Build Your Own DNA Double-Helix Structure Activity

Brought to you by the National Institute of Justice's Forensic Technology Center of Excellence (FTCOE)

Background

Learn about the structure of DNA by constructing your own double helix model using candy through this fun, hands-on activity! During this activity, students will learn about the various components that make up DNA. DNA, or deoxyribonucleic acid, is the molecule that carries the genetic instructions for life.

DNA is composed of two long strands of nucleotides that twist around each other, forming the famous double helix shape discovered through Rosalind Franklin's X-ray image of DNA (infamously known as Photograph 51) later interpreted by James Watson and Francis Crick.

Nucleotides are the chemical building blocks that make up DNA. The four nucleotides in DNA include adenine (A), thymine (T), guanine (G), and cytosine (C) which pair together to create the rungs of the DNA ladder. The sides of the DNA ladder are made of sugar (deoxyribose) and phosphate molecules, while the rungs consist of base pairs of the four nucleotides. In DNA, A always pairs with T (through two hydrogen bonds), and G always pairs with C (through three hydrogen bonds). In RNA, uracil (U) replaces thymine (T). The combination of these base pairs enables double helix formation and minimizes structural errors in a DNA molecule.

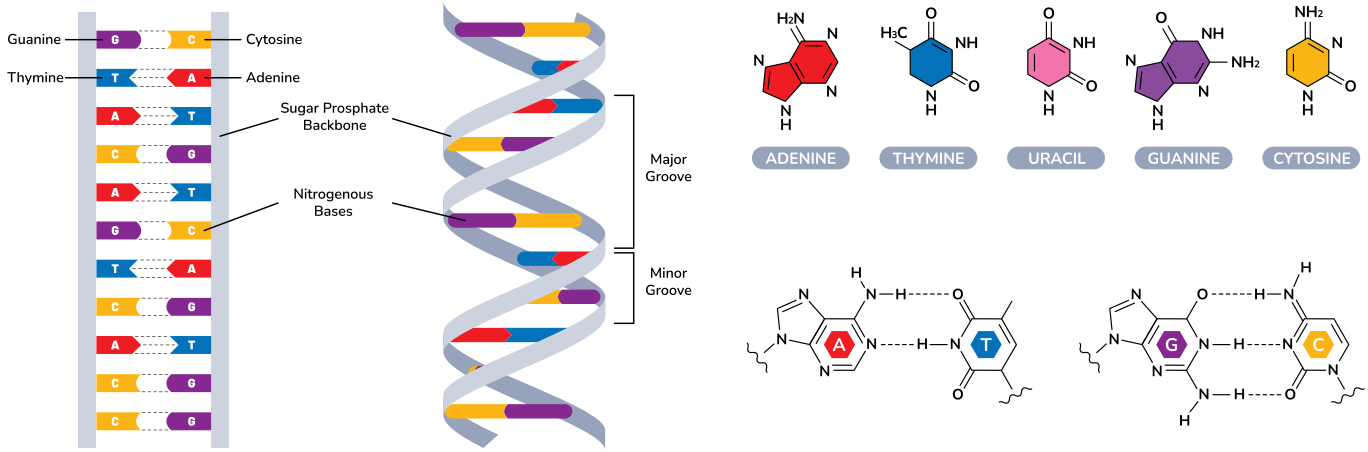

Fig. 1: Structure of DNA including the double helix, nitrogenous bases, base pairs, and hydrogen bonding.

Materials (per pair of students):

- 2 candy ropes (ex: Twizzlers, Nerds Rope, Sweetart Rope)
- 12 toothpicks
- Mini marshmallows in 4 different colors
- Clear tape or glue (optional, for securing the structure)

Material	What it Represents
Candy Ropes	DNA sugar-phosphate backbone
Toothpicks	Bonds connecting the base pairs
Mini Marshmallows in 4 different colors	Nitrogenous Bases: Adenine (A), Thymine (T), Guanine (G), and Cytosine (C)

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Step-By-Step Instructions

Step 1: Prepare the Candy Materials

- Assign a different marshmallow color for each of the four nucleotides:
- Example: Green = Adenine (A); Yellow = Thymine (T); Red = Guanine (G); Blue = Cytosine (C)
- Place the marshmallows in separate piles by color for easy access.

Step 2: Construct the Backbone

Place two candy ropes parallel to each other on a flat surface. These will form the sugar-phosphate backbones of the DNA.

Step 3: Assemble the Base Pairs

- Take a toothpick and push a marshmallow of the color assigned to represent A (adenine) onto one end. On the opposite end of the toothpick, add a marshmallow of the color assigned to represent T (thymine).
- Repeat this step with a marshmallow of the color assigned to G (guanine) and a marshmallow of the color assigned to C (cytosine) to form a new base pair.
- Continue creating pairs: A-T and G-C. You should have 6 toothpicks with A-T pairs and 6 with G-C pairs.

Looking for an Extra Challenge?

Use 2 toothpicks to connect A-T pairs and 3 toothpicks to connect G-C pairs. This will represent the number of hydrogen bonds between the DNA bases.

Step 4: Connect the Base Pairs to the Backbone

- Starting with a completed base pair toothpick, push one end of the toothpick into one candy rope. Push the other end of the toothpick into the other candy rope.
- Repeat this process until the remaining base pair toothpicks are attached between the candy ropes horizontally, resulting in a ladder-like structure. Allow approximately 1 inch between each toothpick attachment, and ensure the base pairs are alternated (e.g., A-T, G-C, A-T...).

Step 5: Twist to Form a Double Helix

Gently twist the candy ropes to mimic the natural spiral shape of a DNA double helix. The marshmallow base pairs should rotate as the candy ropes are twisted, forming a helical shape.

Step 6: Secure Your DNA Model

If needed, use clear tape or glue to secure the marshmallows to the toothpicks or to the candy ropes to prevent the model from coming apart.

Step 7: Discuss and Analyze Your DNA Model

Use the following discussion questions to explore the structure of DNA, the significance of its double-helix shape, and the historical impact of its discovery.

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Discussion Questions

What do the different colored marshmallows represent in your DNA model, and why is it important to pair them correctly?

The different colored marshmallows represent the four nucleotides in DNA: adenine (A), thymine (T), guanine (G), and cytosine (C). Correct pairing is crucial because in DNA, A always pairs with T, and G always pairs with C. This specific pairing occurs due to the molecular structure and chemical properties of the bases: A and T form two hydrogen bonds, while G and C form three hydrogen bonds. The correct pairing ensures the DNA molecule is stable, maintains its uniform shape, and allows for accurate replication during cell division, thereby preserving the genetic code.

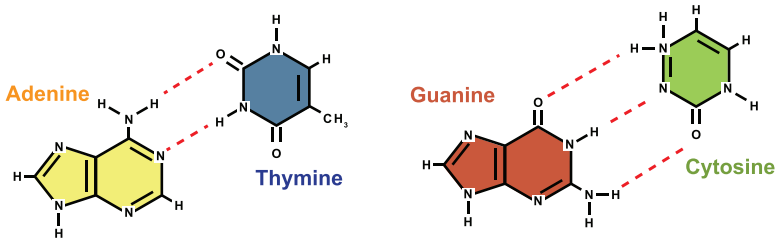
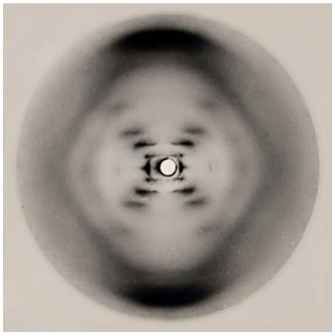


Fig. 2: Hydrogen bonding between DNA base pairs - 2 bonds in the A-T pair and 3 bonds in the G-C pair.

Why does the DNA molecule form a double helix shape, and what role does the sugar-phosphate backbone play in this structure?

The DNA molecule forms a double helix shape due to the chemical properties of the nucleotides and the bonds between them, which twist the two strands around each other. The sugar-phosphate backbone provides structural support and stability, allowing the DNA to maintain its helical shape while protecting the nucleotide base pairs inside.



Why is Rosalind Franklin's work, such as Photograph 51, considered so important to the discovery of the DNA double helix structure?

Rosalind Franklin's work, particularly Photograph 51, provided critical X-ray diffraction evidence that revealed the helical structure of DNA. Her research allowed Watson and Crick to determine the double helix shape and understand how the nucleotides are arranged, leading to the discovery of the DNA model as we know it today.

Fig. 3: Photograph 51 (Franklin & Gosling, Nature, 1953).

For more information, visit ForensicCOE.org or email us a ForensicCOE@rti.org.

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