Land-adapted plants form a monophyletic group (plants originated from a common ancestor).
Land-adapted plants form a monophyletic group (plants originated from a common ancestor).
Charophycean algae are the modern protists most closely related to plants.
FIGURE 1. MAJOR CLADES OF THE GREEN PLANTS. This system reflects all of these changes in the taxonomy of the Viridiplantae with two subkingdoms: Chlorobionta and Streptobionta. See the cladogram adapted from Tudge (2000), the Tree of Life Project, and Palmer et al. (2004) for the consensus view of the molecular/ultrastructural relationships between the higher taxa of the green plants.
VIRIDIPLANTAE
Plants are defined as organisms that:
Plants are defined as organisms that:

1) are multicellular

2) have cellulose cell walls

3) have chlorophyll and are photosynthetic (or originated from photosynthetic ancestors).

4) are adapted to in many ways to life on land (or if aquatic, are descended from land-adapted plants).
Embryophytes

a) Bryophytes
b) Lycophytes
c) Pteridophytes
d) Gymnosperms
e) Angiosperms
All groups of land-adapted plants have a common set of characteristics:

- plant bodies composed of tissues produced by an apical meristem
All groups of land-adapted plants have a common set of characteristics:

- spores with tough walls
All groups of land-adapted plants have a common set of characteristics:

- life history of alternation of generations

haploid gametophyte generation

multicellular, diploid sporophyte generation
All groups of land-adapted plants have a common set of characteristics:

- all plants produce their spores in multicellular enclosures called sporangia
# Traits that characterize the 5 modern plant groups

<table>
<thead>
<tr>
<th>TABLE 21.1</th>
<th>Distinguishing Characteristics of Modern Streptophytes (the land plants and their closest algal relatives)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Charophycean Algae</strong></td>
<td>Apical meristems, when present, do not produce tissues; zygotes the only diploid cells; sporangia absent; spores lack sporopollenin walls</td>
</tr>
<tr>
<td><strong>Embryophytes</strong></td>
<td>Apical-tissue-producing meristems; multicellular sporophytes; sporangia; sporopollenin-walled spores</td>
</tr>
<tr>
<td><strong>Nonvascular Plants</strong></td>
<td>No lignified vascular tissue; no true roots, stems, or leaves; sporophytes unbranched, and cannot grow independently of gametophytes</td>
</tr>
<tr>
<td><strong>Bryophytes (liverworts, mosses, hornworts)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Vascular Plants</strong></td>
<td>Lignified vascular tissue; sporophytes branched and become independent of gametophytes</td>
</tr>
<tr>
<td><strong>Seedless Vascular Plants</strong></td>
<td>Seeds absent; adventitious roots present; embryonic roots absent</td>
</tr>
<tr>
<td><strong>Lycophytes</strong></td>
<td>Leaves lycophylls</td>
</tr>
<tr>
<td><strong>Pteridophytes (ferns)</strong></td>
<td>Leaves euphylls (some lack leaves and/or roots)</td>
</tr>
<tr>
<td><strong>Seed Plants</strong></td>
<td>Seeds present; all leaves are euphylls; embryonic roots present</td>
</tr>
<tr>
<td><strong>Gymnosperms</strong></td>
<td>Flowers and fruits absent; seeds lack endosperm</td>
</tr>
<tr>
<td><strong>Angiosperms</strong></td>
<td>Flowers and fruits present; seeds possess endosperm at least early in development</td>
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</table>
Nonvascular Plants

Bryophytes (liverworts, mosses, hornworts)  
No lignified vascular tissue; no true roots, stems, or leaves; sporophytes unbranched, and cannot grow independently of gametophytes

A) Thallus  
Gametophore of female gametophyte  
Sporophyte

Plagiochila deltoidea, a “leafy” liverwort

Marchantia polymorpha, a “thalloid” liverwort

Marchantia sporophyte (LM)

An Anthoceros hornwort species

B)  
Sporophyte  
Gametophyte

C) Polytrichum commune, hairy-cap moss

Capsule  
Seta  
Sporophyte  
Gametophyte
Vascular Plants

Lignified vascular tissue; sporophytes branched and become independent of gametophytes

Seedless Vascular Plants

Seeds absent; adventitious roots present; embryonic roots absent

Lycophytes
Leaves lycohylls

Pteridophytes (ferns)
Leaves euphylls (some lack leaves and/or roots)
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![Diagram of plant life cycle](image_url)
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Figure 22.1  Plant Biology, 2/e © 2006 Pearson Education

Figure 23.14  Plant Biology, 2/e © 2006 Pearson Education
Major Angiosperm Clades
Major Angiosperm Clades

- The relationships of major angiosperm groups are modeled after the Angiosperm Phylogeny Group 2009 system (APGIII 2009).
APG III 2009

- uses molecular and morphological data

- recognizes only those angiosperm families that are monophyletic
APG III 2009

-classifies one to several families into orders where there is strong evidence that the order is monophyletic
APG III 2009

-classifies one to several families into orders where there is strong evidence that the order is monophyletic

-these designated orders do not represent a hierarchical classification system
Orders can be viewed as convenient placeholders for 1 or more families that appear to comprise a monophyletic group.
Some monophyletic groups that contain several orders are given names.

Ex: Magnoliids
Flowering plants (Angiosperms)

Basal Angiosperms

Amborellales
Nymphaeales
Austrobaileyales
Magnoliids

Monocots
basal Eudicots
Rosids
Asterids

Selected synapomorphies following Judd et al. (2008); tree follows APW October 2008
ANGIOSPERM PHYLOGENY WEBSITE, version 13.
http://www.mobot.org/MOBOT/research/APweb/
The graphic below is redrawn from APG III (page 108, Figure 1, 2009).

APG III Phylogeny of Flowering Plants

http://www.gigantopteroid.org/html/systematics.htm#classification
Amborellaceae

Many phylogenetic analyses agree in placing *Amborella trichopoda* (Amborellaceae) as sister to all of the flowering plants.
Amborellaceae

This means that *Amborella trichopoda* is a descendent of the oldest confirmed branch in the flowering plant family tree.
Amborellaceae

*Amborella trichopoda* is a small, evergreen, shrub of New Caledonia.
Amborellaceae

*Amborella trichopoda* is a small, evergreen, shrub of New Caledonia.
Amborellaceae

Photos: (a) Female flowers, taken by Sangtae Kim, University of Florida. (b) Male flowers, taken by Bill Laidlaw, National Tropical Botanical Gardens. (c) Mature fruit, taken by Jean-Marie Veillon, Faune et Flore de Nouvelle Calédonie.
Nymphaeales
Nymphaeaceae
Nymphaeales
Nymphaeaceae

Nymphaeaceae (water lilies) and Cabombaceae (water shields) are successive sister groups to all other angiosperms.
Nymphaeales
Nymphaeaceae

Aquatic herbaceous plants.

Grow from rhizomes.
Nymphaeales
Nymphaeaceae

Leaves are alternate and simple.

Long petiole and floating blade.
Nymphaeales
Nymphaeaceae

Radially symmetrical flowers with tepals (undifferentiated petals and sepals).
Nymphaeales
Nymphaeaceae

Many free carpels and stamens.

Fig. 441  Flower bud characters of water lily.  a) Intact bud.  b) Front sepals and petals removed to show petaloid staminodes.  c) LS of bud.  Nymphaea odorata
Nymphaeales
Nymphaeaceae

The stamens are poorly differentiated, appearing petal-like.
Nymphaeaceae-Arkansas flora

*Nuphar advena* [syn. *N. lutea*]
Nymphaeaceae-Arkansas flora

*Nuphar advena* [syn. *N. lutea*]

**Fig. 438** Floral characters of spatterdock. a) Portion of perianth removed to show androecium and gynoecium. b) LS of flower. c) All sepals and petals removed to show stamens and stigmatic disk.

*Nuphar luteum*

**Fig. 439** Fruit characters of spatterdock. a) Immature fruit with some persistent sepals and stamens. b) LS of fruit. c) XS of fruit.

*Nuphar luteum*
Nymphaeaceae-Arkansas flora

*Nymphaea odorata* subsp. *odorata* [syn. *N. odorata*]

http://www.ct-botanical-society.org/galleries/pics_n/nymphaeaodor.jpg
Magnoliids

The magnoliid clade consists of:

Magnoliales

Laurales

Piperales

Canellales
Magnoliids

The magnoliid clade consists of:

- Magnoliidae
  - Magnoliales
  - Laurales
  - Piperales
  - Canellales
Magnoliids

The magnoliid clade may be sister to the eudicots.
Magnoliales

Magnoliaceae - *Magnolia* family

The Magnoliaceae consists of trees and shrubs
Magnoliales

Magnoliaceae- *Magnolia* family

The leaves are alternate and simple.

Entire or lobed.

Fig. 443  Leaf of tulip tree, *Liriodendron tulipifera*
Terminal, solitary flowers.

*Magnolia* has spirally arranged tepals, stamens and carpels.
Fig. 447  Floral characters of magnolia.  

a) Flowering branch.  
b) Receptacle bearing intact stamens and stigmas.  
c) Stamen.  
d) CU of stigmas with stigmatic crests on their upper surfaces.  

*Magnolia grandiflora*
Magnoliaceae- *Magnolia* family

The fruit is a cone-like aggregate of follicles or an aggregate of samaras.
Magnoliaceae- *Magnolia* family

The seeds have a fleshy red-orange coat (sarcotesta) (*Magnolia*).
The seeds have a fleshy red-orange coat (sarcotesta) (*Magnolia*).

They are attached to a leaf by a slender thread (funicle).
<table>
<thead>
<tr>
<th>Magnolia Species</th>
<th>Common Name</th>
<th>Arkansas Flora</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnolia acuminata</td>
<td>cucumber magnolia</td>
<td></td>
</tr>
<tr>
<td>Magnolia macrophylla</td>
<td>bigleaf magnolia</td>
<td>4</td>
</tr>
<tr>
<td>Magnolia grandiflora</td>
<td>southern magnolia</td>
<td>1</td>
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**Magnolia acuminata**

**Magnolia macrophylla**

**Magnolia grandiflora**
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1- Introduced

4- Arkansas Natural Heritage Commission Plants of Special Concern (Tracking List)
Magnoliaceae-Arkansas flora

*Magnolia macrophylla*  bigleaf magnolia
Magnoliaceae-Arkansas flora

*Magnolia tripetala*  
*umbrella magnolia*

*Magnolia virginiana*  
*sweetbay magnolia*
Magnoliaceae-Arkansas flora

*Liriodendron tulipifera*  
tulip poplar

Fig. 444 Stem and floral characters of tulip tree.  
a) Branch tip showing new leaf and valvate bud scales.  
b) Flower bud with stipule.  
c) Flower.  
*Liriodendron tulipifera*

Fig. 445 Fruiting structures of tulip tree.  
a) Immature fruit.  
b) Mature fruit (aggregate of samaras).  
c) Samara.  
d) Ring of persistent bracts and central receptacle.  
*Liriodendron tulipifera*
Magnoliales

Annonaceae - custard apple family
Magnoliales

Annonaceae- custard apple family

http://en.wikipedia.org/wiki/Pawpaw

www.fs.fed.us
Annonaceae-Arkansas flora

*Asimina triloba*- pawpaw

http://en.wikipedia.org/wiki/Pawpaw

www.fs.fed.us
Annonaceae-Arkansas flora

Asimina parviflora  
dwarf pawpaw

http://www.duke.edu/~cwcook/trees/aspa.html
Annonaceae-Arkansas flora

Asimina parviflora  
dwarf pawpaw

http://www.duke.edu/~cwcook/trees/aspa.html
Magnoliids

The magnoliid clade consists of:

Magnoliales

Laurales

Piperales
Laurales

Lauraceae—laurel family; bay family
<table>
<thead>
<tr>
<th><strong>Lindera benzoin</strong></th>
<th>spicebush</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lindera melissifolia</strong></td>
<td>pondberry</td>
</tr>
</tbody>
</table>
Lauraceae-Arkansas flora

*Lindera benzoin*  
spicebush

www.sbs.utexas.edu/.../lau/lindera_benzoin.htm
Lauraceae-Arkansas flora

*Lindera benzoin*

spicebush
Lauraceae-Arkansas flora

*Lindera benzoin*  
spicebush

*Lindera melissifolia*  
pondberry  
4
Lauraceae-Arkansas flora

*Lindera melissifolia*  
*pondberry*  

http://www.fs.fed.us/wildflowers/rareplants/profiles/tep/lindera_melissifolia/images/lindera_melissifolia_lg.jpg

www.duke.edu/~cwcook/trees/lime.html
Lauraceae-Arkansas flora

*Lindera melissifolia*  
*pondberry*

http://www.fs.fed.us/wildflowers/rareplants/profiles/tep/lindera_melissifolia/images/lindera_melissifolia_lg.jpg
Persea borbonia  
red bay
Lauraceae-Arkansas flora

Persea borbonia

red bay
Sassafras albidum

http://www.cnr.vt.edu/DENDRO/DENDROLOGY/syllabus/factsheet.cfm?ID=84

greenspade.com/.../sassafras-sassafras-albidum/
Magnoliids

The magnoliid clade consists of:

Magnoliidae

Laurales

Piperales
Piperales

Aristolochiaceae-birthwort family
Aristolochiaceae-Arkansas flora

*Aristolochia reticulata*  Texas Dutchman’s pipe

*Aristolochia serpentaria*  Virginia snakerooot

*Aristolochia tomentosa*  pipevine, Dutchman’s pipe
Aristolochiaceae-Arkansas flora

Aristolochia reticulata  
Texas Dutchman’s pipe

Aristolochia serpentaria  
Virginia snakeroot

Aristolochia tomentosa  
pipevine, Dutchman’s pipe

Aristolochia reticulata

Aristolochia serpentaria

Aristolochia tomentosa
Aristolochiaceae-Arkansas flora

Asarum canadense

wild ginger
Piperales

Sauraceae- lizard’s tail family

![Phylogenetic tree of Piperales and related families]
Sauraceae-Arkansas flora

*Saururus cernuus*  
**lizard’s tail**