# Exploring Waters in the PDB

**Authors**: Keith Johnson, Bradley University, IL and Shuchismita Dutta, Rutgers University, NJ

**Lesson Overview**:

This lesson reviews the importance of water in biomolecular structure and function.

**ASBMB Learning Objectives**

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

## Macromolecular structure determines function and regulation

* Students should be able to **explain and apply core concepts of macromolecular structure and function**, including the **nature of biological macromolecules**, their **interaction with water**, the **relationship between structure and function**, and frequently encountered **mechanisms for regulating their function**.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Activity**:

Exploring three dimensional structures in atomic detail will require you to recognize atoms and the various types of bonds they make to form molecules and interact with other molecules. In Part I of this lesson, we will explore the structure of water (regular and heavy water), while in Part II we will examine how water molecules are transported across membranes through potassium channels.

### **Part I: Light and Heavy Waters**

Water is known to be a universal solvent. Have you heard about heavy water? Did you know that heavy water is used in some reactors to slow down neutrons effectively?

Examine the Ligand summary pages of water ([HOH](https://www.rcsb.org/ligand/HOH)) and heavy water ([DOD](https://www.rcsb.org/ligand/DOD)) and answer the following questions.

Q1. Complete the table for HOH and DOD.

Ans.

| Property | HOH | DOD |
| --- | --- | --- |
| Atom count |  |  |
| Charge |  |  |
| Molecular Weight |  |  |

Q2. Search for similar ligands using the options presented on the ligand summary pages and list the ligand code and chemical name of the heaviest molecule in the result set. (Hint: click on the various options under the section titled “Find related ligands” in the top right corner of the ligand summary page).

Ans:

Heavy water may be used in experiments to explore which parts of the molecule are exposed to the solvent and may undergo hydrogen exchange (a process where groups such as -OH, -NH may be replaced by -OD and -ND respectively).

Read the Molecule of the Month feature on [Ribonuclease A](https://pdb101.rcsb.org/motm/105) and answer the Topics for Further Discussion 1, i.e.,

Q3. PDB entry 5rsa is a structure solved in part by neutron diffraction, which is able to observe the positions of hydrogen atoms. The experiment was performed on crystals that were soaked in deuterated water (heavy water). In the file, you will see that all the water positions are DOD (one oxygen atom and two deuterium atoms), and that many of the hydrogen atoms in the protein have also exchanged hydrogen atoms with the heavy water, and are now deuterium. Can you make sense of why certain positions in the protein are deuterium and why others keep their original hydrogen atoms?

Hint: Visualize the PDB entry 5rsa (<https://www.rcsb.org/3d-view/5RSA>) and click on the residues Tyr 25 and/or Phe 46 to explore which residues have hydrogen atoms

Ans:

### **Part II: Waters interacting with Macromolecules**

#### Specificity of Potassium Channels

Read the Molecule of the Month feature on [Potassium Channels](https://pdb101.rcsb.org/motm/38). Read through the Exploring the Structure section of the feature and answer the following question:

Q1. How do potassium channels selectively allow potassium ions through but filter out sodium ions?

Ans:

Read the Molecule of the Month feature on Restriction Enzymes. Read through the Exploring the structure section of the feature and answer the following question:

Q2. In the structure of the restriction enzyme EcoRV (PDB IDs 1rva and 1rvc), examine the active site residues Asp or D74 and Asp or D91 in both structures. Learn more about [restriction enzymes](https://pdb101.rcsb.org/motm/8).

Comment on what is similar and what is different about the water molecule(s) bound to these residues in both these structures. Use the Sequence Annotations views for your explorations.

<https://www.rcsb.org/3d-sequence/1RVA?assemblyId=1> Explore chain C [auth A] in the top left pulldown menu

<https://www.rcsb.org/3d-sequence/1RVC?assemblyId=1> Explore chain F [auth B] in the top left pulldown menu.

Ans.