Comments on pre-reading quiz 3

1. Which of the following is a good definition of natural selection?

- ( ) Heritable variation in fitness
- ( ) Survival of the fittest
- (✓) The process by which variants with higher fitness increase in frequency in a population

"Survival of the fittest" is bad because it's number of offspring (i.e. fitness in the technical sense) that matters, not survival per se (although surviving longer might mean you end up producing more offspring). Natural selection arises when you have "Heritable variation in fitness", but in itself that's not really a definition. That leaves me with the option I selected, which is a nice technical definition of what natural selection is.

2. Which of the following is *not* required for natural selection to take place?

- ( ) Organisms must differ in the number of offspring they produce
- ( ) There must be variation
- (✓) Organisms must differ in their ability to survive
- ( ) Offspring must resemble their parents

Natural selection requires heritable variation in fitness - it doesn't actually require differences in survival. For instance, natural selection would still be possible in a population of organisms where everybody lived to be exactly 100, if those organisms differed in their number of offspring they had and those differences were heritable. The genotypes which led to more offspring in the fixed 100 year lifespan would tend to proliferate and dominate the population.

3. Genetic algorithms often involve some mutation operator, which takes a genotype and randomly changes some alleles. For example, if an individual's genotype is like this:

11110000

And a mutation occurs at the first and last position (or locus), then the resulting genotype would be this:

01110001

Which of the following statements is true about mutation, as implemented in genetic algorithms?

- [ ] Mutations typically increase fitness
- [x] Mutations typically decrease fitness
- [x] Mutations typically introduce variation into a population
- [ ] Mutation requires sexual recombination
- [x] Mutations tend to occur with low probability (i.e. they tend to be rare)
- [ ] Mutations tend to occur with high probability (i.e. they tend to be common)

The last of these is the easiest - Mitchell says that GAs are typically set up so that mutations are rare events. The reason for this is related to the first box I ticked: mutations tend to decrease fitness, so you don't want them to be too frequent. This is actually a bit subtle - in fact, since mutations are random, they are fitness-neutral, they don't preferentially attack alleles or portions of the simulated genotype that are bad in some way. However, if you run a genetic algorithm for a while, you will end up with a population with quite good fitness - the population of genotypes will have been sculpted by natural selection to be quite well fitted to the fitness function you are using. Then if you take one of those `well-designed' individuals and randomly change some aspect of their genotype, you will probably damage them - since they are well-adapted, any random change you can make will probably make them less well adapted. That's why I ticked the "Mutations typically decrease fitness" box. The cool thing about natural selection is that it feeds on these random changes, throws away the bad ones, and makes sure the good ones proliferate and form the basis for subsequent changes - it's the non-random retention of randomly-generated variation. And that's why I ticked the "mutations typically introduce variation" box - natural selection tends to remove variation from populations (because it preferentially retains the fitter variants), and mutation makes random changes which will reintroduce variation. Since natural selection requires variation (look back at the reading for an explanation of why), the generation of variation (including random variation) is an important component.

4. Genetic algorithms typically specify a fitness function. What is a fitness function?

- ( ) The fitness function is a tool for analysing simulation results, and counts how many offspring each genotype has.
- ( ) The fitness function specifies the space of possible genotypes.
- ( ) The fitness function describes how genotypes are recombined during reproduction to form new genotypes.
- (x) This fitness function assigns a score to each simulated organism, and organisms with higher scores are more likely to be selected to reproduce.

The last option here is the correct one. The first option is a red herring (although it sounds closer to what biologists mean when they talk about fitness). The other two are things that you do indeed need for a GA, but they're just not the fitness function.

5. We are going to use genetic algorithms to simulate the evolution of signalling systems, which are very simple models of communication. Many naturally-occuring signalling systems (e.g. alarm calling systems) are probably the product of natural selection. Do you think that human language is a product of natural selection? Try to explain why you have this opinion, either by reference to the preconditions for natural selection that are laid out in the reading, or on the basis of other stuff you know about language or natural selection.

I will be fascinated to see what you think about this! For starters, I would want to know what is meant by "language" - does this mean the capacity for language, or something else? Based on the reading, I would then want to know to what extent language exhibits (or exhibited) heritable variation in fitness, i.e. to what extent there is/was variation in the capacity for language or the details of how it works, whether that variation is heritable, and whether it has/had consequences for fitness.