Course 2851 Principles of Metabolism
Metabolism and endocrinology programme, Karolinska Institutet

Lecture 3

Oxidation and reduction

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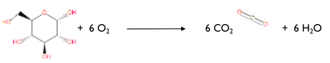
Metabolism consists of oxidation-reduction reactions

Catabolism = oxidation of carbon



C ⟶ e⁻ ⟶ O

(energy carrier, e.g. NAD)

Anabolism = reduction of carbon

Electronegativity

- The ability of an atom to attract electrons
- Electrons "prefer" more electronegative atoms – favorable

Atom	E
H	2.3
P	2.3
C	2.5
S	2.6
N	3.0
O	3.6

↓ More electronegative

Oxidation state of carbon

- Total number of electrons donated (+) or received (–) from bound atoms

Oxidation state = (# bonds shared with N, O) – (# bonds shared with H, P)

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     ?
     |
? —  C — ?
     |
     ?
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Highly reduced "energy rich" ↕ Highly oxidized "energy poor"

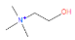
Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—CH(NH_2) —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

Oxidation state of common metabolites

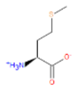
Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—$CH(NH_2)$ —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

Highly oxidized
"energy poor"



Choline



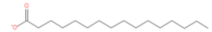
Methionine

Oxidation state of common metabolites

Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—$CH(NH_2)$ —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

Highly oxidized
"energy poor"



Palmitate (saturated fat)

Oxidation state of common metabolites

Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—$CH(NH_2)$ —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

Highly oxidized
"energy poor"

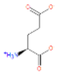
Arachidonate (unsaturated fat)

Oxidation state of common metabolites

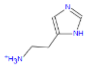
Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—CH(NH_2) —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

Highly oxidized
"energy poor"



Glutamate



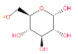
Histamine

Oxidation state of common metabolites

Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—CH(NH_2) —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

Highly oxidized
"energy poor"



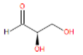
Glucose

Oxidation state of common metabolites

Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—CH(NH_2) —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

Highly oxidized
"energy poor"

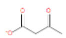


Glyceraldehyde

Oxidation state of common metabolites

Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—$CH(NH_2)$ —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

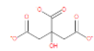

Acetoacetate

Highly oxidized
"energy poor"

Oxidation state of common metabolites

Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—$CH(NH_2)$ —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4


Citrate

Highly oxidized
"energy poor"

Oxidation state of common metabolites

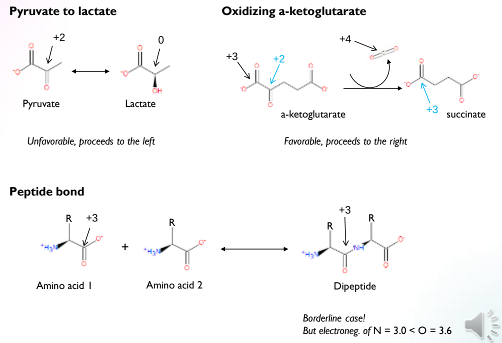
Highly reduced
"energy rich"

Functional group	State
—CH_3	-3
—CH_2—	-2
—CH=CH—	-1
—$CH(NH_2)$ —	0*
—CH(OH) —	0
—CH=O	+1
—(C=O) —	+2
—COOH	+3
CO2	+4

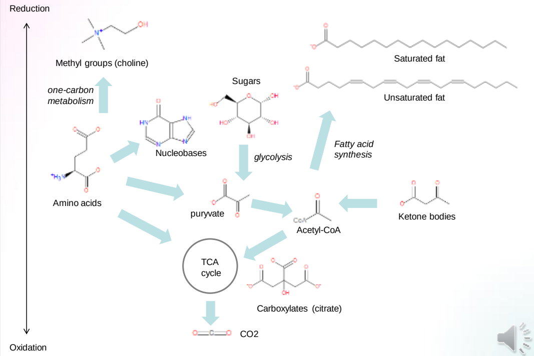
CO2

Highly oxidized
"energy poor"

Can we predict what reactions will happen?



Redox perspective of metabolism



Electron carriers *compartmentalize* redox metabolism