Genetics 453 Name: _____
2002 Final exam

The test is closed book. You may use a calculator, but you can also leave computations in fractional form, such as $2 \times 3.67/19$. You can work in the space provided and also on the back of the sheet (in which case make it very clear which problem is being worked on). The questions total 200 points. Please write your name on each page as we will separate them for grading. Exams will be available in the Genome Sciences office (K357 Health Sciences) starting Monday, March 25.

1. (25 points) In Mark Ridley's text *Evolution* (1993, p.377) he states that "Biological classifications are hierarchic because evolution has produced a tree-like, diverging, hierarchic pattern of similarities among living things."

   Discuss this. Was this Linnaeus's reason for preferring a hierarchical classification system (one with groups inside of groups inside of groups)? Why or why not? Did the groups that he and later biologists defined correspond to branches of the phylogeny? Explain.

2. (30 points) Suppose that a random-mating population of snails has a locus with two alleles, B and b. If we look at the population and see only two genotypes, BB and Bb, finding them in a 700:300 ratio,

(i) What is the gene frequency of B in this population?

(ii) Among newborn snails what genotype frequencies for the three possible genotypes should we see?

(iii) If the absence of heterozygotes is because they die before adulthood, what genotype frequencies will we expect to see among adults of the next generation? (You may assume the population is very big). What will be the gene frequency among those adults?

(iv) What will we expect to happen to the frequency of B in the longer run?

3. (30 points) Here is an actual set of aligned sequences (from phi-eta globin pseudogenes) ("-" means gap: insertion or deletion).

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                1          11          21
                |           |           |
Human           ga-ttaaaaa acacagtaat aaa
Chimp           ga-ttaaaaa acacagtaat aaa
Gorilla         ga-ttaaaaa acacagtaat aaa
Orang           ga-ttaaaaa actcggtaat aaa
Gibbon          gatttaaaaa -catggtaat aaa
Rhesus monkey   gattttaaaa acatggtaat aaa
Spider monkey   ga-ttaaaaa acactgaaat aaa
Galago          ga-ttataaa acacaagaat aat
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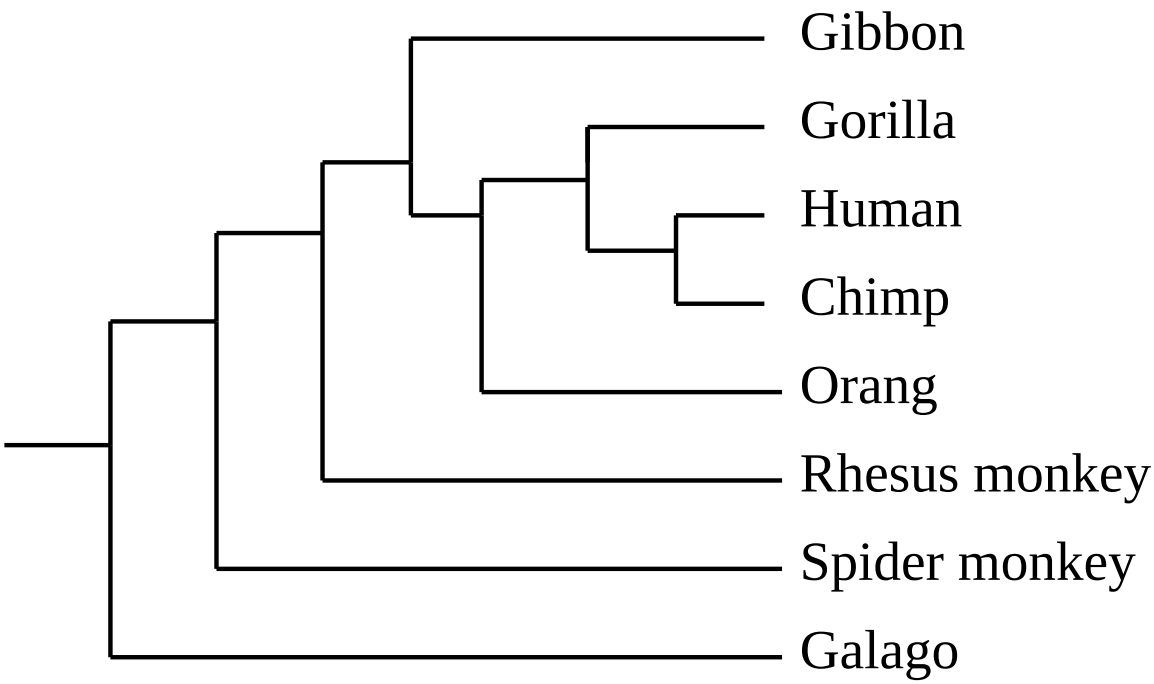
Here is a phylogeny someone has suggested. Where in this tree does the parsimony criterion suggest that the insertions occured? The deletions? The changes of base? Indicate them on the tree. Be specific and indicate which sequence positions each event is for. There may be more than one possible reconstruction of events at some sites.



4. (20 points) A biologist says that "Kimura's neutral mutation theory is obviously wrong. We see much faster substitution at the hemoglobin-β locus than in cytochrome C. But the rate of mutation at those loci is probably about equal. So the rate of substitution is not equal to the rate of mutation." Agree or disagree and explain why.

5. (30 points) Suppose that we have a species with one generation per year, and it splits into two species. One continues to have a large population (say 100,000 individuals) and one is small (1000 individuals) and stays small. The speciation event happened 10,000 years ago). If we use sequences at a locus and look at 4 copies of the gene from each population, and make a tree of these 8 copies of the gene, what would it be expected to look like? Sketch one reasonable tree we might find, with a time scale. Explain your choice.

6. (30 points) Suppose that in a diploid population an individual has a single gamete whose chromosomes did not separate at meiosis, so that two copies of each chromosome are present.

   What will be the chromosome composition of the resulting offspring?

   How will they segregate at meiosis when this offpsring produces gametes? (Be specific).

   Will this second generation of offspring be phenotypically normal?

   Does this make it easy to imagine a tetraploid (doubled) chromosome content arising and taking over a population? Why or why not?

7. (35 points) Suppose that a monoecious flowering plant can produce both pollen and ovules. Pollen are only 1/100 as costly as ovules to produce. Genotype *aa* produces 100 ovules and 20,000 pollen grains per plant. Genotypes *Aa* and *AA* put all their effort into ovules, so they produces 300 ovules per plant and no pollen grains. The pollen is carried around by bees and there is random mating.

   In a population of 99 individuals of genotype *aa* and 1 individual of genotype *Aa*, what fraction of all pollen comes from genotype *aa*? What fraction of all ovules come from from genotype *Aa*?

   If the next generation has half its genetic material come from ovules and half from pollen, what fraction of all of the genetic material comes from the 1% of parents who were of genotype *Aa*? Is allele *A* increasing or decreasing in the population?

   In the long run, will allele *A* take over the population? Why or why not?