1. Suppose that humans develop the technology to clone themselves, making offspring who are genetic duplicates of their parent. Planet Normal is settled using a starting population of 10,000 people and conventional sexual reproduction. Planet Clone is settled using a starting population of 10,000 people and cloning only. In both populations, reproduction is at random. That is, every individual has a chance to reproduce, but some have no children or clones, some have one, some have several–all *at random*. The two populations grow at the same rate. Also, cloning is of adults in the population: there is no gene bank to allow cloning of individuals from previous generations. Note that every time a cell divides, there is some chance of mutation.

   (a) After a few generations, do you expect Normal to have more, less, or the same amount of genetic variation at a randomly chosen gene as Clone? (Note that this asks about a single gene, not about combinations of alleles along a chromosome.)

   (b) What are two advantages of Planet Normal? Be sure to specify if these are short-term or long-term advantages.

   (c) What are two advantages of Planet Clone? Be sure to specify if these are short-term or long-term advantages.

   (d) Based on what you know about humans, do you expect a 50/50 sex ratio on Planet Clone after a very long time? Explain briefly.

   (e) A technological breakthrough enables human females to self-fertilize, and Planet Amazon is colonized by 10,000 self-fertilizing females. How will Planet Amazon differ genetically from the other two after a few generations? (Hint: what happens to blood group AB?)

   (f) Some writers suppose that cloning would "stop human evolution." Assuming that we clone current adult individuals (as opposed to making a gene bank and cloning our first colonists over and over), do you think this is true? Why or why not?

2. The ABO blood group system consists of one gene with three alleles: I^A and I^B alleles produce different cell-surface antigens (and are codominant to each other) and I^O allele produces nothing (and is recessive). Thus, a person with genotype I^AI^A or I^AI^O has blood group A, one with genotype I^BI^Bor I^BI^O has blood group B, one with genotype I^AI^B has blood group AB, and one with genotype I^OI^O has blood group O.

   (a) For allele frequencies of $p(I^A) = 0.3$, $p(I^B) = 0.4$, $p(I^O) = 0.3$, calculate expected Hardy-Weinberg frequencies of blood groups A, B, AB, and O.

   (b) Suppose that a new plague developed which affected all blood types except for AB, so that AB blood group individuals had fitness 1.0 and all other types had fitness 0.9. After a very long time, what frequencies of the three alleles would you expect? You can ignore mutation and drift.

   (c) Consider a population with the fitnesses from (b). Suddenly a new chromosome appears which has a gene duplication, so that both A and B are on the same chromosome (in other words, it creates a new "allele" which has both A and B; call it I^{AB}). If the starting frequencies are $p(I^A) = 0.3$, $p(I^B) = 0.4$, $p(I^O) = 0.2$, and $p(I^{AB}) = 0.1$, what will the new frequencies be after ONE GENERATION? (Assume that any genotype with at least one A and one B has fitness 1.0.)

   (d) What long-term fate do you predict for this new chromosome (fixed, lost, polymorphic)?

3. In corn, each female meiosis produces 1 egg and several "polar bodies" which cannot be fertilized. A chromosomal variant called "knob" can guide the chromosome copy containing it into the egg rather than the polar body. This results in a knob+/knob- female producing eggs that are 70% knob+.

   (a) Assuming that knob+ and knob- are otherwise equally fit, male meiosis ignores knob, and the starting frequency is 10% knob+ in both sexes, what will be the allele frequencies in ONE GENERATION? (Hint: figure out the gene pool contributed by males and the gene pool contributed by females. The new allele frequencies will be the average of these.)

   (b) What would you expect to happen after a long time?

   (c) Suppose that when knob+ arises by mutation, it happens to be linked to a recessive lethal allele at a different gene. Suppose further that they are extremely close together so that they are not separated by recombination. In general terms, how would you expect this chromosome to behave? Would it be lost, fixed, or maintained as a polymorphism? (Assume it starts out common enough that drift is not important.)

   (d) Based on your answers so far, do you think that knob-like genes are likely to be beneficial or harmful to species that have them? Explain briefly.