BIOCHEMISTRY

Electron Transport Chain and Oxidative Phosphorylation

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Chapter Description

- Overview

  This pathway responsible in oxidation of reduced coenzymes to generate ATP.

- Expected Outcomes

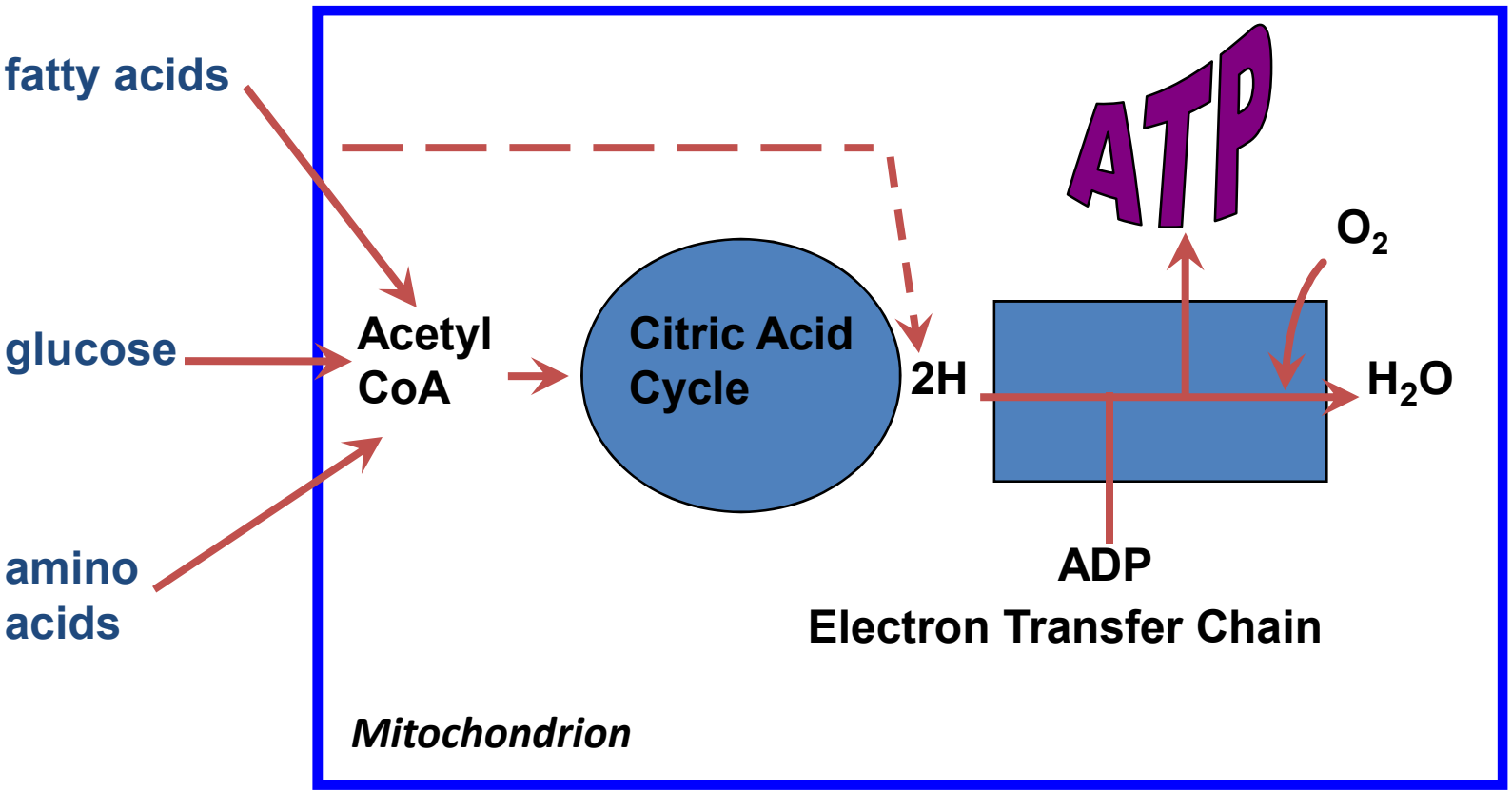
  You should be able to understand on the accepted chemiosmotic theory, importance of ATP synthase, inhibition of complexes within ETC, movement of substrates between cytoplasm and mitochondria.

- Other related Information

  Some relevant questions been provided for improving your understanding of the topic. You are expected to search for external sources for information to adequately answer the questions. All pictures and figures within this chapter categorized as creative commons for the purpose of education only.

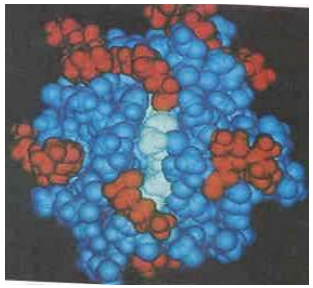
Electron transport and oxidative phosphorylation

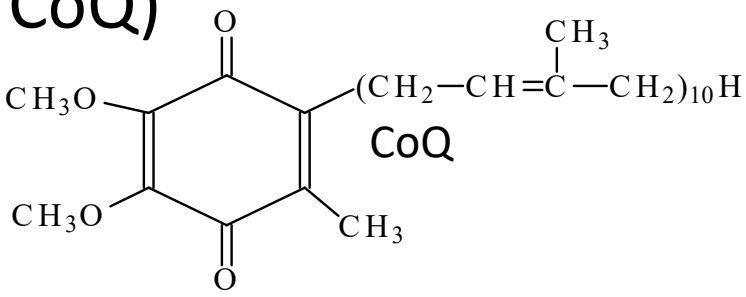
occur within the inner mitochondrial membrane



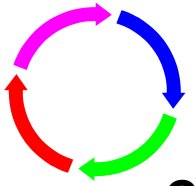
What are the electron carriers in the electron transport chain (ETC)?

- **NADH** and **$FADH_2$** carry electrons from catabolic pathways to ETC
- Within ETC, other electron carriers transport electrons between and within complexes
  - **Ubiquinone** (Coenzyme Q, CoQ)
  - Iron-sulphur proteins
  - **Cytochromes**





The Electron Transport Chain



Succinate → fumarate

Complex II

Succinate dehydrogenase

$Succinate + 1/2O_2 \rightarrow fumarate + H_2O$

$\Delta G = -152\ kJ/mol$

Complex I → CoQ → Complex III → (Cyt c) → Complex IV

NADH dehydrogenase

Cytochrome bc_1 complex

Cytochrome oxidase

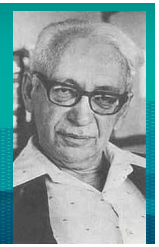
$NADH + H^+$ → NAD^+

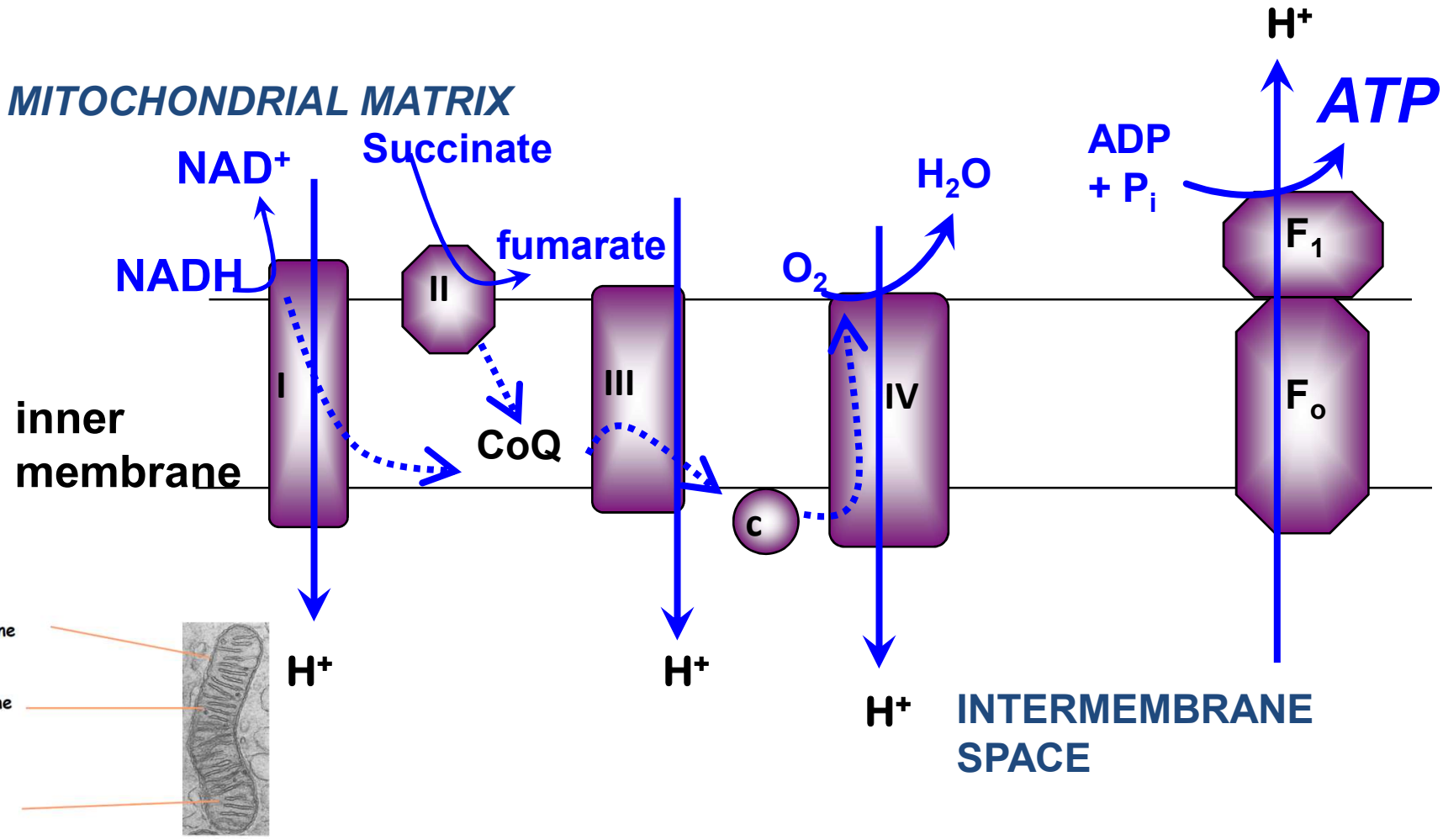
$1/2O_2$ → H_2O

$NADH + H^+ + 1/2O_2 \rightarrow NAD^+ + H_2O$

$\Delta G = -220\ kJ/mol$

The Chemiosmotic model





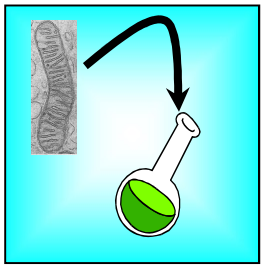
What is ATP synthase?

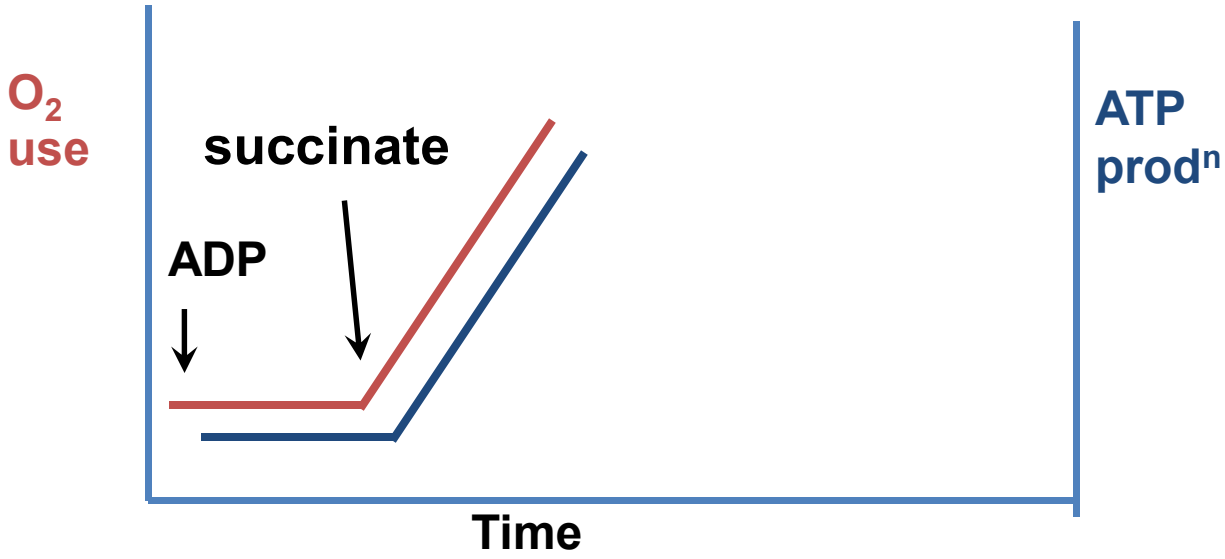
- ATP synthesis is catalysed by ATP synthase (**complex V**)
- F_o component (**stalk**)
  - acts as a H^+ pore
  - sensitive to **oligomycin**
- F_1 component (**knob**)
  -catalyzes ***ATP synthesis***

How do ATP synthase and ETC interact?

- Electron transfer is **coupled** to ATP synthesis

- **In isolated mitochondria preparations**





How many ATPs can glucose provide?

- From Aerobic Glycolysis
  - 2 ATP
  - 2 NADH (=6 ATP)
- 2 x Pyruvate to Acetyl-CoA
  - 2 NADH (=6 ATP)
- 2 x Citric Acid Cycle
  - 2 GTP (=2 ATP)
  - 6 NADH (=18 ATP)
  - 2 $FADH_2$ (=4 ATP)

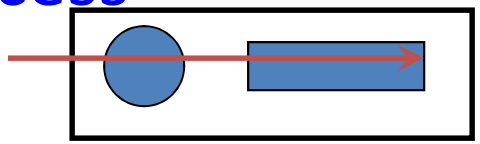
= 38 ATP

(complete oxidation)

What limits the rate of respiration?

Respiration is a catabolic process

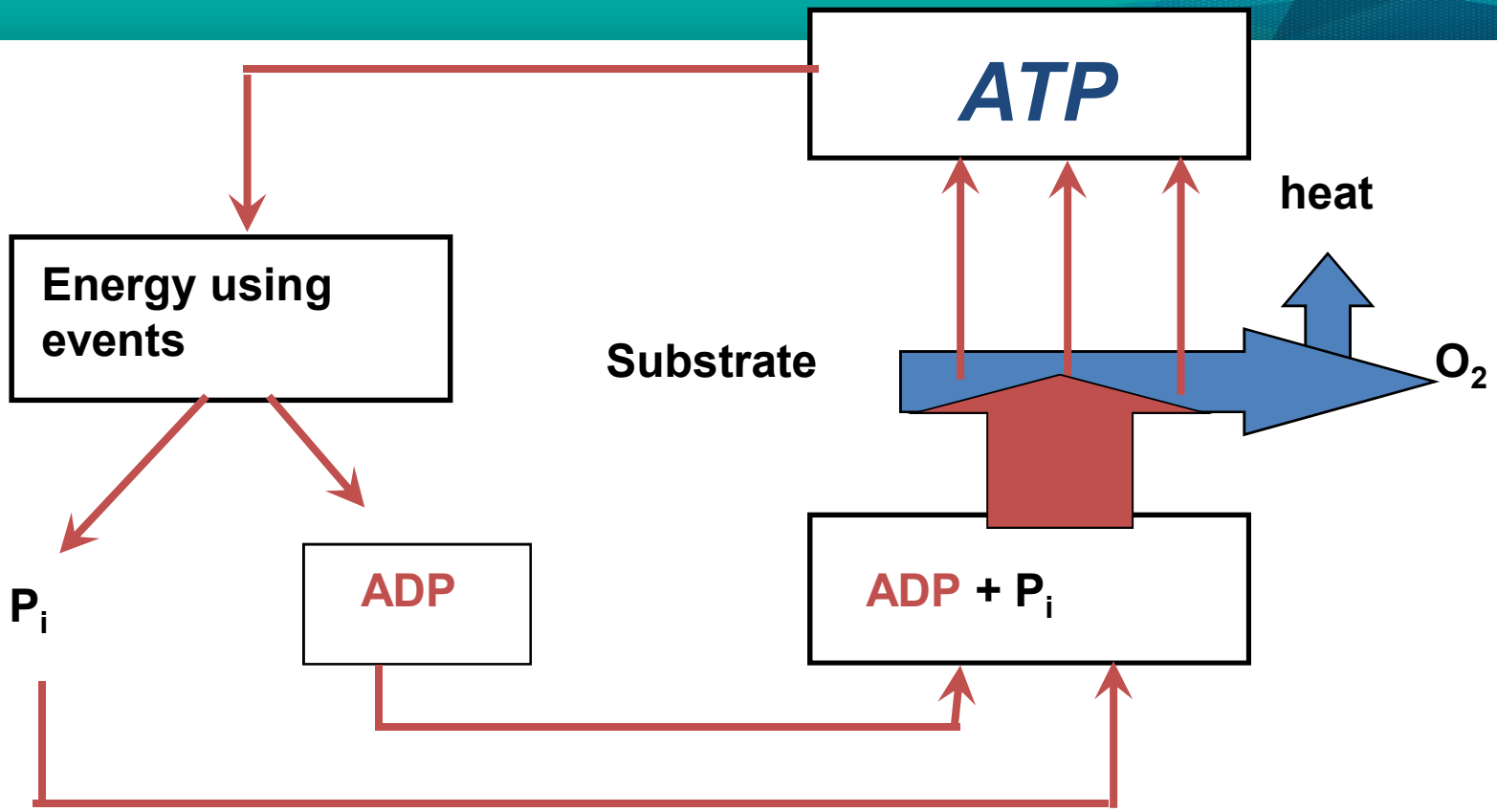
- **uses O_2 to form ATP**



- Conditions limiting respiration rate are:
  1. availability of **ADP and substrate**
  2. availability of **substrate** only
  3. **capacity** of respiratory chain itself
  4. availability of **ADP** only
  5. availability of **O_2** only

Ratio b/n ADP/ATP in the cell

Role of ADP in Respiratory Control

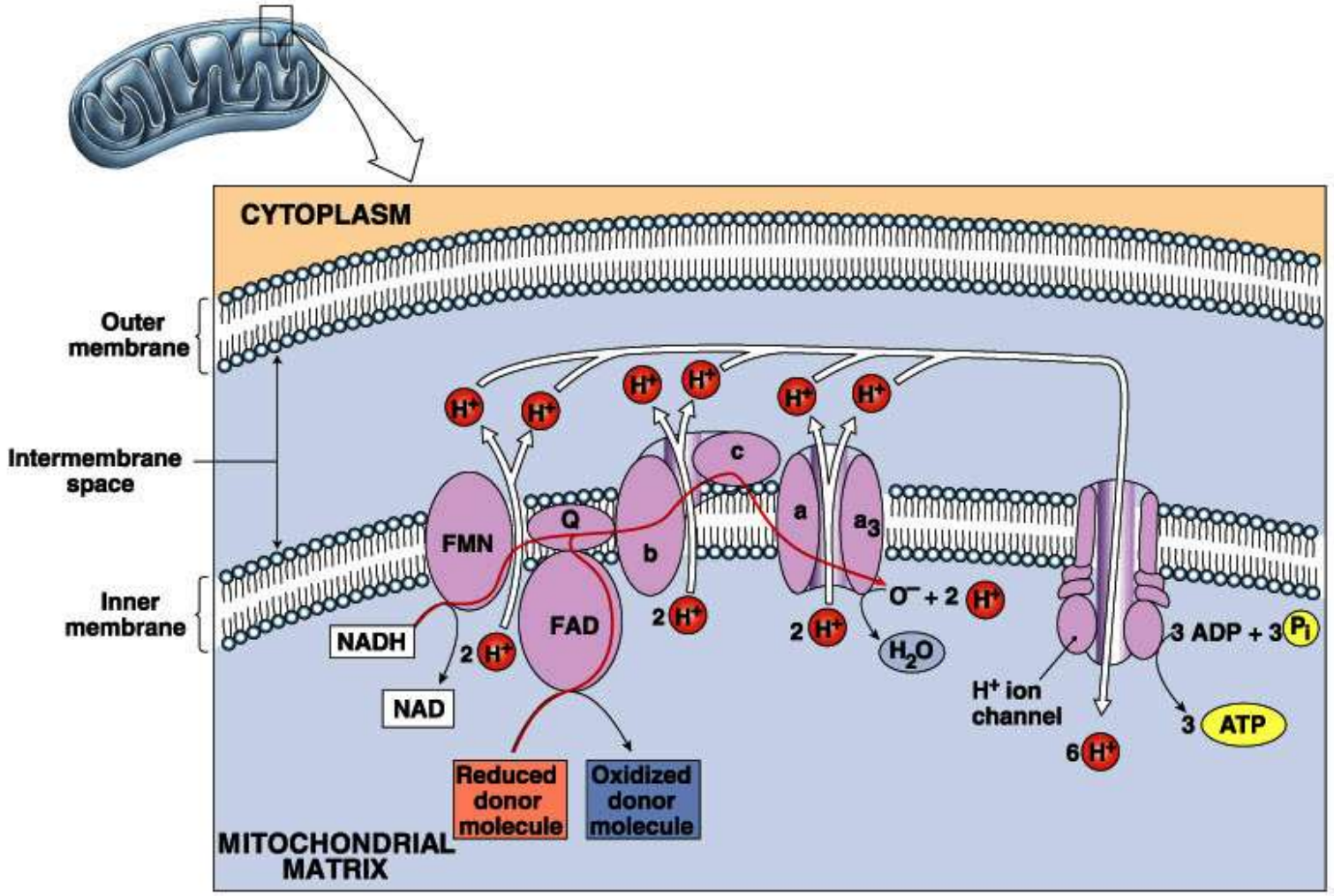


Ratio of ADP/ATP is important in regulating respiration

Electron Transport Chain (ETC)

- carrier proteins found in mitochondria (and chloroplasts)
- Physically arranged in an ordered series
  - Starts with high-energy electrons and low-energy ADP
  - Pass electrons from one carrier to another
  - Ends with low-energy electrons and high-energy ATP

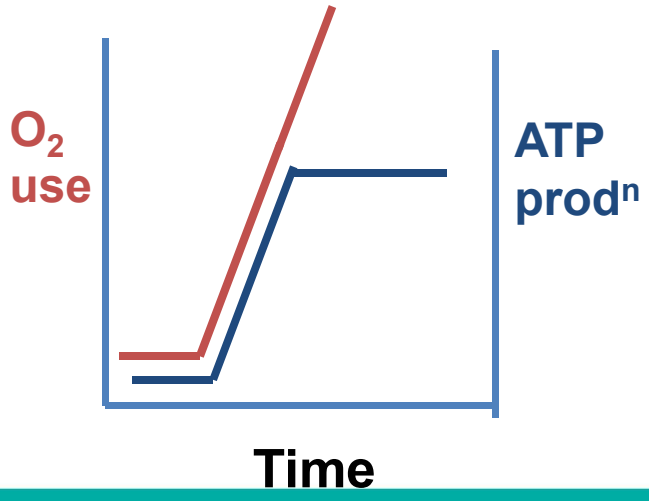
Overview of Electron Transport Chain(ETC)

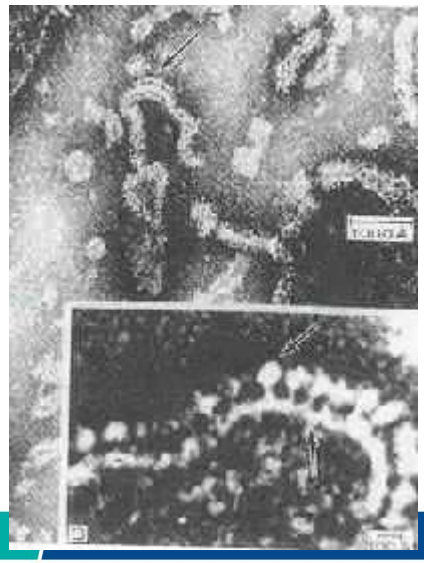


What experimental evidence supports the chemiosmotic theory?

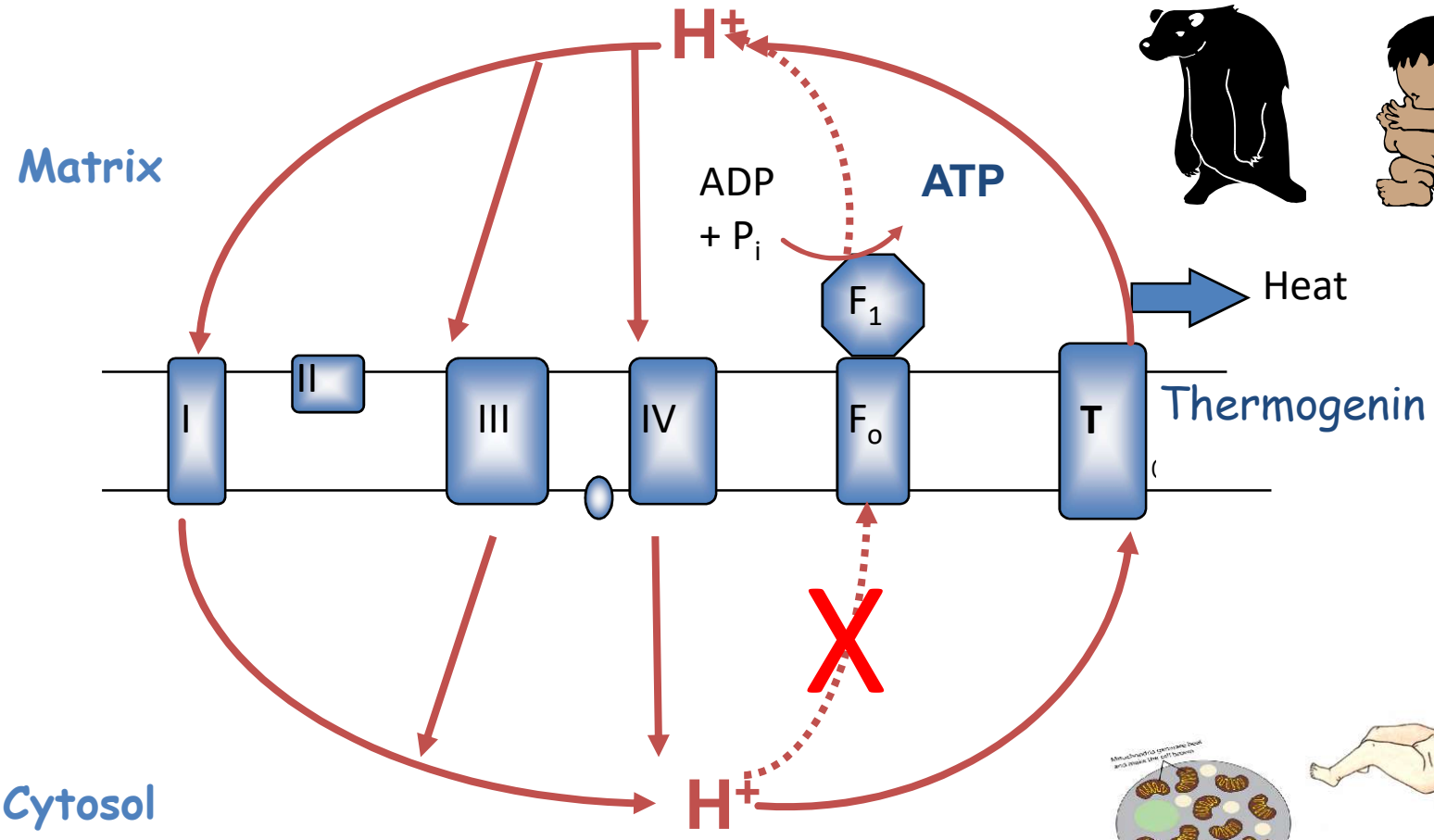
- Acidification outside the mitochondria
- Disruption of membrane

- Artificial gradients
- Uncouplers

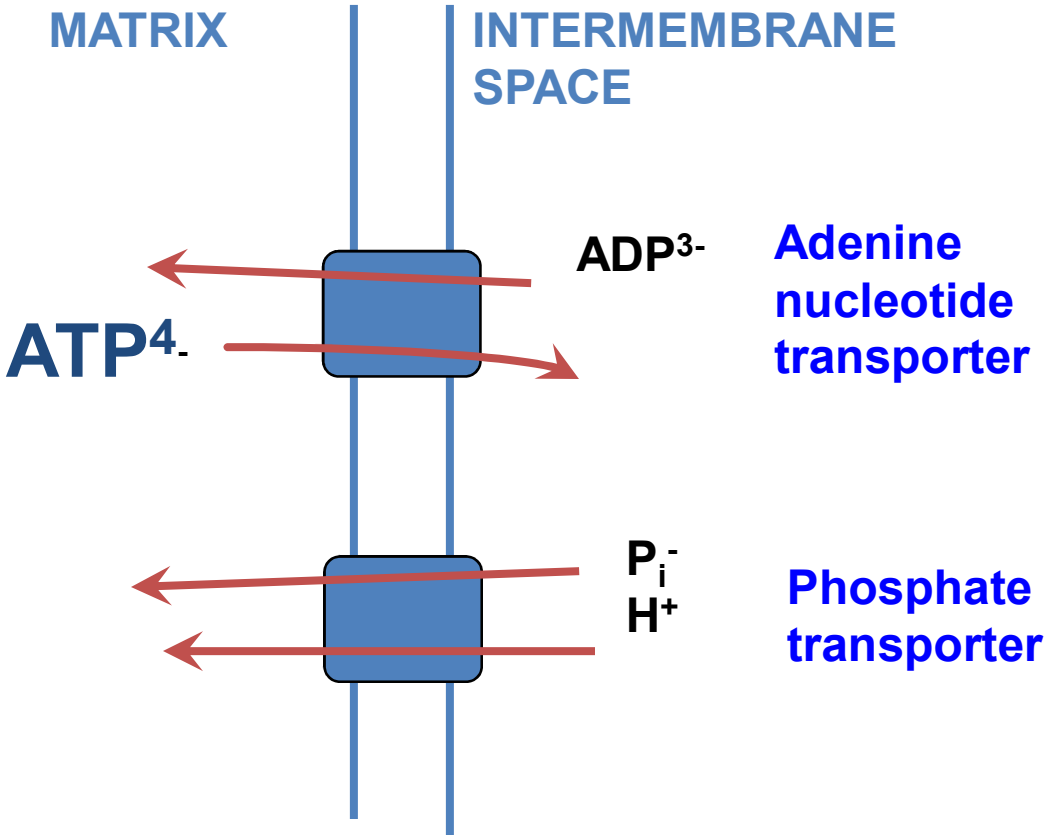




Thermogenin is a natural uncoupling protein



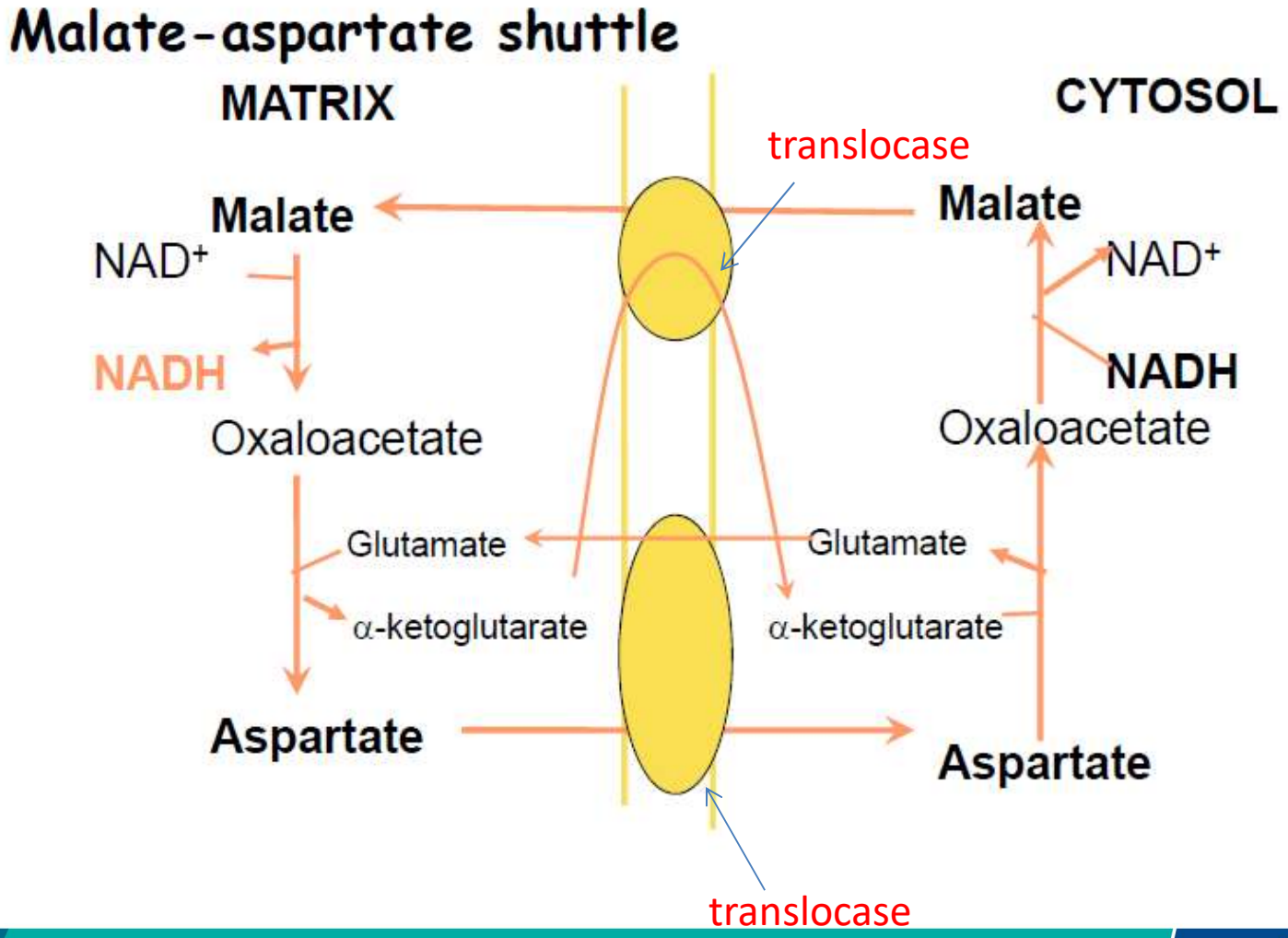
How do substrates enter the mitochondria?



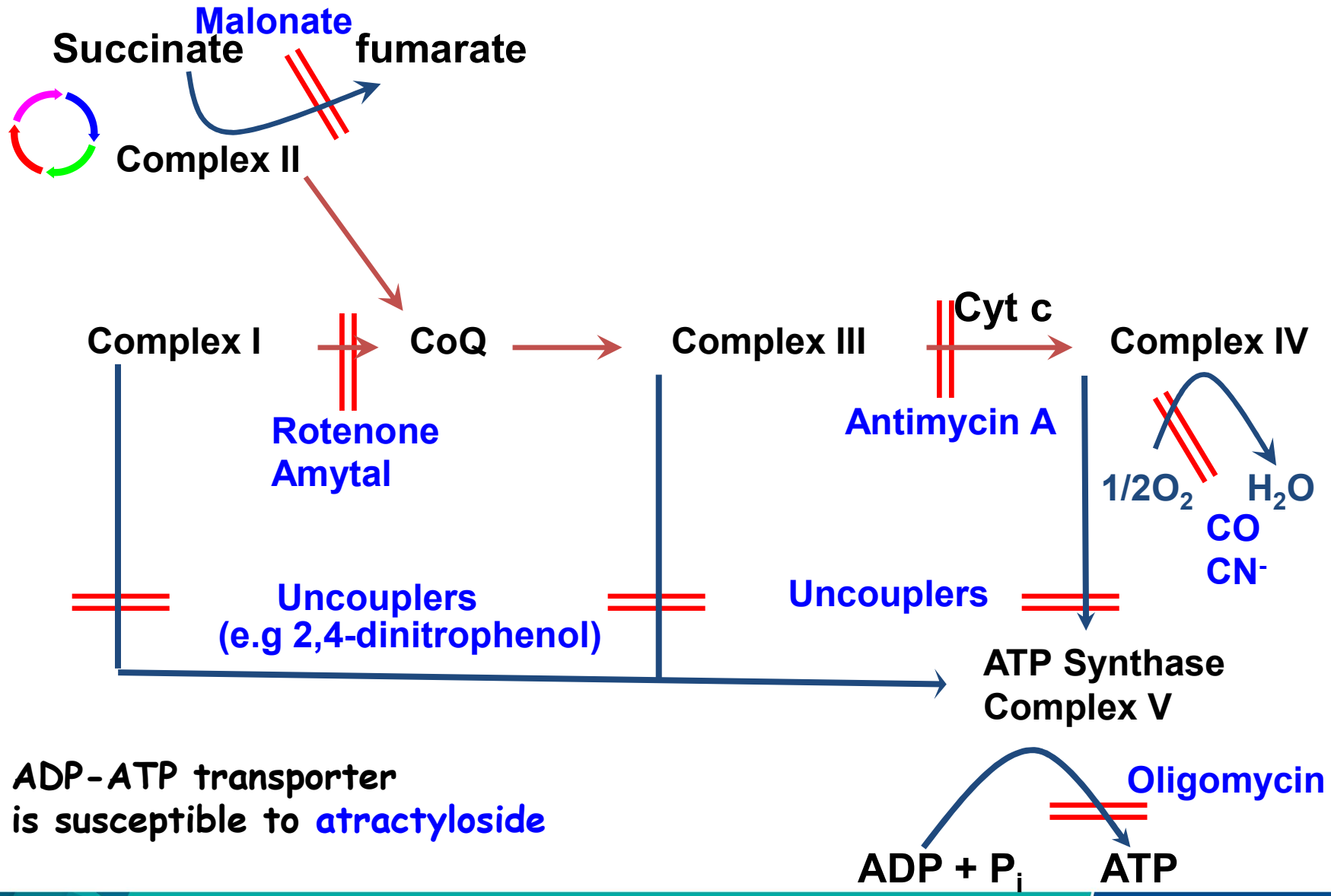
Adenine nucleotide (ADP/ATP) transporter is susceptible to atractyloside

NADH from cytosol to matrix

How do substrates enter the mitochondria?

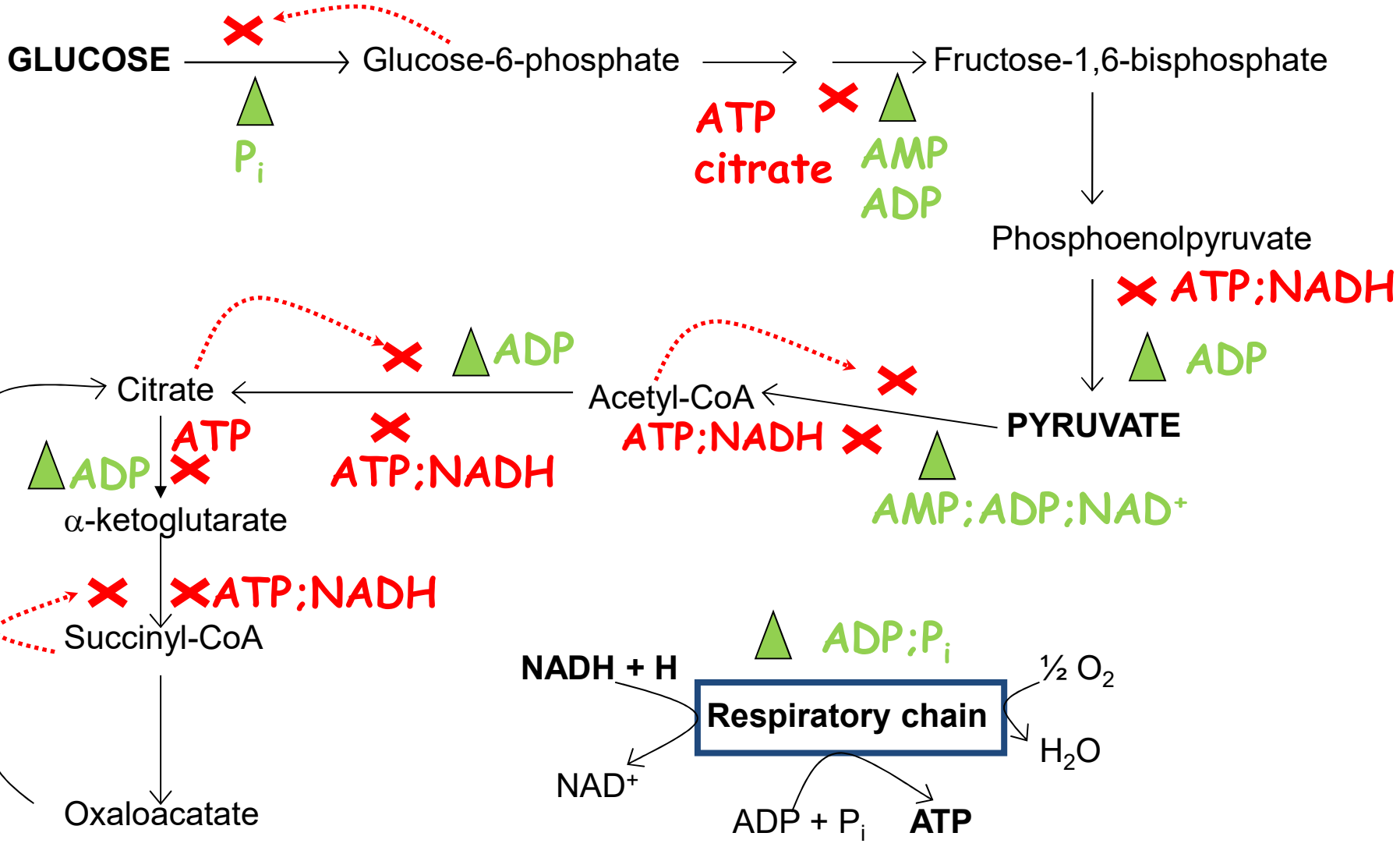


Can oxidative phosphorylation be inhibited?



ADP-ATP transporter
is susceptible to atractyloside

Regulation of Energy Producing Pathways



Energy Metabolism - Summary

- Glycolysis occurs in the cytoplasm and flux is regulated by cellular energy indicators
- Fate of pyruvate under aerobic & anaerobic conditions
- The citric acid cycle occurs in the mitochondria and flux depends on energy status of the cell
- Acetyl-CoA from pyruvate via glycolysis or fatty acids via β-oxidation
- The anaplerotic reactions replenish the intermediates of the cycle
- Reducing equivalents from catabolic p'ways enter the electron transport chain in inner mitochondrial membrane
- Oxidative phosphorylation is coupled to O_2 use and produces many ATPs
- Poisons can interfere with electron transport or other aspects of oxidative phosphorylation

References:

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