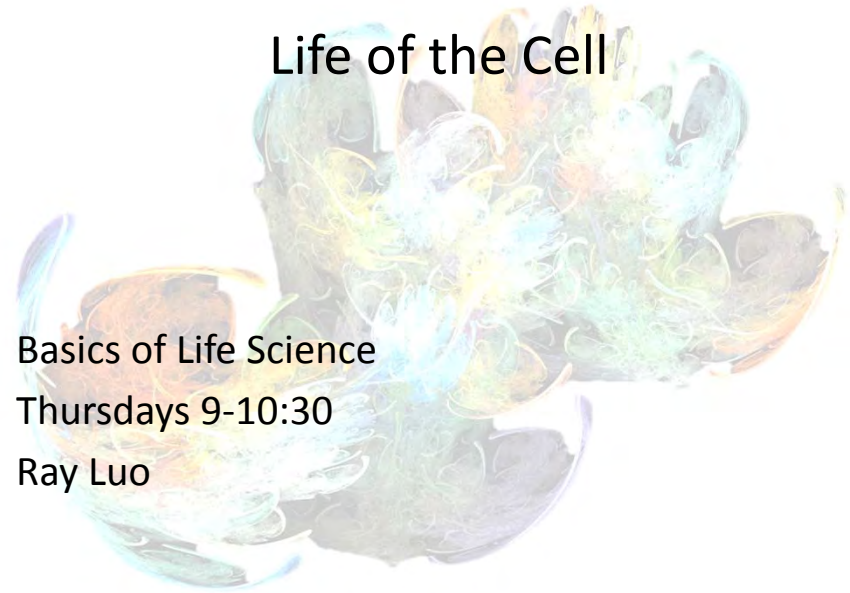
Life of the Cell



Basics of Life Science

Thursdays 9-10:30

Ray Luo

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 (2x23 humans), gametes (1x23)

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

ray LC rluo@aoni.waseda.jp WASEDA UNIVERSITY | SILS

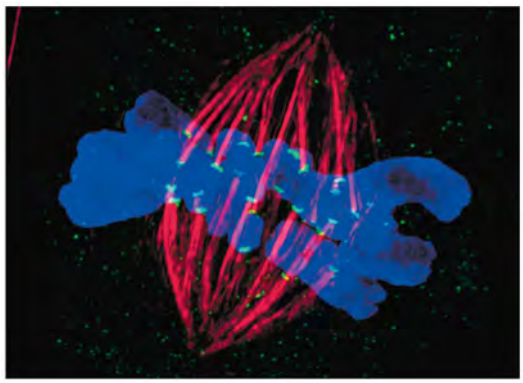


Figure 12.1a

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

Figure 12.4

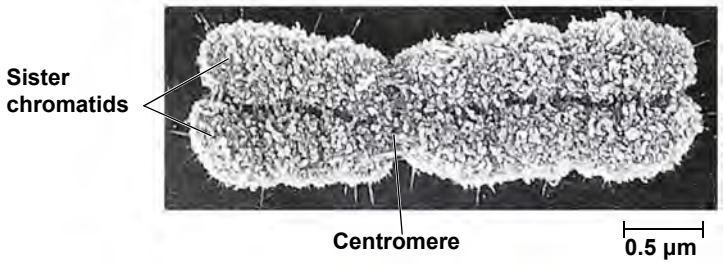
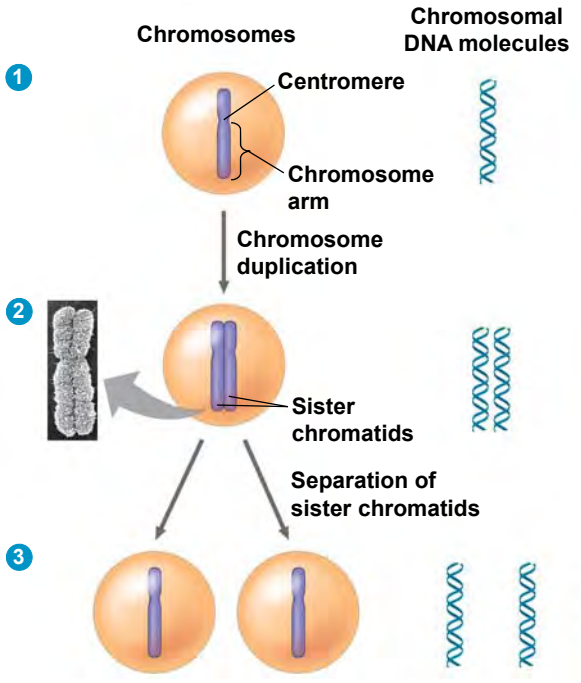


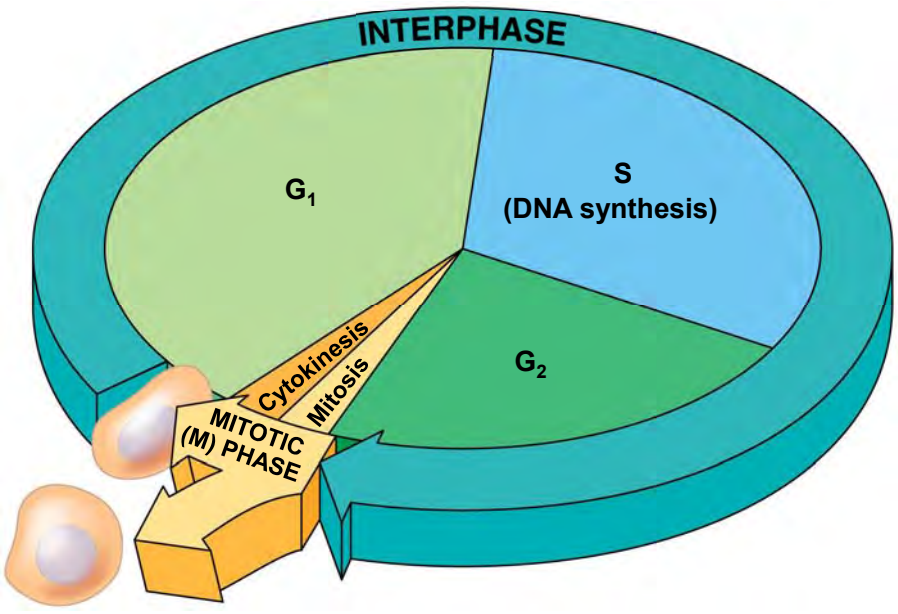
Figure 12.5-3



Mitosis alternates with longer interphase.

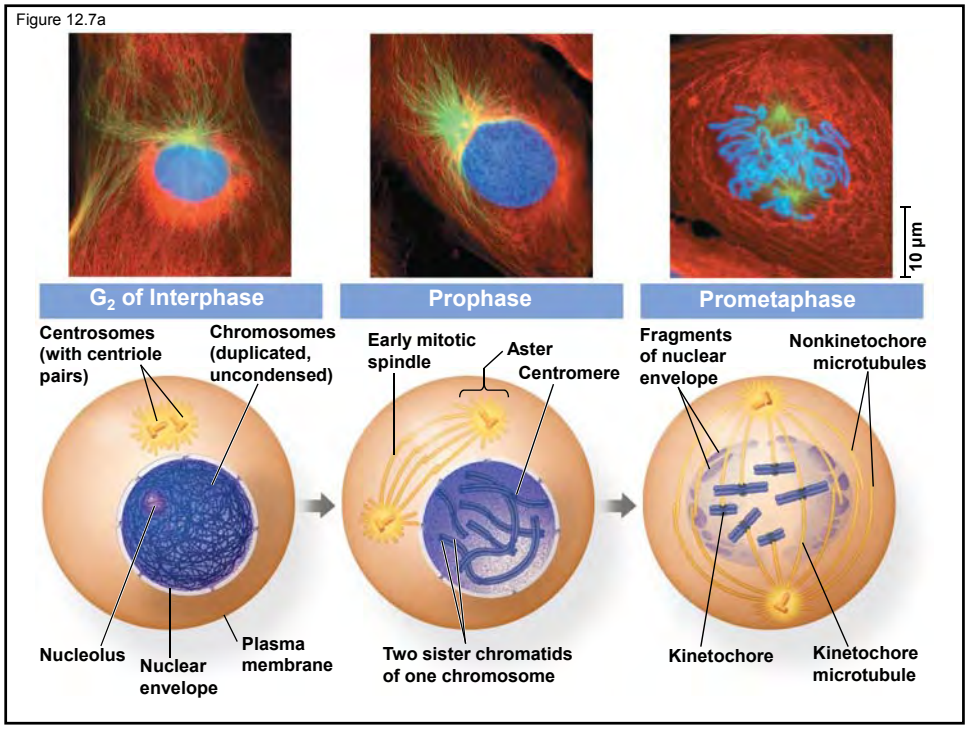
- Interphase G1, S, G2
- S (synthesis) – duplication of chromosomes
- Mitosis + cytokinesis M 1 hr, S 10 to 12 hrs
- G1 variable length (doing job), G2 5 hr prep
- G2 nuceolus envelope, uncondensed chrom
- Normal function and growth is in G1 (what we know cells to be at is G1)

Figure 12.6



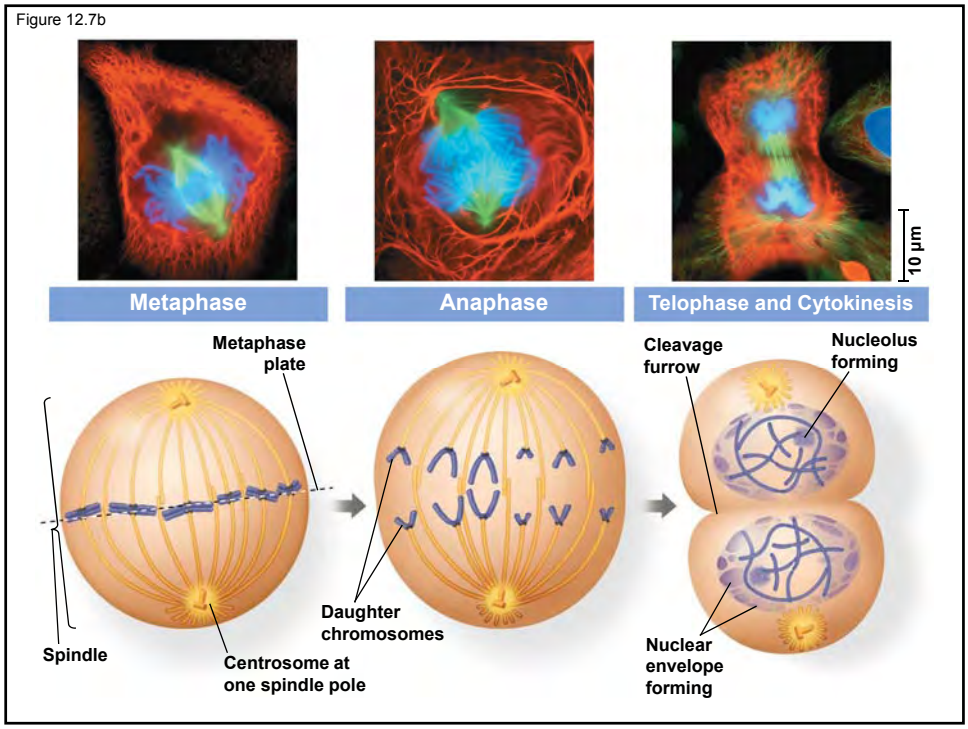
Substages of Mitosis.

- 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



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



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

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

Figure 12.8

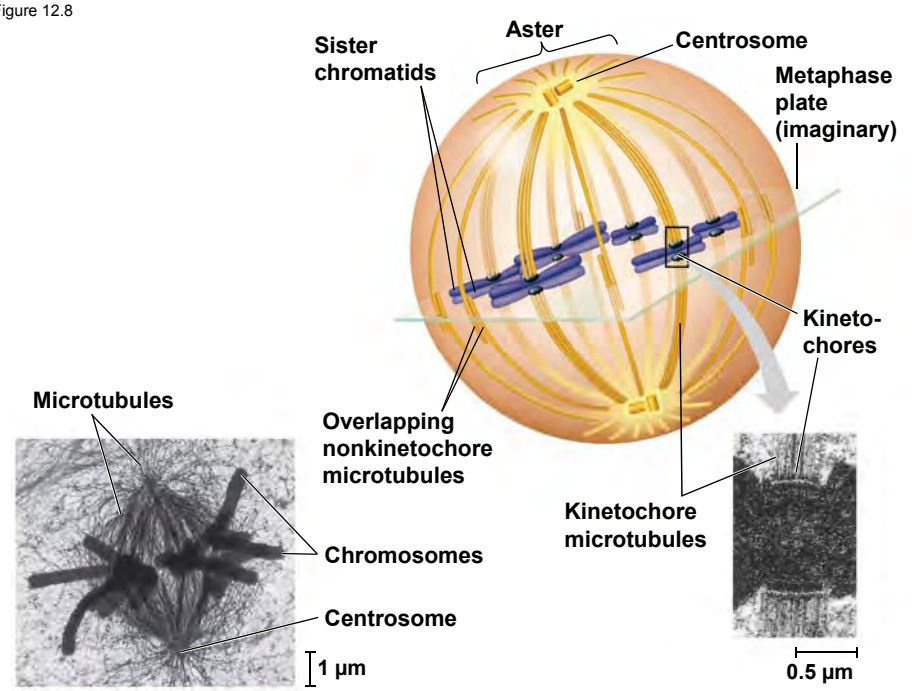
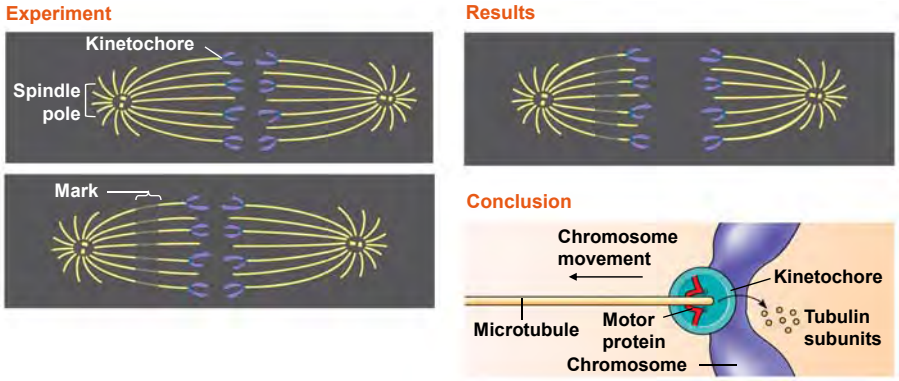


Figure 12.9



A closer look at cytokinesis.

- Animals: cleavage furrow at site of metaphase place 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.

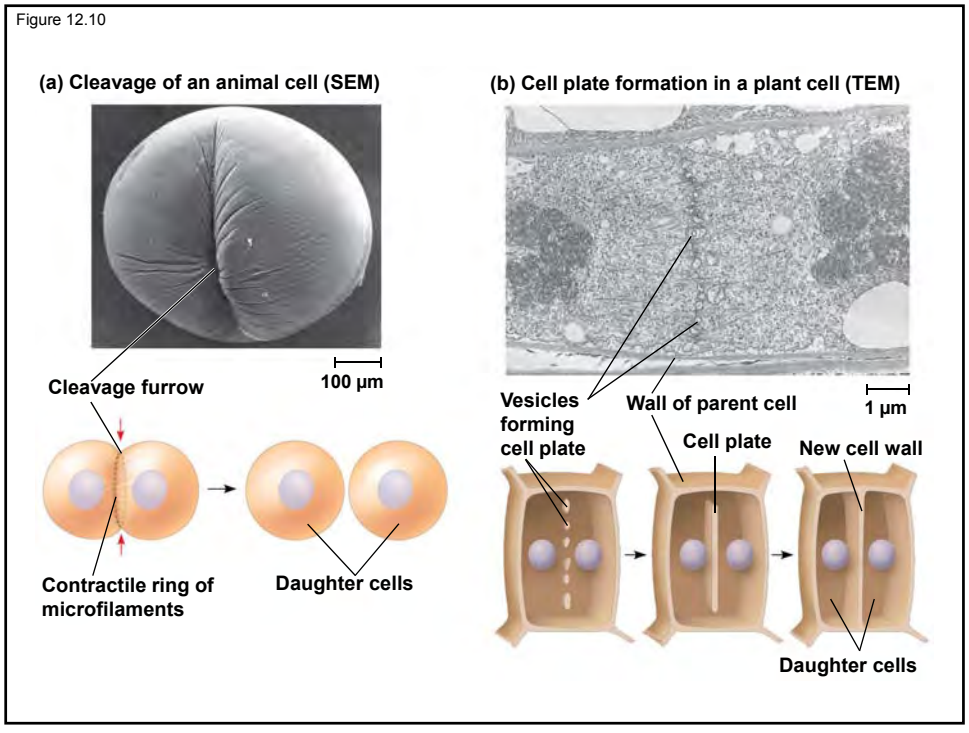
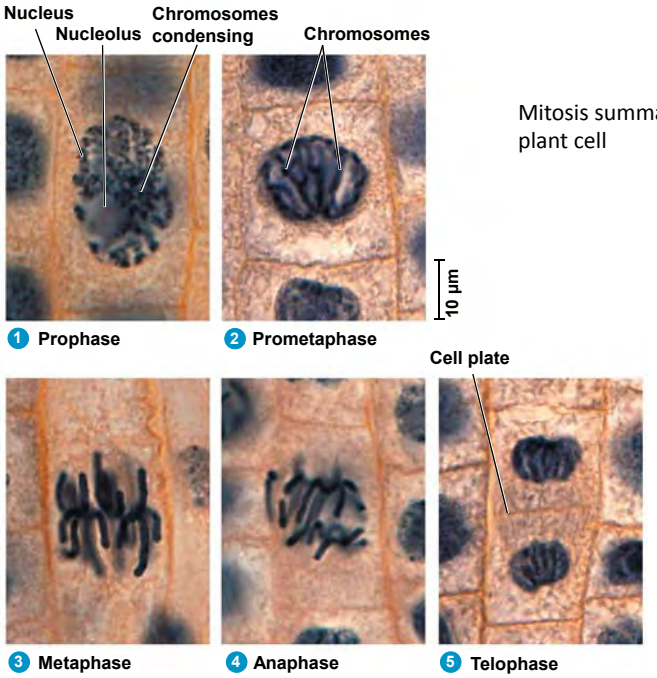


Figure 12.11

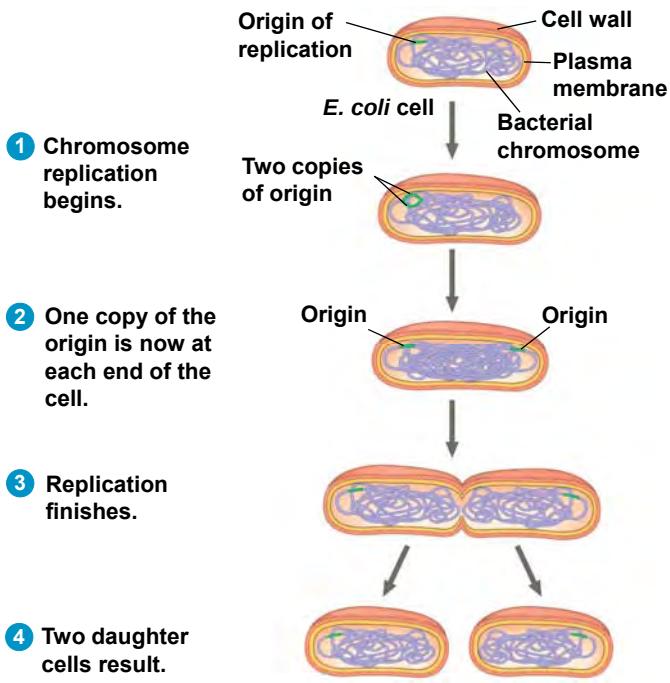


Mitosis summary in a plant cell

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

Figure 12.12-4



Cell cycle control by cylin 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 checkpts.
- 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.

Figure 12.15

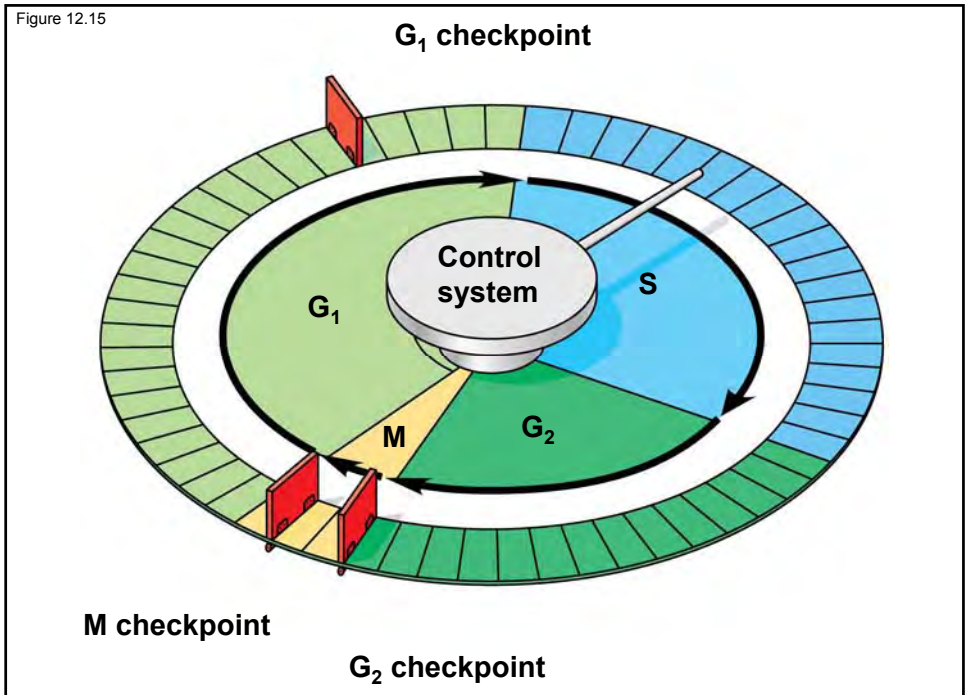
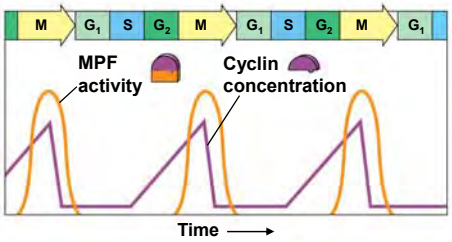
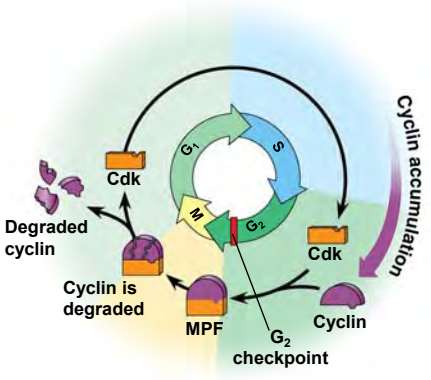


Figure 12.16



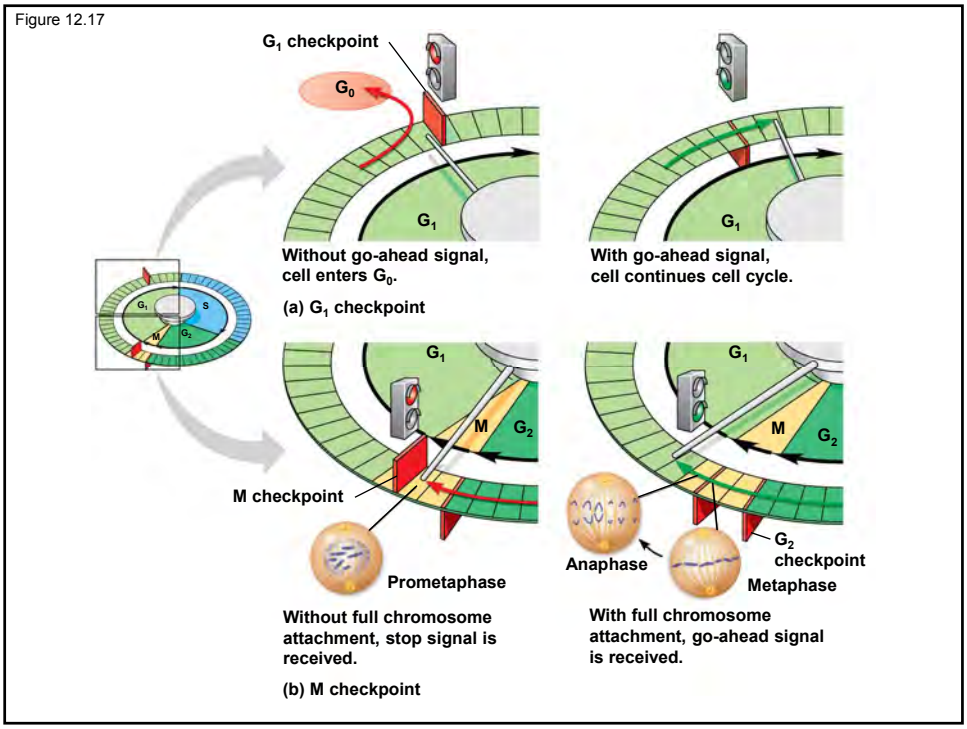
(a) Fluctuation of MPF activity and cyclin concentration during the cell cycle



(b) Molecular mechanisms that help regulate the cell cycle

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



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).

Figure 12.19

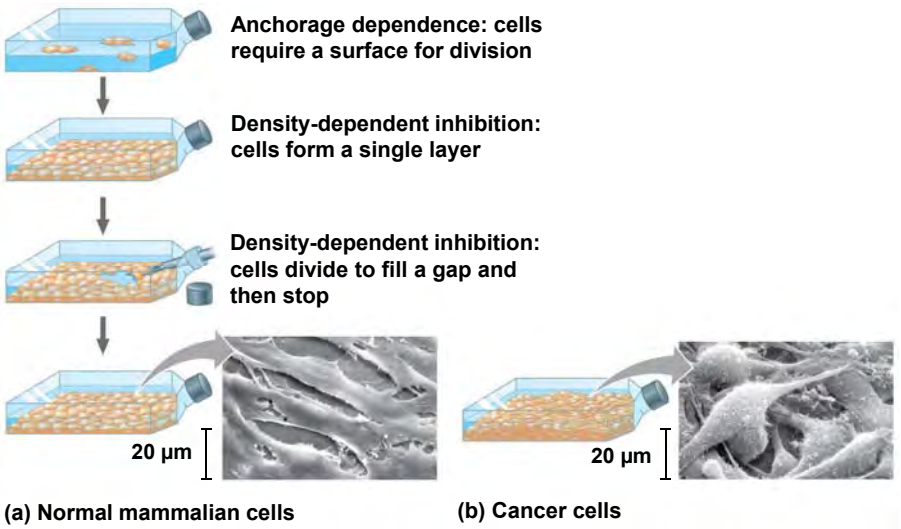
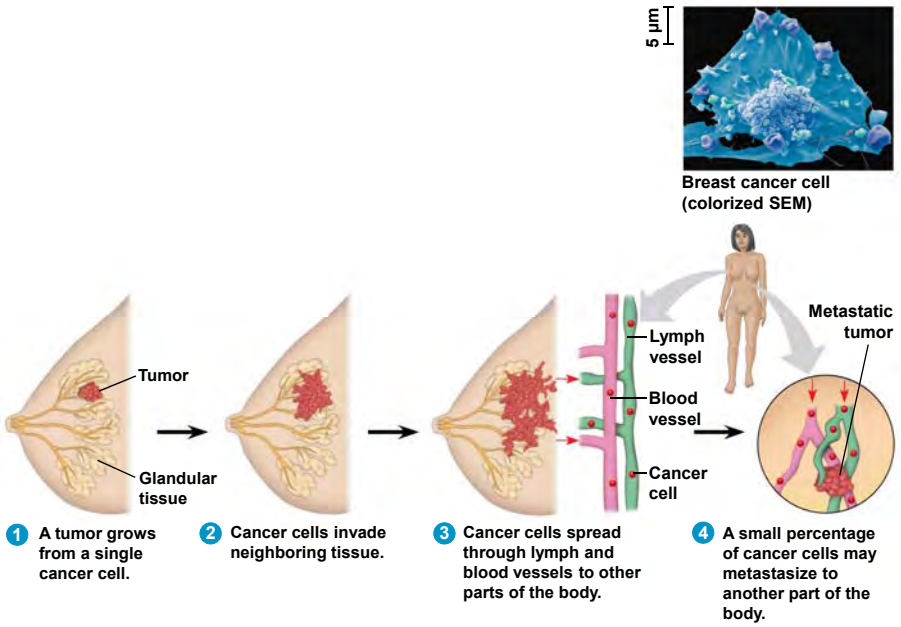


Figure 12.20



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