Final Assignment
Introduction to Evolution and Scientific Inquiry
BIOL 01104, Spring 2020
Instructor: Dr. Spielman
Due Tuesday May 12th at 11:59 PM on Blackboard. Late submissions NOT allowed.
Early deadline: Tuesday May 5th at 11:59 on Blackboard for bonus 10%!!

Instructions

- **This assignment is graded out of 100 points.**
- **Please answer all questions clearly, professionally, in your own words, AND IN A SEPARATE DOCUMENT! THAT'S RIGHT, A SEPARATE DOCUMENT!!!**
- **Number questions correctly and make sure your document is well-organized. You will be graded on professionalism - THINK: WOULD YOU SHOW THIS DOCUMENT TO A FUTURE EMPLOYER?**
- **You may either write or type your answers (not both - pick ONE).**
    - If you TYPE, you will have to show math steps typed out. You could also do the math by hand, scan the math in, and insert images of your math in the appropriate place. Must be legible!!!!
    - If you WRITE, the document should be LEGIBLE!!! and scanned.
- **Remember that this assignment counts as TWO assignment grades!**
- **Questions asking you to "state" do NOT require an explanation. However, if you include an explanation that is incorrect, you will lose points.**
- **Open note, open book, open slides, open friends, open professor! Still, make sure answers are in YOUR OWN WORDS!!!!**

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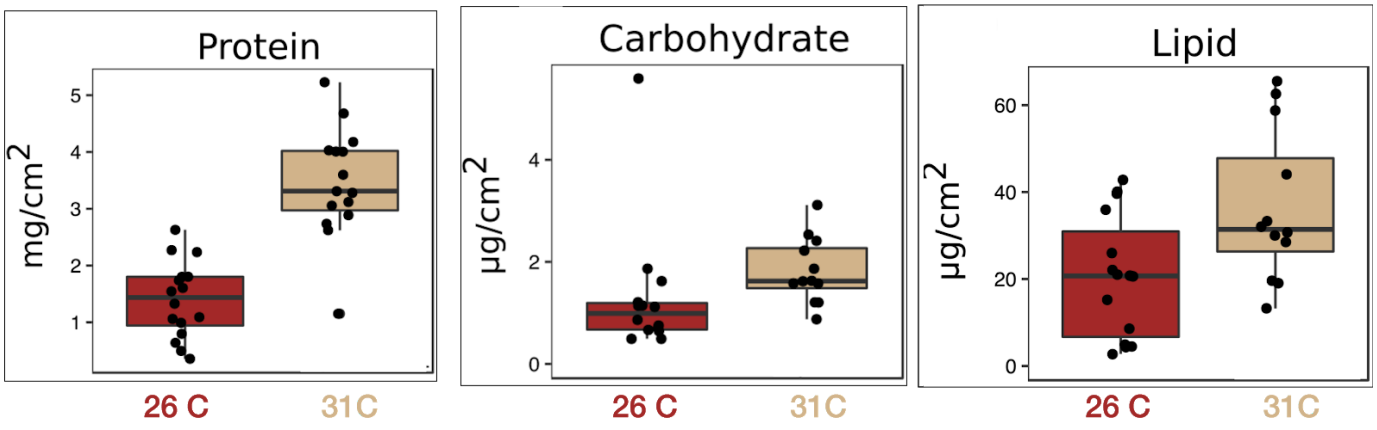
Question 1 (20 points)

Corals (actually a living animal species, close relatives of jellyfish!) secrete a thin layer of mucus that helps protect them from predators and pathogens. The specific composition of this surface mucus has a large effect on how effective the mucus is at protecting the coral. In the current oceans, climate change is triggering many environmental changes, such as increasing water temperatures. Increased water temperatures result in a process called coral bleaching, where corals become very unhealthy and can easily die. In the image on the right, the left panel shows a healthy coral, and the right panel shows an unhealthy bleached coral.

Researchers studied the extent to which increases in water temperature affects the composition of coral mucus in the Florida Keys. To perform their experiment, researchers collected 40 coral fragments and randomly placed each fragment into two experimental groups, "A" and "B" (20 fragments per group). Conditions of both groups were identical to mimic coral reef conditions, *except* for temperature. In Group A, coral were maintained at a temperature of 26℃, which corresponds to the average ocean temperature assuming no heating. In Group B, coral were maintained at a temperature of 31℃, which represents a heated environment.
After allowing the coral fragments to grow for 4 days at each temperature, researchers measured the amount of Protein, Carbohydrate, and Lipids (fats) in the secreted coral mucus. Results for this experiment are shown below. (Note, dots around each boxplot represent the actual data points that comprise the boxplots. You can ignore them - focus on the boxplots alone!)



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a. **State** the null and alternative hypotheses for this experiment. (Be careful to not get too fancy here. See question formatting for a nice little hint…) *(4 points)*

b. **State** the independent and dependent variable(s) in this experiment. For each variable, state whether it is categorical or quantitative. For any quantitative variables, further state if they are discrete or continuous. *(5 points)*

c. Which experimental group (26 degrees or 31 degrees) represents the control group for this experiment? **Explain** in ~1 sentence. *(2 points)*

d. Consider the results showing the distributions of the proteins, lipids and carbohydrates at different temperatures. For each protein/lipid/carbohydrates, **state** which temperature (26 or 31 degrees) has the higher mean. Be sure to answer for all three plots!! *(3 points)*

e. Do the researchers' results provide evidence for the alternative and reject the null, or do they fail to provide evidence for the alternative? **Explain** your reasoning, in 2-3 sentences. In your answer, be sure to explain whether the same conclusion can be drawn for each measurement. *(6 points)*

Question 2 (5 points)
You have identified a new species of beetle that appears to have two color morphs: One is black with purple iridescence (aka, shines purple in sunlight), and one is plain black without iridescence. You assume that one morph is female and the other is male, but you do not know which is which. You therefore dissect these morphs to obtain physical samples of their gametes. You find that the iridescent morph has a few large gametes, and the plain black morph has thousands of tiny gametes that can only be seen at 100-times magnification through a microscope. Based on this information, which color morph is male and which is female? **Explain your reasoning in 1-2 sentences. Part of your explanation must consider how we define between biological males and females** (this definition itself should also be used to answer the question).

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Question 3 (25 points)
You are studying two different populations (called populations A and B) of mountain lions in America. You obtain genetic information from these two populations and determine the following information about four genes, shown in the table below.

	Population A heterozygosity	**Population B heterozygosity**
Gene 1	0.89	0.49
Gene 2	0.47	0.23
Gene 3	0.65	0.31
Gene 4	0.58	0.18

You are trying to determine evolutionary differences between these two mountain lion populations. Remember: this table is showing heterozygosity, NOT allele frequencies!! **No explanations are necessary here!!** To answer these questions, you must consider how different evolutionary forces affect variation in populations.

a. Which population (A or B) has the highest level of overall genetic variation? *(3 points)*

b. Assume, all else being equal, these populations have different mutation rates. Which population likely has the higher mutation rate? *(3 points)*

c. Assume, all else being equal, these populations have different strengths of genetic drift. In which population is genetic drift stronger? In your answer, also make a prediction about differences in population size between mountain lion populations "A" and "B". *(4 points)*

d. **Consider Gene #1 only**: Assume, all else being equal, these populations have different modes of natural selection. State one possibility for the different modes of selection in these two populations, i.e. suggest which mode of selection could be acting for each population. *(3 points)*

e. **Consider Gene #4 only**: Assume, all else being equal, these populations are both under directional selection but selection is operating at different strengths. In which population is selection likely stronger? *(3 points)*

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f. Consider **Population A only**: Assume genes 1 and 2 are both under directional selection operating at roughly the same strength. For which gene will fixation likely occur more quickly? *(3 points)*

g. Assume, all else being equal, one of these populations is sexual and the other is asexual. Which population is most likely which, and which evolutionary force informs your answer to this question? *(3 points)*

h. There is a third population of mountain lions, population "C." Assume, all else being equal, either population A or B only is receiving migrants from population C. Which population is most likely receiving migrants from population C? *(3 points)*

Question 4 (25 points)
Remember, to receive full credit for any math problems, you must show all your work and CLEARLY INDICATE your final answer. If I have to guess what/where your answer is, you may not get credit.

You are studying meerkat (Timon from Lion King!) populations in Africa that have different claw lengths (large, medium, small). You find that claw length is determined by a gene with two alleles, C/c. CC individuals have long claws, Cc individuals have medium-length claws, and cc individuals have short claws.

Although adult meerkats are excellent at escaping predators, baby meerkats are susceptible to being eaten by predators like hyenas, hawks, lions, or baboons. You therefore decide to measure an individual's fitness as the fraction of surviving babies per litter. You collect the following data (assume the experiment is appropriately conducted): 65% of long-clawed (CC) babies survive to adulthood, 80% (Cc) of long-clawed meerkat babies survive to adulthood, 45% (cc) of short-clawed meerkat babies survive to adulthood.

a. Based on this information, is *natural selection* likely acting on meerkat claw length, and if so which mode? **Explain in 1-2 sentences.** *(2 points)*

b. What is the *relative fitness* of each meerkat genotype? **Show all your work.** *(3 points)*

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c. Consider a population of meerkats with 20 CC, 50 Cc, and 40 cc individuals for the remaining questions. What is the **average fitness** of this meerkat population? **Show all your work.** *(6 points)*

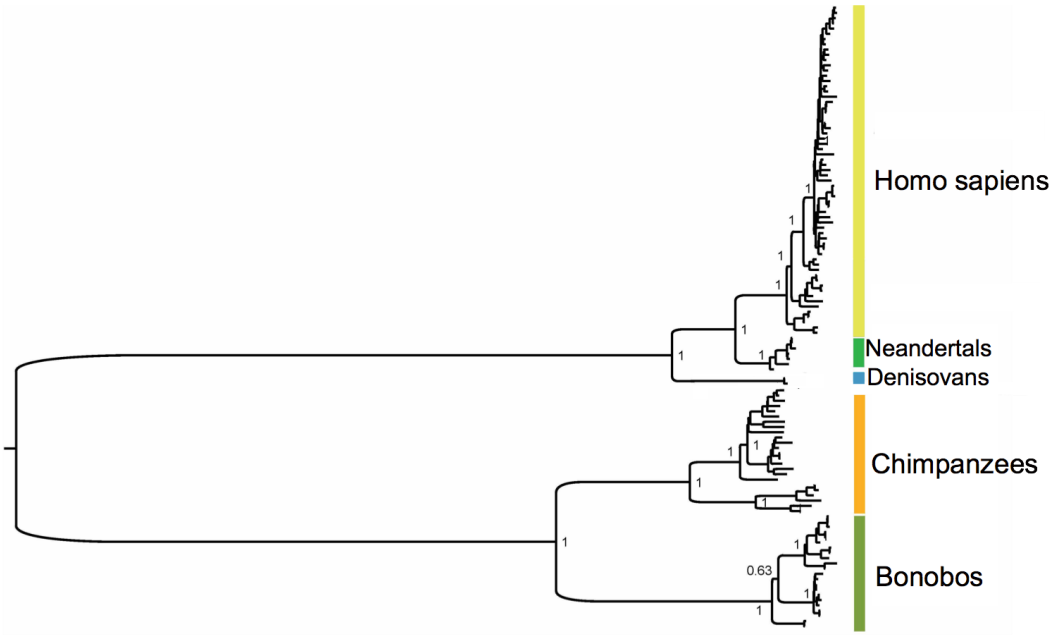
d. What are this population's **allele frequencies**? **Show all your work.** *(4 points)*

e. What are this population's **observed genotype frequencies**? **Show all your work.** *(3 points)*

f. What are this population's **expected genotype frequencies (not counts) under Hardy Weinberg Equilibrium? Show all your work.** *(5 points)*

g. Based on your answers to parts f-g, it is more likely this population is evolving or under HWE? **No explanation necessary.** *(2 points)*

Question 5 (10 points)
The phylogeny below show relationships among individuals from three types of humans and two of our close relatives, chimpanzees and bonobos. Chimpanzees and bonobos do not encounter each other in the wild, but when in captivity, successful matings (with viable and fertile offspring!) have been observed. Bearing this in mind, as well as what we have learned in class about past interactions between Homo sapiens, Neandertals, and Denisovans, answer the following questions.



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a. According to the **phylogenetic species concept**, how many species are present in this phylogeny? Explain your reasoning and what the species groups are in 1-2 sentences. *(5 points)*

b. According to the **biological species concept**, how many species are present in this phylogeny? Explain your reasoning and what the species groups are in 1-2 sentences. *(5 points)*

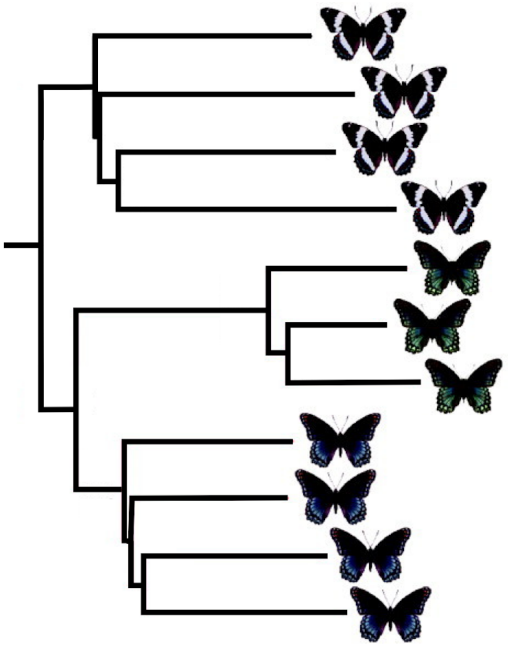
Question 6 (5 points)
The *Battus* butterfly has a distinctive blue/green coloration and is poisonous to predators. Predators have therefore learned to avoid eating butterflies with blue/green coloration. An unrelated butterfly species, the admiral butterfly (*Limenitis arthemis*), has evolved wing colors to mimic the *Battus* butterfly even though it is not poisonous. This mimicry tricks predators into not eating admiral butterflies.
Researchers are studying the evolution of mimicry in admiral butterflies. There are three "subspecies" of this butterfly they chose to study: ***L. a. arthemis* is NOT a mimic, but *L. a. astyanax* and *L. a. arizonensis* are mimics.** For the purposes of this question, assume that *L. a. astyanax* and *L. a. arizonensis* both have the same evolved "mimicry" trait (even though they have slightly different colors).


L. a. arthemis


L. a. astyanax


L. a. arizonensis

The researchers have obtained DNA from several different individuals from each of the three subspecies, producing the phylogeny on the right. Assuming the most parsimonious explanation, does this phylogeny provide evidence that mimicry is homologous or convergent in admiral butterflies? **Explain in 1-2 sentences.** *(5 points)*



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Question 7 (10 points)
The phylogeny below shows different groups of animals, colored by whether each group is able to *regenerate*, i.e. regrow parts (or all!) of themselves after severe injury or limb loss. Determine the number of evolutionary changes on this tree assuming the most parsimonious explanation. **Assume the following:**

- The ancestor to all animals could perform "whole-body regeneration" (blue)
- The trait "whole body regeneration" (blue) is **strictly homologous** for all animal groups who possess the trait.
- Ignore the red stars!

Your answer for this question should simply state the number of times each regeneration version was gained and/or lost. For example (this is NOT at all the right answer), you might say: "Blue was gained 13 times and lost 12 times. Yellow was gained 1 time and lost 80 times. Gray was gained 5 times and never lost." Definitely allowed to use colors instead of the full terms! For the purposes of answering this question, present in the ancestor = 1 gain.