DNA Structure and Function

Enrichment Lab

Central Question:
- Can a desired trait be traced back to the DNA code?

Objectives:
- Demonstrate how DNA is the code for inherited traits
- Describe how transcription and translation result in the form and function of an organism
- Manipulate DNA, mRNA, and tRNA models to observe characteristics of transcription and translation

Related NE Science Standards:
Life Science – Heredity
- SC12.3.2 Students will describe the molecular basis of reproduction and heredity
  - SC12.3.2.b Describe the basic structure of DNA and its function in genetic inheritance

Anticipated Length:
50 minutes

Lab Materials:
- Name tag or tape
- Marker
- Scotch tape
- Scissors
- Copy of Enrichment Lab and Handouts

Teacher Notes:
- This enrichment lab activity is designed to complement your classroom instruction on DNA structure, function, transcription, and translation. The lab is written to be either self-guided by students or enhanced with additional classroom instruction and activities.
- Visit www.ideabin.org for a short video accommodating this lab titled "DNA Structure and Function in Genetic Inheritance".

NEBRASKA SOYBEAN CHECKOFF

Polypeptide Chart and Analysis

Answer Key

	Polypeptide Sequence	Does it include the desired polypeptide? If not, how many amino acids don't match?
Parent 1	Met – Lys – Trp – Pro - STOP	Yes
Parent 2	Met – Pro – Trp - Pro - Gly	No, Gly is not in the desired polypeptide. Pro is, but is not in the correct place in Parent 2.
Parent 3	Met – Lys – Trp – Pro - Gly	Yes

Analysis

1. **None of the parents had the same DNA sequence to start. Explain how it is possible for multiple parents to create the same desirable polypeptide if the DNA was not the same.**

   Multiple anticodons carry the same amino acid. That means that multiple codons can code for the same amino acid which would also mean that the DNA can have some variation as long as it will transcribe and translate back to the same amino acid. For example: DNA segments AAA and AAG create mRNA codons UUU and UUC. These codons bring in anticodons of AAA and AAG, both which carry Phe (Phenylalanine).

2. **Between parents 1, 2, and 3, which would you breed together to increase the chances of passing on the desired polypeptide. Explain your answer in relation to what you know about inheritance.**

   Parent 1 & 3. Both parents are carriers of the desired polypeptide so the chances of passing it on to the offspring is likely 100% unless a mutation were to occur.

DNA Structure and Function: Finding the Code

Student Name: _____

Background

A gene is a segment of DNA that codes for a specific protein which determines the form and function of an organism. Genes are hundreds or thousands of nucleotides long and each is a specific sequence of bases which is the instructions for a unique sequence of amino acids that makes up the protein. Transcription and translation are the two processes that work to create proteins from DNA code.

Transcription is the process that creates mRNA. The mRNA is a strand of nucleotides complementary to the gene DNA. mRNA carries the gene's protein building instructions to the site of translation which is the ribosome. The code and instructions carried by the mRNA is considered a triplet code. This means that 3 bases of the mRNA are read as a group to code for a single amino acid. For example, the three mRNA bases UGG code for one amino acid, Tryptophan which is abbreviated as Trp. The triplet of mRNA bases is called a codon. The mRNA codons are matched up with tRNA anticodons which are a complimentary set of triplet bases.

Translation uses a ribosome to synthesizes a polypeptide, or chain of amino acids, from the instructions carried by the mRNA. Another molecule called tRNA is required for translation. The tRNA caries amino acids to the ribosome where the codons of mRNA and the anticodons of tRNA align to each other so the amino acids can bond together to form a chain of amino acids. Ultimately, the polypeptide of amino acids will be completed, creating a protein to be expressed in the form or function of the organism.

Soybeans and Protein

Soybeans are a great source for plant-based proteins. By weight, roughly 36% of a raw soybean is protein[1]. When thinking of protein in a diet we often think of growth and development of muscle, and specific proteins are great at developing muscle. But to understand how proteins consumed by animals or humans help create new tissues like muscle, or aid in the functions a body must complete throughout a day to live, we need to look at the components of the protein which are the amino acids.

The majority of soybeans produced in the United States are turned into soybean meal and used to feed poultry and livestock[2]. This creates an interest in plant breeders to select and produce soybean varieties that have the amino acids an animal can digest and use to aid in grow and development.

[1]SoyConnection. Retrieved from: http://www.soyconnection.com/soy_foods/nutritional_composition.php on September 21, 2016.
[2]United Soybean Board. Retrieved from: http://nebraskasoybeans.org/education/soybeans-101/ on September 21, 2016.

Finding the Code – Instructions

Student Name: _____

Scenario

A plant geneticist has identified a polypeptide (amino acid) segment in soy protein that has three major benefits to animals. The amino acids and benefits that make up the polypeptide sequence are as follows:

- Lysine (Lys): Direct correlation to normal growth and development. As lysine increases growth and development increase or continues as normal. As lysine decreases, growth and development decrease or are slowed.
- Tryptophan (Trp): Needed to synthesize Vitamin B3 which is used to create cellular energy.
- Proline (Pro): Aids to reduce the reaction and effects of stress.

As a plant breeder, you know this sequence is not uncommon in certain soybeans and you want to make sure the parent plants you are using for breeding already contain this beneficial sequence of amino acids: Lysine – Tryptophan – Proline.

Your job is to analyze identified segments of DNA from three parent plants and choose which plants to use to get the beneficial traits. You will do this by locating the desired amino acid sequence and choosing the parent plants that are most likely to pass this polypeptide to its offspring. If you can prove your soybeans have this trait, you can advertise the additional nutritional benefits of soybeans when used as animal feed.

Procedure

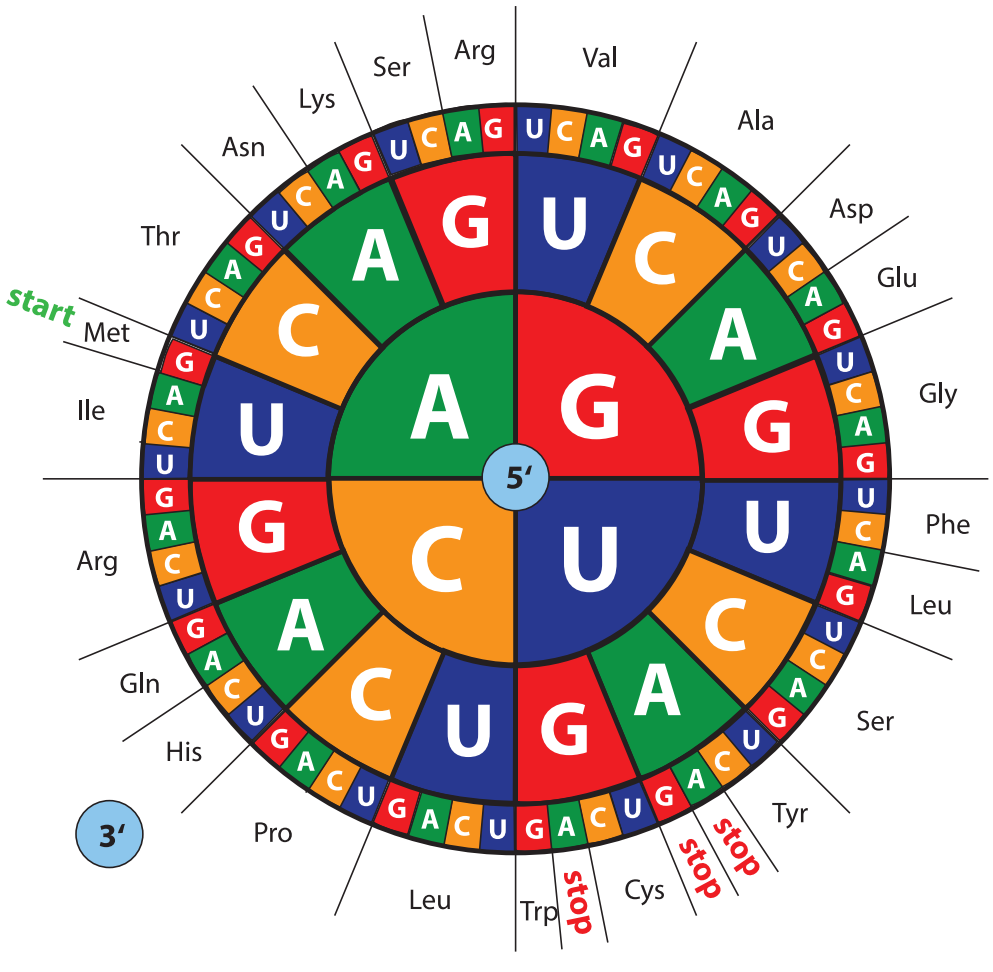
1. Working with a partner, cut out the tRNA rectangles on the bottom of the three parent handouts, mix them in a pile and set aside.
2. Using a name tag or piece of tape, write "DNA Polymerase," and fix it to one person in the pair.
    a. This person will be responsible for the process of transcription (using double-stranded DNA to make a single-stranded copy called mRNA)
3. Using the handout for Parent 1, model transcription by filling in the nitrogen bases on the mRNA strand with letters that correspond with the DNA nitrogen bases on the top strand.
    a. Remember: G => C C => G T => A A => U
4. Complete transcription by cutting on both sides of the mRNA to represent mRNA detaching and leaving the nucleus. Set DNA and mRNA strands aside.
5. Using another name tag or piece of tape, write "Ribosome," and fix it to the other person in the pair.
    a. This person will be responsible for the process of translation (using mRNA and tRNA to assemble an amino acid chain that will create the protein that causes the trait).
6. Match the mRNA with the complementary bases on the tRNA molecules.
    a. Remember: G => C C => G A => U U => A
    b. Ribosomes read mRNA 5' to 3'
7. Once in the correct order, tape the amino acids together above the dashed lines. Then cut along the dashed lines to release the tRNA molecules. Label your new polypeptide chain 1, 2, or 3 correlating to the parent number.
8. Record your polypeptide sequence on the polypeptide chart.
9. Repeat steps 1-8 with the Parent 2 and 3 handouts.
10. Complete the two analysis questions.

Charts for the Lab Activity

Student Name: _____

Base Pairing Rules			
	DNA Replication	Transcription	Translation	
DNA	**DNA**	**mRNA**	**tRNA**
T	A	U	A
A	T	A	U
C	G	C	G
G	C	G	C

Codon to Amino Acid Table



Polypeptide Chart and Analysis

Student Name: _____

Polypeptide Chart

	Polypeptide Sequence	Does it include the desired polypeptide? If not, how many amino acids don't match?
Parent 1		
Parent 2		
Parent 3		

Analysis

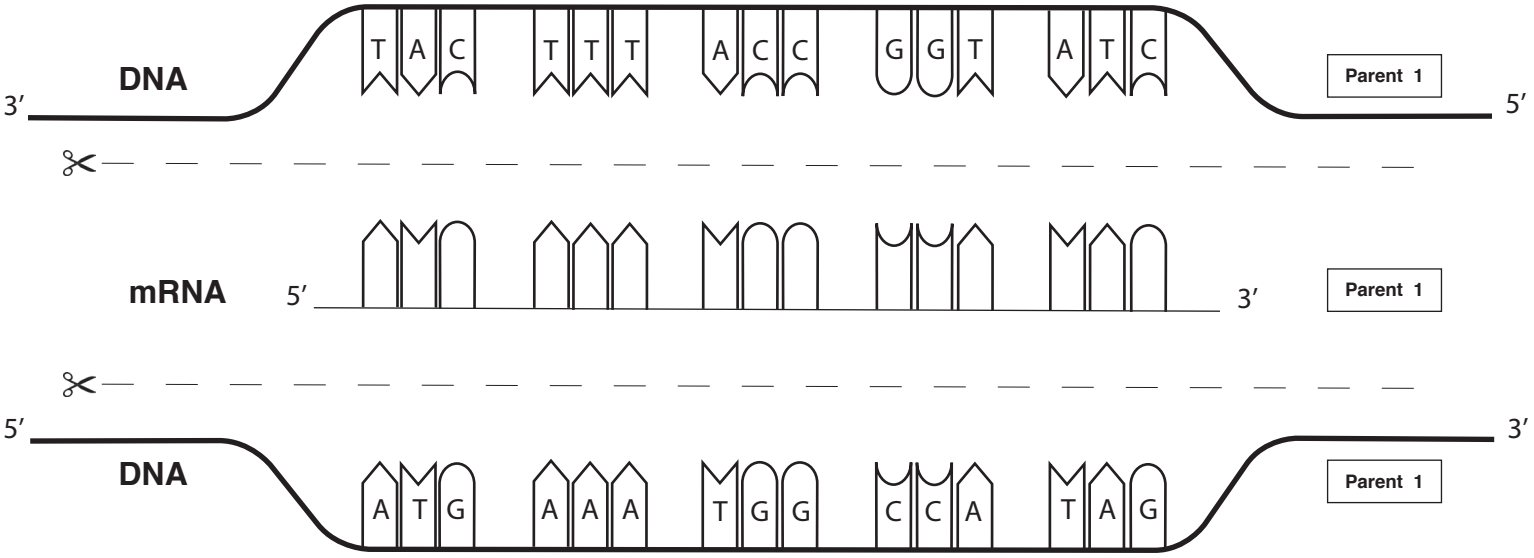
1. **None of the parents had the same DNA sequence to start. Explain how it is possible for multiple parents to create the same desirable polypeptide if the DNA was not the same.**

2. **Between parents 1, 2, and 3, which would you breed together to increase the chances of passing on the desired polypeptide. Explain your answer in relation to what you know about inheritance.**

Parent 1

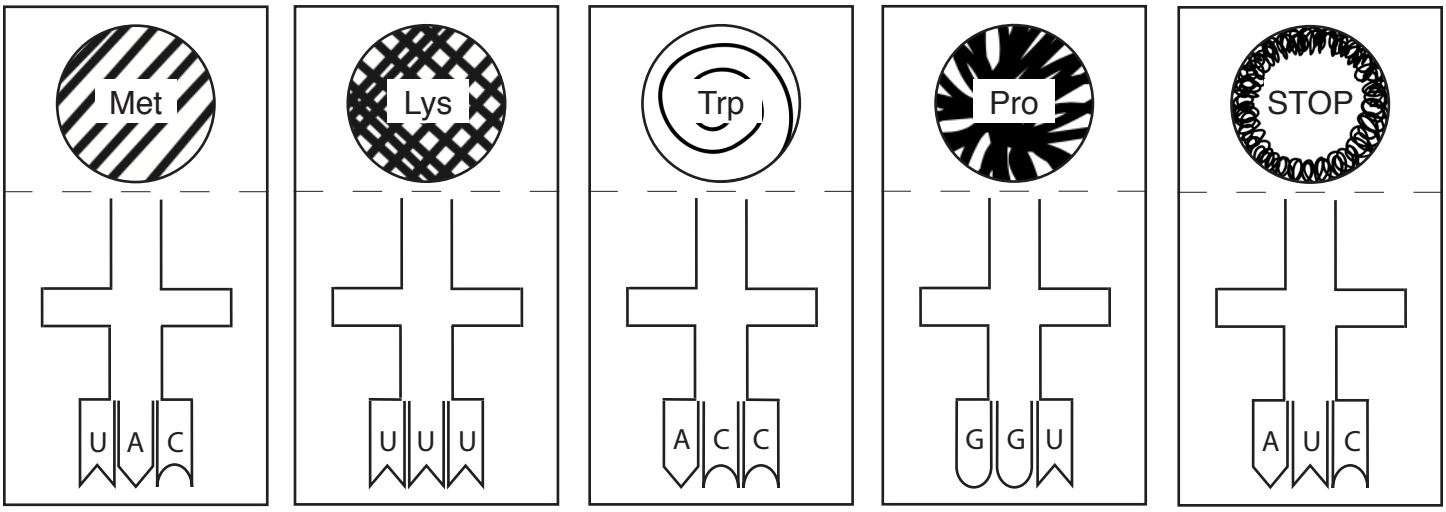
Transcription

Write the complimentary mRNA nucleotide bases in the boxes on the mRNA strand.



Translation

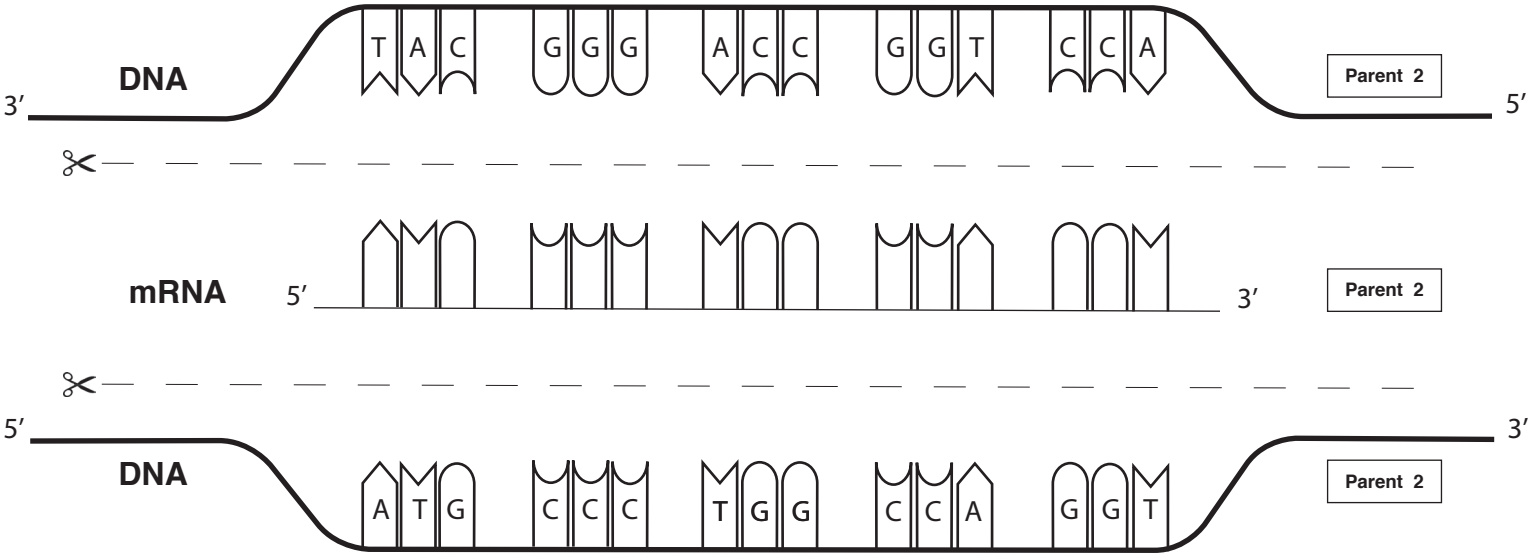
Cut out the boxes and use the tRNA molecule to create an amino acid chain!



Parent 2

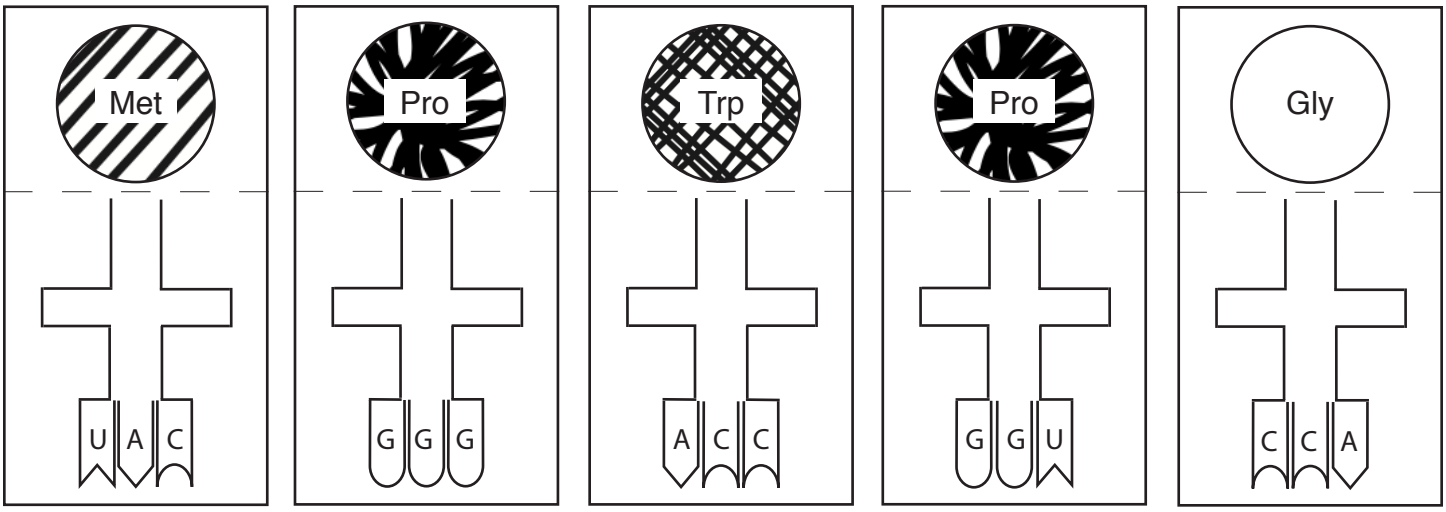
Transcription

Write the complimentary mRNA nucleotide bases in the boxes on the mRNA strand.



Translation

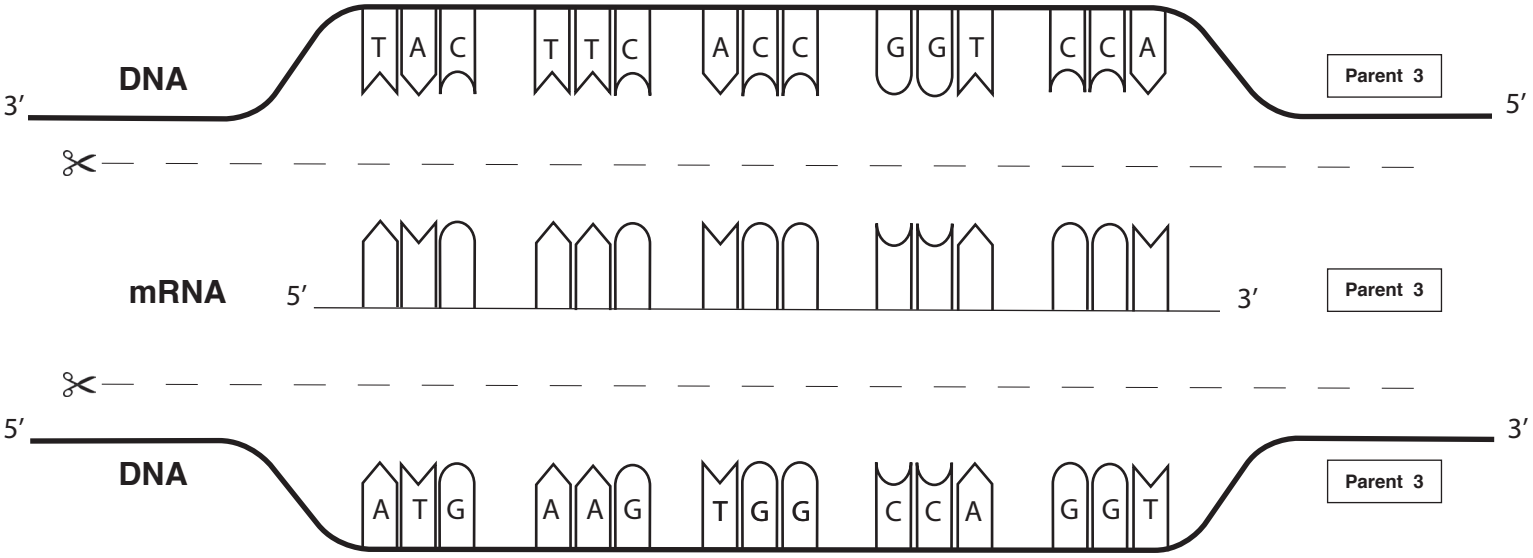
Cut out the boxes and use the tRNA molecule to create an amino acid chain!



Parent 3

Transcription

Write the complimentary mRNA nucleotide bases in the boxes on the mRNA strand.



Translation

Cut out the boxes and use the tRNA molecule to create an amino acid chain!