Course Website:
http://homepages.ualberta.ca/~dsikes/courses.htm
Check weekly for lecture updates, readings, etc.

Course Content:
Theory & Practice of Systematics
Not taxon-specific

25 % alpha taxonomy
75 % phylogenetics

Introduction to Biological Systematics

Website, Course Outline
Readings (text..., reserve reading room)
Midterm & final exam
Project
“Labs” - Fridays meet in BI 182
Beetle exercise
Debates (discussions of readings)
5 Questions - bonus
Open office hours - make appointment

Lecture 2: Introduction to Biological Systematics
Outline: The role and value of Systematics

Taxonomy (α taxonomy) - in decline?
Describing species
Identification, Classification
Collections, Conservation

Phylogenetics (β taxonomy)
Phylogeny
Classification (?)
Evolutionary processes / patterns
Conservation

Godfray (2002)

- alpha taxonomy / phylogenetics
  (descriptive taxonomy / phylogenetic tax.)
  - suffering from lack of prestige & resources

- Solutions?
  - “web monographs” ?
  - unitary taxonomy  ?
Gould - Linnaeus’s Luck

“Descriptive” taxonomy
- Describing
- Cataloging
- Classifying
- Stamp collecting?

Hypothetico-deductive taxonomy
- Descriptions based on theory & hypotheses
- Seek a ‘natural’ classification

α (alpha) taxonomy

“Systematic biology has contracted at British universities to such an extent that it may be in danger of extinction as a sustainable discipline.”

- 1992 the Dainton Report on Systematics in the UK

α (alpha) taxonomy

Demographic trends in alpha taxonomy:
1990 survey
63% of taxonomists > 46 years old
Only 8% < 35 years old

α (alpha) taxonomy

“If we found these demographic trends in a newly discovered species of lemur, we would bring specimens into a zoo and start a programme of captive breeding.

But if these trends continue among taxonomists and systematists, how soon will it be before we cannot recognize a new species of lemur?”


α (alpha) taxonomy

Systematics training in universities -
- molecular systematics (your text)
- phylogenetics
- rarely any training in alpha taxonomy
- knowledge & skills are being lost

α (alpha) taxonomy

Results of this decline -
- systematists who can’t do identifications
- orphaned taxa
- fewer people to describe species
- lots of new trees, but fewer taxonomic changes
“We sit on the brink of a crisis”

Not enough trained taxonomists to describe remaining 5-15 million species - even if we had the money

\( \alpha \) (alpha) taxonomy

Solutions -
- Modernization - new technology
- digitization, web-publication, DNA
- NSF PEET grants (Partnership for Enhancing Expertise in Taxonomy)

Classification - usage of term

Standard:
“Activity of grouping entities or phenomena and giving names to the resulting groups”
-Wiley (1981) p. 194

Classification - usage of term

Actual usage today:
“Activity of grouping entities or phenomena and giving names to the resulting groups”

Phylogenetic analysis

Classification - usage of term

- Not ‘identification’
- Not phylogenetic analysis
  - often used as such (e.g. “3 schools of classification”)  
  - implications are wrong
- Not a phylogeny
  - often thought that “tree = classification”
  - many students misunderstand this
**Classification - usage of term**

So what is it?

- is an arrangement of names - names for groups (of names…)
  - Linnaeus prepared classifications
  - many modern phylogeneticists do not
    - new trees are not new classifications
    - new classifications can be based on new trees however

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**Example Classification**

Phylum Annelida
  - Class Polychaeta
    - Family Siboglinidae
    - Class Clitellata
      - Subclass Oligochaeta
      - Subclass Hirudinea
    - Class Echiura
  - Phylum Sipuncula

We’ll do more on classifications and trees later

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**Biosystematics - value**

1. Provide **Classifications** for our millions of species

   Provide natural classifications
   = reflect evolutionary history
   = based on sound phylogenetic analyses

   Natural classifications allow **predictions**

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**Biosystematics - value**

Allow prediction of attributes of taxa not yet studied

- medicines (antibiotics, etc.)
- biological control agents
- predict ecological relationships
- extinct taxa - singing dinosaurs?

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**Biosystematics - value**

Bad, “unnatural” classifications can be **disastrous**

- e.g. Gypsy moth - brought to Boston by a Frenchman, Leopold Trouvelot
- hoped to start a business in silk
- chose this moth because of its name at that time: *Bombyx dispar*
- oriental silk moth = *Bombyx mori*
Biosystematics - value

Moth was no good for silk
Was very good at eating native trees
Escaped & is still a major pest species
Current name: *Lymantria dispar* (different superfamily from *Bombyx*)!

(Bad) Taxonomy used for conservation assumed 1 species when there were 2+
Resulted in
- possible extinction of a subspecies
- near extinction of a second species
  (extinction of 10 of 40 populations)

Described in *Nature* 347, 177-179 (1990)

Biosystematics - value

2. Infer phylogenies
   - inform our classifications
   - to know what a organism “is” requires phylogeny
     e.g. tongue worms - pentastomids
     bizarre parasites of vertebrates
   - what are they?

Biosystematics - value

3. Understanding evolutionary processes
   a tree is required to study:
   - Cospeciation
   - Historical biogeography, phylogeography
   - Macroevolutionary patterns
     explosive radiations
     extinctions
   - Trait correlations
     Are warning colors related to the evolution of gregariousness?
   - Adaptations

Biosystematics - value

Evolution of Swim Bladders & Lungs

- Both derived from outpocketings of the gut
- Both structures hold gas
  - Swim bladders to adjust buoyancy
  - Lungs for gas exchange
- Tetrapods & some fish have lungs
- Many fish have swim bladders

Which is the came first?

Need a tree...
Biosystematics - value

Sound natural classifications or phylogenies enable biologists to
- intelligently frame their hypotheses
- understand the direction of evolutionary change
- know which taxa are appropriate for comparative studies

Conservation Biology - Biodiversity crisis

- Massive habitat destruction
- ca. 1 species extinction / 20 minutes
- current extinction rates 100 to 1,000 times greater than “normal”

Phylogenies help identify unique lineages
e.g. “living fossils”
e.g. a duckbilled platypus
**Biosystematics**

Systematics "is at the same time the most elementary and most inclusive part of biology, most elementary because organisms cannot be discussed or treated in a scientific way until some taxonomy has been achieved, and most inclusive because systematics in its various branches gathers together, utilizes, summarizes, and implements, everything that is known about organisms, whether morphological, physiological, or ecological."

Paraphrased from George Gaylord Simpson's book, "Animal Taxonomy"

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**History of Taxonomy**

- **Father of Biological Classification**
- **Used concept of nested sets**
- **Named various taxa**
  - e.g. Coleoptera
  - "Sheath-wing"
- **Oldest scientific names still in use**

- **Aristotle**
  - 384-322 B.C.

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**Phylum Annelida**

- **Class Polychaeta**
- **Class Clitellata**
- **Class Echiura**

**Nested Sets**

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**History of Taxonomy**

- **Botanical taxonomy developed faster than zoological**
- **Plants used for medicines & foods**
- **Theophrastus 371-287 B.C. - classified 500 species of plants (e.g. *Asparagus*)**
- **Books on plants (herbals) with illustrations, descriptions & names became common**

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**History of Taxonomy**

- **Herbals copied without improvements throughout the Middle Ages**
- **Very little progress until the 15th century - Gutenberg’s printing press**
- **Botanists began using phrase names - descriptive names of species**
- **Latin, usually < 12 words**

**Phrase names:**
- **Joseph Pitton de *Tournefort* - paved the way for Linnaeus**
- **Key work published in 1700 instituted the genus name**
  - *e.g. Mentha floribus spicatis, foliis oblongis serratis*
  - "mint with flowers in a spike, leaves oblong and toothed"
History of Taxonomy

First Bioinformatics crisis - too many new species & names, chaos reigned

Linnaeus instituted a simpler, more organized system - binominal nomenclature, 1753, [6,000 plants]

based on *binomen* - species name composed of two words - as an abbreviation for the full phrase names
(note: not binomial nomenclature)

History of Taxonomy

Linnaeus’s 5 ranks:

Kingdom - Animalia
   Class   - Insecta
      Order  - Coleoptera
        Genus  - *Silpha*
          Species  - *Silpha vespillo*

All animals in 312 genera

History of Taxonomy

The binominal system was actually first used by Gaspard *Bauhin* (1623) but never caught on

Linnaeus reintroduced & imposed it on the world - chaos was averted

Zoological nomenclature began with the 10th edition of Linnaeus’s *Systema Naturae* (1758) - why this edition?

You should be able to

Describe the decline of alpha taxonomy & ideas to reverse it

Understand the term Classification (not easy!)

Describe the value of phylogenetics

Describe the key people & their influence on the development of Systematics