

# Biochemistry

- The study of molecules and reactions that occur in living organisms.
- Explains the development, maintenance, reproduction and destruction of life forms.
- These biological processes require specific interactions between thousands of 'biochemicals'.

# Biomolecules

- All living matter is considered 'organic'.
- Organic compounds are made up of C, H, O with significant amount of N, P and S.
- Trace elements include Ca, Fe, I, Na, Mg, etc
- Biologically important small molecules:  
water, vitamins, some hormones, heme etc.

# Biomolecules

- Macromolecules divided into 4 classes:

Nucleic acids: DNA and RNA (polynucleotides)

Proteins: polymers of aminoacids (polypeptides)

Carbohydrates: polymers of sugars (polysaccharides)

Lipids: water-insoluble biomolecules. (not polymers)

# Biochemical Reactions

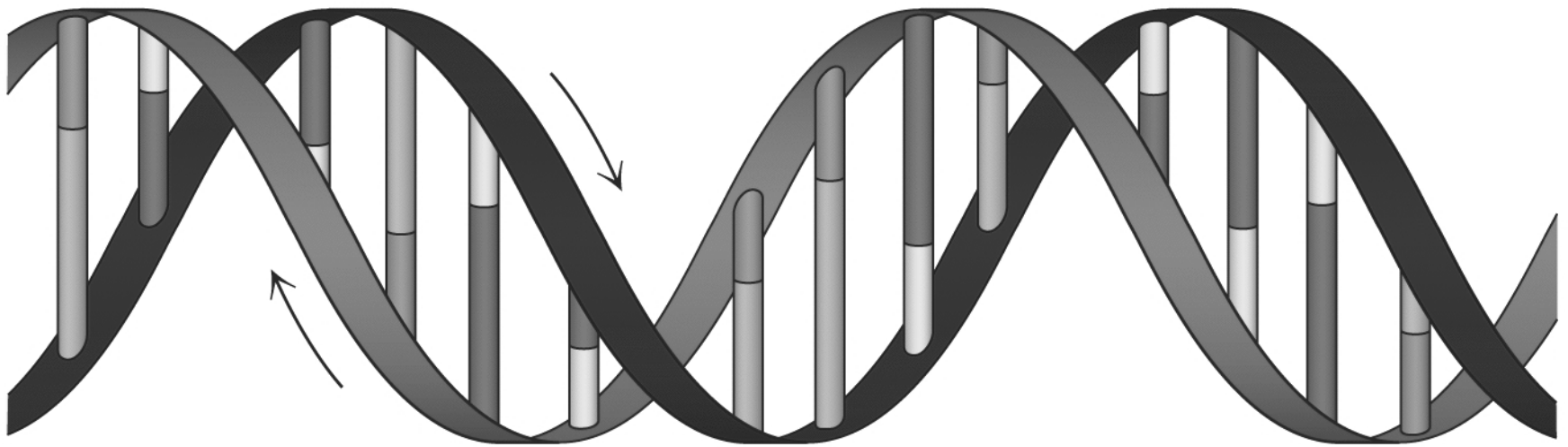
- Enzyme catalyzed
- Together they are called 'Metabolism'
- 2 categories:
- Anabolism make up the synthetic reactions
- Catabolism is the degradation reactions

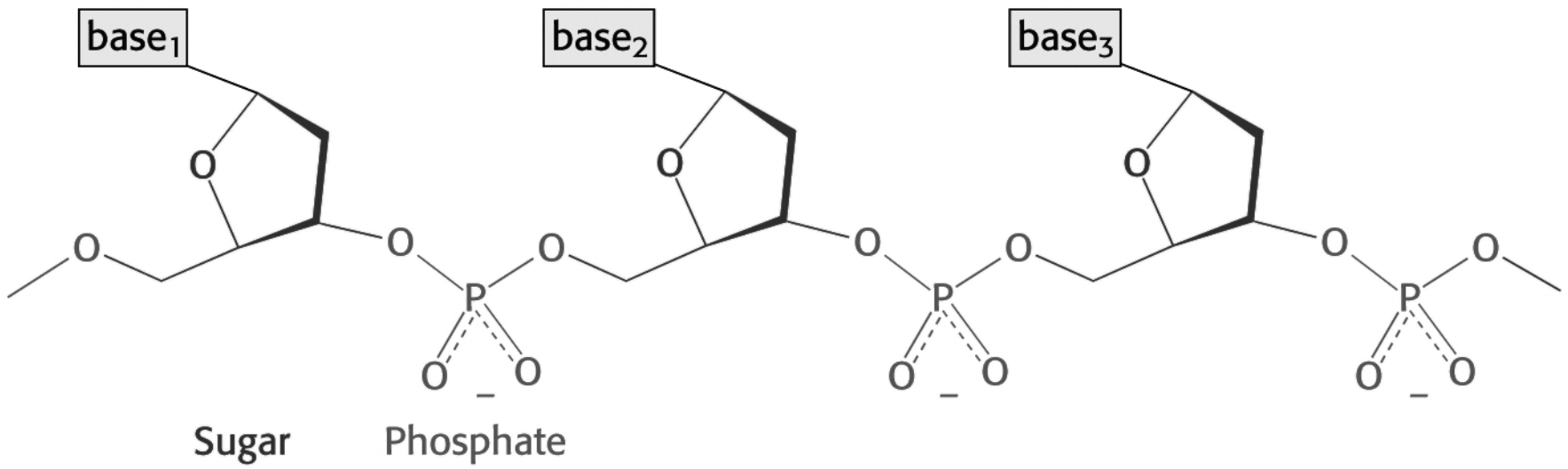
# Reaction Compartments

- Biochemical reactions occur inside the cell
- The cell is compartmentalized into organelles.  
(review your biology)
- Main reaction sites: mitochondria, cytosol, ER
- Compartments allows reactants to remain separated until reaction time.
- Pumps and transporters that facilitate entry of biomolecules into organelles.
- Biochemical signals target molecules to correct site.

# Genetic Information

- Genetic information is contained in DNA.
- The complete human genome is sequenced.
- Need to identify the functions of each gene.
- Which genetic errors cause disease ?
- Gene expression during development.
- Genetic changes during evolution.



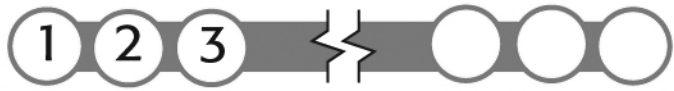


# Flow of Information

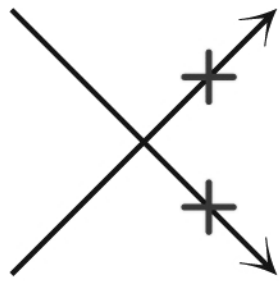
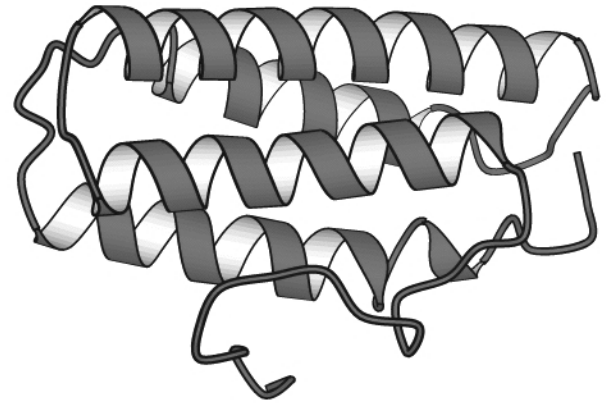
- Genetic information flows from  
DNA → DNA → RNA → Protein → Function
- DNA is the Blue print
- RNA is the Messenger  
(RNA also has structural and adapter roles)
- Protein is the Performer
- DNA and RNA sequences are made up of only 4 bases each
- Protein sequences contain 20 amino acids.

# Structure-Function Relationship

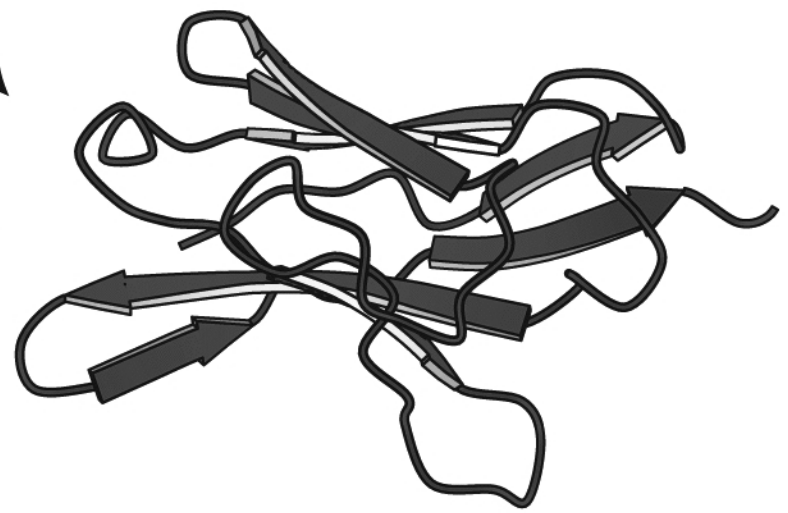
- Underlying principle throughout Biochemistry: Structure determines function.
- The structure (sequence) and therefore, the function, of each gene is unique.
- In the double helix, A-T and G-C pairing is based on chemical structure of A, T, G, and C.
- In proteins, not only the sequence of amino acids, but also the 3D folding patterns affect function.



**Amino acid sequence 1**



**Amino acid sequence 2**



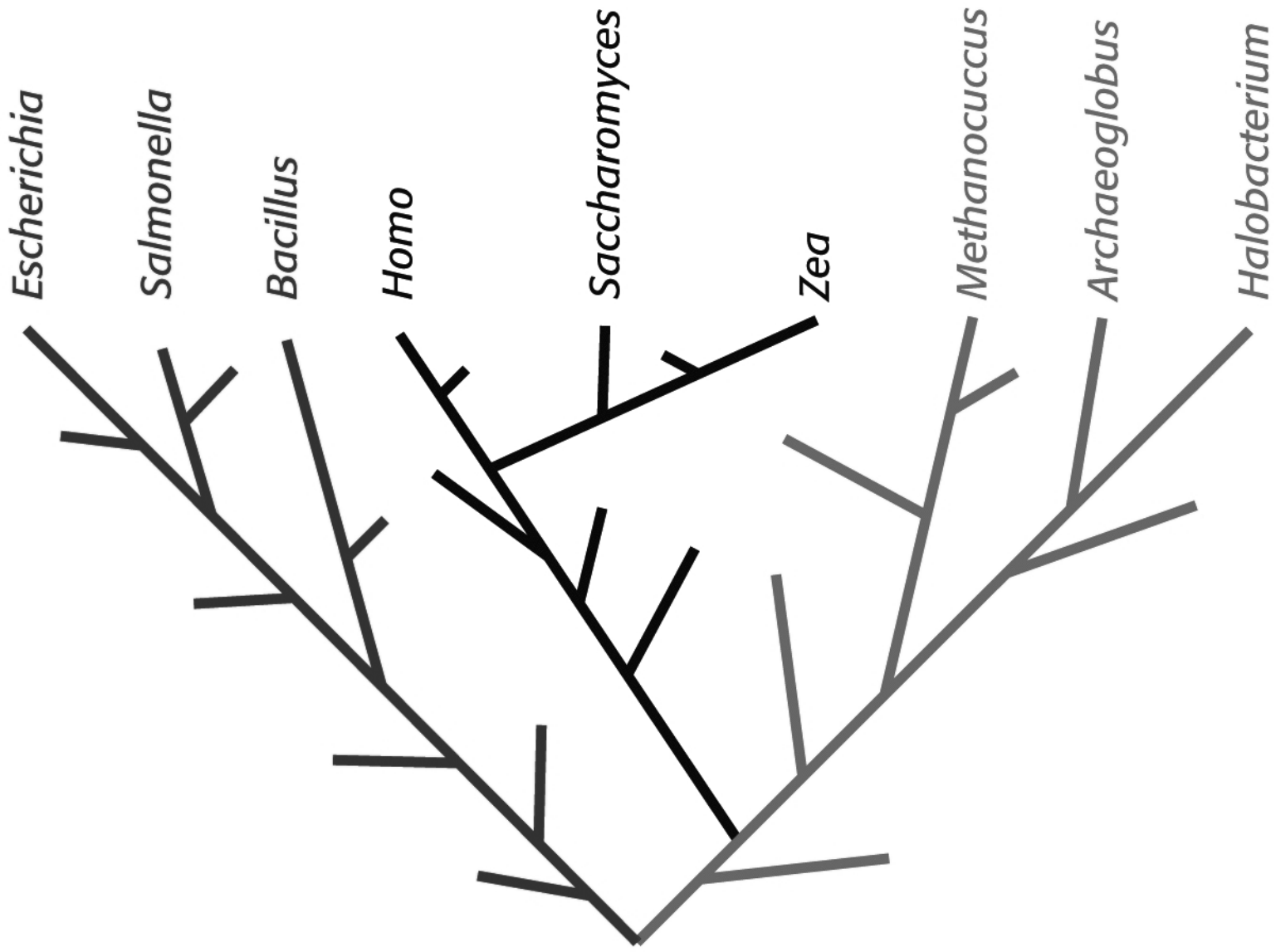
# Biochemical Evolution

- The genetic code is universal.
- Diverse organisms share the same biomolecules.
- These similarities point to a common ancestry for all organisms on earth. (Tree of Life)
- The diversity stems from:
  - adaptation of biomolecules to new roles
  - variable complexity
  - macromolecular interactions.
- One can understand evolutionary progress by comparing genetic and biochemical characteristics of various organisms.

**BACTERIA**

**EUKARYA**

**ARCHAEA**



# Life Started with Chemical Synthesis of Key Biomolecules

- Water
- Amino acids and Proteins
- Carbohydrates (carbon/energy source/store)
- Lipids (also for energy)

# Biochemistry of Evolution

- Prebiotic chemicals evolved into organized complexes capable of growth and duplication (chemistry merged with biology)
- Prehistoric life forms adapted to the environment by using sunlight and chemical energy for physiological functions.
- Stability of these chemical compounds is dependent on covalent bonds; their reactivity depends on non-covalent interactions.

# Chemical Bonds in Biochemistry

## Irreversible Bonds

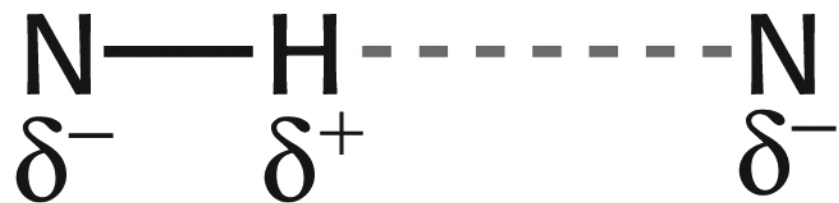
- Covalent bonds
  - Single bonds
  - Double and triple bonds
  - Resonance structures
- Chemical reactions require making and breaking covalent bonds

# Reversible Bonds

- Noncovalent bonds
  - Electrostatic interactions (electrical charge)
  - Hydrogen bonds (H and  $\delta^-$  atom)
  - van der Waals interactions
    - (transiently  $\delta^-$  and  $\delta^+$  atoms)
  - Hydrophobic interactions (nonpolar domains)
- Reversible bonds are the basis for macromolecular 3D structure.

Hydrogen-  
bond donor

Hydrogen-  
bond acceptor

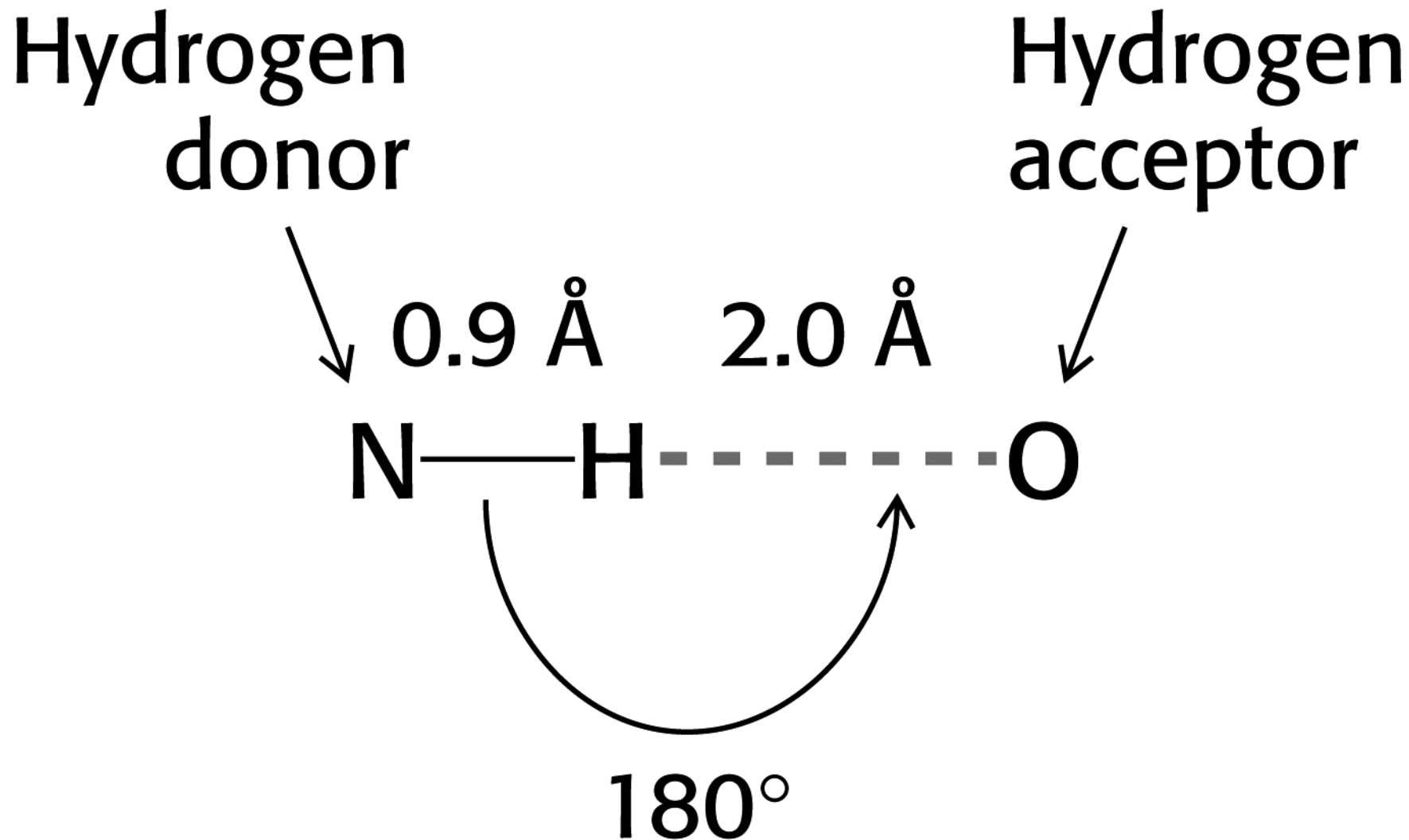


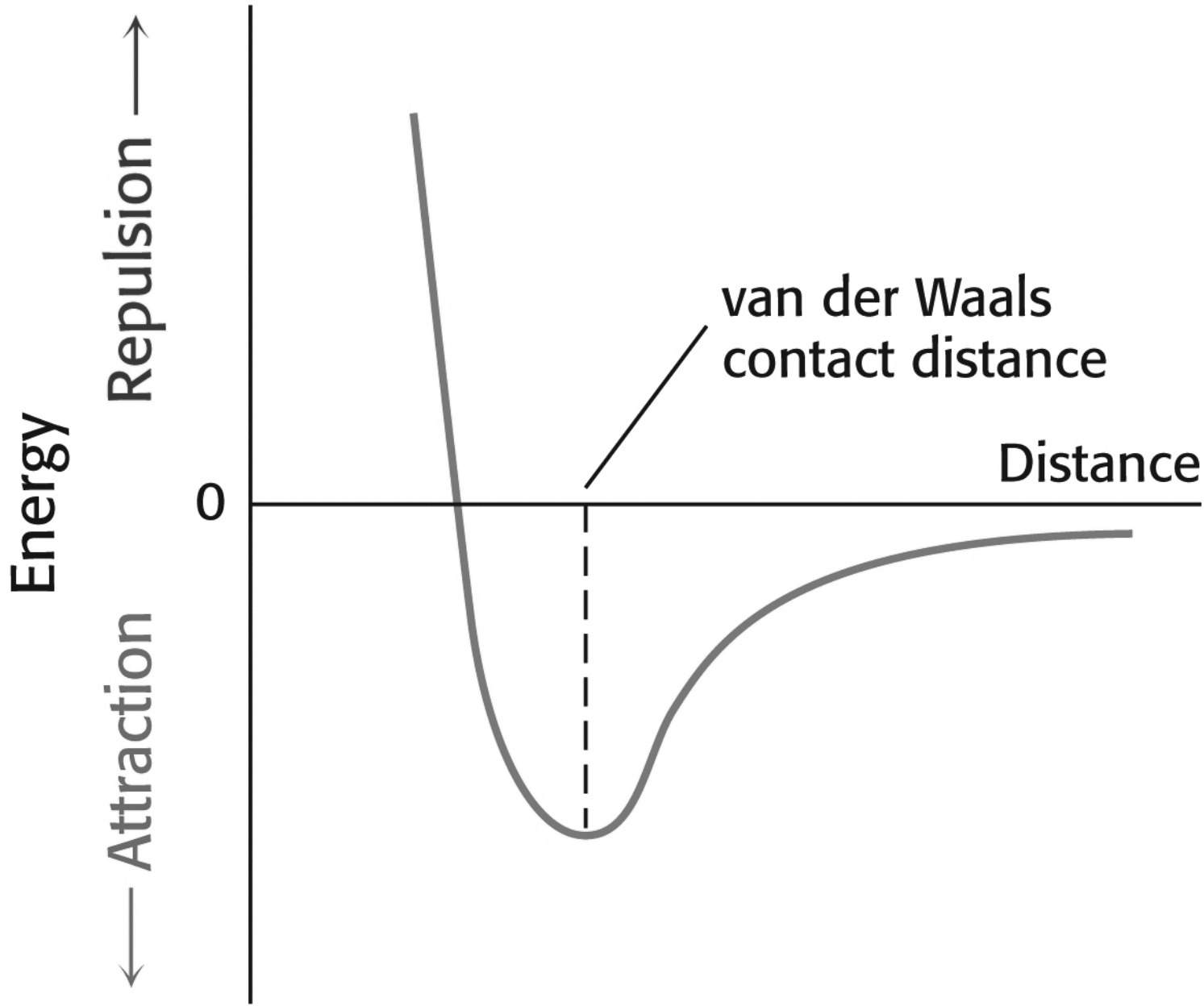
Hydrogen  
donor

Hydrogen  
acceptor



180°





# Hydrophobic Interactions

