Cell Cycle

- **Cell Cycle** – the cell's life cycle that extends from one division to the next
- **G_1 phase**, the first gap phase
  - interval between cell division and DNA replication
  - accumulates materials needed to replicate DNA
- **S phase**, synthesis phase
  - duplicates centrioles
  - DNA replication occurs
- **G_2 phase**, second gap phase
  - interval between DNA replication and cell division
  - finishes centriole duplication
  - synthesizes enzymes that control cell division
  - **repairs DNA replication** errors

Cell Cycle

- **M phase**, mitotic phase
  - cell replicates its nucleus
  - pinches in two to form new daughter cells
- ***Interphase*** – collection of G_1, S, and G_2 phases
- ***G_0 (G zero) phase*** - cells that have left the cycle for a “rest”
  - muscle and nerve cells
- Cell cycle duration varies between cell types

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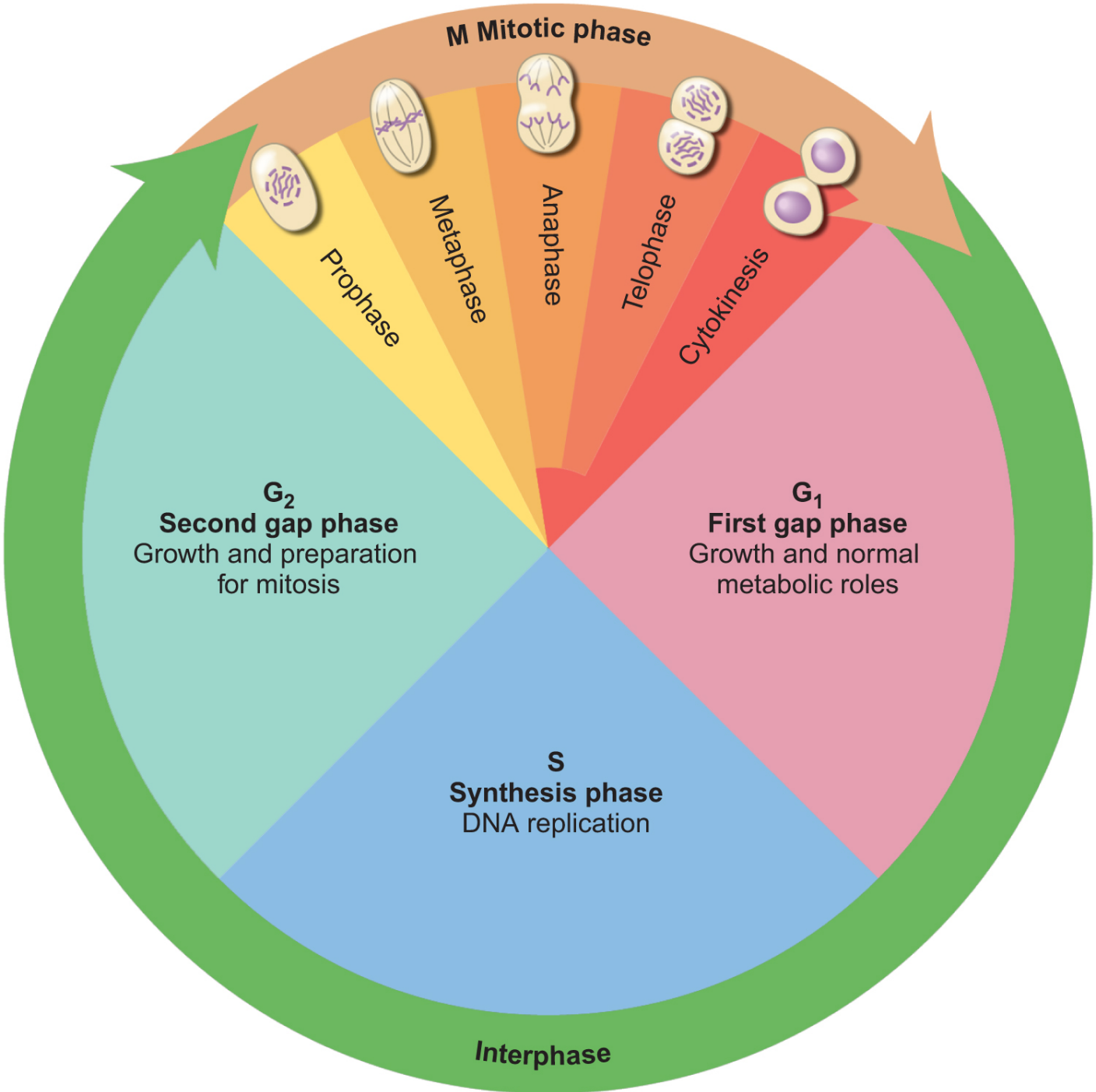
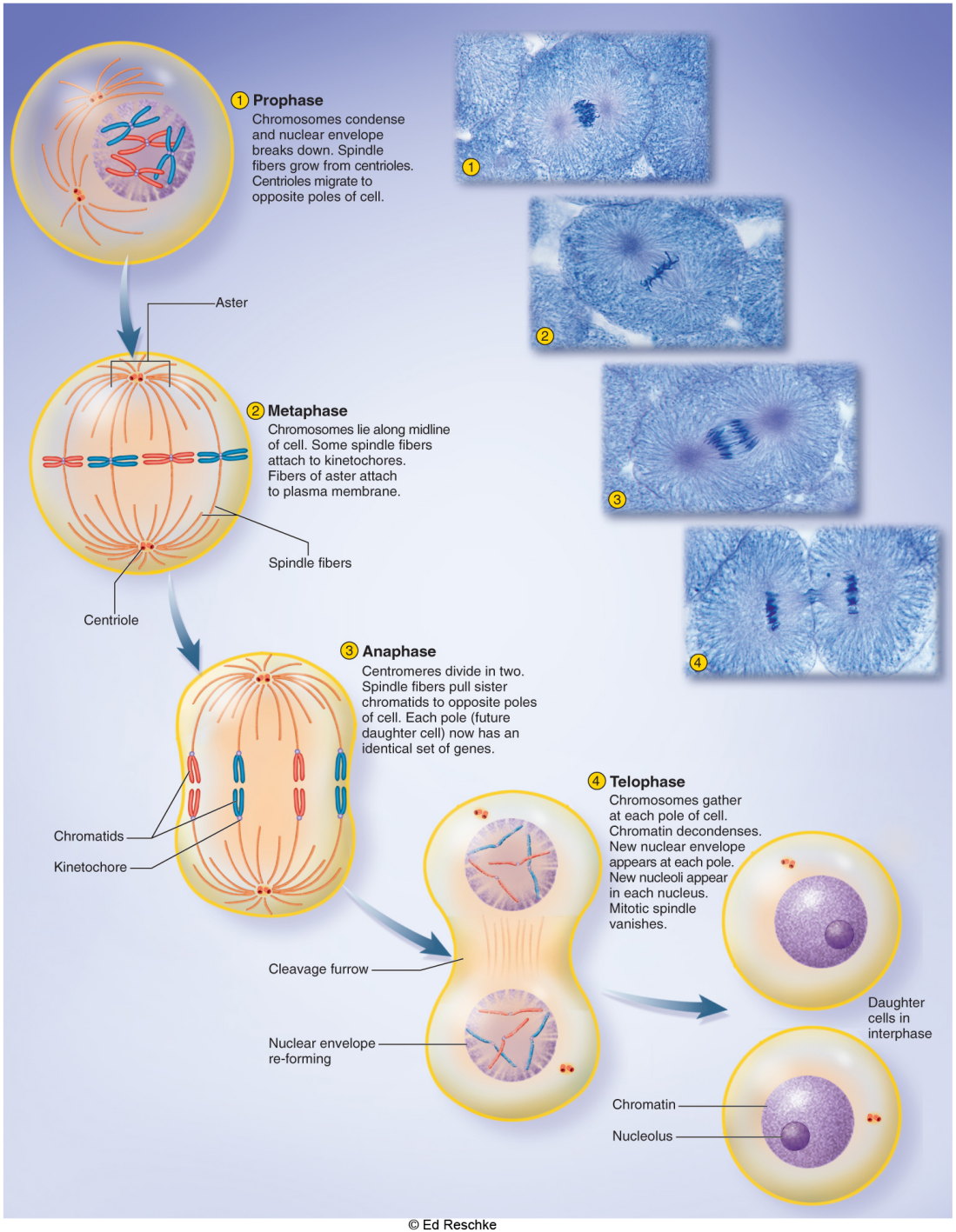


Mitosis

- cell division in all body cells except the eggs and sperm
- Functions of mitosis
  - development of the individual from one fertilized egg to some 40 trillion cells
  - growth of all tissues and organs after birth
  - replacement of cells that die
  - repair of damaged tissues
- 4 phases of mitosis
  - prophase, metaphase, anaphase, telophase



Mitosis: Prophase

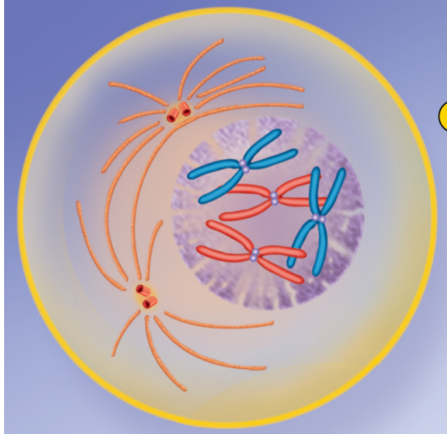
- chromosomes shorten and thicken coiling into compact rods
  - easier to distribute to daughter cells than chromatin
- 46 chromosomes
  - two **chromatids** per chromosome
  - one molecule of DNA in each chromatid
- nuclear envelope disintegrates and releases chromosomes into the cytosol
- centrioles sprout elongated microtubules – **spindle fibers**
  - push centrioles apart as they grow
  - pair of centrioles lie at each pole of the cell
- some spindle fibers grow toward chromosomes and attach to the **kinetochore** on each side of the **centromere**
- spindle fibers then tug the chromosomes back and forth until they line up along the midline of the cell

Mitosis: Telophase

- **chromatids** cluster on each side of the cell
- rough ER produces **new nuclear envelope** around each cluster
- chromatids begin to uncoil and form **chromatin**
- **mitotic spindle** breaks up and vanishes
- each nucleus forms **nucleoli**
  - indicating it has already begun making RNA and preparing for protein synthesis

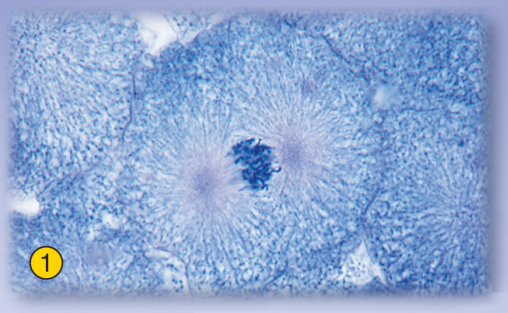
Mitosis: Metaphase

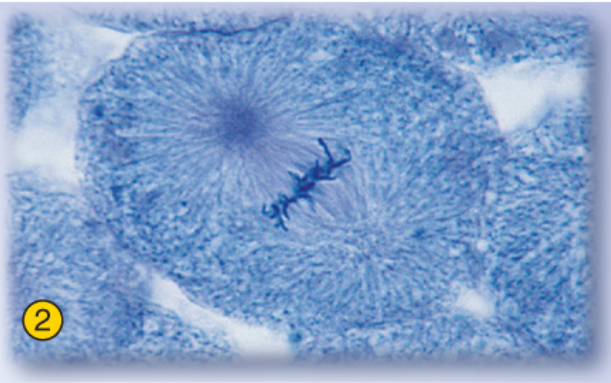
- Chromosomes are aligned on **cell equator**
  - oscillating slightly and awaiting signal that stimulates each of them to split
- **mitotic spindle** – lemon-shaped array of spindle fibers
  - **long spindle fibers** (microtubules) attach to chromosomes
  - **shorter microtubules** (**aster**) anchor centrioles to plasma membrane at each end of cell

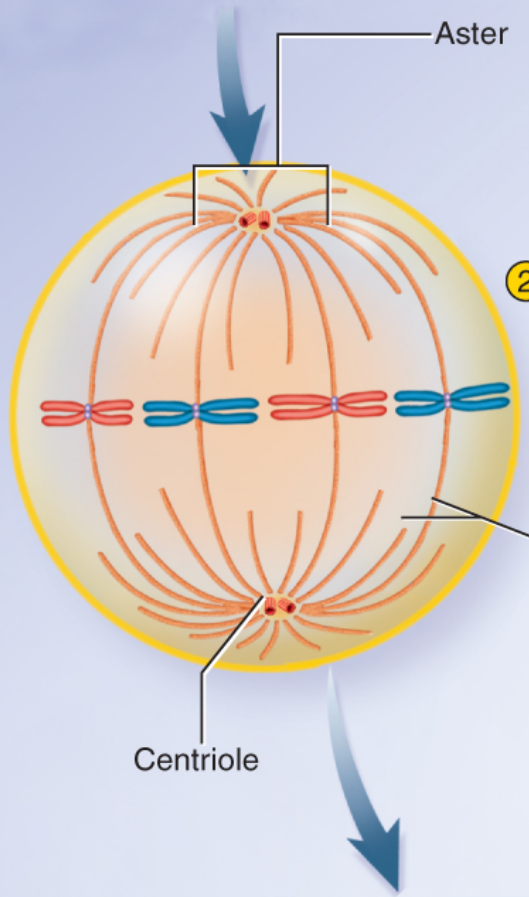


1 Prophase

Chromosomes condense and nuclear envelope breaks down. Spindle fibers grow from centrioles. Centrioles migrate to opposite poles of cell.

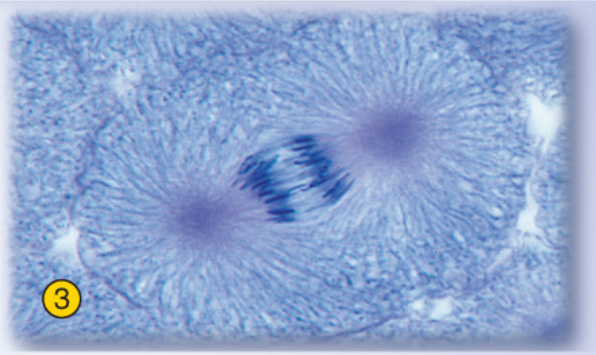


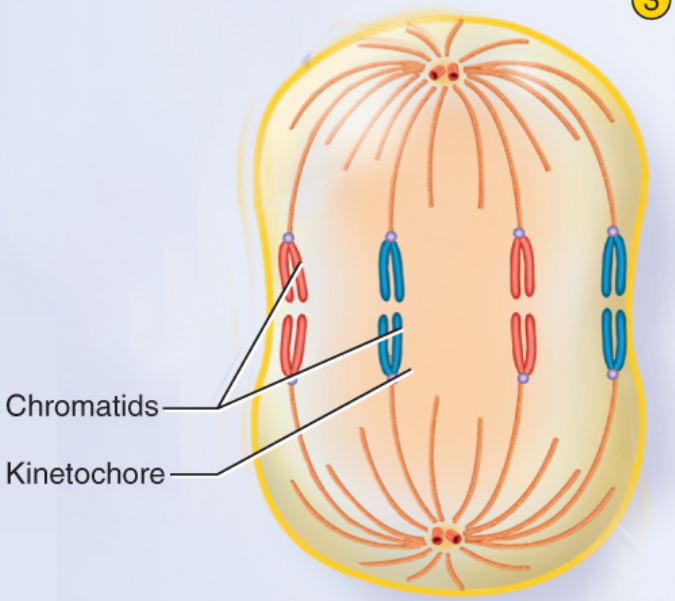




2 Metaphase

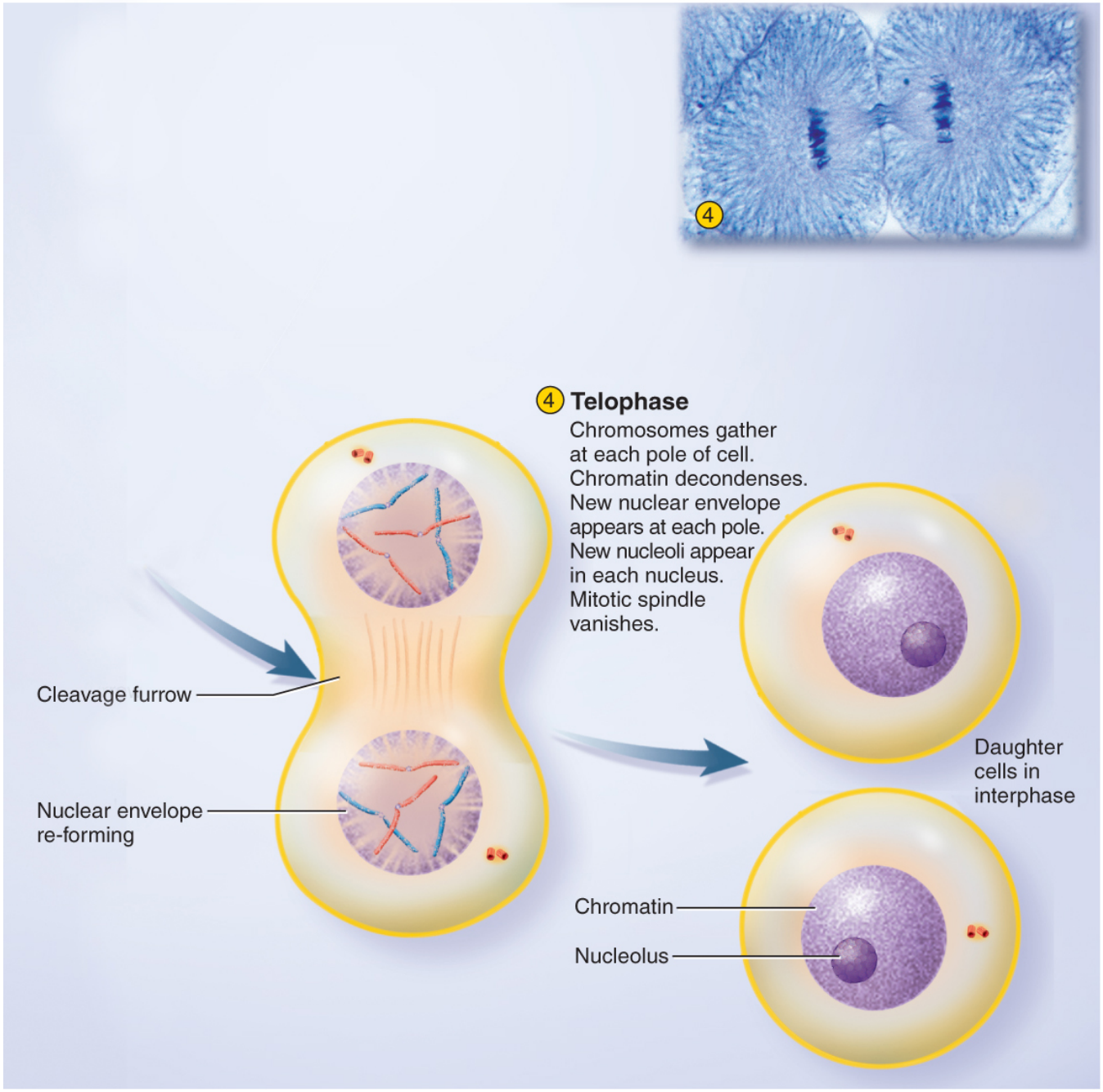
Chromosomes lie along midline of cell. Some spindle fibers attach to kinetochores. Fibers of aster attach to plasma membrane.





3 Anaphase

Centromeres divide in two. Spindle fibers pull sister chromatids to opposite poles of cell. Each pole (future daughter cell) now has an identical set of genes.



Mitosis: Anaphase

- activation of an enzyme that cleaves two sister chromatids apart at centromere

- daughter chromosomes migrate towards each pole of the cell with centromere leading the way
  - motor proteins in kinetochore crawling along the spindle fiber as the fiber itself is ‘chewed up’ and disassembled at the chromosomal end
  - daughter cells of mitosis are genetically identical

Cytokinesis

- **cytokinesis** – the division of cytoplasm into two cells
  - telophase is the end of nuclear division but overlaps cytokinesis
  - early traces of cytokinesis visible in anaphase
- achieved by motor protein **myosin** pulling on microfilaments of **actin** in the terminal web of cytoskeleton
- creates the **cleavage furrow** around the equator of cell
- cell eventually pinches in two

Timing of Cell Division

Cells divide when:

- they have enough cytoplasm for two daughter cells
- they have replicated their DNA
- adequate supply of nutrients
- are stimulated by **growth factor**
  - chemical signals secreted by blood platelets, kidney cells, and other sources
- neighboring cells die, opening up space in a tissue to be occupied by new cells

Cells stop dividing when:

- snugly contact neighboring cells
- when nutrients or growth factors are withdrawn
- **contact inhibition** – the cessation of cell division in response to contact with other cells

Cancer

- **benign tumor**
  - slow growth
  - contained in fibrous capsule
  - will not metastasize
  - usually easy to treat
- **malignant tumor** – called **cancer**
  - fast growing
  - **metastasize** – give off cells that seed the growth of multiple tumors elsewhere
- **Oncology** – medical specialty that deals with both benign and malignant tumors
- **tumor angiogenesis** – ingrowth of blood vessels stimulated by energy-hungry tumors

Cancer

- Cancers are named for the tissue of origin
  - **carcinomas** – originate in epithelial tissue
  - **lymphomas** – originate in lymph nodes
  - **melanomas** – originate in pigment cells of epidermis (melanocytes)
  - **leukemias** – in blood forming tissues
  - **sarcomas** – in bone, other connective tissue, or muscle
- **carcinogen** – environmental cancer-causing agents

Causes of Cancer

- **Carcinogens –** environmental cancer- causing agents
  - **radiation** – ultraviolet rays, X-rays
  - **chemical** - cigarette tar, food preservatives, industrial chemicals
  - **viruses** – human papilloma virus, hepatitis C, and type 2 herpes simplex
- 5 -10% of cancers are hereditary
- carcinogens trigger gene mutations

Malignant Tumor Genes

- **Oncogenes**
  - causes cell division to accelerate out of control
    - excessive production of growth factors that stimulate mitosis
    - the production for excessive growth factor receptors

- **Tumor suppressor genes**
  - inhibit development of cancer
    - oppose action of oncogenes
    - codes for DNA repairing enzymes

Lethal Effects of Cancer

- replace functional tissue in vital organs
- steal nutrients from the rest of the body
  - **cachexia** – severe wasting away of depleted tissues
- weaken one's immunity
- open the door for opportunistic infections
- often invade blood vessels, lung tissue, or brain tissue