The Cell Cycle

Cell division is the process in which one cell, called the parent cell, divides to form two new cells, referred to as daughter cells.

How this happens depends on whether the cell is prokaryotic or eukaryotic.

Cell division is simpler in prokaryotes than eukaryotes because prokaryotic cells themselves are simpler**. Prokaryotic cells** have a single circular chromosome, no nucleus, and few other organelles. **Eukaryotic cells,** in contrast, have multiple chromosomes contained within a nucleus and many other organelles. All of these cell parts must be duplicated and then separated when the cell divides. Cell division is just one of several stages that a cell goes through during its lifetime.

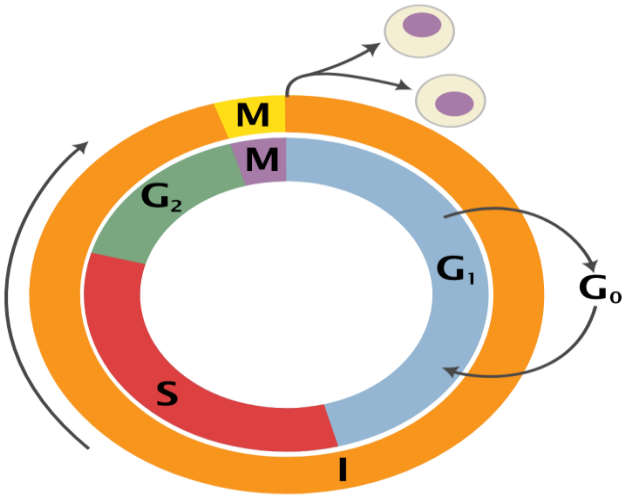
The cell cycle is a repeating series of events that include growth, DNA synthesis, and cell division. The cell cycle in prokaryotes is quite simple: the cell grows, its DNA replicates, and the cell divides. This form of division in prokaryotes is called asexual reproduction. In eukaryotes, the cell cycle is more complicated.

Eukaryotic Cell Cycle

Figure1> represents the cell cycle of a eukaryotic cell. The eukaryotic cell cycle has several phases. The mitotic phase (M) includes both mitosis and cytokinesis. This is when the nucleus and then the cytoplasm divide. The other three phases (G1, S, and G2) are generally grouped together as interphase. During interphase, the cell grows, performs routine life processes, and prepares to divide. These phases are discussed below.

Interphase

The Interphase of the eukaryotic cell cycle can be subdivided into the following phases (Figure .1).



Growth Phase 1 (G1): The cell spends most of its life in the first gap (sometimes referred to as growth) phase, G1. During this phase, a cell undergoes rapid growth and performs its routine functions. During this phase, the biosynthetic and metabolic activities of the cell occur at a high rate. The synthesis of amino acids and hundreds of thousands or millions of proteins that are required by the cell occurs during this phase. Proteins produced include those needed for DNA replication. If a cell is not dividing, the cell enters the G0 phase from this phase.

G0 phase: The G0 phase is a resting phase where the cell has left the cycle and has stopped dividing. Non-dividing cells in multicellular eukaryotic organisms enter G0 from G1. These cells may remain in G0 for long periods of time, even indefinitely, such as with neurons. Cells that are completely differentiated may also enter G0. Some cells stop dividing when issues of sustainability or viability of their daughter cells arise, such as with DNA damage or degradation, a process called cellular senescence. Cellular senescence occurs when normal diploid cells lose the ability to divide, normally after about 50 cell divisions.

Synthesis Phase (S): Dividing cells enter the Synthesis (S) phase from G1. For two genetically identical daughter cells to be formed, the cell's DNA must be copied

through DNA replication. When the DNA is replicated, both strands of the double helix are used as templates to produce two new complementary strands. These new strands then hydrogen bond to the template strands and two double helices form. During this phase, the amount of DNA in the cell has effectively doubled, though the cell remains in a diploid state.

Growth Phase 2 (G2): The second gap (growth) (G2) phase is a shortened growth period in which many organelles are reproduced or manufactured. Parts necessary for mitosis and cell division are made during G2, including microtubules used in the mitotic spindle.

Cell Cycle

Figure .2 : Eukaryotic Cell Cycle. The First Gap (G1), Synthesis (S), and Second Gap (G2) phases make up interphase (I). The mitotic phase (yellow M) includes mitosis (purple M) and cytokinesis. During cytokinesis two cells result. Some cells do not divide and they enter into G0 phage.

Mitotic Phase

Before a eukaryotic cell divides, all the DNA in the cell's multiple chromosomes is replicated. Its organelles are also duplicated. This happens in the interphase. Then, when the cell divides (mitotic phase), it occurs in two major steps, called mitosis and cytokinesis, both of which are described in greater detail in the concept Mitotic Phase: Mitosis and Cytokinesis.

The first step in the mitotic phase of a eukaryotic cell is mitosis, a multi-phase process in which the nucleus of the cell divides.

During mitosis, the nuclear envelope (membrane) breaks down and later reforms. The chromosomes are also sorted and separated to ensure that each daughter cell receives a complete set of chromosomes.

The second major step is cytokinesis. This step, which occurs in prokaryotic cells as well, is when the cytoplasm divides and two daughter cells form.

Cell division

Mitosis (M) Cell growth stops at this stage. Mitosis divides the nucleus into two nuclei, followed by cytokinesis which divides the cytoplasm. Two genetically identical daughter cells result.

Control of the Cell Cycle

If the cell cycle occurred without regulation, cells might go from one phase to the next before they were ready.

What controls the cell cycle?

How does the cell know when to grow, synthesize DNA, and divide?

The cell cycle is controlled mainly by regulatory proteins. These proteins control the cycle by signaling the cell to either start or delay the next phase of the cycle. They ensure that the cell completes the previous phase before moving on. Regulatory proteins control the cell cycle at key checkpoints, which are shown in Figure 3.

There are a number of main checkpoints:

1-The G1 checkpoint: just before entry into the S phase, makes the key decision of whether the cell big enough to divide. If the cell is not big enough, it goes into the resting period (G0)

2-DNA synthesis Checkpoint: The S checkpoint determines if the DNA has been replicated properly.

3-The mitosis checkpoint: This checkpoint ensures that all the chromosomes are properly aligned before the cell is allowed to divide.

Cell Cycle and Checkpoints

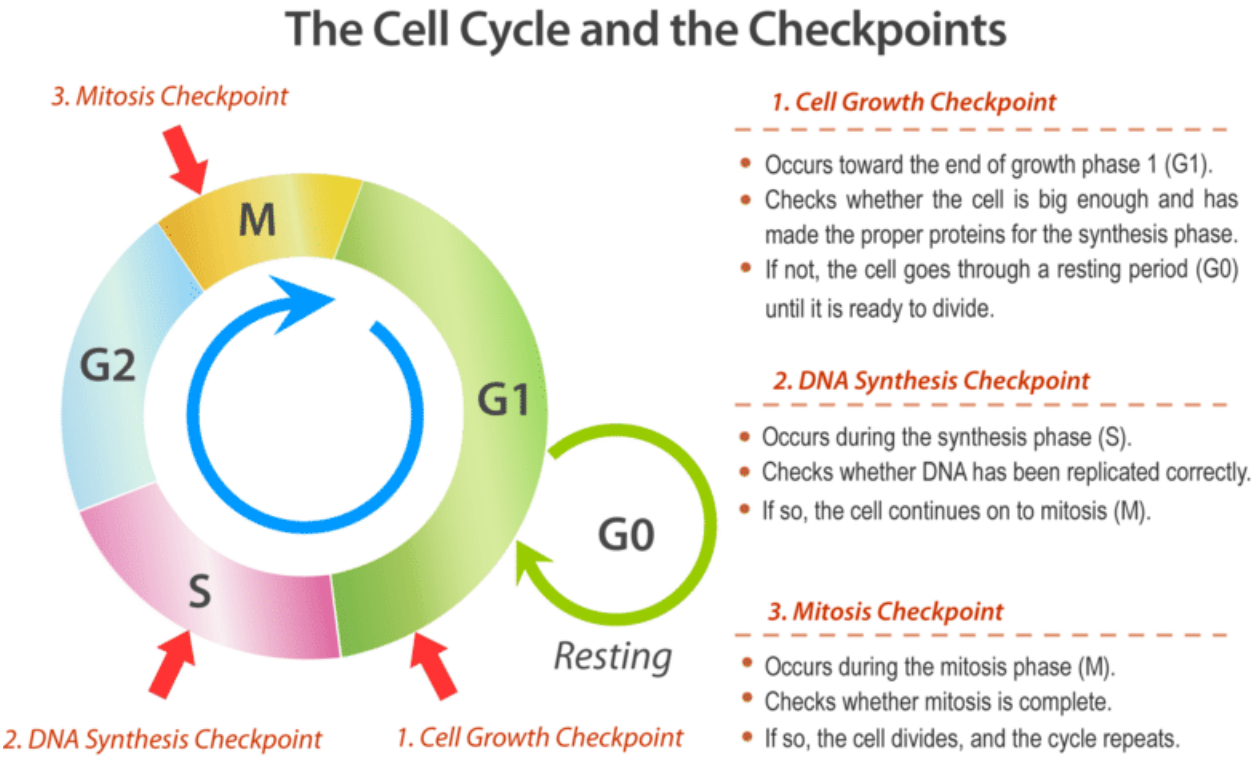


Figure .3 : Checkpoints in the eukaryotic cell cycle ensure that the cell is ready to proceed before it moves on to the next phase of the cycle.

Cancer and the Cell Cycle

Cancer is a disease that occurs when the cell cycle is no longer regulated. This happens because a cell's DNA becomes damaged. This results in mutations in the genes that regulate the cell cycle. Damage can occur due to exposure to hazards such

as radiation or toxic chemicals. Cancerous cells generally divide much faster than normal cells. They may form a mass of abnormal cells called a tumor (Figure 4). The rapidly dividing cells take up nutrients and space that normal cells need. This can damage tissues and organs and eventually lead to death. When uncontrolled cell division happens in the bone marrow, abnormal and nonfunctional blood cells are produced because the division is happening before the cell is ready for division. In these types of cancer, there is not any evident tumor.

Cut colon with polyps and cancerous tumor

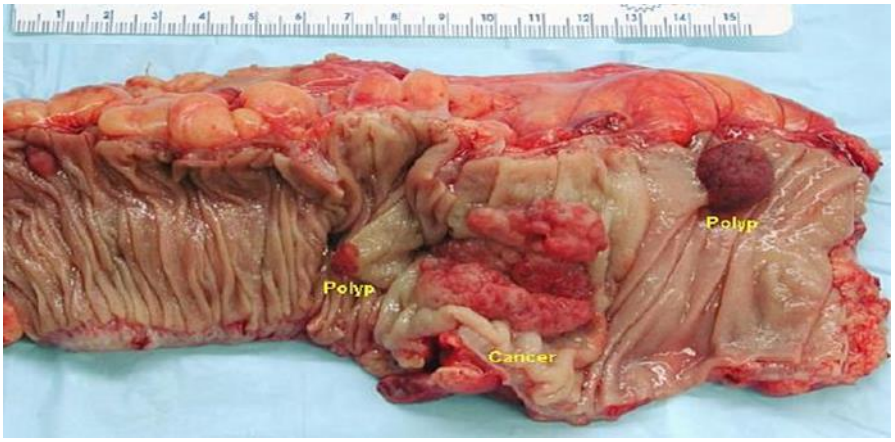


Figure.4 : Gross appearance of an opened large intestine specimen containing an invasive colorectal carcinoma and two adenomatous polyps. The cancer cells have grown out of control and forming a tumor.