**Nicholas’ Story**

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**Section III: Bridgette’s Wish**

*Box 14: Question*

Towards the end of the video Nicholas’ mom (Bridgette) says “I wish they would come up with an instant cure …” The third question that we will ask in this case is “**What are some current and upcoming approaches for managing and treating SCD?**” In this section we will use our understanding of the structure of sickle cell mutant of hemoglobin and current treatment approaches to understand the molecular basis of upcoming options for managing and treating SCD.

**Part 1: Approaches to manage SCD**

*Box 15: Storyline*

Although sickle cell disease (SCD) was first reported in 1910, more than a 100 years later we still do not have any definitive way to treat this condition. Majority of the current treatment approaches either prevent sickling under low oxygen conditions or are focused on preventing the pain experienced. A cure for SCD (where the E6V mutation is reversed) is currently being attempted using gene therapy approaches. Here we will first focus on the anti-sickling approaches.

*Box 16: Concept*

Individuals with HbS show sickling of red blood cells under the following conditions:

* They have a high concentration of HbS in the cells
* The HbS is in a low oxygenation state
* A hydrophobic patch is exposed on the surface of HbS to bind the mutant Val.

Do you think that removing any of these conditions could lead to an anti-sickling treatment approach? Let us explore.

Q1. Based on what you have learned about SCD how does the hydroxyurea treatment help manage SCD?

Q2. If you could do anything to develop a new treatment for sickle cell disease using the above approaches, what would you do?

**Part 2: Oxy vs Deoxy hemoglobin S**

*Box 17: Storyline*

In order to understand how the deoxy form of HbS makes it more likely to form fibers let us explore the structures of oxy and deoxy forms of sickle cell hemoglobin.

*Box 18: Concept*

Oxy hemoglobin is also called the liganded form of the molecule. Carbon monoxide forms a complex like the oxy-hemoglobin, so is also called the liganded form. In this form the hemoglobin molecule adopts a relaxed conformation (also called R-state). In the deoxy form the same hemoglobin adopts a tense or Taut (also called the T) form.

If you are looking to compare the oxy- and deoxy-forms of hemoglobin you may look for structures of the carbonmonoxy and deoxy forms respectively.

a. Query the PDB archive to find any sickle cell hemoglobin structures in the PDB archive. Go to the RCSB Protein Data Bank (<https://www.rcsb.org/>) and type sickle cell hemoglobin in the top search box and run a search.

Q1. Did you find any structures of the oxy- and deoxy-forms of sickle cell hemoglobin in the PDB? What is/are the PDB ID(s)? List all that you think may be relevant.

b. Examine the T- and R-state structures of HbS using iCn3D.

* In a fresh iCn3D session upload the PDB entry of Carbonmonoxy-HbS for visualization
* Display the molecule in all atom mode - Menu Style >> Proteins >> Sphere
* Orient the molecule to look down the central hole in the tetrameric structure.
* Save an image and label as appropriate.
* Repeat the above steps for the deoxy-HbS structure.

Q2. What is a major difference in the overall structures of deoxy- and carbonmonoxy-HbS? Illustrate your answer with suitable figures.

**Part 3: FDA Approves Voxelotor**

*Box 19: Storyline*

In November 2019 the FDA approved voxelotor for adults and pediatric patients 12 years of age and older with sickle cell disease. Here we will explore the mechanism of its action.

a. Go to DrugBank to learn more about the structure of the drug voxelotor.

Q1. What is the chemical structure of voxelotor? Draw or paste a picture of this molecule below and describe its function and known mechanism of action (as listed in DrugBank).

b. A structure of the drug (voxelotor or GBT440) bound to sickle cell hemoglobin is present in the PDB archive (PDB ID 5e83). Examine the structure as follows:

* In a fresh iCn3D session upload the PDB entry 5e83 for visualization
* From the top menus, click on Windows >> Sequences and Annotations > the Details tab.
* Scroll through this window and select the drug (5L7) by clicking and dragging on it. This should highlight the drug with a yellow halo in the graphics window too.
* Select the neighborhood of the residue by
  + Click on Select >> by Distance >> use the default options and click on Display
  + Display amino acids in the neighborhood - In the graphics window click on Style >> Side chains >> Sticks.
  + Focus on selected residues - Click on View >> Zoom in selection to see a closeup of these residues.
  + Clear selections.

Q2. Where is the drug bound? describe in 1-2 sentences and illustrate your answer with a suitably labeled figure.

* The DrugBank mechanism of action suggested that the drug forms covalent linkages with the N-terminal amino acid of the alpha chains.

Q3. Draw the chemical drawing of the drug (from DrugBank) and circle the atom(s) that covalently link to the N-terminus of the alpha hemoglobin chain.

Q4. Based on what you have learned in this case and from the resources you were introduced to, write a short summary of current treatment approaches for sickle cell disease.

Ans. Although a cure for sickle cell disease is not yet widely available, many strategies have been employed to reduce fibril formation, cell sickling, and pain crisis. One common treatment used is hydroxyurea. Newer treatment options such as gene therapy to introduce anti-sickling mutations, increased HbF production, and correction of the gene mutation are under clinical trials. A summary of current treatment options is listed in the following table, taken from a recent review (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6292457/).