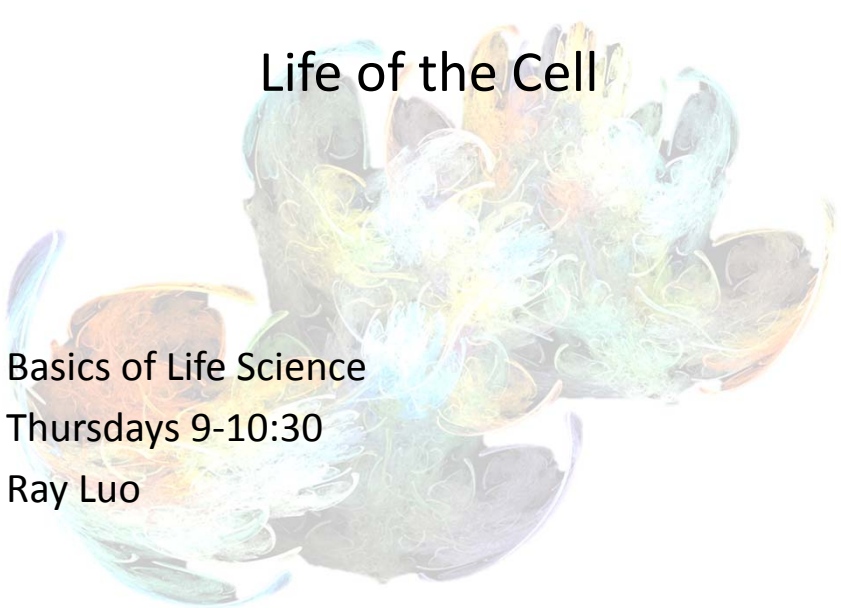


# Life of the Cell



Basics of Life Science  
Thursdays 9-10:30  
Ray Luo

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## Cells can distribute genetic info to their daughter offsprings.

- Every cell comes from a cell
- Cell division distributes DNA to daughter cells
- Mitosis: division -> identical  $2n$  somatic cells
- Meiosis: germ cell -> 4 gametes half the chrom
- DNA has to be copied before divided
- Chromosome organization of  $(2m)$  DNA
- Chromosome chromatin: DNA + proteins only
- Somatic ( $2 \times 23$  humans), gametes ( $1 \times 23$ )

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## Cells can distribute genetic info to their daughter offsprings.

- During division chromosomes condense
- Sister chromatids joined by cohesins
- Centromere: region of DNA where chromatids are attached to each other
- Cytokinesis: division of cytoplasm of cell
- Mitosis: daughter cells get full 2x 23 set
- Meiosis: daughter cells get one set of 23
- One centromere per duplicated chromosome

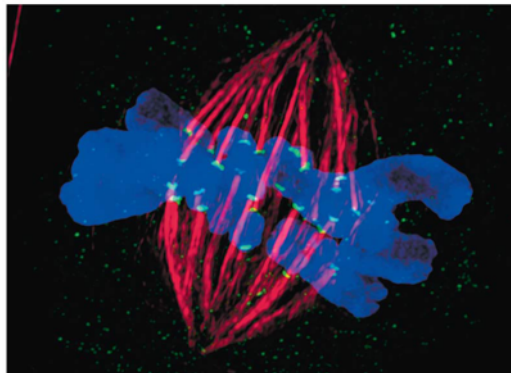
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Figure 12.1a



Chromosomes (blue) are moved by cell machinery (red) during division of a rat kangaroo cell.

Figure 12.4

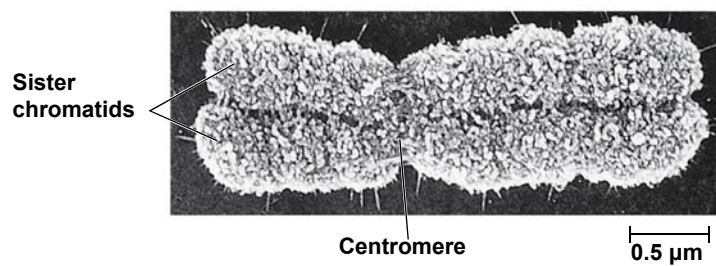
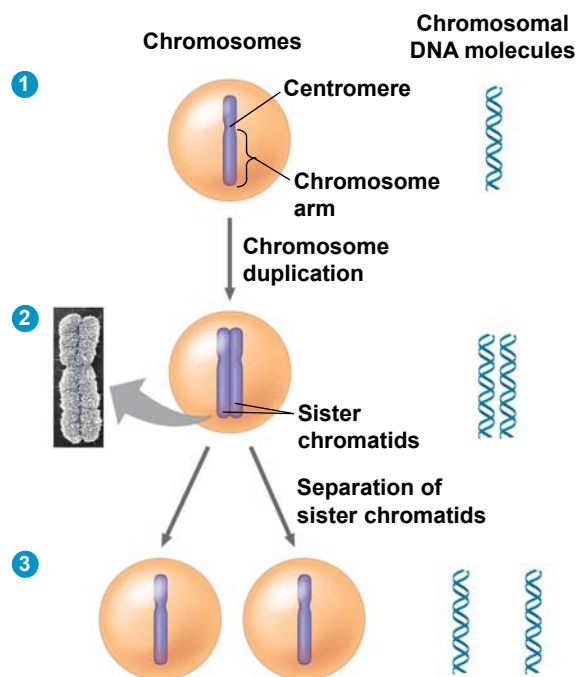


Figure 12.5-3



## Mitosis alternates with longer interphase.

- Interphase G<sub>1</sub>, S, G<sub>2</sub>
- S (synthesis) – duplication of chromosomes
- Mitosis + cytokinesis M 1 hr, S 10 to 12 hrs
- G<sub>1</sub> variable length (doing job), G<sub>2</sub> 5 hr prep
- G<sub>2</sub> nucleolus envelope, uncondensed chrom
- Normal function and growth is in G<sub>1</sub> (what we know cells to be at is G<sub>1</sub>)

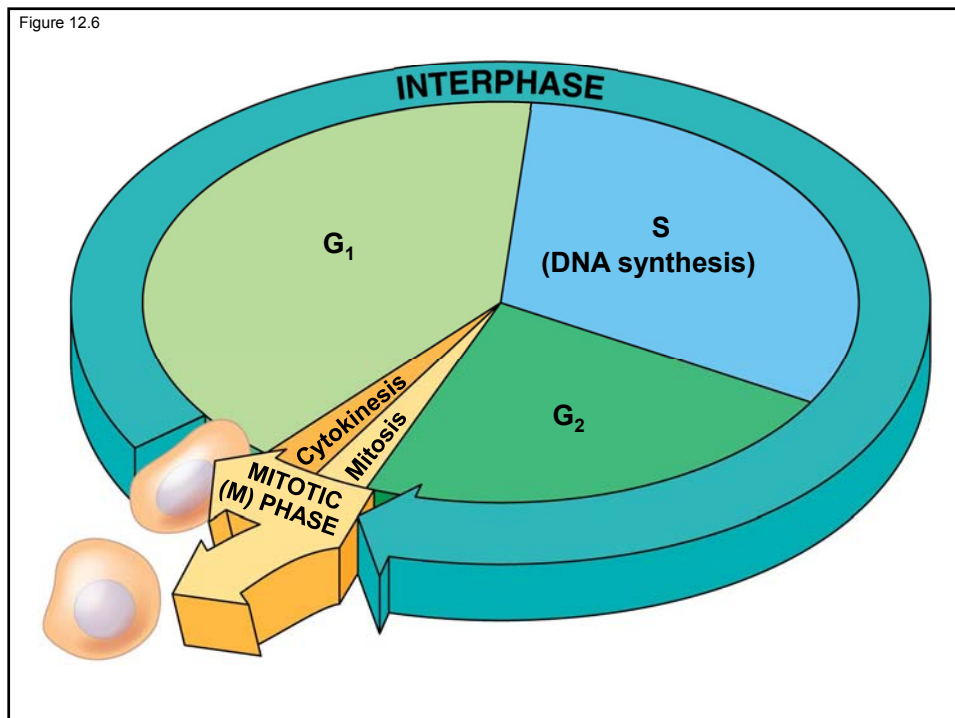
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Figure 12.6



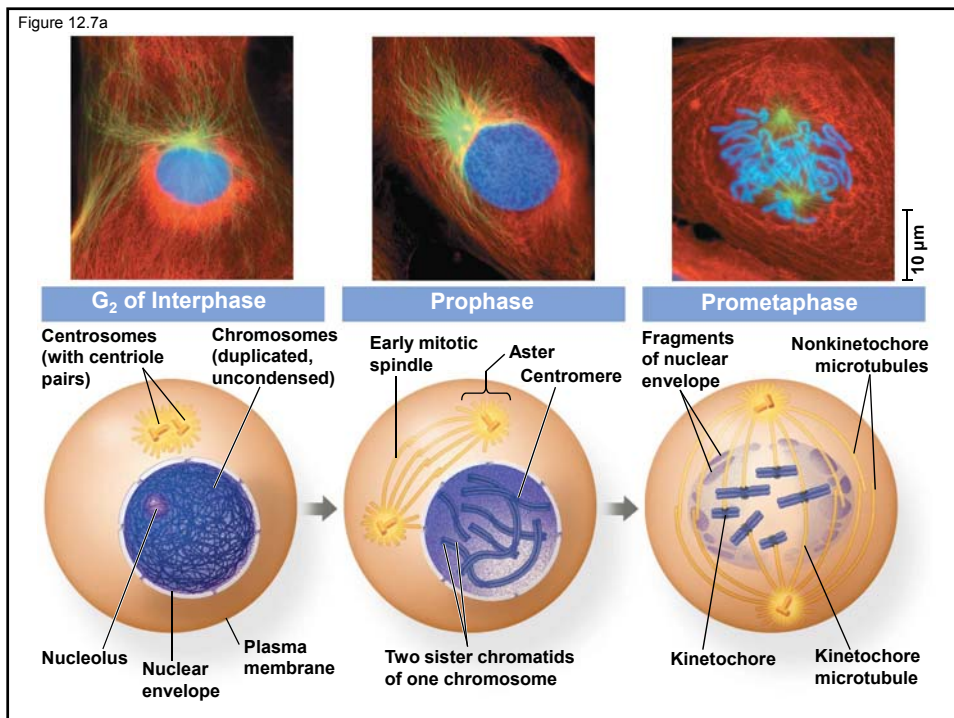
## Substages of Mitosis.

- Prophase: condensed chromatin, nucleolus disappear, chromatids joined with spindles radiating out from centrosome (asters)
- Prometaphase: nuclear envelope disappears, kinetochore protein at centromere, opposite spindle microtubules attach to kinetochore
- Metaphase: centrosomes at opposite poles, chromosomes on metaphase plate, alignment of chromosomes on the equator

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## Substages of Mitosis.

- Anaphase: short, cohesins cleaved allowing sister chromatids of each pair to part, kinetochore microtubules attached shorten
- Telophase: 2 nuclei form from ER and old envelope, chromosomes decondense
- Cytokinesis: cleavage furrow pinches cell into two, two daughter cells

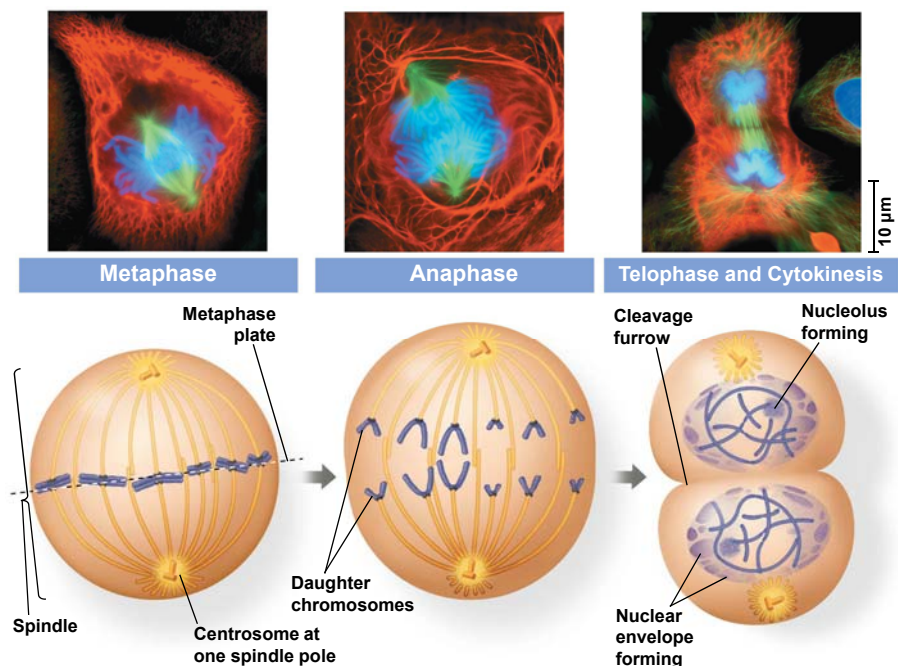
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Figure 12.7b



## A closer look at centrosomes.

- Microtubules consists of tubulin units
- Centrosome organizes microtubules
- Centriole pair inside centrosome nonessential
- Centrosome divides and move to opposite sides of cell by prometaphase
- Aster microtubule array extends out
- Opposite facing kinetochores attach to each sister chromatid, tugged into metaphase plate

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## A closer look at centrosomes.

- Separase enzyme cleaves cohesins allowing chromatids to move to opposite sides
- Motor proteins pull at spindle pole? or Pacman: kinetochore push walk proteins along microtubules which shorten at chromatid end
- Nonkinetochore microtubules from opposite poles join and lengthen, elongating cell

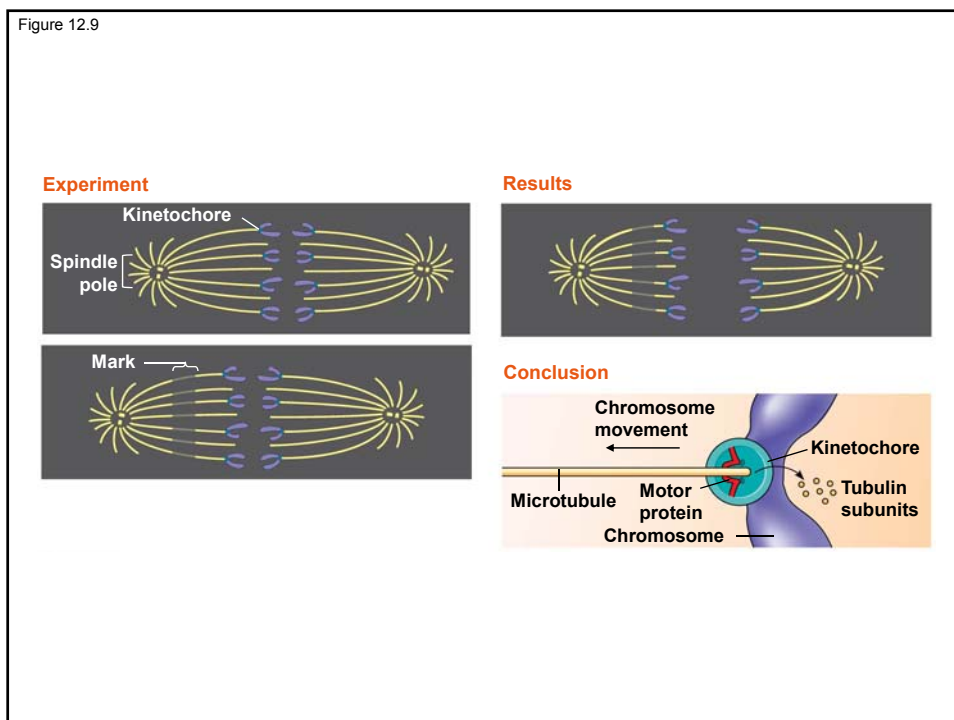
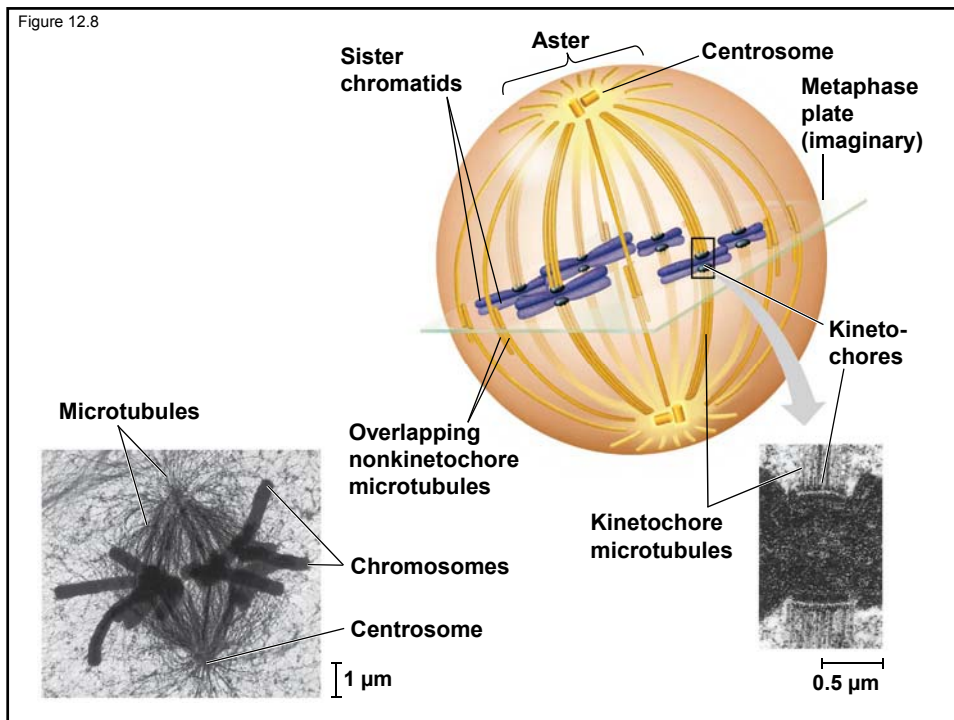
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## A closer look at cytokinesis.

- Animals: cleavage furrow at site of metaphase plate formed by actin-myosin contractile ring pinching cell into two.
- Plants: vesicles from Golgi move along microtubules to center of cell to form cell plate, membranes fuse new cell wall.

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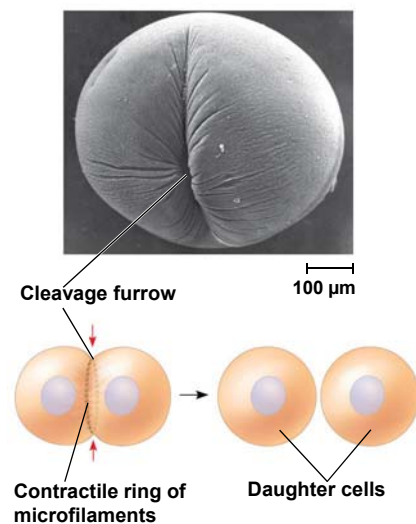
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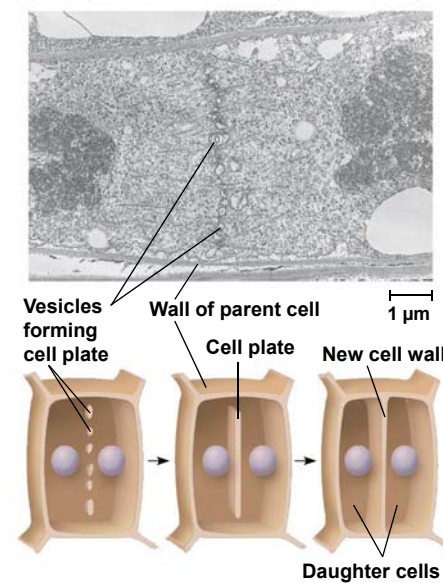


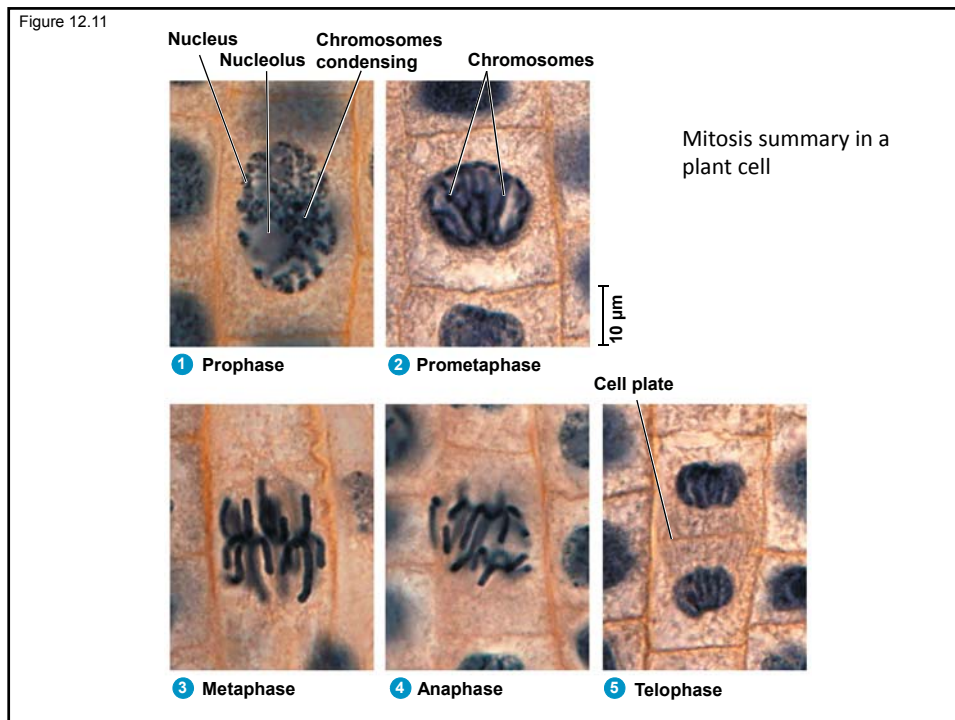
Figure 12.10

(a) Cleavage of an animal cell (SEM)



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

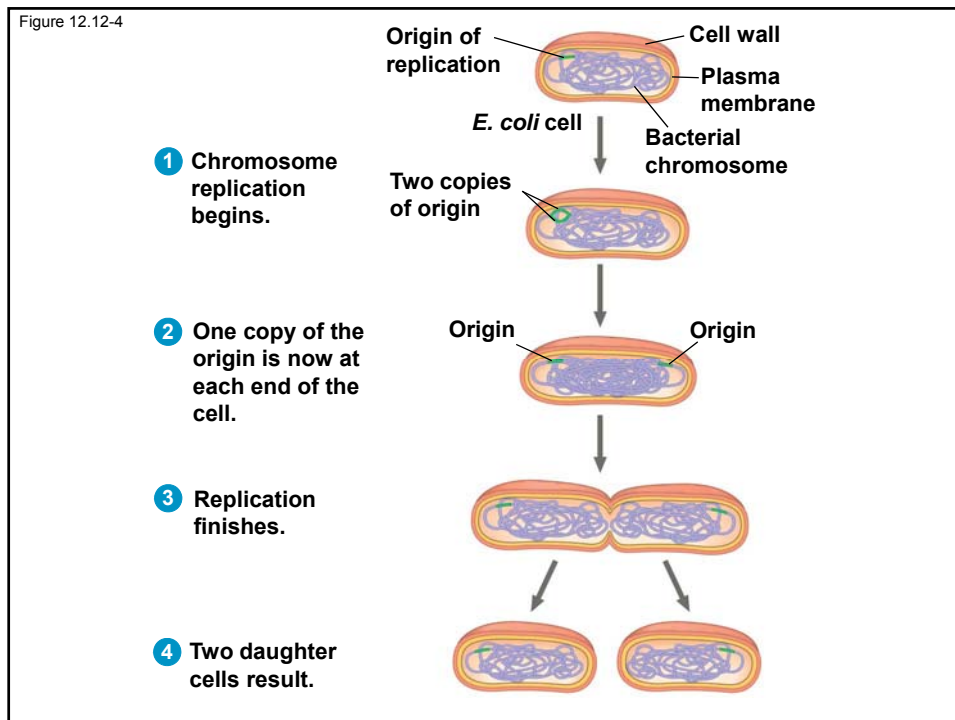




## Prokaryotic cell division.

- Bacteria binary fission (no mitosis)
- Single circular DNA: replication start at origin to make two forks to make DNA copies
- No spindles, actin moves, tubulin pinches membrane inward to get two cells
- Evolution: Prokaryotes -> intact nuclei division in dinoflagellates and diatoms -> mitosis

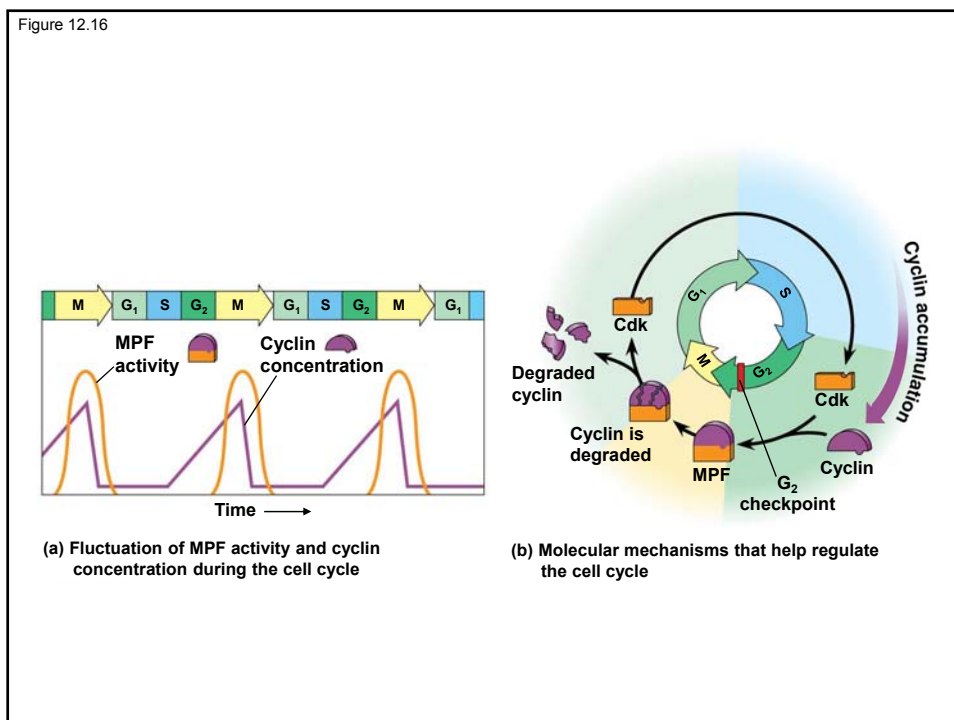
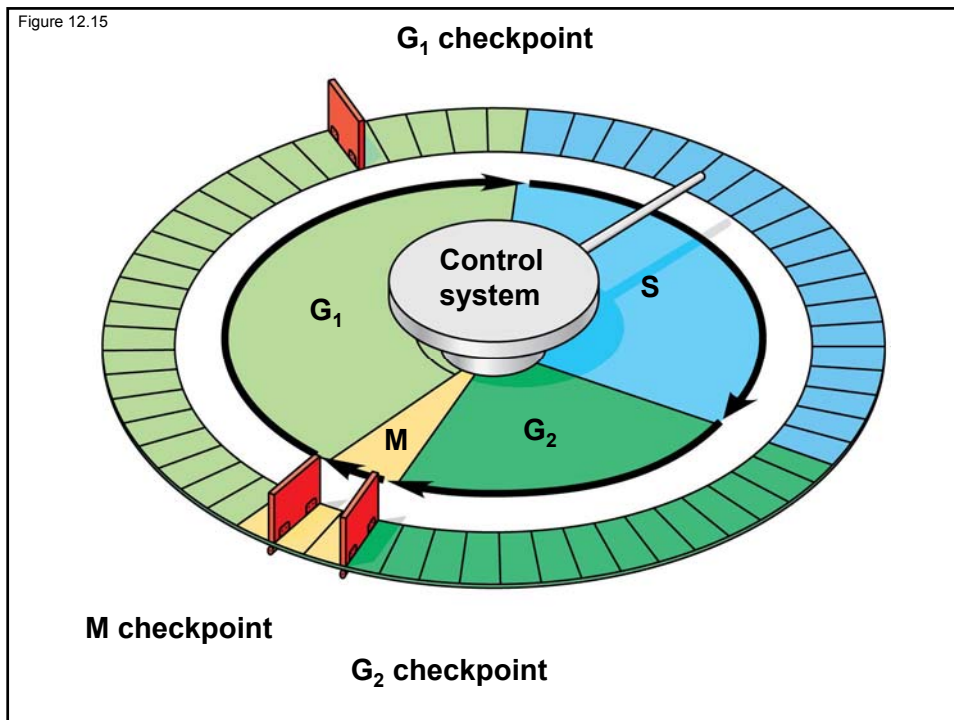




## Cell cycle control by cyclin dependent kinase proteins.

- Fused one cell with two nuclei: if any was in M or S, the other nuclei goes to M or S.
- Cell cycle control as washing machine: built-in clock plus external control, G1 G2 M checkpoints.
- Protein kinases phosphorylate proteins, activating or inactivating them.
- Cyclin-dep kinases CDKs activity fluctuates with cyclin concentration (rise in S G2, fall M).
- Ex MPF triggers mitosis, phosphorylate nuclear lamin -> fragment, anaphase destroys own cyclin.





## Cell Cycle control system.

- G1 checkpoint restriction point: go -> S G2 M, if no signal -> nondividing G0 (neurons, liver)
- Ex. anaphase only when ALL kinetochores are attached will cohesins be cleaved chromatids
- Growth factor + essential nutrients -> divide, ex. Injuries -> release PDGF -> platelets up
- Cell cycle control of excessive cells: density dep inhibition, anchorage dependence

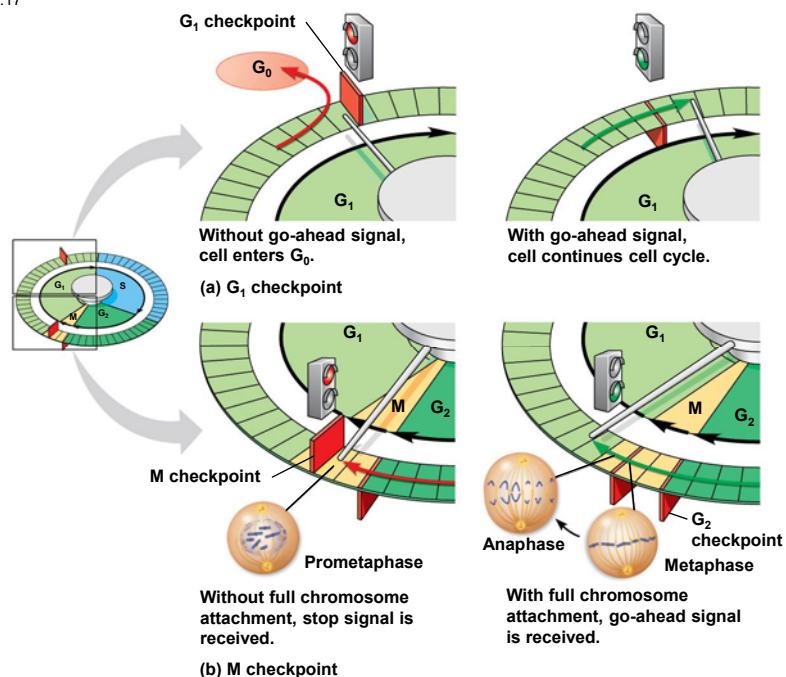
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Figure 12.17



## Cancer cells result from failure in cell cycle control.

- Cancerous cells divide without growth factors, stop at random points in cycle, HeLa cell line.
- Usually 20-50 cycles; cancer evades apoptosis
- Benign tumor: can't survive in diff site
- Malignant tumor: spread to new tissue organs
- Metastasis: spread of cancer e.g. via blood ves
- Radiation of cancers (can't repair), side effect on cells that divide (intestine, hair, immune).

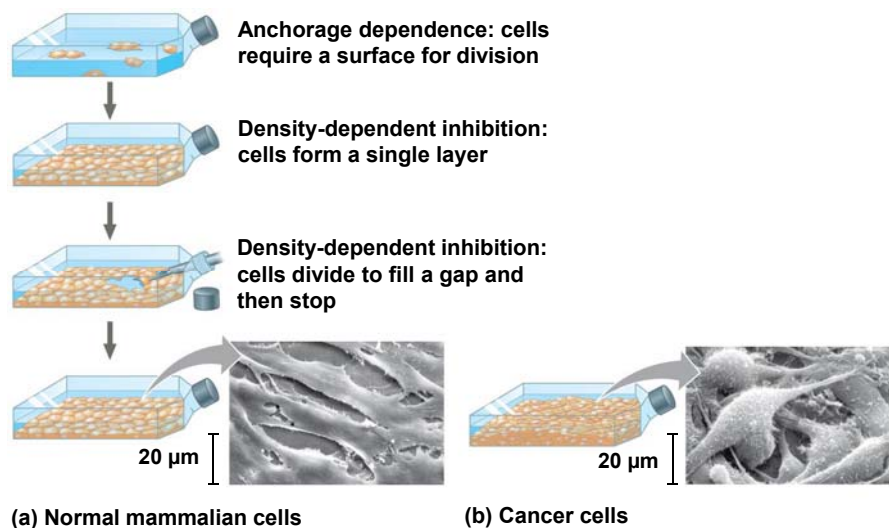
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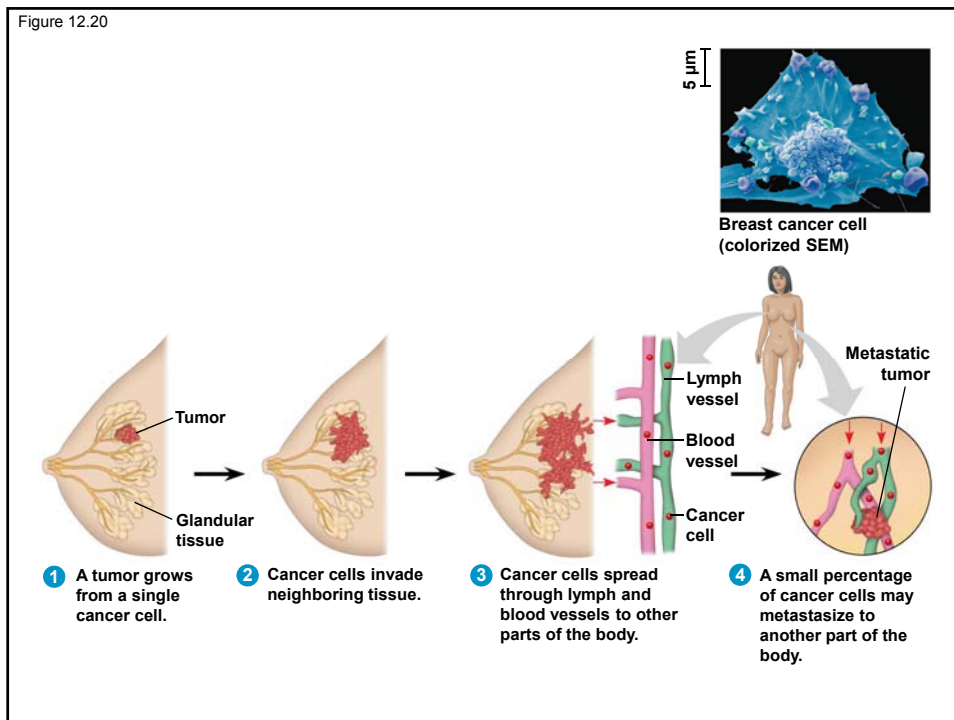
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Figure 12.19





## Team activity: answer these questions in teams of 3 or 4 (and justify):

1. If there are 20 duplicated chromosomes in a cell, how many centromeres are there?

- A) 10
- B) 20
- C) 30
- D) 40

2. Some cells have several nuclei per cell. How could such multinucleated cells be explained?

- A) The cell underwent repeated mitosis, but cytokinesis did not occur.
- B) The cell had multiple S phases before it entered mitosis.
- C) The cell underwent repeated cytokinesis but no mitosis.
- D) The cell underwent repeated mitosis with simultaneous cytokinesis.

3. How is plant cell cytokinesis different from animal cell cytokinesis?

- A) Plant cells divide after metaphase but before anaphase; animal cells divide after anaphase.
- B) The structural proteins of plant cells separate the two cells; in animal cells, a cell membrane separates the two daughter cells.
- C) Plant cells deposit vesicles containing cell-wall building blocks on the metaphase plate; animal cells form a cleavage furrow.
- D) The contractile filaments found in plant cells are structures composed of carbohydrates; the cleavage furrow in animal cells is composed of contractile phospholipids.

4. Besides the ability of some cancer cells to overproliferate, what else could logically result in a tumor?

- A) changes in the order of cell cycle stages
- B) inability to form spindles
- C) inability of chromosomes to meet at the metaphase plate
- D) lack of appropriate cell death

