

Investigate protein synthesis

How are proteins coded for by DNA?

Standards

- **B.H.1:** Cellular genetics
- **B.H.2:** Structure and function of DNA in cells

Introduction

Scientists can obtain new combinations of desirable traits in animals through genetics. Let's take a look at how deoxyribonucleic acid (DNA) regulates the flow of information within a chicken's cells in the process known as protein synthesis. DNA, the molecule of life, is one of the most recognizable nucleic acids, a double-stranded helix. The process by which DNA codes for proteins involves enzymes and additional single-stranded nucleic acids, specifically messenger ribonucleic acid (mRNA) and transfer ribonucleic acid (tRNA). All students need to know the steps in protein synthesis in order to understand the mechanics of genetics and how traits are expressed. This activity helps to assess student understanding and/or review the concept. The steps in protein synthesis—transcription from DNA to mRNA and translation from mRNA to tRNA—can be demonstrated by modeling. In this activity, each triplet code of DNA represents a word in a sentence rather than a code for an amino acid. Introns and exons are omitted. The words can be found by transcribing the DNA into mRNA, then translating into tRNA.

Student prior knowledge

Students should understand that each nucleotide consists of a phosphate group, a sugar molecule (deoxyribose) and one of four nitrogenous bases: adenine (A), thymine (T), cytosine (C), or guanine (G). Students should know that A pairs with T, and C with G, through hydrogen bonds, forming complementary base pairs.

Suggested timeline

1 class period (50 minutes)

Materials

- DNA strand cards and tRNA cards with words on the back
- Transcription/translation data sheet
- Large sheet of paper
- Markers

Teacher preparation

1. Set out DNA strands at a central location in the room.
2. Set out tRNA cards around the perimeter of the room, grouped by first letters of the anticodons (As together, Cs together, etc).
3. Assign sentences to student groups. (If all students will practice all roles, each group of four should have four sentences assigned.)

Procedure

1. Choose one person to be the transcriber. Find the DNA strands assigned located at the table in the center of the room.
2. On the data sheet provided, transcribe the mRNA codons from the DNA strand (without moving the DNA).
3. At the group table, choose a different person to translate the mRNA codons to tRNA anticodons. Write these anticodons on your data sheet.
4. Choose two people to go find the tRNA anticodons around the room. Turn over the anticodons to find the words of the sentence and write that sentence in large print/script on the transcription/translation data sheet.

Hint: The first triplet code is a “start” code, which represents in eukaryotes the amino acid methionine. For this activity, it is the same triplet code for all and is denoted by the word “START.” Each punctuation symbol is represented by different “stop” anticodons.

ANSWER KEY

1. TAC AAA CCC TGA CCG AGG TGA CCC ATG ATT
Soybeans are a leading crop in the United States.
2. TAC AAA CCC TTG GAT ATT
Soybeans are nitrogen-fixing legumes.
3. TAC AAA CCC TGT TGA GAA ATT
Soybeans are high in protein.
4. TAC TCC CTT TGA CCC TCG AGG AAA CCA ATT
Ohio ranks in the top ten soybean production.
5. TAC TCC ATA AGC TGA AGA CCA ATT
Ohio is number 2 in egg production.
6. TAC CGC TTT GCG CCG TGC ATT
Chicken can live 5–10 years.
7. TAC CGC CCC AAC ATT
Chickens are omnivores.
8. TAC CGC CCC TAT CCT ATT
Chickens are warm-blooded animals.
9. TAC CGC TTT AGT GAC ATC ATT
Chickens have excellent night vision.
10. TAC CGC CCA TTA TGG TAA ATT
Chickens originated from red junglefowl.
11. TAC CGC TTT CAT CGT AGA CGG ATT
Chickens can lay 280–320 eggs annually.
12. TAC CGC CAT GAG AGA GTT CTC ATT
Chickens lay one egg every 24–36 hours.
13. TAC AGA TTT CGA TGA GAA ATT
Eggs have 6 grams of protein.
14. TAC CGC CCA AGA TTA GCA CAA ATT
Chickens produce eggs at 18 weeks.
15. TAC ACG TTC CAG ACT CCC GGG TGA CCC AGA ATT
Eggshell color doesn't affect the nutrition of the egg.

Suggested wrap-up activity/discussion questions

- How are chromosomes, DNA, genes, and proteins related?
- 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?
- What area of the cell does your table represent?
- What do the words represent? The completed sentences?
- What do you think the consequences might be if an error occurred in the cell as it goes through the process of protein synthesis?

Differentiation

- Make cards longer sequences with fewer matches.
- Add colors to the strands to make it easier to match.
- Divide groups into sections so they know that someone in their group will match the card.

More challenges

- Research each DNA sentence statement to find evidence to support or refute this statement.
- Have students make their own sentences and strips, then repeat the activity.
- **Home connection:** Have students share the content of the DNA sentences statements at home to highlight Ohio agriculture during family conversation. Students can add in the additional information from their statement research to enrich the conversation. Ask the students to share with the class one statement that surprised people the most during their conversations.

Support information

- **Messenger RNA (mRNA):** carries genetic information from the DNA to the ribosome for protein synthesis.
- **Ribosomal RNA (rRNA):** forms part of the ribosome's structure and catalyzes protein synthesis.
- **Transfer RNA (tRNA):** carries amino acids to the ribosome during protein synthesis.
- **Translation:** begins with the start codon AUG. Find the corresponding AUG on the mRNA strand. Clip three nucleotides at a time (codon) into the ribosome, corresponding to each triplet on the mRNA. Match each codon with its corresponding amino acid according to the genetic code chart. Add the corresponding amino acid card to the growing polypeptide chain to make the DNA sentences.
- **Elongation:** move the ribosome along the mRNA strand, reading each codon. Add the appropriate amino acids to the growing polypeptide chain. These are the words to your sentence.
- **Termination:** when a stop codon (UAA, UAG, or UGA) is reached, translation stops. Complete the polypeptide chain. This is the end of your sentence.
- NOVA scienceNOW: Deadly Letters
pbs.org/wgbh/nova/teachers/activities/0401_02_nsn.html
- Translation: DNA to mRNA to Protein
nature.com/scitable/topicpage/translation-dna-to-mrna-to-protein-393/
- Protein Synthesis (Updated) Amoeba Sisters
youtu.be/oefAI2x2CQM
- DNA, Hot Pockets, & The Longest Word Ever: Crash Course Biology #11
youtu.be/itsb2SqR-R0
- Protein synthesis race
biomanbio.com/HTML5GamesandLabs/LifeChemgames/protsynthracehtml5page.html

Career connections

Have you ever wondered what type of poultry careers help to make a healthy, safe environment for commercial birds? Let's take a look!

- **Breeders** observe the health of the flock and record data on laying efficiency and behavior to select the traits to be combined for future generations.
- **Veterinarians** care for the health of the poultry flock and work to protect public health. They diagnose, treat, and research medical conditions and diseases of pets, livestock, and other animals.
- **Geneticists** are biologists who study genetics, the science of genes, heredity, and variation of organisms.