(1) What are *quantitative traits*? Why are their phenotypic trait values (x) usually distributed approximately normally (*i.e.*, following a bell-shaped curve) within large populations? How is the total phenotypic variance (V_P or V_X or σ_X^2) partitioned into *variance components*?

(2) What is the (narrow-sense) *heritability* of a trait? How can it be estimated? And how can we use an estimate of the heritability, or of the *additive genetic variance*, to predict the trait's response to selection?

(3) What are *norms of reaction*? Why can the environmental and genetic variance components be changed (either or both) by a change in the environment, or by a change of allele frequencies in the population?

(4) What are *tradeoffs*? Give several examples. How do they constrain adaptation? How to they contribute to *speciation*? (That is, how do tradeoffs promote biodiversity?)

(5) A mouse and a songbird are roughly the same size, and the songbird has, if anything, a higher metabolic rate. Why does the songbird have a much longer maximum lifespan? Be sure you identify the *tradeoff* that is believed to cause this difference, and explain how it does so.

(6) Why do we expect parents to want their offspring to be "nicer" to each other than the offspring want to be, even when the offspring are full siblings?

(7) Natural selection is incessantly improving every species' adaptations, and it has produced some wonders of precise and seemingly "clever" apparent "design". Nonetheless, organisms are far from "perfect", or even "optimal" under the given constraints. Why? Give several reasons, and if you can, give at least one *example* of each.

(8) How does the evolution of sex ratios demonstrate the difference between *natural* (individual or gene-level) selection, and *group* (or species-level) selection?

(9) How could you use genetic data to test the hypothesis that there are really two or more species of people? (There aren't.) But for most of the last few million years there were in fact several species of hominids (*Australopithecus* and/or *Homo*) alive at any given time. So our ancestors speciated quite successfully. Why are "we" (*i.e.* future *Homo sapiens sapiens*) very *unlikely* to speciate again?

(10) No one has (yet) studied the diversity and evolution of Hawaiian soil nematodes. For your Ph.D. thesis, you boldly decide to go where no man (or woman) has gone before. You discover four closely related species of *Caenorhabditis* on the islands of Kauai, Oahu, Maui, and Hawaii, respectively. Eagerly, you sequence their mitochondrial COI genes, to determine their phylogenetic relationships. Most likely, what is the phylogeny of these four species? Explain why you can predict how it will probably turn out, even before you have any data!

Biology 3410 **Second midterm exam** 9 March 2007 (condensed to save space)

1. Quantitative traits such as human height, beak depth in Darwin's medium ground finch, and most other scalar measurements of lengths, rates, masses and the like, within sexually reproducing species, are almost always *normally distributed*, at least to a good approximation. *Why*? [20 points]

2. In 1976 (before the drought of 1977), the average adult beak depth of Darwin's medium ground finches on Isla Daphne Major was 9.4 mm. In 1978 (after the drought) the average beak depth of the survivors was 10.1 mm. The survivors then mated at random with respect to beak depth, and produced offspring with an average beak depth of 9.7 mm. From these data, you can estimate the narrow-sense *heritability* of beak depth in this population. Please do so, and *show your work*. [15 points]

3. "If there is any *genetic variance* (V_G) for a quantitative trait, within a population, then the trait values (x) of parents and offspring will be *correlated*." Please carefully explain *what's wrong* with this statement. [15 points]

4. Many species of marine fish and shrimps have been heavily harvested for decades. Fisheries biologists have noticed that most of these species now mature at younger ages and smaller sizes than they did in the past, and that their maximum lifespans are now shorter. These evolutionary changes were caused by fishing, and they could have been *predicted*. Please explain why. [20 points]

5. Suppose you wake up tomorrow morning and read in the *Deseret News* that a new species of South American songbird has been discovered, in which the females are larger and more brightly colored than the males. What would you predict about their breeding system? Does one sex build the nest and do most of the offspring care? If so, which sex? Or do both parents share equally in the work of parenting? *Explain your reasoning.* [15 points]

6. No one knows how many species there are on Earth. Fewer than two million have been described and named, but estimates of the total range from 10 to 100 million. Many experts believe that of this total, more than half (perhaps *way* more than half) will turn out to be parasites. This belief is based mainly on extrapolations from existing data, but it is also supported by theoretical considerations about the process of speciation. What is it about the biologies of parasites that would lead you to think that they might tend to *speciate* at relatively *high rates*? Hint: Parasites are often highly specialized for life on or in particular species of hosts (or groups of closely related host species). Briefly explain your reasoning. [15 points]

Biology 3410, 3rd midterm exam from 2005 (as given 6 April 2005, but condensed to save space)

1. Humans are fond of recording their heights, so we have a great deal of information about the distribution of this simple quantitative trait. Body size measurements of all kinds are usually highly heritable. The heritability of height has been estimated many times in many populations, and the resulting values of h^2 almost always fall between 0.6 and 0.8. *What is heritability*, and what do numbers like 0.6-0.8 imply about the *causes of the observed variation in height?* [25 points]

2. Average human heights have increased dramatically in many countries since World War II. The reasons are always said to be improved nutrition and medical care (*i.e.*, environmental change). We all believe this, *but how do we know?*
What if an overeducated friend of yours said "Nonsense! I think it's *selection!* Quantitative traits evolve like crazy in most natural populations. Haven't you heard of Darwin's finches? Why couldn't something like that happen with human height? It's *highly* heritable, so a large change in the mean trait value seems most likely to be an *evolutionary* change."
On the face of it there's nothing wrong with this argument, so you can't just assert that your friend is out of her mind. (Well you *could*, and you might be right, but doing so won't win the argument.) What you need to do is show that *in fact* these changes were *not* evolutionary. Assume you have access to a comprehensive, LDS-quality genealogical database for Kyoto, Japan, for the years 1935-1995, with information on peoples' adult *heights* as well as their complete family histories (who they married and who their children are). How would you analyze these data to test your friend's hypothesis, and what finding would refute it? *Be specific!* [30 points]

3. In an ecological and evolutionary context, what is a *tradeoff?* Explain (in general) by reference to a *specific example.* [15 points]

4. Given that reproductive altruism *can* evolve by kin selection, why do we expect it to occur mainly between very *closely related* individuals? Why not between *distantly* related individuals? Be sure to include *Hamilton's rule* in your explanation. [15 points]

5. No one knows how long speciation *typically* requires, but several lines of evidence suggest that it *can* and *sometimes does* occur in just a few hundred to a few thousand generations. Describe and briefly interpret one of these lines of evidence (a good choice might be "ring species"). [20 points]