

## CONCEPT 2 – THE CELL CYCLE AND HEREDITY

### 1. Cell cycle

- a. Reason for division- as cells increase in volume, the surface area \_\_\_\_\_ and demand for material resources increases which limits cell size
- b. Smaller cells have a more favorable surface area-to-volume ratio for exchange of materials with the environment (diffusion, etc.). High SA:V ratio is favorable. Ex. 6:1 is better than 6:5
- c. Cell cycle switches between interphase and cell division.
- d. Interphase has three phases: \_\_\_\_\_ (G1), \_\_\_\_\_ of DNA (S) and preparation for \_\_\_\_\_ (G2).
- e. During mitosis duplicated chromosomes line up in center with spindle fibers attached to help pull them apart. Duplicated chromosomes are pulled apart by spindle fibers.
- f. Cytokinesis-division of cytoplasm and reformation of cell membrane. Animal cell- pinches in (cleavage) using microfilaments; plant cell- form cell plate reforms cell wall.
- g. The cell cycle is directed by internal controls or checkpoints. Internal ( \_\_\_\_\_ ) and external signals ( \_\_\_\_\_ ) provide stop and- go signs at the checkpoints. Ex. Mitosis-promoting factor (MPF)
- h. Cancer results from disruptions in cell cycle control (too much \_\_\_\_\_, defective tumor \_\_\_\_\_, overactive genes) which are a result of DNA damage to proto-oncogenes (regulatory genes) which make products like cyclins and cyclin-dependent kinases.
- i. Cells spend different amounts of time in interphase or division. Nondividing cells may exit the cell cycle; or hold at a particular stage in the cell cycle.
- j. Mitosis is used for \_\_\_\_\_ and \_\_\_\_\_ in animals; plants use mitosis to make gametes and for growth or repair.
- k. Mitosis usually begins with 1 cell, makes 2 identical cells or clones; \_\_\_\_\_ chromosome number;  $1n \rightarrow 1n$  or  $2n \rightarrow 2n$ .
- l. Meiosis (occurs after interphase) takes diploid cells and reduces the chromosome number to \_\_\_\_\_.  $2n \rightarrow 1n$ .
- m. During meiosis, \_\_\_\_\_ chromosomes are paired (one from mom and one from dad) and line up in the center of the cell randomly. The homologues are pulled apart and separated in meiosis I. A second division occurs in which the duplicated chromosomes are pulled apart.
- n. Variation occurs in gametes during “ \_\_\_\_\_,” and fertilization because of all possible combinations of homologous chromosomes aligning during metaphase I.

### 2. Mendel's Laws (remember he laid groundwork for genetics but these rules can all be broken looking at chromosome theory and molecular genetics)

- a. Law of \_\_\_\_\_ - one allele will be expressed over another (ex. Aa – if big A is purple it will be seen over little a which is white)
- b. Law of \_\_\_\_\_ - alleles pairs separate from each other during meiosis
- c. Law of Independent Assortment- alleles

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(i.e. AaBb can make gametes AB, Ab, aB or ab)

### 3. Probability, Patterns and Exceptions to Mendel's Rules

- a. product rule- multiply chance of one event happening by the chance of another event happening to get the chance of both events occurring together
- b. autosomal vs. sex-linked (on the X or Y chromosome)
- c. monohybrid cross; one trait; 3:1 (Aa x Aa); 1:1 (Aa x aa) or 4:1 (AA x \_), (aa x aa)
- d. dihybrid cross; 9:3:3:1 genotype (AaBb x AaBb) or test cross 1:1:1:1(AaBb x aabb)
- e. Thomas Hunt Morgan- fruit flies, X- linked traits
  - (1) male- heterozygous \_\_\_\_\_; Y chromosome is very small in mammals and fruit flies with few genes
  - (2) female- homozygous \_\_\_\_\_
  - (3) single gene mutations on X chromosome cause disease such as hemophilia or \_\_\_\_\_
  - (4) sex limited traits are dependent on sex of individual like milk production or male patterned baldness
- f. incomplete dominance- red X white → pink; both protein product are expressed and \_\_\_\_\_
- g. codominance- red x white → red and white; both protein products are \_\_\_\_\_  
ex. AB blood types
- h. epistasis- one gene affects expression of another
- i. linked genes- genes on same chromosome that are inherited together (can be unlinked by crossing over); recombination frequency calculated by recombinants/total; used for chromosome mapping; genes further apart cross over more often
- j. gene/environment- phenotypes affect by environment, Siamese cat, flower color with soil \_\_\_\_\_, seasonal color in arctic animals, human height and weight
- k. polygenic- continuous variation, many genes affect one trait- height, color

### 4. Human Genetics

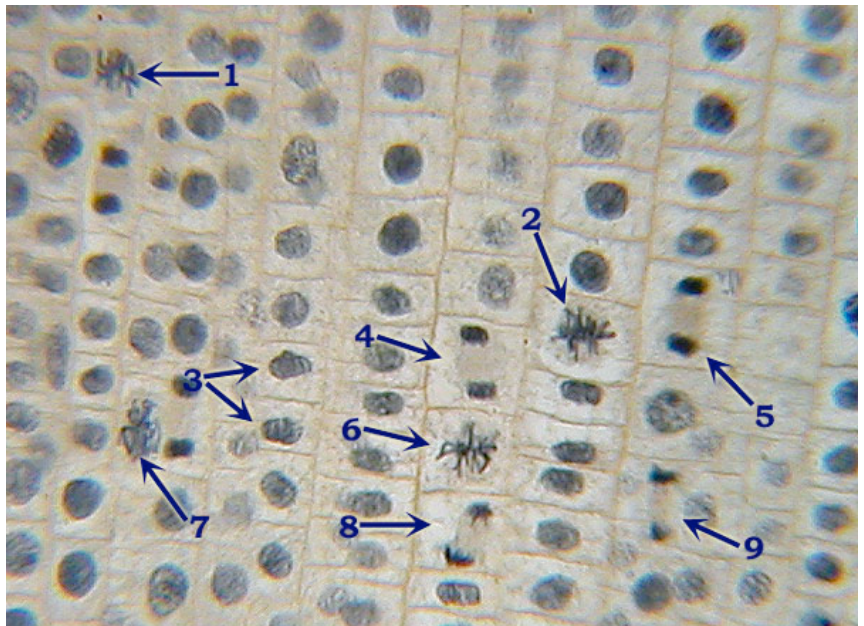
- a. karyotype- 22 pair autosomes & 1 pair sex chromosomes + 46 total chromosomes
- b. Chromosomal Mutations (occur during gamete formation)
  - (1) deletion, inversion, addition of genes as a result of crossing over mistakes
  - (2) chromosomal number abnormalities → \_\_\_\_\_ is failure of chromosomes to separate at anaphase of meiosis

### **Vocabulary**

anaphase	haploid (1N)	sex-linked
autosomal	heterozygous	somatic cell
cancer	homozygous	synapsis
cell cycle	incomplete dominance	synthesis
cell division	independent assortment	telophase
centrioles	homologous chromosomes	
chromosome	independent assortment	
codominance	interphase	
crossing over	meiosis	
crossover frequency	metaphase	
cyclin-dependent kinase	mitosis	
cytokinesis	nuclear division	
diploid (2N)	phenotype	
dominant	prophase	
F1/F2 Generation	recessive	
fertilization	recombination	
gamete	segregation	
genotype	sex chromosome	

## Thinking Practice

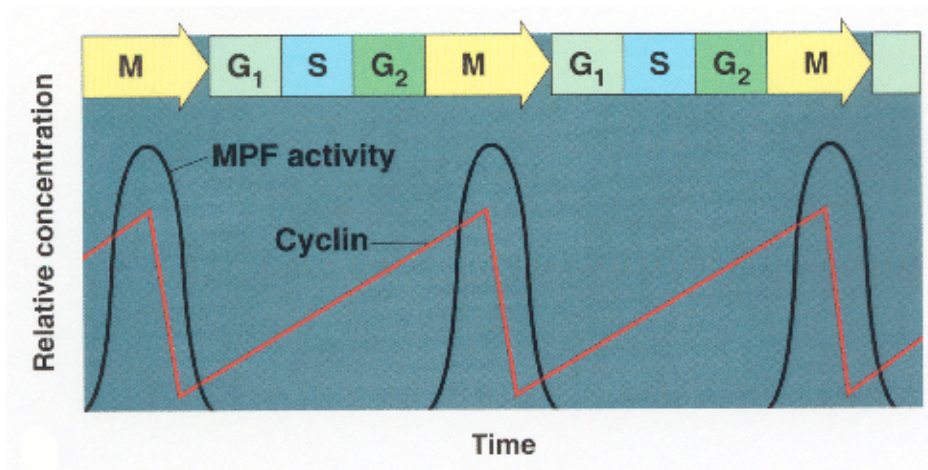
- Refer to the figure to the right.
  - What process is being shown in this picture?
  - What type of organism are these cells from? How do you know?
  - Identify a numbered cell for each of the four major stages of mitosis.
  - In what stage are most of the cells in this image? What does this indicate about the amount of time spent in each phase of the cell cycle?



- Paclitaxel is a chemotherapy drug used to treat a variety of cancers. Paclitaxel inhibits both assembly and disassembly of microtubules.
  - Which phase in the cell cycle is affected by Paclitaxel? How does this drug inhibit the growth of cancer?
  - Paclitaxel affects not only cancer cells, but normal cells as well. Would the effects of Paclitaxel be seen first in organs that have quickly dividing cells (like the intestine and hair follicles) or in organs that have slow or nondividing cells (like muscles and the nervous system). Justify your reasoning.

- Two students debate about proteins that regulate the cell cycle. One argues that MPF triggers the production of cyclin, while the other argues that cyclin triggers the production of MPF.

- Based on the figure to the right, which statement is correct and why?
- Propose a possible function of MPF, based on when it is produced in the cell cycle.



- You have performed a dihybrid cross of plants and got the following data: 206 purple tall, 65 white tall, 83 purple short, 30 white short. Perform a chi-square analysis to test the null hypothesis that purple coloring is dominant to white and tall height is dominant to short height.

5. A space probe discovers a planet inhabited by creatures that reproduce with the same hereditary patterns seen in humans. Three of the phenotypic characteristics of these creatures are: height, antennae, and nose morphology. Earth scientists were able to do some controlled breeding experiments with these organisms. 100 males and 100 females were used in the experiments and the results of a number of crosses are shown below. Review this information and use it answer the questions that follow.

**Cross I:** True-breeding (homozygous) tall creatures were crossed with true breeding short creatures. ALL of the F1 were tall. The F1 creatures were crossed and the following data was obtained.

F2 Phenotype	Male	Female
Tall	2575	2625
Short	1425	1375

**Cross II:** True breeding creatures WITH antennae are crossed with true-breeding creatures WITHOUT antennae. ALL of the F1 had antennae. The F1 creatures were crossed and the following data was obtained.

F2 Phenotype	Male	Female
WITH antennae	3125	3100
WITHOUT antennae	875	900

**Cross III:** Creatures that are true breeding for upturned snout are crossed with creatures with down turned snouts. ALL of the F1 offspring had upturned snouts. The F1 creatures were crossed and the following data was obtained.

F2 Phenotype	Male	Female
Upturned Snout	1750	3475
Down Turned snout	1750	0

**Cross IV:** True breeding tall, with antennae creatures were crossed with true breeding short, without antennae creatures. ALL of the F1 offspring were tall, with antennae. These F1 offspring were crossed with true breeding short, without antennae creatures. The F2 data is in the table below.

F2 Phenotype	Male	Female
Tall, WITH antennae	2360	2220
Tall, WITHOUT antennae	220	300
Short, WITH antennae	260	220
Short, WITHOUT antennae	2240	2180

CHOOSE 2 of the 3 below to answer!

- What conclusions can be drawn from cross I and II? Explain how the data supports your conclusions (Hint! You might need to do a chi square analysis to support conclusions!)
- What conclusions can be drawn from cross III? Explain how the data supports your conclusions (Hint! You might need to do a chi square analysis to support conclusions!)
- What conclusions can be drawn from cross IV? Explain how the data supports your conclusions (Hint! You might need to do a chi square analysis to support conclusions!)