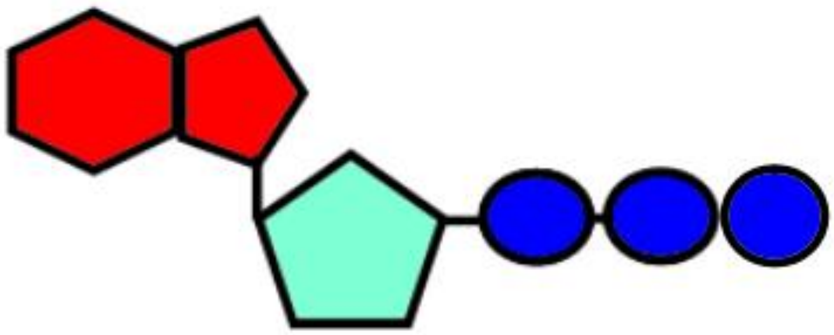
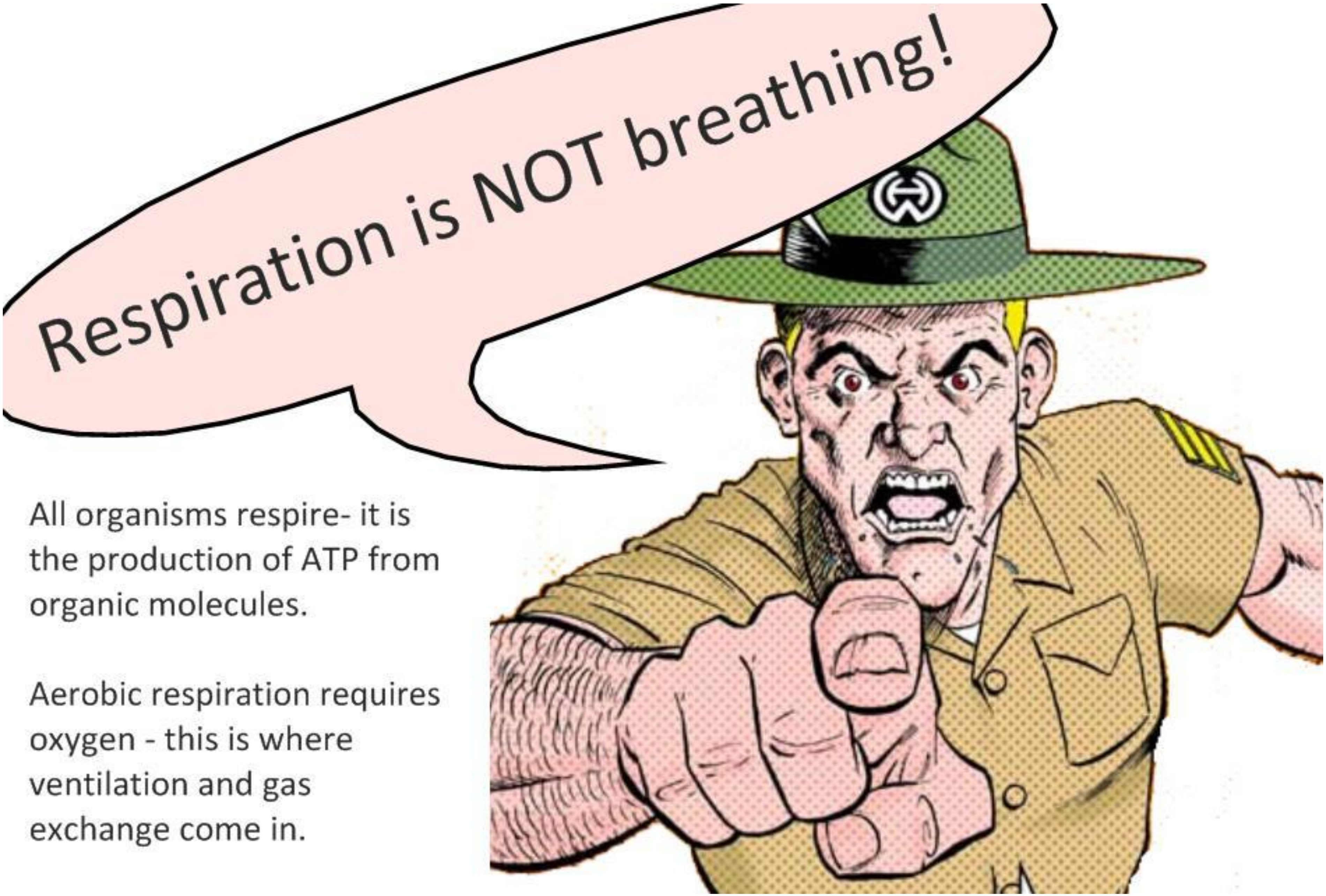


Cellular Respiration
Core & AHL (or SL Option C!)

http://www.youtube.com/watch?v=3aZrkdzrd04
http://www.youtube.com/watch?v=VCpNk92uswY



All organisms respire- it is the production of ATP from organic molecules.

Aerobic respiration requires oxygen - this is where ventilation and gas exchange come in.

Cell Respiration

"The controlled release of energy

by enzymes:

metabolic pathways and cycles!

Cell Respiration

"The <u>controlled</u> release of energy

by enzymes:

metabolic pathways and cycles!

How can cells control the rate of enzyme catalysed pathways and cycles?

Cell Respiration

"The controlled release of energy

by enzymes:

metabolic pathways and cycles!

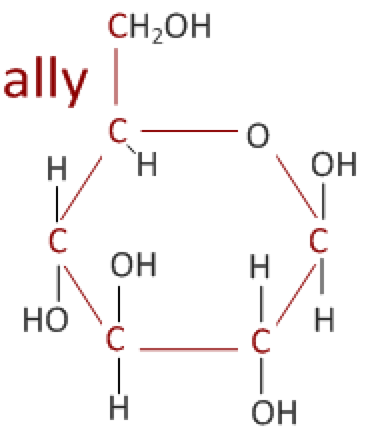
How can cells control the rate of enzyme catalysed pathways and cycles?

end product inhibition!

Cell Respiration

"The controlled release of energy from organic compounds in cells to form ATP"

usually

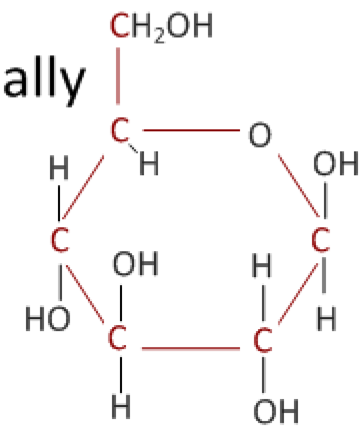


glucose/ carbohydrates

Cell Respiration

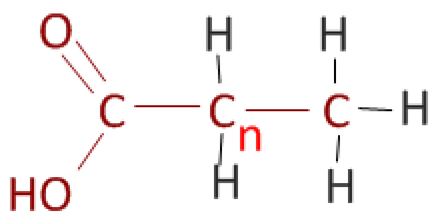
"The controlled release of energy from organic compounds in cells to form ATP"

usually

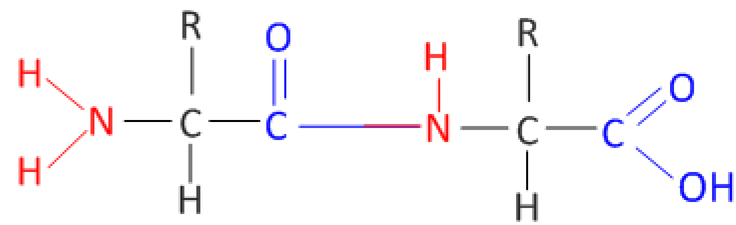


glucose/ carbohydrates

sometimes



lipids/ fatty acids

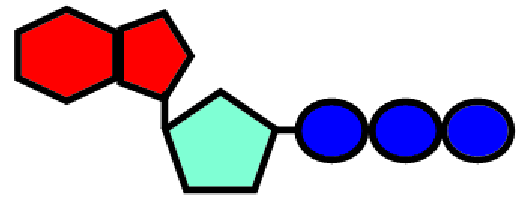


proteins

Cell Respiration

Universality vs diversity!

"The controlled release of energy from organic compounds in cells to form ATP"



used for
energetic processes

muscle contraction

active transport

protein synthesis

vesicle transport

DNA/ RNA replication

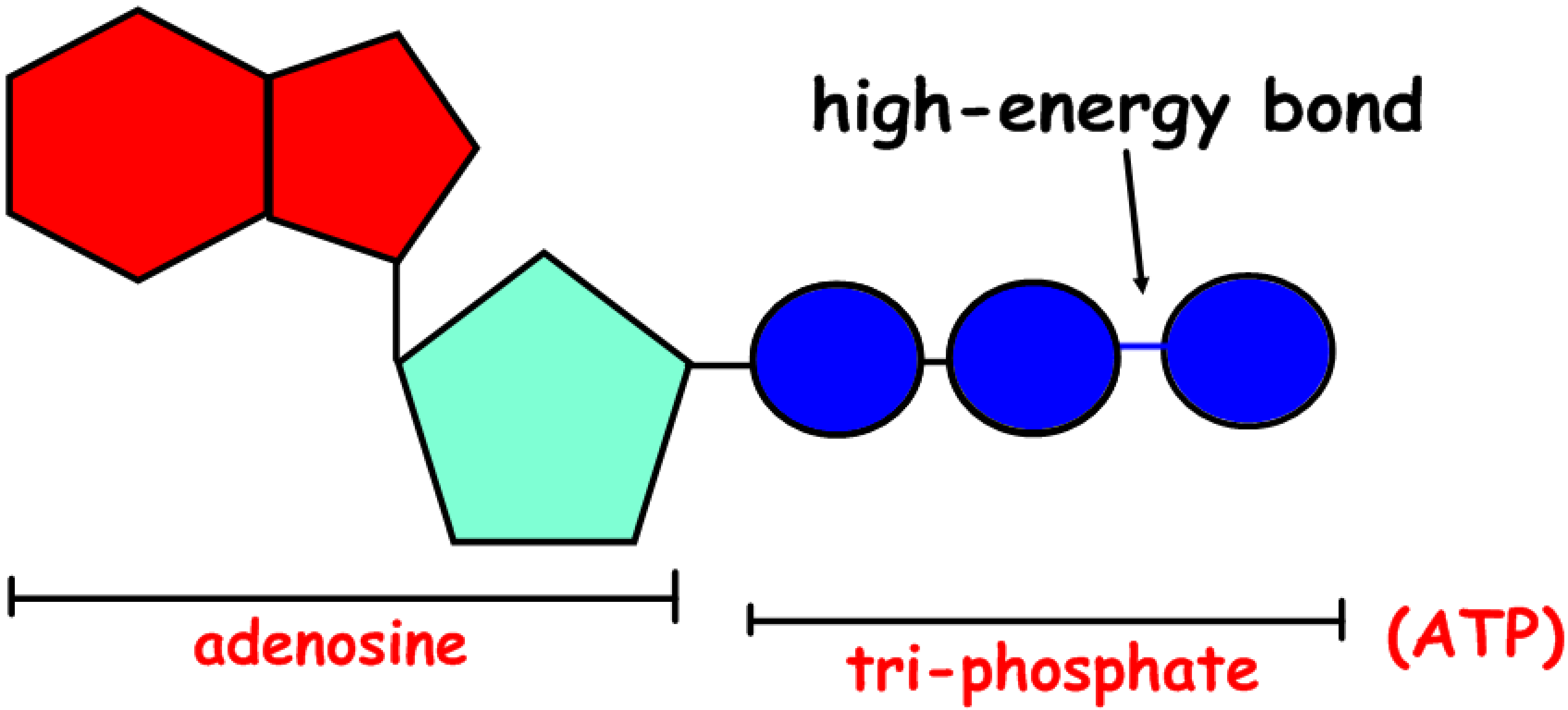
cell signalling

Cell Respiration

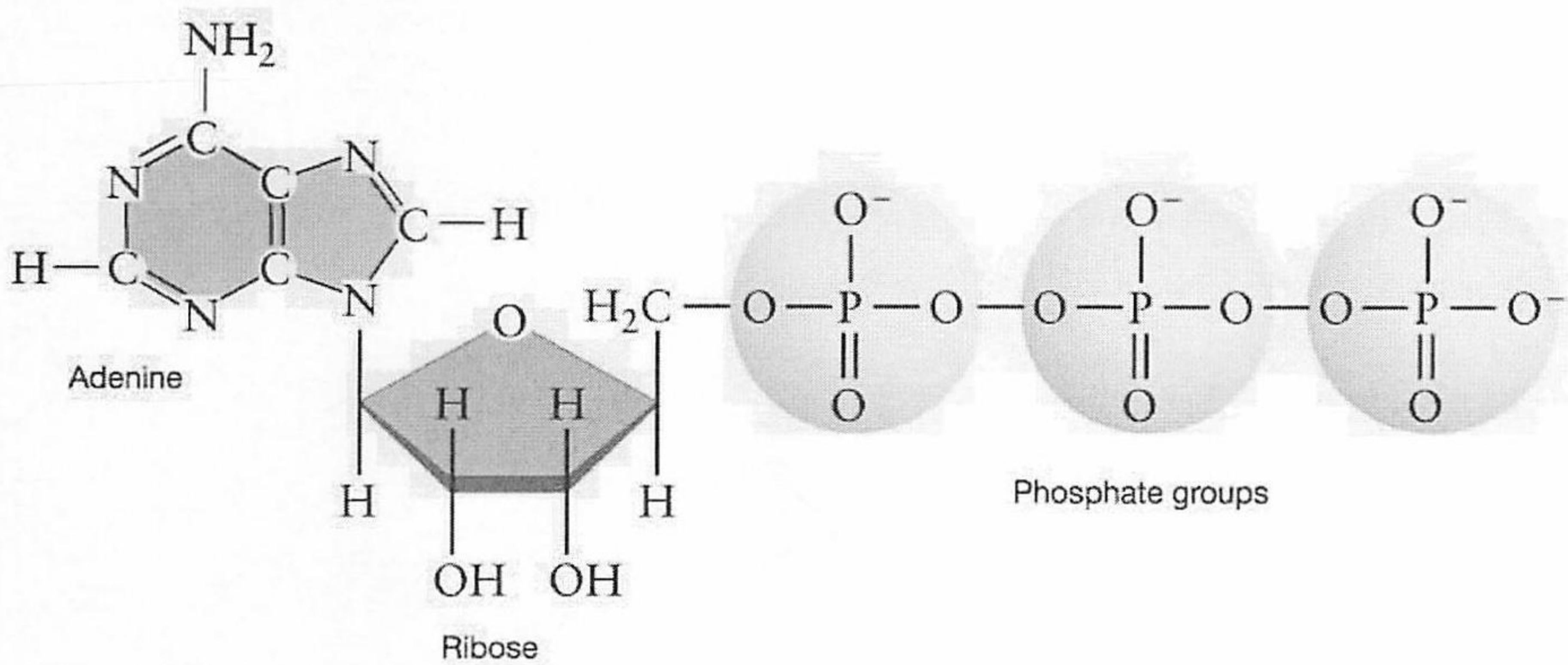
"The controlled release of energy from organic compounds in cells to form ATP"

- What is ATP?
  - The molecule ATP (Adenosine Triphosphate) is the universal energy carrier for the cell.
- Why is ATP a universal energy carrier?
  - ATP can release a small, specific amount of energy quickly on demand.

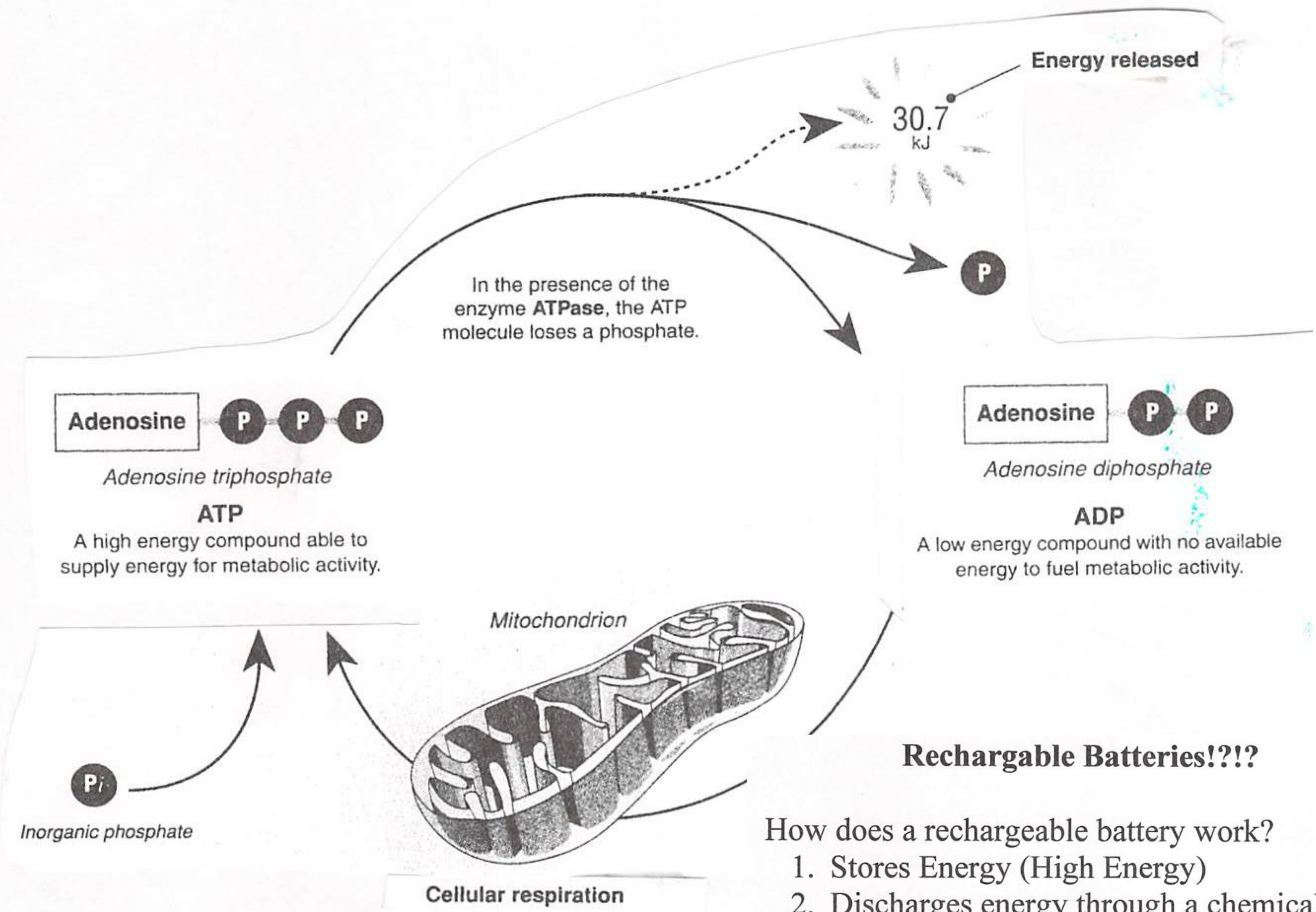
What does ATP Look like?



But really?


NH2
N
C
C
N
C
H
H
C
C
N
N
Adenine
O
H2C
H
H
H
H
OH
OH
Ribose
O-
O-
O-
O
P
O
O
P
O
O
P
O-
O
O
O
Phosphate groups

ATP works just like a rechargeable battery!



Rechargable Batteries!?!?

How does a rechargeable battery work?

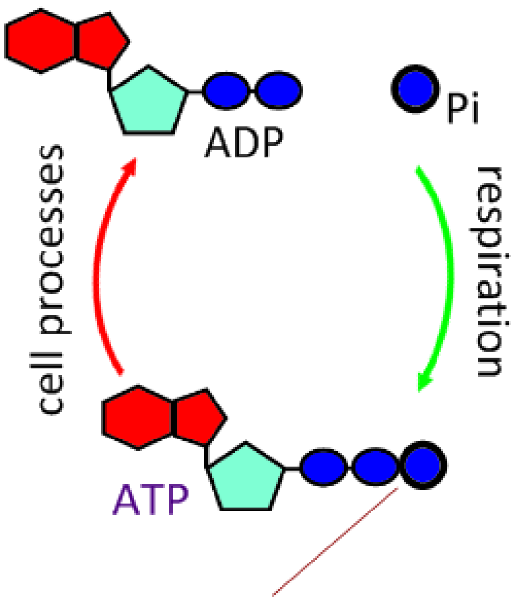
1. Stores Energy (High Energy)
2. Discharges energy through a chemical reaction
3. "Dead Battery" (Low Energy)
4. Battery must be re-charged in an "energy-producing" device.

How do we get the energy to "recharge" our ATP?

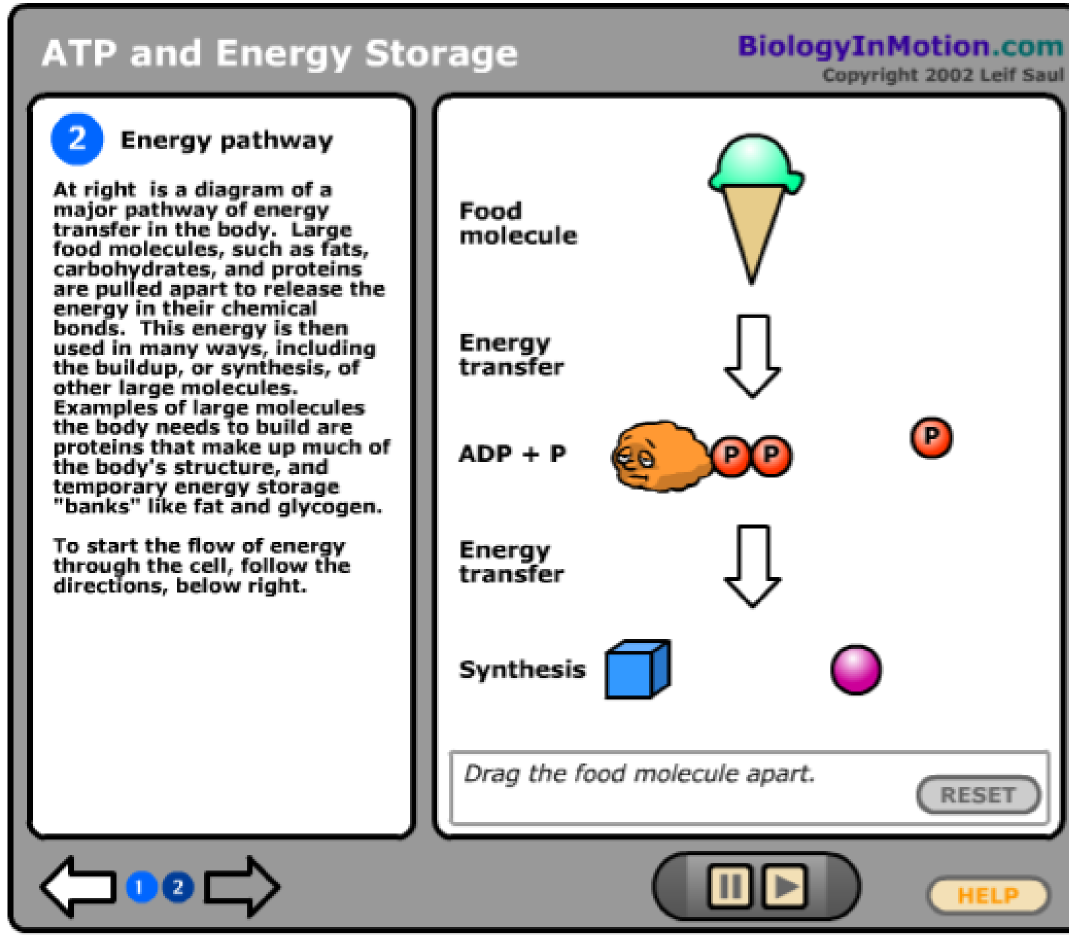
- It is supplied by the controlled breakdown of glucose (or fats and proteins) during cellular respiration.

ATP adenosine tri-phosphate

Respiration generates ATP from ADP and phosphate ions in the cell.



This high energy bond is a temporary store of energy, which is broken to release energy in cell processes.

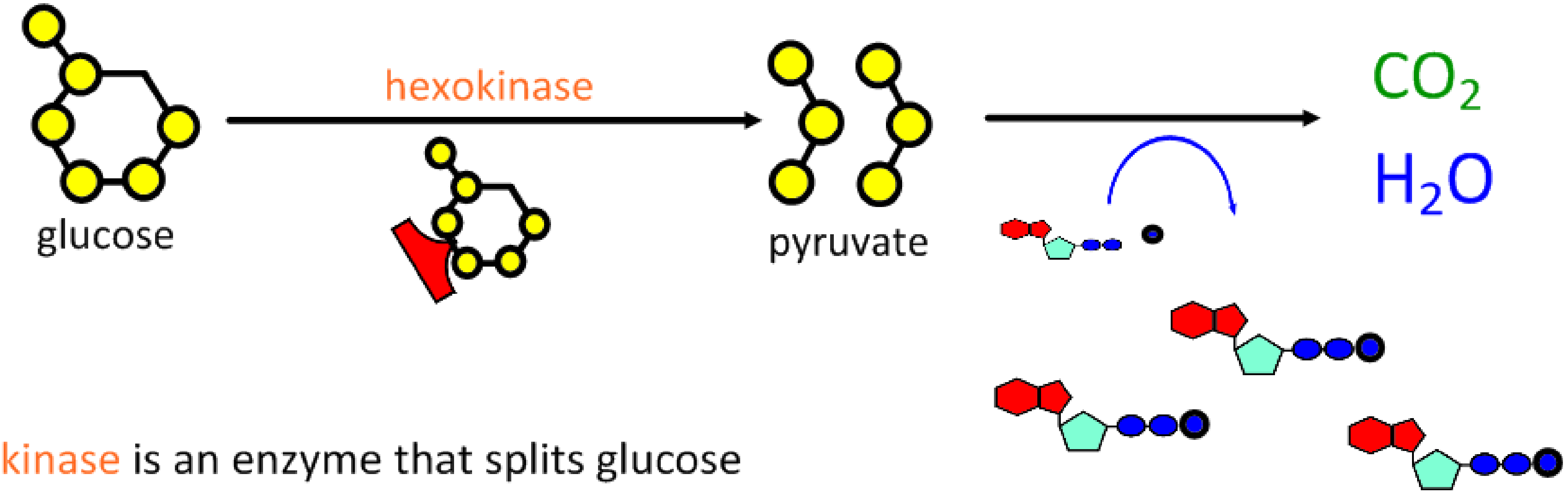


http://www.biologyinmotion.com/atp/index.html

ATP is not a stable long-term energy store. Cells in tissues which have a high energy demand are rich in mitochondria, in order to keep generating sufficient ATP. Long-term stores include lipids and glycogen, which can be metabolised through respiration as needed.

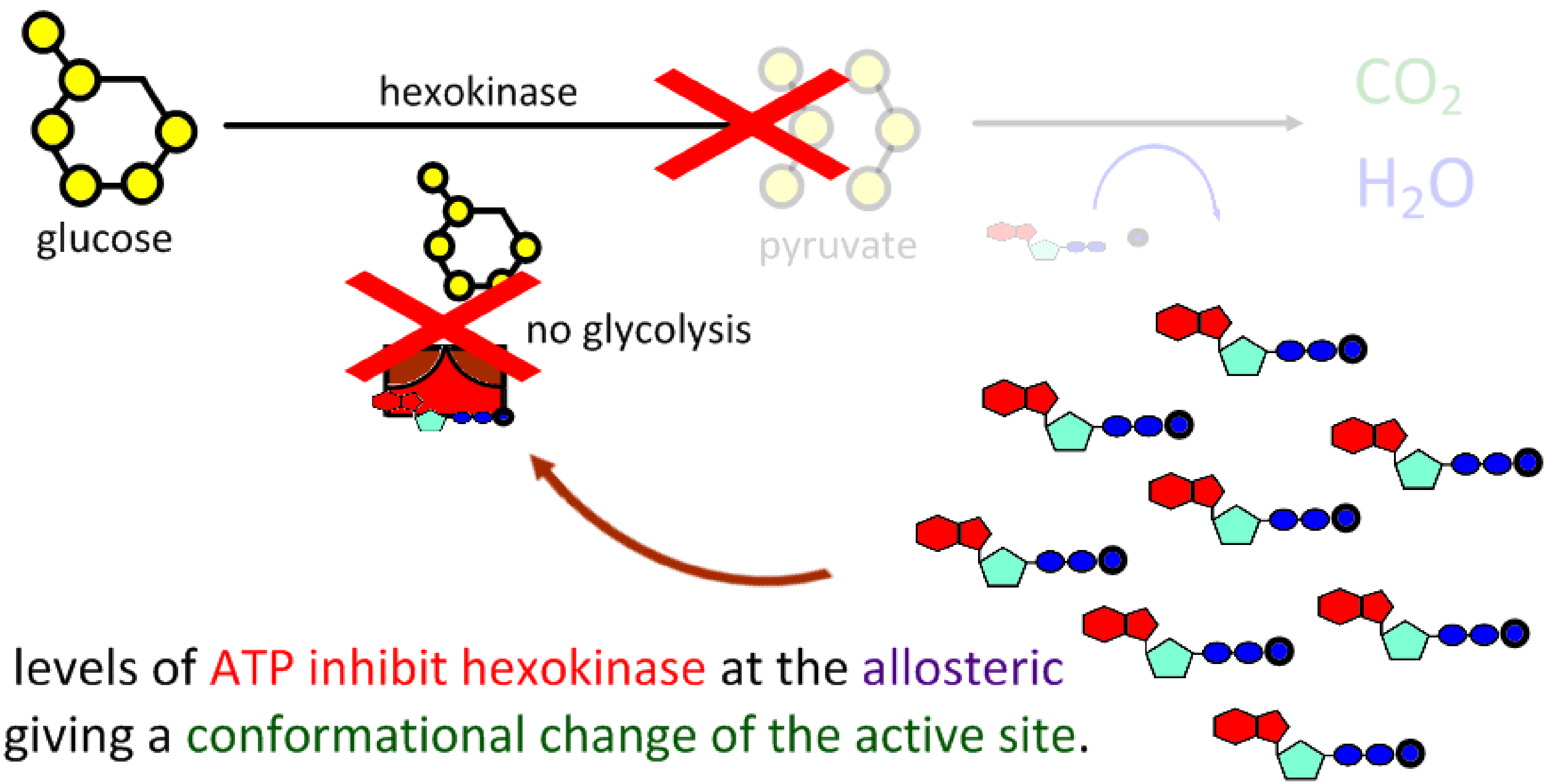
http://www.biologyinmotion.com/atp/

Cell Respiration is an enzyme-controlled metabolic pathway which can be controlled by end-product inhibition.



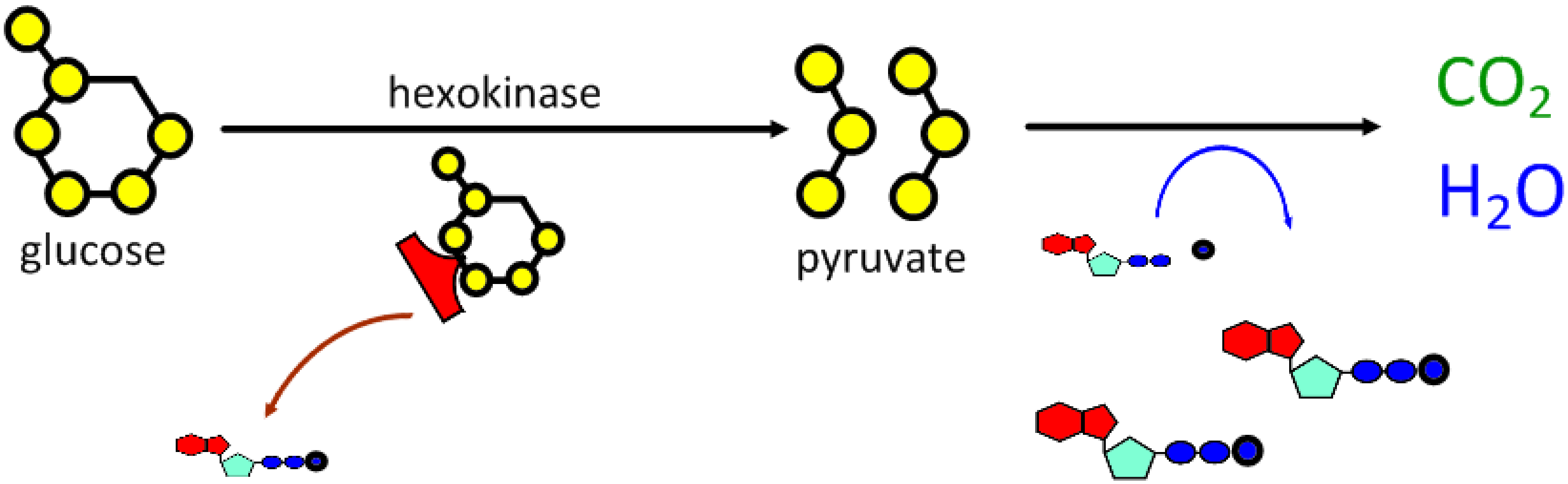
hexokinase is an enzyme that splits glucose into pyruvate molecules (glycolysis).

Cell Respiration is an enzyme-controlled metabolic pathway which can be controlled by end-product inhibition.



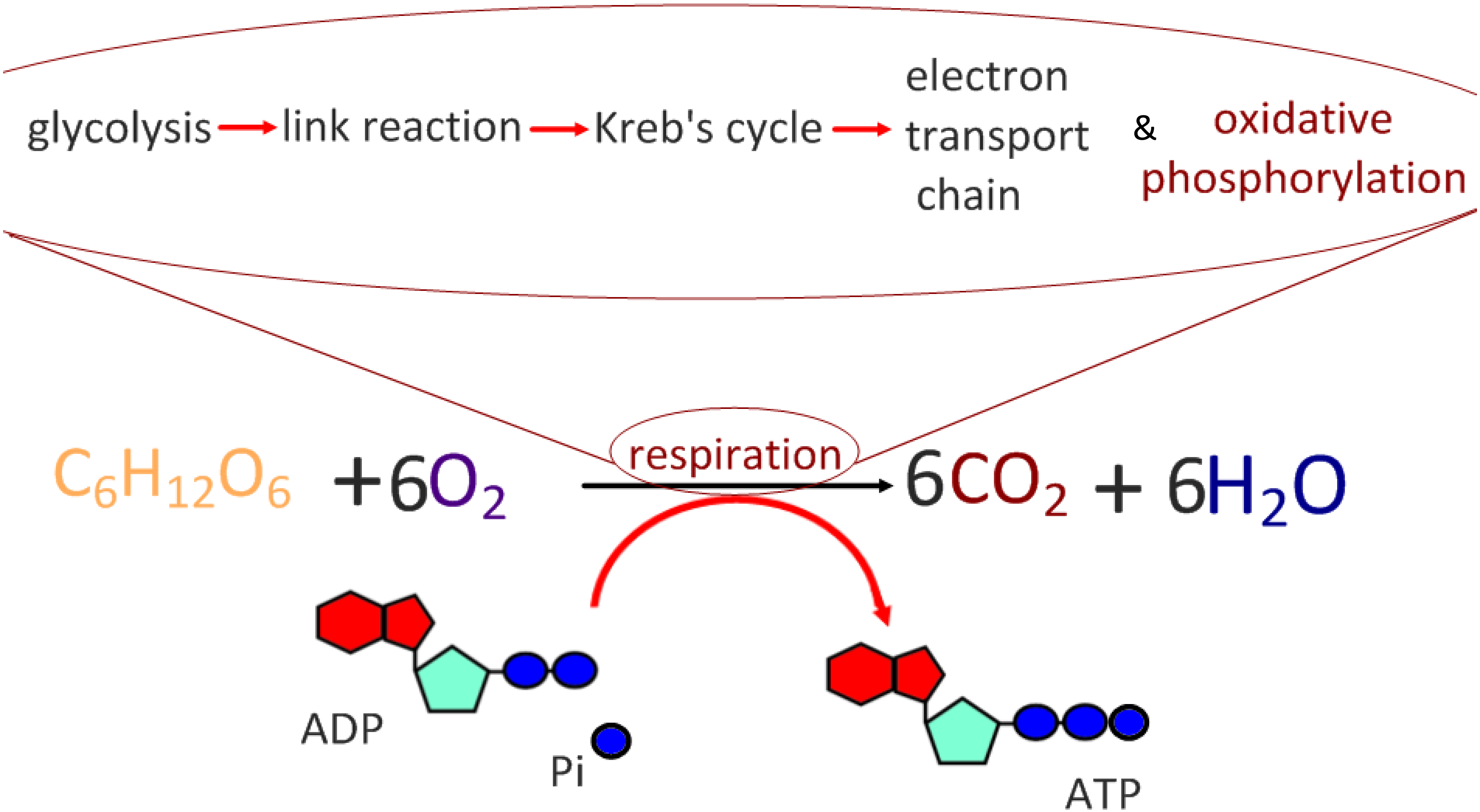
High levels of ATP inhibit hexokinase at the allosteric site, giving a conformational change of the active site.

Cell Respiration is an enzyme-controlled metabolic pathway which can be controlled by end-product inhibition.

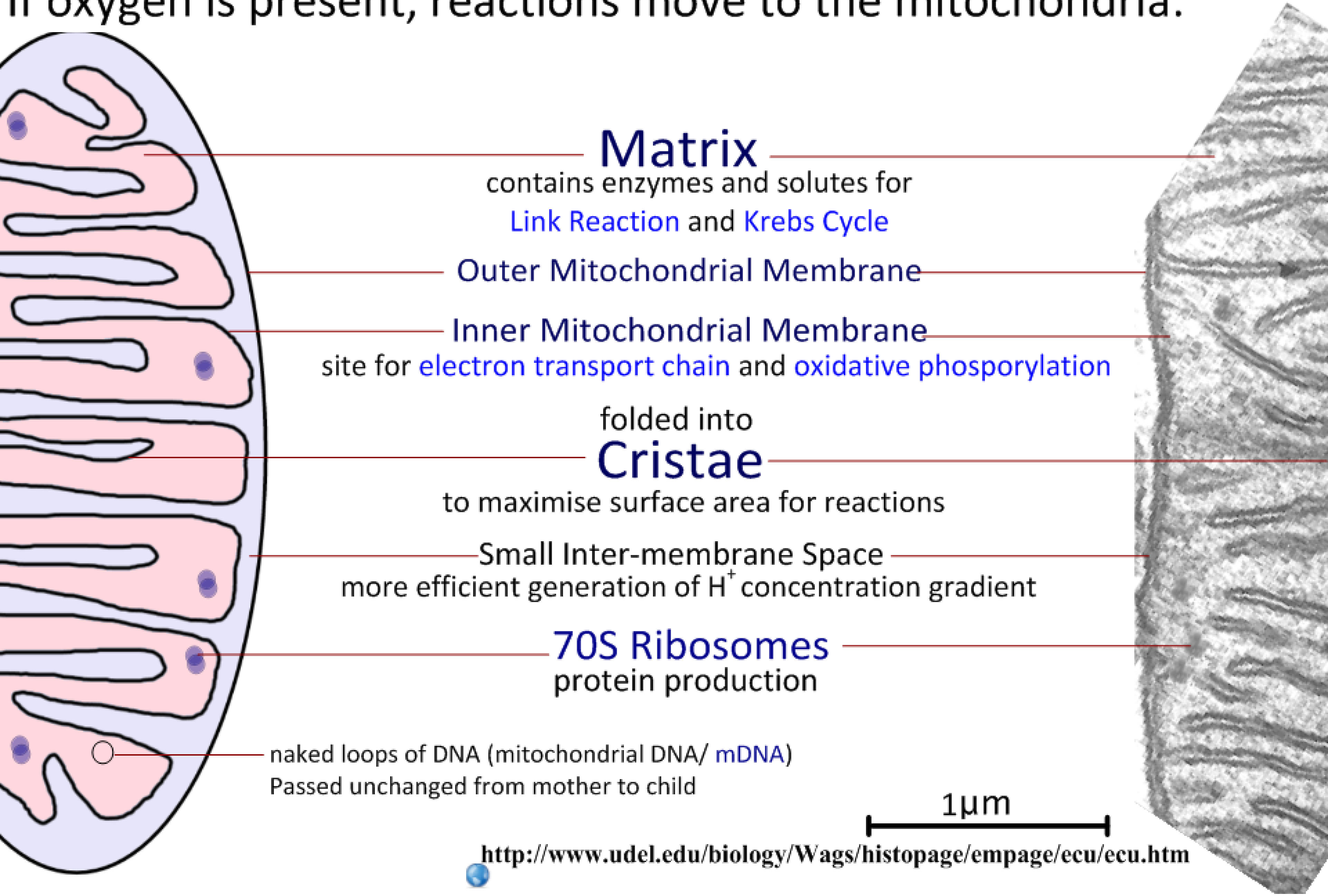


High levels of ATP inhibit hexokinase at the allosteric site, giving a conformational change of the active site.

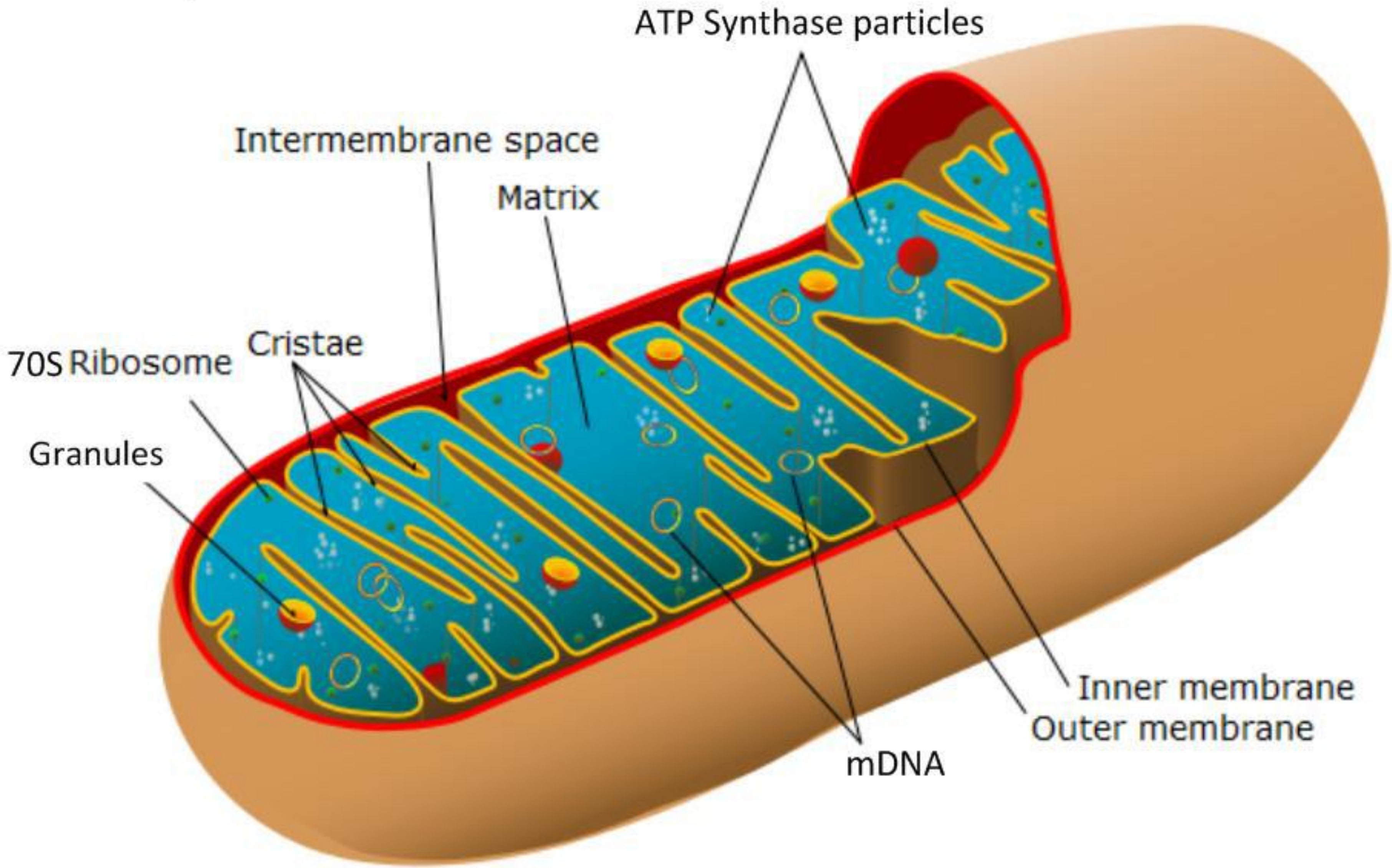
This is reversed when ATP levels return to normal.


glycolysis
link reaction
Kreb's cycle
electron transport chain
&
oxidative phosphorylation
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
respiration
ADP
Pi
ATP

If oxygen is present, reactions move to the mitochondria:



Label the parts:



http://en.wikipedia.org/wiki/Mitochondrion

Label the parts:

outer membrane

inner membrane

inter-membrane space

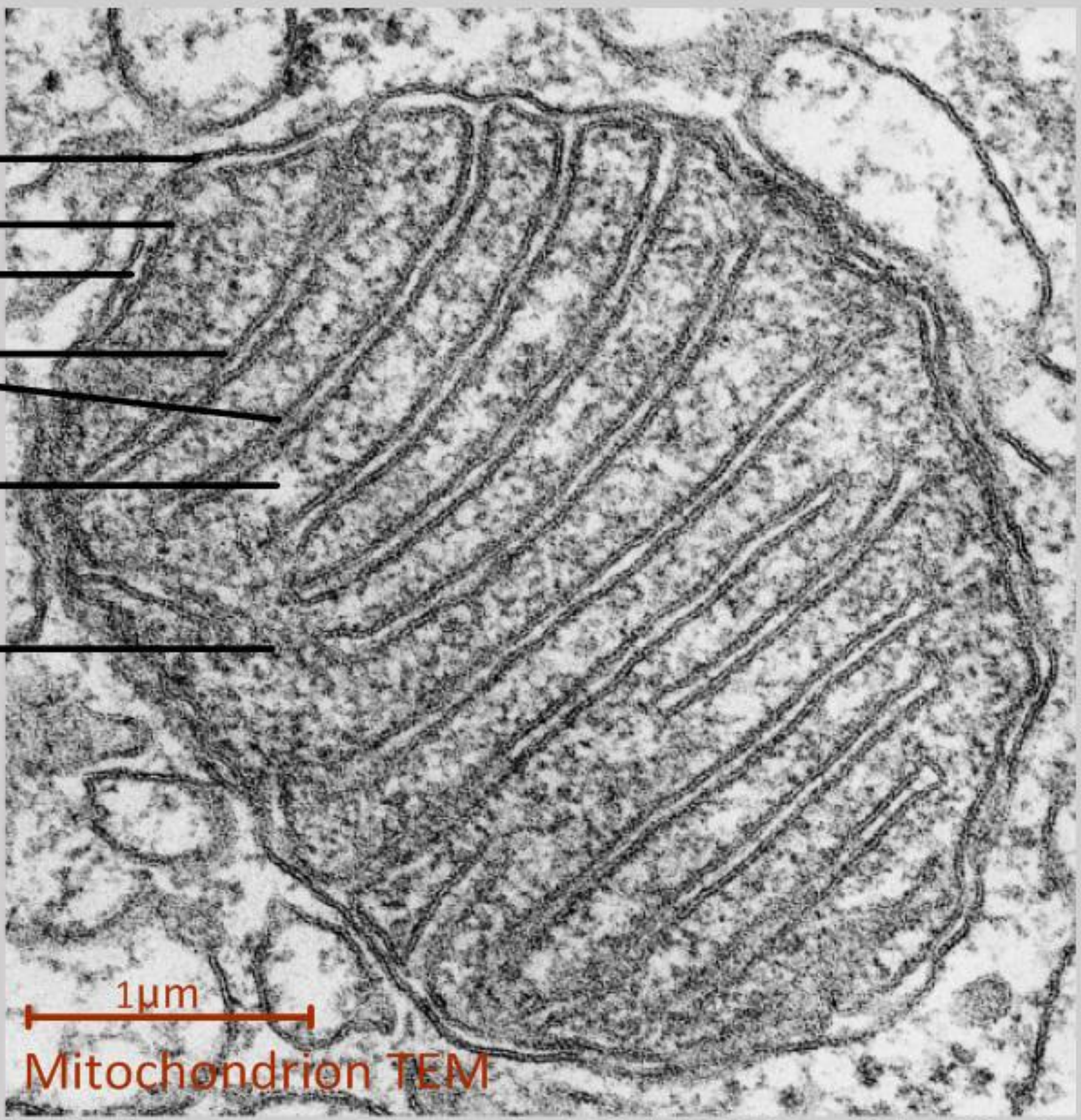
christae

matrix

70S Ribosomes

not easily visible:

- mDNA



http://antiparos.zoo.ox.ac.uk/presentations/Talks/20060526-DataWeb-tech.html

Print this image and calculate:

- magnification
- maximum length
- width of one crista

Make your own Mitochondria ☺

Oxidation & Reduction (Redox)

- In order to understand what is going on in Cellular Respiration, you must understand the chemical processes of Oxidation and Reduction

What happens when cellular respiration decomposes glucose (and other fuels) and why does this yield energy?

- The answer is based on the transfer of electrons during chemical reactions.
- The movement of electrons releases energy stored in foods!

When electrons are transferred from one reactant to another, the oxidation reduction reactions (or REDOX reactions) occur.

Oxidation:

- A reactant is oxidized when it loses electrons (H).
- Oxidation can also mean to gain oxygen!

Reduction:

- A reactant is reduced when it gains electrons (H).
- Reduction can also mean to lose oxygen!

How am I ever going to remember this!?!?!?

OIL RIG

"Oxidation is Loss, Reduction is Gain"

OR TRY…

Leo the lion says Ger

"Loss of Electrons Oxidation,
Gain of Electrons Reduction"

For Example:

oxidation

$$Xe^- + Y \rightarrow X + Ye^-$$

reduction

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O + \text{Energy}$$

Follow the Carbon!

And one more thing...

- The substance that is oxidized is called the reducing agent, because it causes the other reactant to be reduced.
- The substance that is reduced is called the oxidizing agent, because it causes the other reactant to be oxidized.

Try it yourself!

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + \text{Energy}$$

1.) What is oxidized?
2.) What is reduced?
3.) What is the reducing agent?
4.) What is the oxidizing agent?

How do Redox reactions release energy?

- When an electron is added to a molecule the process is referred to as **reduction**.
  - A reduced molecule contains <u>more energy </u>than it does in an unreduced state.
- **Oxidation** is the reverse of reduction. It involves the removal of an electron (or hydrogen).
  - When a molecule is oxidized it <u>releases energy</u>.

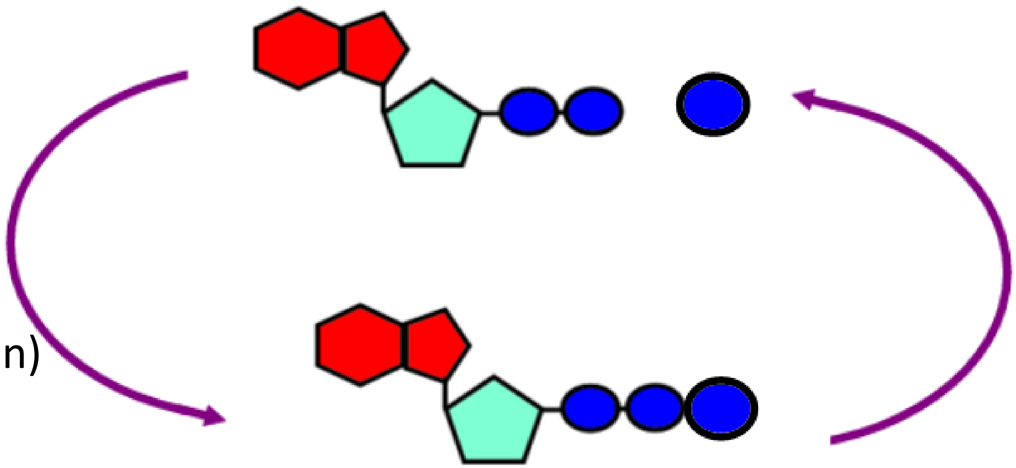
- Usually the processes of oxidation and reduction are coupled in reactions called Oxidation-Reduction (**Redox**) reactions.

Many biochemical reactions are classed as either

REDUCTION or OXIDATION

REDUCTION

(Also condensation)



OXIDATION

(Also hydrolysis)

electrons are gained		electrons are lost
	or	
oxygen is removed		oxygen is added
	or	
hydrogen is gained		hydrogen is lost

Oxidation / Reduction (Redox) Examples

Oxidized / reducing agent…

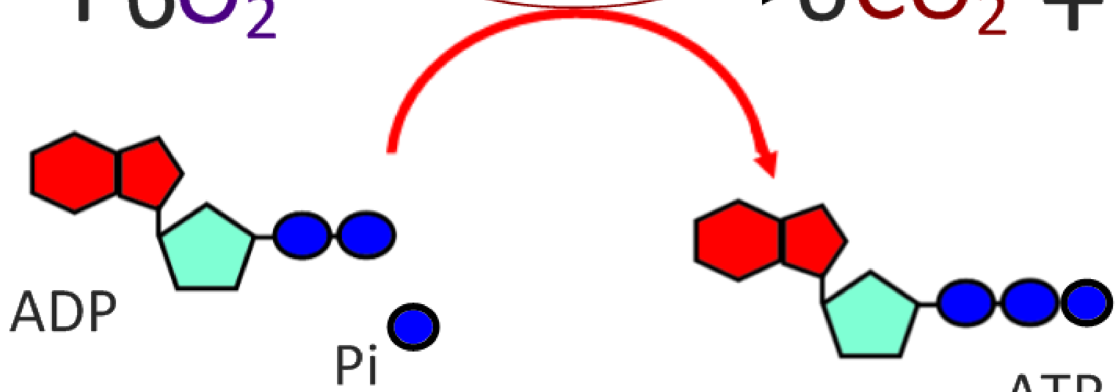
Nice Resource – good explanation!

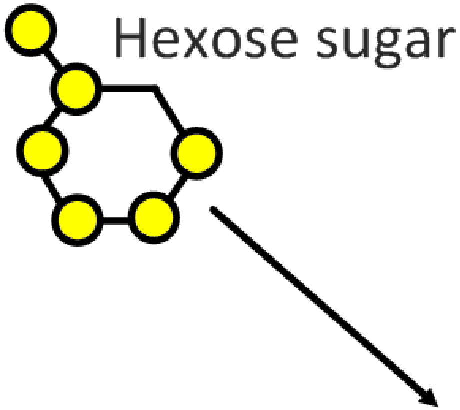
http://www.chemistry.co.nz/redox_new.htm

Back to Work

glycolysis

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{respiration}} 6CO_2 + 6H_2O$$





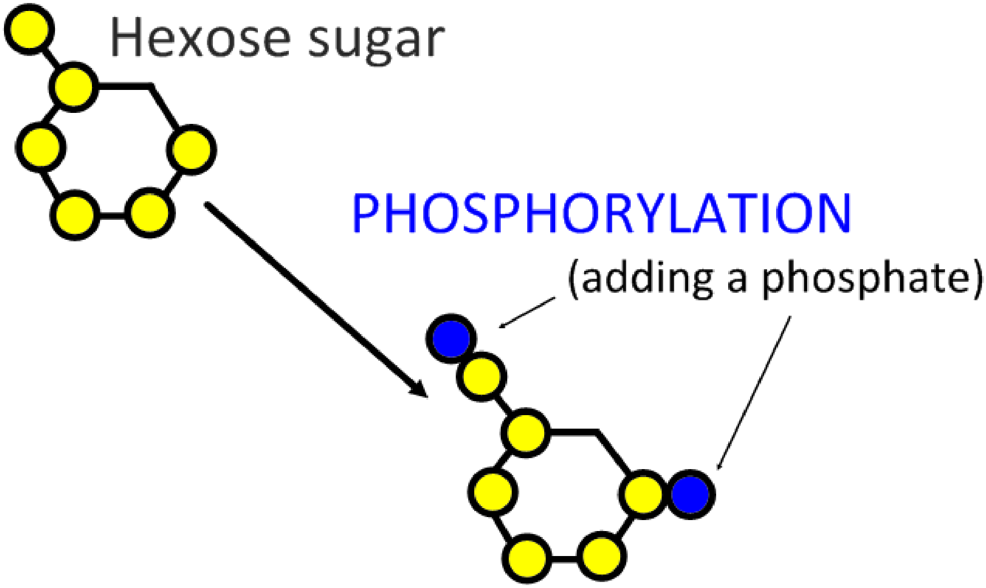
GLYCOLYSIS

sugar splitting

(cytoplasm)

GLYCOLYSIS

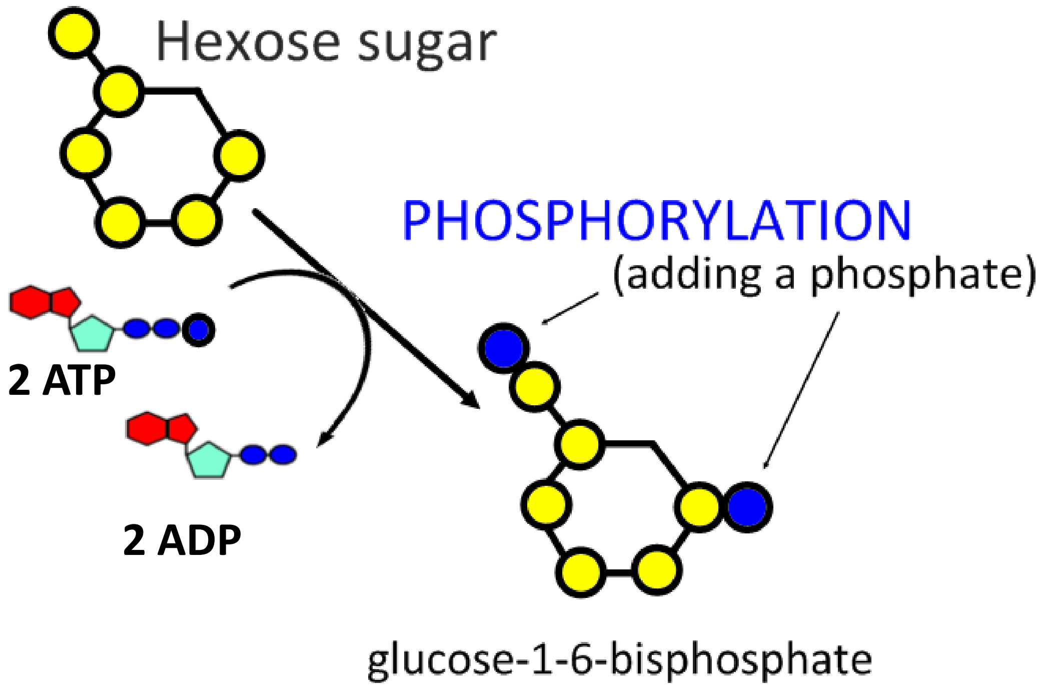
sugar splitting



(cytoplasm)

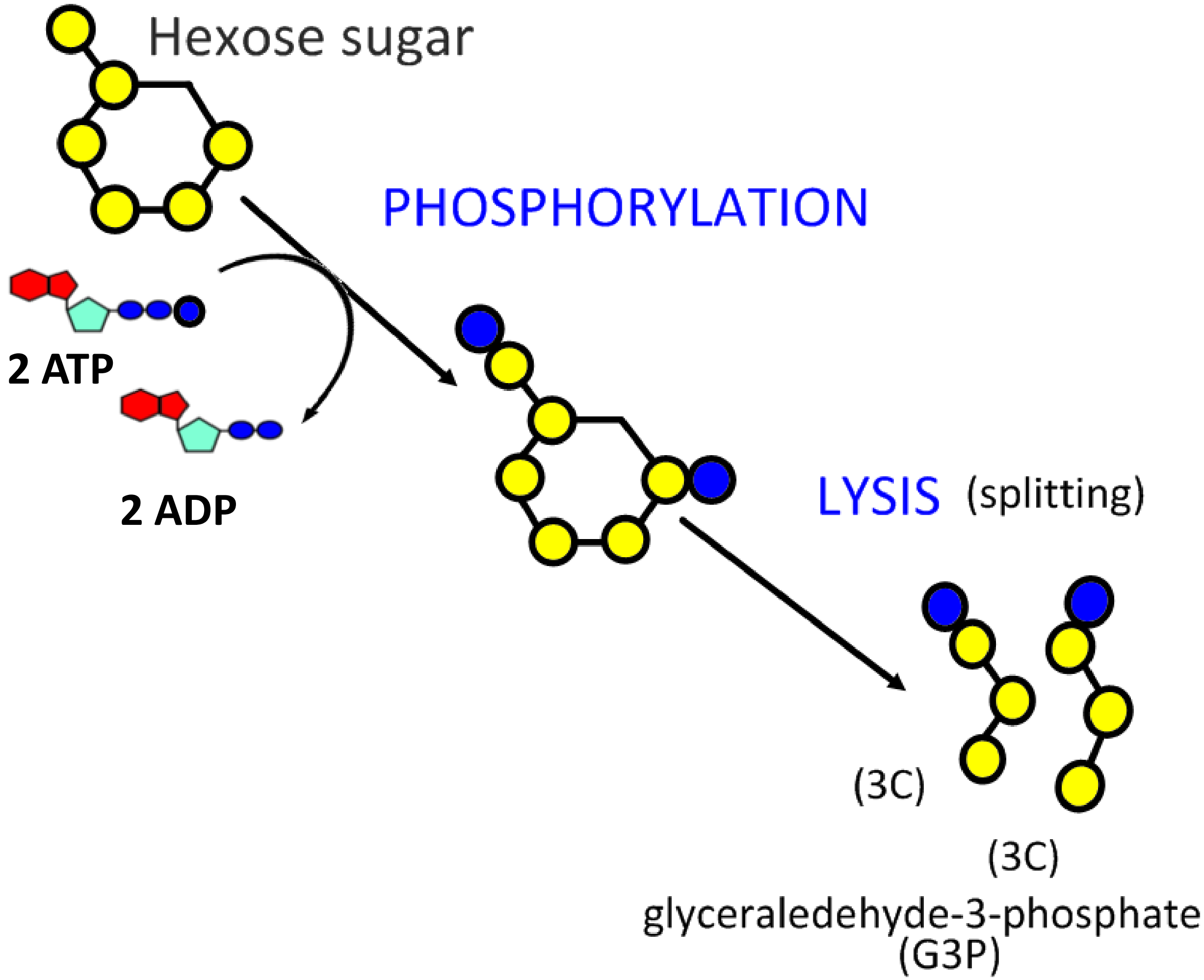
GLYCOLYSIS
sugar splitting

(cytoplasm)

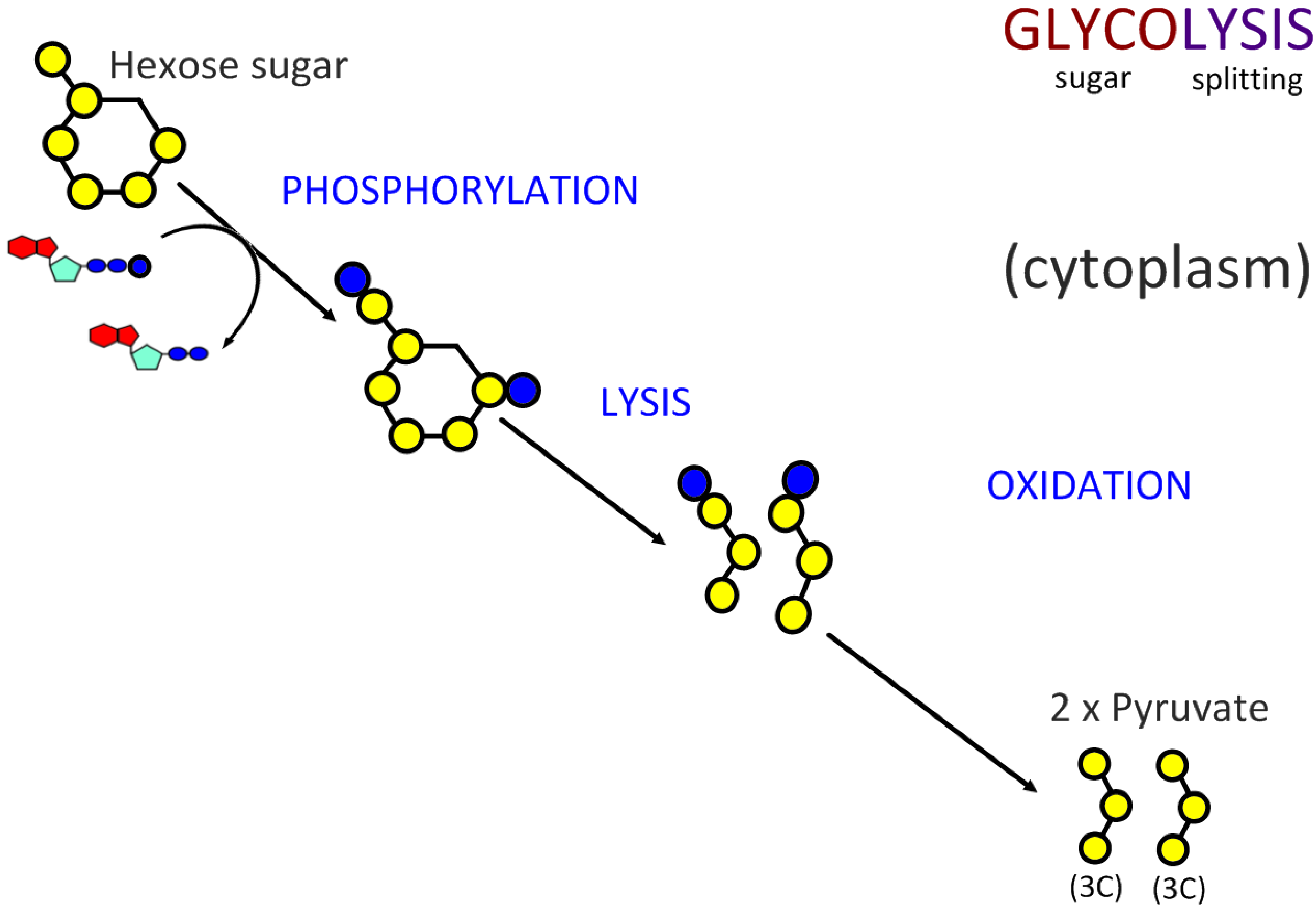


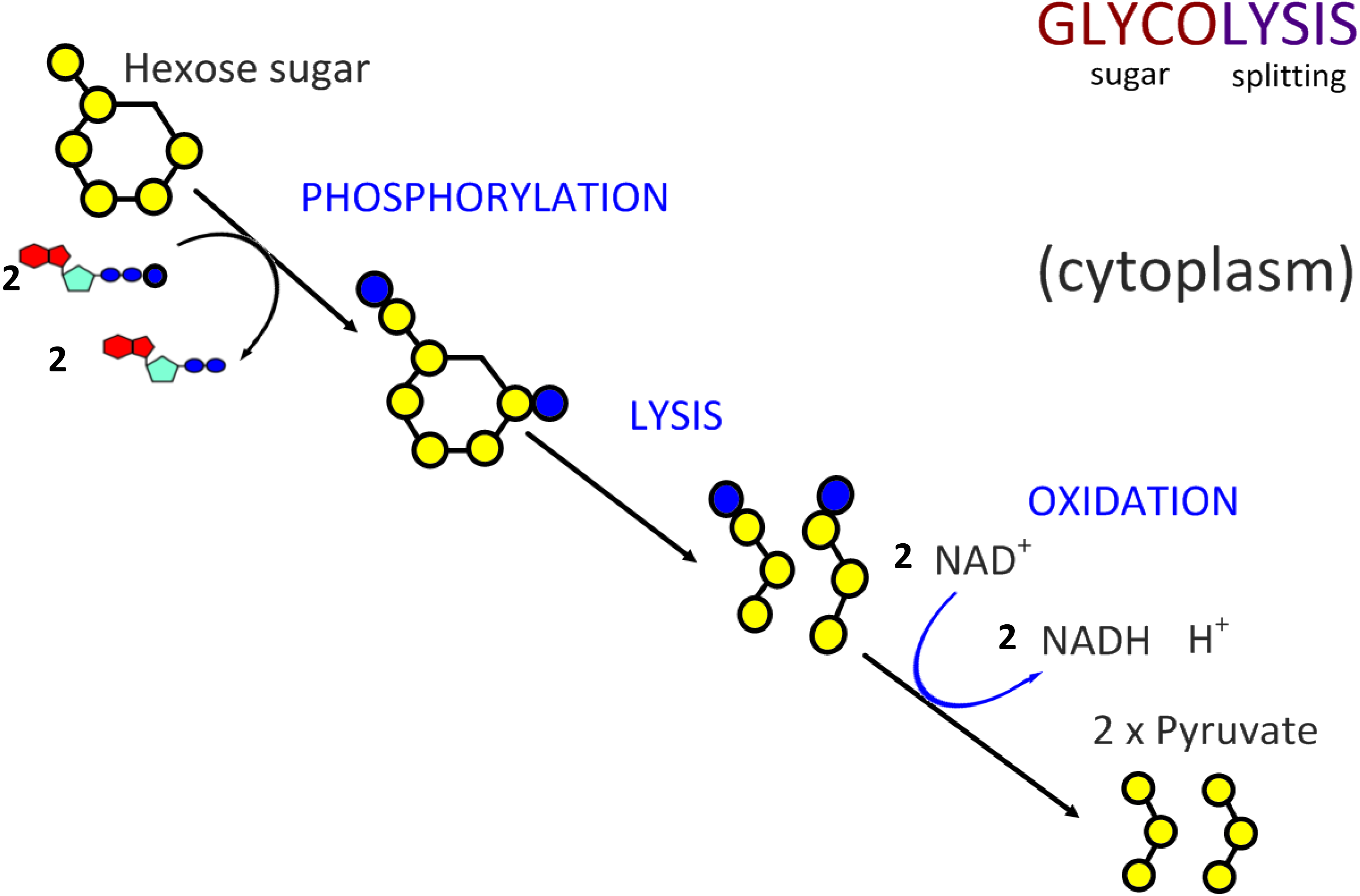
GLYCOLYSIS

sugar splitting



(cytoplasm)

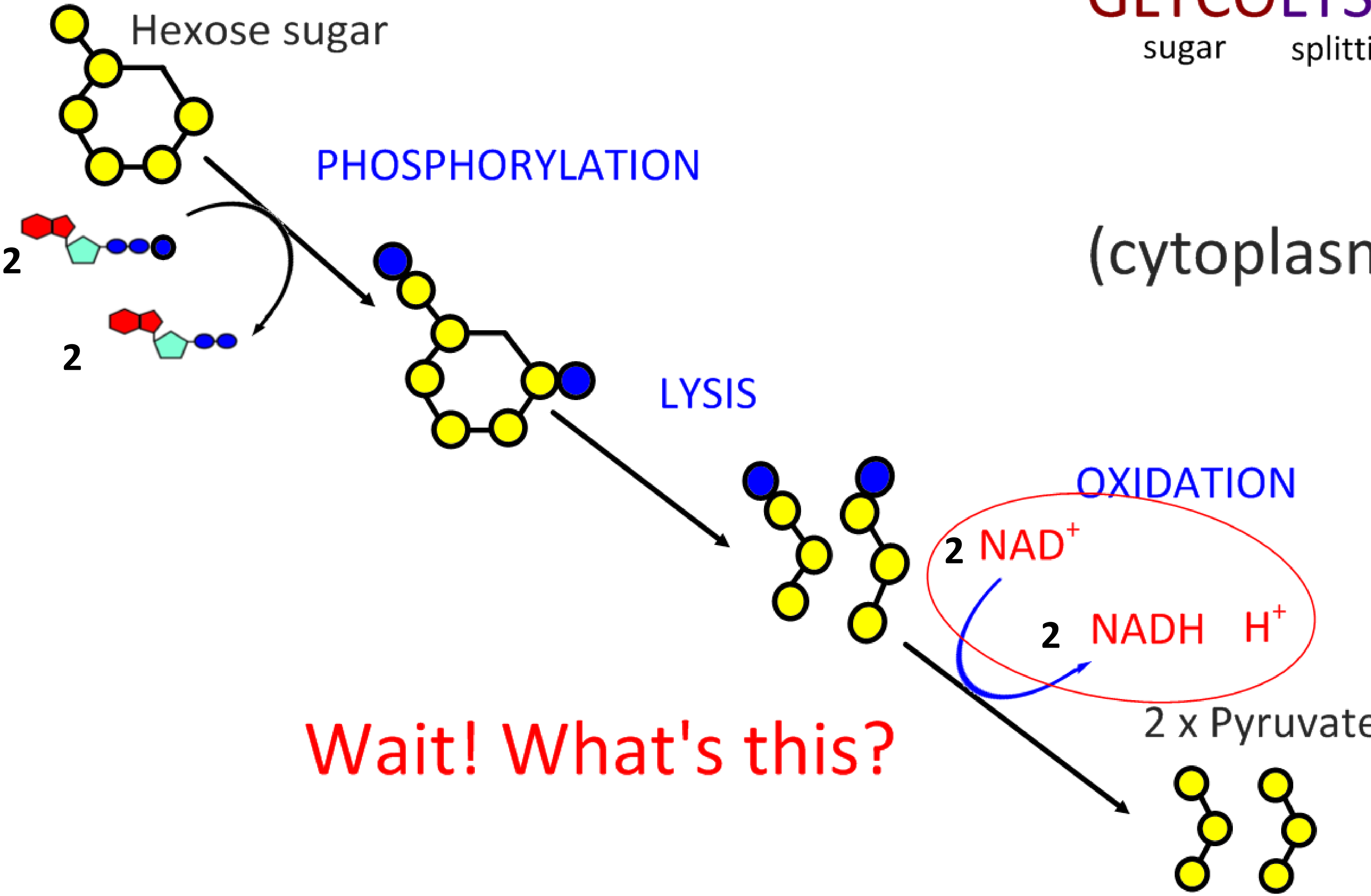

GLYCOLYSIS
sugar
splitting
Hexose sugar
PHOSPHORYLATION
(cytoplasm)
LYSIS
OXIDATION
2 x Pyruvate
(3C)
(3C)


GLYCOLYSIS
sugar
splitting
(cytoplasm)
Hexose sugar
2
2
PHOSPHORYLATION
LYSIS
OXIDATION
2 NAD+
2 NADH H+
2 x Pyruvate

GLYCOLYSIS

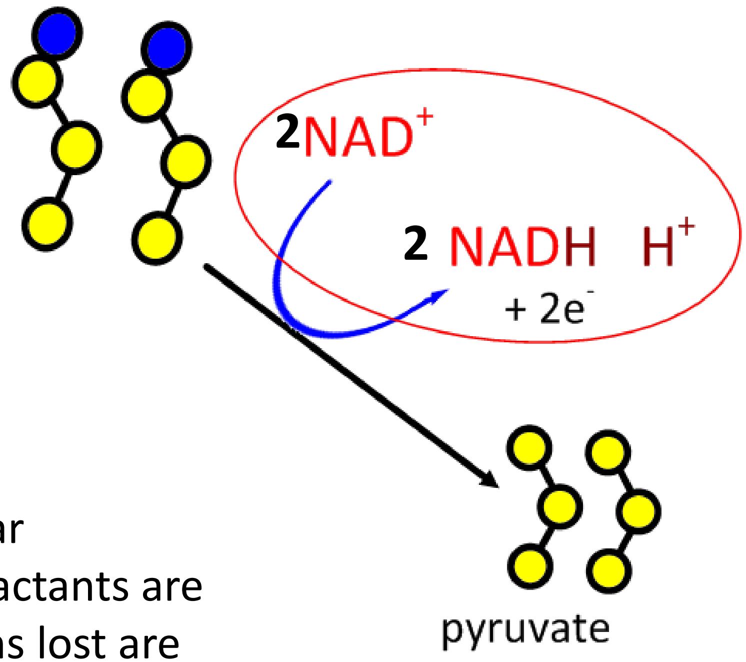
sugar splitting

(cytoplasm)



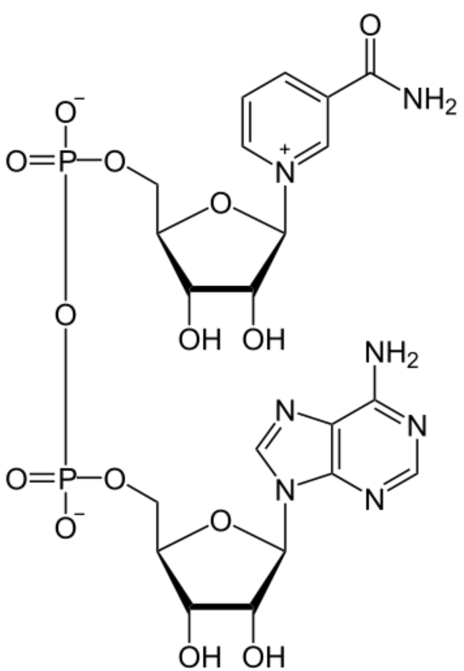
Wait! What's this?

Electron Carriers carry Hydrogen ions to the Electron Transport Chain



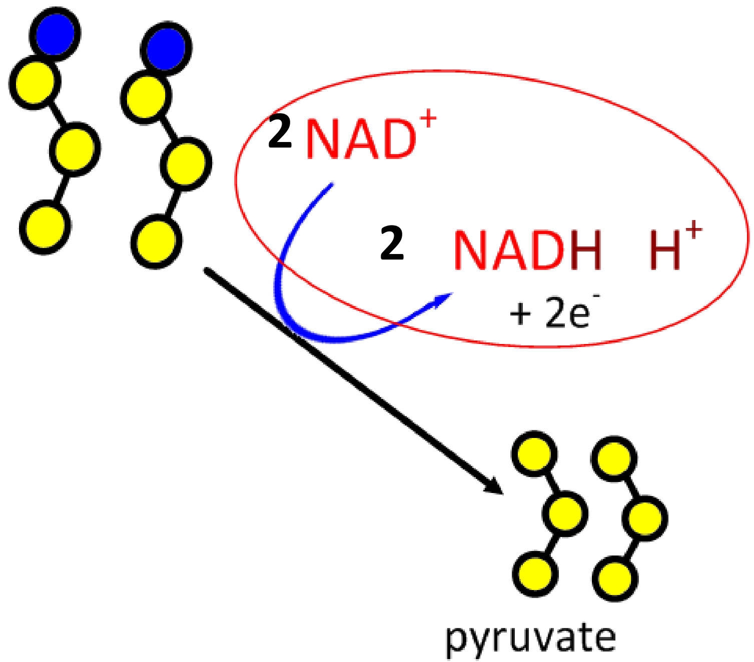
In each step of cellular respiration, as the reactants are oxidized, the electrons lost are picked up by electron (hydrogen) carriers called dehydrogenases.

Nicotinamide adenine dinucleotide (NAD) is
a coenzyme found in all living cells.



Electron Carriers carry Hydrogen ions to the Electron Transport Chain

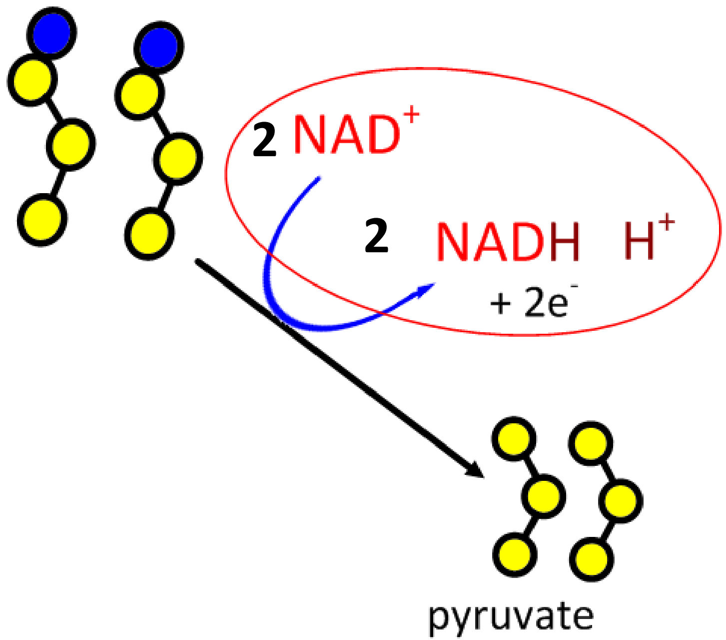
G3P is oxidised
(lose electrons and hydrogens)



NAD+ is reduced
(it gains 2 electrons and 2 hydrogens)

Electron Carriers carry Hydrogen ions to the Electron Transport Chain

G3P is oxidised
(lose electrons
and hydrogens)

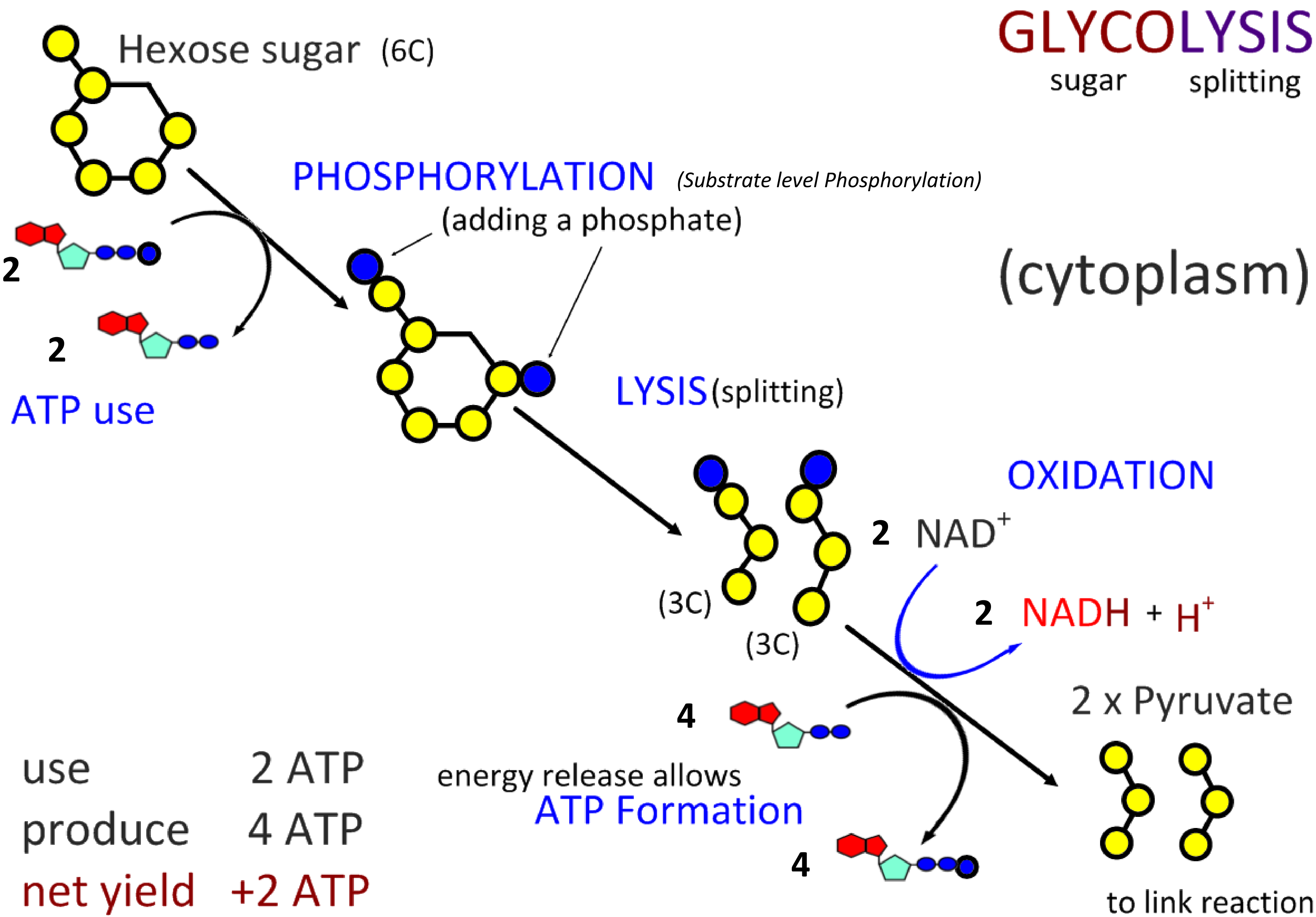


NAD^+ is reduced
(it gains 2 electrons and 2 hydrogens)

- -Carried to electron transport chain
- -Energy from electrons
- -Pumps H^+ across inner mitochondrial membrane
- -Generates H^+ concentration gradient
- -Powers ATP synthase, making ATP

Another electron carrier we'll see later:

$$FADH \xrightarrow[\text{and two electrons}]{\text{add two hydrogens}} FADH_2$$



GLYCOLYSIS
sugar splitting
Hexose sugar (6C)
PHOSPHORYLATION
(Substrate level Phosphorylation)
(adding a phosphate)
(cytoplasm)
2
2
ATP use
LYSIS (splitting)
OXIDATION
2 NAD+
2 NADH + H+
(3C)
(3C)
2 x Pyruvate
4
4
energy release allows
ATP Formation
to link reaction
use 2 ATP
produce 4 ATP
net yield +2 ATP

Overall Equation for Glycolysis

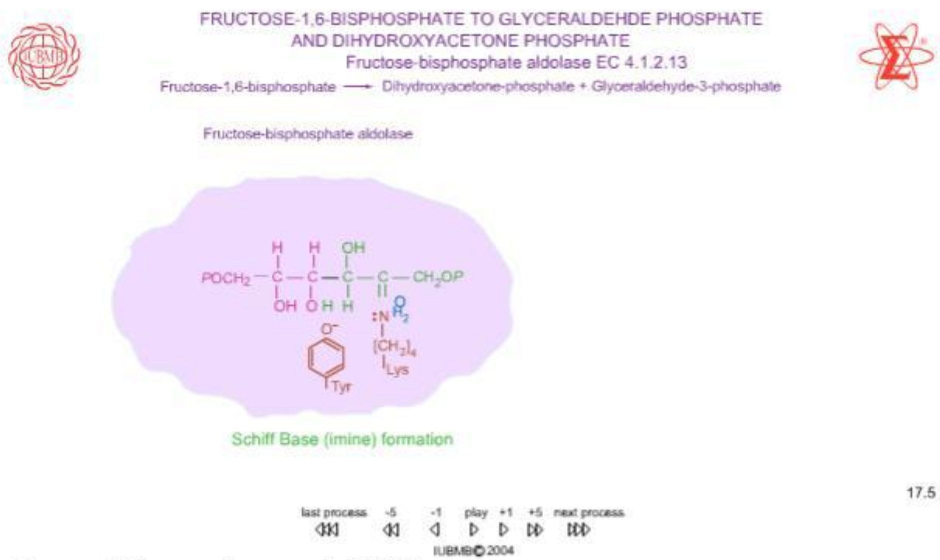
Glucose + 2NAD$^+$ $\rightarrow$ 2 Pyruvate + 2 NADH+H + 2 ATP

OR

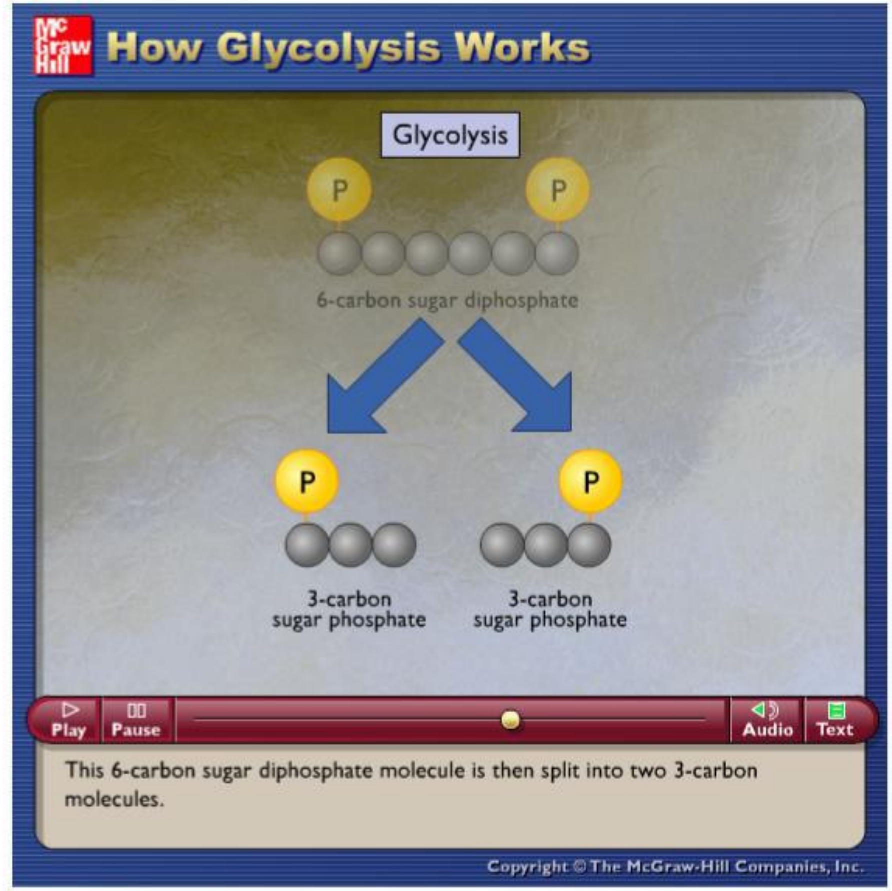
$C_6H_{12}O_6$ + 2NAD$^+$ $\rightarrow$ 2 ($CH_3COCOOH$) + 2 NADH+H + 2 ATP

**What is oxidized? Reduced? Ox. Agent? Reducing Agent?

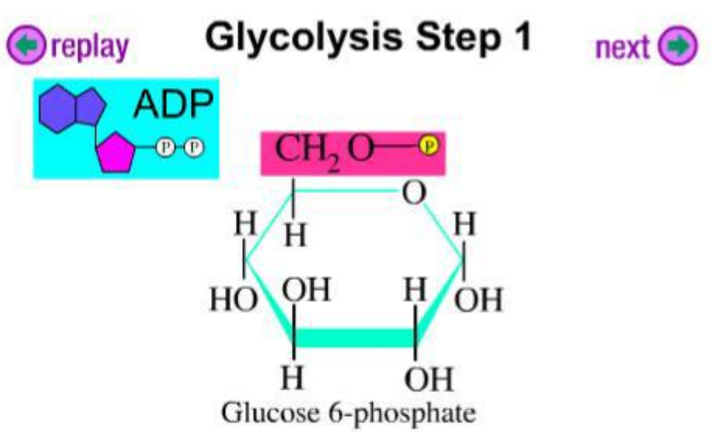
Glycolysis Animations



http://tinyurl.com/ydl5jkn



http://tinyurl.com/yayelo9



The enzyme hexokinase transfers a phosphate group from ATP to glucose.The suffix kinase means that a phosphate group will be transferred.

http://tinyurl.com/oc2v3

Aerobic vs. Anaerobic Respiration

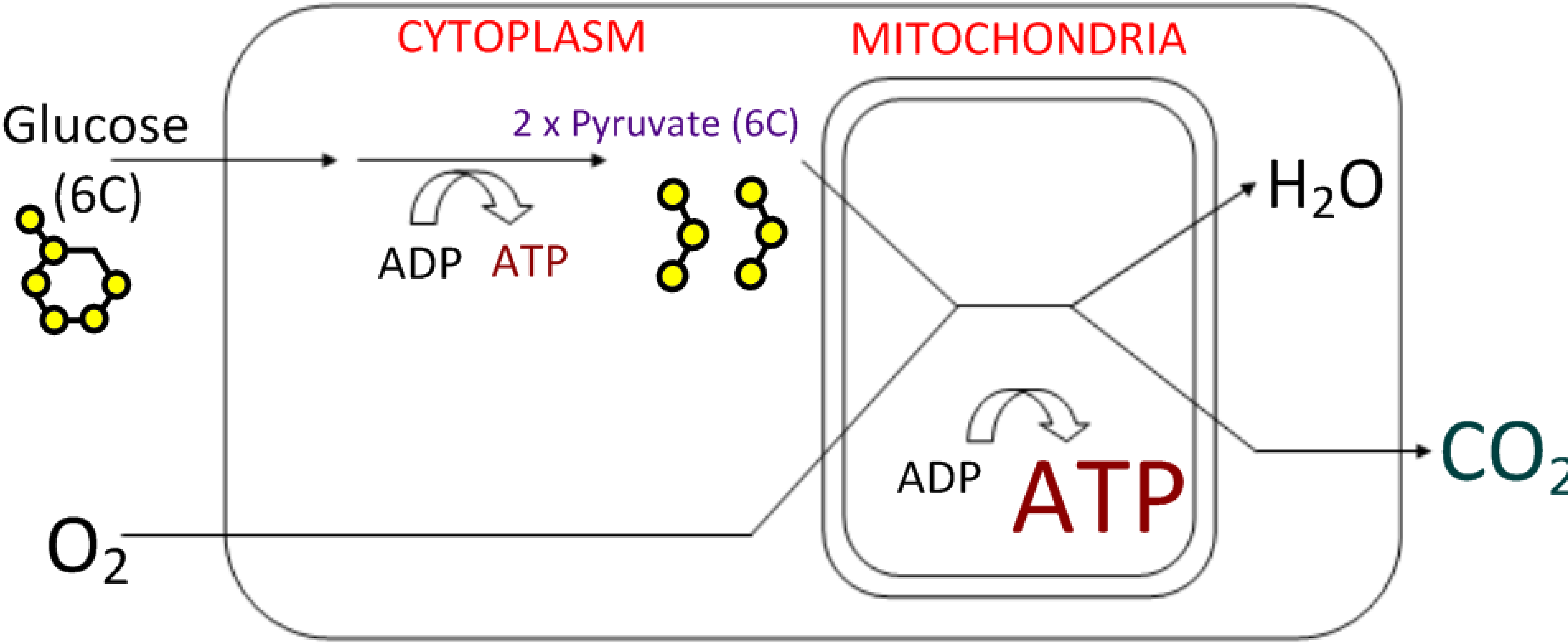
- What happens to the Pyruvate?
  - If the cell has oxygen, the pyruvate will continue through Aerobic Respiration
  - If the cell has no oxygen, the pyruvate will go through Anaerobic Respiration (fermentation).

When might your body be "low" on Oxygen?

Try it yourself!

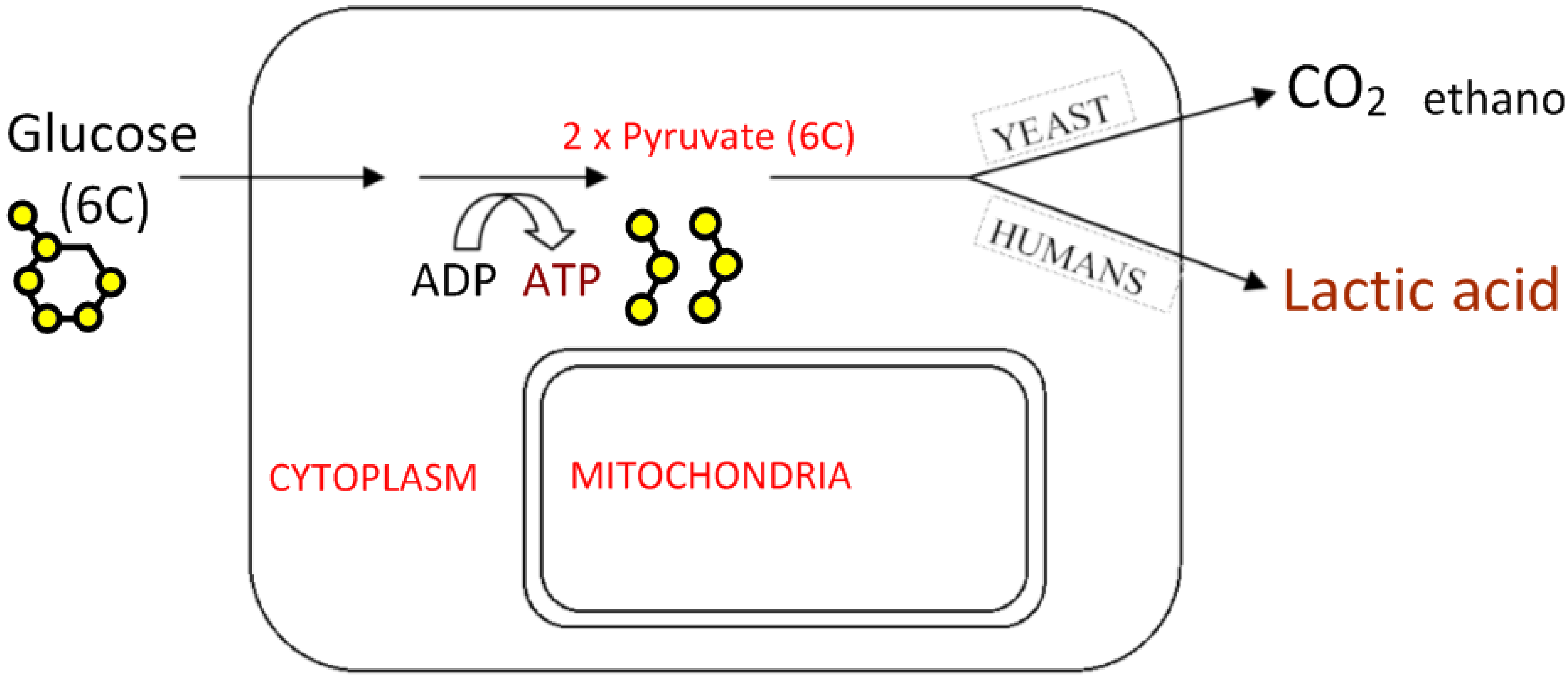
- Anaerobic Respiration (fermentation):
  - Happens in the cytoplasm
  - Lactic Acid fermentation happens in animal cells
    - *And some bacteria & fungi: this type of bacteria that converts lactose into lactic acid in yogurt, giving it its sour taste*
  - Alcoholic fermentation happens in yeast and plant cells
  - The end-products are toxic!
  - NO ATP is produced, the reaction only happens to get rid of pyruvate and regain oxidized NAD+

Aerobic respiration occurs in the presence of oxygen.
Reactions continue in the mitochondria.



A large yield of ATP is given.
Water is a waste product recycled in the cell.
CO_2 is excreted through gas exchange.

Anaerobic respiration occurs in the absence of oxygen.
Reactions do not continue in the mitochondria.



Carbon dioxide and ethanol are produced in yeast (fermentation).
Lactic acid (lactate) is produced in humans and other animals.

The overall yield of ATP is very low.

Bread, Beer, & Wine

- What do these have to do with fermentation?

Overall Equation for Anaerobic Respiration

Lactic Acid Fermentation

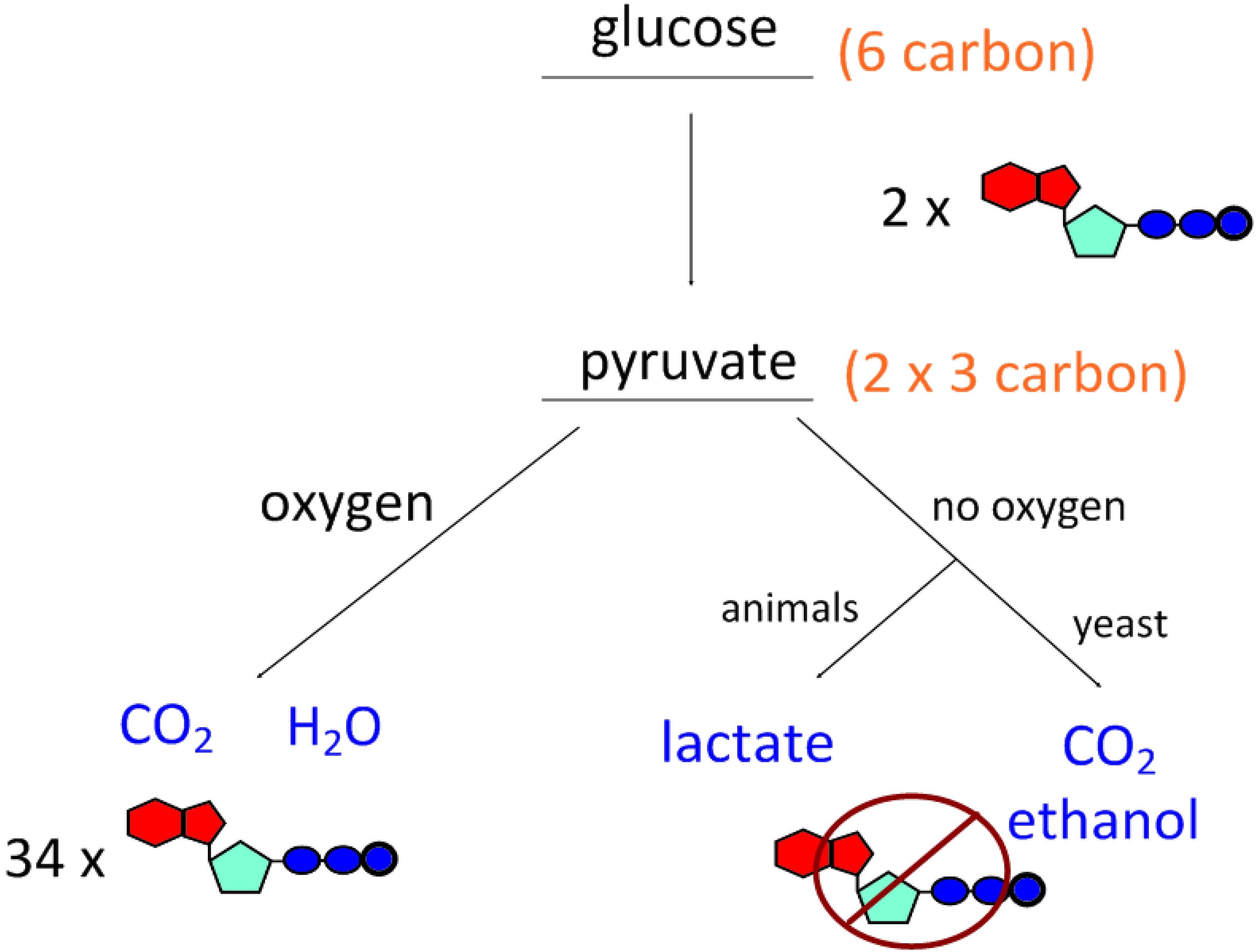
Pyruvate + 2 NADH+H → Lactic Acid+ 2NAD$^+$

OR

Alcoholic Fermentation

Pyruvate + 2 NADH+H → Ethanol + CO_2 + 2NAD$^+$

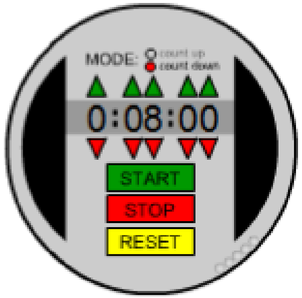
**What is oxidized? Reduced? Ox. Agent? Reducing Agent?


glucose
(6 carbon)
2 x
pyruvate
(2 x 3 carbon)
oxygen
no oxygen
animals
yeast
CO_2
H_2O
lactate
CO_2
ethanol
34 x

Compare aerobic and anaerobic cell respiration.

(8 marks)

Similarities



Differences

Aerobic	Anaerobic

Compare aerobic and anaerobic cell respiration.

(8 marks)

Similarities

Both can start with glucose

Both produce pyruvate (by glycolysis)

Both produce ATP

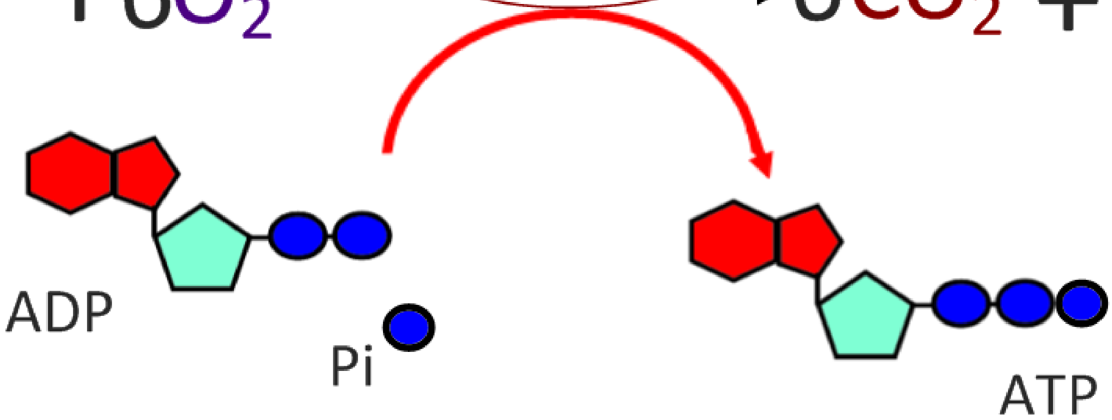
Both produce CO_2

Differences

Aerobic	Anaerobic
Uses oxygen	No oxygen
High yield of ATP	Low yield of ATP
Waste products: CO_2 and water	Waste products: CO_2 and ethanol (yeast) Lactic acid (animals)
Pyruvate carried to mitochondria	Occurs in cytoplasm only
Can metabolise other molecules	

glycolysis → link reaction

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{respiration}} 6CO_2 + 6H_2O$$



OXIDATIVE DECARBOXYLATION

LINK REACTION (matrix)

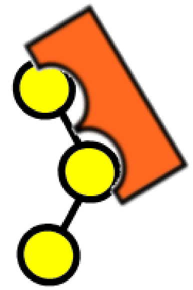
Pyruvate

CoA

coenzyme: a carrier

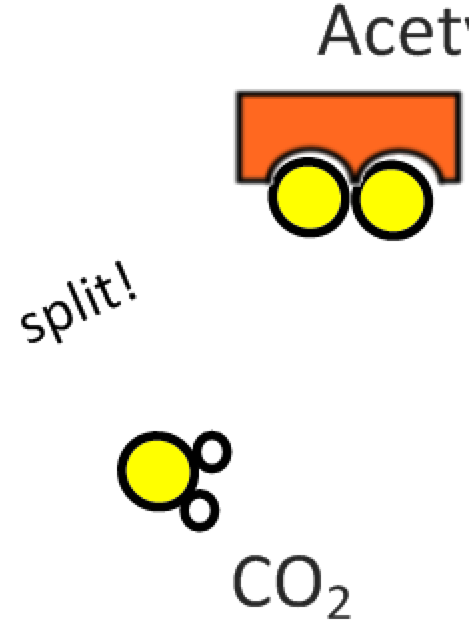
OXIDATIVE DECARBOXYLATION

LINK REACTION (matrix)



LINK

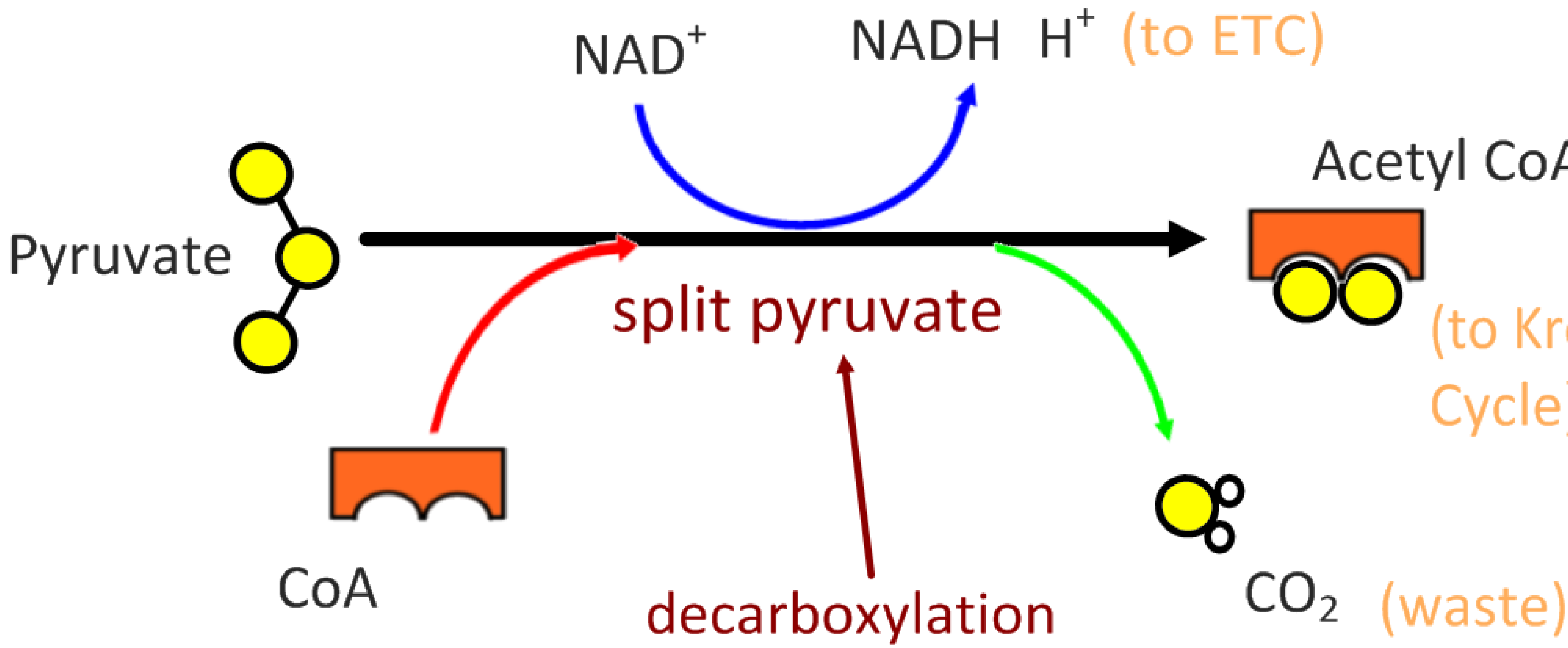
OXIDATIVE DECARBOXYLATION



LINK REACTION (matrix)

mitochondria

OXIDATIVE DECARBOXYLATION



Net yield: 2 Acetyl CoA per glucose molecule

(remember the 6C glucose split into 2 x 3C pyruvate)

Overall Equation for Link Reaction

Pyruvate + NAD^+ → Acetyl CoenzymeA + NADH+H + CO_2

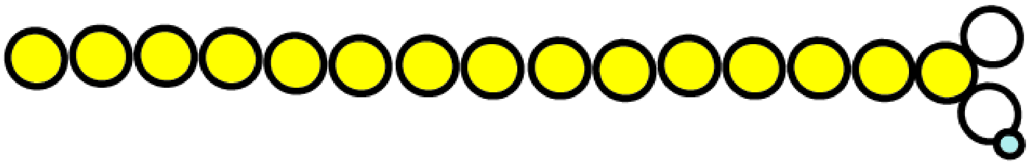
**What is oxidized? Reduced? Ox. Agent? Reducing Agent?

Cell Respiration using fatty acids

Fatty acids can also be a source of energy in respiration:

$CH_3(CH_2)_nCOOH$

Glycolysis is not needed



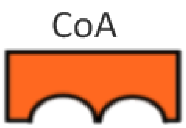
Fatty acids have a long chain of carbon atoms

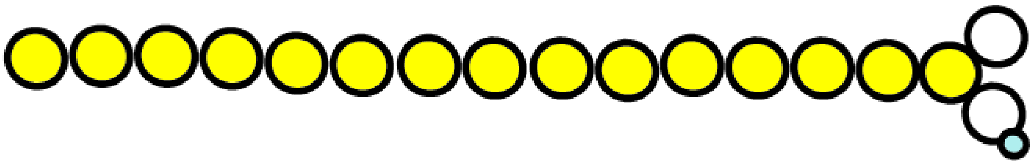
Cell Respiration using fatty acids

Fatty acids can also be a source of energy in respiration:

$$CH_3(CH_2)_nCOOH$$

Cut straight to the link reaction!





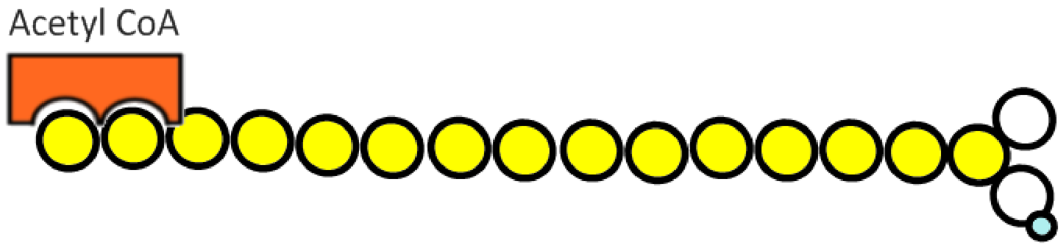
Fatty acids have a long chain of carbon atoms

CoA can oxidise this chain - break it down.

Cell Respiration using fatty acids

Fatty acids can also be a source of energy in respiration:

$$CH_3(CH_2)_nCOOH$$



Fatty acids have a long chain of carbon atoms

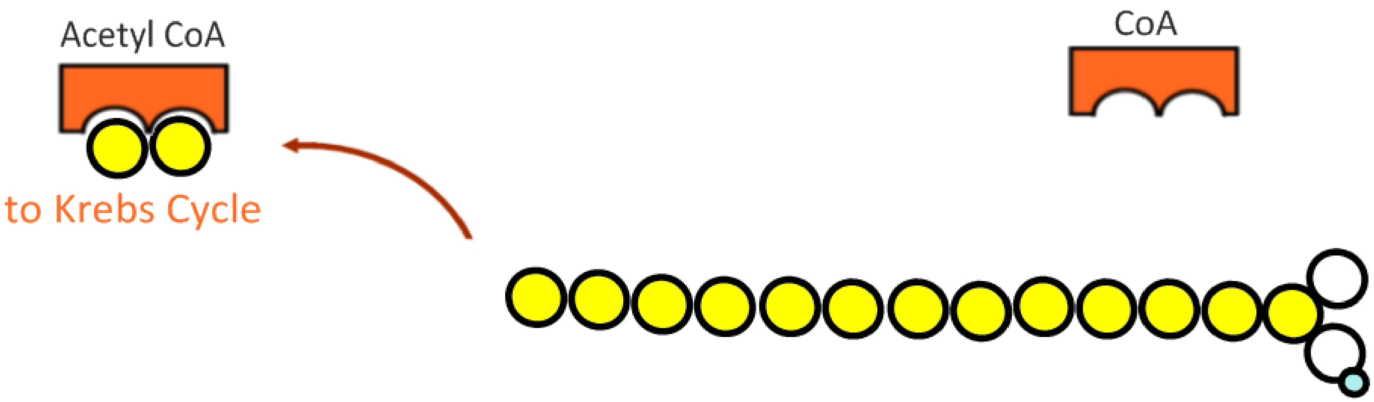
CoA can oxidise this chain - break it down.

It makes Acetyl CoA with two carbons.

Cell Respiration using fatty acids

Fatty acids can also be a source of energy in respiration:

$$CH_3(CH_2)_nCOOH$$



Fatty acids have a long chain of carbon atoms

CoA can oxidise this chain - break it down.

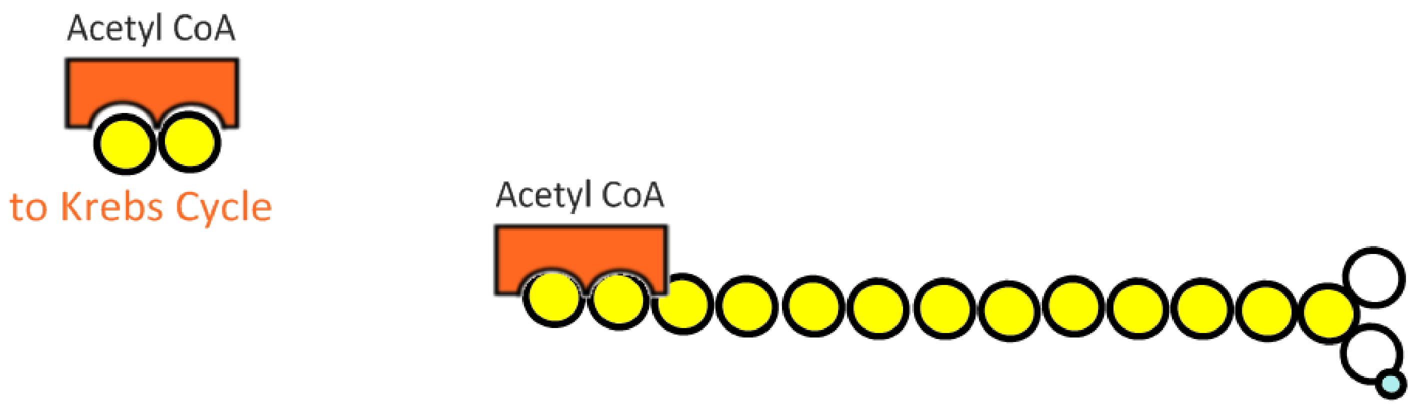
It makes Acetyl CoA with two carbons.

And carries them to the Kreb's Cycle.

Cell Respiration using fatty acids

Fatty acids can also be a source of energy in respiration:

$$CH_3(CH_2)_nCOOH$$



Fatty acids have a long chain of carbon atoms

CoA can oxidise this chain - break it down.

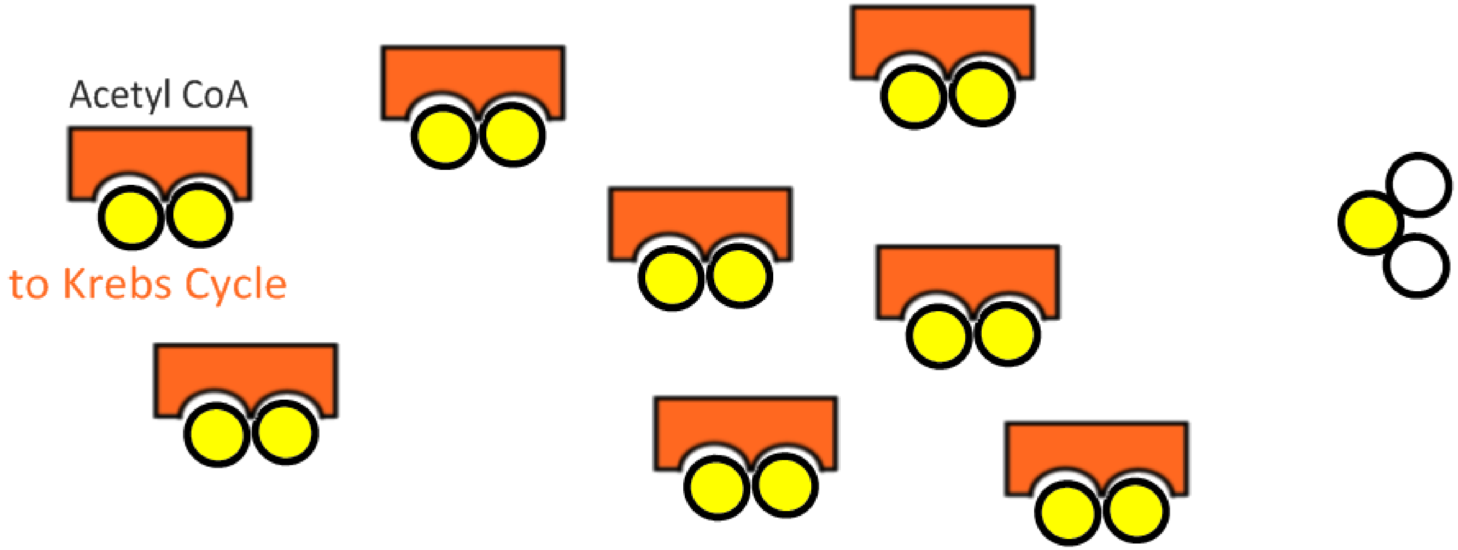
It makes Acetyl CoA with two carbons.

And carries them to the Kreb's Cycle.

Cell Respiration using fatty acids

Fatty acids can also be a source of energy in respiration:

$$CH_3(CH_2)_nCOOH$$



If there are an odd number of carbons, the remaining carbon atom is released as carbon dioxide

Cell Respiration using fatty acids

How many Acetyl CoA molecules can be made from:

1. A fatty acid with 24 carbons?

2. A fatty acid with 25 carbons?

3. A fatty acid with 26 carbons?

4. From stearic acid ($C_{18}H_{36}O_2$)?

5. This fatty acid:

$CH_3(CH_2)_{54}COOH$

Cell Respiration using fatty acids

How many Acetyl CoA molecules can be made from:

1. A fatty acid with 24 carbons? 12

2. A fatty acid with 25 carbons? 12 (plus one CO_2)

3. A fatty acid with 26 carbons? 13

4. From stearic acid ($C_{18}H_{36}O_2$)? 9

5. This fatty acid?

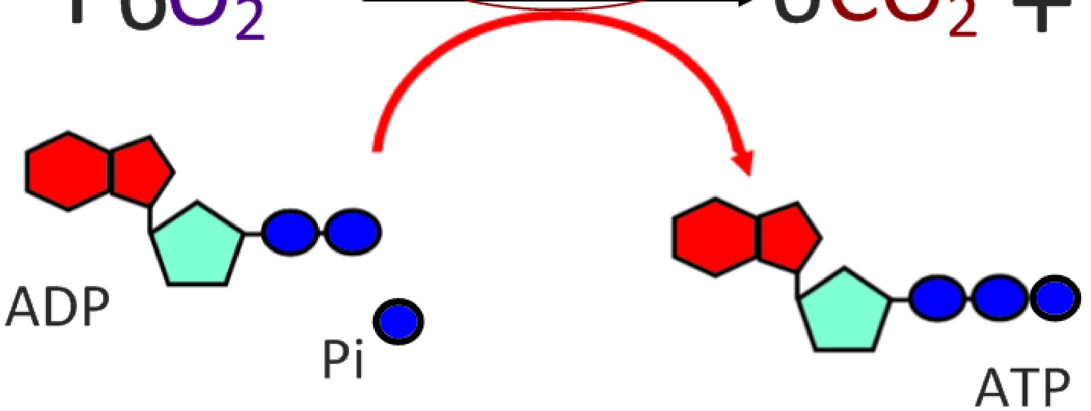
$CH_3(CH_2)_{54}COOH$ 28

Cellular Respiration of Proteins

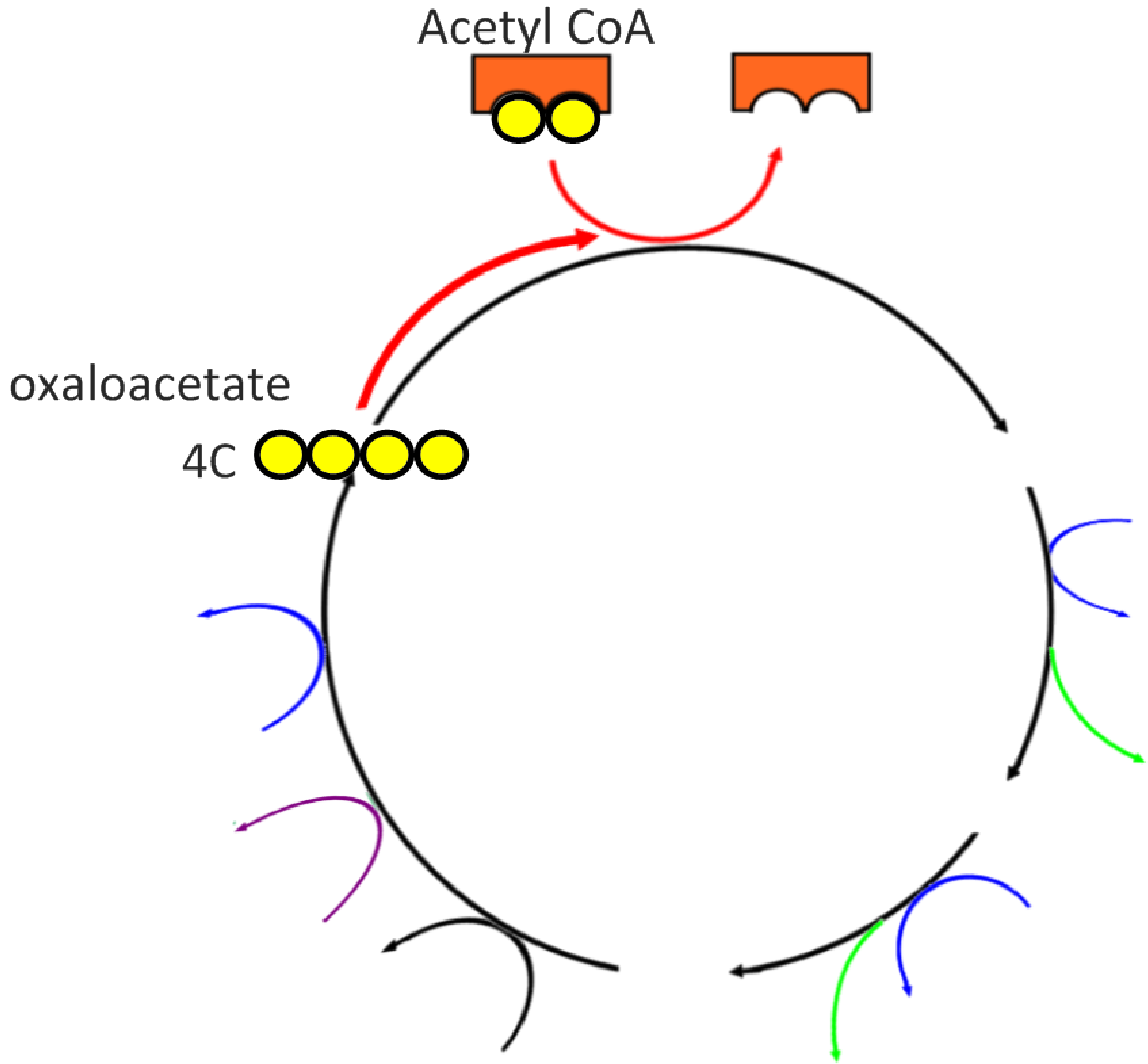
- Excess proteins in our diets cannot be stored like glycogen or fats can, and must be broken down by the body.
- **Proteases** break the peptide bonds of proteins back down to amino acids
- De**amin**ases break the amino group off the **amino** acids, releasing ammonia. This toxic ammonia is converted to urea, and is excreted in urine.
- The remainder of the amino acid (mostly of carbon, hydrogen, and oxygen), and can be rearranged in cells to enter cellular respiration either as **pyruvate**, as **acetyl CoA**, or directly into the **Krebs cycle**.
- **Result:** Still ~32-38 or so ATPs, but from proteins, not glucose!

glycolysis → link reaction → Kreb's cycle

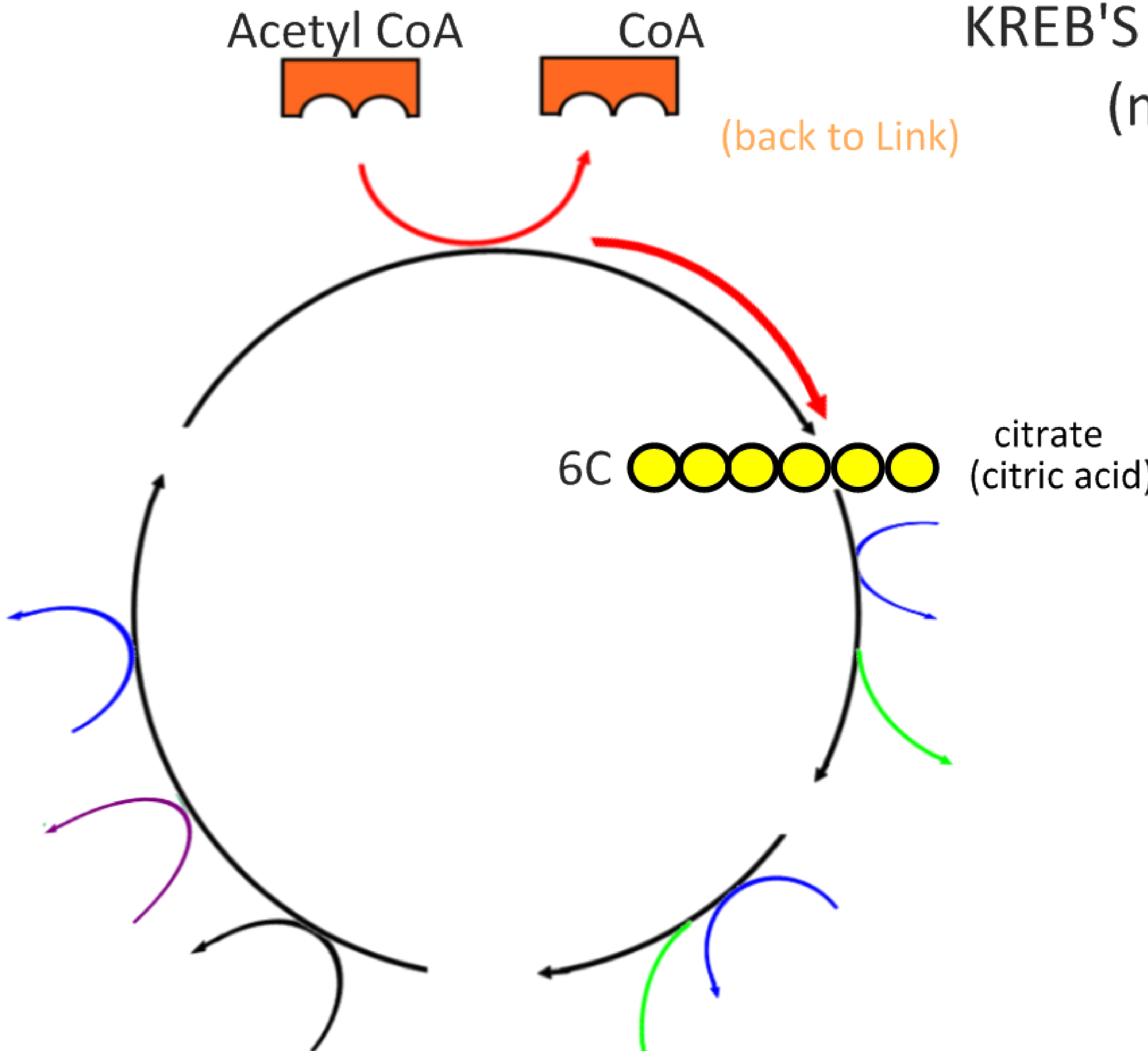
$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{respiration}} 6CO_2 + 6H_2O$$

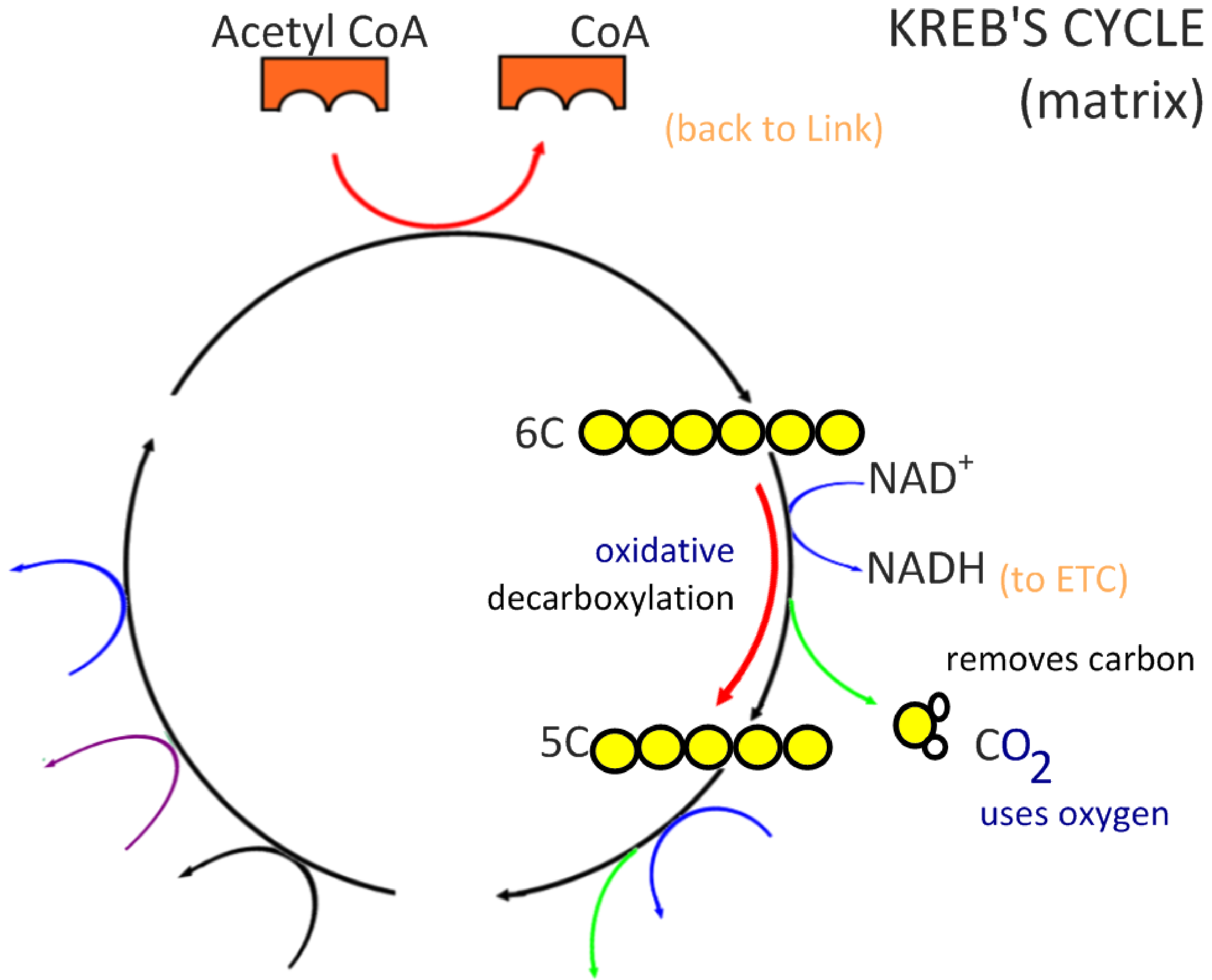


KREB'S CYCLE (matrix)

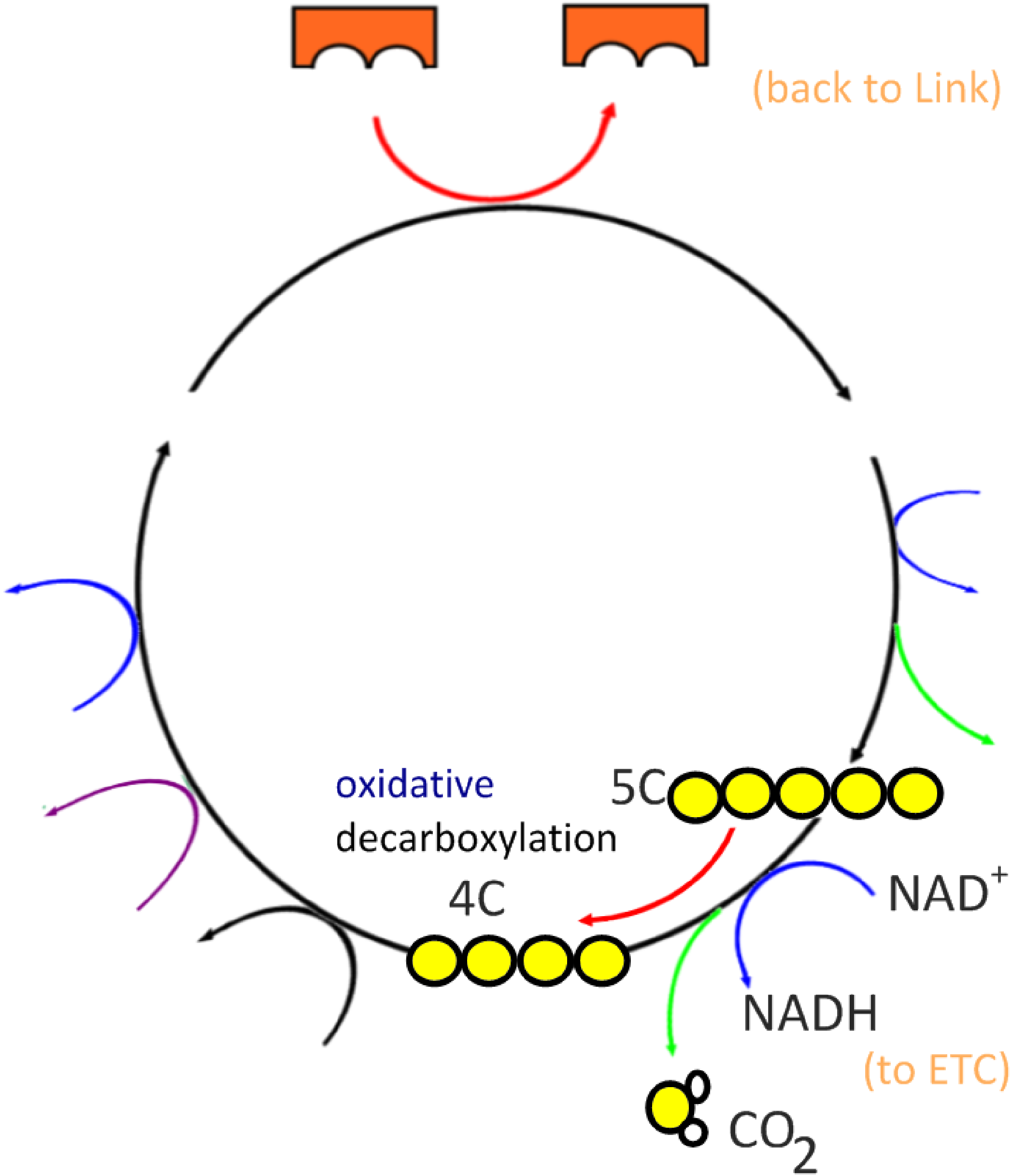


KREB'S CYCLE (matrix)

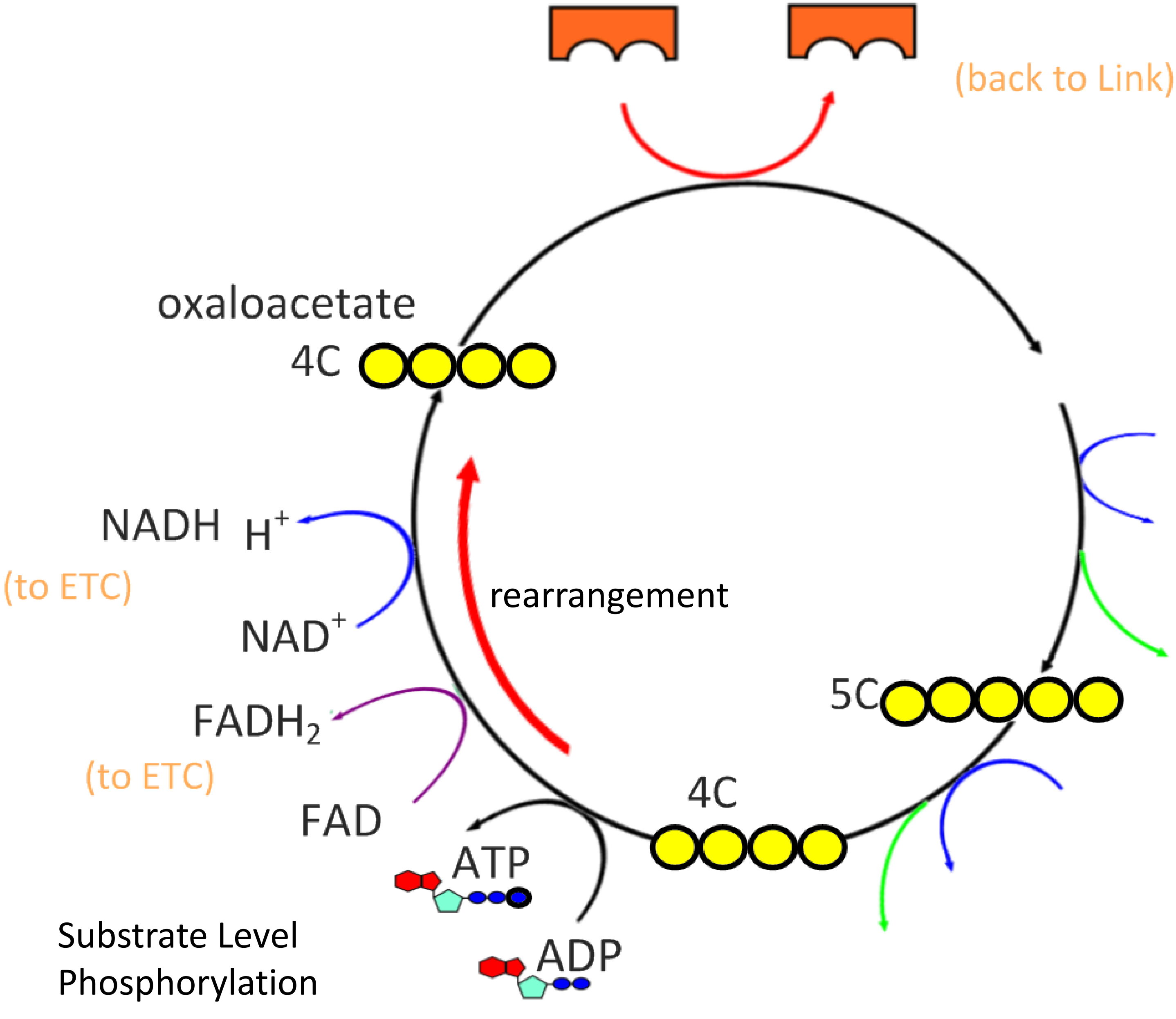


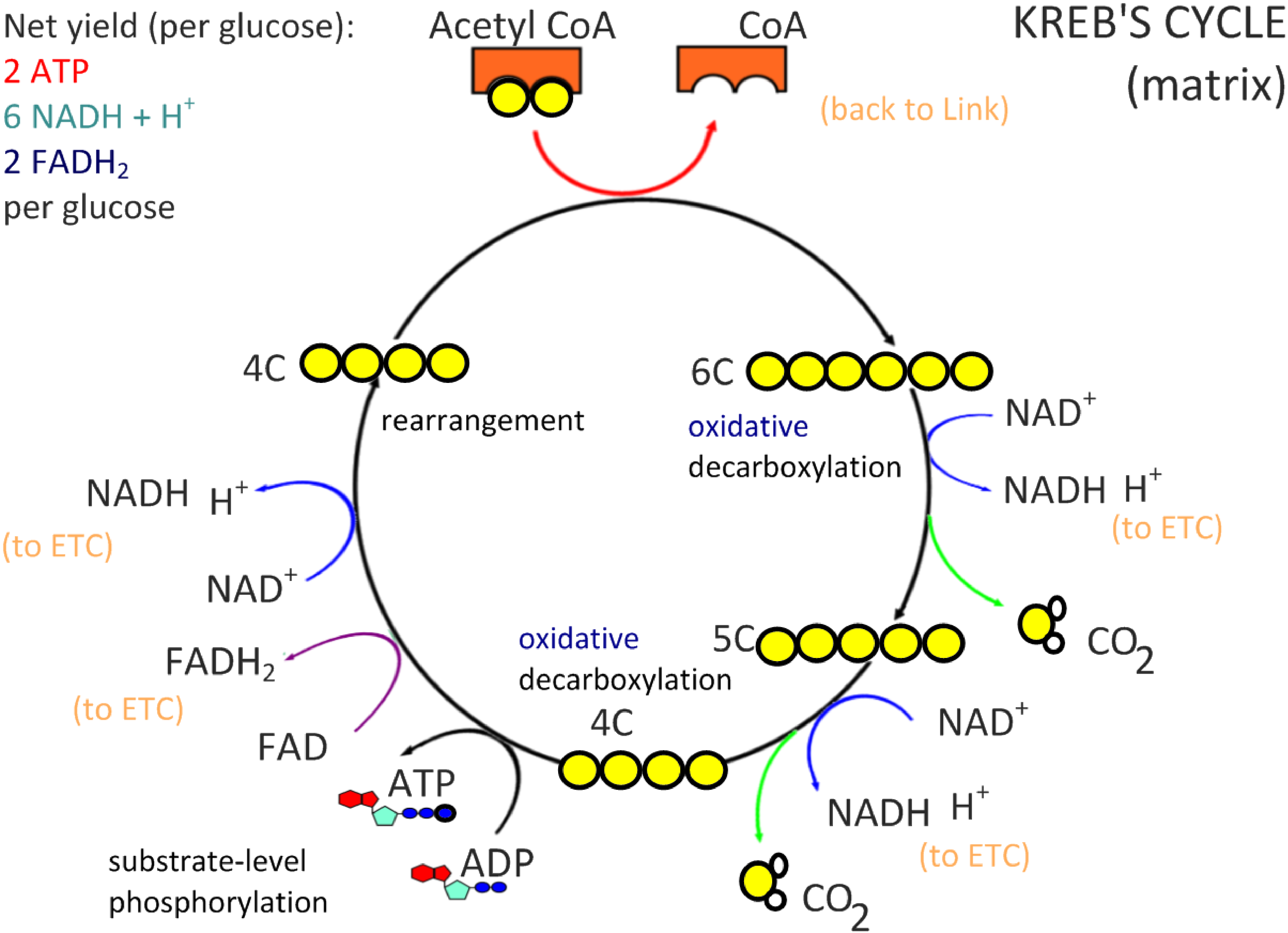

KREB'S CYCLE
(matrix)
Acetyl CoA
CoA
(back to Link)
6C
NAD+
oxidative
decarboxylation
NADH
(to ETC)
removes carbon
5C
CO2
uses oxygen

KREB'S CYCLE (matrix)

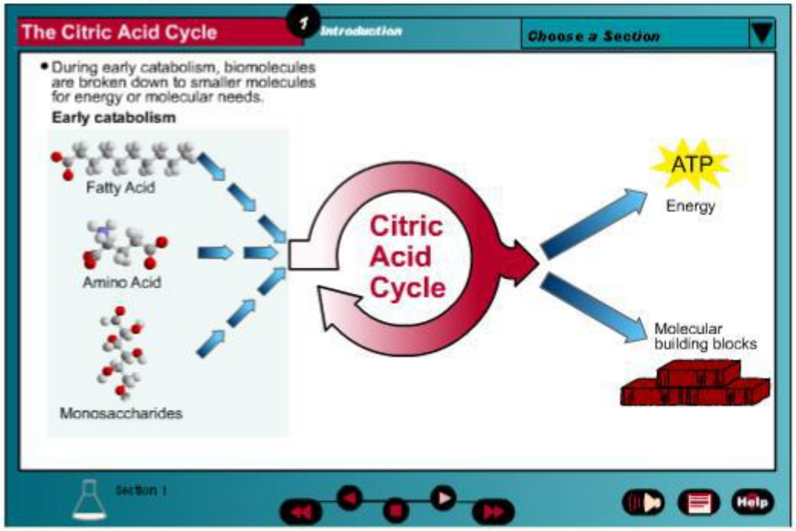


KREB'S CYCLE (matrix)

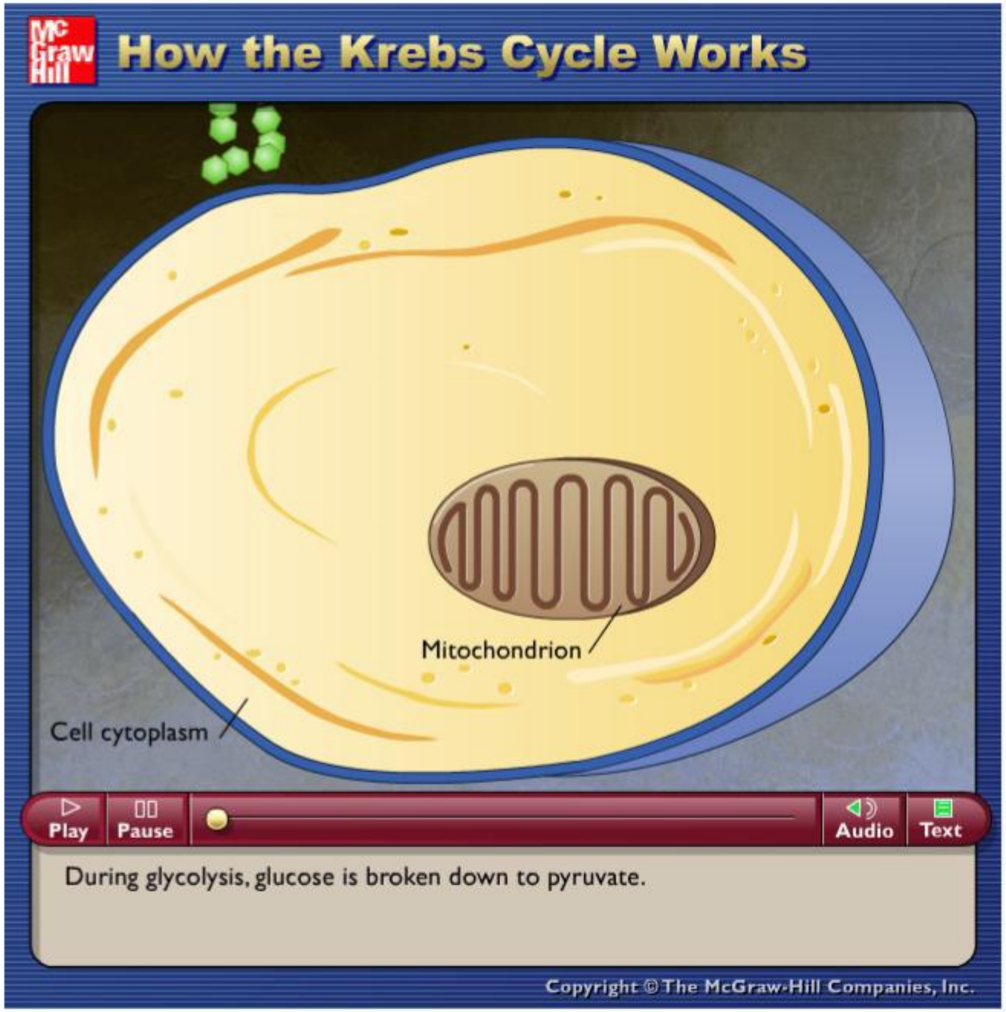



KREB'S CYCLE
(matrix)
Net yield (per glucose):
2 ATP
6 NADH + H+
2 FADH2
per glucose
Acetyl CoA
CoA
(back to Link)
6C
oxidative
decarboxylation
NAD+
NADH H+
(to ETC)
CO2
5C
oxidative
decarboxylation
NAD+
NADH H+
(to ETC)
CO2
4C
ATP
ADP
substrate-level
phosphorylation
FAD
FADH2
(to ETC)
NAD+
NADH H+
(to ETC)
4C
rearrangement

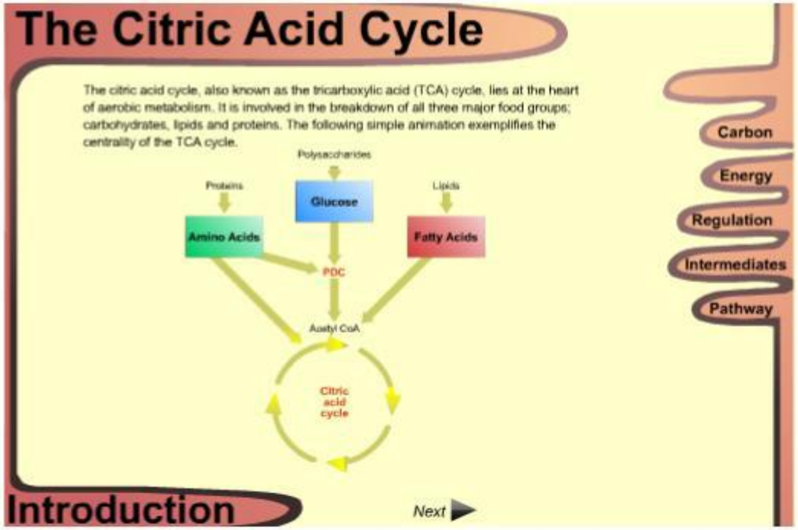
Krebs Cycle animations:



http://tinyurl.com/ewbmn

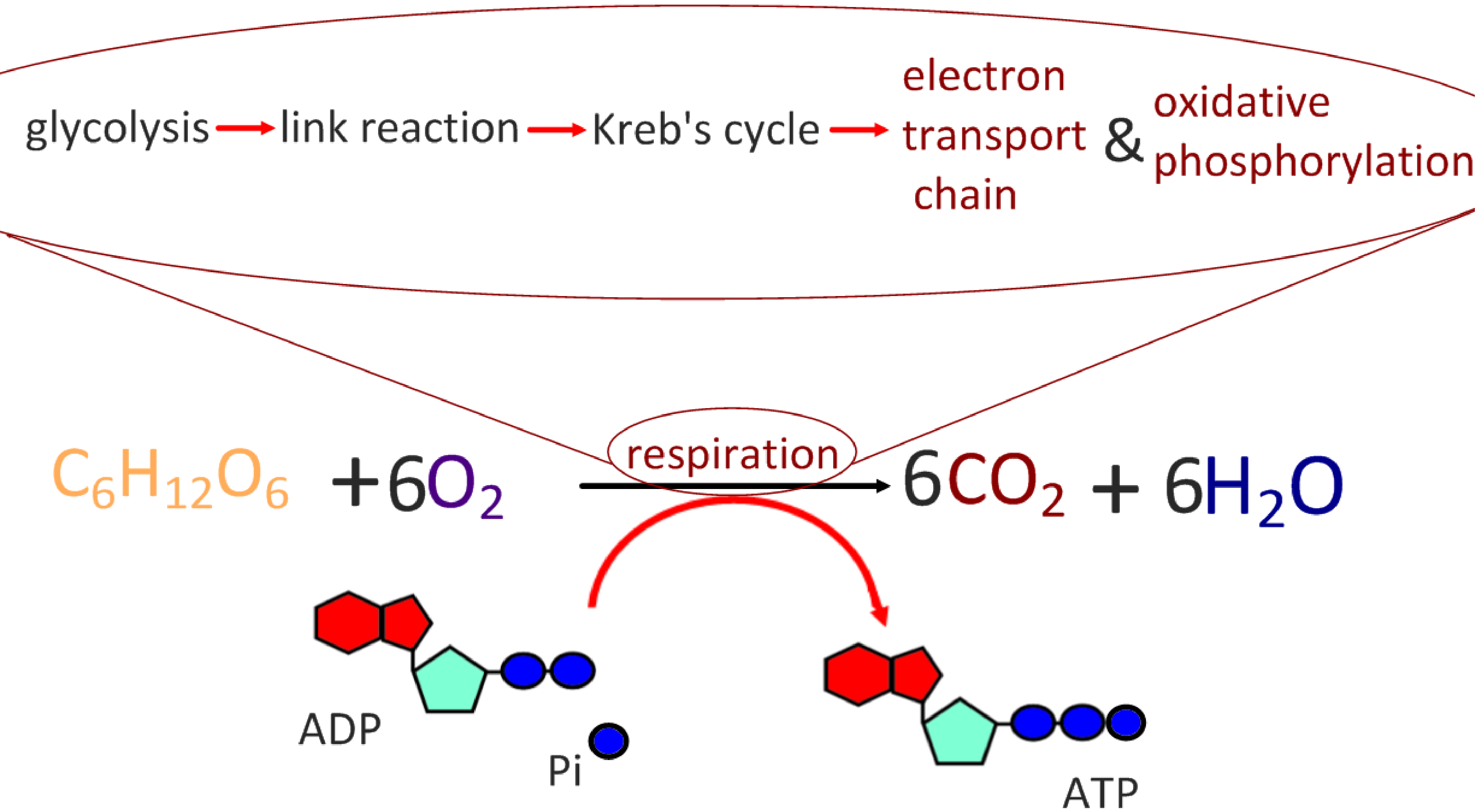


http://tinyurl.com/ydm25ah

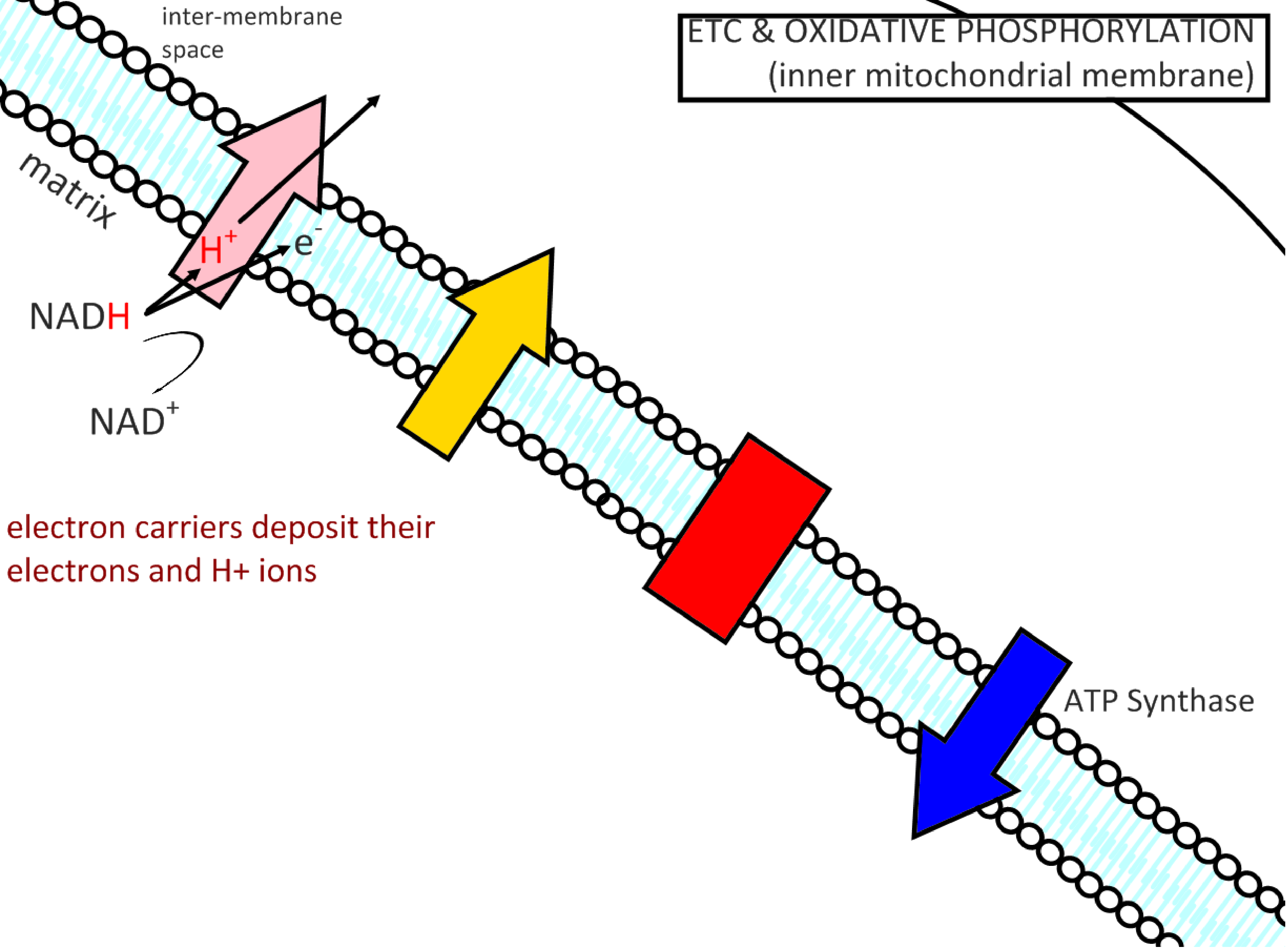


http://tinyurl.com/8hvyl

http://highered.mheducation.com/sites/0072507470/student_view0/chapter25/animation__how_the_krebs_cycle_works__quiz_1_.html


glycolysis
link reaction
Kreb's cycle
electron transport chain
&
oxidative phosphorylation
$C_6H_{12}O_6$ $+ 6O_2$
respiration
$6CO_2 + 6H_2O$
ADP
Pi
ATP

ETC & OXIDATIVE PHOSPHORYLATION (inner mitochondrial membrane)

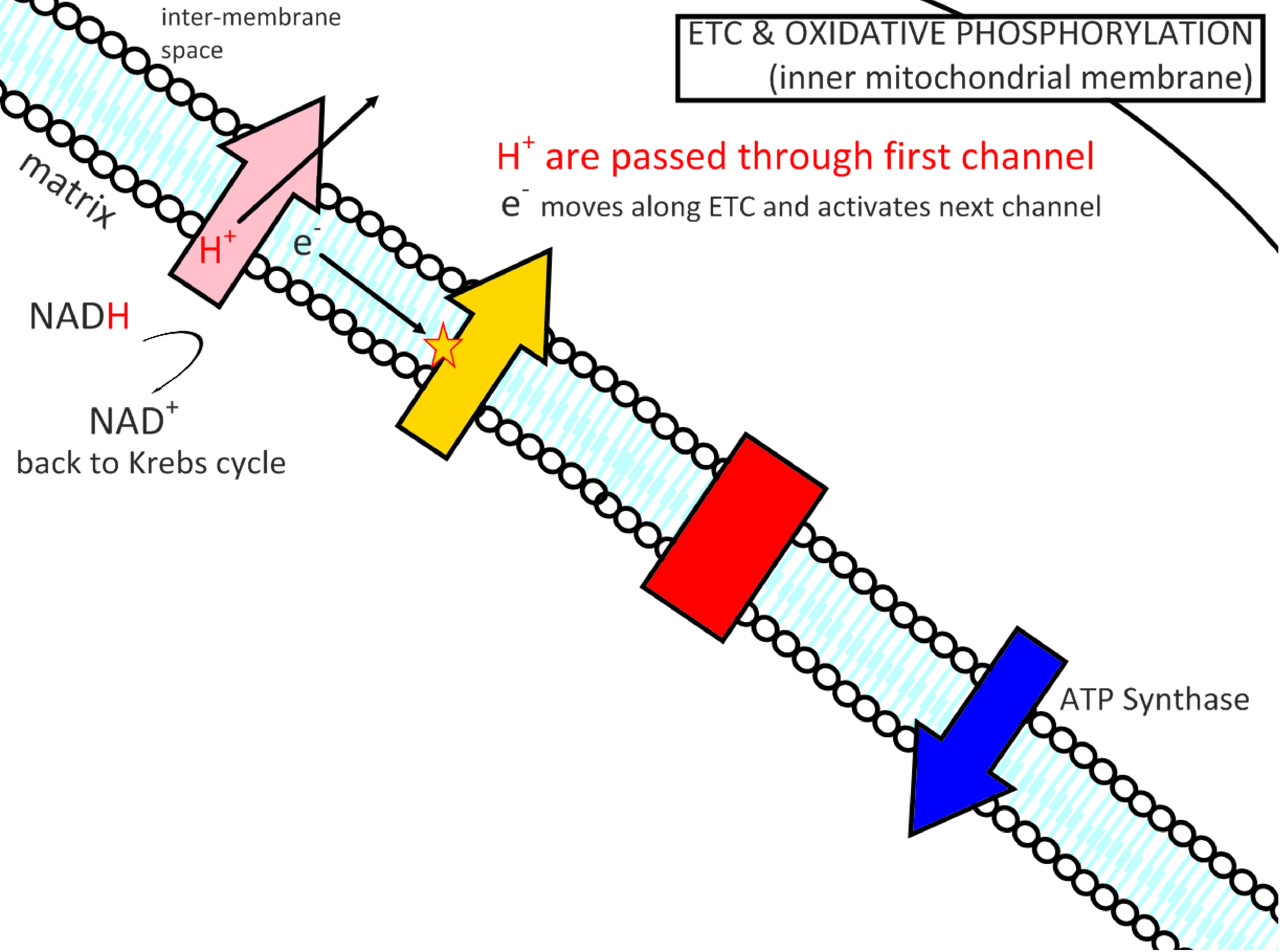


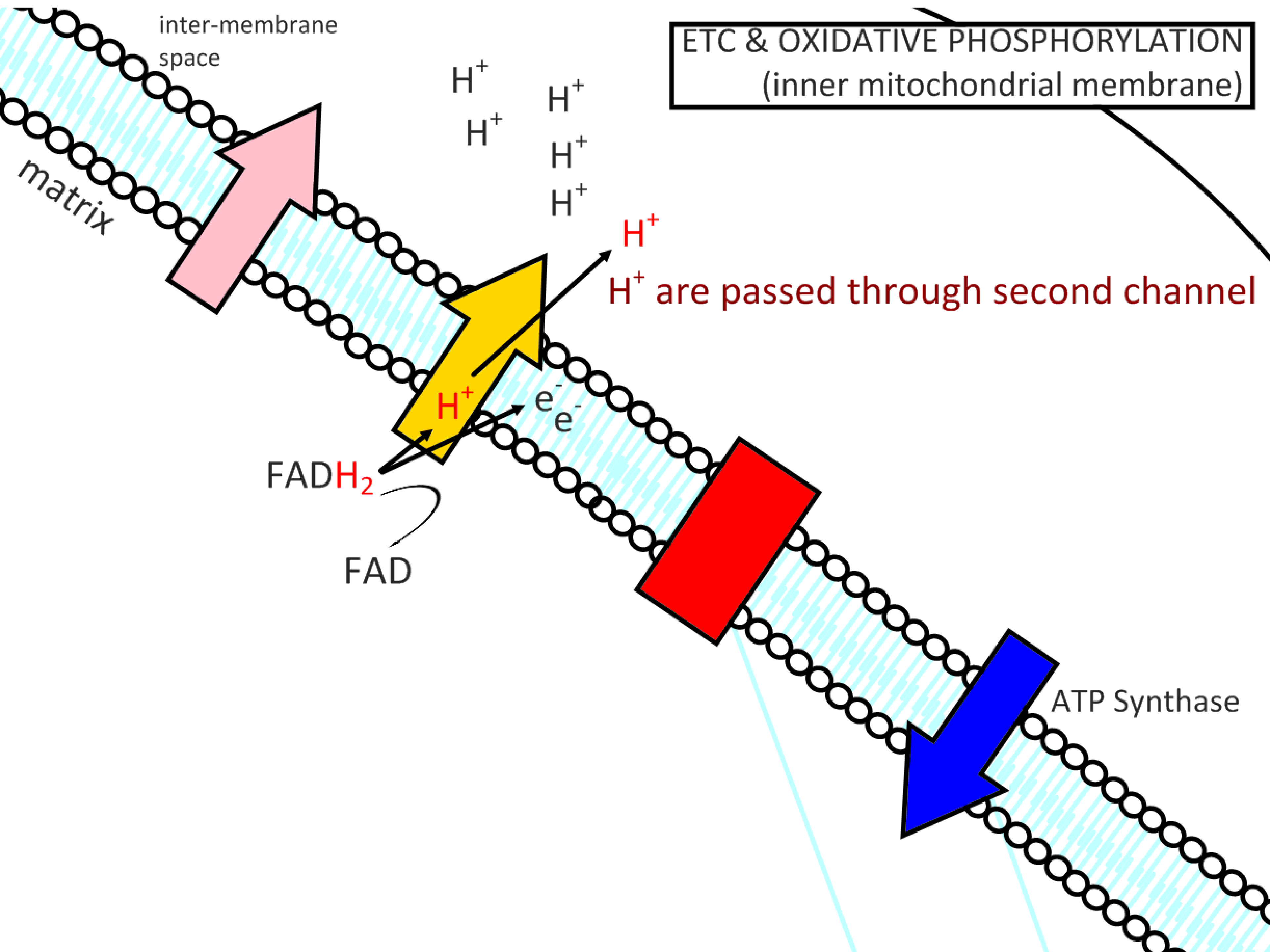
electron carriers deposit their electrons and H+ ions

ETC & OXIDATIVE PHOSPHORYLATION (inner mitochondrial membrane)

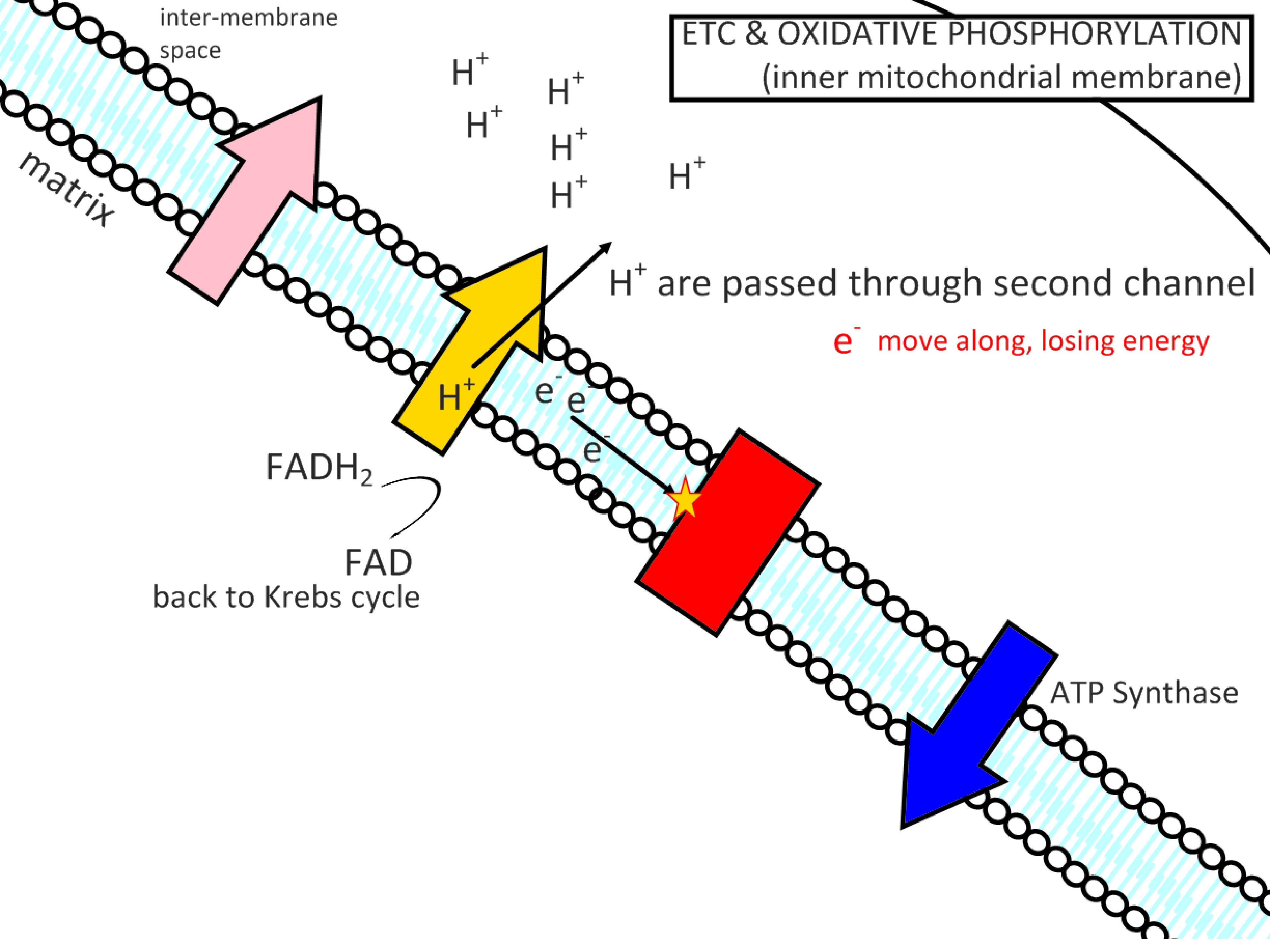
H+ are passed through first channel

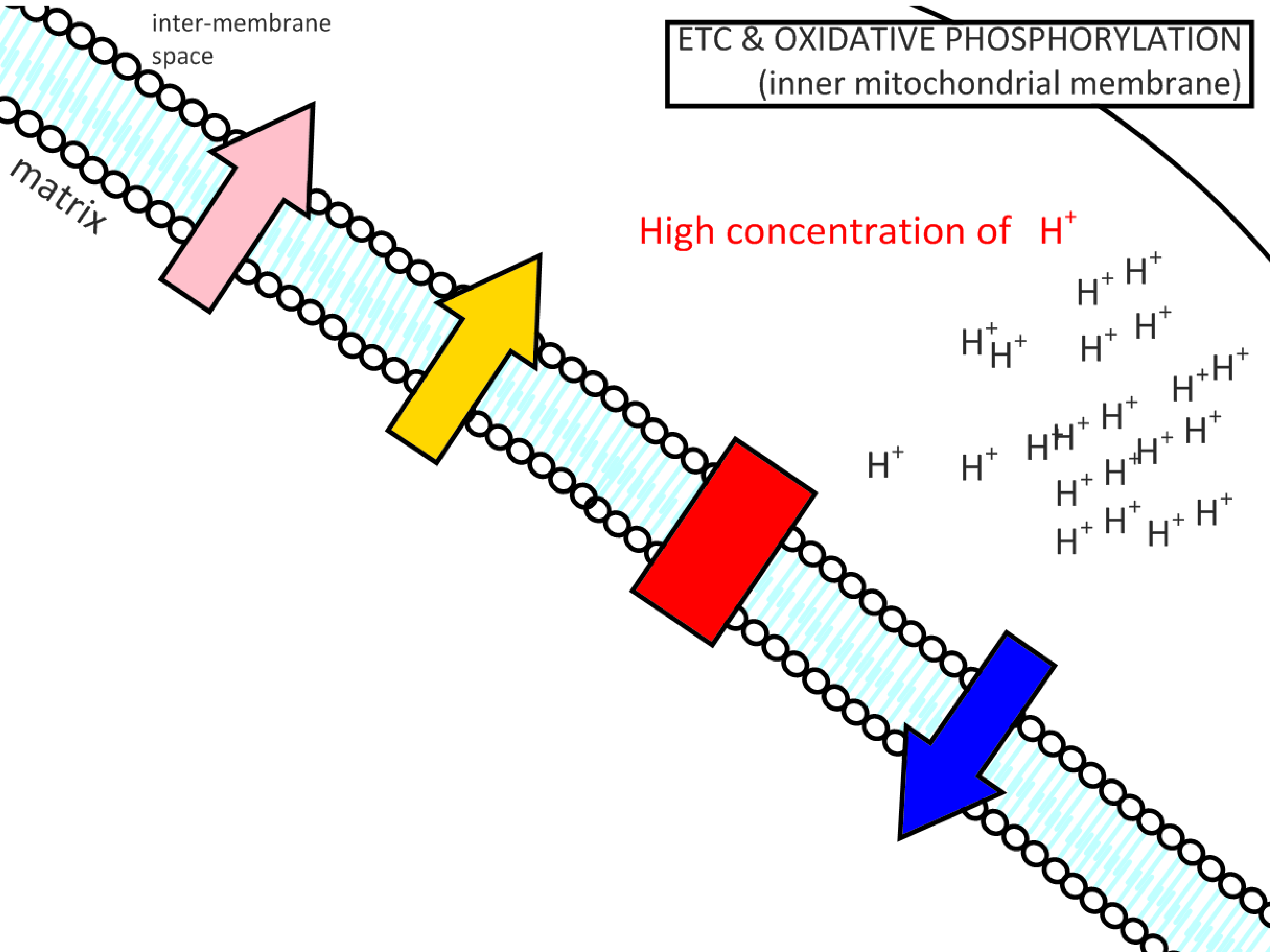
e- moves along ETC and activates next channel





ETC & OXIDATIVE PHOSPHORYLATION
(inner mitochondrial membrane)
inter-membrane space
matrix
H+
H+
H+
H+
H+
H+
H+ are passed through second channel
H+
e-
e-
FADH2
FAD
ATP Synthase

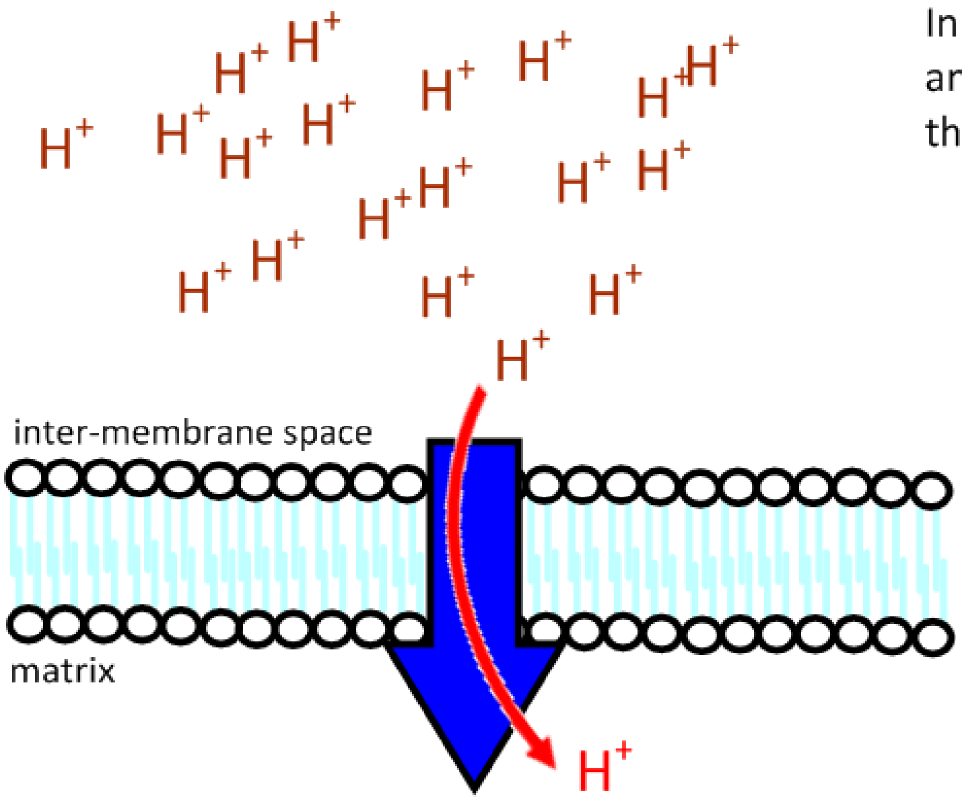

ETC & OXIDATIVE PHOSPHORYLATION
(inner mitochondrial membrane)
inter-membrane space
matrix
H+
H+
H+
H+
H+
H+
H+ are passed through second channel
e- move along, losing energy
H+
e-
e-
e-
FADH2
FAD
back to Krebs cycle
ATP Synthase


ETC & OXIDATIVE PHOSPHORYLATION
(inner mitochondrial membrane)
inter-membrane space
matrix
High concentration of H^+

Chemiosmosis

the diffusion of ions across a semi-permeable membrane, through a carrier protein.

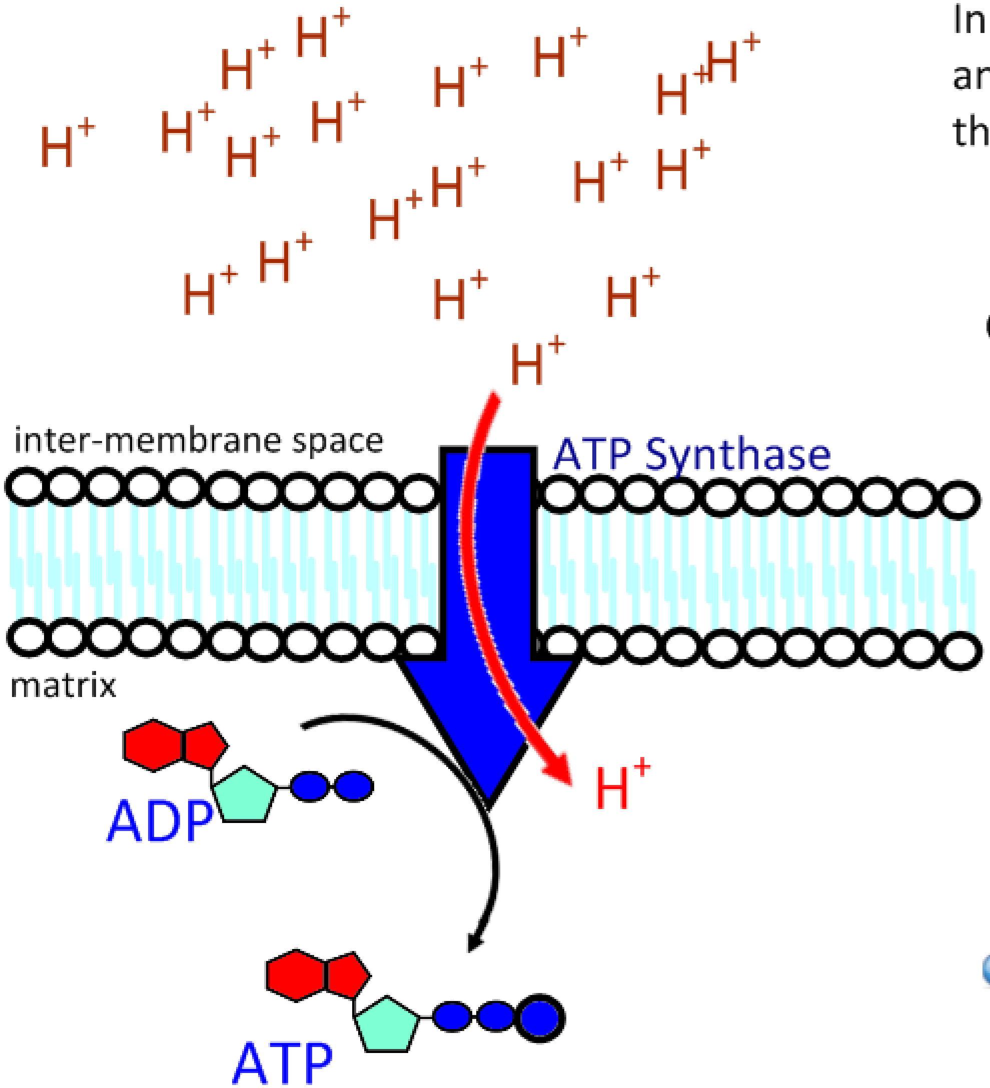
In this case, the ions are hydrogen protons and the carrier is ATP Synthase. The flow of the H^+ through ATP Synthase generates ATP.



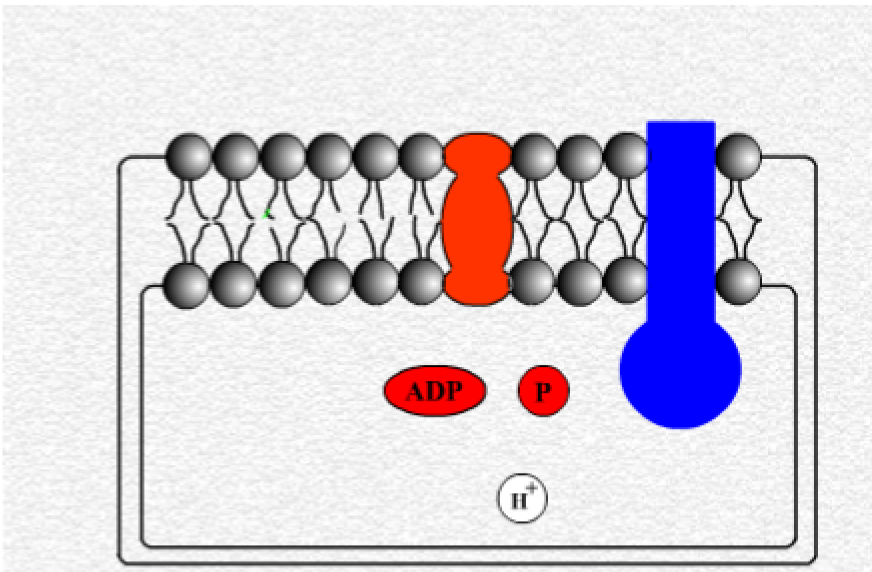
Chemiosmosis

the diffusion of ions across a semi-permeable membrane, through a carrier protein.

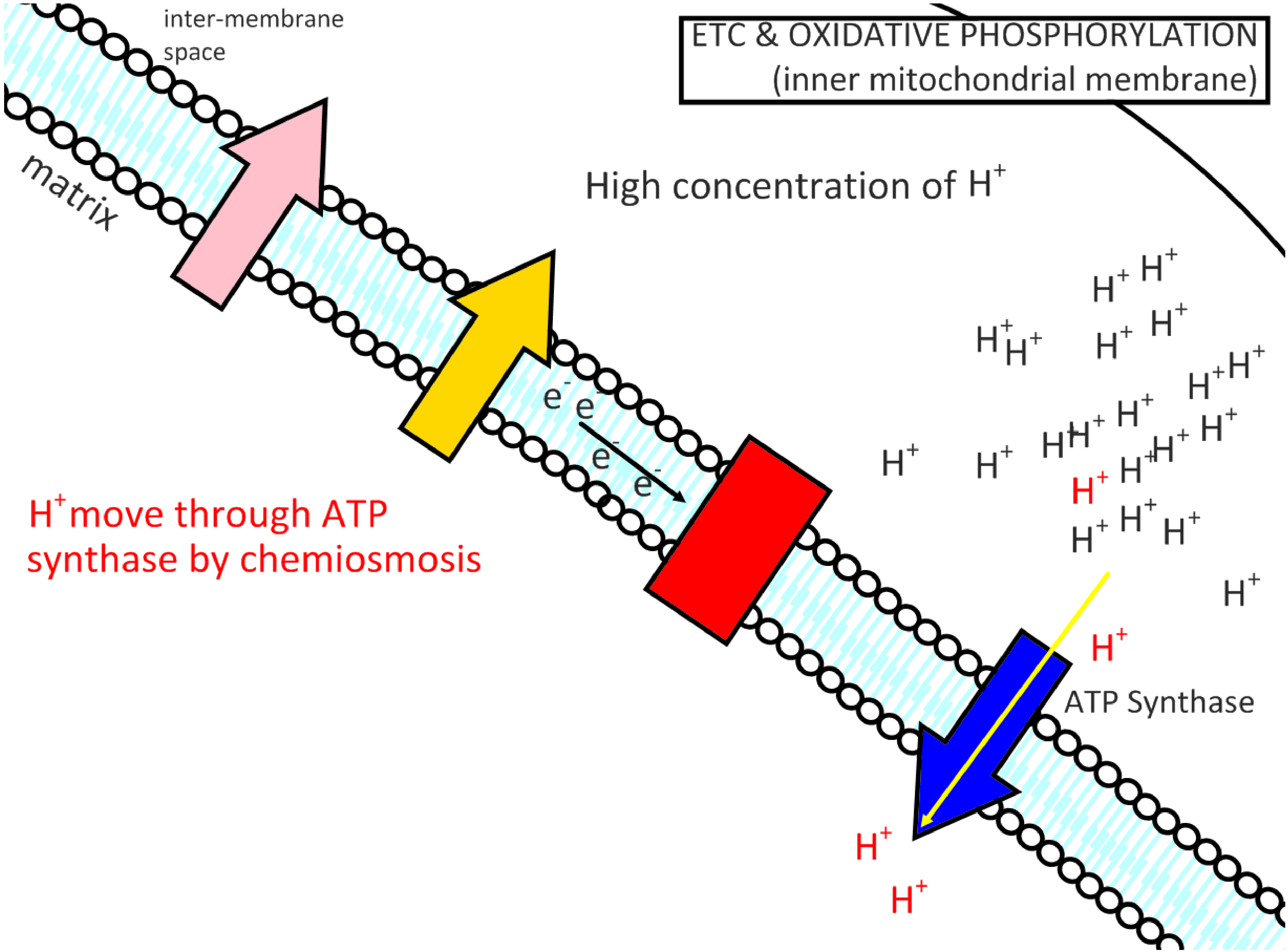
In this case, the ions are hydrogen protons and the carrier is ATP Synthase. The flow of the H^+ through ATP Synthase generates ATP.

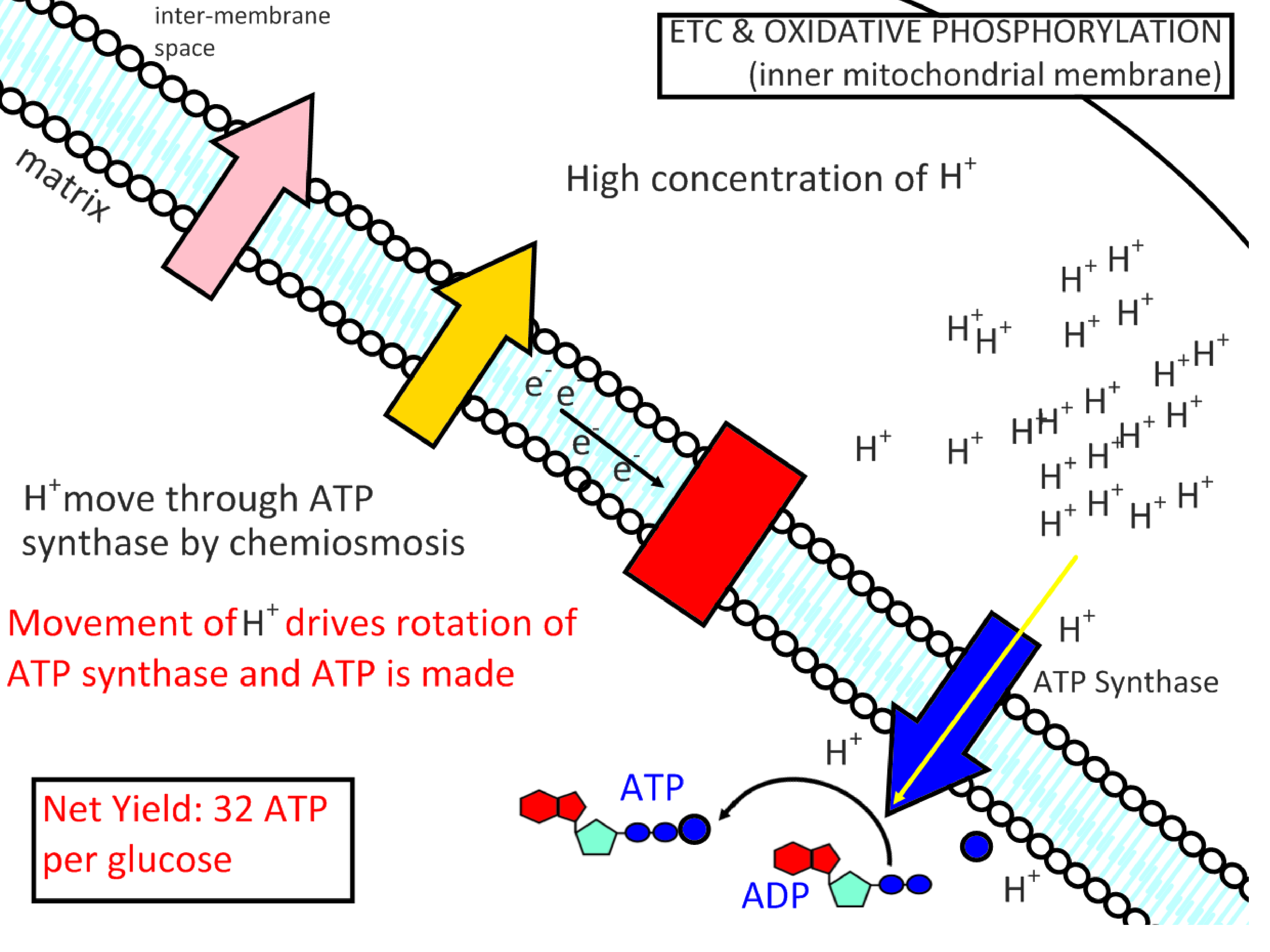


Chemiosmosis:

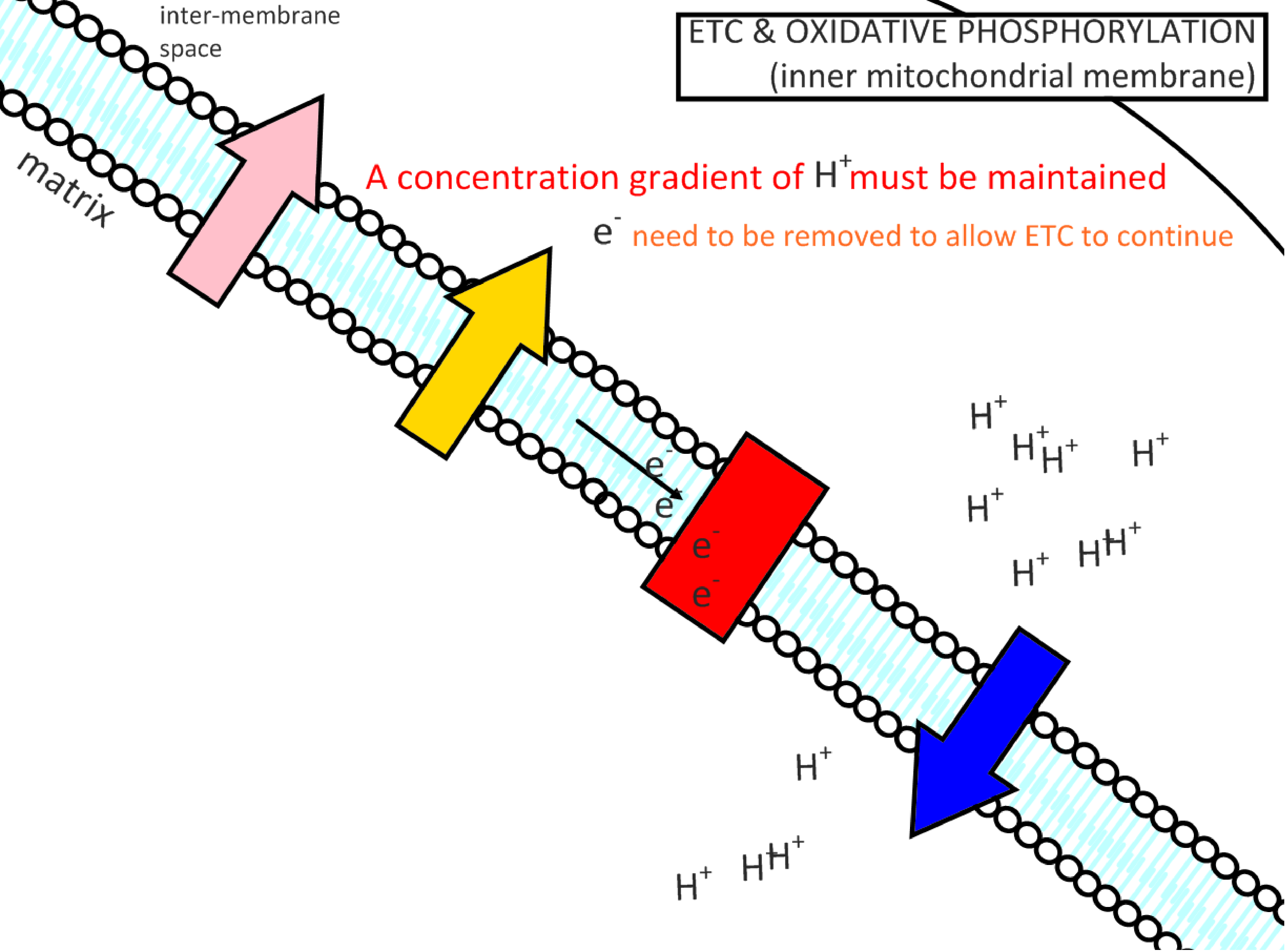


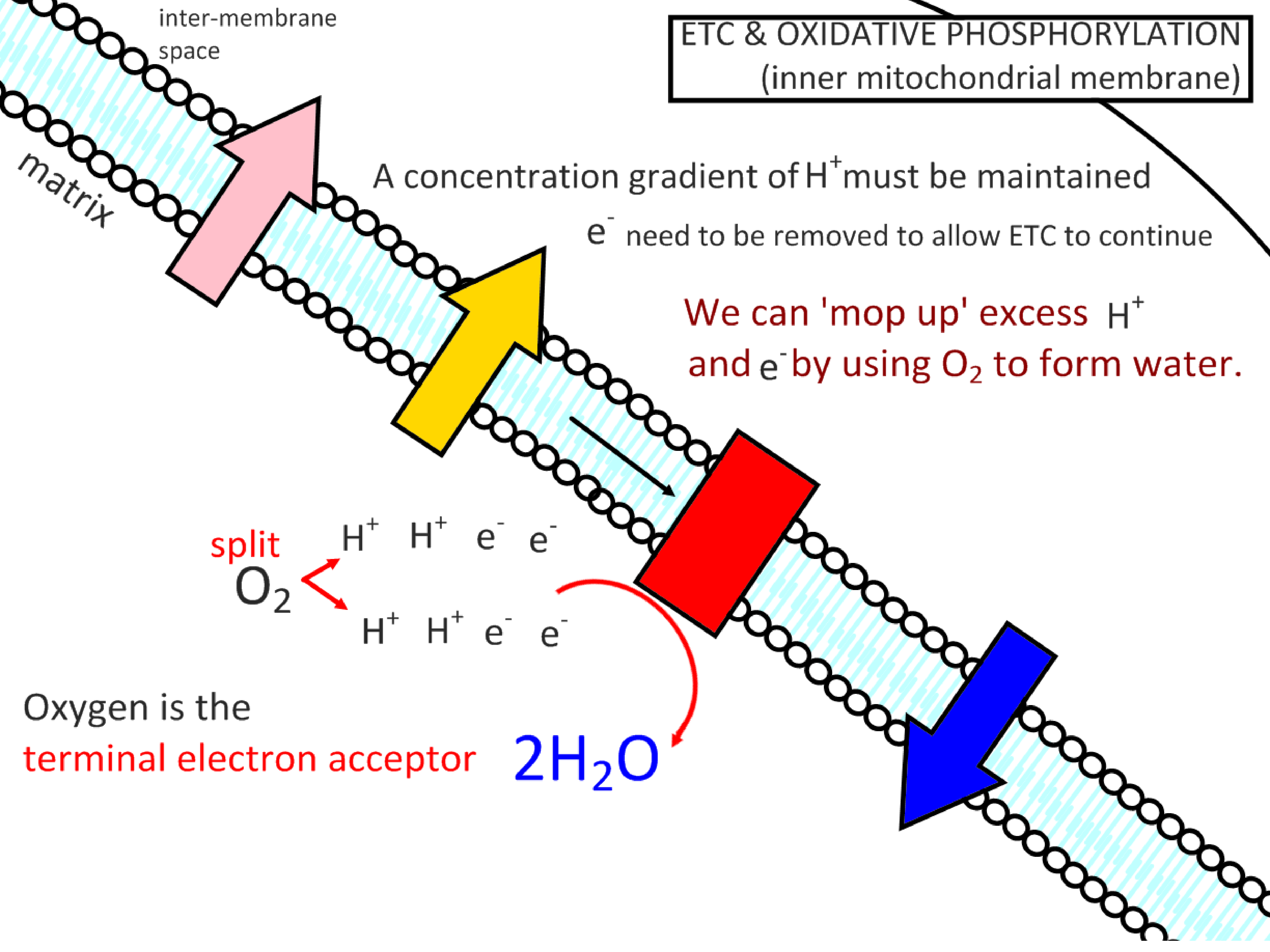
http://www.tvdsb.on.ca/westmin/science/sbioac/plants/chemios.htm


ETC & OXIDATIVE PHOSPHORYLATION
(inner mitochondrial membrane)
inter-membrane space
matrix
High concentration of H+
H+ move through ATP synthase by chemiosmosis
e-
ATP Synthase
H+



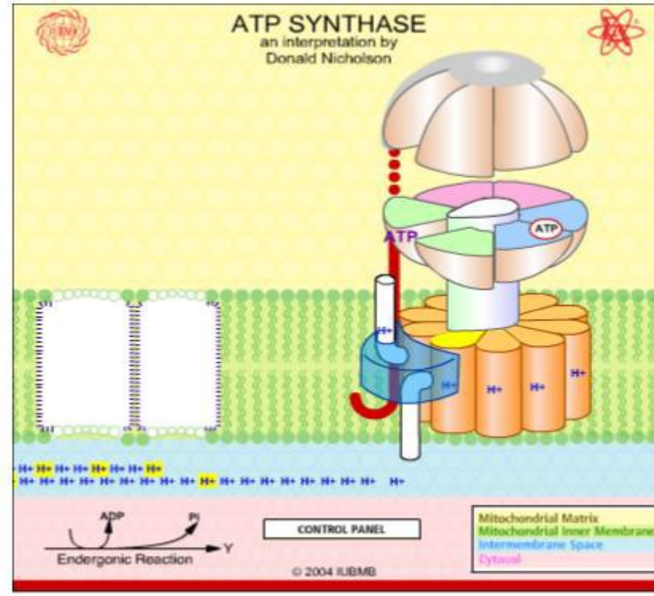
ETC & OXIDATIVE PHOSPHORYLATION
(inner mitochondrial membrane)
inter-membrane space
matrix
High concentration of H+
H+ move through ATP synthase by chemiosmosis
Movement of H+ drives rotation of ATP synthase and ATP is made
ATP Synthase
ATP
ADP
Net Yield: 32 ATP per glucose


ETC & OXIDATIVE PHOSPHORYLATION
(inner mitochondrial membrane)
inter-membrane space
matrix
A concentration gradient of H^+ must be maintained
e^- need to be removed to allow ETC to continue
e^-
e^-
e^-
e^-
H^+
H^+
H^+
H^+
H^+
H^+
H^+
H^+
H^+
H^+
H^+
H^+

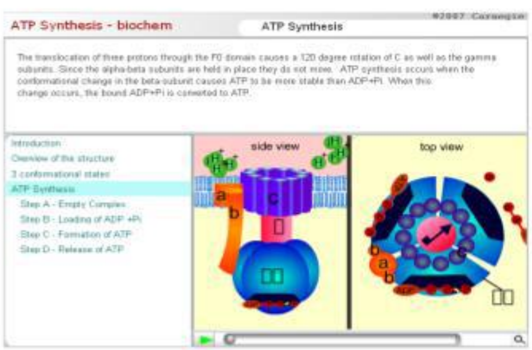

ETC & OXIDATIVE PHOSPHORYLATION
(inner mitochondrial membrane)
inter-membrane space
matrix
A concentration gradient of H^+ must be maintained
e^- need to be removed to allow ETC to continue
We can 'mop up' excess H^+ and e^- by using O_2 to form water.
split
O_2
H^+ H^+ e^- e^-
H^+ H^+ e^- e^-
Oxygen is the terminal electron acceptor
$2H_2O$

ATP Synthase & ETC Animations

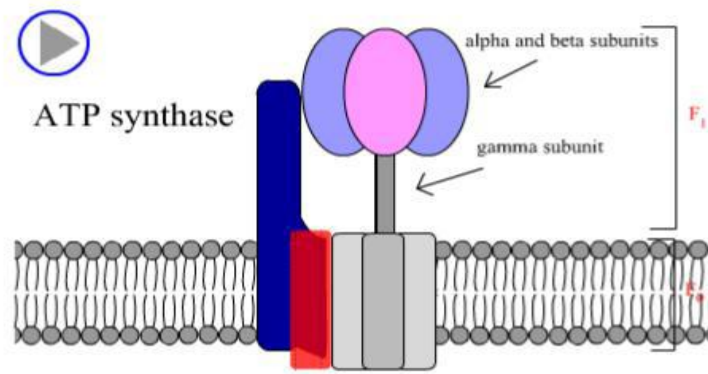
http://www.youtube.com/watch?v=uOoHKCMAUMc



http://www.iubmb-nicholson.org/swf/ATPSynthase.swf



http://tinyurl.com/yewuyg8



http://www.stolaf.edu/people/giannini/flashanimat/metabolism/atpsyn1.swf

https://www.youtube.com/watch?v=PjdPTY1wHdQ

Summary of aerobic cell respiration

REACTION/ STAGE	LOCATION	PURPOSE	ATP YIELD

Summary of aerobic cell respiration

REACTION/ STAGE	LOCATION	PURPOSE	ATP YIELD
GLYCOLYSIS	cytoplasm	convert glucose (6C) to pyruvate (2x3C)	2

Summary of aerobic cell respiration

REACTION/ STAGE	LOCATION	PURPOSE	ATP YIELD
GLYCOLYSIS	cytoplasm	convert glucose (6C) to pyruvate (2x3C)	2
LINK REACTION	matrix	convert pyruvate to acetyl CoA	0

Summary of aerobic cell respiration

REACTION/ STAGE	LOCATION	PURPOSE	ATP YIELD
GLYCOLYSIS	cytoplasm	convert glucose (6C) to pyruvate (2x3C)	2
LINK REACTION	matrix	convert pyruvate to acetyl CoA	0
KREBS CYCLE (citric acid cycle)	matrix	release H^+ to electron carriers (NADHand FADH2) for the electron transport chain	2

Summary of aerobic cell respiration

REACTION/ STAGE	LOCATION	PURPOSE	ATP YIELD
GLYCOLYSIS	cytoplasm	convert glucose (6C) to pyruvate (2x3C)	2
LINK REACTION	matrix	convert pyruvate to acetyl CoA	0
KREBS CYCLE (citric acid cycle)	matrix	release H^+ to electron carriers (NADHand FADH2) for the electron transport chain	2
ELECTRON TRANSPORT CHAIN	inner MITOCHONDRIAL membrane	energy to pump H^+ to intermembrane space to generate concentration gradient	0

Summary of aerobic cell respiration

REACTION/ STAGE	LOCATION	PURPOSE	ATP YIELD
GLYCOLYSIS	cytoplasm	convert glucose to pyruvate (6C) (2x3C)	2
LINK REACTION	matrix	convert pyruvate to acetyl CoA	0
KREBS CYCLE (citric acid cycle)	matrix	release H^+ to electron carriers (NADHand FADH2) for the electron transport chain	2
ELECTRON TRANSPORT CHAIN	inner MITOCHONDRIAL membrane	energy to pump H^+ to intermembrane space to generate concentration gradient	0
OXIDATIVE PHOSPHORYLATION	inner mitochondrial membrane	Uses flow of H^+ ions through ATP Synthase to phosphorylate ADP to ATP	32

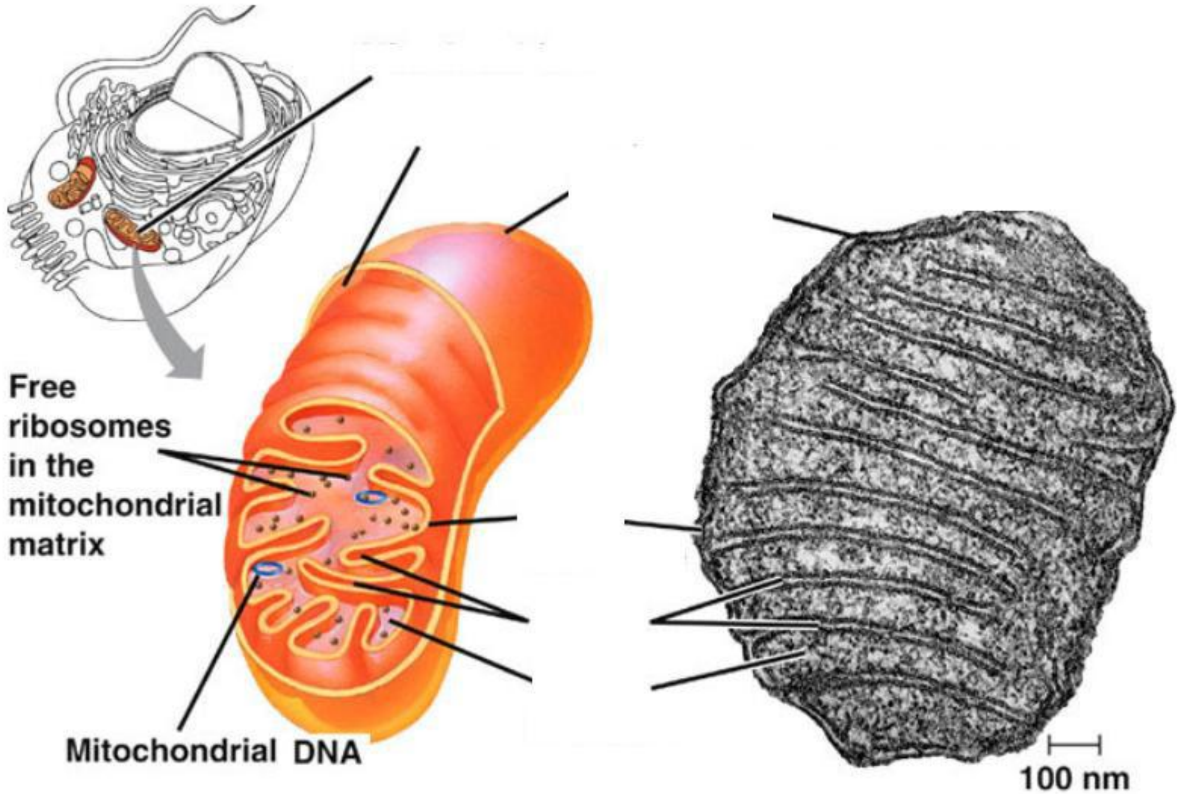
Summary of aerobic cell respiration

REACTION/ STAGE	LOCATION	PURPOSE	ATP YIELD
GLYCOLYSIS	cytoplasm	convert glucose to pyruvate (6C) (2x3C)	2
LINK REACTION	matrix	convert pyruvate to acetyl CoA	0
KREBS CYCLE (citric acid cycle)	matrix	release H^+ to electron carriers (NADHand FADH2) for the electron transport chain	2
ELECTRON TRANSPORT CHAIN	inner MITOCHONDRIAL membrane	energy to pump H^+ to intermembrane space to generate concentration gradient	0
OXIDATIVE PHOSPHORYLATION	inner mitochondrial membrane	Uses flow of H^+ ions through ATP Synthase to phosphorylate ADP to ATP	32

Total ATP yield by aerobic respiration: 36

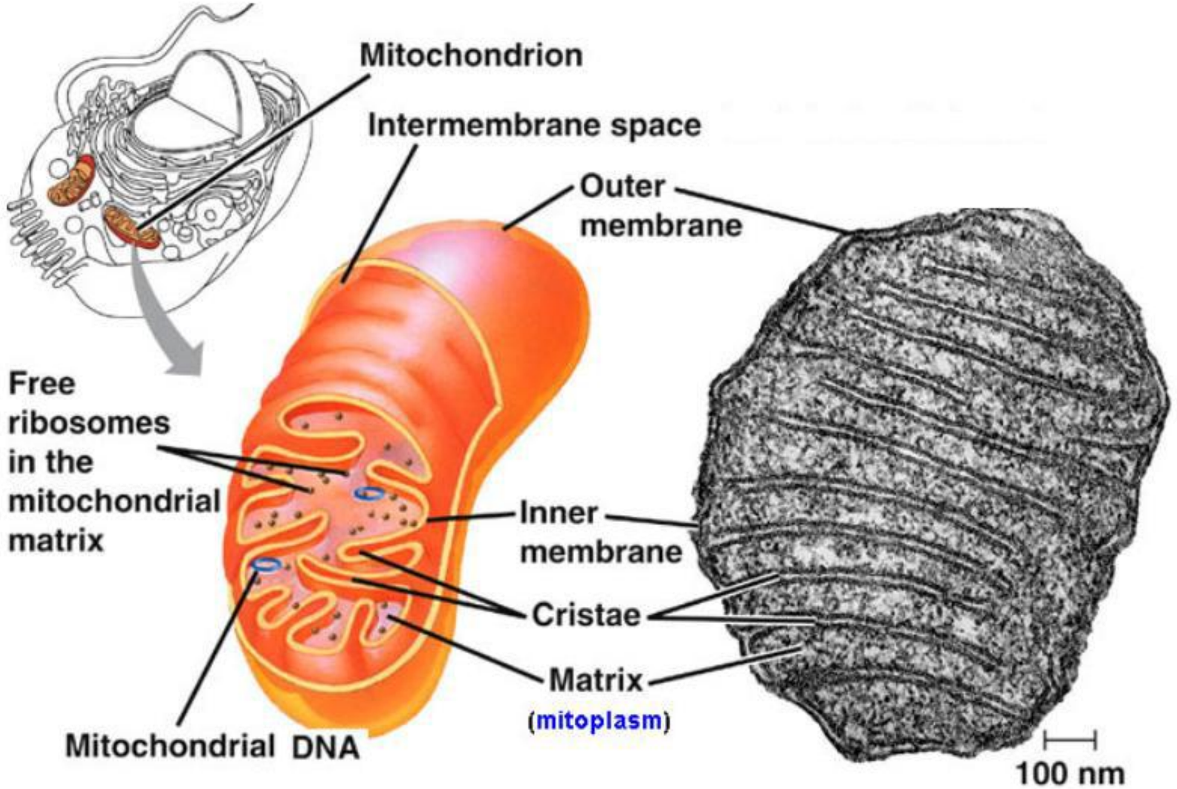
Look at the mitochondrion again:
How is it adapted to carry out its function?

Structure vs function



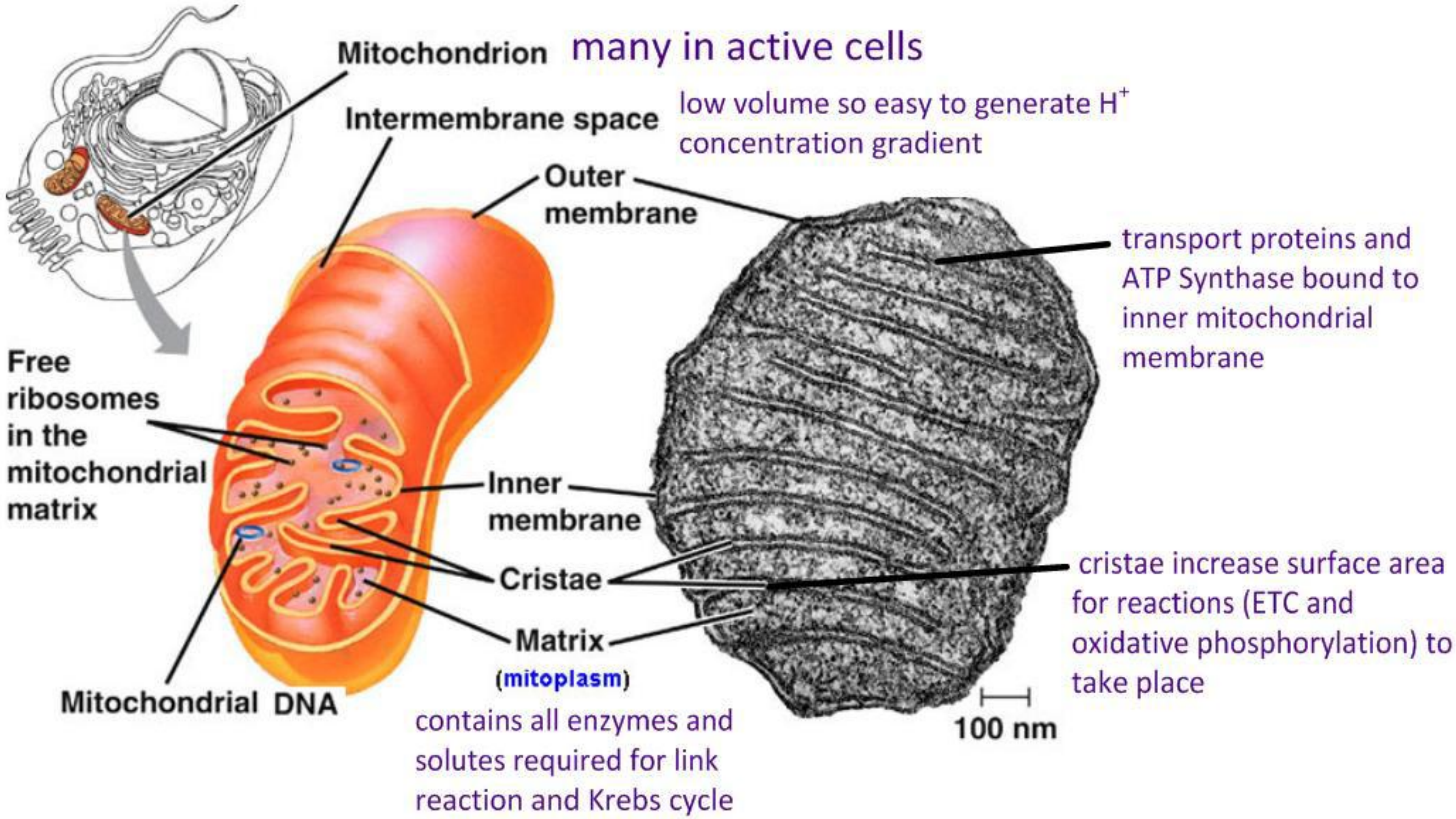
http://www.bio.miami.edu/~cmallery/150/cells/c7.6.17.mitochondrion.jpg

Look at the mitochondrion again:
How is it adapted to carry out its function?



http://www.bio.miami.edu/~cmallery/150/cells/c7.6.17.mitochondrion.jpg

Look at the mitochondrion again:
How is it adapted to carry out its function?



http://www.bio.miami.edu/~cmallery/150/cells/c7.6.17.mitochondrion.jpg

Try this virtual lab activity:

http://www.phschool.com/science/biology_place/labbench/lab5/intro.html

Remember:

Respiration is a process controlled by enzymes - how will various factors affect the rate of reaction?

Pay attention to the rubric and write up the investigation for DCP and CE.

Which is not a product of the Krebs cycle?

CO_2 | $NADH + H^+$ | Pyruvate | ATP

Which is not a product of the Krebs cycle?

CO_2 → from oxidative decarboxylation

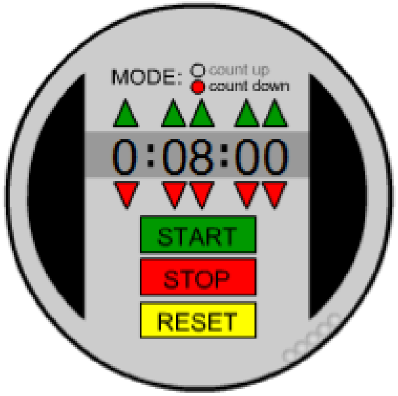
$NADH + H^+$ → from reduction of NAD^+

Pyruvate → GLYCOLYSIS!

ATP → 4C rearrangement

Explain the process of aerobic cellular respiration.

(8 marks)



Explain the process of aerobic cellular respiration.

(8 marks)

glucose is broken down to pyruvate in the cytoplasm;
with a small yield of ATP/net yield of 2 ATP;
and NADH + H^+/NADH;

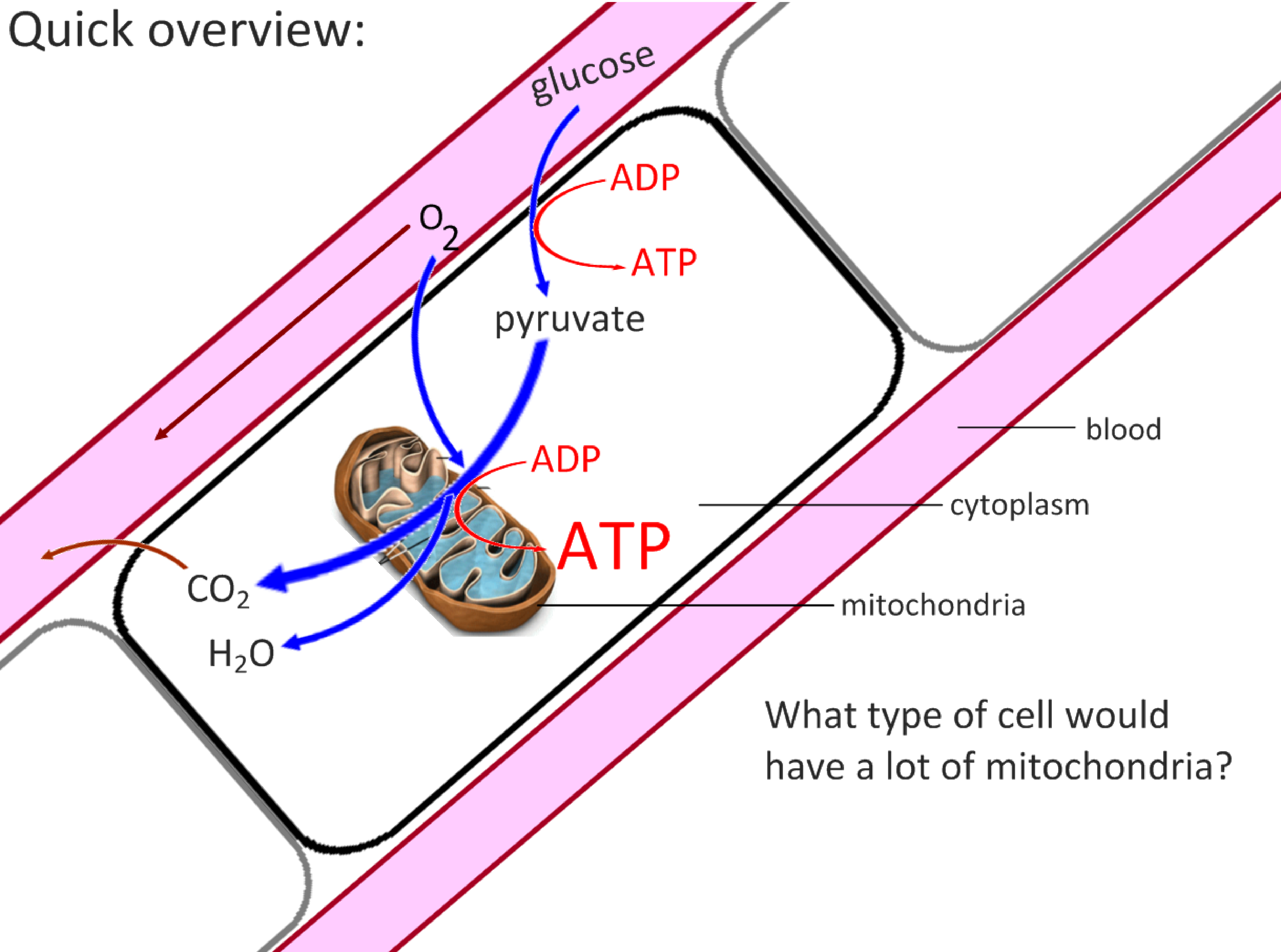
aerobic respiration in the presence of oxygen;
pyruvate converted to acetyl CoA;
acetyl CoA enters Krebs cycle;

Krebs cycle yields a small amount of ATP/one ATP per cycle;
and $FADH_2$ / FADH + H^+ / NADH/ NADH + H^+ /
reduced compounds / electron collecting molecules;

these molecules pass electrons to electron transport chain;
oxygen is final electron acceptor/water produced;
electron transport chain linked to creation of an electrochemical gradient;
electrochemical gradient/chemiosmosis powers creation of ATP;
through ATPase;

From the QuestionBank CDRom

Quick overview:



What type of cell would have a lot of mitochondria?

Cellular Respiration Song

- http://www.youtube.com/watch?v=3aZrkdzrd04

"Oxidate it or love it" / "Electron to the next one" (Stanford)

- http://www.youtube.com/watch?v=VCpNk92uswY

Kickstarting his group, the Rhymbosomes:
(http://therhymebosome.wordpress.com/2012/02/29/oxidate-it-or-love-it-electron-to-the-next-one-lyrics/)

- http://www.youtube.com/watch?v=PjdPTY1wHdQ
- http://www.iubmb-nicholson.org/swf/ATPSynthase.swf
- http://www.stolaf.edu/people/giannini/flashanimat/metabolism/atpsyn1.swf

On a microscopic Level, what is a cell using energy for?

- https://www.youtube.com/watch?v=wJyUtbn0O5Y