

Botany
and
The Nature of Naming

Prince William Master Naturalists
July 28, 2012

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Virginia Native Plant Society

Objectives for Program

- Overview of biological classification with focus on Kingdom Plantae
- Overview of botany
- Introduction to dichotomous keys
- Discussion of native plants and vegetative communities

Classification of Organisms

- All biota arranged in discrete groups based on anatomical and genetic similarities
 - Domain
 - Kingdom
 - Phylum
 - Class
 - Order
 - Family
 - Genus
 - Species

Each level uses (usually) Latin-based descriptor of defining characteristic(s)

- Classification focuses on relatedness
- Allows focus on critical features
- Makes identification easier by use of keys that focus on defining physical characteristics
- Provides understanding of evolution

Classification of Organisms (continued)

- **Species** - one of the basic units of biological classification and a taxonomic rank. A species is often defined as a group of organisms capable of interbreeding and producing fertile offspring. (Wikipedia)
- **Binomial nomenclature**
 - First used by Leonhart Fuchs and introduced as the standard by Carolus Linnaeus in his 1758 classical work *Systema Naturae* 10th edition. (Wikipedia)
 - Uses two word descriptor that firmly places organism in a group and differentiates it from the group by some defining characteristic
- **Common Names**
 - Can be very illustrative (Chikadee; liverwort; etc.)
 - Often deep cultural roots in common names
 - Can cause great confusion due to localized differences, overlap with other species, etc.

Classification of Organisms

Domains

- **Bacteria** (Eubacteria),
- **Archaea** (Archaeobacteria)
- **Eukarya** (Eukaryotes; further divided into **Protista, Plantae, Animalia and Fungi**).

Reference: GJ Olsen and CR Woese (1993). FASEB Journal 7: 113-123.

Kingdoms

- **Monera** (or Procaryotae) (prokaryotes, including Bacteria and Archaea)
- **Protista** (eukaryotes with single- or colonial cellular organisation, may be photosynthetic)
- **Fungi** (generally multinucleate eukaryotes with walled syncytia)
- **Animalia** (wall-less eukaryote cells organised into complex organisms)
- **Plantae** (generally autotrophic plants, mostly with photosynthetic plastids, simple multicellular to advanced tissue organisation)

Reference: RH Whittaker and L Margulis (1978). BioSystems 10: 3-18

Plant: Definition

A multicellular, eukaryotic life forms of the kingdom Plantae characterized by:

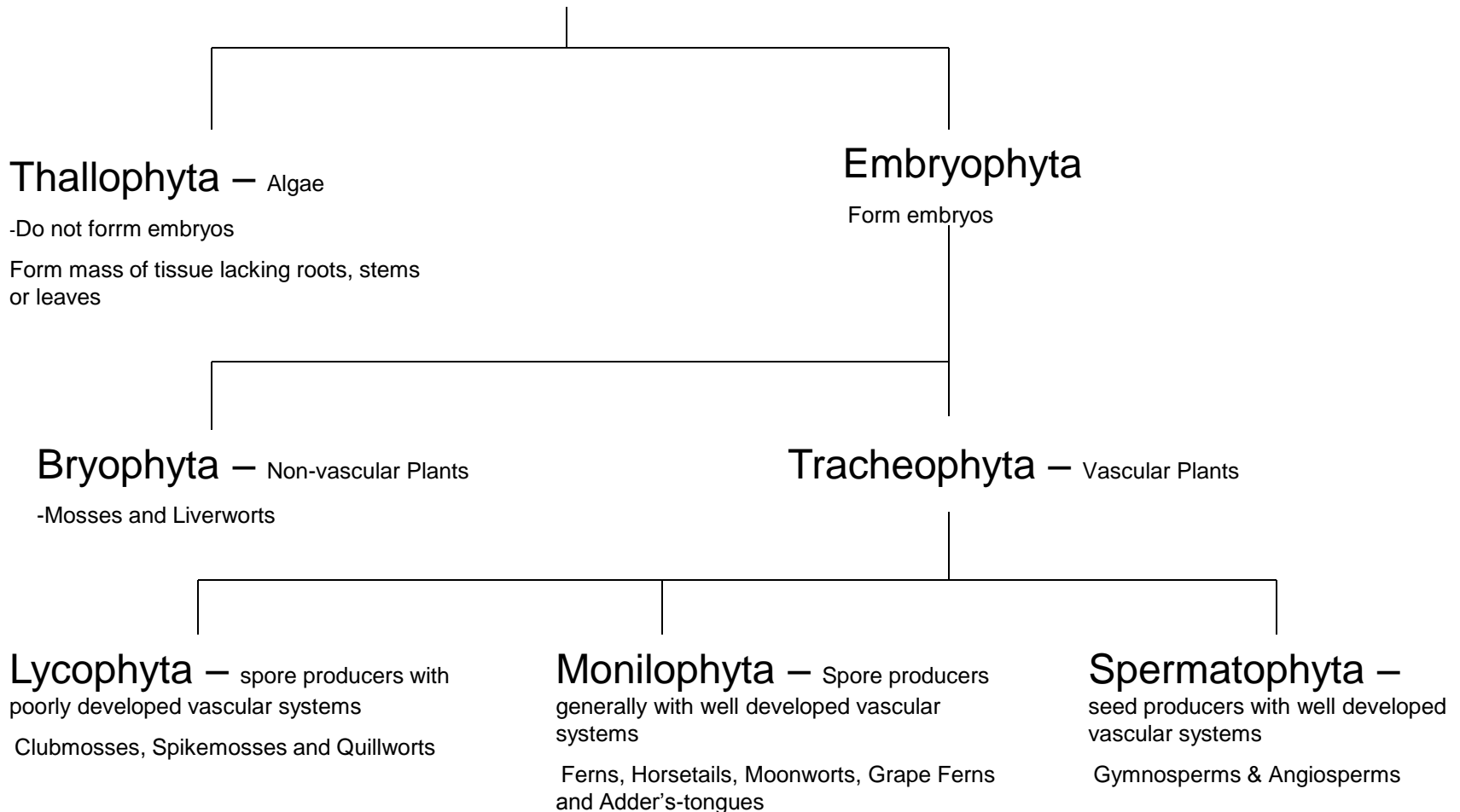
- 1) photosynthetic nutrition, in which chemical energy is produced from water, minerals, and carbon dioxide with the aid of pigments and the radiant energy of the Sun,
- 2) essentially unlimited growth at localized regions,
- 3) cells that contain cellulose in their walls and are therefore to some extent rigid,
- 4) the absence of organs of locomotion, resulting in a more or less stationary existence,
- 5) the absence of sensory and nervous systems, and
- 6) life histories that show an alteration of haploid and diploid generations, with the dominance of one over the other being taxonomically significant.

Kingdom Plantae

- About 350,000 species of plants are estimated to exist currently.
- As of 2010, some 321,212 species had been identified.

Informal group	Phylum name	Common name	No. of living species
Green algae	Chlorophyta	green algae (chlorophytes)	3,800
	Charophyta	green algae (desmids & charophytes)	4,000 - 6,000
Bryophytes	Marchantiophyta	liverworts	6,000 - 8,000
	Anthocerotophyta	hornworts	100 - 200
	Bryophyta	mosses	16,236
Pteridophytes	Lycopodiophyta	club mosses	1,200
	Pteridophyta	ferns, whisk ferns & horsetails	12,000
Seed plants	Cycadophyta	cycads	160
	Ginkgophyta	ginkgo	1
	Pinophyta	conifers	1,021
	Gnetophyta	gnetophytes	70
	Magnoliophyta	flowering plants	281,821

Another Version of Kingdom Plantae*



*Adapted from Peterson Field Guide: Ferns of Northeastern and Central North America, Second Edition.

Major Plant Phyla

Plantae							
Spore Producers				Seed Producers			
			Well Developed Vascular System				
<u>Bryophyta</u> mosses and liverworts	<u>Sphenophyta</u> horsetails	<u>Lycophyta</u> clubmosses	<u>Pteridophyta</u> ferns	<u>Cycadophyta</u> cycads	<u>Coniferophyta</u> conifers	<u>Ginkgophyta</u> ginkgo	<u>Anthophyta</u> flowering plants

Evolution of Plants

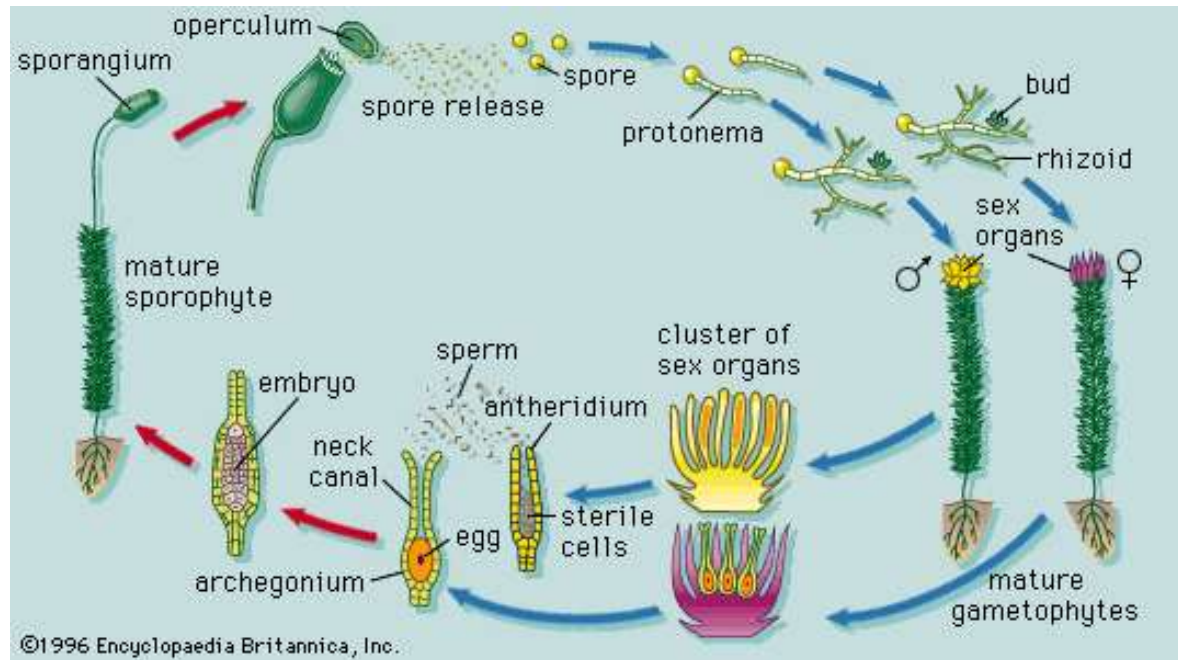
- Likely evolved from green algae
- About 500 mya became established on land – some have returned to water

Non-Vascular Plants – Bryophyta (mosses liverworts and hornworts)

- No vascular tissue
- No roots – rhizoids
- No true leaves – only a few cells thick
- Must have free water – almost as if back in aquatic environment

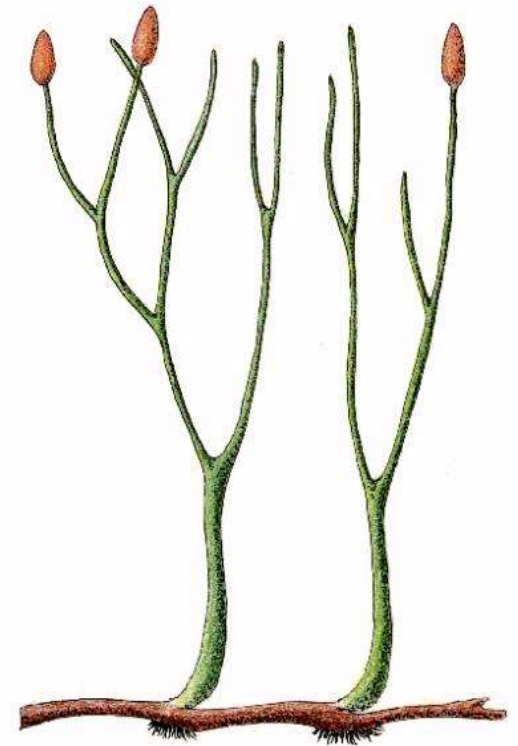
Bryophyta Life Cycle

- Separate gametophyte often larger than sporophyte



Vascular Plants

- Likely evolved about 400 mya
- Example: *Rhynia major*
 - Resembled spike rush
 - Underground stem – rhizoid – for rooting and absorption of water and nutrients
 - Above ground stem with waxy cuticle and stomata
 - Vascular bundles



Vascular Plants (continued)

- Evolved two leaf types: Microphylls and Megaphylls
- Vascular tissue: phloem to conduct sugars and soluble organic compounds; and xylem to conduct water and minerals
- Vascular tissue side-by-side in either vascular bundles or concentric layers (cylinders)
- Gametophyte reduced in size – smaller than sporophyte
- Heterospory – produce two different gametophytes; bryophytes and many ferns and allies have Homospory – produce one kind of spore and sporangium
- Seeds – Gymnosperms and Angiosperms produce seeds containing the embryo (young sporophyte) within an outer covering (seed coat).

Non-Seed Plants

- **Ferns and Allies**

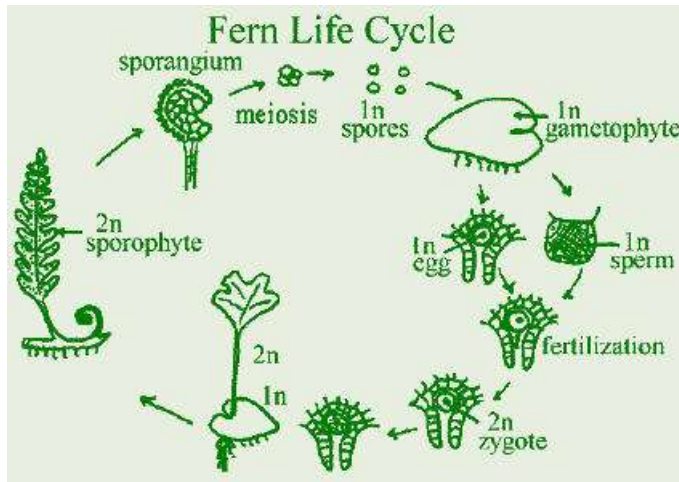
- Have flagellated sperm that require free water for fertilization
- Fairly simple stem
- No secondary growth (increase of girth that forms bark and wood)
- Gametophyte separate and nutritionally independent of sporophyte

- Psilophyta (whisk ferns), Lycophyta (club mosses) and Sphenophyta (horsetails) have Microphylls (simple leaves with single vascular strand)

- Ferns – about 12,000 species evolved about 400 mya

- Sporangia commonly in specialized leaves called sporophylls
- Most are homosporous, but some heterosporous

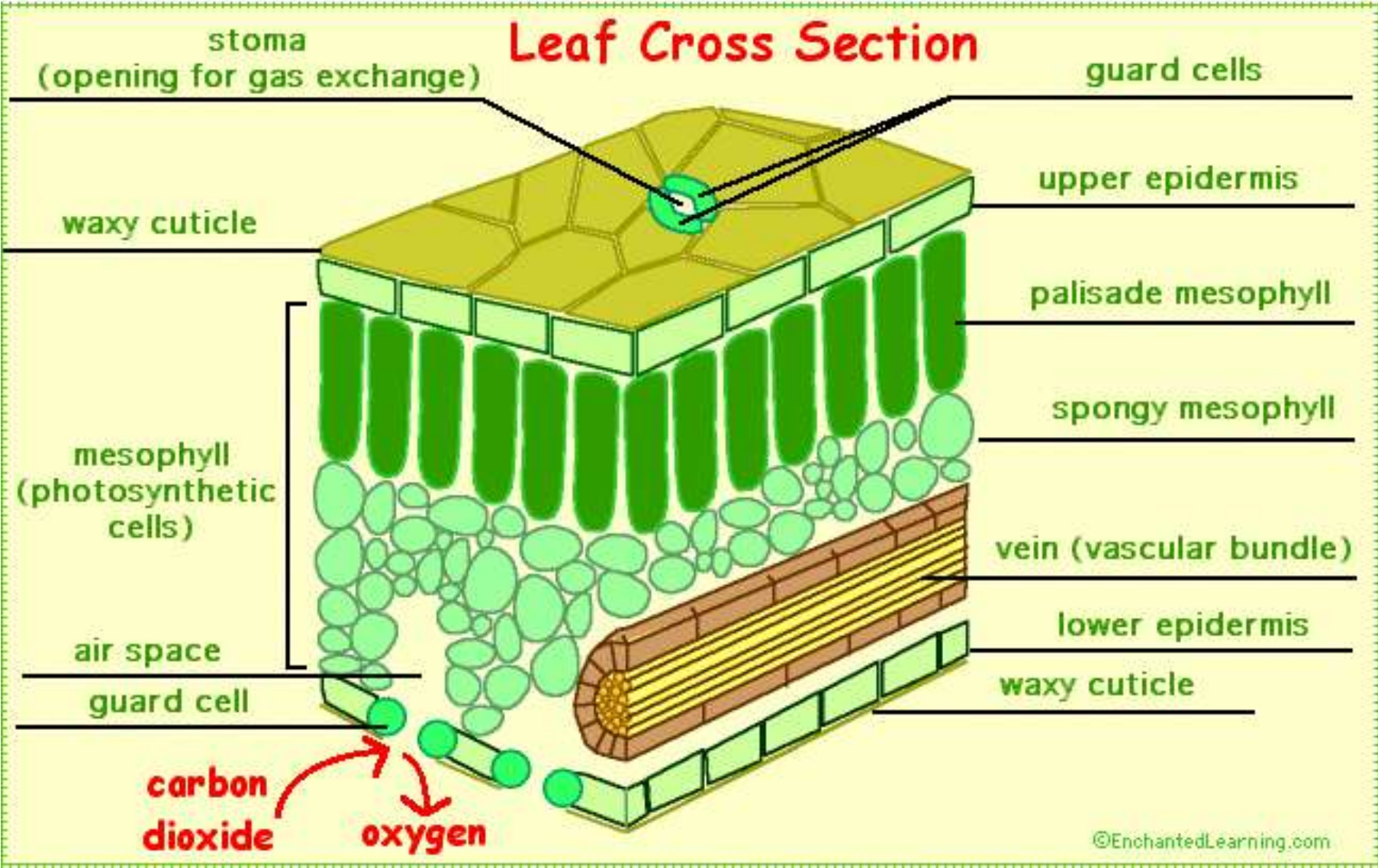
Ferns and Allies



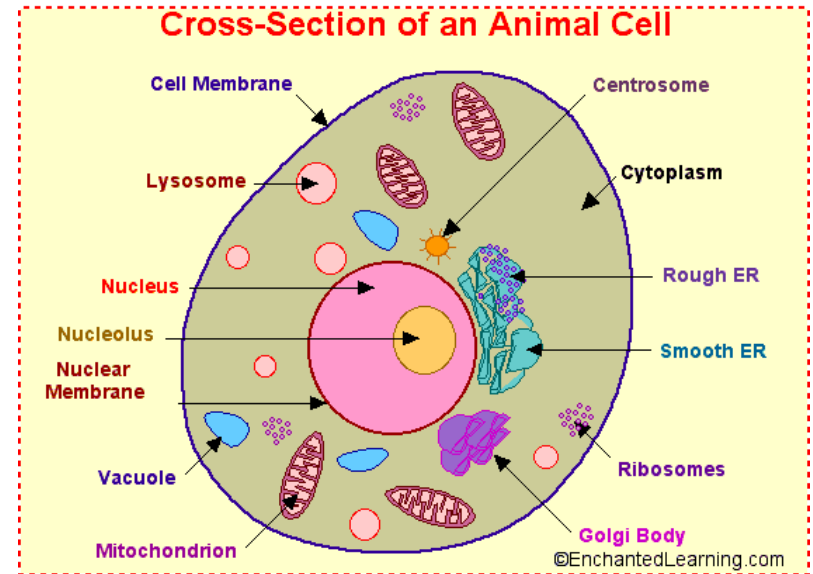
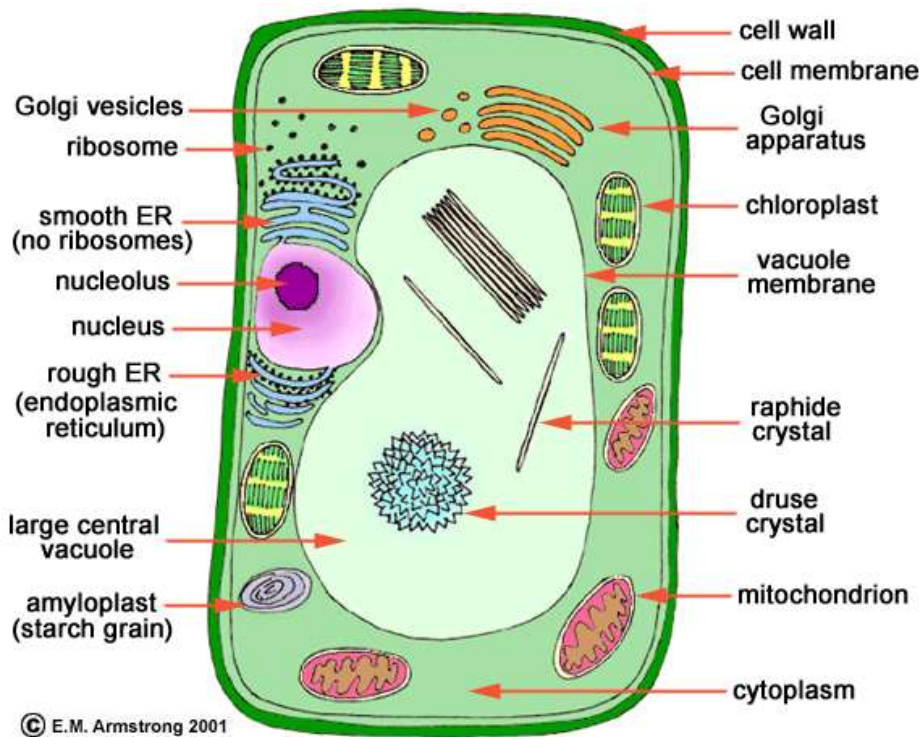
Seed Plants

- In existence since the end of the carboniferous about 280 mya
- Permian (225-280 mya) saw glaciers and drought with severe selective pressure for terrestrial species
- Seeded plants flourished (seeds can lie dormant like spores of bacteria or zygotes of freshwater algae)
- Gametophytes tiny and dependent on sporophyte
- Developed secondary growth
- Leaves are megaphylls – developed from fusion of branched systems and have branched vascular tissue

Leaf Cross Section



Plant Versus Animal Cell



Plant Cells

Anatomy of the Plant Cell

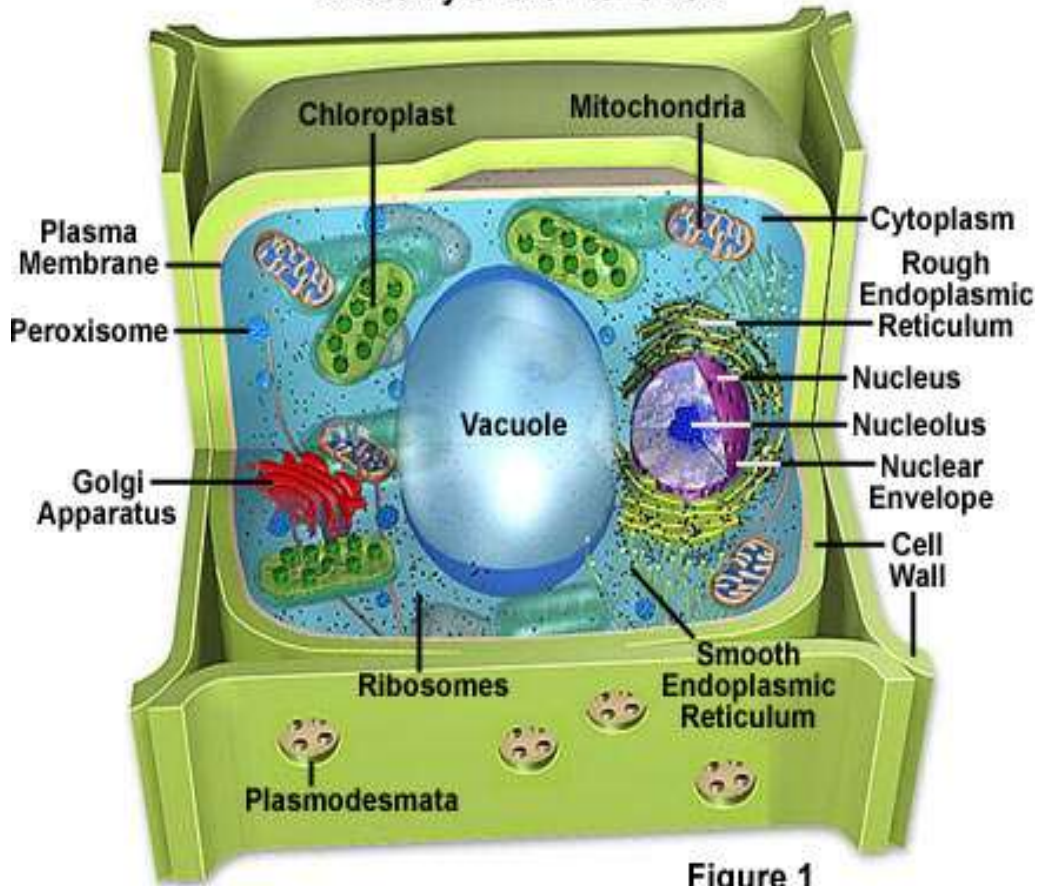
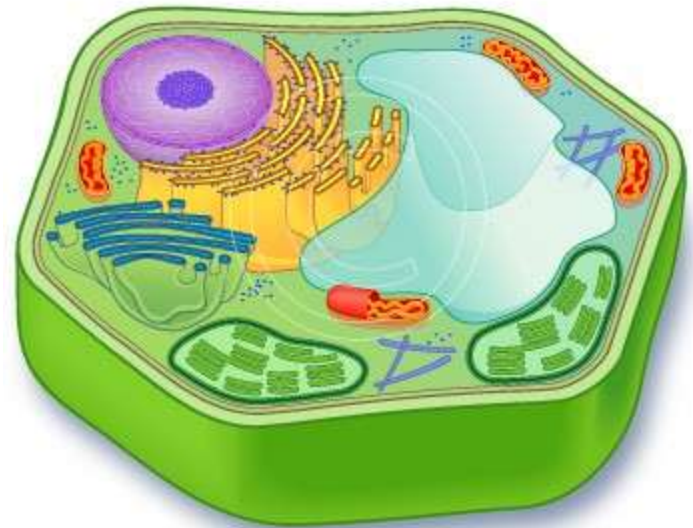
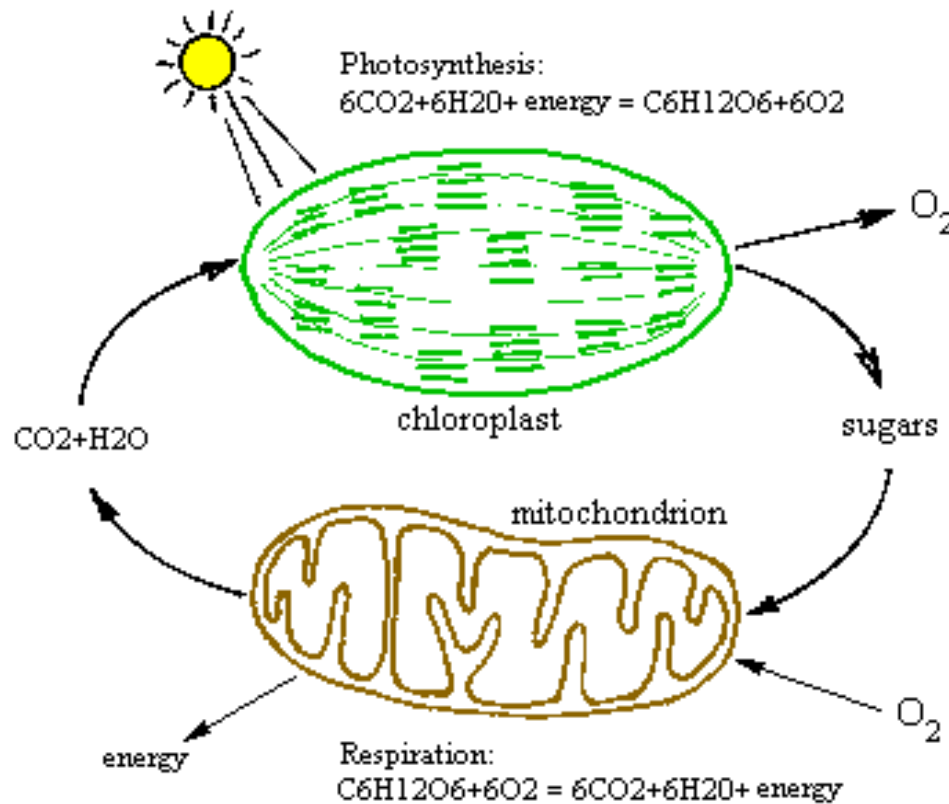


Figure 1



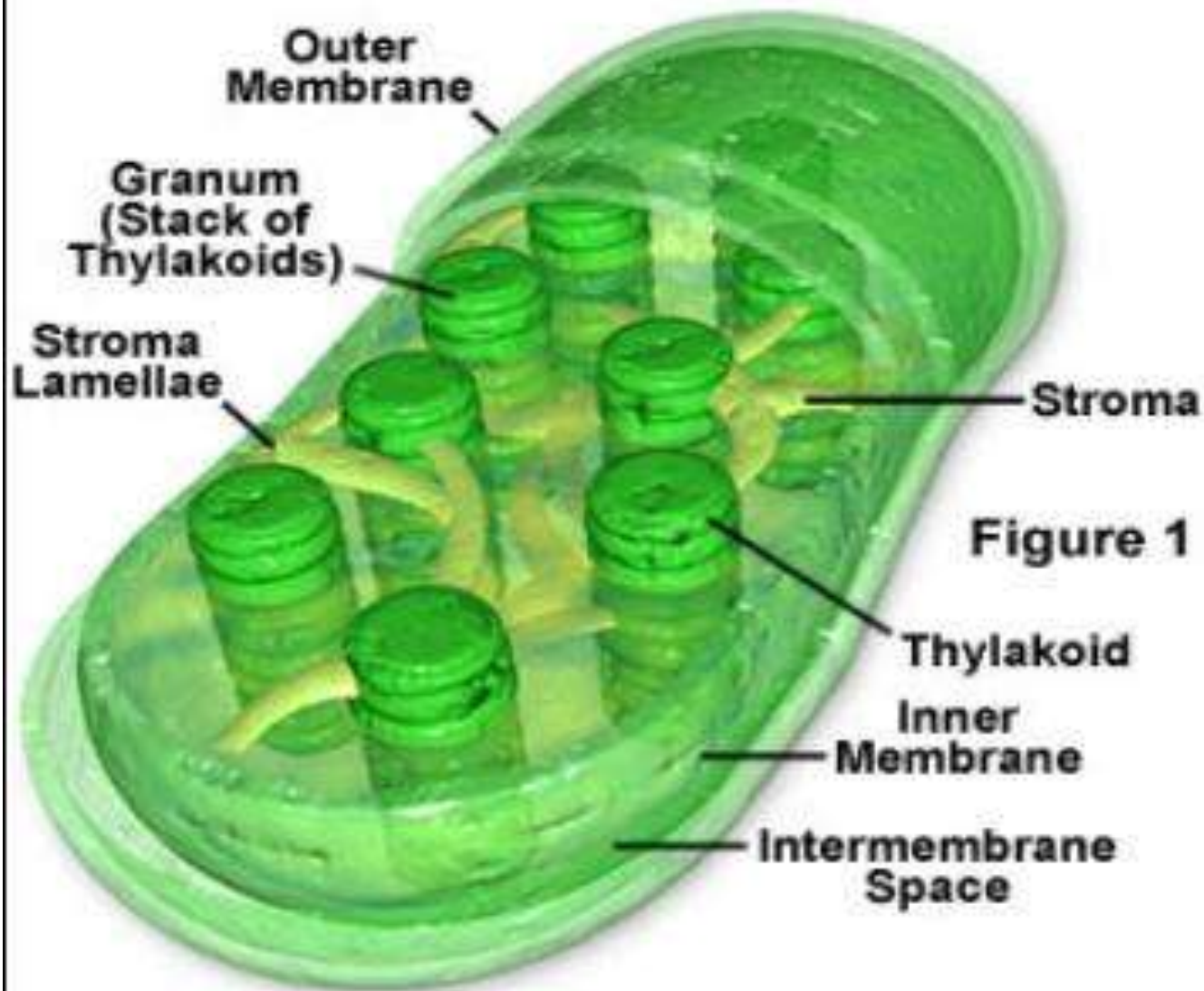
Plant Cell Processes



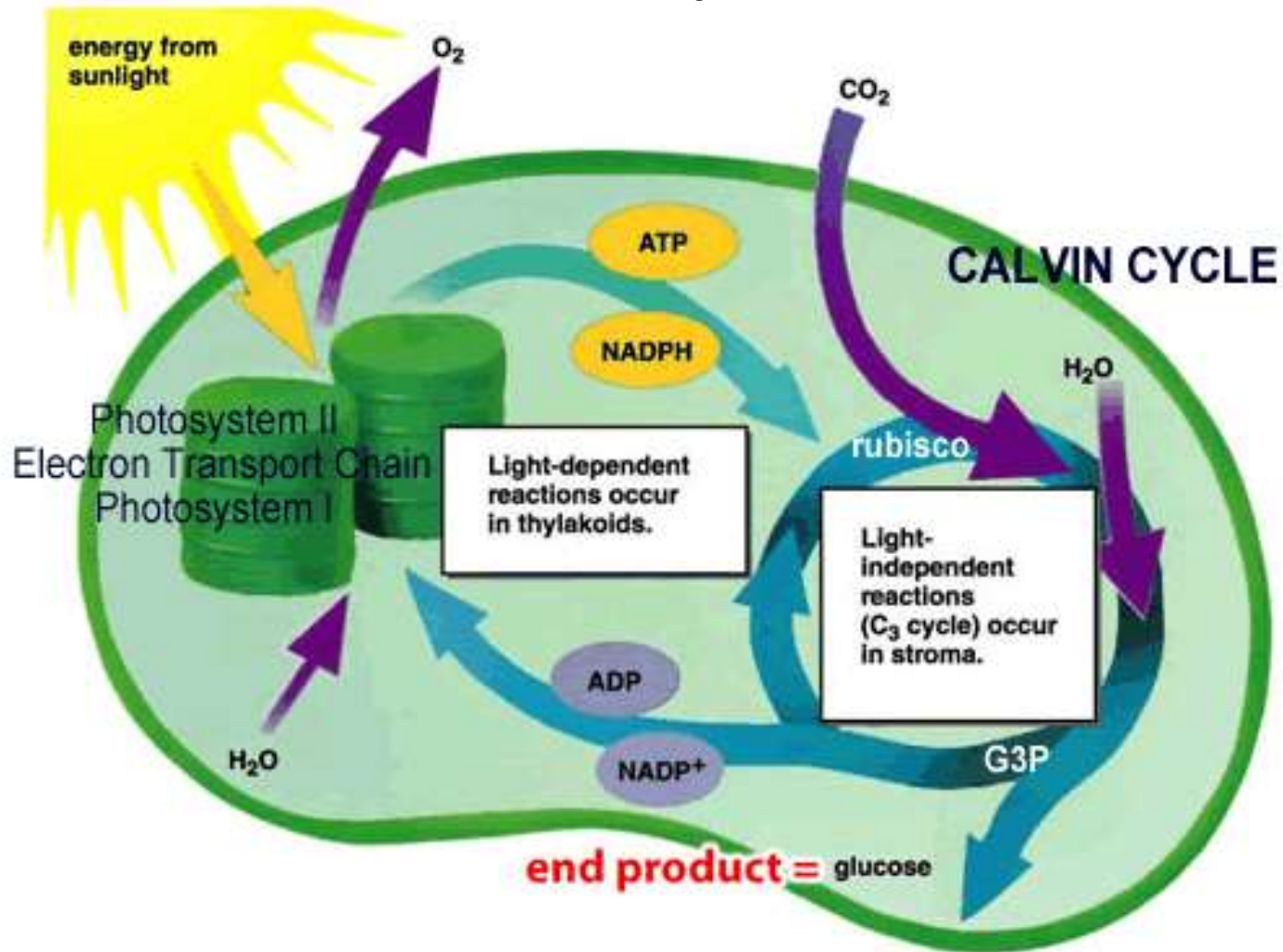
- Plants contain mitochondria and chloroplasts
- Chloroplasts conduct photosynthesis
- Mitochondria conduct respiration

Figure 16 - With the photosynthesis, the solar energy is cumulated by the chloroplasts as sugar molecules. With the glycolysis and the respiration, made by mitochondria, the energy is liberated and supplied to the cell for its biochemical processes.

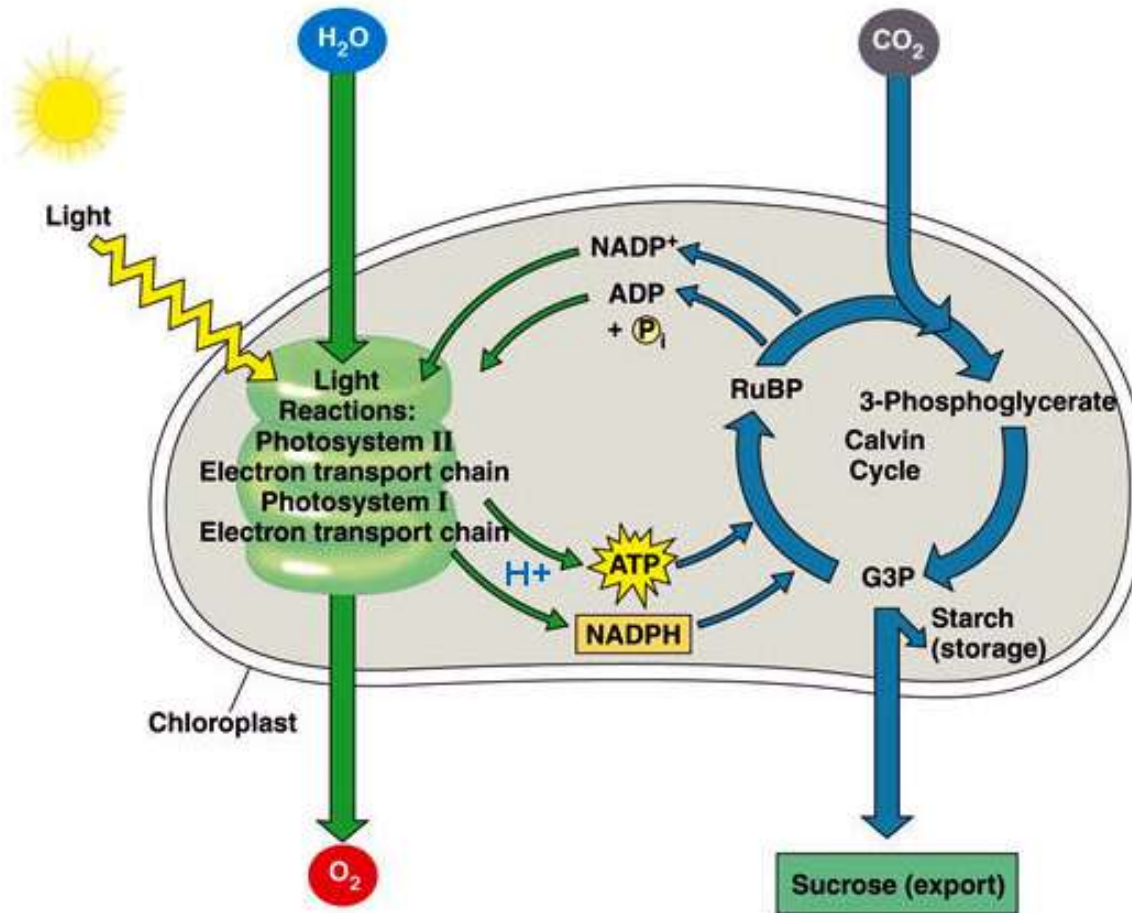
Anatomy of the Plant Cell Chloroplast



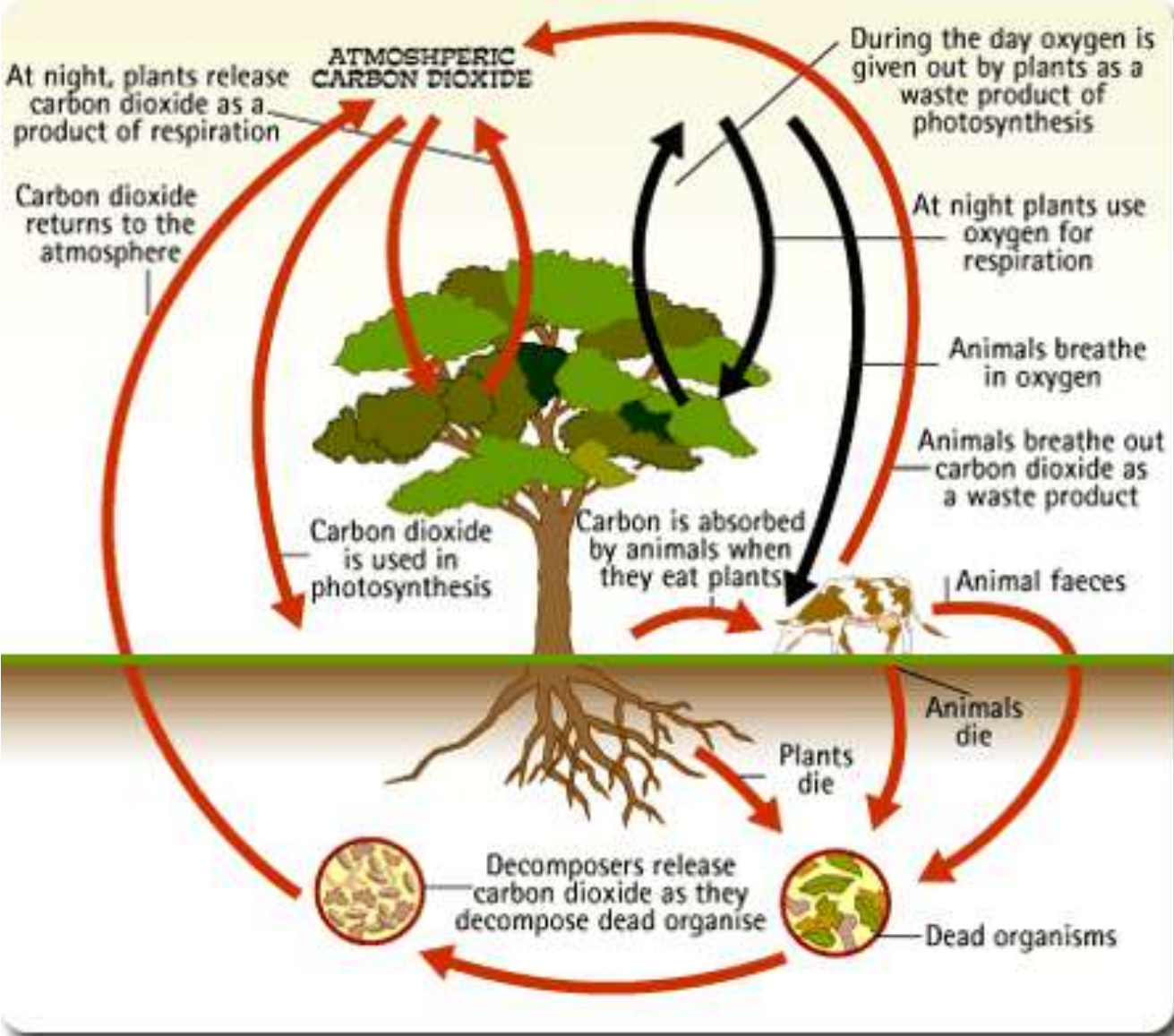
Photosynthesis



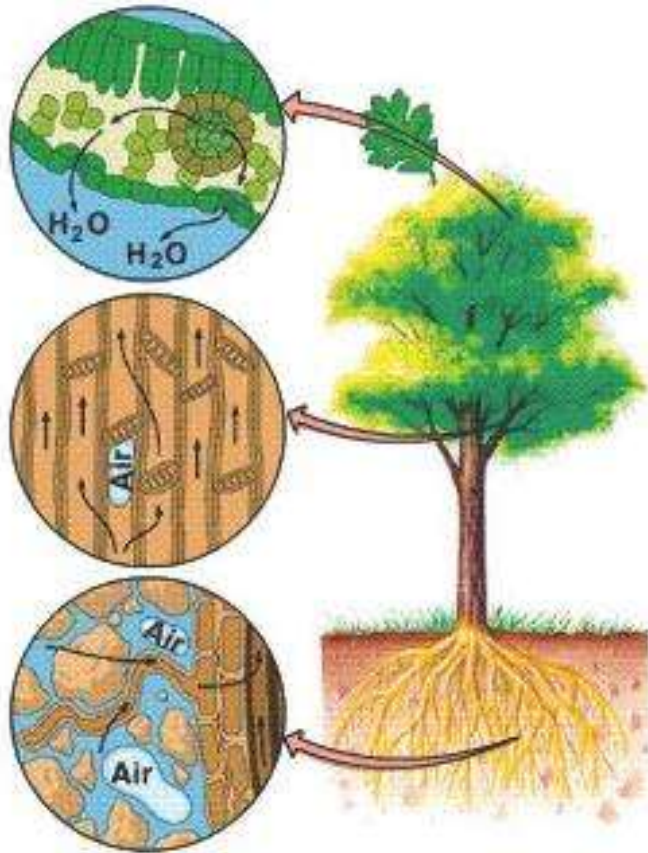
Photosynthesis



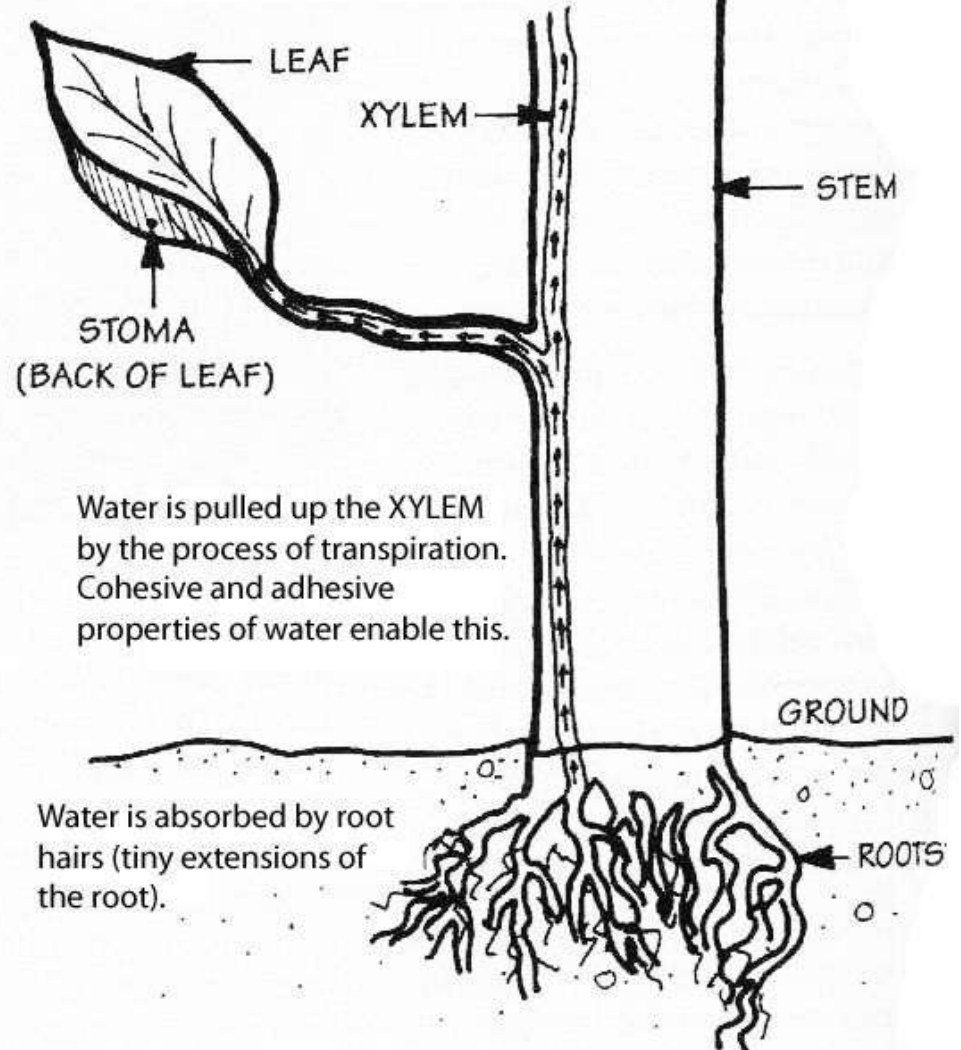
Carbon Cycle



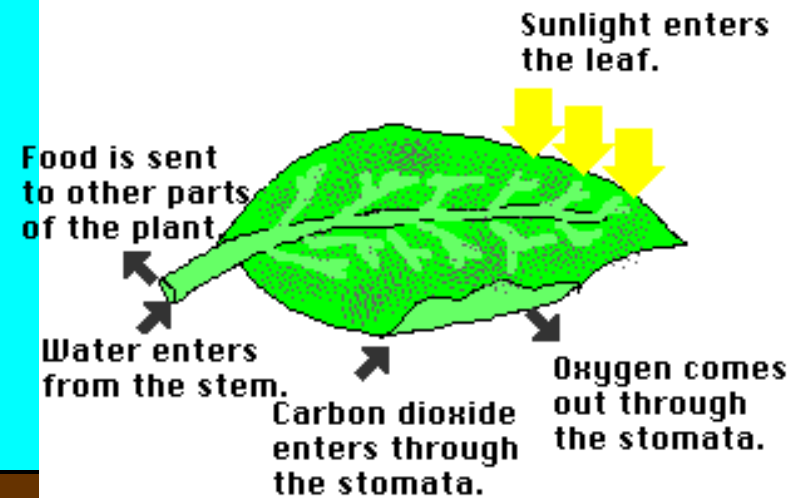
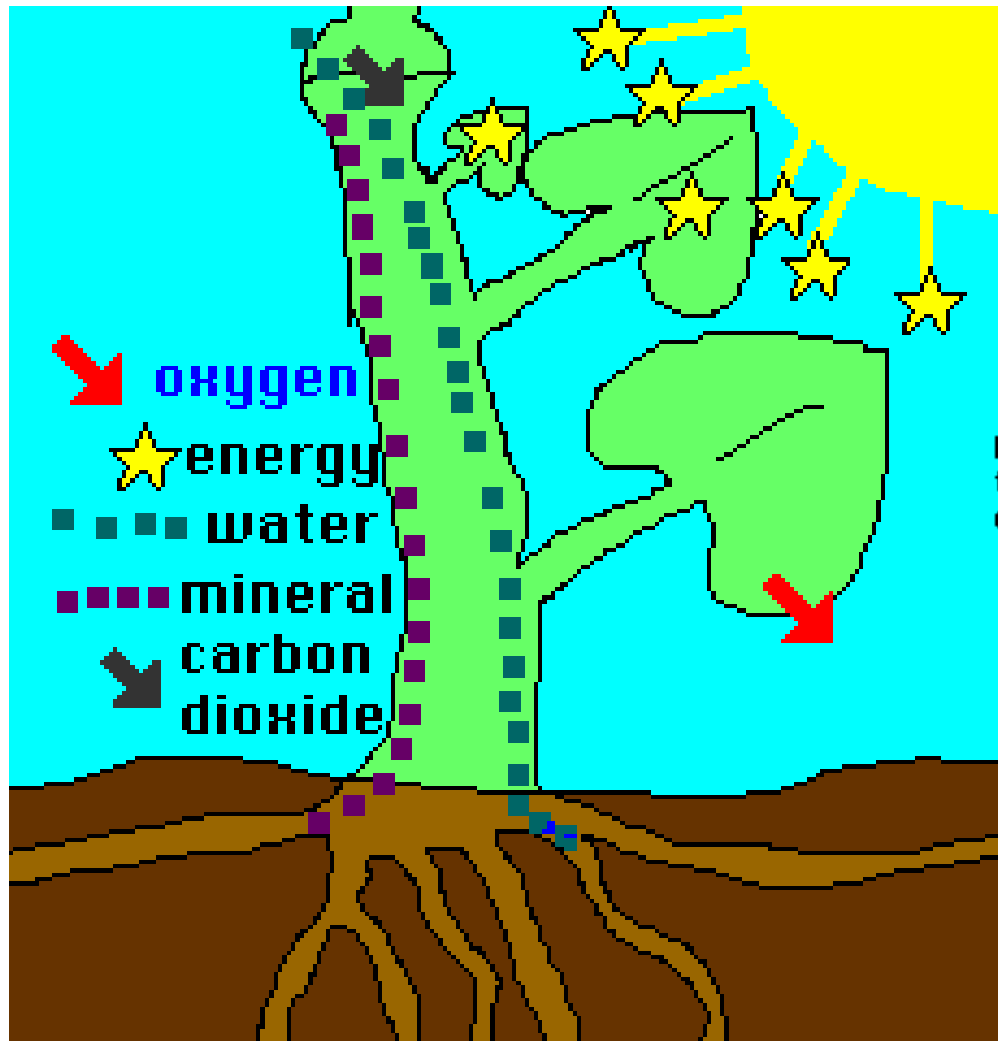
Transpiration



Water exposed to air at the stoma (tiny pore in leaf) is evaporated, creating a pull on surrounding water molecules, including those in the xylem,



Movement of Materials in Plants



Gymnosperms

- Cycadophyta (cycads); Ginkgophyta; Gnetophyta and Coniferophyta
- “Naked” seed
- Seeds can lie dormant for many years
- Conifers developed needles – leaves with heavy cuticle that can resist cold and drought
- Separate male and female reproductive parts (sometimes separate organisms - Diecious)



Classification of Flowering Plants

- Division: Magnoliophyta, Phylum Angiospermophyta or Anthrophyta
- Classes:
 - Magnoliopsida (Dicotyledons) – Dicots
 - Magnoliids
 - Eudicots(magnolias, asters, buttercups, buckwheats, oaks, geraniums, etc.)
 - Liliopsida - Monocots
 - Monocots
 - Commelinids(grasses, orchids, lilies, palms, bananas, ginger, onions)

Angiosperms

- Present by about 140 mya (possibly much older)
- Seeds in a “vessel” (angio) – they are protected
- Often showy flowers to attract pollinators
- Often fleshy seeds to help with dispersal
- Monocots and dicots
- About 65,000 monocots and 170,000 dicots

Monocot versus Dicot

Monocot

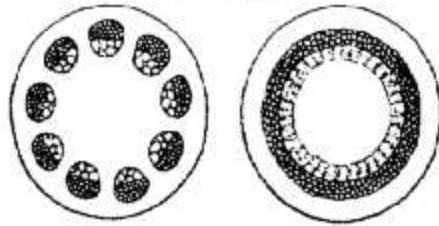


Vascular bundles scattered in stem



Flower parts 3 or multiples

Dicot



Vascular bundles in a circular pattern or joined into a ring



Flower parts 4,5, or multiples



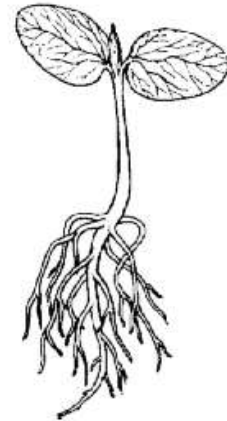
Leaf venation parallel



Leaf venation branched

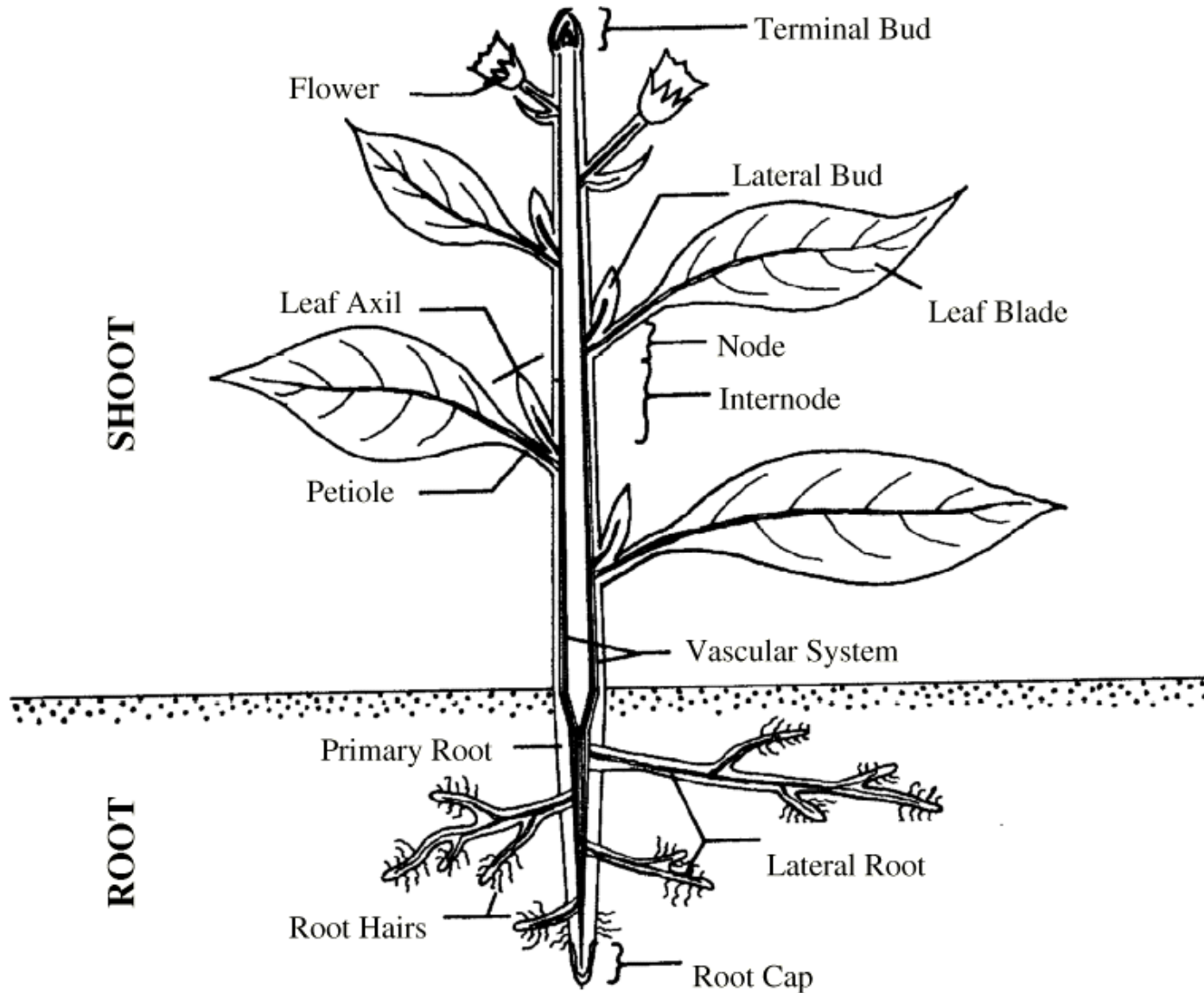


Seedlings with one seed leaf.



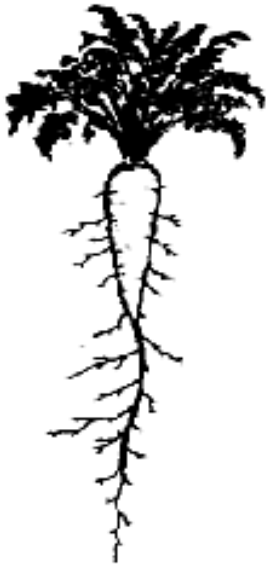
Seedlings with two seed leaves

Principal Parts of a Vascular Plant



Roots

Taproot of Carrot



Fibrous Roots of a Grass

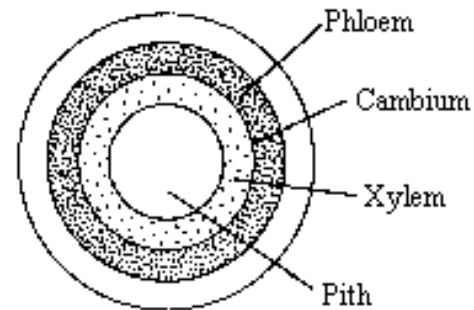
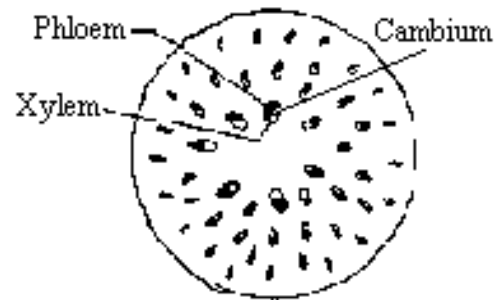


- Roots typically originate from the lower portion of a plant or cutting.
- They possess a root cap, have no nodes and never bear leaves or flowers directly.
- The principal functions of roots are to absorb nutrients and moisture, to anchor the plant in the soil, to furnish physical support for the stem, and to serve as food storage organs.
- In some plants they may be used as a means of propagation.
- There are two primary root types: taproot or fibrous.

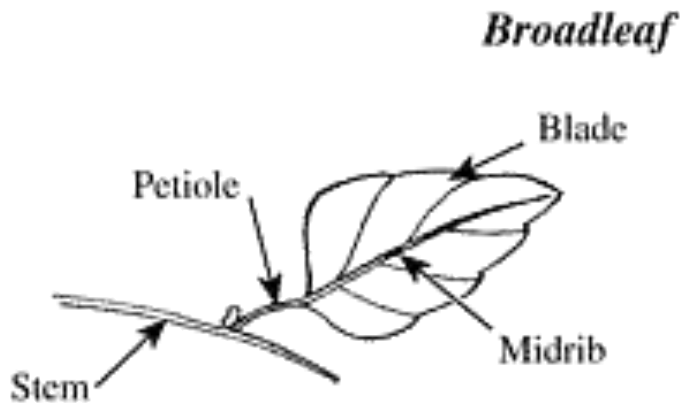
Stems

- Stems are structures which support buds and leaves and serve as conduits for carrying water, minerals, and sugars.
- All stems must have buds or leaves present to be classified as stem tissue.

Cross-Section of a Stem

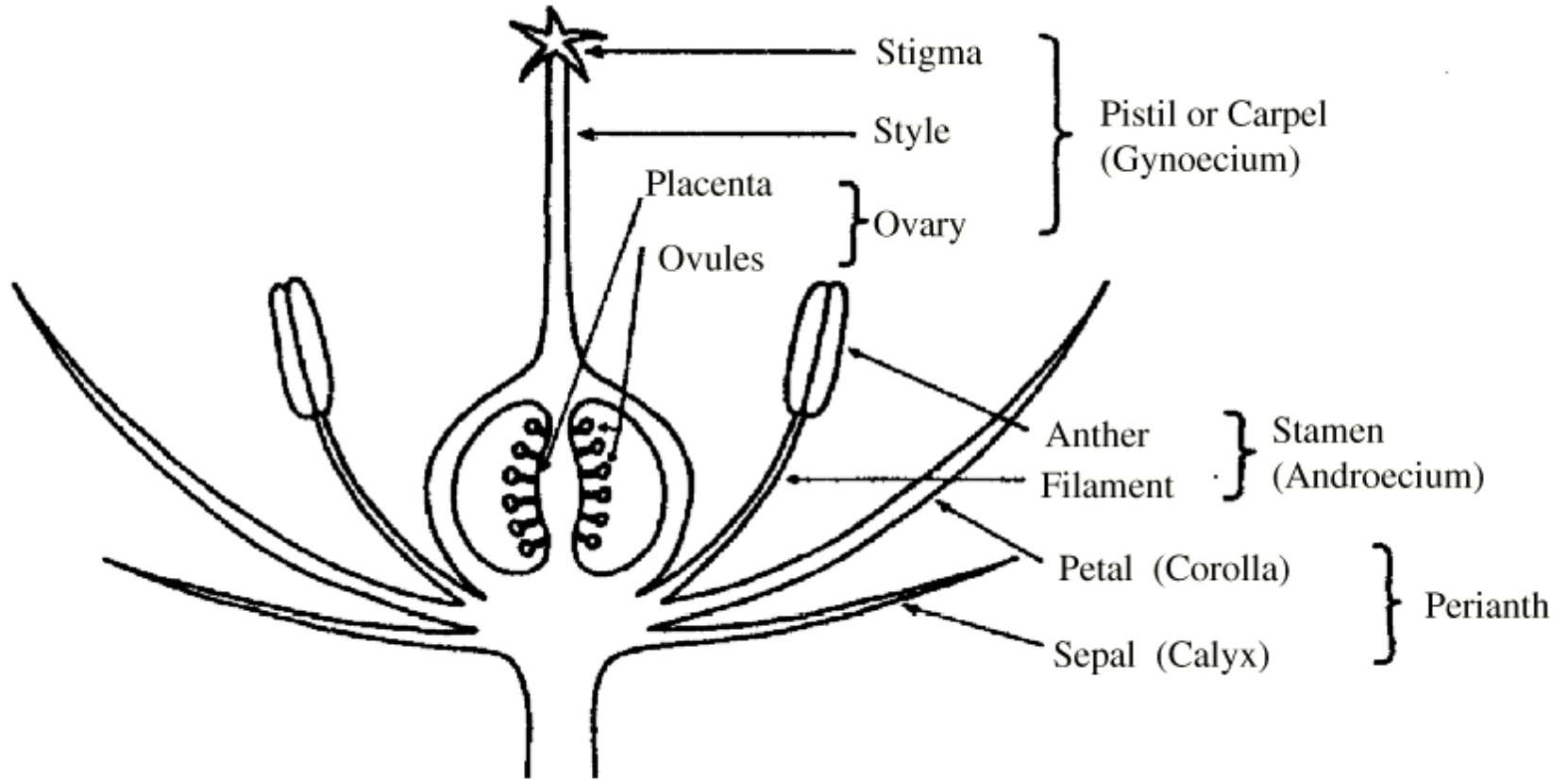


Leaves



- The principal function of leaves is to absorb sunlight for the manufacturing of plant sugars in a process called photosynthesis.
- Leaves develop as a flattened surface in order to present a large area for efficient absorption of light energy.
- The leaf is supported away from the stem by a stem-like appendage called a petiole.
- The base of the petiole is attached to the stem at the node.
- The small angle formed between the petiole and the stem is called the leaf axil.
- An active or dormant bud or cluster of buds is usually located in the axil.

Flower Parts



Fruits



Berry
of tomato



Pepo
of squash



Pome
of apple



Pod
of pea



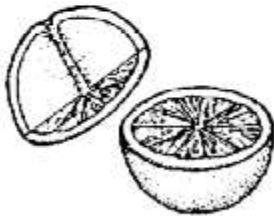
Silique
of crucifer



Follicle
of larkspur



Capsule of
jimson weed



Hesperidium
of orange



Stone or drupe
of peach



Caryopsis
of corn



Achene
of sunflower



Samara
of maple



Schizocarp
of carrot



Nut
of oak

Plants and plant communities

Importance to humans and the environment.

Framework of Life

- Plant communities are the skeletal structure of the biosphere

Air Quality

- Produce oxygen through photosynthesis; can stop the movement of dust and pollutants; can offset the greenhouse effect through carbon intake

Water Quality

- Intercept and slow rain and runoff, facilitate infiltration, control stream flows, and filtering sediments.

Control Erosion and Build Soils

- Stems and leaves shield soils; decaying material protects and provides organic matter; roots hold soils in place.

Climate

- Regional climates are impacted by the amount and type of plant cover. Forest and marshes affect temperature, rain fall, buffer the effects of storms and drought.

Fish and Wildlife Habitat

- Plants and plant communities provide the necessary habitat (a place to live) for wildlife and fish populations.

Importance to humans and the environment. (Continued)

Food

- 3,000 species of plants have been used as food by humans, but 90 percent of the world's food comes from only 20 plant species (most important are 3 species of grasses--rice, wheat, and corn)

Medicine

- Eighty percent of all medicinal drugs originate in wild plants. Only 2 percent of the world's plant species have ever been tested for their medical potential.

Aesthetics

- They add to the beauty of the places that we live.

Industrial Products

- Clothing (fibers); Fuels (wood, ethanol, biodiesel); Construction Materials; Compounds

Recreation

- Plant communities form the basis for many important recreational activities.

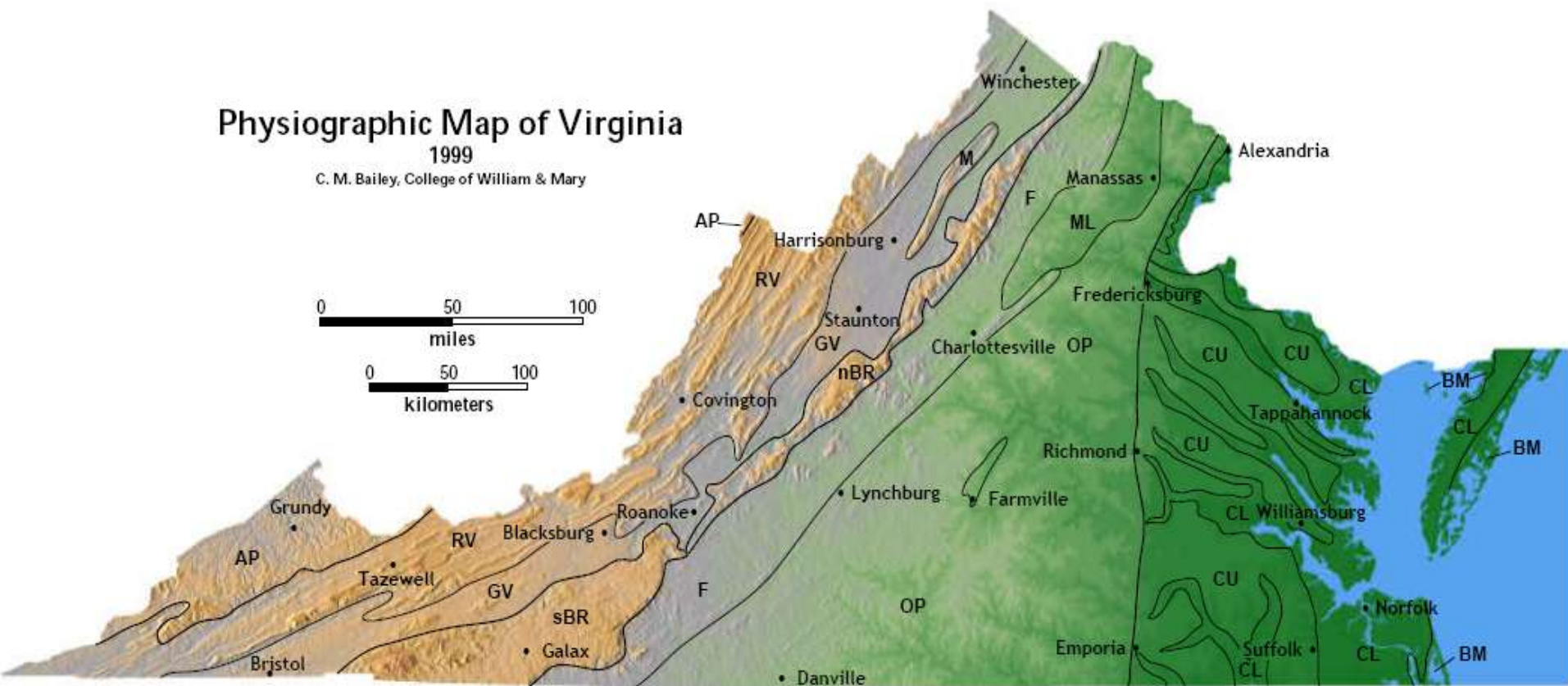
Virginia Plants

- Approximately 4,000 species of plants in Virginia
- Of those 609 considered rare or threatened as of 2007
- Approximately 750 plant species are introduced

Physiographic Map of Virginia

1999

C. M. Bailey, College of William & Mary



Plant Particulars

- 4,000 plant species in Virginia (VA Flora project)
- 120 ecological community groups in VA (largely defined by vegetation)
- Interactions of Plants:
 - Geology/soils, hydrology and localized climate dictate what grows where
 - Plants define the ecosystem and provide the structure/framework for everything else
 - Plants provide food, cover and food that are foundation of communities and ecosystems
 - Plants interact with fungus (up to 90% mycorrhizal associations) and other organisms
 - Plant materials provide organic foundation for soils, roots build soil, roots weather rock
 - Plants locally influence weather (winds; moisture (Blue Ridge); etc.)

Plant Particulars (continued)

- strategies and adaptations
 - niche, growth habit
 - growing in marginal habitats
 - pollination method (wind, self, pollinators)
 - seed dispersal method
- adaptations and how they relate to environmental factors
 - light adaptation
 - hydrologic adaptation
 - temperature and altitude
 - other

Plant Particulars (continued)

- Plants that indicate habitat qualities
 - great blue lobelia, Maryland golden asters, white woodland aster
- Plant associations (include adaptations of individual plants)
 - Table mountain pine and scrub oak
 - Chestnut oak and sassafras
 - Indian grass and little bluestem



Threats to VA Flora and Communities

- Human land conversion & fragmentation
- Frequent disturbance – human or natural
- Over-simplification
- Invasives (EAB, plants, fungal, worms, etc.)
- Deer herbivory
- Human ignorance and attitudes
- Other (climate change, natural catastrophic events, acid rain/air quality, etc.)
- Compound effects





Brasília

Goiânia

Uberlândia

Fortaleza

Recife

Salvador

Belo Horizonte

Rio de Janeiro

Grande São Paulo

Florianópolis



Thunder Bay

Toronto

Ottawa

Saguenay

Sept-Iles

St. John

Québec

Montréal

Detroit

Those light are Boston, New York, Philadelphia and Washington.

Dallas

Houston

Miami

Puerto Rico

Mexico City

Havana

Port-au-Prince

It's still daylight in California

Additional Concepts

- Ecological Memory
- Legacy Forest
- Restoration – what does it mean?
- Land Use History

Natural Resource Management

- Assess and monitor resource
- Define issues and threats — consult experts and stakeholders
- Create Realistic Plan
- Secure Staff, Funds & Equipment
- Manage system, not species
- Preserve best resources and buffers — prioritize
- Control what you can — people, invasives, deer, erosion
- Use Science-based best practices — remove subjectivity; promote objective, best practices
- Think ahead — 50 years, 500 years

Restoration

- Restore Ecological Functions
- Create/Restore Naturally Regenerating Native Plant Systems

Basic Plant ID Questions

- What type of plant is it? (moss, clubmoss, fern, conifer, flowering plant)
- Is it a tree, shrub, vine or herbaceous plant?
- Are the leaves and/or branches/twigs opposite or alternate one another?
- Are the leaves simple, divided or compound?
- If flowers are present, are they irregular or regular, and how many parts do they have?

Tree Characteristics

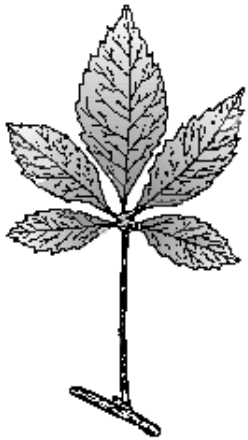
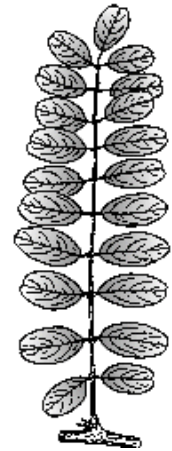
- TREE TYPE --Deciduous or Conifer? Tree or a shrub? Determining these things starts you off on your way to tree identification.
- LEAF --Leaves are often the easiest way to identify most trees. Are the leaves arranged in an opposite or alternate pattern?
- BARK --Bark can be helpful for identifying some types of trees.
- FRUIT --The wide variety of fruit shapes makes them useful when identifying trees.
- TWIG --You can actually tell a lot just by looking at the twig.
- FORM --The way a tree grows can tell you a great deal about a tree.

Tree Leaf Shapes

Simple - not compound, not
divided into secondary units
[Cercis canadensis](#)



Pinnately compound - compound
leaf with the leaflets arranged
on both sides of the rachis or
axis
[Fraxinus americana](#)



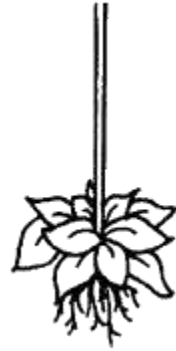
Palmately compound - three or more
leaflets radiating fan-like from a
common basal point of
attachment
[Aesculus hippocastanum](#)



Bipinnately compound - twice
pinnate, the primary leaflets
are divided into secondary
leaflets, also written 2-pinnate
[Gleditsia triacanthos](#)

Leaf Arrangement Along a Stem

Rosulate



Opposite



Alternate

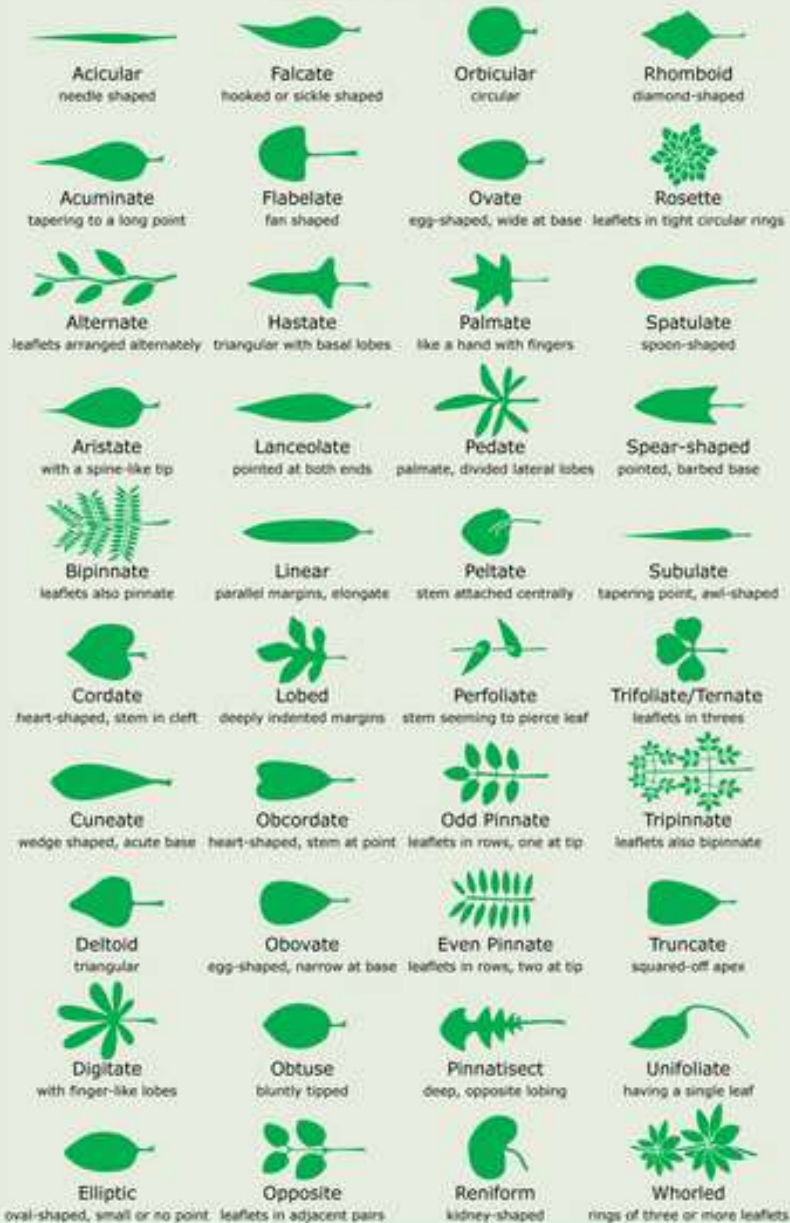


Whorled

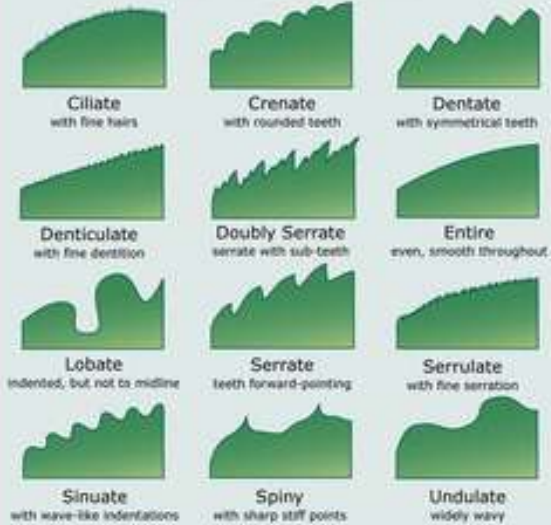


Plant Leaf Shape

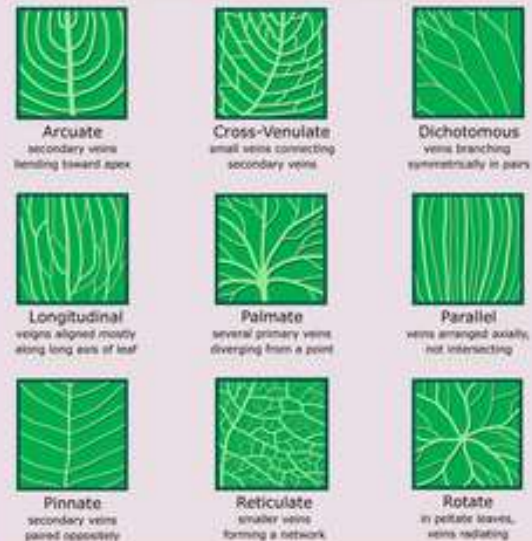
SHAPE



MARGIN

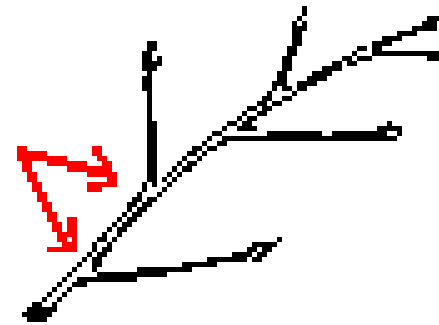
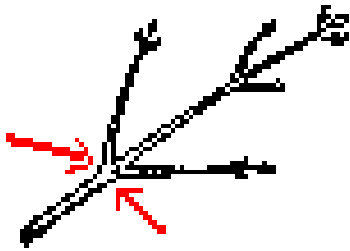


VENATION



Tree Twig Arrangement

Opposite twigs



Alternate twigs

References

- <http://ag.arizona.edu/pubs/garden/mg/botany/index.html>
- http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookPLAN_TANAT.html
- <http://www.colby.edu/info.tech/BI211/Bio211.html>
- Virginia Tree Leaf Key:
<http://www.fw.vt.edu/dendro/forsite/key/intro.htm>
- Multiple Organism Keys:
http://www.amnh.org/learn/biodiversity_counts/resources.html
- Virginia Native Plant Society: <http://www.vnps.org/>
- Digital Atlas of the Virginia Flora: http://www.biol.vt.edu/digital_atlas/
- Virginia Natural Heritage Program:
http://www.dcr.virginia.gov/natural_heritage/
- USDA Forest Service: <http://www.fs.fed.us/database/feis/plants>
- USDA Natural Resources Conservation Service Plant Database:
<http://plants.usda.gov/java>