

Use PCR & a Single Hair To Produce a "DNA Fingerprint"

A. Malcolm Campbell John H. Williamson Diane Padula
Steve Sundby

As biology teachers, we are aware of the ever growing amount of information and new methods that we would like to incorporate into our classes. One area of particular growth has been in the field of DNA manipulations, or molecular biology. All of us want to share with our students these new and exciting techniques that are driving the revolution in biotechnology in addition to the fundamentals of population genetics, DNA structure, replication and mutations.

We have developed a laboratory procedure that draws upon all of these topics and is appropriate for introductory level college biology courses (for majors and/or nonmajors), as well as advanced high school biology classes. Using the protocols described in this article, in two lab periods of two hours each, every student extracts his or her own DNA from a single hair follicle, uses polymerase chain reaction (PCR¹) to amplify a polymorphic locus, electrophoreses the PCR products on an agarose gel, and visualizes the alleles to gener-

ate a "DNA fingerprint." These single-locus fingerprints can be used to generate population genetics data or to solve a fabricated crime.

Theoretical Background

A few fundamental concepts of biology are critical for students to understand in order to appreciate this laboratory exercise. We use "DNA fingerprinting" as a motivational tool to make relatively abstract concepts seem more tangible, exciting and easier to learn. In this paper, we describe the basics of PCR, variable number of tandem repeats (VNTRs), and electrophoresis that are integral to this laboratory procedure.

Kary Mullis developed the Nobel Prize winning technique of PCR that has been described previously (Garrison & dePamphilis 1994; Mullis 1990). PCR allows you to start with one molecule of double-stranded DNA and replicate a selected portion of that DNA over a billion times within three hours. The portion that is replicated is defined by two primers, short stretches of single-stranded DNA, which are used to prime the DNA polymerase. The sequences of the two primers are complementary to opposite strands of the double helix and have their 3' ends facing

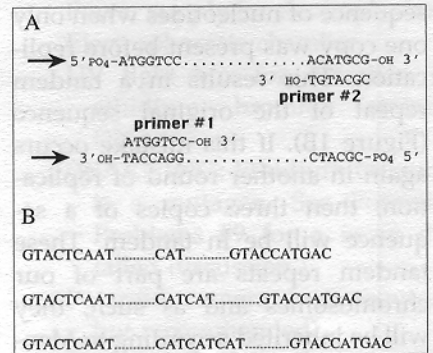


Figure 1. Panel A is a diagram illustrating how PCR primers are complementary to opposite strands of DNA and have their 3' termini facing towards each other. The arrows point to the two strands of the original template DNA; the dots represent an unspecified length of DNA that is bounded by the primers. Primers are usually longer than those shown here. Panel B illustrates a repeat unit (CAT) mistakenly replicated two and three times which resulted in a variable number of tandem repeats (VNTR). Dots represent the connecting DNA of an unspecified length.

towards each other (Figure 1A). The power behind PCR is the chain reaction component; replication is expanded exponentially because after each replication, the resulting DNA is unzipped, or denatured, by raising the temperature to 95°C. After a newly polymerized segment of DNA is denatured, it becomes the template for the next round of replication. The DNA polymerase used in this process can withstand such extreme temperatures because the enzyme was

A. Malcolm Campbell is Assistant Professor, John H. Williamson is Professor, and Diane Padula is a Laboratory Assistant, in the Biology Department of Davidson College, Davidson, NC 28036. Steve Sundby is Laboratory Supervisor in the Biology Department of Macalester College, St. Paul, MN 55105.

¹ PCR is patented by Hoffmann-La Roche and has been licensed to Promega Corporation.