UNIT 4 STUDY GUIDE FOR BIO 181

CHAPTER 12: The Cell Cycle

Cell Cycle and Mitosis:

1. List and describe some of the functions of cell division.

2. Define "cell cycle".
   a) Name the 3 main stages of the cell cycle, and describe the major events of each stage.
   b) What must happen to the DNA of a cell before the cell divides? Why?
   c) What is the total amount of genetic information inside a cell called?
   d) What is the difference between somatic and gametic cells? How does the number of chromosomes in each compare?
   e) What types of cells undergo the cell cycle (prokaryotic, eukaryotic, etc.)?

3. Describe the structure and composition of chromosomes, and describe (and draw) how a chromosome's structure compares before and after the 'S-Phase" of interphase
   a) Do sister chromatids exist before or after the S-Phase?
   b) What are sister chromatids (define)?
   c) What is a centromere?
   d) What material / chemical compounds make up a chromosome?

4. Describe the events that occur during the G1 and G2 phases of interphase.
   a) When do these events occur in relation to the S-Phase?
   b) What proportion of the cell cycle is taken up by the events of interphase?
   c) What is the cell trying to accomplish during these respective phases?

5. List AND draw the 5 stages of mitosis in the correct order, and describe the most significant events of each stage.
   a) What are centrosomes, and what is their function?
   b) What are spindle fibers, and where do they come from?
   c) What is a kinetochore, and what is its function?
   d) Describe the differences (in function) between kinetochore and nonkinetochore microtubules.
   e) What are the chromosomes doing at each stage?

6. Describe how plants and animals differ in their mechanism of cytokinesis. Explain why plants cannot divide their cells in the same way as animals.

7. Describe how prokaryote cell division contrasts with eukaryote cell division.

8. Describe some of the variations in mitosis among various eukaryotic groups (i.e., dinoflagellates vs. diatoms vs. other eukaryotes), and discuss any similarities to binary fission.

9. Describe how the cell cycle control system works, and how cell division is regulated.
   a) What is a checkpoint, and how is it regulated?
   b) What might cause a cell to enter the G_0 phase?
   c) Explain how density-dependent inhibition and anchorage dependence may control cell division.

10. Explain how the cell cycle of cancer cells is different from normal cells, and describe some hypotheses for the differences.
    a) Compare and contrast benign tumors, malignant tumors, and metastasis.

CHAPTER 13: Meiosis and Sexual Life Cycles

11. Differentiate between asexual and sexual reproduction, and the type of cell division used in each strategy.

12. Explain why meiosis must occur in sexually reproducing organisms.

13. Describe and draw the sexual life cycle of animals.

14. List the stages of Meiosis I and Meiosis II, and describe the significant events at each stage (especially crossing over and independent assortment; when do these happen, how do they happen, and what are the results of these events?). Identify the point at which cells become haploid. Identify the way by which diploid cells produce haploid cells (i.e., what stage(s) of meiosis are crucial for producing haploid cells?).

15. Explain how independent assortment occurs, and name the stages of meiosis during which this event happens. Explain the "random fertilization of gametes" that occurs when sexually reproducing organisms mate, and explain how both independent assortment and random fertilization produce variations among organisms.

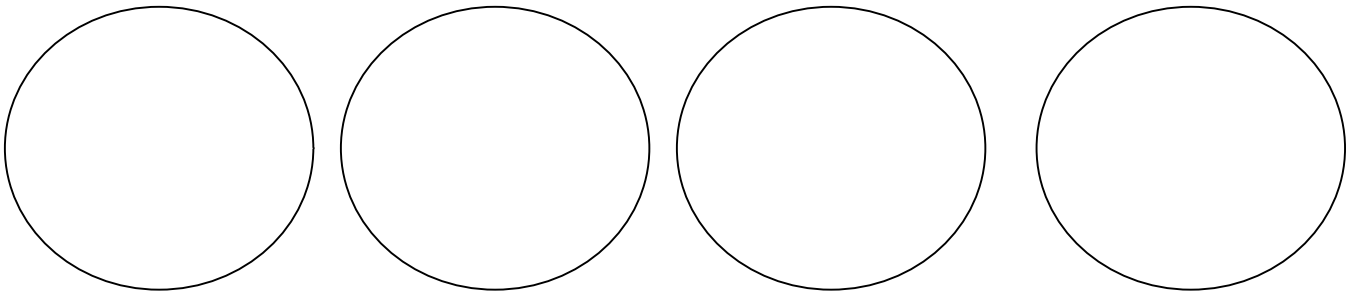
16. Describe what a karyotype is, and how it is prepared and interpreted.

17. Define autosome, sex chromosome, somatic cells, gametes, homologues, genes, alleles, chromatin, chromosome, chromatid, centromere, kinetochore microtubules, nonkinetochore microtubules, metaphase plate, centrosome, cleavage furrow, tetrad, synapsis, haploid, diploid, and any other terms that come your way in lecture! ☺

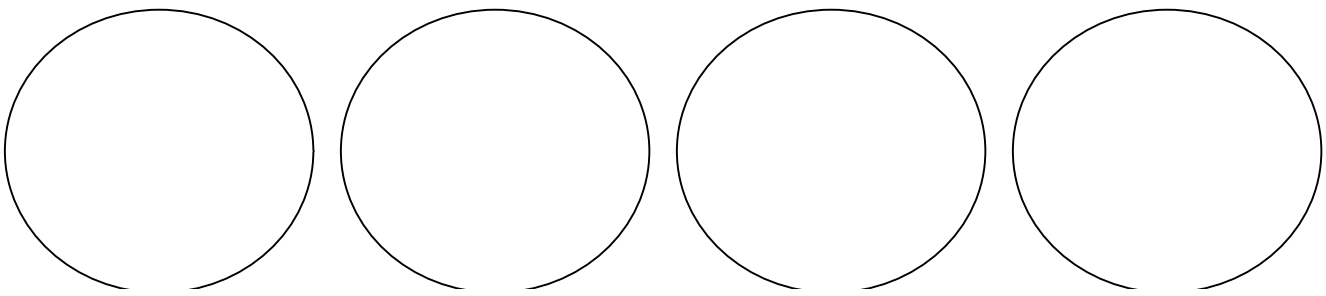
Problems (for both Mitosis <u>and</u> Meiosis):

1. A parasitic nematode worm has a diploid number of 6 (2n=6) in its somatic cells. Show the arrangement of the chromosomes as they would appear during the following stages:

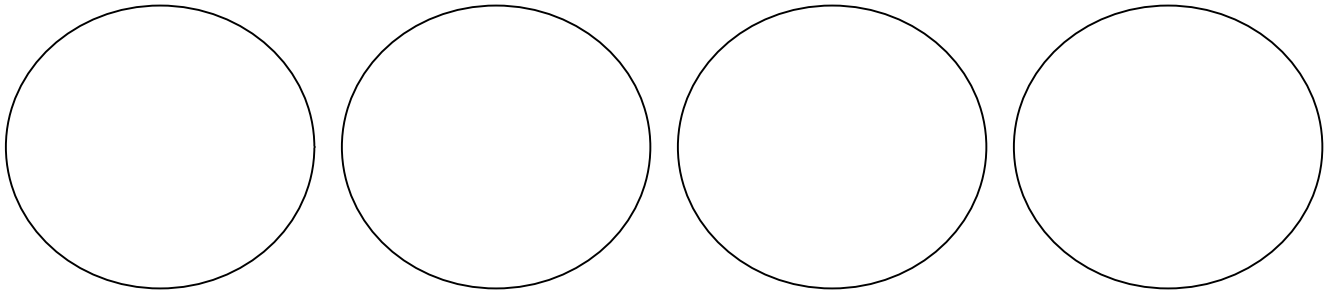
Mitosis: Prometaphase Metaphase Anaphase Telophase



Meiosis: Prophase I Metaphase I Anaphase I Telophase I



Prophase II (1 of 2 cells) Metaphase II Anaphase II Telophase II



2. A cell begins interphase with 12 chromosomes (2n = 12).

   (A) After the "S" phase of interphase, how many chromosomes are there? How many sister chromatids?

   (B) During anaphase of mitosis, how many chromosomes are there? How many sister chromatids?

   (C) During anaphase of Meiosis I, how many chromosomes are there per cell?

   (D) During anaphase of Meiosis II, how many chromosomes are there per cell?

   (E) After Meiosis II is complete, and cytokinesis occurs, how many chromosomes are there per cell?

3. A cell has a diploid number of 8 (2n = 8). If nondisjunction of one chromosome pair occurs during Meiosis I, how many gametes would be aneuploid by the end of meiosis? What would the chromosome numbers be in the resulting cells? Draw the outcome (what the cells would look like).

4. A cell has a diploid number of 8 (2n = 8). If Meiosis I occurs normally, but nondisjunction of one chromosome pair in one of the cells occurs during Meiosis II, what proportion of the gametes would be aneuploid? Draw the outcome (what the cells would look like).

5. A karyotype of a developing fetus shows that only one sex chromosome, the "X" chromosome, is present. How would you diagnose this person (i.e., what syndrome does this person have)? What symptoms are expected during this person's lifetime?

6. A mule is the offspring of a horse and a donkey (two different species). A donkey sperm contains 31 chromosomes, and a horse egg cell 32 chromosomes, so the zygote contains a total of 63 chromosomes. The zygote develops normally, producing the mule. However, a mule is sterile; meiosis cannot occur normally in testes or ovaries. Explain why mitosis is normal in mule cells, but meiosis fails to produce functional gametes in a mule.

CHAPTERS 14 & 15: Mendel and the Idea of the Gene

Objectives:

1. Define the following: genetics, monohybrid cross, gene, allele, dominant, recessive, homozygous, heterozygous, Punnett Square, genotype, phenotype, principle of segregation, complete dominance, incomplete dominance, codominance, pleiotropy, polygenic inheritance, autosomes, sex chromosomes, sex-linked genes

2. When Gregor Mendel crossed (mated) pea plants that were taken from different strains (e.g., purple vs. white flowers, tall vs. short plants), ALL offspring expressed the same phenotype. When these offspring were allowed to self-fertilize, the phenotype ratios for the offspring always were 3:1. Explain these results. Use the terms homozygous, heterozygous, dominant, recessive, allele, and gamete in your response.

3. Using a Punnett Square, be able to show and predict the genotype and phenotype ratios of offspring when the parents' genotypes are given. See example problems below.

4. Explain why genetic disorders caused by a dominant allele are much less common than genetic disorders caused by recessive alleles. Give at least two examples each of recessive and dominant disorders.

5. Compare and contrast complete dominance, incomplete dominance, and codominance. Explain how each of these patterns of inheritance results.

6. Explain how sickle disease serves as an example of pleiotropy.

7. Explain how polygenic inheritance accounts for the great variations in human skin color, eye color, and height.

8. Define **linked genes**. Explain how the degree of linkage between genes affects the degree of genetic recombination in offspring.

9. Differentiate between autosomes and sex chromosomes. Define sex linked gene and give some examples. Explain why sex-linked disorders mostly affect males rather than females. Use Punnett Squares to solve genetic problems involving sex-linked genes.

10. Describe how environmental factors may produce varying phenotypes. Give at least two examples.

11. Explain how amniocentesis and chorionic villus sampling may be used to check for genetic disorders. Explain how ultrasound and fetoscopy may be used to check for genetic disorders. Which procedure carries the highest risk? The lowest risk?

<u>Genetics Problems:</u> See problem set from lab, and genetics problems on pages 272 – 273 in your textbook.

CHAPTER 16: MOLECULAR BIOLOGY OF THE GENE (DNA Replication)

Objectives:

1. Briefly summarize the contributions of each to our understanding of DNA:
   - (A) Griffith
   - (B) Avery
   - (C) Hershey and Chase
   - (D) Chargaff
   - (E) Rosalind Franklin
   - (F) Watson and Crick

2. Describe how DNA replication makes two identical copies of the double helix. Explain why the process is described as "semi-conservative."

(A) Why are the two strands of nucleic acid in DNA referred to as 'antiparallel'?
(B) What are "origins of replication"?
(C) What does DNA Polymerase do?
(D) What does helicase do?
(E) Why are there "leading" and "lagging" strands of daughter DNA? Describe how replication occurs along each of these.
(F) What does primase do? Why is this enzyme necessary?
(G) What does topoisomerase do? Single-strand binding protein?
(H) What does DNA ligase do?
(I) What does nuclease do, and why?
(J) What are telomeres, and why does eukaryotic DNA, and not prokaryotic DNA, have them? What is the function of telomerase?

3. Explain the relationship between sister chromatids and the resulting two daughter DNA molecules following DNA replication.

CHAPTER 17: From Gene to Protein

1. Describe how the sequence of nucleotides in DNA indirectly determines the sequence of amino acids in a protein. What two general processes are involved in synthesizing a protein from the corresponding gene found on DNA [Hint: one occurs in the nucleus, the other in the cytoplasm]?

2. Describe the processes of transcription and translation (what happens in each process?). Identify from the following list the molecules that are important in each process: DNA polymerase, RNA polymerase, ribosomes, DNA, mRNA, tRNA, amino acids, individual DNA nucleotides (A, T, G, C), individual RNA nucleotides (A, U, G, C). Explain what these molecules do (function).

3. Contrast template and coding strands of DNA; which is transcribed? Which contains the actual gene?

4. Where in the cell do the processes of transcription and translation take place?

5. List and describe the steps in transcription. Include the role of the promoter, transcription unit, RNA polymerase, exons, and introns.

6. Distinguish between the functions of mRNA, tRNA, and rRNA. Also, *how* are they synthesized? *Where* are they synthesized?

7. Describe the structure of the ribosome and its function(s) during translation. What is the function of the "P-site"? The "A-site"?

8. Define each of the following: codon, anticodon, translocation, A-site, P-site, and peptide bond. How many different codons are possible? How many different amino acids are there? Do some amino acids have more than one codon? Give a couple examples.

9. Draw and list the sequence of events that are necessary to (a) Initiate translation, (b) Elongate a polypeptide, and (c) Terminate translation.

10. Define "mutation". Describe how a mutation in the DNA can affect the shape and ultimately the function of a protein. Differentiate among insertions, deletions, silent mutations, missense

mutations, and nonsense mutations. Which of these are considered "frameshift" mutations? Which "type" of mutation would usually cause the most serious and detrimental effects? Why?

Additional Problems:

1. Draw a piece of DNA (gene) and label the template and nontemplate strands. Draw an enlarged portion of the gene, with the 2 DNA strands separated, and draw RNA polymerase and a growing RNA molecule.

2. Draw a series of pictures showing:
   (A) steps of Initiation during translation
   (B) steps of Elongation during translation
   (C) steps of Termination during translation

3. Shown below is double stranded DNA. The template and coding strands are indicated. Show the mRNA that would be transcribed from this DNA. Show the polypeptide that would be translated from this mRNA.

   (template strand)
   C C G T A C G G G A T A T C G A T G C G T A T T T C

   G G C A T G C C C T A T A G C T A C G C A T A A A G
   (coding strand)

4. There are several ways that genetic information can be changed or mutated. Bases can be added, deleted, or changed.

   (A) How will the sequence of amino acids change if an additional nucleotide, A, is inserted between the sixth and seventh nucleotide in the DNA sequence shown in problem 4?

   (B) How will the amino acid sequence change if the second "C" in the original template sequence is changed to an "A"?

5. Mutations that have no effect on amino acid sequence are sometimes referred to as "silent mutations." Give some examples of single base substitutions that would be silent mutations. How might the redundancy of the genetic code (see Figure 17.5) provide a possible benefit to organisms?