

Chapter 9: How Cells Reproduce

Division Mechanisms

- **Eukaryotic organisms**
 - Mitosis
 - Meiosis
- **Prokaryotic organisms**
 - Prokaryotic fission or Binary fission

Roles of Mitosis

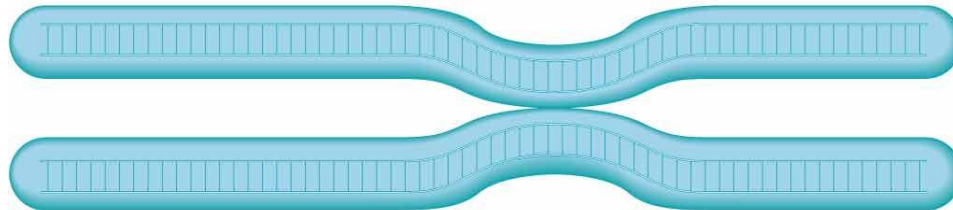
- **Multicelled organisms**
 - Growth
 - Cell replacement
- **Some protistans, fungi, plants, animals**
 - Asexual reproduction

Chromosome

- A DNA molecule & attached proteins
- Duplicated in preparation for mitosis



one chromosome (unduplicated)



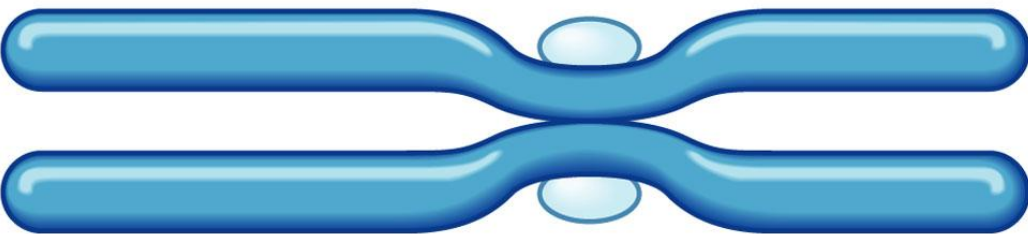
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one chromosome (duplicated)

Chromosome



a One chromosome (unduplicated)



one chromatid

one chromatid

two sister chromatids

b One chromosome (duplicated)

Stepped Art

Fig. 9-3a, p.142

Chromosome

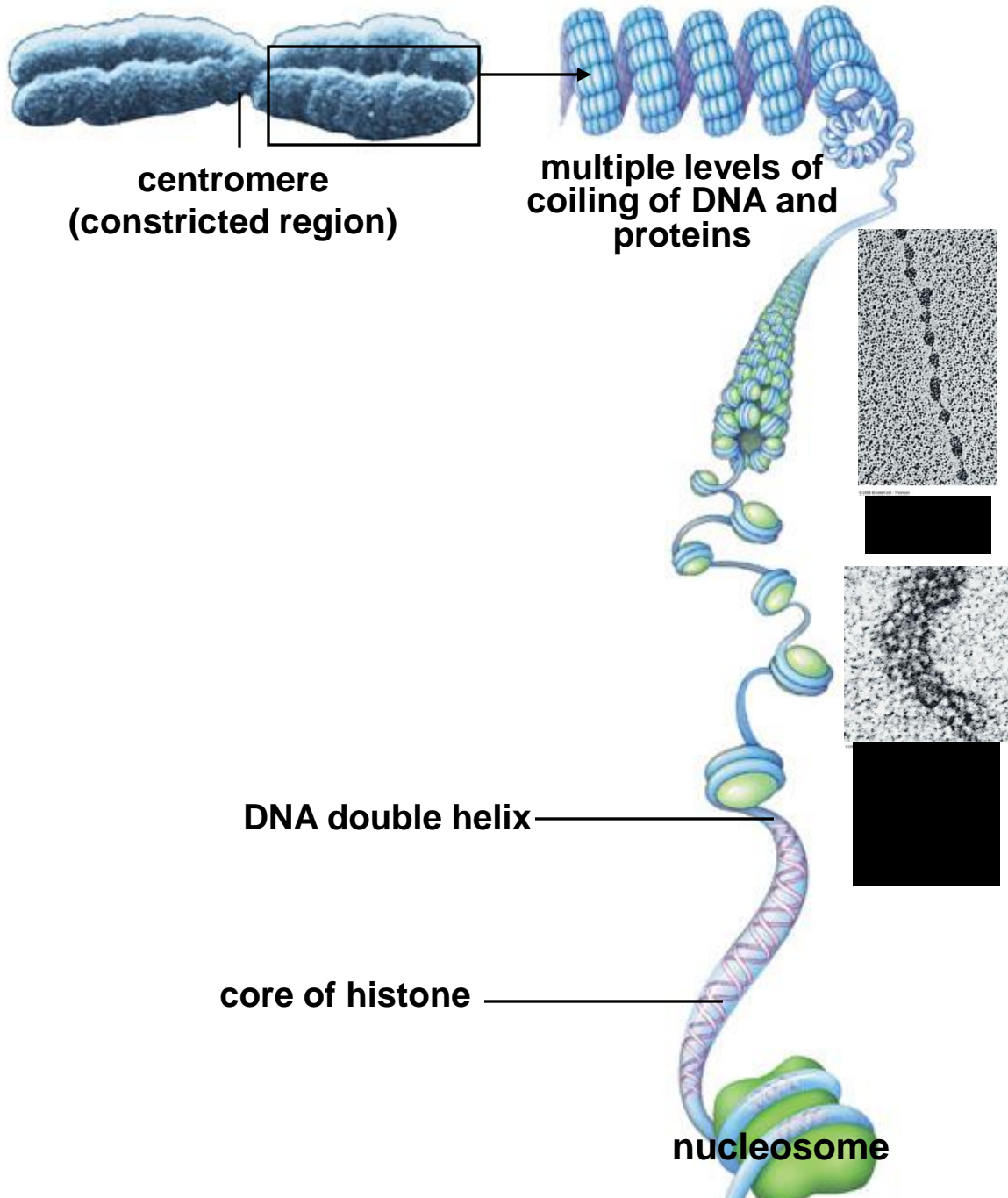


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Table 9.1 Comparison of Cell Division Mechanisms

| Mechanisms | Functions |
|--|--|
| Mitosis, cytoplasmic division | <p>In <i>all</i> multicelled eukaryotes, the basis of the following three processes:</p> <ol style="list-style-type: none">1. Increases in body size during growth2. Replacement of dead or worn-out cells3. Repair of damaged tissues <p>In single-celled and many multicelled species, <i>also</i> the basis of asexual reproduction</p> |
| Meiosis, cytoplasmic division | <p>In single-celled and multicelled eukaryotes, the basis of sexual reproduction; precedes gamete formation or spore formation (Chapter 10)</p> |
| Prokaryotic fission | <p>In bacteria and archaeans, the basis of asexual reproduction (Section 21.2)</p> |

Chromosome

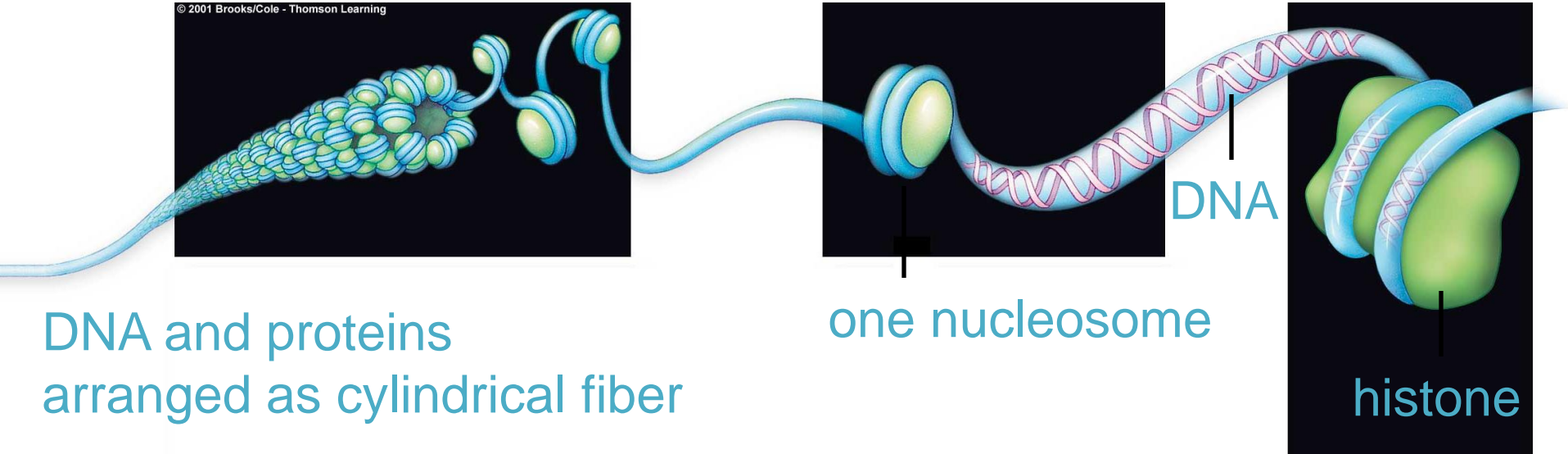


Chromosome Number

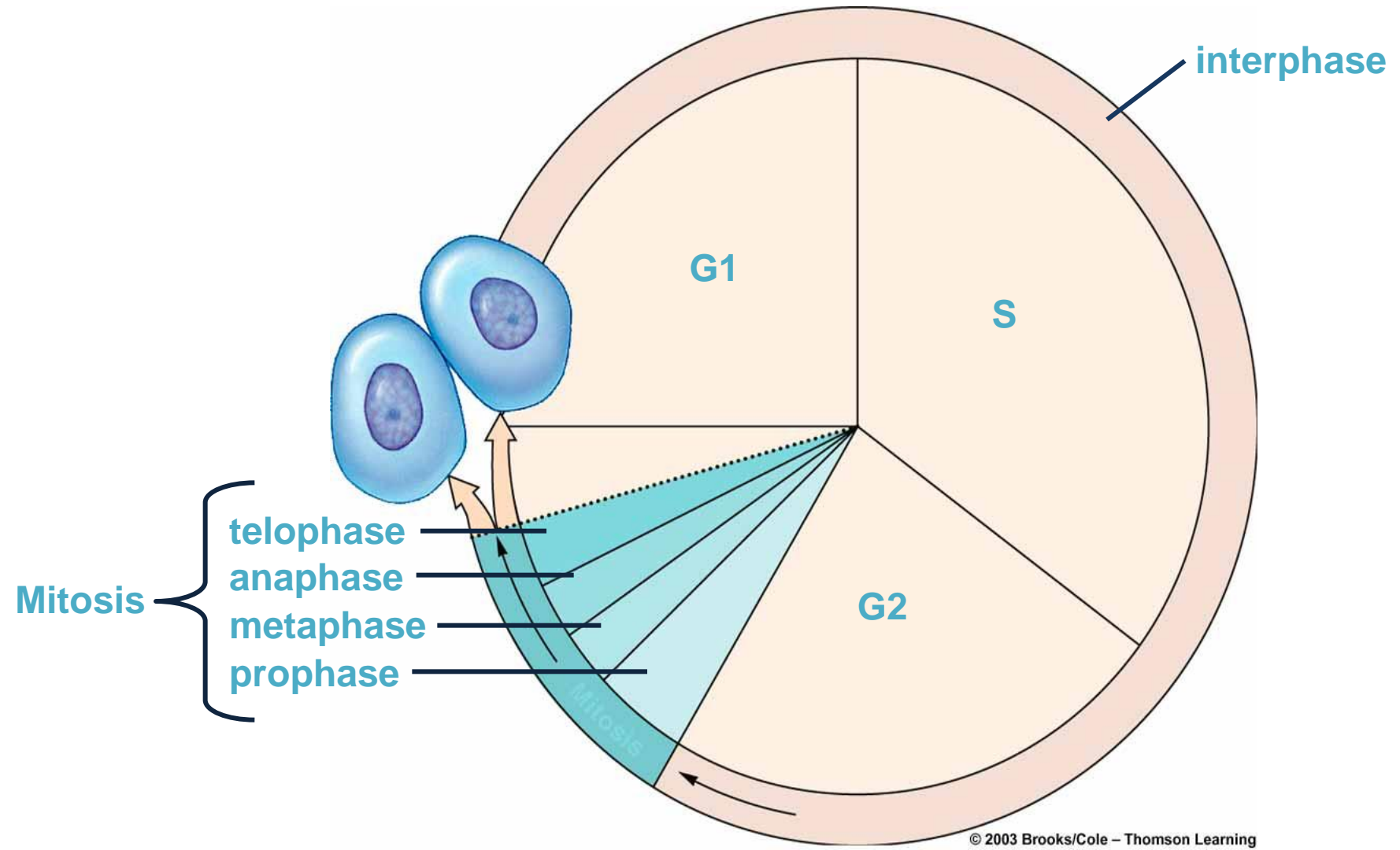
- Sum total of chromosomes in a cell
- Somatic cells
 - Chromosome number is diploid ($2n$)
 - Two of each type of chromosome
- Gametes
 - Chromosome number is haploid (n)
 - One of each chromosome type

Organization of Chromosomes

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The Cell Cycle

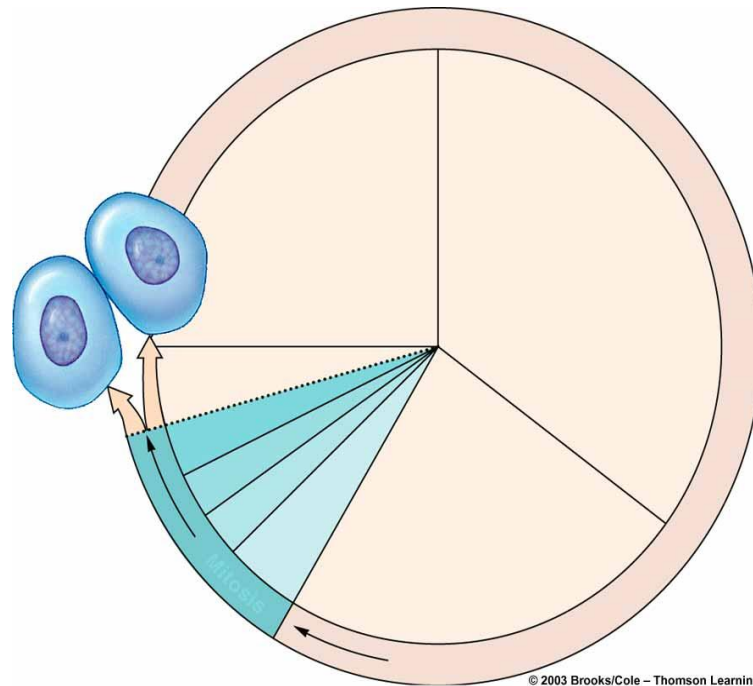


Interphase

- Usually longest part of the cycle
- Cell increases in mass
- DNA is duplicated

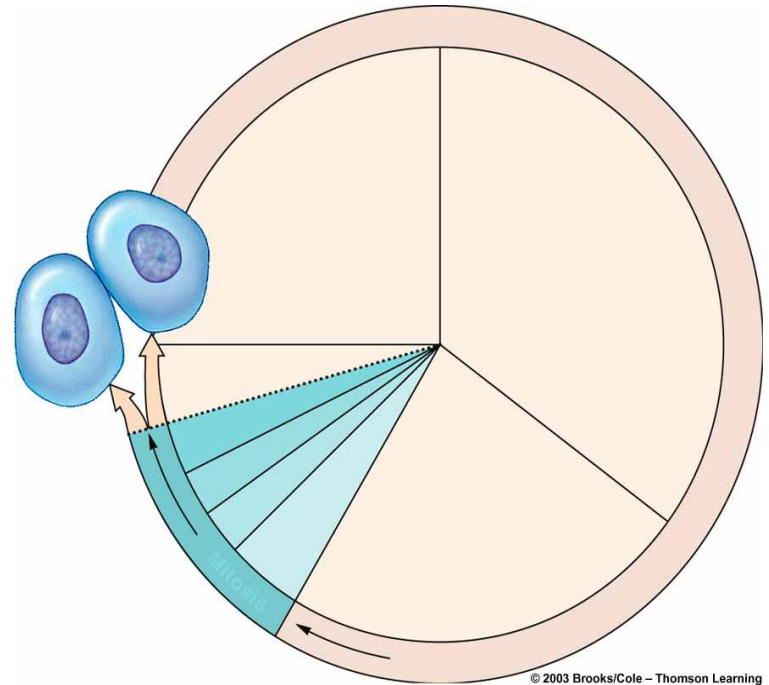
Mitosis

- Period of nuclear division
- Usually followed by cytoplasmic division
- Four stages:
 - Prophase
 - Metaphase
 - Anaphase
 - Telophase



Control of the Cycle

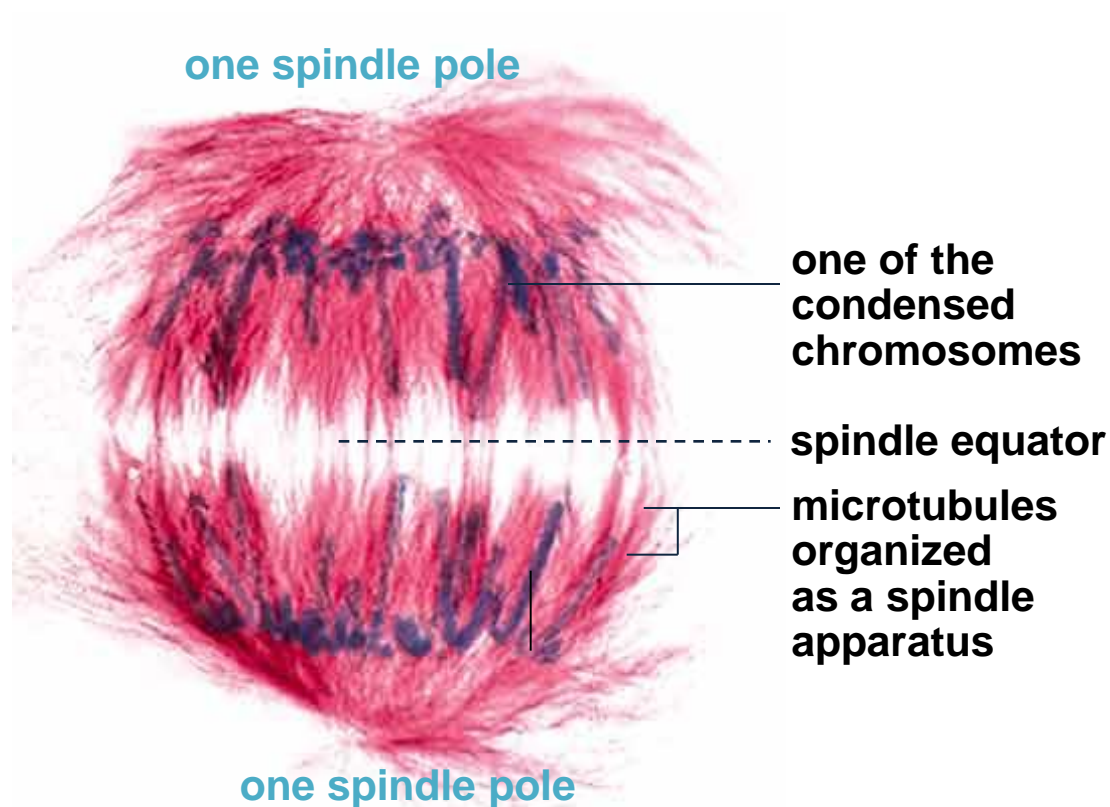
- Once S begins, the cycle automatically runs through G2 and mitosis
- The cycle has a built-in molecular brake in G1
- Cancer involves a loss of control over the cycle, malfunction of the “brakes”



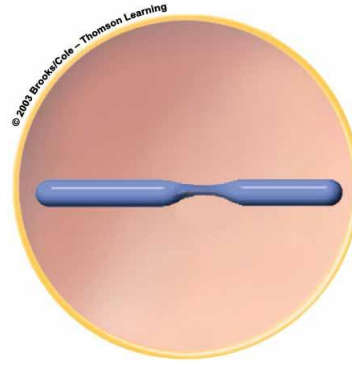
The Spindle Apparatus

- Consists of two distinct sets of microtubules
 - Each set extends from one of the cell poles
 - Two sets overlap at spindle equator
- Moves chromosomes during mitosis

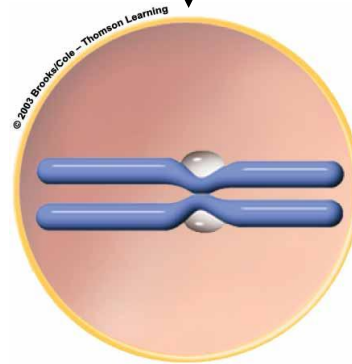
Spindle Apparatus



Maintaining Chromosome Number



**chromosome (unduplicated)
in cell at interphase**

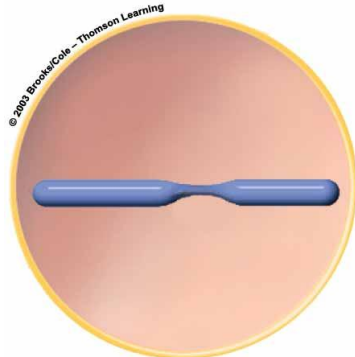


**same chromosome
(duplicated) in interphase
prior to mitosis**

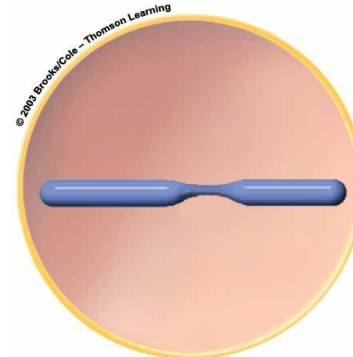
mitosis, cytoplasmic division



**chromosome
(unduplicated)
in daughter cell
at interphase**



**chromosome
(unduplicated)
in daughter cell
at interphase**

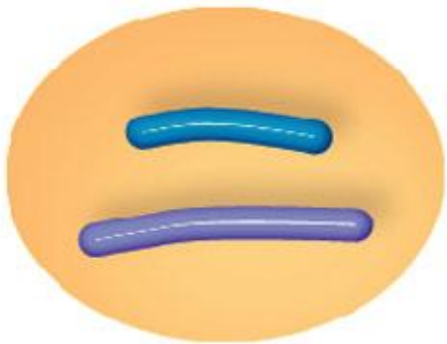


Maintaining Chromosome Number

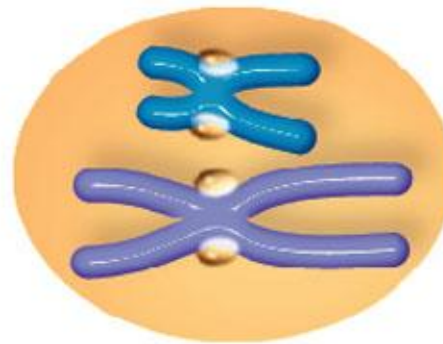


Fig. 9-6a, p.145

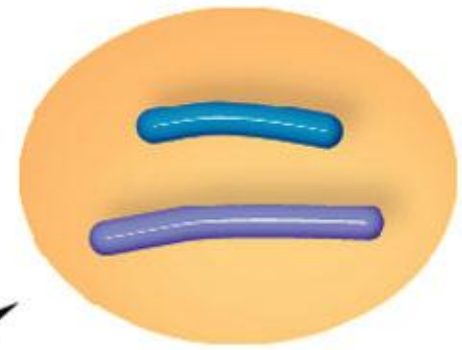
Maintaining Chromosome Number



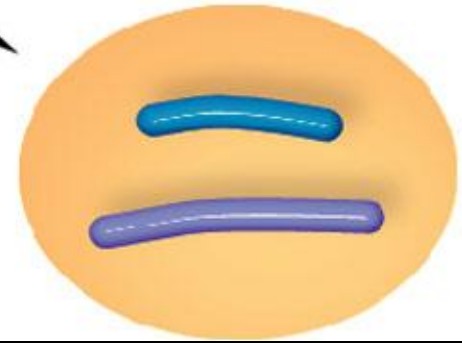
a Two of the chromosomes (unduplicated) in a parent cell at interphase



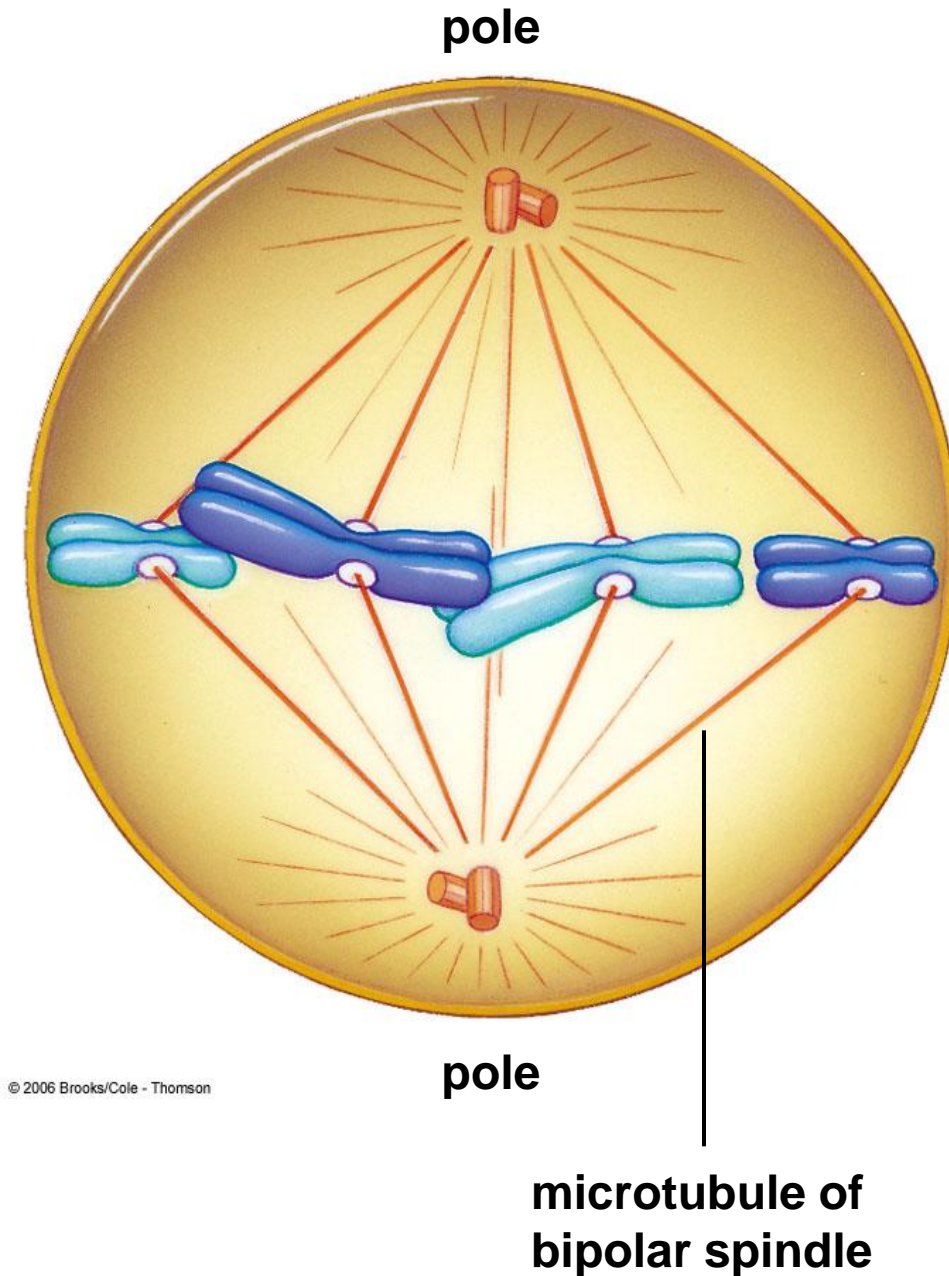
b The same two chromosomes, now duplicated, in that cell at interphase, prior to mitosis



c Two chromosomes (unduplicated) in the parent cell's daughter cells, which both start life in interphase



Maintaining Chromosome Number



Stages of Mitosis

Prophase

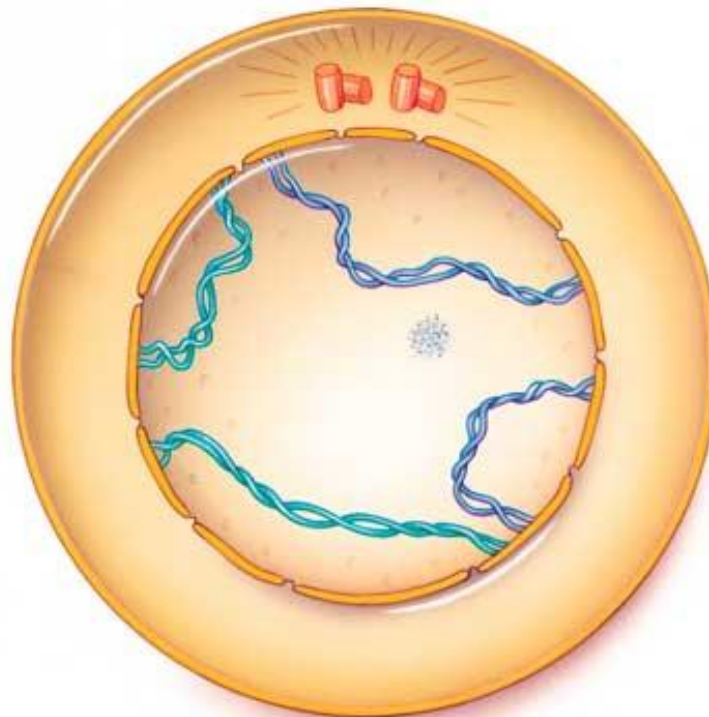
Metaphase

Anaphase

Telophase

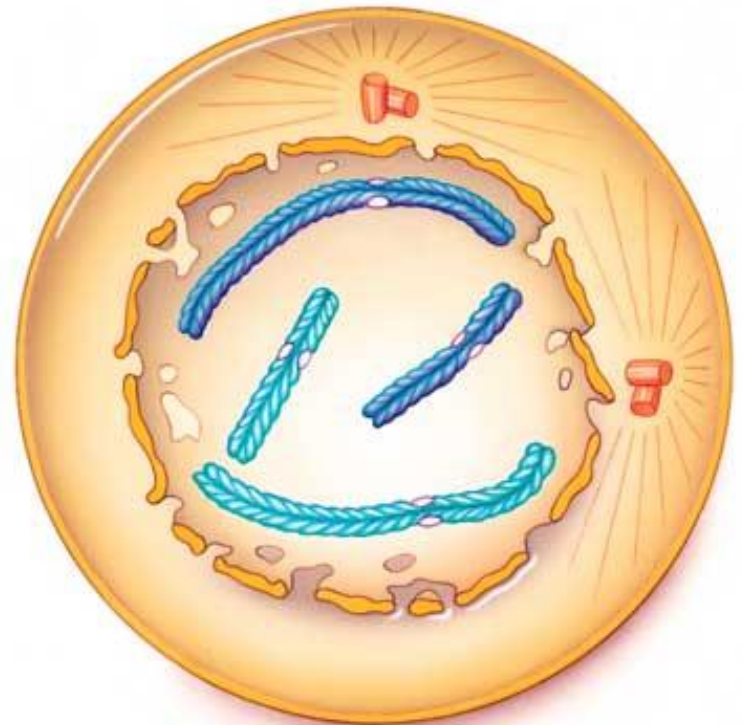
Early Prophase - Mitosis Begins

Duplicated chromosomes begin to condense



Late Prophase

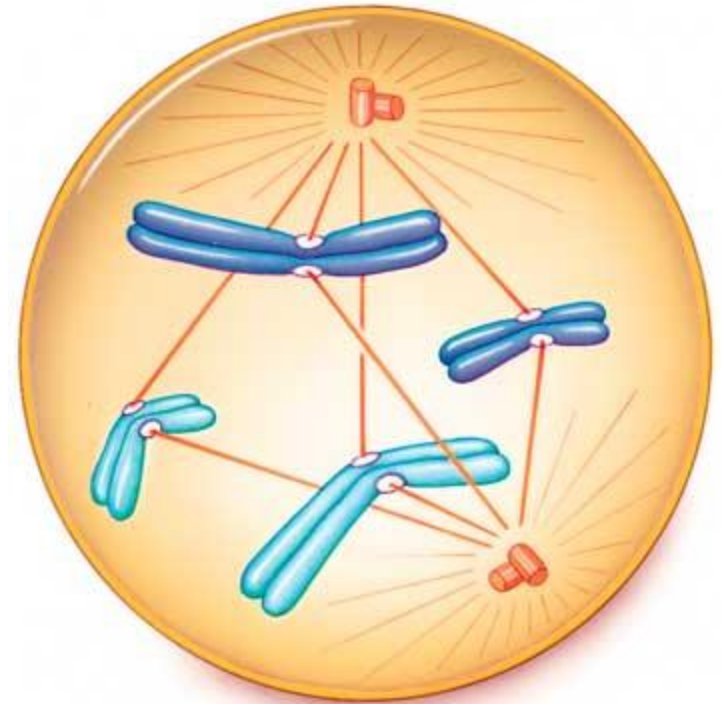
- New microtubules are assembled
- One centriole pair is moved toward opposite pole of spindle
- Nuclear envelope starts to break up



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Transition to Metaphase

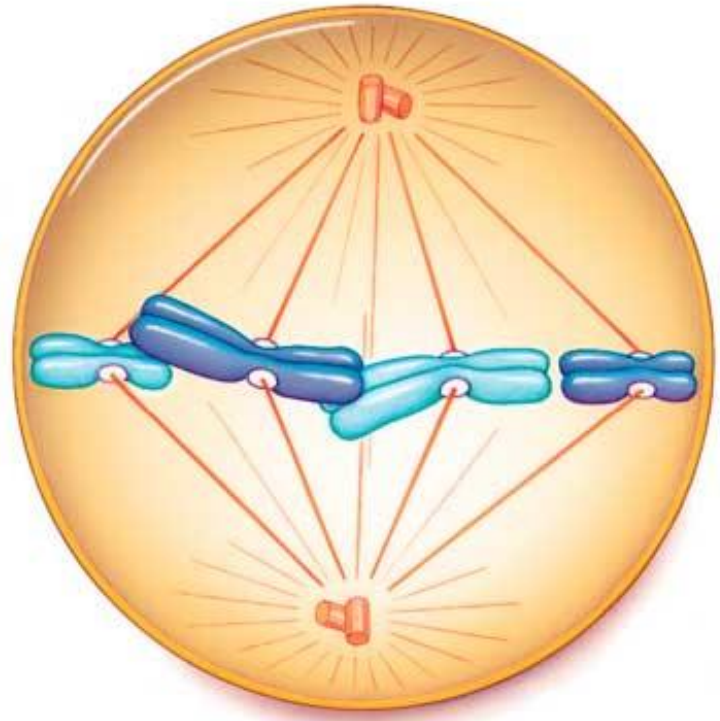
- Spindle forms
- Spindle microtubules become attached to the two sister chromatids of each chromosome



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Metaphase

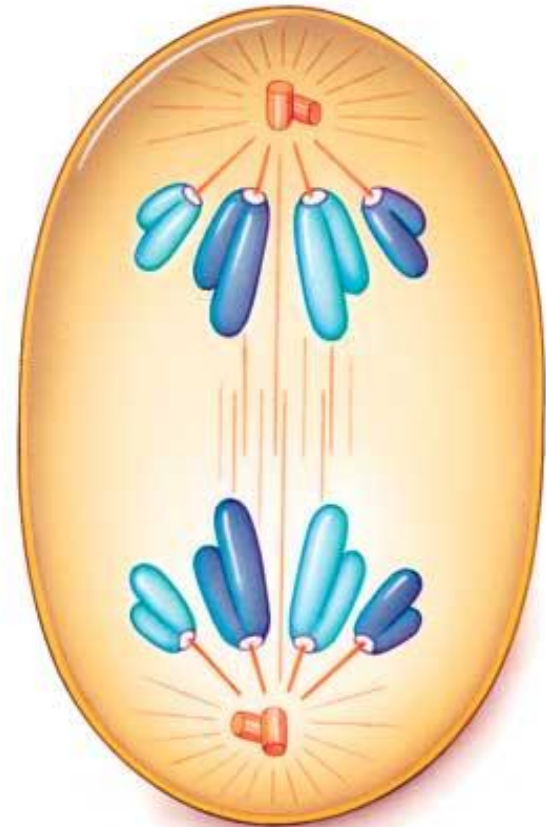
- All chromosomes are lined up at the spindle equator
- Chromosomes are maximally condensed



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Anaphase

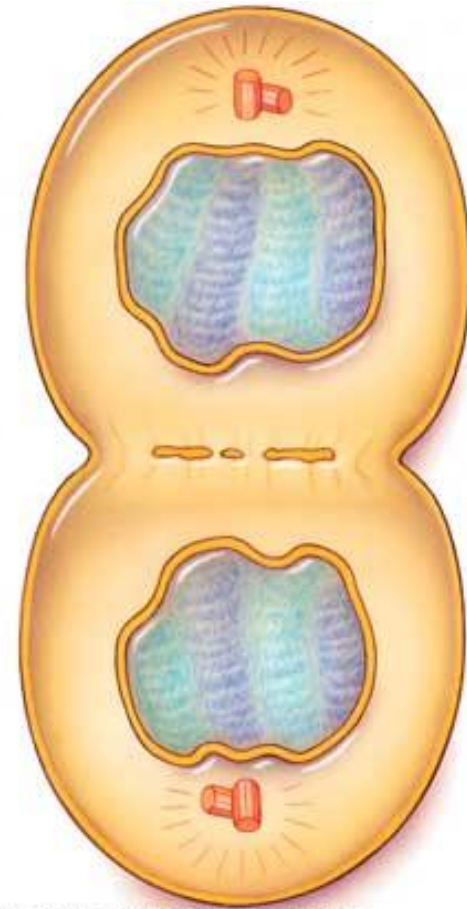
- Sister chromatids of each chromosome are pulled apart
- Once separated, each chromatid is a chromosome



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Telophase

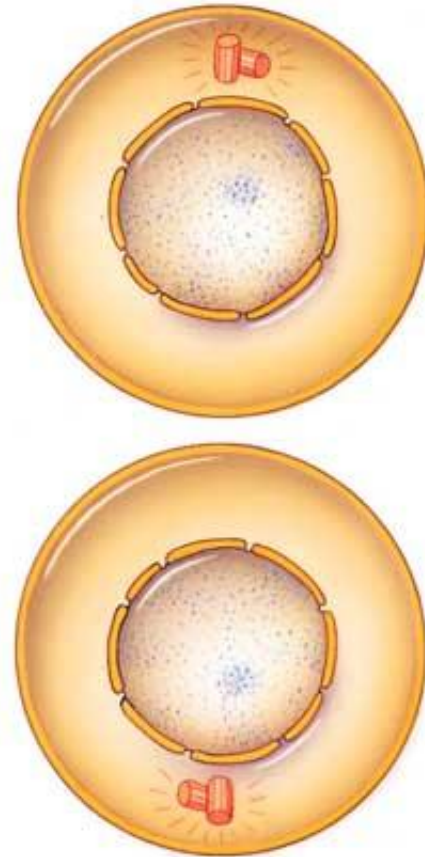
- Chromosomes decondense
- Two nuclear membranes form, one around each set of unduplicated chromosomes



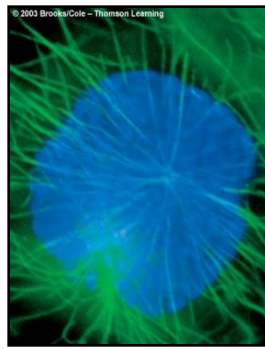
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Results of Mitosis

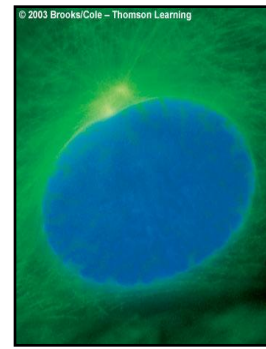
- Two daughter nuclei
- Each with same chromosome number as parent cell
- Chromosomes in unduplicated form



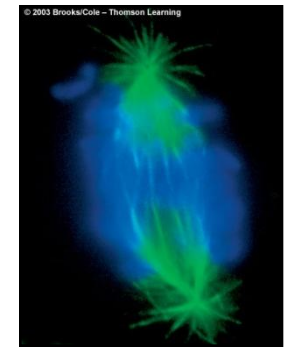
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Interphase



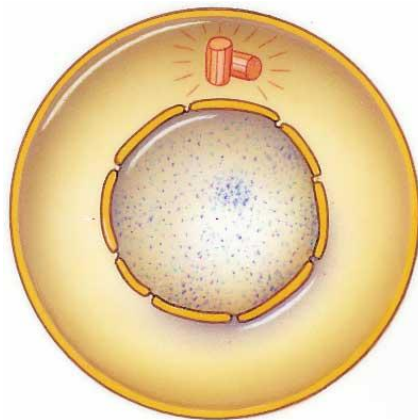
Early Prophase



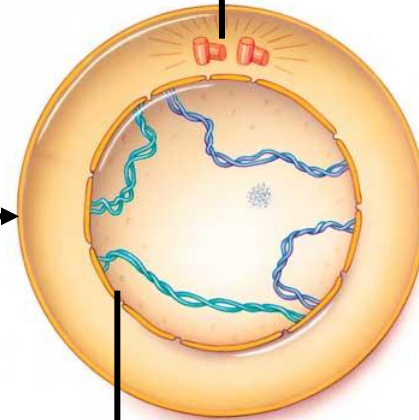
Late Prophase

Prometaphase

pair of centrioles

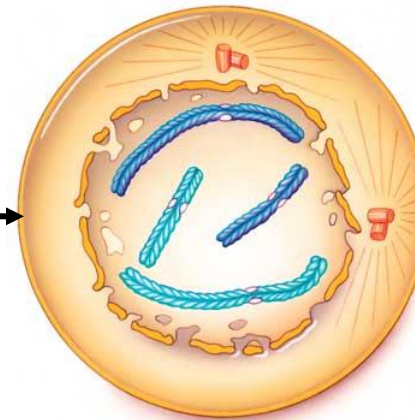


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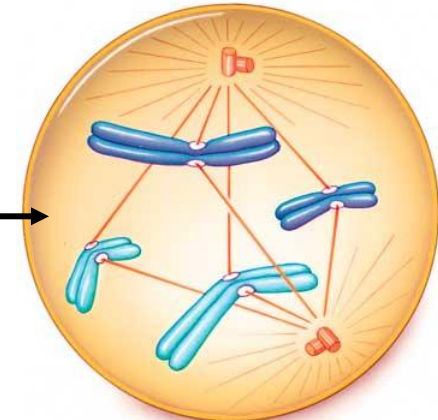


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**nuclear
envelope**

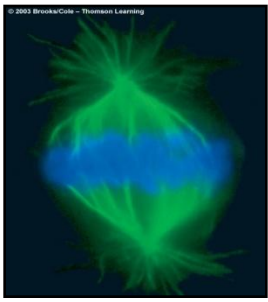


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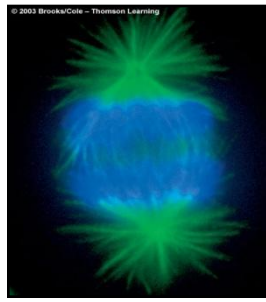


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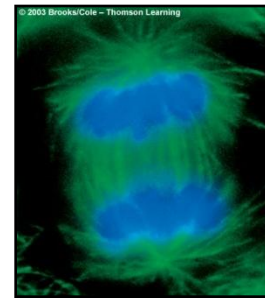
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Metaphase

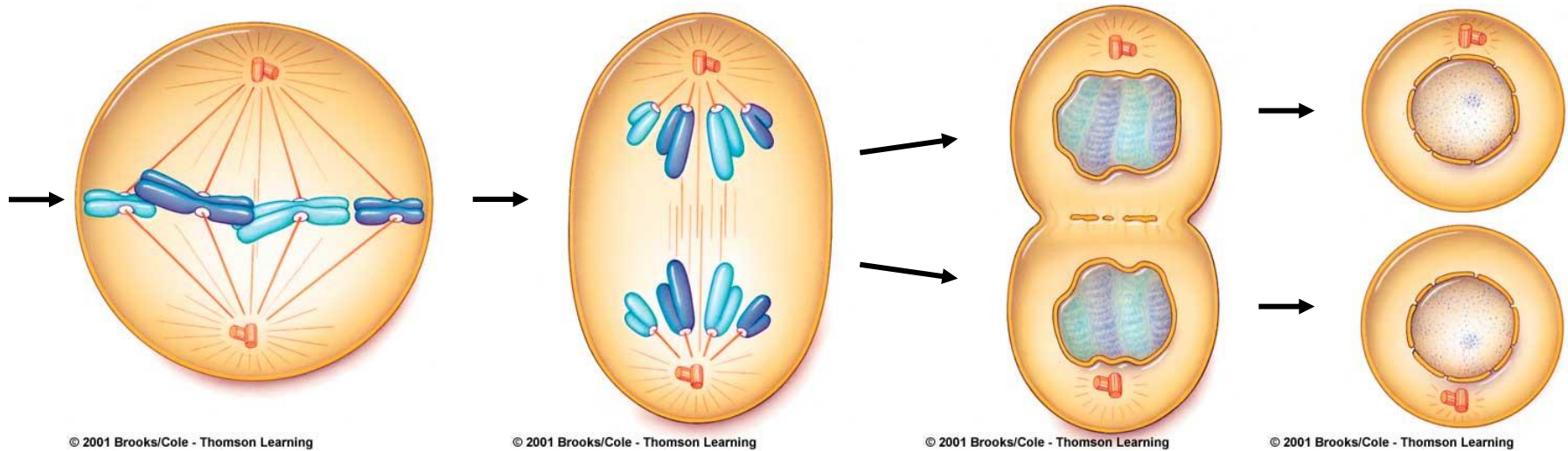


Anaphase



Telophase

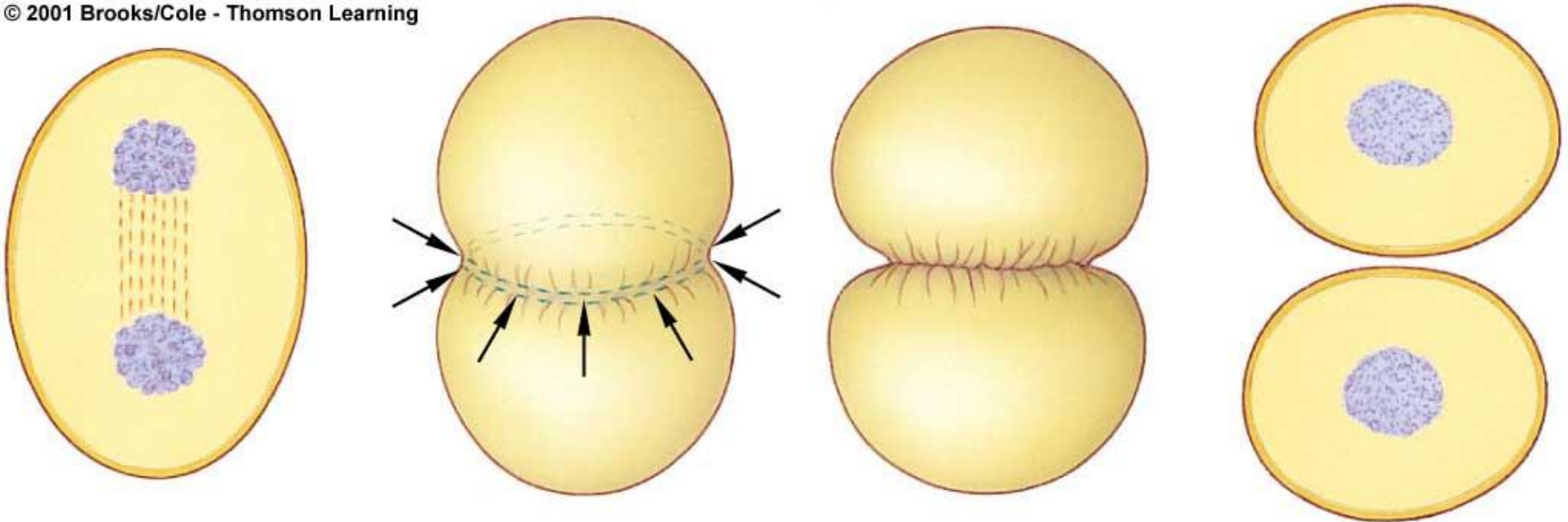
Interphase



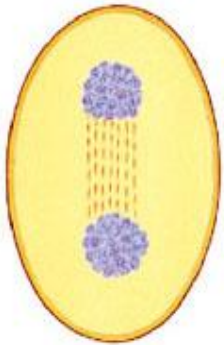
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Animal Cell Division

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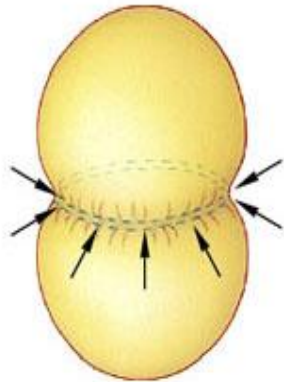


Animal Cell Division

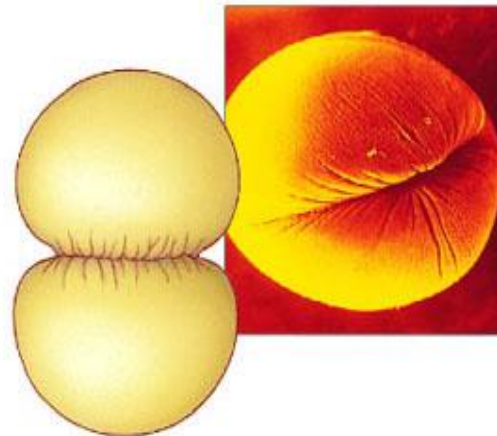


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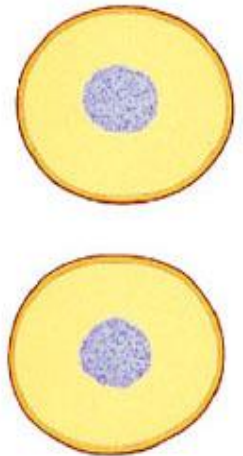
1 Mitosis is over, and the spindle is now disassembling.



2 At the former spindle equator, a ring of micro-filaments attached to the plasma membrane contracts.

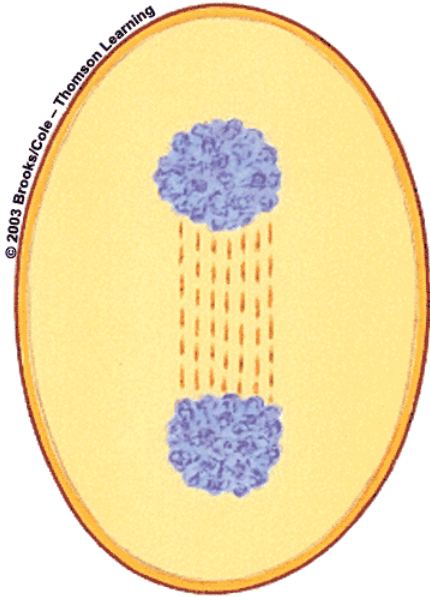


3 As its diameter shrinks, it pulls the cell surface inward.

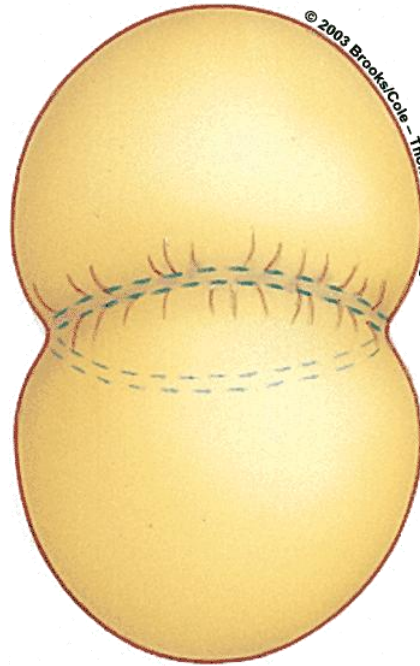


4 Contractions continue; the cell is pinched in two.

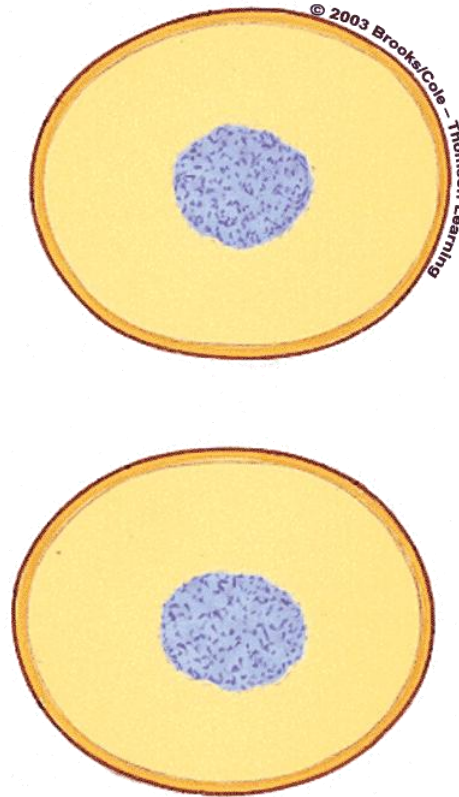
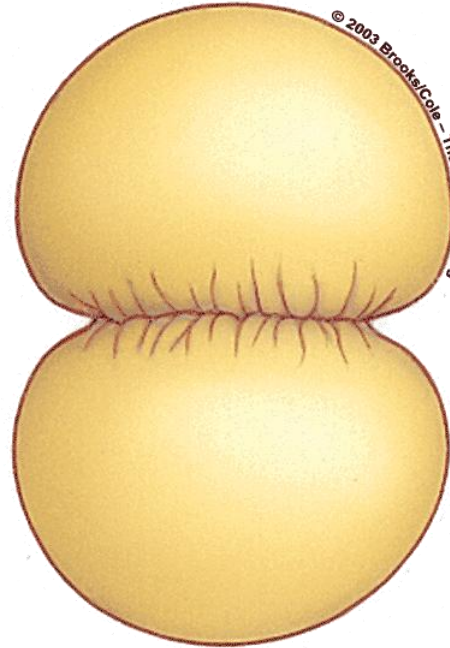
Animal Cell Division



Mitosis is over, and the spindle is now disassembling.



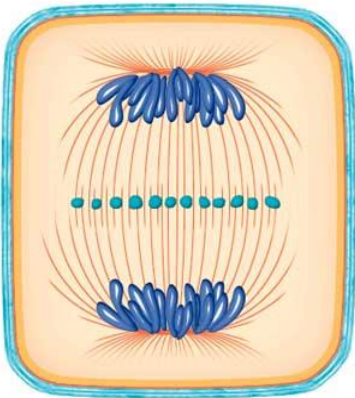
Band of microfilaments at the former spindle equator contracts.



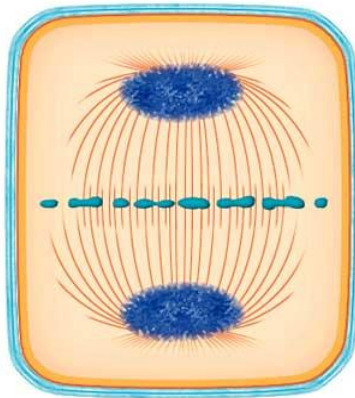
The contractions continue and cut the cell in two.

Stepped Art

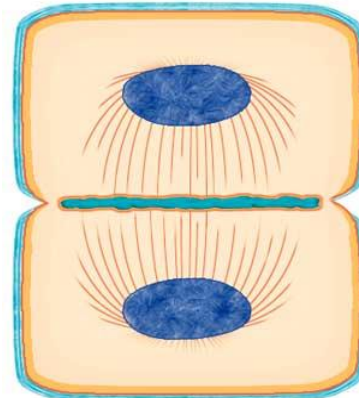
Cell Plate Formation



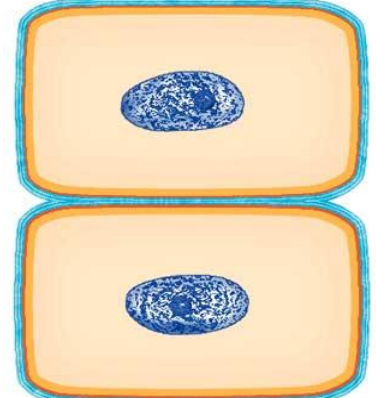
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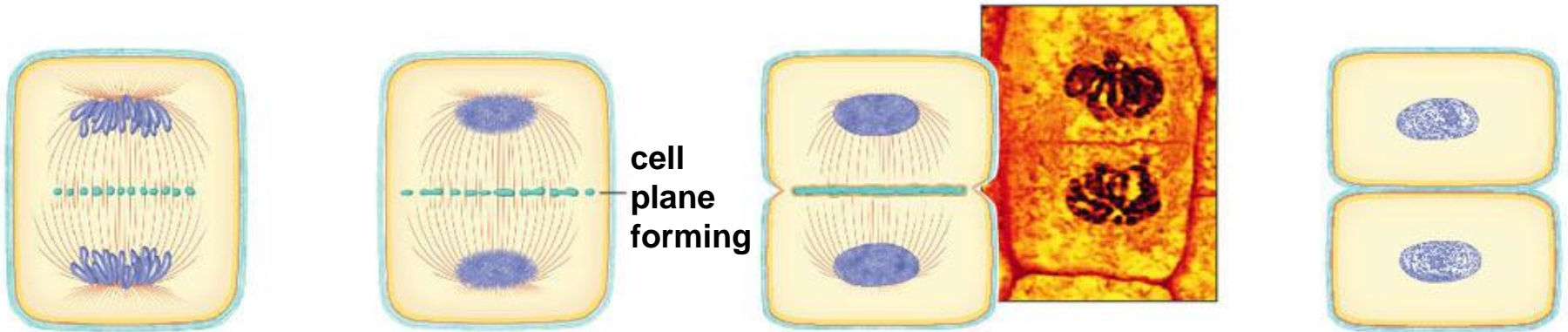


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Cell Plate Formation



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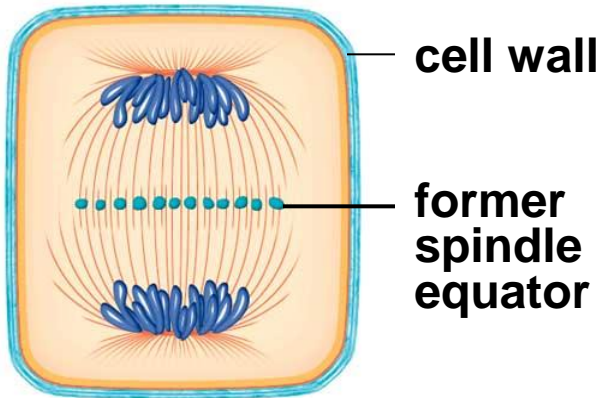
1 As mitosis ends, vesicles cluster at the spindle equator. They contain materials for a new primary cell wall.

2 Vesicle membranes fuse. The wall material is sandwiched between two new membranes that lengthen along the plane of a newly forming cell plate.

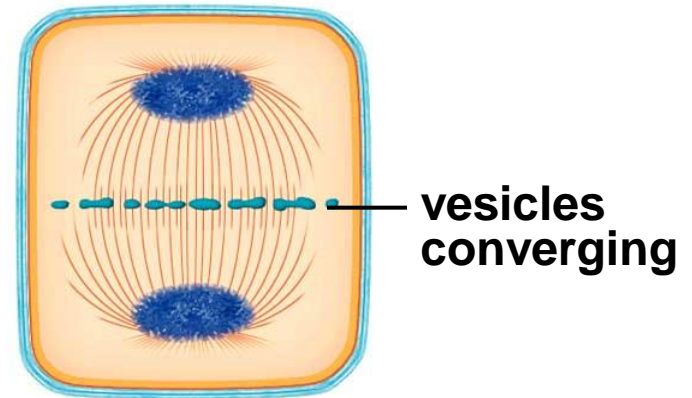
3 Cellulose is deposited inside the sandwich. In time, these deposits will form two cell walls. Others will form the middle lamella between the walls and cement them together.

4 A cell plate grows at its margins until it fuses with the parent cell plasma membrane. The primary wall of growing plant cells is still thin. New material is deposited on it.

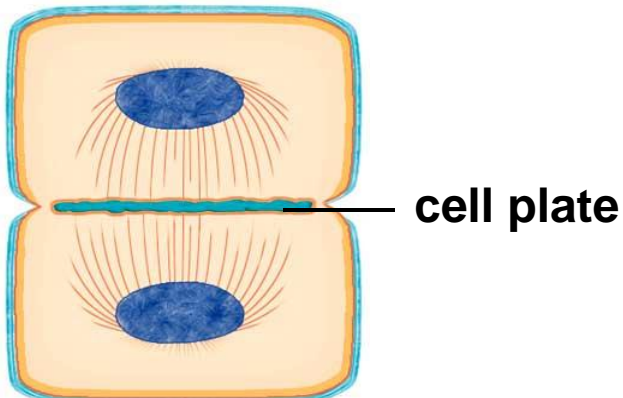
Cell Plate Formation



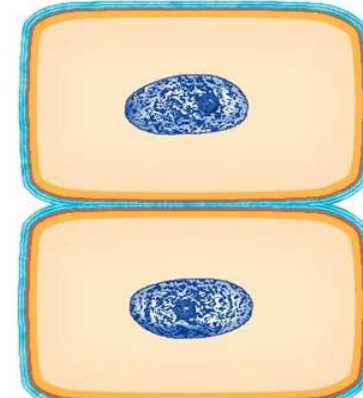
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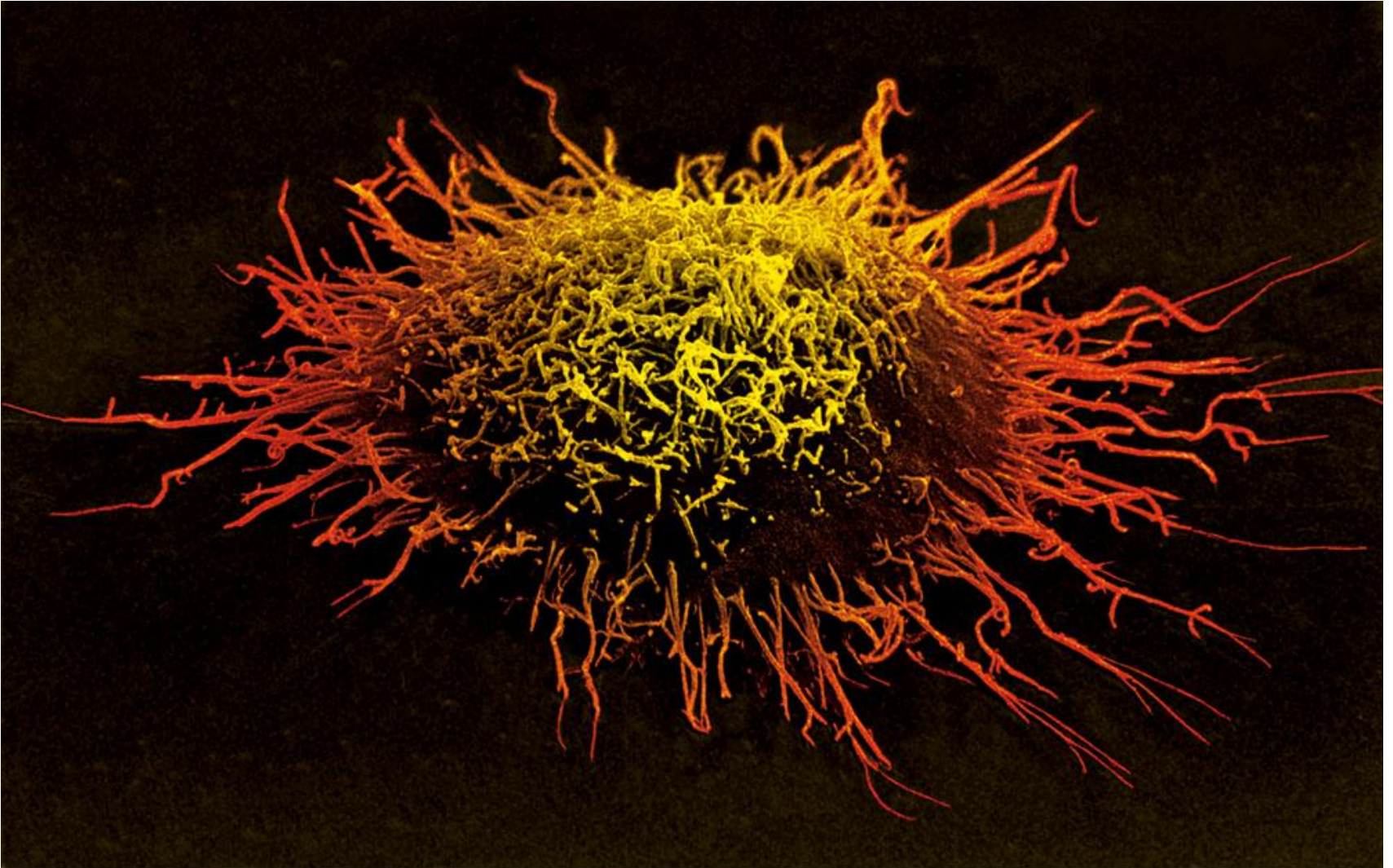
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Tumors

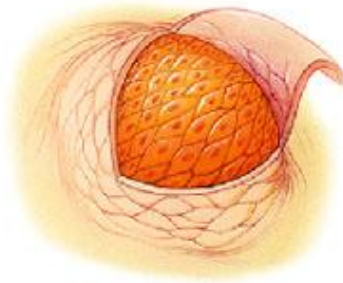
- Sometimes a checkpoint gene mutates and control over cell division is lost.
- Cells uncontrollable division forms an abnormal mass called a tumor.
- Neoplasms

Cancer



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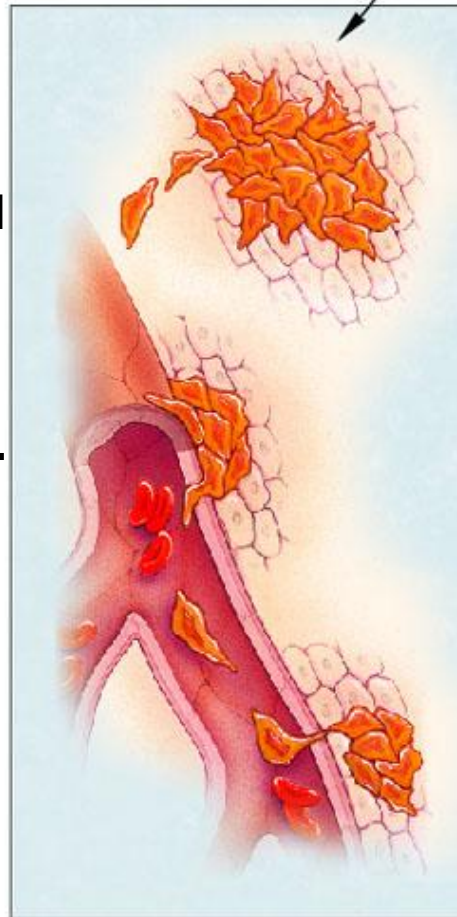
benign tumor



malignant tumor



2 The metastasizing cells become attached to the wall of a blood or lymph vessel. They secrete digestive enzymes onto it. Then they cross the wall at the breach.



1 Cancer cells slip out of their home tissue

3 Cancer cells creep or tumble along inside blood vessels, then leave the bloodstream the same way they got in. They start new tumors in new tissues.

Cancer



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Cancer



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Cancer



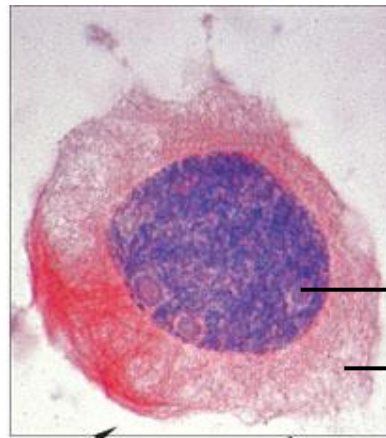
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Fig. 9-14c, p.151

HeLa Cells

- Line of human cancer cells that can be grown in culture
- Descendents of tumor cells from a woman named Henrietta Lacks
- Lacks died at 31, but her cells continue to live and divide in labs around the world

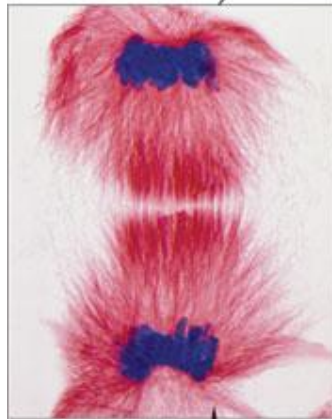
**cell at
interphase**



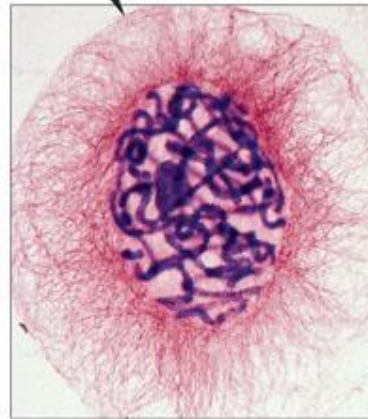
nucleus

cytoplasm

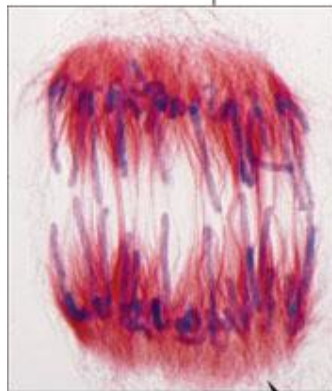
telophase



prophase



anaphase



metaphase

