# Cell cycle: Mitosis & Meiosis

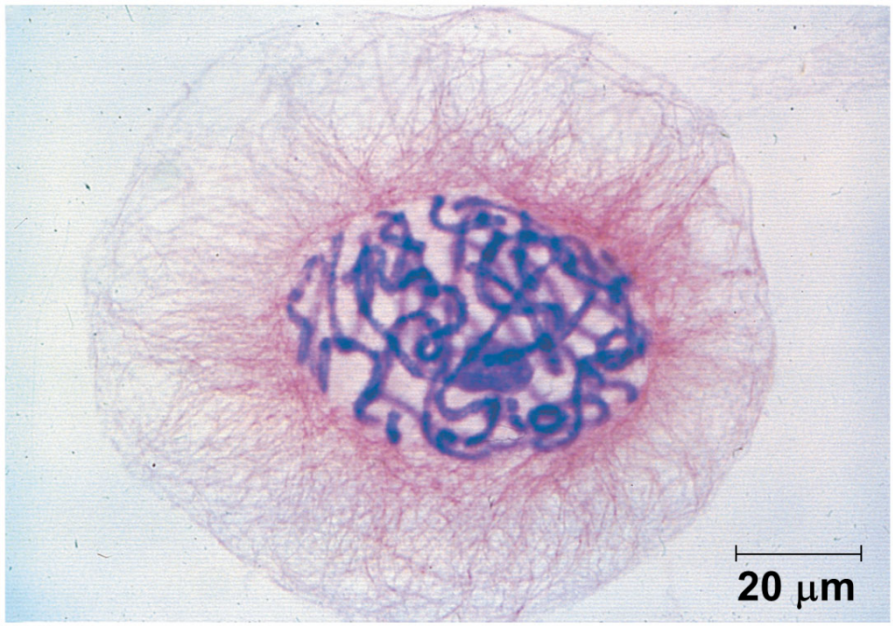
## Tutorial 4

## Chapters 12

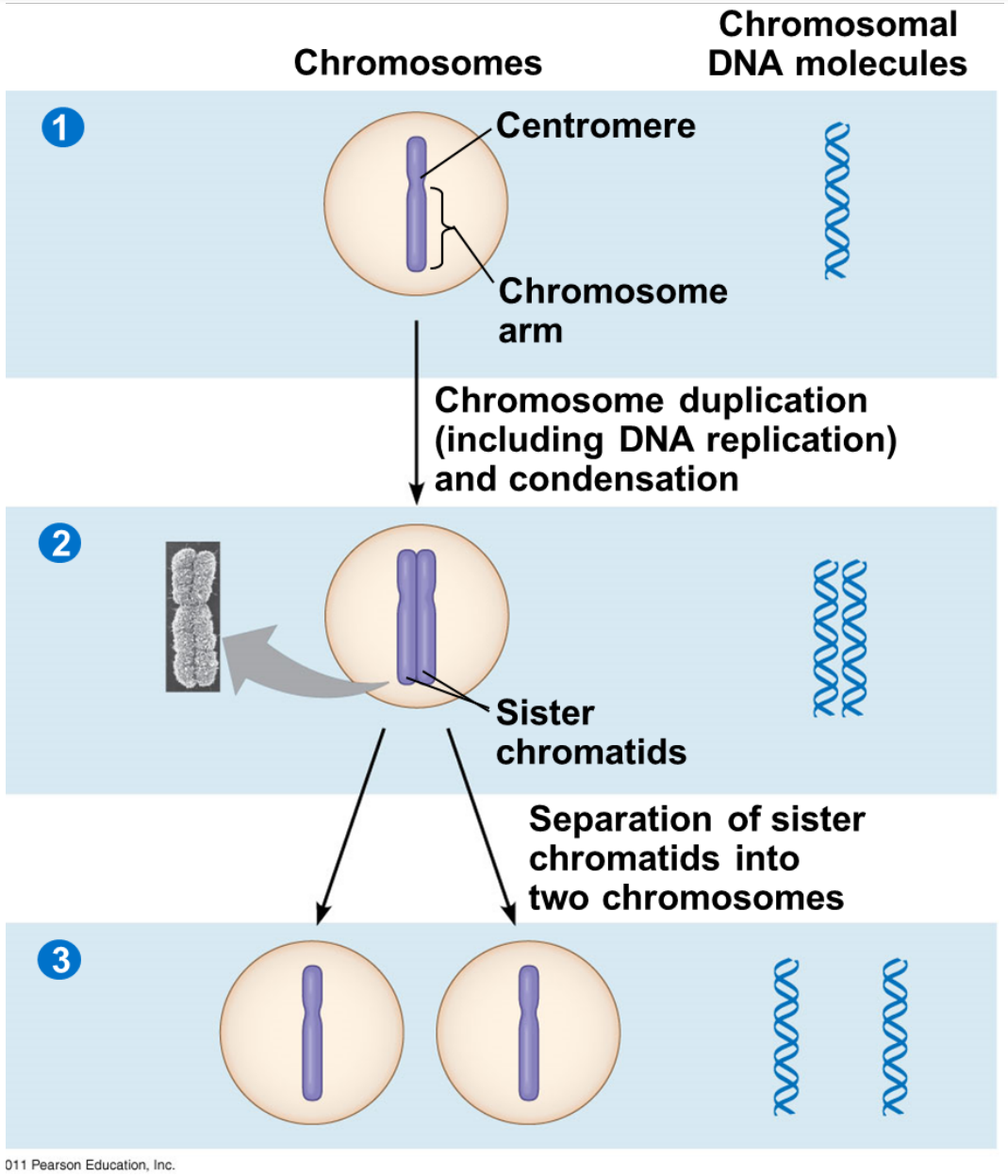
- Cell division & regulation

## Cellular Organization of the Genetic Material

- A genome can consist of a single DNA molecule (common in prokaryotic cells) or a number of DNA molecules (common in eukaryotic cells)
- **Somatic cells** (non-reproductive cells) have two sets of chromosomes
- **Gametes** (reproductive cells: sperm and eggs) have half as many chromosomes as somatic cells



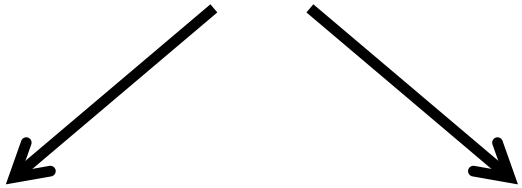
# Distribution of Chromosomes During Eukaryotic Cell Division






Sister chromatids are joint at the centromere

# Cell Cycle



## Mitosis

- Division of somatic cells
- Two daughter cells are produced with same amount of DNA as mother cell

## Meiosis

- Division of gamete cells (Sperm and ovum)
- Four daughter cells are produced with half the amount DNA as mother cell

(You have studied this during our discussion of Mendel)

# Mitotic cell cycle

## Interphase

Constitutes 90% of cell cycle and can be divided into three sub phases:

1. G1 phase (first gap)
2. S phase (DNA synthesis phase)
3. G2 phase (second gap)

## Mitotic phase

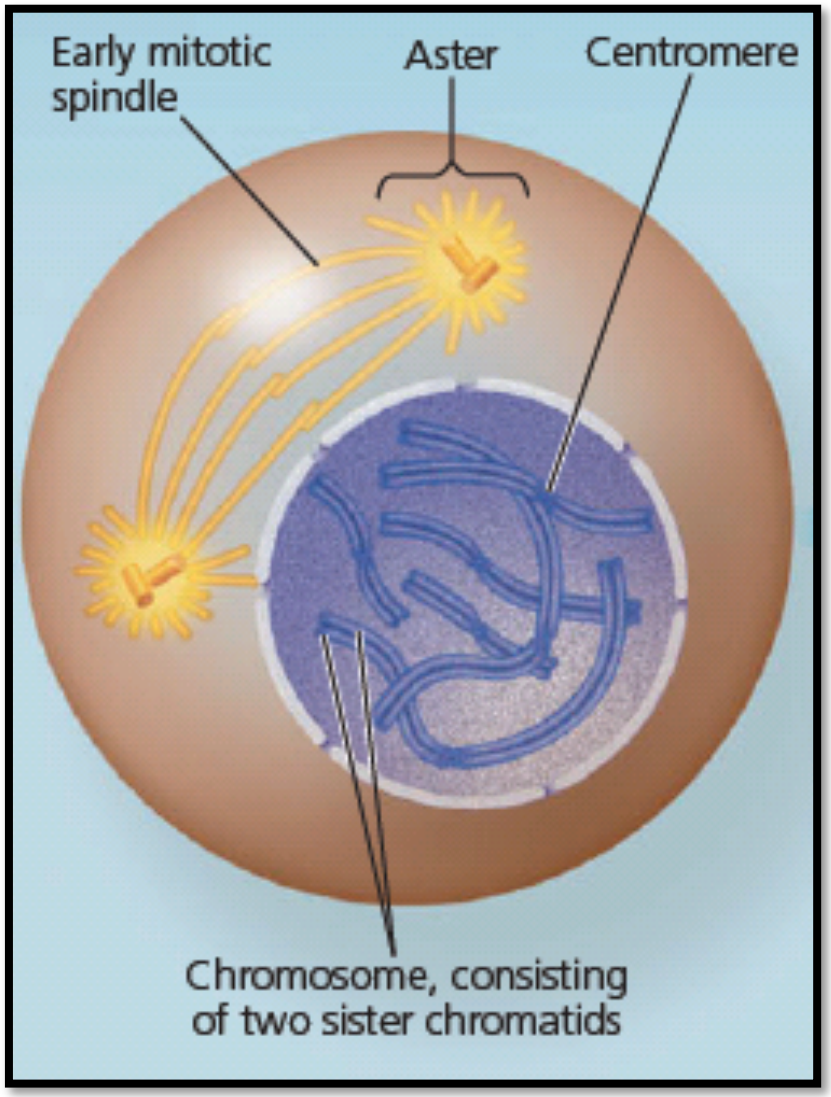
Constitutes only 10% cell cycle and can be divided into six sub phases:

1. Prophase
2. Prometaphase
3. Metaphase
4. Anaphase
5. Telophase
6. Cytokinesis

# Mitosis

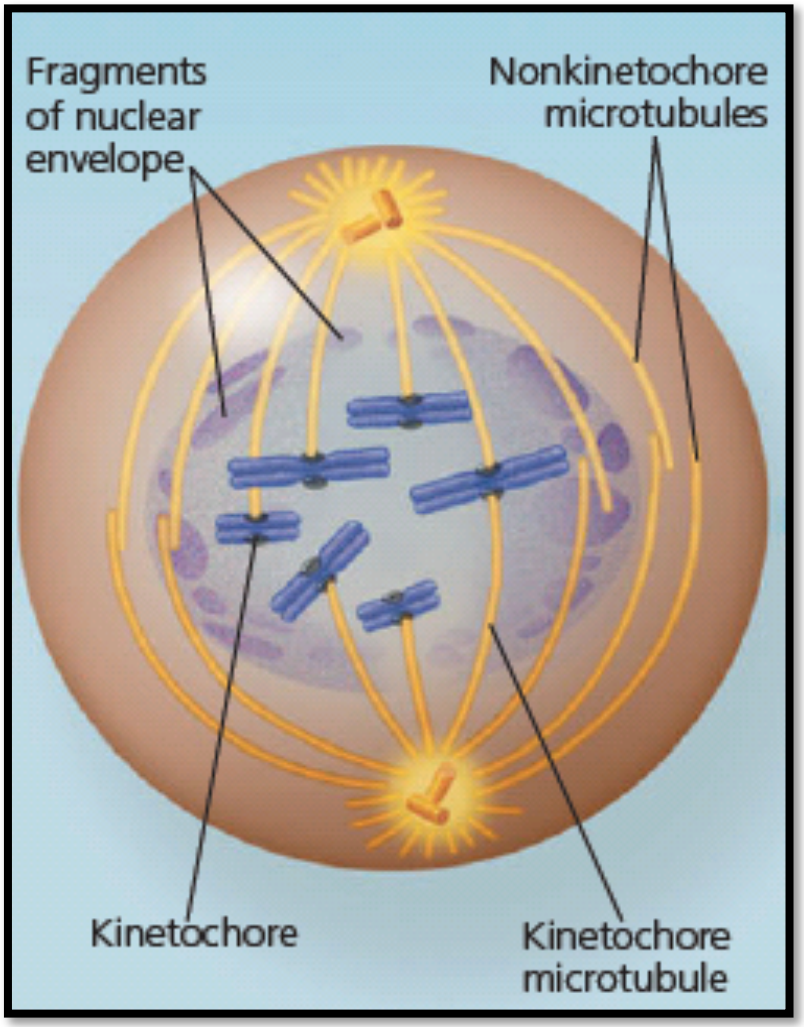
## Prophase

- Chromatins condense into discrete chromosomes
- Centrosomes (asters) move apart
- Mitotic spindle begins to form



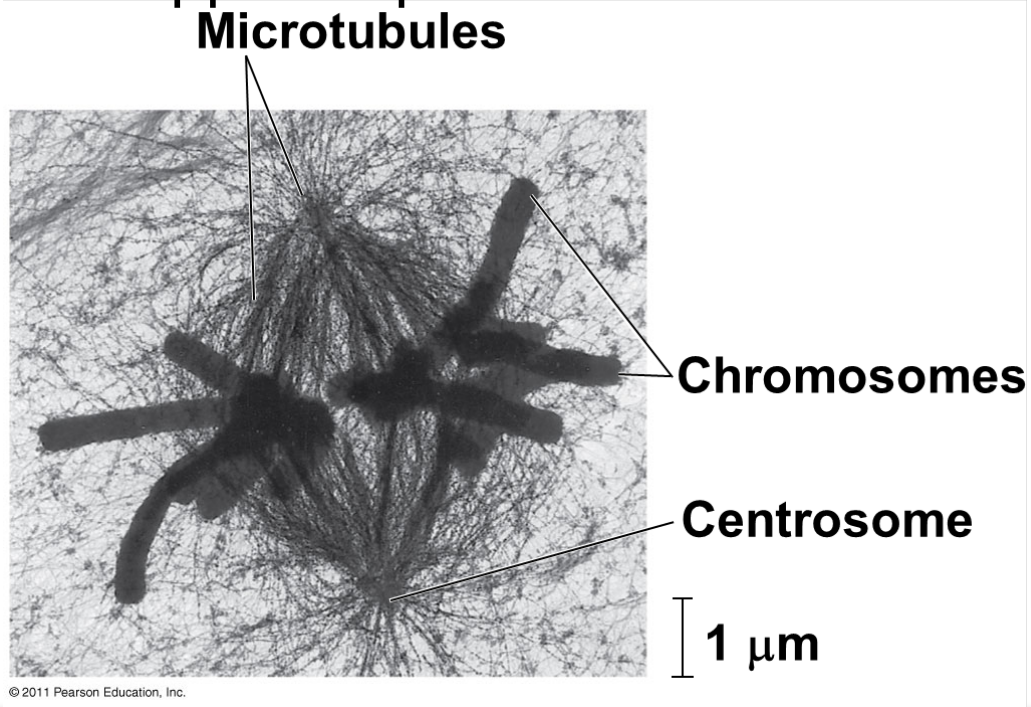
# Prometaphase

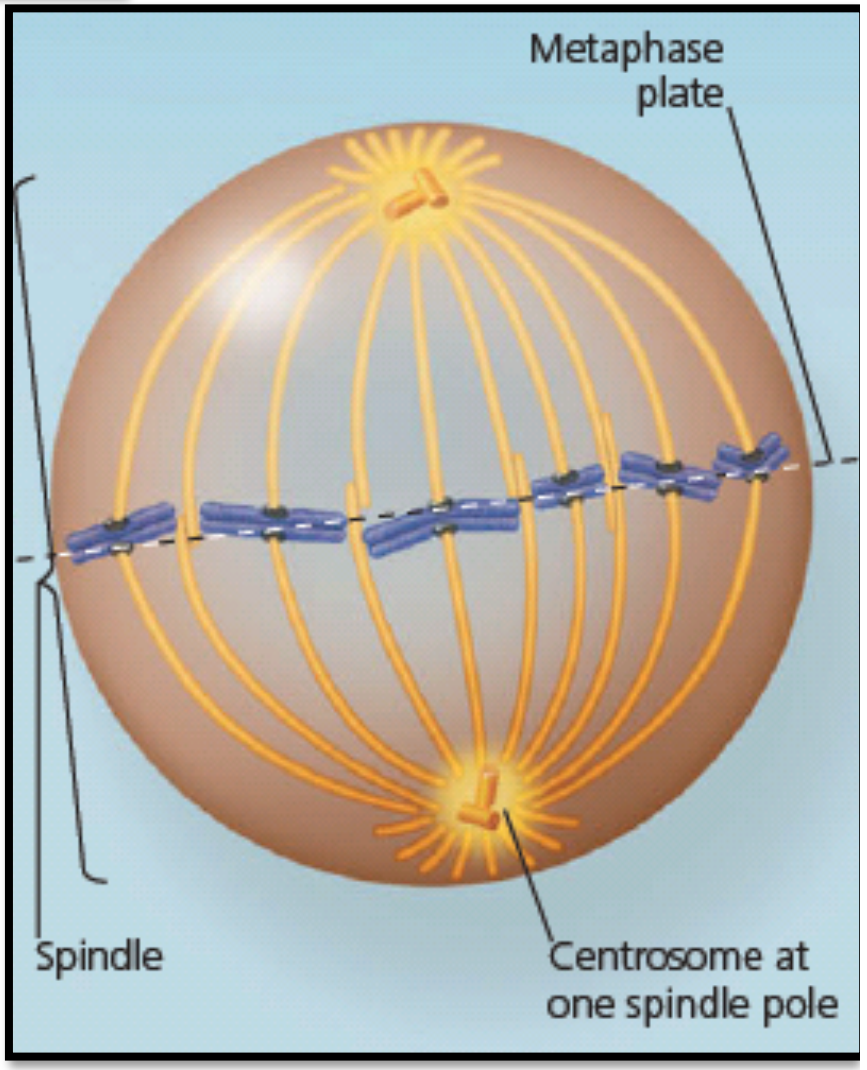
- Nuclear membrane fragments
- Microtubules grow
- Each of the two chromatids have kinetochore proteins at centromere
- Some microtubules attach to kinetochores called "kinetochore microtubules"



## Metaphase

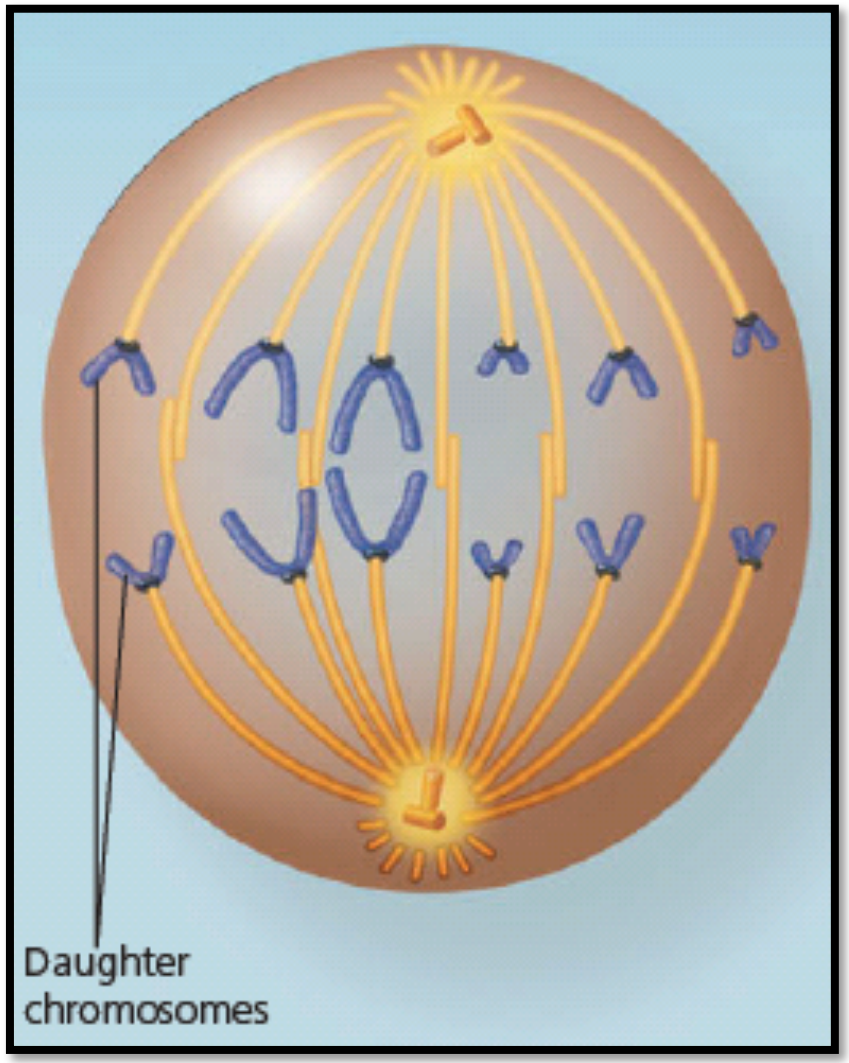
- All the chromosomes assemble at metaphase plate
- For each chromosome sister chromatids are attached to kinetochore microtubules arising from opposite poles



## Anaphase

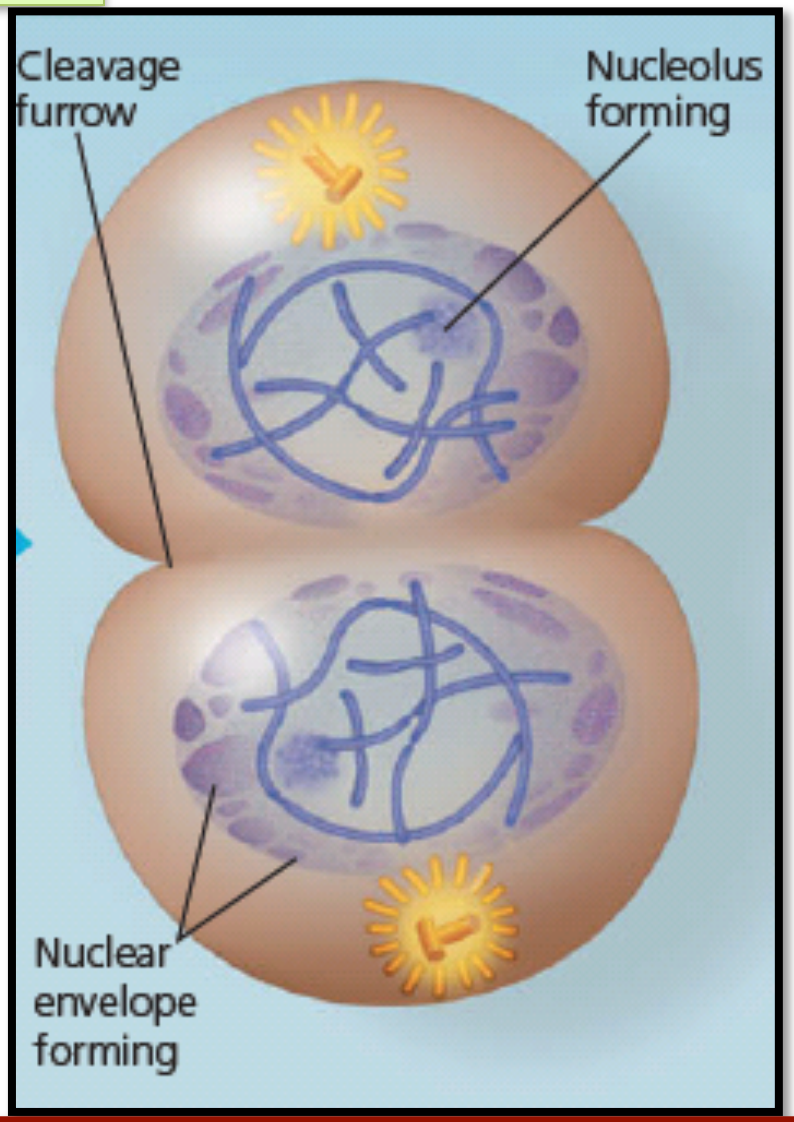
- Sister chromatids separate
- Each chromatid now behaves as a chromosome
- Daughter chromosomes move towards opposite poles due to shortening of kinetochore microtubules



## Telophase

- Two daughter nuclei form in the cell
- Nuclear envelope reappears
- Spindle microtubules depolymerize
- Chromosomes become less condensed

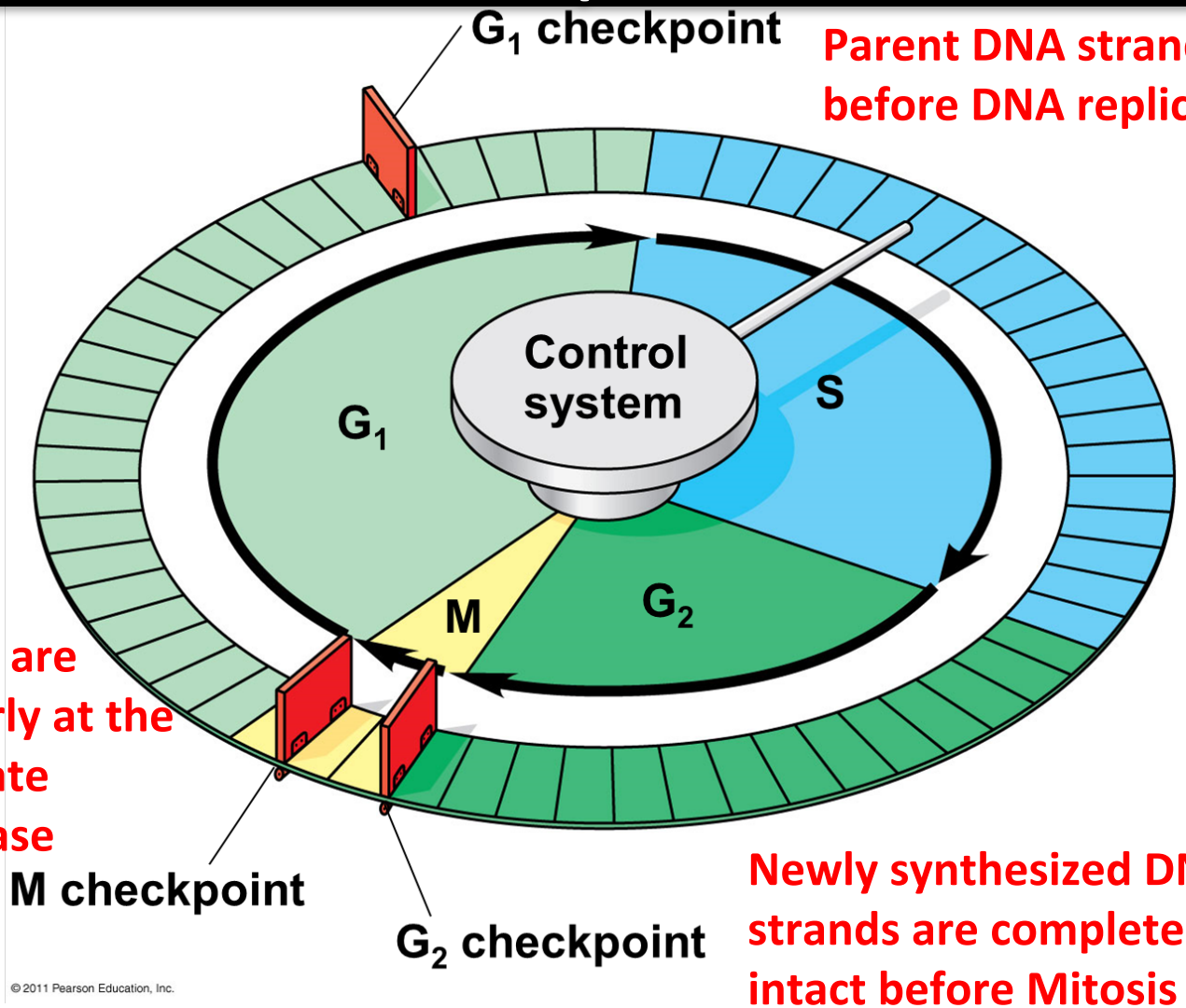
Karyokinesis (division of nucleus) completes



## Cytokinesis

- Formation of cell furrow
- Division of cytoplasm to give rise to two daughter cells

# Checkpoints



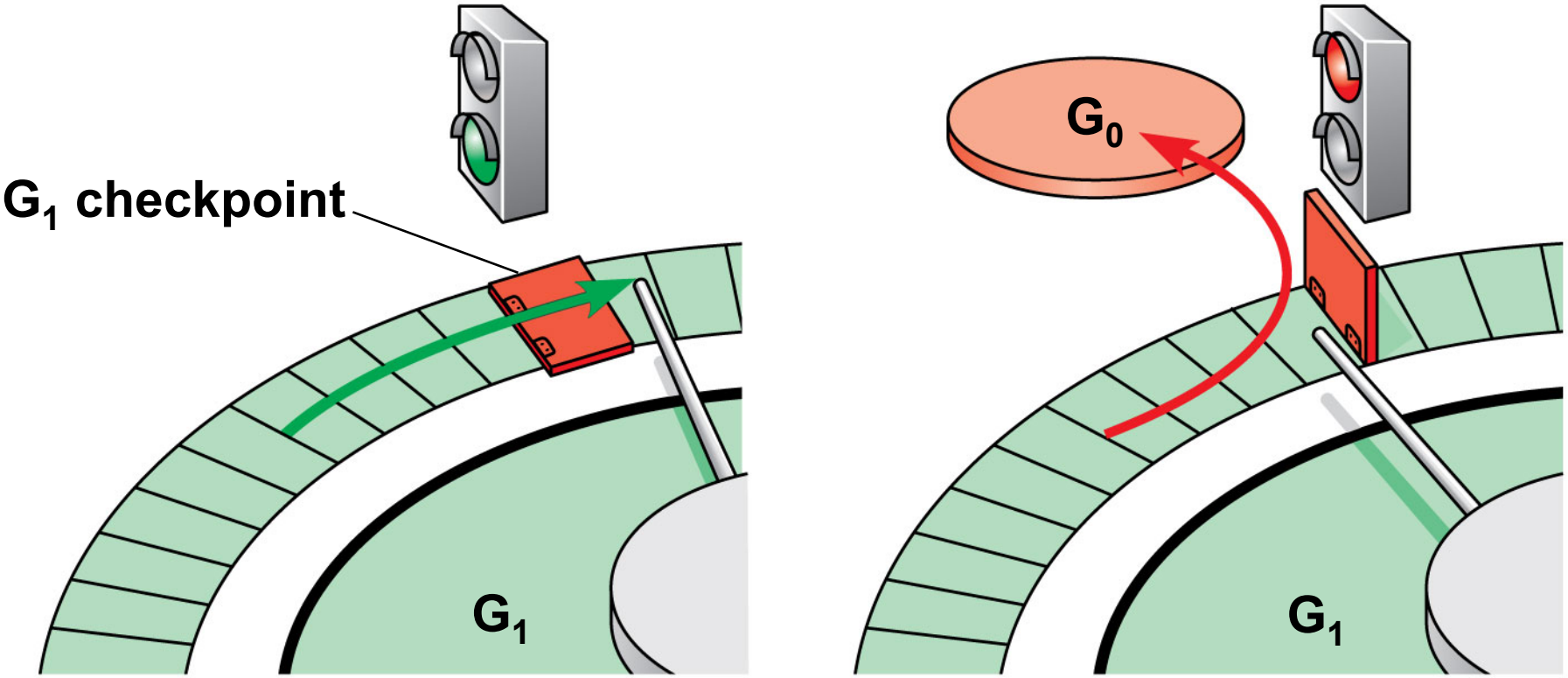

Parent DNA strands are intact before DNA replication begins

Chromosomes are aligned properly at the metaphase plate before Anaphase

Newly synthesized DNA strands are complete and intact before Mitosis

**Checkpoints are essential for the correct distribution of complete chromosome sets between daughter cells**

# For many cells G1 checkpoint is the most important checkpoint




(a) Cell receives a go-ahead signal.

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



Regulation of cell cycle is monitored by proteins called Cyclins and Cyclin dependent kinases

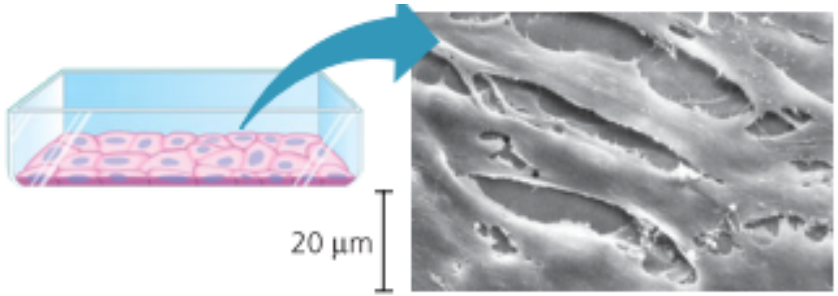
# Regulation of cell cycle by external signals

External signals

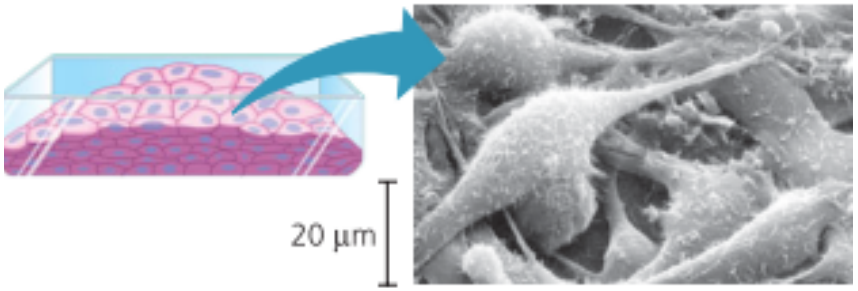
- Nutrients
- Growth factors
- Space (crowded cells stop dividing) also known as **density dependent inhibition**
- Substratum for anchorage (**anchorage dependence**)

# Cancer cells lose dependence on internal and external signals for proliferation

- Cancer cells do not stop at cell cycle checkpoints
- Continue to divide even after the presence of errors in the DNA
- Do not exhibit density dependent inhibition (form multiple layers of cells)
- Do not require anchorage with the substratum

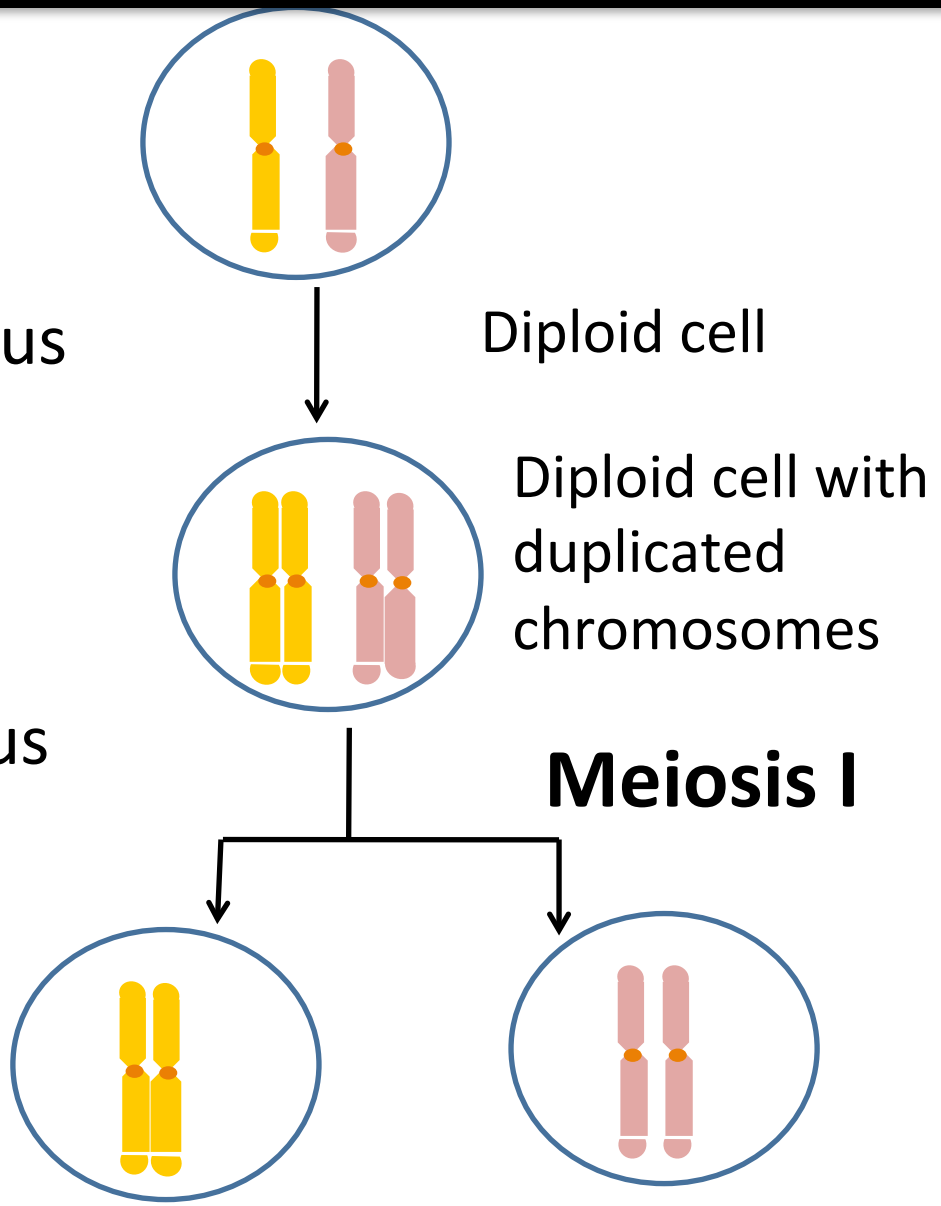



Normal mammalian cells




Cancer cells

# Meiosis reduces chromosome number

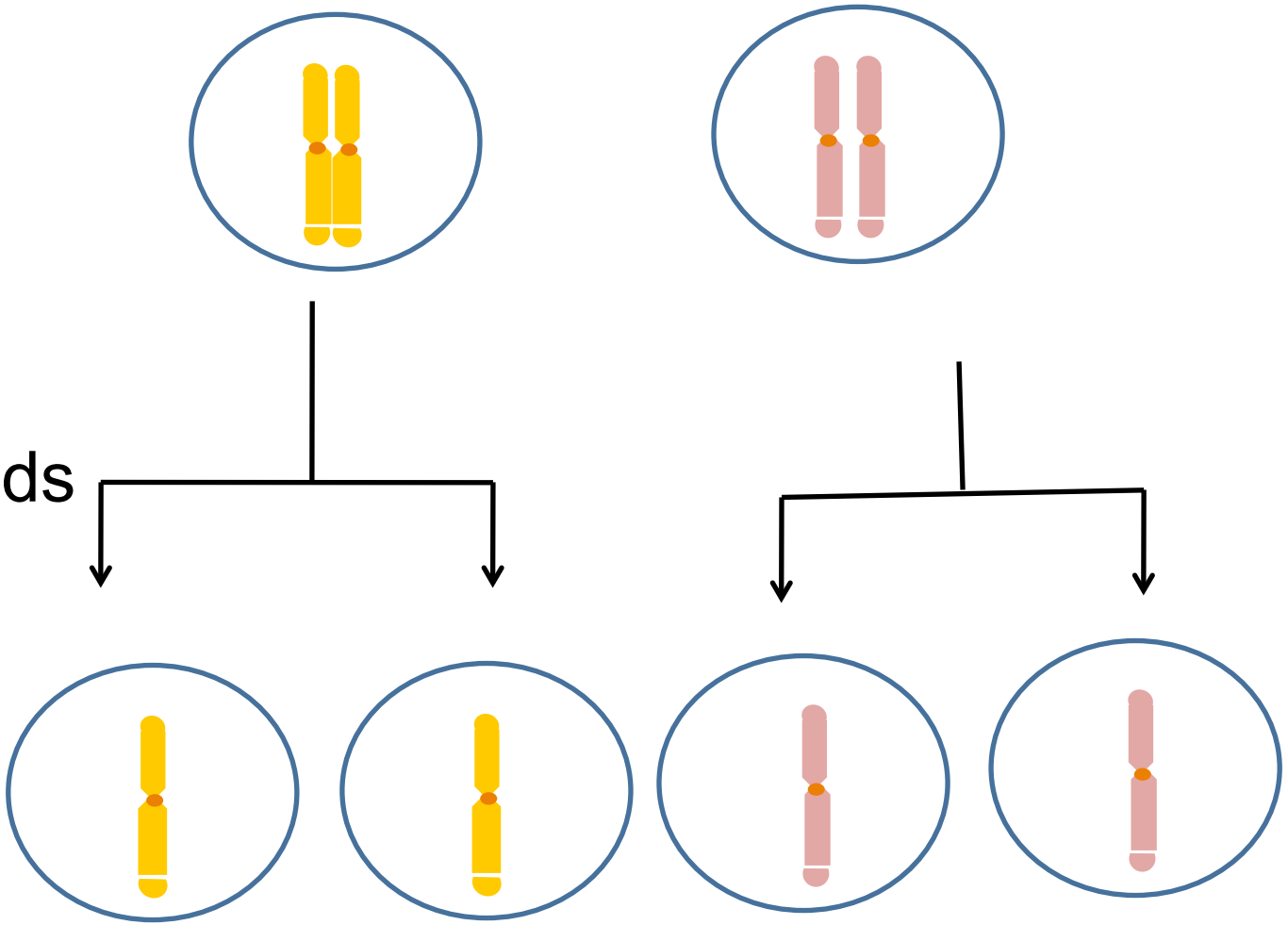


# Meiosis reduces chromosome number

**Meiosis II**

Separation of sister chromatids

(Similar to mitosis)



Haploid cells with unduplicated chromosomes

**Seen in gametes**