Comparison of fluorescence and antibacterial properties of DNA-templated silver nanoclusters with variable cytosine hairpin loop sizes.

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OBJECTIVES

- Preparation and analyze nine DNA-templated silver nanocluster (DNA-AgNCs) samples with various sizes of cytosine hairpin loops.,
- The main objectives are to:
  - Evaluate the fluorescence properties of these samples after synthesis and explore mixing different DNA-AgNCs to form a color wheel.
  - Evaluate the impact of different DNA-AgNCs on *E. coli* to understand if color relates to function.

BACKGROUND

- Bacteria are rapidly evolving to resist common antibiotics and the current overuse and misuse of antibiotics drives this evolution.. There is a need for novel antibiotics that are more difficult for bacteria to evolve against.
- Silver has been used for centuries to prevent bacteria growth and prevent food spoilage. More recently, silver nanoparticles and silver nanoclusters have been explored as antibacterial agents.
- The synthesis of AgNCs could be a part of Biology classes to drive content and career pathways.

METHODS

- Synthesis of DNA-AgNCs:
  - Combine ssDNA + $AgNO_3$ + NH_4OAc + ddiH_2O
  - Vortex and centrifuge the mixture.
  - Incubate at 2 min and immediate place in ice(4°C) for 20 minutes
  - Add $NaBH_4$→Wrap in Aluminum Foil→Store 4 ℃ overnight

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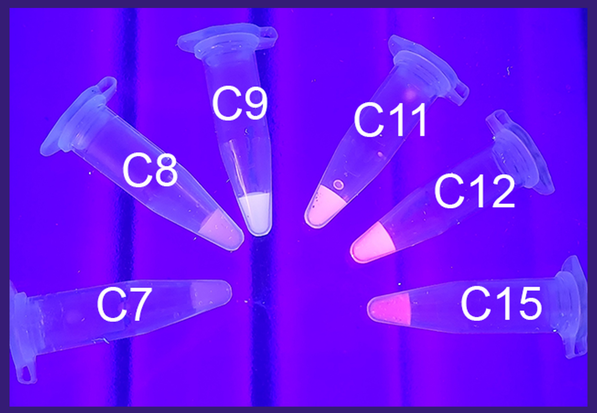
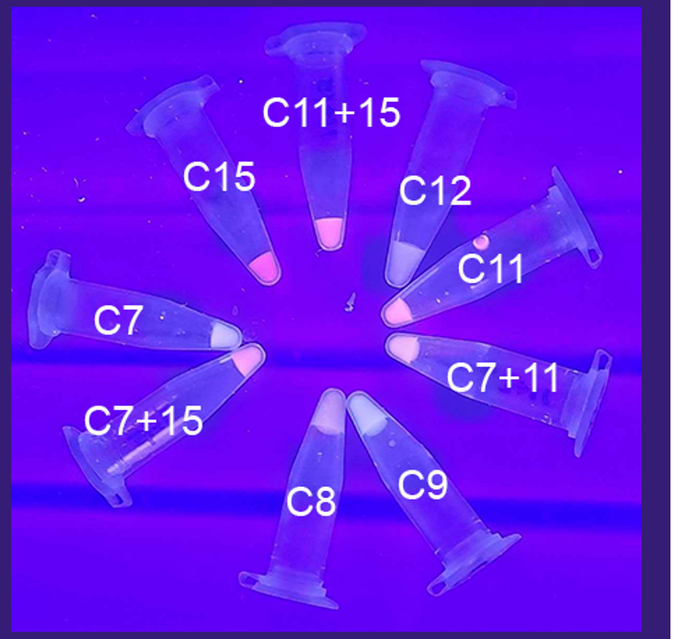
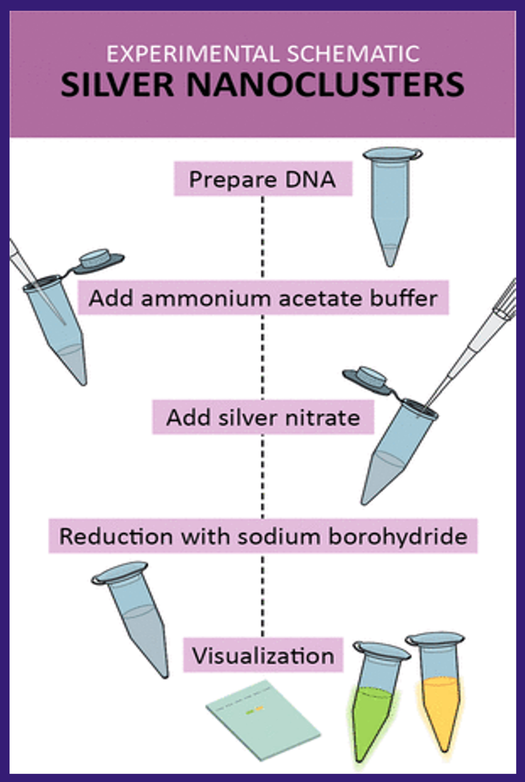
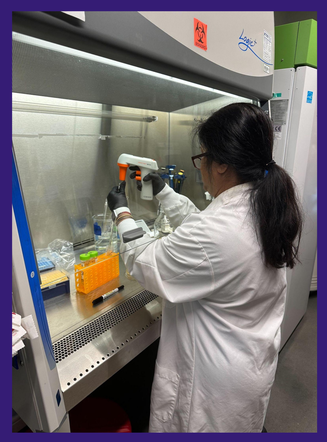




DNA sequence drives fluorescence and antibacterial properties of DNA-AgNCs.





OBSERVATIONS AND ANALYSIS

Fluorescent Properties: Eleven DNA-AgNCs (C5 to C15) exhibited distinct fluorescent colors under UV light, correlating with cytosine content. Primary colors identified were blue (C7), yellow (C11), and red (C15), while secondary colors included purple (C8), green (C9), and orange (C12).

Color Mixing: Mixing primary color samples (C7, C11, C15) did not yield the expected secondary colors. Instead, red (C15) consistently dominated the mixtures.

COMBINATION	EXPECTED COLOR	PERCEIVED COLOR
C7 (blue) + C11 (yellow)	Green	Orange
C7 (blue) + C15 (red)	Purple	Orange
C11 (yellow) + C15 (red)	Orange	Orange

Antibacterial Assays: The antibacterial efficacy of DNA-AgNC samples was tested on E. coli cultures grown on LB agar plates, treated with primary and secondary color DNA samples, and incubated at 38°C. Research of antibacterial properties is ongoing.

CONCLUSION

- While DNA-AgNCs exhibited promising fluorescent properties, their antibacterial efficacy was variable and inconclusive.
- The dominance of red fluorescence in mixtures suggests a need for further research to understand the chromatic mechanisms and optimize ssDNA-AgNC formulations for consistent antibacterial effects.

ALIGNMENT OF HIGH SCHOOL CURRICULA

BIG iDEAS (AP BIOLOGY)	DESCRIPTION
1	The process of evolution drives the diversity and unity of life.
2	Biological systems use energy and molecular building blocks to grow, reproduce, and maintain homeostasis.
3	Living systems retrieve, transmit, and respond to information essential to life processes.
4	Biological systems interact, and these interactions possess complex properties.

NC BIOLOGY STANDARDS	DESCRIPTION
LS Bio.1	Analyze how the relationship between structure and function supports life processes within organisms
LS.Bio. 2	Analyze the growth and development processes of organisms. .
LS. Bio 8	Understand applications of genetics and biotechnology.