

## Pipe cleaner DNA

In my first year of teaching biology, I came to the chapter on DNA without having done a tremendous amount of advance planning. Faced with a lab period the next day, I needed to design a way to build a DNA model with materials I could buy at the store that afternoon. The pipe cleaner DNA model uses simple materials—I only had to buy about \$20 worth of supplies at a local craft store. The model offers limitless opportunities for realistic manipulation, including DNA replication, mutation, and protein synthesis. The activity is also appropriate for students at many levels.

### Materials

Students will need rolls of masking tape, scissors, metersticks or rulers for measuring, and pipe cleaners in four or five colors (I use green, red, blue, yellow, and white).

### Procedure

Students work in pairs. DNA strands can be completed in approximately 30 minutes, with one partner working on the tape and the other partner preparing the nitrogen bases. (The teacher may prepare a sample model for students.) Students should:

- ◆ Lay out a strip of masking tape 50 cm long. The sticky side should be facing up. Small pieces of tape are used to secure the strip to the table.
- ◆ Choose colors for pipe cleaner nitrogen bases. For example, red for adenine, green for thymine, blue for guanine, and yellow for cytosine.
- ◆ Cut the pipe cleaners into 10 cm

pieces. Once this is done, all the thymine (green) and cytosine (yellow) pieces are folded in half.

- ◆ Make marks on the tape every 3 cm (15 total) for 5 codons of bases.
- ◆ Lay a pipe cleaner piece on the first mark perpendicular to the tape, so that it overlaps exactly one half of the tape. This step is repeated with random colors until there is a sequence of 15 bases (Figure 1).
- ◆ Fold the tape over lengthwise to secure the pipe cleaner bases. This is repeated with a second strip of tape, except a sequence of nitrogen bases that complements the sequence on the first strand is used. In other words, a thymine is placed opposite adenine, and cytosine opposite guanine.
- ◆ Place the strands opposite one another so that the corresponding nitrogen bases overlap. The free ends of the adenine and guanine pieces are fed into the corresponding loops of thymine and cytosine and folded into a hook to secure them (Figure 2).

The DNA model is now complete, although it could be further decorated by adding colored spots to the tape to represent the deoxyribose and phosphate molecules.

### DNA replication and mutation

Significantly, this DNA model can be used to show the essential function of DNA. To demonstrate DNA replication, my students first create a pool of “free-floating” ni-

FIGURE 1

Students attach nitrogen bases to the first strand.



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FIGURE 2

The two strands are hooked together to form a completed DNA model.

[Note mutation on the second base pair from the left (oops!).]

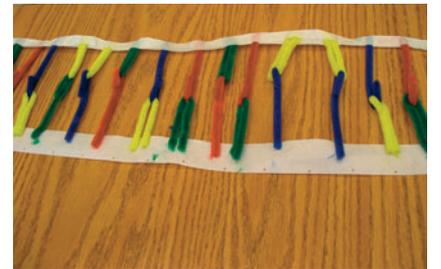


FIGURE 3

Students unhook strands and attach new bases (DNA replication).



trogen bases, each attached to a 3 cm piece of tape. After separating the two DNA strands by unhooking the base pairs, complementary new bases are attached to each strand, ultimately forming two identical DNA molecules (Figure 3, p. 58). I encourage my students to make at least one error in this process to demonstrate mutation, either by base-substitution or by skipping a base. The actual effects of the mutation can then be determined (see protein synthesis).

### Protein synthesis

The DNA models also illustrate the steps of protein synthesis. As in DNA replication, the first step is to unzip the DNA strand. From the pool of available bases, students create a two-codon messenger RNA (mRNA) molecule corresponding to one of the DNA strands. The mRNA will be identical to the other DNA strand, except that uracil (white) is used instead of thymine (green). The mRNA is then detached from the DNA and moved to a ribosome, modeled as a big purple blob (construction paper). Here, two corresponding transfer RNA (tRNA) molecules are attached to the mRNA. My students look up the amino acids coded for by the RNA using a conversion table available in many textbooks or on the Internet (ThinkQuest 1999). Students can also determine whether a mutation in their models actually affects the coded amino acid.

### Display

Several colorful and informative displays can be constructed to conclude this project. All of the DNA strands can be linked together to create an impressively long strand. My students create a poster featuring their DNA, mRNA, and tRNA molecules to describe the processes

of replication, mutation, and protein synthesis.

DNA is the fundamental substance of all living things, encoding the unique traits of every organism on Earth. By modeling the essential functions of replication, mutation, and protein synthesis, students can gain a deep appreciation and understanding of this amazing molecule!

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### Reference

ThinkQuest. 1999. *Webcytology: An Exploration of Unicellular Life*. library.thinkquest.org/27819.