1. Why do we need NS? We typically use NS to explain why organisms are well-matched to their environment, but this could easily be explained just as well by ‘Creation Science’ (intelligent, all-powerful creator). In fact, we need NS to explain why organisms are NOT as well suited as they might be. To get to this understanding, we have to go beyond the usual simple version of Darwin’s theory presented in most texts (including ours).

2. Darwinian theory:
   a. Phenotypic variation
   b. Selection (some phenotypes do better than others)
   c. Inheritance of traits (genes of more successful phenotypes are passed on to future)

3. More in-depth look at above:
   a. Phenotypic variation – where does this variation come from?
      i. History -- evolutionary background dictates which or how many alleles are available to be present at locus A and the genetic ‘background’
      ii. ‘random’ mutation from common ancestor; concept of genetic ‘load’
      iii. recombination and sexual reproduction create distinct genetic backgrounds from a given ancestral genotype
      iv. distinct environments create distinct expressions of a given allele/genotype
   b. Selection. Differential survival AND reproduction of individuals with particular phenotypes.
      i. Optimizing (‘improving’) PROCESS, but no guarantees.
      ii. Direction and strength of selection can vary a lot over time.
         (1) stabilizing
         (2) directional
         (3) disruptive
      iii. Random component (‘drift’, founder effects)
   c. Inheritance. Problem: NS works on phenotypes, but evolution requires changes in allele frequency. Phenotypes NOT equal to genotypes, nor to sum of alleles. Why?
      i. Phenotype may depend on combinations of loci, not just their sum (pleiotropy)
      ii. Recombination guarantees that genotypes get scrambled each generation.
         Analogy of message (genes) vs. text (phenotype).
      iii. Environmental influence adds non-genetic variation (although some of this variation may be dictated by genes = ‘genotype-by-environment’ interaction).

4. Conclusion: NS is an slow, faltering, history-laden process of perfection, but most organisms will NOT be at the pinnacle of perfection most of the time, unlike the pattern predicted from an ‘intelligent’ creator. A useful aspect of NS is that it can be used to predict what values of a trait the organism SHOULD have in theory (but may not have, because mutation and history and recombination are ‘random’). Such modeling is a very important part of BE, and is one of the great success stories of modern evolutionary science – it is what separates ‘old-fashioned’ natural-history story-telling from the modern predictive approach that dominates the field today, in short what makes us a science!!
5. Example: Infanticide in primates. Langurs live in groups with a single male and multiple females. When a new male takes over a group, infants usually die. Observations show that these are killed by one or more invading males. WHY? Possible hypotheses:
   a. “Social pathology”. Behavior is not adaptive, but just a side effect. At high densities, males become aggressive toward and will fight with other males, females, and infants. Prediction: infx should only occur at high densities; males may kill their own offspring.
   b. “Group selection”. During periods of overcrowding, killer males will kill infants to prevent overcrowding for the good of the group. Prediction: should only occur at high densities; males may kill their own offspring.
   c. Cannibalism. Males kill and eat infants to replenish the resources lost during fight to take over a group. Prediction: infx should only occur shortly after takeover; males should eat the infants; males may kill their own offspring (but probably rare).
   d. Sexual selection (reproductive opportunities) hypothesis. Males kill nursing infants to bring females back into reproductive condition faster. Predictions: 1) Should only occur shortly after takeover; 2) nursing females become sexually receptive quickly after the loss of their current young; 3) males should not kill their own offspring; 4) only lactating infants get killed; 5) males should not usually eat the infants.

6. Observations on infanticide in primates (not just langurs)
   a. Infanticide does not occur only at high densities (disproves social pathology, group selection)
   b. Infanticide only occurs for a short period after the new male takes over (compatible with hungry males and SS hypothesis)
   c. Male Hanuman langurs never observed eating infants (disproves hungry males), although sometimes seen in other primate species
   d. Females without young become sexually receptive more quickly (compatible with SS hypothesis)
   e. Males almost never kill their own offspring (compatible with SS hypothesis, against social pathology, group selection)
   f. Only nursing infants are killed (compatible with SS hypothesis, against cannibalism)

7. Overall evidence for male infanticide in primates strongly favors the SS hypothesis, although on occasion other factors may operate. How general is this explanation?
   a. Similar behavior and contexts are well-documented in lions and mice (odd combo!)
   b. Infanticide by fish occurs, but often by father (appears to be cannibalism)
   c. Infanticide by FEMALES in giant water bugs and jacanas (species in which males take care of offspring) is similar to that by males in most primates.
   d. Infanticide by females is also common in many mammals with predominantly female parental care, but shows very distinct contexts from male infanticide.
   e. Argument against group selection is basically correct, but it should NOT be discarded without testing! (Example, if time: food calls in capuchin monkeys)