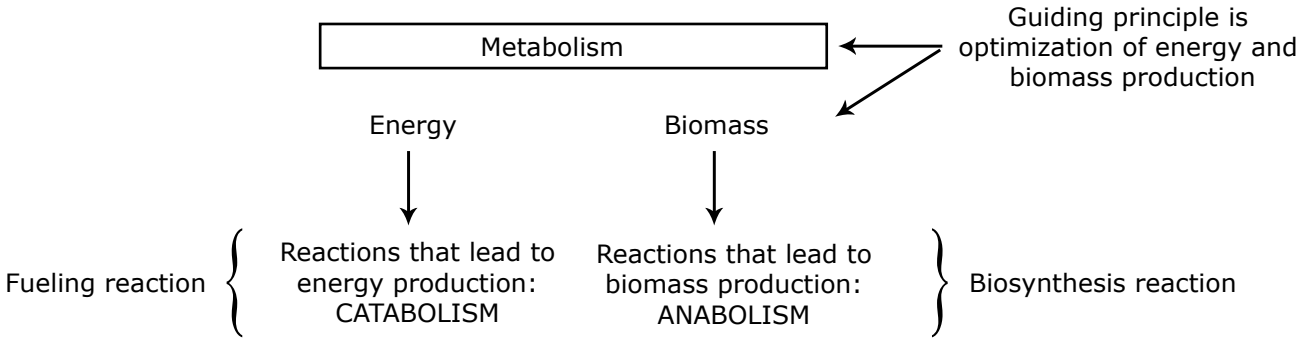
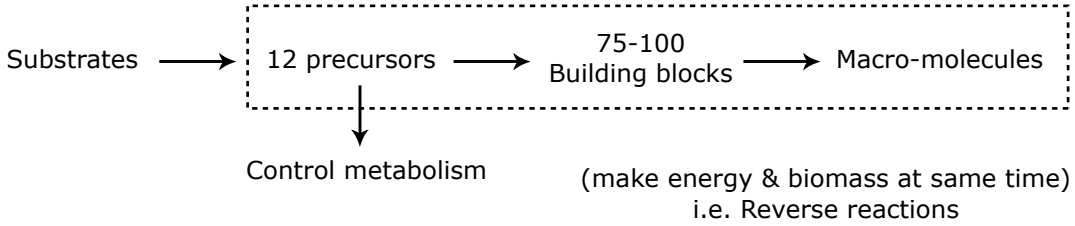
1.89, Environmental Microbiology
Prof. Martin Polz
Lecture 7



Metabolism

Energy (catabolism) + Biomass (anabolism)

- Catabolism → substrates with highest energy yield are preferentially used.
- Anabolism → substrates with lowest required energy input to biomass are preferentially used.
- Environmental substrates (example: CO_2, N, S, P, C) are "biodegraded" or "hydrolyzed" to form 12 precursor molecules which are used to make 75-100 building blocks which are in turn used to make a variety of macromolecules (example: lipids, cell wall, etc.)



Biosynthesis

1. Chemical composition of a cell is relatively constant.
2. 12 precursors & 75-100 building blocks.

Assimilation of Inorganic Nutrients

(N) (S) Present in biological material in the most reduced state

(P) Always present as phosphate (most oxidized form of phosphorus)

(N) - 3 oxidation state: NH_3 (ammonia) → (N) present in amino acids & nucleic acids

Bacteria

- organic N-containing material
- all can take up $NH_4^{\oplus}$ ammonia
- many can take up $NO_3^{\ominus}$ nitrate, $NO_2^{\ominus}$ nitrite
- some can take up N_2

$NO_3^{\ominus}$, $NO_2^{\ominus}$ → taken up & immediately reduced i.e. uptake is mediated by assimilatory nitrate reductase (converts NO_3^- to NO_2^-) & by assimilatory nitrate reductase (converts NO_2^- to NH_3)

Point: to get N in form of NH_3!

Preference for N compounds:

[Note: Assimilation vs. Dissimilation]

anabolism catabolism

(More reduced)

NH_3 over

NO_2^- over

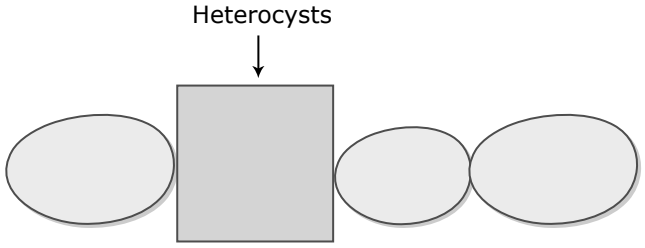
NO_3^-

(More oxidized)

Fixation of molecular Nitrogen (N_2)

- 80% of atmosphere is N_2
- but N_2 is difficult to metabolize because of its triple bond $N \equiv N$
- N_2 fixation is unique to bacteria
- Fixation via nitrogenase → requires 6-15 mol ATP per 1 mol fixed N_2

  Nitrogenase is very O_2 - sesitive, so that nitrogen-fixation is much more efficient in anaerobic environments. Bacteria in anaerobic environments have special adaptations.



Ammonia assimilation:

Two pathways:

1. L-glutamate dehydrogenase (GDH)
   Reductive amination; cost is NADPH. Ammonia is transferred between amino acids by transamination.

2. Glutamine synthetase & glutamate synthetase (GS-GOGAT)
   Requires ATP, more energy needed that in 1st pathway, but can therefore exploit lower concentrations of N.

$\therefore$ Cells use cheapest pathways to conserve energy.

<u>Sulfur</u>: (Sulfite = SO_3^{2-})

Sulfide $= H_2S \rightarrow$ is most reduced state, only present in anaerobic environments because oxygen quickly oxidizes it.
$\|$
$HS-$

$SO_4^{2-} \rightarrow$ Form present in <u>aerobic</u> environments

↳ oxidized state is costly for bacteria to take up, so bacteria instead prefer to take up sulfur in the form of organic sulfur compounds.

<u>Phosphorus</u>:

1. Redox does not change
2. Assimilated in ATP pathways (energy pathways)

   ↳ as ATP

Note: cells can <u>not</u> take up organic phosphate compounds. Can only take up inorganic phosphate.

Alkaline phosphatase hydrolyzes phosphate from organic compounds on cell surface so that cell can take up P as inorganic P.