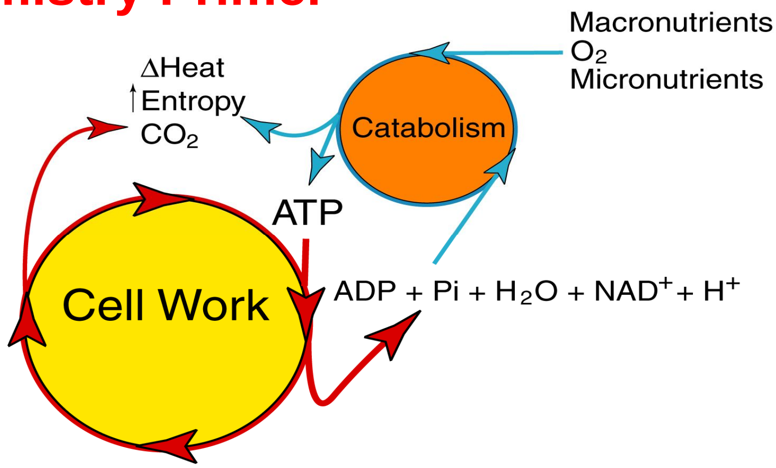
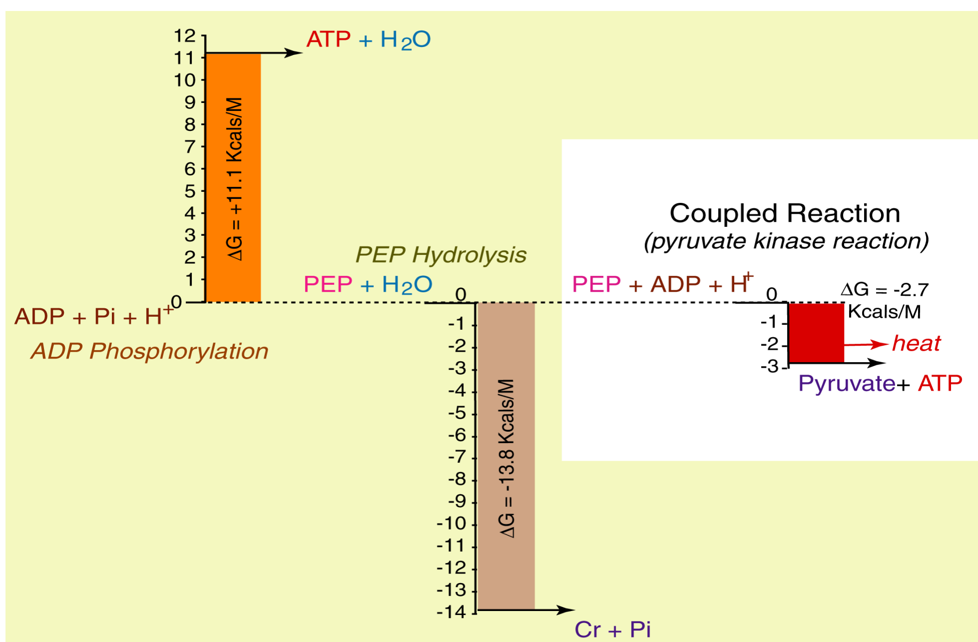
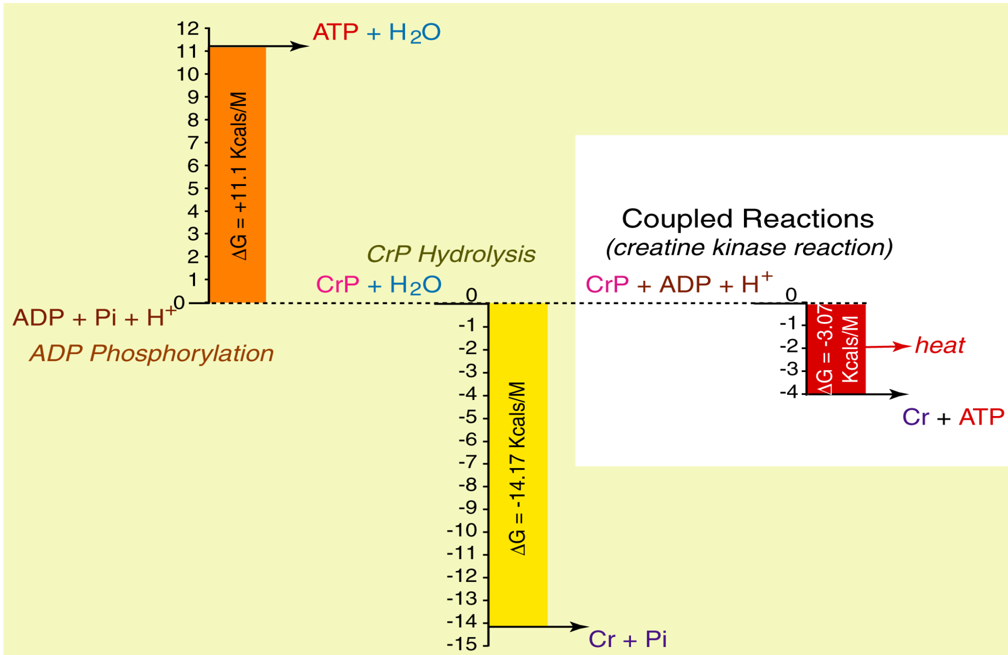
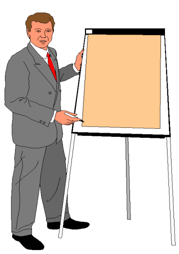
Chemistry Primer



Some of the **exergonic** reactions of catabolism use ADP and ATP to "harness" free energy. ATP can then be used to provide the free energy needed to make *endergonic* reactions **exergonic** (eg. **COUPLING**), or produce work (eg. muscle contraction).







QUESTIONS

1. What is the concentration of ATP within a muscle fiber?

2. Will the following reaction and direction occur by itself inside a cell?

$$ADP + Pi + H^+ \longrightarrow ATP$$

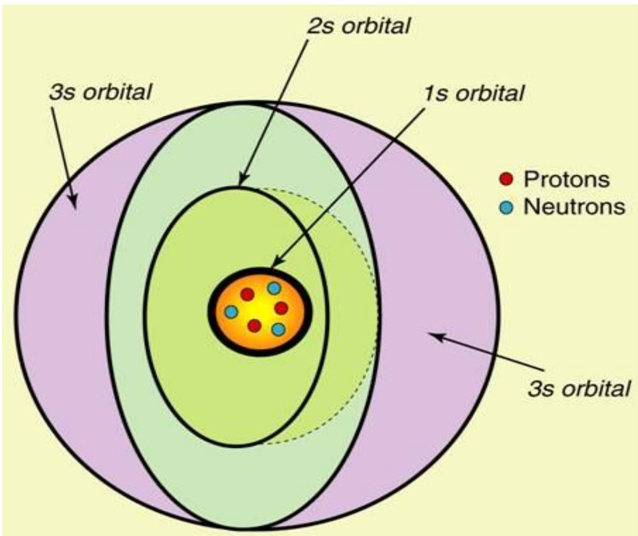
3. How much free energy is needed to make this reaction proceed in this direction inside a cell? (what is the reaction's ΔG?)

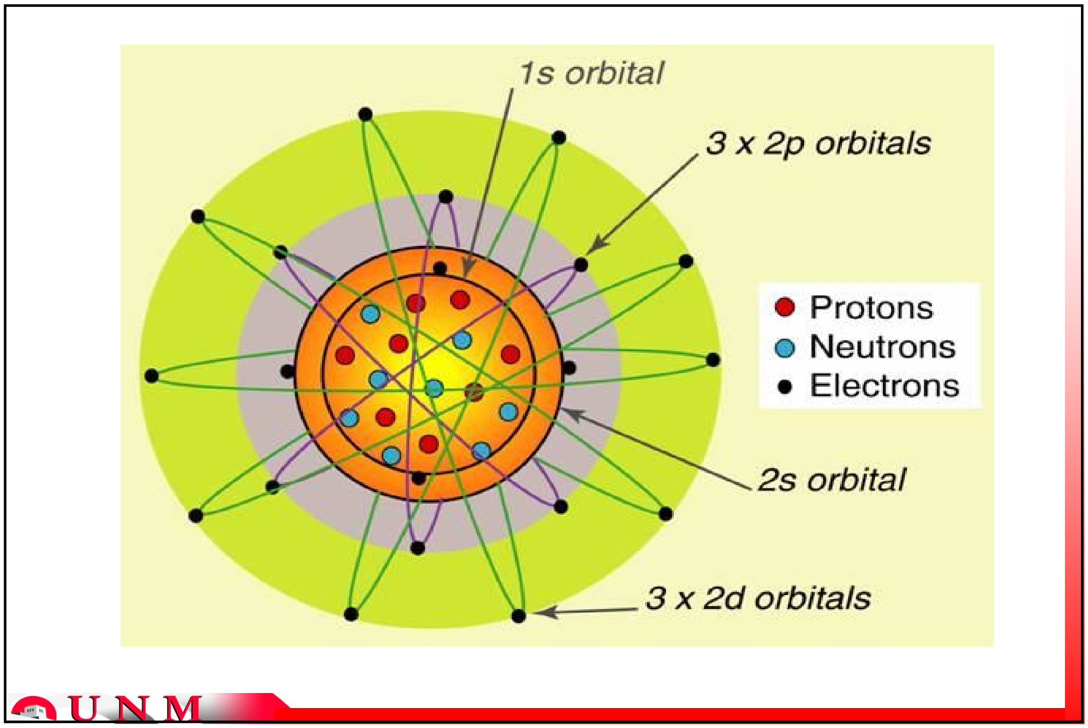
4. How is this "endergonic reaction" allowed to proceed inside a cell without violating the second law of bioenergetics?

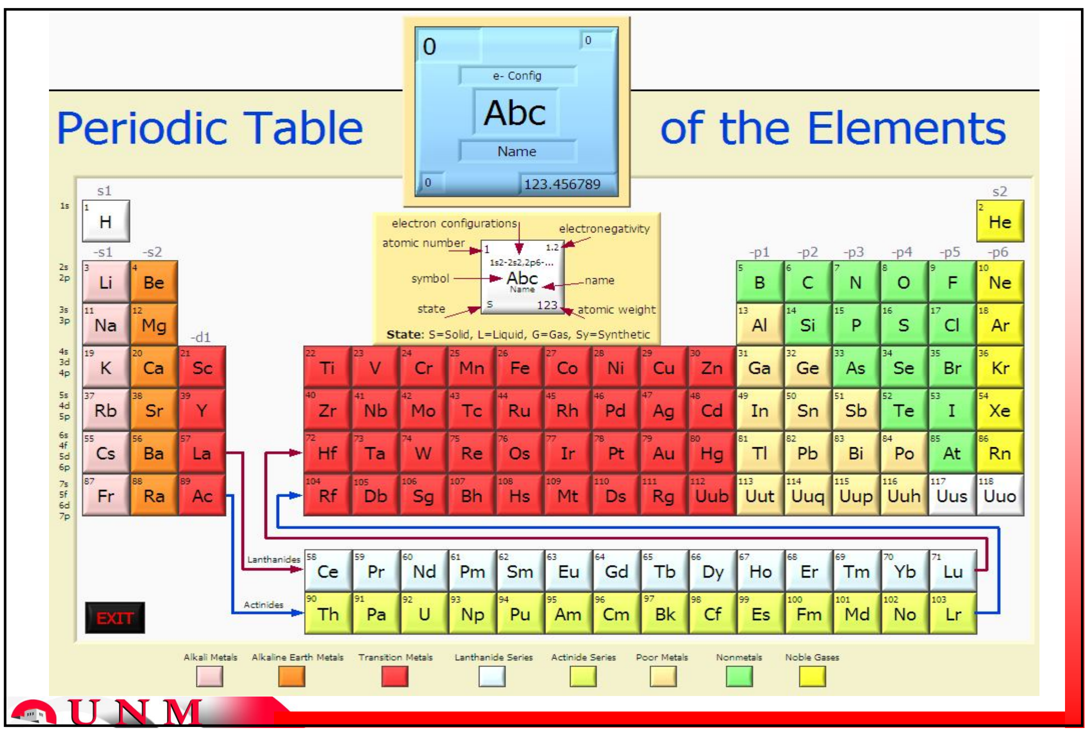
Electrons, protons, and oxidation-reduction reactions.

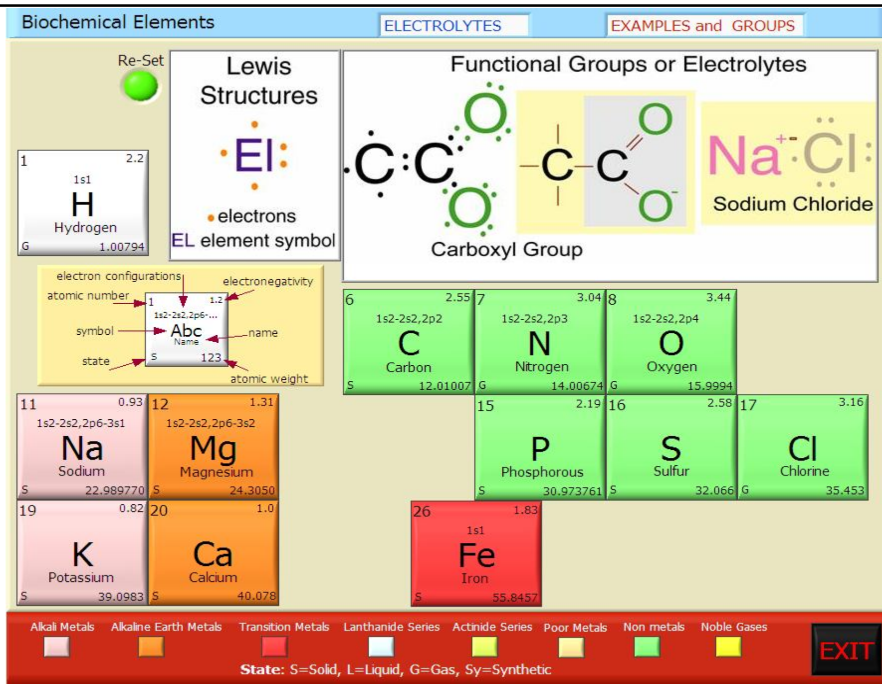
- **Electrons** are negatively charged subatomic particles that circulate around the atom nucleus.
- Electrons are essential for atoms to form **covalent** (electron sharing) **bonds**.
- During many chemical reactions, electrons are either removed or added to molecules.
- Molecules that lose one or more electrons are ***oxidized***, whereas molecules that gain electrons are ***reduced***.

Atoms & Electrons




1s orbital
3 x 2p orbitals
Protons
Neutrons
Electrons
2s orbital
3 x 2d orbitals
UNM


Periodic Table
of the Elements
e- Config
Abc
Name
123.456789
electron configurations
electronegativity
atomic number
symbol
name
state
atomic weight
State: S=Solid, L=Liquid, G=Gas, Sy=Synthetic
Lanthanides
Actinides
EXIT
Alkali Metals
Alkaline Earth Metals
Transition Metals
Lanthanide Series
Actinide Series
Poor Metals
Nonmetals
Noble Gases
UNM



Consequently, ***oxidation*** *involves the loss of electrons*, and ***reduction*** *involves the gaining of electrons*.

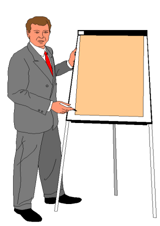
As oxidation and reduction reactions occur together, they are often termed *oxidation-reduction* or **redox reactions**.

$$A{:}e + B \longleftrightarrow A + B{:}e$$

for example,

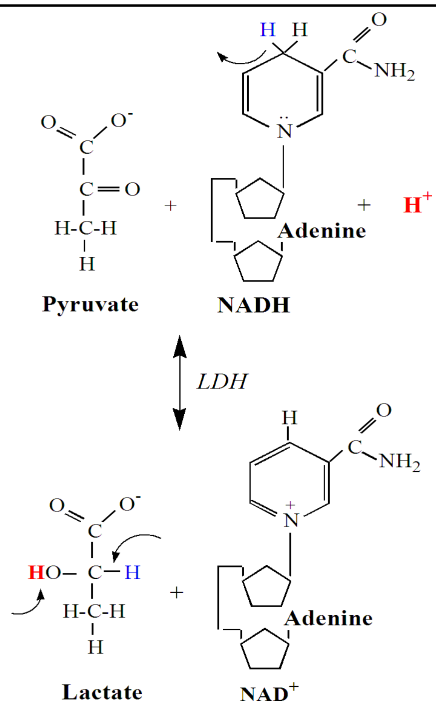
pyruvate + NADH + H^+ ⟷ lactate + NAD^+

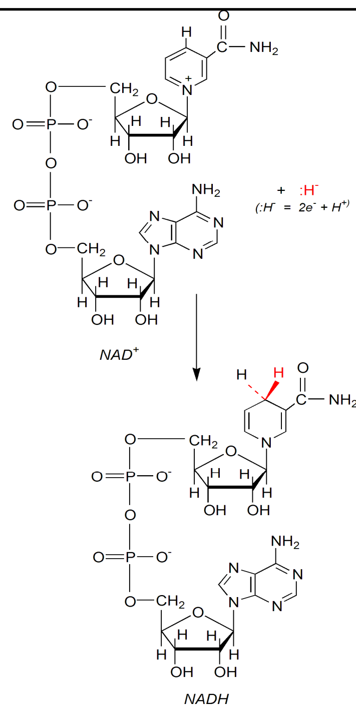
Lactate dehydrogenase

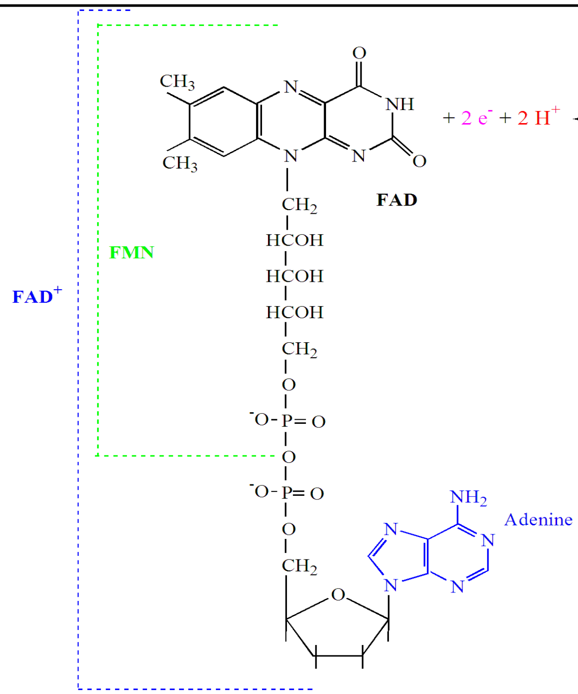


Question

Which of the above molecules was reduced, and which was oxidized in the direction of lactate production?


Pyruvate
NADH
Adenine
H+
LDH
Lactate
NAD+
Adenine


NAD+
+ :H-
(:H- = 2e- + H+)
NADH



Why are protons important?

A **proton** (H^+) is a hydrogen atom that has lost its electron.

The concentration of protons ($[H^+]$) in solution determines the acidity of the solution, and is represented numerically by the negative log of the $[H^+]$

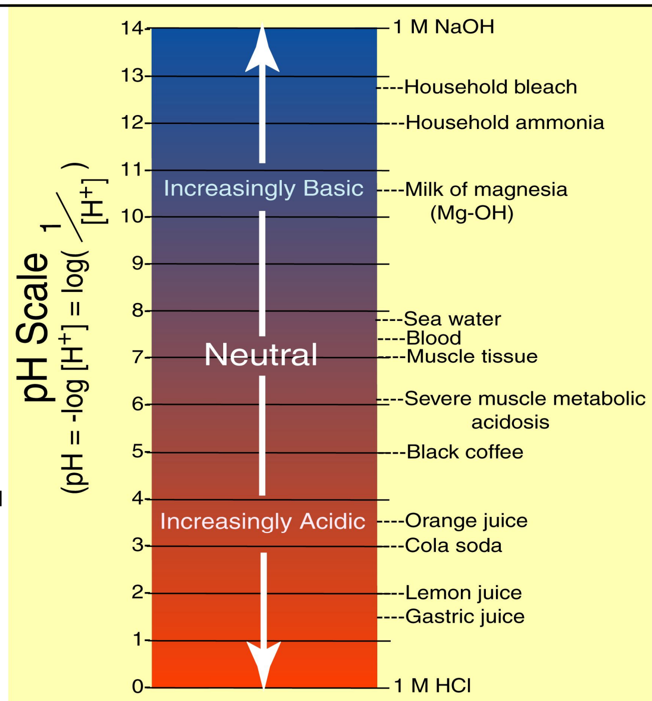
(**pH** = -log $[H^+]$)

Thus, ***a low pH represents high acidity***, and vice-versa.

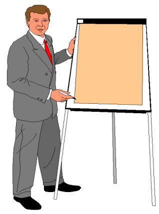
Cellular pH is important to maintain (7.0 at rest), for when pH falls too far (< 6.8), electrons are forced to leave certain molecules. For proteins (eg. enzymes), this occurrence can alter the shape of the molecule, decreasing its effectiveness.

pH Scale and Examples

$[H^+]$ (M)	pH	$[OH^-]$ (M)	pOH
10^0(1)	0	10^{-14}	14
10^{-1}	1	10^{-13}	13
10^{-2}	2	10^{-12}	12
10^{-3}	3	10^{-11}	11
10^{-4}	4	10^{-10}	10
10^{-5}	5	10^{-9}	9
10^{-6}	6	10^{-8}	8
10^{-7}	7	10^{-7}	7
10^{-8}	8	10^{-6}	6
10^{-9}	9	10^{-5}	65
10^{-10}	10	10^{-4}	4
10^{-11}	11	10^{-3}	3
10^{-12}	12	10^{-2}	2
10^{-13}	13	10^{-1}	1
10^{-14}	14	10^0(1)	0



Acid	Ionization Reaction	Base	pKa
Acetic acid	$CH_3COOH \leftrightarrow CH_3COO^- + H^+$	Acetate	4.76
Adenosine triphosphate	$HATP^- \leftrightarrow ATP^{-2} + H^+$	ATP^{-2}	6.48
Adenosine diphosphate	$HADP^- \leftrightarrow ADP^{-2} + H^+$	ADP^{-2}	6.38
Ammonium	$NH4^+ \leftrightarrow NH_3 + H^+$	Ammonia	9.26
Carbonic acid	$H_2CO_3 \leftrightarrow HCO_3^- + H^+$	Bicarbonate	3.77
Formic acid	$HCOOH \leftrightarrow HCOO^- + H^+$	Formate	3.75
Histidine	$Histidine^+ \leftrightarrow Histidine + H^+$	Histidine	6.0
Lactic acid	$CH_3CH(OH)COOH \leftrightarrow CH_3CH(OH)COO^- + H^+$	Lactate	3.67
Phosphoric acid	$H_3PO_4 \leftrightarrow H_2PO_4^- + H^+$	Dihydrogen phosphate	2.14
Dihydrogen phosphate	$H_2PO_4 \leftrightarrow HPO_4^{-2} + H^+$	Monohydrogen phosphate	6.75
3-Phosphoglyceric acid	$CH_2OPO_3^{-2}CH(OH)COOH \leftrightarrow CH_2OPO_3^{-2}CH(OH)COO^- + H^+$	3-Phosphoglycerate	6.21
2-Phosphoglyceric acid	$CH_3(OH)CHOPO_3^{-2}COOH \leftrightarrow CH_3(OH)CHOPO_3^{-2}COO^- + H^+$	2-Phosphoglycerate	7.0
Propionic acid	$CH_3CH_2COOH \leftrightarrow CH_3CH_2COO^- + H^+$	Propionate	4.87
Pyruvic acid	$CH_3COCOOH \leftrightarrow CH_3COCOO^- + H^+$	Pyruvate	2.26



Questions

1. Calculate the $[H^+]$ for the following pH values.

7.4	0.39×10^{-7}
7.0	1.00×10^{-7}
6.8	1.58×10^{-7}
6.4	3.98×10^{-7}
6.1	7.94×10^{-7}

2. How many times more acidic is a pH of 6.1 vs 7.0?

7.94 times as acidic

UNM