NAME: _____ **Time Started: _____**
BIO 112: Organisms, Evolution, and Ecosystems **Review 1**
Dr. Chris Paradise Fall 2007

This review was worth 150 points (15% of your course grade).

1. Answer **all** of the following questions regarding natural selection (15 pts).
   a. Discuss how Darwin's theory of evolution by natural selection explains the unity of life.
   You must discuss how Darwin's theory included the idea of descent with modification (although you didn't need to use that exact phrase) and that there were general shared traits that were widespread among descendents of a common ancestor. Homology or ancestral traits were terms also accepted besides "general shared trait."

   b. Consider the article by David Quammen (Was Darwin Wrong? NO) and our class discussions, and describe how the theory of evolution by natural selection explains the diversity of species-rich groups like orchids.
   To earn full credit, you must have discussed adaptations to new or changing environments, how isolation of gene pools leads to speciation, and some mode of speciation, such as allopatry.

   c. List three requirements necessary for biological evolution by natural selection to occur.
   Environmental or selective pressures, competition for limited resources, genetic variability expressed phenotypically, heritable variation, mechanisms of generating variation (not just mutation) all lead to differential survival and fitness

2. Name three mechanisms of evolution, other than natural selection, and describe how they work together or against one another to cause **or** prevent changes in allele frequencies (15 pts).
   Genetic drift, gene flow, mutation, and non-random mating are the other four. You should have selected three of them and described how they interact with one another. A description of how each one works in isolation does not answer question and does not garner full credit. For instance, Gene flow works against drift, to replace or restore proportions of alleles lost or changed due to drift. Mutation creates new alleles, increasing diversity, so it also works against drift. The integrative effects of non-random mating and drift will depend on the specific mating situation, but loss of alleles, or even reduction, through drift, can have impacts on availability of mates with desirable traits.

3. Periodical cicadas (a type of insect) have a very wide distribution in North America, and can be found all over the eastern half of the continent. Immature nymphs live in the soil, feeding on roots of trees. In one species, nymphs take 17 years to develop, with a different brood emerging each year, and each brood emerging as adults only once every 17 years. Adults live only for a couple of months in the summer, mate, lay eggs, and die. Each female is capable of laying dozens to hundreds of eggs. Answer **all** of the following questions (15 pts).
   a. What kind of reproductive isolation exists between broods?
   Temporal isolation, because each brood emerges in a different year. I accepted geographic <u>only</u> if a good case was made as to how that could lead to isolation.

   b. What is your prediction regarding the potential for speciation among populations (i.e., broods) of cicadas?
   Your prediction could be slow or fast, depending on your argument. A long generation time, high mortality of nymphs, and non-random mating could slow down a speciation event, but the total isolation of broods and high reproductive rate of broods could lead to a speciation event, given enough time. Subpopulations within the same brood, living in different geographic regions could experience different selective pressures, but that is not

true for different broods in the same population, except in the sense that adults, when they emerge, might experience different above ground climate conditions.

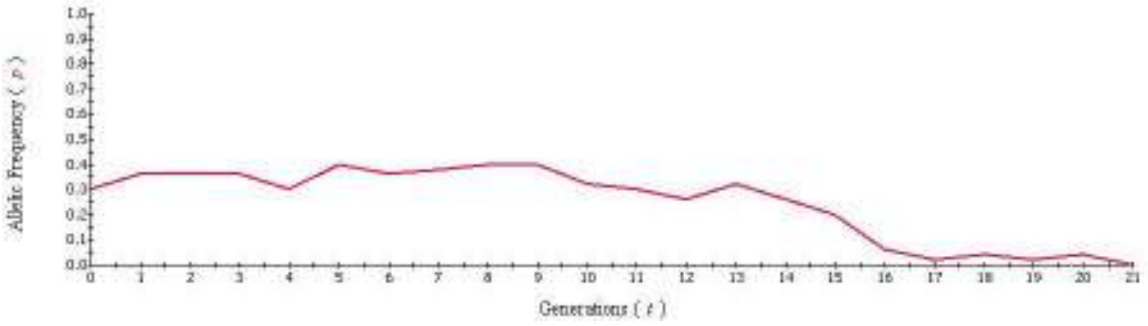
c. If cicadas underwent speciation in this example, what kind of speciation would it be?
Sympatric, if temporal isolation, and allopatric if geographically isolated.

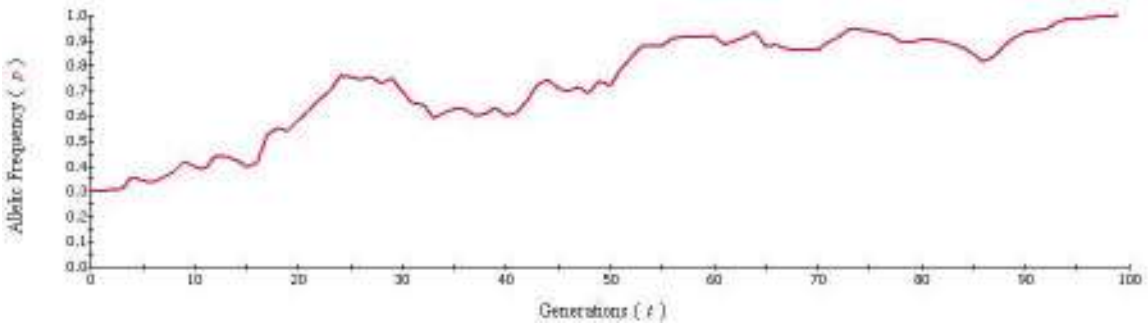
d. What would you predict might be a consequence to between-brood variation and within-brood variation for broods isolated in such a manner?
Between-brood variation would increase, and within-brood variation would decrease.

4. In the graphs below, depicting the allele frequency of a dominant allele ("A"), all the initial conditions are the same, except that in the top graph, the population size is 25 and in the bottom graph it is 100. There is weak selection against the homozygous recessive phenotype (W_{aa} = 0.9). Answer **all** of the following questions (15 pts).
   a. Heterozygotes have equal fitness to homozygous dominants, so how is it that the "A" allele is fixed in the bottom graph, and lost in the top graph?
Genetic drift is occurring, along with selection. Given a small enough population, drift could lead a population in the opposite direction of selection. Remember, the strength of drift increases as population sizes become smaller, and it also depends on the strength of selection, which in this case, is weak.

   b. What are the fitnesses of heterozygotes and homozygous dominants?
W_{AA} and W_{Aa} = 1.0. They are both equally fit, and we know that selection against the homozygous recessive is 0.9. So they must be greater, and since they are of the highest relative fitness, they must have fitness of 1.0.

   c. If we ran this simulation again, would we get the same result? Explain.
It would be very unlikely to get exactly the same trace of p over time, and it might be a different generation each time when the A allele is fixed or lost from the population. When the population is small and the starting frequency of p is low, it is quite possible for the A allele to be lost, although it could be fixed, too. At larger population sizes, selection will likely outweigh drift, making fixation more likely, but we cannot predict when that will occur in a stochastic model.





5. Consider the following questions regarding speciation (15 pts):
   a. What is the mode of speciation where populations are separated by geographic barriers?
   Allopatric speciation

   b. What kind of nonrandom mating is more likely to lead to a speciation event than the other kind of nonrandom mating?
   Positive assortative mating

   c. What kind of natural selection is most likely to lead to a speciation event?
   Disruptive selection

   d. Can a cline lead to speciation, and if so, what mechanisms of evolution facilitate speciation, and what is the mode of speciation?
   Yes, and it's facilitated by strong natural selection, genetic drift, and mutation. Gene flow must be extremely weak or non-existent.

   e. What is the most common mechanism of speciation in populations living in the same geographical region?
   Polyploidy, but I also accepted sympatric speciation

6. Discuss **one of the following two** questions (10 pts):
   a. What is the evidence that supports the endosymbiotic theory of evolution in eukaryotes?
   Evidence includes the following. Both mitochondria and chloroplasts possess some genetic material, they possess prokaryote-like ribosomes, and their own, albeit limited, protein synthesis machinery. It's not sufficient to claim the possession of genetic material in an organelle – you must also make the point that there is some similarity in DNA sequences between mitochondria and bacteria, and chloroplast and cyanobacteria. Further, there's some evidence that mtDNA are monophyletic, and some prokaryotic sequences fit into that monophyletic group. Antibiotic affects both mitochondria and chloroplasts, and there are some similarities between bacterial and organellar ribosomes. Finally, mitochondria and chloroplasts have double or triple membranes, suggestive of endosymbiotic events, and there are some differences between inner and outer membranes that relate to prokaryotes and eukaryotes, respectively.

   b. Discuss how relative and absolute dating methods are used to determine the age of the Earth, and how both point to a very old age (determined to be about 4.6 billion years).
   Stratigraphy and fossil evidence are relative methods that were used to show that the Earth and it's inhabitants have changed over time. Given that geologic processes are uniform and gradual, the many strata observed in cliffs and the Grand Canyon must have been laid down over long periods of time. The fact that many of the species of fossils are extinct and that the fossils in strata closer to the surface (are more recent) appear more similar to extant creatures is further evidence that the earth is much older than previously supposed. Use of radiometric data provides absolute dates to many rock formations and fossils. Using the fact that radioactive decay of a sample of radioactive isotope is constant and measurable, along with various facts about the formation of the rock from which a sample is derived, allows us to accurately data rocks from some strata. Use of multiple techniques validates estimates of age. All of these data point to an extremely old age for the Earth.

7. In a population of the Common Sunflower *Helianthus annuus*, 100 individuals were sampled, and gel electrophoresis was used to determine the genotypes at the alcohol dehydrogenase (ADH) locus. Three alleles were found, which we'll call "a", "b" and "c"; none was determined to be dominant to the others. The following genotypic frequencies were found in this sample; aa = 15,

ab = 16, bb = 11, ac = 26, bc = 24, and cc = 8. Answer each of the following questions (**SHOW WORK** – 15 points).

a. Calculate the allele frequencies (set a = p, b = q, and c = r).
Use the equation [(2 x #aa) + #ab + #ac] / (2 x N) to get p = 0.36, and then use similar equations to obtain q = 0.31, and r = 0.33.

b. Calculate the expected genotypic frequencies for the ADH locus in *Phlox* under Hardy-Weinberg equilibrium assumptions.
p2 = (0. 36) x (0. 36) = 0.13 (compare to aa = 0.15)
2pq = 2 x (0. 36) x (0. 31) = 0.22 (compare to ab = 0.16)
2pr = 2 x (0. 36) x (0. 33) = 0.24 (compare to ac = 0.26)
q2 = (0. 31) x (0. 31) = 0.096 (compare to bb = 0.11)
2qr = 2 x (0. 31) x (0. 33) = 0.205 (compare to bc = 0.24)
r2 = (0. 33) x (0. 33) = 0.11 (compare to cc = 0.08)
Do they add to 1? Check it.

c. Is there evidence for evolution occurring in this population? If so, what microevolutionary mechanism may be in operation, judged by actual vs. expected genotypic frequencies? **(If not, state that evolution is not occurring)**
There could be selection against ab, but that's really the only one that's much different than expected based on H-W equilibrium theory. Could be just genetic drift, which seems likely because there's no real pattern and frequencies aren't that far from expected.

8. Discuss the interdisciplinary approach (molecular biology, animal behavior, ecology, paleontology, and geology) that was used to determine the evolutionary history of cats (F. Felidae). Be specific in your description, although you don't need to use all of the listed disciplines in your answer (10 pts).
Your description must include some aspect of how 2 or more disciplines were used together. It must also include the basis of the work, which is a genomic approach where all extant species of cats were sampled and 30 genes were sequenced and used to create a cladogram. The phylogenetic tree was dated based on fossil data, and the biogeographical history of cats, including where speciation may have taken place, was determined based on fossils, evolutionary relationships, and climate change data, which indicated when sea levels rose and fell, facilitating cat dispersal.

9. Discuss generality and applicability of the Morphological Species Concept (10 pts).
The MSC is applicable to a wide range of species, although it falls short when used for species that cannot be easily distinguished based on appearance, such as bacteria and other microbes. It is also not applicable to polymorphic species. It is generalizeable across a wide range of taxa, although again, it breaks down when one attempts to distinguish microorganisms.

10. Are protists (Kingdom Protista) a true lineage? Briefly describe the characteristics of the kingdom and depict their phylogeny in relationship to the other Eukarya Kingdoms using a cladogram (10 pts).
This was a tough one for most of you. We discussed in class how protists are not a monophyletic lineage, and that they are paraphyletic when considering the common ancestor of all eukaryotes. Your cladogram should thus reflect that, with different branches of ancestral protists leading to current protists and one of the other eukaryote kingdoms. For instance, green algae and plants are thought to be sister taxa, as are chaonoflagellates and animals. While you didn't need to indicate which protists are sister

lineages to plants, animals, or fungi, your cladogram need to reflect the paraphyletic nature of this group.

11. Major advances in animal evolution have led to changes in animal body plans, which then have led to adaptive radiations. Discuss one such major advance, indicate how it provided a selective advantage to the animals possessing it, and describe how it led to changes in animal diversity – be specific (10 pts).
It must be one of the major advances we discussed in class (e.g., evolution of jaws, lungs, legs from fins, shelled egg), and there must be a clear description of how new habitats or new niches could be invaded and how that led to an adaptive radiation. So there must be also be a description of the evolutionary process of adaptive radiation.

12. Consider the cladograms on the next page, which represent three possible scenarios of the evolution of pulse rate in the mating songs of crickets in the genus *Gryllus*. The pulse rate character was divided into two traits (< 35 pulses per second, or > 35 pulses per second), and is overlaid on top of an accepted cladogram of the species in the genus, developed using other characters. Answer the following questions (10 pts).
a. What is meant in the caption below the figure that the scenarios are equi-parsimonious?
Each tree has the same number of evolutionary changes, and it's the fewest number, given the data.

b. What is the ancestral pulse rate in the middle cladogram (B)?
<35 pulses per second

c. Pulse rate in the mating song of crickets seems like a character that may change relatively easily with the right kind of selection pressure. Briefly describe a scenario where a mating song may change over evolutionary time.
There are many possibilities. In your scenario, you must include the selective pressure and describe how it affects pulse rate and selects for a different pulse rate.

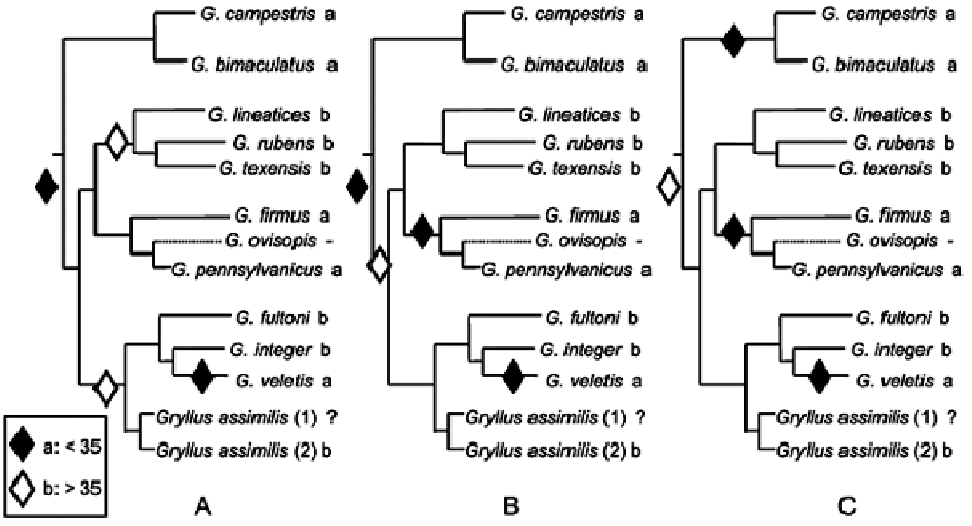


Fig. 4 – Evolution of pulse rate in *Gryllus* song. (A, B, C), alternative equi-parsimonious scenarios. Outgroup taxa not represented. Dotted line: song loss. After Desutter-Grandcolas and Robillard (2003).