Student Worksheet

Carrying Cargo: Exploring non-covalent interactions between proteins and small molecules in blood transport

Accessing the web resources for this lesson:

- ***Molecule of the Month* on Serum Albumin**: from the top menu of **pdb101.rcsb.org**, choose *Molecule of the Month* and access Serum Albumin article by title
- **Serum Albumin Structure 1e7i**: go to **rcsb.org** and enter 1e7i into the search bar
- **Mol* tutorial**: from the top menu of **pdb101.rcsb.org** choose *Browse*, go to *Structure and Structure Determination* then to *Visualizing Molecules* and locate among the Learning Resources: *Exploring PDB structures in 3D with Mol* (MolStar)*

Based on the information found in ***Molecule of the Month article*** **(*Introduction* and *Carrying Fatty Acids* sections**), answer the questions

1. What is the function of serum albumin? Why is it important to have appropriate levels of this protein in the blood plasma?

Based on the information found on the **Structure Summary** page for the Protein Data Bank structure 1e7i, answer the questions (see Mol* tutorial section 1-3):

2. How many chains does the protein have?

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3. How many types of small molecules (ligands) interact with the polymer?

Explore the ligand by accessing its **Summary Page** by clicking on the ligand ID

4. What atoms/how many of them is the ligand made of? How are they arranged?

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5. If you were to use the words “head” and “tail” to describe the ligand, how would you describe the arrangement of the atoms within them? The small molecule is called Stearic Acid. Which part makes it an ACID? How would the acid behave in water solution? What charge would it carry? How would the tail behave in the water? Would it carry any charge?

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6. Why does this lipid need a transport protein to be carried in the water-based blood plasma? What type of amino acids (hydrophobic, hydrophilic, or charged) would need to be present on the outside of the protein? What about in the core of the protein? What types of amino acid side chains in the carrier protein would the 'head' interact with: polar, charged, or hydrophobic? What types of amino acid side chains in the carrier protein would the 'tail' interact with: polar, charged, or hydrophobic? Explain why. Draw a model of a transport protein with stearic acid and highlight these interactions.

Use the **3D View tab on the Structure Summary** page access the 3D view of serum albumin. Explore the protein and answer the following questions:

7. What elements of secondary structure are predominant? What does the overall shape of the protein resemble?

8. Evaluate your predictions from previous part of the lesson: what types of amino acids are present on the outside of the protein? What kind of amino acids make up the core of the protein? Why? You can change the polymer representation to spacefill and the color theme to hydrophobicity to evaluate your predictions (see Mol* tutorial section 7 and 10).

9. How many ligands can you spot interacting with the protein? (you might change the ligand representation to spacefill and apply different colors to them using selections in order to help you spot all of them). Two ligands are

overlapping. Do you think both of those orientations can happen at the same time? How many ligands total can this protein transport?

Click on a ligand to place it in the "Focus" mode and adjust the settings to show hydrophobic interactions. Be sure to display hydrophobic interactions and hydrogen bonds (see Mol* tutorial section 9).

10. What types of amino acids does the 'head' interact with? What non-covalent interactions do you observe? What types of amino acid side chains does the 'tail' interact with? What non-covalent interactions do you observe? Click on other ligands and observe the interactions. What do you notice?

11. Change the representation for the polymer to gaussian surface and the representation of ligand to spacefill and use selections to adjust colors (see Mol* tutorial section 7 and 12). What overall structural features do you observe when looking at the protein in this representation?

12. Summarize how the shape of serum albumin is optimal for its function of transporting of fatty acids in the blood plasma. Compare with your hypothesis.

Finish reading the *Molecule of the Month* article.

13. What other substance can serum albumin carry in the blood? What other blood transport proteins does the *Molecule of the Month* article mention and what ligands do they transport? Use the PDB IDs to access these proteins on rcsb.org and observe the interactions with the ligands in 3D.