GENETICS & DEVELOPMENT

Physical Basis of Inheritability - Cell Division

Cell Reproduction

- cells reproduce identically, yet with variation (new traits)
  "All living cells arise from pre-existing cells"

Genetics asks
- how at cellular & molecular level

Development reveals – the life cycle of organisms

1. gametic cells divide ---> egg & sperm cells
2. reproduction mechanisms of organisms - fertilization
3. growth of organism..... zygote to adult
   - cell differentiation
   - differential gene activity
   - totipotency & cloning

METHODS of CELL REPRODUCTION

- Fission - binary = 2 equal halves (bacteria)
- Budding - outgrowths detach = new organism
- Asexual - Mitosis = identical cell copies
- Sexual - Meiosis = produces sperm & egg
Asexual Cell Division...
duplication of DNA & division of chromosomes
(liver cells - 1x/yr  vs. epithelial cells - 1x/day)

CELL CYCLE - Life Cycle of a Cell........[ 3 Stages ]

Interphase - between successive divisions (3 parts)
  G1, before DNA synthesis (S), & G2 period after
Cytokinesis - physical division of cell into two parts
Nucelar Division Phase – MITOSIS

Stages of Mitosis
  Interphase   - DNA (chromatin) duplicates
  Prophase     - chromatin condenses
each homolog has 2 chromatids
  Metaphase    - chromosome align at equator
  Anaphase     - MT attach to kientochore
  Telophase    - chromosome decondense

time determination of stages done by Pulse-Chase exp
Chromosomes

*bacteria* = 3,000 genes  
- 1 chromosome  
*human* = 25,000 genes (?)  
- 46 chromosomes

Genes occur in *chromatin* of nucleus, which condense into *CHROMOSOMES* at time of cell reproduction

Human:  
has 46 chromosomes,  
23 HOMOLOGOUS pairs

in mitotic division:  
each homolog  
has 2 chromatids  
which separate into 2 cells
Control of Cell Division & Cell Cycle 2001 Nobel prize

Regulated by "Growth Factors" -
  proteins that promote cell division
  MPF - mitotic promoting factor...
    a protein complex* of cdk + cyclin
  MPF is a kinase enzyme, ones that switches on/off
    target proteins by phosphorylating them...
    inactive  ----------------> active-P
    ATP ----> ADP

  MPF - promotes mitosis by phosphorylating other proteins
    including ones that leads to destruction of cyclin itself

  cdk - another cell division control protein...
    - a 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

Cell Division is also regulated via critical CHECK POINTS...
  1. G1 checkpoint - cell size adequate, polymerases
  2. G2 Checkpoint - chromosome replication successful
  3. metaphase checkpoint - chromosome attached to
     spindle fibers
SEXUAL CELL REPRODUCTION - meiosis

Where does meiosis occur in sexual cell reproduction:
- haploid gametes --> fertilization --> diploid (chrm # = 46)
- meiosis -------> haploid gametes (half chrm # = 23)

Stages of Sexual Cell Division
are same as asexual (interphase, cytokinesis, nuclear)
but, 2 Divisions → Meiosis I & Meiosis II 1 = 2 = 4 cells

Names of stages are same & have analogous functions
- **Prohase I** = chromosomes condense
- **Metaphase I** = chromosomes align at equator
  homologs PAIR together - *synapsis*
crossover exchange at *chiasmata*
- **Anaphase I** = chromosomes migrate toward poles
- **Telophase I** = chromosome at poles

- **Meiosis I** ---> separated homologs of homologous pair
- **Meiosis II** is just like mitosis ---> separates chromatids of one homolog of a homologous pair

3/14/2007 Bil 150 - Cell Division
Comparison of Mitosis/Meiosis

**mitosis** – separates chromatids

**meiosis** – separates homologs, then chromatids

**Independent Assortment** - random alignment homologs

**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....
4. cells halve the number of parent cell chromosomes
e   - diploid ---- > haploid
5. **Stages have same nomenclature** as Mitosis
   - prophase, metaphase, anaphase, telophase, 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 of homologs to allow exchange
   - **chiasmata** = points of exchange of sister chromatids

**Consequence of sex**... new gene/chromosome combos that did not exist in either parent, which will become the stuff of evolution