Both of these problems have fictional specific details, though they are based on real biological phenomena. They are both quite tricky! Drawing diagrams can help.

1. A crocodile species normally has temperature-dependent sex determination. There are no sex chromosomes. If the temperature at which the eggs incubate is relatively cool, offspring will be mostly male; if it is relatively warm, they will be mostly female.

   A temperature-switch gene Tmp has two alleles. Tmp+ allows temperature to affect sex. Under current climate conditions a population which is all Tmp+ will be 80% females and 20% males. Tmp- causes all offspring to be male. Tmp- is dominant to Tmp+.

   We begin a population with 800 Tmp+/Tmp+ females, 200 Tmp+/Tmp+ males, and 200 Tmp+/Tmp- males.

   (a) (2 pts) We can't find any Tmp-/Tmp- males to breed from. Why? *All animals with Tmp- are male. To get a homozygote you would need two Tmp- parents, but both would be male. I gave 1 point for speculation about inviability of Tmp-/Tmp- but there is a much simpler explanation.*

   (b) (2 pts) After one generation, what will be the proportions of males and females? (Hint: draw a Punnett Square with male parents on one side and females on the other, because they do not have the same allele frequencies.) *+/+ males give + to all offspring. +/- males give + to half and - to half. Despite the unequal number of males and females, every offspring needs a male and a female parent, so we can just look at each sex separately:*

	Males	
	0.5 +/+	*0.5 +/-*
Females 1.0 +/+	*0.5 +/+*	*0.25 +/+* *0.25 +/-*

   So +/+ animals are 0.75, and of those, 80% are female, or 0.6. Everyone else is male, 0.4.

   (c) (2 pts) After one generation, what are the allele frequencies of Tmp+ and Tmp- in males? In females? *In females clearly p(Tmp+)=1.0 and p(Tmp-)=0.0 (this will always be the case). In males, we have +/+ males at 0.15 and +/- males at 0.25. So the relative frequency is p(Tmp+)=(0.15+0.5(0.25))/0.4 = 0.6875 and p(Tmp-) must be 0.3125. Many people gave the frequency of Tmp+/Tmp- rather than the frequency of Tmp- here.*

   (d) (2 pts) After a long time, what will be the proportions of males and females, assuming the climate remains the same? (This can be answered on general principles.) *On general principles it should be 50/50 whenever individuals have one parent of each sex and the cost of making male and female offspring is the same.*

   If you wanted to test your general reasoning you could use the frequencies from (e) and breed one more generation; if 50/50 is truly the equilibrium, the population should stay there next generation.

   To test this:

	Males	
	0.25 +/+	*0.75 +/-*
Females 1.0 +/+	*0.25 +/+*	*0.375 +/+* *0.375 +/-*

   The allele frequencies do not change, so this really is the equilibrium.

   (e) (2 pts) At the point where the sex ratio is 50/50, what is the frequency of Tmp-? *All of the females are +/+ and they are 50% of the population. We know that +/+ animals are 80% female, so those 50% females are the female proportion of 62.5% of the population which is +/+. There are then 12.5% +/+ males and 37.5% +/- males. Check that this adds up to 100% and that males and females are each 50%. The allele frequency of Tmp- is 0.1875.*

   It is an unsolved mystery why real alligators do not evolve to have a 50/50 sex ratio. Perhaps daughters are cheaper to produce than sons (less effort keeping the temperature high during incubation?) Or perhaps the population is not at equilibrium for some reason (meiotic drive locus? human disturbance of the environment?) Or–a teaser for a lecture later this term–perhaps some other species prefers female alligators and can influence the sex ratio?

2. Male elephant seals compete for females. Winners accumulate harems of around 40 females. Assume that losers do not mate at all. (In fact, some sneaky mating probably goes on; this has been found in almost every harem-keeping species in which paternity testing has been done.)

This raises an obvious evolutionary question: why is the sex ratio still close to 50/50? The excess males appear wasteful. We know that mammals can evolve unequal sex ratios (this has been observed in rodents) so why haven't elephant seals done so?

(a) (2 pts) How many surviving offspring will the average male have in the next generation, assuming the population size is constant? (Note that this average must include both successful and unsuccessful males.) *2. The lucky male will have 80 offspring to replace 40 females, himself, and 39 unsuccessful males. The other 39 males have no offspring. The mean is 2. Quite a few students said 1, but 2 kids are necessary to replace their 2 parents. If this problem once in parts a, b and c, I took off two points for it; if it appeared more than once I took off 3 points. Also please note that I asked for the average male, not the winning male!*

(b) (2 pts) How many offspring will the average female have? *2. The 40 females have to replace 80 animals, requiring 2 offspring each.*

(c) (2 pts) Suppose that the sex ratio shifts so that 90% of births are now females. How many offspring will the average male have now? The average female? *100 animals are now 10 males and 90 females. The 10 males have to produce 100 offspring, or 10 offspring each. The 90 females have to produce 100 offspring, or 1.1 offspring each.*

(d) (4 pts) It's been argued that a genetic variant leading to more female offspring should spread in this population, as the excess males are "wasted." Based on your answers so far, critique this argument. (In other words, if a genetic variant which could make more females did occur, why wouldn't it become common?) *Such a variant would mainly be in females, which have low reproductive success compared to males. So it would decline rather than increasing. The overall productivity of the population (total kids) would be higher, but the gene wouldn't benefit from that as it would get into too few of those kids compared to a gene in a male.*

There are other reasons why a highly skewed sex ratio might be bad–lack of male competition, reduced gene pool, genetic drift–but the reason it doesn't tend to occur in the first place is that individual self-interest pushes toward 50/50, as seen in the answers to (a)-(c).