Biosystematics and Taxonomy

PRESENTED BY:
DR. SAPNA KUMARI

MZOCCC – 208
SEMESTER – II
UNIT - 1
Biosystematics

- Systematic biology (hereafter called simply systematics) is the field that-
  (a) provides scientific names for organisms,
  (b) describes them,
  (c) preserves collections of them,
  (d) provides classifications for the organisms, keys for their identification, and data on their distributions,
  (e) investigates their evolutionary histories, and
  (f) considers their environmental adaptations.

The term biosystematics was coined by W. H. Camp and C. L. Gilly (1943).
• Blackwelder and Boyden (1952) gave a definition that “systematics is the entire field dealing with the kinds of animals, their distinction, classification and evolution”.

• C. G. Simpson (1961) considers that “Systematics is the scientific study of the kinds and diversity of organisms and of any and all relationships among them”.
Fig. 1. The scope of Biosystematics in broader sense
1. Studying the diversity of organisms and the differentiation between extinct and living creatures. Biologists study the well-understood relationships by making many different diagrams and "trees".

2. Including the scientific names of organisms, species descriptions and overviews, taxonomic orders, and classifications of evolutionary and organism histories.

3. Explaining the biodiversity of the planet and its organisms. The systematic study is that of conservation.

4. Manipulating and controlling the natural world. This includes the practice of 'biological control', the intentional introduction of natural predators and disease.
Characterisation
The organism to be studied is described for all its morphological and other characteristics.

Identification
It is the finding of correct name and place of an organism in a system of classification. It is done with the help of keys. This is carried out by determining similarities with already known organisms.

Classification
It is the placing of an organism or a group of organisms in categories according to a particular system which is based on certain easily observable but fundamental characters and in conformity with a nomenclature system. A hierarchy is maintained for these categories.

Nomenclature
It is the science of providing distinct and proper names to organisms so that they can be easily recognised and differentiated from others.
DEFINE TAXONOMY

- Discipline of classifying organisms and assigning each organism a universally accepted name.

TURKEY VULTURE (Cathartes aura)
Taxonomic Components

1. Classification
   Animals are arranged into groups of similar characteristics. The groups are considered as categories or taxa and form the taxonomic system.

2. Identification
   To identify and derive the name of an organism by referring to an existing classification.

3. Nomenclature
   To provide a scientific name to an organism.

4. Description
   To describe the characteristics of a taxon e.g. a family.
WHY CLASSIFY?

1. How do biologists use a classification system to study the diversity of life? 

to name organisms and group them in a logical manner.
WHY CLASSIFY?

2. How do taxonomists group organisms when they classify them?

Into groups that have biological significance.
WHY CLASSIFY?

3. How does classification make life easier?

3a. What are some things we classify?
Taxonomic Characters

- Morphological
- Anatomical
- Embryological
- Paleontological
- Molecular
- Biochemical
- Ecological-geographic

- Similarities and differences in shape, structure, color, size, etc.
- Anatomical similarities and differences
- Similarities during the embryonic development
- Documentation of the evolution of living organisms through fossils
- Similarities based on genes
- Different organisms have different chemical composition
- Organisms that occupy the same area share a recent common ancestor
Taxonomic characters are the taxonomic attributes that can be used to provide the evidence from which relationships (the phylogeny) between taxa are inferred.

Kinds of taxonomic characters include:

1. Morphological characters
   - General external morphology
   - Special structures (e.g. genitalia)
   - Internal morphology (anatomy)
   - Embryology
   - Karyology and other cytological factors

2. Physiological characters
   - Metabolic factors
   - Body secretions
   - Genic sterility factors
3. Molecular characters
• Immunological distance
• Electrophoretic differences
• Amino acid sequences of proteins
• DNA hybridization
• DNA and RNA sequences
• Restriction endonuclease analyses
• Other molecular differences

4. Behavioural characters
• Courtship and other ethological isolating mechanisms
• Other behaviour patterns
5. Ecological characters
   • Habit and habitats
   • Food
   • Seasonal variations
   • Parasites and hosts

6. Geographic characters
   • General biogeographic distribution patterns
   • Sympatric-allopatric relationship of populations
Morphological

Similarities and differences in shape, structure, color, size, etc.
Anatomical

Anatomical similarities and differences

Human  Dog  Bird  Whale
Embryological
Similarities during the embryonic development
Paleontological

Documentation of the evolution of living organisms through fossils
Molecular

Similarities based on genes
Biochemical

Different organisms have different chemical composition

- Water: 62%
- Protein: 16%
- Oxygen: 65%
- Carbon: 18%
- Hydrogen: 9.5%
- Nitrogen: 3.2%
- Calcium: 1.5%
- Phosphorus: 1.2%
- Minerals: 6%
- Fat: 16%
- Carbohydrate: 1%

Elemental Composition

- Potassium: 0.4%
- Sulfur: 0.2%
- Sodium: 0.2%
- Chlorine: 0.2%
- Magnesium: 0.1%
- Other: >1%

The Human Body

C. ASSIGNING SCIENTIFIC NAMES

1. Many organisms may have several different common names.

1a. The cougar is also known as the mountain lion, catamount, or puma ... thus the need for a scientific name.
ASSIGNING SCIENTIFIC NAMES

2. A Swedish botanist named Carolus Linnaeus developed Binomial Nomenclature, a two-word naming system for naming all species on earth.

What do you study?
ASSIGNING SCIENTIFIC NAMES

2a. The first part of the scientific name is the genus.

This word is always written first and capitalized.

It appears in italics or is underlined.

H. sapien

U. arctos horribilis

Grizzly bear picture is reproduced with permission from WWF. © 2004 WWF - World Wide Fund For Nature (Formerly World Wildlife Fund). All Rights Reserved.
www.panda.org
ASSIGNING SCIENTIFIC NAMES

2b. The second part of the scientific name is the species name. This word is always written second and is not capitalized. It appears in italics or is underlined.

*Homo sapien*

*Ursus arctos horribilis*
Classification of Animals

• Aristotle classified organisms over 2000 years ago.

• When Carolus Linnaeus developed his system of classification, he had only 2 kingdoms, Plants and Animals, but the microscope led to the discovery of new organisms and the identification of differences in cells.

• A 2-kingdom system was no longer useful we now use 6 kingdoms.
Hierarchy of Categories

Domain: Eukarya

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Carnivora

Family: Canidae

Genus: Vulpes

Species: Vulpes vulpes

Red fox (Vulpes vulpes)
LINNAEUS'S SYSTEM OF CLASSIFICATION

1. Linnaeus' hierarchical system of classification includes seven levels called taxa. They are, from largest to smallest, Kingdom, Phylum, Class, Order, Family, Genus, Species.
LINNAEUS'S SYSTEM OF CLASSIFICATION

2. The Kingdom is the largest and most inclusive (includes) of the taxonomic categories.

3. Species is the smallest and least inclusive of the taxonomic categories.
LINNAEUS’S SYSTEM OF CLASSIFICATION

Kingdom, Phylum, Class, Order, Family, Genus, Species.

- More specific
- Place the taxa in the correct level of the pyramid.
- More general
LINNAEUS’S SYSTEM OF CLASSIFICATION

4. The more taxonomic levels that two organisms share, the more closely related they are considered to be.
<table>
<thead>
<tr>
<th>Organism</th>
<th>Cat</th>
<th>Wolf</th>
<th>Fly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingdom</td>
<td>Animalia</td>
<td>Animalia</td>
<td>Animalia</td>
</tr>
<tr>
<td>Phylum</td>
<td>Chordata</td>
<td>Chordata</td>
<td>Arthropoda</td>
</tr>
<tr>
<td>Class</td>
<td>Mammalia</td>
<td>Mammalia</td>
<td>Insecta</td>
</tr>
<tr>
<td>Order</td>
<td>Carnivora</td>
<td>Carnivora</td>
<td>Diptera</td>
</tr>
<tr>
<td>Family</td>
<td>Felidae</td>
<td>Canidae</td>
<td>Muscidae</td>
</tr>
<tr>
<td>Genus</td>
<td>Felis</td>
<td>Canis</td>
<td>Musca</td>
</tr>
<tr>
<td>Species</td>
<td>F. domesticus</td>
<td>C. lupus</td>
<td>M. domestica</td>
</tr>
</tbody>
</table>
THINKING CRITICALLY

1. What type of animal is *Musca domestica*?
   - Animal; insect

2. From the table, which 2 animals are most closely related?
   - Cat and Wolf

3. At what classification level does the evolutionary relationship between cats and wolves diverge (become different)?
   - Family Level
E. EVOLUTIONARY CLASSIFICATION

1. Biologists group organisms into categories that represent lines of evolutionary descent, or phylogeny, not just physical similarities.

2. Define Phylogeny: The study of evolutionary relationships among organisms.
3. Classification using Cladograms
   a. Cladograms are diagrams that show the evolutionary relationships among a group of organisms.
   b. A phylogenetic tree is a specific type of cladogram.
Phylogenetic trees

- Phylogeny – evolutionary history of a species or group of species
- To propose a phylogeny, biologists use the tools of systematics
- Trees are usually based on morphological or genetic data
Phylogenetic tree

- Diagram that describes phylogeny
- A hypothesis of evolutionary relationships among various species
- Based on available information
- New species can be formed by
  - Anagenesis – single species evolves into a different species
  - Cladogenesis – a species diverges into 2 or more species
E. EVOLUTIONARY CLASSIFICATION

Example of a phylogenetic tree.

Speciation: formation of two new species from one

Clade or lineage
3. CLADOGRAMS

c. This cladogram shows the evolutionary relationship among several vertebrates.

- Hagfish
- Fish
- Frog
- Lizard
- Pigeon
- Mouse
- Chimp

Feathers
Fur & Mammary Glands
Claws or Nails
Lungs
Jaws
d. Characteristics listed below the line are called derived characters (traits).
- Monophyletic group or clade
  - Group of species, taxon, consisting of the most recent common ancestor and all of its ancestors
- Smaller and more recent clades are nested within larger clades that have older common ancestors
- Paraphyletic group
  - Contains a common ancestor and some, but not all, of its descendents
(a) Monophyletic

(b) Paraphyletic

(c) Polyphyletic
Over time, taxonomic groups will be reorganized so only monophyletic groups are recognized.

Reptiles were a paraphyletic groups because birds were excluded.
Homology

- Similarities among various species that occur because they are derived from a common ancestor
- Bat wing, human arm and cat front leg
- Genes can also be homologous if they are derived from the same ancestral gene
Morphological analysis

- First systematic studies focused on morphological features of extinct and modern species
- Convergent evolution (traits arise independently due to adaptations to similar environments) can cause problems
An analysis of fossilized bones provided the phylogenetic tree described here.
4. VENN DIAGRAMS

Venn Diagrams can be used to make models of a classification scheme.

- Venn diagrams show hierarchy and grouping relationships of organisms.
- Four groups are represented by circular regions.
- Each region represents different taxonomic levels.
- Regions that overlap, share common members.
- Regions that do not overlap do not have common members.
Matching:
- Mammals [C]
- Animals with backbones [B]
- Insects [D]
- All animals [A]
Important Criteria for Classifying Animals

• Symmetry
• Segmentation
• Appendages
• Skeleton
• Sex
• Embryonic development
• Larvae
THE LIVING WORLD → PLANT KINGDOM

ANIMAL KINGDOM
(No chlorophyll and cellulose cell-wall; locomotion and sensory reception developed)

Subkingdom and Phylum
(1) PROTOZOA (Unicellular)

Infrakingdom Enterozoa
(tissue or organ grade; obvious mouth and digestive cavity present)

Grade Radiata
(tissue grade; radial symmetry; common digestive and body cavities)
(3) Phylum CNIDARIA

Section
EUCEOLOMATA (true coelom present)

(5) Phylum ASCHELMINTHES

Schizocoelic
(6) Phylum MOLLUSCA—soft, slimy unsegmented body.
(7) Phylum ANNELIDA—segmented worms with non-chitinuous cuticle and unjointed appendages.
(8) Phylum ARTHROPODA—segmented body with chitinuous cuticle and jointed appendages.

Enterocoelic
(9) Phylum ECHINODERMATA—unsegmented body; secondary pentamerosus radial symmetry.
(10) Phylum CHORDATA—segmented, bilateral body with notochord, pharyngeal gill clefts and dorsal, hollow tubular central nervous system.
CLASSIFICATION OF ANIMALS

This is the grouping together of animals with similar characteristics. Animals can be classed as either vertebrates or invertebrates.

VERTEBRATES

These are animals that have a backbone.

- **Reptiles**
  - Have dry scaly skin.
  - Lay eggs on dry land.
  - Are cold blooded. (Snake, Crocodile)

- **Fish**
  - Have scales on their bodies.
  - Have gills for breathing.
  - Are cold blooded. (Shark, Tuna)

- **Amphibians**
  - Have moist slimy skin.
  - Lay eggs in water.
  - Are cold blooded. (Frog, Newt)

- **Birds**
  - Have feathers and wings.
  - Have beaks and lay eggs.
  - Are warm blooded. (Wren, Swan)

- **Mammals**
  - Have fur or hair.
  - Feed young on milk.
  - Are warm blooded. (Cow, Human)

INVERTEBRATES

These are animals that do not have a backbone.

- **Protozoa**
  - Single cell organisms all microscopic.

- **Flatworms**
  - Simple and soft bodied.
  - (Tapeworm, Flukes)

- **Annelid Worms**
  - Segmented bodies.
  - (Earthworm, Leech)

- **Echinoderms**
  - Spiny sea creatures.
  - (Starfish, Sea urchin)

- **Arthropods**
  - Hard external skeleton and jointed limbs.

- **Coelenterates**
  - Soft bodied, stinging cells.
  - (Jellyfish, Sea anemone)

- **Molluscs**
  - Soft bodied, most have shells.
  - (Snails, Limpets)

- **Annelid Worms**
  - Segmented bodies.
  - (Earthworm, Leech)

- **Echinoderms**
  - Spiny sea creatures.
  - (Starfish, Sea urchin)

- **Arthropods**
  - Hard external skeleton and jointed limbs.

- **Coelenterates**
  - Soft bodied, stinging cells.
  - (Jellyfish, Sea anemone)

- **Molluscs**
  - Soft bodied, most have shells.
  - (Snails, Limpets)

- **Arachnids**
  - Eight legs, two body parts, no antennae.
  - (Spider, Scorpion)

- **Crustaceans**
  - Mostly sea creatures.
  - Many legs and two sets of antennae.
  - (Crab, Lobster)

- **Insects**
  - Wings, six legs, three body parts, one pair of antennae.
  - (Bee, Ladybird)

- **Myriapods**
  - Many legs and body segments.
  - (Centipede, Millipede)
Thank you