

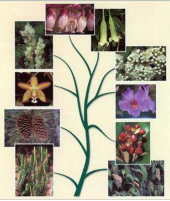
FAQs

Textbook – Is the textbook mandatory or suggested?


Is edition 7 equivalent to edition 8?

Midterm – what is the format & content?

Possibility of a revision class prior to the midterm?

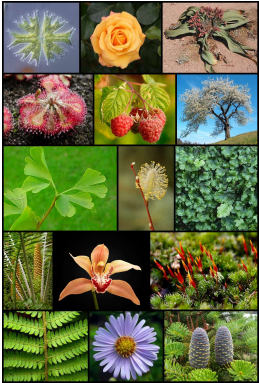


Recap
Evolutionary Processes
in Plants
Chapter 11



THE ORIGIN OF PLANT SPECIES

- *Species* is a Latin word meaning “kind” or “appearance”
- **Morphological species concept** – differentiation of species based on anatomical and morphological criteria (ie, appearance)



So, what is a species?

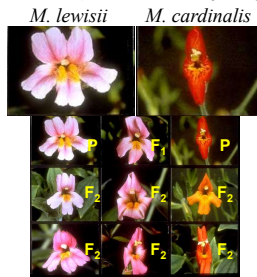
The **biological species concept**: a species is a group of interbreeding natural populations that are entirely **reproductively isolated** from other such groups



M. lewisii and *M. cardinalis* have overlapping habitat ranges but do not interbreed in nature

So, what is a species?

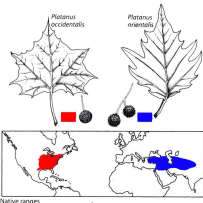
Biological species concept - implies that two individuals of different species cannot produce fertile young...



These sister species may be cross-fertilized in a lab and produce fertile offspring...so are these distinct species?

Plants Hybridize Widely!

Hybridization: the crossing of unlike parents (could be individuals within a species or even different species)



Populations of *P. orientalis* and *P. occidentalis* were isolated for 50MY

Hybridization in Europe produced fertile offspring



London Plane Sycamore



NYC Parks

So, what is a species?

Phylogenetic species concept: a population whose members are descended from a common ancestor and who all possess a combination of certain defining, or derived, traits

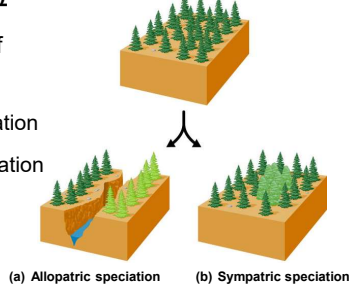
- This implies genetic isolation but **does not** require a breeding test or **complete** genetic isolation to determine whether two things are species



Mechanisms of Speciation

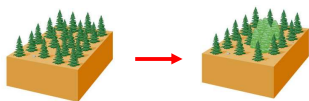
- For a species to evolve, there needs to be the creation of a **reproductive barrier** (we need genetic isolation)
- The two modes of speciation are

1. **Allopatric** speciation
2. **Sympatric** speciation



2. Sympatric Speciation

Sympatric speciation occurs if a genetic change produces a reproductive barrier between **mutants** and the **parent population**



Especially prevalent in **plants**...less so in animals

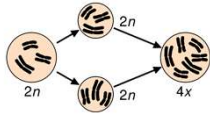
The major process is...

Polyploidy

2. Sympatric Speciation

Polyploidy = the possession of more than two sets of chromosomes

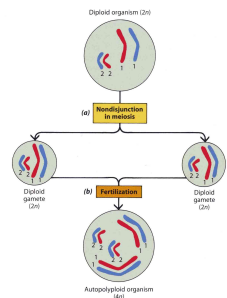
"Instant Speciation"
genetic isolation
is immediate



Two kinds:

1. **Autopolyploidy** = multiple sets of chromosomes from a single species
2. **Allopolyploidy** = multiple sets of chromosomes from different species (two or more)
 - More common

2. Sympatric Speciation - Autopolyploidy

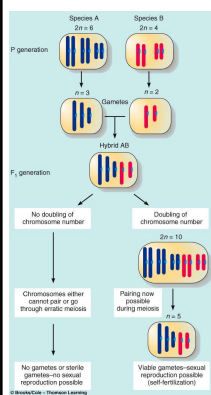


Oenothera (Onagraceae)
"Evening Primroses"



Note that polyploids are often larger than their diploid ancestors → Cells have twice the DNA, twice the size

2. Sympatric Speciation - Allopolyploidy



"Instant Speciation" genetic isolation is immediate





Originate from a cross between 2 species to produce a (sterile) hybrid

↓
Autopolyploidy
↓
Allopolyploidy

Note: Allopolyploidy is an example of **Hybrid Speciation**

Plant Evolution: Polyploidy

Polyloid types are termed according to the number of chromosome sets in the nucleus:

- triploid (three sets; 3x) → INFERTILE 
- tetraploid (four sets; 4x) → FERTILE 
- pentaploid (five sets; 5x) → INFERTILE 
- hexaploid (six sets; 6x) → FERTILE 

Systematics: the Science of Biodiversity



Previously we discussed the mechanisms of evolution
Today, we consider the products of evolution – the diversity of life forms on this planet

Systematics: The scientific study of biodiversity

• ca. 1.75 million species known
• Possibly 30 to 50 million to find




Systematics

The science that names, classifies, and determines the evolutionary relationships of living organisms


Taxonomy

- consists of identifying, naming and classifying species




Phylogeny

- Evolutionary history of organisms



The Modern Origin of Systematics



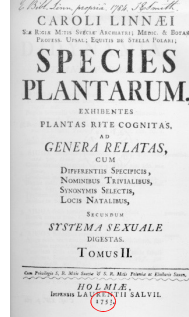
Carl Linnaeus
1707 – 1778

Devised the binomial system for naming species

8000 species
(all known plants at the time)

↓

Today we recognise over 260 000 species of plants



The Binomial System

e.g., *Tilia americana* L.
(Basswood or Linden Tree)


Binomial 'two term' nomenclature

Polynomial descriptive Latin phrases

Species names: written in *Latin* and in *italics* or underlined

A complete species name consists of three parts:

- i) genus
- ii) a specific descriptor or epithet
- iii) (author)



Carl Linnaeus
1707 – 1778

Species Plantarum 1753

The Binomial System

e.g., *Tilia americana* L.
(Basswood or Linden Tree)



Carl Linnaeus
1707 – 1778

Binomial 'two term' nomenclature

Polynomials

descriptive Latin phrases

A complete species name consists of three parts:

- i) genus e.g., *Tilia*
- ii) epithet e.g., *americana*
- iii) (author) e.g., Linnaeus

Tilia americana L.



The Binomial System

Polynomials (descriptive Latin phrases):
Nepeta floribus interrupte spicatus pedunculatis

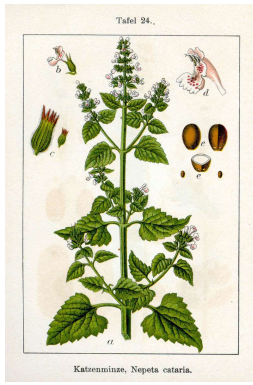
Translated: *Nepeta* with flowers in an interrupted pedunculated spike

Epithet: *cataria* (cat-associated)

Author: Linnaeus

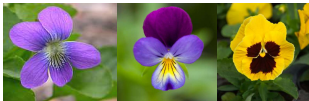
Complete species name:
Nepeta cataria L.

a.k.a. catnip!



The Binomial System

Important points: The generic name (i.e., genus) may be written alone when referring to all species within that genus



Viola is comprised of ~500 species.
also permissible is '*Viola* sp. represent ~500 members'.

The Binomial System

Important points: You cannot use the epithet alone



*Artemisia
biennis*

*Oenothera
biennis*

*Lactuca
biennis*

biennis biennis, biennis, bienne
adjective two years old; lasting two years;

Type Specimen

Typically a dried plant representing the first specimen of the new species/genus

Stored in a museum or herbarium by the author (or someone else)

Basis for comparison with other specimens to determine if same species.



Taxonomic Hierarchy

Taxon (pl. taxa) = all named organisms/groups
e.g., *Prunus* is a taxon within the category of genus

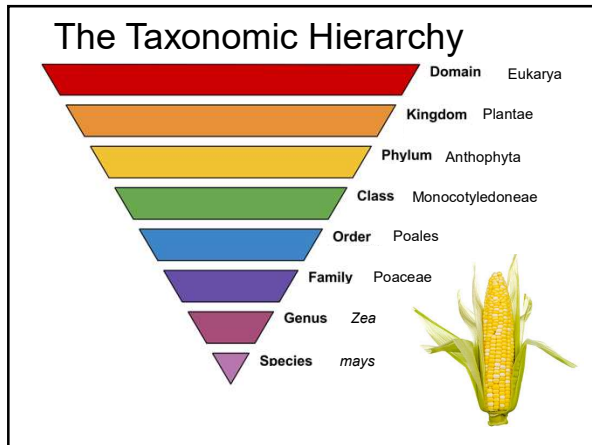
Species are grouped into higher taxa that are more and more inclusive according to their affinities (similarity to other species and taxa)

Taxa are grouped in a strict series of ranks with standardised endings

– Kingdom	Plantae	Protists	Fungi
– Divison	- <i>phyta</i>	- <i>phyta</i>	- <i>mycota</i>
– Class	- <i>opsida</i>	- <i>phyceae</i>	- <i>mycetes</i>
– Order	- <i>ales</i>	- <i>ales</i>	- <i>ales</i>
– Family	- <i>aceae</i>	- <i>aceae</i>	- <i>aceae</i>

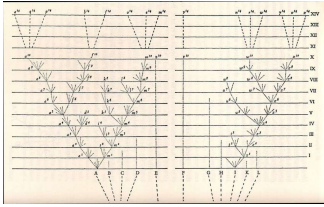
The Taxonomic Hierarchy

Rank	Taxon	Standardised Ending
Domain	Eukarya	
Kingdom	Plantae	
Division/Phylum	Anthophyta	-phyta = Division/Phylum
Class	Magnoliopsida	-opsida = Class
Order	Asterales	-ales = Order
Family	Asteraceae	-aceae = Family
Genus	<i>Aster</i>	} Always <u>underlined</u> or in <i>Italics</i>
Species	<i>alpinus</i>	



What is a valid classification?
(how do we classify organisms?)

((why is this important?))



A phylogenetic tree of species relationships

The members of a group are similar because they have a common evolutionary origin → Phylogeny – Evolutionary relationships among organisms

New desire for classifications to accurately reflect evolutionary relationships
Such classifications are referred to as '**Natural classifications**'

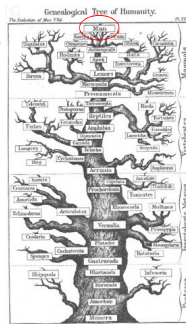
Let's take five...



Phylogenetic tree: a representation of the genealogical relationships of taxa, based on a hypothesis of these relationships

Traditionally, phylogenetic relationships were inferred by outward similarities (anatomy, morphology)

(influenced by investigator's opinions regarding which factors are most important)

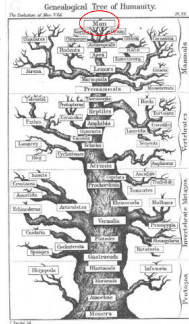


Phylogenetic Tree (as hypothesized; subjective)

Phylogenetic tree: a representation of the geneological relationships of taxa, based on a hypothesis of these relationships



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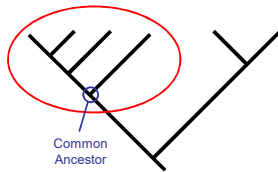
Phylogenetic Tree (as hypothesized; subjective)

How do we classify organisms?

Classification must be based on **natural** (i.e., evolutionary) **groups**.

Monophyletic = Clade

Natural

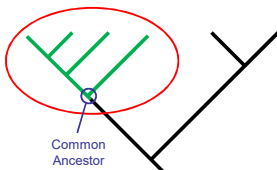


Natural, monophyletic groups (i.e., clades) comprise all the descendants of the single, most recent common ancestor for the group

How do we classify organisms?

Natural

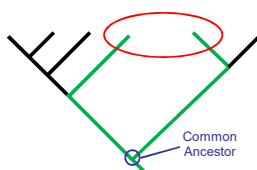
Monophyletic = Clade



Natural, monophyletic groups (i.e., clades) comprise all the descendants of the single, most recent common ancestor for the group

Artificial

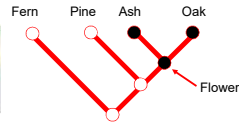
Non-monophyletic



Artificial groups lack one or more descendants of the most recent common ancestor

How do we identify natural groups?

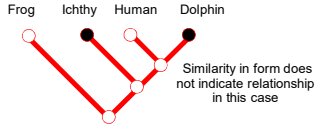
Homology: similarity due to common ancestry



Analogy: similarity due to convergence



Dolphin
(modern mammal like us)



Homology versus Analogy

Embrace the following rules:

Homologous features have a common **origin**

Analogous features have a common **function**
(but different origin)



Edible Root Tubers of Sweet Potato



Edible Stem Tubers of Potato

Homology versus Analogy

Embrace the following rules:

Homologous features have a common **origin**

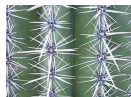
Analogous features have a common **function**
(but different origin)



Trap of a venus fly trap



Leaf of a maple tree



Spine of a cactus



Thorn of a hawthorn

Appearances can be deceiving!

Analogous traits

Genes conserved for arbuscular mycorrhizal symbiosis identified through phylogenomics
Andrews-Shanks, Thomas Ock, Nathan Fungler, Leticia A. Mueller and Black J. Hamdorf

Used a phylogenomics strategy to identify genes that are present in AMS hosts and absent from genomes of AMS non-host plants

62,319 proteins in Medicago (a plant that forms the symbiosis)

↓

Searched the genomes of 11 non-host plants + 39 host plants for matching proteins

↓

Identified 138 proteins that are present in host-plants and absent in non-host plants

Exam ↓ Most of these were entirely new candidates, previously unsuspected of playing a role in symbiosis

Cladistics – most commonly used classification today

Synapomorphies are character traits that arose in a common ancestor and are present in all progeny (i.e., shared, derived characters)

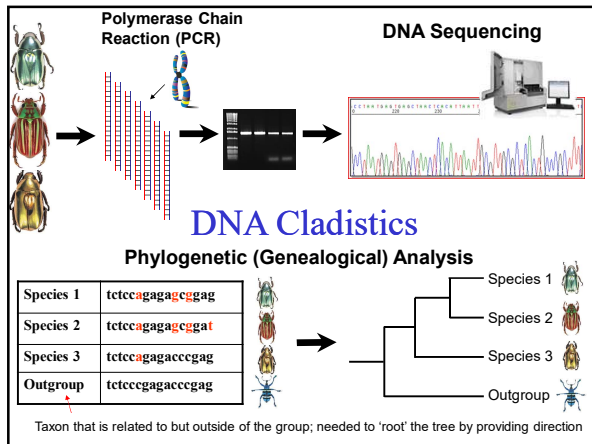
A **cladogram** is a working model (hypothesis) of phylogenetic relationships among a group

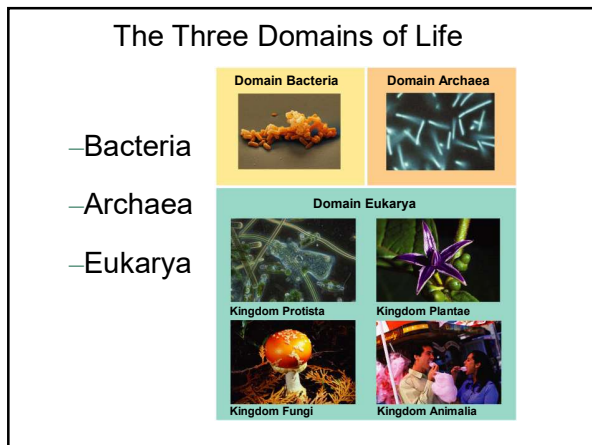
Willi Hennig
 Founder of cladistics

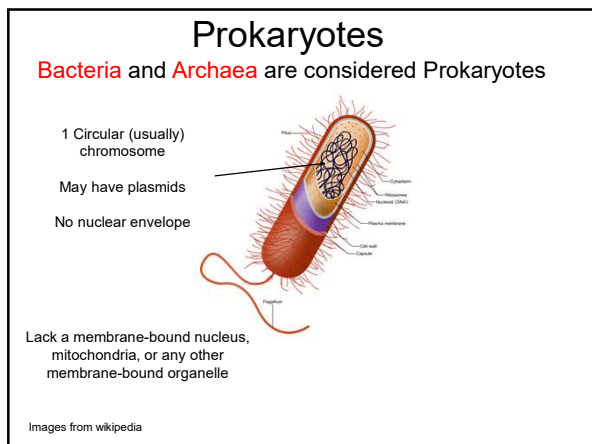
A **cladogram** is a working model (hypothesis) of phylogenetic relationships among a group, based upon shared derived characters

	Characters				
Taxon	Xylem & Phloem	Wood	Seeds	Flowers	
Mosses					
Ferns					
Pines					
Oaks					

Traditionally, classification was based on morphology and anatomy...
 ...advent of molecular techniques ushered in a new era







Evolutionary relationships between the 3 domains of life

