

Biology 101

Cellular Reproduction

What is cellular division? One cell growing in size and dividing to produce two new cells

Also called "simple cellular division"

Functions for:

- 1) Growth and development
- 2) Repair and reproduction

Reproduction = single or multiple celled organisms producing a new generation

2 Types:

- 1) **Asexual**: production of offspring by a single parent, no sexes or genders
- 2) **Sexual**: production of offspring by two or more parents resulting in genetic recombination

Purpose: to pass on the genome

In Prokaryotes: No nucleus!

Use process called binary fission, DNA replicated and divided between two new cells.

In Eukaryotes: Nucleus !!

→ Simple Cell Division: has **2** parts

- 1) **Nuclear Division**: division of nuclear contents
- 2) **Cytoplasmic Division**: division of the cytoplasm

Nuclear division (only eukaryotes) can take one of two forms

MITOSIS

- This is simple cell division
- Used for growth and repair
- Used for *asexual* reproduction
- **One parent cell gives rise to two daughter cells**
- **Each daughter cell *exactly* identical genetically to parent**
- Occurs in *somatic* cells
- Most common form of division
- Ex. protists, fungi, plants and animals

or

MEIOSIS

- Also called Reduction Division
- One purpose only, and that is *sexual* reproduction
- **One parent cell will give rise to four daughter cells**
- **Each daughter cell is *nonidentical* genetically to parent or each other**
- Occurs only in *germ* cells that give rise to the *gametes*, the sperm and eggs
- **Reduces number of genes in gametes to 1/2 of parents, so called reduction**

Chromosomes and Duplication

Chromosome Numbers and Sets

Duplication: each daughter cell gets a full copy of genes

Duplicated Chromosome Structure: chromatin, centromeres and sister chromatids

The Cell Life Cycle

(From one division to the next)

Total cycle: Has 2 major parts or *phases*.

1. INTERPHASE

Has 3 Subphases

- 1) G (gap) one (G-1)
- 2) S (synthesis) phase (S-phase)
- 3) G (gap) two (G-2)

2. MITOTIC PHASE (mitosis + cytokinesis)

Has 4 Subphases (4 phases of mitosis)

- 1) Prophase
- 2) Metaphase
- 3) Anaphase
- 4) Telophase

- Then cytokinesis

Mitosis:

Prophase - early:

- Chromosomes coil up and become visible
- Centrioles start to move towards opposite ends of cell
- Mitotic spindle begins to form

Prophase - late:

- Centrioles finally at opposite ends of cell
- Nucleolus degenerates and disappears
- Nuclear envelope breaks down and disappears
- Rest of spindle forms

Metaphase:

- Chromosomes line up in a straight single row
- Centromeres of each chromosome attach to mitotic spindles from both sides

Anaphase:

- Centromeres finish duplicating and break apart, separating the sister chromatids of the chromosome
- Spindles shorten, pulling sister chromatids toward opposite ends of the cell

Telophase:

- Chromosomes (previously sister chromatids) finish migrating to ends of cell
- New nuclear envelope forms around each batch of chromosomes
- Nucleoli reform inside each nucleus
- Eventually cytokinesis occurs

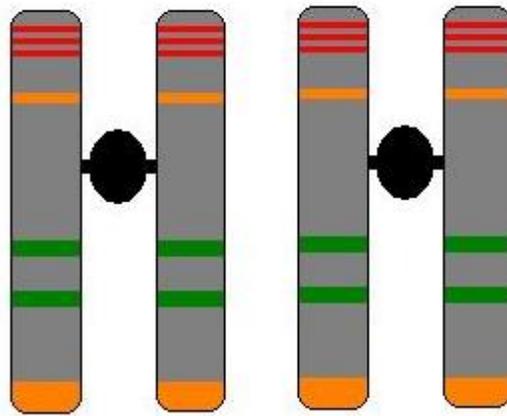
Differences between animal and plant mitosis:

1. Cytokinesis: animal cells develop a cleavage furrow while plants form a new cell wall
2. Plants lack centrioles, but still have a mitotic spindle which anchors to the cell wall

Homologues

Chromosomes in the body come in pairs, called *homologous pairs* or *homologues*

- One homologue from each pair comes from one parent while the other homologue comes from the other parent
- Homologues are similar in that they have the same genes at the same loci, same shape, size and banding pattern. But they may contain different alleles for the genes.

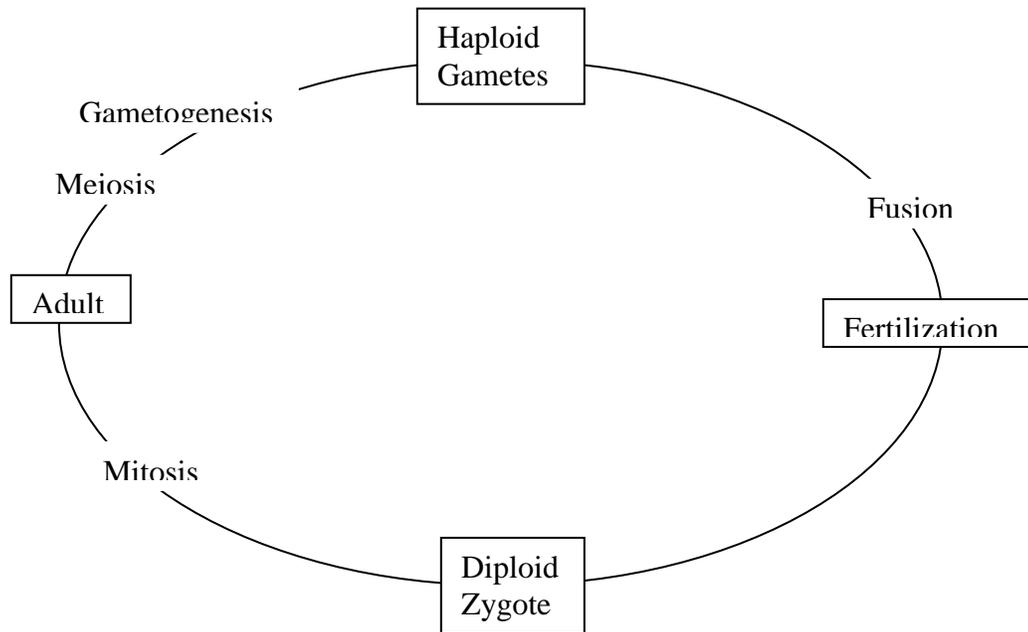


Normal cells are *diploid*, or $2N$, they have 2 sets of chromosomes

Sex cells, *gametes* (sperm and eggs), are *haploid*, or $1N$, they have 1 set of chromosomes

Meiosis

- Used for sexual reproduction
- Only one part of process; also requires gametogenesis and fertilization



Process of Meiosis

- Reduction division ($2N \rightarrow 1N$)
- Most steps are *similar* to mitosis
- Consists of 2 separate divisions called
 1. **Meiosis I**
 2. **Meiosis II**
- Each division has all four phases: **PMAT**
- Reduction occurs in **Meiosis I**

Meiosis I

Interphase:

- Same as mitosis, DNA replicates, cell prepares to divide

Prophase I:

- Most complex and longest phase of Meiosis
- Chromosomes condense and become visible

- Centrioles migrate towards poles of cell, spindle starts to form
- Nuclear envelope breaks down and disappears
- 2 important events occur during prophase I:
 1. **Synapsis**: homologous chromosomes come together as pairs, resulting in a structure called a **tetrad**
 2. **Crossing-over**: non-sister chromatids of homologous chromosomes exchange segments. Since homologues have same genes, but maybe different alleles, this creates novel gene combinations and increases genetic diversity.

Metaphase I:

- Homologous chromosome pairs (tetrads) are moved to metaphase plate (equatorial plane) and aligned in middle of cell
- Chromosomes now in a double row
- Spindles attach to centromeres, one spindle to one centromere

Anaphase I:

- Tetrads split up. Unlike mitosis, sister chromatids stay together.
- Homologous pairs split up and one entire chromosome migrates to poles of cell
- !! Actual reduction has occurred here!!

Telophase I and cytokinesis:

- Chromosomes arrive at poles
- Now haploid, though still in **duplicate** form

- Chromosomes uncoil, new nuclear membrane forms, new nucleoli form
- Cytokinesis finally takes place
- **No DNA replication between Telophase I and Prophase II**

Meiosis II

Essentially the same as mitosis

Prophase II

Metaphase II

Anaphase II

Telophase II (and cytokinesis)

Accidents of Meiosis

Non-Disjunction: members of a chromosome pair (tetrad) fail to separate during Anaphase I. Leads to *aneuploidy* and *polyploidy*

Trisomy 21 (Down Syndrome)

Turner's Syndrome

Klinefelter's Syndrome

Forms of advanced Asexual Reproduction

In plants

stolons

grafting

spores

In animals

fission

regeneration

budding

Animal Life Cycle vs. Plant Life Cycle (see figure in class)

(Note plant gametophyte and sporophyte generations)