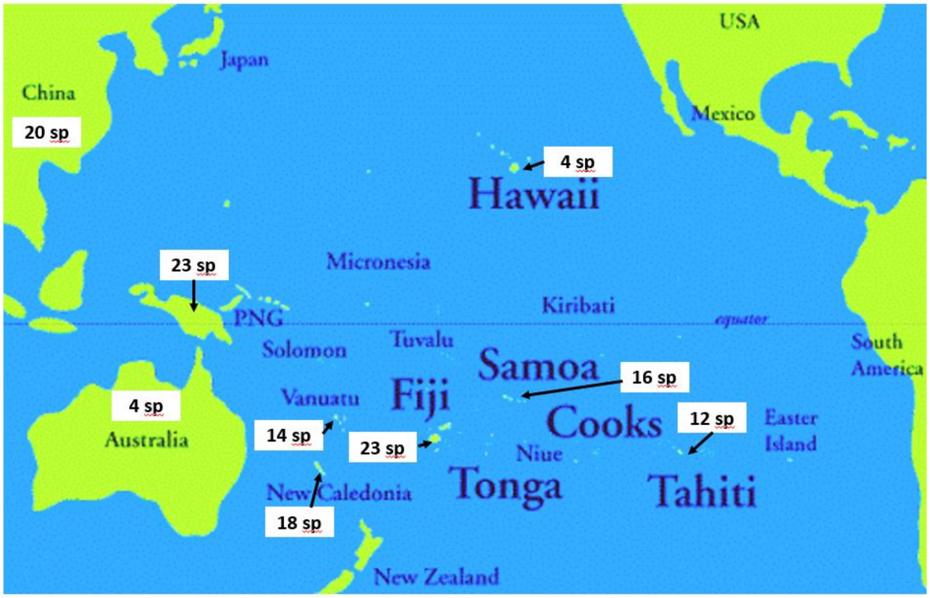
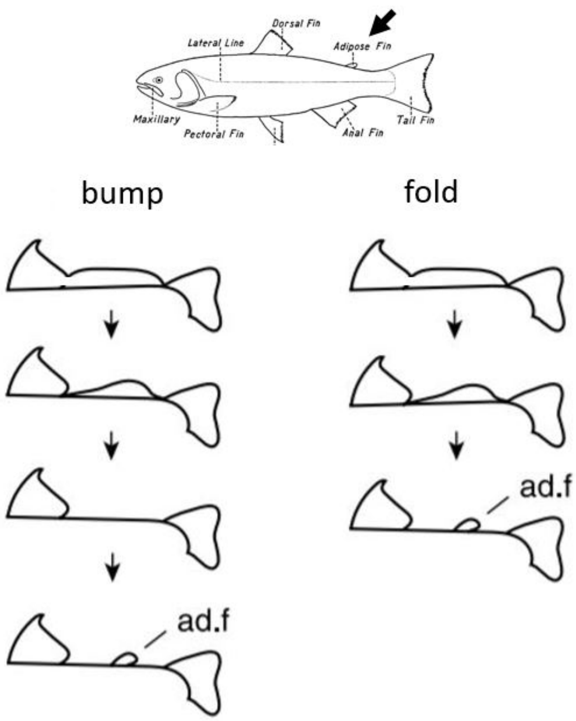
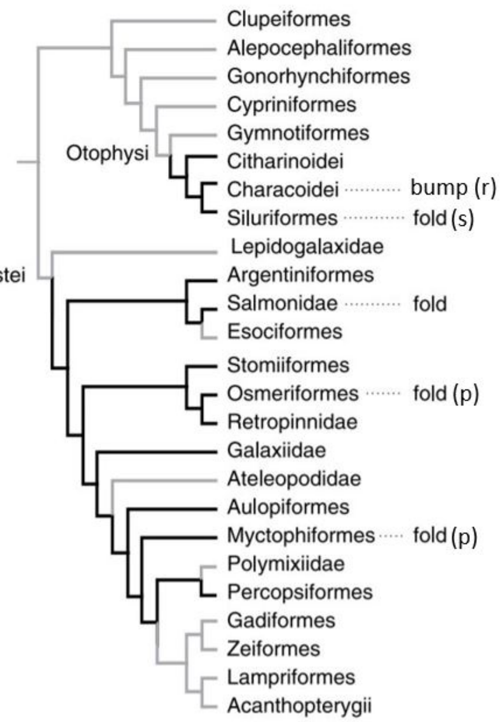
Questions

1. (1 point) *A virus is a package of genetic material sealed inside a protein coat that, when it is encountered by a cell, has a chance of entering the cell and getting the cell to copy the virus. A virus' traits (protein coat, structure of the genetic material, etc) influence the probability a cell will replicate it (produce it in the presence of other cells). Because the cell replicates the virus, a virus transmits not even a single atom to its descendants. A word is a distinct set of sounds/letters that, when it is encountered by a person, has a chance of entering the human's memory and getting the human to copy the word (verbally or in writing). A word's traits (meaning, sound, etc) influence the probability a human will replicate it (produce it in the presence of others).* Given the definition of evolution by selection: (a) can an animal that uses DNA to encode traits evolve by natural selection? (b) Can a virus that uses DNA to encode traits evolve by natural selection? (c) Can a virus that uses RNA to encode traits evolve by natural selection? (d) Can a word that uses human neurons to encode traits evolve by natural selection? Yes to all



2. (1 point) *Nerite snails are common aquatic snails across the southern hemisphere. In the south Pacific islands, most species spend their adult stage in freshwater streams, and their larval stage in the ocean. The adults live in steep, fast-flowing streams so that when they reproduce, the young will be washed rapidly out to sea (if they take too long, they die). Once at sea, the larvae stay in the ocean for several years, swimming and following along ocean currents, before settling in a new freshwater stream. Once they find a stream, they migrate up it and then reproduce, beginning the cycle again. Above is a map of the south Pacific, with the number of nerite species present in key locations indicated.* (a) Which location has the greatest mismatch between the observed number of nerite species and what would be expected under the Theory of Island Biogeography? (b) Propose a likely explanation for these data. (a) Australia. (b) These islands are *not* ecological islands from the perspective of the semi-marine (amphidromus) snails, so richness isn't expected to follow an "island" pattern at all. As we discussed in class, sharp unsuitable habitat bounds are needed, and those aren't present here. So the immigration rate *is not controlled by water distance.* Any explanation that explicitly posits some other form of control on immigration rate garners full credit (n.b., the number of steep, fast-flowing streams with marine outlets in an area is the primary driver of the richness pattern here, as it is impossible for the snails to immigrate where there are no such streams)





3. (1 point) (basically) *All ray-finned fish have dorsal fins and tail fins. Some species of fish possess an extra fin, called an adipose fin, between the dorsal & tail fins (see diagram at top left). In fish, early on in development, a large median fin develops along the entire length of the fish's, and as the embryo grows, this fin degenerates in places and leaves the tail and dorsal fin behind. In some fish (Characoidei), the adipose fin emerges as a "bump"* after *the median fin disappears (see above, left). In other fish the adipose fin develops as a remnant of the median fin fold that never degenerated. The adipose fins of fish also have anatomical differences with some possessing bony plates ("p"), slender rays ("r"), others sharp spines ("s"), and others possessing no connection to any bone at all (e.g., in Salmonidae). The diagram above shows a large number of fish groups with a description of the development and anatomical relationships of the adipose fins in those groups that possess one.* (a) How does the developmental data shown above influence your understanding of the homology between the adipose fin in different groups? (b) How does the anatomical data compare to the developmental data?

(a) The developmental data imply at least two (probably three +) separate origins (one from the median fin, one from some other group of cells). So the Characoidei would have an adipose fin that may not be homologous to the other groups, which (given the distribution of taxa) mean that the siluriform fin is probably distinct from the other fold-based adipose fins. (b) The anatomical data is consistent with several different origins, with osmeriiforms and myctophiforms having one origin, salmonids another, and siluriforms a third, in addition to the characoid fin also being distinct. Or it's consistent with rapid functional evolution! Regardless, the anatomical evidence also strengthens the idea of (at least) three origins with silurifoms and characoids have non-homologous adipose fins as their anatomy *and* development differs. (n.b., for what it's worth, it is very likely the case that siluriforms and characoids have homologous adipose fins, but based solely on the limited data shown here, it'd be hard to draw that conclusion)

However, none of these data are strong enough to be conclusive (e.g., characoid and siluriform fins could be homologous, and their anatomy and development could have changed for functional reasons). Further, the consistency of the distribution of the trait on the tree conflicts with the other evidence (did not need to note this for full credit, but it is shown in the data).

4. (1 point) *The distribution of parrots in the Old World is shown above in black. A Siberian fossil from 17 million years ago is shown as a black star, while European fossils from around 10 million years old are shown with white stars. Three researchers are discussing the nature of these data. The first researcher says that the fossils represent dispersal events, where the birds dispersed to an unsuitable environment and thus promptly went extinct. The second says that these fossils show that the geographic range of ancient parrots was broader than living ones. The third argues that the oldest parrots were adapted to the cold, and over time they become increasingly adapted to warm climates.* (a - c) Why are each of these ideas bad, based on the data shown above? (d) What can you say with confidence using these data? a) It'd be so unlikely that a short-lived, small-population dispersal event would leave a fossil record behind that we can reasonably reject the idea that it happened four times. Also, no information on extinction time/how long they persisted given isolated individual occurrences. (b) We have no information whatsoever on the geographic ranges of the ancient fossils, only individual points in time. Fossils provide bad spatial data, so making a comparison like "broader" between the extinct and modern is folly. (c) This is really wild, as it presupposes that (1) climates are constant over time, (2) species within groups can't be specialized to different environments than other members of the group, (3) there was the same or fewer number of species in the past as now such that the variation in climate tolerance didn't produce any outliers simply due to greater past richness. None of those three presuppositions is good, naming any of them gets full credit here. (d) In the past, some parrots lived in places that living parrots do not now live in. Given the limits of the fossil record we've discussed, you can't really say anything else.

5. (1 point) *You're hanging out with your coolest friend, sipping a fine drink, when they ask you, "You know how homology describes a sameness in structures between different species? I was wondering, are: arms and legs homologous to each other? As in, within a single indivdiual. My understanding of anatomy is that they have very similar patterns of bones, muscles and nerves, and my understanding of development is that they both form using similar genes and from similar groups of cells. Also, it seems like most things that have one set, like arms, also have legs, with only a few exceptions. What do you think? Can they be homologous even though they're within a single individual?"* How do you answer their question? Your coolest friend here is describing a cool concept called serial homology. The answer is "yes, to an extent." For now it's sufficient to note that they satisfy all of the requisite conditions, so there's some substantial degree of homology between them. Later, in the evo-devo section, we'll discuss how the legs are actually descended from the arms. But you don't need to know that for this question.

An alternate way to think about this question: homology is a description of fundamental sameness between biological structures (due to shared ancestry). It also comes in degrees, with structures homologous to various extents. A good way to come around on this question is to think of it transitively: a human's arm and a chimp arm are VERY homologous. Further, under the criteria we have, a chimp's *leg* is *to some degree* homologous with a human's arm. Thus human arm = chimp arm $\approx$ human leg, so for that to be true there must be some degree of sameness (some degree of homology) between a human arm & leg.