Problem set I: due 1/31 at the beginning of class

1) *Drosophila melanogaster*, the fruit fly, has a 2*n* chromosome number of 8 (4 chromosomes – 3 autosomes and 1 sex chromosome). Assume that you are microscopically examining the mitotic and meiotic cells of this organism. You note that in the female, two chromosomal pairs are metacentric and two pairs are acrocentric.

    a. Draw the chromosomal configurations as you would expect to see them at the stages listed:
        i. mitotic metaphase
        ii. primary oocyte (meiotic metaphase 1)
        iii. secondary oocyte (meiotic metaphase II)
        iv. oocyte (gamete G1)
        v. second polar body

    b. Given that the previously mentioned cells are from individuals heterozygous for two independently segregating, autosomal loci, *plum eyes* and *curled wings*, place appropriate symbols (of your designation) on chromosomes in the drawings you made for part (a). Assume no crossing over, and there may be more than one correct answer, **if so draw all correct answers**. Indicate which allele is the dominant and which is the recessive. (Capital letters are usually used for dominant and lowercase for recessive.)

    c. Assuming that a somatic non-dividing nucleus from the individuals mentioned above contains about 8.0 picograms of DNA, how much nuclear DNA would you expect in each of the cells mentioned in part (a)

2) In lab next week you are going to be using drosophila flies with sepia mutations (SE, se) causing brown eyes found on chromosome 3 and apterous mutation (AP, ap) on chromosome 2 causing loss of wings. These are recessive mutations. Red eye is the wild-type phenotype.
    a. Assuming you have a female heterozygous at both loci. Draw the chromosomes as they go through meiosis (Make sure you show somatic cell, prophase I, metaphase I, metaphase II, gametes.)
    b. Draw all possible gametes.
    c. Assuming this female mates with a male that is also heterozygous at both loci and they have 1000 progeny. What are all possible phenotypes you could recover.?
    d. How many of each phenotype do you expect?
    e. What are all the possible genotypes would you expect?
    f. How many progeny of each genotype do you expect?
    g. You find a Red eye fly with wings.
        i. What is the probability this fly is homozygous SE/SE?
        ii. What is the probability this fly is heterozygous SE/se?
        iii. What is the probability that this fly in male?
    h. What cross could you do to determine if its homozygous or heterozygous at the SE locus.

3) If a typical somatic cell has 64 chromosomes, how many chromosomes are expected in each gamete of that organism?

4) Consider an organism that has a haploid-diploid lifecycle. If the diploid form has 54 chromosomes, how many homologous chromosome pairs does one of it's cells have prior to disjunction in anaphase I of meiosis?

5) What happens during nondisjunction?

6) Name two evolutionarily significant benefits of meiosis that are not present in mitosis.

7) Polydactyly is a phenotype in which an individual has extra fingers and/or toes. Assume that a man with six fingers on each hand and six toes on each foot marries a woman with a normal number of digits. Having extra digits is caused by a dominant allele. The couple has a son with normal hands and feet, but the couple's second child has extra digits. What is the probability that their next child will have polydactyly?

8) You discover a new species of rodent that seems to come in two varieties, hairy and smooth. You suspect that this difference is determined by a single gene, H (call H the dominant allele and h the recessive allele). Examine the results of the following crosses. For each cross, indicate the genotypes of the parents and progeny:

cross#	parents	progeny
1.	hairy x hairy	3/4 hairy, 1/4 smooth
2.	hairy x smooth	1/2 hairy, 1/2 smooth
3.	hairy x smooth	all hairy

9) A certain type of congenital deafness in humans is caused by a rare autosomal recessive gene. In a mating involving a deaf man and a deaf woman, could some of the children have normal hearing? Explain your answer.

10) Leeuwenkoek- the famous cell biologist – tried his hand at genetics to prove his theory of inheritance; in which males determine inheritance because a tiny little human being exists in the sperm. He crossed a gray male rabbit to a female white rabbit and got all gray rabbits. You are the reviewer of his paper, what experiment will you make him do before he can publish? Explain.

11) Peas heterozygous for three independently assorting genes were intercrossed
    a. What proportion of the offspring will be homozygous for all three recessive alleles?

    b. What proportion of the offspring will be homozygous for the recessive allele of at least one gene?

12) Lots of scientists were interested in understanding why children look like their parents? This question drives to the heart of our understanding of one of the important facets of life- how it passed from one generation to another. However, the data is very confusing, some children look very much like their fathers, while other children don't look like any of their parents. What were Mendel's breakthroughs that allowed him to answer this question.

13) In an exotic species of bird, the difference between smooth feathers and ruffled feathers is controlled by a single gene: birds with a dominant allele, R, have smooth feathers, and birds homozygous for the recessive allele, r, have ruffled feathers. Birds with a dominant allele for a pigment gene, B, have black feathers and homozygous recessive bb birds have blue feathers.

a. How would you set up a dihybrid cross between a black bird with smooth feathers (which happens to be homozygous for the dominant alleles of both genes), and a blue bird with ruffled feathers? Show the phenotypes and genotypes of the parents and F_1 progeny.

b. From a mating between two of these F_1 progeny, what proportion of the resulting F_2 progeny are expected to be...
   i. black with smooth feathers?
   ii. blue with smooth feathers?
   iii. black with ruffled feathers?
   iv. blue with ruffled feathers?

c. From these F_2 progeny, a black bird with smooth feathers is chosen at random.
    i. What is the probability that this bird is homozygous BB?

    ii. What is the probability that this bird is heterozygous Bb?

d. What cross could you do to determine whether the chosen bird from part c is BB or Bb (assume that birds of all genotypes mentioned so far in this problem are available for crosses)? Indicate what the expected results would be if the bird is BB and if it is Bb.

14) Why were true breeding plants important to Mendel?

15) Many people think Mendel got lucky? What meiotic event did Mendel's postulates not account for? What specifically would change.

16) Mendel postulated inheritance occurring through paired unit factors. What is the physical basis of paired unit factors? Explain.

17) The white eyed recessive mutation (w) occurs on the X chromosome in flies. Like humans females are XX and males XY. If you cross a white eyed female to a red eyed male –
    a. What are the possible genotypes?
    b. What are the possible phenotypes?
    c. How many males will have white eyes?
    d. How many females will have white eyes?

18)
    a. Why did Cell Biologists think Chromosomes could form the basis of genetic inheritance?

    b. How did Morgan prove genes are on chromosomes?

19) How many genetically *different* gametes can be formed by individuals with the following genotypes?
    a. XxYy
    b. AaBB
    c. EeFfGghh

20) Hair length and hair color are two traits in cats that are inherited in a Mendelian fashion. If White hair (W) is dominant over any other colored hair (w) and Long hair (L) is dominant over short hair (l), how many different *phenotypes* can you ever expect to see if: a white, long-haired male cat (heterozygous for hair color only) named JoJo makes little kittens with a black, short-haired cat named Bella?

21) Sickle cell anemia and albinism are both recessive traits in humans. Imagine that a couple, already pregnant with fraternal twins, has just learned that they (the couple) are both heterozygous for both of these traits. As the couple's genetic counselor, the couple asks you what is the probability of having both of the twins be albino and have sickle-cell anemia

22)

a. In thinking about the genetic definition of a gene (a unit of inheritance), name two requirements.

b. Based on these requirements, could chromosomes function as the unit of inheritance? Why or why not?

23) After completing this problem set, what topic gave you the most trouble?

Optional Problems:

- From chapter 2 of Essentials of Genetics, 9th edition
  - "Insights and solutions" problems 1 – 4 (page 28-29)
  - Problems 26-31 pg. 30

- Trisomy 21 or Down syndrome occurs when there is a normal diploid chromosomal complement of 46 chromosomes plus one (extra) chromosome 21. Such individuals therefore have 47 chromosomes. Assume that a mating occurs between a female with Down syndrome and a normal 46-chromosome male. What is the probability the offspring would be expected to have Down syndrome? Explain.

- From chapter 3 of Essentials of Genetics, 9th edition
  - Insights and Solutions problems 1-3 (page 49-50)
  - Problem 12