7.1 - Mutations & Change Unit, Packet 1

Score
□ Above & Beyond
□ Meets Expectations
□ Near Expectations
□ Incomplete – *fix the following pages*:

First & Last Name: _____ Period/Hour:_____

NOTE: Packets are due after completing Part 5. Check each page to be sure <u>all</u> blanks are completed.

Driving Question: How does a protein get its shape & function?

Anchoring Phenomenon: We now know that the order of bases in a gene determines the order of amino acids in a protein, which determines the shape & function of a protein. This determines a specific trait. What happens when the order of bases in a gene changes because of a mutation? We will explore this through a disease called sickle cell anemia.

Deeper Questions

1. How does a chain of amino acids form a functional protein?
2. How do amino acid properties affect protein shape and function?
3. What happens if the order of amino acids in a protein is changed?

Schedule

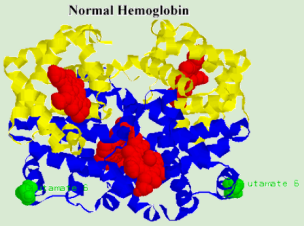
Part 1: Introduction
- Initial Ideas & Data Dive - Sickle Cell Anemia
- Discussion & Developing Explanations

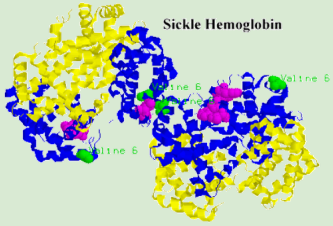
Part 2: Core Ideas
- Core Ideas
- Revisions of Part 1 Explanations

Part 3: Investigation
- Pipe Cleaner Proteins

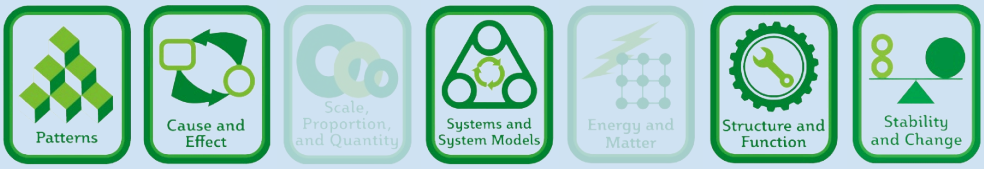
Part 4: Review & Assessment
- Ranking Your Readiness
- Formative Assessment & Mastery Check

Part 5: Life Connections
- CRISPR-Cas9 & Sickle Cell Anemia





[NGSS Standards](#) (*PEs* & *CCCs are summarized below. SEPs are noted throughout the packet*).
HS-LS1-1 - How the structure of DNA determines the structure of proteins and function.
HS-LS1-2 - How inheritable variations result from 1) changes via meiosis; 2) errors during replication; 3) mutations via environmental factors HS-LS1-4: How mitosis and differentiation enable complex organisms.



Semester Schedule

5. Traits & Genes
5.1: What determines the traits of an organism?
5.2: How are traits inherited from parents?
5.3: Can we predict traits?
5.4: Unit Assessment

6. DNA & Proteins
6.1: What is DNA and how does it work?
6.2: How does DNA affect protein assembly?
6.3: Unit Assessment
6.4: How are genes modified? *(mini-unit)*

7. Mutations & Change
7.1: How does a protein get its shape & function?
7.2: How do mutations change genes & proteins?
7.3: How can mutations create new traits & species?
7.4: Unit Assessment
7.5: How Does Antibiotic Resistance Occur?

8. Biodiversity
8.1: How does biodiversity affect ecosystems? Why is biodiversity being lost?

These materials were partly developed with assistance from artificial intelligence.

Resource Links: Class Website; Core Ideas; Video Quiz; Summary Video; Protein Folding Video; Protein Folding GIF; NPR CRISPR Article; NBC CRISPR Video;

Part 1: Introduction – Sickle Cell Anemia (7.1.1)

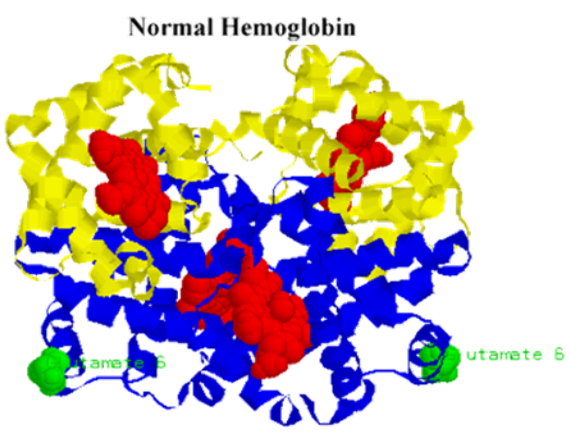
Overview: Discuss your initial ideas about mutations. Then use data to develop initial explanations.

Initial Ideas - *Record your ideas separately (scratch paper, etc.).* *SEP: Engaging in Argument from Evidence*

1. Daryll discovered that some family members carry genes for sickle cell anemia. This disease results from a change in a single base in a gene. This alters the assembly of hemoglobin proteins, changing the shape of red blood cells. This causes symptoms like blood clots and reduced oxygen levels.Daryll discusses this with his friends at lunch. They each share their ideas. **Do you agree or disagree with each student's claim?**
   - Daryll: "I know that DNA provides the instructions for assembling a protein. Maybe changing one base changes the entire DNA" *Agree/ Disagree*
   - Avery: "I know that DNA is read in groups of 3 bases. The entire protein must have changed because a single amino acid was changed." *Agree / Disagree*
   - Chandra: "This makes sense – if proteins are made from DNA, then changing the DNA will change the protein." *Agree / Disagree*
2. Discuss your group's ideas. How are your ideas similar or different? Be prepared to present your ideas.

Data Dive - *SEP: Analyzing & Interpreting Data*

Make observations about differences in genes and protein shape that occur in sickle cell anemia. Use the images below to answer the questions on the following pages.



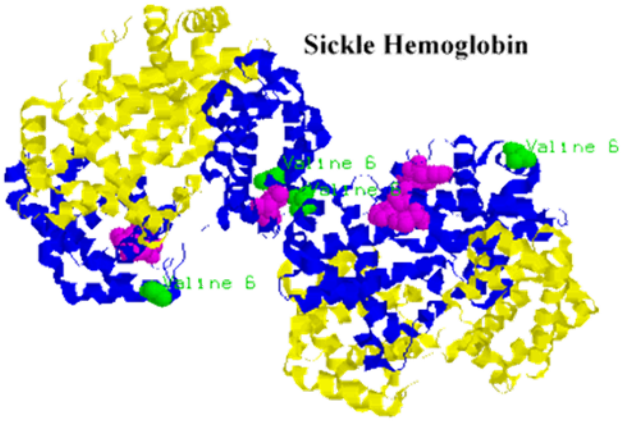


Image Source: PBWorks

Data Dive Questions - *SEP: Engaging in Argument from Evidence*

1. **Begin by individually attempting to make sense of these images**. What trends or patterns do you notice? How does this relate to any prior knowledge or experience that you have?
2. **Next, work in your teams to discuss your ideas**. Where do you agree? Where do you disagree? Can you use this data to reach an agreement? Do others have prior knowledge/experience that could help?
3. **What is one conclusion that would be supported by this data?** How is this conclusion supported by this data? What specifically suggests that your claim is accurate?
4. **What is a second conclusion that would be supported by this data?** How is this conclusion supported by this data? What specifically suggests that your claim is accurate?
5. **Does this data support or refute any of the initial claims on the previous page?** If so, explain.

Discussion - *Record your ideas in the spaces below.* *SEP: Asking Questions & Defining Problems*

We generally agree that…	***We disagreed or were unsure if…***

Initial Explanations - *Record your ideas in the spaces below.* *SEP: Constructing Explanations & Designing Solutions*

How does a protein get its shape & function? Write down an initial explanation below. Don't worry if you aren't completely sure about this. You will revise this explanation as you gain more information.

Part 2: Core Ideas (7.1.2)

Overview: In this activity, you will use an intro video and a short presentation to provide you with information that will help you improve and revise your initial ideas. Your instructor will decide on how to implement this portion. You will then work in small teams to address the questions listed below.

Driving Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Developing & Using Models

1. What determines the function of a protein? What properties determine the shape of a protein?
2. What is the difference between a hydrophobic amino acid and a hydrophilic amino acid?
3. Where are hydrophobic and hydrophilic amino acids found in a protein? Why?
4. How does the positive or negative charge of some amino acids affect the shape of a protein?
5. How are cysteine amino acids unique? How do these amino acids affect the shape of a protein?
6. Sickle cell anemia occurs when a T-base in DNA is substituted for an A. How does changing a single base result in changes at the molecular, cellular, and bodily levels?

Revising Explanations - *Record your ideas in the spaces below.* *SEP: Constructing Explanations & Developing Solutions*

How does a protein get its shape & function? Based on this new info, how would you now respond?

_____

_____

_____

Use this space for notes if needed.

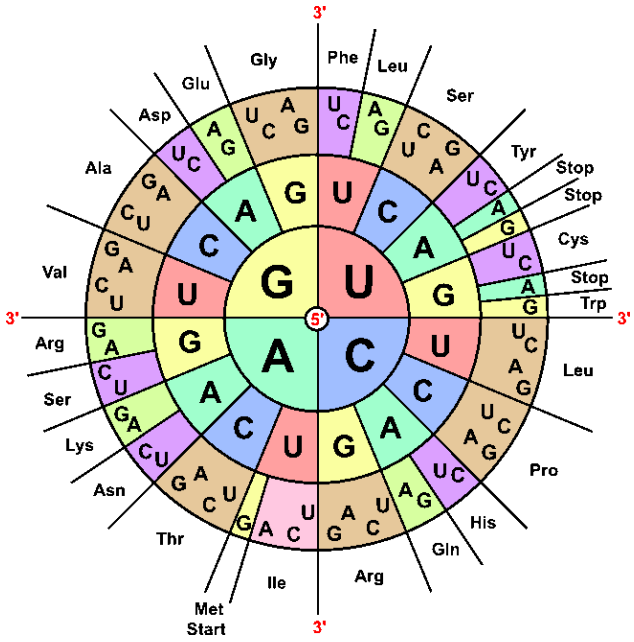
Part 3 Investigation: Pipe Cleaner Proteins (7.1.3)

Overview: you will use models to explore how amino acid properties affect protein shape and function.

Background: A scientific model is a substitute for the actual thing we are studying that is similar to what it represents. It follows the same rules as the actual object, but it provides a simpler version of a complex concept.

You'll create a protein model using pipe cleaners, beads, and straws based on the instructions on the next page. Three key amino acid properties affect protein folding. Your model will illustrate how these properties influence protein shape and function: 1) Hydrophobic amino acids move to the inside the protein, while hydrophilic amino acids move outside. 2) Oppositely charged amino acids attract, while similarly charged amino acids repel. 3) Cysteine amino acids form strong bonds with each other.

1. **First, transcribe DNA into mRNA in the table below.** The first two codons are completed for you.
2. **Next, translate the mRNA into amino acids based on the codon wheel shown at the right.**
3. **Third, use the information below to determine which beads represent each amino acid.**
   a. Yellow = hydrophobic amino acids; Purple = hydrophilic amino acids.
   b. Blue = positively-charged amino acids. Red = negatively-charged amino acids.
   c. Green = cysteine amino acids
4. **Once you have completed the table, you can begin assembling your protein.**
   a. Wrap a yellow bead securely at one end of a pipe cleaner for the first amino acid (*methionine*).
   b. Next, add a cut-up piece of a straw to represent the bond between amino acids before adding a blue bead for the next amino acid (*arginine*).
   c. Continue adding beads and cut-up straws until every amino acid in your sequence is represented. Use a second pipe cleaner if more space is needed. *Remember: STOP = the end of a protein.*



DNA	3' TAC	TCT	CGA	TTA	TAC	ACG	CAA	TGG	ATA	TTG	AAA	TAT	AGG	ACC	TTG	CTC	TTT	AAT	TGT	CAC	ACG	ACT 5'
mRNA	AUG	AGA																				
Protein	MET	ARG																				
Beads	YEL	BLU																				

Amino Acid	Charge	Hydrophobicity	Bead Color	Amino Acid	Charge	Hydrophobicity	Bead Color
alanine - ala	Neutral	Hydrophobic	Yellow	leucine - leu	Neutral	Hydrophobic	Yellow
arginine - arg	**Positive**	*Hydrophilic*	Blue	lysine - lys	**Positive**	*Hydrophilic*	Blue
asparagine - asn	Neutral	*Hydrophilic*	Purple	methionine - met	Neutral	Hydrophobic	Yellow
aspartic acid - asp	**Negative**	*Hydrophilic*	Red	phenylalanine - phe	Neutral	Hydrophobic	Yellow
cysteine - cys	Neutral	*Hydrophilic*	Green	proline - pro	Neutral	Hydrophobic	Yellow
glutamine - gln	**Positive**	*Hydrophilic*	Blue	serine - ser	Neutral	*Hydrophilic*	Purple
glutamic acid - glu	**Negative**	*Hydrophilic*	Red	threonine - thr	Neutral	*Hydrophilic*	Purple
glycine - gly	Neutral	Hydrophobic	Yellow	tryptophan - trp	Neutral	Hydrophobic	Yellow
histidine - his	**Positive**	*Hydrophilic*	Blue	tyrosine - tyr	Neutral	Hydrophobic	Yellow
isoleucine - ile	Neutral	Hydrophobic	Yellow	valine - val	Neutral	Hydrophobic	Yellow

5. **Finally, you will need to fold your protein using the guidelines below.**
   a. Purple hydrophilic amino acids are on the outside; yellow hydrophobic amino acids are inside.
   b. Connect your opposite charges (red and blue amino acids) by twisting them around each other.
   c. Connect your green cysteine amino acids by twisting them around each other.

6. **Raise your hand when you finish. Your instructor will check your work & ask clarifying questions.**

   This activity was successfully completed: _____

   (instructor signature)

7. **Submit your completed protein with your names attached to it (using masking tape or whatever your instructor provides for you) to the location that your instructor has provided.**

Part 4: Review & Assessment (7.1.4)

Step 1: Rank each Driving Question in Part 2 based on your comprehension (you can rank them as *1,2,3* or *green/yellow/red*, or any other method). Then work in teams to review anything that is still unclear.
Step 2: Identify any remaining areas of confusion or concern. Then review these topics with your instructor.
Step 3: Complete the Formative Assessment (*last page of the packet*). Your instructor will determine if you will work individually, in pairs, or in small groups. Then compare and evaluate your responses as a class.
Step 4: Individually complete a Mastery Check. If your performance indicates that additional support is needed, your instructor will determine how to help you move forward.

Part 5: Life Connections – CRISPR & Sickle Cell (7.1.5)

Overview: For this activity, you will use a real-world case study about an individual who was cured from sickle cell anemia using CRISPR-Cas9 genetic modification.

Directions:

1. Your instructor will determine which of the following resources will be used for this activity:
    a. News Article: *Sickle cell patient's success with gene editing raises hopes and questions* - https://www.npr.org/sections/health-shots/2023/03/16/1163104822/crispr-gene-editing-sickle-cell-success-cost-ethics
    b. Video:*https://www.nbcnews.com/now/video/fda-approves-treatment-that-uses-gene-editing-for-sickle-cell-disease-199814213562*
2. After utilizing the resources above, discuss the following questions in your assigned groups:
    a. What were the main points from this resource?
    b. How was CRISPR-Cas9 used to cure this disease?
    c. Are there any concerns associated with this technology? Why?
    d. Is this a credible source? Why or why not?
    e. What is your stance? Should this technology be made more widely available? Should this approach be banned? What would you recommend and why?
3. As a group, try to achieve a consensus on this issue. What is your stance, and what evidence supports your stance? Record your final ideas below. Be prepared to discuss as a class.

What is your stance on this issue?_____

_____

_____

Why is this your stance? What reasoning or evidence supports this? _____

_____

_____

Mutations & Change Unit - Packet 7.1 Formative Assessment

Name: _____ Hour_____ Date:_____ Score:_____ /_____

Directions: A 3x5 notecard with handwritten notes can be used to guide your answers. Your instructor may allow you to work in assigned groups. If so, have a different person write each response while others assist.

1. **What primarily determines the function of a protein? How does this relate to DNA?** Include and underline the following terms: *shape, function, amino acids.*

2. **Briefly explain & summarize how each of the following amino acid properties affect protein shape and function:**

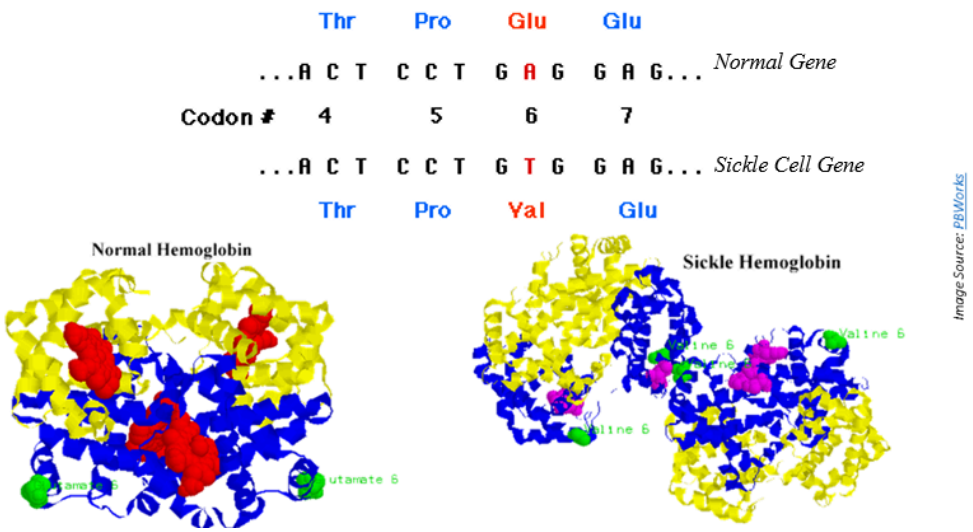
   Hydrophobicity:

   Positive / Negative Charge:

   Cysteine Bonds:

3. **If one base letter is changed in a gene, would this affect a) transcription, b) translation, c) both, or d) neither? Explain.**

   It would affect _____ because…



4. The image above shows the genes associated with normal hemoglobin proteins as well as sickle cell hemoglobin. The proteins are shown below these genes. **A) How do the genes and proteins in individuals with sickle cell anemia differ from those unaffected by this condition? B) How does changing a single base affect hemoglobin proteins, red blood cells, and the entire body?**

5. Sickle cell anemia occurs when a negatively-charged glutamic acid amino acid is replaced by valine (which is neutral and has no charge) in the hemoglobin protein. There are over 500 amino acids in this protein. **Why would changing a single amino acid affect the entire protein? Begin by explaining how different properties of amino acids (attraction/repulsion to water, chemical charge, and cysteine bonds) determine the shape of a protein.**