Introduction

Fundamentals of Plant Systematics

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What is a plant? How can this be answered?

1) By characteristics of “plants”:
   Photosynthetic
   Cell walls
   Spores
   Sedentary

2) By phylogenetic relationships
Three major groups of life!
Photosynthesis: Evolved multiple times.
How did chloroplasts evolve?

By endosymbiosis:
Primary Endosymbiosis
Secondary Endosymbiosis
Non-photosyn. w/ cell walls & spores
Photosynthetic eukaryotes, including:

- euglenoids
- dinoflagellates
- brown plants
- red algae
- green plants: green algae + land plants

Slime Molds, Water Molds, Fungi

[Formerly, also included bacteria/blue-green "algae" ]
In this course:

“Plants” = Land Plants (Embryophytes)

1) A monophyletic group

2) What most people mean when they say “plants”, as in Plant Systematics.
Chlorobionta (Viridiplantae) - green plants

Embryophytes - land plants

Tracheophytes - vascular plants

Spermatophytes - seed plants

Gymnosperms

Angiosperms

"Green Algae"

Liverworts

Mosses

Hornworts

Lycophytes

Equisetales

Marattiales

Polypodiales

Ophioglossales

Psilotales

Cycads

Ginkgo

Conifers (incl. Gnetales)

Monocots

Eudicots

Flower, carpels, stamens (+ sev. other features)

Seeds

Wood

Xylem & phloem vascular tissue

Independent sporophyte

Cuticle, gametangia, embryo (sporophyte)

Green plant chloroplast
Land Plants - Embryophytes

Liverworts, Hornworts, Mosses
Vascular Plants - Tracheophytes

Lycophytes (Lycopods)

*Isoetes orcuttii*

*Selaginella apoda*

*Selaginella bigelovii*
Vascular Plants

Equisetophytes (Equisetales): *Equisetum*

*Equisetum arvense*
Common Horsetail

*Equisetum spp.*
Scouring-Rush
Vascular Plants

Ophioglossoid Ferns (Ophioglossales)

*Ophioglossum californicum*
Calif. Adder’s Tongue
Vascular Plants - Tracheophytes

Psilotophytes (incl. *Psilotum*, *Tmesipteris*)
Vascular Plants - Tracheophytes

Marratiophytes
Vascular Plants

Leptosporangiate Ferns
(Polypodiales)

Polypodium californicum
California Polypody

Dryopteris arguta
Coastal Wood Fern
Seed Plants: Gymnosperms

Cycads

Cycas circinalis

Ginkgo

Ginkgo biloba
Conifers

*Abies concolor*
White Fir

*Pinus torreyana*
Torrey Pine

*Cupressus forbesii*
Tecate Cypress
Gnetales

Welwitschia mirabilis

Ephedra spp.  Mormon Tea
Seed Plants: Angiosperms - Flowering Plants
Monocots

parallel venation

floral parts in 3’s (often)
Eudicots

- 2 cotyledons
- floral parts in 4’s or 5’s (often)
- net venation

NON-MONOCOT

- embryo
  - epicotyl
  - hypocotyl
  - radicle
- seed coat
- endosperm
- 2 cotyledons
Why study plants? Why important?

Oxygen

Primary producers

Economically important to human

agricultural plants (food): vegetables, fruits, seeds
flavoring plants: herbs & spices
euphoric/hallucinogenic plants
fiber, wood plants
medicinal plants
plant extracts: essential oils, gums, rubber, etc.
What is Systematics?

Inclusive of *taxonomy*
Goal is to infer *evolutionary history* (phylogeny)
Using all types of evidence
What is (biological) evolution?

Descent with Modification
Descent

The origin of new life from pre-existing life by transfer of DNA from parent to offspring generation after generation.
Descent results in a **lineage** (clade)!

- **Lineage** or **clade** = a sequence of ancestors (parents) and descendants (offspring)
- Involves transfer of DNA through space and time
What is modified?

Genetic material:

DNA

(DeoxyriboNucleicAcid)
Two mechanisms for evolutionary change?

**Natural Selection** - non-random, directed by survivorship & reproductive ability

**Genetic drift** - random, directed by chance events
What is a functional feature that results in increased survivorship and reproductive ability?

Adaptation
Taxonomy: D.I.N.C.

Description

Identification

Nomenclature

Classification
Description

Assignment/listing of features or attributes to a taxon

character

= a feature

e.g., “flower color”

character states

= two or more forms of a character

e.g., “white,” “red,” “yellow”
Identification

Associating an unknown taxon with a known one

How?

- taxonomic key
- compare to a photograph/illustration
- compare to a specimen
- ask an expert
**Key (dichotomous/indented):**

1. Stamens fused at base into a tube ....................  *Dichelostemma*

1' Stamens not fused at base into a tube

*Lead:*

2. Fertile stamens 3 ............................................................  *Brodiaea*

*Lead:*

2' Fertile stamens 6

3. Stamens strongly winged at base .........................  *Bloomeria*

3' Stamens not strongly winged at base ....................  *Muilla*

*Couplet = two Leads*
Key (dichotomous/indented):

1  Ovary inferior
   2  Ovule 1 per carpel ................................................................. Dilatris
   2’ Ovules 2 or more per carpel
      3  Ovules 2 per carpel .............................................................. Haemodorum
      3’ Ovules 5-7 per carpel ............................................................ Lachnanthes
1’ Ovary superior
   4  Perianth actinomorphic; ovules ∞ per carpel .................................. Xiphidium
   4’ Perianth zygomorphic; ovules 1-4 per carpel
      5  Fertile stamen 1 .................................................................. Pyrorrhiza
      5’ Fertile stamens 3
         6  Stamens unequal, the two latero-posterior reduced; ovules 3-4 per carpel .... Schiekia
         6’ Stamens equal; ovule 1 per carpel
            7  Inflorescence a raceme; functional carpel 1; style subterminal .......... Barberetta
            7’ Inflorescence a thyrse; functional carpels 3; style terminal .......... Wachendorfia
Nomenclature

Formal means of naming life.

E.g., binominal nomenclature for species names:

For *Adenostoma fasciculatum* Hook. & Arn.

*Adenostoma* = genus name
*fasciculatum* = specific epithet
*Adenostoma fasciculatum* = species name

Hooker & Arnott = authors of species name
Classification

= placing objects, e.g., life, into some type of order.

**Taxon** = a taxonomic group (plural = **taxa**).
# Rank Classification

Hierarchical - each higher rank is inclusive of lower ranks

<table>
<thead>
<tr>
<th>Rank</th>
<th>Example</th>
<th>Ending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylum</td>
<td>Magnoliophyta</td>
<td>-phyta</td>
</tr>
<tr>
<td>Class</td>
<td>Liliopsida</td>
<td>-opsida</td>
</tr>
<tr>
<td>Order</td>
<td>Liliales</td>
<td>-ales</td>
</tr>
<tr>
<td>Family</td>
<td>Liliaceae</td>
<td>-aceae</td>
</tr>
<tr>
<td>Genus</td>
<td><em>Lilium</em></td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td><em>Lilium parryi</em></td>
<td></td>
</tr>
</tbody>
</table>
How to classify life

Phenicetic classification

Based on overall similarity

Those organisms most similar to one another are classified more “closely” together.
Problem with phenetic class.:

Can be arbitrary,

e.g., classify these:
Phylogenetic classification

Based on known (inferred) evolutionary history.

Advantage:
- Classification reflects pattern of evolution
- Classification not ambiguous
All of life is interconnected by descent.
Cladogram or Phylogenetic Tree

TIME

TAXA

A B C D E F

speciation
Apomorphy

= derived (new) feature, e.g.,

sporophyll  ------->  carpel
(ancestral feature)  (apomorphy)

Presence of carpels - an **apomorphy**
for flowering plants.
Taxa are grouped by apomorphies

Apomorphies - the result of evolution.

Taxa sharing apomorphies underwent same evolutionary history, should be grouped together.
Phylogeny = Evolutionary History

Represented as: Cladogram / Phylogenetic Tree

TAXA

TIME

Apomorphies for taxa B&C
Apomorphies for taxon D
Apomorphy for taxa B-F
Common ancestry

Cladogram or Phylogenetic Tree
Split of one lineage into two?

Evolutionary divergence.

Can lead to speciation - origin of new species from pre-existing species.
Cladogram or Phylogenetic Tree

TIME

TAXA

speciation

A B C D E F
What is a monophyletic group?

A group consisting of:

- A common ancestor +
- All descendants of that common ancestor
Cladogram or Phylogenetic Tree
Cladogram or Phylogenetic Tree

- **Taxa**: A, B, C, D, E, F
- **Monophyletic group**: Branching off from a common ancestor (of taxa A, B, C, D, E, F)
- **Common ancestor** (of taxon A & taxa B-F): The point where the branches diverge from the common ancestor of taxa A, B, C.
- **Common ancestor** (of taxon D, E, & F): The point where the branches diverge from the common ancestor of taxa D, E, F.
Relationship

■ = recency of common ancestry

i.e., taxa sharing a common ancestor more recent in time are more closely related than those sharing common ancestors more distant in time.
Example:

Are fish more closely related to sharks or to humans?
Shark  Fish  Humans

common ancestor of Fish and Humans

common ancestor of Sharks, Fish, and Humans
monophyletic group
common ancestor of Sharks, Fish, and Humans
common ancestor of Fish and Humans
monophyletic group
common ancestor of Fish and Humans
Vertebrata
Osteichthyes
Shark
Fish
Humans
TIME
Major goal in systematics today:

Recognize only monophyletic groups
Polyphyletic group

Group with more than one common ancestor.

(Common ancestor of components of group is not a member of the group.)
Group consisting of B, C, E, & F is polyphyletic: two common ancestors
Lotus

Lotus s.l. is not monophyletic. It is polyphyletic!

Type: Lotus corniculatus L.

Fig. 1. Strict consensus of the eight most parsimonious trees based on ITS sequence data. Numbers above the branches are decay values/branch lengths; numbers below the branches are bootstrap percentages. The traditional tribal classification is also shown, with filled circles (●) denoting members of Loteae and open triangles (△) denoting Cornillieae. The most recent taxonomic arrangements (Polhill, 1994; Sokoloff, 1998) combine members of these two tribes under Loteae.

Species Planatarum
Volume 2, page 773.
Therefore, we now recognize three monophyletic genera (formerly all *Lotus*).

**Acmispon**

**Hosackia**

**Lotus** s.s.

Fig. 1. Strict consensus of the eight most parsimonious trees based on ITS sequence data. Numbers above the branches are decay values/branch lengths; numbers below the branches are bootstrap percentages. The traditional tribal classification is also shown, with filled circles (●) denoting members of Loteae and open triangles (△) denoting Coronilleae. The most recent taxonomic arrangements (Polhill, 1994; Sokoloff, 1998) combine members of these two tribes under Loteae.
Paraphyletic group

Consist of common ancestor but not all descendents
"Dicots" paraphyletic!
Features that defined traditional “Dicots” (two cotyledons in embryo seed) are primitive (not apomorphies)
Monocots monophyletic
Major goal in systematics today:

Recognize only monophyletic groups

Polyphyletic and paraphyletic groups distort evolutionary history, should not be recognized.
Eudicots monophyletic!
Why study systematics?

Foundation of biology

Integrative, unifying science

Practical value - economically important plants

Conservation biology - rare/endangered spp.

Intellectually challenging / fun