DNA: A Kinesthetic Experience

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Sandra Johnson is an Assistant Professor of Biology at the Middle Tennessee State University. As a plant ecologist, her research and teaching interests focus on plants and their interactions with each other and with other organisms. Current research looks at how fire impacts community composition in Cedar Glades. She teaches the Botany segment of her department's required General Biology sequence and Plant Physiology. Dr. Johnson recently proposed a new course, Plant-Animal Interactions, which will be taught for the first time in Fall 2001. She also teaches a Topics in Biology course for non-majors each semester.

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The exercise in this workshop enables students to get “up close and personal” with the DNA molecule as their bodies become nucleotides, the basic subunits of all nucleic acids. This exercise clarifies concepts and vocabulary, which are central to understanding gene expression in a concrete and kinesthetic way.

DNA is the molecule that transmits hereditary information to subsequent generations. As is often true in the structure/function world of modern biology, concrete experiences with the structure of DNA can help students better understand its central role as the self-replicating genetic material. As students enter the classroom, each receives a colored slip of paper identifying the individual as A, T, G, or C. During the few minutes before lecture begins, the group is usually abuzz with discussion about the slips of paper. The lecture begins by questioning students regarding their hypotheses of what we’ll discuss during the lecture, and the bases for those hypotheses. The group is usually quick to agree that the lecture's subject will be DNA. Subsequently we brainstorm, and one student records, everything the group knows about DNA. A second transparency reveals DNA-related vocabulary that will be clarified in the exercise, *e.g.* antiparallel, 5' to 3' direction, covalent vs. hydrogen bonding, and other terms. Now we're ready to begin.

Each student becomes a nucleotide, the torso is a sugar residue, deoxyribose in the case of DNA, the left elbow is a phosphate residue; and the right elbow is the nitrogenous base. Remember, students have already received their new identity (actually their right elbow's identity) as one of the nitrogenous bases: adenine (A), thymine (T), cytosine (C), or guanine (G). Students with slips of a designated color are asked to form one strand of the polymer. The order of bases in this first group is unimportant. However, DNA synthesis proceeds in a 5' to 3' direction, thus left and right shoulders are identified as 5' and 3' carbons, respectively, so that synthesis can proceed in the correct direction. Then, the second group (second color slips) forms complementary base pairs with the appropriate base. But where does the opposing strand begin? Students quickly grasp the meaning of antiparallel when they see that 5' to 3' synthesis can't begin at the first strand's start site. The relative strength of chemical bonds is also enacted through the strong bond of left hand grasping the 3' C of the adjacent nucleotide, as opposed to the weak hydrogen bond of palms together holding the two strands of the helix together. Finally, the group ends up in a ladder-like structure similar to the DNA molecule. However, in reality the molecule is a double helix, not just a ladder. Students examine a model double helix and are challenged to come up with a workable ways to twist the model (working individually or in groups).

Finally to close the exercise, we review the brainstormed ideas originally held by students, reinforcing those that were correct and correcting erroneous ideas, then write clear definitions for the vocabulary terms.