

# The California Nanotech 2025 Project

Presented By  
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Executive Director of Education Programs and Outreach  
San Diego Nanotechnology Infrastructure

*at The SDNI-NNCI Educational Symposium 2020*  
*“Integrating Nanotechnology Contents with Current K-12 State-wide Science Curricula: Challenge and Strategies”*  
*Virtually from UC San Diego*  
*September 12 – 13, 2020*



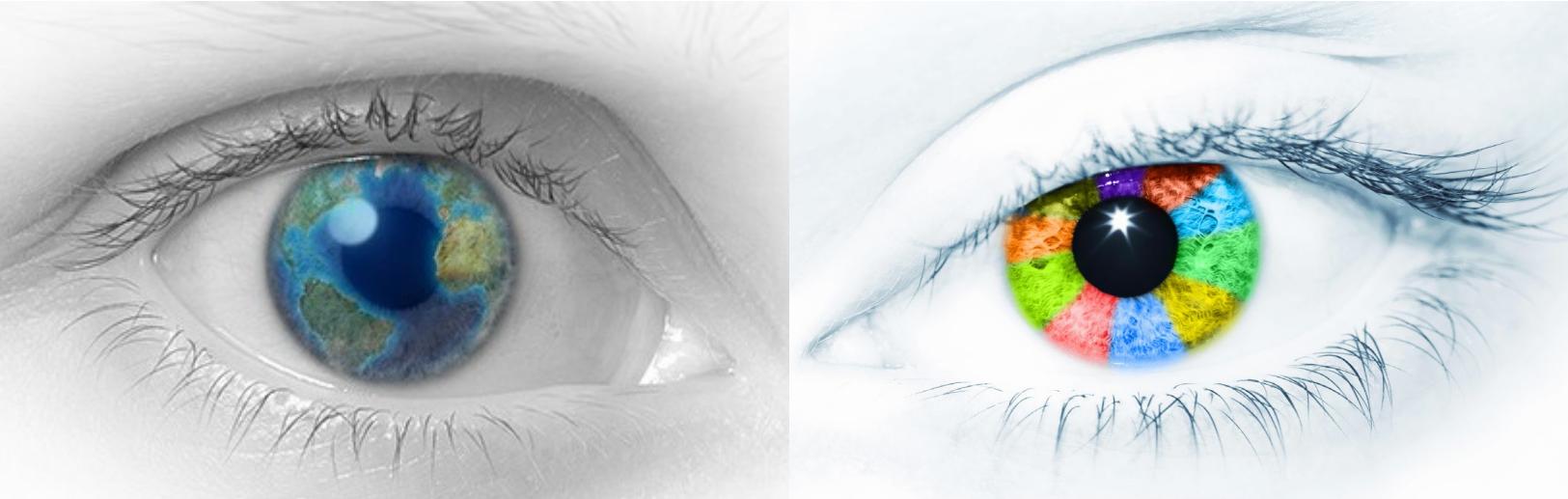
# CALIFORNIA NANOTECH 2025 PROJECT

A photograph of two hands, one from each side, holding a clear, spherical crystal ball. The hands are positioned to support the ball from both sides, with fingers visible. The background is a bright, slightly overexposed blue sky with wispy white clouds.

**GOAL**

To ensure that quality nanotechnology content is integrated to the K-12 NGSS-aligned current and future science curricula in every school district across California by year 2025

# CALIFORNIA NANOTECH 2025 PROJECT



-  Develop a scalable model in California and share with NNCI and other networks for outreach in respective states.
-  Apply NNCI-aligned scalable model for all States.
-  Use Nationwide scalable model to benchmark with other countries.
-  Improve and Maintain US Global Competitiveness through Education and Work Force Development in Nanotechnology and Related Convergence Sciences and Technologies.

# NANOTECHNOLOGY

**The application of scientific knowledge to engineer systems enabling the investigation of structures and behaviors in the nanoscale range and to manipulate and control matter in such range to make use of size- and structure-dependent properties and phenomena distinct from those at smaller or larger scales.**

*(ISO 2010 modified by Yves Theriault, 2019)*

# Nanotechnology: A Convergence Science

**Nanosystems Engineering - Nanofabrication**

**Nanostructures Characterization**

**Nanoparticles**

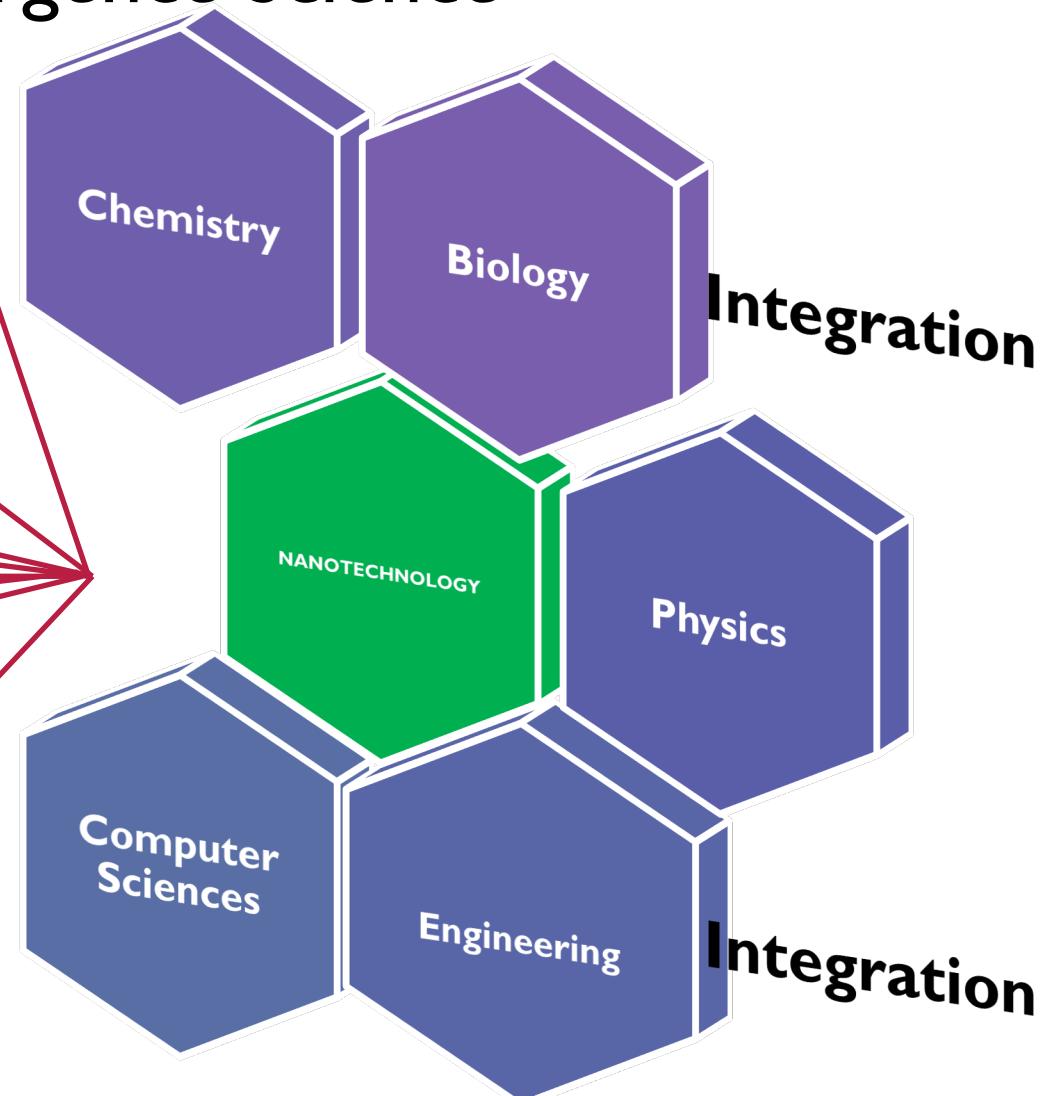
**Nanomaterials**

**Atomic and Molecular Engineering**

**Biomimetics**

**Nanophotonics**

**Atomic and Molecular Self-Assembly**



# Nanotechnology

Energy  
Electronics

Medicine  
Drugs

Biotechnology

Optical  
Engineering

Nano-  
materials

Cosmetics

Environment

Agriculture

Defense  
Security

# Medicine and Biotechnology

Drug Delivery

Biocompatible Materials

Implants

Biosensors

Tissue Engineering

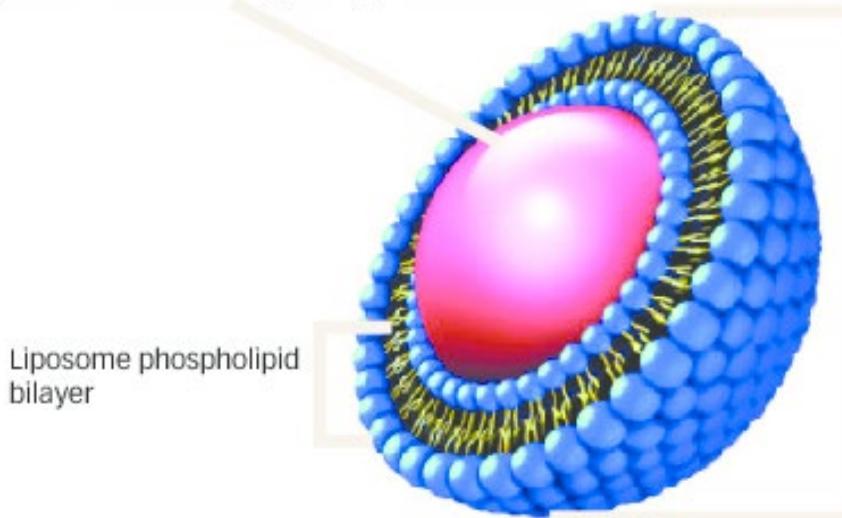
Multifunctional Nanoparticles

Diagnostics  
Genomics  
Epigenetics  
Devices

# Liposome Embedded Small Molecule Drugs:

## DaunoXome

Aqueous core containing entrapped daunorubicin citrate

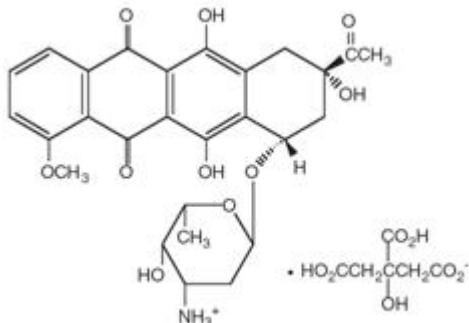


DaunoXome  
liposome is  
between  
35–65 nm

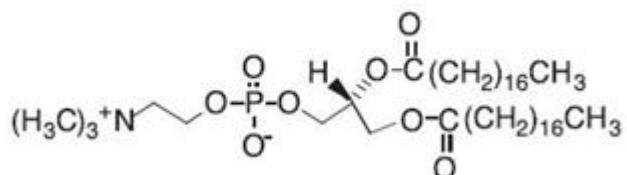


**DaunoXome is a liposomal preparation of daunorubicin formulated to maximize the selectivity of daunorubicin for solid tumors in situ.**

Daunorubicin citrate has the following chemical structure:

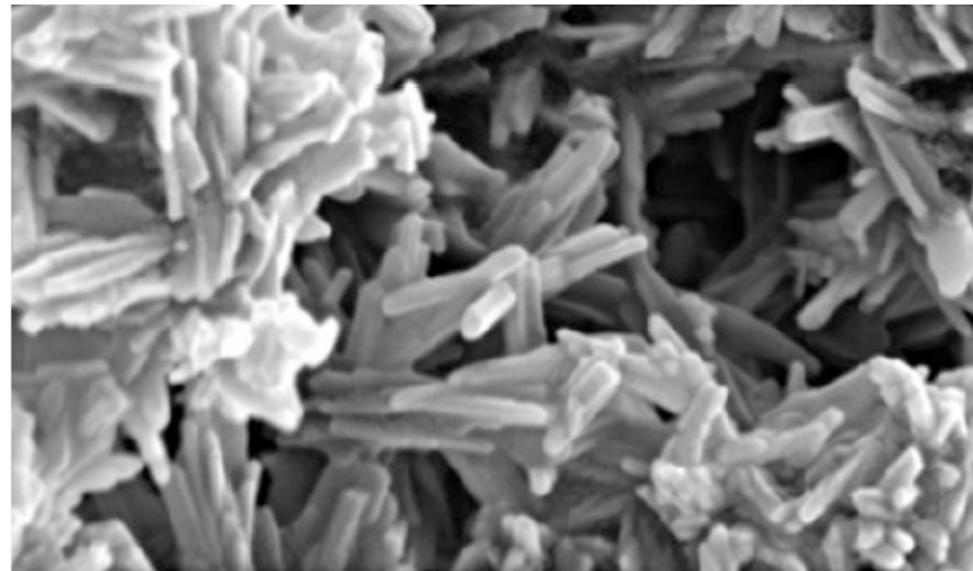


DSPC (distearoylphosphatidylcholine) has the following chemical structure:



**DaunoXome contains an aqueous solution of the citrate salt of daunorubicin encapsulated within lipid vesicles (liposomes) composed of a lipid bilayer of distearoylphosphatidylcholine and cholesterol (2:1 molar ratio), with a mean diameter of about 45 nm. The lipid to drug weight ratio is 18.7:1 (total lipid:daunorubicin base), equivalent to a 10:5:1 molar ratio of distearoylphosphatidylcholine:cholesterol:daunorubicin.**  
**Daunorubicin is an anthracycline antibiotic with antineoplastic activity, originally obtained from *Streptomyces peucetius*. Daunorubicin has a 4-ring anthracycline moiety linked by a glycosidic bond to daunosamine, an amino sugar.**  
**Daunorubicin may also be isolated from *Streptomyces coeruleorubidus* and has the following chemical name: (8S-cis)-8-acetyl-10-[(3-amino-2,3,6-trideoxy- $\alpha$ -L-lyxohexopyranosyl)oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy-5,12-naphthacenedione hydrochloride.**

## Biomimetics and Stem Cells



Rod-Shaped Hydroxyapatite Nanoparticles

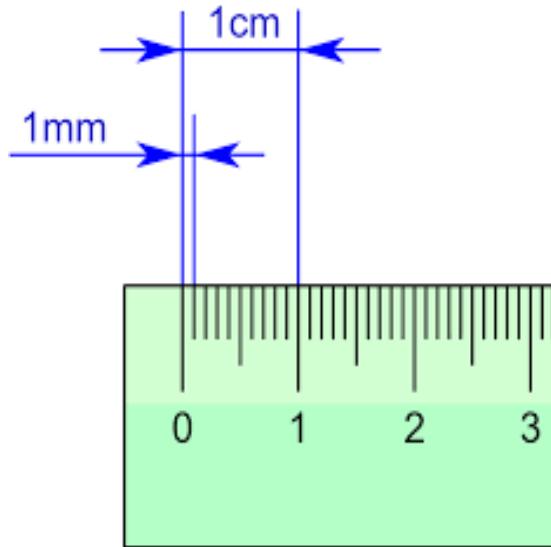
## Mimicking Bone Microenvironment for Bone Tissue Engineering



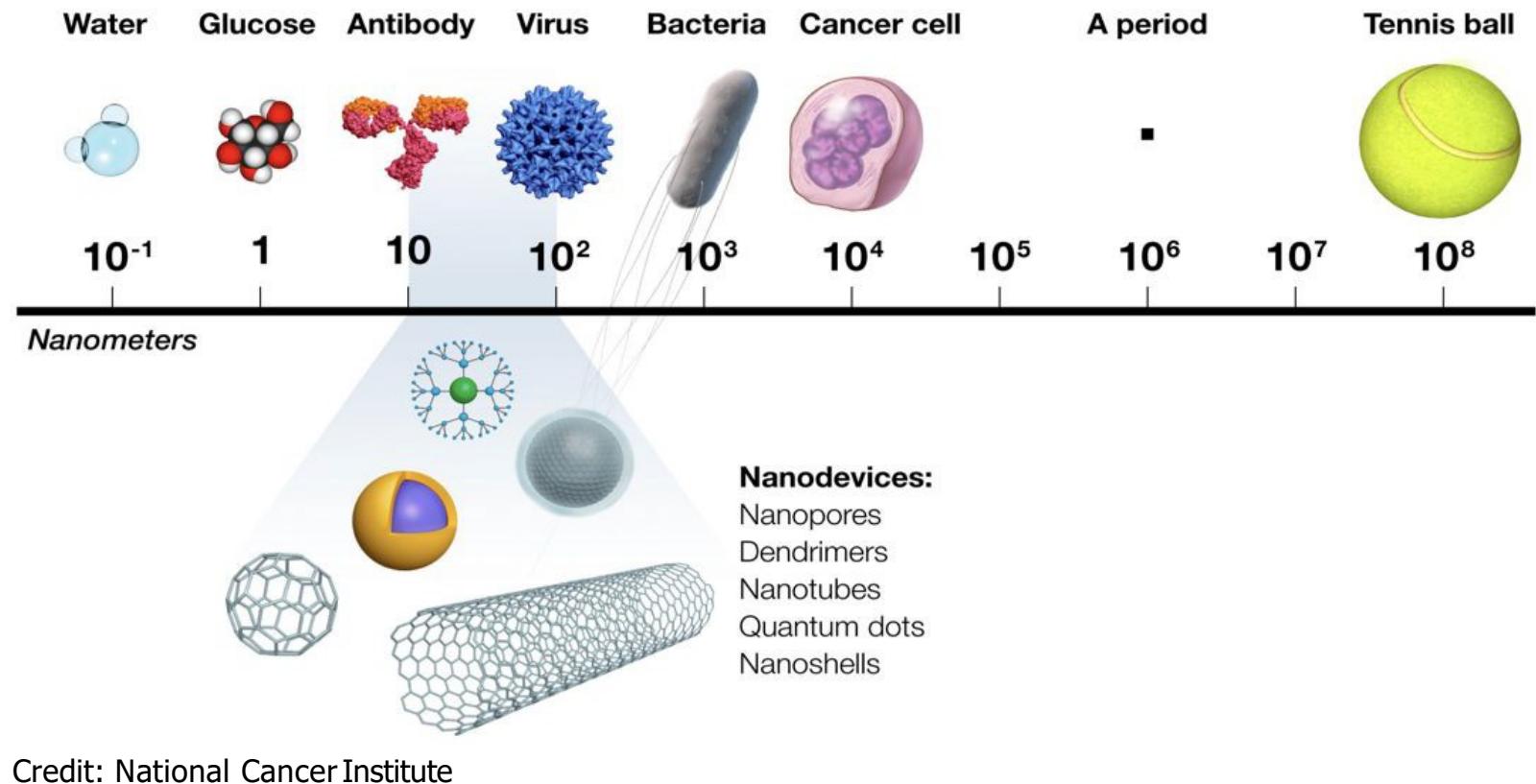
Where do we....



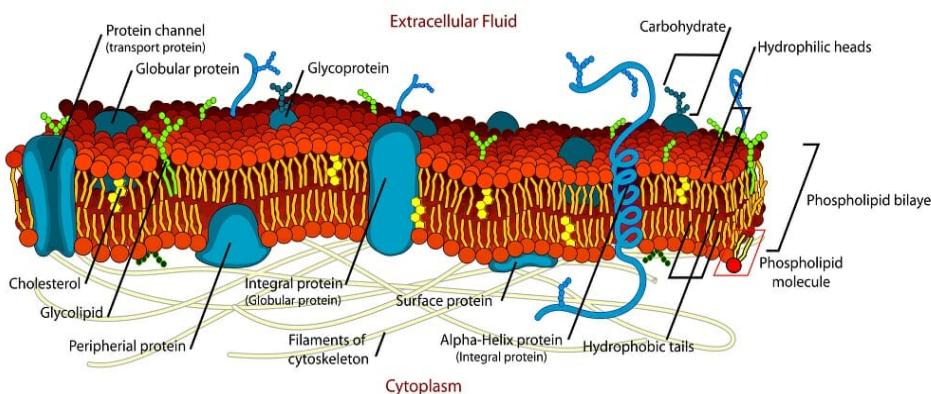
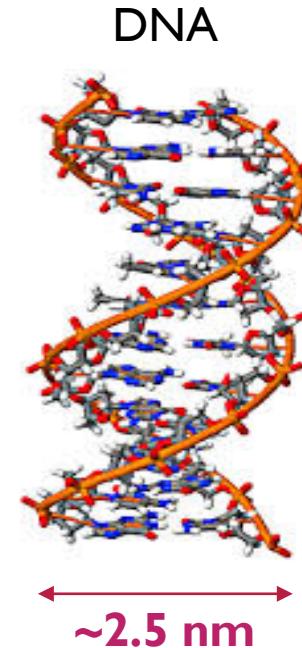
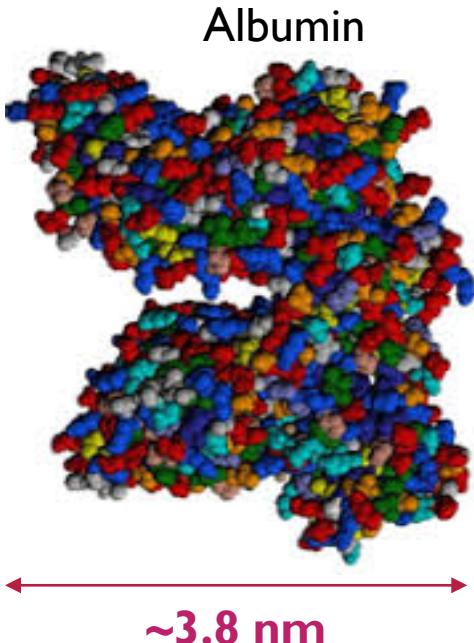
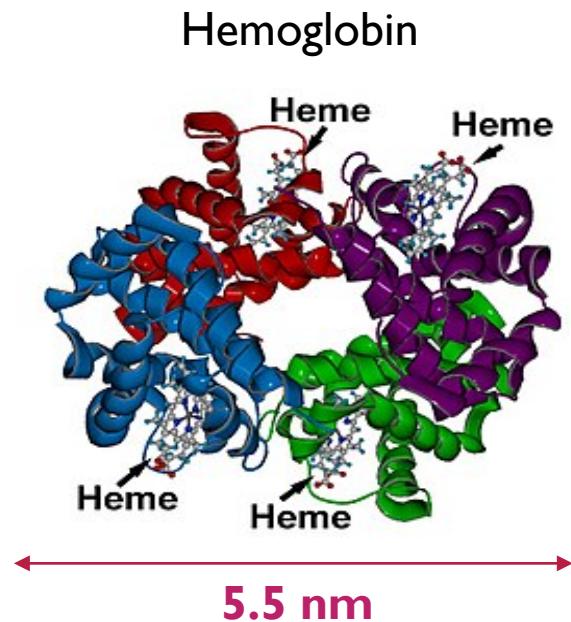
# The Nanoscale...



One millionth of a millimeter is  
a **Nanometer**  
 $10^{-3} \times 10^{-6} = 10^{-9}$  meter



# Scale at which most BIOLOGY occurs



Animal Cell Membrane  
~7.5 – 10 nm thick

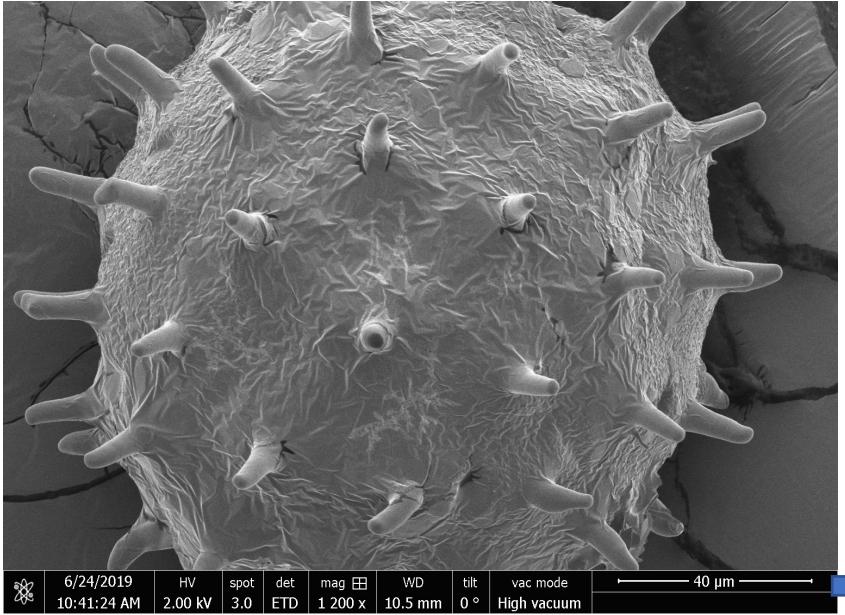
# OPEN EDUCATIONAL RESOURCES

<https://www.ncbi.net/resources-educators-k-16>

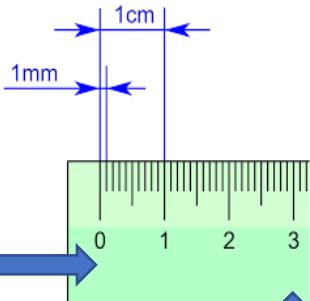
<https://www.nano.gov/education-training/teacher-resources>

<http://nano4me.org/>  
<https://nanohub.org/>

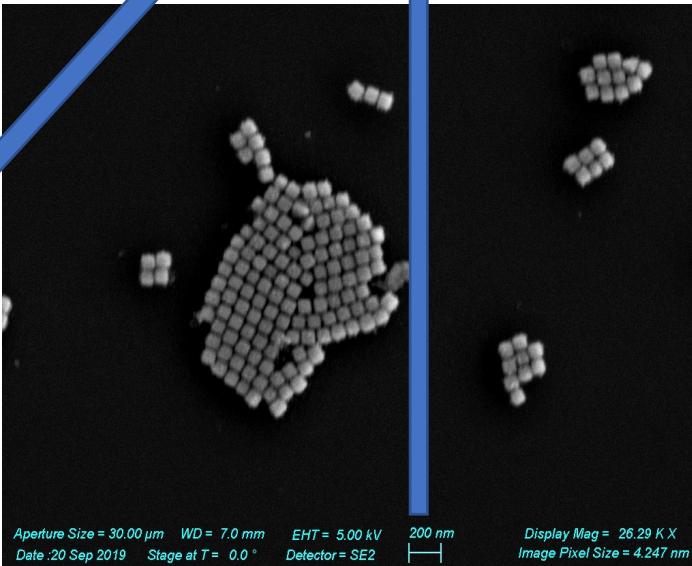
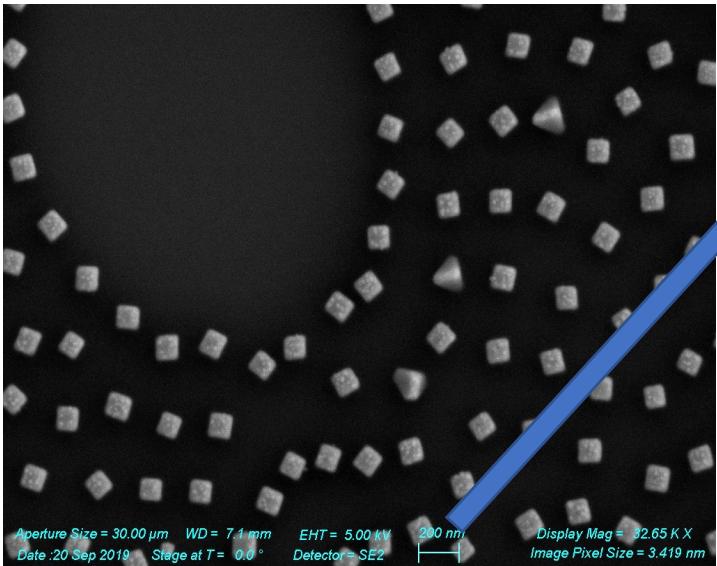
<http://sdni-center.ucsd.edu/>



- Scale
- Proportions
- Measurements
- Scientific Notation



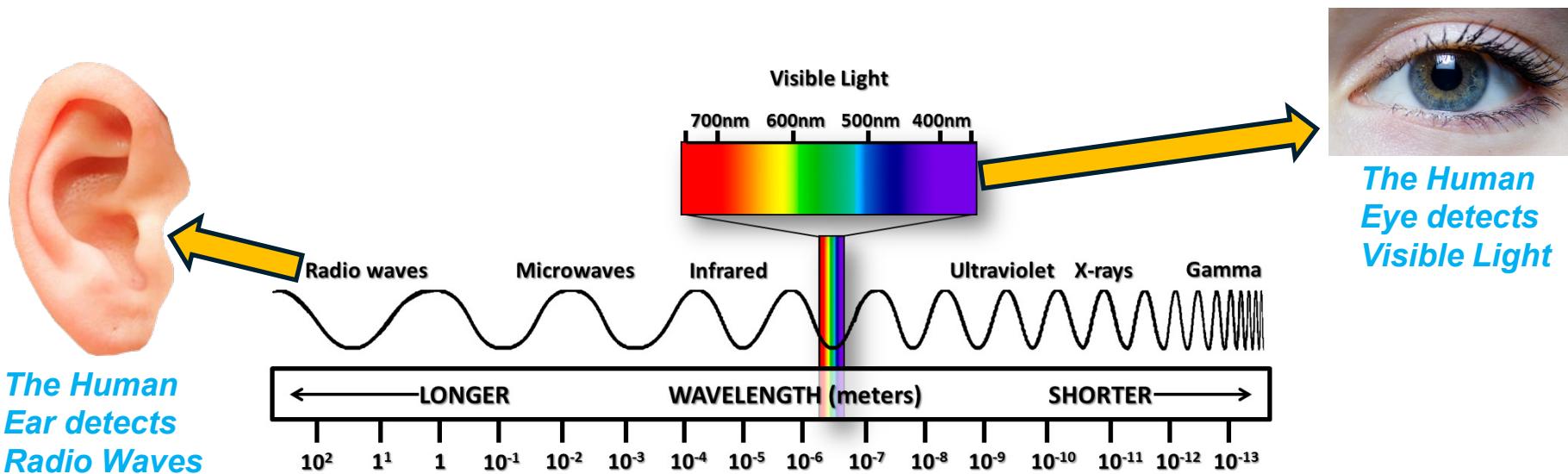
$$\text{Scale: } 40 \times 10^{-6} \text{ m} / 35 \text{ mm} = 1.1 \text{ micron/mm}$$



$$\text{Scale: } 200 \text{ nm} / 7.0 \text{ mm} = 29 \text{ nm/mm}$$

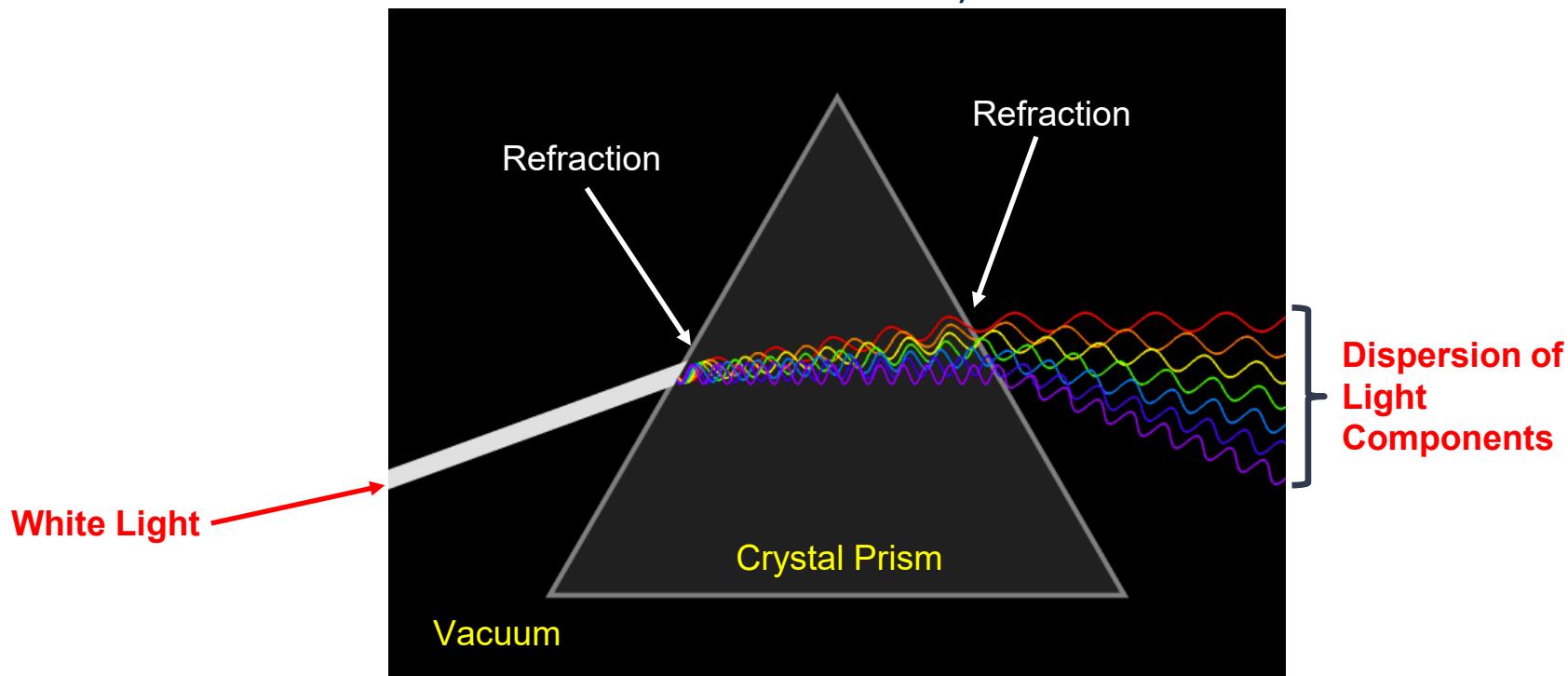
$$\text{Scale: } 200 \text{ nm} / 5.0 \text{ mm} = 40 \text{ nm/mm}$$

Light is part of the Electromagnetic Spectrum which covers from Radio waves to Gamma rays.



Light is an Electromagnetic Radiation with wavelengths ranging from 380 nm to 760 nm.

Light can be decomposed into 7 components, each component having its specific wavelength and associated color: red, orange, yellow, green, blue, indigo, and purple (nowadays, indigo is often omitted)



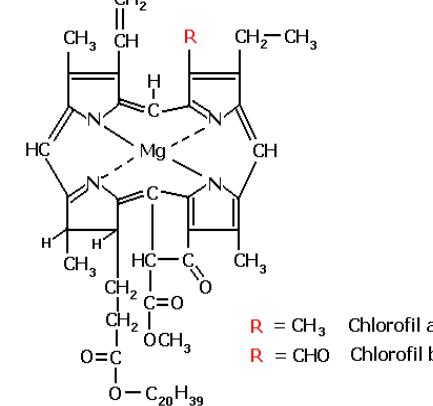
[https://commons.wikimedia.org/wiki/File:Light\\_dispersion\\_conceptual\\_waves.gif#/media/File:Light\\_dispersion\\_conceptual\\_waves.gif](https://commons.wikimedia.org/wiki/File:Light_dispersion_conceptual_waves.gif#/media/File:Light_dispersion_conceptual_waves.gif)



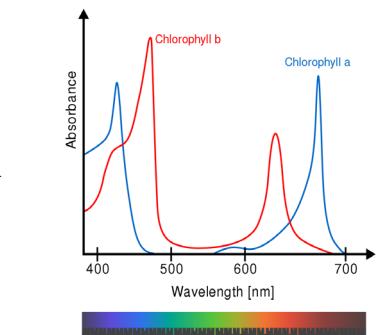
Chlorophyll contained in the leaves of these trees give them the beautiful green color.

White Light

Chlorophyll Molecules



Light Absorption Spectrum



Green Color

# INORGANIC PAINT PIGMENT COMPOUNDS

A number of inorganic compounds can be used as pigments in paints. Many of these compounds are coloured due to the absorption of light energy by electrons in d orbital subshells, meaning we see colours depending on which wavelengths of light are not absorbed by the compound.



CARBON BLACK

Carbon, C



CERULEAN BLUE

Cobalt (II) stannate,  $\text{Co}_2\text{SnO}_4$



CHROME GREEN

Chromium (III) oxide,  $\text{Cr}_2\text{O}_3$



COBALT VIOLET

Cobalt (II) phosphate,  $\text{Co}_3(\text{PO}_4)_2$



CADMIUM ORANGE

Cadmium sulfoselenide,  $\text{Cd}_2\text{SSe}$



TITANIUM WHITE

Titanium dioxide,  $\text{TiO}_2$



ULTRAMARINE BLUE

Sulfur-containing sodium silicate,  $\text{Na}_4\text{Al}_4\text{Si}_4\text{S}_4\text{O}_{20}$



VIRIDIAN GREEN

Hydrated chromium oxide,  $\text{Cr}_2\text{O}_3$



CADMUM YELLOW

Cadmium sulfide,  $\text{CdS}$



CADMUM RED

Cadmium selenide,  $\text{CdSe}$



ANTIMONY WHITE

Antimony trioxide,  $\text{Sb}_2\text{O}_3$



PRUSSIAN BLUE

Ferric hexacyanoferrate,  $\text{Fe}_7(\text{CN})_{18}$



CADMUM GREEN

Cadmium sulfide & chromium (III) oxide



ZINC YELLOW

Zinc chromate,  $\text{ZnCrO}_4$



ZINC WHITE

Zinc oxide,  $\text{ZnO}$



COBALT BLUE

Cobalt (II) aluminate,  $\text{CoAl}_2\text{O}_4$



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# Luminescence

## Fluorescence & Phosphorescence:

Fluorescent and Phosphorescent materials absorb light and emit light of a lower energy (longer wavelength) and associated color.

## Chemiluminescence:

Light is Created via a chemical reaction (energy release). Color depends on the wavelength.

## Bioluminescence:

Light is created via cellular biochemical reaction and coloration depends on wavelength.

# FLUORESCENCE



Emission after excitation with UV light

## Examples of Fluorescent Molecules:

Quinidine

Fluorescein

Rhodamine D

Acridine

Pyridine 1

# BIOLUMINESCENCE

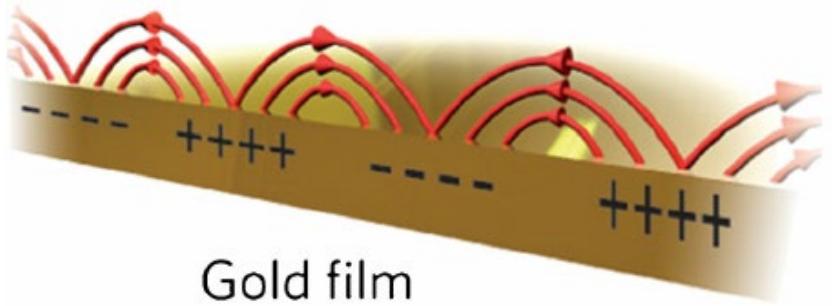


Flying and Glowing Firefly, *Photinus Pyralis*

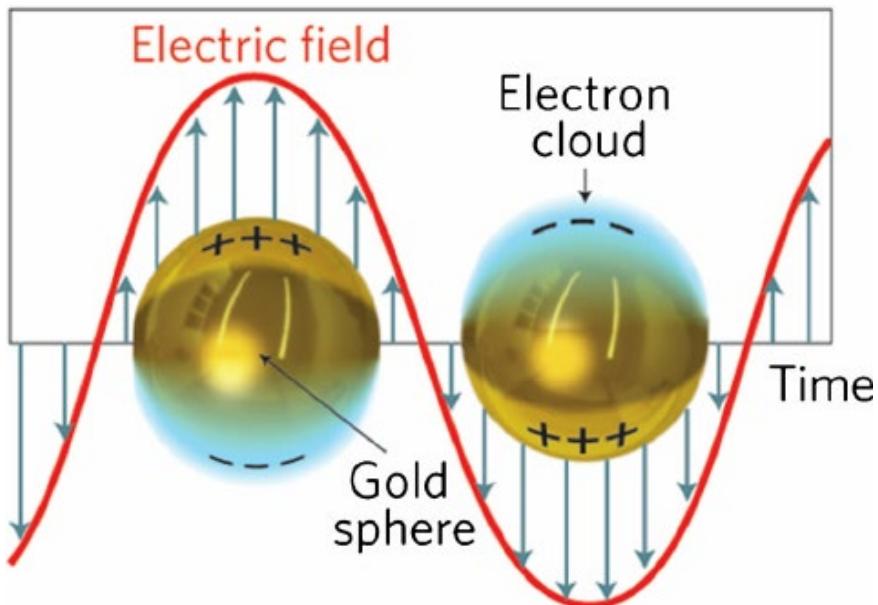


Crystal Jelly *Aequorea Victoria*

# PLASMON RESONANCE



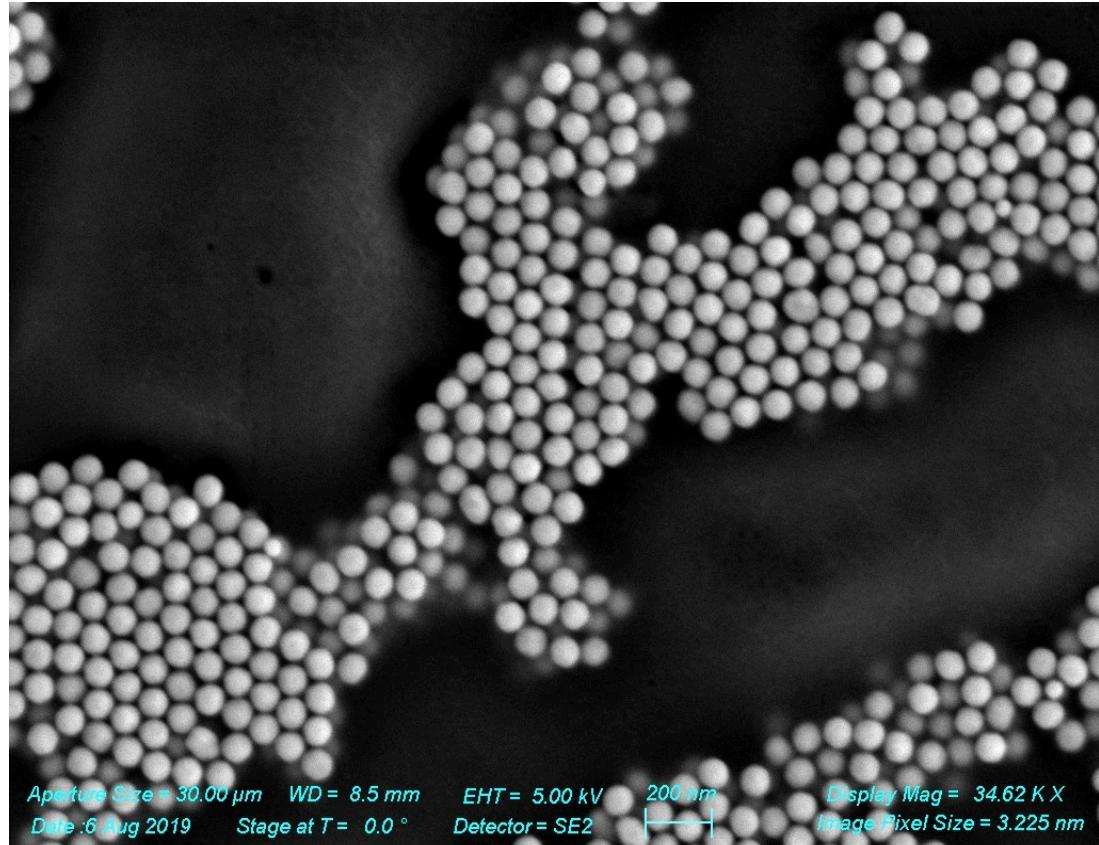
Gold film



When light interacts with the surface of a bulk piece of gold, the resonance frequency is limited and results in only one color: GOLD

When gold is broken down into nanoparticles, the size and shape of the nanoparticles have an influence on the resonance frequency and light absorption occurs at different wavelengths resulting in several different colors.

# SEM of Gold Nanoparticles



80 nm gold nanoparticles  
Courtesy of UC San Diego Nano3 Facility

A bulk piece of gold has only One color... GOLD!

Colloidal solutions of different size nanoparticles have different colors

# Color of Gold Nanoparticles

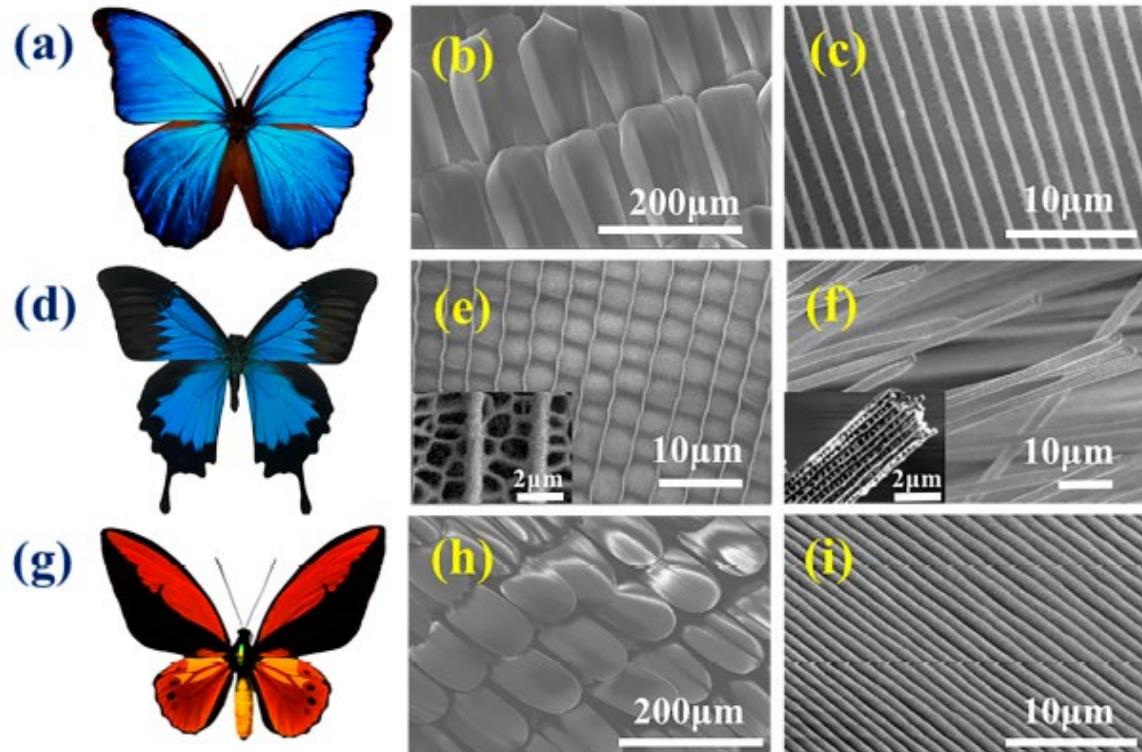


The size, shape, and distance between the gold nanoparticles will cause the difference in colors.



**THIS BUTTERFLY IS  
NOT BLUE**

# Structural Colors



**The wings of the butterfly are made of nanostructures that make light waves interfere with each other and the resulting observed light provides coloration that may change with the observation angle.**

# Colors:

- Selective absorption of light components (wavelengths) by organic and inorganic pigments
- Luminescence
- Plasmonic Resonance
- Structural colors: interaction of light with nanometer range structures

## IMPLEMENTATION STRATEGY

Complementary Modules;  
Standards-Aligned  
(NGSS)

Life Science  
Physical Science  
Earth and Space Science  
Environmental Science  
Engineering

Complementary Modules;  
Standards-Aligned  
(Not NGSS)

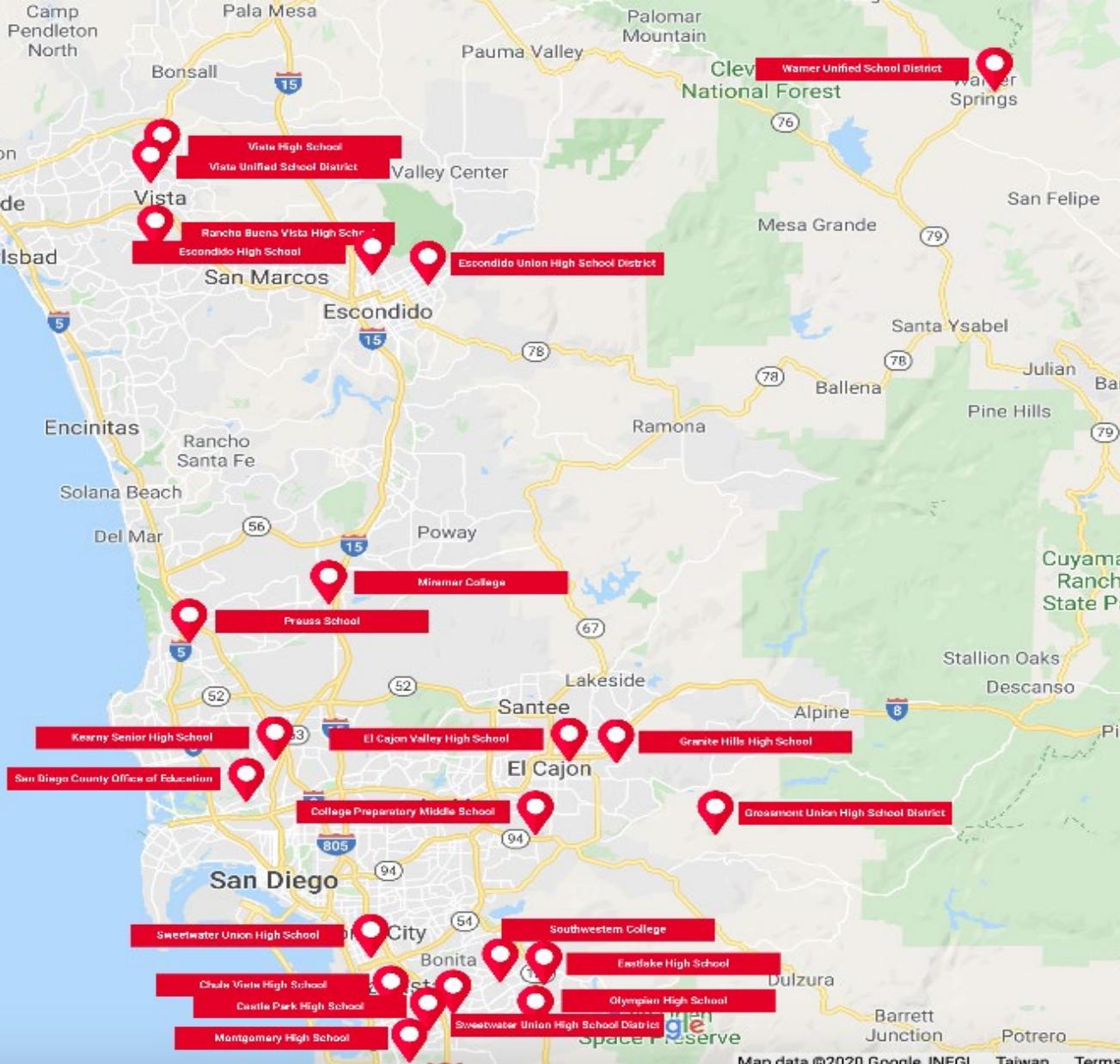
Biology  
Chemistry  
Geography/Environmental Sciences  
Physics  
Engineering

Full Nanotechnology  
Course (Elective & AP)  
(including Quantum)

Omni Nano – Marco Curreli  
Daniella Duran

## FACILITATING TOOLS

Phenomena-based lesson packages; Presentations; Teacher and Student guides;  
Materials for lab activities; Videos for materials intensive lab activities...



## Planting the seeds: San Diego County

### Institutions listed on the map:

San Diego County Office of Education, Escondido Union High School District, Grossmont Union High School District, Sweetwater Union High School District, Vista School District, Warner Unified School District, Chaffey College, Imperial College, Miramar College, Southwestern College, Castle Park High School, Chula Vista High School, College Preparatory Middle School, East Lake High School, El Cajon Valley High School, Escondido High School, Granite Hills High School, Kearny High School, Montgomery High School, Olympian High School, Preuss School, Rancho Buena Vista High School, Sweetwater High School, Vista High School, Warner Springs Middle School.

**Outreach: > 2,500 students from their classes**

**The student population in the schools listed above is highly diverse with a minority enrollment of 70%.**

**Institutional Outreach in View of Nanotechnology Curriculum Development Initiative.**

Imperial County Office of Education

Los Angeles Office of Education

Orange County Department of Education

Riverside County Office of Education

Santa Barbara County Education Office

San Bernardino County Superintendents of Schools

San Diego County Office of Education

Ventura County Office of Education

+ Northern  
California



We will also work with teacher associations and STEM coordinators (locally and nationally)

**Contact Info:**

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