**Happy Blue Baby**

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**Part 2: Molecular Basis of Cyanosis**

To explore the molecular bases of the newborn’s cyanosis, search the Protein Data Bank (at [www.rcsb.org](http://www.rcsb.org)) for structures of this mutant protein.

*Box 1: Resource*

RCSB Protein Data Bank (**RCSB PDB**, [www.rcsb.org](http://www.rcsb.org)) provides access to 3D structural data of biological macromolecules (proteins, nucleic acids, carbohydrates and their various complexes). In addition, it provides information about the experiment used to derive the data, details about the molecules included in the experiment, and links to various bioinformatics resources that can provide additional information about the protein/molecule of interest. Each structure in the PDB is identified by a unique identifier (called PDB ID). Atomic coordinates form the PDB can be visualized and analyzed using various visualization software (some available from RCSB PDB).

You can start your search using the protein name or other details that you know. (Hint: search by the name of the mutation, or the mutation itself (e.g. X##Y, where X is the original amino acid, ## is the position of that amino acid in the protein chain, and Y is the mutated amino acid). Examine the search results and refine them as necessary.

Q1. Did you find any structures in the PDB that contain the mutation that the Toms River newborn (focus of this case) has? List the PDB ID(s).

Q2. For the PDB ID that you wish to explore open the structure summary page for the entry by entering the PDB ID in the top search box on [www.rcsb.org](http://www.rcsb.org). Explore Box 2 to learn what you can find on this page, review the page and complete the following table.

*Box 2: Navigating the Structure Summary Page*

1. **Title** - that tells you what the structure is about

2. **Snapshot** - of what the structure of the molecule/complex looks like.

3. **Authors** – who solved the structure

4. **Literature** –access the article that describes the structure. This section also includes links to PubMed page and the abstract of the article describing this structure, when available.

5. **Macromolecules** – All proteins and nucleic acids present in the structure are listed here. Each unique type of macromolecule or molecular chain is listed as a separate entity. There may be multiple copies of each molecule in the structure.

6. **Small molecules** – All ligands, ions, cofactors, inhibitors that are present in the structure are listed here. You can find links here to explore the interaction of this ligand with the target protein.

7. **Experimental details** – describe details about how the structure was determined

8. **Structure quality** – shows a slider that provides insights about the quality of the structure and its agreement with the experimental data and geometric standards.

See <http://pdb101.rcsb.org/learn/guide-to-understanding-pdb-data/introduction> for details

|  |  |
| --- | --- |
| PDB ID |  |
| Author(s) of entry |  |
| Year when the structure was published/released |  |
| Structure determination method |  |
| Number of protein chains in the entry |  |
| Names and number of copies of ligands (Small Molecules) present in the structure |  |

*Box 3: Concept*

Carbon monoxide binds to the same location in hemoglobin as oxygen, but it binds very tightly. In order to study the changes in conformation of hemoglobin, carbon monoxide bound structures are often used to model oxygen bound hemoglobin.

Visualize the PDB structure that you have identified and use the following directions to explore:

* Go to the iCn3D website at <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.

Q3. How many protein chains do you see? Take and screenshot of the structure and include it below. Alternatively, you can save an image of the structure by clicking on Files >> Save Files >> iCn3D PNG image.

Q4. What is the most common secondary structural element seen in this structure?

To examine the location of the mutated residue, use the following steps:

* Click on Windows >> View Sequences & Annotations. Click on the Details tab
* Click and drag on the sequence at position 67 to select the amino acid in the sequence and graphics window. When you release the mouse button this residue is highlighted in yellow.
* Click on the Style button >> Side chains >> Stick. Now the side chain of the mutated residue is visible. In order to make it more prominent color it in a different color by clicking on the button called Color >> Unicolor >> Magenta (or select any other color of your choice).

Q5. What secondary structural element is this mutated amino acid located on?

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.
* Save and image of these residues and upload the image to power point or other graphics software to add labels and upload the labeled image below.

Q6. Are there any small molecules/ligands in the neighborhood of M67? If so, what is/are it/they?

Review the contents of Box 3 regarding intermolecular interactions.

*Box 4: 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).

Q7. List the names and positions of two amino acid residues located in the neighborhood of the mutated residue. What type of intermolecular interactions exist between the mutated residue and these residues? If necessary, click on the View button and use any appropriate options to view specific intramolecular interactions.

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

Note: To compare the structure of the native and mutant proteins we will select the chain F (beta hemoglobin chain with O2 bound to it).

Q8. Does the native protein have the same interactions as seen in the mutant protein? Support your answer with suitable figure(s).

Q9. Explain how the mutation in the Toms River baby girl (subject of this case) may interfere with normal function of the protein?