Department of Cell Biology and Genetics
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FSC 111

INTRODUCTORY BIOLOGY

HEREDITY : MITOSIS and MEIOSIS

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What is Genetics?

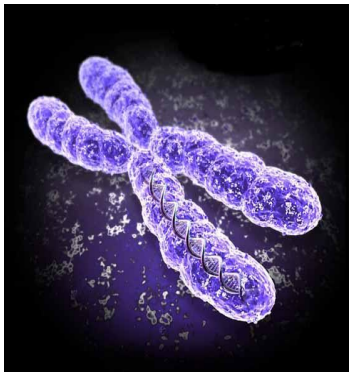
- It is primarily and originally a science dealing with heredity i.e. transmission of characteristics from parents to offspring.
- In addition, it also involves the study of the factors which show the relationship between parents and offspring as well as account for the many characteristics which organisms possess.

Some facts

- William Bateson, a British Biologist in 1906 coined the term Genetics
- The hereditary materials or factors that are transmitted were first called Genes by a Danish Biologist Wilhelm Ludvig Johannsen in 1909.
- Gregor Mendel (1822-1884), Austrian monk, whose experimental work became the basis of modern hereditary theory

More facts

- Genes are bits of biochemical instructions found inside the cells of every organism from bacteria to humans
- Geneticists seek to understand how the information encoded in genes is used and controlled by cells and how it is transmitted from one generation to the next
- Chromosomes are microscopic structure within cells that carries the genes and consequently the molecule, deoxyribonucleic acid (DNA)



Still more facts

- Cells divide to make more cells. While all the other organelles can be randomly separated into the daughter cells, the chromosomes must be precisely divided so that each daughter cell gets exactly the same DNA.

Still more facts exist

- Genes occupy precise locations on the chromosomes.
- Transmission of traits and characters ensures continuity of life.
- The cell theory was extended by Rudolph Virchow in 1855 by declaring that new cells come from pre-existing cells by **cell division**

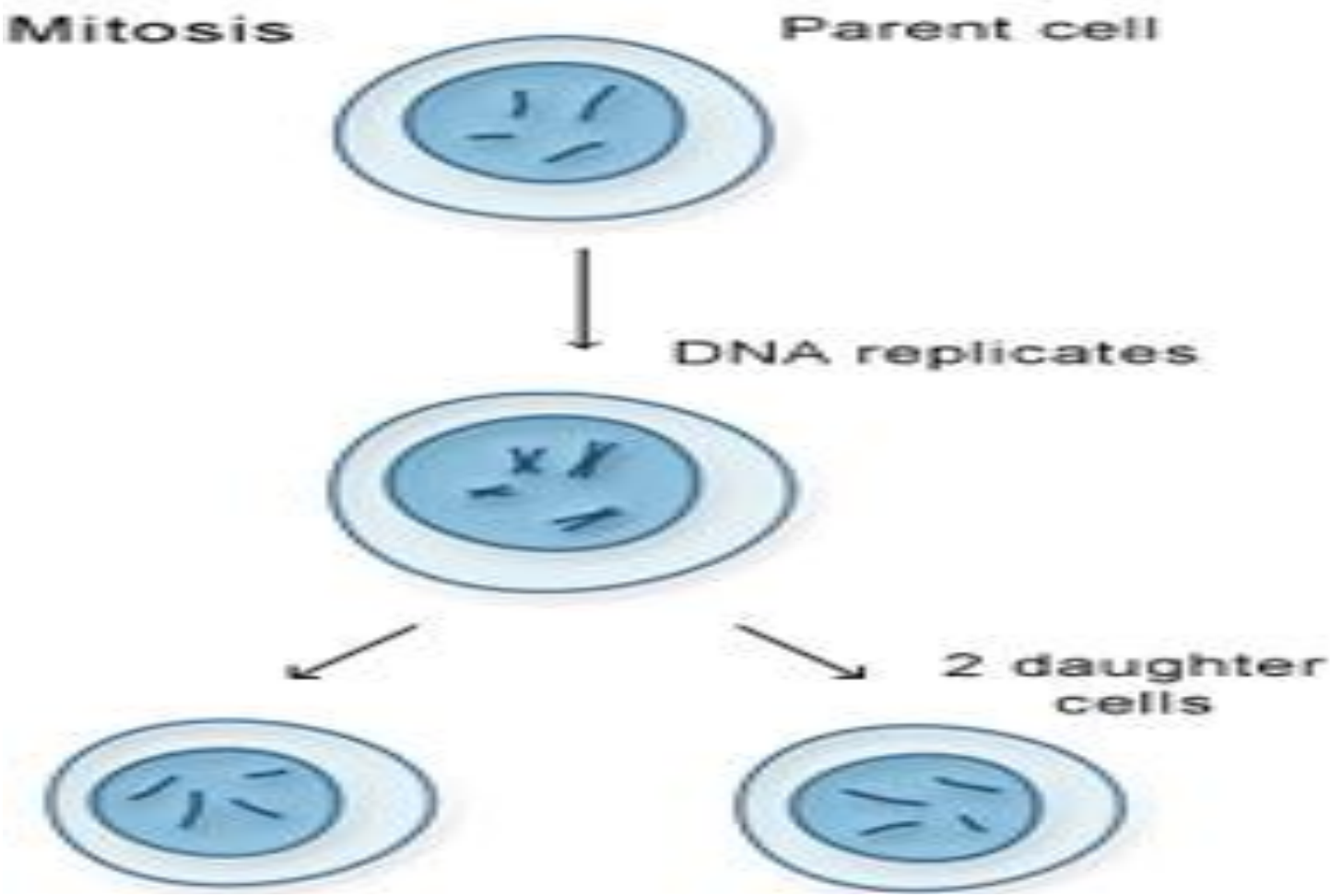
CELL DIVISION

- Cell division is the cornerstone of life
- In 1879 Boveri and Flemming described the events occurring within the nucleus leading to the production of two identical cells.
- 1887 Weismann suggested that a specialized form of division occurred in the production of gametes.
- These two forms of cell division are called **MITOSIS** and **MEIOSIS** respectively.

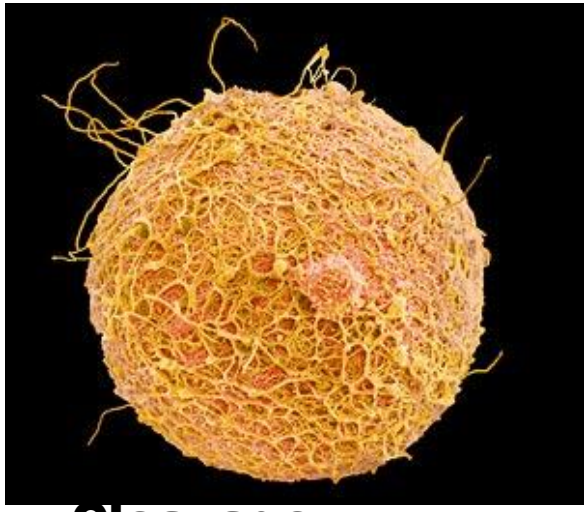
Mitosis

- Mitosis is a type of Cell Division that occurs during growth in Organisms.
- A method of division of nucleus that is used to create new cells in eukaryotes, growth, maintenance and repair.
- Method of asexual reproduction in procaryotes.
- **Mitosis can be defined as a mechanism of cell division in which a parent cell divides into two daughter cells that will be exactly equal in all respect and similar to the parent cell that gave rise to them.**

SUMMARY OF MITOTIC PROCESS



Importance Of Mitosis



Cleavage

Growth

Replacement

Repair

The Process Of Mitosis

- The events that occur within the nucleus during mitosis are usually observed in cells that have been fixed and stained. This in effect provides a series of ‘snapshots’ of the phases through which the chromosomes pass during cell division. Mitosis is seen as a continuous process but it is divided into **four stages** for convenience.

- Before the cell go through the mitotic phases, it passes through a preparatory stage called the **‘resting stage’** because of non-division status of the stage. When this is included one can look at the process of having five phases;

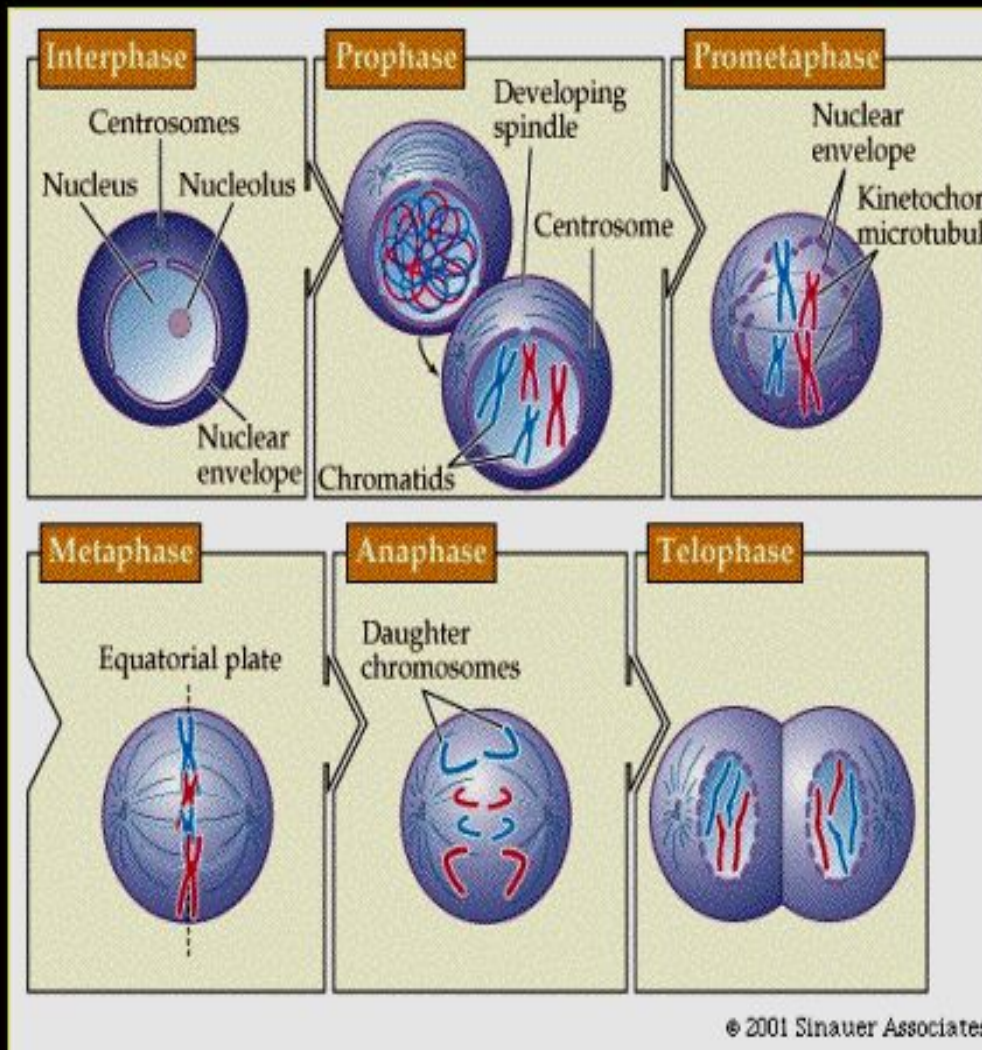
Stages Of Mitosis

- **INTERPHASE**
- **PROPHASE**
- **METAPHASE**
- **ANAPHASE AND**
- **TELOPHASE**

in that order.

Mitosis is a Contiuum

- But, it's divided into *subphases* for description
  - Prophase
    - prometaphase
  - Metaphase
  - Anaphase
  - Telophase



Interphase Events

- Intensive cellular synthesis including cell organelles
- Cell metabolism is increased
- Cell growth
- DNA replication
- Each Chromosomes becomes two chromatids.
- Energy stores increases.
- Cells spend about 90% of life cycle at interphase

Prophase Events

- Longest phase of division stages.
- The cell starts the process of cell division.
- Chromosomes shorten and thicken by coiling and are more visible by staining.
- Chromosomes seen as containing two chromatids held by a centromere.
- In Animal cells centrioles move to opposite poles of the cell.
- Asters are formed from centrioles and radiates from that to form spindle fibres.
- Nucleoli and Nuclear membrane disintegrates

Prophase

- *Chromatin* coils into visible chromosomes
  - Under a light microscope, only the nuclear envelope (with nucleoli) and a tangle of chromatin are visible
- *Centrosomes*: mitotic centers, poles for division

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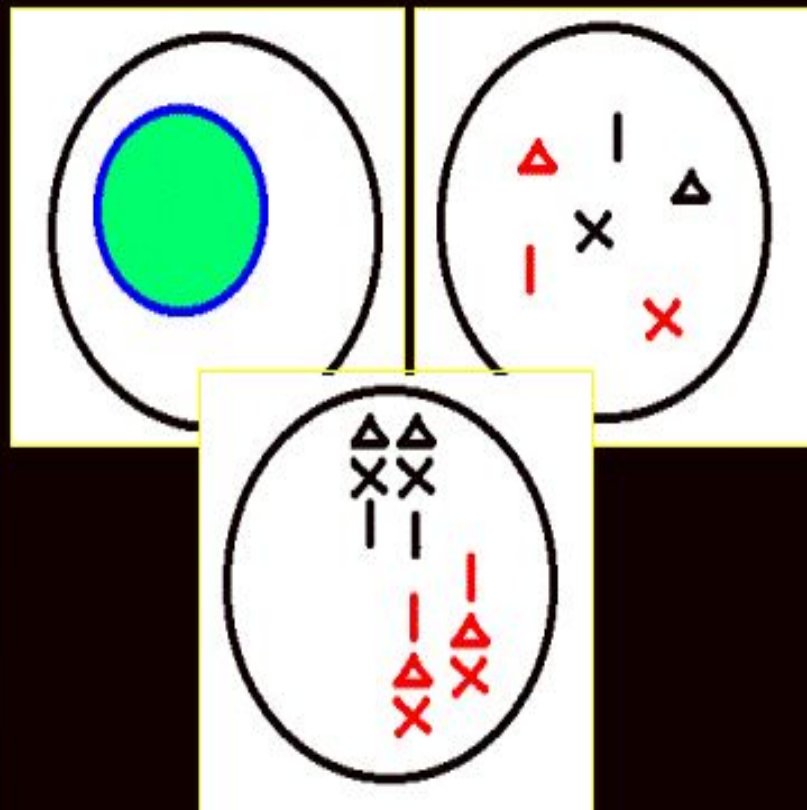
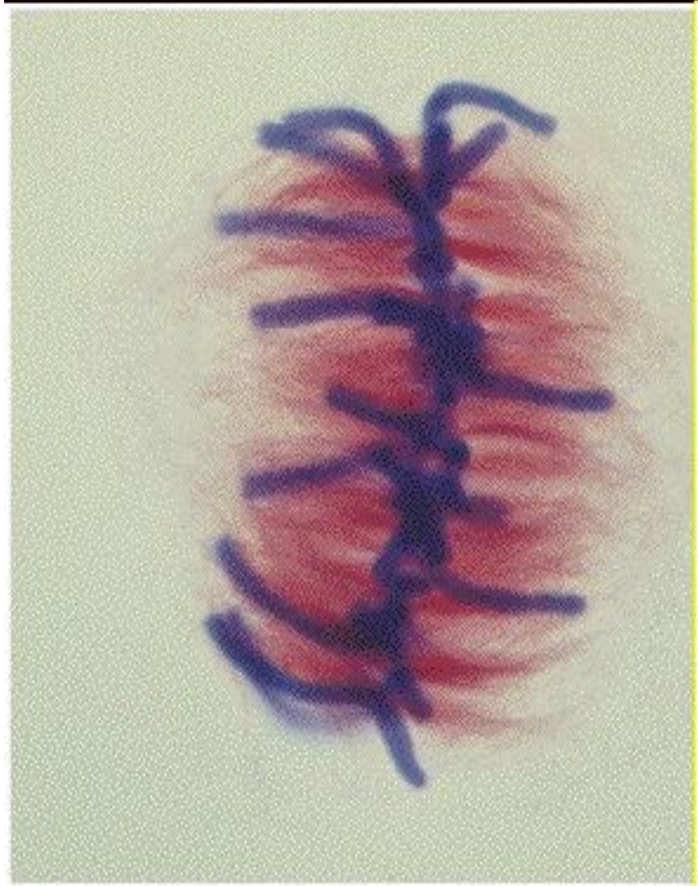


Metaphase Events

- Chromosomes line up around the equator of the spindle, attached by their centromeres to the spindle fibres.
- Shortest stage of mitosis.
- Highly condensed chromosomes and most visible.

Metaphase

- Chromatids align on a plane at cell's equator
  - *Metaphase plate* (MITOTIC SPINDLE)



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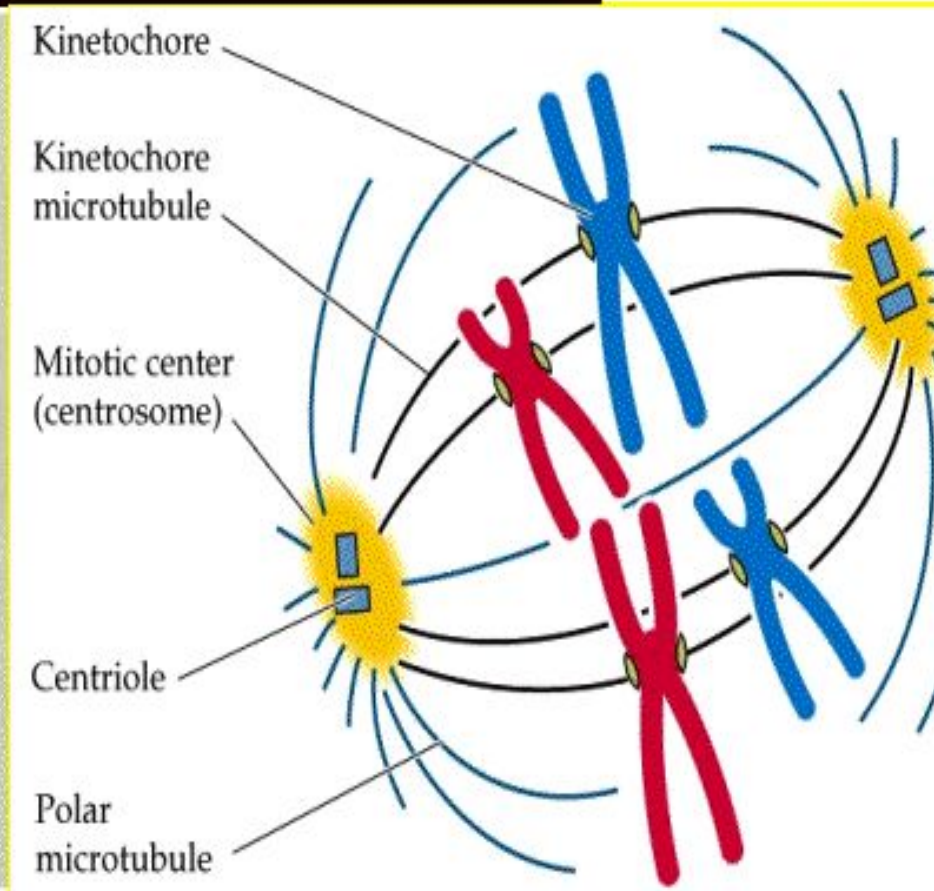


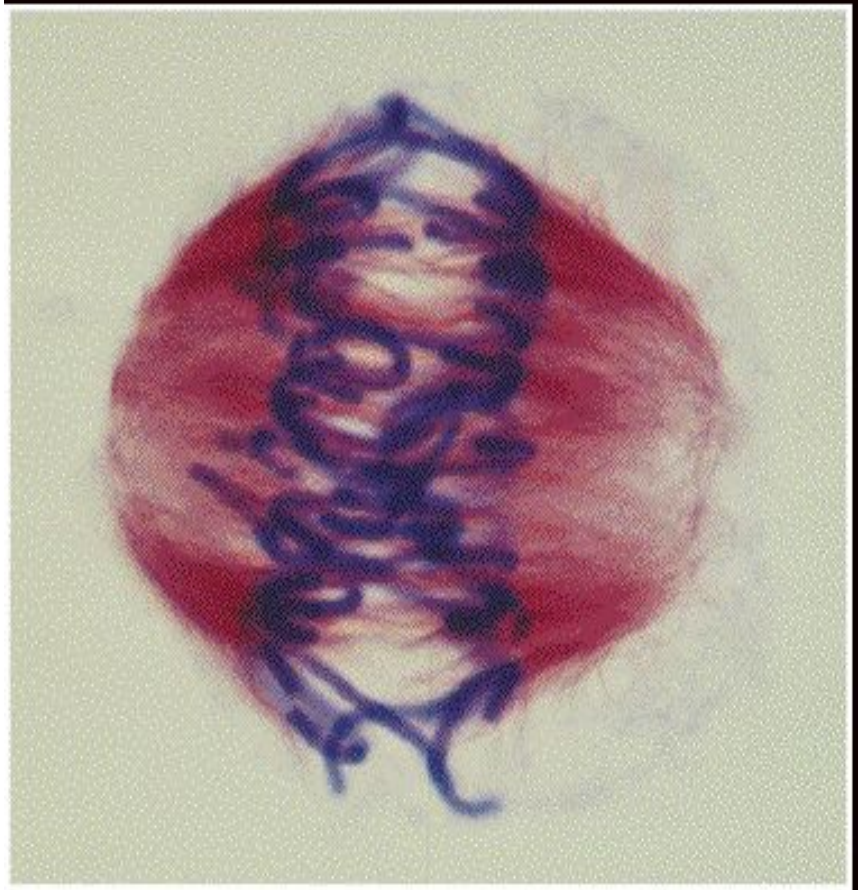
Anaphase events

- Centromeres split into two and spindle fibres pull the chromatids of the same chromosomes to opposite poles.

- The separated chromatids are pulled along behind the centromere. It is a very rapid stage.

Anaphase

- Chromatids separate simultanously
- *Sister chromatids* become *daughter chromosomes*



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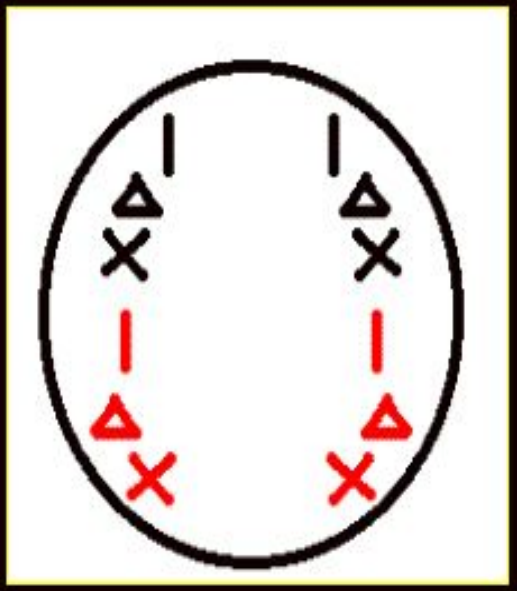
Late



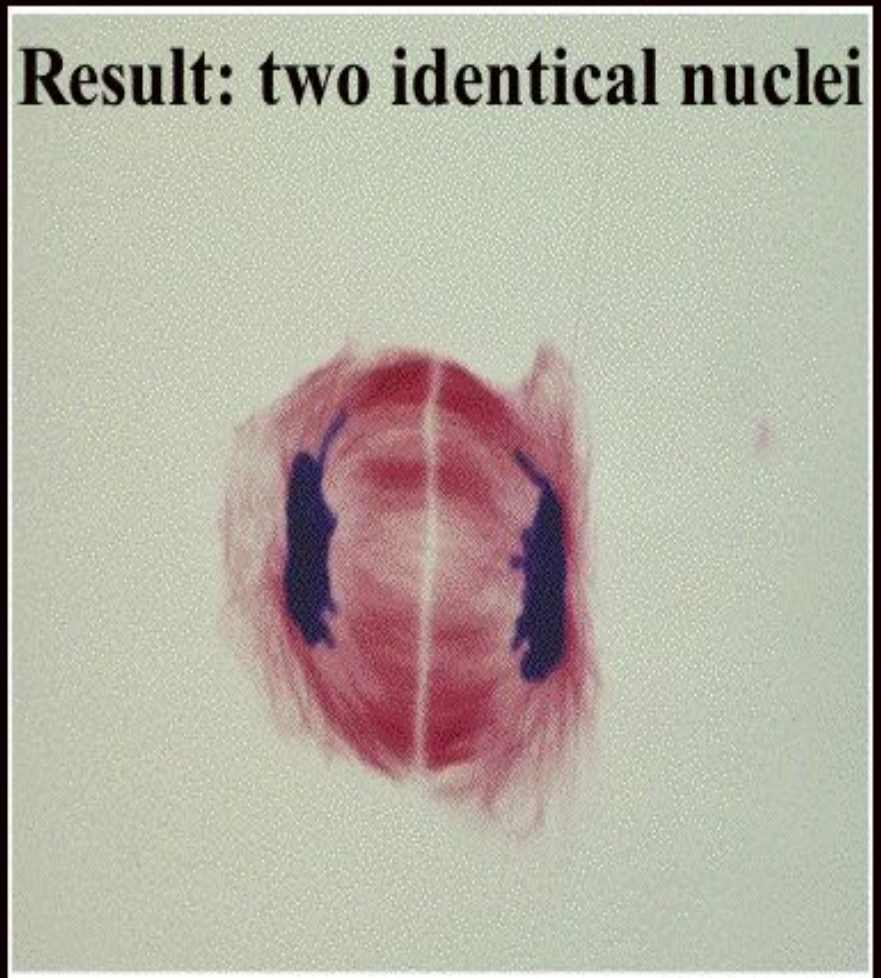
Telophase Events

- Chromatids reach the poles of the cell.
- Uncoil and lengthen to form chromatin again.
- Spindle fibres disintegrate.
- Centrioles replicate.
- Nuclear envelope and Nucleoli are reformed.
- In Animal cells cytokinesis (division of cytoplasm) occurs by invagination at center of cell.
- In Plant Cells, Cell plate is formed to give two cells.

Telophase

- Daughter chromosomes stop moving
  - Chromosomes uncoil, nucleus and nucleoli reform

Result: two identical nuclei



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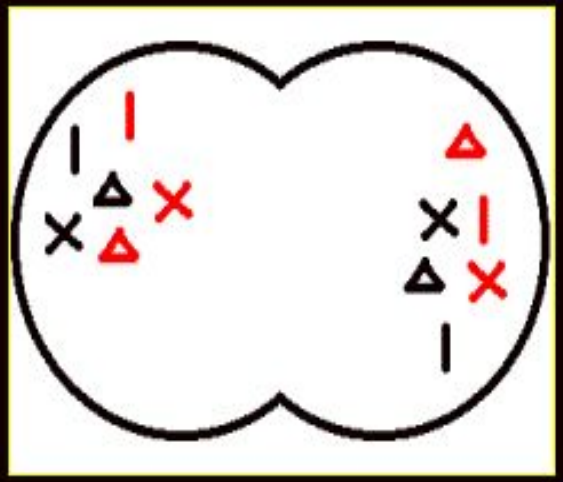
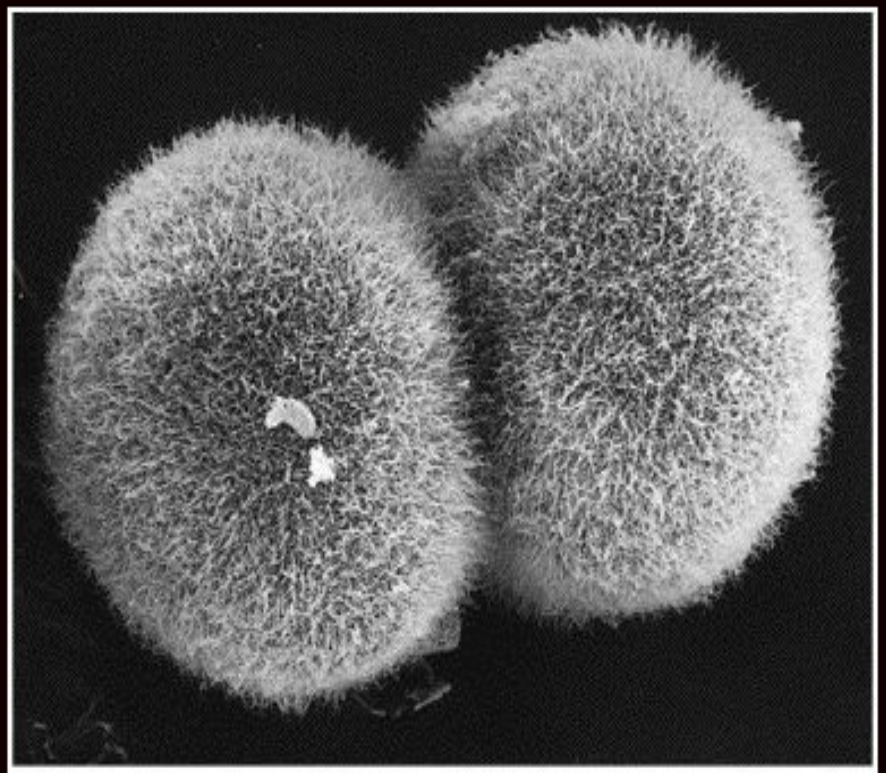
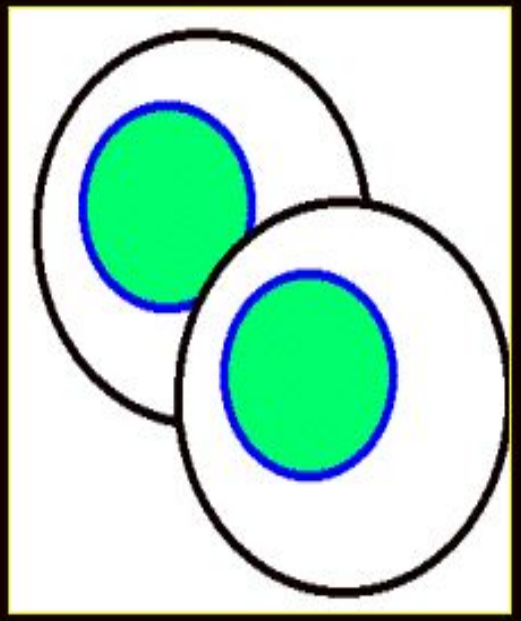


Cytokinesis

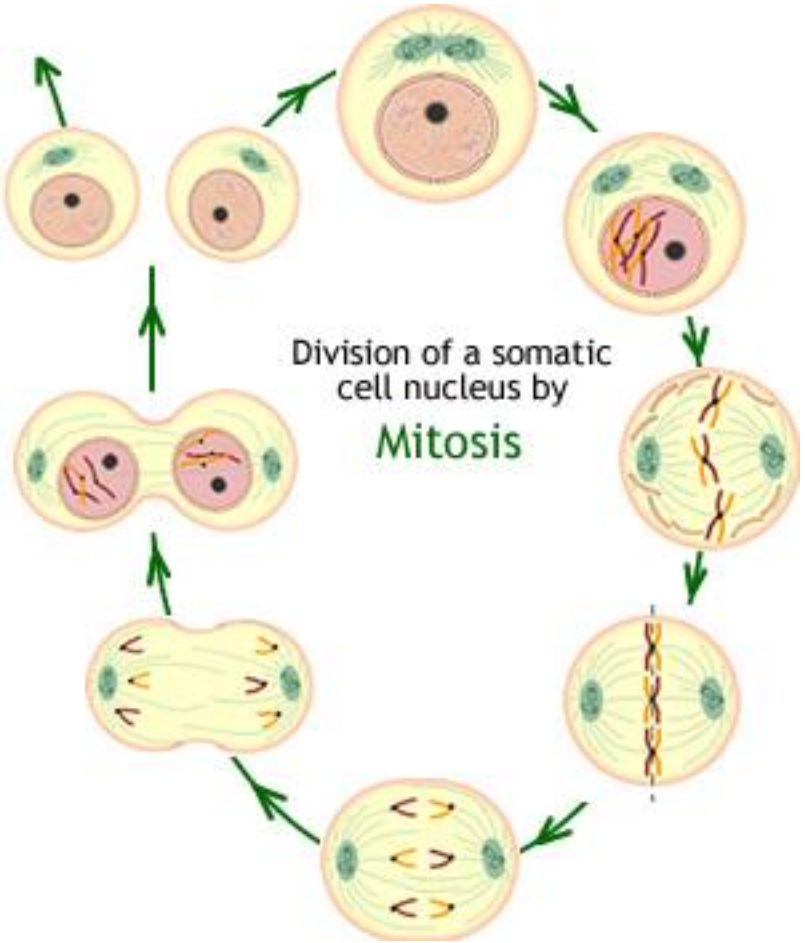
- Mitosis: nuclear division (*karyokinesis*)
- Division of cell cytoplasm after mitosis is known as *cytokinesis*



End



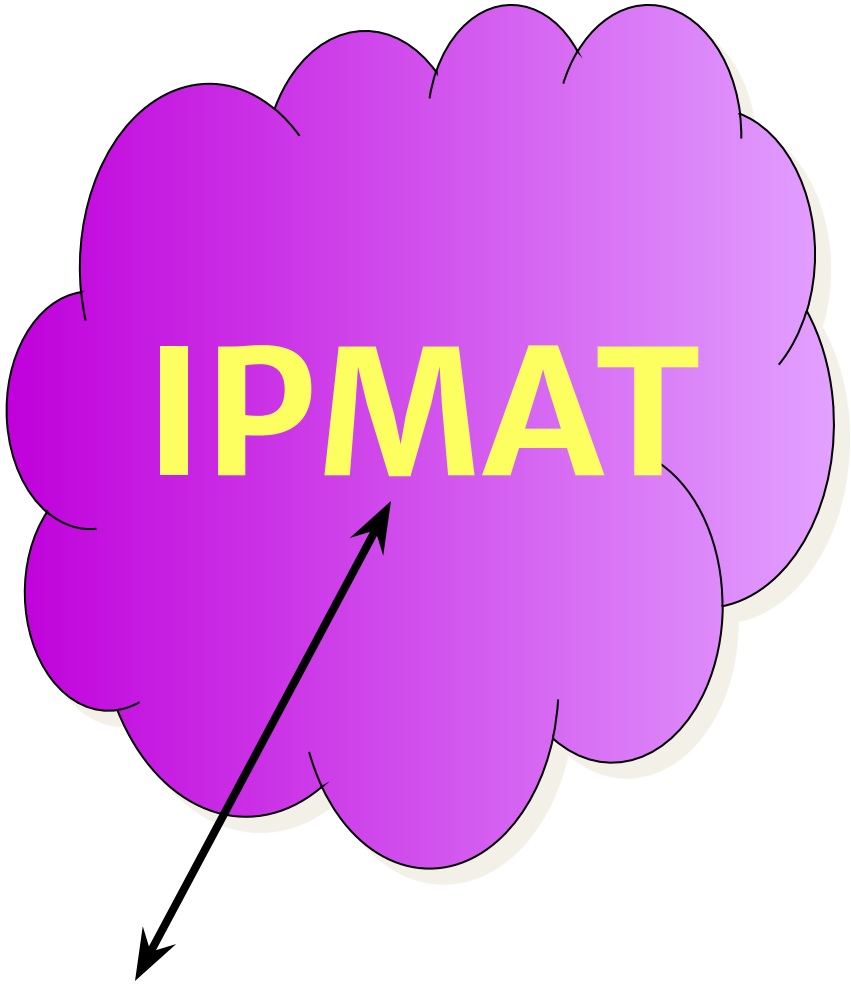
Mitotic Process Is Cyclic



Remember

A mnemonic to help remember the stages of mitosis.

- **I**nterphase
- **P**rophase
- **M**etaphase
- **A**naphase
- **T**elophase

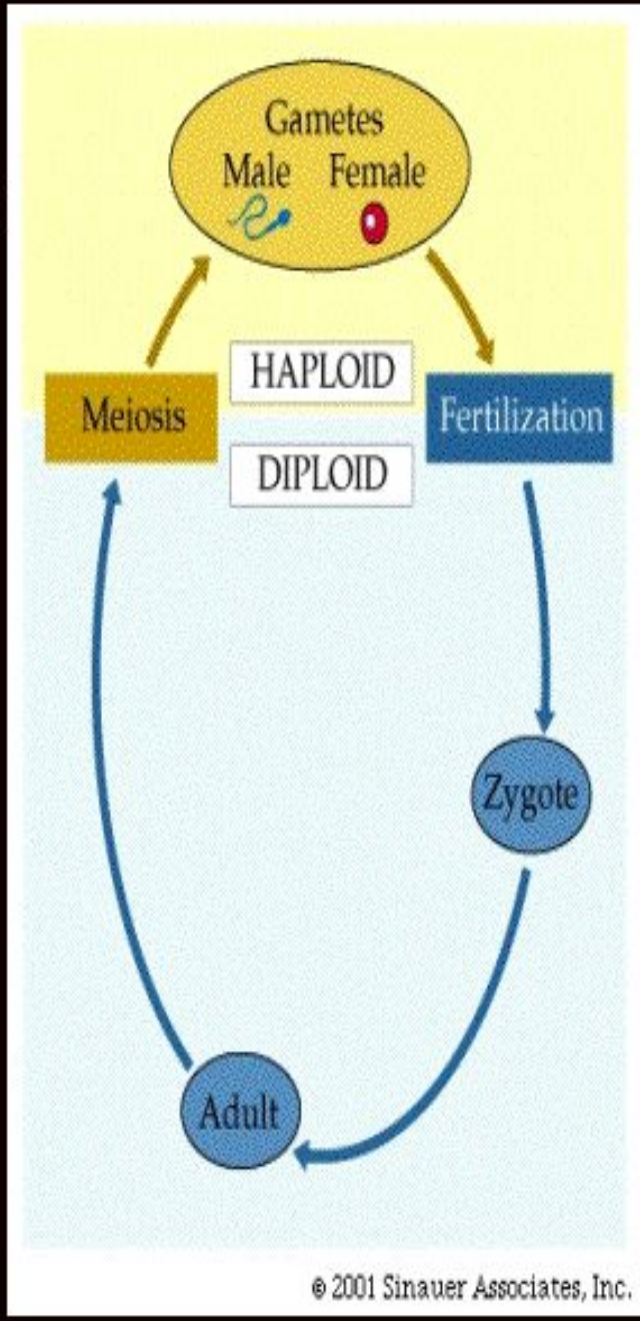


I Pray More And Teach

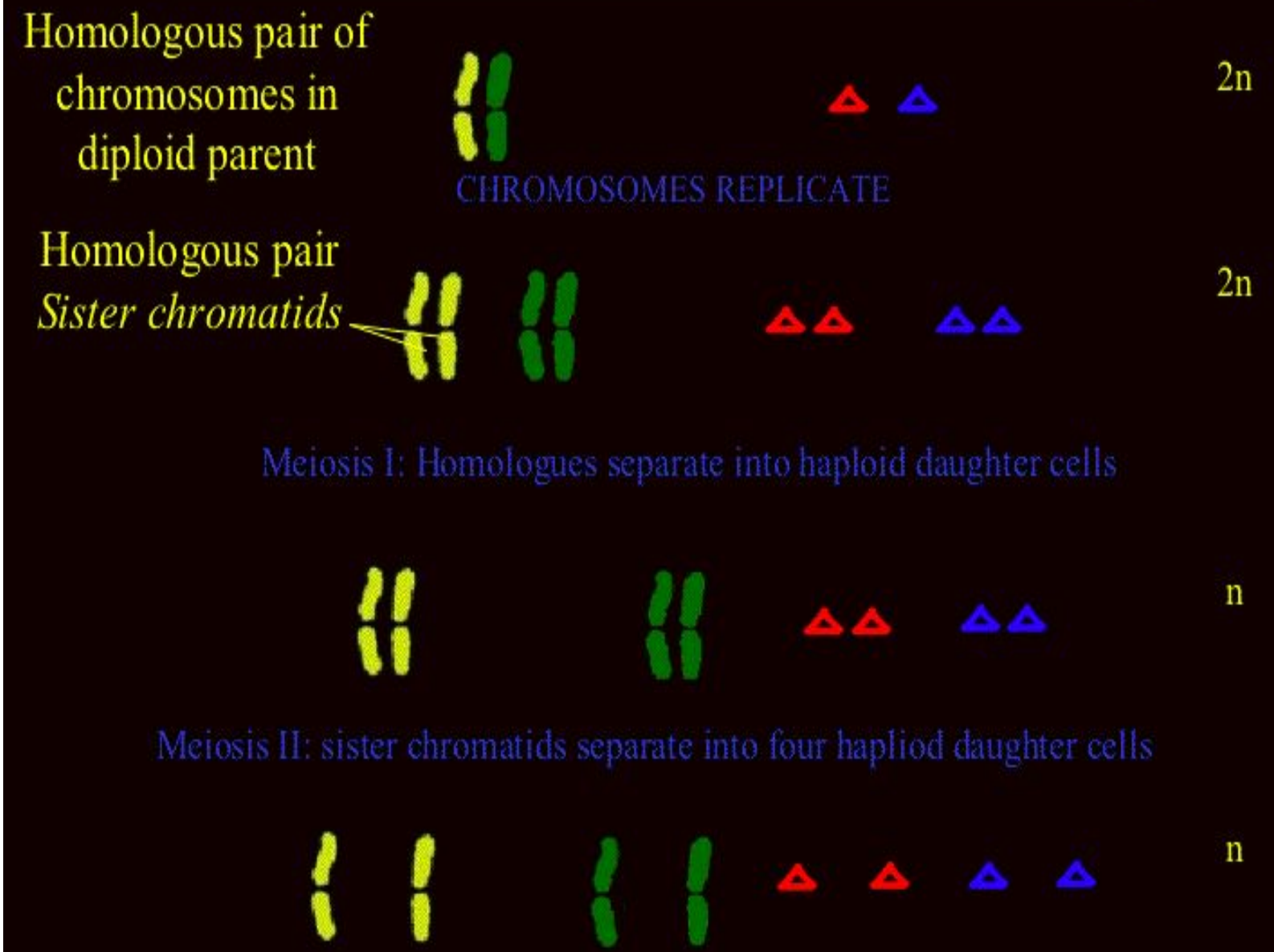
MEIOSIS

Meiosis

- Meiosis is *reductionist division*
- Highly specialized form of mitosis
- Takes place in gonads
- Produces gametes (*sperm and egg*)
  - Gametes are **haploid (n)**
  - Gametes rejoin during fertilization
    - Returns to 2n
    - Sexual fertilization results in greater variation



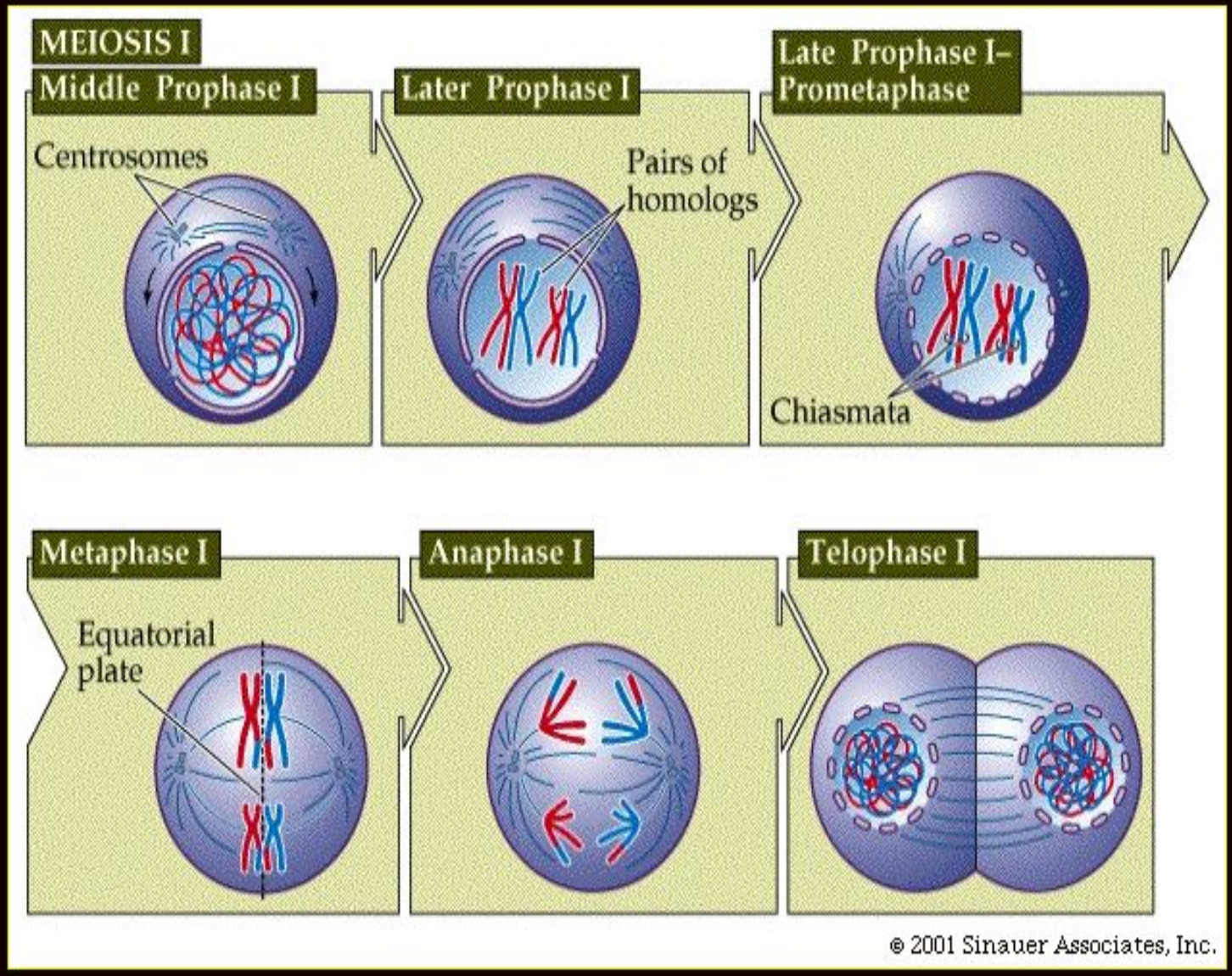
Chromosome number reduction



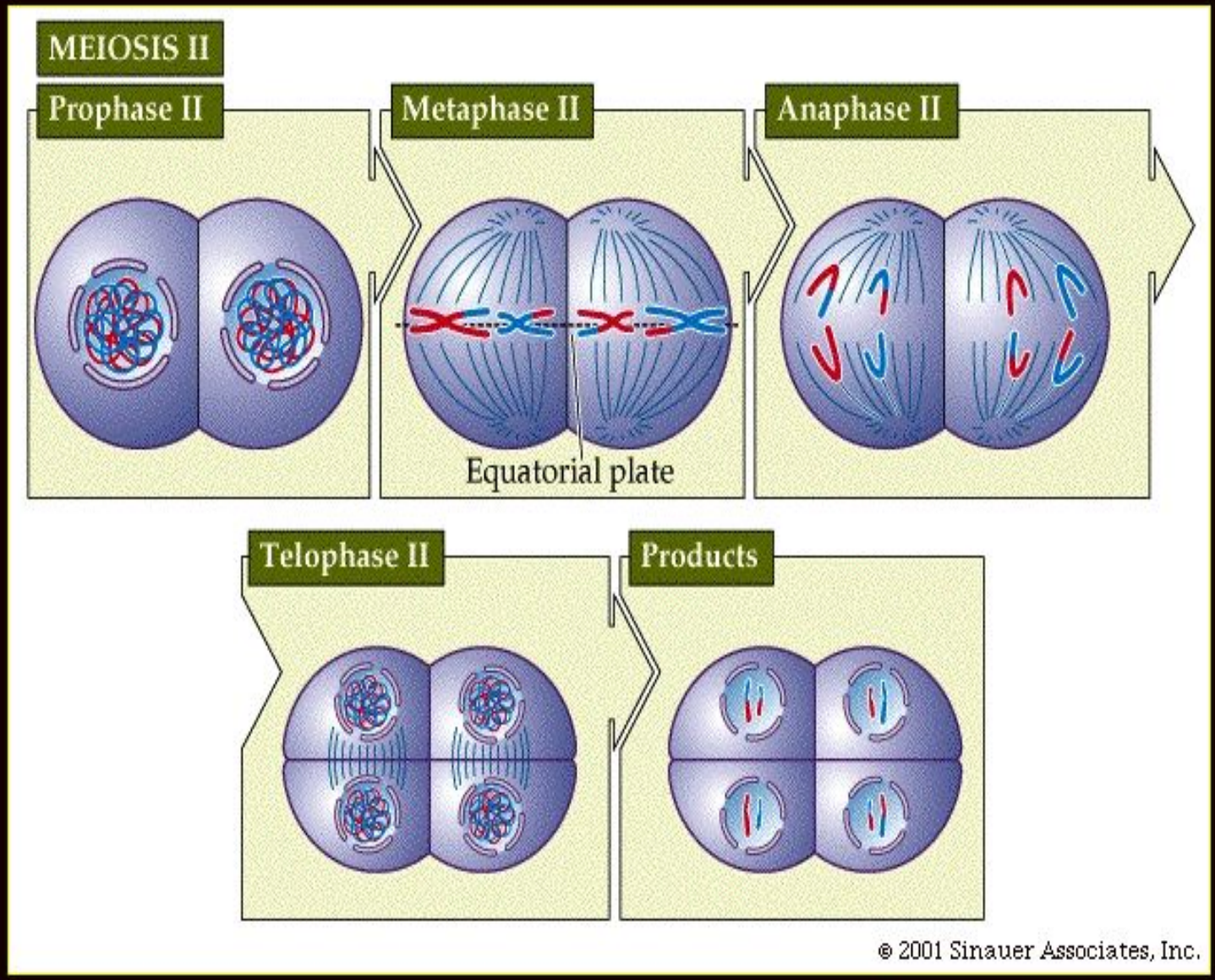
Stages of Meiosis

- **Meiosis I:** reduces chromosome number
  - Prophase I, Metaphase I, Anaphase I, Telophase I
- **Meiosis II:** separates chromatids
  - Prophase II, Metaphase II, Anaphase II, Telophase II
- **Result: four *haploid* daughter cells**

Stages of Meiosis: Meiosis I



Stages of Meiosis: Meiosis II

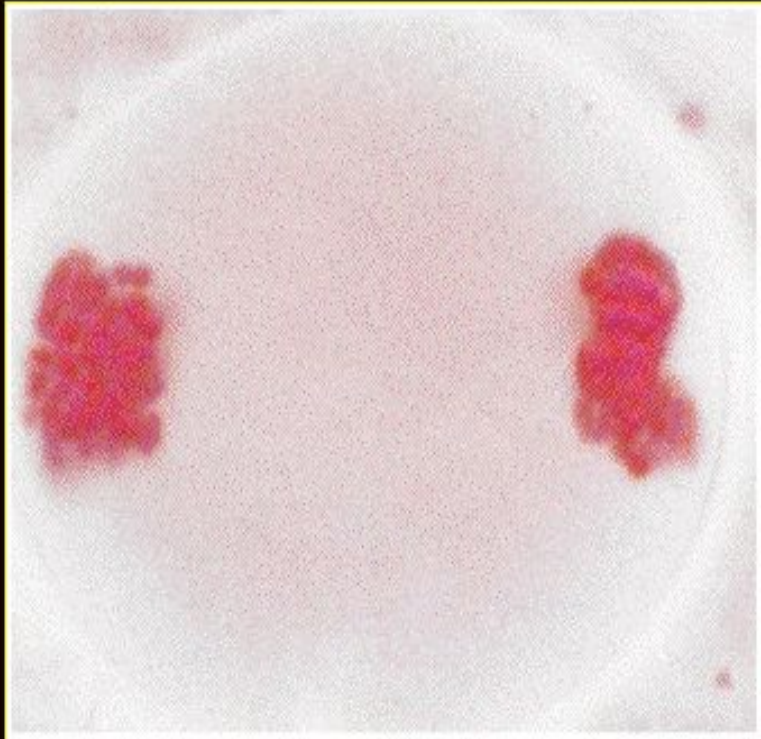


Meiosis I

- **Prophase I**: chromatin condenses, homologous pairs (with copies) align
- **Metaphase I**: homologous pairs (and copies) align at metaphase plate

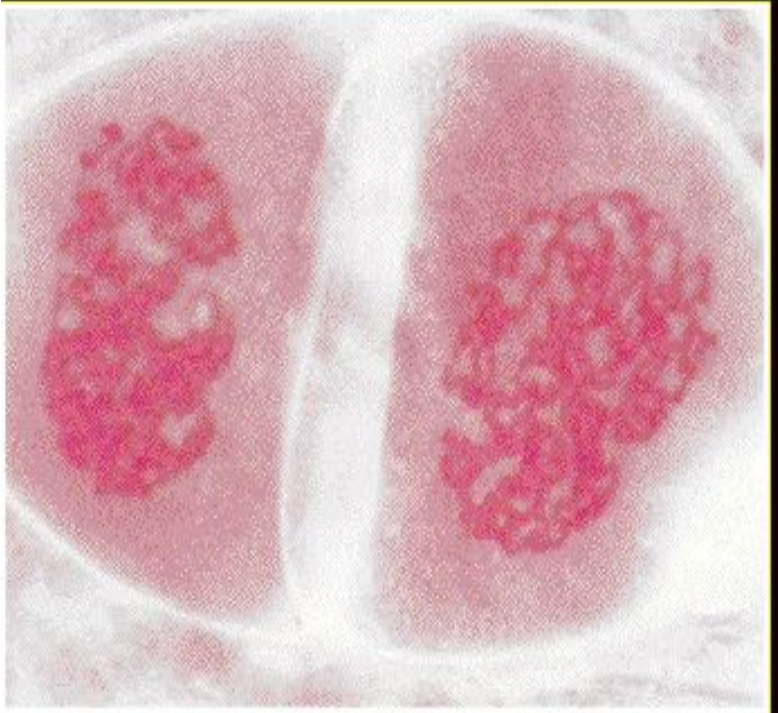
Meiosis I

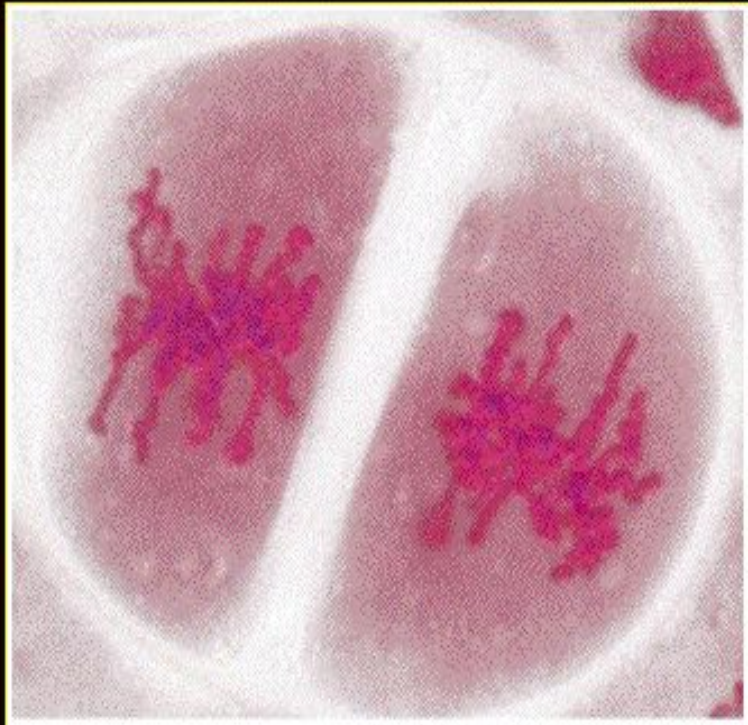
- **Anaphase I**: homologous chromosomes (each with two chromatids) move to opposite ends
- **Telophase I**: chromosomes gather into nuclei, original cell divides



Meiosis II

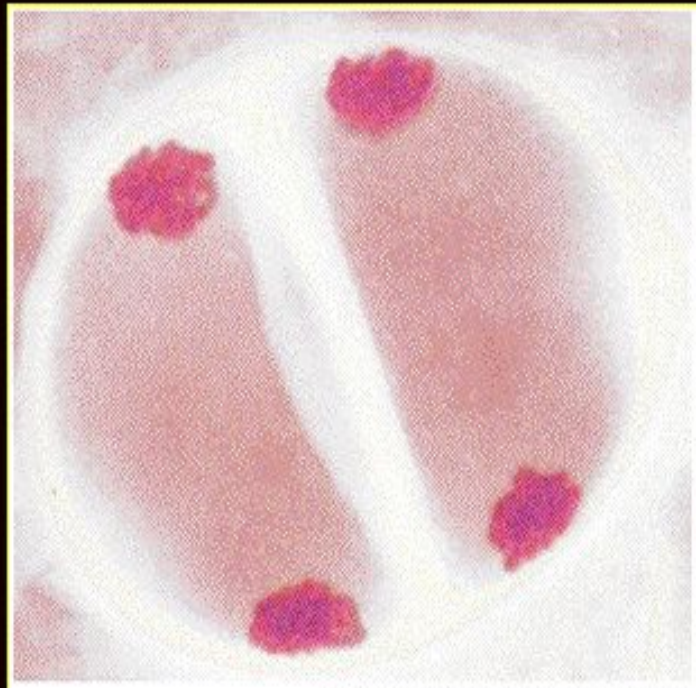
- Interphase with *no DNA replication* (interkinesis)
- **Prophase II**: chromosomes condense again
- **Metaphase II**: kinetochores of paired *chromatids* align at metaphase plate





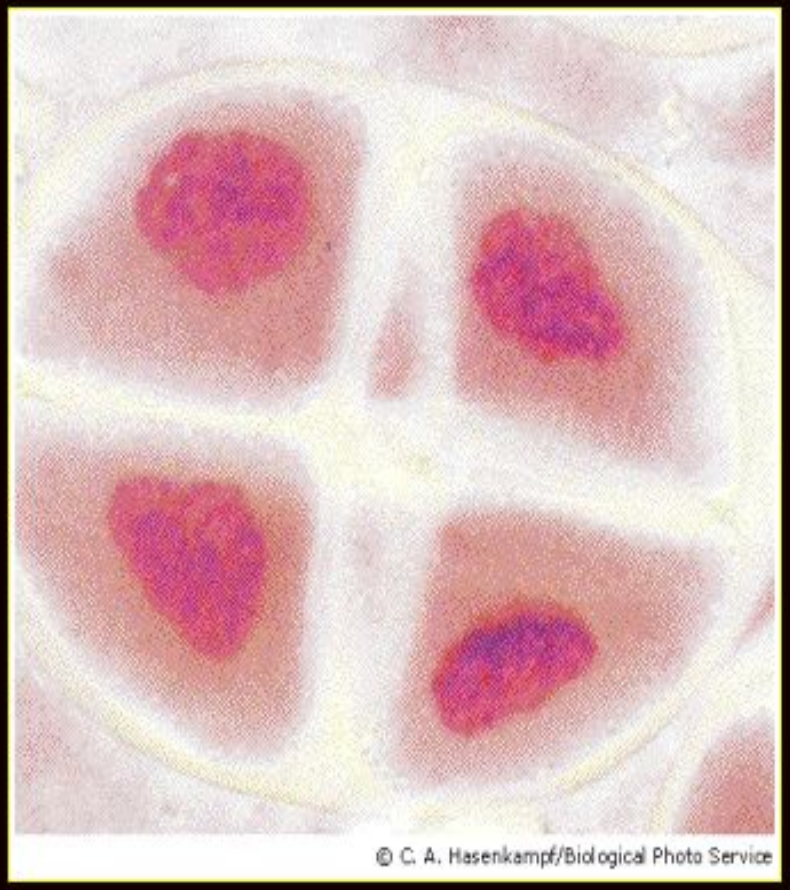
Meiosis II

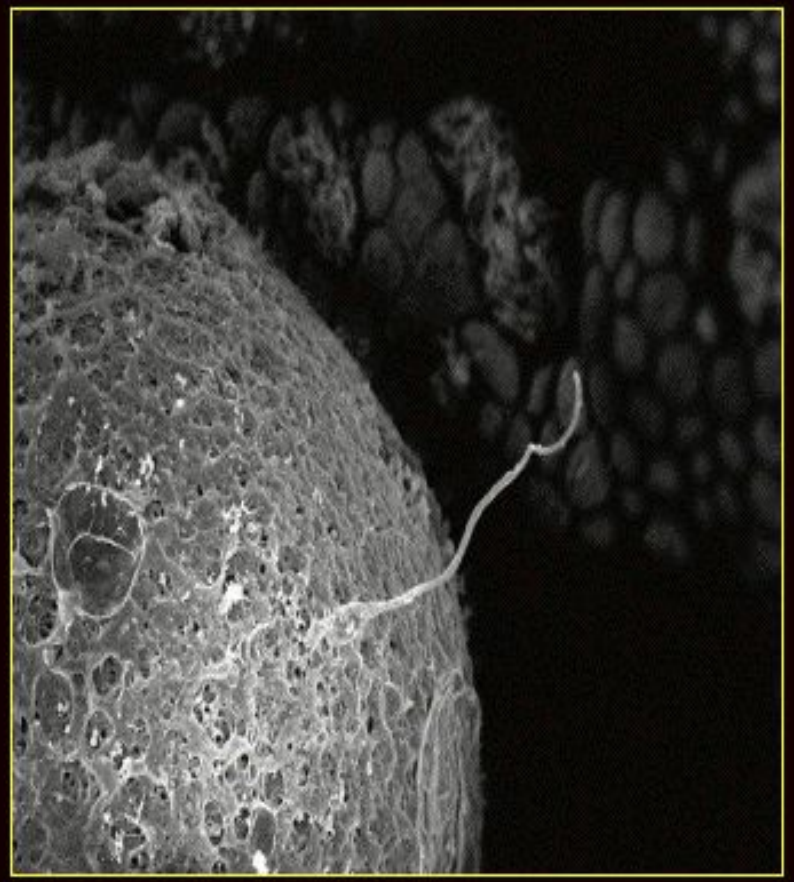
- **Anaphase II**: *chromatids* separate to opposite poles *(=> chromosomes)*
- **Telophase II**: *chromatids* gather into nuclei, cells divide



Results

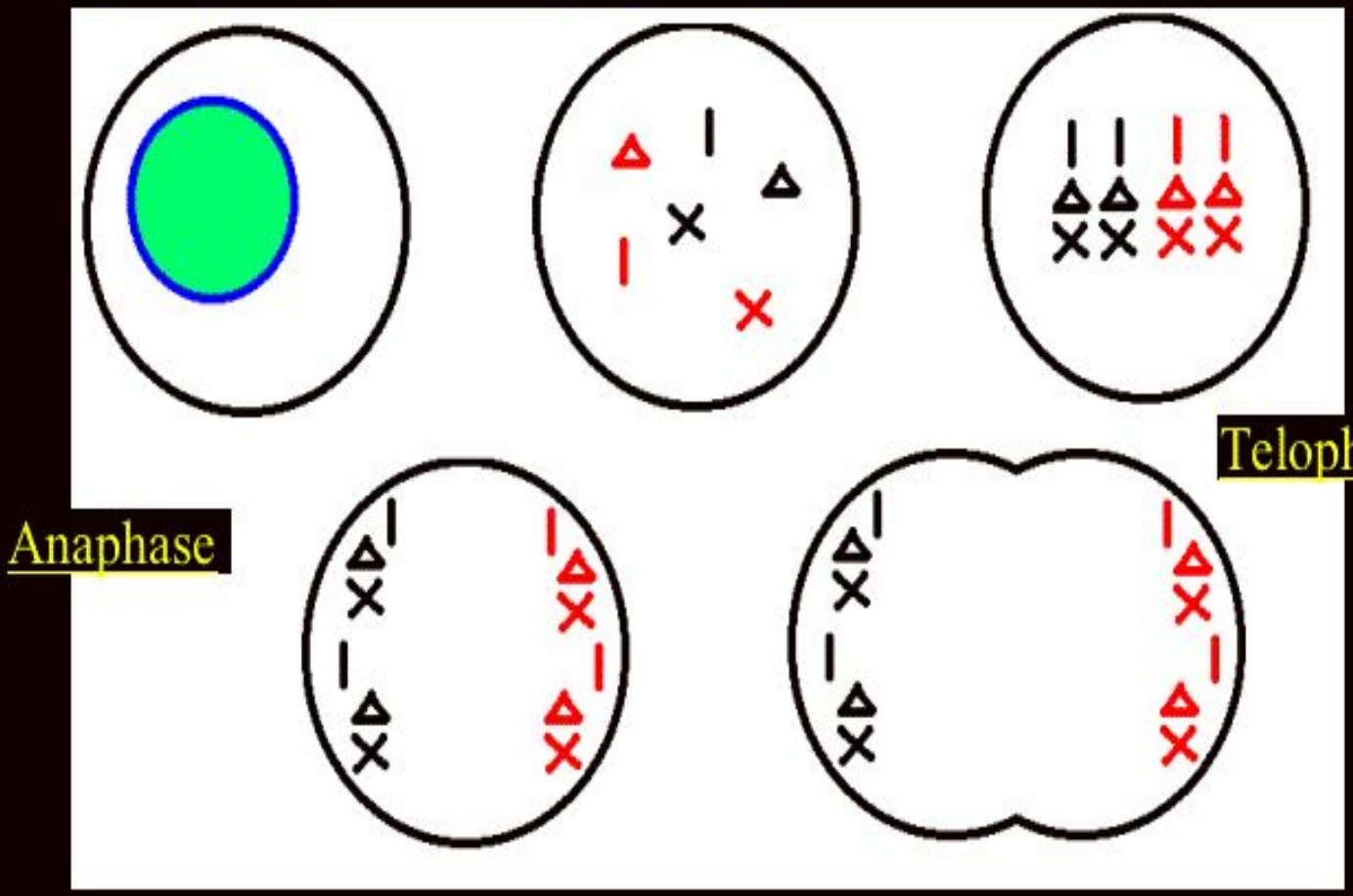
- Gametes are **haploid (n)** – half as many chromosomes as parent cell





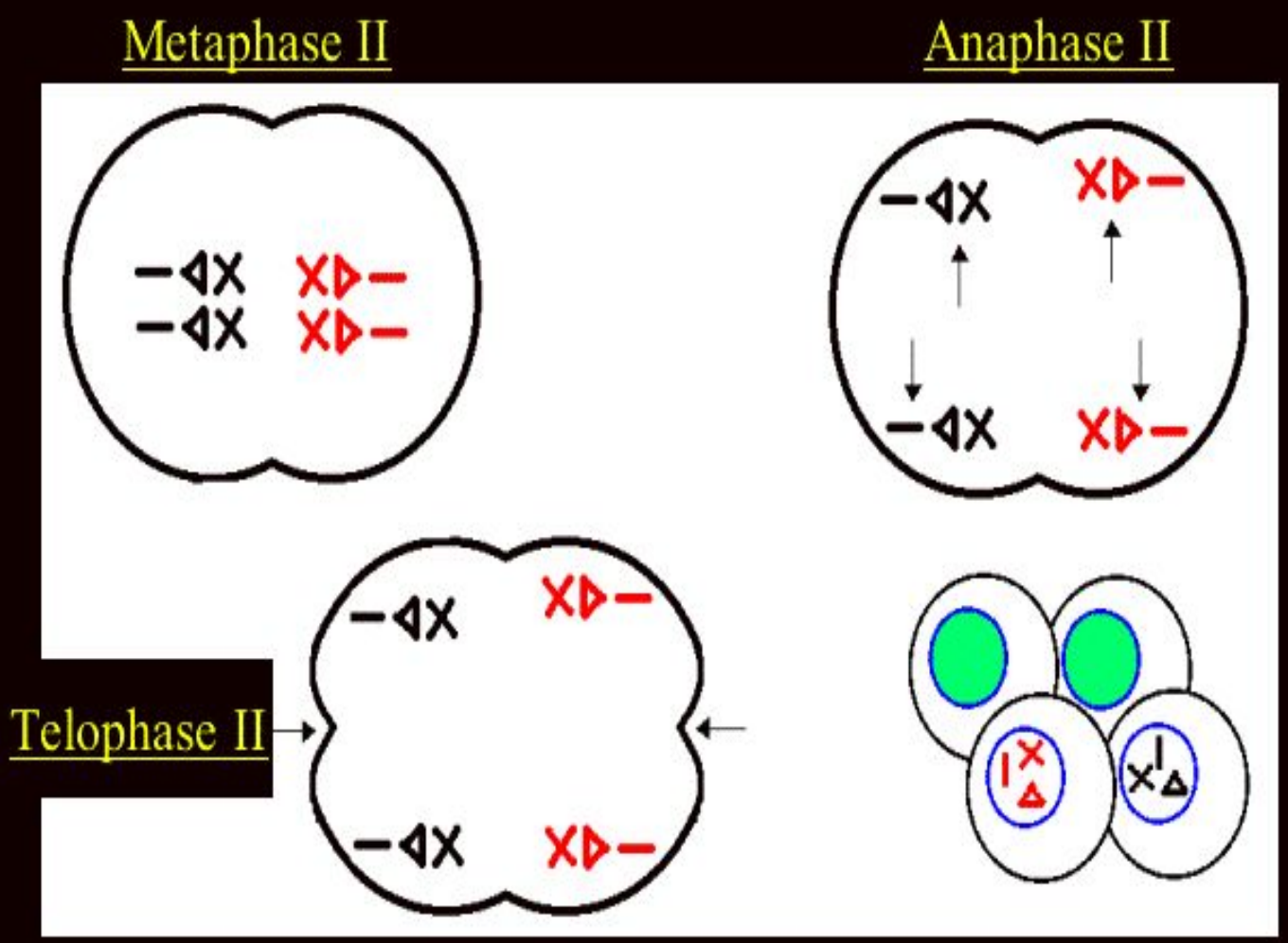
Overview

- **Meiosis I (2n=6)**

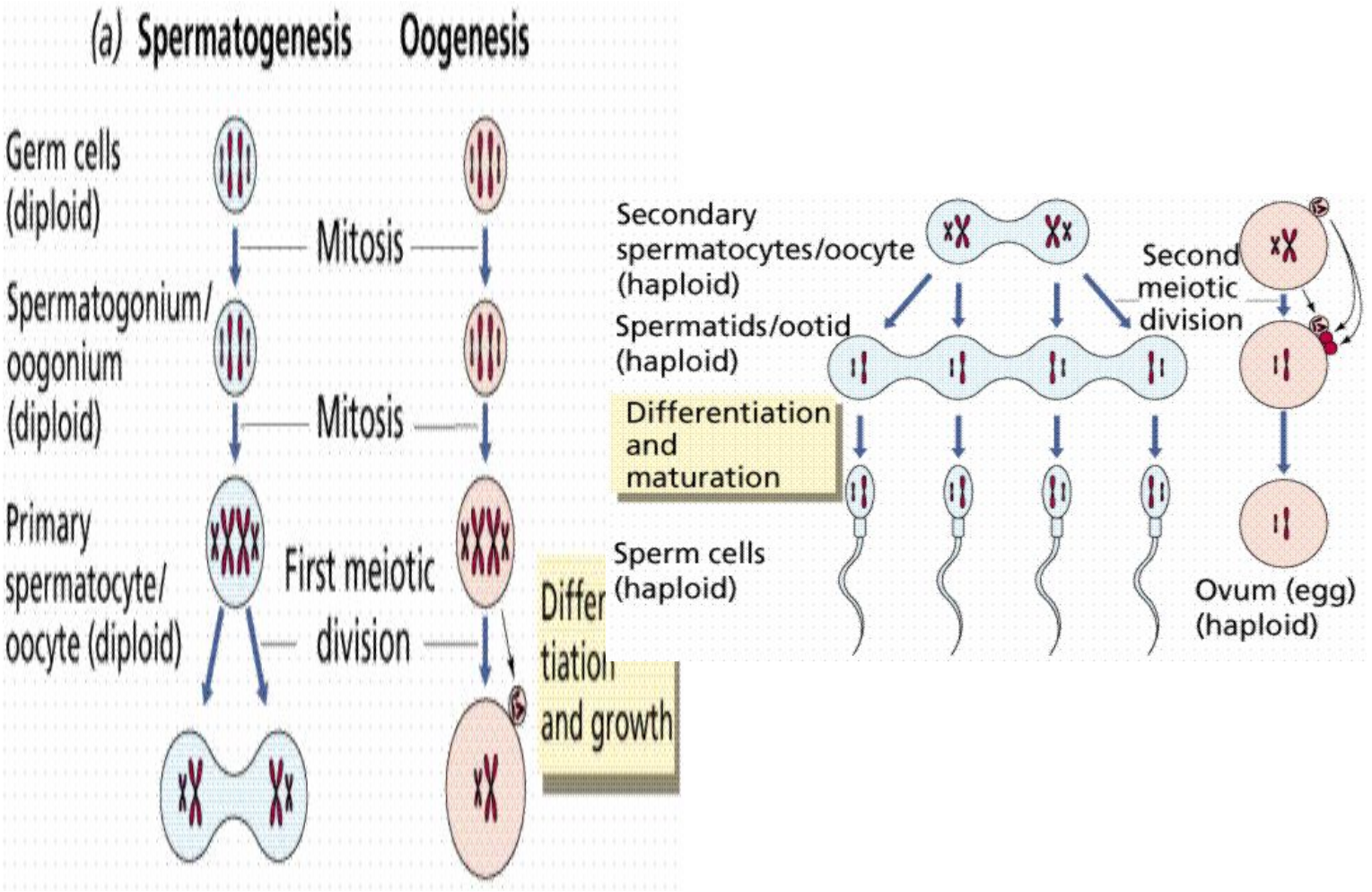


Overview

- Meiosis II (result: n=3)

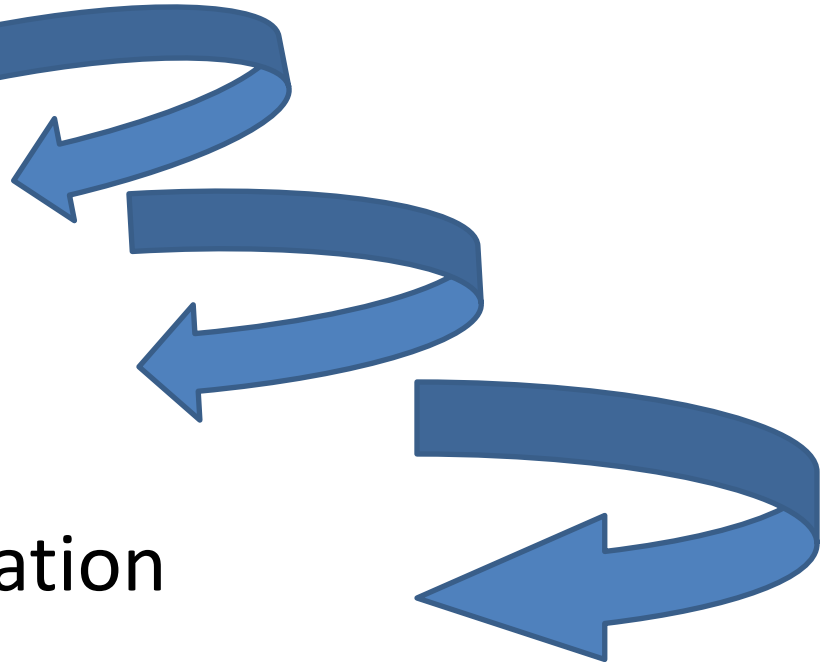


Production Of Gametes



What Next After Gamete Formation

- Fertilization or fusion or Syngamy of the gametes
- Zygote formation.
- Embryo development.
- Individual progeny formation



Kindly name the stages A to P