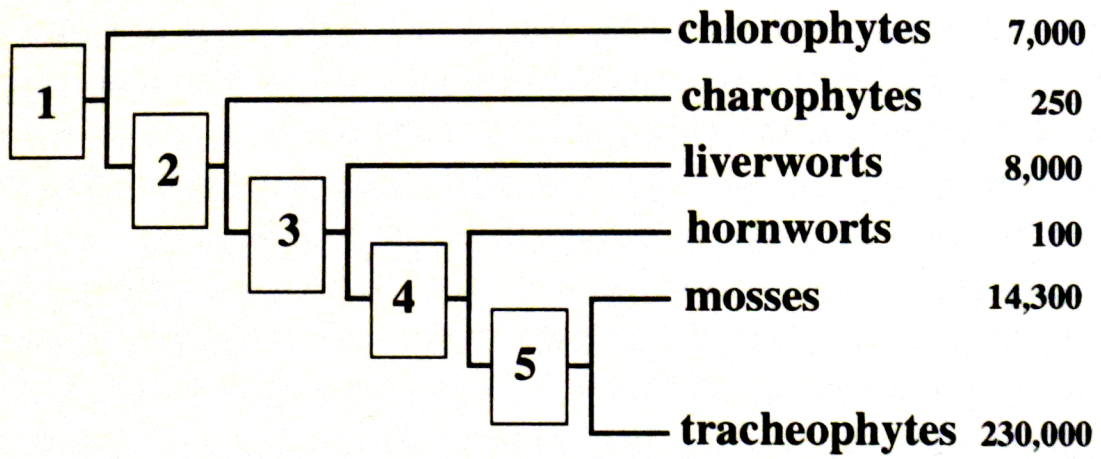


Figure 4.4. Phyletic hypothesis purporting to show the evolutionary relationships among green algae, bryophytes (liverworts, hornworts, and mosses), and tracheophytes (pteridophytes, gymnosperms, and angiosperms). The approximate number of extant species in each group is shown on the right. Some of the characters used to construct the phyletic hypothesis are as follows: 1 = chlorophylls *a* and *b*, carotenoids, starch; 2 = phragmoplastic cell division, glycolate oxidase; 3 = archegonium and antheridium; 4 = indeterminant growth of sporophyte; 5 = water and cell sap conducting tissue system. Adapted from Mishler and Churchill 1984, 1985.

Karl Niklas (1997) The Evolutionary Biology of Plants

CRITERIA USED TO CONSTRUCT THE EVOLUTIONARY "TREE"

[1] chlorophylls a and b, carotenoids, starch

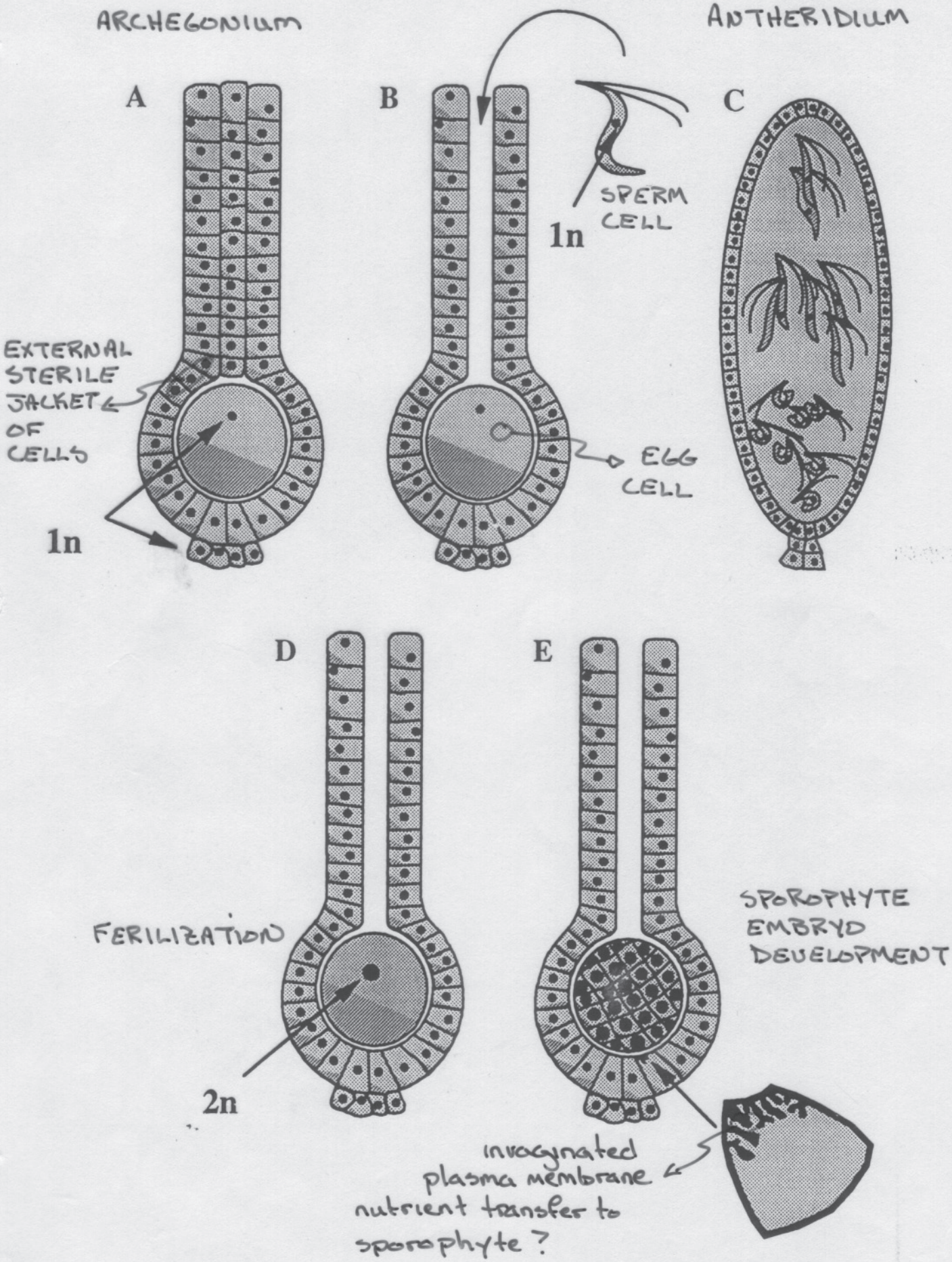
[2] • phragmoplastic cell division
• glycolate oxidase (photorespiration)

[3] archegonium and antheridium

[4] indeterminant growth of sporophyte

[5] water and cell sap conducting tissue system
(vascular tissue: xylem and phloem)

GAMETOPHYTE



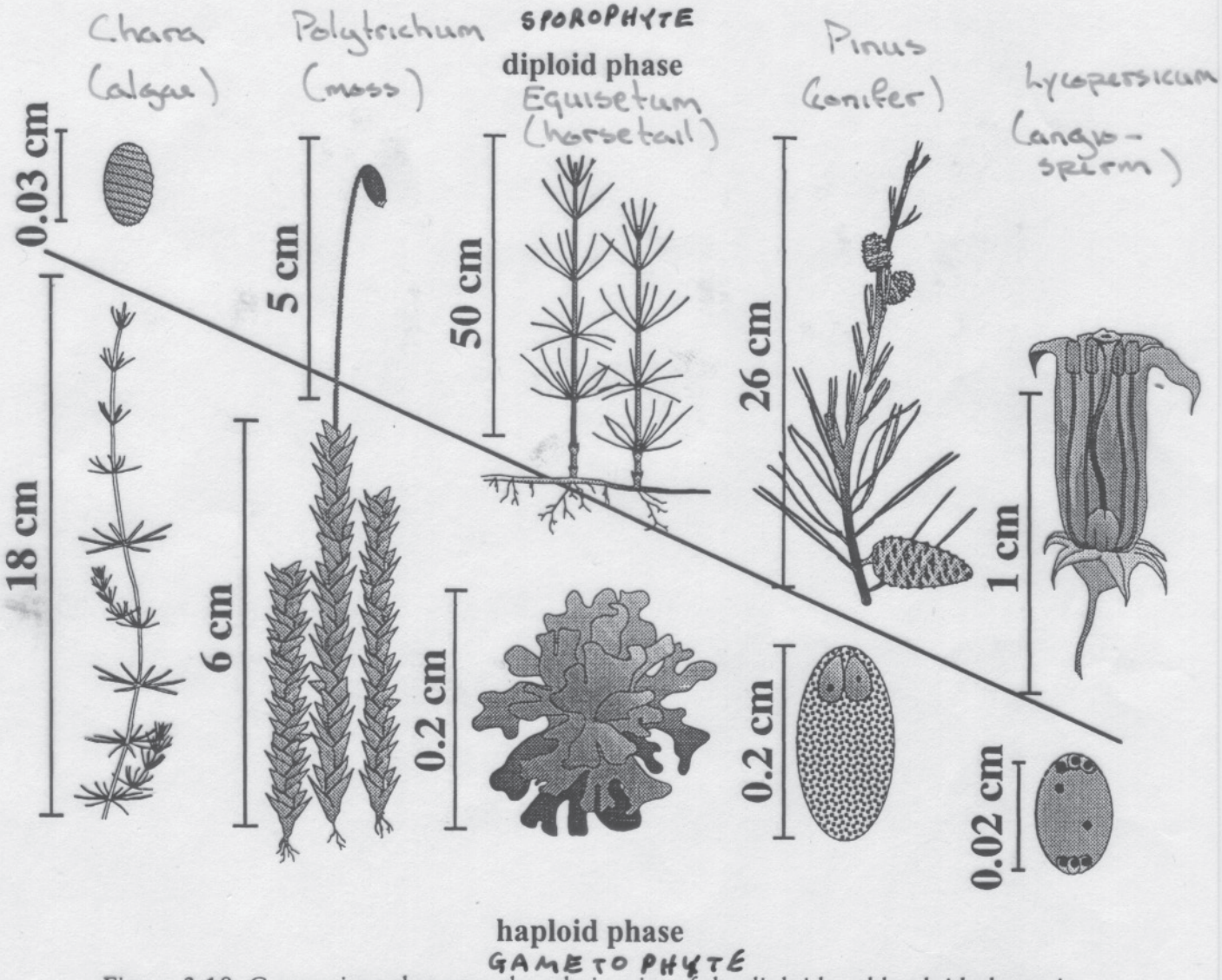


Figure 3.18. Comparisons between the relative size of the diploid and haploid phases in the life cycles of representative plants from progressively more recent lineages (from left to right). The diploid phase in each life cycle is shown above its corresponding haploid phase. The reduction in the size of the haploid phase relative to the size of the complementary diploid phase broadly corresponds to a reduction in the duration of the phase in the life cycle. From left to right: *Chara,* a green alga; *Polytrichum,* a moss; *Equisetum,* a horsetail; *Pinus,* a gymnosperm; *Lycopersicum,* a flowering plant.

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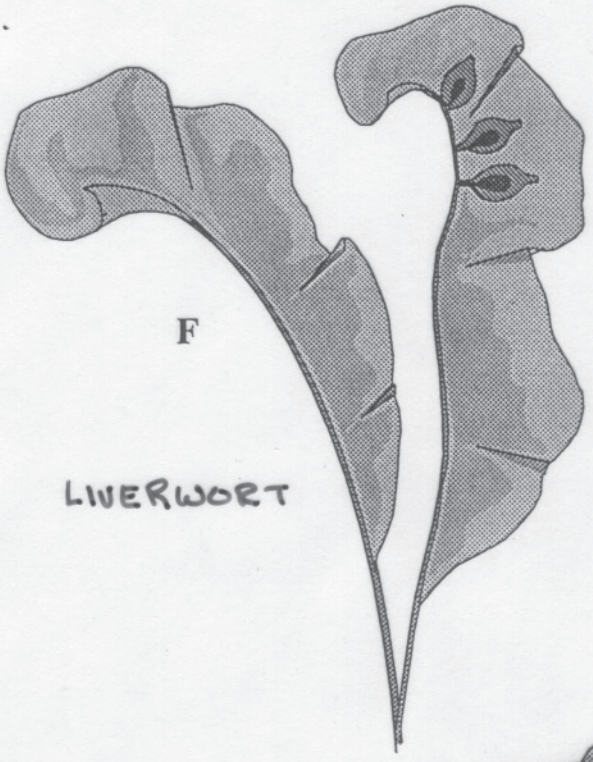
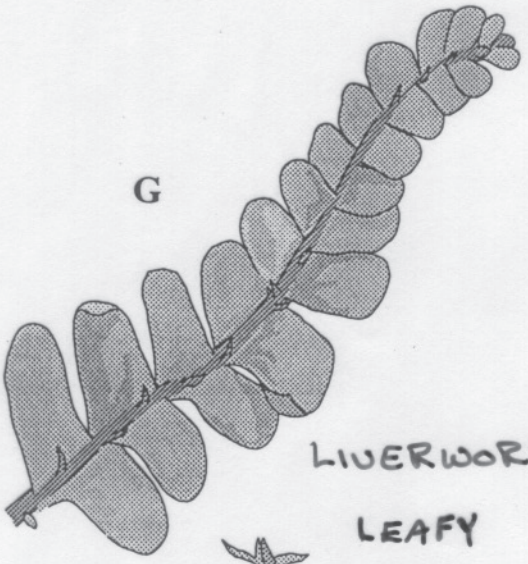
GO Green



F

LIVERWORT

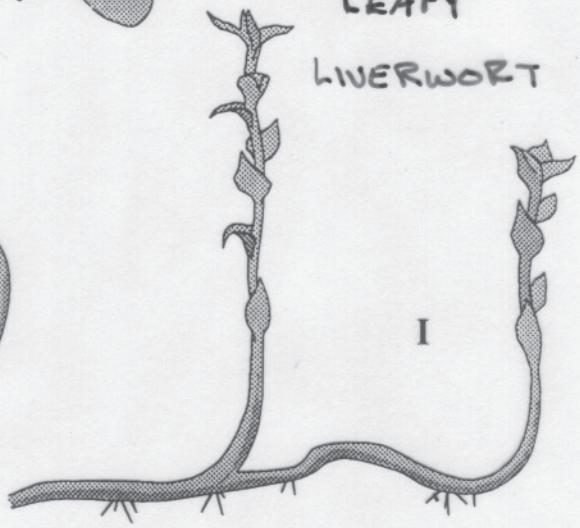


G

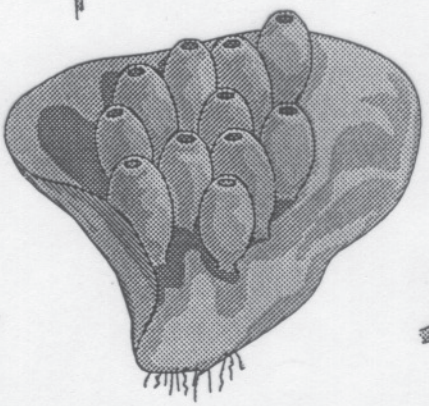
LIVERWORT

LEAFY

LIVERWORT



I



H

LIVERWORT

(THALLUS)

HORNWORT

J

K

MOSS

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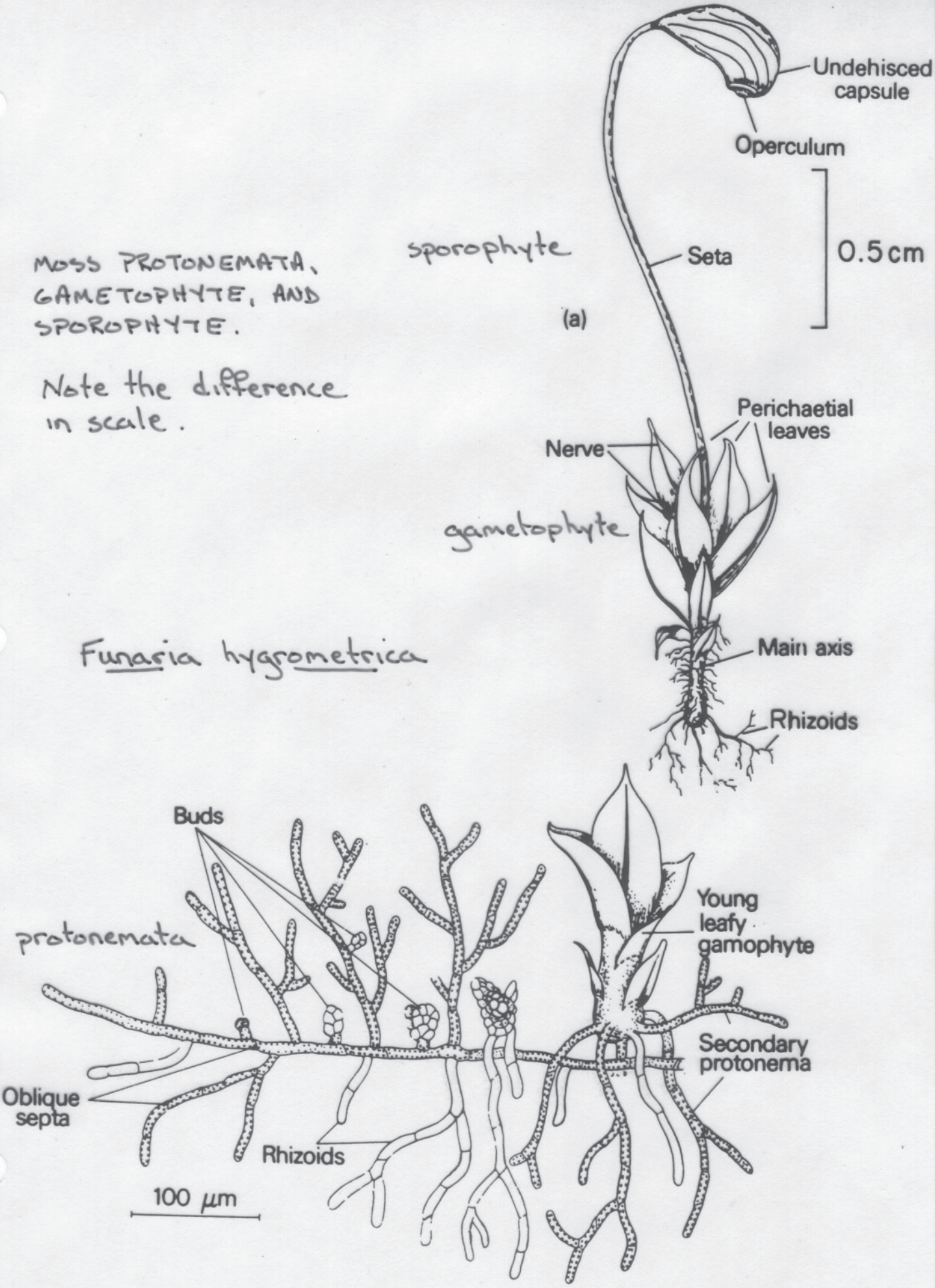
MOSS PROTONEMATA, GAMETOPHYTE, AND SPOROPHYTE.

Note the difference in scale.



Funaria hygrometrica

He was strangled with a rope, his throat was slit, he was drowned in a bog lake. Then, *Sphagnum* spp. preserved him in a crucible of acidity, tannins and anti-microbials for two thousand years. His body, his face, his fingerprints remain. His name is lost.

Learn about the mosses

GOreen

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The Plant's Reply to Vegetarians

Photo by Noah Elhardt

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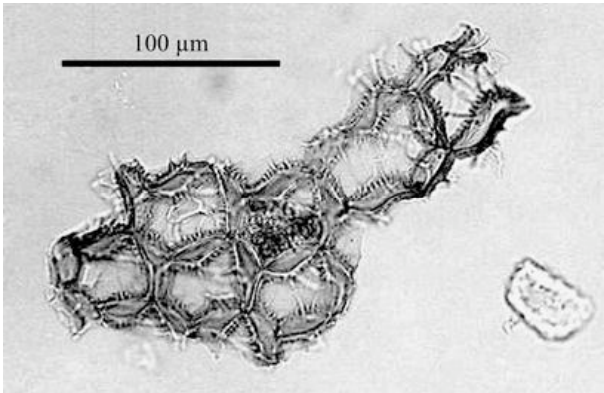
BOG MOSSES AND ETHNOBOTANY

The 5,200 year old Otzi Ice Man was discovered as a consequence of glacier melting in the European Alps. There has been a long process of scientific analysis of the well-preserved body and associated clothing and other implements found with the corpse.

Isolated from his intact colon was the fragment of plant material shown to the left: Identified as *Sphagnum imbricatum* by modern-day bryologists[1]. In a more comprehensive analysis of Bryophyta and the Ice Man, Dickson and his colleagues note[2]:



"Alone among mosses, species of Sphagnum have been used for external medical treatment as wound dressings, a use that continued on a large scale well into the 20th century during both world wars. Dried Sphagnum is highly absorbent and, much more than that, there are the wound-healing properties of Sphagnum holocellulose ("sphagnan", a kind of pectin), discussed by Painter (2003). This acts by immobilizing bacterial cells and depriving them of their nutrients."

Leading to the hypothesis that it was used as a wound dressing, and ingested due to adhering to the Ice Man's hands when he was eating.

---

[1] Dickson, JH, W Hofbauer, W Kofler, K Oeggl and J Platzgummer (2005) How to find the bogmoss, Sphagnum imbricatum s.l., in South Tyrol, Italy: Microscopically examine the Iceman's colon contents. Vegetation History and Archaeobotany 14(3):207–210.

[2] Dickson, JH, W Hofbauer, R Porley, A Schmidl, W Kofler and K Oeggl (2009) Six mosses from the Tyrolean Iceman's alimentary tract and their significance for his ethnobotany and the events of his last days. Vegetation History and Archaeobotany 18:13–22.

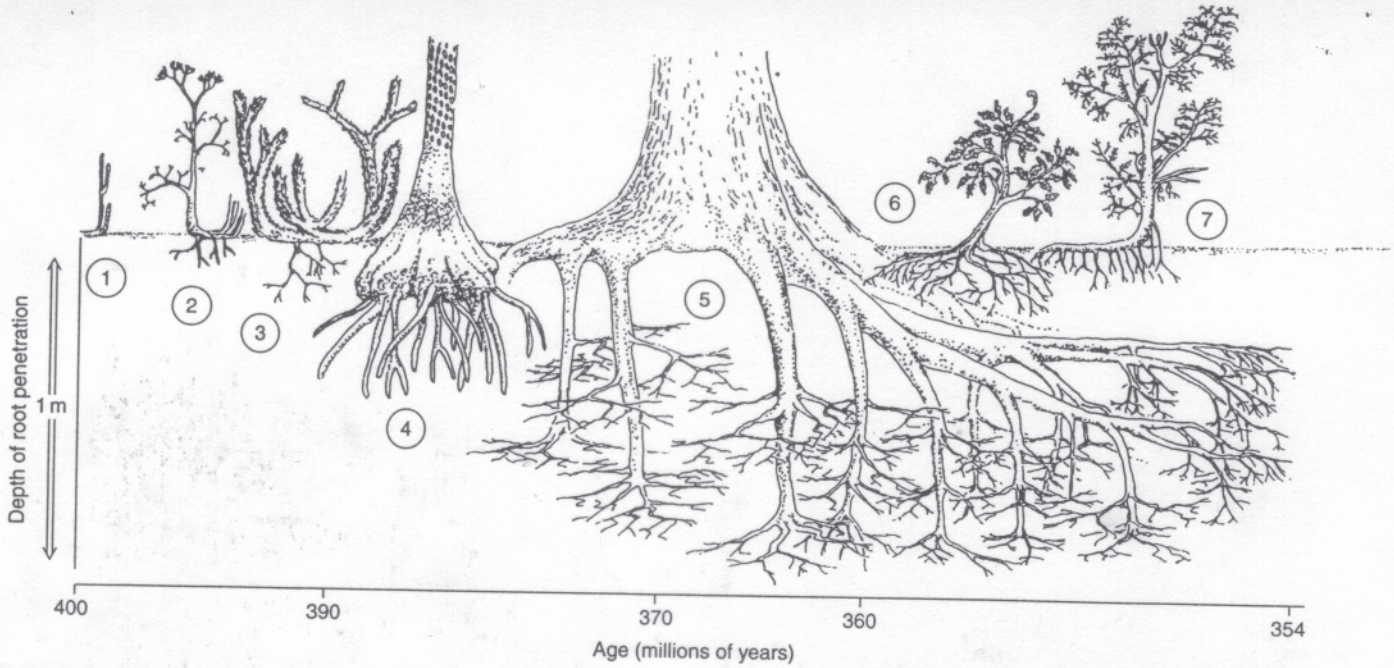
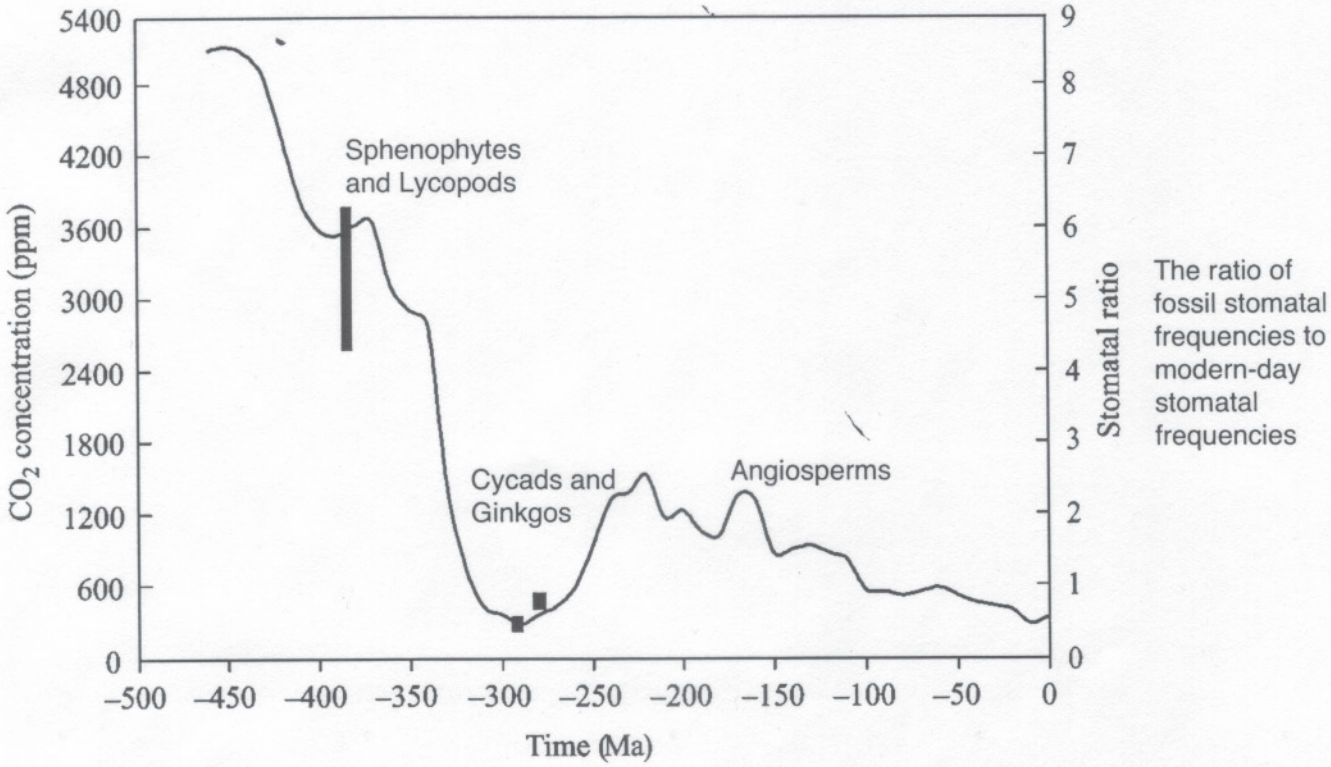
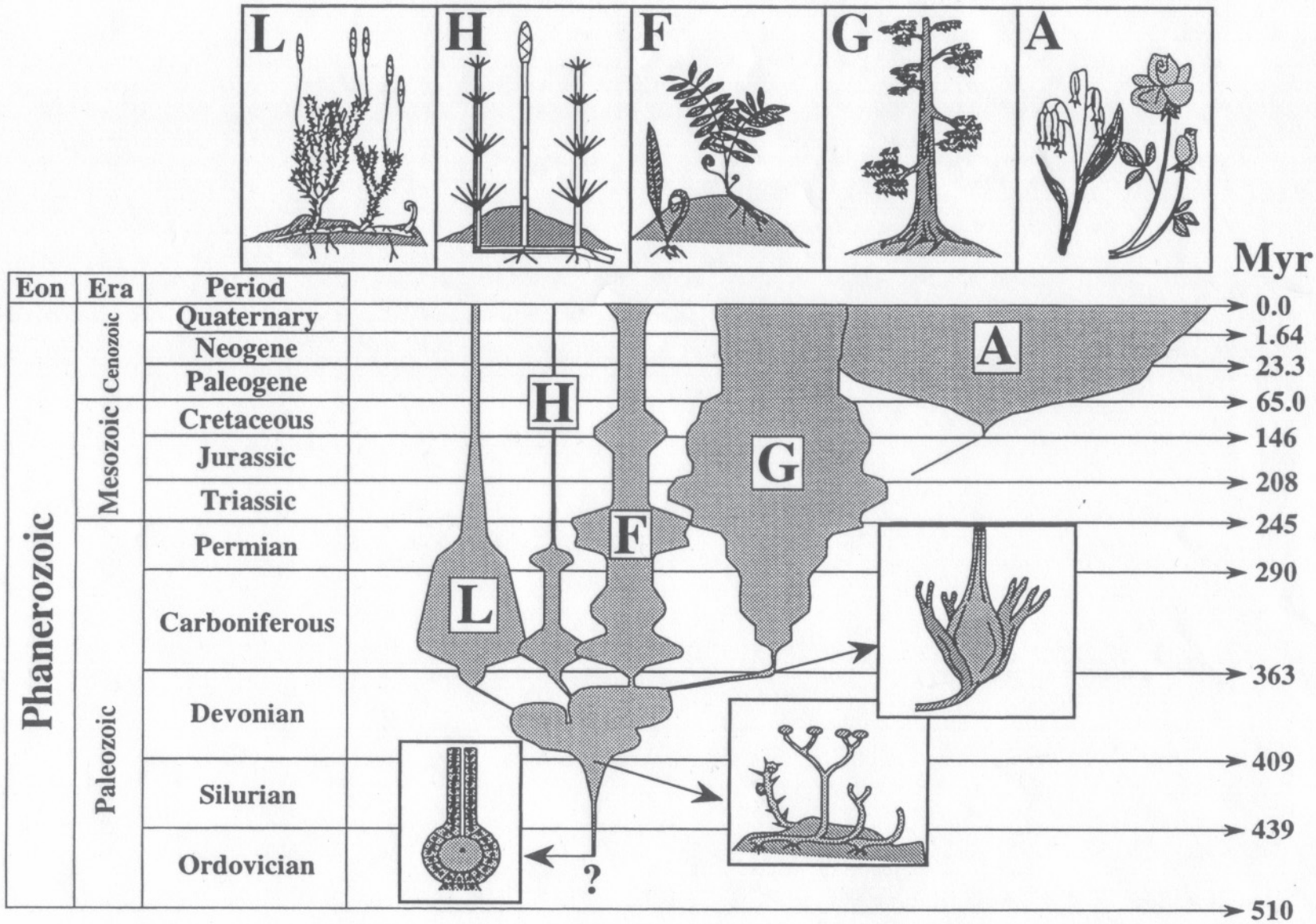
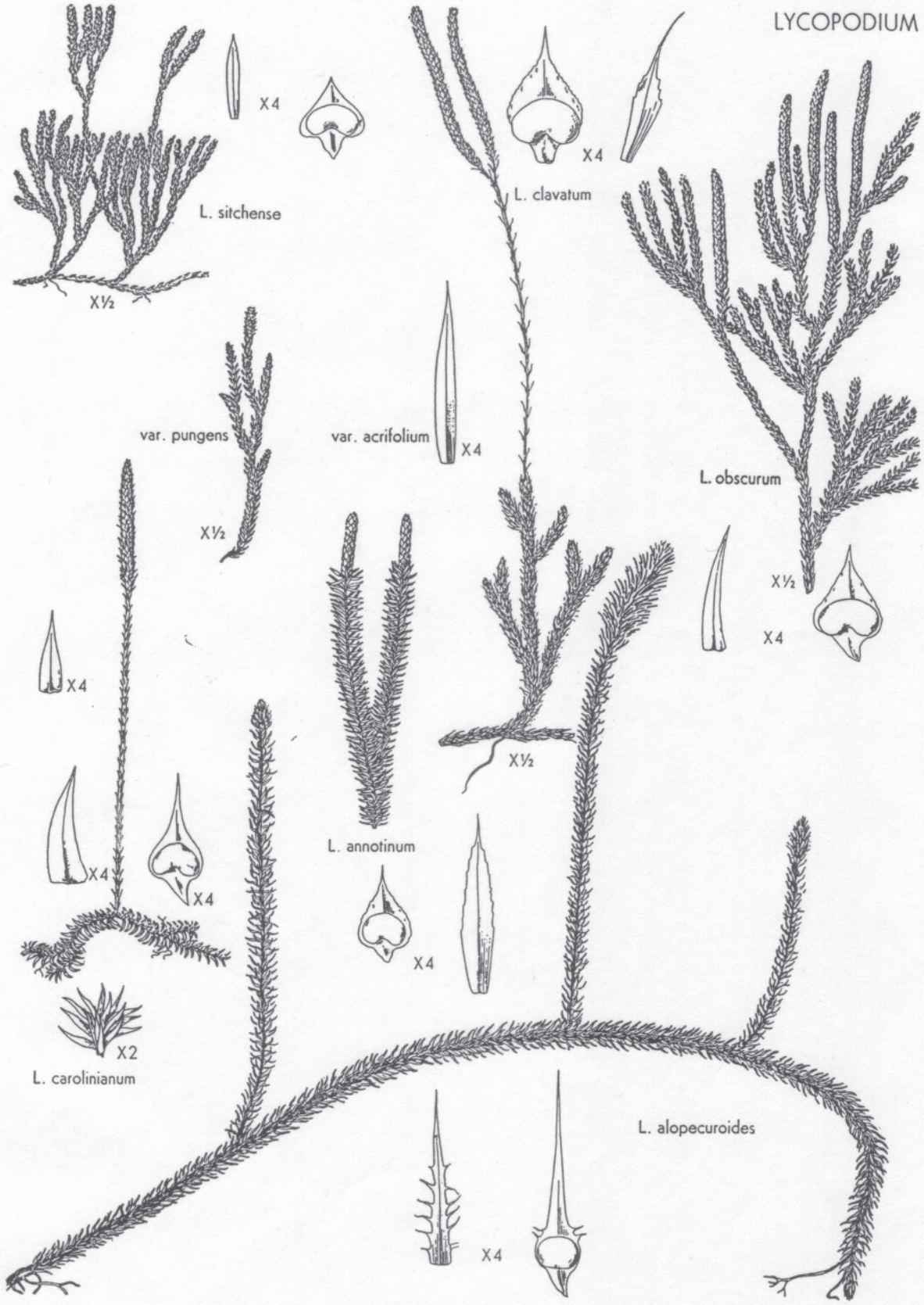


Figure 4.6 Relative sizes, shapes, and penetration depths of root systems during the early, middle, and late Devonian (~400–354 Ma; age axis is not drawn to scale) (redrawn from Algeo and Scheckler, 1999). Representative plant types are as follows: 1, Rhyniopsida, e.g. *Aglaophyton*; 2, trimerophytes, e.g. *Psilophyton*; 3, early herbaceous lycopsids, e.g. *Asteroxylon*; 4, early tree lycopsids, e.g. *Lepidodendron*; 5, progymnosperm, e.g. *Archaeopteris*; 6, early gymnosperm, e.g. *Elkinsia*; and 7, filicopsid, e.g. *Rhacophyton*.

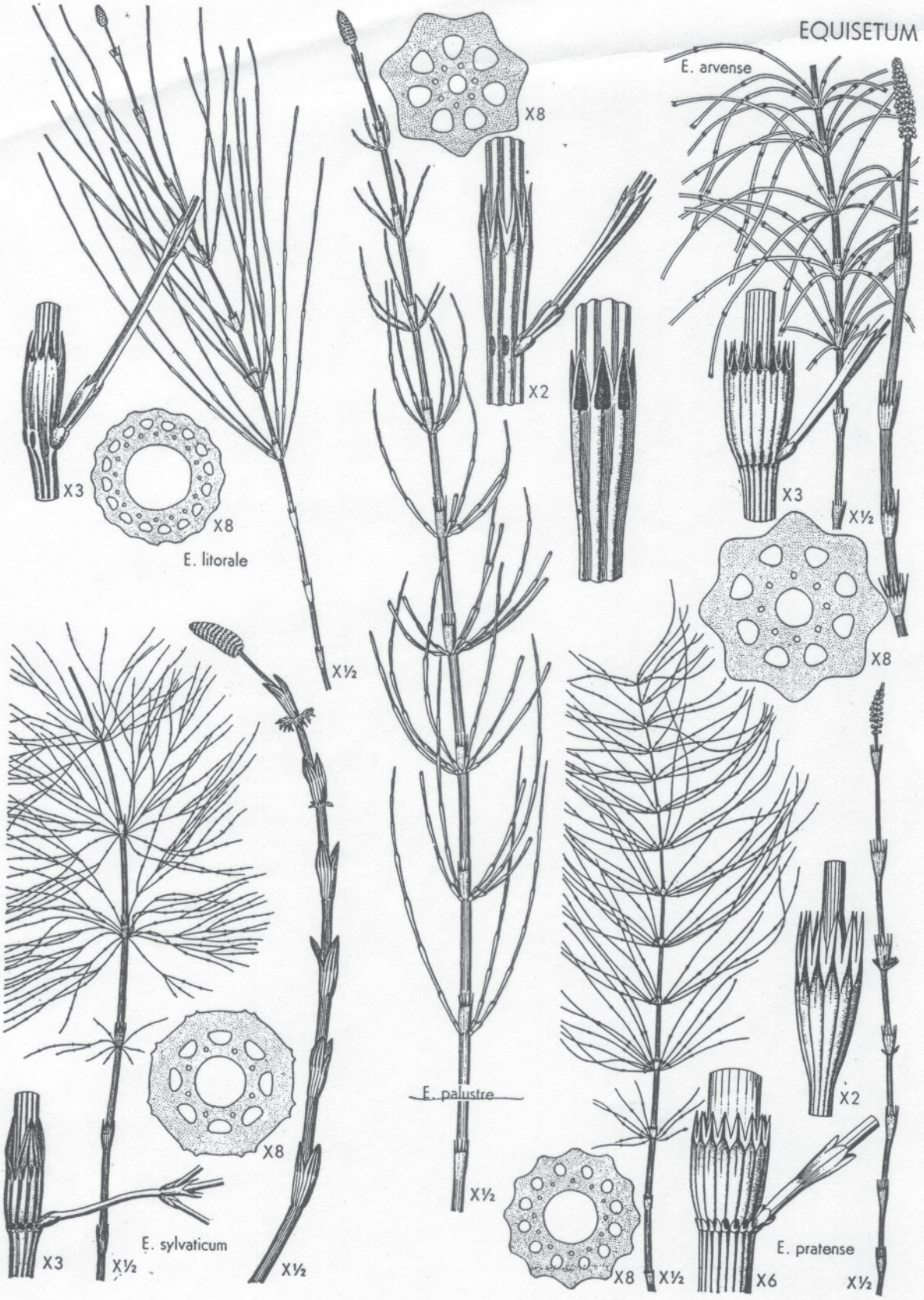


Modified from: Willis, K.J. and J.C. McElwain. 2002. The Evolution of Plants. Oxford University Press.

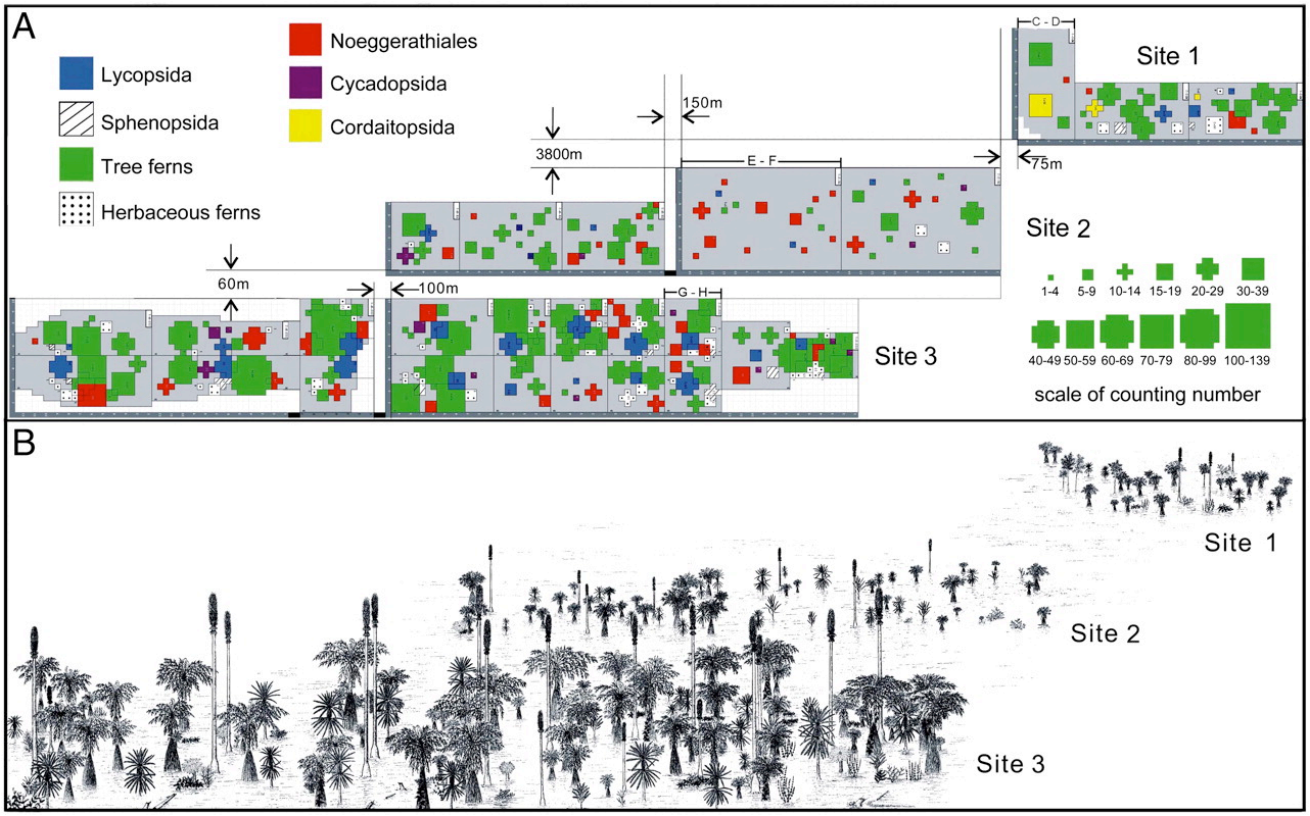

L
H
F
G
A
Myr
Eon
Era
Period
Phanerozoic
Cenozoic
Mesozoic
Paleozoic
Quaternary
Neogene
Paleogene
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Silurian
Ordovician
0.0
1.64
23.3
65.0
146
208
245
290
363
409
439
510
?


LYCOPODIUM
X4
L. sitchense
X½
X4
L. clavatum
var. pungens
var. acrifolium
X4
L. obscurum
X½
X½
X4
X4
X½
L. annotinum
X4
X4
X4
X2
L. carolinianum
L. alopecuroides
X4

EQUISETUM


E. arvense
X8
X2
X3
X1/2
X8
E. litorale
X1/2
X8
E. palustre
X1/2
X2
X8
X1/2
X6
X1/2
E. pratense
X3
X1/2
X1/2
E. sylvaticum

Reconstruction of a peat-forming swamp forest from the Permian period. The forest was buried relatively intact in volcanic tuff near Wuda, Inner Mongolia, China.



Wang J, HW Pfefferkorn, Y Zhang, Z Feng 2012. Permian vegetational Pompeii from Inner Mongolia and its implications for landscape paleoecology and paleobiogeography of Cathaysia. PNAS 109:4927-4932 ©2012 by National Academy of Sciences

Spatial data for peat-forming swamp forest buried in volcanic tuff near Wuda, Inner Mongolia, China during the Permian period (250–300 million years ago). ***Upper panel***. Tree ferns (green) are dominant; lycopsids (blue) and noeggerathialeans (red) are other common groups. Sphenopsids (white with black lines), Cordaites (yellow), and early cycads (purple) were rare or occurred only in certain areas. Herbaceous plants (white with black dots) are found only in isolated spots. ***Lower panel***. The reconstruction of the flora on these sites is based on the actual position of trees.

Unravel into the Light

Learn about the Ferns

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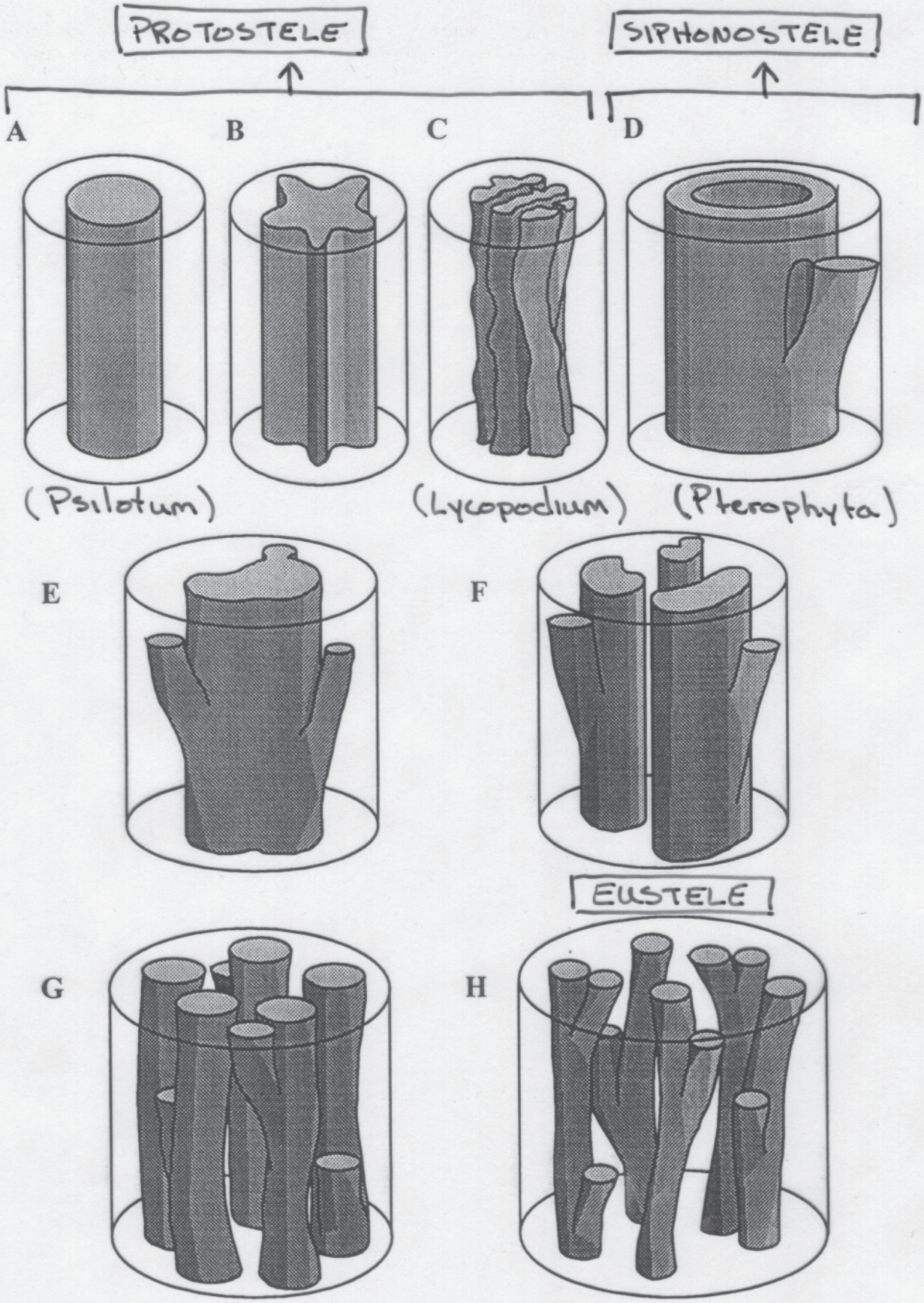
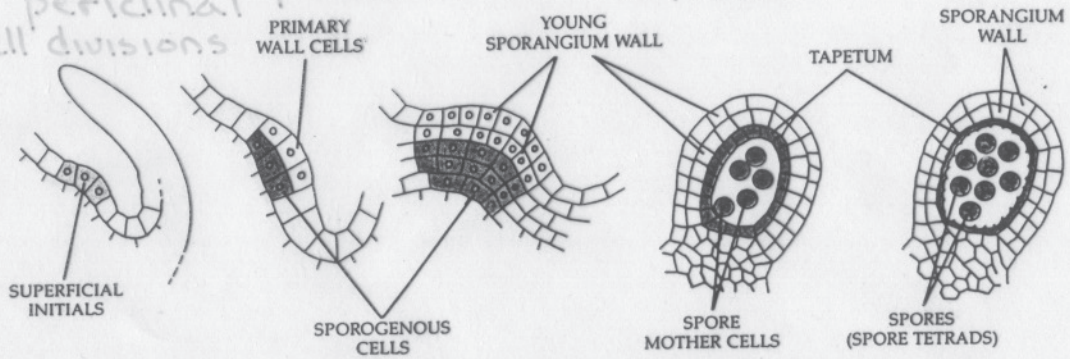


Figure 6.18. Stelar anatomy. Diagrams render the basic anatomical appearance of the primary xylem (shaded areas) in the plant stem (open cylinders): (A) haplostele; (B) actinostele; (C) plectostele; (D) siphonostele with leaf trace and leaf "gap"; (E–H) anatomical transformations posited for the evolution of the eustele (H) from a lobed haplostele (E). Adapted from Gifford and Foster 1989.

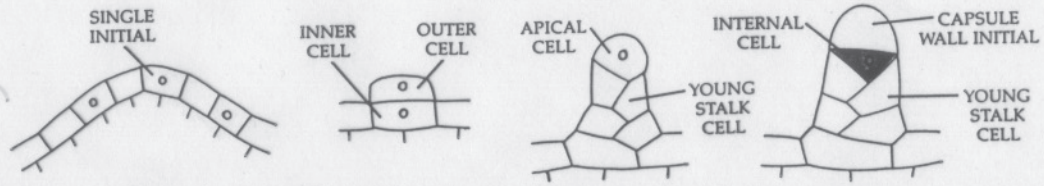
anticlinal &
periclinal periclinal cell divisions
cell divisions

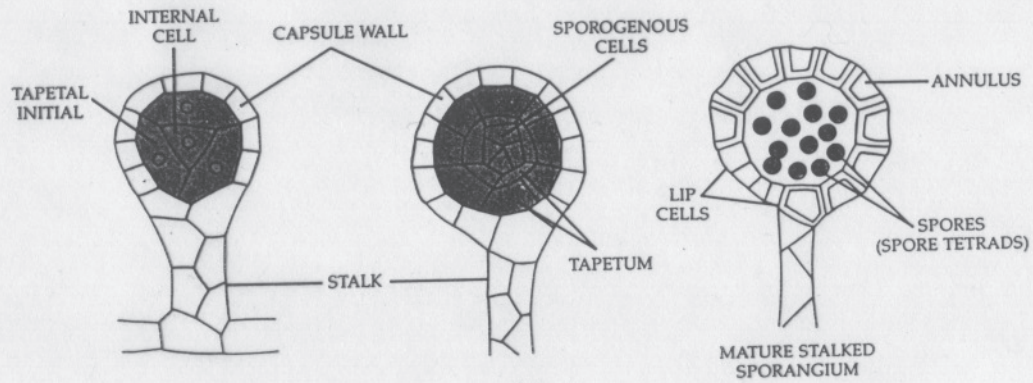
Eusporangium



(a)

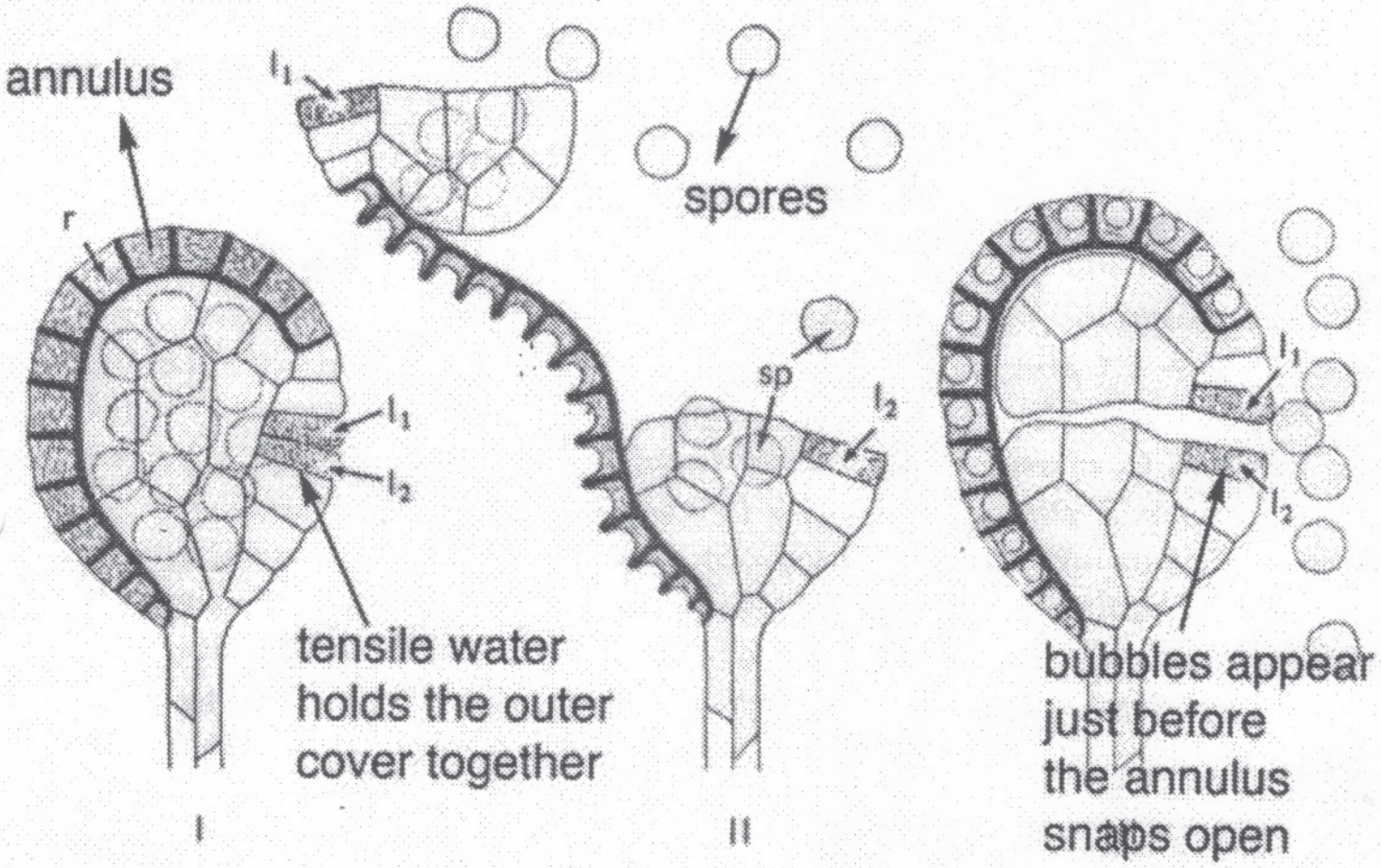
Leptosporangium





(b)

16–28
Development and structure of the two principal types of fern sporangia. (a) *The eusporangium originates from a series of superficial parent cells, or initials. It develops a wall two or more layers thick (although at maturity the inner wall layers may be crushed) and a high number of spores.* (b) *The leptosporangium originates from a single initial cell, which first produces a stalk and then a capsule. Leptosporangia give rise to a relatively small number of spores.*


annulus
r
l_1
l_2
tensile water holds the outer cover together
I
l_1
spores
sp
l_2
II
l_1
l_2
bubbles appear just before the annulus snaps open

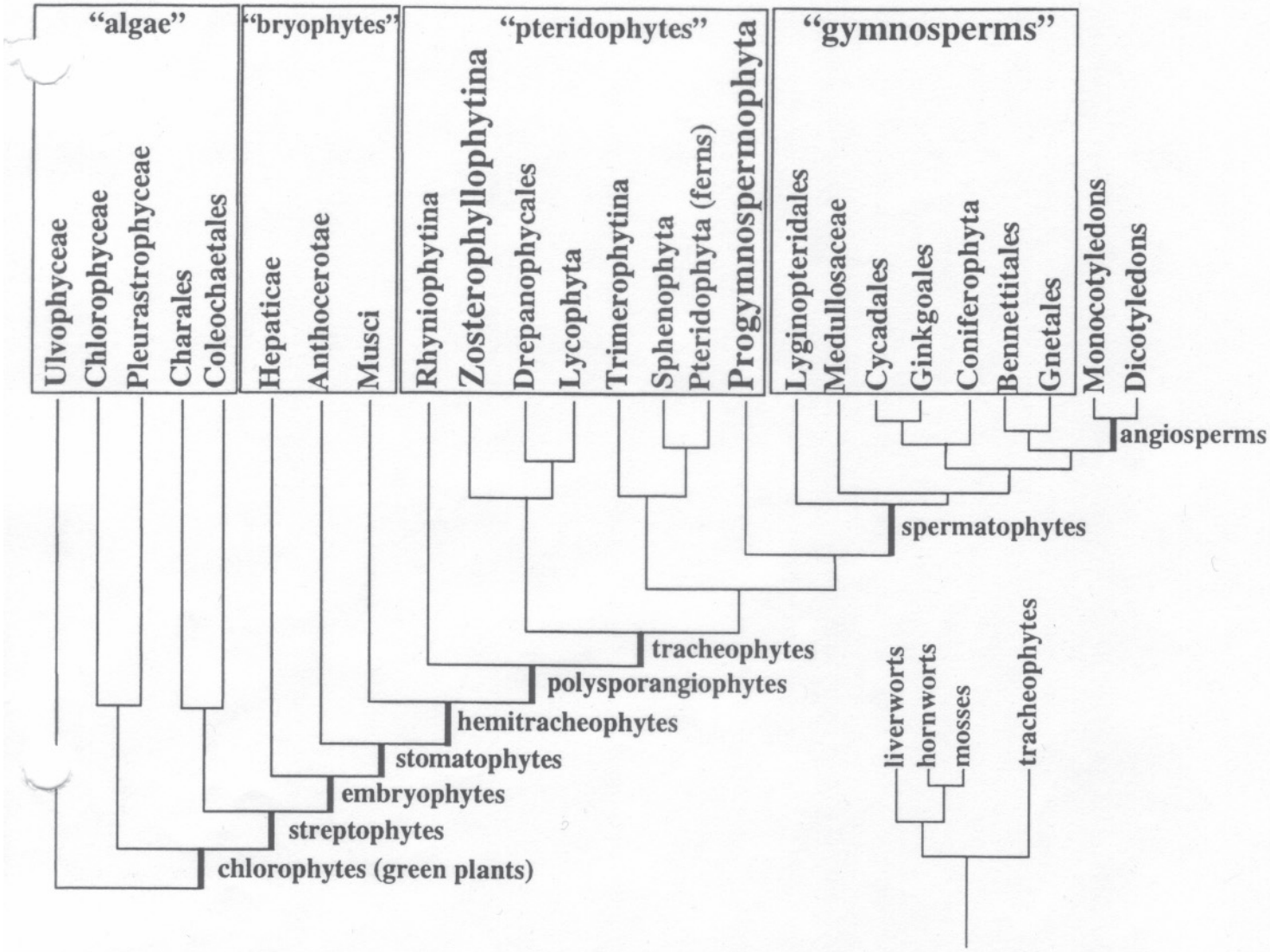


Figure 4.15. Simplified cladogram rendering a phyletic hypothesis for the embryophytes and evolutionarily related green algal lines. Different lineages sharing the same level of morphological or reproductive organization (i.e., evolutionary grades) are grouped in boxes. The informal names for these grades are given in parentheses (e.g., "algae"); formal taxonomic designations are given in boxes (e.g.., Ulvophyceae). Plant groups sharing the same ancestor are indicated by dark vertical links (e.g., chlorophytes). Note that not all the formal taxa are of equal taxonomic rank (e.g., "aceae" designates family rank, "ales" indicates an order, and "phyta" indicates division). According to this cladogram, "bryophytes" are a paraphyletic group (an assembly of organisms that excludes some species that share the same common ancestor with species included in the group). The small cladogram (bottom right) depicts the more traditional view that the bryophytes (Hepaticae = "liverworts," Anthocerotae = "hornworts"; Musci = "mosses") are monophyletic (i.e., Bryophyta) and shared a last common ancestor with the vascular plants (tracheophytes). Adapted from Mishler et al. 1994; Nixon et al. 1994; and Rothwell and Serbet 1994.