E. Take the pot of thick, pulpy pineapple mixture and heat it on high for three minutes. Keep stirring it constantly, in order to distribute the heat evenly. The thick, pulpy mixture may boil. That's fine; just keep stirring.

F. After three minutes of heat, take one tablespoon of the hot pulpy mixture and pour it into one of the two bowls that have only Jell-O in them. Use a different tablespoon than the one you used in step (C). Stir vigorously. Label that bowl as "heated pineapple juice."

G. Put all three bowls in the refrigerator and wait for the amount of time described on the Jell-O box.

H. Examine the three bowls of Jell-O. What happened?

You should have seen that the Jell-O in the bowl with nothing added gelled as you would expect, as did the Jell-O in the bowl which had heated pineapple juice added to it. However, the Jell-O in the bowl that had room-temperature pineapple juice in it should not have gelled. If it did, you did not use fresh pineapple. Why did this happen?

Pineapple contains an enzyme that stops the reaction which causes Jell-O to gel. Remember, catalysts can either speed up or slow down a reaction. In this case, the enzyme catalyst slows the reaction down to essentially a halt. As a result, when pineapple juice is added to Jell-O, the Jell-O cannot gel. As is the case with all enzymes, however, this enzyme is very fragile. The heat that you added to the thick, pulpy pineapple mixture in the pot was enough to destroy the enzyme, and that's why the Jell-O in the bowl with the heated pineapple juice added was still able to gel. This should give you an idea of how fragile enzymes are. In fact, enzymes are so fragile that most food processing destroys them. That's why the experiment called for a fresh pineapple. In processed pineapple juice (canned or frozen), the enzyme used in this experiment has been destroyed by the processing. Interestingly enough, pineapple also contains enzymes which can break down your gums. That's why your gums bleed if you eat a fresh pineapple core.

Because enzymes are so fragile, they break down soon after they are formed. Even in the fresh pineapple that you used in the experiment, most of the relevant enzyme had already broken down before you used it. However, even a tiny amount of enzyme is enough to see the effect that you saw in the experiment, so even though most of the enzyme in the pineapple was gone, enough was left to make the experiment work. Since enzymes break down soon after they are formed, your body must continually produce more and more enzymes, just to replace the ones that are breaking down. That's why it's important to eat protein in your diet. The protein that you eat gets broken down into its constituent amino acids, and those amino acids are shipped to the cells in your body so that they can produce more enzymes.

ON YOUR OWN

5.19 Since dehydration reactions link amino acids in order to form proteins, why don't proteins break down into their amino acids when they are mixed with water?

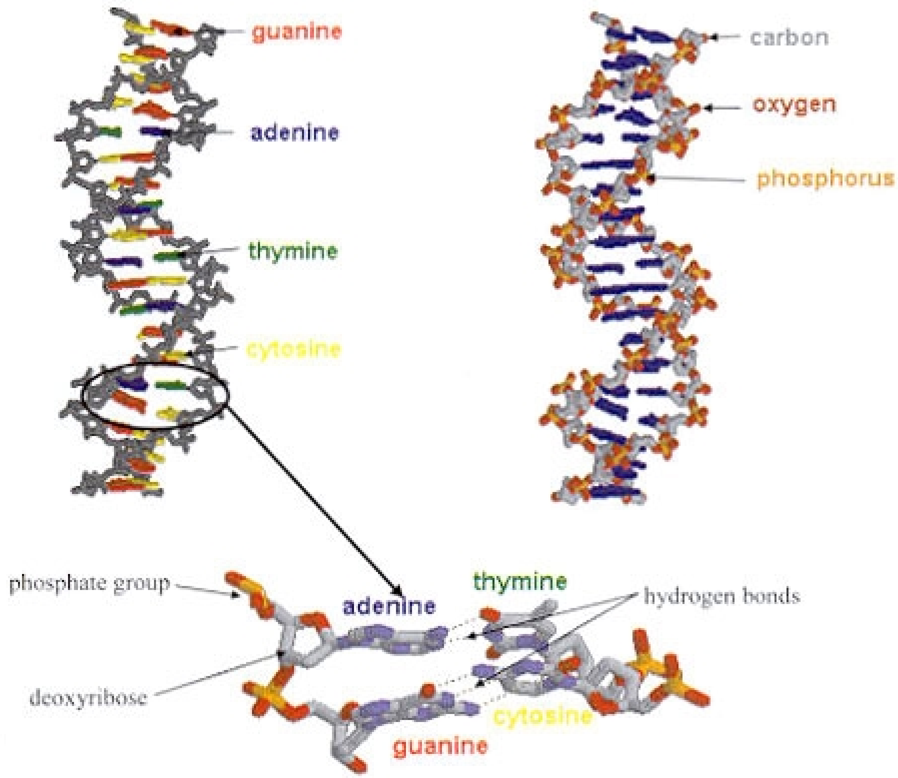
DNA

Our discussion of chemistry would not be complete, of course, without a brief description of DNA, the molecule which forms the basis of life. If you thought proteins were complex, you haven't seen anything until you have studied DNA! To begin your study of DNA, examine the schematic representations given in Figure 5.9.

FIGURE 5.9
Two Schematic Representations of DNA

DNA double helix, emphasizing the nucleotide bases adenine, cytosine, thymine, and guanine

DNA double helix, emphasizing the backbone, which is made of carbon, oxygen, and phosphorus



The four nucleotides, as they exist in the DNA double helix

Illus. constructed by Dr. Jay L. Wile with RASMOL, a molecular modeling program.

Deoxyribonucleic (dee' ox ee rye boh noo klay' ick) acid, or DNA, is a double chain of chemical units known as nucleotides (noo' klee uh tides). These two chains twist around one another in the double-helix that is so familiar to most who have studied any amount of biology. The nucleotides that make up these two chains are comprised of three basic constituents: **deoxyribose** (a simple sugar that contains 5 carbons), a **phosphate group** (an arrangement of phosphorous, hydrogen, and oxygen atoms), and a **base**. A nucleotide's base can be one of four different types: **adenine** (add' uh neen), **thymine** (thye' meen), **guanine** (gwa' neen), or **cytosine** (sie' toh seen).

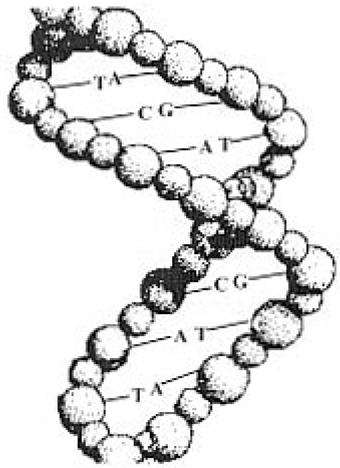
In the lower part of the figure which shows the nucleotides, you can see that the phosphate groups link one nucleotide to another. The sugar part of the nucleotide supports the base. The two nucleotide chains are held together because the bases link together in a process known as **hydrogen bonding**.

Hydrogen bond - A strong attraction between hydrogen atoms and certain other atoms (usually oxygen or nitrogen) in specific molecules

Hydrogen bonding is actually a very complex process that you will learn much more about in chemistry. For right now, you just need to realize that it is very dependent on the types of molecules involved and the attraction between the atoms in hydrogen bonding is about 15% as strong as the attraction between two atoms that have a true chemical bond linking them. Thus, the hydrogen bonds in DNA are strong enough to keep the two chains together in a double helix, but are significantly weaker than a true chemical bond. Since they are weaker than a true chemical bond, it is rather easy for the two helixes in DNA to unravel. That, as we will learn in the next chapter, is VERY fortunate.

Since hydrogen bonding is highly dependent on the molecules involved, it turns out that only certain nucleotide bases can link together using hydrogen bonds. The nucleotide base adenine can only hydrogen bond to thymine. It cannot hydrogen bond to cytosine or guanine. In the same way, thymine can only hydrogen bond to adenine. Likewise, cytosine can only hydrogen bond to guanine and guanine to cytosine. As a result, DNA is often pictured as drawn in Figure 5.10.

FIGURE 5.10
Another Way of Picturing DNA



Illus. by Dr. Jay L. Wile

In this figure, "T" represents thymine, "A" adenine, "G" guanine, and "C" cytosine. The balls in the figure represent the backbone of the DNA. Notice that T's are only linked to A's and C's are only linked to G's and vice-versa. This represents the fact that only adenines and thymines or cytosines and guanines link together.

Now you can finally learn how DNA stores all of the marvelous information that it uses as the instructions for making life. Just as the entire English language can be reduced to sequences of dots and dashes in Morse code, all of the information necessary for life can be reduced to sequences of nucleotide bases in a DNA molecule. Cells, as we will learn in the next chapter, have chemical machinery which decodes the sequences of nucleotide bases into instructions for what structures need to be built and where to build them. Isn't that marvelous?

ON YOUR OWN

5.20 One way that chemists can "unwind" DNA so that the individual strands can be studied is to heat a sample containing DNA. This causes the two strands of nucleotides to unravel. Based on that information, what can we say about the effect of heat on hydrogen bonds?