SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

Accredited by NBA-AICTE and Accredited by NAAC – UGC with A+ Grade

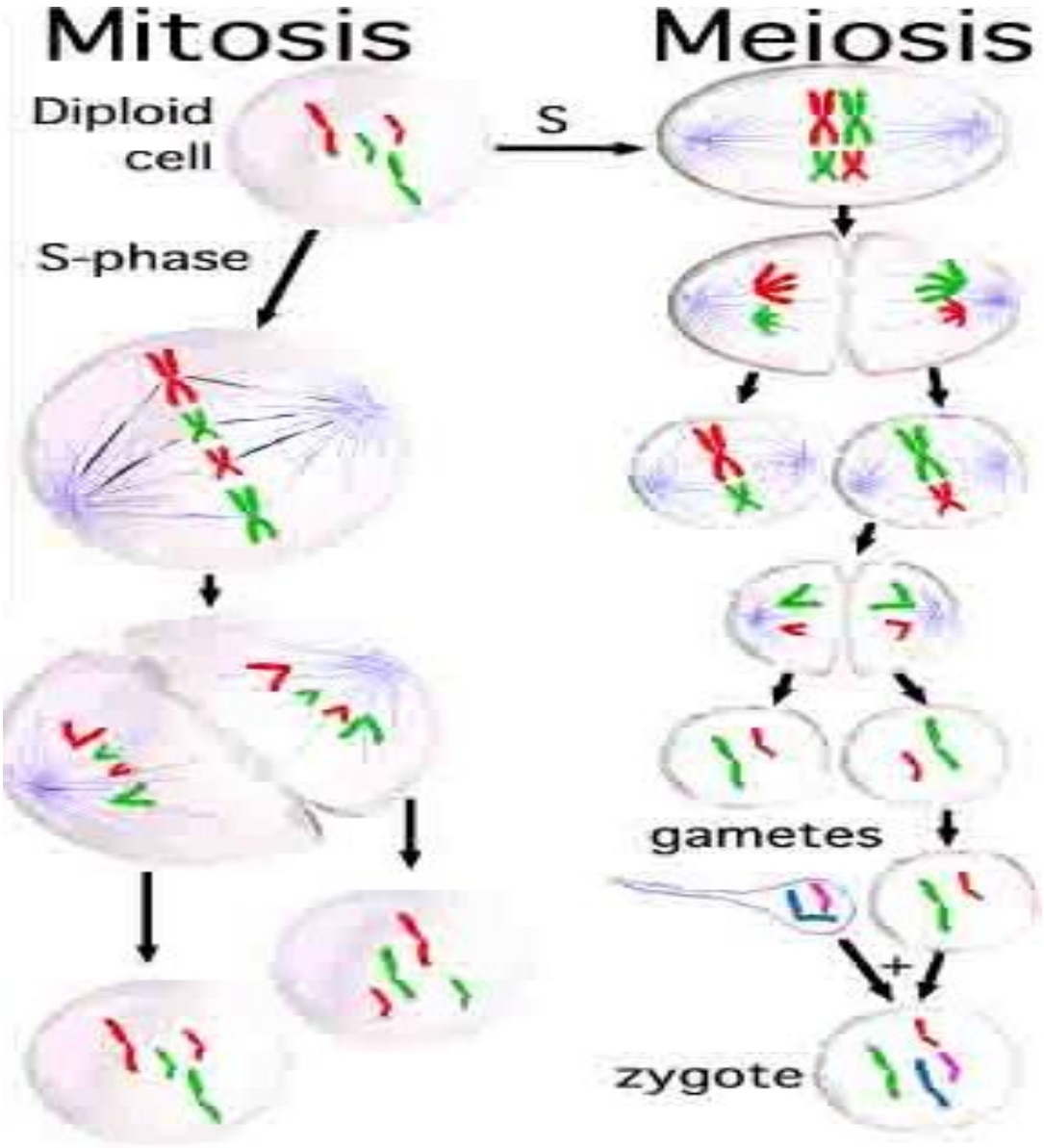
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

19GET277 / Biology For Engineers

IV YEAR / VII SEMESTER

UNIT-III: GENETICS AND IMMUNE SYSTEM

MITOSIS AND MEIOSIS



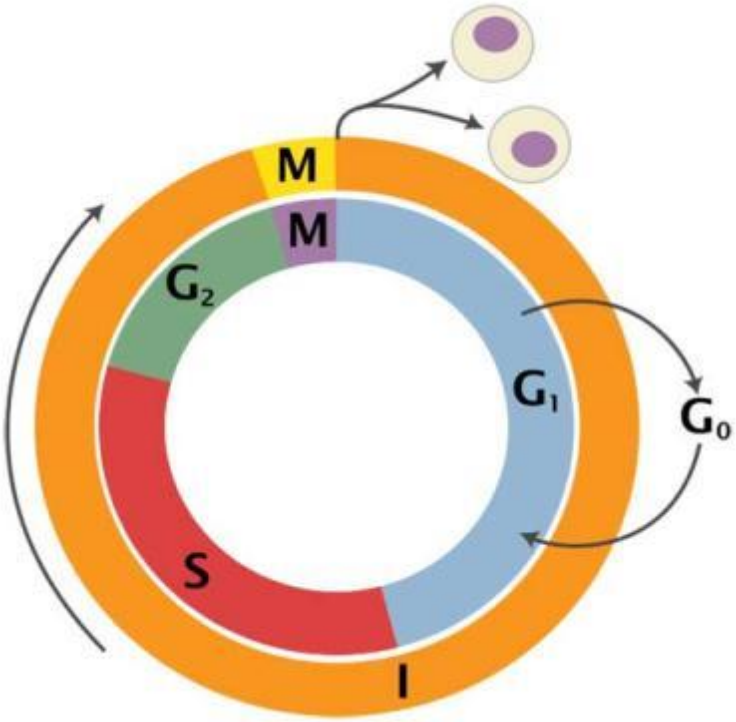
Cell Division

Mitosis & Meiosis

Image: Cell Division, Wikipedia

Eukaryotic Cell Cycle

– Cell grows.
– DNA is replicated.
– Mitotic cell division produces daughter cells identical to the parent.
– Repeat.



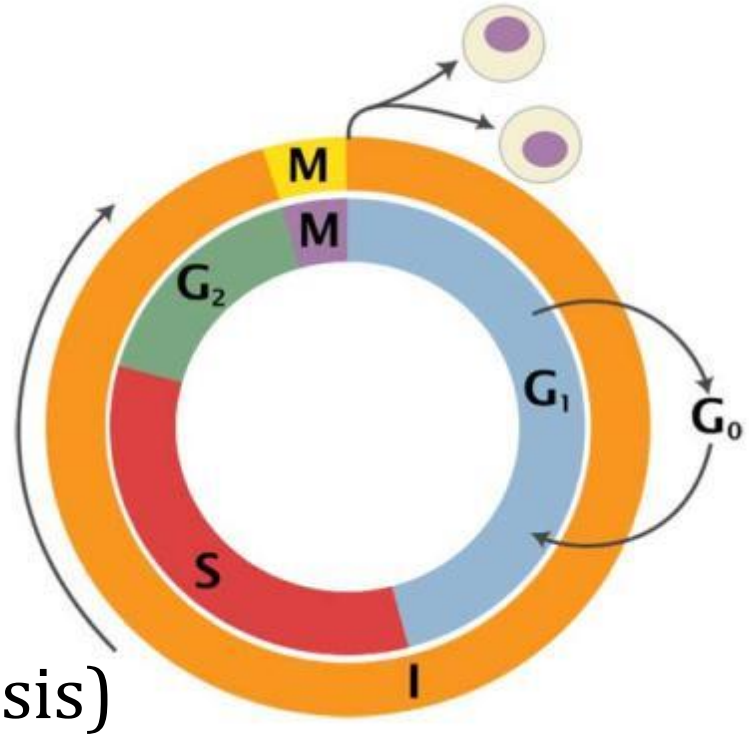
The timing of replication and cell division is highly regulated.

Image: Cell cycle by Richard Wheeler

Eukaryotic Cell Cycle

2 major phases:

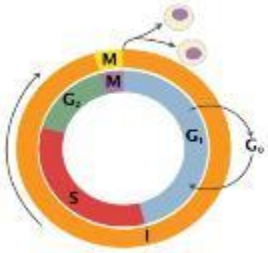
- **Interphase** (3 stages)
  - DNA is not condensed



- **Mitosis** (4 stages + cytokinesis)
  - Nuclear division & division of cytoplasm
  - DNA condensed

Image: Cell cycle by Richard Wheeler

From the Virtual Cell Biology Classroom on ScienceProfOnline.com



Interphase

Non-dividing state with 3 sub-stages:

Gap 1 – cell grows in size
– organelles replicated

Synthesis – replication of DNA
– synthesis of proteins associated with DNA

Gap 2 – synthesis of proteins associated with mitosis

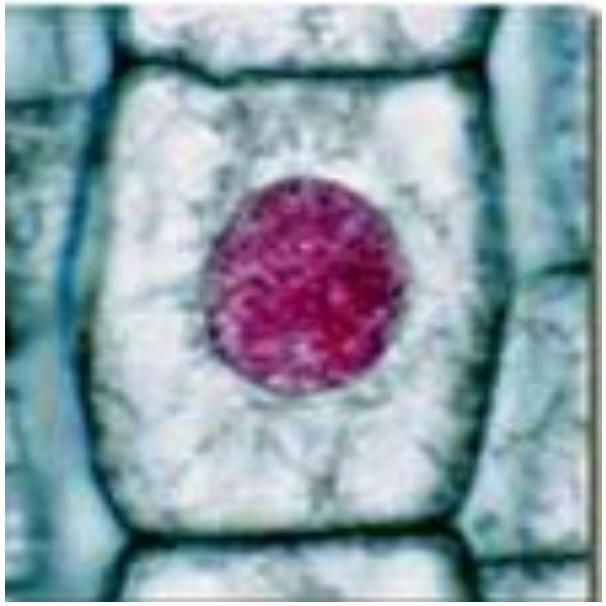
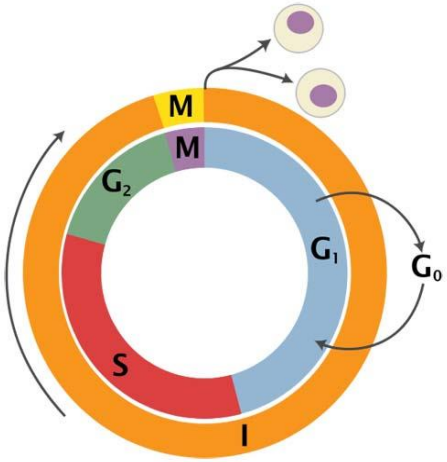


Image: Cell cycle by Richard Wheeler; Interphase in Onion Cell Drawing & Photo, Source Unknown

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

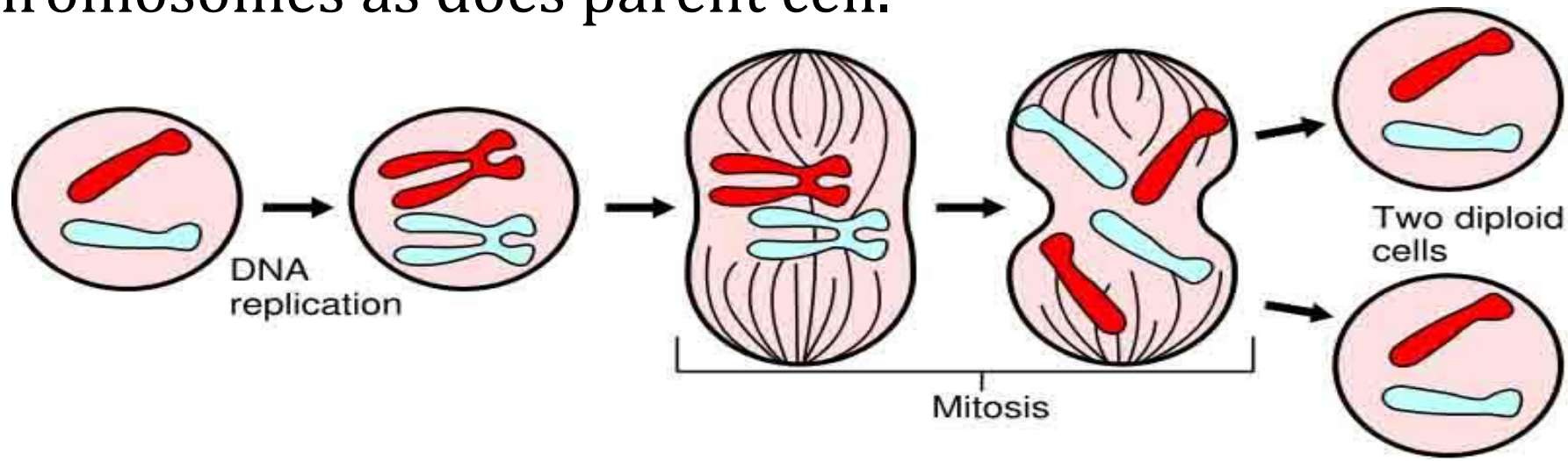
Mitosis

Division of **somatic** cells (non-reproductive cells) in eukaryotic organisms.



A single cell divides into two identical daughter cells.

Daughter cells have same number of chromosomes as does parent cell.



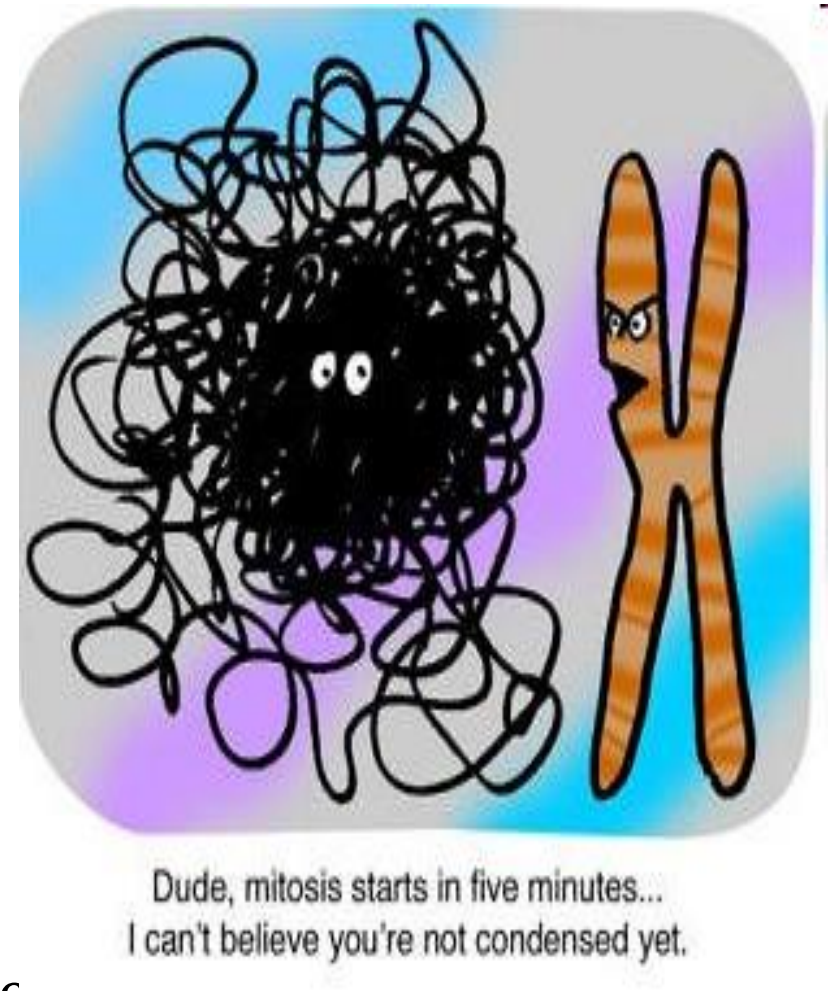
Packing for the move…

When the cell is not dividing…

- DNA molecules are in extended, uncondensed form = **chromatin**
- Cell can only replicate and transcribe DNA when it is in the extended state.

When the cell is preparing for division…

- DNA molecules condense to form **chromosomes** prior to division.
  - each chromosome is a single molecule of DNA
  - easier to sort and organize the replicated DNA into daughter cells



Mitosis

4 sub-phases:

1st – Prophase

2nd – Metaphase

3rd – Anaphase

4th – Telophase

followed by

Cytokinesis

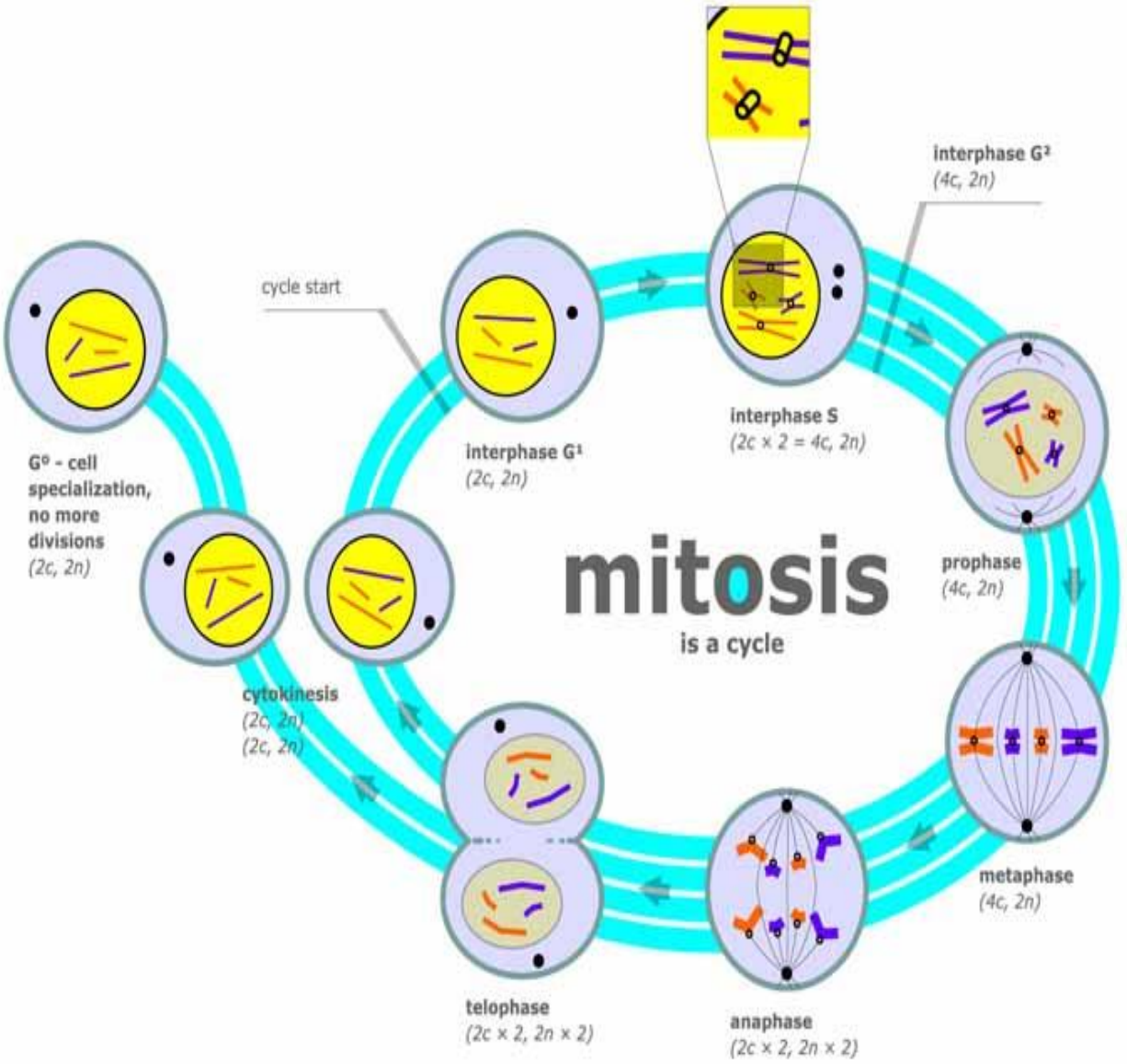
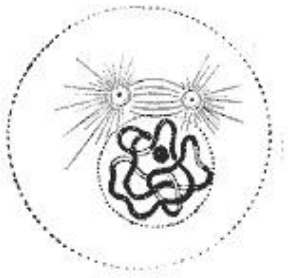
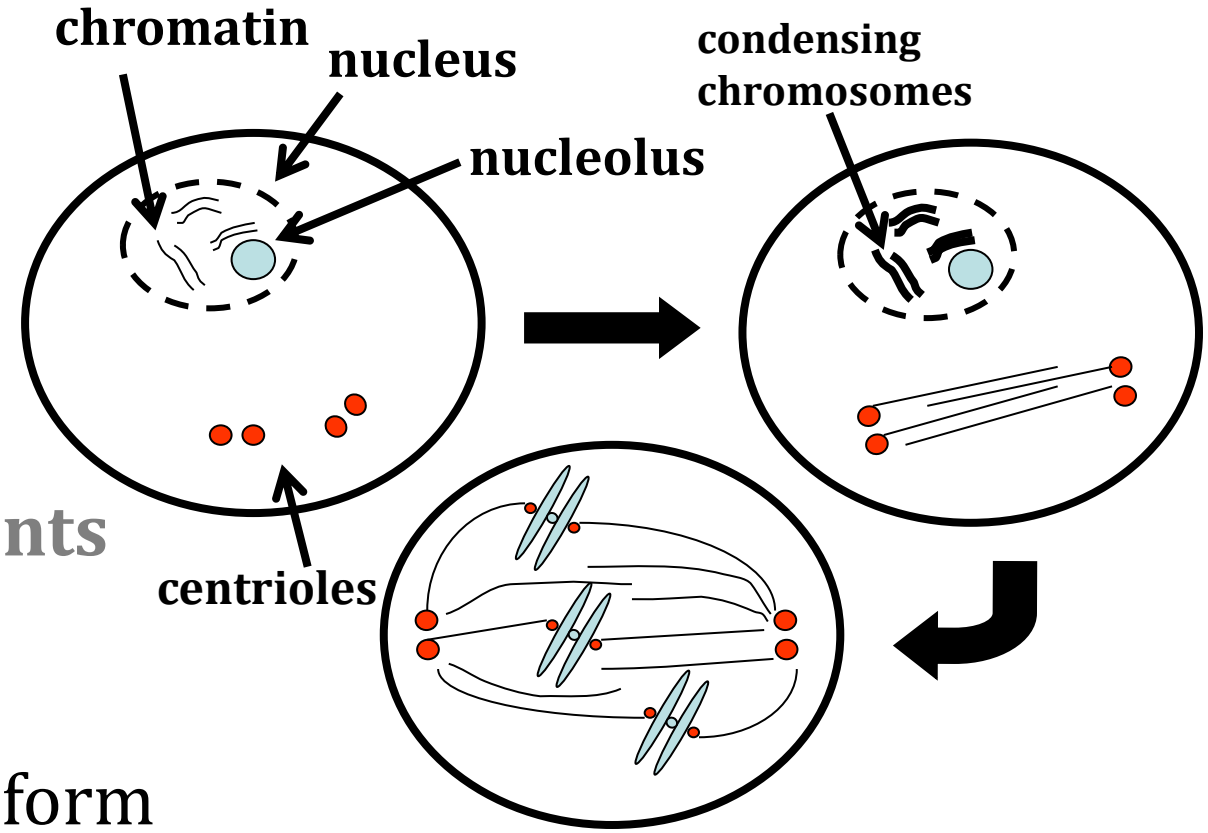


Image: Mitosis diagram, Marek Kultys

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

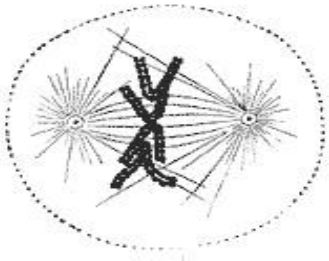


1. Prophase

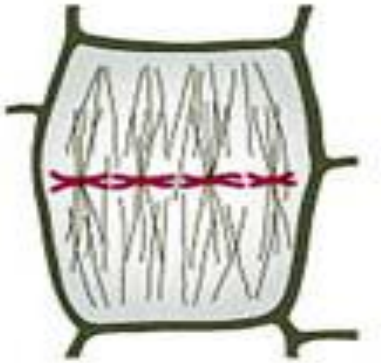


Three Major Events

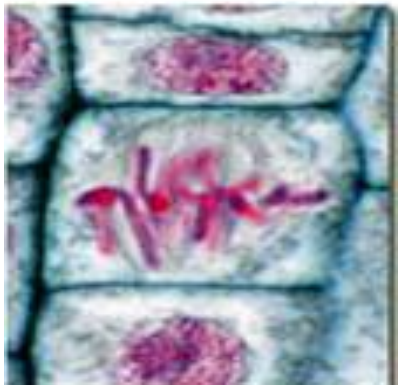
1. chromosomes condense
2. spindle fibers form
    1. (spindle fibers are specialized microtubules radiating out from centrioles)
3. chromosomes are captured by spindle

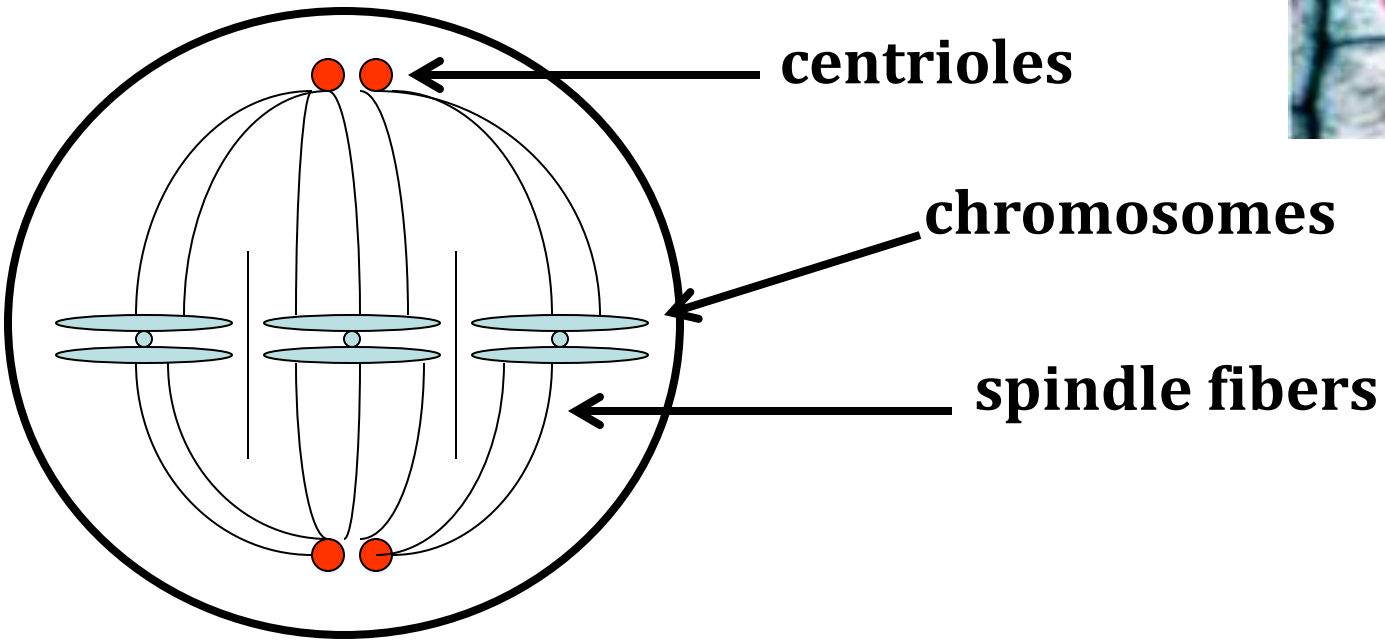


2. Metaphase

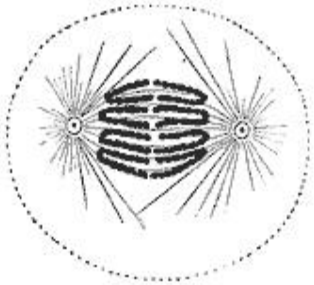


- chromosomes align along the equator of the cell, with one chromatid facing each pole

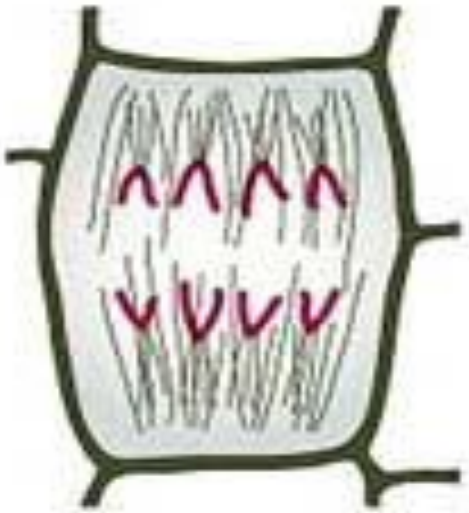




Images: Metaphase drawing, Henry Gray's Anatomy of the Human Body; Metaphase Onion Cell Drawing & Photo, Source Unknown

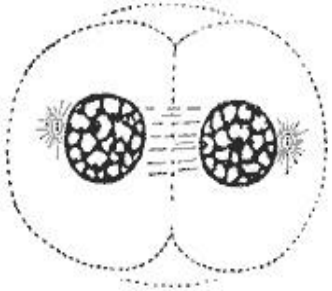


3. Anaphase



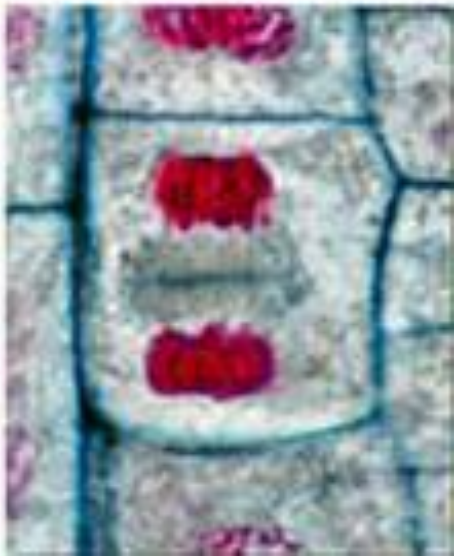
- sister chromatids separate
- spindle fibers attached to kinetochores **shorten** and **pull** chromatids towards the poles.
- free spindle fibers **lengthen** and **push** the poles of the cell apart

Images: Anaphase drawing, Henry Gray's Anatomy of the Human Body; Anaphase Onion Cell Drawing & Photo, Source Unknown

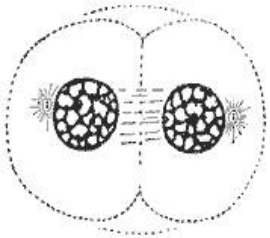


4. Telophase

- spindle fibers disintegrate
- nuclear envelopes form around both groups of chromosomes
- chromosomes revert to their extended state
- cytokinesis occurs, enclosing each daughter nucleus into a separate cell



Images: Telophase drawing, Henry Gray's Anatomy of the Human Body; Telophase Onion Cell Drawing & Photo, Source Unknown



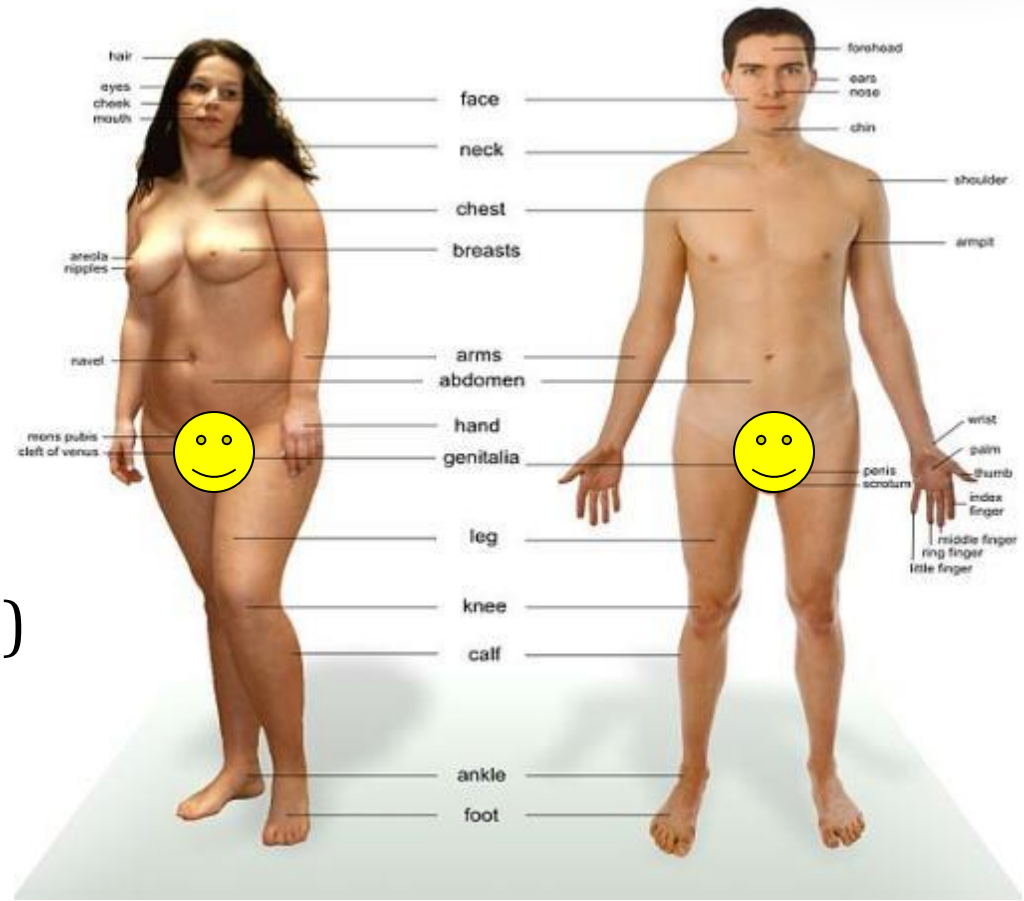
Cytokinesis – Plant vs. Animal Cell

- **Plant cells** undergo cytokinesis by forming a cell plate between the two daughter nuclei.
- **Animal cells** undergo cytokinesis through the formation of a cleavage furrow. A ring of microtubules contract, pinching the cell in half.

Images: Telophase drawing, Henry Gray's Anatomy of the Human Body; Ciliate dividing, TheAlphaWolf; Telophase Onion Cell Photo, Source Unknown

Genetics Terminology

SEXually reproducing eukaryotes have two types of body cells…



1. **somatic cells**

2. **sex cells**
(a.k.a. gametes, germline)

Image: Superficial human anatomy, Mikael Häggström& Rainer Zenz; Sperm & egg, Wikipedia

What is cell division of gametes called?

Meiosis

- A single germ cell divides into four unique daughter cells.

- Daughter cells have half the # of chromosomes as parent cell, so they are considered **haploid**.

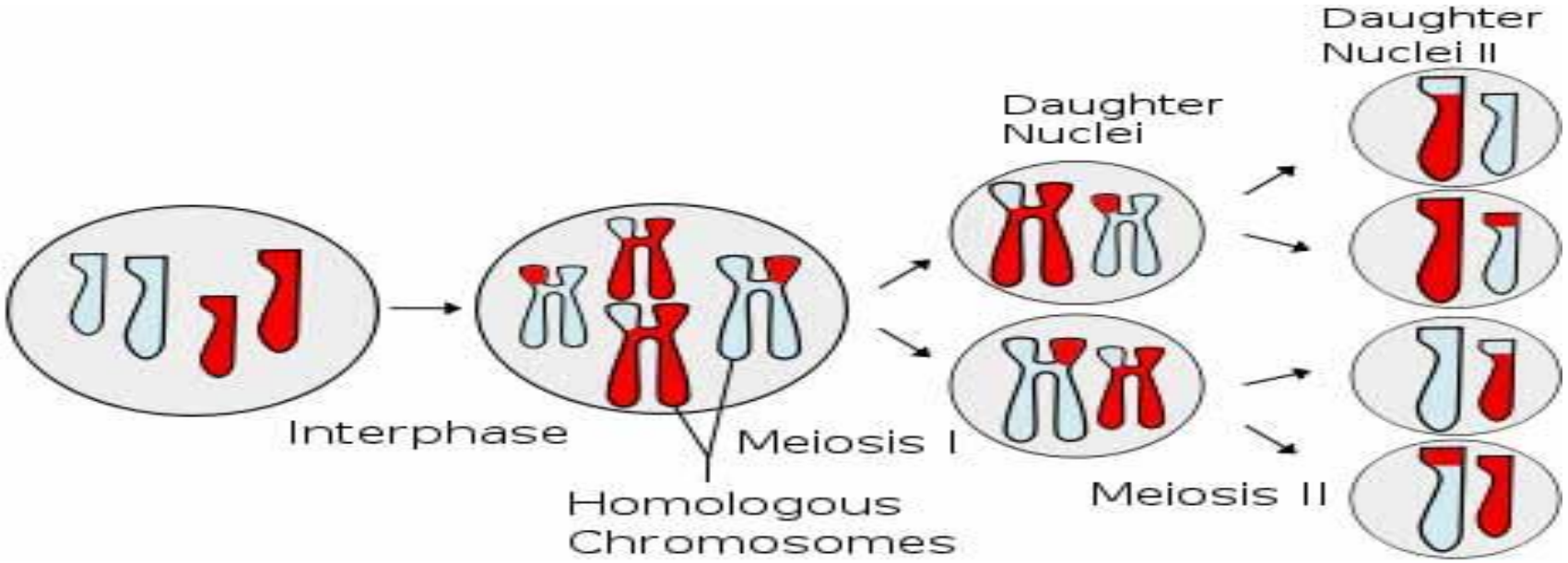


Image: Overview of Meiosis, National Institutes of Health

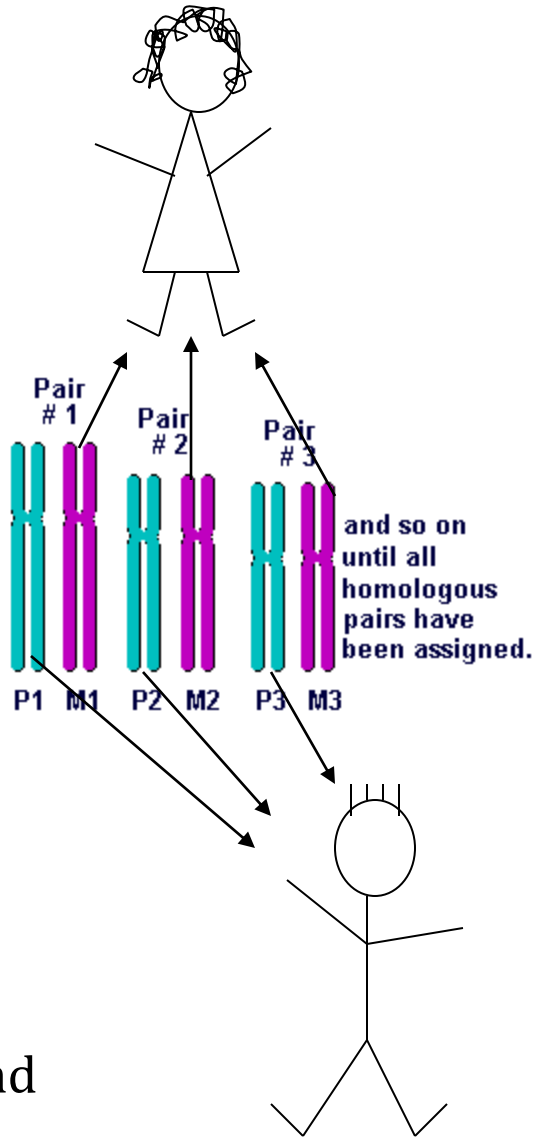
Genetics Terminology: Ploidy

Refers to the number of sets of chromosomes in cells.

- **Haploid** – one copy of each chromosome
  - designated as "n", the number of chromosomes in one "set"
  - gametes

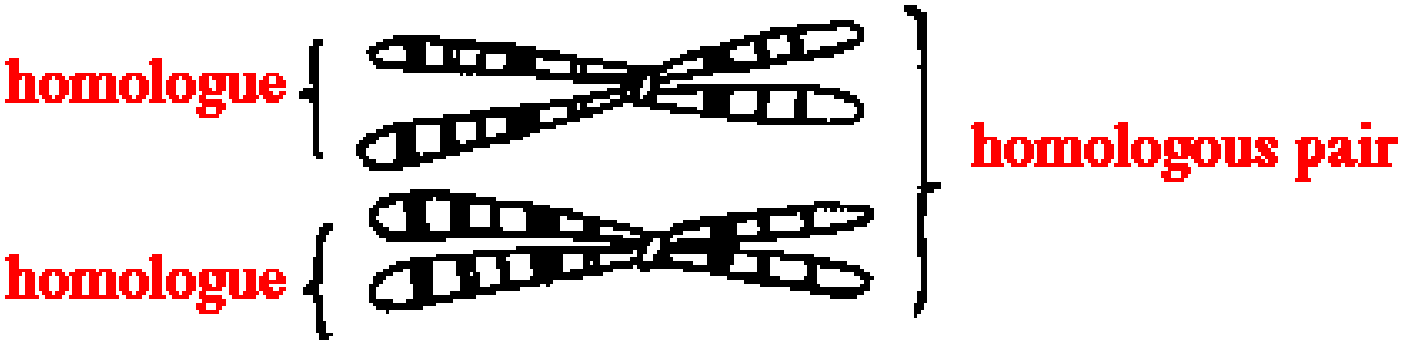
- **Diploid** – two sets of chromosomes (two of each chromosome)
  - designated as "2n"
  - somatic cells

Diploid organisms receive one of each type of chromosome from female parent (maternal chromosomes) and one of each type of chromosome from male parent (paternal chromosomes)



Genetics Terminology: Homologues

Chromosomes exist in homologous pairs in diploid (2n) cells.

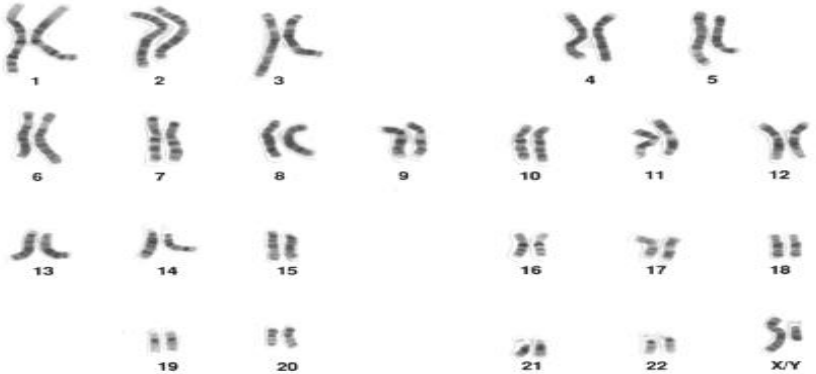


Exception: **Sex chromosomes** (X, Y).

All other chromosomes (**autosomes**) have homologues.

Karyotype

- **Q:** How many homologous pairs are in each karyotype?
- **Q**: How is the bottom karyotype different from the top two?



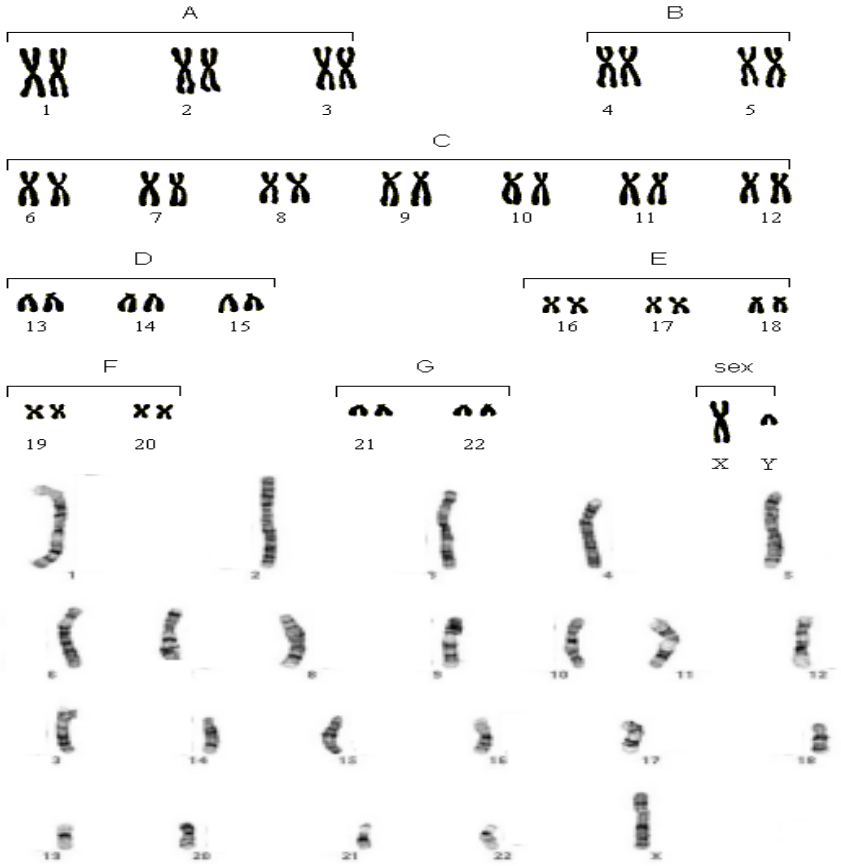


Image: Karyotype, National Human Genome Research Institute

Sexual Reproduction

- Fusion of two **gametes** to produce a single zygote.
- Introduces greater genetic variation, allows genetic recombination.
- Zygote has gametes from two different parents (except in cases of self-fertilizing organisms).

Rose + Greg = Steven

Images: Rose, Greg, and Steven, Steven Universe

Sexual reproduction in humans …

- At fertilization, 23 chromosomes are donated by each parent.

  (total = 46 or 23 pairs).

- **Gametes** (sperm/ova):
  - Contain 22 autosomes and 1 sex chromosome.
  - Are haploid (haploid number *"n" = 23 in humans*).

- Fertilization results in diploid zygote.
  - Diploid cell; *2n = 46*. (*n = 23 in humans*)

- **Q**: Most cells in the body are produced through what type of cell division? (Remember, only *gametes* are produced through **meiosis**)

Image: Superficial human anatomy, Mikael Häggström& Rainer Zenz; Sperm & egg, Wikipedia

Meiosis - Sex Cell (Gamete) Formation

In meiosis, there are **2** divisions of the nucleus:

meiosis I

&

meiosis II

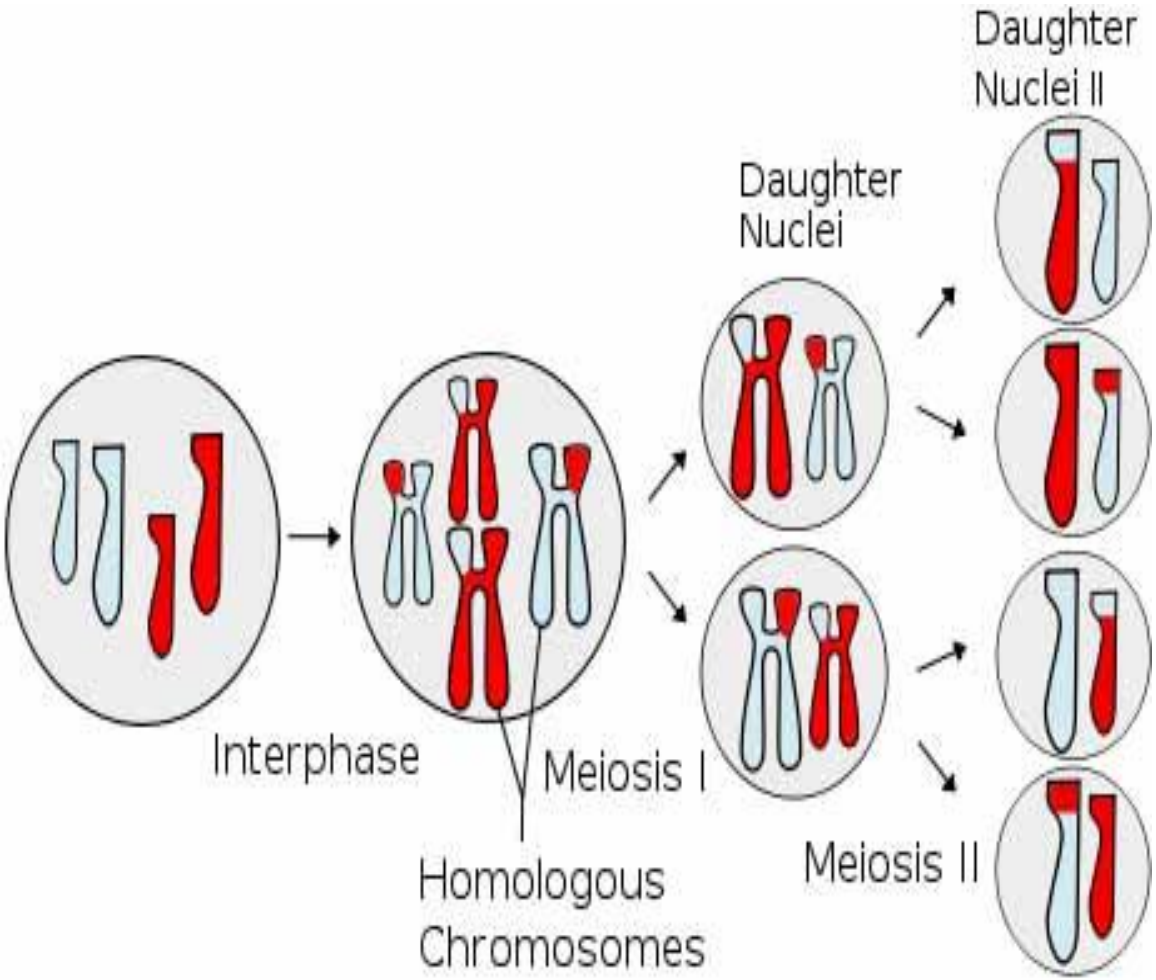


Image: Overview of Meiosis, National Institutes of Health

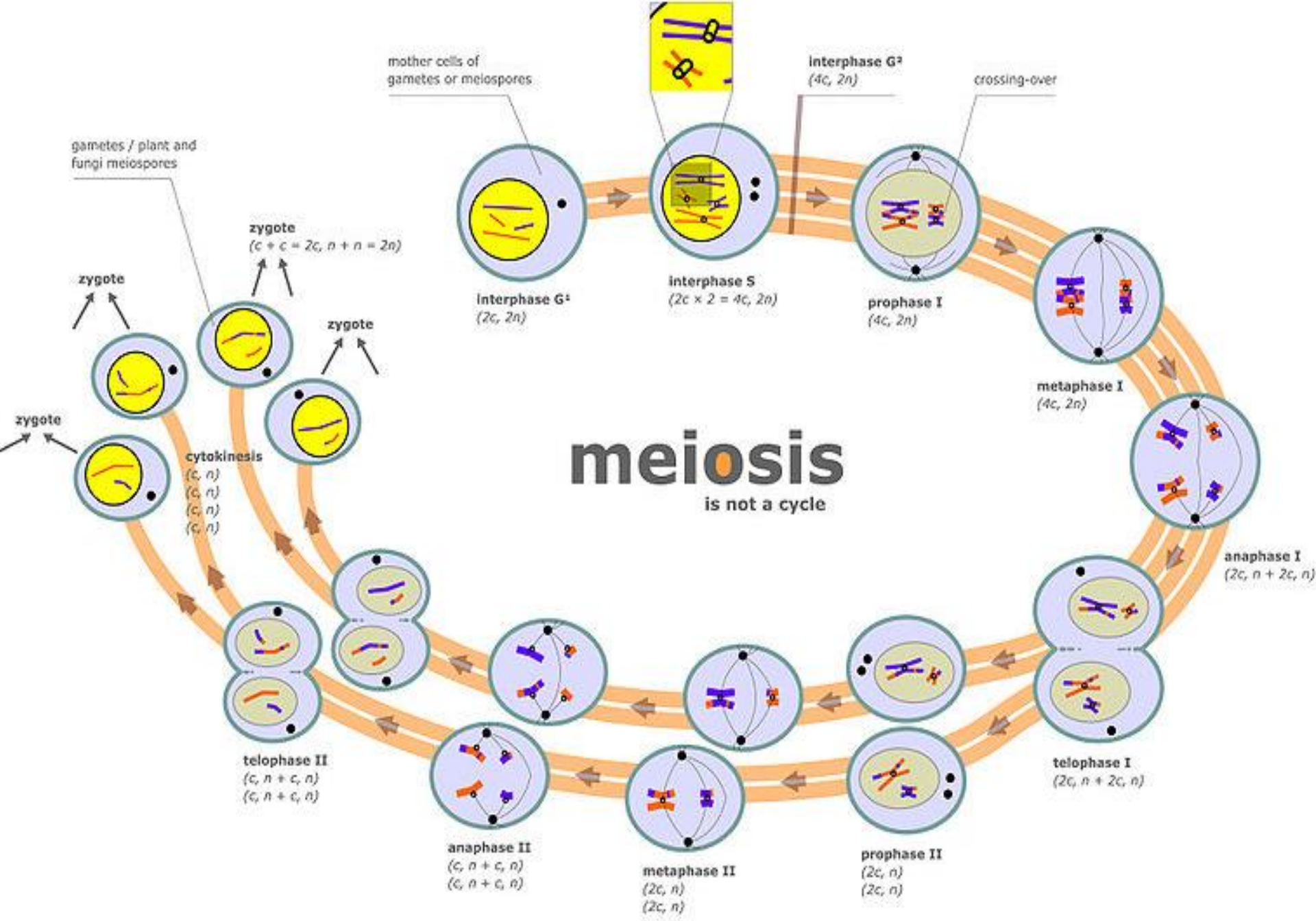


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Image: Meiosis diagram, Marek Kultys

Meiosis & Sexual Reproduction

Life Cycle

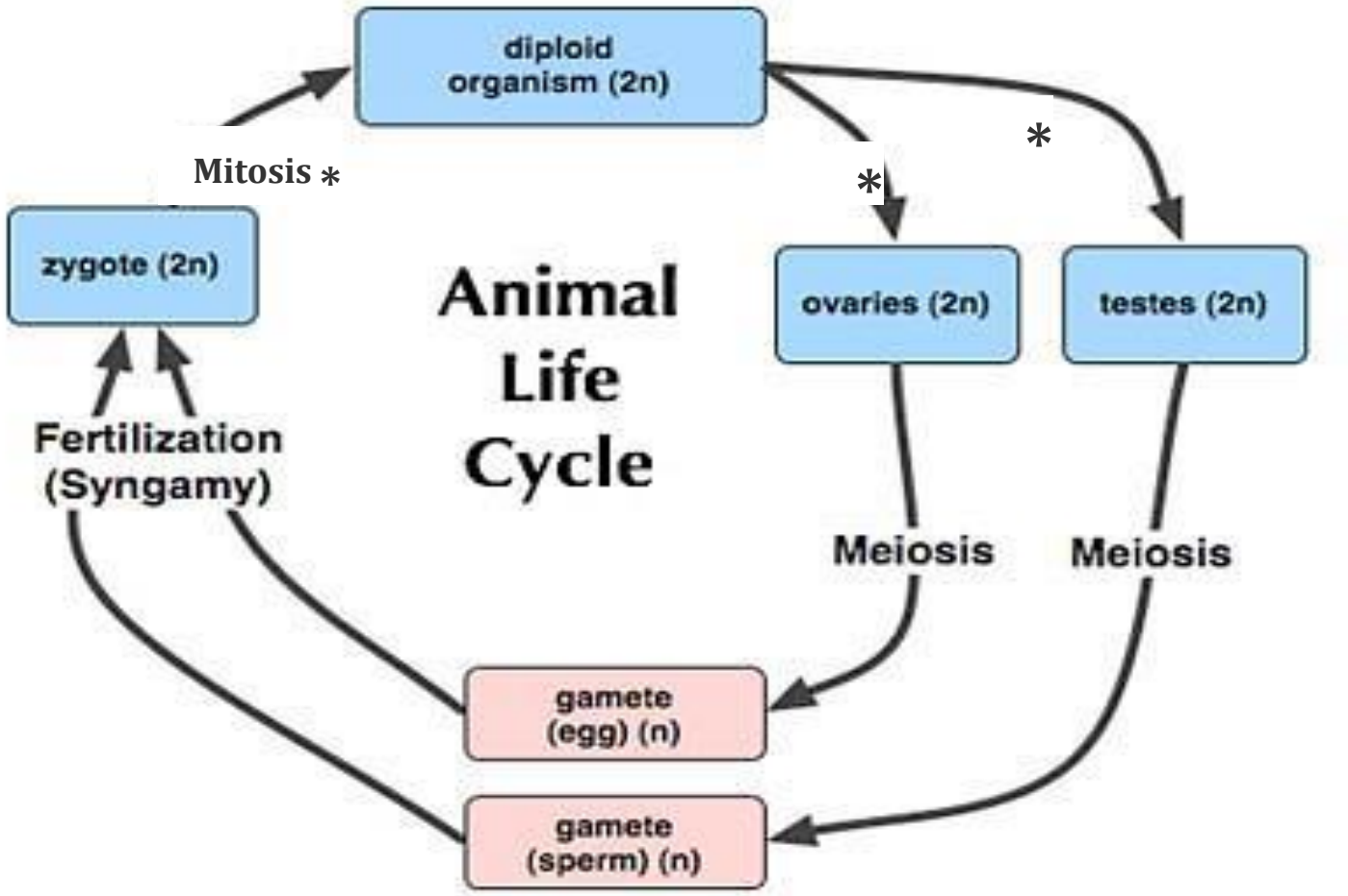
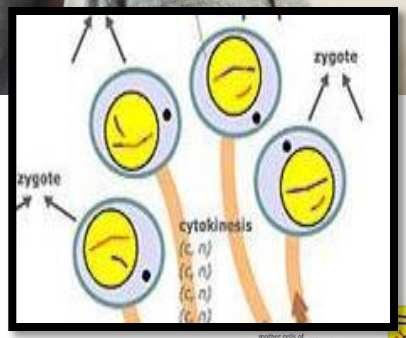


Image: Animal Life Cycle, Dr. T's Bio 328 Genetics

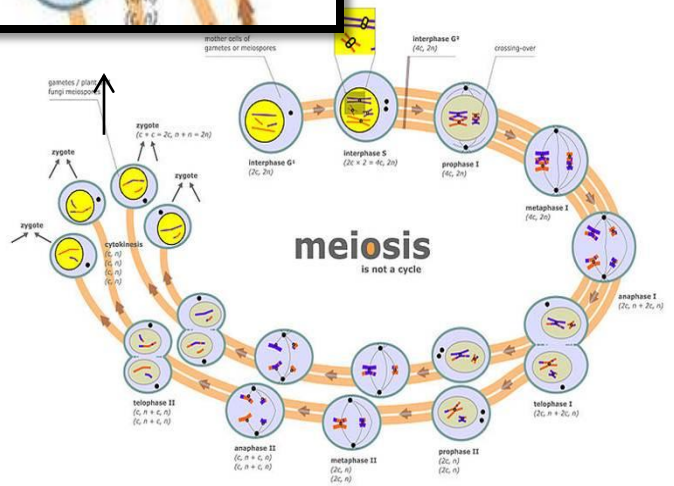
Genetic Variation in Diploid Organisms



Fusion of sperm and egg results in unique offspring…

…but not only because the young are a product of two individuals with different genetic makeup.

Meiosis also “shuffles” the genes so that the an individual’s gametes are genetically different from one another.



How is this shuffling accomplished?

From the Virtual Cell Biology Classroom on ScienceProfOnline.com

Image: Meiosis diagram, Marek Kultys

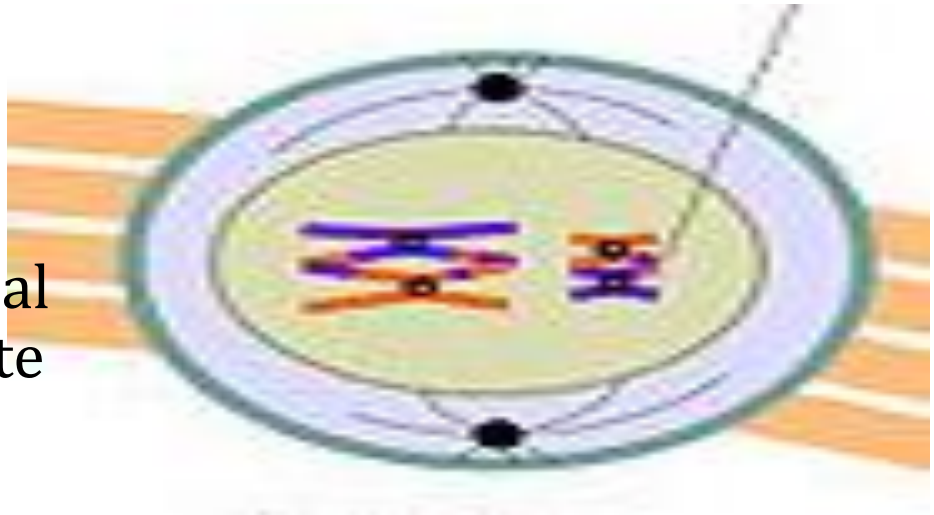
Genetic shuffling of Meiosis I

In addition to a new combination of chromosomes resulting from **fertilization**, there are also events in Meiosis I that shuffle the genes.

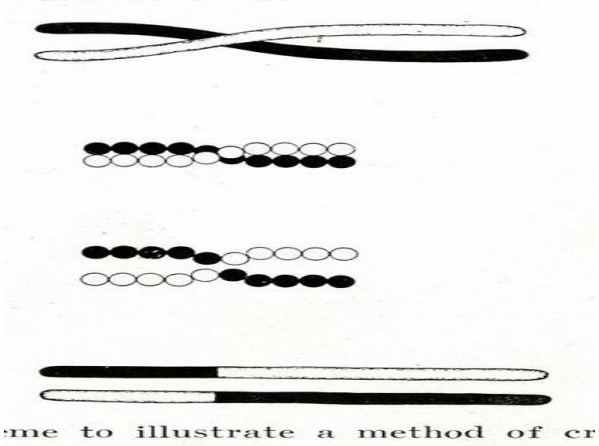
1. **Crossing over** in Prophase I.

2. **Independent assortment** in Metaphase I.

Crossing Over

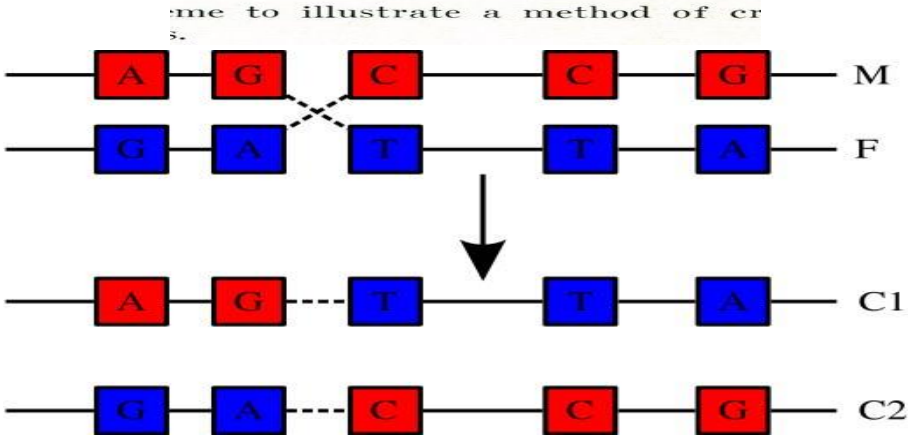


- Homologues break at identical locations, then rejoin opposite partners.



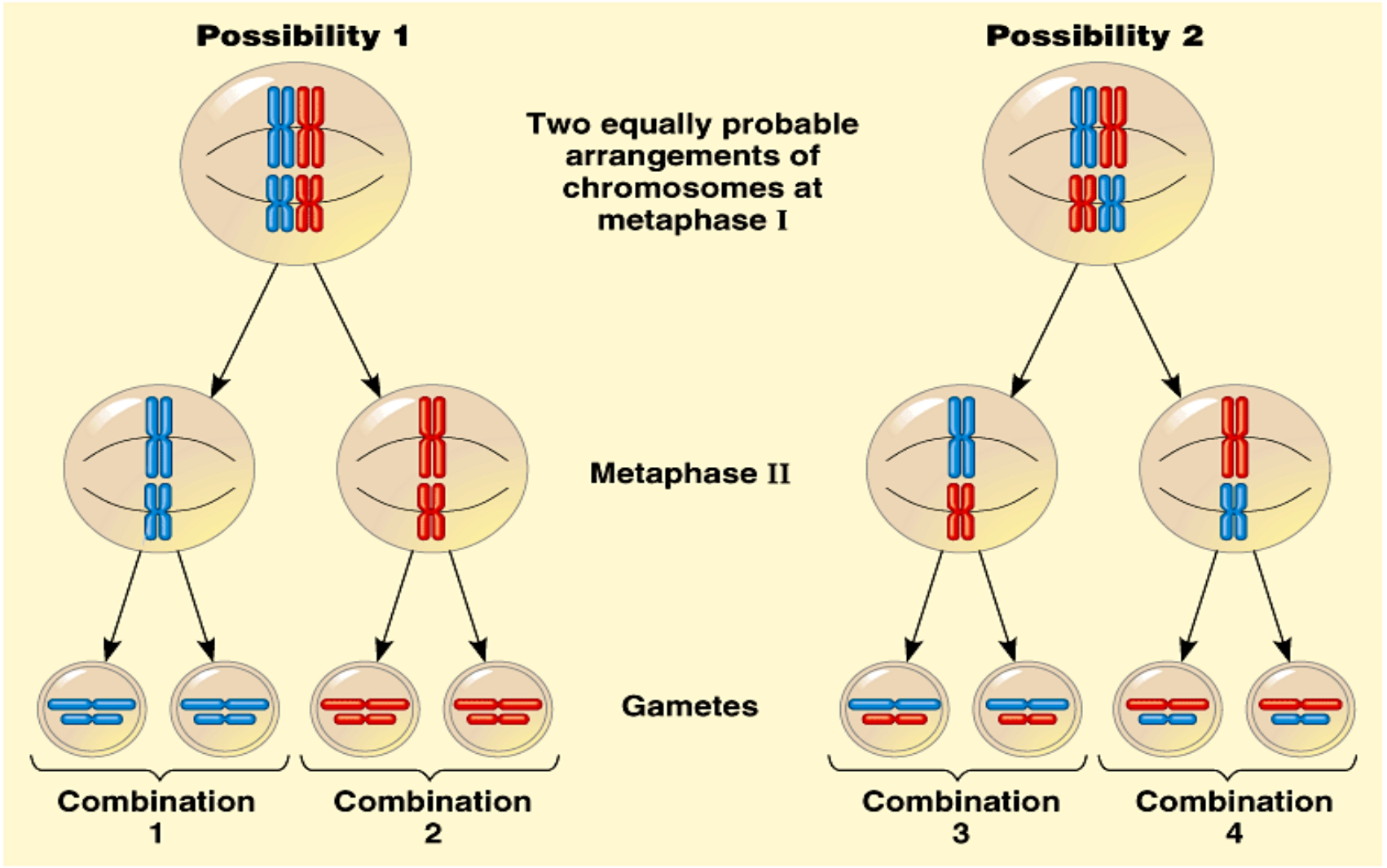
- This creates new combinations of the alleles on each chromosome.

- Occurs randomly several times on every chromosome.



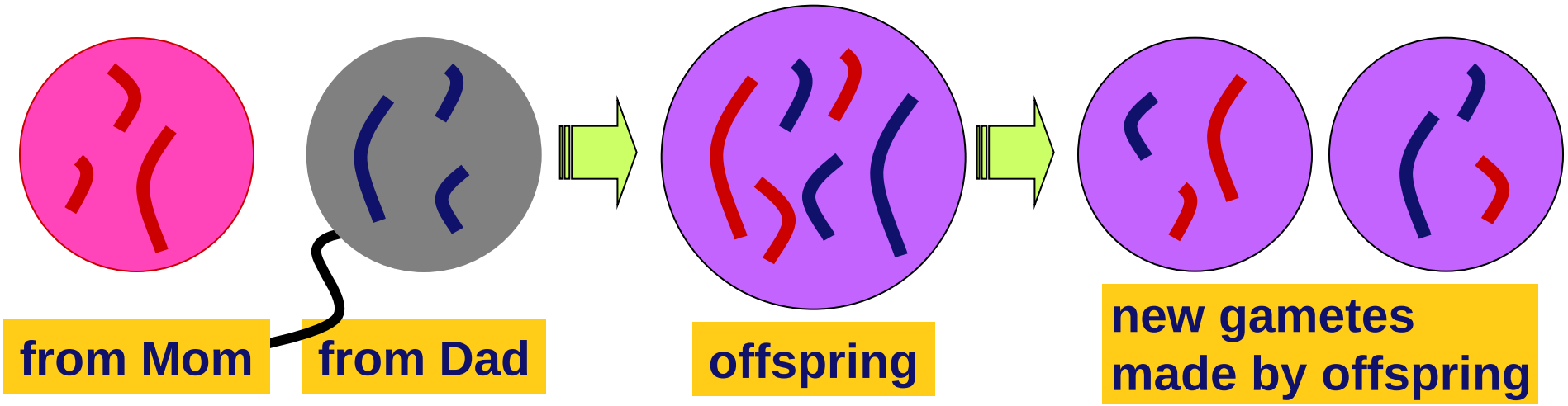
- Results in mixing of the genes you inherited from your parents.

Independent Assortment



Variation from genetic recombination

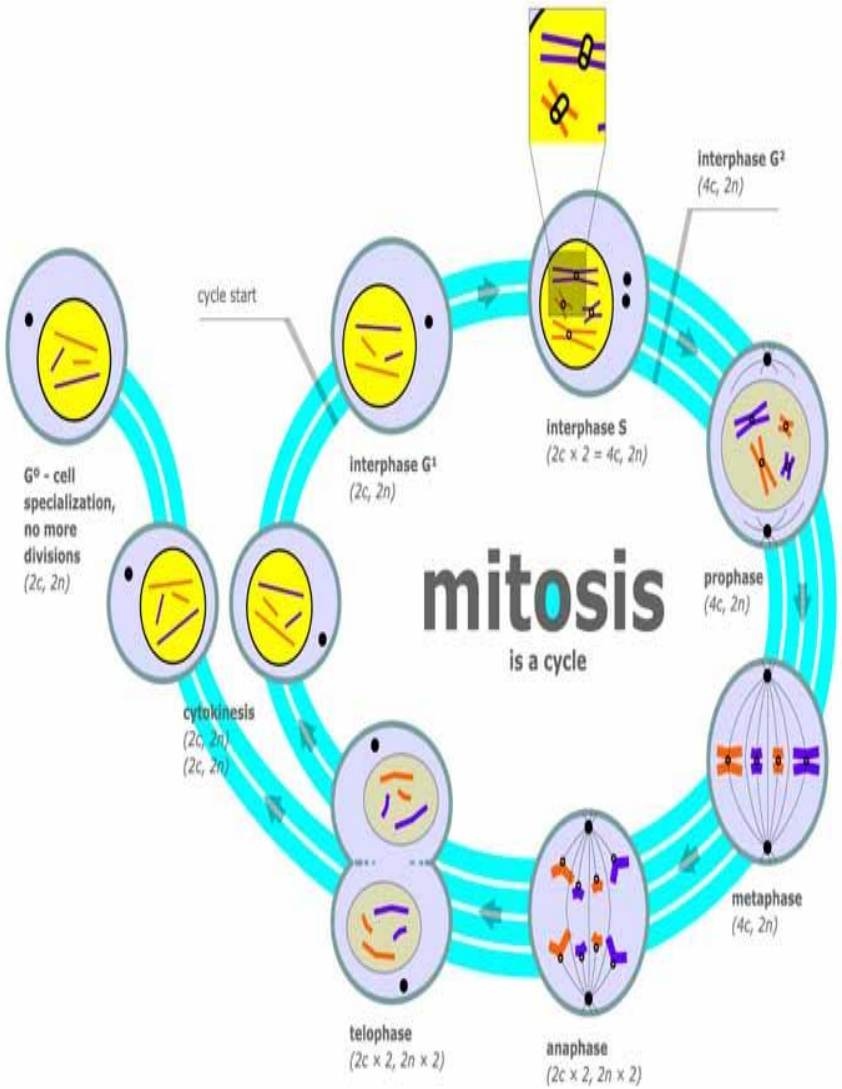
- Independent assortment of chromosomes
  - meiosis introduces genetic variation
  - gametes of offspring do not have same combination of genes as gametes from parents
    - random assortment in humans produces 2^{23} (8,388,608) different combinations in gametes



Mitosis vs. Meiosis

- 2n
- Clone
- Same genetic information in parent cell and daughter cell.
- Give me another one just like the other one!

- 1n
- Daughter cells different from parent cell and from each other.
- Daughter cells have ½ the number of chromosomes as somatic cell.
- Shuffling the genes
(Mix it up!)



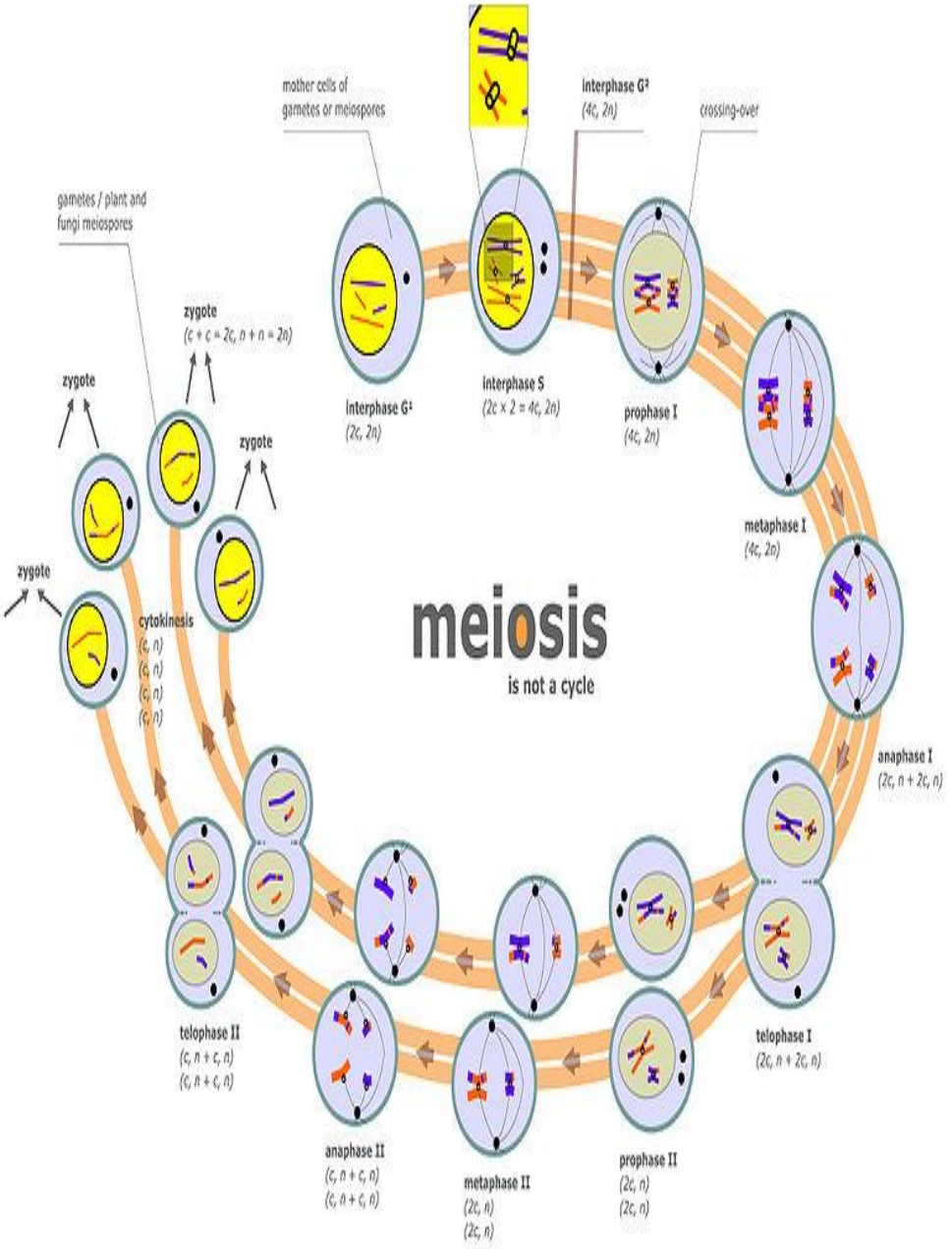


Image: Mitosis diagram & Meiosis diagram, Marek Kultys

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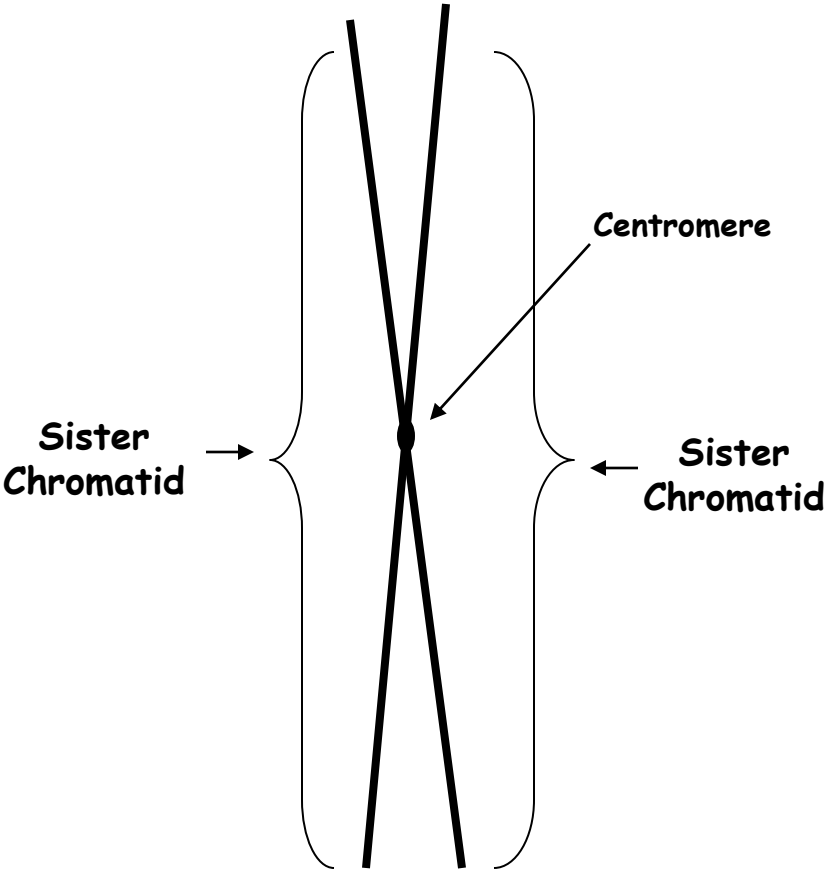
Drawing and Labeling Chromosomes

Unreplicated
Uncondensed
Chromosome

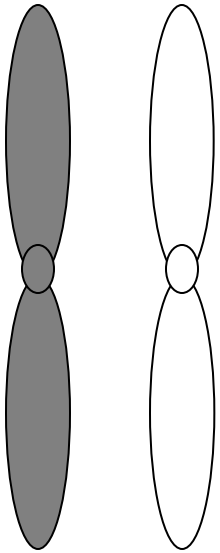
(chromatin)



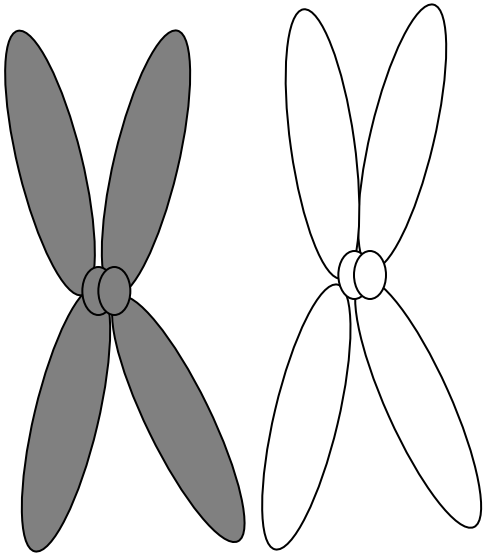
Replicated
Uncondensed
Chromosome

(chromatin)

Drawing & Labeling Homologous Chromosomes



Unreplicated, Condensed, Homologous Chromosomes



Replicated, Condensed, Homologous Chromosomes