The Mystery of the Crooked Cell

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This unit will introduce students to the genetic disease, sickle cell anemia. Students will develop questions about the disease while looking at blood smear for healthy and sickle patients. Throughout the unit, students will analyze pieces of evidence to answer their questions and eventually come to understand the mechanism of sickle cell anemia.

# STANDARDS ALIGNMENT

**NGSS CONNECTIONS**

**HS-LS1-1:** Construct an explanation based on evidence for how the structure of DNA determines that structure of proteins, which carry out the essential functions of life through systems of specialized cells.

**TEKS CONNECTIONS**

**B.6A:** identify components of DNA, identify how information for specifying the traits of an organism is carried in the DNA, *and examine scientific explanations for the origin of DNA*

**B.6E:** identify and illustrate changes in DNA and evaluate the significance of these changes

*Italics denote aspects of the standard not covered in the activity bundle.*

# LEARNING OBJECTIVES

**Students will know:**

* Amino acids and protein structures
* Transcription and translation
* Function of red blood cells

**Students will understand:**

* How changes in DNA lead to phenotypic outcomes and diseases
* The symptoms and mechanism of sickle cell anemia

**Students will be able to:**

* Ask scientific questions about images of two provided blood smears
* Interpret data about the blood cell counts for both of the provided samples
* Demonstrate how a change in DNA causes a change to the protein it codes for
* Use a model of hemoglobin to assess how a change to an amino acid affects protein function
* Conduct an investigation to determine how blood cell shape can affect blood flow
* Construct an explanation based on evidence for why sickled red blood cells differ from normal red blood cells

# UNIT PLAN

## Phenomena

Students are provided the following two images, [Patient 1](https://drive.google.com/file/d/1MjfXpuOK6Fm4DJvTU7dI7mhO3lCRmOFO/view?usp=sharing) and [Patient 2](https://drive.google.com/file/d/15624oaeaDN7ZMiKTbpqvnxbM7E-nCvcV/view?usp=sharing). The instructor explains that the images are blood smears from two different people viewed under a microscope. A brief explanation of the types of cells in view should be given. Allow students to ask questions that come to mind, these will set the stage for the investigation.

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| In classroom | Synchronous online | Asynchronous online |
| Phenomena can be provided in the form of print outs for groups of students or a projection of the images.    Students can analyze the images on their own, discuss questions in small groups, and share out their questions with the class as a whole. | Phenomena can be shown as a screen share in a presentation or on their own. They can also be provided to students before the session.    If possible, breakout rooms can be used to allow for student discussion of questions that they think of.    Students could also submit questions via a chat window or interactive platform like Pear Deck. | Phenomena can be provided on the school LMS in the form of an assignment or Google Doc.    Students can discuss questions they have via a forum in the LMS or group Google documents. |

Common questions might include:

* Why are there more red blood cells in sample 1 than in sample 2?
* Why are there more white blood cells in sample 2 than in sample 1
* Why are there red blood cells that aren’t circles in sample 2?

Students will be guided through pieces of evidence to help them make sense of the questions they have asked.

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## Evidence

### What are Patient 2’s symptoms?

* Students are provided a patient description for Patient 2. This will give students insight into the symptoms the patient is experiencing.
  + [Patient Description Worksheet](https://docs.google.com/document/d/1lJGRIXUDvdXbVpjPXHedhPHa9FqM2KCfPQgqxAxSF_A/edit?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Patient description can be provided as a handout to students.    Students can work in pairs or small groups to complete.    Students can then share out to the class as a whole the answers they found. | Patient description can be provided to the students on a Google Slide.    If possible, breakout rooms and a Jamboard of the slide can be used to allow for student discussion as they complete the questions and determine what other questions they think of. Students can share out their answers to the class as a whole.    Students could also submit questions via a chat window or interactive platform like Pear Deck. | Patient description can be provided on the school LMS in the form of an assignment or Google Doc.    Students can discuss questions they have via a forum in the LMS or group Google documents. |

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### What are blood cells?

* Students watch the Macmillan Cancer Support video [“What are blood cells?”](https://www.youtube.com/watch?v=7KTkojnNhTU) (1:40) to learn about the function of red blood cells. Students are asked what new questions they have about the patient after gathering this information.
  + [Types of Blood Cells Worksheet](https://docs.google.com/document/d/1Pwjeit4oIU_XYyDBHzseGOn7liUilv6VLhOWcsxaE7M/edit?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Video can be played to the class and a worksheet can be provided to students.    The questions provided can also act as a discussion/debrief after the video has ended. | Video can be played via screen share during class session.    Students can be tasked with answering the 3 questions on the worksheet in breakout rooms and then sharing answers with the class.    Students could also submit questions via a chat window or interactive platform like Pear Deck. | Playposit video can be provided for students to complete.    For the final question, students will submit their own questions and can comment on other students’ as well. |

### What does the blood count data look like for both patients?

* Students are given blood count data about the samples. Students are asked to analyze data comparing sickle patients to controls. Students then provide a diagnosis for Patient 2.
  + [Blood Count Data Worksheet](https://docs.google.com/document/d/1xTDsMjgG9Rb4UAW9v18H1KQxlWXsAkP6eXrQqHy7zC0/edit?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Data can be provided to the students in the form of a worksheet.    Students can work in pairs or small groups and can review the answers with the class as a whole afterward. | Handout can be provided to the class as homework and class time can be used to review the worksheet and to discuss the final questions.    Students can take a poll on the last question using Mentimeter, Pear Deck, or a polling feature of the video conferencing platform. Poll data should be shown in real time to the students. | Handout can be provided to the class as homework and a forum on the LMS should be used to discuss the final question.    Students can take a poll on the last question using Poll Everywhere or Google Forms. Poll data should be shown in real time to the students. |

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### How is hemoglobin different for these patients?

* Students view how normal and sickle hemoglobin respond to electrophoresis to understand how structural change affects the protein charge.
  + [Electrophoresis video](https://vimeo.com/405925057)
  + [Electrophoresis video worksheet](https://docs.google.com/document/d/1vTGk86CU5Wk3j4xFnP0dSs1r48ReaMbdpsOksUmDz5c/edit?usp=sharing)
  + [Electrophoresis Result](https://drive.google.com/file/d/1Yjy2HrhbJUjfBssesFDlkRuhvhUWjmdA/view?usp=sharing)
* Students examine the genetic sequence for 2 different types of hemoglobin. Students transcribe and translate each sequence to determine how the sequence change results in a change in charge.
  + [A Closer Look at the Cause of Sickle Cell Worksheet](https://docs.google.com/document/d/1XNxAQBqzj5Qxr-08NJ2O8c36OU7-xn9iXQpydooEFgg/edit?usp=sharing)
  + [A Closer Look Reference Guide](https://docs.google.com/document/d/1JYBGJYV90g1qfs-qUTWDwMj47tSML47pbkbXNM0B_bU/edit?usp=sharing)
* Students view the structure of the hemoglobin for both types using a [computer model.](http://bioinformatics.org/jmol-tutorials/jtat/hemoglobin/7sickle/chapter.htm)
  + [Normal and Sickle Hemoglobin Protein Structures Worksheet](https://docs.google.com/document/d/163yEbg-IFL0C6_Wj0woV_9pDwE1AHGSQksROahk7Xq0/edit?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Students can watch the electrophoresis video as a class and can complete the worksheet as they watch.  Students can work on the sequences worksheet in pairs before looking at the model on the computer. | Students can view the electrophoresis video via screen share and students can answer the questions via polls on PollEverywhere, Mentimeter, or within the video conferencing platform.  Students can work on the sequences worksheet as homework before looking at the model in class via screen share.    Students can ask and answer questions about the model using platforms like a chat window or Peardeck. | Students can view a Playposit video of the electrophoresis video and answer the questions as the video plays.  Students can work on the sequences worksheet on their own. A video review of transcription and translation might be necessary.    Students can complete the worksheet with the computer model as a Google doc to submit or the worksheet can be transformed into a Google Quiz or Form. |

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### What effect does sickling have on the body?

* Students test the effects of this new shape at home using different shaped candies and racing them through narrow bottle necks.
  + [Vaso-Occlusion At Home Model](https://docs.google.com/document/d/1KF50k-pFhBfDqXXHlHXci9yccQIBCarq8OPenmyvMeg/edit?usp=sharing)
* Students view SCDSilentDamage.com’s video [“Impact of Hemoglobin S Polymerization on sickle cell disease morbidity”](https://d8yuai347eky0.cloudfront.net/SCDsilentdamage.com/hcp-video.mp4) (until 2:11) to learn more about how sickling damages the cells and causes hemolysis.
  + [Impact of Hemoglobin Polymerization Worksheet](https://docs.google.com/document/d/1OEfatUgck7J9S4Mhbf_q1Y9ZgpiRXyTtIrr3Z_Q0S5c/edit?usp=sharing)
* *For advanced students:* Students analyze evidence regarding the sickling shape of RBC in regard to oxygen levels.
  + [Using oxygen to determine the severity of sickle cell on red blood cells: Guided Primary Source Worksheet](https://docs.google.com/document/d/14mKZRMGlSTcQF7ZL4guarykfZsJH4ZN-bdspCEmrOx0/edit?usp=sharing)
  + [Scientific Paper: Rab et al., 2019](https://drive.google.com/file/d/19qo7II07xgIFeylzIxKAeW2F7D_IRULV/view?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Students can work on the Vaso-Occlusion model in small groups. A class discussion about the results can occur afterward.    Students can watch the SCDSilentDamage.com’ video as a class and can complete the worksheet as they watch.    For advanced classes, students can be provided the scientific journal article and can work in small groups or pairs to complete the accompanying worksheet. | Students can work on the Vaso-Occlusion model at home before class. A class discussion about the results can occur afterward. A class demo of this model might be necessary for students who can’t conduct it at home.    Students can watch the SCDSilentDamage.com’ video via screen share and students can answer the questions via polls on PollEverywhere, Mentimeter, or within the video conferencing platform.    For advanced classes, students can be provided the scientific journal article and can work on the accompanying worksheet at home. A synchronous review or discussion about the article is recommended. | Students can work on the Vaso-Occlusion model at home before class. Students can submit through to an LMS forum or Google doc for small groups.    Students can watch the PlayPosit of SCDSilentDamage.com’ video and answer the questions provided.    For advanced classes, students can be provided the scientific journal article and can work on the accompanying worksheet at home. A synchronous or recorded video review or forum discussion about the article is recommended. |

## Conclusions

* Students construct a claim backed up by evidence and reasoning to answer the following question:
  + [How are the sickle red blood cells of Patient 2 different from normal red blood cells of Patient 1?](https://docs.google.com/document/d/13WR5pGtBeLdg3QEaYTe_PaYECRWEJd5CLcZ94orU6vw/edit?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Students can work on this individually, then in pairs or small groups.    Groups should present their argument to the other groups and students should provide feedback on the presented argument. | Students can work on this individually, then in pairs or small groups via a shared Google Doc. This should be done before the synchronous session.    Groups should present their argument to the other groups and students should provide feedback on the presented argument.    As a class, ask students to answer the question again via a platform like a chat window or Pear Deck. | Students can work on this individually, then in pairs or small groups via a shared Google Doc.    Groups should create a document (Google Doc, Slides, or video) of their argument to be shared with other classmates. Classmates will review the argument and provide feedback.    As a class, ask students to answer the question again via Google Quiz or LMS forum. |

**Additional resources**

* Ted Ed video [“How this disease changes the shape of your cells”](https://www.youtube.com/watch?v=hRnrIpUMyZQ) (4:40)
* Osmosis video [“Sickle cell anemia- causes, symptoms, diagnosis, treatment & pathology”](https://www.youtube.com/watch?v=fIIJmg_1hv0) (until 3:08)
  + [Corresponding Video Questions](https://docs.google.com/document/d/1ZwjZet3bzzfhahYMvNrP8nPFrt61fWNxIwJZ5ZkFa_Q/edit?usp=sharing)
* [Histological Examination Worksheet](https://docs.google.com/document/d/14ePns9F4PC1ugsLoUgjQ0tpDrylR9zWhGkaHZkIxKIw/edit?usp=sharing)
* [Lab Worksheet](https://docs.google.com/document/d/1nZ5JHxgKn5bOQlbFIzU9CNm8p0dqEHEghdGAiHqD0SM/edit?usp=sharing)
  + [Lab Worksheet Walkthrough](https://vimeo.com/411537562)
* [Prevalence of Sickle in Malarial Regions Worksheet](https://docs.google.com/document/d/1Abi51hBrrEG2cm_aMzhFGykcZOYCvwN7SnVg91W65rQ/edit?usp=sharing)
  + [Prevalence Of Sickle in Malarial Regions Reference Guide](https://drive.google.com/file/d/1GWlmdvZnZ4qa0kSb5KlJIGvlUtMOPgoz/view?usp=sharing)