The polymerase chain reaction (PCR) is a technique widely used in molecular biology. It derives its name from one of its key components, an enzyme called DNA polymerase. This enzyme is used to amplify a piece of DNA by a replication process. As PCR progresses, the DNA generated is used as a template for replication. This sets in motion a chain reaction in which the DNA template is exponentially amplified. Using PCR it is possible to generate billions of copies of a single piece of DNA in a relatively short time by simply changing the temperature. Although the use of PCR in genetic analysis, forensics and clinical diagnostics is ubiquitous, its true potential is somewhat limited by the instruments used to perform the reaction. These instruments (known as thermal cyclers) are conceptually simple but possess a number of technical frailties that limit the speed and efficiency of the amplification process. A fundamental requirement for efficient PCR is rapid heat transfer, i.e. the system should transfer heat quickly to the sample on heating, and quickly away when cooling. Most conventional thermal cyclers have high power requirements and generate slow heating and cooling. Consequently, reaction times are typically > 90 minutes. The current project will utilize lab-on-a-chip (or microfluidic) technology and computational fluid dynamics to create a new generation of PCR devices able to concurrently perform thousands of individual PCR reactions in a few minutes. DNA amplification will be performed within picoliter aqueous droplets encapsulated by a continuous oil phase (an emulsion). Thousands of droplets will be made each second and driven along a microfluidic channel the width of a human hair. Thermal cycling will be achieved by moving the droplets through zones of defined temperature. We will then use sensitive fluorescence methods to identify and quantify the DNA amplified (or not amplified) in each droplet. It is expected that these innovations may define a new platform technology for point-of-care diagnostic applications.