بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

PHYSIOLOGY

Final | Lecture 3

Receptors' Functions and Signal Transduction Pt.1

وَلَقَدْ خَلَقْنَا الْإِنسَانَ وَنَعْلَمُ مَا تُوَسْوِسُ بِهِ نَفْسُهُ ۖ وَنَحْنُ أَقْرَبُ إِلَيْهِ مِنْ حَبْلِ الْوَرِيدِ

Written by : Omar Mahmoud

Reviewed by : Yaman Khalil

Color coding used in the modified:

- *Black: the original slides*
- *Blue: the doctor's explanation/words*
- *Gray: additional information and explanation*
- *Red: important information*

Receptors Functions and Signal Transduction L1- L2

Faisal I. Mohammed, MD, PhD

Introduction to Physiology (0501110) Spring 2026

Subject	Lecture No.	Lecturer	Pages in the 13th edition. textbook	Pages in the 14 th edition textbook
Receptors: types and adaptation - Membrane or intracellular - Ion channels - G-protein - Enzyme linked - Intracellular - Second messengers - cAMP and cGMP, Phospholipid - Calcium calmodulin and IRS		Dr. Faisal	915-927	925-935
Signal Transduction (Regulation of cellular machinery) Extracellular regulators: nervous, endocrine, paracrine and autocrine		Dr. Faisal	944-946	954-956
Steroids: Their Signal Transduction And Mechanism Of Action		Dr. Faisal	960-961 966-967	970-971 976-977

Textbook: Guyton Medical Textbook of Physiology By: Guyton and Hall 12th edition

Objectives

- Define first messenger (Hormones)
- List hormone types
- Describe receptor types
- Outline the hormone receptors interactions
- Describe second messenger mechanism of action
- List second messengers

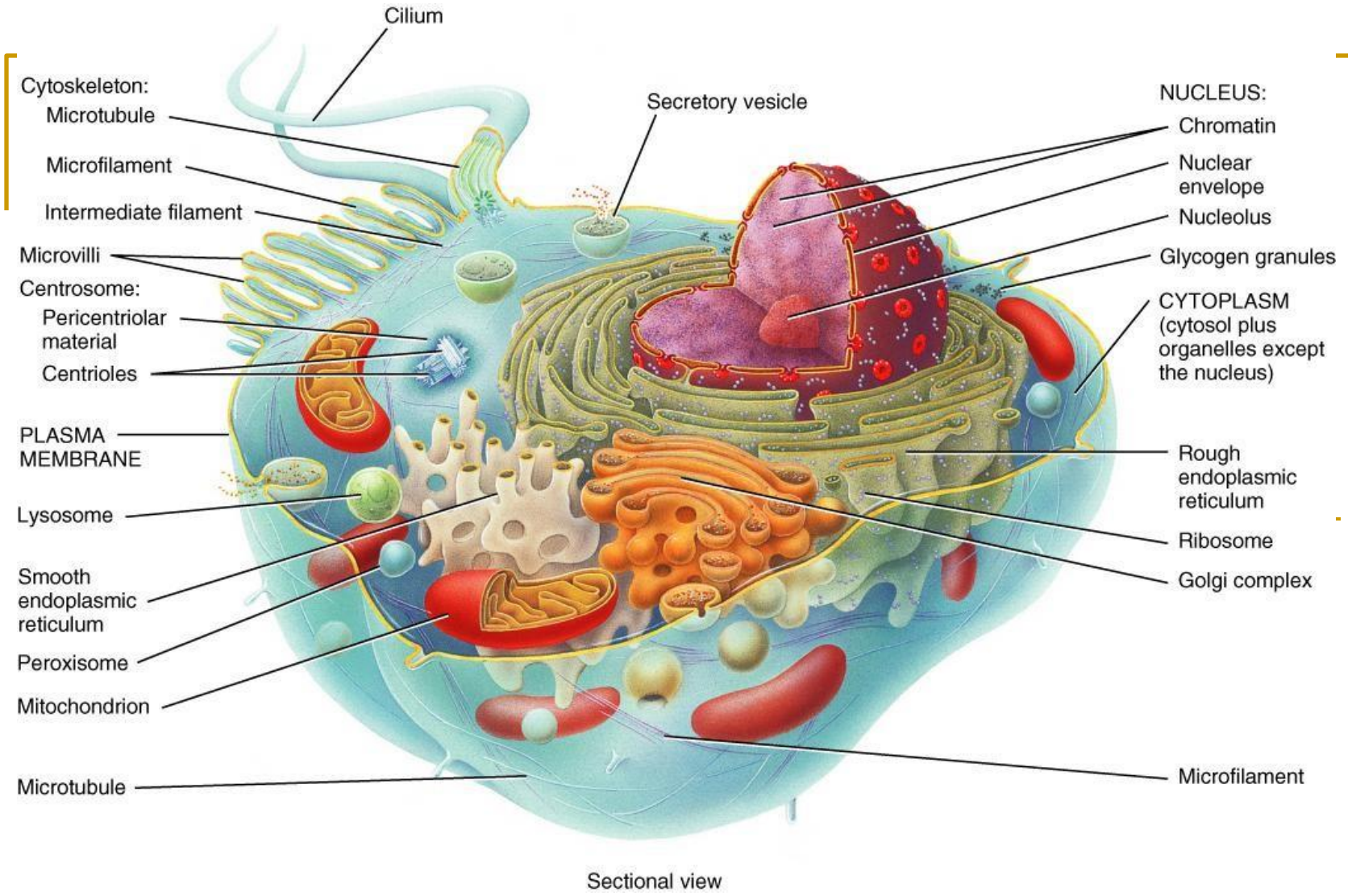
Based on Dr.Faisal:

The first messenger is the chemical that binds to the receptor.
The first messenger can be a ligand or a hormone.

If there is a first messenger, there is a secondary messenger as well.

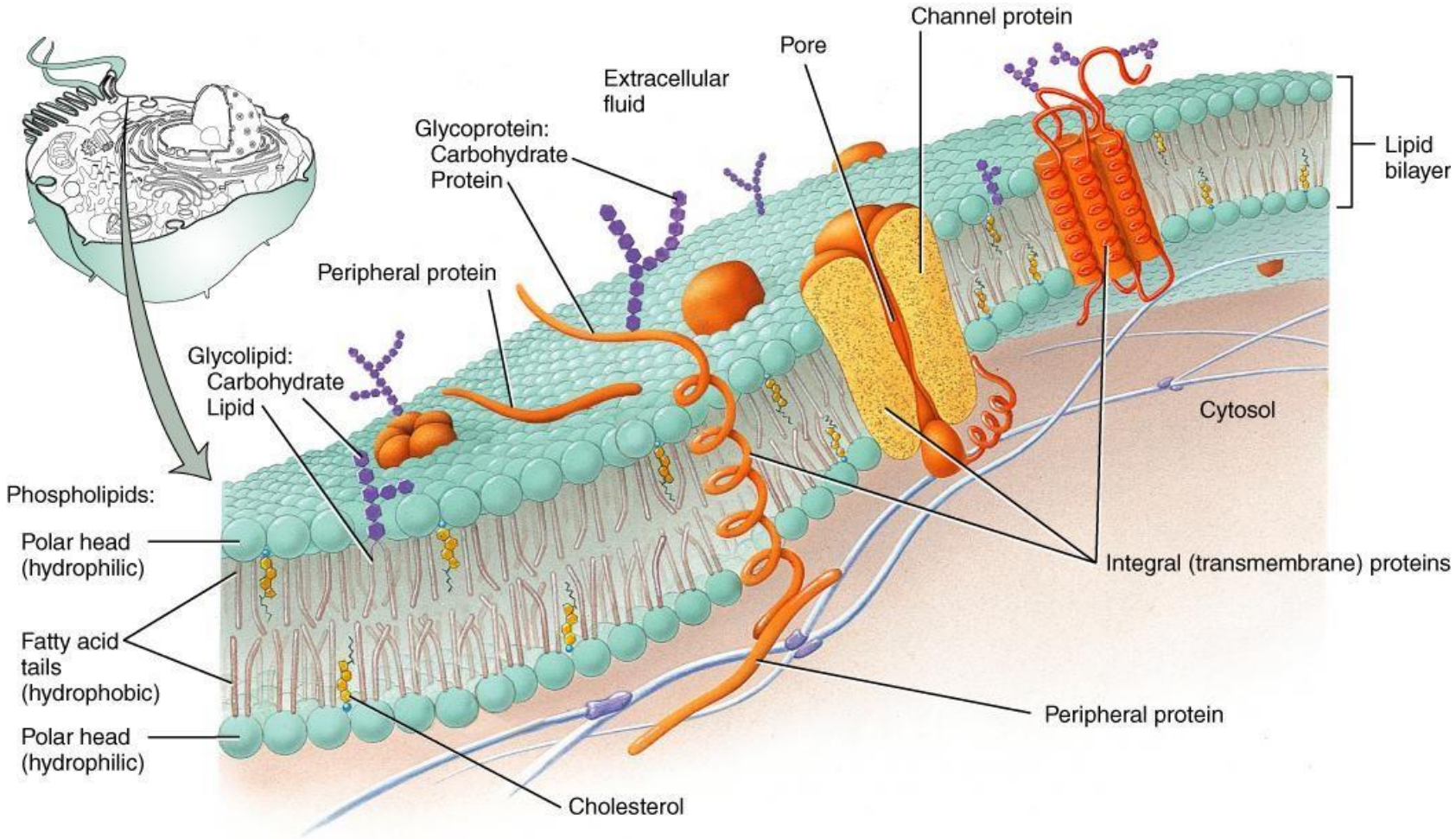
The secondary messenger is responsible for transmitting the extracellular signals in the cell and for amplification for the sake of producing an intracellular response.

40% of the cell membrane is composed of proteins. The amount of protein varies based on the type and function of the cell.

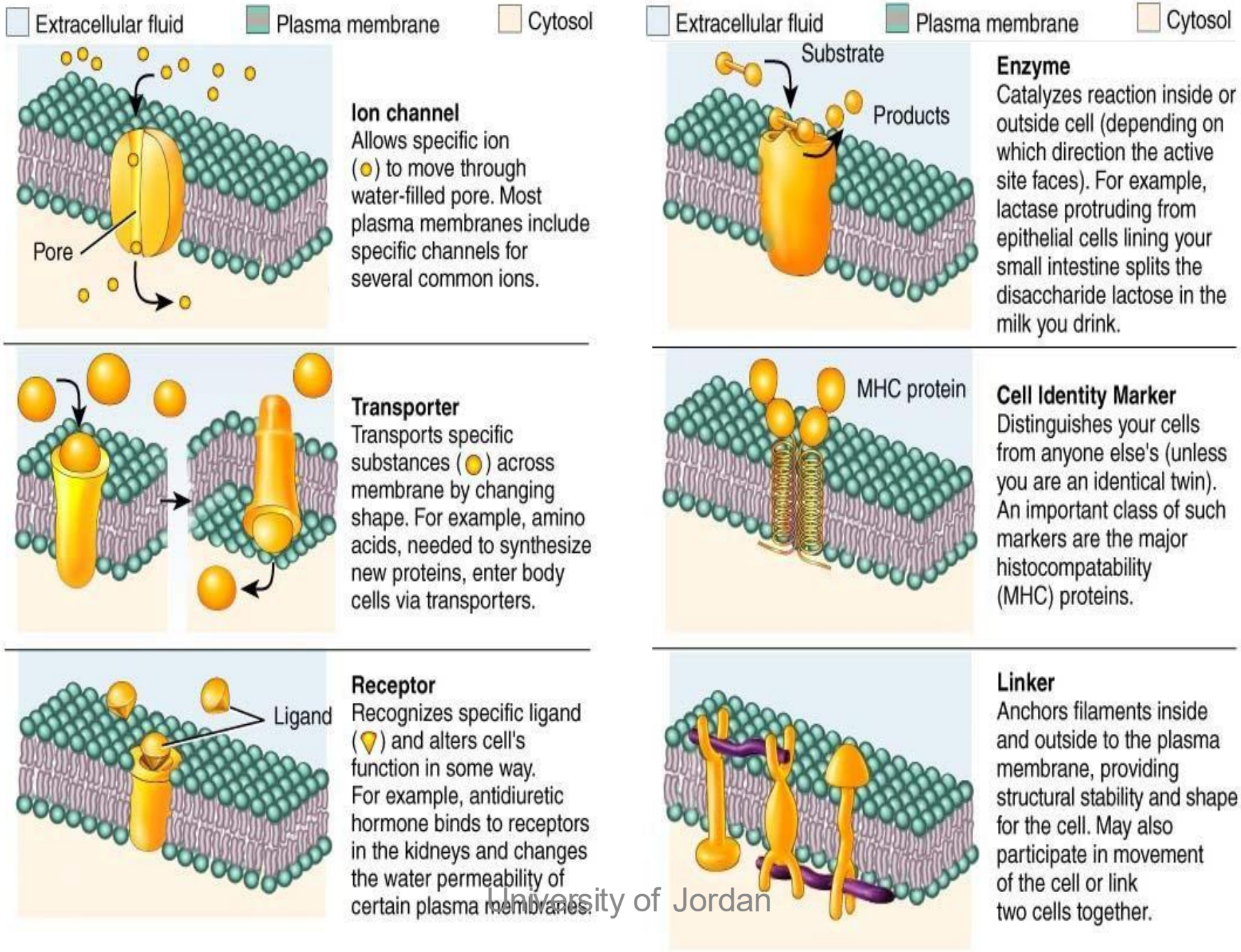


Sectional view

Key Idea: Proteins are highly specific.



Integral proteins (structural) are integrated or embedded within the plasma membrane.



Linked to antigens and to kidney transplants.

Intercellular Communication

Endocrine

Far signalling / The response is initiated in a **far-distant** cell.

Neuroendocrine

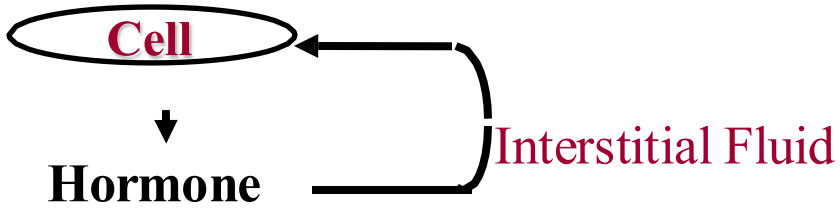
Like Acetylcholine and epinephrine. Certain neurotransmitters work as neurohormones (can be transmitters and can be hormones)

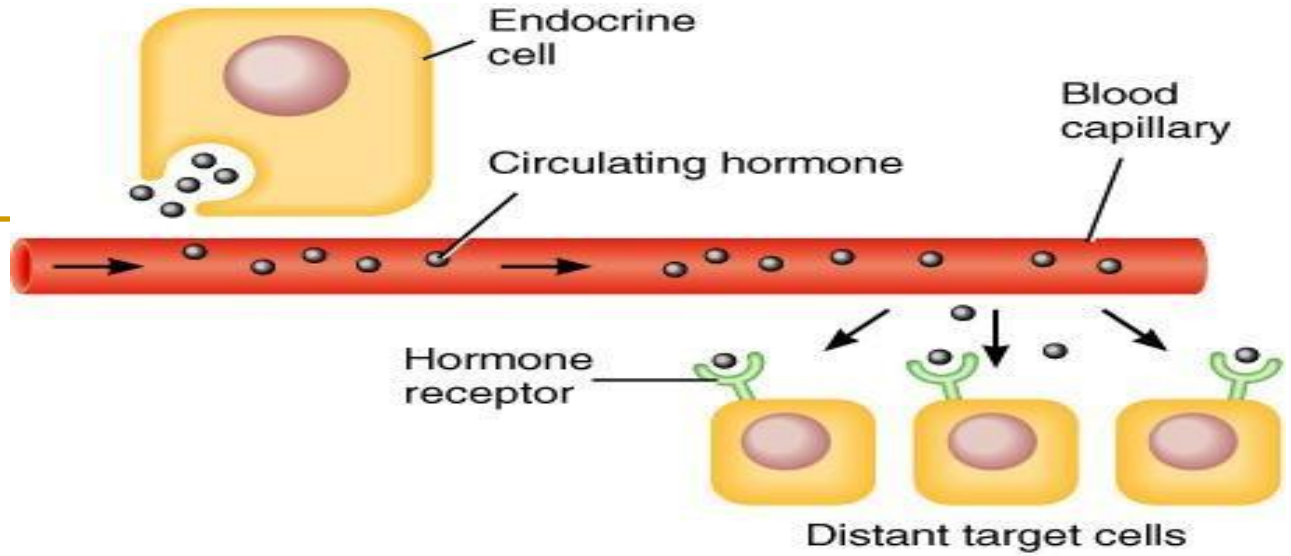
Paracrine

Para: Beside / **nearby**

Autocrine

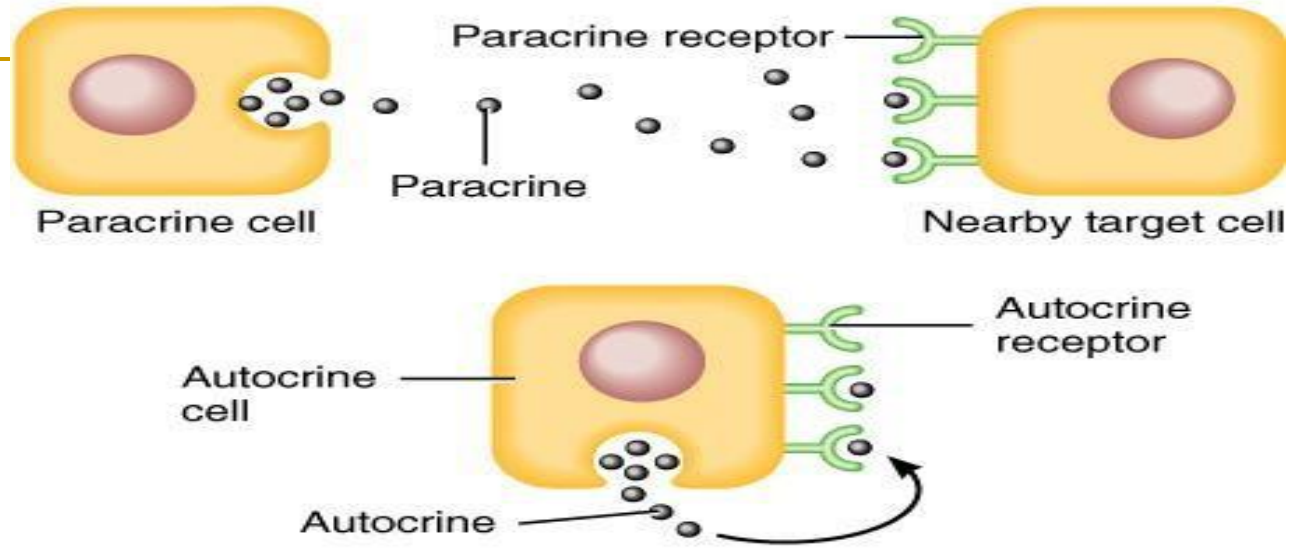
Auto: **self**





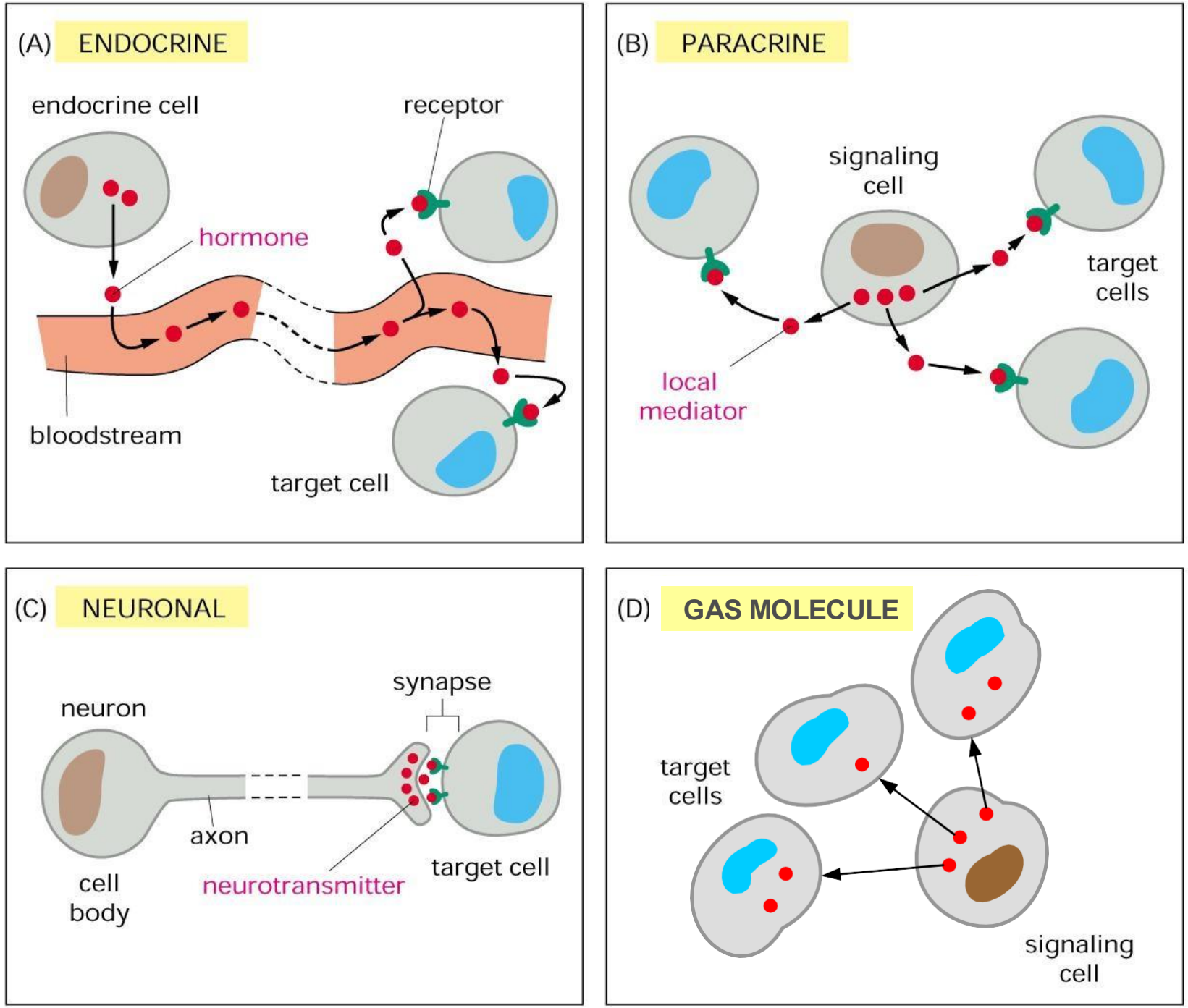
(a) Circulating hormones

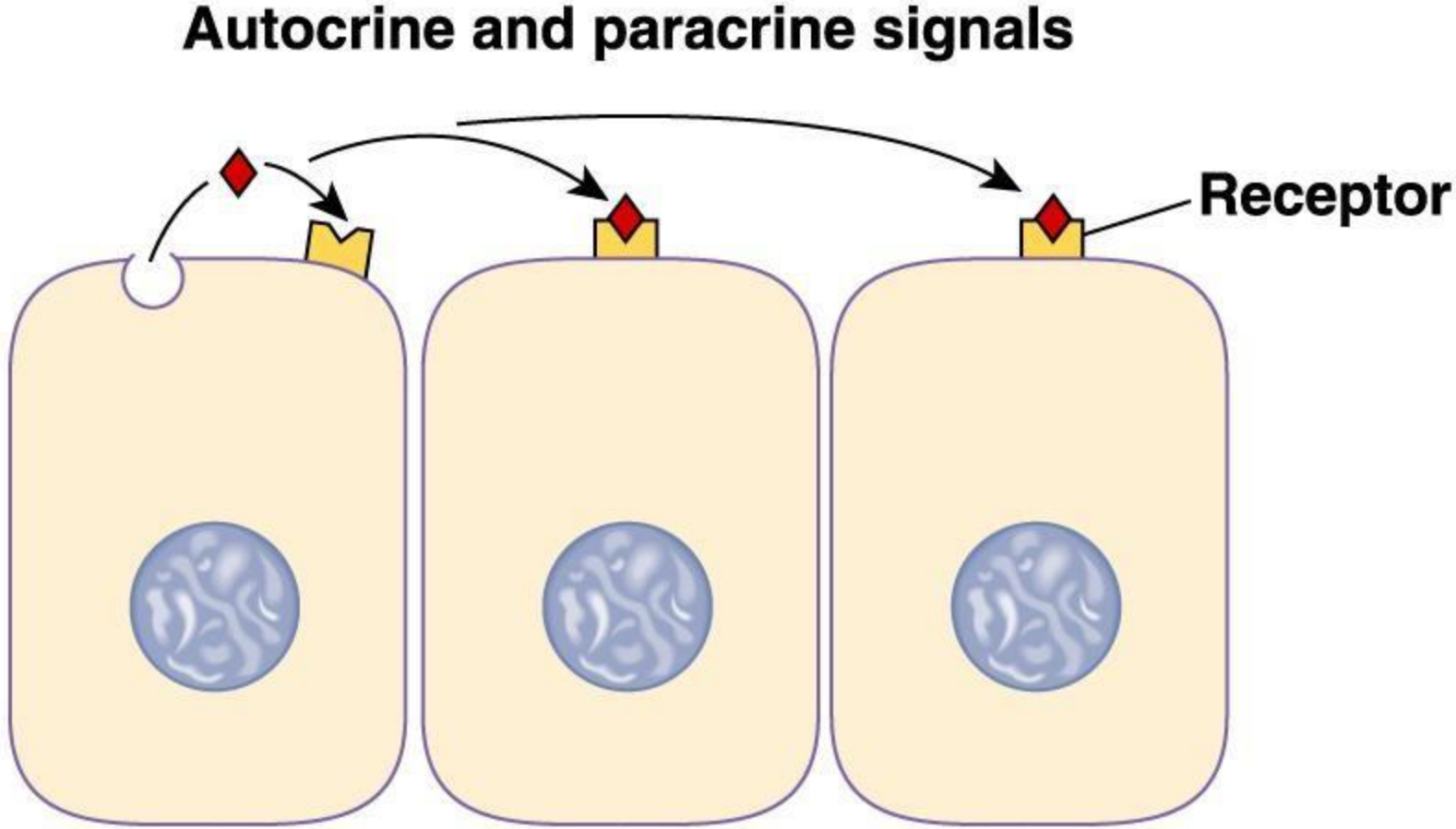
Acetylcholine affects non-neural cells, like cardiac cells, so acetylcholine in the heart is a hormone. However, between neurons and adjacent effector cells (neuro muscular junction for example) it works as a neurotransmitter



(b) Local hormones (paracrines and autocrines)

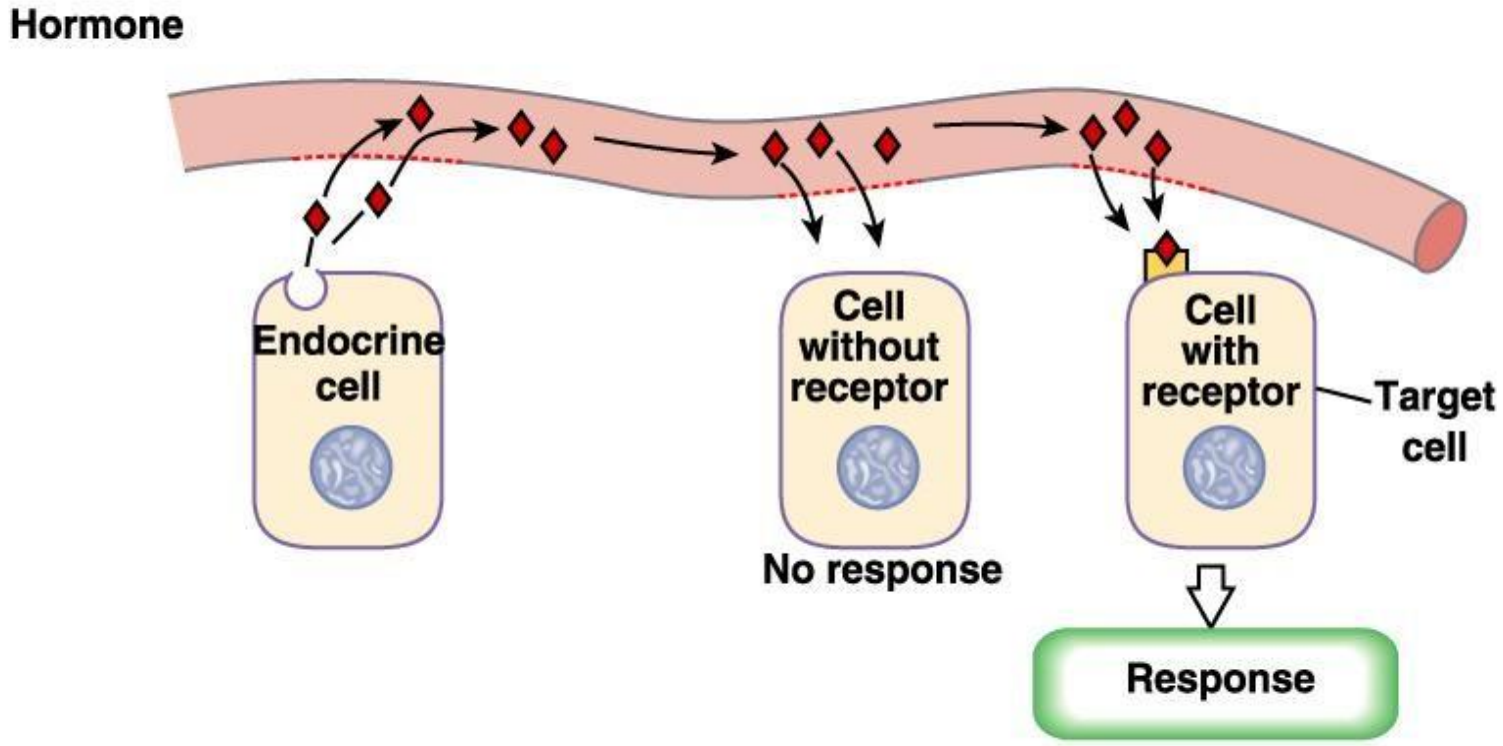
18.02


(A) ENDOCRINE
endocrine cell
receptor
hormone
bloodstream
target cell
(B) PARACRINE
signaling cell
target cells
local mediator
(C) NEURONAL
neuron
synapse
axon
cell body
neurotransmitter
target cell
(D) GAS MOLECULE
target cells
signaling cell

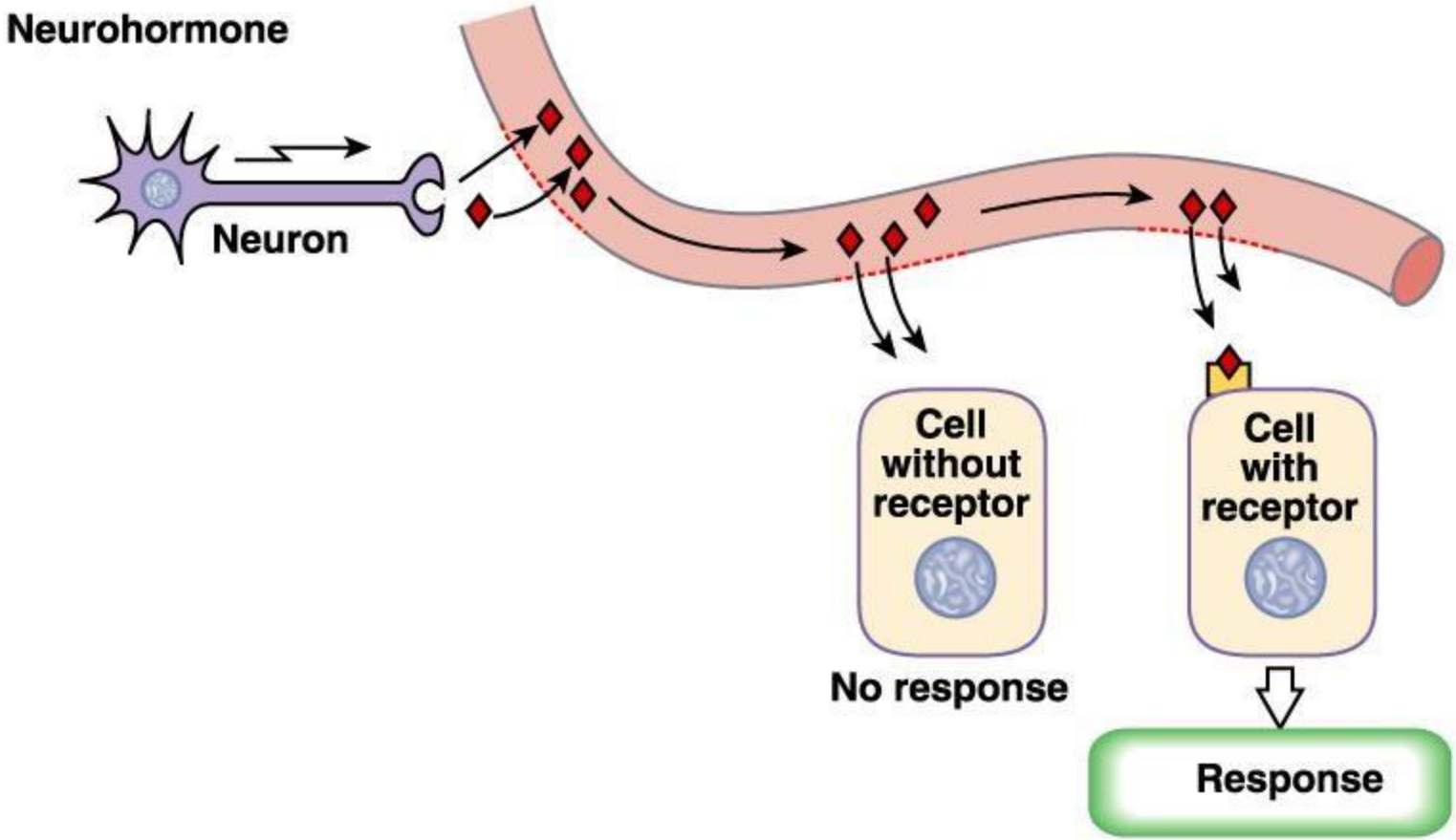

Autocrine and paracrine signals
Receptor

In order for a response to be initiated, the hormone (primary messenger) should be present, and the receptor for the hormone should also be present.

The absence of one of them will prevent any response.



Feminizing syndrome: congenital absence of the testosterone receptor---> increased testosterone levels because there is no response. Because of that, although the baby has a 44+XY (male genotype) but he develop as a female phenotype but without the organs of the female reproductive system (ovaries, uterus....)


Neurohormone
Neuron
Cell without receptor
Cell with receptor
No response
Response

Endocrine Glands and Hormones

There are two control systems:
1. Nervous System: Action potentials/ fast, might travel 120 meters/second

2. Endocrine Systems: hormones/ slow

- Neurohormone:
  - Specialized neurons that secrete **chemicals** into the blood **rather than synaptic cleft.**
    - **Chemical secreted is called neurohormone.**
- Hormones:
  - Affect metabolism of target organs.
    - Help regulate total **body metabolism, growth, and reproduction.**

Classes of Hormones

ADH (Anti-Diuretic Hormone) and Oxytocin are both **octapeptides.** However, they are functionally different, because they have different amino acid sequences.

Key idea: The amino acid sequence determines the hormone's type, shape, and function/ action. The amino acid sequence is unique to each hormone.

What's the difference between a peptide and a protein?

Answer: A peptide consists of a chain of **less than 100 amino acids,** on the other hand, A protein consists of an amino acid sequence with **more than 100 amino acids.**

Similarity: Both peptides and proteins are water-soluble

- Peptide and Protein Hormones (amino acid chain)
- Steroid Hormones (derived from cholesterol)

Cholesterol is composed of **4 fused rings.** Steroids are derived from Cholesterol. Hydroxylation of C18 of cholesterol by certain enzymes give rise to certain hormones known as, "steroids." Steroids could be secreted from the adrenal cortex, the testis, and ovaries. One of the steroids secreted by the testis is Testosterone. Estrogen and Progesterone are secreted from the ovaries.

- Amine Hormones (derived from amino acid e.g tyrosine)

Amines : Epinephrine(adrenalin), Norepinephrine(noradrenalin),
Thyroxine (T4: tetraiodothyronine), T3: Triiodothyronine. Both hormones are active, but **T3 is more active than T4.**
Amines are derived from amino acids.

- Gas – Nitric Oxide (NO) or Carbon Monoxide (CO)

- Hormone types
  - Circulating – circulate in blood throughout body (In endocrine signalling)
  - Local hormones – act locally
    - **Paracrine** – act on **neighboring** cells
    - **Autocrine** – act on the **same** cell that secreted them (Auto means self)

Chemical classes of hormones

- **Lipid-soluble hormones**- use transport proteins in the plasma. Lipid soluble hormones doesn't dissolve in plasma, so they need carriers/ transport proteins like albumin, globulin. It isn't necessary to be a lipid-soluble hormone to be carried by those transport proteins, it could be lipid-soluble vitamins (Vitamin K, Vitamin A, Vitamin E, Vitamin D)
  - Steroid: Lipids derived from cholesterol.
    - Are lipophilic hormones.
      - Testosterone. (derived from cholesterol)
      - Estradiol. (estrogen) (derived from cholesterol)
      - Cortisol.
      - Progesterone.
      - Thyroid (amine but lipid soluble)
  - Eicosanoid (prostaglandins) derived from arachidonic acid (20 carbons 4 double bonds)- lipid soluble

it is located in the membrane (certain phospholipases act on it to be converted to prostaglandins)

Chemical classes of hormones …cont

- Water-soluble – circulate in "free" form in the plasma (no need for transporter (carrier))
  - Some Amines:
    - Some Hormones derived from tyrosine and tryptophan(serotonin).
  - Polypeptides and proteins:
    - Polypeptides:
      - Chains of < 100 amino acids in length.
        - ADH. (Allows reabsorption of water from the kidney, returning it to ECF.)
        - Oxytocin (Positive feedback / Allows contraction of the uterus during delivery.)
    - Protein hormones:
      - Polypeptide chains with > 100 amino acids.
      - Growth hormone.
      - Prolactin (milk hormone) consists of approx. 191 amino acids

Epinephrine, norepinephrine, and **thyroxin(T4) and T3** are derived from tyrosine, but the first two are water soluble and T3 and T4 are lipid soluble

Chemical Classification of Hormones ...cont

- Glycoproteins:
  - Long polypeptides (>100) bound to 1 or more carbohydrate (CHO) groups.
    - **FSH and LH, TSH and hCG** (human chorionic gonadotropin)

      They have α and β subunits (α is ***common*** and β is ***specific***)

      In order to measure the action of certain hormone, beta subunit should be measured.

hCG Comes from the placenta

- Hormones can also be divided into:
  - Polar:
    - H_20 soluble.
  - Nonpolar (lipophilic):
    - H_20 insoluble.
      - Can gain entry into target cells.
      - Steroid hormones and T_4 (thyroxine –tetraiodothyronine)

Peptide and Protein hormones are synthesized in the RER.

SER produces lipids.

Path of the Prohormone :

After the Prohormone is synthesized in the RER, it will move towards the Golgi Apparatus for post-translational modification, in order to splice it and extract the active hormone from it.

Prohormones and Prehormones

- Prohormone:
  - Precursor is a longer chained polypeptide that is cut and spliced together to make the hormone.
    - Proinsulin – gives insulin
- Preprohormone:
  - Prohormone derived from larger precursor molecule.
    - Preproinsulin.
- Prehormone: (inactive)
  - Molecules secreted by endocrine glands that are inactive until changed into hormones by target cells.
    - **T_4 converted to T_3 (tri-iodothyronine).**

Preprohormone is the largest.
Preprohormone after splicing yields Prohormone.
Prohormone after splicing yields hormone.
Hormone is the smallest.

Read Only

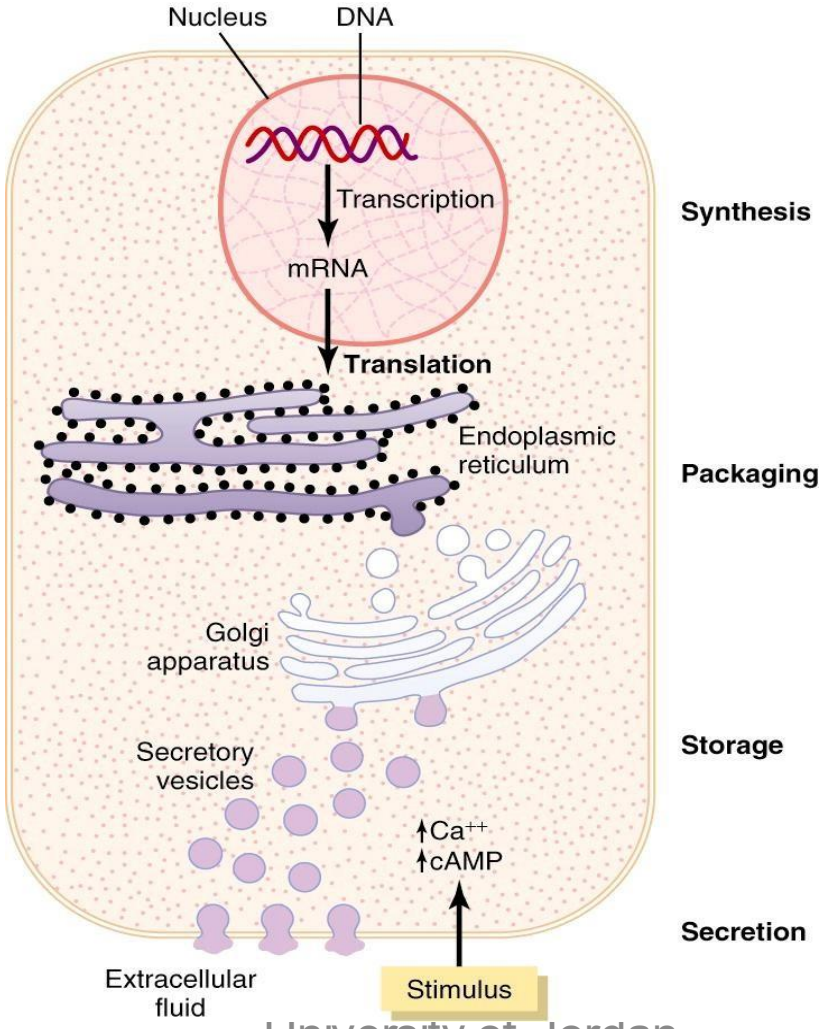
Peptide & Protein Hormones

Gland/Tissue	Hormones	Gland/Tissue	Hormones
Hypothalamus	▪ TRH, GnRH, CRH GHRH, Somatostatin,	Placenta	▪ HCG, HCS or HPL
Anterior pituitary	▪ ACTH, TSH, FSH, LH, PRL, GH	Kidney	▪ Renin
Posterior pituitary	▪ Oxytocin, ADH	Heart	▪ ANP
Thyroid	▪ Calcitonin	G.I. tract	▪ Gastrin, CCK, Secretin, GIP, Somatostatin
Pancreas	▪ Insulin,Glucagon, Somatostatin		
Liver	▪ Somatomedin C (IGF-1)	Adipocyte	▪ Leptin
Parathyroid	▪ PTH	Adrenal medulla	▪ Norepinephrine, epinephrine

Synthesis and secretion of peptide hormones

Brief description: After the Prohormone is synthesized in the RER, it will move towards the Golgi Apparatus for post-translational modification, in order to splice it and extract the active hormone from it.

Exocytosis is considered as an active transport mechanism because it need **ATP**



Amine Hormones

Gland/Tissue	Hormones
Hypothalamus	▪ Dopamine (A catecholamine that is derived from **tyrosine**)
Thyroid	▪ T_3, T_4
Adrenal medulla	▪ Epinephrine and Norepinephrine (NE, EPI)

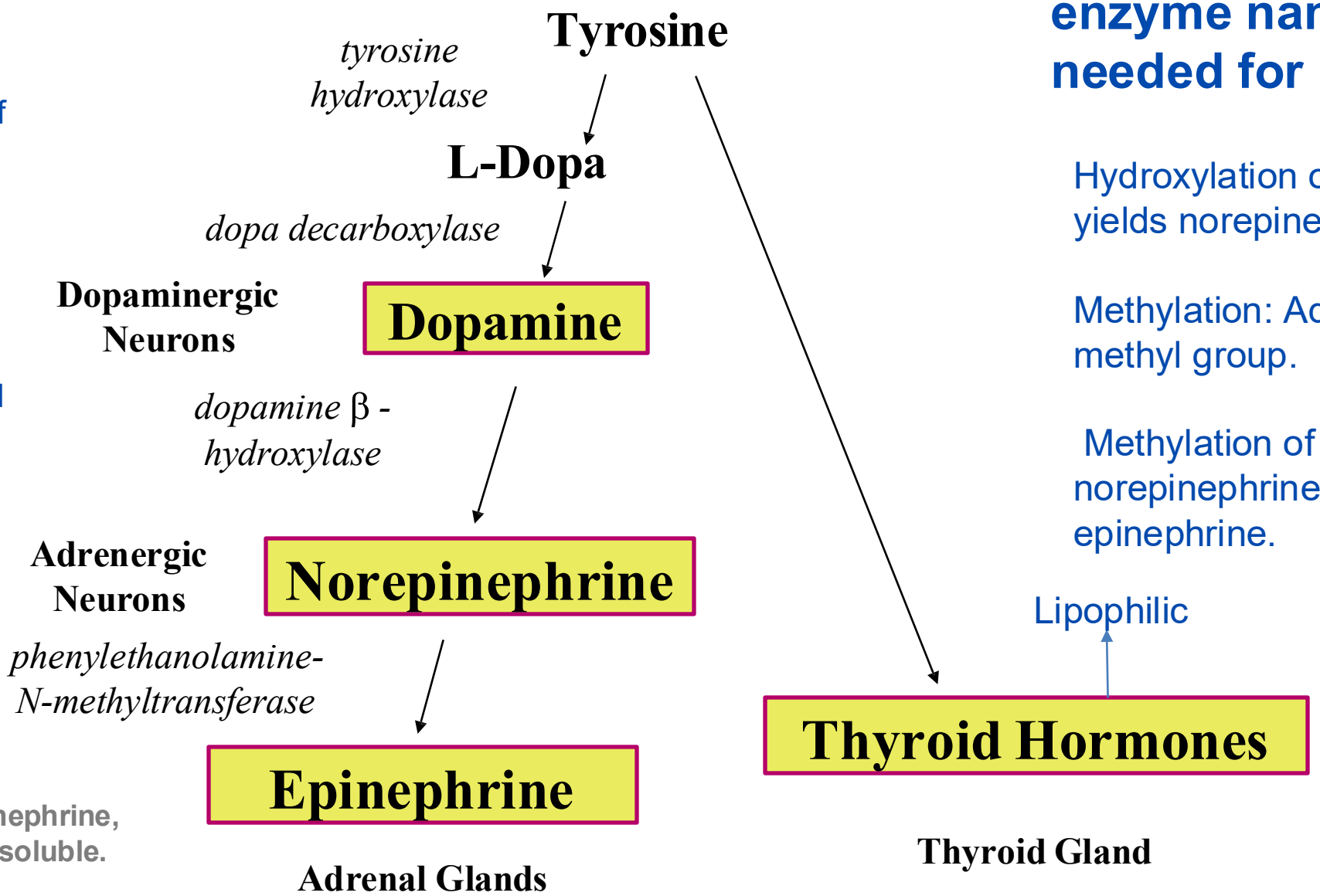
L-Dopa is sometimes adminstered to patients diagnosed with neurological diseases such as parkinson's disease.

Hydroxylation: Addition of an OH group.

Tyrosine hydroxylase hydroxylates tyrosine forming L-Dopa. That means L-Dopa is water soluble since it has an OH group.

Hydroxylated tyrosine (tyrosine with an OH group) = L-Dopa

Synthesis of Amine Hormones



Note: you don't have to memorize the enzyme names. Not needed for now.

Hydroxylation of dopamine yields norepinephrine.

Methylation: Addition of methyl group.

Methylation of norepinephrine yields epinephrine.

L-Dopa, Dopamine, Norepinephrine, and Epinephrine are water-soluble.

Epinephrine and Noreinephrine are secreted from the **Adrenal Medulla.**

The adrenal medulla is sometimes called the neural tissue. The Adrenal Medulla originates from the **ectoderm.**

The adrenal cortex is sometimes called glandular tissue. The Adrenal Cortex originates from the **mesoderm**.

Steroid Hormones

Gland/Tissue	Hormones
Adrenal Cortex	■ Cortisol, Aldosterone, Androgens
Testes	■ Testosterone
Ovaries	■ Estrogens, Progesterone
Corpus Luteum	■ Estrogens, Progesterone
Placenta Kidney	■ Estrogens, Progesterone ■ 1,25-Dihydroxycholecalciferol (calcitriol) → **Active Vitamin D**

Converts inactive vitamin D to active vitamin D.

Hormone Activity

- Hormones affect only specific target tissues with specific receptors.
- Receptors are dynamic and constantly synthesized and broken down.
  - Down-regulation- decrease in receptor number or activity.
  - Up-regulation- increase in receptor number or activity.

ALWAYS: Action depends on two factors :

1. Amount of the hormone.
2. Amount of the receptor.

Thank you

Test your knowledge

https://forms.gle/WXc858Z4JmxvSXge8

Additional Resources:

رسالة من الفريق العلمي:

Reference Used:
(numbered in order as cited in the text)

1. Dr.Faisal's recorded lecture

Extra References for the Reader to Use:

1. Textbook: Guyton Medical Textbook of Physiology
   By: Guyton and Hall 12th edition

For any feedback, scan the code or click on it.

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			