

Microbial Fuel Cells: Cellulose Conversion to Electricity

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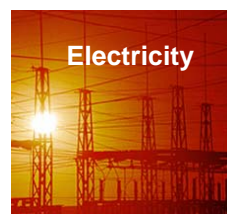
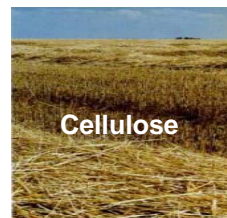
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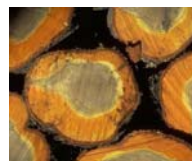
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Cellulosic biomass

- The most abundant renewable source for bioenergy production
- 30 to 40% of agro-forestry and municipal solid wastes

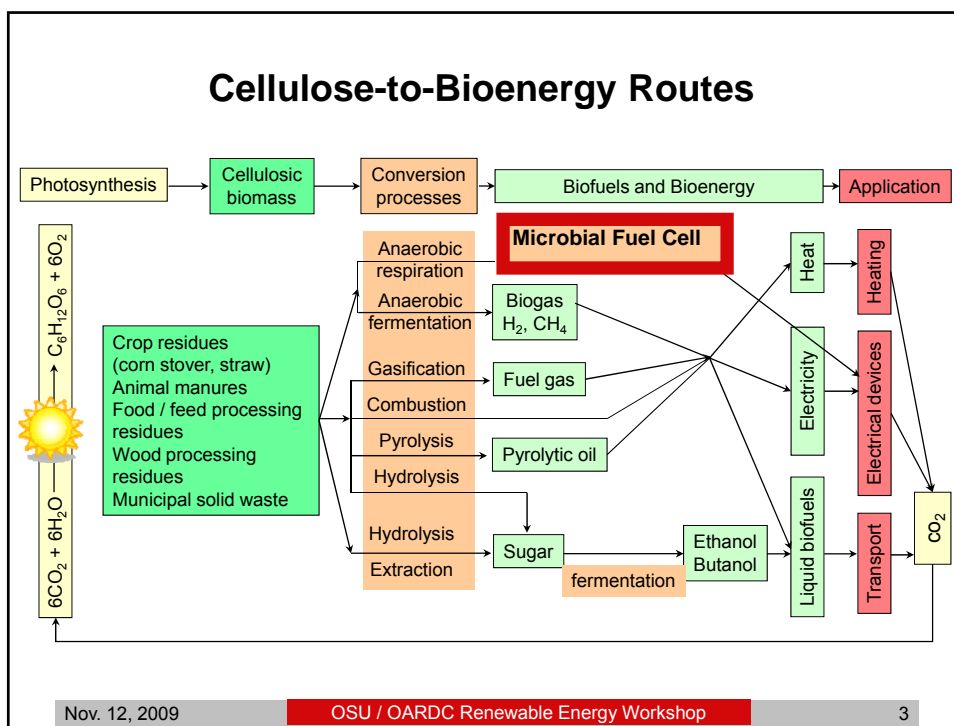


Perlack et al. 2005. Biomass as feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply. USDOE-USDA.

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MFC: a Direct Conversion Process of Biomass-to-Electricity

- Bio-electro-chemical device, which applies:
- Anaerobic respiration
- Krebs cycle
- Redox chemistry

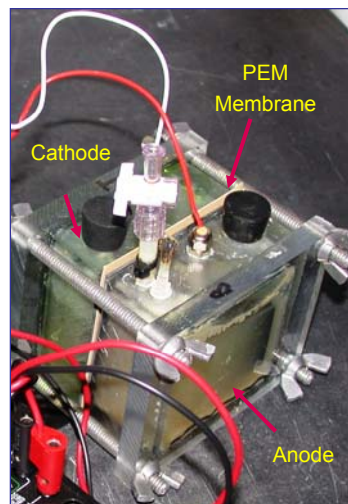
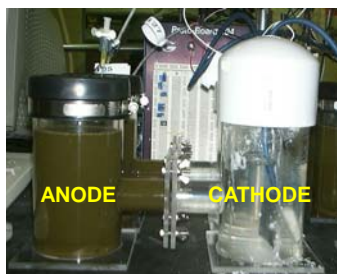
Proton Exchange Membrane

Switches from normal electron acceptor (oxygen, nitrate) to solid graphite electrode

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From microbial electron transport chain to electricity

Electrons flow from the **anode** through a **wire** to the **cathode** where electron acceptors are reduced. **Protons** flow across a **proton exchange membrane (PEM)** to complete the circuit.

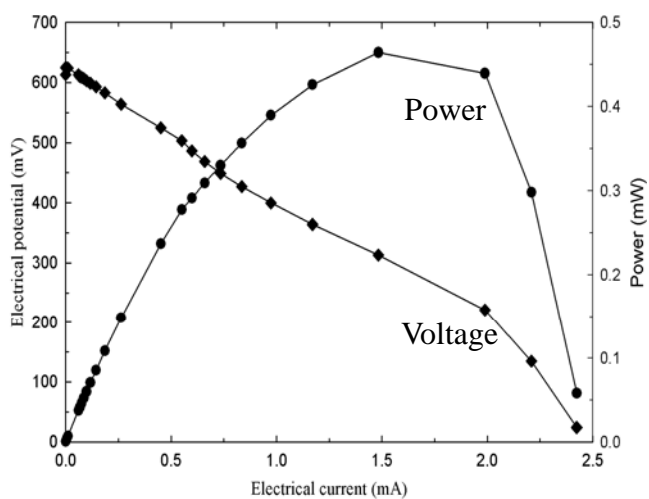


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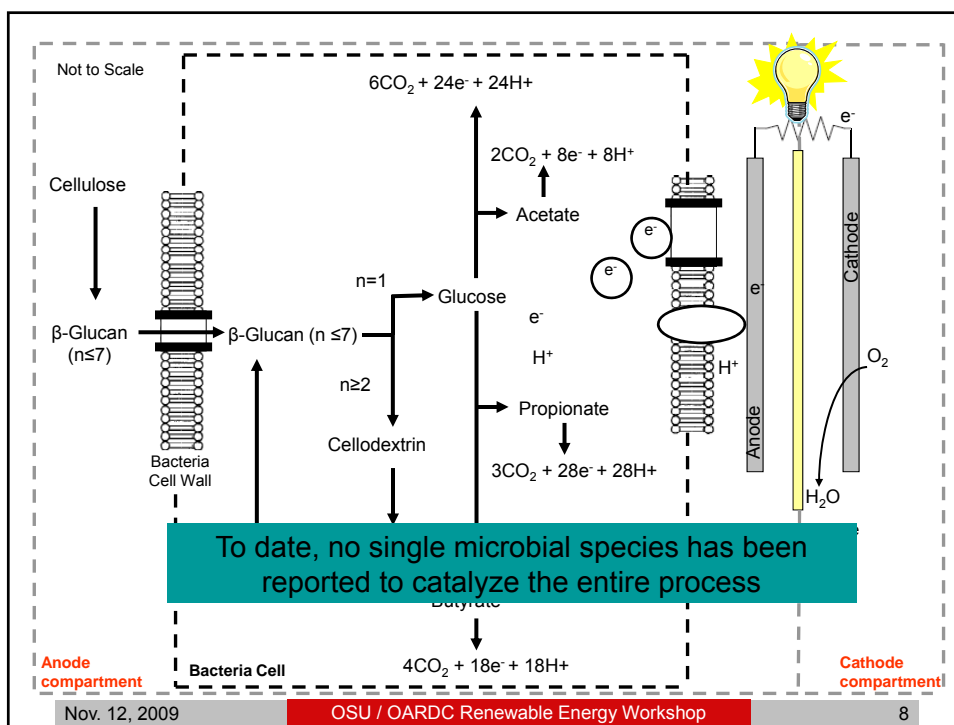
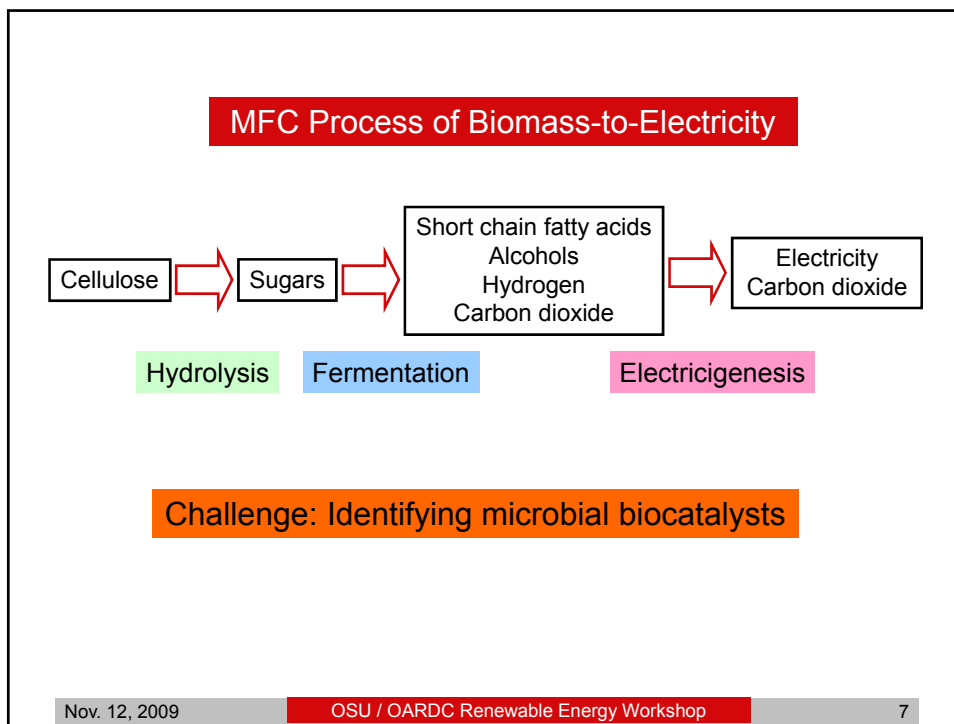
Example Output of an Microbial Fuel Cell

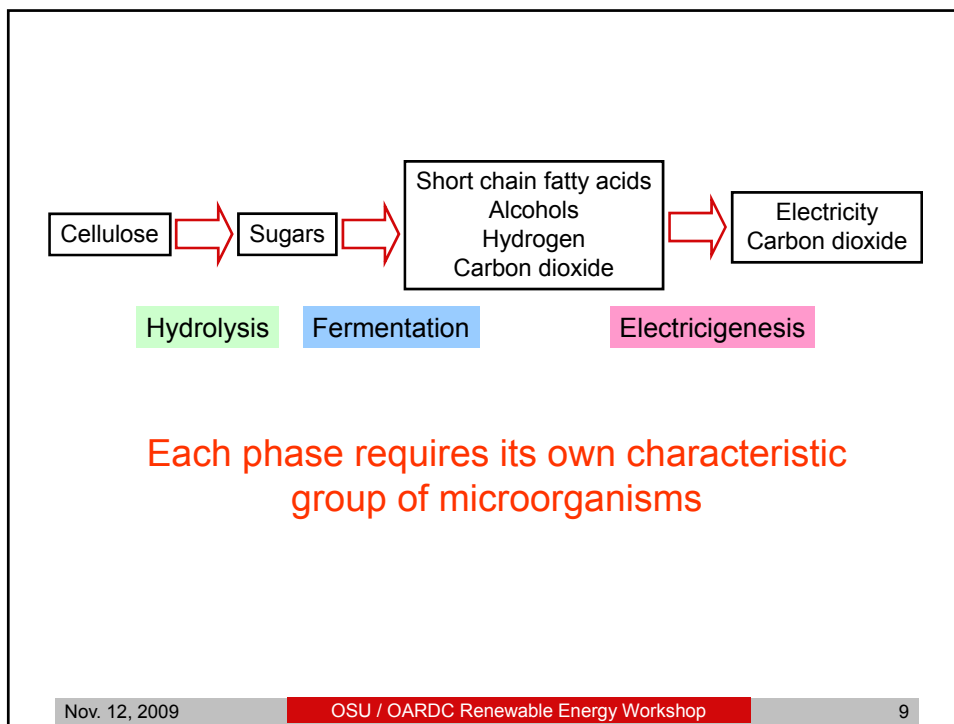


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Choice of biocatalysts

- **Pure cultures:**
 - Mono-cultures (e.g., *Clostridium* spp.¹)
 - Co-cultures (e.g., *Clostridium cellulolyticum* + *Geobacter sulfurreducens*²)
- **Microbial consortia**
 - Digestive tract of ruminants³
 - Soil⁴ and Sediment⁵
 - Waste water

Advantage:

- ✓ Understanding of underlying mechanisms

Constraints:

- ✓ Biological contamination
- ✓ Incapable of converting all the end products to electricity

Advantage:

- ✓ More robust and efficient than pure cultures for

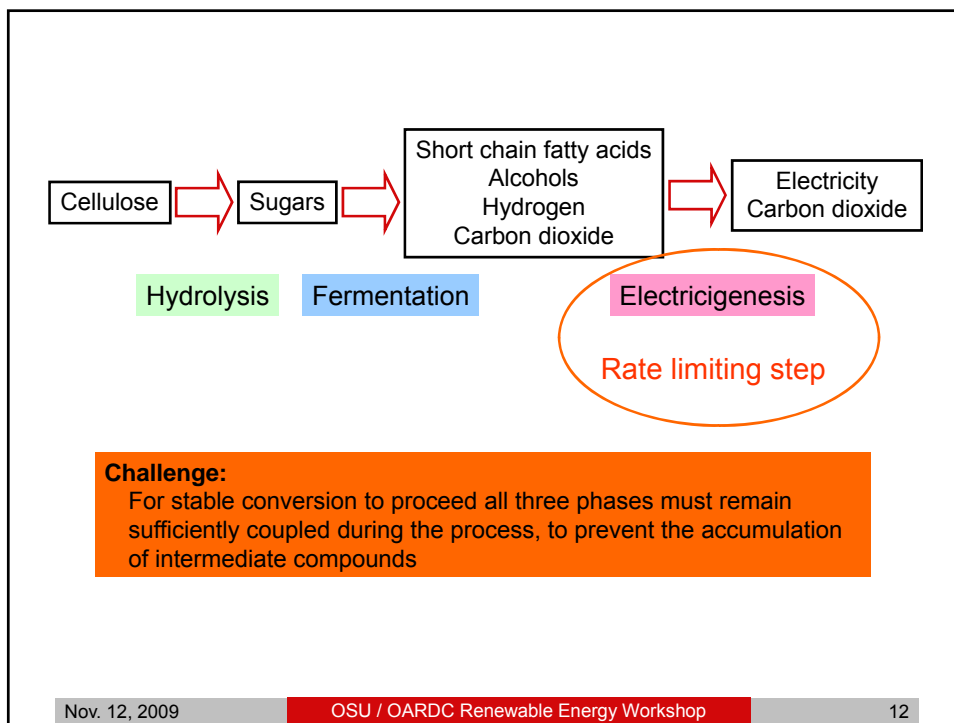
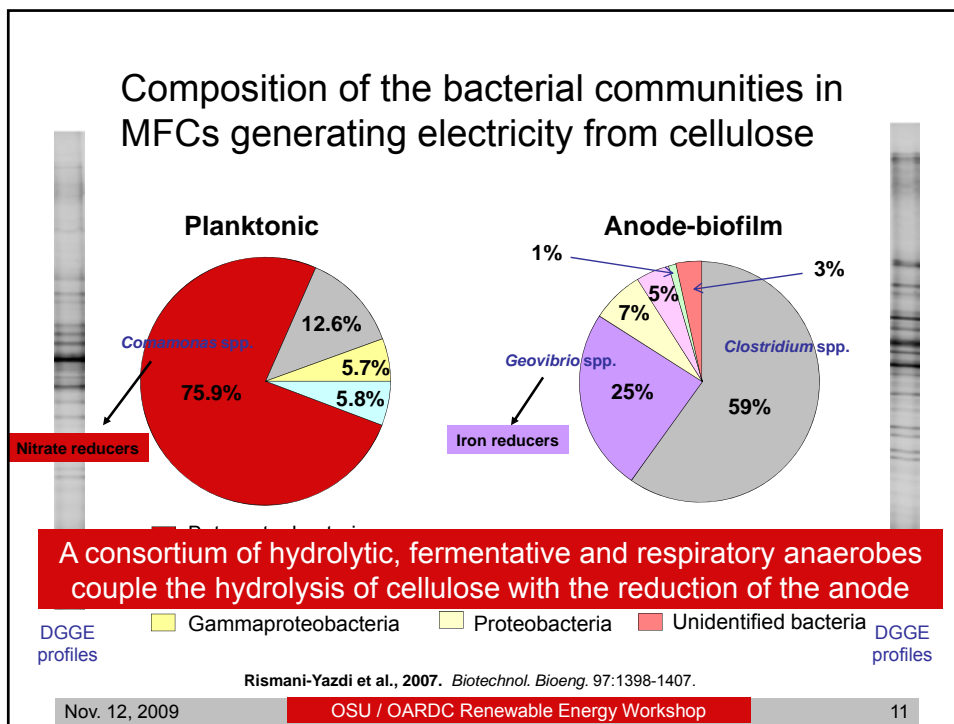
High cellulolytic activities

- ✓ Endoglucanases
- ✓ Exoglucanases
- ✓ Glucosidases

Anaerobic respirators

¹Niessen et al. 2005, ²Ren et al. 2007, ³Rismani-Yazdi et al. 2007, ⁴Niessen et al. 2006, ⁵Ishii et al. 2008, Rezai et al 2007,

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What is next?

- Develop micro-scale microbial fuel cells which can be stacked to increase electrical output
- Study the effect of system design and operating factors on diversity and activity of microorganisms
- Design nano-structured electrode materials to increase surface area of anode for microbial adhesion
- Investigate microbial population interactions in MFCs
- Design and test MFCs able to operate as continuous processes

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