AP BIOLOGY
CELL UNIT
ACTIVITY#6

NAME_____
DATE_____**HOUR**_____

GENETICS & DEVELOPMENT - Cell Division

Physical Basis of Inheritability...

Mechanisms of Cell Reproduction... egg & sperm cells

cells reproduce identically, yet with variations (new traits)

"All living cells arise from pre-existing cells"

GENETICS asks.... HOW? mechanisms at cellular & molecular level

DEVELOPMENT looks.... at the LIFE CYCLE of organisms

1. Reproduction mechanisms of organisms
2. Growth of organism..... zygote to adult

cell differentiation - how one cell becomes different from another

differential gene activity - genes are active at different times

totipotency & cloning - exact genetic copies of cells

METHODS of CELL REPRODUCTION include...

Fission - binary = 2 equal halves (bacteria & cyanobacteria & protozoans)

Budding - outgrowths detach = new organism (unequal split)

(hydra)

Mitosis - asexually = identical genetic copies [cytokinesis]

genetically equal somatic cells

Meiosis - sexually produces sperm & egg cells with

1/2 chromosome # & new gene combos

Mitosis - Asexual Reproduction Cell Cycle...

results in copying & equal duplication of parental cell's DNA

and the equal division of chromosomes into two daughter cells

(rates = liver cells 1x/yr - epithelial cells 1x/day)

the Life cycle of a Cell... is referred to as the "**CELL CYCLE**"...

G_1 = growth and preparation of the chromosomes for replication;

S = synthesis of DNA and duplication of the centrosome;

G_2 = preparation for

M = mitosis.

When a cell is in any phase of the cell cycle other than mitosis, it is often said to be in **interphase**.

[3 Stages] - Cell Cycle is depicted as a circle 360° [G1 - S - G2 - M]

Interphase - period between successive divisions of a cell

3 parts = G1 - before, DNA synthesis (S), & G2 period after

MITOSIS - nuclear division phase; separation & duplication of chromosomes

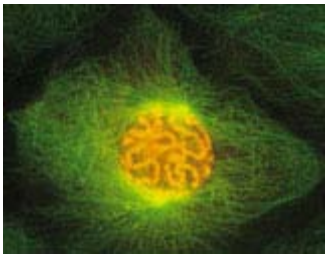
Cytokinesis - physical division of cell into two parts: animals/plants

Prophase - chromatin condenses into chromosomes	
Prometaphase - chromosome MicroTubule's attach to kinetochores each homolog has 2 chromatids	
Metaphase - chromosomes align at equator homologs align independently of each other	
Anaphase - MT attached to kinetochore; chromatids are pulled apart & poles move apart	
Telophase - chromosomes at opposite poles; daughter cells form by cytokinesis	

Names and Numbers -

Chromosomes

Genes occur in chromatin of nucleus, which condense into CHROMOSOMES (colored bodies) visible only during MITOSIS



bacteria have about 3,000 genes & 1 chromosome **(DNA molecule)**

humans have some 20 to 25,000+ genes & 46 chromosomes

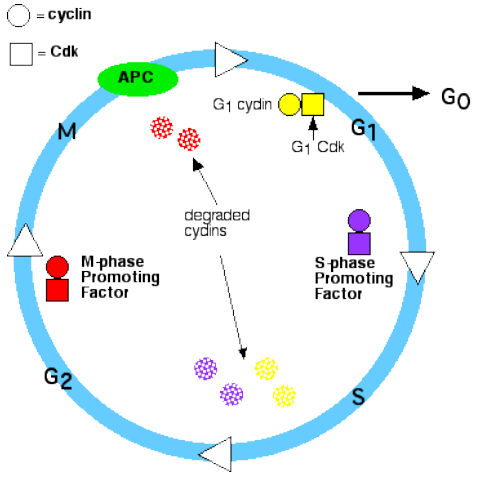
Humans have **46** chromosomes or **23 HOMOLOGOUS pairs**

23 maternal chromosomes

23 paternal chromosomes

Control of Cell Division and the Cell Cycle

Regulated by "Growth Factors" - proteins that promote cell division
Their levels in the cell rise and fall with the stages of the cell cycle.



- **Cyclins**
  - a **G_1 cyclins** (D cyclins)
  - **S-phase cyclins** (cyclins E and A)
  - **mitotic cyclins** (B cyclins)
- **Cyclin-dependent kinases (Cdks)**
  - a **G_1 Cdk** (Cdk4)
  - an **S-phase Cdk** (Cdk2)
  - an **M-phase Cdk** (Cdk1)

MPF - mitotic promoting factor... [complex of two proteins cdk + cyclin]
MPF is a kinase enzyme, one that switches on/off target cell cycle proteins by phosphorylating them.....

inactive cycle protein → active-protein-P

ATP → ADP

MPF promotes entrance into mitosis from the G2 phase by phosphorylating multiple proteins during mitosis including one that leads to destruction of cyclin itself

cdk - a cell division control protein - cyclin dependent kinase; active only when bound to cyclin;

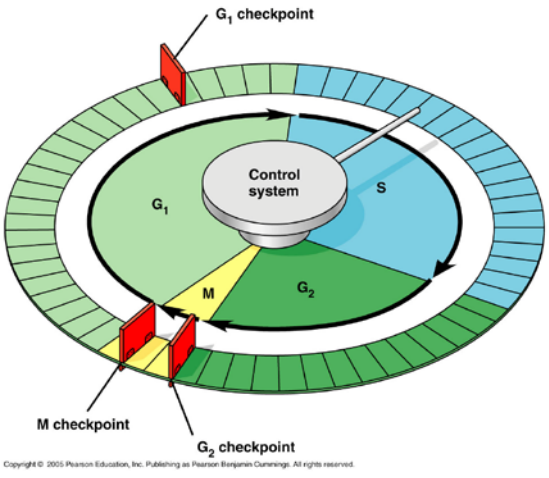
cyclin - a protein whose amount varies cyclically; when in high concentrations, binds to cdk makes MPF...

[cyclin + cdk = MPF]... favors Mitosis

Checkpoints: Quality Control of the Cell Cycle

The cell has several systems for interrupting the cell cycle if something goes wrong.

- **DNA damage** checkpoints. These sense DNA damage both before the cell enters S phase (a G_1 checkpoint) as well as after S phase (a G_2 checkpoint).
  - Damage to DNA before the cell enters S phase inhibits the action of Cdk2 thus stopping the progression of the cell



cycle until the damage can be repaired. If the damage is so severe that it cannot be repaired, the cell self-destructs by apoptosis.
    - Damage to DNA after S phase (the G_2 checkpoint), inhibits the action of Cdk1 thus preventing the cell from proceeding from G_2 to mitosis.
- **A check on the successful replication** of DNA during S phase. If replication stops at any point on the DNA, progress through the cell cycle is halted until the problem is solved.
- **Spindle checkpoints**. Some of these that have been discovered
    - detect any failure of spindle fibers to attach to **kinetochores** and arrest the cell in **metaphase** until all the kinetochores are attached correctly (M checkpoint)
    - detect improper alignment of the spindle itself and block cytokinesis;

SEXUAL CELL REPRODUCTION... "MEIOSIS"
nuclear division phase of sexually dividing cells

The physical differences between nuclear divisions of MEIOSIS & MITOSIS
so the Distinct Differences are:

meiosis = 4 progeny cells [1 = 2 = 4]... thus 2 divisions
mitosis = 2 daughter cells only... thus 1 cell division
meiosis = one-half number of chromosomes
mitosis = same # of chromosomes as parent cell
meiosis = new combinations of genes not in parents & chromosomes sort randomly of each other
mitosis = daughter cells are genetically identical

Sexual Cell Reproduction (Meiosis)

Where does meiosis occur during sexual cell cycle?

Meiosis → produces cells half chrm # = 23 (sperm & egg - haploid)
only specialized cells - gametes - can undergo meiosis.
Fertilization (sperm + egg) → diploid life cycle (chrm # = 46)
Alternation of Generations & Human life Cycle

Stages of Sexual Cell Division

same 3 phases... just as in asexual division
(Interphase, Nuclear Division, Cytokinesis)
but, 2 Divisions Meiosis I and Meiosis II
1 cell = 2 cell = 4 cells

Names of stages are same & have analogous functions

Meiosis I...

Prophase I = chromosomes condense
SYNAPSIS - homologs PAIR together = tetrad
CROSSOVER - exchange occurs at a chiasma

Metaphase I = chromosomes align at equator

Anaphase I = chromosomes migrate toward poles

Telophase I = chromosome at poles - cell domains separate

Meiosis I separates homologs of homologous pair

Meiosis II... is just like mitosis [but without an S phase]
separates chromatids of one homolog of the homologous pair
just as is done in mitosis

Independent Assortment - random alignment of homologous pairs

Crossing Over - exchange of chromosome material

Summary of MEIOSIS

1. Nuclear division phase of sexual cell reproduction
2. Two successive divisions, results in 4 daughter cells...
   Meiosis 1 and Meiosis 2
3. Reduction/division occurs.... diploid → haploid
   daughter cells $\frac{1}{2}$ number of parent cell chromosomes
4. Stages have same nomenclature as Mitosis
   prophase, metaphase, anaphase, telophase, M1 & M2
5. Only one S phase, where DNA is duplicated
   often may be no interphase between M1 & M2
6. Homologs separate in Meiosis 1
   Chromatids separate in Meiosis 2 (mitotic-like)
7. Random Assortment occurs..... homologs align
   at equitorial plates independent of each other
8. Crossing over... may occur in Prophase I...
   synapsis = close pairing homologs allows exchange
   chiasma = point exchange of sister chromatids