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Synthesis and Functionalization of Small Silver Nanoparticles

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DNA FUNCTIONALIZATION OF NAKED SILVER NANOPARTICLES

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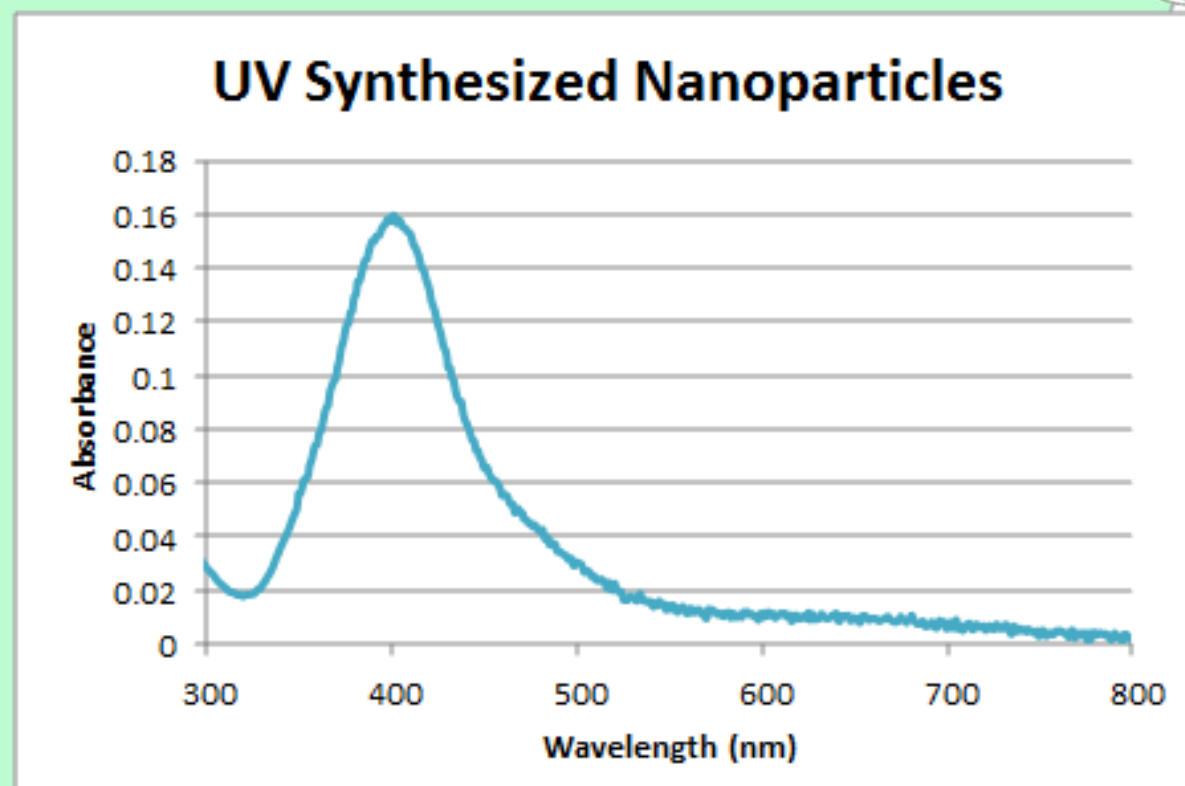
SYNTHESIS SCHEME 1: PHOTO-REDUCTION OF METALLIC PRECURSORS



- Beaker Contains:
- 0.020 mmol Bis(p-sulfonatophenyl) phenylphosphine (BSPP)
 - 0.020 mmol silver nitrate
 - 0.100 mmol sodium citrate
 - 0.500 mmol sodium hydroxide

SCHEME 1 RESULTS:

- TEM images:
- Particles clumped together
 - 15-20 nm range
 - Inconclusive
 - Staining artifacts?
 - Result of functionalization?



- UV-Vis spectrum:
- Slightly broad size range
 - Peak slightly over 400 nm
 - Particle sizes slightly over 10 nm

- Synthesis conditions:
- Room temperature
 - Purified DNA
 - Purified silver nanoparticles

SYNTHESIS SCHEME 2: CHEMICAL REDUCTION OF METALLIC PRECURSORS

- Initial Conditions:
- Nitrogen purged water
 - Inert atmosphere
 - Dark



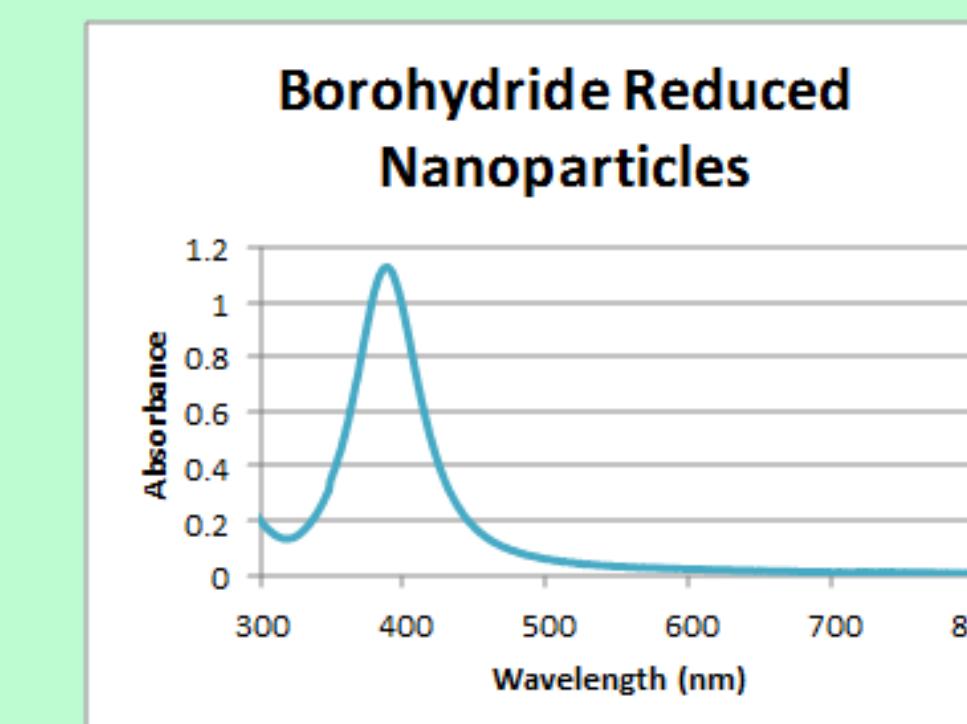
- Synthesis (Injected):
- BSPP (limiting reagent)
 - Silver nitrate (2x BSPP)
 - Sodium citrate (3x Ag)
 - Sodium borohydride (5x Ag)

- Reagents (in addition to silver particles):
- Thiolated DNA strands (500-1000 strands/particle)
 - Phosphate buffer (10-20 mM, pH 6.8-7.4)
 - 1% Sodium dodecyl sulfate (SDS) solution

- Incubate 8+ hours
- Slowly bring sodium chloride concentration up to 0.3 M
- Stable solution?
 - Purify
 - Characterize
 - Use for further experimentation

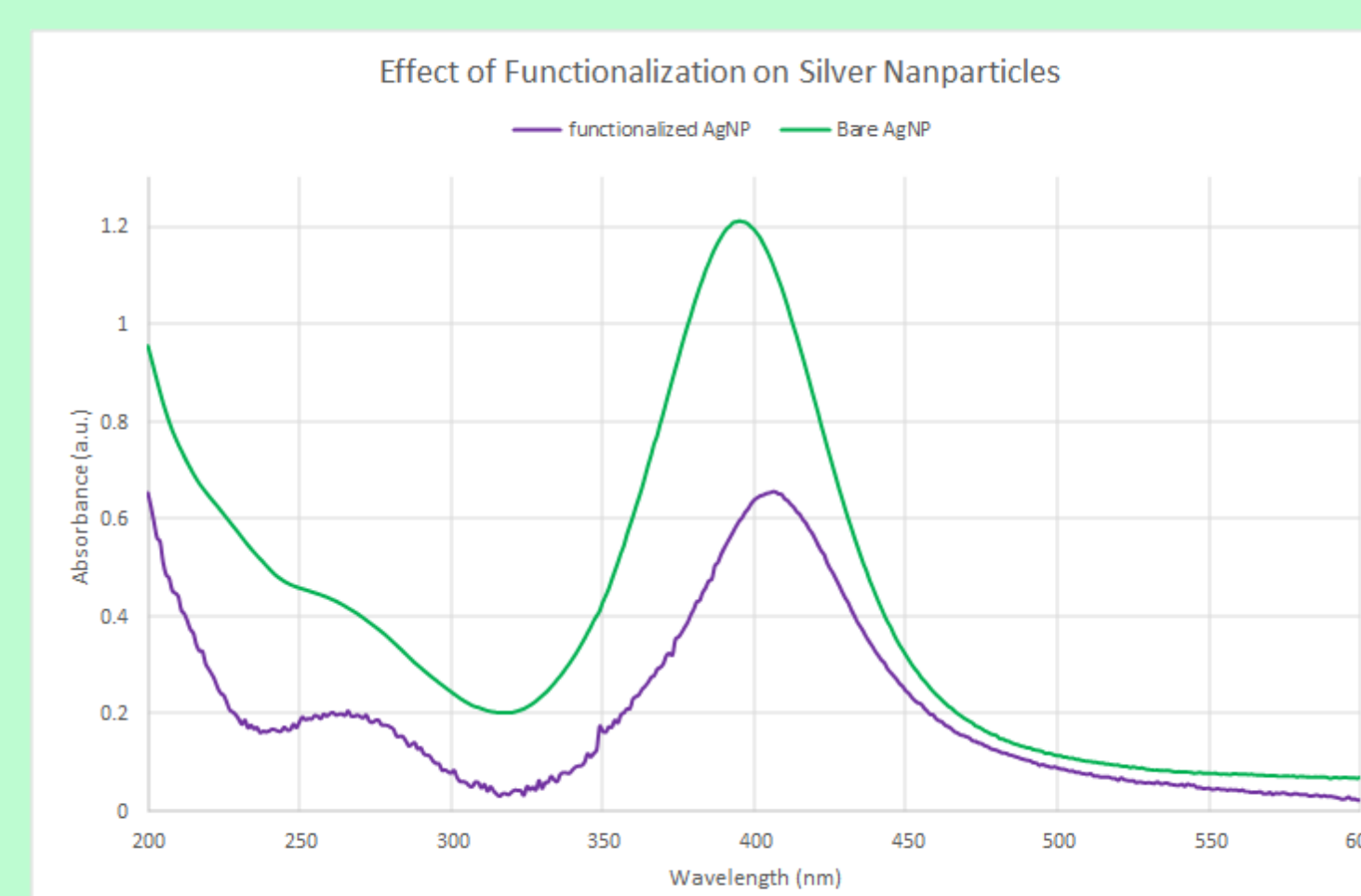
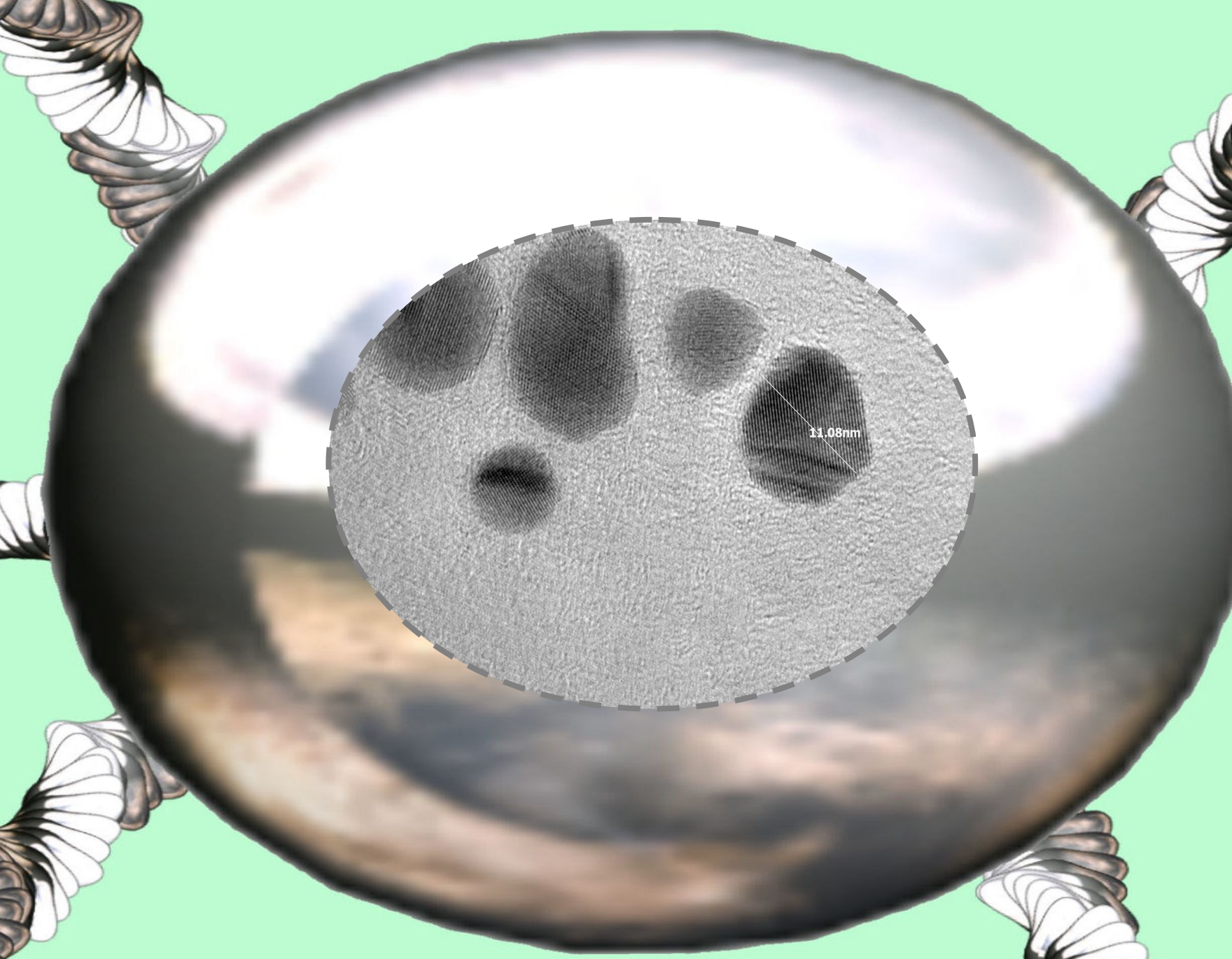
SCHEME 2 RESULTS:

Discrepancy of size distribution between TEM and UV-Vis could be a time or a light exposure effect



- UV-Vis spectrum
- Peak around 400 nm
 - small silver particles \leq 10 nm
 - Narrow size distribution

- TEM image:
- Significant aggregation
 - Larger than expected size range
 - Time factor?
 - Light exposure?
 - Small particles confirmed



- Functionalization results in a slight peak shift
- The TEM image shows a fringe around the particle

Applications/Potential

- Targeted molecular labeling
- Adding particles to DNA heterostructures as a template for directed nanowire growth
- Targeted biosensors
- Surface Enhanced Raman Spectroscopy
- Solar cells

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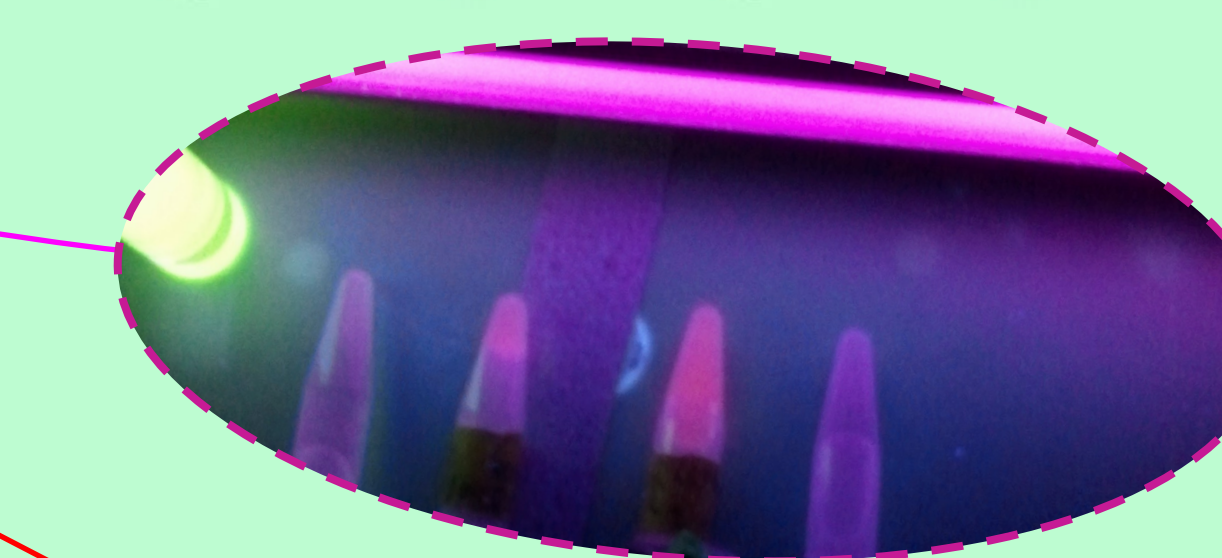


ACKNOWLEDGEMENTS

Future Work

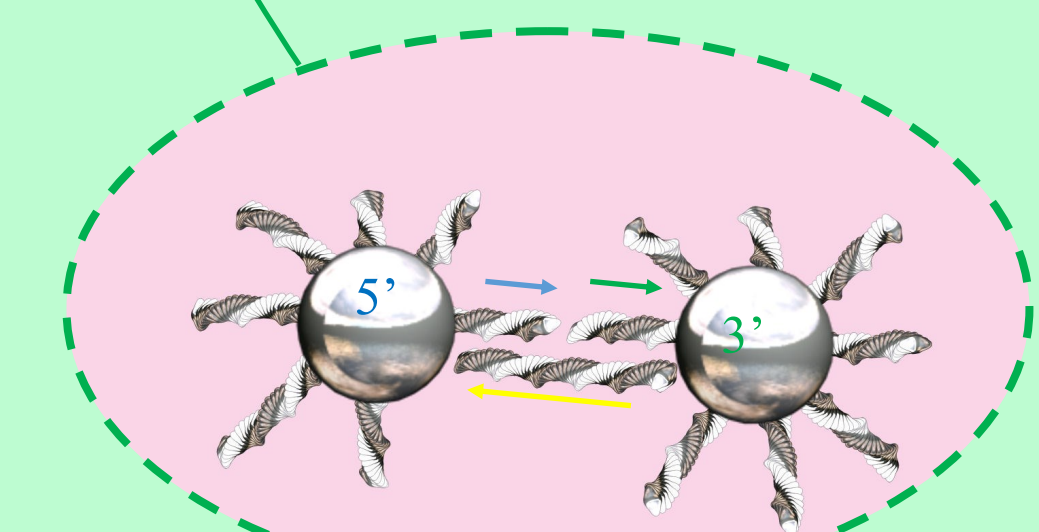
Challenges/Questions

- Silver is more readily oxidized than gold
- Silver is more touchy than gold and is less stable in colloidal form
- Assuming that silver can indeed be functionalized, can the resulting product be purified easily without losing its stability?
- Can silver be functionalized at all without a gold shell?
- Does the gold functionalization procedure need to be modified in order to work on silver?
- Assuming that silver can be functionalized, is it as stable as its gold counterpart?

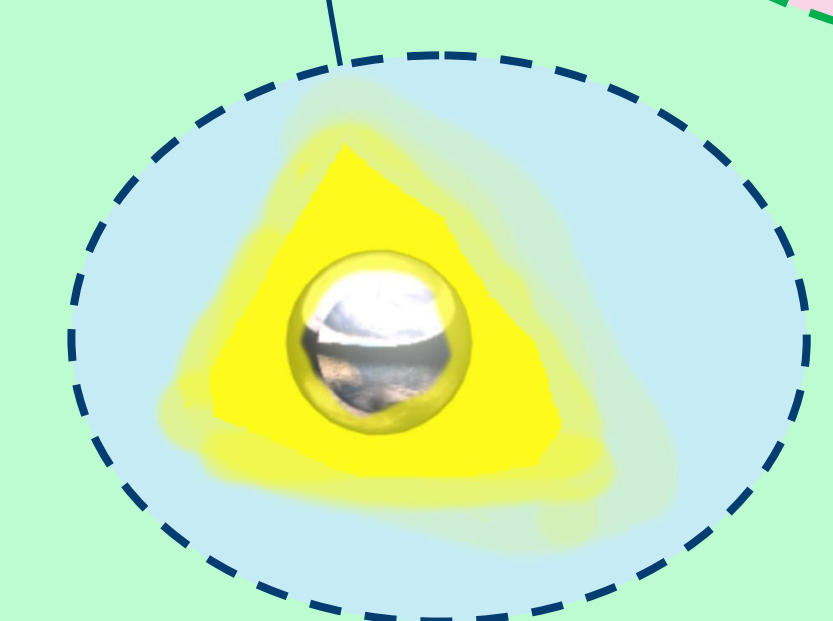


- Silver Nanocluster Project:
- The synthesis of fluorescent silver nanoclusters directly onto a DNA strand
 - AgNCs exhibit strong fluorescence under UV light

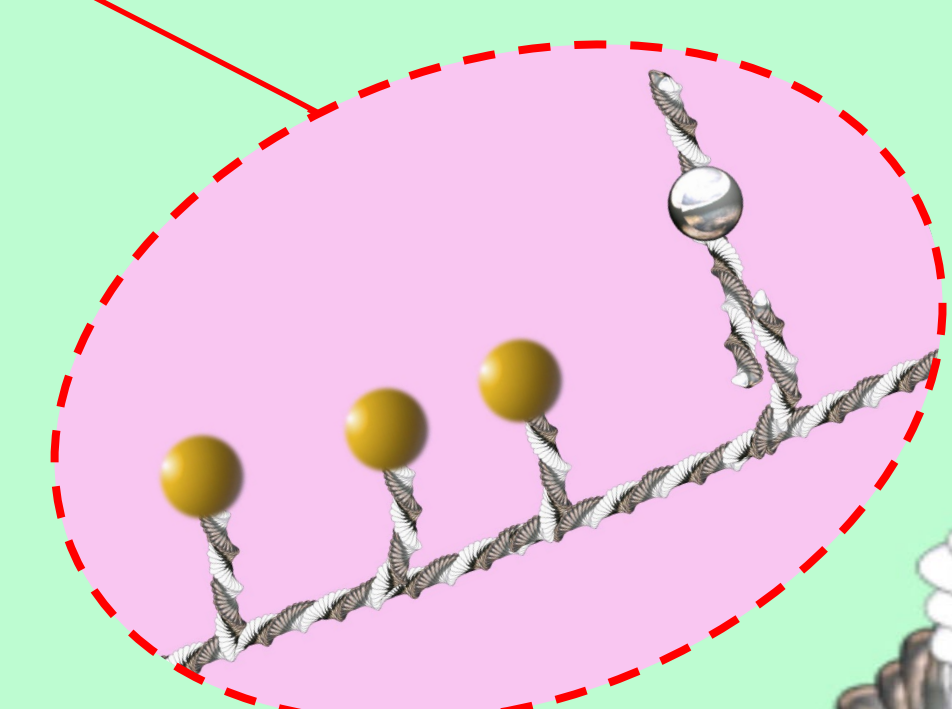
- DNA Heterostructures:
- Functionalized particles are connected to complimentary sticky ends on a DNA substrate that is already decorated with gold



- Direct Aggregation:
- Two types of functionalized particles are connected with a complimentary linker strand



- Seeded Nanoprism Growth:
- Silver particles are used as seeds to grow nanoprisms or nanowires



- NOTES:
- UV-Vis spectra were taken on a Varian Cary 100 UV-Vis spectrophotometer
 - Micrographs were taken on a Jeol JEM-2100 HR Transmission Electron Microscope (TEM) at the BSCMC
 - The solution in the round bottom flask is a generic representation and does not bear any resemblance to an actual product

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Zhang, J.; Langille, M. R.; Mirkin, C. A. Synthesis of Silver Nanorods by Low Energy Excitation of Spherical Plasmonic Seeds. *Nano Lett.* **2011**, *11*, 2495-2498.