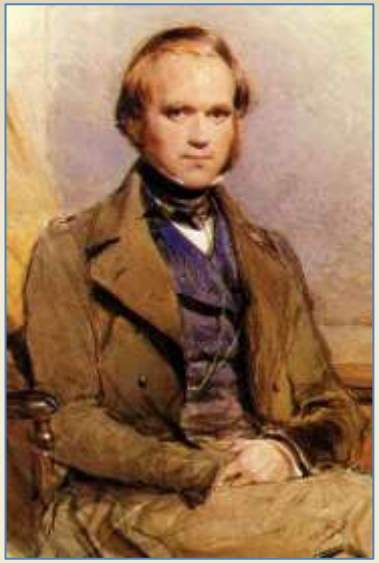
Plant Systematics and Evolution



CAROLI LINNÆI

EQUITIS DE STELLA POLARI,

ARCHIATRI REGII, MED. & BOTAN. PROFESS. UPSAL.;
ACAD. UPSAL. HOLMENS. PETROPOL. BEROL. IMPER.
LOND. MONSPEL. TOLOS. FLORENT. SOC.

SYSTEMA NATURÆ

PER

REGNA TRIA NATURÆ,

SECUNDUM

CLASSES, ORDINES,
GENERA, SPECIES,

CUM

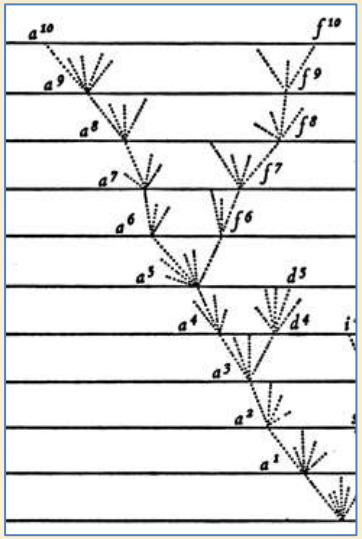
CHARACTERIBUS, DIFFERENTIIS,
SYNONYMIS, LOCIS.

TOMUS I.

EDITIO DECIMA, REFORMATA.

Cum Privilegio Sac. Reg. Majest. Suecia.

HOLMIÆ,
IMPENSIS DIRECT. LAURENTII SALVII,
1758.



Cave Paintings – Lascaux, France – Cro-Magnon - 17,300 years old

Where do plant and animal names come from?

Prehistory - Bushmen?

San women gathering for food.
Ghanzi, Botswana.

The Bible – Adam?

And out of the ground the Lord God formed every beast of the field and every fowl of the air and brought them unto Adam to see what he would name them, and whatsoever Adam called every living creature, that was the name thereof.
--Genesis 2:19

Prehistory - Naming Plants

- Ancient people needed to communicate about which plants were edible, poisonous or could be used medicinally
- They needed to identify plants to be used for food, medicine, fiber, or for shelter
- Names varied from region to region and among different languages and cultures

Common Names of Plants

Many ways to classify plants - climate; seasons; edible parts; use; foliage, flowers, growth habits, etc.

Every culture and language group throughout history has had their own names for plants (and still do).

Common Names

- Common names can be confusing
  - Poison Oak is not an oak
  - Poison Ivy is not an ivy
  - Canna lily is not a lily
  - Pineapple is not an apple

- Can you think of others?

Common Names

Problems with common naming include:

- One plant having many common names
  - *Maclura pomifera*, commonly called Osage orange, also known as hedge apple, horse apple, monkey ball, bois d'arc, bodark, bodock, wild. orange, mock orange etc.

- Many different plants having the same common name, for example:

- "Creeping Jenny" can apply to 15 different plants

Common names change with time

Example – the Tomato has had many names.

- Tomatotl – name used by the Aztecs. Domesticated in Mexico.
- Tomate in Spanish.
- Apple of Peru. Spanish Conquistadors brought it back to Europe, distributed it at home and colonies.
- *Poma amori* - the love apple, started life either as *poma di Mori*, the apple of the Moors or *poma di ori*, the golden apple. Over time, became corrupted to *poma amoris,* and the tomato was presumed to be a powerful aphrodisiac
- Wolf Peach (*Lycopersicum*) – Genus name for many years, reference to supposed poison.
- Now placed in genus *Solanum*

Why we need a single “scientific name”

- Facilitate communication
- Scientists worldwide rely on accurate information about organisms, need to be able to look up information.
- Buyers require correct ordering information to guarantee they receive the correct plant species

Some concepts and definitions…..

Nomenclature – system for naming objects.

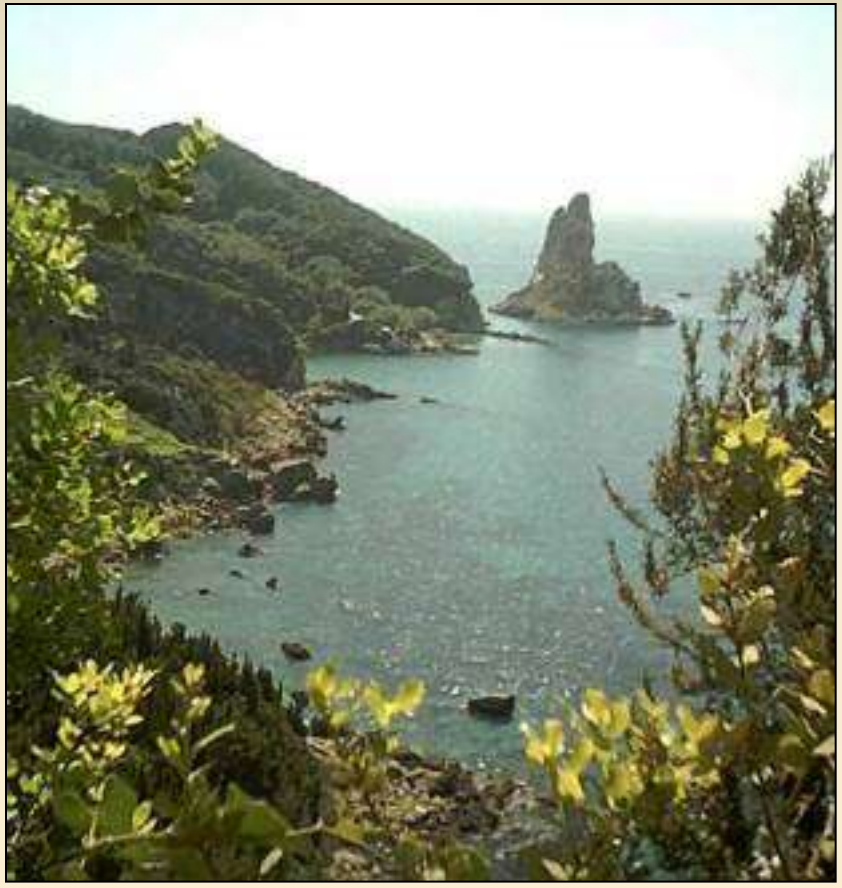
Classification - arrangement of objects and organisms into groups.

Taxonomy - the science of identifying classifying objects, including plants and animals.

Systematics - the scientific study of the diversity and relationship of organisms and how they are related in an evolutionary context.

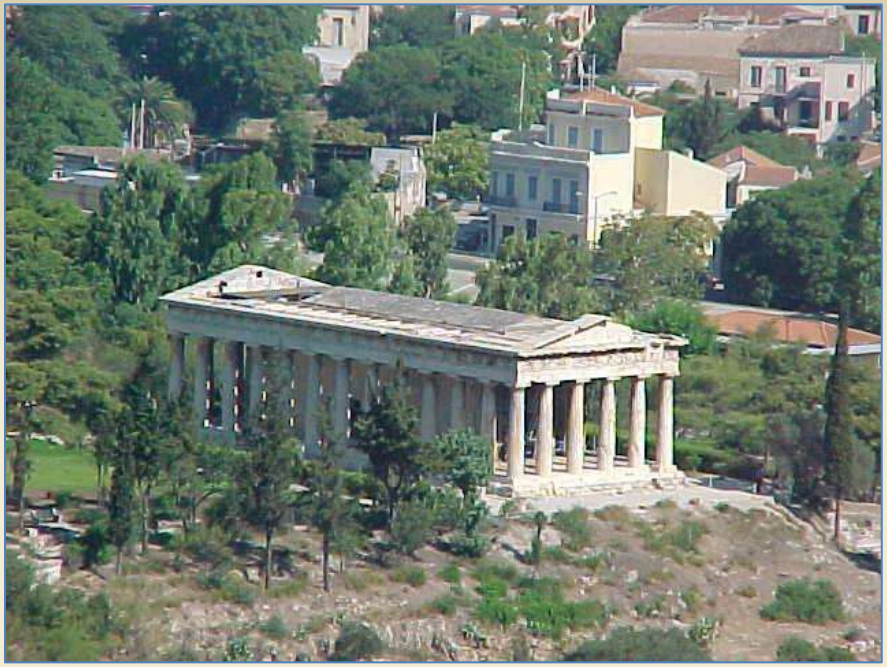
Phylogeny - is the branching evolutionary relationships among organisms.

Scientific Classification and Systematics
Origins in Ancient Greece – Why Greece?



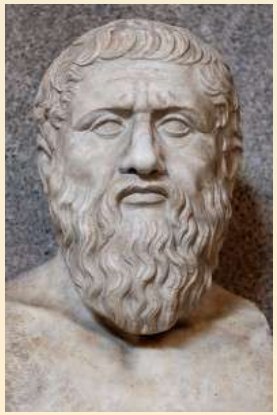
- Region of isolated valleys, hills, small plains, peninsulas, and islands
  - Sea formed its focal point
- Fringe area to older civilizations of the Middle East
- Tiny, unimportant, and poor in natural resources
- Polytheistic?
- Democracy?

Greek Architecture



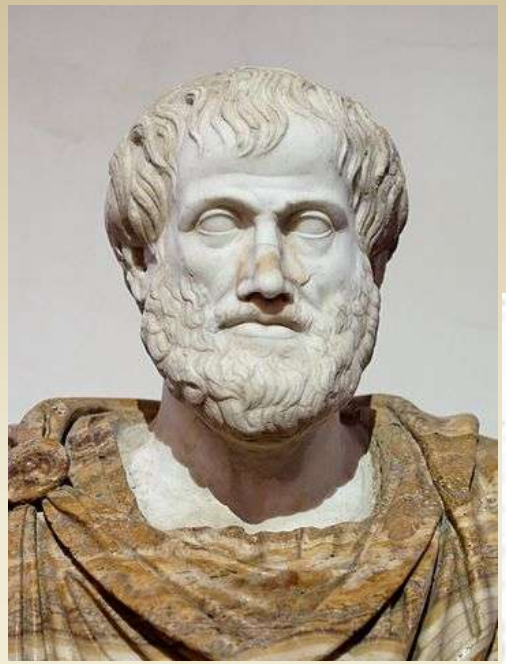
Greek Philosophers and Thinkers

- Philosophers: Socrates, Plato, Aristotle
- Logical thinking, rhetoric, politics
- Playwrights: Sophocles, Euripides, Aeschylus
- Science and Mathematics: Hippocrates, Epicurus, Archimedes, Pythagoras
- Academies for higher education



Why do we still talk about them? Books

- Greeks wrote many books (scrolls) and maintained large libraries
- Major works were later copied by Romans
- Many lost during the Dark Ages, some saved by Arabs



Aristotle
384 – 322 BC

Aristotle - famous Greek naturalist

Classification System - *Scala Naturae*

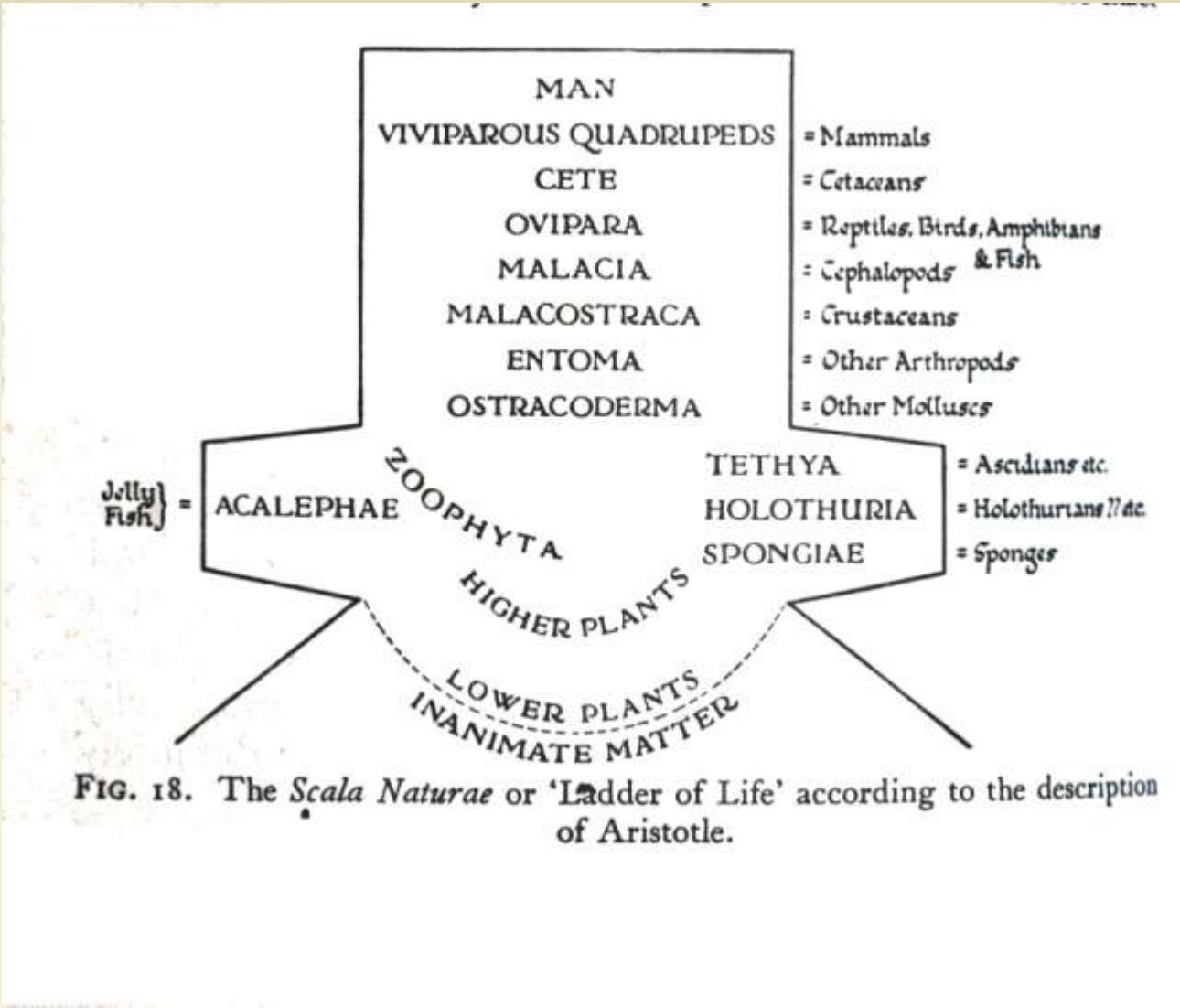
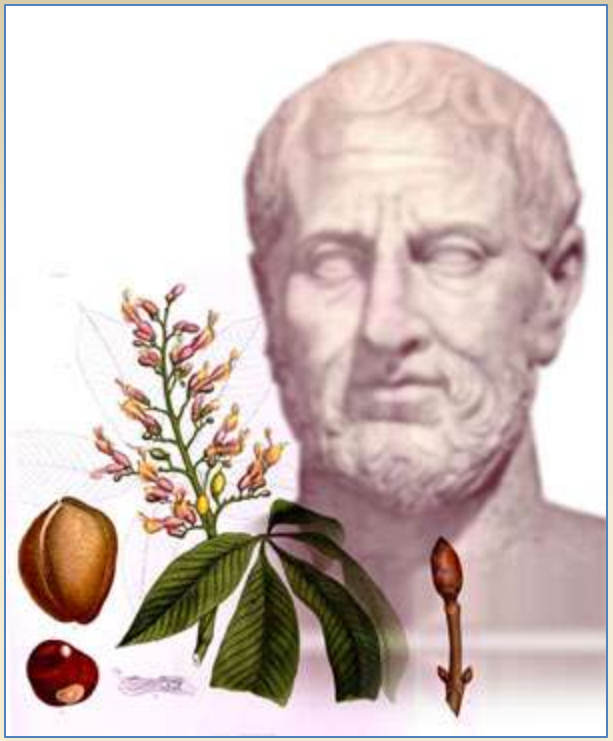


FIG. 18. The *Scala Naturae* or 'Ladder of Life' according to the description of Aristotle.

Theophrastus of Athens

(ca. 372 - ca. 287 BC)

- often referred to as the "Father of Botany"
- Immediate successor of Aristotle
- Writings deal with the medical qualities and peculiarities of plants
- Unusually accurate, even in the light of present knowledge
- Described 500 species of plants.



The most important of his books are two large botanical treatises, *Enquiry into Plants* (Περὶ φυτῶν ἱστορία), and *On the Causes of Plants* (Περὶ φυτῶν αἰτιῶν), which constitute the most important contribution to botanical science during antiquity and the Middle Ages

Quotes

“Life is ruled by fortune, not wisdom.“

“Time is the most valuable thing a man can spend”

Dioscorides

- Greek physician (40 – 90 AD), traveled throughout the Roman Empire with Emperor Nero's army
- Wrote De Materia Medica, 70 AD
- Classified 600 medicinal plants, designed to improve medical services to the Roman Empire.
- Translated into several languages both ancient and modern, and later supplemented with commentary by European, Middle Eastern, and Indian authors
- Became the principal book on plant classification for nearly 1,500 years!
- Also became the basis for herbals


Dioscorides

Middle Ages

- Collapse of Rome, barbarian invasions.
- Decline of science and inquiry in “the West”. Dark Ages.
- Reunification of Europe under Charlemagne.
- Age of herbalists, alchemists
- Greek authorities maintained (Aristotle, Galen) without question. No “why questions”.
- **Latin** was the common language of Church and scholars (incl. botany)
- **Arab scholars** translated works of Greeks, contributed to fields of math (algebra) and chemistry.

Examples of early plant classifications

- 2000 BC - Indian (Ayurvedic) texts described medicinal plants
- 1000-1700 AD - “Age of Herbals” in Europe

Herbals: books which document the supposed medicinal properties of plants. Medieval herbals were frequently illustrated

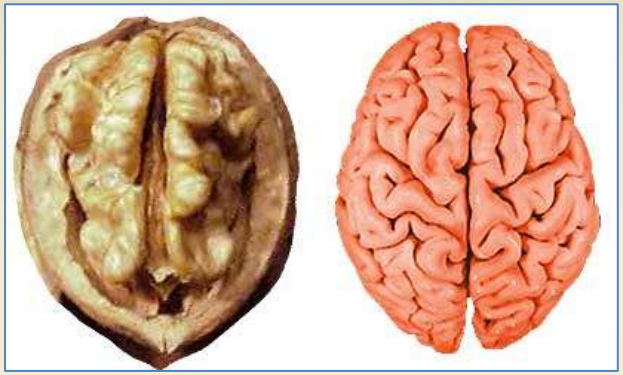
1. Contains: much folklore

2. Doctrine of signatures: Herbals often followed the *Doctrine of signatures* which holds that if a plant part resembled a part of the human body, it would be useful in treating ailments of that part.

Doctrine of Signatures

- Formalized by Pliny
- Followed by some up to the 16th century
- Related Sympathetic Magic

- Walnut meats, which contain something that looks like tiny brains, were used to treat brain disease, memory-loss.



- Hepatica leaves, which look like the lobes of liver, were used to treat liver ailments

Here's more:

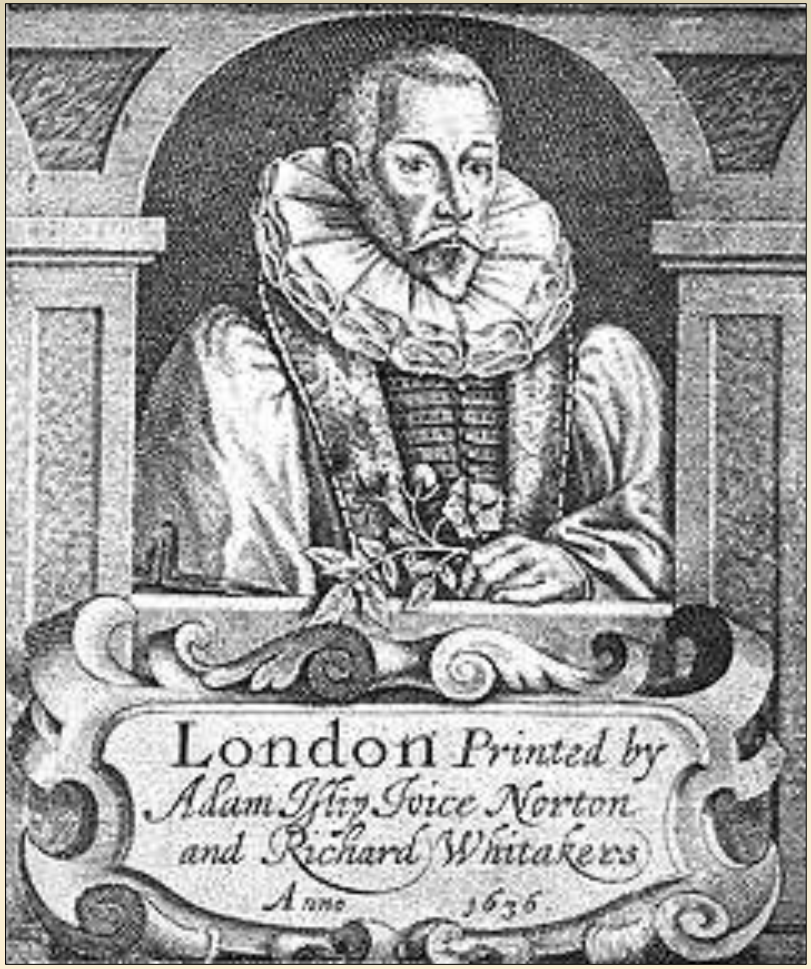
- *Sanguinaria* (bloodroot) – blood infections
- *Euphrasia* (eyebright) - infections of the eye
- *Pedicularis* (lousewort) - repel lice
- *Marchantiophyta* (liverwort) - liver problems
- *Asplenium* (spleenwort) - conditions of the spleen
- *Lathraea* (toothwort) - relieve toothaches
- *Artemisia* (wormwood) - expel intestinal parasites
- *Ageratina* (snakeroot) - antidote for snake venom
- *Adiantum* (maidenhair fern) - cure for baldness

Regardless of the medical truth behind the *Doctrine of Signatures*, the concept is valuable for archaeologists to understand because it allows them to interpret a site through the eyes of the people who inhabited it.

Gerard's Herbal

John Gerard (1545-1612)

- Famous Elizabethan herbalist.
- 1597 - Published his Historie of Plants, the most famous of all herbals. The most widely circulated botany book in English in the 17th century
- A stunning compendium of the properties and folklore of plants. 1,480 pages.
- Still in press, and followed by some.



Naming Plants

Polynomials – naming plants with a long sentence.

- In the late sixteenth century, the science of scientific naming started
- Up into the 1600's, plants and animals were given long, polynomial Latin names.
  Example - the tomato was given the long Latin polynomial
  Solanum caule inermi herbaceo, foliis pinnatis incisis
  which means
  the 'solanum with the smooth stem which is herbaceous and has incised pinnate leaves'
- This became increasingly problematic as diversity increased. As other lands, such as the New World, were discovered and explored, the system became complicated.

Carolus Linnaeus - 1707 - 1778

Tried to name and classify all organisms.

Incredibly prolific, he and his students named 12,000 species (7,700 plants, 4,300 animals).

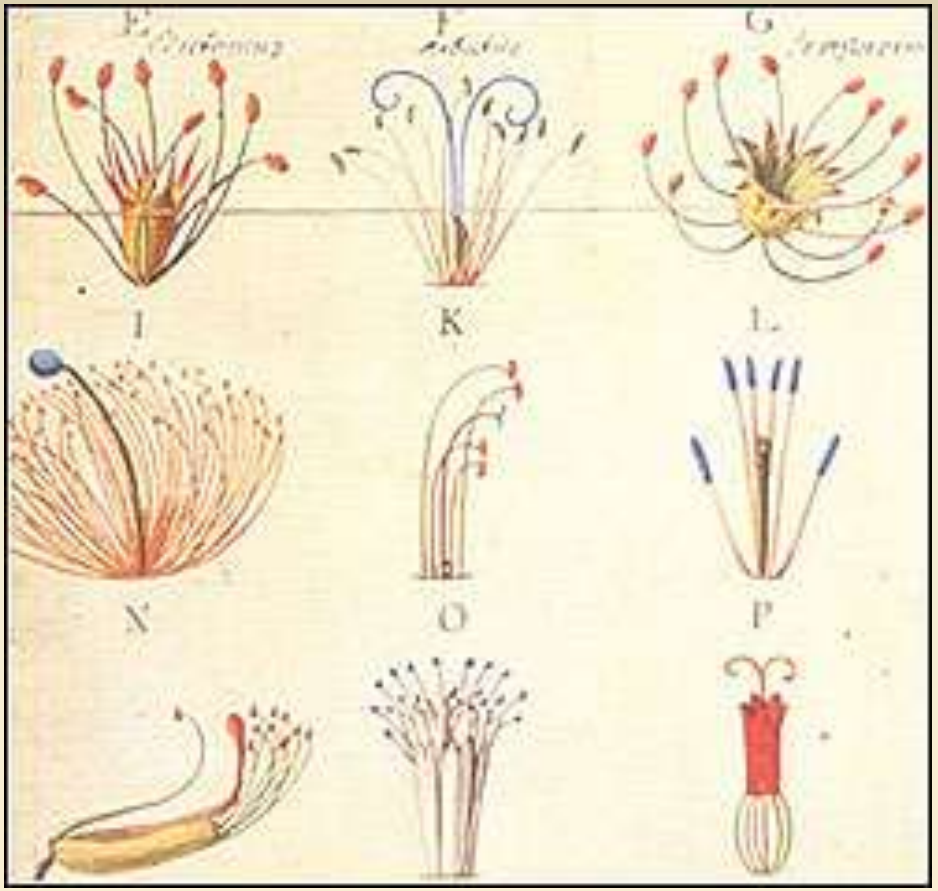
1,105 genera named by Linnaeus.

Famous for 3 Main Things:

1. Sexual System of Classification, based on number of stamens and pistils
2. Binomial nomenclature, introduced in *Species Plantarum* – 1753
3. Hierarchical Classification – species, genus, family, order, class.

The “Sexual System” of Linnaeus

- Instead of looking at the totality of a plant, as would a herbalist, Linnaeus concentrated on one particular character and organized all plants according to that character.
- The characters that he chose were the number of stamens, the male parts, and the number of pistils, the female parts.



Linnaeus's sexual system as drawn by G.D. Ehret (1736).

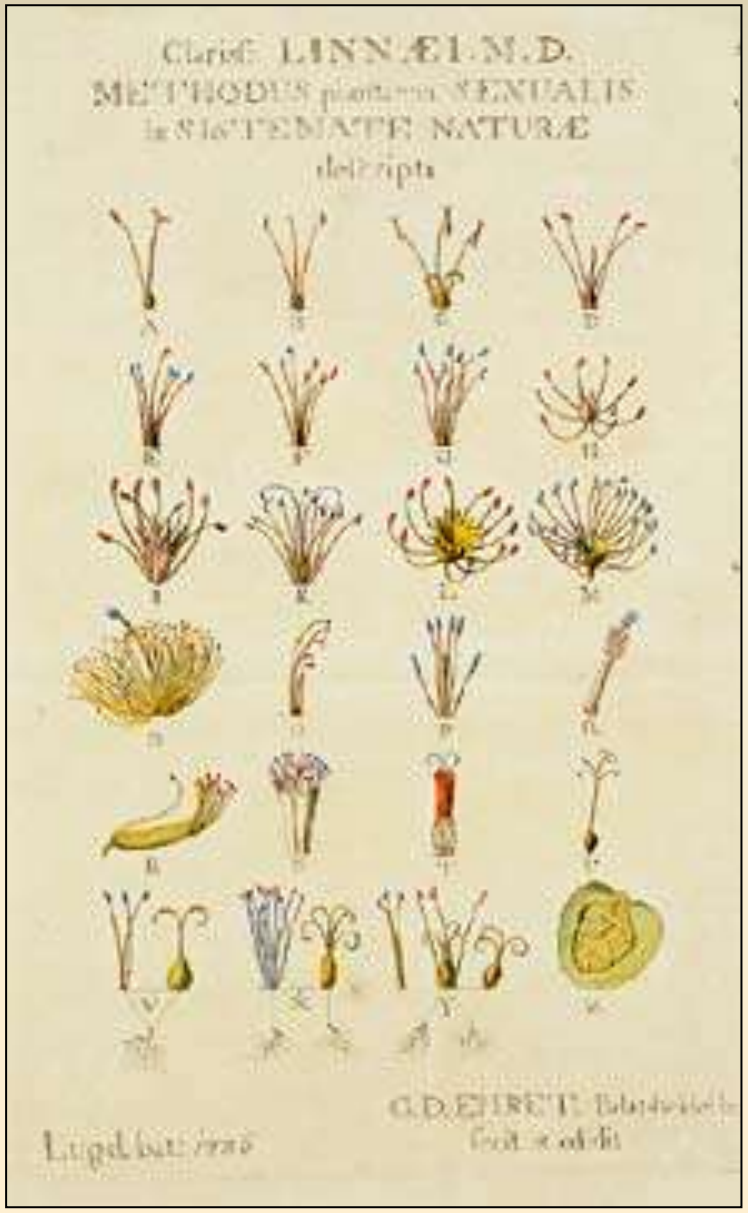
Rivals criticized his system as 'loathsome harlotry (scortationes quasi destabiles)'. It was thought that ladies shouldn't deliberately look at the sexual parts of plants.

Identify this plant using Linnaeus's Sexual System.

How many stamens?

How many pistils?

Linnaeus' sexual system, an artificial, yet practical, method for identification of plants. Simply count stamens and pistils



A View of the Twenty-four Classes of the SEXUAL SYSTEM *of* LINNÆUS, *with their Names and Characters; also the Number and Explanation of Orders contained in each.*

Number of the Classes.	*Their Names and Characters.*	*Number of Orders in each.*	*Their Names, expressive of the Number of Female Parts or Styles.*	*Names.*
1.	MONANDRIA. One fertile ſtamen, i. e. having the *Anthera.*	2	1. Monogynia,	1
			2. Digynia,	2
2.	DIANDRIA. Two fruitful *Stamina* or male parts.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
3.	TRIANDRIA. Three ditto.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
4.	TETRANDRIA. Four ditto, all of equal length, by which it is diſtinguiſhed from the fourteenth claſs.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Tetragynia,	4
5.	PENTANDRIA. Five ditto.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Triginia,	3
			4. Tetragynia,	4
			5. Pentagynia,	5
			6. Polygynia,	many
6.	HEXANDRIA. Six ditto, all of equal length, by which this is diſtinguiſhed from the ſixteenth claſs.	5	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
			4. Tetragynia,	4
			5. Polygynia,	many
7.	HEPTANDRIA. Seven ditto.	4	1. Monogynia,	1
			2. Digynia,	2
			3. Tetragynia,	4
			4. Heptagynia,	7
8.	OCTANDRIA. Eight ditto.	4	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
			4. Tetragynia,	4
9.	ENNEANDRIA. Nine ditto.	3	1. Monogynia,	1
			2. Trigynia,	3
			3. Hexagynia,	6

10. DECAN-

6. Aloë foliis ovato-lanceolatis carnosis apice triquetris: angulis inerme dentatis. *Hort. cliff.* 131. *Hort. upſ.* 86. *Roy. lugdb.* 24.
Aloë africana minima atroviridis, ſpinis herbaceis numeroſis ornata. *Boerh. lugdb.* 2. *p.* 131. *t.* 131.
Habitat in Æthiopiæ *campeſtribus.* ♄
Flores *in hoc genere ſpecierum certiſſimi indices conjungunt Margaritiferam & Arachnoideam.*

9. ALOE floribus ſeſſilibus reflexis imbricatis priſmaticis. *Uvaria.*
Aloë foliis linearibus radicalibus membranaceis. *Hort. cliff.* 133. *Roy. lugdb.* 23.
Aloë africana folio triangulari longiſſimo & anguſtiſſimo, floribus luteis fœtidis. *Comm. hort.* 2, *p.* 29. *t.* 15. *Seb. thef.* 1. *p.* 29. *t.* 19. *f.* 3.
Habitat ad Cap. b. Spei. ♄

AGAVE.

1. AGAVE foliis dentato-ſpinoſis, ſcapo ramoſo. *Gen. nov.* 1102. *americana.*
Agave foliis ſpinoſo-dentatis mucronatisque. *Hort. upſ.* 81.
Aloë foliis lanceolatis dentatis ſpina terminatis radicalibus. *Hort. cliff.* 130. *Roy. lugdb.* 22.
Aloë folio in oblongum mucronem abeunte. *Bauh. pin.* 286.
Habitat in America *calidiore.* ♄

2. AGAVE foliis dentatis, ſtaminibus corollam æquantibus. *vivipara.*
Aloë americana polygona. *Comm. rar.* 65. *t.* 65.
Habitat in America.
Confer. Aloe americana ſoboliferà. *Herm. lugdb.* 16. *t.* 17.

3. AGAVE foliis dentato-ſpinoſis, ſcapo ſimpliciſſimo. *virginica.*
Gen. nov. 1102.
Aloe foliis lanceolatis ſpina cartilaginea terminatis, floribus alternis ſeſſilibus. *Gron. virg.* 152.
Habitat in Virginia. ♄

4. AGAVE foliis integerrimis. *Gen. nov.* 1102. *fœtida.*
Aloe foliis integerrimis patentiuſculis aculeo-terminatis, radice cauleſcente. *Hort. cliff.* 132.
Aloe americana, viridi rigidiſſimo & fœtido folio, Piet dicta indigenis. *Comm. hort.* 2. *p.* 35. *t.* 18.

Linnaeus's Binomial Names

- The binomial names were so much easier to remember that people soon started using them in place of the 'correct' names.
- Eventually they replaced the polynomial names completely, and became the correct names. It is the way we now name all plants and animals
- Genus - The first part of the name is called the genus and is always capitalized.
- Species - The second part of the name is called the species epithet and is not capitalized.
- In the correct format of a scientific name a person's name (sometimes abbreviated) appears after the genus and species name, and this refers to the person who first coined the name.

- **BINOMIAL NOMENCLATURE**
  - System for giving each organism a two-word scientific name
  - First used consistently by Carolus Linnaeus

Scientific Names
Binomial Names

- Biologists use scientific names to precisely identify organisms

- Each organism has only one scientific name
  - Avoids confusion of many common names

Binomial Nomenclature

- **Species**
  - The basic unit of classification

- The scientific name of each species has two parts:
  - generic name (genus)
  - specific epithet

Plant Nomenclature

Species names ("scientific names") are Latin binomials

***Lewisia rediviva* Pursh.**

- Genus (pl. genera)
- Always capitalized
- Abbreviated on 2nd use (*L. rediviva*)

- Specific epithet
- Not capitalized
- Often a descriptive adjective
- Not abbreviated

- Authority

➢ Always underline or *italicize* species names (genus + specific epithet)

Linnaean Hierarchy
Nested, box within a box

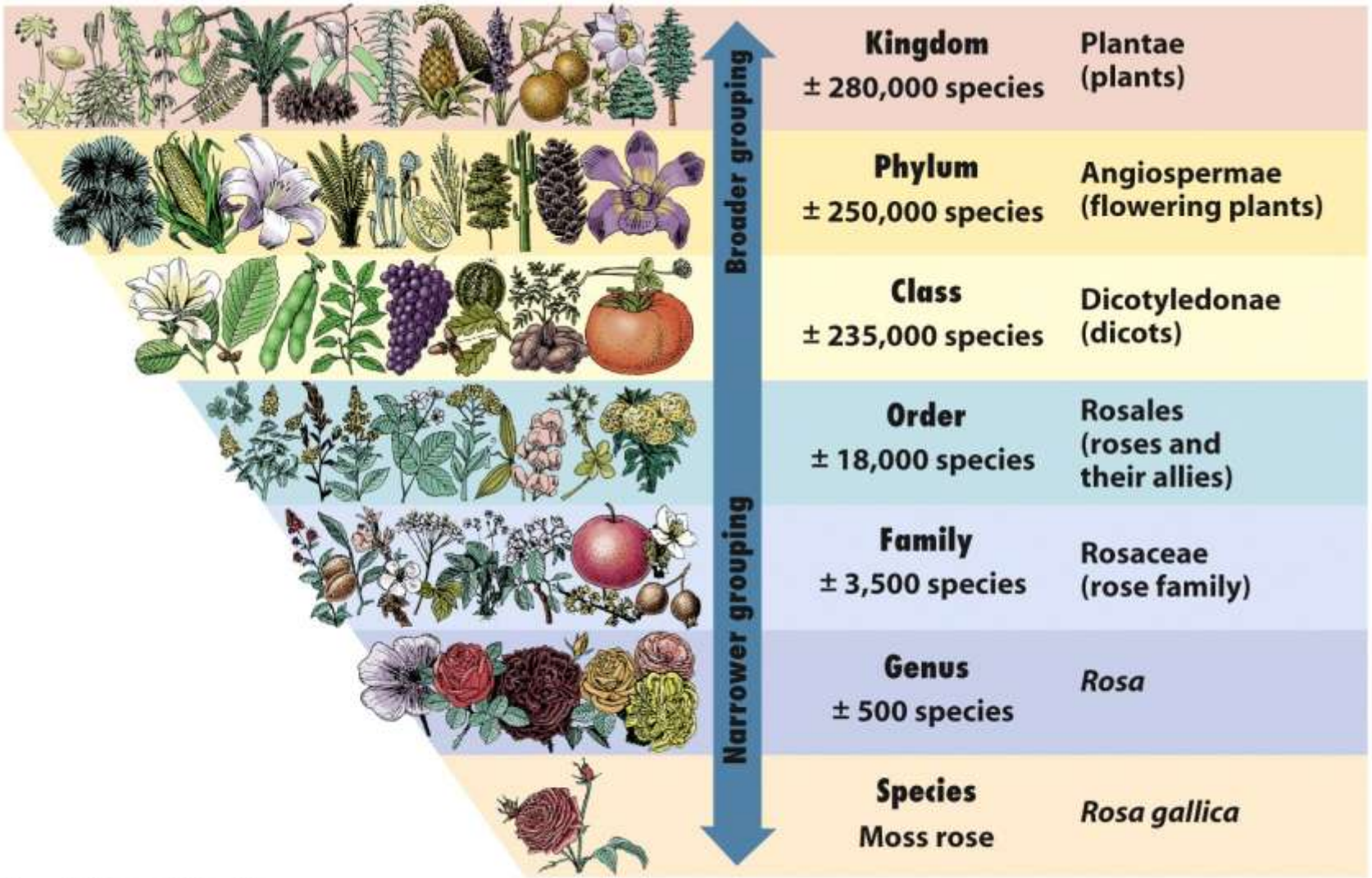
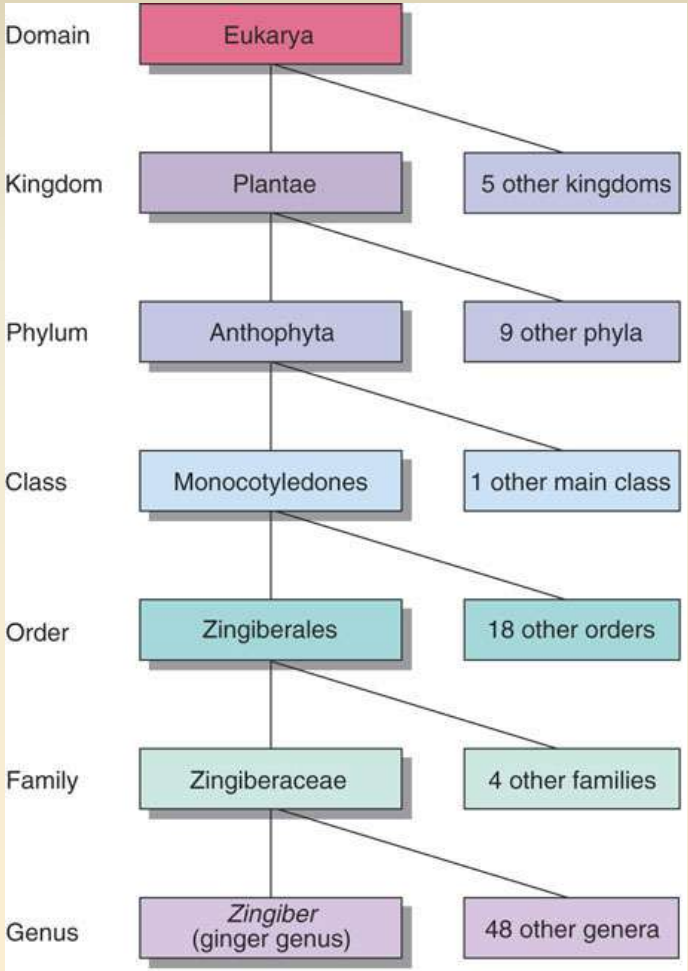


Figure 2-6 Discover Biology 3/e

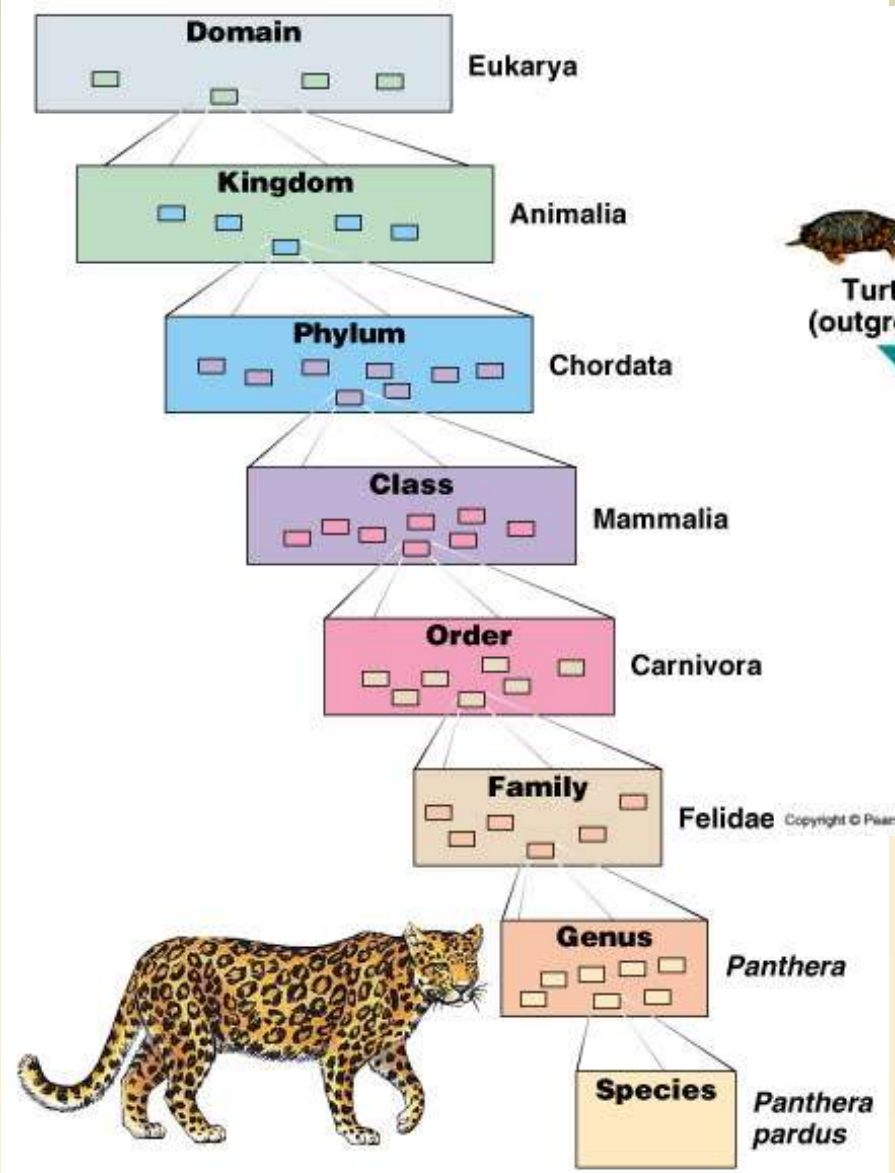
Classification of Ginger

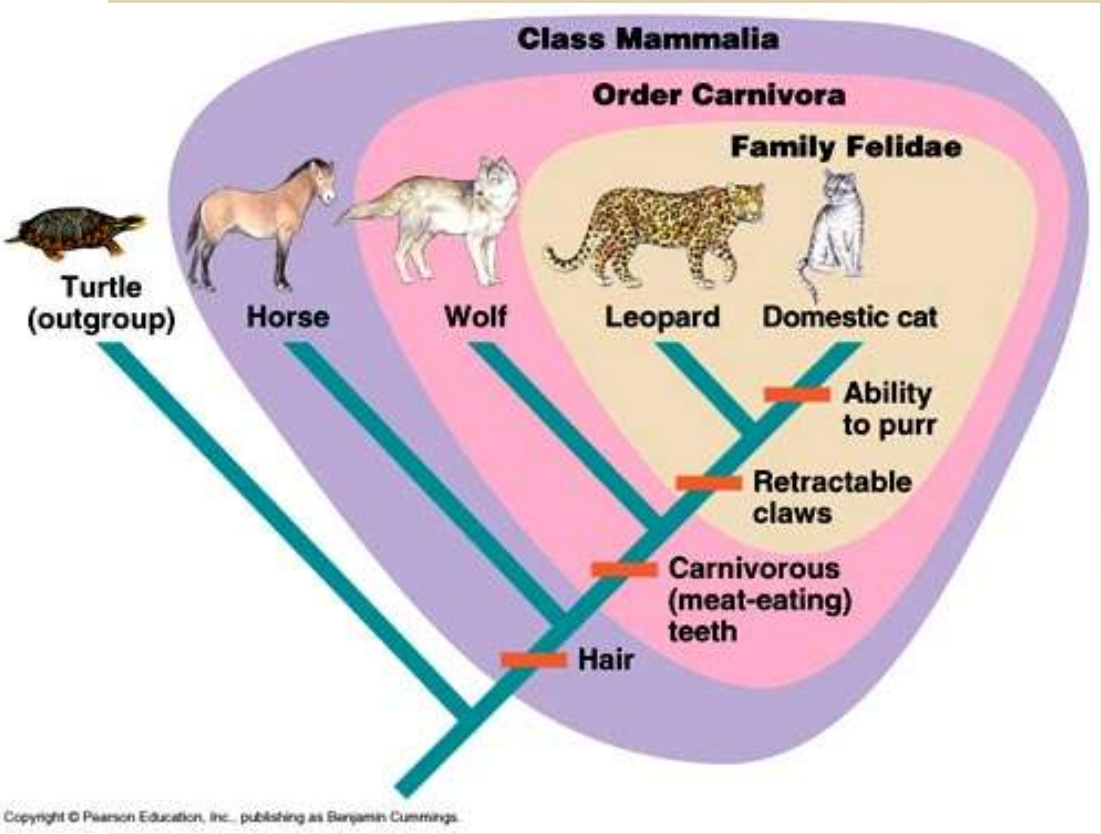
(a) A spike of ginger (*Zingiber*) flowers. The genus name is from *Zingiberi*, the name given this plant by Dioscorides; it is derived from an Indian word.



(b) Each taxonomic level is more inclusive than the one below it. For example, the order Zingiberales consists of 5 families. The family Zingiberaceae contains 49 genera and a total of about 1300 species.

Nested box-within-box hierarchy is consistent with descent from a common ancestor, used as evidence by Darwin.





Plant Nomenclature

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➢ Always underline or *italicize* species names (genus + specific epithet)

Genus (plural genera)

- a group of plants which is a closely related, definable group of plants exhibiting similar characteristics (flowers, fruit, stems, leaves, or roots) and genetic affinity

The genus is usually a noun, capitalized and can serve to describe one of the following:

- a plants appearance-*Hemerocallis* (day and beauty)
- supposed medicinal qualities- *Pulmonaria* (lungwort)
- resemblance to body parts-*Hepatica* (liver)
- honors a person by using their name – *Kalmia* (Peter Kalm)

Specific epithet

- the second word in a scientific plant name, not capitalized and usually an adjective used to describe size, color, leaf shape, growth habit, origin of the plant or to commemorate a person.

The specific epithet can give us hints about the plant:

- *Cotoneaster horizontalis*
- *Coreopsis gigantea*
- *Clerodendrum thomsoniae*
- *Godetia grandiflora*
- *Cistus x purpureus*
- *Chionanthus virginicus*

Plant nomenclature in practice

ICBN (International Code of Botanical Nomenclature)

Goal: Standardization of scientific names for plants

- First adopted in 1903; includes fungi, lichens and algae

Basic rules

- Every taxon must have a type specimen
- Names of higher ranks must be based on names of lower ones
- Priority of publication determines “correct” name
- Only 1 name is allowed per taxon, 1 taxon per name

How to pronounce scientific names? However works!!

Some guidelines:

1. Pronounce 1 syllable for every vowel
   Anemone = A-ne-mo-ne
   Cardamine = Car-da-mi-ne

2. But, pronounce proper names more-or-less normally
   Carex jonesii = Carex jones-ee-ee

3. Weird double consonants are usually silent
   Pseudotsuga = Su-do-(t)su-ga

Species Concepts - What exactly is a species?

- **Morphological Species Concept** – based on the way the plant or animal looks. Similar-looking individuals grouped together. Look for breaks in morphological characters.

- **Biological Species Concept** – a group of interbreeding populations reproductively isolated from any other such group.

Plant Collecting

- Fieldwork involves plant presses, careful note-taking, insect nets and hard work getting from place to place, just as it did in the past.
- Specimens are placed in a plant press to dry. The plant is trimmed and placed between sheets of newspaper and corrugated cardboard. The whole press goes into a drying oven.

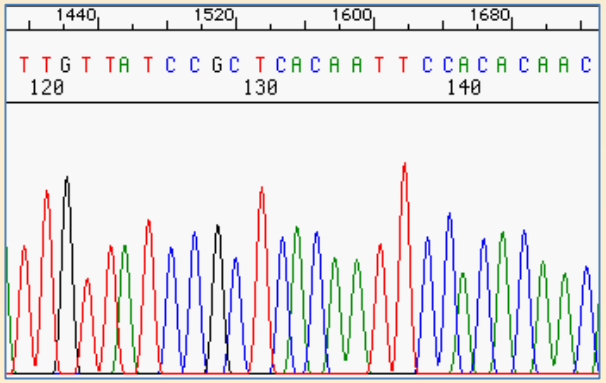
Taxonomists house their collected specimens in museums (called a herbarium), for their use and for that of future generations of scientists.

Morphology is still important in the study of evolutionary patterns, so specimens continue to have a critical role in taxonomy.

But today's researchers have at their disposal an armory of ways of looking at the relationships between species--from electron microscopes for examining the tiniest organisms to DNA sequencers for looking at genes.

Extracting DNA

PCR



DNA Sequence

Philosophical Concepts Evolution and Phylogeny

For Linnaeus and his successors, the prevailing belief was the recognition of God-given relationships

<u>No concept of change and no concept of extinction</u>

Linnaeus believed he was revealing God's creation

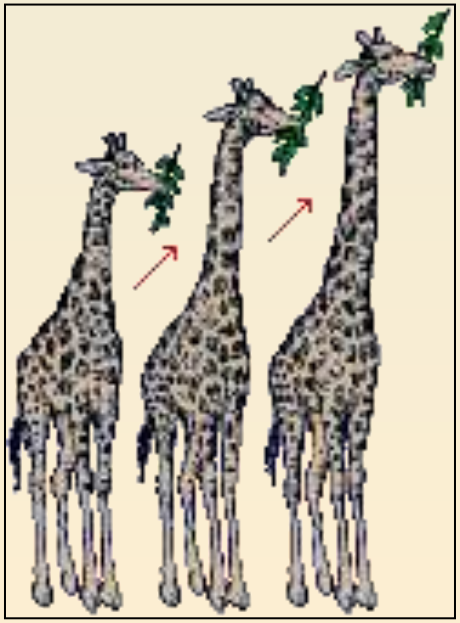
Jean-Baptiste Lamarck (1744-1829) formulated new ideas about the relationships between animals, and then about the transmutation of species into new ones.

Statue of Lamarck in the Jardin des Plantes, Paris. The inscription reads, "Fondateur de la doctrine de l'évolution" (Originator of the doctrine of evolution)

Lamarck: Theory of Inheritance of Acquired Characters

- Organs grow in size if used in life, and lost if not used.
- This growth or loss could be passed on to offspring

The long necks of giraffes is the most-remembered example Lamarck used, insinuating that giraffes stretched their necks purposefully in order to reach the leaves on high branches, and then by successive generations passed their longer, stretched necks on to their offspring.

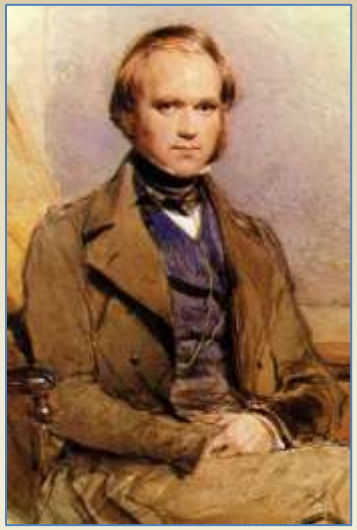


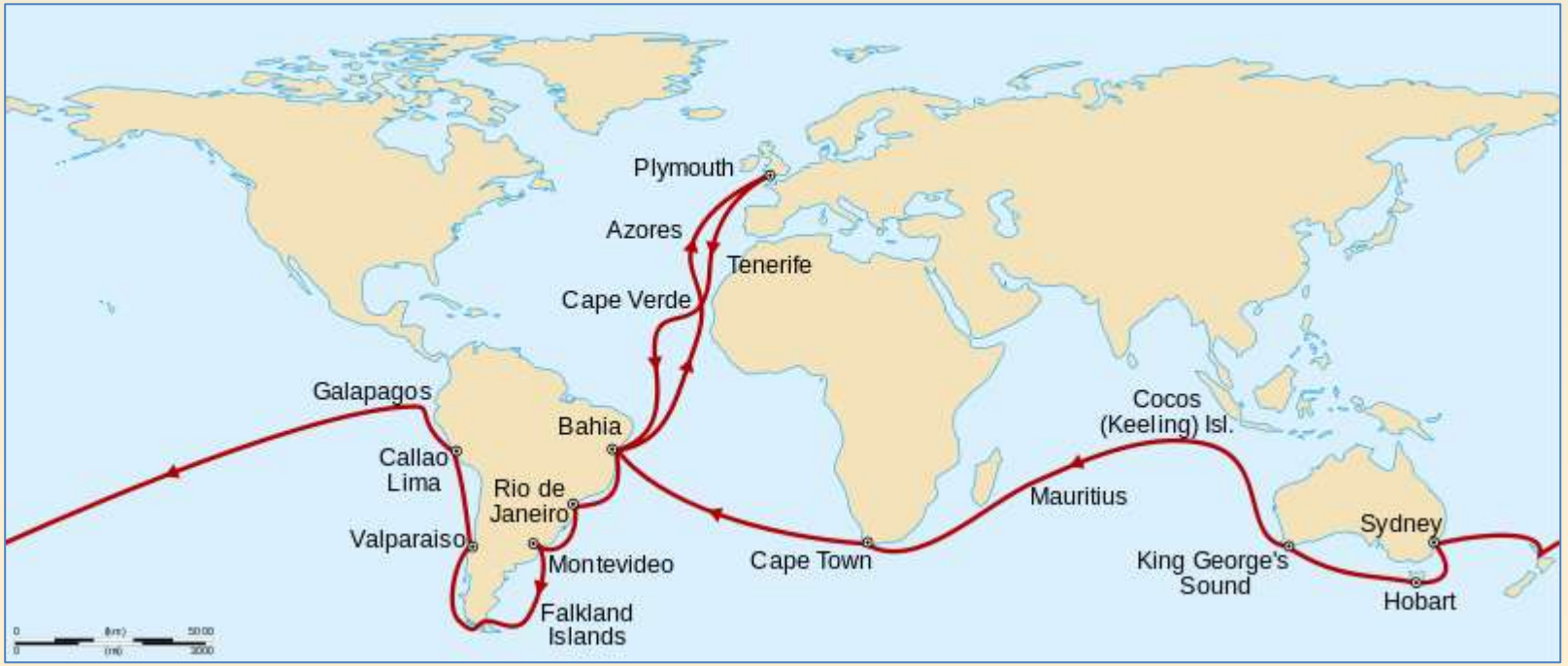
By the mid 1800's most scholars had abandoned the view that species were immutable and had accepted a view of change over time.

The question was how?

Charles Darwin and Alfred Wallace provided answers

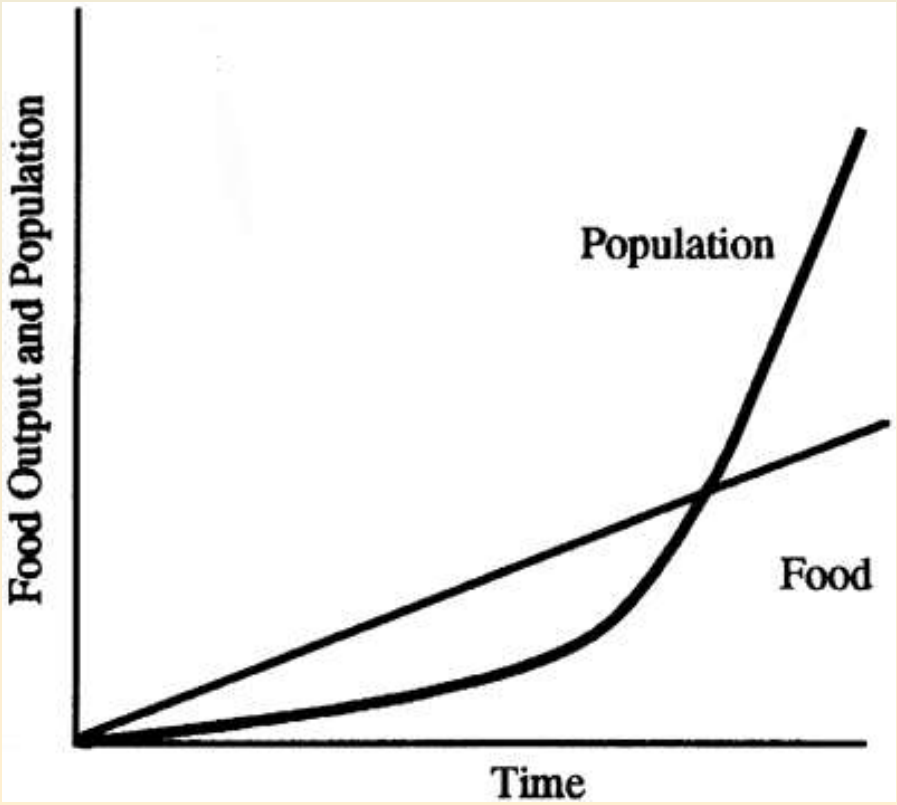
As a young man, Darwin went on a 5-year voyage around the world….





Influence of Malthus

Two years after he returned, Darwin read **"Essay on the Principle of Population"** by the political economist **Thomas Malthus**, who argued that <u>human populations always increase faster than the food supply</u>.



What is the Mechanism of Evolution?

"Preservation of Favored Races in the Struggle for Life"
= Natural Selection

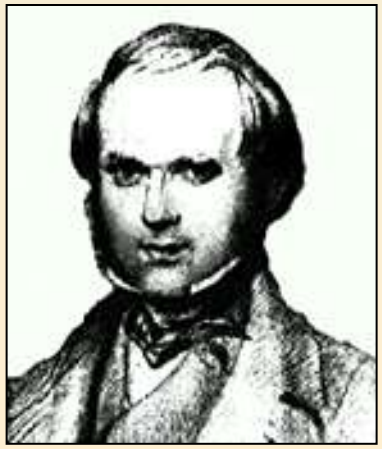
1. **Variation** - There is **variation** in function or behavior between individuals. Some traits are more **adaptive** than others. Traits are **heritable**.
2. **Overproduction** – More offspring are produced than can survive.
3. **Competition** – Individuals compete for limited resources. Struggle for existence.
4. **Survival** - Individuals that are more **adapted to the environment** live to reproduce or **reproduce more.**

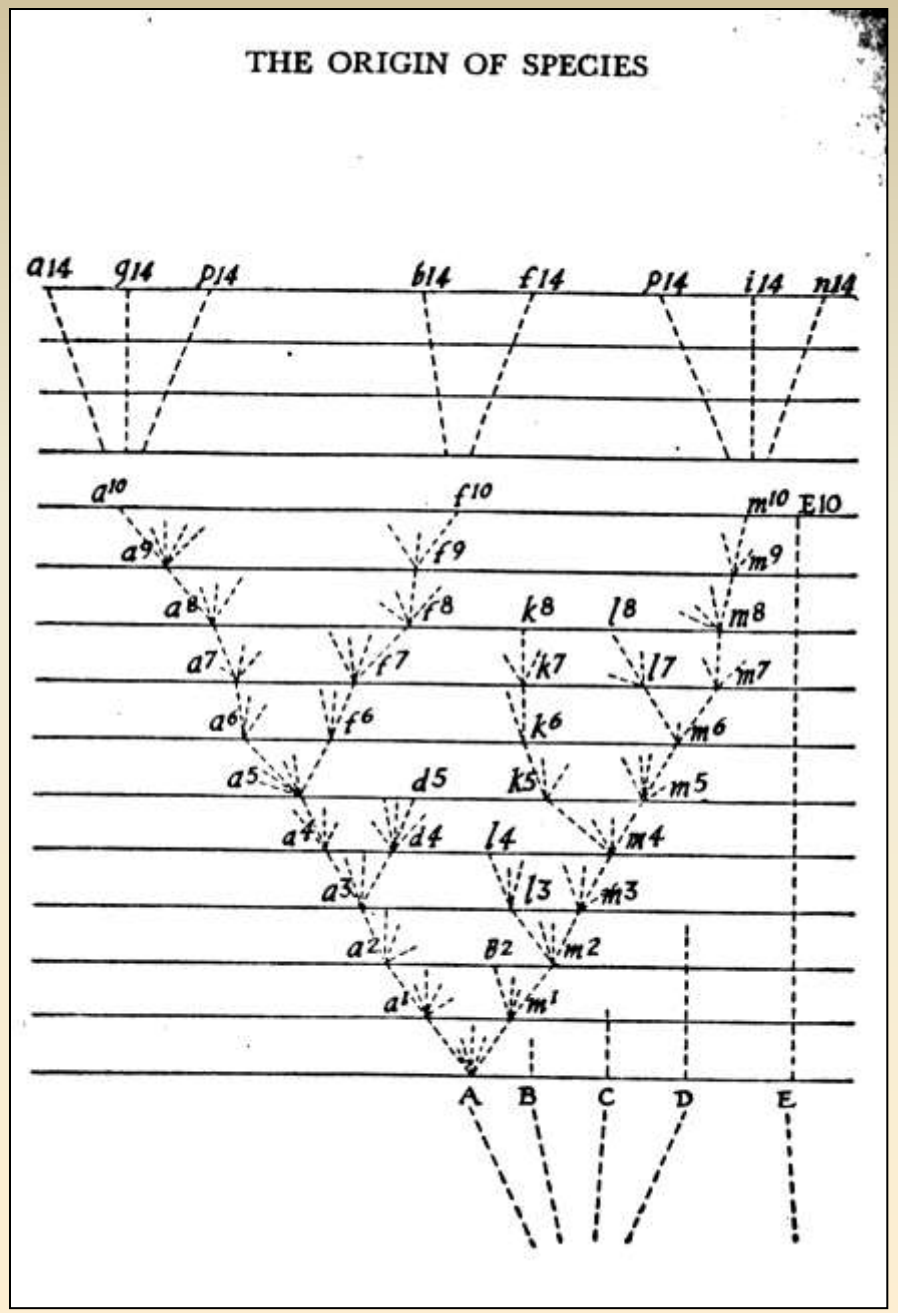
Less adaptive traits become less common in populations.
The gene frequencies or proportions in the population change.

Charles Darwin 1859

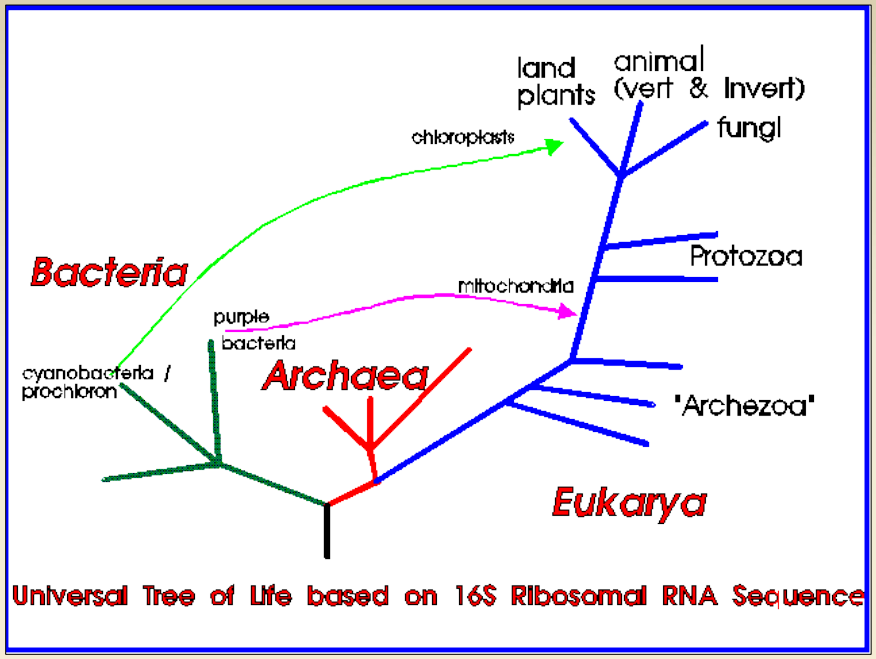
- "Origin of Species by Natural Selection, or the Preservation of Favored Races in the Struggle for Life"
- "Origin of Species"

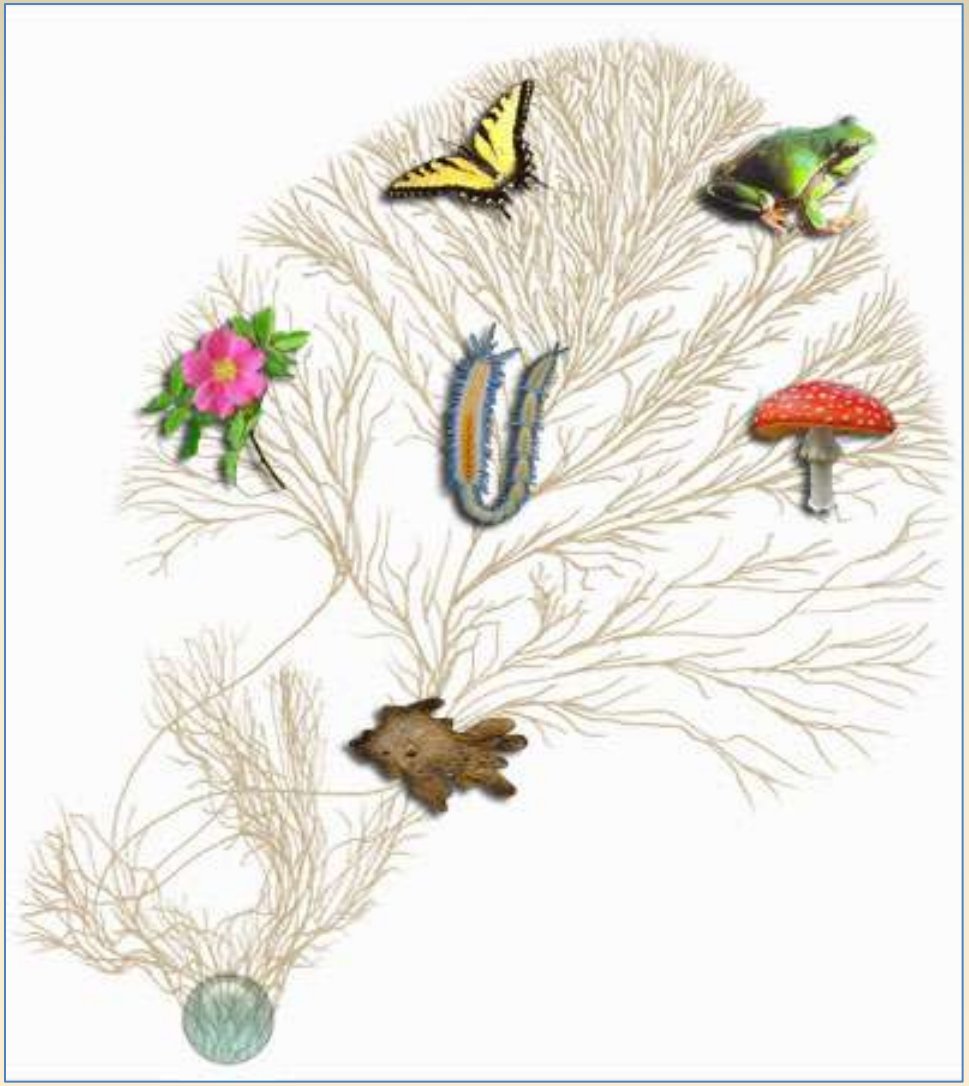
1. Natural Selection
2. Descent from Common Ancestor





Tree of Life





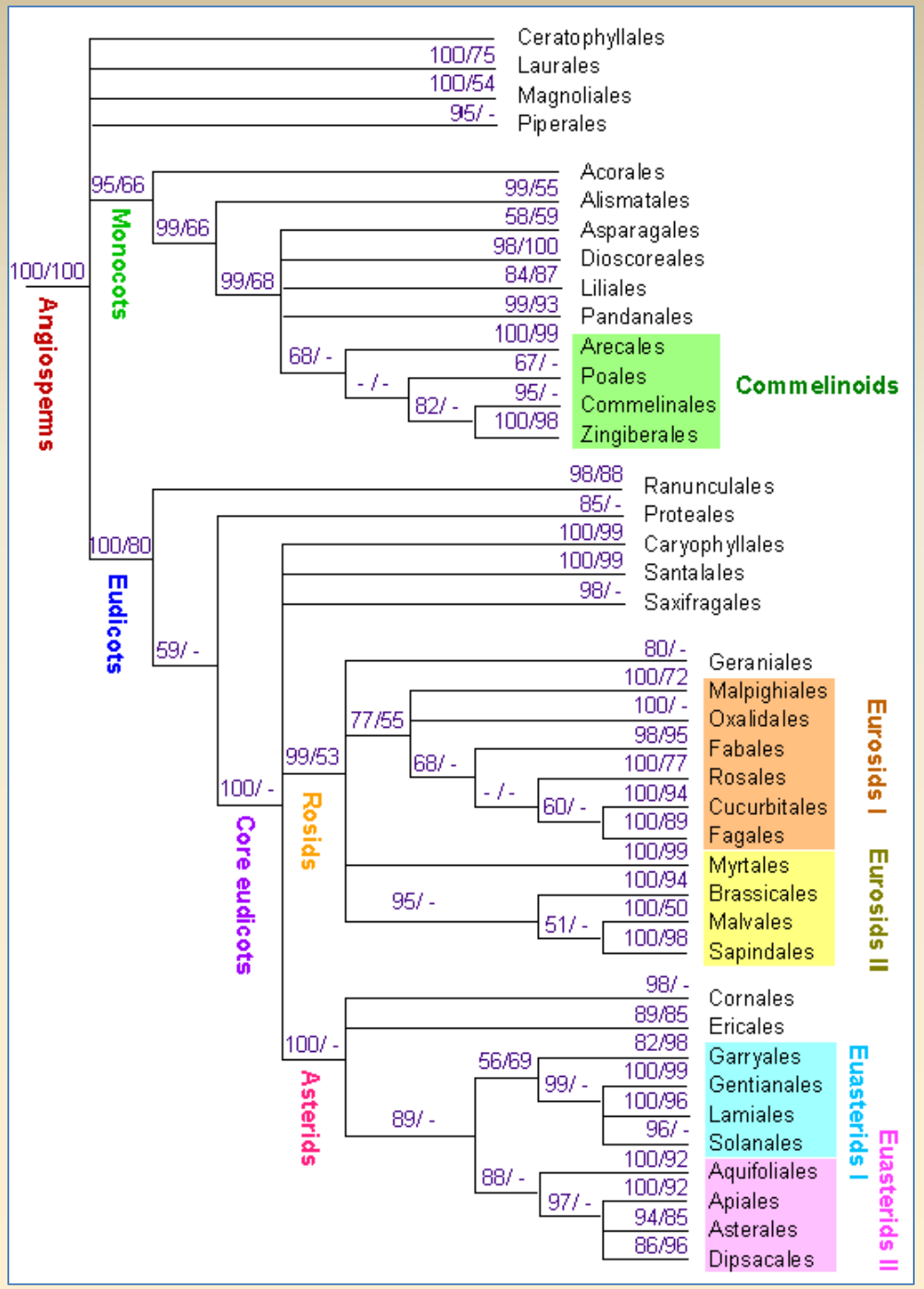
Common Ancestor

DNA Phylogeny and Classification of Plants

APG System

Angiosperm Phylogeny Group

Based mostly on DNA sequence data



Acceptance of Evolution

- Scientists were the first to accept Darwin's concepts but since genes were unknown, there was considerable controversy about the mechanism

- Slowly religious leaders came on board

- With the discovery of Chromosomes and Mendel's work (early 1900's), a deeper understanding of the mechanisms of selection resulted in a "new evolutionary synthesis" that included genetics

- Today nearly all biologists accepts evolution as the best explanation for the diversity of life on Earth

End