The Magnetic Board: An Aid in Teaching Difficult Concepts

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The magnetic board described in this article is an instructional aid that clarifies difficult principles for all students and draws the marginally interested student into the study of biology. Its interlocking, moveable components also stimulate the interest of mechanically inclined students.

Commercially prepared instructional materials similar to those shown in the accompanying photographs are currently available, but they are expensive and the range of topics covered is limited. Moreover, they are not tailored to the individual teacher's style. The instructional units we have used in our biology program were developed over several years, beginning in 1969; they are based on the models used in the AIBS film series. Three study units are described in this article; additional units on photosynthesis, nerve impulse generation, nephron function, patterns of circulation, meiosis, and genetics have also been developed.

Making the Boards

The term "magnetic board" is a misnomer; the board is simply spray-painted sheet metal. It is magnetic because of the magnetic ribbon that is glued to the back of the mat board models that temporarily adhere to the sheet metal. The basic instructional board is a piece of 26 gauge, 76.8 cm by 2.44 m (30-inch by 8-foot) sheet metal available locally from sheet metal suppliers. The metal is glued to masonite with panel adhesive. Placing the sheet metal and masonite on the floor and adding books for weight over a weekend ensures that the metal will adhere permanently to the masonite backing board. We spray on a light-green background color, which adds visibility and provides contrast to the model colors. Once the paint dries, the board can be hung or mounted on a wall to supplement the chalkboard.

Making the Models

Models that can be moved around on the surface of the board are best made from mat board of heavy posterboard. Two pieces of magnetic ribbon approximately 1 cm by 4 cm will hold a large molecular model (150 cm^2) to the metal backboard and, at the same time, allow the model to be easily manipulated. Magnetic ribbon can be purchased locally or ordered from Edmond Scientific.

The Teaching Units

The units developed at our school focus on concepts that beginning students find difficult to understand through more traditional forms of instruction. As with most models, some degree of oversimplification is necessary, and minor inaccuracies result. However, the increase in student comprehension offsets, in our opinion, the minor inaccuracies. The accompanying photographs have all of the components in position; thus they do not do complete justice to the value of the instructional aid because they present a cluttered view. In the usual classroom setting, the board is completely empty as the presentation begins; and models are added or moved one at a time.

Protein synthesis (fig. 1) is developed step by step after identi-

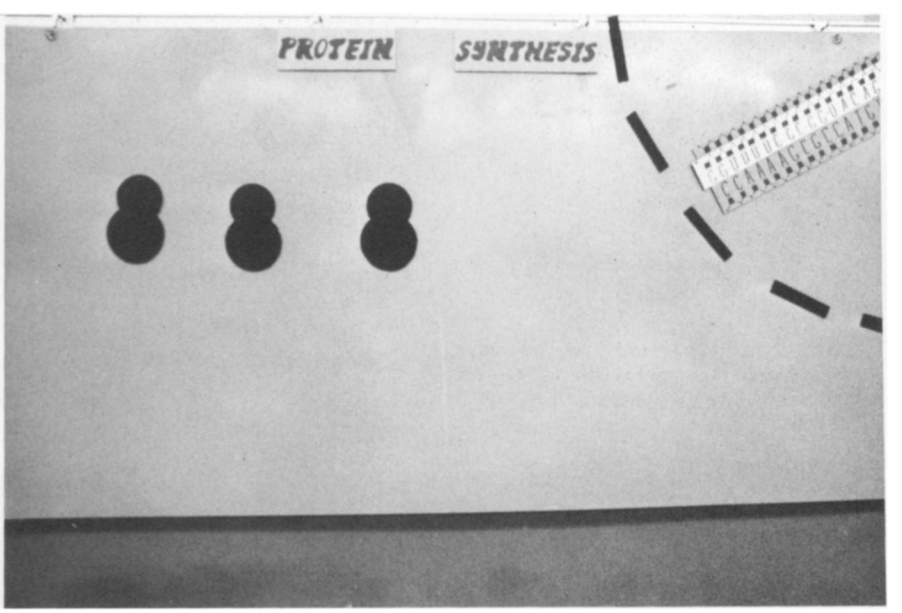

FIGURE 1. Most of the DNA segment is uncoiled. Nitrogen base pairings on the DNA molecule can be noted by the student as well as the substitution of uracil on the mRNA

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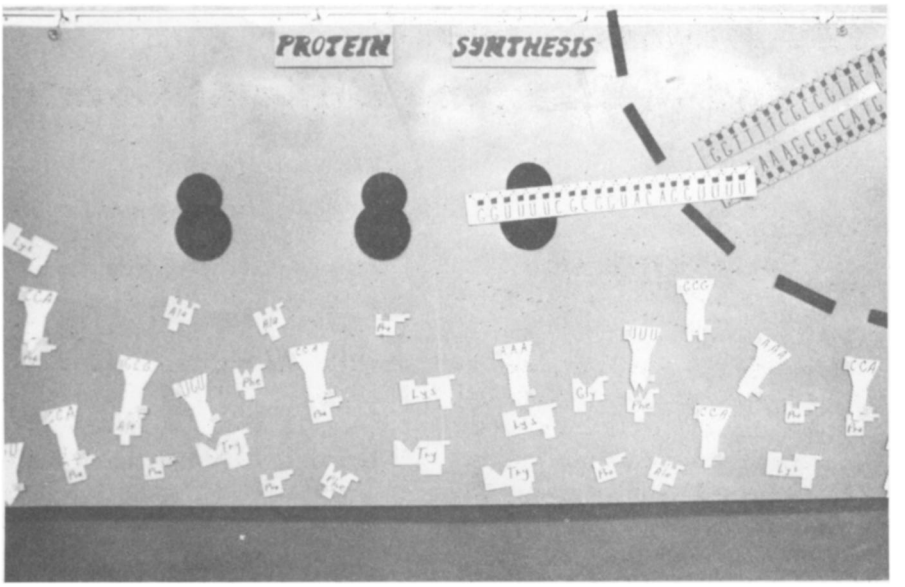

FIGURE 2. The mobile aspect of the amino acid, tRNA, and mRNA molecules emphasizes the mechanical nature of the process.

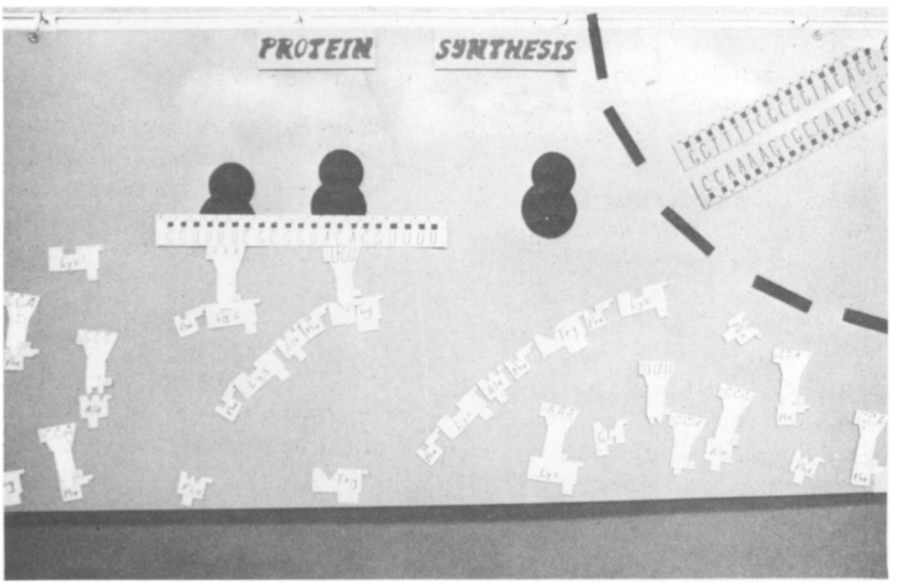

FIGURE 3. The repeating nature of the synthesis process is represented as the mRNA contacts the individual ribosomes.

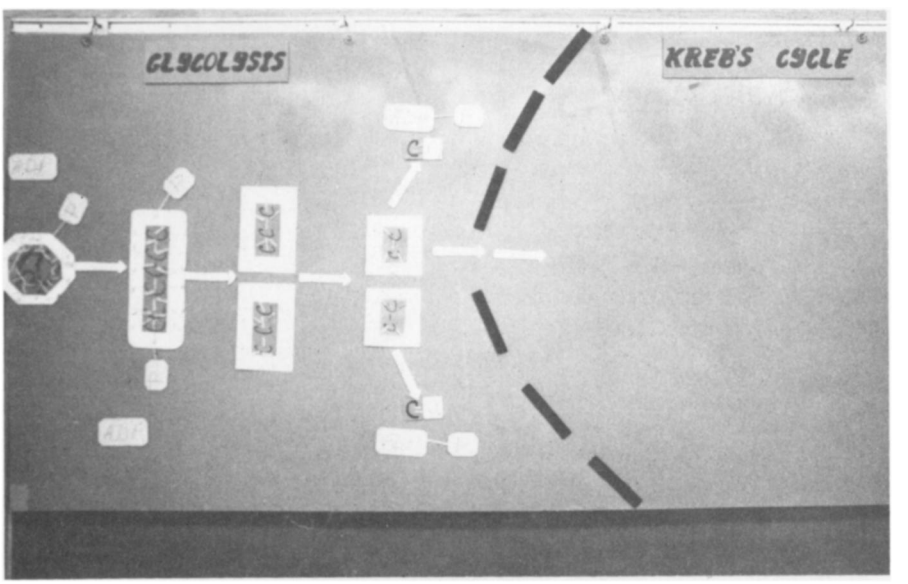

FIGURE 4. Glycolysis can be easily modified, using many of the same models, to represent fermentation.

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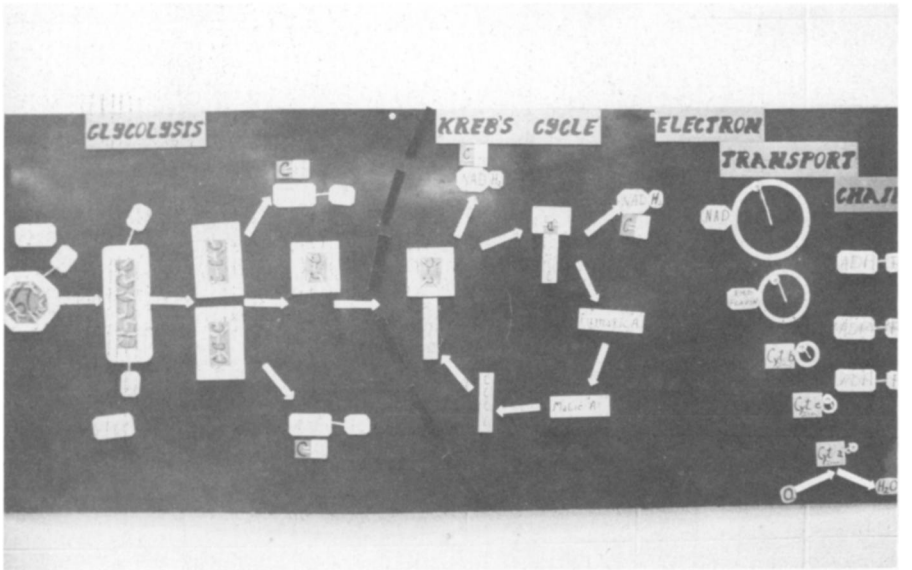

FIGURE 5. The energized H electrons are represented with differing shell diameters. As the electron is passed from carrier to carrier the electron associated energy can be moved from the electron to form ADP ~ P.

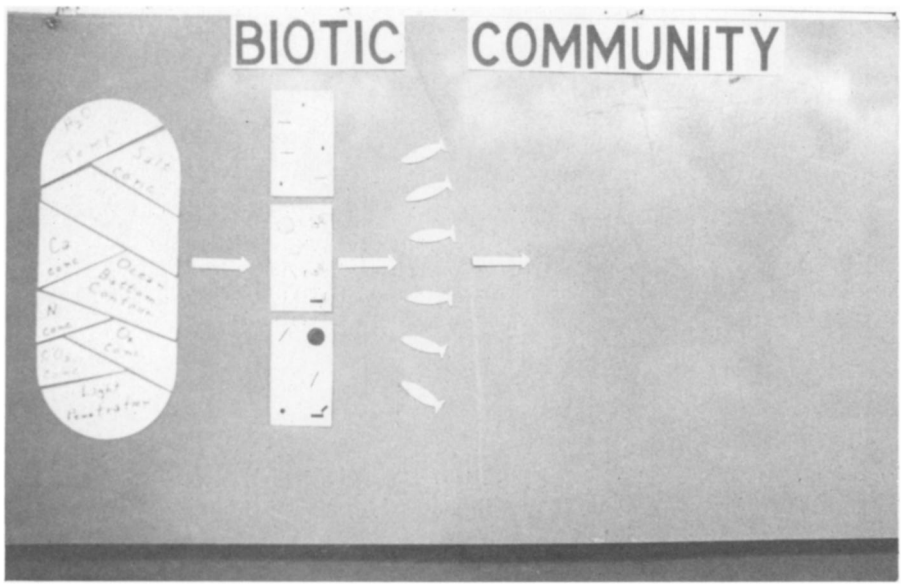

FIGURE 6. The ocean type food chain was developed due to our inland location. A grass lands chain may be more of interest to ocean locals.

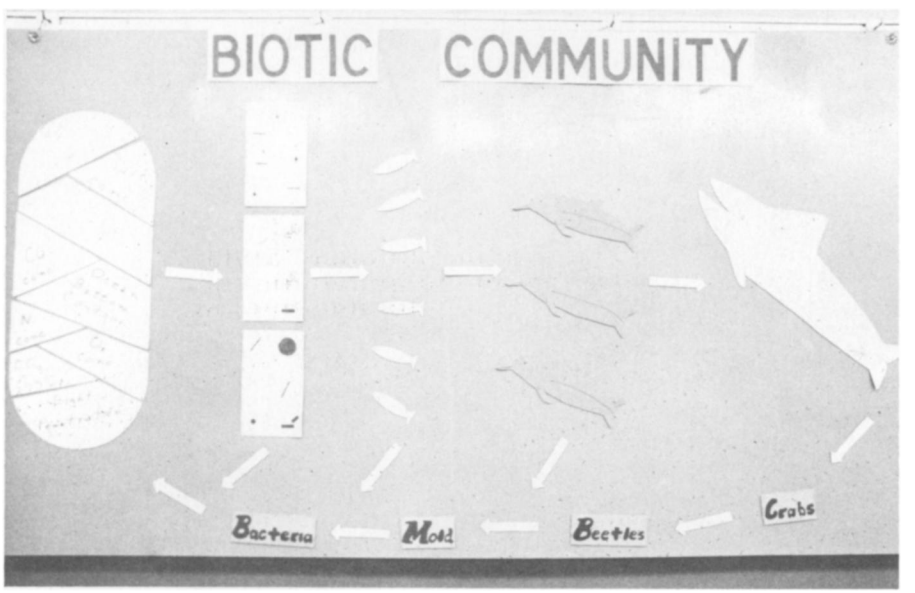

FIGURE 7. This ocean food chain can be converted into an energy web after the basic components are well understood.

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fying the regions of cytoplasm, ribosomes, nuclear membrane, and nuclearplasm. Next, a segment of uncoiled DNA is placed in the nuclear region, followed by the positioning of complementary mRNA next to the DNA. Amino acid molecules, as well as tRNA, are then added in the cytoplasm region. Later (fig. 2) mRNA can be slipped through the nuclear pore, after which it comes in contact with one or more of the ribosomes. It can then be shown that the tRNA's are specific as to their pairing with amino acids and that the complementary triplet codes will determine the order of the tRNA next to the mRNA, and thus the order of the amino acids in the chain. Other amino acid chains are begun as the mRNA is moved along and comes in contact with additional ribosomes (fig. 3).

Cellular respiration (fig. 4) is presented in three major steps, with several intermediate stages depending on the level of understanding of the students. We use magnetic board lessons during both years of our program. Glucose is represented at the left side of the board; intermediate compounds are added to the board until the 2-carbon fragment is formed. The mitochondrial membrane (fig. 5) surrounds the abbreviated Kreb's Cycle and the descending electron cascade of the electron transport chain. Both in cellular respiration and in photosynthesis ATP is represented as ADP$\sim$P, where the $\sim$ high energy bond and the end phospate can be removed or added as needed. Chemical bond energy, the thread of continuity in many life processes, is represented on these models with short sections of yellow pipe cleaners.

We have also developed a lesson on photosynthesis in a sequential fashion using some of the same models developed for the cellular respiration unit. The chlorophyll molecules are made with removable electrons in the molecular shells; and as such, the ferridoxin can then pick up the excited electrons and continue into the cyclic or noncyclic aspects of photosynthesis.

Genetics instruction can, with considerable variation, also be introduced with the magnetic board. Relationships among meiosis, fertilization, and mitosis are easily represented with lettered chromosome models. The mechanisms for sex determination and inheritance of single traits and sex-linked genes have been explained with this teaching tool.

Biotic communities, food chains and energy webs, although not especially difficult topics as usually presented in high school, can also be developed with one member being presented at a time. Students are more likely to understand the role of the food chain components if these components are presented one at a time (fig. 6 and 7). Proportionally sized models of pyramids of mass and numbers tend to impress students with these relationships.

Advantages of the Teacher-made Models

This teaching tool is inexpensive in comparison to the $80 cost of each teaching unit manufactured by commercial firms. Materials for the magnetic board can be purchased for less than $15. After this initial investment, each lesson would cost less than $2.00.

On several occasions after I have made the initial presentation, I have found my students moving the models around the board explaining the process over again to other students. Many mechanically inclined students, who would never read the textbook, find themselves teaching other students simply because they enjoy working with the interconnecting models.

Reference

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES. (undated) *The role of green plants, cell respiration, energy cycles within cells.* (AIBS Biology Course Series). New York: McGraw-Hill Book Company.

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