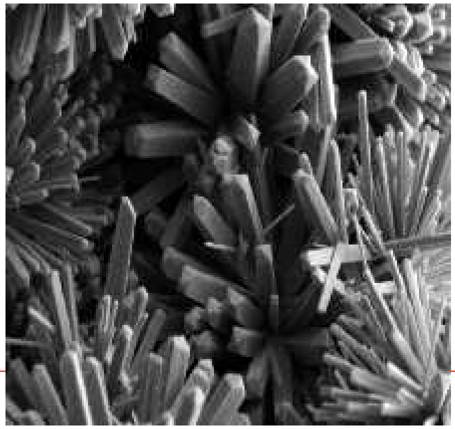
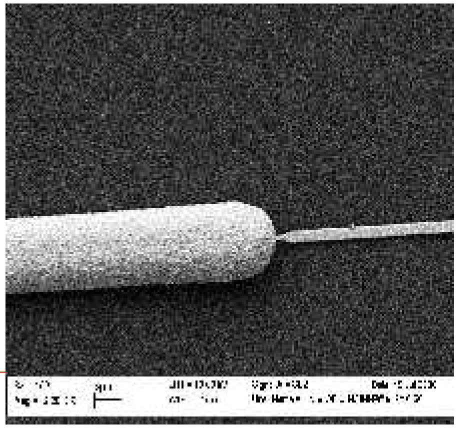
Nanoscience & Microscopies SEM,TEM, AFM

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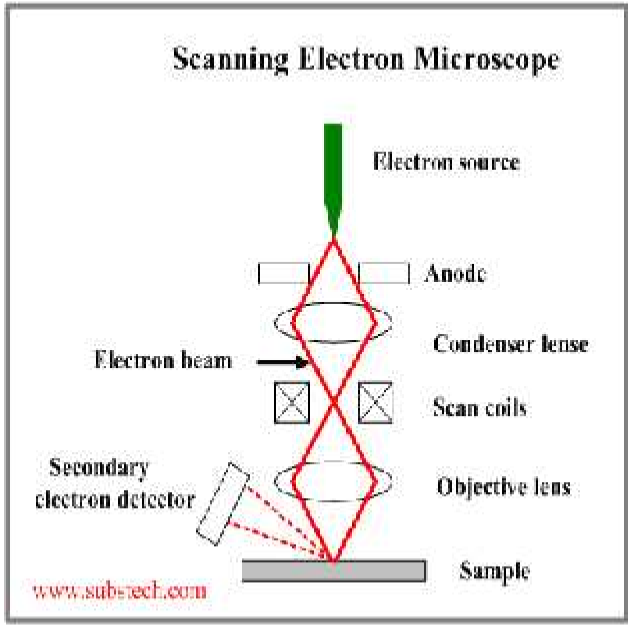
Department of Physics and Astronomy

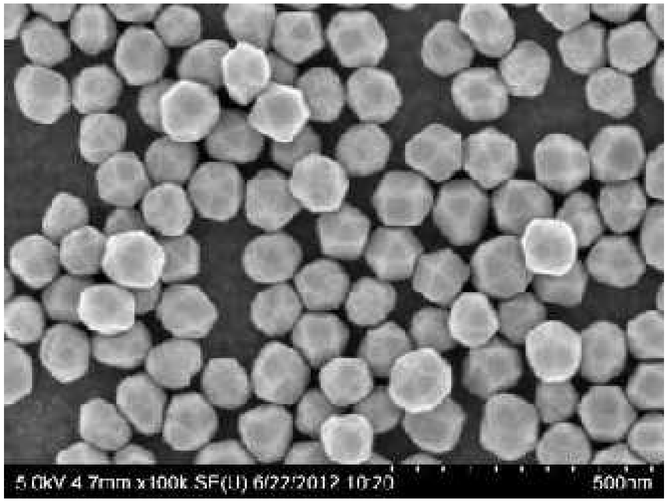
Science College

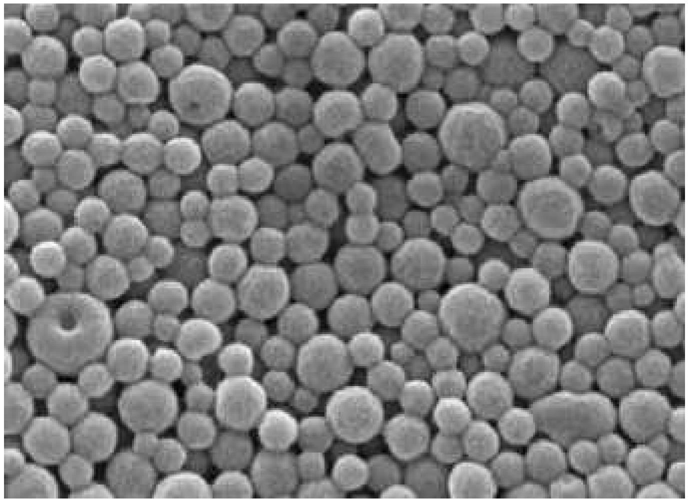
King Saud University

Scanning Electron Microscope (SEM)

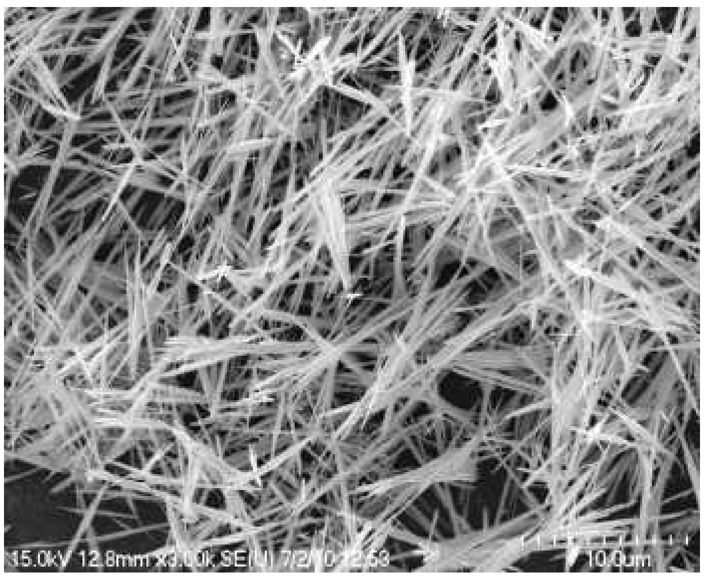


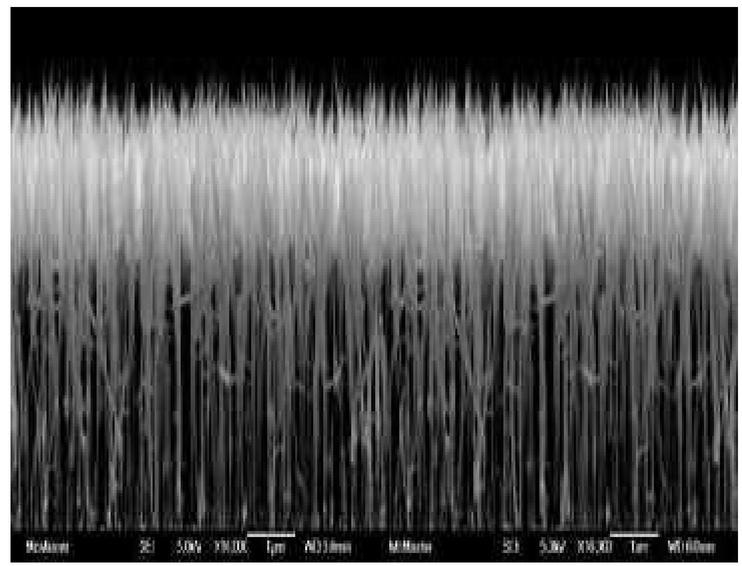
Nanoparticles are generally 0D nanostructures which may be (roughly)spherical having diameters within 99nm!



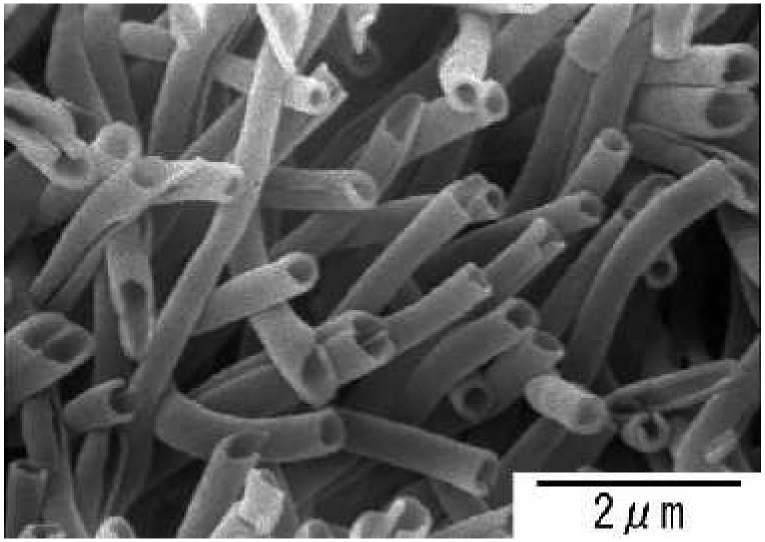


Nanowires are 1D nanostructures which generally have diameters of the order of tens of nanometers, with unconstrained length scales! ***The length to diameter ratio may be as much as 1000***!

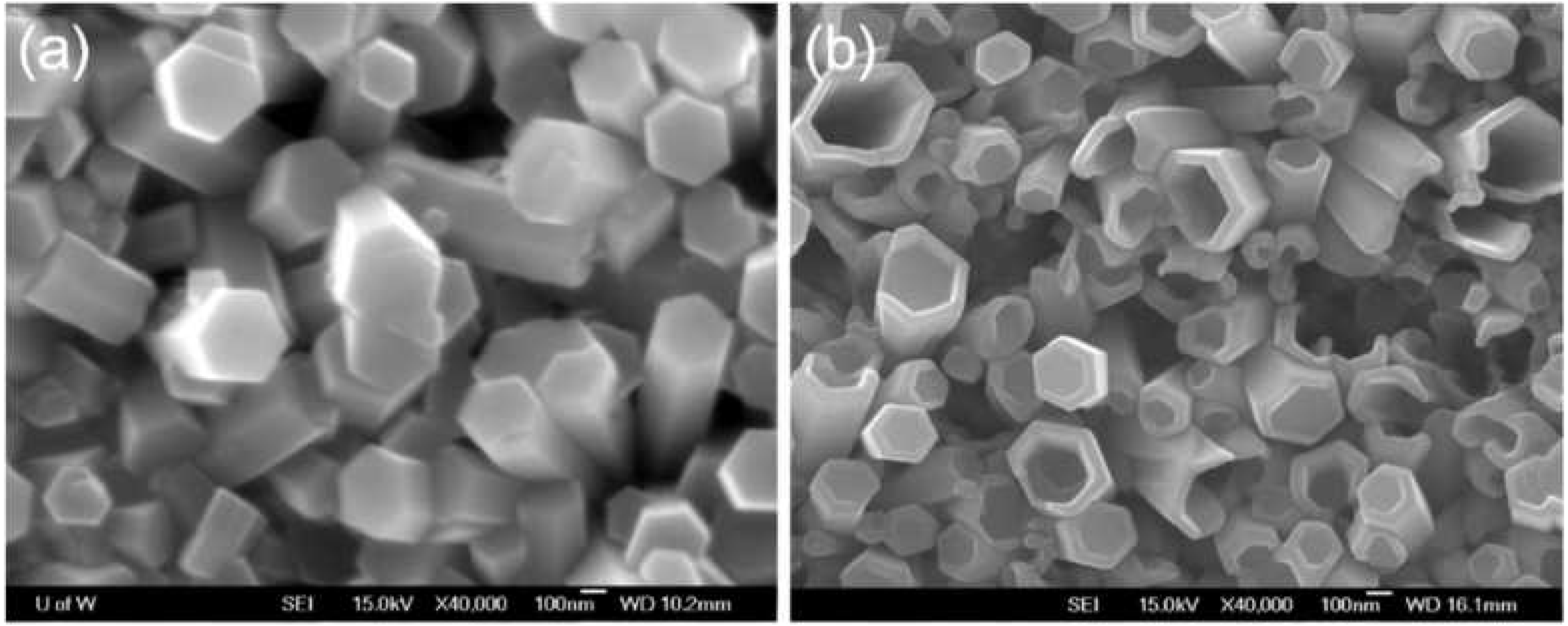




A **nanotube** is a nanometer-scale tube-like structure, which are also like nanowires, in terms of aspect ratio; but unlike wires, tubes are hollow! Nanotubes maybe single-walled or multi-walled!

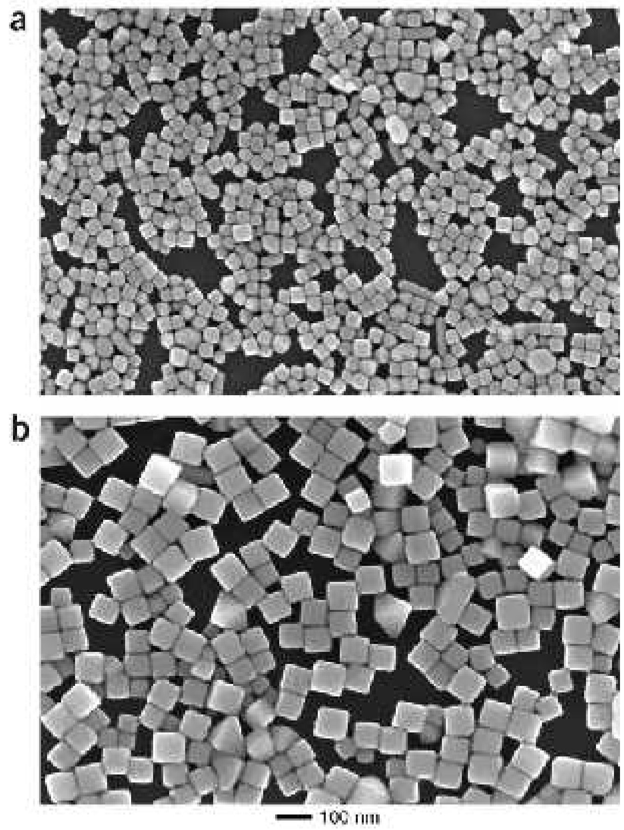


SEM of Single Walled Carbon Nano-tubes (SWCNT).

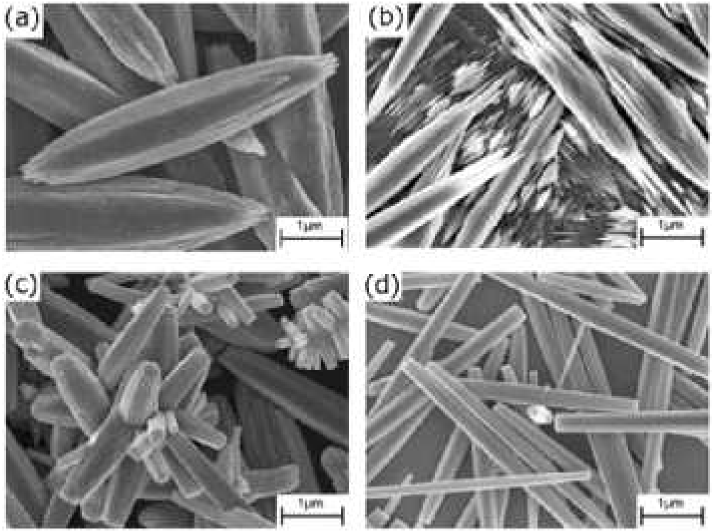


(a) SEM of ZnO nano-rods (b); and ZnO nano-tubes

(a) An SEM image of Ag nanocubes, approximately 45 nm in edge length, prepared using the sulfide-mediated polyol method. The reaction was quenched when media appeared green. (b) An SEM image of Ag nanocubes, approximately 90 nm in edge length

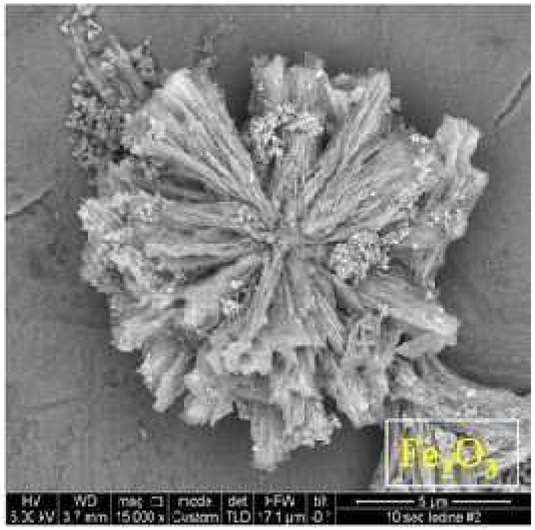


Nanorods are also 1D nanostructures where each of their dimensions range from 1–100 nm. ***Standard aspect ratios (length divided by width) are 3-5.***

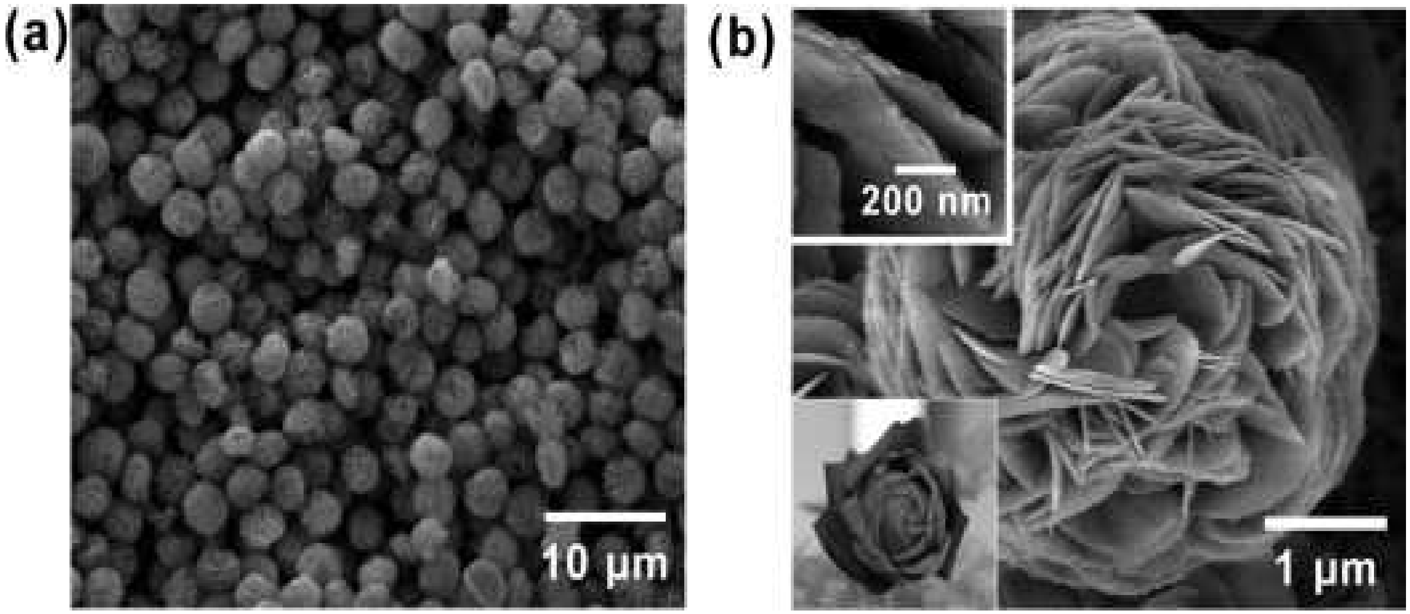


<u>ZnO nanorods</u>

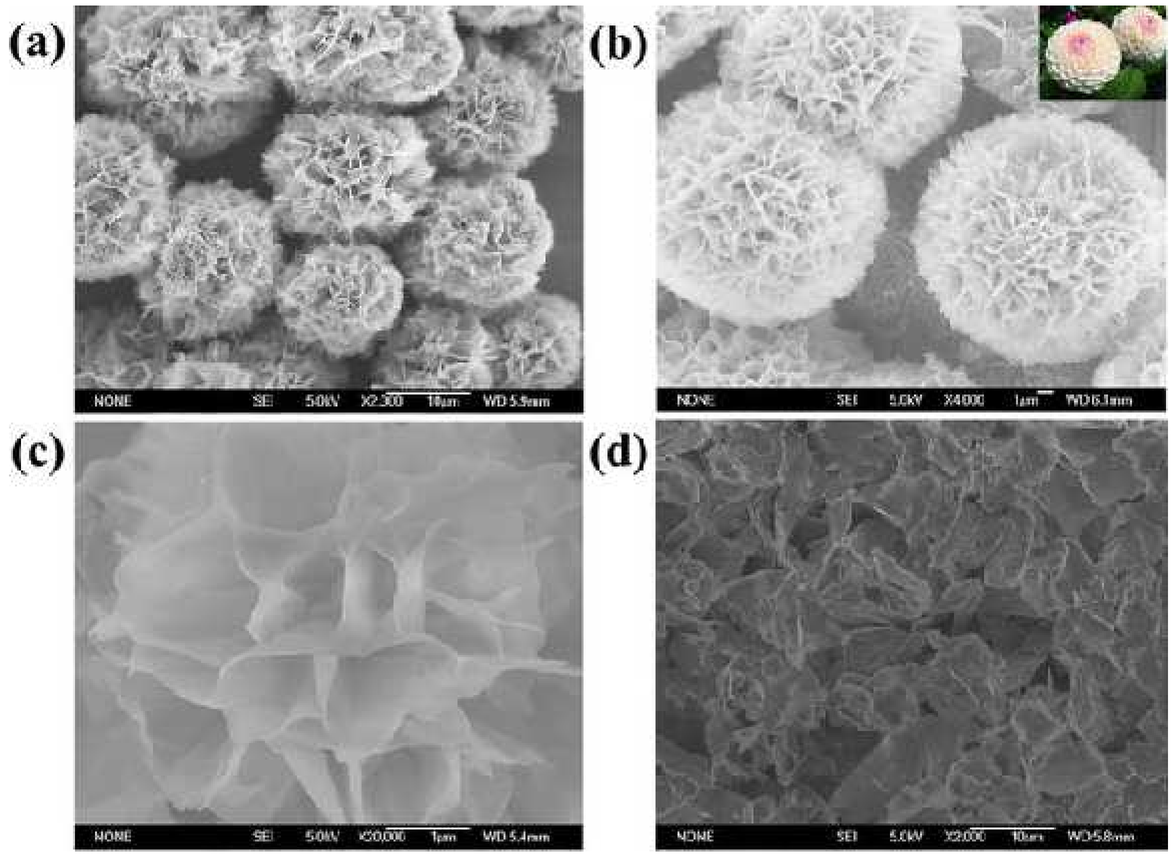
Nanoflowers



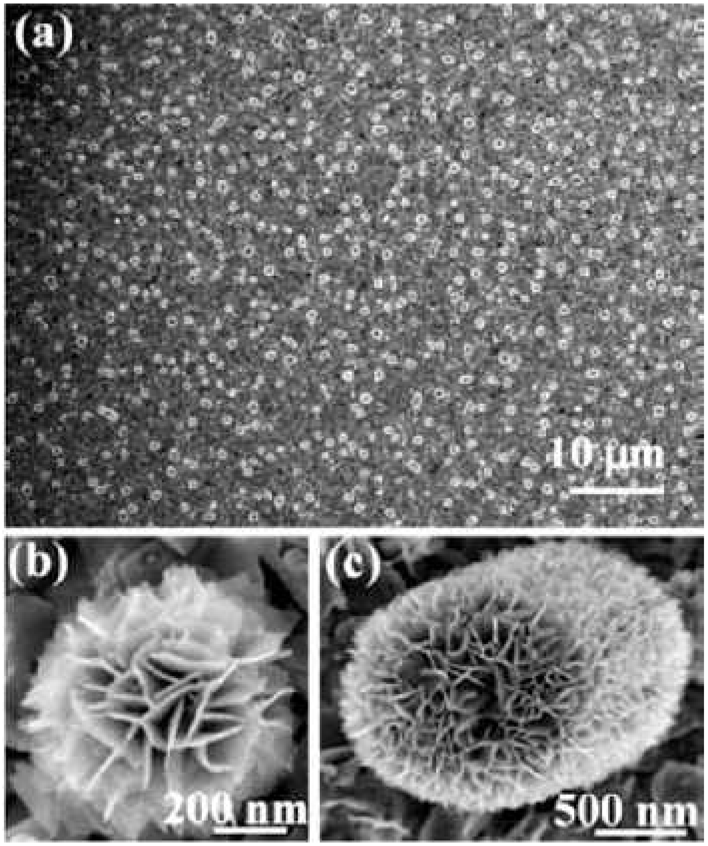
The objects (shown above) consist of a protein encased in copper phosphate "petals." As well as looking pretty, these petals perform two important functions. First, they stabilize the protein to prevent it from breaking down. Secondly, if the protein has catalytic properties—that is, if it speeds up other chemical reactions—encasing it in a nanoflower makes it a more effective catalyst.



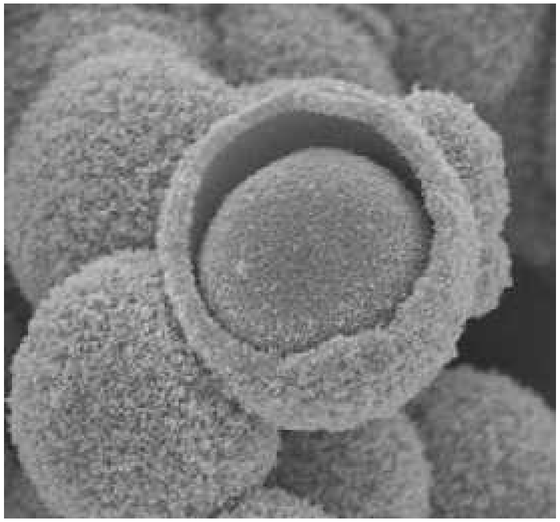
Scanning electron microscopy (SEM) images of a) laccase–copper phosphate nanoflowers; b) a laccase–copper phosphate nanoflower at high resolution. Inset image shows the nanostructure of the petals, inset photo shows a flower in nature.

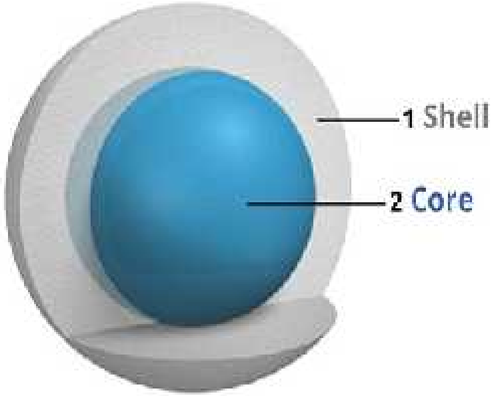


(a) SEM image of the nanoflowers; (**b**) a single nanoflower; (**c**) High-resolution SEM image of the porous structure of the petals; (**d**) the disordered fragments formed without Asn;
the inset of (**b**) the Dahlia in nature.



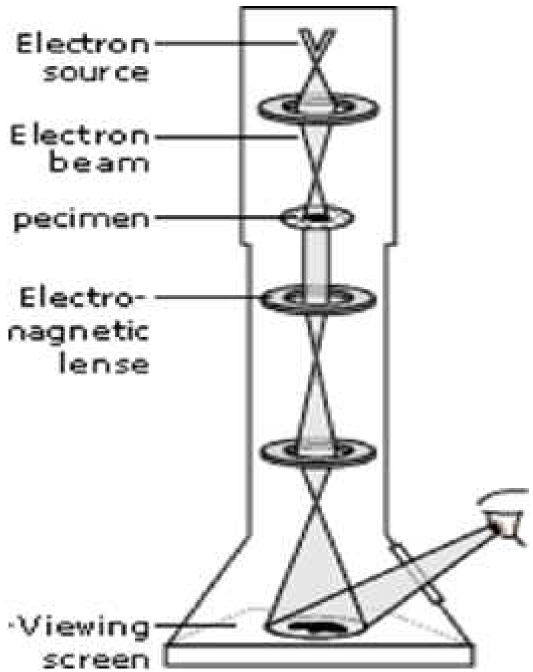
SEM images of MoS 2 flower-like nanostructures: a) low magnification view; b) and c) high magnification view



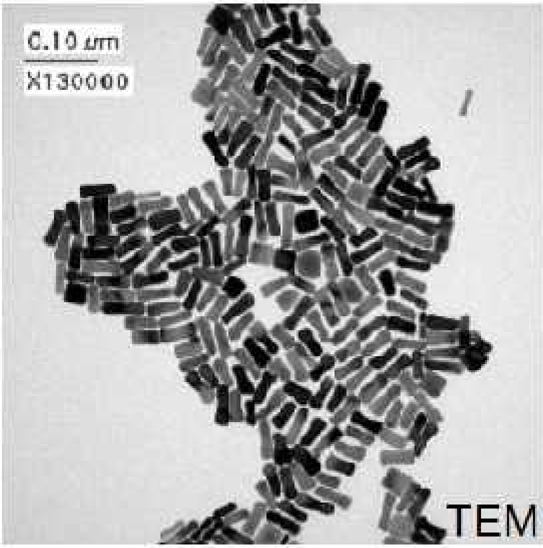


Cu SiO_2 core/shell Nanoparticles

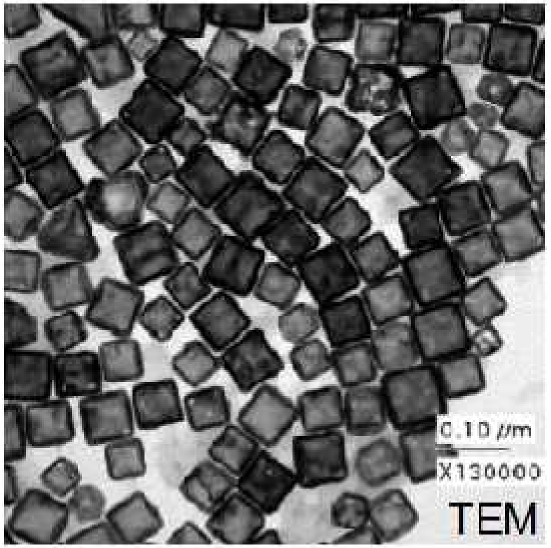
Transmission Electron Microscope (TEM)

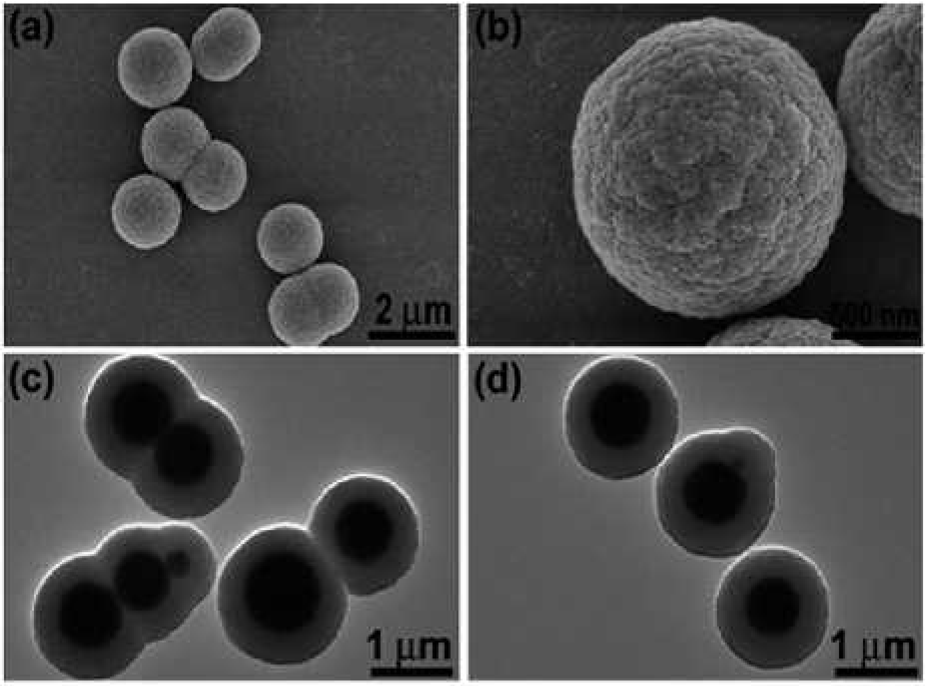


Gold Nanorods



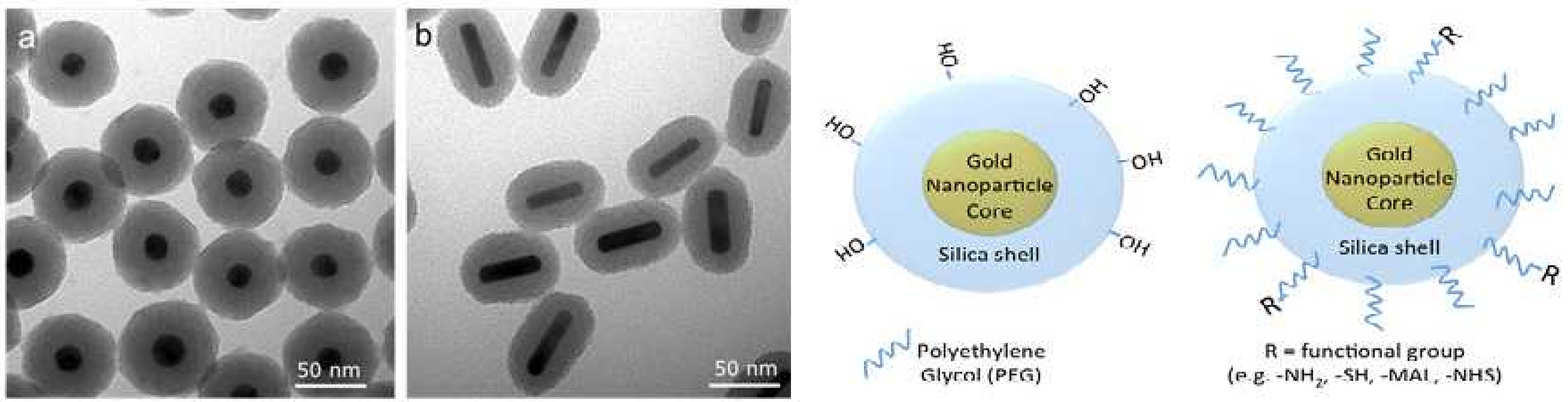
Gold Nanocages





Fe_3O_4@MOF core–shell magnetic microspheres

Identification of Core-shell Structure by TEM



Scanning electron microscopy (SEM) image of (a) Silica-coated gold nanospheres (b) silica-coated gold nanorods

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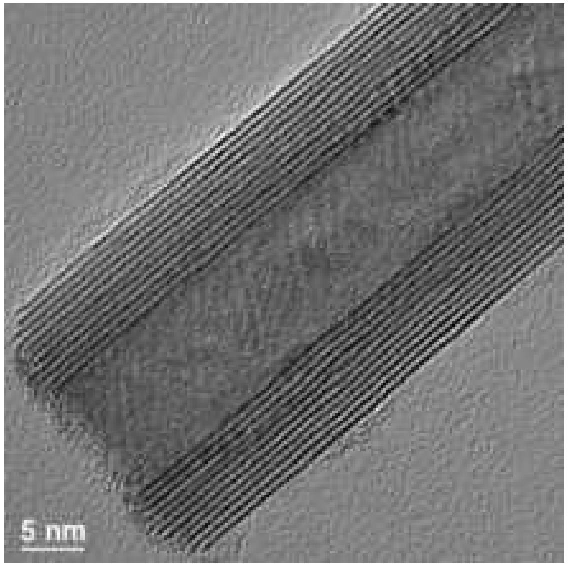
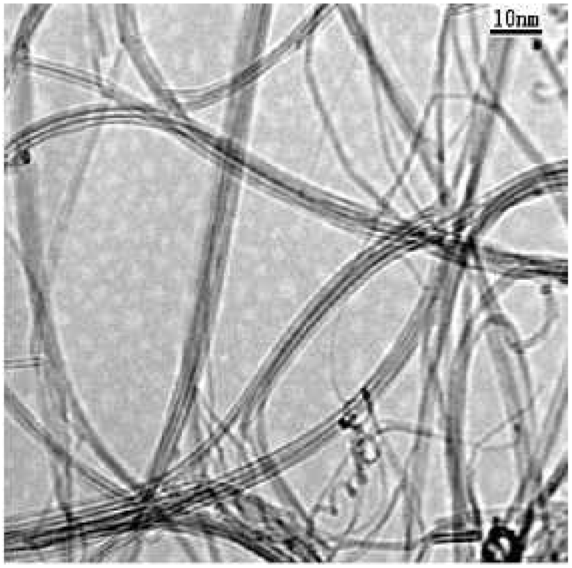
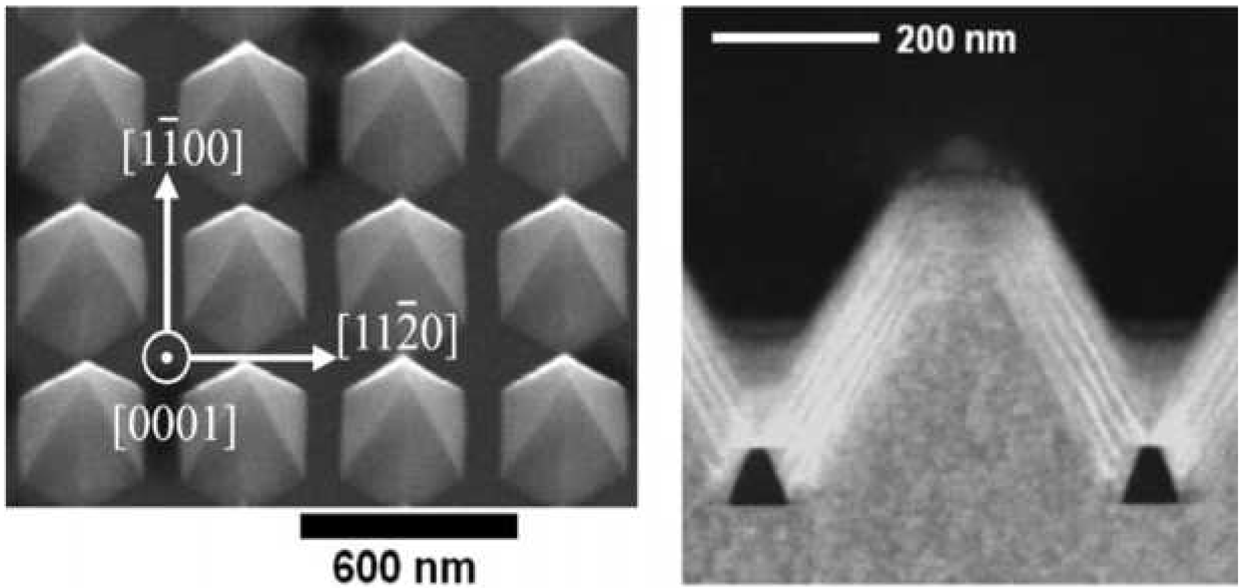
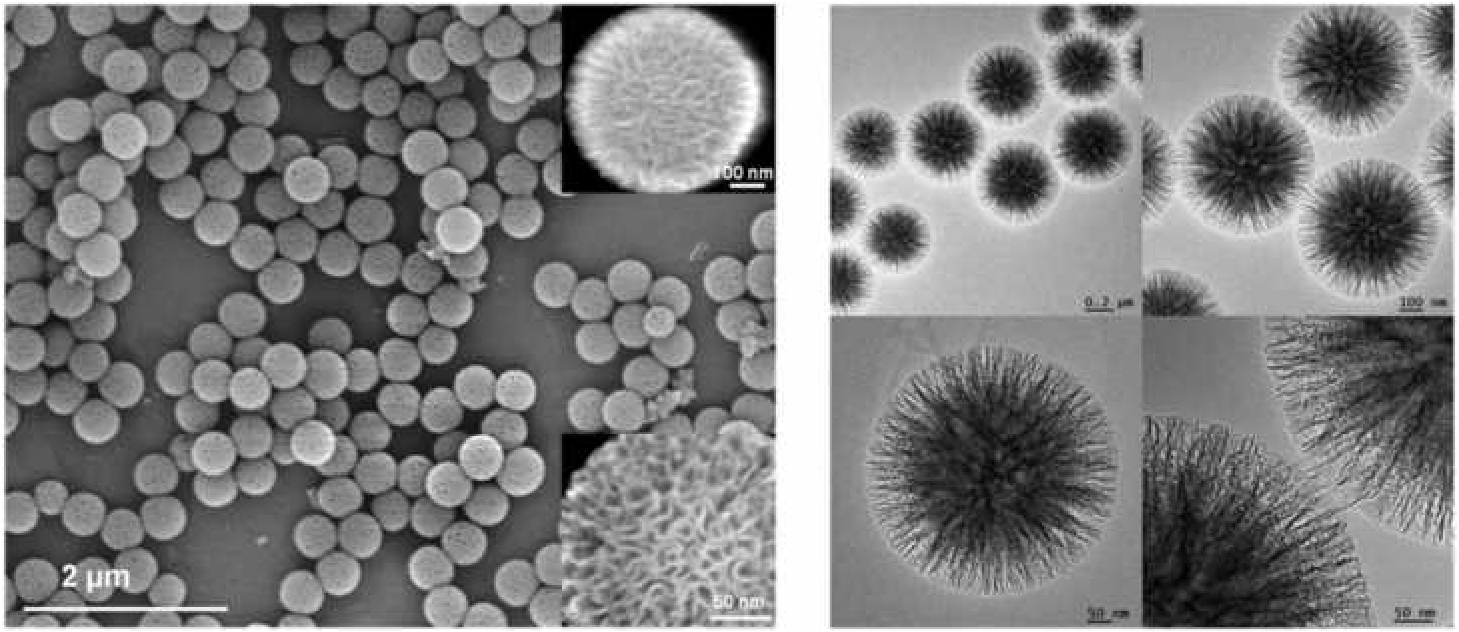




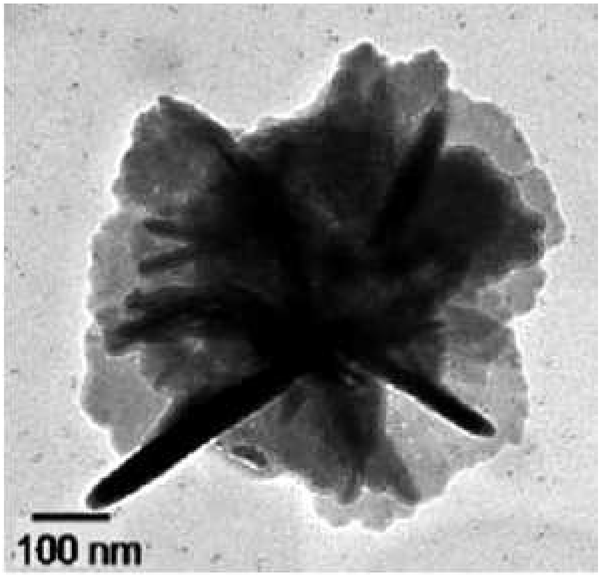
(a) Scanning electron microscope image of hexagonal nanopyramid array. Crystallographic directions are shown.
(b) Cross sectional transmission electron microscope image of the nanostructure.



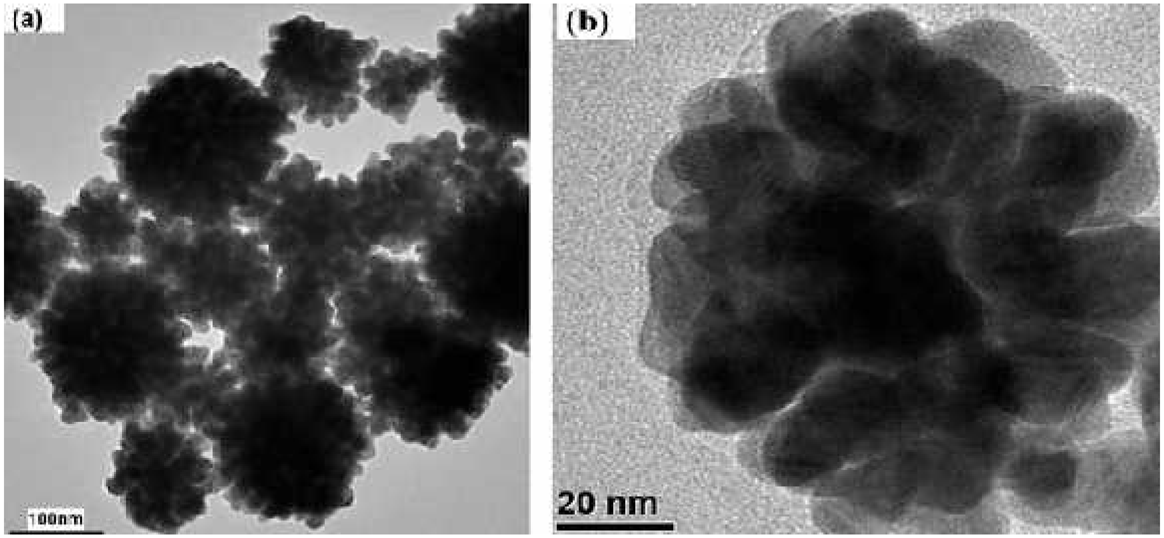
(a) (b)



SEM (left) and TEM (right) imaging of silica nanospheres indicates the presence of fibers



TEM image of a single $Cu_2(OH)_3Cl$ nanoflower



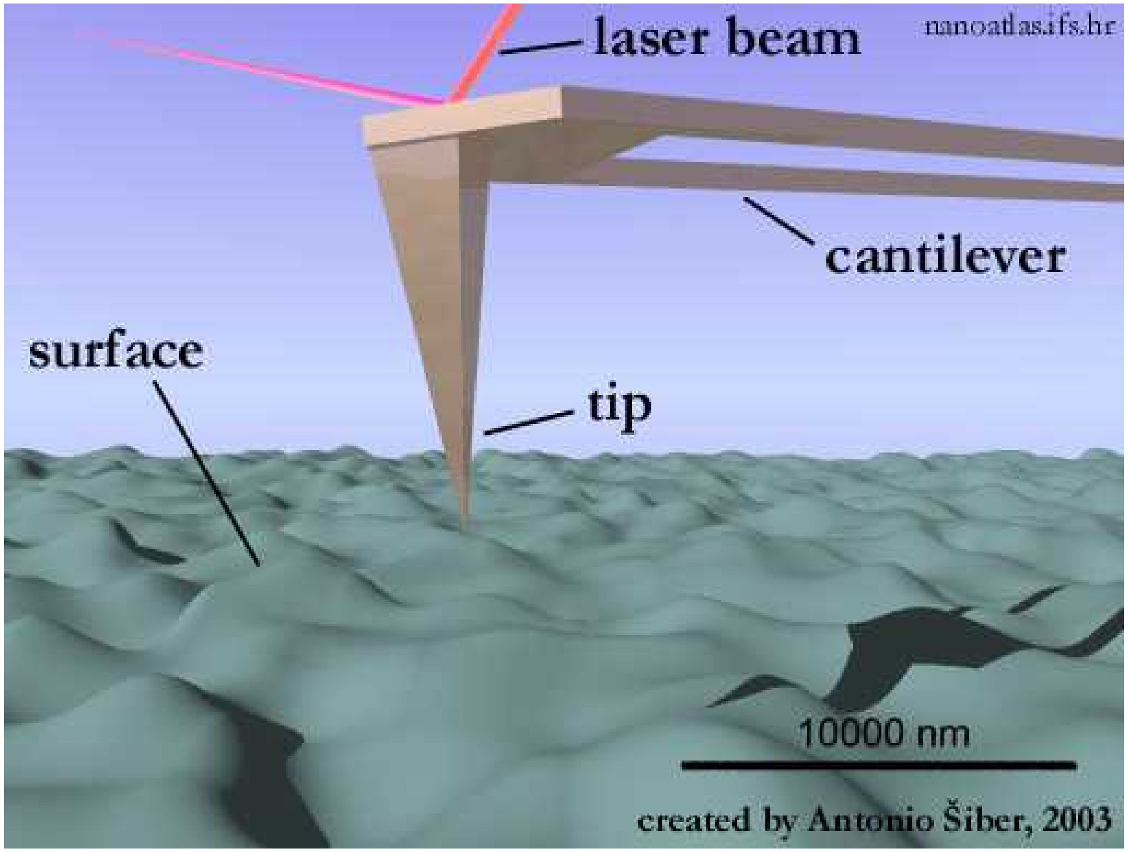
(a) Transmission electron microscopy (TEM) image of gold nanoflowers. (b) A TEM image of a single nanoflower shows a clear demarcation between the capping enzyme and gold nanoparticles.
The edge of the nanocrystal reveals many small gold nanoparticless assembled into a large flower-like nanoparticle.

Atomic Force Microscopy (AFM)

- Cantilever structure on end on end of wafer holds the pyramidal tip

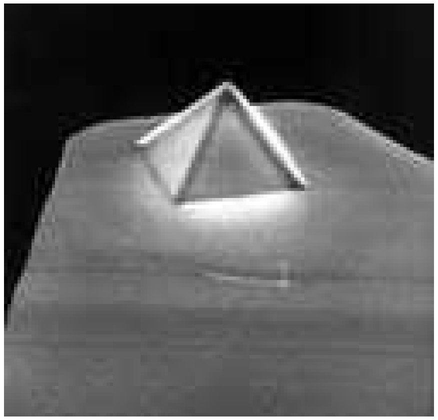
- Light from a diode laser bounces of tip and strikes a split photodetector

- Motion is detected by differences in intensity on the detector portions

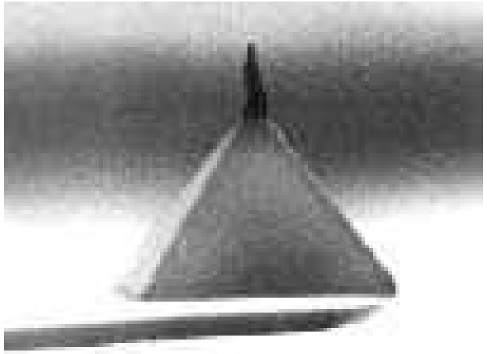


AFM Tips

- Si or SiN – 10 nm at end – ~100 atoms



(a) normal tip (3 μm tall)

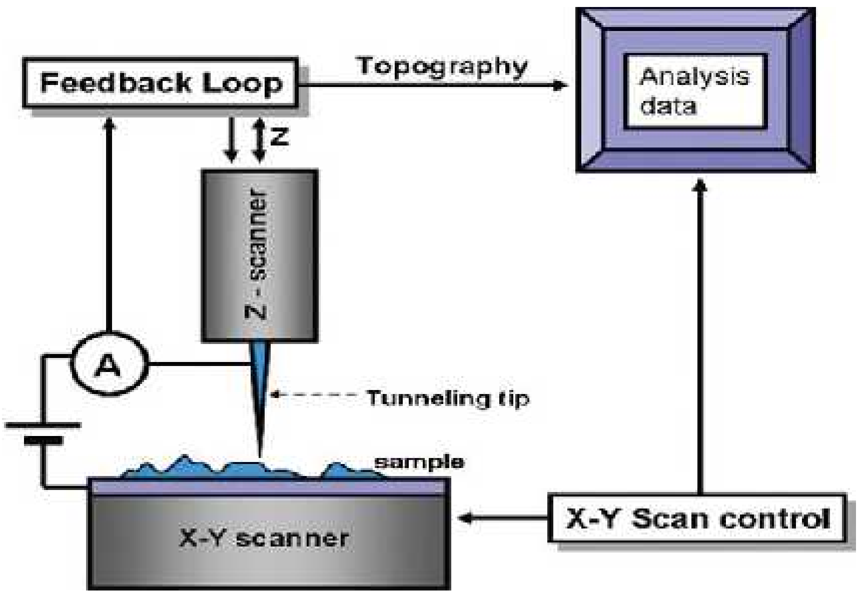


(b) Supertip

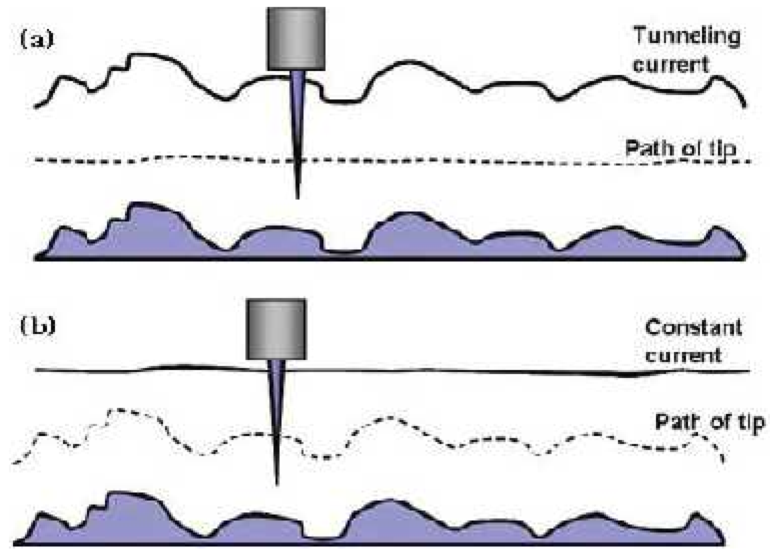
(c) Ultralever (also 3 μm tall)

AFM Modes

- Contact Mode
- Non-contact Mode
- STM Mode (Scanning Tunneling Microscope)
  Scanning Tunneling Microscopy (STM) is one of the application modes for Park AFM. STM is the ancestor of all atomic force microscopes.

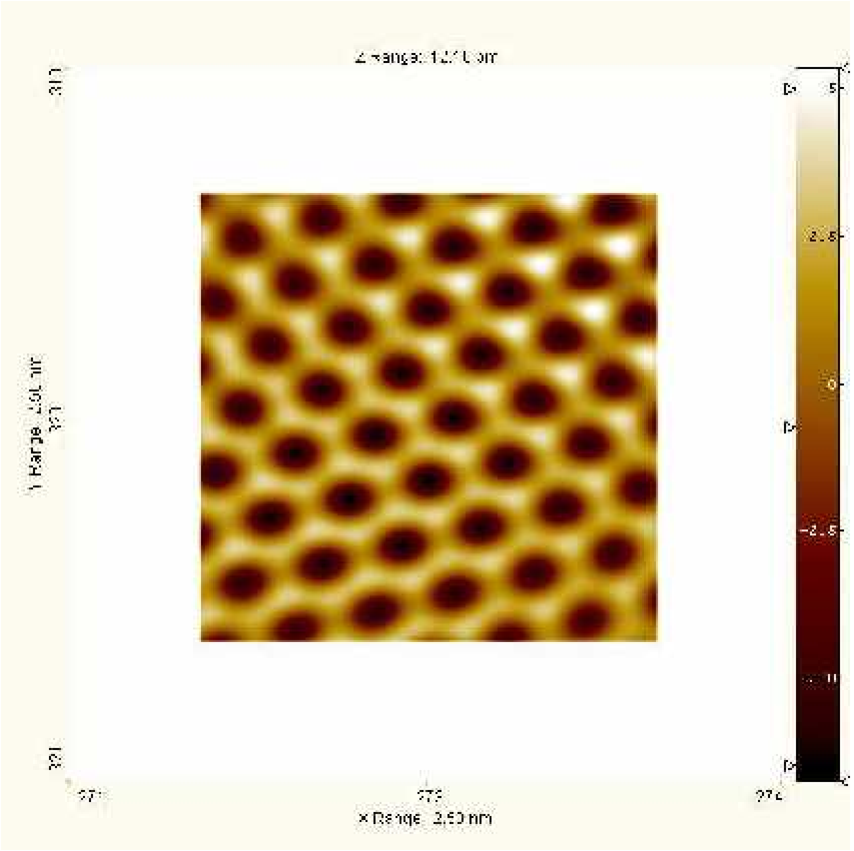


Schematic diagram of the Park AFM system

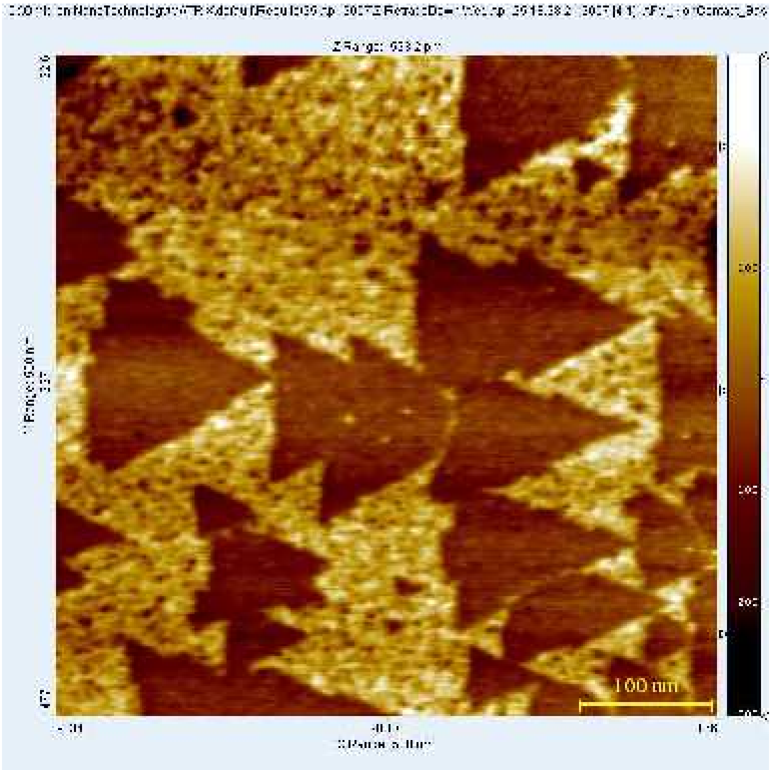


Comparison of (a) constant-height and (b) constant-current mode for STM.

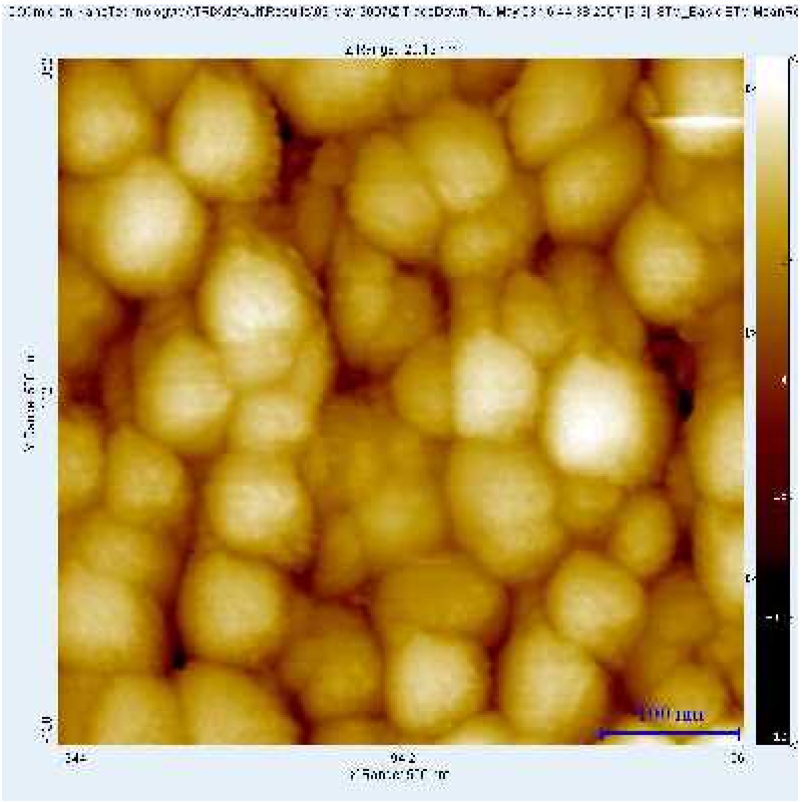
Highly oriented pyrolitic graphite AFM contact mode.



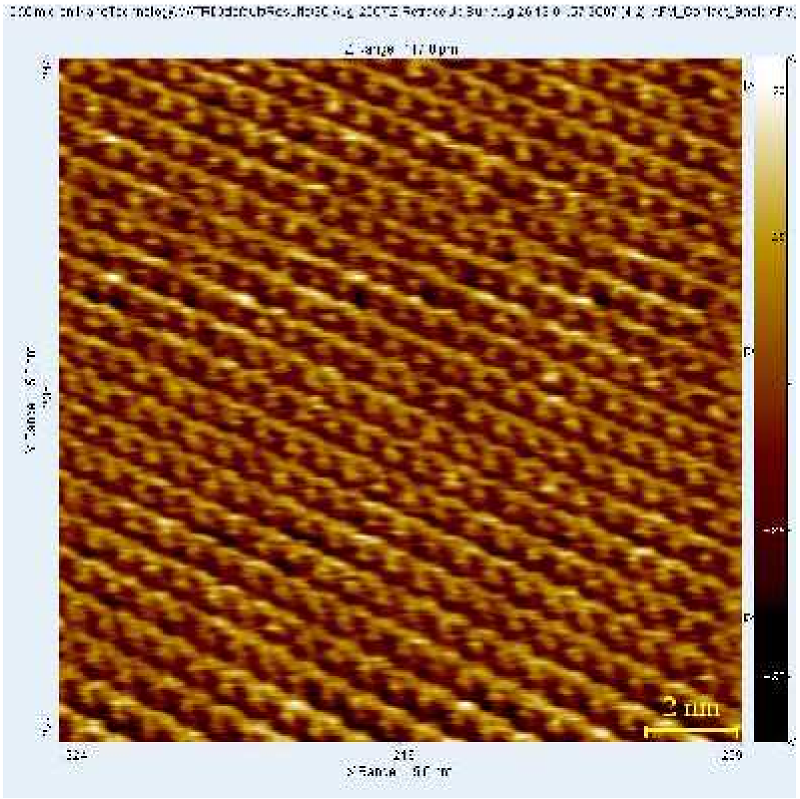
Si (111) contaminated with Ni AFM non-contact mode.



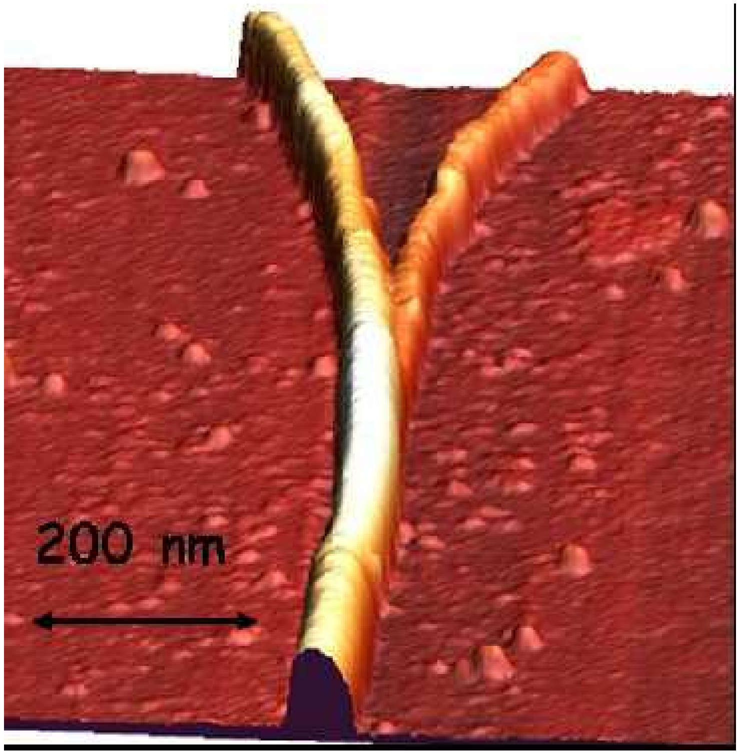
Gold on silica STM mode



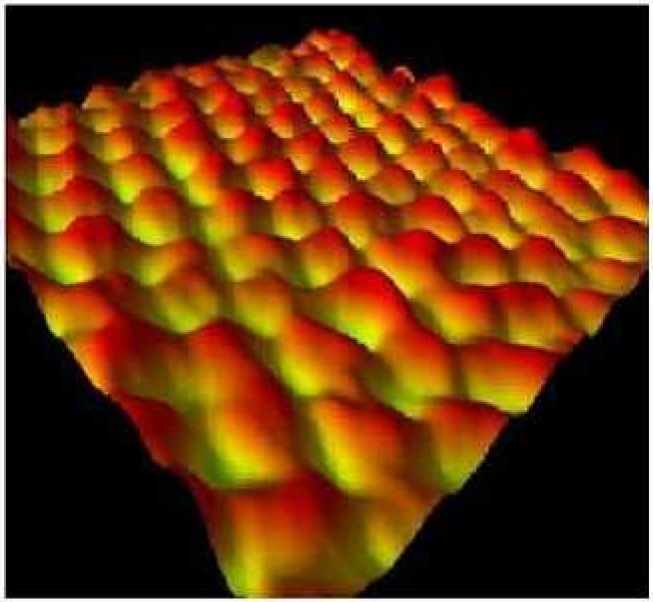
$CuGeO_3$ AFM contact mode



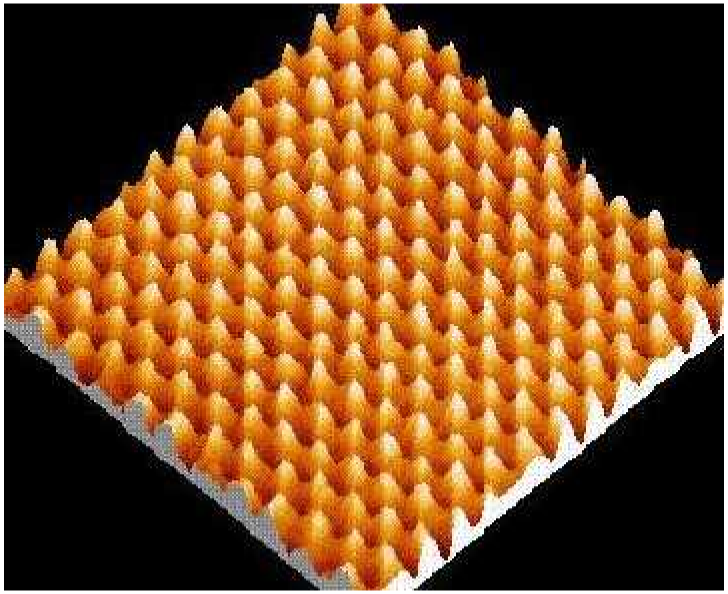
Carbon Nanotube.



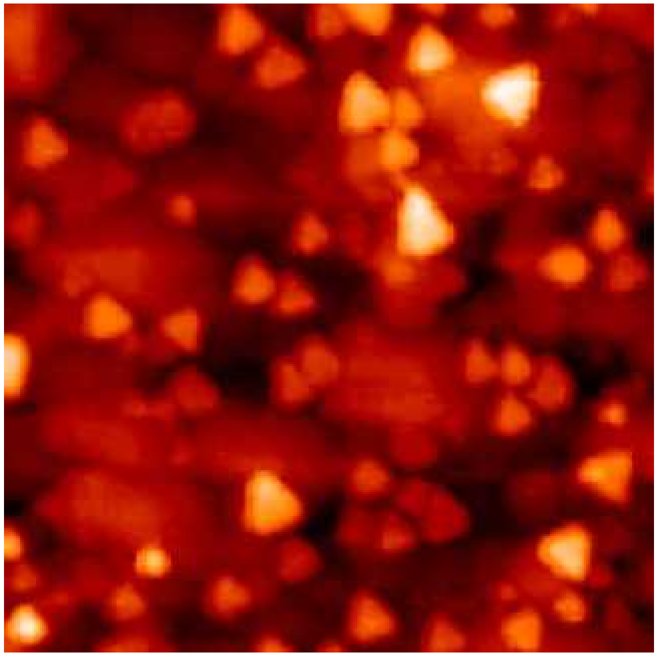
A three dimensional rendering of an STM image of a periodic array of carbon atoms



An STM image of a periodic array of carbon atoms



STM image of Au triangular islands formed when gold atoms are evaporated onto a MoS_2 substrate.



A transmission electron microscope image of an ordered array of single crystal Au nanoclusters.