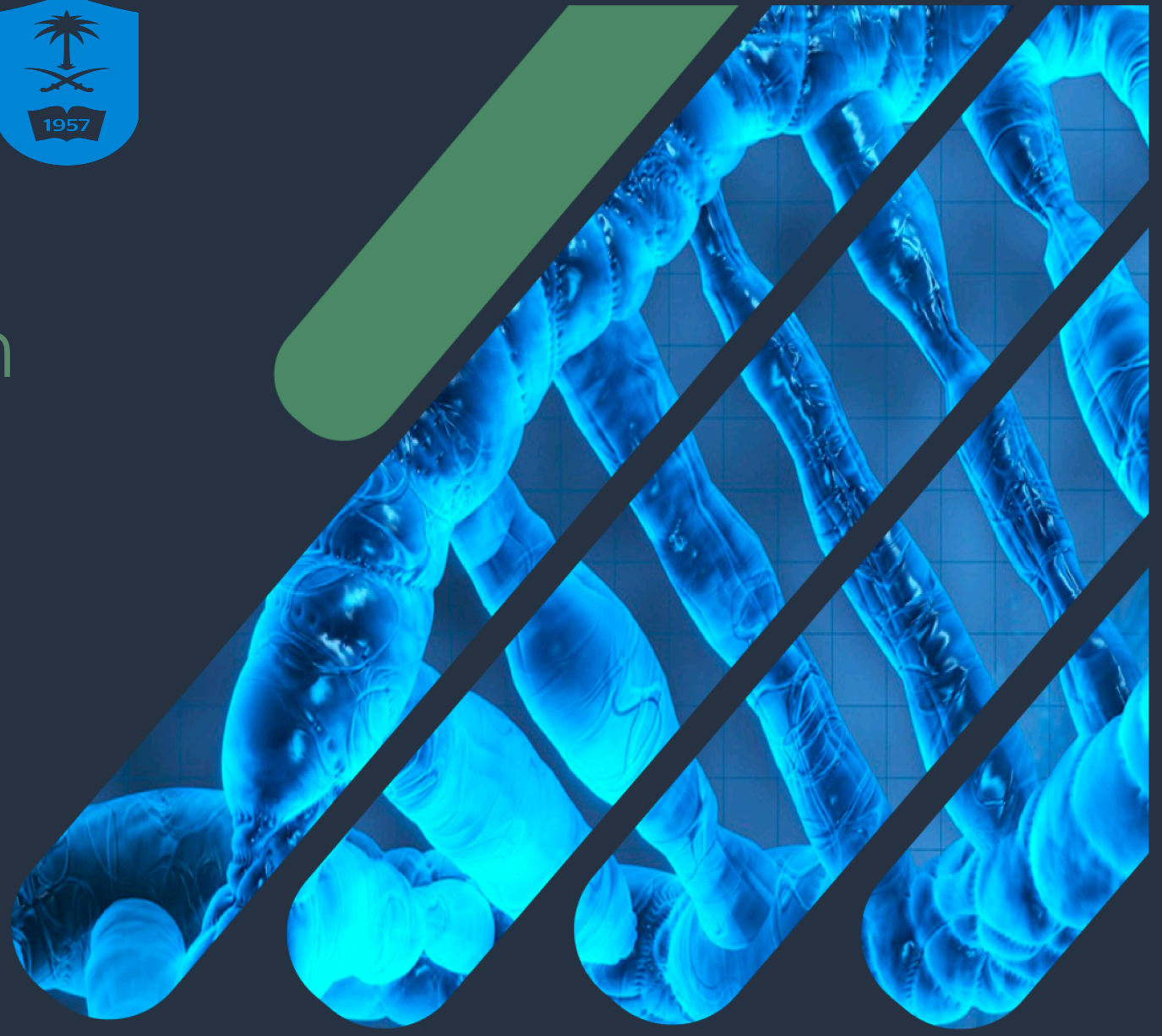
Biochemistry

Electron Transport Chain (Respiratory Chain)



Your patient is someone's mom\ someone's wife \ someone's best friend.
Please study hard ..

- Important.
- Extra Information.
- Doctors slides

Biochemistry team 436

OBJECTIVES:

- By the end of this lecture the students will be able to:
  - Understand how energy-rich molecules including glucose are metabolized by a series of oxidation-reduction reactions ultimately yielding CO2 and water.
  - Explain the process of electron transport chain that releases free energy, which is used for ATP synthesis and heat production.
  - Recognize the reactions of electron transport chain taking place in mitochondria that are coupled to oxidative phosphorylation

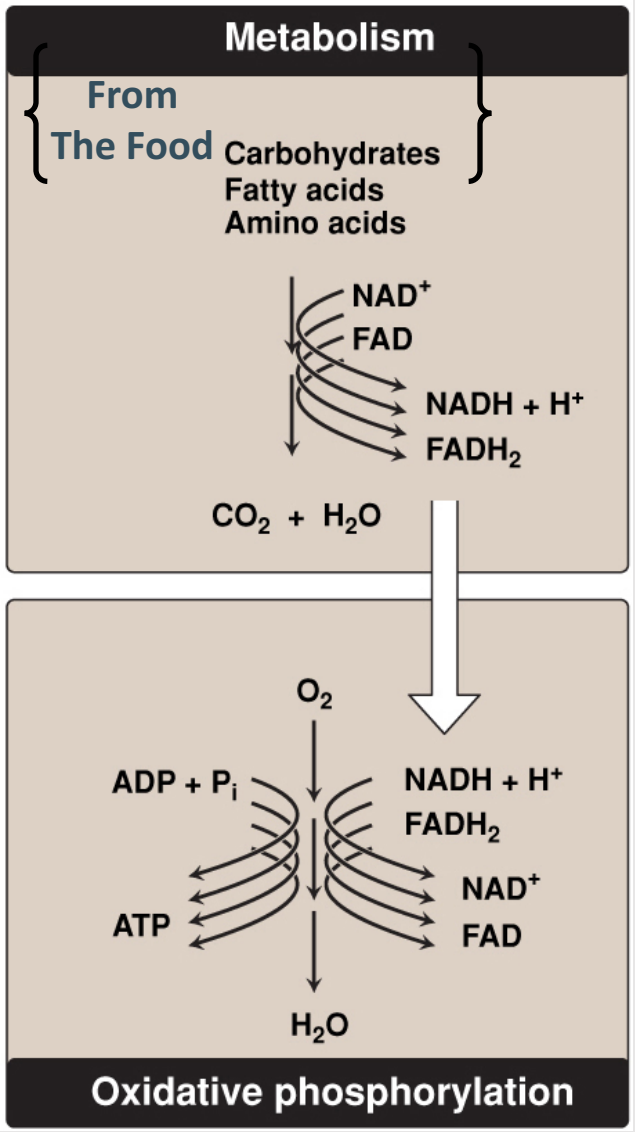
Electron Transport Chain (ETC)

Recall:
1-The ETC happens after krebs cycle.
2-Most of the ATP is synthesized by this process.
3-Proteins transport the electrons.
4- Respiratory chain \ ETC \ cellular respiration are the same

Another difinition of ETC that Dr.Sumbul mentioned:
It's a process which involves the transfer of electrons to create a proton gradient because it's the proton gradient that is responsible of generation of ATP not the ETC directly

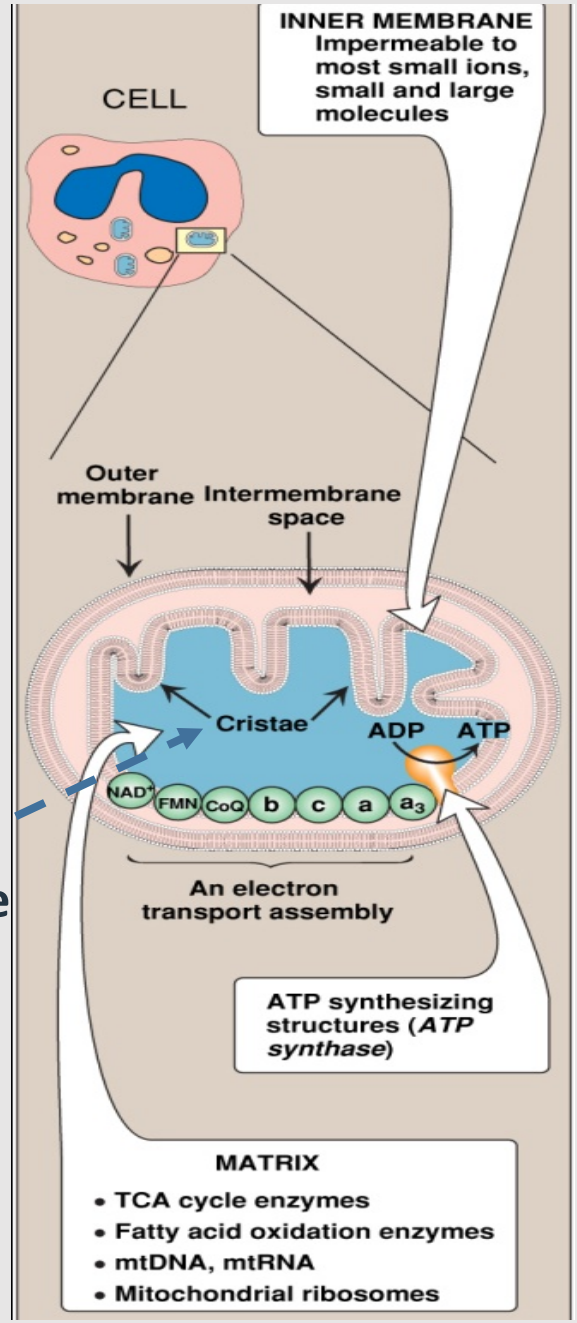
- A system of electron transport that uses respiratory O_2 to finally produce ATP (energy) Which is the purpose of ETC
- Located in the inner mitochondrial membrane
- Final common pathway of metabolism Everything is metabolized into simple molecules CO2\H2O
- Electrons from food metabolism are transported to O_2 Such as: Carbohydrates, fat and protenis
- Uses maximum amount of body's oxygen That's why its called ETC

Metabolic breakdown of energy yielding molecules



Reduced co-enzymes which are energy rich molecules, transfer their electrons to molecule and during this process they generate energy.

Cristae increase the surface area



MITOCHONDRIA

- **Excess energy generates heat**
- **Electrons (e^-) lose their free energy**

Mt= mitochondrial

Biochemistry team 436

Mitochondrion

You remember all these information from the foundation block, aren't you GENUIS ?!!

- **Inner membrane:**

Impermeable to most ions, small and large molecules .folded to increase the surface area.

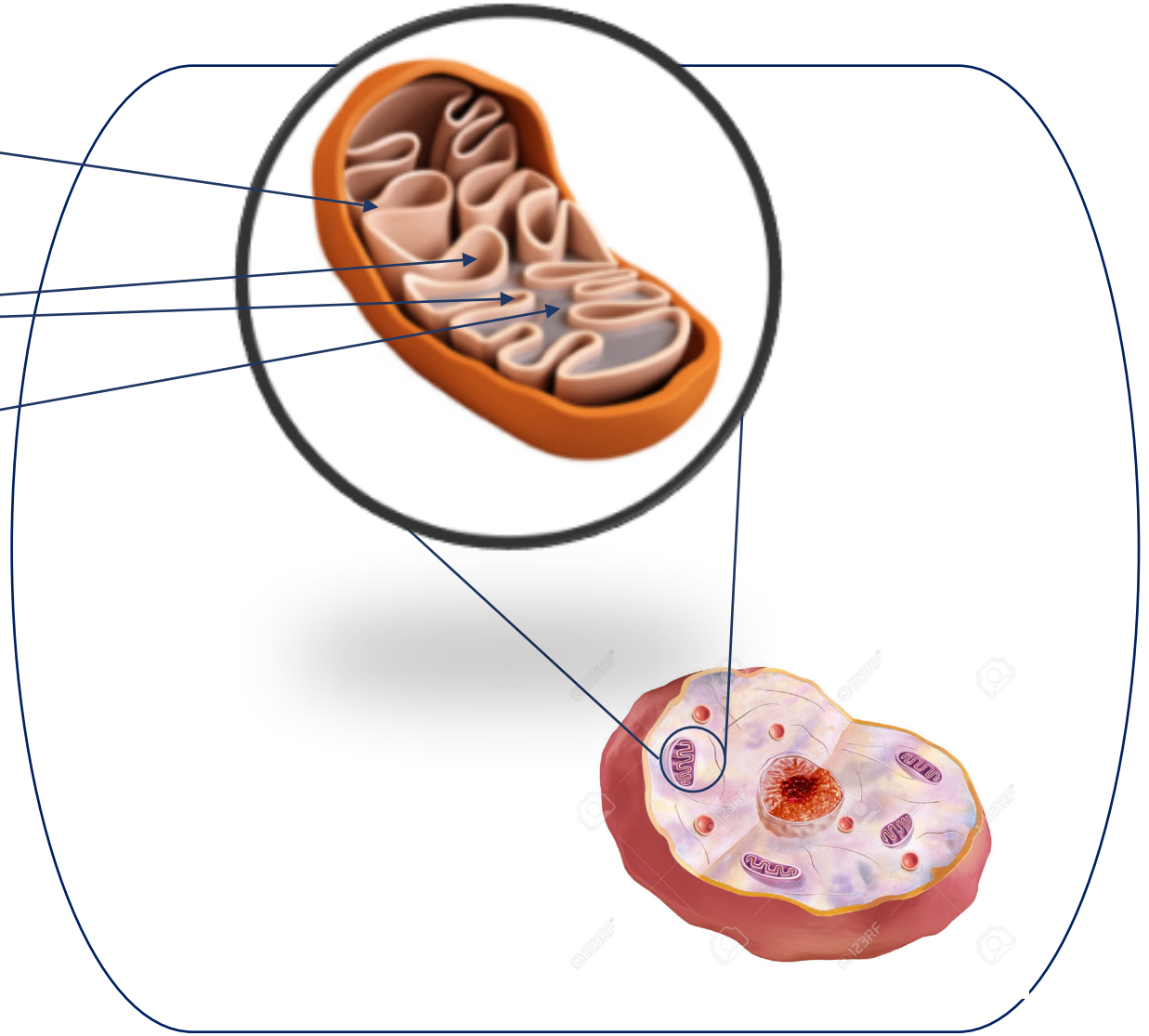
- **Cristae:**

Increase surface area .

- **Matrix:**

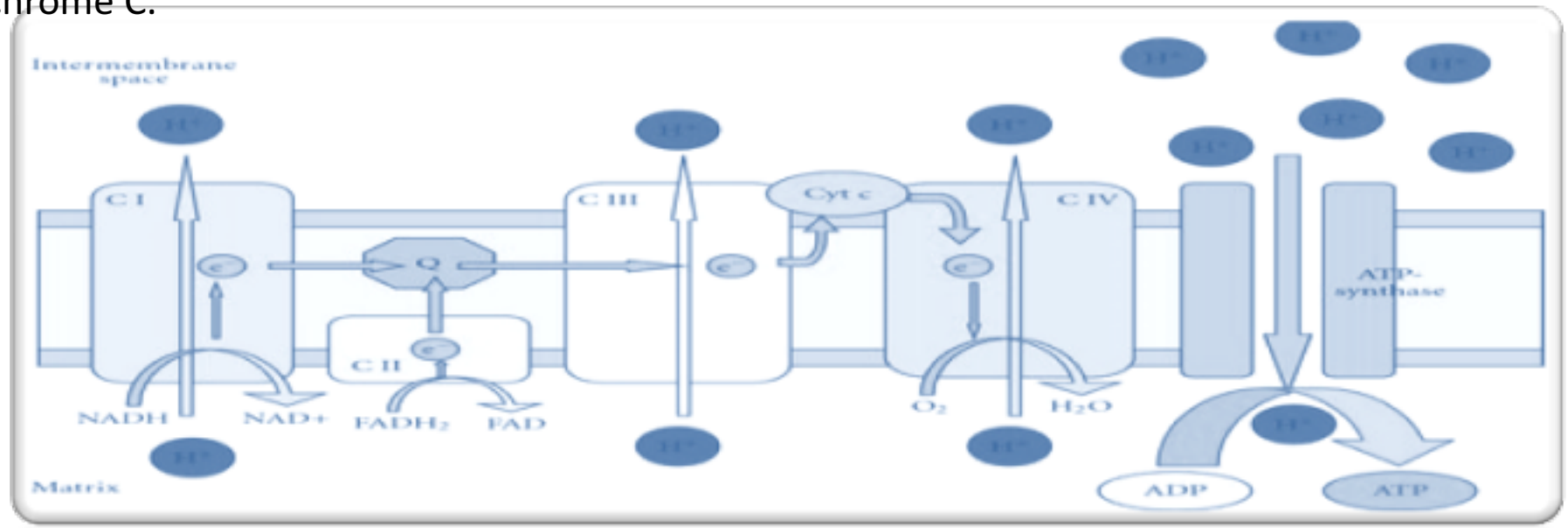
~TCA cycle enzymes.
~Fatty acid oxidation enzymes.
~MtDNA, mtRNA.
~Mitochondrial ribosomes.

*ATP synthesising structure (ATP synthase) is found in the inner membrane.



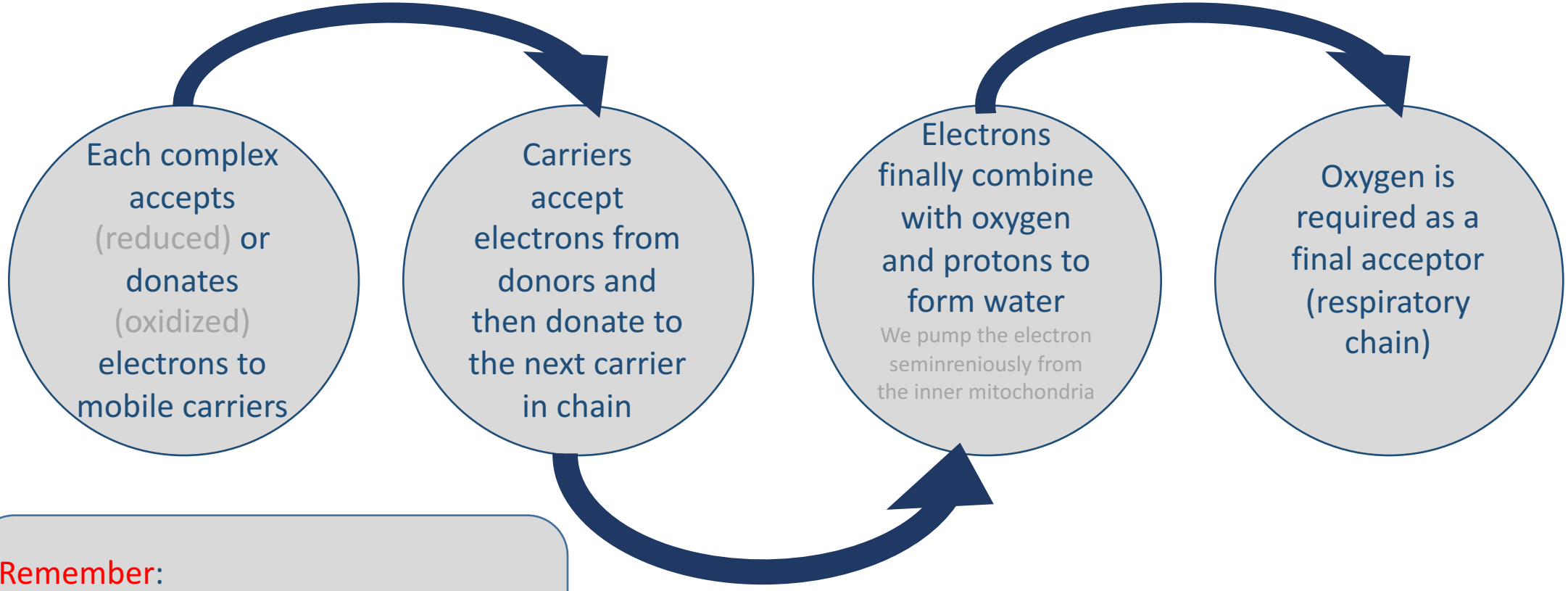
Components of ETC

- All components are located in the inner mitochondrial membrane(IMM)
- IMM contains 5 complexes: (protein complexes)
  - **Complex I, II, III, IV.** (part of ETC)
  - **Complex V** (ATP synthase: catalyzes ATP synthesis). Participates in oxidative phosphorylation it is not a part of ETC
  - **Mobile electron carriers**: they can move
- CoQ.
- Cytochrome C.



Biochemistry team 436

Organization of ETC



Remember:

- Oxidation is losing H (electrons).
- - Reduction is giving H (electrons).

Biochemistry team 436

Complex I - NADH Dehydrogenase: collects the pair of electrons from NADH and passes them to CoQ

Note : it is proton pump

Complex I I -Succinate dehydrogenase:

-It is also a part of the krebs cycle.

-Transfers electrons to CoQ.

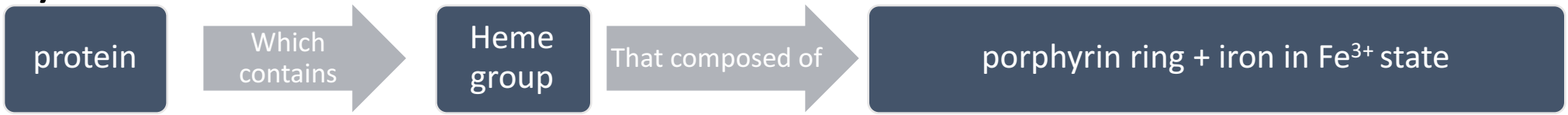
Note: it's not proton pump

COENZYME Q (COQ) :

- Also called ubiquinone (because it is ubiquitous in biological system) .
- A non-protein member of the ETC (electron transport chain) it's the only one which is non protein
  Lipid soluble and mobile (moving)

Cytochromes

cytochrome is:



- When cytochromes accept electron
  - Fe^{3+} (ferric) is converted to Fe^{2+} (ferrous)
  - Fe^{2+} is reoxidized to Fe^{3+} when it donates lost electrons to the next carrier

Remember .. ! In Cytochromes: Heme group = porphyrin ring + iron in Fe3+ (Ferric) In HB: Heme group = porphyrin ring + iron in Fe2+ (Ferrous)

Complex III and IV

- Complex III: Cytochrome bc1
- Complex IV: Cytochrome a + a3
- Electrons flow from:

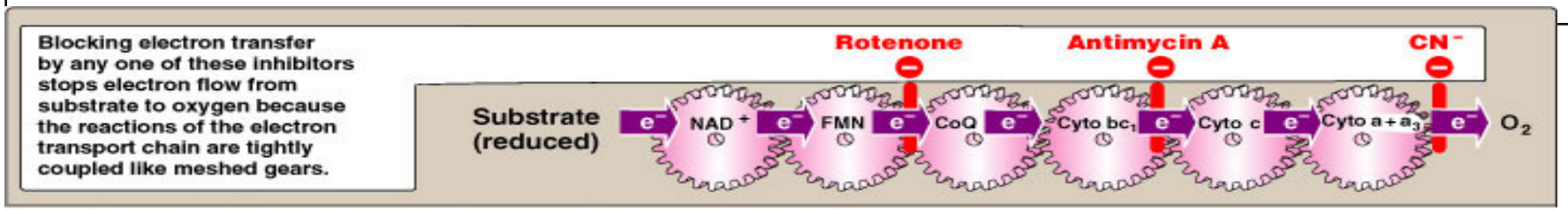
CoQ → Complex III → Cyt. c → Complex IV

Site-specific inhibitors of ETC

They are compounds that prevent the passage of electrons by binding to a component of the chain, blocking the oxidation reduction reaction

The inhibitors are :

Rotenone	AntimycinA	Cyanide



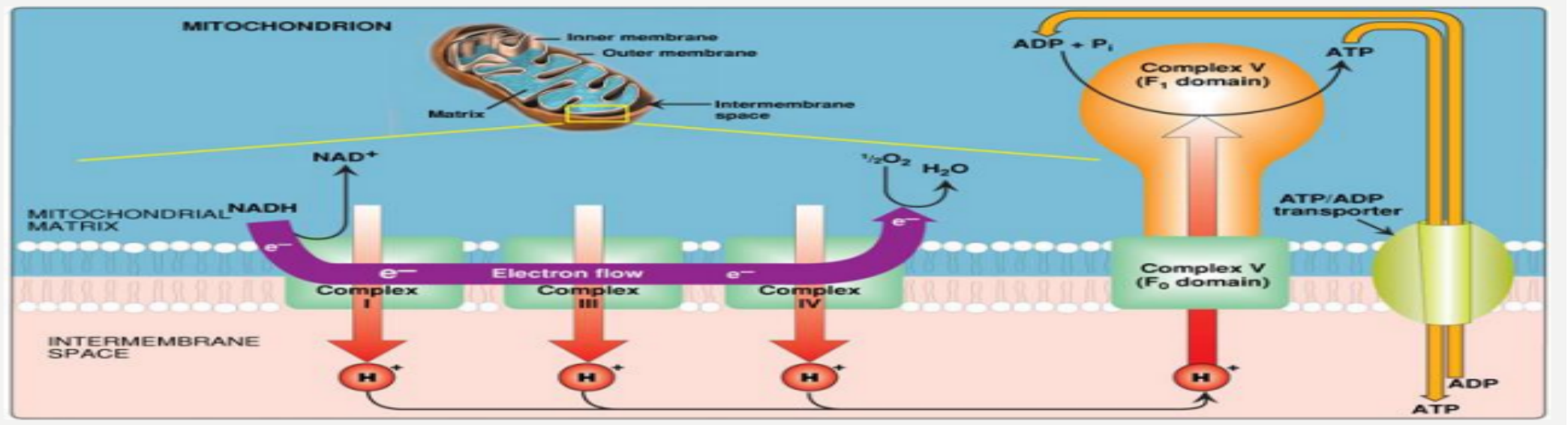
اضافة الى
CN, CO , H2S and NaN3

ETC is coupled to proton transport for ATP synthesis

- The energy of electron transfer is used to drive the protons out of the matrix (that will increase proton concentration between the membranes of mitochondria)
- It is done by complexes I, III and IV (proton pumps)
- This creates a proton gradient across the IMM to synthesize ATP. (the mitochondria uses the concentration gradient force of proton which will synthesis the ATP when the proton influx in ATP synthase)

Oxidative phosphorylation: production of free radicals

Transport of protons:



Simultaneously protons are pumped from the matrix to the inner part of the membrane so you have lots of hydrogenised in the IMM which has to come back inside.

Every proton enters will rotate F0 which will cause conformational change in F1 subunit. So when 4 electrons come inside they lead to the production of 1 ATP molecule

Energetics of ATP synthesis :

- The energy required for phosphorylation of ADP to ATP = 7.3kcal/mol
- Energy produced from the transport of a pair of electrons from NADH to O2 = 52.58 kcal
- No. of ATP molecules produced is 3 (NADH to O2)
- Excess energy is used for other reactions or released as heat

*Excess energy is used for other reactions or released as heat.

P:O ratio :

ندى اقوى من فهد عشان كذا تكون اكثر منه ATP

- ATP made per O atom reduced
  - –For NADH
- P:O = 3:1 " 3 ATP are made per oxygen atom reduced"
  - –For FADH2
- P:O = 2:1 "2 ATP are made per oxygen atom reduced"

ATP synthase

ATP synthase (Complex V) synthesizes ATP

Consists of two domains:

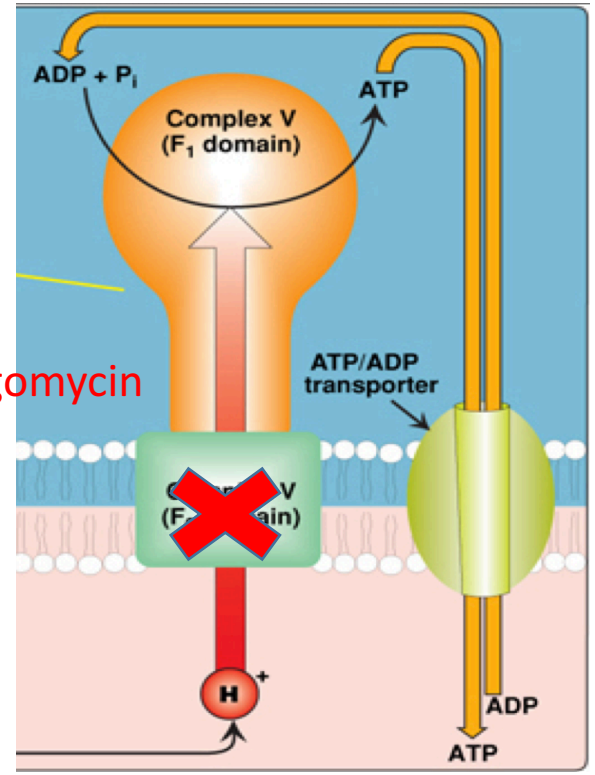
- F0 – membrane spanning domain
- F1 – extramembranous domain

Biochemistry team 436

Inhibitors of ATP synthesis :

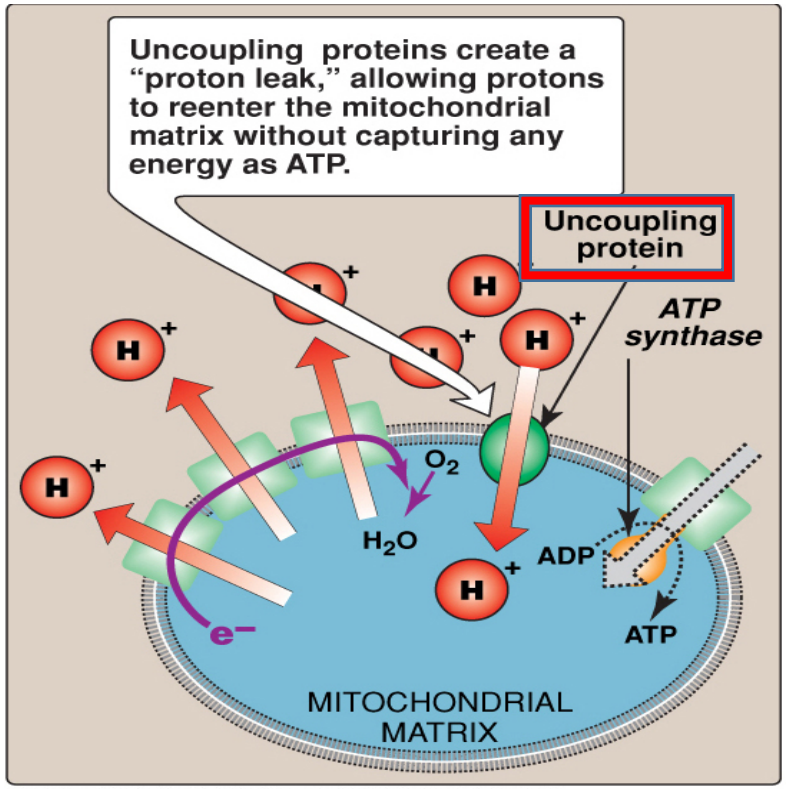
- Oligomycin :
  - Binds to F0 domain of ATP synthase and closes the H+ channel
- Uncoupling proteins (UCPs) :
  - Create proton leaks (allow protons to reenter the matrix without ATP synthesis)
  - Energy is released as heat (non-shivering thermogenesis)

Pottasium channel:
When it's closed no proton comes back into the matrix so no twisting on F0 subunit and no conformational change in F1 so no ATP synthesis



Oligomycin

Non shivering thermogenesis: is present in brown fat which's present in animals and newborn babies and it looks brown because it has a lot of mitochondria

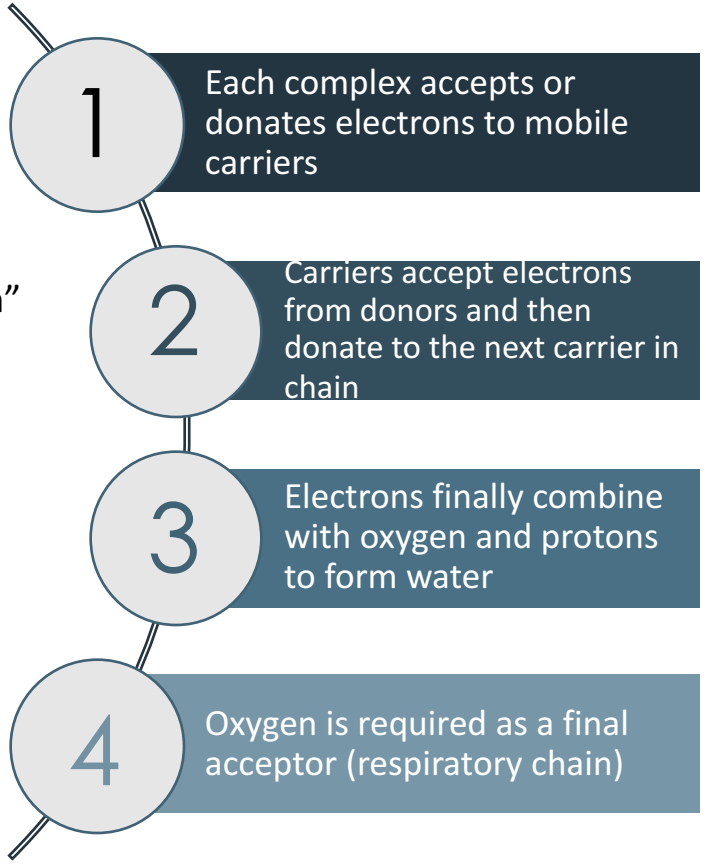


(Extra slide)

Quick summary of the concept ☺

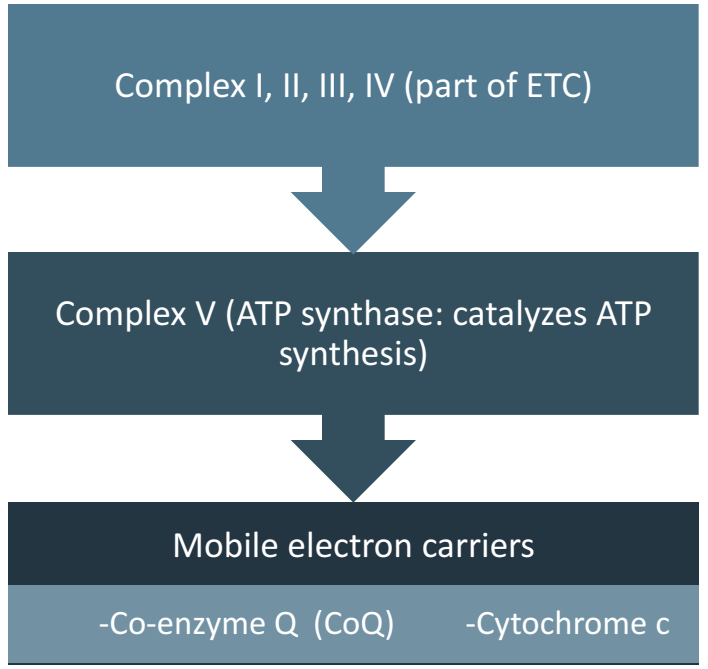
- Energy-rich molecules (like glucose are metabolized by a series of oxidation reactions ultimately yielding Co2 and water.
- The intermediates of these reactions donate electrons to form energy-rich reduces forms (NADH and FADH2)
- The reduced enzymes donate a pair of electrons to special set of electron carriers called “the electron transport chain”
- 1- Electron transport chain of the mitochondrion: it’s in the inner membrane of mitochondria
- 2- Components (with the exceptions of co-enzyme Q, which is a lipid-soluble quinone, all members of the chain are proteins)
- 3- organization of the electronic transport chain
- **Phosphorylation of ADP to ATP:**
- 1- Proton Pump (done by complexes I, III and IV)
- 2- ATP synthase (Complex V)

Organization of ETC



Components of ETC

- All members/components are located in the inner mitochondrial membrane (IMM).
- IMM contains 5 complexes:



Quiz

SAQ

https://www.onlineexambuilder.com/etc-saq/exam- 131861

MCQ's:

https://www.onlineexambuilder.com/electron-transport-chain/exam- 131853

https://www.onlineexambuilder.com/etc-extra/exam- 131862

Both are important ..

Helpful video

https://www.youtube.com/watch?v=xbJ0nbzt5Kw

TEAM MEMBERS

مهند الزهراني

طلال الطخيم

فهد العتيبي

عبدالعزيز الصومالي

سعود الشنيفي

صالح التويجري

حمد الحسون

محمد العسيري

TEAM LEADERS

- محمد المطلق
- رانيا العيسى

نورة الشبيب

Biochemistry team 436

THANK YOU

PLEASE CONTACT US IF YOU HAVE ANY ISSUE

- Review the notes

https://www.youtube.com/watch?v=xbJ0nbzt5Kw

- Lippincott's Illustrated Reviews: Biochemistry, 6th E

- @436Biochemteam

- Biochemistryteam436@gmail.com

Biochemistry team 436