RU RMT 2
Anatomy and Physiology
Lecture 5
Cell Bio Cellular Level

Mitosis

* Mitosis: cell division for somatic cells
* Goal: produce 2 diploid cells
    * Genetically identical
* Why: replaces dead or injured cells, or adds new ones during tissue growth
* 2 parts: 1st occurs in the nucleus of the cell, 2nd occurs in the cytoplasm

Cell Division

* Most cells of the human body undergo **cell division**
  * The process by which cells reproduce themselves

* 2 Types:
  * **Mitosis:** somatic cell division (every cell in body except gametes)
  * **Meiosis:** reproductive cell division (gametes: sperm & oocyte)

Meioisis

* Meiosis: cell division for reproductive cells
  * Occurs only in the tests and ovaries
* Goal: produce four haploid cells
* Why: produces gametes, the cells needed to form the next generation of sexually reproducing organisms

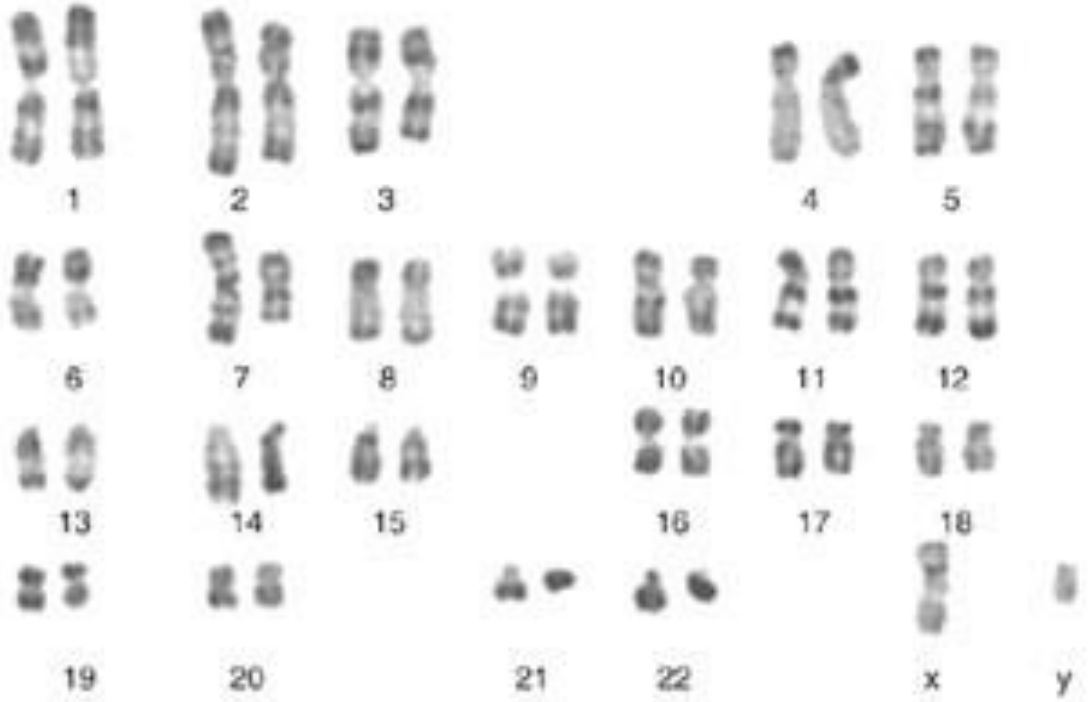
Cell Division

* The somatic **cell cycle** is a sequence of events in which a somatic cell duplicates its contents and divides in two
* Human cells contain 23 pairs of chromosomes, for a total of 46
  * One from each parent
* The two chromosomes that make up a pair are called homologous chromosomes
  * They contain similar genes arranged in the same order

Cell Division

* The exception to this rule is one pair of chromosomes, called the **sex chromosomes -** Designated X and Y

Females: homologous pair = XX Males: homologous pair = XY



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Mitosis

* When a somatic cell reproduces, it must duplicate all of its chromosomes to pass on to the next generation of cells

Cell cycle has 2 major periods:

1. **Interphase:** when a cell is not dividing
2. **Mitotic Phase:** when a cell is dividing

Mitosis

Interphase

* The cell replicates its DNA
* The cell produces additional organelles and cytosolic components, in anticipation of cell division
* Interphase is a state of high metabolic activity, and consists of 3 phases:

1. G_1 phase
2. S phase
3. G_{2-}phase

Interphase

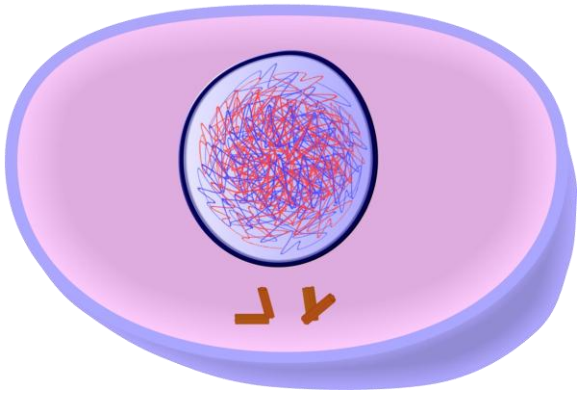
1. Gap--1 phase: (G_1 phase): the cell duplicates its organelles (but not its DNA)

1. Synthesis phase: (S phase): DNA replication occurs

1. Gap--2 phase: (G_{2--}phase): cell growth continues, and enzymes and other proteins are synthesized in preparation for cell division

Interphase

* A microscopic view of a cell during interphase shows a clearly defined nuclear envelope, a nucleolus, and a tangled mass of chromatin
* Chromosome pairs called chromatids (formed in the S phase) cannot be distinguished



Mitotic Phase

Once a cell completes its activities during the 3 stages of interphase, the mitotic phase begins

* The mitotic phase of division consists of a nuclear division (mitosis) and a cytoplasmic division (cytokinesis)
* In the end, 2 identical daughter cells are formed

Nuclear Division (Mitosis)

Mitosis

* The distribution of 2 sets of chromosomes into 2 separate nuclei

Mitosis occurs in 4 stages:

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase

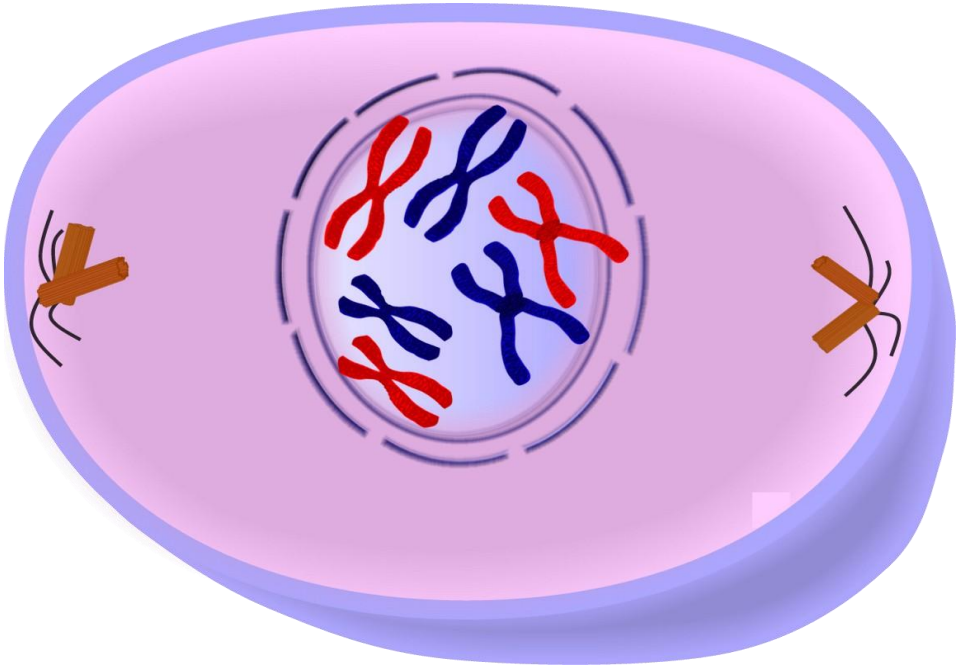
Mitosis

1. Prophase

* Chromatin fibers condense and shorten into chromosomes that are visible under a microscope
* The mitotic spindle starts to form
  * They are responsible for separation of chromatids during subsequent stages
* The nucleolus disappears and the nuclear envelope starts to break down

Prophase

* Chromatids
* Mitotic spindles
* No more nucleolus & break down of nuclear envelope



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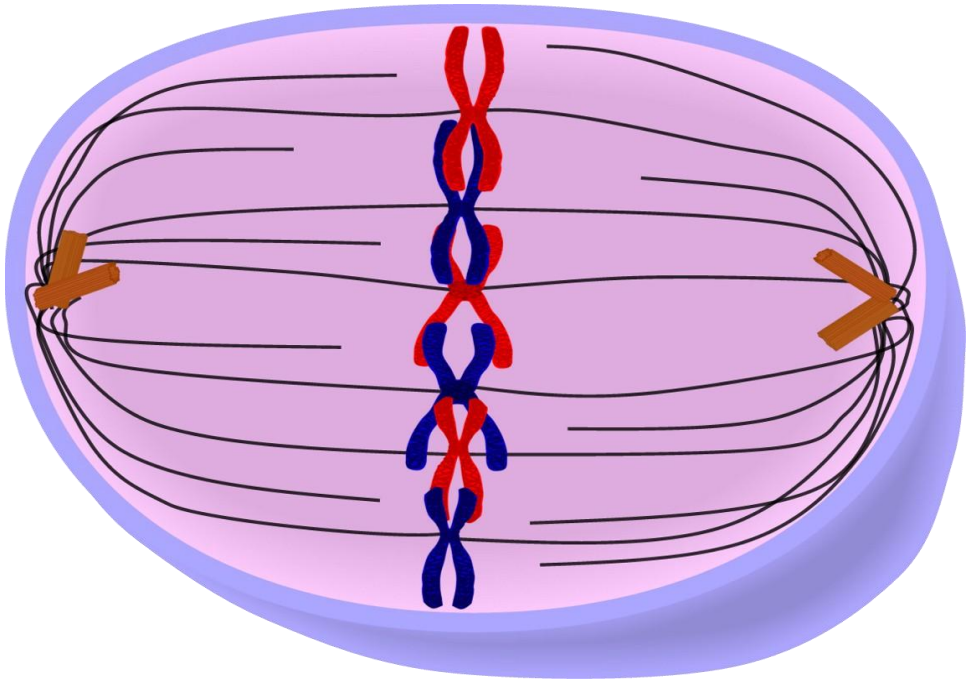
Mitosis

2. Metaphase

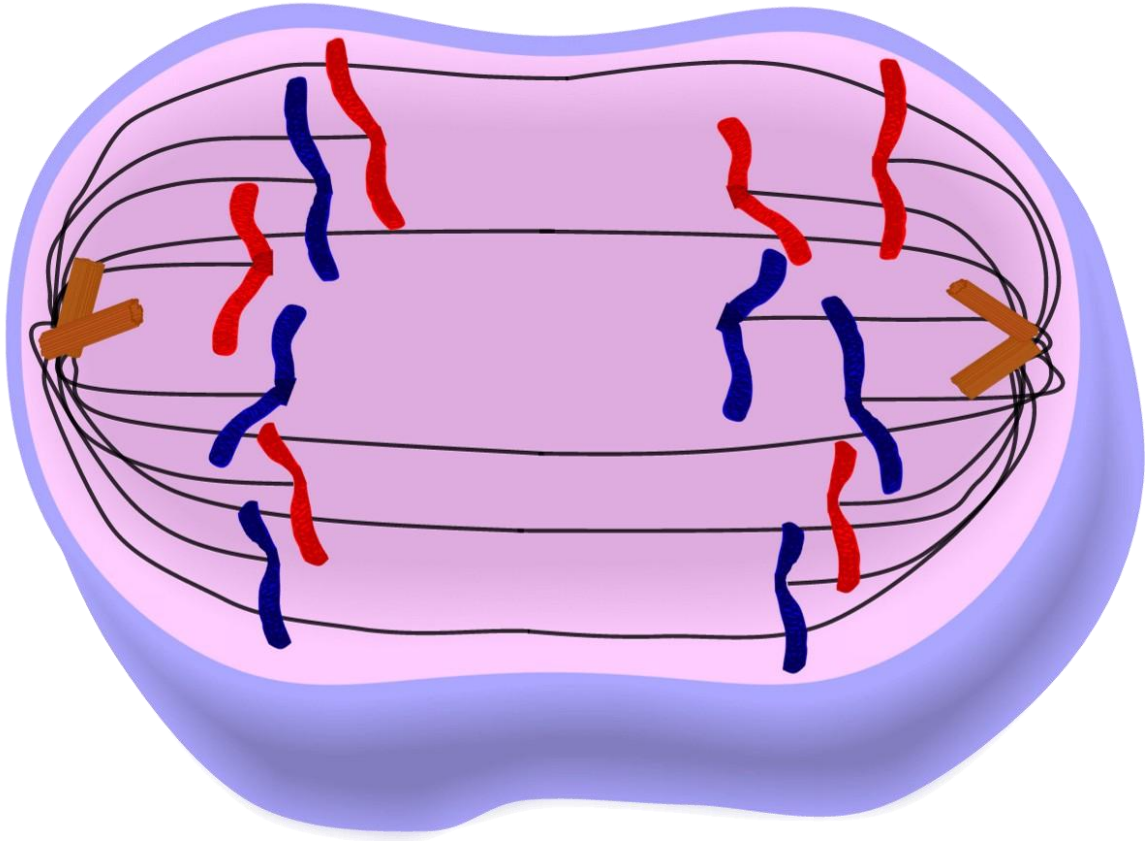
* The chromatid pairs are arranged at the exact centre of the mitotic spindle in the region called the metaphase plate



Mitosis

3. Anaphase

* The two members of each chromosome pair separate and move toward the opposite poles of the cell

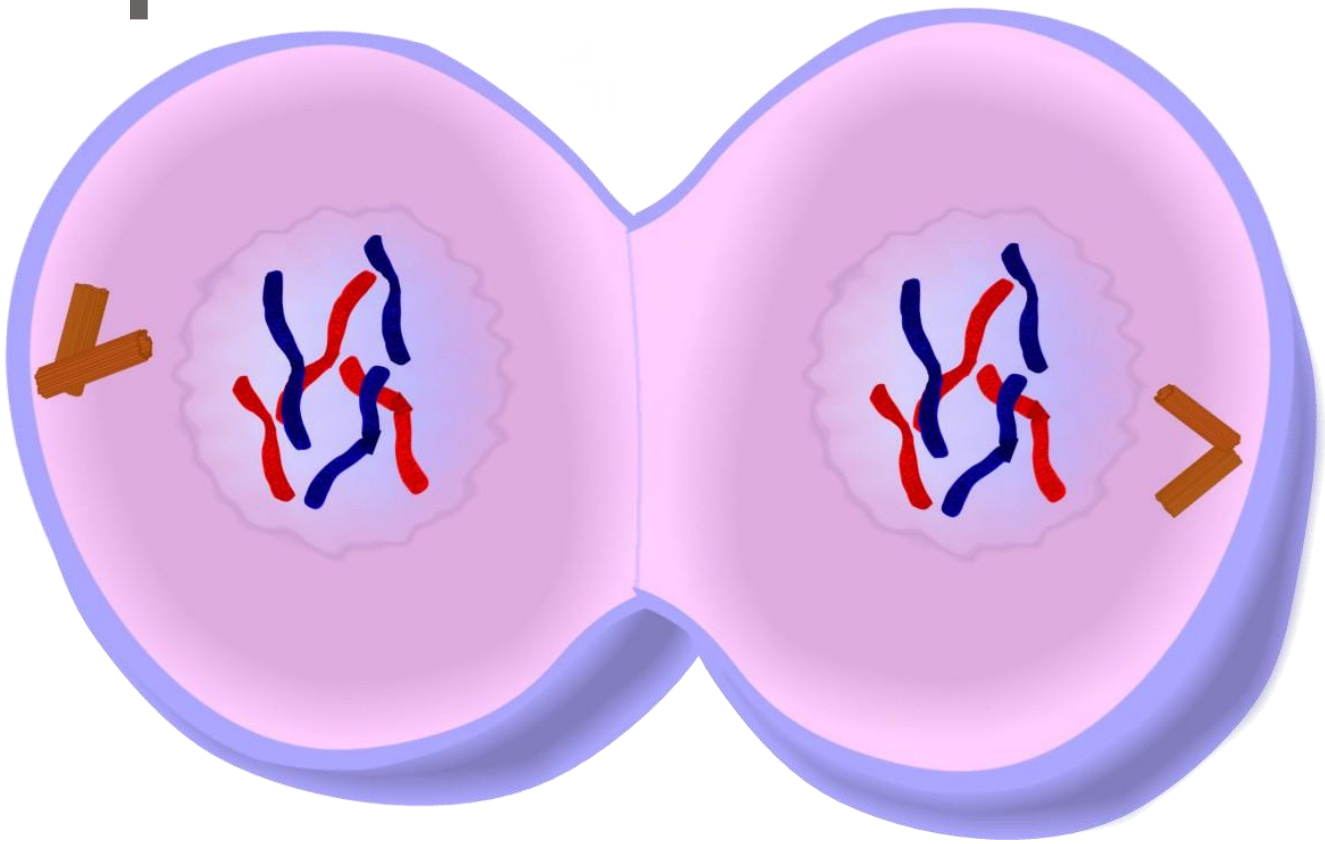


Mitosis

4. **Telophase**

* This is the final stage of mitosis and begins as soon as chromosomal movement stops
* The identical sets of chromosomes at opposite poles of the cell uncoil and revert back to their tangled form
* A new nuclear envelope forms, the nucleolus reappears in nucleus and the mitotic spindle breaks up

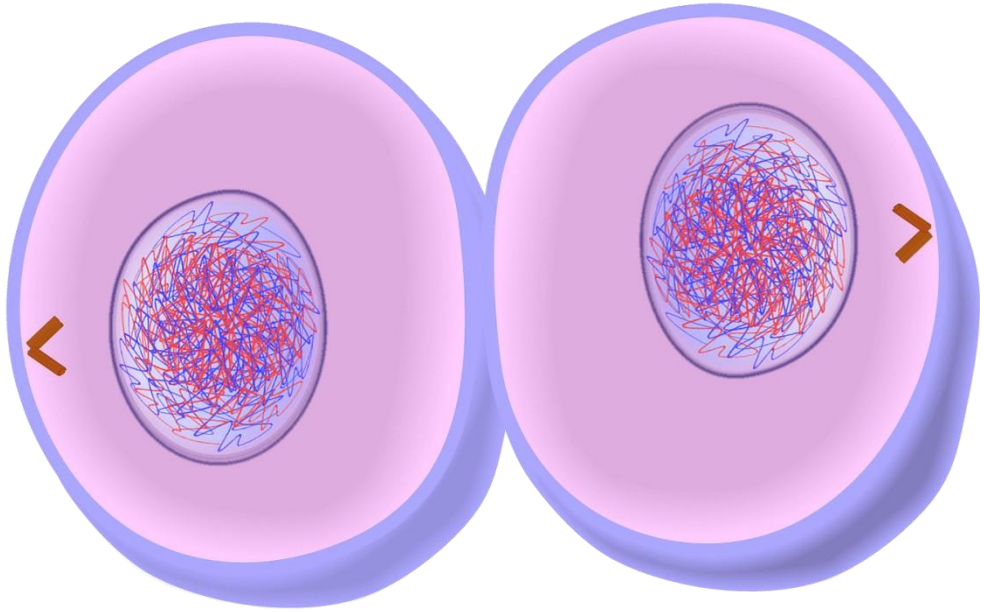
Telophase



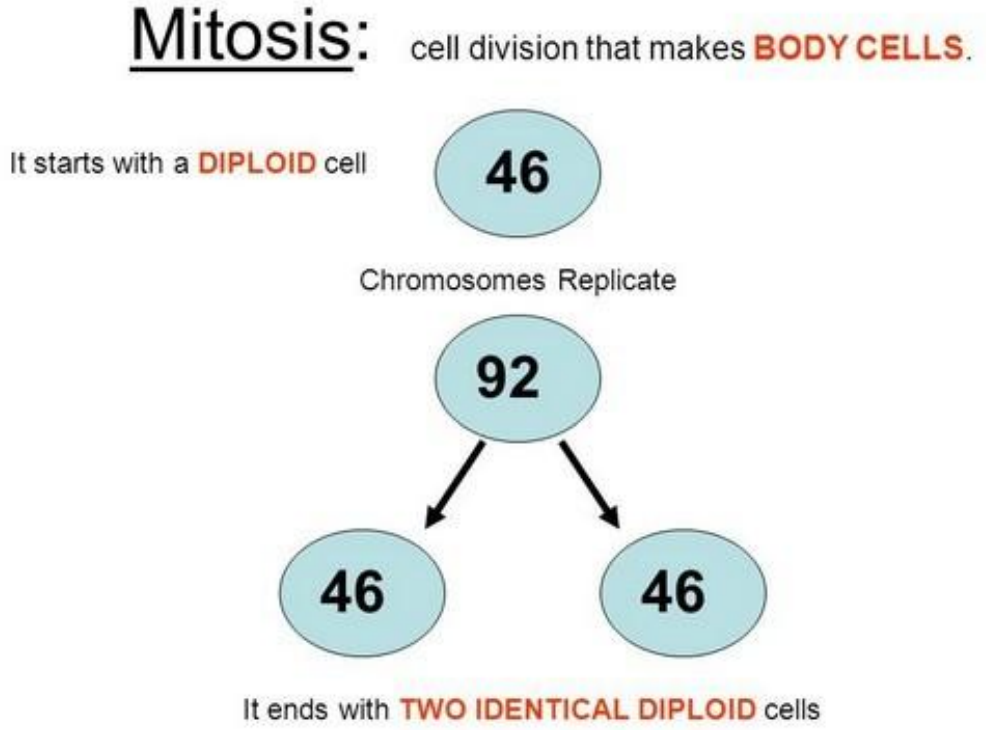
Nucleus chromosomes have separated

Cytokinesis

* The division of a cell's cytoplasm and organelles into two identical cells
* Begins in late anaphase and completed after telophase
* Once cytokinesis is complete, interphase begins



Mitosis Math



Meiosis

1. Meiosis produces gametes in which the number of chromosomes is reduced by half and occurs in two successive stages namely Meiosis I and Meiosis II
2. These gametes (sperms and oocytes) are called haploid cells because they contain a single set of 23 chromosomes and is written as “n”
3. Meiosis produces 4, genetically unique haploid cells
4. Fertilization involves the fusion of sperms and oocytes and it restores the diploid (2n) number of chromosomes

Meiosis

* During interphase that precedes meiosis I, the chromosomes of the diploid cell start to replicate during the S--phase and each chromosome then consists of two sister (genetically identical) chromatids, attached at their centromeres. This replication is similar to the one that precedes mitosis in somatic cell division
* Begins once chromosomal replication is complete and consists of 4 phases:
  1. Prophase I
  2. Metaphase I
  3. Anaphase I
  4. Telophase I

Meiosis

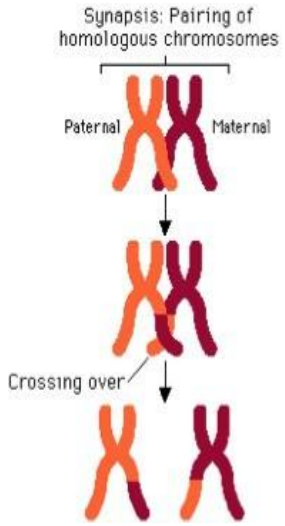
Prophase I

* Chromosomes shorten and thicken
* Nuclear envelope and nucleoli disappear and the mitotic spindle forms

Two further events occur that are not seen in mitotic prophase:

1. Synapsis:

* The two sister chromatids of each pair of homologous chromosomes pair and form a tetrad



Meiosis

2. Crossing over:

* Parts of the adjacent chromatids of two homologous chromosomes are exchanged with one another
* This permits an exchange of genes between chromatids of homologous chromosomes and hence the resulting cells are genetically unlike each other, and genetically unlike the starting cell that produced them
* This results in genetic recombination, which accounts for the genetic variation among individuals

Meiosis

Metaphase I

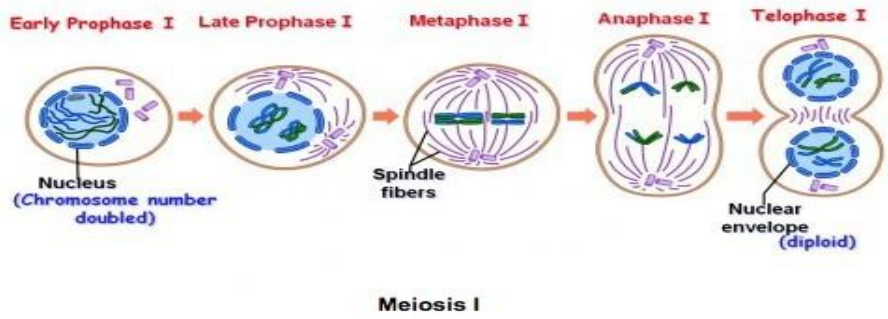
* The two paris of chromatids line up along the metaphase plate with homologous chromosomes side by side

Anaphase I

* Members of each homologous pair of chromosomes separate as they are pulled to the opposite poles of the cell by microtubules attached to the centromeres
* Note that the paired chromatids are still held by a centromere and remain together . The do not separate as in mitotic anaphase

Telophase I and Cytokinesis I

* Are similar to mitosis

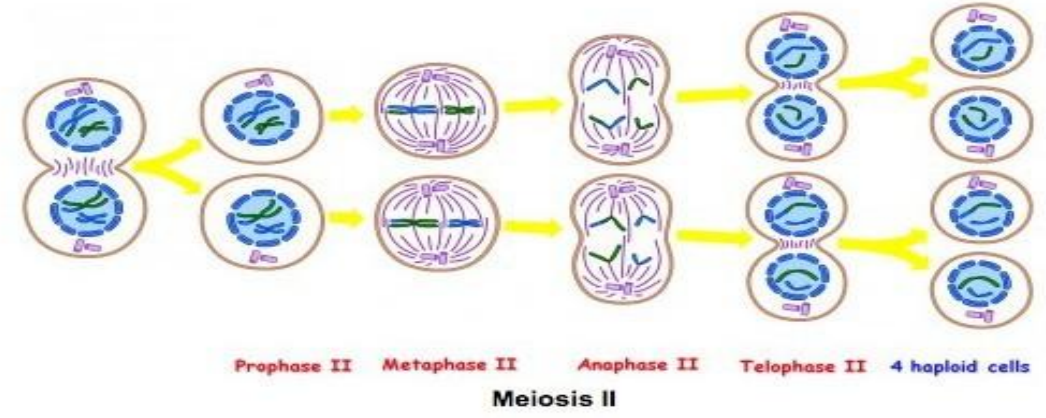


Meiosis I

Meiosis

Meiosis II

* Phases are similar to those that occur during mitosis
* Each of the cells formed in meiosis I divide so that the net result is four haploid gametes that are genetically different from the original diploid cell



Meiosis II

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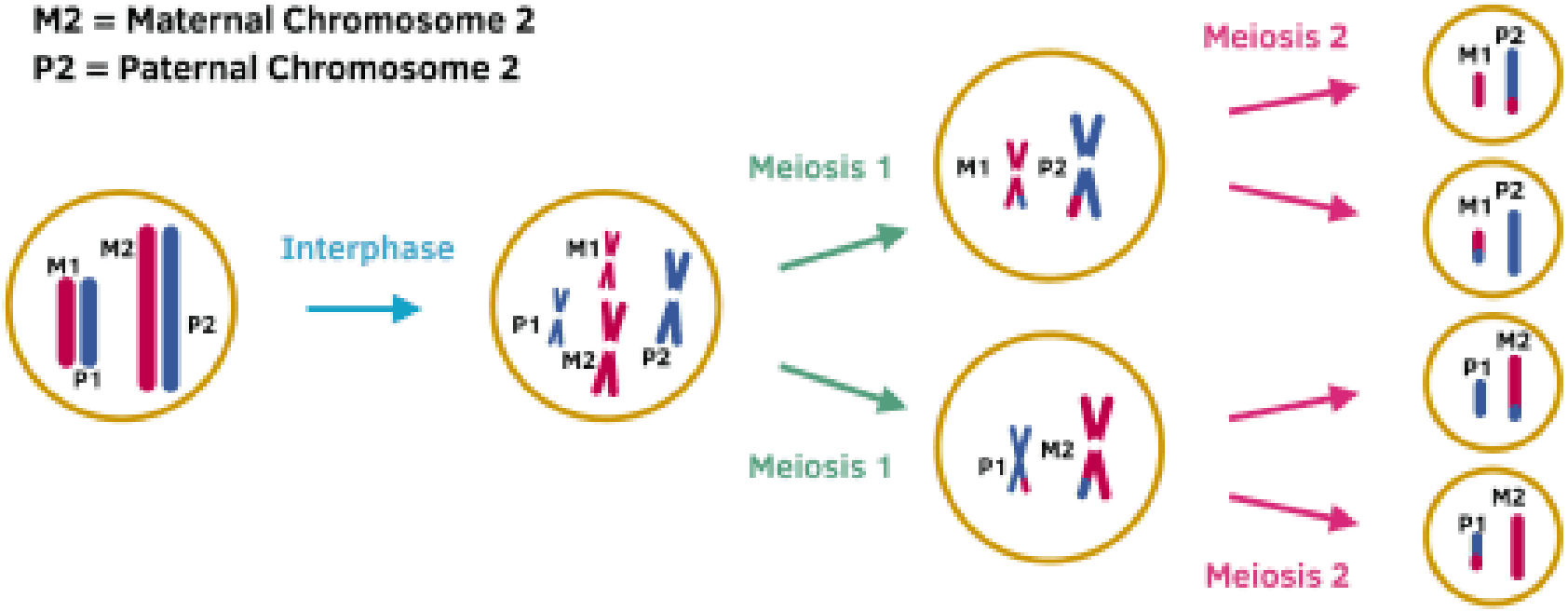
Meiosis Math

M1 = Maternal Chromosome 1
P1 = Paternal Chromosome 1
M2 = Maternal Chromosome 2
P2 = Paternal Chromosome 2



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Control of Cell Destiny

- A cell has three possible destinies:
  1. to remain alive and functioning without dividing
  2. to grow and divide
  3. to die

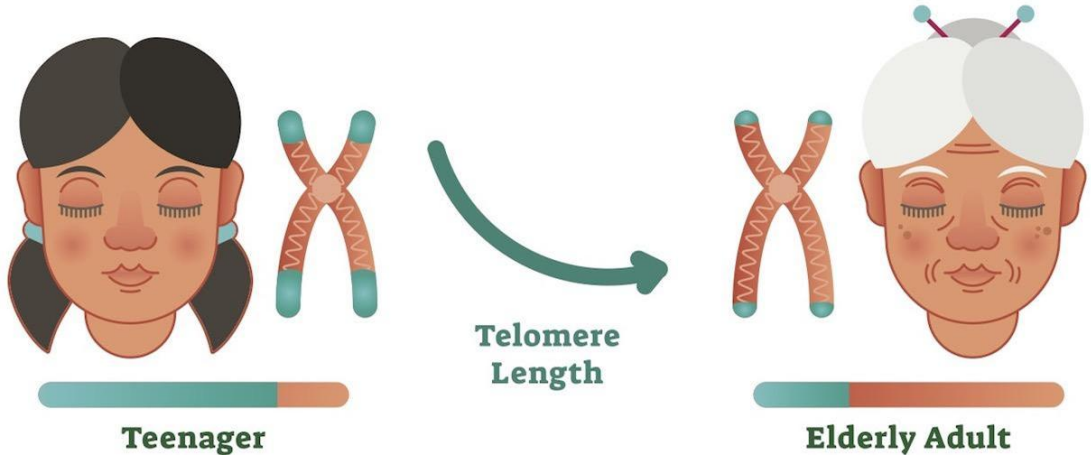
* When there is a balance between cell death and cell proliferation, homeostasis is maintained
* Various signals tell a cell when to exist, when to divide, and when to die

Aging and Cells

* Aging is a normal process accompanied by a progressive alteration of the body's adaptive process
* It produces observable changes in structure and function and increases vulnerability to environmental stress and disease
* Although many millions of new cells are produced normally certain types of cells such as skeletal muscle cells and nerve cells do not divide and remain permanently in this phase which is referred to as the G0 phase.

Aging and Cells

* Another aspect of aging involves telomeres which are specific DNA sequences found only at the tips of each chromosome
* These telomeres protect the tips of chromosomes from erosion
* With aging the telomeres are lost and hence chromosomal damage occurs
* This phenome
many of the feature



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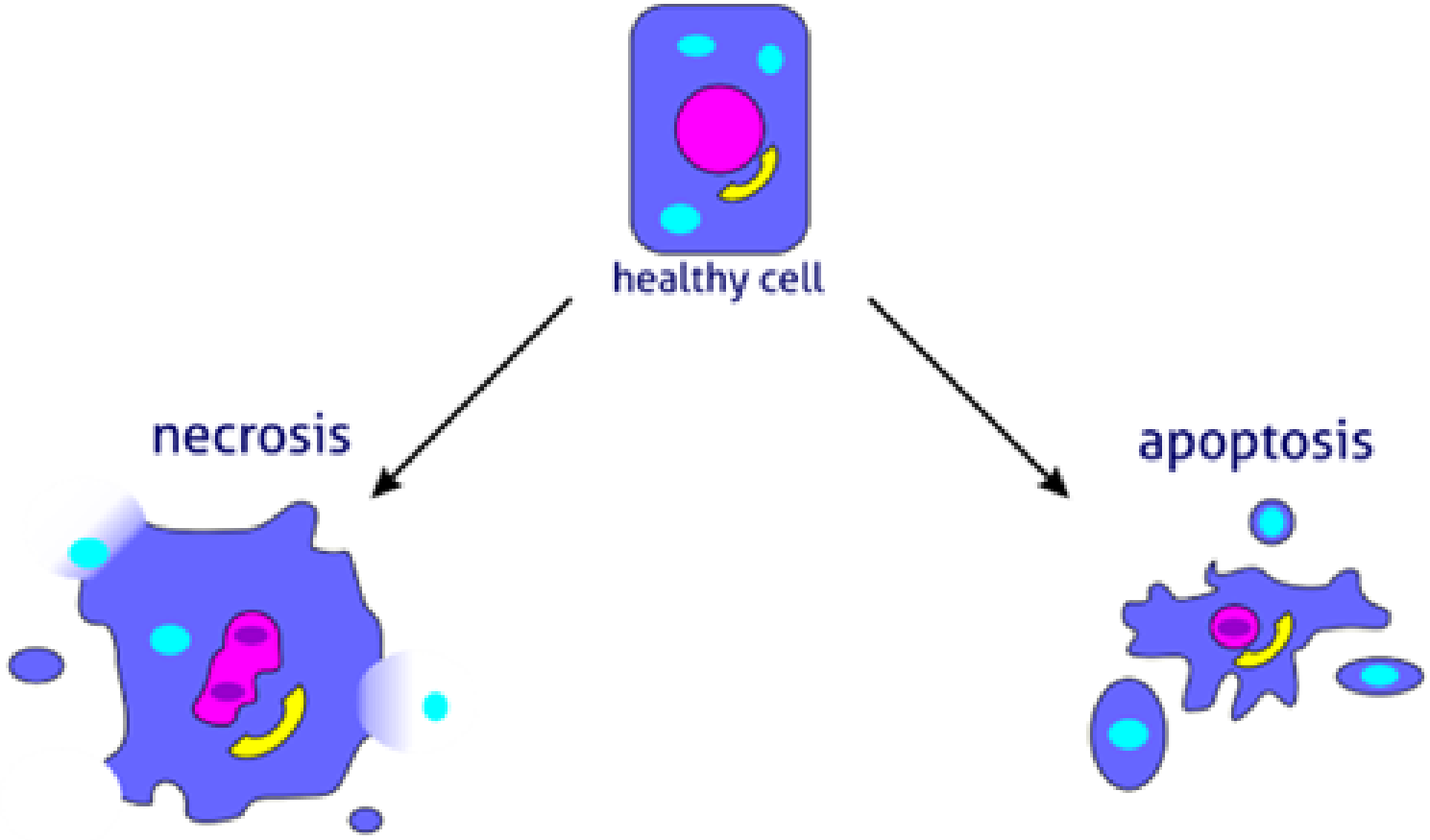
Apoptosis

* It refers to normal, regulated, and genetically programmed cell death
* It is regulated by genes that produce enzymes that damage the cell and phagocytes ingest the dying cell

Necrosis

* It is pathological cell death that due to tissue injury
* The affected cells swell and burst and stimulate an inflammatory response

Cell Death



- increase in cell volume
- loss of plasma membrane integrity
- leakage of cellular contents

- cell shrinkage
- plasma membrane blebbing
- formation of apoptotic bodies