NOYCE Summer Institute **Summer 2015**
Cross-Cutting Biology & Mathematics
What is Sickle Cell Anemia?

Learning Objectives
Students will be able to...

- Compare and contrast normal red blood cells with sickle cells.
- Determine that sickle cells transport oxygen molecules at a slower rate than normal red blood cells.
- Compare the oxygen carrying capacity of normal red blood cells and sickle cells.
- List five consequences of sickle cell anemia to the human body.
- Justify how the body responds to sickle cell anemia in an attempt to maintain homeostasis.
- Describe how sickle cell anemia impacts body systems in addition to the circulatory system.

Instructional Resources and Materials to engage students in learning**:**

- Handouts: Warm-Up Mind Map, Sickle Cell Anemia Student Worksheet
- Resources: Smartboard, Audio speakers, Sickle Cell Anemia Video, 15 Computers, Sickle Cell Anemia Netlogo model

Instructional Strategies and Learning Tasks that support diverse student needs. (Include what you and students will be doing.)**:**

Lesson Component:	**Activity:**
Warm-Up (5 minutes)	• **Students will complete a mind map to recall their prior knowledge on the circulatory system and how it interacts with other organ systems.**
Engage (5 minutes)	• **Students will watch a video to be introduced to sickle cell anemia.** http://www.dnalc.org/resources/3d/17-sickle-cell.html + • **Students will complete a vocabulary alphabet worksheet to record notes.**
SickleCellAnemia NetLogo Activity (30 minutes)	• **Students explore the circulatory system and sickle cell anemia via Netlogo model**
Evaluate (5 minutes)	• **Students will explain their understanding of sickle cell anemia and how it can affect other body systems.**

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Purpose of Model:

The purpose of this model is to deepen student understanding of the human body through investigating the structure and function of red blood cells in the human circulatory system. The students will compare and contrast structure and function between normal red blood cells and sickle blood cells and will learn how disruptions in one body system can disrupt homeostasis in other body systems (conditions of stability and determinants of change). Students will engage in mathematics to support their observations and inferences founded within the simulation. Data will be collected to construct linear graphs and build a relation to model the relationship between the number of cells and amount of oxygen transported. This relation will be used to interpret and explain the effects of Sickle Cell Anemia.

Description of Model:

The Sickle Cell Anemia model is a computational representation of a cross section of two separate vessels. The first vessel represents a vessel found in an individual with normal red blood cells evident by the circular red blood cells. While the second vessel represents a vessel found in an individual with sickle cell anemia evident by the presence of sickle shaped blood cells. The model simulates the natural phenomena of blood cells transportation through blood vessels. Each blood cell carries oxygen by the hemoglobin molecules which are within the blood cells. The model counts the amount of oxygen that is carried by the blood cells through each vessel. This simulation demonstrates the properties of sickle cell anemia by showing proportionally less oxygen transportation by the sickle cells compared to the normal red blood cells.

Addition, this simulation allows the user to adjust the heart rates of the individual vessels separately. This function will allow the user to discover that an individual with sickle cell anemia will require a increased heart rate to supply the body with an adequate level of oxygen. The user is able to make these discoveries by interpreting and analyzing the relation of oxygen transmission with heart rate which is a plot of the amount of oxygen transported versus the number of cells transported.

Authors: David Krebs, Joshua Dubay, and Lauren Thresh
dkreb1@u.brockport.edu, jduba1@u.brockport.edu, and lthe1@u.brockport.edu

How to use the Model:

Open SickleCellAnemia Netlogo file.

1. Press the purple **Setup** button in the upper left of the screen - This resets the model for use.
2. Make sure you are set to **normal speed** using the slider in the upper-center of the screen.
3. Both green sliders **red_blood_cell_heart_rate** and **sickle_cell_heart_rate** should be set to 70 bpm - These heart rates may be set to any bpm.
4. Press the purple **Go** button next to the Setup button - runs the simulation at a normal speed.
5. To stop the process, press the **Go** button again.
6. To watch the simulation step-by-step, press the purple **Go once** button.
7. Once stopped, the model can be continued by either **Go** or **Go once**.
8. The simulation will count the amount of oxygen that passes through a vessels as will as the total number of cells that pass through the vessels in yellow **Monitors**.
    a. **Red Blood Cell Oxygen** - counts the amount of oxygen which is carried by the red blood cells through the vessel.
    b. **Sickle Cell Oxygen** - counts the amount of oxygen which is carried by the sickle cells through the vessel.
    c. **Total Red Blood Cells** - counts the total number of red blood cells which are transported through the vessel.
    d. **Total Sickle Cells** - counts the total number of sickle cells which are transported through the vessel.
9. The simulation will plot the data on a graph **Oxygen Transmission with Heart Rate**.
    a. The relation of **Number of Red Blood Cells and Amount of Oxygen** is plotted in red.
    b. The relation of **Number of Sickle Cells and Amount of Oxygen** is plotted in black.

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Standards

Crosscutting Concepts:

Stability & Change	**For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.**

NYS Living Environment Standards:

1.2b	**Humans are complex organisms. They require multiple systems for digestion, respiration, reproduction, circulation, excretion, movement, coordination, and immunity. The systems interact to perform the life functions.**
1.2d	**If there is a disruption in any human system, there may be a corresponding imbalance in homeostasis.**
5.2a	**Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.**

Next Generation Science Standards (NGSS):

HS-LS1-2	**Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.**

NYS Common Core Standards for Mathematical Practice:

1. Make sense of problems and persevere in solving them	**Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution.**
2. Reason abstractly and quantitatively	**Mathematically proficient students make sense of quantities and their relationships in problem situations.**
3. Look for and make use of structure	**Mathematically proficient students look closely to discern a pattern or structure.**
4. Model with mathematics	**Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace.**

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Name: _____ Date: _____

Sickle Cell Anemia Model Activity

1. Model Introduction:
    a. Press the purple **Setup** button in the upper left of the screen.
    b. Make sure you are set to **normal speed** using the slider in the upper-center of the screen.
    c. Both green sliders red_blood_cell_heart_rate and sickle_cell_heart_rate should be set to 70 bpm.
    d. Press the purple **Go** button next to the Setup button. To stop the process, press the **Go** button again. To watch the simulation step-by-step, press the purple **Go once** button next to the Go button.
        i. In this model, what is being represented by…
            1. the two pink columns in the small window? _____
            2. the round red circles? _____
            3. the red crescent moon shapes? _____

2. Sickle Cells:
    a. Press **Setup** to clear the window. Make sure both green sliders are set to 70 bpm. Press **Go** to run the model for roughly 300 ticks (the ticks appear in the upper left corner of the two column window). The **Go** can be stopped by pressing the **Go** button again, and then continued with either the same **Go** button or with the **Go once** button for a slower, frame-by-frame, pace.
        i. Given that normal red blood cells live for roughly 120 days and sickle cells only live for roughly 20 days, why does it appear that there are fewer red crescent moon cells than red circles when you run this model?

    b. Both cell types are counted by the model as they pass a center horizontal line that cuts both columns in half vertically (y = 0), like a finish line. These counts are reflected in the first yellow box pairs.
        i. Using this data and that provided by the second pair of yellow boxes, calculate the proportion of oxygen per normal red blood cell compared to the proportion of oxygen per sickle cell. Estimate how much more oxygen is carried by a normal red blood cell than a sickle cell proportionally.

ii. Use reliable sources from the internet to explain why normal red blood cells typically carry more oxygen than sickle cells? State your source.

iii. Given the information provided,

Calculate the amount of oxygen (O_2) carried by a normal red blood cell in men and in women? Keep in mind these are average values.

280 million hemoglobin molecules per red blood cell
4 oxygen molecules (O_2) per hemoglobin molecule

Calculate the amount of oxygen transported per average heart beat?

4,600,000 red blood cells per microliter blood (men)
5,200,000 red blood cells per microliter blood (women)
70ml blood per heartbeat (1 microliter = 0.001 milliliter)

Are you surprised by the values you calculated above?

iv. Why is oxygen transport by red blood cells important? Consider the destination.

v. List and briefly explain four consequences of sickle cell anemia due to this reduced oxygen carrying capacity. List one consequence of sickle cell anemia not associated with oxygen but rather another feature of the disease.

3. Heart Rate:

a. Set both heart rates to 70 bpm and run for roughly 200 ticks.

i. What is the graph in the bottom left corner of the screen showing?

ii. Hold the cursor over any point on either line. What is being shown by the values that appear?

iii. Use the graph to provide the number of cells necessary for an individual with all normal red blood cells to transport an amount of oxygen equal to 250. How many cells are necessary to transport the same amount of oxygen if the individual has all sickle cells.

b. Try different heart rates for both cell types. Try increasing both, keeping the bpm equal. Try changing which cell type has a greater bpm and the degree of that difference.

i. What do you observe occurring visually in the two column window? Be sure to mention any patterns/trends noticed.

ii. What changes do you observe in the graph as the heart rates change?

iii. Why is the sickle cell graph line always below and shorter than the normal red blood cell graph line?

c. What condition would need to change for the individual with sickle cell anemia to transport the same amount of oxygen as the individual with all normal red blood cells in roughly the same amount of time? Generally speaking, in what way would this condition need to change?

4. Elaborate on Understanding:

a. *Scenario*: Two friends went to the YMCA together after school as the start of a pact to improve their health, a fitness routine they both vowed to keep together. One of the friends has sickle cell anemia while the other does not. They both like the elliptical machines. Side-by-side, they set their workouts to the same settings. Fifteen minutes in, the friend with sickle cell anemia is feeling very fatigued, but the unafflicted friend is not. Both continue to power through for another five minutes, but the friend with sickle cell anemia is not feeling any better. Both compare their heart rates and the friend with sickle cell anemia's heart rate is much higher than the friend.

i. Assuming all other health factors equal (weight, exercise history, etc.), why is the friend with sickle cell anemia feeling fatigued?

ii. Why is the friend with sickle cell anemia's heart rate so much greater than the friend with all normal red blood cells?

iii. What possible damage could be occurring in the sickle cell anemic friend's body? Consider body systems in addition to the cardiovascular system, using what you know about how multiple systems interact.

What is Sickle Cell Anemia (SCA)?

BY

Lauren T., Joshua D., David K

Crosscutting

Standards:

Crosscutting Concepts:
Stability & Change - For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

NYS LE Standards
1.2b: Humans are complex organisms. They require multiple systems for digestion, respiration, reproduction, circulation, excretion, movement, coordination, and immunity. The systems interact to perform the life functions.

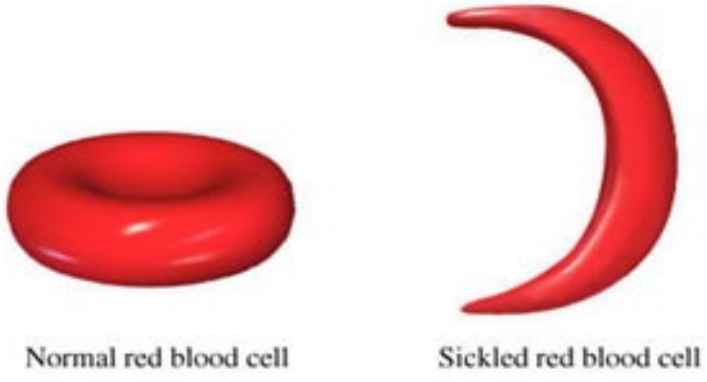
1.2d: If there is a disruption in any human system, there may be a corresponding imbalance in homeostasis.

NYS Mathematics: Standards for Mathematical Practice
The Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students.

1. **Make sense of problems and persevere in solving them** - Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution.
2. **Reason abstractly and quantitatively** - Mathematically proficient students make sense of quantities and their relationships in problem situations.
3. **Look for and make use of structure** - Mathematically proficient students look closely to discern a pattern or structure.
4. **Model with mathematics** - Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace.

How did we do this ?

- **Conceptualization**
- **Process**
- **Concerns/Limitations**



Normal red blood cell

Sickled red blood cell

Students will be able to....

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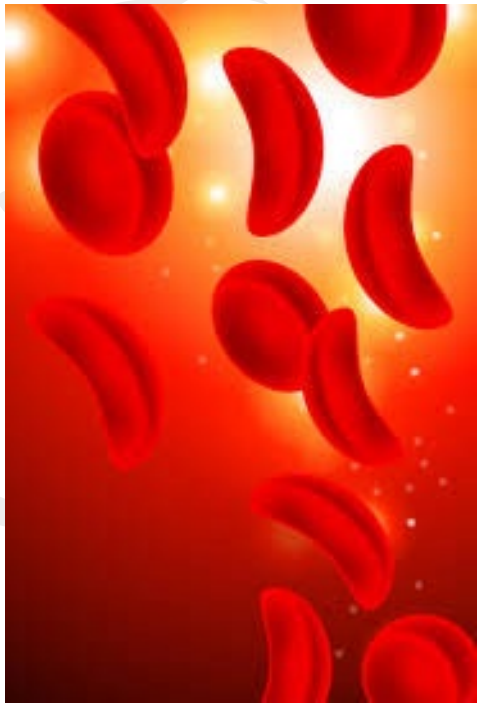
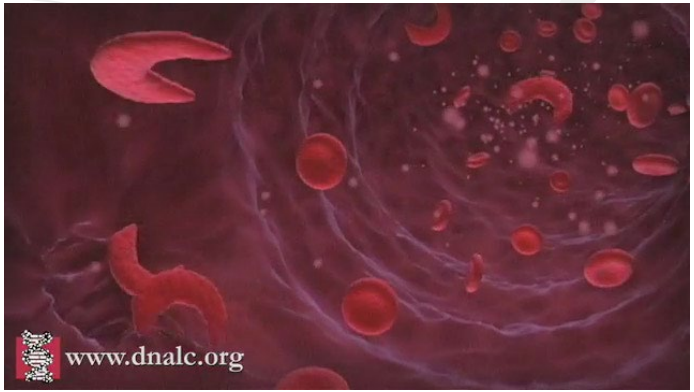


The Lesson Plan

- **Warm-Up**: Students will complete a mind map to recall prior knowledge learned from previous lessons regarding the circulatory system and how it interacts with other organ systems. (5 minutes)
- **Engage**: Introduce students to SCA with video (5 minutes)
- **Explore**, **Explain**, & **Elaborate**: Through NetLogo model activity (30 minutes)
- **Evaluate**: Demonstrate learning in exit ticket (5 minutes)



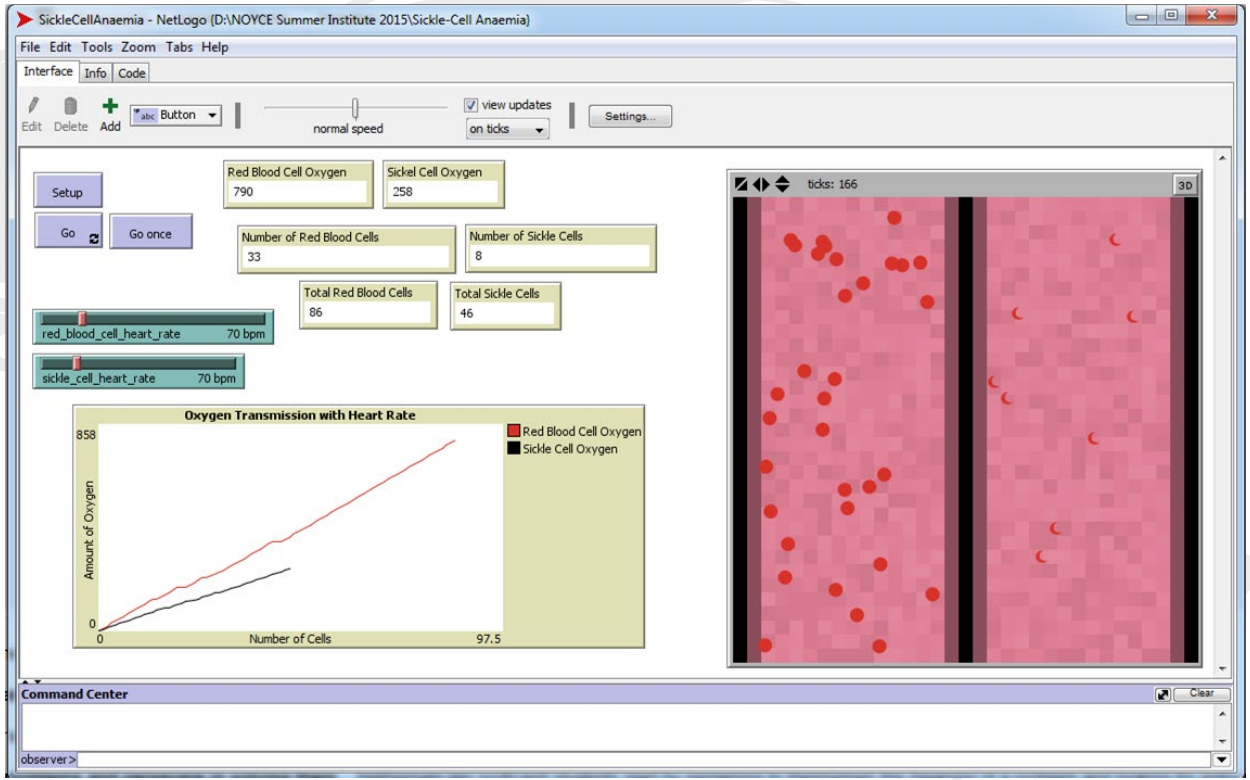
Our Simulation

PLAY IT JOSH!

Process of Deeper Understanding

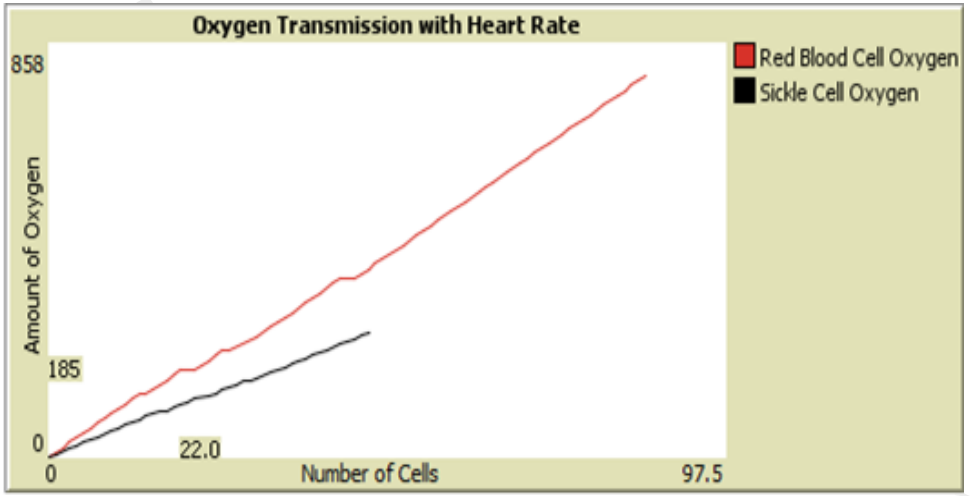
SCAFFOLDED

- ➔ Observation
- ➔ Inquiry
- ➔ Data Collection
- ➔ Determine stability and change
- ➔ Analyze data
- ➔ Interpret & explain understanding
- ➔ Apply understanding in real world context



Analyzing

- Interpret the relation between number of cells and oxygen transmission



Demonstrating Mastery

- Students will use understanding of SCA (structure & function) to infer its importance in our body.
- Students will compare and contrast transmission rates of oxygen between red blood cells and SCA.
- Students will elaborate on knowledge by explaining why sickle cells carry less oxygen.
- Students will apply their understanding of SCA in a real life scenario to justify how SCA impacts other body systems.