Magneto-Aerotaxis in Bacterial Microbots

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Hypoxia and heterogeneity in tumor microenvironment is widely recognized as a difficult challenge in conventional cancer therapeutics. Our NanoLab group has verified the use of flagellated magnetotactic bacteria (MTB) as multifunctional medical microbots that can be loaded with chemotherapeutic drugs and magnetically steered through the body for targeted drug delivery. Beyond an autonomous flagellar thrust force that allows them to deep penetrate tumor tissues, it is proposed that aerotactic properties in MTB naturally direct them towards difficult-to-access hypoxic regions. Here, the various magneto-aerotactic mechanisms underlying the control of MTB navigation were characterized. In a two-dimensional plane with a constant flow of oxygen, the formation of a MTB ring at the oxic/anoxic transition zone (OATZ) was found to occur spontaneously to drive the bacteria to their preferred oxygen concentration. With a finite supply of oxygen in the form of a bubble, there was a two-way stream of bacteria toward and away from the source as the bacteria consume the oxygen. The interplay between aerotaxis and magnetotaxis was also determined by inducing a magnetic field near the bacteria at the OATZ and varying the placement and number of magnetic fields. Aerotaxis was found to dominate at the OATZ, implying that the MTB will be controlled by aerotaxis once they penetrate the tumor. Finally, the existence of the swarm effect in MTB was verified. A microfluidic channel system that can be visualized under microscope was designed. Preliminary results suggested that collective behavior is exhibited by the bacteria, prompting them to migrate together. In the body, this would influence the bacteria to travel together through the human microvasculature for targeted drug delivery.

Awards Won:

First Award of $5,000