Chapter 5: Cell Growth and Division
Background Info

- Formation of New Cells
  - ~2 trillion cells formed/day in human body
  - ~25 million cells/second

- Cell division = cell reproduction
  - DNA must be copied before a cell divides
Types of Cell Division

- Prokaryotic
- Eukaryotic
- Gamete Formation
Prokaryotic Cells

- No nucleus or membrane-bound organelles
  - Ex: bacteria
- Reproduce by **binary fission**
Binary Fission

- Asexual
- Produces **identical** offspring
  - clones

- Two Stages:
  - DNA is copied
  - Cell divides
Eukaryotic Cells

- Have: nucleus and membrane-bound organelles
- Ex: You!
5.1 The Cell Cycle
The Cell Cycle

- Repeating sequence of:
  - Growth
  - DNA duplication
  - Division
4 Main Stages

- Gap 1 (G₁)
- Synthesis (S)
- Gap 2 (G₂)
- Mitosis (M)
Interphase

- Normal appearance
- Once called “resting” stage
- Includes G$_1$, S, and G$_2$
Interphase

- Longest stage
- \( \sim 90\% \) of cell’s time
Gap 1 (Stage 1)

- Normal function
- Increase in size
- Replicate organelles
- Lots of time spent here
  - Varies by cell
G₁ Checkpoint

- At end of stage
- Checks for
  - Proper nutrition
  - Size
  - DNA damage
Synthesis (Stage 2)

- “combining of parts to make a whole”
- DNA copied
  - Hardly visible
- By end of stage: two copies of DNA
  - 2 chromatids attached at centromere
Gap 2 (Stage 3)

- More growth!
- Getting ready for nuclear division
- Normal cell functions
$G_2$ Checkpoint

- End of $G_2$
- Checks:
  - Cell big enough?
  - DNA okay?
- If okay – bring on Mitosis!
Stage 4

- Includes Mitosis and Cytokinesis
Mitosis (M)

- Nucleus is divided into two
  - Same # chromosomes in each new nucleus
Mitosis Checkpoint

- Triggers exit from mitosis
- Signals beginning of $G_1$
Cytokinesis

- “Cyto” = cell
- “Kinesis” = motion
- Overlaps mitosis
  - Begins during telophase
- Divides cytoplasm
- 2 daughter cells
  - Genetically identical
  - [Cell Cycle video 5 min](#)
Control of Cell Cycle

- Checkpoints
  - Controlled by proteins

- Thinker:
  - What might happen if the $G_1$ checkpoint stopped working?
    - Wrong size, damaged DNA, fail to divide
Control of Cell Cycle

- 3 Checkpoints:
  - Cell growth checkpoint
  - DNA synthesis checkpoint
  - Mitosis
Genes

- Code for protein production
  - Regulate cell growth and reproduction

- **If gene is mutated**
  - Protein does not function
  - Disrupts the cell cycle
Division Rate

- Linked to need
- Interphase – usually ~12 hours in humans
- Longer in adults
Division Rate

- Varies by cell
  - Skin – 2 weeks
  - RBC – 4 months
  - Liver – 300-500 days
  - Intestine (internal lining)
    - 4-5 days
  - Intestine (muscle and other tissues)
    - 16 years
$G_0$

- Cells that divide rarely stay in this stage
- Perform normal functions
- Ex:
  - Neurons – may remain permanently
  - Lymphocytes – remain for years until needed to fight an invader
Cell Size

- Very small!
- ~50 human cells fit on dot of “i"
- Some exceptions:
  - Chicken Eggs
  - Some nerve cells
Limits of Cell Size

- Must be:
  - Big enough to house organelles
  - Small enough to move nutrients and wastes efficiently
Surface Area to Volume Ratio

- Materials must move through cell efficiently
- Better ratio when cell is small
  - More efficient
- See p. 129
5.2 Chromosomes

- In nucleus
- Rod shaped
- DNA coiled up
  - short and thick
- Visible during cell division
Chromatin

- DNA uncoiled
  - long and thin
  - “spaghetti” stage
Chromosome Structure
Chromosome Structure

- Consist of:
  - Two sister chromatids
    - Identical DNA molecules
  - Centromere
    - Connects chromatids
Chromosome Structure

- **Histones** – group of proteins that DNA wraps around to become a chromosome
  - Helps compact DNA
  - Chromatin winds around and becomes a chromosome
Chromosome Structure

- **Telomeres** – ends of DNA molecules
  - Repeating nucleotides
  - Do NOT form genes
  - Prevents chromosomes from attaching to each other
Genes

- Segments of DNA
- Code for protein
- Code for a trait
Cell Division and Chromosomes

- Chromosomes are moved with help of **Spindles**
Spindles (Fibers)

- Made of:
  - Centrioles
  - Microtubule fibers

- Plant and animal cells have
Spindles

- Form when centrioles move apart (during prophase)
- Attach pole to pole OR attach to centromeres
- Spindle fibers shorten
  - Reel in the separated chromatids
Centrosomes

- Made of 2 centrioles
- Located at poles
- Help make spindles
- Only in animal cells
Centrioles

- Made of microtubules
  - Nine triplets arranged in a circle
Mitosis

- Divides nucleus
- Continuous
- 4 stages:
  - 1) Prophase
  - 2) Metaphase
  - 3) Anaphase
  - 4) Telophase
1) Prophase

- Chromatin coils and becomes visible
- Nuclear membrane dissolves
- Spindles form
- “Spaghetti” appearance
2) Metaphase

- Chromosomes line up at equator
- Spindles link chromatids to cell poles
3) Anaphase

- Centromeres divide
- Sister chromatids separate
  - Spindle fibers shorten
  - Move toward opposite poles
4) Telophase

- Opposite of prophase
  - Nuclear membrane reappears
  - Chromosomes disappear by uncoiling
  - Spindles dissolve
Cytokinesis

- Starts during telophase
- Cytoplasm is divided

- End result of mitosis and cytokinesis:
  - 2 genetically identical cells
Mitosis
Cytokinesis in Animal Cells

- No cell wall = Flexible
- Belt of protein tightens
  - Cell pinches in half
Cytokinesis in Plant Cells

- Cell wall
  - Vesicles fuse and form **cell plate**
  - New cell wall forms
  - Cell separates into 2
Identification of Mitosis Phases
Mitosis in Onion Root Tip Cells
5.3 Regulation

- **External Factors**
  - Come from outside the cell
  - Can be physical
    - Cells bump into each other and stop growing
  - Can be chemical
    - Ex: **Growth factors** – proteins that stimulate cell division
Regulation

- **Internal factors**
  - Come from inside the cell
  - Help control cell cycle with proteins
Apoptosis

- Programmed cell death
- Dead cells are recycled
- Ex: webbed fingers and toes prior to birth
Cancer

- Uncontrolled cell growth
  - Cells do not respond to control mechanisms

- Caused by mutations
  - Errors in genes
  - Ex: Oncogenes — accelerate cell cycle
Cancer

- **Metastasize** – cells spread to other areas
  - Forms tumor
Cancer

- **Tumors:**
  - **Benign** – cells typically remained clumped together
  - Usually can be removed
  - **malignant** – cells move to other parts of body
  - More difficult to get rid of
Cancer

Some caused by:
- UV radiation
- **Carcinogens** – Chemicals that promote cancer development
  - Ex:
    - Tobacco smoke
    - Air pollutants
- Inherited genes??
  - Ex: breast cancer??
- Viruses
  - Ex: cervical cancer
Cancer

- Cells do **not** do required jobs
- Require lots of food and oxygen
- Can exert pressure on surrounding organs
Cancer Treatment

- **Radiation therapy**
  - Uses radiation
  - Kills cells and shrinks tumors
  - Damages DNA so cells cannot divide
  - Usually *localized*
  - Can still hurt healthy cells
Cancer Treatment

- **Chemotherapy**
  - Uses drugs
  - Kills actively dividing cells
  - Kills some healthy cells too
  - Travels thru *entire body*

- Often both treatments are used
Cancer Research

- Grow cancer in labs
- HeLa Cells
  - Most famous cancer cells
  - From Henrietta Lacks
    - 1951
    - cervical tumor
  - Still growing . . .
  - Controversial
- HeLa News 2013 2:45
5.4 Asexual Reproduction

- Requires one parent
- No gametes
- Genetically identical offspring
Asexual Reproduction

- **Advantages:**
  - Great in stable environments
  - High numbers
  - Energy efficient
  - Don’t have to attract mate

- **Disadvantages:**
  - Bad if unstable conditions
  - No genetic diversity
Binary Fission

- Asexual
- Used by prokaryotes
- No spindle fibers
- Less DNA
  - Usually one circular chromosome
- 2 stages:
  - DNA copied
  - Cytokinesis
Mitosis

- Asexual
  - 3 forms:
    - 1) Budding
    - 2) Fragmentation
    - 3) Vegetative reproduction

Asexual Reproduction song 3:40
1) Budding

- Bud grows on parent
- May stay on parent or break off
- Ex: hydra
2) Fragmentation

- Parent splits into pieces
- Each grows into adult
- Ex:
  - Seastars
  - Flatworms
3) Vegetative

- Modification of stem or underground structure of parent

- Ex:
  - Strawberries
  - Potatoes
Reproduction

- Some organisms can do both

What is the benefit?
5.5 Multicellular Life

- Review:
- Cellular organization
  - Cells
  - Tissues
  - Organs
  - Organ systems
  - Organism
Cell differentiation

- Process
  - cells develop specific form and function
- Only certain genes are used in each cell
- Location within embryo helps determine
Stem Cells

- Unique body cell

- Can:
  - 1) Divide and live a long time
  - 2) Remain undifferentiated
  - 3) Develop into variety of cells

Stem Cells 4:30

- See chart p. 146 for types
Adult Stem Cells

- Partially undifferentiated
- All over body
- Also found in children
- “somatic stem cells”
Adult Stem Cells

- **Advantage:**
  - Can take from patient, grow in lab, and put back in patient

- **Disadvantages:**
  - Very few
  - Difficult to isolate
  - Tricky to grow
  - DNA abnormalities
Embryonic Stem Cells

- Result from embryos grown in lab
- Donated
- Taken at 3-5 days from embryo
Embryonic Stem Cells

- **Advantages:**
  - Undifferentiated
    - Can form any type of cell

- **Disadvantages:**
  - May be rejected
    - "foreign" material to recipient
  - Could grow as a tumor
  - Ethical questions
    - Embryo is destroyed
Stem Cell Research

- Used now to treat some cancer patients
- May be used to treat damaged organs
- May be used to test new drugs

What do you think we should do??????