Plant Diversity I

Chapter 29
and section 28.5

5 major Eukaryote Clades

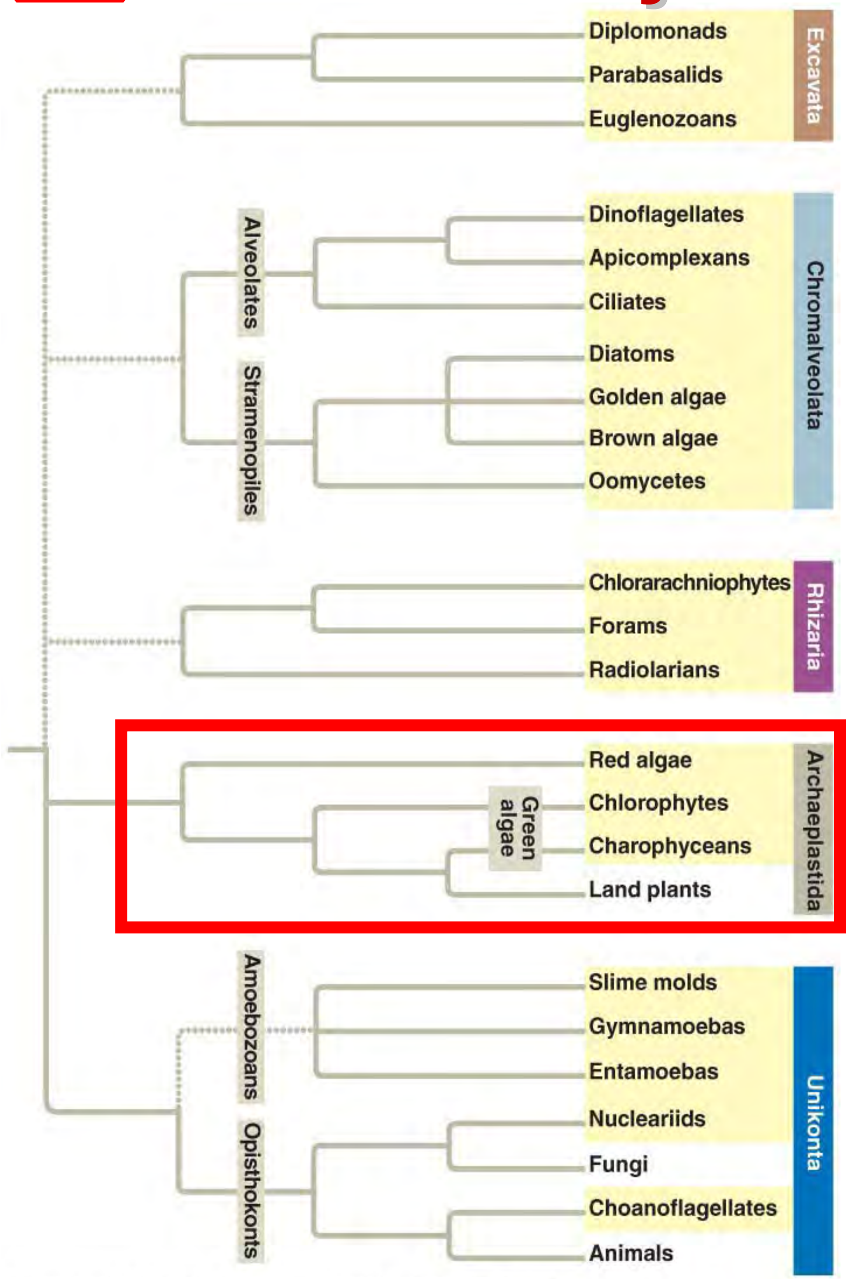
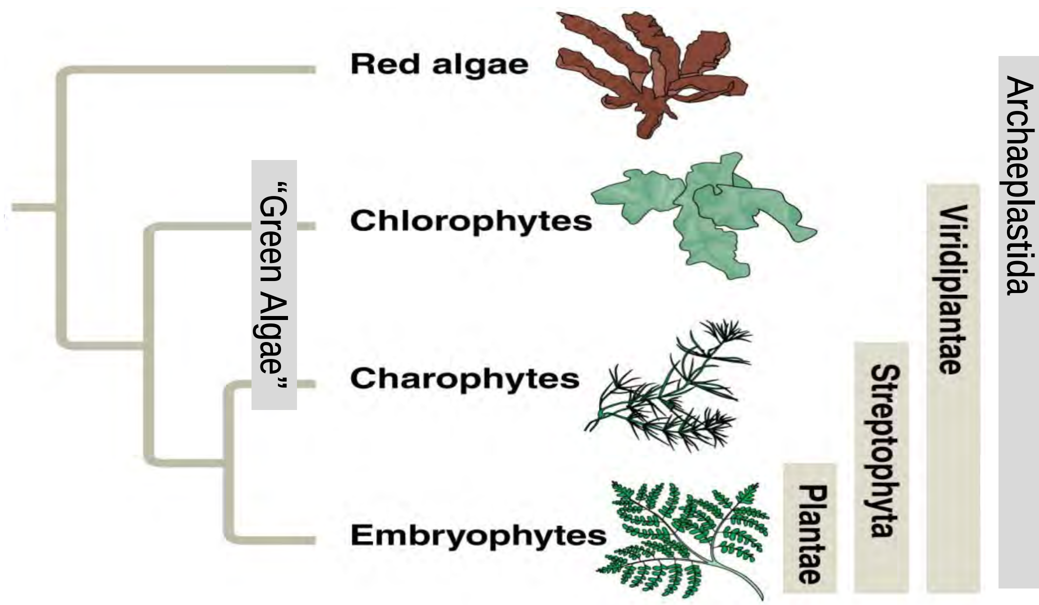


Figure 28.3 (Campbell et al.)

Archaeplastida

4 Subclades:



Synapomorphy:

Chloroplasts w/ double membrane

Modified from Figure 29.4 (Campbell et al.)

Clade: Archaeplastida

Synapomorphy: Chloroplasts w/ double membrane

Acquired chloroplasts via 1º endosymbiosis

- thus have a double membrane not triple or quadruple as in 2º endosymbiosis

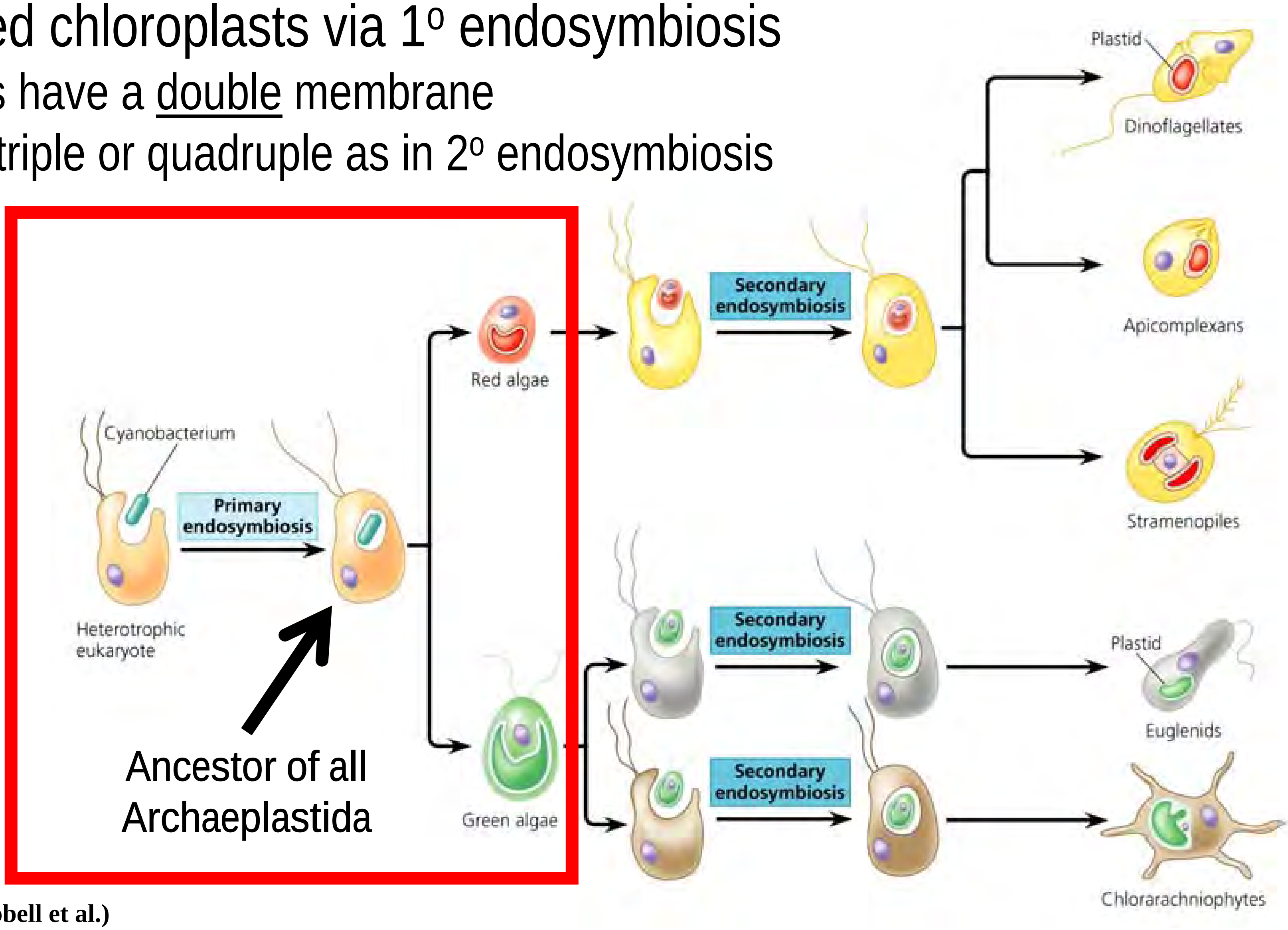
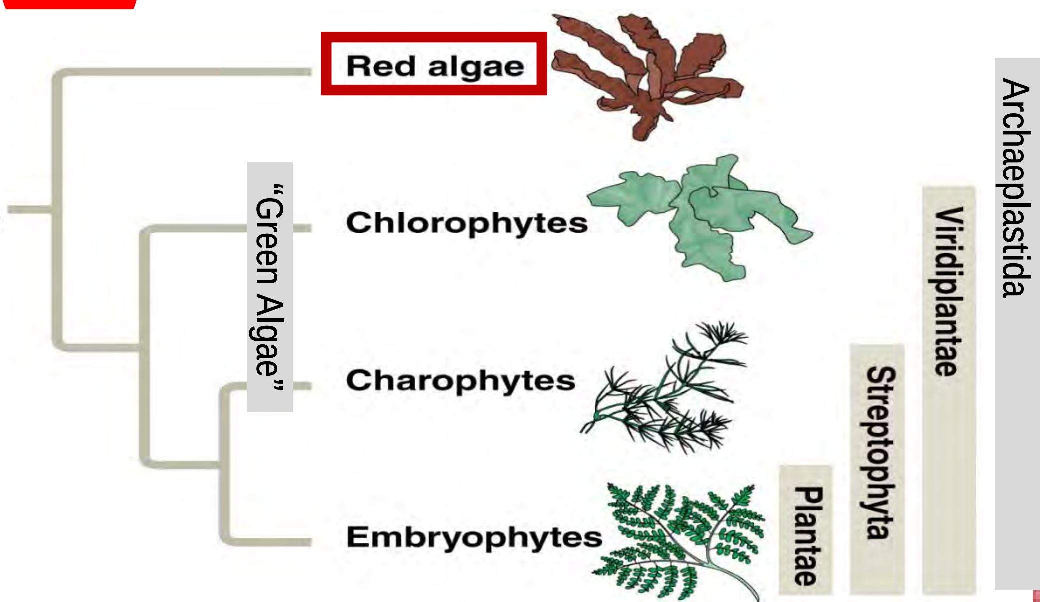


Figure 28.2 (Campbell et al.)



Subclade: Red algae (Rhodophyta)

- 5,000–10,000 species
- Mostly multicellular
- Mostly marine
  (~200 spp freshwater)
- Many "seaweeds"

Figure 28.3 (Campbell et al.)

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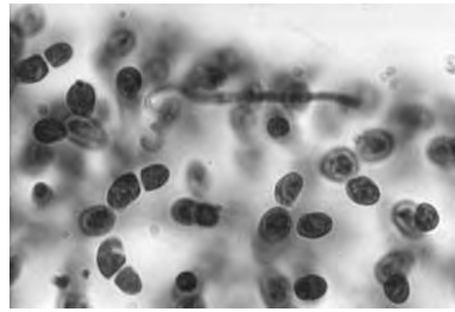
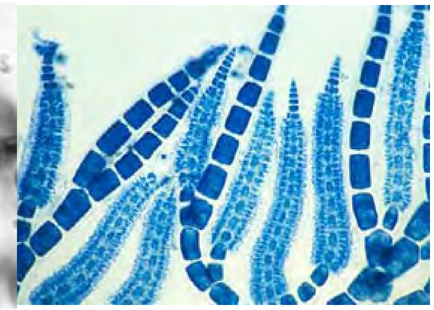
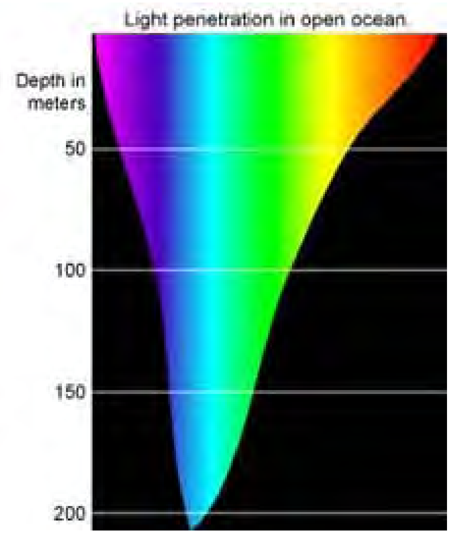
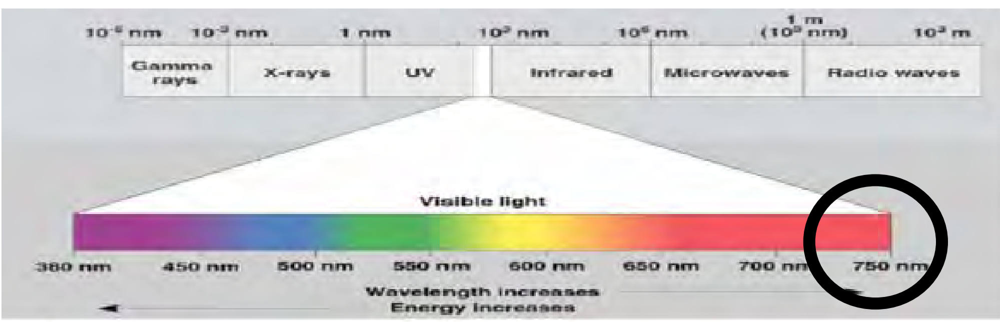
Red Algae Synapomorphies

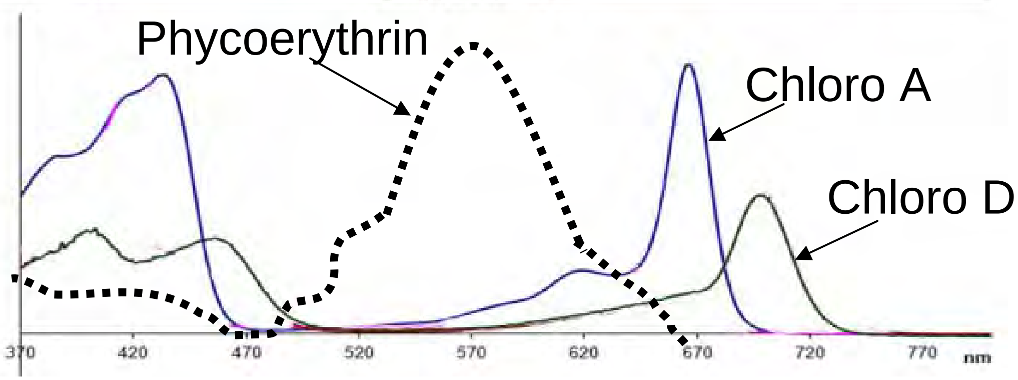
1. Eukaryotic cells <u>w/o</u> flagellated gametes
2. Store glucose as starch
   <u>outside</u> chloroplasts (in cytoplasm)
   - vs most organisms inside chloroplast
3. Chloroplasts with Chlorophyll <u>a</u> & <u>d</u>
   & accessory pigment <u>phycoerythrin</u>
   F-eye-coh-ear-ith-rin

♀ gametes (gametangium) ♂ gametes (spermatangia)







- Red since chloros a & d & Phycoerythrin together absorb all light except red.
- Phycoerythrin improves photosynthesis at greater depths (known to 260m).
- Chloro D ↑ absorption spectrum but only useful near surface or when shaded

6

Commercial Uses

Cell walls w/ 3 polysachrides: 1) cellulose; 2) agar; 3) or carrageenan

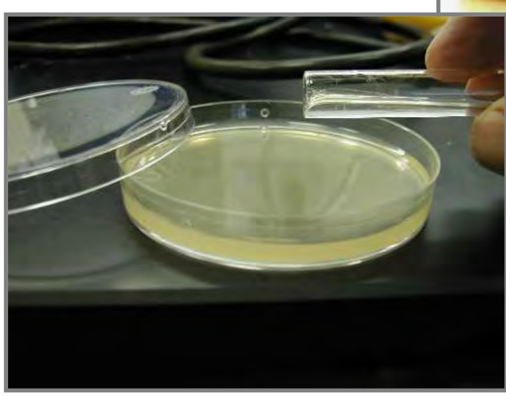
Nori

thickener

stabilizer

clarifier

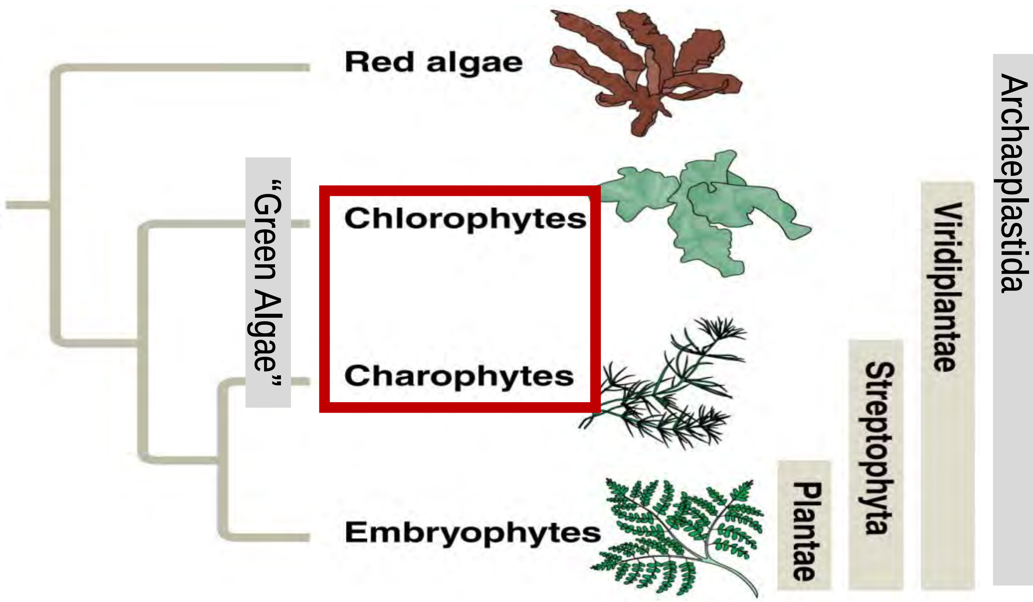
texture agent

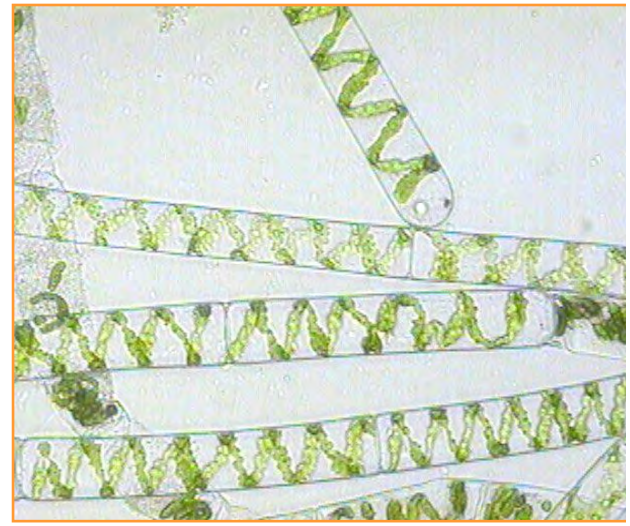


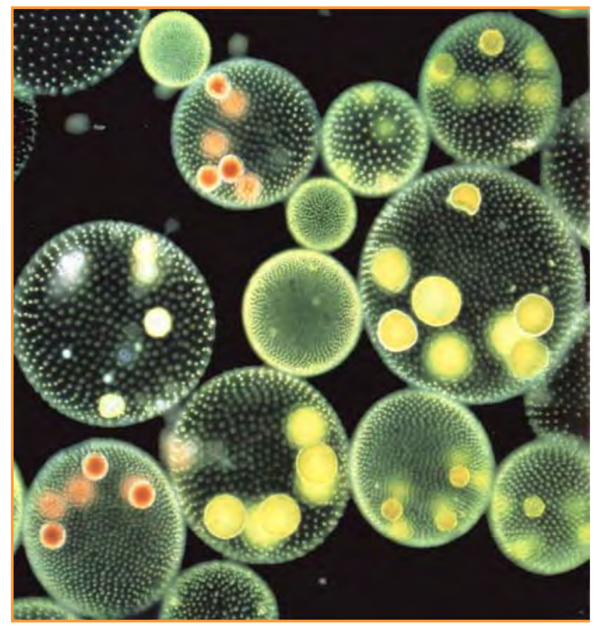
culture medium

7

"Green algae"







- <u>Paraphyletic</u> subgroup of Archaeplastida
  - Includes an ancestral green algae and <u>some but not all</u> of its descendants.
    - i.e. Does not include embryophytes.
    - However, the Virdiplantae IS monophyletic
- 2 groups:
  - Chlorophytes (monophyletic clade)
  - "Charophytes" (actually also a paraphyletic group)
    - Contains the group most closely related to land plants (i.e. sister group)

Figure 29.4 (Campbell et al.)

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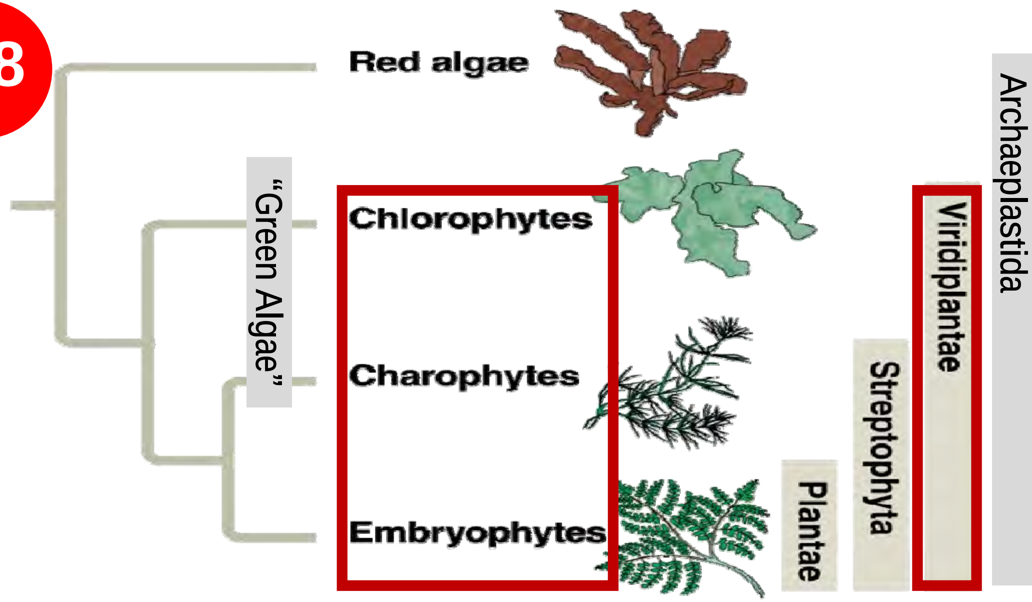


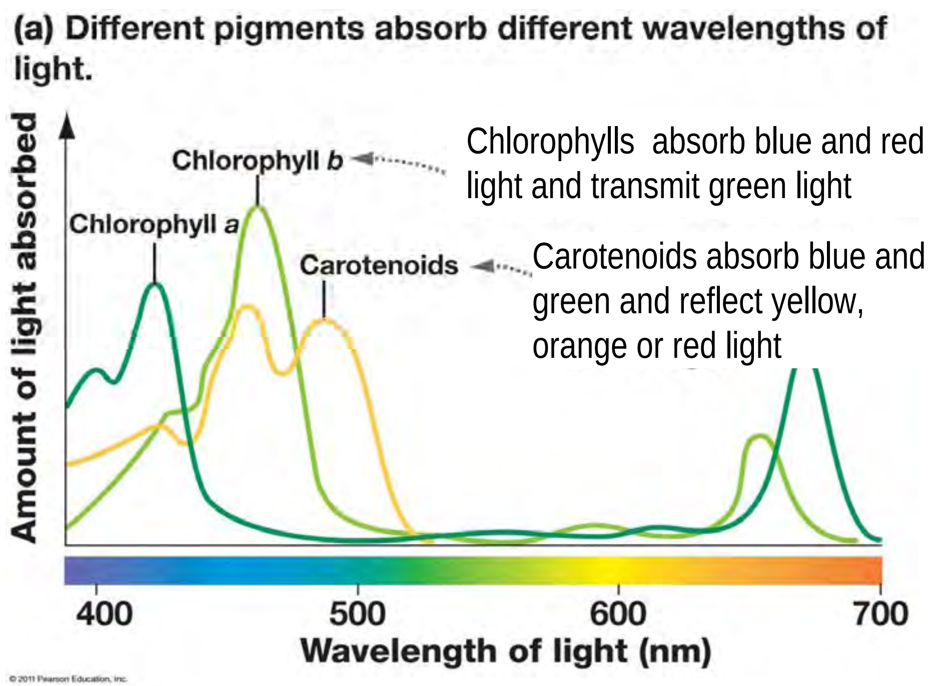
Clade: Viridiplantae

Synapomorphies:

1. Similar DNA sequences

2.Chloroplasts w/ Chloro a & b
& accessory pigment
beta-carotene

3.Store glucose as starch
inside chloroplasts



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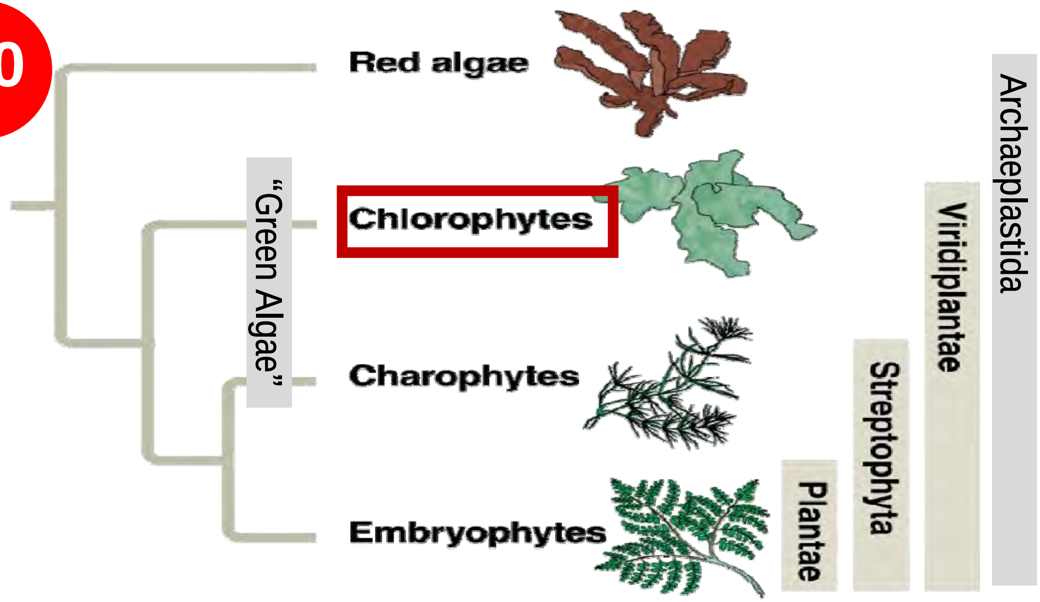
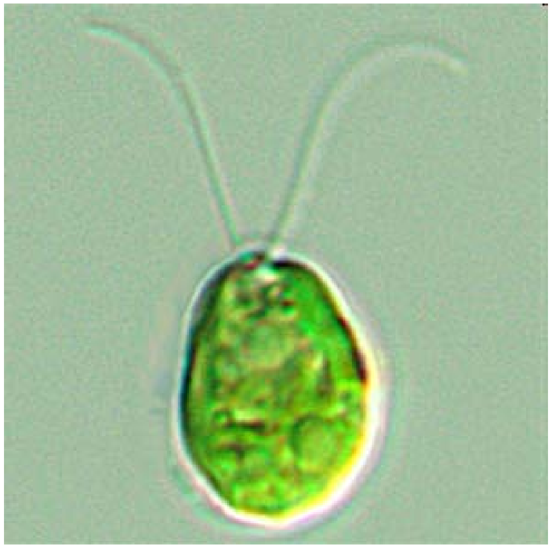


Clade: Chlorophyta

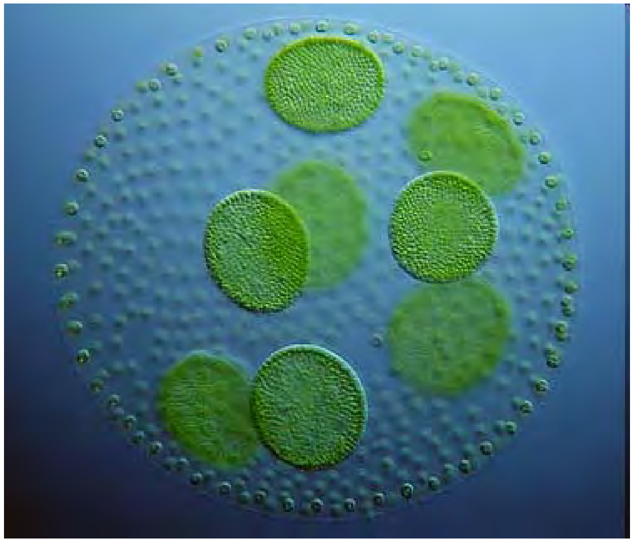
Synapomorphies:

1. Similar DNA sequences
2. 2 flagella on cell or gamete
3. Cup-shaped chloroplast



Unicellular
e.g. *Chlamydomonas*

Multicellular
e.g. *Ulva* (sea lettuce)



Colonial
e.g. Volvox

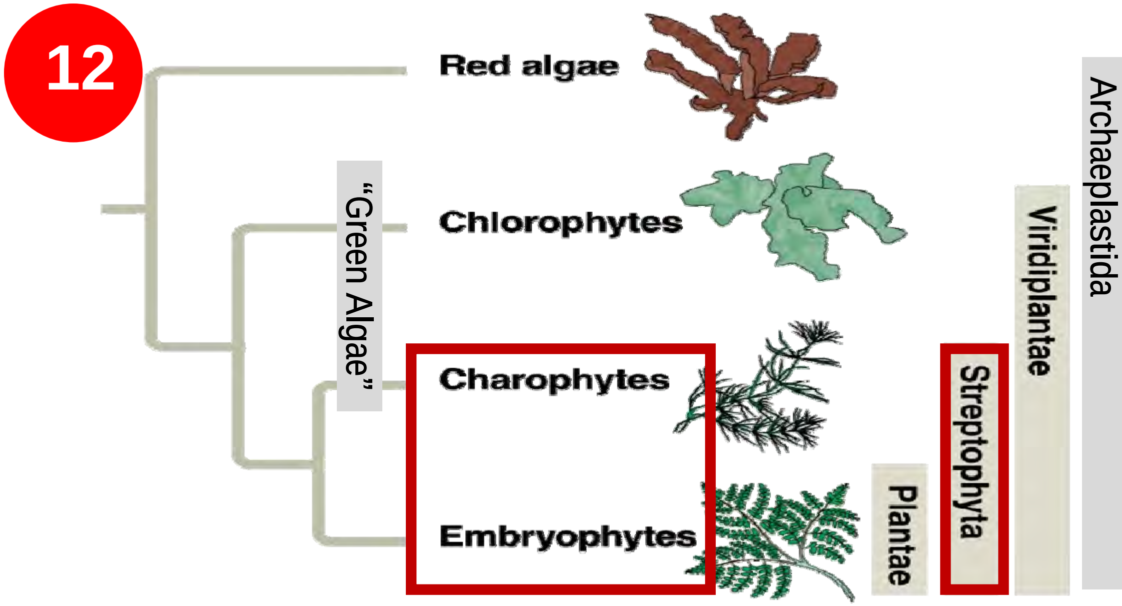
Figures 29.4, 28.21, 28.22 (Campbell et al.)

http://www.youtube.com/watch?v=MDY2SZ_-tc8

11 Volvox and cellular slime molds give insights into the origin of multicellularity

- Multicellularity evolved multiple times
  i.e. Occurs in at least 25 unrelated lineages
- Several hypotheses as to how:
  - Colonial hypothesis

- Multiple single-celled individuals of a spp form a colony.
- Different individuals specialize on different functions and become reliant on one another.
- e.g. Cellular slime mold fruiting body
  - Only upper “amoebas” reproduce
- e.g. Volvox
  - Up to 50k cells w/ only a few reproducing
    (a few asexually and a few others sexually).



Clade: Streptophyta

Includes:

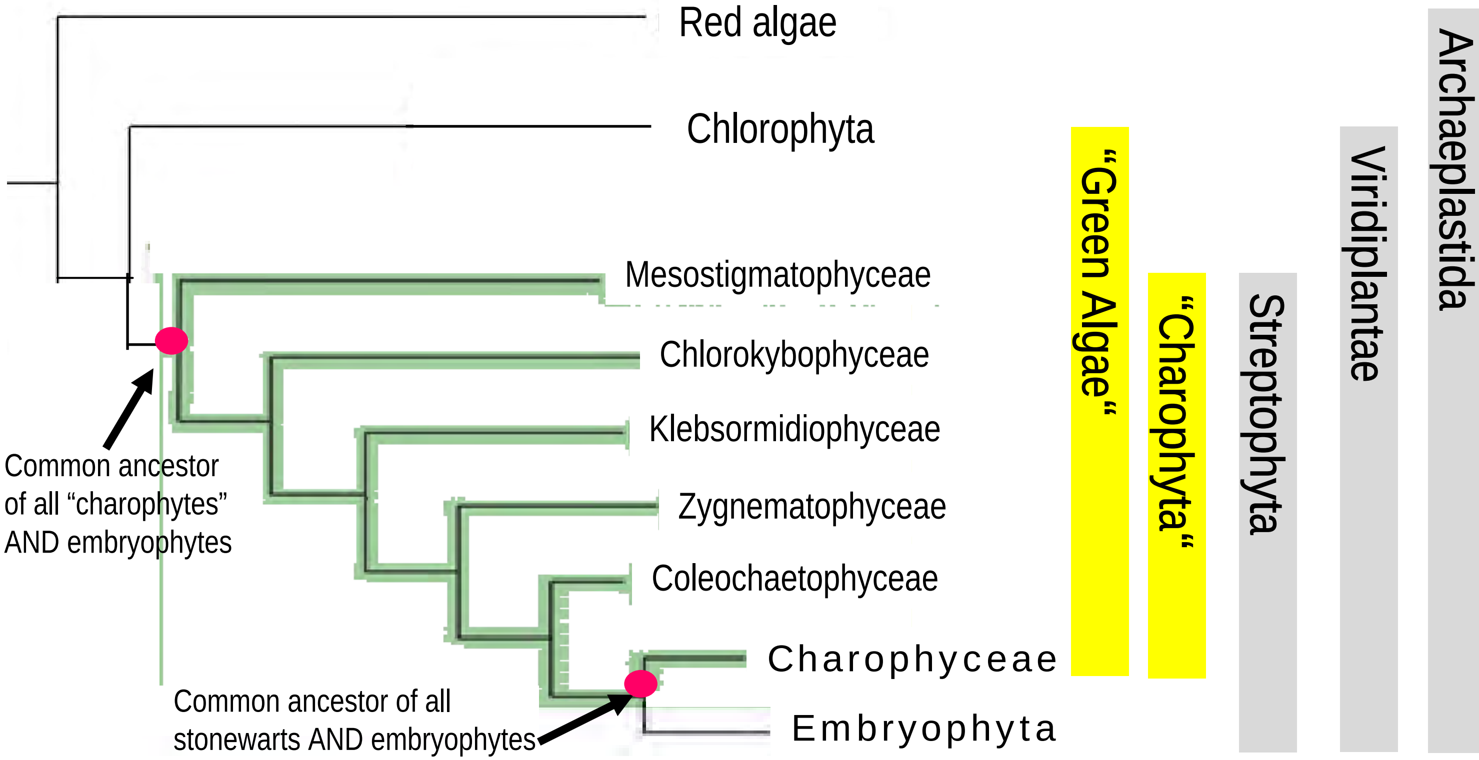
1. "Charophyta" (paraphyletic)
2. Embryophyta (land plants) (monohyletic)

Synapomorphies:

1. Similar DNA sequences
2. Morphological characters

Figures 28.3, 28.21, 28.22 (Campbell et al.)

13 Changing taxonomy: “Charophyta” really paraphyletic



Note
Do not need to know all groups in the “Charophyta”

- “Charophyta” really includes several groups.
- One group within the Charophyta, the Charophyceae (aka stonewarts), is the closest relative to land plants (Embryophyta)
- Thus: Like “green algae”, Charophyta” is really paraphyletic since it does not include Embryophyta

http://comenius.susqu.edu/biol/202/archaeplastida/viridiplantae/green%20algae/charophyta/charophyta-cladogram.jpg

Charophyceans and Plants

Charophyceans (aka <u>stone</u>worts)
are the closest living relatives of land plants

Synapomorphies:

1. DNA Similarities

\+

<u>Four key morphological similarities</u>:

2. circular proteins in cell wall for cellulose synthesis (vs. others w/ straight)
3. Similar enzymes (↑ photosynth efficiency)
4. Structure of flagellated sperm similar
5. Similarities in mitosis
   (e.g. Formation of <u>phragmoplast</u>
   (microtubules btwn daughter nuclei)

Fig 29.3 (Campbell et al)

Fig 29.2 (Campbell et al)

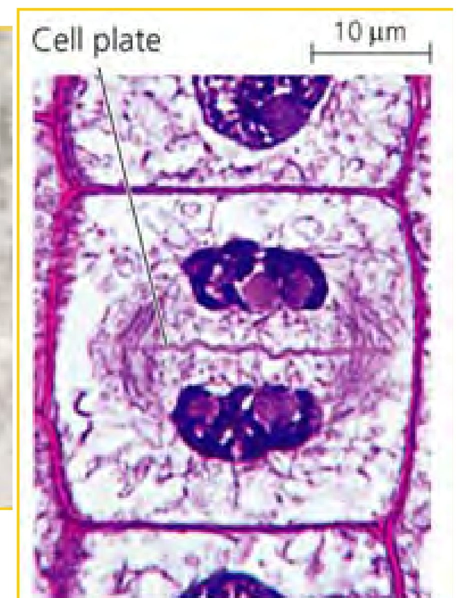
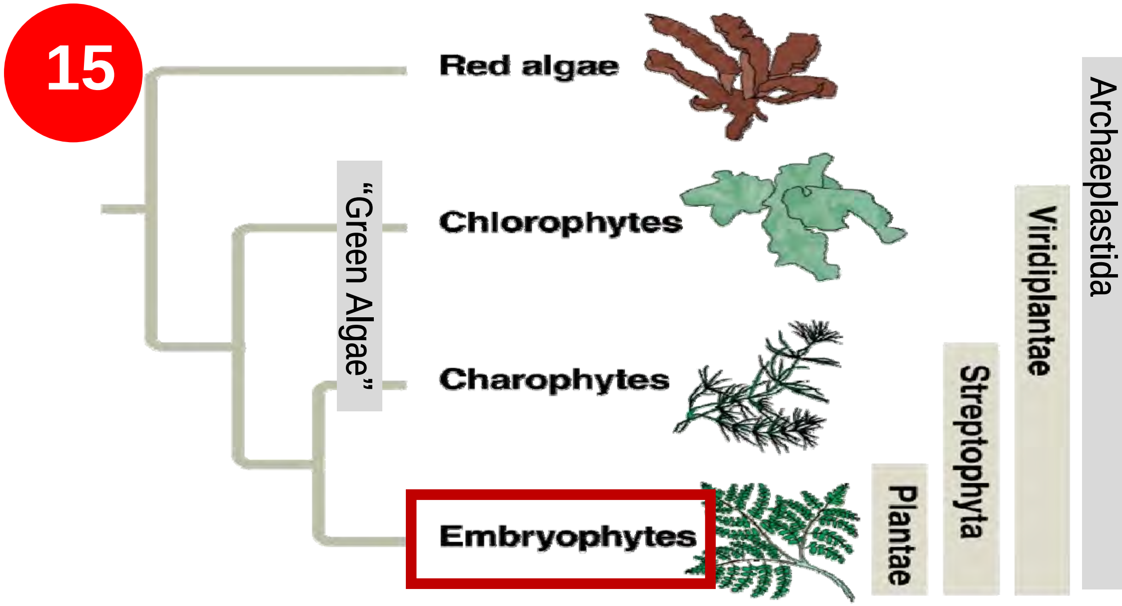


Fig 12.11-5 (Campbell et al)



Clade: Embryophyta

Plants

~300,000 known extant (living) plant species

16

Tropical Rainforests contain a substantial diversity of plant species

Tropical Rainforests: South America, Africa, Asia

17

Even the harshest deserts contain plant species

Painted Desert: Arizona

Atacama Desert: Chile

Namib Desert: Southern Africa

Sahara Desert. Northern Africa

18

The Poles

Arctic:
~1000 vascular spp
and many more
nonvascular spp.

Antarctic:
- 99% of land is plantless
- 2 small vascular plants,
- Rest are non-vascular

~100 mosses,
~25 liverworts,
~300-400 lichens

Antarctic pearlwort (*Colobanthus quitensis*)

Antarctic hair grass (Deschampsia antarctica)

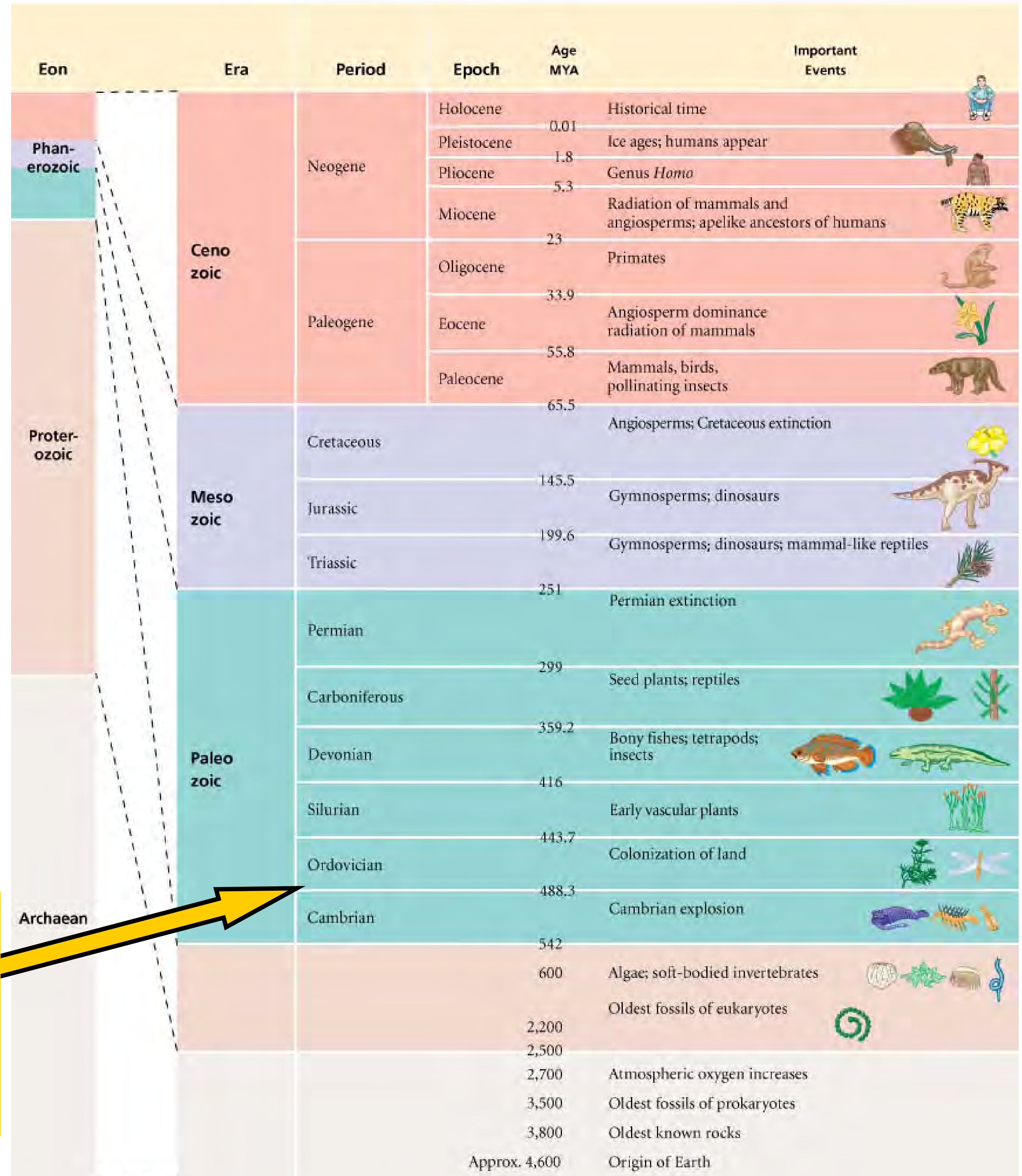
19

LIFE ON LAND:

1.2 Billion Years ago: Land began to host thin coatings of Cyanobacteria:

20

History of Plants

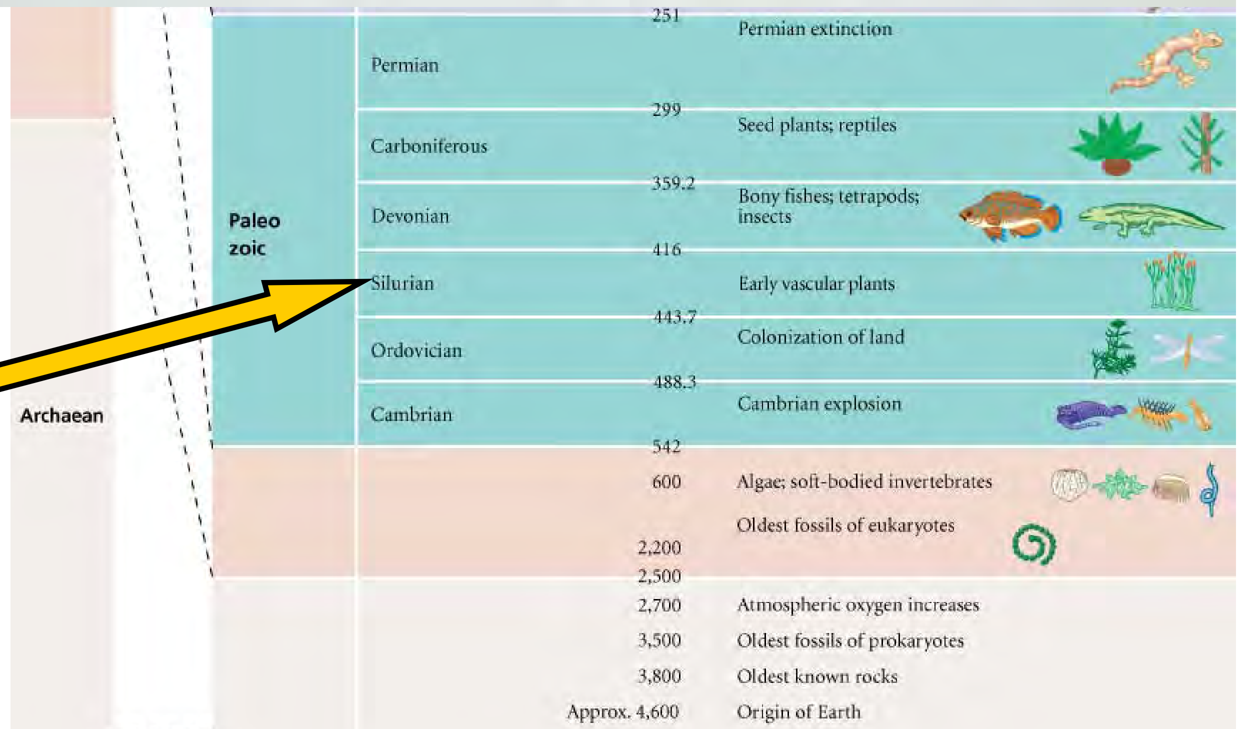


land plants

~475 mya (Ordovician)

21

History of Plants



Vascular Plants (seedless)

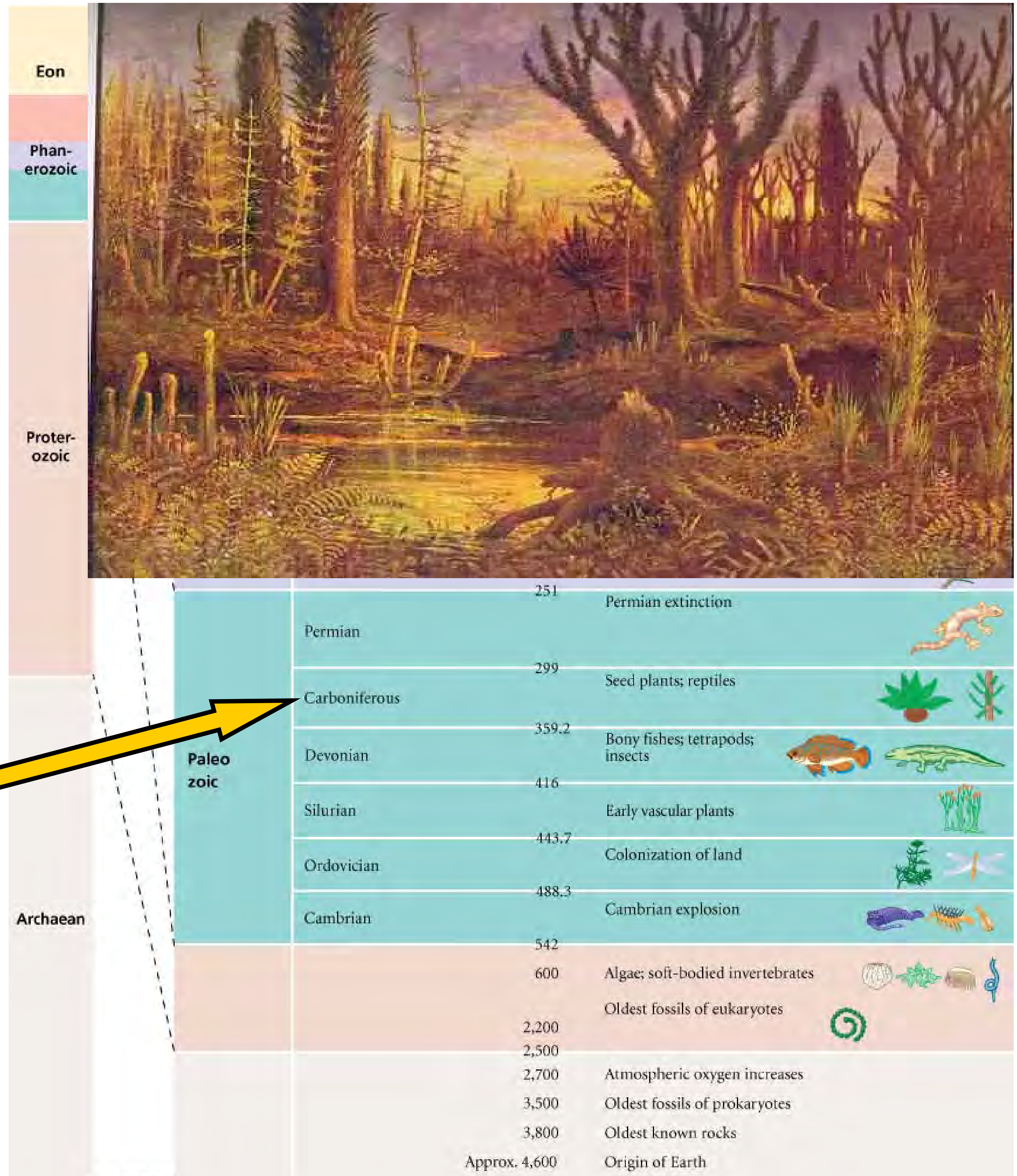
~420 mya (late Silurian)

22

History of Plants

First seed plants

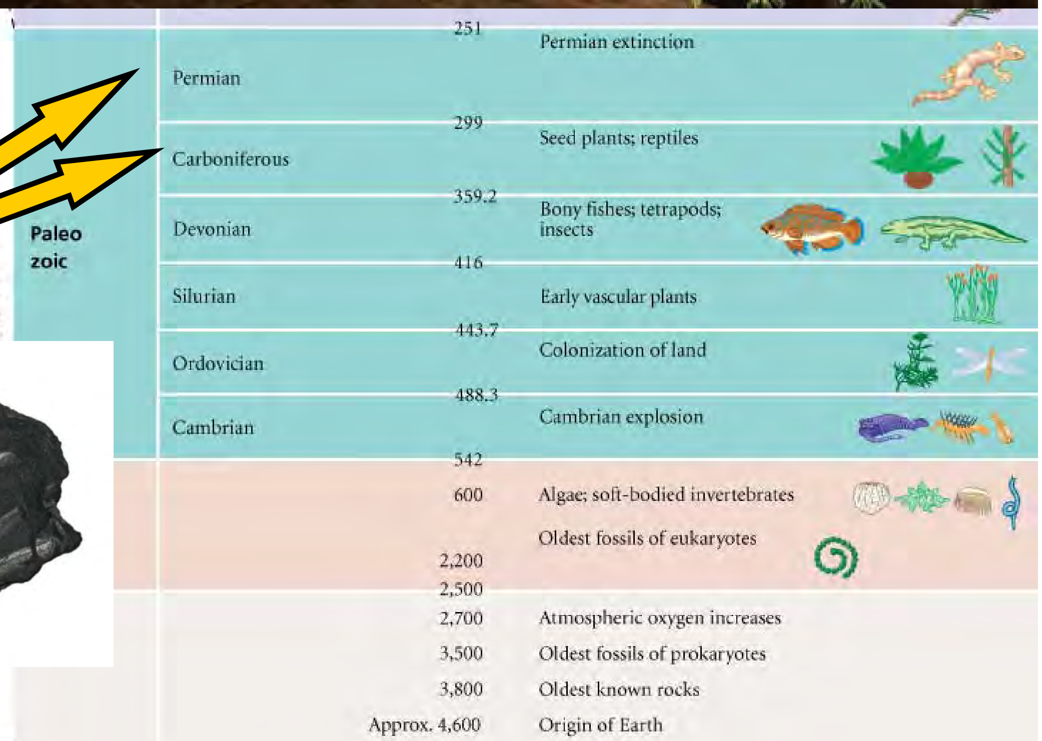
~360 mya (Carboniferous)



23

History of Plants

Vascular seedless plants dominated for ~100 my until mid-Permian



Lush Tropical Forests of vascular seedless plants

- Giant lycopods, ferns, horsetails & first seed plants

- Today's coal deposits

~325-275 mya
(mid Carboniferous - mid Permian)

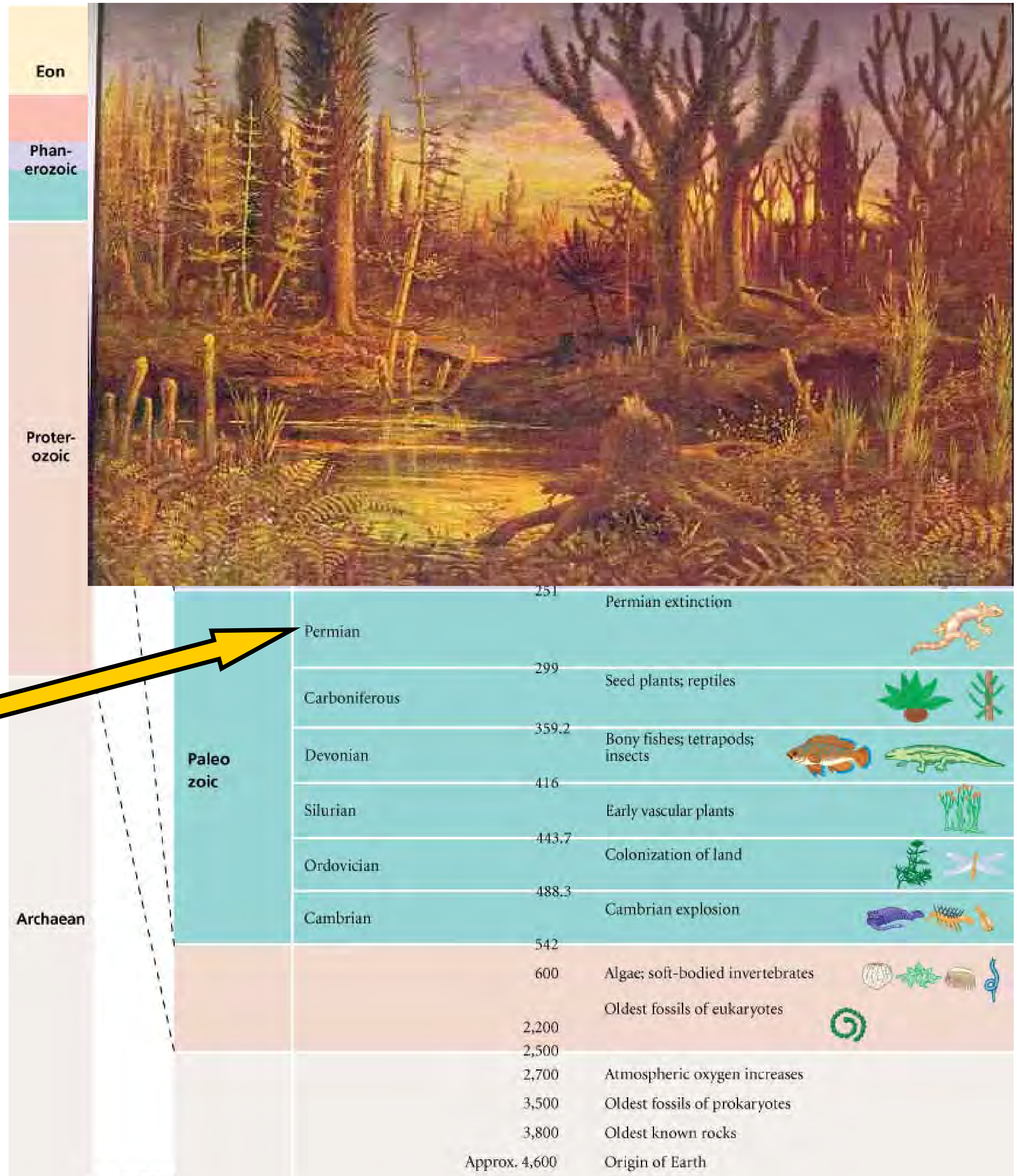
24

History of Plants

Seed plants have dominated for ~275my since mid-Permian

Forests of vascular seed plants (mid-Permian - Present)

~275 - 0 mya



26

Derived Plant Traits

1 **Apical meristems**

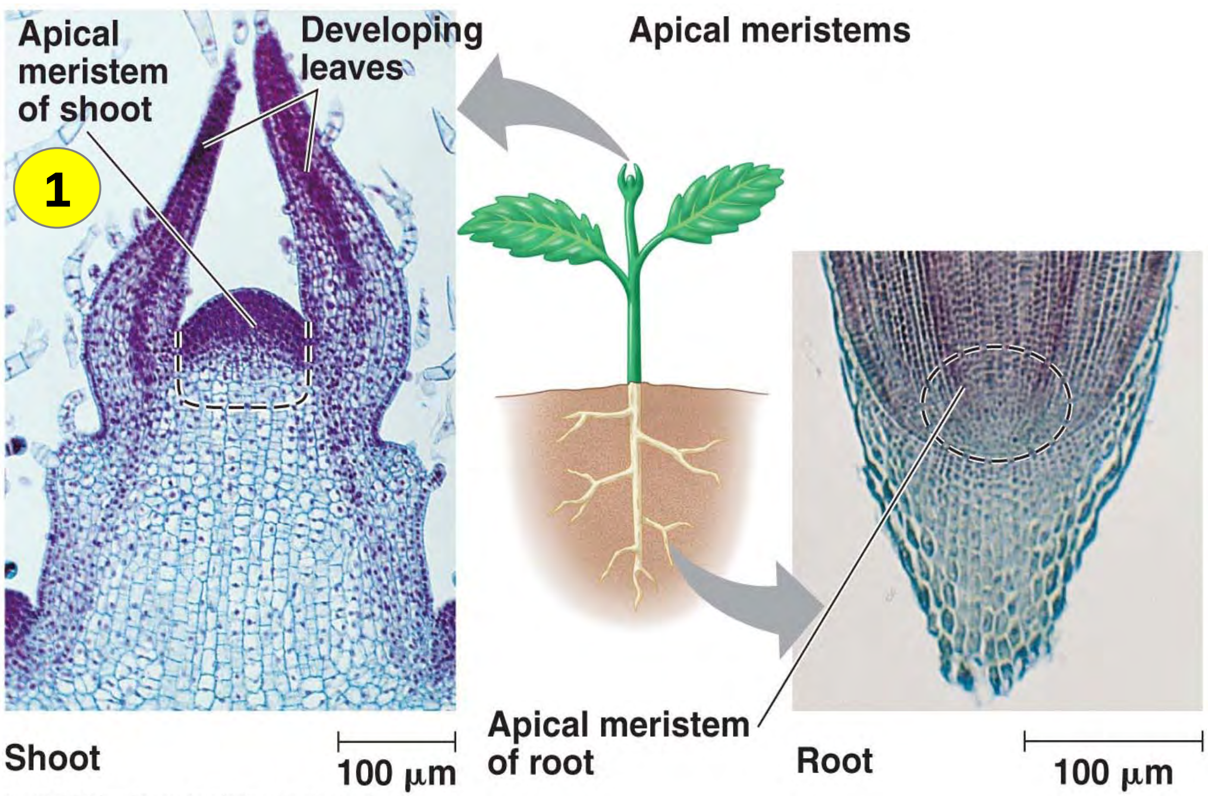


Fig. 29.5 (Campbell et al)

Plant tissue that remains embryonic

Produces "stem" cells that differentiate into specialized cells

27

Derived Plant Traits

1 **Apical meristems**

2 **Alternation of generations**

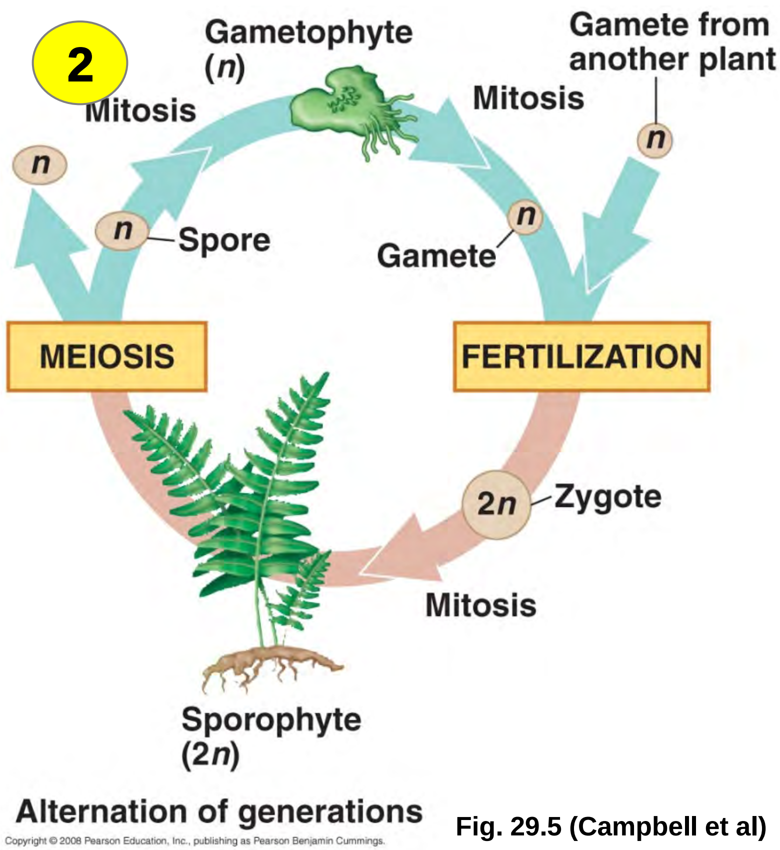


Fig. 29.5 (Campbell et al)

2 multicellular stages

1. Sporophyte
   - Diploid
2. Gametophyte
   - Haploid

Alternation of Generations

Alternation of *multicellular* haploid and diploid stages.

Occurs in most plants & some protists

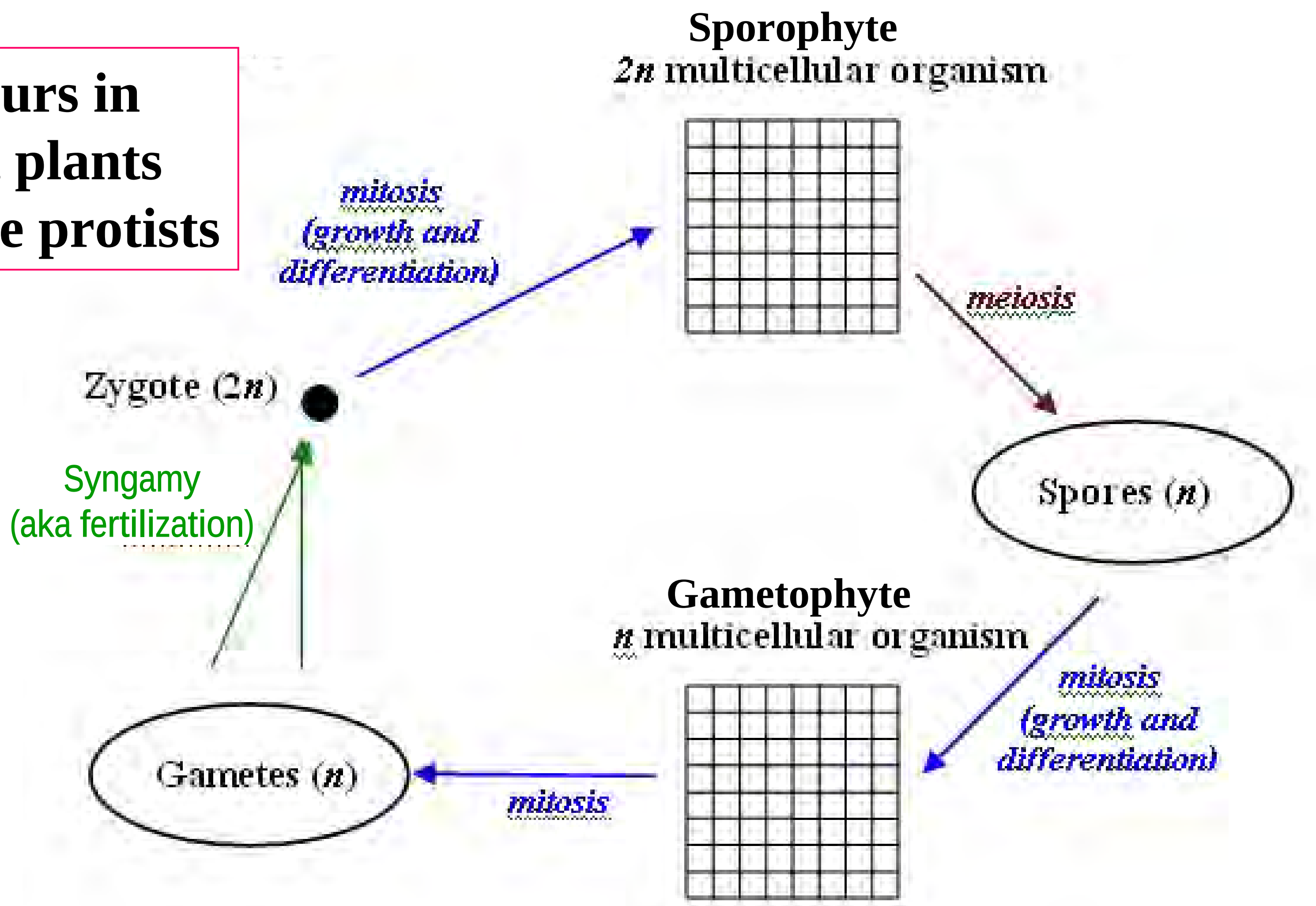
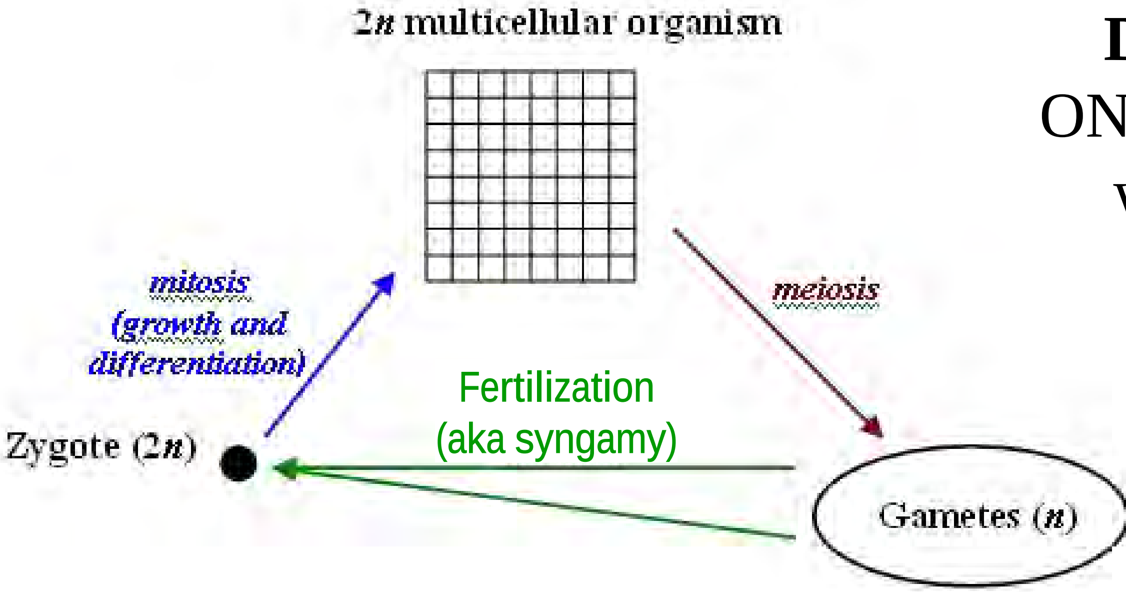


Fig. 13.6 (Campbell et al.)

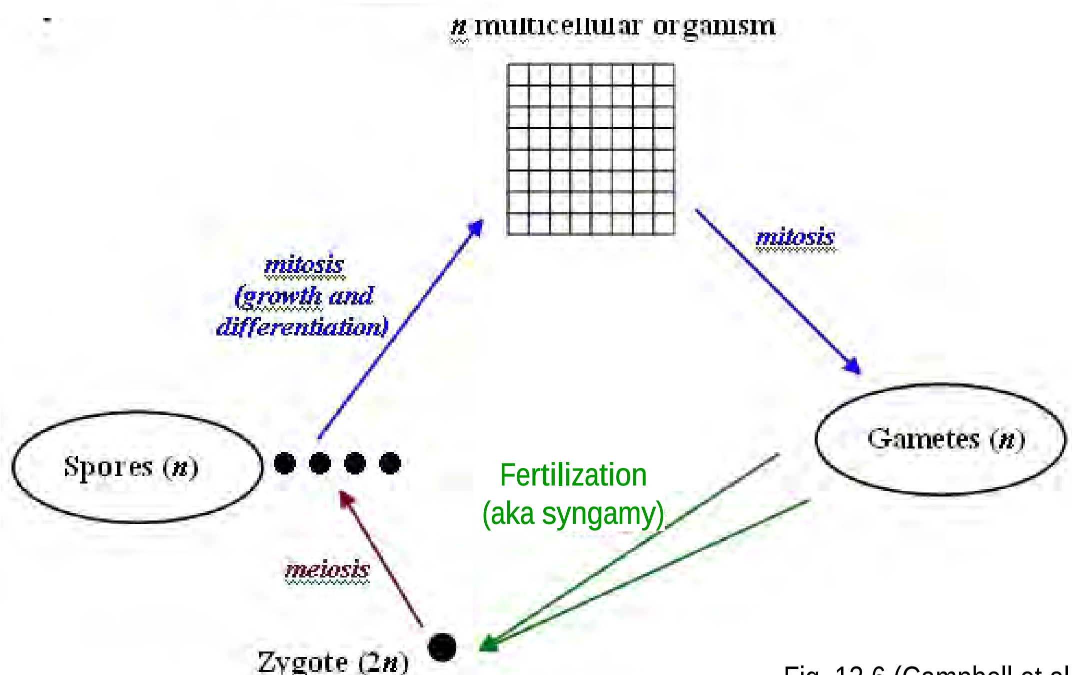
Alternation of Generations vs …



Diploid Dominant

ONE multicellular stage
w/ all diploid cells

Occurs in animals
& some protists



Haploid Dominant

ONE multicellular stage
w/ all haploid cells

Occurs in fungi
& some protists

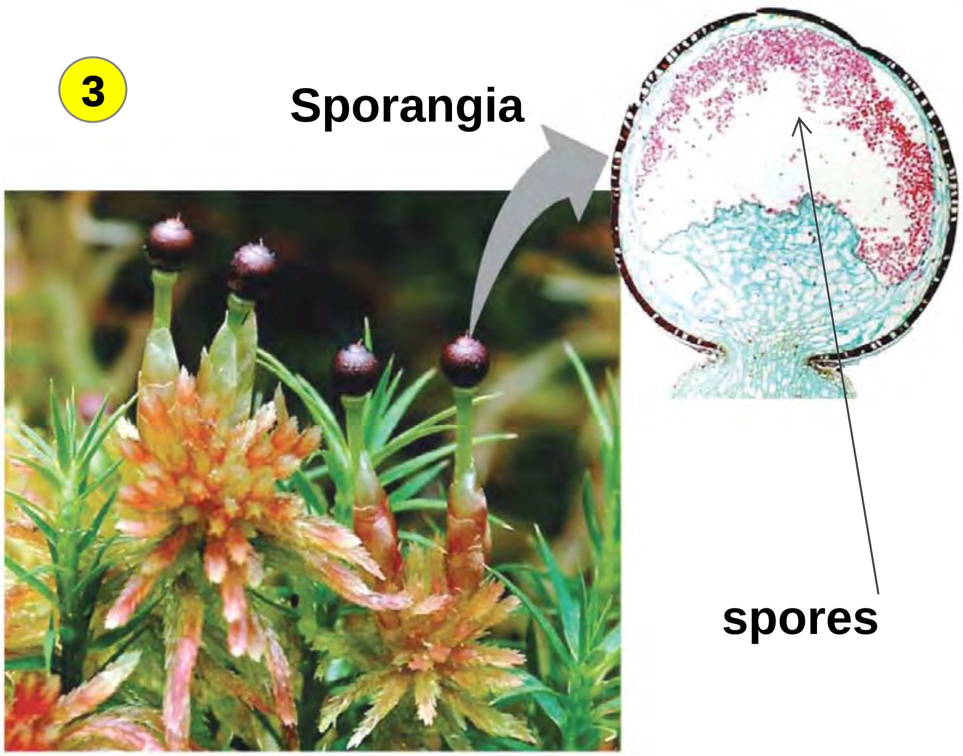
Fig. 13.6 (Campbell et al.)

30

Derived Plant Traits

1. Apical meristems
2. Alternation of generations
3. Walled spores in sporangia

3



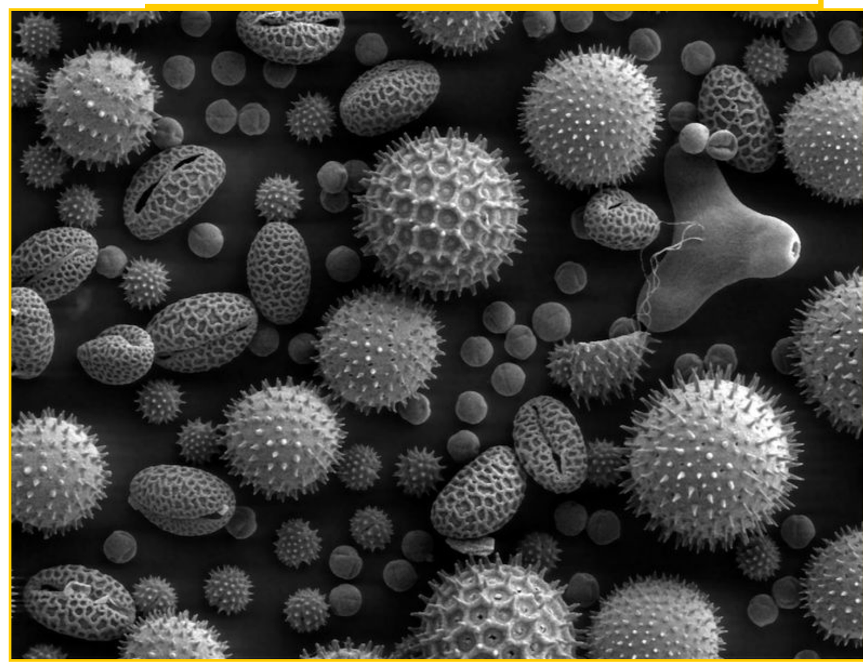


Fig. 29.5 (Campbell et al)

31

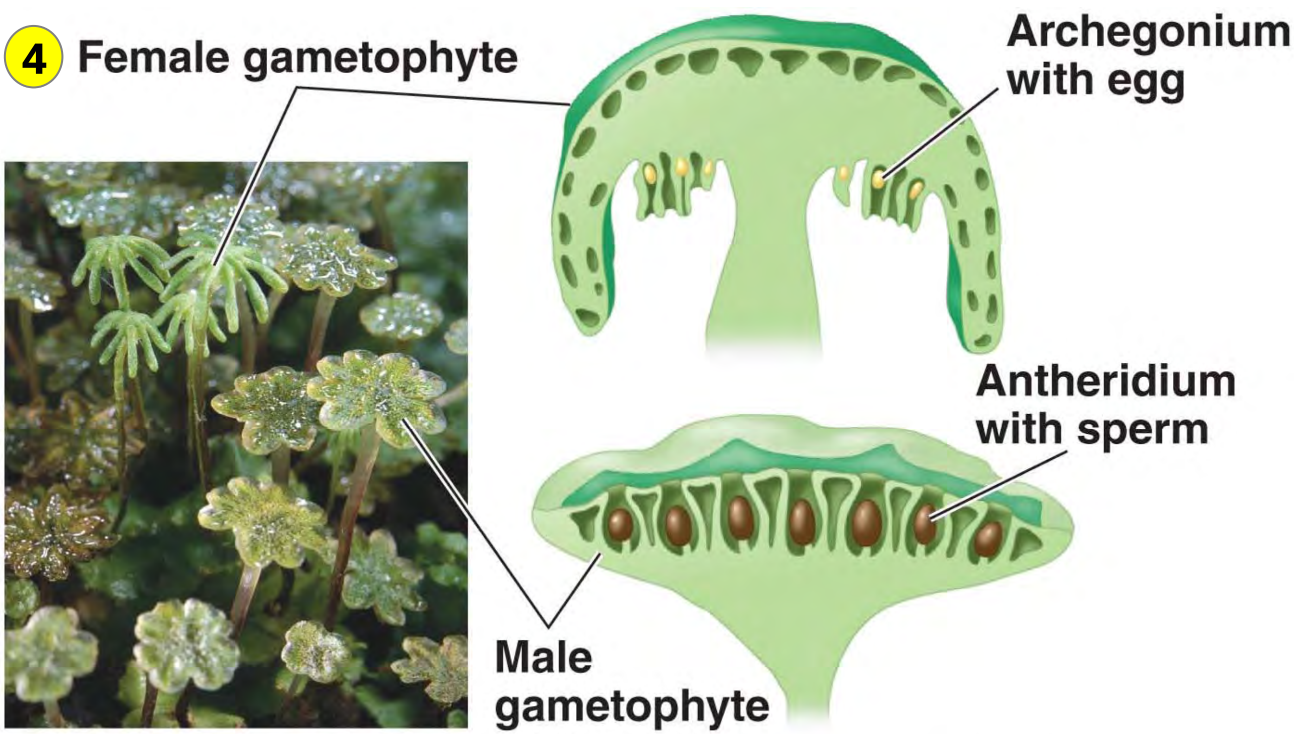
Derived Plant Traits

1 **Apical meristems**

2 **Alternation of generations**

3 **Walled spores in sporangia**

4 **Multicellular gametangia**



Archegonia and antheridia of *Marchantia* (a liverwort)

Fig. 29.5 (Campbell et al)

<u>Gametangium</u>

Organ in which gametes produced

♀= Archegonium

♂ = Antheridium

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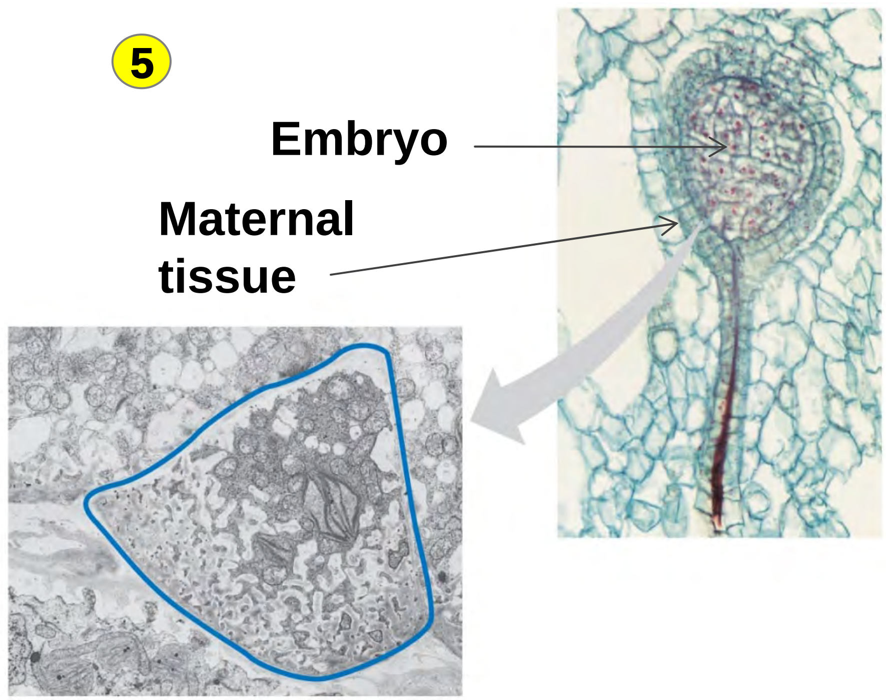
Derived Plant Traits

1. Apical meristems
2. Alternation of generations
3. Walled spores in sporangia
4. Multicellular gametangia
5. Multicellular dependant embryos

5



Placental transfer cells

Fig. 29.5 (Campbell et al)

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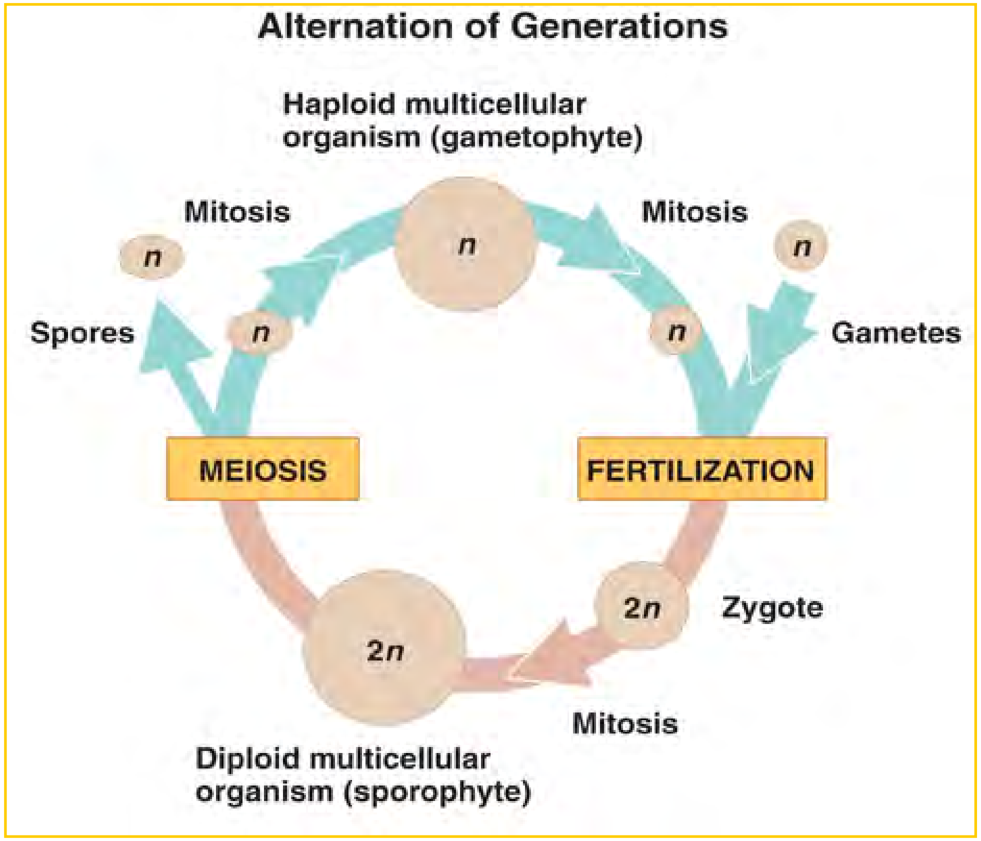
GAMETOPHYTE: multicellular haploid phase that produces gametes (haploid) by mitosis in GAMETANGIA (male = Antheridia female = archegonia)

SPORES: haploid reproductive cells formed in sporphyte by meiosis that develop into new organism (gametophyte phase) without fusing into another cell.



GAMETES: Haploid reproductive cells formed in gametophyte by mitosis that develop into new diploid organism (sporophyte phase) after fusing with another haploid gamete.

SPOROPHYTE: multicellular diploid stage that produces spores (haploid) by meiosis in SPORANGIA (Spore producing organ)

34

Spore vs Gamete

	Spore	Gamete
Ploidy?	Haploid	Haploid
Where formed?	Sporophyte in sporangium	Gametophyte in gametangium
How formed?	By meiosis (Since sporophyte is diploid)	By mitosis (Since gametophyte is haploid)
Develop into?	Gametophyte (w/o fusion)	Sporophyte after fusion w/ another gamete
Wall Covering?	Sporopollenin (in plants)	No wall

35

Non-vascular vs. Vascular Plants

Lack of vascular tissue limits size

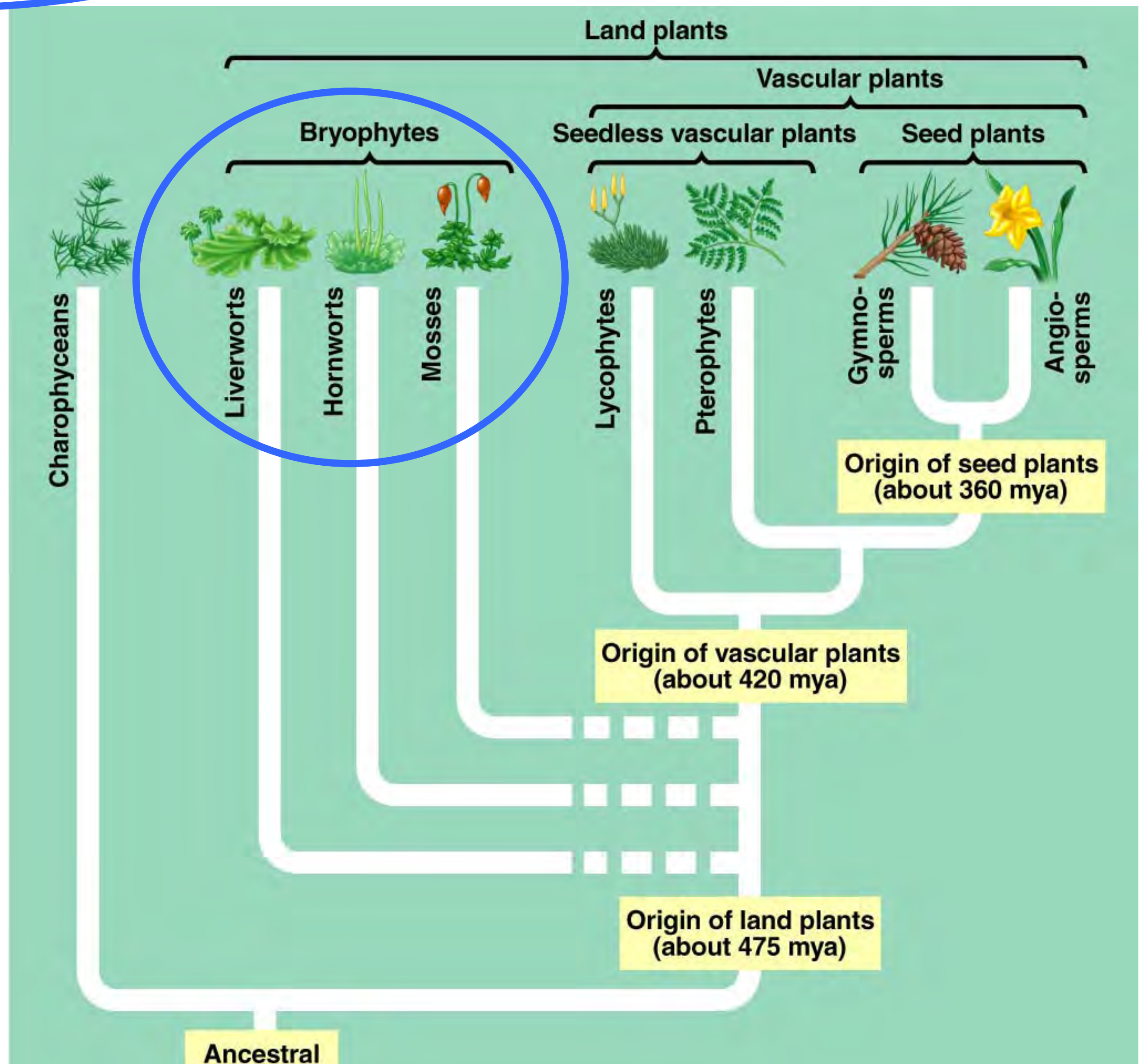


Figure 29.7 (Campbell et al) and Table 29.1

36

Bryophytes

~24,100 spp total

Liverworts

~9,000 spp

Hornworts

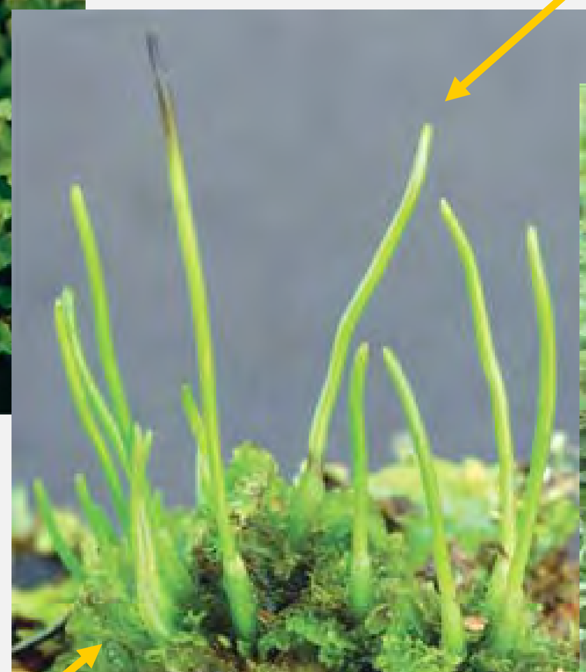
~100 spp

Mosses

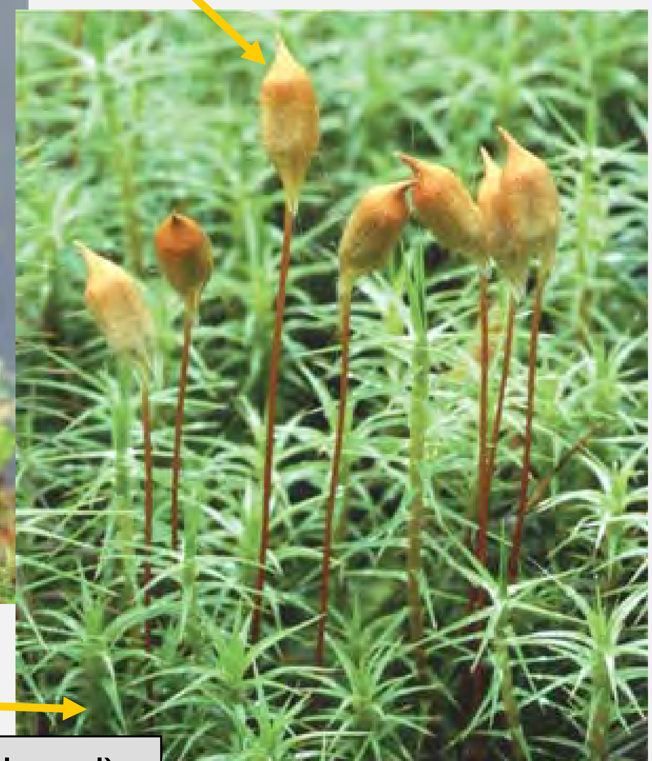
~15,000 spp

Sporophyte

Marchanctia



Anthoceros



Careful: <u>liver</u>wort is a bryophyte, <u>stone</u>wort is a green algae

Gametophyte

Figure 29.9 (Campbell et al)

Bryophyte Life Cycle

Gametophyte (n)
- ♀and ♂ separate plants
- <u>Dominant (longest lived) life stage</u> in bryophyte alt of gen life cycle

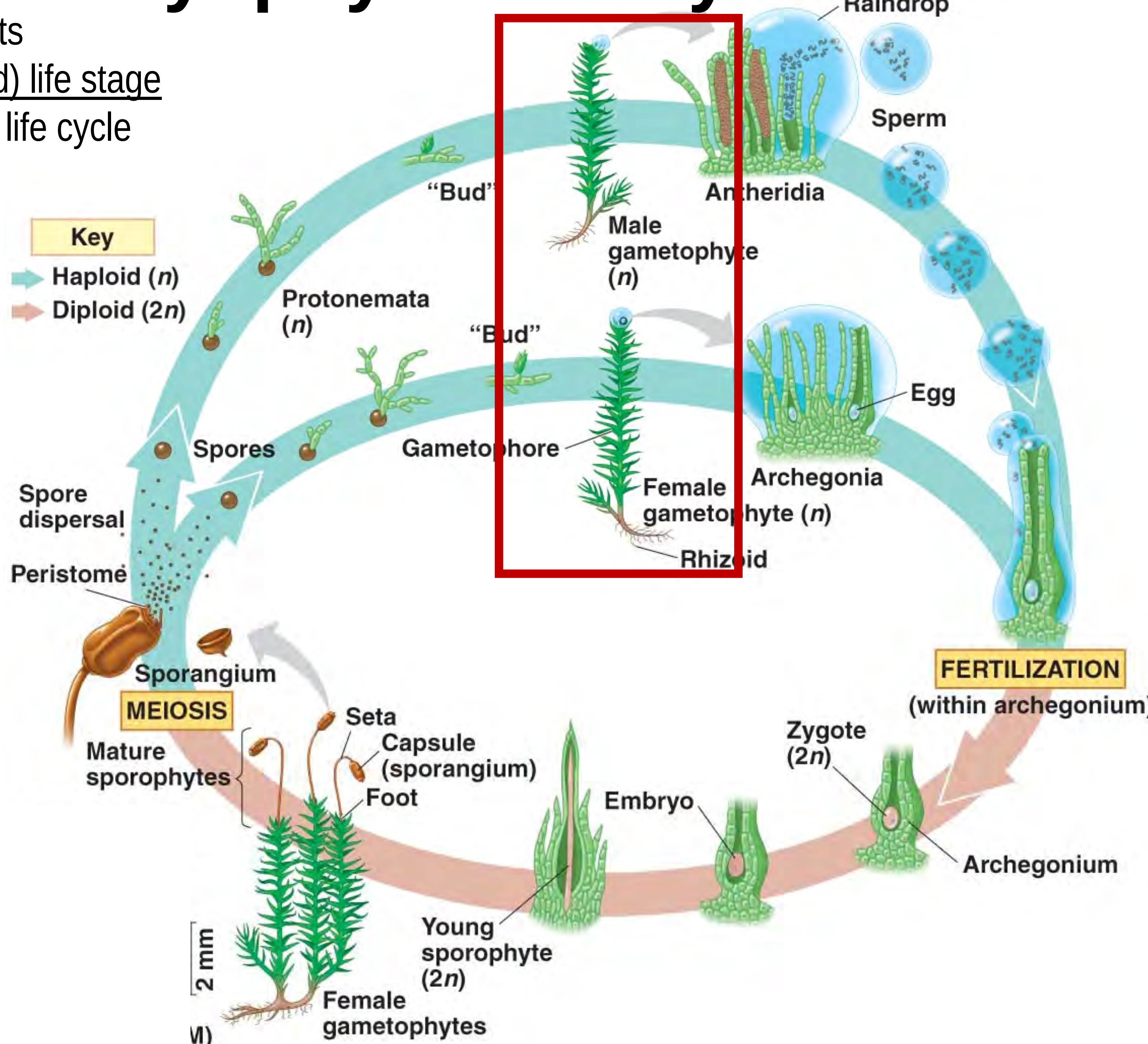


Figure 29.8 (Campbell et al)

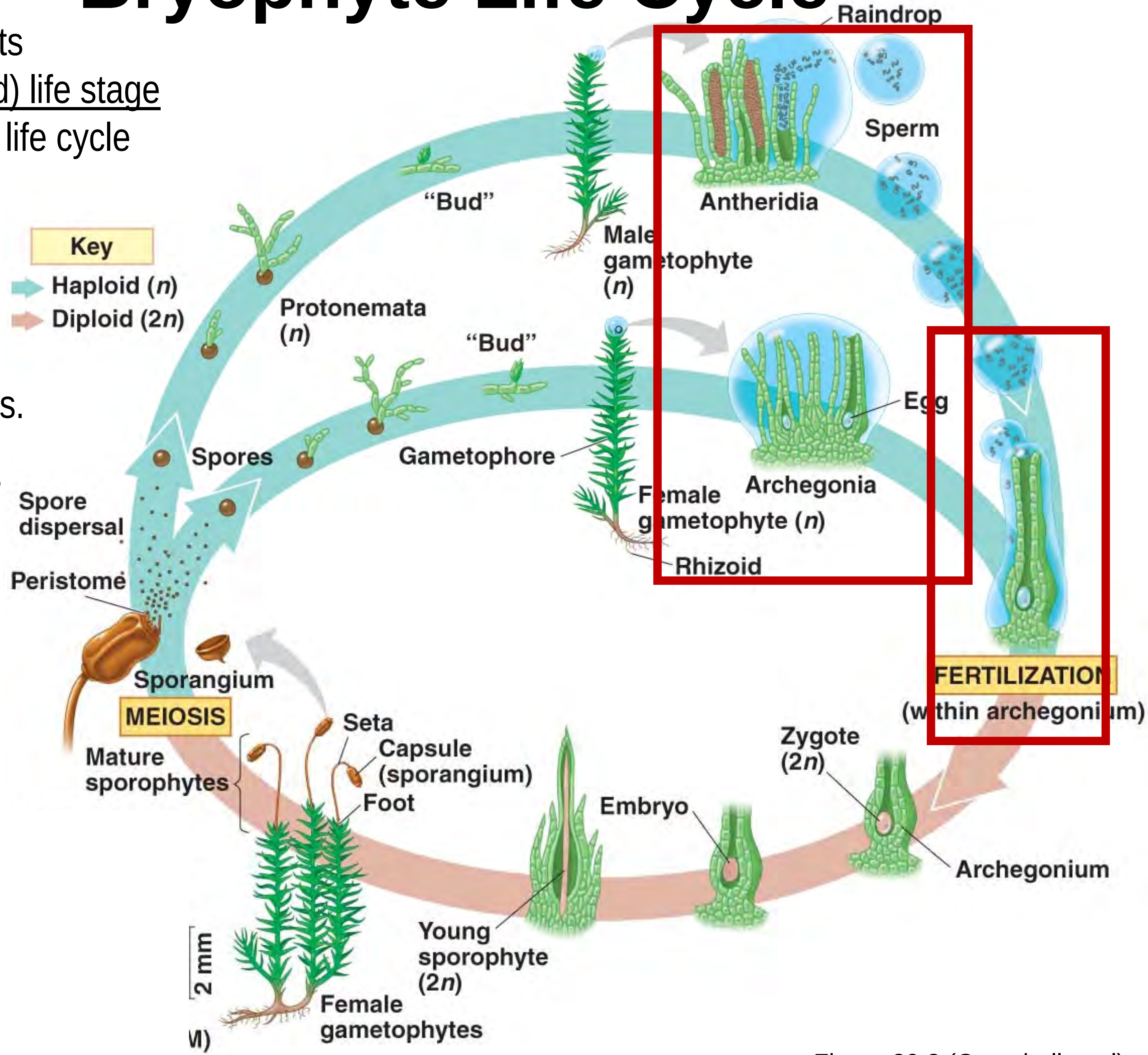
Bryophyte Life Cycle

Gametophyte (n)

- ♀and ♂ separate plants
- <u>Dominant (longest lived) life stage</u> in bryophyte alt of gen life cycle

Gametangia:
Sperm develop in antheridia and swim to egg in archegonia where fertilization occurs.

(Swimming sperm limits bryophytes to damp environments)



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Sporophyte (2n)
Grows from Archegonium (i.e. is attached) & is nutritionally dependent on it

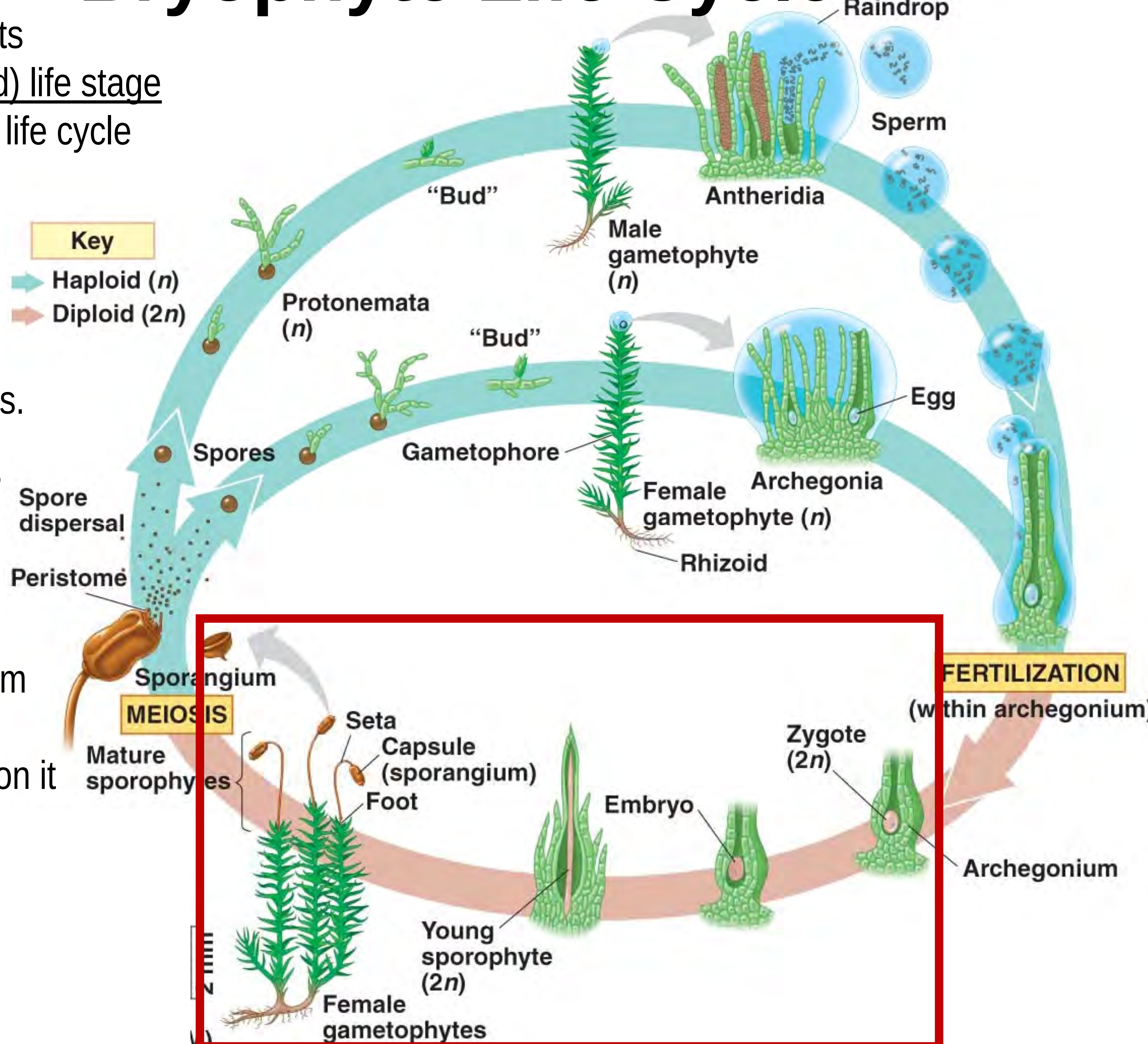

Figure 29.8 (Campbell et al)

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Sporophyte (2n)
Grows from Archegonium (i.e. is attached) & is nutritionally dependent on it

Sporangium
Develops on sporophyte (2n) and produces spores (n)

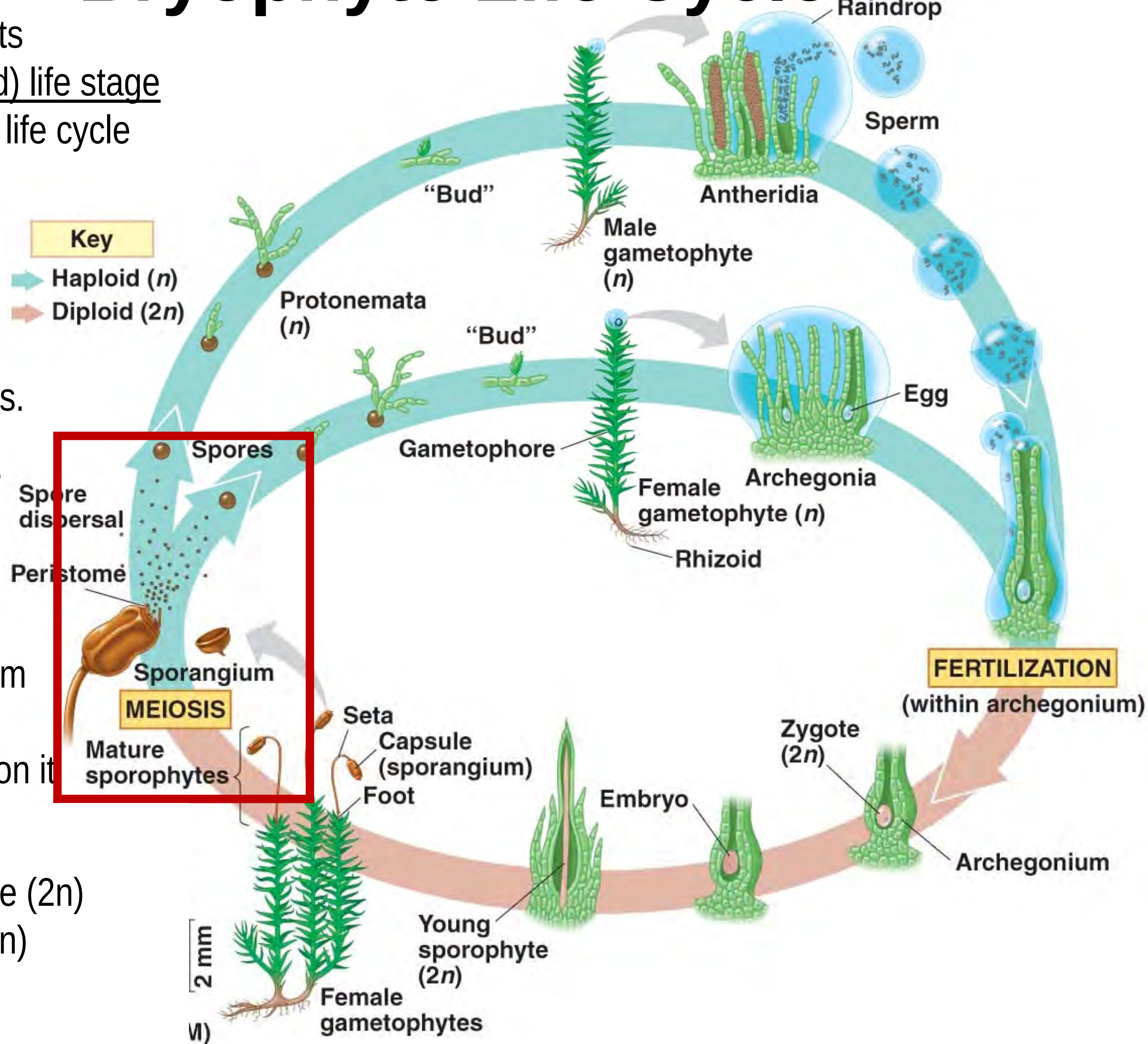

Figure 29.8 (Campbell et al)

Bryophyte Life Cycle

Gametophyte (n)
•♀and ♂ separate plants
•<u>Dominant (longest lived) life stage</u>
 in bryophyte alt of gen life cycle

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Sporophyte (2n)
Grows from Archegonium (i.e. is attached) & is nutritionally dependent on it

Sporangium
 Develops on sporophyte (2n)
 and produces spores (n)

Spore (n)
 Develops into gametophyte (n)

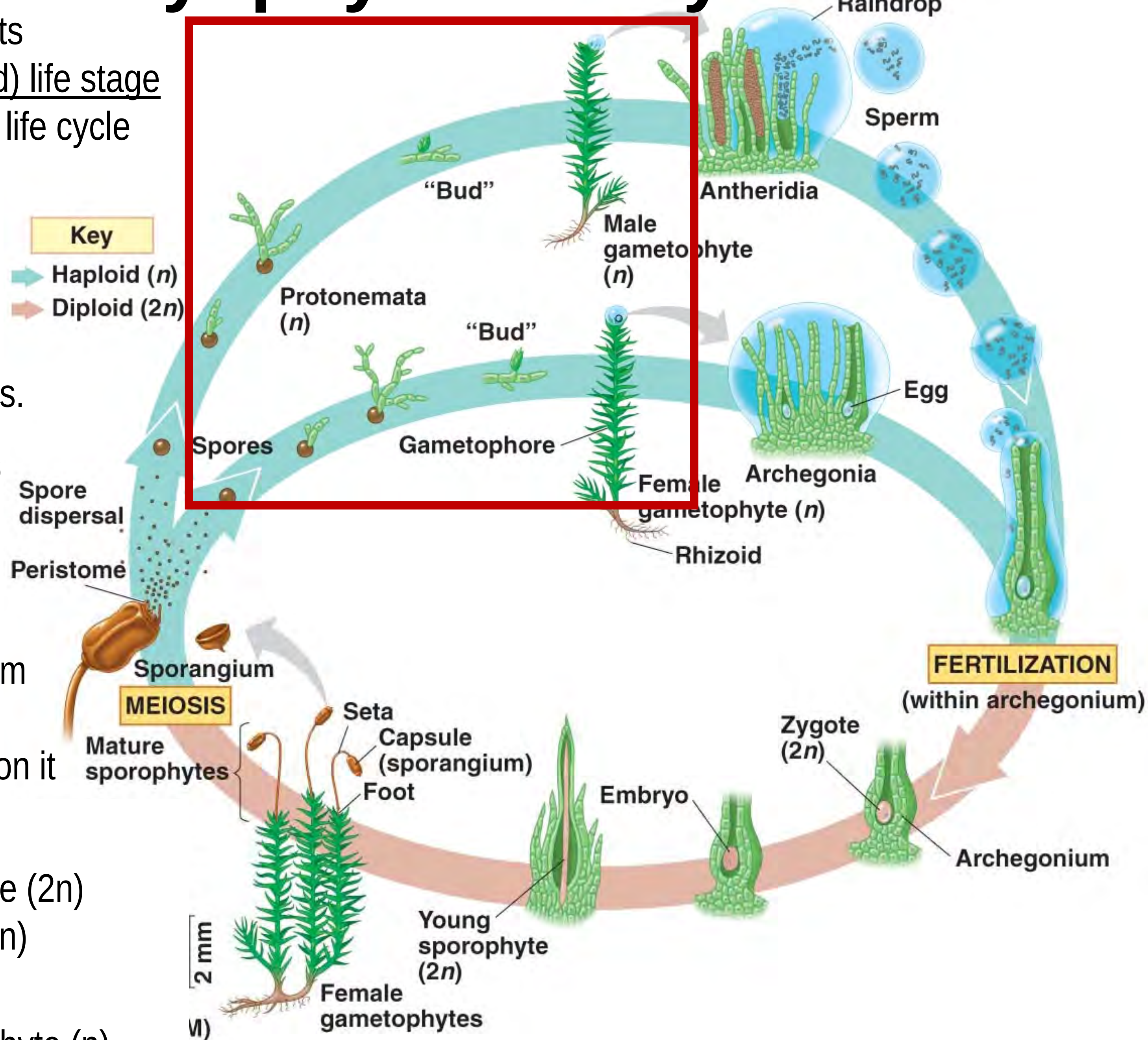

Figure 29.8 (Campbell et al)

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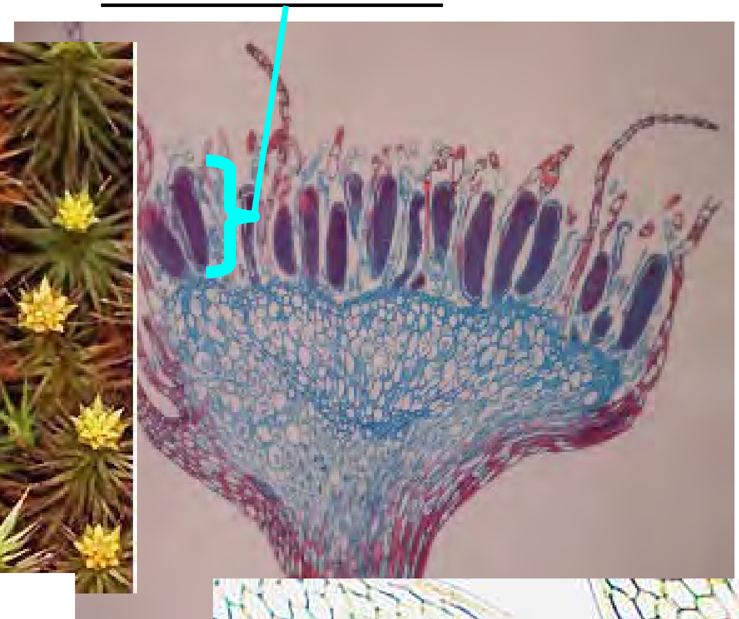
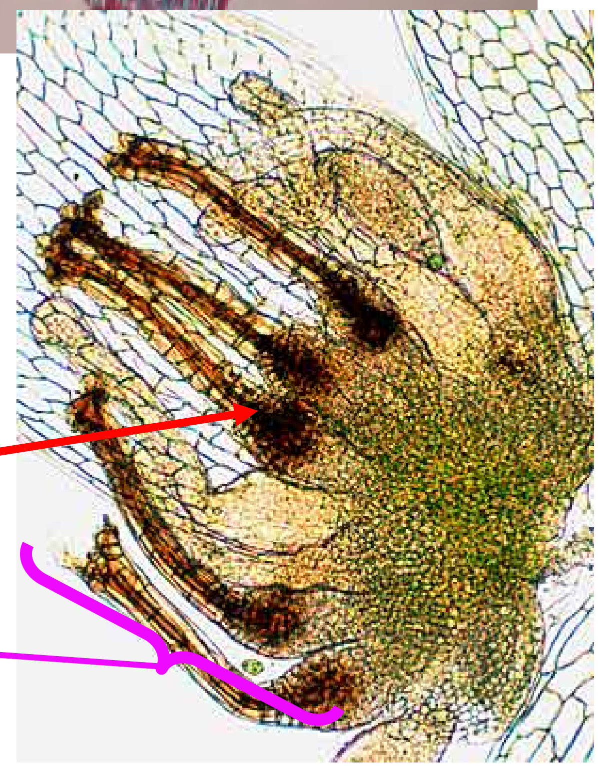
Bryophytes

Antheridium





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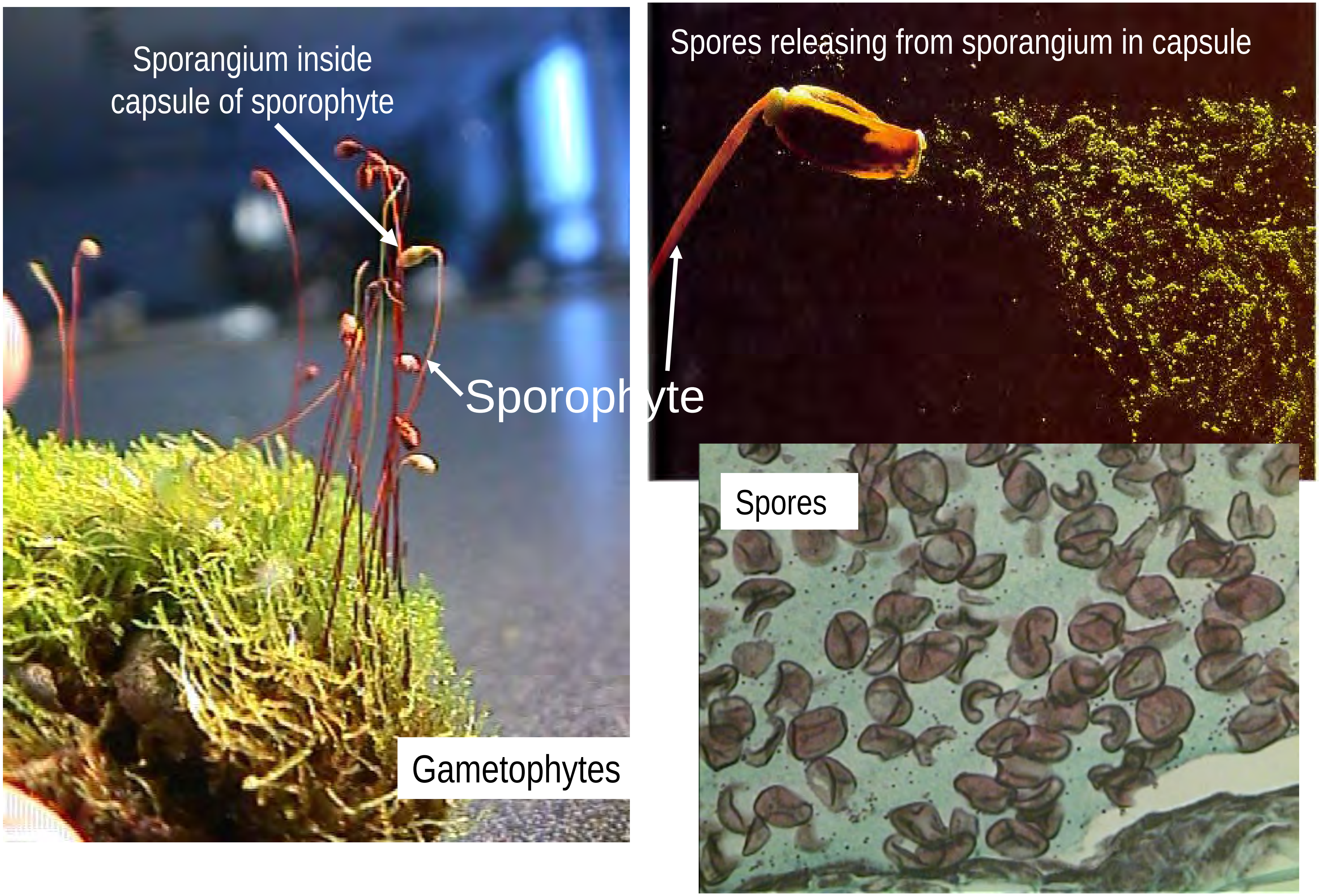
Bryophytes



45 *Sphagnum* spp "peat moss"

gametophyte

sporophyte

<u>Peat Bogs</u> = 3% of all land
~30% of world's stored soil carbon

Canada & Alaska (Muskeg)
Minnesota and Michigan

Ireland & Scotland
Poland, Germany, Holland
Scandinavia

Sphagnum peat bogs

1. Cold

2. Extremely acidic:
Phenolic compounds protect mosses from UV radiation

Therefore: little decomposition: BIOACCUMULATION

-**FEW NUTRIENTS AVAILABLE:**

Many carnivorous plants
Many rare endemics

47

Irish Peat Bogs: Historically Ireland was 15% peat bog:

Figure 29.11a (Campbell et al)

48

Bog Men

(b) "Tollund Man," a bog mummy

405-100 BC

Figure 29.11b (Campbell et al)

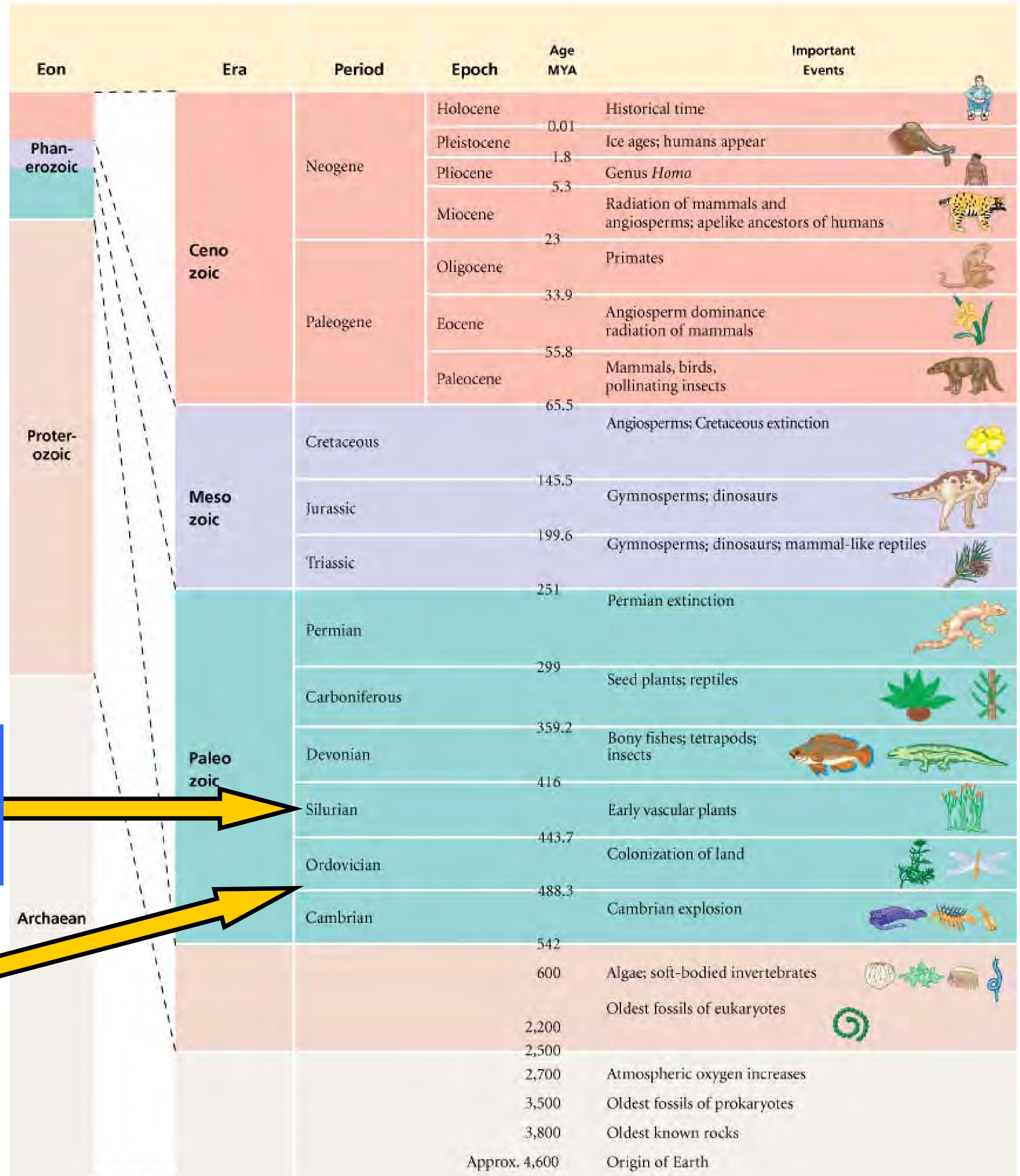
49

History of Plants

Non-vascular plants dominated for 100my

Vascular plants (Silurian)

Non-vascular land plants (Ordovician)



Eon	Era	Period	Epoch	Age MYA	Important Events
Phanerozoic	Cenozoic	Neogene	Holocene	0.01	Historical time
			Pleistocene	1.8	Ice ages; humans appear
			Pliocene	5.3	Genus *Homo*
			Miocene	23	Radiation of mammals and angiosperms; apelike ancestors of humans
		Paleogene	Oligocene	33.9	Primates
			Eocene	55.8	Angiosperm dominance radiation of mammals
			Paleocene	65.5	Mammals, birds, pollinating insects
	Mesozoic	Cretaceous		145.5	Angiosperms; Cretaceous extinction
		Jurassic		199.6	Gymnosperms; dinosaurs
		Triassic		251	Gymnosperms; dinosaurs; mammal-like reptiles
	Paleozoic	Permian		299	Permian extinction
		Carboniferous		359.2	Seed plants; reptiles
		Devonian		416	Bony fishes; tetrapods; insects
		Silurian		443.7	Early vascular plants
		Ordovician		488.3	Colonization of land
		Cambrian		542	Cambrian explosion
Proterozoic				600	Algae; soft-bodied invertebrates
				2,200	Oldest fossils of eukaryotes
				2,500	
Archaean				2,700	Atmospheric oxygen increases
				3,500	Oldest fossils of prokaryotes
				3,800	Oldest known rocks
				Approx. 4,600	Origin of Earth

50 What Are Vascular Plants?

Vascular tissue

Cells form tubes to transport H_20 & nutrients

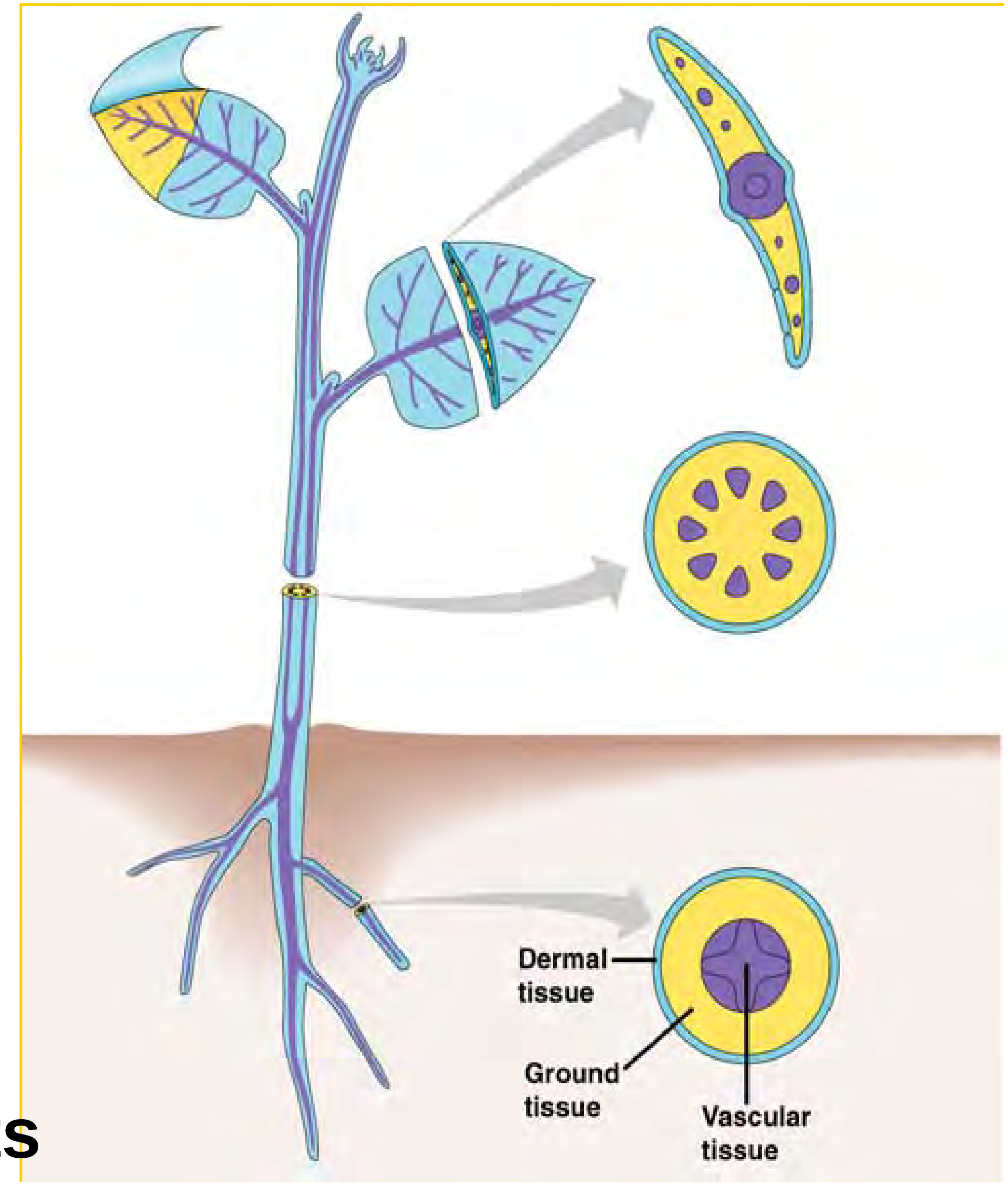
Xylem

- Transport of H_20 and minerals
- Dead tubular cells with lignin in walls (contribute to support)

Phloem

- Transport of sugars, amino acids, & other organic products:
- Living tubular cells

Alleviate size constraints

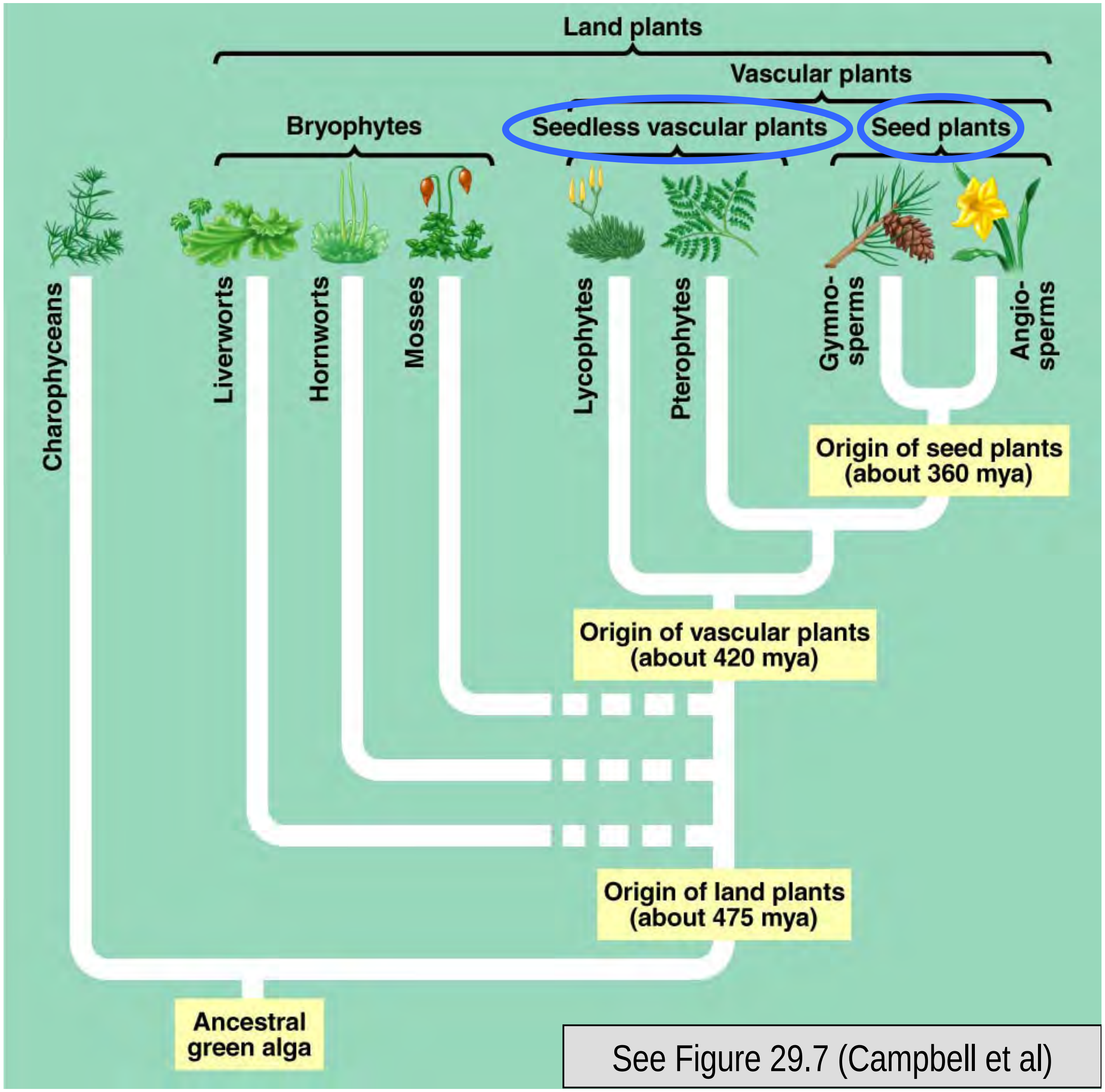


Vascular Plants

Some are seedless

Others have seeds

No non-vascular plants have seed



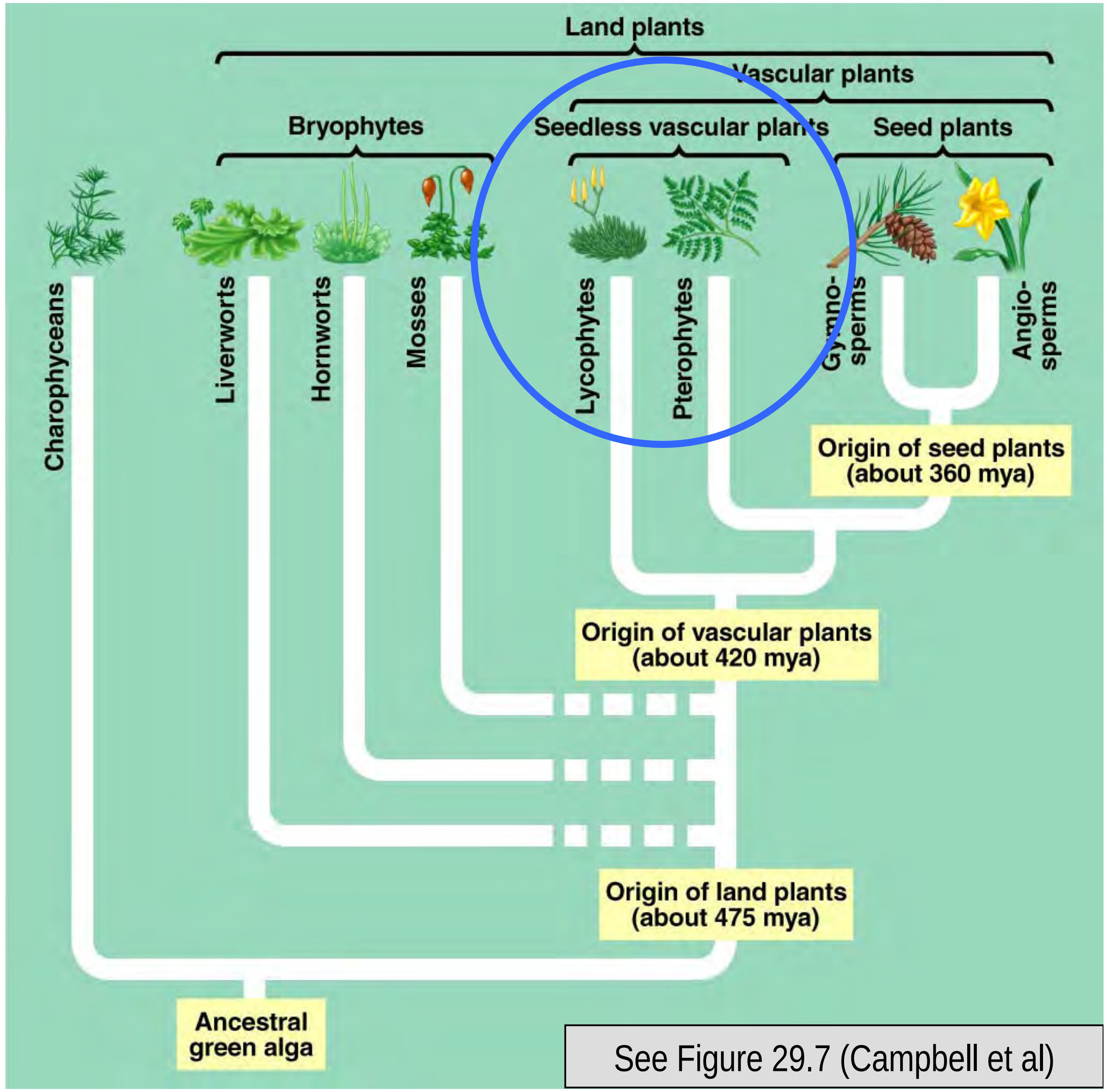
See Figure 29.7 (Campbell et al)

52

Seedless Vascular Plants

Have flagellated sperm which swim to eggs through a film of water (like in Bryophytes).

STILL HEAVY RELIANCE ON WATER



See Figure 29.7 (Campbell et al)

53 2 clades of Seedless Vascular Plants

Seedless **~13,000 spp**

Lycophytes **~1,200 spp**

~12,000 spp Pterophytes

Seedless Vascular Plants

Seedless

Lycophytes

Club mosses

Spike mosses

Quillworts

Careful: club and spike mosses (lycophytes) are not really mosses (a bryophyte)

55

Seedless Vascular Plants

Seedless

Pterophytes

Ferns | Horsetails | Wiskferns

57 Vascular Plant Adaptations

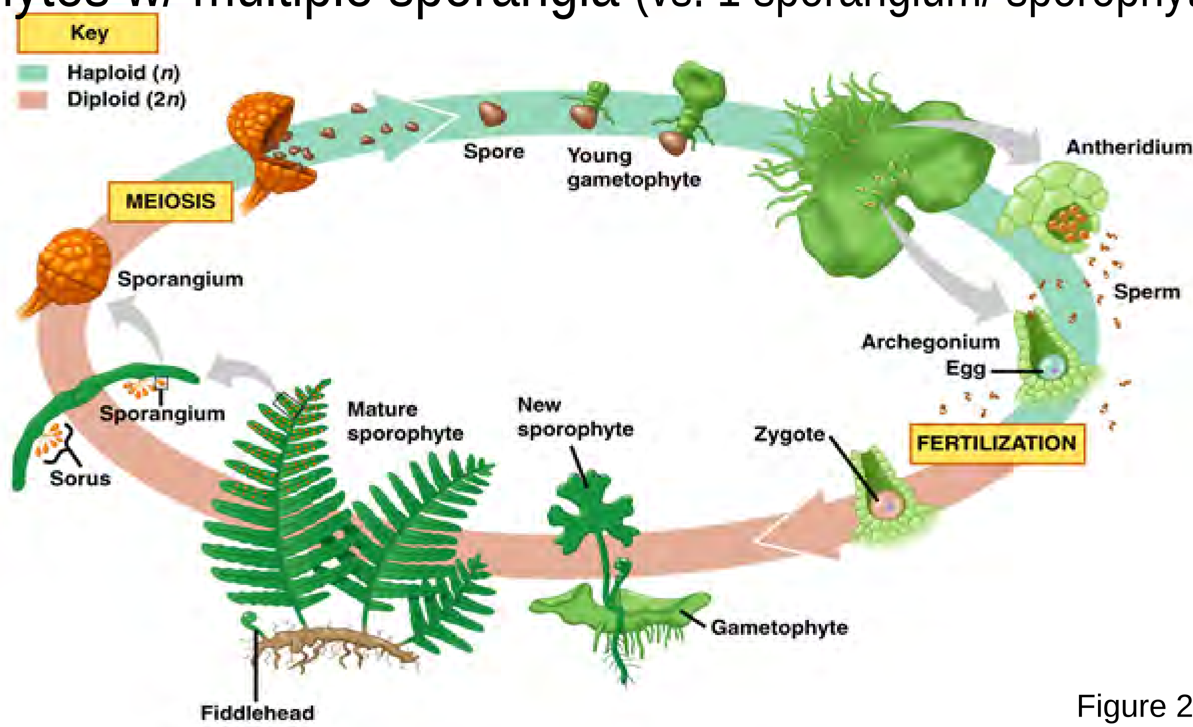
1. Sporophyte dominant

In contrast to Bryophytes:

•Sporophyte most visible and dominant (i.e. longest lived) part of lifecycle

•Sporophyte: NOT DEPENDENT UPON Gametophyte

•TALL sporophytes w/ multiple sporangia (vs. 1 sporangium/ sporophyte in bryophytes)



Reduced Gametophyte

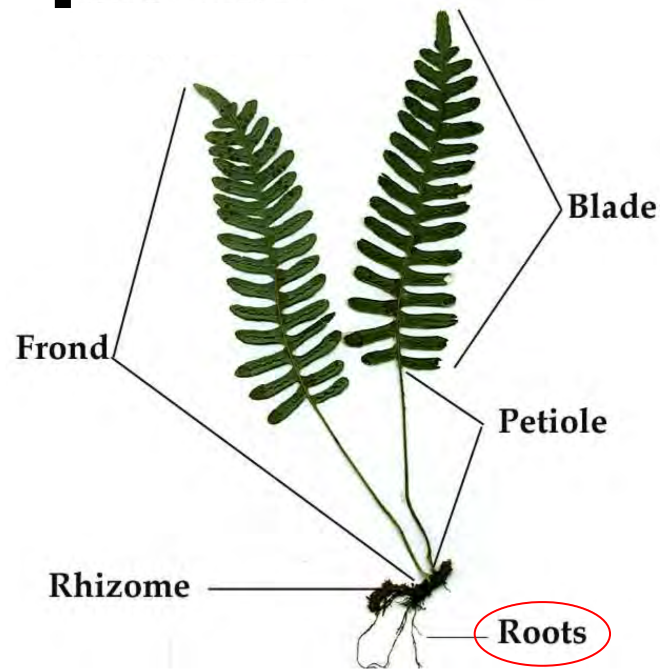
Figure 29.13 (Campbell et al)

58 Vascular Plant Adaptations

FOUND IN ALL 4 OF THE MAJOR VASCULAR PLANT CLADES

2. Roots

- Anchor plants
- Absorb water and nutrients
- Provide support for vertical growth



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Vascular Plant Adaptations

3. Leaves

Lycophytes have MICROphylls: small spineshaped leaves w/ a single strand of vascular tissue

Pterophytes + all seed plants have MEGAphylls: larger leaves w/ complex branching vascular tissue

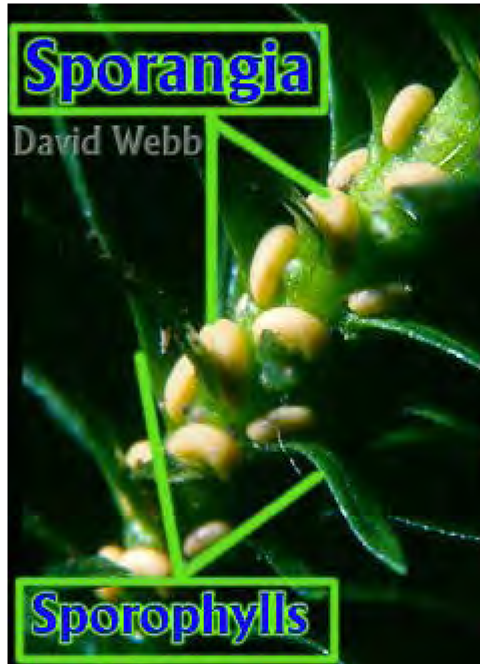
Figure 29.14 (Campbell et al)

60

Vascular Plant Adaptations

In Lycophyta topside of sporophyll in strobili (cones) has sporangia that produce spores

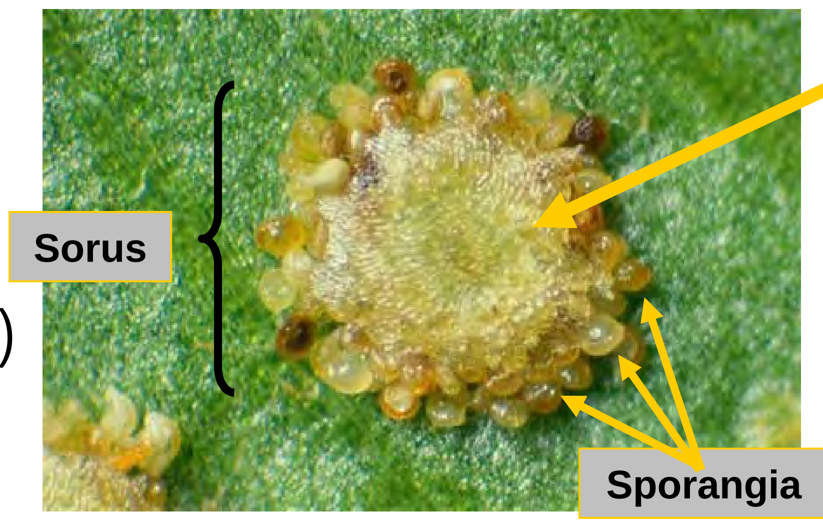
Lycopodium **with Strobili (Cones)**



4. Sporophylls

Modified leaves that bear sporangia

In Pterophyta *underside* of sporophyll has groups of sporangia (*sori*) that produce spores



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Fern sporophytes

Fiddlehead
(young leaf)

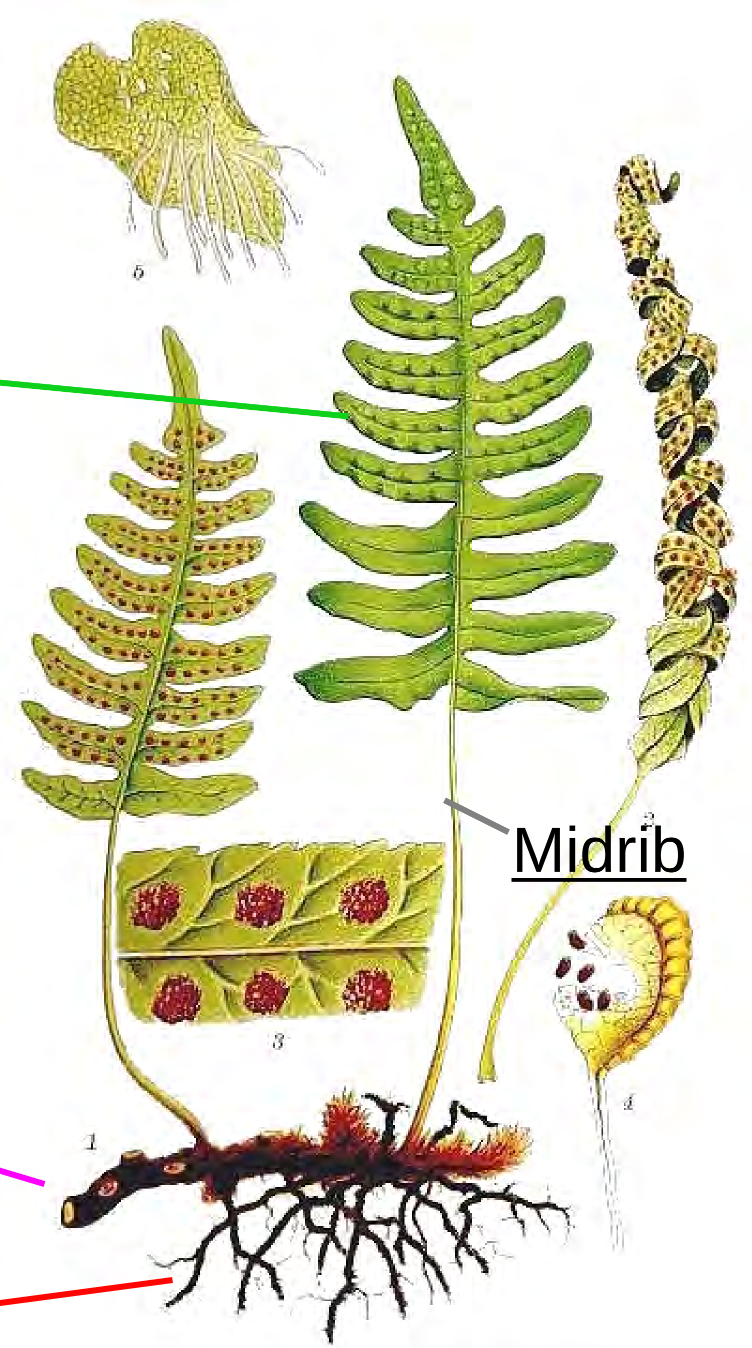
Leaflet
(pinna)

Leaf
(frond)

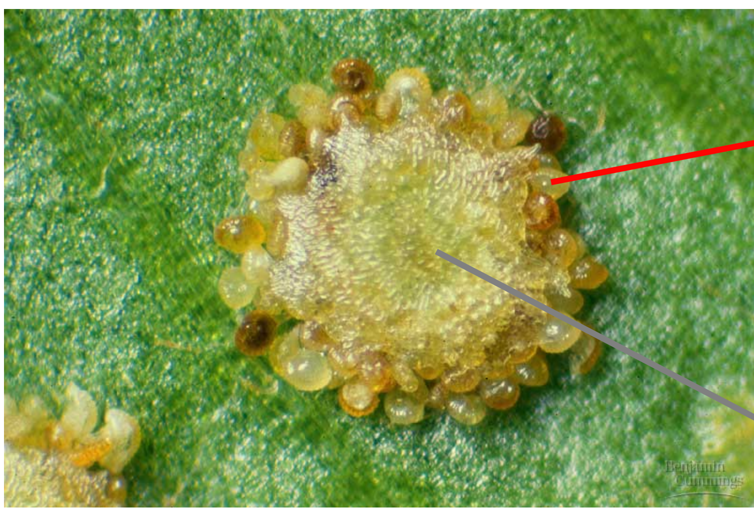
Rhizome
(horizontal stem)

Roots

Midrib



STENSÖTA, POLYPODIUM VULGARE L.



Frond (sporophyll)

Sporangia

Spore producing organ

Sorus

Group of sporangia

Indusium – covers most sori

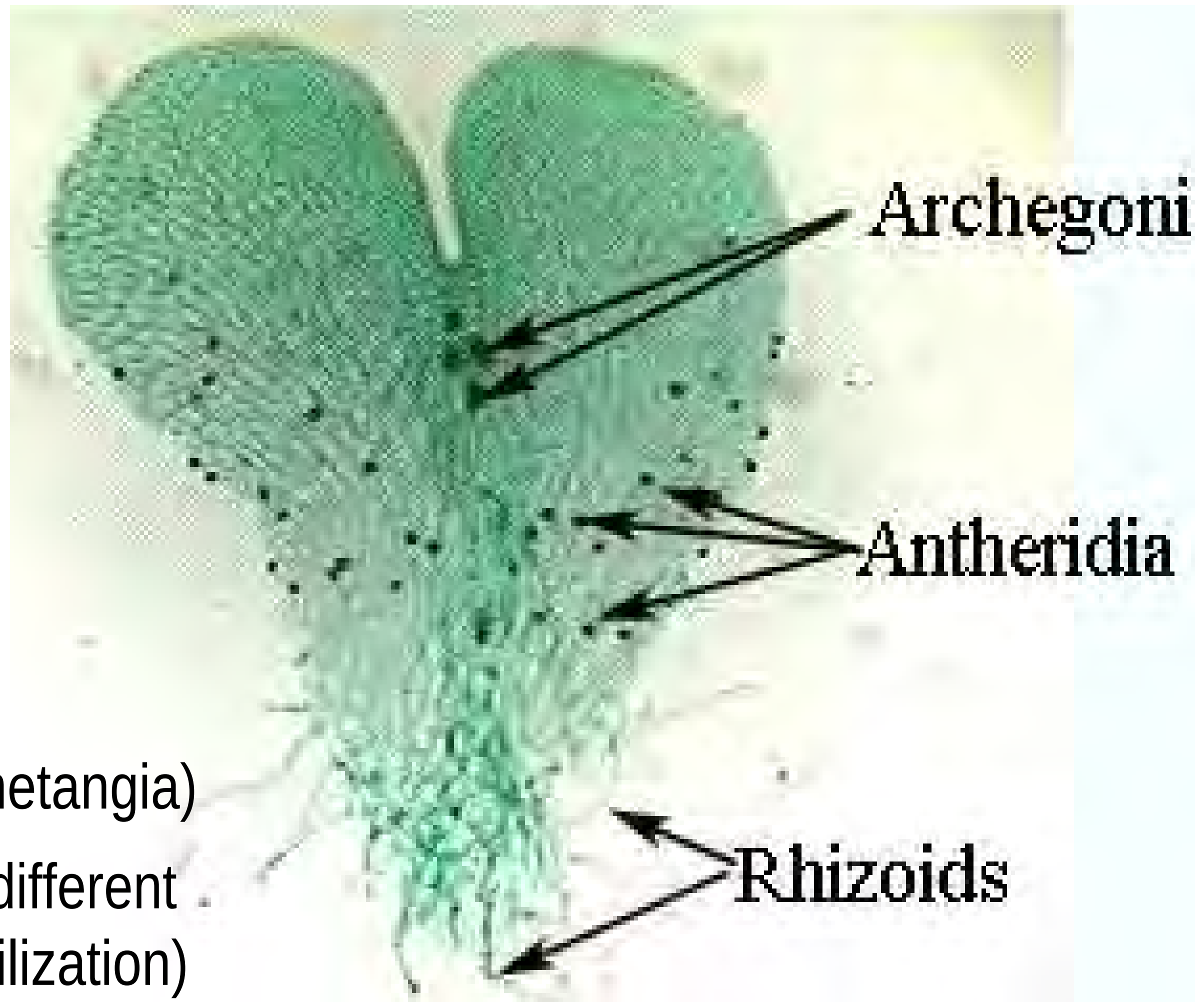
Fern gametophytes

- Very small

- Short lived
  - Sporophyte grows from gametophyte which then dies (i.e. is nutritionally independent)

- Most species have bisexual gametophyte (i.e. has both ♂ and ♀ gametangia)

  (egg & sperm produced at different times to prevent self-fertilization)



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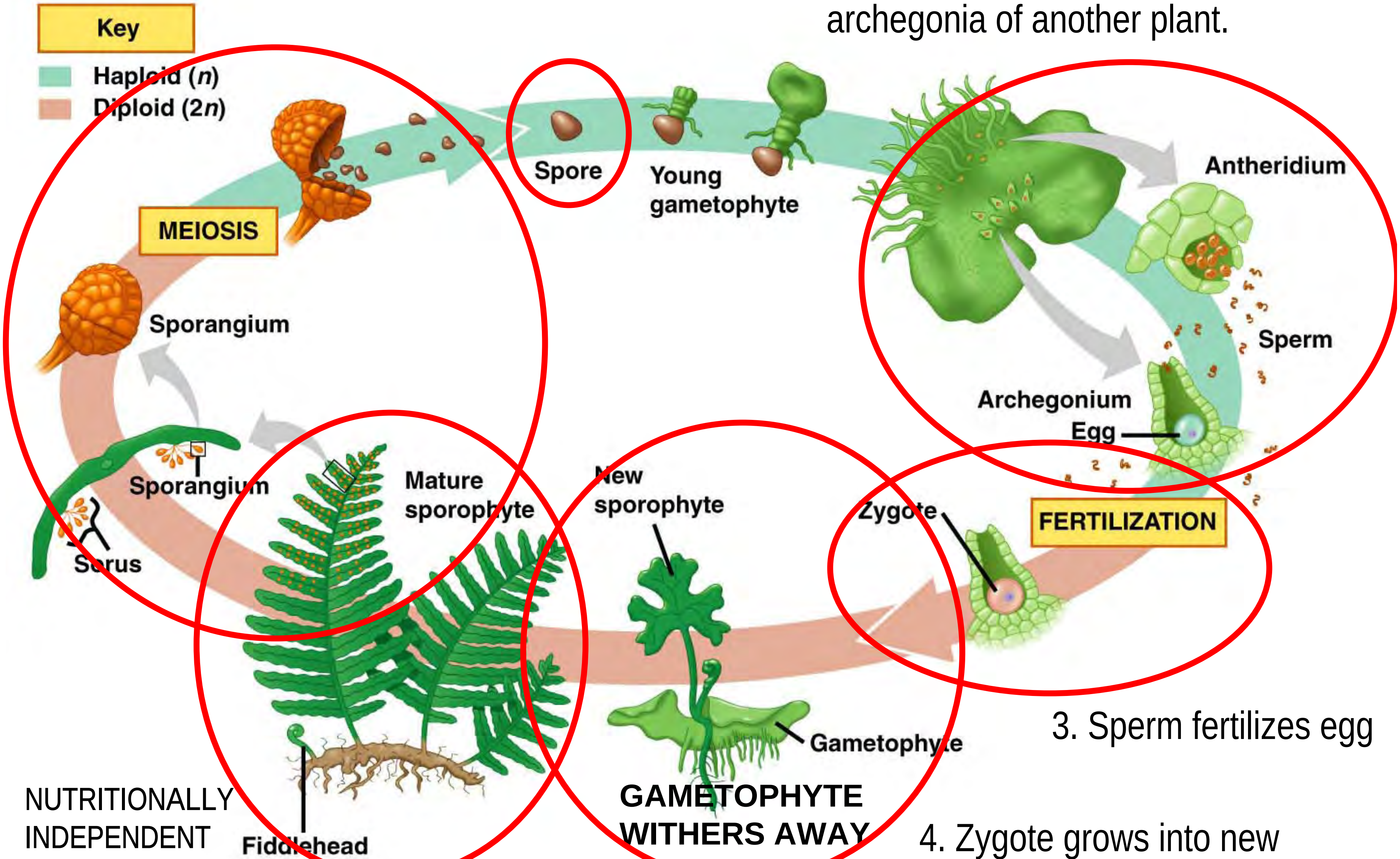
1. Sporangia releases spores which grow into gametophyte

2. Gametophytes develop gametangia. Sperm swims from antheridia to archegonia of another plant.



3. Sperm fertilizes egg

4. Zygote grows into new sporphyte and grows out of gametophyte archegonium

5. Sporophyte grows into mature adult and produces spores in sporangia

Homosporous vs Heterosporous

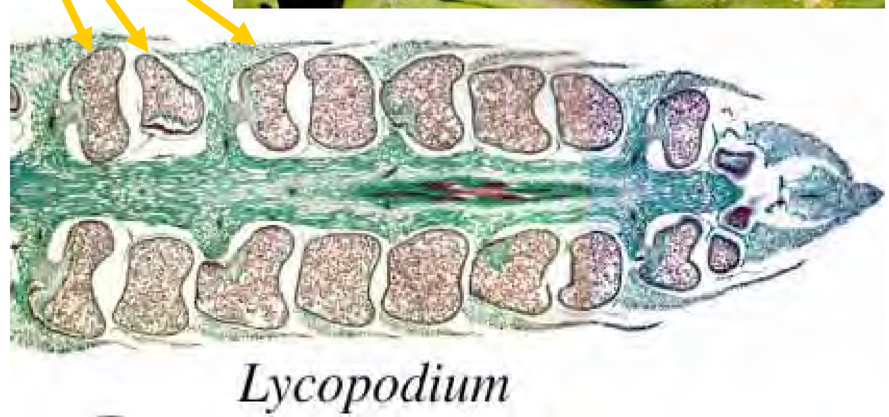
Homosporous

Sporophyte → Single type of spore → Typically a bisexual gametophyte → Eggs / Sperm

See Table on page 613 (Campbell et al)

Most seedless vascular plants are:

Sporangia



HOMOsporous

- Have 1 type of sporangium
  - that produces 1 type of spore
  - that grows into a bisexual gametophyte
  - that produces both sperm and eggs (in antheridia and archegonia)

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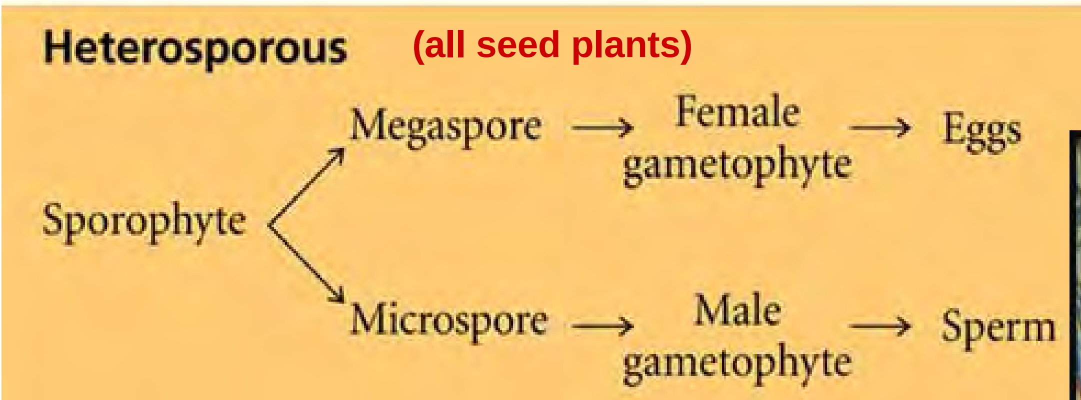
Homosporous vs Heterosporous



See Table on page 613 (Campbell et al)

Megasporangium Microsporangium

All seed plants and
a few seedless vascular plants are:

HETEROsporous

- Have 2 types of sporangia
  - each type produces 1 different type of spore
  - Spores grow into unisexual gametophytes
  - Megasporangium →Megaspore → ♀gametophyte → egg
  - Microsporangium → Microspore → ♂ gametophyte → sperm

Female cones w/ megaspores

Male cones w/ microspores

73 Readings on which you will NOT be tested

Figure 28.22

Figure 29.10 (Inquiry)

Figure 29.14

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 30 – Plant Diversity II: Seed Plants