Exploring Polysaccharides in the PDB

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**Lesson Overview**:

This lesson reviews polysaccharides (or carbohydrates), how they are constructed (linear vs branched), and how they are stabilized.

**ASBMB Learning Objectives**

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

4. Macromolecular interactions

* Students should be able to discuss the interactions between a variety of biological molecules (including proteins, nucleic acids, lipids, carbohydrates and small organics, etc.) and describe how these interactions impact specificity or affinity leading to changes in biological function *(Intermediate).*

***Note: To complete this lesson you will need to be able to capture an image from your screen. Find a good way to print screen or capture the contents of the screen as an image that can be imported into powerpoint or other graphics programs to add annotations and labels.***

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**Part I: Branched or Not**

Polymers of saccharides (or carbohydrate building blocks) may or may not be linear.

1. Explore linear and branched polysaccharides in the PDB. Search for PDB entries that have Branched entity type “Oligosaccharide” and do not include either proteins, DNA, or RNA. See [search results here](https://www.rcsb.org/search?request=%7B%22query%22%3A%7B%22type%22%3A%22group%22%2C%22nodes%22%3A%5B%7B%22type%22%3A%22group%22%2C%22logical_operator%22%3A%22and%22%2C%22nodes%22%3A%5B%7B%22type%22%3A%22group%22%2C%22nodes%22%3A%5B%7B%22type%22%3A%22terminal%22%2C%22service%22%3A%22text%22%2C%22parameters%22%3A%7B%22attribute%22%3A%22pdbx_entity_branch.type%22%2C%22operator%22%3A%22exact_match%22%2C%22negation%22%3Afalse%2C%22value%22%3A%22oligosaccharide%22%7D%7D%2C%7B%22type%22%3A%22terminal%22%2C%22service%22%3A%22text%22%2C%22parameters%22%3A%7B%22attribute%22%3A%22entity_poly.rcsb_entity_polymer_type%22%2C%22operator%22%3A%22exact_match%22%2C%22negation%22%3Atrue%2C%22value%22%3A%22Protein%22%7D%7D%2C%7B%22type%22%3A%22terminal%22%2C%22service%22%3A%22text%22%2C%22parameters%22%3A%7B%22attribute%22%3A%22entity_poly.rcsb_entity_polymer_type%22%2C%22operator%22%3A%22exact_match%22%2C%22negation%22%3Atrue%2C%22value%22%3A%22DNA%22%7D%7D%2C%7B%22type%22%3A%22terminal%22%2C%22service%22%3A%22text%22%2C%22parameters%22%3A%7B%22attribute%22%3A%22entity_poly.rcsb_entity_polymer_type%22%2C%22operator%22%3A%22exact_match%22%2C%22negation%22%3Atrue%2C%22value%22%3A%22RNA%22%7D%7D%5D%2C%22logical_operator%22%3A%22and%22%7D%5D%2C%22label%22%3A%22text%22%7D%5D%2C%22logical_operator%22%3A%22and%22%7D%2C%22return_type%22%3A%22entry%22%2C%22request_options%22%3A%7B%22pager%22%3A%7B%22start%22%3A0%2C%22rows%22%3A25%7D%2C%22scoring_strategy%22%3A%22combined%22%2C%22sort%22%3A%5B%7B%22sort_by%22%3A%22score%22%2C%22direction%22%3A%22desc%22%7D%5D%7D%2C%22request_info%22%3A%7B%22query_id%22%3A%223529c4d50a1259338e793f61641cf1cd%22%7D%7D).
   1. Explore these structures and identify one PDB entry with a branched polysaccharide and one with a linear polysaccharide. Complete the following table:

| Feature | Branched saccharide containing | Linear saccharide containing |
| --- | --- | --- |
| PDB ID |  |  |
| Molecule name |  |  |
| Method of structure determination |  |  |
| List the monosaccharides present in the structure |  |  |
| Type of linkages seen in the polysaccharide  (see 2D diagrams) |  |  |

**Part II: Exploring Saccharide Structures**

Agar is a polysaccharide derived from red algae that is widely used in food, medicines, and in bacterial cultures. The gel forming property of the polysaccharide is widely used in all these applications. Commercially produced agar is a mixture of different neutral and charged polysaccharides, including carrageenan and other miscellaneous sulfated galactans. Agarose, the neutral component is agar, can withstand cycles of heating and cooling to form gels. This property is widely used in making gels for electrophoresis, chromatography, and more.

1. Explore the structure of Agarose in PDB ID [1aga](https://www.rcsb.org/structure/1aga) and answer the following questions:
   1. What saccharides are present in this structure? List chemical component identifiers of the saccharides and linkage between them in the linear polysaccharides.

* 1. Examine the structure of agarose based on what you see in Mol\* at <https://www.rcsb.org/3d-view/1AGA/1>. Take a screenshot of the structure and include it here along with a description of the structure
  2. Which non-covalent interactions stabilize this structure?

(Hint: in the Controls panel of Mol\*, in the components section - click on the All >> Add representation >> Non-covalent interactions (see below). Save an image showing the non-covalent interactions displayed.

1. Compare structures of Agarose (a linear polymer made up of the repeating unit of agarobiose, PDB ID [1aga](https://www.rcsb.org/structure/1aga)) and iota-Carrageenan (a vegetarian and vegan alternative to gelatin, PDB ID [1car](https://www.rcsb.org/structure/1CAR)).
   1. What are the saccharides that make up carrageenan? How are they linked to each other in the polymer chain?
   2. List the types of structure stabilizing non-covalent interactions seen in Agarose vs Carrageenan?

(Hint: use the same steps as described in 2c above). Save an image showing the non-covalent interactions displayed.

* 1. What is similar and what is different in these structures?