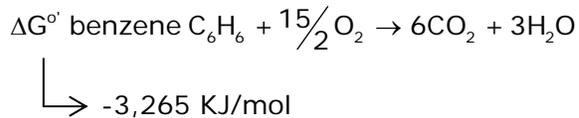
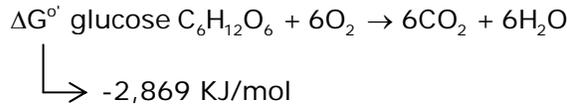


1.89, Environmental Microbiology
Prof. Martin Polz
Lecture 12

Energetics: biomass yield } optimized
ATP, NADH yield }



- Benzene appears to be more energetically favorable
- However, biomass formation using benzene is actually more costly
- Solubility of benzene is lower
- Benzene has longer half-life

Autotrophy

- CO₂ = carbon source
- ATP energy provided by light or oxidation of inorganic chemicals
- Oxidation of inorganic chemicals → gets reducing power from NADPH

CO₂ - fixation

- Several pathways
 - a) Calvin Benson cycle: all plants, cyanobacteria & many other bacteria
 - Most important CO₂-fixation pathway
 - Runs ~ 6 times before fructose – 6 phosphate can be used for biosynthesis
 - Key enzyme: RuBisCo (Ribulose 1, 6-bisphosphate Carboxylase/Oxygenase)
 - b) Reverse TCA cycle: green sulfur bacteria
 - c) Acetyl-CoA pathway: anaerobic respirers when growing with H₂ as energy source
 - d) Serine pathway: methanotrophs (oxidize methane)

Phototrophy

- 1st step: light is absorbed by photopigment
- Chlorophyll is most important pigment (chlorophyll is excited by light & donates e⁻s, leading to generation of proton motive force)
 - Chlorophyll a, plants, algae, cyanobacteria (all of these absorb between 450-700 nm)
 - Other chlorophyll has different absorption ranges → plays a role in ecological differentiation

Accessory pigments

- Example: carotenoids
- Also capture light → energy transfer to chlorophylls

2 types of photosynthesis

1. Anoxygenic Photosynthesis → oxygen is not created as an end product

Reducing power comes from H₂S, etc.

- Anaerobic bacteria
- Cyclic e⁻ flow
 - Excited chlorophyll
 - Donates e⁻ into e⁻ transport chain
 - Leads to generation of H⁺ gradient
 - e⁻ ultimately reduces an oxidized chlorophyll molecule
- NADPH generation occurs via "Reverse-flow"
 - Inorganic compounds (H₂S, S⁰, Fe²⁺, H₂) serve as electron donors & are oxidized (but many are too electropositive to directly reduce NADP⁺ ⇒ they are ∴ oxidized by components of e⁻ transport chain)

Quinines = e⁻ donors for NADP⁺ (regenerate NADPH)

2. Oxygenic → oxygen is created as end product (Figure 15.19)

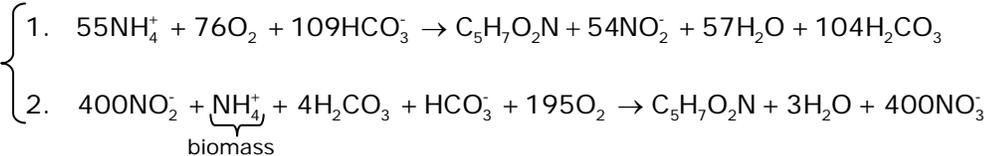
Reducing power comes from H₂O

- 2 photosystems (PS): PSI (analogous to anoxygenic PS) & PSII (replenishes e⁻ lost by PSI and uses H₂O as e⁻ donor (O₂ generated as result))
- ATP generation occurs via cyclical e⁻ flow in PSI
- NADPH generation occurs via "z-scheme" where PSII acts as an e⁻ donor for PSI (which is oxidized by NADP⁺ reduction)
- e⁻ in PSII replenished by H₂O → 1/2 O₂ + 2H⁺

Lithotrophy

- Diverse group of bacteria which gain energy by oxidation of inorganic chemicals with molecular O₂ (or NO₃⁻)
- Hydrogen oxidizers: H₂ + 1/2 O₂ → H₂O
- Nitrifiers:
 1. Ammonia oxidizers → nitrite
 2. Nitrite oxidizers → nitrate

Biosynthesis: both processes are not very efficient, must use a lot of N substrate to get 1 mol C₅H₇O₂N



Energy:

1. NH₄⁺ + 3/2 O₂ → NO₂⁻ + 2H⁺ + H₂O
2. NO₂⁻ + 1/2 O₂ → NO₃⁻

Note: denitrifiers use NO_3^- as electron acceptors & reduce it to N_2 gas.

- Anamox: $5\text{NH}_4^+ + 3\text{NO}_3^- \rightarrow 4\text{N}_2 + 9\text{H}_2\text{O} + 2\text{H}^+$
wastewater treatment? – need exact stoichiometry (no O_2 , add NO_3^-)

Chemolithoautotrophs: All need reduced chemicals & oxygen or nitrate as e^- acceptors.