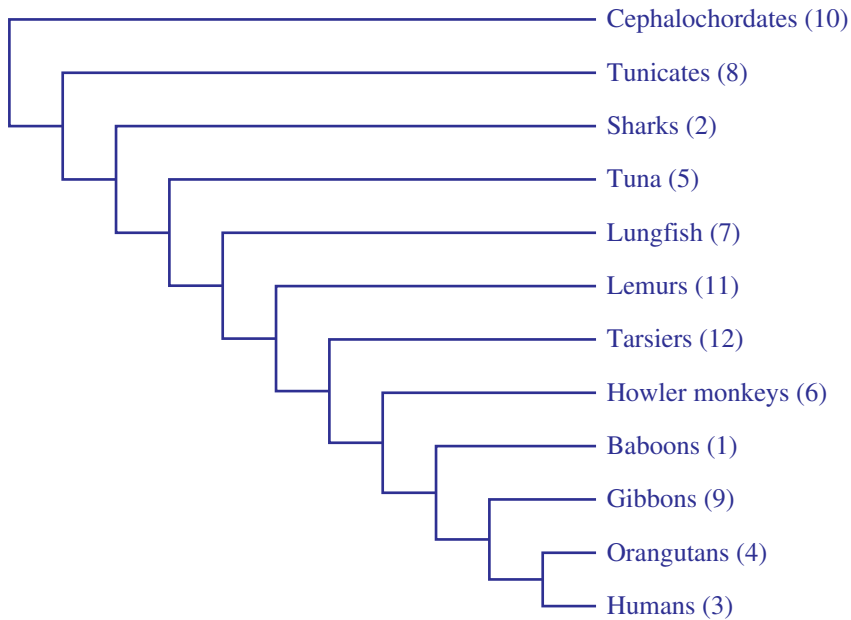


Midterm Exam 2 - Organic Evolution

- Hybrids between different species are infertile because they lack homologous chromosome pairs (3 pts). This problem is overcome if all chromosomes are duplicated, but this produces a tetraploid individual whose gametes are incompatible with those of either parent species (4 pts). Since the occurrence of such a tetraploid is a very rare event, a new species is likely to emerge only if this sole tetraploid hybrid can self-fertilize (3 pts).
 - When different species within the group have chromosome numbers that differ by factors of 2. (Or: when some species are found to have chromosomes that are derived from two other species.)
- This suggests that polymorphisms have been maintained in both lineages since before the common ancestor (or for over 28 my) (4 pts, 3 for just saying that they were maintained for a long time). Two alleles can be maintained in a population for this amount of time only if there is balancing selection (6 pts). (3 pts if they say only that the gene tree does not match the species tree, or that there has been incomplete lineage sorting.)
- The timing of expression of both Globin and Hox genes is influenced by their position on the chromosome. Since a duplicate gene will have a different position, it is expected to be expressed earlier or later than the original gene. (5 pts)
Gamma globin arose soon after the appearance of placental mammals. The fetus in placentals is selected to have blood with higher oxygen binding efficiency than that of the mother's blood. Adaptation of gamma globin thus improved the efficiency of placental fetal development. (5 pts, 3pts for just listing γ hemoglobin with no explanation)
- Individuals that are heterozygous for a chromosomal aberration generally have low fitness (because different chromosome structures cause problems in meiosis, leading to many nonfunctional gametes). Such chromosomal aberrations thus do not last long in populations (4 pts). Chromosomal aberrations can go to fixation by drift (2 pts). When this happens, it often leads to speciation, since hybrids between the isolate and the parent population will have reduced fitness (4 pts). We thus find many pairs of closely related species that differ in chromosome structure.

5. (a) The gene was probably copied by the SVA element (2 pts). Retroelements copy themselves by making an RNA transcript that is then reverse transcribed into DNA, which is inserted elsewhere in the genome (1 pt). They can "pick up" downstream genes by transcribing through their own stop signal, making an RNA transcript that includes downstream genetic material (2 pts). This extra material is then reverse transcribed elsewhere with the retroelement.
- (b) $\frac{K_a}{K_s} < 1$ implies that purifying selection was acting on the ancestral AMAC gene. $\frac{K_a}{K_s} = 1$ implies neutrality, so the purifying selection was relaxed when there were more copies of the gene. (ok if they just say purifying selection on the original single gene and no (or weakened) selection on the multiple copies)
6. Reducing age specific survivorship (or just survivorship, or p_x) of adults selects for earlier reproduction (5 pts). The fact that the age of sexual maturity changed so drastically in a relatively short time suggests that human hunting had a large effect on adult survivorship (2 pts) and thus population growth (3 pts).
7. If a new allele is in the process of sweeping through a population, then we expect to see reduced variation at sites that are closely linked to that allele (5 pts). By contrast, there should be normal amounts of variation at sites that are closely linked to the older allele, that is in the process of being selected out (5 pts).



8.

-1 pt for each branch that must be added or moved. $-\frac{1}{2}$ pt for each extra taxon that is added.

9. Briefly define the following terms. (2 pts each)

- (a) A trait that experiences disruptive selection and for which there is assortative mating.
- (b) Shared derived traits in different organisms.
- (c) Choosing the tree (or hypothesis in general) that maximizes the probability of the observed data.
- (d) A nonfunctional DNA sequence that has clear sequence similarity to a functional gene.
- (e) Transfer of genetic material between any two organisms other than parent and offspring. Often used in cases of gene transfer between separate species.
- (f) Process by which certain alleles (or tightly linked groups of alleles) consistently show up in more than half of the gametes produced by heterozygotes.
- (g) Genes encoding for transcription factors that provide positional information during the development of plants. (Or: Plant analogue of Hox genes)
- (h) Abrupt decline of age specific survivorship (or p_x) to zero at a characteristic age.

- (i) All and only the descendants of a common ancestor, including the ancestor itself.

- (j) Genes at different loci that arose from a common ancestor through a gene duplication event.