Our world desperately needs an energy efficient way to produce H\textsubscript{2} for energy production without producing waste pollutants. Catalytic cracking of molecules and newly developed fuel cells offer two possibilities. Wouldn't it be great if a reactant like water could be used for H\textsubscript{2} production (without the use of electrolysis) or expensive metal catalysts? Nature may show the way. Bacteria (even \textit{E. Coli} found in our GI system) can use simple metals like iron to produce H\textsubscript{2} from H\textsuperscript{+} with electrons for the reduction of H\textsuperscript{+} coming from a donor (such as a reduced heme in proteins):

\[
\Delta \text{red} + \text{H}^+ \rightleftharpoons \Delta \text{ox} + \text{H}_2 \]

The reaction is also reversible in the presence of an acceptor of electrons from H\textsubscript{2} as it gets oxidized:

\[
\text{Aox} + \text{H}_2 \rightleftharpoons \text{Ared} + \text{H}^+ \]

The enzymes that catalyze hydrogen production are \textbf{hydrogenases} (not dehydrogenases). Note that the name hydrogenases best reflects the reverse reaction when a molecule (P) in an oxidized state gets reduced (to S) and H\textsubscript{2} gets oxidized to H\textsuperscript{+}.

Crystal structures of hydrogenases show them to be unique among metal-containing enzymes. They contain two metals bonded to each other. The metal centers can either be both iron or one each of iron and nickel. The ligands interacting with the metals are two classical metabolic poisons, carbon monoxide and cyanide. Passages for flow of electrons and H\textsubscript{2} connect the buried metals and the remaining enzymes. The metals are also bound to sulfhydryl groups of cysteine side chains. It appears that two electrons are added to a single proton making a hydride anion which accepts a proton to form H\textsubscript{2}. In the two Fe hydrogenases, the geometry of the coordinating ligands distorts the bond between the two iron centers, leading to irons with different oxidation numbers. Electrons appear to flow from one center to the other, as does carbon monoxide as well. Ultimately, hydrogenases or small inorganic mimetics of the active site could be coated on electrodes and used to general H\textsubscript{2} when placed in water in electrolytic experiments.

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