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THIS WAS MADE WITH THE HELP OF MOAZ MOHAMED

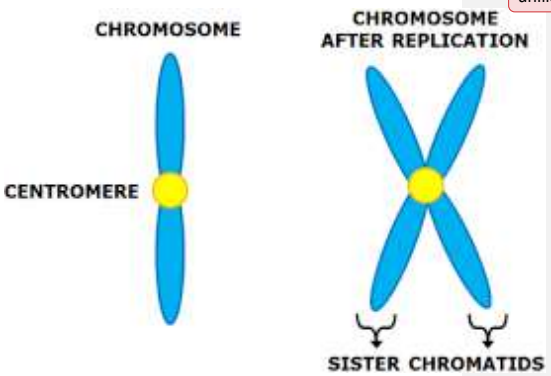
there are 2 types of cells:

- Somatic cells
- Gametes or sex cells

Somatic cells have a **diploid number of chromosomes,** they are produced through **mitotic "aka mitosis" division.**

Commented [SD1]: It means " اعداد زوجيه من الكروموسومات"
For example, **in humans**
each **Somatic/body** cell has **46** chromosomes, or **23** pairs, unlike Gametes that have only 23 **unpaired chromosomes**

Chromosomes are long thin DNA coiled with proteins, when the DNA replicates, the chromosome will consist of two chromatids.



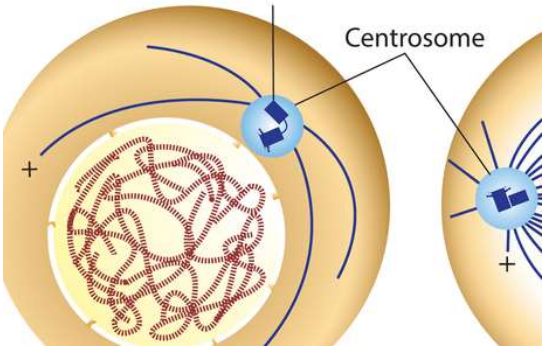
Chromosomes are **condensed DNA,** while chromatin is a **loose DNA.**

Chromosomes are formed in the **cell division.**

The chromosome contains a point called **centromere,** this point is where the microtubules are attached during cell division.

In double-stranded chromosomes, the centromere is the site where the sister chromatids meet.

Centrosome is an organelle that is responsible for the formation of microtubules during cell division.

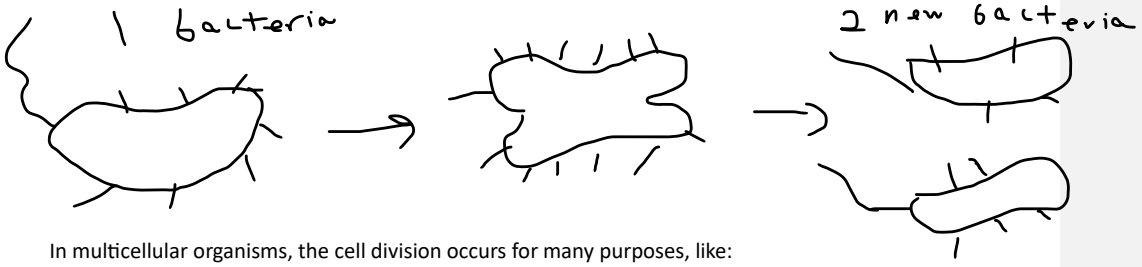


Cell division

The ability of living organisms to reproduce distinguishes the living organisms from the nonliving matter.

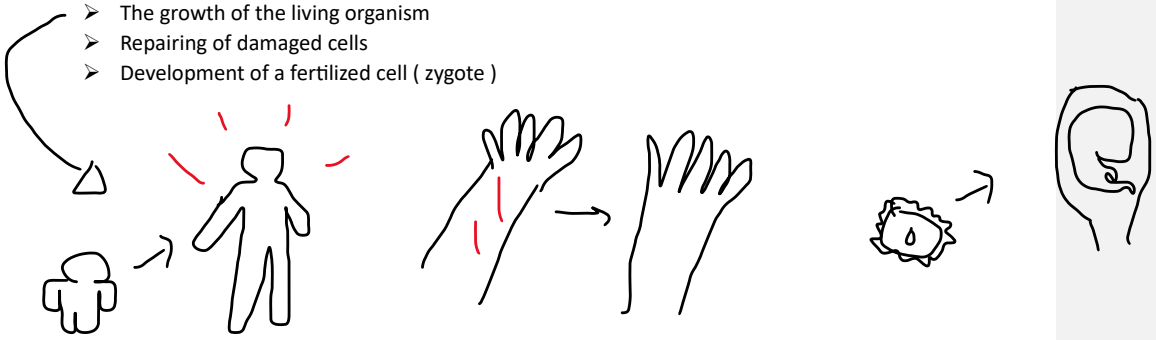
The cell has the ability to reproduce as well. In fact, the continuity of life is because of the reproduction of cells, or the **cell division.**

In unicellular organisms, the cell division reproduces the entire organism.(like in **binary fission)**



In multicellular organisms, the cell division occurs for many purposes, like:

- The growth of the living organism
- Repairing of damaged cells
- Development of a fertilized cell (zygote)



Cell cycle is the cell's life cycle, from its formation to its own division. So cell division is the main part of the cell cycle.

Cell division results in **genetically identical daughter cells.** Meaning that the cells that resulted in the cell division have identical genetic information, **DNA,** to the parent cell.

The meiotic division on the other hand, which occurs in **sex cells**, produces **nonidentical** daughter cells.

Commented [SD2]: as they are a mix from both parents

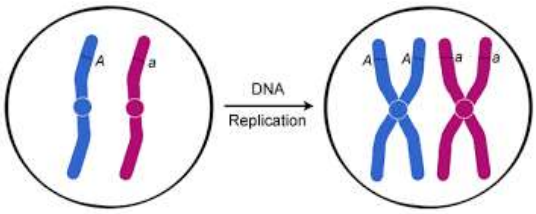
All the DNA in a cell constitutes the cell **genome.** The genome may consist of a single DNA molecule like in some prokaryotic cells, or a number of DNA molecules like in eukaryotic cells.

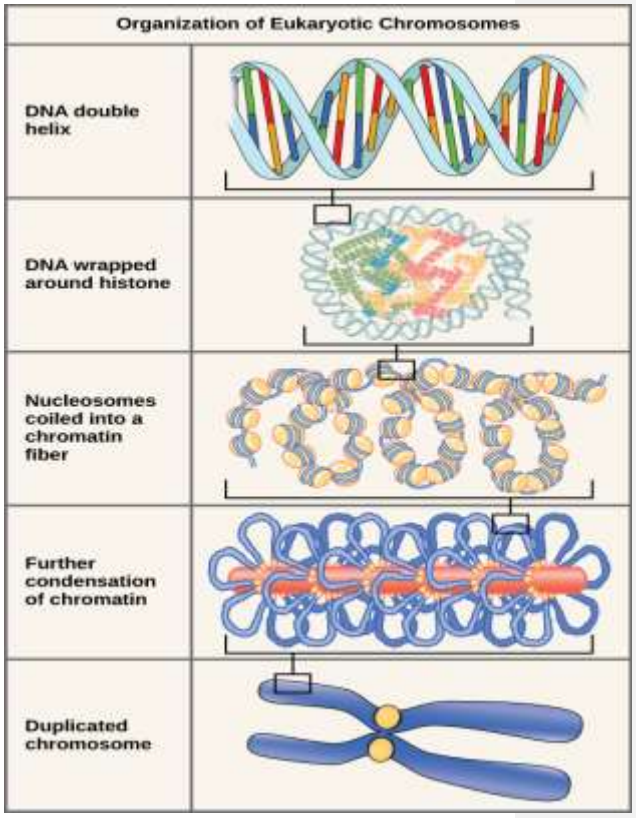
The DNA is packaged into a **chromosome** by being coiled around proteins called **Histones.**

Eukaryotic chromosomes consist of **chromatin,** a complex of DNA and protein that condenses during cell division.

In preparation for cell division, DNA is replicated, then the chromatin condenses forming **chromosomes.**

Each duplicated chromosome consists of two sister chromatids, which will separate during cell division, and a centromere.





Eukaryotic cell division contains two processes:

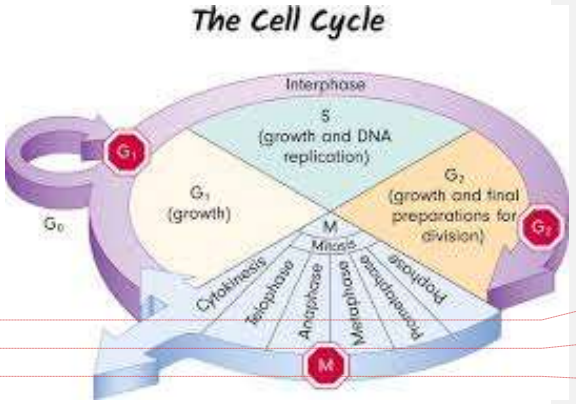
- Mitosis
- Cytokinesis

Mitosis is the division of the nucleus, while **cytokinesis** is the division of the cytoplasm.

THE CELL CYCLE

The cell cycle contains two phases:

- Interphase, in which the cell grows and the DNA replicates as preparation for cell division.
- The mitotic (M) phase, includes mitosis and cytokinesis.



Interphase represents **90%** of the cell cycle, it can be divided into 3 subphases:

- **G_1 phase** (first gap), **or growth**
- **S phase** (synthesis)
- **G_2 phase** (second gap), **or growth**

The cell grows during the three phases, but the DNA replication happens only during the S phase.

Commented [SD3]: G1 = It begins growing to "mature"

Commented [SD4]: S = Replicate its DNA

Commented [SD5]: G2 = more growing and preparation for mitosis

Miotic (M) phase

Contains mitoses and cytokinesis

Mitosis is divided into 5 phases:

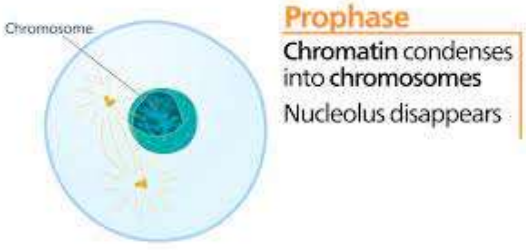
- Prophase
- Prometaphase
- Metaphase
- Anaphase
- Telophase

Cytokinesis occurs **right after telophase.**

After the cell has prepared itself for the division in the G_2 phase of the interphase. The prophase starts.

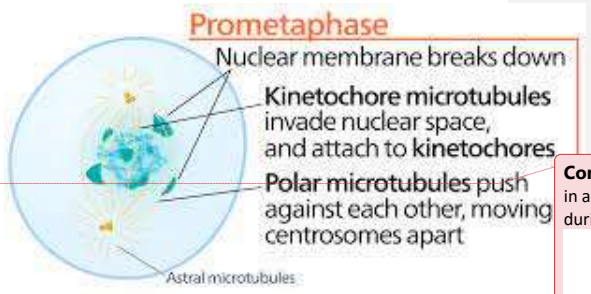
In prophase:

- The chromatin condenses and changes into chromosomes.
- The nucleolus disappears.
- The centrosomes begin to get further into the two poles of the cell and begin initiating the formation of microtubules (mitotic spindle).

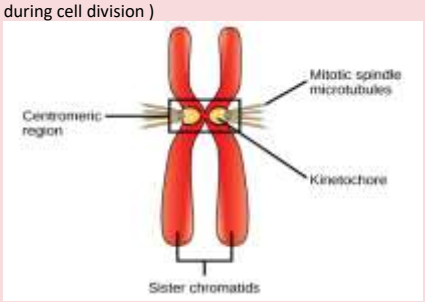


In prometaphase:

- The nuclear envelope breaks down into small fragments, which free the chromosomes from the nucleus.
- The centrosomes are on the two poles of the cell.
- The microtubules attach to the kinetochores making kinetochore microtubules.

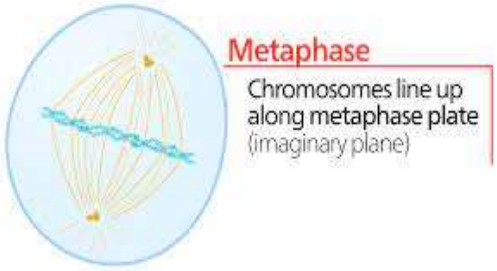


Commented [SD6]: (kinetochore is a disc-shaped protein in a duplicated chromosome where the microtubules attach during cell division)



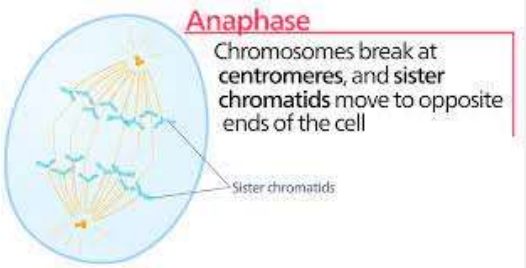
In metaphase:

- The chromosomes are standing along the "equator line" of the cell, as there is a plate holding them, this imaginary plate is called **metaphase plate.**
- The microtubules are along the whole cell.
- The metaphase is the **longest phase** in mitotic, lasting approximately 20 minutes.



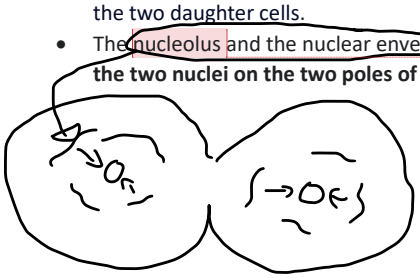
In anaphase:

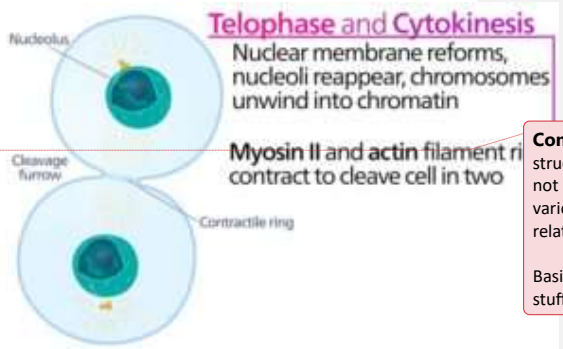
- The real division occurs between the two sister chromatids.
- The microtubules split and the chromosome is broken at the centromere, so each sister chromatid goes onto one of the cell poles making them **daughter chromosomes.**



In telophase:

- **Cleavage furrow** occurs, which is the indentation at the center of a dividing cell, which ingresses into a bridge that connects the two daughter cells.
- The nucleolus and the nuclear envelope **form the two nuclei on the two poles of the cell.**





- After that, cytokinesis takes place.
- Chromosomes unfold back into chromatin.

A closer look at mitotic spindles

The mitotic spindle is an apparatus of microtubules that controls chromosome movement in the division.

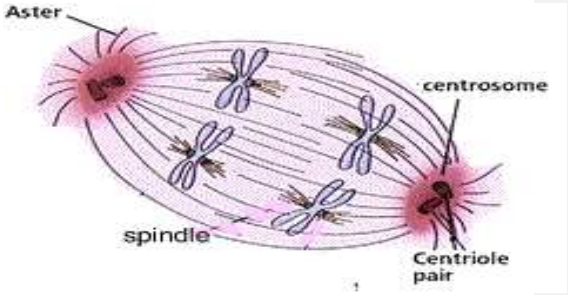
They begin to assemble from the **centrosome** during the prophase.

The centrosome duplicates and the two centrosomes travel into the two poles of the cell, where the mitotic spindle grows out from them.

Aster is a radial array of short microtubules extending from each centrosome.

The spindle includes:

- The centrosome
- The spindle microtubules
- The aster

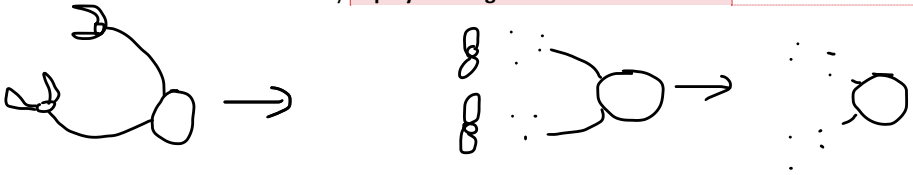


During prometaphase, some spindle microtubules attach to the **kinetochores** of the chromosome and begin to control the movement of the chromosome.

Microtubules that don't attach to kinetochores are called **nonkinetochore microtubules.**

During anaphase, the sister chromatids separate and move along the kinetochore-microtubule to the opposite sides of the cell.

The microtubules are shortened by **depolymerizing** at their kinetochore end.



Commented [SD7]: The nucleolus is a prominent structure found within the nucleus of eukaryotic cells. It's not enclosed by a membrane but is a distinct region where various components gather to perform specific functions related to ribosome production.

Basically, it's the area around the nucleus where important stuff like the endoplasmic reticulum reside

Commented [SD8]: They dissolve from the end to the start

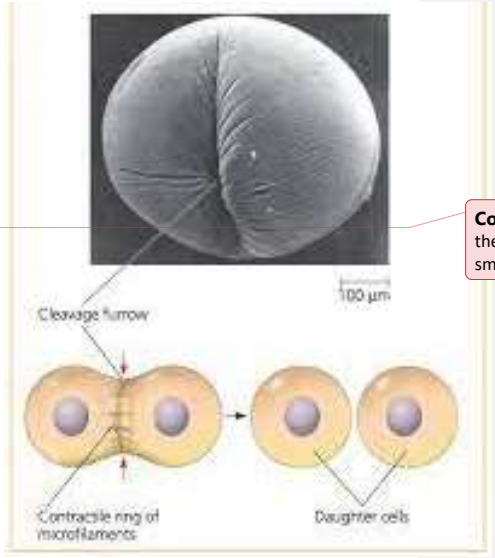
Nonkinetochore microtubules from opposite sides overlap and push against each other, **elongating the cell till the end of the division.**

Cytokinesis

In animal cells, cytokinesis occurs by a process known as **cleavage,** known as **cleavage furrow.**

Cleavage furrow occurs by a **contractile ring of microfilaments,** which contains **actin protein.**

In plant cells, a **cell plate** forms during cytokinesis.



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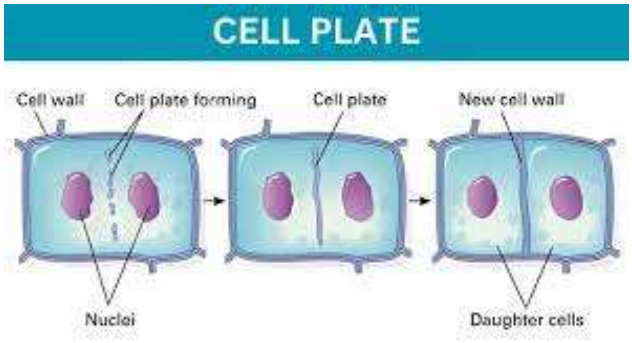


Commented [SD9]: It's like a ring that occurs between the two connected daughter cells, it gets smaller and smaller until it seperates them

Prokaryotic cells **(bacteria and archaea)** reproduce through **binary fission.**

Commented [SD10]: Where the cell splits into two new cells

Since prokaryotes evolved before eukaryotes, mitosis probably evolved from binary fission.

Some protists exhibit types of cell division that are between binary fission and mitosis.

Notes:

The frequency of cell division varies with the type of the cell.

These cell cycle differences result from regulation at the molecular level.

As you can see, the **M** phase is very important for life

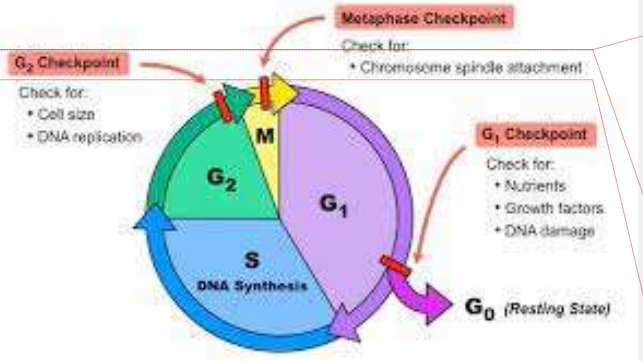
so when a cell has bad mutations or errors, it might lead to the creation of new **bad cells**, so you do not want these faulty cells to divide as they can be harmful

this is where **checkpoints** come in

CELL CYCLE CHECKPOINTS

They are checkpoints across the cell cycle made to check if the cell is **growing, replicating DNA,** and **functioning CORRECTLY!**

there are checkpoints in phases **G1, G2, M**



the cell cycle appears to be driven by specific **chemical signals** present in the cytoplasm

the cell cycle **control system** is regulated by both internal and external controls

For many cells, **the G_1 checkpoint** is the most important checkpoint.

If the cell receives the go-ahead signal at the G_1 checkpoint, it will usually pass the S, G_2, and S phases and divide.

If the cell doesn't receive the go-ahead signal, it will exit the cycle, entering a non-dividing state called the **G_0 phase.**

what happens if the cell fails a checkpoint?

If the problem causing the cell to fail can be fixed

- then it will pause here and try to fix the issue

but if it's unfixable

- A **protein** involved in **negative regulation** is **p53,** it is the protein responsible for initiating **APOPTOSIS** when the cell is unfixable
- the cell will commit **APOPTOSIS,** which is basically **suicide** for cells, ensuring that the irreparable cells won't divide

Commented [SD11]: G1 checkpoint -> Checking if the cell is
- growing enough
- if there are any damages in the DNA before moving on to **replication (S)**
- if the cell has enough resources to move on to the rest of the phases

Commented [SD12]: G2 checkpoint -> checks if the
- DNA was replicated correctly
- Is it growing well enough
- Does it have enough resources to move to M phase

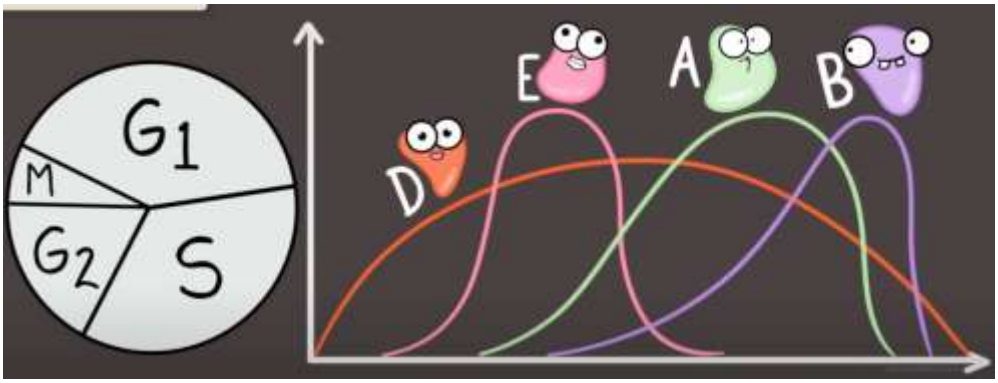
Commented [SD13]: M checkpoint -> checks if the
- The metaphase in mitosis, to check if the chromosomes are lined up correctly to be split (will be discussed later)

THE MEMBERS OF THE CELL CYCLE CONTROL SYSTEM

They are two **regulatory proteins:**

- Cyclin
- Cyclin-dependent kinases (Cdks)

These two proteins **fluctuate** during the cell cycle.



MPF (maturation-promoting factor) is a cyclin-Cdk complex that triggers the cell's passage from the G_2 phase to the M phase, so it's like a **go-ahead** signal

INTERNAL SIGNALS

- Kinetochores not attached to a spindle fiber, will send a message to delay **anaphase**

EXTERNAL SIGNALS

- Most of them are **growth factors**, which are proteins released by certain cells to stimulate other cells to divide, for example
  - **platelet-derived** growth factor (PDGF), it stimulates the division of human **fibroblast cells**
- **density-dependent inhibitions**, is where crowded cells stop dividing
  - **cancer cells** do not follow it, that's why they divide with no control
- **anchorage dependence** is exhibited by most animal cells, it's where cells must be attached to a substratum in order to divide

Commented [SD14]: Fibroblast cells are a type of connective tissue cell found in the body's connective tissues

Commented [SD15]: A substratum refers to a surface or underlying material upon which cells or organisms grow, attach, or move.

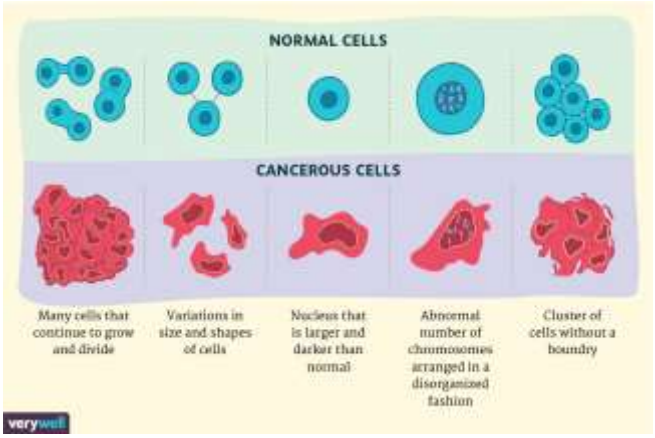
Cancer cells and its relation with the cell cycle

Cancer cells exhibit neither **density dependence** nor **anchorage dependence**.

Cancer cells **don't respond normally** to the body's control mechanisms.

Cancer cells **don't need growth factors** to grow and divide, as they:

- Can make their own growth factors.
- Convey the growth factor signal without the presence of the growth factor.
- May have an abnormal cell cycle control system.



A **normal cell** is converted into a **cancerous cell** through a process called **transformation.**

Cancer cells form **tumors,** masses of abnormal cells within otherwise normal tissue.

If abnormal cells remain at the original site, the tumor is called a **benign tumor.**

Malignant tumors can invade other tumors and metastasize, exporting cancer cells to other parts of the body, where they can form **secondary tumors.**

Commented [SD16]: Transformation, in the context of cell biology, refers to the process by which a normal cell undergoes genetic changes that cause it to become cancerous

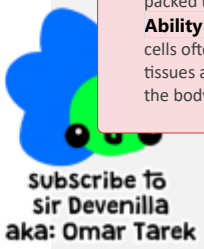
Several factors can contribute to cellular transformation:

Mutations: Changes in the DNA sequence can occur due to various factors such as exposure to carcinogens (like UV radiation or certain chemicals), errors in DNA replication, or inherited genetic mutations. These mutations can affect genes involved in cell cycle regulation, DNA repair, or signaling pathways that control cell growth.

Oncogenes and Tumor Suppressor Genes: Mutations can activate oncogenes, which are genes that promote cell growth and division excessively. Conversely, mutations can also inactivate tumor suppressor genes, which normally inhibit cell division or promote cell death when necessary. Dysregulation of these genes can lead to uncontrolled cell growth.

Loss of Contact Inhibition: Normal cells exhibit a phenomenon called contact inhibition, where they stop dividing when they come into contact with other cells. Cancer cells may lose this inhibition, allowing them to keep dividing even when tightly packed together, leading to uncontrolled growth.

Ability to Invade and Metastasize: Transformed cells often acquire the ability to invade surrounding tissues and metastasize (spread) to other parts of the body, forming secondary tumors.



FACTORS OF DEVELOPING CANCER

1. **Genetic Factors:** Inherited genetic mutations can increase the risk of certain cancers. These mutations can be passed down through generations and predispose individuals to cancer.
2. **Environmental Factors:** Exposure to carcinogens such as tobacco smoke, ultraviolet radiation, certain chemicals, asbestos, and pollutants can contribute to genetic mutations and increase the risk of developing cancer.
3. **Lifestyle Choices:** Poor lifestyle habits like smoking, excessive alcohol consumption, an unhealthy diet lacking in fruits and vegetables, lack of physical activity, and obesity can increase the risk of cancer.
4. **Infections:** Some infections, such as certain strains of human papillomavirus (HPV), hepatitis B and C viruses, and Helicobacter pylori, are linked to an increased risk of specific cancers.
5. **Age:** Cancer risk often increases with age due to accumulated genetic mutations and longer exposure to risk factors.
6. **Hormonal Factors:** Hormonal imbalances, such as high levels of estrogen in relation to progesterone in women, can increase the risk of breast and uterine cancers.
7. **Immune System Weakness:** A weakened immune system due to conditions like HIV/AIDS, organ transplantation, or certain medications can increase susceptibility to certain cancers.

HOW VIRAL INFECTION MIGHT INDUCE CANCER