

Technologies for Understanding and Treating Cancer

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Cancer is a complex group of more than 100 diseases characterized by uncontrolled cell growth. Approximately 40% of people will be diagnosed with a form of cancer in their lifetime, and approximately 15% of people will die from cancer. Therefore, there is significant research being pursued to understand and treat these devastating diseases. At the molecular level, cancer is caused by mutations in genes that regulate several important cellular functions. These genetic mutations may be inherited from parents, acquired via exposure to environmental hazards (chemicals in tobacco smoke, radiation and/or sunlight) or caused by other unknown factors.

Human cells normally grow and divide as needed and die when they are old, damaged, or overcrowded. Cancerous cells fail to respond to normal signals that regulate cell growth and death, leading to uncontrolled growth. In some cases this leads to the formation of large cellular masses (tumors), while in other cases it does not (such as in cancers of the blood). Malignant tumors can spread into nearby tissues, and cancerous cells can break off existing tumors and travel to other parts of the body to initiate the formation of new tumors. The ability of cancer cells to co-opt normal cells to form blood vessels to feed tumors and remove their waste is critical to sustaining their uncontrolled growth. Another key is the ability of cancer cells to evade the immune system that normally eliminates damaged or abnormal cells from the body.

Cancer presents a number of challenges that engineers from different disciplines are working to address. Understanding how cancer develops and what makes some cancer cells migrate to new sites is essential to identify the necessary conditions for these events and how they may be prevented or arrested. Early detection of cancer is known to be an important factor in survival, but more sensitive and selective tools are needed to identify rare cancer cells and biomolecules indicative of cancer from highly complex biological mixtures such as blood. Treatment of cancer has many challenges including high toxicity in healthy tissues, development of drug resistance, and the need to better match drugs with particular cancer subtypes. New methods of drug delivery specifically to cancer cells and alternative therapeutic approaches with new molecules and/or physical ablation methods are needed. Additionally, better imaging methods are necessary to identify smaller tumors, assist surgeons in removing all cancerous cells and only cancerous cells, and track response to treatment. Together these challenges require biological and molecular expertise along with engineering innovation.

The first speaker, Cynthia Reinhart-King, will set the stage by discussing how cancer cells go awry. She will address how extracellular signals and the microenvironment around cancer cells influences their uncontrolled growth and expansion. Then Brian Kirby will address the area of cancer detection. He will discuss recent advances in detecting rare cancer cells using microfluidics that can be used for non-invasive detection and improved diagnosis and treatment planning of cancer. Next, Jennifer Cochran will describe methods for interfering with the spread of cancer. She will discuss therapeutic molecules that block the ability of cancer cells to leave the initial tumor and start new tumors. Finally, Darrell Irvine will discuss strategies for harnessing the immune system to target and destroy cancer cells. He will highlight approaches for using material science and biotechnology methods to control and sustain anti-tumor immune responses specific for different types of cancer.