Python Coding Lesson

Lesson Title:	**Transcription and Translation**
Grade Level:	**High School**
Subject:	**Biology**
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Engagement:

- Students will be asked to remove both of their shoes.
- They will lie the right side of their clothing items in a straight line, and the left shoe will be placed into a pile, and the items will be mixed up.
- From here the students will need to search the pile for their left side and match it to the right side.
- Once every student has matched their shoe, they may put on the left shoe and left shoe only and walk out of the room.
- These steps will mirror the base DNA strand that is changed into an (m)RNA strand through the transcription process.
- The same process will be done again except three students will have to group their three remove left shoes together in order to become a whole protein.
- The trio will link arms to indicate that they are protein, make sure they only have on their left shoe. (This will resemble the translation step)

Exploration:

- Students will read and annotate (highlight what is important, circle what they do not understand) the Kahn Academy article and compare in their groups: https://www.khanacademy.org/science/high-school-biology/hs-molecular-genetics/hs-rna-and-protein-synthesis/a/hs-rna-and-protein-synthesis-review
- Students should only read up to the Mutations section
- Discuss the transcription and translation model in the article as a class.
- Inform students that they will now be looking at a code which in some ways models the process of transcription and translation.

This material is based upon work supported by the Office of Naval Support under Award No. N00014-17-1-2948.

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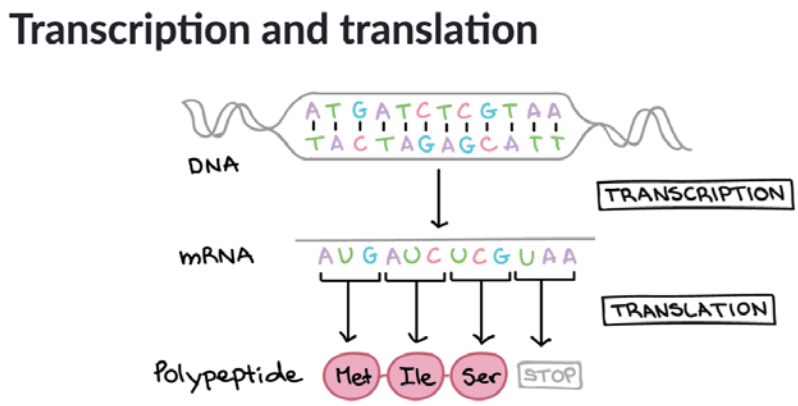

Source: https://www.khanacademy.org/science/high-school-biology/hs-molecular-genetics/hs-rna-and-protein-synthesis/a/hs-rna-and-protein-synthesis-review

Transcription

- Have the students open and observe the code to the right and tell them that it represents the process of Transcription.
- Then, ask student groups to input a random sequence of A, T, G, and C using the code to the left and observe the output. Ask students:
    - What happened to the original sequence?
    - What pattern do you see between the output and the input?
    - Do you agree with the output of the code? Does it agree with what?

```
my_dna = input("Enter your DNA sequence?")
mycomp = ""
for base in my_dna:
    if base == "A":
        mycomp += "U"
    elif base == "T":
        mycomp += "A"
    elif base == "C":
        mycomp += "G"
    elif base == "G":
        mycomp += "C"
print(mycomp)
```

Source: Lesson Contributors' Python Code

Translation

- Students will open a new code

```
codon = input("What is your codon sequence?")
if codon == "UUU":
    print ("Phenylanine")
elif codon == "UUC":
    print ("Phenylanine")
else:
    print ("Stop")
```

Source: Lesson Contributor's Python Code

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representing Translation.

- Have the students think-pair-share about the function of the code before they run it. Discuss as a class.
- Have students input UUU and run the code. Ask groups:
    - How many possible inputs and outputs are there for the code?
    - What is different about this code from the last?

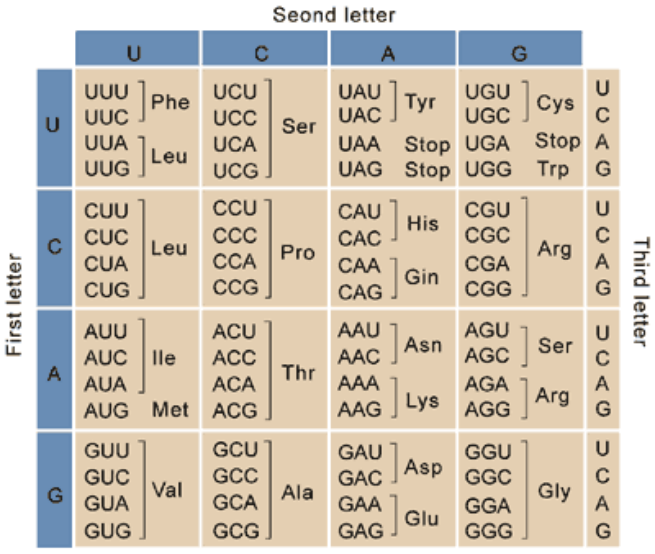
Explanation:

Transcription

- Students will watch a 3D animation which describes the actual process of Protein Expression and take notes on the two main steps (Transcription and Translation) and the function of the following intermediate molecules: DNA, mRNA, and tRNA.
    - Animation: https://www.youtube.com/watch?v=2BwWavExcFI
- Have each group create a group summary of how the first code represented the process of Transcription and create a class diagram of connections on the board.

Translation

- Present students with amino acid chart and point out that each triplet or codon codes for an amino acid, just as described in the video. Be sure to review how to read the chart with the students.
- Have students look back at the second code and compare it with the chart. Ask students if the code is complete? (Answer: *no*)
- Prompt students to complete the code in their group by adding more e*lf* conditions until all the codons and amino acids have been accounted for. Encourage students to mimic the format of the initial code and end the code with *else*.



First letter	Seond letter: U	Seond letter: C	Seond letter: A	Seond letter: G	Third letter
U	UUU, UUC: Phe; UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr; UAA, UAG: Stop	UGU, UGC: Cys; UGA: Stop; UGG: Trp	U C A G
C	CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His; CAA, CAG: Gin	CGU, CGC, CGA, CGG: Arg	U C A G
A	AUU, AUC, AUA: Ile; AUG: Met	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn; AAA, AAG: Lys	AGU, AGC: Ser; AGA, AGG: Arg	U C A G
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp; GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	U C A G

Source: https://www.khanacademy.org/science/high-school-biology/hs-molecular-genetics/hs-rna-and-protein-synthesis/e/hs-rna-and-protein-synthesis

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- Close the explore part of the lesson by having each group run another group's program to check for errors and compare differences in code.

Elaboration:

Student groups will be given supplies to make a poster that displays the process of transcription and translation. The directions for this activity are listed below.

- Obtain the cardstock with 4 sections of DNA. Cut the strips out along straight lines and tape them together to make a long one-sided DNA molecule. Each section is numbered. Lay them out on the desk from left (#1) to right (#4). See the diagram below. This will form one long strand of DNA and will serve as the template strand of our gene.
- We are going to use this section of our DNA as a gene to be transcribed and then translated into a protein the cell needs. Remember it used to be part of a double-stranded DNA molecule. But it has already been unzipped and now will be used as the template to build mRNA, one base at a time. So, first design an RNA polymerase enzyme to do this mRNA synthesis job.
- You have also been supplied with mRNA nucleotides. Build a mRNA molecule, one base at a time, from this gene by transcribing your DNA template. Don't forget to only start transcribing downstream from the TATA box promoter sequence. As you are transcribing, tape this mRNA molecule along its length to simulate the covalent bonds between bases. This way, it will be a stable molecule and can be moved off the DNA to the ribosome for translation in the cytoplasm. Do not tape the mRNA to the DNA! Remember it must leave the DNA in the nucleus and travel to the ribosome in the cytoplasm. Follow the diagram below.
- You have just made a primary transcript. It must be processed so it successfully travels to the ribosome in the cytoplasm. Although we will not be simulating intron and exon splicing in this lab, you do need to add a 5" GTP cap and a 3" poly-A tail to the mRNA to protect the mRNA. Although poly-A tails may be 20-100 bases long, add 6 adenine bases for your simulated poly-A tail.
- To be ready for the mRNA in the cytoplasm, design a ribosome to use in your simulation. Be sure to distinguish the small and large ribosomal subunits and mark the A, P, and E sites of the ribosome.
- To help the ribosome do its job, use a pencil to draw lines which divide your mRNA into triplet codons. Now obtain tRNA molecules and write in the complementary anticodons

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to match your mRNA codons so that the tRNAs bring the correct amino acid to the ribosome.

- Label the name of the amino acid that each tRNA is carrying. To help you with this, use the mRNA codon chart and the amino acid code chart supplied by your teacher. Start reading the mRNA at the START codon and end at the STOP codon. Follow the diagram below
- As the tRNA molecules match the mRNA codons, cut off the amino acid and bond them together in a chain to simulate the action of the ribosome — covalently bonding the amino acids in a polypeptide chain. Show your completed mRNA and your polypeptide to your teacher for credit.

Evaluation:

Standards**:**

- BIO.B.2.2.1 Describe how the processes of transcription and translation are similar in all organisms.
- BIO.B.2.3.1 Describe how genetic mutations alter the DNA sequence and may or may not affect phenotype (e.g., silent, nonsense, frameshift).
- After completing their poster, students will show mastery of transcription and translation by completing the handout.

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