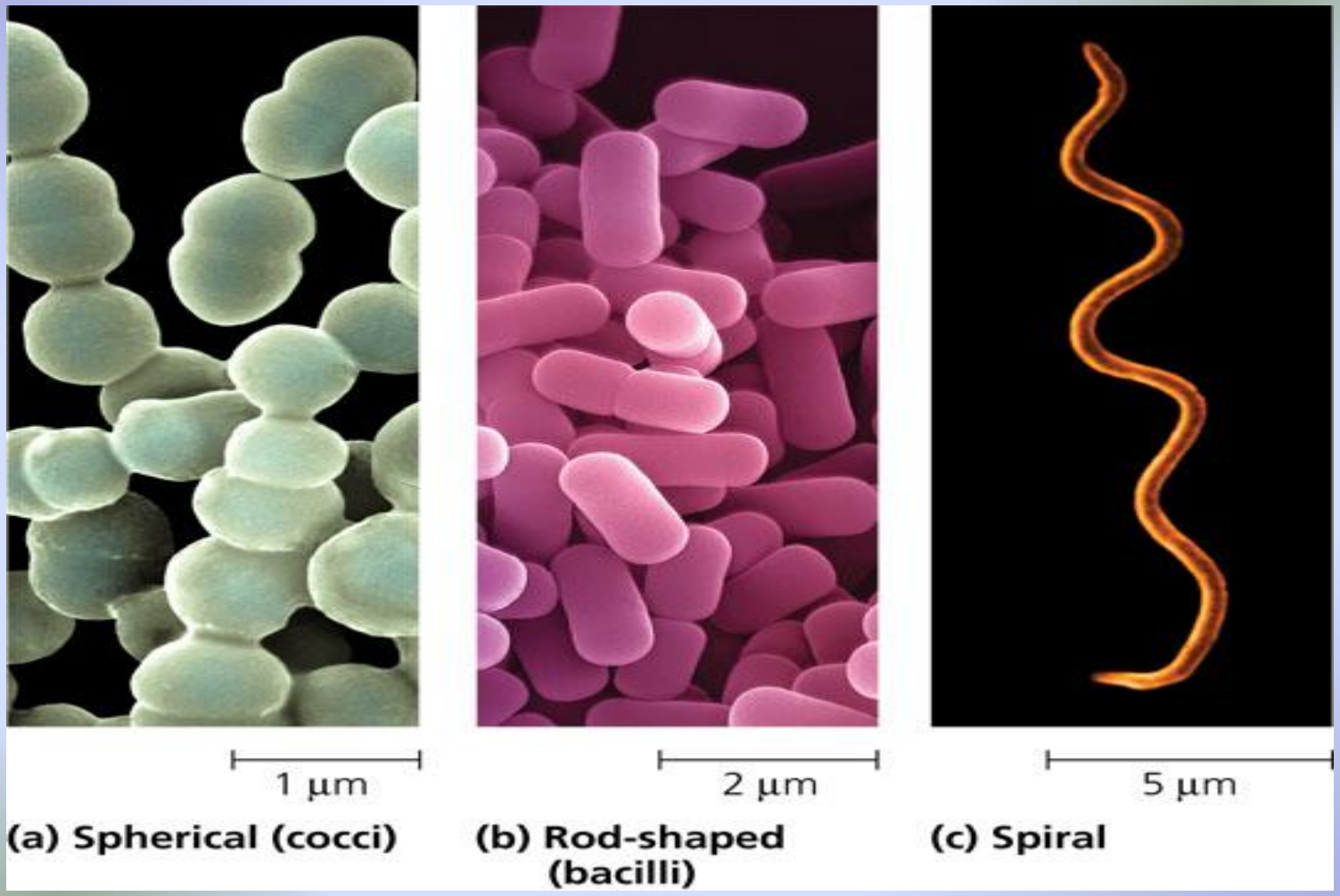
Nutritional Modes

Mode of Nutrition	Energy Source	Carbon Source	Types of Organisms
Autotroph			
Photoautotroph	Light	CO_2	Photosynthetic prokaryotes (for example, cyanobacteria); plants; certain protists (algae)
Chemoautotroph	Inorganic chemicals	CO_2	Certain prokaryotes (for example, *Sulfolobus*)
Heterotroph			
Photoheterotroph	Light	Organic compounds	Certain prokaryotes (for example, *Rhodobacter, Chloroflexus*)
Chemoheterotroph	Organic compounds	Organic compounds	Many prokaryotes (for example, *Clostridium*) and protists; fungi; animals; some plants

Domains…….

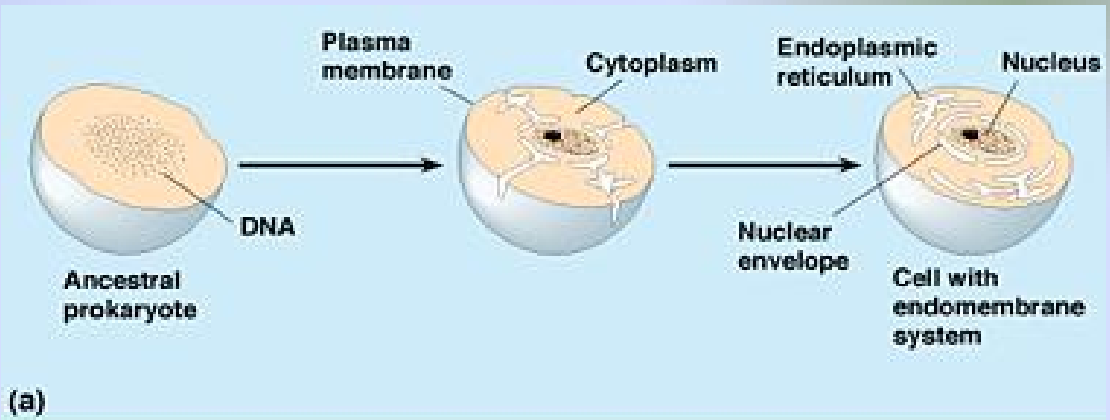

Domain Bacteria
Domain Archaea
Domain Eukarya
Proteobacteria
Alpha
Beta
Gamma
Delta
Epsilon
Chlamydias
Spirochetes
Cyanobacteria
Gram-positive bacteria
Korarchaeotes
Euryarchaeotes
Crenarchaeotes
Nanoarchaeotes
Eukaryotes
Universal ancestor

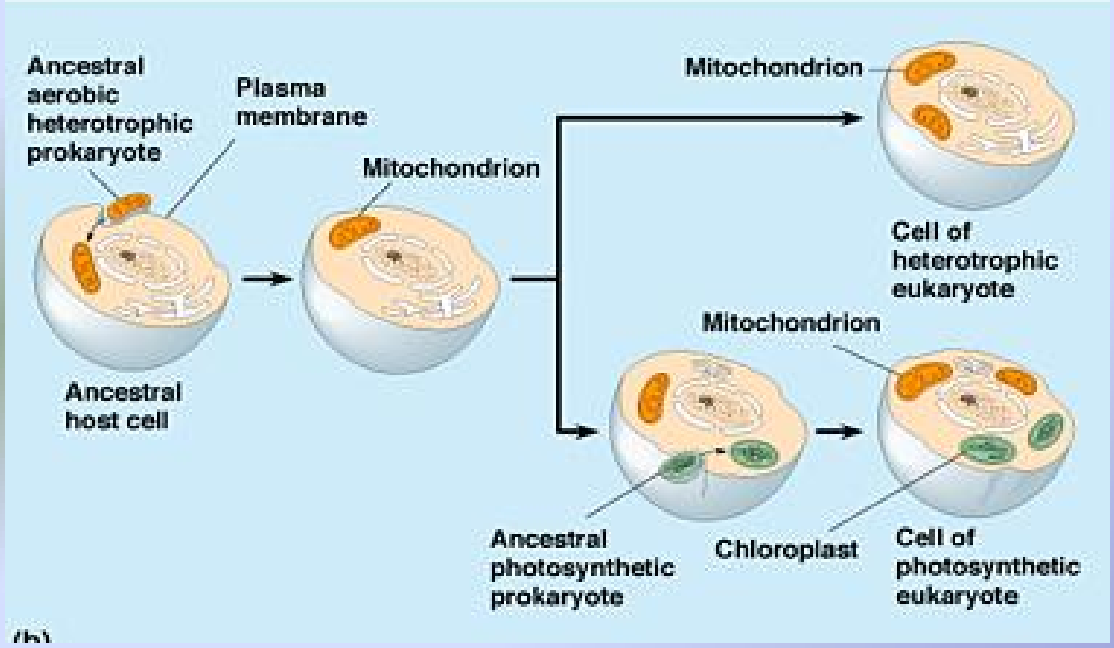
Prokaryote Shapes: Eubacteria



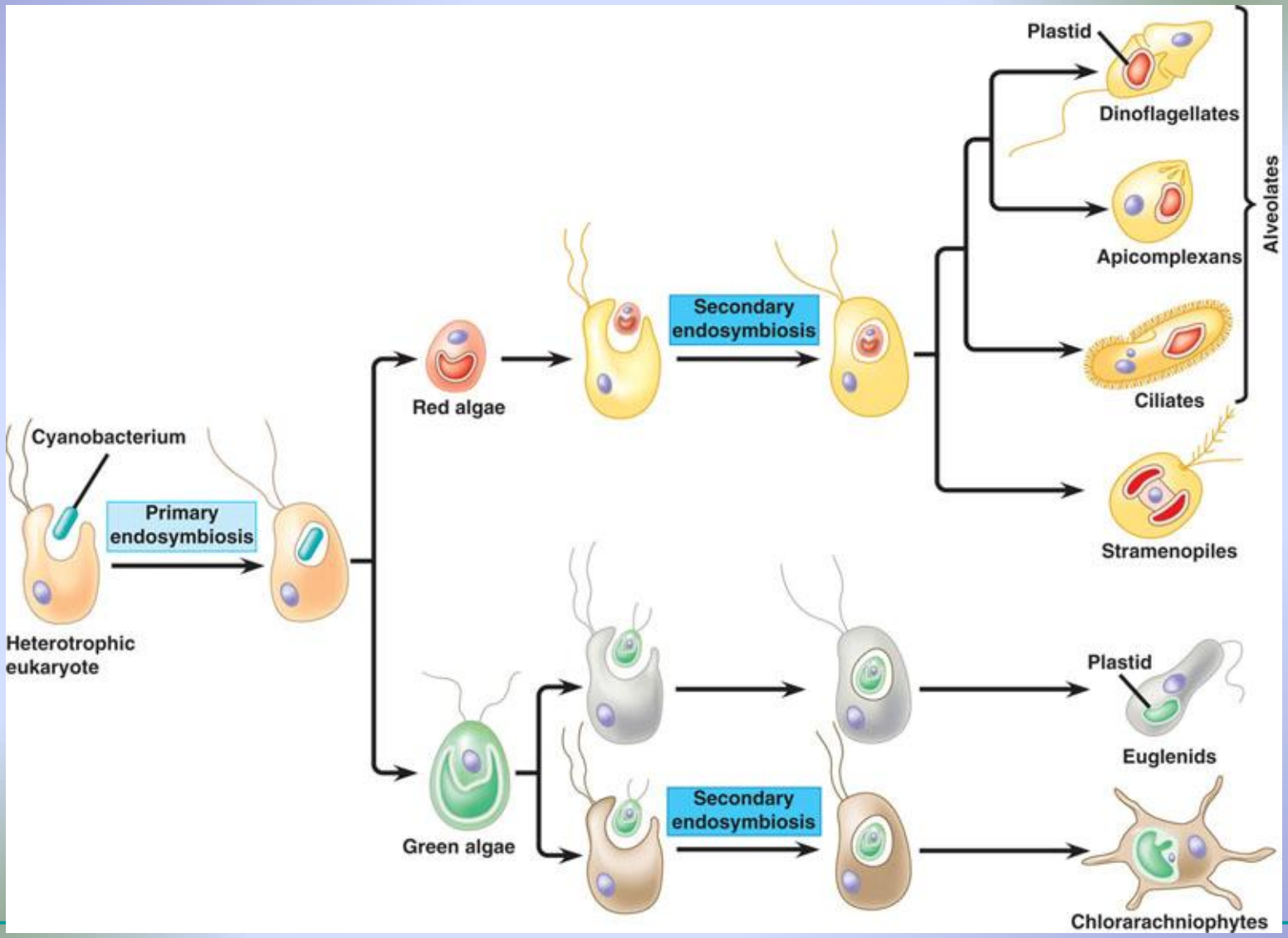
Endosymbiosis:

more than the sum of the parts

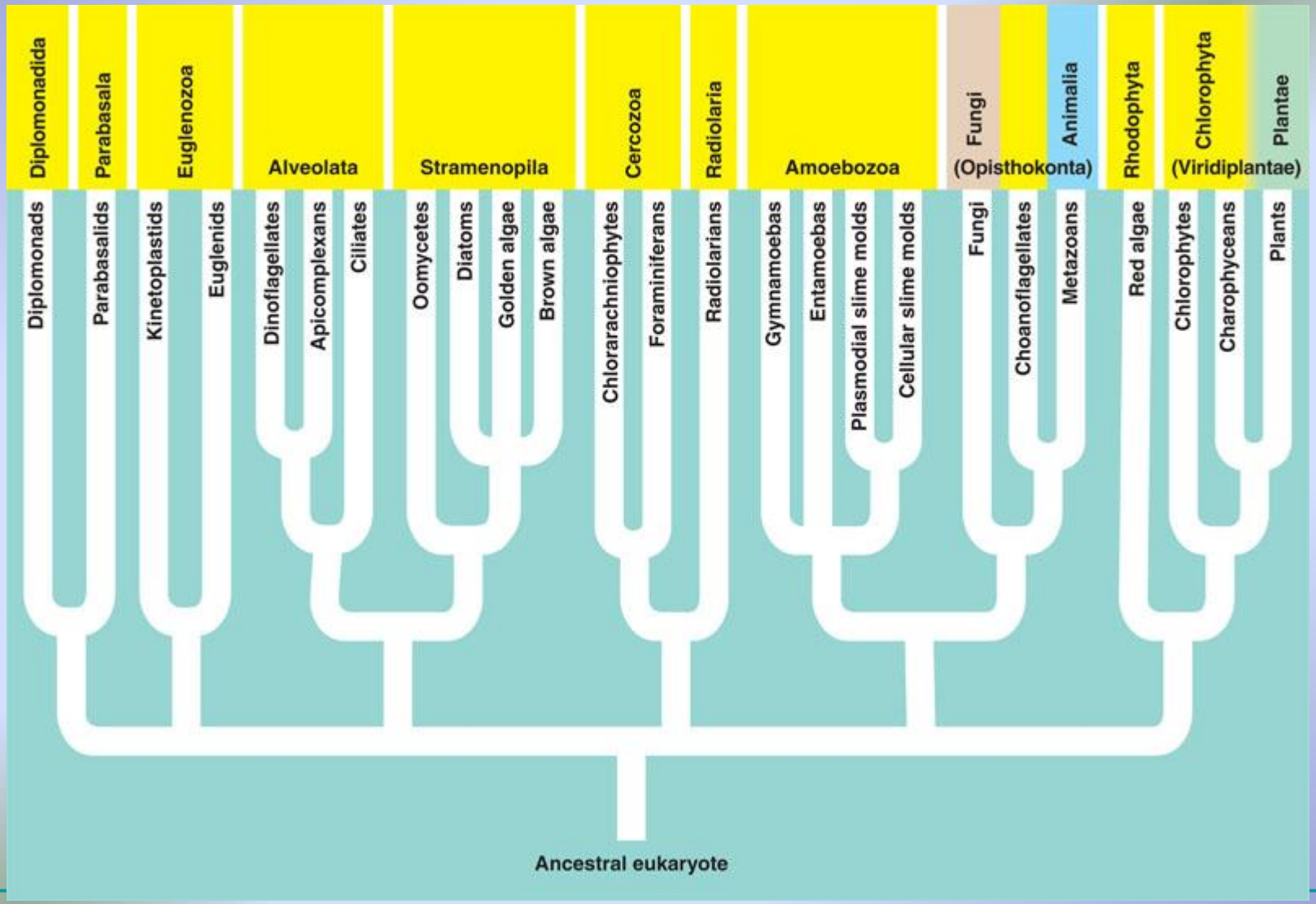




Endosymbiosis…..and plastids



Protista…..lots of them!



Protist Diversity

Major Clade	Key Characteristics	Examples from Chapter
Diplomonadida (diplomonads)	Two equal-sized nuclei; modified mitochondria	*Giardia*
Parabasala (parabasalids)	Undulating membrane; modified mitochondria	*Trichomonas*
Euglenozoa (euglenozoans)	Spiral or crystalline rod inside flagella	
Kinetoplastida (kinetoplastids)	Kinetoplast (DNA in mitochondrion)	*Trypanosoma*
Euglenophyta (euglenids)	Paramylon as storage molecule	*Euglena*
Alveolata (alveolates)	Alveoli beneath plasma membrane	
Dinoflagellata (dinoflagellates)	Armor of cellulose plates	*Ceratium, Pfiesteria*
Apicomplexa (apicomplexans)	Apical complex of organelles	*Plasmodium*
Ciliophora (ciliates)	Cilia used in movement and feeding; macro- and micronuclei	*Paramecium, Stentor*
Stramenopila (stramenopiles)	Hairy and smooth flagella	
Oomycota (oomycetes)	Hyphae that absorb nutrients	Water molds, white rusts, downy mildews
Bacillariophyta (diatoms)	Glassy, two-part wall	
Chrysophyta (golden algae)	Flagella attached near one end of cell	*Dinobryon*
Phaeophyta (brown algae)	All multicellular, some with alternation of generations	*Laminaria, Macrocystis, Postelsia*
Cercozoa (cercozoans) and Radiolaria (radiolarians)	Amoebas with threadlike pseudopodia	
Foraminfera (forams)	Porous shell	*Globigerina*
Radiolaria (radiolarians)	Pseudopodia radiating from central body	
Amoebozoa (amoebozoans)	Amoebas with lobe-shaped pseudopodia	
Gymnamoeba (gymnamoebas)	Soil-dwelling, freshwater, or marine	*Amoeba*
Entamoeba (entamoebas)	Parasites	*Entamoeba*
Myxogastrida (plasmodial slime molds)	Multinucleate plasmodium; fruiting bodies that function in sexual reproduction	*Physarum*
Dictyostelida (cellular slime molds)	Multicellular aggregate that forms asexual fruiting bodies	*Dictyostelium*
Rhodophyta (red algae)	Phycoerythrin (accessory pigment); no flagellated stages	*Bonnemaisonia, Delesseria, Palmaria*
Chlorophyta (one group of green algae)	Plant-type chloroplasts	*Caulerpa, Chlamydomonas, Spirogyra, Ulva, Volvox*

The Algae: Protists or Plants

Euglenozoa: *Euglena* and *Peranema*

- unicellular, flagellate, autotrophic

Pyrophyta: dinoflagellates

- unicellular, flagellate, photoautotrophic, cellulose cell plates
- (red tide, fire algae)

Bacillariophyta: diatoms

- Unicellular, photoautotrophic, silica "test" (Petri dish)
- diatomaceous earth

Chrysophyta: golden algae

- Unicellular and multicellular, photoautotrophic, pectin or silica in cell walls

Phaeophyta: brown algae

- Multicellular, photoautotrophic, cellulose cell walls,
- Kelp

Rhodophyta: Red algae

- Multicellular, photoautotrophic, cellulose and polysaccharide cell walls

Chlorophyta: green algae

- Unicellular, colonial, multicellular, photoautotrophic, cellulose cell walls

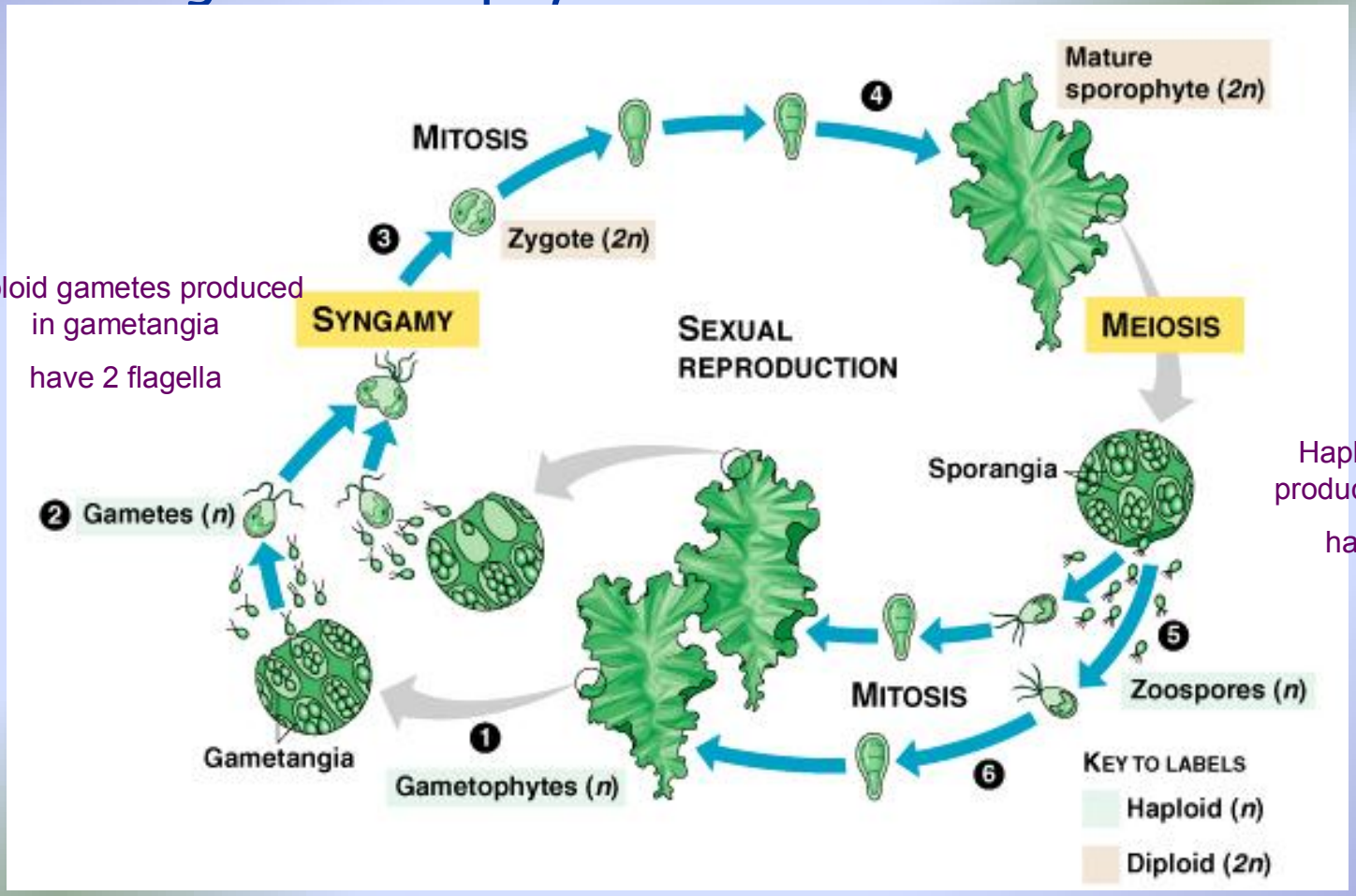
Ulva Life Cycle

isomorphic alternation of generations

green algae Chlorophyta

Haploid gametes produced in gametangia

have 2 flagella



Haploid zoospores produced in sporangia

have 4 flagella

– gamy … –morphy … –spory

so many terms, so little time…….

Heterogamy
- Male and female differ in size and/or shape

Isogamy
- Male and female same size and shape

Anisogamy
- Differ in size and/or shape

Oogamy
- Egg much larger than sperm
- Non-motile egg

Heteromorphy
- Sporophyte (2n) and gametophyte (n) are noticeably different in appearance

Isomorphy
- Sporophyte (2n) and gametophyte are very similar in appearance

Isospory
- All spores same size and structure

Heterospory
- Microspores
- Macrospores

Colonization of the Land

Adaptations for reproducing on land

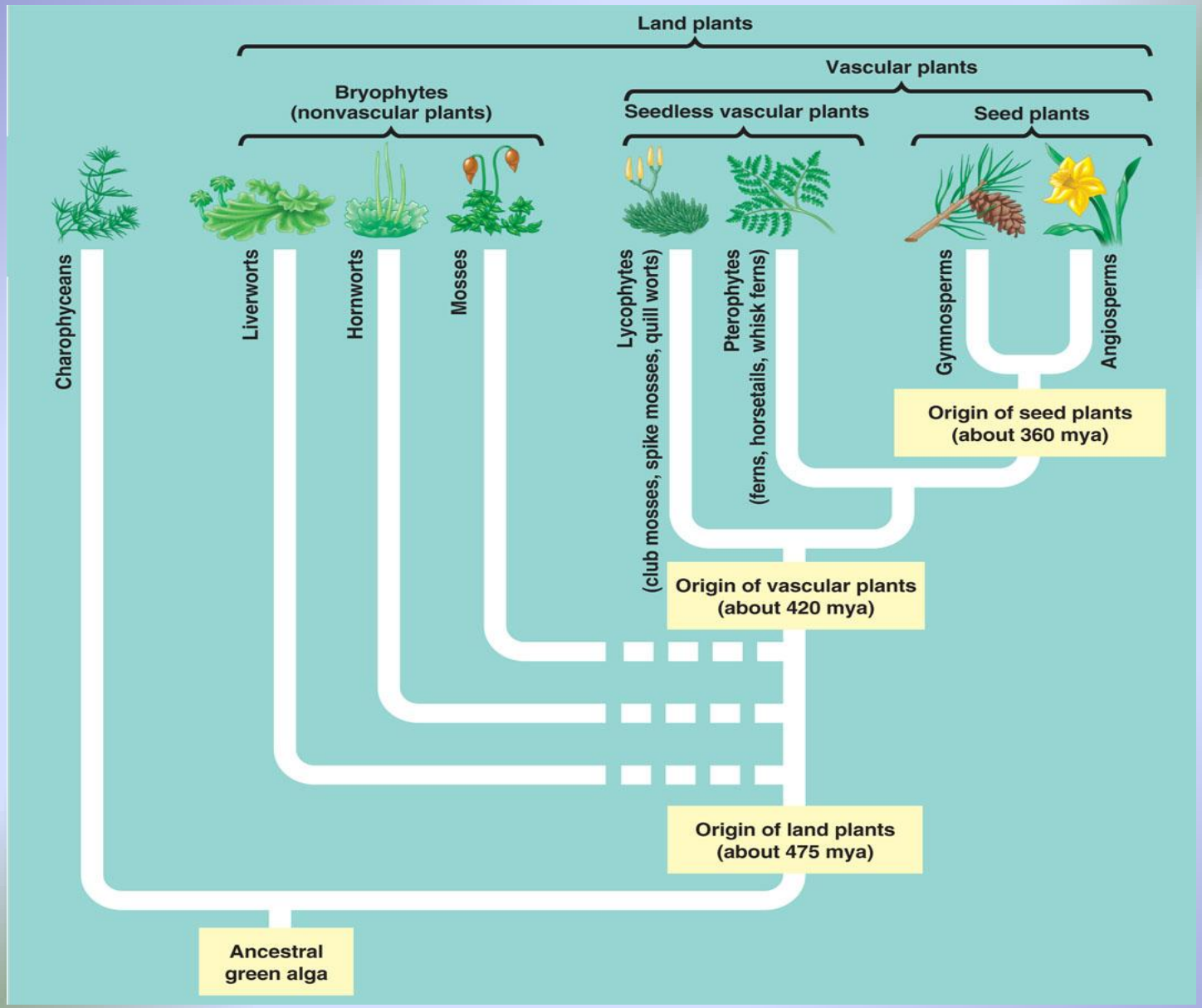
- Embryophyte plants
- Seed plants

Subterranean and aerial organs

- Rhizomes and roots….leaves, cones, flowers….

Chemical Adaptations

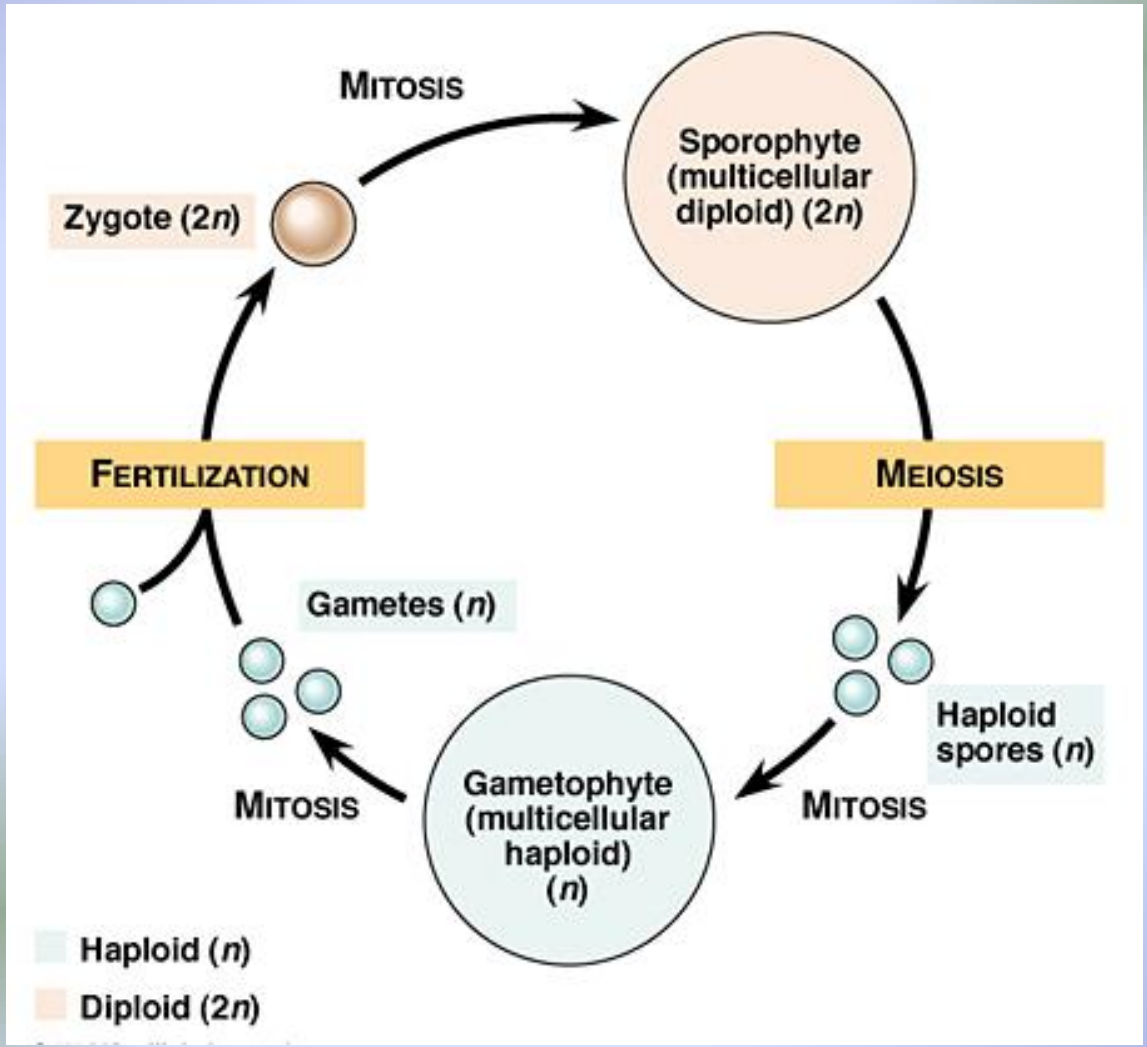
- Primary products: glucose, cellulose, amino acids for structure, storage, metabolism, growth
- Secondary products for protection
  - Lignin→ wood
  - Poisons → eg cardiac glycosides
  - Sporopollenin → polymer resistant to environmental damage (spore coats)


Land plants
Vascular plants
Bryophytes
(nonvascular plants)
Seedless vascular plants
Seed plants
Charophyceans
Liverworts
Hornworts
Mosses
Lycophytes
(club mosses, spike mosses, quill worts)
Pterophytes
(ferns, horsetails, whisk ferns)
Gymnosperms
Angiosperms
Origin of seed plants
(about 360 mya)
Origin of vascular plants
(about 420 mya)
Origin of land plants
(about 475 mya)
Ancestral
green alga

Plants

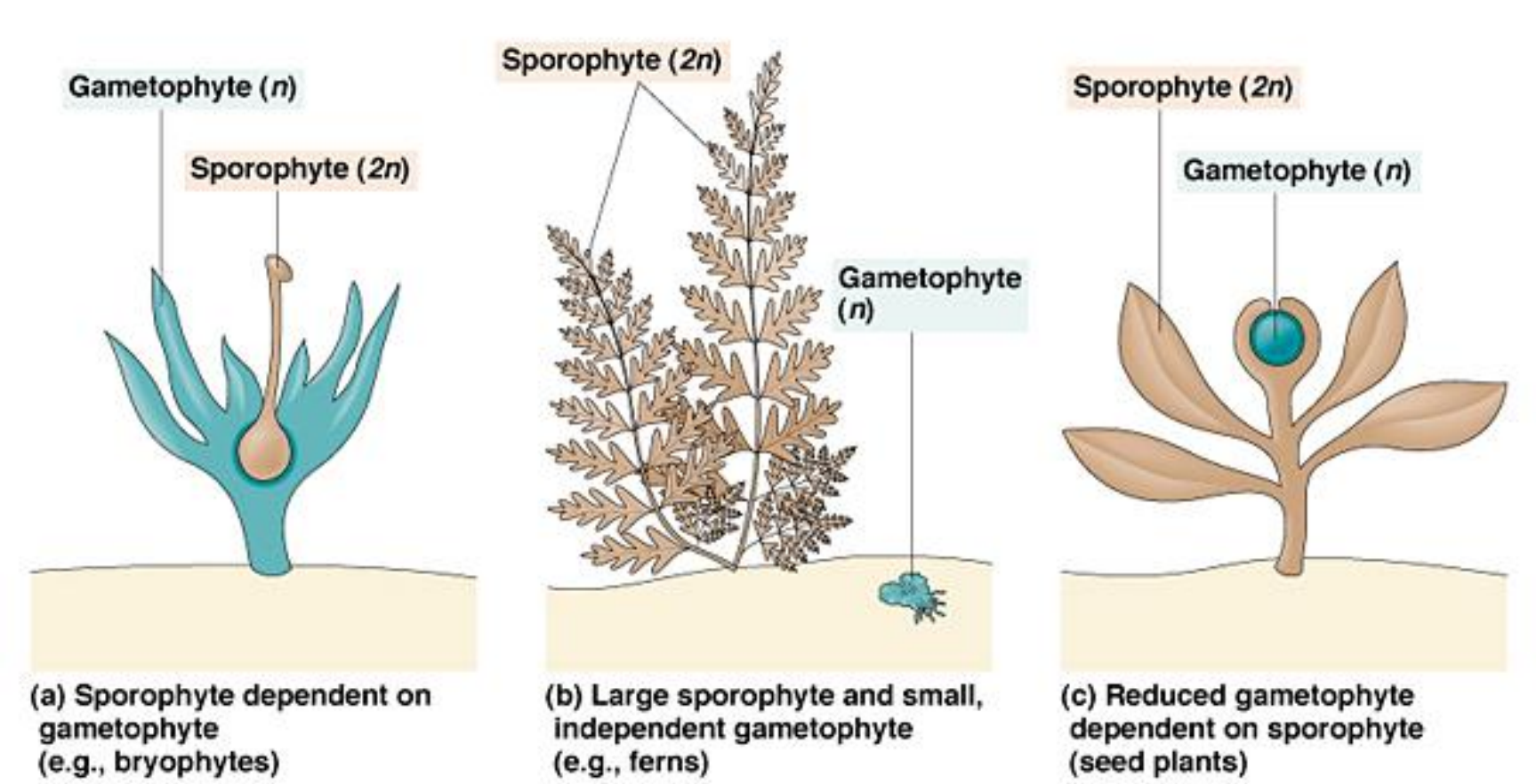
	Common Name	Approximate Number of Extant Species
Bryophytes (nonvascular plants)		
Phylum Hepatophyta	Liverworts	9,000
Phylum Anthocerophyta	Hornworts	100
Phylum Bryophyta	Mosses	15,000
Vascular Plants		
Seedless Vascular Plants		
Phylum Lycophyta	Lycophytes (club mosses, spike mosses, and quillworts)	1,200
Phylum Pterophyta	Pterophytes (ferns, horsetails, and whisk ferns)	12,000
Seed Plants		
Gymnosperms		
Phylum Ginkgophyta	Ginkgo	1
Phylum Cycadophyta	Cycads	130
Phylum Gnetophyta	Gnetophytes (*Gnetum*, *Ephedra*, and *Welwitschia*)	75
Phylum Coniferophyta	Conifers	600
Angiosperms		
Phylum Anthophyta	Flowering plants	250,000

Alternation of Generations: General

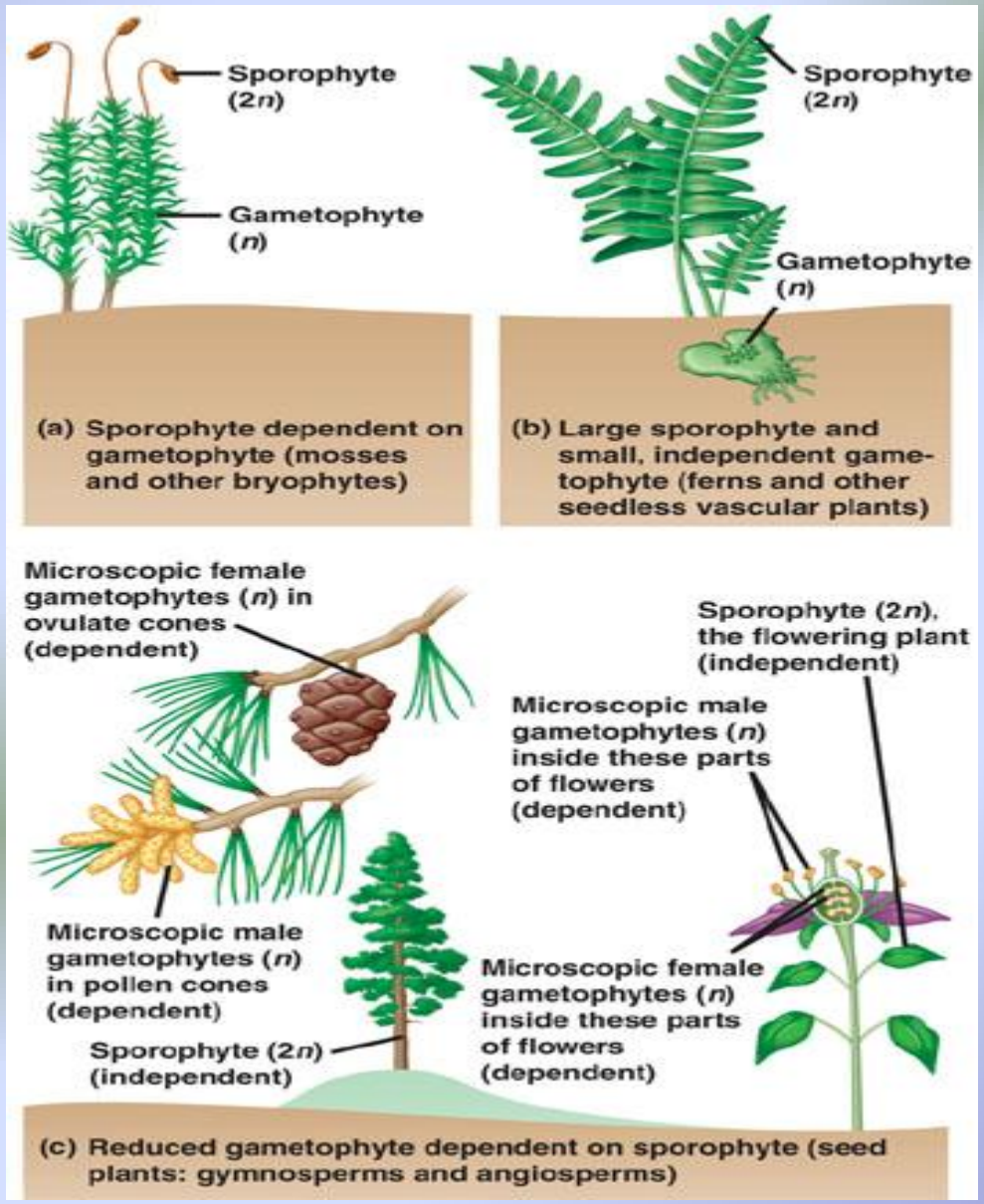


Alternation of generations:

variations on a theme…….



Sporophytes & Gametophytes

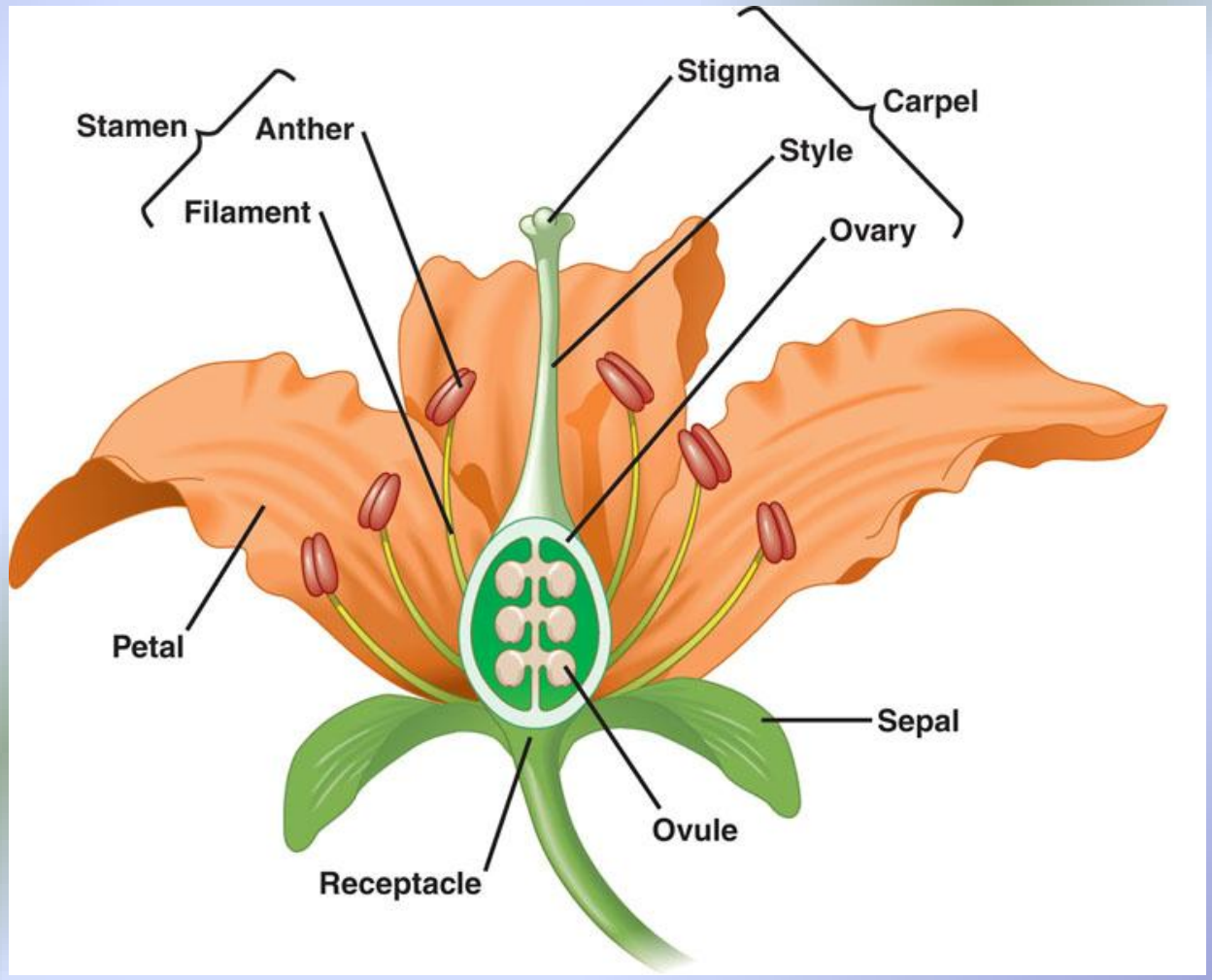


Medicines derived from seed plants….

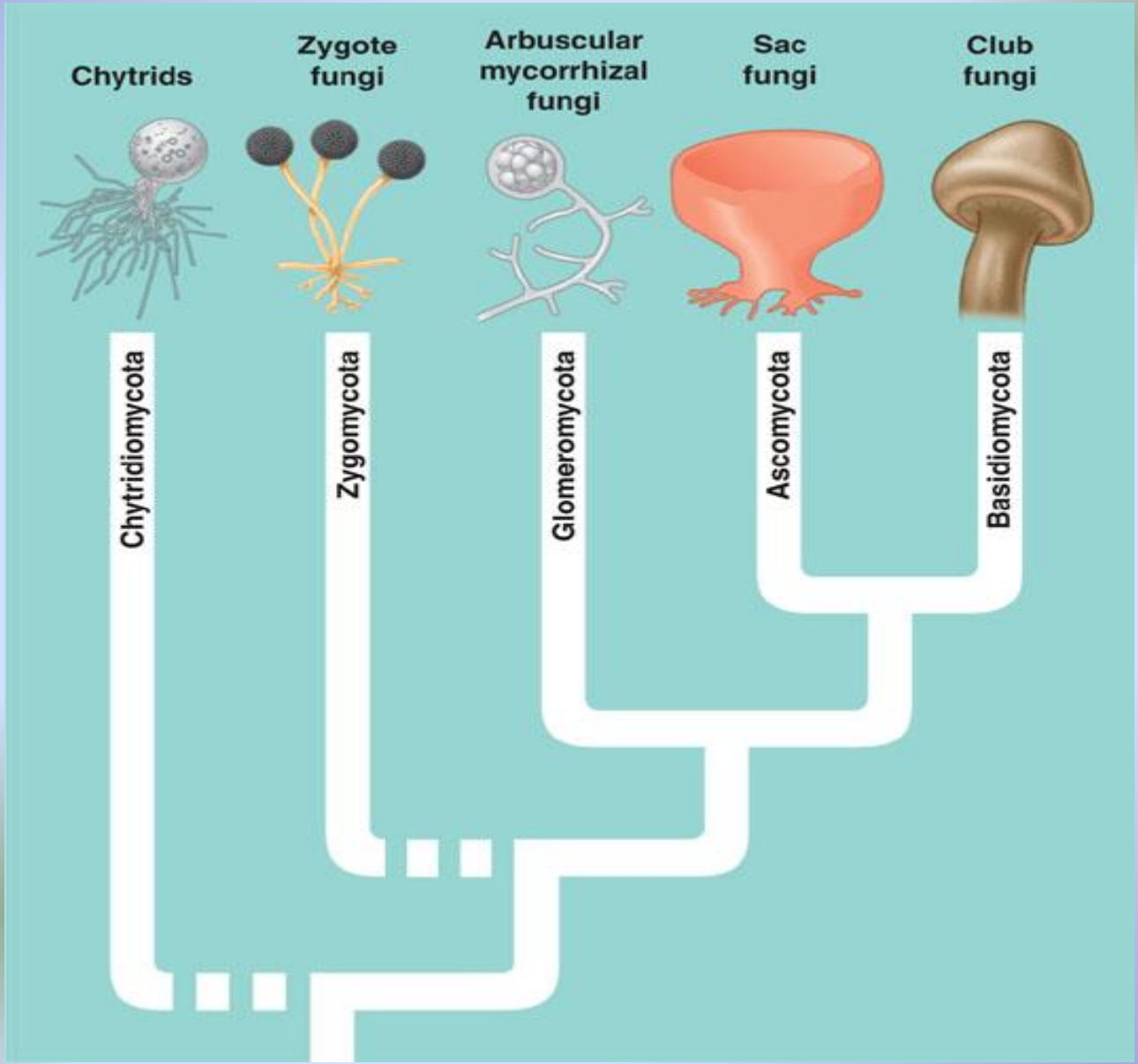
Compound	Example of Source	Example of Use
Atropine	Belladonna plant	Pupil dilator in eye exams
Digitalin	Foxglove	Heart medication
Menthol	Eucalyptus tree	Ingredient in cough medicines
Morphine	Opium poppy	Pain reliever
Quinine	Cinchona tree (see below)	Malaria preventative
Taxol	Pacific yew	Ovarian cancer drug
Turbocurarine	Curare tree	Muscle relaxant during surgery
Vinblastine	Periwinkle	Leukemia drug

Cinchona bark, source of quinine

Angiosperms: Covered Seeds



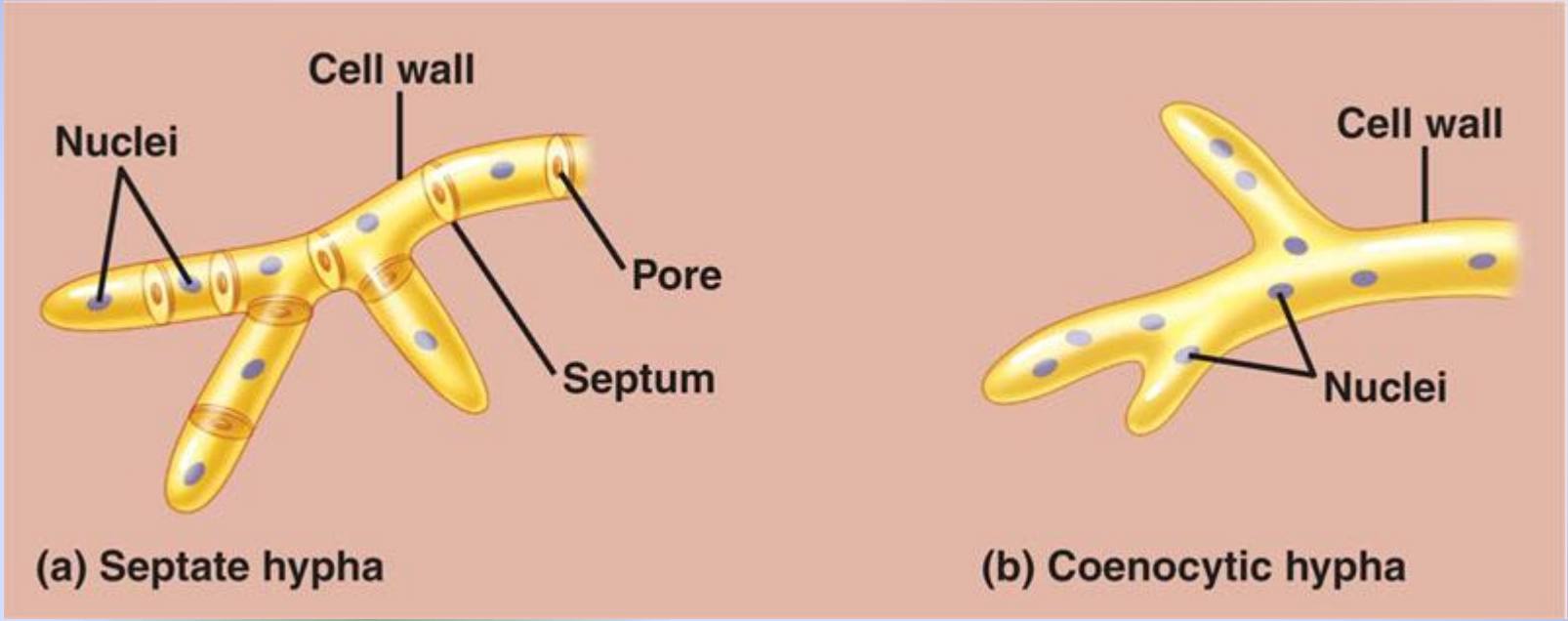
Fungi


Chytrids
Zygote fungi
Arbuscular mycorrhizal fungi
Sac fungi
Club fungi
Chytridiomycota
Zygomycota
Glomeromycota
Ascomycota
Basidiomycota

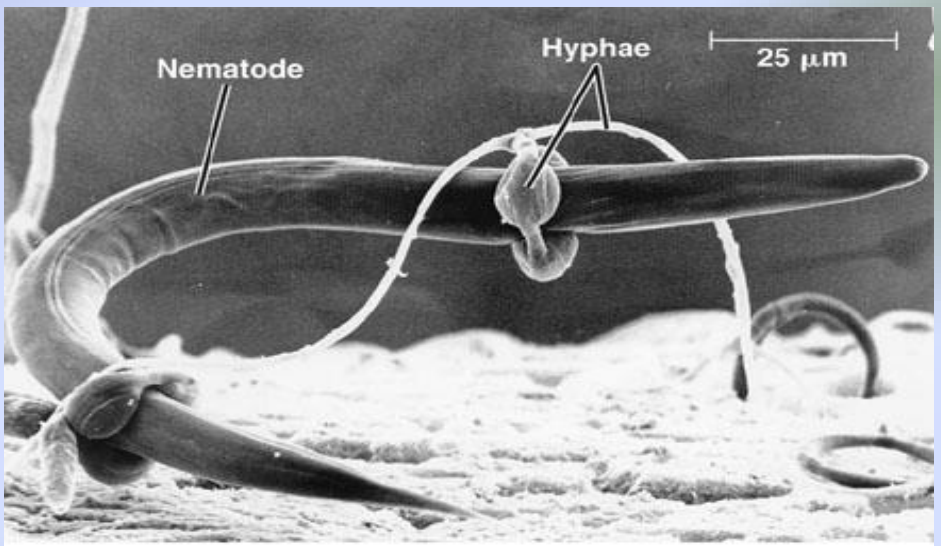
Fungi……

Phylum	Distinguishing Feature	
Chytridiomycota (chytrids)	Motile spores with flagella	
Zygomycota	Resistant zygosporangium as sexual stage	
Glomeromycota	Arbuscular mycorrhizae	
Ascomycota (sac fungi)	Sexual spores borne internally in sacs called asci	
Basidiomycota (club fungi)	Elaborate fruiting body called basidiocarp	

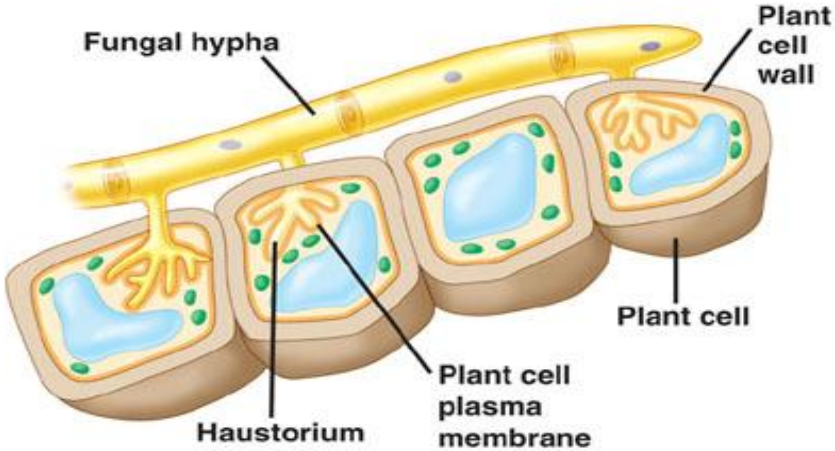
Fungal hyphae…….



Specialized Hyphae

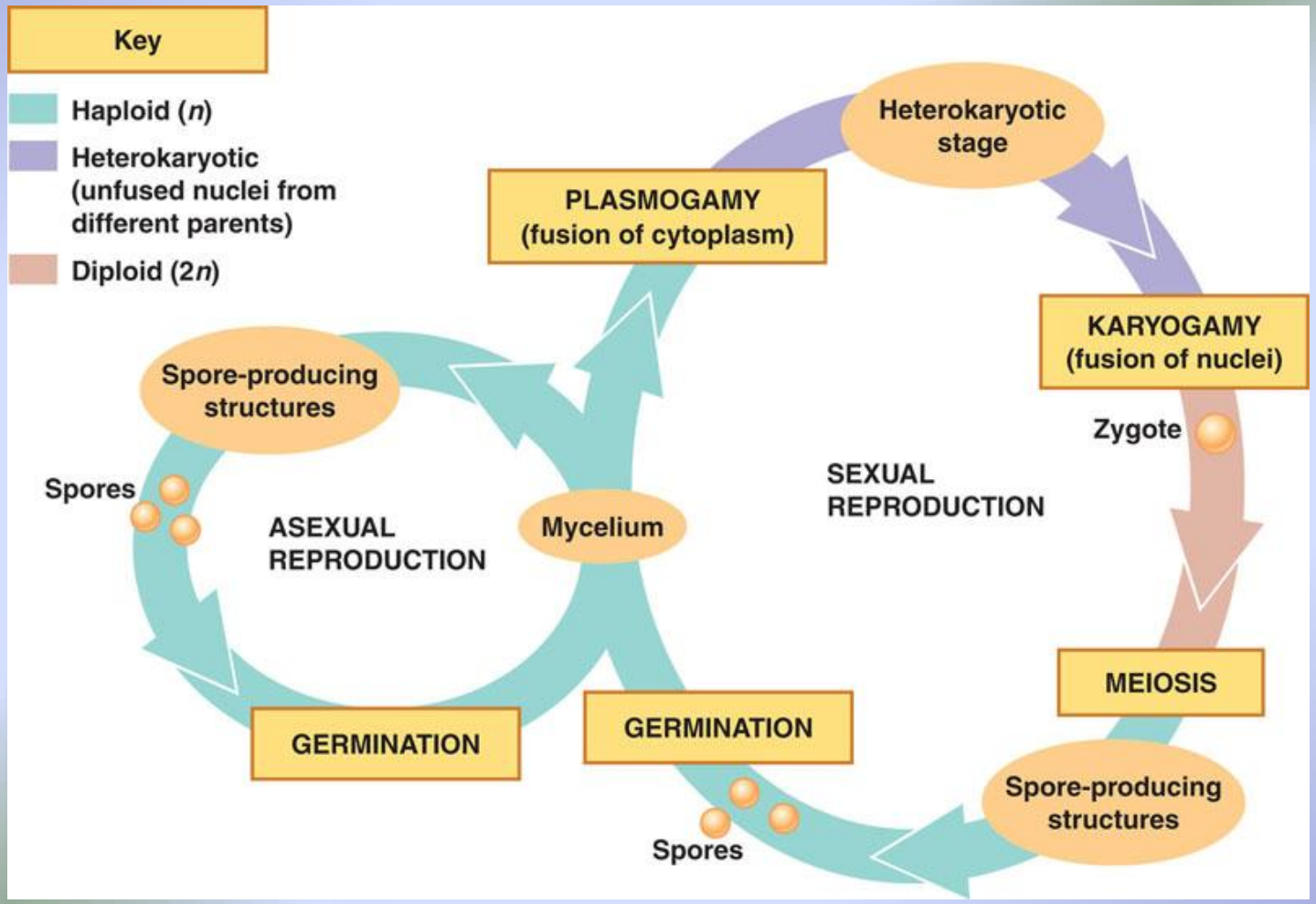


(a) Hyphae adapted for trapping and killing prey

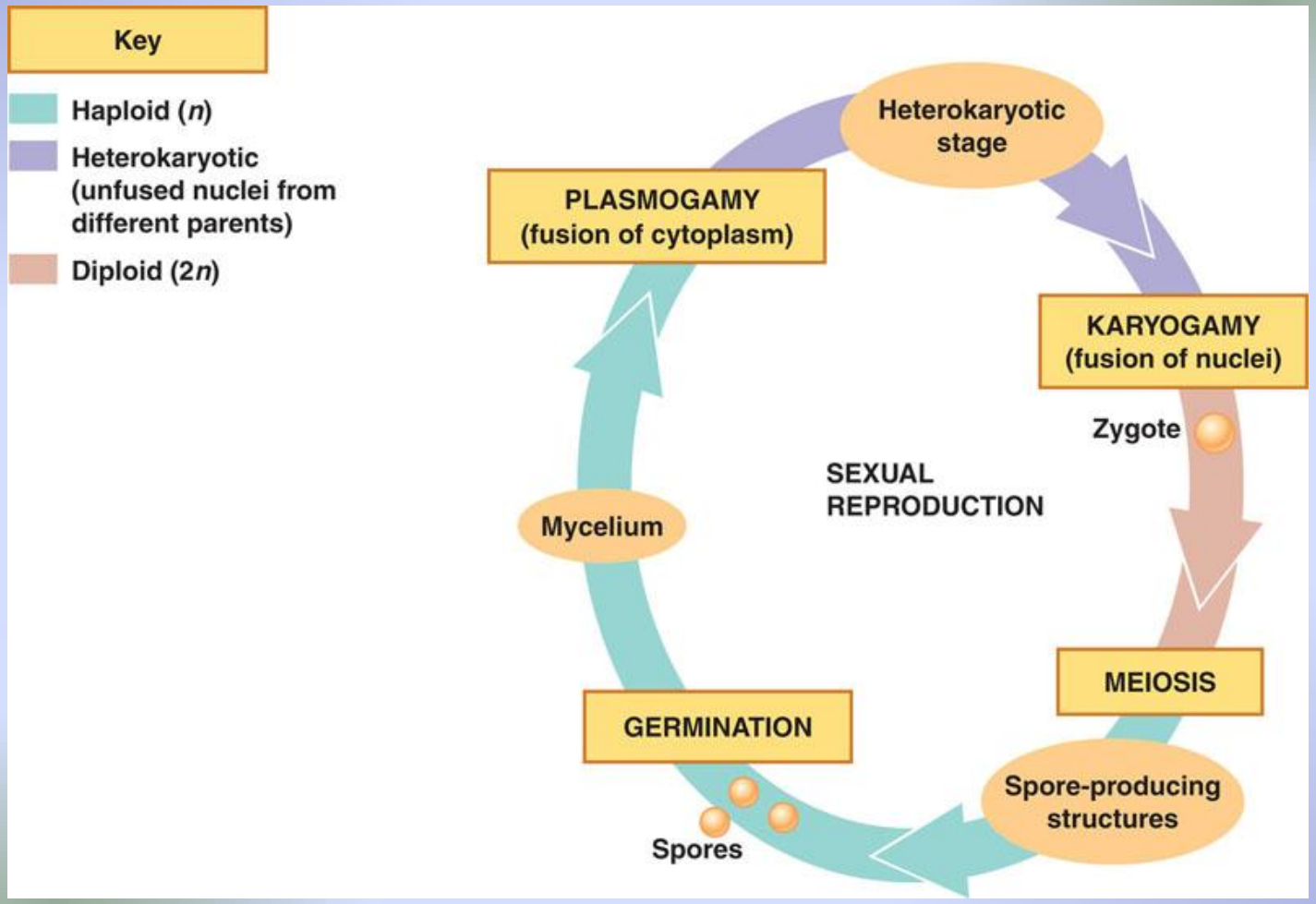


(b) Haustoria

Fungal Life Cycle I



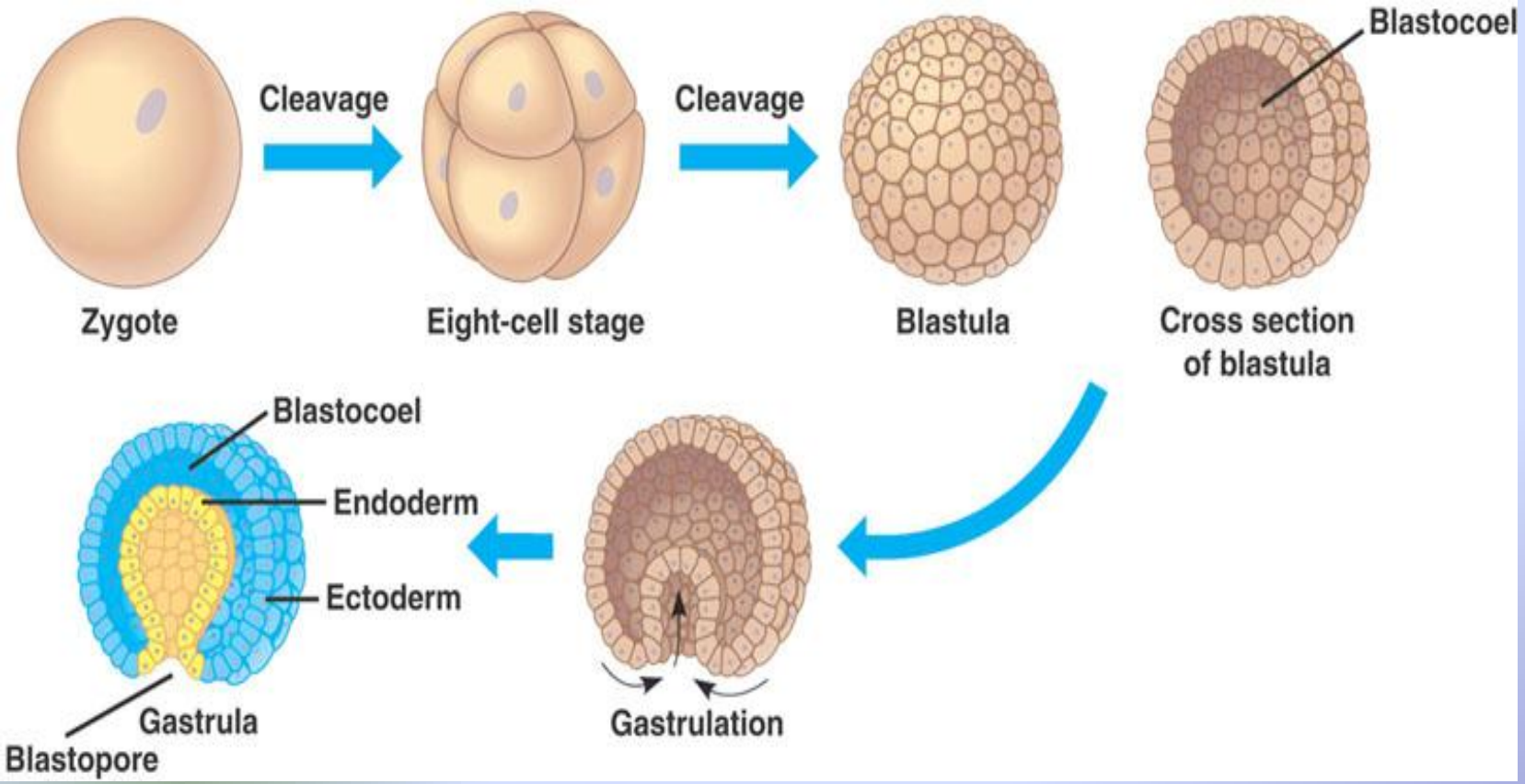
Fungal Life Cycle II



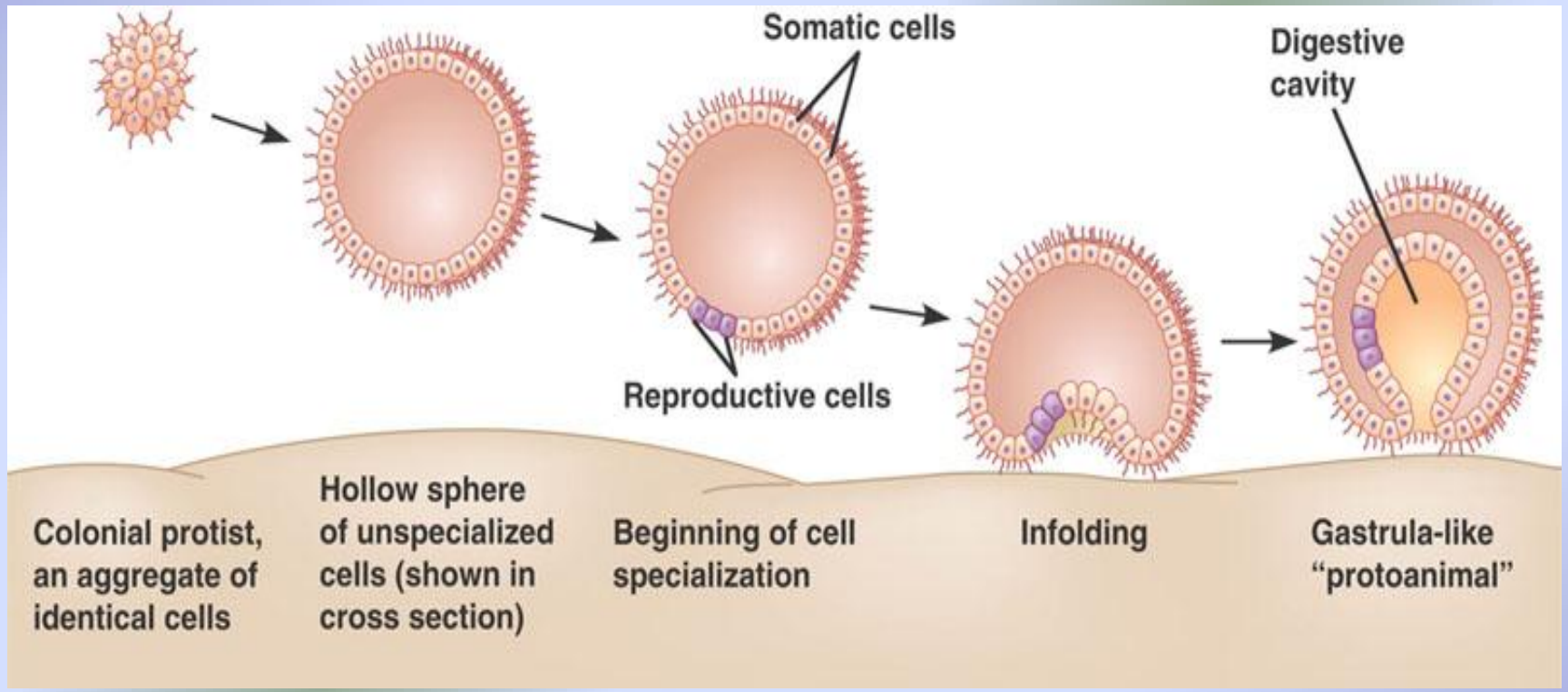
What is an animal?

- Eukaryotic
- Multicellular
- Heterotrophic
- Ingest food
- Lack cell walls
- Collagen as main structural protein
- Nervous and muscle tissue
- Diploid life stage dominant
  - Only gametes are haploid

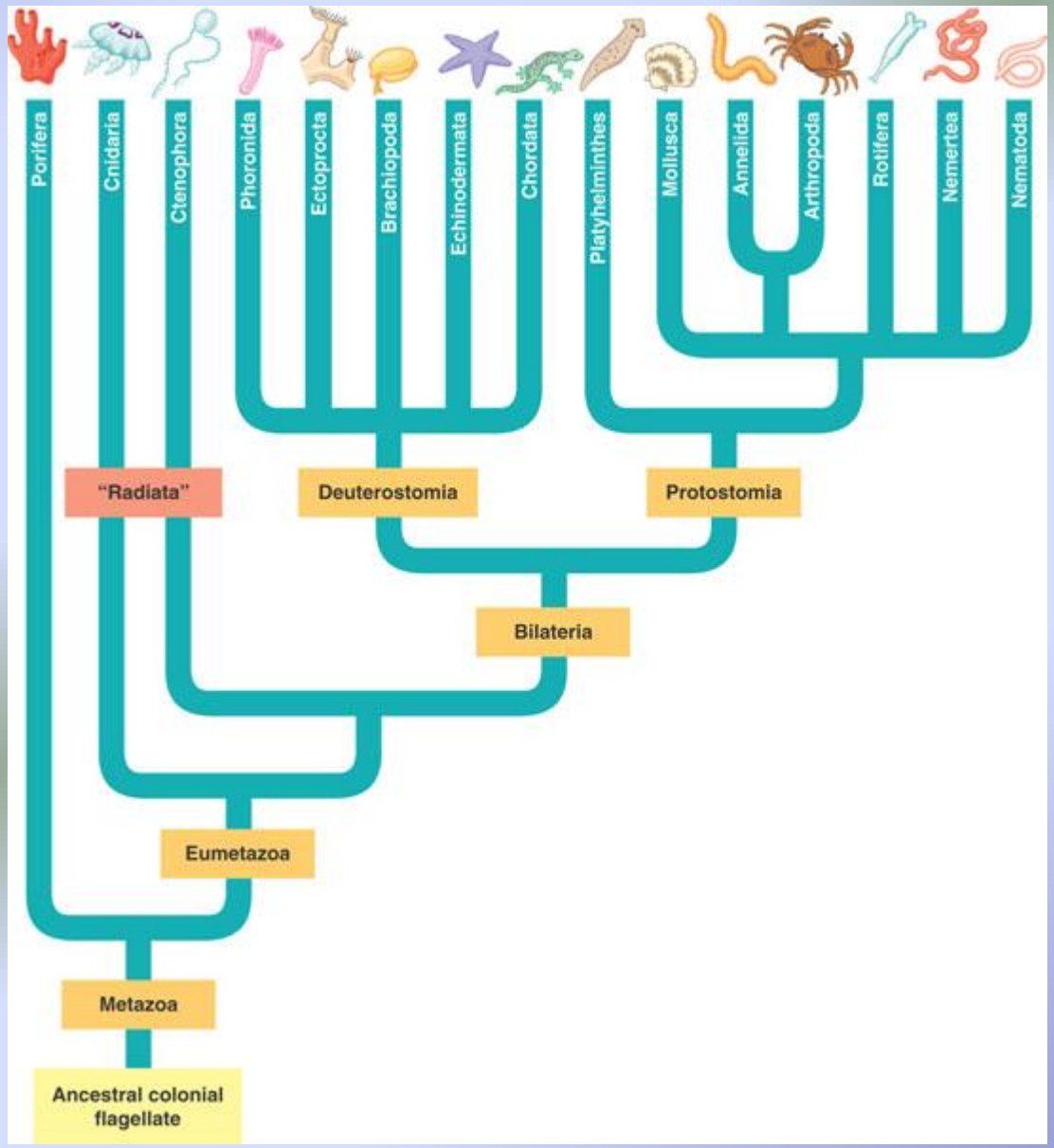
Animal Development:



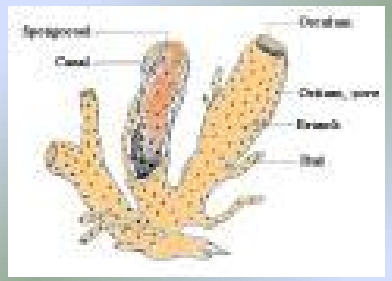
Hypothetical transition from colonial protist to gastrula-like *protoanimal*



- Parazoa
- Eumetazoa
  - Radiata
  - Bilateria
    - Acoelomate
    - Pseudocoelomate
    - Coelomate
      - Protostome
      - Deuterostome

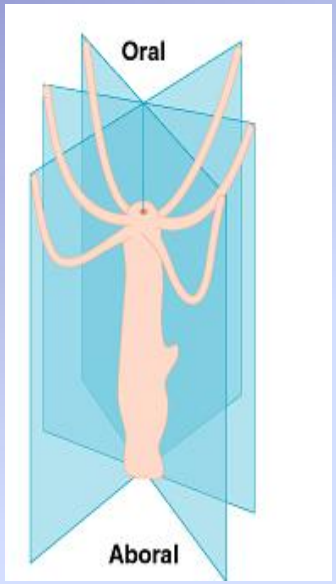


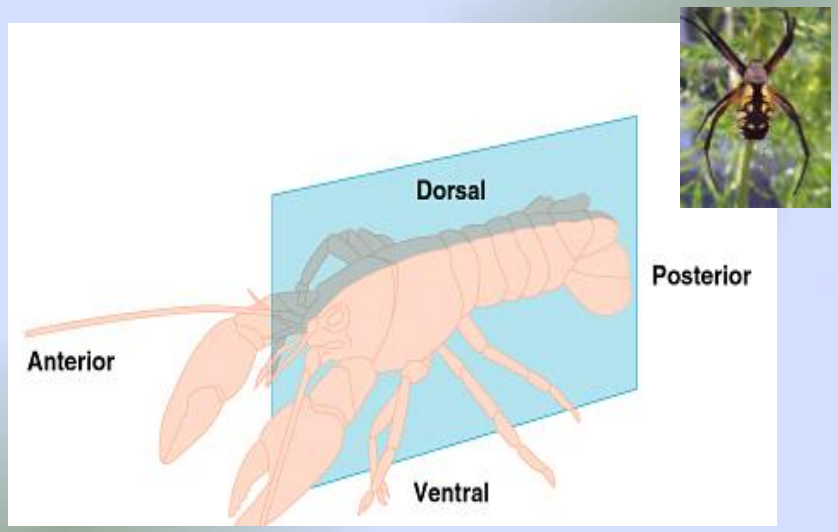
- Parazoa:
  - Multicellular
  - No true tissues
  - Porifera….sponges

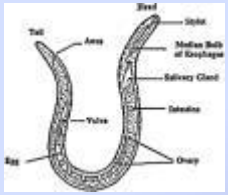


- Eumetazoa
  - Multicellular
  - True tissues

Symmetry







- Radiata:
  - Radial symmetry
  - Diploblastic
    - Cnidaria
    - Ctenophoroa

- Bilateria
  - Bilateral symmetry
  - Triploblastic

Acoelomate

Pseudocoelomate

Eucoelomate

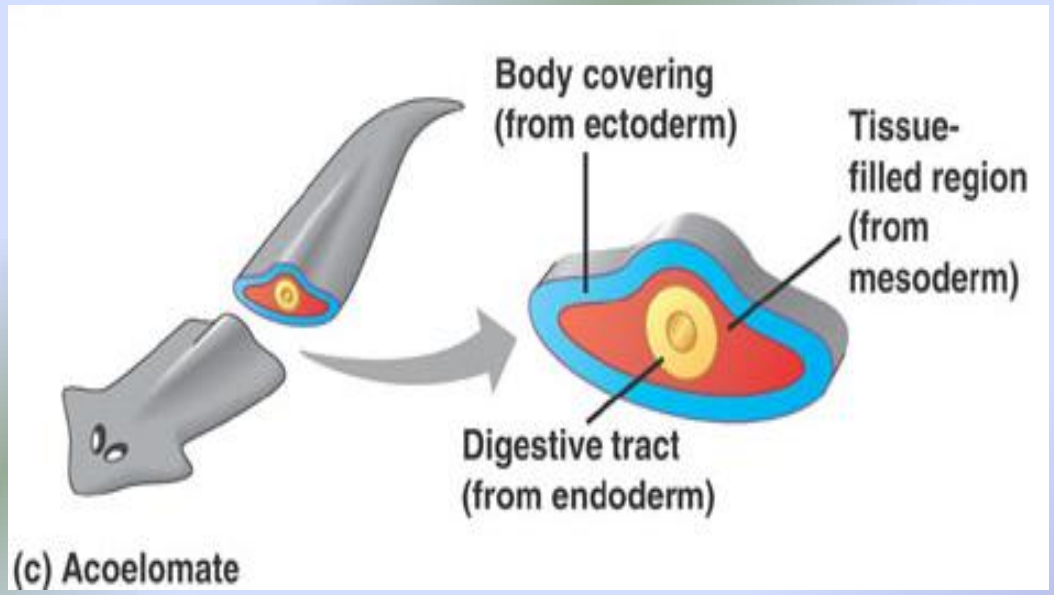
Coelom = Body Cavity

Acoelomate

Solid body with no cavity

Platyhelminthes

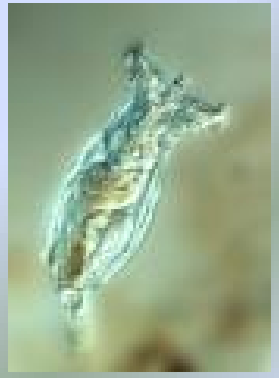
planaria
flukes
tapeworms

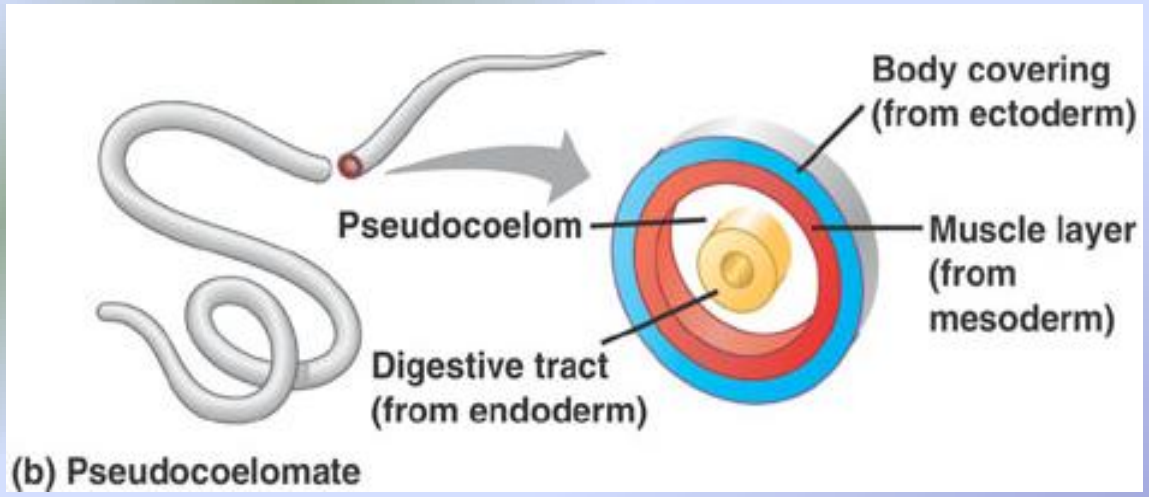


Pseudocoelomate

Body cavity has outer but not inner mesoderm lining

nematodes
rotifers

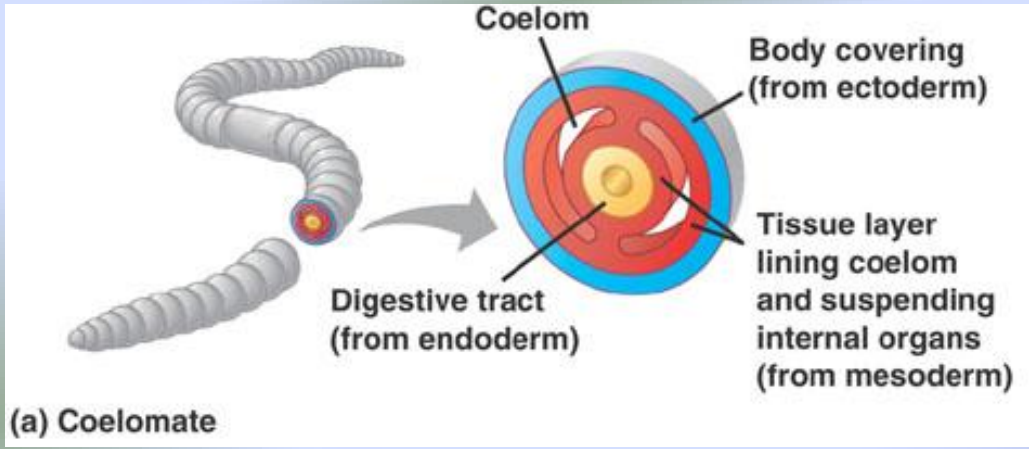




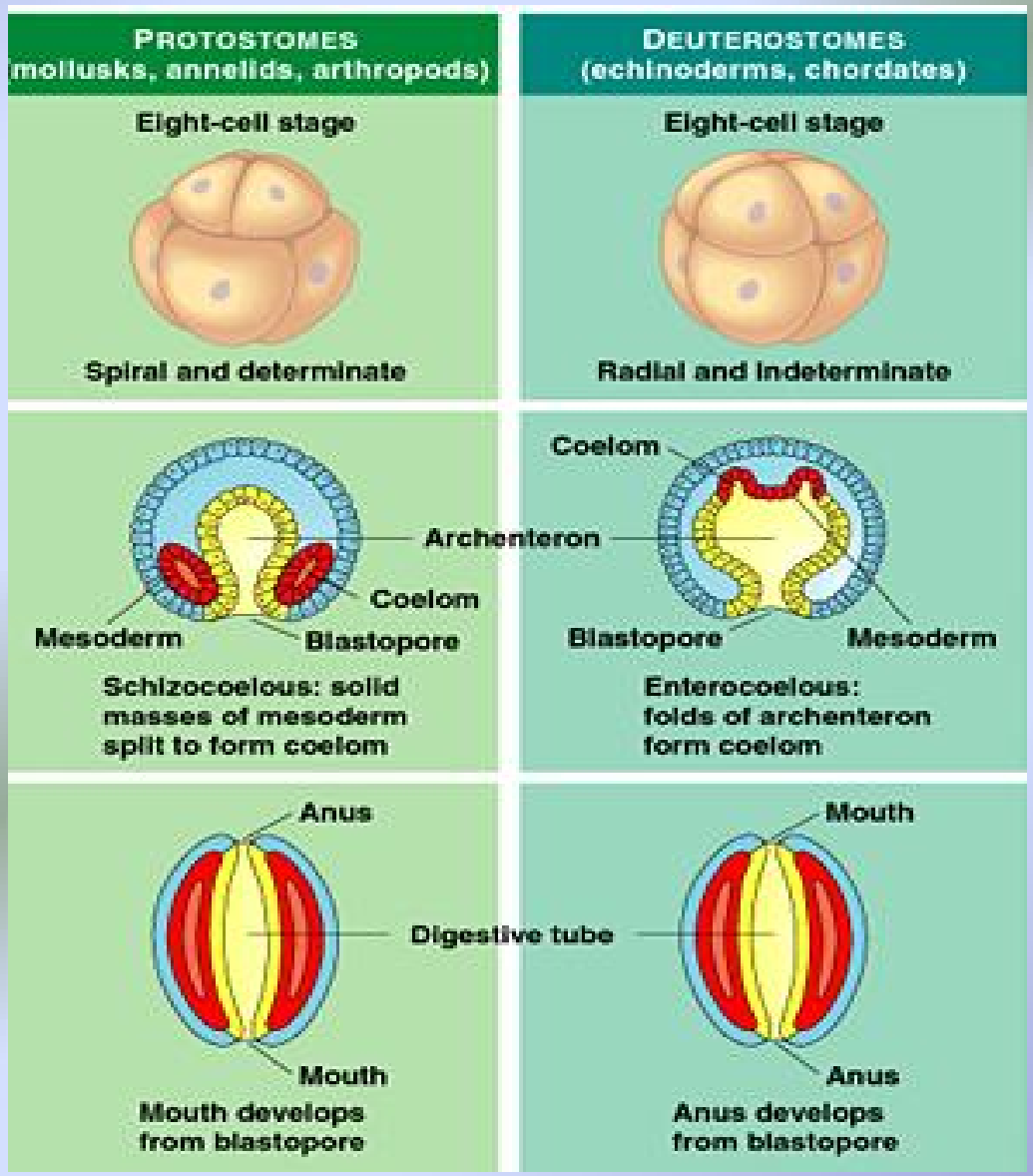
Eucoelomate (Coelomate)

Body cavity lined completely with mesoderm

annelids
molluscs
arthropods
echinoderms
chordates



Protostome or Deuterostome?



Protostomes

- Spiral cleavage
- Determinate cleavage
- Schizocoelous coelom
  - Mesoderm splits to form body cavity
- Mouth develops from blastopore (1st mouth) and anus develops as a 2nd opening….primitive anus become mouth!

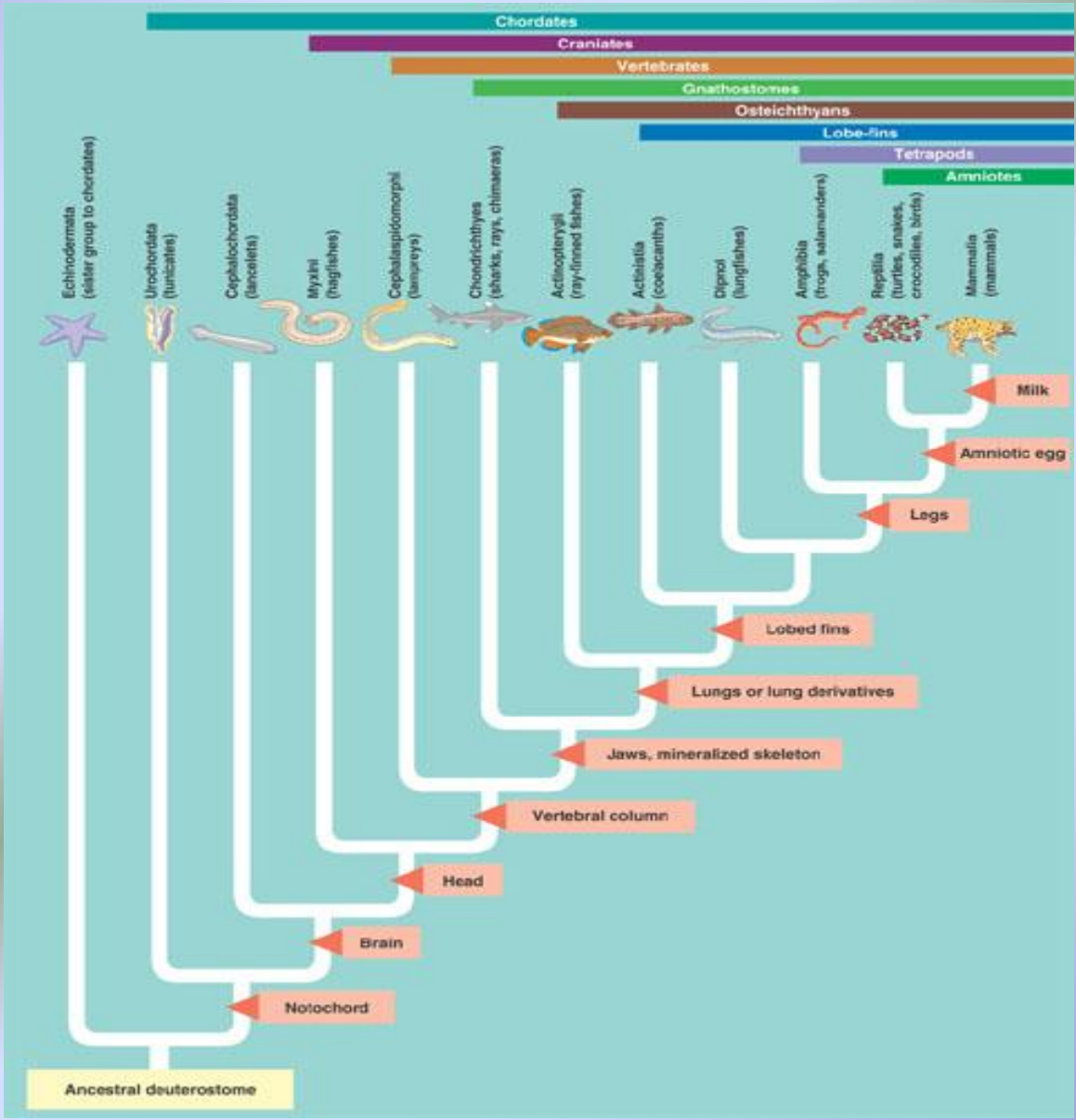
Deuterostomes

- Radial cleavage
- Indeterminate cleavage
- Enterocoelous
  - Mesoderm splits from wall of archenteron and becomes a coelom
- Mouth develops from a 2y opening (2nd mouth) and blastopore becomes anus

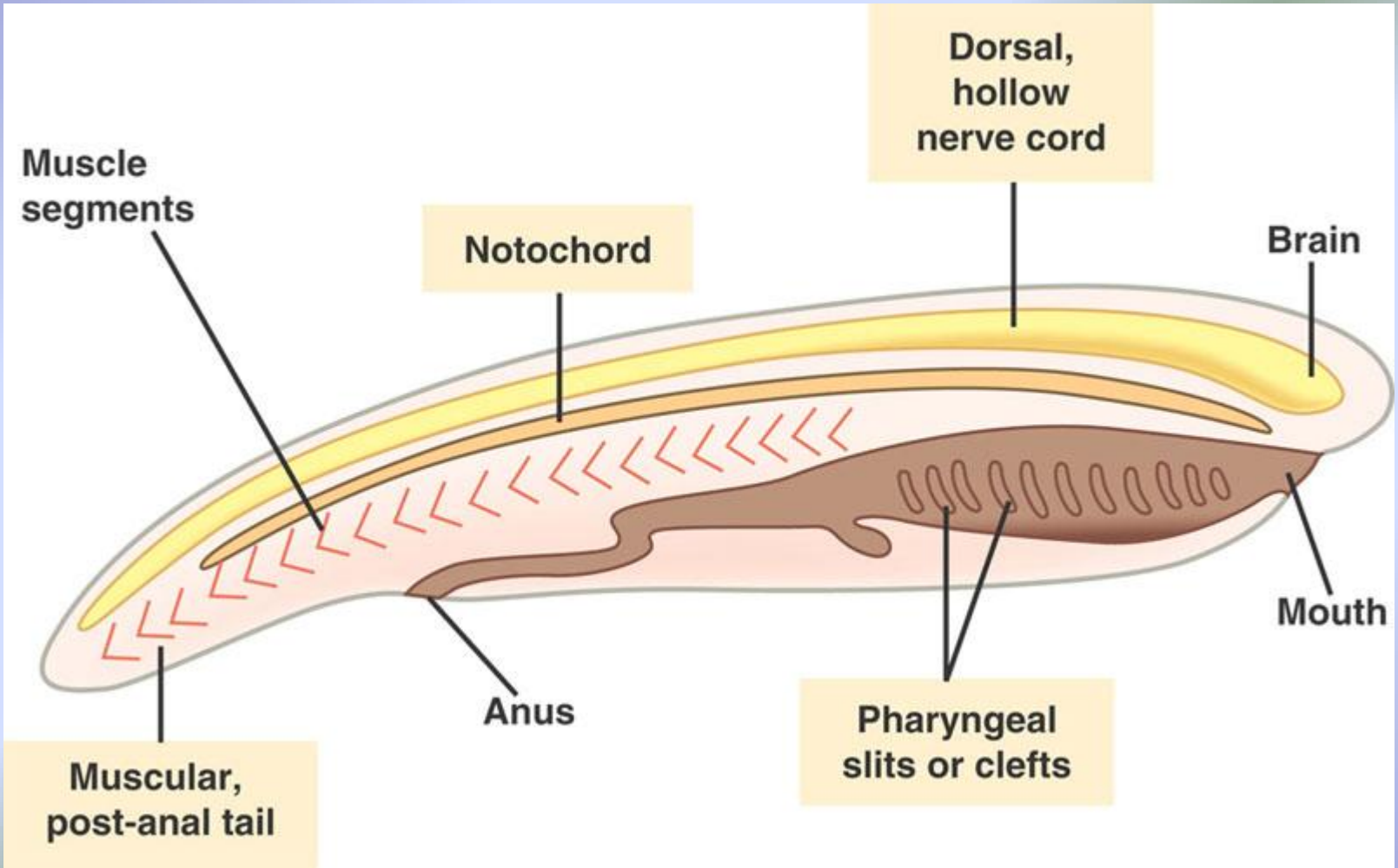
Selected Animal Phyla

	Phylum	Description
Metazoa	Porifera (sponges)	Lack true tissues; have choanocytes (collar cells—unique flagellated cells that ingest bacteria and tiny food particles)
Eumetazoa	Cnidaria (hydras, jellies, sea anemones, corals)	Unique stinging structures (cnidae), each housed in a specialized cell (cnidocyte); gastrovascular cavity (digestive compartment with a single opening)
Bilateria	Platyhelminthes (flatworms)	Dorsoventrally flattened, unsegmented acoelomates; gastrovascular cavity or no digestive tract
Bilateria	Rotifera (rotifers)	Pseudocoelomates with alimentary canal (digestive tube with mouth and anus); jaws (trophi) in pharynx; head with ciliated crown
Bilateria	Lophophorates: Ectoprocta, Phoronida, Brachiopoda	Coelomates with lophophores (feeding structures bearing ciliated tentacles)
Bilateria	Nemertea (proboscis worms)	Unique anterior proboscis surrounded by fluid-filled sac; alimentary canal; closed circulatory system
Bilateria	Mollusca (clams, snails, squids)	Coelomates with three main body parts (muscular foot, visceral mass, mantle); coelom reduced; most have hard shell made of calcium carbonate
Bilateria	Annelida (segmented worms)	Coelomates with body wall and internal organs (except digestive tract) segmented
Bilateria	Nematoda (roundworms)	Cylindrical, unsegmented pseudocoelomates with tapered ends; no circulatory system
Bilateria	Arthropoda (crustaceans, insects, spiders)	Coelomates with segmented body, jointed appendages, and exoskeleton made of protein and chitin
Deuterostomia	Echinodermata (sea stars, sea urchins)	Coelomates with secondary radial anatomy (larvae bilateral; adults radial); unique water vascular system; endoskeleton
Deuterostomia	Chordata (lancelets, tunicates, vertebrates)	Coelomates with notochord; dorsal, hollow nerve cord; pharyngeal slits; muscular, post-anal tail

Chordates

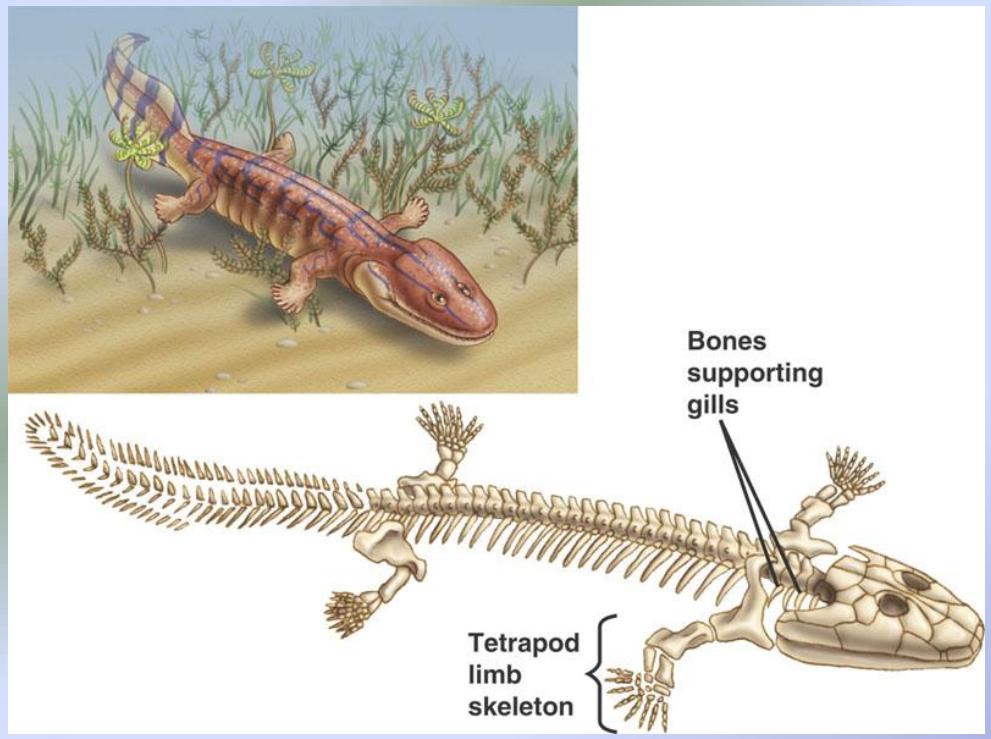

Chordates
Craniates
Vertebrates
Gnathostomes
Osteichthyans
Lobe-fins
Tetrapods
Amniotes
Echinodermata (sister group to chordates)
Urochordata (tunicates)
Cephalochordata (lancelets)
Myxini (hagfishes)
Cephalaspidomorphi (lampreys)
Chondrichthyes (sharks, rays, chimaeras)
Actinopterygii (ray-finned fishes)
Actinistia (coelacanths)
Dipnoi (lungfishes)
Amphibia (frogs, salamanders)
Reptilia (turtles, snakes, crocodiles, birds)
Mammalia (mammals)
Milk
Amniotic egg
Legs
Lobed fins
Lungs or lung derivatives
Jaws, mineralized skeleton
Vertebral column
Head
Brain
Notochord
Ancestral deuterostome

Chordate Characteristics



Vertebrates

- Agnatha
- Chondrichthyes
- Osteichthyes
- Amphibians
- Reptiles
- Birds
- Mammals



Source

Campbell Biology 7th edition

http://www.aw-bc.com/campbell/