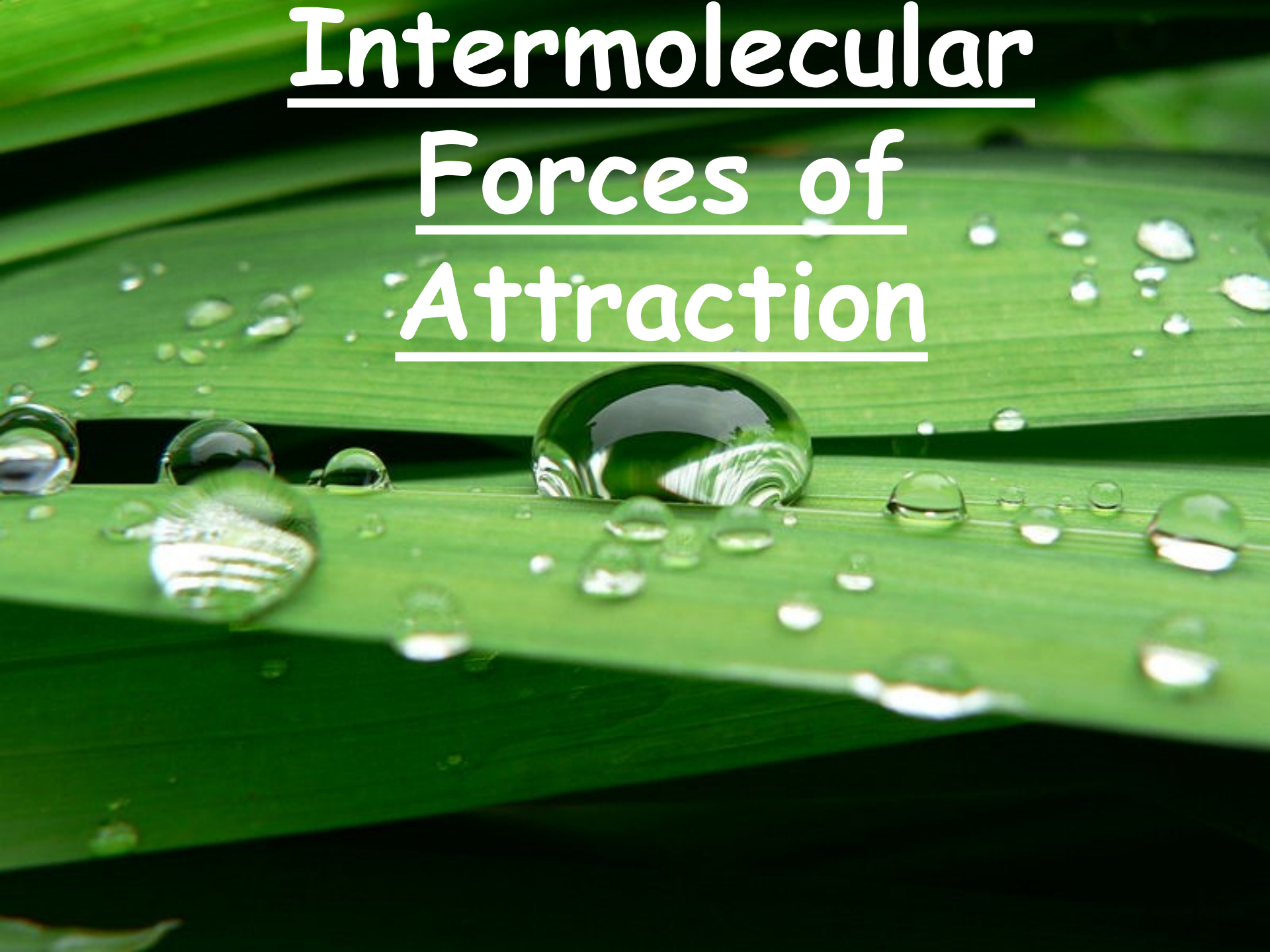


Intermolecular Forces of Attraction

CA Standards

Students know the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.

Intermolecular Forces

- Forces that attract molecules to *other* molecules. These include:
  - Hydrogen bonding
  - Dipole-dipole attraction
  - London dispersion forces

Relative Magnitudes of Forces

The types of bonding forces vary in their strength as measured by average bond energy.

Strongest

Covalent bonds (400 kcal)

Hydrogen bonding (12-16 kcal)

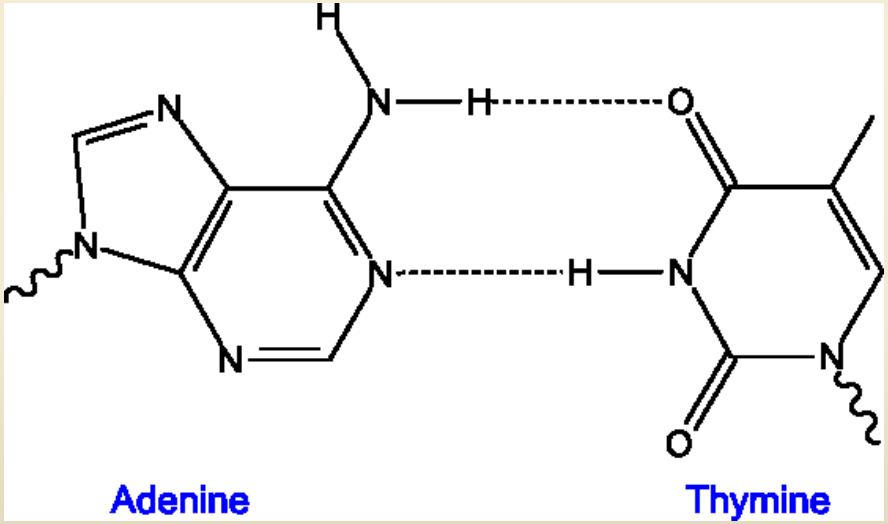
Dipole-dipole interactions (2-0.5 kcal)

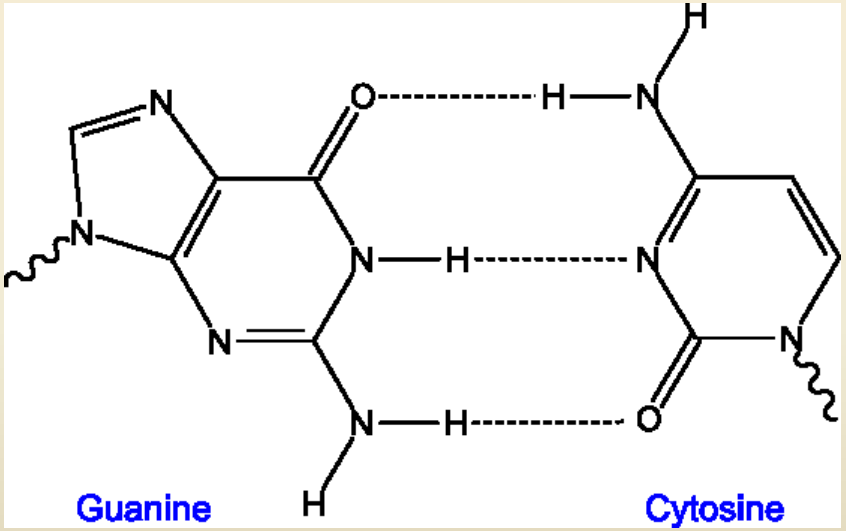
Weakest

London forces (less than 1 kcal)

Hydrogen Bonding

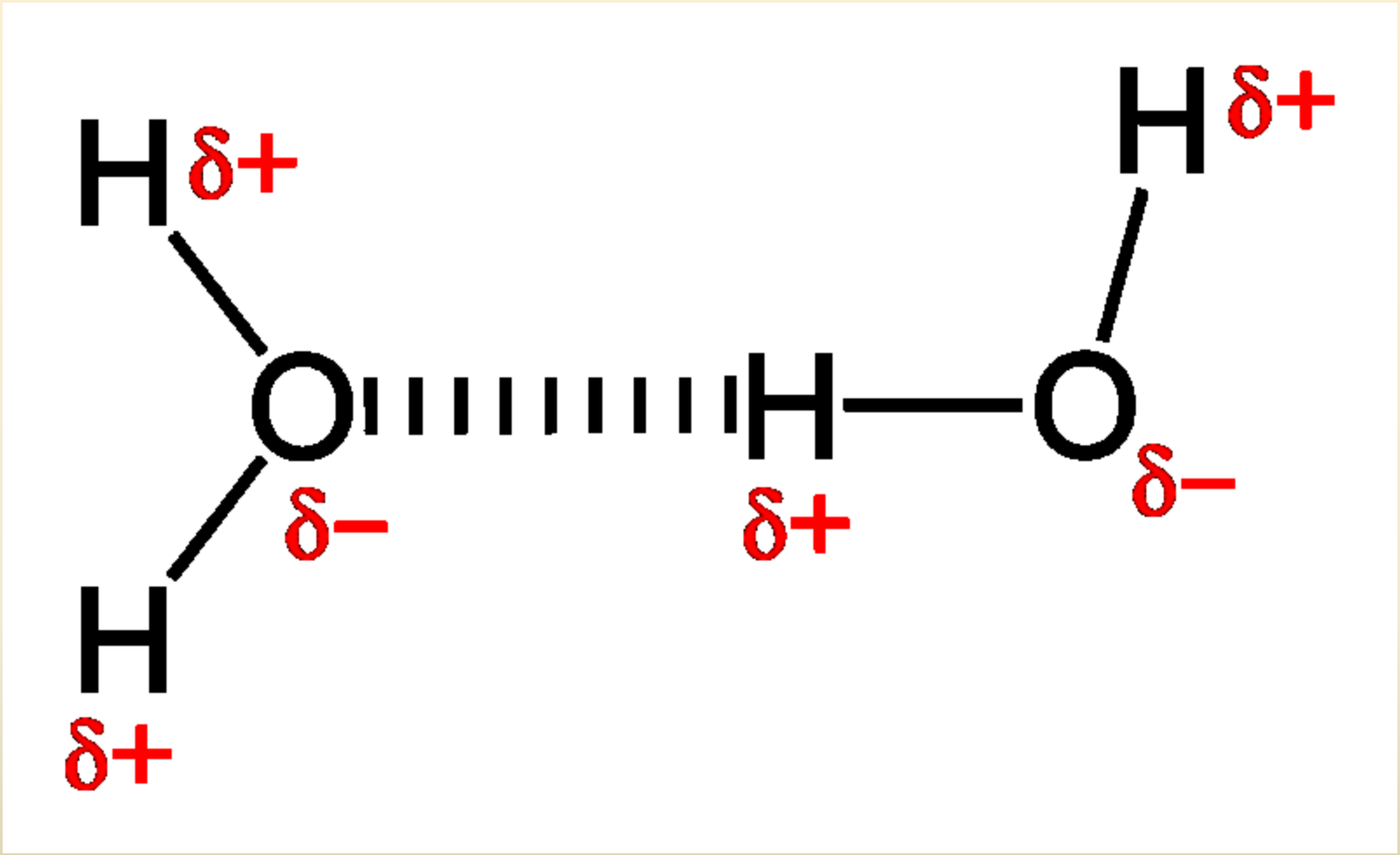
Bonding between hydrogen and more electronegative neighboring atoms such as oxygen and nitrogen





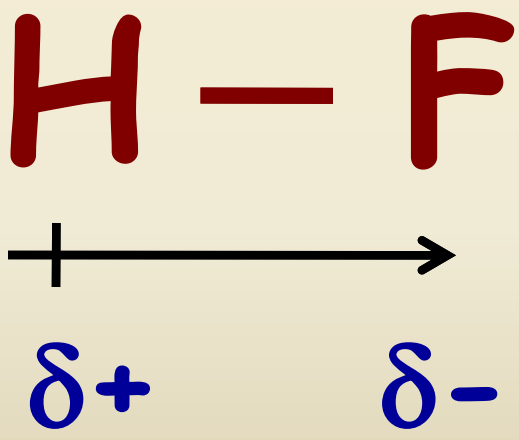
Base pairing in DNA by hydrogen bonding

Hydrogen Bonding in Water



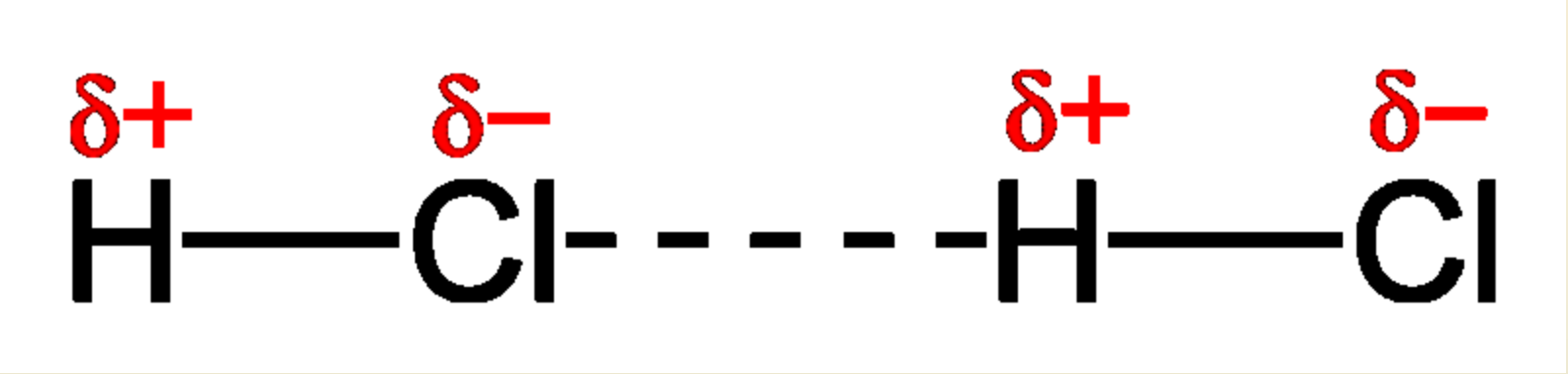
Polarity

A molecule, such as HF, that has a center of positive charge and a center of negative charge is said to be polar, or to have a dipole moment.



Dipole-Dipole Attraction

Attraction between oppositely charged regions of neighboring molecules.



Dipole-dipole attraction in hydrogen chloride, a gas that is used to make hydrochloric acid

London (Dispersion) Forces

- The weakest of intermolecular forces, these forces are proportional to the mass of the molecule
- These are the only forces of attraction between completely nonpolar molecules
  - Large nonpolar molecules may have substantial dispersion forces, resulting in relatively high boiling points
  - Small nonpolar molecules have weak dispersion forces and exist almost exclusively as gases

London Forces in Hydrocarbons