Taxonomy and Classification

Taxonomy

= the science of naming and describing species

"Wisdom begins with calling things by their right names"
-Chinese Proverb

museums contain ~ 2 Billion specimens worldwide

about 1.5 M different species of life have been described

→each year ~ 13,000 new species are described

most scientists estimate that there are at least 50 to 100 Million actual species sharing our planet today

most will probably remain unknown forever:
- → the most diverse areas of world are the most remote
- → most of the large stuff has been found and described
- → not enough researchers or money to devote to this work

Common vs Scientific Name

many larger organisms have "common names"
- → but sometimes >1 common name for same organism
- → sometimes same common name used for 2 or more distinctly different organisms

eg. daisy	eg. moss
eg. mouse	eg. fern
eg. bug	

without a specific (unique) name it's impossible to communicate about specific organisms

What Characteristics are used

how do we begin to categorize, classify and name all these organisms

there are many ways to classify:

- form
- color
- size
- chemical structure
- genetic makeup

earliest attempts used general appearance
- ie anatomy and physiological similarities
  - plants vs animals
    - → only largest animals were categorized
      - everything else was "vermes"
    - → but algae, protozoa

today, much more focus on molecular similarities
- proteins, DNA, genes

History of Classification

Aristotle

was the first to try to name and classify things based on structural similarities

described ~520 species of animals; esp around Greece

believed a name should reflect hidden reality or essence

used phrases or single words, not consistent

Theophrastus classified plants into herbs, shrubs and trees

after invention of the printing press in 1400's "**Herbals**" were printed
they emphasized plants with medicinal uses

Carolus Linnaeus,
a Swedish botanist,

developed and published the first comprehensive and consistent classification system for both plants and animals:

plants: **Species Plantarum 1753**
(described and classified all plants known in his time = 7300 species)

animals: **Systema Naturae 1758**

Linnaeus

categorized and classified ~8000 different plants and ~10,000 animals

(including 828 mussels & molluscs; 2100 insects; 4777 fish, birds & mammals)

'God designed life; Linnaeus did the filing'

offered the first comprehensive, consistent and much simpler method of naming and organizing species into a collection:

1. emphasized morphological characteristics as the basis for arranging specimens in a collection

2. each species is given a unique scientific name
   → while some species can have 100's of common names each has only one binomial name

3. each unique name is a binomial

   binomial name: Genus + species epithet

   before – species consisted of up to 12 words

   eg. tomato
   was: **Solanum caule inerme herbaceo foliis pinnatis incisis racemis simplicibus**
   (= Solanum with a smooth herbaceous stem, incised pinate leaves and simple inflorescence)
   Linnaeus: **Solanum lycopersicum**

   "God Created, Linnaeus arranged"

   most names are descriptive, latinized or greek forms, often to honor someone

   but there are also some irreverent names:
   eg. *Verae peculya* → arthropod (?insect)
   eg. *Heerz lukenatcha* → arthropod (?insect)
   eg. *Pison eyvae* → arthropod (?insect)
   eg. *Agra phobia* → beetle
   eg. *Phthiria relativitae* → fly

   sometimes "overdo" the descriptive value of a name:
   eg. *Gammaracanthuskytodermogammarusloricatobaicalensis*

→ was later disapproved

4. species were arranged in an ascending series of inclusive categories or 'taxa'

ie a hierarcy:

kingdom
phylum
class
order
family
genus – a typical genus contains about 10-12 species
species

in this classification scheme only "**species**" is a real category

the **species** is the basic unit of classification
→the only real unit
→ higher taxa are purely mythical creations to help us understand relationships between organisms

and sometime change as our knowledge of the group increases

eg. "lumpers and splitters"

biological species concept:

species = group of organisms capable of interbreeeding

but fossils
asexual reproduction

'type' species is collected and described

when a new species is discovered a representative sample is collected and used as the "type"

this becomes a permanent part of a museum collection

it is the type that is described and named

if there are any future questions it can be examined further

when Linnaeus 1st proposed his system
Evolution had not yet been formally proposed

after Darwin and Wallace
Taxonomy took on a new role
→was also used to reflect **evolutionary relationships**

systematics = determining **phylogeny** of a species

phylogeny = evolutionary relationships
based on phenotypic similarities and differences

the original hierarchy was originally used just to categorize degrees of similarity between organisms

after Darwin it was interpreted to show phylogenetic relationships
→ to construct **evolutionary trees**

1. look for anatomical and physiological similarities
2. compare with similar fossils that might exist
3. study its embryological development
4. ecological characteristics

eg. classes older common ancestor
eg. genera younger common ancestor

New criteria and terminology for classification:

Primitive vs Advanced

Primitive → more similar to hypothetical ancestor
Advanced → considerable change from ancestor

eg. magnolia vs orchid
eg. scorpion vs spider
eg. bat or primate vs mouse or shrew

Generalized vs Specialized

Generalized → one structure can be used for lots of different things
Specialized → structure is modified to perform a specific function

eg. insect ovipositor to lay eggs
becomes specialized to sting, drill holes, parasitize hosts, etc
eg. leaf for photosynthesis
becomes specialized as thorns, tendrils, food or water storage, flower parts, etc

Homologous vs Analogous

Homologous → structures with same origin
implies evolutionary relationship

eg. bird wing, human arm, whale flipper

Analogous → structures with similarity in function and sometimes appearance
with no evolutionary connection

eg. bird wing, insect wing
eg. octopus eye, human eye

but analogous structures can indicate
convergent evolution

eg. cacti in America, euphorbs in Africa
eg. placentals in west, marsupials in australia
eg. insect wing arose several times in evolution

Numerical Taxonomy

studies and opinions on these criteria are used to construct phylogenetic trees

but each decision is a value judgement
→ some traits get more emphasis or more importance than others

numerical taxonomy is an attempt to remove some of the subjectivity

uses a large number of characteristics

all characteristics have equal value

the more features shared between organisms the more closely related they are assumed to be

Cladistics

an even more specific method of comparison

tries to remove even more of the subjectivity

uses only **homologous structures** in comparing orginisms
→ completely new traits are not used

each change in "primitive" structure is given equal weight

those with the most changes in the structure are the most distantly related

Molecular Taxonomy

more recently, molecular evidence is used
- provides a more objective way to determine relationships

the variations in structure of proteins or genes on strand of DNA can be used to calculate how close of a relationship there is between several organisms

can also be used to estimate how long ago new groups evolved

generally parallels other information

but sometimes provides new insight into evolutionary relationships

Phylogeny

each species is included in a hierarchy of classification

each level of the hierarchy is more general than the one below

each level = a **taxon**

before Darwin
- species names were given based on
  - eg. physical characteristics or
  - eg. to honor a researcher in field,
  - eg. location where found, etc
- classification into higher taxa was by their
  - structural similarities (**morphology**)

after Darwin classification became closely tied to
- evolutionary relationships (= **phylogeny**)

each taxon must be **monophyletic**
- → all members must be from same original
  - ancestor

Phylocode [www.ohio.edu/phylocode]

a new type of taxonomy seeks to more closely reflect
- these phylogenetic relationships in the naming of a species

propose renaming many species to reflect evolutionary

position

an alternative to traditional binomial name:

→a species name might be shortened or hyphenated with its former genus name

→or given a numerical designation

instead of being grouped into ranks such as genus, family, order, etc

→ organisms would be assembled into "**clades**"

clade = any set of organisms with a common ancestor