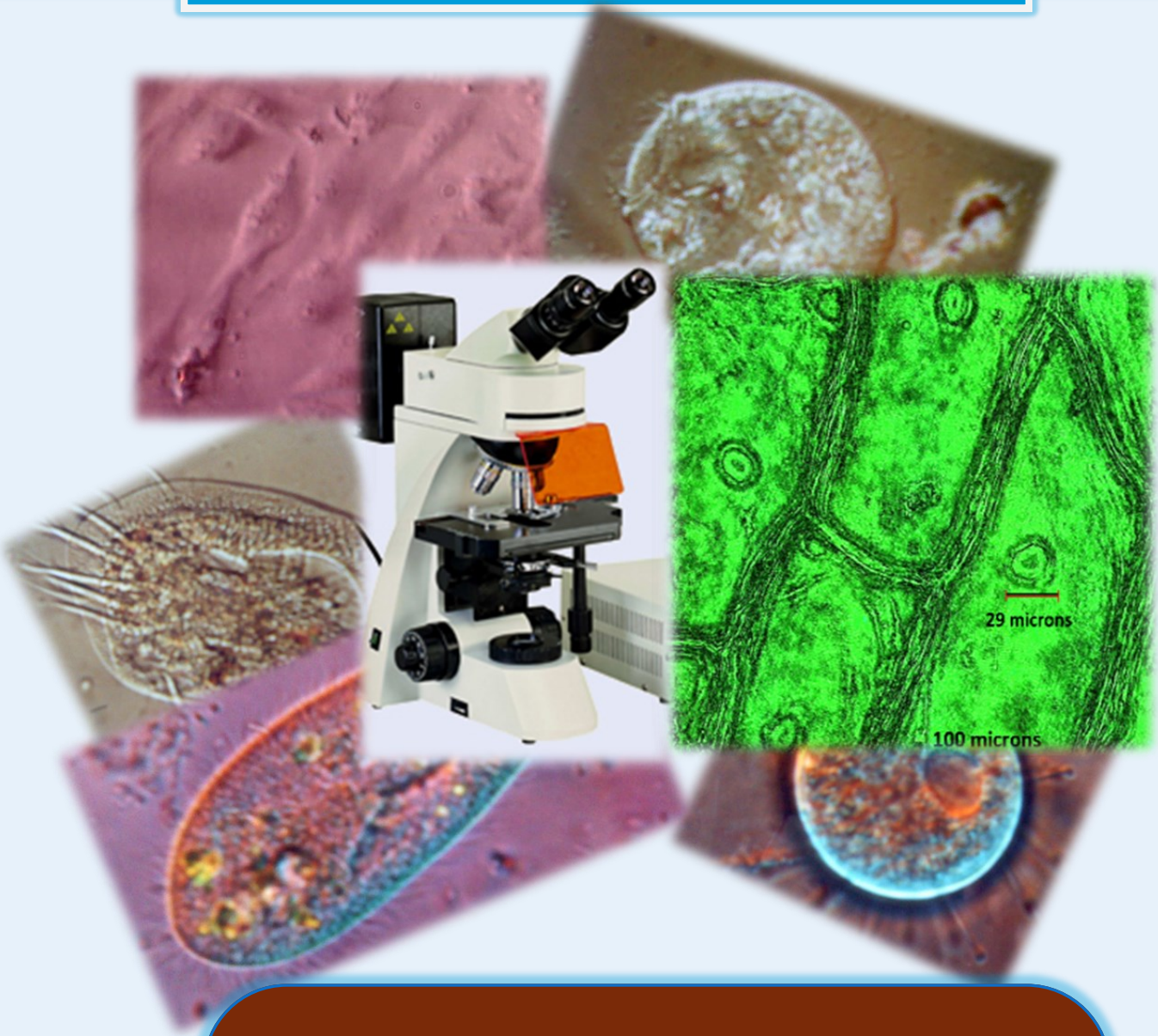
DEPARTMENT OF SCIENCE AND TECHNOLOGY

TECHNOLOGY SYSTEMS DEVELOPMENT PROGRAMME



Low Cost Optical Multimodal Microscope

DEPARTMENT OF PHYSICS

SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING

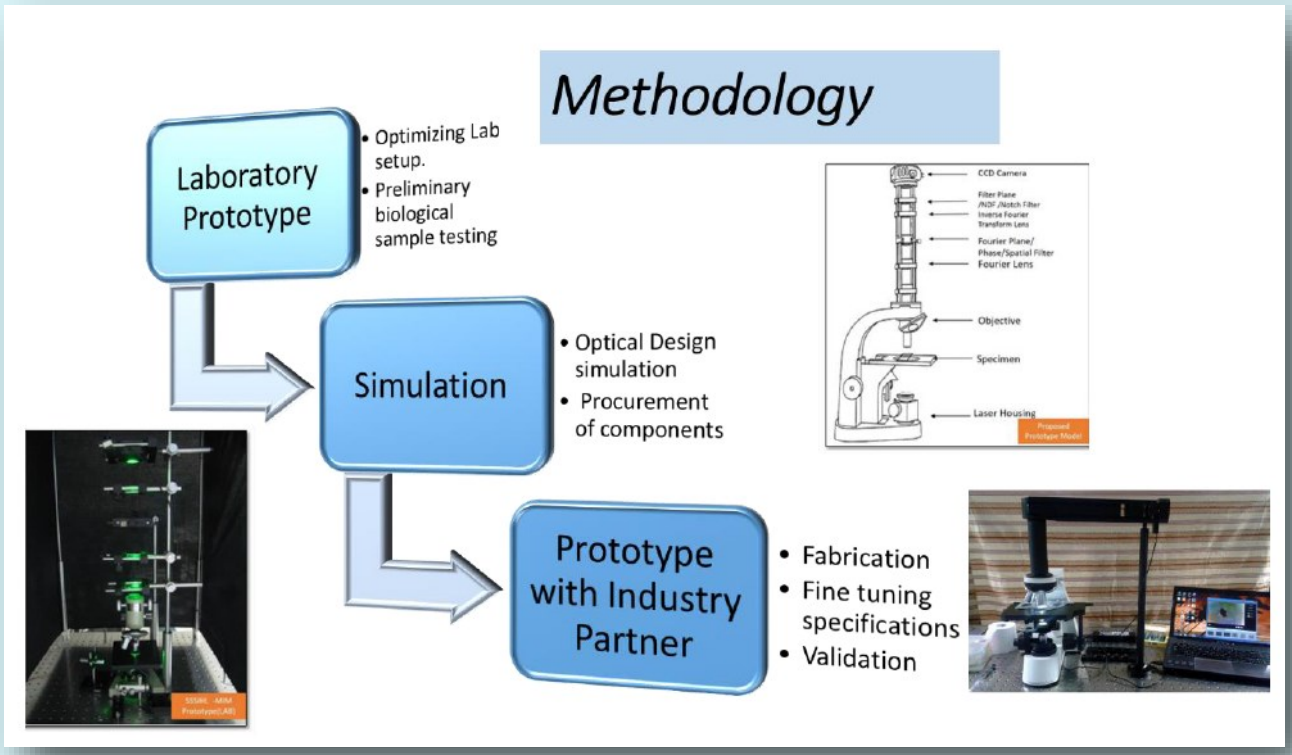
ANDHRA PRADESH, INDIA

DESIGN AND DEVELOPMENT OF MULTIMODAL OPTICAL MICROSCOPE USING FOURIER OPTICAL IMAGE PROCESSING

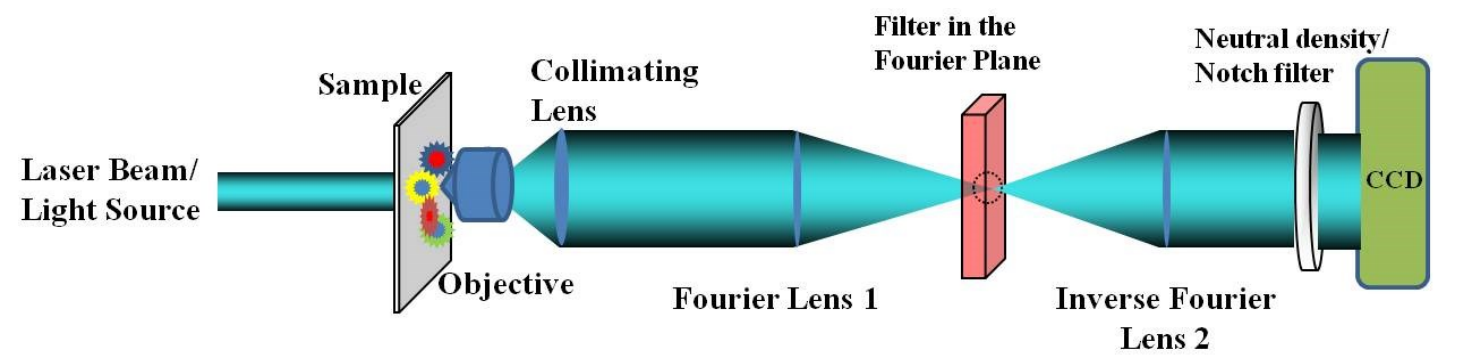
Project Grant Funded: Rs. 29 Lakhs

In India, Tubercolosis, HIV, Malaria and Diarrohea are rated as the major diseases (WHO source, 2011). On an average more than 1 million cases are reported annually under each disease by the National Vector Borne Disease Control Programme (GOI). Early diagnosis of these diseases require a minimal clinical or a pathological microscope facility. In most of the developing countries, failure of establishing good microscopic facilities and essential skill set in Primary health care centers has been identified as the major reason for wide spread of infection. Although fast and reliable, the Rapid Detection Techniques (RDTs) extensively implemented during an epidemic outbreak, are expensive and have a short shelf life which makes them non ideal for diagnosis at primary health care level. Additionally, outbreak of drug resistance superbugs complicates the disinfectant management at larger scales. In such contexts, microscopic investigation plays a vital role. But affordability of such sophisticated clinical and pathological microscope is a major concern. Low cost microscopic screening methods and effective diagnostic tools become an alternative option. Our nation with more than 20,000 primary healthcare centers (PHCs) will certainly be benefitted if such cost effective screening and diagnostic tools are deployed and made functional.

We have developed a multimodal optical microscope keeping in mind the worldwide development in achieving cost effective disease diagnosis tools as well as an essential research & teaching tool. The sanctioned DST project aimed at developing a cost effective multimodal optical imaging microscope. This optical microscope encompasses multiple functionalities like Bright Field imaging, Phase Contrasting, Edge enhancement and Fluorescence imaging, all provided in a single platform. The primary necessity for developing such a device arises from the growing need for **affordable diagnostic tools in India.** Optical microscopic investigations have become an essential tool in routine clinical pathology and developmental biology research work. We have adopted Fourier optical image processing techniques to incorporate the multimodalities. Apart from being relatively cost effective in its design, it offers a functional advantage of easier live cell imaging with simplicity in operation. Seeing the sample under various modalities is achieved by just changing the filters without disturbing the sample.

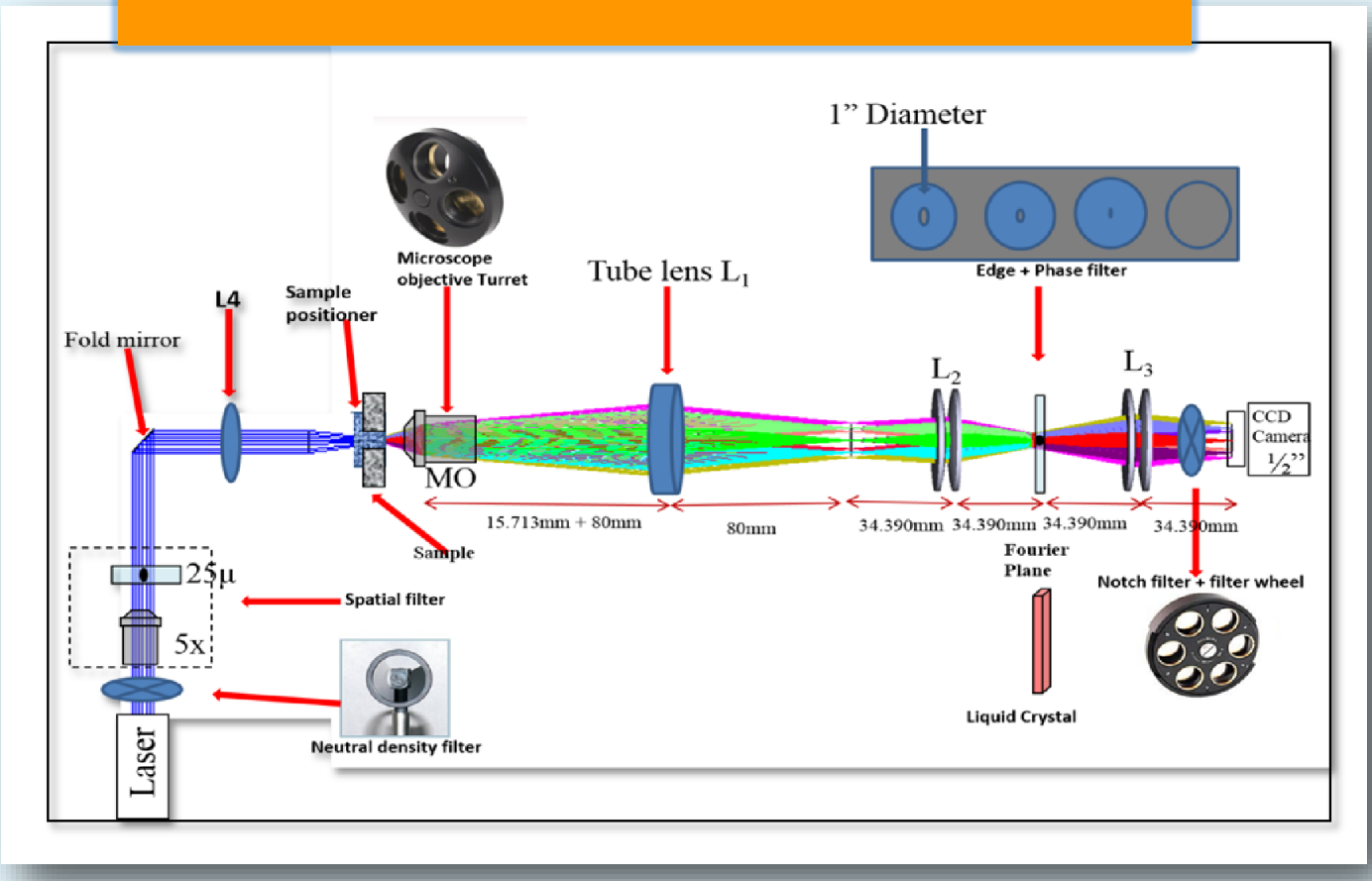


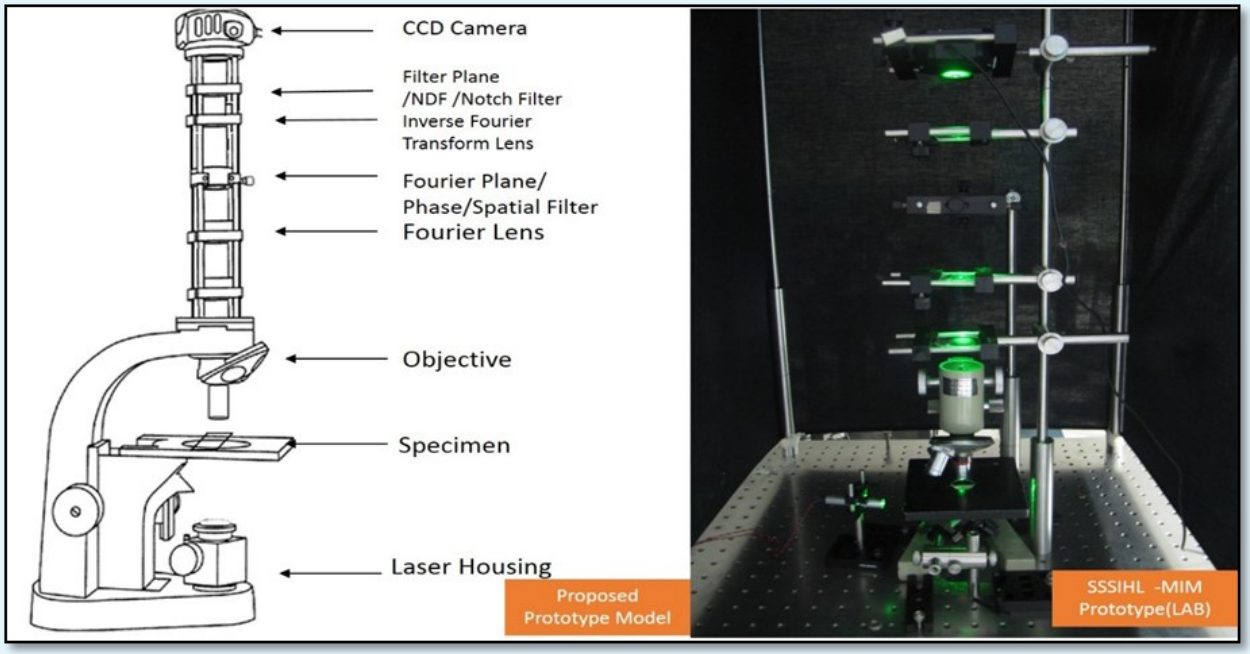
Basic principle: A well- collimated laser beam is incident on the object that is to be processed. Optically, the light bearing the object information is Fourier transformed with the help of a Fourier lens. In the resultant Fourier spectrum, the low spatial frequencies occur at the center with high intensity while the high spatial frequencies at the edges with low intensity. Various image processing techniques, such as low-pass, band-pass, high-pass and phase-shift are employed at the Fourier plane to process different spatial frequencies for various applications. An inverse Fourier transform is obtained by subsequently employing another Fourier lens. The processed image is captured by a CMOS camera.



Multimodal imaging Operation: For amplitude objects, a spatial (amplitude) filter is employed at the Fourier plane, while for phase objects, a phase filter is used to alter the phase difference between high and low spatial frequencies. We have incorporated liquid crystal filter that is optically Passive, as a Phase contrasting component, to provide both structural and functional information. Addition of Fluorescence and edge enhancement filters further enhance the Image quality in the above module making it highly suitable for developmental biology studies and clinical pathology. A laboratory prototype was developed to establish the proof of the concept after augmenting the optical design of this microscope using ***Zemax,*** a powerful simulation software. Subsequent to optimization of the design parameters, an industrial prototype of the multimodal microscope was fabricated.

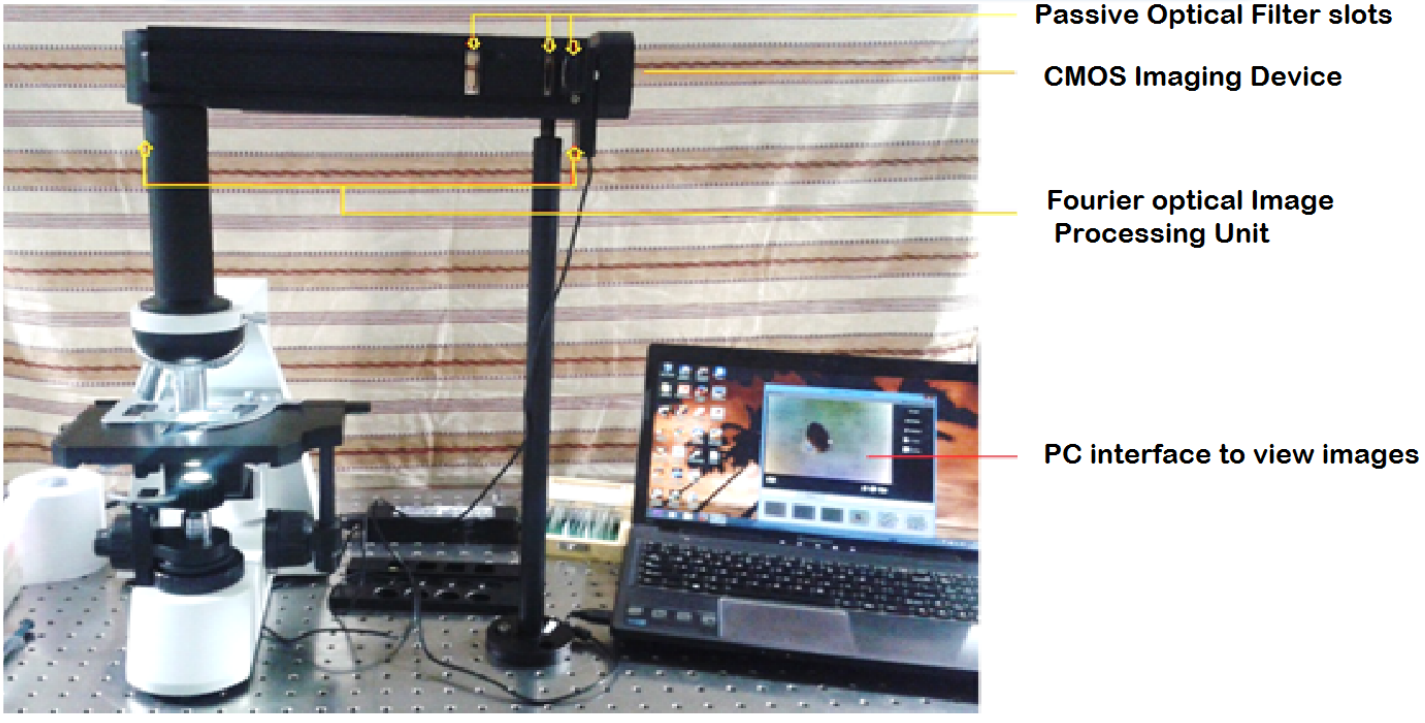
"ZEMAX" SIMULATION OF THE OPTICAL DESIGN OF THE MICROSCOPE



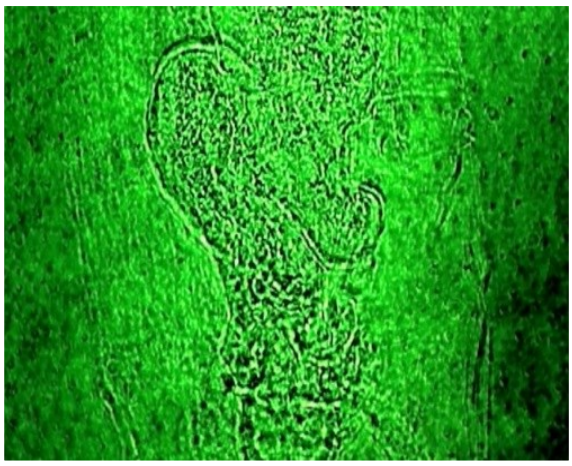


We demonstrated the multimodal imaging modalities to developmental biologists for studying the embryo of *Drosophila* (fruit fly), an important model organism in Genetics and Developmental Biology. We are in the process of demonstrating its capabilities to the Doctors of Department of Pathology at Sri Sathya Sai Institute of Higher Medical Sciences, a super specialty hospital at Puttaparthi and to take their feedback in optimizing the functionalities of the microscope.

Prototype Multimodal optical Microscope developed by SSSIHL



A



B

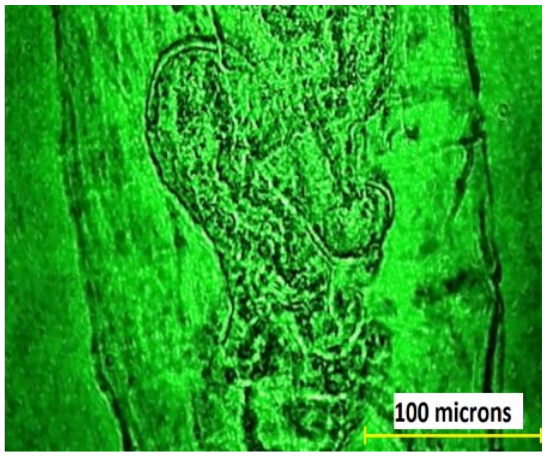
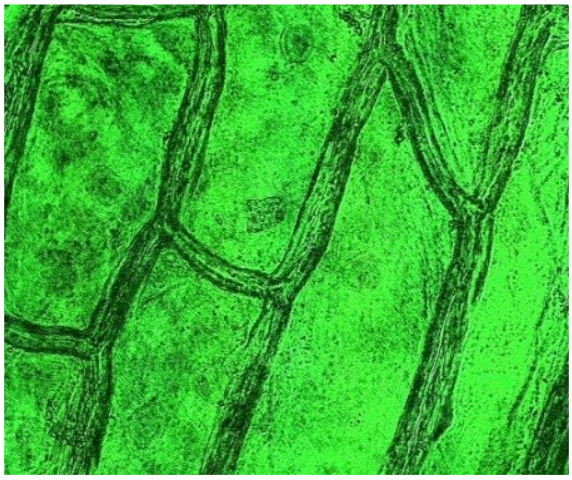


Fig A. Gut region of **Drosophila melanogaster larva** seen under **bright field** modality.

B. seen under **phase contrast** modality.



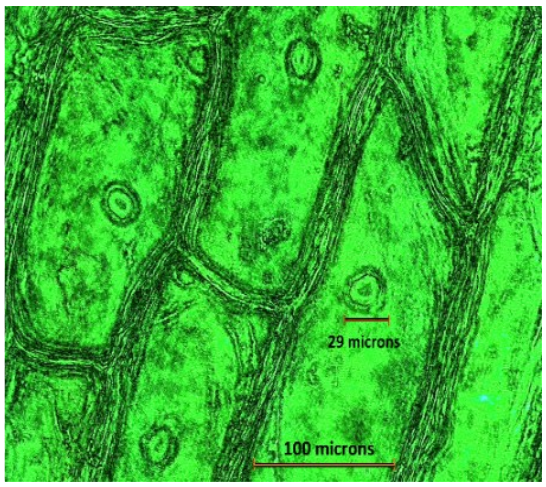
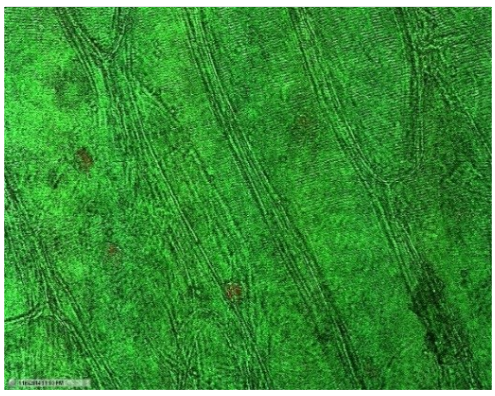
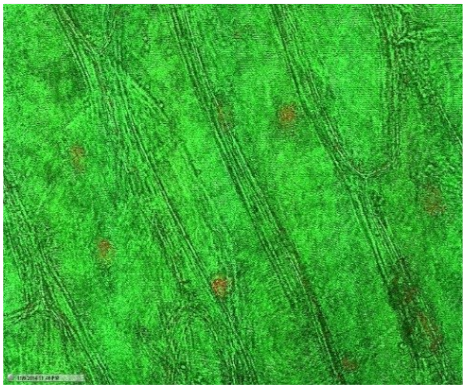
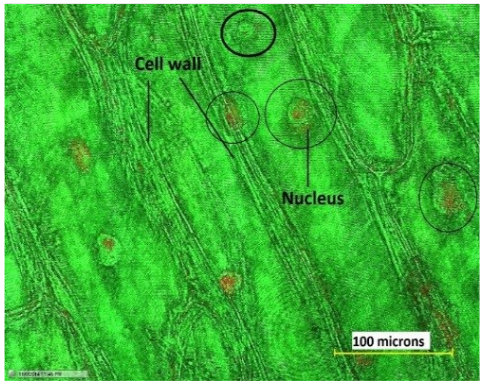


Fig A. Onion epithelial cells under **bright field** modality

B. Phase contrast modality showing the presence of cell organelles invisible in the bright field image (encircled)







Rhodamine stained onion epithelialacells under **bright field** modality **alone**.

The onion epithelial cells viewed under **phase contrast** modality **alone**.

The onion epithelial cells viewed under **phase contrast and fluorescence modalities combined** shows a marked difference in the image.

Knowledge Partners	
Prof. D V G N L Rao & *Dr. Chandra Yelleswarupu*	*University of Massachusetts, Boston*
Prof. Lakshmi Narayan & *Dr. Arun Roy*	*Raman Research Institute, Bangalore*
Prof. B. R. Prasad	*Indian Institute of Astrophysics, Bangalore*

INDUSTRY PARTNER

Mr. Ajay Chada

Lab Engineers , Bangalore

Field Trail Partners *: Clinical and Microbiology laboratory Departments of Sri Sathya Sai Institute of Higher Medical Sciences, Prashanthigram, A.P.*

MAKE IN INDIA

ULTIMATE GOAL

Developing LOW COST (under Rs.3.00 Lakhs) Multimodal Optical Microscope