Each beat of the heart is triggered by an electrical wave that propagates through the muscle. Normally, the wave is initiated in a specific location and follows a well-defined, pathway. Each wave is fully extinguished before the next begins. Disturbances to this basic rhythm are called cardiac arrhythmias. We are particularly interested in ventricular fibrillation (VF). This arrhythmia is usually the cause of sudden cardiac death, which kills on the order of 300,000 people in the US alone each year.

We have studied the dynamics of cardiac waves computationally using the finite element method to solve reaction-diffusion equations that model cardiac propagation. Using this method, we have identified mechanisms by which geometric and structural properties of the heart can affect the stability of high-frequency rotating waves that are thought to be important in VF. We also use electrical and optical mapping techniques to record electrical signals from the heart surface and from within the wall. We make heavy use of custom designed algorithms to quantify the observed VF patterns and to test hypotheses relating to VF mechanisms.