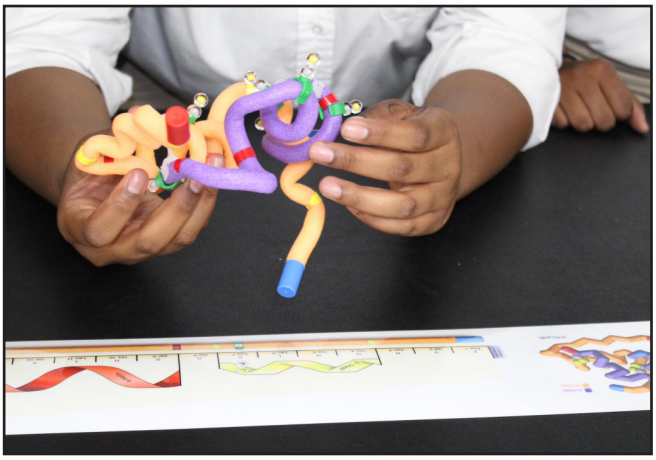
In Brief: Key Teaching Points for the Insulin mRNA to Protein Kit©

Overall Student Learning Objective: Some proteins, like insulin, are made as longer precursor proteins that are later cleaved to create the active protein.

- Insulin is important in regulating glucose homeostasis.
- The linear sequence of nucleotides in a gene codes for the linear sequence of amino acids in a protein.
- Proteins that will be secreted or inserted into membranes contain a hydrophobic signal sequence that is often cleaved after the protein is made.
- After protein synthesis, some proteins undergo post-translational processing. This may include removal of signal sequences and/or other sequences. Other modifications, such as phosphorylation of specific residues, or the attachment of lipids or carbohydrates, occur at specific sites on some proteins.
- Proteins fold into specific three-dimensional shapes based on the linear sequence of amino acids, following basic rules of chemistry.
- Proteins consisting of two or more chains exhibit protein quaternary structure.
- Disulfide bonds are covalent bonds between two cysteine sidechains in some proteins that help to stabilize protein structure.
- Molecules involved in the synthesis of secreted proteins are transported through the cellular endomembrane system.
- Introduction to genomics: how do scientists identify a consensus sequence?
- Thinking like a scientist: what is the function of the C peptide in proinsulin?

The Insulin mRNA to Protein Kit© starts with a processed mRNA sequence (introns have been removed) and moves students through translation of the sequence to produce preproinsulin then describes post-translational processing, leading students finally to use minitoobers to accurately fold an insulin molecule. We recommend using the Amino Acid Starter Kit© to introduce students to basic principles of chemistry involved in protein folding followed by the Map of the Human β-Globin Gene© to introduce students to introns and promoters, before using the Insulin mRNA to Protein Kit©.



Exploring Insulin mRNA and Protein Structure

The role of insulin in regulating glucose homeostasis can be introduced with the animation “Insulin and the Regulation of Glucose in the Blood” available at *http://youtu.be/OlHez8gwMgw*.

The Primary Student Handout reviews protein synthesis from mRNA then provides an overview of insulin synthesis within the beta cells of the pancreas, indicating which steps of the process occur in what organelles. This is followed by an exploration of the structure and function of the signal peptide and the C peptide. Students map the disulfide bonds on the A and B chains, then fold a three dimensional model of insulin using minitoobers.

Role of C Peptide

Why do cells make insulin with the additional C peptide, when it is only cut out and discarded? Isn't this a waste of energy? Students can model one hypothesis in this interactive activity.

Identifying a Consensus Sequence

How did we determine that all genes begin with AUG, coding for methionine? This was the work of Dr. Marilyn Kozak, who aligned thousands of human gene sequences to find the pattern. She then created mutations in the insulin gene sequence to test her proposed consensus sequence. Students can repeat this work (using many fewer sequences!) to learn how consensus sequences are determined.

Further Explorations in Drug Development

Since insulin was the first "drug" that was created using genetic engineering, and several modifications to the protein have been engineered to create fast acting insulin and slow release insulin, insulin provides a great avenue for research projects related to drug design and development. Links to historical background articles and current developments are provided in the kit to launch student research projects in this field.

The Insulin mRNA to Protein Kit© can be borrowed from the MSOE Model Lending Library (*cbm.MSOE.edu/LendingLibrary*) or purchased from 3D Molecular Designs (*3dmoleculardesigns.com*). Find complete lessons and activities at *http://www.3dmoleculardesigns.com/Teacher-Resources/Insulin-mRNA-to-Protein-Kit.htm*.