ASU LightWorks
ARIZONA STATE UNIVERSITY

microbial conversion of biomass into useful energy

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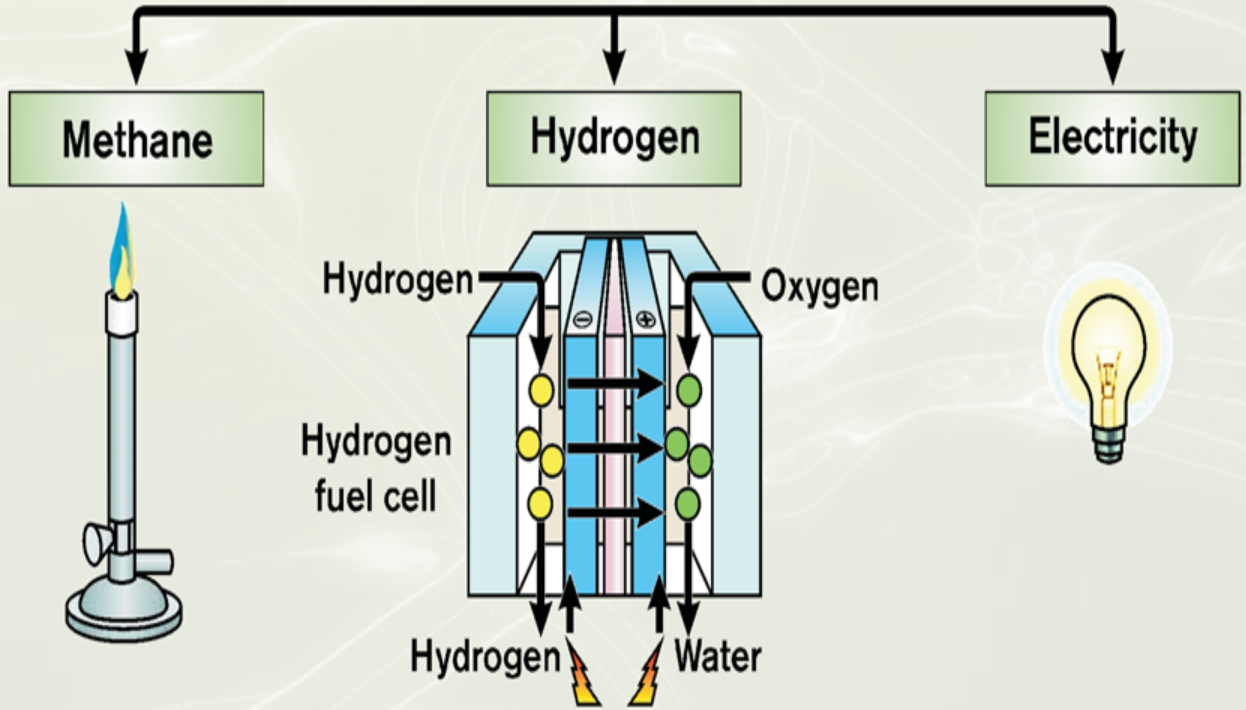
sources of biomass for bioenergy production

Biomass from human activities contains renewable energy, but in an inconvenient form.

our goal is to have microorganisms convert that energy into a form useful to society

energy outputs from biomass

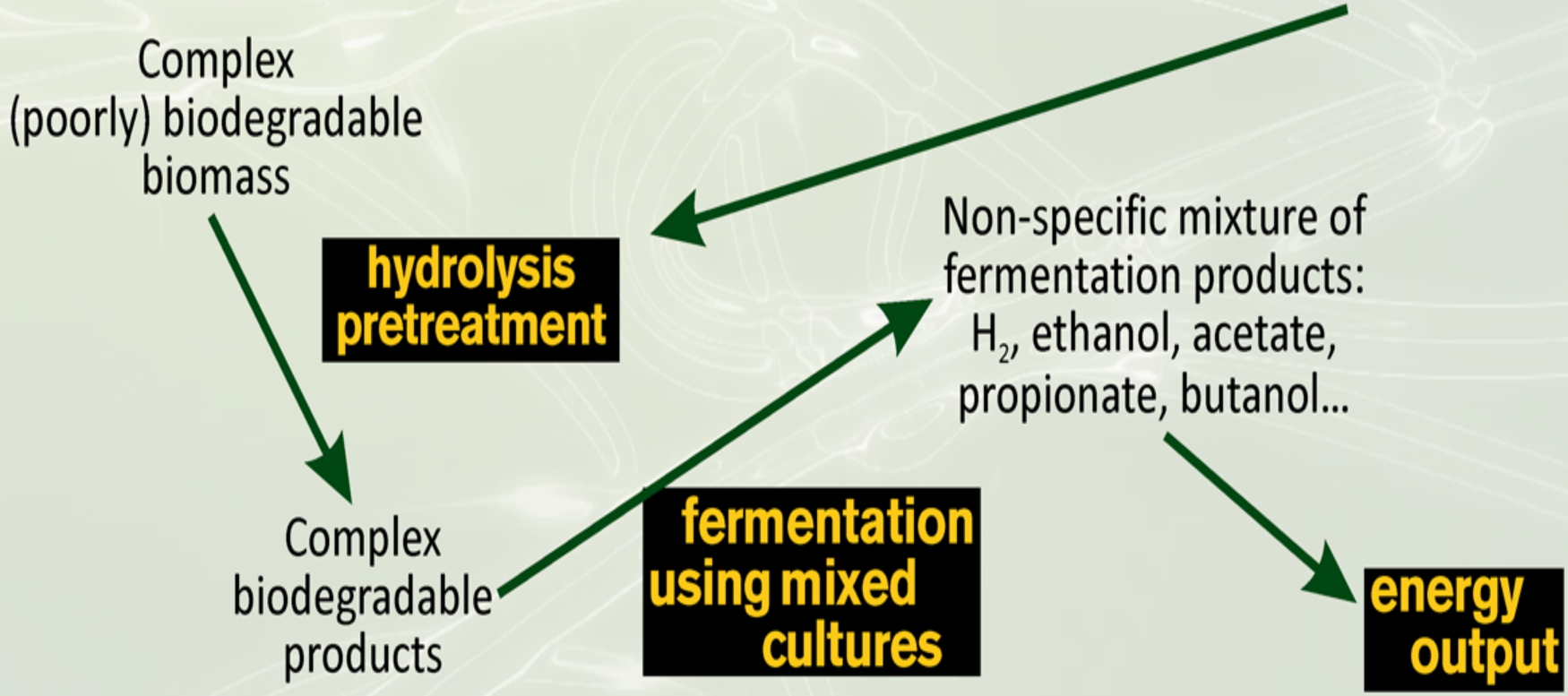
Biomass from plants, animals, and microorganisms **can be converted by microorganisms** to useful energy outputs: including methane gas, hydrogen gas, or electricity.



energy conversion outputs

accelerating the first steps

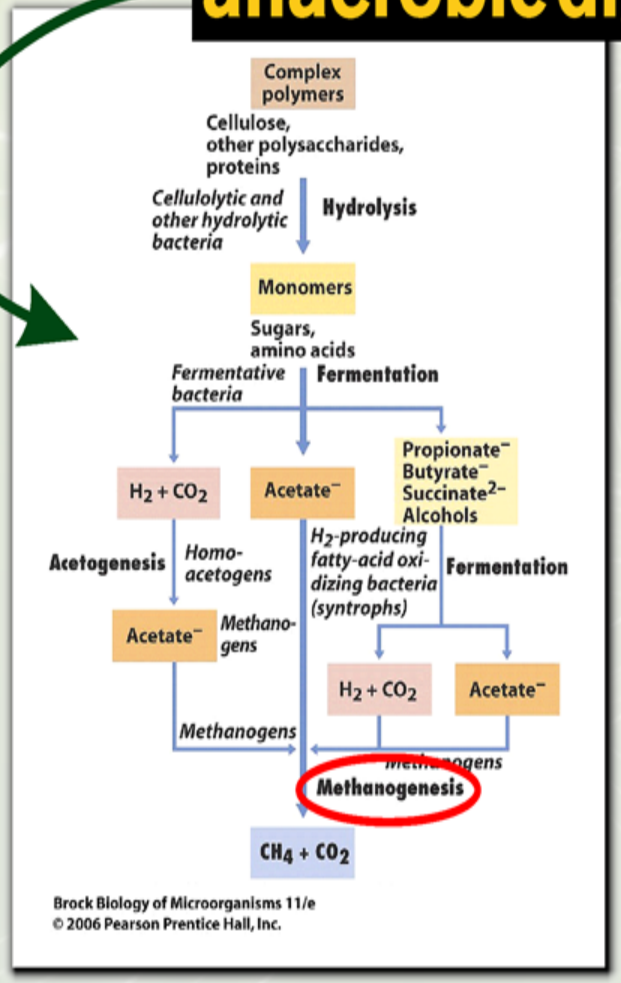
Microbial conversion of biomass begins with hydrolysis and fermentation to make products that are convertible to the useful output. We accelerate the first steps using biomass pre-treatment.

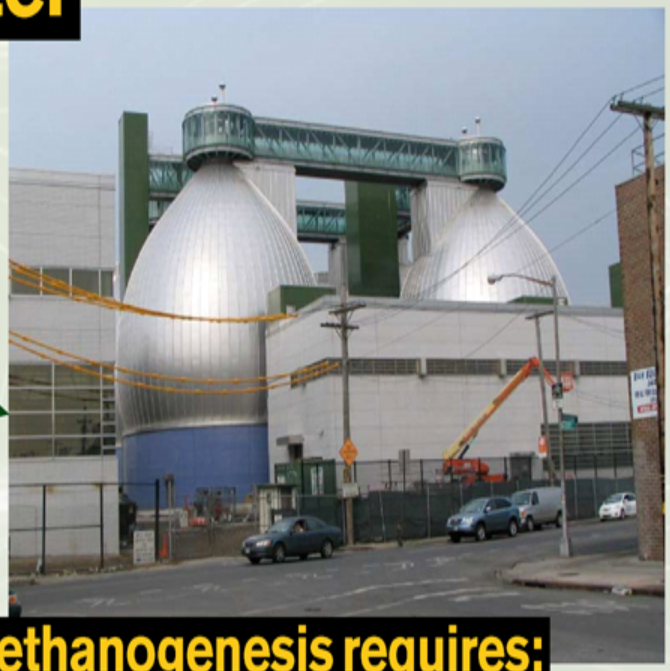


an established microbial process: methanogenesis

These processes are carried out in an

anaerobic digester





methanogenesis requires:

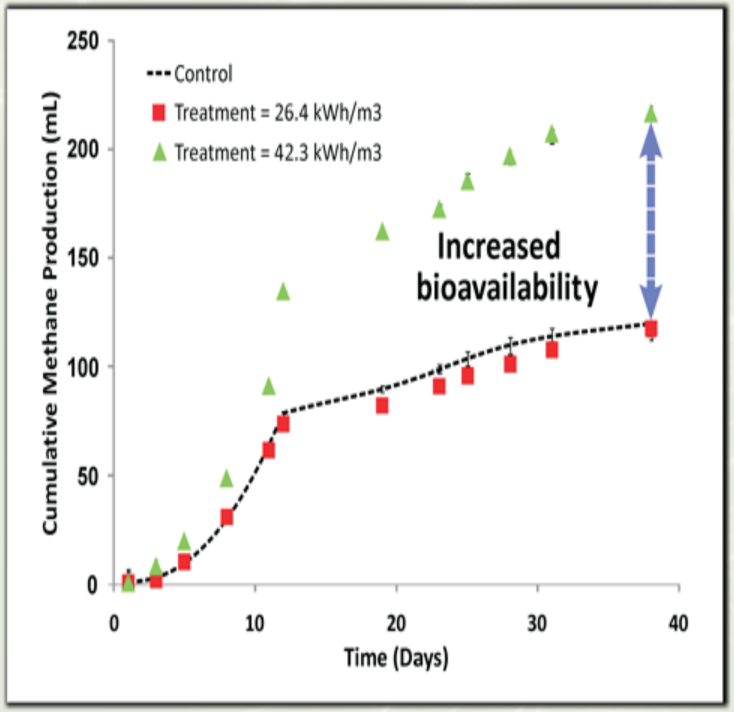
1. Obligate anaerobic conditions
2. Narrow pH range (6.8-7.6)
3. Alkalinity of around 2500 mg/L as $CaCO_3$

accelerating methanogenesis by pre-treatment

Focused Pulsed® technology

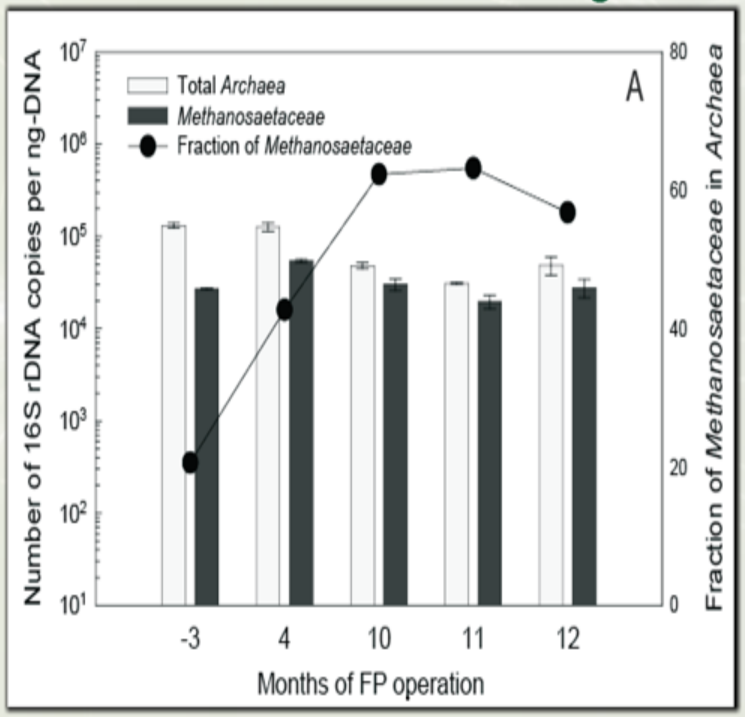
for pre-treatment of biomass:

~30 kV pulses for defined short time period (8 µsec)



Pig waste shows nearly 100% increase in methane production!

Focused Pulsed® technology increases bacterial diversity and the predominance of desired *Methanosaetaceae* methanogens.

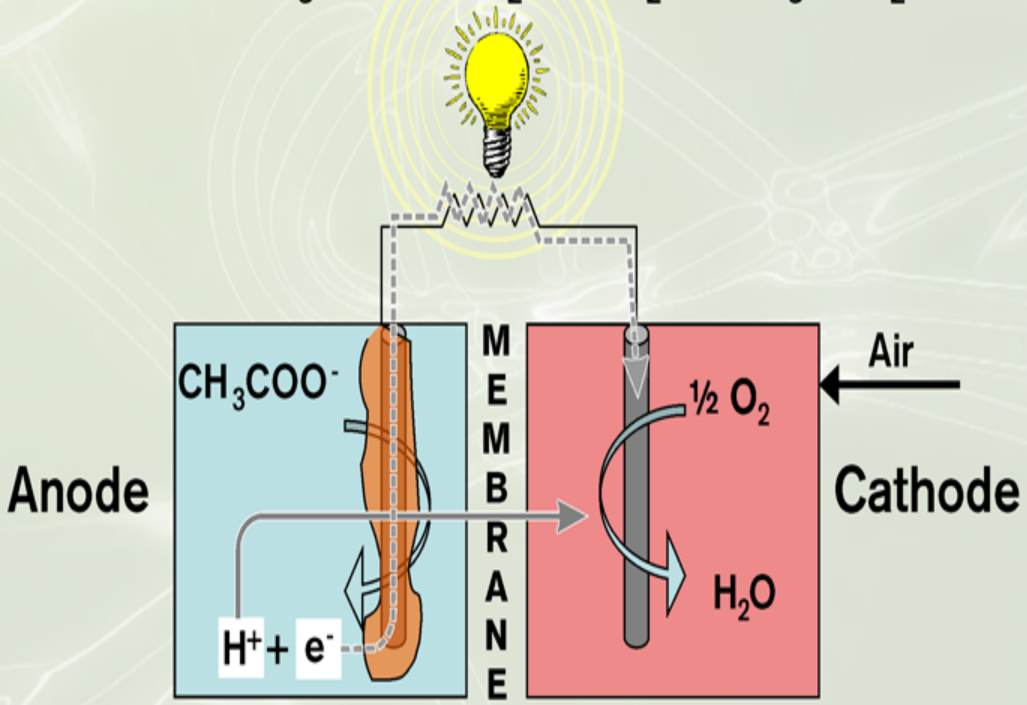


Methanosaetaceae **consume acetate efficiently to produce more methane.**

MFC – a novel approach the microbial fuel cell

electrical power generation

e^- donor half reaction:	$CH_3COO^- + 3\,H_2O \rightarrow CO_2 + HCO_3^- + 8H^+ + 8e^-$	-0.29 V
e^- acceptor half reaction:	$2O_2 + 8H^+ + 8e^- \rightarrow 4H_2O$	0.81 V
Net reaction:	$CH_3COO^- + 2O_2 \rightarrow CO_2 + HCO_3^- + H_2O$	1.10 V

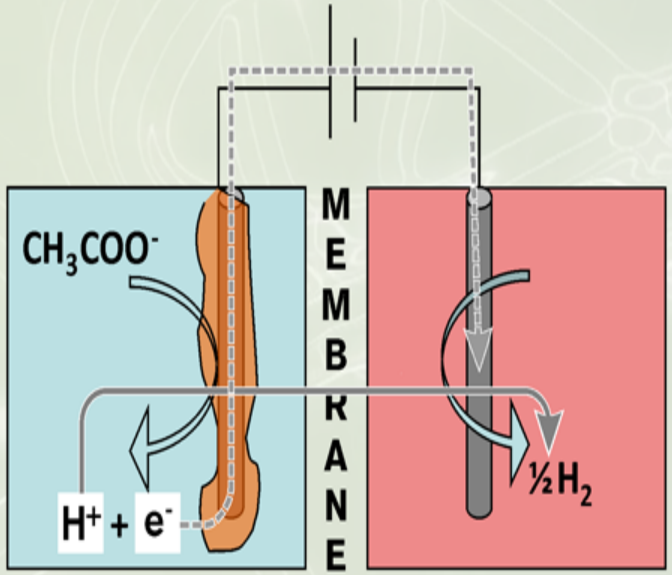


an MFC generates electrical power from biomass by oxidizing it into CO_2 and H_2O

MEC – a variation: the microbial electrolysis cell

renewable H_2 gas production

e^- donor half reaction:	$CH_3COO^- + 3\,H_2O \rightarrow CO_2 + HCO_3^- + 8H^+ + 8e^-$	-0.29 V
e^- acceptor half reaction:	$8H^+ + 8e^- \rightarrow 4H_2O$	-0.41 V
Net reaction:	$CH_3COO^- + 3H_2O \rightarrow CO_2 + HCO_3^- + 4\,H_2$	-0.12 V



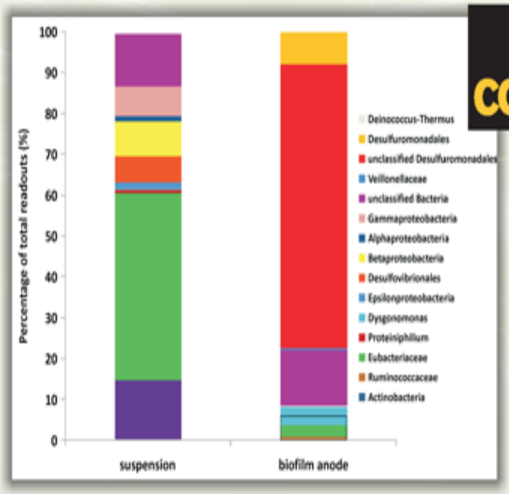
an MEC converts biomass into H_2 gas, a useful energy carrier

understanding anode respiring bacteria (ARB)

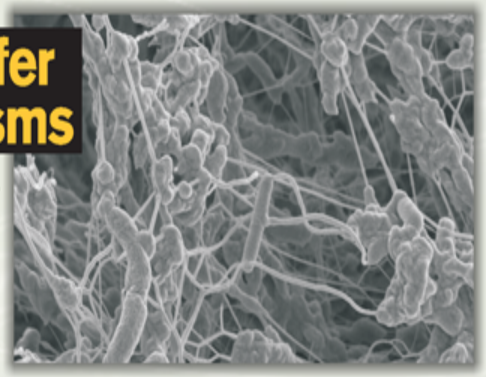
ARB are responsible for oxidation of biomass organics to generate electron flow from the anode to the cathode.

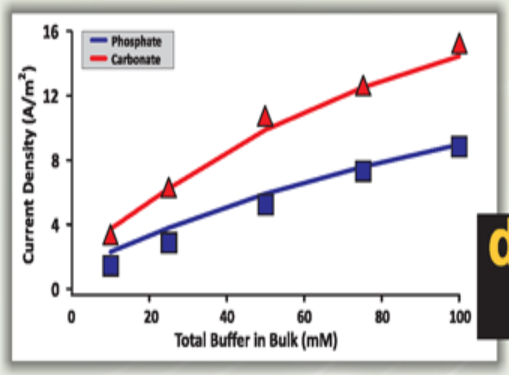
We study all aspects of that process.

microbial community



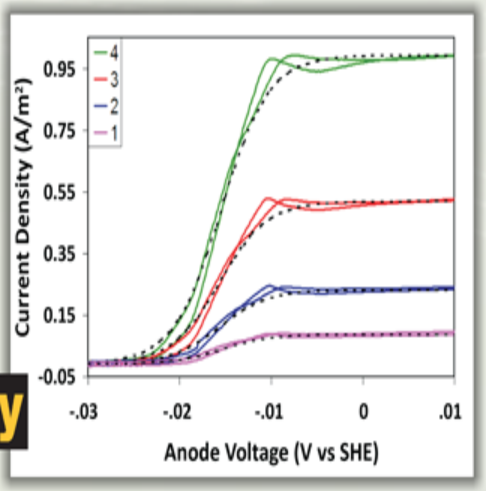
electron-transfer mechanisms





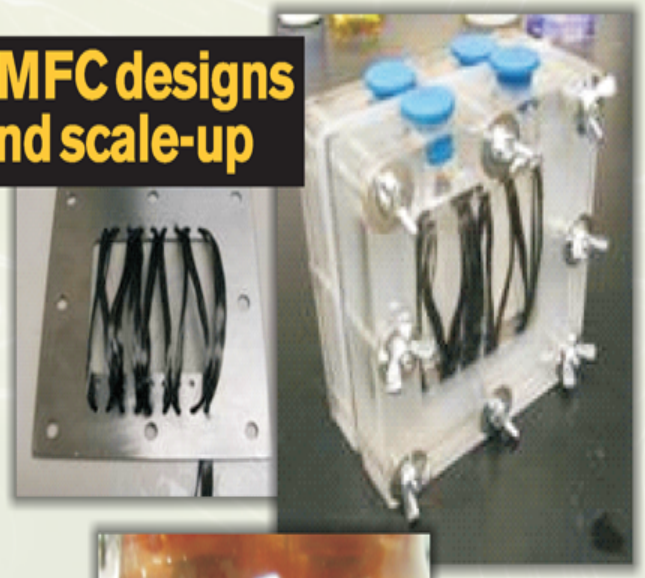
diffusion modeling

electrochemistry

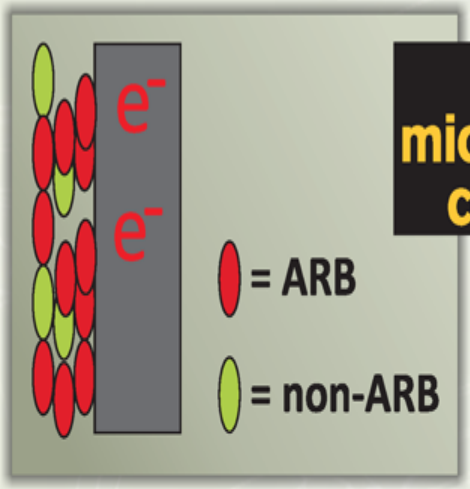


future directions for MFCs and MECs

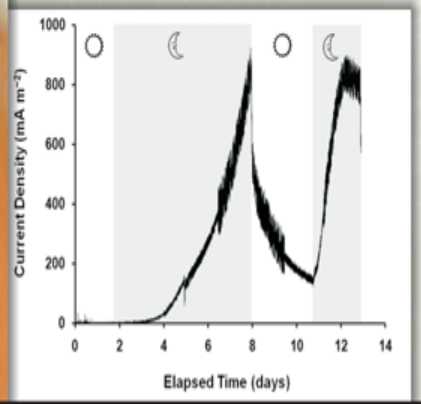
better MFC designs and scale-up



managed microbial communities



microbial phototrophic cells



microbial kinetics