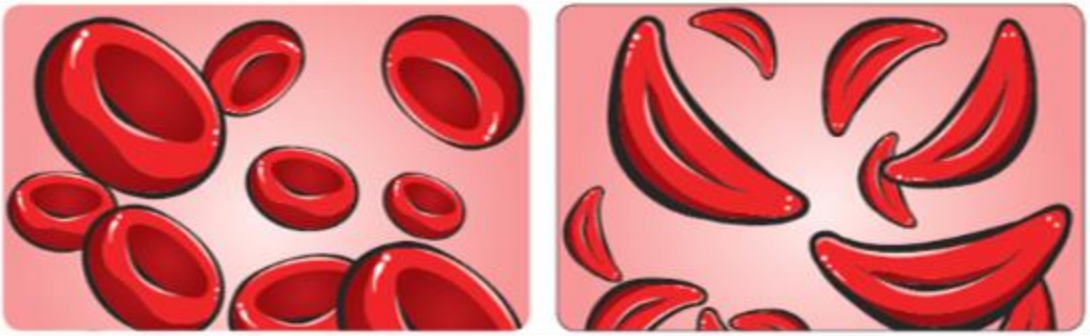
Carolina Biological Supply Company

Modeling DNA to Protein

Go Hands-On with Protein Synthesis and Mutation

"How could Terra develop the genetic disease sickle-cell anemia if neither of her parents had it?"



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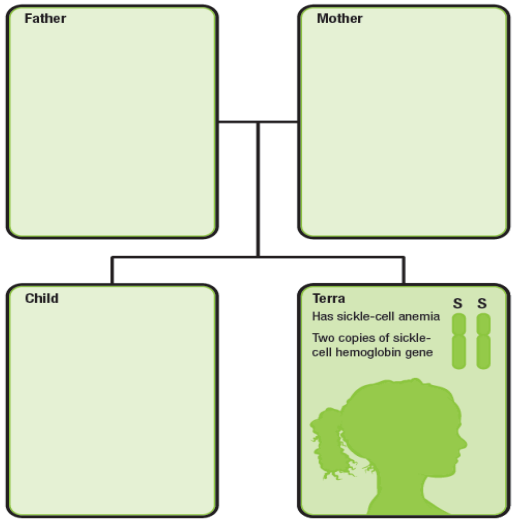
Workshop Overview

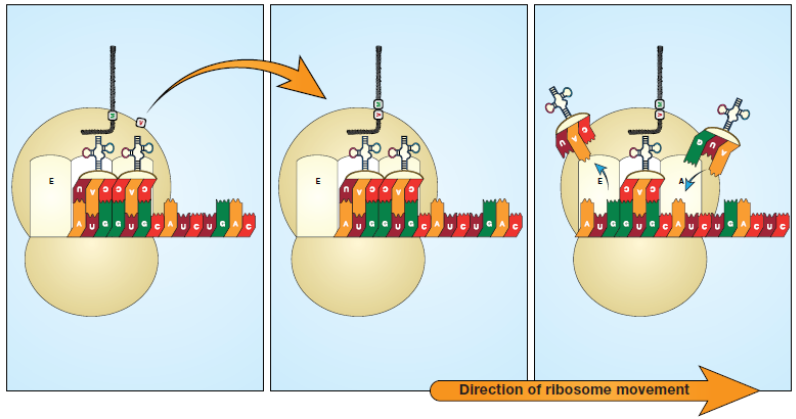
Phenomenon

"How could Terra develop the genetic disease sickle-cell anemia if neither of her parents had it?"



Objectives

- **Model** the processes of protein synthesis.
- **Construct and revise an explanation** for the mechanisms of sickle-cell disease **using models as evidence.**
- **Construct an explanation** for how DNA structure results in the production of different proteins and how a change can result in a genetic disease.



Building Toward 3-Dimensional Learning

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• Developing and using models • Constructing explanations and designing solutions	LS1.A: Structure and function	• Systems and system models • Structure and function[1]

Materials

- Nucleotide Magnets
- tRNA Magnets
- Storage Cups with Lids
- Pipe Cleaner
- Red Clay
- Cornstarch or Flour
- Ribosome Transparency
- Magnetic Whiteboards
- Amino Acid 1-Letter Abbreviation Charms
- Funnel
- Ruler
- Whiteboard or Dry-Erase Markers

1. NGSS Lead States, *Next Generation Science Standards: For States, By States* (Washington, DC: The National Academies Press, 2013), retrieved from www.nextgenscience.org or ngss.nsta.org.

Time Required

Three 45-minute class periods

Time Requirements

Teacher Preparation (Total)	**30 minutes**
Previewing Videos and Interactive Lessons	10 minutes
General Preparation	10 minutes
Investigation Preparation	10 minutes
Introduction (Total)	**30 minutes**
Phenomenon	15 minutes
Introduction Questions	15 minutes
Investigation 1	**30 minutes**
Investigation 2 (Total)	**50 minutes**
Modeling	30 minutes
Analysis	20 minutes
Conclusion	**25 minutes**
Final Performance	**25 minutes**

To maximize the limited time of our workshop we will:

- **Split up the activities.** Work in 2 groups per table and share data between groups.
- **Discuss,** rather than complete, **some activities.**
- **Omit portions of the lab.**

Activate Background Knowledge and Reflect

1. What differences do you observe between normal and sickled red blood cells?
2. Use your prior knowledge and information from the illustrations to predict how the sickling of red blood cells could influence their functioning in Terra's body.
3. Neither Terra's older brother nor her parents suffer from sickle-cell disease, yet her medical team knows that Terra has inherited the disease from her parents. Record some questions you now have about sickle-cell anemia, the transmission of genetic diseases such as sickle-cell disease, Terra's family history, or the methods used to diagnose Terra.

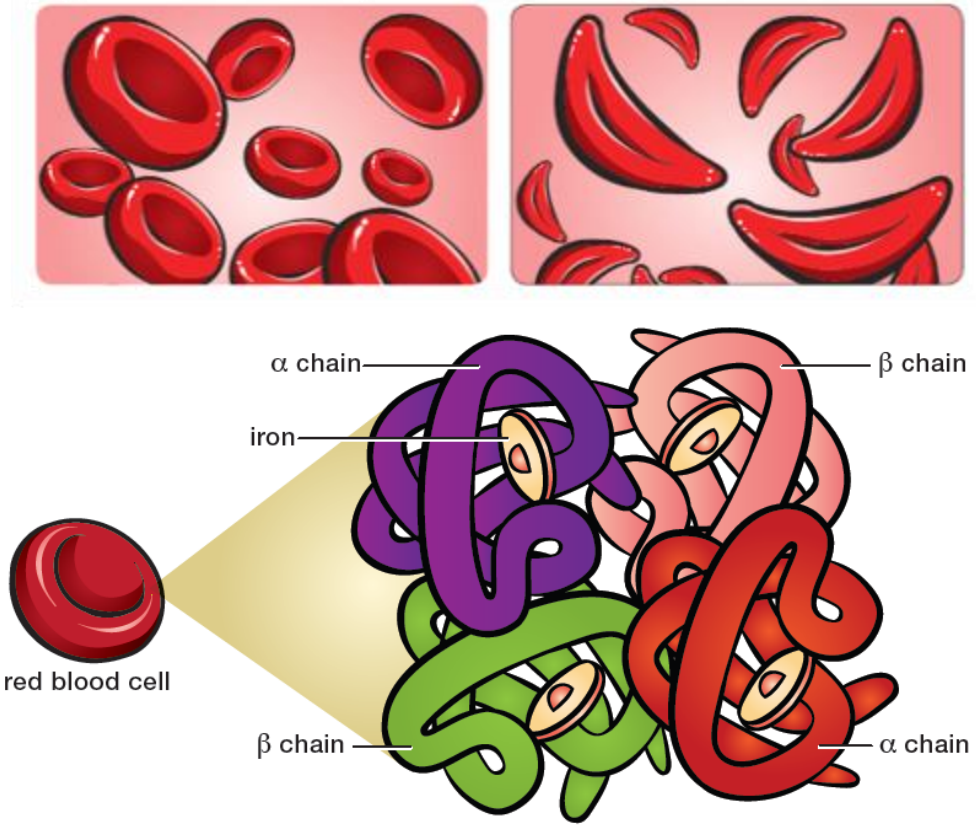


Figure 2. Normal hemoglobin protein

Procedure—Introduction

Objective: Model the process of **transcription** in the same region of the normal and the sickle-cell beta hemoglobin gene in humans to determine any differences in the resulting **mRNA sequences.**

Split each table into 2 groups of 4

Group 1: Normal Gene

TAC CAC GTA GAC TGA GGA CTC

1. **Complete steps 1-4 to transcribe the normal gene sequence.**

DNA Base A – T
Pairing Rules G – C

Group 2: Mutant Gene

TAC CAC GTA GAC TGA GGA CAC

1. **Complete steps 5-8 to transcribe the normal gene sequence.**

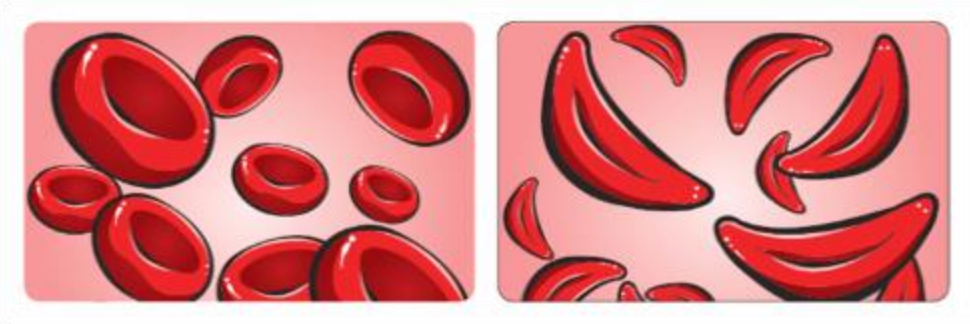
RNA Base A – U
Pairing Rules G – C

2. **Share results between groups.**
3. **Complete introduction questions 1 and 2.**

Procedure—Introduction

Objective: Model the process of **transcription** in the same region of the normal and the sickle-cell beta hemoglobin gene in humans to determine any differences in the resulting **mRNA sequences.**

1. Compare the DNA sequences in the normal and sickle-cell anemia hemoglobin genes, then make a claim about the structure of Terra's red blood cells.



2. After simulating transcription, identify any differences between the mRNA sequences in normal and sickle-cell hemoglobin. How did these differences arise?

Normal Gene

Mutant Gene

Procedure—Investigation 1

Objective: Model the process of **translation** in the same region of the normal and the sickle-cell beta hemoglobin gene in humans to determine any differences in the resulting **amino acid sequences.**

Table 1 (workshop handout page 6)

Type of Hemoglobin		1st Codon	2nd Codon	3rd Codon	4th Codon	5th Codon	6th Codon	7th Codon
Normal (wild-type)	DNA	TAC	GAC	GTA	GAC	TGA	GGA	CTC
	mRNA	AUG	CUG	CAU	CUG	ACU	CCU	GAG
	Amino Acid							
Sickle-Cell (mutant)	DNA	TAC	CAC	GTA	GAC	TGA	GGA	CAC
	mRNA	AUG	GUG	CAU	CUG	ACU	CCU	GAG
	Amino Acid							

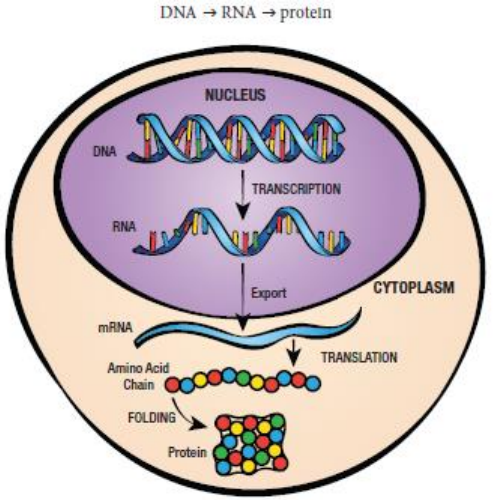


Figure 1. The central dogma of molecular biology: The flow of genetic information

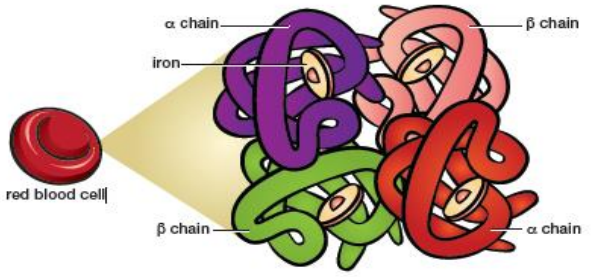


Figure 2. Normal hemoglobin protein

Procedure—Investigation 1

Objective: Model the process of **translation** in the same region of the normal and the sickle-cell beta hemoglobin gene in humans to determine any differences in the resulting **amino acid sequences.**

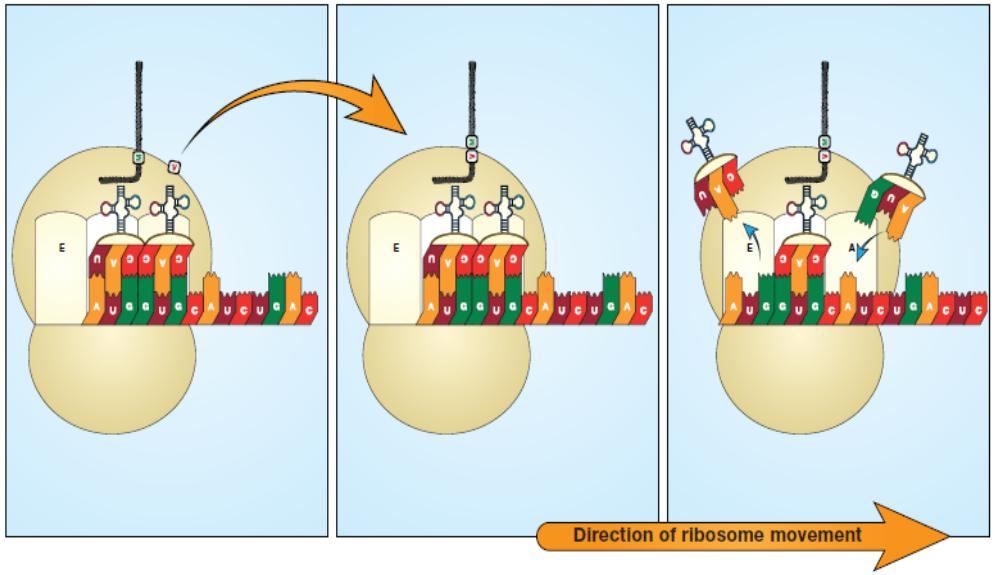
Procedure—Investigation 1

Objective: Model the process of **translation** in the same region of the normal and the sickle-cell beta hemoglobin gene in humans to determine any differences in the resulting **amino acid sequences.**

Stay in your groups

Group 1 and Group 2

1. Complete the 3 Steps of Translation (workshop handout pages 6-10, steps 2-13) using your group's mRNA sequence.
2. Complete steps 14-16 (workshop handout page 10) by sharing with the other group.



Helpful Tips:

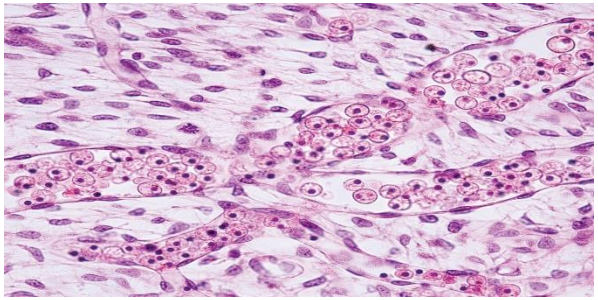
- Workshop handout page 11 has a codon chart.
- Divide actions among group members, e.g.:
  Member 1: uses codon chart to translate
  Member 2: identifies and adds charms
  Member 3: finds and moves tRNA
  Member 4: moves mRNA for each step

Procedure—Investigation 2

Objective: Model the effect of a change in the amino acid sequence of the hemoglobin gene **on red blood cell structure and function** when blood cells move from blood vessels into narrow capillaries.

Stay in your groups

Group 1: Normal Gene	Group 2: Mutant Gene
	
1. Complete **steps 1-3** to model normal blood cells.	1. Complete **steps 4-6** to model sickle-cell blood cells.



2. **Share results between groups.**

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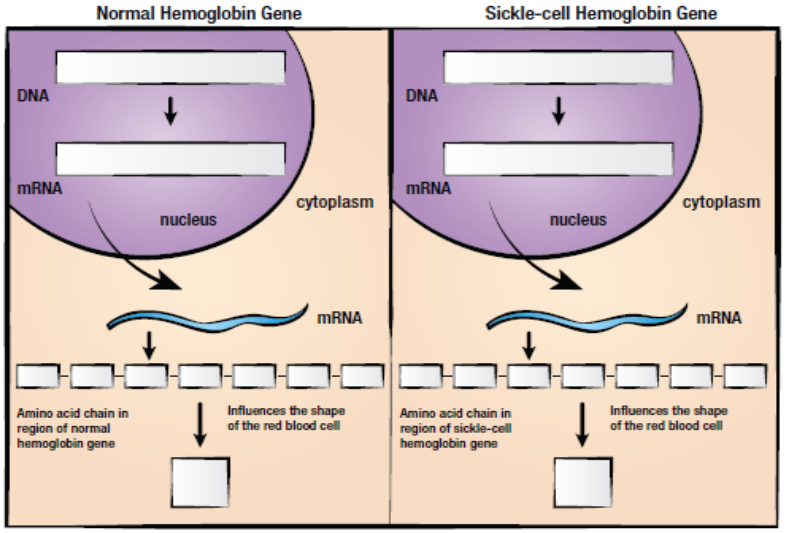
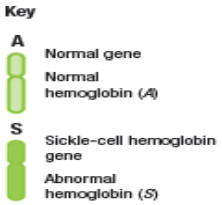
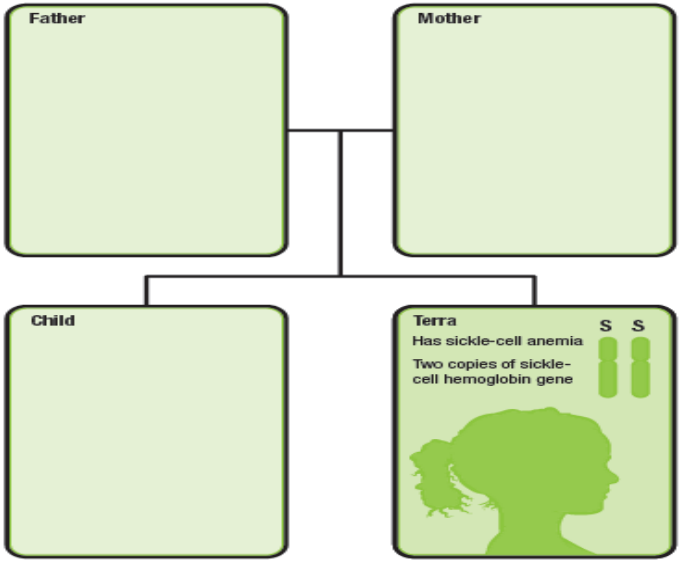
Analysis Examples

1. This model represents the process of transcription and translation in a portion of normal and sickle-cell hemoglobin genes.
   - Fill in the blanks.
   - Label each process.
   - Revise model by drawing and labeling tRNAs, amino acids, and ribosomes.
   - Draw the shape of the resulting red blood cell represented by your clay model after each gene has been translated into normal or sickle-cell hemoglobin.



2. Use the family tree template to construct a model that explains how Terra inherited sickle-cell disease, although her parents do not have it.
   - Label each family member's likely genotype (AA, AS, or SS), disease status (has sickle-cell anemia, is a carrier, or is normal), and number of each gene (normal or sickle) possessed.
   - List all likely possibilities for individuals when multiple genotypes are possible.





Resources from Carolina

Modeling DNA to Protein Kit

1-Station version: Item #211181

8-Station version: Item #211183

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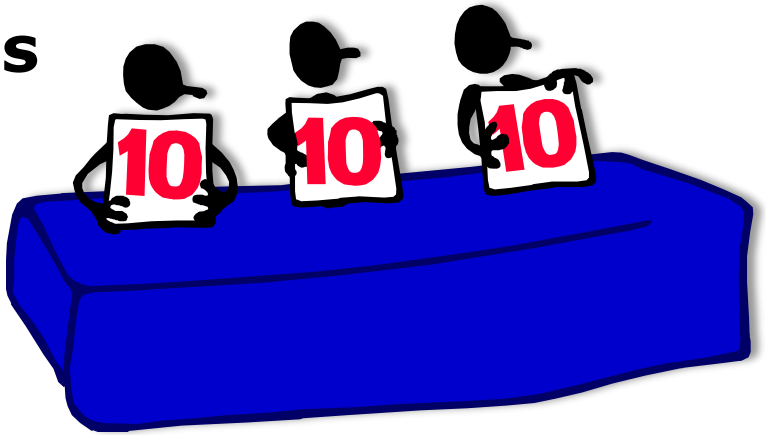
Evaluations: Share Your Thoughts!

We are striving to make our workshops great!



Please evaluate this session and presenter on a scale from 0 to 10. (10 = best)

Please help us reset the room by gathering your belongings and exiting between sessions.

THANK YOU!

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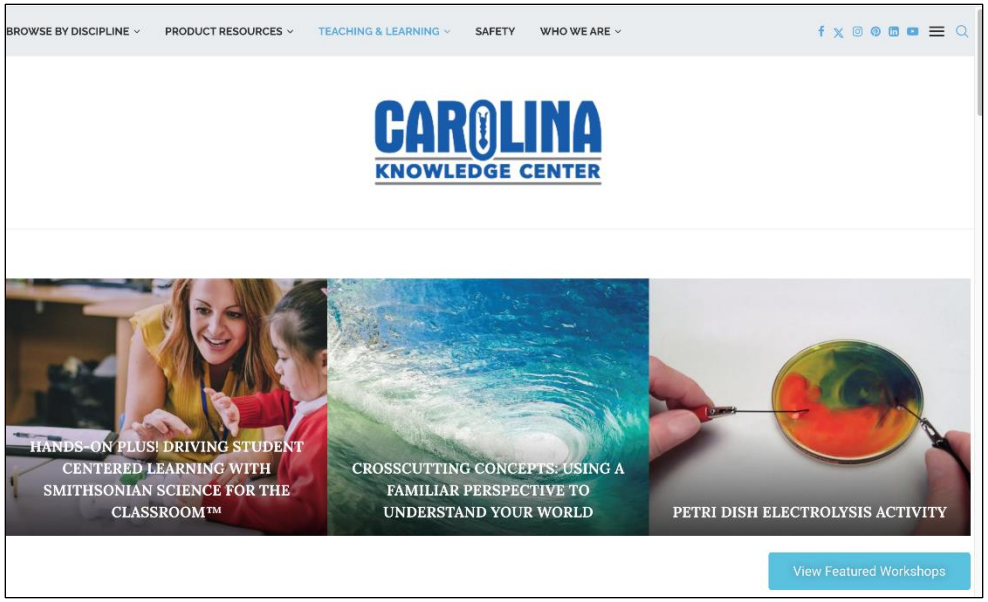
And remember: You can access all Carolina workshop materials later.



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