**The Molecular Mechanism of Diabetes**

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| **Grade Level:** 7-12 Life Science  **Duration:**  Prep time: Time will vary depending on your familiarity with insulin, insulin-related proteins, and the molecular visualization software Jmol.  Activity duration:   * To complete the entire master model (map of phenomenon, essential questions, and activities to address the essential questions): 3+ weeks of classroom time * To do the 2 MSOE modeling activities 135 minutes * To do the 2 MSOE modeling activities and Jmol modeling: 1.5 weeks of classroom time   **NGSS Practices**  The bolded practices below are included in these lessons: | |
| 1. **Asking questions** 2. **Developing and using models** 3. Planning and carrying out investigations 4. Analyzing and interpreting data | 1. Using mathematics and computational thinking 2. Constructing explanations 3. Engaging in argument from evidence 4. **Obtaining, evaluating, and communicating information** |

**Objectives for MSOE protein modeling and Jmol:**

* Students will be able to compare structure and function of different proteins
* Students will be able to explain how organisms maintain homeostasis
* Students will be able to create a model of insulin and explain the role of ribosomes, endoplasmic reticulum, golgi apparatus, and the nucleus take part in the production of insulin.
* Students will be able to create a model of fast acting or long lasting insulin and explain how genetic engineering has impacted the treatment of diabetes.

**Materials**

* A classroom set of 3D Molecular Designs Insulin: mRNA to Protein Kit and associated student handouts.
* A classroom set of 3D Molecular Design Amino Acid Starter Kit and associated student handouts.
* Insulin model
* Computer for each student
* Jmol software (open source free software found [here](http://cbm.msoe.edu/crest/crestJmolResources.php%20))
* Jmol tutorial (<https://sites.google.com/view/csats-mechanism-of-diabetes/jmol-tutorial>)

**Background**

Diabetes mellitus is caused by impaired insulin function and leads to high glucose levels in the blood. High blood glucose levels leads to dehydration and life-threatening changes in blood pH. These changes cause severe long-term effects on the body. Diabetes is one of today’s chronic diseases reaching an epidemic health crisis.

These lessons are part of a larger unit (included in the Master Model on the USB drive) that work to answer the question: *What is the role of insulin in the body and how does its impaired function contribute to diabetes?* The lessons included in this BlueBox explore two sub questions:

1) How does diabetes result from impaired insulin and insulin-related proteins function?

2) How is insulin manufactured and engineered for medicinal purposes?

**Procedures**

1. Amino Acid Starter Kit teacher instructions and student handout can be found [here](https://www.3dmoleculardesigns.com/Teacher-Resources/Amino-Acid-Starter-Kit.htm). These handouts are also on the USB drive included in the BlueBox. You will need to request access from 3D Molecular Designs to see the answer keys. You do not have to do everything in the student handouts, please choose what is most appropriate for your students.
2. Insulin: mRNA to Protein Kit teacher instructions and student handout can be found [here](https://www.3dmoleculardesigns.com/Teacher-Resources/Insulin-mRNA-to-Protein-Kit.htm). These handouts are also on the USB drive included in the BlueBox. You will need to request access from 3D Molecular Designs to see the answer keys. You do not have to do everything in the student handouts, please choose what is most appropriate for your students.
3. A tutorial has been created for the Jmol modeling with insulin portion. You can find the tutorial [here](https://sites.google.com/view/csats-mechanism-of-diabetes/jmol-tutorial). You can use this tutorial to familiarize yourself with Jmol and with your students.
4. To model designer insulins in Jmol a list of potential .pdb files for fast-acting and long-lasting insulin has been included in the USB drive for the BlueBox. You can also use the PDB101 molecule of the month information found [here](https://pdb101.rcsb.org/motm/194) to help you and your students.

**References**

3D Molecular Designs. (n.d.). Amino Acid Starter Kit Teacher Resources. Retrieved from <https://www.3dmoleculardesigns.com/Teacher-Resources/Amino-Acid-Starter-Kit.htm>

3D Molecular Designs. (n.d.). Insulin mRNA to Protein Kit Teacher Resources. Retrieved from <https://www.3dmoleculardesigns.com/Teacher-Resources/Insulin-mRNA-to-Protein-Kit.htm>

Goodsell, D.S. (2016). Designer Insulins. Retrieved from <http://pdb101.rcsb.org/motm/194>