TEM data analysis/ solar cell assembly

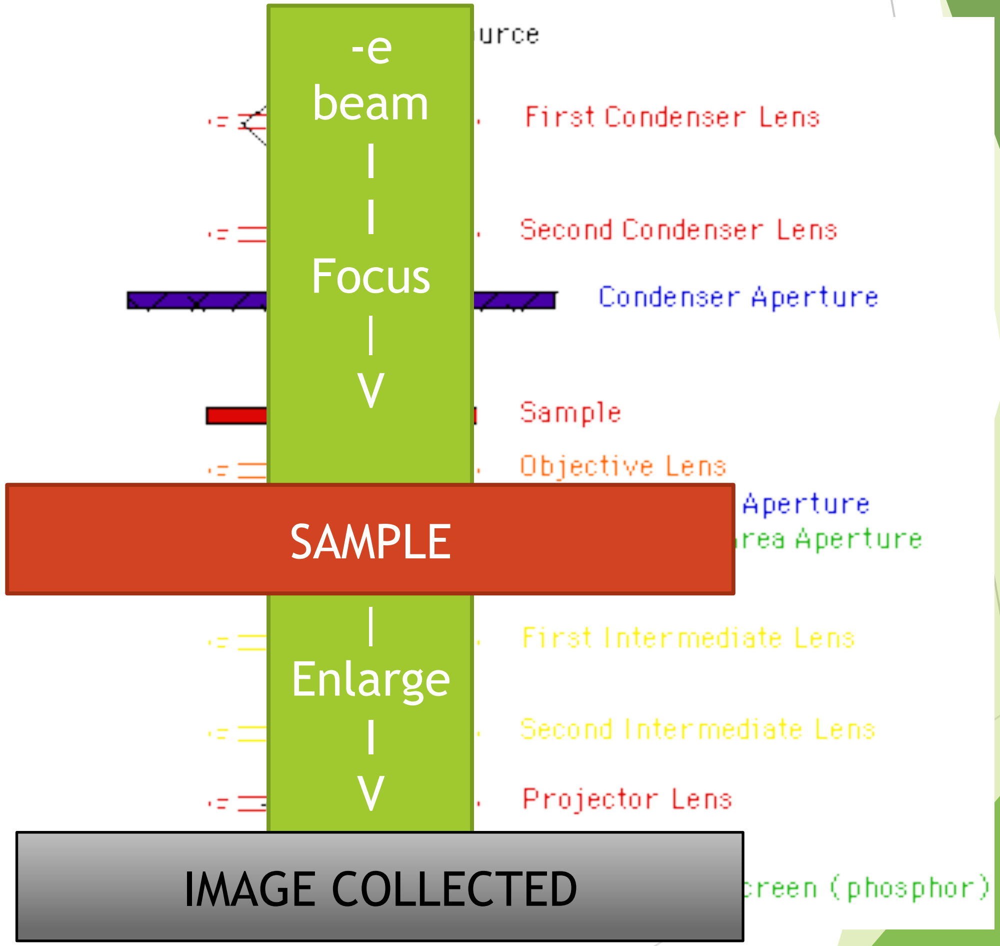
What are we doing today?

- **Result analysis:** Analyze compiled TEM images and discuss execution of first three lab days
- **Lab preview:** Solar cell assembly
- **Beyond 20.109:** A Brief Introduction to Field and Scope of Biotemplating

Results of M3D1-M3D3 lab work

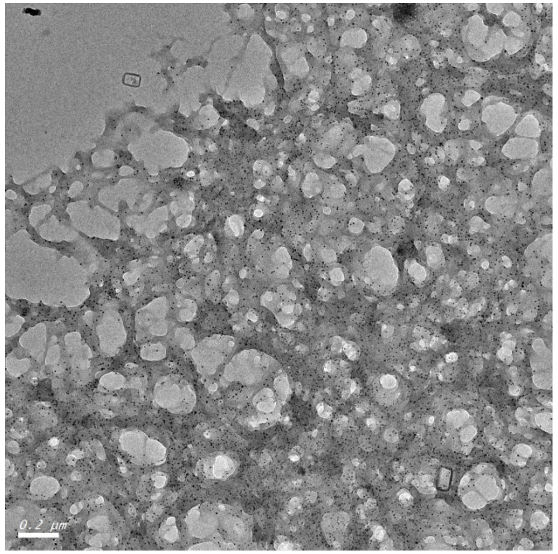
Things to keep in mind when looking at TEM images

- You are looking at a “shadow” which makes your information mostly 2D
- Electron conducting materials have better contrast and resolution
- Thick portions of the sample will appear darker
- Density of subjects in TEM image is dependent on sample preparation

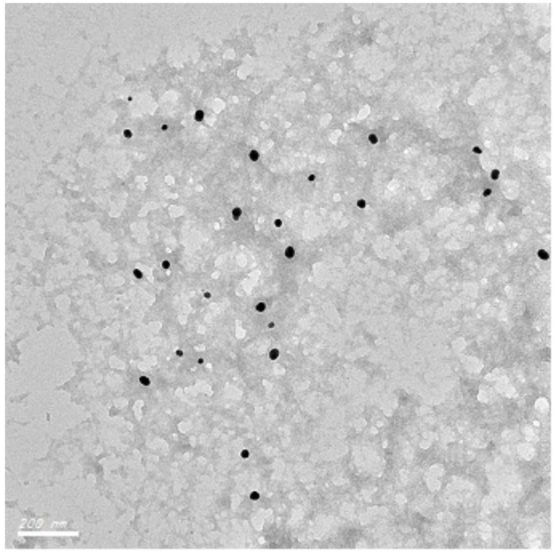


(M3D1) M13 gold binding was successful

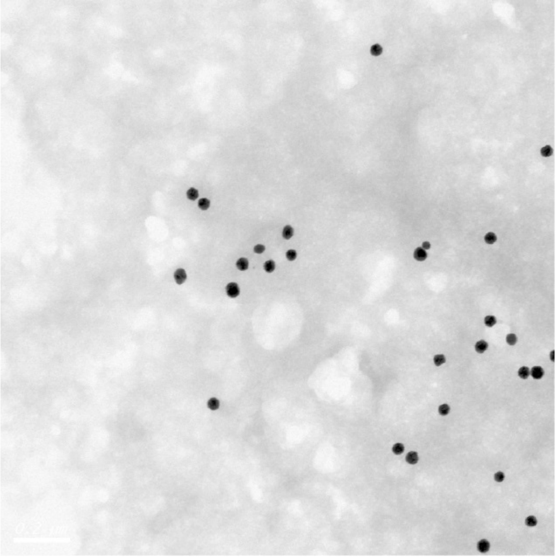
5nm particles



20nm particles



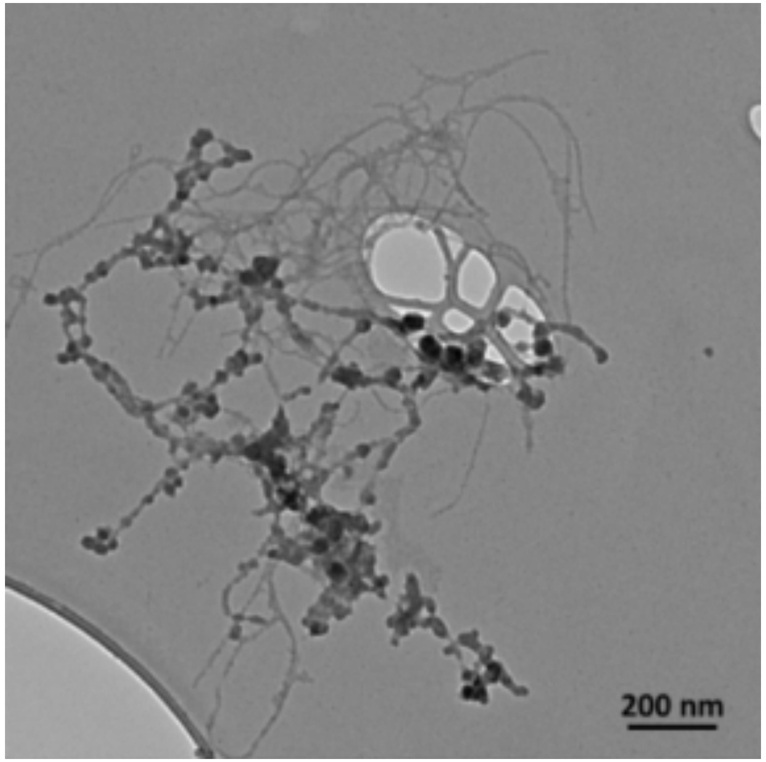
40nm particles



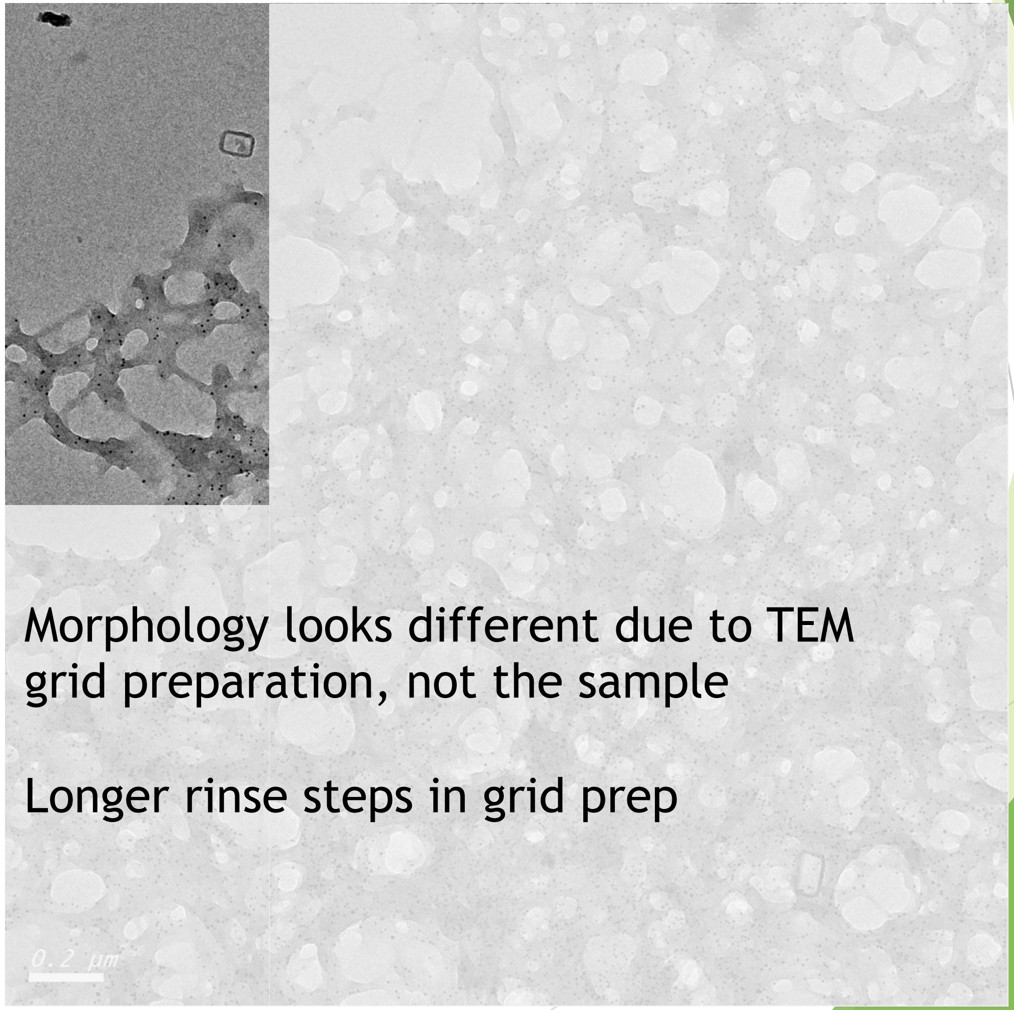
- Gold weight percent is constant but radii increase. Thus the number of particles decreases as a function of radius^3
- Electron conducting materials have better contrast and higher resolution. Thus densely coated 5nm condition is the clearest

(M3D2) Titania nucleation was successful

Goal Morphology



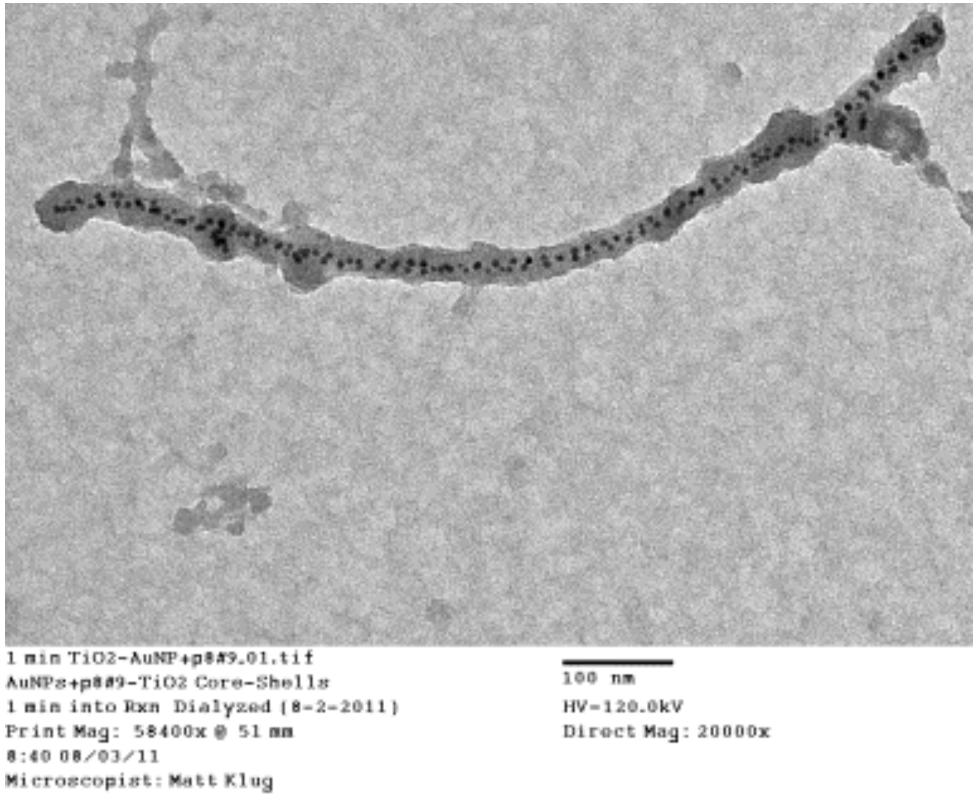
Our morphology

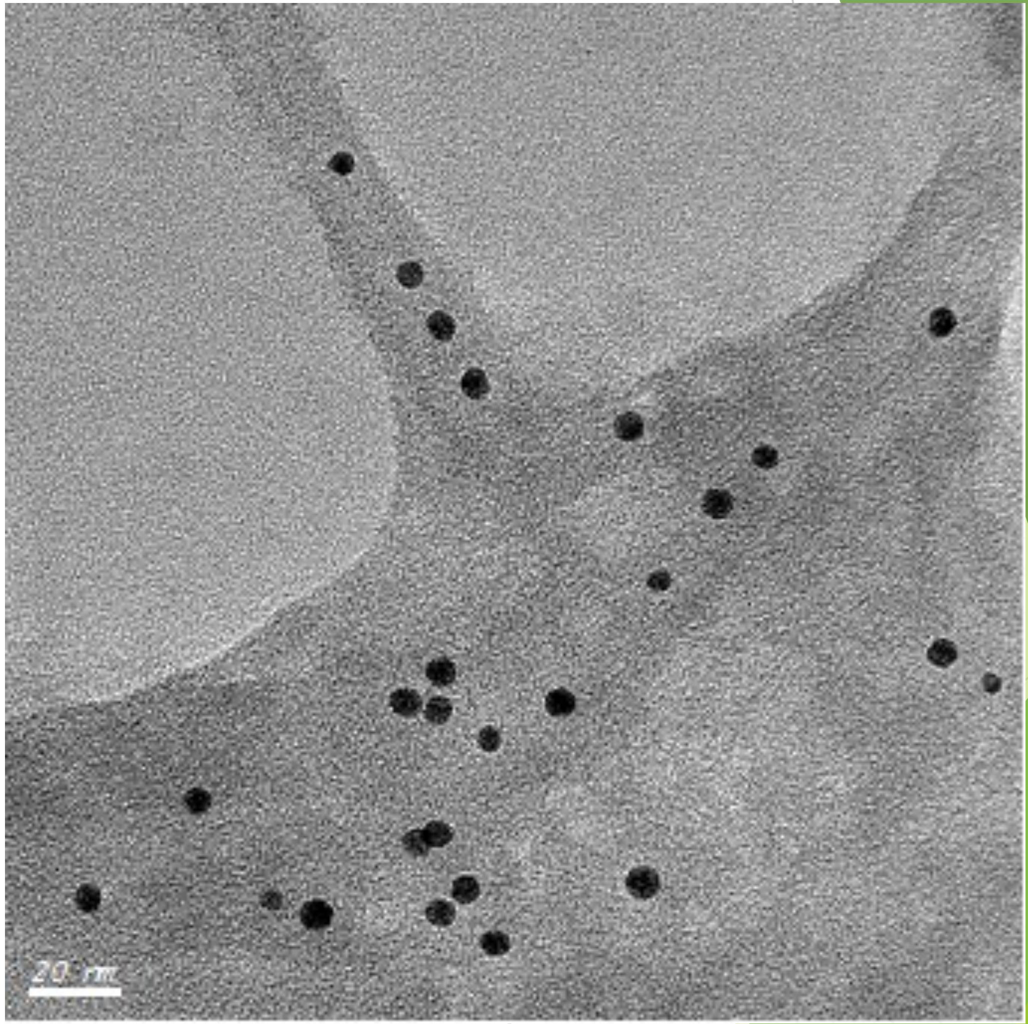


Morphology looks different due to TEM grid preparation, not the sample

Longer rinse steps in grid prep

Core shell structure – successful



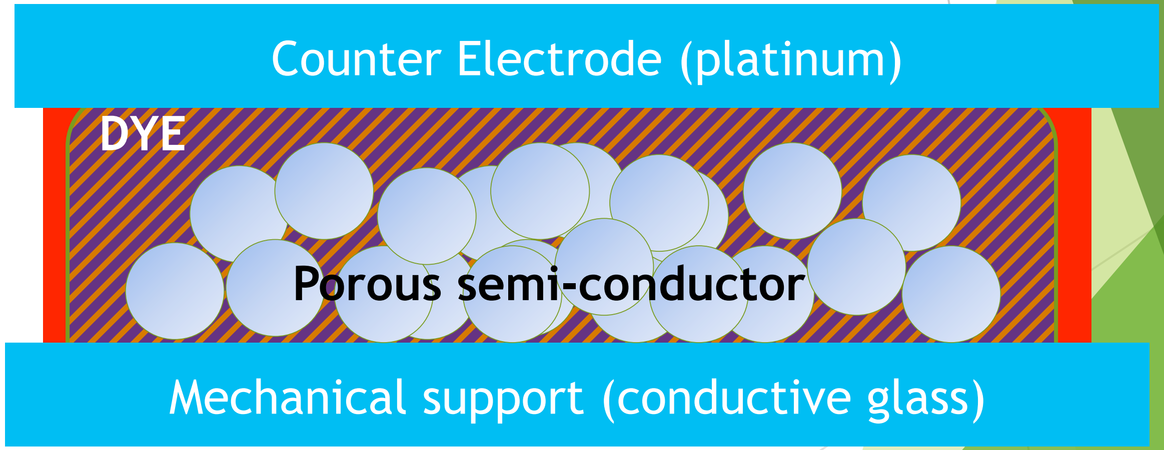


Lab preview: Solar cell assembly

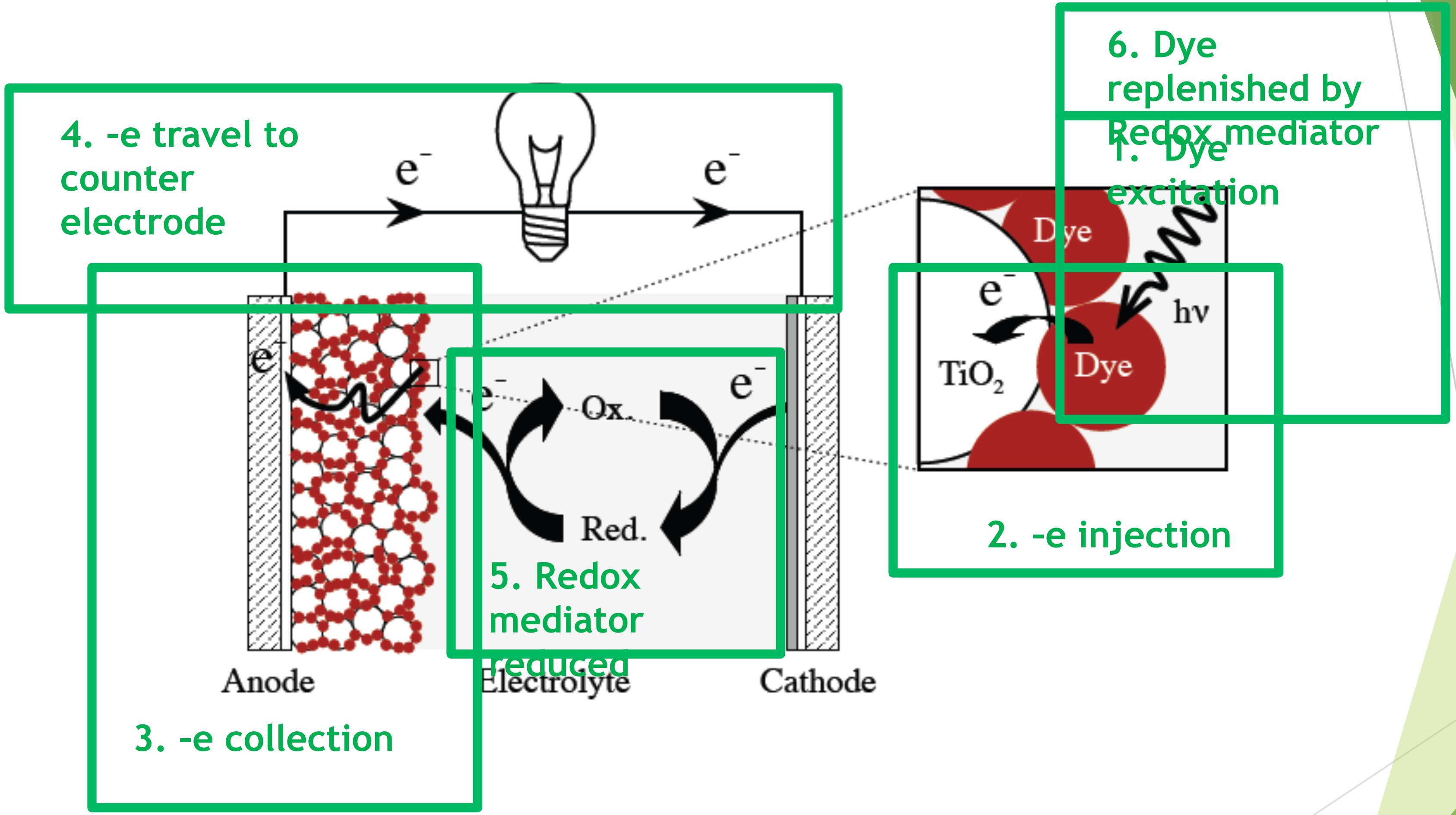
Overview for dye sensitized solar cell assembly

There are 5 main components you need to assemble

1. **Mechanical support:** FTO glass and TCO, transparent conducting oxide
2. **Semi -conductor:** TiO2
3. **Sensitizer (dye):** N719 dye
4. **Electrolyte and redox mediator:** I_3- / I-
5. **Mask:** Surilin
6. **Counter electrode:** Platinum



DSSC function: -e flow diagram



http://www.solaronix.com

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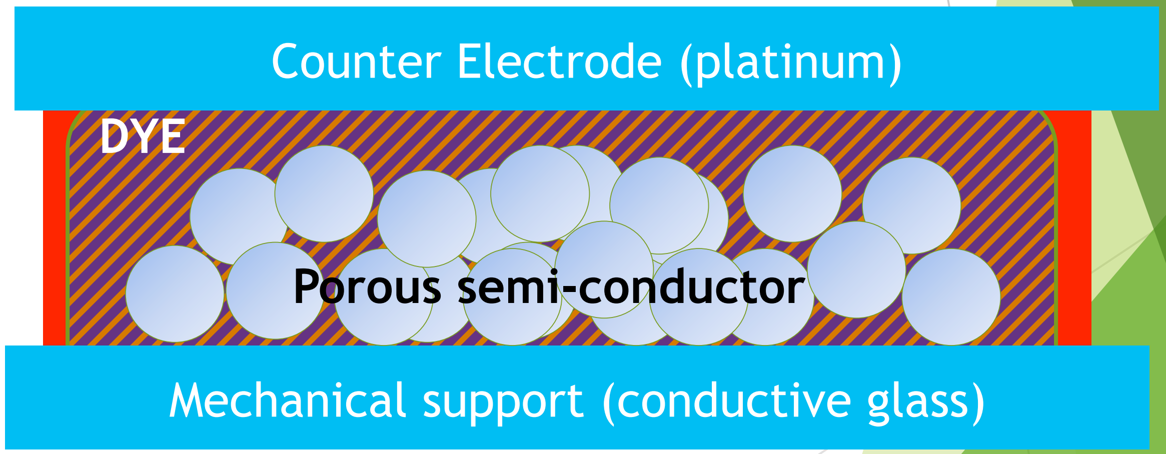
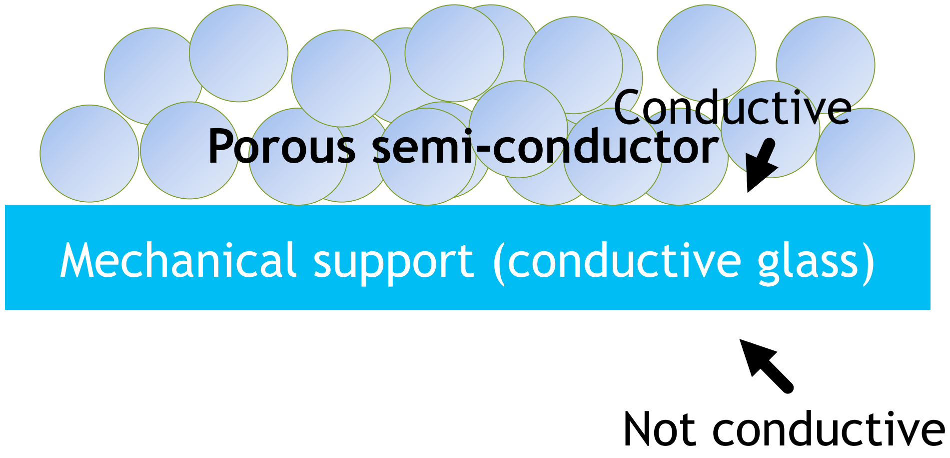
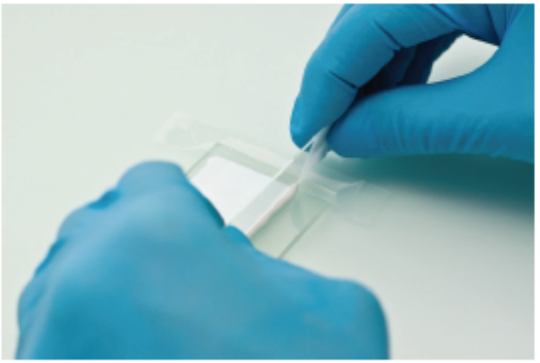


Mechanical support and semi-conductor assembly

1) Identifying the conductive side of the TCO (transparent conductive oxide)

2) "Doctor-blading" the titania (TiO_2) paste





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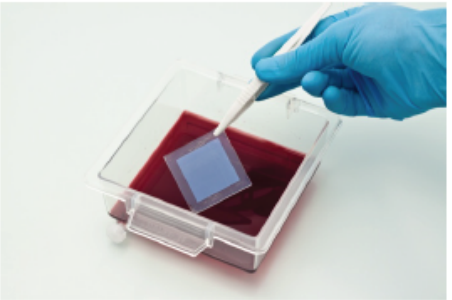
Dye and electrolyte loading

3) Make pores for dye penetration / process semi-
4) Adding electrolyte and dye



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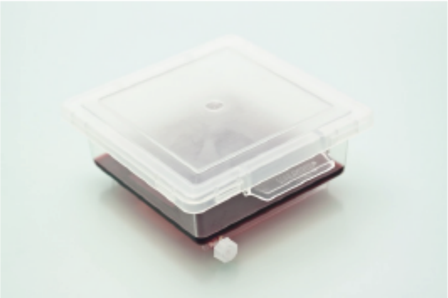

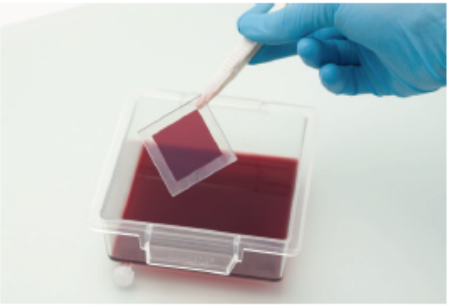

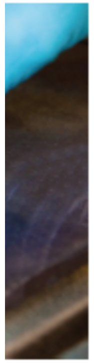

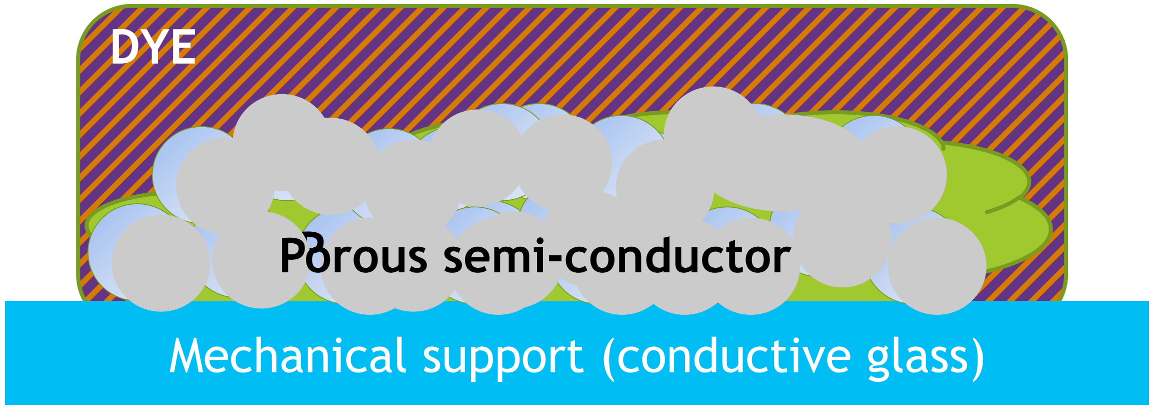

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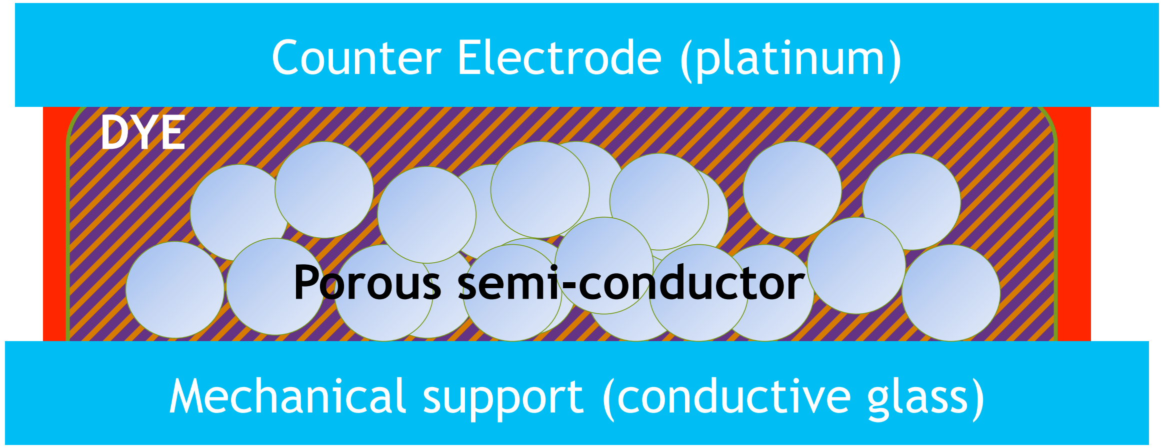
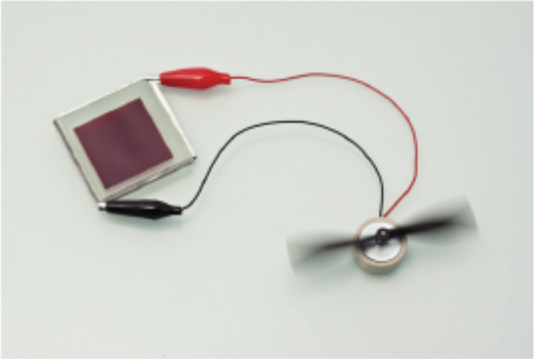
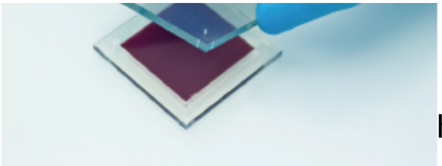
Add counter electrode

5) Add counter electrode to top
6) Fill with electrolyte
7) Test solar cell

- Mask bottom electrode
- Add top electrode







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Beyond 20.109: A Brief Introduction to Field and Scope of Bio-templating

What is biotemplating?

The use of a biological material to synthesize a structure. This can be achieved via:

1. Direct nucleation
2. Binding affinity
3. Transformation of biological material
4. Biological cage

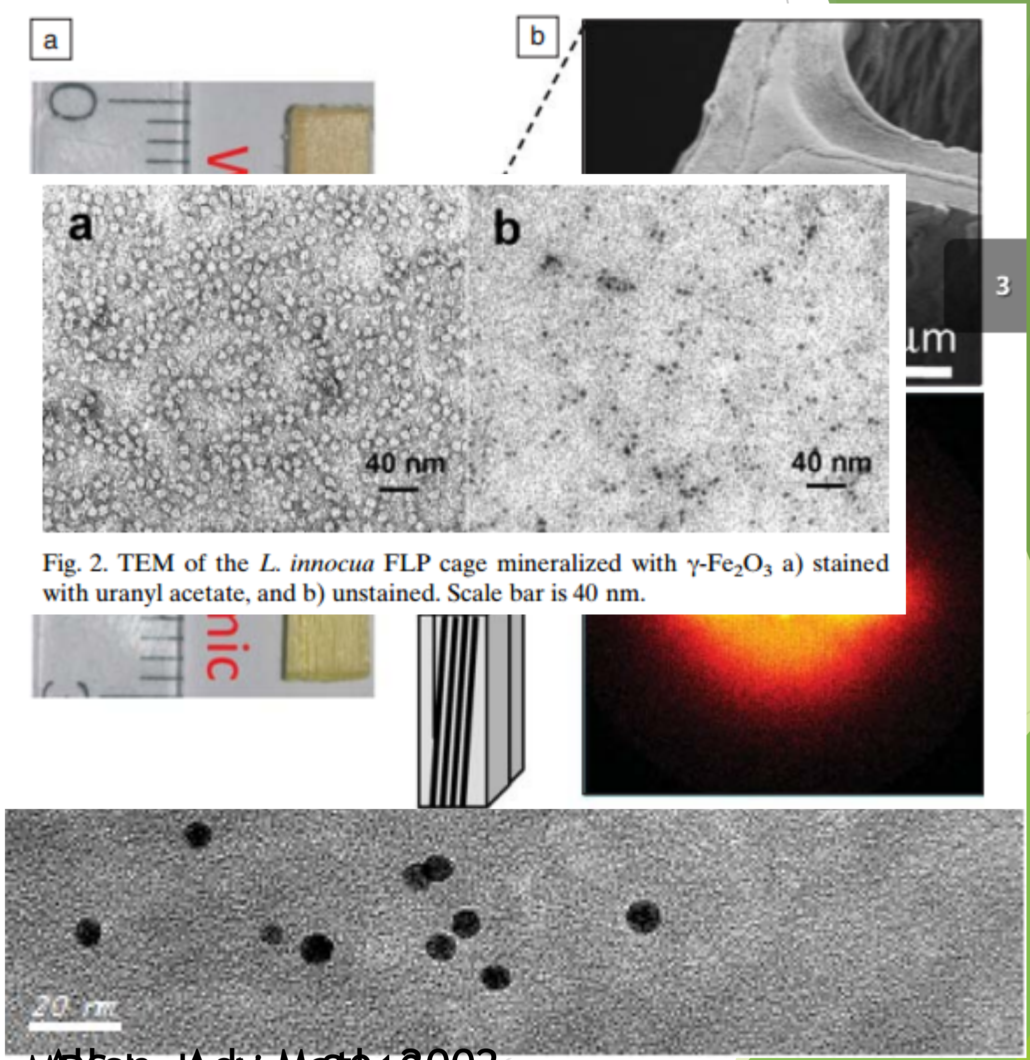


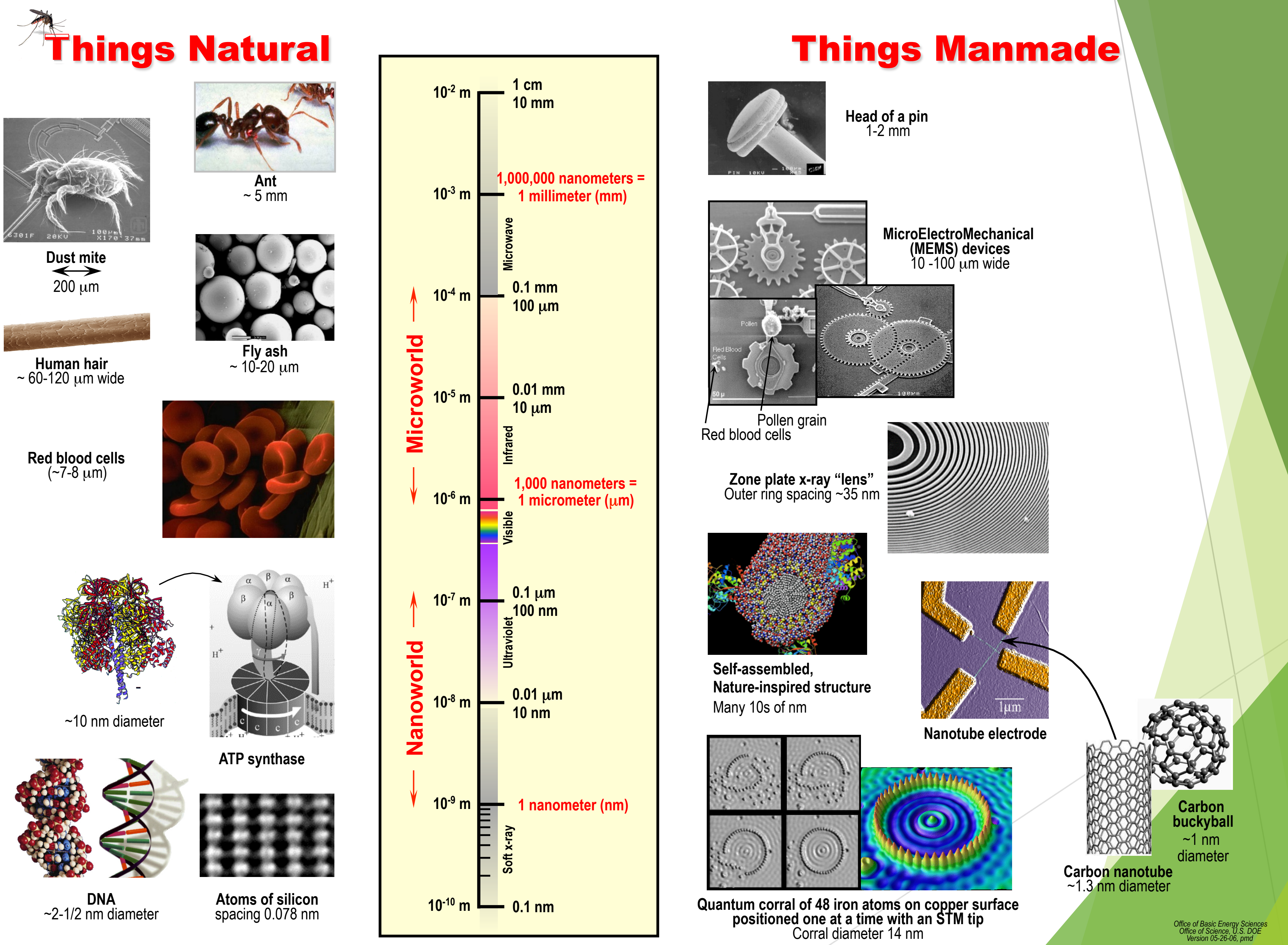
Fig. 2. TEM of the *L. innocua* FLP cage mineralized with γ-Fe_2O_3 a) stained with uranyl acetate, and b) unstained. Scale bar is 40 nm.

MRS bulletin, 2016

Allen, Adv. Mat., 2002

What can be biotemplated?

- Any biological solid



Things Natural
Dust mite
200 μm
Ant
~ 5 mm
Human hair
~ 60-120 μm wide
Fly ash
~ 10-20 μm
Red blood cells
(~7-8 μm)
~10 nm diameter
ATP synthase
DNA
~2-1/2 nm diameter
Atoms of silicon
spacing 0.078 nm
10-2 m
1 cm
10 mm
10-3 m
1,000,000 nanometers =
1 millimeter (mm)
Microwave
10-4 m
0.1 mm
100 μm
10-5 m
0.01 mm
10 μm
Infrared
10-6 m
1,000 nanometers =
1 micrometer (μm)
Visible
10-7 m
0.1 μm
100 nm
Ultraviolet
10-8 m
0.01 μm
10 nm
10-9 m
1 nanometer (nm)
Soft x-ray
10-10 m
0.1 nm
Microworld
Nanoworld
Things Manmade
Head of a pin
1-2 mm
MicroElectroMechanical
(MEMS) devices
10 -100 μm wide
Pollen grain
Red blood cells
Zone plate x-ray "lens"
Outer ring spacing ~35 nm
Self-assembled,
Nature-inspired structure
Many 10s of nm
Nanotube electrode
Carbon buckyball
~1 nm
diameter
Carbon nanotube
~1.3 nm diameter
Quantum corral of 48 iron atoms on copper surface
positioned one at a time with an STM tip
Corral diameter 14 nm
Office of Basic Energy Sciences
Office of Science, U.S. DOE
Version 05-26-06, pmd

Why is biotemplating useful?

- Green
  - Allows synthesis with lower pressure and temperature
  - Reduces use of catalysts and harsh chemicals in the synthesis process
- Allows for the formation of unique composites
- Gives control on difficult length scales

Can M13 template more than TiO2?

- Loading mass
- Secondary structures
- Surface area
- Alloying / dopant