Introduction to some evolutionary terms and concepts

Variation and Natural Selection

Evolution is defined in many ways. Descent with modification (Darwin's expression) or change in the allele frequency of a population from one generation to the next are popular definitions. Allelic evolution occurs within a local population of interbreeding individuals, and it is usually inferred from the differences observed between two or more such populations. In an extreme sense, individuals simply act as vehicles for the genetic material, and depending upon their degree of success in leaving offspring, they are able to contribute more or less of their genetic identity, specifically alleles, to the succeeding generation. This is intra-population evolution.

Evolution is a purely mechanical, entirely opportunistic, process. There is no predetermined goal for it to achieve. Two of the major factors required for evolution to occur are a source of variation and a means of selecting among the variants. Genetic variation allows for sustained evolution. It is produced by two processes, recombination of different alleles and mutation.

Mutation is a familiar process: the most common form is the alteration or change in genetic structure, for instance, replacement of one nitrogen base in the DNA molecule with another. The alteration of a gene modifies the biochemical message released to a cell, which in turn may eventually lead to a physiological or anatomical change. Mutations alter the basic chemical processes of cells and they are frequently lethal; however, their lethality is usually expressed only in a homozygous state. Thus, a mutant allele is not necessarily eliminated from the gene pool (the total genetic composition of the local population) as soon as it appears. The second source of genetic variation, recombination, is probably more important. In this process, the structure of the gene is not altered, but rather new combinations of genes and their alleles are produced. These new arrangements result from the processes of segregation, independent assortment and crossing over, and mating. Recombination may appear to be a minor factor in evolution but a gene's position relative to other genes can affect its expression, just as different combinations of alleles often produce different phenotypes.

The non-random process that favors certain genotypes among the available genetic variants is natural selection, and operationally it occurs by differential reproduction. Simply, within a population some individuals leave a larger percentage of their alleles in the following generation because of their greater survivorship and fecundity. More fit individuals are those which produce more young that survive and reproduce. It should be emphasized that evolution is identified with the population, but natural selection acts on individual organisms, or closely related groups of individuals. Also, some intra-population evolution can be ascribed to chance. The accidental fixation of an allele is an important consideration when there are only a small number of individuals interbreeding. What types of social systems might limit the number of interbreeding individuals? What other chance-based phenomena might contribute to evolution? What is the founder effect?

Phylogeny, Nomenclature and Classification

The historical pattern of ancestor-descendant evolution of species is termed phylogeny. The evolutionary tree, or cladogram, that you also received is a hypothesis of vertebrate phylogeny. Cladograms make no hypotheses about rates of evolution, or particular

common ancestral species. Cladograms only imply relatedness in terms of group membership: two members of a group share a more recent common ancestor than either does with any assemblage outside that group. The evidence for group membership is shared novelties, or synapomorphies.

If you think of a cladogram as an estimation of genealogical history, and the nested series of groups (species, or sets of species) as the parts of that history, then it is easy to see how a set of names, one name (taxon) for each group, can be consistent with that historical pattern. A set of inclusive taxonomic names is called a taxonomy. Certain terms have been used to designate rank-ordered levels of generalization for all organic diversity, plant and animal. A genealogically older, more general, level of divergence includes those levels that have diverged more recently, within it: phylum includes subphylum, subphylum includes class, and so on.

A proper name(s) is used for each of the classificatory categories recognized for a particular cladogram. The categories and associated nomenclature for the human, the red fox and the domestic cat are given in Table 1. Can you reconstruct a cladogram of the three from the nomenclature provided in Table 1? You should be able to do so if each taxonomy is consistent with the hypothesis of relative recency of common ancestry.

A cladogram, or phylogenetic tree, is a hypothesis based on observations that, in turn, require some assumptions. What are the assumptions? Why can't phylogeny be observed? Can there be more than one phylogeny for a given group of organisms? Can there be more than one history?

All taxa (proper names) in the hierarchical classification on Lab Handout 2 (LH2) are monophyletic, according to the cladogram on LH3. A taxon is monophyletic when it includes a common ancestor and all of its descendants (a clade, as visualized on a particular cladogram). Unfortunately, some classifications include non-monophyletic (paraphyletic and polyphyletic) assemblages. A paraphyletic group includes a common ancestor and some, but not all, of its descendants, and thus is an incomplete representation of history. A polyphyletic group does not include the most recent common ancestor of its members. Monophyletic groups can be diagnosed as real parts of history, on which evolution acted. Non-monophyletic groups do not reflect history; they are entirely a figment of human imagination. Paraphyletic groups are often a necessary by-product of biological classification, and thus will continue to persist in our science and language even though they are not "real." Polyphyletic groups are to be avoided at all costs—there is no scientific or practical advantage to maintaining polyphyletic groups.

Table 1

Categories	Nomenclature		
Phylum	Chordata	Chordata	Chordata
Subphylum	Vertebrata	Vertebrata	Vertebrata
Class	Mammalia	Mammalia	Mammalia
Order	Carnivora	Carnivora	Primates
Family	Felidae	Canidae	Hominidae
Genus	*Felis*	*Vulpes*	*Homo*
Species	*sylvestris*	*fulva*	*sapiens*
Familiar name	Domestic cat	Red fox	human