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Curriculum topics:

- Biology
- Genetics
- DNA
- Molecules
- Macromolecules
- Base Pairing Rules

Subject: Life Science

Grade range: 7 – 12

MODELING DNA THE CODE OF LIFE

Just add a twist

This simplified DNA model uses beads and chenille stems (pipe cleaners) to represent nucleotide components. DNA is the fundamental hereditary material for all living organisms. The structure of DNA (deoxyribonucleic acid) was understood only after years of scientific research. Although simple in structure, DNA carries the code for all the complexities of life.

Who we are:

Resource Area for Teaching (RAFT) helps educators transform the learning experience through affordable "hands-on" activities that engage students and inspire the joy and discovery of learning.

For more ideas and to see RAFT Locations

www.raft.net/visit-raft-locations

http://www.raft.net/raft-idea?isid=229

Materials required

- Chenille stems (pipe cleaners)
- Pony beads of 6 colors

To do and notice

1 Assign the bead colors to DNA model parts: 1 color of bead to represent sugar, another color to represent the phosphate group, and 4 different colors to represent the bases (1 color each for adenine, thymine, guanine, cytosine). Use the two most common bead colors to represent sugar and phosphate groups.

2 String 6 beads onto a chenille stem: phosphate group, sugar, base pair, sugar, phosphate group. (NOTE: the order of bases does not matter as long as the bases are paired correctly: adenine next to thymine, guanine next to cytosine). See figure 1.

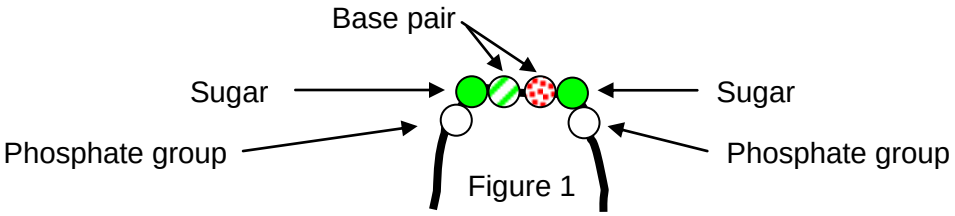


Figure 1

3 Add 4 more beads onto one end of the chenille stem: sugar, base pair, sugar. See figure 2.

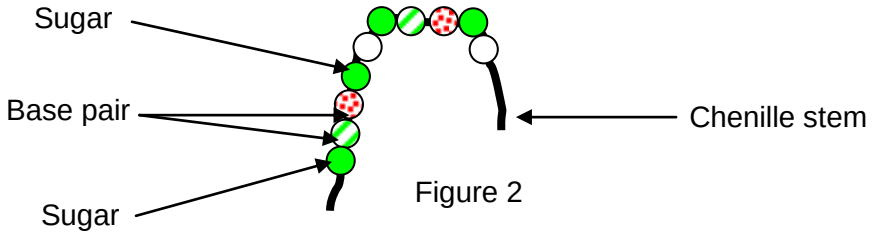


Figure 2

4 Loop one end of the chenille stem back through the 4 beads just added. See figure 3.

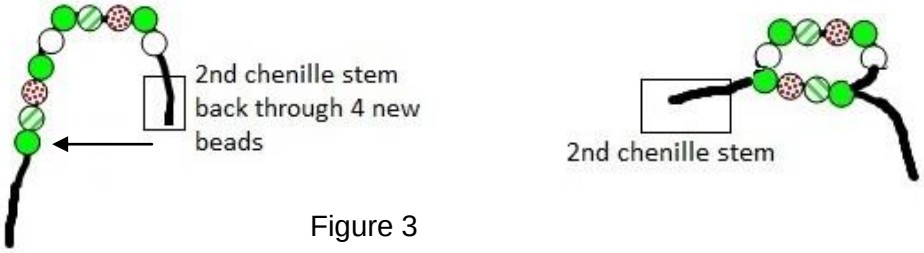


Figure 3

5 Add a phosphate group bead to each end of the chenille stem. See figure 4.

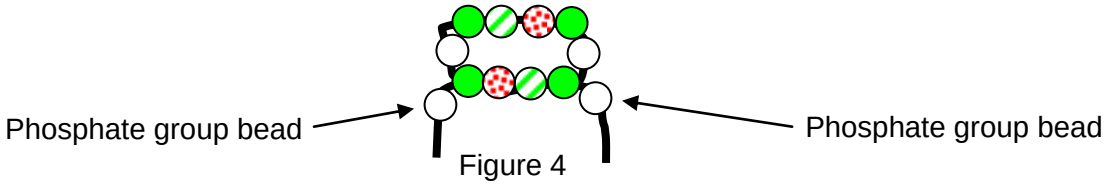


Figure 4

6 Repeat steps 3 through 5 to create a piece of DNA of any desired length. Add additional chenille stems by threading them through the last few strung beads.

7 Twist the DNA strand counter-clock wise (right to left) to create a double-helix. A longer strand twists more easily.

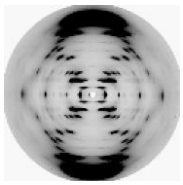
The science behind the activity

DNA is the fundamental hereditary material for all living organisms. The structure of DNA (deoxyribonucleic acid) was understood only after years of scientific research.

During the 1920s, English physician Frederick Griffith found that DNA from one organism can transform another organism.

The work of Avery, McLeod, and McCarty (1944) showed that DNA is the genetic material in cells.

In 1952, Alfred Hershey and Martha Chase conducted studies that established DNA as the carrier of hereditary information.



In the early 1950s x-ray crystallography was used to get a rough picture of DNA structure. This technique involves isolating and purifying a substance so that it can be made into a crystal.

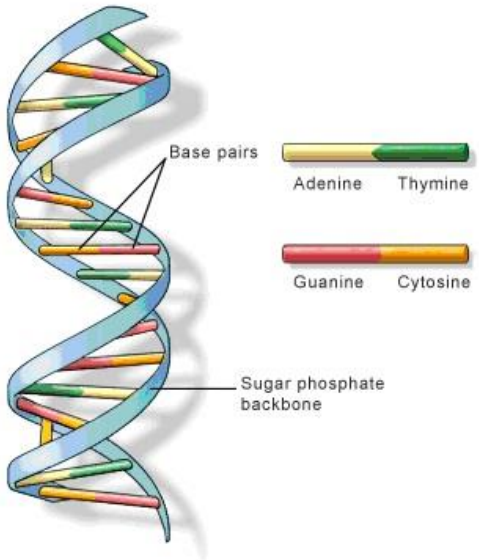
Passing x-rays through the crystal produces a pattern used to infer the positions of atoms within the crystal, which allowed English chemist Rosalind Franklin and biophysicist Maurice Wilkins to produce an image of DNA (right).

Biochemist Erwin Chargaff found in 1950 that in DNA the amount of adenine (A) is equal to the amount of thymine (T) and the same relationship exists between guanine (G) and cytosine (C). In addition, the total amount of adenine and guanine (purines) is equal to the total amount of thymine and cytosine (pyrimidines) along the DNA molecule. This information is known as Chargaff's rule.

English physicist Francis Crick and American geneticist James Watson combined all of these findings with modeling techniques used by American chemist Linus Pauling into one coherent DNA model in 1953.

There are four key features that define DNA structure:

- Double helix (double-stranded cylindrical spiral)
- Uniform diameter
- Right-handed (twists to the right)
- Anti-parallel (has to do with order of base pairs)



The two outside strands are composed of sugar and phosphate molecules while the inner rungs of the helix are made of the nitrogenous bases adenine, thymine, guanine, and cytosine, which are held together via hydrogen bonds. Adenine (purine) always bonds with thymine (pyrimidine) while guanine (purine) always bonds with cytosine (pyrimidine). This pattern is called complementary base pairing. The AT and CG pairs in the double helix have equal lengths and fit identically into the helix. This is why DNA has a uniform diameter. Although simple in structure, DNA can carry the code for all the complexities of life because of its incredible length, which is achieved by stacking the base pairs efficiently in a compact space. Human DNA contains about 3 billion base pairs. If this bead model were that long, it would cover over 60,000 km (37,000 miles) and would wrap around the Earth at the equator 1½ times!

(DNA graphic courtesy of US National Library of Medicine.)

Curriculum Standards:

Structure of DNA (Next Generation Science Standards: High School, Life Science 1-1)

Genes and DNA (Next Generation Science Standards: Middle School, Life Science, 3-1; High School, Life Science, 3-1)

Molecules (Next Generation Science Standards: High School, Life Science, 1-6);

Additional standards at: http://www.raft.net/raft-idea?isid=229

Learn more

- Combine small models (pieces of DNA) into one long model.
- Estimate, and then count, the number of purines and pyrimidines in each model.
- Draw one strand from a model and give the drawing to a partner to complete with a complementary strand drawing.
- Ask students to line up and position themselves as though they are the beads in the models, creating a kinesthetic activity.
- Assign different colors to each nitrogenous base and identify the complementary bases.
- Estimate the number of rungs per length of the model, then verify. Create an equation to make this calculation.
- Relate DNA structure to protein structure using the RAFT Idea Sheet ***Codon Necklaces***.
- Create a model with other materials that can "unzip" to explore replication and transcription.

Related activities: See RAFT Idea Sheets:

Codon Necklaces -
http://www.raft.net/ideas/Codon Necklaces.pdf

Who's the Daddy? -
http://www.raft.net/ideas/Who is the Daddy.pdf

Who's Your Mummy? -
http://www.raft.net/ideas/Who is Your Mummy.pdf

Resources

Visit www.raft.net/raft-idea?isid=229 for "how-to" video demos & more ideas!

See these websites for more information on the following topics:

- **DNA structure information** – http://www.umass.edu/molvis/tutorials/dna/
- **The discovery of DNA: Nobel website** – http://nobelprize.org/nobel_prizes/medicine/laureates/1962/
- **Information on the human genome** – http://www.genome.gov/
- **DNA animations -** http://www.hhmi.org/biointeractive/dna/animations.html
- **Video on DNA from the Khan Academy** – https://www.khanacademy.org/science/biology/evolution-and-natural-selection/v/dna