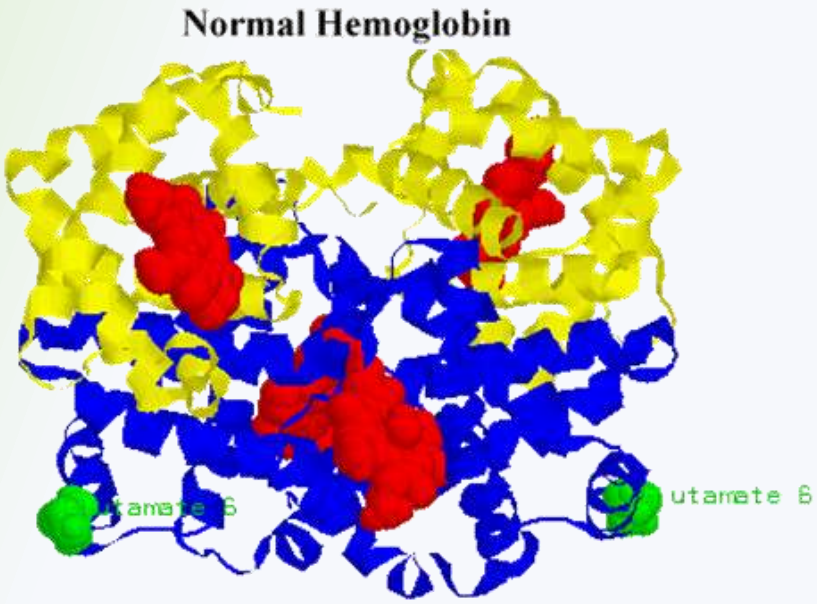
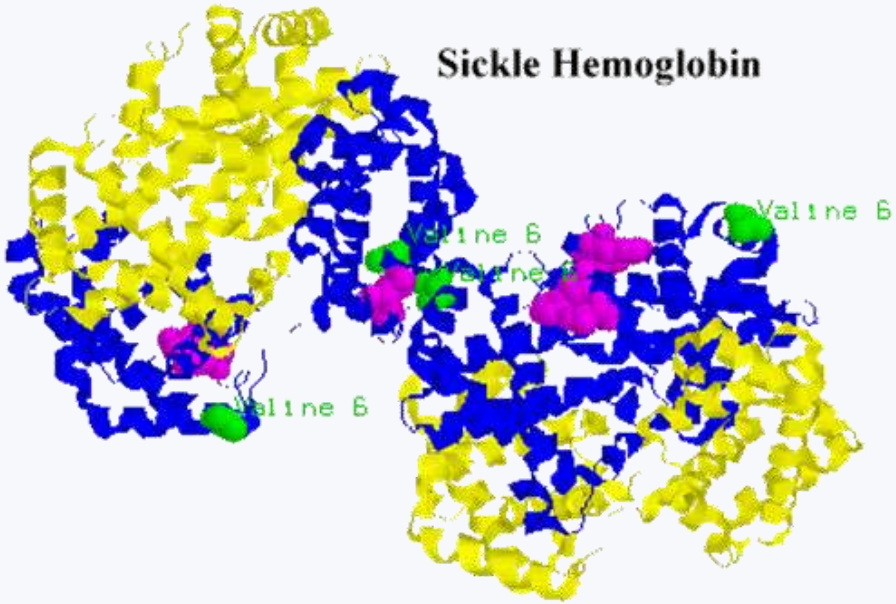
WUHS Biology: Mutations & Change Unit

Packet 1 – How does a protein acquire its shape & function?





Mutations & Change Unit – Packet 1

- **Driving Question: How does a protein acquire its shape & function?**
- How does a chain of amino acids form a functional protein?
- How do the properties of the amino acids determine the shape and function of the protein?
- What happens if the order of amino acids in a protein is changed?

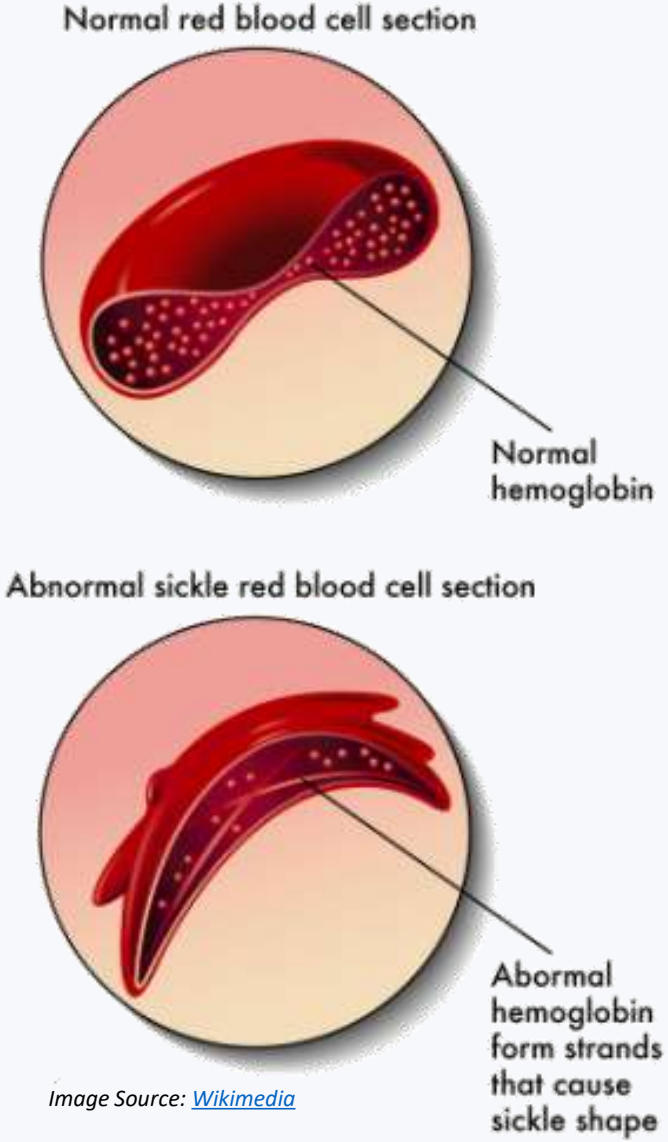


Image Source: Wikimedia

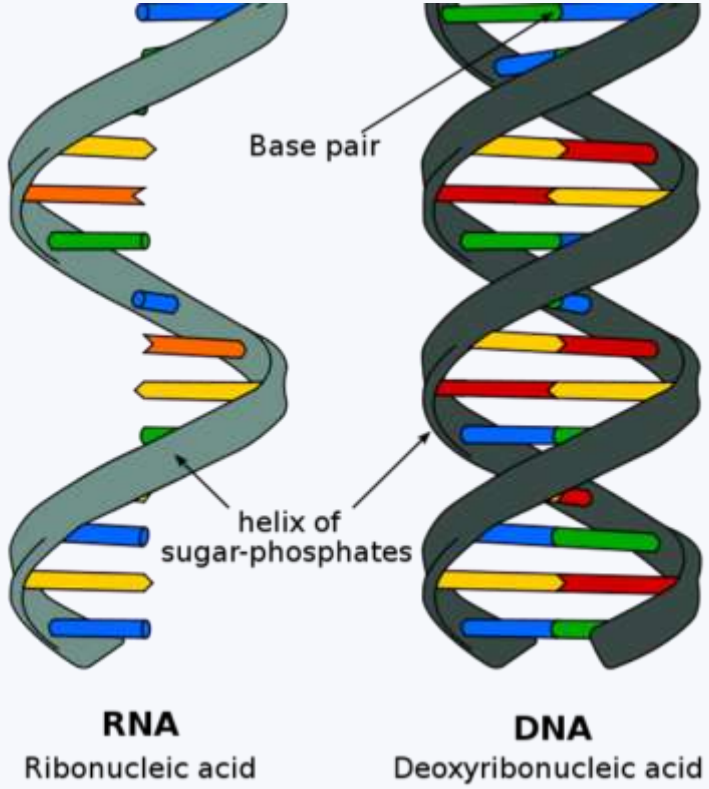
Recap of the DNA Unit

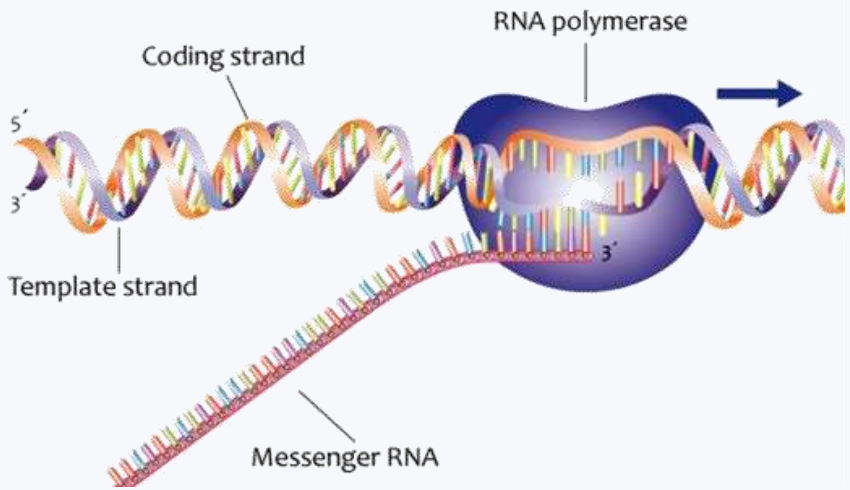
RNA serves as a link between the information stored in DNA and the assembly of proteins.

Unlike DNA, RNA is 1) single stranded, 2) has a slightly different sugar molecule, and 3) uses U instead of T.

Transcription produces an RNA copy of DNA known as mRNA (short for messenger RNA).
mRNA is a copy of the information stored in a gene; it provides a link between the DNA in the nucleus and the protein assembly at the ribosome.

RNA polymerase is the enzyme that creates the mRNA copy.





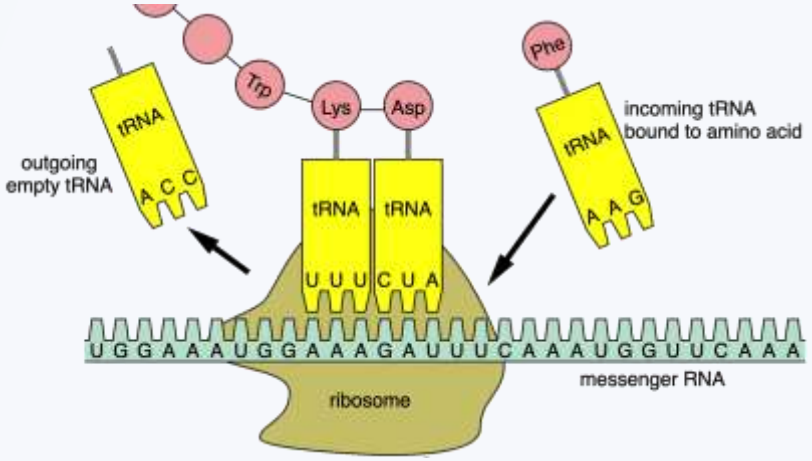
Recap of the DNA Unit

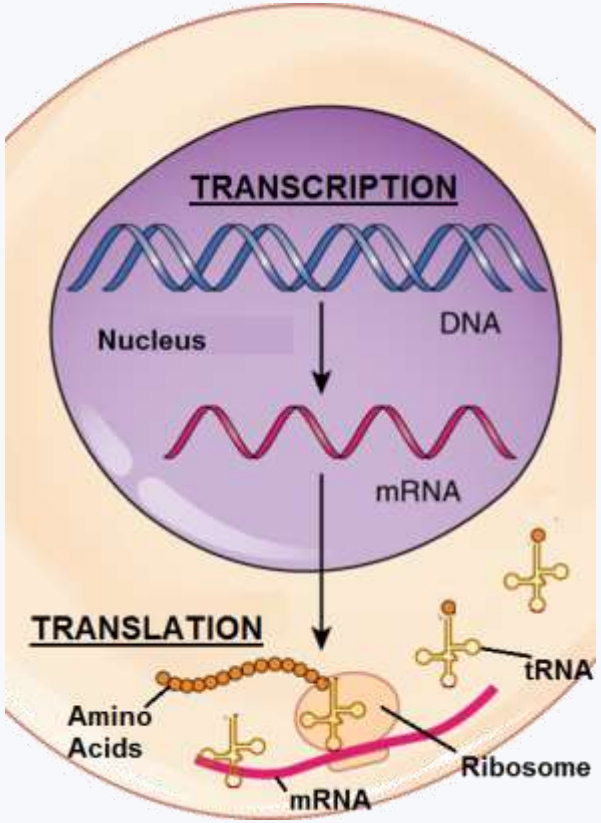
Translation is the actual assembly of a protein from amino acids using the mRNA copy.

Ribosomes are made from ribosomal RNA (rRNA). Ribosomes function like cellular factories that make proteins from amino acids.

As mRNA moves through the ribosome, tRNA delivers amino acids to the ribosome based on each mRNA codon.

tRNA will bind to a codon in mRNA if it has a complementary codon (e.g., CGA → GCU). As tRNA delivers amino acids, they will form a chain that folds into a functional protein.





Protein Shape Determines Function

- **All cells assemble proteins in generally the same way.**
  - The order of bases in the mRNA copy of DNA determines the order in which amino acids are delivered and assembled at a ribosome.
  - A protein generally consists of a chain of hundreds of amino acid molecules.

- **Each protein has a different shape and function.**
  - Amino acids do not stay in a straight line as they leave the ribosome.
  - Instead, the chain of amino acids will fold into a specific shape.

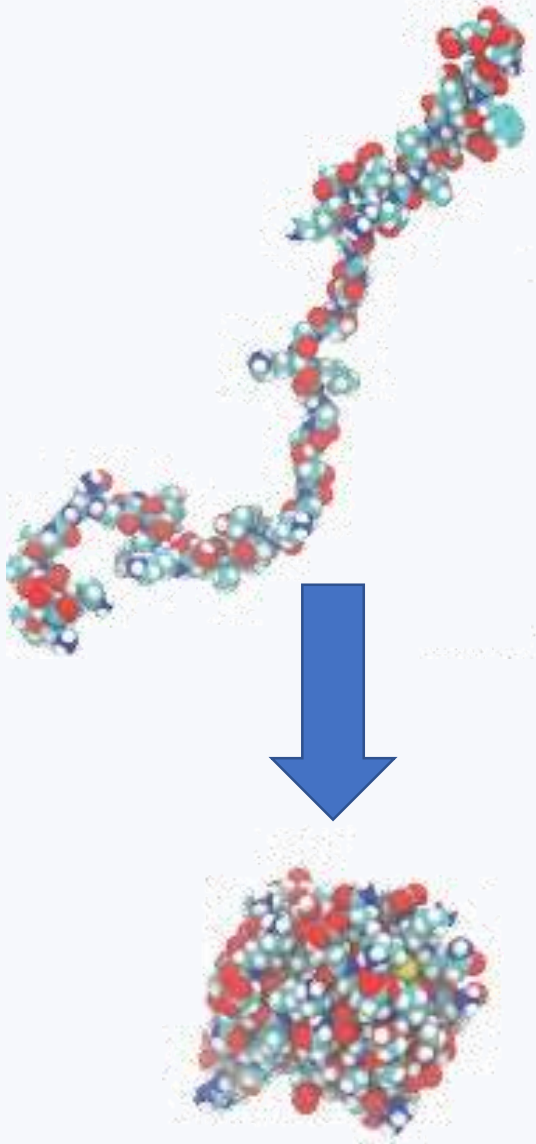


Image Source; Medium

Chains of amino acids fold into a specific shape. This shape determines the function.

Amino Acid Properties

- **Different amino acids have different properties.**
  - The properties of amino acids determines the three-dimensional shape of the protein.
  - The shape of a protein determines its function.

- **The shape of the protein is determined by two key properties in its amino acids:**
  - 1) Whether individual amino acids are attracted to water or repelled by it*.
  - 2) Whether amino acids are attracted to other amino acids or repelled by them.

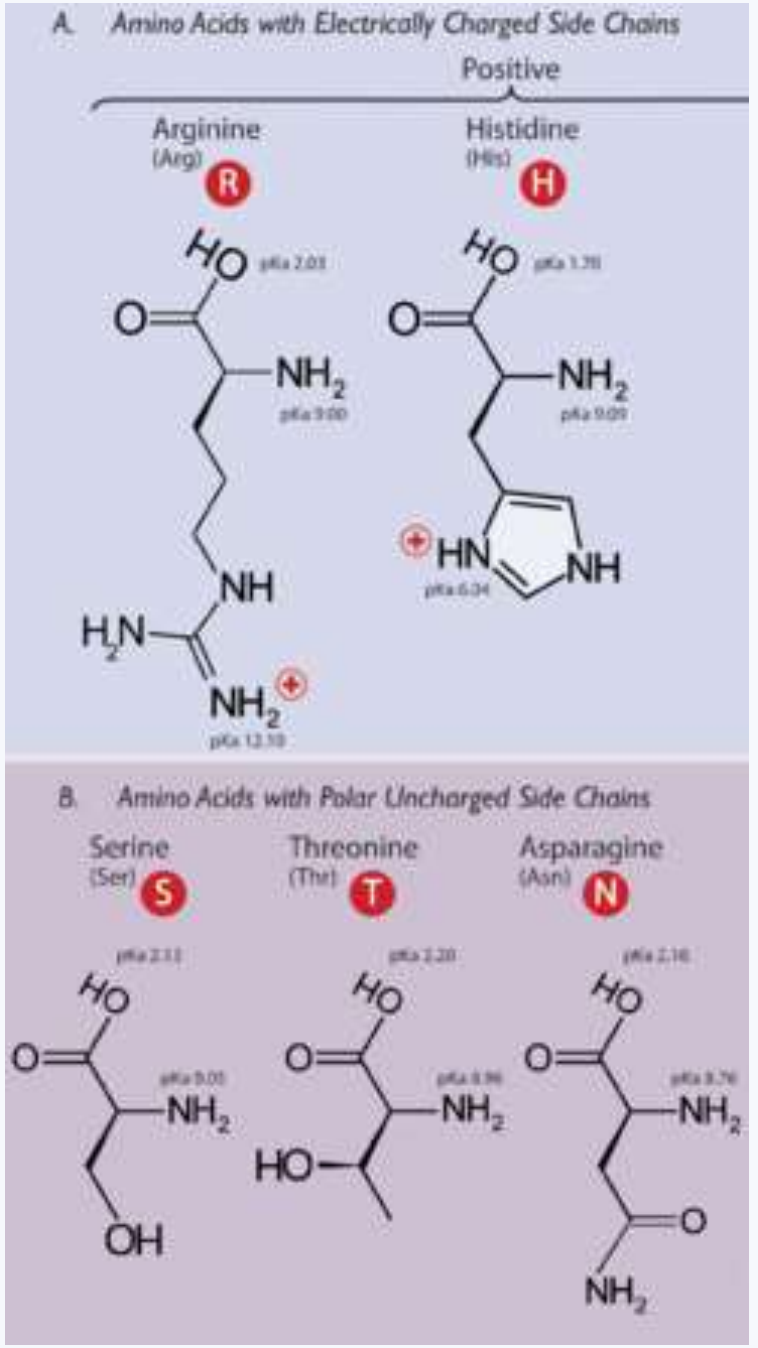


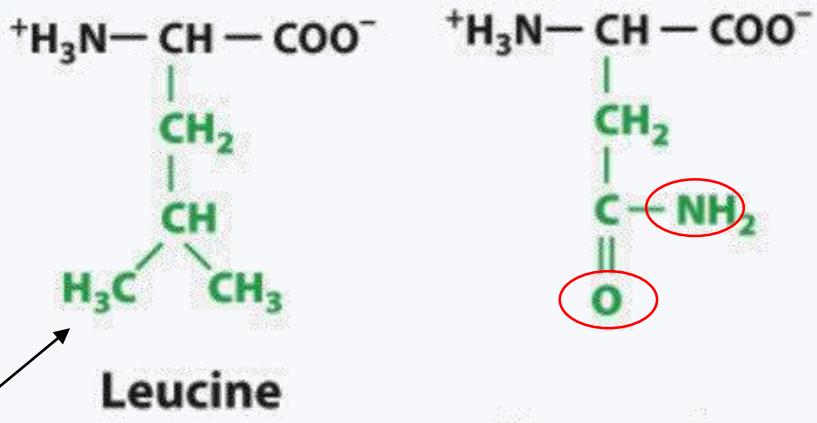
Image Source: Wikimedia

* *This matters because the inside of cells is primarily comprised of water.*

Hydrophobic vs. Hydrophilic

- **The types of elements found in an amino acid determines whether it is attracted to water or repelled by it.**
  - Amino acids that are mostly carbon and hydrogen tend to repel water (hydrophobic).
  - Amino acids with more oxygen and nitrogen atoms are attracted to water (hydrophilic).

- **Whether amino acids are hydrophobic or hydrophilic affects their placement.**
  - *Hydrophobic* amino acids move to the center of a protein to "hide" from water. →
  - *Hydrophilic* amino acids move to the outside of a protein to be closer to water. →



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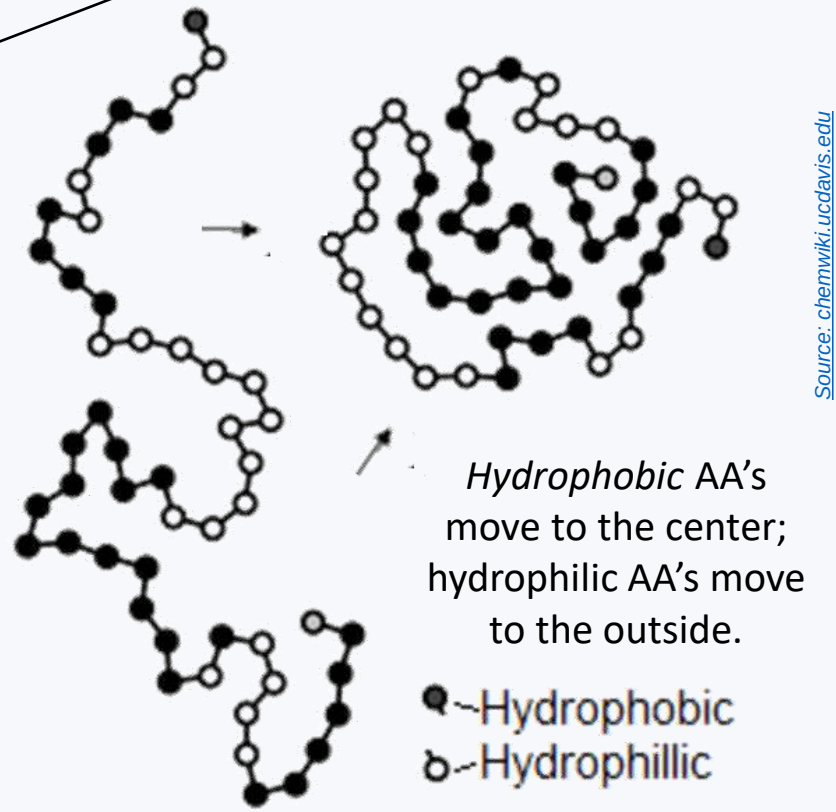


Source: chemwiki.ucdavis.edu

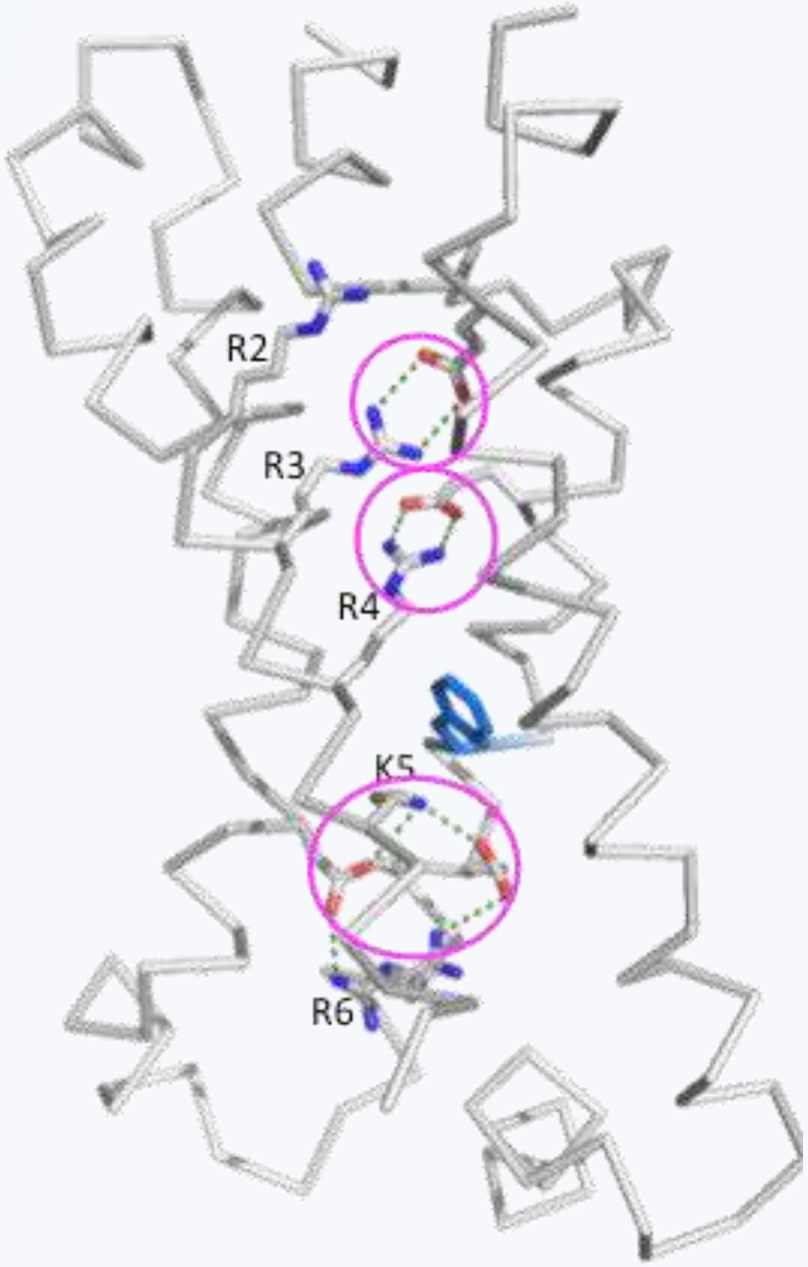
Elements are types of atoms, such as carbon, oxygen, hydrogen, & nitrogen.

Opposite vs. Similar Charge

- **Some amino acids have a positive or a negative charge.**

- **Oppositely-charged amino acids are attracted to each other.**
  - A negatively-charged amino acid will move closer to a positively-charged amino acid.
  - This is similar to how opposite ends of a magnet are attracted to each other.

- **Similarly-charged amino acids repel each other.**
  - Two amino acids with the same charge (*positive-positive or negative-negative*) will try to move further apart.

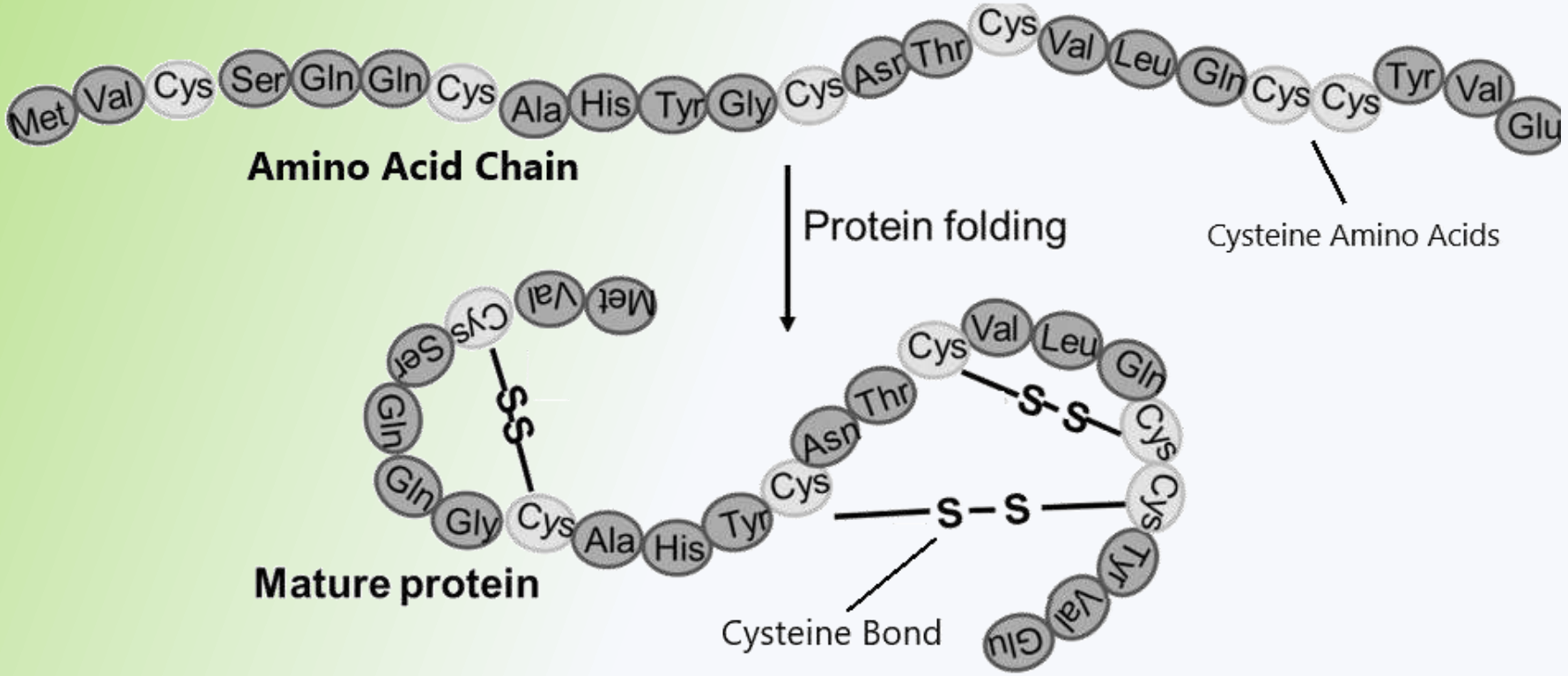


The amino acids in the pink circles are oppositely-charged, and are attracted to each other.

Image Source

Cysteine Bonds

- **A type of amino acid called <u>cysteine</u> forms special bonds with other cysteine molecules.**
  - Cysteine amino acids will move the whole chain of amino acids to bond together.
  - The bonds between two cysteine amino acids is very strong and provides additional stability to a protein.



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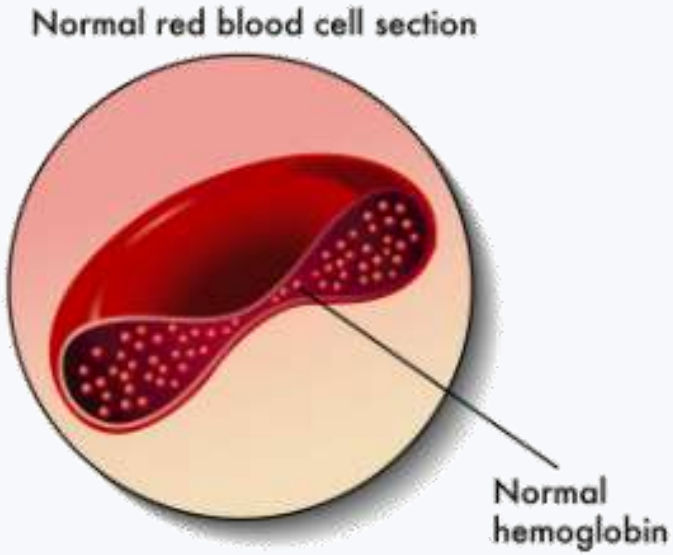
Protein Folding & Misfolding

- **Small variations in genes and amino acid sequences can completely change protein shape & function.**
  - If even one base in a gene changes, it can change the order of amino acids as the protein is assembled.
  - Replacing one amino acid with another amino acid with different properties changes the protein's shape & function.

- **For example, *hemoglobin* is the protein that binds oxygen molecules on a red blood cell.**
  - Altering one base in the hemoglobin gene changes a single amino acid in the hemoglobin protein.
  - The new amino acid has different properties, which changes the shape and function of this protein.
  - This causes a disease called *sickle cell anemia*, which damages blood vessels and decreases blood flow.



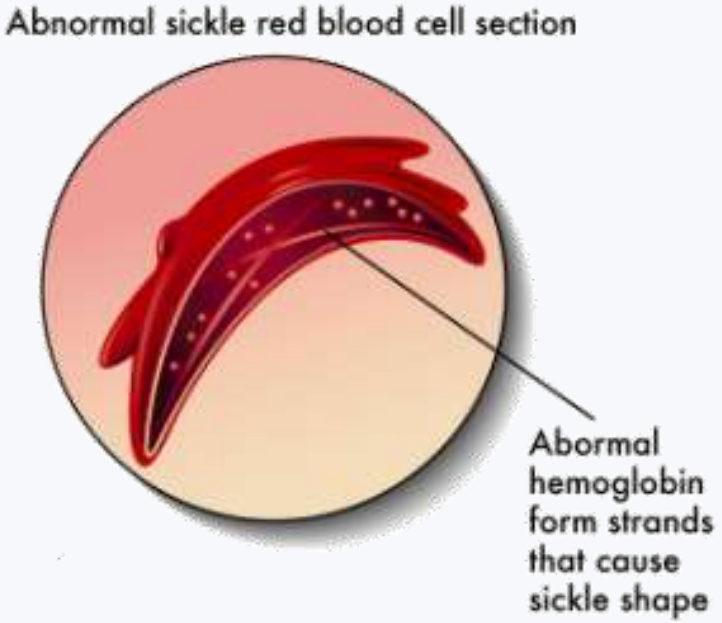


Image Source: Wikimedia

Sickle Cell Anemia

- **Sickle cell anemia occurs when a T in DNA is changed to an A.**
  - This switches one kind of amino acid (glutamic acid) in the protein for another (valine).
- **Changing one amino acid changes the entire hemoglobin protein.**
  - This changes the shape of red blood cells.
  - This causes blood clots and tissue damage.

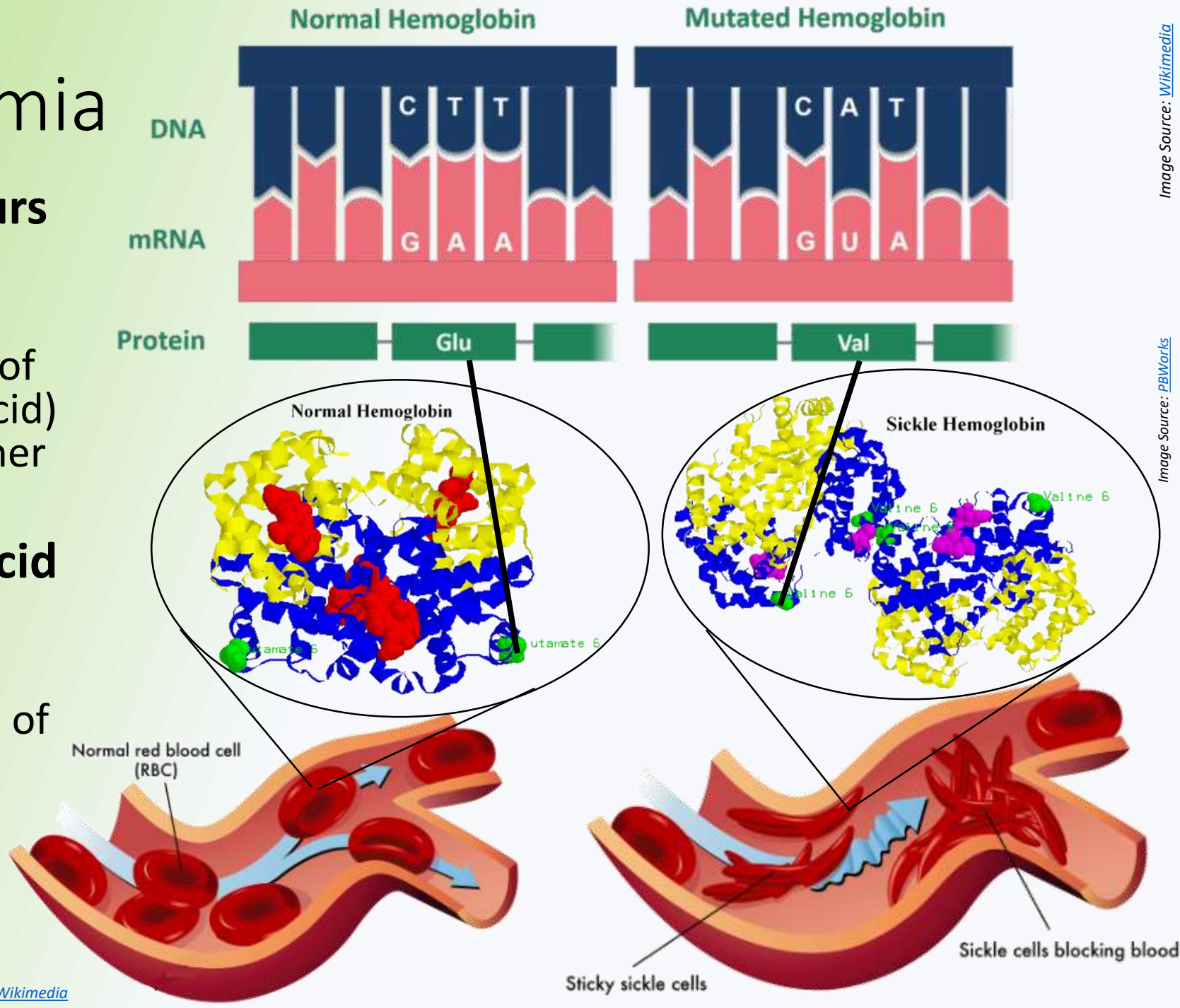


Image Source: Wikimedia

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Revising Our Claims

- **Revisit your ideas from Part 1.**
  - How could you improve your responses to our Driving Questions?
- **How does a protein acquire its shape & function?**
  - How does a chain of amino acids form a functional protein?
  - How do the properties of the amino acids determine the shape and function of the protein?
  - What happens if the order of amino acids in a protein is changed?

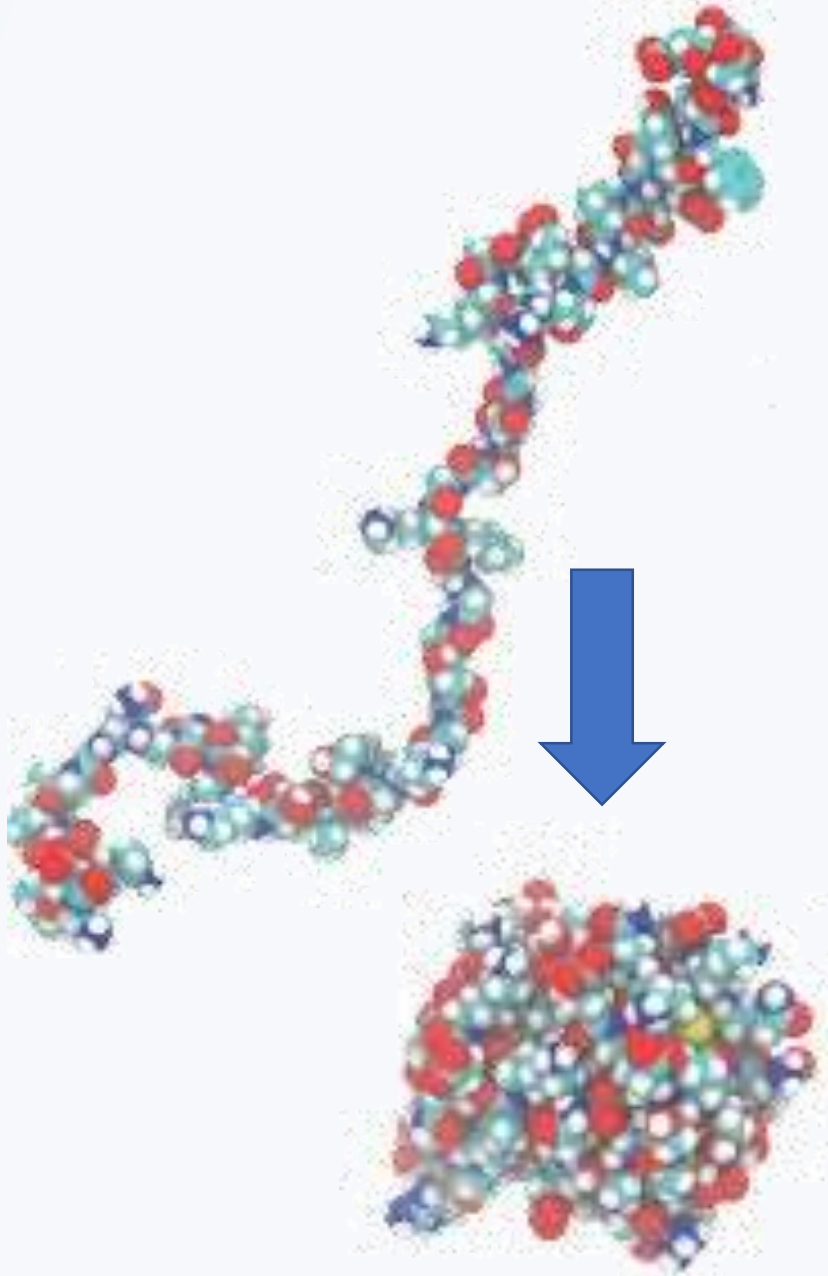

Image Source; Medium

Looking Ahead: Part 3 Investigation

- **In Part 3 you will use models to demonstrate how chains of amino acids fold into specific shapes based on the properties of each amino acid.**

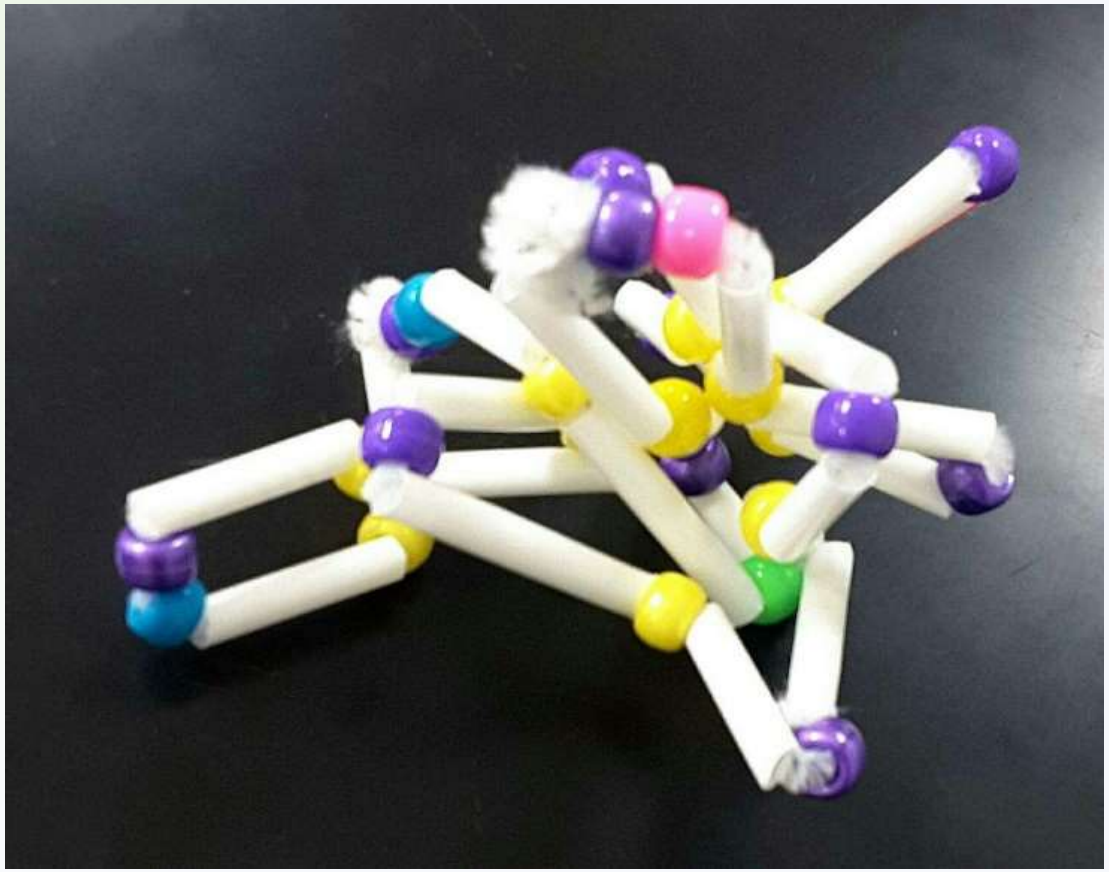

Image Source: Craig Kohn

Key Points

- **The shape of a protein determines its function.**
  - The shape of the protein is determined by the order in which amino acids are assembled (which is coded in the mRNA copy strand).
- **Different amino acids have different properties.**
  - These properties determine the shape of the protein.
- **Some amino acids are attracted to water (hydrophilic). Some amino acids repel water (hydrophobic).**
  - Hydrophobic amino acids move to the center of a group of amino acids.
  - Hydrophilic amino acids move to the outside of a group of amino acids.
- **Some amino acids that are attracted to each other. Some amino acids that repel each other.**
  - Oppositely-charged amino acids are attracted to each other.
  - Similarly-charged amino acids repel each other.

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Key Points

- **Cysteine amino acids form special bonds with other cysteine molecules.**
  - Cysteine bonds are very strong and provides additional stability to a protein.
- **Small changes in amino acid sequences have major consequences for protein folding.**
  - For example, sickle cell anemia is caused when a single base is changed in the gene, changing one amino acid which disrupts the folding of the entire protein.
  - This deforms red blood cells, causing clots and tissue damage.
- **Key Vocab:**
  - Hydrophilic: attracted to water.
  - Hydrophobic: repelled by water.
  - Cysteine: an amino acid that forms unique bonds with other cysteines.

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