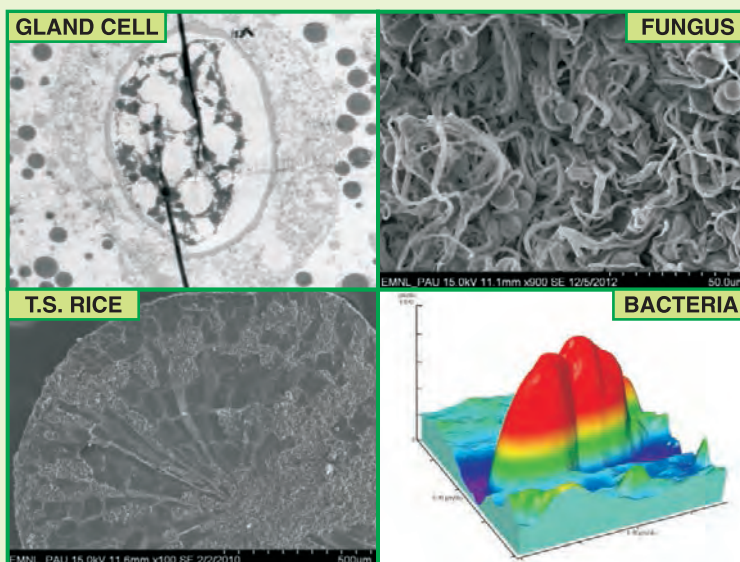


ELECTRON MICROSCOPY AND NANOSCIENCE LABORATORY

*High resolution imaging
facility for exploring nano-realms
in agricultural research*



ELECTRON MICROSCOPY & NANOSCIENCE LABORATORY
PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA – 141004, INDIA
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Electron Microscopy & Nanoscience Laboratory was established in 2005 at the Punjab Agricultural University, Ludhiana, India. It is the foremost state-of-the-art facility to boost nanoscience and nanotechnology research in agriculture in India. It hosts ultramodern models of SEM with EDS, TEM, AFM, FT-IR and Raman Spectroscopy, Ultramicrotome, Gold Sputter Coater, CPD unit, Fluorescence Microscope, Optical Research and Stereo Zoom Microscopes, and other facilities under one roof. It runs post-graduate and graduate courses. It has initiated research work on the use of nanofabricated-P as fertilizer and on the development of methodology for separation of heavy-metal free P-fertilizer from rock phosphate. The Laboratory has facilitated frontline research work on varietal distinctions of crop species, sex-signaling in insects, in food processing and high resolution imaging of biological and material samples. It has been organizing training programmes for students, researchers and professionals in agriculture, veterinary and engineering. It has been visited by eminent scholars and dignitaries from across the world. The Laboratory is providing high resolution imaging facilities to cater the advance research goals of universities, institutions, and industries across the nation and abroad. It has provided pristine images and elemental distribution of nanowire, textile fibers, dental surfaces, nematodes, insects and their body parts, spermatozoa of rats and mammalian RBCs, rice structures (trichomes, seed, leaf, straw, husk), maize and black gram, unicellular prokaryotic bacteria, multicellular filamentous fungi and budding yeast as well as material samples that include carbon nanotubes, nanowires, rice husk silica, and clay minerals, to name a few. More than 160 masters' and doctoral candidates from PAU, and 65 from other institutes have utilized these facilities.

■ Transmission Electron Microscope (TEM)

Specification: Hitachi H-7650 with 40-120 kV accelerating voltage; 0.2 nm resolution; magnification range 200x-200000x in High contrast (HC) mode; 4000x - 600000x in high resolution (HR) mode; Tungsten and LaB₆ filaments; 1024x1024 pixels digital camera.



TEM of plant virus

Application: TEM exhibits ultrastructure, and physical and chemical properties of cells of plant, animal and microbes. It characterizes biological and abiotic materials from morphological, chemical and structural point of view. It helps in studying viral morphology, pathogen detection and to understand the mechanism of pathogenesis. It plays an important role in imaging of nanoparticles, nanocomposites, nanostructured materials including aerosolic materials and many other solid materials. Apart from agricultural applications, it is used in ceramics, clinical pathology and cancer research.

■ Scanning Electron Microscope (SEM)

Specification: Hitachi S-3400N with 0.3-30 kV accelerating voltage; 10 nm resolution at 3 kV; 3 nm resolution at 30 kV with Secondary Electron (SE) detector in high vacuum mode; 4 nm at 30 kV in low vacuum mode with BSE detector; magnification range 5x –300000x; Maximum permissible specimen diameter 200 mm; digital camera with wide pixel range adjustment.

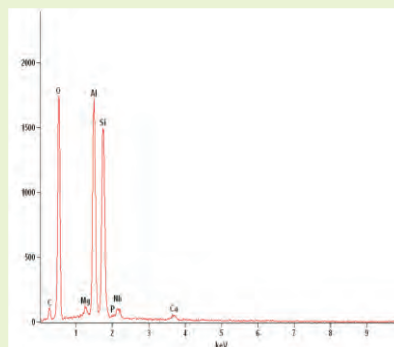


SEM of *Rhizobium* sp.

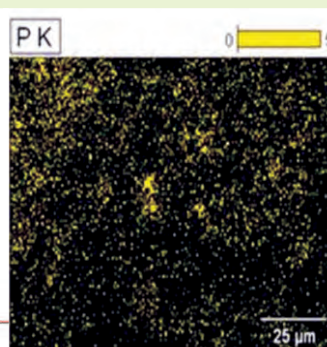
Application: Application areas include varietal characterization of crop species, morphology of plant, insect and microorganisms, and soil mineralogy. It is particularly useful for host-parasite interactions, study of pathogenicity, fish-scales, dental, carbon nano tubes, nanowire, and characterization of surface properties of biological, industrial and material samples.

■ Energy Dispersive Spectroscopy (EDS)

Specification: Thermo Noran System SIX with intelligent digital beam; high resolution Liquid Nitrogen (LN₂) cooled Si (Li) detector; crystal areas 10 mm² to 50 mm².



SEM-EDS spectra of nanosilicate

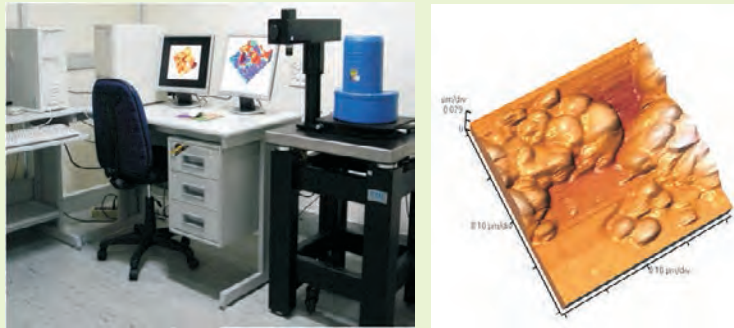


X-Ray mapping of nanofabricated P-adsorbed on silicate

Application: Spectral analysis, detection, quantification and X-ray mapping of elements in solid substances. Elements from beryllium to uranium can be detected. It is an indispensable tool for clay mineralogy, formulation and residue analysis of pesticides, analysis of food, natural and man-made fibres, corrosion-resistance properties of agricultural implements, and in the fields of metallurgy and material sciences.

■ Scanning Probe Microscope (SPM)

Specification: Veeco di CP-II Scanning Probe Microscope in Atomic Force mode with closed loop 5x5 micron scanner; XY resolution 0.01 nm and Z resolution 0.007 nm; sample size 50x50x20 mm; colour CCD camera; contact mode; tapping mode; scanning tunnelling microscopy (STM); phase imaging; vibration isolation; 3D image analysis software.

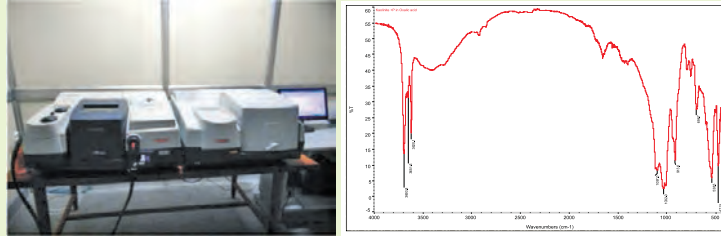


AFM of gold nanoparticles

Application: It is used for nanoscale characterization of surface features of biological and non-biological samples. It provides virtual 3-D nanoscale images of macromolecules (e.g., DNA, RNA, protein), virus, bacterial / plant / animal cells, biological unit membranes, food components (cellulose microfibrils, starch granules), nanoparticles, films, fibers, metal / glass / dental surfaces. It can provide information about the surface properties of biological and non-biological samples by phase imaging or, LFM modes. STM mode is useful for imaging at the atomic scale of the conductive or metal surfaces as well as for the identification of conductor semiconductor blends. Single molecule spectroscopy is useful for the identification of specific interactions of two macromolecules like antibody-antigen, DNA and activator proteins, and RNA and DNA.

■ Infrared and Raman Spectrometer

Specification: Thermo Nicolet 6700 Fourier Transform Infrared (FT-IR) Spectrometer with NXRFT Raman Accessory Module. Infrared (IR) spectrometer collects spectra in the mid-IR ($400 \sim 4\,000\text{ cm}^{-1}$), near-IR ($4\,000 \sim 14\,000\text{ cm}^{-1}$), far-IR ($4 \sim 400\text{ cm}^{-1}$) ranges with 0.09 cm^{-1} optical resolution and 0.01 cm^{-1} wave number precision. Accessories include ATR (attenuated total reflection), IR transparent NaCl windows and NIR probe. The NXR FT-Raman module is configured with the research-grade 2.5 Watt Nd:YVO₄ laser operating at 1064 nm.

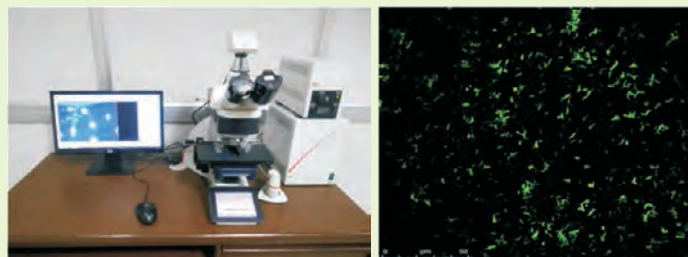


FT-IR Spectrum of P adsorbed on nano-silicate

Application: Both Raman and IR spectroscopy provide characteristic fundamental vibrations that are employed for the elucidation of molecular structure of the material. Infra Red spectroscopy detects the chemical functional groups present in the sample and its amount in a mixture. Raman Spectroscopy identifies the material on the basis of its composition, stress /strain state and quality by analyzing the vibrational bands. Both solid and liquid samples in bulkform and nanoform can be analyzed for their properties. Techniques are particularly useful for analyzing pharmaceutical, clay mineral, biomaterial, polymers, semiconductors and materials samples.

■ Fluorescence Microscope

Specification: Leica DM 5000 B, with fully automated transmitted light axis and 5x or 8x fluorescence axis; touch-sensitive Leica screen (7.3 x 7.3 cm) with information and control panels, 1xRS 232 interface; 2-gear mechanical drive; absolute encoded 7xM25 thread objective turret; ceramic-coated stage; 110° rotation; telescopic stage drive with adjustable torque (6 freely programmable function buttons; automatic illumination manager; automatic contrast manager; Constant Colour Intensity Control (CCIC); motorized 5/8 position filter turret for fluorescence.



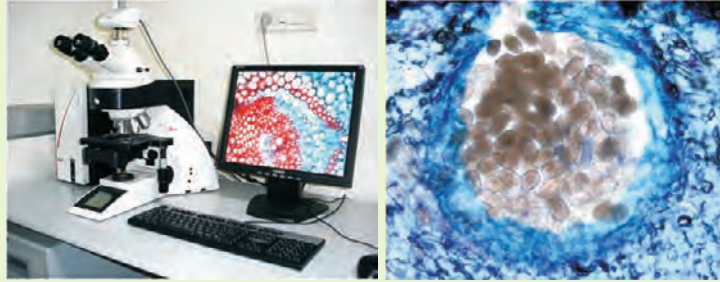
Fluorescence micrograph of *Azorhizobium caulinodans* Gfp⁺ cells

Application: For live cell analysis and cytological studies and for advanced fluorescence applications involving fixed cells, live cells, and tissues.

■ Optical Microscopes

Optical Upright Research Microscope :

Specification: Leica DM5000 B with Filter magazine for transmitted light; HCL 2TU 4/5/7 phototube; HC PLAN S 10x25 Br. M eye piece; N PLAN objectives; digital camera with 2.9 mega pixel resolution, magnification 50x-1000x.

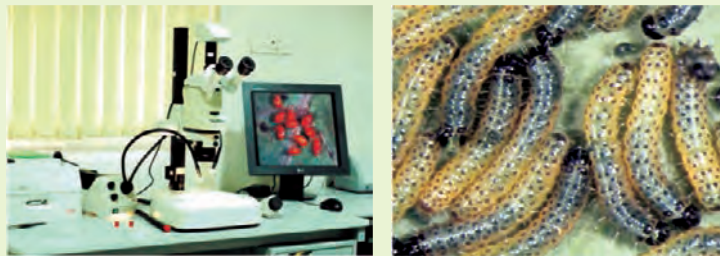


Bright field micrograph of
Root-knot nematode infected root

Application: Bright field, dark field and phase contrast microscopy for general histology, histochemistry of tissue sections and for study of microorganisms.

Stereo Zoom Microscope :

Specification: Leica MZ16 A stereo zoom microscope; magnification range 7x-115x; trinocular tube; transmitted light base HL; cool fibre optics; digital camera with 2.9 mega pixel resolution



Stereo zoom micrograph of insect larvae

Application: Gross morphology of different organisms and their parts, or any other biological or industrial material particularly useful for plant tissue culture imaging; biodiversity studies of invertebrates; varietal differences in plants.

■ Nanoscale Microtomy

Ultracut Microtome :

Specification: Leica Ultracut microtome model UC6 with advanced touch-sensitive-control unit; manual and automatic modes; anti-vibration and anti-static systems for preventing climatic effects on sectioning.



Application: High precision microtomy for obtaining ultra-thin and semi-thin sections (1 to 15000 nm) of biological and industrial samples for viewing under TEM, AFM, SEM, and EDS.

Cryo attachment for ultra microtomy :

Specification: Leica EM Cryo chamber FC6 model with rotating knife holder; anti-static electrode; LN₂ pump.



Application: Semi and ultra-thin cryo sectioning of biological samples in temperature range from -15° C to -185° C.

■ Sample preparation equipments

Ion Sputter Coater :

Specification: Hitachi model E-1010 with gold and carbon coating units; discharge current range : 0 to 30 mA; coating rate 10 nm min⁻¹ for specimen size of 50 mm diameter X 15 mm height.



Application: For coating of gold or, carbon on the surface of non-conductive samples of biological or, non-biological origin. The purpose of coating is to prevent image distortion due to charging up of the specimen surface.

Bench Top Evaporator :

Specification: Polaron E6500 MHVE; Turbo Molecular Bench Top Evaporator with power supply output up to 10 V at 100 A for carbon coating unit and 20 V at 50 A for metal evaporation.



Application: Preparation of carbon support films, replicas, and shadowing, and cleaning of aperture.

Critical Point Dryer (CPD) :

Specification: Polaron E3000 CPD with specimen chamber 75 mm long X 32 mm diameter; liquid CO₂ is used as drying medium; critical pressure 1073 psi and critical temperature 31.1° C maintained through CO₂; microcontroller based hot / cold water circulation system.



Application: Sample dehydration prior to SEM examination.

Access to EMN Lab

Web link: http://web.pau.edu/index.php?_act=manageLink&DO=firstLink&intSubID=70

Proforma for charges and sample analysis can be obtained by sending an email to <services-emnl@pau.edu>

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