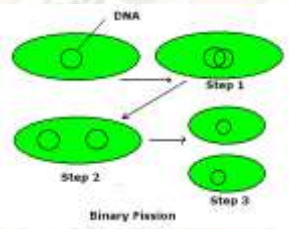
Cell Division

Binary Fission, Mitosis & Meiosis

Prokaryotes: Binary Fission

- Most cells reproduce through some sort of **Cell Division**
- Prokaryotic cells divide through a simple form of division called **Binary Fission**
- 3 step process
- Single "naked" strand splits and forms a duplicate of itself.
- The two copies move to opposite sides of the cell
- Cell "pinches" into two new and identical cells called "**daughter cells**". (Cell wall then forms if applicable)
- **BUDDING** is another form of asexual reproduction that forms a mother and daughter cell with the daughter cell being smaller



Eukaryotes: Mitosis

- Eukaryotes divide by a more complicated system called **Mitosis**
- This is because:
  1. They have a nucleus which must be broken up and then reformed
  2. They have their DNA "packaged" in the form of **Chromosomes**
  3. Chromosomes are composed of **Chromatin**
     1. Made of DNA Strands & Proteins
  4. They usually have more than 1 chromosome (Humans have 23 pairs)
  5. They have numerous organelles to equally share

Why divide?

- Growth

Reminder!

  - Surface area to volume ratio keeps cells small
- Repair
- Replacement

DNA

- *Macromolecule that contains the genetic instructions used in the development and function of the cell*
- *Three parts:*
  - *Sugar (deoxyribose)*
  - *Phosphate*
  - *Nitrogenous base*

DNA And Chromosomes

- An average eukaryotic cell has about 1,000 times more DNA then an average prokaryotic cell.
- The DNA in a eukaryotic cell is organized into several linear chromosomes, whose organization is much more complex than the single, circular DNA molecule in a prokaryotic cell

Chromosomes

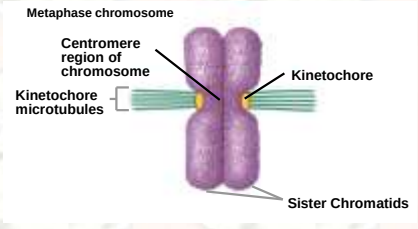
- Non-homologous chromosomes
  - Look different
  - Control different traits
- Sex chromosomes
  - Are distinct from each other in their characteristics
  - Are represented as X and Y
  - Determine the sex of the individual, XX being female, XY being male
- In a diploid cell, the chromosomes occur in pairs. The 2 members of each pair are called homologous chromosomes or homologues.

Homologues

- **Homologous chromosomes:**
  - **Look the same**
  - **Control the same traits**
  - **May code for different forms of each trait**
  - **Independent origin - each one was inherited from a different parent**

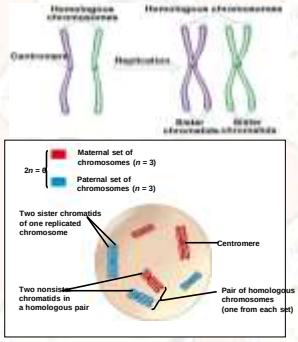
Structure of Chromosomes

- The ***centromere*** is where sister chromatids are attached to each other
- ***Kinetochores*** help move chromosomes during cell division by attaching the ***spindle apparatus*** to the centromeres
- The ***spindle apparatus*** is formed during mitosis and move sister chromatids during mitosis—the spindle apparatus includes the ***spindle*** and ***asters***

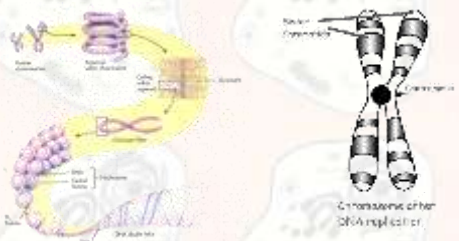


Structure of Chromosomes

- Diploid - A cell possessing two copies of each chromosome (human body cells).
  - Homologous chromosomes are made up of sister chromatids joined at the centromere.
  - A human has 46 chromosomes (2n = 46)
- Haploid - A cell possessing a single copy of each chromosome (human sex cells).



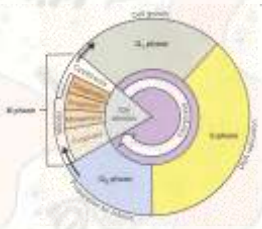
Chromatin / Chromosomes



The Cell Cycle

•Most of the cell's life is spent doing its regular function.
•Cells divide along a rough time frame called its **Cell Cycle**.
•The Cell cycle consists of the following steps:
•Interphase
- **•G1 (Gap 1)** Phase - Cell performs its normal function (cells which do not divide stay in this stage for their entire life span)
- **•S (Synthesis) Phase** - Here the cell actively duplicates its DNA in preparation for division
- **•G2 (Gap 2) Phase** - Amount of cytoplasm (including organelles) increases in preparation for division.

•Mitosis - Actual division occurs



Interphase

- Cell Replicates its DNA/Chromosomes in preparation of upcoming division

Animal Cell

Plant cell

Prophase

1. **Chromosomes** Shorten and become visible.
2. **Centrioles** move to opposite sides of the cell
3. Nuclear envelope disappears
4. **Spindle Fibers & Astral Fibers** both together are known as the **Spindle Apparatus** begin to form

Animal Cell

Plant Cell

Metaphase

- Chromosomes line up along center of cell called the **Metaphase Plate**
- Chromosomes attach to spindle fibers
- Spindle & Astral fibers are now clearly visible

Animal Cell

Plant Cell

Anaphase

- **Centromeres** break up separating chromosome copies
- Chromosomes are pulled apart to opposite sides of cell
- Spindle & Astral fibers begin to break down

Animal Cell

Plant Cell

Telophase (cytokenesis)

- Nuclear envelope forms around both sets of chromosomes
- DNA uncoils
- Spindle & Astral fibers completely disappear
  - **Cytokenesis** happens with most (but not all) cells
  - Cytoplasm & organelles move (mostly equally) to either side of the cell.Cell Membrane "pinches" to form 2 separate cells

Animal Cell

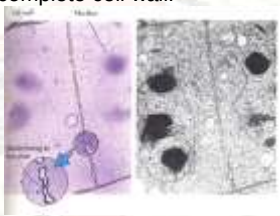
Plant Cell

Animal Cytokeneisis

- Cytokenesis differs significantly between Animal & Plant cells.
- With animals, the membranes pinch together to form a **Cleavage Furrow**, which eventually fuses to form two daughter cells

Plant Cytokenesis

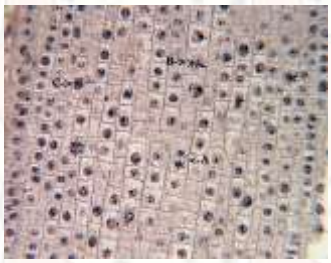
- With Plants, a cell wall must be formed between the 2 daughter cells.
- **Vessicles** containing Cellulose form and fuse between the tow daughter cells, eventually forming a complete cell wall.



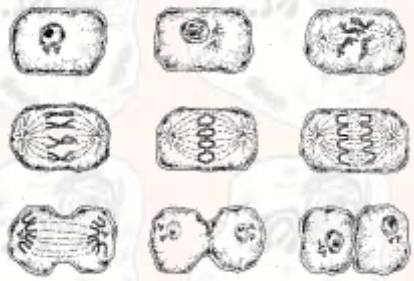
Mitosis Activity

The roots of most plants are significant active sites of mitosis.

Onion root tip:



Overview of Mitosis



Control of the Cell Cycle "Cancer"

Do you know anyone with Cancer? You most likely do…

Based on rates from 2006-2008, 41.21% of men and women born today will be diagnosed with cancer of all sites at some time during their lifetime. This number can also be expressed as 1 in 2 men and women will be diagnosed with cancer of all sites during their lifetime.
http://seer.cancer.gov/statfacts/html/all.html

"Normal" Cell Cycle

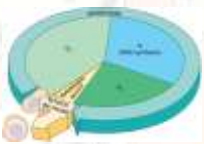
- Interphase

  Longest phase of the cell cycle.

  Normal growth and maintenance occurs
- Mitosis (Cell Division)

  Prophase- Metaphase-Anaphase-Telophase

  During this time cells make copies of themselves.



How do cells make copies of themselves?

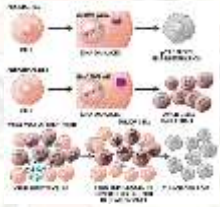
- Special proteins known as *cyclins* control the cell cycle.
- For added control, these cyclins need help from specific enzymes to regulate when, where and how many times cells are copies.

- If there are
  - NOT enough enzymes
  - TOO many enzymes
  - Enzymes attach at the WRONG TIME…

THE CYCLE LOSES CONTROL

CANCER= UNCONTROLLED CELL GROWTH

Mitosis occurs over and over….



Causes of uncontrolled cellular growth..

- Segments of DNA, called genes control the production of protein and enzymes.
- Disruption of these genes can cause uncontrolled cellular division or cancer.
- Environmental conditions (ex: sun) and your own genes (ex: family history) can cause changes within the cell.

Damaged "Jeans"

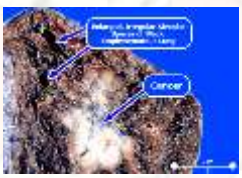
Key Words

- Malignant- Cancerous cell
- Tumor- Mass of cancerous cells/tissue
- Metastasis- Spreading of cancerous cells to other organs by the circulatory system.
- Stage I-IV- Stages of Cancer. Later stages are more advanced and often harder to treat.
- Carcinogens- Cancer causing agents.

Use your Key Words

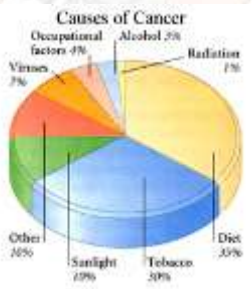
Metastasis

Malignant Tumor



Potential Causes of Cancer

- Difficult to distinguish exact causes…
- Cigarette smoke
- Polluted air and water
- Exposure to Ultraviolet rays (UVA)
- Viral infections



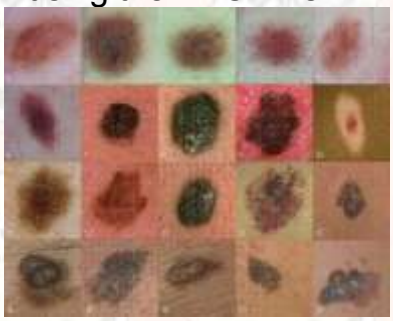
Cancer Prevention

- Scientific proof that …
  Healthy Lifestyle = Less likely to develop cancers
  LOW FAT
  HIGH FIBER
  VITAMINS & MINERALS
  DAILY EXERCIES

ABCDE'S of Skin Cancer

- A= Asymmetrical
- B= Border
- C=Color
- D=Diameter (less then the size of an eraser)
- E=Elevated/ Evolution

Skin Cancer- Can you identify using the ABCDE's???



Types of Skin Cancer

- Squamous cell Carcinoma
- Basal cell Carcinoma
- Melanoma * Most Dangerous*

OFTEN Preventable

- Use sunscreen (SLIP SLAP SLOP)
- Avoid sun from 10am-2pm
- UPF clothing
- Eyewear

You have *built-in* sun protection

- Tanned skin is already a sign of damaged skin!
- Melanocytes are the brown pigments in the skin that darken with UV exposure.
- Melanocytes protect the nucleus where your DNA is located.
- Your skin's melanocytes are umbrellas for your DNA!!

Hats and Long sleeves are a must or else!




Public Service Announcements

Public Service Announcement 2

Stem Cells

DNA within an Organism

- With few exceptions, ALL cells of an organism have the same DNA and same number of chromosomes but differ in expression of genes
  - Example: Skin cells have the same DNA as your brain cells.
- Multicellular organisms begin as undifferentiated masses of cells!
  - Variation in gene expression and gene activity determines the DIFFERENTIATION of cells and ultimately their SPECIALIZATION

Specialization

How do cells become ***specialized(become different)***?

•During differentiation, only specific parts of the DNA are activated (switches on and off)

•The parts of the DNA that are activated determine the function and specialized structure of the cell

•PROTEINS (like hormones) can act as switches to turn genes on or off in a cell

Differentiation

- Because all cells contain the same DNA in a organism, all cells initially have the POTENTIAL to become any type of cell
- But, once a cell differentiates, the process cannot reverse
  - The cell is stuck in its cell cycle!

Environmental Influence

- Genetic switches can be turned on and off by environmental factors
  - Temperature, chemicals, light

Peer Pressure

Chemical signals may be released by one cell to influence the development and activity of another cell

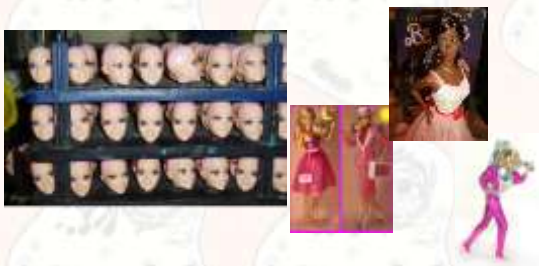
Tumors

So, what about those undifferentiated cells?

Stem cells

Stem Cells

We cells can do anything, right Barbie?



Stem Cells

- Unspecialized cells that continually reproduce themselves and have, under **appropriate** conditions, the ability to differentiate into one or more types of cell

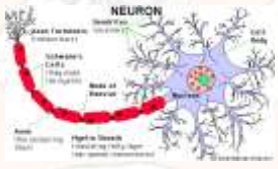
Types of Stem Cells

- Embryonic
  - Not yet differentiated into various cells types
- Adult
  - Differentiated into niches to produce specific types of cells

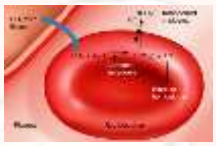
Stem Cell Niches in Humans (Adult Stem Cells!)

- Neural stem cell niche: neurons, nerve cells
- Bone stem cell niche: osteocytes (bone cells) for growth and repair
- Blood stem cell niche: red blood cells, white blood cells, platelets (controls bleeding)
- Muscle stem cell niche: produces satellite cells which differentiate into muscle cells
- Germ stem cell niche: sperm and egg

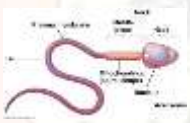
DNA → Cell Structure → Cell Function



Muscle Cell

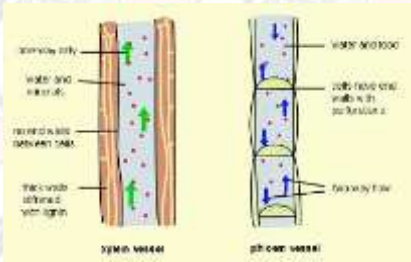


Red blood cell



Sperm cell

Cell Differentiation in Plants



Xylem: water up!

Phloem: two ways for sugars and solutes.

Homologues

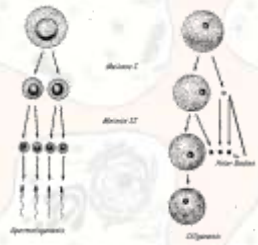
- **Homologous chromosomes:**
  - **Look the same**
  - **Control the same traits**
  - **May code for different forms of each trait**
  - **Independent origin - each one was inherited from a different parent**

Meiosis

- Similar in many ways to mitosis
- Several differences
- Involves 2 cell divisions
- Results in 4 cells with 1/2 the normal genetic information

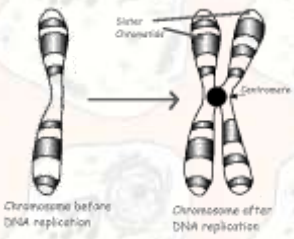
Vocabulary

- **Diploid (2N)** - Normal amount of genetic material
- **Haploid (N)** - 1/2 the genetic material.
- Meiosis results in the formation of haploid cells.
- In Humans, these are the **Ova** (egg) and **sperm**.
- Ova are produced in the **ovaries** in females
- Process is called **oogenesis**
- Sperm are produced in the **testes** of males.
- Process is called **spermatogenesis**



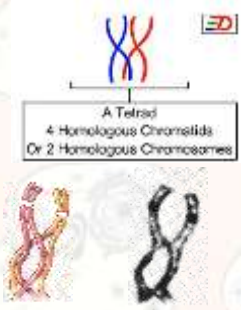
Meiosis Phases

- Meiosis occurs in 2 phases; **Meiosis I**, & **Meiosis II**.
- **Meiosis I.**
  - Prior to division, amount of DNA doubles



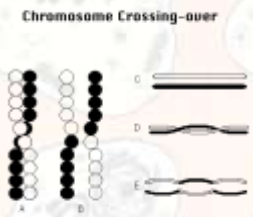
Crossing Over

- **Tetrad forms during Prophase 1**
- During metaphase 1 homologous chromosomes line-up along the metaphase plate
- Areas of homologous chromosomes connect at areas called **chiasmata**



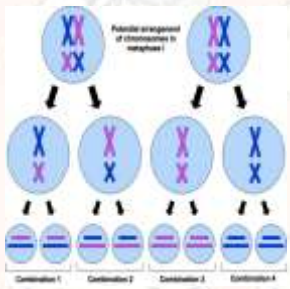
Crossing over contd.

- **Crossing Over** of genes occurs now
  - Segments of homologous chromosomes break and reform at similar locations.
  - Results in new genetic combinations of offspring.
  - **This is the main advantage of sexual reproduction**



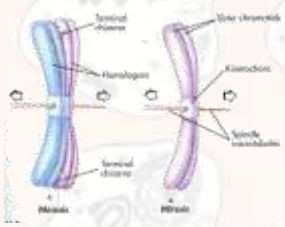
Independent Assortment of Chromosomes

- Random assortment of chromosomes during meiosis
- Increases genetic diversity
- Unique combination of alleles (forms of genes) in all gametes
- 2^{23} = 8,388,608 combinations (per person!)



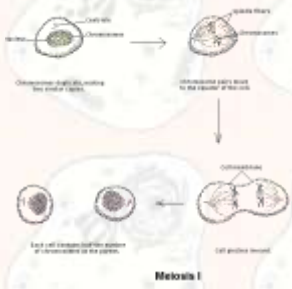
Chromosome reduction

- During anaphase 1, each homologous chromosome is pulled to opposite sides of the cell. Unlike mitosis, **THE CENTROMERES DO NOT BREAK.**



Meiosis I continued

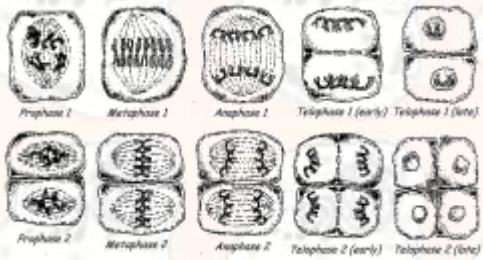
- Nuclei may or may not reform following division.
- Cytokenesis may or may not occur



Meiosis II

- DNA **does not** double
- Chromosomes randomly line-up along metaphase plate like regular mitosis.
- During anaphase 2, **CENTROMERES BREAK** and each chromosome is pulled to opposite sides of the cell.
- Nuclei reform and cytokenesis usually occurs (although it is often unequal).

Overview of Meiosis



Comparison of Mitosis & Meiosis