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AUTOMATED PHAGE SUSCEPTIBILITY TESTING IN MICROGRAVITY USING DIGITAL MICROFLUIDICS TO ADVANCE SPACE HEALTHCARE IN LONG-TERM MISSIONS

Abstract

Previous research has revealed that microgravity conditions change the behavior of bacteriophages, viruses that specifically consume bacteria. Often referred to as 'nanobot soldiers', they selectively eliminate and target a disease-causing bacteria by commanding the bacterial host metabolism to replicate more phages. They have a heavy influence on the human gut microbiome, which makes them a pivotal subject of study to understand astronaut health during long-term missions to Mars. Additionally, utilizing phages to combat bacteria is a promising alternative treatment method to the rising global public threat of antimicrobial resistance. As such, understanding the dynamics of phage-bacteria interactions is critical for developing effective phage therapy strategies for both space and terrestrial settings. Conventional techniques used on earth and in space to study these interactions demand many manual interventions, high expertise, and long turnaround time. To overcome these challenges, our approach is to develop a digital microfluidic (DMF) instrument that can provide high-throughput automated phage susceptibility testing in point-of-care and microgravity settings. This technology manipulates discrete fluidic droplets on the surface of electrodes coated with a hydrophobic insulator, offering reliability in microgravity conditions. It allows to perform multiple samples handling, mixing, incubation and monitoring fluorescence of bacteria-phage interactions without the need for manual intervention, and high-power consumption. Compared to traditional microfluidic devices, our DMF platform also offers a wide range of potential applications ranging from bacterial infections to nucleic acid diagnostics and beyond. Its versatility makes it a valuable tool to advance our understanding of space microbiology and improve healthcare conditions, both in space and on Earth.