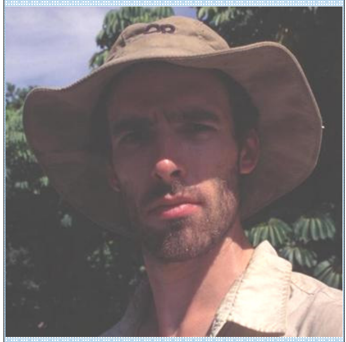
STEM Connections

Connecting the Science, Technology, Engineering, and Math concepts to our everyday lives.

By Dr. Barbara J. Shaw

Meet a Scientist:

Dr. Mark P. Simmons



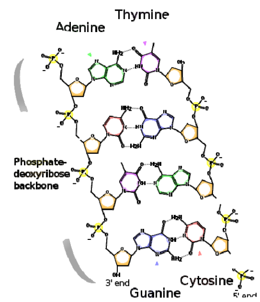
Dr. Simmons is a scientist at CSU. He uses DNA sequences to infer relationships among the ~ 1,300 species in the plant family Celastraceae, which includes vines, shrubs, and trees found from tropical to temperate regions. *Euonymus*, for instance, is commonly cultivated in Colorado. Using these data, he can infer how the genotypes (DNA sequences) of these species have changed through time. Most genes code for proteins. Closely related species, such as burning bush (*Euonymus alatus*) and winter creeper (*Euonymus fortunei*) generally have the same proteins, but make them slightly differently (in the same manner that English usage in Britain is slightly different from English usage in the U.S.). More distantly related species, such as burning bush and American bittersweet (*Celastrus scandens*), still generally have the same proteins, but make them very differently (such as English vs. German). Generally, the more closely related two species (or organisms) are, the more similar their DNA and protein sequences are to each other. The greater the time since the two species shared a common ancestor, the less similar they generally are to each other. As genetic differences accumulate, the phenotypes (physical characteristics based on gene expression) change as well. Therefore, Dr. Simmons can use DNA sequences to infer phenotypic changes.

4-H Projects:

- Any project in 4-H that deals with living organisms; livestock, fowl (although birds do have DNA in their red blood cells—only mammals don't), entomology, crops, etc.

DNA Structure

Learning the Basics



Every cell in your body (except your red blood cells) have DNA, and it is identical in every single cell in your body! If you could stretch the DNA from a single cell, you would have about 2 feet of DNA, but it's so thin, you couldn't see it.

DNA is has two strands. Each strand has a sugar phosphate backbone that faces outwards. This structure makes DNA very stable. Located on the inside are 4 molecules (the letters of the genetic alphabet) Adenine (A), Thymine (T), Guanine (G), and Cytosine (C). The sequence of these 4 molecules is the blueprint for making you! For example, on one strand, the sequence could be:

ATTGGCCAAGAT

If A only pairs with T, and G only pairs with C, then the other strand will line up with the correct pair. The DNA for this "gene" would be:

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<—strand    ATTGGCCAAGAT    strand—>
            | | | | | | | | | | | |
<—strand    TAACCGGTTCTA    strand—>
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AT and GC, when they are hydrogen bonded, are called base pairs. Hydrogen bonds weakly hold the base pairs together. When DNA is used, these base pairs unzip, allowing the code to be read.

The double strands then coil like a cork screw. This shape is called a helix. DNA's structure is therefore a double stranded helix.

EXPLORE IT - DESIGN IT - DO IT

All the evidence we have for the structure of DNA is robustly supported. With this model, you can visualize the DNA molecules that are so small that even the most powerful microscopes can not take clear images. Models help us to understand the natural world that is either too small, too far away, or too big to imagine. You can see the base pairing of Adenine to Thymine (Pink pairs with Green) and Guanine to Cytosine (Yellow pairs with Orange). The final step is to hold the opposite ends of the model and twist. Since DNA is a double stranded helix, our model need to have a twist.

There is one more thing you can do with your model before you eat it; take a pair of scissors and cut the toothpicks between the marshmallows. This simulates how the hydrogen bonds can pull apart and the DNA sequence can be read on a strand. Of course, real base pairs will snap back together after the DNA is read because the hydrogen bonds act like magnets!

Materials:

- Color mini-marshmallows
- 2 licorice sticks
- 12 toothpicks
- scissors

Directions:

Marshmallow Color Code
A = pink (P)
T = green (G)
G = yellow (Y)
C = orange (O)

A pairs with T
G pairs with C

- Spacing as evenly as possible, push the 12 toothpicks into the licorice stick
- The sequence on one strand of DNA: ATTGGCCAAGAT
- Using the marshmallow color code, push one marshmallow of the appropriate color on the toothpick, and slide it almost to the licorice stick.
- Check the color code: PGGYYOOPPYPG
- Remember the way base pairs match: Pink—Green Green—Pink Yellow—Orange Orange—Yellow.
- Add the base pair on the toothpick.
- Check your color code for the second strand of DNA: GPPOOYYGGOGP
- Push your second licorice stick onto the open end of the toothpicks,.
- Twist the two ends to for a double strand helix DNA!

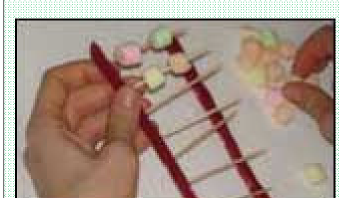

Illustration of ATGC pairing: http://en.wikipedia.org/wiki/DNA

Lesson modified and photo of edible model from: http://teach.genetics.utah.edu/content/begin/dna/eat_DNA.html