

## TOPIC: CELL CYCLE

### Key Knowledge:

- The eukaryotic cell cycle, including the characteristics of each of the sub-phases of mitosis and cytokinesis in plant and animal cells
- Disruption to the regulation of the cell cycle and malfunctions in apoptosis that may result in deviant cell behaviour: cancer and the characteristics of cancer cells

## CELL CYCLE

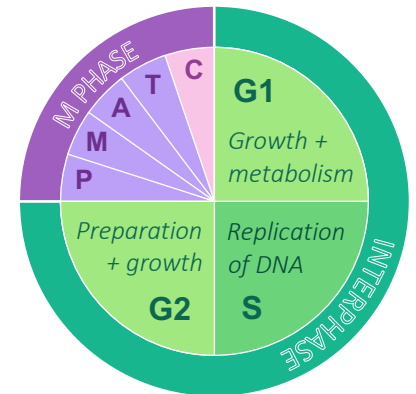
The cell cycle is an ordered set of events which results in the division of eukaryotic cells into identical daughter cells. It involves two key phases:

**Interphase** is an active phase of the cycle with many processes occurring in the nucleus and cytoplasm. It is a continuum of three distinct stages:

- **G1:** Cell grows and prepares for division (organelles are duplicated)
- **S:** A synthesis stage in which DNA replication occurs in the nucleus
- **G2:** Acts as a final growth and preparation stage prior to cell division

The **M phase** is the period of the cycle in which the cell and its contents are divided into two separate daughter cells. It involves two key stages:

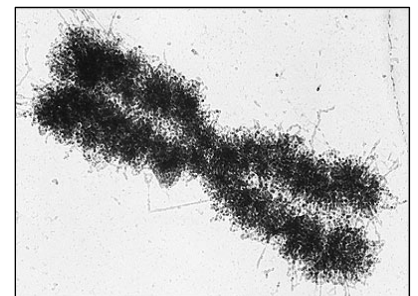
- **Mitosis:** A process of nuclear division (duplicated DNA is separated)
- **Cytokinesis:** A process of cytoplasmic division (the cell splits in two)



*The cell cycle moves in a clockwise direction as per the diagram shown above*

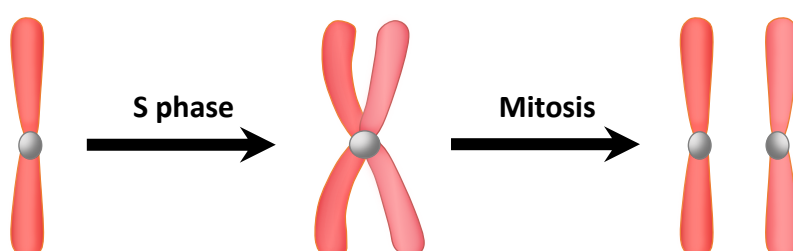
## CHROMOSOMES

Within eukaryotic cells, the DNA is organised into discrete units that are called **chromosomes**. Normally, these chromosomes are packaged in an uncondensed form called **chromatin** to allow for the cellular machinery to access the genetic instructions that determine cell activity. However, when a cell divides, the DNA supercoils and the chromatin condenses to form discrete chromosomes that will be visible under a light microscope (after division, chromosomes decondense and reform into chromatin).



## DNA REPLICATION

When DNA is replicated during the S phase, chromosomes will temporarily consist of two identical DNA molecules. These strands are called **sister chromatids** and are held together at a site called a **centromere**. When chromatids separate during mitosis, they become two identical chromosomes (one for each cell).

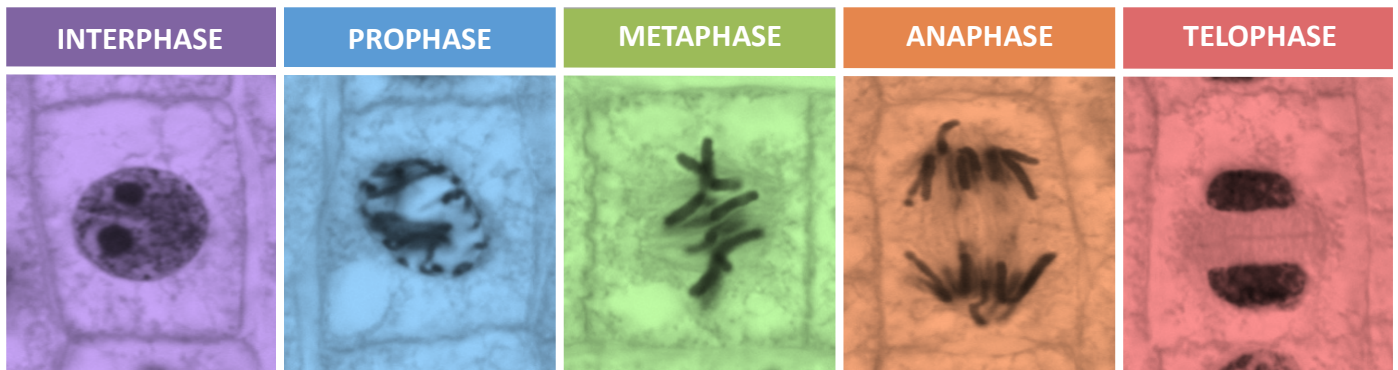


*DNA replication (S phase) produces chromosomes with sister chromatids  
These will separate during mitosis into two genetically identical chromosomes*

# MITOSIS

Mitosis is the process of nuclear division, whereby the duplicated DNA molecules (i.e. sister chromatids) are arranged into two separate nuclei. Mitosis is preceded by interphase and involves four distinct stages:

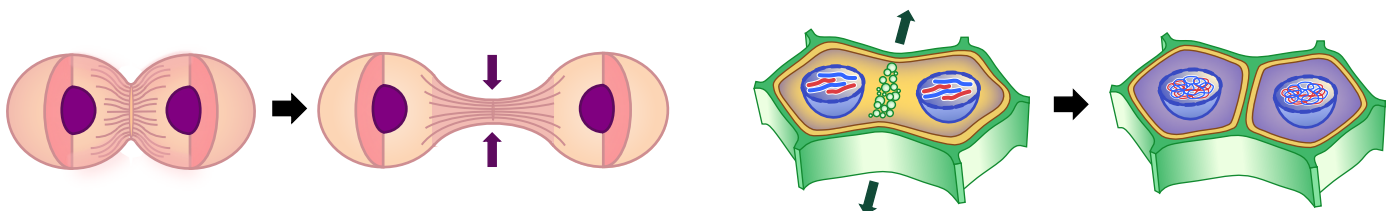
- **Prophase:** Chromosomes condense, nucleus dissolves and paired centrosomes move to opposite poles
- **Metaphase:** Centrosomes connect to centromeres via spindle fibres and move chromosomes to middle
- **Anaphase:** Spindle fibres contract and separate sister chromatids, moving them to the opposite poles
- **Telophase:** Chromosomes decondense and nuclei reform around the two separated chromosome sets



# CYTOKINESIS

Mitosis only separates the duplicated DNA into separate nuclei. The division of the cell in two (cytokinesis) occurs concurrently with the final stage of mitosis (telophase). Cytokinesis differs in animal and plant cells:

- **Animals:** Microtubule fibres form an outer contractile ring (cleavage furrow) – division is *centripetal*
- **Plants:** Vesicles form at the centre of the cell and fuse to form an end plate – division is *centrifugal*



# CANCER

Errors in the cell cycle can lead to uncontrolled cell division (**cancer**). The abnormal cell growths are called **tumours** and can occur in any tissue or organ. Some tumours are benign and will remain in their original location, while other tumours are malignant and will spread to invade neighbouring tissue (**metastasis**).

Disruptions to the cell cycle are caused by gene mutations that are either inherited (genetic predisposition) or triggered by **mutagens**. Mutagens can be either physical (radiation), chemical (tobacco or asbestos) or biological (certain viruses). A mutagen that specifically causes cancer is called a **carcinogen**, whereas a mutagen that causes abnormal embryonic or foetal development is called a teratogen. There is a strong positive correlation between cigarette smoking and the development of lung and tongue cancer.



Risk Factors:



# OVERVIEW OF MITOSIS

Mitosis involves four phases (prophase, metaphase, anaphase, telophase) and is preceded by interphase.

STAGE	DIAGRAM	KEY EVENTS
<b>Interphase</b> (2n)	<p>Before: <b>S phase</b> After:</p>	<ul style="list-style-type: none"> <li>DNA is uncondensed (chromatin)</li> <li>DNA is replicated (S phase) to form two identical sister chromatids</li> <li>Cell grows in size and organelles are duplicated (<math>G_1</math> and <math>G_2</math>)</li> </ul>
<b>Prophase</b> (2n)	<p>Nuclear membrane dissolves</p> <p>Centrosomes move to poles</p>	<ul style="list-style-type: none"> <li>DNA supercoils and condenses (forms visible chromosomes)</li> <li>Nuclear membrane dissolves</li> <li>Centrosomes move to poles and begin to produce spindle fibres</li> </ul>
<b>Metaphase</b> (2n)	<p>Spindle fibres</p> <p>M = Middle</p>	<ul style="list-style-type: none"> <li>Centrosome spindle fibres attach to centromeres of each chromosome</li> <li>Spindle fibres contract and move the chromosomes towards the equator</li> <li>Chromosomes form a line along the equator (middle) of the cell</li> </ul>
<b>Anaphase</b> (2n → 4n)	<p>Chromatids</p> <p>A = Apart</p>	<ul style="list-style-type: none"> <li>Spindle fibres continue to contract</li> <li>Sister chromatids separate and move to opposite sides of the cell</li> <li>Sister chromatids are now regarded as two separate chromosomes</li> </ul>
<b>Telophase</b> (4n)	<p>Nuclear membranes reform</p>	<ul style="list-style-type: none"> <li>Chromosomes decondense (DNA forms chromatin)</li> <li>Nuclear membranes form around the two identical chromosome sets</li> <li>Cytokinesis occurs concurrently</li> </ul>
<b>Cytokinesis</b> (2n × 2)		<ul style="list-style-type: none"> <li>Cytoplasmic division occurs to divide the cell into two daughter cells</li> <li>Each daughter cell contains one of the identical sister chromatids</li> <li>Daughter cells are genetically identical</li> </ul>