Chapter 12

The Cell Cycle

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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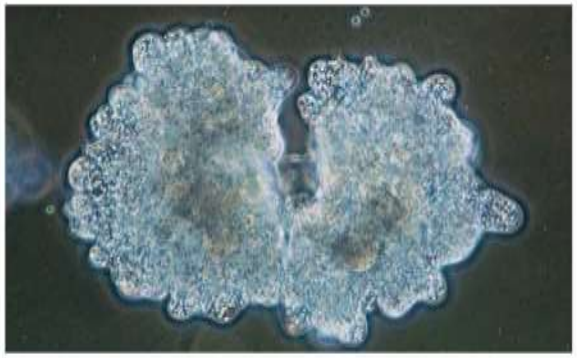
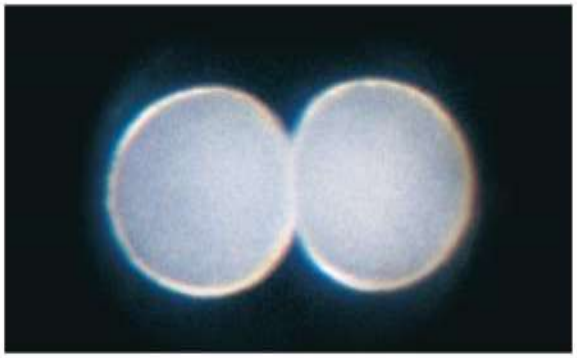
Overview: The Key Roles of Cell Division

- The ability of organisms **to reproduce** best distinguishes living things from nonliving matter
- The continuity of life is based on the reproduction of cells, or **cell division**
- **Multicellular** organisms depend on cell division for:
  - **Development** from a fertilized cell
  - **Growth**
  - **Repair**
- Cell division is an **integral part** of the **cell cycle**, the **life of a cell from formation to its own division**

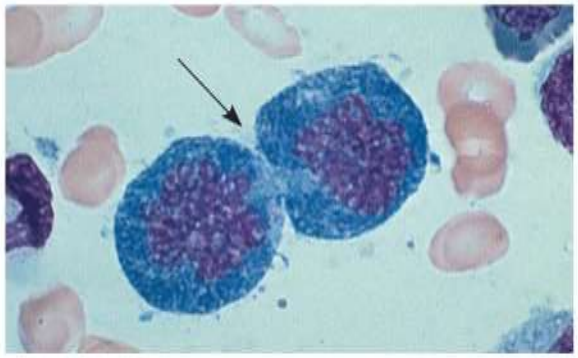
The functions of cell division



(a) Reproduction



(b) Growth and development



(c) Tissue renewal

Cell division results in genetically identical daughter cells

- Most cell division results in **daughter cells** with **identical genetic information, DNA**
- A special type of division, **meiosis**, produces **nonidentical daughter cells** (gametes, or sperm and egg cells)

Cellular Organization of the Genetic Material

- All the DNA in a cell constitutes the cell's **genome**
- A genome can consist of a single DNA molecule (common **in prokaryotic cells**) or a number of DNA molecules (common **in eukaryotic cells**)
- DNA molecules in a eukaryotic cell are packaged into **chromosomes**

Eukaryotic chromosomes

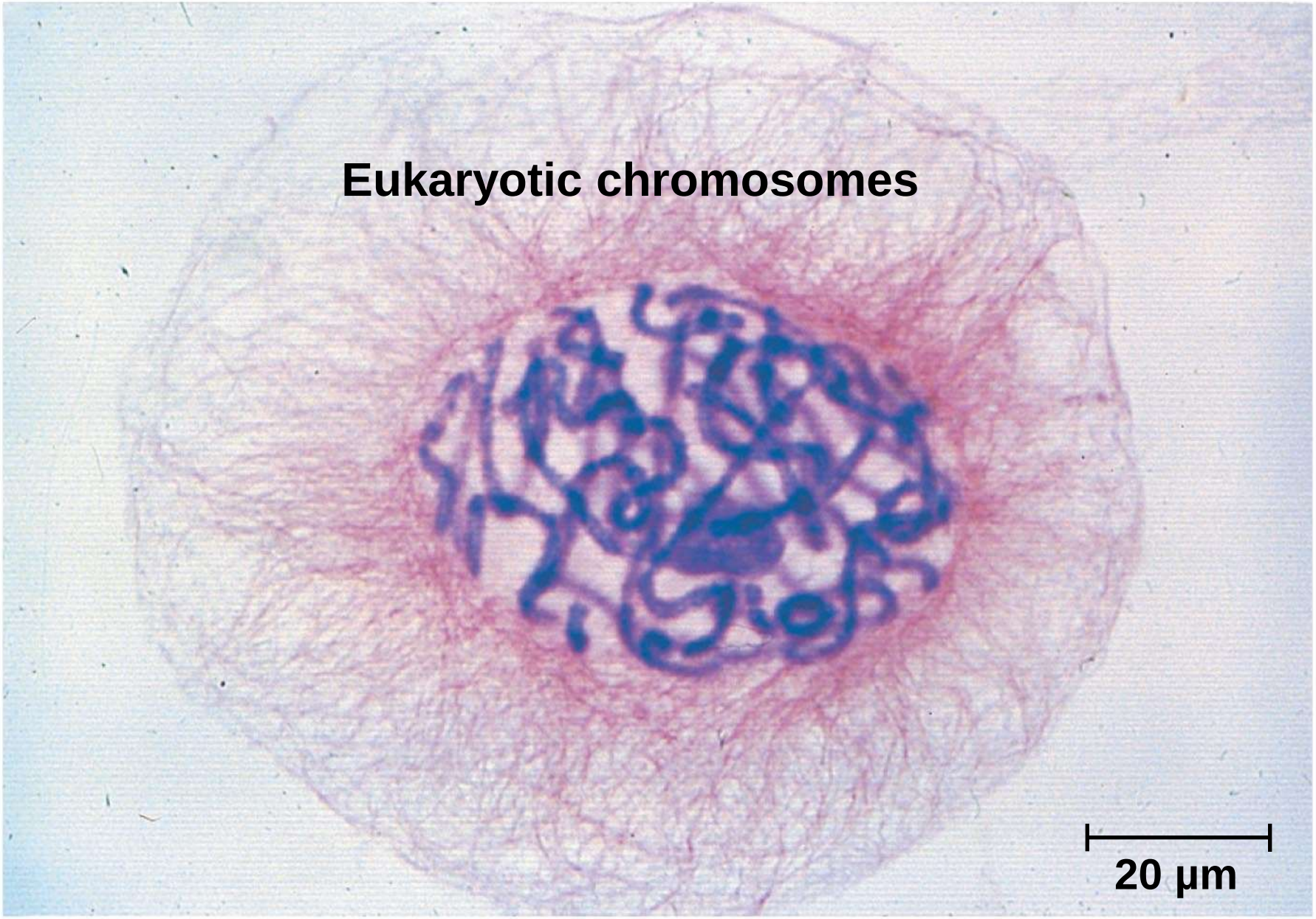
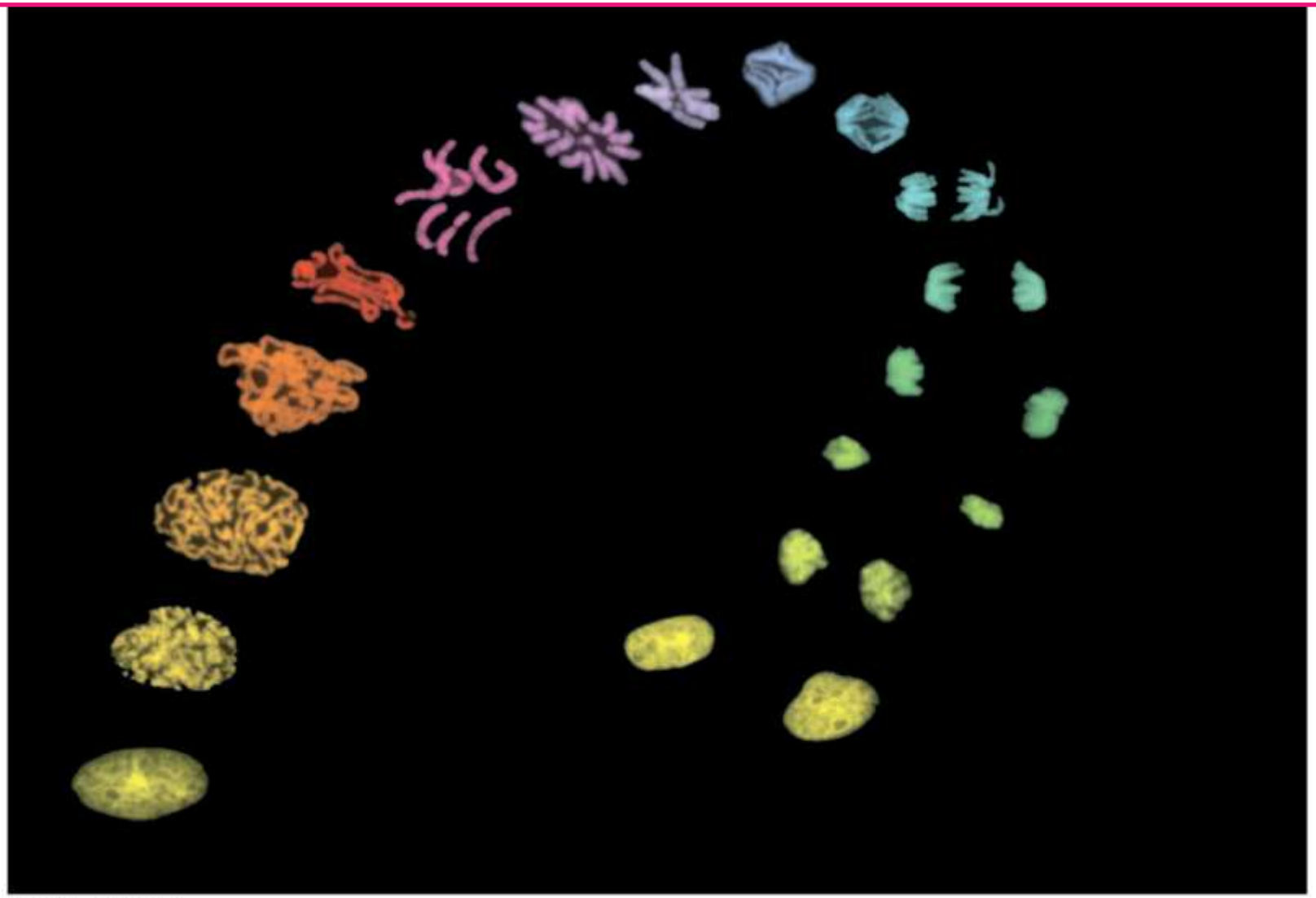


Figure 12.1

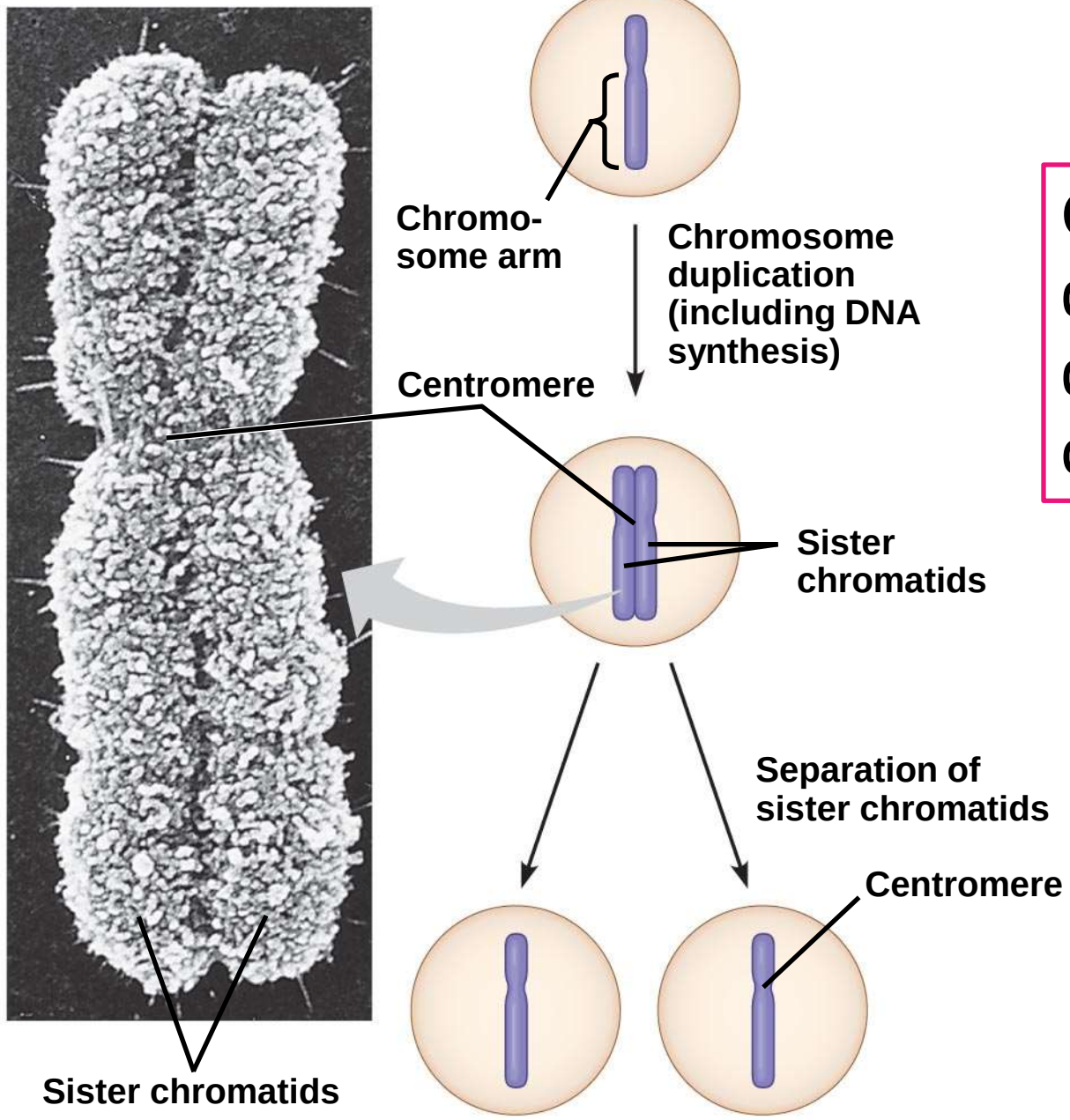
How do a cell's chromosomes **change** during **cell division?**



- Every eukaryotic **species** has a **characteristic number of chromosomes** in each cell nucleus
- **Somatic cells** (nonreproductive cells) have **two sets of chromosomes**
- **Gametes** (reproductive cells: sperm and eggs) have **half as many chromosomes as somatic cells**
- Eukaryotic chromosomes consist of **chromatin**, a **complex of DNA and protein that condenses during cell division**

Distribution of Chromosomes During Eukaryotic Cell Division

- In preparation for cell division, DNA is **replicated** and the chromosomes condense
- Each duplicated chromosome has **two sister chromatids**, which separate during cell division
- The **centromere** is the narrow "waist" of the duplicated chromosome, where the two chromatids are most closely attached



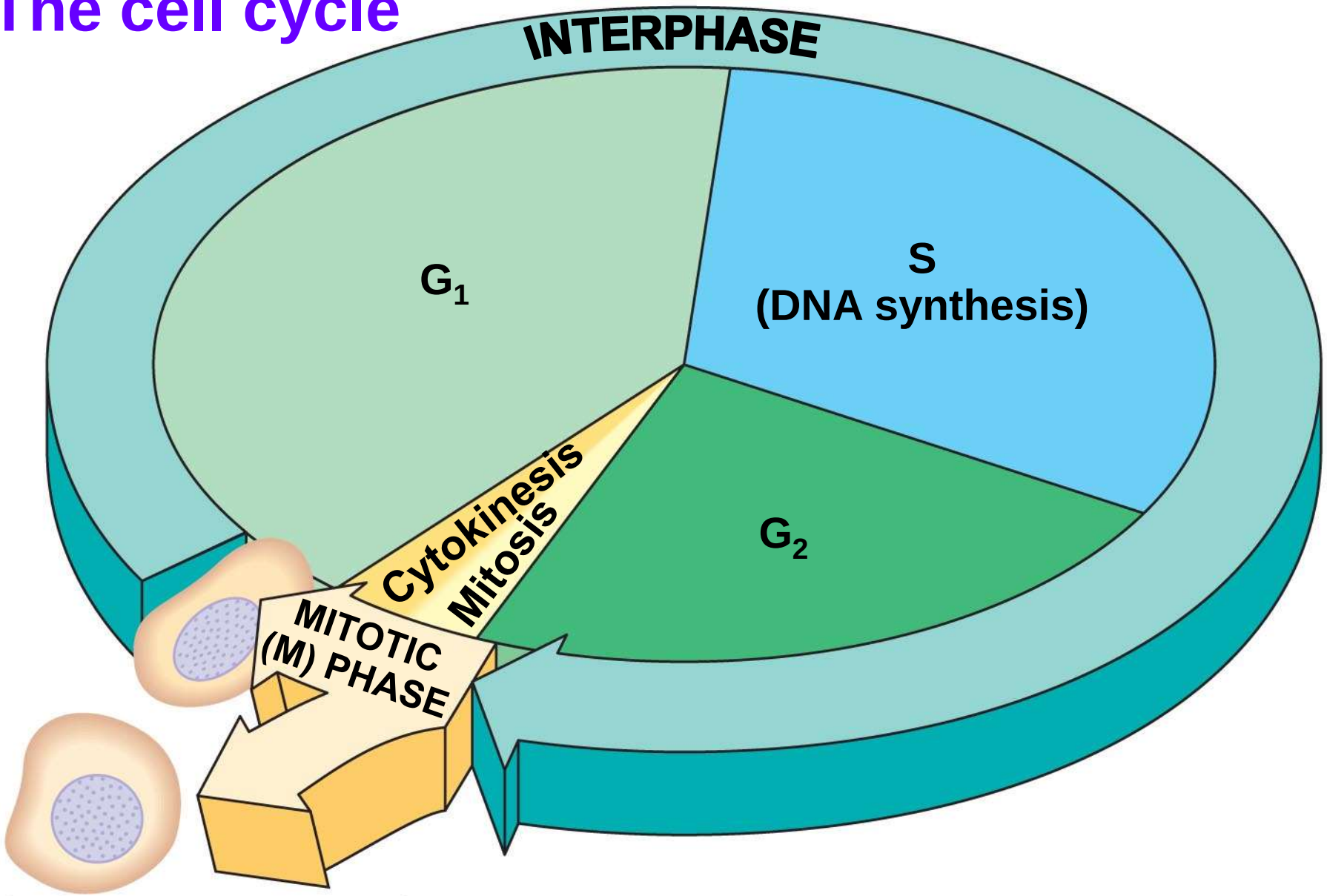
Chromosome duplication and distribution during cell division

Phases of the Cell Cycle

- The **cell cycle** includes:
  - **Mitotic (M) phase** (mitosis and cytokinesis)
  - **Interphase** (cell growth and copying of chromosomes in preparation for cell division)

- Interphase (about 90% of the cell cycle) can be divided into subphases:
  - **G_1 phase** ("first gap")
  - **S phase** ("synthesis")
  - **G_2 phase** ("second gap")
- The cell **grows during all three phases**, but chromosomes are **duplicated** only during the S phase

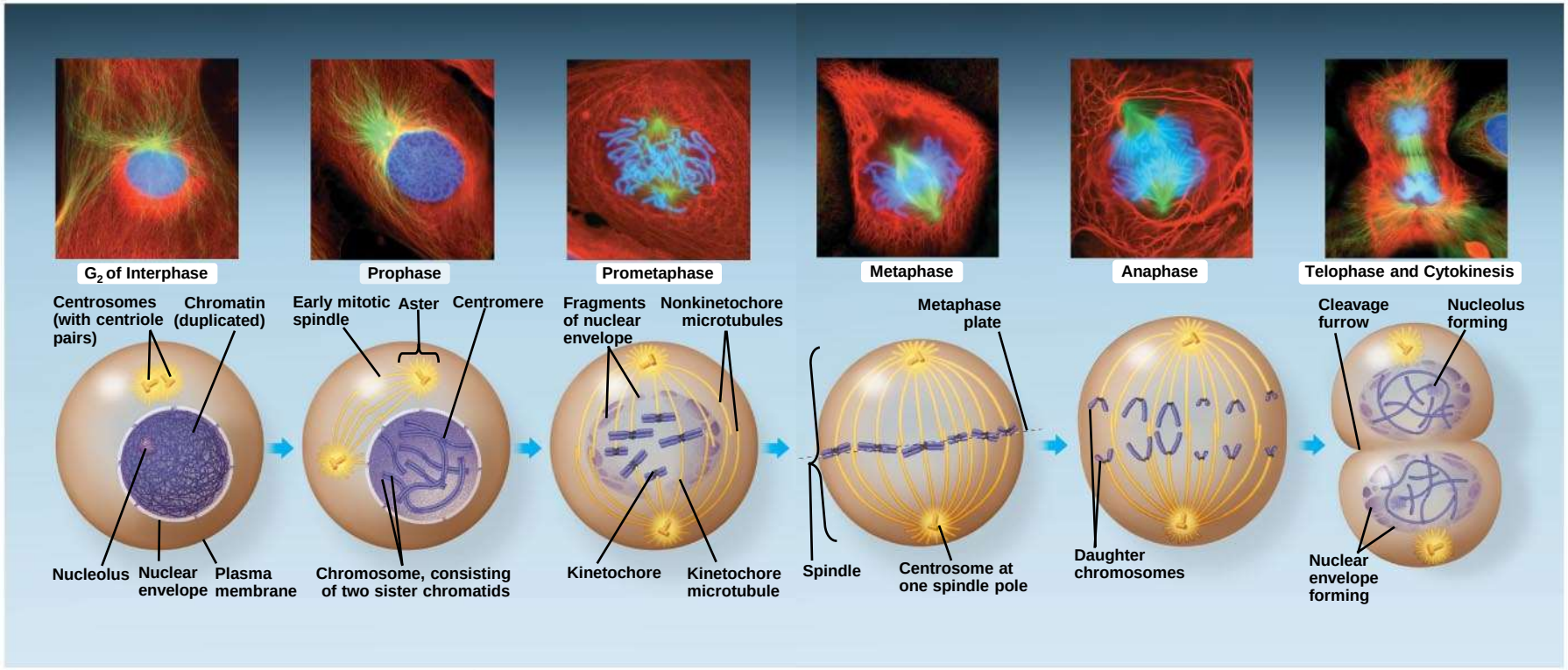
The cell cycle



- **Mitosis** is conventionally divided into four (five) phases:
  - **Prophase (+ prometaphase)**
  - **Metaphase**
  - **Anaphase**
  - **Telophase**
- **Cytokinesis** is well underway by late telophase

PLAY BioFlix: Mitosis

The mitotic division of an animal cell



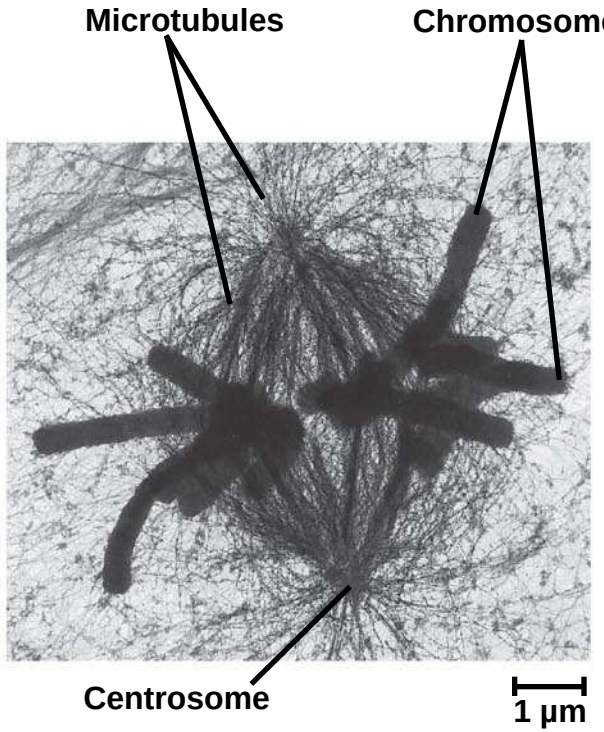
The Mitotic Spindle: *A Closer Look*

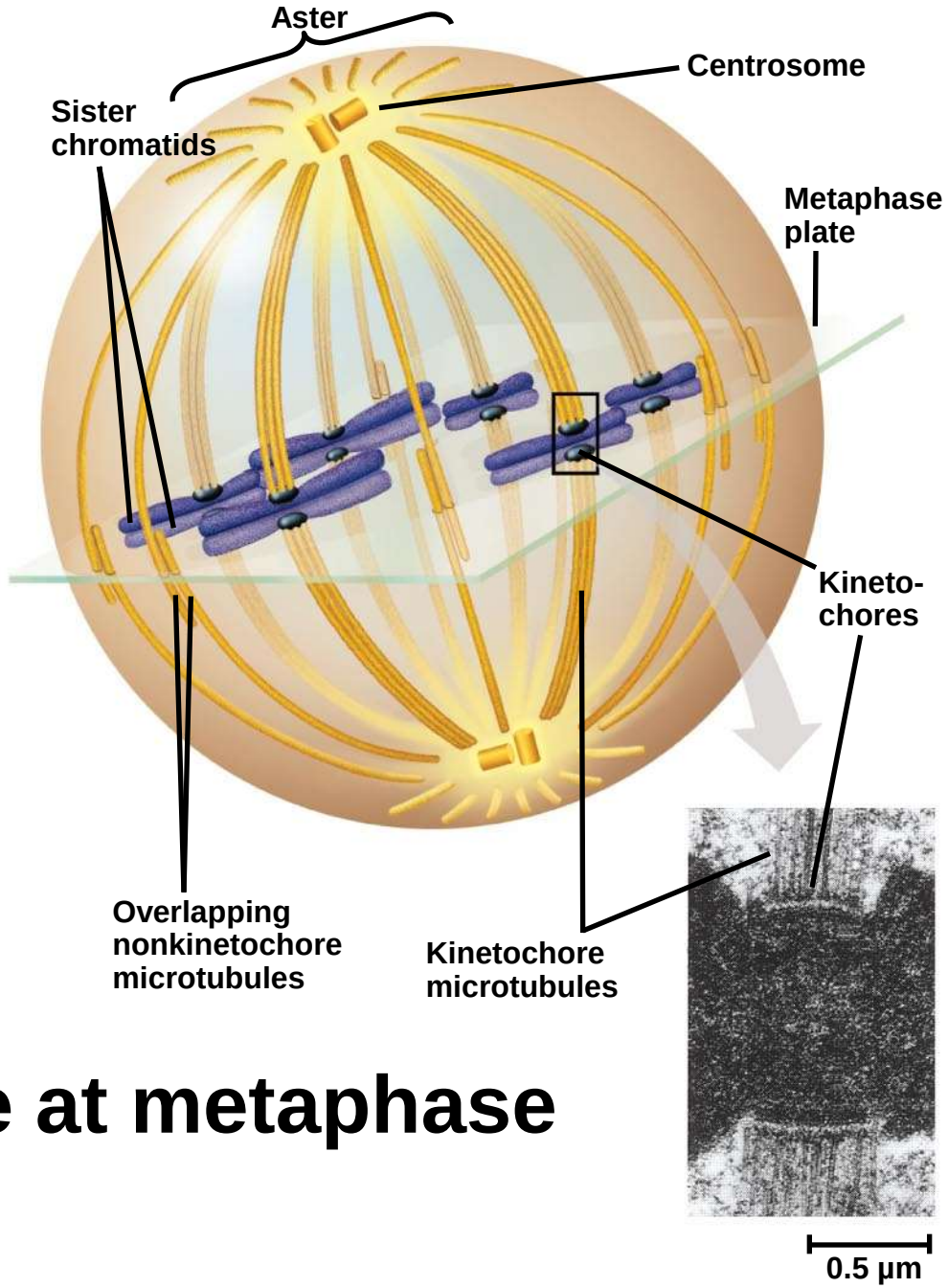
- The **mitotic spindle** is an apparatus of microtubules that controls chromosome movement during mitosis
- During prophase, assembly of spindle microtubules begins in the **centrosome**, the microtubule organizing center
- The centrosome replicates, forming **two centrosomes** that migrate to opposite ends of the cell, as spindle microtubules grow out from them

- An **aster** (a radial array of **short** microtubules) extends from each centrosome
- The **spindle** includes the centrosomes, the spindle microtubules, and the asters

- During early metaphase, some spindle microtubules attach to the **kinetochores** of chromosomes and begin to move the chromosomes
- At metaphase, the chromosomes are all lined up at the **metaphase plate**, the midway point between the spindle's two poles

Fig. 12-7





The mitotic spindle at metaphase

- In **anaphase**, sister chromatids separate and move along the kinetochore microtubules toward opposite ends of the cell
- Nonkinetochore microtubules from opposite poles overlap and push **against** each other, elongating the cell

Cytokinesis: *A Closer Look*

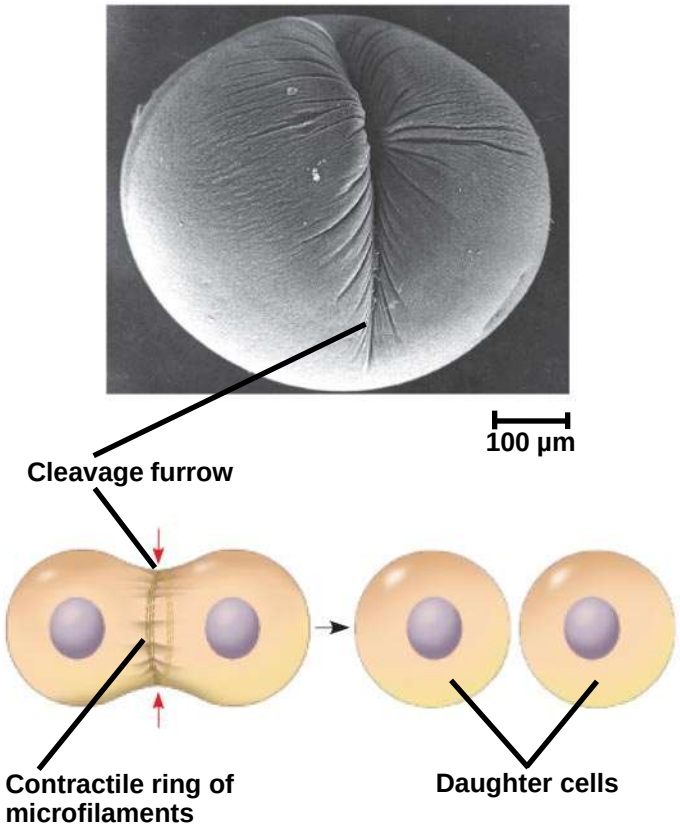
- In telophase, genetically identical **daughter nuclei** form at opposite ends of the cell
- In animal cells, cytokinesis occurs by a process known as **cleavage**, forming a **cleavage furrow**
- In plant cells, a **cell plate** forms during cytokinesis

PLAY Animation: Cytokinesis

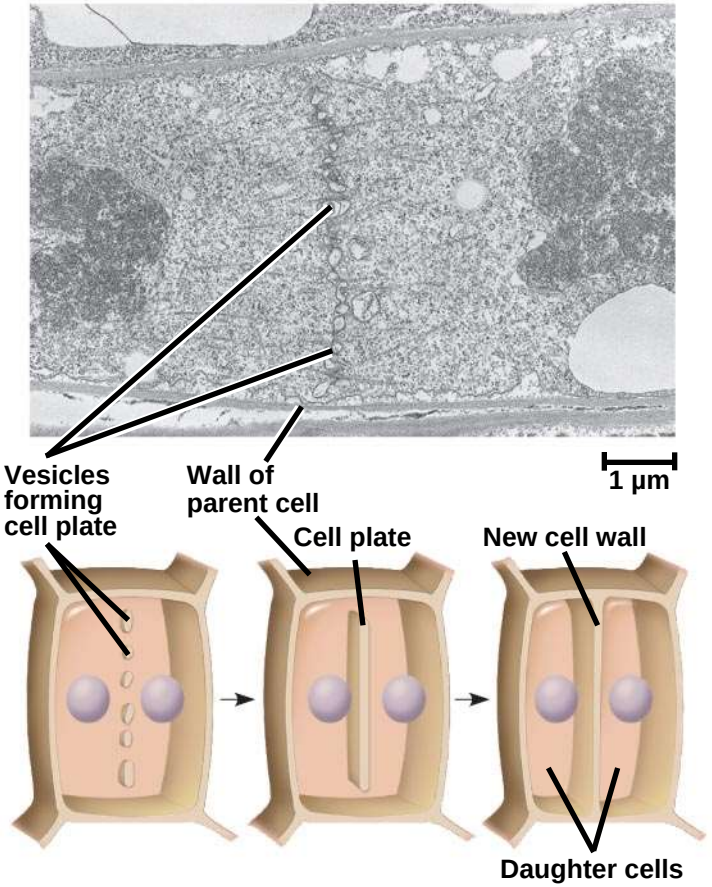
PLAY Video: Sea Urchin (Time Lapse)

PLAY Video: Animal Mitosis

Cytokinesis in animal and plant cells

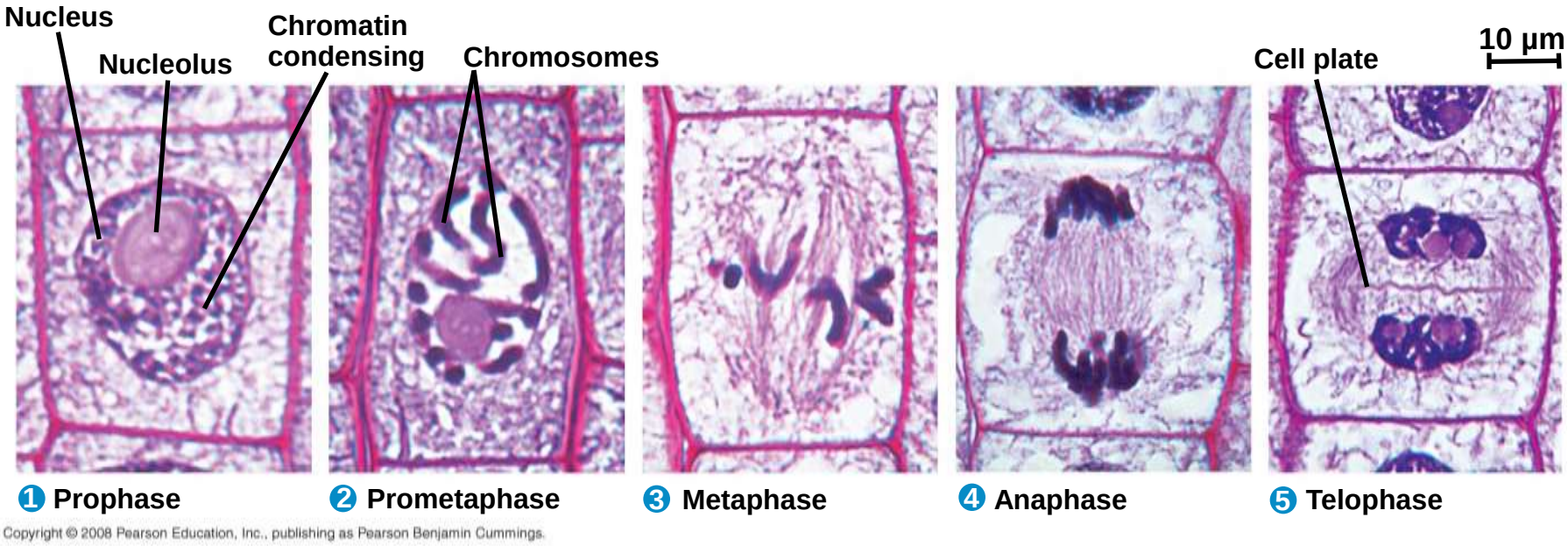


(a) Cleavage of an animal cell (SEM)



(b) Cell plate formation in a plant cell (TEM)

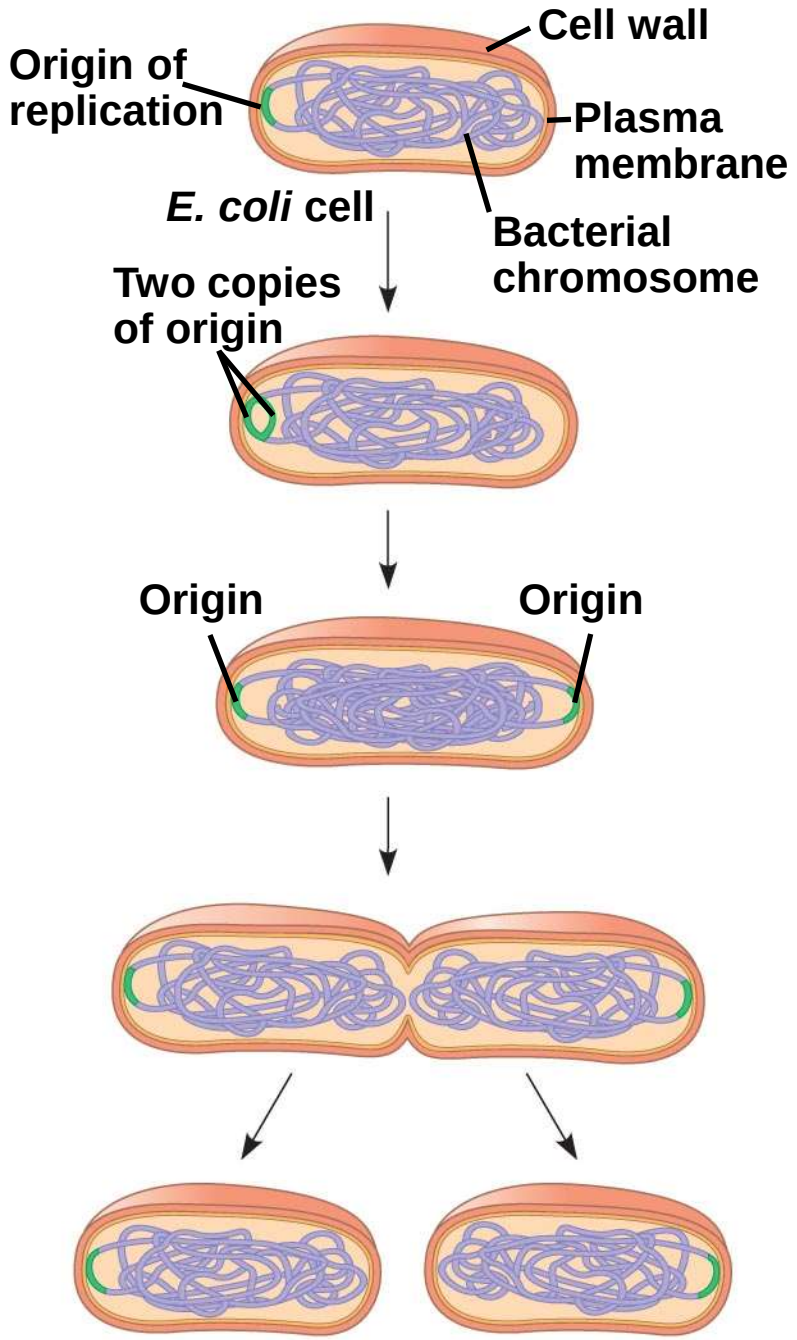
Mitosis in a plant cell



Binary Fission

- **Prokaryotes (bacteria and archaea)** reproduce by a **type of cell division** called **binary fission**
- In binary fission, the chromosome replicates (beginning at the **origin of replication**), and the two daughter chromosomes actively move apart

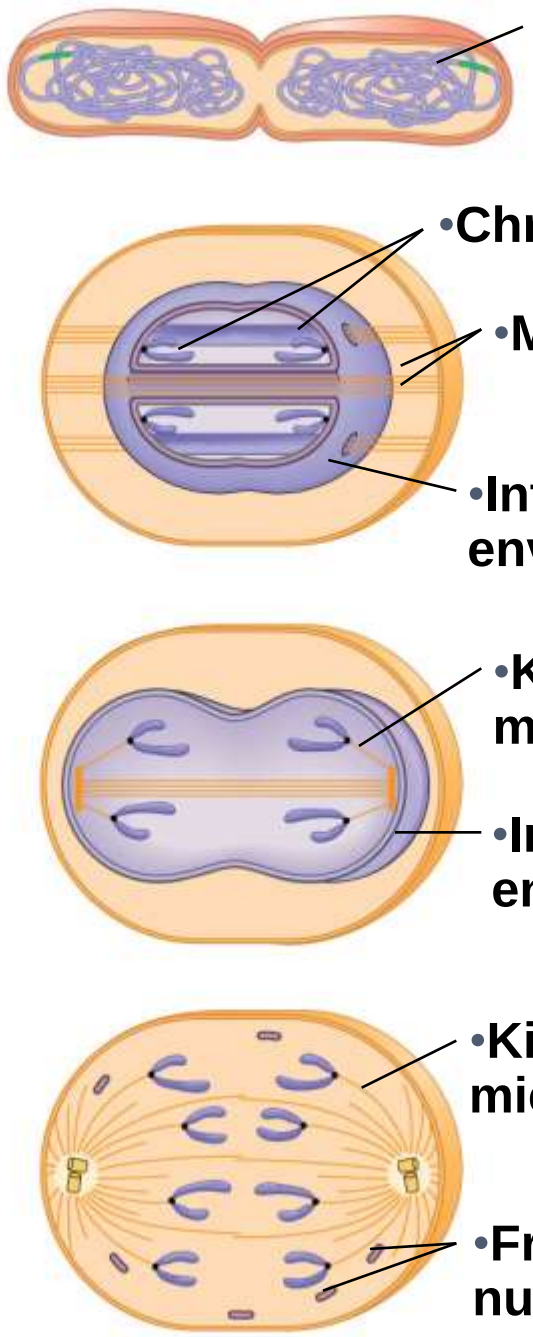
Bacterial cell division by binary fission



The Evolution of Mitosis

- Since prokaryotes evolved before eukaryotes, **mitosis probably evolved from binary fission**

Figure 12.13

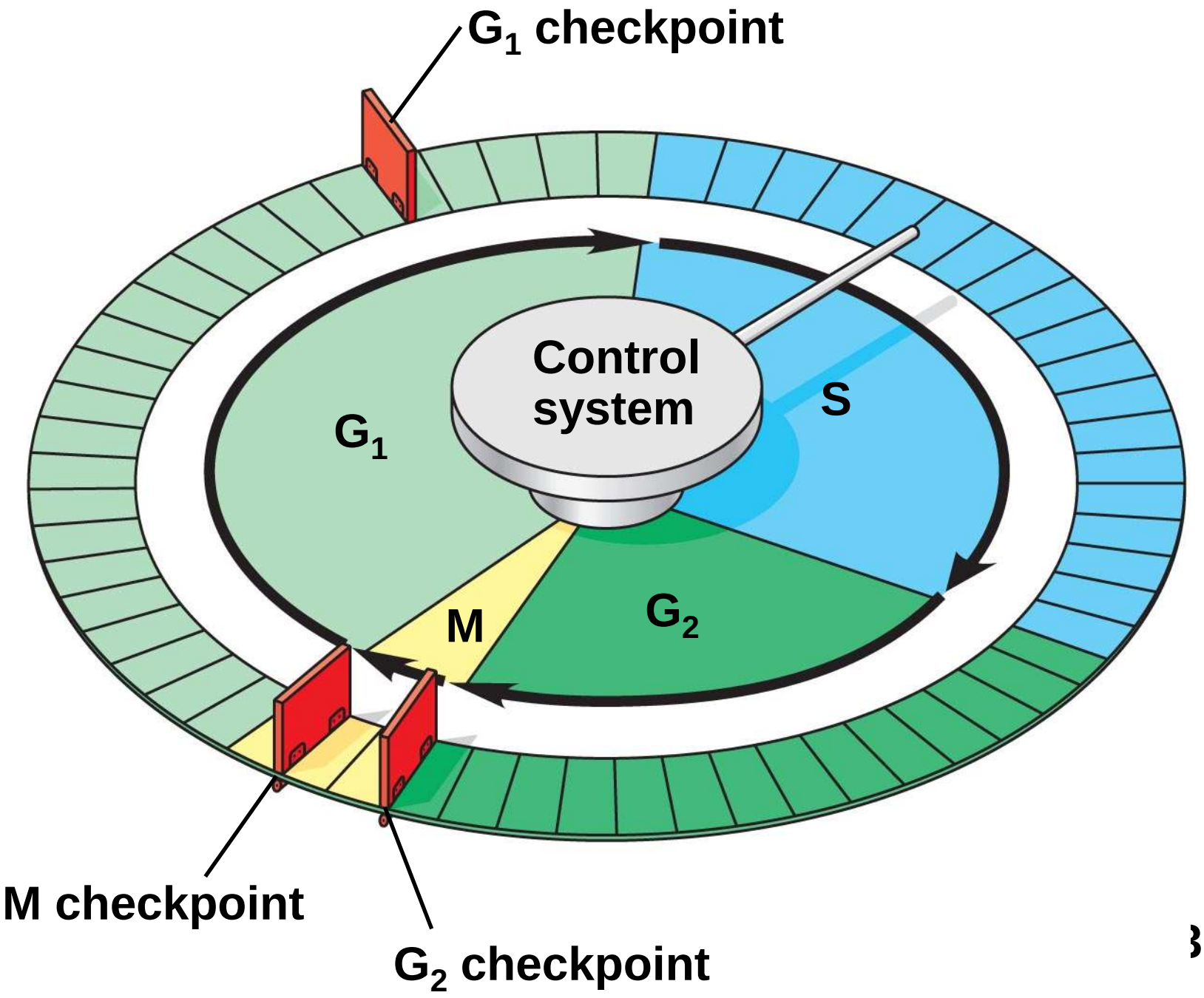


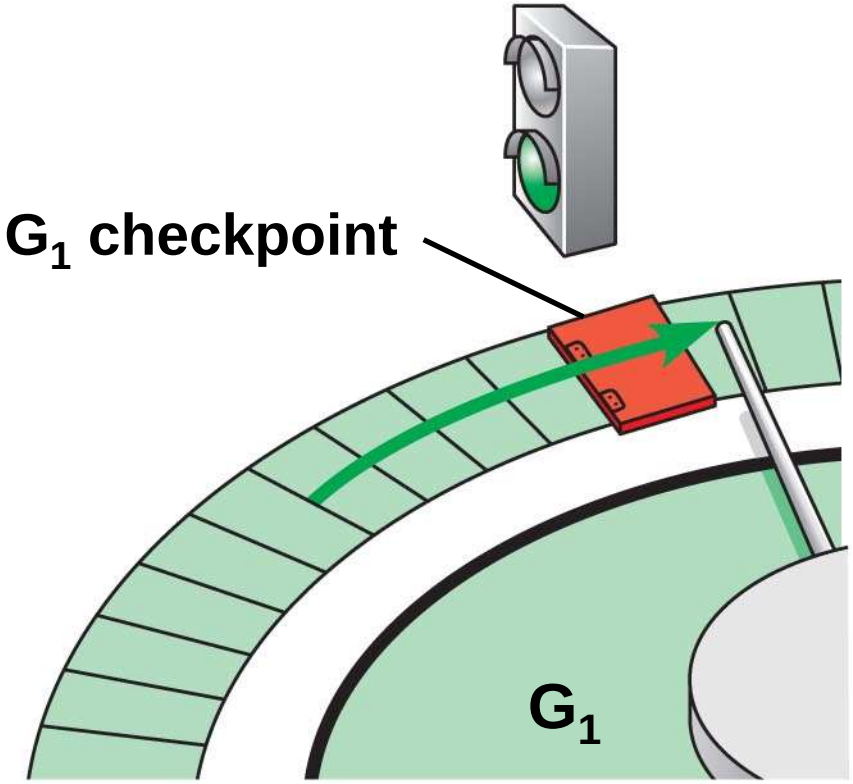
The eukaryotic cell cycle is regulated by a molecular control system

- The **frequency** of cell division varies with the **type of cell**
- These cell cycle differences result from regulation at the molecular level

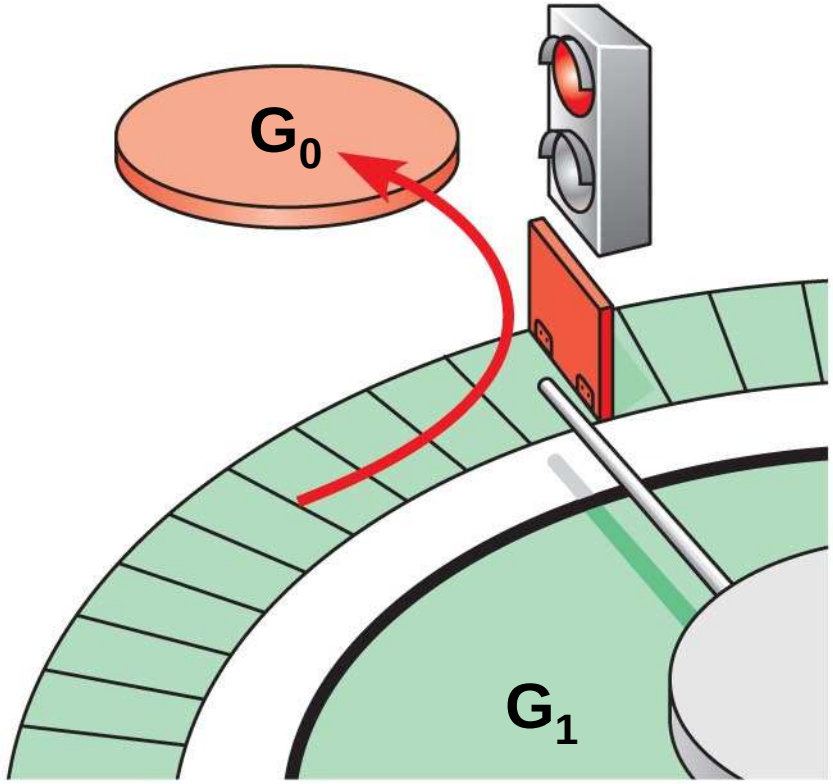
The Cell Cycle Control System

- The sequential events of the cell cycle are directed by a distinct **cell cycle control system**, which is **similar to a clock**
- The cell cycle control system is regulated by both internal and external controls
- The clock has specific **checkpoints** where the cell cycle stops until a go-ahead signal is received





(a) Cell receives a go-ahead signal



(b) Cell does not receive a go-ahead signal

- For many cells, the **G_1 checkpoint seems to be the most important one**

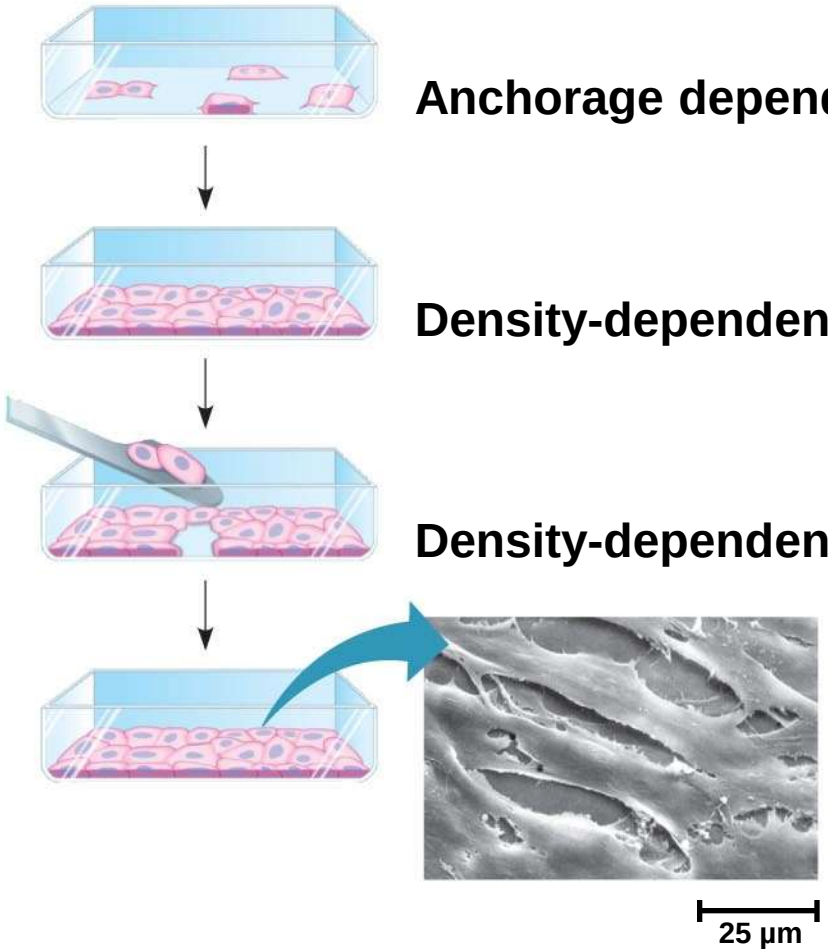
- If a cell receives a go-ahead signal at the G_1 checkpoint, **it will usually complete the S, G_2, and M phases and divide**

- If the cell does not receive the go-ahead signal, it will exit the cycle, switching into a **nondividing state** called the **G_0 phase**

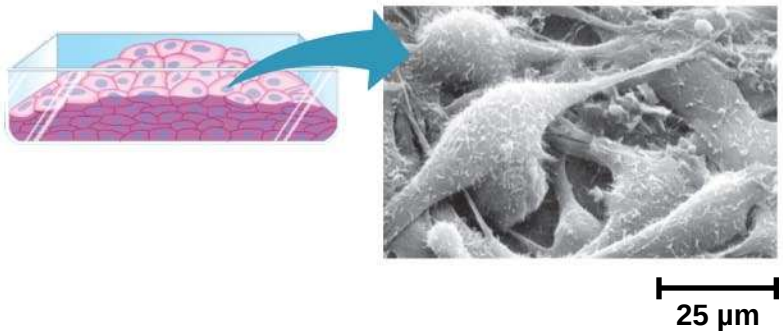
Stop and Go Signs: Internal and External Signals at the Checkpoints

- An example of an internal signal is that kinetochores not attached to spindle microtubules send a molecular signal that delays anaphase
- Some external signals are **growth factors**, proteins released by certain cells that stimulate other cells to divide

- Another example of external signals is **density-dependent inhibition**, in which **crowded** cells stop dividing
- Most animal cells also exhibit **anchorage dependence**, in which they **must be attached to a substratum** in order to divide



(a) Normal mammalian cells



(b) Cancer cells

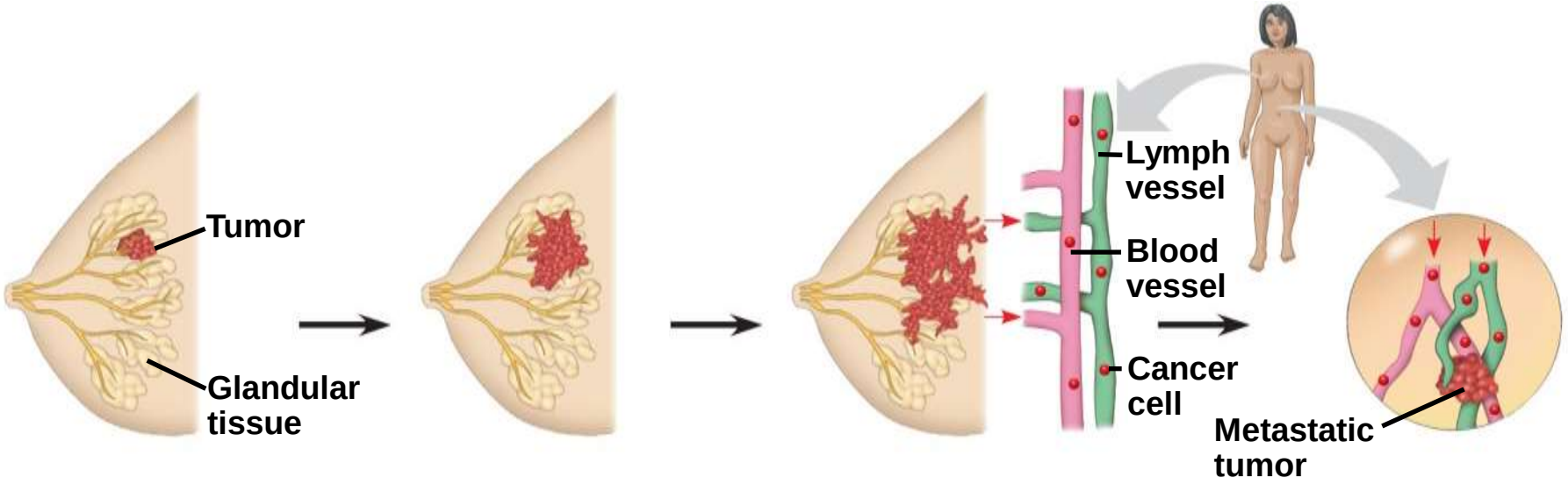
Cancer cells exhibit neither density-dependent inhibition nor anchorage dependence

Loss of Cell Cycle Controls in Cancer Cells

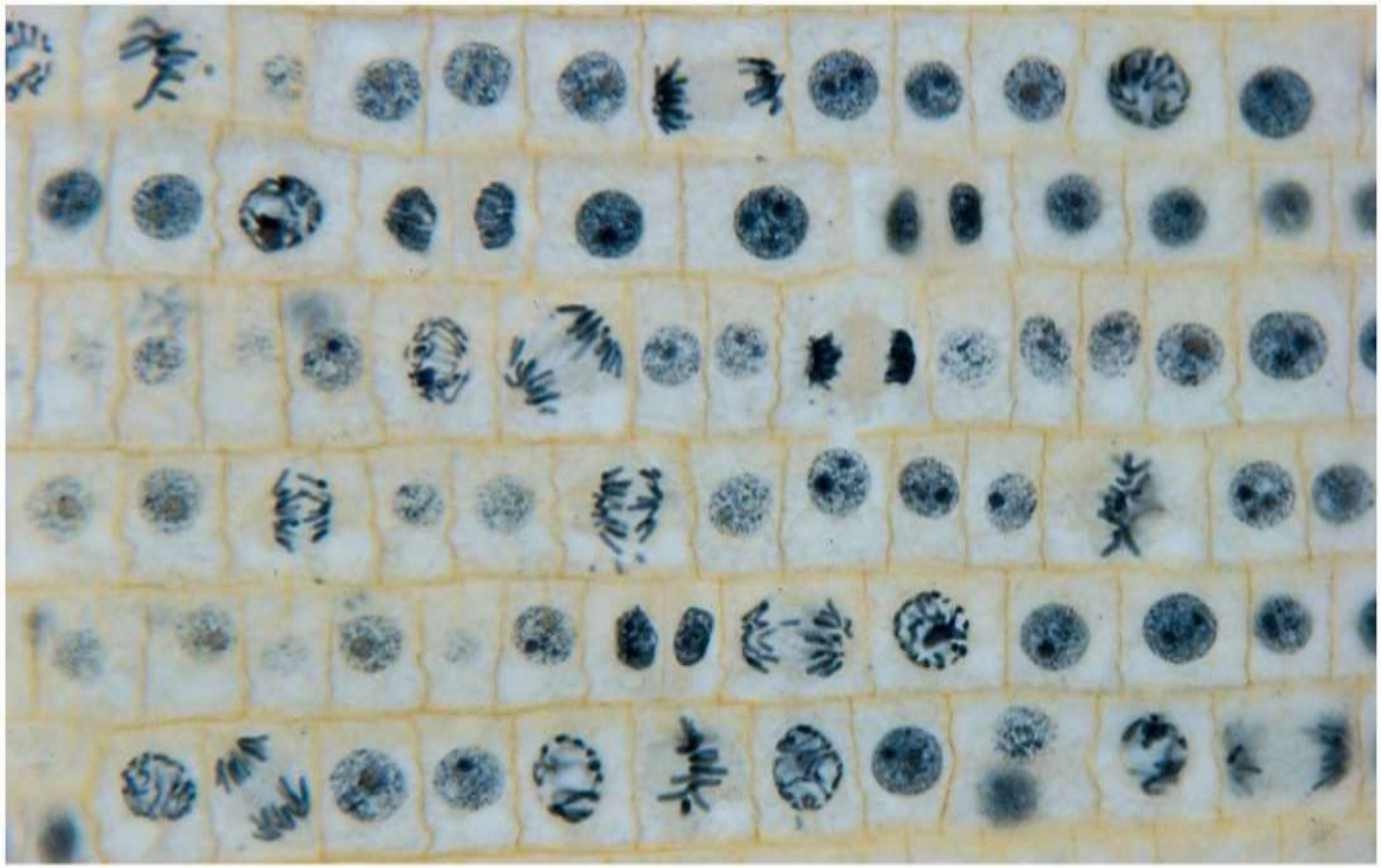
- Cancer cells **do not respond** normally to the body's control mechanisms
- Cancer cells may not need growth factors to grow and divide:
  - They may make their own growth factor
  - They may convey a growth factor's signal without the presence of the growth factor
  - They may have an abnormal cell cycle control system

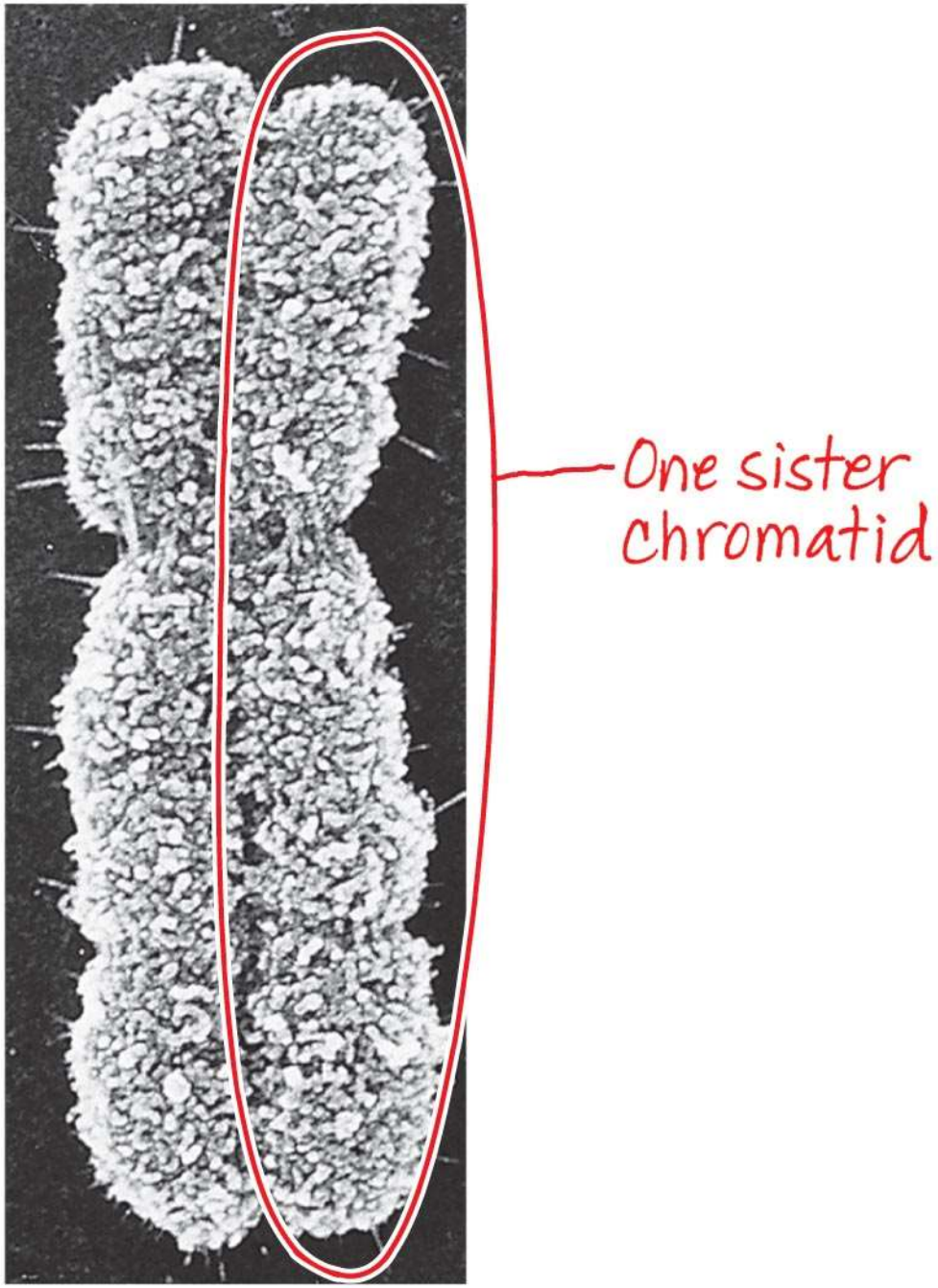
- A normal cell is converted to a cancerous cell by a process called **transformation**
- Cancer cells form **tumors**, masses of abnormal cells within otherwise normal tissue
- If abnormal cells remain at the original site, the lump is called a **benign tumor**
- **Malignant tumors** invade surrounding tissues and can **metastasize**, exporting cancer cells to other parts of the body, where they may form secondary tumors

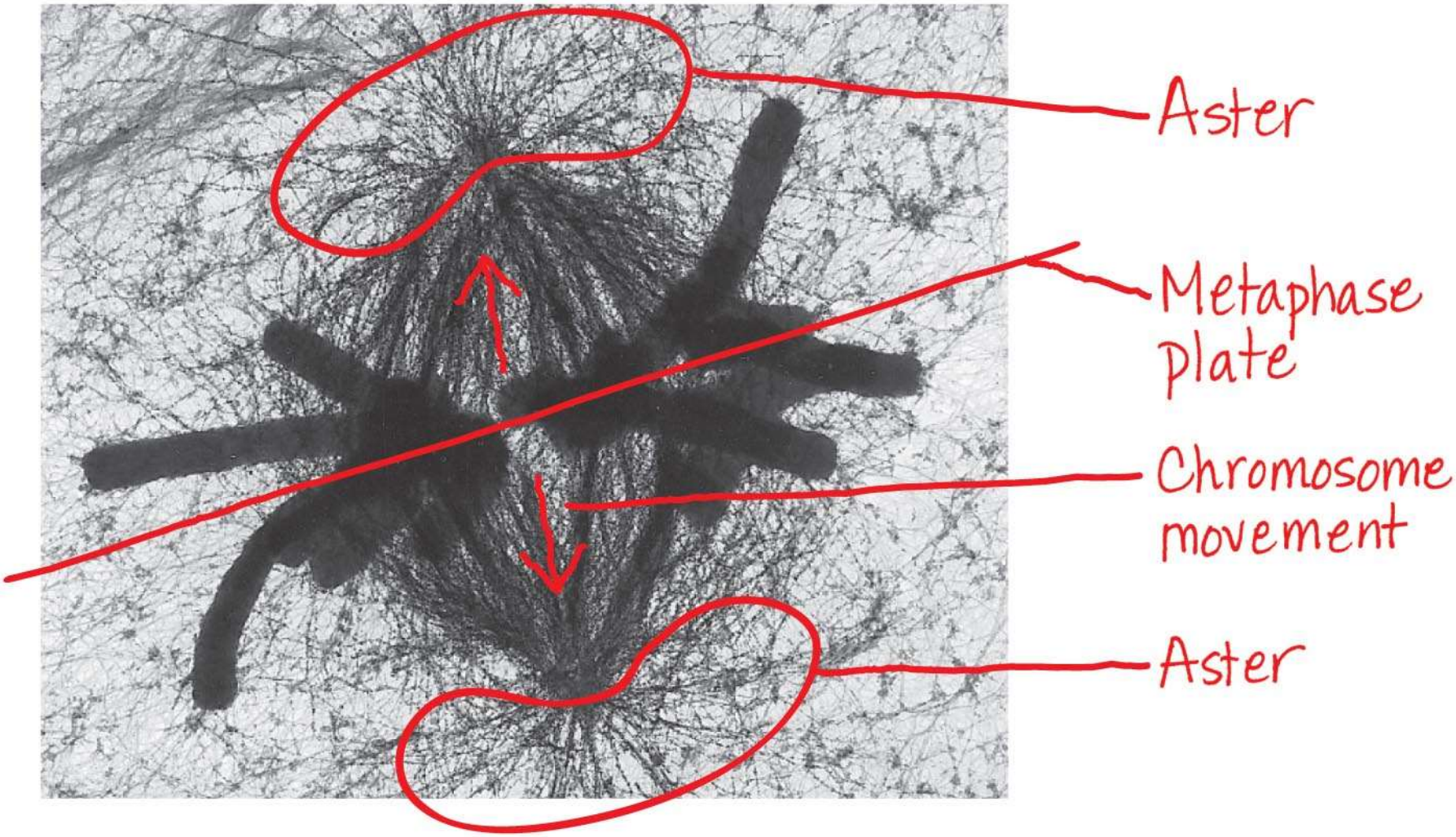
The growth and metastasis of a malignant breast tumor

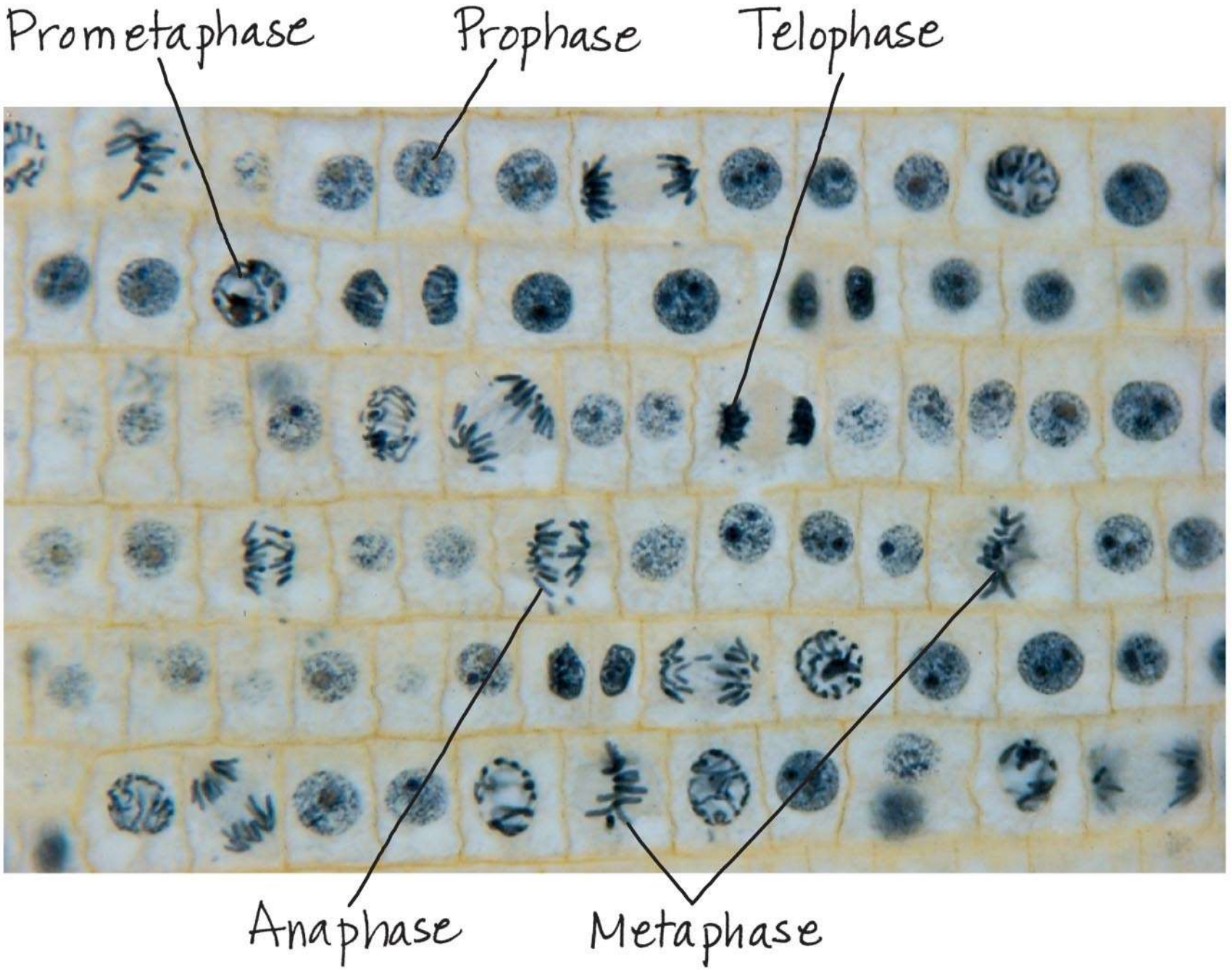


1. A tumor grows from a single cancer cell.
2. Cancer cells invade neighboring tissue.
3. Cancer cells spread to other parts of the body.
4. Cancer cells may survive and establish a new tumor in another part of the body.









Questions ?

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