Central Dogma Relay Race

Objective: Provide a hands on experience to understand the various processes of the central dogma (including DNA replication, transcription, and translation). During this exercise students will understand how each step in the central dogma feeds directly into the next step, and how the central dogma ultimately leads from DNA to proteins. In addition, the inclusion or absence of an RNA-proof reader will show students how errors can be incorporated and propagated to yield nonsensical peptide products. This also provides context for how mutations at the level of DNA can impact protein products, and elucidate how evolution can occur.

Materials: For this exercise all that is required are printed out copies of pages 5-7 and one copy of a codon table for each Large ribosomal subunit. Variations of this exercise can be developed to include small tangible pieces to represent nucleotides and amino acids.

Directions: The class will be split into two groups of 5 and one group of 6. Roles will be randomly distributed to each member of each group. These roles will dictate what the students' jobs are in the central dogma.

As each student completes the objective outlined in their role description, the student will pass along the new genetic information to the next person in line along the relay system (no older information can be passed along with the new information). The DNA polymerase will relay a complementary DNA sequence to the DNA proof-reader. The DNA proof-reader will relay a correct complementary DNA sequence to the RNA polymerase. The RNA polymerase will relay a complementary mRNA sequence to the RNA proof-reader. The RNA proof-reader will relay a correct complementary DNA sequence to the small ribosomal subunit. The small ribosomal subunit will identify the start codon and verbally communicate the sequence of codons to the large ribosomal subunit. The large ribosomal subunit will use the codon table to write out the amino acid sequence as the small ribosomal subunit relays the codons.

At each step of the central dogma, each student can only utilize the information provided to them by the student preceding them in the steps of replication, transcription, and translation. At no point can a person later along the process of the central dogma look back at work more than one step behind them.

ROLES FOR THE GROUP OF 6:

DNA Polymerase: Your role is to replicate DNA and maintain the organism's genetic information. Here you will take a template strand and generate the complementary strand of DNA. Once you have finished generating the complementary strand, hand off your sequence to the DNA polymerase Proof-reader.

DNA Proof-reader: Rumor has it you never make mistakes. As the proof-reading domain of the DNA polymerase you ensure that no errors get incorporated into the DNA. As such, you're responsible for ensuring there are no mistakes in the complementary strand generated by the DNA polymerase. Once you have corrected any errors, hand off the sequence to the RNA polymerase.

RNA Polymerase: You are responsible for the transcription step of the Central Dogma. Your job is to generate a complementary strand of mRNA using the DNA sequence handed to you as a template. Once you have finished generating the complementary mRNA strand, hand off your sequence to the RNA polymerase proof-reader.

RNA Proof-reader: Slipups happen when people work fast, but that's where you come in! You are the proof-reading domain of the RNA polymerase. You are responsible for catching the mistakes of the RNA polymerase and correcting them before errors ensue. Once you have corrected any errors in the mRNA strand given to you, hand off the sequence to the small ribosomal subunit.

Small ribosomal subunit: You and your closest friend, the large ribosomal subunit, work together to translate mRNA sequences into peptides. As the small subunit, your job is to relay the information presented on the mRNA to the large subunit, so it can create the peptide chain. Identify where the start codon is on the mRNA and communicate verbally to the large ribosomal subunit the sequence of codons encoded on the mRNA.

Large ribosomal subunit: You don't really speak the same language as your colleagues, but your closest friend the small ribosomal subunit is able to translate most messages for you. As the large subunit, you are responsible for converting the codon sequences relayed to you by the small subunit into amino acids to generate a peptide sequence. However, you are unable to directly see the mRNA sequence yourself. Once you reach a stop codon you terminate translation and produce a complete peptide sequence.

ROLES FOR THE GROUPS OF 5:

DNA Polymerase: Your role is to replicate DNA and maintain the organism's genetic information. Here you will take a template strand and generate the complementary strand of DNA. Once you have finished generating the complementary strand, hand off your sequence to the DNA polymerase Proof-reader.

DNA Proof-reader: Rumor has it you never make mistakes. As the proof-reading domain of the DNA polymerase you ensure that no errors get incorporated into the DNA. As such, you're responsible for ensuring there are no mistakes in the complementary strand generated by the DNA polymerase. Once you have corrected any errors, hand off the sequence to the RNA polymerase.

RNA Polymerase: You are responsible for the transcription step of the Central Dogma. Your job is to generate a complementary strand of mRNA using the DNA sequence handed to you as a template. Once you have finished generating the complementary mRNA strand, hand off the sequence to the small ribosomal subunit.

Small ribosomal subunit: You and your closest friend, the large ribosomal subunit, work together to translate mRNA sequences into peptides. As the small subunit, your job is to relay the information presented on the mRNA to the large subunit, so it can create the peptide chain. Identify where the start codon is on the mRNA and communicate to the large ribosomal subunit the sequence of codons encoded on the mRNA.

Large ribosomal subunit: You don't really speak the same language as your colleagues, but your closest friend the small ribosomal subunit is able to translate most messages for you. As the large subunit, you are responsible for converting the codon sequences relayed to you by the small subunit into amino acids to generate a peptide sequence. Once you reach a stop codon you terminate translation and produce a complete peptide sequence.

SEQUENCING CHEAT SHEET (For instructors)

Sequence 1: (PATHWAY AT YALE)

Template strand: CGAGATG-GAG-CTA-GCA-TAC-ACG-GCT-TAT-GCA-TGG-CAT-ACT-GCC-CCT-TAG

Complementary strand: GCTCTAC-CTC-GAT-CGT-ATG-TGC-CGA-ATA-CGT-ACC-GTA-TGA-CGG-GGA-ATC

mRNA Strand: CGAGAUG-GAG-CUA-GCA-UAC-ACG-GCU-UAU-GCA-UGG-CAU-ACU-GCC-CCU-UAG

Peptide Sequence: M-E-L-A-Y-T-A-Y-A-W-H-T-A-P-*

Sequence 2: (YALE CHEMISTRY)

Template Strand: CGAGATG-TAT-CGT-ACT-TCT-ATA-ATG-GAA-CAT-TGT-GAG-CTT-GCT-TAC-TAG

Complementary Strand: GCTCTAC-ATA-GCA-TGA-AGA-TAT-TAC-CTT-GTA-ACA-CTC-GAA-CGA-ATG-ATC

mRNA Strand: CGAGAUG-UAU-CGU-ACU-UCU-AUA-AUG-GAA-CAU-UGU-GAG-CUU-GCU-UAC-UAG

Peptide Sequence: M-Y-R-T-S-I-M-E-H-C-E-L-A-Y-*

Sequence 3: (DNA RNA PEPTIDE)

Template Strand: CGAGATG-GAA-GAT-ATC-ACT-CCT-GAG-CCA-GCT-CAG-GAC-GCC-AAT-AGG-TAG

Complementary Strand:
GCTCTAC-CTT-CTA-TAG-TGA-GGA-CTC-GGT-CGA-GTC-CTG-CGG-TTA-TCC-ATC

mRNA Strand:
CGAG<u>AUG-GAA-GAU-AUC-ACU-CCU-GAG-CCA-GCU-CAG-GAC-GCC-AAU-AGG-UAG</u>

Peptide Sequence: M-E-D-I-T-P-E-P-A-N-D-A-N-R-*
Template strand #1:

CGAGATGGAGCTAGCATACACGGCTTATGCATGGCATACTGCCCCTTAG

Complementary strand #1:

mRNA Strand #1:

Peptide Sequence:

Complementary Strand #1 (DNA proofreader’s copy):

G	C	T	C	T	A	C	C	T	C	G	A	T	C	G	T	A	T	G	T	G	C	C	G	A	A	T	A	C	G	T	A	C	C	G	T	A	T	G	A	C	G	G	G	G	A	A	T	C	

mRNA Strand #1 (RNA proofreader’s copy):

C	G	A	G	A	U	G	G	A	G	C	U	A	G	C	A	U	A	C	A	C	G	G	C	U	U	A	U	G	C	A	U	G	G	C	A	U	A	C	U	G	C	C	C	C	U	U	A	G	

Template Strand #2:

CGAGATGTATCGTACTTCTATAATGGAACATTGTGAGCTTGCTTACTAG

Complementary strand #2:

mRNA Strand #2:

Peptide Sequence:

Complementary Strand #2 (DNA proofreader’s copy):

G	C	T	C	T	A	C	A	T	A	G	C	A	T	G	A	A	G	A	T	A	T	T	A	C	C	T	T	G	T	A	A	C	A	C	T	C	G	A	A	C	G	A	A	T	G	A	T	C	

mRNA Strand #2 (RNA proofreader's copy):

C	G	A	G	A	U	G	U	A	U	C	G	U	A	C	U	U	C	U	A	U	A	A	U	G	G	A	A	C	A	U	U	G	U	G	A	G	C	U	U	G	C	U	U	A	C	U	A	G	

Template Strand #3:

CGAGATGGAAGATATCACTCCTGAGCCAGCTCAGGACGCCAATAGGTAG

Complementary strand #3:

mRNA Strand #3:

Peptide Sequence:

Complementary Strand #3 (DNA proofreader's copy):

G	C	T	C	T	A	C	C	T	T	C	T	A	T	A	G	T	G	A	G	G	A	C	T	C	G	G	T	C	G	A	G	T	C	C	T	G	C	G	G	T	T	A	T	C	C	A	T	C	

mRNA Strand #3 (RNA proofreader's copy):

C	G	A	G	A	U	G	G	A	A	G	A	U	A	U	C	A	C	U	C	C	U	G	A	G	C	C	A	G	C	U	C	A	G	G	A	C	G	C	C	A	A	U	A	G	G	U	A	G	