WiTT STEM Kit
Gene Expression Kit

An engaging approach to learn how the genetic code in the DNA is converted into protein.

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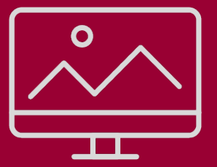
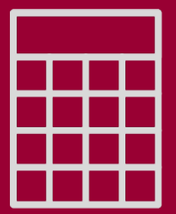
What is S.T.E.M?

STEM stands for Science, Technology, Engineering and Mathematics

The aim of STEM is the integration of these four disciplines together in teaching and learning. As, in the real world, these four disciplines rely heavily and seamlessly on each other.

STEM helps strengthen key life skills such as analytical thinking, problem solving, creativity, teamwork and technical skills





What is WiTT?

WiTT stands for Women in Technology and Trades

WiTT is a group that increases opportunities and support for women in technology and trades in all fields, through a rich networking and support community

WiTT welcomes industry, staff, students and faculty across all areas of the college and all genders, backgrounds, races and orientation to become involved and contribute to the support of women in technology and/or trades.

WiTT STEM Kit

Gene Expression Kit

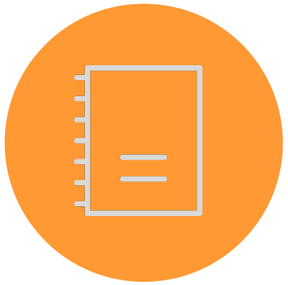
An enjoyable supplementary teaching tool.

Teaches students the steps involved in protein translation and the various terminologies related to gene expression.

An easy to set-up kit and is inexpensive.

Goal: To impart a fun learning experience that will encourage students to continue exploring, boost their curiosity, and to increase science literacy.

Benefits of Completing the Kit



The kit promotes active learning which can lead to a greater retention of the subject material.

The kit will help students to be actively engaged, curious, and more empowered to learn on their own.

The kit encourages students to collaborate and share ideas. This will strengthen their critical thinking skills.

Curriculum Points

Biology, Grade 11, University Preparation. Page 55. Part D. Genetic Processes. Subpart D3. Understanding Basic Concepts. Section D3.2. Discusses the concepts of DNA, genes, chromosomes, etc. and how they relate to transmission of hereditary characteristics

Biology, Grade 12, University Preparation. Page 83. Part D. Molecular Genetics. Subpart D3. Understanding Basic Concepts. Section D3.1. Understanding the current model of DNA replication and repair mechanisms. Section D3.2. Comparing the structures of DNA and RNA and their roles in protein synthesis.

Science, Grade 12, University/College Preparation. Page 237. Part F. Biotechnology. Subpart F3. Understanding Basic Concepts. Section F3.2. Learning the functions of macromolecules(e.g., DNA and RNA) and how proteins are synthesized.

Biology, Grade 12, University Preparation. Page 82. Part D. Molecular Genetics. Subpart D2. Developing Skills of Investigation and Communication. Section D2.1. Learning the different terminology related to molecular genetics. Section D2.2. Determining the genetic code and DNA base pairing.

Gene Expression

Central Dogma of Molecular Biology

- A double helix structure that carries the genetic information.
- Base Pairing**:
  - A ⟷ T
  - C ⟷ G

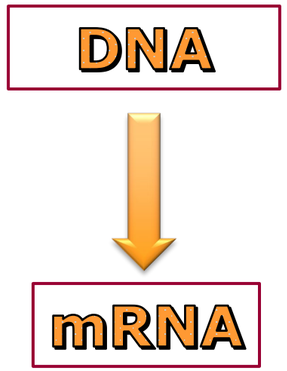
- A single-stranded RNA molecule that is complementary to the DNA template strand.
- Base Pairing**:
  - A ⟷ U
  - C ⟷ G

- A molecule made up of a chain of amino acids.
- Important for cell functions.

****A**= Adenine; **T**= Thymine; **C**= Cytosine; **G**= Guanine; **U**= Uracil**

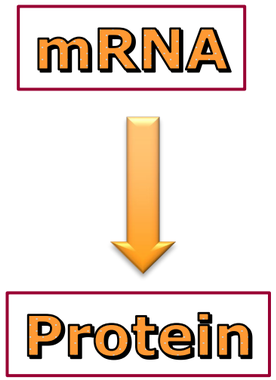
Key Steps of Gene Expression

1. Transcription



- The **DNA template strand** is read in the 3′ to 5′ direction to create an mRNA strand in the 5′ to 3′ direction. Its sequence is complementary to the DNA template strand except the base U replaces the base T

2. Translation



- mRNA is read in sets of three consecutive bases (codon). Each codon specifies an amino acid.
- Amino acids form a protein.

Amino Acids

Codon Table

1st	2nd Base of Codon								3rd
	U		C		A		G		
U	UUU	Phenylalanine (Phe)	UCU	Serine (Ser)	UAU	Tyrosine (Tyr)	UGU	Cysteine (Cys)	U
	UUC		UCC		UAC		UGC		C
	UUA	Leucine (Leu)	UCA		UAA	STOP Codon	UGA	STOP Codon	A
	UUG		UCG		UAG		UGG	Tryptophan (Trp)	G
C	CUU	Leucine (Leu)	CCU	Proline (Pro)	CAU	Histidine (His)	CGU	Arginine (Arg)	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Glutamine (Gln)	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Isoleucine (Ile)	ACU	Threonine (Thr)	AAU	Asparagine (Asn)	AGU	Serine (Ser)	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lysine (Lys)	AGA	Arginine (Arg)	A
	AUG	Methionine (Met)(start)	ACG		AAG		AGG		G
G	GUU	Valine (Val)	GCU	Alanine (Ala)	GAU	Aspartic Acid (Asp)	GGU	Glycine (Gly)	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glutamic Acid (Glu)	GGA		A
	GUG		GCG		GAG		GGG		G

- There are 20 types of amino acids.
  - Alanine
  - Arginine
  - Asparagine
  - Aspartic Acid
  - Cysteine
  - Glutamic Acid
  - Glutamine
  - Glycine
  - Histidine
  - Isoleucine
  - Leucine
  - Lysine
  - Methionine
  - Phenylalanine
  - Proline
  - Serine
  - Threonine
  - Tryptophan
  - Tyrosine
  - Valine
- Most amino acids are encoded by more than one codon. 61 codons specify amino acids while 3 codons are stop codons.
- Each amino acid can be abbreviated in a 1 or 3-letter code.
  (e.g. Alanine= Ala)

Importance of Protein

Function	Examples
Oxygen Transport	Hemoglobin
Structural and Mechanical	Keratin, Actin, Myosin, and Tubulin
Enzymes	Amylase, Lipase, Pepsin, and Trypsin
Hormones	Thyroxine, Somatotropin (growth hormone), and Insulin
Antibodies	Immunoglobulins
Intercellular Ground Substance	Collagen
Storage	Albumin and Ferritin

Important Terms

- **3’ end of DNA/RNA strand**- the carbon end of the strand with a hydroxyl (OH) group sticking out.
- **5’ end of DNA/RNA strand**- the carbon end of the strand with a phosphate group sticking out.
- **Codon**- a sequence of three consecutive nucleotides that corresponds to a specific amino acid.
- **DNA Coding/Non Template Strand**- the DNA sequence that is identical to the base sequence of the mRNA, except Thymine is replaced by Uracil.
- **DNA Non Coding/ Template Strand**- the DNA sequence that is read and copied for the synthesis of the mRNA complementary strand.
- **Transcription**- DNA to mRNA.
- **Translation**- mRNA to protein.

Kit Materials

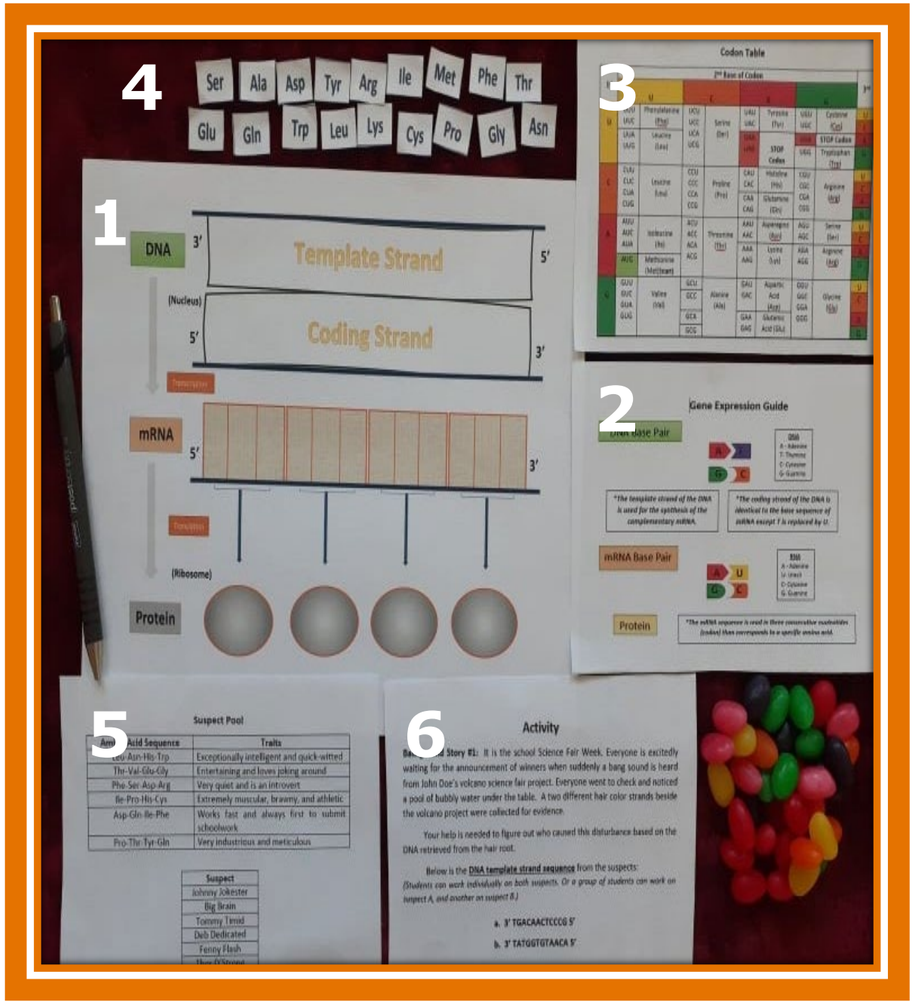
Printable Material

1. The gene expression board
2. The gene expression guide
3. Codon table
4. Amino acid cut outs
5. Suspect pool table
6. Activity cards

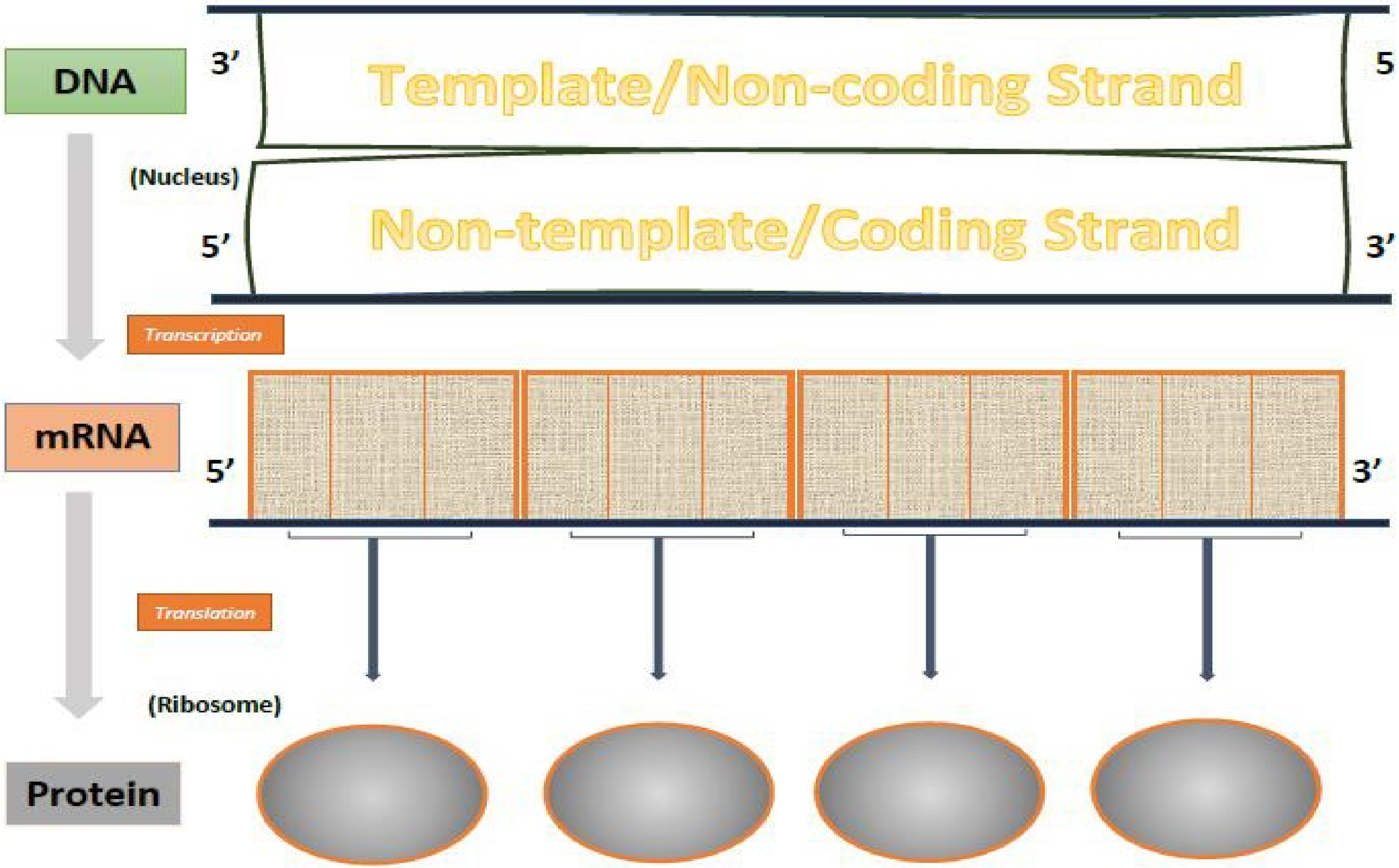
Additional Material

- ❑ Any item that is available in 5 different colors (red, green, yellow, purple, and orange). E.g. beads, jelly-bean candies, paper clips, buttons, Lego, etc. Approximately 15 to 18 pieces of each color will be needed.

- ❑ A pen and paper to create more DNA sequences as an additional activity.



1. Gene Expression Board



2. Gene Expression Guide

DNA Base Pair

DNA
A - Adenine
T- Thymine
C- Cytosine
G- Guanine

**The template strand of the DNA is used for the synthesis of the complementary mRNA.*

**The non template strand of the DNA is identical to the base sequence of mRNA except T is replaced by U.*

DNA template/ New mRNA Base Pairs

RNA
A - Adenine
U- Uracil
C- Cytosine
G- Guanine

Protein

**The mRNA sequence is read in three consecutive nucleotides (codon) than corresponds to a specific amino acid.*

3. Codon Table

Codon Table

1st	2nd Base of Codon								3rd
	U		C		A		G		
U	UUU	Phenylalanine (Phe)	UCU	Serine (Ser)	UAU	Tyrosine (Tyr)	UGU	Cysteine (Cys)	U
	UUC		UCC		UAC		UGC		C
	UUA	Leucine (Leu)	UCA		UAA	STOP Codon	UGA	STOP Codon	A
	UUG		UCG		UAG		UGG	Tryptophan (Trp)	G
C	CUU	Leucine (Leu)	CCU	Proline (Pro)	CAU	Histidine (His)	CGU	Arginine (Arg)	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Glutamine (Gln)	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Isoleucine (Ile)	ACU	Threonine (Thr)	AAU	Asparagine (Asn)	AGU	Serine (Ser)	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lysine (Lys)	AGA	Arginine (Arg)	A
	AUG	Methionine (Met)(start)	ACG		AAG		AGG		G
G	GUU	Valine (Val)	GCU	Alanine (Ala)	GAU	Aspartic Acid (Asp)	GGU	Glycine (Gly)	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glutamic Acid (Glu)	GGA		A
	GUG		GCG		GAG		GGG		G

4. Amino Acid Cut Out

Amino Acid Cut Out

Met	Leu	Ile	Val	Ser
Glu	Tyr	Ala	Thr	Pro
Asp	Lys	Asn	Gln	His
Phe	Cys	Trp	Arg	Gly

- These are the 3-letter code of the 20 amino acids to be used on the protein translation box.

5. Suspect Pool Table

Suspect Pool

Amino Acid Sequence	Traits
Leu-Asn-His-Trp	Exceptionally intelligent and quick-witted
Thr-Val-Glu-Gly	Entertaining and loves joking around
Phe-Ser-Asp-Arg	Very quiet and is an introvert
Ile-Pro-His-Cys	Extremely muscular, brawny, and athletic
Asp-Gln-Ile-Phe	Works fast and always first to submit schoolwork
Pro-Thr-Tyr-Gln	Very industrious and meticulous

Suspect
Johnny Jokester
Big Brain
Tommy Timid
Deb Dedicated
Fenny Flash
Thor D'Strong

6. Activity Card

Background Story #1: It is the Science Fair Week. Everyone is excitedly waiting for the announcement of winners when suddenly a loud bang was heard. Everyone went to see what it was and realized that John Doe's volcano science project erupted. It produced a vast pool of liquid on the table, ruining other science projects. The principal noticed 2 hair strands beside the volcano project which he collected for investigation.

Your help is needed to figure out who caused this disturbance based on the DNA from the hair strands.

Below are the **DNA template strand sequences** obtained from the hair strands that can help lead you to the suspects' identity.

(Students can work individually on both suspects. Or a group of students can work on suspect A, and another on suspect B.)

Suspect A - 3' TGACAACTCCCG 5'

Suspect B - 3' TATGGTGTAACA 5'

Background Story #2: When the students came back from a holiday break, they discovered that Einstein, the beloved school hamster, is missing. Some students cried while others frantically searched for Einstein. The entire day search for Einstein was unsuccessful.

Your help is urgently needed to figure out who stole Einstein. Solve the case based on the DNA left on the chewing gums found near where Einstein's cage used to be.

Below is the **DNA template strand sequence**:

(Students can work individually on both suspects. Or a group of students can work on suspect A, and another on suspect B.)

Suspect A - 3' GAGTTAGTGACC 5'

Suspect B - 3' AAAAGACTAGCA 5'

Instructions

1. Create the complementary sequence of each suspect's **DNA Template Strand**.

   (Use the gene expression guide for the correct base pairing.)

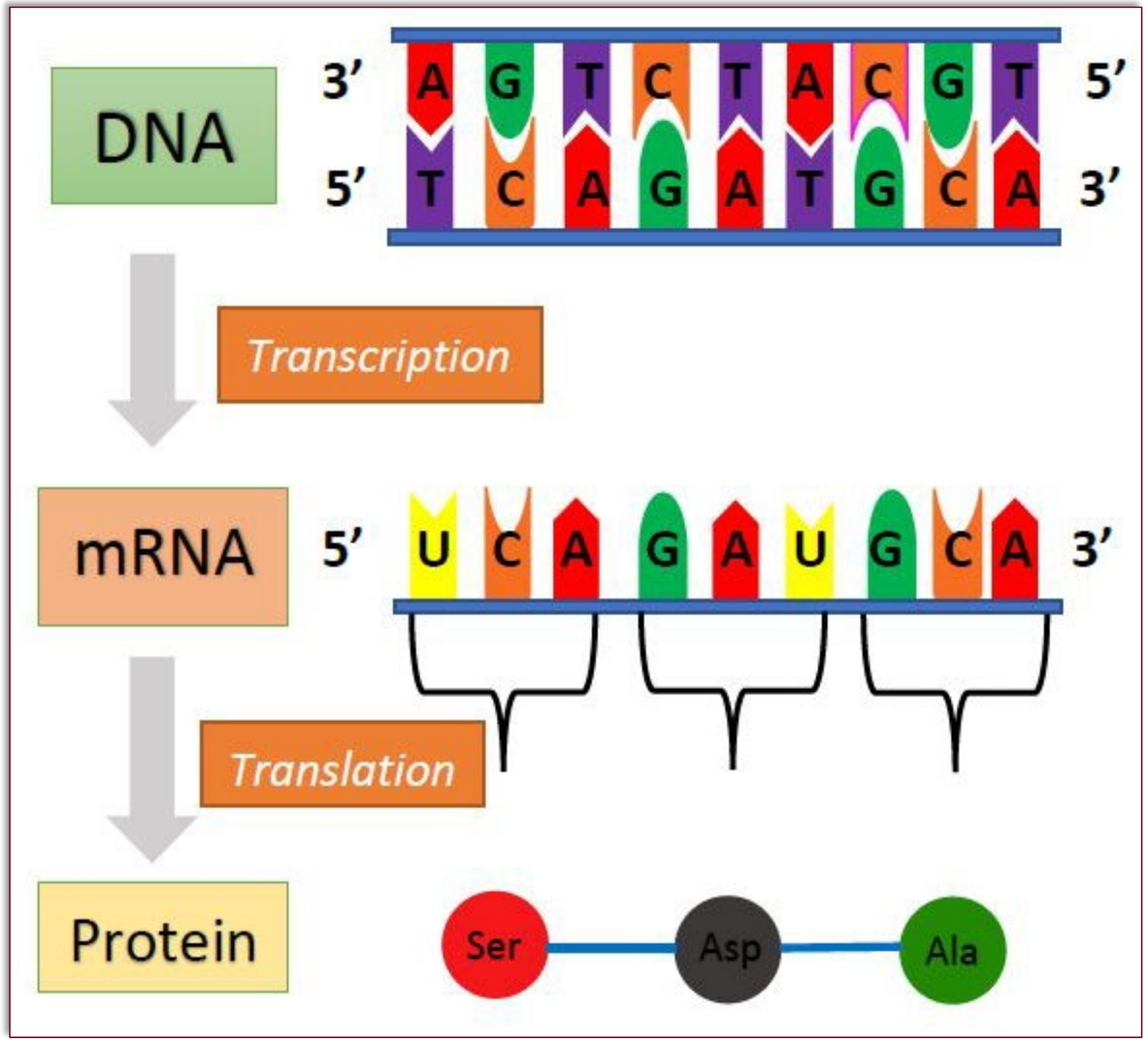
2. Transcribe the DNA sequence into the mRNA sequence.

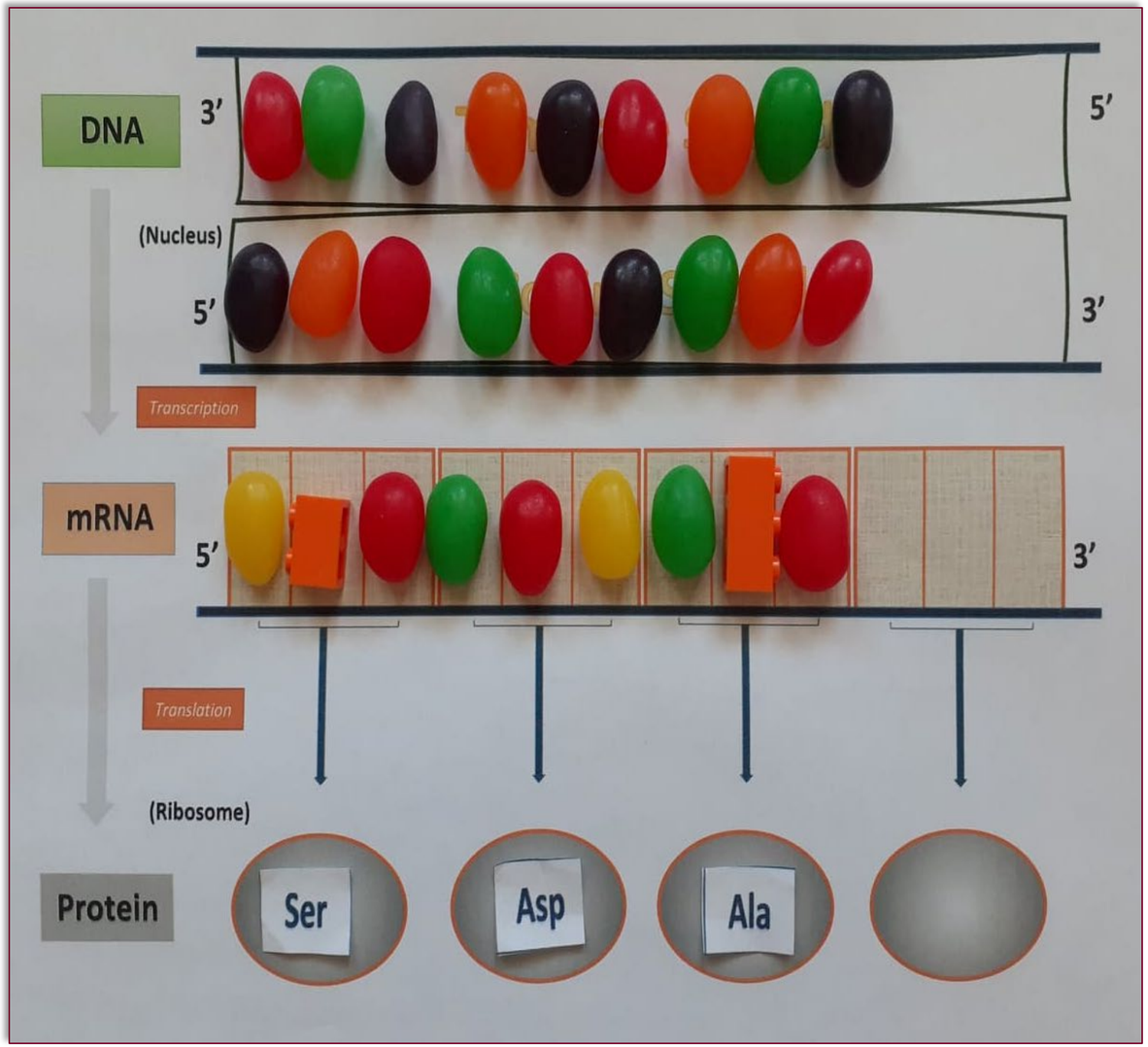
   (Hint: Use the correct DNA strand).

3. Using the codon table, figure out what is the amino acid for each codon.

4. Determine the traits of your amino acid sequence from the suspect pool card. Then, match those amino acid traits to the list of the possible suspects to uncover the identity of whose DNA matches your sequence.

Option: For added fun, the name of the suspects can be change to the name of the students in the class.





Example of the Gene Expression Activity

Extra Challenges and Critical Thinking

- Investigate what will happen if one of the bases in the DNA strand is changed for another base.
- Choose a protein suspect and create his/her protein. Then work your way up to the mRNA and the DNA sequences. Are the sequences transcribed the same as your classmates? Why do you think that is?
- Create your own DNA sequences and figure out the amino acid sequence you have made.
- Why are there many codons that code for the same amino acid. What might be the benefit/s of this, if there is/are any?
- What are the things you knew about gene expression before doing this activity? Were they correct? What did you learned after completing this kit?

Where Can We Go

- The kit can be explored by:
  - Introducing to students what will be the consequence if one or more base in the DNA sequence is deleted or substituted.
  - Introducing a longer DNA sequences and protein sequences.
  - Incorporating the Start and Stop codon in the sequences.

Thank You for Supporting the Kit.

To enjoy and explore other WiTT STEM kits, please visit our website.

https://www.mohawkcollege.ca/women-technology-and-trades

Thank you to RBC for Sponsoring WiTT Curriculum Kits

RBC is supporting all of Mohawk College's Women in Technology and Trades initiatives as part of their Future Launch Program

WiTT STEM Kit

Gene Expression Kit

- Gene Expression Kit is a straightforward and enjoyable educational activity that focuses on teaching students on how our genes are translated into a product critical for cell functions.
- Not only is this kit easy to set up; it is also inexpensive and incredibly convenient as all the needed materials are easily accessible.
- **Goal:** To impart a fun learning experience that will encourage students to continue exploring, boost their curiosity, and to increase science literacy.
- After completing the activity, students will:
  - Learn the various terminologies related to gene expression.
  - Be familiar with the steps involved in protein translation.