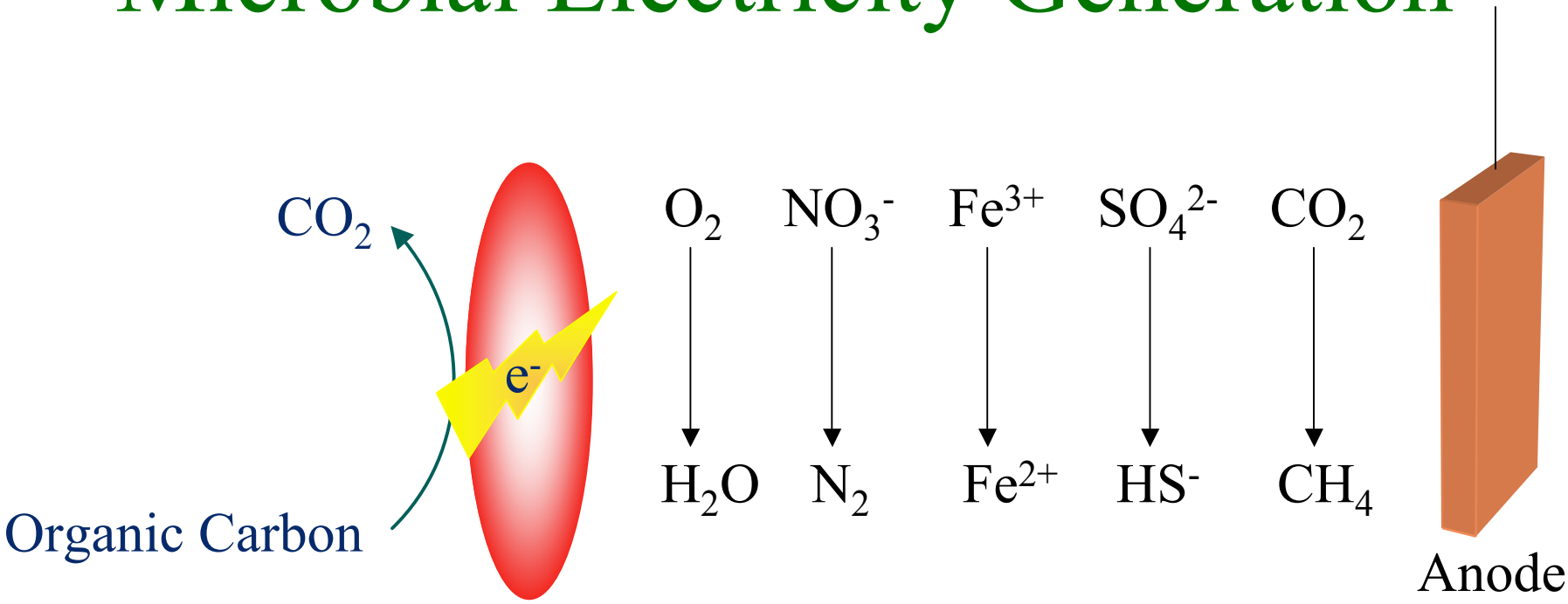
The Possibilities of Biological Fuel Cells

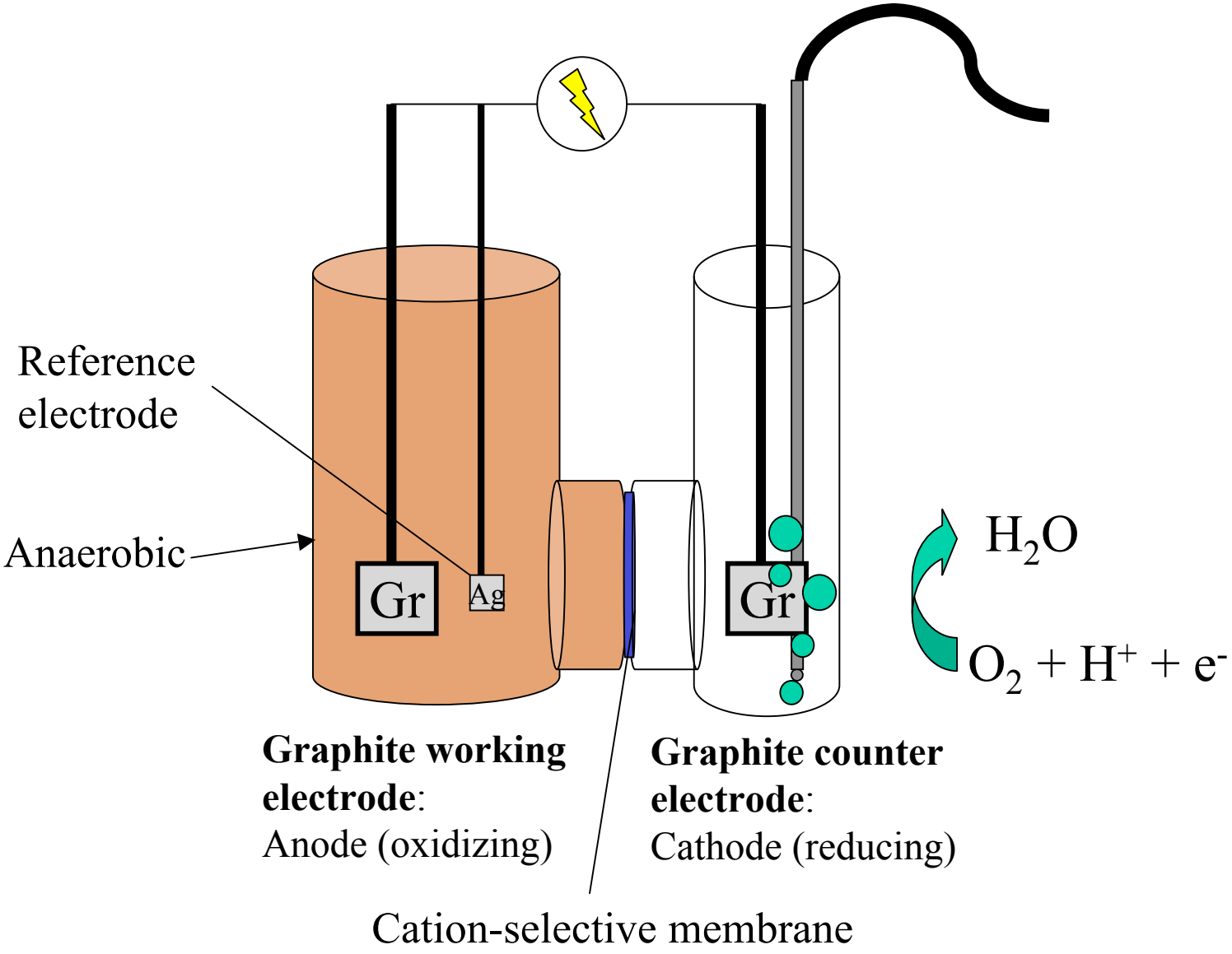
Microbial Electricity Generation



$$CH_3COO^- + 2OH^- \rightarrow 2CO_2 + 5H^+ + 8e^-$$

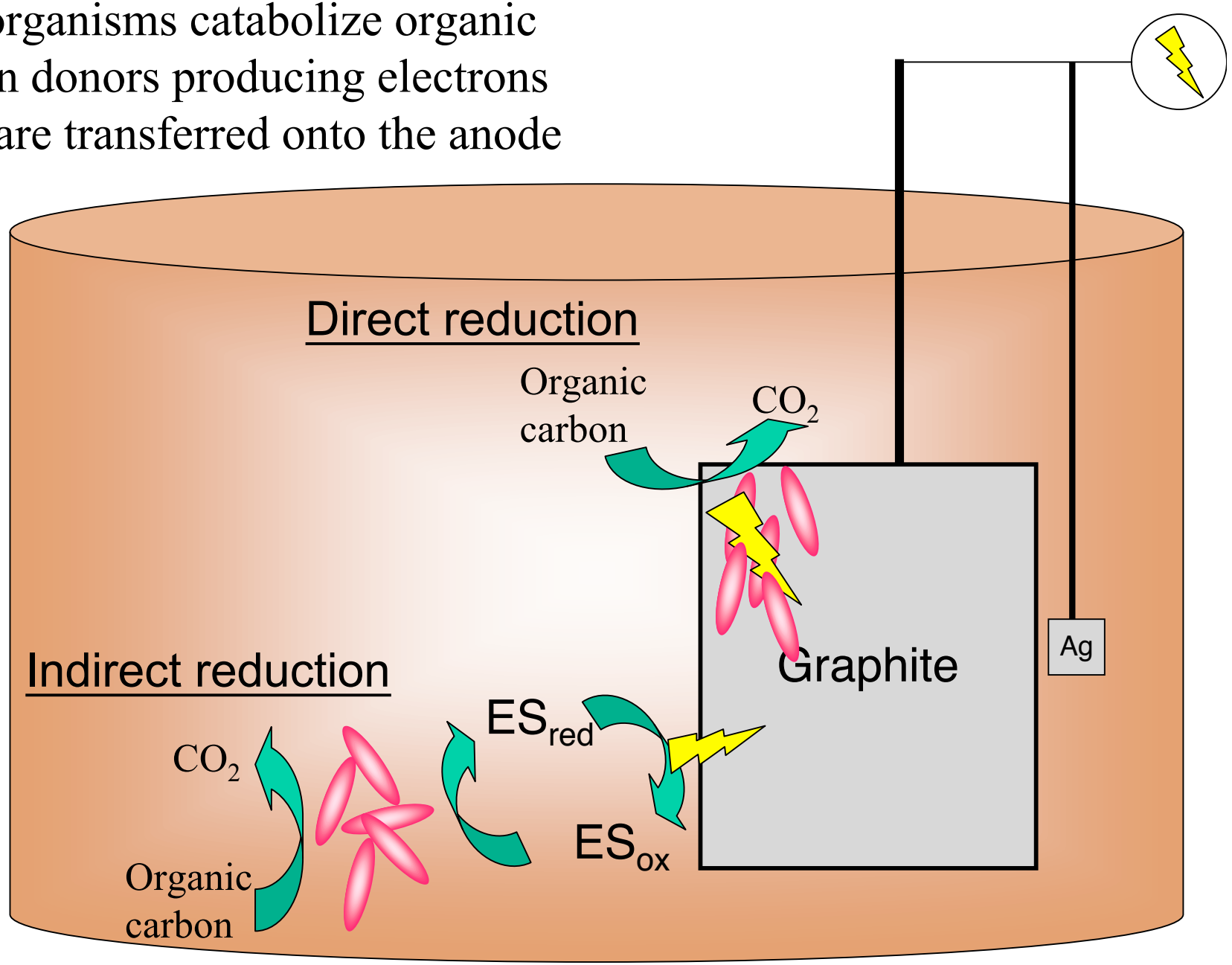
Microbial fuel cells are based on the recently identified ability of microorganisms to pass electrons directly onto the surfaces of electrodes during catabolic respiration.

Two-chambered (poised-potential) electrochemical cell



Concept

Microorganisms catabolize organic electron donors producing electrons which are transferred onto the anode



Advantages of Biofuel cells

- More efficient than turbine (~25%) or solar (~15%) electricity generation
- Does not require substrate to be combustible
- Does not require the use of toxic and expensive heavy metals or metalloids
- Is not limited by the reactivity of the electron donor
- Do not produce toxic endproducts

Potential Applications of Biofuel cells

- Powering Monitoring Devices in Remote Locations
- Powering Electronic Devices from Renewable Energy Sources
- Decentralized domestic power source
- Conversion of waste organic matter to electricity instead of methane
- Conversion of renewable biomass to electricity instead of ethanol

Improved efficiency

- Bioremediation of environmental contaminants

Crucial parameters of operational effectiveness

1. Bacterial metabolism
2. Bacterial electron transfer

Biological

3. Performance of the cation selective membrane
4. Intrinsic electrical resistance of the system

Physical

5. Efficiency of the cathode oxidation step

Chemical and Biological

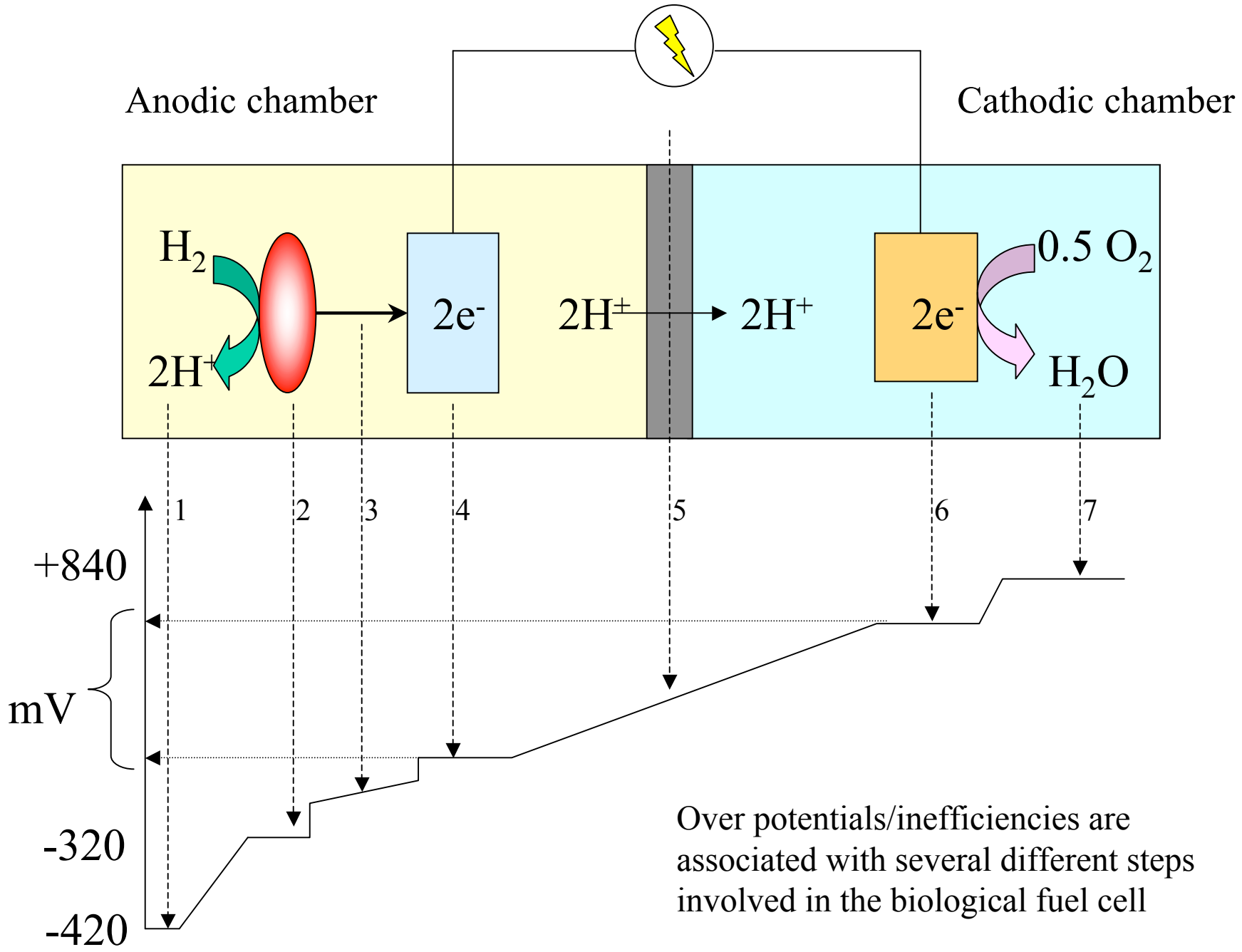
Studies done to date have:

1. Investigated electricity generation under constant resistance (load) or constant voltage

2. Investigated electricity generation by pure cultures under a poised potential with glucose, lactate, benzoate, acetate, or H_2 as the electron donor

3. Investigated microbial communities on the anode surfaces in sediment systems with either glucose or NOM as the electron donor

Redox	E'_o (mV)
$2H^+ + 2e^- \rightarrow H_2$	-420
Ferredoxin(Fe^{3+}) + e^- → Ferredoxin(Fe^{2+})	-420
$NAD^+ + H^+ + 2e^- \rightarrow NADH$	-320
$S + 2H^+ + 2e^- \rightarrow H_2S$	-274
$SO_4^{2-} + 10H^+ + 8e^- \rightarrow H_2S + 4H_2O$	-220
$Pyruvate^{2-} + 2H^+ + 2e^- \rightarrow lactate^{2-}$	-185
$FAD + 2H^+ + 2e^- \rightarrow FADH_2$	-180
$Fumarate^{2-} + 2H^+ + 2e^- \rightarrow Succinate^{2-}$	+31
Cytochrome *b*(Fe^{3+}) + e^- → Cytochrome *b*(Fe^{2+})	+75
Ubiquinone + $2H^+ + 2e^- \rightarrow Ubiquinone_{red}$	+100
Cytochrome *c*(Fe^{3+}) + e^- → Cytochrome *c*(Fe^{2+})	+254
$NO_3^- + 2H^+ + 2e^- \rightarrow NO_2^- + H_2O$	+421
$NO_2^- + 8H^+ + 6e^- \rightarrow NH_4^+ + 2H_2O$	+440
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+840



Over potentials/inefficiencies are associated with several different steps involved in the biological fuel cell