7.2.3

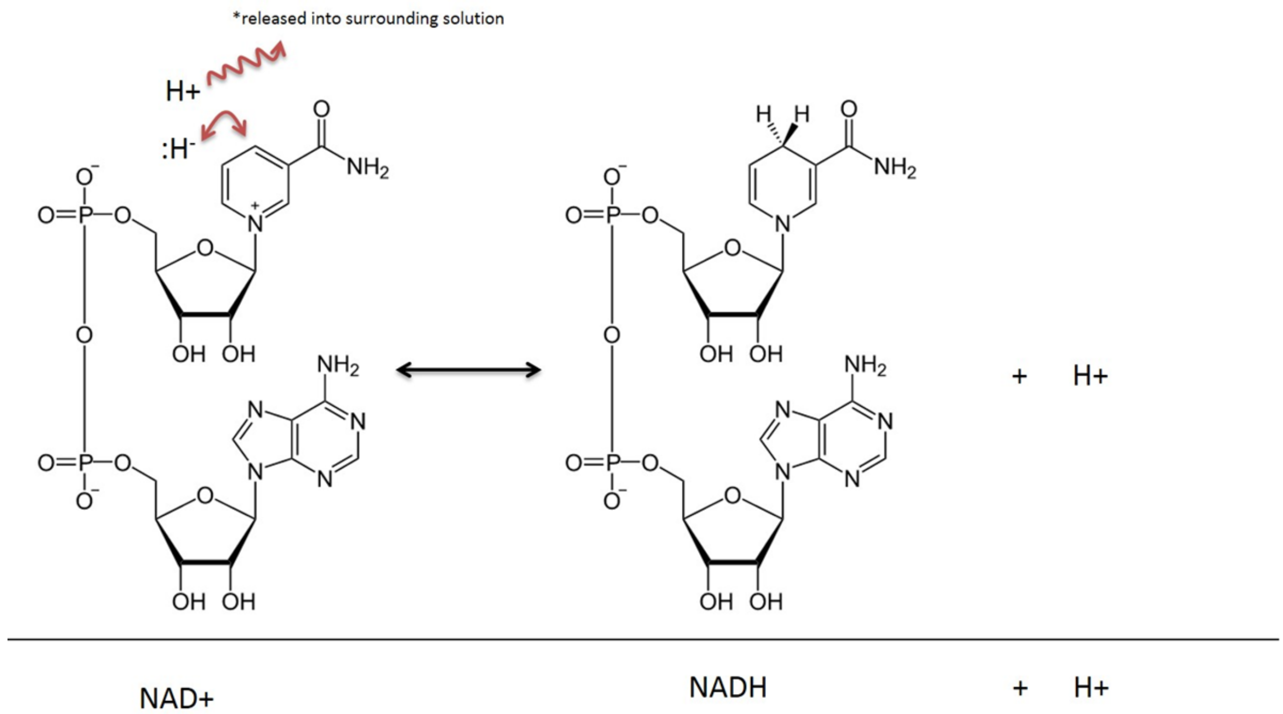
Electron Carriers (NAD and FAD)

Nicotinamide Adenine Dinucleotide (NAD) and **Flavin Adenine Dinucleotide** (FAD) are coenzymes involved in reversible oxidation and reduction reactions. It is often stated that these compounds are electron carriers because they accept electrons (become reduced) during catabolic steps in the breakdown of organic molecules such as carbohydrates and lipids. Then, these reduced coenzymes can donate these electrons to some other biochemical reaction normally involved in a process that is anabolic (like the synthesis of ATP).

NAD^+ / NADH

Nicotinamide Adenine Dinucleotide in its oxidized state is called **NAD^+**, after being reduced (or accepting electrons), it is referred to as **NADH.** *Note: the + in the NAD^+ doesn't refer to the overall charge on the molecule, but just the fact that it is without electrons and will accept a hydride*. The coenzyme vitamin Niacin (also called B3) is used to derive this compound. Niacin provides the organic ring structure that will directly participate in the transfer of a hydrogen atom and 2 electrons. NAD^+ is often found in conjunction with a "d*ehydrogenase*" enzyme. A dehydrogenase reaction removes two hydrogen atoms; one as a hydride ($:H^-$) (*a hydride is a hydrogen atom with 2 electrons*) and one as a hydrogen cation (H^+) (*and of course, a hydrogen cation has no electrons*). The hydride bonds with NAD^+ and creates a reduced compound of Nicotinamide Adenine Dinucleotide (NADH). The second hydrogen atom (H^+) is released into solution.

As you examine the reactions for metabolism, look for reactions that yield NADH. NADH will be important as it will deliver the hydrogens and electrons that it picks up to biochemical processes that can use the electrons and hydrogens to make ATP.

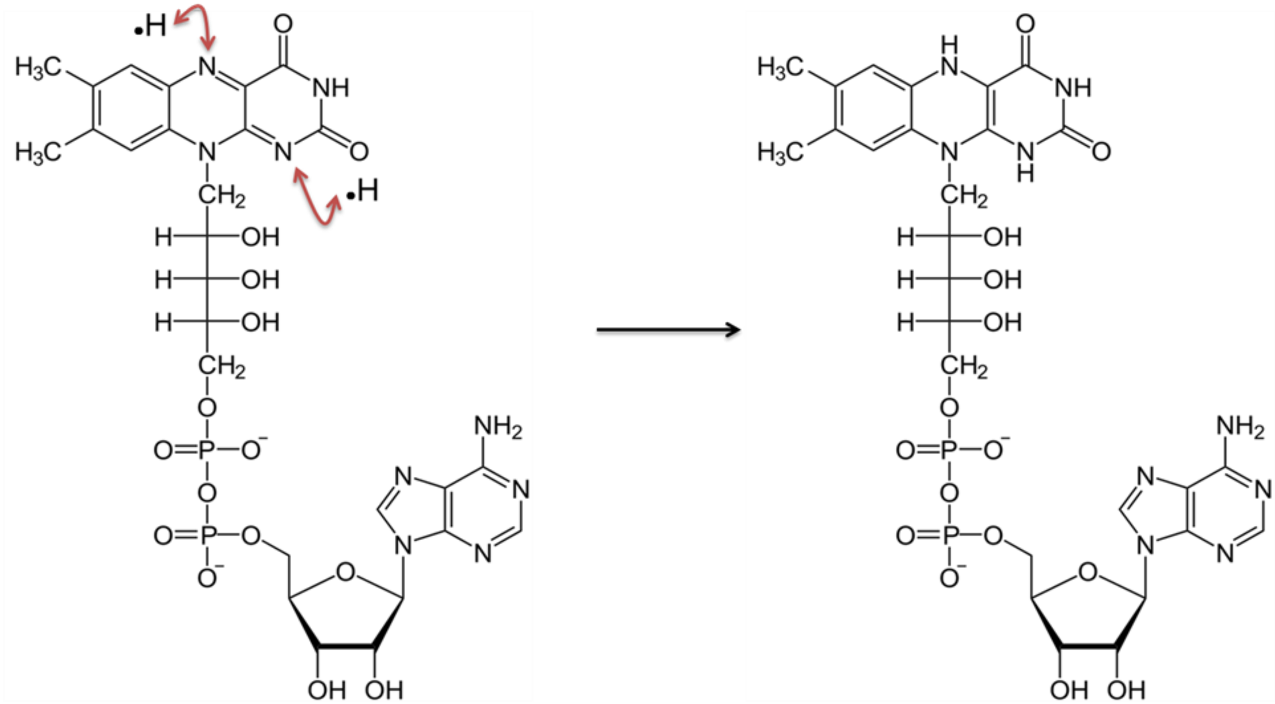


***NAD^+ Reduction to NADH + H^+**. Image created by JS at BYU-Idaho Fall 2013.*

In metabolic reactions that involve NAD, two hydrogen atoms and two electrons are removed from a substrate and transferred to NAD^+. NAD^+ accepts a hydride ion (a hydrogen with 2 electrons) and becomes Nicotinamide Adenine Dinucleotide in the reduced form (NADH). The hydrogen cation that is also captured in the reaction is released into the surrounding solution. Remember that this reaction is reversible. In the explanation of reactions that occur in Metabolism, it is common to ignore the H^+ released into solution and this text will depict the outcome of NAD reduction as simply NADH, rather than NADH + H^+.

FAD / $FADH_2$

Flavin adenine dinucleotide in its oxidized state is called FAD. After being reduced, it is called $FADH_2$. The coenzyme vitamin, riboflavin (or B2) is used to derive this compound. Riboflavin provides the ring structures that will directly participate in the transfer of two hydrogen atoms (each with one electron this time). Similar to NAD, FAD works in association with a "*dehydrogenase*" enzyme. The reaction removes two hydrogen atoms: each a proton with one electron. Both hydrogen atoms bond with FAD. This reaction does not release an H^+ into solution like the reduction of NAD does.



FAD FADH$_2$

FAD Conversion to FADH$_2$*. Image created by JS at BYU Idaho F2013.*

Flavin adenine dinucleotide in the oxidized form (FAD) accepts two hydrogen atoms (each with one electron) and becomes FADH$_2$.

As you examine the reactions for metabolism, look for a reaction that yields FADH$_2$. Like NADH, FADH$_2$ will be important as it will deliver hydrogens and electrons to biochemical processes that can use the electrons and hydrogens to make ATP.