Teacher Guide: Have Your DNA and Eat It Too

ACTIVITY OVERVIEW

Abstract:
Students build an edible model of DNA while learning basic DNA structure and the rules of base pairing.

Module:
The Basics and Beyond

Prior Knowledge Needed:
DNA contains heritable instructions for building and maintaining an organism.

Key Concepts:
DNA structure, double helix, base pairing

Materials:
Student handouts, licorice, colored marshmallows, toothpicks, paperclips, masking tape

Appropriate For:
Ages: 10 - 18
USA grades: 5 - 12

Prep Time:
1 hour (gathering materials and review time)

Class Time:
45 minutes

Activity Overview Web Address:
http://gslc.genetics.utah.edu/teachers/tindex/overview.cfm?id=193

Other activities in ***The Basics and Beyond*** module can be found at:
http://gslc.genetics.utah.edu/teachers/tindex/

Teacher Guide: Have Your DNA and Eat It Too

TABLE OF CONTENTS

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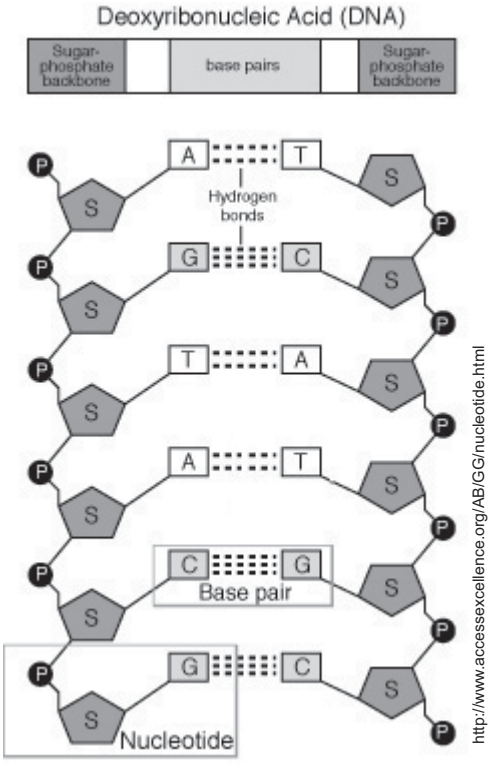
I. PEDAGOGY

A. Learning Objectives

- Students will be able to describe the structure of the DNA molecule.
- Students will be able to explain the rules of base pairing.
- Students will understand that information is stored within the DNA molecule in the form of a sequence of chemical bases, each referred to by the first letter of its name (A, T, C and G).

B. Background Information

DNA provides the instructions for building and operating all living things. The DNA instructions are divided into segments called genes. Each gene provides the information for making a protein, which carries out a specific function in the cell.

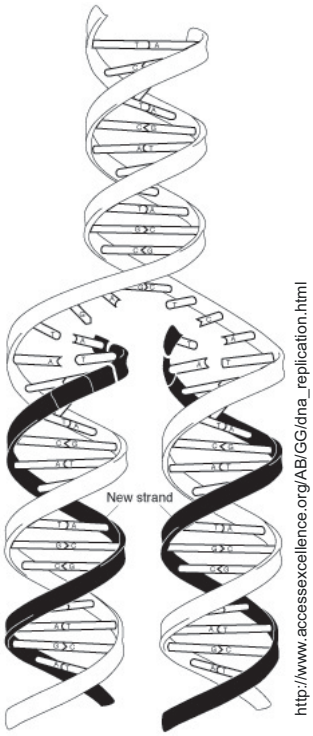


A molecule of DNA (DeoxyriboNucleic Acid) is composed of two backbones and four types of chemical bases. The backbone is formed by a chain of alternating phosphates and sugars. Each sugar molecule in the backbone provides an attachment site for one of the chemical bases. The four types of chemical bases are: adenine, thymine, cytosine and guanine. They usually are represented by their first letters: A, T, C and G. The bases form pairs in a very specific way: A always pairs with T, and C always pairs with G. A pair of bases is connected by hydrogen bonds. Each base in the pair is also connected to a sugar compound in the DNA backbone.

A DNA molecule is often compared to a ladder, with the two backbones forming the sides of the ladder and the base pairs forming the steps, or rungs. However, instead of a straight ladder, DNA looks like a twisted ladder, known as a double helix ("double" for the two backbones). The DNA sequence is the consecutive order of bases on one side, or strand, of the twisted ladder. The other strand has a complementary sequence determined by the base pairing rules.

The specific matching of the base pairs, A with T and C with G, provides a way

for exact copies of DNA to be made. This process is called DNA replication. In DNA replication, the double helix ladder is untwisted and the two strands are separated by breaking the hydrogen bonds between the base pairs. Next, two new strands are made by reading each side of the DNA ladder, one step (base) at a time. At each step, the matching base fills in (with its associated sugar and phosphate) to complete the rung and lengthen the new DNA strand. When the process is complete, there are two identical DNA double helices, each containing one original and one new strand.



http://www.accessexcellence.org/AB/GG/dna_replication.html

DNA replication is an important part of the cell division process. Before a cell divides, it first duplicates its DNA so that the new cell will have the same genetic information. The specific base pair matching during replication ensures that exact DNA copies are made.

C. Teaching Strategies

1. Timeline

- Day before activity:
  - Make photocopies of the student handouts.
  - Gather licorice sticks, colored marshmallows, toothpicks, paperclips, and masking tape.
  - Snip holes in the bag(s) of marshmallows and allow them to dry slightly. This makes the marshmallows easier to pierce with a toothpick.
  - Optional: Prepare a self-closing plastic bag for each student or group containing their activity supplies (see Detailed Materials List).
- Day of activity:
  - Discuss the structure of the DNA molecule and how specific features, such as the sequence of chemical bases and the rules of base pairing, allow the molecule to carry and pass on information related to the inheritance of traits.
  - Have students build an edible model of DNA with a given sequence of chemical bases.

2. Classroom Implementation

- Begin class with a discussion about DNA. Include in your discussion that DNA contains all of the instructions necessary to build and operate a living

organism and that DNA molecules can be found inside the cells of all living things.

- Show students a diagram depicting what the DNA molecule looks like as you describe its structural features. Inform students about the four-letter DNA alphabet, A, T, C, and G, and describe the rules of base pairing. Explain that information is stored within the DNA molecule in the form of a sequence of chemical bases represented by these four letters. You may want to use the information and animations in *What is DNA?* (see Additional Resources).
- Invite students to work alone or with a partner to follow the instructions in the student handout and build their very own edible model of the DNA molecule.
- When students have completed the activity, assess their understanding of the structure of DNA by examining whether or not they have built and labeled their models correctly and followed the rules of base pairing.
- Reinforce that the structure of DNA and the rules of base pairing enable the molecule to perform its function of storing heritable information.

3. Adaptations

- Before students carry out the activity, lead them through the interactive animation *Build a DNA Molecule* (see Additional Resources) while explaining the rules of base pairing, or have students use the animation in a computer lab.

4. Extensions

- Follow this activity with the *Reading DNA* activity (see Additional Resources) in which students use their edible DNA models to transcribe a short gene, then translate it into a protein.
- Either before or after this activity have students extract and visualize DNA from Mendel's favorite organism, the pea, by following the instructions in *How to Extract DNA From Anything Living* (see Additional Resources).
- Have students research when and how the structure of the DNA molecule was discovered and by whom.
- Have students simulate DNA replication using their models. Break the toothpicks in the center to separate the two strands. Use another stick of licorice, more marshmallows, and toothpick halves to form the new DNA strand.

5. Assessment Suggestions

- Assess student understanding of DNA and basic genetics by having them complete the activity *Tour of the Basics Web Quest* (see Additional

Resources).

6. Common Misconceptions

- Although students may understand that living systems are made of cells, they may not understand that living things are also made of molecules. (Students often associate molecules only with physical science.) Emphasize that DNA is found inside the cells of all living things, and that the structure of the DNA molecule is the same in all living things.
- Because the structure of the DNA molecule is the same in all living things, students may not understand that the diversity of life is the result of differences within the DNA sequence. To emphasize this point, you might use the short online activity *Genes In Common* in which students learn how much DNA they share with other living things (see Additional Resources).

II. ADDITIONAL RESOURCES

A. Activity Resources linked from the online Activity Overview at:

http://gslc.genetics.utah.edu/teachers/tindex/overview.cfm?id=193

- Animation: *Build a DNA Molecule*. Interactive animation for building a short strand of DNA using the rules of base pairing.
- Activity: *Reading DNA.* Students use edible DNA models to transcribe and translate a short gene.
- Activity: *How to Extract DNA from Anything Living.* A step-by-step tutorial that guides you through the process of extracting DNA from peas.
- Activity: *Tour of the Basics Web Quest.* Students navigate the *Tour of the Basics* online acitivity to complete a web quest in which they learn the basics about DNA– where it is found in our cells, what it looks like, and how its structure enables the molecule to encode heritable information in the form of genes.
- Website: *Genes In Common.* Students learn how much DNA they share in common with other living organisms.

B. Other Resources

- Book: DNA Is Here to Stay, by Dr. Fran Balkwill. 1992. Harper Collins Publishers, Ltd., London, England. ISBN # 0-00-191165-1 (Ages 9-15)
- Book: Have a Nice DNA, by Dr. Fran Balkwill and Mic Rolph. 2002. Cold Spring Harbor Laboratory Press, Woodbury, N.Y. ISBN # 0-87969-614-1 (Ages 9-15)

- Book: Double Talking Helix Blues, by Joel Herskowitz. 1993. Cold Spring Harbor Laboratory Press, Woodbury, N.Y. Book and cassette tape. ISBN # 0-87969-431-9 (Ages 8 and up)

III. MATERIALS

A. Detailed Materials List

- Student handout (S-1 to S-2)
- Licorice sticks (e.g., Twizzlers)– 2/student or group
- Colored marshmallows– 9 green, 9 pink, 9 yellow, and 9 orange/student or group
- Toothpicks– 12/student or group
- Paperclips– 5/student or group
- Masking tape– 1/several groups

IV. STANDARDS

A. U.S. National Science Education Standards

Grades 5-8:

- Content Standard C: Life Science - Reproduction and Heredity; every organism requires a set of instructions for specifying its traits; hereditary information is contained in genes, located in the chromosomes of each cell; a human cell contains many thousands of different genes.

Grades 9-12:

- Content Standard C: Life Science - Molecular Basis of Heredity; in all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, T, C, and G); the chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular “letters”) and replicated (by a templating mechanism); each DNA molecule in a cell forms a single chromosome.

B. AAAS Benchmarks for Science Literacy

Grades 9-12:

- The Living Environment: Heredity - The information passed from parents to offspring is coded in DNA molecules.

C. Utah Secondary Science Core Curriculum

Seventh and Eighth Grade Integrated Science

- Standard IV: Students will understand that offspring inherit traits that make them more or less suitable to survive in the environment.
  Objective 1: Compare how sexual and asexual reproduction passes genetic information from parent to offspring.
  - Distinguish between inherited and acquired traits.
  - Compare inherited structural traits of offspring and their parents.
- Demonstrate Awareness of Social and Historical Aspects of Science
  - Recognize contributions to science knowledge that have been made by both men and women.

Biology (9-12)

- Theme: The structures in all living things occur as a result of necessary functions.
- Standard 2: Students will understand that all organisms are composed of one or more cells that are made of molecules, come from preexisting cells, and perform life functions.
  Objective 1: Describe the fundamental chemistry of living cells.
  - Identify the function of the four major macromolecules (i.e., carbohydrates, proteins, lipids, nucleic acids).
- Standard 4: Students will understand that genetic information coded in DNA is passed from parents to offspring. The basic structure of DNA is the same in all living things.
  Objective 3: Explain how the structure of DNA is essential to heredity.
  - Use a model to describe the structure of DNA.
  - Relate the historical events that lead to our present understanding of DNA to the cumulative nature of science knowledge and technology.

V. CREDITS

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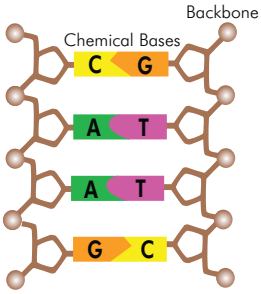
Have Your DNA and Eat It Too!



When isolated from a cell and stretched out, DNA looks like a twisted ladder. This shape is called a double helix. The sides of the DNA ladder are called the backbone and the steps (also called rungs) of the ladder are pairs of small chemicals called bases. There are four types of chemical bases in DNA: Adenine (A), Cytosine (C), Guanine (G), and Thymine (T). They form pairs in very specific ways: Adenine (A) always pairs with Thymine (T) and Cytosine (C) always pairs with Guanine (G).

Your task is to use the following materials and procedure to construct an edible model of DNA. When you are finished, use toothpicks and tape to label one of each of the chemical bases.

You will need:

2 pieces of licorice
12 toothpicks
9 pink marshmallows
9 yellow marshmallows
9 green marshmallows
9 orange marshmallows
5 paperclips
Masking Tape

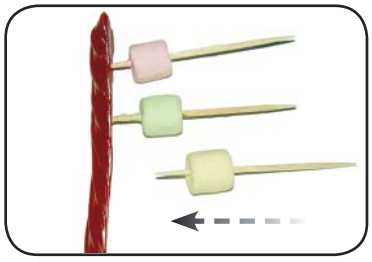
Step 1: Choose one of the sequences below.

Sequence 1: T A C G T A T G A A A C

-or-

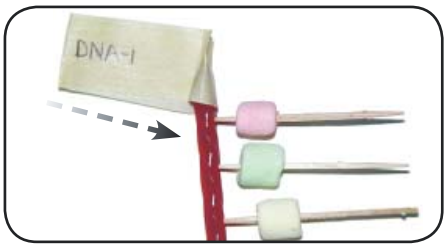
Sequence 2: T G G T T T A G A A T T

Adenine (A) = Green
Thymine (T) = Pink
Cytosine (C) = Yellow
Guanine (G) = Orange

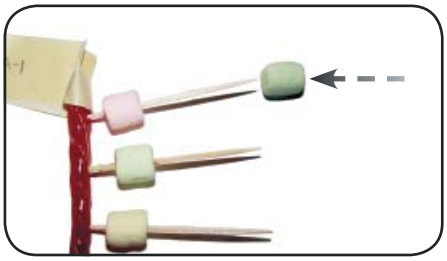


Step 2: Assemble one side of your DNA molecule. A piece of licorice will form the backbone and marshmallows will be the chemical bases. Place a marshmallow on the end of a toothpick so that the point of the toothpick goes all the way through. Anchor the toothpick into the licorice backbone. Refer to the table above to choose the correct color marshmallow to represent the chemical bases in your sequence.

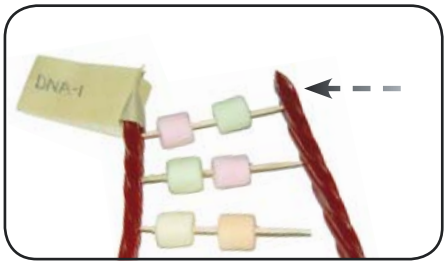
Have Your DNA and Eat It Too! continued...



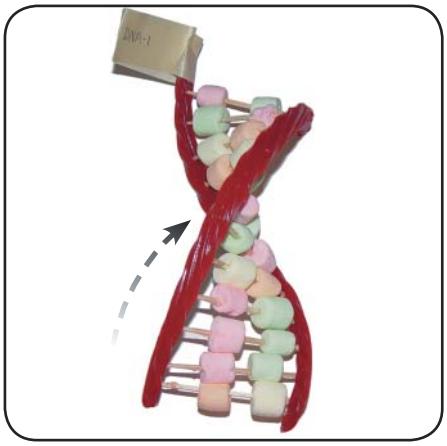
Step 3: Label the backbone. With a marker or pen and masking tape, label your licorice backbone "DNA- 1" or "DNA-2" depending on which sequence you used. Write the label on the left end of the licorice.



Step 4: Match the chemical base pairs. Place the color marshmallow for the matching chemical base on the other end of each toothpick. Remember that A always pairs with T and C always pairs with G!



Step 5: Complete your DNA model. Attach the other backbone so your model looks like a ladder.



Step 6: Twist your DNA model. Carefully twist your DNA molecule so that it looks like a double helix.

Step 7: Label your model. Make flags to label the parts of your DNA out of paper clips and tape. Label one of each of the following: Adenine, Thymine, Cytosine, Guanine, and Backbone. **Make sure your chemical base pairs are correct!**