Physiology

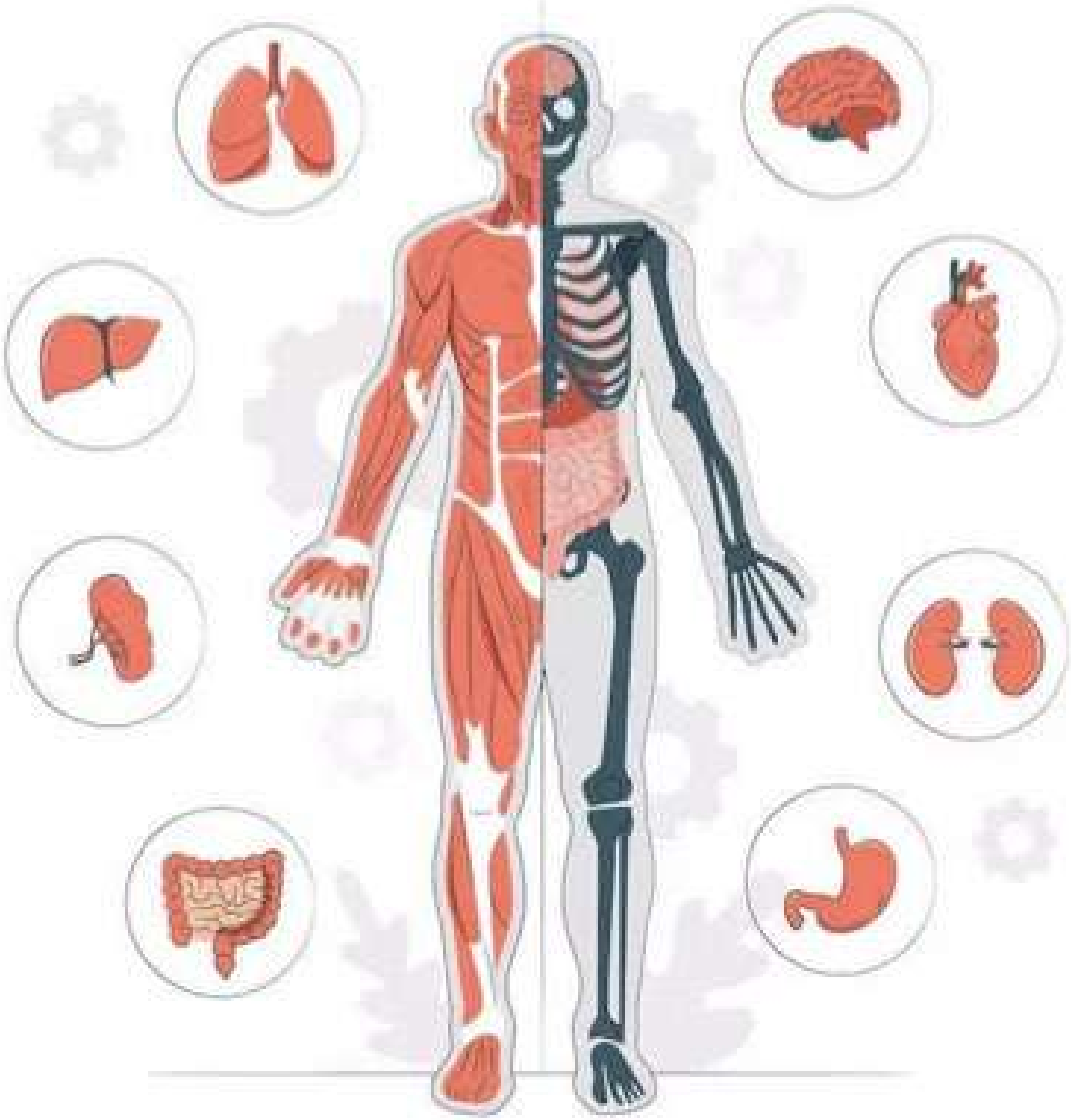
Mammalian cell, Homeostasis and Intercellular Communication

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Medicine is not just about recognizing symptoms; it's about understanding **why** they occur and **how** the body responds.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Physiology is the study of **how** the human body functions from the cellular level to complex organ systems working together to maintain life.



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

The three fundamental topics in physiology:

1. The Structure and Functions of a Mammalian Cell " Understanding how cells are built and how they operate.
2. The Principles of Homeostasis " How the body maintains a stable internal environment.
3. Intercellular Communication " How cells communicate with each other to coordinate body functions.

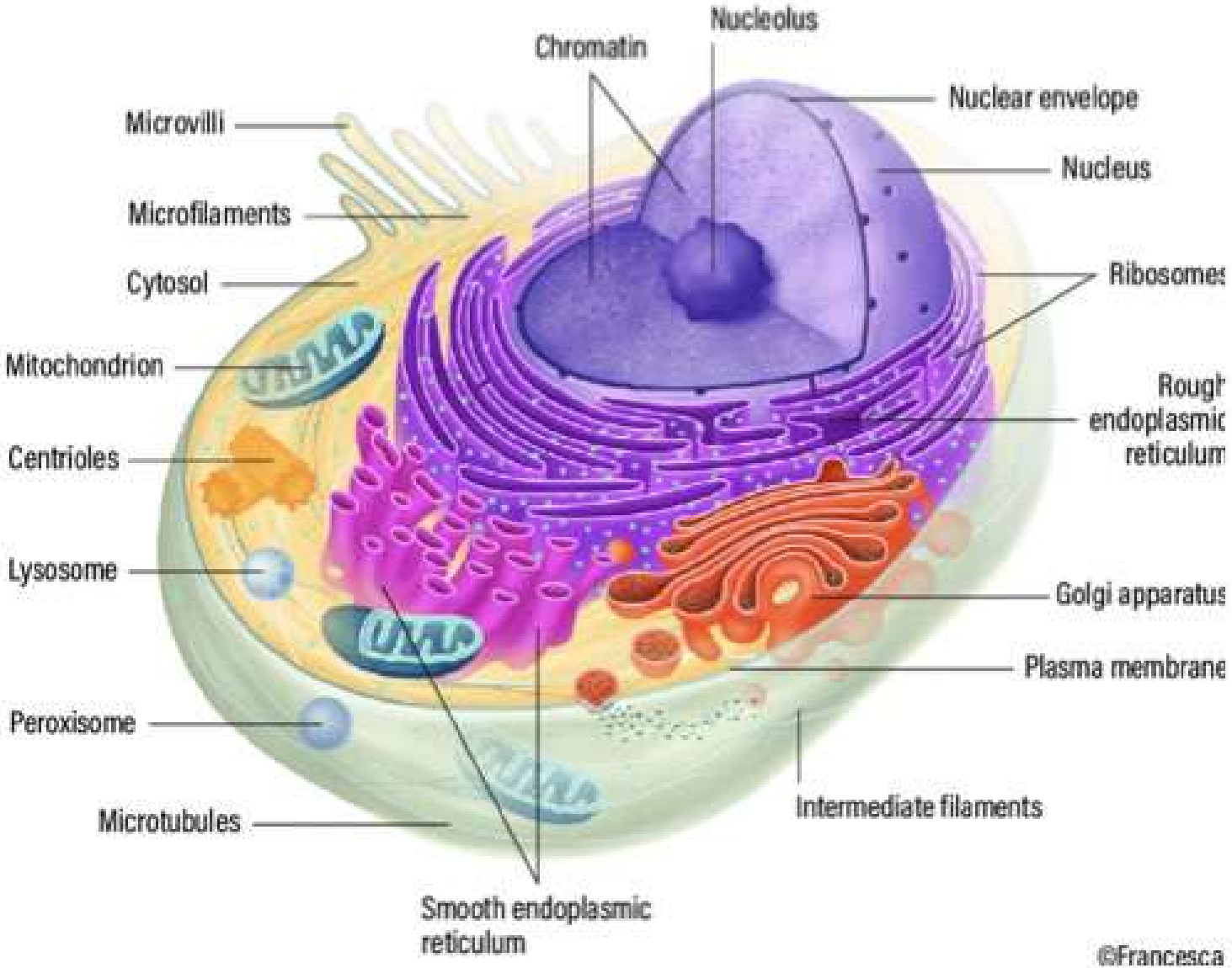
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Structure and Functions of a Mammalian Cell

" Understanding how cells are built and how they operate.

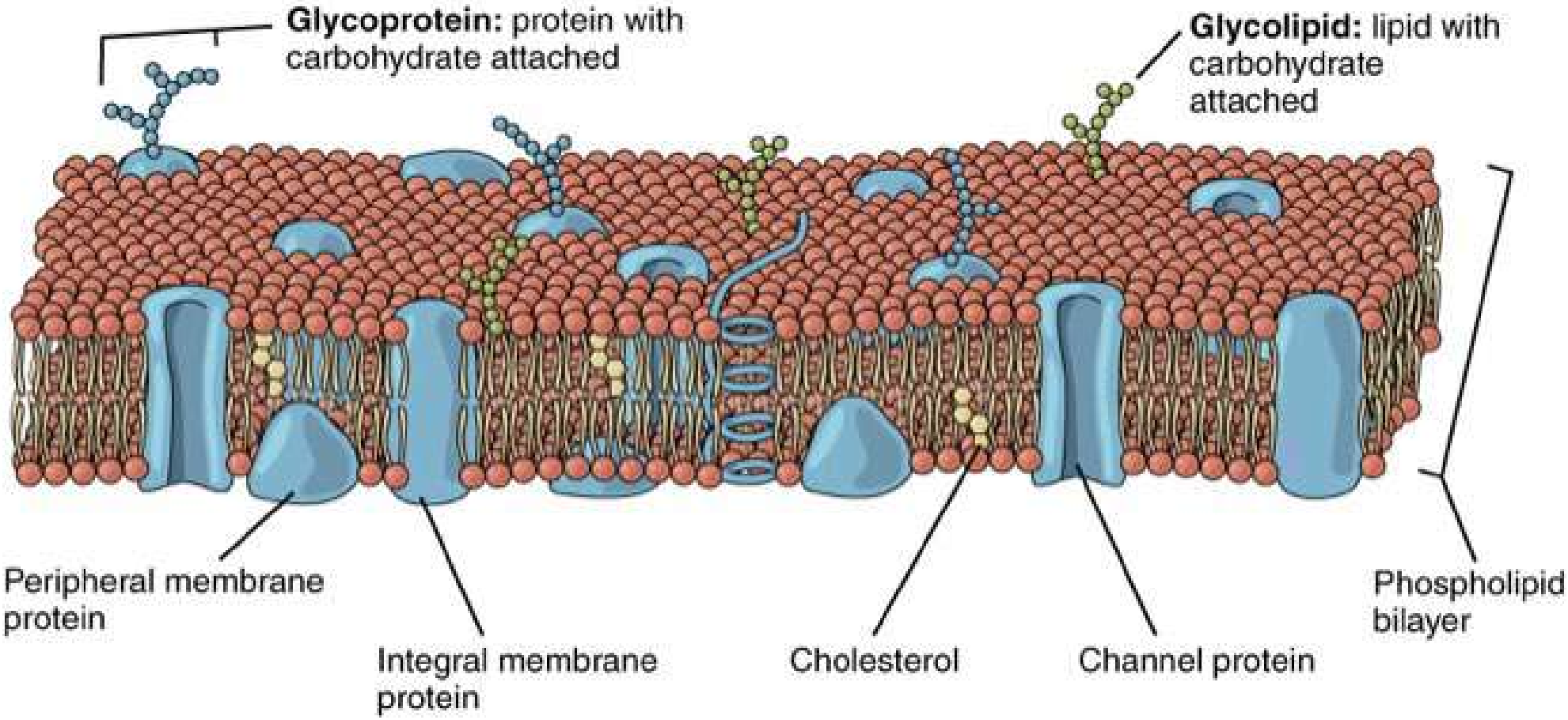
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

A mammalian cell is the basic unit of life in the body. It consists of different organelles, each with a specific function.



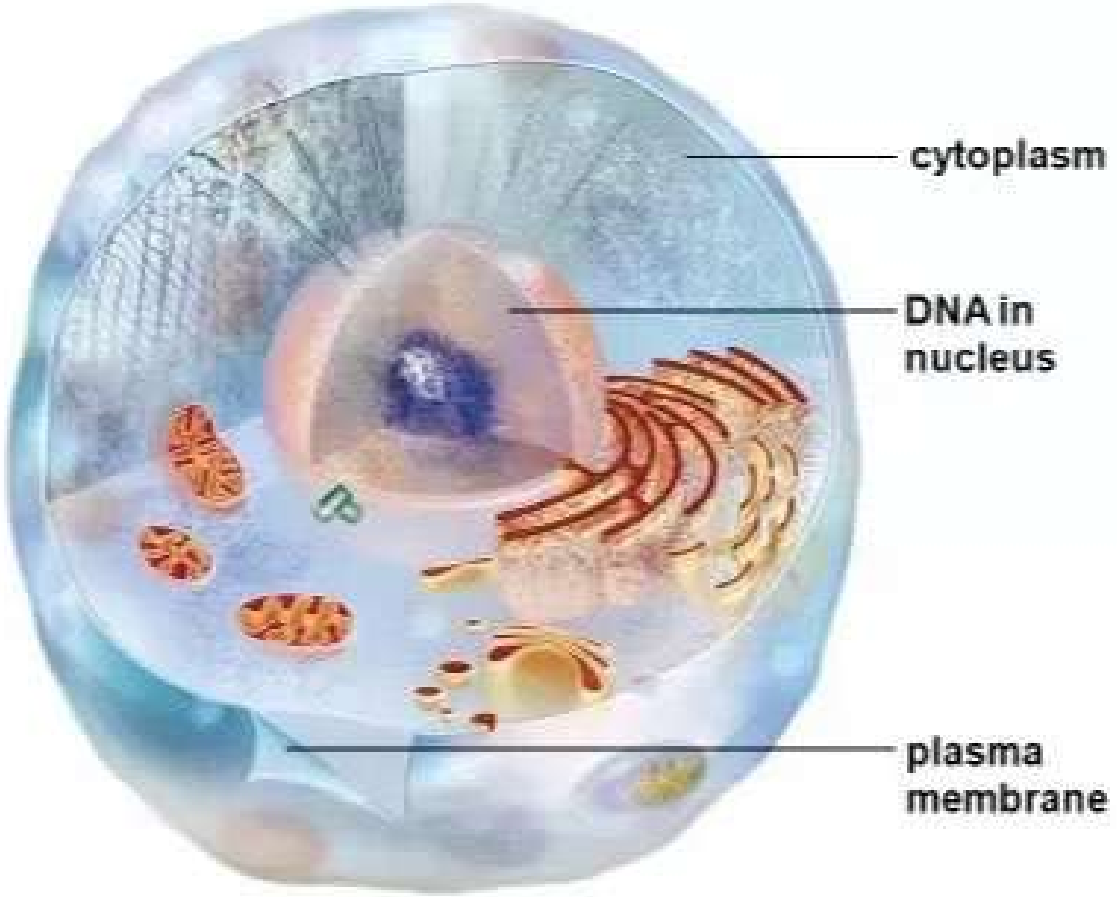
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Plasma Membrane: A selectively permeable barrier composed of a phospholipid bilayer with embedded proteins. It regulates the movement of substances in and out of the cell and is involved in cell signaling.



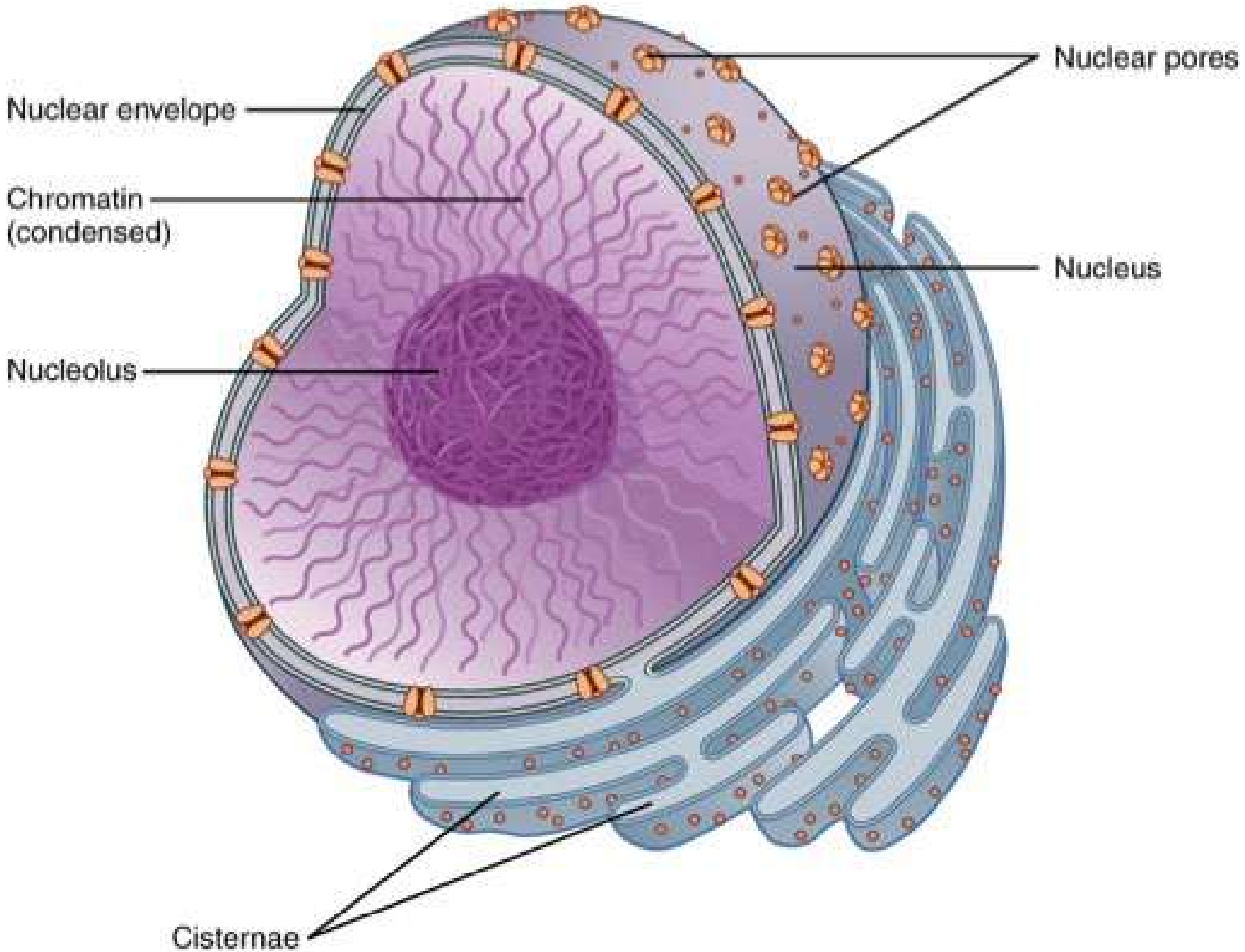
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Cytoplasm: The fluid that fills the cell, containing organelles, enzymes, and ions.



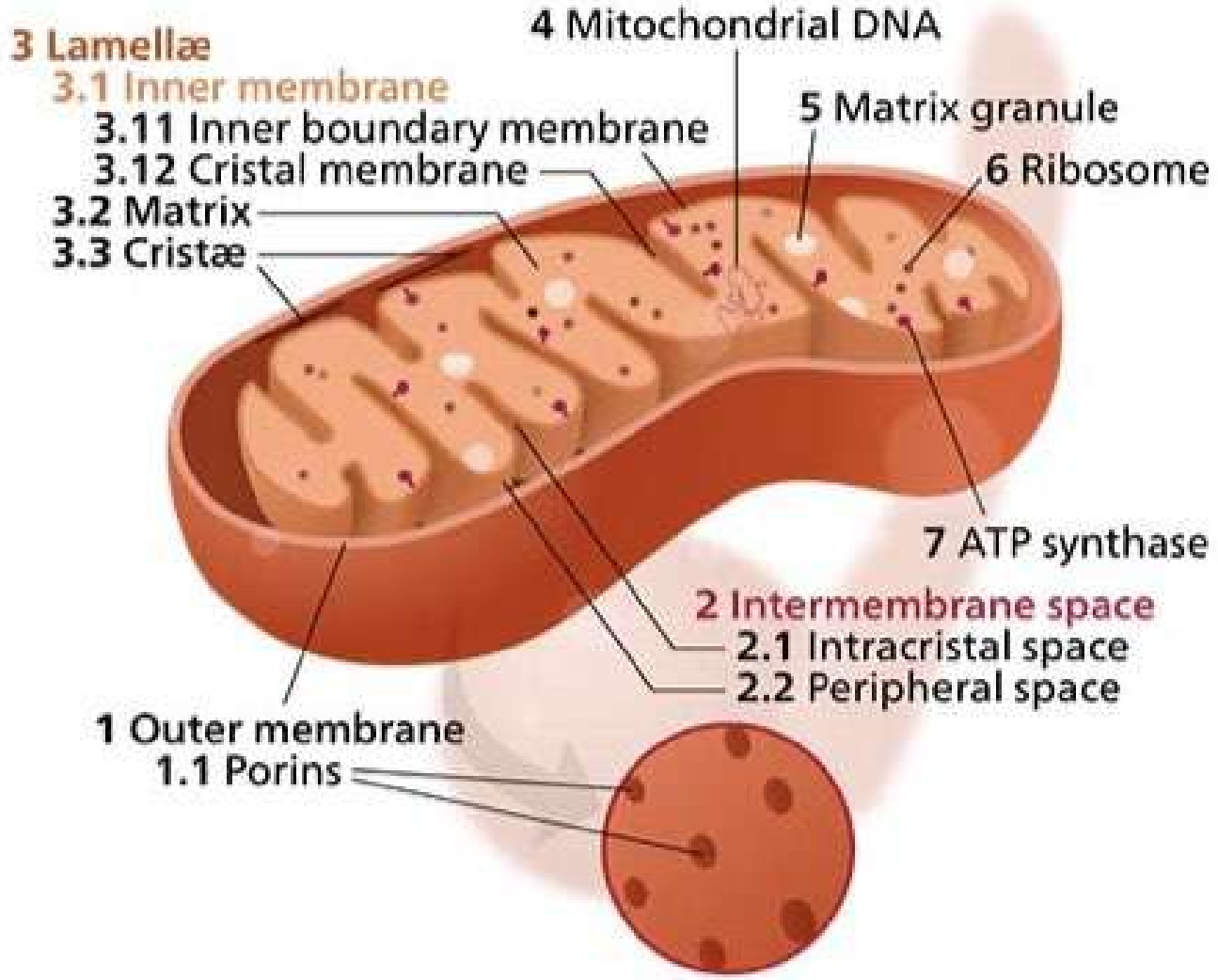
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Nucleus: Contains DNA and controls cell activities through gene expression.



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Mitochondria: The powerhouse of the cell, responsible for ATP production via cellular respiration.

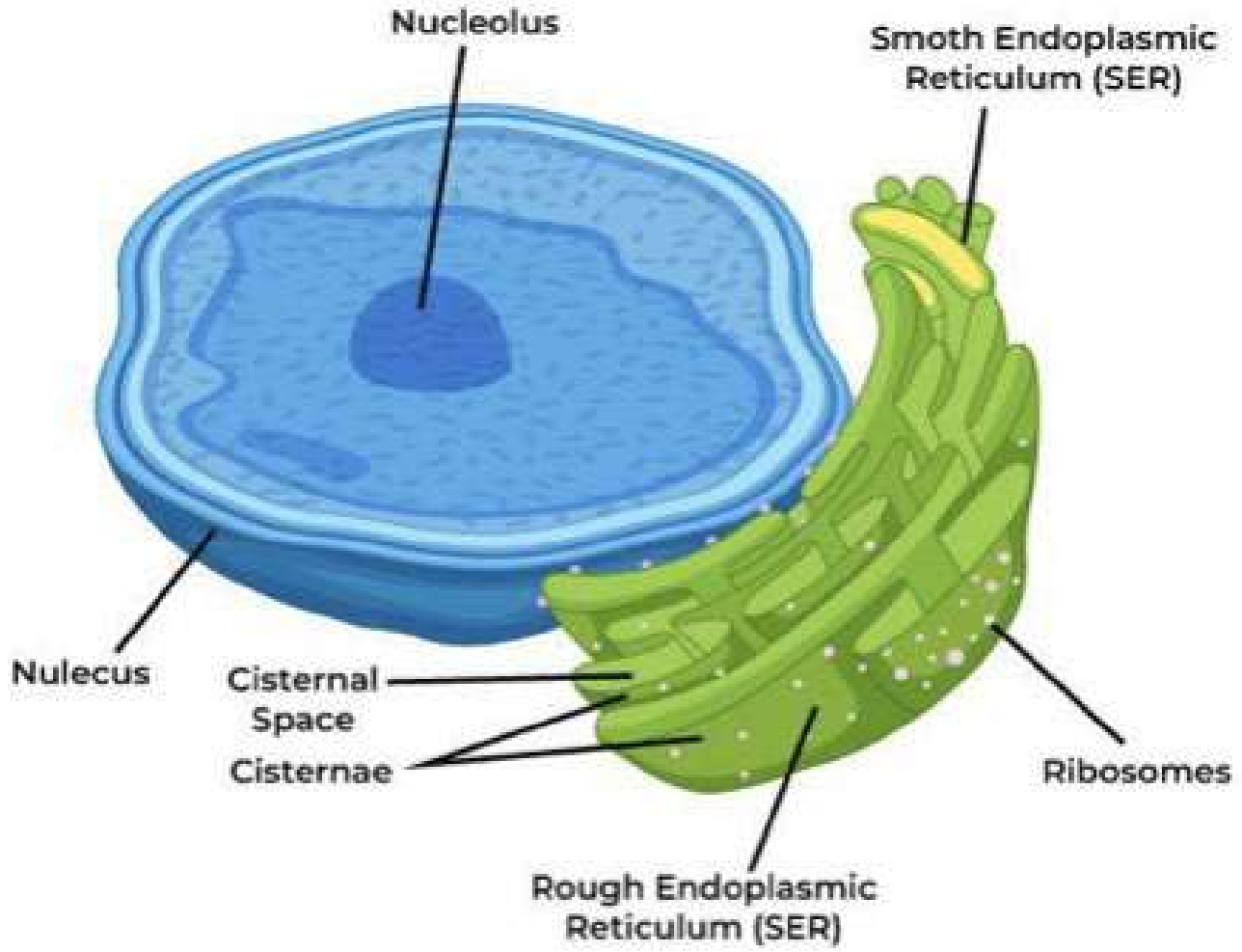


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Endoplasmic Reticulum (ER)

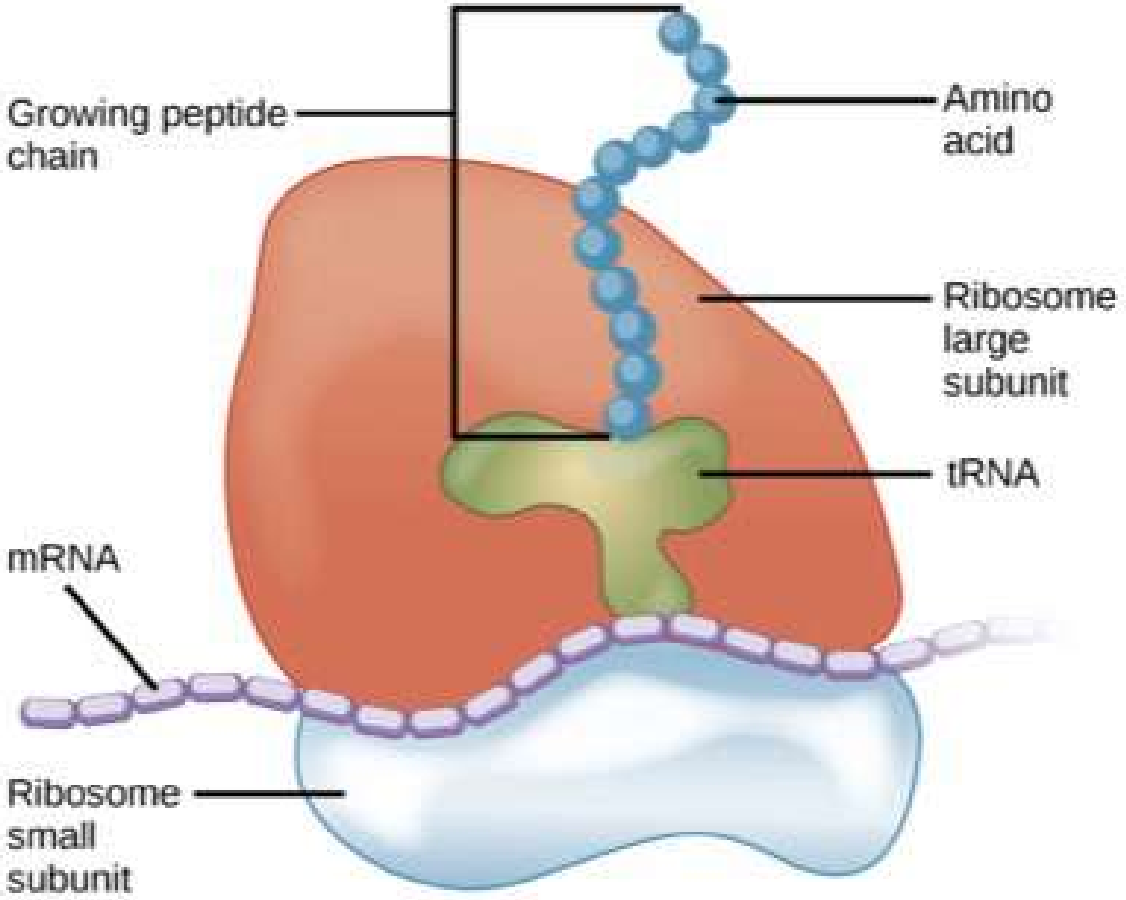
Rough ER: Studded with ribosomes; involved in protein synthesis.

Smooth ER: Involved in lipid synthesis and detoxification.



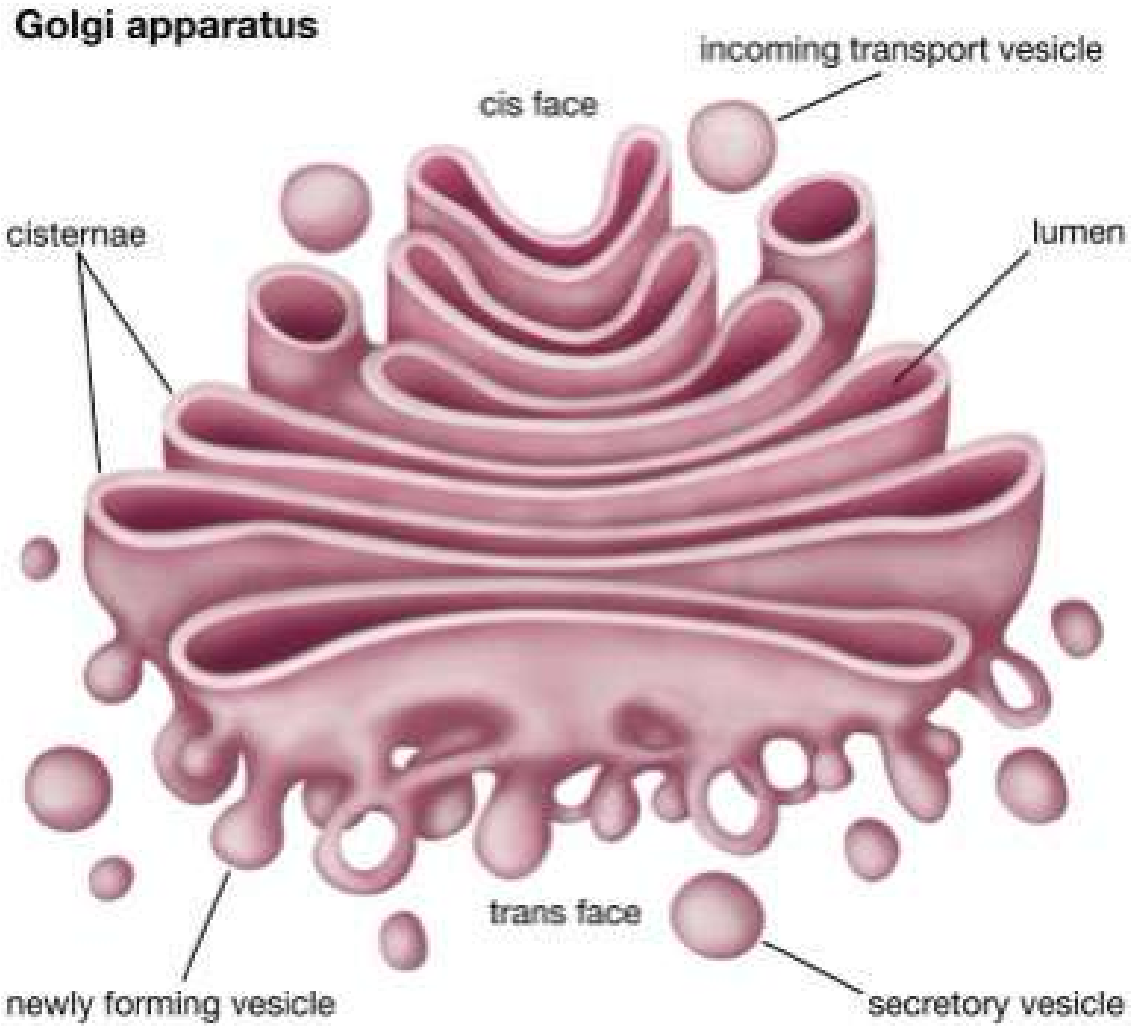
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Ribosomes: Sites of protein synthesis, either floating in the cytoplasm or attached to the rough ER.



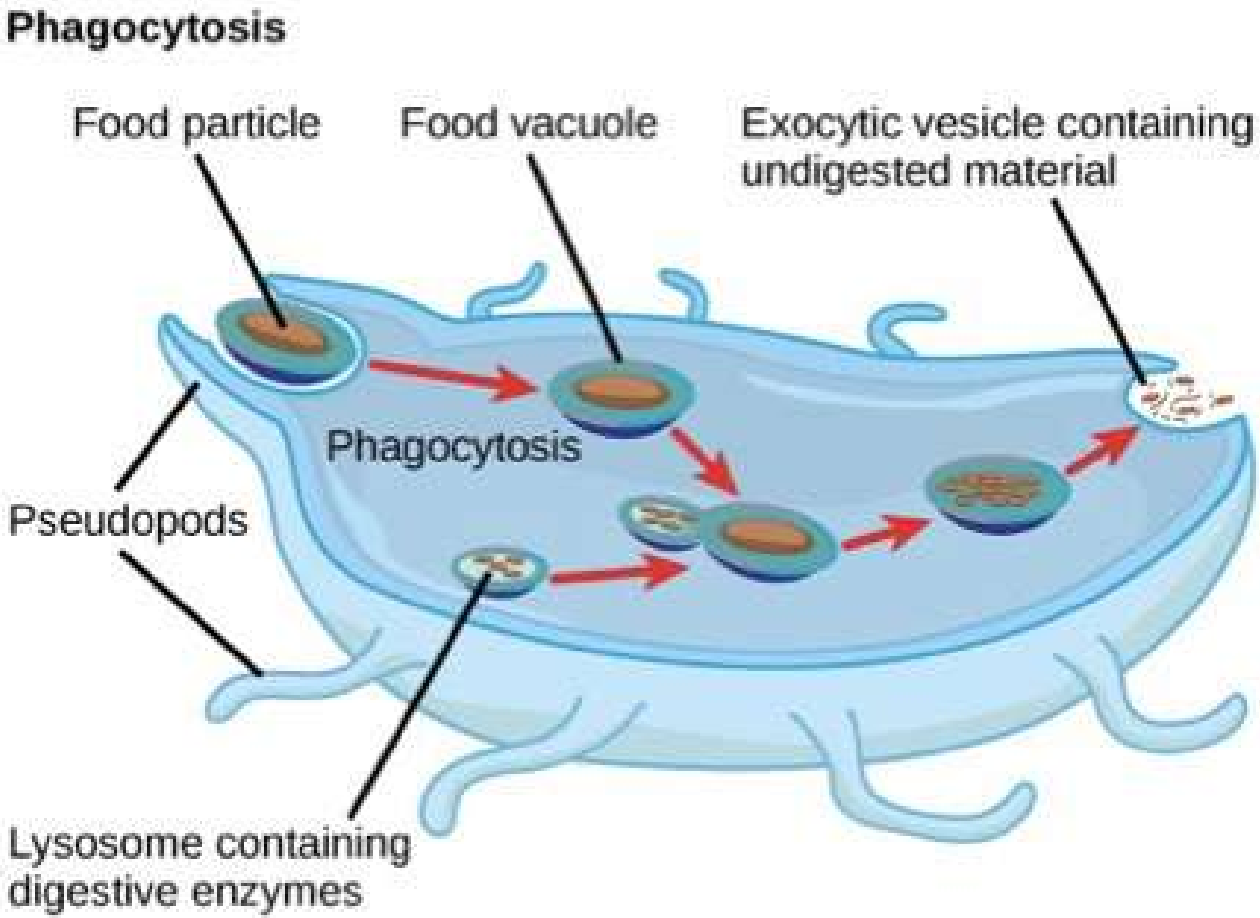
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Golgi Apparatus, Modifies, sorts, and packages proteins for secretion or transport within the cell.



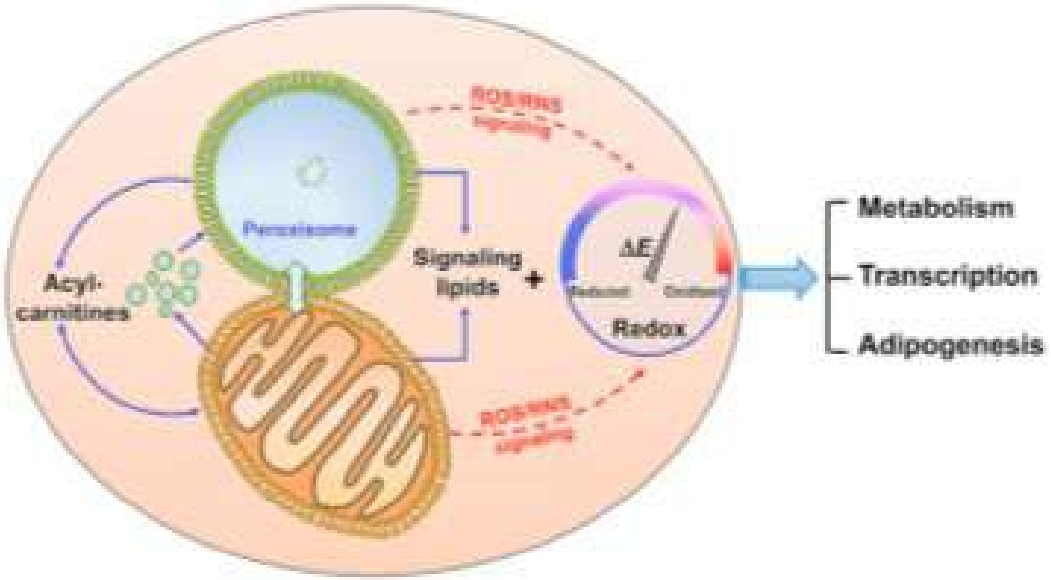
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Lysosomes: Contain digestive enzymes to break down waste and cellular debris.



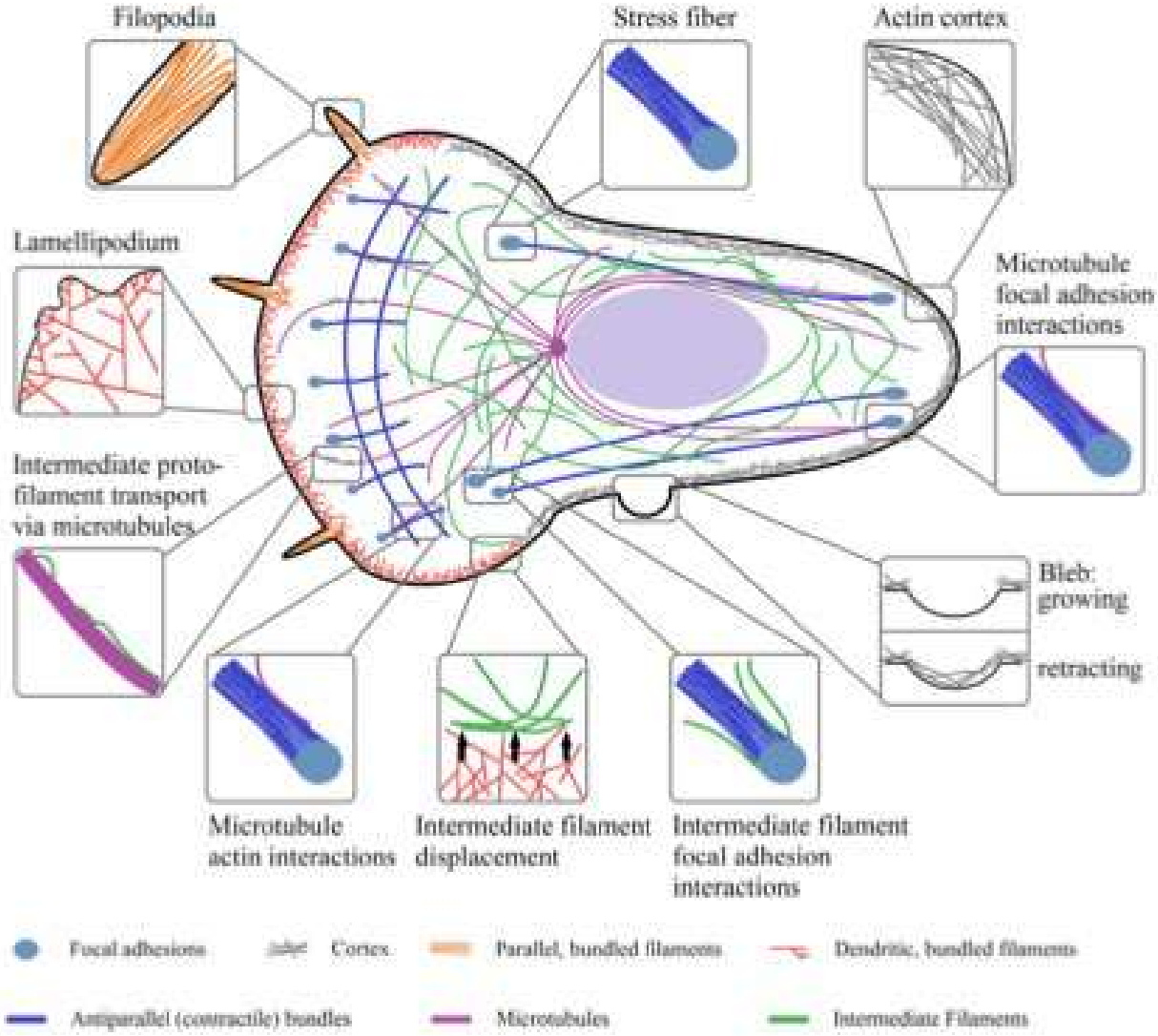
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Peroxisomes: Detoxify harmful substances and break down fatty acids.



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Cytoskeleton: A network of protein filaments (microtubules, actin filaments, and intermediate filaments) that provide structure, support, and intracellular transport.



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Functions of a Mammalian Cell

Metabolism: Cells carry out biochemical reactions to generate energy and build molecules.

Protein Synthesis: The nucleus directs the production of proteins, which carry out essential functions.

Growth and Division: Cells grow and divide through the processes of mitosis and meiosis.

Communication: Cells send and receive signals to coordinate functions.

Transport: The plasma membrane regulates the movement of nutrients, gases, and waste products.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

The Principles of Homeostasis

Homeostasis is the body's ability to maintain a stable internal environment despite external changes.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

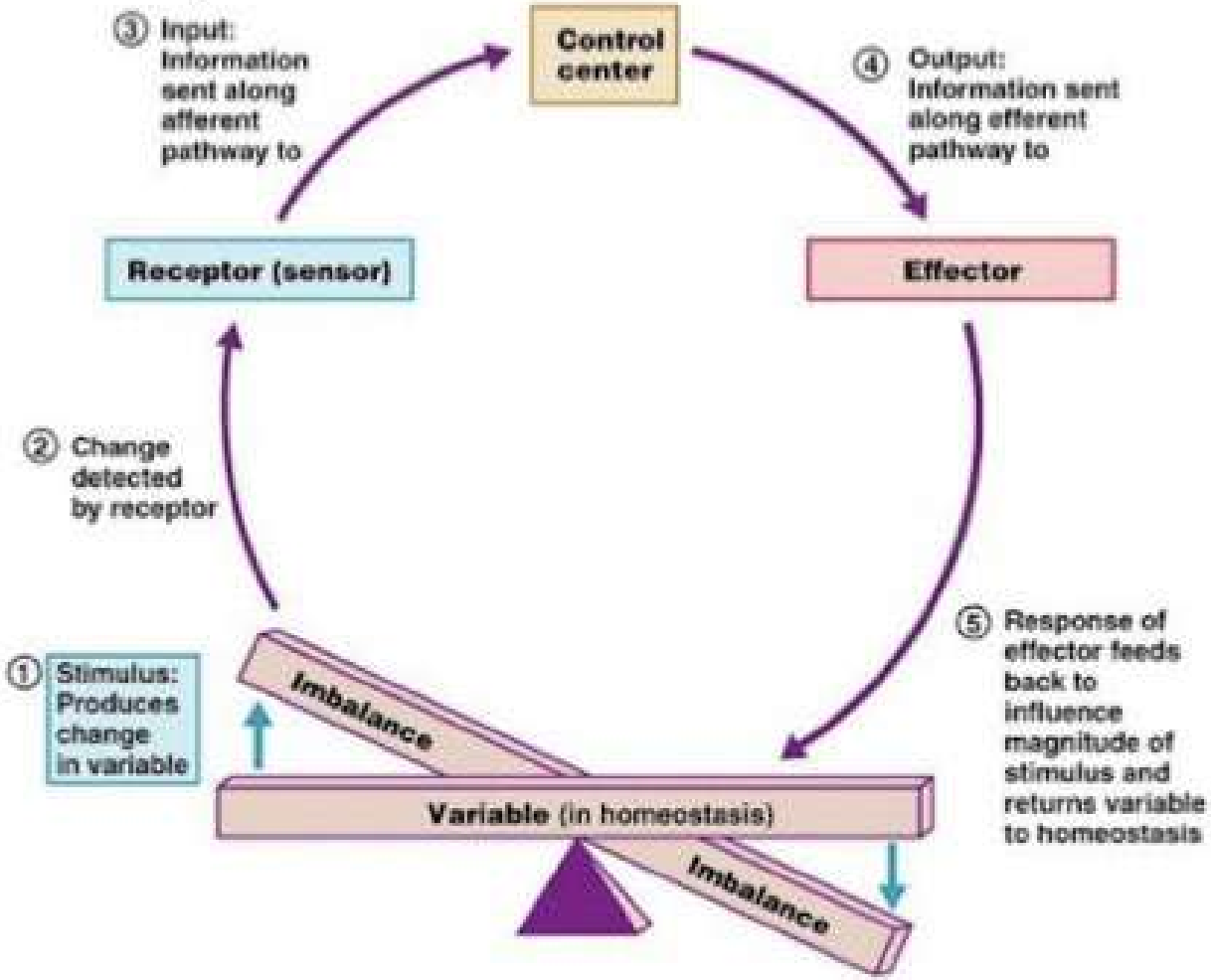
Key Components of Homeostasis

Stimulus: A change in the internal or external environment.

Receptor: Detects the stimulus and sends signals to the control center.

Control Center (usually the brain or endocrine glands): Processes the information and determines the response.

Effector: Carries out the response to restore balance.



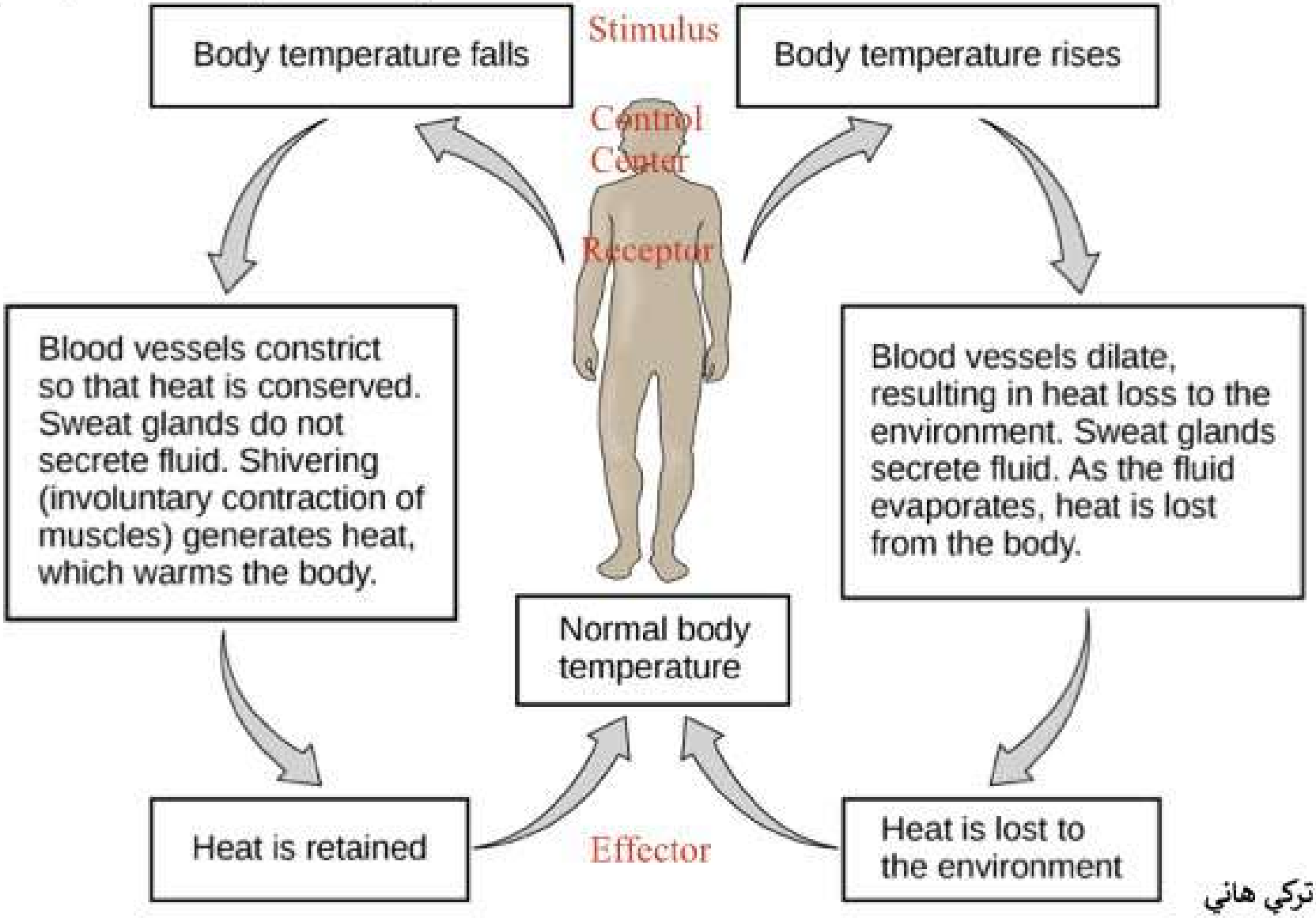
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Examples of Homeostatic Mechanisms

Body Temperature Regulation

If body temperature rises, sweat glands activate, and blood vessels dilate to release heat.

If body temperature drops, shivering and vasoconstriction occur to conserve heat



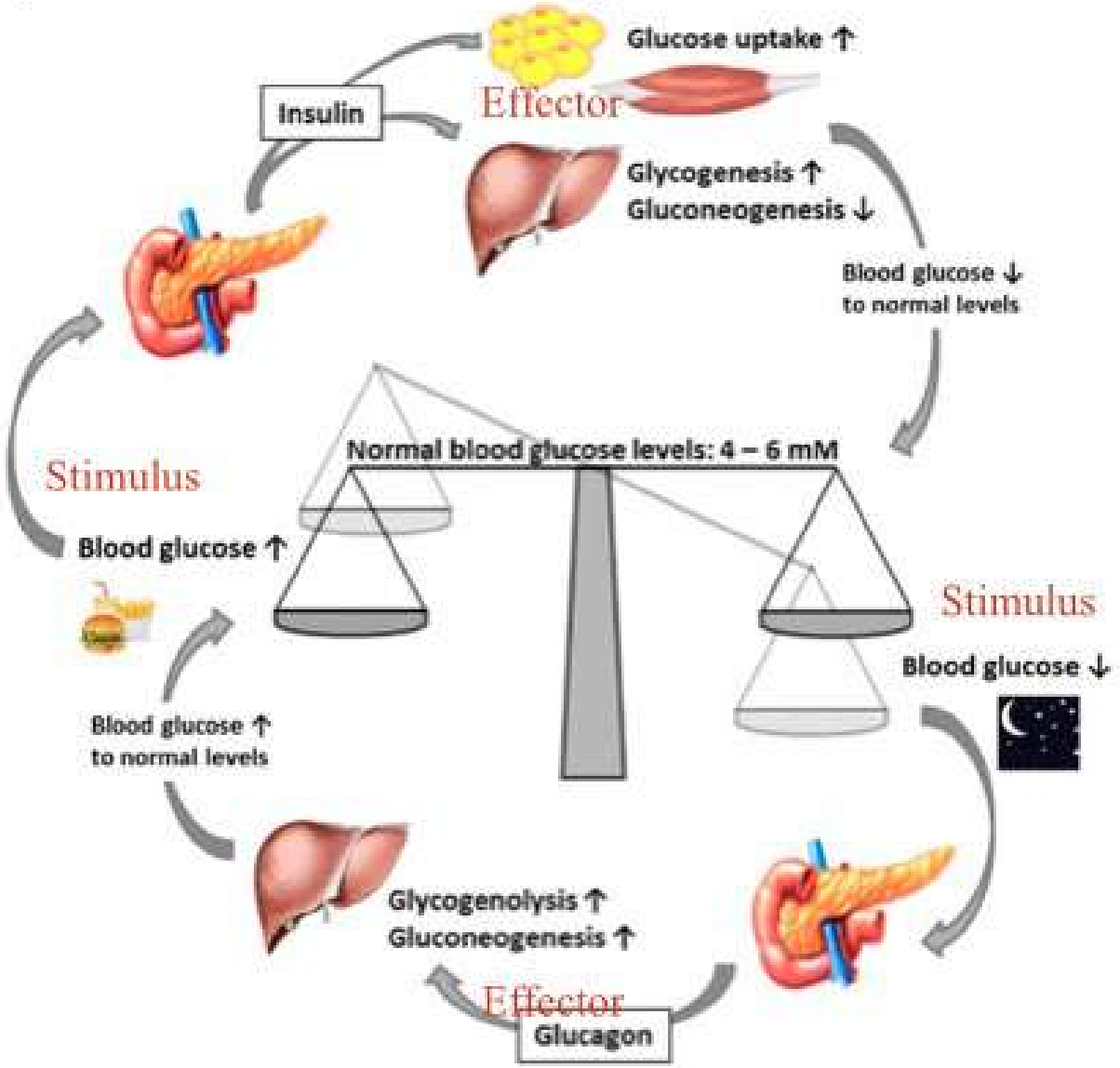
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Examples of Homeostatic Mechanisms

Blood Glucose Regulation

After a meal, insulin is released to lower blood glucose.

When fasting, glucagon is released to increase blood glucose.

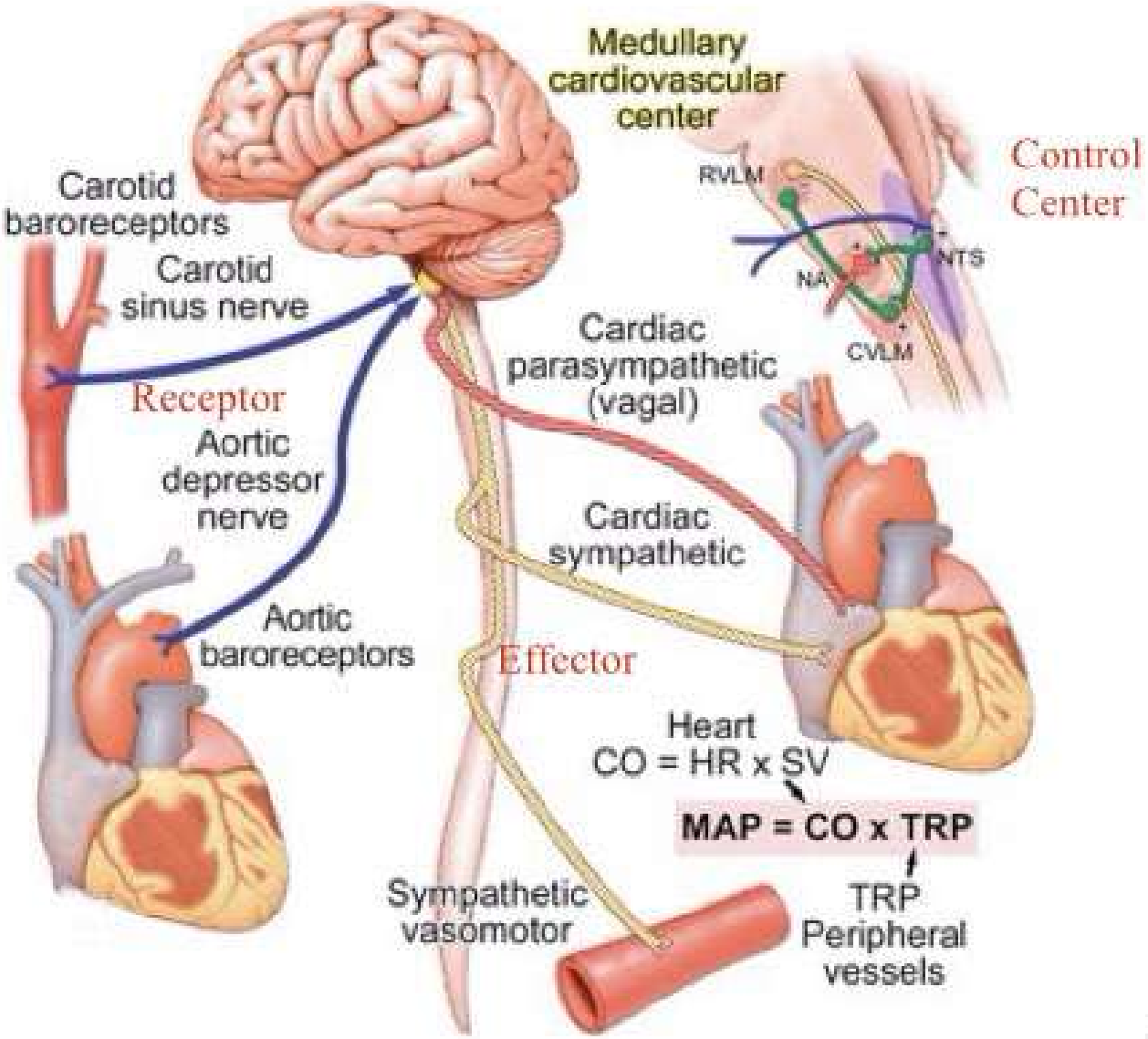


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Examples of Homeostatic Mechanisms

Blood Pressure Regulation

The heart and blood vessels adjust to maintain proper circulation.



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Negative and Positive Feedback Loops

Negative Feedback: The most common homeostatic mechanism that counteracts a change. (Example: Blood sugar regulation)

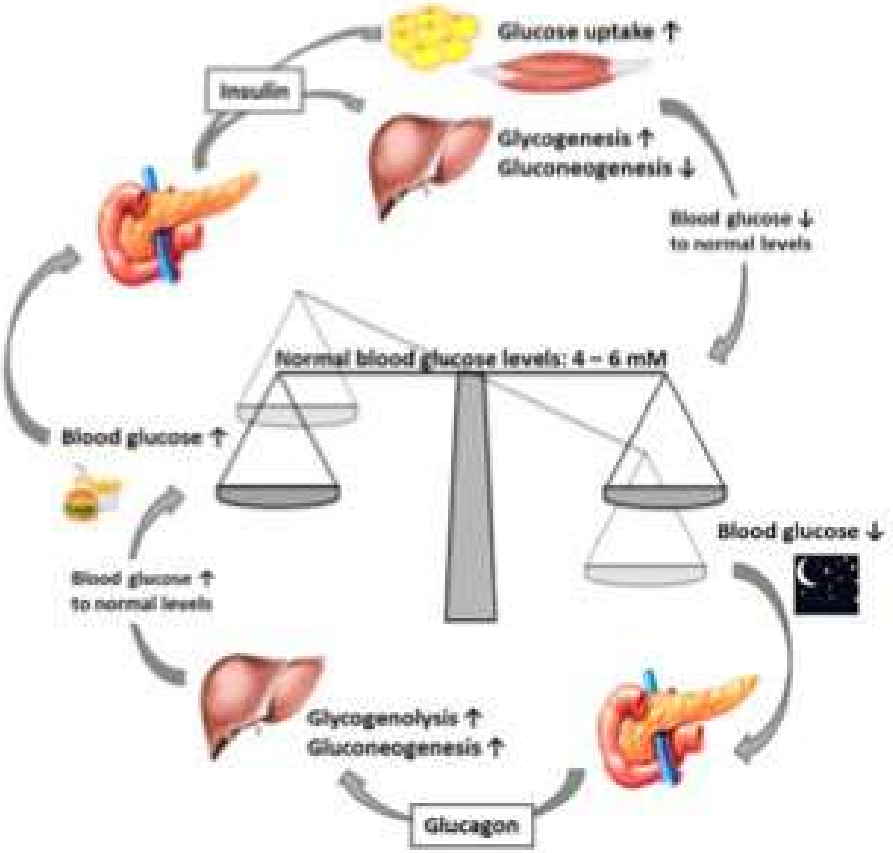
Positive Feedback: Reinforces a change until an event is completed. (Example: Childbirth and blood clotting)

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

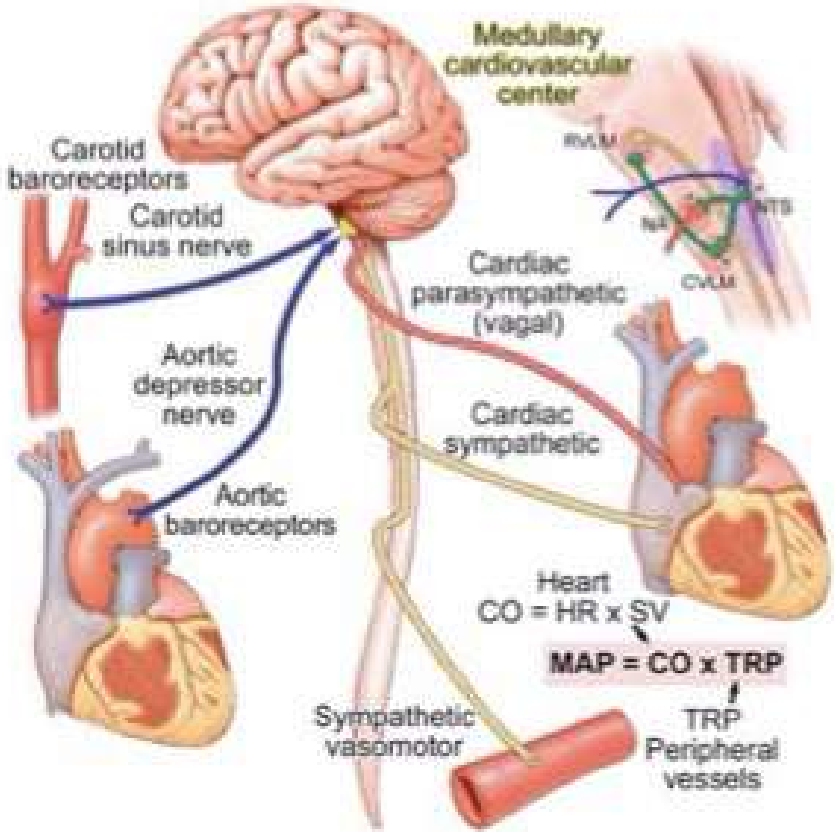
Negative Feedback:

This mechanism works to reverse a change and restore balance. It is the most common feedback mechanism in the body.

Blood Sugar Regulation



Blood Pressure Regulation

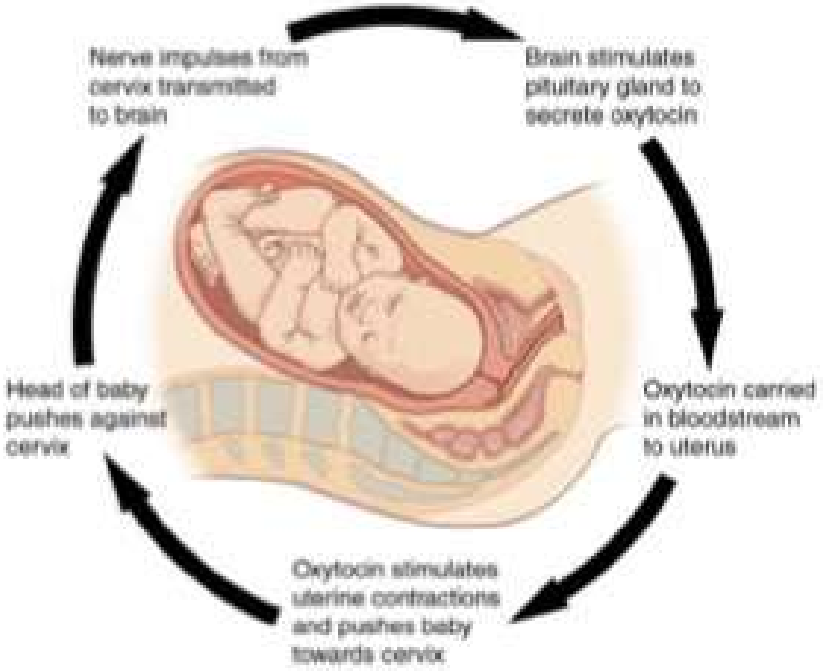


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

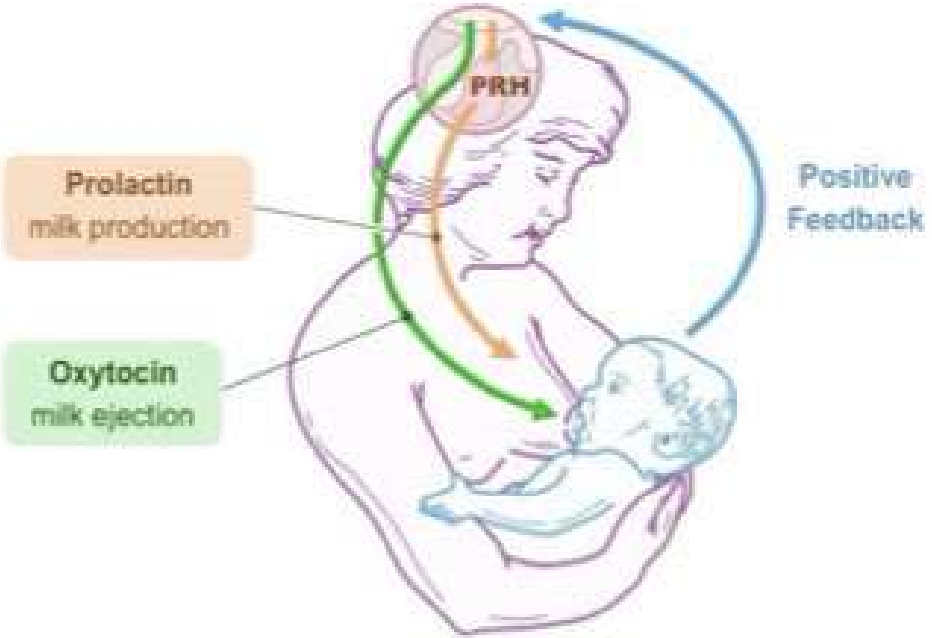
Positive Feedback:

This mechanism amplifies a change rather than reversing it. It is less common and usually occurs in special situations.

Child birth



Breast feeding

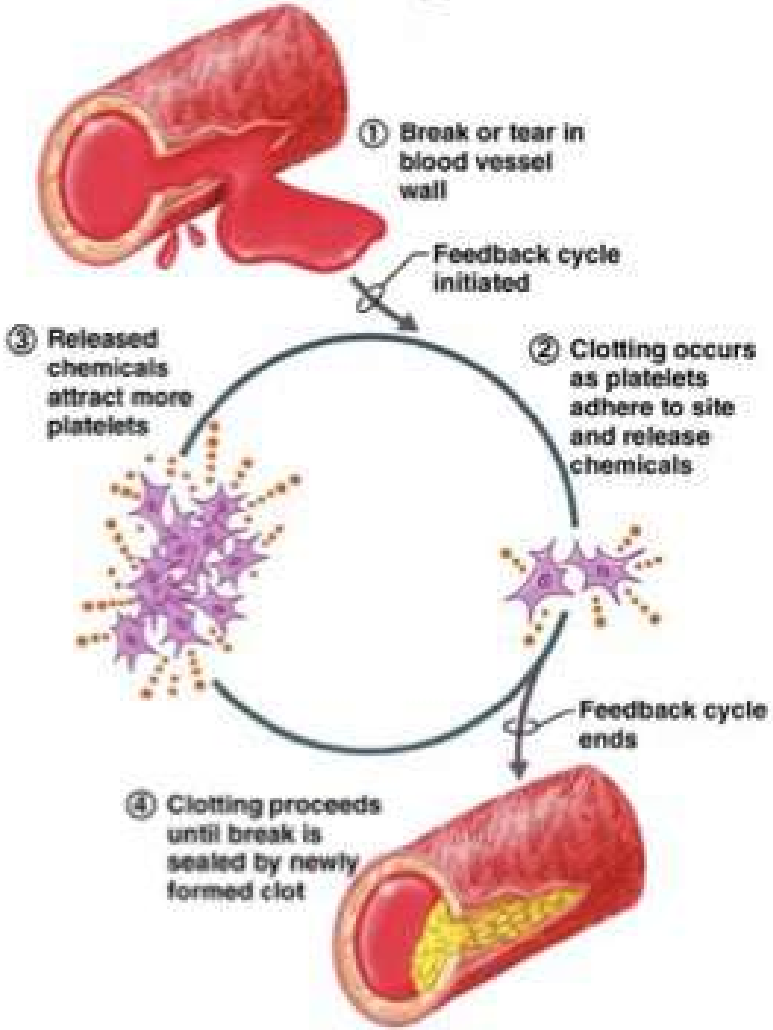


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Negative feedback maintains stability, while positive feedback enhances specific processes until a desired outcome is achieved.

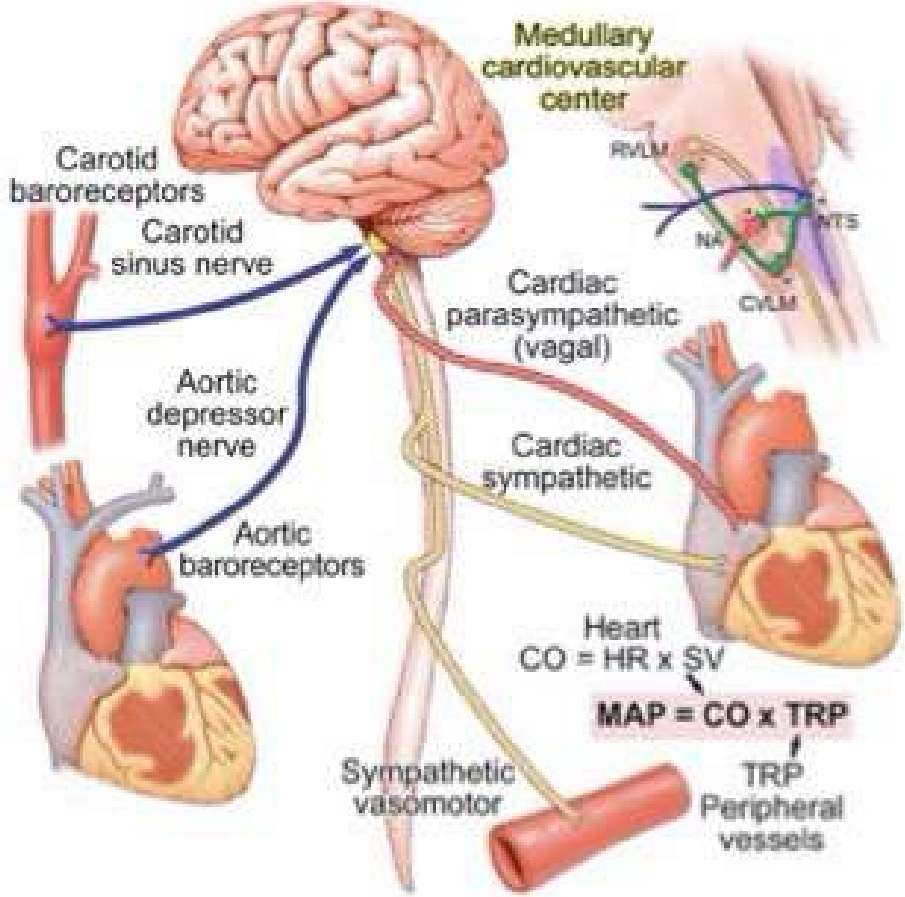
Positive Feedback:

Blood clotting



Negative Feedback:

Blood Pressure Regulation

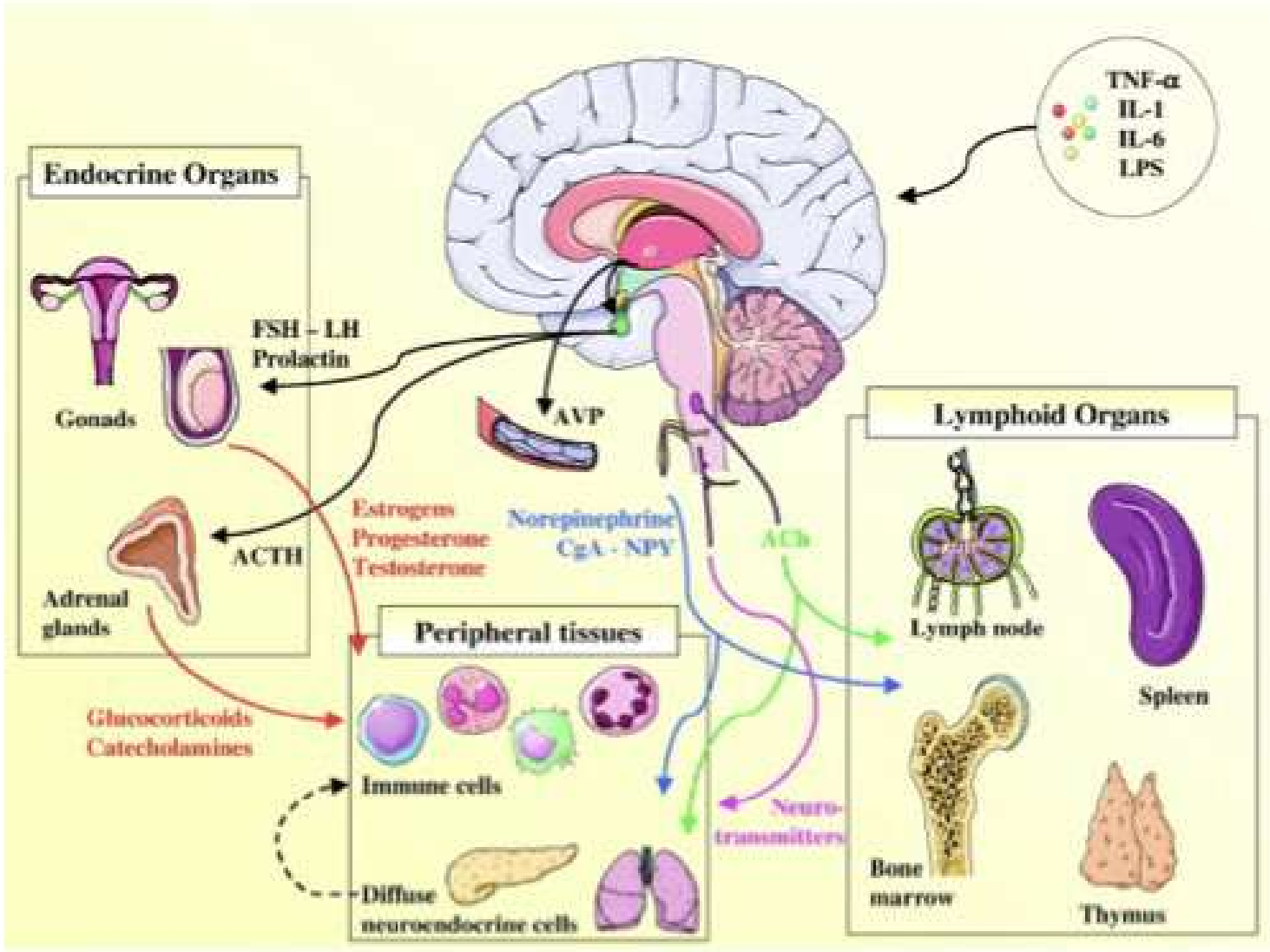


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Intercellular Communication

Cells communicate to coordinate body functions and respond to their environment.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.

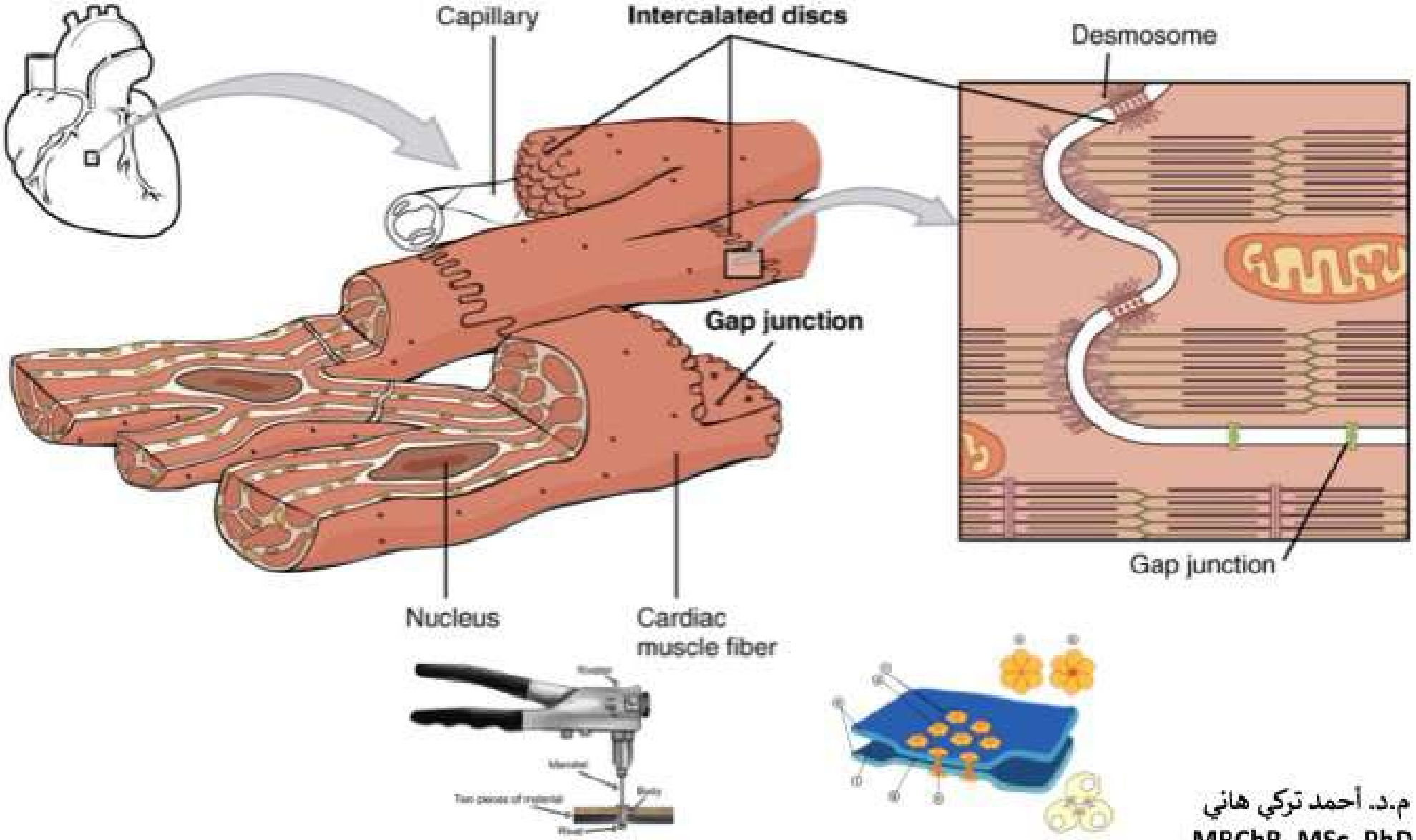


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Types of Intercellular Communication

1. Direct Cell-to-Cell Contact

Gap junctions allow ions and molecules to pass directly between neighboring cells (e.g., heart muscle cells).



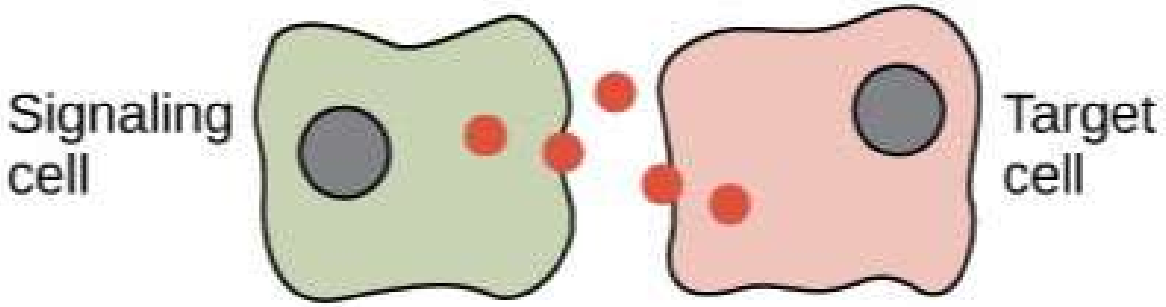
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Types of Intercellular Communication

2. Paracrine Signaling

Cells release signaling molecules that act on nearby target cells (e.g., immune response).

Paracrine	A cell targets a nearby cell.



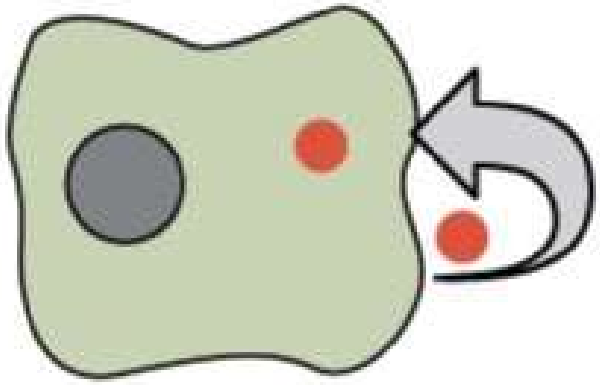
م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Types of Intercellular Communication

3. Autocrine Signaling

A cell releases signals that act on itself (e.g., some immune cells).

Autocrine	A cell targets itself.

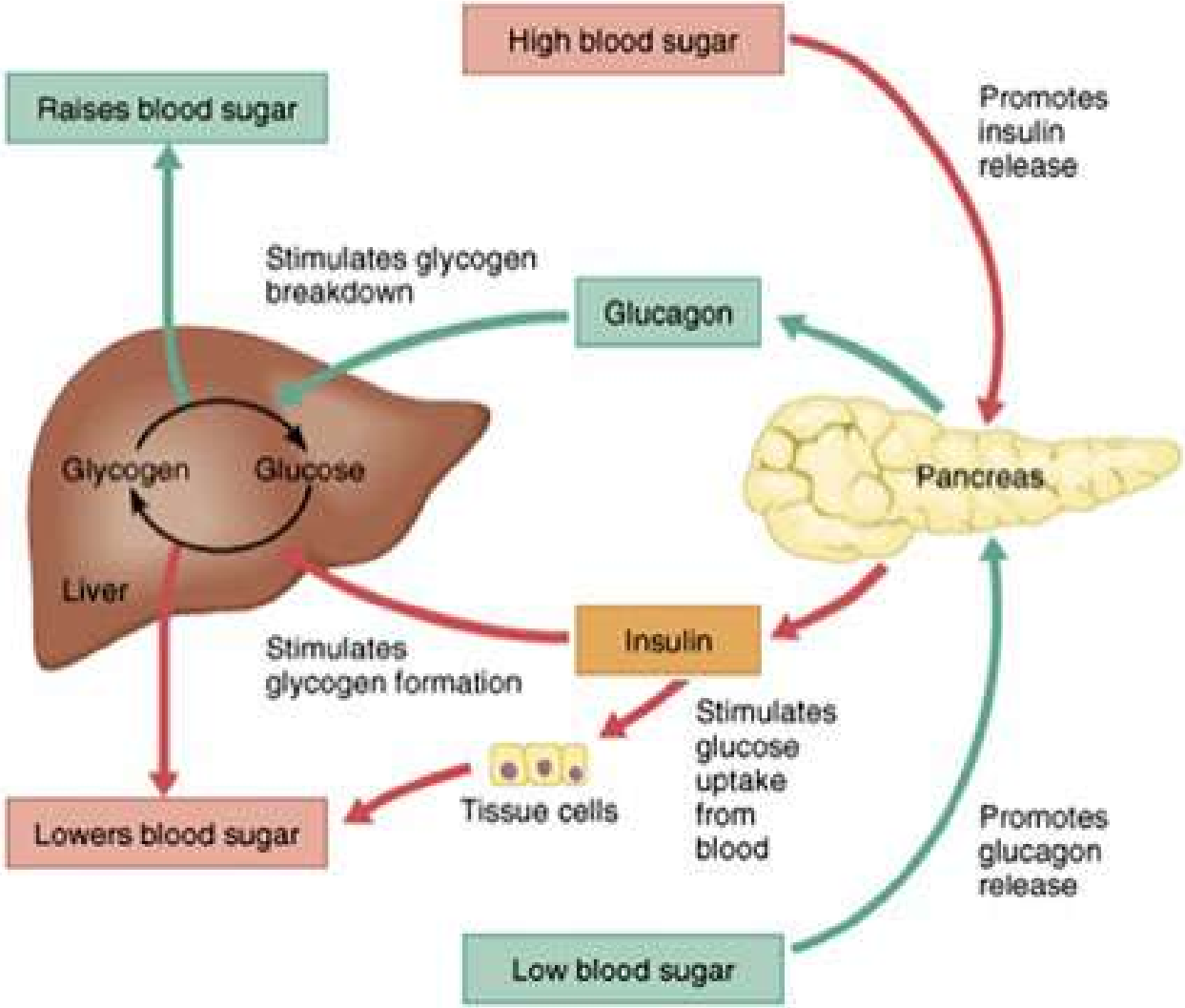


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Types of Intercellular Communication

4. Endocrine Signaling

Hormones are released into the bloodstream and act on distant targets (e.g., insulin from the pancreas regulating blood glucose).

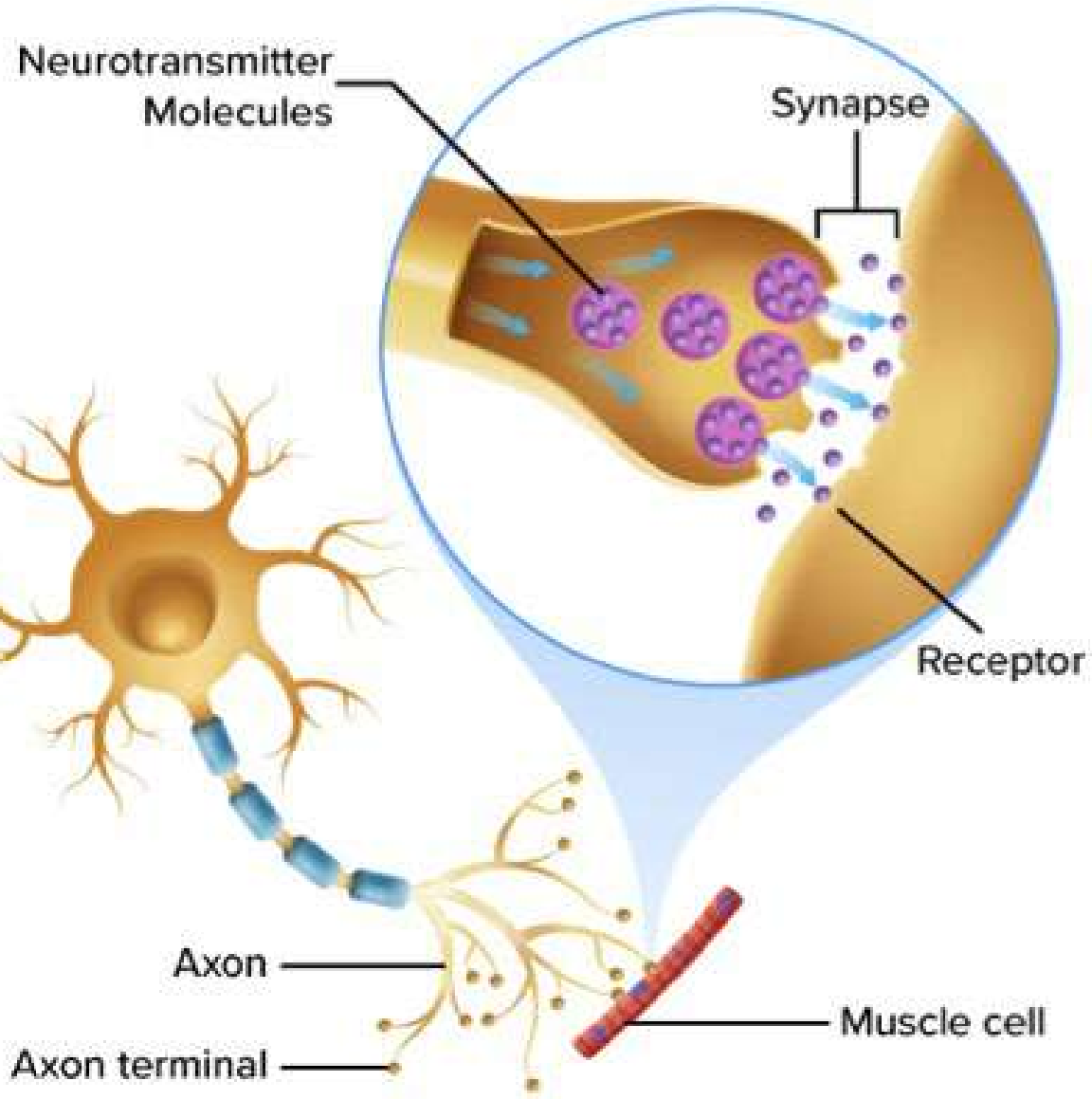


م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Types of Intercellular Communication

5. Synaptic (Neuronal) Signaling

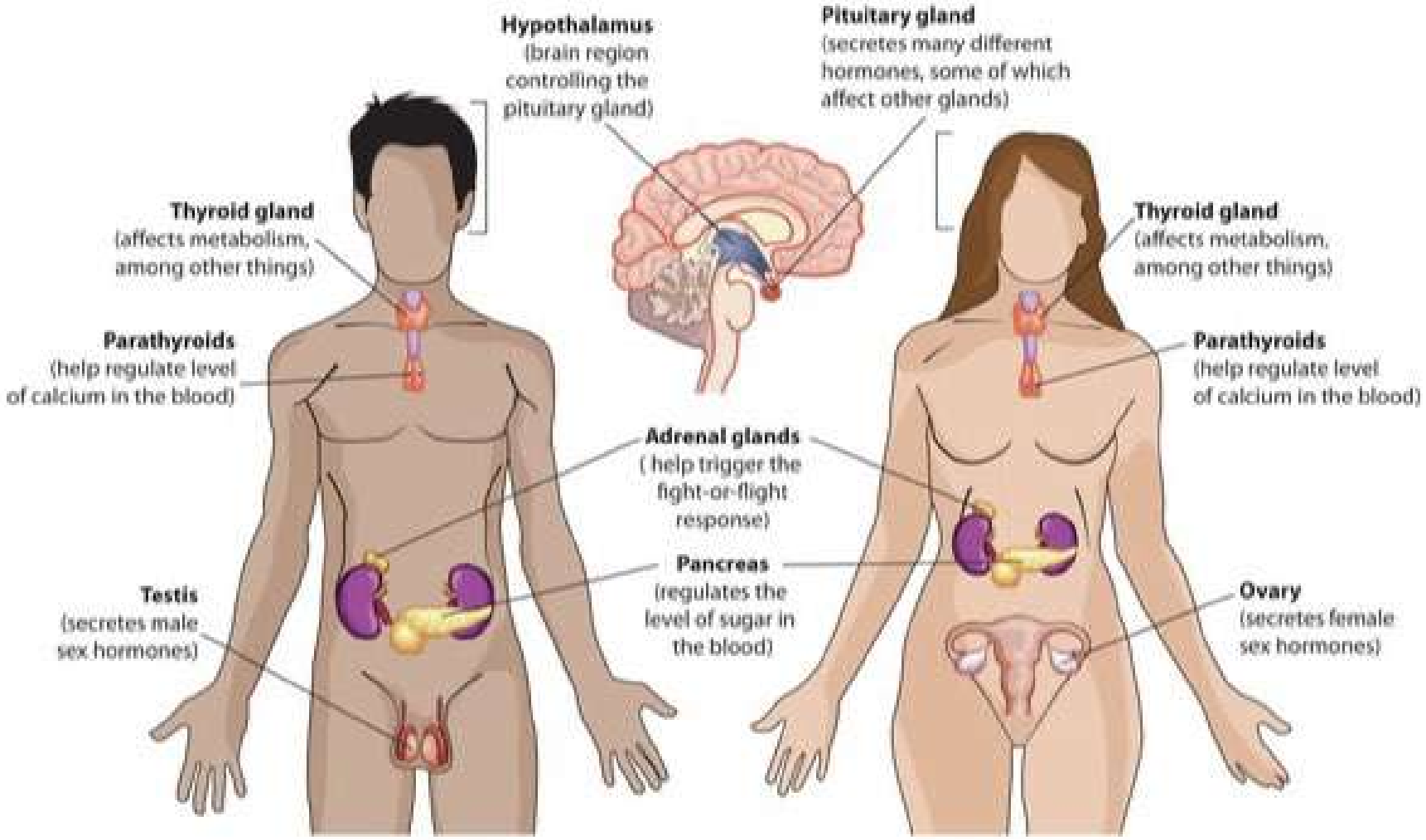
Neurotransmitters are released from nerve cells to transmit signals across synapses (e.g., acetylcholine in muscle contraction).



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Key Signaling Molecules

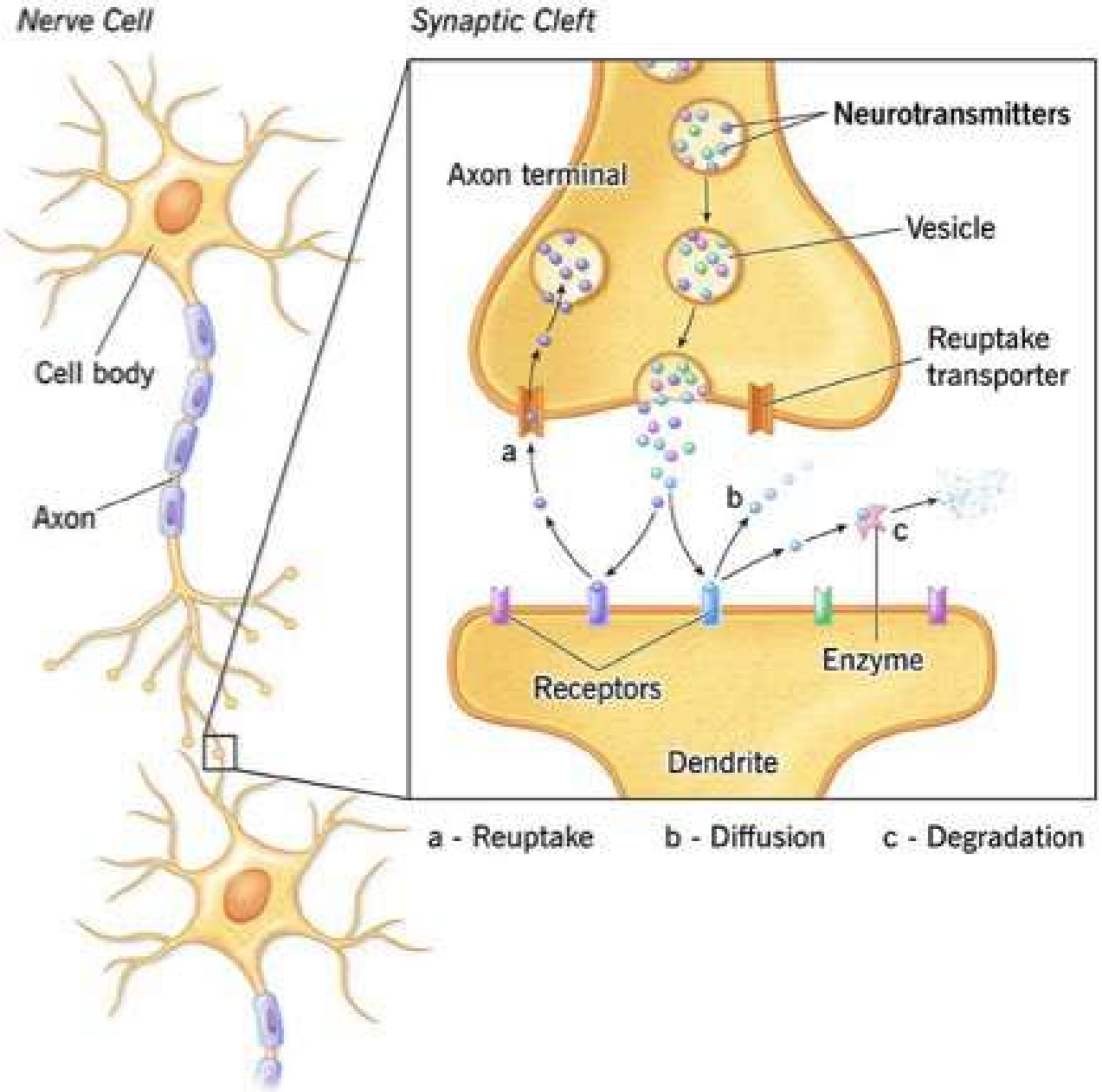
Hormones: Chemical messengers secreted by endocrine glands (e.g., insulin, adrenaline).



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Key Signaling Molecules

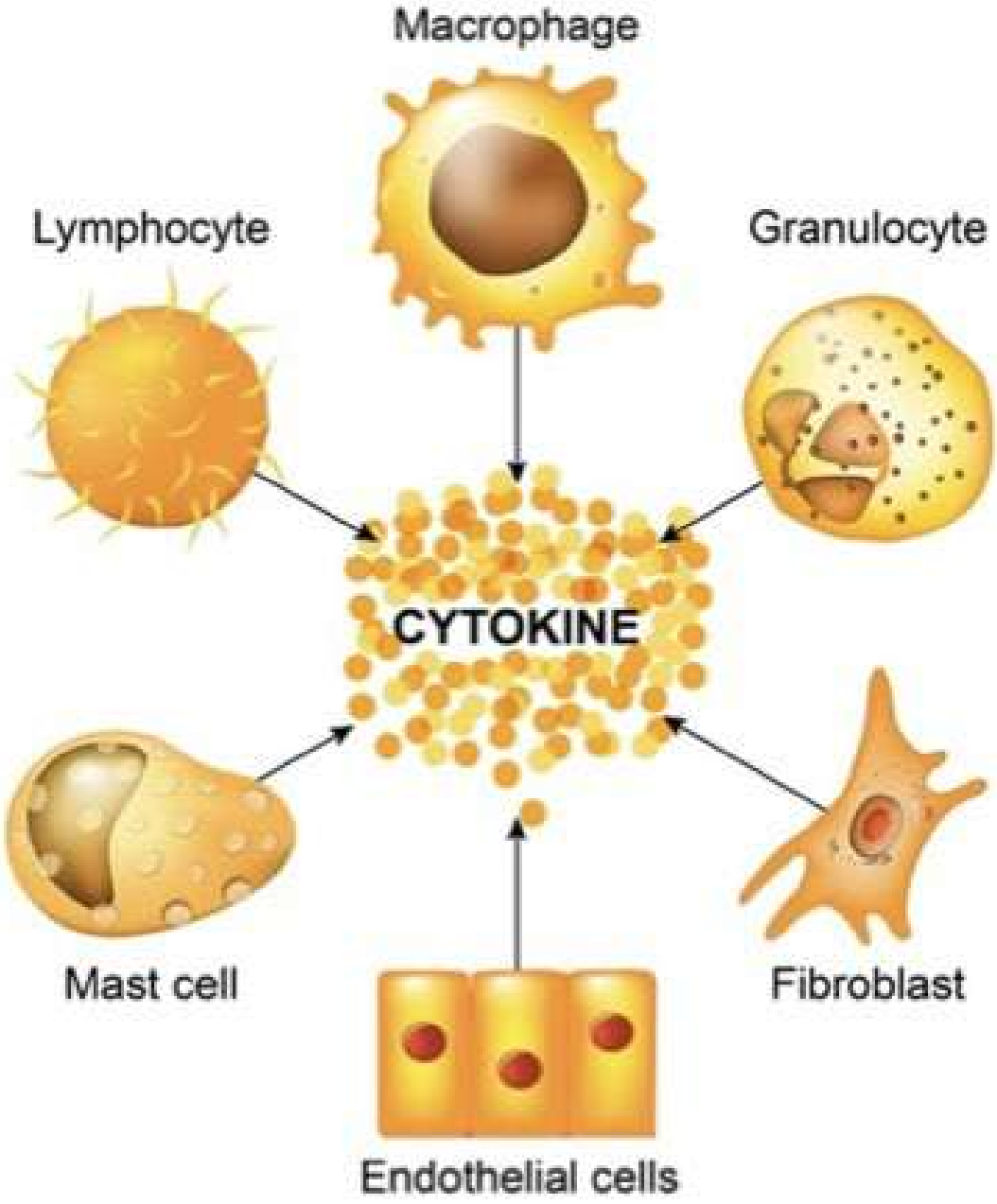
Neurotransmitters: Chemical signals used by nerve cells (e.g., dopamine, serotonin).



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Key Signaling Molecules

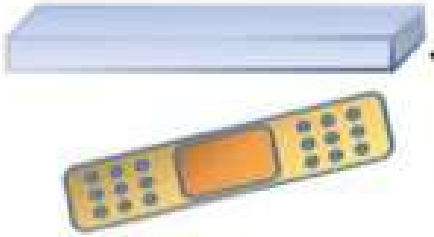
Cytokines: Molecules that regulate immune responses.



م.د. أحمد تركي هاني
MBChB. MSc. PhD.

Key Signaling Molecules

Growth Factors: Proteins that control cell growth and repair.



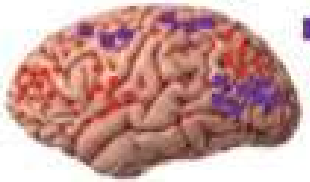
✓ hydrogel material, wound dressing

VEGF, NTs, FGFs

✓ chronic wounds healing

FGFs

✓ neurodegenerative diseases treatment

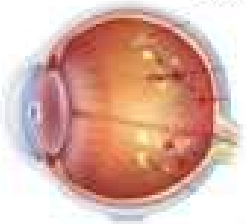


- Altzheimer's disease
- Parkinson's disease

NTs, VEGF

✓ age-related retina degeneration diabetic and retinopathy treatment

VEGF, NT



✓ obesity treatment

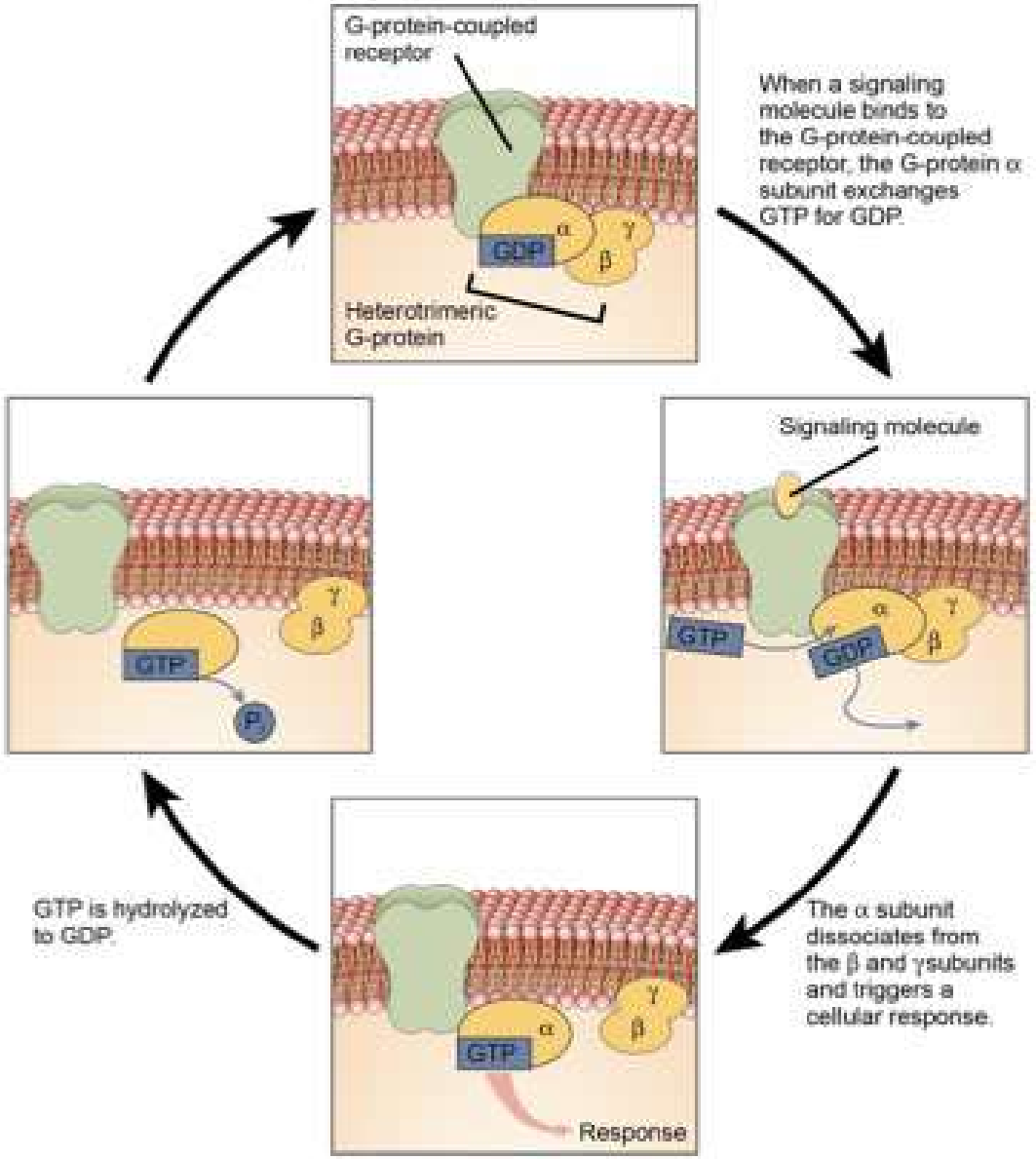
FGFs

م.د. احمد تركي هاني

MBChB. MSc. PhD.

Receptor Types and Signal Transduction

Cell-Surface Receptors: Detect signals from outside the cell and trigger an internal response (e.g., G-protein-coupled receptors).

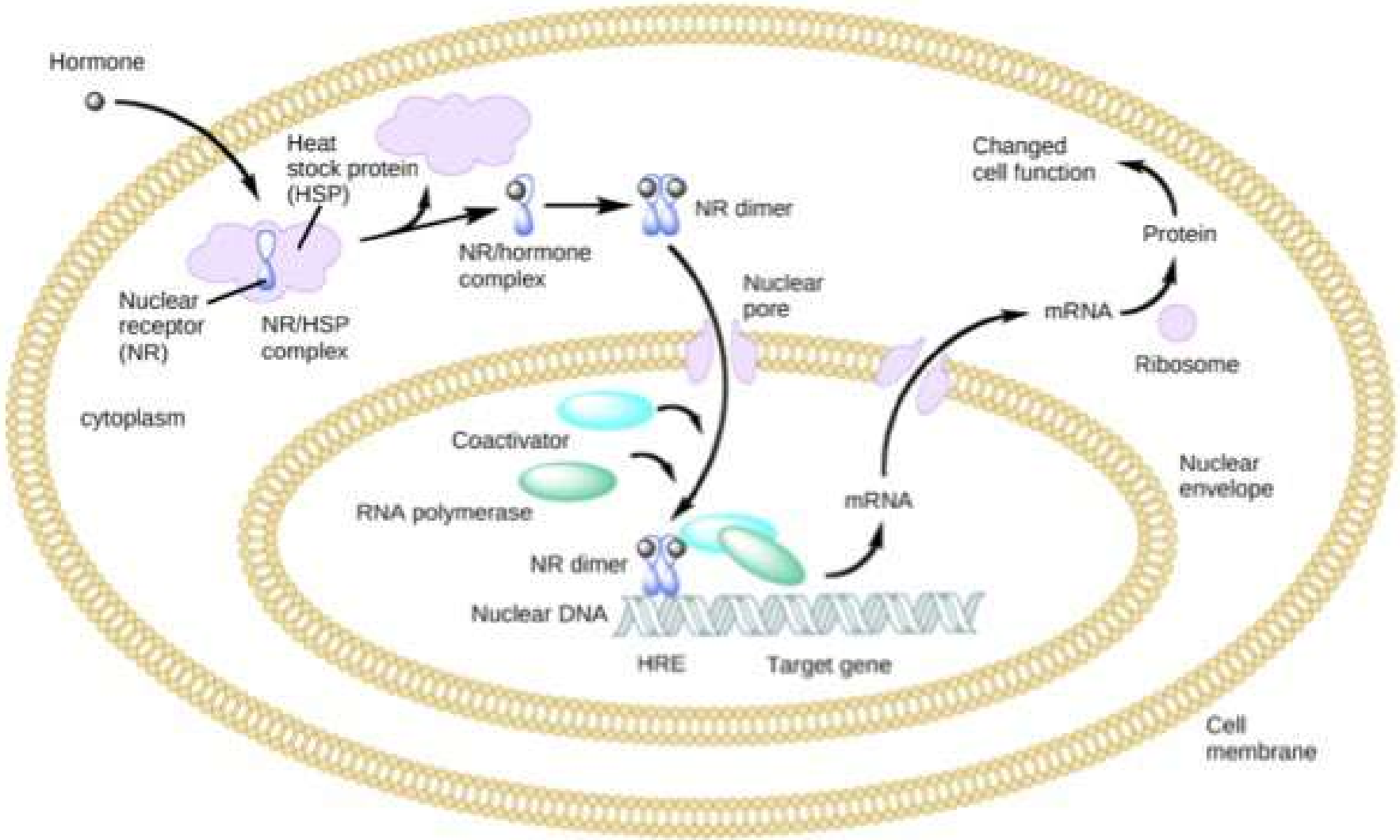


م.د. أحمد تركي هاني

MBChB. MSc. PhD.

Receptor Types and Signal Transduction

Intracellular Receptors: Located inside the cell; activated by lipid-soluble signals like steroid hormones.

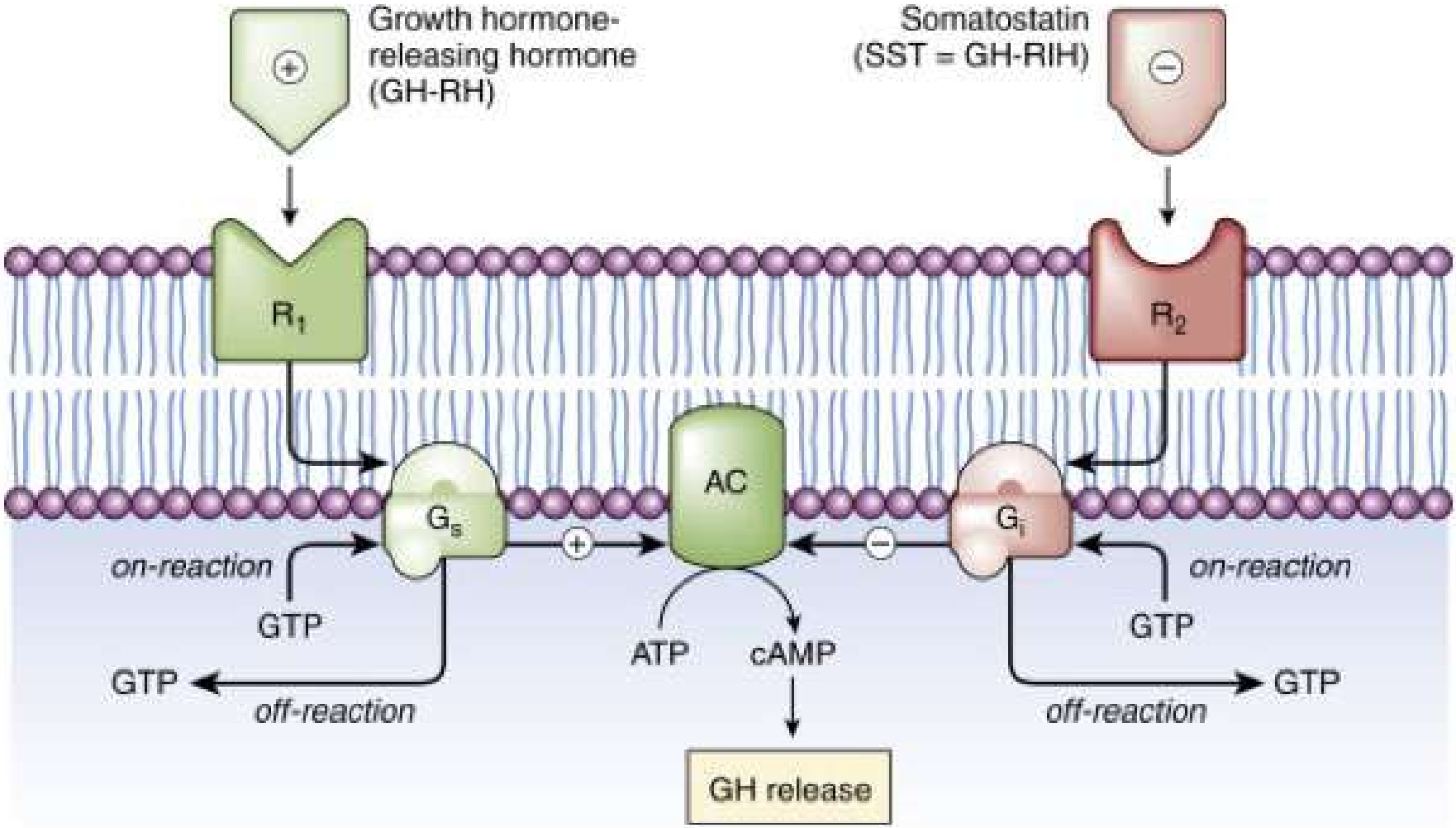


م.د. أحمد تركي هاني

MBChB. MSc. PhD.

Receptor Types and Signal Transduction

Second Messenger Systems: Relay signals inside the cell (e.g., cAMP pathway).



م.د. أحمد تركي هاني

MBChB. MSc. PhD.

Conclusion

- Mammalian cells are the basic units of life, with specialized structures and functions.
- Homeostasis is essential for maintaining a stable internal environment, using feedback mechanisms.
- Intercellular communication ensures coordination between cells through chemical and electrical signals.

م.د. أحمد تركي هاني
MBChB. MSc. PhD.