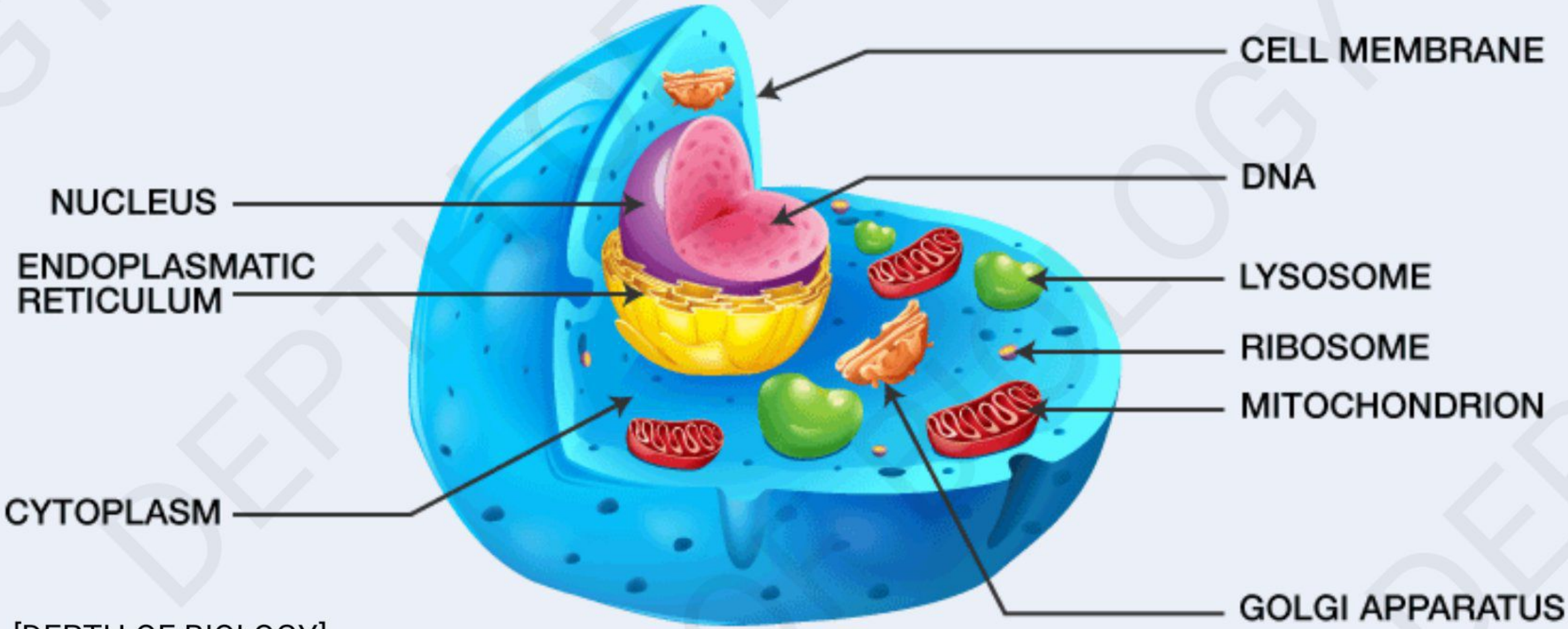
CELLULAR LEVEL OF ORGANISATION

[DEPTH OF BIOLOGY]

What is a Cell?

- A cell is the structural and fundamental unit of life. The study of cells from its basic structure to the functions of every cell organelle is called Cell Biology. Robert Hooke was the first Biologist who discovered cells. [DEPTH OF BIOLOGY]
- All organisms are made up of cells. They may be made up of a single cell (unicellular), or many cell (multicellular)
- Mycoplasma are the smallest known cells. Cells are the building blocks of all living beings. They provide structure to the body and convert the nutrients taken from the food into energy.

[DEPTH OF BIOLOGY]



[DEPTH OF BIOLOGY]

CELL STRUCTURE

[DEPTH OF BIOLOGY]

- The cell structure comprises individual components with specific functions essential to carry out life's processes. These components include- cell wall, cell membrane, cytoplasm, nucleus, and cell organelles. Read on to explore more insights on cell structure and function.

- [DEPTH OF BIOLOGY]

CELL MEMBRANE

[DEPTH OF BIOLOGY]

- The cell membrane supports and protects the cell. It controls the movement of substances in and out of the cells. It separates the cell from the external environment. The cell membrane is present in all the cells. [DEPTH OF BIOLOGY]
- The cell membrane is the outer covering of a cell within which all other organelles, such as the cytoplasm and nucleus, are enclosed. It is also referred to as the plasma membrane.
- By structure, it is a porous membrane (with pores) which permits the movement of selective substances in and out of the cell. Besides this, the cell membrane also protects the cellular component from damage and leakage. [DEPTH OF BIOLOGY]

- It forms the wall-like structure between two cells as well as between the cell and its surroundings.
- Plants are immobile, so their cell structures are well-adapted to protect them from external factors. The cell wall helps to reinforce this function

CELL WALL

- The cell wall is the most prominent part of the plant's cell structure. It is made up of cellulose, hemicellulose and pectin.
- The cell wall is present exclusively in plant cells. It protects the plasma membrane and other cellular components. The cell wall is also the outermost layer of plant cells. [DEPTH OF BIOLOGY]
- It is a rigid and stiff structure surrounding the cell membrane.
- It provides shape and support to the cells and protects them from mechanical shocks and injuries.

CYTOPLASM

- The cytoplasm is a thick, clear, jelly-like substance present inside the cell membrane.
- Most of the chemical reactions within a cell take place in this cytoplasm. [DEPTH OF BIOLOGY]
- The cell organelles such as endoplasmic reticulum, vacuoles, mitochondria, ribosomes, are suspended in this cytoplasm.

[DEPTH OF BIOLOGY]

NUCLEUS

- The nucleus contains the hereditary material of the cell, the DNA. [DEPTH OF BIOLOGY]
- It sends signals to the cells to grow, mature, divide and die.
- The nucleus is surrounded by the nuclear envelope that separates the DNA from the rest of the cell.
- The nucleus protects the DNA and is an integral component of a plant's cell structure [DEPTH OF BIOLOGY]

CELL ORGANELLES

- Cells are composed of various cell organelles that perform certain specific functions to carry out life's processes. The different cell organelles, along with its principal functions, are as follows: [DEPTH OF BIOLOGY]

- **Nucleolus**

The nucleolus is the site of ribosome synthesis. Also, it is involved in controlling cellular activities and cellular reproduction.

- **Nuclear membrane**

The nuclear membrane protects the nucleus by forming a boundary between the nucleus and other cell organelles.

- **Chromosomes**

Chromosomes play a crucial role in determining the sex of an individual. Each human cells contain 23 pairs of chromosomes.

- **Endoplasmic reticulum** [DEPTH OF BIOLOGY]

The endoplasmic reticulum is involved in the transportation of substances throughout the cell. It plays a primary role in the metabolism of carbohydrates, synthesis of lipids, steroids and proteins.

- **Golgi Bodies**

Golgi bodies are called the cell's post office as it is involved in the transportation of materials within the cell.

- **Ribosome**

Ribosomes are the protein synthesizers of the cell.

- **Mitochondria** [DEPTH OF BIOLOGY]

The mitochondrion is called "the powerhouse of the cell." It is called so because it produces ATP – the cell's energy currency.

- **Lysosomes**

Lysosomes protect the cell by engulfing the foreign bodies entering the cell and help in cell renewal. Therefore, they are known as the cell's suicide bags.

- **Chloroplast** [DEPTH OF BIOLOGY]

Chloroplasts are the primary organelles for photosynthesis. It contains the pigment called chlorophyll.

- **Vacuoles**

Vacuoles store food, water, and other waste materials in the cell. [DEPTH OF BIOLOGY]

FUNCTION OF CELL

- A cell performs major functions essential for the growth and development of an organism. Important functions of cell are as follows:
- ***Provides Support and Structure*** [DEPTH OF BIOLOGY]

All the organisms are made up of cells. They form the structural basis of all the organisms. The cell wall and the cell membrane are the main components that function to provide support and structure to the organism. For eg., the skin is made up of a large number of cells. Xylem present in the vascular plants is made of cells that provide structural support to the plants.

- ***Facilitate Growth Mitosis*** [DEPTH OF BIOLOGY]

In the process of mitosis, the parent cell divides into the daughter cells. Thus, the cells multiply and facilitate the growth in an organism.

- ***Allows Transport of Substances*** [DEPTH OF BIOLOGY]

Various nutrients are imported by the cells to carry out various chemical processes going on inside the cells. The waste produced by the chemical processes is eliminated from the cells by active and passive transport. Small molecules such as oxygen, carbon dioxide, and ethanol diffuse across the cell membrane along the concentration gradient. This is known as passive transport. The larger molecules diffuse across the cell membrane through active transport where the cells require a lot of energy to transport the substances.

- ***Energy Production*** [DEPTH OF BIOLOGY]

Cells require energy to carry out various chemical processes. This energy is produced by the cells through a process called photosynthesis in plants and respiration in animals.

- ***Aids in Reproduction***
- A cell aids in reproduction through the processes called mitosis and meiosis. Mitosis is termed as the asexual reproduction where the parent cell divides to form daughter cells. Meiosis causes the daughter cells to be genetically different from the parent cells. [DEPTH OF BIOLOGY]

CELL STRUCTURE [DEPTH OF BIOLOGY]

CELL MEMBRANE/PLASMA MEMBRANE

- *SEPARATES CELL CONTENTS FROM EXTERNAL ENVIRONMENT
- *CONTROLS EXCHANGE OF MATERIALS BETWEEN THE EXTRACELLULAR FLUID & INTRACELLULAR FLUID

PROTOPLASM

CYTOPLASM (AQUEOUS SUBSTANCE)

ORGANELLES

- *MITOCHONDRIA
- *RIBOSOMES
- *CENTRIOLE
- *GOLGI APPARATUS
- *VACUOLES
- * GRANULES
- *ENDOPLASMIC RETICULUM
- *LYSOSOME

INCLUSION BODIES

CYTOSKELETON

COMPLEX FIBRE NETWORK MAINTAIN CELL STRUCTURE, SHAPE & MOVEMENT

NUCLEUS

NUCLEOPLASM

- NUCLEOLI
- CHROMATIN

NUCLEAR MEMBRANE

[DEPTH OF BIOLOGY]

TRANSPORT ACROSS CELL MEMBRANE

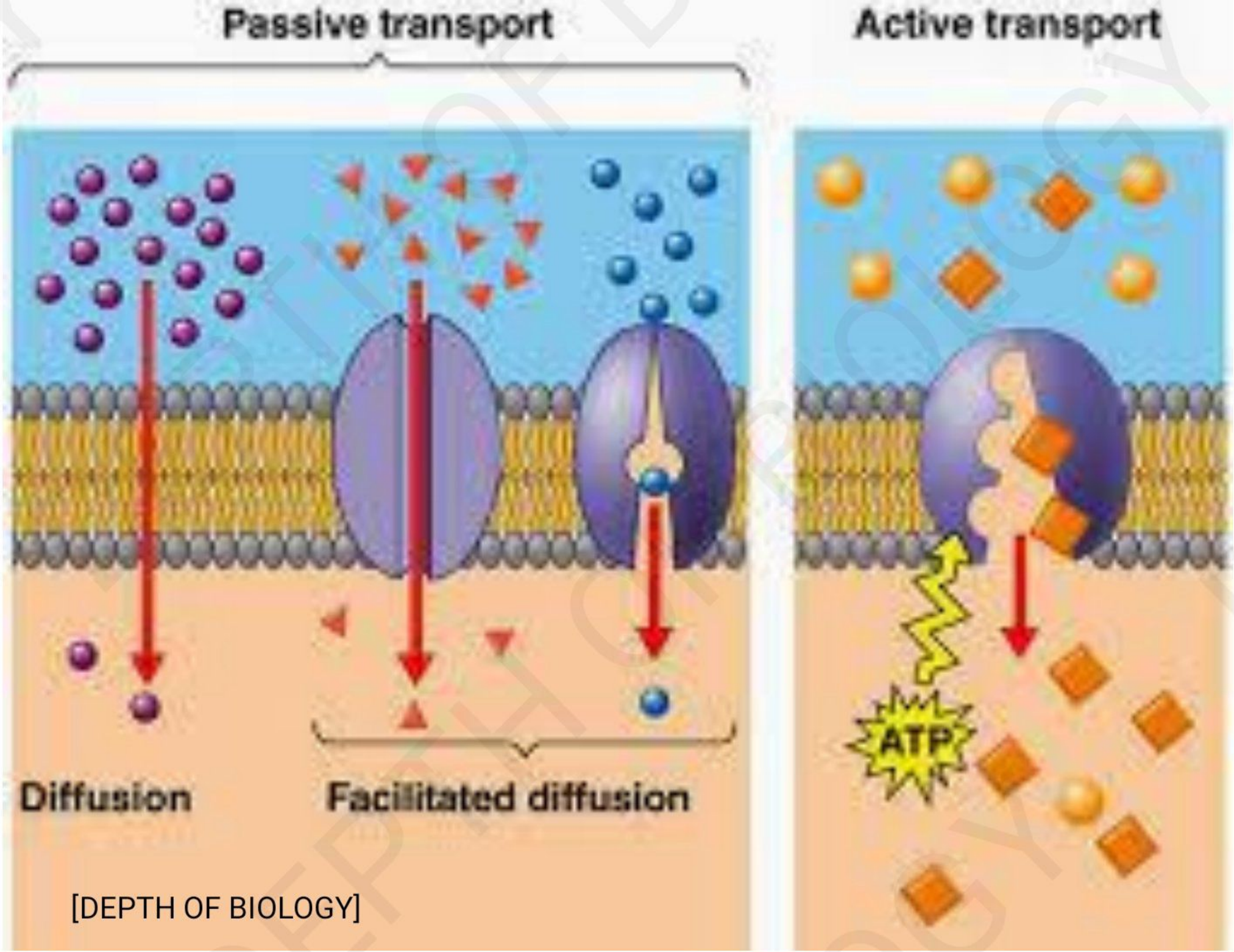
[DEPTH OF BIOLOGY]

- The movement of a substance across the cell membrane is known as cell transports. The substance can move either in or out of the cells. Sometimes the solution moves to through the phospholipids bilayer or else, its substance is combined with protein to pass through the cell membrane. The transport across cell membrane is classified into three types. Types of transport across cell membrane are listed below.
- Active Transport [DEPTH OF BIOLOGY]
- Passive Transport
- Facilitators

- **Active Transport:** Active transport requires energy in the form of ATP, solute from lower concentration to higher concentration transport through cell membrane. [DEPTH OF BIOLOGY]

- **Passive Transport:** Passive transport does not require any energy and it transmits solute from high concentration to lower concentration through the transport through cell membrane. [DEPTH OF BIOLOGY]

- **Facilitators:** The facilitators will allow the diffusion process to take place through the membrane made up of glycoprotein. [DEPTH OF BIOLOGY]



[DEPTH OF BIOLOGY]

TYPES OF ACTIVE TRANSPORTS

The active transports are classified into four types based on their action mechanism. They are listed below.

- Antiport Pumps
- Symport Pumps
- Endocytosis
- Exocytosis

- **Antiport Pumps:** The transmembrane is made up of co-transporter protein. This will pump a substance in one direction and transport the substance to another direction. The ATP molecules are enough to perform this process. An example of an antiport pump is the sodium-potassium pump.

- **Symport Pumps:** The molecules of two different substances can move in the same direction related to each other through the protein transmembrane. Here, the movement of molecules or substances occurs from higher concentration to lower concentration. An example for symport pumps transport is a sodium-glucose transport protein

- **Endocytosis:** The larger molecules or large substances of extracellular fluid will enter into the cell through the process of endocytosis. The cell utilizes its protein membrane to fold the membrane into the pockets. The pocket formed around the larger molecules enters the cell. These membrane packets, which carry materials inside the cells are termed vesicles. [DEPTH OF BIOLOGY]

- **Exocytosis:**. The vesicle present inside the cell moves outside of the cell membrane is known as exocytosis. This is commonly occurring, when the cell needs to export a molecule, enzymes and hormones In eukaryotic cells, the protein products are made up of endoplasmic reticulum.

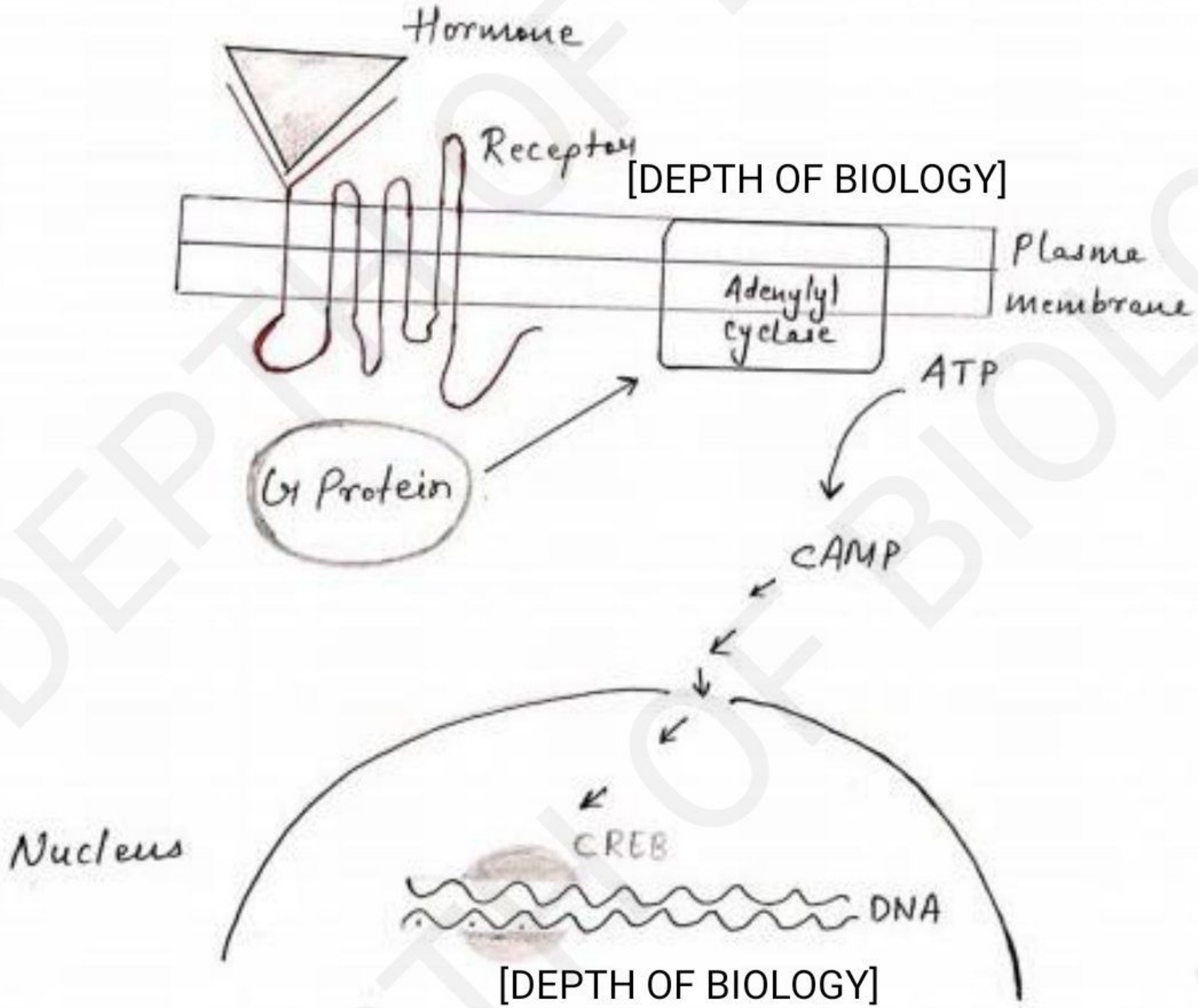
- This often packs vesicles and send them to Golgi bodies. The Golgi apparatus acts as a cellular post office.
- It receives the package from the endoplasmic reticulum and addresses them by adding molecules. The receptor utilizes the molecules to find the vesicles.
- The vesicle's contents are then released into the extracellular space.

MECHANISM [DEPTH OF BIOLOGY]

- The major principle behind the movement of solutes transport across cell membrane is based on the diffusion process.
- According to the diffusion process, dissolved substances transport across membrane through a concentration gradient.
- This does not require external energy to move from a higher concentration to a lower concentration. This diffusion continues and starts decreasing gradually till it attaining the equilibrium state. The random diffusion occurs from both places at an equal ratio during the equilibrium state [DEPTH OF BIOLOGY]

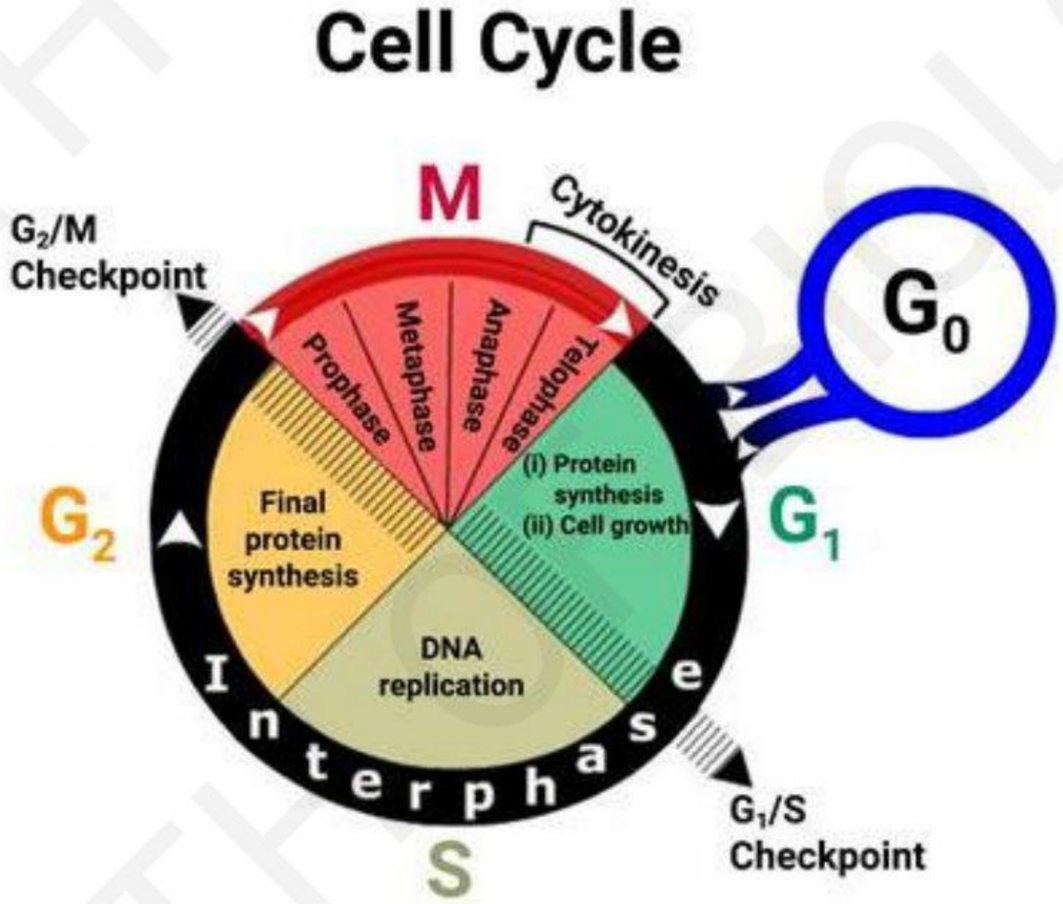
- A solute at a high concentration has high free energy. These are capable to do more work than the solute at low concentration. [DEPTH OF BIOLOGY]
- While performing the diffusion process, the solutes lose their free energy. So, the solutes are unable to return to the high concentration, after attaining the lower concentration or equilibrium state. [DEPTH OF BIOLOGY]
- But, it is possible to perform transport of ions across cell membrane to higher concentration through ion pump.

- Each hormone has receptors that are found on the cell membrane of the target organ. [DEPTH OF BIOLOGY]
- Once the hormone bind to it`s designated receptor, a series of actions are initiated to release Secondary messengers inside the cell.
- These secondary messengers are responsible for relaying information to the nucleus or other organelles [DEPTH OF BIOLOGY]



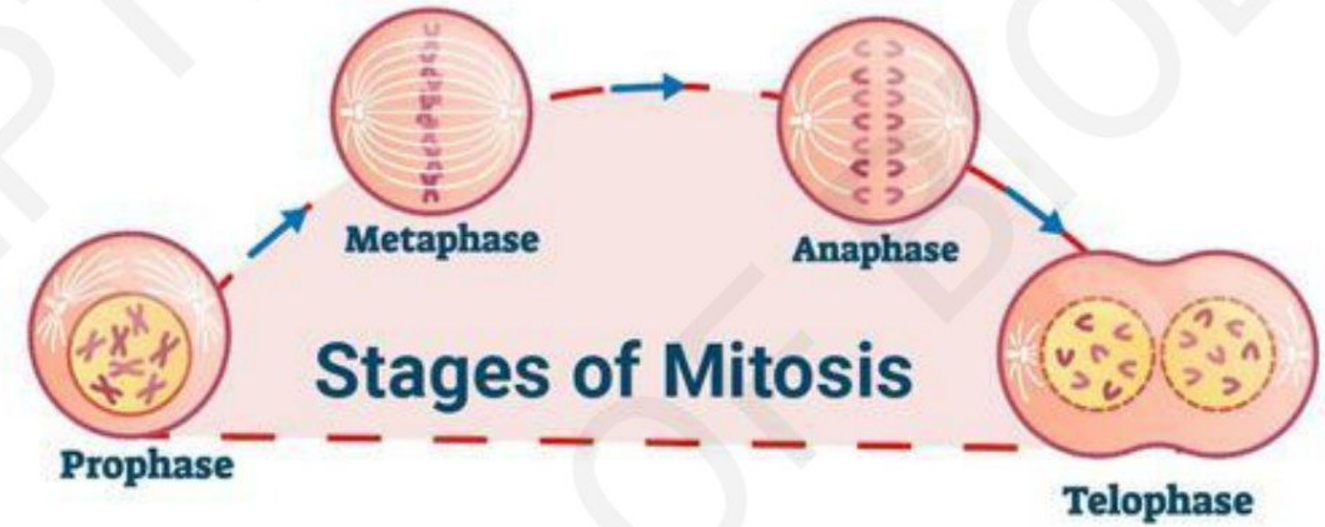
cAMP Response Element

CELL DIVISION

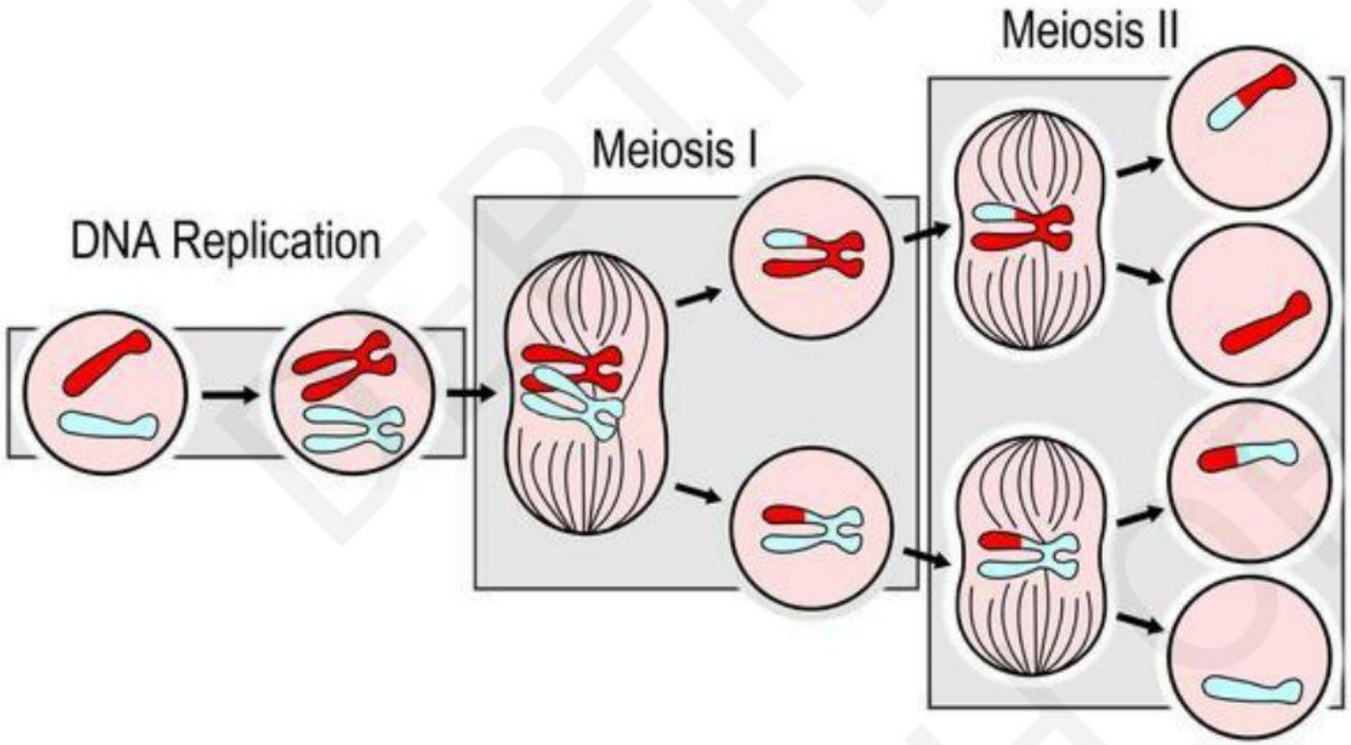


[DEPTH OF BIOLOGY]

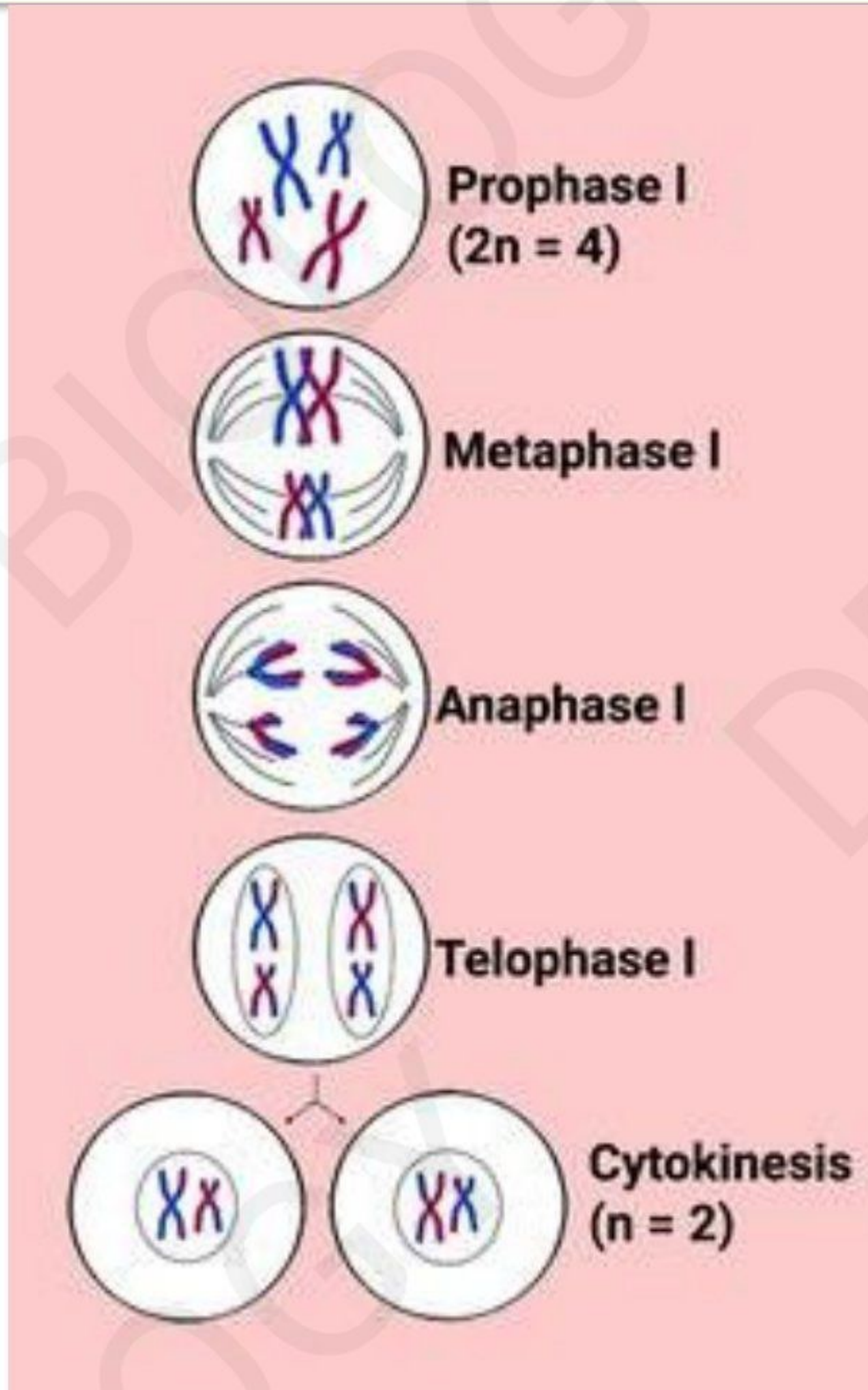
STAGES OF MITOSIS



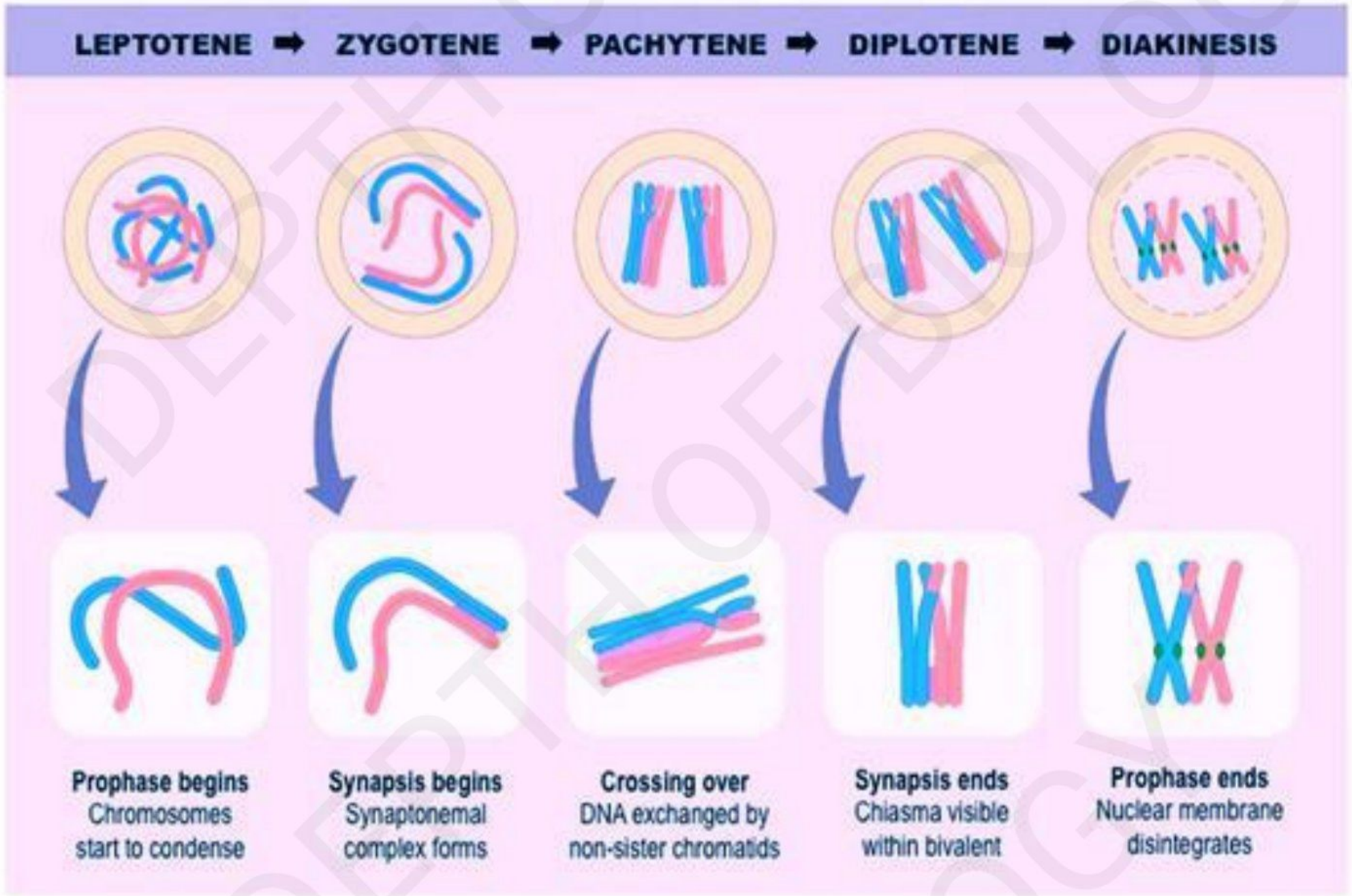
OVERVIEW OF MEIOSIS



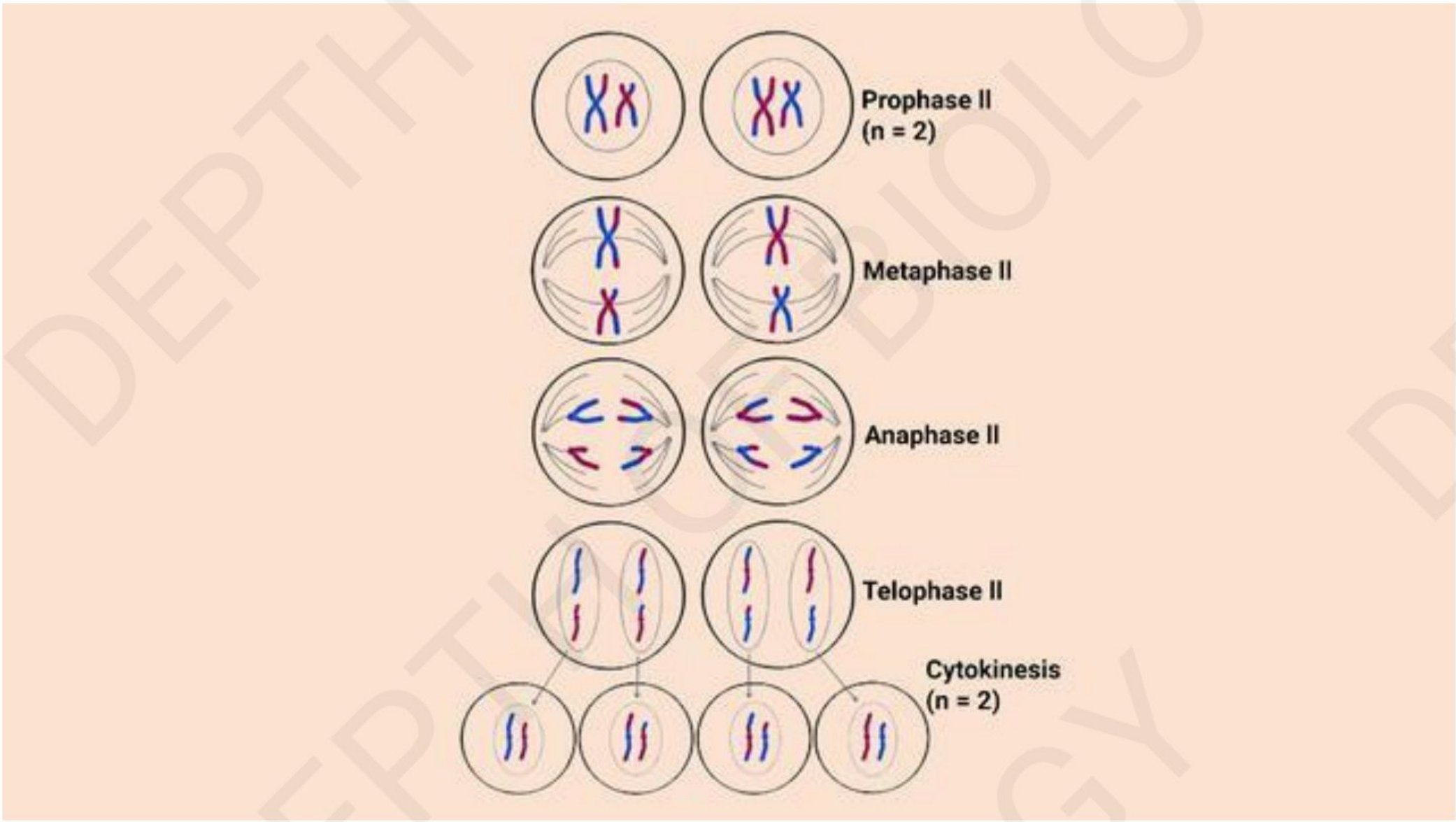
STAGES OF MEIOSIS 1



PROPHASE 1 OF MEIOSIS 1



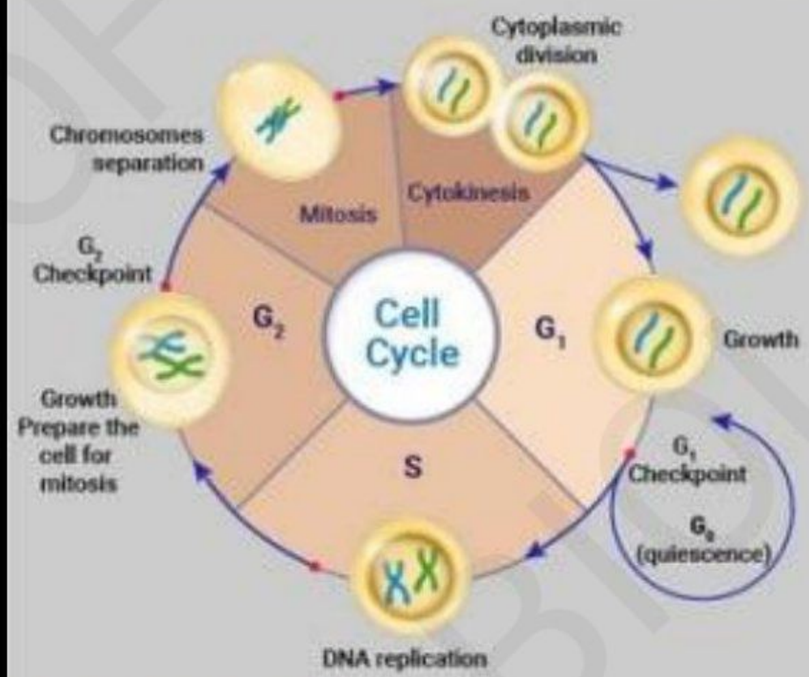
STAGES OF MEIOSIS II



- ***CONCLUSION OF***

CELL CYCLE & DIVISION

Interphase



Cell Cycle Duration for Humans

G_1 Phase – 11 hours
S phase – 8 hours
G_2 phase – 4 hours
M phase – 1 hour

Cell cycle duration for yeast – 90 minutes

Gap_1 (G_1 phase)

- Cell starts growing and enlarges physically
- Forms the copy of organelles, produces all the necessary molecular building blocks
- Activation of a checkpoint to ensure proper functioning of G_1

S phase

- DNA replication begins
- Microtubule-organizing structure (centrosome) is also copied.

Gap_2 (G_2) phase

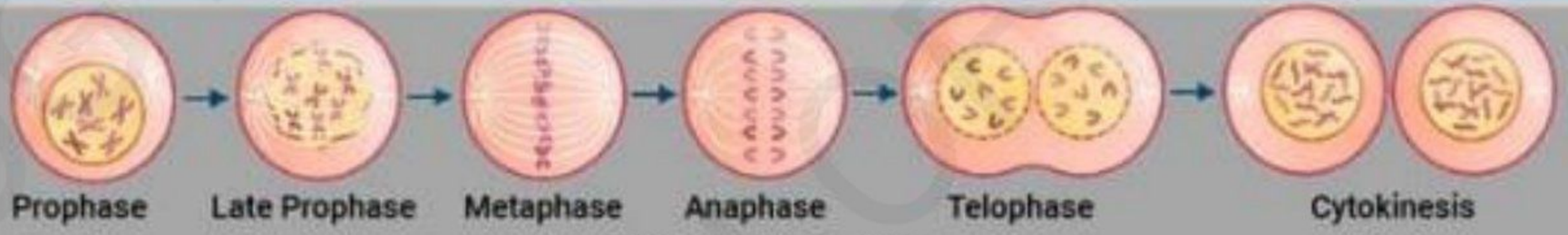
- Cell grows further, produces proteins and organelles and starts rearranging the constituents of the cell for mitosis phase.
- G_2 checkpoint activated to ensure everything is ready for division in M phase.

Gap_0 (G_0) Phase

- Sometimes cell leaves the cycle at G_1 phase and temporarily stops dividing (or stops permanently, Ex. Neurons)

Uncontrolled cell cycle or cell division leads to cancer.

Cell Division - Mitosis



Stages of Mitosis

Significance of Mitosis

- Genetic stability
- Growth
- Replacement and regeneration of new cells
- Asexual reproduction

Prophase

- Chromatin fibres condense into chromosomes
- Pairs of centrioles move away from each other towards the poles
- Nuclear envelope disintegrates and the nucleolus disappears

Late Prophase

- Spindle fibres move from the pole to the centre of the cell and kinetochores attach themselves to microtubules

Metaphase

- The chromosomes arrange themselves in the metaphase plate at 90 degree to the spindle poles

Anaphase

- The sister chromatids of paired chromosomes, separate and form daughter chromosomes
- Daughter chromosomes start moving towards the poles in the opposite ends through the spindle apparatus

Telophase

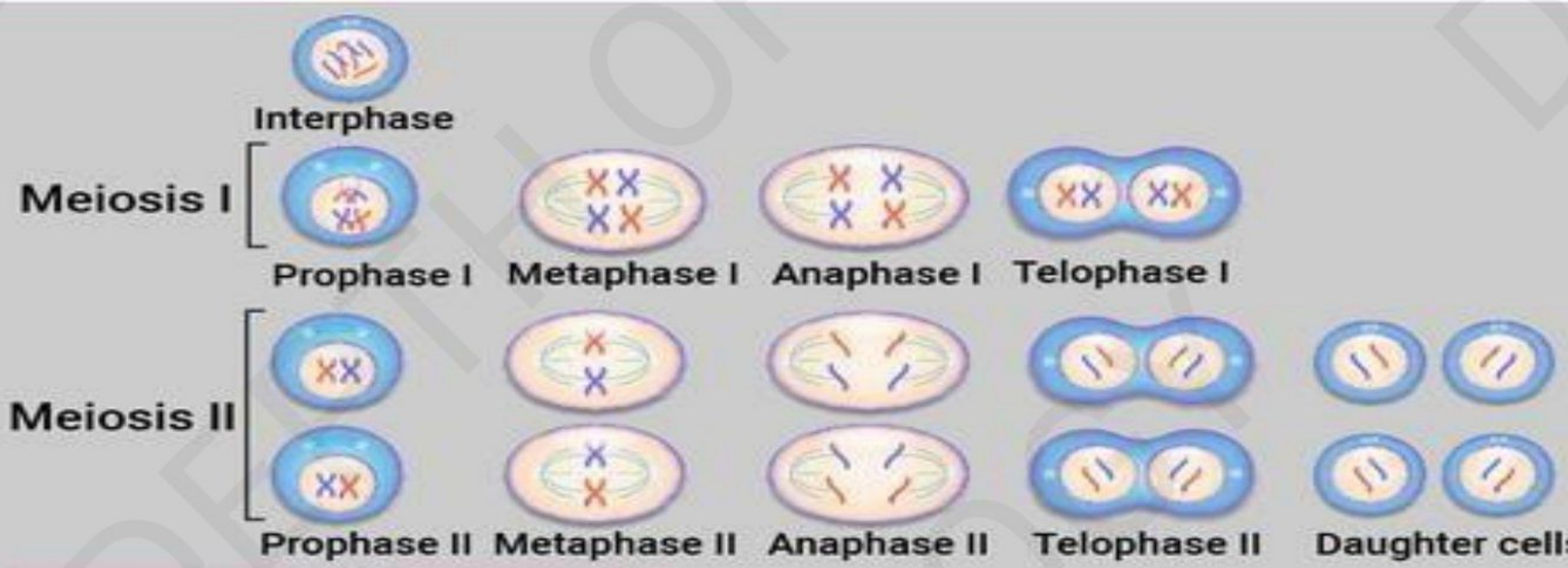
- Nuclear envelopes start developing from the leftover pieces of the nuclear envelope the parent cell and from the endomembrane system
- Chromatin fibres of the chromosome unwind
- Genetic material of the parent cell is equally divided into two nuclei

Cytokinesis

- Division of cytoplasm takes place and two new separate daughter cells are formed

Meiosis

Single cell divides twice to form four daughter cells that possess exactly half the number of chromosomes of the parent cell



Prophase I

- Sister chromatids or the chromosomes of the maternal set combines together with their homologs of the paternal chromosomes set
- The maternal and paternal chromatids exchange their parts of DNA (crossing over) and recombine to develop genetic variations
- Nuclear membrane of the cell breaks down

Metaphase I

- Chromosome sets arrange themselves next to each other along the equator of the cell
- The meiotic spindle attaches to the combined sister chromatid

Anaphase I

- Chromosome pairs are gradually pulled apart when the meiotic spindle fibres start to contract

Telophase I

- The chromosomes completely move apart and are present in the opposite poles of the cell

Cytokinesis

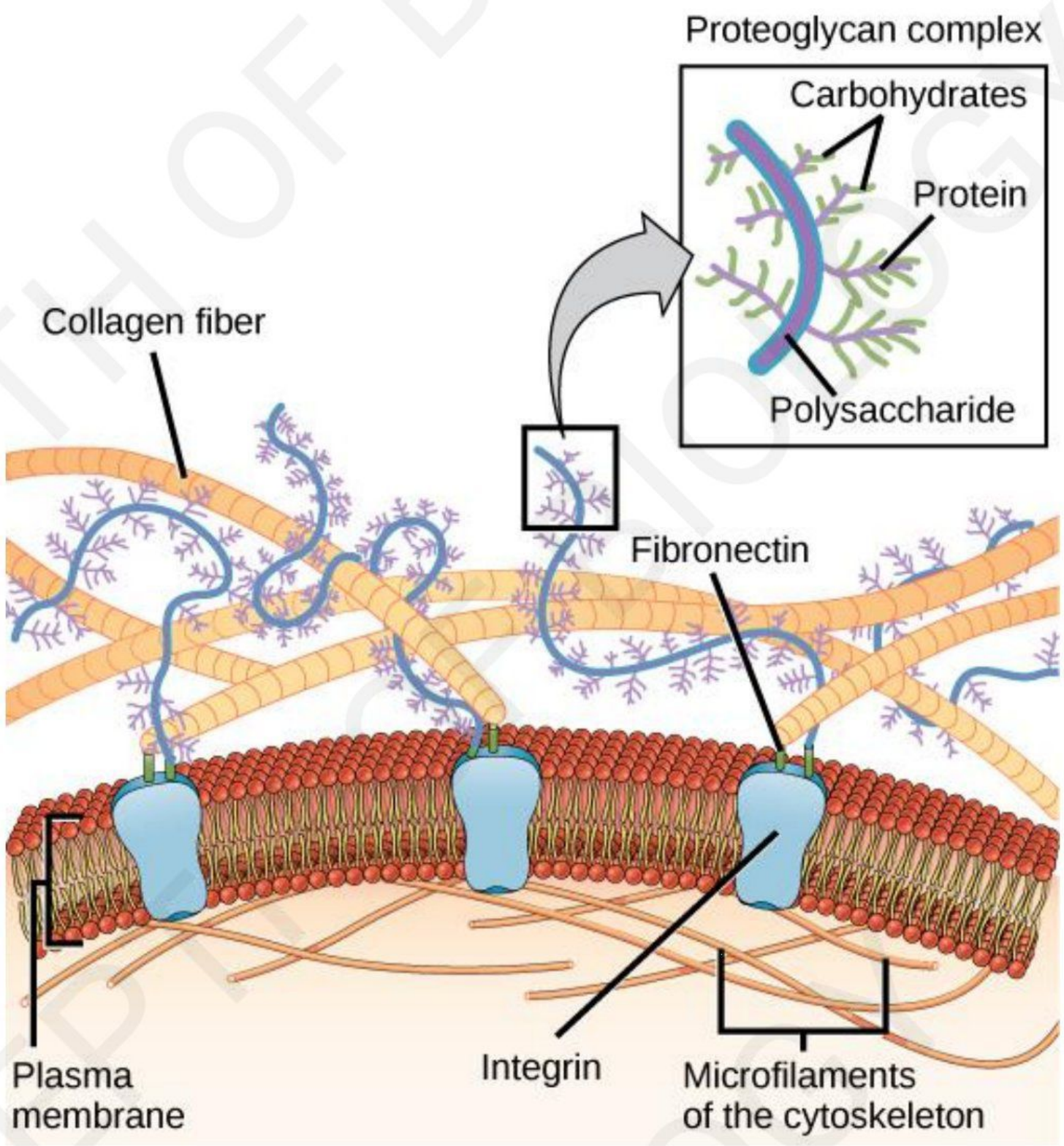
- Single cell splits in the middle to create two separate daughter cells with full set of chromosomes
- The newly formed daughter cells enter into meiosis II without further duplication of chromosomes

Meiosis II

- Similar to the process of mitosis; resulting in production of four daughter (haploid) cells at the end

EXTRACELLULAR MATRIX OF ANIMAL CELLS

- Most animal cells release materials into the extracellular space. [DEPTH OF BIOLOGY]
- The primary components of these materials are proteins, and the most abundant protein is collagen. Collagen fibers are interwoven with carbohydrate-containing protein molecules called proteoglycans.
- Collectively, these materials are called the **extracellular matrix** . [DEPTH OF BIOLOGY]
- Not only does the extracellular matrix hold the cells together to form a tissue, but it also allows the cells within the tissue to communicate with each other.



- Cells have protein receptors on the extracellular surfaces of their plasma membranes. When a molecule within the matrix binds to the receptor, it changes the molecular structure of the receptor. [DEPTH OF BIOLOGY]

- The receptor, in turn, changes the conformation of the microfilaments positioned just inside the plasma membrane. [DEPTH OF BIOLOGY]

- These conformational changes induce chemical signals inside the cell that reach the nucleus and turn “on” or “off” the transcription of specific sections of DNA, which affects the production of associated proteins, thus changing the activities within the cell.

- Blood clotting provides an example of the role of the extracellular matrix in cell communication. When the cells lining a blood vessel are damaged, they display a protein receptor called tissue factor. [DEPTH OF BIOLOGY]

- When tissue factor binds with another factor in the extracellular matrix, it causes platelets to adhere to the wall of the damaged blood vessel.

- Stimulates the adjacent smooth muscle cells in the blood vessel to contract (thus constricting the blood vessel), and initiates a series of steps that stimulate the platelets to produce clotting factors. [DEPTH OF BIOLOGY]

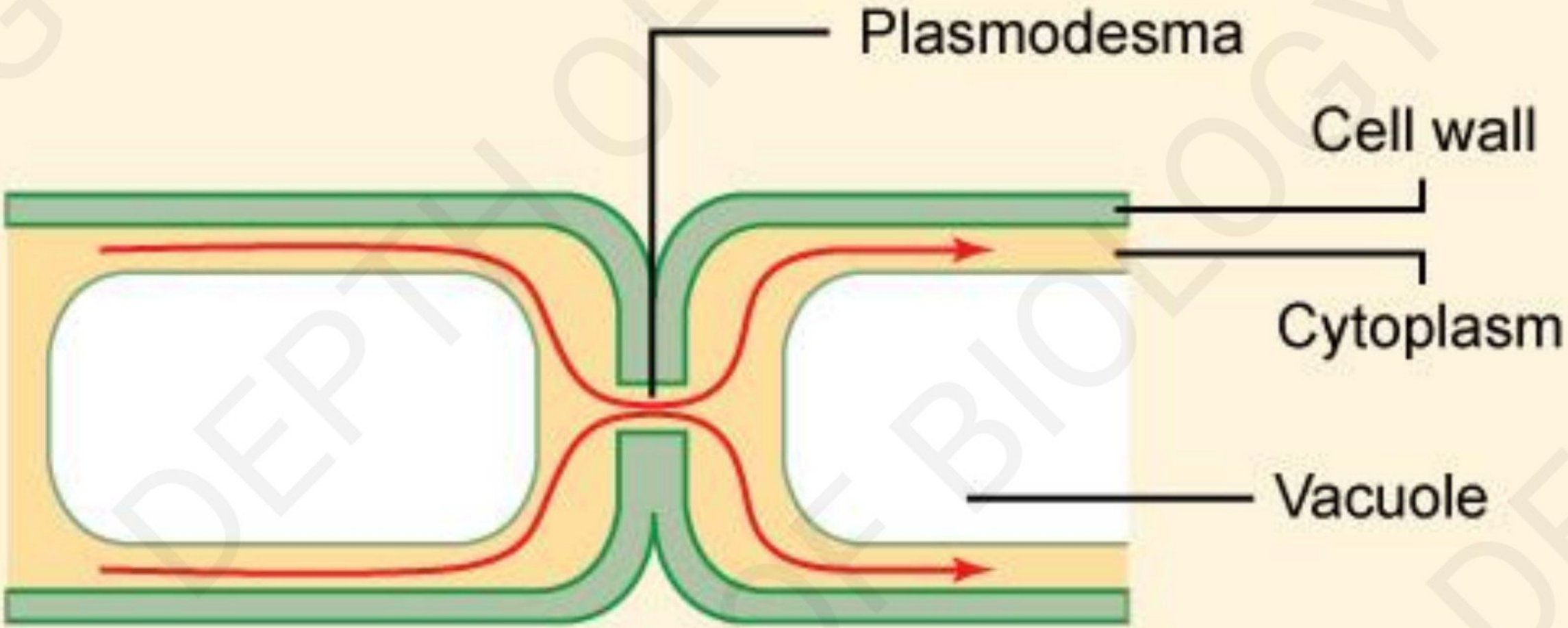
INTERCELLULAR JUNCTIONS

- Cells can also communicate with each other via direct contact, referred to as intercellular junctions. There are some differences in the ways that plant and animal cells do this. Plasmodesmata are junctions between plant cells, whereas animal cell contacts include tight junctions, gap junctions, and desmosomes. [DEPTH OF BIOLOGY]

PLASMODESMATA

- In general, long stretches of the plasma membranes of neighboring plant cells cannot touch one another because they are separated by the cell wall that surrounds each cell.
- Such transport uses the vascular tissues (xylem and phloem) primarily. [DEPTH OF BIOLOGY]
- There also exist structural modifications called plasmodesmata (singular = plasmodesma), numerous channels that pass between cell walls of adjacent plant cells, connect their cytoplasm, and enable materials to be transported from cell to cell, and thus throughout the plant

[DEPTH OF BIOLOGY]



Pathways through the cytoplasm

TIGHT JUNCTION

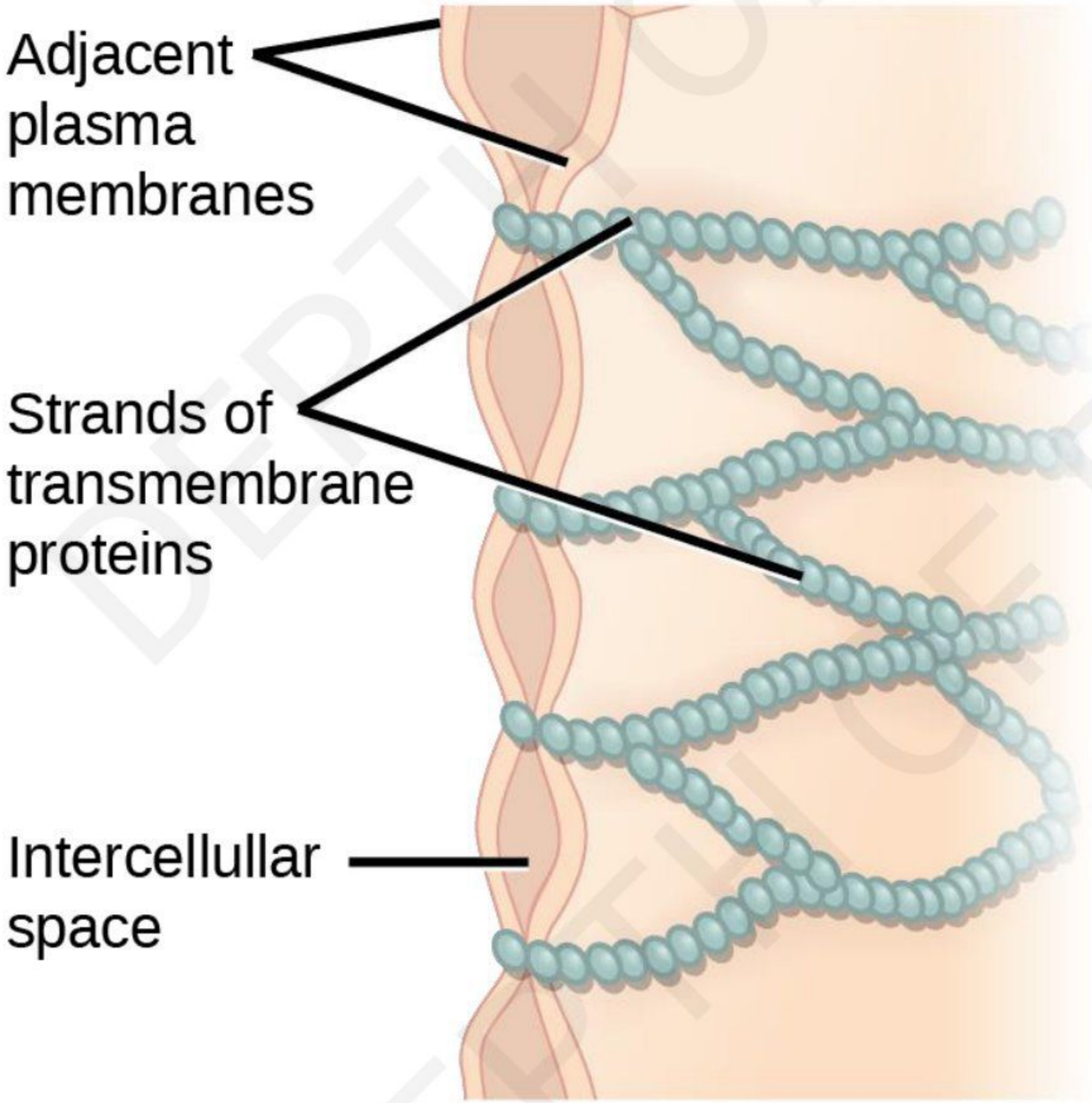
- A **tight junction** is a watertight seal between two adjacent animal cells .The cells are held tightly against each other by proteins (predominantly two proteins called claudins and occludins).

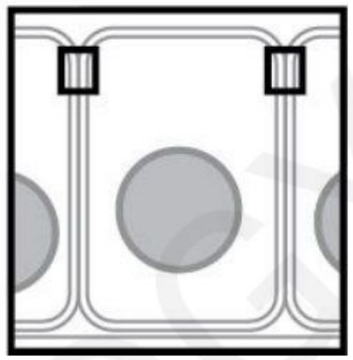
[DEPTH OF BIOLOGY]

- This tight adherence prevents materials from leaking between the cells; tight junctions are typically found in epithelial tissues that line internal organs and cavities, and comprise most of the skin.

- For example, the tight junctions of the epithelial cells lining your urinary bladder prevent urine from leaking out into the extracellular space. [DEPTH OF BIOLOGY]

Tight junction





DESMOSOMES

- Also found only in animal cells are **desmosomes**, which act like spot welds between adjacent epithelial cells .

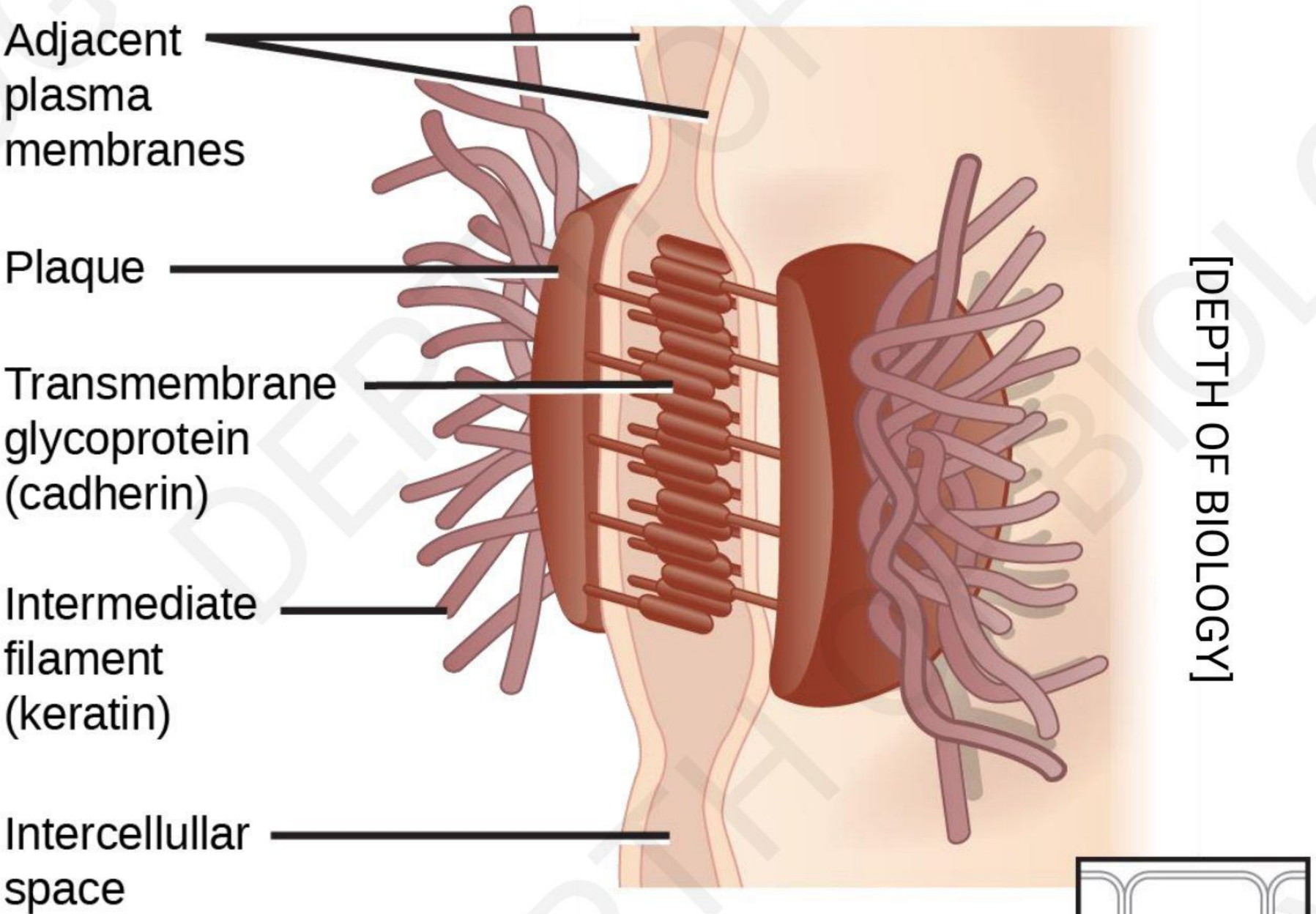
[DEPTH OF BIOLOGY]

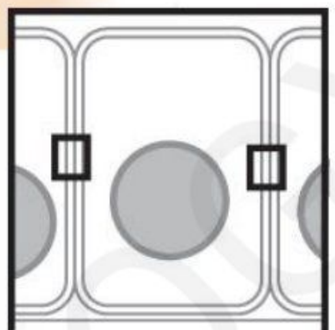
- Short proteins called cadherins in the plasma membrane connect to intermediate filaments to create desmosomes.

- The cadherins join two adjacent cells together and maintain the cells in a sheet-like formation in organs and tissues that stretch, like the skin, heart, and muscles

[DEPTH OF BIOLOGY]

Desmosome





Gap Junctions

[DEPTH OF BIOLOGY]

- **Gap junctions** in animal cells are like plasmodesmata in plant cells in that they are channels between adjacent cells that allow for the transport of ions, nutrients, and other substances that enable cells to communicate (Figure 5). Structurally, however, gap junctions and plasmodesmata differ.
- Gap junctions develop when a set of six proteins (called connexins) in the plasma membrane arrange themselves in an elongated donut-like configuration called a connexon. When the pores ("doughnut holes") of connexons in adjacent animal cells align, a channel between the two cells forms. [DEPTH OF BIOLOGY]

Gap junction