Many severe infections in humans affect the airways. Different types of pneumonia are major causes of morbidity and mortality in patients with various weakening conditions, and often ineffective anti-microbial therapies fail to remove the infecting microbes. One of the most severe genetic diseases affecting human airways is cystic fibrosis. Cystic fibrosis (CF) patients suffer from a genetic defect that influences the salt transport over the cell membranes. Due to this effect, the mucus layer becomes very viscous as the defect in salt transport inhibit diffusion of and establishment of the important airway surface liquid (ASL). A direct consequence of the impaired ASL is the impairment of the mucocilliary clearance mechanisms. This results in frequent infections in the airways of CF patients, with the risk of pneumonia. Since bacteria infect the lungs of these patients in large numbers, the immune system tries to eradicate the infections, but with reduced success. This is due to the fact that the bacteria reside embedded in mucus and are more or less recalcitrant to the attack. Instead, the lung tissue is gradually damaged by the ongoing immunological exposure, eventually leading to massive pulmonary deficiency and death.

The classical ways of studying CF related bacterial infections, primarily Pseudomonas aeruginosa, are either to use animal models or to grow the bacteria in flow cell systems. The use of animal models raises ethical concerns and is costly. Besides, CF related animal models are still not ideal, mainly because the immune response differs between man and e.g. mouse, and because the lung pathology after infection is very different in animals compared to humans. In flow cell based systems the bacteria are allowed to form a biofilm on the surface, as in the airways, and their growth is then monitored using confocal microscopy. However, this is not either a suitable CF model as the human airways are subdivided into aerobic and anaerobic compartments. To investigate the different compartments of the human airways system it is crucial importance to construct a microfluidic model system in which the oxygen level can be regulated and the migration of cells between individual compartments can be controlled and monitored. Furthermore, the special conditions in the CF bronchi need to be mimicked as the thick mucus plug present there seems to be another essential factor in the failure of treating infections in CF patients. Therefore, in this work we propose novel microfluidic devices that on one hand can mimic different airway environments by controlling the oxygen levels and on the other hand can mimic the microenvironment of the cystic fibrosis bronchi.