To be able to count and visualize multiple species in-flow with intra-cellular resolution is a boon to health-care and medicine. The next generation imaging cytometry system is setting-up platform that is capable of fast, precise and high throughput analysis. A new entrant called integrated lightsheet imaging and flow-based enquiry (iLIFE) system is miniaturizable, cost-effective and almost does not need human intervention for operational purpose. At the heart of the iLIFE system is the light-sheet illumination that can non-invasively interrogate (visualize and count) specimens flowing through the microfluidic chip. The advantage lies in its ability to interrogate multiple diverse species in parallel (a departure from the existing point scanning system) and simultaneously obtain sectional images with intracellular resolution. The iLIFE technology is expected to impact Clinical Health-care and Disease Diagnosis.

iLIFE is the next generation technology. Developed by our lab (Mondal Lab) at Indian Institute of Science, iLIFE may be the first of its kind of technology on a microfluidic chip. The beginning of this research work goes back to 2013 when the first working system was designed for interrogating mammalian cancer cells (HeLa) and the research was reported in Wiley research journal (Micros. Res. Tech. 76, 1101, 2013). An advanced version of iLIFE system was realized in 2016 and reported in the AIP journal (Applied Physics Letters, 111, 243702, 2017)’. iLIFE use Light Sheet illumination that can generate sectional images. This enables counting and 2D/3D reconstruction of flowing specimens apart from providing other critical parameters such as, sorting.

Existing techniques use conventional point focusing to interrogate the specimens (mammalian cells, bacteria, RBC etc.) despite its complexity and limitations. They require sheath focusing to collimate the flowing specimens. In addition, these systems are engineered to count specimens in a sequential manner. Existing cytometry systems are complex, resulting in high cost and are mostly not miniaturizable. Light-sheet is an advanced technique that readily generates sectional images and enables simultaneous interrogation of multiple species in parallel. The technique is realized on a microfluidic chip, hence it is miniaturizable and cost-effective. Since the first realization of iLIFE system, the idea has inspired similar systems by other research groups (Nature Photonics 9, 113, 2015) | Lab. Chip 16, 1743, 2016 | Sci. Rep., 5, 10751, 2015 | Biomed. Opt. Exp., 9, 3424, 2018 | Biol. Bull., 231, 14, 2016). We envision immediate applications in health-care (pathology, hematology) and diagnosis.

A key challenge in iLIFE imaging (fluorescence mode) is the tradeoff between spatial and temporal resolution. This arise due to the fact that high flow rates (better temporal resolution) limits the specimen exposure time, thereby reduce the number of detected photons that is required for high spatial resolution. In general, spatial and temporal resolution are given by, \[ \Delta_s = \Delta / \sqrt{N} \] and \[ \tau_T = 3 \tau_p \propto k^{-1} \], respectively, where, \( \Delta \) is the diffraction limited resolution, \( N \) is the number of detected photons and \( k \) is the emission rates (both radiative and non-radiative) (Front. Mol. Biosci., 1, 11, 2014). Note that the exposure to illumination light during flow determines the molecule emission cycle, thereby the number of emitted photons. So, there is a sort of uncertainty relation between spatial and temporal resolution for an imaging cytometry system, \( \Delta_s \tau_T = \varphi \), where \( \varphi \) is a constant of the imaging system. \( \varphi \) can be determined by the quantum efficiency and emission cycle of the fluorescent molecule used to label the specimen.

iLIFE system is designed to interrogate life at micro-to-millimeter scale (from cells to worms (C. elegans) ). The system is highly economical and can be used to interrogate a wide range of species. iLIFE system can be home-built with a fraction of cost of the existing commercial systems. We envision iLIFE system as a futuristic diagnostic tool for hospitals, diagnostic centers, research institutions and universities.