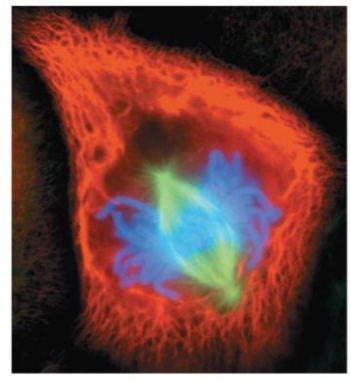
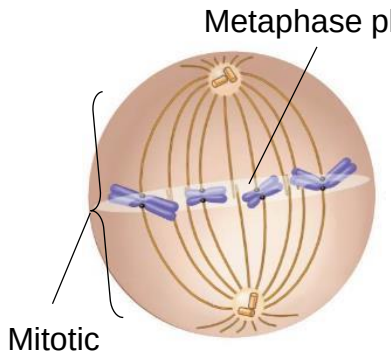
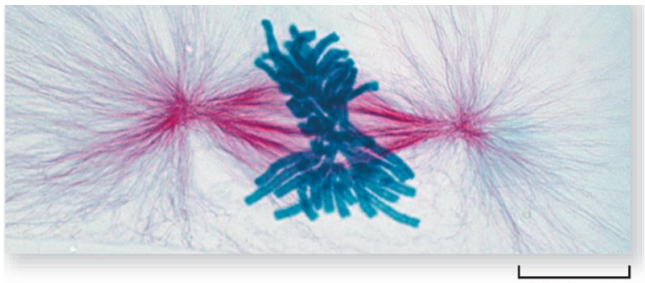
4). metaphase: 中期
chromosomes line up on metaphase plate (equatorial plane) due to the pulling force from the opposite poles and cohesion



Metaphase



1



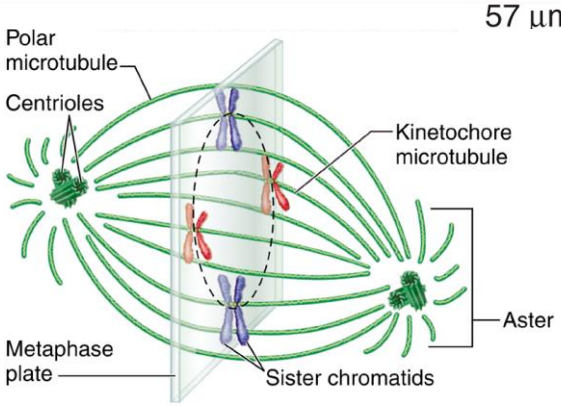


Fig.10.12

2

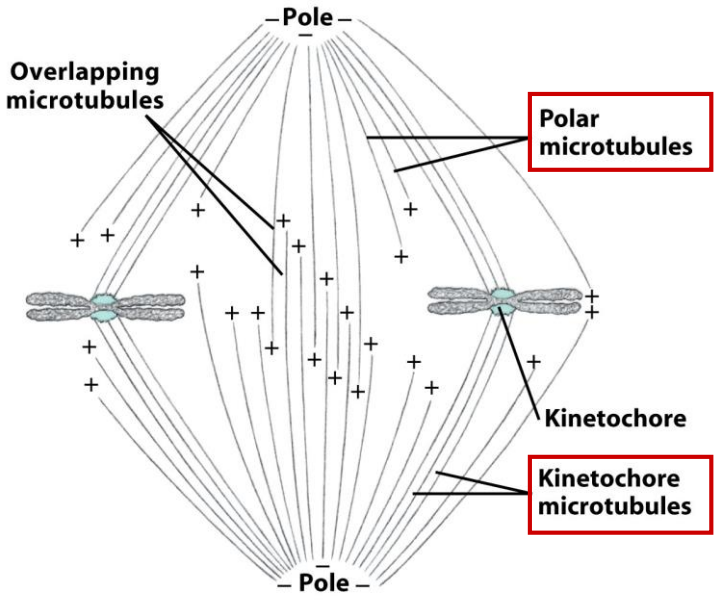


Figure 3-42
Biology of Plants, Seventh Edition

3

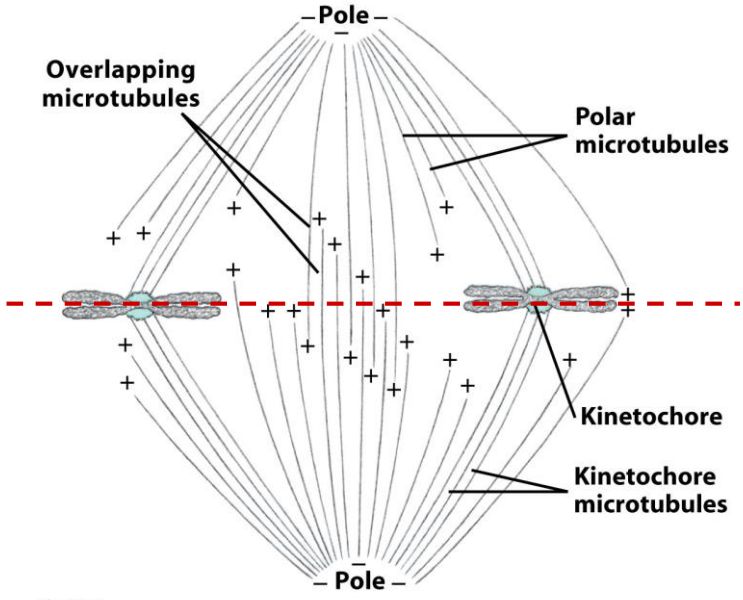


Figure 3-42
Biology of Plants, Seventh Edition

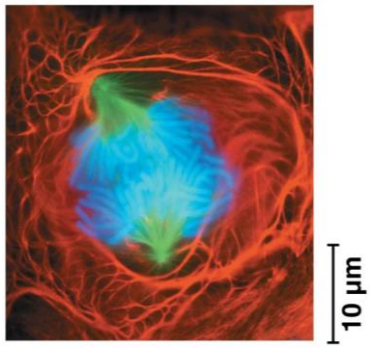
4

§ in mitosis and meiosis
chromosomes line up on equatorial plane (metaphase plate), due to bipolar attachments
-> bilateral symmetry (to each separation unit)
-> to ensure proper separation of sister chromatids

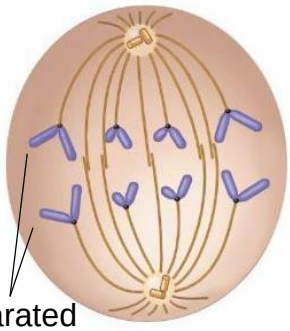
do not forget cohesion

5

5). anaphase:後期
- sister chromatids separate
-> daughter chromosomes
-> move toward opposite poles



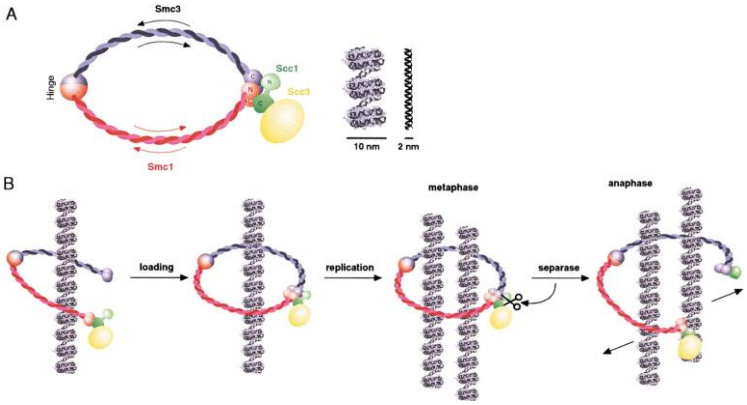
Anaphase


Separated chromosomes

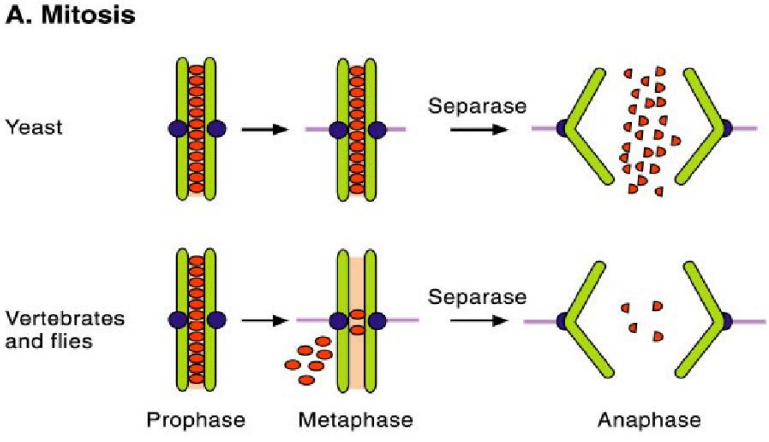
6

5). anaphase:

- sister chromatids separate
  (proteolysis of cohesin complex)
  -> daughter chromosomes
  -> move toward opposite poles

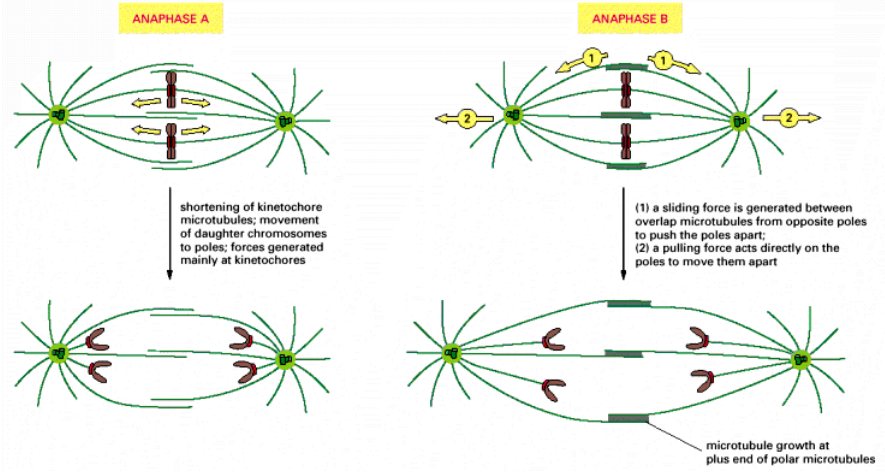


7



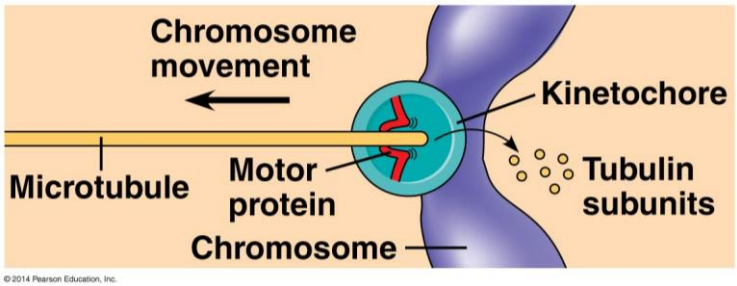
8

anaphase A: poleward movement of chromosomes
anaphase B: poles move farther apart

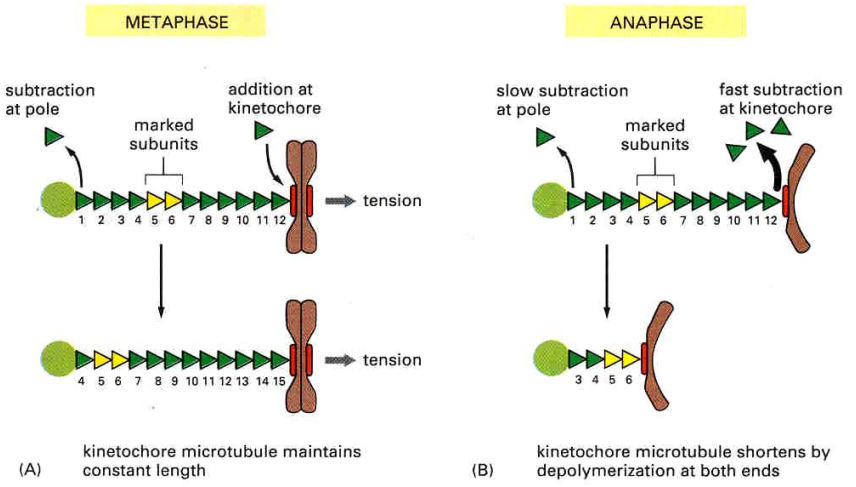


9

anaphase A: poleward movement of chromosomes
two mechanisms:
shortening of kinetochore microtubules
kinetochore "walking" on microtubules

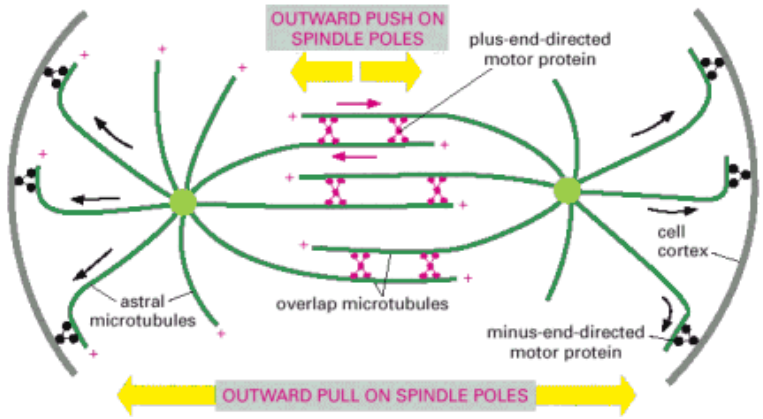


10

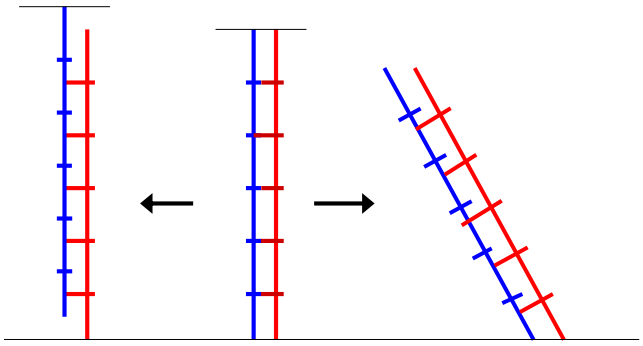


11

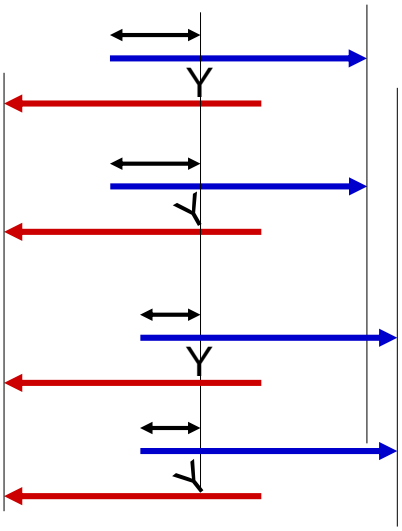
anaphase B: poles move farther apart
by a pushing force between the polar microtubules from the opposite poles and pulling force to the poles by astral microtubules
-> daughter chromosomes move further apart



12

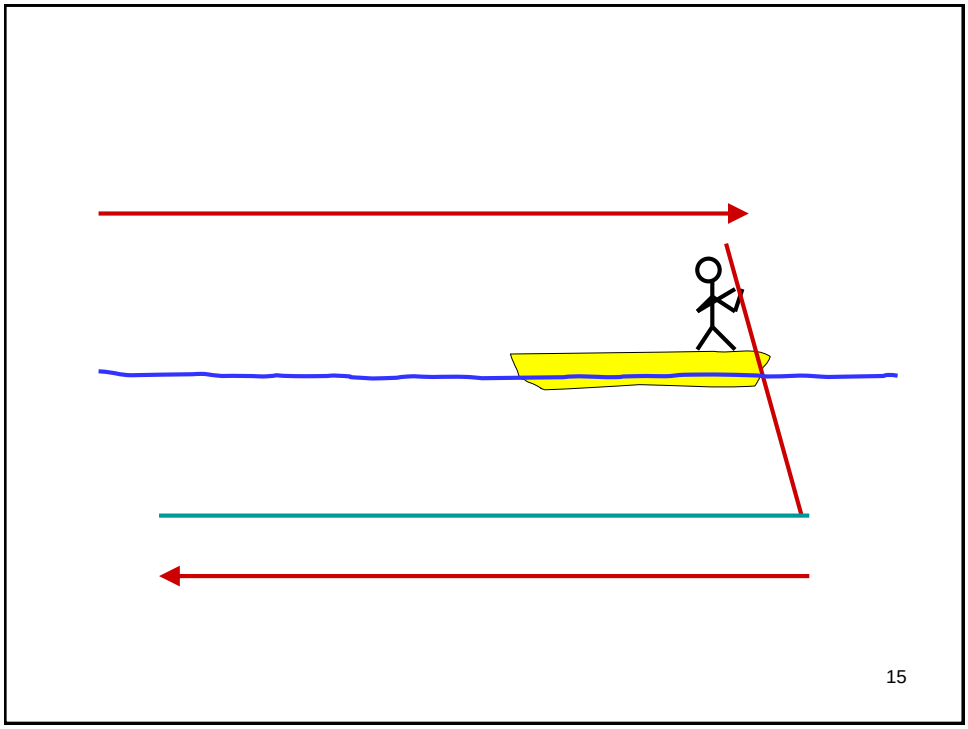


13

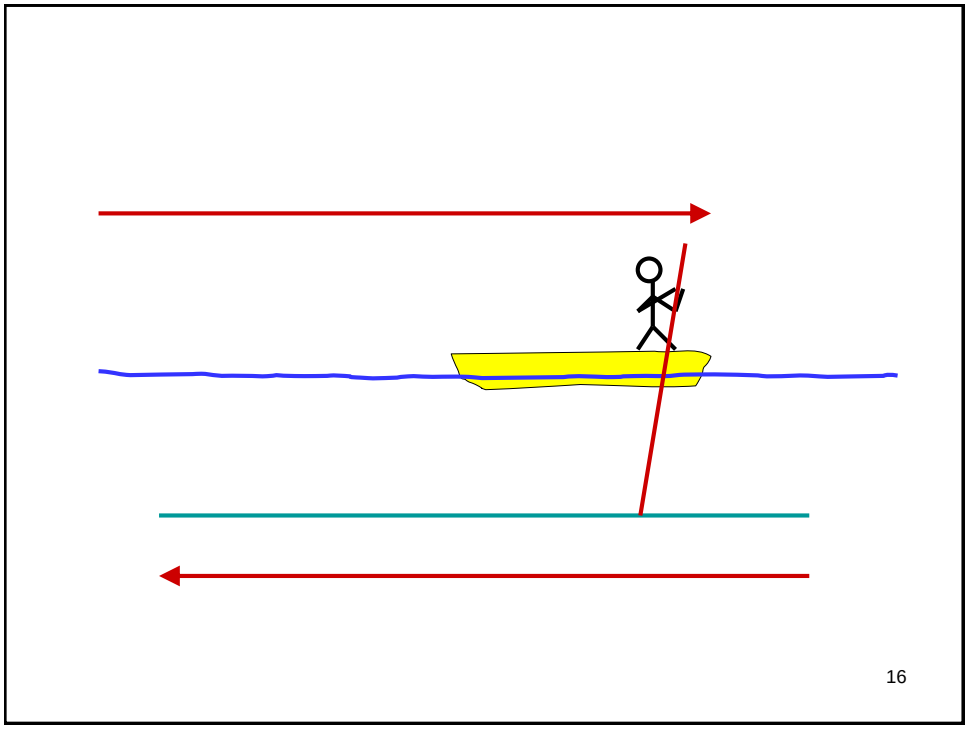


A model for how motor proteins may act in anaphase B.

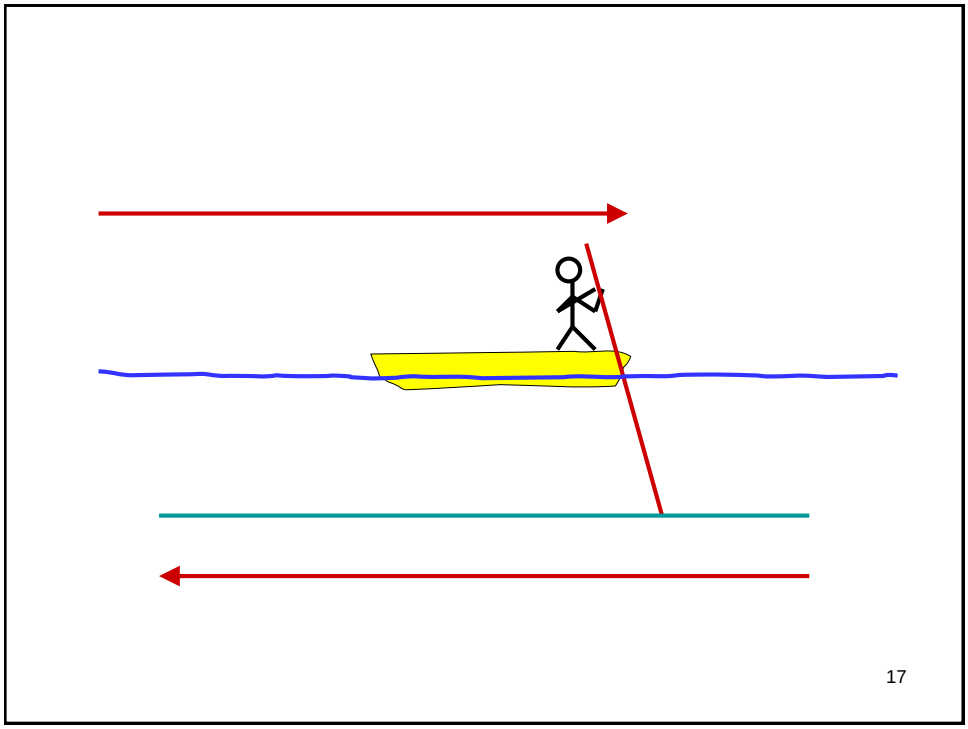
14



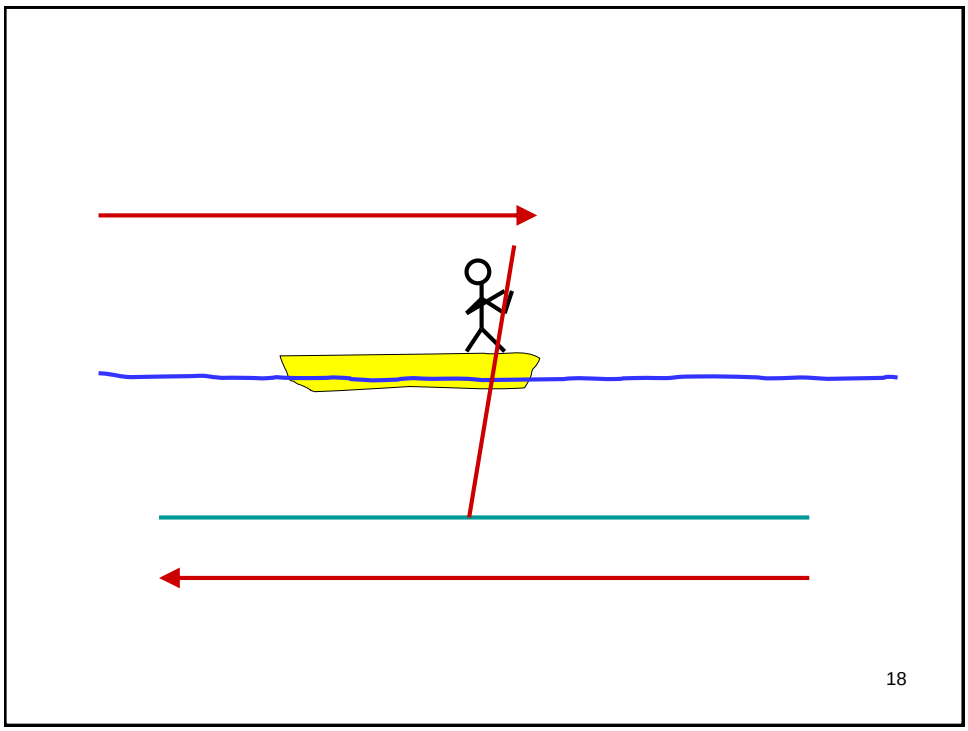
15



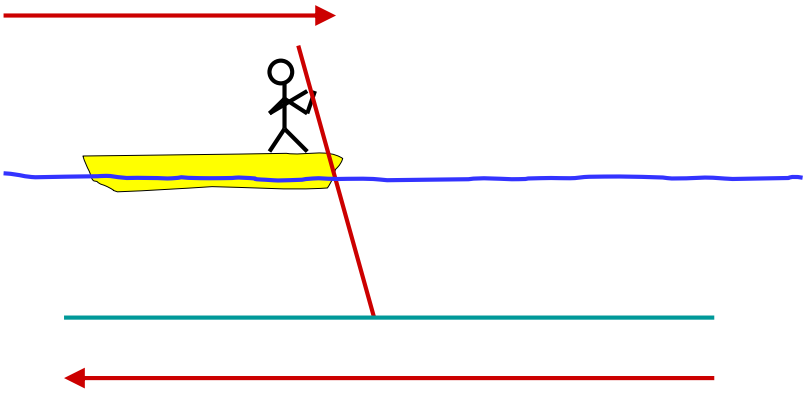
16



17

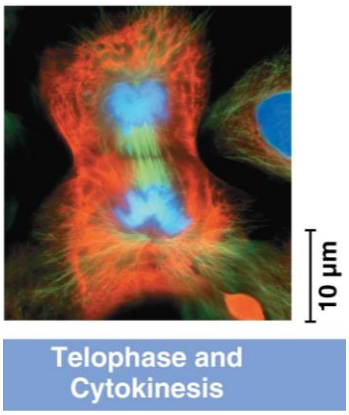


18

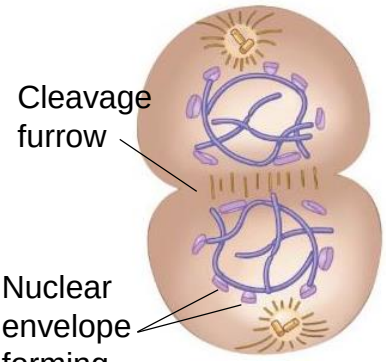


19

6). telophase 末期
- spindle disassembles
- nuclear envelopes form -> daughter nuclei appear
- nucleolus appears
- chromosomes decondense



Telophase and Cytokinesis



20

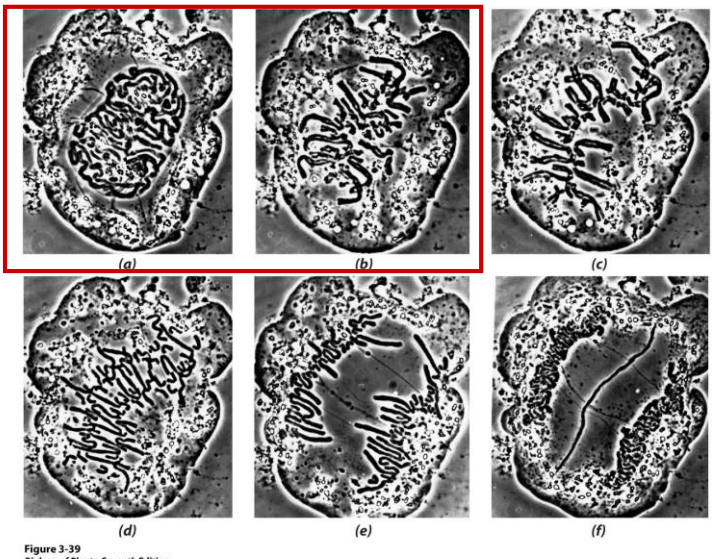


Figure 3-39
Biology of Plants, Seventh Edition

a: prophase; b: prometaphase

21

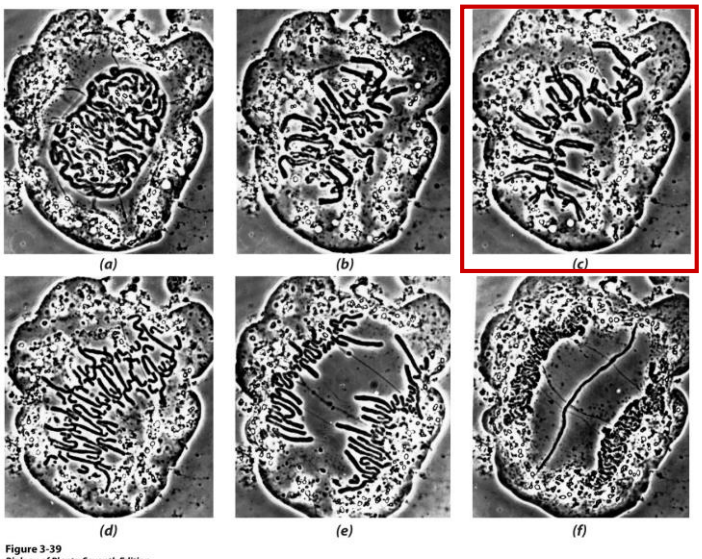


Figure 3-39
Biology of Plants, Seventh Edition

c: metaphase

22

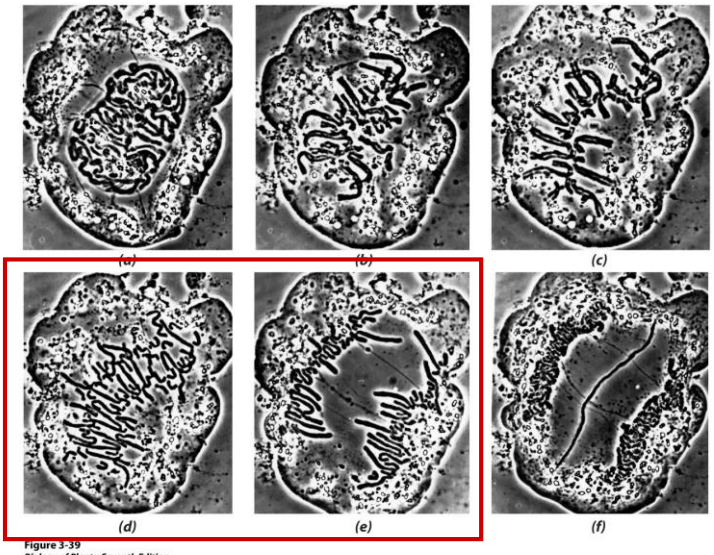


Figure 3-39
Biology of Plants, Seventh Edition

d,e: anaphase

23

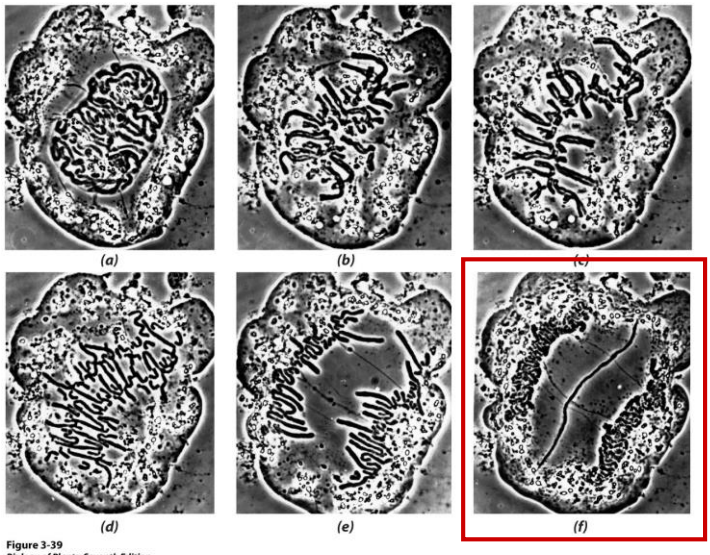
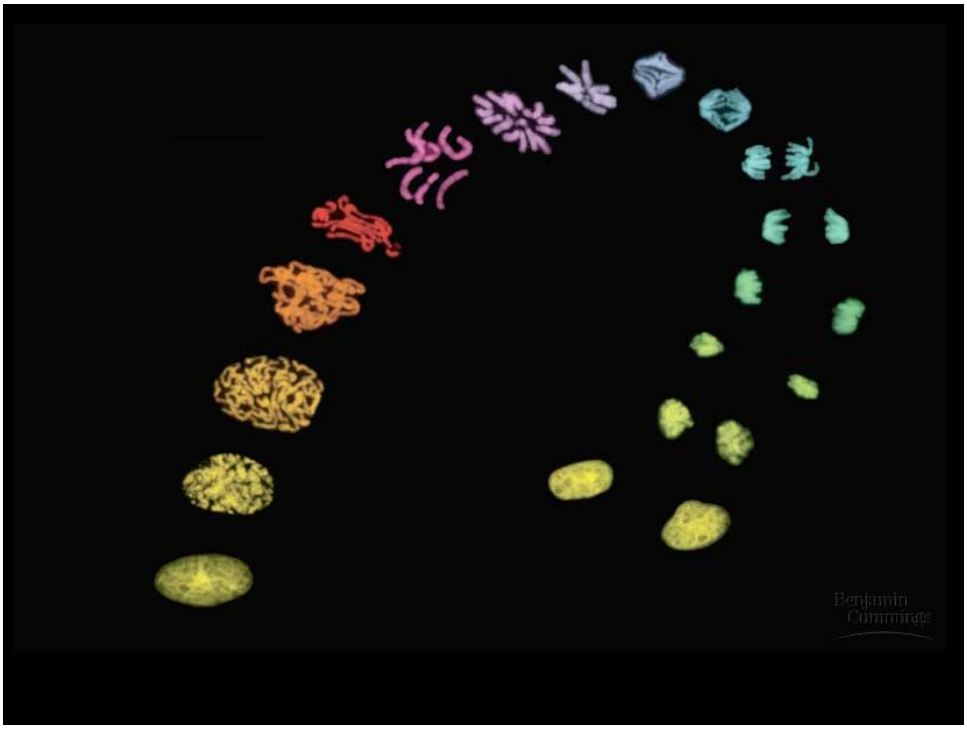


Figure 3-39
Biology of Plants, Seventh Edition

f: telophase

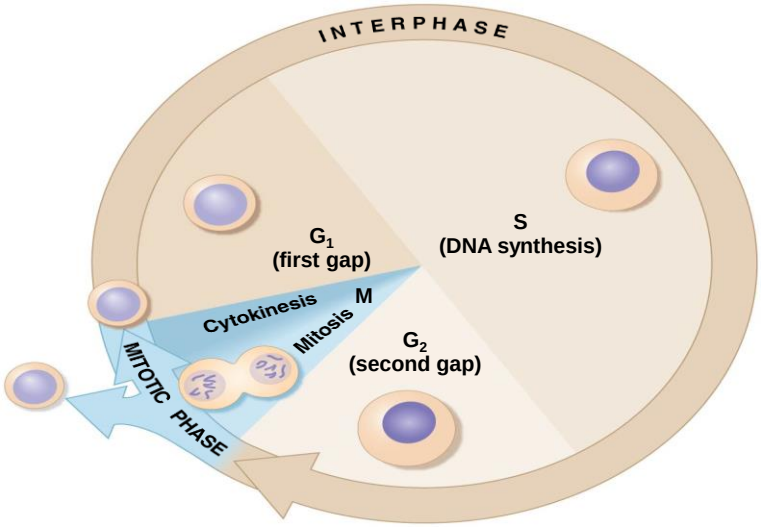
24



2). M (mitotic) phase

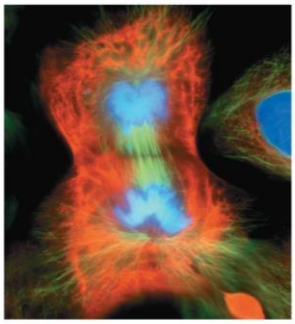
a. mitosis - chromosome separation

b. cytokinesis - division of cytoplasm

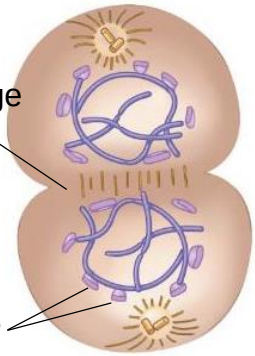


26

7). cytokinesis – divide the cell into two
- replication of organelles in S or G2
  -> partition into two daughter cells
- usually occurs along with telophase

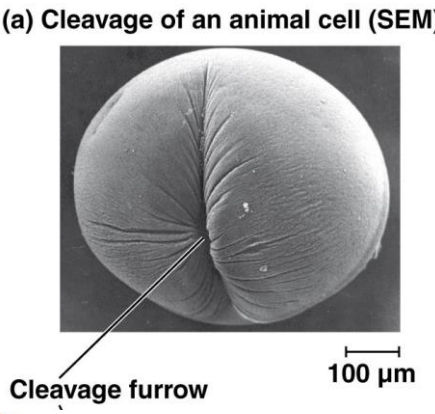


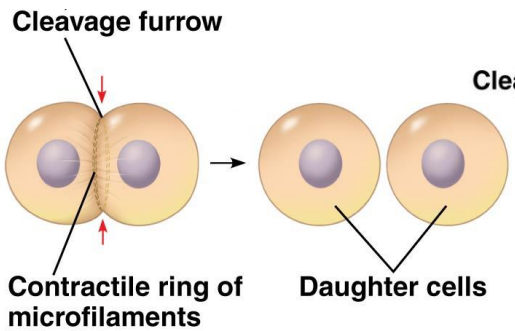
Telophase and Cytokinesis



27

- animal cells:
  ring of microfilament
  -> contracts
  -> cleavage furrow 分裂溝
  -> two cells

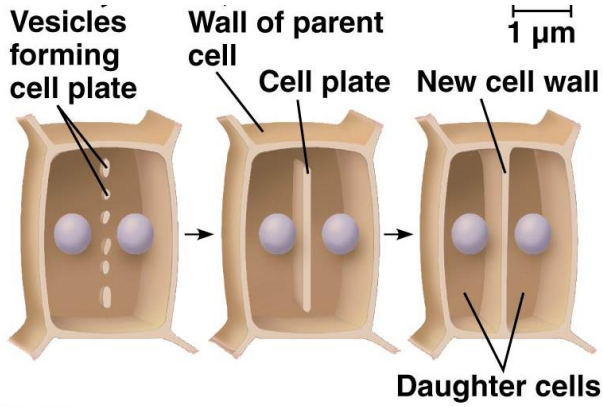




28

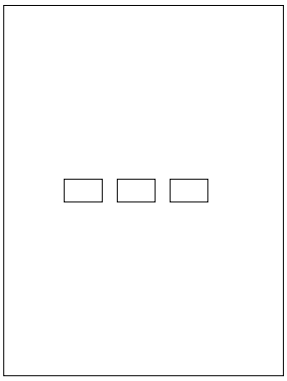
- plant cells:
  membrane-enclosed vesicles (containing cell wall materials) from the Golgi apparatus move to the middle of the parent cell

-> fuse to form cell plate 細胞板



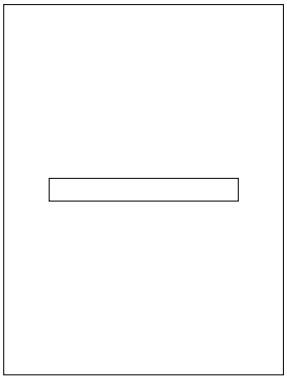
29

-> growing cell plate reaches and fuses with plasma membrane



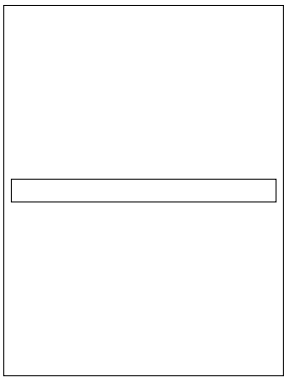
30

-> growing cell plate reaches and fuses with plasma membrane



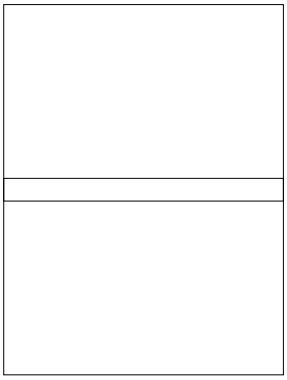
31

-> growing cell plate reaches and fuses with plasma membrane



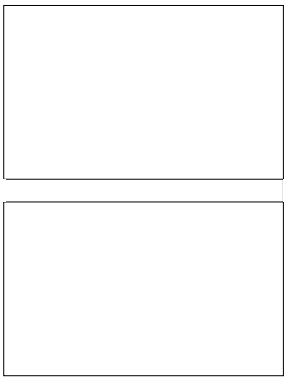
32

-> growing cell plate reaches and fuses with plasma membrane



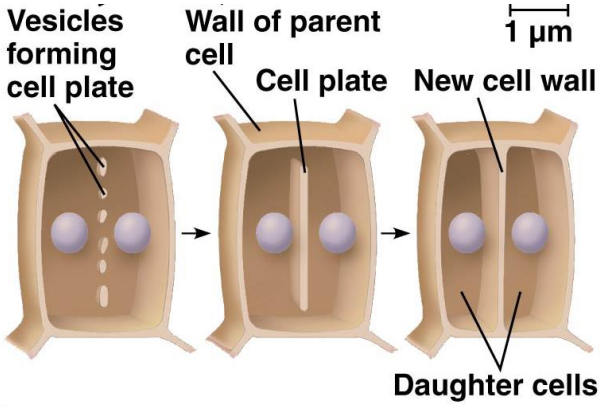
33

-> growing cell plate reaches and fuses with plasma membrane



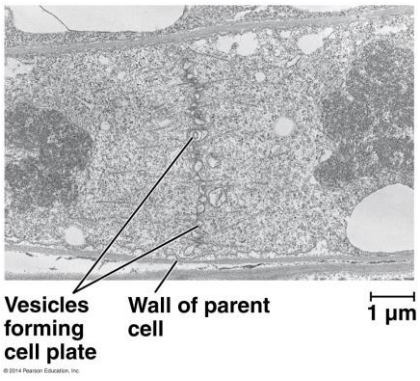
34

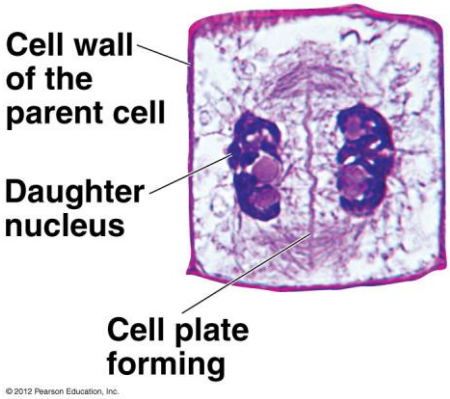
-> cell plate grows and fuses with plasma membrane
-> cell wall formation
-> two cells



35

- plant cells:
membrane-enclosed vesicles (containing cell wall materials) from the Golgi apparatus move to the middle of the parent cell





36

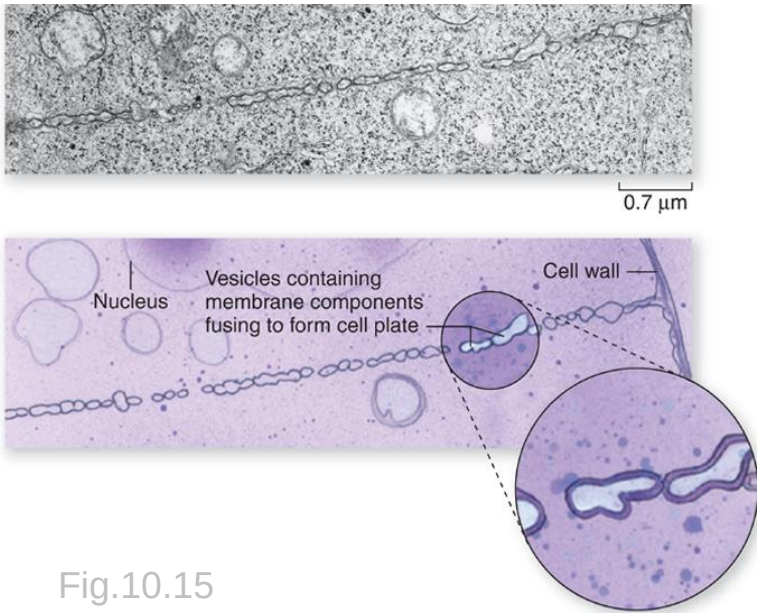
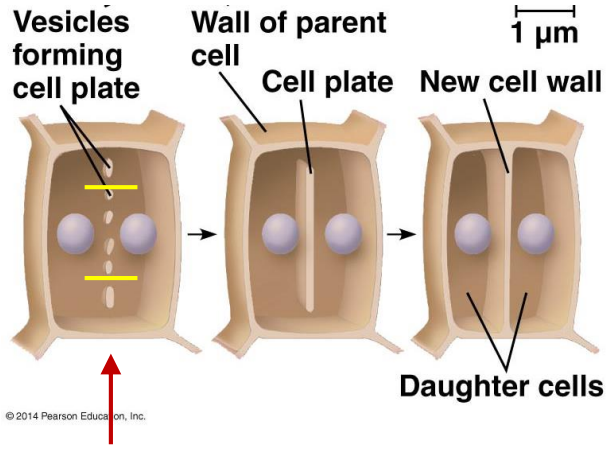


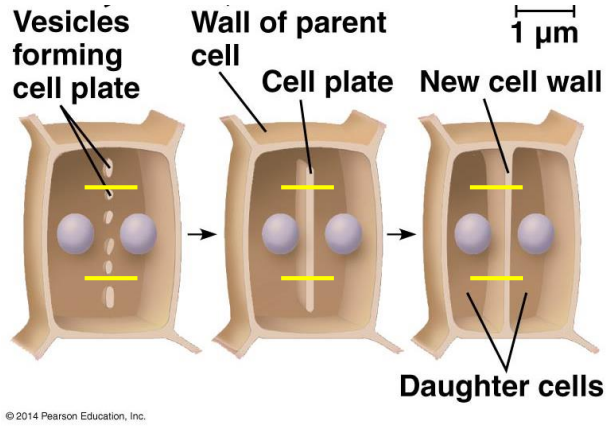
Fig.10.15

37



site of metaphase plate

38



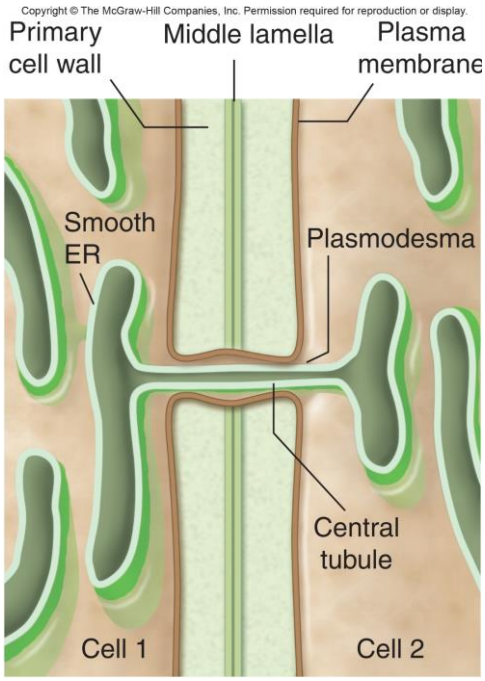
39

plasmodesmata: channels b/w adjacent cells,

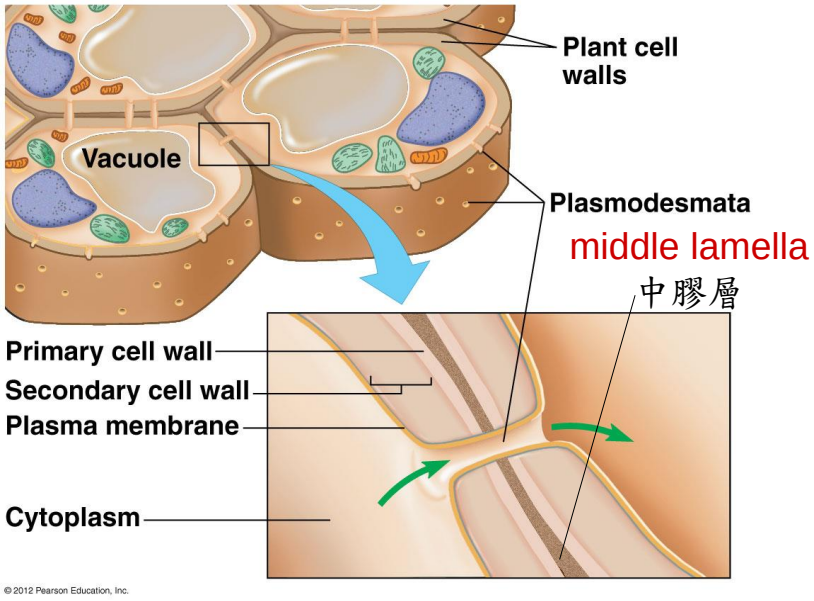
water and small molecules can pass through

原生質絲

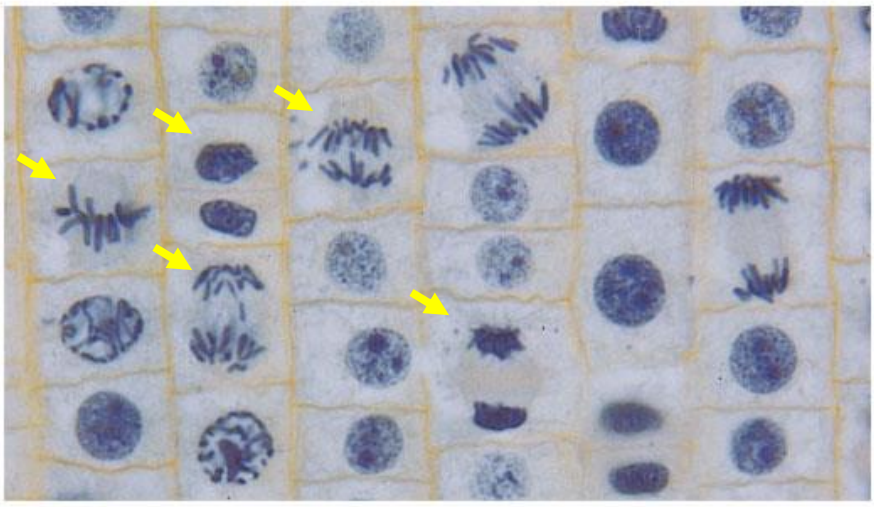
Fig.4.29



40


Plant cell walls
Vacuole
Plasmodesmata
middle lamella
中膠層
Primary cell wall
Secondary cell wall
Plasma membrane
Cytoplasm
© 2012 Pearson Education, Inc.

41



42

VI. Cell cycle control

1) Cell division is a complicated process and needs a good control

- cell-cycle control system triggers and coordinates cell cycle events

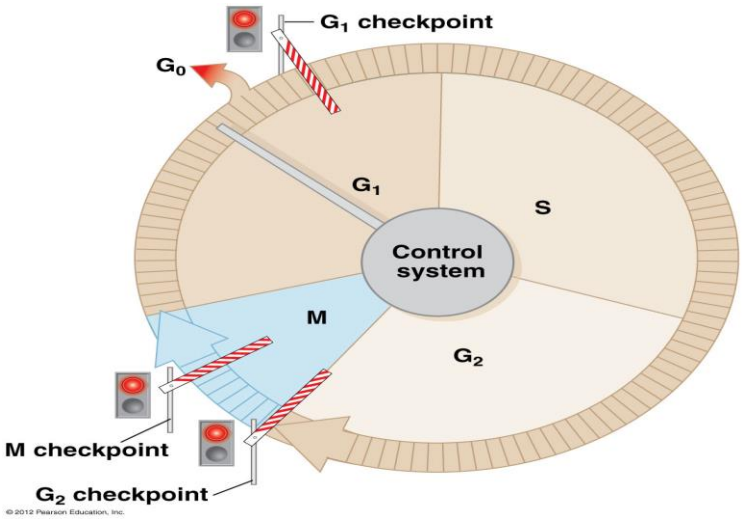
a. irreversible points:
DNA replication, separation of sister chromatids

b. can be arrest (put on hold) at specific points
-> checkpoints

43

2) checkpoints

cell-cycle control works through checkpoints to determine the initiation or continuation of cell cycle:



44

2) checkpoints

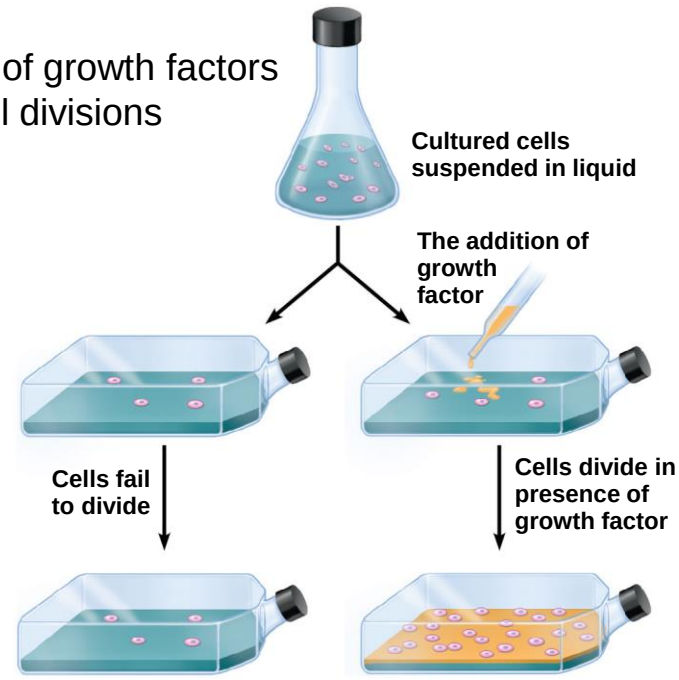
- sense and execute

A. cell-cycle control system responds to signals

- outside:
  - nutrients,
  - growth factors,
  - anchorage dependence,
  - density-dependent inhibition
- inside:
  - cell size,
  - events of the cycle

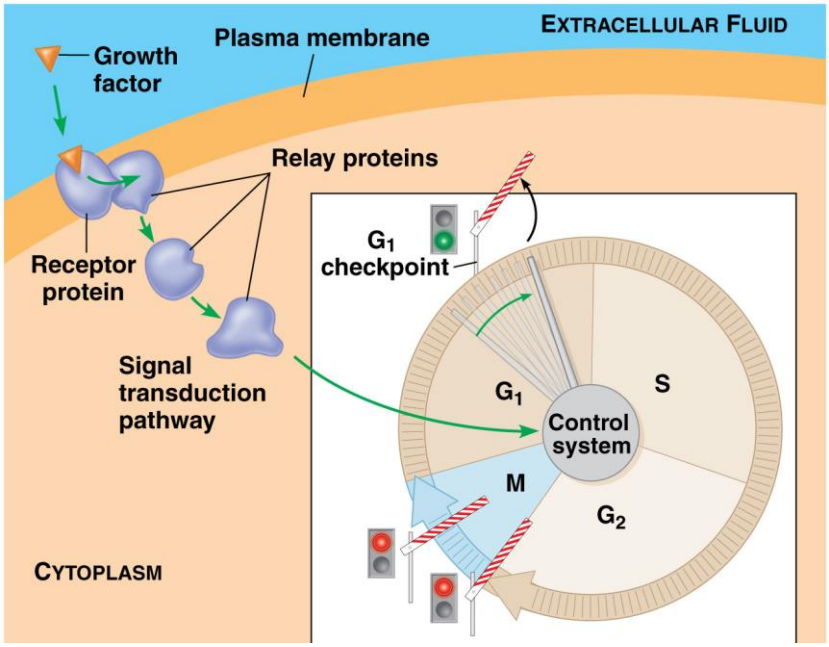
45

effect of growth factors on cell divisions

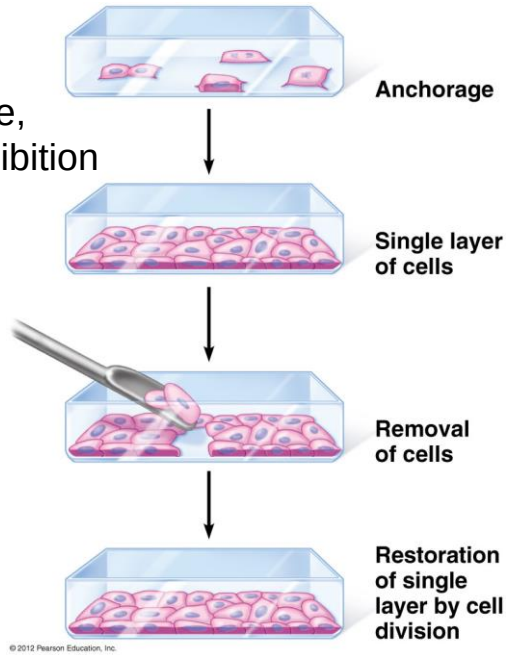


46

signal transduction of growth factors



anchorage dependence,
density-dependent inhibition



2) checkpoints

- sense and execute

A. cell-cycle control system responds to signals

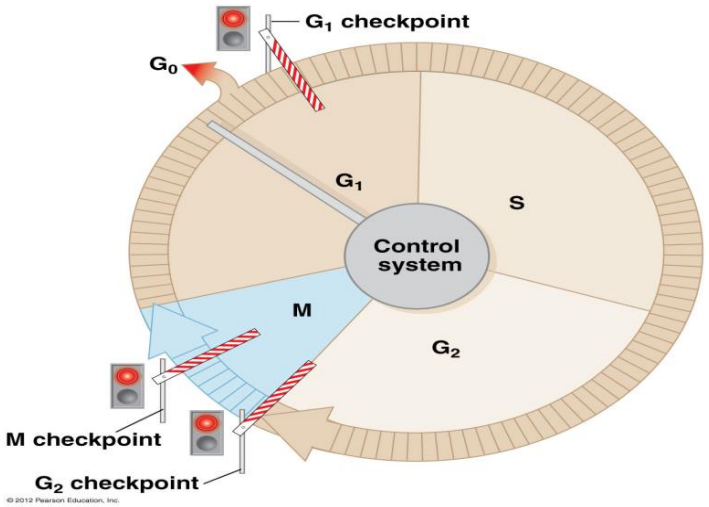
- outside:
  - nutrients,
  - growth factors,
  - anchorage dependence,
  - density-dependent inhibition
- inside:
  - cell size,
  - events of the cycle

49

B. where and how to control

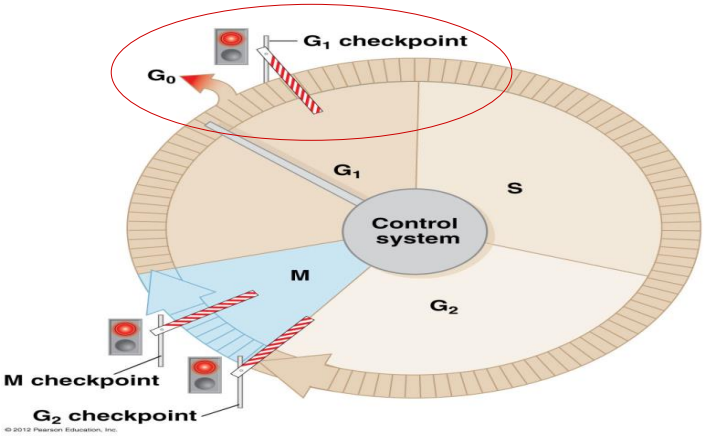
mostly, built-in stop signal, negative regulation

-> block, until overridden by go-ahead signal



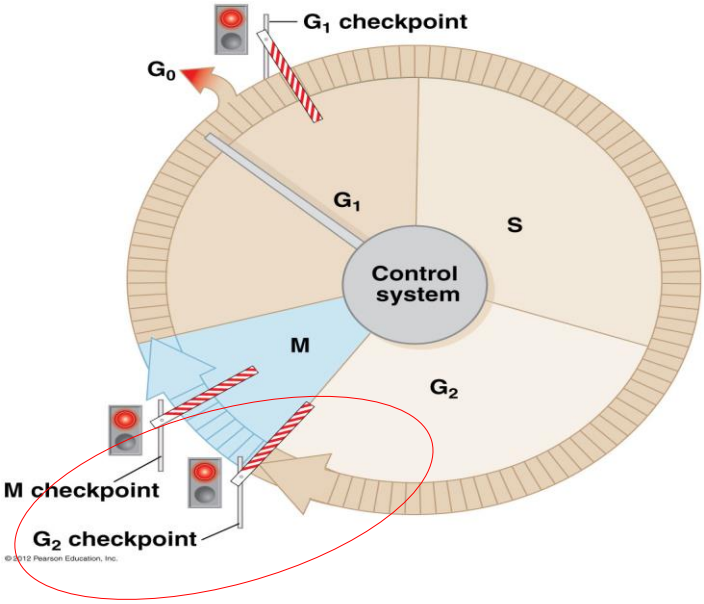
50

- major checkpoint:
  a. G1/S start cell cycle?
  START in yeast,
  restriction point (R point) in animals
  G0: exit from cell cycle, e.g., nerve cells



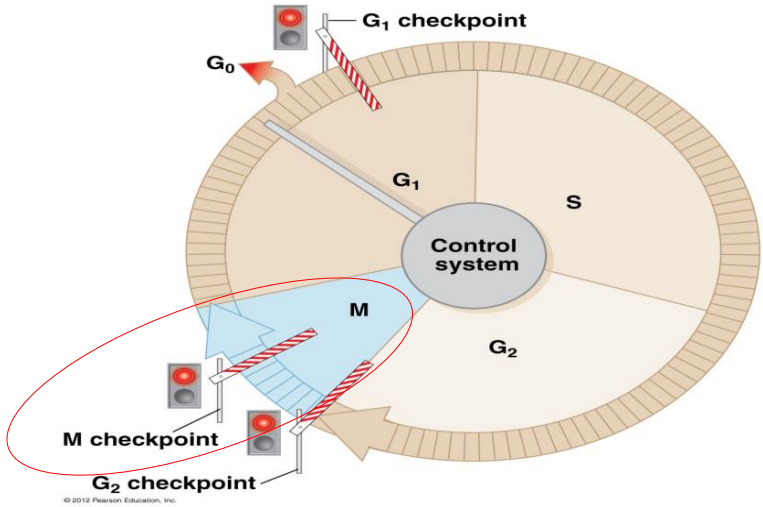
51

b. G2/M DNA replication complete?



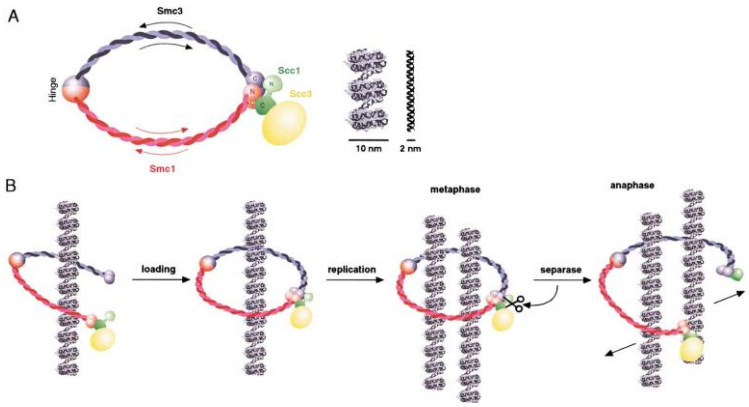
52

c. metaphase/anaphase (spindle checkpoint)
kinetochores attach to spindle microtubule?



53

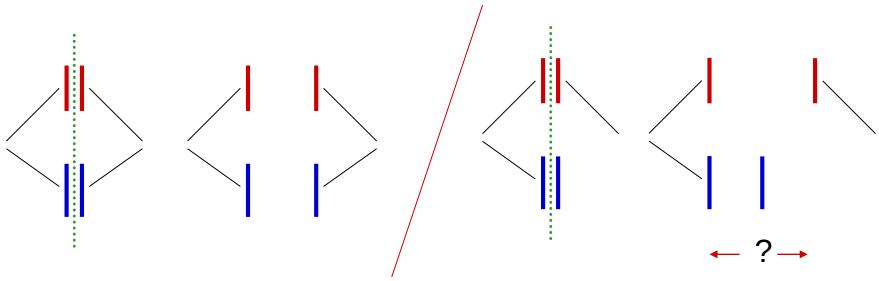
anaphase:
- sister chromatids separate
(proteolysis of cohesin complex)
-> daughter chromosomes
-> move toward opposite poles



54

c. metaphase -> anaphase checkpoint,
- if anaphase is initiated before kinetochores become properly attached to microtubules

-> nondisjunction, daughter cells have missing or extra chromosomes



55

Checkpoints ensure the proper order of events in mitotic cell cycle by arresting or delaying in response to defects in cellular process.

Therefore, the integrity of genetic information is maintained

-> to prevent failure and inviability in cell division

56

3). cancer, a cell cycle disease
- single cell -> transformation (mutation)
  -> cell cycle out of control
  -> division
  -> excessive growth of cells
  -> tumor

57

The Nobel Prize in Physiology or Medicine 2001

for their discoveries of key regulators of the cell cycle

Leland H. Hartwell

Fred Hutchinson Cancer Research Center
Seattle, WA, USA

b. 1939

Sir R. Timothy Hunt

Imperial Cancer Research Fund
London, United Kingdom

b. 1943

Sir Paul M. Nurse

Imperial Cancer Research Fund
London, United Kingdom

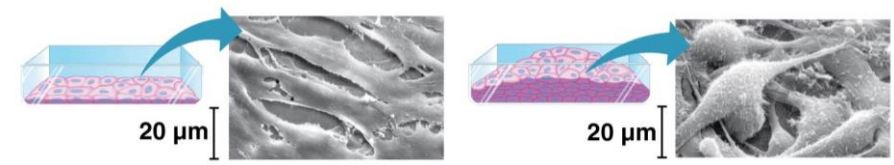
b. 1949

58

3). cancer, a cell cycle disease
- single cell -> transformation (mutation)
  -> cell cycle out of control
  -> division
  -> excessive growth of cells
  -> tumor

59

- immortal, don't need growth factor,
  no density inhibition, no anchorage dependence,
  no apoptosis 細胞凋亡

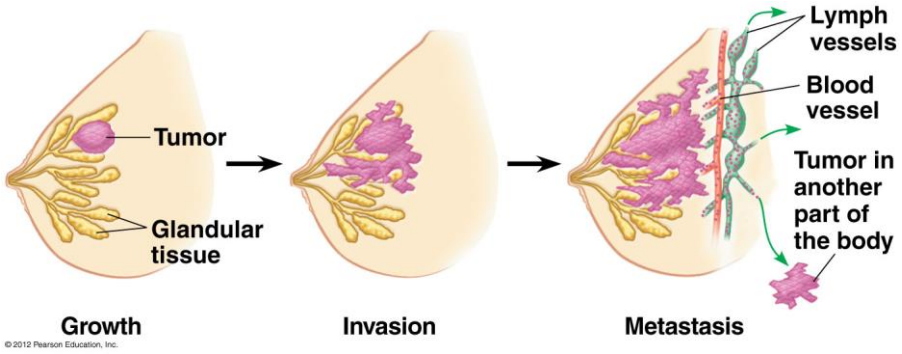


(a) Normal mammalian cells

(b) Cancer cells

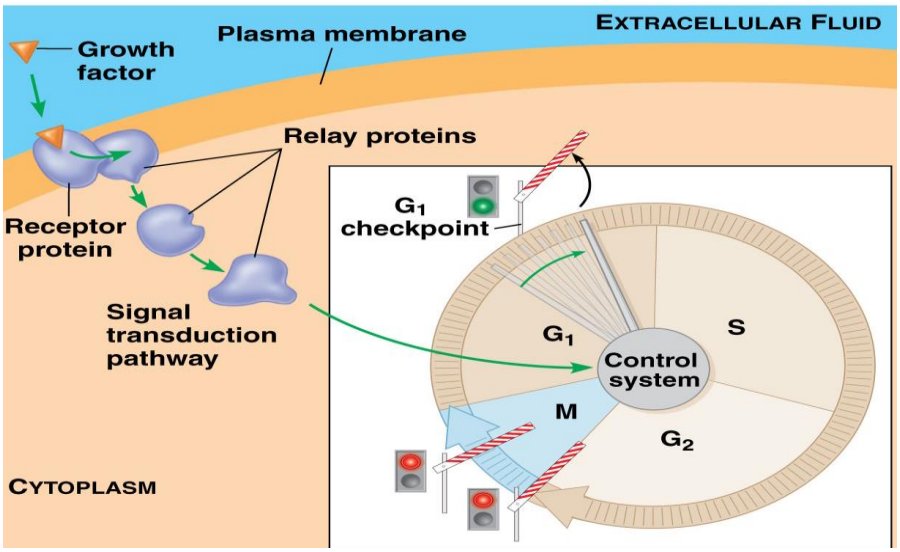
60

a. benign tumor: remain at the original site
b. malignant tumor:
-> spreading into neighboring and other tissue
-> displace normal cells -> cancer



61

- causes: defects (mutations) in the cell-cycle control system,
e.g., receptor, messenger, checkpoints



a. tumor suppressor genes:
e.g., p53 (DNA damage checkpoint),

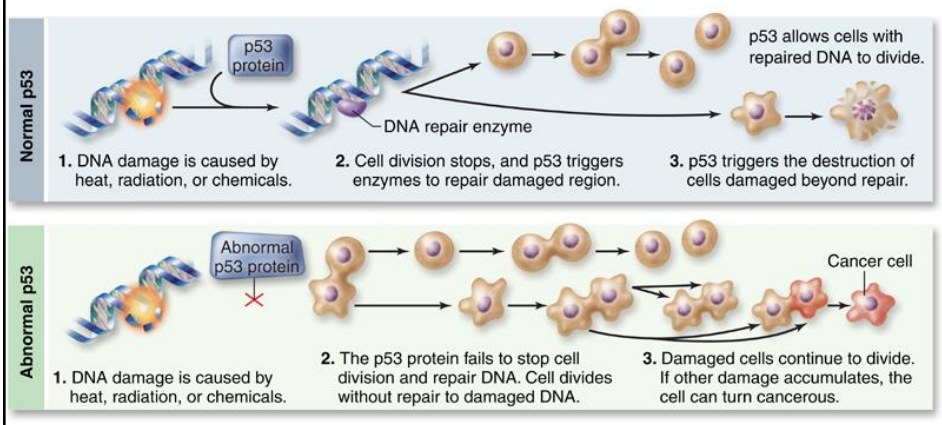


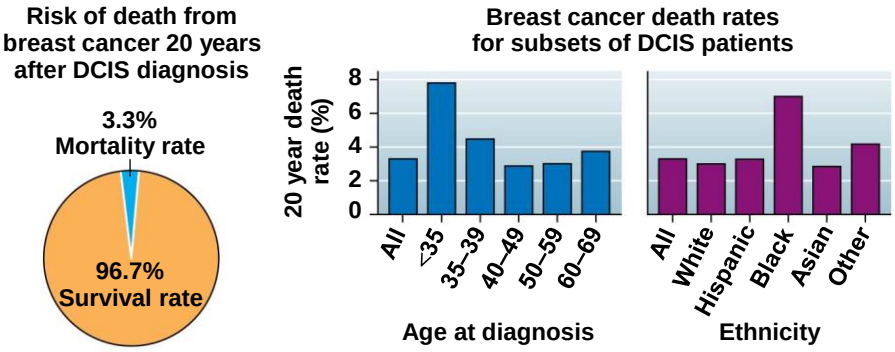
Fig.10.23

63

- treatments
  a. localized tumor:
    - surgery or radiation
  b. spreaded tumor:
    - chemotherapy
      -> disrupt specific steps in cell cycle,
      e.g., Taxol -> freeze spindle
      -> side effect, also target on normal cells

64

the breast cancer treatment may vary by individual
-> personalized therapy



DCIS: ductal carcinoma in situ 乳腺管原位癌

65