BIOTECHNOLOGY (HS)

DNA sentences

Focus question	How are proteins coded for by DNA?
Learning target	Students use DNA, codons, and anticodons to transcribe and translate sentences related to information about corn.
Vocabulary	Deoxyribonucleic acid (DNA), messenger RNA (mRNA), transfer RNA (tRNA), CRISPR, transcription, translation, codons, anticodons, introns, exons

LS1: From Molecules to Organisms: Structures and Processes

Performance expectation HS-LS1-1	**Classroom connection:** Students use DNA, codons, and anticodons to transcribe and translate sentences related to information about corn.

Science and engineering practices

Constructing Explanations and Designing Solutions	**Classroom connection:** Students construct an explanation by writing out the processes of transcription and translation for proteins after completing their groups' four sentences (proteins) from words (amino acids) correctly using the terms: DNA, mRNA and tRNA. (Students will need to correct the sentences if they are incorrect before constructing their explanation). Students design solutions by modeling "genetically modified" DNA to make a different sentence using the transcription and translation rules they followed; describing that the sentence they make will represent a different protein. Extension: Model CRISPR by "knocking out" a portion of a gene to make a different protein.

Disciplinary core ideas

LS1.A: Structure and Function	**Classroom connection:** DNA is shown as the guide for the creation of proteins; changes in DNA create changes in the mRNA and tRNA, therefore in the words (amino acids) of the sentences (proteins).

Cross-cutting concepts

Structure and Function	**Classroom connection:** Students determine a new DNA combination to change the composition of the words (amino acids) and sentence (protein).

Materials

- DNA strand cards and tRNA cards with words on the back
- Transcription/Translation data sheet
- Large sheet of paper for each group
- Markers

Prior knowledge

In order to successfully complete this activity, students must know that DNA bases match according to the following table:

DNA	mRNA	tRNA
A	U	A
C	G	C
T	A	U
G	C	G

In addition, those three letter codes actually match up with amino acids to make proteins just as the words in this activity make sentences. The order and number of the amino acids determine the protein.

Teacher preparation

1. Copy the DNA strips and cut into separate strands.
2. Copy the tRNA cards front to back so anticodons are on one side with words on the other.
3. Set out DNA strands at a central location in the room. (This location represents the nucleus; remember that DNA does not leave the nucleus.)
4. Set out tRNA cards around the perimeter of the room, grouped by first letters of the anticodons (*A*s together, *C*s together, etc.)
5. Group students by fours; provide each group with a copy of the Transcription/Translation data sheet copied front to back so each group has enough for the number of sentences assigned. *Note: Each box in the grid is for a codon or anticodon (three-letter code).*
6. Assign sentences to groups. (If all students will practice all roles, each group of four should have four sentences assigned.)
    a. Students will send their transcriber to the nucleus to transcribe the DNA to mRNA.
    b. After transcription, the student returns to the group table and hands the transcription to the translator (tRNA).
    c. After translation, the runners go to find the matching translated tRNA anticodons around the room and once they find the match, they copy the word to their data sheet. *Students must not take the tRNA cards* as they are used in multiple sentences.
    d. Together, the group determines the sentence, looking for errors.
    e. Students switch roles (transcriber becomes translator, translator becomes a runner, one runner becomes the transcriber).
    f. Repeat these steps for the number of sentences assigned.
    g. Have students *construct an explanation* (orally, on video, or written) of the process they used to transcribe and translate the sentences correctly using the words: DNA, mRNA, tRNA, amino acids and proteins.
7. Students, in groups or individually, *design a solution* by creating their own DNA sentence that will code for a different sentence (using the words in the simulation). Students exchange their new DNA strand with another group/student to check their "genetic engineering."

Student handout

Reflection

1. How are chromosomes, DNA, genes, and proteins related?

Chromosomes are strands of DNA; they contain genes, which are portions of the DNA strands. The bases of DNA that are contained in a gene code for amino acids in a specific order to create proteins that create a trait.

2. What area of the cell does the table holding DNA represent in this modeling activity? Why can't the DNA strand be brought back to your group?

The nucleus is where DNA is located in a cell. DNA does not leave the nucleus.

3. What area of the cell does your table represent?

The table represents the ribosome. The ribosome is the location of protein synthesis.

4. What do the words represent? The completed sentences?

The words represent amino acids, and the completed sentences represent the proteins.

5. What do you think the consequences might be if an error occurred in the cell as it goes through the process of protein synthesis?

If an error occurs in the transcription or translation process, different codons and anticodons would be produced. This might result in different amino acids that might change the function of the protein and/or prevent a protein from being formed at all.

Differentiation

Other ways to connect with students with various needs:

- **Local community:** Students may identify common proteins in food sources and test using Biuret solution to see relative amounts.
- **Students with special needs (language/reading/auditory/visual):** Cards can be enlarged for the visually impaired or spoken so all can participate in the activity.
- **Extra support:** If students are struggling, they may watch Transcription and Translation: From DNA to Protein **youtu.be/bKIpDtJdK8Q**
- **Extensions:** After completing transcription and translation of the assigned sentences, students may research the evidence for or against the statement. Additionally, students could model CRISPR-Cas9 by "knocking out" a portion of a gene to make a different sentence (protein). Follow the CRISPR HHMI Biointeractive Click and Learn to see the mechanism used.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins.	Participated in the DNA sentence activity. Explanation of the function of DNA and the roles of DNA, mRNA, and tRNA in transcription and translation of DNA into proteins does not accurately or completely explain the process.	Participated in the DNA sentence activity. Explanation of the function of DNA and the roles of DNA, mRNA, and tRNA in transcription and translation of DNA into proteins is complete and accurate; new DNA describes a different sentence (protein).	Participated in the DNA sentence activity. Explanation of the function of DNA and the roles of DNA, mRNA, and tRNA in transcription and translation of DNA into proteins is complete and accurate; new DNA strand describes a different "sentence" that describes an actual protein that will carry out a particular function. (i.e. GFP, insulin, etc)

Rubric for self-assessment

Skill	Yes	No	Unsure
I participated in each role during the DNA activity.			
I can explain the function of DNA and the roles of DNA, mRNA, and tRNA in transcription and translation of DNA into proteins.			
I created a new "sentence" (protein) using DNA triplets to create a different set of words (amino acids)			
We divided up the work fairly.			

AAA

AAC

AAG

AAU

ACA

ACC

ACG

ACU

PESTICIDE

GMOs

SOIL

SUSTAINABILITY

POUNDS/GALLONS/
PERCENT

MOST

SOME

CAN

AGA

AGC

AGG

AGU

AUA

AUC

AUG

AUU

NUTRITION

USE(D)/USING

ETHANOL

CORN

ENERGY/FUEL

DEMAND

.

FROM

CAA

CAC

CAG

CAU

CCA

CCC

CCG

CCU

DROUGHT

FOOD

TO

MAKES/EQUALS

INCREASE(ING)/
IMPROVE(ING)/
MORE

DISTILLER'S
DRIED GRAINS

LAND

DECREASE(S)/
DECREASING/
LESS

CGA

CGG

CGU

CUU

GAA

GAC

GAG

GAU

BIOTECHNOLOGY

MEET(S)

ONE

YIELD

CLEAN

DENT

BUSHEL

AND

GCA

GCG

GCU

GUA

GUU

UAA

UAC

UAG

WILL

MARGINAL

OUR

QUALITY

LIFE

WATER

CO_2

START

UAU

UCC

UCG

UGA

UGC

UGG

UGU

UUA

IS/ARE

FOR

PRODUCE(S)/
PRODUCTS/
PRODUCTION

THE

MOLECULE

POVERTY

DNA

GROW

UUC

UUG

UUU

17.5/56/2.8/40

TOLERANT

OF/ON

1 TAC AGT CCG TAG TGA ATT

2 TAC AGT TCC GAC ATC ATG AGG ATT

3 TAC AAA CCC AGC ATT

4 TAC TTA TCC TCG TGG TTT TAA ATT

5 TAC CGG CCC CGT ATT

6 TAC CGG CCG AAC AGA ATT

7 TAC AAA GCG CGA TCG CCC ATA TAT CAA ATT

8 TAC AAA CCG TGC GAG CCC AAG ATT

9 TAC AAA ACG TGT TTT GCA CCT ATT

10 TAC ACT AGG TCC CAC TTC ATT

11 TAC CTT GAT TTT AGG AGA TAT AGT CAG TTG ACC TTT CCA ATT

12 TAC AGG AGT CGA TCG ATA TAT ATC GAG CAA ATT

13 TAC CTT GAT TTT AGG CAG TTG ACC ATT

14 TAC CTT GAT TTT AGG CAG TTG ACC TTT AGT ATT

15 TAC AAA TGT CCC CAA TTT CCG CCT ATT

16 TAC CGG CCG ATC AGA ATT

17 TAC CGG CCG TAG TGA ATT

18 TAC CGG CCC GTT GAG GTT GCT ATT

19 TAC TTG ACC TTT AGG TCC AGA CAT TGA AGT ATT

20 TAC GAA AGG TGA ACA AGG TGA ATT

Transcription/translation group data sheet

Sentence number: _____

Transcriber name: _____

mRNA codons:

Translator: _____

tRNA codons:

Sentence: _____

tRNA runner name: _____

tRNA runner name: _____

Transcription/translation group data sheet

Sentence number: _____

Transcriber name: _____

mRNA codons:

Translator: _____

tRNA codons:

Sentence: _____

tRNA runner name: _____

tRNA runner name: _____

Key: Sentences with DNA codes

1. Ethanol decreases CO2 production.
   TAC AGT CCG TAG TGA ATT
2. Ethanol is clean energy from corn.
   TAC AGT TCC GAC ATC ATG AGG ATT
3. GMOs improve nutrition.
   TAC AAA CCC AGC ATT
4. DNA is the molecule of life.
   TAC TTA TCC TCG TGG TTT TAA ATT
5. Biotechnology increases yield.
   TAC CGG CCC CGT ATT
6. Biotechnology decreases pesticide use.
   TAC CGG CCG AAC AGA ATT
7. GMOs will meet the increasing demand for food.
   TAC AAA GCG CGA TCG CCC ATA TAT CAA ATT
8. GMOs decrease poverty and increase sustainability.
   TAC AAA CCG TGC GAG CCC AAG ATT
9. GMOs can grow on marginal land
   TAC AAA ACG TGT TTT GCA CCT ATT
10. Some corn is drought tolerant.
    TAC ACT AGG TCC CAC TTC AAT
11. One bushel of corn used for ethanol makes 17.5 pounds of distiller's dried grains.
    TAC CTT GAT TTT AGG AGA TAT AGT CAG TTG ACC TTT CCA ATT
12. Corn ethanol meets the demand for fuel and food.
    TAC AGG AGT CGA TCG ATA TAT ATC GAG CAA ATT
13. One bushel of corn equals 56 pounds.
    TAC CTT GAT TTT AGG CAG TTG ACC ATT
14. One bushel of corn makes 2.8 gallons of ethanol.
    TAC CTT GAT TTT AGG CAG TTG ACC TTT AGT ATT
15. GMOs grow more food on less land.
    TAC AAA TGT CCC CAA TTT CCG CCT ATT
16. Biotechnology decreases energy use.
    TAC CGG CCG ATC AGA ATT
17. Biotechnology decreases CO2 production.
    TAC CGG CCG TAG TGA ATT
18. Biotechnology improves water and soil quality.
    TAC CGG CCC GTT GAG AAT GCT ATT
19. 40% of corn is used to produce ethanol.
    TAC TTG ACC TTT AGG TCC AGA CAT TGA AGT ATT
20. Dent corn produces most corn products.
    TAC GAA AGG TGA ACA AGG TGA ATT