Genetic diversity

Gene expression and Regulation of Cell cycle

基因多樣性與細胞週期

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Cell Cycle and Cell Division

Cycling= replicating of somatic cells

1. Cell division:

- Produce two daughter cells

2. Cell cycle

- An ordered series of factors that lead to cell division

Mitosis

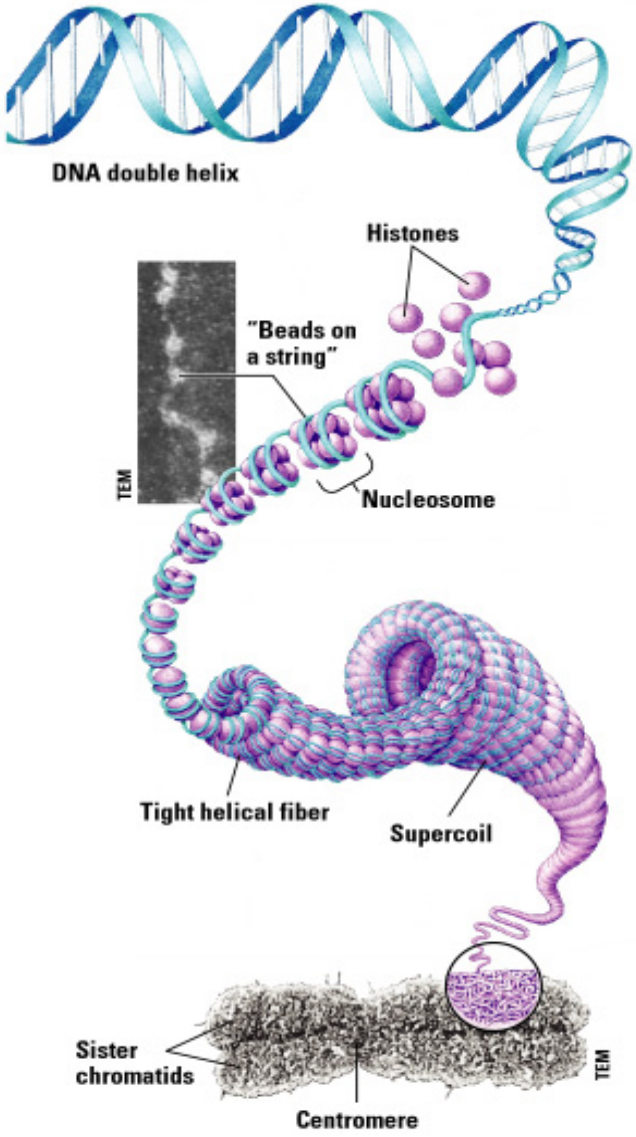
<u>功能:</u>

1. Growth
2. cell replacement
3. asexual reproduction

<u>兩階段:</u>

有絲分裂mitosis

細胞質分裂 cytokinesis



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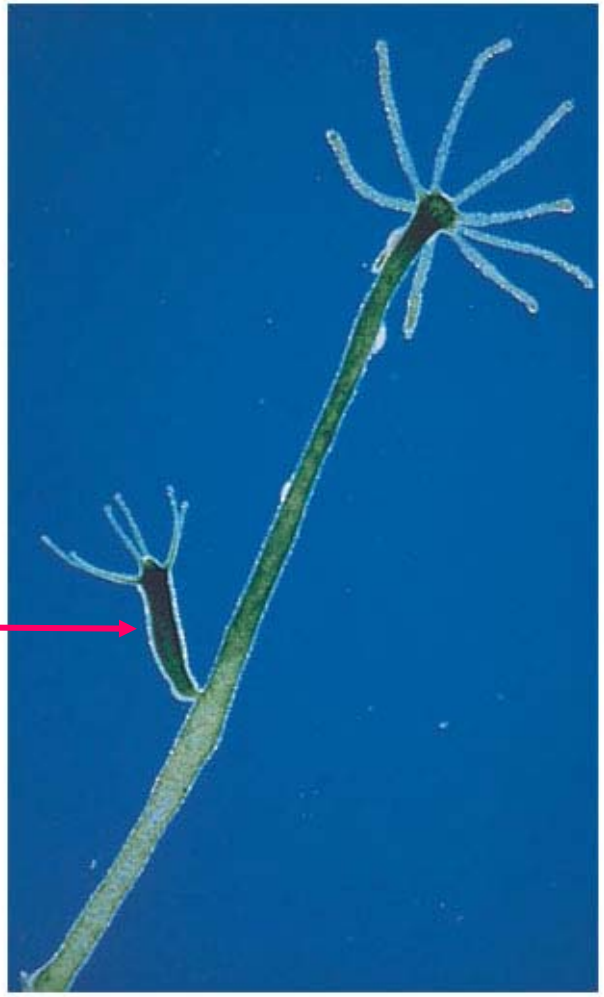
- Asexual reproduction (無性生殖)

出芽生殖



LM 10×

Figure 8.11C

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Cell proliferation/division:

- Replication of DNA

- Cell division

- 個體內組織內細胞複製差異
- 發育過程中的差異
- 保持生物個體的連續與穩定性。

Type: amitosis, mitosis, and meiosis

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8.3 Prokaryotes reproduce by binary fission (二分裂法)

- Prokaryotic cells
  - Reproduce asexually by cell division

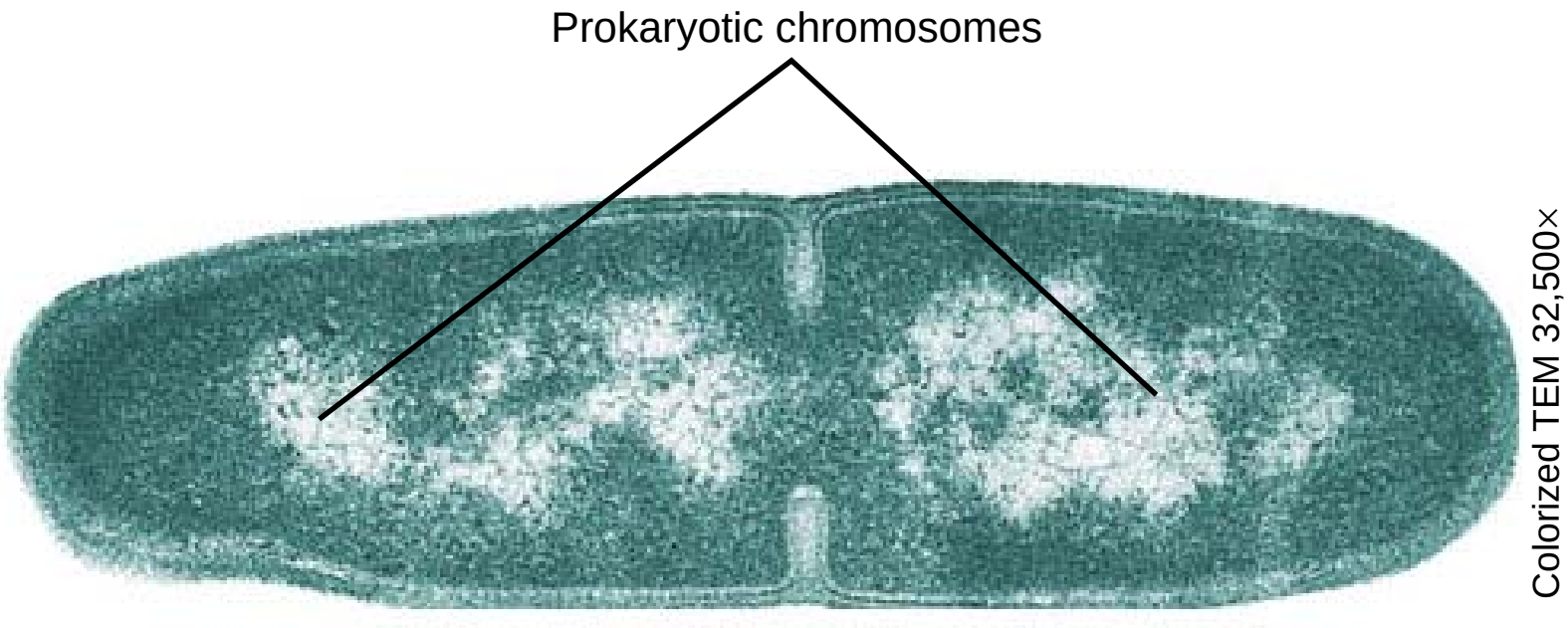

Figure 8.3B

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- As the cell replicates its single chromosome, the copies move apart
  - And the growing membrane then divides the cells

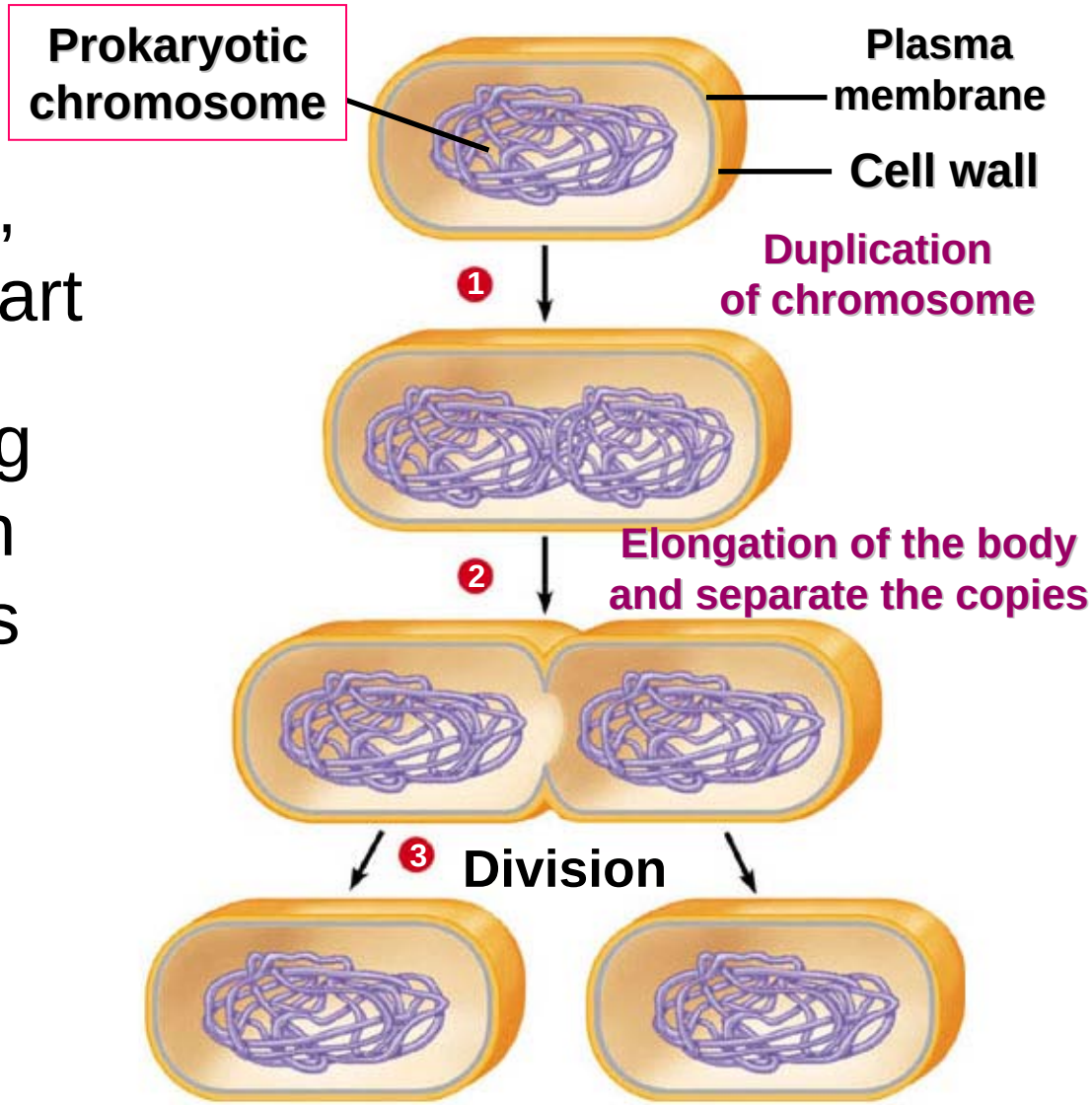

Figure 8.3A

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OVERVIEW of Cell Cycle

-An adult human consists of 10^{14} cells

-Millions of new cells are made everyday to replace dying ones and to adapt tissue mass to new demand

Cell self-replicate by duplicating their contents and dividing into two – mitotic cell cycle

細胞週期 cell cycle

1. G_0: 細胞生長期
2. G_1: 細胞準備期-1 (gap 1)
3. S: DNA 合成時期 (synthesis)
4. G_2: 細胞準備期-2 (gap 2)
5. M: 細胞分裂期 (Mitosis and cytokinesis)

間期 Interphase

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- During **interphase (G1+S+G2)**
  - Chromosomes duplicate and cell parts are made
- During the **mitotic phase (M phase)**
  - Duplicated chromosomes are evenly distributed into two daughter nuclei

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- The sister chromatids then separate
  - And move to opposite poles of the cell, where two nuclei form
- **Cytokinesis 細胞質分裂**, in which the cell divides in two
  - Overlaps the end of mitosis

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- The stages of cell division

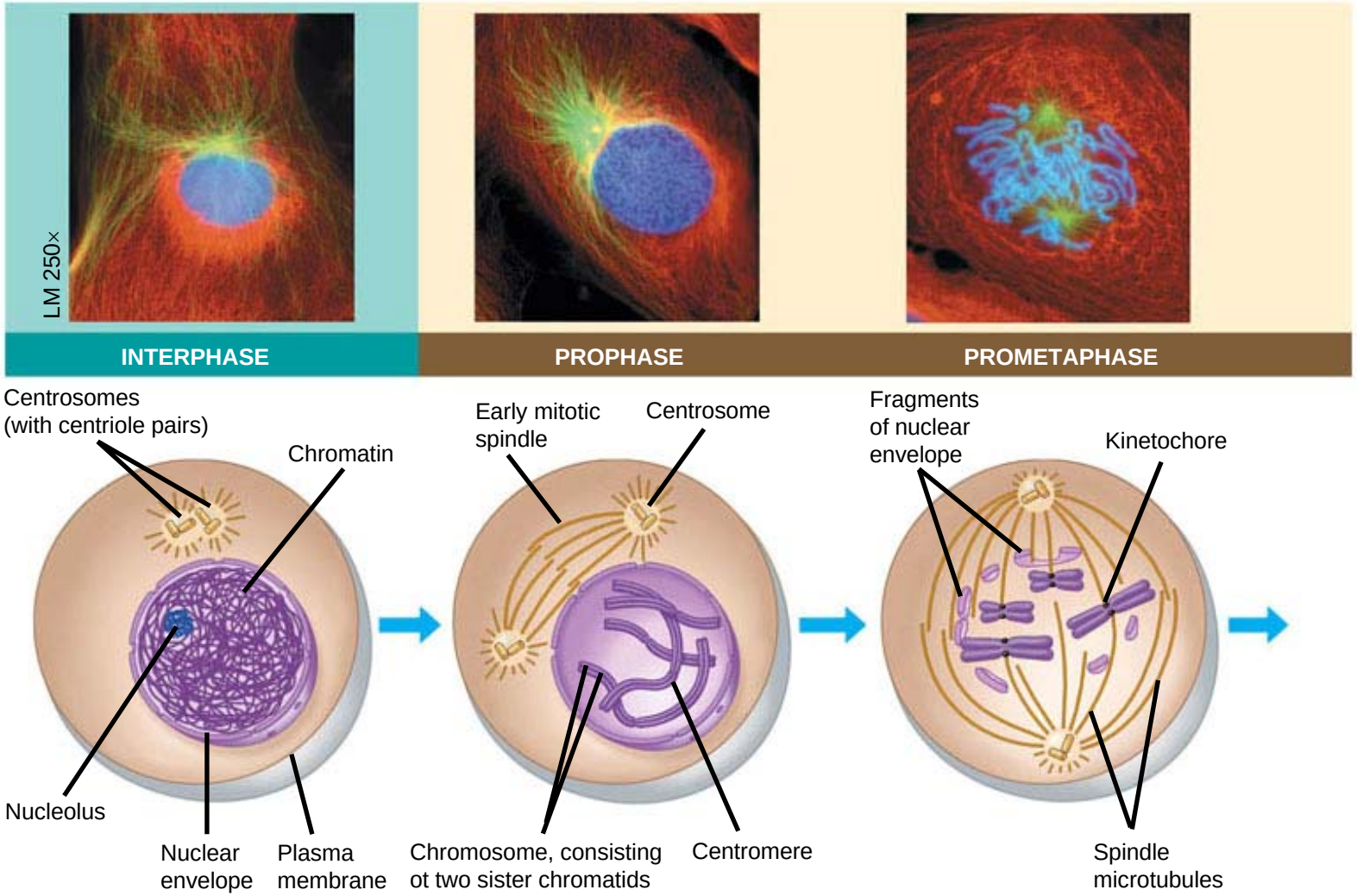

Figure 8.6 (Part 1)

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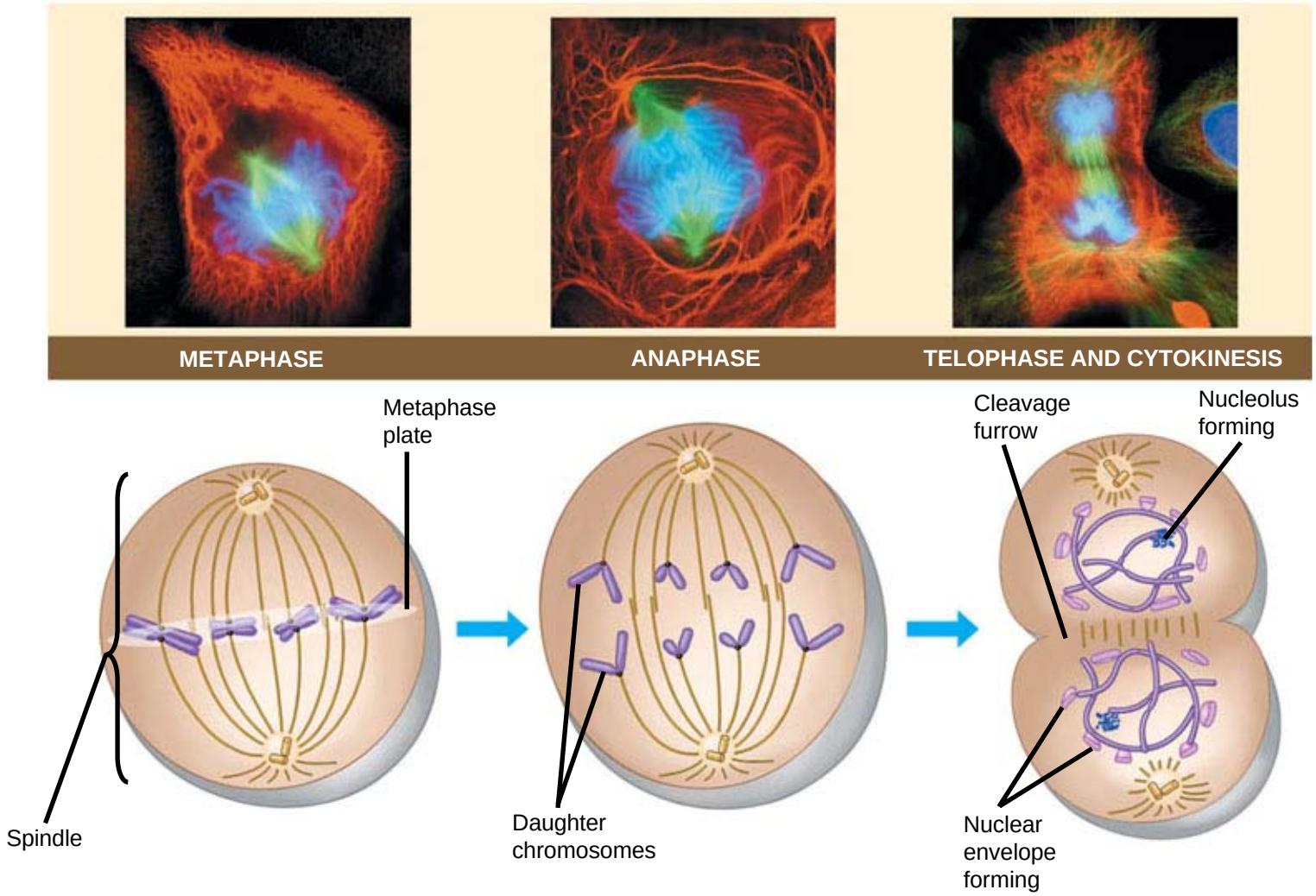

Figure 8.6 (Part 2)

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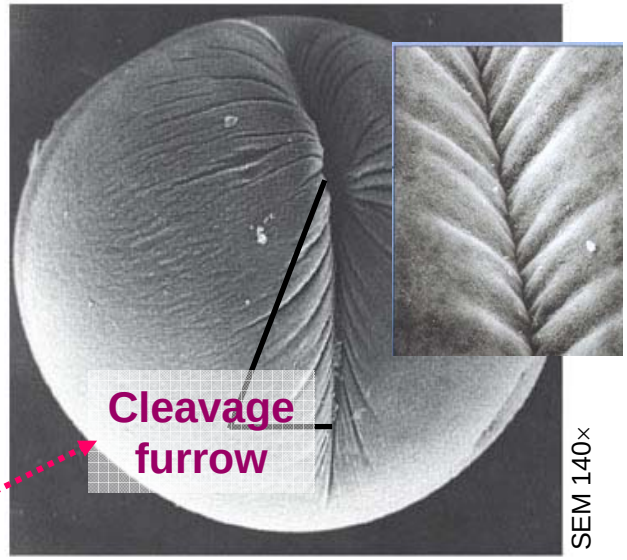
8.7 Cytokinesis differs for plant and animal cells

- In animals
  - Cytokinesis occurs by a constriction of the cell (cleavage)



分裂溝 **(Cleavage furrow)** ：

1. 由於 **microfilament** 收縮

2. 植物細胞無此現象**!**

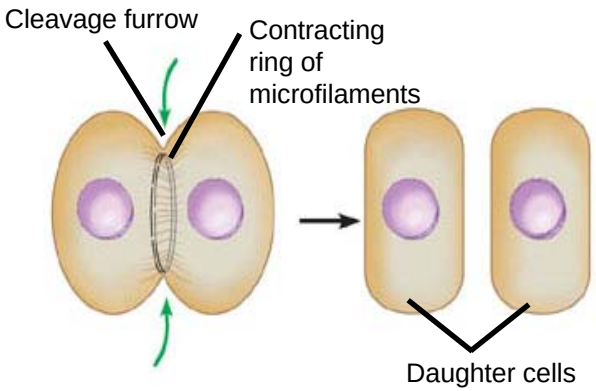


Figure 8.7A

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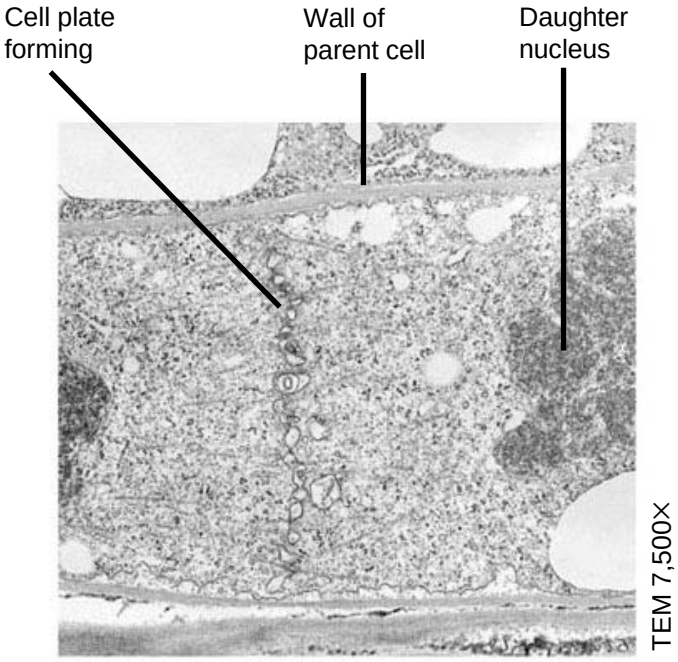
- In plants
  - A membranous **cell plate** splits the cell in two



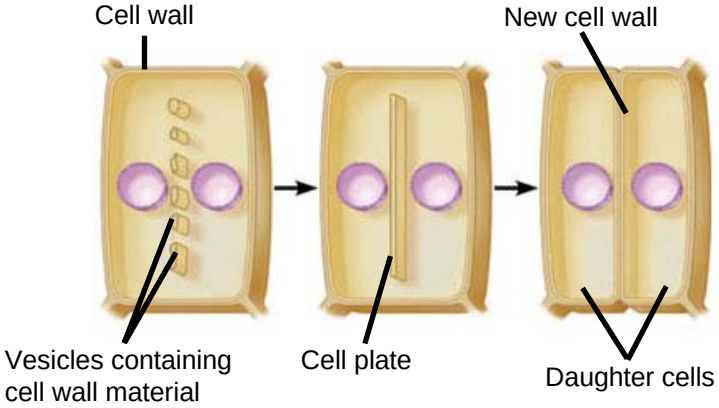


Figure 8.7B

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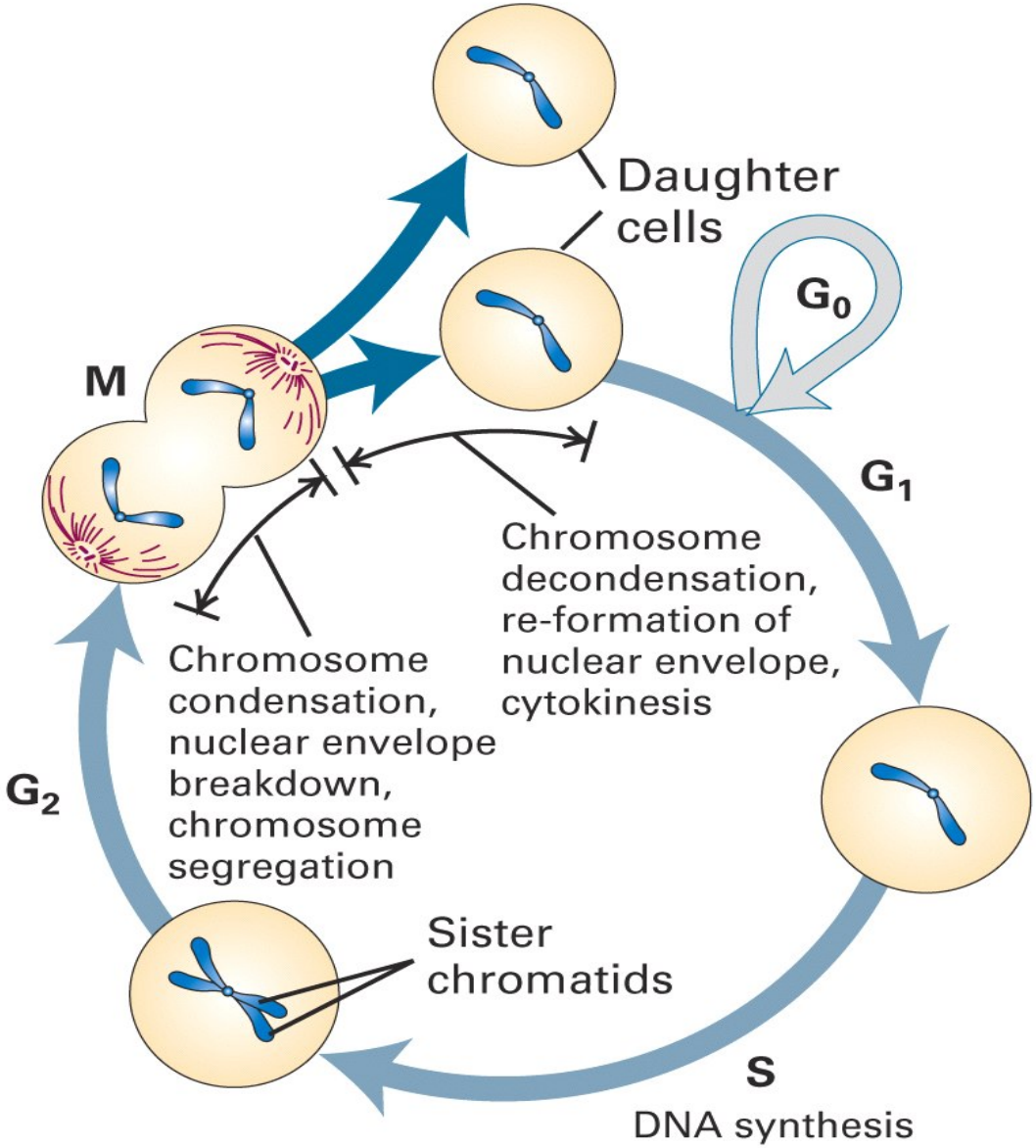
Highly conserved across species

Fig 21.1

Overview of the Eukaryotic Cell Cycle



Four phases:

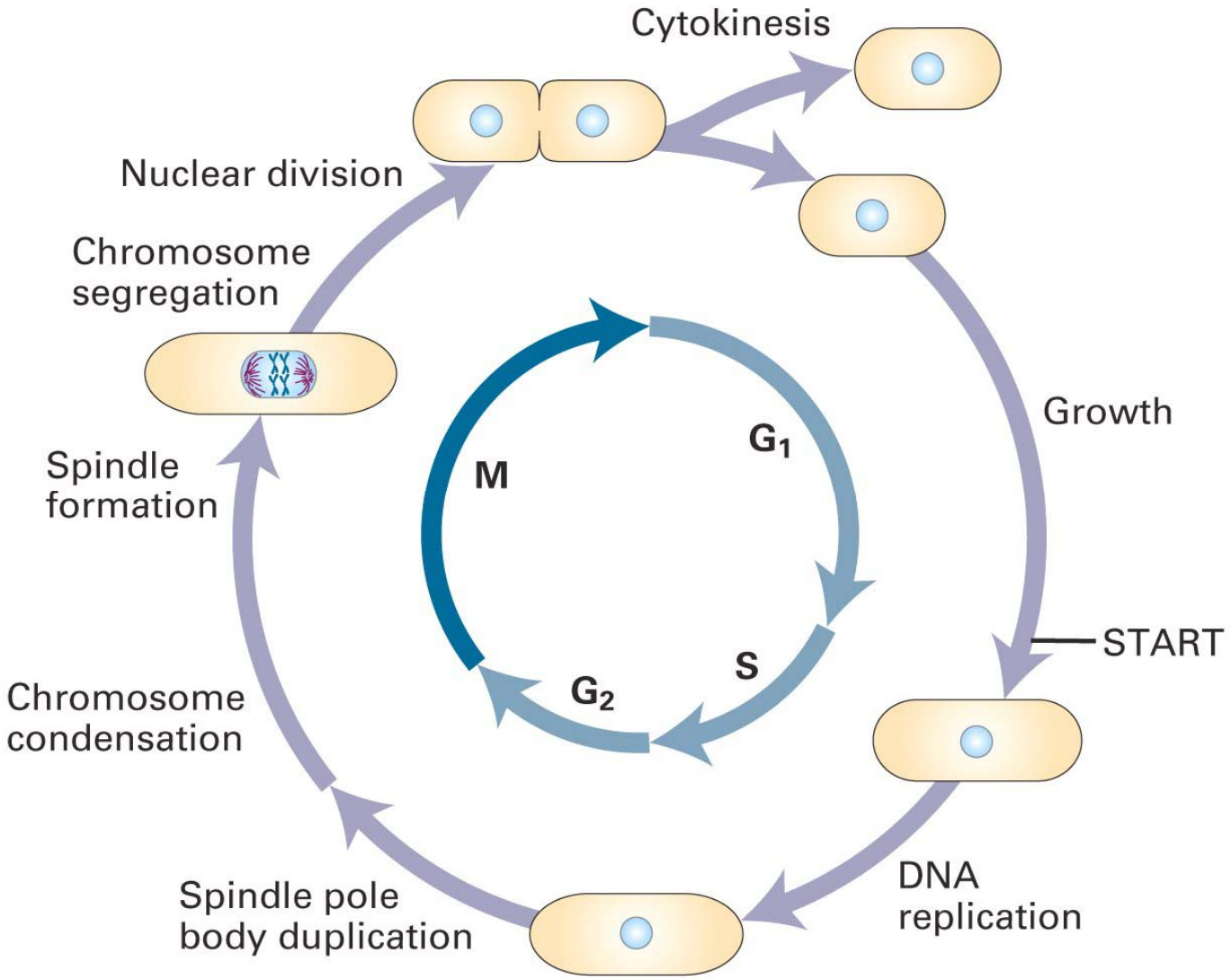
- M (mitosis)
- G_1 (1st gap)
- S (DNA synthesis)
- G_2 (2nd gap)

$G_1 + S + G_2$ = Interphase

G_0 = long-lasting state

In yeast : 90 min
human: 24 hours

Main events in the *S. pombe* cell cycle 酵母菌



"start" = restriction point in mammalian cells.

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Control factors of cell cycle envents

Cyclins (調節單位)

-Regulatory subunits of the heterodimeric protein kinase that control cell-cycle events

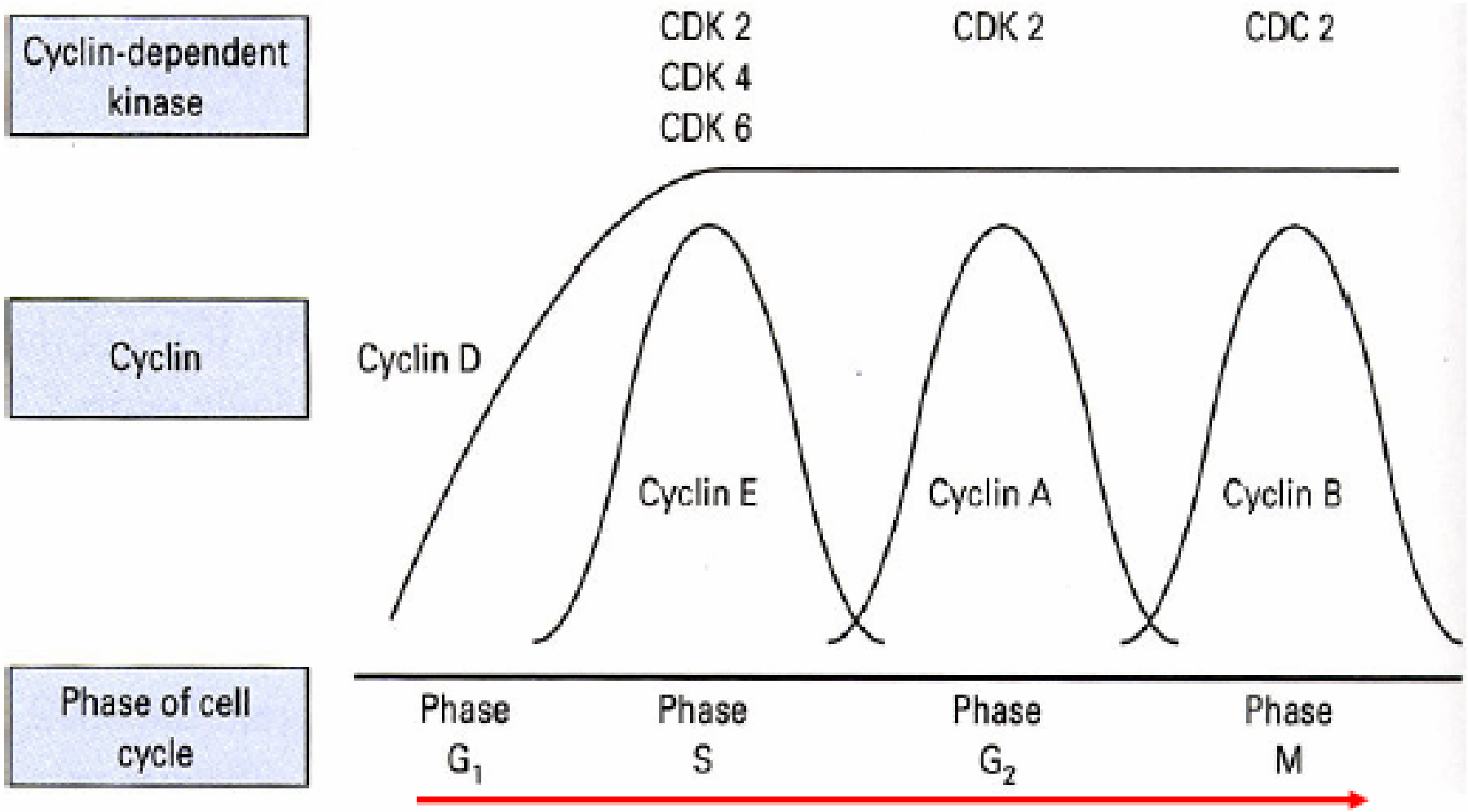
-Increase or decrease through cell cycle

Cyclin-dependent kinase (CDK) (催化單位)

--catalytic subunits

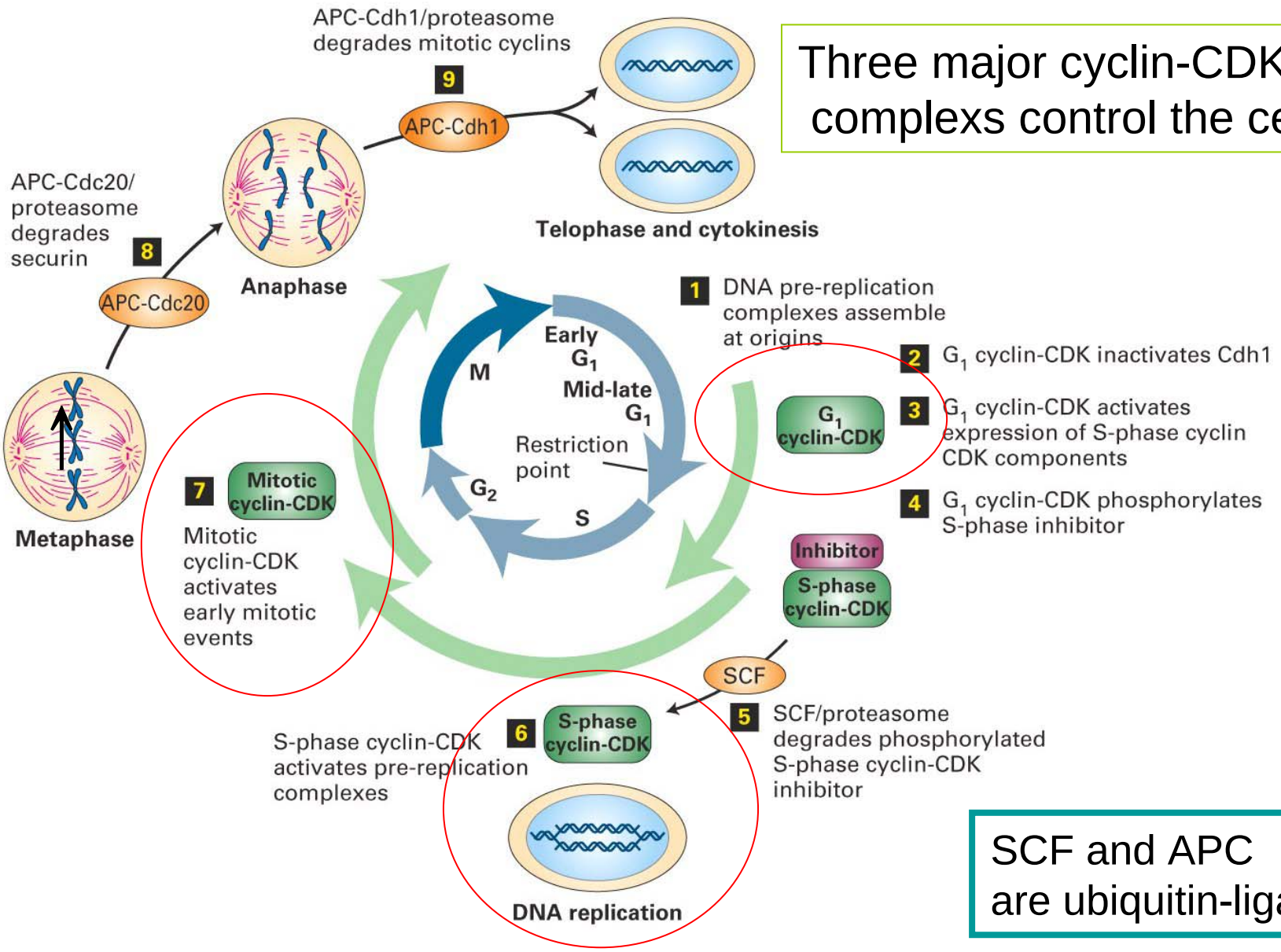
-Activate or inhibit CDKs by Phosphorylation

--specific for correspondence cyclins


Cyclin-dependent kinase
CDK 2
CDK 4
CDK 6
CDK 2
CDC 2
Cyclin
Cyclin D
Cyclin E
Cyclin A
Cyclin B
Phase of cell cycle
Phase G_1
Phase S
Phase G_2
Phase M

Regulation of the mammalian cell cycle

p855



Three major cyclin-CDK complexs control the cell cycle

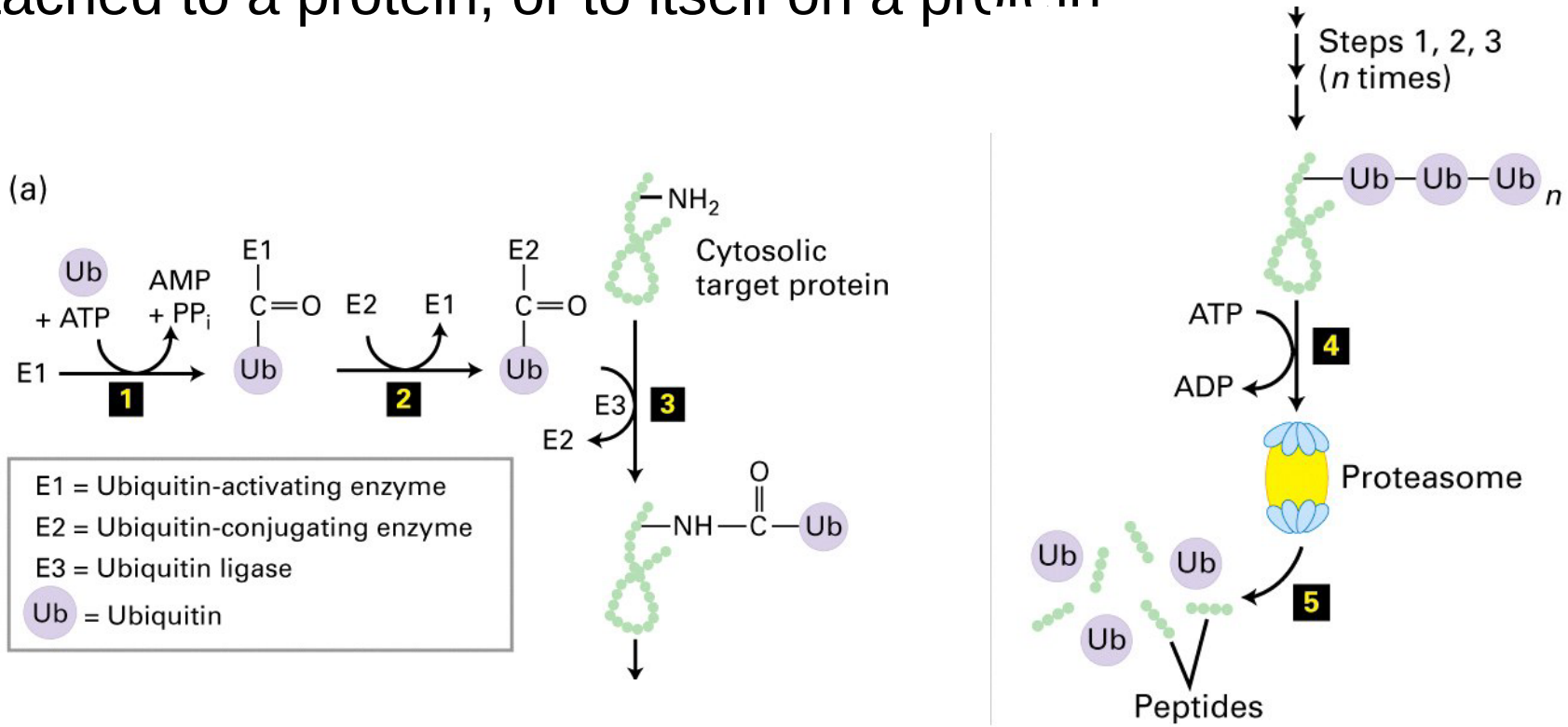
SCF and APC are ubiquitin-ligase

Fig 3-13

The ubiquitin-mediated proteolytic pathway

調節 cyclin 濃度的方式!!

Ub is a small peptide that is activated and then attached to a protein, or to itself on a protein



Regulation of two classes genes in mammalian cell cycle

Depending on how soon their encoded mRNA appear

1. **Early response genes**:

- many genes encode transcription factors (c-jun and c-fos)

2. **Delayed response genes**:

- Few genes encode additional transcription factors
- Others encode cyclin D/E, CDK2/4/6

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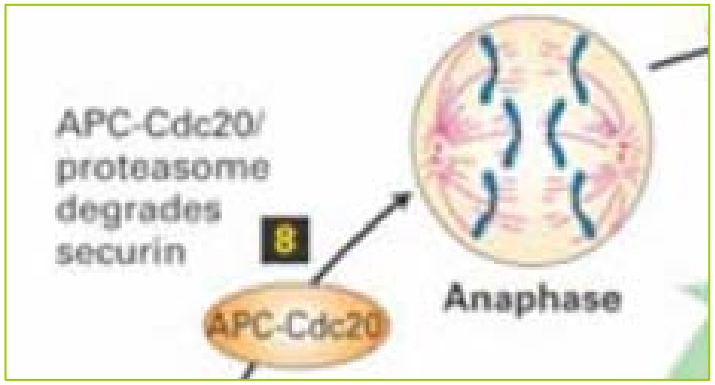
Mitosis 有絲分裂

Anaphase promoting complex (**APC**)

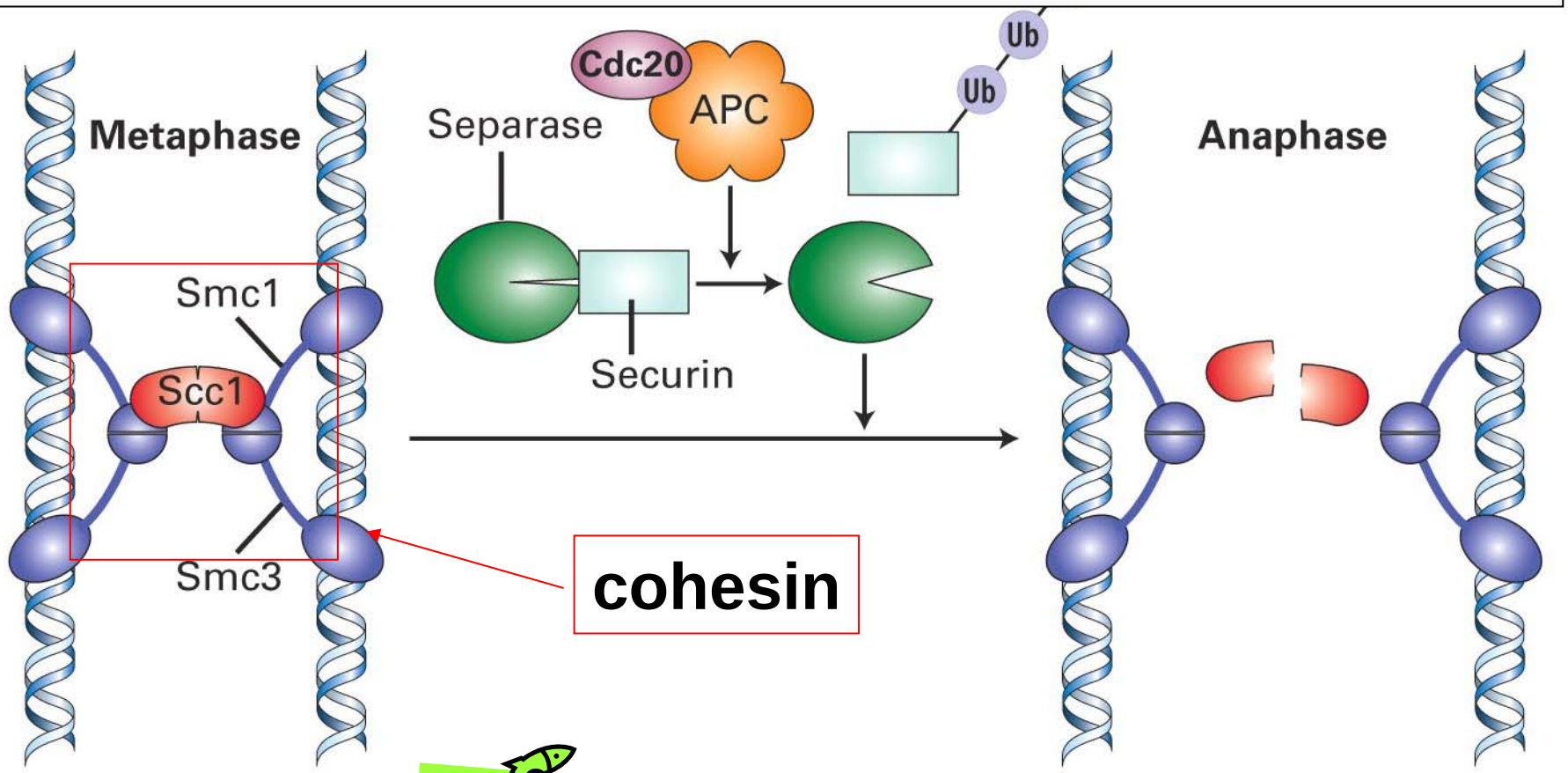
-ubiquitin ligase

Polyquinitinates key regulatory enzymes **securin**, which inhibits degradation of cross-linking proteins (**cohesin**) between sister chromatids.

securin degrades→cohesin degrades →free sister chromatid→ anaphase



Model for the control of entry into Anaphase



metaphase | ***anaphase***

Checkpoints in cell cycle

- Signals affecting critical checkpoints in the cell cycle
  - Determine whether a cell will go through the complete cycle and divide

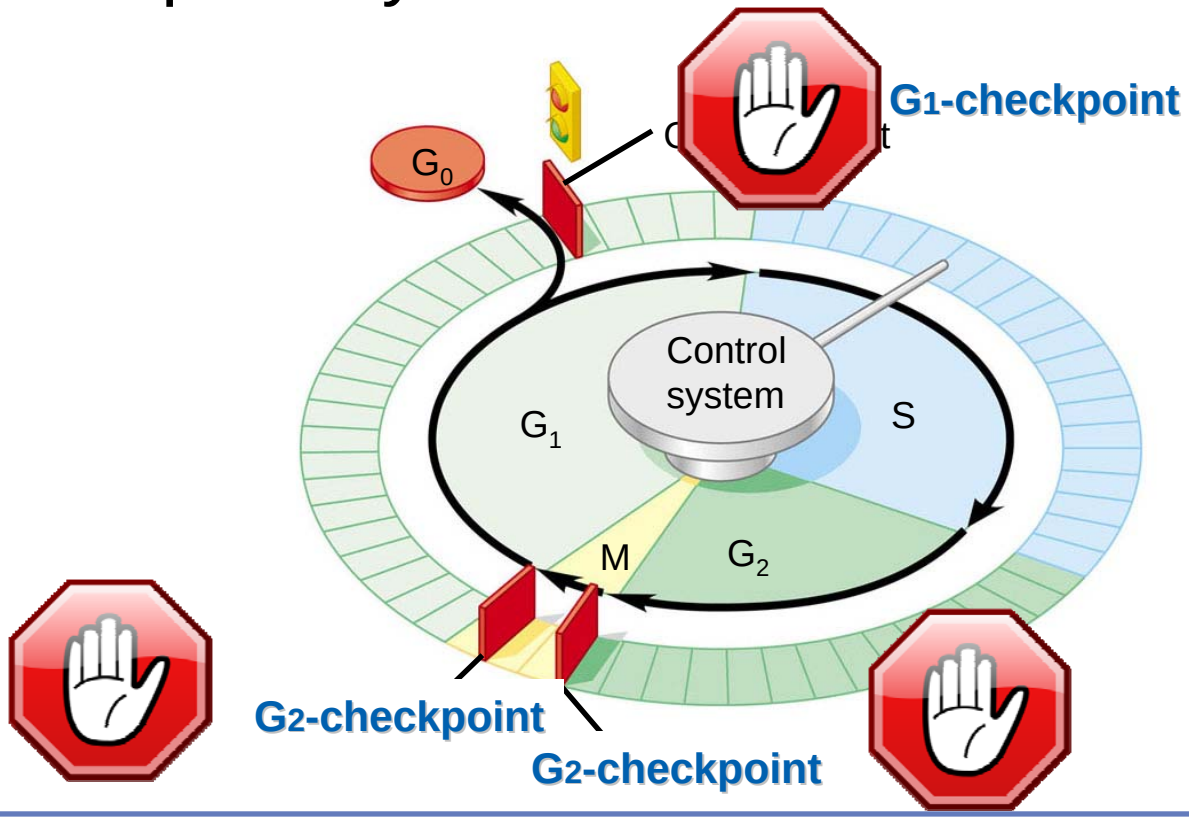


Figure 8.9A

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減數分裂（meiosis）

有性生殖生物在配子形成過程進行特殊分裂模式。

染色體僅複製一次，但進行兩次細胞分裂。

結果：產生四個子細胞，染色體數目減少一半。

位置：生殖組織/器官內

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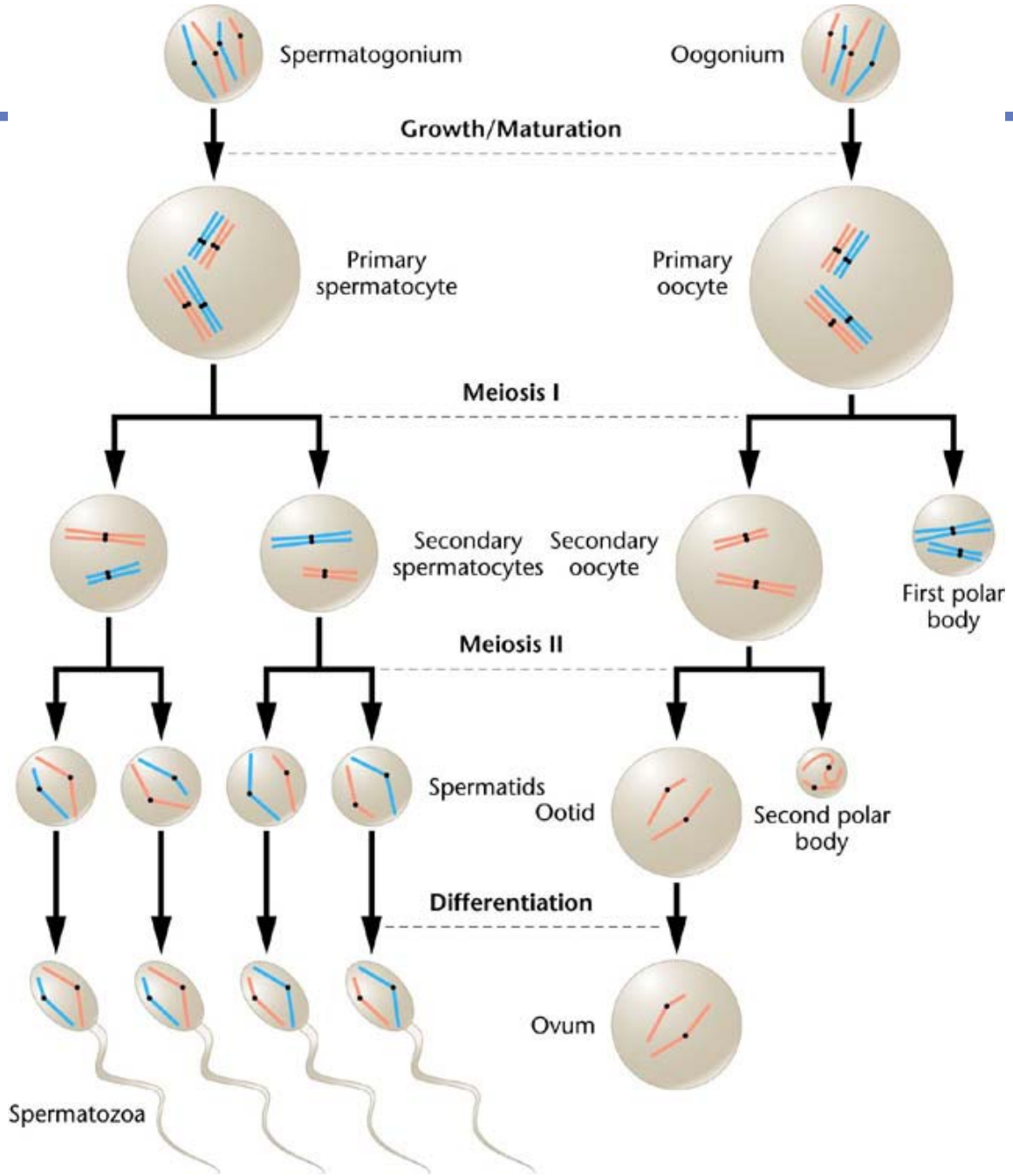

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Cell cycle in species

生物間細胞週期運行的時間差異很大

蠶豆細胞 (G1=5, S=7.5, G2=5, M=2)=19.5 hours

人　24 hours

腫瘤細胞　4-24 houurs

小鼠　22 hours

酵母菌 0.5 hours

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Cell cycle diversity in tissues

組織間細胞週期運行的時間差異也很大，以人類為例

平均　24 hours

部分肝細胞 – 一年

腦細胞, 肌肉細胞- 不分裂

腫瘤細胞　4-24 houurs

胚胎細胞 (數小時)

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特殊細胞週期

正常週期：S期染色體（DNA）複製一次，M期著絲點分離一次，細胞分裂一次，一個母細胞→2個子細胞。

1. S期複製，M期著絲點不分離→多線染色體

   example: 雙翅目昆蟲唾液腺細胞染色體（果蠅唾腺）

2. S期複製，著絲點分離，細胞不分裂→多倍體細胞 即染色體數目加倍(單子葉，植物細胞常見)。

3. 細胞質不分離（多核)- 骨骼肌、部分肝細胞、蝕骨細胞、原生生物。

Polytene 多線染色體

http://203.72.198.245/web/Content.asp?ID=20273

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Questions

1. Describe the Mitosis, Amitosis, and Meiosis.
2. What are the physiological significances of diversity of cell cycle in human bodies?
3. What are the evolutionary significances of cell cycle in species?
4. How cyclins/cdks and CKI control the cell cycle progression
5. The importances of three checkpoints in cell cycle progression.

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