Environmental Science Institute
UNIVERSITY OF TEXAS AT AUSTIN

Construct a DNA Double Helix

Grade: 9th – 10th, Biology

Purpose: The purpose of this activity is to help students to understand how DNA helix is formed. Students will construct a "DNA Helix" by connecting tags, which represent different bases. While connecting the tags, students will observe the bond strength between the bases (phosphodiester bond) and between the helices (hydrogen bond).

Materials:
"DNA Bases: Warm-up Stage" Handout
"DNA Bases: Challenging Stage" Handout
"DNA Bases: Advanced Stage" Handout
Tapes
Staplers
Scissors

Lesson Duration: 90 minutes

TEKS Objectives:

§112.43. Biology. (c) (2a-d) (6a)

Background: Deoxyribonucleic acid (DNA) is famous for its ability to store genetic information. DNA consists of two chains of nucleotides. A nucleotide is composed of two parts: sugar (deoxyribose, in this case) and a base. Adenine, cytosine, guanine, and thymine are the only four bases found in DNA nucleotides. Although there are only four bases, there are specific mechanisms that make a DNA helix a stable structure, such as base-pairing between two helices through hydrogen-bonding.

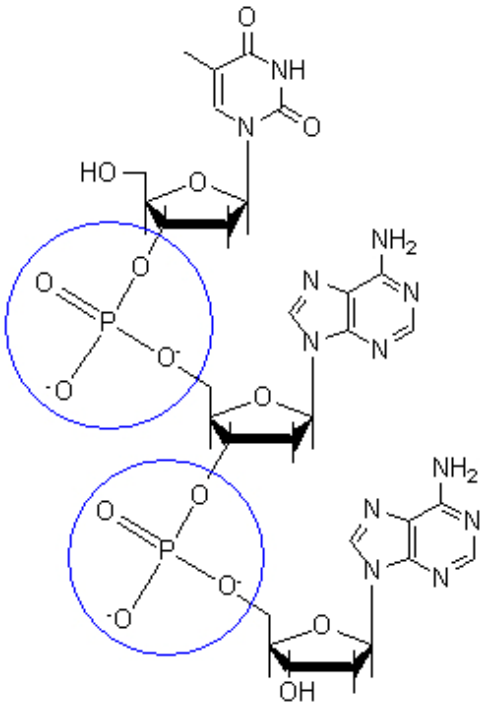

Figure 1. Phosphodiester Bond between different nucleotides (in blue circle) *Source: Wikipedia.com*

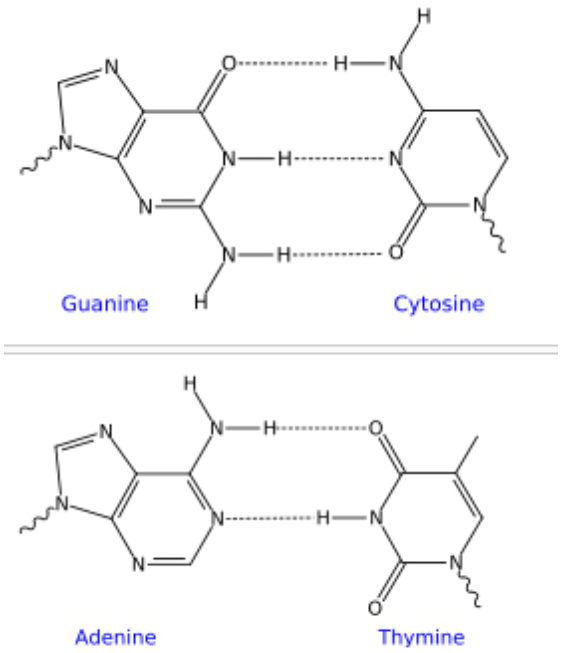

Figure 2. Hydrogen-bonds between base pairs *Source: Wikipedia.com*

In Figure 1, we can see how nucleotides bond to each other *within* a DNA helix. Phosphodiester bond is a strong covalent bond that supports the structure of a helix. In Figure 2, dashed lines between nitrogen and hydrogen in the middle represent the hydrogen-bonds. They are weak compared to covalent bonds; however, they are the strongest intermolecular force. (The surface tension of water is a result of hydrogen-bonding.) Hydrogen bonds hold two DNA helices in position, forming a double helix.

Activity

Students will conduct hands-on activities in the lesson. They will create their own DNA double helix using the given materials. The focus will be on students' understandings of the component and structure of DNA, and the differences between phosphodiester bonds and hydrogen bonds.

Procedure

Warm-up Stage:

1. Each group will be given two copies of the “DNA Bases: Warm-up Stage” and a pair of DNA sequence. The tags on the handout, containing the bases’ names and symbols, represent different DNA bases.

2. Students should cut the tags out according to their shapes.

3. The student will create a “double helix,” a two-column chain, resembling the actual DNA helix.

4. The students will use tape to connect the smooth (top and bottom) edges and staple the side edges. The tape represents the phosphodiester bond, which is covalent and strong. The staple represents the hydrogen bond, a weak molecular interaction compared to covalent bond. Using this approach, the students will have a visual concept about the bond strength between the DNA bases.

5. After the students finish resembling the DNA sequence, they will have three minutes to observe and discuss the pattern of the sequence. The anticipated outcome is that the students will discover that adenine only binds with thymine while cytosine only binds with guanine, and vice-versa, in both cases, through hydrogen-bonding.

Challenging Stage:

1. At this stage, the student will perform a similar task; however, only 1 DNA sequence is given.

2. They should have “DNA Bases: Challenging Stage” handout. The tags on the handout contain only the bases’ symbols. Students must be familiar with the symbols in order to be successful at this stage.

3. This stage reinforces the concept of cytosine-guanine (CG) and adenine-thymine (AT) base pairing. Although the shapes of the bases give a hint as to what each respective base will hydrogen-bond with, students are encouraged to know the base-pairing at this stage.

Advanced Stage:

1. Students will be given “DNA Bases: Advanced Stage.” The tags contain only the symbols of the bases.

2. This stage is similar to the previous stage, however, students must know about base-pairing in order to create a DNA helix.

DNA Bases: Advanced Stage

A	A	A	A	A
T	T	T	T	T
C	C	C	C	C
G	G	G	G	G
A	A	A	A	A
T	T	T	T	T
C	C	C	C	C
G	G	G	G	G