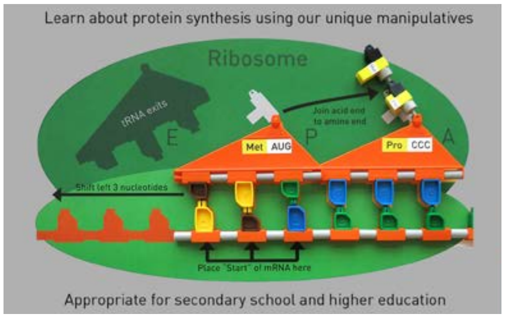

MIT Edgerton Center tRNA Kits

Teacher Guide

Kathleen M. Vandiver
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FAQ: Why does a tRNA classroom set have only 4 kits?

Translation is tricky!   It has numerous steps; the students have lots of misconceptions; and the activity requires having three sets of models available for each team. Now, imagine 12-14 teams trying to do this all at the same time in class and you can see how their translation might lack fidelity and the students might still retain their misconceptions….

Therefore we recommend beginning the lesson with a teacher–led participatory demonstration on translation. After the students have better idea of the process, select how the four kits can be used by student teams independently. Each tRNA kit can be constructed to translate a different channel protein gene.

Recommended Lesson Plan for Translation

Overview

When teaching a 45-55 min period class, divide the class in half. Give half the class an independent task such as reading /writing. Gather the other half around a small table or move two desks put together in front of the room. You will switch activities half way through the class, spending about 20 minutes with each group.
Day 2 can be optional, but will help your students feel confident and help those who might have been absent. Have all students get more practice by now using all four different tRNA kits at the same time in teams of ~ 6. You will need to have 4 different mRNA transcripts with their matching tRNA kits. Or you may choose to have all four teams do the same gene. You will need to prepare tRNA molecules in the kits for that.

Teacher Classroom Preparation (20 - 30 min will needed for the first time)

To teach translation with the models you will need: one prepared tRNA kit, one prepared mRNA transcript, and a protein kit. Select and build the beta mutated mRNA transcript (See **tRNA Booklet 1: page 11**). Construct the beta mutated tRNA molecules (See **tRNA Booklet 1: page 9)**. For your demonstration with ~12 students (half the class) gather them around one table. Make sure everyone can see the action!

To prepare, review these instructions with a ribosome mat and the materials.

Students will help prepare the cell for protein synthesis

- First have the students load all the tRNAs with their correct amino acids. As in nature, the amino acids are connected to the tRNA by their acid groups.
- The "Stop" model will not have an amino acid. Explain this model will have a special role.
- Give a brief overview explaining how mRNA leaves the nucleus and attaches to the ribosome that is in the cytoplasm (or is attached to the rough endoplasmic reticulum.)

Translation activity guided by the teacher

- Teacher will demonstrate the steps 1) –6) below.
- Students repeat translation steps with the charged tRNA molecules. All observe/and coach as needed.
- Teacher will then provide a wrap-up and explain what the "stop" does.
- Teacher demonstrates how the beta mutated protein folds up and is inserted into the membrane.

See detailed instructions on Page 2

Details: Teacher demonstrates key concepts (steps 1-6) with Met and Pro

1) Explain how individual tRNAs are selected
   - To demonstrate how tRNA bind, try out a couple of tRNAs that are not the right shape for AUG on the mRNA. They do not bind, because they do not fit together.
   - Bring in the tRNAs that are carrying Met and Pro and let the tRNA bind to the mRNA. The tRNA anticodons are the right shape.
   - Explain that the tRNAs will only bind to the mRNA when it is on the ribosome. NOTE: *Students will attach tRNA along the length of the mRNA, if you do not clarify this point!*
2) Remove the (Met) from the Met tRNA. Explain that it requires energy to form the new peptide bond.
3) Move the amino acid over towards the incoming amino acid. (It is Met for this first action.) The incoming amino acid stays attached. (It is Proline for this first action.)
   - This amino acid transfer is counter-intuitive for most students. *It's a good idea to call attention to this common misconception. Clarify which amino acid is transferred.*
   - The black arrow on the ribosome indicates the correct direction to move the amino acid to create the peptide bond.
4) After the peptide bond is formed. Slide the whole the mRNA strand over one codon to the left on the ribosome. Both tRNAs remain attached.
5) Release the Met tRNA from the mRNA strand now. Use the "pinch technique" to release the hydrogen bonds between the nucleotides.
6) Move the empty Met tRNA into the exit position (labeled) on the ribosome.
   - Show the Met tRNA moving away from the ribosome.
   - Wait for a student to ask, "What happens to the empty tRNA?"
   - You might explain that a tRNA molecule works like taxi? (**t= t**axi) **t**RNAs continuously go around picking up passengers and delivering them to the right spot.

Students repeat the steps above with other tRNA molecules

7) Next, have students with their charged tRNAs take turns completing steps (1-6 above) and explaining what is happening on the ribosome for each amino acid. (Enjoy the drama together…. We discovered students like to make sound effects for each step.) Generally, students are quick to correct each other. The teacher just needs to observe. It's an opportunity for students to have guided learning with repetition.

Teacher demonstrates the stop (8) and asks KEY question (9)

8) The last piece to bind to the mRNA is the STOP. It is actually not a tRNA molecule but a protein.
   - Show how the STOP will release the protein chain from the adjacent tRNA.
   - The STOP also causes the mRNA and the tRNA to fall off of the ribosome.
9) Lead an IMPORTANT follow-up conversation now about mutations:
   - Pick up the protein chain and hold it from the #1 Met end. What pattern characterizes the sequence of amino acids in a channel protein? Students look for the pattern: 2 hydrophobics, 2 hydrophilics, and 2 hydrophobics.
   - This protein does not have the correct pattern. The mutated beta gene produces three hydrophilics in the middle, not two! (No procedural problem caused this error.)
   - What will happen when this mutated helix forms? In this case, the protein will probably not work well. The hydrophilic side of the helix may stick out into the pore's channel and fewer molecules might be able to pass through.
   - Explain cystic fibrosis (CF), a common genetic disease that affects channel proteins. There are many different mutations in the CF gene that occur in people with CF, but the result is they all create a defective channel protein. These proteins cannot do their job helping chloride ions to pass through the cell membrane. This causes problems, particularly in the lungs where fluids become too thick to work well. People with CF have trouble breathing.