BIOL 1030 – TOPIC 1 LECTURE NOTES

Topic 1: Classification and the Diversity of Life (Chapters 25, 26.6)

I. Background review (Biology 1020 material)

A. Scientific Method

1. observations
2. scientific model
   - explains observations
   - makes testable predictions
3. test predictions (can confirm predictions)
4. reject, revise, or tentatively accept scientific model
5. caveats:
   - *Scientific models can only be proven false, never proven true.*
   - *Correlation does not equal causation.*
   - *Testable predictions cannot include the supernatural (the supernatural cannot, by definition, be tested scientifically); thus, the supernatural is outside the realm of science.*
   - *The term "theory" has a very different meaning in science than in most everyday conversations.*
6. terms:
   - *hypothesis – model that has not been tested or has only been tested some*
   - *theory – model that has been tested extensively and is accepted by most scientists in that field*
   - *law – usually a very well-established theory that explains a wide body of observations*

B. Theory of Evolution: The Modern Synthesis

1. Evolutionary relationships between organisms provides the theoretical framework for modern classification systems; as such, it is the major organizing principle underlying the structure of most of this course
2. In POPULATIONS, new mutations (random) and recombination of current variations (random) occurs.
3. Populations encounter EVOLUTIONARY MECHANISMS:
   - natural selection (greater reproduction by the "fittest")
   - genetic drift (random, greater for small populations)
   - gene flow (genetic exchange with other populations)
   - mutations (new changes in genetic material)
4. Evolutionary mechanisms cause MICROEVOLUTION: changes in population genotype and allele frequencies for the next generation.
5. Adding any REPRODUCTIVE ISOLATION MECHANISM allows MACROEVOLUTION (speciation).
   - Examples of reproductive isolation mechanisms include physical separation, selective mating, and sterile offspring.
6. Speciation can be rapid (punctuated equilibrium) or gradual; relative amounts of these are debated but both appear to occur.

II. Classification of organisms

A. Biologists use a **binomial system** for classifying organisms.
   1. **taxonomy** - the science of classifying and naming organisms.
   2. **Carolus Linnaeus** (18th century biologist) developed a system of classification that is the basis of what is used today
      - binomial system: today each species' official scientific name is made of 2 words (bi="2" nomen="name")
      - names are Latin
        - same language used universally in biology
        - dead language – not changing
        - names of people can be "Latinized" for use in naming
   3. **species** - basic unit of classification or taxonomy (more on this later)
      - if sexual, a group of organisms that can interbreed and produce fertile offspring
      - if asexual, grouped based on similarities (DNA sequence is best)
      - about 1.8 million living species have been described, likely millions more
   4. **genus** - a group of closely related species.
   5. together the **genus and specific epithet names make up the binomial name** used to name a species
      - the Genus name is always capitalized, and the specific epithet is never capitalized.
      - the Genus and specific epithet are always together, and italicized (or underlined).
      - example: *Homo sapiens* or Homo sapiens

B. Taxonomic classification is hierarchical.
   1. A group of related genera make up a **Family**.
   2. Related families make up an **Order**.
   3. Related orders are grouped into a **Class**.
   4. Related classes are grouped into a **Phylum** or **Division**.
   5. Related phyla or divisions are grouped into a **Kingdom**.
   6. Related kingdoms are grouped into a **Domain**, the highest level of classification in the modern system.
   7. The gold standard for "related" is based on DNA sequence similarities, but other criteria are used as well (we don't have the complete DNA sequence of all known species)

III. What is a species?

A. Species: "Kind of living thing"

B. Word "species" is both plural and singular

C. relatively easy to define for sexual organisms, hard for asexual organisms and extinct species
   1. **biological species concept** (for sexual organisms) – one or more populations whose members are capable of interbreeding and producing fertile offspring, and whose members are **reproductively isolated** from other such groups
      - not always clear-cut, because some can interbreed under "artificial" conditions but don't appear to do so in nature
      - sometimes, "race" and "subspecies" designations are used, but often different specific epithets are used when there are clear morphological differences involved
   2. asexual species – definition based on biochemical (think DNA sequence) and morphological differences; no solid rules

- also includes use of "race," "subspecies," and "strain" designations
- in asexual species, microevolution over time directly leads to macroevolution (speciation)

3. **evolutionary species concept** – a single line of descent (lineage) that maintains its distinctive identity from other lineages; works for all species, but it can be hard to clearly define "distinctive identity"

D. So how many species are there?

1. no one knows for sure, best guess is about 10 million, but only about 1.8 million have been described by humans
2. most are tropical
3. human activities (particularly in the tropics) are certainly destroying many species before they can even be described; we are undergoing the sixth mass extinction event in the history of life on earth (and the first one driven by the activities of man)

IV. Classification: constructing phylogenies

A. classification is largely based on inferred evolutionary relationships between organisms; the two major approaches to this are **cladistics** and **traditional taxonomy**

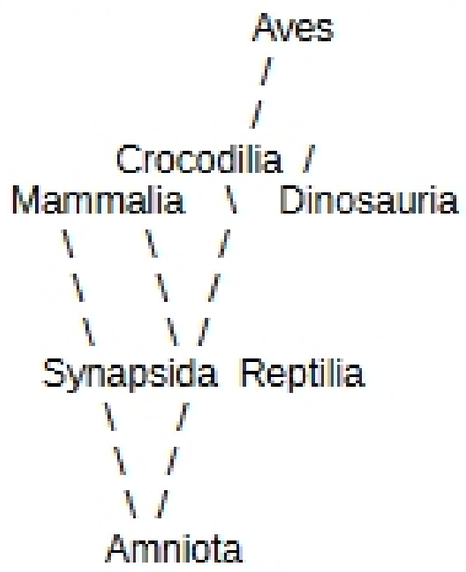
1. **phylogeny** – evolutionary tree; explanation of evolutionary relationships among groups (what evolved from what, in what order, and when)
2. **systematics** – study and reconstruction of phylogenies
3. groups of organisms may be:
   - **monophyletic** (includes most recent common ancestor and all descendants)
   - **paraphyletic** (includes most recent common ancestor BUT not all descendants)
   - **polyphyletic** (does not include most recent common ancestor)
4. both cladistics and traditional taxonomy avoid polyphyletic groups; cladistics also avoids paraphyletic groups

---

EXPLANATION

What do terms monophyletic, paraphyletic and polyphyletic mean?

These terms are used to describe groupings of organisms, and indicate the extent to which they can be considered as ``natural groups". They are best explained using examples, so consider the following family-tree diagram:



Here are examples of all three types of group:

- Consider the group consisting of all the animals in this diagram - that is, Amniota. This group is monophyletic because it consists of a single animal together with all of its descendants. The Dinosauria, including the modern birds, is another