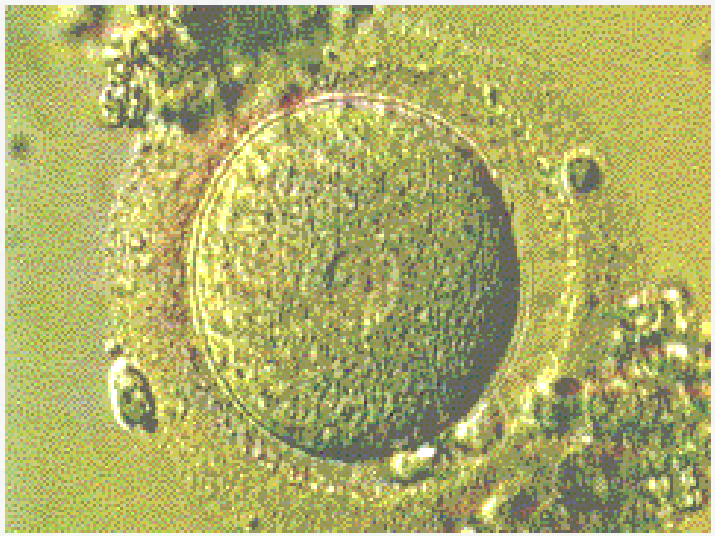
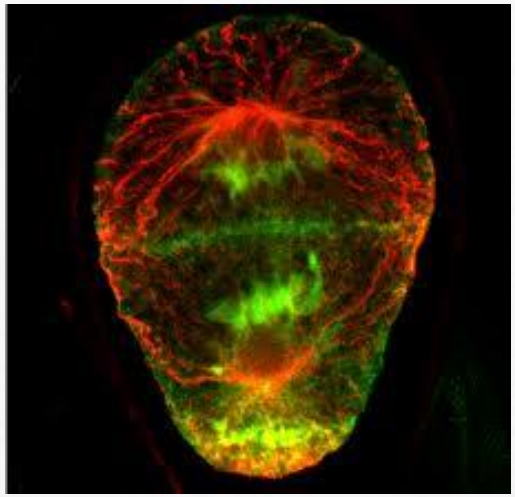
Cell Division

- **In multicellular organisms, the zygote is the earliest developmental stage.**

- **the zygote divides by mitosis to produce identical offsprings.**



Different cells divide at different rates:



- Embryo: every 20 minutes
- Skin cells: one time in 12-24 hours
- Liver cells: 1-2 times in a year (maybe ..)

some cells don’t...

- Muscle and nerve cells, mature egg ???

Getting Older…

All cells are only allowed to complete a certain number of divisions

Then they die (programmed cell death)

How does cell division change over a lifetime?

Childhood = cell division > cell death

Adulthood = cell division = cell death

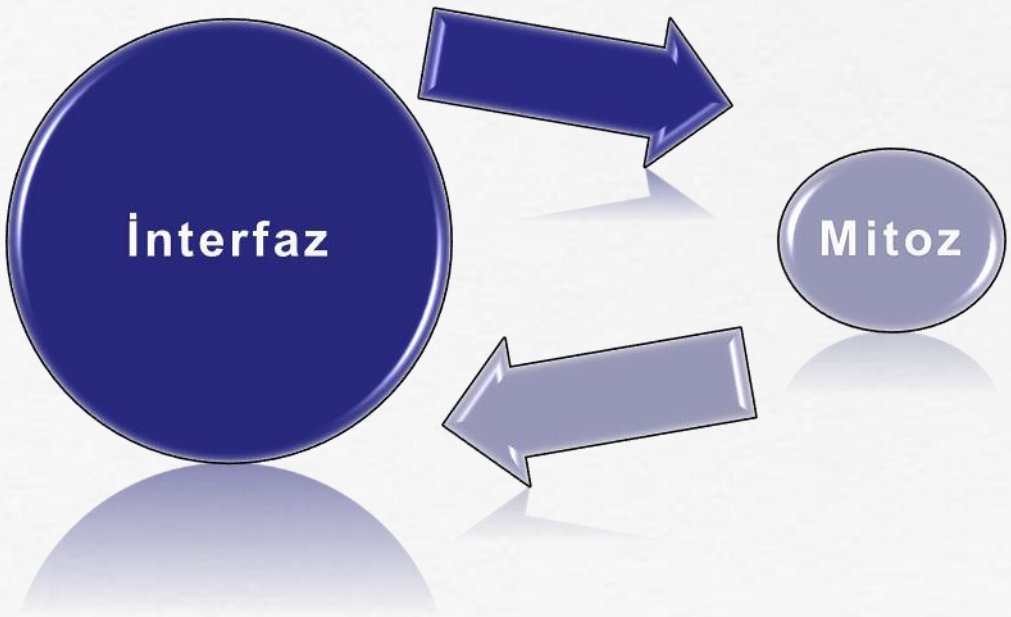
The Later Years = cell division < cell death

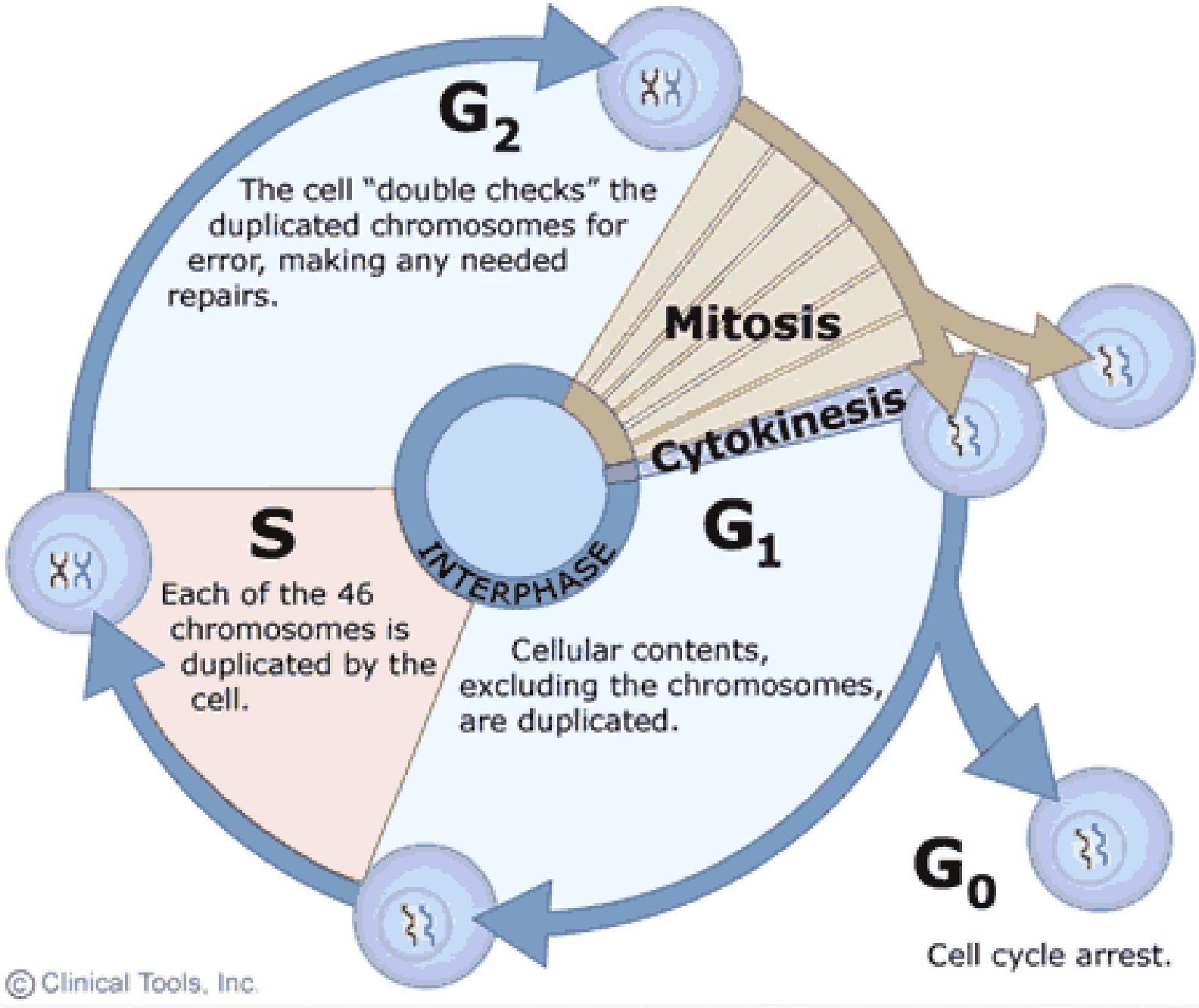
There are two stages in a cell's life.

interphase (growth & replication of DNA)

mitotic phase (division of cell into 2 daughter cells)

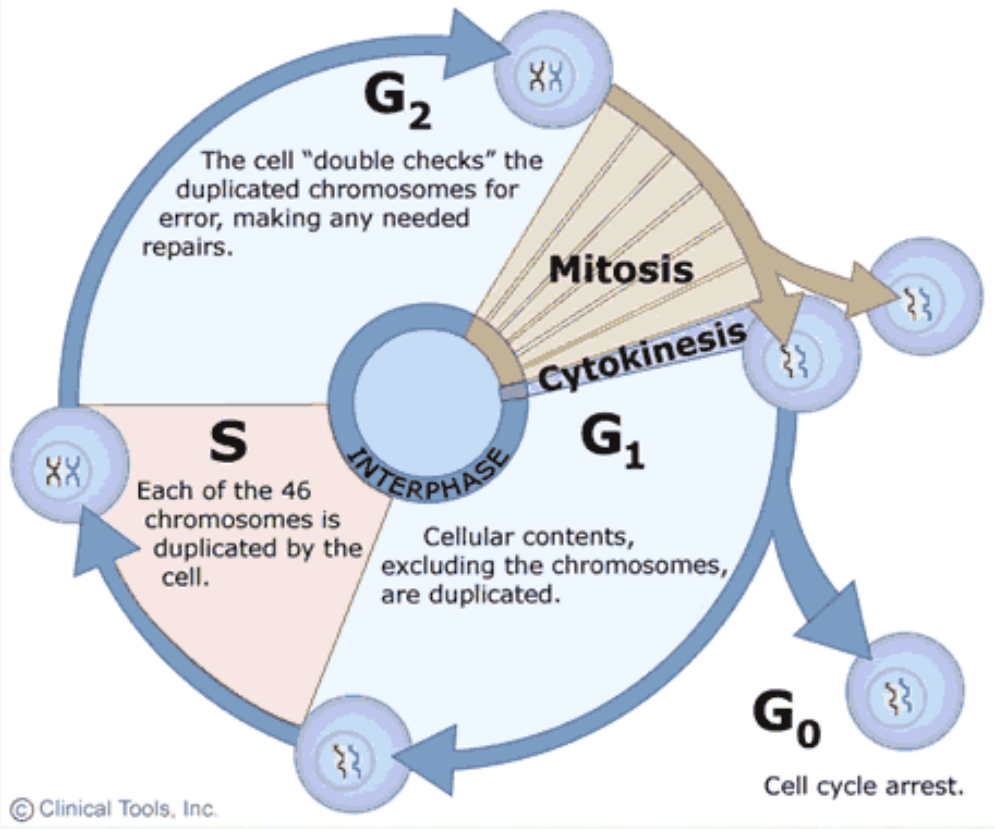
- Cell spends about 90% of the time in interphase



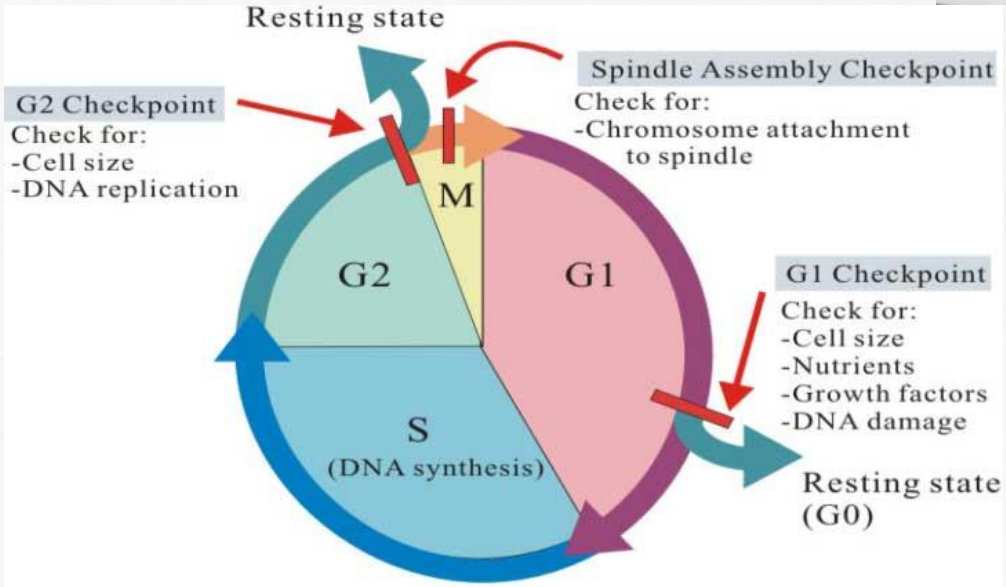

G2
The cell "double checks" the duplicated chromosomes for error, making any needed repairs.
Mitosis
Cytokinesis
S
Each of the 46 chromosomes is duplicated by the cell.
INTERPHASE
G1
Cellular contents, excluding the chromosomes, are duplicated.
G0
Cell cycle arrest.
© Clinical Tools, Inc.

Interphase is divided into 3 phases

- **G1 (1st gap) = small cell absorbs the nutrients, sythhesize proteins and ATP… growing & doing its job**

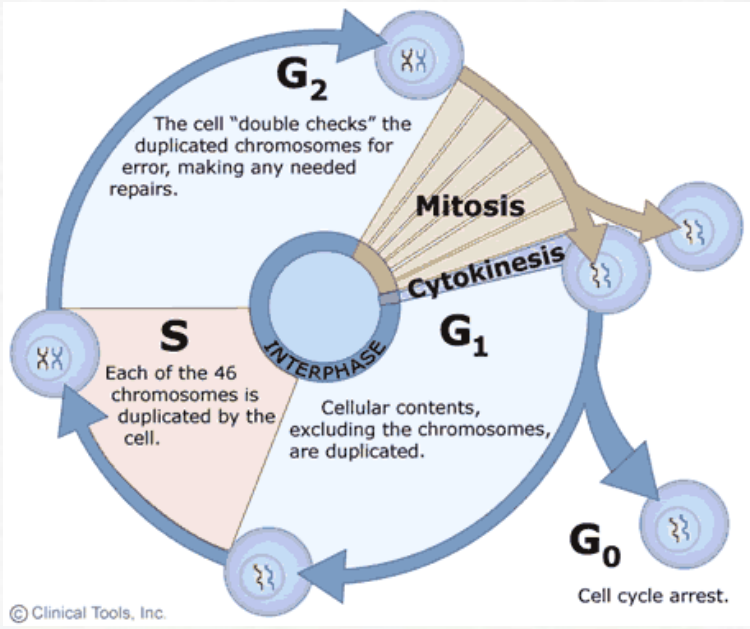


- # 1. checkpoint
- **the main decision point**
- **At the G1 checkpoint, cells decide whether or not to proceed with division based on factors such as:**
  - **Cell size**
  - **Nutrients**
  - **Growth factors**
  - **DNA damage**
-

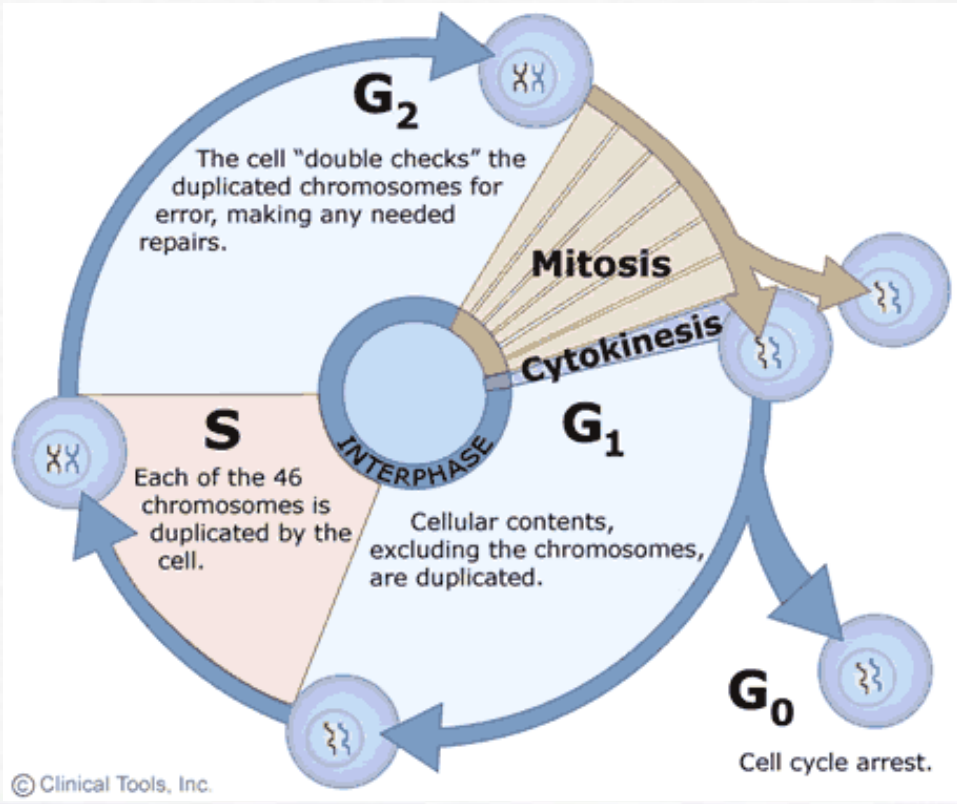


- **located at the end of G1 phase, before the transition to S phase.**
- **If cells don't pass the G1 checkpoint, they may "loop out" of the cell cycle and into a resting state called G0, from which they may subsequently re-enter G1 under the appropriate conditions.**

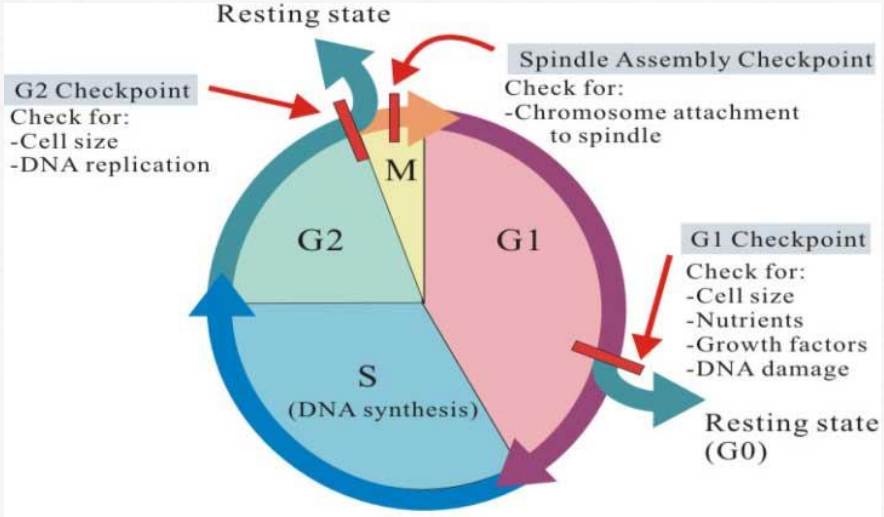
Muscle and nerve cells, mature egg in G0 until the cels die



- **if the cell passes G1**
- **S (synthesis) Phase= cell is continuing to grow & <u>duplicates its DNA.</u>**



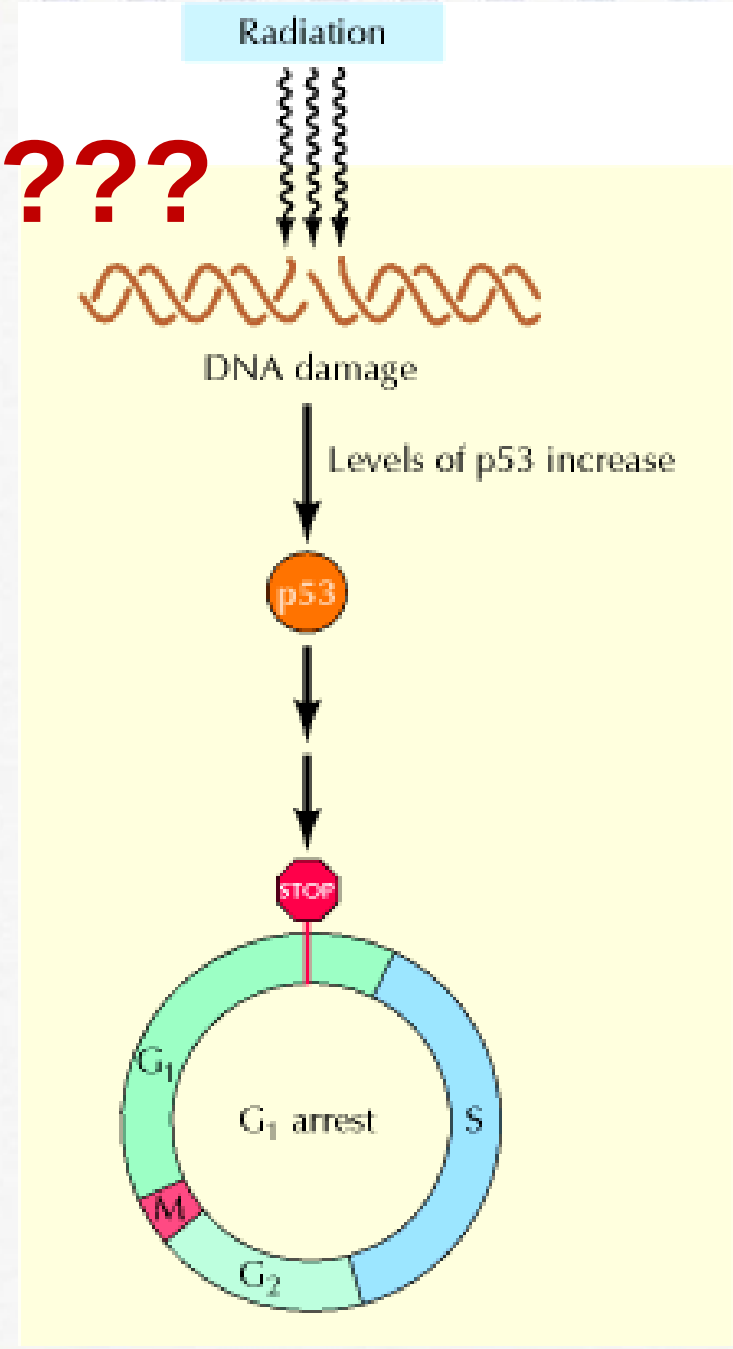
- **G2 phase:** G2 (2nd gap) = cell keeps growing & doing its job.
- **At the G2 checkpoint,** the cell checks for:
  - DNA damage
  - DNA replication completeness



Cancer cells???

If there is a damage???

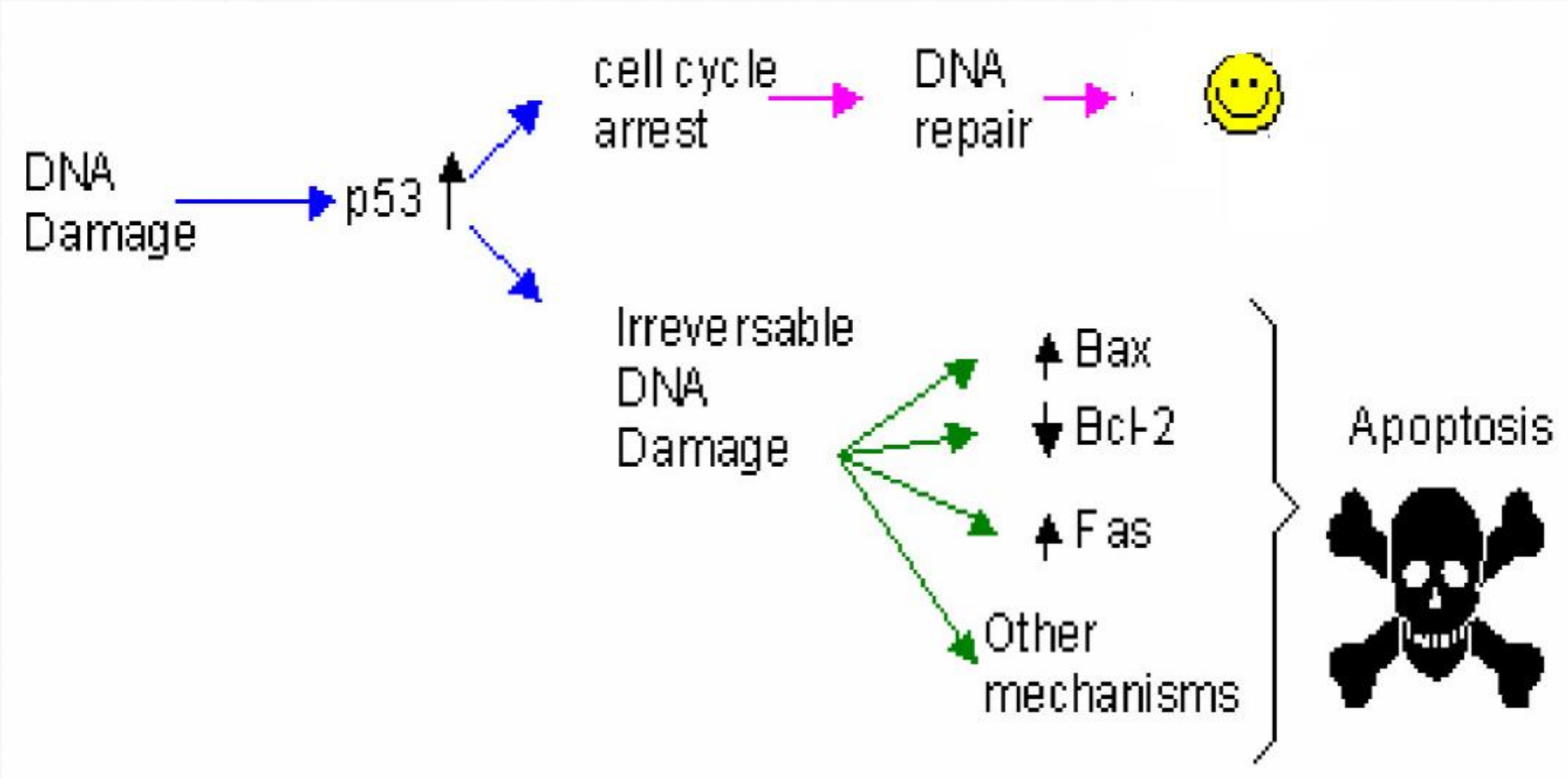
- P53
- Stop the cycle
- apoptosis



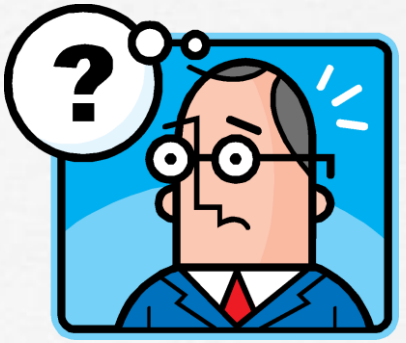
- mutant p53 protein plays a role in many cancer types
- As a result;

P53 loses function ...

- Damaged DNA is unstoppable in G1 and replicates in S phase.
- The inheritance of damaged DNA leads to an increase in the frequency of mutation and the general instability of the cell genome that accompanies cancer development.


DNA
Damage
p53
cell cycle
arrest
DNA
repair
Irreversable
DNA
Damage
Bax
Bcl-2
Fas
Other
mechanisms
Apoptosis


Everything is OK
only on Catriot.com


?

Mitosis

- **16 hours:**

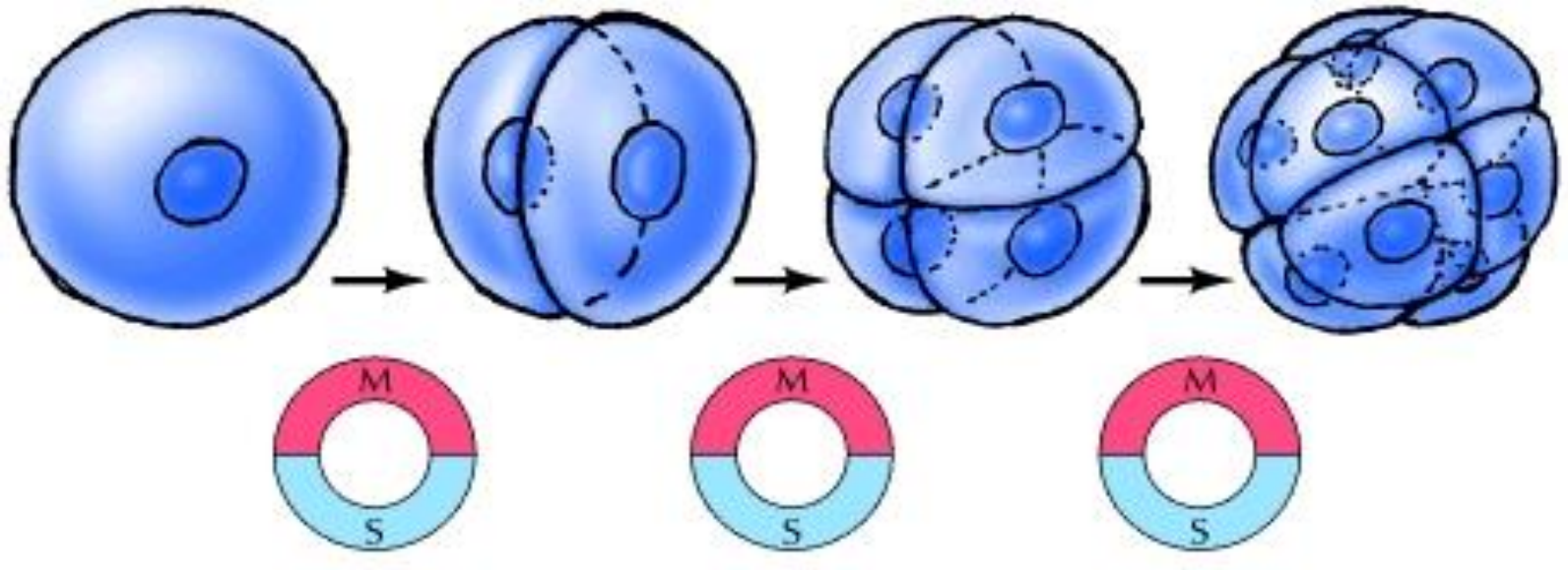
INTERPHASE			MITOSIS
G1	S	G2	M
5	7	3	1

Hours…

Pro	Met	Ana	Tel
36	3	3	18

minutes…

embryo



The Cell: A Molecular Approach, Third Edition

The Mitotic Phase

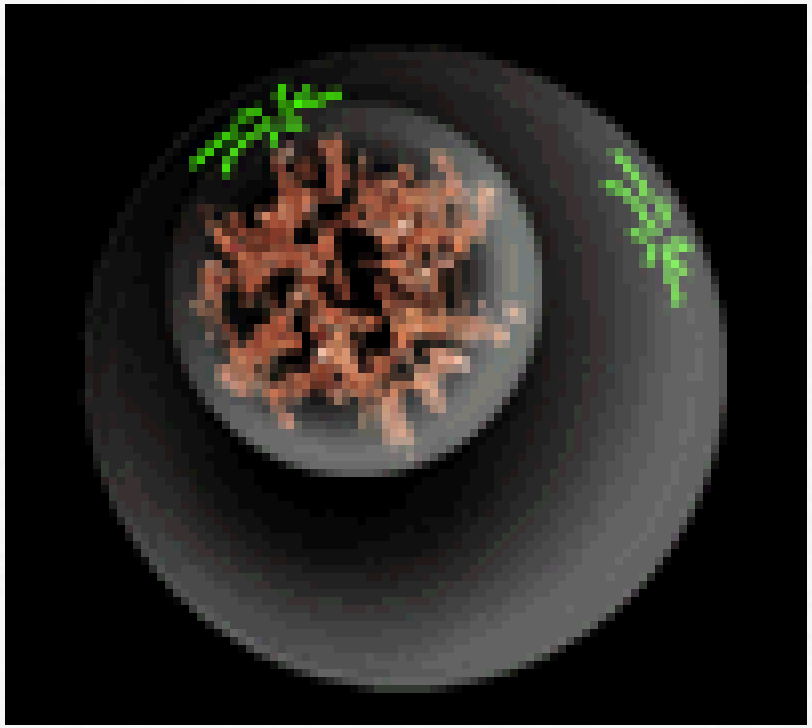
- Prophase +Prometaphase
- Metaphase
- Anaphase
- Telophase

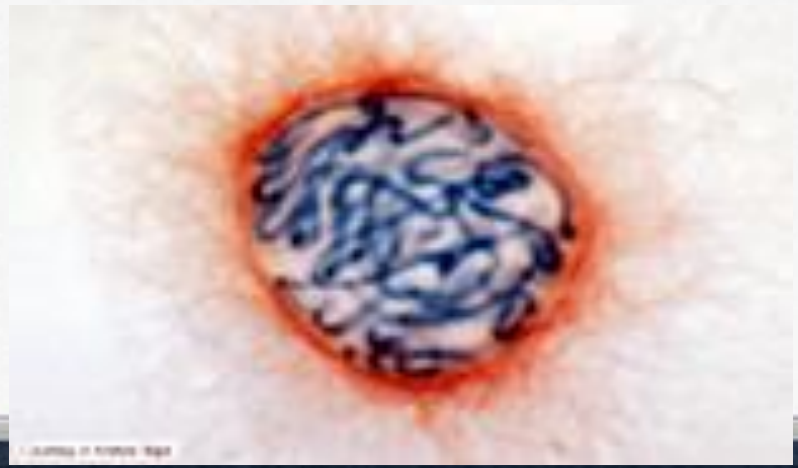
karyokinesis

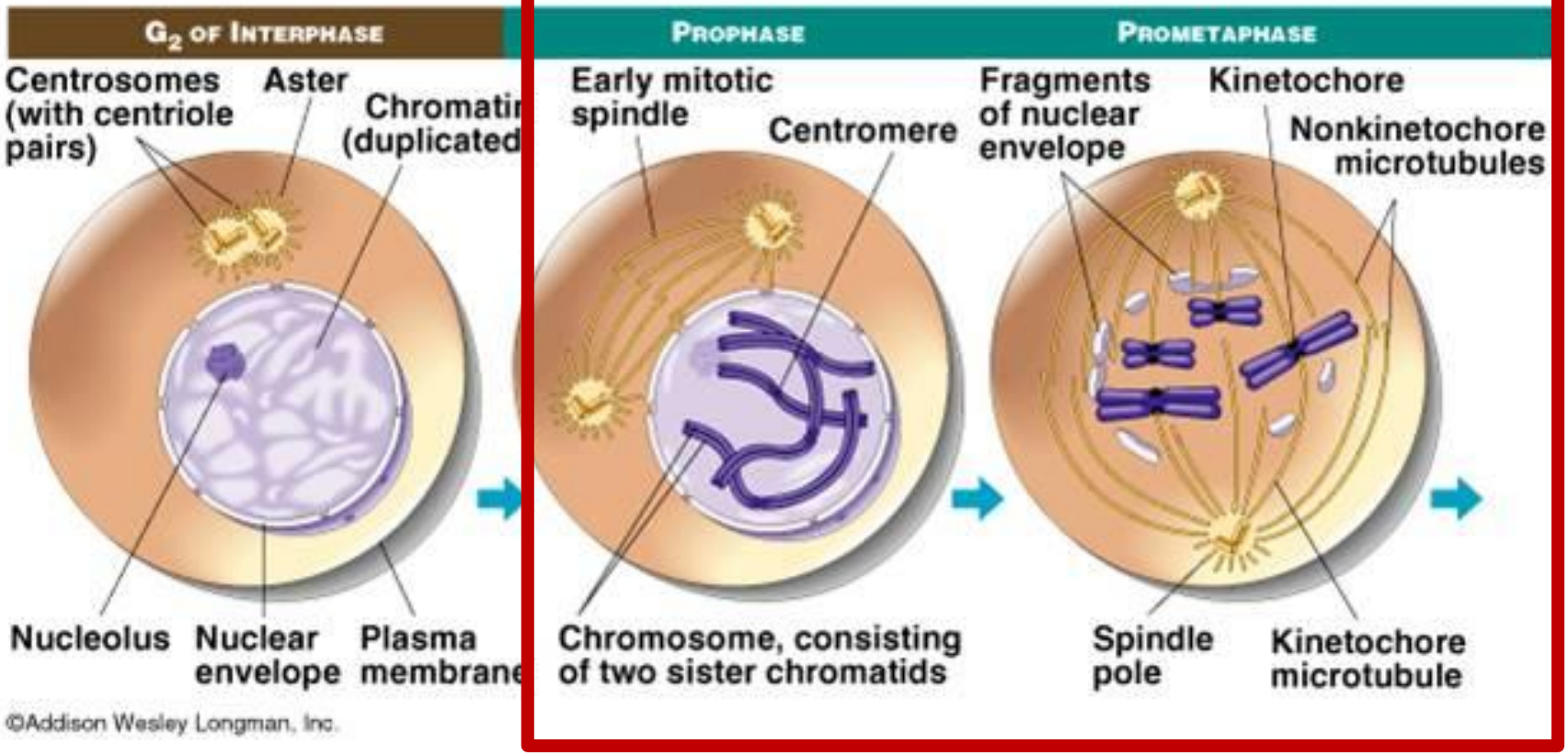
Cytokinesis

Prophase

Chromatids condense becoming visible.
Nuclear membrane dissolves
The centrioles (an organelle that makes microtubules) appears and migrate to opposite sides.
spindle fibers start to form between them

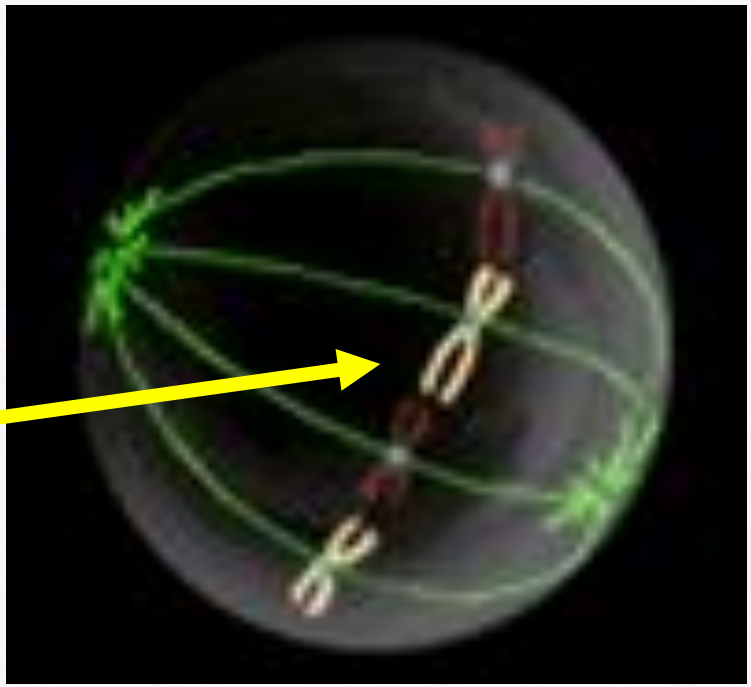


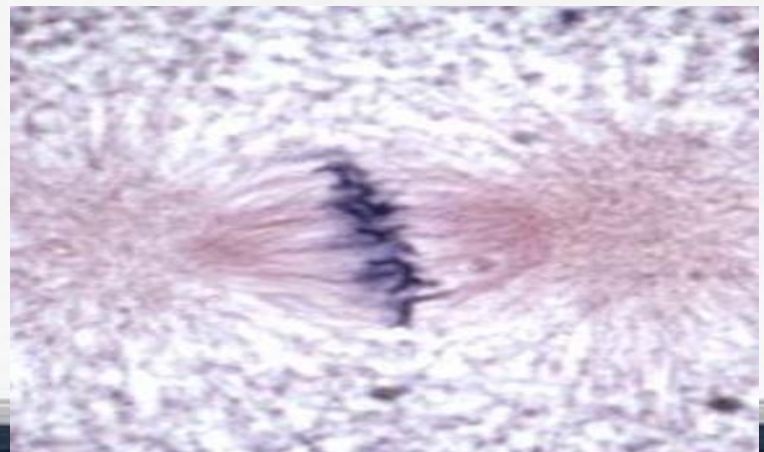


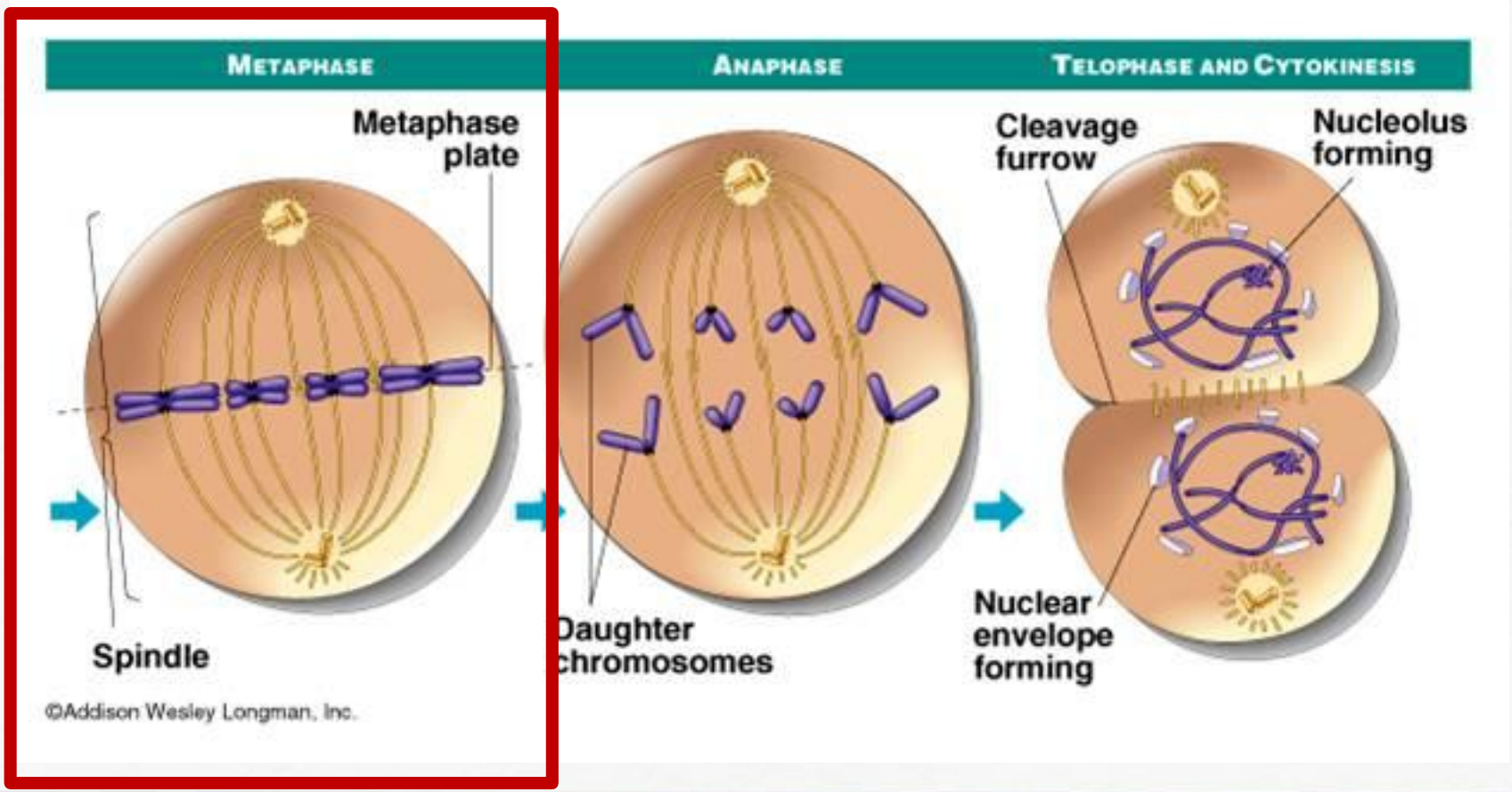

G2 OF INTERPHASE
Centrosomes (with centriole pairs)
Aster
Chromatin (duplicated)
Nucleolus
Nuclear envelope
Plasma membrane
PROPHASE
Early mitotic spindle
Centromere
Chromosome, consisting of two sister chromatids
PROMETAPHASE
Fragments of nuclear envelope
Kinetochore
Nonkinetochore microtubules
Spindle pole
Kinetochore microtubule
©Addison Wesley Longman, Inc.

Metaphase

- Chromosomes line-up on the metaphase plate
- Centromeres are attached to spindle fibers

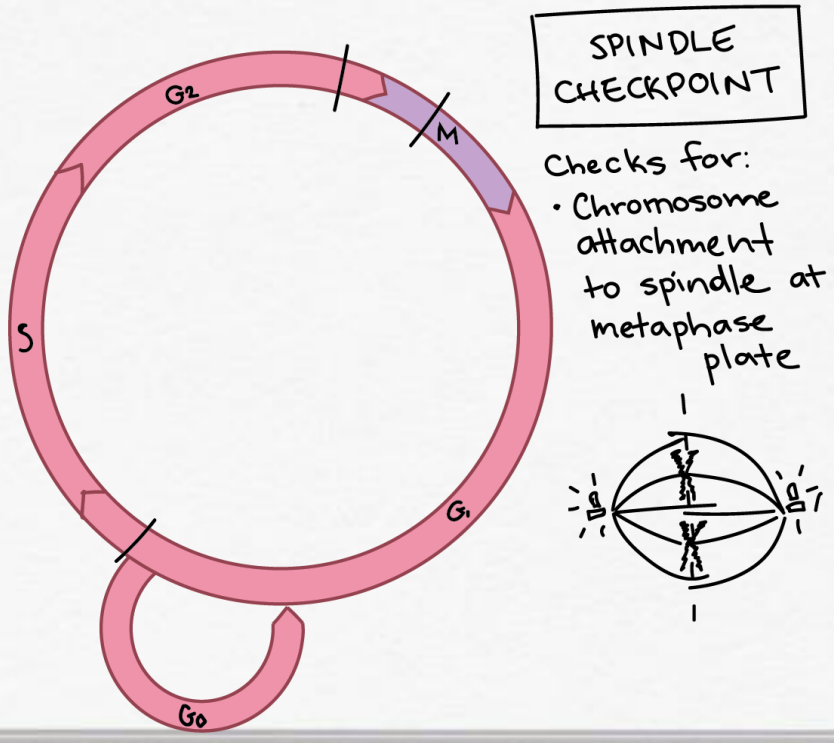





METAPHASE
ANAPHASE
TELOPHASE AND CYTOKINESIS
Metaphase plate
Spindle
Daughter chromosomes
Cleavage furrow
Nucleolus forming
Nuclear envelope forming
©Addison Wesley Longman, Inc.

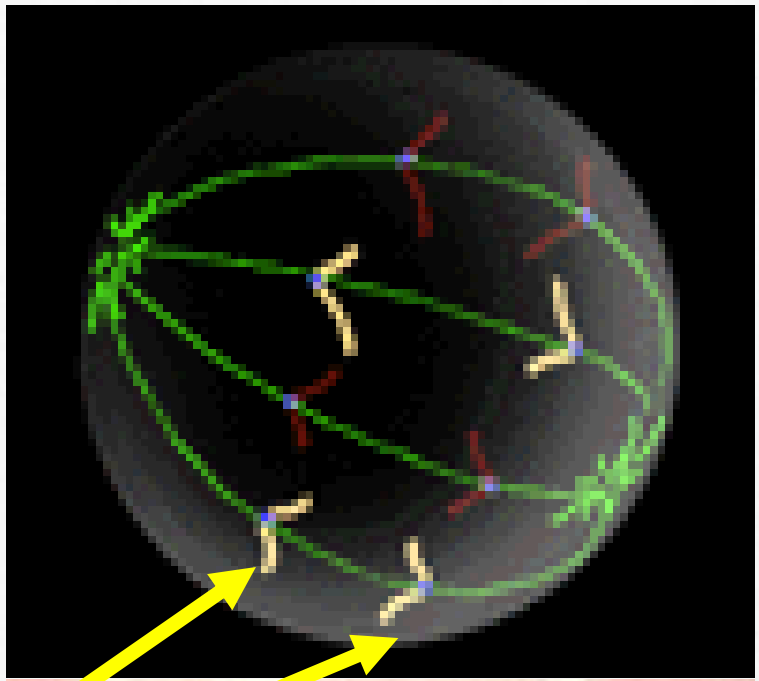
- **3. checkpoint**

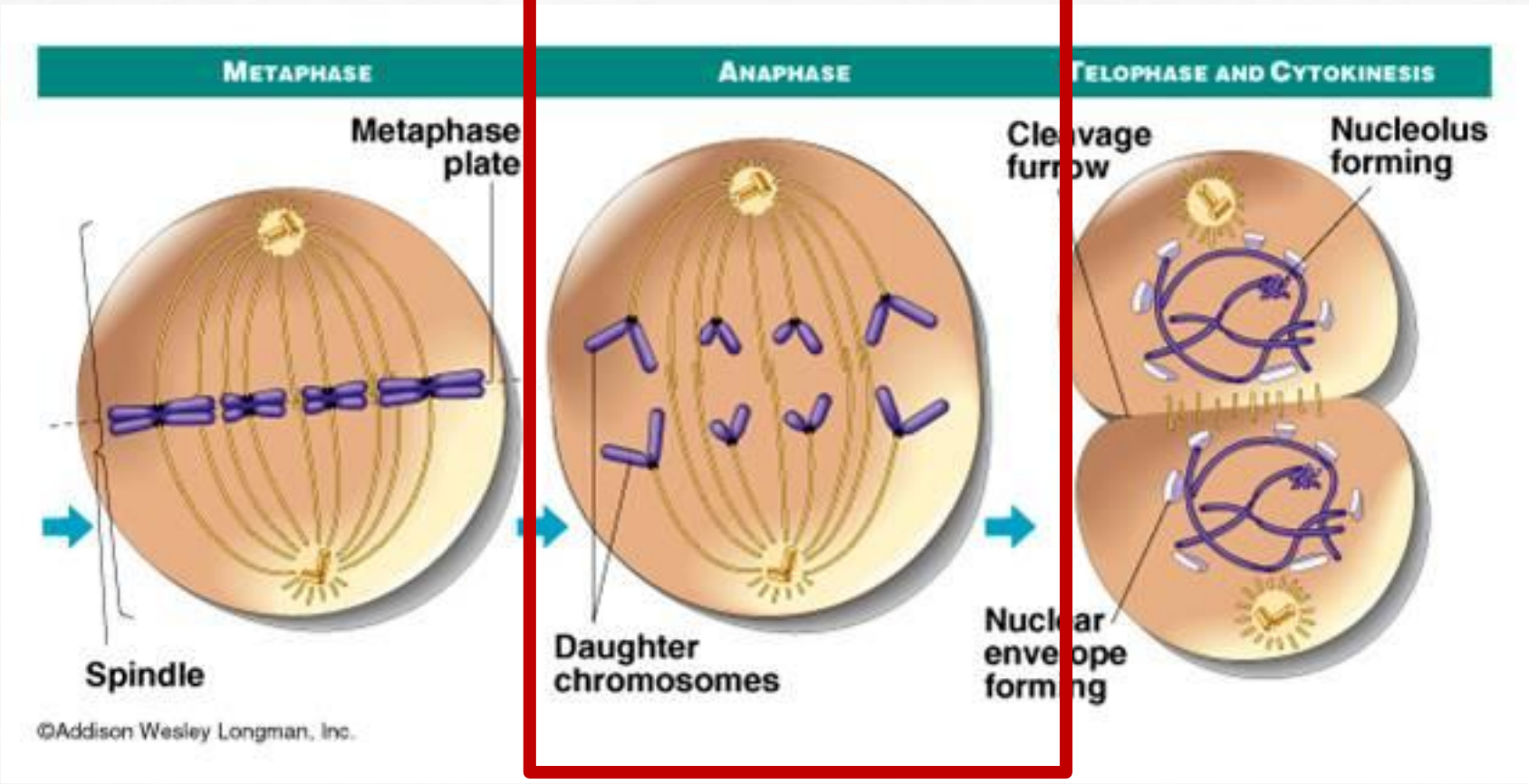
If a chromosome is misplaced, the cell will pause mitosis, allowing time for the spindle to capture the stray chromosome.



Anaphase

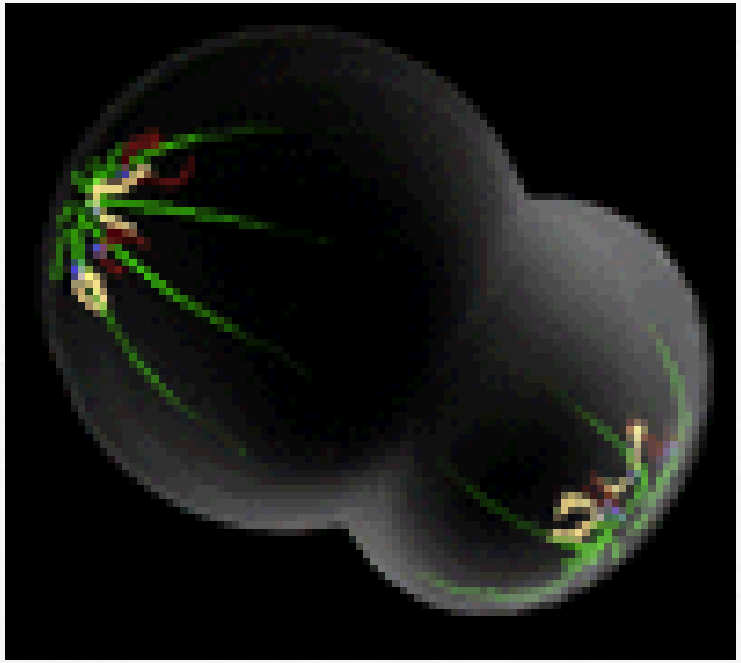
Spindle fibers contract
Centromeres divide
Sister chromatids are pulled away from each other towards the poles

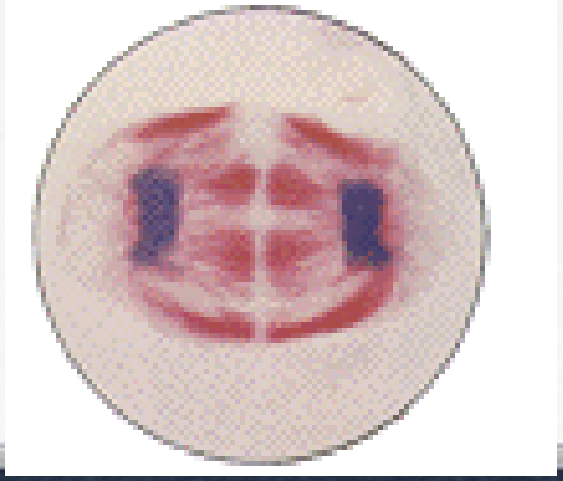


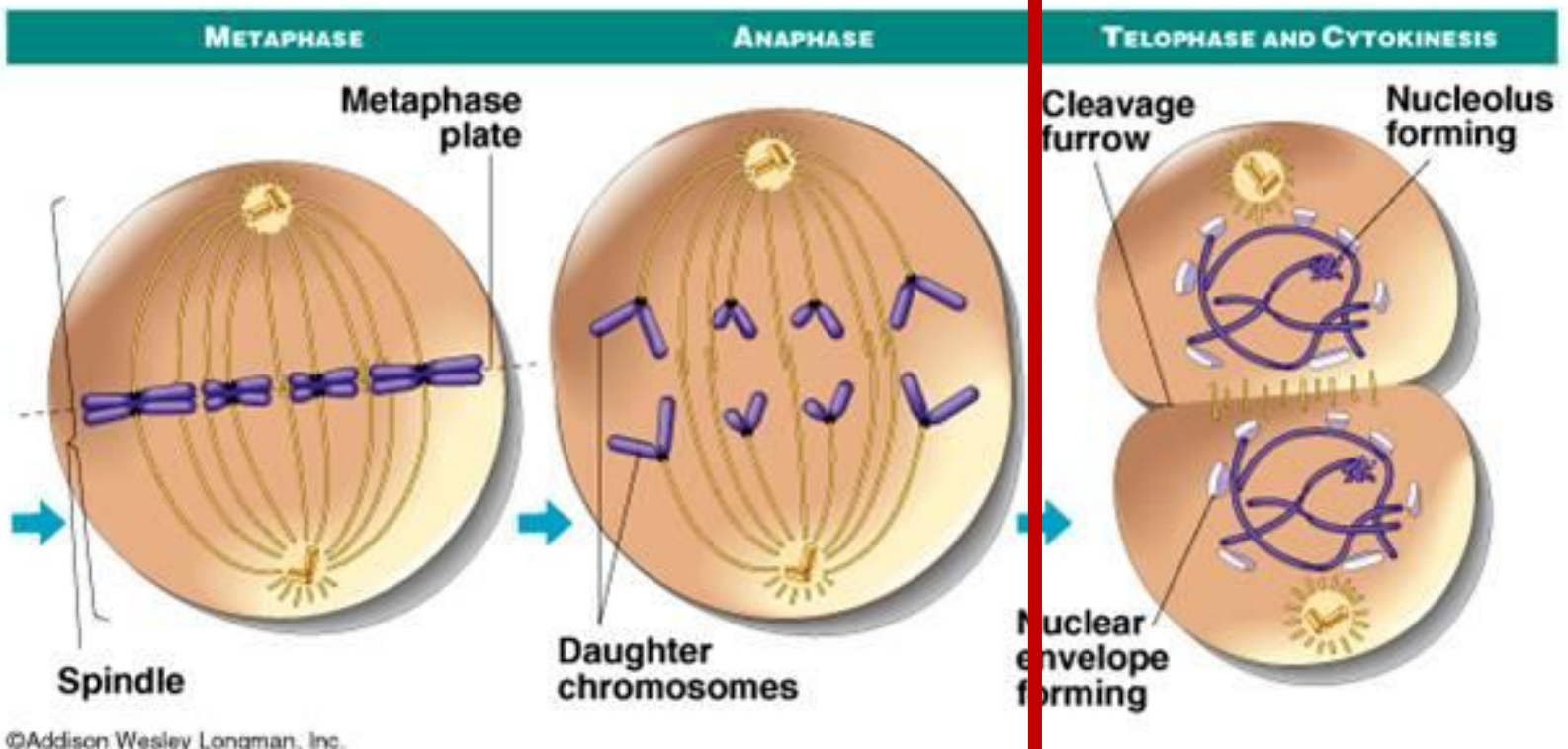

METAPHASE
ANAPHASE
TELOPHASE AND CYTOKINESIS
Metaphase plate
Spindle
Daughter chromosomes
Cleavage furrow
Nucleolus forming
Nuclear envelope forming
©Addison Wesley Longman, Inc.

Telophase

The chromosomes reach the poles
Nuclear membranes form around the 2 new nuclei

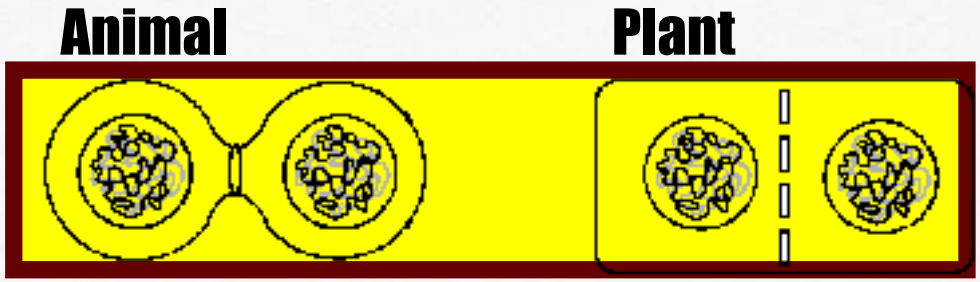


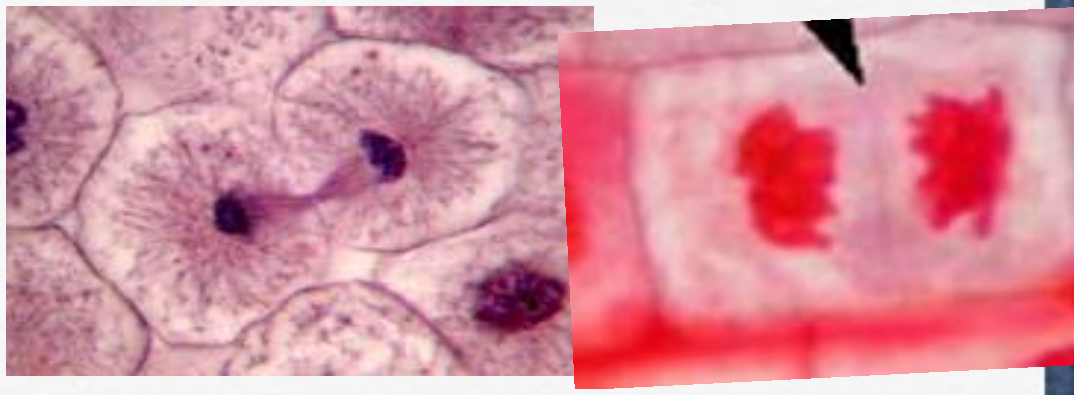



METAPHASE
ANAPHASE
TELOPHASE AND CYTOKINESIS
Metaphase plate
Spindle
Daughter chromosomes
Cleavage furrow
Nucleolus forming
Nuclear envelope forming
©Addison Wesley Longman, Inc.

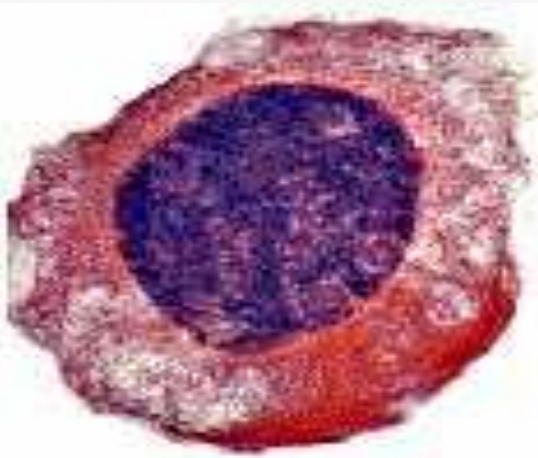
Cytokinesis

- The cytoplasm distributed equally between the 2 new cells
- In animals, a cleavage furrow forms from outside in
- In plants, a cell plate forms from inside out

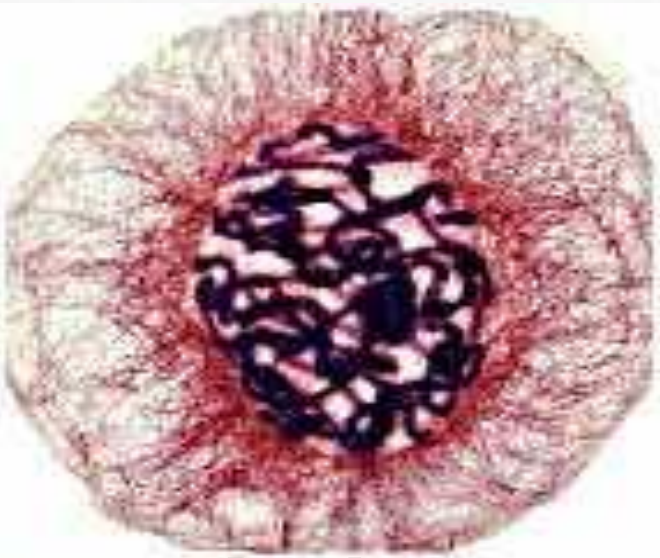




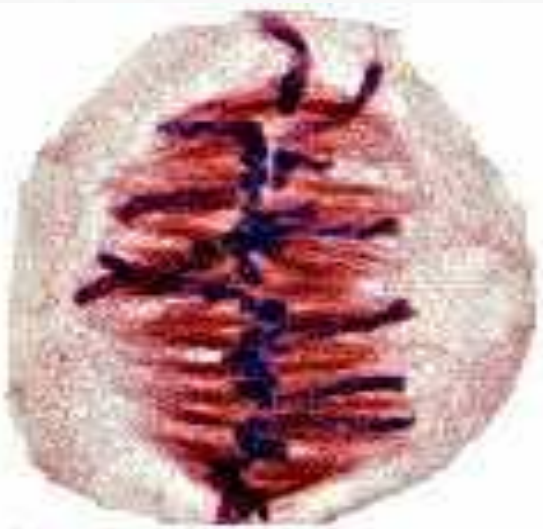
What Mitosis Actually Looks Like



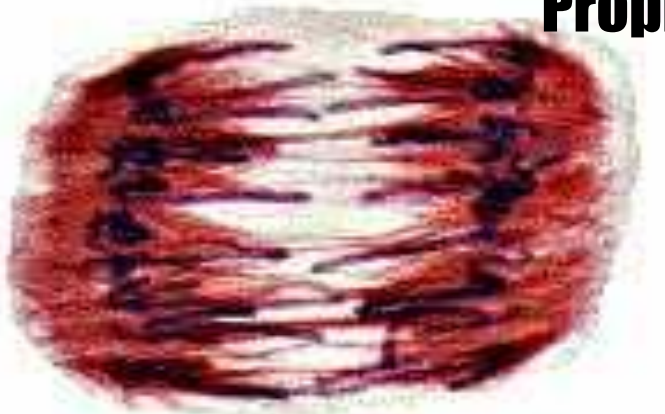
Interphase



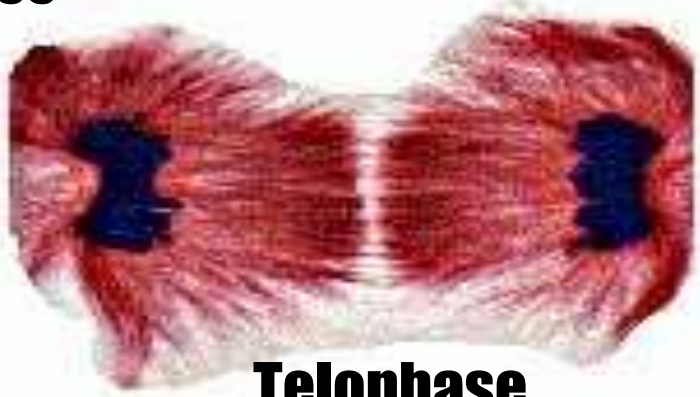
Prophase



Metaphase



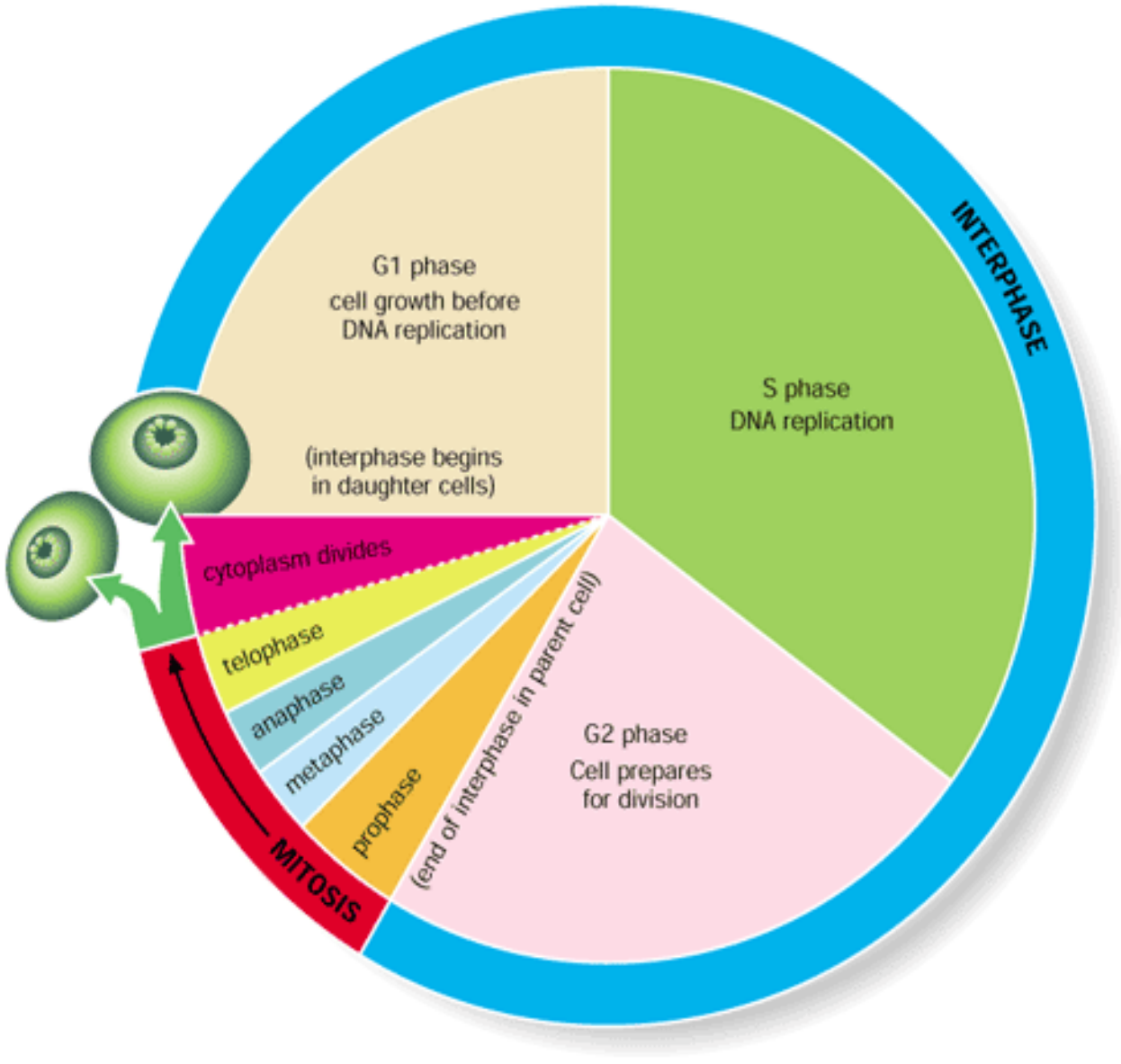
Anaphase



Telophase

What Happens After Mitosis?

- The cell returns to interphase
- Chromosomes uncoil back into chromatin
- The cycle repeats itself over & over…

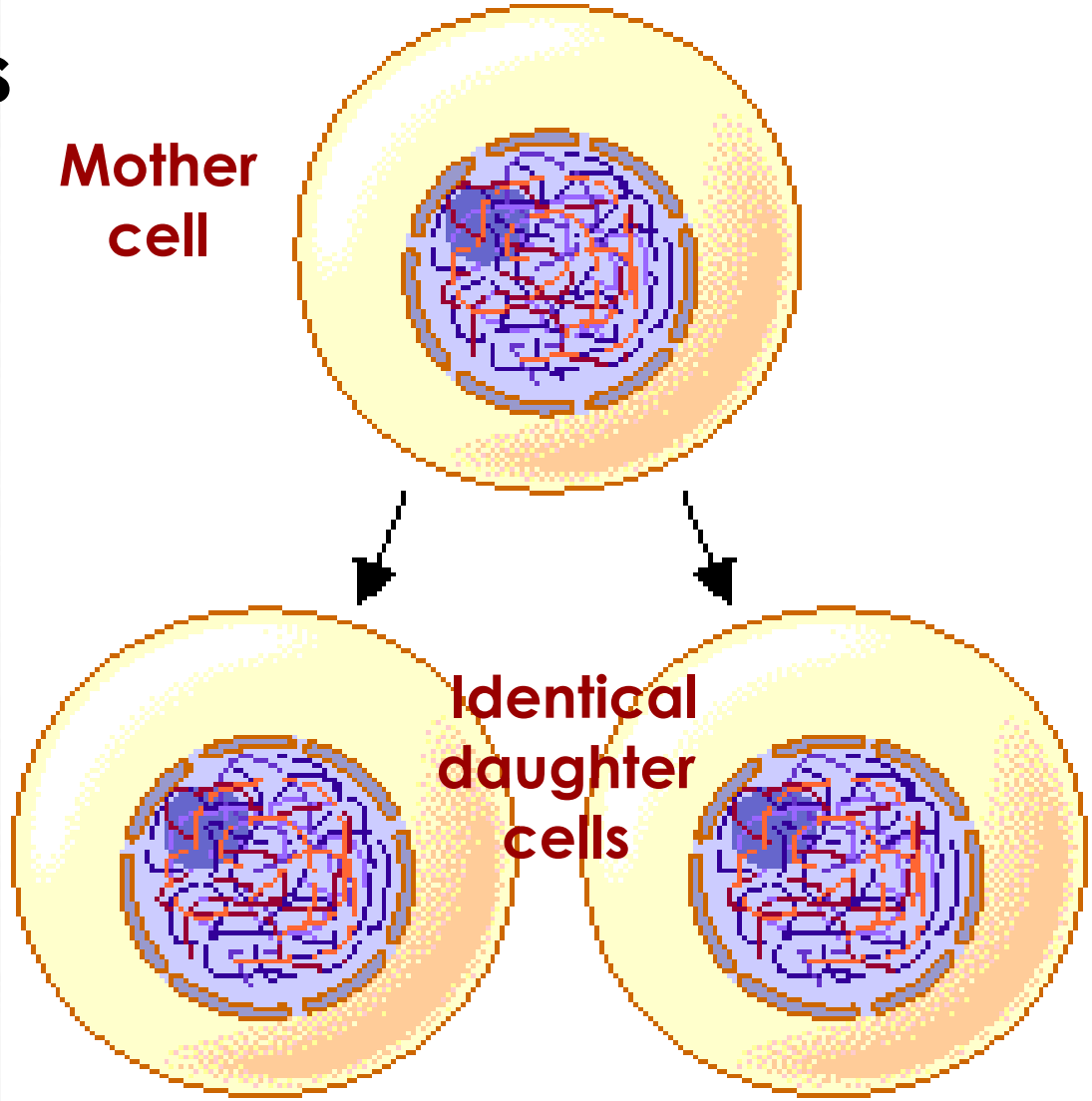


The Guarentee

The product of mitosis is 2 cells

The daughter cells are identical to each other & to the mother cell

Why is this so important?



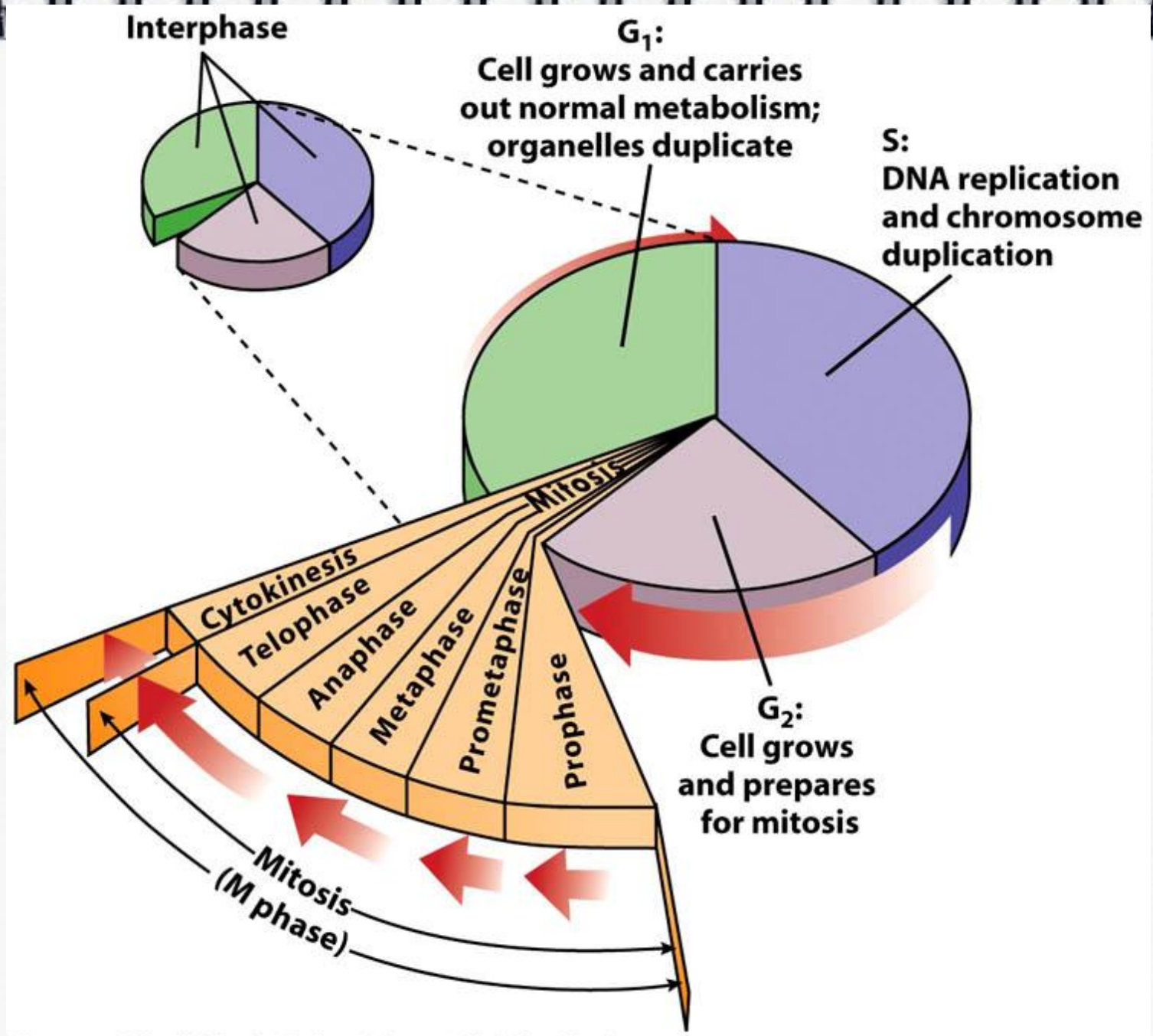


Figure 14-1 Cell and Molecular Biology, 5/e (© 2008 John Wiley & Sons)

MEIOSIS

Organisms that reproduce Sexually are made up of two different types of cells.

1. **Somatic Cells** are "body" cells and contain the normal number of chromosomes ….called the "Diploid" number (the symbol is 2n). Examples would be … skin cells, brain cells, etc.

1. **Gametes** are the "sex" cells and contain only ½ the normal number of chromosomes…. called the "Haploid" number (the symbol is n)….. Sperm cells and ova are gametes.

n = number of chromosomes in the set… so….2n means 2 chromosomes in the set…. Polyploid cells have more than two chromosomes per set… example: 3n (3 chromosomes per set)

Gametes

- The **Male Gamete** is the **Sperm** and is produced in the male gonad the **Testes**.

- The **Female Gamete** is the **Ovum (ova = pl.)** and is produced in the female gonad the **Ovaries**.

During **Ovulation** the ovum is released from the ovary and transported to an area where **fertilization**, the joining of the sperm and ovum, can occur

Fertilization results in the formation of the **Zygote**. (fertilized egg)

Sperm + Ovum (egg) —**fertilization**→ **Zygote**

Chromosomes

- **If an organism has the Diploid number (2n) it has two matching homologues per set. One of the homologues comes from the mother the other homologue comes from the father**
- **Most organisms are diploid.**

Humans have 23 sets of chromosomes… therefore humans have 46 total chromosomes….. The diploid number for humans is 46 (46 chromosomes per cell).

Homologous Chromosomes

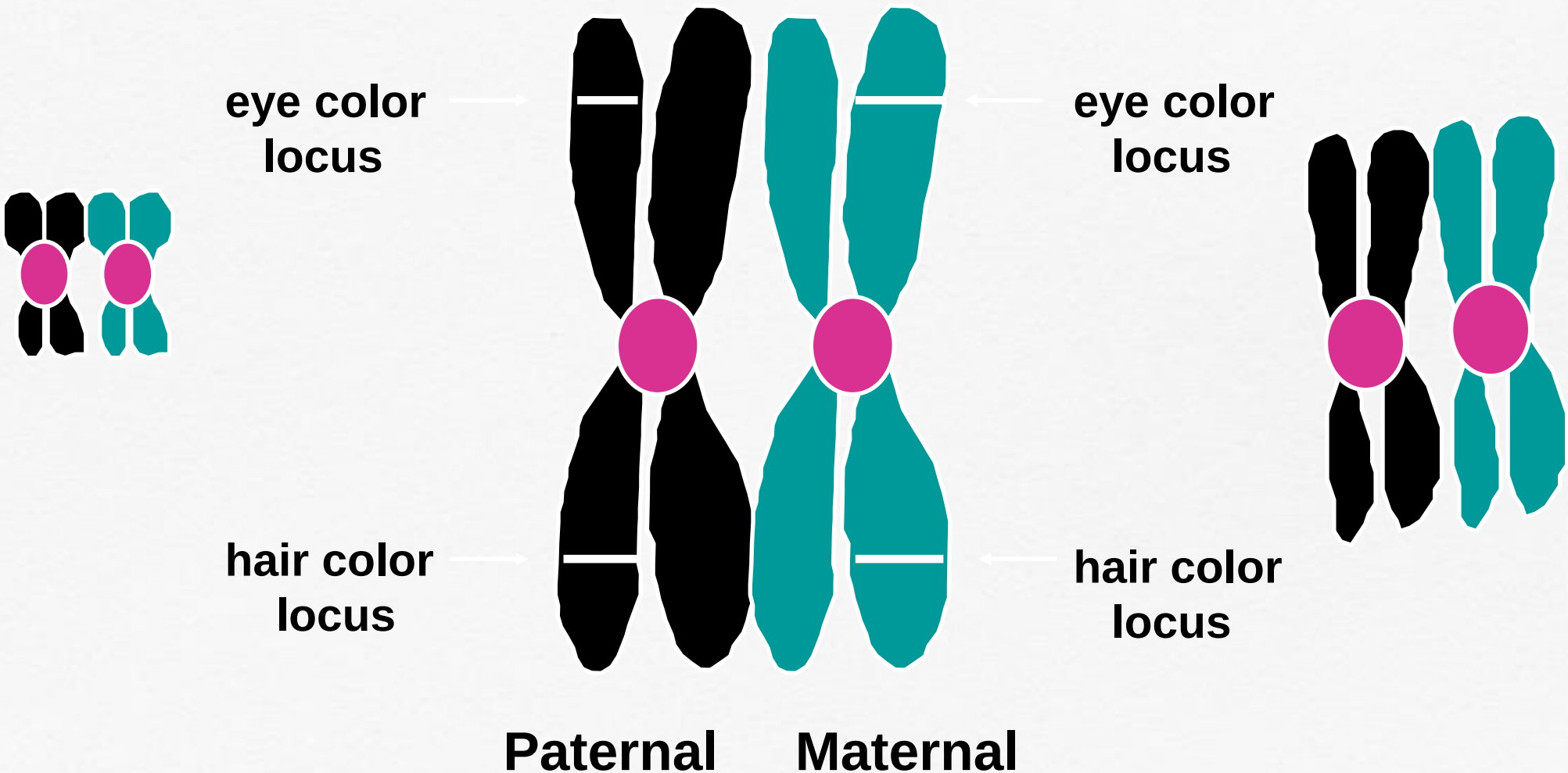
- Pair of chromosomes (maternal and paternal) that are similar in shape and size.
- Homologous pairs (tetrads) carry genes controlling the same inherited traits.
- Each locus (position of a gene) is in the same position on homologues.
- Humans have 23 pairs of homologous chromosomes.

  22 pairs of autosomes

  1 pair of sex chromosomes

Homologous Chromosomes

(because a homologous pair consists of 4 chromatids it is called a “Tetrad”)



Meiosis

is the process by which ”gametes” (sex cells) , with half the number of chromosomes, are produced.

During Meiosis diploid cells are reduced to haploid cells

Diploid (2n) → Haploid (n)

If Meiosis did not occur the chromosome number in each new generation would double…. The offspring would die.

Meiosis

Meiosis is Two cell divisions

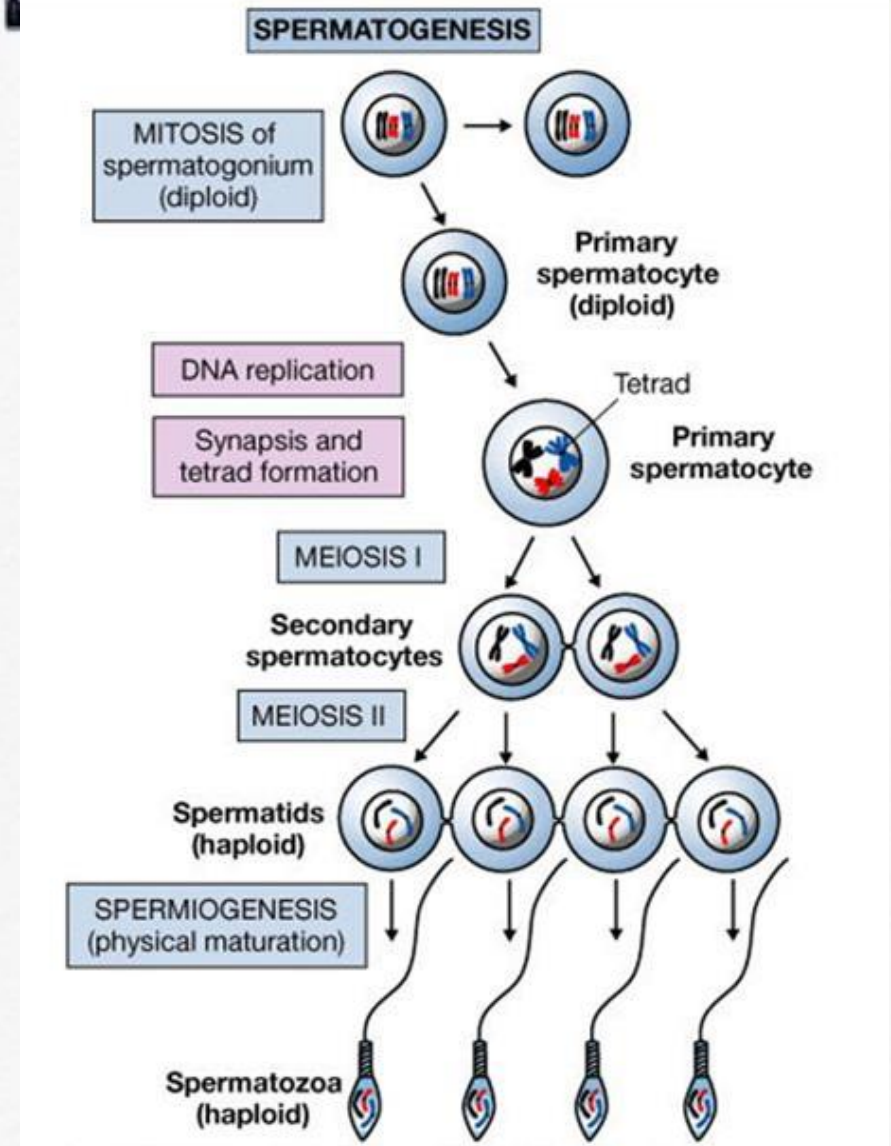
(called meiosis I and meiosis II)

with only one duplication of chromosomes.

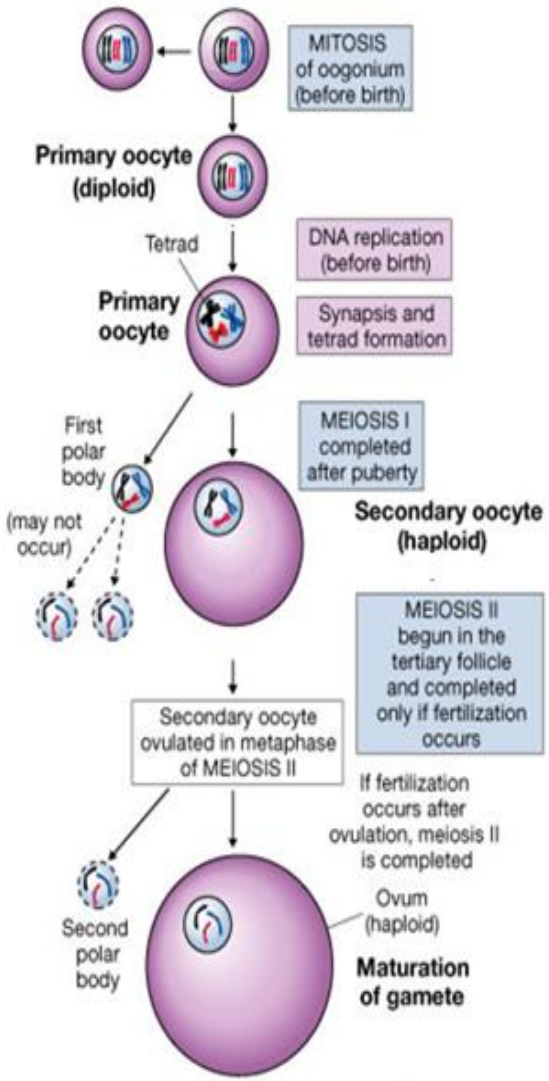
Meiosis in males is called spermatogenesis and produces sperm.

Meiosis in females is called oogenesis and produces ova.

Spermatogenesis



Oogenezis



4 sperm cells are produced from each primary spermatocyte.

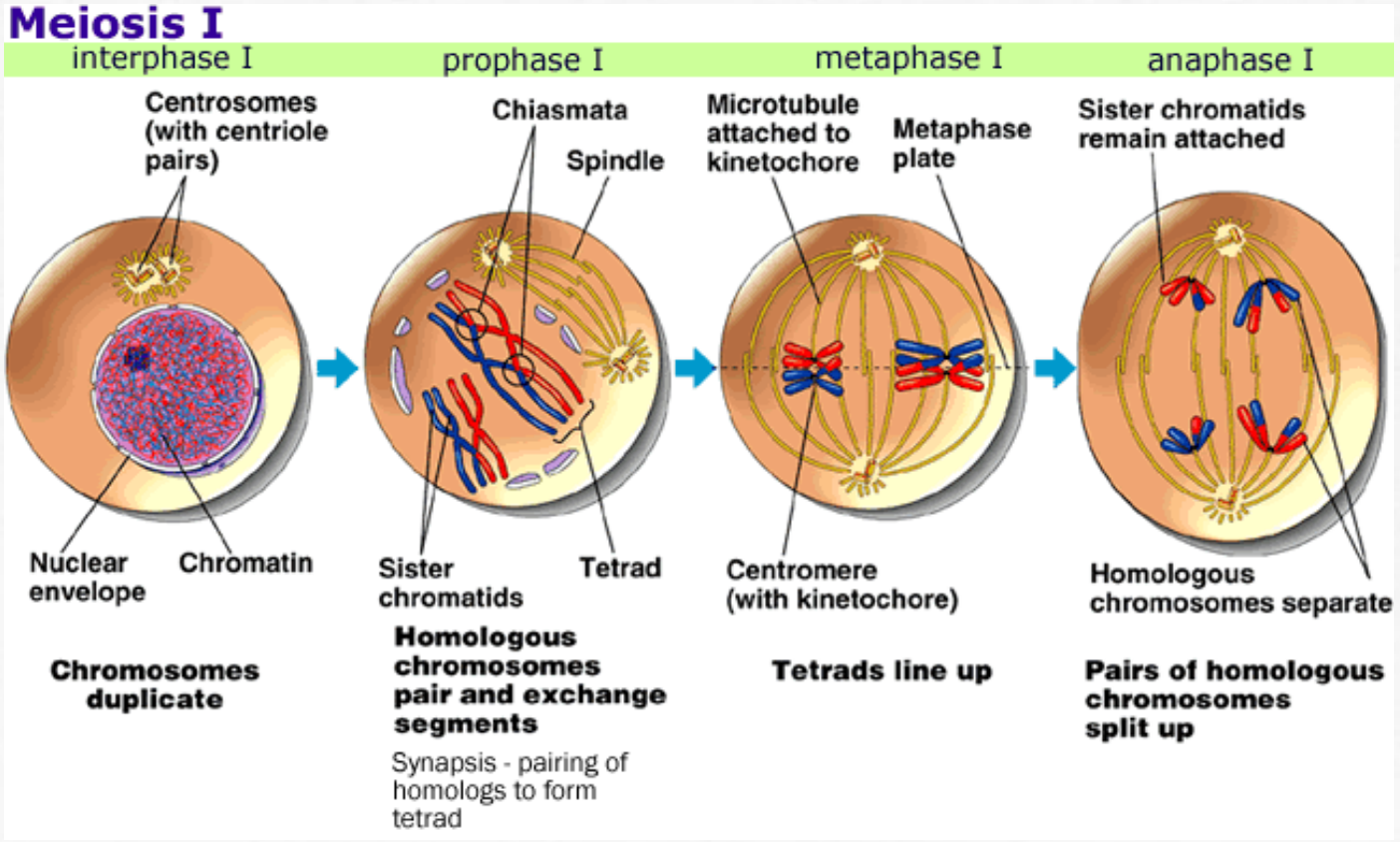
***** The polar bodies die… only one ovum (egg) is produced from each primary oocyte.**

Interphase I

- Similar to mitosis interphase.
- Chromosomes replicate (S phase).
- Each duplicated chromosome consist of two identical sister chromatids attached at their centromeres.
- Centriole pairs also replicate.

Meiosis I (four phases)

- **Cell division that reduces the chromosome number by one-half.**



Prophase I

- Longest and most complex phase.
- 90% of the meiotic process is spent in Prophase I
- Chromosomes condense.
- Synapsis occurs: homologous chromosomes come together to form a tetrad.
- Tetrad is two chromosomes or four chromatids (sister and nonsister chromatids).

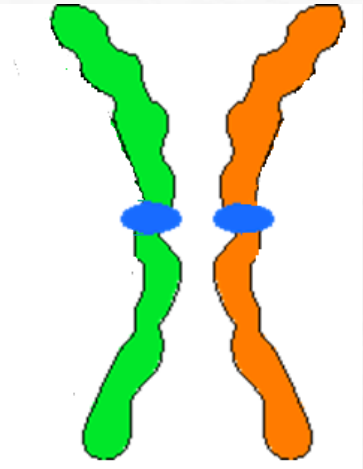
During Prophase I
"Crossing Over" occurs.

Crossing Over is one of the Two major occurrences of Meiosis

(The other is Non-disjunction)

- **During Crossing over segments of nonsister chromatids break and reattach to the other chromatid. The Chiasmata (chiasma) are the sites of crossing over.**

homologous chromosomes



nonsister chromatids

Replication

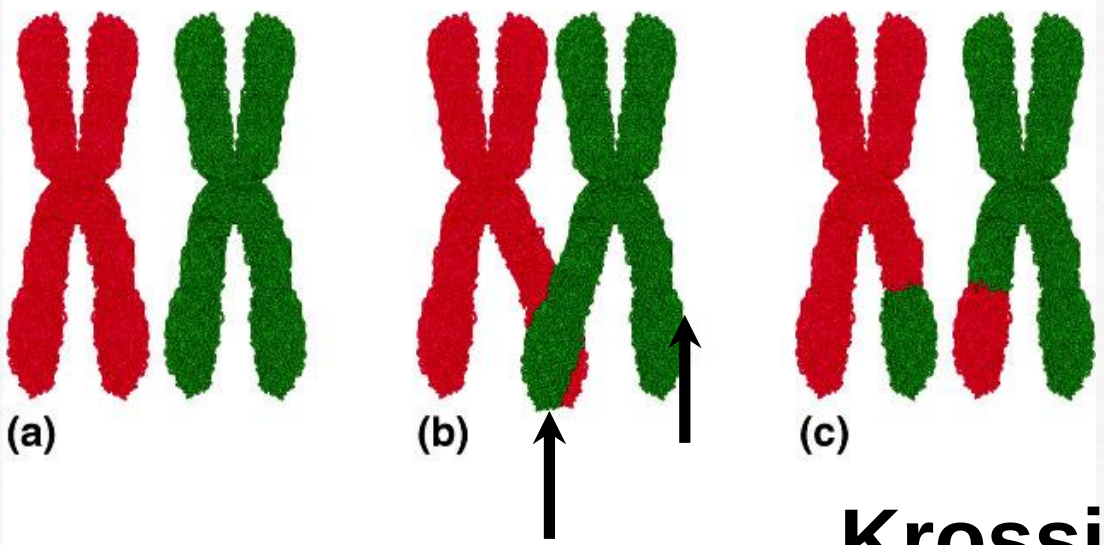
Sinapsis

sister chromatids

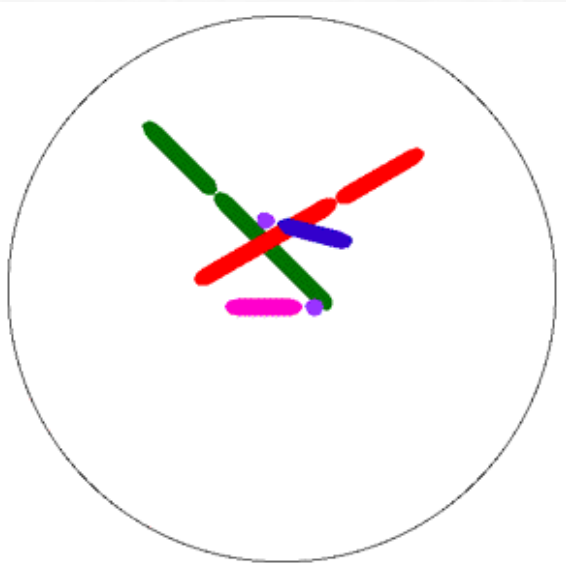
Tetra d

Crossing Over

creates variation (diversity) in the offspring's traits.



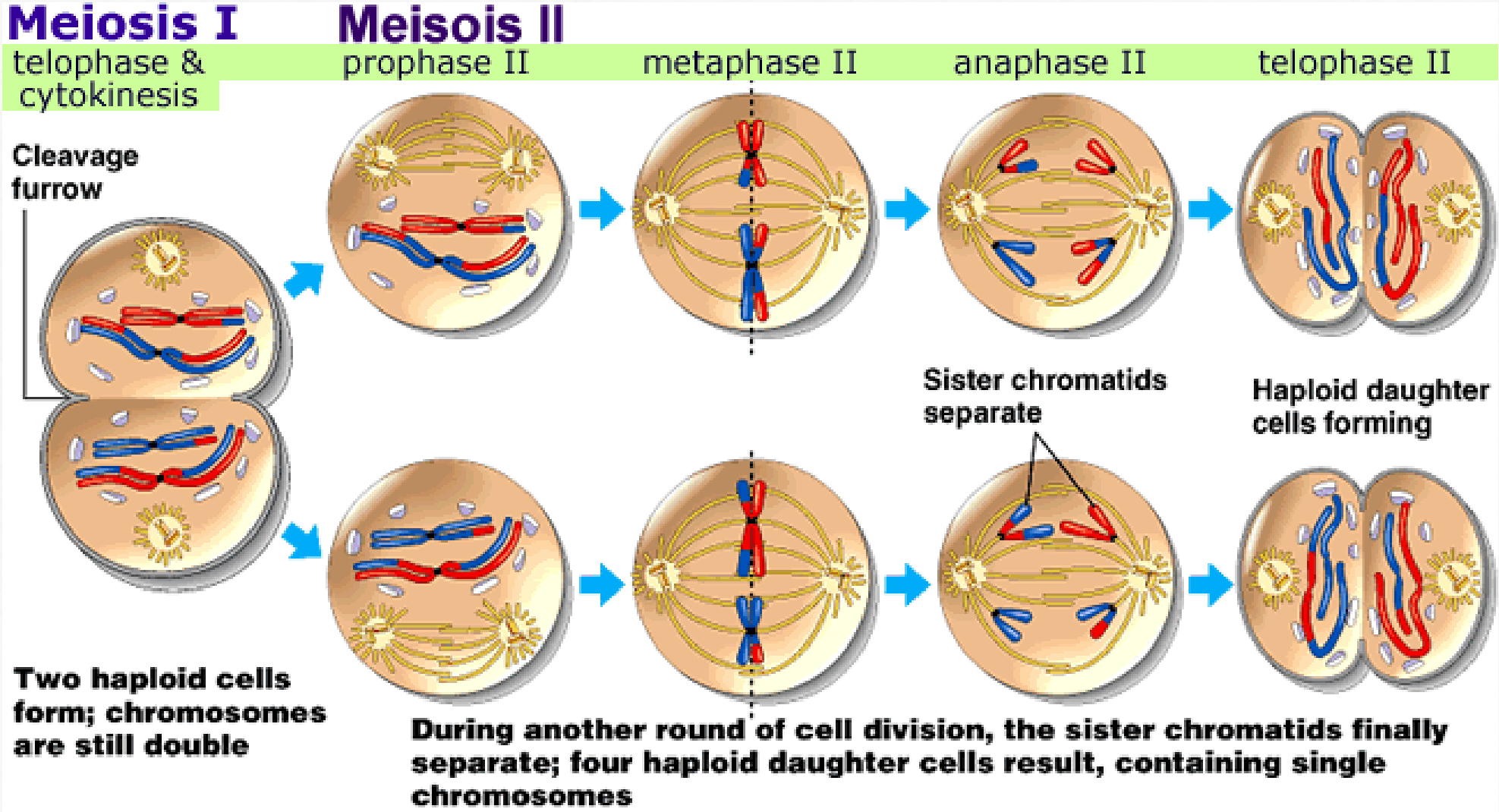
chiasma

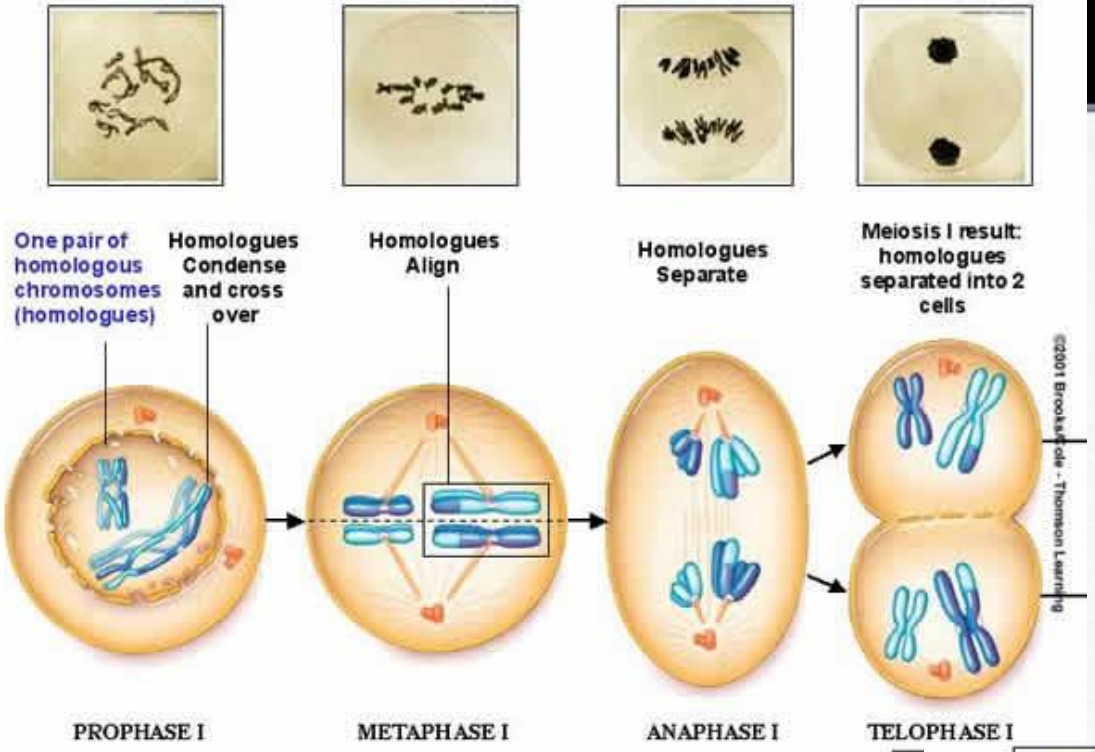


Krossing over

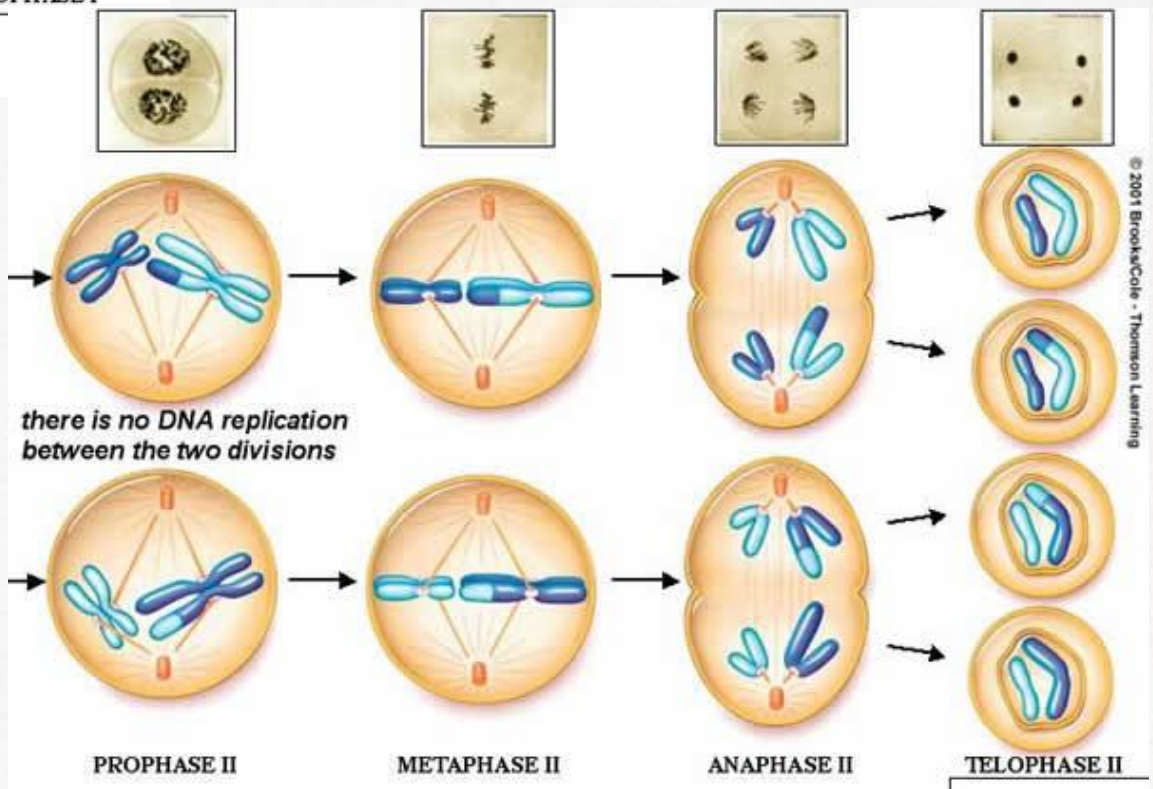
Meiosis II

is similar to mitosis
(no more DNA replication)





MEIOSIS I: Separate the Homologues



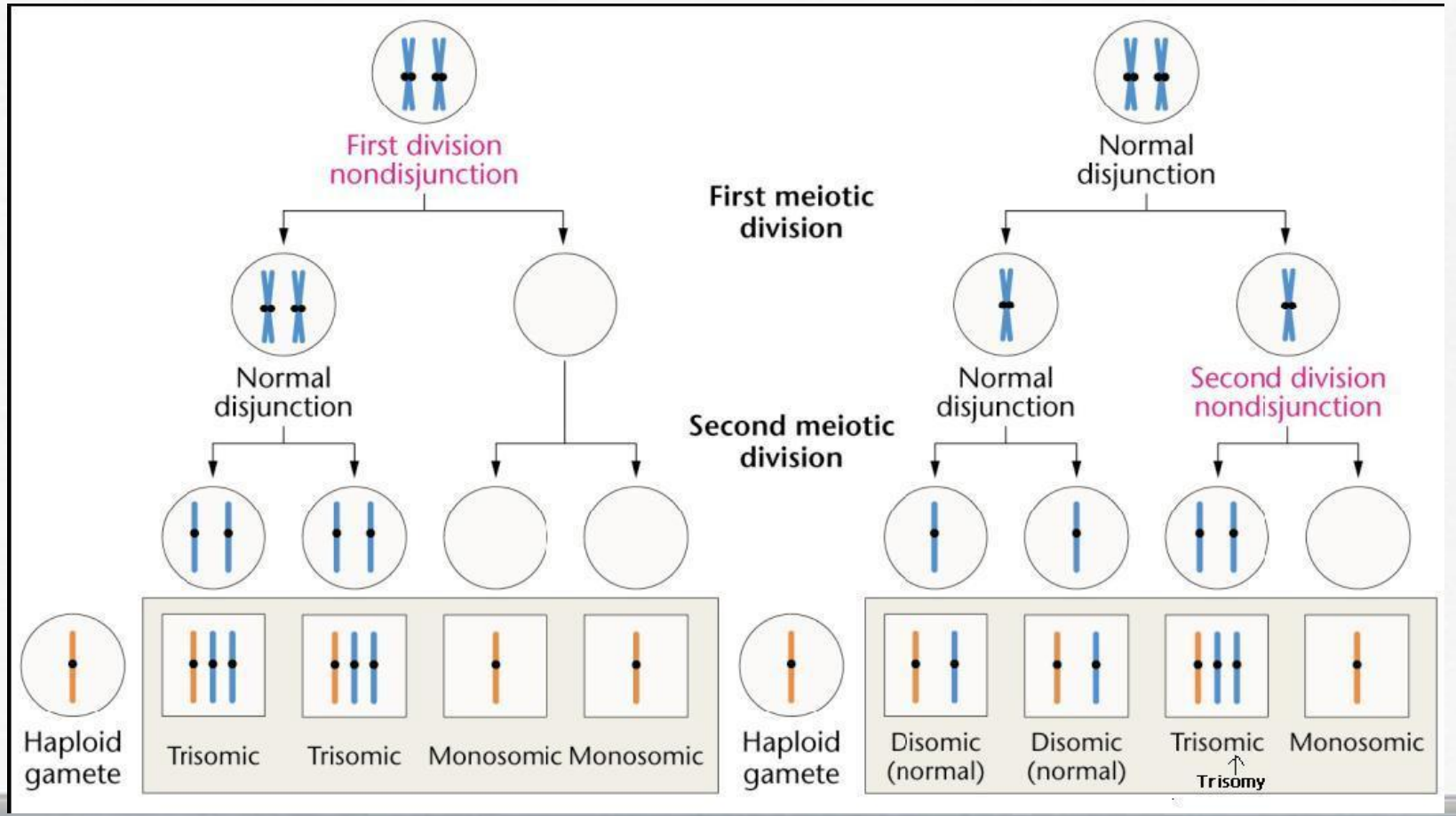
MEIOSIS II: Separate the Sister Chromatids (by mitosis)

Non-disjunction

- **Non-disjunction is the failure of homologous chromosomes, or sister chromatids, to separate during meiosis.**
- **Non-disjunction results with the production of zygotes with abnormal chromosome numbers…… remember…. An abnormal chromosome number (abnormal amount of DNA) is damaging to the offspring.**

Non-disjunctions usually occur in one of two fashions.

- **The first is called Monosomy, the second is called Trisomy. If an organism has Trisomy 18 it has three chromosomes in the 18^{th} set, If an organism has Monosomy 23 it has only one chromosome in the 23^{rd} set.**

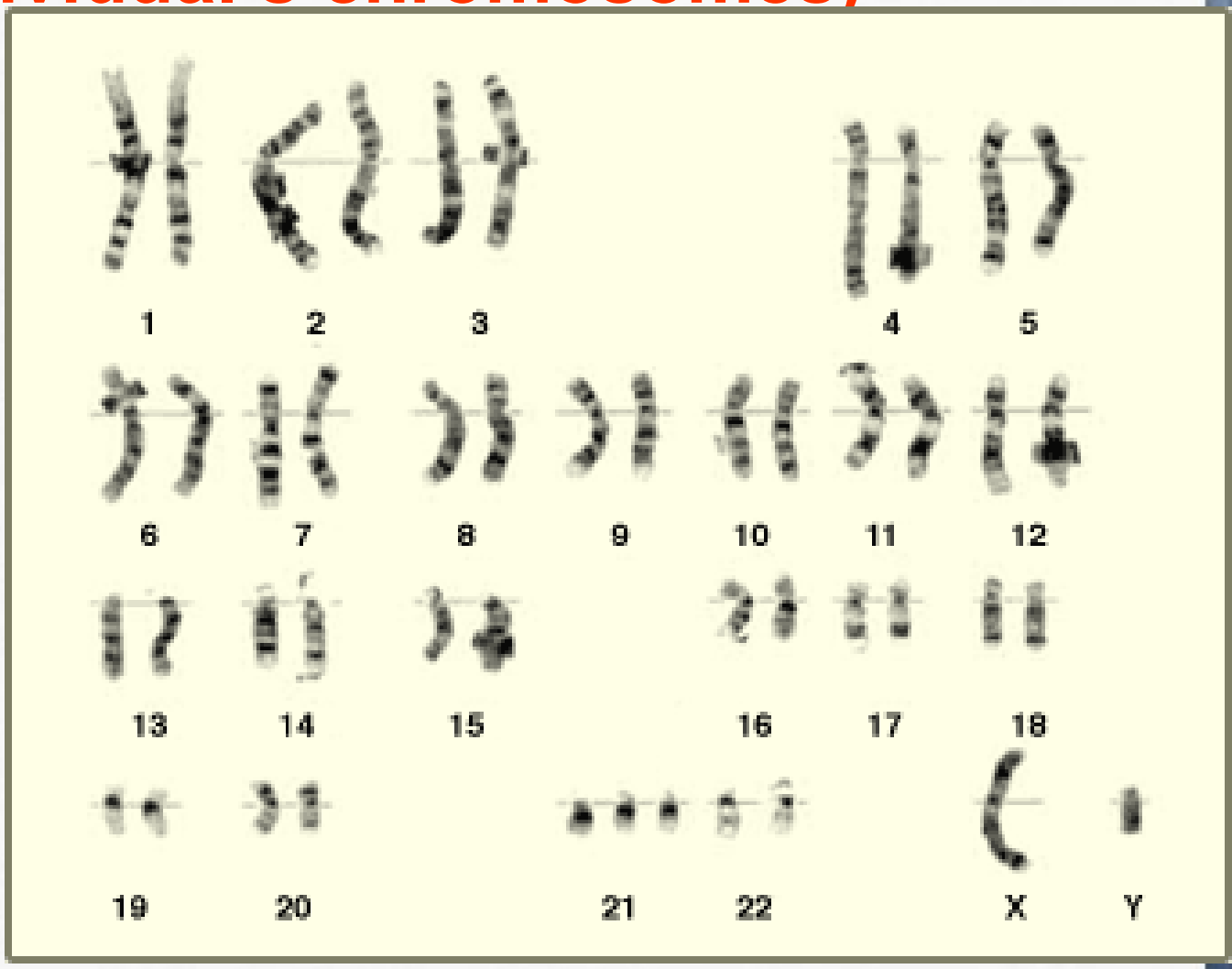


Karyotype

(picture of an individual's chromosomes)

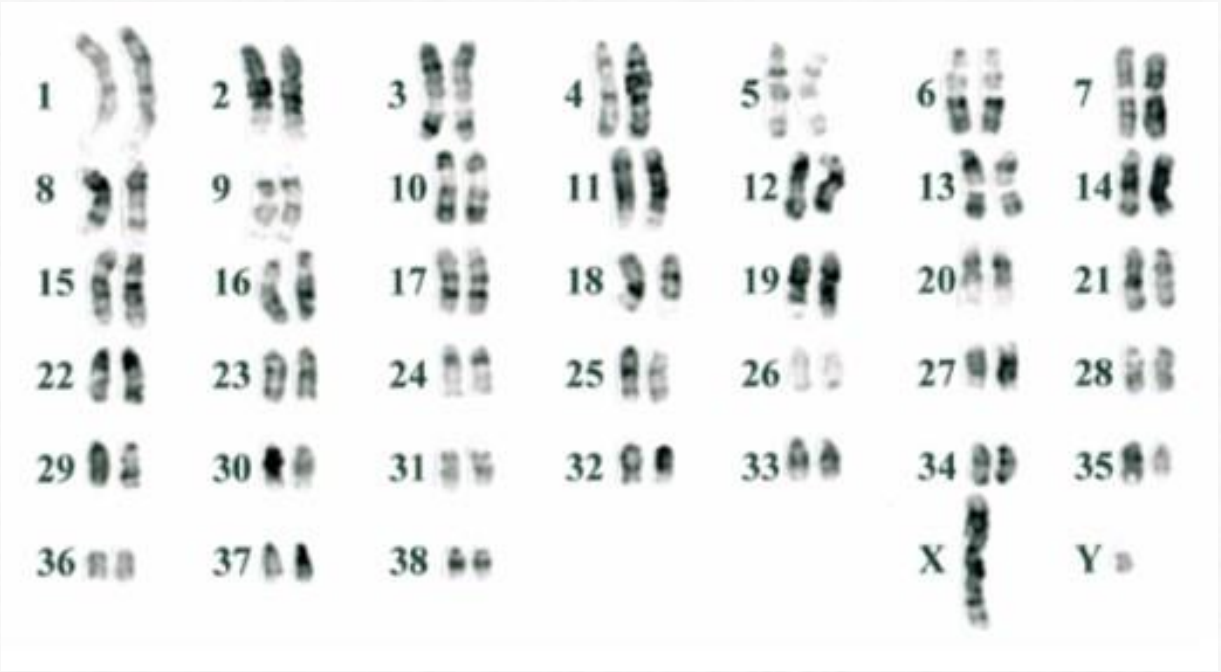
One of the ways to analyze the chromosomal aberrations is to make a Karyotype.

..describes the chromosome count of an organism and what these chromosomes look like under a light <u>microscope</u>.



What genetic disorder does this karyotype show?

- **Dog**
- **2n: 78**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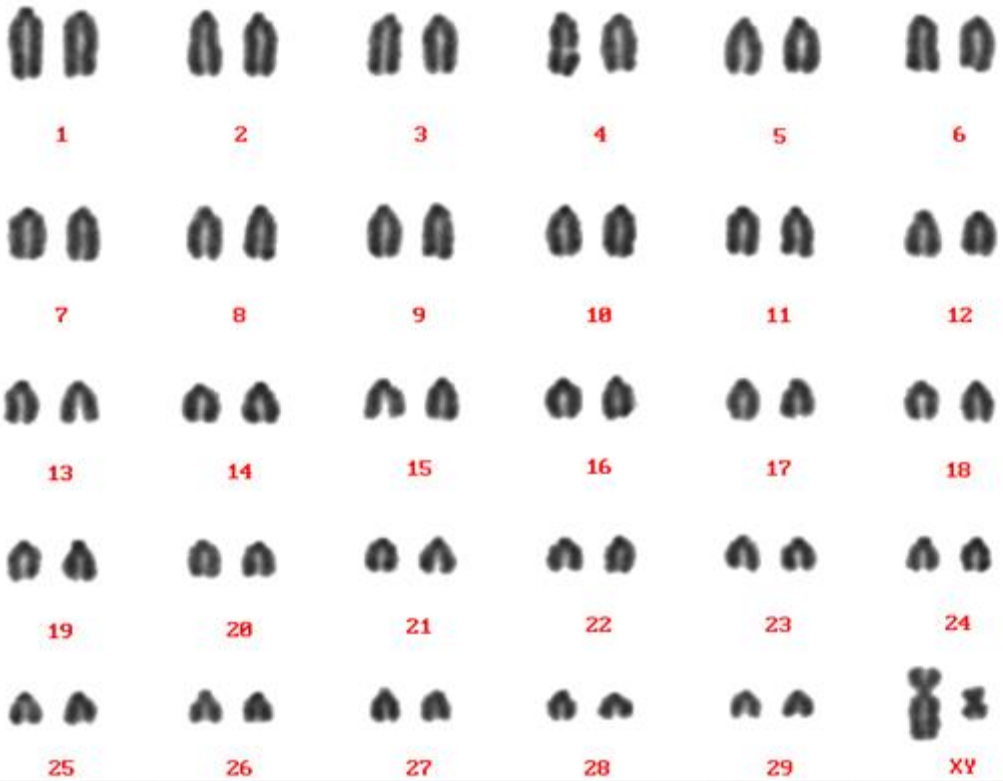
X
Y

- **Cow**
- **2n: 60**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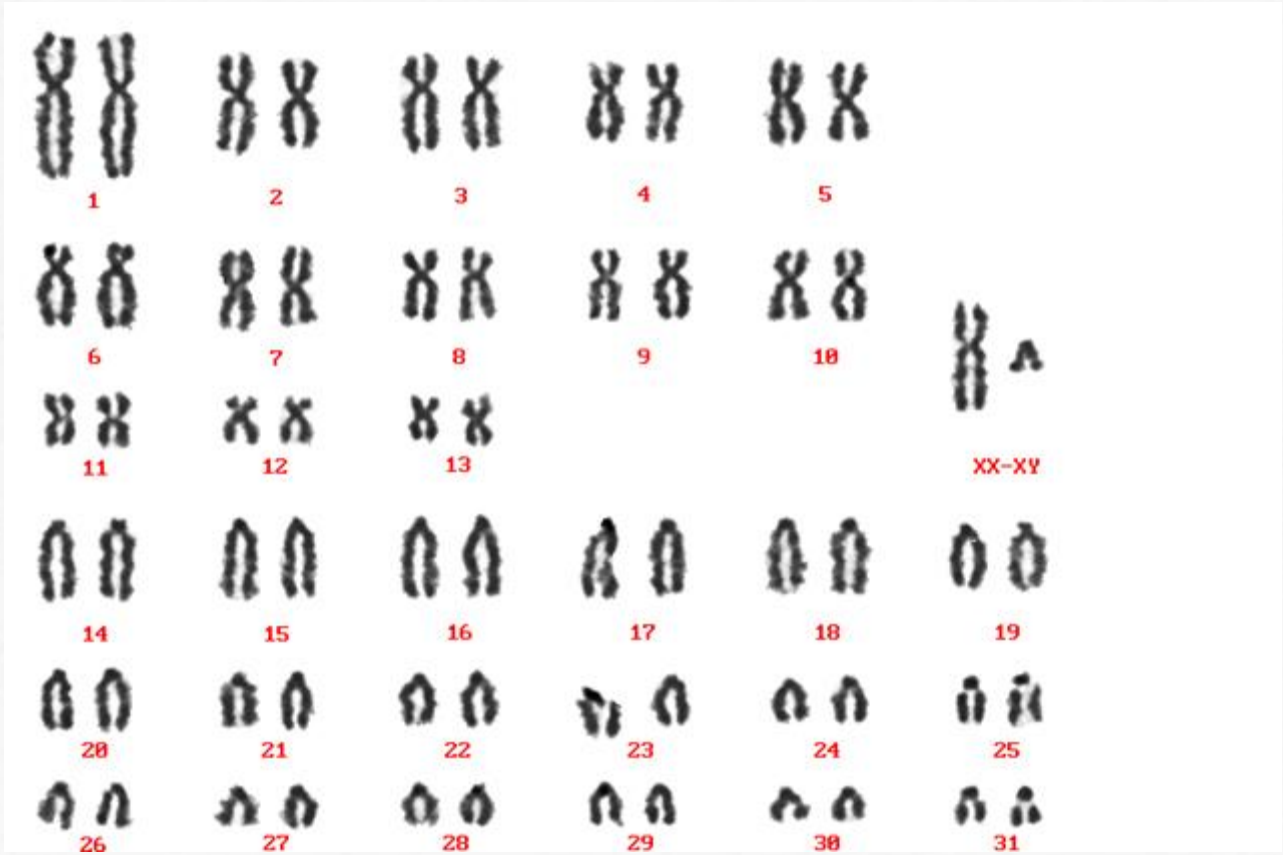
- **Horse**
- **2n: 64**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- **Chicken**
- **2n: 78**
- **9 macrochromosome,**
- **Sex chromosomes Z and W**

ZZ=♂

ZW=♀

The ZW sex-determination system is a chromosomal system that determines the sex of offspring in birds, some fish and some insects (including butterflies), and some reptiles, including Komodo dragons.

MITOSIS

1 – In the body cells of multicellular organisms

2 – Allows the development of the organism

3 – The number of chromosomes remains constant

4 – The resulting cells are identical

5 – Two cells are formed

6 – Only one division

7 – It takes from the formation of the zygote to the death.

MEIOSIS

1. In the reproductive cells of multicellular organisms
2. Allows the reproduction
3. As a result of division, the number of chromosomes goes down, and remains constant
4. Individuals differ with new chromosomal combinations.
5. Four cells are formed
6. The nucleus and cytoplasm division occurs twice.
7. Tetrad and crossing-over events occur during division. Provides variation ...
8. begins in adolescence, lasts during the reproductive period.