## **DNA Structure and Function**

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**Lesson Overview**:

This lesson reviews DNA structure and function in the context of a designed DNA molecule. DNA only structures may be a little different because the long polymeric molecule is represented by small DNA polymers that may have symmetry, may be repeated over and over again, may span over multiple asymmetric units (as in the case seen here).

**ASBMB Learning Objectives**

(<https://www.asbmb.org/education/core-concept-teaching-strategies/foundational-concepts/structure-function>)

2. Structure is determined by several factors

* Students should be able to **recognize the repeating units in biological macromolecules** and be able to discuss the **structural impacts of the covalent and noncovalent interactions** involved *(Introductory).*
* Students should be able to discuss the **chemical and physical relationships between composition and structure of macromolecules** *(Introductory).*
* Students should be able to compare and contrast the **primary, secondary, tertiary and quaternary structures** of proteins and nucleic acids *(Intermediate)*.

### **Part I: Begin with the RCSB PDB Molecule of the Month**

The focus in this part is to learn about DNA structure and function and its potential in engineering nanoscale lattices.

Read the RCSB PDB Molecule of the Month Article on Designed DNA Crystal (<https://pdb101.rcsb.org/motm/119>) and answer the following questions.

1. About the Featured Molecule(s)
	1. *Function:* Does the DNA lattice have a biological function?
	2. *Molecules:* What is special about these designed DNA molecules? What type of interactions are holding these DNA lattices together?
2. Explore the double helical DNA structure with sticky ends shown in the feature (PDB ID 309d).
	1. If the sequence of the DNA strand in the structure is 5’-CGACGATCGT-3’ , what is the sequence of the DNA that is complementary to it?
	2. For the same DNA sequence (in section 2a.) what would the sequence of the complementary strand be if 2 nucleotides on the 5’ end, i.e., 5’-CG-3’ were to remain unpaired?

1. Go to the “Exploring the Structure” section in the article and analyze the structures shown in detail. Examine the static images, and JSmol interactive views available. Answer the following questions.
	1. Of all the DNA strands shown, what is the color of the longest strand?
	2. Select the radio button called “Color one double helix”. Rotate the DNA lattice in the interactive view and take screenshots of a view (in JSmol) showing the long double helix molecule in color running from one corner of the screen to the other. Include the image here.

* 1. According to this Molecule of the Month article, if you made a nanoscale structure, where would you package other molecules?

### **Part II: Exploring the DNA Lattice Structure using Mol\***

The focus in this part is to learn more about the DNA lattices’

1. Composition and interactions (Primary and Secondary structure)
2. Assembling the DNA lattice (Quaternary structure)

Go to the [RCSB PDB home page](https://www.rcsb.org/) and enter the PDB code 3gbi in the top search box and click on it to open the Structure summary page for this PDB structure or go to the page (<https://www.rcsb.org/structure/3GBI>).

On the top left corner of the page there is an image showing the structure of the molecule.



*Figure 1: Structure of a self-assembled three-dimensional DNA Crystal, PDB ID 3gbi. The link to open the structure in Mol\* is highlighted in a red box.*

Click on the word Structure next to 3D view or on the 3D View tab on the top of the page to visualize the structure in Mol\*

* 1. *Composition:* How many types of DNA polymers (strands) does the DNA lattice structure have?
	2. *Interactions:* Explore the neighborhood of the nucleotide 125 in Chain B, Asm\_1. Describe the interactions of this nucleotide. Support your answer with a suitable image.
	3. *Assembly*: The assembly and function of the DNA lattice examined here can be extended because of sticky ends. Show the structure of any two sticky ends in this structure. Label the nucleotides that are not involved in base pairing in the sticky end and also the polymer chain ID where these bases are located.

### **Part III: Finding other DNA Lattice Structures in the PDB**

Go back to the structure summary page for the PDB code 3gbi (<https://www.rcsb.org/structure/3GBI>).

Below the image in the top left corner of the page there is a hyperlink “Find Similar Assemblies”.



*Figure 2: Structure of a self-assembled three-dimensional DNA Crystal, PDB ID 3gbi. The link to launch a search in the archive for structures with the same assembly is highlighted in a red box.*

* 1. List the PDB identifiers of any 3 assemblies from the results of this search, for which the structure match score is greater than 30. and complete the following table.

Answer:

| PDB ID | Structure title | Year of structure release | Authors |
| --- | --- | --- | --- |
| 3gbi | The Rational Design and Structural Analysis of a Self-Assembled Three-Dimensional DNA Crystal | 2009 | Birktoft, J.J., Zheng, J., Seeman, N.C. |
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