This homework is worth a total of 20 points. Please type or write your answers clearly on a separate sheet of paper. If you use more than one sheet of paper, please use a stapler.

1. (1 point) Here is the sequence of a single strand of DNA:

\[5' \text{CAAGTTGTAACCTAGGTACGCTACCTGTAGTCATTTA} \ 3'\]

Which of the following DNA strands would be synthesized by DNA polymerase, given the template strand above (assuming that an appropriate primer sequence is available)?

a) \[5' \text{GTTCAACATTTGACATCCAATCAGCGATGGACATCGATTAAT} \ 3'\]

b) \[5' \text{ATTTACTGATGTCCATCGCTGATTGGATCTCAATGTTGAAC} \ 3'\]

c) \[5' \text{CAAGTTGTAACCTAGGTACGCTACCTGTAGTCATTTA} \ 3'\]

d) \[5' \text{TAATGACTACAGGTACGCTACCTGTAGTCATTTA} \ 3'\]

2. (1 point) Which of the following is/are possible phenotypic outcome(s) after a single mitotic recombination event that occurs between the singed and yellow loci in a sn y+/sn+ y somatic cell? (as opposed to occurring between the centromere and both genes). To answer correctly, you need to know the locations of the singed and yellow loci relative to the centromere (as shown in Hartwell figure 5.24 or lecture slides).

a) normal cells

b) a twin spot (a singed spot next to a yellow spot)

c) a singed spot

d) a yellow spot

e) two yellow spots that are not next to each other

3. (3 points) A red-eyed beetle was crossed to a beetle with pink eyes. The F1 progeny all had pink eye color. When F1 males and females were crossed to each other, 44 beetles with pink eyes and 16 beetles with red eyes were observed.

a) What is the likely pattern of dominance, based on this observation?

b) Suppose you set up matings between pink-eyed F2 beetles in separate vials. Each mating (i.e., each vial) yields several dozen (F3) progeny. For some pairs of beetles, no red-eyed progeny are observed. For other pairs of beetles, some red-eyed progeny are observed. What fraction of the matings will yield some red-eyed progeny?

c) In those specific crosses in 3b where some red-eyed progeny are observed, what fraction of the F3 progeny from that cross will be red-eyed?

4.

(2 points) The pedigree above is for cutis laxa, a rare connective tissue disorder in which the skin hangs in loose folds.

a) Assuming complete penetrance (and keeping in mind that the trait is rare), what is the apparent mode of inheritance? Explain your reasoning.

b) What is the probability that individual II-2 is a carrier? Explain your reasoning.

c) What is the probability that individual II-3 is a carrier? Explain your reasoning.

d) What is the probability that individual III-1 is affected by the disease? Explain your reasoning.
5. (3 points) Consider a family with three children in which both parents are known to be carriers for cystic fibrosis.
   a) What is the probability that they will have exactly one affected child?
   b) What is the probability that all three children will be affected?
   c) What is the probability that they will have exactly two affected children?

6. (2 points) Suppose you carry out a study of families whose children have cystic fibrosis. Your study group consists of families with exactly three children that are full siblings, at least one of which has cystic fibrosis. You verify that each child in the study is actually the genetic descendent of the two unaffected parents. The fraction of children in the study that are affected is greater than 1/4.
   a) To what can we attribute the fact that more than 1/4 of the children are affected?
   b) What fraction of children in the study population do you expect to be affected?

7. You are new to a laboratory that studies yeast. Your lab mate initiated a project with two closely linked genes, ABC1 and ABC2, that are involved in the same metabolic pathway. She previously measured the recombination rate between these two genes very precisely and deduced that when abc1 ABC2 / ABC1 abc2 heterozygous diploids are sporulated, almost exactly 1/1,000 of the resulting haploid cells are wild type (ABC1 ABC2). You repeat her experiment, sporulating 500 cells to yield 2,000 haploid spores, and find four recombinant ABC1 ABC2 spores. How likely is that (given the 1/1,000 expected rate)? In other words
   a) (1 point) What is the probability that you would obtain exactly four wild-type (ABC1 ABC2) spores? Calculate this answer exactly using the binomial distribution.
   b) (1 point) What is the probability that you would obtain four or more wild-type (ABC1 ABC2) spores? Calculate this answer exactly using the binomial distribution.
   c) (1 point) Once again, use the Poisson approximation to calculate your answer to a. What answer would you get?
   d) (1 point) Again assuming that the 1/1,000 number is precisely correct (for the expected number of recombinant ABC1 ABC2 haploids), how far apart are ABC1 and ABC2 (in cM.)?

8. Consider two genes: HIP1 and HOP1. When a strain carrying HIP1 and hop1 is crossed to a strain carrying hip1 and HOP1, the following tetrads are observed:
   159 tetrads with two HIP1 hop1 spores and two hip1 HOP1 spores.
   7 tetrads with two HIP1 HOP1 spores and two hip1 hop1 spores.
   34 tetrads with one HIP1 HOP1 spore, one hip1 hop1 spore, one HIP1 hop1 spore and one hip1 HOP1 spore.
   a) (1 point) What is the observed % recombination?
   b) (1 point) What is your best estimate of the distance between HIP1 and HOP1 in cM? Explain.

9. (1 point) Two wild-type alleles, 1 and 2, are present in a population in Hardy-Weinberg equilibrium and together make up 96% of the allele frequency at that locus. Homozygotes for allele 1 represent 9% of the population. What fraction of the population is homozygous for allele 2?

10. (1 point) In Drosophila, a single X-linked gene in a male cell during the G1 phase is present as part of a single (double-stranded) molecule. Suppose you are studying a protein that binds to a single site on the X chromosome only in males. The Drosophila genome is approximately 150 Mbp, which means that a single haploid genome (one allele of each gene) would be 150,000,000 base pairs (bp). Recalling that Avogadro's number is $6 \times 10^{23}$ (no units; this is a "pure" number), how many diploid G1 male Drosophila cells would be needed to have 1 picomole of protein-DNA complex?