Principles of Genetics (Zoo-352)

Lecture 3

The cell cycle and its checkpoints Chromosomes

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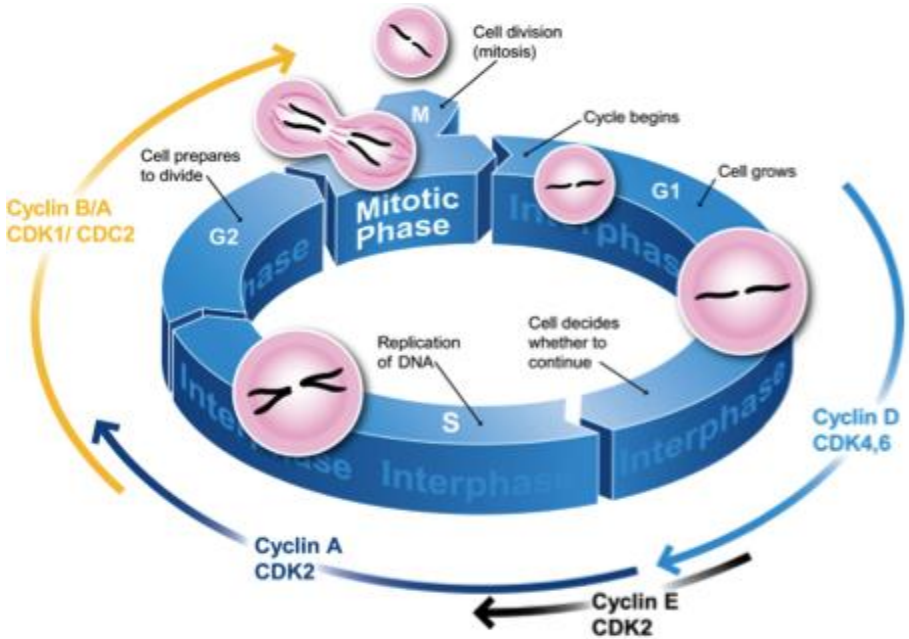

The cell cycle

- The continuity of life depends on cells growing, replicating their genetic material, and then dividing- **a process called the cell cycle**.
- The interval time between each mitotic cell division is termed a cell cycle.
- The cell cycle consists of two basic stages: **interphase** and **M phase**.
- Interphase can be subdivided into three ordered stages: **G1 (Gap 1), S (DNA synthesis) and G2 (Gap 2)** (Figure 1).

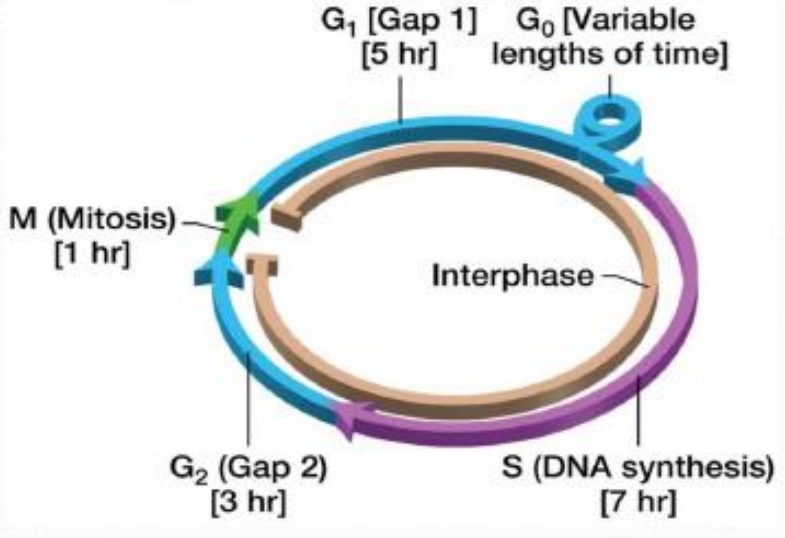

Figure 1: Typical cell cycle of a human cell

The cell cycle

- **S phase** is defined as the stage where the DNA **replication** occurs.
- **M phase** is where the cell is ready to **divide into 2** daughter cells.
- There are two gaps between the S and M phases, **G1** and **G2**.
- In the G1 phase, the **cell is growing** and also preparing for the process of DNA replication.
- In the second gap, **G2**, which comes after the S phase, the cell **prepares for the process of division**.
- The **cell cycle can continue** for the life of some cells. Other cells, such as **neuron** (nerve cell), **do not continue to grow and divide** after they completely differentiate.
- These cells leave the cell cycle and enter the **G0 phase**, where they remain metabolically active and viable.
- Some cells also enter the G0 temporarily and then reenter the cell cycle.

The cell cycle

- Occasionally, cells either fail to enter G0 phase or do not remain in the G0 phase, which results in their continual proliferation (growth and division). This uncontrolled cell proliferation can lead **to cancerous growth**.
- The length of time required for a complete life cycle varies with cell type.
- Mitosis (M phase) is usually the shortest period.
- Mitosis or the M phase has four stages:
  - **1.Prophase**
  - **2.Metaphase**
  - **3.Anaphase**
  - **4.telophase**.

Cell cycle checkpoints

- Some points in the cell cycle, such as the initiation of mitosis can be delayed until all necessary conditions are in place, such as the repair of the damaged DNA.
- These checkpoints allow the cell to make sure that various events have been properly completed before it moves to the next phase of the cell cycle.
- There are **three major checkpoints** in the cell cycle (Figure 2):

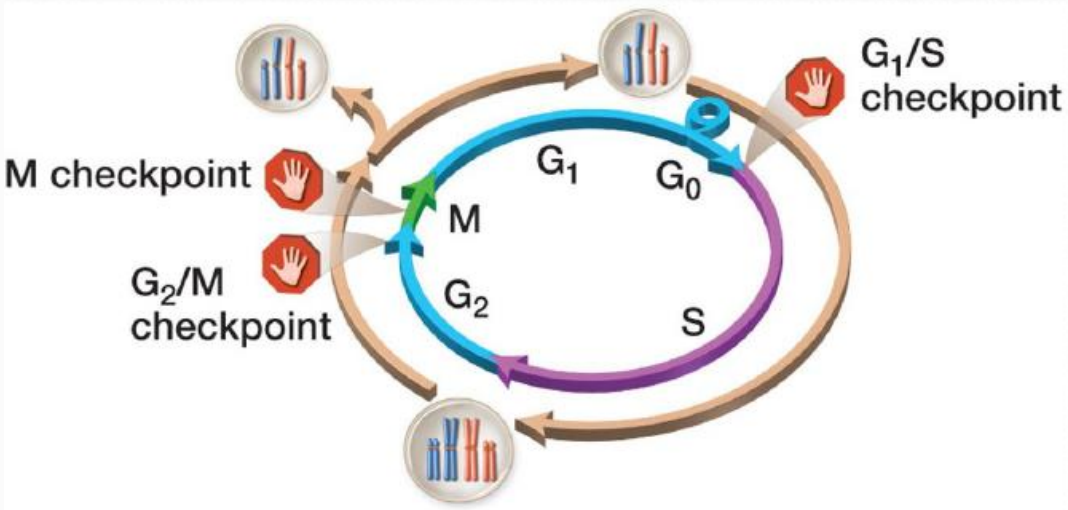

Figure 2: Cell cycle checkpoints

Cell cycle checkpoints

- **1. The G1/S checkpoint:**
  - Determines whether the cell has reached the proper **size** and determines if the DNA is damaged.
  - For example, if the cell attempts to replicate damaged DNA, breaks will occur in the DNA or replication will be blocked.
- **2. The G2/M checkpoint:**
  - Evaluates whether DNA replication is completed and if any damaged DNA still needs to be repaired.
- **3. The M checkpoint:**
  - Evaluates whether spindle fibers are properly assembled and attached to the kinetochores.
  - If either of these two events is not completed, the chromosomes cannot faithfully be separated into the daughter cells.

Cell cycle checkpoints

- The cell cycle routinely arrests when genetic damaged is present, giving the cell a chance to repair the damage before committing to cell division.
- If the damaged is too extreme, the cell can enter **a programmed cell death (apoptosis).**
- If the G1/S checkpoint detects DNA damage, **the *p*53 protein** targets the cells for regulated death.
- If the *p*53 gene is defective, then the controlled death of the damaged cells would not take place, and the possible uncontrolled cell growth would result in cancer.
- In fact, a number of human cancers, including colon, breast, and lung cancers, have been shown to be associated with mutations in the *p*53 gene.