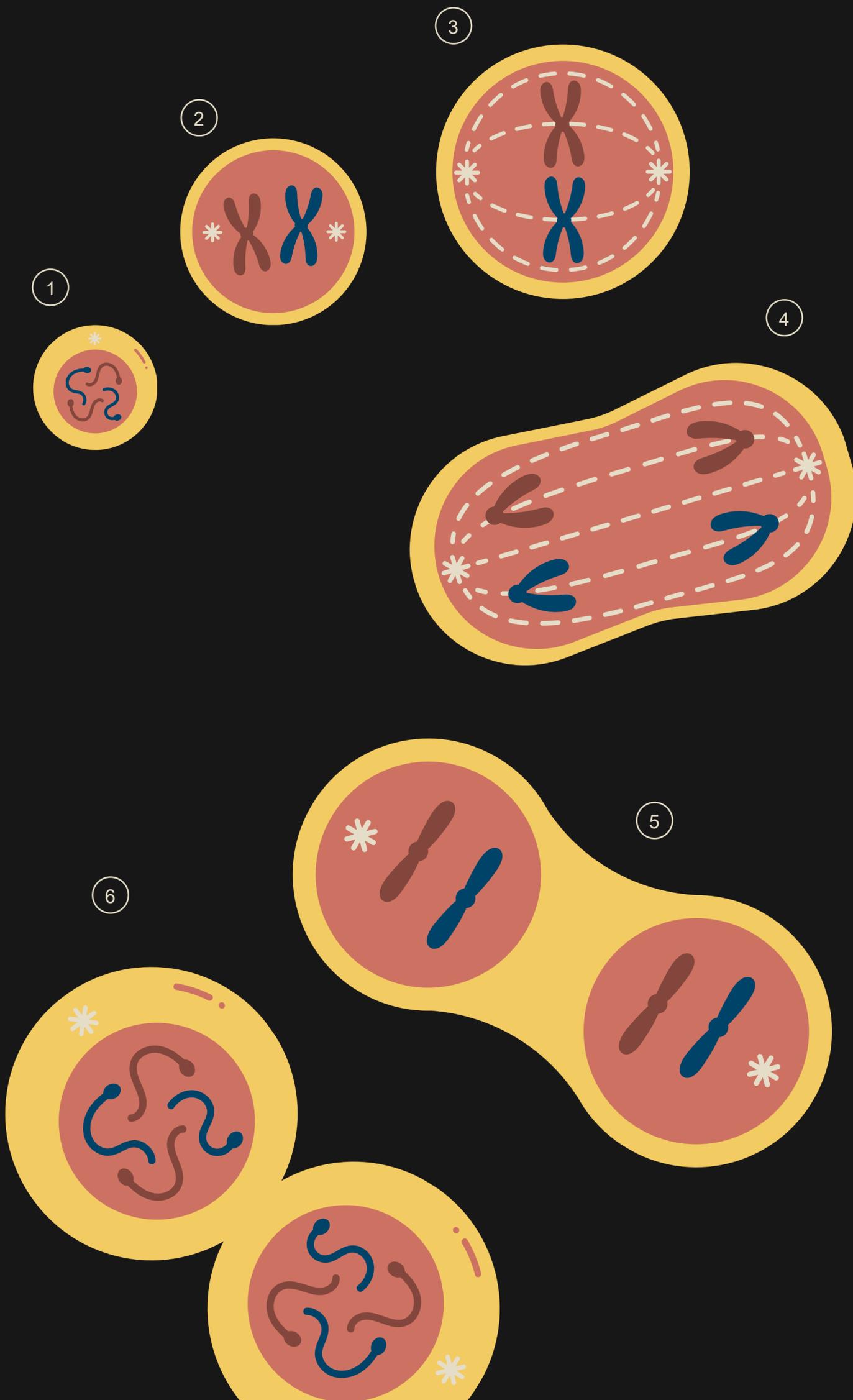


UNIT 4: THE CELL CYCLE AND CELL COMMUNICATION



4.1 Cell Communication:

Cells rely on signaling to coordinate activities and respond to their environment. There are several major types of cell signaling, each defined by distance and method of communication.

- **Juxtacrine signaling** occurs through direct physical contact between neighboring cells.
- **Paracrine signaling** involves signals that travel short distances to nearby target cells.
- **Autocrine signaling** happens when a cell releases a signal that binds to receptors on its own surface.
- **Endocrine signaling** uses hormones that travel long distances through the bloodstream to reach target cells.

Each signaling type allows cells to communicate efficiently depending on the biological context.

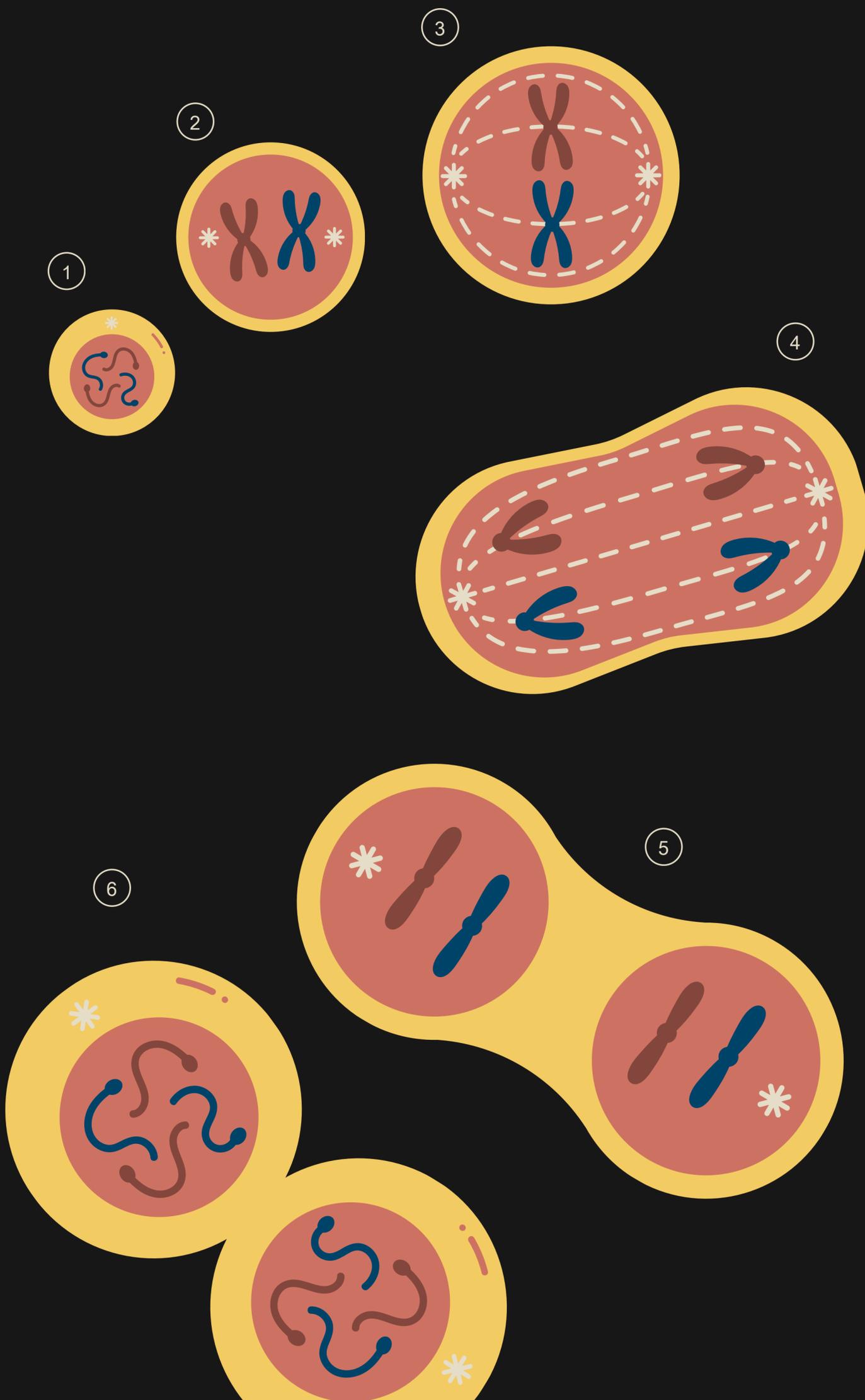
4.2 Introduction to Signal Transduction:

Signal transduction explains how cells convert an external signal into an internal response. Because cells cannot directly “talk,” they rely on chemical signals and receptors to transmit information.

Signal transduction occurs in a sequence of steps, similar to a chain reaction where one event triggers the next. This process has three main stages:

1. Reception
2. A signaling molecule, known as a ligand, binds to a specific receptor protein on or inside the target cell.
3. Transduction
4. The signal is relayed through the cell via a series of molecular interactions, often involving phosphorylation cascades that amplify the signal.
5. Response
6. The cell carries out a specific action, such as activating an enzyme, changing gene expression, or producing a protein.

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4.3 Signal Transduction Pathways:

Cells respond to environmental cues through many signal transduction pathways. One example is quorum sensing, where bacteria release signaling molecules to measure population density and coordinate group behavior.

In multicellular organisms, many internal processes depend on signaling pathways. For example, insulin acts as a ligand that signals cells to reduce blood glucose levels. Without proper signaling, essential regulatory functions would fail. Signal transduction also plays a role in apoptosis, or programmed cell death, which allows organisms to remove damaged or unnecessary cells in a controlled manner.

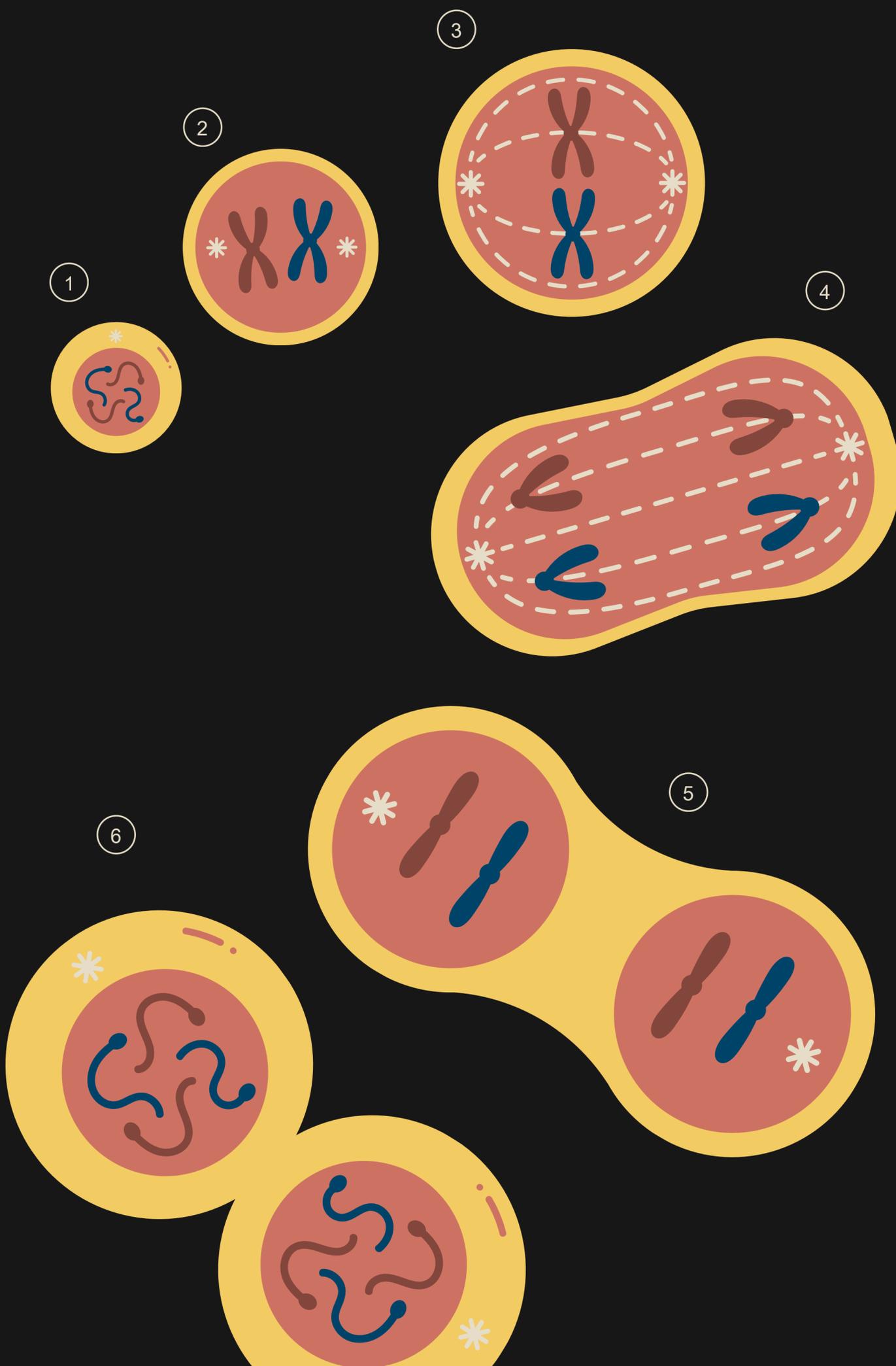
4.4 Changes in Signal Transduction Pathways:

Signal transduction pathways can be disrupted by mutations or chemical interference. Mutations may alter receptor proteins or signaling molecules, preventing proper regulation of cell division. This loss of control can lead to uncontrolled cell growth, such as cancer.

Certain chemicals can also interfere with signaling pathways by activating or inhibiting steps that should normally remain regulated. These disruptions can significantly alter cell behavior.

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The cell cycle is the series of events that a cell goes through as it grows, replicates its DNA, and divides into two daughter cells. It is a highly regulated process that ensures that the daughter cells receive the correct number of chromosomes and genetic information from the parent cell.



4.5 Homeostasis and Feedback Loops:

Homeostasis is the maintenance of stable internal conditions and is achieved through feedback mechanisms.

- Negative feedback loops counteract changes in a system. If a variable rises, the response brings it back down, and if it falls, the response raises it back up.
- Positive feedback loops amplify changes, causing an initial stimulus to produce an increasingly stronger response.

Negative feedback is more common in biological systems, while positive feedback typically occurs during specific events such as labor contractions or blood clotting.

4.6 The Cell Cycle:

The cell cycle is the series of stages a cell undergoes as it grows and divides. It consists of five main phases:

- G1 phase: the cell grows and carries out normal functions
- S phase: DNA is replicated
- G2 phase: the cell continues to grow and prepares for division
- Mitosis: the nucleus divides
- Cytokinesis: the cytoplasm divides, forming two daughter cells

Mitosis includes four stages: prophase, metaphase, anaphase, and telophase, each ensuring accurate chromosome separation.

4.7 Regulation of the Cell Cycle

Cell division must be carefully regulated to prevent abnormal growth.

Checkpoints ensure that each phase of the cycle is completed correctly before moving on.

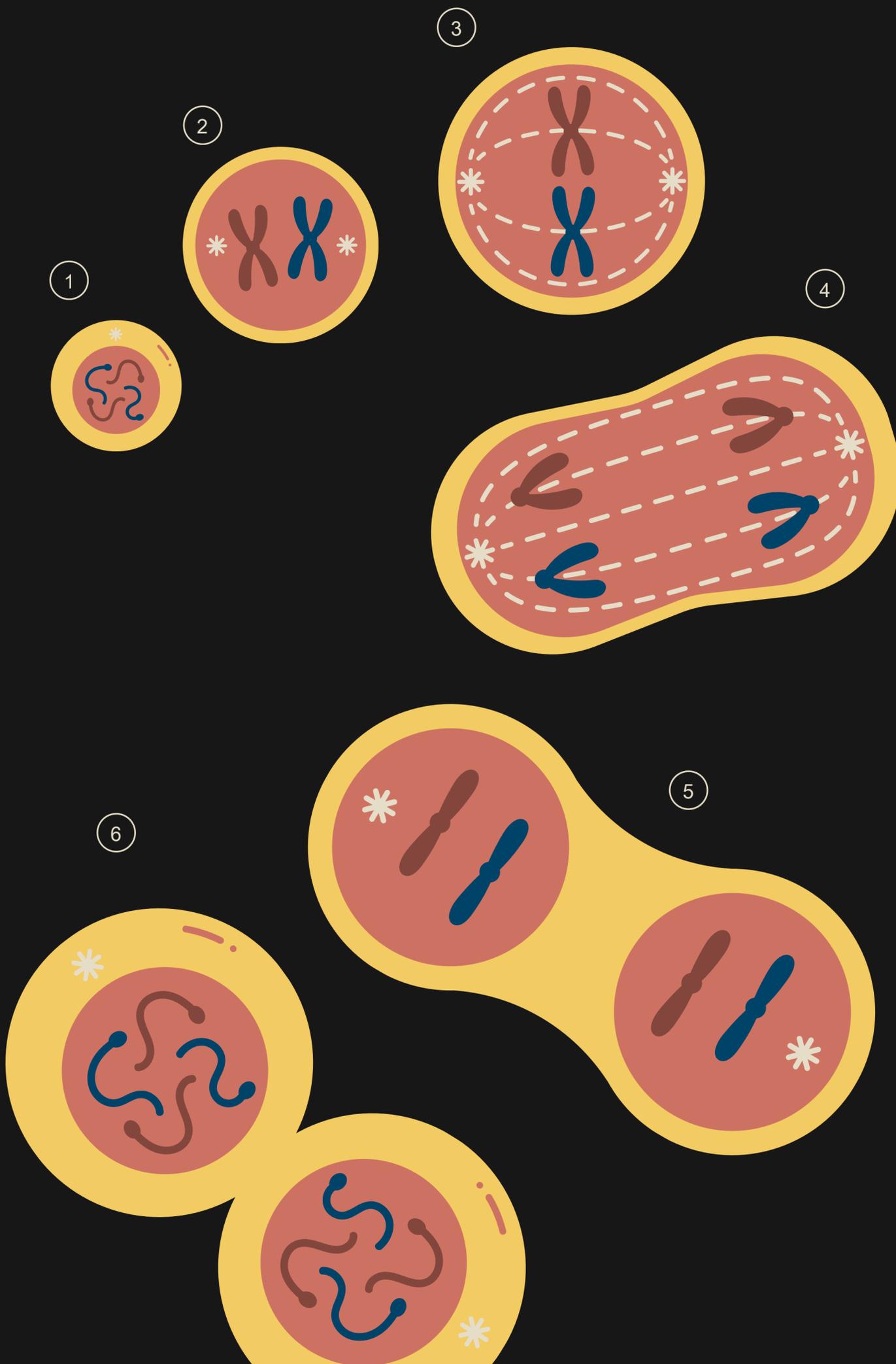
The cyclin-Cdk complex plays a key role in controlling progression through the cell cycle. When cyclin levels increase, mitosis is triggered. After mitosis, cyclin is broken down, preventing continuous division.

The protein p53 also regulates the cell cycle by checking DNA for damage. If damage is detected, p53 can halt the cycle to allow repair or trigger apoptosis. Without functional p53, damaged DNA may persist, increasing cancer risk.

Because regulation is a major theme in AP Biology, understanding these control mechanisms is especially important.

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Key Vocabulary for Unit 4:

- Direct contact
- Plasmodesmata
- Gap junctions
- Paracrine signaling
- Synaptic signaling
- Synapse
- Cell surface receptors
- Hydrophobic
- Hydrophilic
- Ligand
- Ion channel receptors
- G protein-coupled receptors
- Transduction
- Signal transduction pathway
- Cascade effect
- Homeostasis
- Negative feedback loops
- Positive feedback loops
- Cell cycle phases
- Interphase (G1, S, G2)
- Centrosome
- Centrioles
- Prophase
- Metaphase
- Anaphase
- Sister chromatids
- Telophase
- Mitosis
- Meiosis
- Cytokinesis
- Cell plate
- Cleavage furrow
- Cancerous cells
- Metastasis
- Apoptosis