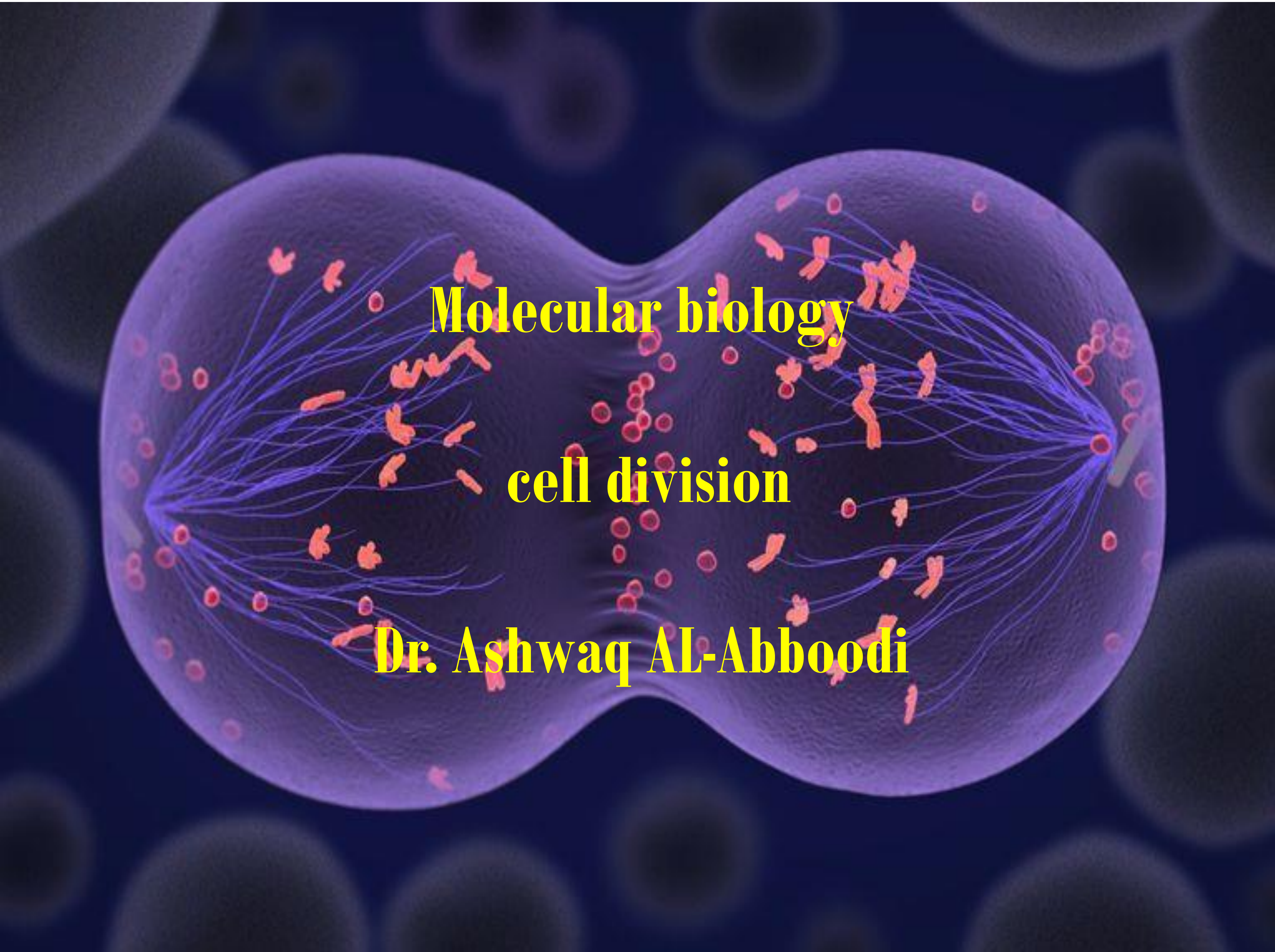

Molecular biology

cell division

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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?
Is cell division occurring in prokaryotic or eukaryotic or in both?

Actually this process happens depend on whether the cell is prokaryotic or eukaryotic. cell division is simpler in prokaryotes than eukaryotes because:-

1- prokaryotic cells themselves are simpler.
2- prokaryotic cells have a single circular chromosome,
3- prokaryotic cells don't have nucleus,
4- prokaryotic cells have a few other organelles.

in contrast

eukaryotic cells 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

cell division

the cell cycle in prokaryotes is quite simple:

the cell grows

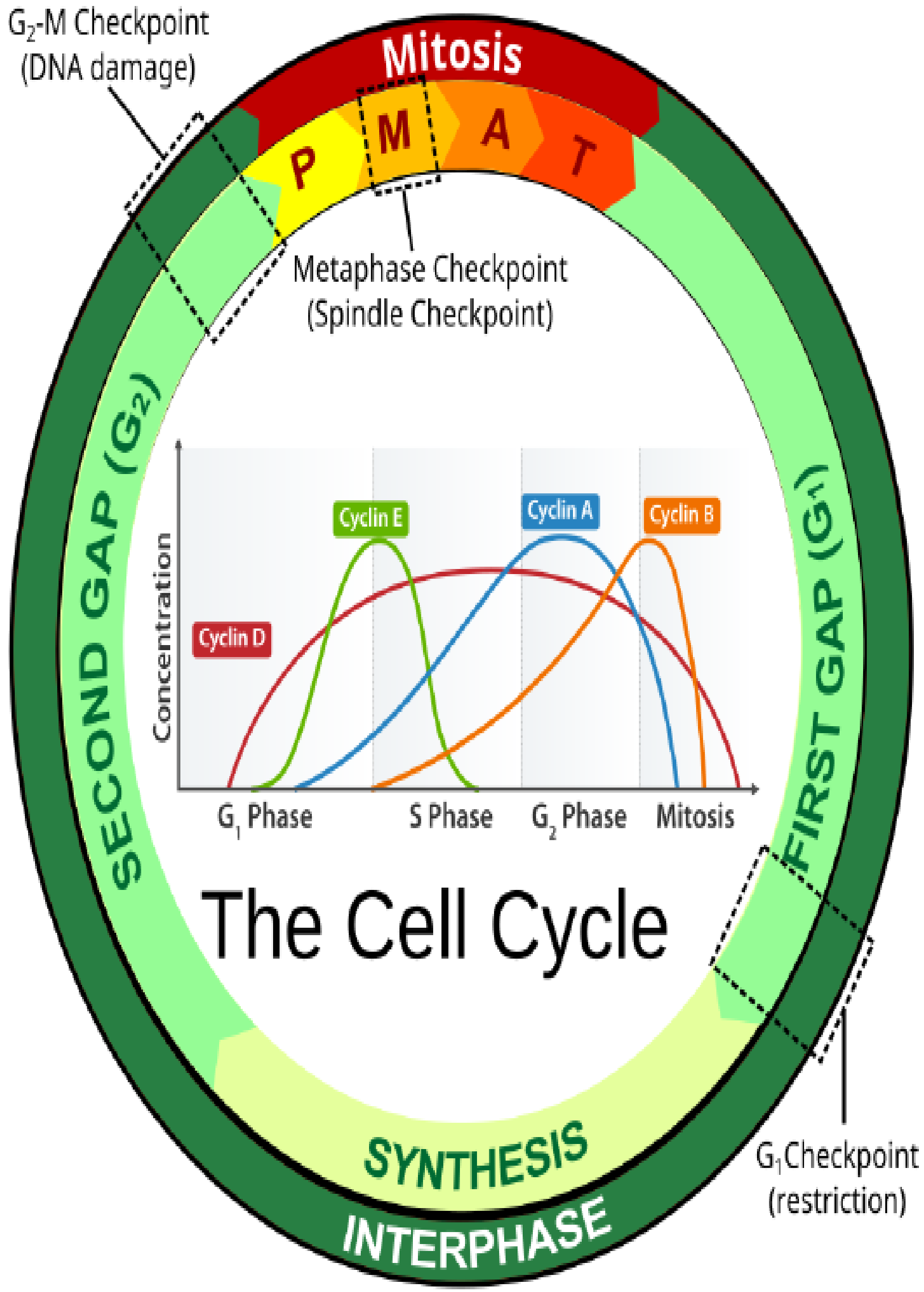
its DNA replicates

the cell divides

this form of division in prokaryotes is called asexual reproduction.

in eukaryotes

the cell cycle is more complicated. eukaryotic cell cycle the diagram below represents the cell cycle of an eukaryotic cell. as you can see, the eukaryotic cell cycle has several phases. the mitotic phase (m) actually includes both mitosis and cytokinesis. this is when the nucleus and then the cytoplasm divide. the other three phases (g_1, s, and g_2) 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

1- Growth Phase 1 (G_1): The cell spends most of its life in the first gap (sometimes referred to as growth) phase, G_1. During this phase, a cell undergoes rapid growth and the cell 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 G_0 phase from this phase.

G_0 phase: The G_0 phase is a resting phase where the cell has left the cycle and has stopped dividing. Non-dividing cells in multicellular eukaryotic organisms enter G_0 from G_1. These cells may remain in G_0 for long periods of time, even indefinitely, such as with neurons. Cells that are completely differentiated may also enter G_0. 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.

2- Synthesis Phase (S): **Dividing cells enter the Synthesis (S) phase from G_1. 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.**

3- Growth Phase 2 (G_2): **The second gap (growth) (G_2) phase is a shortened growth period in which many organelles are reproduced or manufactured. Parts necessary for mitosis and cell division are made during G_2, including microtubules used in the mitotic spindle.**

State	Name	Description
Quiescent Senescent	Resting phase (G_0)	A resting phase where the cell has left the cycle and has stopped dividing.
Interphase	1st growth phase (G_1) Synthesis phase (S) 2nd growth phase (G_2)	Cells increase in size in G_1. Cells perform their normal activities. DNA replication occurs during this phase. The cell will continue to grow and many organelles will divide during their phase.
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 have resulted.

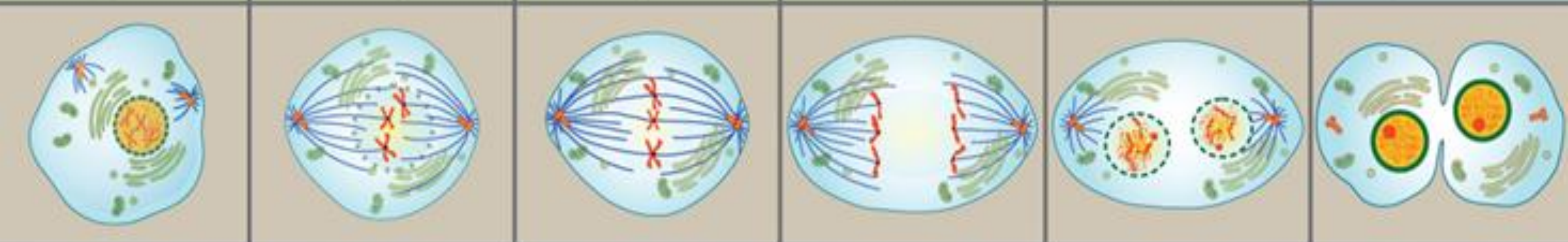
mitotic phase

before a eukaryotic cell divides, all the dna in the cell’s multiple chromosomes is replicated. its organelles are also duplicated. this happens in interphase. then, when the cell divides (mitotic phase), it occurs in two major steps, called 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.

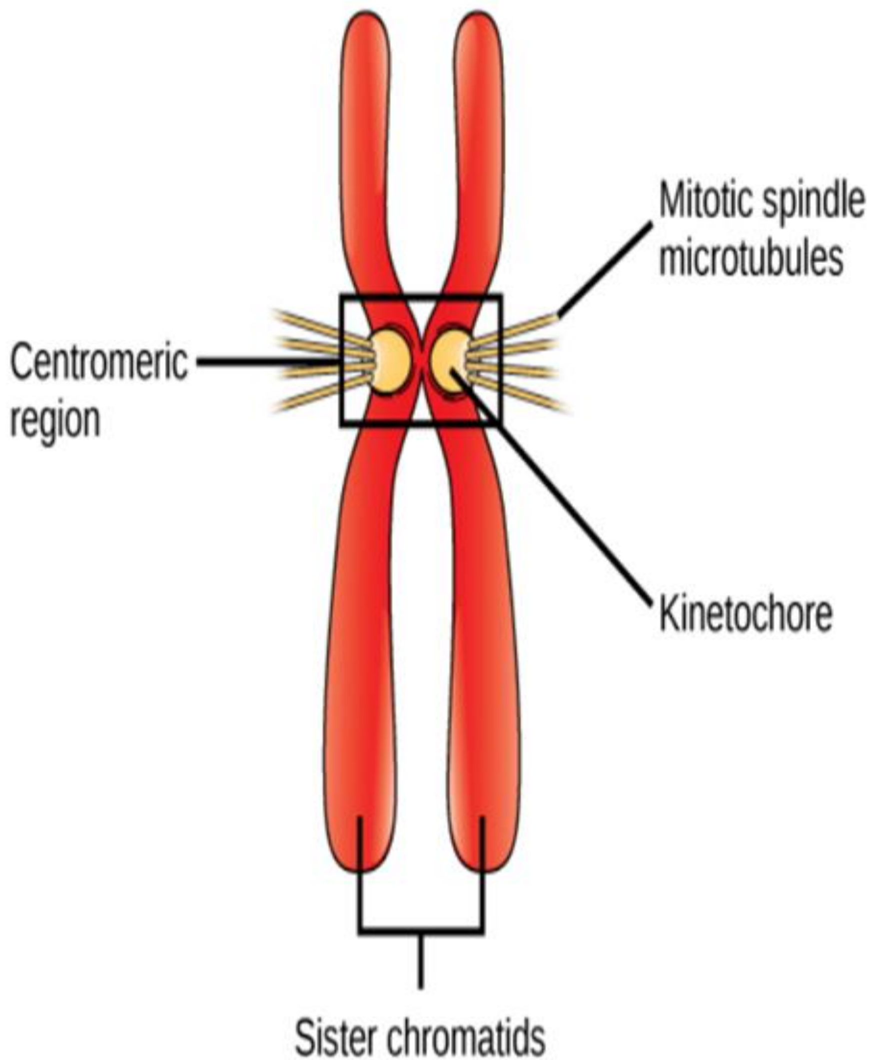
MITOSIS IS DIVIDED INTO A SERIES OF PHASE:-

PROPHASE, PROMETAPHASE, METAPHASE, ANAPHASE, AND TELOPHASE

THAT RESULT IN THE DIVISION OF THE CELL NUCLEUS



Prophase	Prometaphase	Metaphase	Anaphase	Telophase	Cytokinesis
• Chromosomes condense and become visible • Spindle fibers emerge from the centrosomes • Nuclear envelope breaks down • Centrosomes move toward opposite poles	• Chromosomes continue to condense • Kinetochores appear at the centromeres • Mitotic spindle microtubules attach to kinetochores	• Chromosomes are lined up at the metaphase plate • Each sister chromatid is attached to a spindle fiber originating from opposite poles	• Centromeres split in two • Sister chromatids (now called chromosomes) are pulled toward opposite poles • Certain spindle fibers begin to elongate the cell	• Chromosomes arrive at opposite poles and begin to decondense • Nuclear envelope material surrounds each set of chromosomes • The mitotic spindle breaks down • Spindle fibers continue to push poles apart	• Animal cells: a cleavage furrow separates the daughter cells • Plant cells: a cell plate, the precursor to a new cell wall, separates the daughter cells


Mitotic spindle
microtubules
Centromeric
region
Kinetochore
Sister chromatids

During prophase, the "first phase," several events must occur to provide access to the chromosomes in the nucleus. The nuclear envelope starts to break into small vesicles, and the Golgi apparatus and endoplasmic reticulum fragment and disperse to the periphery of the cell. The nucleolus disappears. The centrosomes begin to move to opposite poles of the cell. The microtubules that form the basis of the mitotic spindle extend between the centrosomes, pushing them farther apart as the microtubule fibers lengthen. The sister chromatids begin to coil more tightly and become visible under a light microscope.

During prometaphase, many processes that were begun in prophase continue to advance and culminate in the formation of a connection between the chromosomes and cytoskeleton. The remnants of the nuclear envelope disappear. The mitotic spindle continues to develop as more microtubules assemble and stretch across the length of the former nuclear area. Chromosomes become more condensed and visually discrete. Each sister chromatid attaches to spindle microtubules at the centromere via a protein complex called the kinetochore.

During metaphase, all of the chromosomes are aligned in a plane called the metaphase plate, or the equatorial plane, midway between the two poles of the cell. The sister chromatids are still tightly attached to each other. At this time, the chromosomes are maximally condensed.

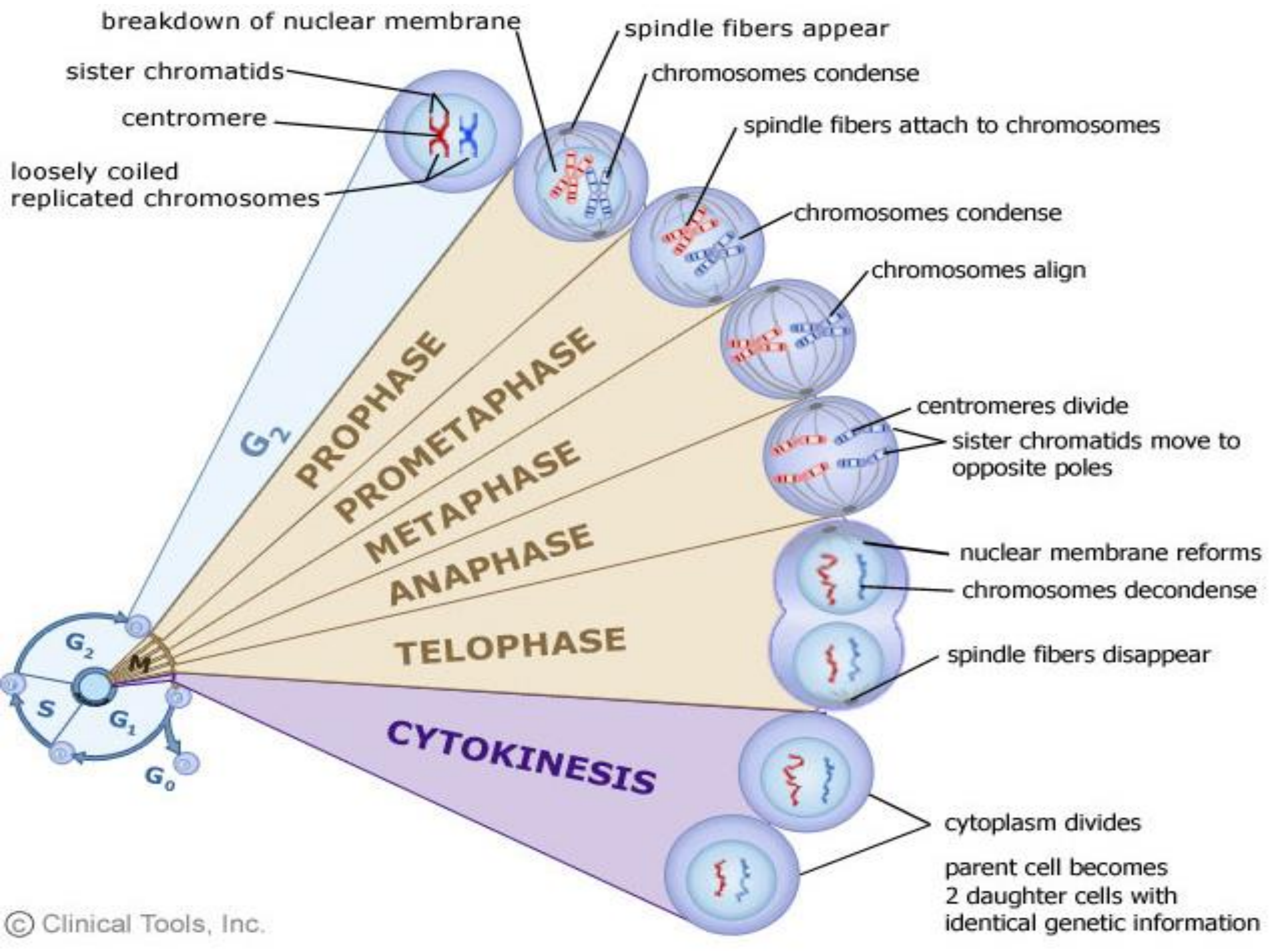
During anaphase, the sister chromatids at the equatorial plane are split apart at the centromere. Each chromatid, now called a chromosome, is pulled rapidly toward the centrosome to which its microtubule was attached. The cell becomes visibly elongated as the non-kinetochore microtubules slide against each other at the metaphase plate where they overlap.

During telophase, all of the events that set up the duplicated chromosomes for mitosis during the first three phases are reversed. The chromosomes reach the opposite poles and begin to decondense (unravel). The mitotic spindles are broken down into monomers that will be used to assemble cytoskeleton components for each daughter cell. Nuclear envelopes form around chromosomes.

Differences Between Mitosis and Meiosis

Organisms grow and reproduce through cell division. In eukaryotic cells, the production of new cells occurs as a result of mitosis and meiosis. These two nuclear division processes are similar but distinct. Both processes involve the division of a diploid cell, or a cell containing two sets of chromosomes (one chromosome donated from each parent).

- **In mitosis, the genetic material (DNA) in a cell is duplicated and divided equally between two cells. The dividing cell goes through an ordered series of events called the cell cycle. The mitotic cell cycle is initiated by the presence of certain growth factors or other signals that indicate that the production of new cells is needed. Somatic cells of the body replicate by mitosis. Examples of somatic cells include fat cells, blood cells, skin cells, or any body cell that is not a sex cell. Mitosis is necessary to replace dead cells, damaged cells, or cells that have short life spans.**



breakdown of nuclear membrane
spindle fibers appear
sister chromatids
chromosomes condense
centromere
spindle fibers attach to chromosomes
loosely coiled
replicated chromosomes
chromosomes condense
chromosomes align
G2
PROPHASE
PROMETAPHASE
METAPHASE
ANAPHASE
TELOPHASE
CYTOKINESIS
centromeres divide
sister chromatids move to
opposite poles
nuclear membrane reforms
chromosomes decondense
spindle fibers disappear
G2
M
S
G1
G0
cytoplasm divides
parent cell becomes
2 daughter cells with
identical genetic information
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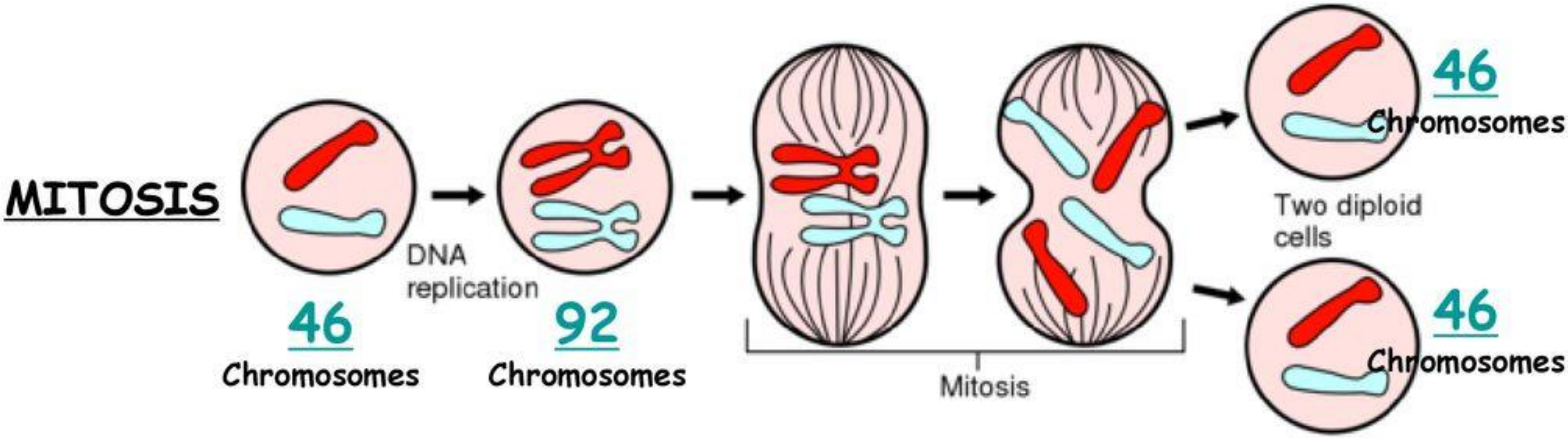
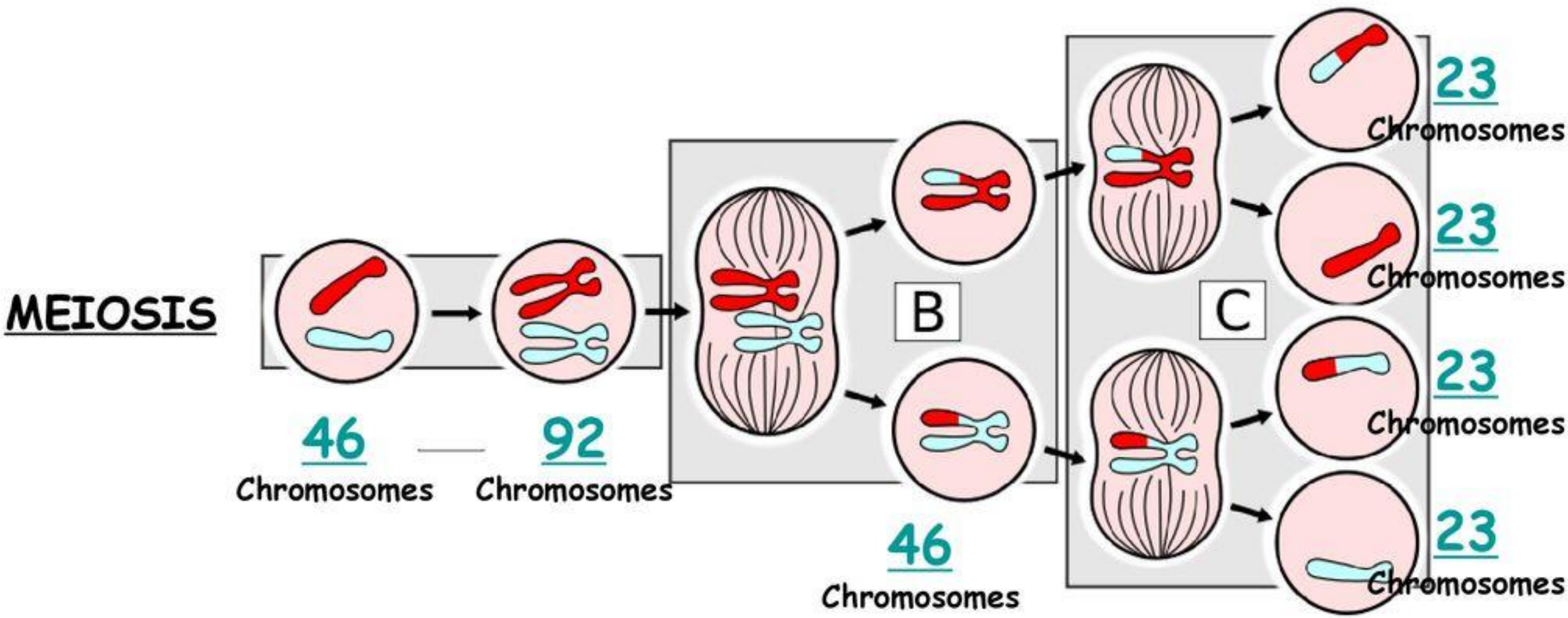
- **Meiosis is the process by which gametes (sex cells) are generated in organisms that reproduce sexually. Gametes are produced in male and female gonads and contain one-half the number of chromosomes as the original cell. New gene combinations are introduced in a population through the genetic recombination that occurs during meiosis. Thus, unlike the two genetically identical cells produced in mitosis, the meiotic cell cycle produces four cells that are genetically different.**

Briefly

- **Mitosis and meiosis are nuclear division processes that occur during cell division.**
- **Mitosis involves the division of body cells, while meiosis involves the division of sex cells.**
- **The division of a cell occurs once in mitosis but twice in meiosis.**
- **Two daughter cells are produced after mitosis and cytoplasmic division, while four daughter cells are produced after meiosis.**
- **Daughter cells resulting from mitosis are diploid, while those resulting from meiosis are haploid.**
- **Daughter cells that are the product of mitosis are genetically identical. Daughter cells produced after meiosis are genetically diverse.**
- **Tetrad formation occurs in meiosis but not mitosis.**


MITOSIS
46
Chromosomes
DNA
replication
92
Chromosomes
Mitosis
Two diploid
cells
46
Chromosomes
46
Chromosomes


MEIOSIS
46
Chromosomes
92
Chromosomes
B
46
Chromosomes
C
23
Chromosomes
23
Chromosomes
23
Chromosomes
23
Chromosomes

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 next Figure.

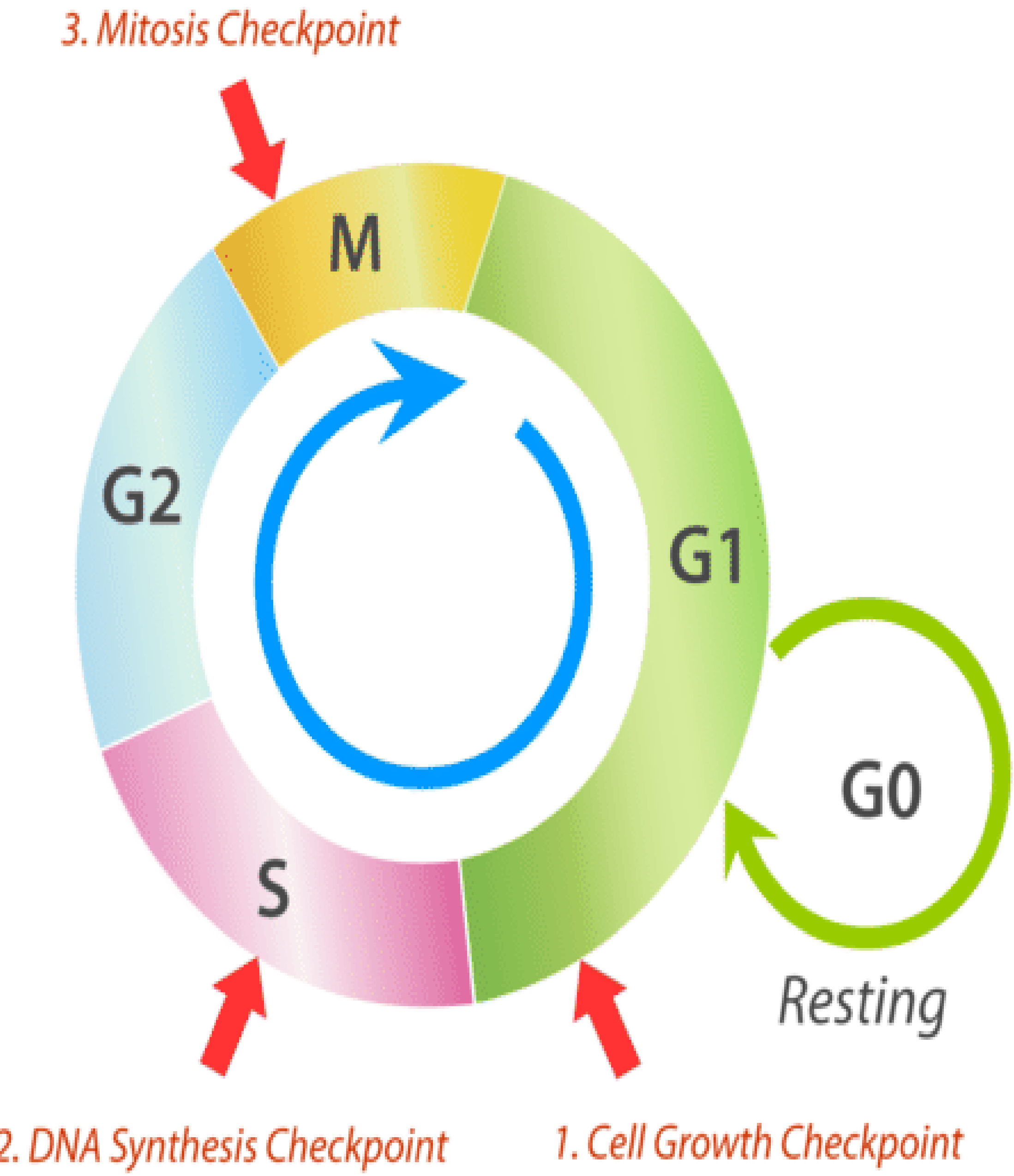
There are a number of main checkpoints:

1-The G1 checkpoint, just before entry into S phase, makes the key decision of whether the cell should divide.

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

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

The Cell Cycle and the Checkpoints



1. Cell Growth Checkpoint

- Occurs toward the end of growth phase 1 (G1).
- Checks whether the cell is big enough and has made the proper proteins for the synthesis phase.
- If not, the cell goes through a resting period (G0) until it is ready to divide.

2. DNA Synthesis Checkpoint

- Occurs during the synthesis phase (S).
- Checks whether DNA has been replicated correctly.
- If so, the cell continues on to mitosis (M).

3. Mitosis Checkpoint

- Occurs during the mitosis phase (M).
- Checks whether mitosis is complete.
- If so, the cell divides, and the cycle repeats.

Thank you for your attention