

# How Cells Reproduce

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# Overview of Cell Division Mechanisms

- Individual cells or organisms produce offspring by the process of reproduction
  - When a cell reproduces, each descendent receives information coded in DNA, and enough cytoplasm to begin operating
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# Mitosis, Meiosis, and the Prokaryotes

- Eukaryotic cells
    - **Mitosis** copies DNA and divides a nucleus, producing two identical nuclei
      - Basis of growth, cell replacements, and tissue repair in multicelled species
      - Basis of asexual reproduction in many single-celled and multicelled species
    - **Meiosis** is a nuclear division that produces haploid gametes for sexual reproduction
      - Basis of sexual reproduction
  - Prokaryotic cells reproduce asexually by prokaryotic fission (don't worry about yet!)
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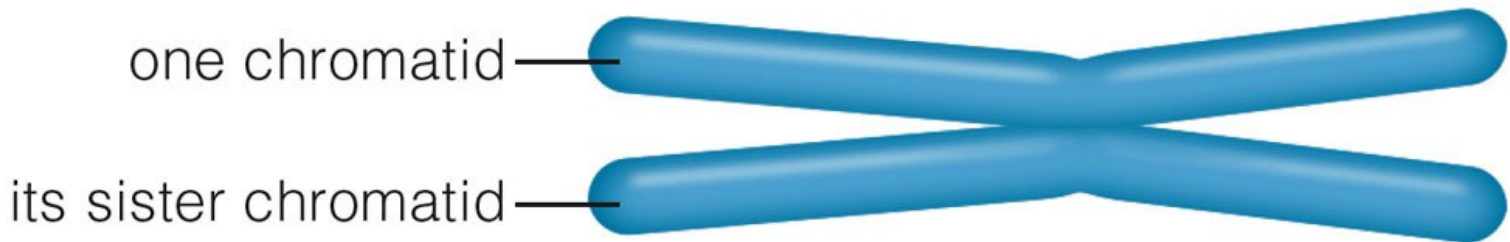
# Key Points About Chromosome Structure

- Each species has a characteristic number of chromosomes that differ in length and shape
    - Each consists of one double strand of DNA
    - After duplication, each consists of two double strands (**sister chromatids**) that remain attached to each other at a **centromere** until late in nuclear division
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# A Chromosome and Sister Chromatids



one chromosome  
(unduplicated)



one chromatid

its sister chromatid

one chromosome  
(duplicated)

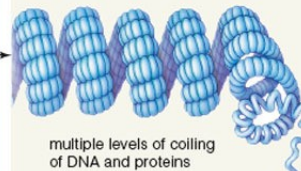
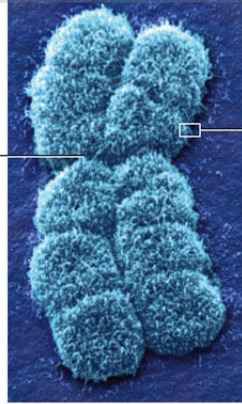
# Key Points About Chromosome Structure

- A chromosome consists of DNA that is wrapped around proteins (**histones**) and condensed
  - Each histone and the DNA wrapped around it make up a **nucleosome**, the smallest unit of structural organization in chromosomes
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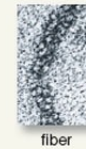
# Chromosome Structure

**A** Duplicated human chromosome in its most condensed form. If this chromosome were actually the size shown in the micrograph, its two DNA strands would stretch out about 800 meters (0.5 miles).

centromere



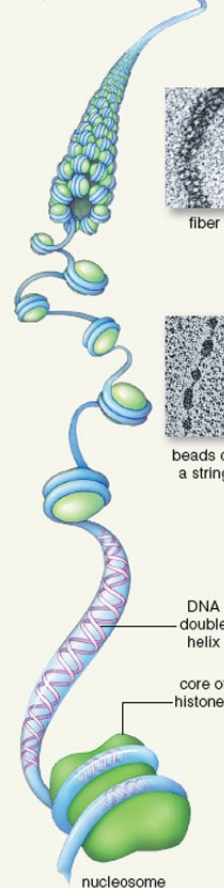
**B** When a chromosome is at its most condensed, the DNA is packed into tightly coiled coils.



**C** When the coiled coils unwind, a molecule of chromosomal DNA and its associated proteins are organized as a cylindrical fiber.



**D** A loosened fiber shows a "beads-on-a-string" organization. The "string" is the DNA molecule; each "bead" is one nucleosome.



DNA double helix

core of histones

nucleosome

**E** A nucleosome consists of part of a DNA molecule looped twice around a core of histone proteins.

<http://www.youtube.com/watch?v=gbSIBhFwQ4s>

# Introducing the Cell Cycle

- **Cell cycle**

- A sequence of three stages (interphase, mitosis, and cytoplasmic division) through which a cell passes between one cell division and the next
  - Starts when a new cell forms
  - Ends when cell reproduces by nuclear and cytoplasmic division
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# Interphase

- **Interphase** consists of three stages, during which a cell increases in size, doubles the number of cytoplasmic components, and duplicates its DNA
    - G1: Interval of cell growth and activity
    - S: Interval of DNA replication (synthesis)
    - G2: Interval when the cell prepares for division
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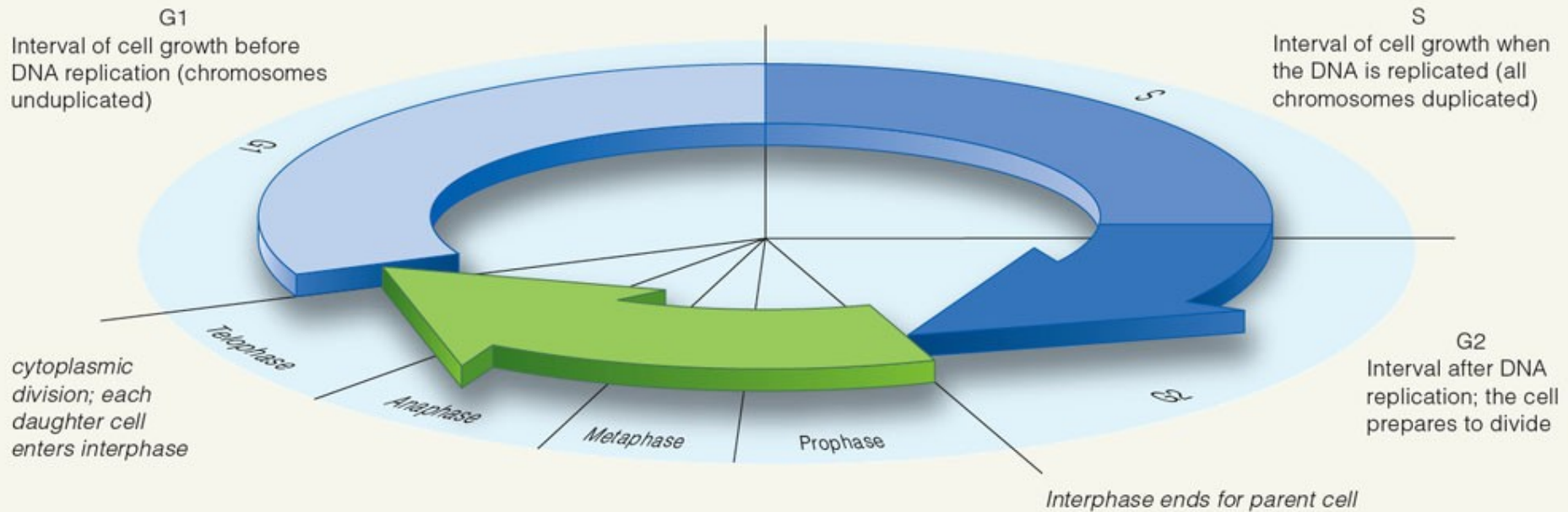
# Interphase and the Life of a Cell

- Most cell activities take place during G1
- Control mechanisms work at certain points in the cell cycle; some can keep cells in G1
- Loss of control may cause cell death or cancer (uncontrolled cell growth – tumors)
  - Benign: surrounded by healthy layer of cells and don't spread to other areas
  - Malignant: not encapsulated and are invasive. They spread to different areas of the body to form new tumors (metastasizes)

[http://www.youtube.com/watch?v=7RJKX-Hz6\\_Q&feature=related](http://www.youtube.com/watch?v=7RJKX-Hz6_Q&feature=related)

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# Eukaryotic Cell Cycle

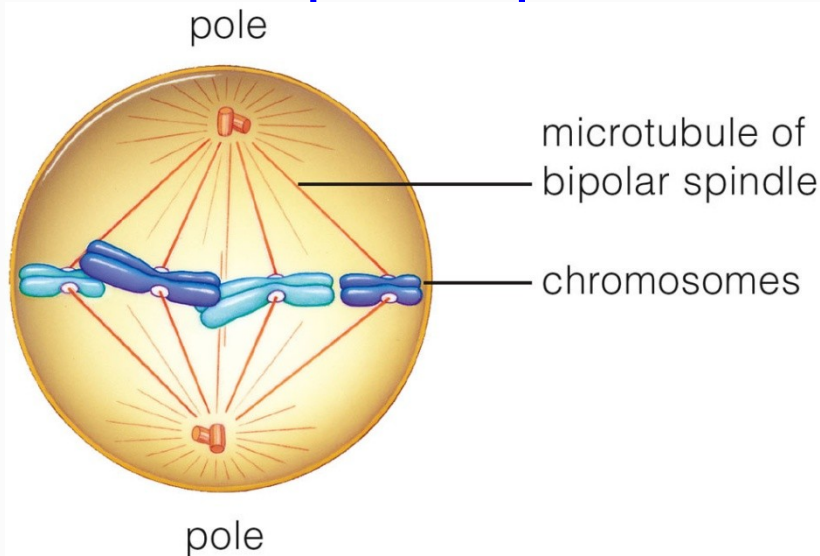


# Mitosis and the Chromosome Number

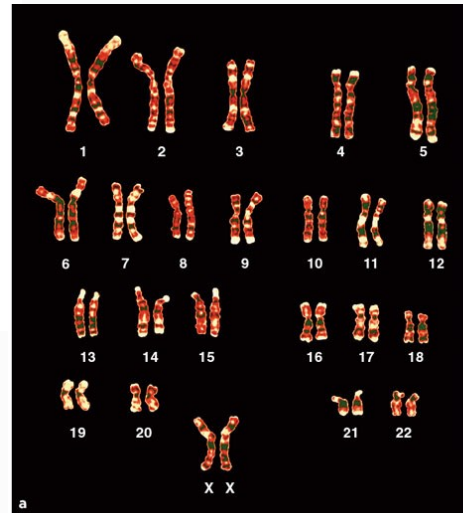
- Mitosis produces two diploid nuclei with the same number and kind of chromosomes as the parent
  - **Chromosome number**
    - The sum of all chromosomes in a type of cell
    - Human cells have 46 chromosomes paired in 23 sets (**diploid** number)
      - One set from father, one from mother
    - Pairs have the same shape and information about the same traits (except sex chromosomes XY)
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# Mitosis and Chromosome Number

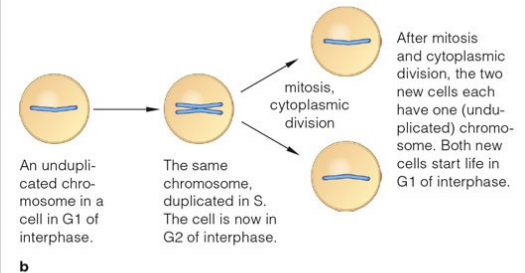
- **Mitosis** maintains parental chromosome number from one generation to the next
  - **Bipolar spindle** divides **sister chromatids**



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# Mitosis and the Chromosome Number

## ■ **Bipolar spindle**

- A dynamic network of microtubules that forms during nuclear division
  - Grows into the cytoplasm from opposite poles of the cell and attaches to duplicated chromosomes
  - Microtubules from opposite poles attach to different sister chromatids and separate them
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# **Key Concepts:**

## **Where Mitosis Fits in the Cell Cycle**

- *A cell cycle starts when a new cell forms by division of a parent cell, and ends when the cell completes its own division*
  - *A typical cell proceeds through intervals of interphase, mitosis, and cytoplasmic division*
  - *In interphase, a cell increases its mass and number of components, and copies its DNA*
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# A Closer Look at Mitosis

- When a nucleus divides by mitosis, each new nucleus has the same chromosome number as the parent cell
  - Mitosis proceeds in four stages:
    - Prophase
    - Metaphase
    - Anaphase
    - Telophase
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# Prophase

## ■ Prophase

- Chromosomes condense
- Microtubules form a bipolar spindle
- Nuclear envelope breaks up
- Microtubules attach to the chromosomes

## ■ Centrosome

- A region near the nucleus that organizes spindle microtubules; usually includes two centrioles
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# Transition to Metaphase

- Microtubules from one spindle pole harness one chromatid of each chromosome
    - Microtubules from the opposite spindle pole harness its sister chromatid
  - Other microtubules extend from both poles and grow until they overlap at the spindle's midpoint
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# Metaphase and Anaphase

- **Metaphase**

- All duplicated chromosomes line up midway between the spindle poles

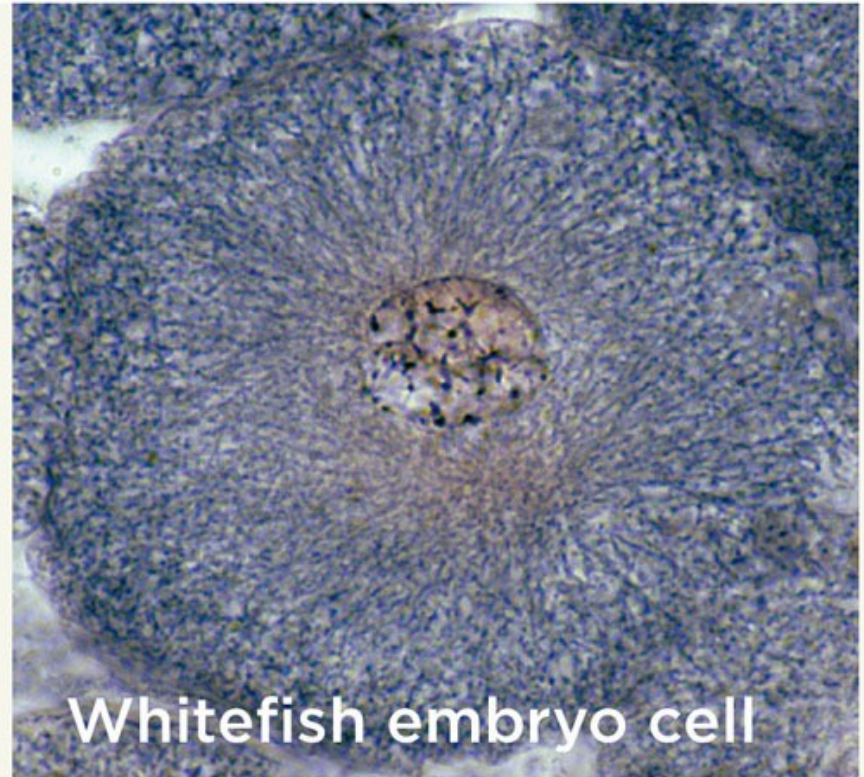
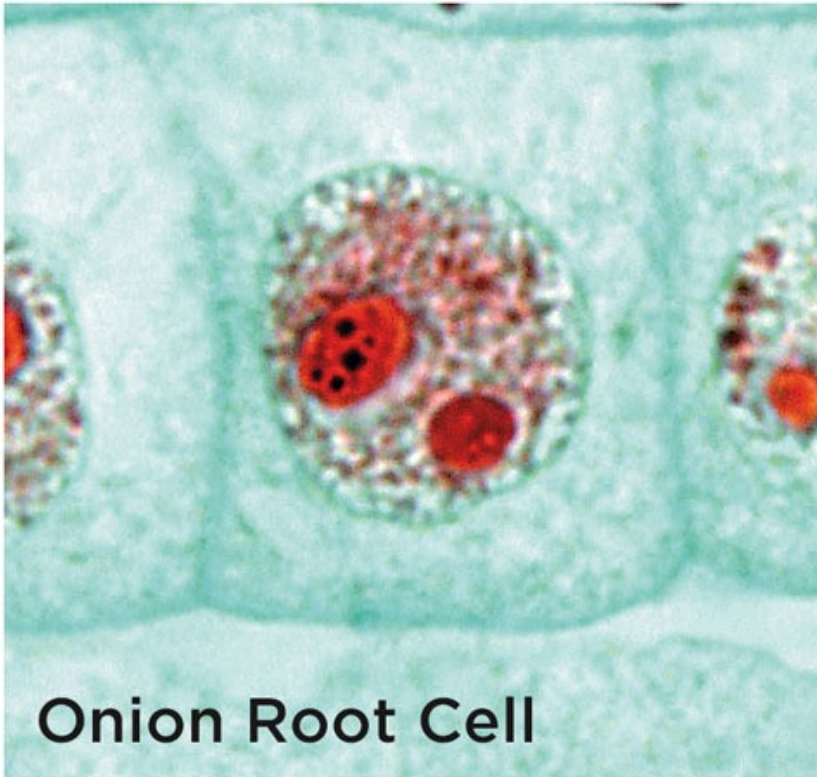
- **Anaphase**

- Microtubules separate the sister chromatids of each chromosome and pull them to opposite spindle poles
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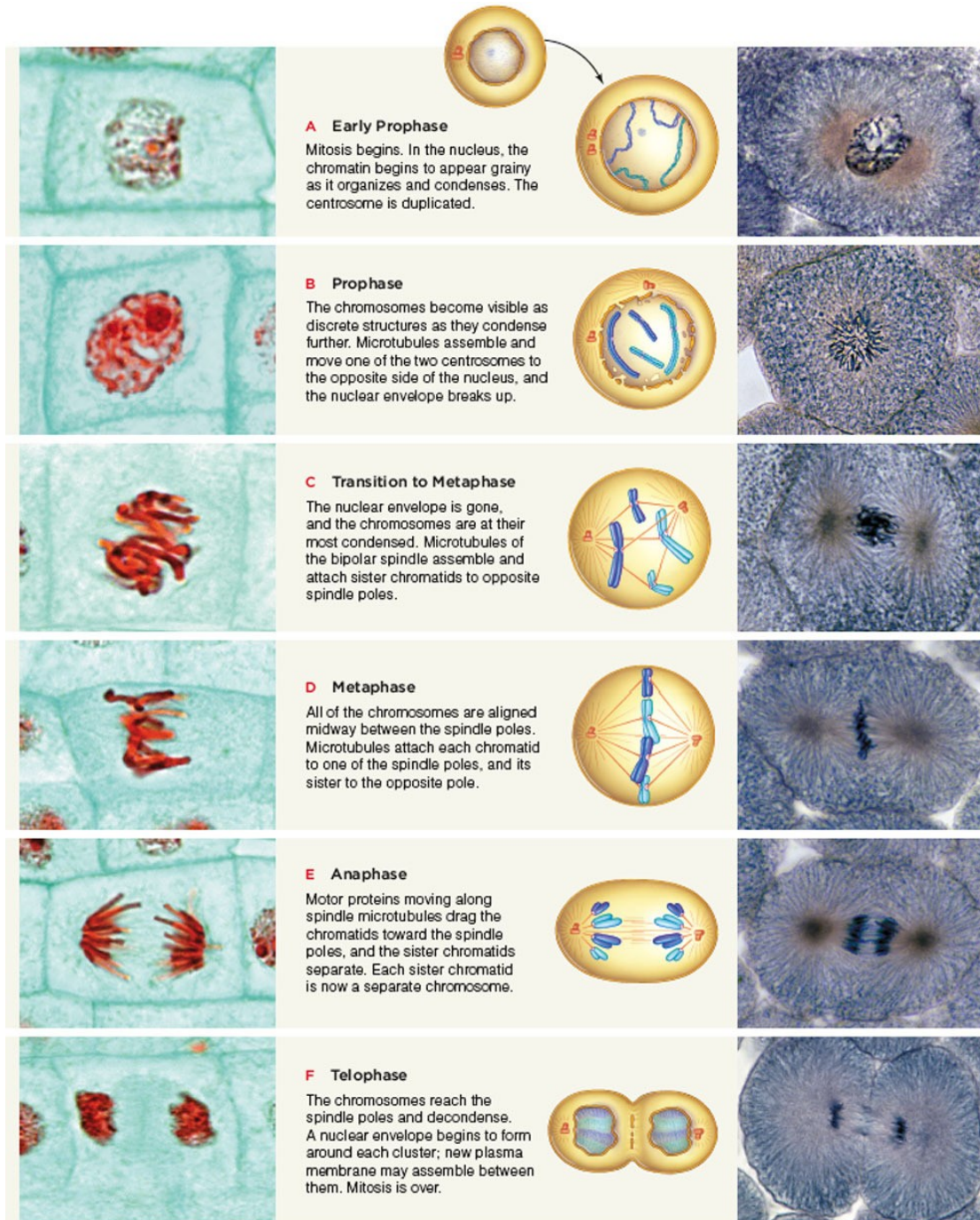
# Telophase

- **Telophase**
    - Two clusters of chromosomes reach the spindle poles
    - A new nuclear envelope forms around each cluster
  - Two new nuclei are formed, each with the same chromosome number as the parent cell
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# Mitosis







# Animation: Mitosis-step-by-step

3-D Video!!!



# **Key Concepts:**

## **Stages of Mitosis**

- *Mitosis divides the nucleus, not the cytoplasm*
  - *Mitosis has four sequential stages: prophase, metaphase, anaphase, and telophase*
  - *A bipolar spindle forms; it moves the cell's duplicated chromosomes into two parcels, which end up in two genetically identical nuclei*
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# Cytoplasmic Division Mechanisms

- In most kinds of eukaryotes, the cell cytoplasm divides between late anaphase and the end of telophase, but the mechanism of division differs
  - **Cytokinesis**
    - The process of cytoplasmic division
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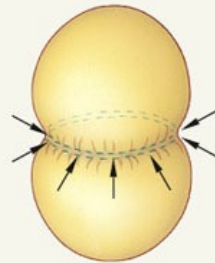
# Cytoplasmic Division in Animal and Plant Cells

- Animal cells
    - A **contractile ring** partitions the cytoplasm
    - A band of actin filaments rings the cell midsection, contracts, and pinches the cytoplasm in two
  - Plant cells
    - A **cell plate** forms midway between the spindle poles; it partitions the cytoplasm when it reaches and connects to the parent cell wall
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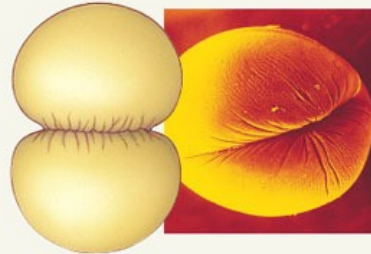
# Cytoplasmic Division in Animal and Plant Cells



**1** Mitosis is completed, and the bipolar spindle is starting to disassemble.



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

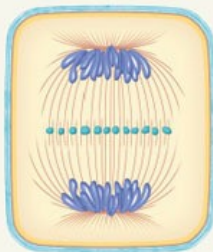


**3** This contractile ring pulls the cell surface inward as it continues to contract.

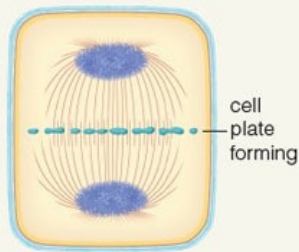


**4** The contractile ring contracts until the cytoplasm is partitioned and the cell pinches in two.

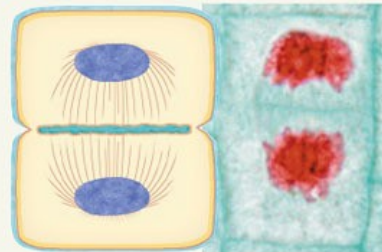
## A Contractile Ring Formation



**1** The plane of division (and of the future cross-wall) was established by microtubules and actin filaments that formed and broke up before mitosis began. Vesicles cluster here when mitosis ends.



**2** The vesicles fuse with each other and with endocytic vesicles bringing cell wall components and plasma membrane proteins from the cell surface. The fused materials form a cell plate along the plane of division.



**3** The cell plate expands outward along the plane of division until it reaches the plasma membrane. When the cell plate attaches to the plasma membrane, it partitions the cytoplasm.



**4** The cell plate matures as two new primary cell walls surrounding middle lamella material. The new walls join with the parent cell wall, so each daughter cell becomes enclosed by its own wall.

## B Cell Plate Formation

# ***Key Concepts:***

## **How the Cytoplasm Divides**

- *After nuclear division, the cytoplasm divides*
  - *One nucleus ends up in each of two new cells*
  - *In animal cells, the cytoplasm pinches in two*
  - *In plant cells, a cross-wall forms in the cytoplasm and divides it*
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