
CELL DIVISON
MITOSIS & MEIOSIS

INTRODUCTION

Divide and Conquer!

Have you ever wondered how your body knows how to grow, heal a paper cut, or make you taller without turning into a giraffe overnight? (That would be awkward in gym class.) Well, it's all thanks to something happening deep inside your body every second—cell division! Your cells are like tiny superheroes, working behind the scenes, copying themselves, checking their work, and keeping everything running smoothly.

In this unit, you're going to dive into the cell cycle—the set of steps cells go through to grow, copy their DNA, and divide. First, there's Interphase, where the cell gets ready for action by growing and copying its DNA (kind of like studying before a test). Then comes Mitosis, where the cell's nucleus splits and creates two brand-new, identical cells. And finally, there's Cytokinesis, where the cell finishes dividing, and tada! Now there are two cells instead of one!

But that's not all. You'll also learn about Meiosis, a different kind of cell division that happens when plants and animals make babies. Meiosis is a little more dramatic. It mixes up DNA to create special cells called gametes (like eggs and sperm) that have just half the normal amount of DNA. That mix-up is super important because it leads to genetic diversity, which is science-speak for making sure no two people (or puppies, or pine trees) are exactly the same!

You'll even learn how cells know when to divide, when to stop, and what happens when things go wrong (hint: it can lead to something serious like cancer). So get ready to explore how your body grows, heals, and creates life—one tiny cell at a time. It's kind of like a microscopic dance party... with some very important rules.

VOCABULARY

Vocabulary Word	Definition
Anaphase	
Asexual Reproduction	
Cancer	
Cell Cycle	
Centrioles	
Centromere	
Chromosome	

Vocabulary Word	Definition
Crossing Over	
Cytokinesis	
Diploid	
Double Helix	
Fertilization	
Gametes	
Genome	
Haploid	

Vocabulary Word	Definition
Homologous	
Interphase	
Law of Independent Assortment	
Law of Segregation	
Meiosis	
Metaphase	
Mitosis	
Nucleotide	

Vocabulary Word	Definition
Prophase	
Replication	
Spindle	
Synthesis	
Telophase	
Zygote	

PHENOMENON

The Growing Problem in the HAB

Mission Log – Sol 74

Something strange is happening inside the Mars HAB.

Last week, you and the crew noticed something odd in the hydroponic lab.

The algae cells in the growth tanks—used to produce oxygen and food—were dividing faster than normal. At first, everyone was excited. "Free bonus energy!" one crewmate joked. But now, the algae is growing out of control, turning thick and slimy, clogging the oxygen lines. Something's not right.

You take a closer look under the microscope. The cells aren't going through the normal cell cycle. They're skipping checkpoints. Some are dividing without finishing interphase, and others are dividing so quickly, they're making mistakes in their DNA replication. These errors are building up fast. It's like they've lost their brakes. The word floats through your mind: cancer-like behavior.

Meanwhile, in the human tissue samples you've been monitoring (part of an experiment on long-term space exposure), you find something even more shocking. One group of test cells is stuck in G0, refusing to divide at all. Another sample is making gamete-like cells—like it's accidentally started meiosis without a signal. That's not supposed to happen outside a living body.

You sit back and start to connect the dots. The radiation levels outside the HAB have been spiking lately. Could cosmic radiation be mutating DNA and confusing the cells' instructions? Could the damage be turning normal cell division into something dangerous?

Now the clock is ticking. If this rogue cell growth spreads to the HAB's oxygen systems or contaminates your own body's cells, it could spell disaster. Your mission has changed:

You must figure out how the cell cycle is supposed to work, how cells replicate DNA, how mitosis and meiosis function, and what happens when cells grow out of control. The survival of the crew may depend on it.

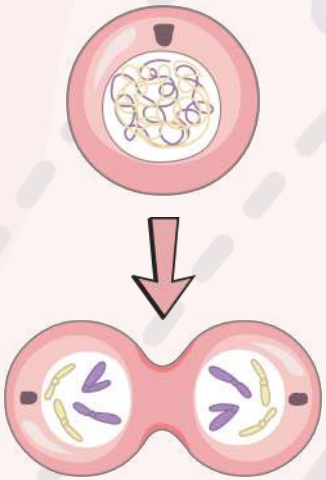
1. What evidence from the story shows that the algae cells are not going through the cell cycle correctly?
   - "The algae cells are not going through the cell cycle correctly because _____."
   - "One clue is that they are dividing without _____."
   - "This shows a problem with the _____ stage or the _____."
2. Why is interphase an important part of the cell cycle, and what happens during it?
   - "Interphase is important because it helps the cell _____."
   - "During interphase, the cell _____ and _____."
   - "If a cell skips interphase, it might not be ready for _____."
3. How does DNA replication work, and why is it important before a cell divides?
   - "DNA replication is important because each new cell needs _____."
   - "In the semi-conservative model, each new DNA molecule has _____ and _____."
   - "If DNA does not copy correctly, the cell might _____."
4. What is the difference between mitosis and meiosis, and why does it matter that some cells are doing the wrong one?
   - "Mitosis is used for _____, and it makes _____ cells."
   - "Meiosis is used for _____, and it makes _____ cells."
   - "If a cell accidentally starts meiosis instead of mitosis, it might create _____ instead of _____."
5. How could problems with the cell cycle lead to something like cancer?
   - "Cancer can happen when cells divide without _____."
   - "Checkpoints in the cell cycle are supposed to _____."
   - "If those checkpoints fail, cells may _____, which could lead to _____."

IMPORTANCE OF CELL DIVISION

Reproduction is how living things create new organisms. There are two main types: asexual reproduction and sexual reproduction.

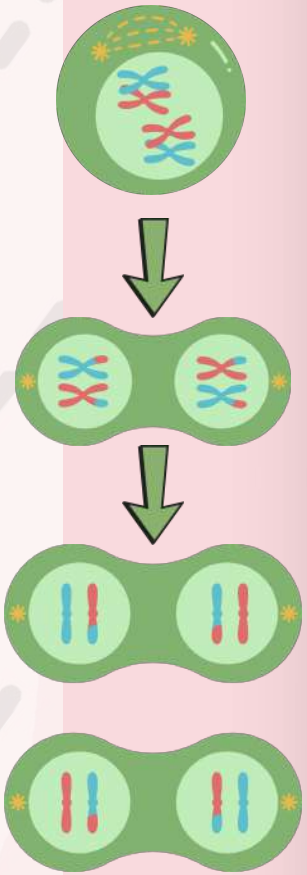
- **Asexual Reproduction** involves **one** parent and produces offspring that are identical to the parent. This happens through a process called **Mitosis**. Mitosis is important for **growth**, **repair**, and **maintenance** in multicellular organisms. It ensures that each new cell has the **same genetic** material as the original cell.

- **Sexual Reproduction** involves **two** parents. Each parent contributes a **gamete** (sex cell), which come together during **fertilization** to form a new organism with a **mix** of **traits** from both parents. This process involves **Meiosis**, which creates genetic **diversity** in the offspring. Meiosis is crucial for evolution and **adaptation** because it produces **offspring** with **varied traits**, increasing the chances of **survival** in changing environments.



Asexual

Sexual

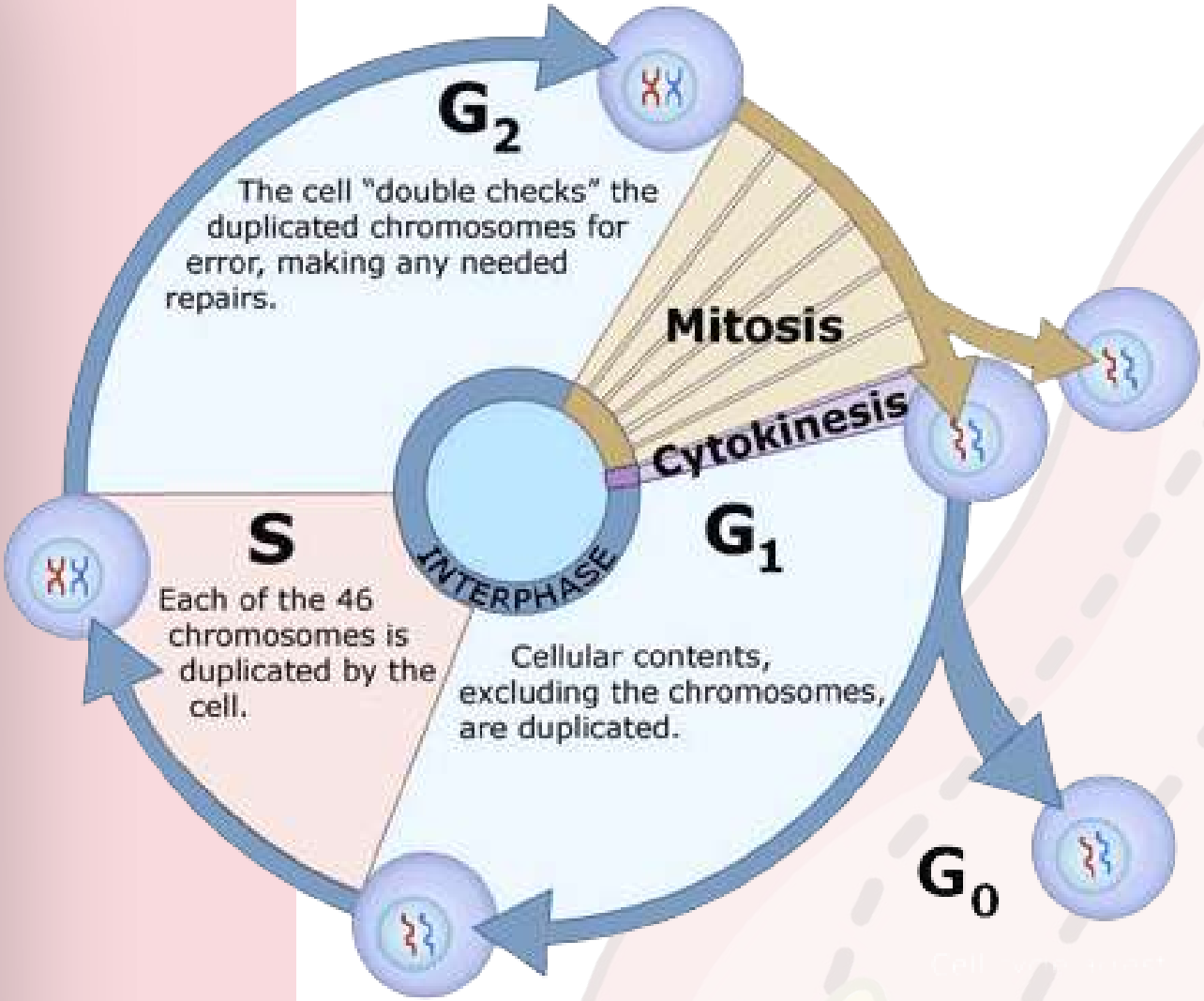


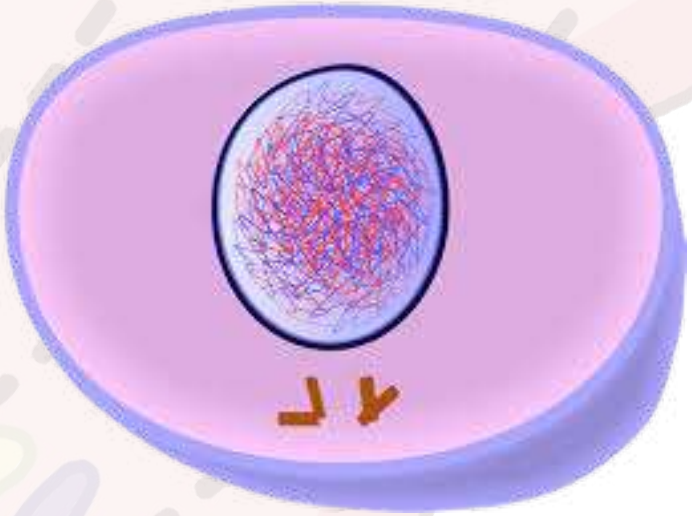
IDENTIFY THE STAGES OF THE CELL CYCLE

- The **cell cycle** is the series of stages a cell goes through as it grows and divides. It has three main stages: **Interphase**, **Mitosis**, & **Cytokinesis**

- **Interphase:** The cell **grows**, makes **proteins**, and **copies** its **DNA**.
  - During this stage, the DNA is in long strands called **chromosomes**. The chromosomes are copied, so the cell has two sets of genetic material. **Centrioles** in animal cells also duplicate to help in cell division.

- **Recognize the Importance of Interphase - Interphase is crucial for cell division because:**
  - **G1 / Gap1 or Primary Growth -** The cell grows larger and produces more organelles.
  - **Synthesis / S-Phase:** The DNA is copied, ensuring that each new cell will have a complete set of chromosomes.
    - **Replication is semi-conservative** because each new DNA molecule has one old strand and one new strand. The DNA double helix unwinds, and enzymes help match new nucleotides to the old strands, forming two identical DNA molecules.
  - **G2 / Gap2 or Secondary Growth:** The cell checks that everything is ready for division, preparing for Mitosis.

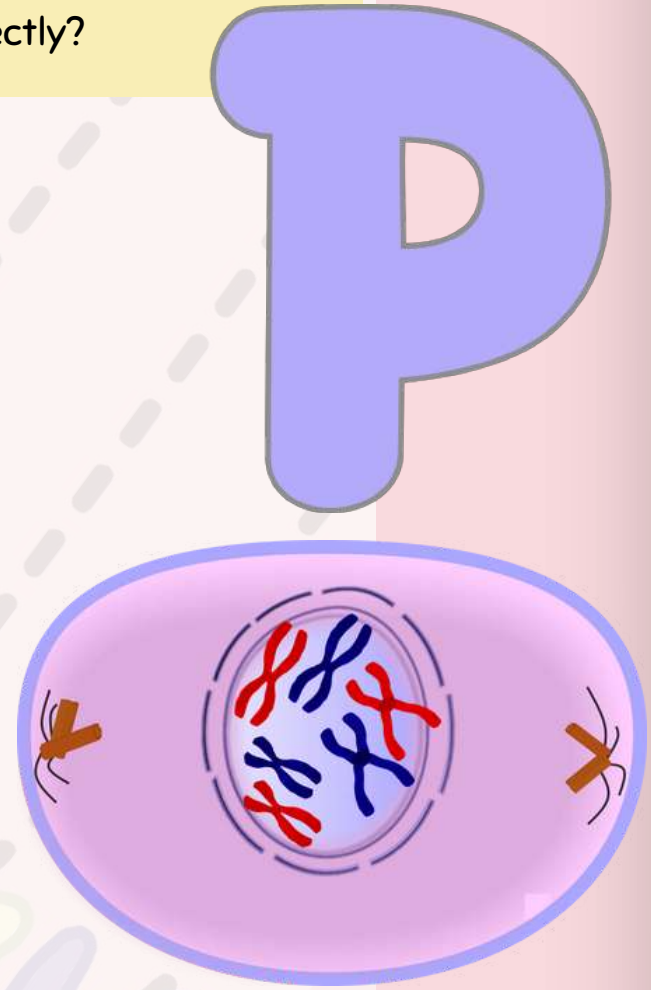

G2
The cell "double checks" the duplicated chromosomes for error, making any needed repairs.
Mitosis
Cytokinesis
G1
INTERPHASE
S
Each of the 46 chromosomes is duplicated by the cell.
Cellular contents, excluding the chromosomes, are duplicated.
G0



1. What happens during Interphase? Explain in your own words what the cell does during this stage.
2. Why is Interphase important for the cell? Discuss why this stage is necessary before a cell divides.
3. What are the three stages of Interphase? Can you name them and describe what happens in each stage?
4. How does the cell prepare for division during Interphase? Talk about how the cell gets ready to divide and why this is important.
5. What might happen if the cell didn't complete Interphase correctly?

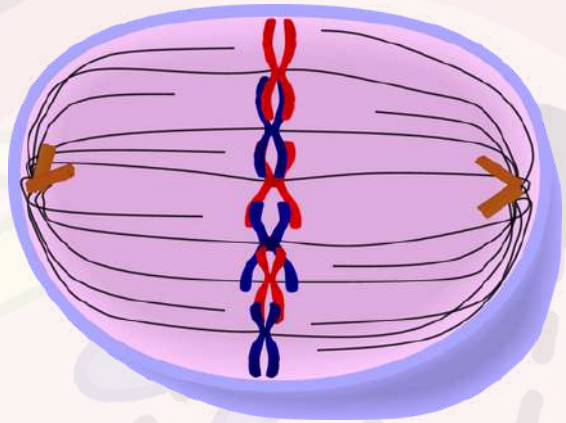
MITOSIS

- **Mitosis**: This is when the cell's nucleus divides. It includes four steps:
  - **Prophase**: The **chromosomes** condense and become visible. The **nuclear membran**e starts to **break down**, and the **spindle** fibers begin to form.



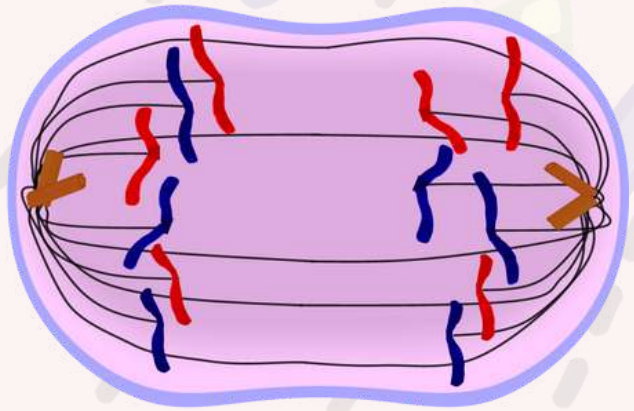
M

- **Metaphase**: The chromosomes **line up** in the **middle** of the cell. Each **chromosome** is attached to **spindle fibers** at its **centromere**.



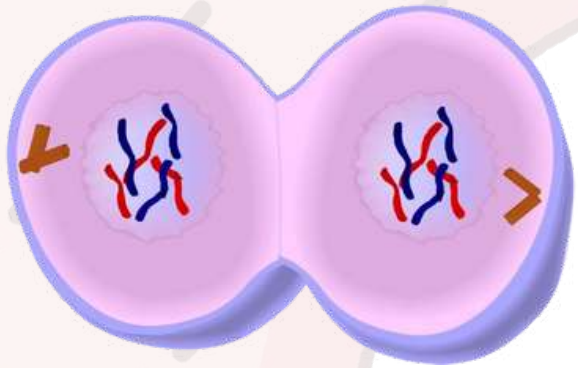
A

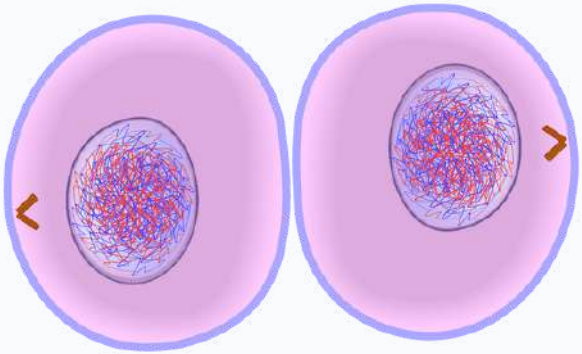
- **Anaphase**: The **sister chromatids** (copies of chromosomes) are pulled **apart** and move to **opposite** sides of the cell.



T

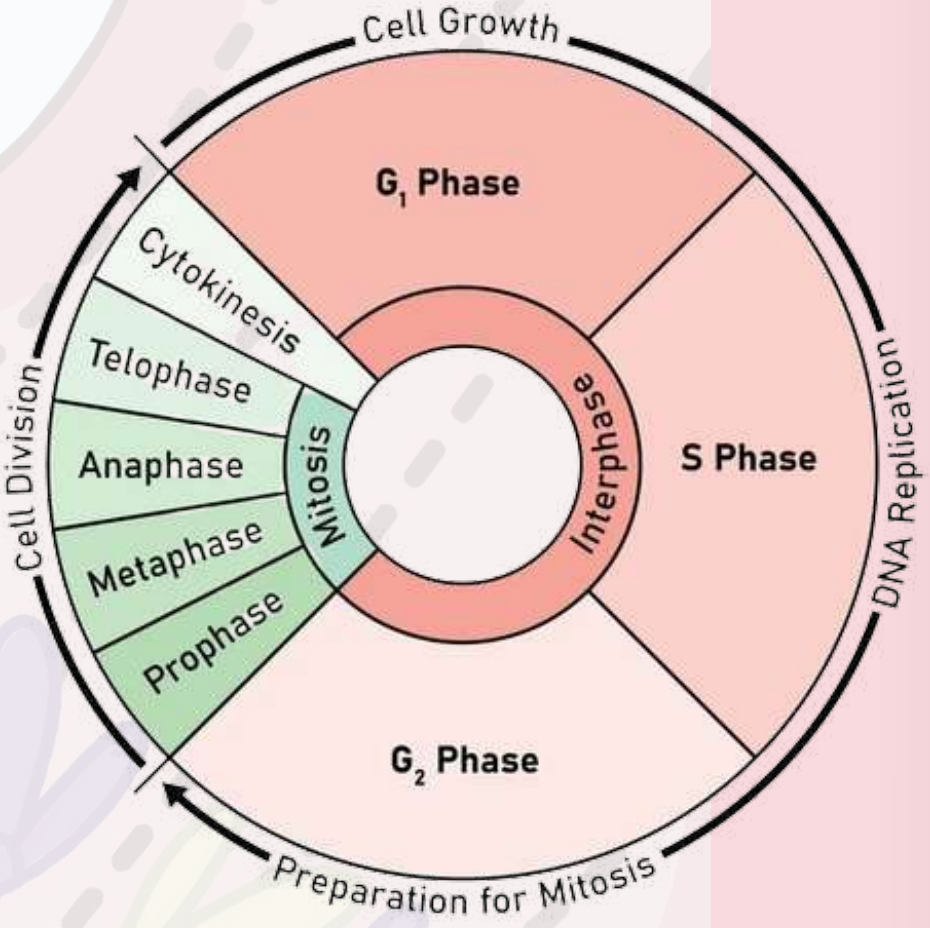
- **Telophase**: New **nuclear membranes** form around each set of **chromosomes**. The chromosomes start to **spread** out again. In **animal cells**, a **cleavage furrow** forms, pinching the cell membrane and eventually splitting the cell into two. In **plant cells**, a **cell plate** forms down the middle, which will develop into a new **cell wall** that separates the two daughter cells.





- **Cytokinesis:** The **division** of the cell's **cytoplasm** occurs after the **nucleus divides**, creating **two identical daughter** cells, each with the **same** number of **chromosomes** as the original cell.

- **G0 (Cell Arrest):** Sometimes, cells enter a **resting** stage called G0. In this stage, the cell is **not** actively **dividing**. It can stay in this stage for a long time, depending on the type of cell and its role in the body. Some cells, like nerve cells, may stay in G0 permanently.

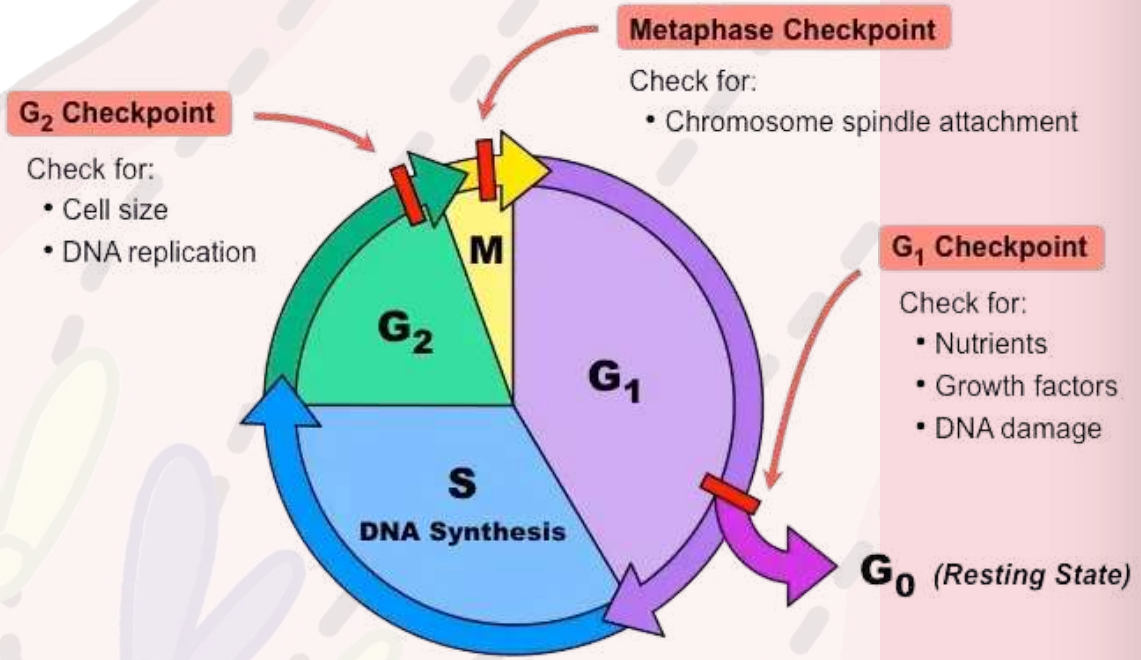


- What is the G1 Phase like for the cells in Cellopolis? Describe how the cells prepare during the G1 Phase and why this stage is important for the upcoming repair mission.
- How do cells make sure they have everything they need before moving on from the G1 Phase? Explain what happens at the G1 Checkpoint and why it's important for cells to pass this checkpoint.
- What happens during the S Phase, and why is it crucial for cell division? Discuss what the cells do during the S Phase and how making copies of their DNA helps them prepare for the repair.
- What do cells do in the G2 Phase to get ready for the big repair operation? Talk about the final preparations cells make in the G2 Phase and what they check before starting the repair.
- Why might some cells enter Stage G0, and what does apoptosis mean for the cell cycle? Explain why some cells might take a break in Stage G0 and what apoptosis means for cells that are not needed anymore.

CELL CYCLE CONTROL

Explain Cell Cycle Control Mechanisms

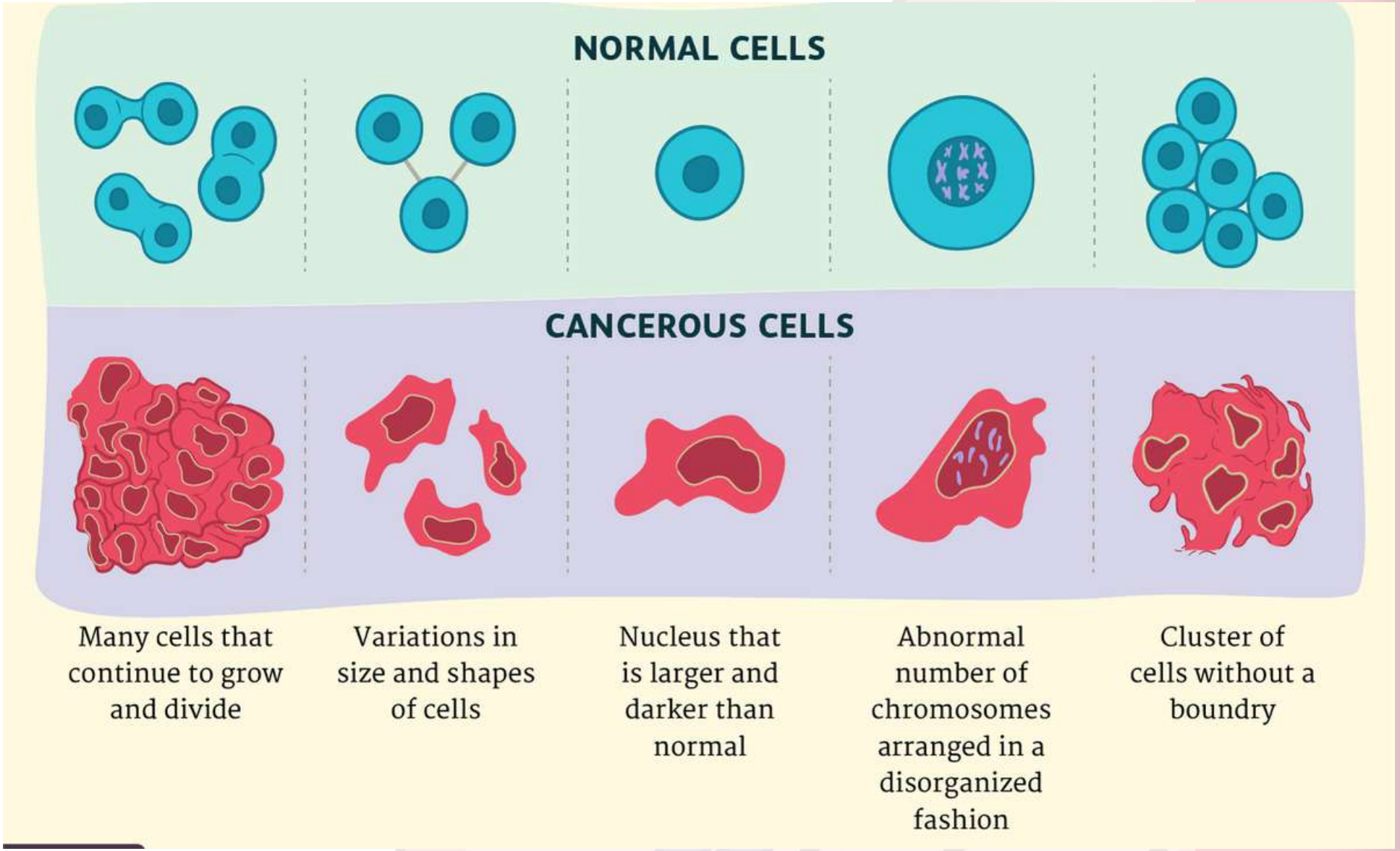
- The cell cycle is carefully controlled by:
  - **Checkpoints**: These are points in the cell cycle where the cell checks to see if it is ready to move to the next stage. For example, before Mitosis begins, the cell checks that the DNA is copied correctly.
- **Cyclins:** These are **proteins** that help **control** the **timing** of the cell cycle. They ensure that each stage happens at the right time.
- **Apoptosis:** If the cell **detects** severe **damage** that cannot be **repaired**, it may undergo **apoptosis**, also known as **programmed cell death**. This process ensures that damaged or **dangerous** cells do **not** continue to **divide** and potentially cause problems like **cancer**.



CELL CYCLE OUT OF CONTROL - CANCER

Link Cell Cycle Disruptions to Cancer

- When the cell cycle doesn't work properly, cells can grow and divide **uncontrollably**, **unregulated** cell **division**, leading to the formation of a **tumor**. A tumor is a **mass** of **abnormal** cells, and it can be either **benign** or **malignant**:
  - **Benign Tumors:** These are **non-cancerous** tumors. They grow **slowly** and do **not** spread to other parts of the body. Although they are generally less dangerous, they can still cause problems if they press on vital organs or tissues.
  - **Malignant Tumors:** These are **cancerous** tumors. They grow **rapidly** and can **invade** nearby tissues. Unlike benign tumors, malignant tumors can **spread** to other parts of the body through a process called **metastasis**. During metastasis, cancer cells **break away** from the original tumor, travel through the **bloodstream** or **lymphatic** system, and form new tumors in other parts of the body.
- **Cancer** occurs when **mutations** or changes in the **DNA** cause the cell cycle to go out of control. If **checkpoints** fail or apoptosis does not occur as it should, damaged cells can survive and divide, contributing to the development and spread of cancer.

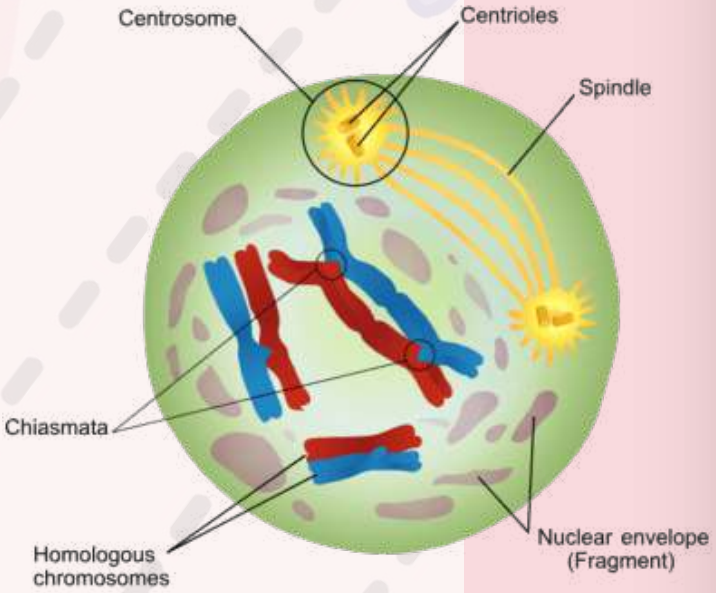

NORMAL CELLS
CANCEROUS CELLS
Many cells that continue to grow and divide
Variations in size and shapes of cells
Nucleus that is larger and darker than normal
Abnormal number of chromosomes arranged in a disorganized fashion
Cluster of cells without a boundry

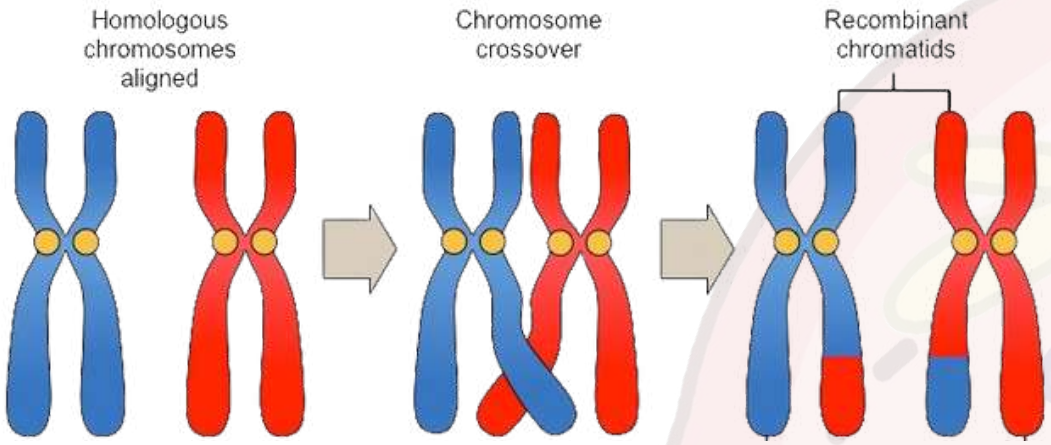
- What are the main stages of the cell cycle, and what happens in each one? Describe the key stages: Interphase (G1, S, G2), Mitosis (Prophase, Metaphase, Anaphase, Telophase), and Cytokinesis. How does each stage contribute to cell division?
- Why are the checkpoints during Interphase crucial for cell cycle control? Explain the role of the G1 Checkpoint, S Phase, and G2 Checkpoint. How do these checkpoints help ensure that cells are ready to move to the next stage?
- How does DNA replication during the S Phase prepare cells for division? Discuss how the cell copies its DNA during the S Phase and why this process is important for producing two identical daughter cells.
- What role do cyclins play in regulating the cell cycle? Describe how cyclins and cyclin-dependent kinases (CDKs) work together to control the timing of the cell cycle phases. Why is this regulation important?
- What happens if there are problems with cell cycle control, and how can this lead to cancer? Explain how errors in cell cycle checkpoints or regulation can result in uncontrolled cell growth and the formation of tumors. What does this mean for the cell cycle?

MEIOSIS

Understand Meiosis and Genetic Diversity

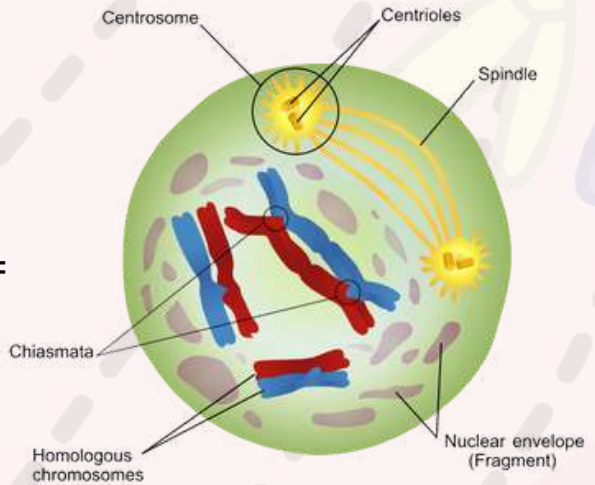
- **Meiosis** is a special type of cell division that creates gametes (sex cells: sperm and eggs), and it occurs in two main stages: Meiosis I and Meiosis II. Each of these stages has its own specific steps:
  - **Meiosis I:**
    - **Interphase**: Occurs just like in Mitosis
    - **Prophase** I: **Diploid** Cell enters - Full set of chromosomes
      - **Tetrad** Formation: Homologous chromosomes (chromosomes with the same genes but from different parents) pair up to form a tetrad.
      - **Crossing Over**: The homologous chromosomes exchange genetic material, leading to new combinations of genes - **INCREASED VARIATION**

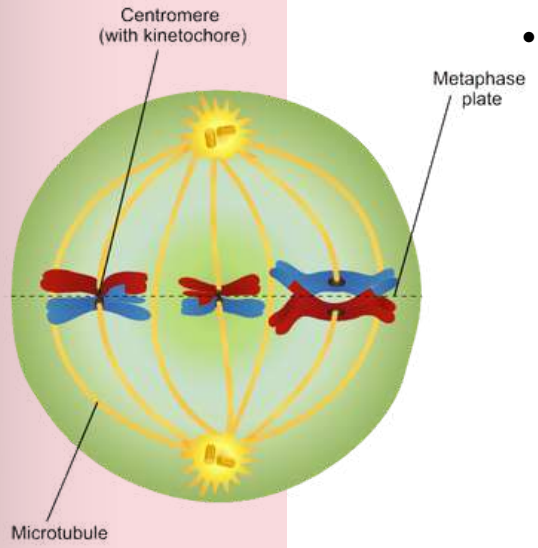




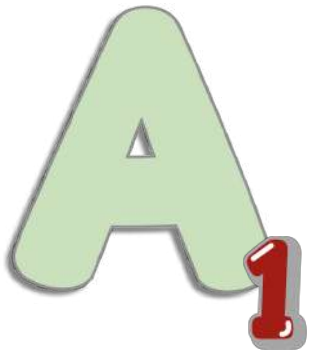
MEioSiS 1

- **Prophase I**
  - **Tetrad** Formation
  - **Crossing Over** - forms new combinations = **increase** genetic **diversity**

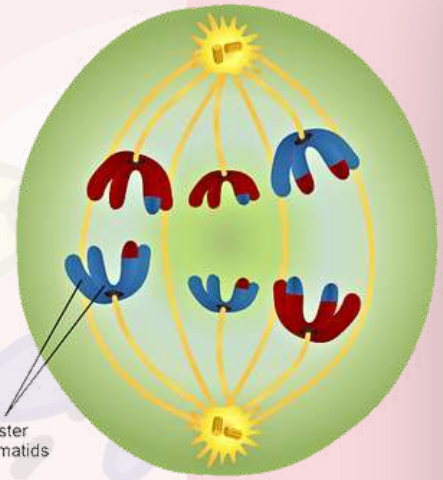


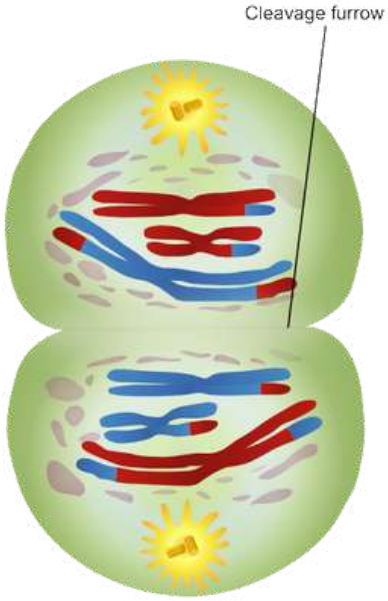


- **Metaphase I**
  - **Independent Assortment:** The tetrads line up in the **middle** of the cell. The orientation of each pair is random, leading to independent assortment (random)of chromosomes, which **increases** genetic **diversity**

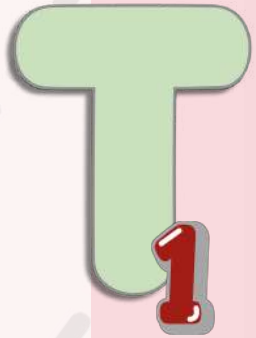


- **Anaphase I**
  - The **homologous chromosomes** are pulled **apart** to opposite sides of the cell.



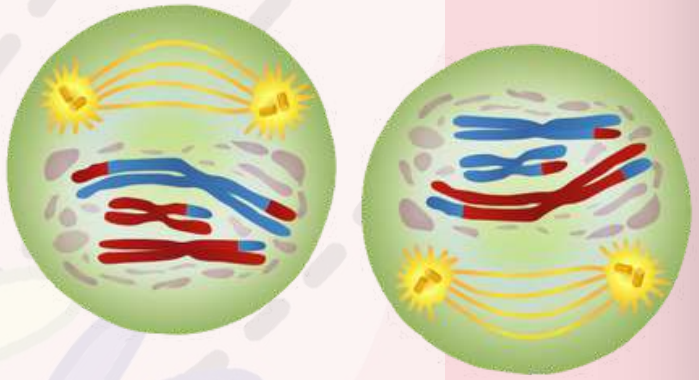


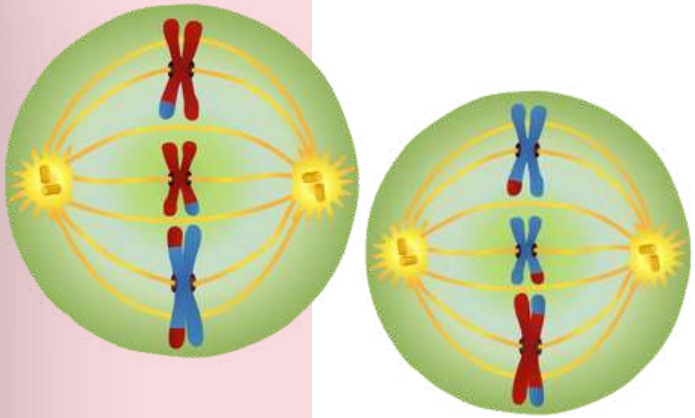
- **Telophase I**
  - The cell divides, resulting in two **haploid** cells.
  - These cells have **half** the **number** of **chromosomes** as the **original** cell.



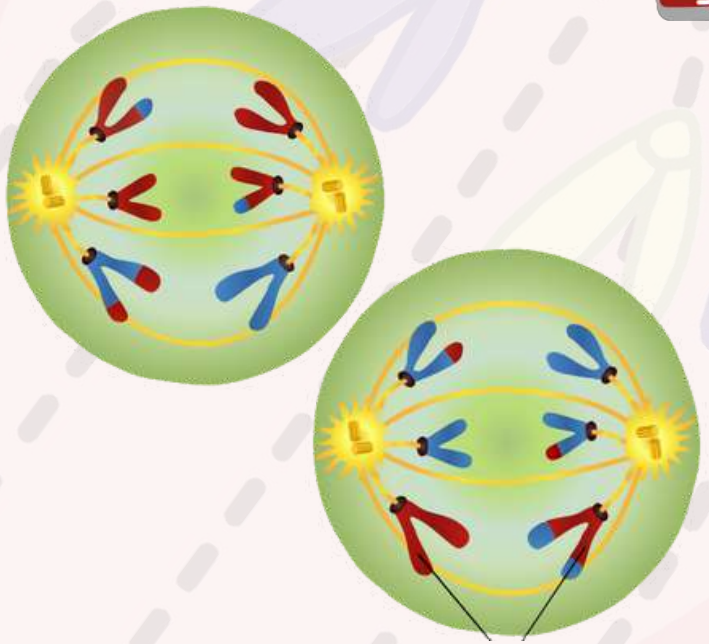
MEIOSIS 2

- **Prophase II**
  - The **chromosomes condense** again, and a new **spindle** forms in each of the two **haploid** cells.

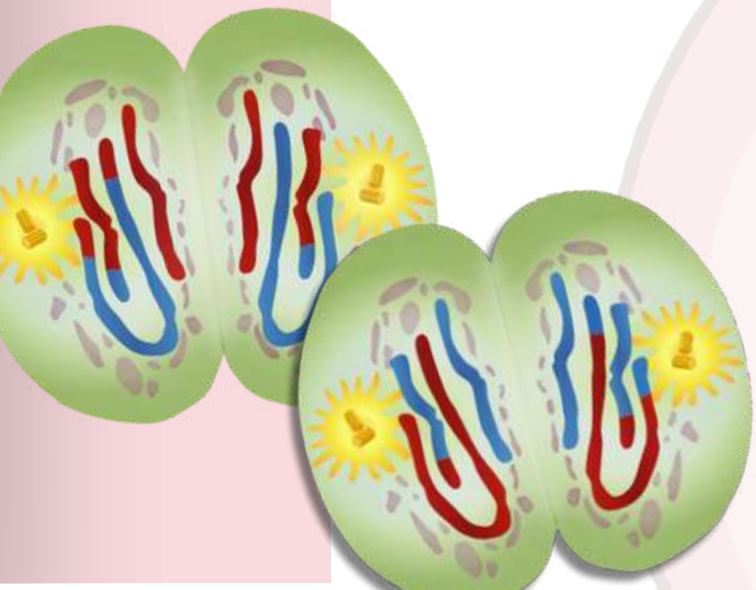




- **Metaphase II**
  - The **chromosomes** line up in the **middle** of each cell.



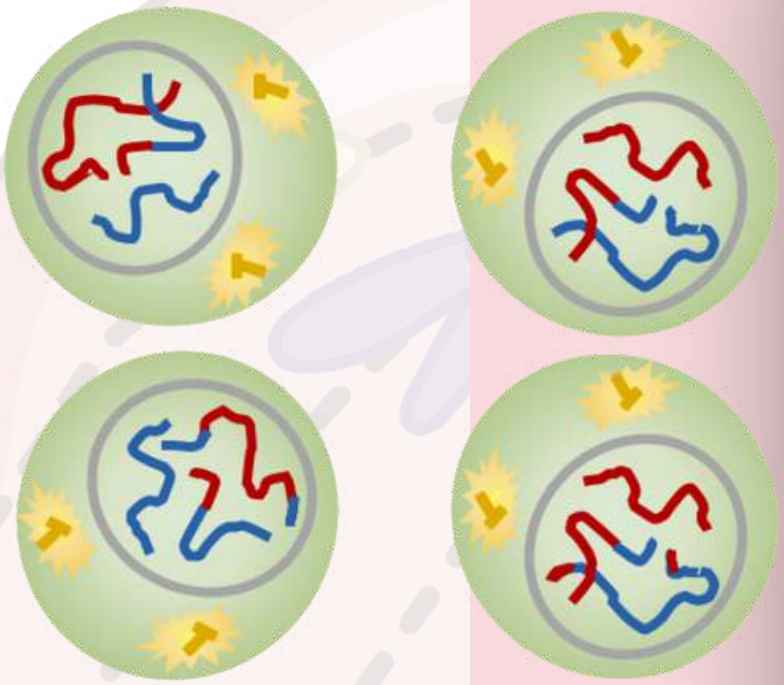
- **Anaphase II**
  - The **sister chromatids** (copies of chromosomes) are pulled **apart** to opposite sides of each cell.



- **Telophase II**
  - The cells **divide** again, resulting in a total of **four haploid gametes**. These **gametes** are genetically **unique** due to the processes of **crossing over** and **independent assortment**.

C

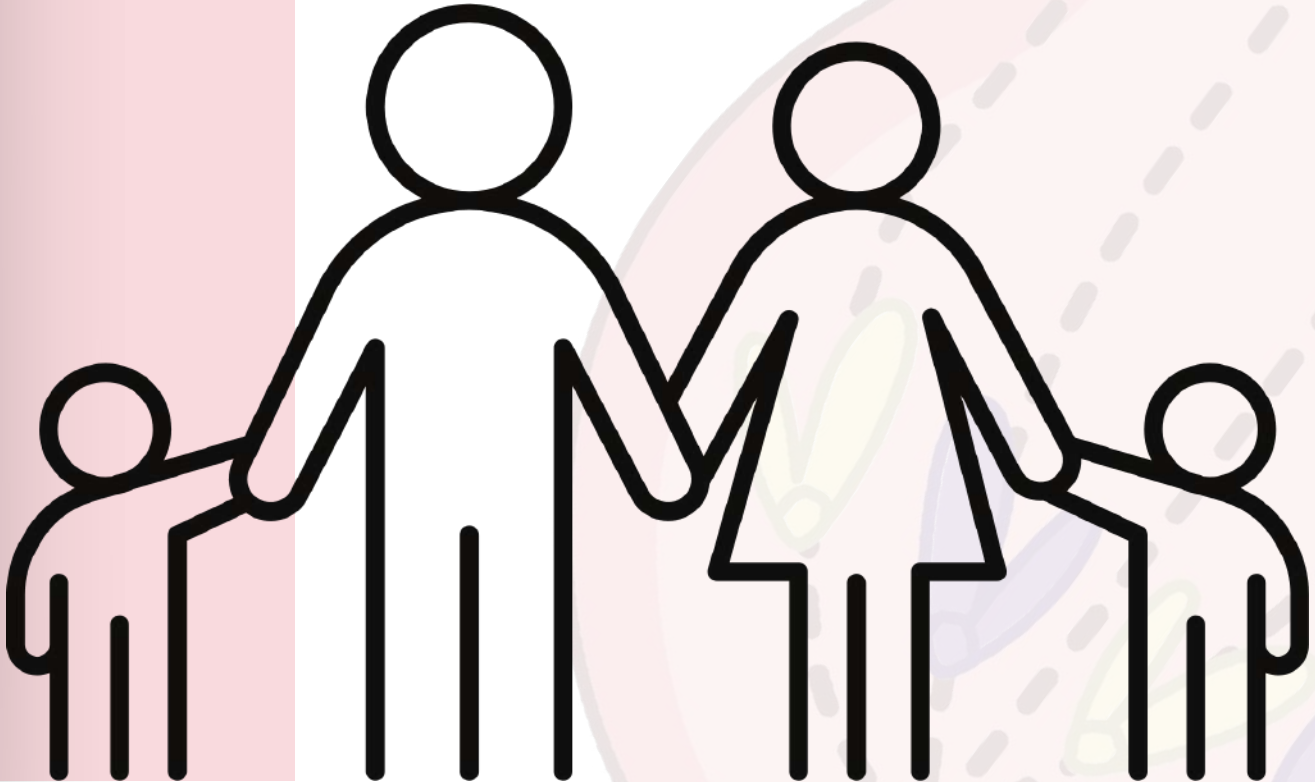
- **Cytokinesis**
  - **Division** of the **cytoplasm** forming 4 **unique** cells = **gametes**
  - Male**: 4 sperm**
  - Female**: 3 polar bodies and 1 egg**



- What are the main stages of Interphase, and what happens in each one? Based on the video and the transcript, explain the roles of the G1 Phase, S Phase, and G2 Phase. How does each stage prepare the cell for division?
- How does Interphase prepare a cell for meiosis and mitosis? Discuss the importance of Interphase in both processes. How does the preparation during Interphase differ when preparing for meiosis compared to mitosis?
- What is crossing-over, and when does it occur during meiosis? Using information from the transcript, describe what happens during crossing-over in Prophase I of meiosis. Why is this process important for genetic diversity?
- How do Meiosis I and Meiosis II differ, and what are the outcomes of each? Explain the stages of Meiosis I and Meiosis II based on the video and transcript. How does each division contribute to the formation of four unique haploid gametes?
- What are chromosome reduction and independent assortment, and how do they contribute to genetic diversity? Describe how chromosome reduction and independent assortment occur during meiosis. How do these processes contribute to the genetic variation in offspring?

GENETIC VARIATION

- **Sexual** reproduction **increases** genetic variation because**:**
  - During **fertilization, gametes** from two parents combine**, leading** to offspring with a **mix of traits** from both parents**.**
  - The processes of **crossing over** and **independent assortment** during **Meiosis** ensure that each gamete is unique, which leads to **more** diverse offspring.



Acronym	Meaning	Mitosis	Meiosis
D	Divisions	One division creates two identical daughter cells.	Two divisions create four genetically unique daughter cells.
I	Independent Assortment	Does not occur.	Independent assortment happens during Metaphase I, increasing genetic diversity.
S	Synapsis	Does not occur.	Synapsis happens during Prophase I when homologous chromosomes pair up.
C	Crossing Over	Does not occur.	Crossing over happens during Prophase I, where chromosomes exchange genetic material.
O	Outcomes	Produces two identical diploid cells for growth and repair.	Produces four non-identical haploid cells for sexual reproduction.
P	Ploidy	Maintains diploid chromosome number (2n).	Reduces ploidy to haploid (n) after the first division.
U	Use	Used for growth, repair, and asexual reproduction.	Used to produce gametes for sexual reproduction.
G	Genetics	Produces cells with identical genomes.	Produces gametes with different genomes, leading to genetic diversity.

- What does the acronym D.I.S.C.O.P.U.G. stand for, and how does it help you remember the differences between Mitosis and Meiosis? Discuss how each letter of the acronym relates to the processes of Mitosis and Meiosis. How does it help you understand their similarities and differences?
- How do the divisions in Mitosis and Meiosis differ, and what are the outcomes of each process? Explain the number of divisions in Mitosis versus Meiosis and the resulting number of daughter cells. How do these divisions contribute to the overall goals of each process?
- What is Independent Assortment, and how does it contribute to genetic diversity during Meiosis? Describe the concept of Independent Assortment in Meiosis. Why is it important for creating genetic diversity in gametes?
- What role does Synapsis play in Meiosis, and how is it different from what happens in Mitosis? Explain what happens during Synapsis in Meiosis. How does this process compare to what happens in Mitosis, and why is it important for genetic recombination?
- How does Crossing Over contribute to genetic variation, and why does it only occur in Meiosis? Describe the process of Crossing Over in Meiosis. Why does this process occur only in Meiosis and not in Mitosis? How does it impact genetic diversity?

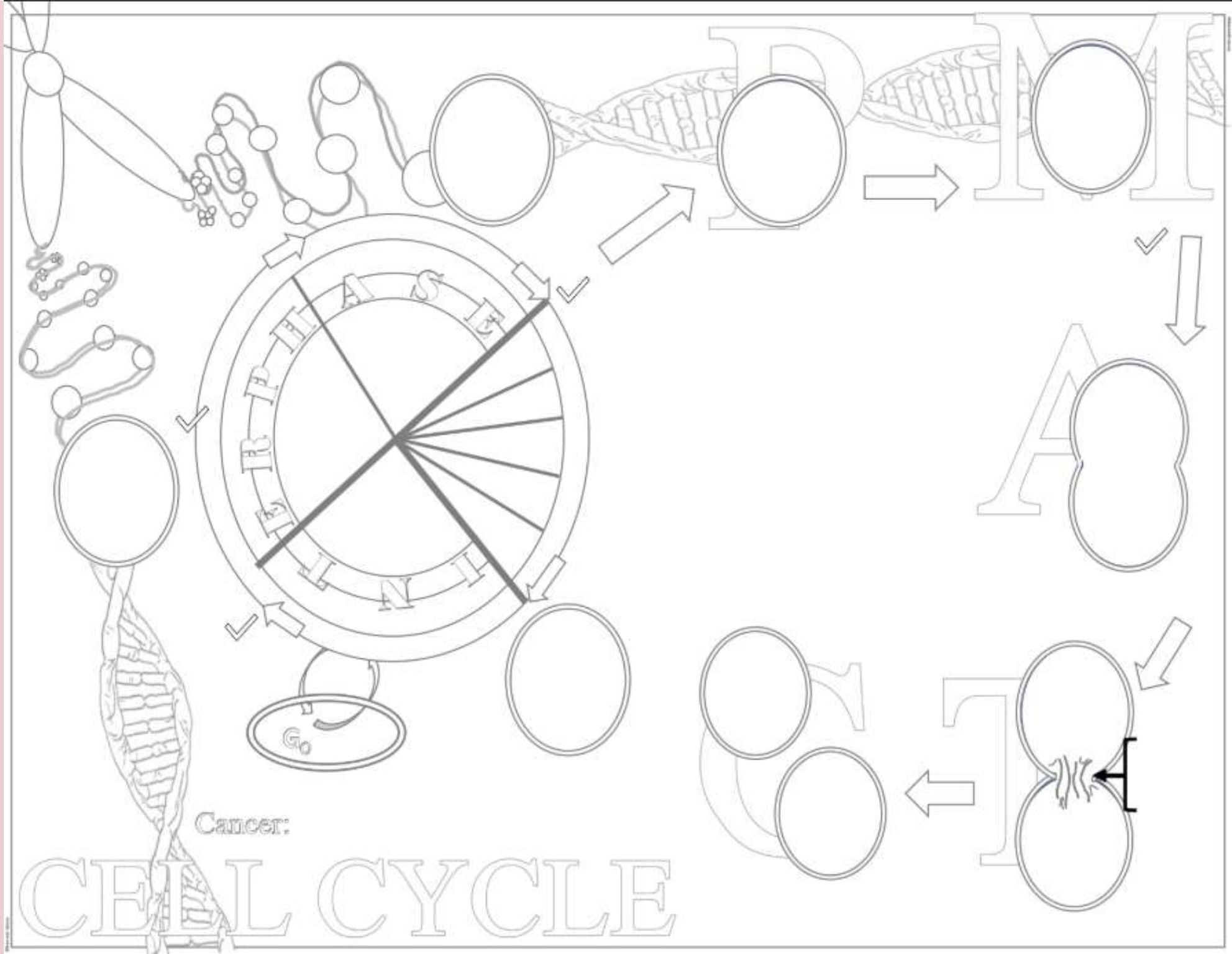
RESOURCES

Osmosis from Elsevier. (2024, December 29). Cell cycle – microbiology, biology, physiology [Video]. YouTube. https://www.youtube.com/watch?v=zNJJ_C2j4gk

Amoeba Sisters. (2018a, March 20). The Cell Cycle (and cancer) [Updated] [Video]. YouTube. https://www.youtube.com/watch?v=QVCjdNxJreE

CrashCourse. (2024, February 13). Meiosis: Why are all humans unique?: Crash course Biology #30 [Video]. YouTube. https://www.youtube.com/watch?v=pj1oFx42d48

Beverly Biology. (2017, December 9). Mitosis vs Meiosis (updated) [Video]. YouTube. https://www.youtube.com/watch?v=2z4XFGgvkkg


INTERPHASE
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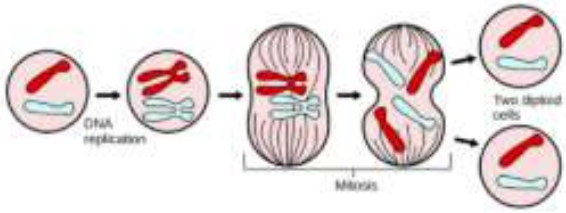
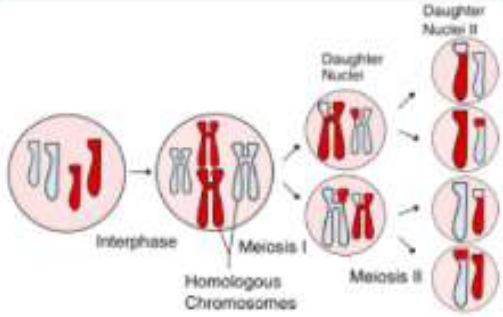
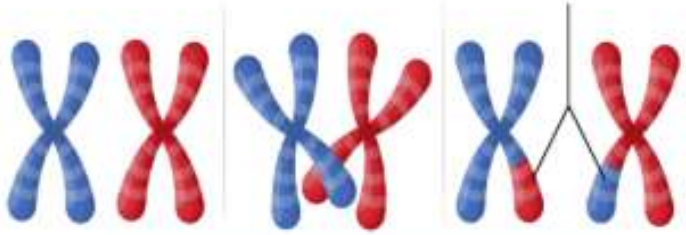
Cancer:
CELL CYCLE







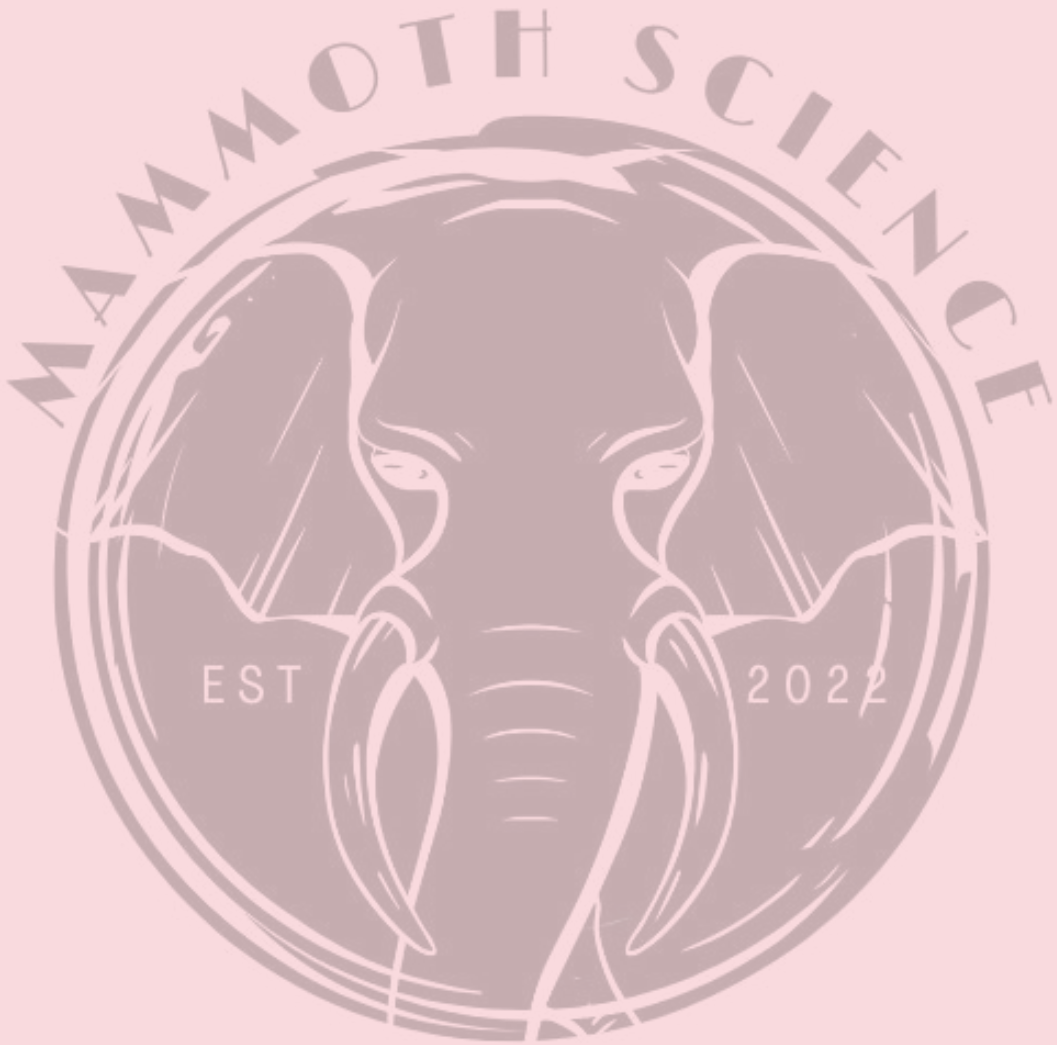
Leads to

Any change in DNA

At Metaphase, alignment is random, genes assort independently

Divisions		
Ind Assortment		
Synapsis		
Crossing over		
Outcome		
Ploidy		
Use		
Genetics		

Sexual Reproduction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