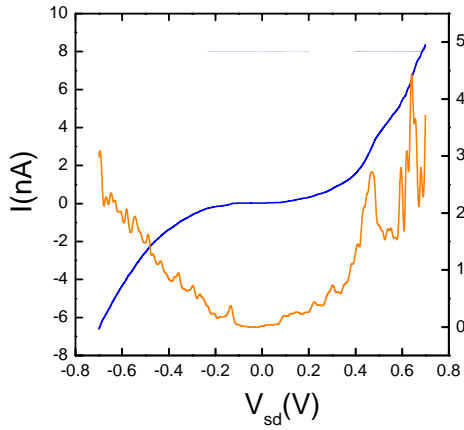
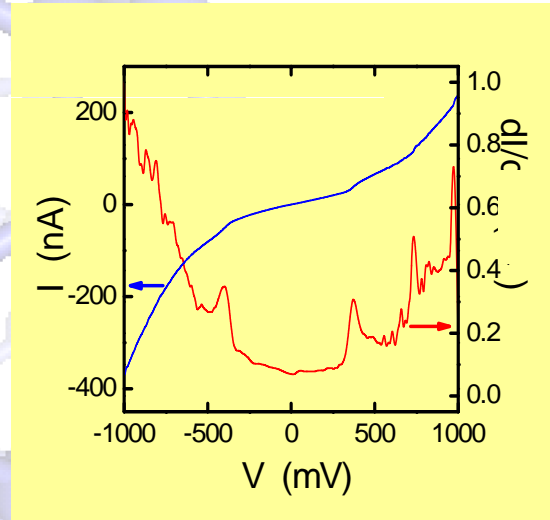


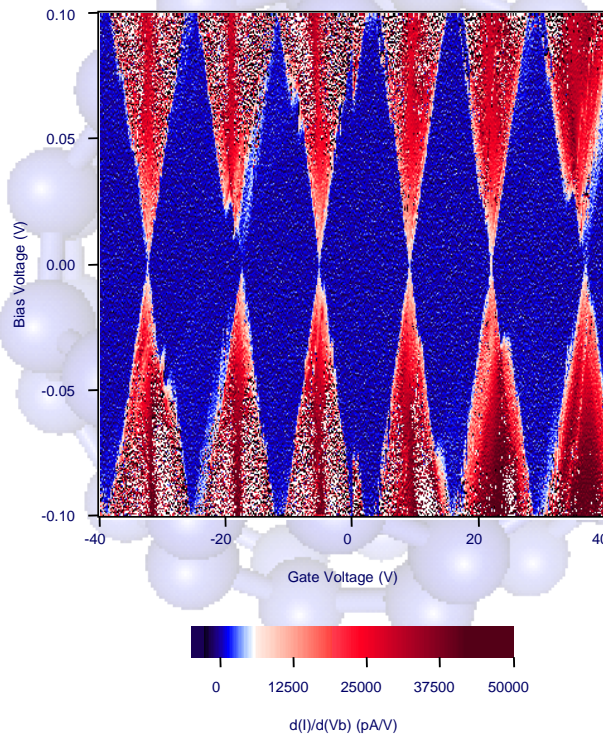
Electrical transport measured in devices with in 1,4-phenylenediisocyanide



Lateral Device



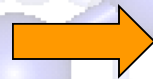
Vertical Device



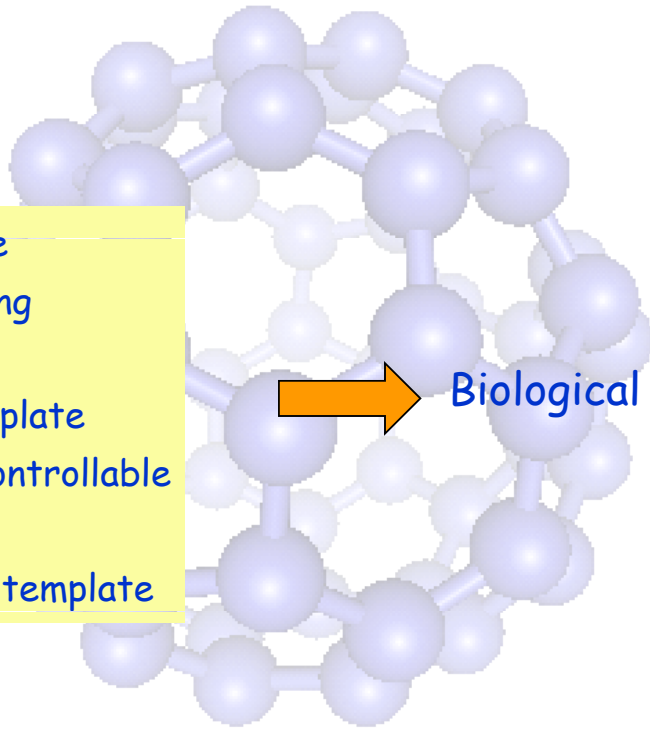
An Idea borrowed from biology

We desire...

Self assemble
Self correcting
Self healing
Grows on template
Selectively controllable
RT/ambient
Recycles own template



Biological systems



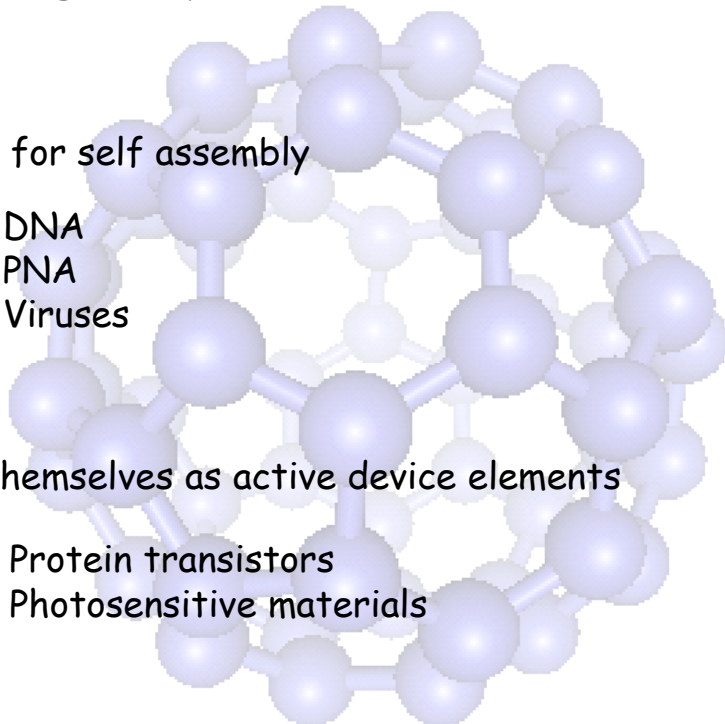
Using biological system for molecular electronics

1. Used for self assembly

- DNA
- PNA
- Viruses

2. Use themselves as active device elements

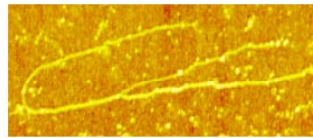
Protein transistors
Photosensitive materials



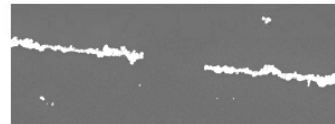
Self assembly using biomolecules

Self assembly and device fabrication of carbon nanotubes with DNA sequence specific lithography

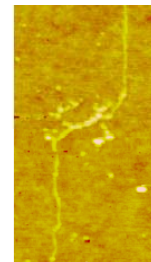
• DNA junction formation



• Patterning of DNA metallization



• Localization of molecular objects on DNA



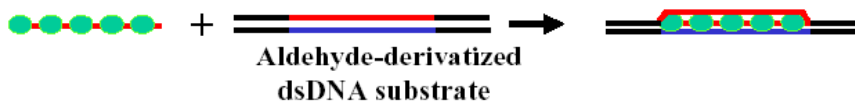
K. Keren et al.

Sequence specific binding of CNT

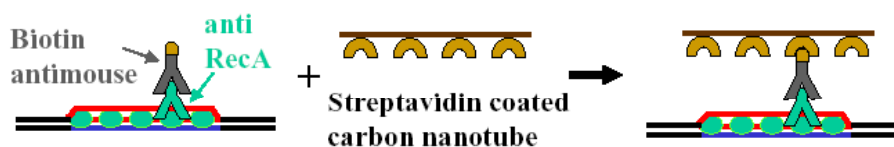
(i) RecA Polymerization



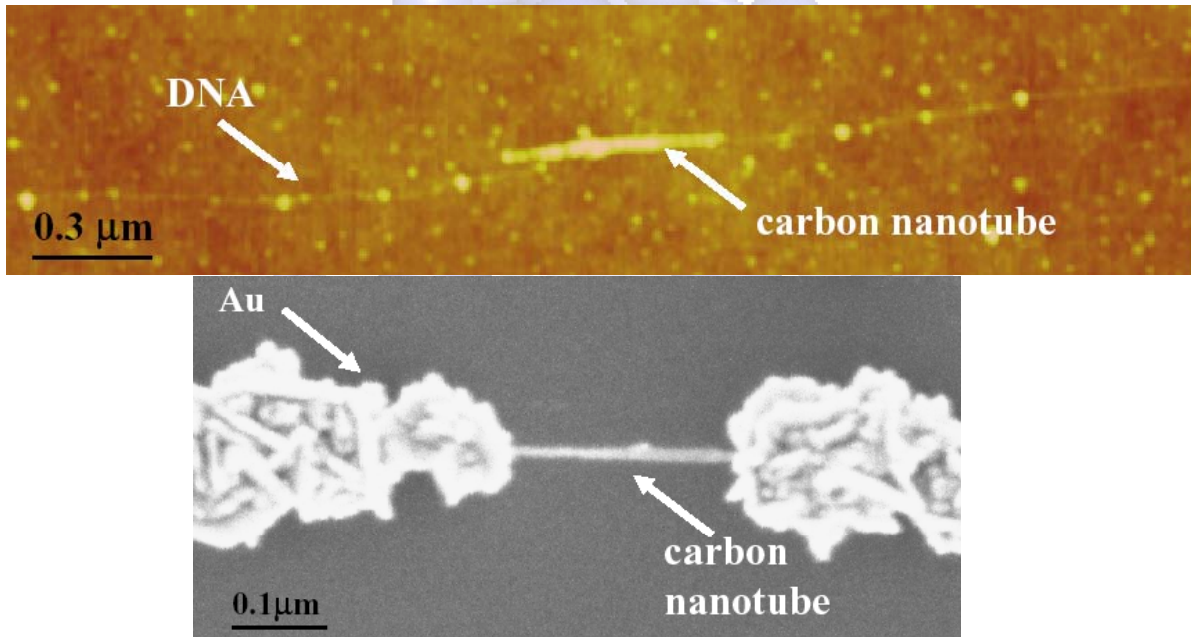
(ii) Homologous recombination



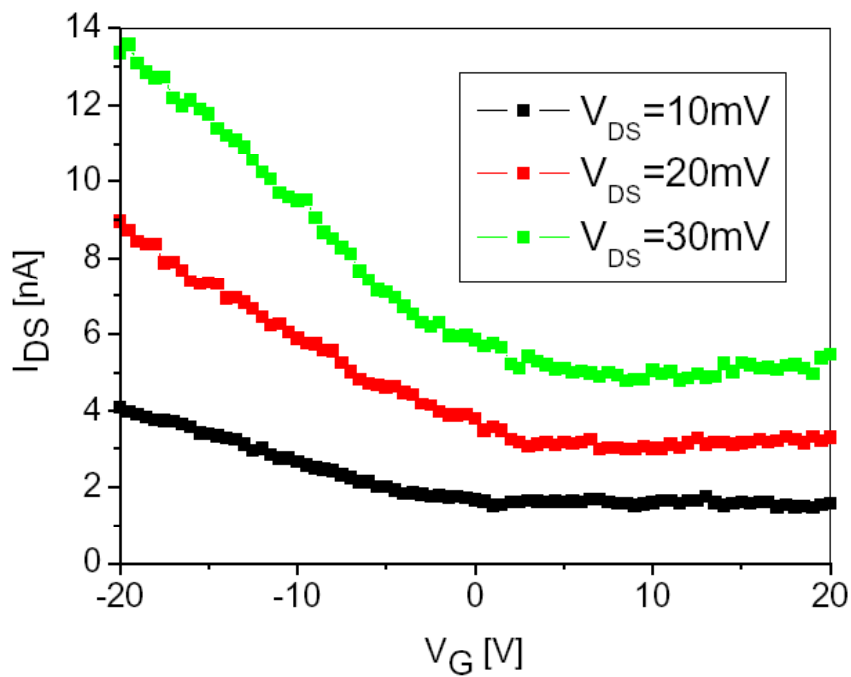
(iii) Localization of carbon nanotube using antibodies



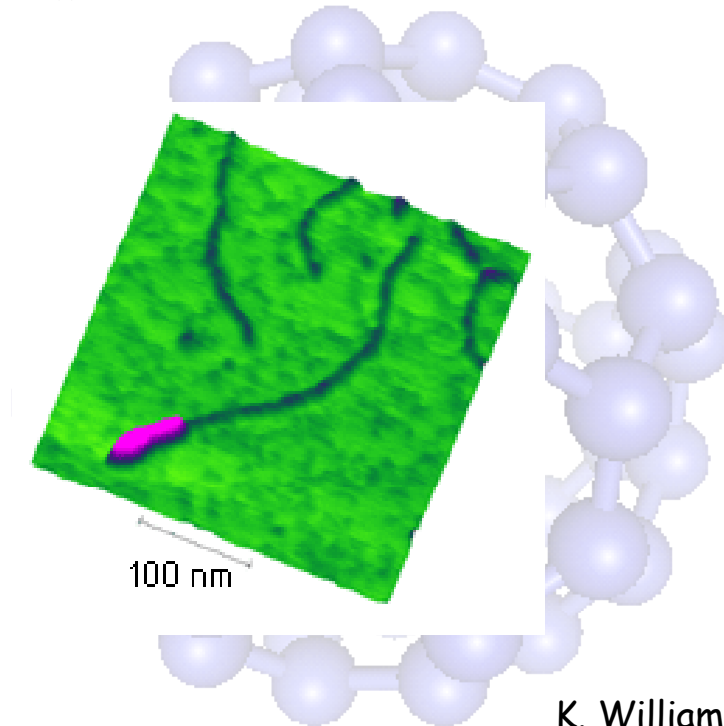
Fabrication of CNTFET templating DNA molecules



Characteristics of DNA-templated CNTFET



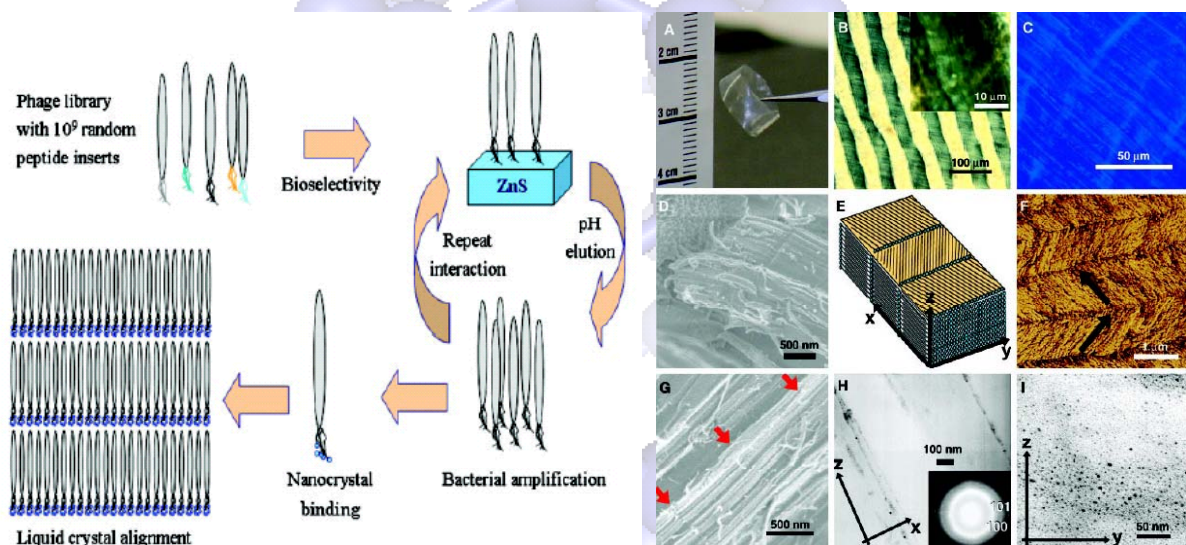
PNA assembled carbon nanotubes



K. Williams et al.

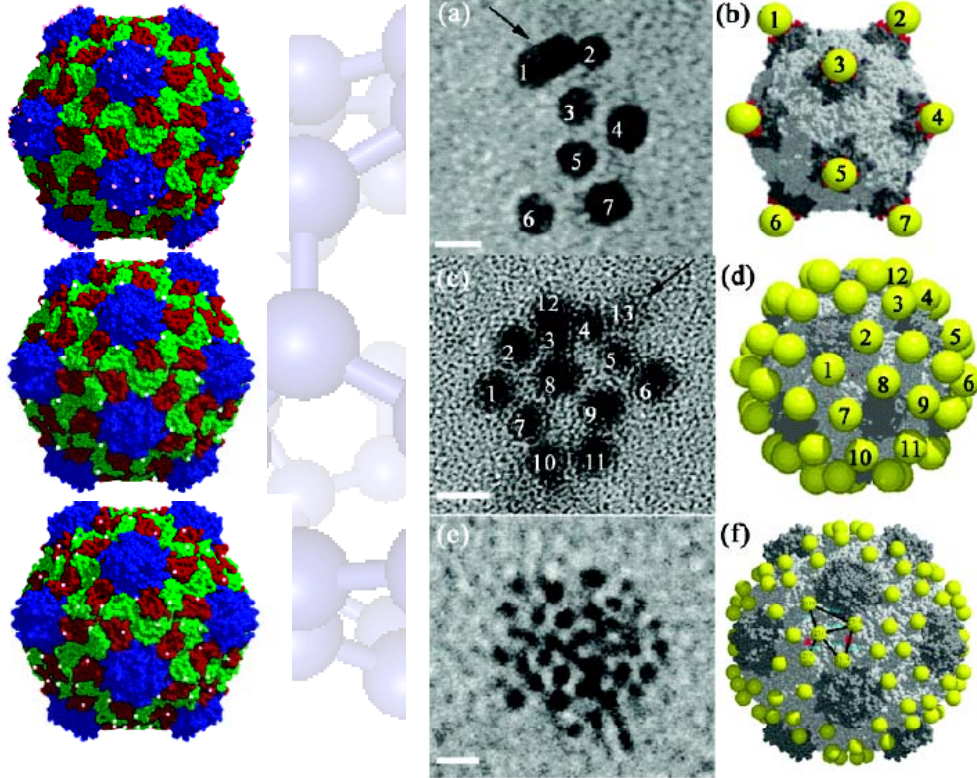
Virus mediated Assembly

Quantum dots assembled with genetically engineered viruses



A. Belcher et al.

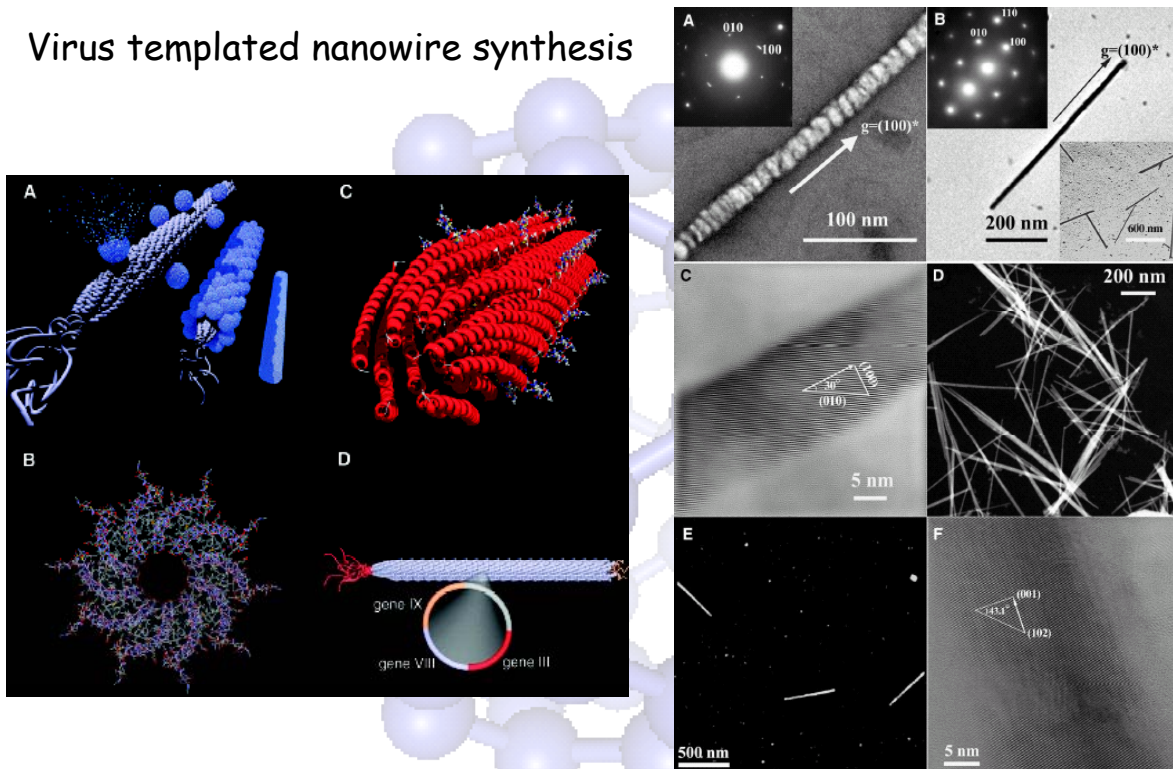
Virus as a scaffold for 3-D assembling of Au nanoparticles



Amy Szuchmacher Blum et al.

Nano Materials Research Team

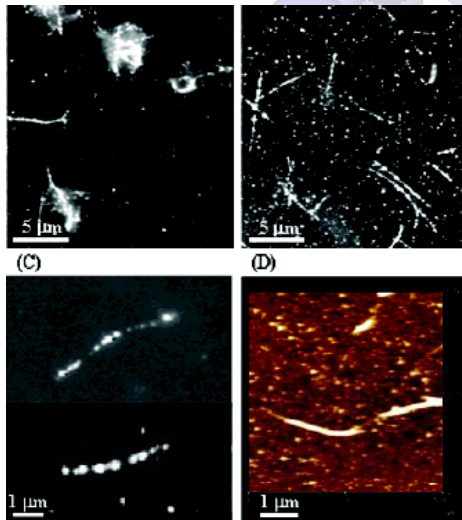
Virus templated nanowire synthesis



A. Belcher et al.

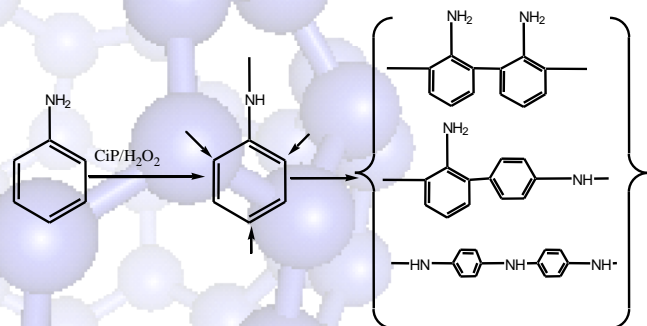
Nano Materials Research Team

Assembly and transport of quantum dots using microtubules and kinesin motor proteins



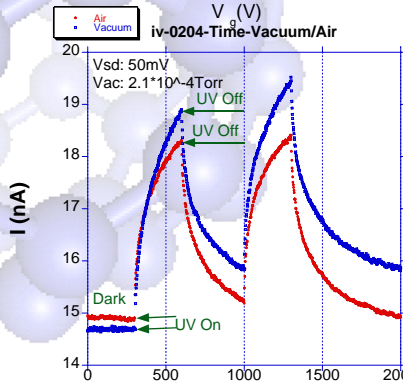
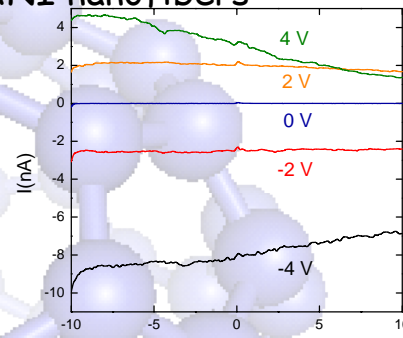
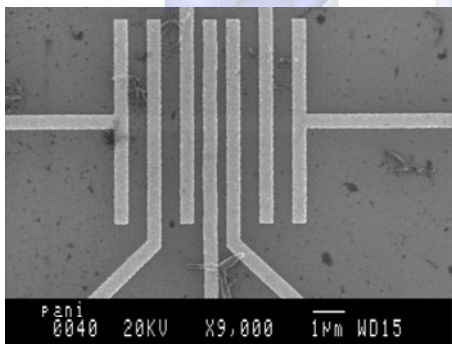
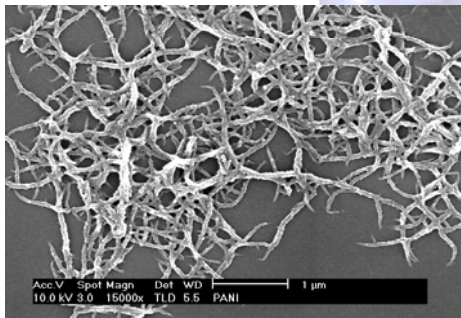
MOVIE
nl049811hsi20040203_034011.mov

Synthesis of polyaniline nanofibers by enzyme peroxidase



Synthesis of polyaniline nanofibers by enzyme peroxidase

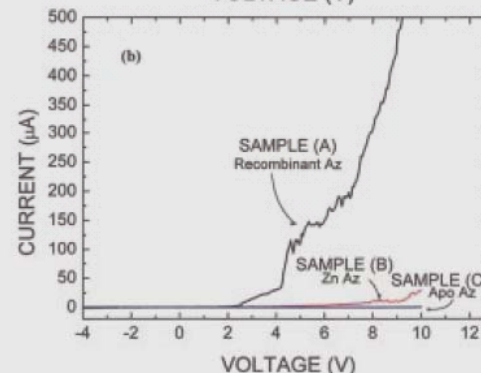
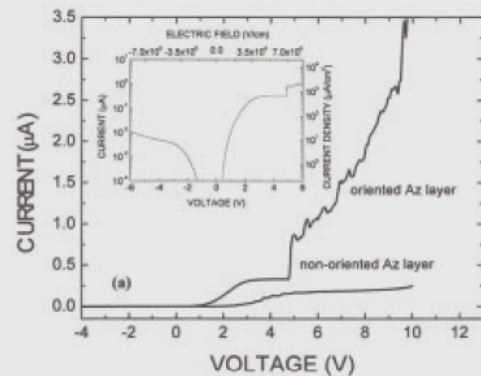
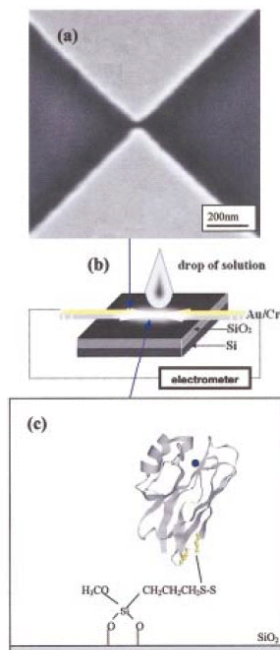
Electrical transport through PANI nanofibers



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Bioelectronic devices

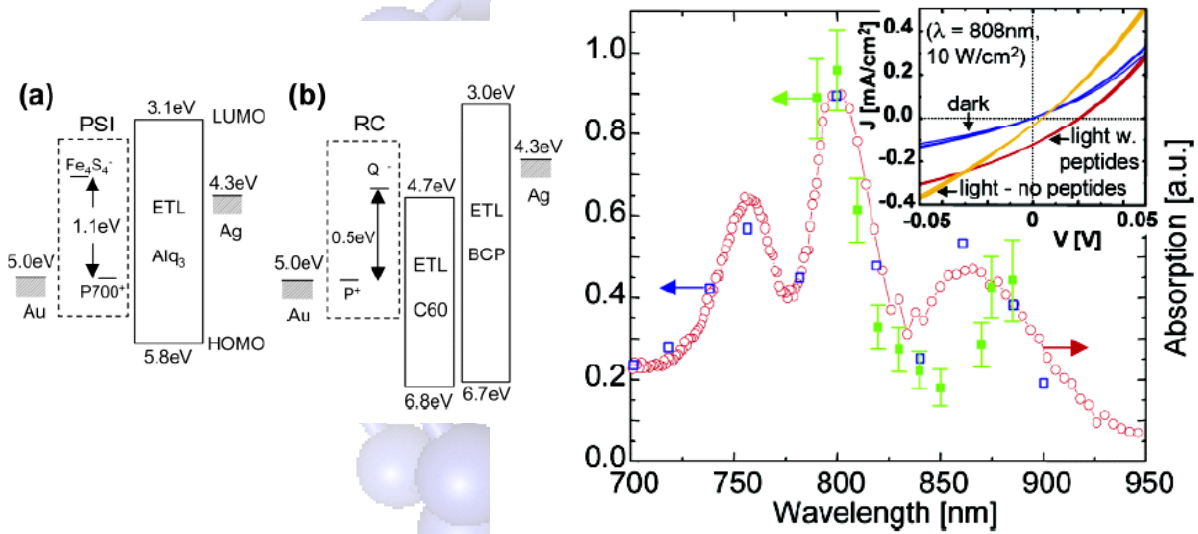
1. Protein transistors
2. Photo sensitive materials



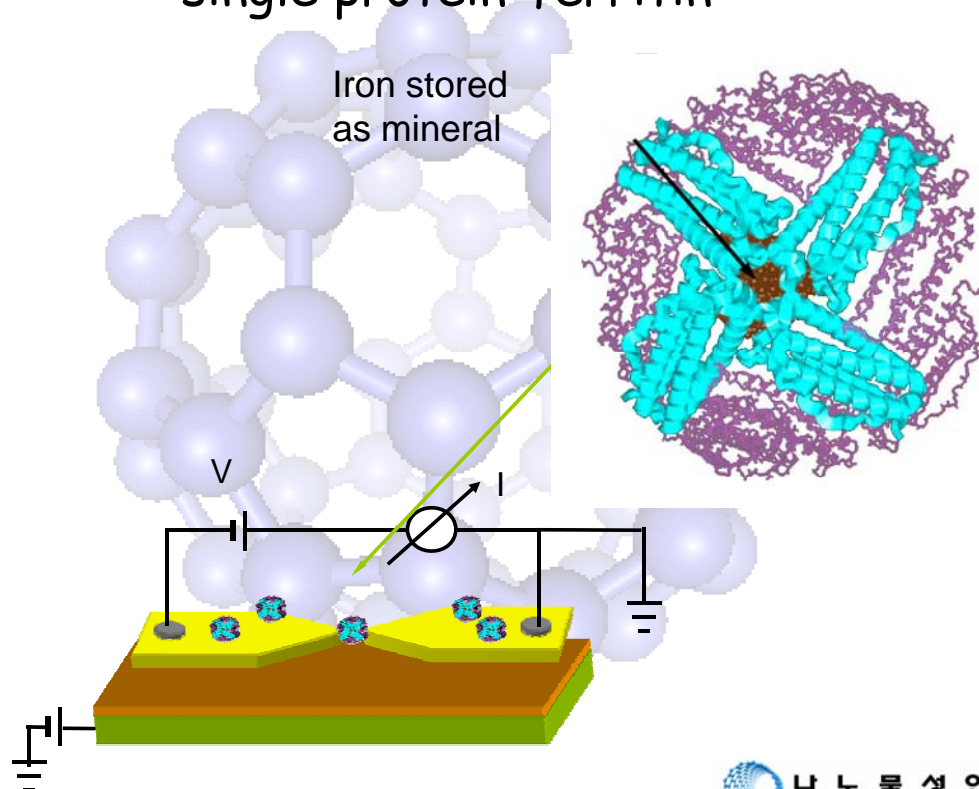
Rinaldi et al. 2003

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Protein photodetectors with photosynthetic proteins



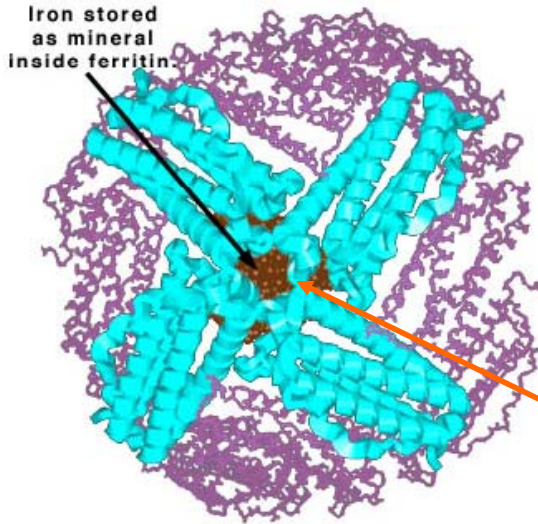
Electrical transport measurement on a single protein-ferritin



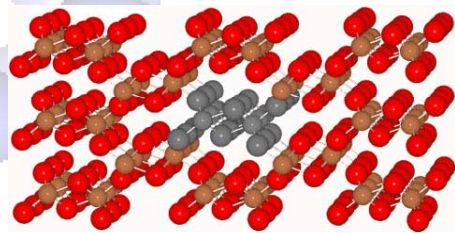
What is ferritin?

Ferritin; Iron storage protein in biological system

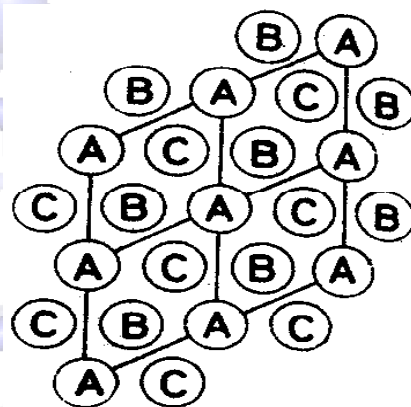
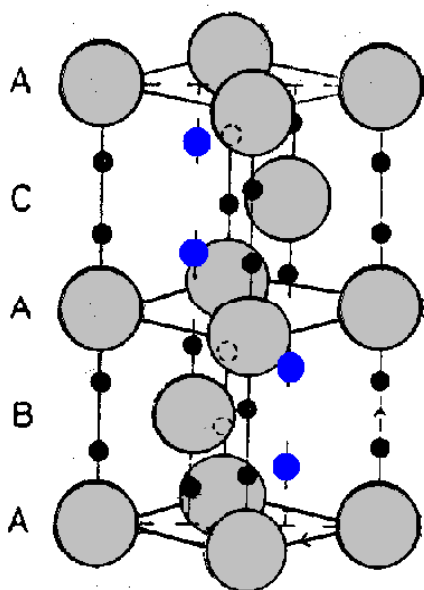
Iron stored
as mineral
inside ferritin.



- Consists of 24 peptide units (molecular weight ~440kDa)
- 3-fold channels ; Fe(II) transfer
- 4-fold channels ; electron transfer



Proposed model by *Drits*
(1996, *Clay. Miner.*)



Closed-packed hexagonal layers of oxygen (O^{2-} , OH, H_2O) in a sequence ABACA,

Cell dimensions $a=3 \text{ \AA}$, $c=9.4 \text{ \AA}$.

Fe in octahedral sites (coordinated to six O atoms)