

# The Science of Stained Glass

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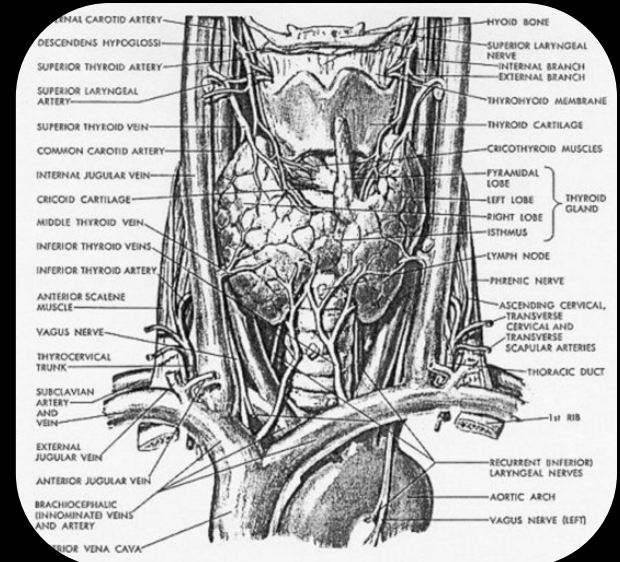


Are science and art connected?

Scientists have affected how artists create art by, for example, developing non-toxic paints and paint in tubes.



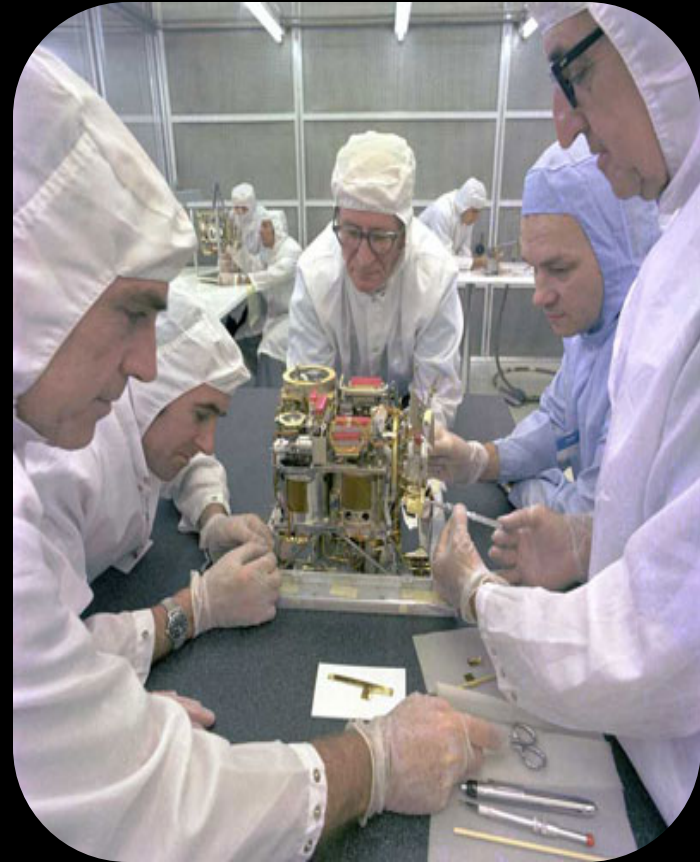
Artists, like medical and science illustrators, draw pictures of scientific findings.



# How are these connected?



Depiction of a forest glass shop from *Sir John Mandeville's Travels*, Dated 1420 – 1450. British Library, London

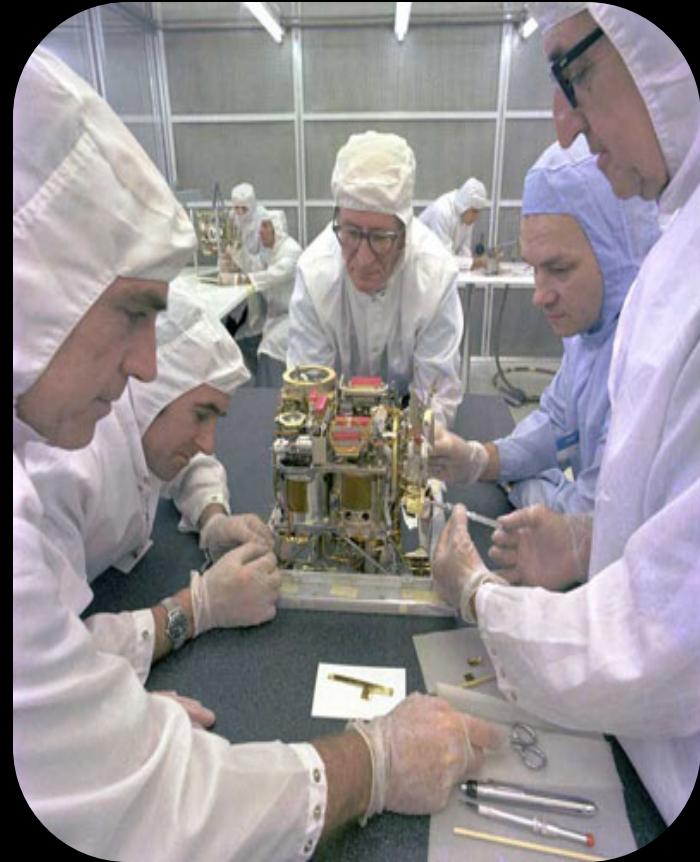




# How are these connected?



Depiction of a forest glass shop from *Sir John Mandeville's Travels*, Dated 1420 – 1450. British Library, London



Both show *nanotechnologists*!!

# What is nanotechnology?

Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications.

Encompassing nanoscale science, engineering and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.

--National Nanotechnology Initiative (2003)

...But what does that *mean*?

# What is nanotechnology?

1. The nanometer is *extremely small*.
2. At the nanometer scale, many materials behave *differently*.
3. We can use this new behavior to make *new* technologies.

...How small is *extremely* small?

# Exactly *how* small is a nanometer?



meter



$1/100^{\text{th}}$  of a  
meter  
(centimeter)

$1/10^{\text{th}}$   
of a  
meter



$1/1000^{\text{th}}$  of  
a meter  
(millimeter)



All these are still visible  
with your *eyes*.



. . . Smaller than you can see!



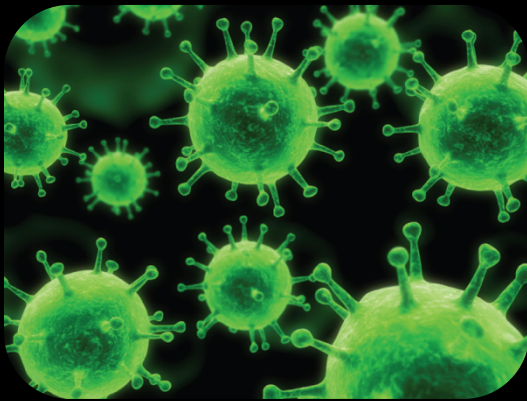
6-8  $\mu\text{m}$

One-millionth  
of a meter  
(micrometer)

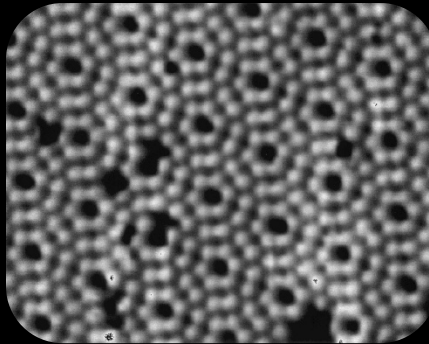
Nanoscale objects are  
1,000 times **smaller!!!**

... Smaller than you can see!

A nanometer is one **billionth** of a meter!!

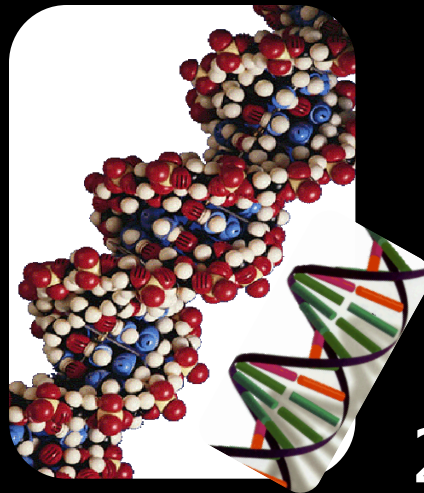
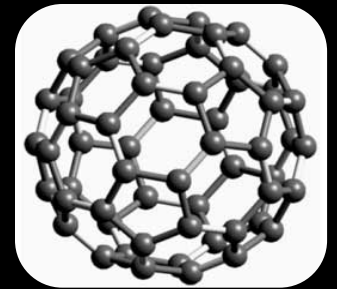


Viruses  
3-50 nm

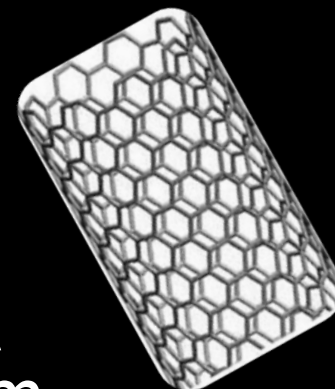


Atoms  
<1 nm

Buckyball  
~1 nm

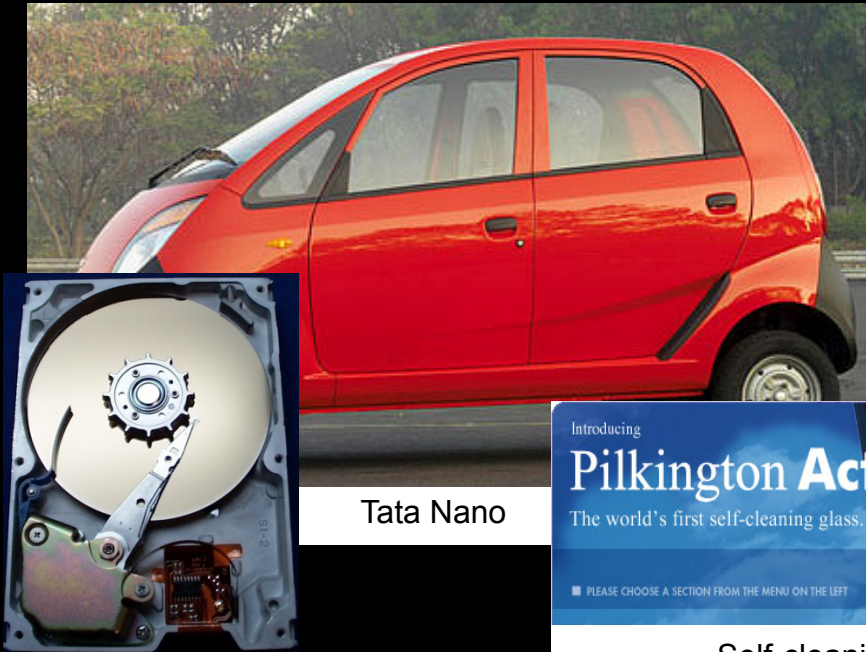


DNA  
2.5 nm

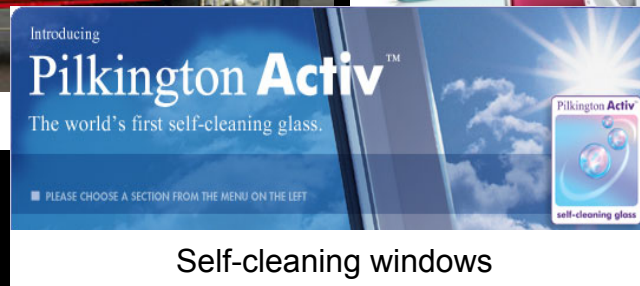


Nanotube  
~1 nm

# "Nano" all around us



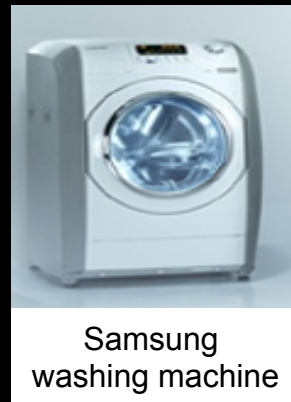
Tata Nano



Self-cleaning windows



VX Nano Cordless  
Laser Mouse



Samsung  
washing machine



Apparel with silver  
nanoparticles



Baby gear



# Medieval nanotechnologists

## Recipe for stained glass

1. Sand
2. Chemicals to lower the melting point of sand
  - Sodium Carbonate (soda ash)
  - Calcium Oxide (lime)
3. Chemicals to create the **color**
4. Lots of heat!
  - Mixture becomes molten at 1500 °F



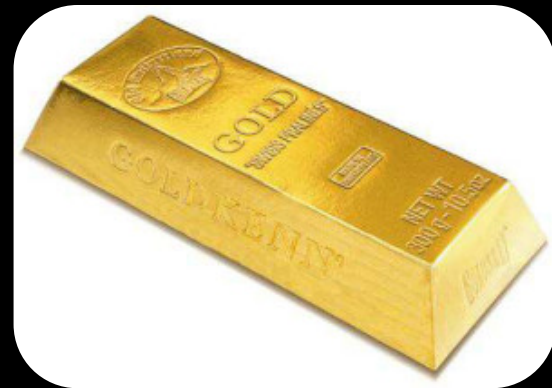
Depiction of a forest glass shop from *Sir John Mandeville's Travels*, Dated 1420 – 1450. British Library, London

# Things are different . . .

## Size really does matter!



Bulk



Nano

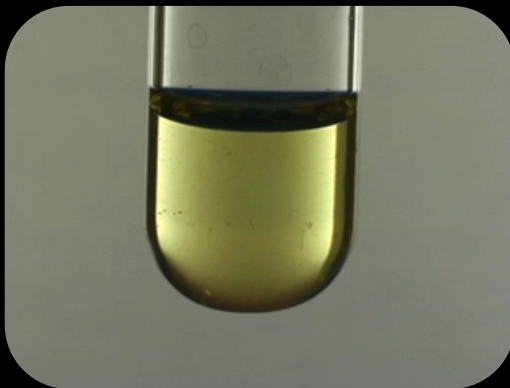


# Things are different . . .

## Size really does matter!



Bulk



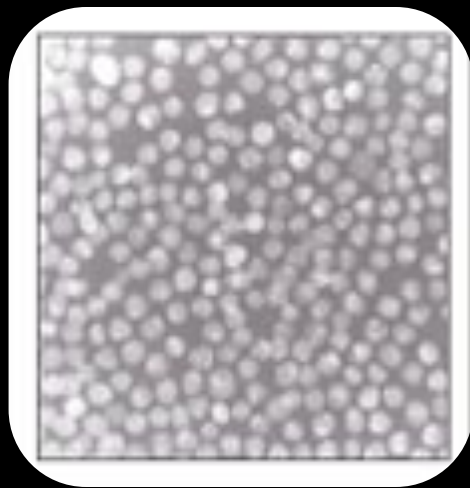
Nano



Nanoparticles interact differently with light.



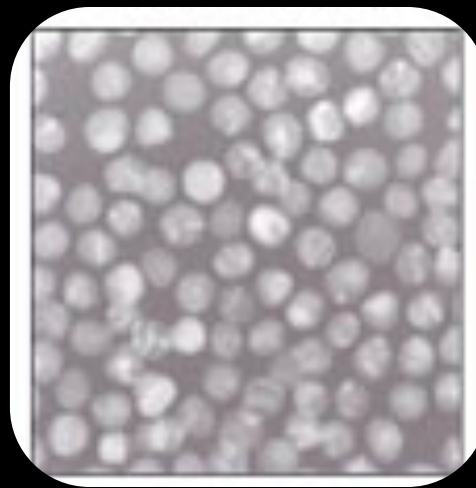
# Changing the size of the gold particles affects color.



Size=25 nm

Shape: Spherical

Color: **RED**



Size=50 nm

Shape: Spherical

Color: **GREEN**



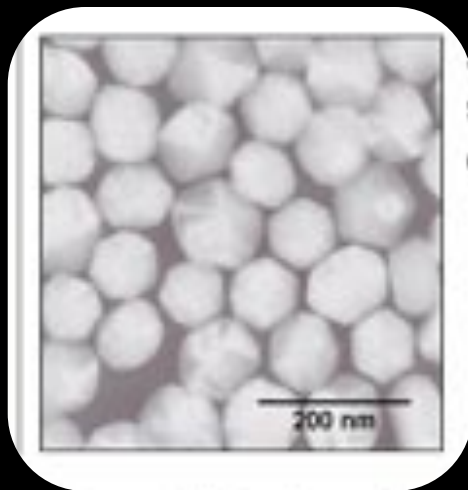
Size=100 nm

Shape: Spherical

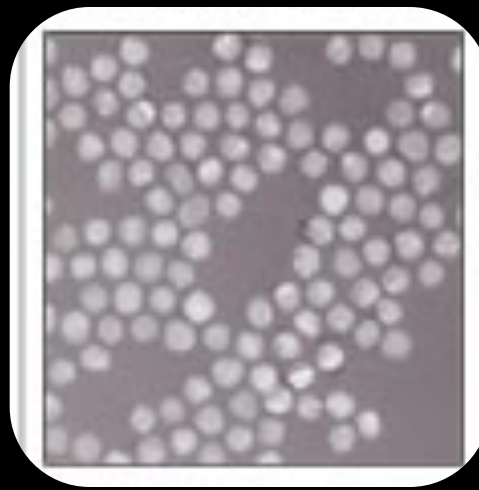
Color: **ORANGE**



# Changing the size and shape of the silver particles affects color.



Size=100 nm  
Shape: Spherical  
Color: **YELLOW**



Size=40 nm  
Shape: Spherical  
Color: **BLUE**



Size=100 nm  
Shape: Triangular  
Color: **RED**

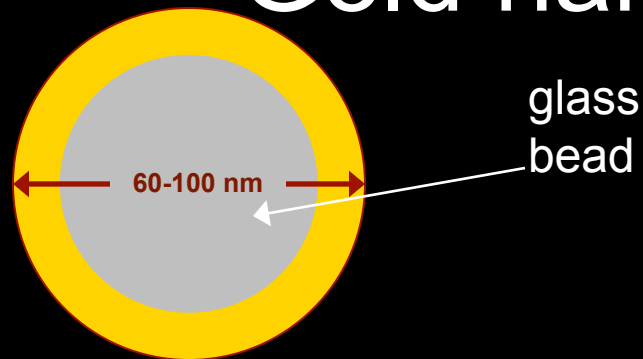


# Plasmon resonance



A small class vs. a football stadium full of people

# Gold nanoparticles today



## How does it work?

- Nanoshells absorb infrared light, which causes them to heat up.
- Tissue absorption of infrared light is minimal; Penetration is optimal.
- Shells are coated with targeting-molecules: concentrates in tumor cells.
- Increasing the temperature of the cells by more than 30°C kills them!



# Silver nanoparticles today

Silver nanoparticles are used to kill bacteria in:

- Athletic apparel
- Socks
- Refrigerators
- Storage containers
- Washing machines



**DISHWASHER & MICROWAVE SAFE**  
Nanoparticles remain effective.

**FREEZER & REFRIGERATOR SAFE**

**FresherLonger™**  
**Miracle Food Storage**  
by Sharper Image®

**AIRTIGHT SEALS REDUCE SPOILAGE**

Silicone-gasket locking system and impermeable polypropylene construction keep out oxidizing air to reduce spoilage.

**REDUCES BACTERIA, MOLD & FUNGUS**

Anti-microbial silver nanoparticles infused into the containers reduce growth of bacteria, mold and fungus by 98%.

**SPILLPROOF & SHATTERPROOF**

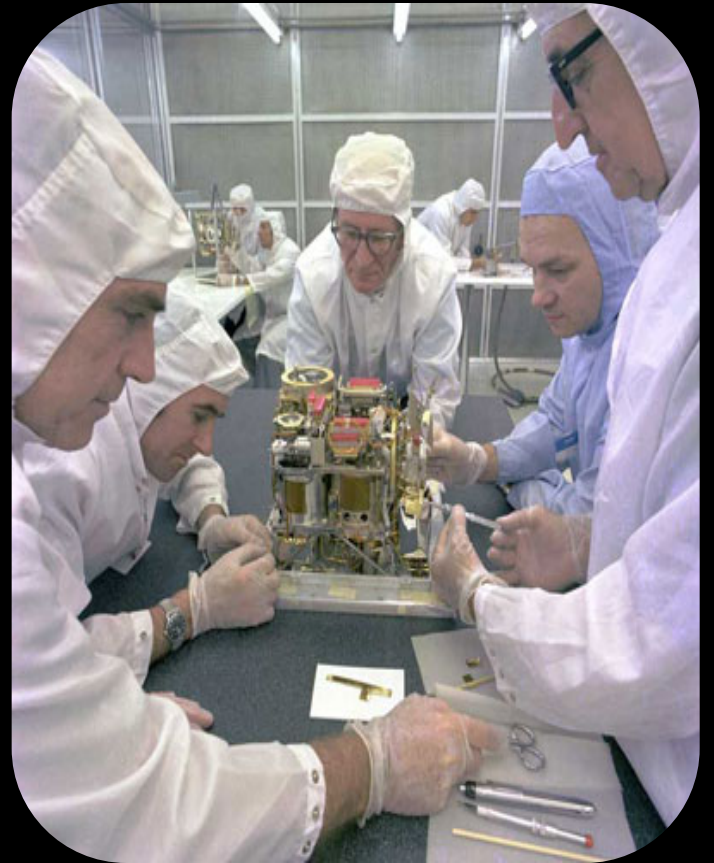
Heat-resistant polypropylene containers will not leak or break.



# Your turn!



↔ You ↔



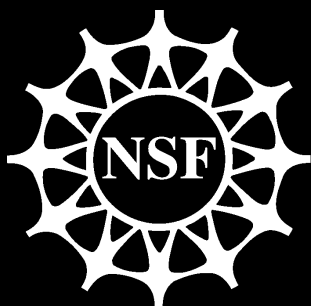
# Your turn!

Two activities:

1. Synthesize gold and silver nanoparticles.
2. Make a nanostained glass window to take home.



# Thank you!



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Any opinions, findings, and conclusions or recommendations are those of the author and do not necessarily reflect the views of the Foundation.

