DNA/RNA, Protein, and tRNA Sets

Essentials for Teaching

AN INNOVATION IN MOLECULAR MODELS

Unlike most molecular models used in classrooms today, the MIT models are designed to teach not just what molecules look like, but what the molecules do. This is breaks the mold! The classic DNA model always shows DNA's chemical form in a frozen shape.

Today, biology teachers need to be able to teach about what molecules do. As hard as it is to teach about molecular structure – teaching about a molecular process is even harder! In cell processes, molecules undergo structural changes in multiple steps, making it difficult to understand what is going on. So let's take a look at the MIT models.

The molecules were made to be manipulated and are designed to demonstrate the multiple steps of cell processes. Students actually can perform all the key process: DNA replication, mRNA transcription, and tRNA translation. The structure/function relationship in proteins can also be simulated. Chains of amino acids can be produced. They can be folded into three dimensional shapes and all four levels of protein folding can be illustrated in this way.

This innovative capability to capture cell processes also serves to increase student engagement. These hands-on experiences bring on a level of fun and with it, a set of unique teaching challenges! To quickly become proficient in the use of these teaching tools, please read the following tips.

TIPS FOR INSTANT SUCCESS:

1. First, practice and play with the hands-on models yourself to gain proficiency and confidence.

   During your practice time, please use the Teacher Guide online. Select the ‘Demonstration Videos’ to see close-up views of exactly what to do (and what not to do!) for each simulation. Mastering the modeling precisely is important. Students will be acting out the cell processes with the models to learn it correctly. They need to physically do it correctly. Luckily, most biomolecules are polymers! Students will get lots of practice with each step. For example, the two strands of the double helix are held together by weak hydrogen bonds. In the cell, the two strands are easily separated and easily rejoined. The models are designed to show this. With the correct technique as shown in the ‘Demonstration Video’, the DNA strands should easily pop apart moving along as you continue to move your hands along the molecule.

2. Utilize the models’ universal design features to meet student needs.

   The models are well suited for multiple levels of instruction including middle school, high school and the university/professional levels. For example, the model’s universal design supports an emphasis of nucleotide chemistry for university students, with the 3’ designation on the sugar molecules. However, the middle school teacher can fully use the models in class without ever mentioning the 3’ ends.

   Overall, flexibility of instruction is supported. Instructors can elaborate on the chemistry that is represented, choose to use vocabulary they desire, and add selected advanced lessons from Booklet 2. In keeping with universal design, the booklets minimize the number of terms so teachers can choose the scientific terms they will add and require their students to learn. Thus teachers are given the flexibility they need to tailor the curriculum to the appropriate level for their students.

   The models provide an ideal means of teaching molecular biology to second language learners. Held back by their lack of vocabulary, these students don't often get the opportunity to learn exciting concepts. But here the concepts are conveyed with the models. Teachers in the US remark how rewarding it is to see English language learners (ELL)
become so engaged, eager to ask questions. Additionally the models are ideal for tutoring purposes. They provide flexibility for high school students with different learning needs. Knowing this, if you are a classroom or lab teacher, you may wish to plan ahead to include staff/teaching assistants in your training sessions.

» While a wide age-range is possible for learners, we do not recommend the models for typical students under 11 years for physical motor skill and subject matter reasons. Age-appropriate instruction suggests that students should have the sufficient mental maturity for working with cells and molecules.

3. **Teach ‘Proteins before DNA’ in your lesson plan. See why and how to do this.**

   » 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 biology (DNA-> RNA-> Protein). This common practice makes things more difficult than it needs to be. First, proteins are unfamiliar molecules to most students who are learning protein synthesis. Thus, teachers are typically trying to teach about proteins at the same time as they are teaching about protein synthesis.

   » However, if teachers have already taught proteins with our models, the students will be able to focus on the process of synthesizing a protein from a gene. To be specific, if you teach proteins before the protein synthesis lesson, students can anticipate that the amino acids will be joined into a long chain. Furthermore, the students already recognize that the order of the amino acids determines a protein’s shape and function. So they understand how important it is to get the amino acid sequence right.

   » So- try it! Teach our protein lessons first-- even to middle school students! We know teaching about proteins is uncommon at this grade level. However, aren’t middle schoolers taught that DNA codes for something? So learning about proteins will give the students a much better understanding about DNA. Admittedly, teachers have had difficulty teaching about proteins because they couldn’t find any suitable protein models. Our amino acids make the assembly and folding of protein chains into an understandable and satisfying hands-on activity.

4. **Employ the Team Kit Care Record to maintain your sets**

   » Here we concern ourselves with the practical matters of maintaining the set. This involves numbering the kits beforehand and instructing the teams how to complete the Team Kit Care Record as the start of every lesson. There are 14 kits in the DNA/RNA Set and 14 kits in the Protein Set. Here is how it works: Kits #1-12 become the student kits; Kit #13 is placed aside for replacement parts; and kit #14 is kept as the teacher kit for demonstrations.

   » See the adjacent figure to set up your kits. Mark the outside of kits as described and place the folded ‘Team Kit Care Record’ inside the box. Remove the small bag in the lower right hand compartment. Only the 3 white tags inside are needed for Booklet 1 lessons, so only replace the 3 white tags in the compartment. We recommend removing the bag for save-keeping. Amend the Team Kit Care Record paper to list 3 white tags the compartment. This speeds-up the kit check process. When teaching with Booklet 2 (Advanced) lessons, you will need to return the small bag of parts.

   » 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 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

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**Prepare your kits with these 3 steps**

1. Create kits #1-14. Place numbered #1-14 strips of labeling/masking tape between the black latches on the side of kit.

2. Write #1-14 on the labels on the top of the kit.

3. Make 14 photocopies (plus a couple of extras) of this file: [Team Kit Care Record](#) also found in the Teacher Guide. Write the Kit # on the paper and check the appropriate boxes on the page. Fold the paper “Team Kit Care Record” in quarters. Make sure the “page 1” faces out. Place this paper inside each kit under the lid.

Assign the student teams to a kit # that they will always use. This simplifies the care of kits as well.

Find a small box to be designated as the Lost & Found.
on the paper labeled “teacher initials” is optional. Use this for teams that require your close supervision or for teacher notes/comments.

» Why is this Team Kit Care system so effective? Teams keep the same kits. Checking is only done at the beginning of each class. Thus, each team checks the previous team’s use. Also the student kits were designed to minimize manual counting. Small quantities can be discerned by a glance. Lastly, remember to instruct the teams to place any extra pieces into a box designated as the Lost & Found Box. Lastly, the clear plastic box makes it possible the teacher to see the materials inside for quick visual confirmation.

This concludes the Introduction to the Teacher Guide with recommendations for use. In summary: play with the models yourself first; plan for matching programmatic student needs with available staff; teach proteins before DNA; and lastly, prepare the kits and students for kit care accountability.