**Nicholas’ Story**

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**Part 1: The Sickle Cell Mutant**

*Box 2: Question*

In the video Nicholas describes his pain crisis as “it feels like someone is squeezing you, thumping – ba boom, ba boom”. Nicholas’ mom also talks about how he would have to be hospitalized frequently to treat his pain crisis. The first question that we will ask in this case is “**What is the molecular basis of Nicholas’ pain crisis?**”In this section we will explore the molecular basis for SCD pain crisis and some ways to reduce it.

In class, review the answers to questions in Part 0 then begin the molecular exploration.

*Box 3: Storyline*

Since we know that the pain is related to SCD, let us begin by exploring the molecule that was introduced in Part 0 as the cause of SCD.

To understand the significance of the sickle cell mutation, let us explore available molecular structures as follows:

* Where are the heme groups located in hemoglobin?
* How do they bind oxygen?
* Where is the mutation located? How does it impact the structure of mutant protein?

***Explorations using readymade virtual exhibits at the Online Macromolecular Museum***

1. Explore the Section II of the exhibit at

<http://earth.callutheran.edu/Academic_Programs/Departments/BioDev/omm/jsmolnew/hemo/hemoglobina.html#II>.

Examine the four polymer chains of hemoglobin (2 alpha chains and 2 beta chains), illustrated in ribbon representations. Carefully examine the section about heme mediated oxygen binding to understand how heme is bound to hemoglobin and how it impacts oxygen binding.

Q1. List one interaction through which a Heme group is bound to the hemoglobin structure. Include screenshots of the interaction(s) to substantiate your answer.

Q2. Where does the oxygen bind and how? Include screenshots of the interactions to substantiate your answer.

1. To learn about different kinds of covalent and non-covalent interactions, see exhibit at <http://earth.callutheran.edu/Academic_Programs/Departments/BioDev/omm/jsmolnew/bonding/chymo.html>

Hydrophobic interactions can sometimes be difficult to recognize so we will practice identifying them by exploring the section on hydrophobic interactions - now answer the following question.

Q3. List four amino acids that participate in hydrophobic interactions. Include screenshots of the interactions to substantiate your answer.

*Extra credit:* As you explore the hydrophobic residues note the PDB ID at the bottom of the page. Type the PDB ID in the top search box of the RCSB PDB website ([www.rcsb.org](http://www.rcsb.org)) to find out what this protein is.

Q3 extra: What is the protein that you are exploring?

1. To learn about the physiological impact of the structural changes resulting from the mutation of Glutamate 6 to Valine

<http://earth.callutheran.edu/Academic_Programs/Departments/BioDev/omm/jsmolnew/hemo/hemoglobina.html#III>

Explore the structures in this section and answer the following questions.

Q4. In the hemoglobin beta chain Glutamate 6 is located on the surface. How would the surface properties of the Sickle cell mutant protein change? Hint: What is the nature of the Valine side chain?

Q5. Which intermolecular forces (noncovalent interaction) leads to sickle cell hemoglobin (HbS) aggregation? Include screenshots of the interaction(s) to substantiate your answer.

**Part 2: Nicholas’ Pain Crises**

*Box 4: Storyline*

The structural explorations reveal how hemoglobin with the sickle cell mutation can aggregate.

A review article (Hematology Am Soc Hematol Educ Program. 2017 Dec 8; 2017(1): 546–555.), explains “A unique feature of SCD is vaso-occlusive crises (VOCs) characterized by episodic, recurrent, and unpredictable episodes of acute pain. Microvascular obstruction during a VOC leads to impaired oxygen supply to the periphery and ischemia reperfusion injury, inflammation, oxidative stress, and endothelial dysfunction, all of which may perpetuate a noxious microenvironment leading to pain.”

Here we will explore the relationship between aggregation of mutant hemoglobin to pain.

A glossary for some of the key words/phrases used in the explanation above is included below:

* Microvascular obstruction – small blood vessels are obstructed
* ischemia reperfusion injury - tissue damage caused when blood supply returns to tissue after a period of lack of oxygen
* inflammation - a localized physical condition in which part of the body becomes reddened, swollen, hot, and often painful, especially as a reaction to injury or infection.
* oxidative stress - a state where oxidative forces exceed the antioxidant systems due to loss of the balance between them
* endothelial dysfunction – condition when the inner lining of blood vessels fail to perform their normal functions.
* noxious microenvironment – poisonous local environment

Q5. Explain in a few sentences and with a suitable drawing how the HbS aggregation is connected to pain.

Q6. Based on your understanding of the structural basis of pain, can you suggest two approaches that can avoid the pain crises?

Q5. If you had to develop a new treatment for sickle cell disease how would you approach the problem. (Hint: use the deoxy HbS structure for inspiration).