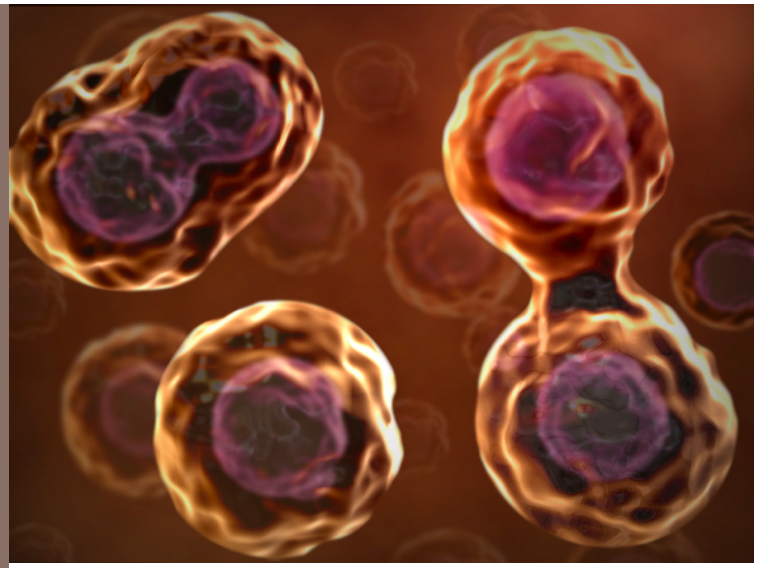
- Question of the Day: How does cell division cause cancer?



“Cell Division and Development”

Life Span

- Like all organisms, human cells have a given life span from birth to death.
- Cells with long life spans don't divide.
- Cells with short life spans do divide.
- Depends on the function of the cell.

CONTROLS ON CELL GROWTH

- DEPENDS ON FUNCTION
  - Muscle and nerve cells don't divide
  - Skin, digestive, and bone marrow divide rapidly to replace those that wear out or break down

II. Why Cell Division?

A. Necessary for the growth of organisms.

B. Necessary for every cell in organism to have the genetic instructions to survive.

C. Genetic instructions passed through DNA in chromosomes.

I. DNA:

A. Cell reproduction begins with DNA.

B. DNA is a long, thin molecule stores genetic information!

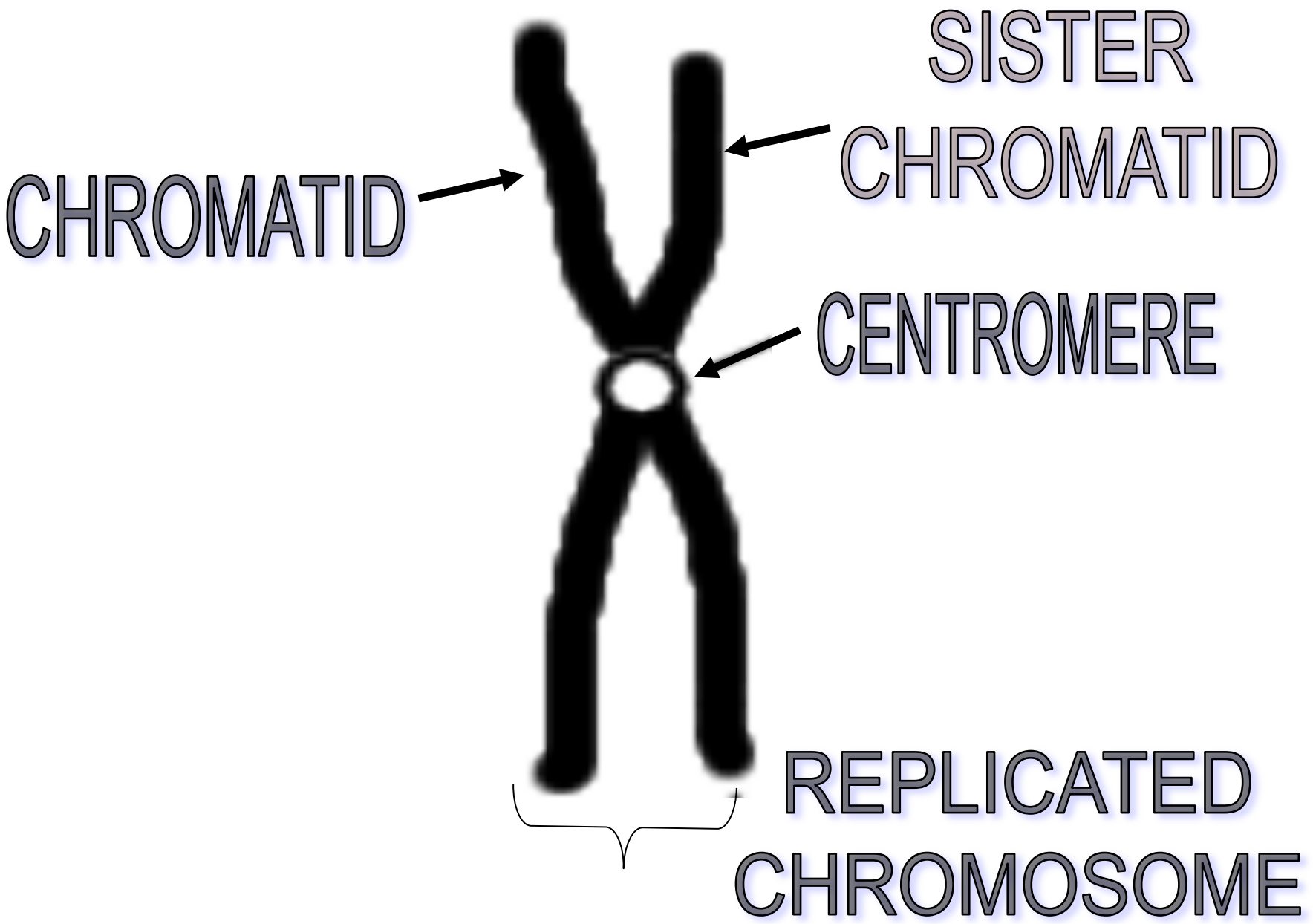
C. Found in nucleus of eukaryotic cells.

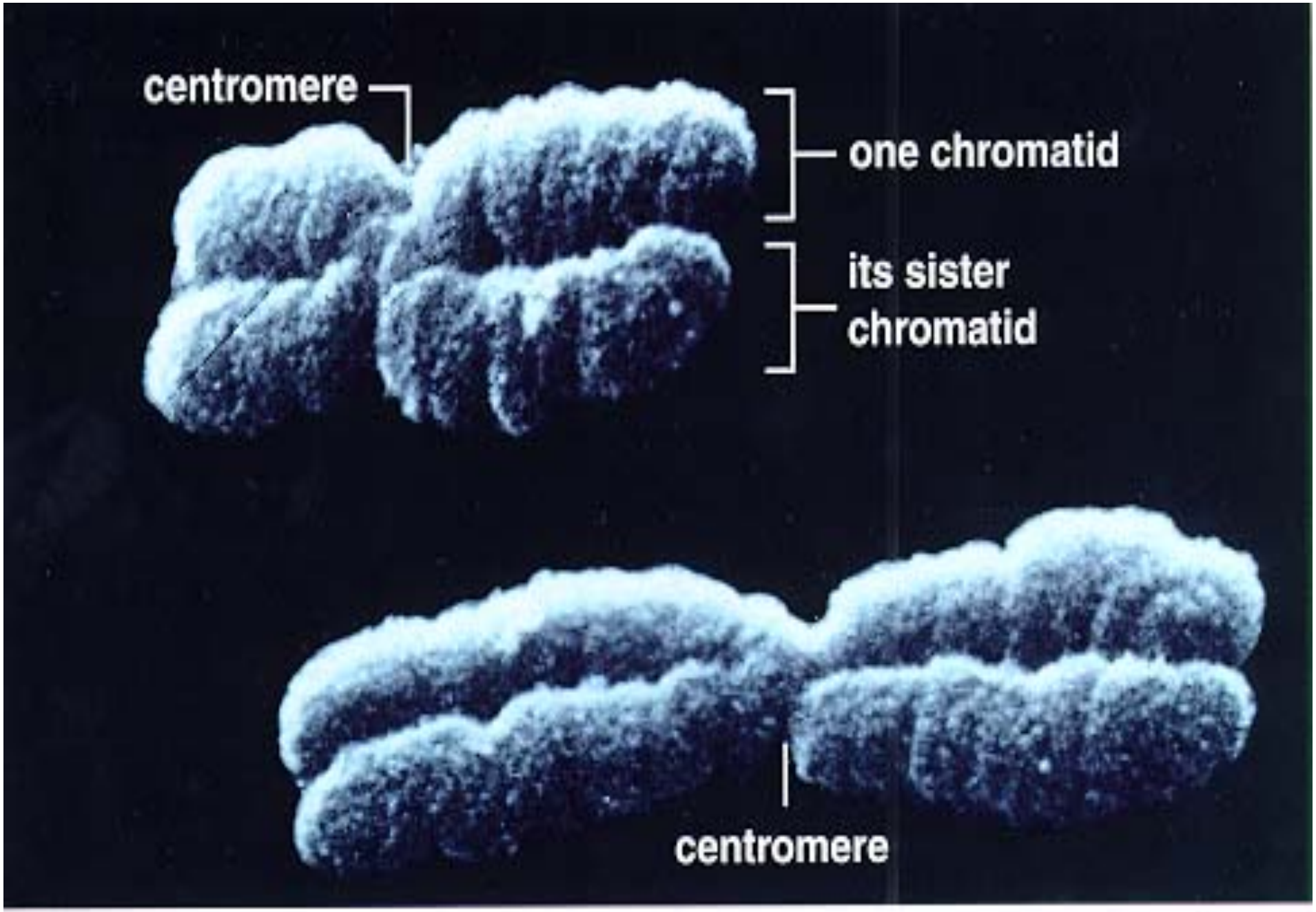
III. What are Chromosomes?

A. Rod-shaped structures of coiled DNA and proteins.

B. Histones: proteins in chromosomes that help DNA form its double helix shape.

C. Nonhistones: proteins that control activities of DNA


SISTER CHROMATID
CHROMATID
CENTROMERE
REPLICATED CHROMOSOME


centromere
one chromatid
its sister
chromatid
centromere

V. Chromosome Types:

A. Sex Chromosomes:

1. Chromosomes that determined the sex of an organism.
2. In humans, are either X or Y.
3. Females have two X chromosomes.
4. Males have an X and Y pair.

B. Autosomes:

1. All the other chromosomes in an organism.
2. Homologous Chromosomes:

a) Two copies of each autosome.

b) Found in every cell of organisms produced by sexual reproduction.

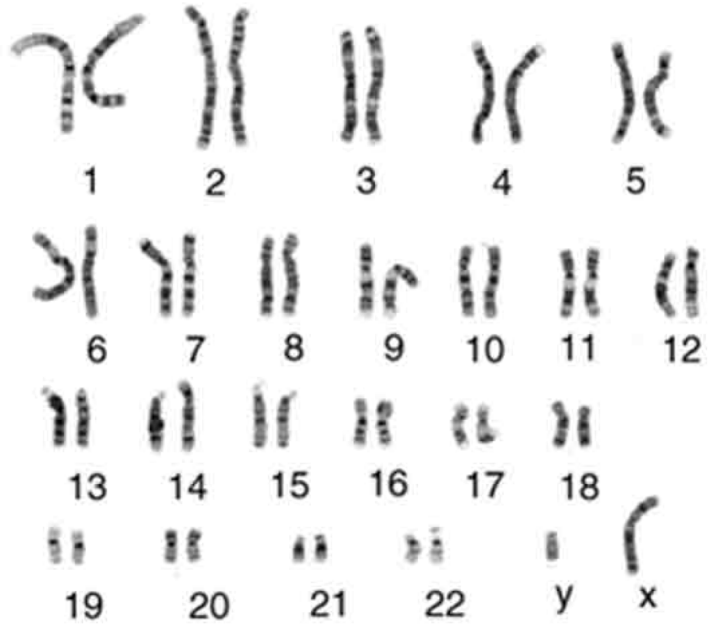
Human sex chromosomes

Females: XX

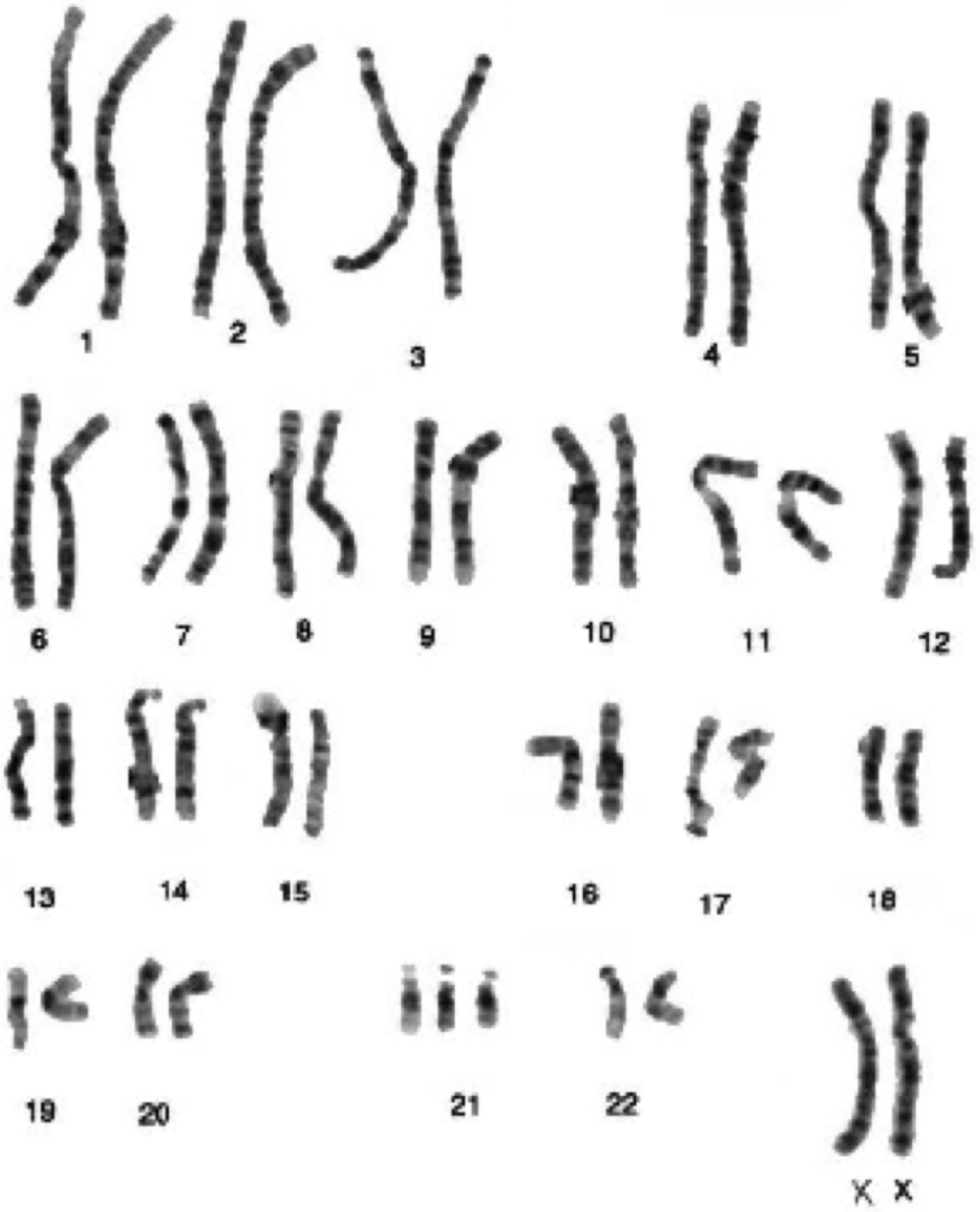
Males: XY

Karyotype

- Karyotype: A photomicrograph of chromosomes arranged according to a standard of classification.



Trisomy 21
47,XX,+21



VI. Diploid and Haploid Cells:

A. Diploid Cells:

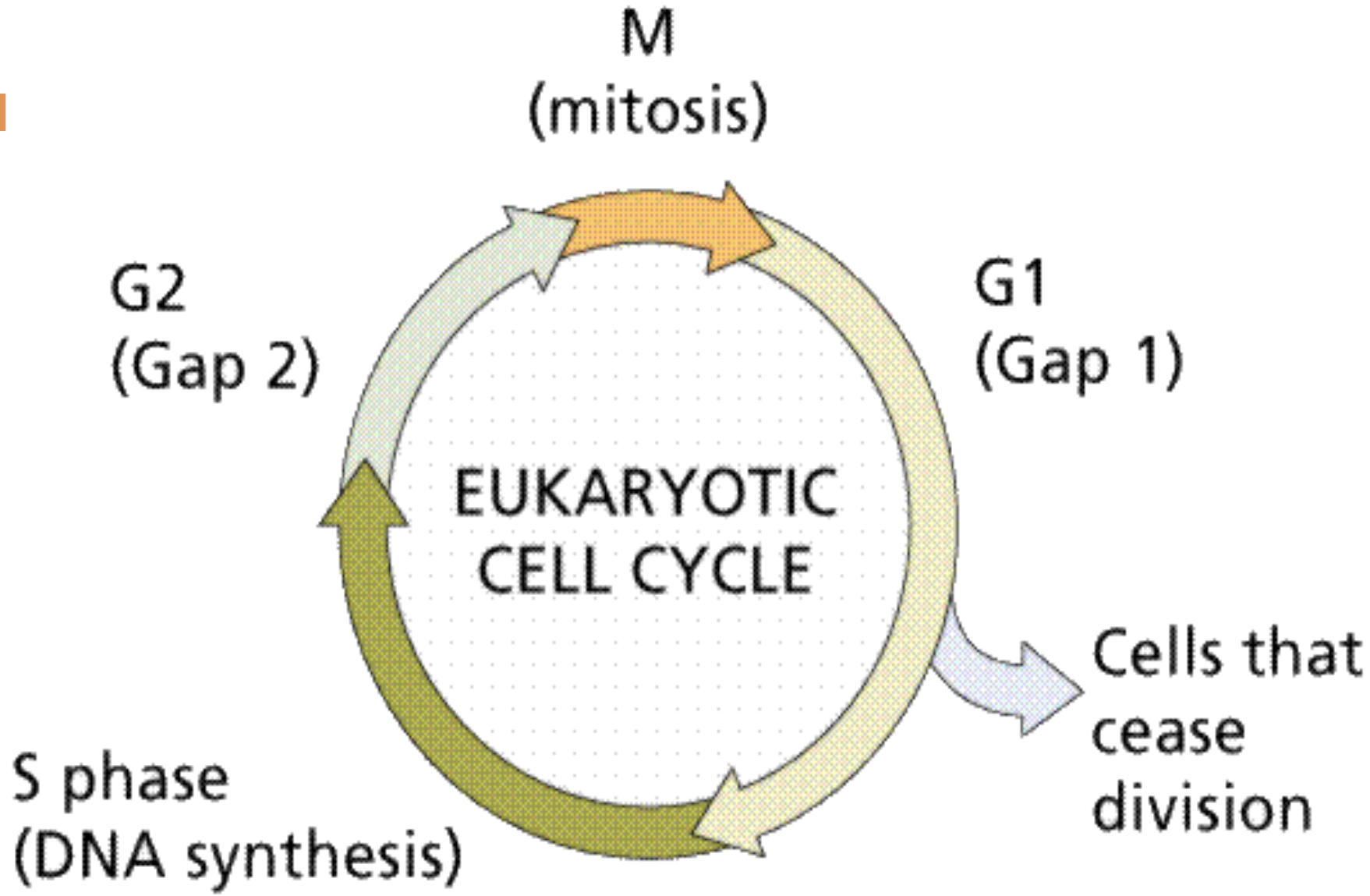
1. Cells with two sets of chromosomes.
2. Abbreviated as *2n*.
3. In humans, the diploid number is 46 (22 pairs of homologous chromosomes, 2 sex chromosomes).

B. Haploid Cells:

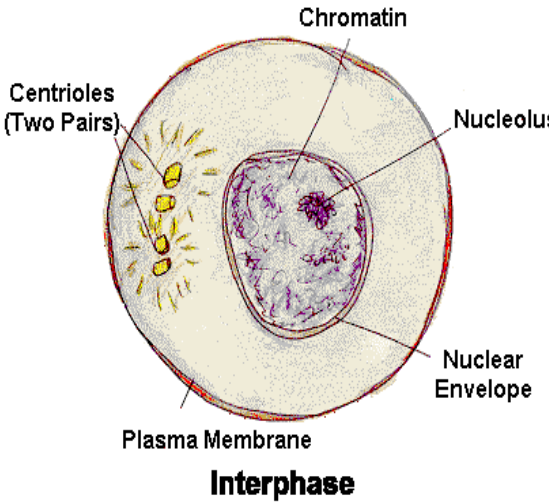
1. Contain only one set of chromosomes.
2. Examples are human sperm and egg cells.
3. Two haploid (*1n*) cells combine to produce a new diploid (*2n*) organism.

I. The Cell Cycle:

A. Cell division occurs during the cell cycle
B. It is the repeating set of events that make up the life cycle of a cell.
C. Divided into two phases:
    1. Interphase: time between cell divisions
    2. Cell Division: consists of two stages
        a. Mitosis: division of nucleus.
        b. Cytokinesis: division of cytoplasm of the cell.

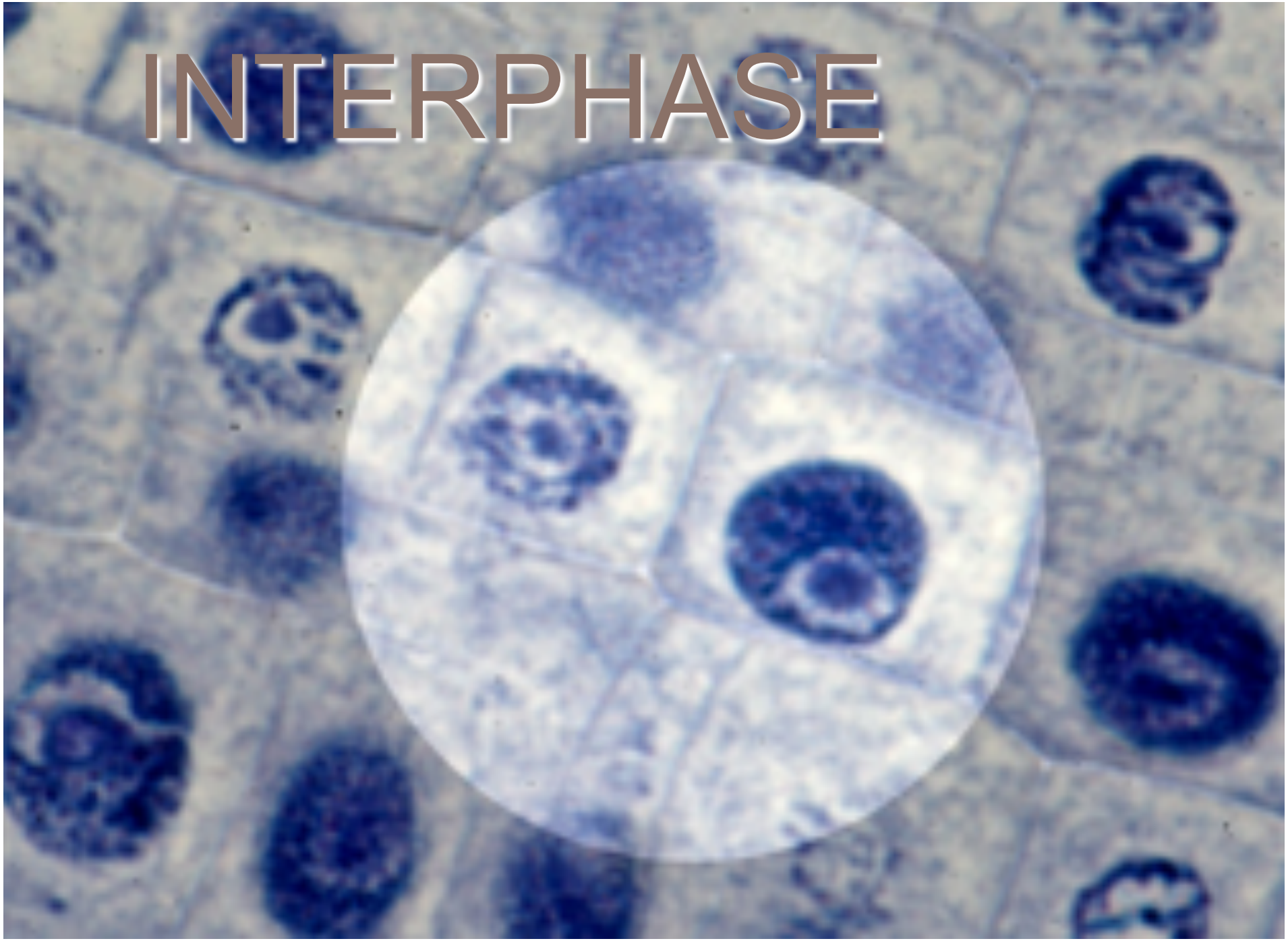

M
(mitosis)
G2
(Gap 2)
G1
(Gap 1)
EUKARYOTIC
CELL CYCLE
Cells that
cease
division
S phase
(DNA synthesis)

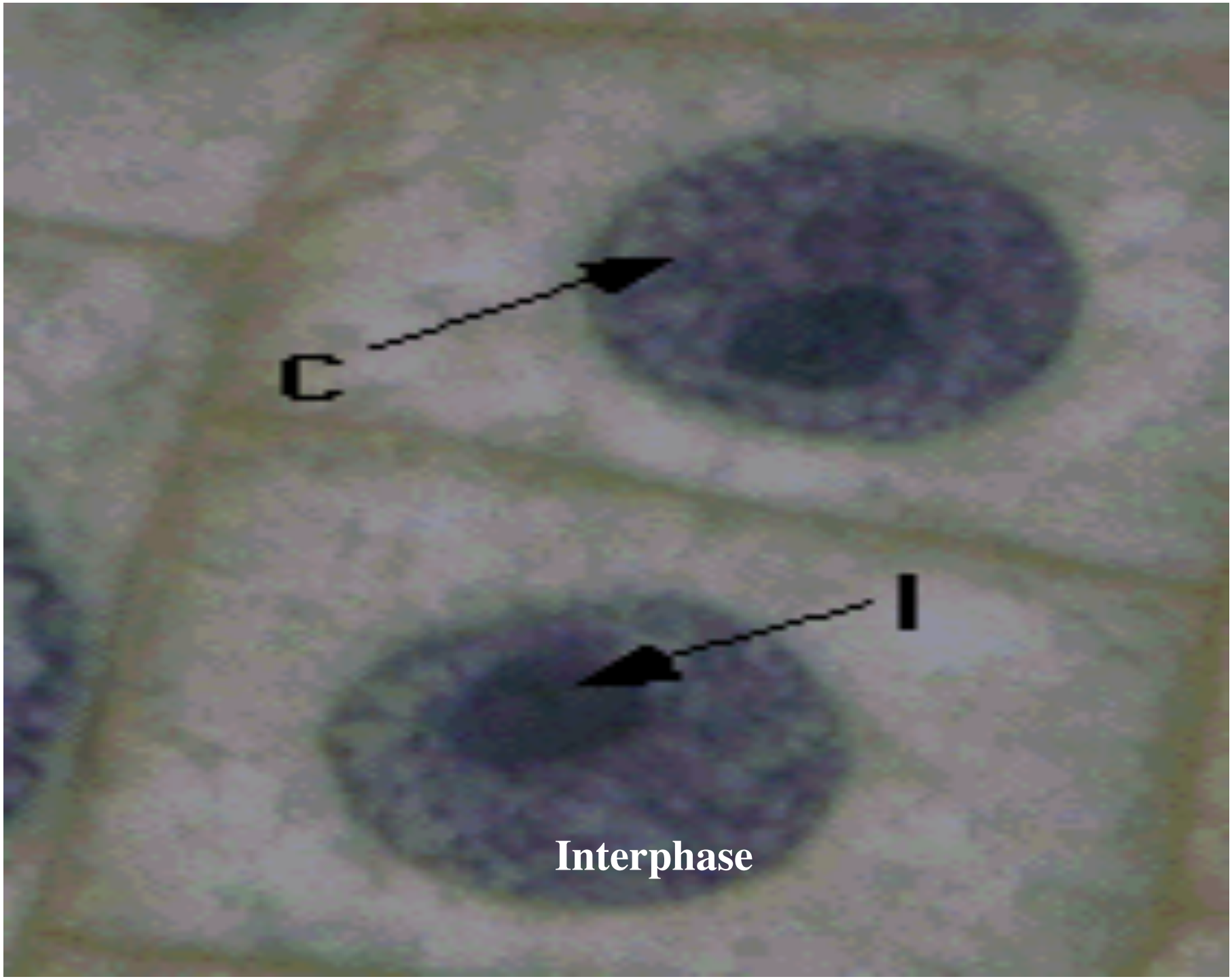
VII. Stages of Interphase:

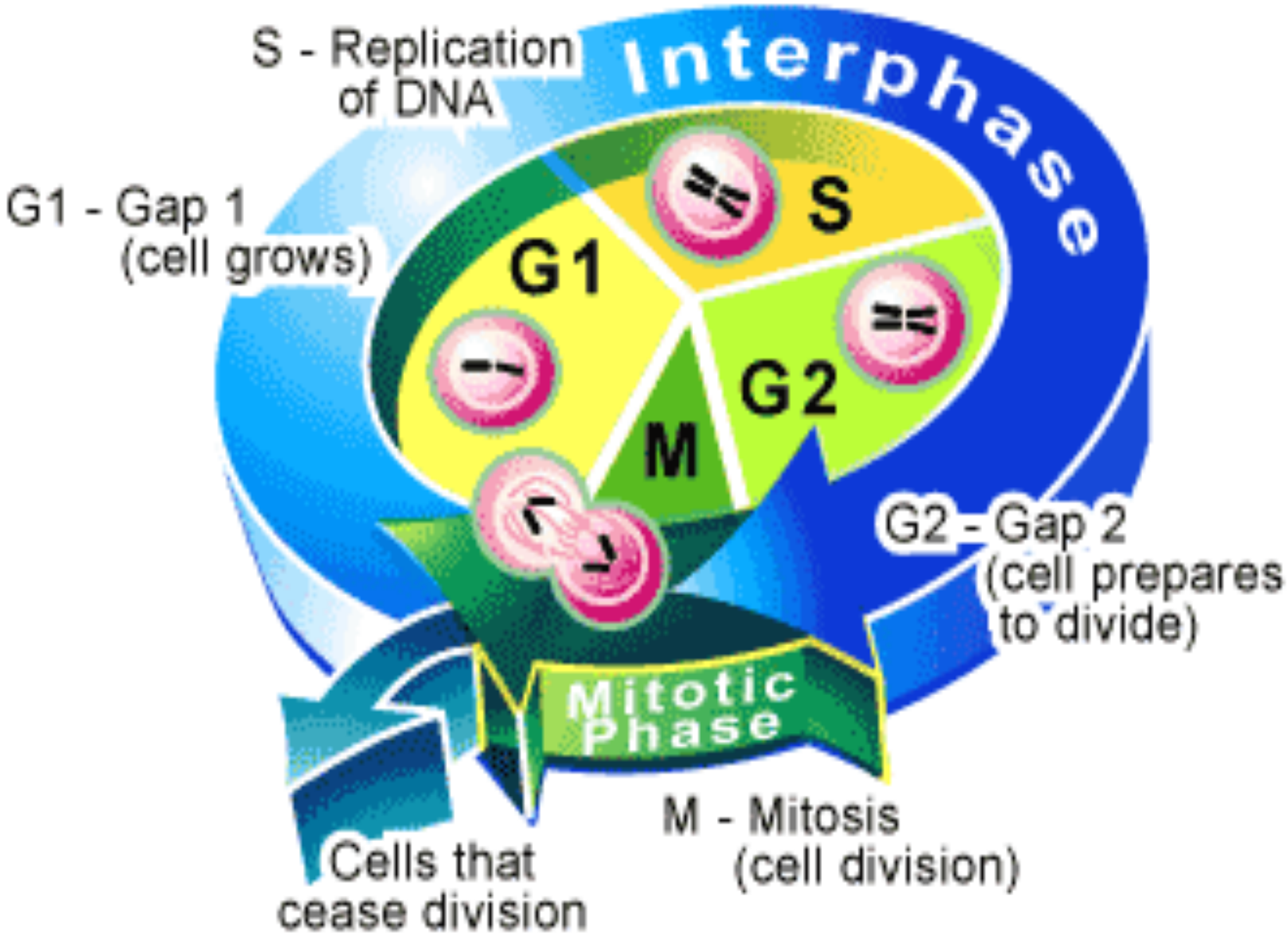


1. G_1 Phase: cell growth.
2. S Phase: DNA replication.
3. G_2 Phase: growth and preparation for cell division

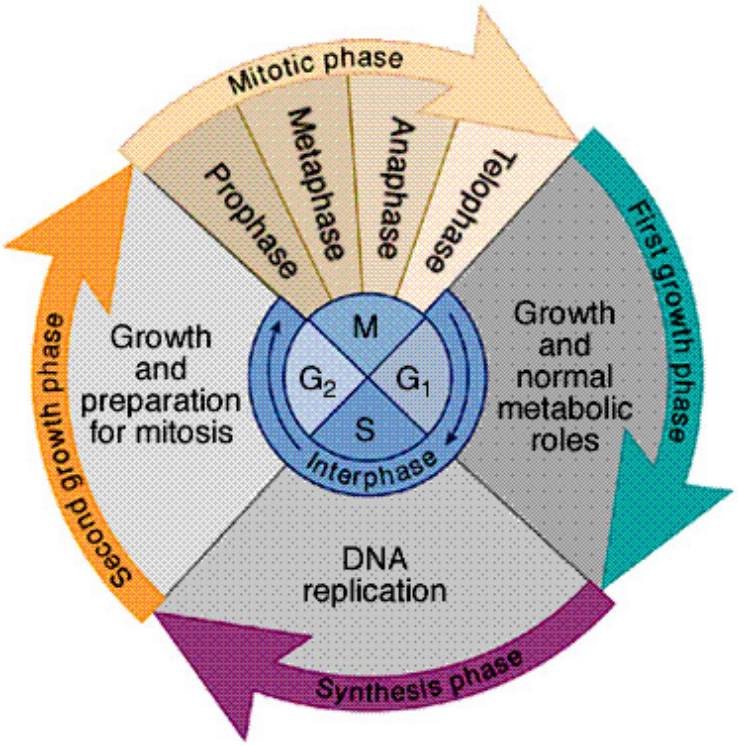
***G_0 Phase: used by some cells to exit cell cycle; usually occurs after G_1 Phase; examples include mature nerve cells.

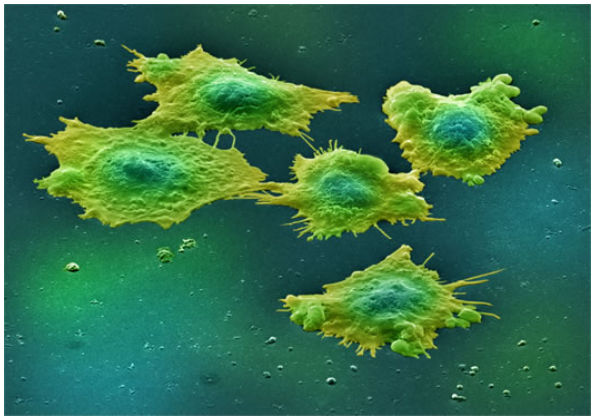

INTERPHASE

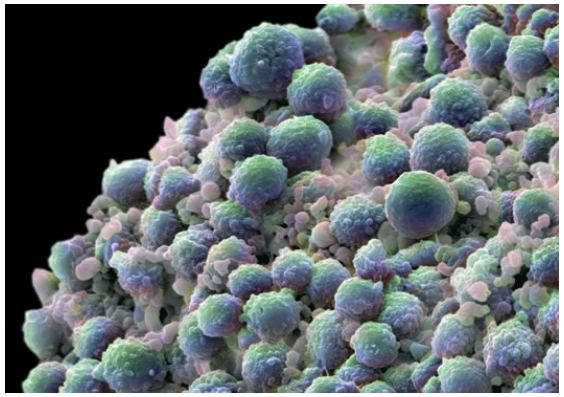

C
I
Interphase


S - Replication of DNA
Interphase
G1 - Gap 1 (cell grows)
S
G1
G2
M
G2 - Gap 2 (cell prepares to divide)
Mitotic Phase
M - Mitosis (cell division)
Cells that cease division

The Cell Cycle and Cancer



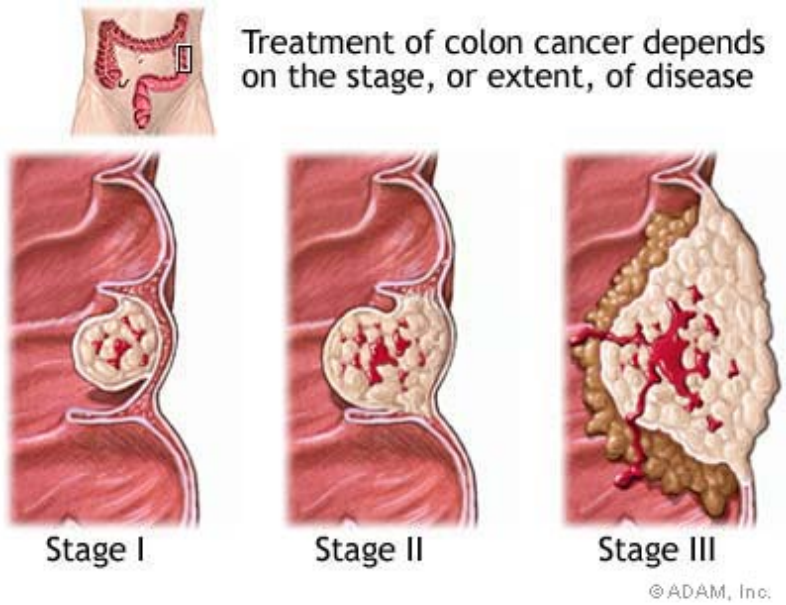




Cancer is a disease of the cell cycle. Some of the body's cells divide uncontrollably and tumors form.

Tumors in Liver

Tumor in Colon



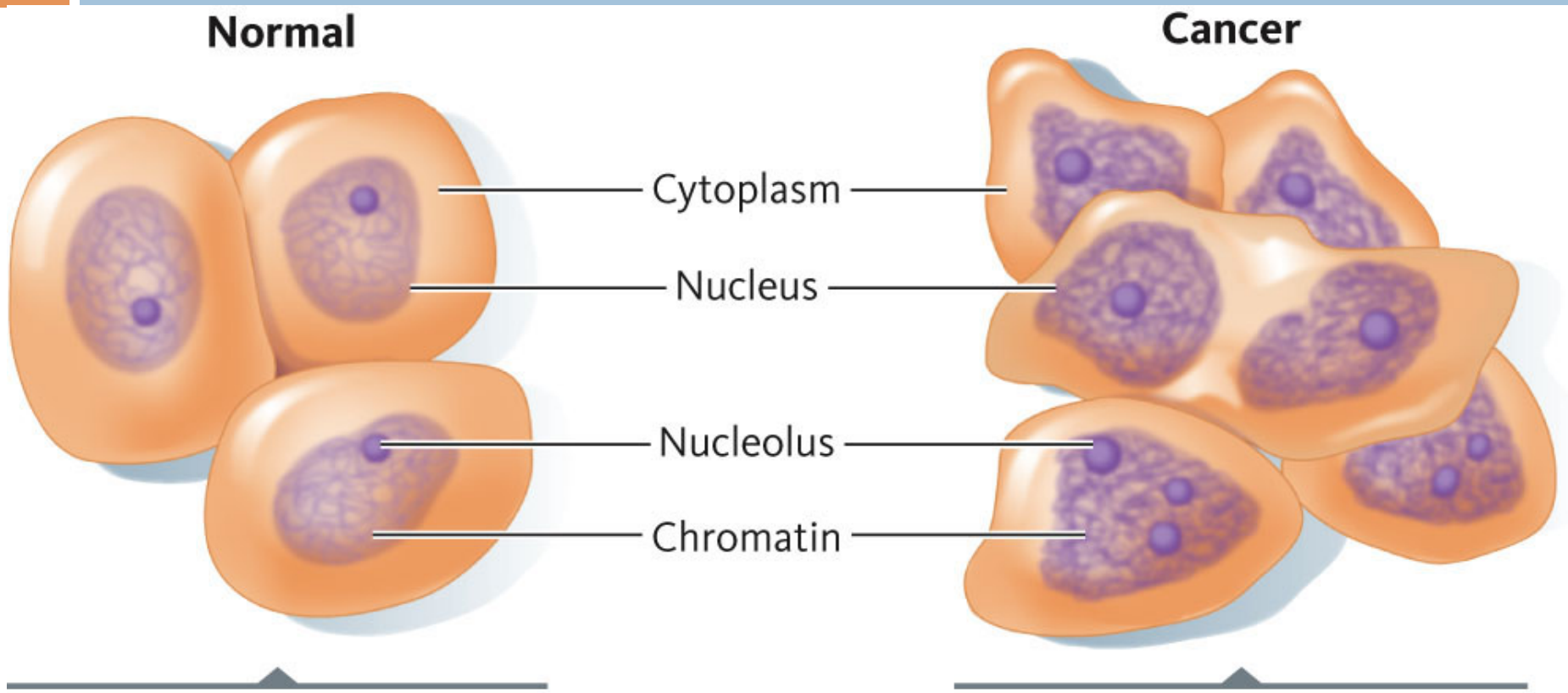

Smoking
causes fatal lung cancer

Some Tumors Are Cancer, Others Are Not

Hyperplasmia

- Cells in a tissue overgrow
- Resulting defined mass: **tumor (neoplasm)**
  - **Benign**, e.g., **moles**
    - Slow growth
    - Expands in the same tissue; does not spread
    - Cells look nearly normal
  - **Malignant**
    - Rapid growth
    - Invades surrounding tissue and metastasizes
    - Cell differentiation usually poor

Cancer cells



- Large cytoplasm
- Single nucleus
- Single nucleolus
- Fine chromatin

- Small cytoplasm
- Multiple nuclei
- Multiple and large nucleoli
- Coarse chromatin

Normal Moles Are Common Examples of Benign Growths

a Benign mole

b Melanoma

Cancer Cells Also Do Not Divide Normally

- Cancer cells don't necessarily divide faster than normal cells; more cancer cells are dividing than dying

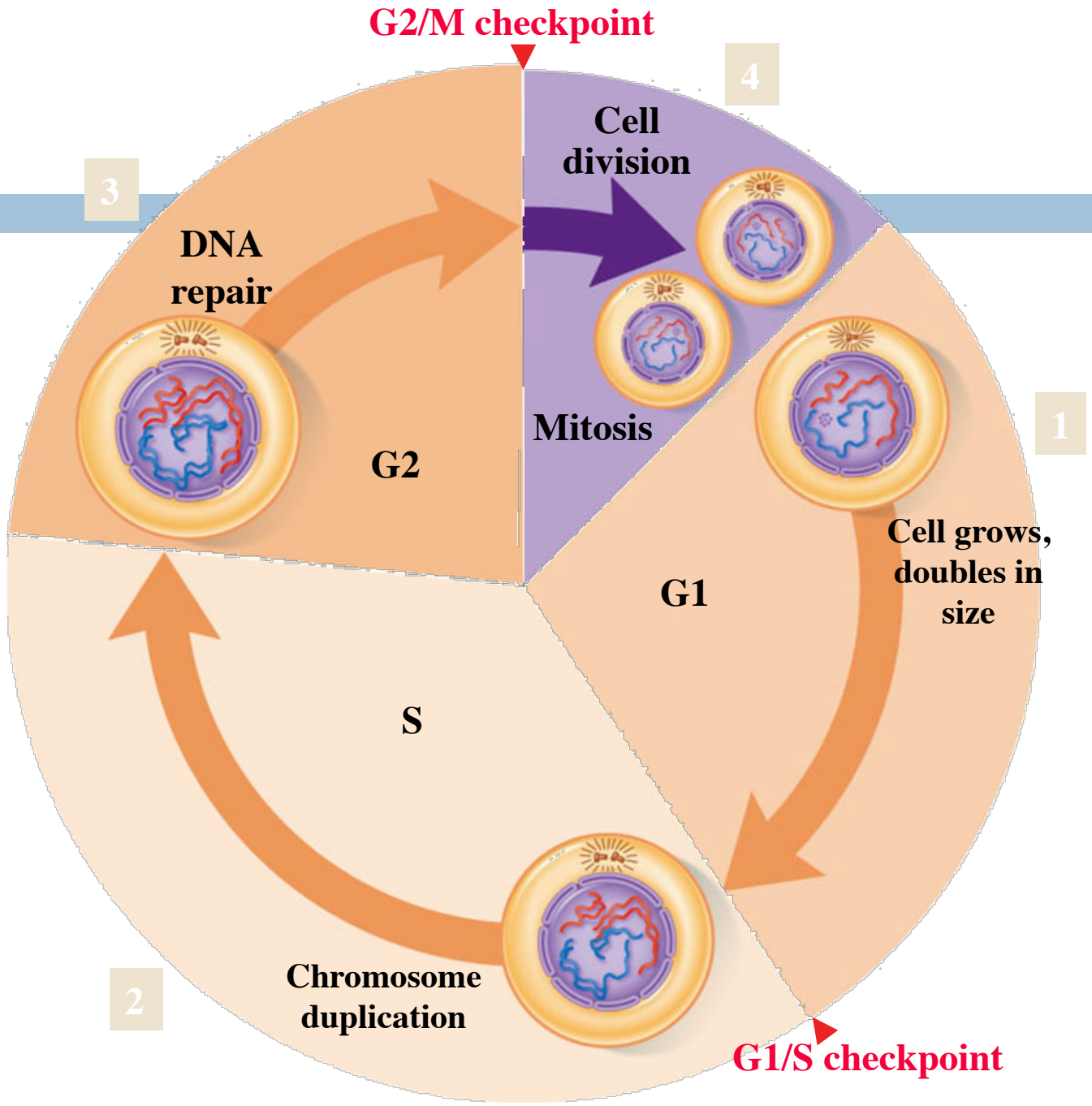
- Cancer cells do not respond to crowding; loss of contact inhibition
  - Leads to a disorganized mass; cells may have extensions
  - **Metastasis:** makes a cancer malignant

Cancer Usually Involves Several Genes

- **Proto-oncogenes**
  - In normal cells
    - Code for proteins involved in the stimulus of cell division
  - If altered, may form **oncogenes**
    - Alone, do not cause malignant cancer
    - Require other mutations, including one in a **tumor suppressor gene**

Cancer Usually Involves Several Genes

- Tumor suppressor genes
  - Stop cell growth and division; prevent cancer formation
  - May prevent expression of oncogenes
  - p53: codes for a regulatory protein that turns off cell division when the cell is stressed or damaged
    - If mutated, runaway cell division
    - More than half of cancers has a mutated or missing p53 gene



Stepped Art

p. 181

Other Factors Also May Lead to Cancer

- **Inherited susceptibility to cancer**
  - ~5% of cancers

- **Viruses**
  - Viral DNA may be inserted into a host cell's DNA
    - May switch on a proto-oncogene
    - May carry oncogenes

Other Factors Also May Lead to Cancer

- **Chemical carcinogens**
  - **Carcinogens:** cancer-causing substances that can lead to a mutation in DNA
    - Asbestos, vinyl chloride, and benzene
    - Hydrocarbons in cigarette smoke
    - Aflatoxin: fungal product
- **Radiation**
  - UV from the sun and tanning lamps
  - X-rays: medical and dental
  - Radon, cosmic rays, and gamma radiation

Other Factors Also May Lead to Cancer

- **Breakdowns in immunity**
  - Healthy immune system can target and destroy cancer cells
  - When cancer cells have altered proteins at its surface, cells are not destroyed
  - Risk of cancer increases:
    - With age
    - When an immune system has been suppressed for a long time
      - HIV infection
      - Immunosuppressant drugs
      - Anxiety and depression

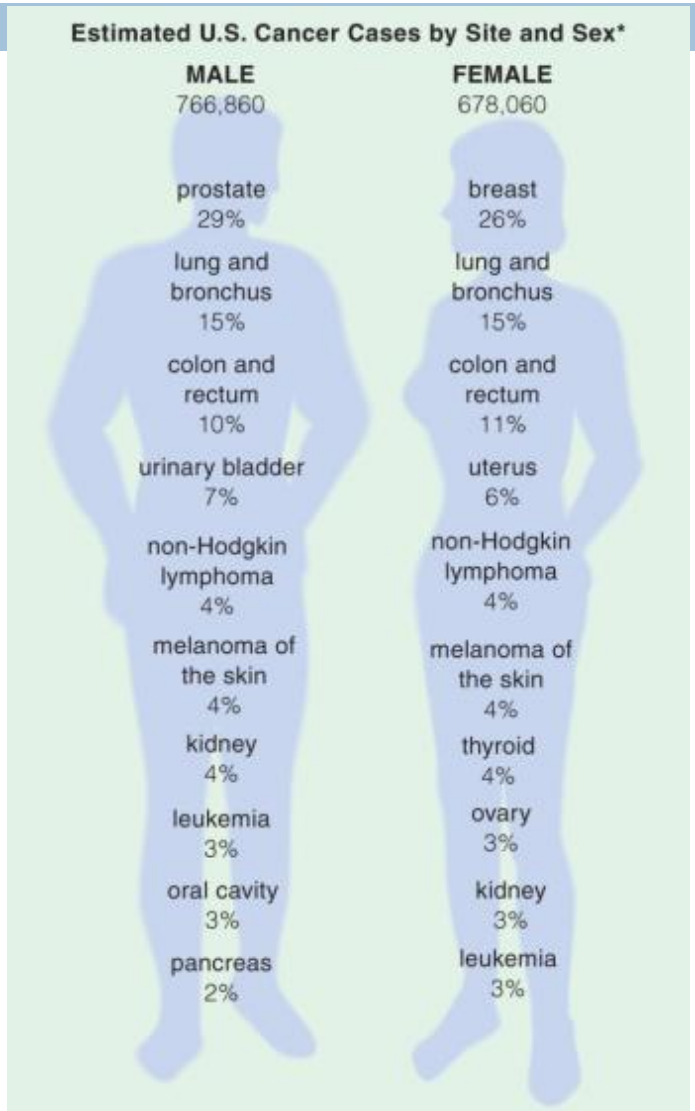
Some Industrial Chemicals Linked to Cancer

Chemical/Substance	Type of Cancer
Benzene	Leukemias
Vinyl chloride	Liver, various connective tissues
Various solvents	Bladder, nasal epithelium
Ether	Lung
Asbestos	Lung, epithelial linings of body cavities
Arsenic	Lung, skin
Radioisotopes	Leukemias
Nickel	Lung, nasal epithelium
Chromium	Lung
Hydrocarbons in soot, tar smoke	Skin, lung

Some Major Types of Cancer

- *In general, a cancer is named according to the type of tissue in which it first forms*
  - **Sarcomas:** cancer of connective tissue
  - **Carcinomas:** cancer arising from epithelium
  - **Lymphomas:** cancer of lymphoid tissue
  - **Leukemias:** cancer of stem cells
  - **Gliomas:** cancer of brain glial cells

In the U.S., More than 1 Million People Are Diagnosed with Cancer Each Year



Chemotherapy and Radiation Kill Cancer Cells

- **Chemotherapy**
  - Drugs used to kill cancer cells; disrupt some aspect of cell division
  - Toxic to healthy cells; hair, bone marrow, lymphocytes, and epithelial cells of intestinal lining
  - Side effects include hair loss, nausea, vomiting, and reduced immune responses
  - Genetic approach to chemo in the future

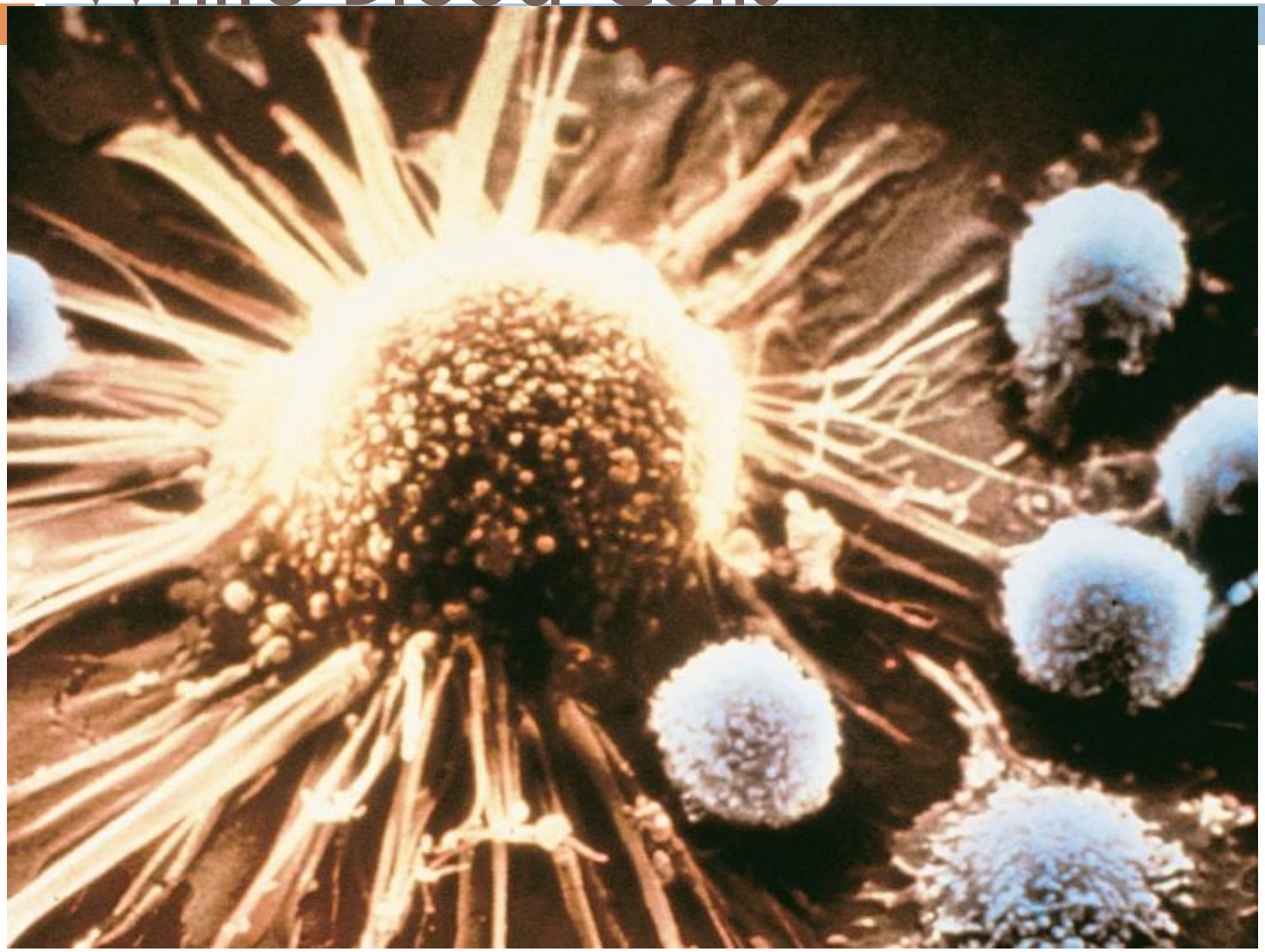
Chemotherapy and Radiation Kill Cancer Cells

- **Radiation therapy**
  - Used when cancer is small or has not spread

Good Lifestyle Choices Can Limit Cancer Risk

- Avoid tobacco completely
- Maintain a desirable weight; eat a low-fat diet with plenty of fruits and vegetables
- Drink alcohol in moderation
- Make sure your living and work environment is safe from carcinogens
- Protect your skin from the sun's UV rays

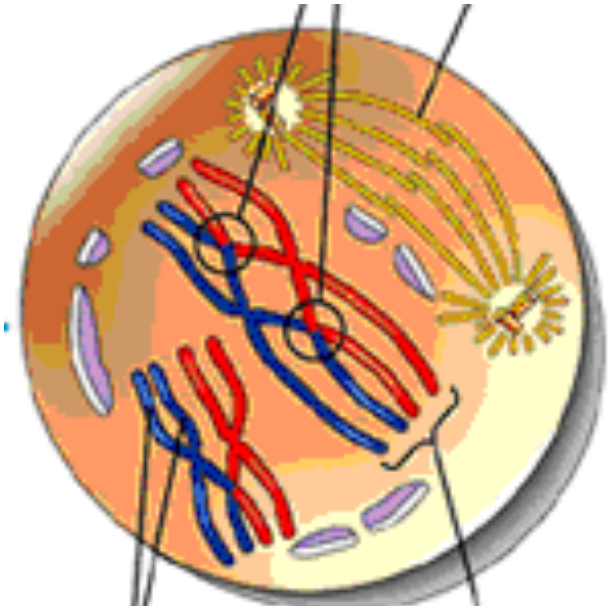
This Cancer Cell Is Surrounded by White Blood Cells



PLAY

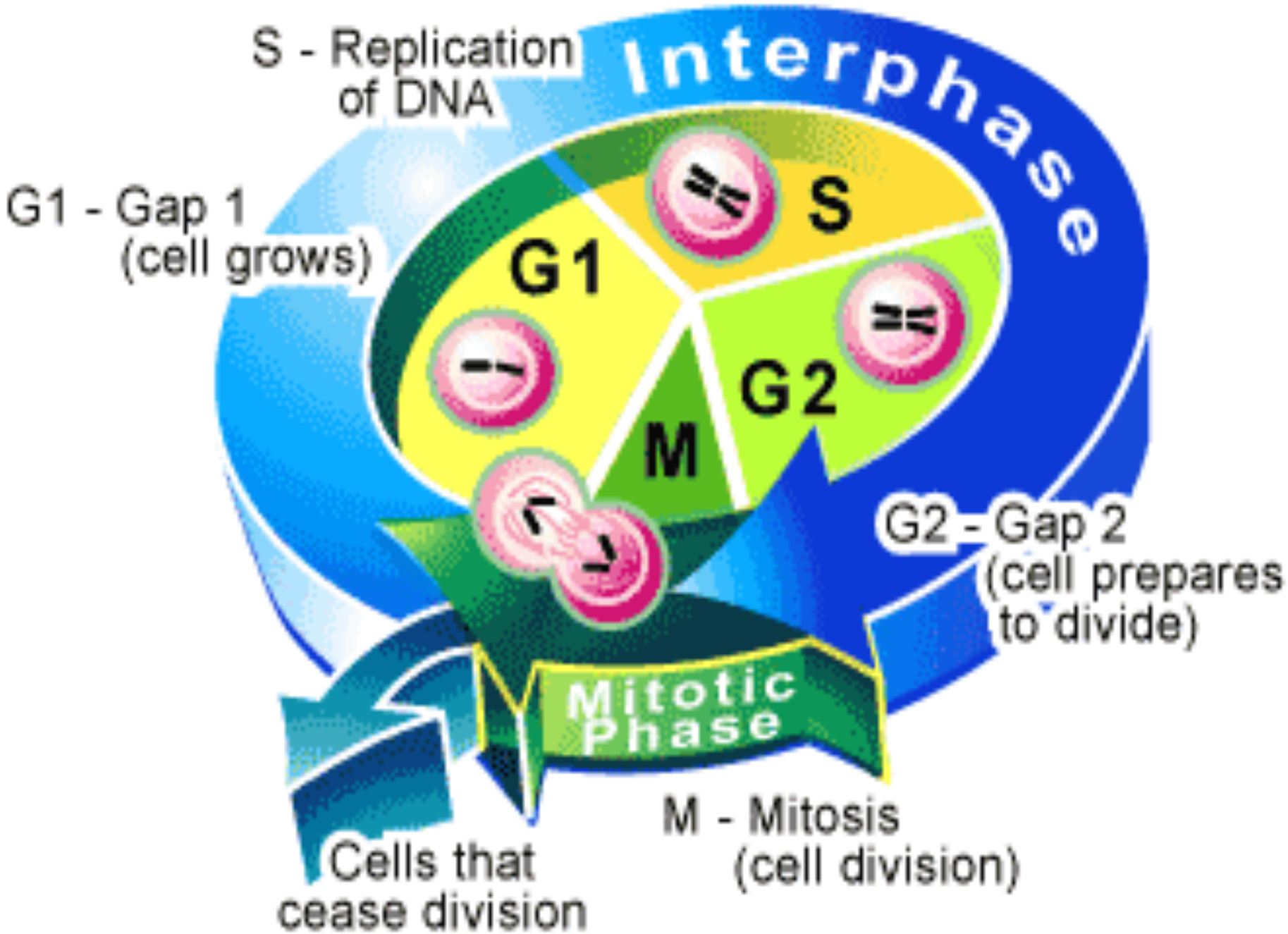
PLAY

- Question/Quote: "There are a thousand hacking at the branches of evil to one who is striking at the root." Thoreau



Opening Activity

- Which of the following is the longer stage of the cell cycle?
  - Cell division
  - Interphase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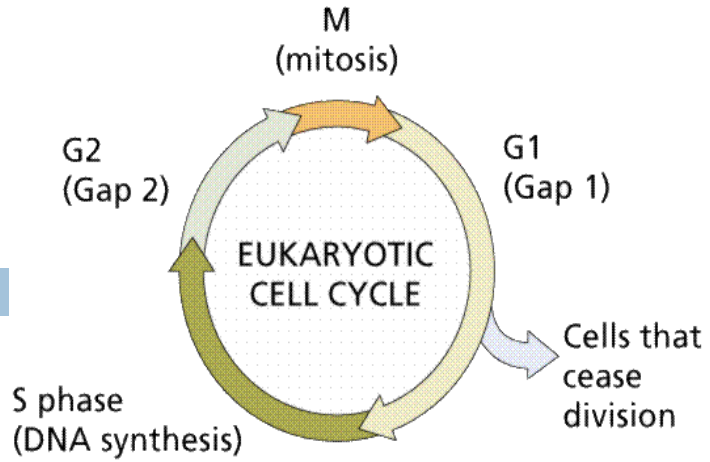
I. The Cell Cycle:



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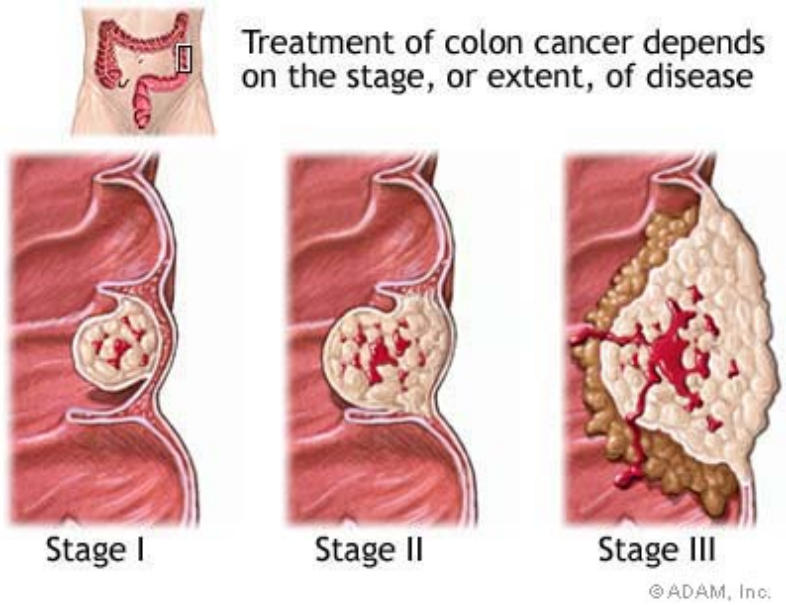

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  - If altered, may form **oncogenes**
    - Alone, do not cause malignant cancer
    - Require other mutations, including one in a **tumor suppressor gene**

IX. Stages of Cell Division in Eukaryotes:

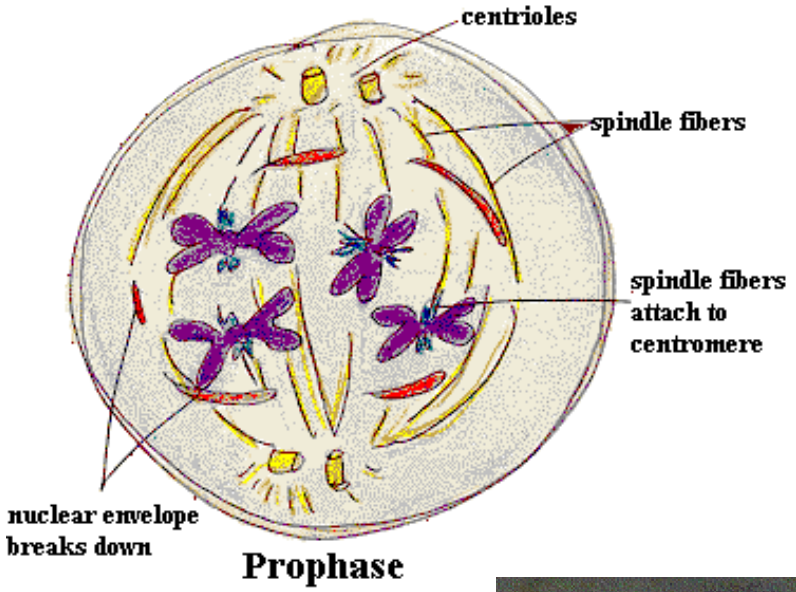
Mitosis: division of the nucleus

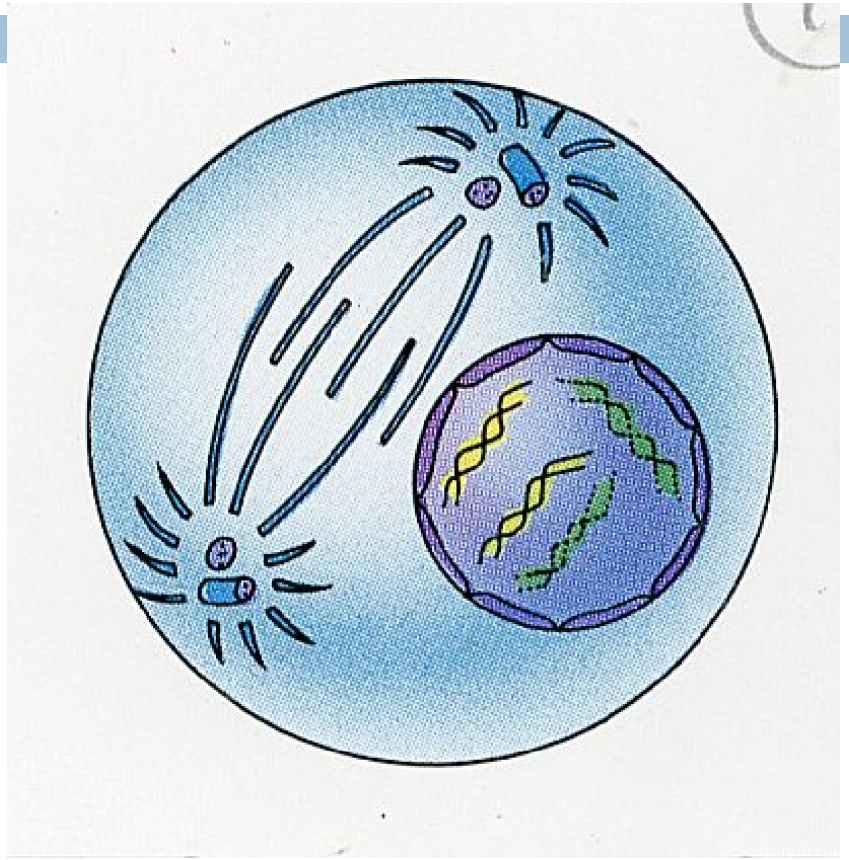
1) Prophase
2) Metaphase
3) Anaphase
4) Telophase

Cytokinesis: division of the cell

X. Events of : Prophase

1) DNA coils into chromosomes.
2) Nucleolus disappears; nuclear membrane disappear.
3) Centrioles appear and migrate to opposite sides of cell.
4) Spindle fibers form

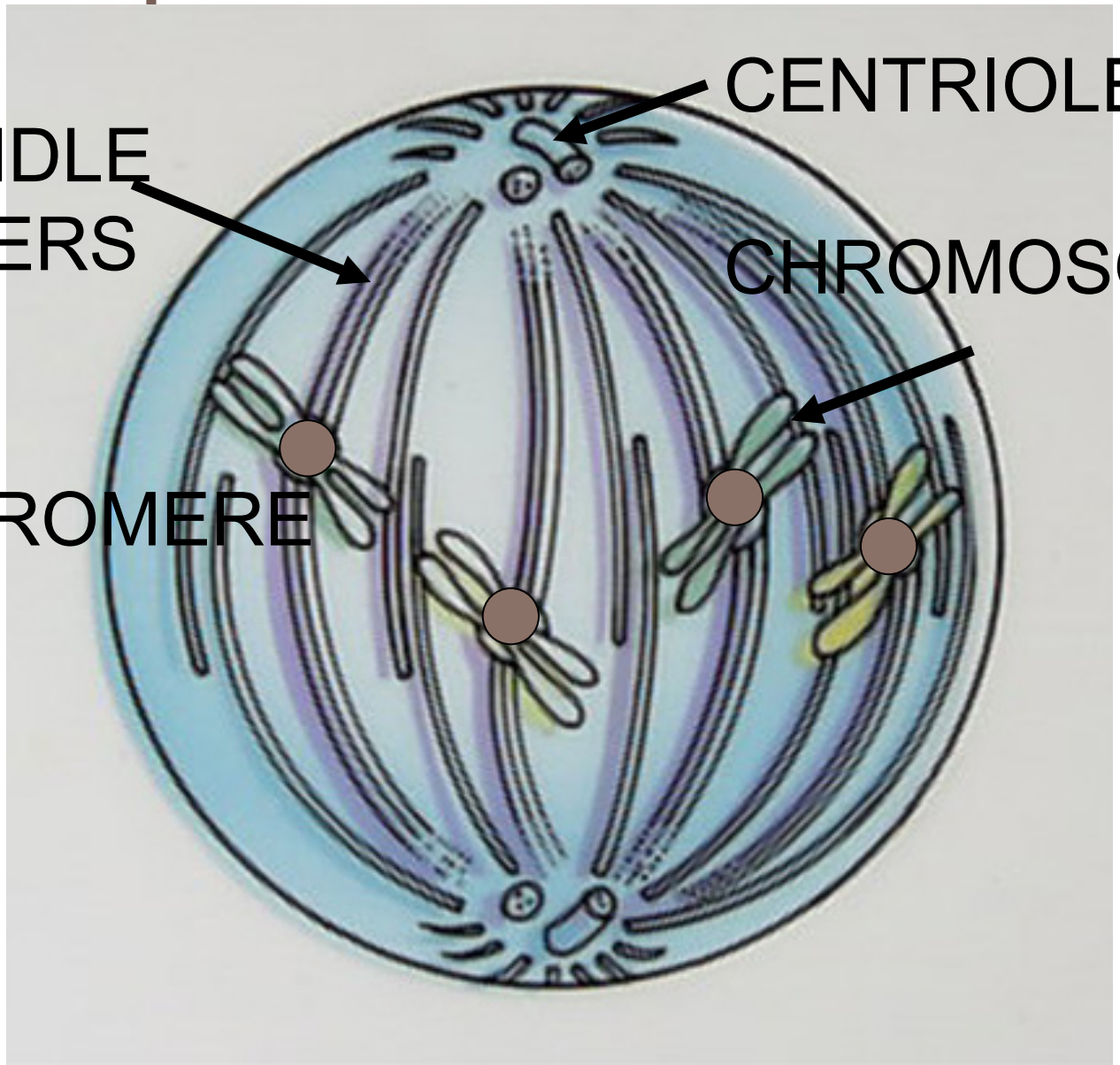




PROPHASE (late)

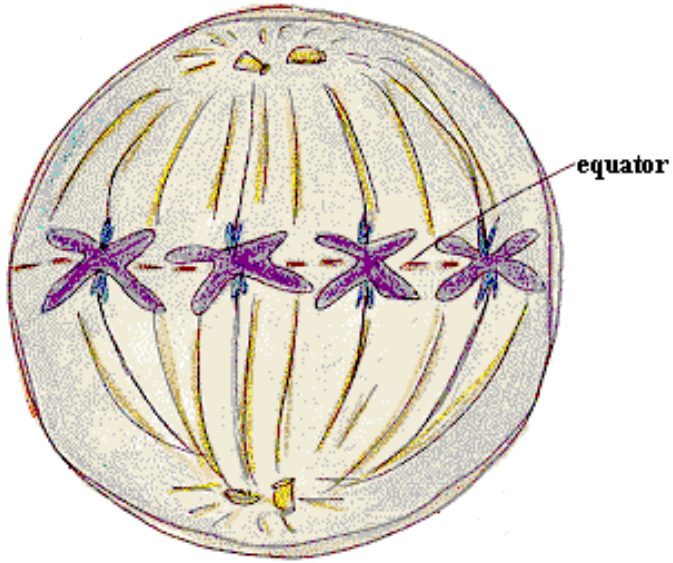
- CHROMOSOMES BECOME ATTACHED TO THE SPINDLE FIBERS AT THE CENTROMERE
- **SPINDLE FIBERS – FANLIKE MICROTUBULE STRUCTURE THAT SEPARATES THE CHROMOSOMES**

Late Prophase

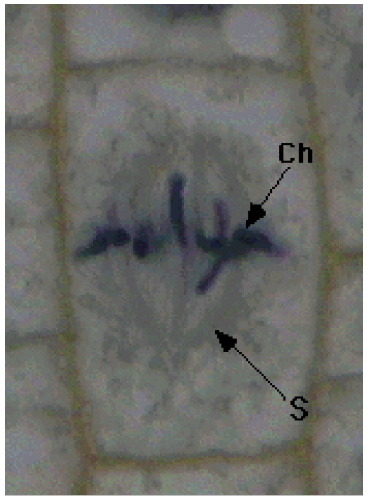


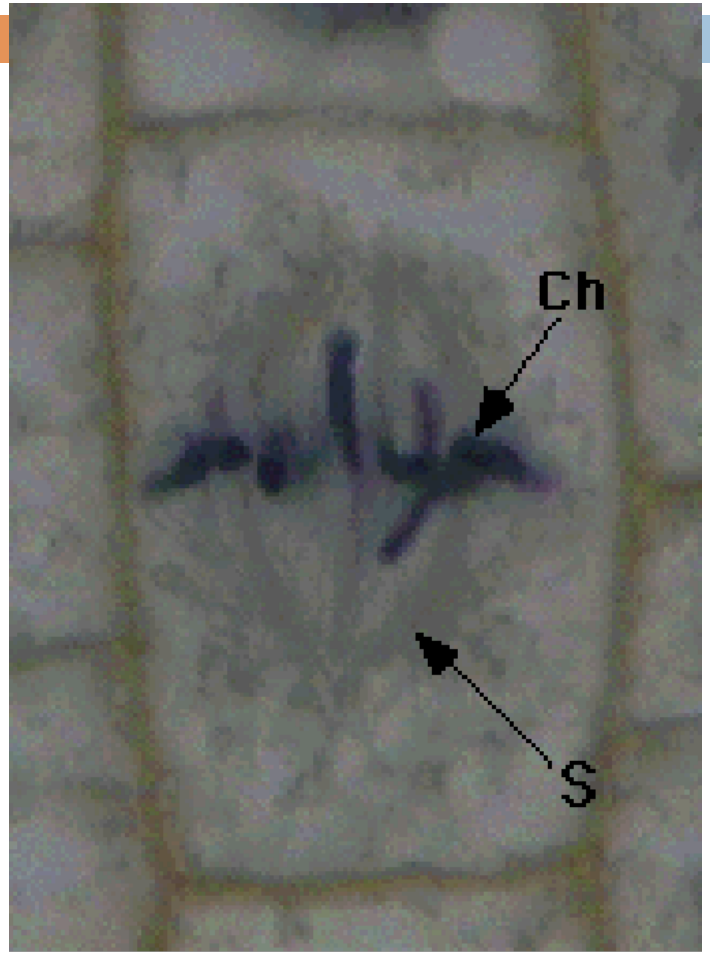
XI. Events of : Metaphase

1) Chromosomes migrate to the center of the dividing cell. Held in place by the spindle fibers.



Metaphase

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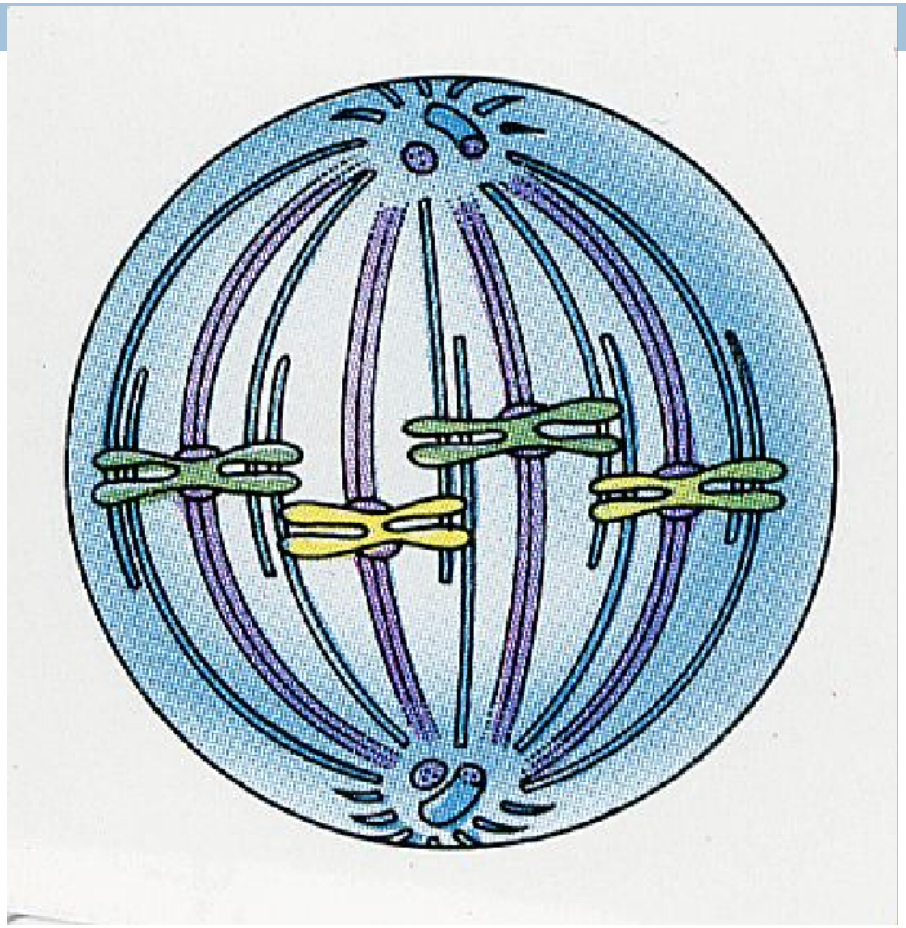
S

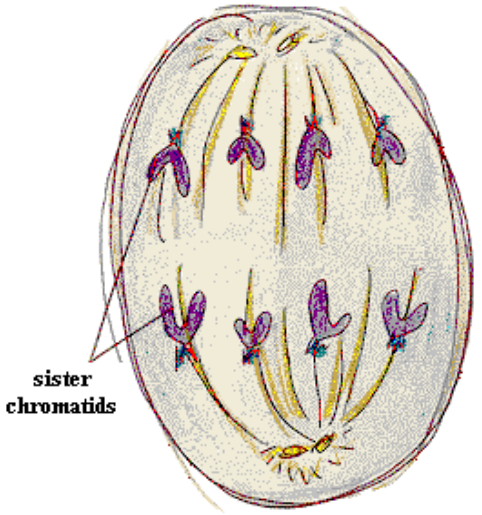


XII. Events of : Anaphase

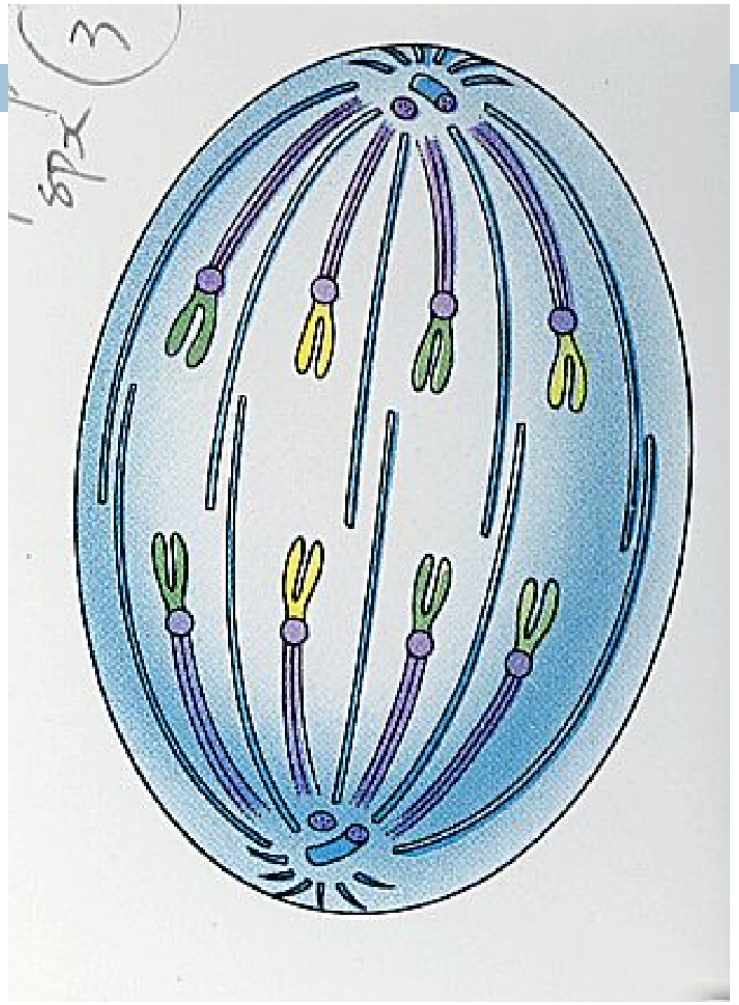
1) Sister Chromatids pulled apart by fibers.

2) Chromatids pulled toward centrioles.

3) Now have individual chromosomes at opposite ends of cell.

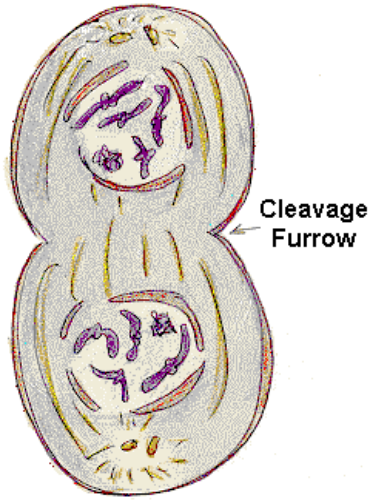


Anaphase

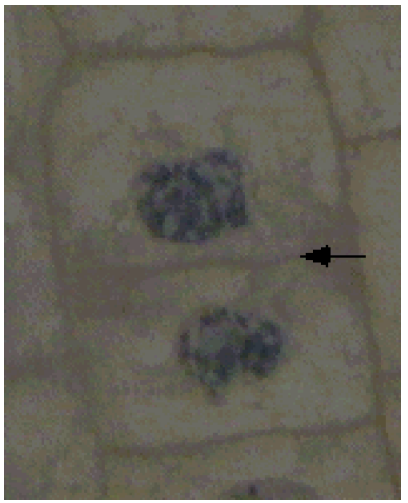


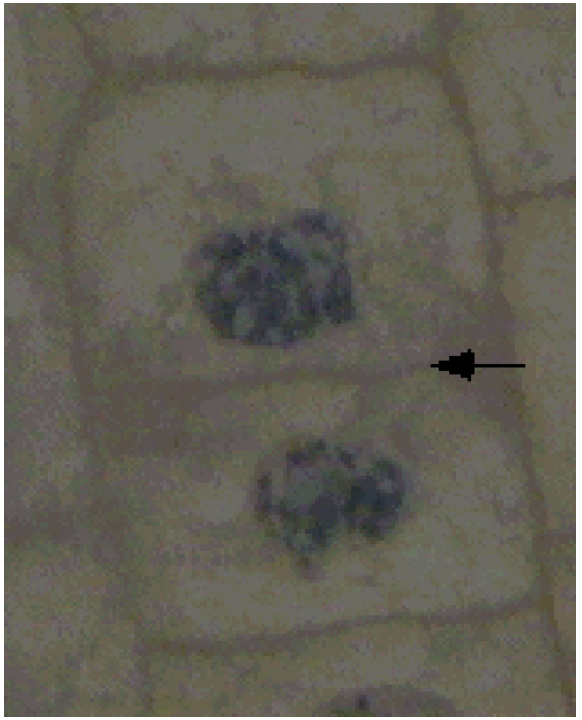
XIII. Events of: Telophase and Cytokinesis

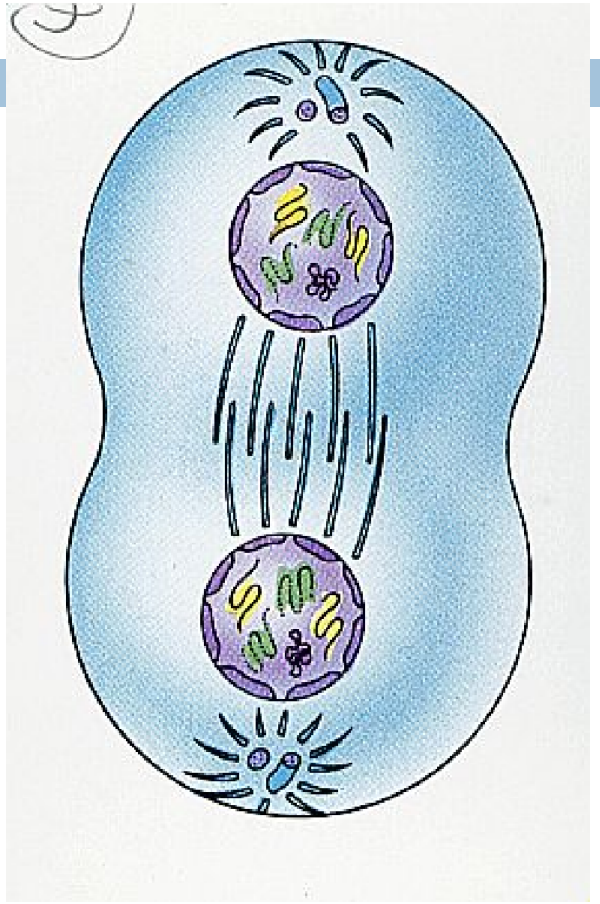
1) Spindle fibers disassemble.
2) Nuclear membranes form around chromosomes at each end.
3) Chromosomes uncoil.
4) Nucleolus forms in each new nucleus.
5) CYTOKINESIS occurs.
6) Cell membrane pinches inward (forms cleavage furrow) until two cells form.



Telophase and Cytokinesis



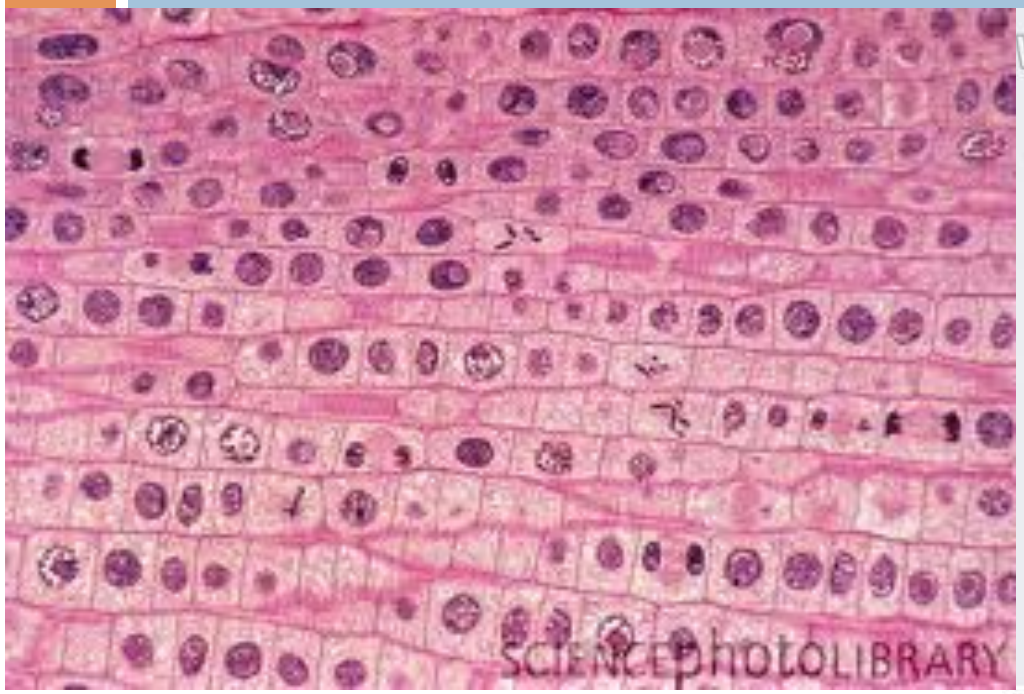


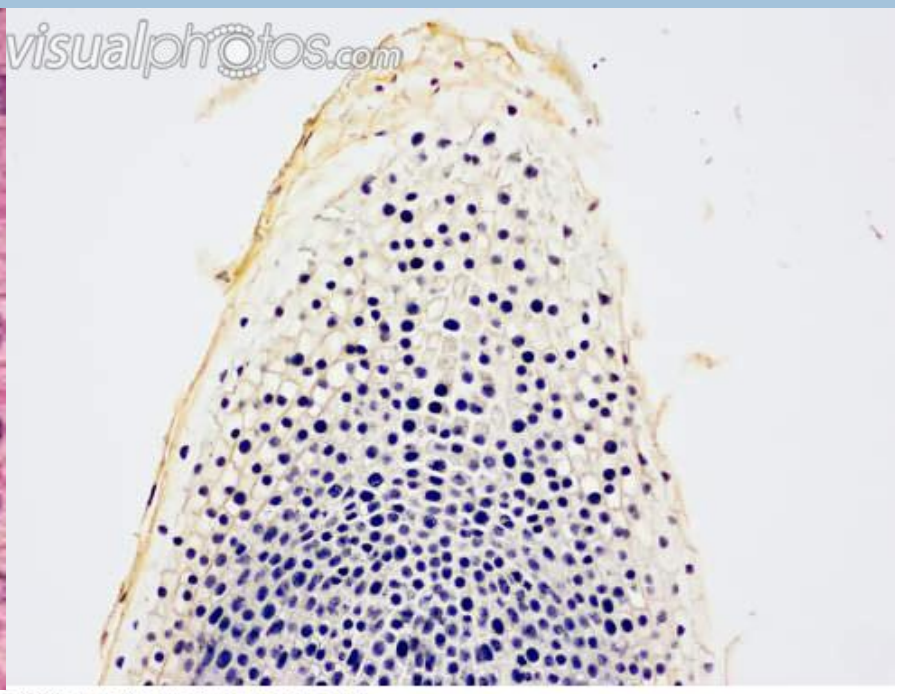


Opening Activity

- Which of the following is not a stage of mitosis?
  - Anaphase
  - Prophase
  - Interphase
  - Telophase

Onion root tip





BJ2767 [RM] © www.visualphotos.com

SHORTCUT TO REMEMBER THE CELL CYCLE

- I nterphase
- P rophase
- M etaphase
- A naphase
- T elophase
- C ytokinesis

- I
- Passed
- Math
- At
- Tecumseh
- Congrautations (?)

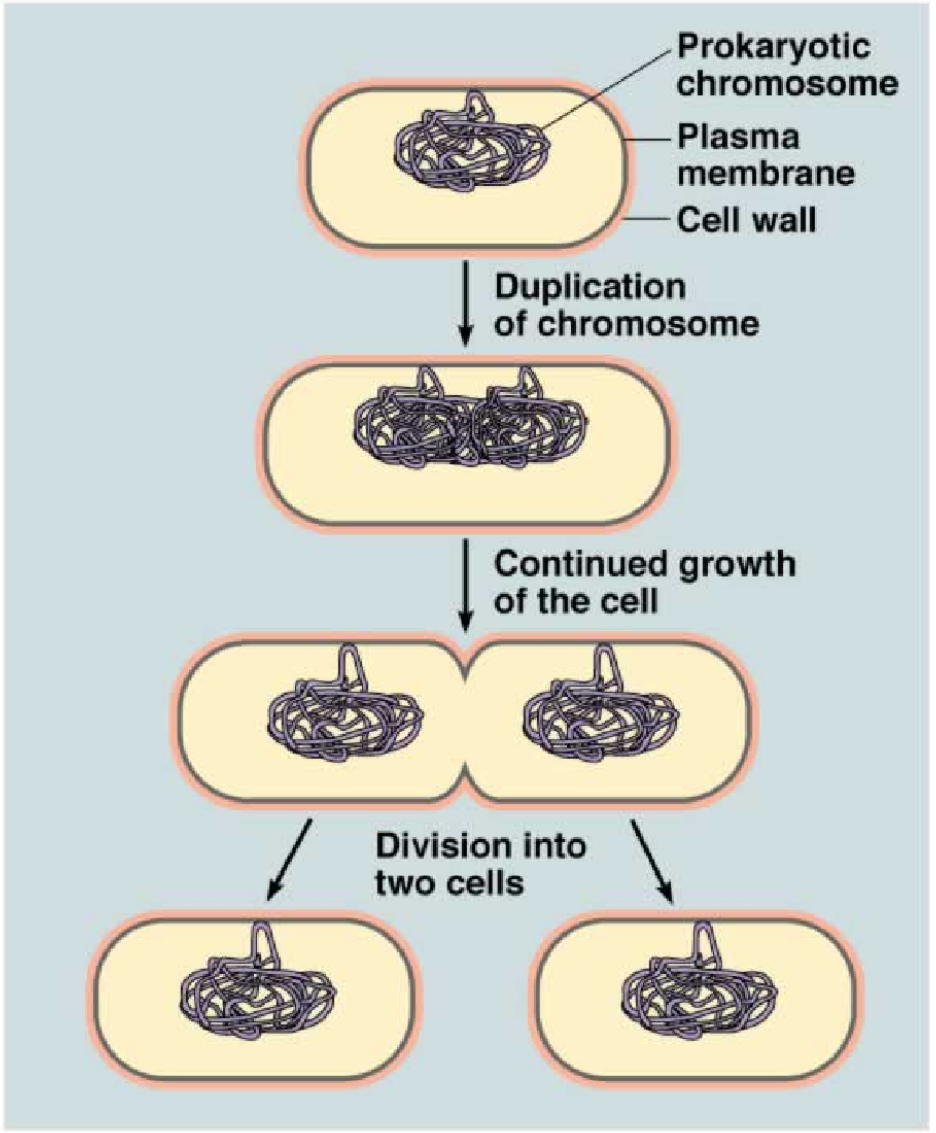
VIII. Stages of Cell Division in Prokaryotes:

A. Process called Binary Fission.

1. Chromosome makes copy of itself.

2. Cell grows until it is twice its normal size.

3. Cell wall forms between two chromosomes, and splits into two new cells.



Opening Activity

- Chromatids separate and move to opposite sides of the cell during
  - Prophase
  - Metaphase
  - Anaphase
  - Telophase

- Option 1
  - Notes
  - Study time
  - Quiz
- Option 2
  - Study time
  - Quiz
  - Notes

CELL DIVISION: MEIOSIS

II. Sexual Reproduction:

- Processes that pass a combination of genetic material to offspring, resulting in diversity.
- The main two processes are meiosis (involving the halving of the number of chromosomes) and fertilization (involving the fusion of two gametes and the restoration of the original number of chromosomes.

Diploid vs. Haploid

Diploid – a cell that contains both sets of homologous chromosomes (two sets); represented by the symbol 2N

- Found in somatic or body cells (ex. Skin, digestive tract)
- Example : Humans – 2N = **46**

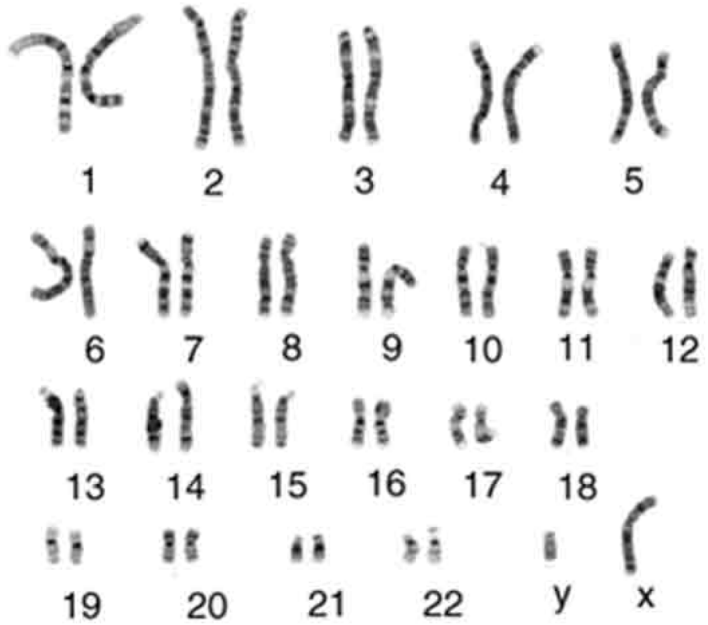
Haploid

A cell that contains only a single set of chromosomes (one set); represented by the symbol N or 1N

- Found in gametes or sex cells – sperm & egg
- Example: Humans – N = 23

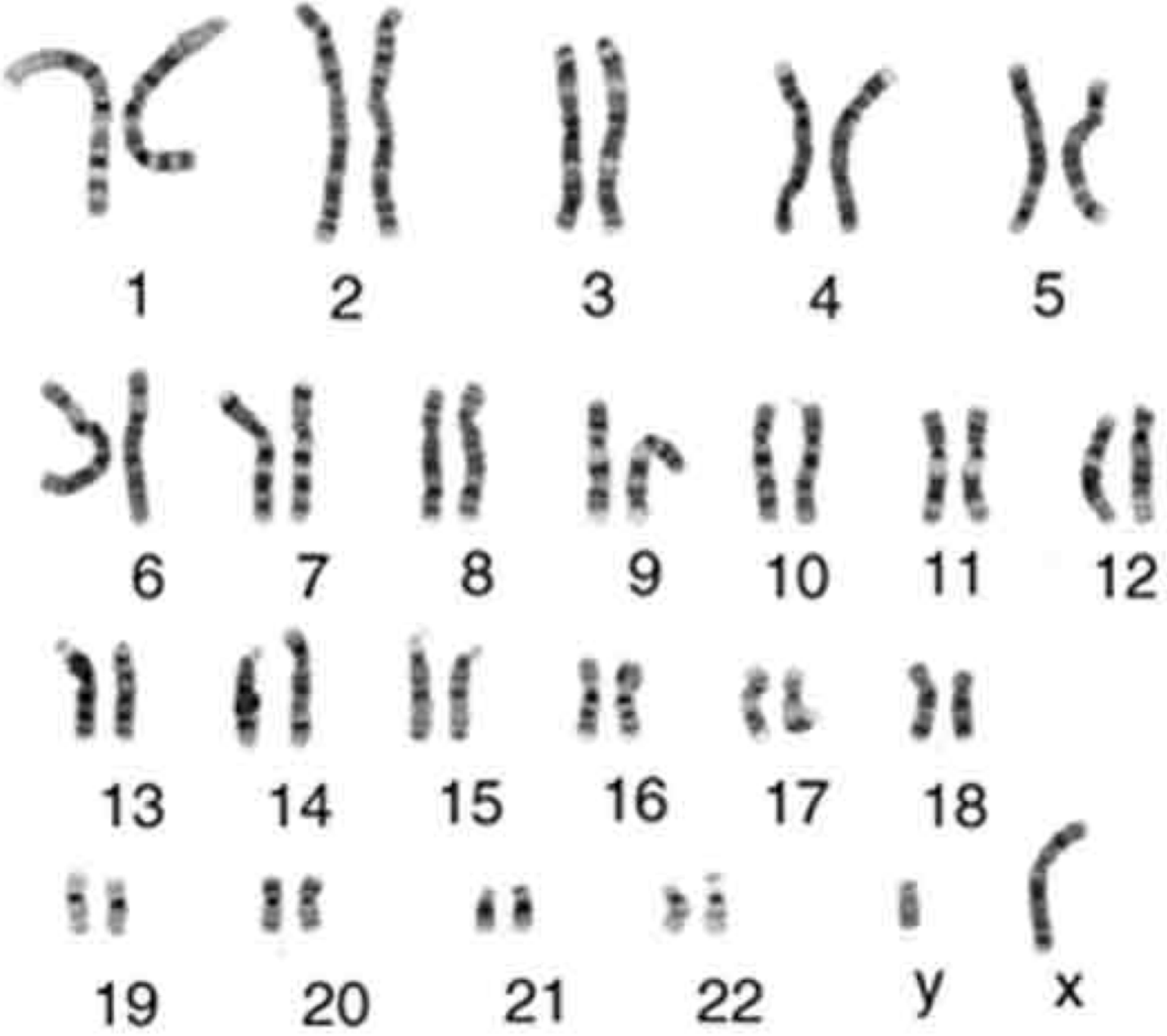
Body cells vs. Gametes

- Gametes:
  - Sperm and egg cells
  - Produced by meiosis
  - Haploid
  - Passed to offspring



Homologous chromosomes

Chromosomes that have a corresponding chromosome from the opposite-sex parent (2 sets of chromosomes, one from each parent)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2
3
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5
6
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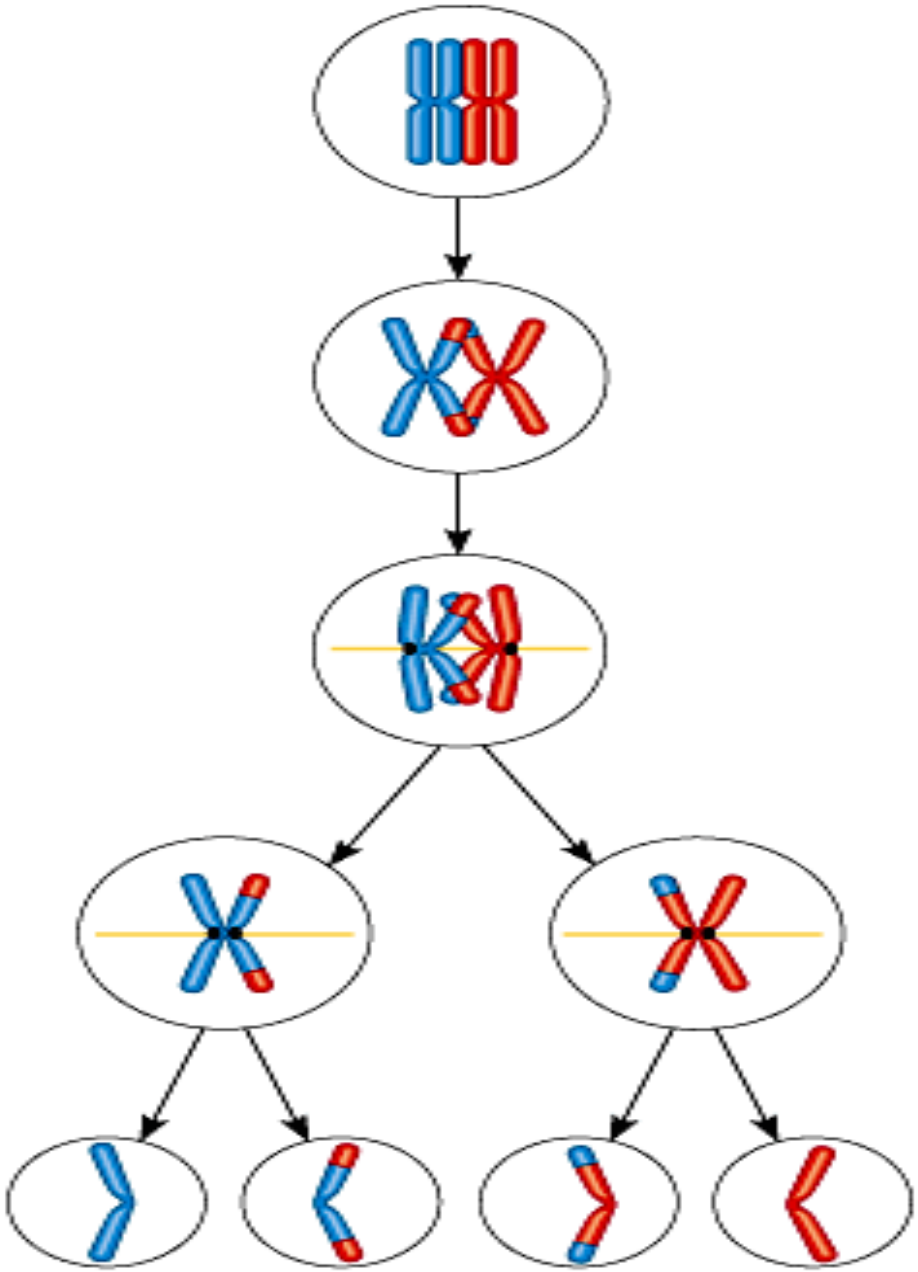
17
18
19
20
21
22
y
x

Meiosis

Process of reduction division in which the number of chromosomes per cell is cut in half by the separation of homologous chromosomes in a diploid cell; happens in gametes (sex cells) – sperm & egg

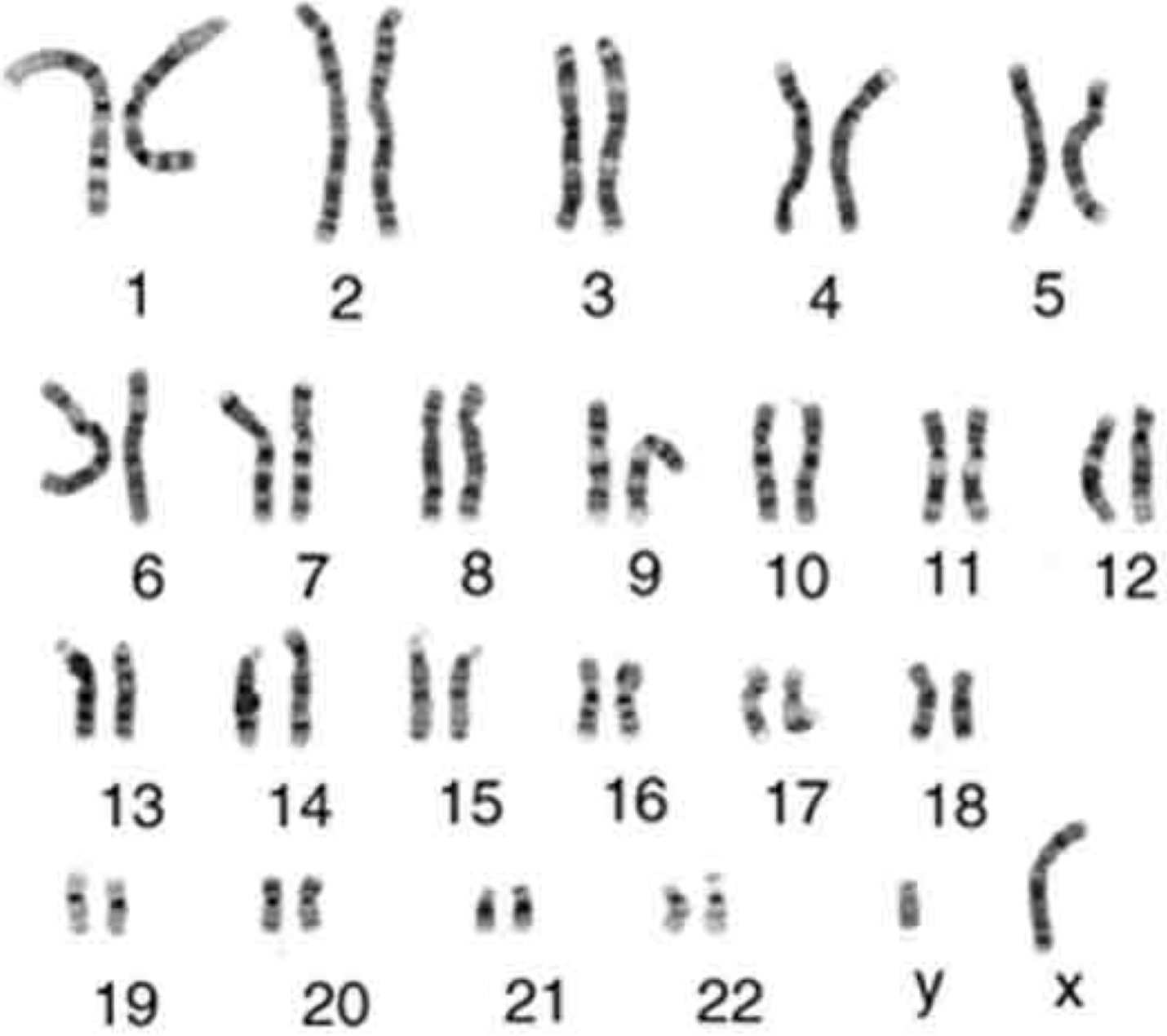
Steps of Meiosis

- Meiosis usually involves two distinct divisions, called Meiosis I and Meiosis II
- By the end of Meiosis II, the one diploid cell that entered meiosis has become 4 haploid cells



Opening Activity

- Meiosis produces _____ cells
  - Diploid (46 chromosomes)
  - Haploid (23 chromosomes)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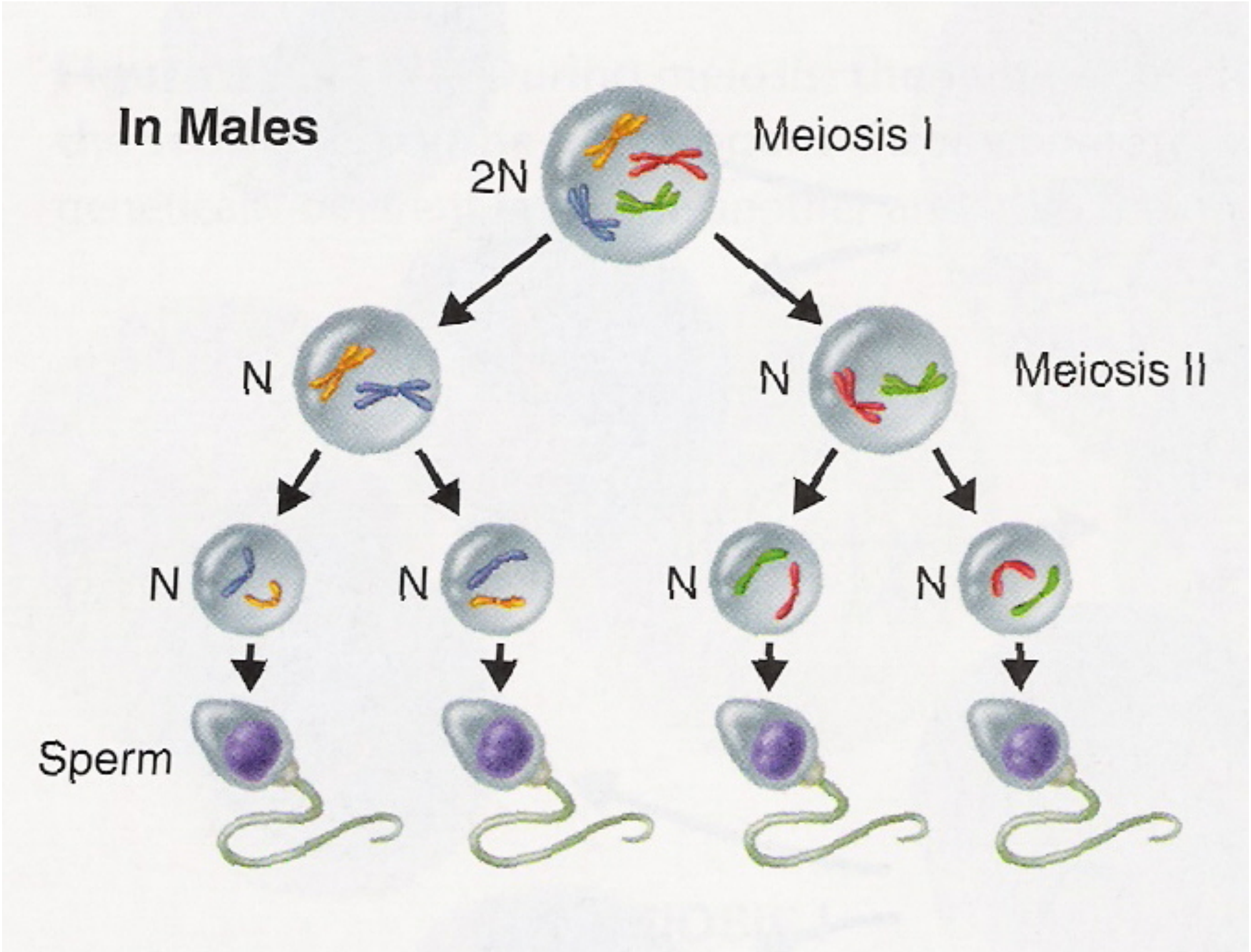
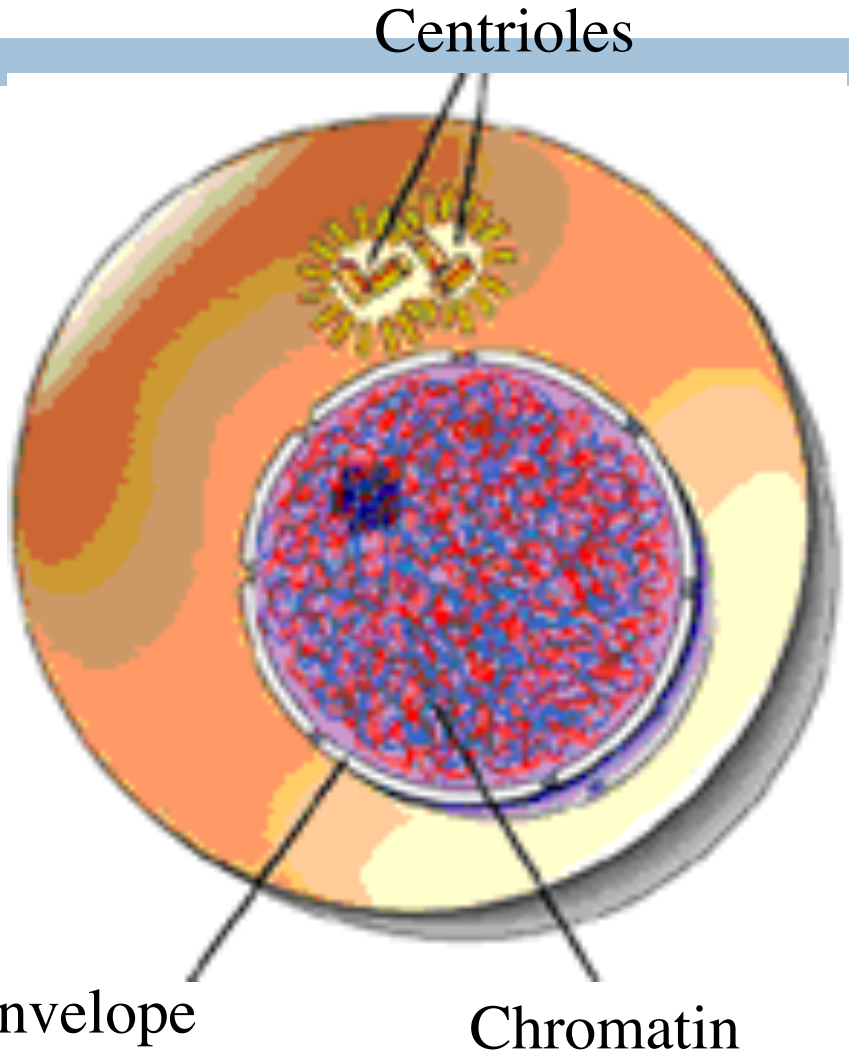
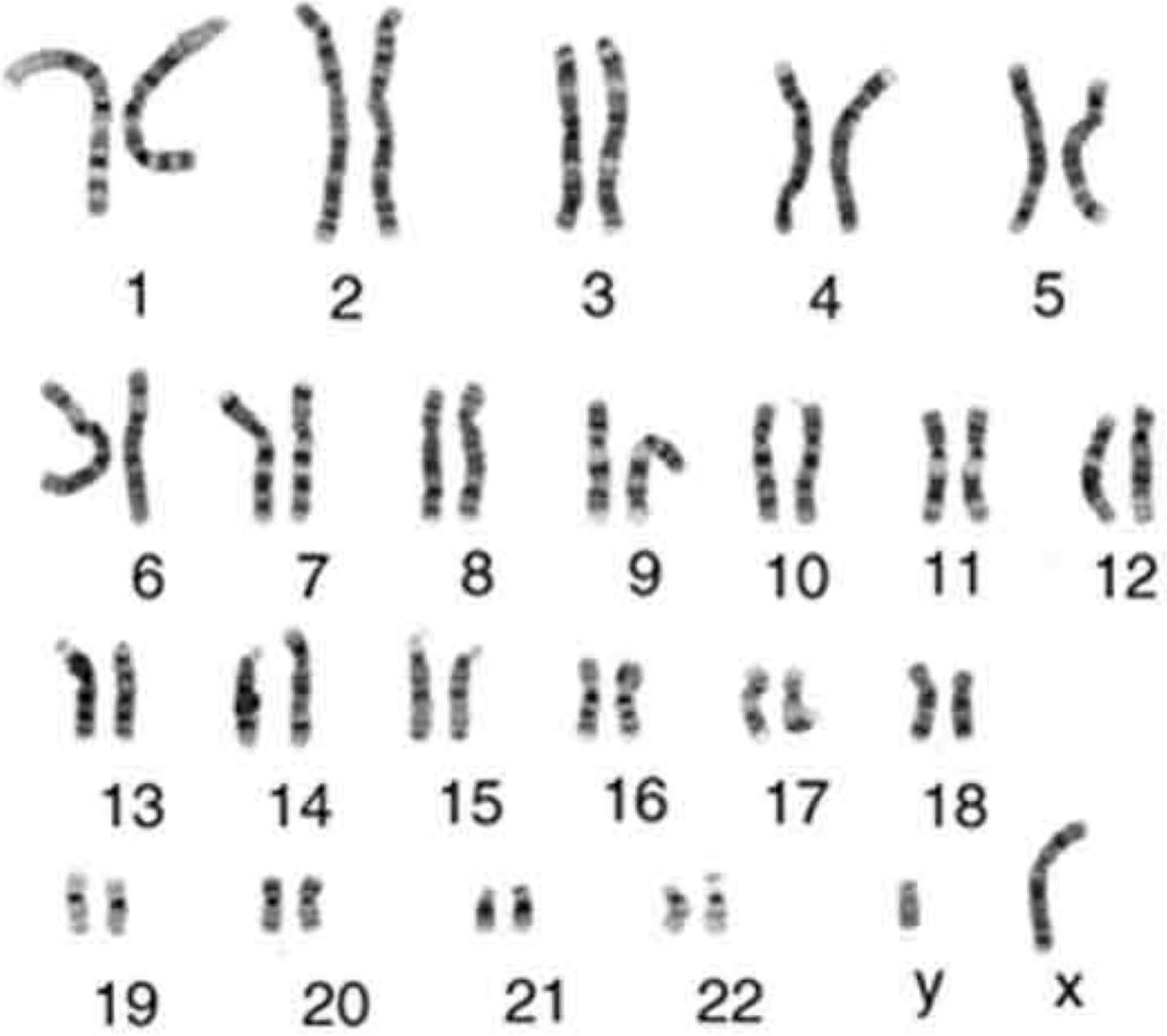
y
x


In Males
2N
Meiosis I
N
N
Meiosis II
N
N
N
N
Sperm

Interphase I

Cell undergoes a round of DNA <u>replication</u> forming <u>duplicate</u> chromosomes.

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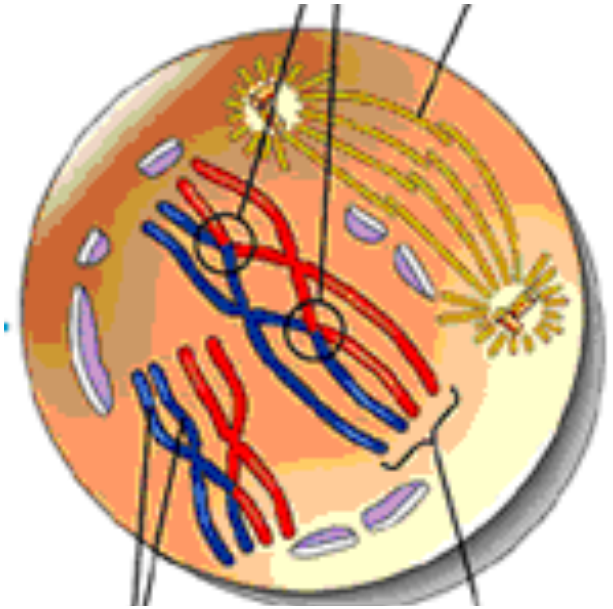
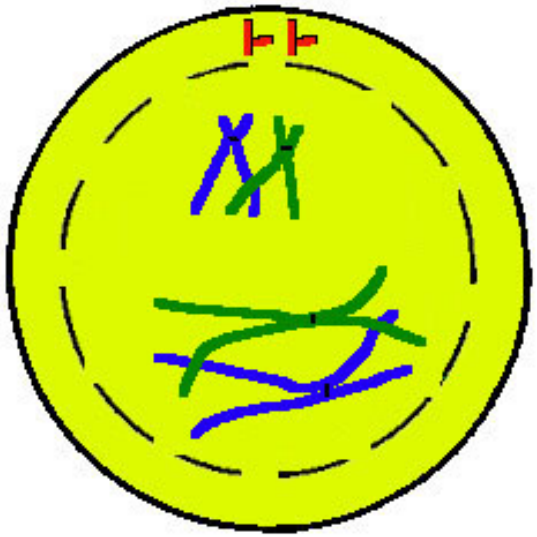
21
22
y
x

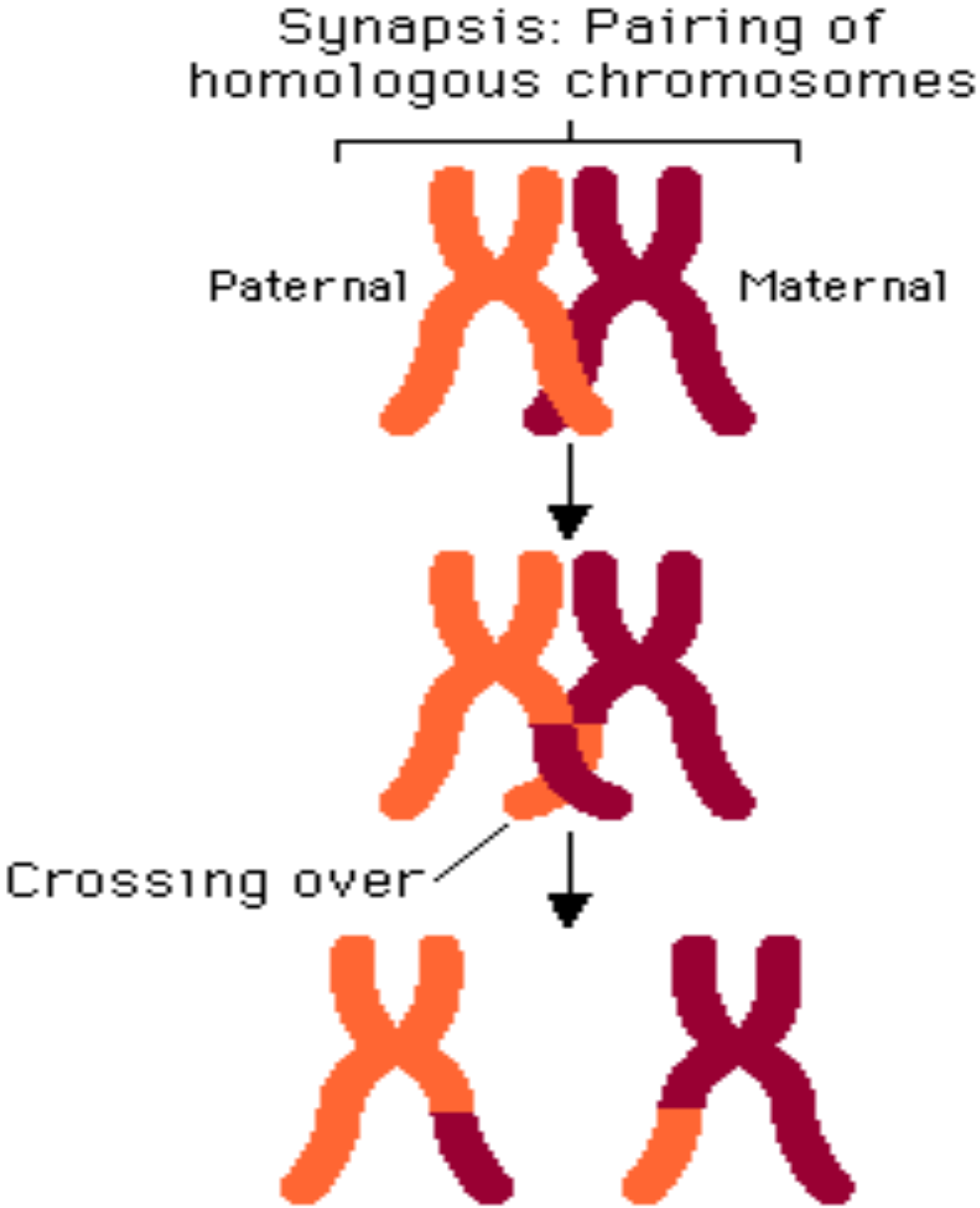
Prophase I

Each chromosome pairs with its corresponding homologous chromosome to form a **tetrad**

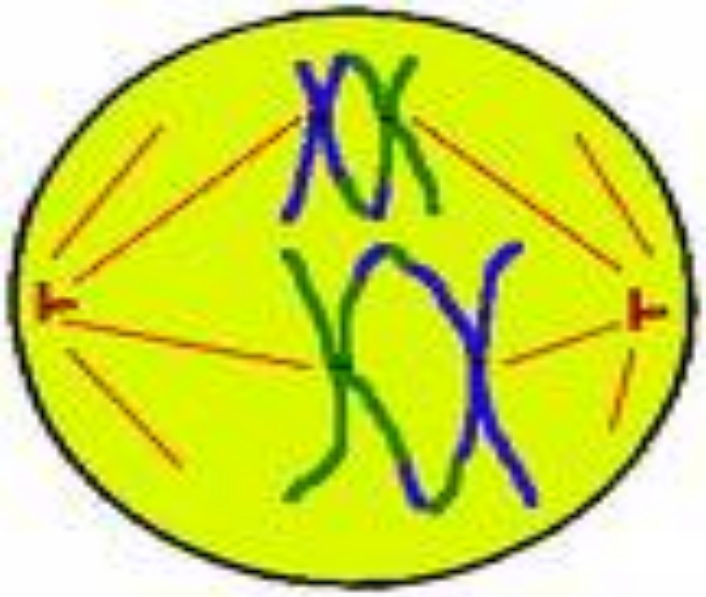


1) **Synapsis occurs (the pairing of homologous chromosomes/tetrads- does not occur in mitosis); CROSSING-OVER occurs (does not occur in mitosis).**

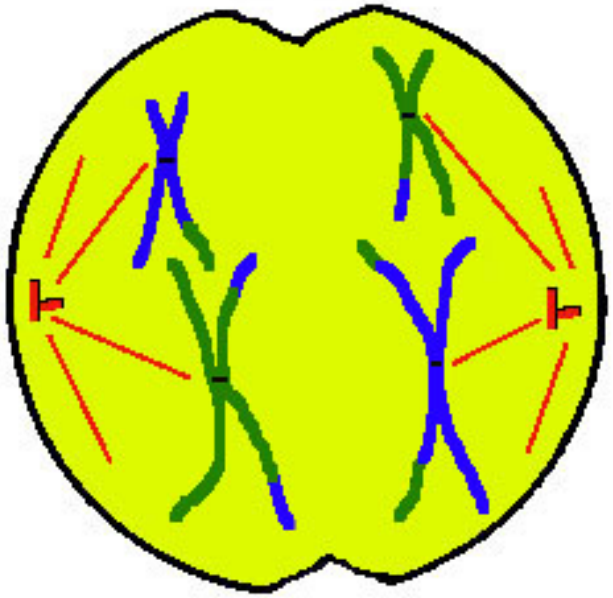



Synapsis: Pairing of homologous chromosomes
Paternal
Maternal
Crossing over

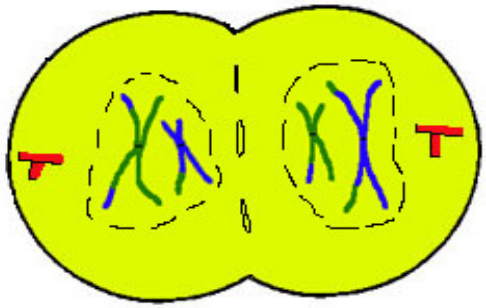
1) **Metaphase I: Tetrads line up randomly along the equator of the cell.**

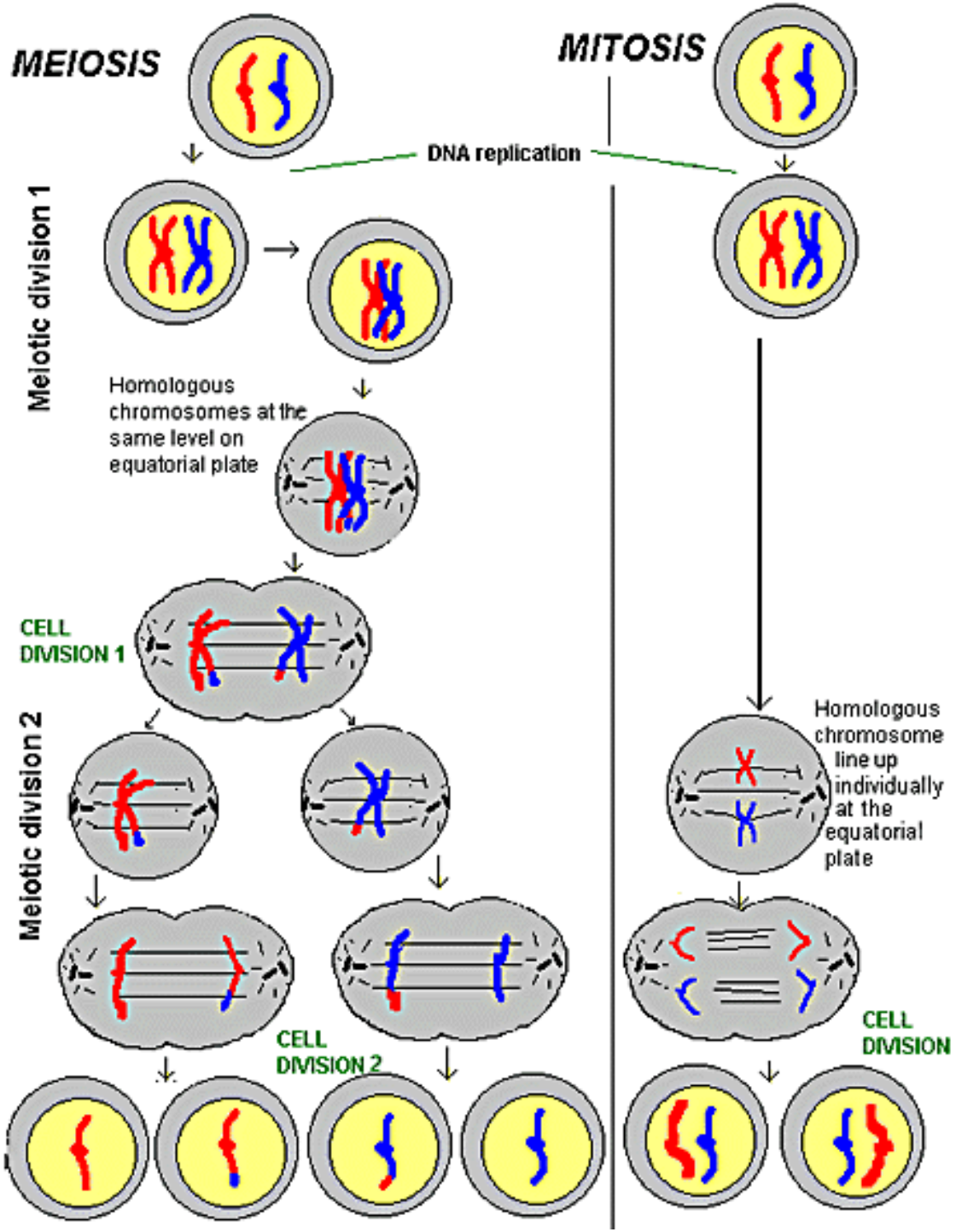


1) **Anaphase I: Each chromosome moves to opposite pole of cell**



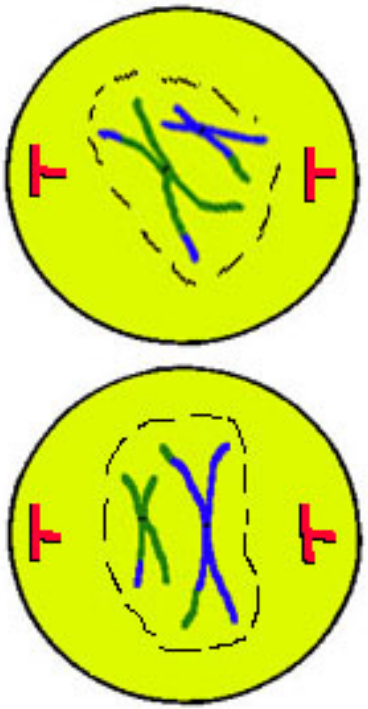
- **Telophase I: Chromosomes reach opposite sides of cell, cytokinesis begin. Result is two new cells that contain 1 set of chromosomes (46 total).**



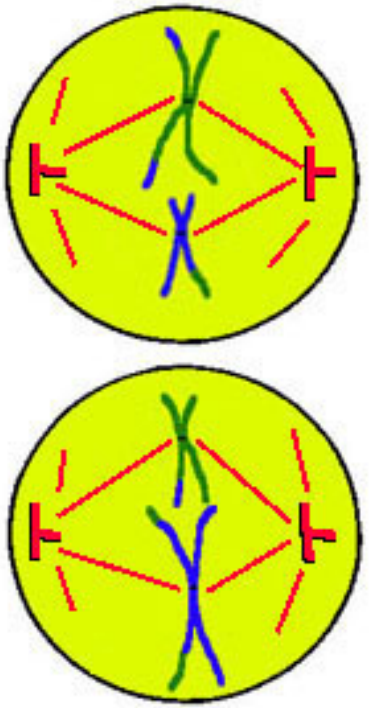

MEIOSIS
MITOSIS
DNA replication
Meiotic division 1
Homologous chromosomes at the same level on equatorial plate
CELL DIVISION 1
Meiotic division 2
Homologous chromosome line up individually at the equatorial plate
CELL DIVISION 2
CELL DIVISION

V. Steps of Meiosis II: same as mitosis

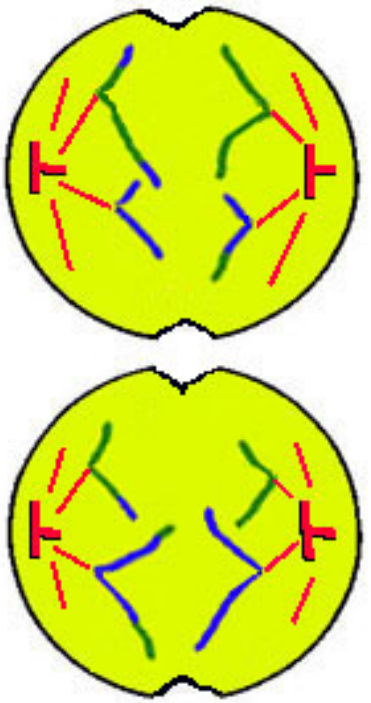
1) **<u>Prophase II</u>: <u>Spindle fibers</u> form in each cell from Meiosis I.**



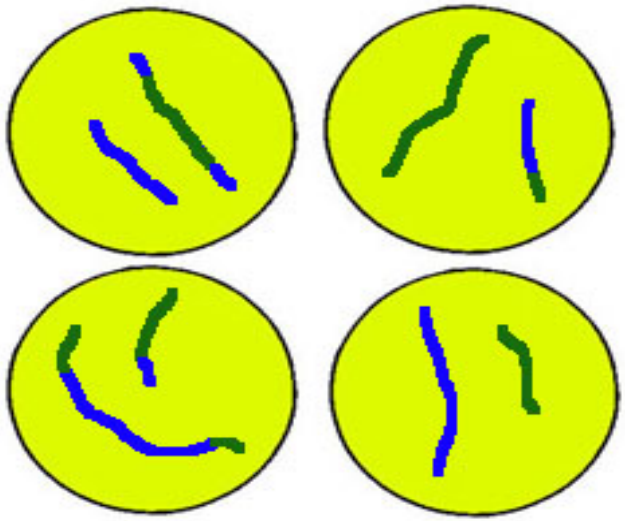
1) **<u>Metaphase II</u>: <u>Chromosomes</u> move to the equator of the daughter cells.**

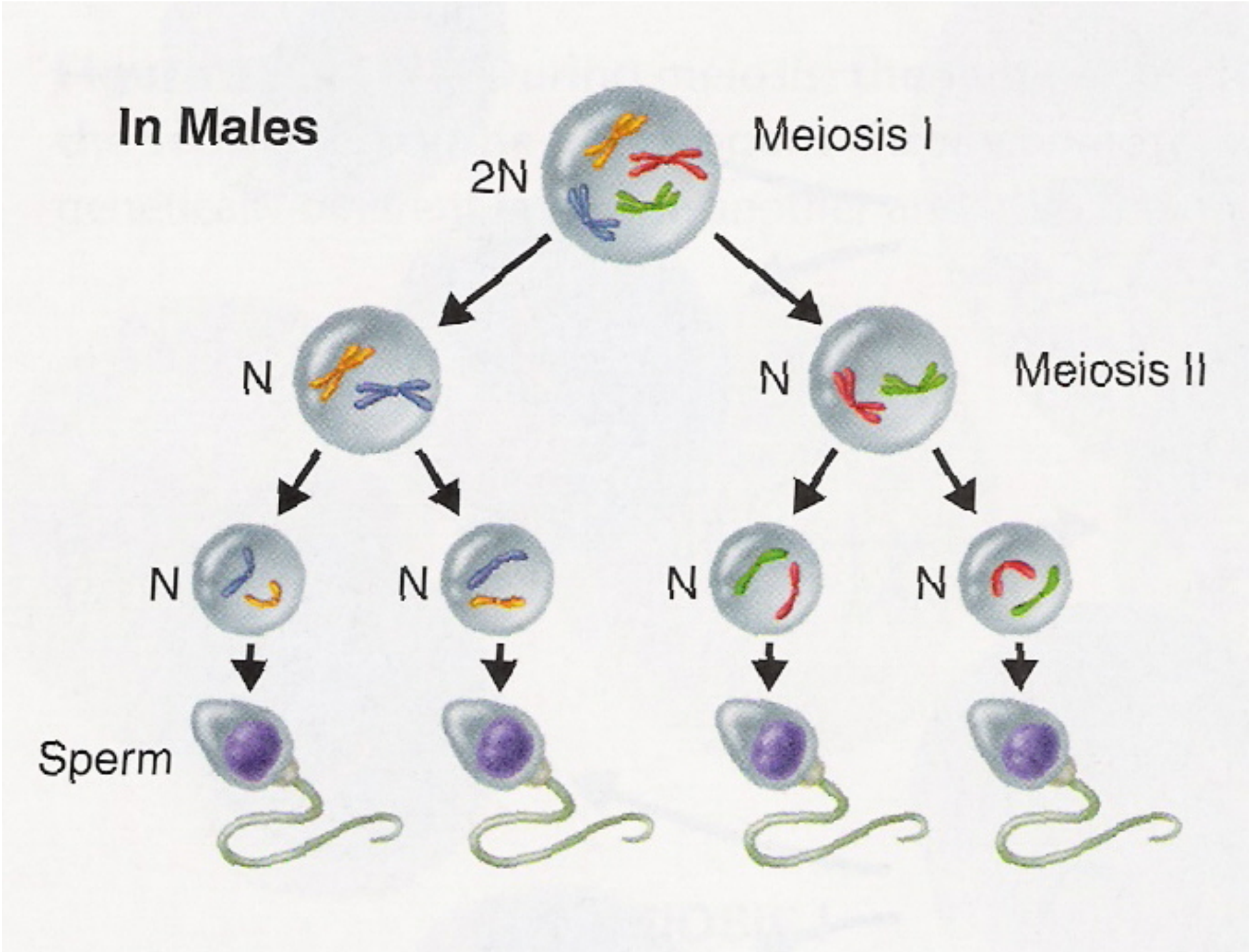


1) **Anaphase II: Chromatids separate and move towards the poles of the cell.**



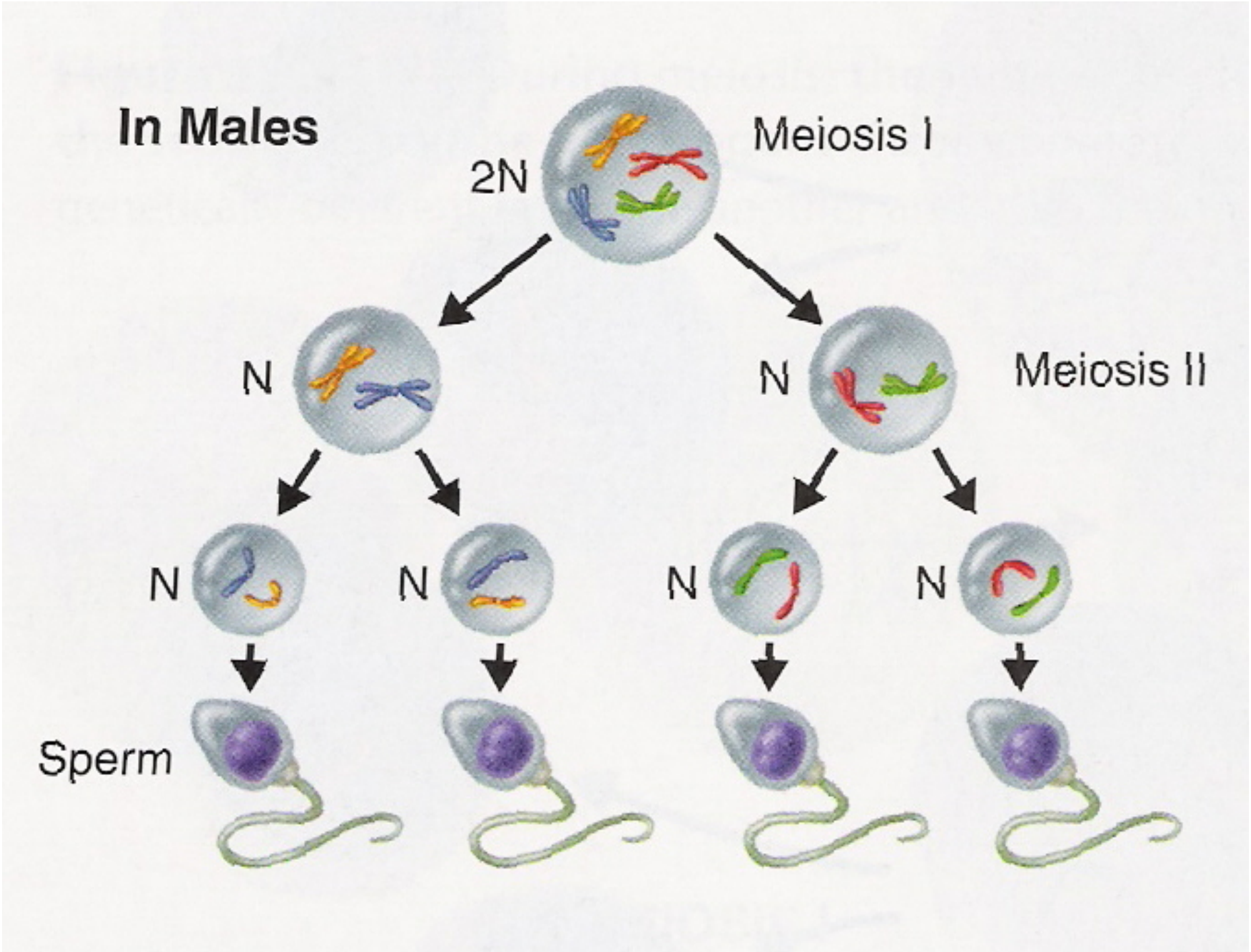
- **Telophase II/Cytokinesis: Nucleus reappears in each of four new cells; each cell contains half of the original cell's number of chromosomes**




In Males
2N
Meiosis I
N
N
Meiosis II
N
N
N
N
Sperm

Gamete (Sex Cell) Formation

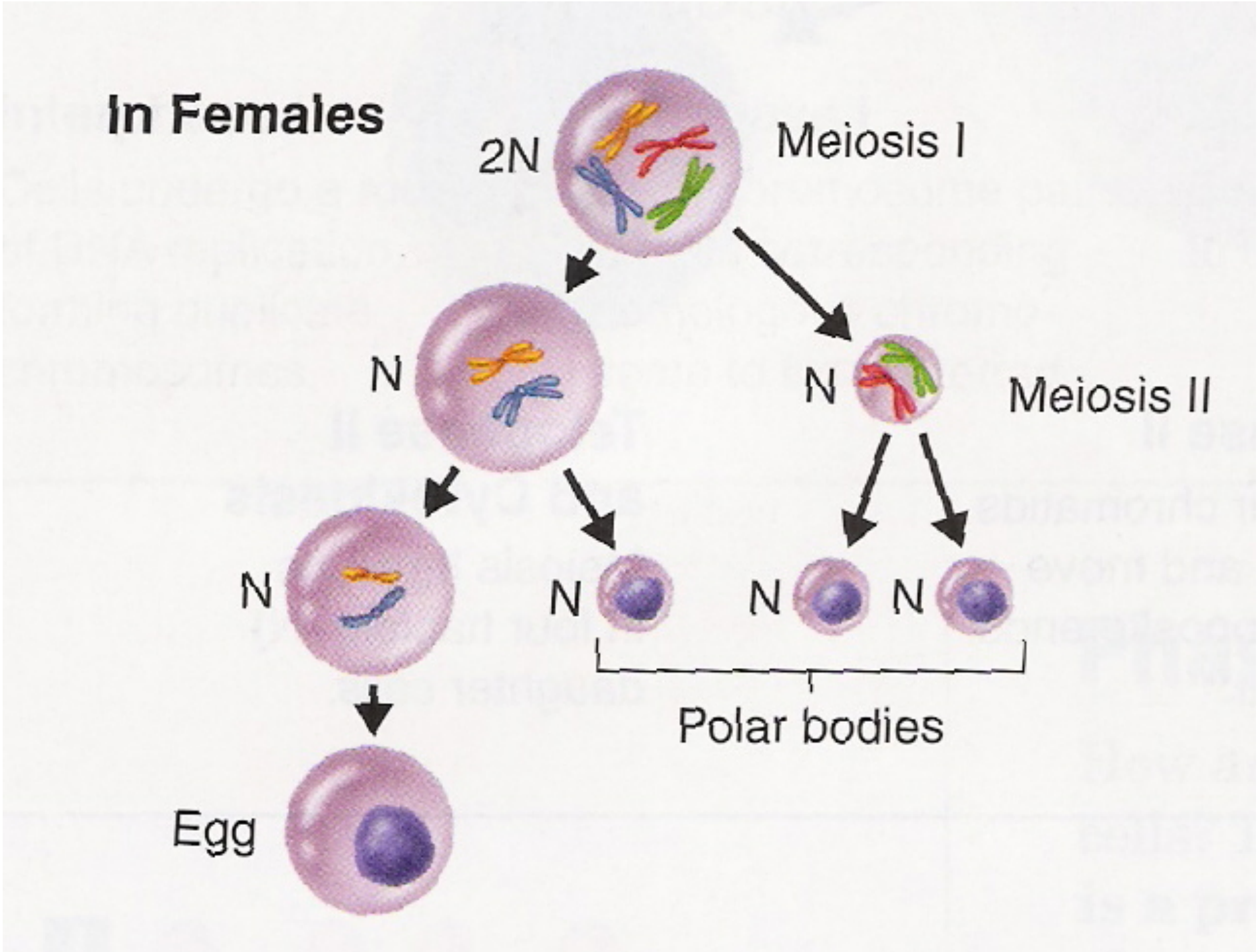
- In male animals (including humans), the haploid gametes produced by meiosis are called sperm
- 4 sperm are produced from one meiotic division


In Males
2N
Meiosis I
N
N
Meiosis II
N
N
N
N
Sperm

Gamete (Sex Cell) Formation

- In female animals (including humans), the haploid gametes produced by meiosis are called eggs (ova – plural; ovum-singular)

- The cell divisions at the end of meiosis I & II are unequal, so that 1 large egg is produced and other 3 cells produced, called polar bodies, are not involved in reproduction


In Females
2N
Meiosis I
N
N
Meiosis II
N
N
N
N
Polar bodies
Egg

- Spermatogenesis: formation of 4 haploid sperm
- Oogenesis: formation of 1 haploid egg and three polar bodies