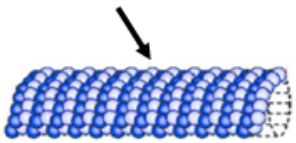
The Cytoskeleton

The cytoskeleton provides **mechanical support** and **shape** to cells.

It consists of different **protein** structures including **microtubules**, which are found in all eukaryotic cells.

Tubulin protein



Microtubules Structure

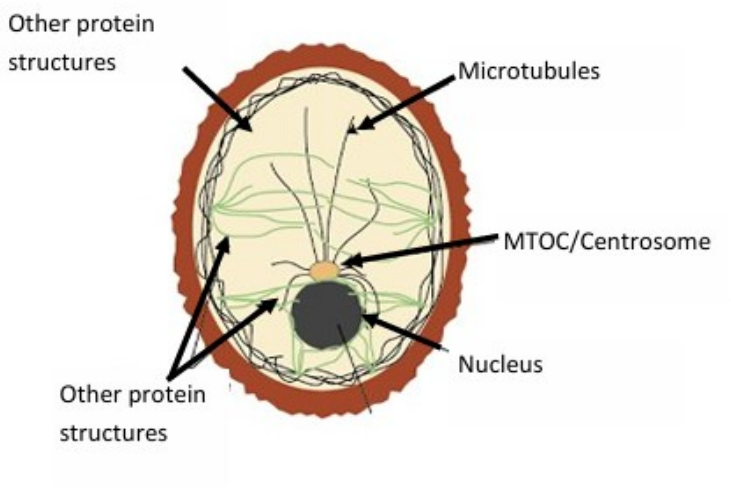
Hollow cylinders composed of the protein **tubulin**.

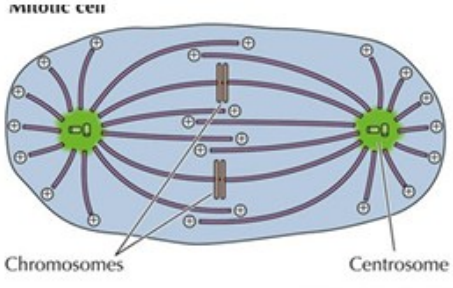
Microtubules Function

1. Control the movement of **membrane-bound organelles.**

2. Control the movement of **chromosomes** though formation of **spindle fibres** that are active during cell division.

Microtubules radiate from the **microtubule organising centre** (MTOC)/ **centrosome** near the nucleus.



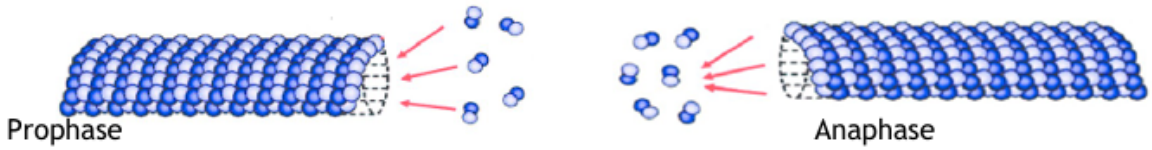


Cell Division & cytoskeleton

Cell Division requires **remodelling** of the cytoskeleton through **polymerisation.** and **depolymerisation** of **tubulin** in the formation/ break down of **spindle fibres**.

Formation of Spindle fibres (polymerisation)

Breakdown of Spindle fibres (depolymerisation)



Prophase

Anaphase

Likely applied knowledge Question

Chemotherapy cancer drugs such as colchicine and paclitaxel are designed to destroy microtubule formation in tumour cells that show an increase rate of cell division.

Disadvantage

Cell division in normal cells also inhibited OR cannot move organelles within cell.

Other drugs interfere with another stage of the cell cycle such as cisplatin which prevents successful DNA replication.

The Cell Cycle

The Cell Cycle

Consists of **interphase** and **mitotic phase**.

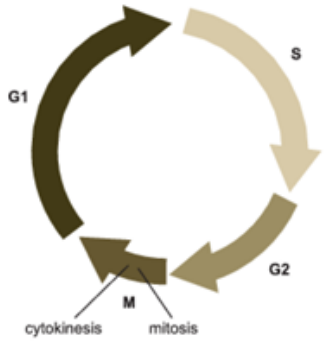
a) Interphase

This Phase involves growth of the cell and DNA synthesis.

- G1 - Growth phase

- S - DNA replication

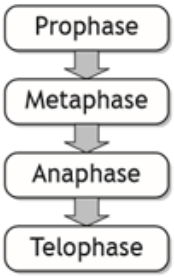
- G2 - Second growth phase



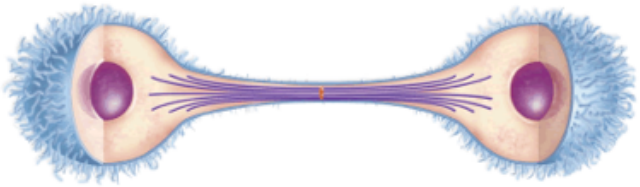
Cell cycle

b) Mitotic (M) Phase

1. Mitosis — The chromosomal material is separated by the spindle fibres in a **4 stage** process.



2. Cytokinesis — The **cytoplasm** is **separated** into two daughter cells.



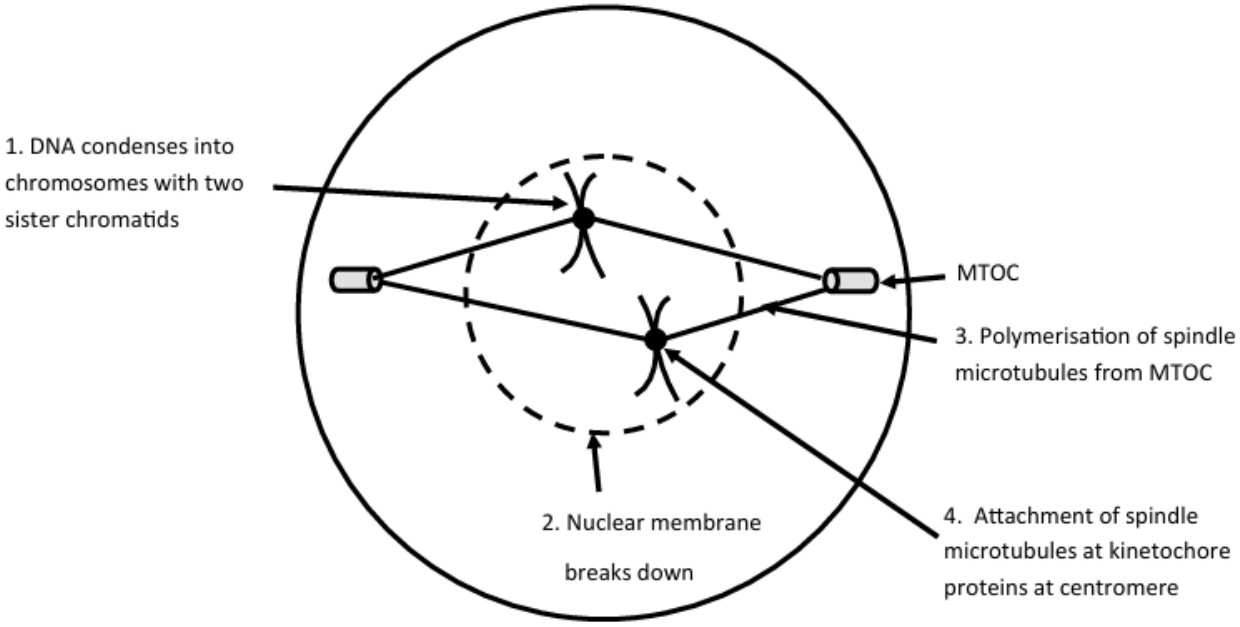
Stages of Mitosis

1. Prophase

a. DNA **condenses** into chromosomes each consisting of two **sister chromatids**.

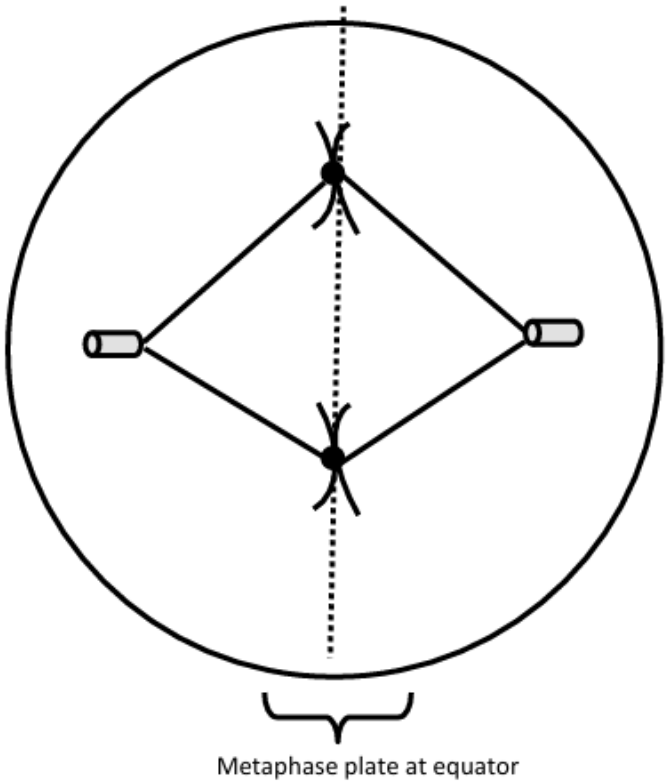
b. The **nuclear membrane** breaks down.

c. **Spindle microtubules** extend from the MTOC by **polymerisation** attach to chromosomes via their **kinetochores** in the centromere region.



2. Metaphase

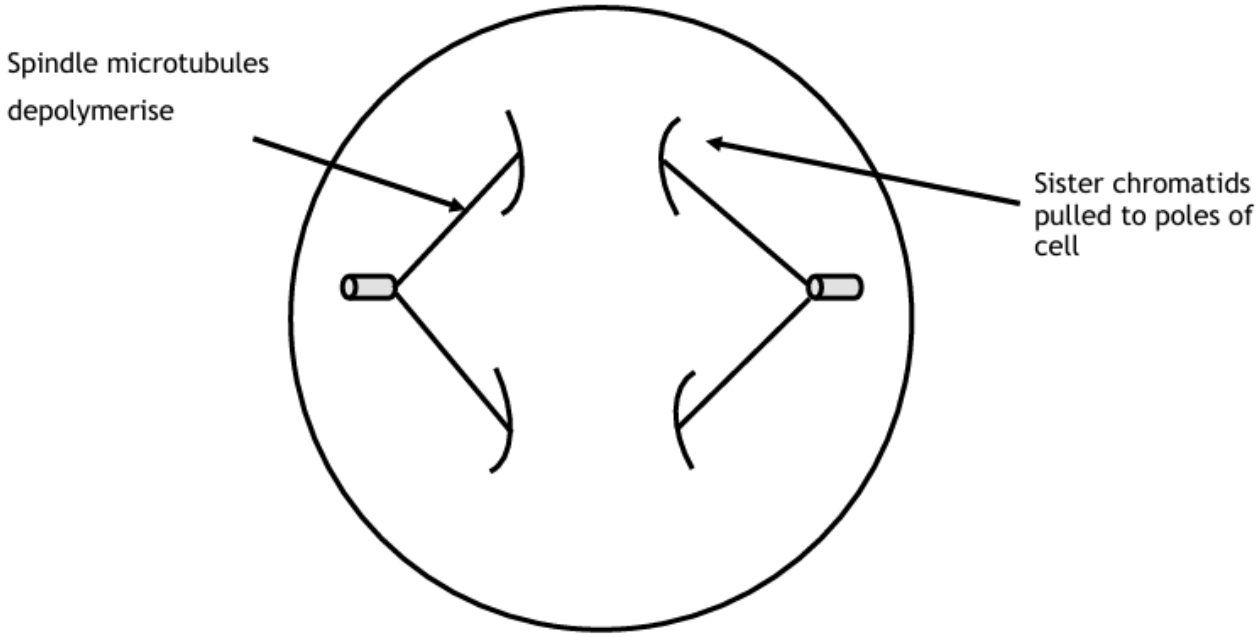
Chromosomes are aligned at the **metaphase plate** (equator of the spindle).



Stages of Mitosis

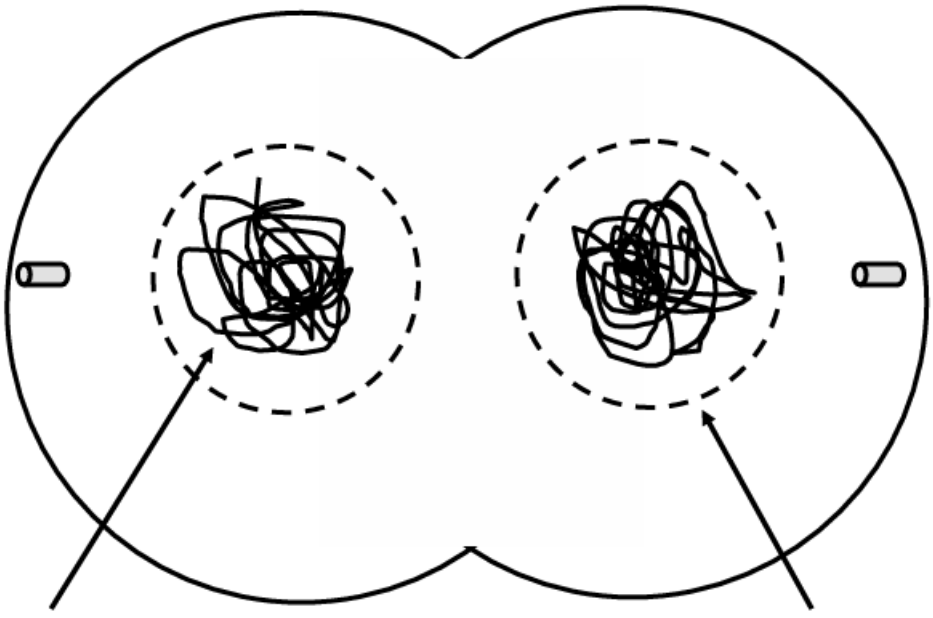
3. Anaphase

Spindle microtubules shorten by **depolymerisation**, separating **sister chromatids** which are pulled to **opposite poles**.



4. Telophase

The chromosomes **decondense** and **nuclear membranes** are formed around them.



Cell Cycle Checkpoints

Three Cell Cycle Checkpoints

Mechanisms within the cell that assess the condition of the cell during the cell cycle and **halt progression** to the **next phase** until certain requirements are met.

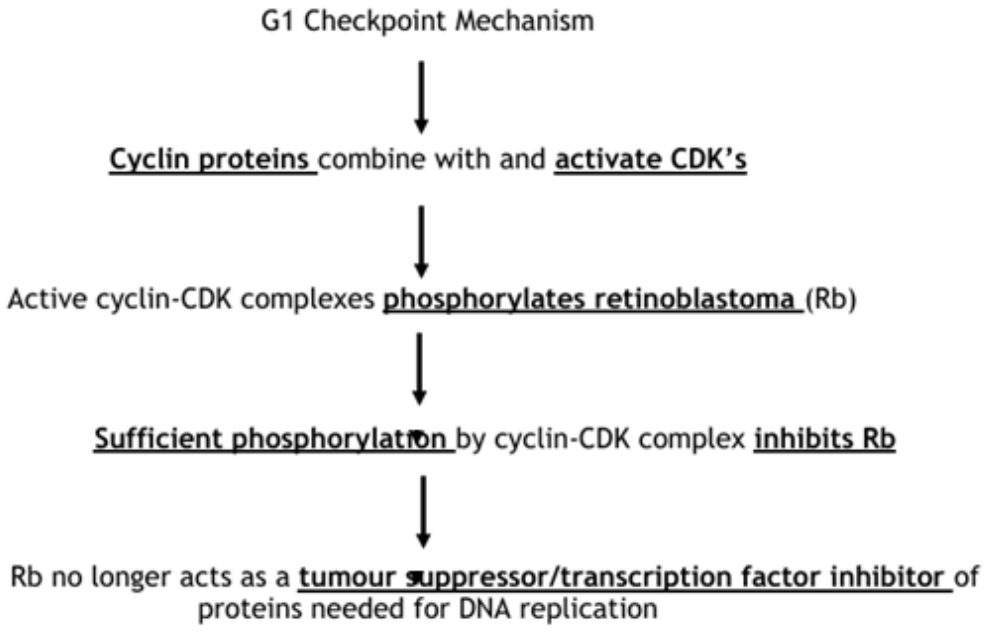
Name of Checkpoint	Cell Checkpoint	Halts entry before
G1 checkpoint	Assesses cell size through sufficient cyclin proteins that accumulate during **cell growth**	S phase
G2 Checkpoint	Success of **DNA replication** & any **DNA damage** is assessed.	M phase
M Checkpoint	Checks whether chromosomes have aligned correctly on the **metaphase plate** and attached to the spindle microtubules	Anaphase

Cyclin proteins

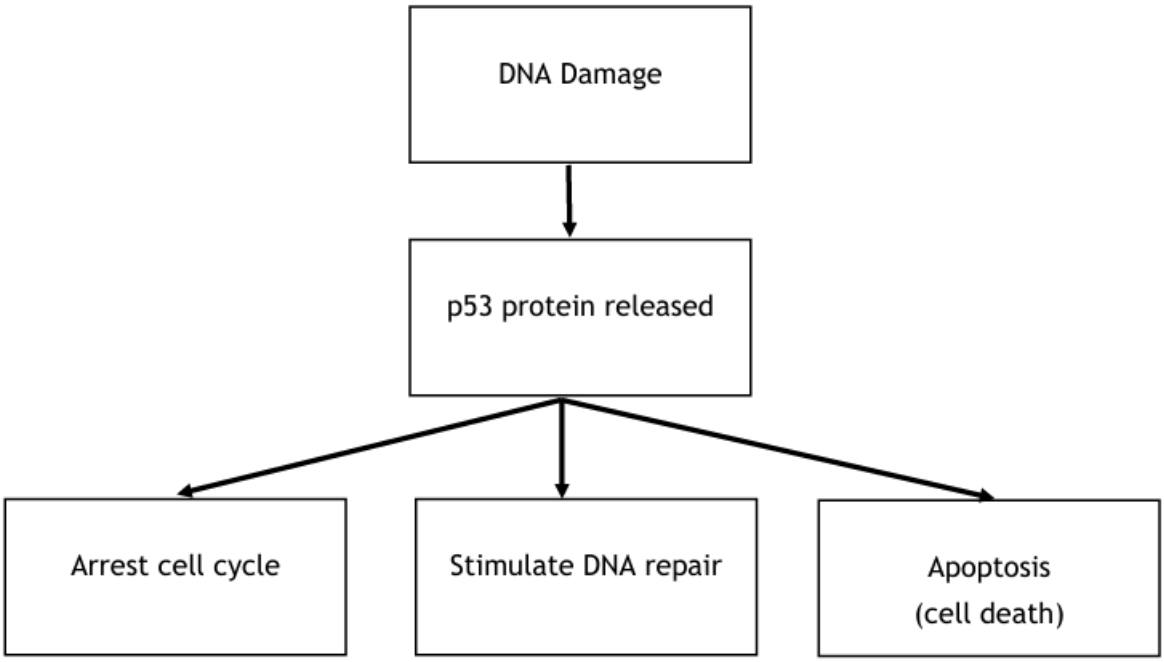
Accumulate during **cell growth** and are involved in **regulating** the cell cycle.

Cyclins combine with and activate **CDK's**.

Active cyclin-CDK complexes **phosphorylate specific proteins** that regulate progression through the cycle. If **sufficient phosphorylation** is reached, progression occurs.



DNA Damage & p53



Cell Cycle Rate

1. **Uncontrolled reduction** in the rate of the cell cycle
   - may result in **degenerative disease.**

2. **Uncontrolled increase** in the rate of the cell cycle
   - may result in **tumour formation.**

Proto-oncogene → Onco gene

Normal gene
Involved in **cell growth/division**

Mutated gene
Promotes **tumour formation**

Apoptosis

Apoptosis

1. External Cell death signal - **Lymphocytes**

2. Internal Cell death signal – **DNA damage/absence of growth factors (GF)**

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External death signal molecules

1. **Lymphocyte** releases cell death signal
2. This signal molecule bind to a **surface receptor** protein
3. A **protein cascade** is triggered within the cytoplasm
4. Resulting in activation of **caspases (proteases)** that cause destruction of the cell

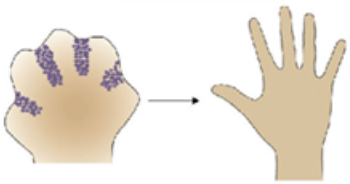
Internal death signal

1. DNA damage/absence of GF activates **p53 tumour suppressor protein.**
2. Resulting in activation of **caspases** that cause destruction of the cell

Importance of Apoptosis

Remove cells no longer required during the process of **development/metamorphosis**

Organism development



Metamorphosis