Mitosis Notes AP Biology Mrs. Laux

I. Cell Cycle-includes interphase and mitosis (IPPMAT)
A. Interphase
1. accounts for 90% of the cycle
2. cell grows and copies its chromosomes in preparation for cell division
3. produces proteins and cytoplasmic organelles
4. Subphases
a. G_1 phase-first gap
-growth
b. S phase-synthesis of DNA
-only subphase where chromosomes are duplicated
-more growth
c. G_2 phase-second gap
-even more growth
5. single centromere duplicates forming two (each with a pair of centrioles in animal cells)
6. nucleus well defined-bounded by nuclear envelope
7. one or more nucleoli
B. Mitosis and Cytokinesis in Eukaryotic Cells
Phases (M Phase)
-cell division
-continuum of changes
1. Prophase
a. chromatin condenses to form visible chromosomes
1. chromatin has already duplicated during S phase of interphase; therefore, 2 copies of each chromosome
2. sister chromatids (identical) bound together at centromere-constricted region at specific point on chromosome
b. nucleoli disappear
c. mitotic spindle begins to form
1. centrosomes move away from each other

2. microtubules begin to extend from microtubule organizing center (MTOC)→elongating themselves by collecting tubulin units from cytoplasm

3. microtubules begin as asters (star-like projections) as they extend from MTOC

2. Prometaphase

a. nuclear envelope fragments

b. microtubules of spindle can now invade nuclear area and interact with chromosomes

c. bundles of microtubules extend from each pole toward middle of cell

d. each of 2 chromatids of chromosome now has specialized structure called kinetochore-part of centromere

→specialized protein structure that attaches microtubules to chromosomes

-each one pulls chromosome towards its pole (tug of war)

-when number of kinetochore microtubules attached to each chromosome is equal, exert pull on chromosomes

-causes stalemate→at this time, all chromosomes are lined up along equator of cell

-chromosomes begin jerky movements

-nonkinetochore microtubules interact with those from opposite pole of cell (these will lengthen cell)

→ beginning of metaphase

2. Metaphase

a. chromosomes lined up on metaphase plate (imaginary) -centromeres are directly on plate

b. chromosomes highly condensed→may be photographed for a karyotype

c. centrosomes now at opposite poles

d. for each chromosome, kinetochores of sister chromatids are attached to microtubules coming from opposite poles of cell

3. Anaphase

a. replication of centromeres allows spindle to pull sister chromatids apart

b. once they have own centromeres- considered full-fledged chromosomes

→ each has complete DNA molecule/protein needed for offspring

c. kinetochore microtubules still attached to kinetochores

→begin to shorten via depolymerization

1. lose tubulin monomers

2. microtubules shorten→pulling chromosomes apart

3. since microtubules are attached to centromeres, center of chromosome comes first

4. moves chromosomes to opposite sides of cell

d. during this time, nonkinetochore microtubules, which were overlapping, slide past each other

→causes cell to lengthen and pushes ends farther apart

1. energy using process→done by motor proteins

→actual movement largely unknown

e. end of anaphase, chromosomes (equivalent and complete) are found at opposite ends of elongating cell

4. Telophase

a. nonkinetochore microtubules continue to lengthen cell

b. nuclear envelope begins to reform

1. from material left over from parent cell (envelope)

2. from additional membrane from endomembrane system (ER, Golgi…)

c. nucleoli reappear

d. chromatin is reformed as chromosomes uncoil-mitosis complete

e. cytokinesis well underway

B. Cytokinesis

1. Animal cells

a. process→cleavage

b. microfilaments make a ring from plasma membrane towards center of cell

→actin

→contraction in muscle cells and cleavage

c. microfilaments shorten, causing cell to pinch in half→drawstring

→indent is called cleavage furrow

d. microfilaments pull plasma membrane inward until cell pinches in 2

→produces 2 separate daughter cells

2. Plant cells

a. no cleavage furrow

b. as cell elongates, vesicles from Golgi apparatus travel to midline (metaphase plate) of old parent cell to form cell membrane

→vesicles carry membrane pieces

c. vesicles move along microtubules

d. fuse together to form 2 separate plasma membranes

e. cell wall forms between them

*2 separate cells marks end of mitosis (M stage)→growth

C. Results of Mitosis

-2n→2n

→2n

-2 daughter cells are formed that are genetically identical to the parent

-each cell has original chromosome number

D. Factors that affect cell division: (Mitosis)

1. surface area-to-volume ratio

a. cell grows: increased volume much quicker than surface area

-volume expands in cubes-m^3

-surface area in squares-m^2

b. SA/V ratio high→cell can efficiently take in and expel materials

→ enough SA to bring in adequate amounts of material in sufficient time for use by the cell

c. SA/V ratio low

-not enough SA to efficiently take in and expel materials from cell in time

-alleviated by cell division

→ increases SA/V ratio

2. genome to volume ratio

a. genome in nucleus "controls" cell by producing enzymes and other substances that control reactions in cell

b. enzymes, etc. control cellular activities

c. genome is limited by its finite amount of genetic material

d. as volume of cell increases, the cell's size exceeds the ability of the genome to produce sufficient amounts of materials for regulating cellular activities

→therefore, cell must divide

3. Availability of a certain nutrient

→some cells

-ex: mammalian cells→growth factor

-ex: fibroblast (connective tissue, works during clotting) cells will not divide unless in the presence of Platelet Derived Growth Factor

→binding of PDGF on receptor sites stimulates mitosis

a. when cut occurs, platelets burst and release PDGF in area of injury

b. PDGF binds to fibroblasts, which begin cell division and help to heal the wound

→ why "clots" form and new skin forms over cut

-other ex:

a. various other protein growth factors

ex: HGH (human growth hormone)

ex: Cdk (cyclin-dependent protein kinase)

1. protein kinases add Pi groups to molecules→activate or inactivate other molecules

2. Cdk regulates cell cycle

-work when bound to protein cyclin (flux with cell cycle)

3. Phosphorylation of certain proteins activates or inactivates enzymes that control cell cycle

-can arrest cycle at some stage

4. anti-cancer medication uses similar proteins to halt active division of cancer cells

-also halts active division of other usually dividing cells-in digestive tract, hair

-causes side effects

b. colchicines→drug that blocks cell division in eukaryotes

-binds to unpolymerized tubulin units, prevents elongation of microtubules

c. cytokinins-plant hormones that stimulate mitosis

d. genes that cause cell division are oncogenes

-when activated abnormally-may cause cancer

4. Density→plays a key role in cell division

→density dependent inhibition

a. many cells will stop dividing once the surrounding cell density reaches a maximum

b. growing and dividing cells compete for nutrients and growth regulators

c. at certain density→amount of these substances is insufficient to allow continued growth

→normal cells stop

→cancer cells do not exhibit density dependent inhibition

5. Many types of cells stop dividing once matured
    -ex: nerve cells, muscle, RBCs
    a. cell division ceases during G1 phase
    →restriction point
    →just before DNA synthesis would have occurred
    b. cell stops dividing→in G0 phase
        1. nerve, muscle cells will never reenter dividing cycle
        2. most human cells are in G0
            -these have ability to divide again if environment favors, like liver
            -ex: HGH
                PDGF (repair of tissue)
                -cell will reenter at S phase