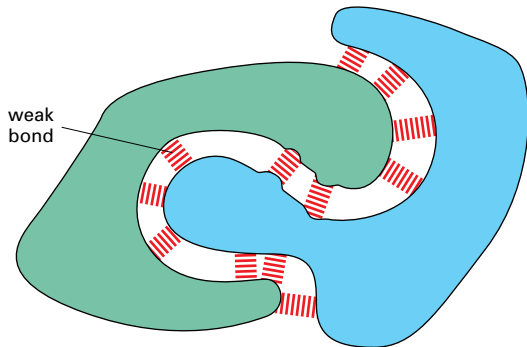


**PANEL 2-3** The Principal Types of Weak Noncovalent Bonds that Hold Macromolecules Together

**WEAK CHEMICAL BONDS**

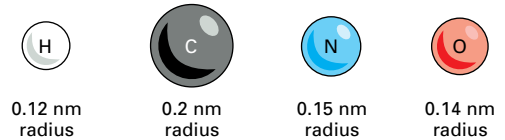
Organic molecules can interact with other molecules through short-range noncovalent forces.



Weak chemical bonds have less than 1/20 the strength of a strong covalent bond. They are strong enough to provide tight binding only when many of them are formed simultaneously.

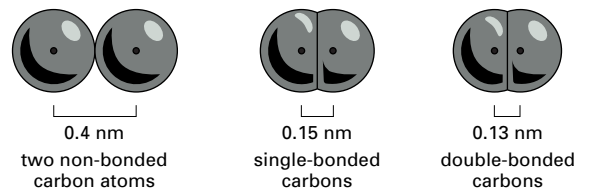
**VAN DER WAALS ATTRACTIONS**

If two atoms are too close together they repel each other very strongly. For this reason, an atom can often be treated as a sphere with a fixed radius. The characteristic "size" for each atom is specified by a unique **van der Waals radius**. The contact distance between any two non-covalently bonded atoms is the sum of their van der Waals radii.



At very short distances any two atoms show a weak bonding interaction due to their fluctuating electrical charges. The two atoms will be attracted to each other in this way until the distance between their nuclei is approximately equal to the sum of their van der Waals radii. Although they are individually very weak, **van der Waals attractions** can become important when two macromolecular surfaces fit very close together, because many atoms are involved.

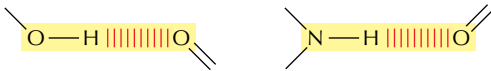
Note that when two atoms form a covalent bond, the centers of the two atoms (the two atomic nuclei) are much closer together than the sum of the two van der Waals radii. Thus,



**HYDROGEN BONDS**

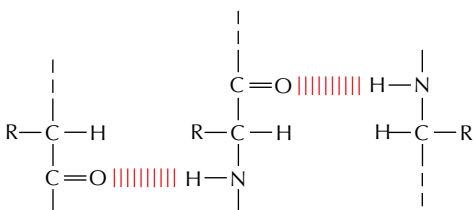
As already described for water (see Panel 2-2) **hydrogen bonds** form when a hydrogen atom is "sandwiched" between two electron-attracting atoms (usually oxygen or nitrogen).

Hydrogen bonds are strongest when the three atoms are in a straight line:

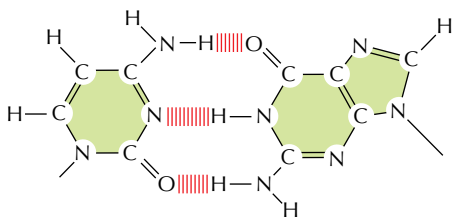


Examples in macromolecules:

Amino acids in polypeptide chains hydrogen-bonded together.



Two bases, G and C, hydrogen-bonded in DNA or RNA.



**HYDROGEN BONDS IN WATER**

Any molecules that can form hydrogen bonds to each other can alternatively form hydrogen bonds to water molecules. Because of this competition with water molecules, the hydrogen bonds formed between two molecules dissolved in water are relatively weak.

