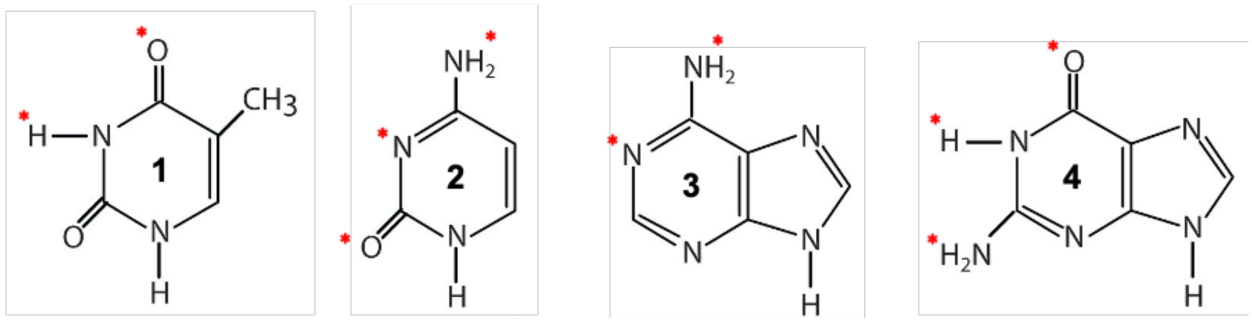
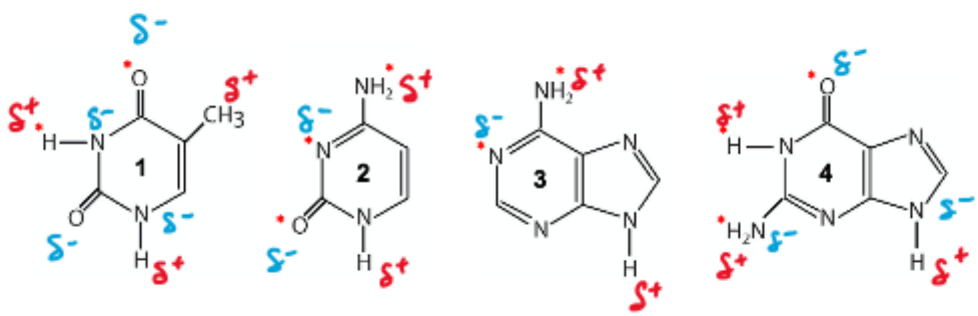
What helps hold DNA together?

A. Base pairing is the term used to describe how two DNA strands are held together. Below are the molecular structures of the four bases which make up DNA. What intermolecular forces would you expect the molecules to have? Justify your answer.

   a. *Having trouble? Review questions from Chapter 10: 7, 8, 9, and 10.*

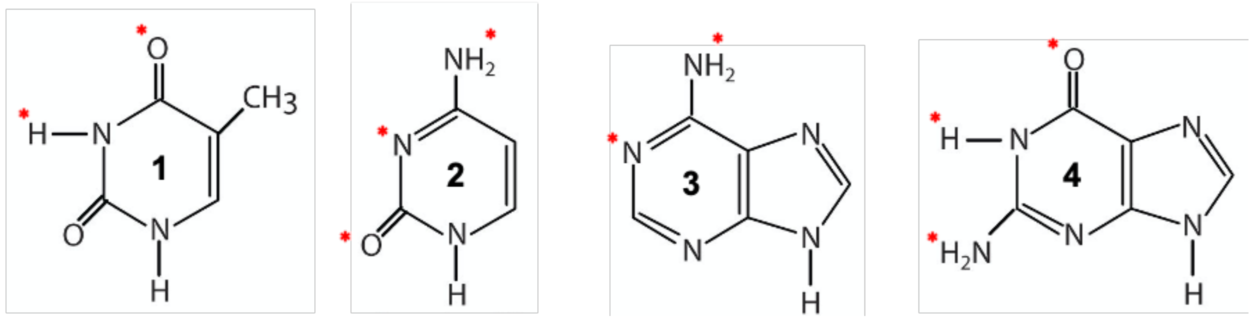


- As all molecules have dispersion forces, each of the base pairs then have dispersion forces.
- To decide if a molecule has dipole-dipole force there must be a permanent dipole on the molecule. Looking at the molecules, there are many electronegative atoms on the edges of the molecule but there is no clear, positive side and negative side across the molecule. Therefore it is hard to determine if dipole-dipole force is present in bases of DNA without more information.

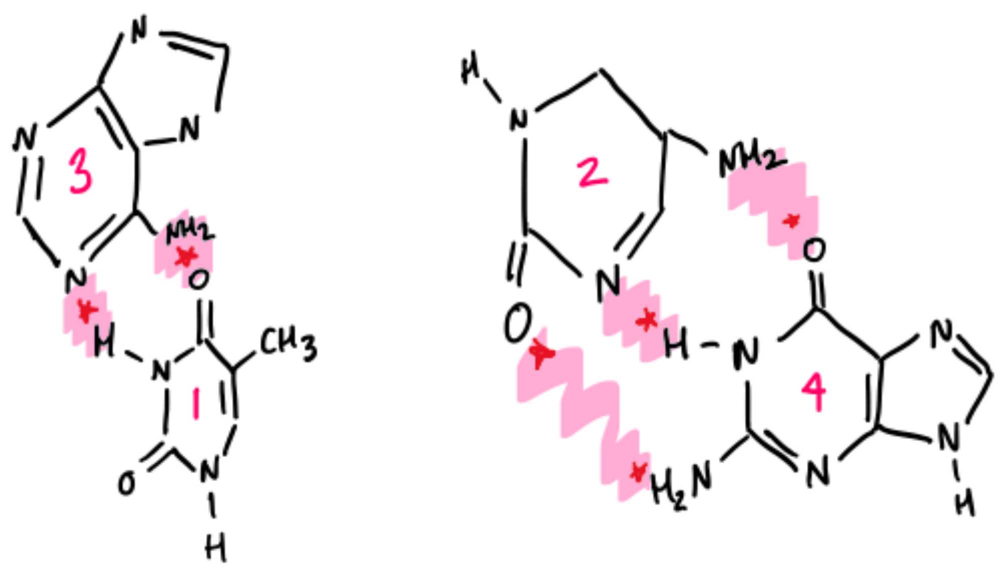


- There is a strong likelihood for hydrogen bonding in these molecules, since there are many N-H and O-H bonds, which generate strongly slightly negative and strongly slightly positive places on the molecule.
- Since there are no ions present, we can disregard ion-dipole force.

B. Identify which bases pair together. *The stars (*) indicate important atoms in each structure.* How did you determine your answer?



- Since the base pairs are paired, two molecules go together. By looking at the starred atoms, one can see that molecules 1 and 3 have two starred atoms, while molecules 2 and 4 have 3 starred atoms. Looking more closely at the starred atoms and reorienting the molecules we can see that the number of special groups match but that they are of opposite charges on the two molecules that base pair. In pair 1-3, the 1 molecule has an H+ and an O-, which pairs with an N- and H+ on the 3 molecule. The same type of attractions can be seen on 2 and 4.

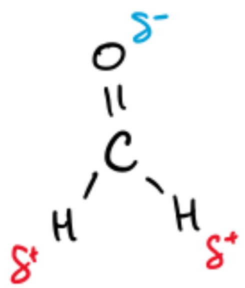


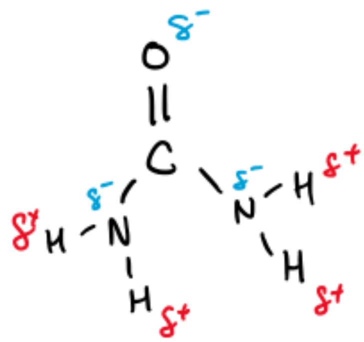
C. If DNA is heated to 90 °C, the DNA strands separate. What is the best explanation for this?
    a. *Having trouble? Review questions from Chapter 10: 13 and 15.*

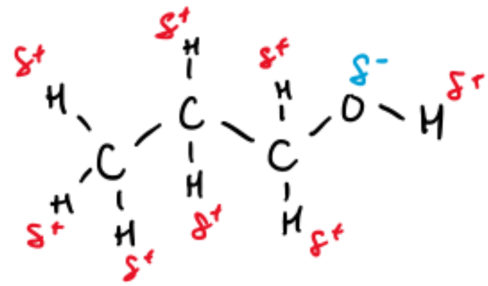
- Looking at the answer to Part B, we can see that the bases pair together because of attractions between partial positive and partial negative charges on the molecules. Since these are partial charges and not full charges they result in intermolecular forces. IMF can be broken by increases in temperature because an increase in thermal energy results in an increase in kinetic energy in the molecules. More kinetic energy means the molecular movement increases, increasing the chance that molecules can break free of the IMF keeping them close. The question states that 90 °C is point where the DNA strands separate, so this must be the temperature at which the base pairs can break free of their IMF.

D. In addition to temperature, specific molecules can separate DNA strands. Work to determine which molecule, CH_2O, $CO(NH_2)_2$, or CH_3CH_2OH would cause the most disruption to double stranded DNA. Justify your answer with explanations and drawings.

   a. *Having trouble? Review questions from Chapter 4: 40, 48, and 50 and Chapter 10: 17, 15, and 21.*







- The three molecules likely can disrupt DNA base pairs because they have partial positive and partial negative regions.
- CH_2O has a dipole but no H+ which could hydrogen bond, only the O could H-bond. Thus while it likely disrupts DNA, it might not be as disruptive as other molecules.
- CH_3CH_2OH has a dipole and an OH group which could participate in hydrogen bonding. However, a whole half of the molecule has H atoms bound to C, which do not generate enough partial positive charge to participate in H-bonding.
- $CO(NH_2)_2$ has a dipole and two NH_2 groups which could participate in hydrogen bonding. Compared to CH_2O, the molecules look similar but the presence of the NH_2 groups generate H atoms which can hydrogen bond, in addition to the O atom which can participate in H bonding. Compared to CH_3CH_2OH, the molecules both have atoms which can participate in H bonding, but $CO(NH_2)_2$ has more of them. Also,
- Based on the analysis, $CO(NH_2)_2$ is probably the most disruptive molecule though all three likely disrupt DNA base pairing between strands.

E. What helps hold the base pairs on separate strands together? Use your answers to the previous answers to justify your choice.

- Based on the analysis above (details below) hydrogen bonding is the most likely force to help hold strands of DNA together.
- From Part A, we see that the bases in DNA could have dispersion forces and hydrogen bonding, but dipole-dipole is harder to tell with the information we have.
- From Part B, we see that bases 1 and 3 go together and 2 and 4 go together, due to attractions between permanent partial negative and partial positive groups on the molecules. Since dispersion is between temporary partial charges, it seems more likely that hydrogen bonding is responsible.
- From Part C, we know that when water boils the hydrogen bonds between molecules are being broken but the covalent bonds are not. Since 90 °C is quite hot, close to the temperature of water boiling (100 °C), it adds support that hydrogen bonding breaks between the base pairs when the temperature reaches 90 °C. If the strands separated at a much lower temperature then dispersion forces would seem more likely.
- From Part D, we see that certain molecules can also disrupt DNA base pairing. All of the molecules suggested contain permanent partial positive and partial negative charges, which could get in between the base pairs, disrupting the strands being held together.