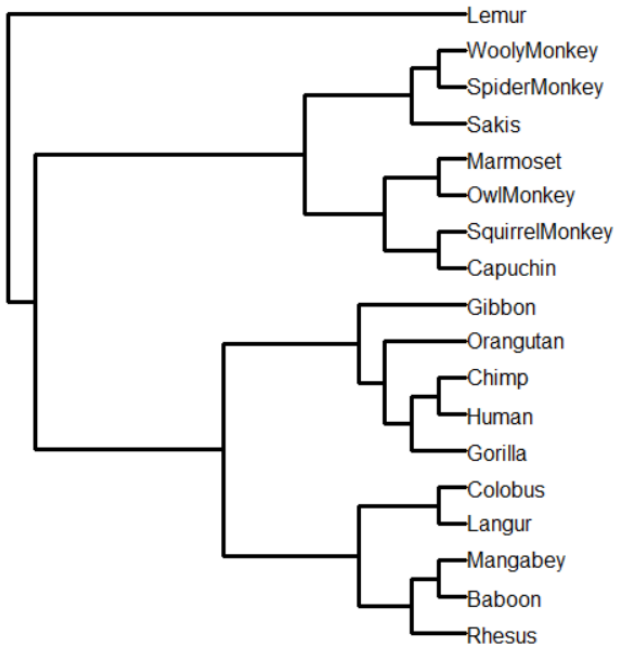
Same rules as previous exams. Again, although we've discussed it before and after literally every other test: do not summarize things. I do not want summaries. Especially in questions where you have limited word usage, make your explanations as **clear and precise as possible**. Do not summarize. Given the importance of getting every single point from this exam, take time and care when crafting your answers. Read them aloud to yourself. Read them aloud to another person. Actually read them aloud, don't just think "reading this in my head is good enough", or "I definitely nailed that one, no reason to read it over again". You have a week to craft these resposnes, you have one another, and you have all of the internet at your disposal. There's no real wiggle room for unclear, rambling answers here. **Summaries are not explanations**.

Write less, but say more. It's easy to take an approach where you type out lots of phrases and assertions in an attempt to make a lot of different points, hoping one is correct. It's much harder to make a single clear and well-supported point. But the latter is much more valuable. I am not examining your ability to assert lots of things you found in papers. I'm examining how thoroughly and deeply you understand the material. If you have less than 100 words, trying to make more than one point clearly is probably folly. Try to identify the most important thing to say in answer to each question and focus on it. If your answer rambles or goes on tangents or makes too many points...edit it! You have plenty of time to work through it and read it aloud before turning it in. Do so!

This exam has 17 points worth of questions. The remaining 3 points will be allocated based on your contributions to the overall class' succession through discussions on the forum. Asking questions, challenging answers, and proposing ideas and refinements to help your fellow students all count as contributions. Posting summaries of zoom or in-person discussions to the forum for all to see also count. **Work together!**

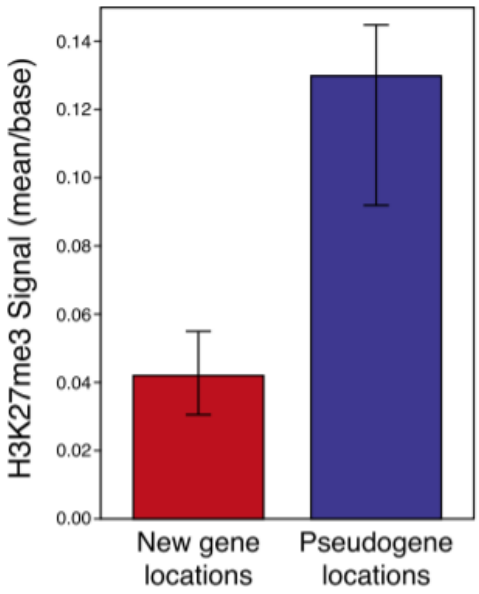
One final note: you're all expected to work together, but you're each responsible for the work you turn in. You need to be self-assessing. If your group comes up with an answer, and you don't *fully and deeply* understand it, I would discourage you from just going with the flow. Either speak up, or spend some time convincing yourself it's correct. It's hard to recognize when you don't really understand something that seems superficially correct to you, but if each of you do this and put forth the effort to figure the solution out, everyone will do much better on this test than on previous ones. **You're all capable of understanding and answering these questions**, they just take real effort and thought! Don't expect the first thing that springs to mind, or the first thing someone else suggests that "sounds good" is correct–really interrogate everything and you'll do fine.



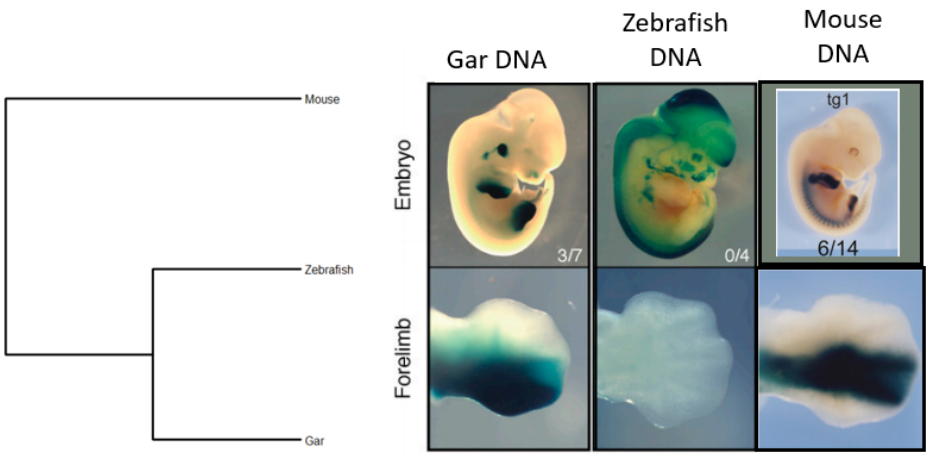
1. (1 point) *A common question from folks who do not understand evolution goes roughly along the lines of "if humans evolved from monkeys, why are there still monkeys?" Above is a phylogeny of primates.* In fewer than 100 words, give a clear, precise, and accurate answer to this question.

2. (1 point) Please read this essay by Holly Dunsworth (`https://jonsmitchell.com/biol461/final/final_estrogen.pdf`) and describe in detail what data you could collect to test whether the childbirth/competition hypothesis or the estrogen/allometry hypothesis for sex-based skeletal differences is better supported. [*Nota bene:* approach your answer as if you were going to add a graph or figure to this paper, and describe how you would generate it]

3. (3 points) There's a classic paper in evolutionary biology by Stephen J Gould and Dick Lewontin which you can access at `https://jonsmitchell.com/biol461/final/01_GouldLewontin.pdf`. Note, this paper is old (written and conceived by men who were old in the 1970's) and uses some outmoded language with respect to some human cultures. Based on your reading of this paper: (a) In your own words, explain why the authors contend that the concepts of *spandrel* and *exaptation* are useful. (b) In less than 100 words, choose what you think the **strongest** argument made in the paper is and ***explain why* you think it is the strongest**. (c) In less than 100 words, choose what you think the **weakest** argument made in the paper is and ***explain why* you think it is the weakest**.



4. (2 points) *Above are data from a paper by Rob Arthur. Using data from fruit flies, he & some colleagues found rates of H3K27me3 occurrence along the genome at sites where a gene had been duplicated. H3K27me3 is a repressive structure, that prevents nearby genes from being expressed. We discussed in class that a duplicated gene can either remain a gene (gaining a new function, a specialized function, a subfunction, etc) or it can be "broken" in which case it becomes a pseudogene (e.g., if the start codon is mutated, no protein is made, and so it's no longer a gene). The y-axis here is the amount of H3K27me3 in the (reconstructed) ancestor at the location where the duplicated gene ended up. The x-axis shows what happened to that gene in the living fruit fly (lost function so a pseudogene, or still functioned so a new gene). Since gene duplications typically result from errors in meiosis, it's safe to assume that the location the duplicate ends up is random with respect to it's fitness effects.* (a) Do these data support selection as the primary force for reducing the effect of duplicated genes? (b) Concisely explain your answer to part a. The paper is accessible here: `https://jonsmitchell.com/biol461/final/final_geneDuplication.pdf`



5. (2 points) *Fins in fish and limbs in tetrapods are quite different in form and function, although limbs evolved from fins and still retain much of the original genetic network that creates them–albeit with a few modifications. One of the changes to the genetic network involves the timing and location of* Hox *expression. Above is a phylogeny showing the relationship between three species: gar fish, zebrafish, and mouse. These mouse embryoes are transgenic, which means that a researcher added a specific regulatory element called island I from a gar (left), zebrafish (middle), and mouse (right) to the mouse embryo's DNA. They then used a special stain to see where that added regulatory element was controlling gene expression. The top row of images shows the whole embryo, and features a lot of noise. The lower images show a close-up of the front limb and is more reliable in this particular case.* (a) Which two species are most closely related? (b) Which two species have the most similar pattern of expression? (c & d) If we could sequence the DNA of the common ancestor of these three species and implant it in the mouse, what is the *most likely* pattern of expression we'll observe in the limb? The paper is accessible here: `https://jonsmitchell.com/biol461/final/final_limbRegulation.pdf`

6. (2 points) Please read this paper by Blount et al (`https://elifesciences.org/articles/55414`) and answer the following questions. (a) How does the rate of nonsynonymous mutations vary between `Cit+` mutant strains in ctirate-only and glucose+citrate media? (b) What does the difference identified in part (a) suggest about the relative importance of different evolutionary forces?

7. (2 points) Please read this paper by Zhang et al. (`https://jonsmitchell.com/biol461/final/05_Zhangetal.pdf`) and answer the following questions. (a) Why doesn't maximal dosing kill the most cancer cells in the long run? (b) What is most troubling about Figure 2d? (c & d) Briefly (< 100 words) explain the key result being illustrated by Fig 5.

8. (2 points) Please read this paper by Smaers et al. (`https://jonsmitchell.com/biol461/final/final_brainbody.pdf`) and answer the following questions. (a) What is allometry? (b) How does the slope of the regression line between body size and brain size relate to allometry? (c) If a new species of pinniped (seal) evolves and increases its ln body size by 2 units, how do you expect that species' ln brain size to change? (d) If a new species of eulipotyphlan (shrew) evolves and increases its ln body size by 2 units, how do you expect that species' ln brain size to change? (e) Briefly (< 100 words) explain why relative brain size should not be used as a proxy for intelligence.

9. (2 points) Please read this paper by Shoemaker & Clauset (`https://jonsmitchell.com/biol461/final/final_horseEvo.pdf`) and answer the following questions. (a) Does species selection play a major role in the distribution of horse body masses according to these analyses? (b) What is meant by the statement that horse body size is neutral at the macroevolutionary scale? (c & d) Do these results imply that larger individual horses have no fitness advantages over other horses in their own populations?