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Better Living Through Biology: Studying Enzymes to Make Industrial Processes More Efficient

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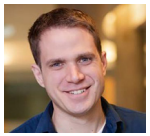
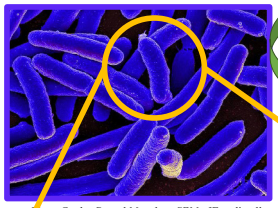


Background

- Enzymes are the molecular machinery needed for life to occur
- Microorganisms have specialized enzymes to survive in challenging environments
- Some enzymes can funnel electrons in specific and opposing directions; this is called "electron bifurcation"
- Our investigation into these enzymes impact future industrial applications

Context



Waste gasses
CO_2
Methane

Biofuels
Chemical Precursors
Agricultural Feedstocks

Photo Credit: Daniel Mietchen, SEM of E. coli *cells*

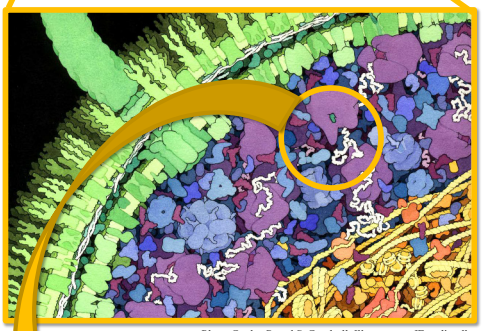
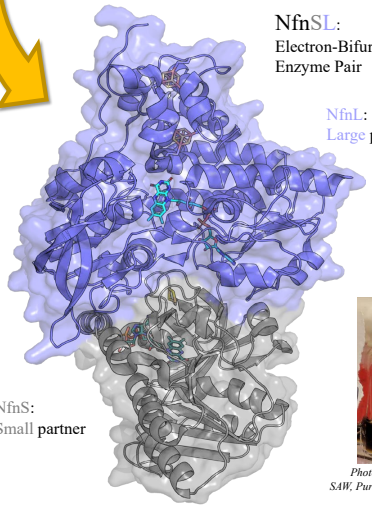


Photo Credit: David S. Goodsell. Illustration of E. coli *cell*



NfnSL:
Electron-Bifurcating
Enzyme Pair

NfnL:
Large partner

NfnS:
Small partner

Photo Credit:
SAW, Pure Enzyme

2 **electron** storage

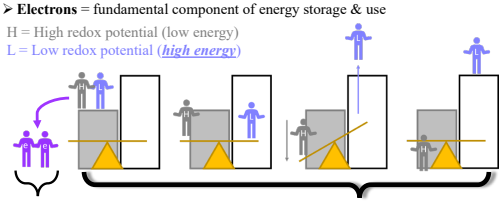
1x Biological energy commodity

1x low energy product

Our Work

➢ **Electrons** = fundamental component of energy storage & use

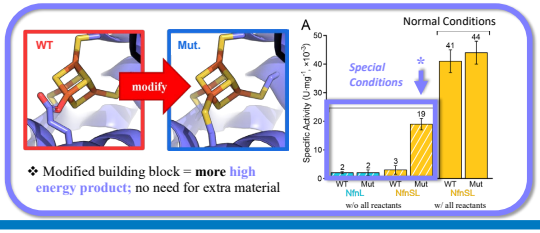
H = High redox potential (low energy)
L = Low redox potential (*high energy*)



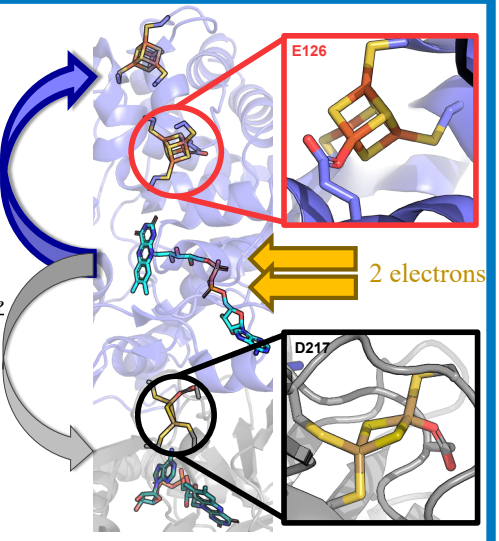
Typical electron transfer
= 2 lower energy products

Electron bifurcation
= 1 lower & *1 higher* energy product

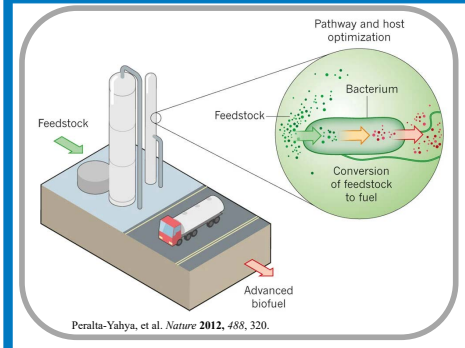
❖Electron bifurcation = ***energy conserving*** process utilized in all life.
❖Makes a *high energy product* **from lower energy input.**
❑***Can we engineer the biological systems to be better & to do reactions we want?***



❖ Modified building block = **more** high energy product; no need for extra material



Applications



Peralta-Yahya, et al. *Nature* **2012,** *488*, 320.

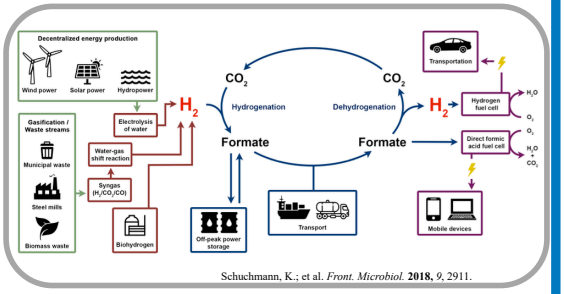
❖We want to manipulate bacterial metabolism to ***produce specific chemical feedstocks*** for industry in an efficient & environmentally conscious manner. Use electron bifurcation for *2 electron carriers* such as:
- ❑NADPH (for biofuels)
- ❑Hydrogen (H_2)
- ❑Carbon dioxide (CO_2)

Key Targets Chemical Feedstock Use:

Aviation fuels (significant challenge in sustainability)

Ammonia for agriculture

Off-grid energy dense molecules **for storage & use** (e.g. home heating, electricity)



Schuchmann, K.; et al. *Front. Microbiol.* **2018,** *9*, 2911.

Summary & Acknowledgements

1. How we manage electrons = a key component to **sustainability**
2. Electron bifurcation = ***coupling*** favorable & unfavorable reactions
   - Can be used to get high energy products from lower energy starting materials
3. We can modify electron bifurcation enzyme's building blocks to **get more high energy products per unit**
4. The high energy product from an electron bifurcation reaction can **contribute to key industrial processes**

References

[1]*Metabolites.* **2022,** *12*, 823. [2]*Nat. Chem. Biol.* **2017,** *13*, 655. [3]*Proc. Natl. Acad. Sci.* **2022,** *119*. [4] *BBA - Bioenerg.* **2021,** *1862*, 148377. [5] *J. Biol. Chem.* **2023,** *299*, 105403. [6] *Chem. Comm.* **2019,** *55*, 11823.

Photo Credit: Joshua Bauer, Bryan Bechtold. 6/9/2023 - NREL's South Table Mountain campus.

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