**Biol 215/Genetics**
**Problem set 1**
**Mitosis/Meiosis/Cell cycle**

Answers to this problem set are posted a day prior to the exam. The idea is that the problems are answered using problem solving, reading, discussion and review. The problem set is not graded, and group work is encouraged. Having the answers immediately at hand creates a false sense of confidence while studying the material. You will undoubtedly do much better on the exam if you do the problem set and then check the answers, not vice versa. Use scratch paper, a white board, sidewalk chalk...but do before you peek...

**Some questions may imply that all cells undergo mitosis and meiosis. Remember only germ cells undergo meiosis.

1. Sketch a cartoon figure of a somatic cell from an organism that has a haploid chromosome number of 5 as it would look in metaphase. Pretend this cell has a metacentric large chromosome, a submetacentric medium-size chromosome, a submetacentric small chromosome, an acrocentric small chromosome, and a tiny telocentric chromosome. (See attached page)

2. Show a primary spermatocyte from the same organism as it would look in metaphase I of meiosis I. (See attached page)

3. Suppose an organism has a chromosome number, 2n=12:

a. In preparation for mitosis, how many chromatids are present in G1 of interphase? 12

b. In preparation for mitosis, how many chromatids are present in G2 of interphase? 24

c. In preparation for meiosis, how many bivalents/tetrads are present in metaphase I? 6

d. In preparation for meiosis, how many bivalents/tetrads are present in metaphase II? 0

e. How many chromosomes are in the cells produced by mitosis? 12

f. How many chromosomes are in the cells produced by meiosis? 6

**4.** What are homologous chromosomes? What features would tell you 2 chromosomes are homologs? Homologous chromosomes are pairs of the same type of chromosome inherited by each parent. For example, consider human chromosome #1—humans inherit 1 copy of this chromosome from each parent to make a homologous pair of chromosomes. Homologous chromosomes are the same size, have the centromere in the same position, and most importantly have the same set of genes in exactly the same positions along the length of the chromosome.

**5.** In rare cases 2 different, but related species can mate and produce live offspring that are a hybrid of each species. Mules are the offspring of a horse, and a donkey.
Horses are 2n=64 (n=32)
Donkeys are 2n=62 (n=31)

a. How many chromosomes are in somatic cells of mules? Explain your reasoning. There should be 2n=63 chromosomes in mule's somatic cells. Horse's gametes should have n=32 and donkey's gametes should have n=31. The fusion of horse and donkey gametes would create a zygote with 2n= (32+31)=63 chromosomes.

b. Mules are infertile—defective in some aspect of reproduction. Give an explanation based on what you know about meiosis. Presumably the chromosomes inherited by mules are not true homologs so homologous pairing might not be possible during meiosis. Moreover, with an odd number of chromosomes (63), the complete pairing of semi-homologous chromosomes would not be possible. It would always leave an odd, unpaired chromosome. Therefore, the gametes of mules would not be viable for reproduction of a mule.

**6.** If fruit flies (*Drosophila melanogaster*) have n=4 chromosomes...

a. How many genetically unique sperm can male fruit flies make by randomly assorting the maternal and paternal chromosomes during spermatogenesis? $2^4$=16

b. How many genetically unique ova can female fruit flies make by randomly assorting the maternal and paternal chromosomes during oogenesis? $2^4$=16

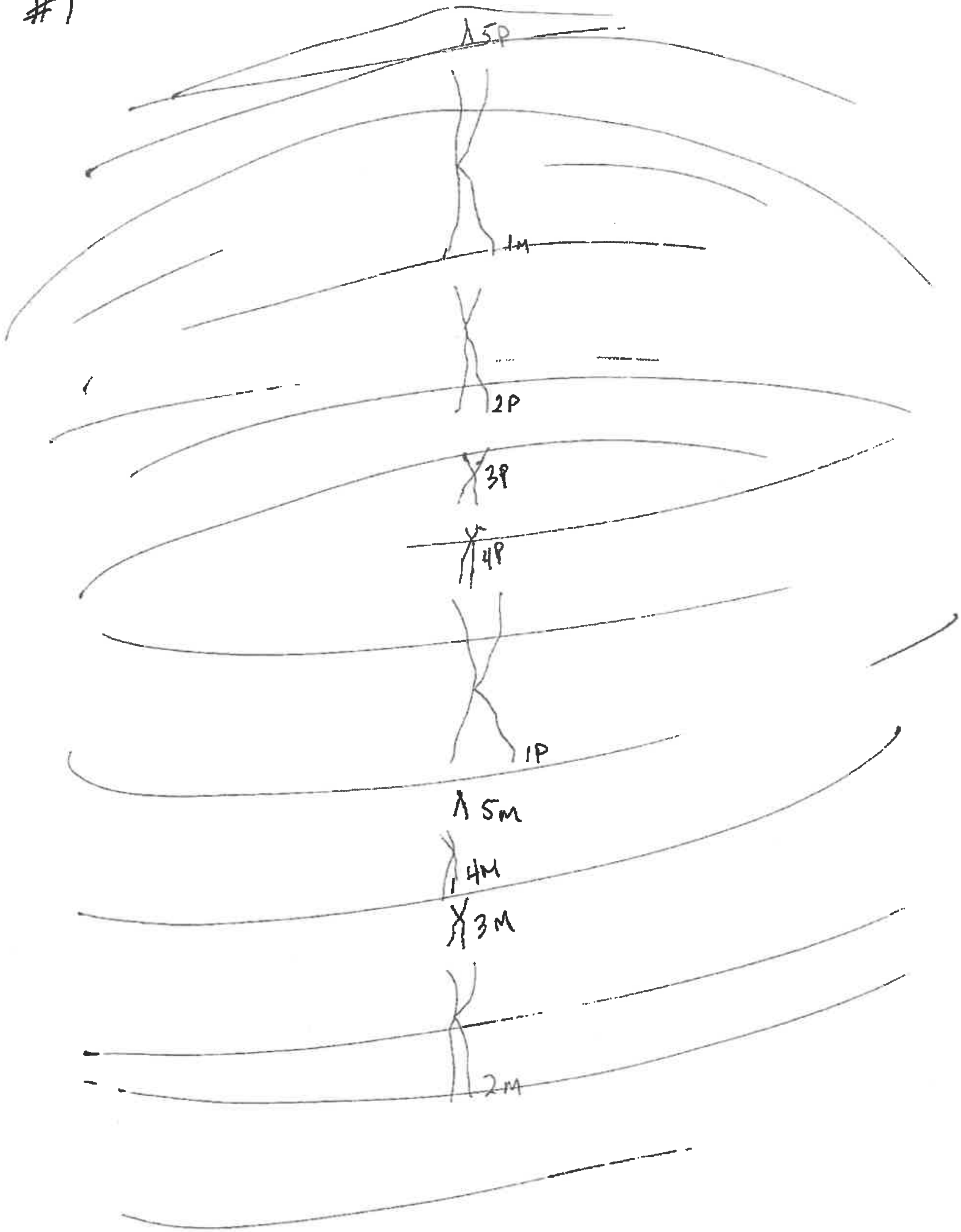
c. How many genetically unique offspring can one pair of *Drosophila* make based on randomly assorted maternal and paternal chromosomes during gametogenesis? $2^4$ X $2^4$ X $2^4$ = 256

d. Using color and size to distinguish chromosomes, show 2 possible combinations of chromosomes from male and female *Drosophila* in 2 offspring. (See attached page)

**6.** In 3 or 4 sentences, describe the link between cell cycle and cancer. Be as specific as possible. In order to perfectly duplicate a cell during mitosis (somatic cell division) a precise program of events occur in succession in a multi-step cell cycle. The program includes some growth, DNA replication, formation of the structure known as the spindle, and precise distribution of one copy of each chromosome to 2 new daughter cells. The cell has a set of proteins encoded by genes known as cell cycle check point genes to make sure that a cell is perfectly suited to divide and that these events have occurred perfectly before the cell can continue the program. When genes encoding these proteins that control the cell cycle check points are mutated and these proteins are lost or malfunction cell's divide without regulation—too often and this is the disease we call cancer.

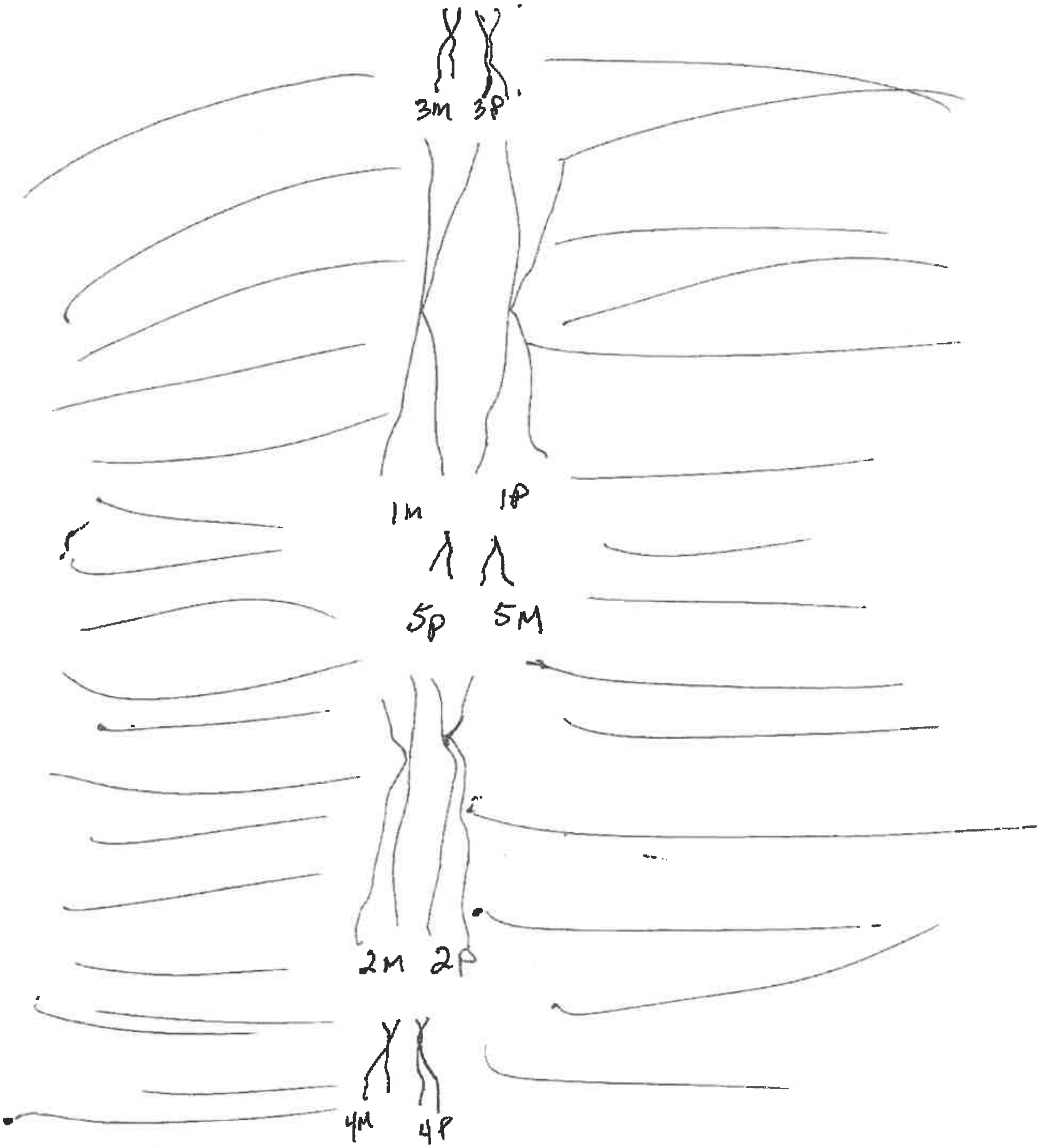
**7.** *TP53*, BRCA 1, and *cMyc* are considered to be "cancer genes", yet everyone has these genes, whether they get cancer or not. Explain why they are called cancer genes. These genes are mutated and not functioning correctly in cancer cells. These genes' normal roles is to regulate cell cycle . When they are not doing their normal jobs, the cell divides to rapidly, and the result is cancer.

#1



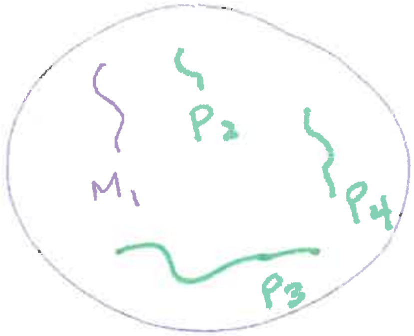

n=5
2n=10
Maternal & paterna copies—unpaired @ cell equator

#2




5 pairs aligned @ cell equator attaching to spindle.

6. d



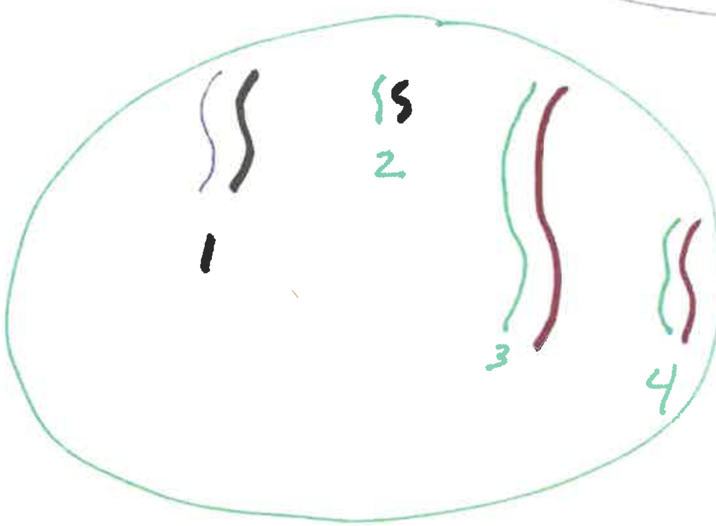

egg (one possible combo)

Female fruit fly inherits chromosomes from her parents and assorts independently


Sperm (one possible combo) → Male fruit fly inherits chromosomes from his parents and assorts independe

$n=4$ → each gamete can have $2^4 = 16$ unique combos of M:P chromosomes.

Offspring (one possible combo)




Offspring could have $2^4 \times 2^4$ different combinations

$16 \times 16 = 256$