EDGERTON CENTER

Massachusetts Institute of Technology

DNA/RNA, Protein, and tRNA Sets
Essentials for Teaching

AN INNOVATION IN MOLECULAR MODELS

Today's biology teachers need to teach about molecular function. This is hard to do. Students find it difficult to follow the many structural changes that molecules can undergo.

How can the innovative MIT models help?

The models were designed to be manipulated and are inviting to touch. The molecules' functional groups are accentuated by attractive and colorful shapes. These features help students focus on the key aspects of the cell processes that they are re-enacting. The processes include DNA replication, mRNA transcription, and tRNA translation. Chains of amino acids are flexible, so after translation students can fold proteins into different shapes, illustrating all four levels of protein structure. The innovative models make it possible to demonstrate how a change in a single nucleotide can change a protein's structure and function.

Since our models are unique, they bring a unique set of challenges to the classroom! To become familiar with the best practices for teaching with these innovative tools, please be attentive to the following 4 essentials that we will describe in detail:

1. Practice with the hands-on models to become a skillful and confident leader.

2. Use the models at multiple levels to meet student needs.

3. Teach 'Proteins before DNA' to increase student understanding.

4. Prepare your kits and follow maintenance instructions.

4 ESSENTIALS FOR TEACHING:

1. **Practice with the hands-on models to become a skillful and confident leader.**

   You need to become familiar with how the student booklets are designed to work. The class will be grouped in teams of two with each team sharing one kit and one booklet. A **bold type** sentence in the booklet indicates an action for the students to do with the models. The adjacent photo provides a visual for this action. An underline in the text alerts the students to a new vocabulary word. A yellow highlighted question in the text is intended to have the students pause and reflect. The questions function as a periodic "check-in" for student understanding. Answers to these questions are in the back of booklet.

   Before teaching, we strongly suggest taking out a kit and following the instructions in Booklet 1 very carefully. During your practice time, please use the Lesson Guides online: http://edgerton.mit.edu/DNA-proteins-sets. Watch the 'Demonstration Videos' to see close-up views of exactly what to do with the models for each simulation. Mastering the modeling yourself first is important. Students will be acting out the cell processes with the models to learn the steps, so they need to physically do it correctly to learn it correctly. For example, the two strands of the double helix are held together by weak hydrogen bonds. In the cell, the two DNA strands are easily separated and easily rejoined. With the right technique as demonstrated in the 'Demonstration Video' the model DNA strands should pop apart easily!

2. **Use the models at multiple levels to meet student needs.**

   The models were designed for multiple levels of instruction: middle school, high school and the university/professional levels. For example, the model's universal design supports an emphasis on nucleotide chemistry at the university level with the 3' designation on the sugar models. However, the middle school teacher can fully use the models without referring to the 3'. In keeping with universal design, the booklets minimize the number of scientific terms so teachers can choose the scientific terms they will require students to learn. This gives all teachers flexibility and autonomy. Instructors can elaborate on the chemistry that is represented and choose appropriate vocabulary.

   The models provide flexibility for many students with different learning needs. The models are an excellent means for teaching molecular biology to English language learners (ELL) because the concepts can be visually conveyed. Additionally, the models are ideal for tutoring. Instructors may wish to introduce their support staff in the use of the kits.

   While a wide age range is possible, we do not recommend the models for students under 11 years old. It is preferable for students to have mature motor skills and a working knowledge of cells and molecules before using the models.

3. **Teach 'Proteins before DNA' to increase student understanding.**

   High school and university instructors usually teach DNA first and then move on to teaching protein synthesis. This sequence mimics the central dogma sequence of molecular

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biology (DNA-> RNA-> Protein) but makes the content more difficult to learn. Proteins are unfamiliar molecules to most students who are learning protein synthesis. Thus, students are trying to learn about proteins and protein synthesis at the same time.

However, if you teach proteins before DNA, students will be able to focus on the process of synthesizing a protein from a gene during protein synthesis. Students can anticipate that the amino acids will be joined into a long chain and recognize that the order of the amino acids determines a protein's shape and function.

So try teaching proteins before DNA! Learning about proteins will give the students a much better understanding about DNA. Admittedly, teachers have had difficulty teaching about proteins in the past because suitable models were unavailable. Our amino acids make the assembly and folding of protein chains into understandable and satisfying hands-on activities.

4. Prepare your kits and follow maintenance instructions.

There are 14 kits in the DNA/RNA Set and 14 kits in the Protein Set. Kits #1-12 become the student kits; Kit #13 is placed aside for replacing parts as needed in the future; and Kit #14 is kept as a teacher kit for demonstrations. (The tRNA Set has 4 kits and is used in a different classroom manner. See separate tRNA instructions.)

Prepare all kits before use:

• Place strips of labeling or masking tape numbered #1-14 between the black latches on the side of each kit.

• Number the top label on each kit #1-14 to match the strip on the side.

• Make 14 photocopies of this file: Team Kit Care Record

• Fold the Team Kit Care Record papers into quarters so page 1 faces out. Place one paper inside each kit. Check off the kit type and write the number of the kit on the paper.

• For the DNA/RNA kits: Remove the small bag in the lower right hand compartment of each kit. Take the 3 white tags out of the bag and put them in the compartment.

(Only the 3 white tags inside are needed for DNA/RNA Booklet 1 and we recommend removing the rest of the bag from the kits for safe-keeping. When teaching the Advanced Topics DNA lessons in Booklet 2, you will need to return the small bag of parts.

Maintain kits with the following method:

Assign each student team to a kit # that they will always use. At the beginning of each lesson, give teams about 3 minutes to fill out the Team Kit Care Record. Initially explain that you expect teams to inspect kit pieces and confirm the piece counts. Students should report the kit status and not leave any blanks on the paper. The additional column on the paper for teacher initials is optional. Use this for teams that require your close supervision or for teacher notes/comments. Find a small box to be designated the "Lost & Found" for the whole class. Instruct the teams to place any extra pieces into the Lost & Found Box. Teams should also look for any missing pieces from their kit in the Lost & Found Box.

Why is this Team Kit Care system so effective? Teams keep the same kits, checking is only done at the beginning of each class, and each team checks the previous team's use. The student kits were designed to minimize manual counting; the number of pieces in small compartments can be discerned by a glance and the clear plastic box makes it possible for the teacher to see the materials inside for quick visual confirmation.

This concludes the Essentials for Teaching. In summary:

1. Practice with the models first yourself.

2. Plan to use the models in multiple ways to meet diverse student needs.

3. Teach proteins before DNA to help your students learn the key concepts.

4. Prepare your kits and maintain your models well with the help of your students.

Enjoy!

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