BIOL_ACTIVITY_5

CHAPTER 12

What is mitosis?

1. What is the overall purpose of mitosis?

Mitosis is the process of cell division, and occurs only in "somatic" or body cells. When haploid sperm meets haploid egg, a chain of events that begins with a single diploid cell and ends with an adult organism made of billions of cells is set in motion. The single cell divides into 2, and each of those 2 divide again, and this process continues geometrically along the following progression: 1, 2, 4, 8, 16, 32, 64, 128, and so on into the billions. Therefore, the first purpose of mitosis is growth. The second function of mitosis is repair. Cells are constantly wearing out and getting damaged and unless an organism replaces them at least as fast as they are lost, a gradual deterioration will occur.

2. In what types of organism(s) and cells does mitosis occur?

Mitosis occurs exclusively in eukaryotic cells, but the process varies in different species. For example, animals undergo an "open" mitosis, where the nuclear envelope breaks down before the chromosomes separate, while fungi such as *Aspergillus nidulans* and*Saccharomyces cerevisiae* (yeast) undergo a "closed" mitosis, where chromosomes divide within an intact cell nucleus.

3. What type of cell division occurs in bacteria?

Bacteria divide by binary fission since they are classified as prokaryotes. Binary fission is a form of asexual reproduction where identical bacteria are formed from another previously existing one.

What are the products of mitosis?

4. How many cells are produced at the end of a single mitotic division?

Two diploid cells per parent cell are produced at the end of a single mitotic division.

5. How many different kinds of cells are produced at the end of a single mitotic division?

Identical cells, not different cells, are produced at the end of a single mitotic division.

6. Six centromeres are observed in a prophase cell from another species of insect.

a. How many pairs of chromosomes does this organism contain? Three pairs of chromosomes are contained in the organism.		
b. For each stage of mitosis, indicate the number of centromeres you would expect to find and the number of copies of chromosomes attached to each centromere.		
Stage of mitosis:	Number of centromeres visible per cell	Number of chromosome copies attached to each centromere
Prophase	6	2
Anaphase	12	1

Haplopappus is an annual flowering plant that grows in deserts. It is of interest because its 2n number is only four.

7. This means that cells in the vegetative parts of the plant that are not undergoing mitosis have how many DNA molecules in their nuclei?

Prior to the DNA replication in S interphase, these would have four DNA molecules. After DNA replication, there would be eight DNA molecules.

8. During metaphase of mitosis, how many DNA molecules would be in the nucleus?

There are no DNA molecules in the nucleus, but there are eight nuclear DNA molecules within the cell.

CHAPTER 13

What is meiosis?

1. What is the overall purpose of meiosis?

The purpose of meiosis is to reduce the normal diploid cells (2 copies of each chromosome / cell) to haploid cells, called gametes (1 copy of each chromosome per cell). In humans, these special haploid cells resulting from meiosis are eggs (female) or sperm (male). The purposes of meiosis are sexual reproduction, genetic variation (adaptability), and chromosome update and repair. Meiosis is cell division. It is when the diploid cell divides to create gametes. There is an independent assortment of chromosomes in meiosis, through that each daughter cell gets maternally or paternally derived homolog.

2. In what types of organism(s) does meiosis occur?

Meiosis occurs in animals, plants, some algae, most fungi, and some protists.

What are the products of meiosis?

4. Consider a single cell going through meiosis.

a. How many cells are produced at the end of meiosis?

There are four cells produced at the end of meiosis.

b. How many chromosomes, and which chromosomes, does each of the daughter cells contain?

Each daughter cell contains one chromosome. The daughter cell depends on whether the original cell is XX or XY.

5. Six centromeres are observed in a prophase I cell from another species of insect.

a. How many pairs of chromosomes does this organism contain? Three pairs		
b. For each stage of meiosis, indicate the number of centromeres you would expect to find and the number of copies of chromosomes attached to each centromere.		
Stage of meiosis:	Number of centromeres visible per cell	Number of chromosome copies attached to each centromere
Anaphase I	3	2
Prophase II	3	3

Nondisjunction of sex chromosomes during human gamete formation may lead to individuals with sex chromosome trisomy. An individual with the sex chromosome trisomy of XXY may have resulted from nondisjunction occurring in (Circle T if true, F if false): Please explain your answers.

1. Meiosis I in the father's sperm production

FALSE.

2. Meiosis II in the father's sperm production

TRUE. Klinefelter syndrome is the disease where extra copies of genes on the X chromosome interfere with male sexual development, preventing the testes from functioning normally and reducing the levels of testosterone.

3. Meiosis I in the mother's egg production

FALSE. Nondisjunction only happens in paternal genes.

4. Meiosis II in the mother's egg production

FALSE. Nondisjunction only happens in paternal genes.

Review the processes of mitosis and meiosis in Chapters 12 and 13 of *Biology*, 8th edition, then fill in the chart. Keep in mind that the stages of cell division were first recognized from an examination of fixed slides of tissues undergoing division. On fixed slides, cells are captured or frozen at particular points in the division cycle. Using these static slides, early microscopists identified specific arrangements or patterns of chromosomes that occurred at various stages of the cycle and gave these stages names (interphase, prophase, and so on). Later work using time-lapse photography made it clear that mitosis and meiosis are continuous processes. Once division begins, the chromosomes move fluidly from one phase to the next.

1. What events occur during each phase of mitosis and meiosis?

	Interphase	Prophase	Metaphase	Anaphase	Telophase & cytokinesis
Mitosis	-A nuclear envelope bounds the nucleus. -The nucleus contains one or more nucleoli.	-The chromatin fibers become more tightly coiled, condensing into	-The centrosomes are at opposite poles of the cell. -The chromosom	-Begins when the cohesion proteins are cleaved. This allows the two sister	-Two daughter nuclei from in the cell. -Ncuclear envelopes arise from the

	-Two centrosomes have formed by replication of a single centrosome. -In animal cells, each centrosome features two centrioles. -Chromosomes, duplicated during S phase, cannot be seen individually because they have not yet condensed.	discrete chromosomes observable with a light microscope. -The nucleoli disappear. -Each duplicated chromosome appears as two identical sister chromatids joined together at their centromeres and all along their arms by cohesions (sister chromatid cohesion). -The mitotic spindle begins to form. It is composed of the centrosomes and the microtubules that extend from them. -The centrosomes move away from each other, apparently propelled by the lengthening microtubule	es convene on the metaphase plate, an imaginary plane that is equidistant between the spindle's two poles. The chromosomes' centromeres lie on the metaphase plate. -For each chromosome, the kinetochores of the sister chromatids are attached to kinetochore microtubules coming from opposite poles.	chromatids of each pair to part suddenly. Each chromatid thus becomes full-fledged chromosome. -The two liberated chromosomes begin moving toward opposite ends of the cell as their kinetochore microtubules shorten. Because these microtubules are attached at the centromere region, the chromosomes move centromere first. -The cell elongates at the nonkinetochore microtubules lengthen. -By the end of anaphase, the two ends of the cell have equivalent – and	fragments of the parent cell's nuclear envelope and other portions of the endomembrane system. -The chromosomes become less condensed. -Mitosis is complete. Cytokinesis -The division of the cytoplasm is usually well under way by late telophase, so the two daughter cells appear shortly after the end of mitosis. -In animal cells, cytokinesis involves the formation of a cleavage furrow, which pinches the cell in two.

		s between them.		complete – collections of chromosomes.	
Meiosis I		-Chromosomes begin to condense, and homologs loosely pair along their lengths, aligned gene by gene. -Crossing over (the exchange of corresponding segments of DNA molecules by nonsister cromatids) is completed while homologs are in synapsis, held tightly together by proteins along their lengths (before the stage shown). -Synapsis ends in mid-prophase, and the chromosomes in each pair move apart slightly.	-Pairs of homologous chromosomes are now arranged on the metaphase plate, with one chromosome in each pair facing each pole. -Both chromatids of one homolog are attached to kinetochore microtubules from one pole; those of the other homolog are attached to microtubules from the opposite pole.	-Breakdown of proteins responsible for sister chromatid cohesion along chromatid arms allows homologs to separate. -The homologs move toward opposite poles , guided by the spindle apparatus. -Sister chromatid cohesion persists at the centromere, causing chromatids to move as a unit toward the same pole.	-At the beginning of telophase, each half of the cell has a complete haplod set of replicated chromosomes. Each chromosome is composed of two sister chromatids; one or both chromatids include regions of nonsister chromatid DNA. -Cytokinesis usually occurs simultaneously with telophase, forming two haploid daughter cells. -In animal cells, a cleavage furrow forms. In plant cells, a cell plate forms.

		-Each homologous pair has one or more chiasmata, points where crossing over has occurred and the homologs are still associated due to cohesion between sister chromatids. -Centrosome movement, spindle formation, and nuclear envelope breakdown occur as in mitosis. -in the late prophase, microtubules from one pole or the other attach to the two kinetochores, protein structures at the centrosomeres of the two homologs. The homologous pairs then move toward the metaphase			

		plate.			
Meiosis II		-A spindle apparatus forms. -Chromosomes, each still composed of two chromatids associated at the centromere, move toward the metaphase plate.	-The chromosomes are positioned on the metaphase plate as in mitosis. -Because of crossing over in meiosis I, the two sister chromatids of each chromosome are not genetically identical. -The kinetochores of sister chromatids are attached to microtubules extending from opposite poles.	-Breakdown of proteins holding the sister chromatids together at the centromere allows the chromatids to separate. The chromatids move toward opposite poles as individual chromosomes.	-Nuclei form, the chromosomes begin decondensing, and cytokinesis occurs. -The meiotic division of one parent cell produces four daughter cells, each with a haploid cells, each with a haploid set of unreplicated chromosomes. -Each of the four daughter cells is genetically distinct from the other daughter cells and from the parent cell.

2. Fill in the chart to summarize the major similarities and differences in the two types of cell division (mitosis vs. meiosis). For similarities, include the event(s) that always happen(s) at that stage, no matter which of the cell division cycles you're describing.

	Interphase	Prophase	Metaphase	Anaphase	Telophase
a. What similarities do you see?	- The cell grows by producing proteins and cytoplasmic	- The genetic material is replicated: each of its chromosom	- The kinetochores are attached to the centromere	- The chromatids are pulled apart towards the opposite	- The chromosomes arrive at the poles. -

	organelles.	es duplicates.	s. - The chromosomes become aligned.	ends by the shortening kinetochores.	Cytokinesis occurs, completing the creation of two daughter cells, in the case of meiosis. This process happens at the latter part of the telophase in the mitosis.
b. What differences do you see?	- Meiosis II consists of decoupling each chromosome's sister strands (chromatids), and segregating the individual chromatids into haploid daughter cells.	- Crossing-over occurs between homologous chromosomes in the Meiosis I.	- Homologous pairs align in the Meiosis I.	- In mitotis, the cell has succeeded in separating identical copies of the genetic material into two distinct populations. In meiosis, whole chromosomes are pulled toward opposing poles, forming two haploid sets. Each chromosome still contains a pair of sister chromatids.	- The chromosomes in the daughter cells created after the mitotic process have the same material as that in the parent cell. In meiosis, the resulting daughter cells are different from the parent cells due to the crossing-over.
c. If the amount of DNA in a somatic cell equals *C* during G1 of interphase, then how much DNA is present in the cell during each phase of mitosis and meiosis?					
Amount of DNA in:	Interphase	Prophase	Metaphase	Anaphase	Telophase

Mitosis	***C* in G1 2 *C* in G2**	***2C***	***2C***	***C***	***C***
Meiosis I	***C* in G1 2 *C* in G2**	***2C***	***2C***	***2C***	***2C***
Meiosis II	***C* in G1 *C* in G2**	***2C***	***2C***	***C***	***C***

3. How do the similarities in prophase of mitosis and meiosis compare with the similarities in telophase of mitosis and meiosis?

- The processes in the Telophase is basically the reverse of the Prophase stage. The only similarity is that the cells in both stages are in the busiest state. In the Prophase, the cell prepares a great deal in producing proteins, disintegrating the nucleus, etc. In the telophase, the cleavage formation occurs and cytokinesis commences .

4. At what stage(s) does/do most of the differences among mitosis, meiosis I, and meiosis II occur? Why do these differences exist?

- During prophase I in meiosis I, DNA is exchanged between homologous chromosomes in a process called homologous recombination, or crossing-over occurs between homologous chromosomes. The new combinations of DNA created during crossover are a significant source of genetic variation, and may result in beneficial new combinations of alleles. The main difference in the meiosis II is that the end result is production of four haploid cells.

CHAPTER 14

Mendel did not know anything about chromosomes, genes, or DNA. Because modern genetics uses vocabulary that assumes students today understand these ideas, it's helpful to review some key terms.

Match each commonly used genetics term with its appropriate definition or example.

Terms	**Definitions and Examples**
__heterozygous	a. Blue-eyed blonde mates with brown-eyed brunette
__homozygous	b. *BB* or *bb*
__monohybrid cross	c. not on sex chromosomes
__autosomal	d. blue or brown eyes
__genotype	e. *Bb*
__phenotype	f. locus on a chromosome that codes for a given polypeptide*
__gene	g. Blonde mates with brunette
__allele	h. *BB*, *Bb*, or *bb*
__dihybrid cross	i. Males have only one for each gene on the X chromosome

What genetic and chromosomal traits does your organism have?

1. Your individual is male/female (choose one). Females are XX and males are XY. For simplicity, assume that the individual is diploid with 2*n* _ 6, including the sex chromosomes. On one pair of autosomes (the nonsex chromosomes), the individual is heterozygous for hair color (*B* _ brown and dominant, *b* _ blonde and recessive). On another pair of autosomes, the organism is heterozygous for hair structure (*C* _ curly and dominant, *c* _ straight and recessive). Assume further that the individual's mother was homozygous dominant for both traits and the father was homozygous recessive for both.

a. Is your individual's hair curly or straight? Brown or blonde?

b. What did the individual's mother's hair look like? What did the father's hair look like?

c. What chromosomes and alleles were in the egg and the sperm that gave rise to your individual?

What are the products of meiosis?

2. From a single sex cell going through meiosis, how many daughter cells are produced?

3. For your model organism or individual (defined in question 1), how many different kinds of gametes can be produced from a single cell undergoing meiosis? (Assume no crossing over occurs.)

4. Your individual is heterozygous for two genes on separate pairs of homologous chromosomes. His/her genotype is *CcBb*. Given this information alone, how many different kinds of gametes could this individual produce? (Again. assume no crossing over occurs.)

What aspect(s) of meiosis account(s) for:

1. Mendel’s law of segregation?

2. Mendel’s law of independent assortment?

Basic Assumptions to Make When Solving Genetics Problems

1. Are the genes linked?

If the problem does not (a) indicate that the genes are linked or (b) ask whether the genes are (or could be) linked, then you should assume that the genes are not linked.

2. Are the genes sex-linked?

Similarly, if the problem does not (a) indicate that the genes are sex-linked (that is, on the X chromosome) or (b) ask whether the genes are (or could be) on the X chromosome (or Y chromosome), then you should assume that the genes are on autosomes and are not sex-linked.

3. Is there a lethal allele?

If a gene is lethal, then you should assume that the offspring that get the lethal allele (if dominant) or alleles (if homozygous recessive) do not appear; that is, they are not born, do not hatch, and so on. Therefore, they are not counted among the offspring. An obvious exception is lethal genes that have their effect late in life. If this is the case, however, it should be noted in the question.

4. Are the alleles dominant, recessive, or neither?

Unless the problem states otherwise, assume that capital letters (*BB*, for example) designate dominant alleles and lowercase letters (*bb*, for example) indicate recessive alleles. When there is codominance or incomplete dominance, the alleles are usually designated by the same capital letter and each one is given a superscript (for example, *CRCW* in Figure 14.10, page 272, of *Biology*, 8th edition).

5. How are genotypes written?

Assume a gene for fur color in hamsters is located on the number 1 pair of homologous autosomes. Brown fur (*B*) is dominant over white fur (*b*). The genotype for fur color can be designated in different ways:

a. The alleles can be shown associated with the number 1 chromosome. In this notation, an individual heterozygous for this gene is designated as |*B*|*b*.

b. Most commonly, this notation is simplified to *Bb*.
In problems that involve sex-linked genes, the chromosomes are always indicated—for example, X*A*X*a* and X*a*Y.

6. What information do you need to gather before trying to solve a genetics problem?

Before trying to solve any problem, answer these questions:

a. What information is provided? For example:

- What type of cross is it? Is it a monohybrid or dihybrid cross?
- Are the genes sex-linked or autosomal?
- Linked or unlinked?

b. What does the information provided tell you about the gene(s) in question? For example:

- What phenotypes can result?
- How many alleles does the gene have?
- Are the alleles of the gene dominant? Recessive? Codominant?

c. Does the question supply any information about the individuals' genotypes? If so, what information is provided?

- Grandparent information?
- Parental (P) information?
- Gamete possibilities?
- Offspring possibilities?

How can you determine all the possible types of gametes?

To solve genetics problems in which genotypes are given, you must first know what types of gametes each organism can produce.

1. How many different kinds of gametes can individuals with each of the following genotypes produce?

a. *AA*

b. *aa*

c. *Aa*

d. *AaBB*

e. *AaBb*

f. *AaBbCC*

g. *AaBbCc*

h. *AaBbCcDdEeFf*

2. Based on your answer in question 1, propose a general rule for determining the number of different gametes organisms like those described in question 1 can produce.

3. Two individuals have the genotypes *AaBbCcDd*.
a. How many different types of gametes can each produce?

b. What are these gametes?
