Genetic diversity

Gene expression and Regulation of Cell cycle

基因多樣性與細胞週期

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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

功能:
1. Growth
2. cell replacement
3. asexual reproduction

兩階段:
有絲分裂mitosis
細胞質分裂cytokinesis
• Asexual reproduction (無性生殖)

Figure 8.11C
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
8.3 Prokaryotes reproduce by binary fission (二分裂法)

- Prokaryotic cells
  - Reproduce asexually by cell division

Figure 8.3B

Colorized TEM 32,500×
• As the cell replicates its single chromosome, the copies move apart
  – And the growing membrane then divides the cells

Figure 8.3A
- 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. G₀: 細胞生長期
2. G₁: 細胞準備期-1 (gap 1)
3. S: DNA 合成時期 (synthesis)
4. G₂: 細胞準備期-2 (gap 2)
5. M: 細胞分裂期 (Mitosis and cytokinesis)
• 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
• 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
• The stages of cell division

![Diagram showing stages of cell division]

**Figure 8.6 (Part 1)**
Figure 8.6 (Part 2)
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!
• In plants
  – A membranous **cell plate** splits the cell in two

**Figure 8.7B**

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Overview of the Eukaryotic Cell Cycle

Four phases:
- M (mitosis)
- $G_1$ (1st gap)
- S (DNA synthesis)
- $G_2$ (2nd gap)

$G_1 + S + G_2 = \text{Interphase}$

$G_0 = \text{long-lasting state}$

In yeast: 90 min
Human: 24 hours

Highly conserved across species
Main events in the *S. pombe* cell cycle 酵母菌

“start” = restriction point in mammalian cells.
Control factors of cell cycle events

**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

Cyclin

Phase of cell cycle

Phase $G_1$  Phase $S$  Phase $G_2$  Phase $M$
Regulation of the mammalian cell cycle

Three major cyclin-CDK complexes control the cell cycle.

SCF and APC are ubiquitin-ligase.
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
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
• Signals affecting critical checkpoints in the cell cycle

  – Determine whether a cell will go through the complete cycle and divide
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
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 hours
小鼠 22 hours
酵母菌 0.5 hours
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 hours

胚胎細胞 (數小時)
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
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/cdkks and CKI control the cell cycle progression
5. The importances of three checkpoints in cell cycle progression.