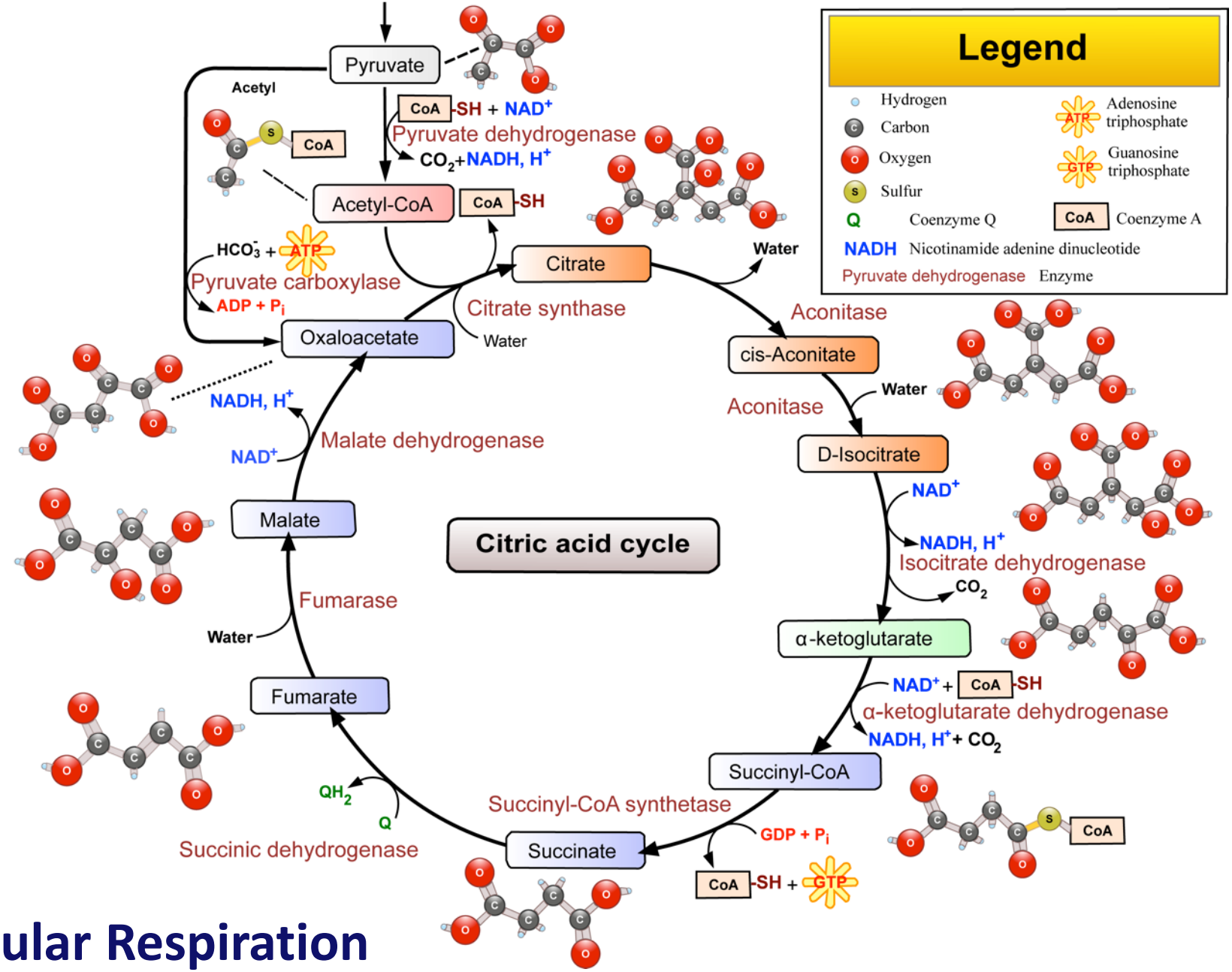
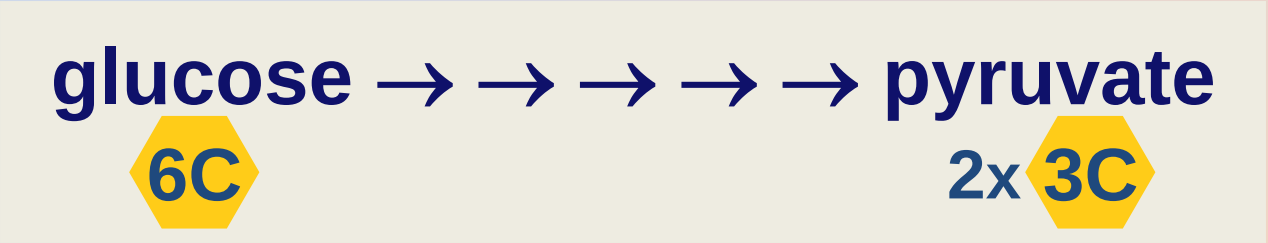


Cellular Respiration

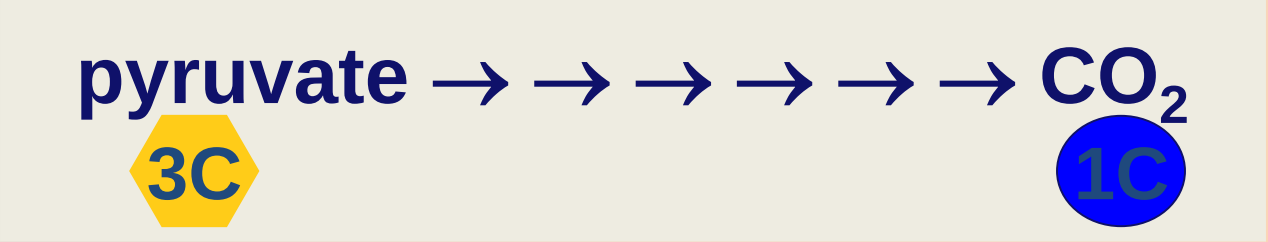
Stage 2 & 3: Oxidation of Pyruvate & Krebs Cycle (Ch. 9)

Glycolysis is only the start

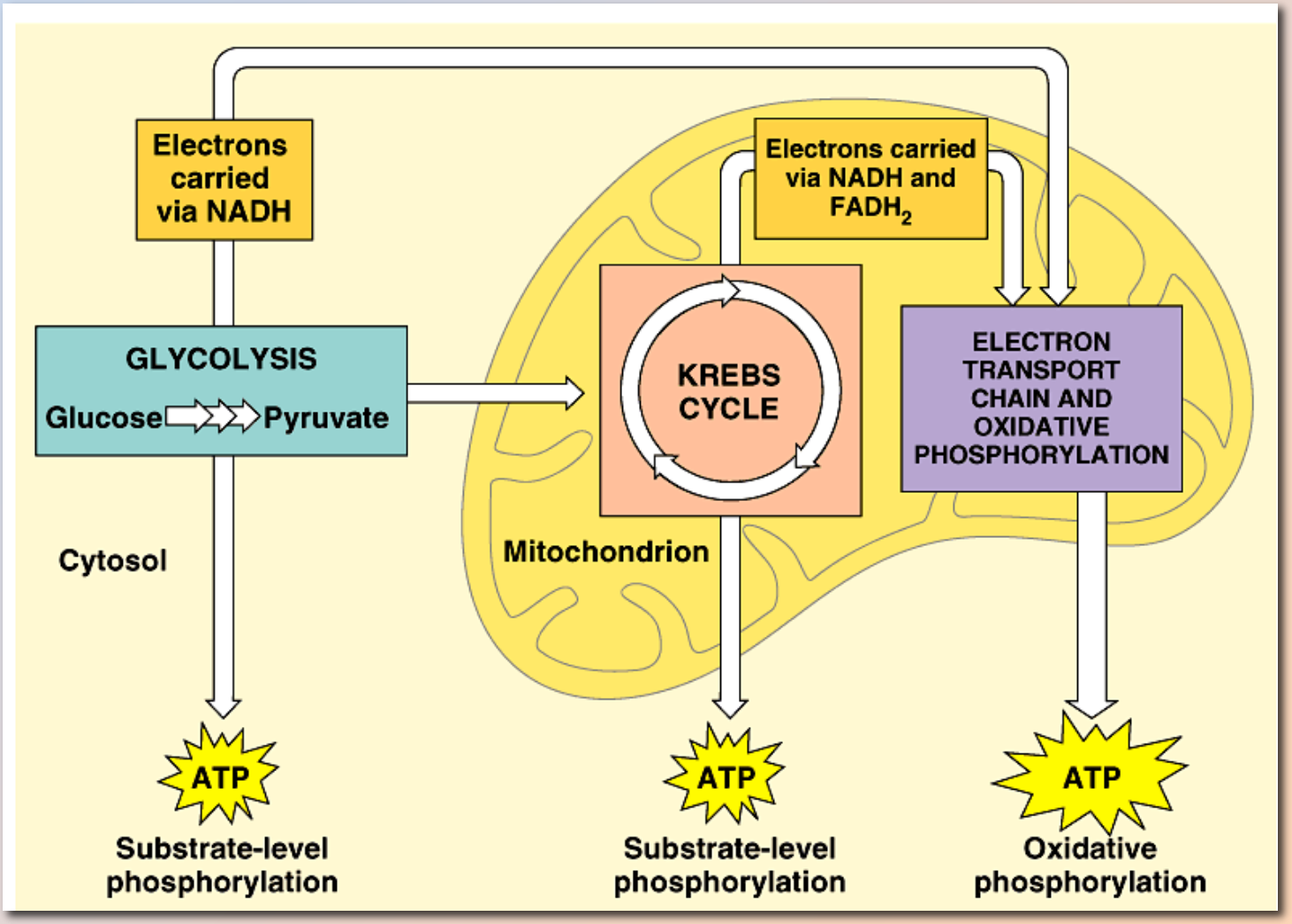
- Glycolysis



- Pyruvate has more energy to yield
  - 3 more C to strip off (to oxidize)
  - if O_2 is available, pyruvate enters mitochondria
  - enzymes of Krebs cycle complete the full oxidation of sugar to CO_2



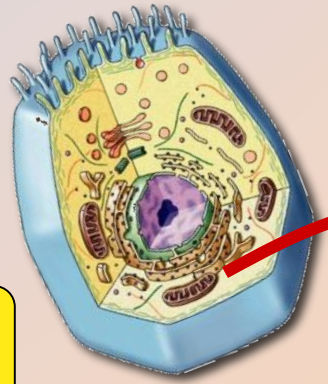
Cellular respiration

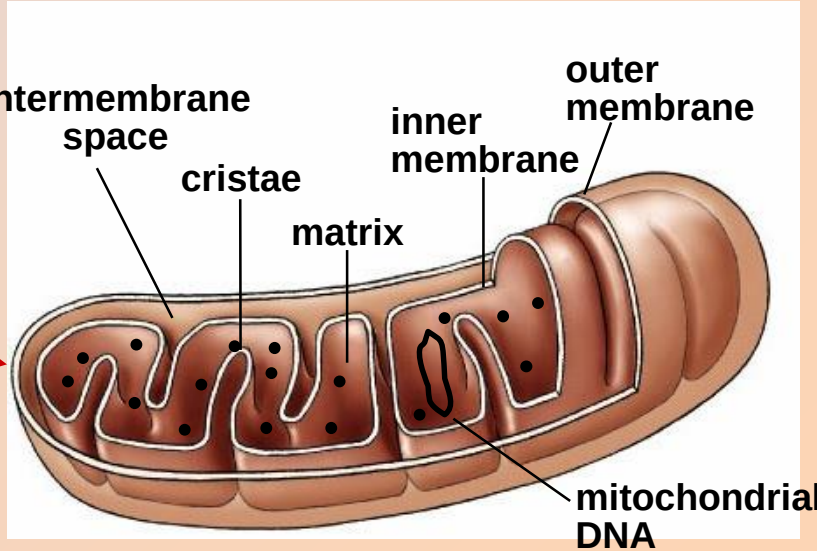


Mitochondria — Structure

- Double membrane energy harvesting organelle
  - smooth outer membrane, highly folded inner membrane
    - cristae
  - intermembrane space
    - fluid-filled space between membranes
  - matrix
    - inner fluid-filled space

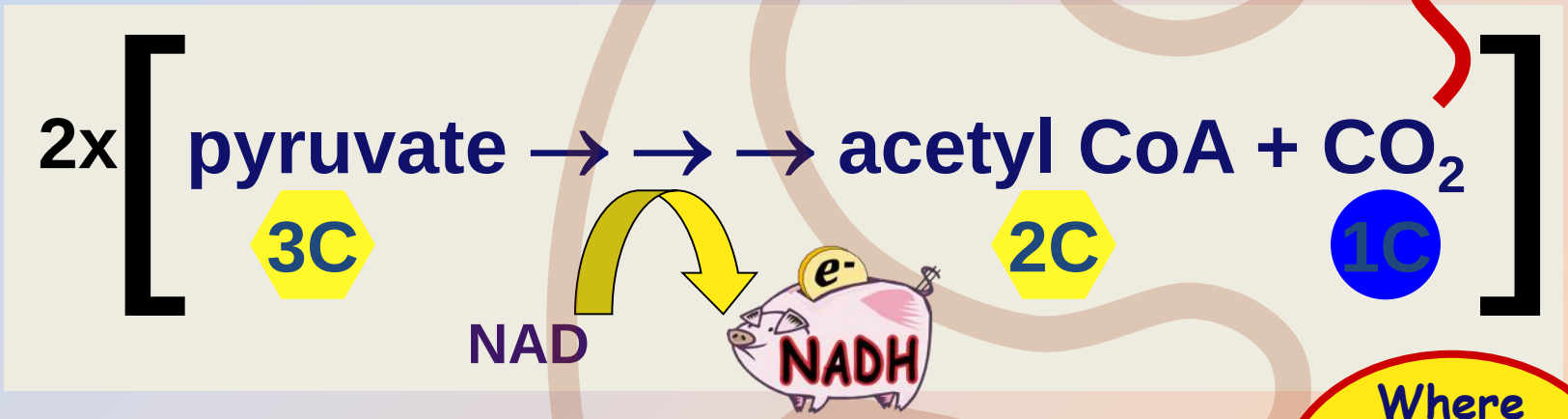
What cells would have a lot of mitochondria?





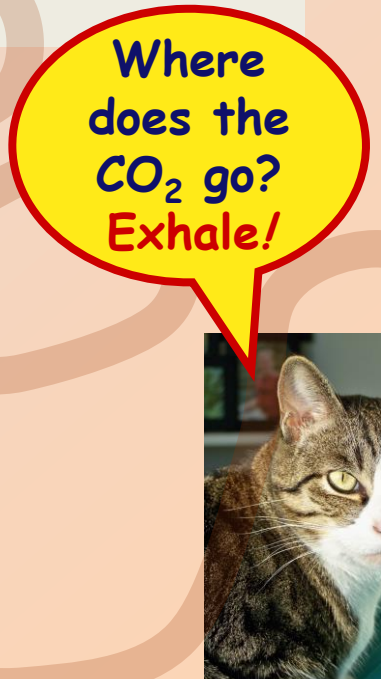
Oxidation of pyruvate

- Pyruvate enters mitochondrial matrix

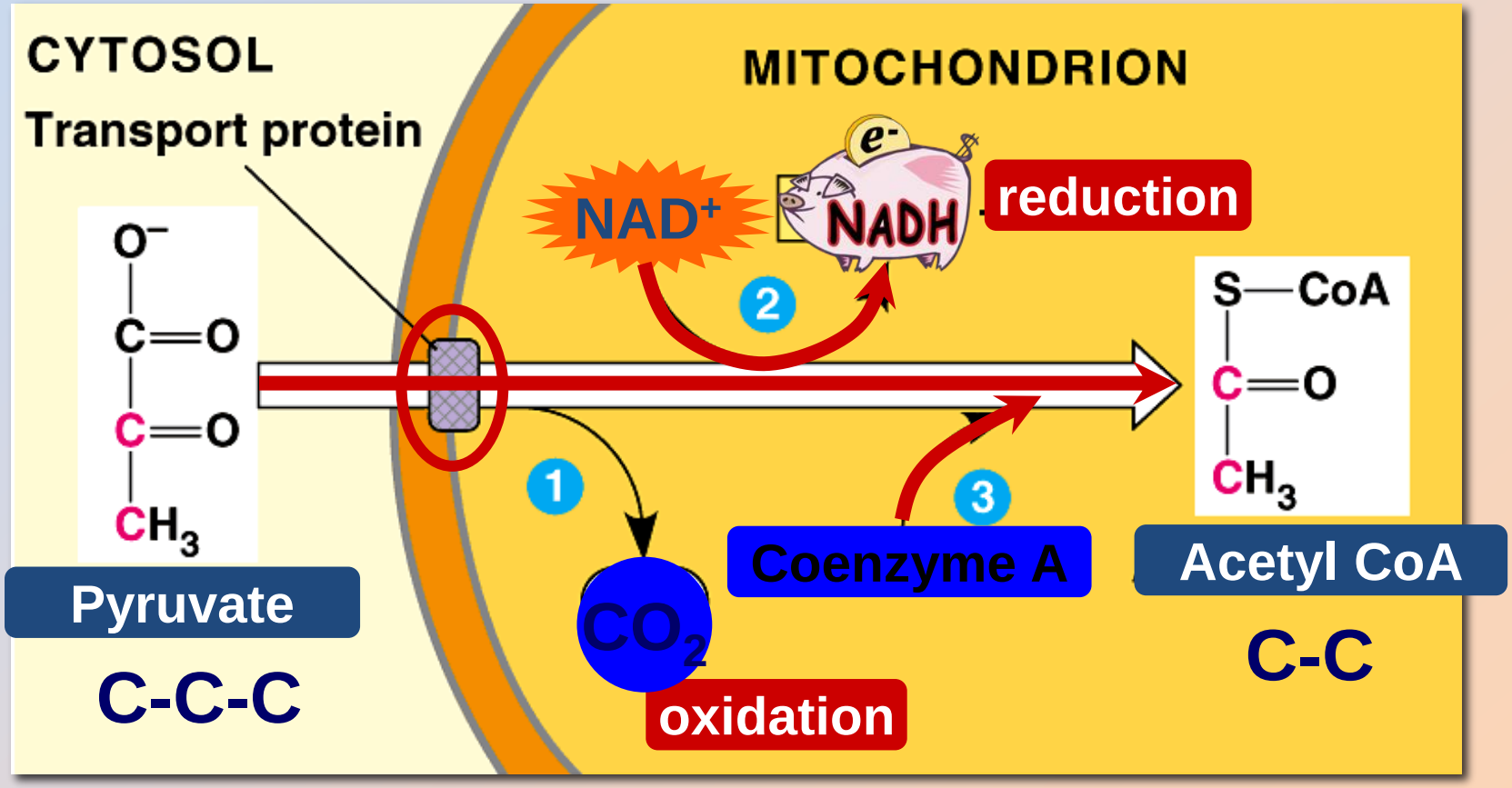


  - 3 step oxidation process
  - releases 2 CO_2 (count the carbons!)
  - reduces 2 NAD → 2 NADH (moves e^-)
  - produces 2 acetyl CoA

- Acetyl CoA enters Krebs cycle



Pyruvate oxidized to Acetyl CoA



2 x [Yield = 2C sugar + NADH + CO_2]

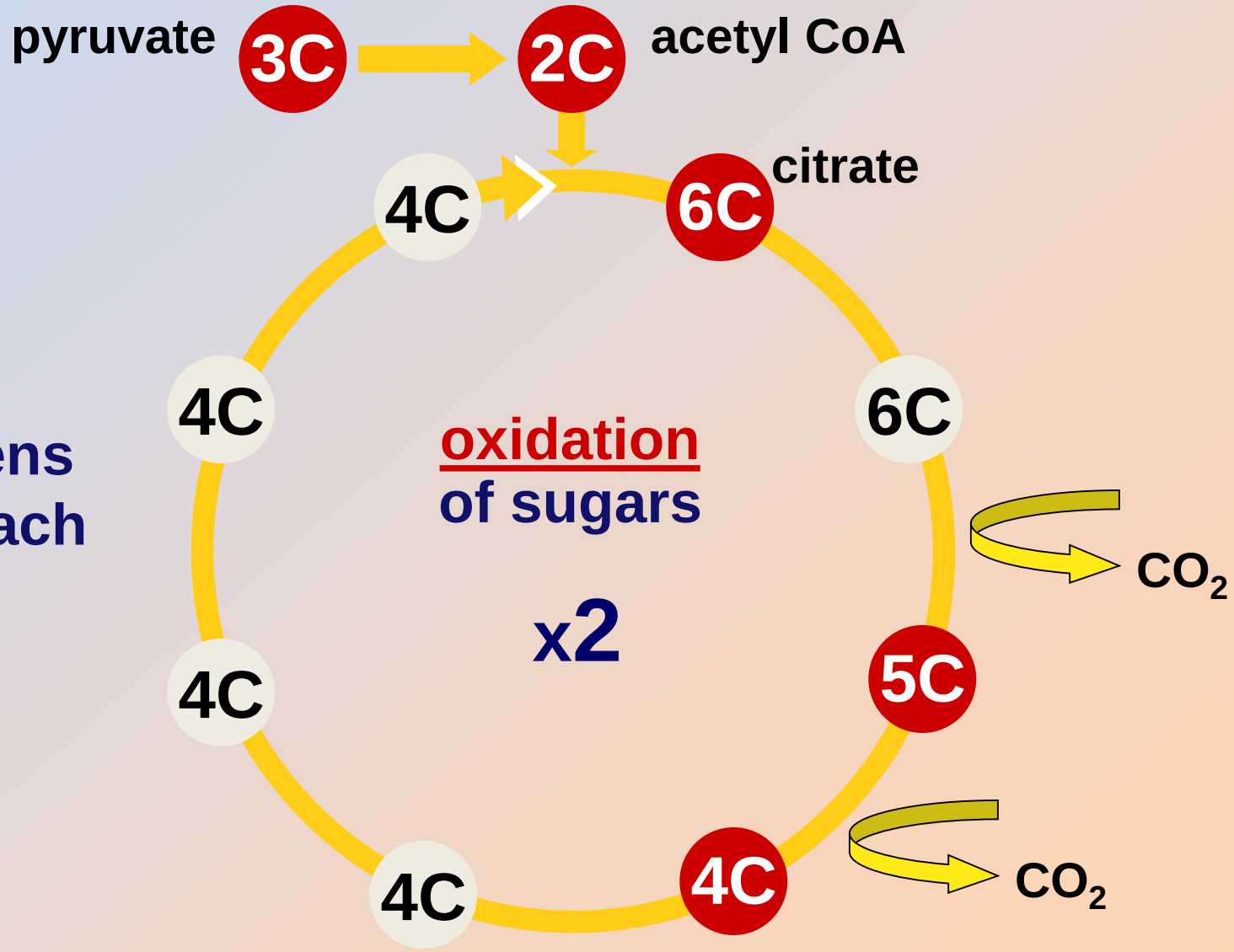
Krebs cycle

1937 | 1953

Hans Krebs
1900-1981

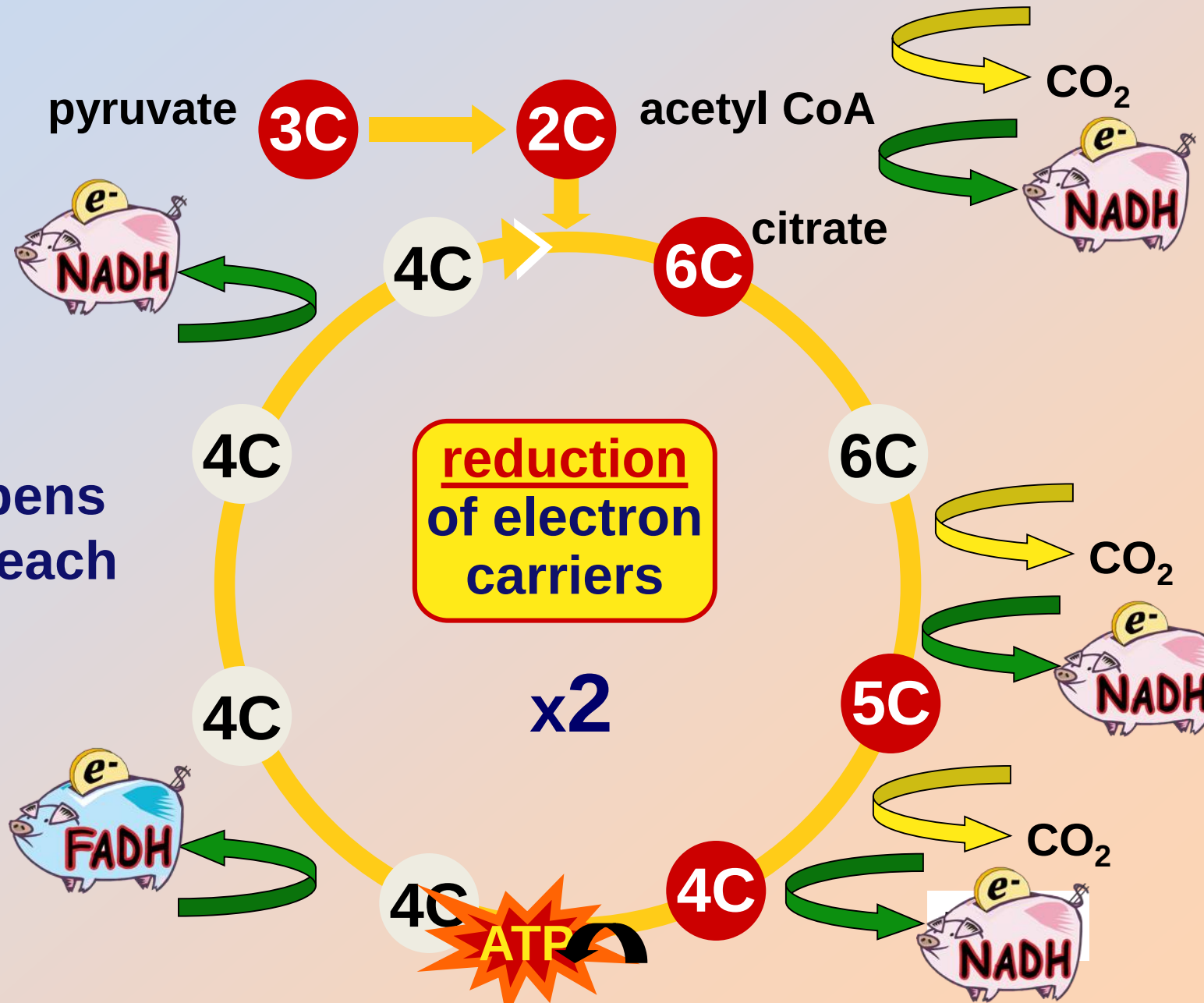
- aka Citric Acid Cycle
  - in <u>mitochondrial matrix</u>
  - 8 step pathway: each catalyzed by specific enzyme
    - step-wise <u>catabolism</u> of <u>6C citrate</u> molecule
- Evolved later than glycolysis
  - does that make evolutionary sense?
    - bacteria $\rightarrow$3.5 billion years ago (glycolysis)
    - free O_2 $\rightarrow$2.7 billion years ago (photosynthesis)
    - eukaryotes $\rightarrow$1.5 billion years ago (aerobic respiration = organelles $\rightarrow$ mitochondria)

Count the carbons!



This happens twice for each glucose molecule

Count the electron carriers!



This happens twice for each glucose molecule

Whassup?

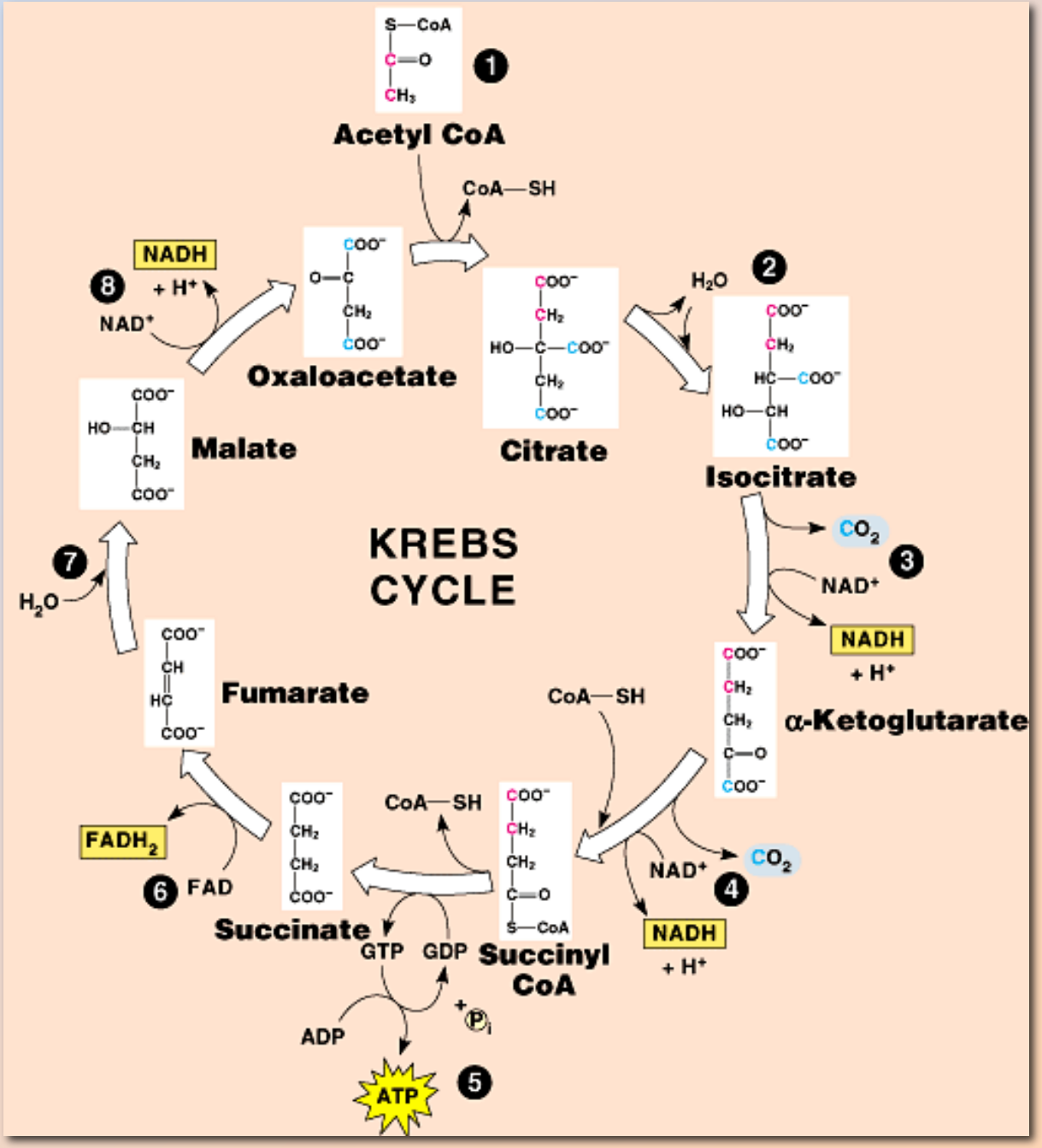
So we fully oxidized glucose

$C_6H_{12}O_6$

↓

CO_2

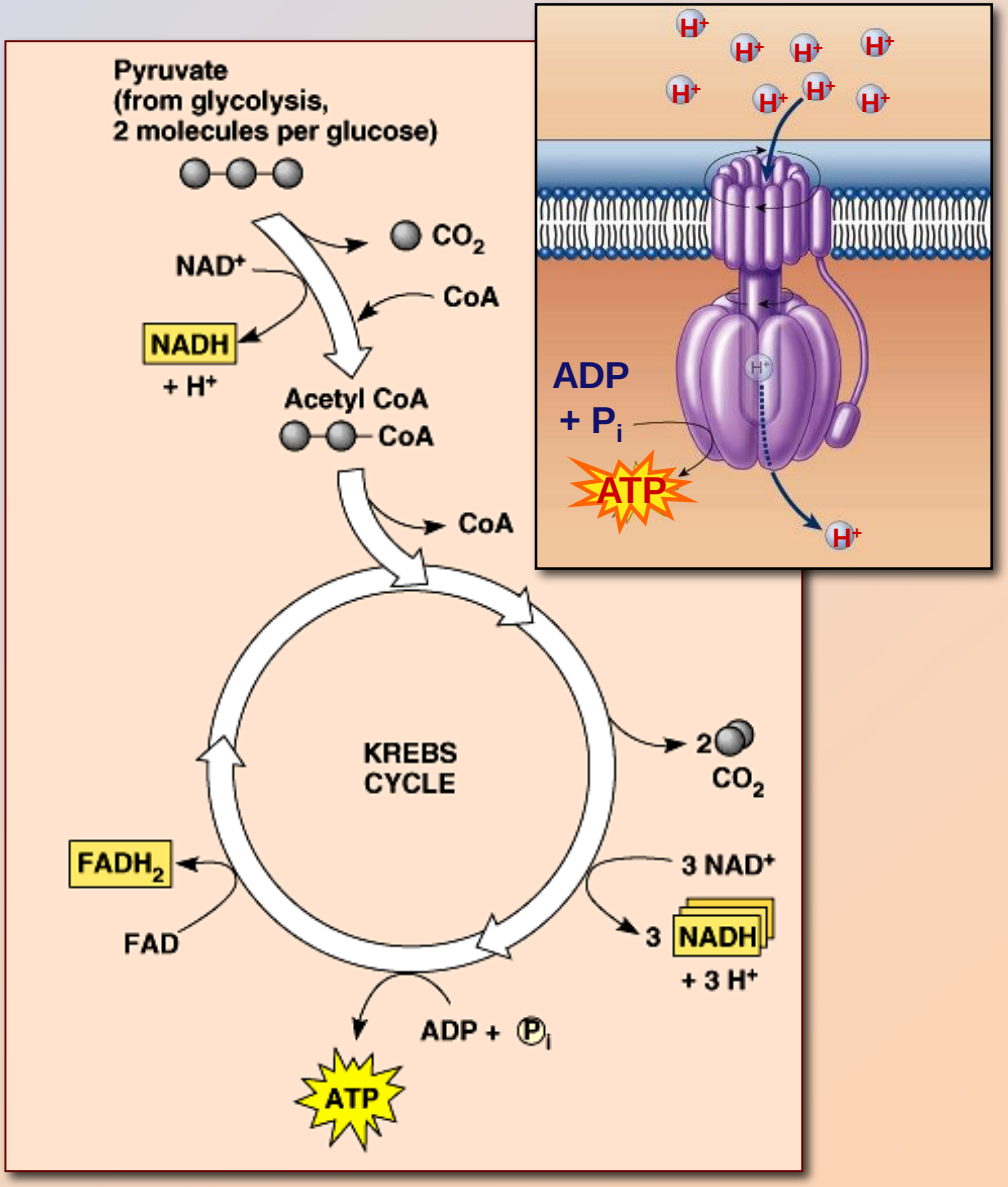
& ended up with 4 ATP!



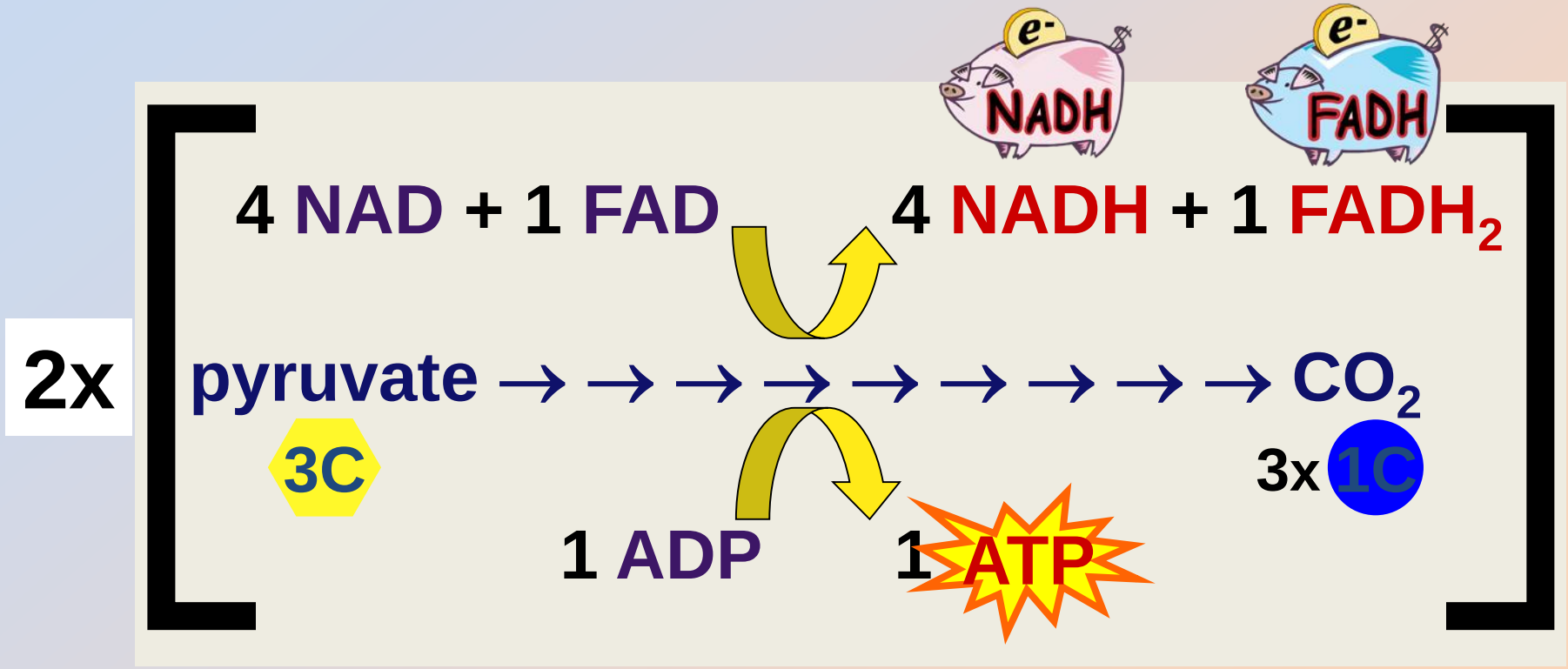
Electron Carriers = Hydrogen Carriers

- **Krebs cycle produces large quantities of <u>electron carriers</u>**
  - **NADH**
  - **$FADH_2$**
  - **go to <u>Electron Transport Chain</u>!**

What's so important about electron carriers?



Energy accounting of Krebs cycle

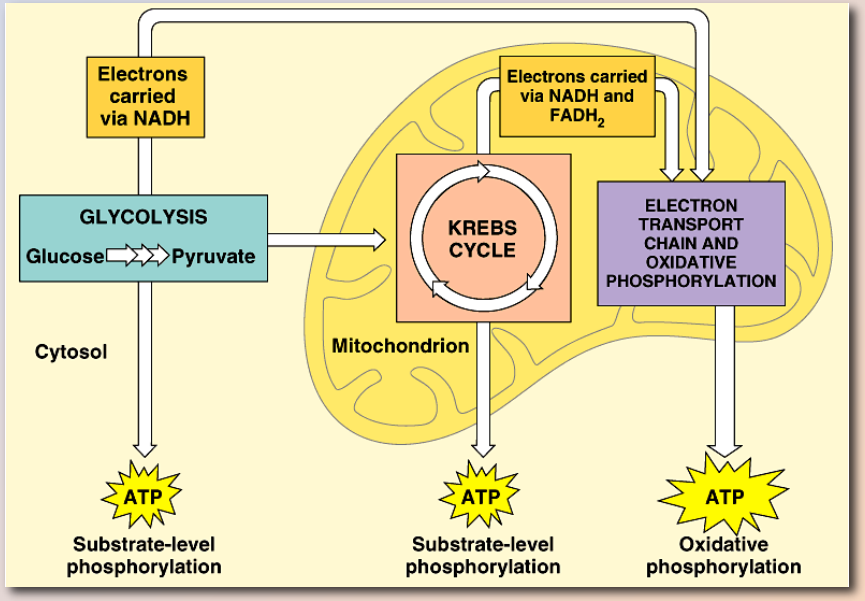


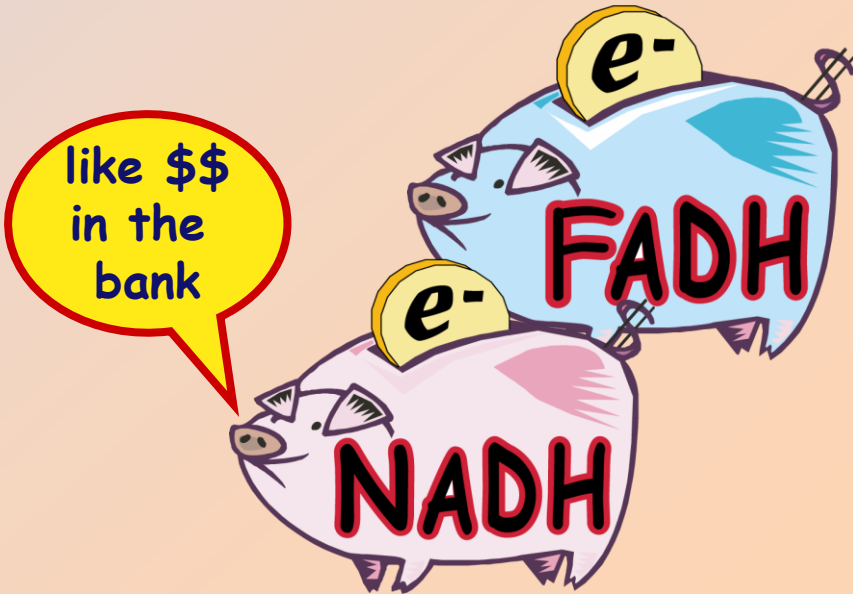
Net gain = 2 ATP

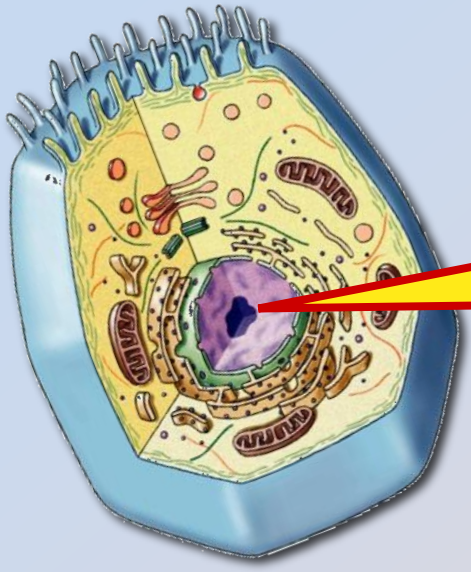
= 8 NADH + 2 $FADH_2$

Value of Krebs cycle?

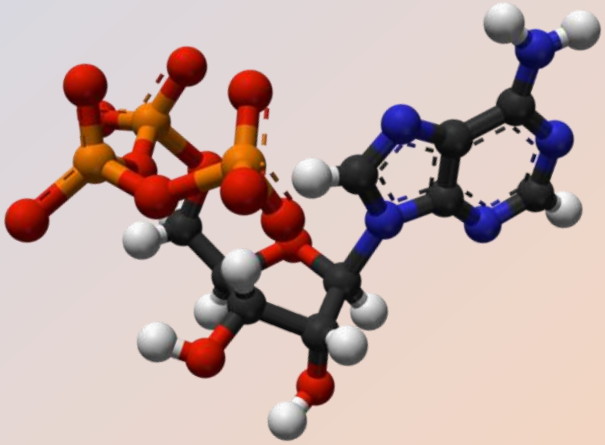
- If the yield is only 2 ATP then how was the Krebs cycle an adaptation?
  - value of $NADH$ & $FADH_2$
    - electron carriers & H carriers
      - reduced molecules move electrons & H^+
    - to be used in the Electron Transport Chain







What's the point?



The point is to make ATP!

ATP

Review Questions

1. All of the following molecules are produced by the Kreb's cycle EXCEPT

2. ATP

A. CO_2

B. Pyruvate

C. FADH

D. NADH

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3. By the end of the Kreb's cycle, which of the following statements are true

I. All of the carbon from the original glucose molecule has been oxidized to Carbon Dioxide

II. All of the electrons from the original glucose molecule have been transferred to ATP molecules

III. Oxygen is no longer necessary for the remaining steps of aerobic respiration

A. I only
B. II only
C. III only
D. I and II only
E. I, and III only

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