Phases of the Cell Cycle

Dhani Biscocho
Product Manager
Biotechnology, Forensics, and Genetics

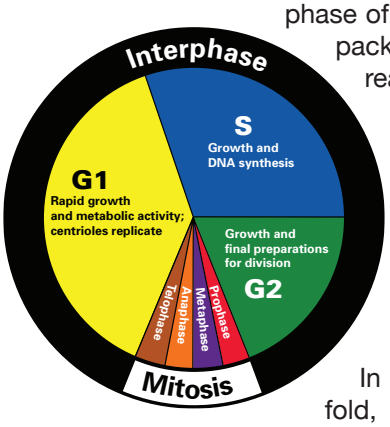
September 2015

The life cycle of a typical eukaryotic cell occurs in stages. The longest of these stages is called interphase. **Interphase** can generally be divided into 3 subphases: G_1, S, and G_2.

In the **G_1 phase (GAP 1)**, cells grow larger and synthesize RNA and proteins necessary for DNA synthesis in the upcoming phases. G_1 phase includes a checkpoint at which the cell becomes committed to completing the cell cycle. Cell growth rate can depend on factors such as availability of nutrients, growth factor proteins, space, and temperature. Cells that have arrested growth due to a lack of these factors can enter **G_0 phase**, a non-dividing state.

DNA replication starts in the **synthesis phase (S phase)**. Clusters of DNA unzip as they synthesize daughter strands until the amount of DNA in the cell has doubled.

During the **G_2 phase (GAP 2)**, the replicated DNA, still contained within a nuclear envelope, undergoes another checkpoint. Here the DNA is checked for damage, which sometimes occurs in the synthesis phase of the cell cycle. After the cell passes this checkpoint, the DNA undergoes nuclear packaging. DNA is wound around proteins, creating chromatin fibers. The cell is now ready for mitotic division.



The phases of mitosis

Mitosis is a type of nuclear cell division that occurs in somatic (non-reproductive) cells, whereby the same number of chromosomes are maintained from parent cell to daughter cell. Mitosis can be divided into four stages: **prophase**, **metaphase**, **anaphase**, and **telophase**.

In **prophase**, nuclear packaging continues further as the chromatin fibers loop, fold, and finally condense into discrete chromosomes. Chromosomes (which were duplicated during interphase) consist of 2 pairs of identical sister chromatids joined together by a centromere. Microtubules and centrosomes assemble to form an early mitotic spindle.

During **metaphase**, the nuclear envelope breaks, and the microtubules attach to the chromatids. The centrosomes move to the opposite sides of the cell, moving the sister chromatids to align along the metaphase plate equidistant from the 2 centrosome poles.

During **anaphase**, when sister chromatids pull apart and separate from each other, they are referred to as independent chromosomes. The microtubules shorten, bringing the chromosomes closer to the poles, and the cell elongates. Each of the polar sides then has an equivalent set of chromosomes.

Finally, in **telophase**, 2 daughter nuclei form, and a nuclear envelope forms around them.

Cancer and loss of cell cycle control

Cancer is cell division run amok. Proper cellular division is an intricate concert controlled by the expression of genes. As described above, cellular division has checkpoints to ensure there are no deleterious effects

in the cell cycle. However, cancerous cells have lost the ability to respond to control mechanisms regulated by gene expression.

Three types of genes control cellular division: oncogenes, proto-oncogenes, and tumor suppressor genes. Proto-oncogenes promote normal cellular division; oncogenes cause cancer. Oncogenes can consist of damaged or improperly assembled DNA. The purpose of tumor suppressor genes is to inhibit unwanted cellular division. These types of genes code for molecules involved in signaling pathways that tell the cell to grow, stop growing, divide, and stop dividing. Without properly functioning proto-oncogenes and tumor suppressor genes to keep the oncogenes in check, cancerous cells can divide uncontrollably with detrimental effects to the host.

Cancer is not exclusive to mammals. It has been observed in many organisms across the animal kingdom, as well as in plants. Much research has been done to identify individual genes and pathways responsible for abnormal cell division pathways. A full understanding of the cell cycle and cellular division is essential to further decipher the disease.

References

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., and Watson, J.D. (1983) Molecular Biology of the Cell. New York, NY: Garland Science.

Starr, C. and Taggart, R. (1992) Biology: The Unity and Diversity of Life. Belmont, CA: Wadsworth Publishing Company.

Campbell, N.A. and Reece, J.B. (2005) Biology Seventh Edition. San Francisco, CA: Pearson Education.