**Part 5: *Does the patient’s point mutation destabilize the entire protein?***

Visualize the mutant F Hb structure as follows in order to examine the protein:

* Go to the iCn3D website

 <https://www.ncbi.nlm.nih.gov/Structure/icn3d/full.html>

* Click on the button called File >> Retrieve by ID >> PDB ID so that a new window opens. Input the PDB ID of the structure you wish to visualize and click on Load.
* The structure opens in a new tab – rotate the molecule and examine the overall structure.
1. Take a screenshot of the structure. Paste it below.
2. How many separate chains are in this structure?

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1. Does the mutation cause any of the subunits to lose the capability of binding to heme?

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1. If a sample of purified mutant gamma globin was subjected to circular dichroism spectroscopy, would its spectrum most closely resemble that of human retinol binding protein, the transmembrane domain of the human retinol receptor, or a sample of either one of these proteins that has been boiled for 10 minutes in detergent? Why?

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1. Where are the ligands (CMO) located within the structure? Do all of the protein chains bind CMO?

**Part 6: *What is the consequence of the (fetal) gamma globin V67M mutation?***

To examine the mutated residue and interaction with carbon monoxide - click on the button called Windows >> View Sequences & Annotations. Now click on the Details button to see the one letter code sequence of all the protein chains in the structure. Scroll down to the bottom of the “Sequences and Annotations” window and click and drag on the carbon monoxide (shown as CMO). When you release the mouse button these ligands are highlighted in yellow. Click on the Style button >> Chemicals >> Sphere. Now the carbon monoxide (CMO) molecules in the structure should be displayed with yellow halos around them.

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1. Why did the authors use carbon monoxide (as opposed to oxygen or carbon dioxide) in their crystal structure, if this was not a case of carbon monoxide poisoning? How is this structural analysis limited because they used carbon monoxide?

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* Scroll up to see the protein sequences shown in the “Sequences and Annotations” window. Identify the mutated residue in any one of the mutated protein chains – click on it and drag the mouse to select that amino acid residue in the sequence. Simultaneously the same residue is selected in the graphics window and highlighted with a yellow halo.
* Click on the Style button >> Side chains >> Stick. Now the side chain of the mutated residue is visible. To make it more prominent, color it by clicking on the button called Color >> Unicolor >> Magenta.
* Examine the neighborhood of the mutated amino acid to explore its interactions. Click on the Select button >> by Distance >> a new window opens up >> input distance 4 angstrom and select the chain ID >> click on Display. This should highlight the neighboring residues in yellow. Close the new window.
	+ Show the side chains of these amino acid residues (click on Style button >> Side chains >> Ball and Stick.
	+ Color the select amino acids and other ligands by clicking on the Color button >> Atom. This will make it easier to see the nature of atoms in the neighborhood of the mutated residue and figure out the types of interactions it participates in.
	+ Focus in on the selected residues by clicking on View >> Zoom in Selection.
* Take a screenshot of these residues and include the image below (with labels showing key amino acids and key interactions).
1. Are there any small molecules/ligands in the neighborhood of the mutation? If so, what is/are it/they?

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*Box 2: Concepts*

Biomolecular structural stability, interactions and functions are dependent on various non-covalent interactions. Some key interactions in molecular structures are:

**Hydrogen bonds** - formed between two partially negatively charged atoms with a hydrogen atom between and covalently linked to one of them. e.g. in structures look for examples of O/N … H\_\_O/N, where … denotes hydrogen bond and \_\_ denotes a covalent bond

**Salt bridges** or **ionic interactions** - formed between oppositely charged amino acid side chains and/or charged ligands/ions. e.g. in structures look for interactions between Lys/Arg/His and Glu/Asp. These interactions may also involve phosphate groups and ions such as K+, Na+, Cl- etc.

**Hydrophobic interactions** - formed between hydrophobic amino acid side chains positioned away from the aqueous environment. e.g. look for regions with large numbers of carbon and hydrogen atoms in close proximity. Aliphatic amino acids such as Ala, Leu, Val, Ile participate in hydrophobic interactions.

**Pi stacking** - seen between amino acids with aromatic side chains (e.g. Tyr, Trp, Phe). Pi clouds of aromatic rings interact with each other in staggered stacks, face to edge interactions, or interactions with positively charged amino acid side chains (pi-action interaction).

1. List the names and positions of two amino acid residues with side chains located in the neighborhood of the mutated residue. What type of intermolecular interactions exist between the side chain of the mutated residue and these residues? If necessary, click on the View button and use any appropriate options to view specific intramolecular interactions.

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1. In a separate window view the structure of the native (wild type) protein (PDB ID 4MQJ). In the native protein, focus in on the same residues (mutated residue and its neighbors). Compare and contrast the intramolecular interactions with the neighboring residues listed in the above answer.

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1. Explain how the baby’s mutation may interfere with normal function of the protein.

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