These $-PO_3^-$ groups make big electric fields and deform proteins. Many proteins become active enzymes only when certain $-PO_3^-$ groups are added (by kinases) or removed (by phosphatases).

\[
-\overset{\text{O}}{C-}\overset{\text{O}}{\text{O}}^-\overset{\text{P}}{\text{O}}^-\overset{\text{O}}{\text{O}}^- = -\overset{\text{O}}{C-}\overset{\text{O}}{\text{O}}^-\overset{\text{P}}{\text{O}}^-\overset{\text{O}}{\text{O}}^- \quad \text{(catalysis by a kinase)}
\]

A phosphate and a carboxyl group (or two) makes an acid anhydride:

\[
\overset{\text{O}}{-\overset{\text{O}}{\text{O}}^-\overset{\text{P}}{\text{O}}^-\overset{\text{O}}{\text{O}}^-} + \overset{\text{O}}{\overset{\text{O}}{\text{H}}\overset{\text{O}}{\text{O}}^-\overset{\text{P}}{\text{O}}^-\overset{\text{O}}{\text{O}}^-} \overset{\text{H}_2\text{O}}{\longrightarrow} \overset{\text{O}}{-\overset{\text{O}}{\text{O}}^-\overset{\text{P}}{\text{O}}^-\overset{\text{O}}{\text{O}}^-} \overset{\text{H}_2\text{O}}{\longleftarrow} \overset{\text{O}}{-\overset{\text{O}}{\text{O}}^-\overset{\text{P}}{\text{O}}^-\overset{\text{O}}{\text{O}}^-}
\]

\[
\overset{\text{O}}{-\overset{\text{O}}{\text{O}}^-\overset{\text{P}}{\text{O}}^-\overset{\text{O}}{\text{O}}^-} = \overset{\text{O}}{-\overset{\text{O}}{\text{O}}^-\overset{\text{P}}{\text{O}}^-\overset{\text{O}}{\text{O}}^-}
\]

This is an acyl phosphate bond (= carboxylic-phosphoric acid anhydride); it has energy, big time.
ATP has three $\ominus$ groups — it is the fuel source of cells.

At 37°C, 15.7% of H2O's form "flickering clusters."

Ice does not flicker, so it swells.
H-bonds join these $\text{H}_2\text{O}^+$

$\text{H}^+$ $\text{O}^-$ $\text{H}^+$ $\text{O}^-$

$1\text{Å}$

$2.7\text{Å}$

Substances that easily dissolve in water are hydrophilic. They are ions in polar molecules.

$\text{Na}^+$ $\text{Cl}^-$

This is how salt dissolves in water.

Polar molecules like urea form H-bonds with $\text{H}_2\text{O}$.
Molecules formed by non-polar bonds often are insoluble in H₂O and are called hydrophobic.

Most hydrocarbons are hydrophobic.

Sugar is a solute in the solvent water. Pepsi.

Acids:

Strong acid: \( \text{HCl} \rightarrow \text{H}^+ + \text{Cl}^- \) in water

Weak acid:

\[
\text{H}_2\text{CO}_3 \quad \rightarrow \quad \text{H}^+ + \text{HCO}_3^-
\]

in water, reversible

Protons can jump from one H₂O to another:

\[
\text{H}_2\text{O} \quad \rightarrow \quad \text{H}^+ \text{H}_2\text{O} \quad \rightarrow \quad \text{H}_3\text{O}^+ + \text{OH}^-
\]

This is often written as

\[
\text{H}_2\text{O} \quad \rightleftharpoons \quad \text{H}^+ + \text{OH}^-
\]

Pure water has \([\text{H}^+]) = 10^{-7} \text{ M} \) and \([\text{OH}^-]) = 10^{-7} \text{ M}.\)
Here "M" means molal i.e. moles/liter i.e.

\[ 6.022 \times 10^{23} \text{ molecules/liter} = 1 \text{ M} \]

\[ \text{pH} = -\log_{10} [H^+] \]

Square brackets means concentration in moles/liter. A liter is 1 kg of \( H_2O \) = 10^3 cc of \( H_2O \).

Bases reduce \([H^+]\) in water solutions.

\[ \text{NH}_3 + H^+ \rightarrow \text{NH}_4^+ \]

ammonia

\[ \text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^- \]

Weak bases:

\[ \text{NH}_2^- + H^+ \rightarrow \text{NH}_3 \]

amino group
Weak chemical bonds,

These weak bonds can be ionic, H, vdWalls, or "hydrophobic."

Hydrogen bonds:

\[ \text{O} - \text{H} \equiv \text{O} \quad \text{N} - \text{H} \equiv \text{O} \]

are key to holding proteins and nucleic acids together.