Principals of taxonomy

PRINCIPLES OF TAXONOMY

Interesting tool, need to understand concept and meaning of :

- ☻ **Taxonomy**
- ☻ **Systematics**
- ☻ **International code of nomenclature**

Revision

TAXONOMY

- **Taxonomy deals with the naming and classification of organisms** and is an integrative part of biological systematics, the science of biodiversity.
- The information provided by taxonomic research is a fundamental basis for all fields of biology.

TAXONOMY

(Greek, taxis= arranged; nomos= law)

- **Making and maintaining collection**
- **Differentiating species**
- **Identification (Keys) and diagnosis of species and genera**
- **Naming and describing species and genera**

WHAT IS A KEY ?

- A tool to identify of an unknown organism where large numbers of taxa are difficult to distinguish just by using the naked eye and memory.
- An Expert in the relevant field puts together the information and builds the key
- The builder of a key must choose features that best distinguish between taxa. Each feature has a number of states e.g. pink, yellow, blue etc.
- Clearly defining these states is crucial to the efficient working of a key

DICHOTOMOUS KEY

- Dichotomous key form a series of numbered questions arranged in couplets as shown below:

1. Antennae shorter than head……………………………….2
   Antennae as long as or longer than head……………3

2. Ocelli present ………………………………………….4
   Ocelli absent ……………………………………….. 7

TAXONOMIC HIERARCHY

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Hymenoptera
Family: Apidae
Genus: Apis
Species: *mellifera* Linn

CLASSIFICATION

- **Arrangement of organisms into taxonomic groups**
- **Natural classifications are objective**

  Monophyletic vs Polyphyletic
- **Artificial classifications are subjective (**The characters are not considered in relation to their Phylogeny)

NOMENCLATURE & TYPES

- Formation and use of scientific names
- The Linnaean using a combination two words of binomial scientific name of insects
  Common name: Honey Bee
  Scientific Name: *Apis mellifera* Linn
- **International Code of Zoological Nomenclature** (ICZN), rules that must be obeyed
- Registering all new names, making all new names unique across Kingdom, and providing authoritative guidance on the formation of new names

Binomial Nomenclature

- **Names** were based **on Latin or Ancient Greek words** - scientist everywhere understood these languages.
- The FIRST word of the Scientific Name (Species Name) is **<u>the name of the genus to which the organism belongs.</u>**
  - The Genus name refers to the relatively small group of organisms to which a particular type of organism belongs.
- **<u>The SECOND word of the name is the species.</u>** (Species identifier)
  - The Species name is usually a Latin description of some important characteristic of the organism.

Binomial Nomenclature: Rules for Writing Scientific Names

- When we use the Latin name for an organism, we **<u>ALWAYS capitalize the Genus (first part) but NOT the species identifier (second part).</u>**
- We also print the name in **Italics or Underline them. For example:**
  - *Acer rubrum* (scientific name) - red maple tree (common name) or <u>Acer rubrum</u>
    - *Acer* is the Latin name for Maple (genus)
    - *rubrum* is the Latin word for Red (species)
  - OR the name can be abbreviated as: A. rubrum

SYSTEMATICS

(Greek, systema = a whole made of several parts)

- Develops the classification of organisms
- Species comparison and grouping into higher categories
- Organisms are arranged in definite, hierarchical order
- The order of the system is based on hypothesis of common descend

  (“Study of the kinds and diversity of organisms and the relationships between them”)

Systematics

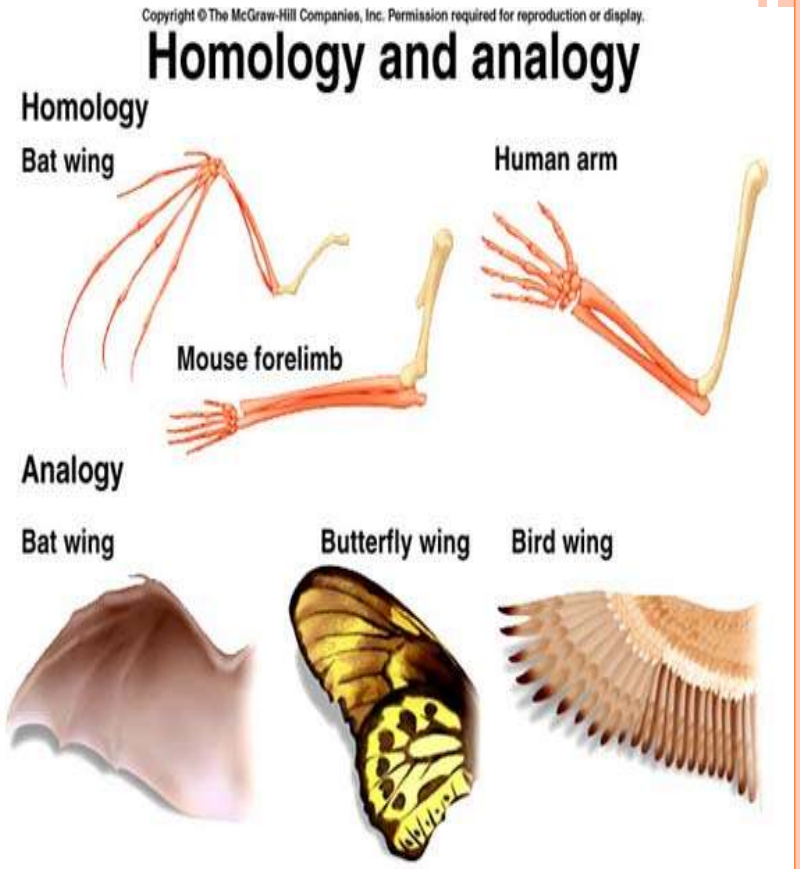
- **Systematics** is a system that organizes the tremendous diversity of organisms into a **phylogenetic** tree.
  - A phylogenetic tree is a family tree that's shows the evolutionary relationships thought to exist between organisms.
  - It represents a hypothesis that is based on lines of evidence such a the fossil record, morphology, embryological patterns of development, and chromosomes and macromolecules.

The Fossil Record

- The fossil record often provides clues to evolutionary relationships
- It can not be read like a story book because some fossil records are incomplete
- Systematic taxonomists consider other evidence to confirm information contained within the fossil record with other lines of evidence.

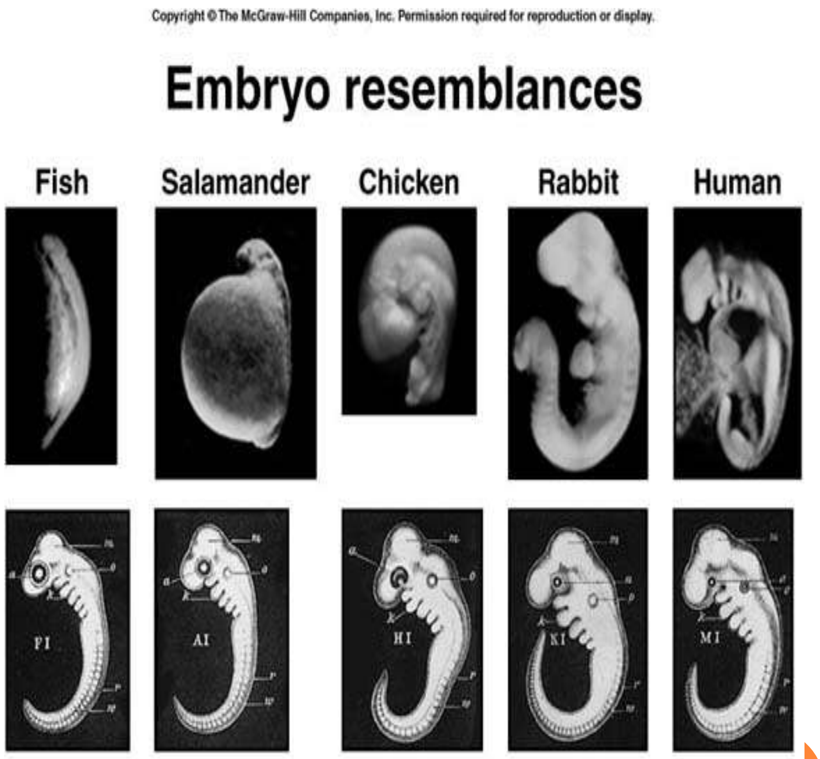
MORPHOLOGY

- Taxonomists study an organism's morphology and compare it to other living organisms.
  - **Homologous** features are important but it is important to separate features that are truly homologous with those the seem homologous but are actually **analogous.**
  - The more homologous features two organisms share, the more closely related they are thought to be.



EMBRYOLOGICAL PATTERNS OF DEVELOPMENT

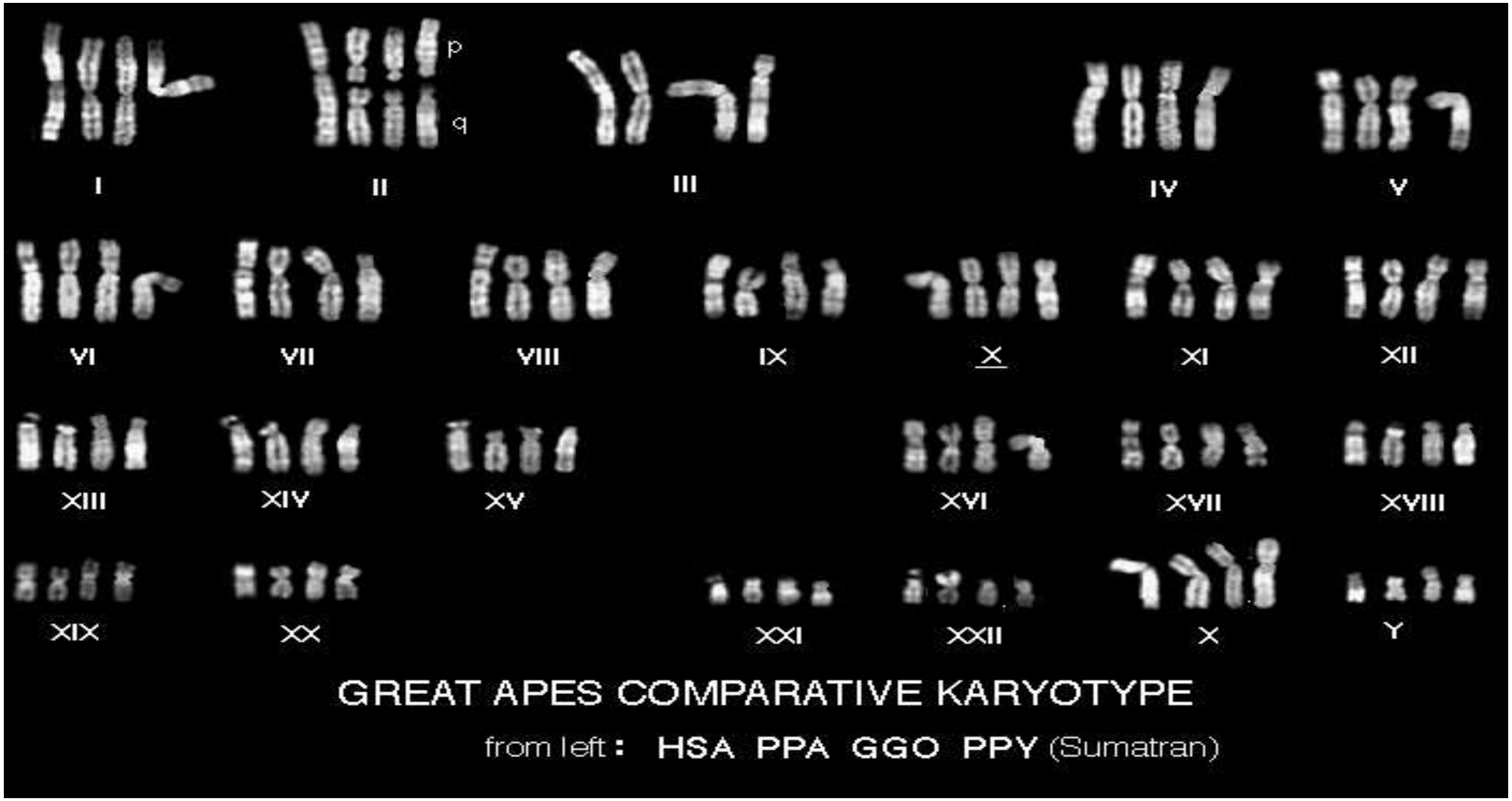
- Early pattern in embryological development provide evidence of phylogenetic relationships.
- They also provide means of testing hypotheses about relationships that have developed from other lines of evidence



Chromosomes and Macromolecules

- Taxonomists use comparisons of macromolecules such as DNA, RNA, and proteins as a kind of "molecular clock".
- Scientists compare amino acid sequences for homologous protein molecules of different species.
- The number of amino acid differences a clue to how long ago two species diverged from a shared evolutionary ancestor.

Comparison of Karyotypes



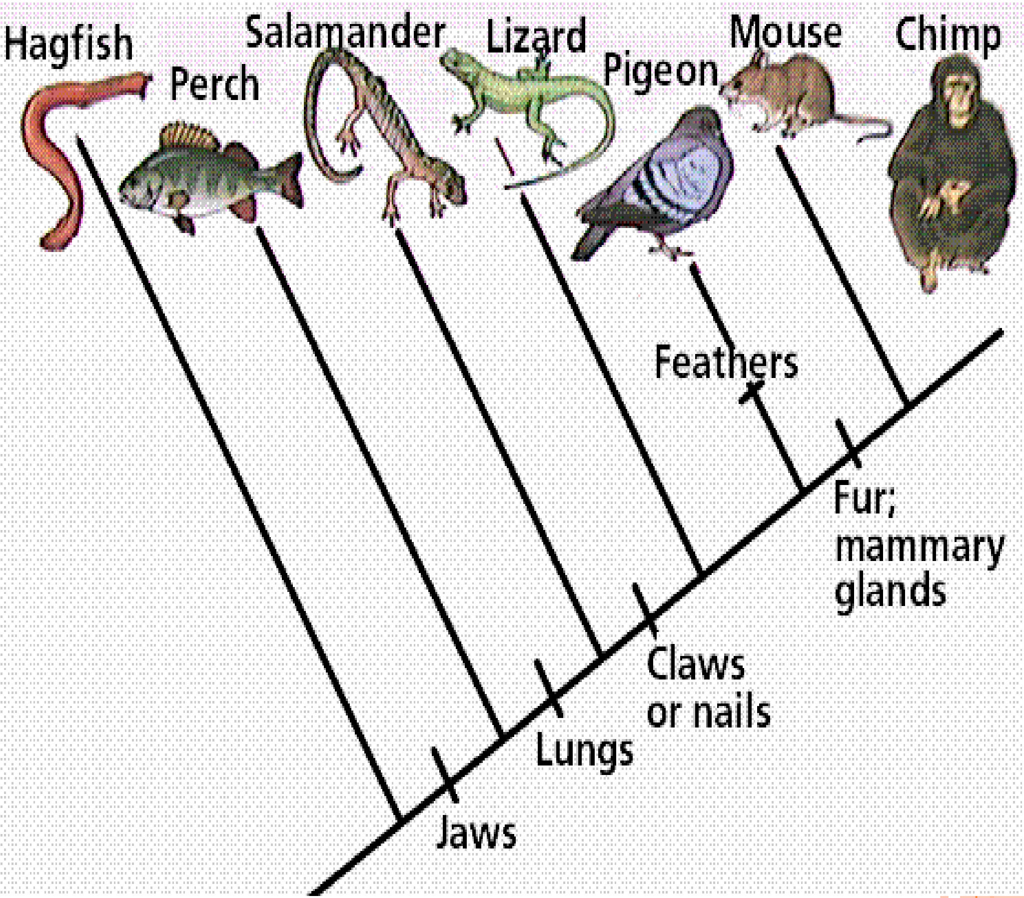
- Human (HSA), chimpanzee (PPA), gorilla (GGO), and orangutan (PPY) chromosomes are illustrated in a comparative karyotype of the great apes.
  - Photo courtesy of Dr. Mariano Rocchi, Institute of Genetics, Italy.

Cladistics

- Cladistics is a system of taxonomy that reconstructs phylogenies by inferring relationships based on similarities.
- It is used to determine the sequence in which different groups of organisms evolved.
- To do this, it focuses on a set of unique characteristics found in a particular group of organisms.
- These unique characteristics are called derived traits or derived characters.

Cladogram

- Using patterns of shared derived traits, biologists used cladisitcs to construct a branching diagram called a cladogram.
- A cladogram shows show a sequence in which different groups of organisms evolved
- The key to Cladistics is identifying morphological, physiological, molecular, or behavioral traits that differ among the organism being studied and that can be attributed a common ancestor.



INTRODUCTION

- **Taxonomy** is the science of the description and classification of organisms, essential in theoretical and applied biology.
- About 1.7 million species have been named since Linnaeus and it is estimated that only around 5-10% of the world's biota has been described so far, and, obviously, taxonomy plays the major role in this sense.

INTRODUCTION

However, taxonomy is in crisis:

- funding for taxonomy is inadequate,
- there is a lack of taxonomists,
- the recruitment of young scientists into taxonomy and systematics is extremely low, the impact factor of taxonomical journals is very low,
- and taxonomists have not been able to get the society and other disciplines concerned about the importance of taxonomy.

INTRODUCTION

- Fortunately, during the last years, several progresses are emerging. The general interest about biodiversity conservation, the advances of internet and web pages, the progress in molecular techniques, the development of statistics in phylogeny, and the new taxonomic funding initiatives and global projects are giving some light: taxonomy is getting fashionable again and topics like Phylocode and Bar Coding are among the most controversial and discussed subjects in taxonomy today.

INTRODUCTION

- In this course a major summary about modern trends in taxonomy, and the main concepts and topics in taxonomy today are revised.

CLAR IFYING SOME IMPORTA NT CONCEPTS: TAXONOMY, SYSTEMATICS AND PHYLOGENY

- The word **taxonomy** is derived from the Greek words *taxis* (= arrange- ment) and *nomos* (= law). Taxonomy is the science of the description and classif ication of organisms, essential to the inventory of life on earth

- Godfray (2002a) indicates that taxonomy, the classification of living things, has its origins in ancient Greece (with the first basic classification of **Aristotle**) and in its modern form dates back nearly 250 years, to when **Linnaeus** introduced the binomial classification still used today.

- The discipline of taxonomy traditionally covers three areas of stages: alpha (analytically phase), beta (synthetic phase) and gamma (biological phase) taxonomy (Kapoor, 1998; Disney, 2000). **Alpha taxonomy** is the level at which the species are recognised and described; **beta taxonomy** refers to the arrangements of the species into a natural system of lower and higher categories, and **gamma taxonomy** is the analysis of intraspecific variations, ecotypes, polymorphisms, etc.

- **taxonomy** would be just a part of **systematics;**
- taxonomy includes classification, but leans heavily on systematics for its concepts,
- and systematics includes both, taxonomy and phylogeny.

- taxonomy and **nomenclature** are different disciplines
- . Taxonomy recognizes **classificatory units** or **taxa,** whereas nomenclature attaches a given scientif ic name to each of these units.
- **Taxonomy is a scientific discipline, whereas nomenclature is a technique.**

- Strongly correlated (even overlapping) concepts to taxonomy and systematics, are the words phylogeny, phylogenetics and phylogenetic systematics.
- **Phylogeny** can be defined as the evolutionary history of a group or lineage, the origin and evolution of higher taxa, or the natural process or repeated irreversible splitting of populations (see Lincoln *et al*., 1998; Wägele, 2005).

- **Phylogenetics** is the science of the reconstruction of phylogeny, and

- **phylogenetic systematics** is a method of classification based on the study of evolutionary relationships between groups of organisms, and the integration of proper names of groups of organisms into a hierarchical system which reflects their phylogeny.

THE IMPORTANCE OF TAXONOMY…

- It is very important to know the living organisms around us,
- and careful and accurate identification and classification are of vital importance (Kapoor, 1998).

- Without taxonomy, nobody would be sure of the identity of organisms they were interested in, or whether they belonged to the same or different species as the organisms studied by others.
- Without taxonomy, there would be no meaningful genome projects, and medical science, for example, would be seriously compromised.

- Without taxonomy, <u>we could not begin to understand biodiversity and the related issue of conservation (Nature, 2002).</u>

- As Kapoor (1998) pointed out, taxonomy is essential in theoretical and applied biology (agriculture and forestry, biological control, public health, wild life management, mineral prospecting through the dating of rocks by their enclosed fauna and flora, national defence, environmental problems, soil fertility, commerce, etc).

- About 1.7 million species have been named since Linnaeus and it is generally estimated that only around 10% of the world's biota has so far been described (Wilson, 2000; Disney, 2000).
- Obviously, <u>taxonomy plays the major role, and its importance as basic science for the remaining sciences should be taken into consideration.</u>

- However, although society has a growing need for credible taxonomic information in order to allow us to conserve, manage, understand, and enjoy the natural world, support for taxonomy and collections is failing to keep pace (Wheeler *et al*., 2004) and passing through a world crisis (Boero, 2001).
- There are several reasons for this crisis and we have compiled here some of the reasons reported recently in the literature.

- **<u>Taxonomy is suffering from an important lack of funding.</u>** Funding for taxonomy is inadequate and largely diverted to studies of phylogeny, while thousands of species are threatened by imminent extinction (Wheeler, 2004; Wheeler *et al*., 2004).
- one reason is that taxonomist lack clearly achievable goals that are both realistic and relevant; the goal of describing every species on Earth is not realistic at present.
- Furthermore, there is a tendency among young and upwardly mobile ecologists to view museums and herbaria as "dusty" places with old people old-fashioned working on them

- The results is that taxonomical experts retire and are not replaced, zoology and botany disappear from university curricula and new researchers in biodiversity end up being either molecular biologists or ecologists (Boero, 2001).
- On the other hand, taxonomy often pays insuff icient attention to its 'end users': the ecologists, conservationists, pest managers and amateur natural- ists who need or want to identify animals and plants (Godfray, 2002a). Ecologists working in the tropics have felt the lack of taxonomic knowledge as an impediment that inhibits their ability to analyze community-level phenomena (see review by Brosnan, 1992), and taxonomy must facilitate, not obstruct, ecological and biodiversity studies (Wheeler *et al*., 2004).

- In this sense, taxonomy also must face up to the ‘species problem’, which is, together with ‘homology’ the main issue in comparative biology, being the subject of continuing discussion and debate (Rieppel, 2004). Species are complex things (Agapow & Sluys, 2005) and, therefore, taxonomy is a dynamic science. But this involves the problem that taxonomic organiza- tion of species is constantly changing, and some authors (see Isaac *et al.*,
- 2004) have asserted that species numbers are increasing rapidly owing to
- ‘taxonomic inflation’, where known subspecies are raised to species as a result in a change in species concept, rather than to new discoveries, and this has a great influence on macroecology and conservation. Taxonomists are often accused of creating confusion with so many changes.

- in fact, one of the main reasons responsible for the 'bad image' of taxonomists are we taxonomists ourselves; we have not been able to 'sell our product' properly. in spite of the importance of taxonomy, even today we are not able to get society and other disciplines concerned about this, which is, in part, our fault. we have been complaining about our situation in front of our microscopes at our universities or museums, but we have not done very much to try to solve the problem.

However, during the last few years, the situation is fortunately chang- ing, and although we are still in a global crisis and many things need to be improved, some progress is emerging. The general interest about biodiversity conservation, the revolution of internet and web pages, the advances in molecular techniques, the development of statistics in phylogeny, and the new taxonomic funding initiatives and global projects are given some light; taxonomy is getting fashionable again, and we could be witnessing the start of a ‘taxonomic revolution’.

BIODIVERSITY AND CONSERVATION:

(AN INPUT OF OXYGEN FOR TAXONOMY)

A lot of taxa remain to be discovered

Although there is no agreement among scientists about the estimation of the number of unknown species, it is estimated that about 90% of the world species are still undescribed.

Questions