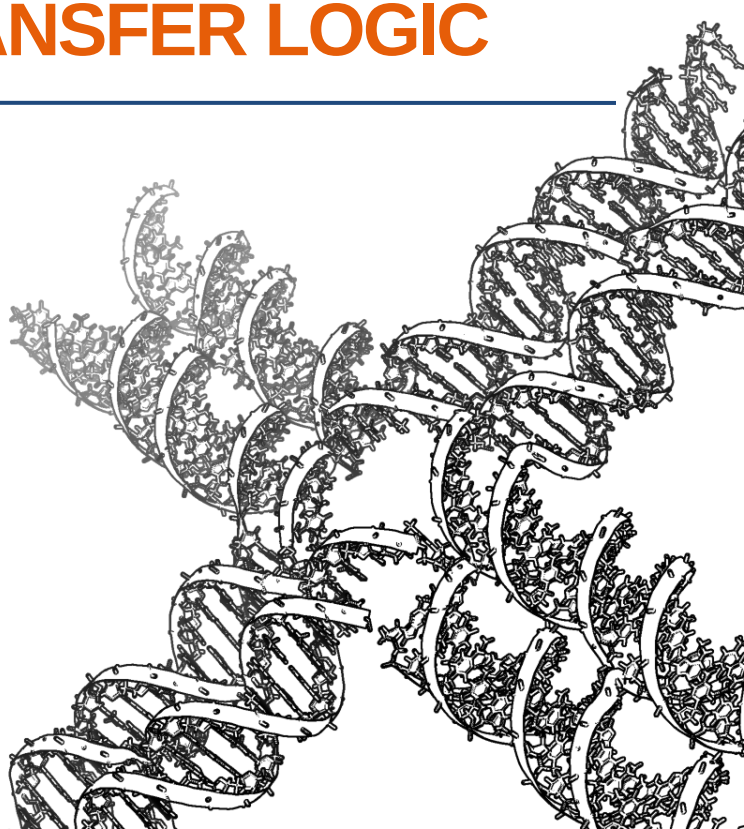
SIGNAL RESTORATION

IN RESONANCE ENERGY TRANSFER LOGIC

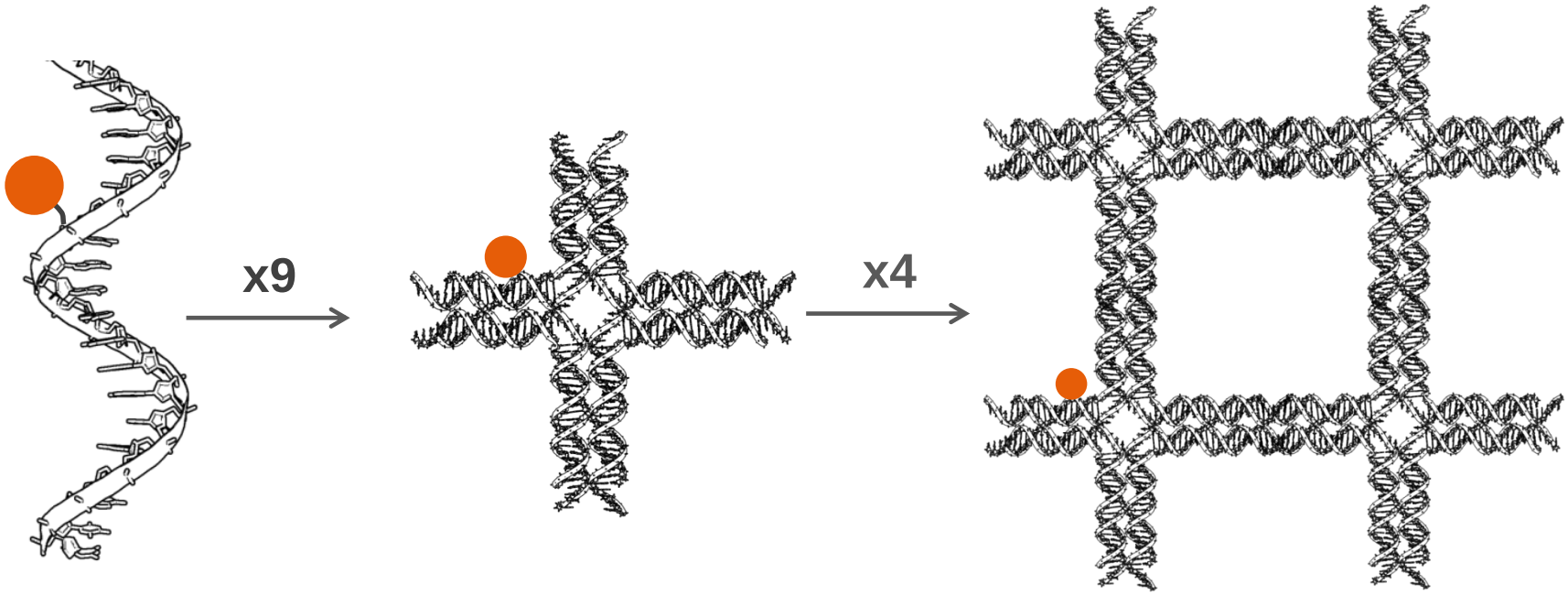
Craig LaBoda



Integrated Molecular Circuits

We build integrated molecular circuits:

- Self-assembled using a DNA scaffold
- Computation performed by fluorescent molecules (fluorophores)



Single-stranded DNA **DNA Tiles** **DNA Grids**

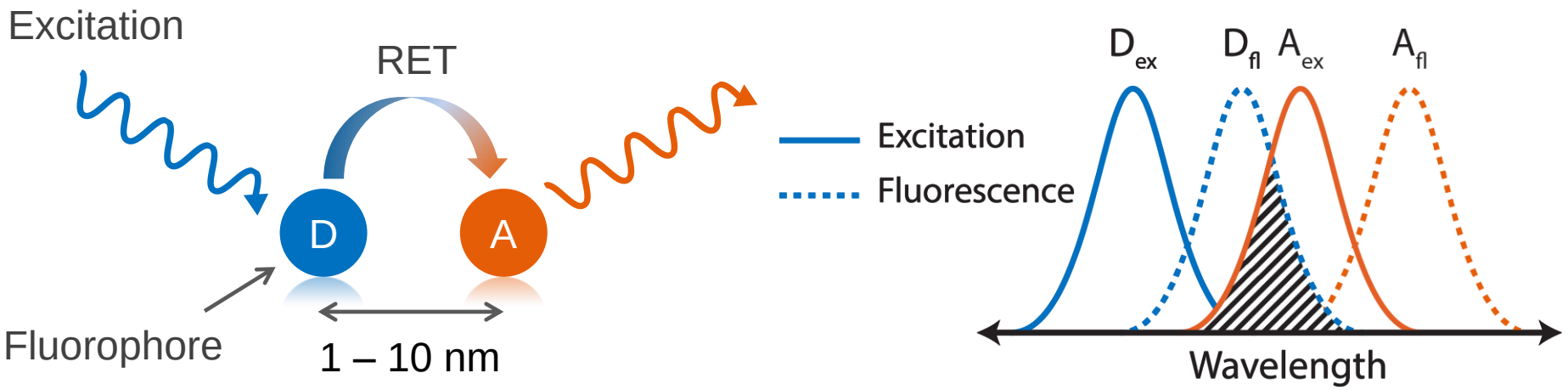
Fluorescence and RET

Fluorescence:

- Emission of a photon from a substance after absorbing a photon

Resonance Energy Transfer (RET):

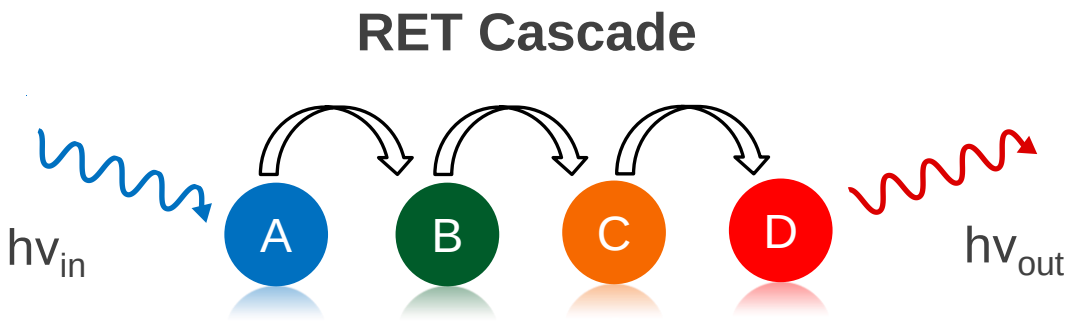
- Donor fluorophore (D) gives energy to acceptor (A) - transfers exciton
- Acceptor's excitation must overlap donor's emission



RET Logic

RET Logic – networks of fluorophores that can perform computation

- Inputs/Outputs – photons absorbed or fluoresced
- Internal signal transport - RET

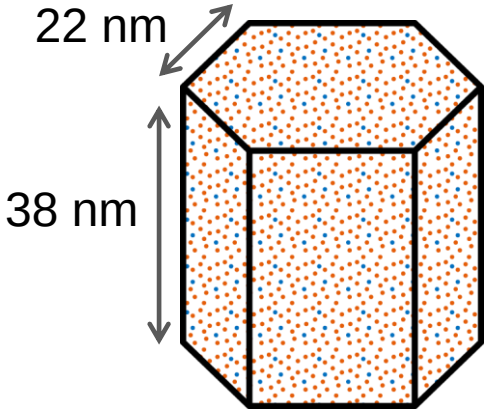


Problem: Excitons lose energy as they travel through RET circuits.

Without a way to restore this energy, we can't build large circuits.

Upconverting Nanoparticles (UCNPs)

UCNPs convert low energy light into high energy light



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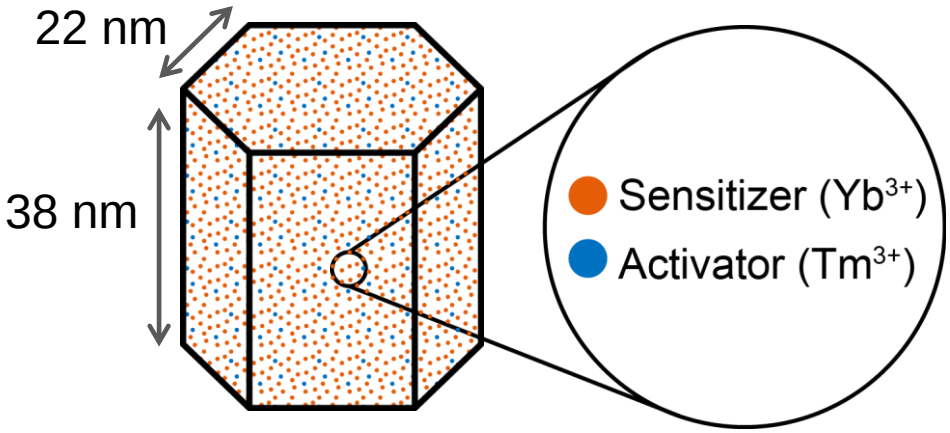

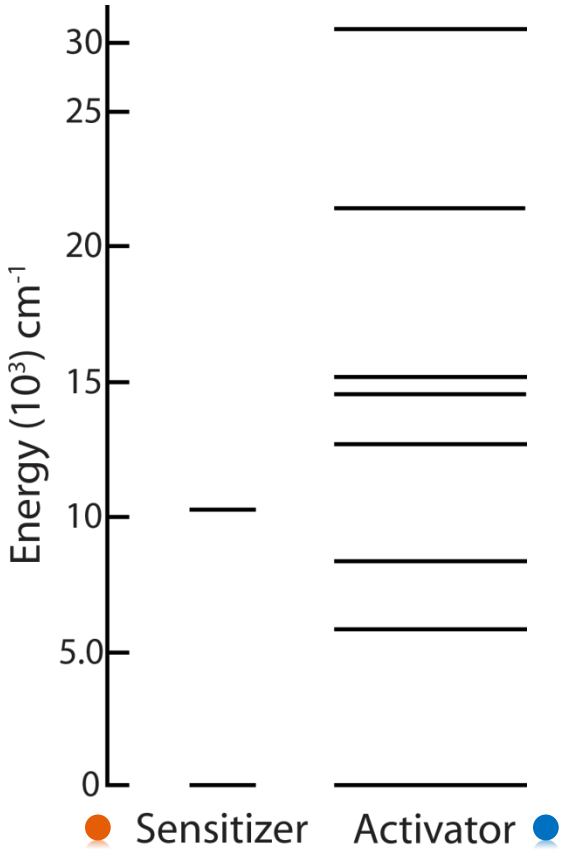

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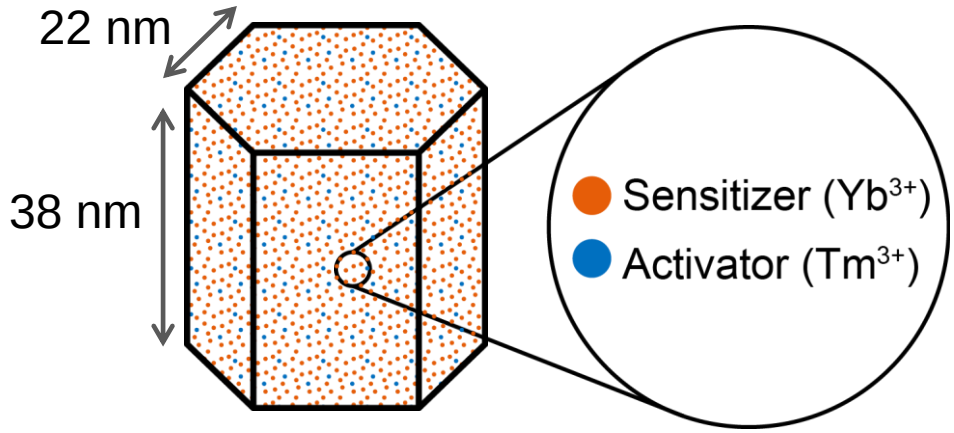

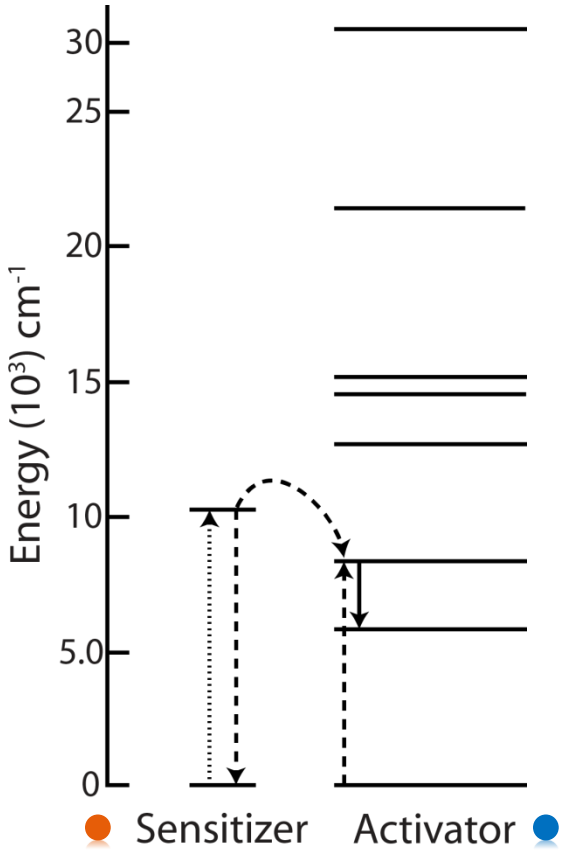

Upconversion Process:

1. Sensitizer is excited at 980 nm
2. Sensitizer transfers energy to activator

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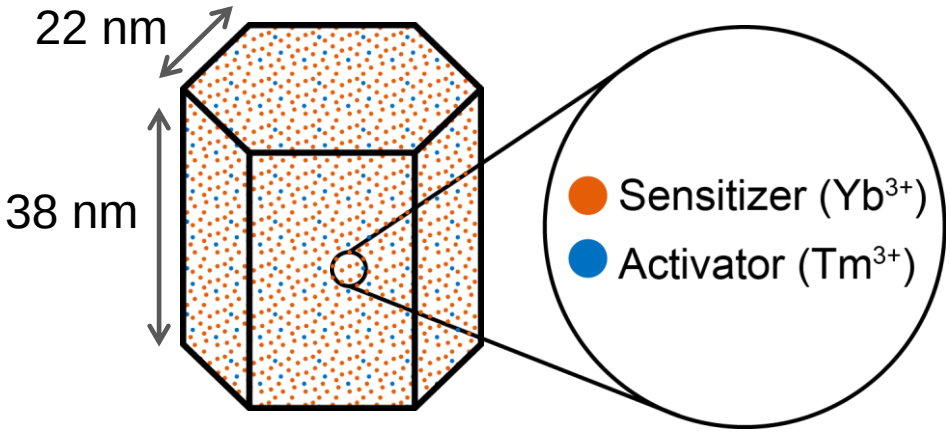

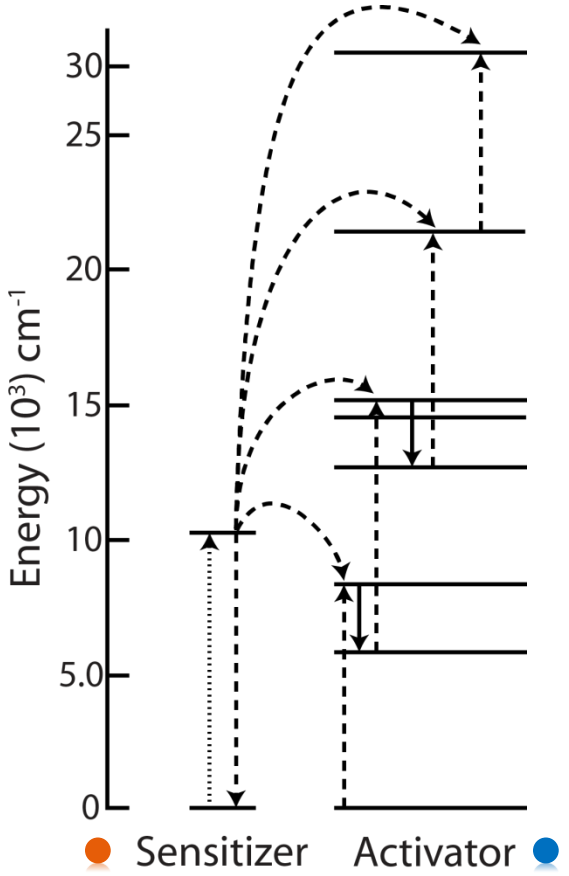

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3. Repeat steps 1-3 until activator is highly excited

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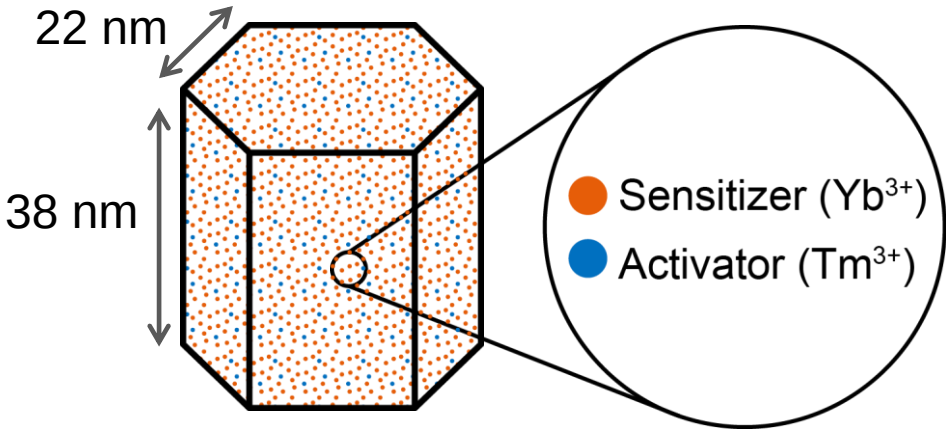

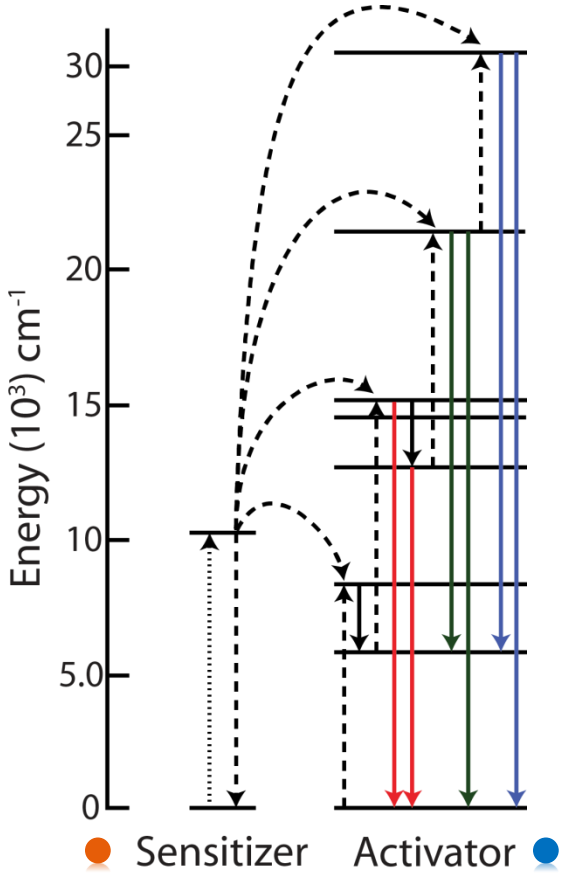

Upconversion Process:

1. Sensitizer is excited at 980 nm
2. Sensitizer transfers energy to activator
3. Repeat steps 1-3 until activator is highly excited
4. Activator emits visible light

Upconverting Nanoparticles (UCNPs)

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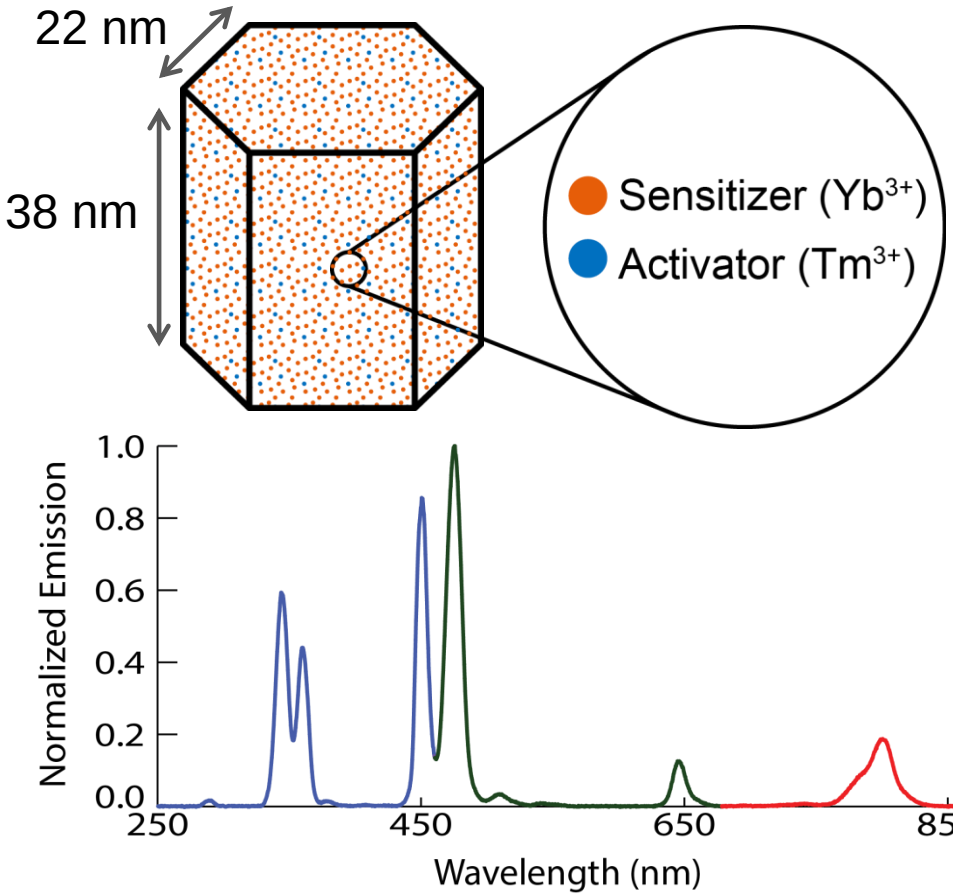
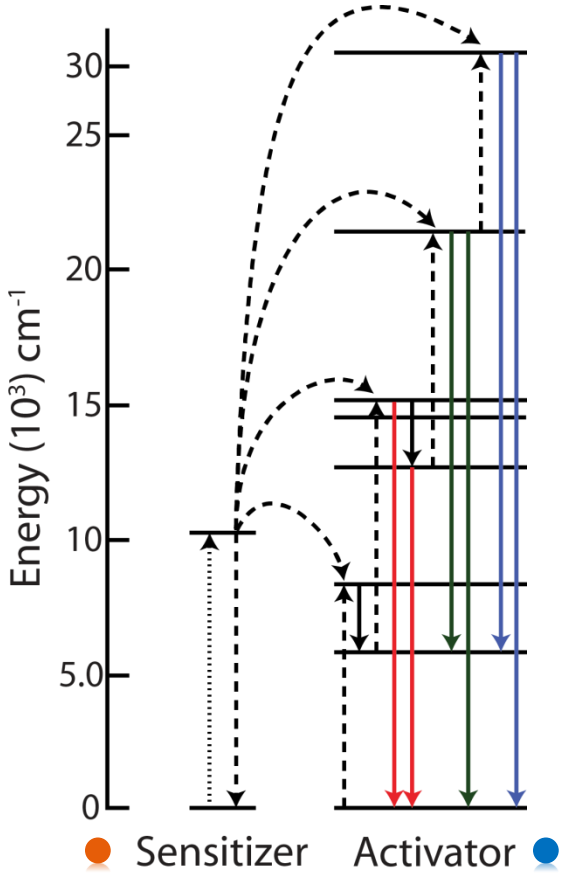
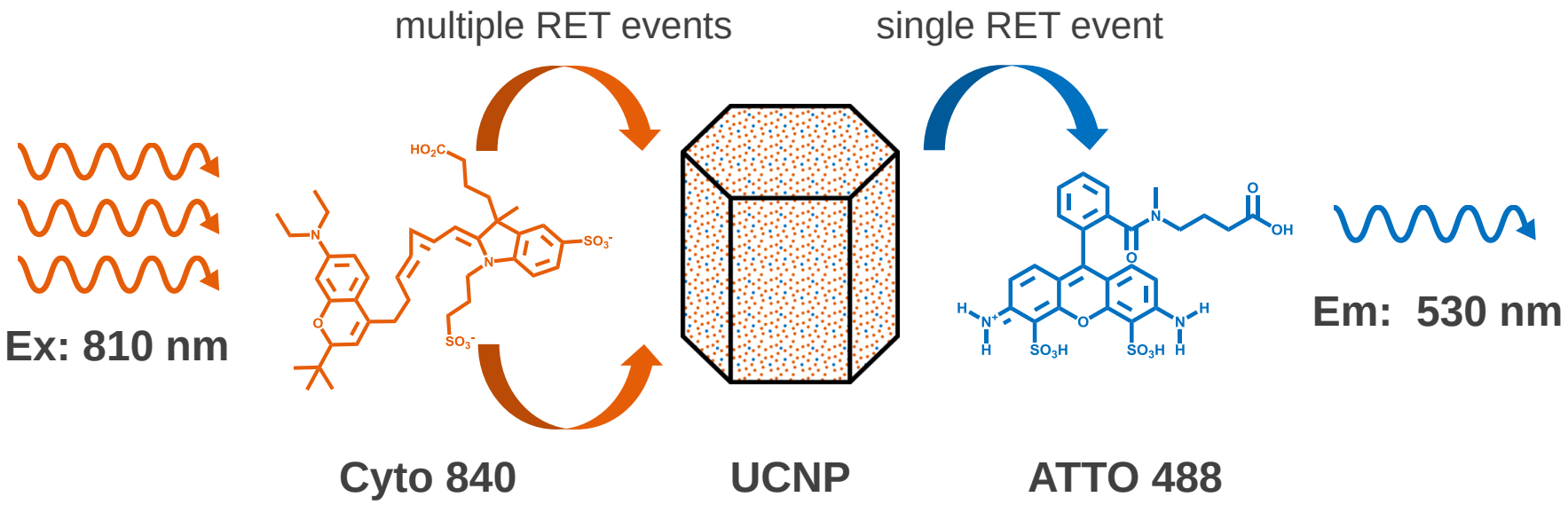




UCNP Based RET Relay

The RET relay converts low energy excitons into high energy excitons

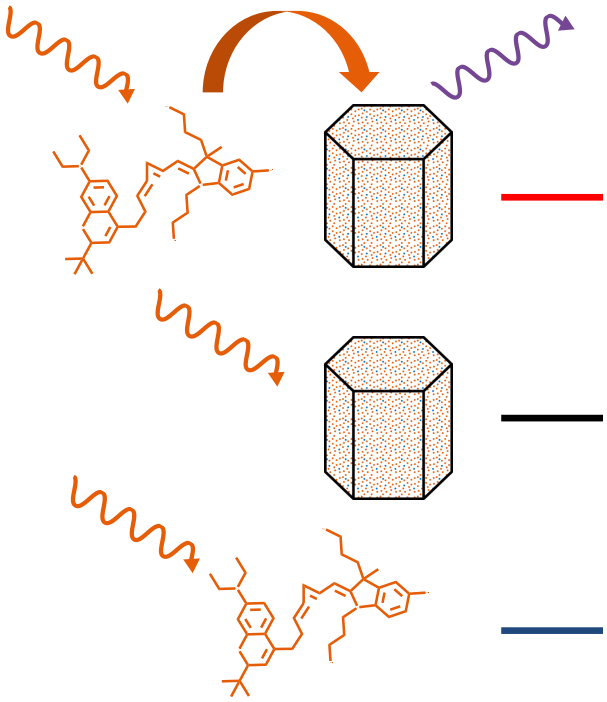
1. Cyto 840 transfer multiple excitons to the UCNP
2. The UCNP accumulates these excitons to reach a highly excited state
3. The UCNP transfers a single exciton to ATTO 488

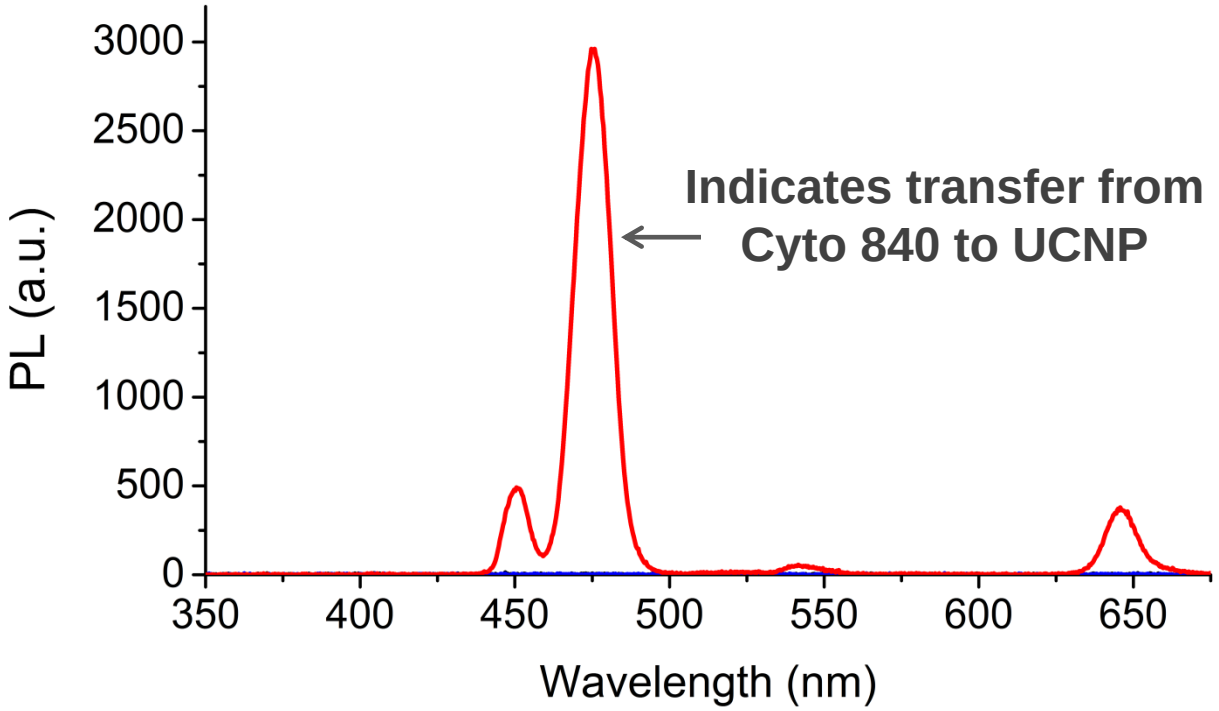


Transfer From Cyto 840 to UCNP

Testing energy transfer from Cyto 840 to the UCNP:

1. Assemble first half of relay and controls (individual components)
2. Excite at Cyto 840 wavelength, look for UCNP photoluminescence (PL)

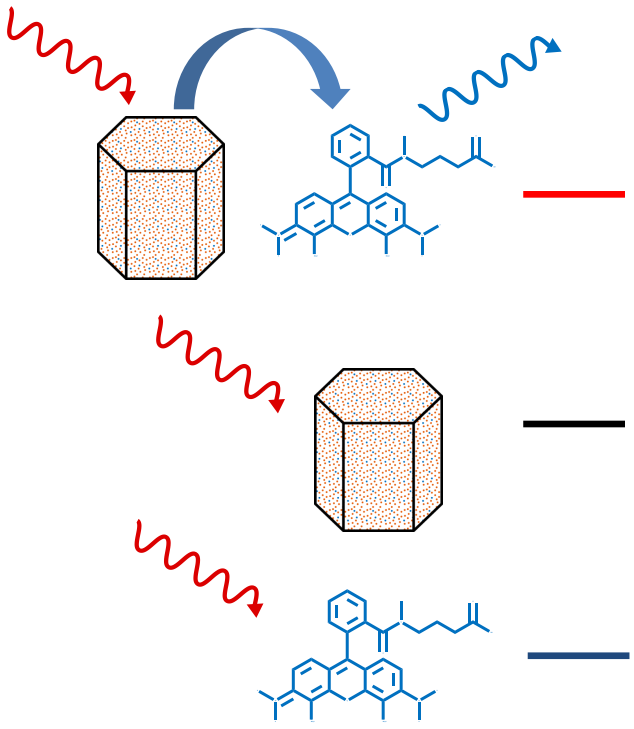


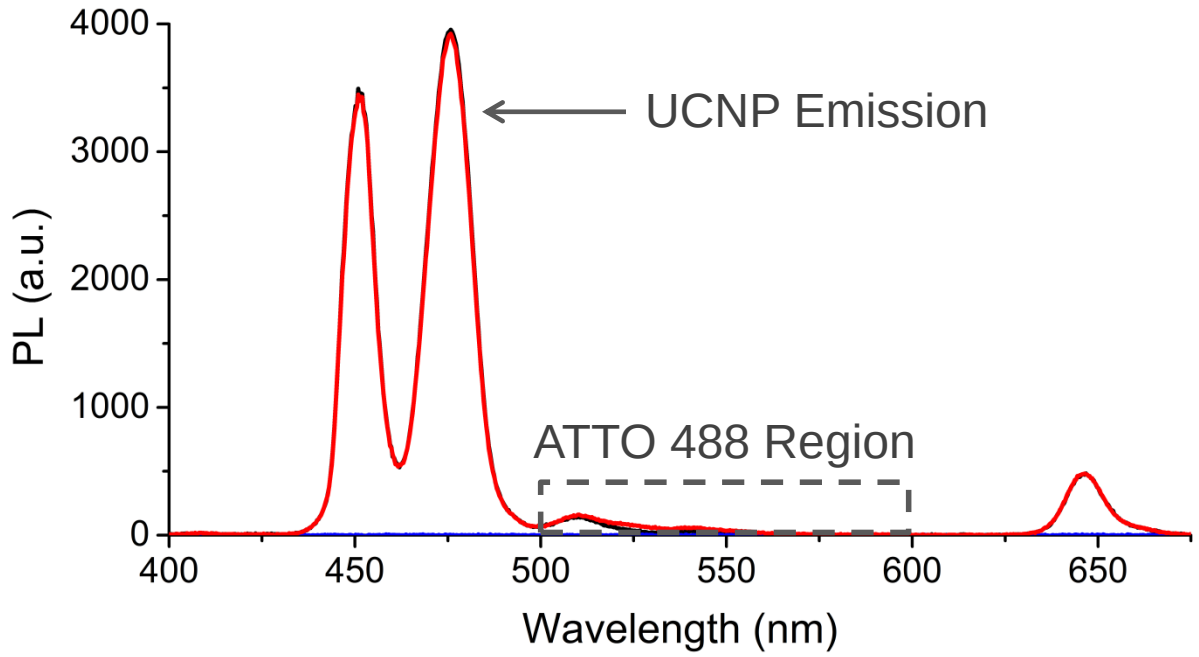


Transfer From UCNP to ATTO 488

Testing energy transfer from the UCNP to ATTO 488:

1. Assemble second half of relay and controls (individual components)
2. Excite the UCNP and look for ATTO 488 PL





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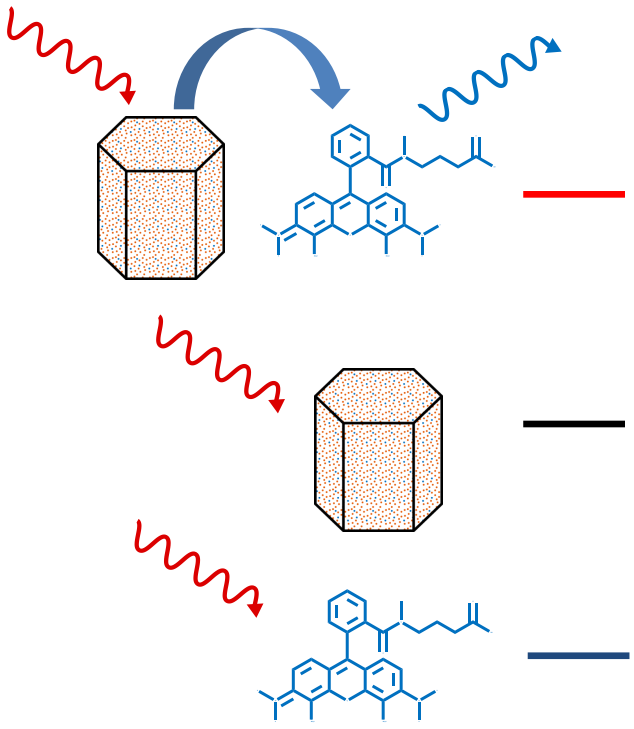

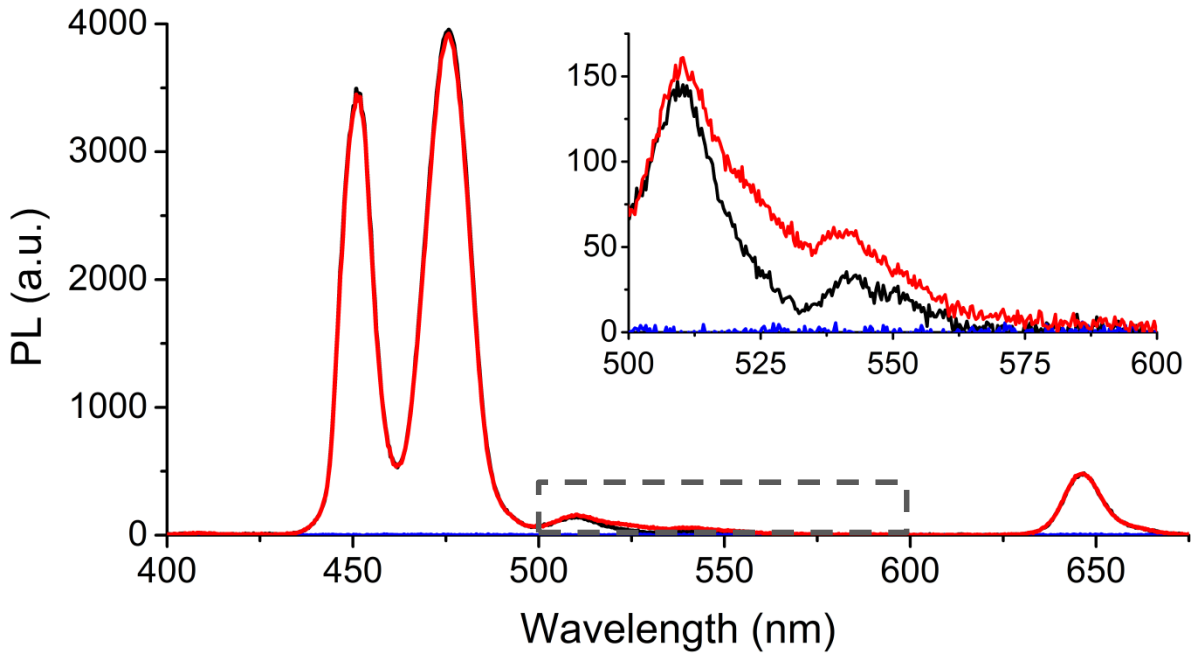

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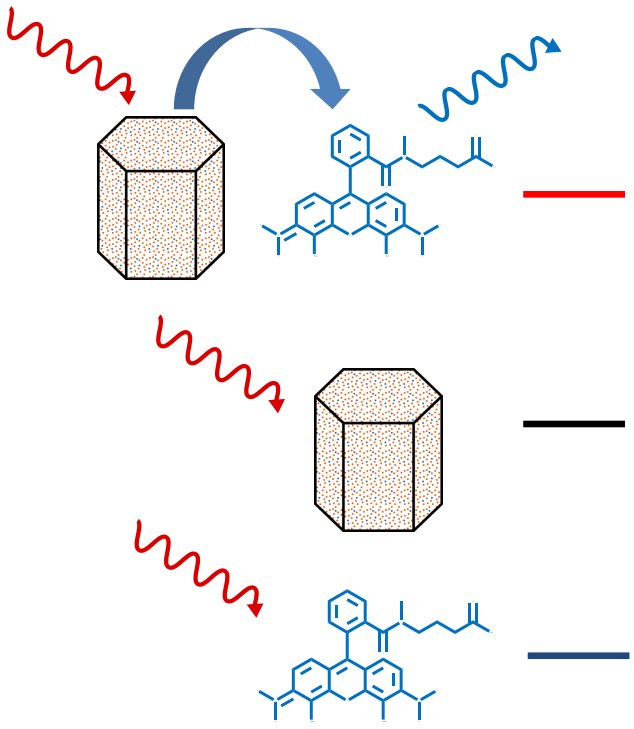
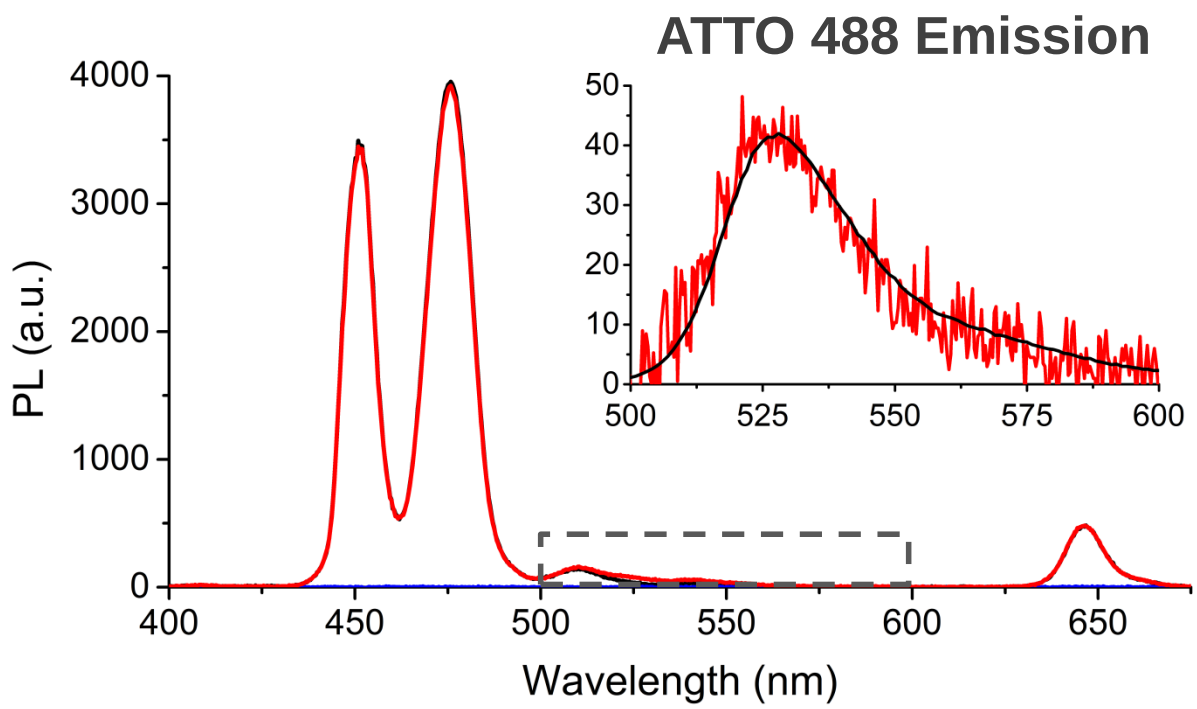
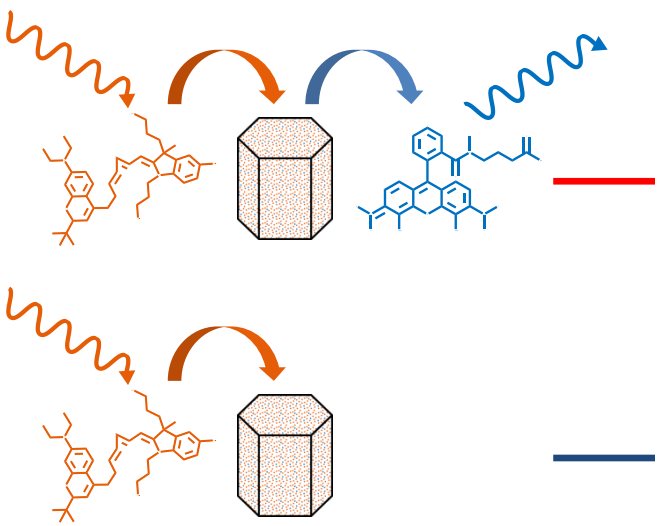


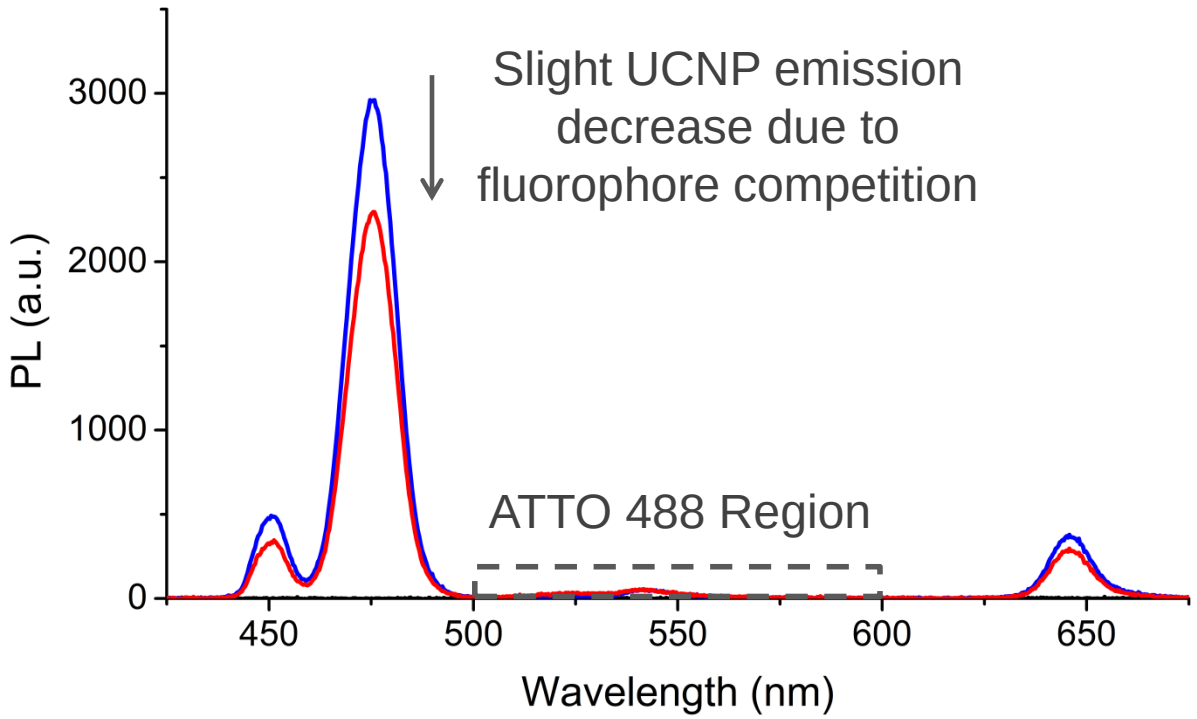


Demonstration of the Full Relay

Testing the full relay:

1. Assemble relay and controls
2. Excite at Cyto 840 wavelength and look for ATTO 488 PL





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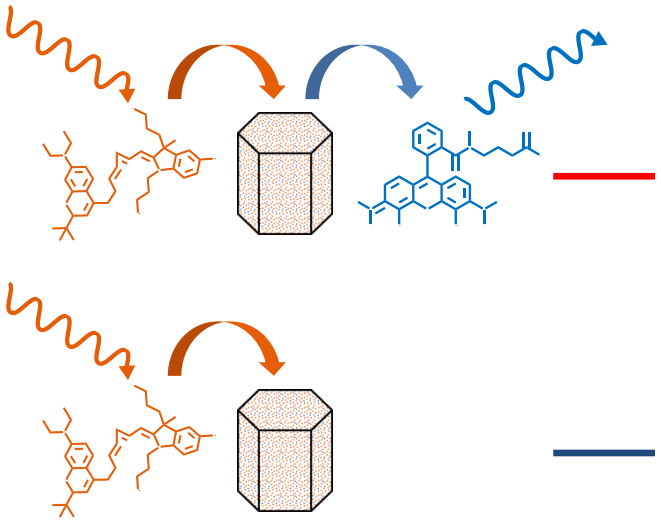

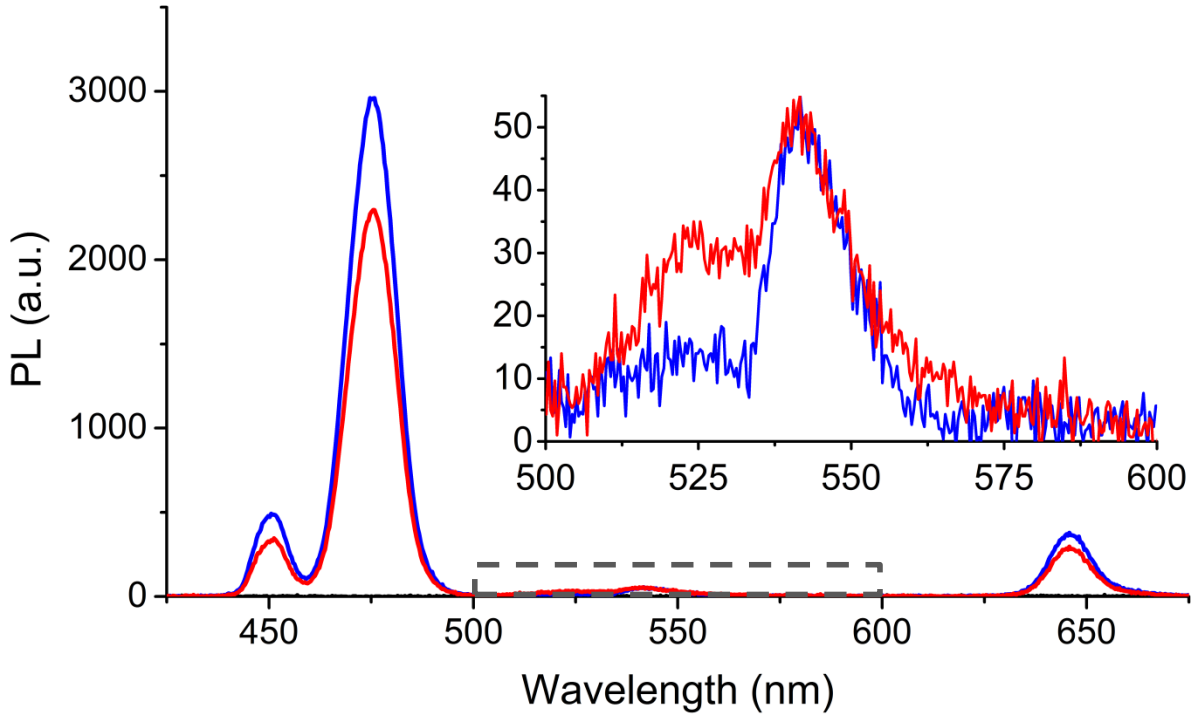

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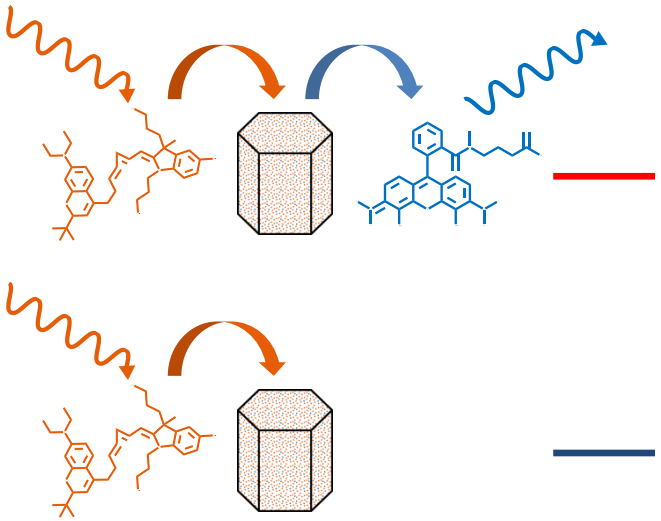
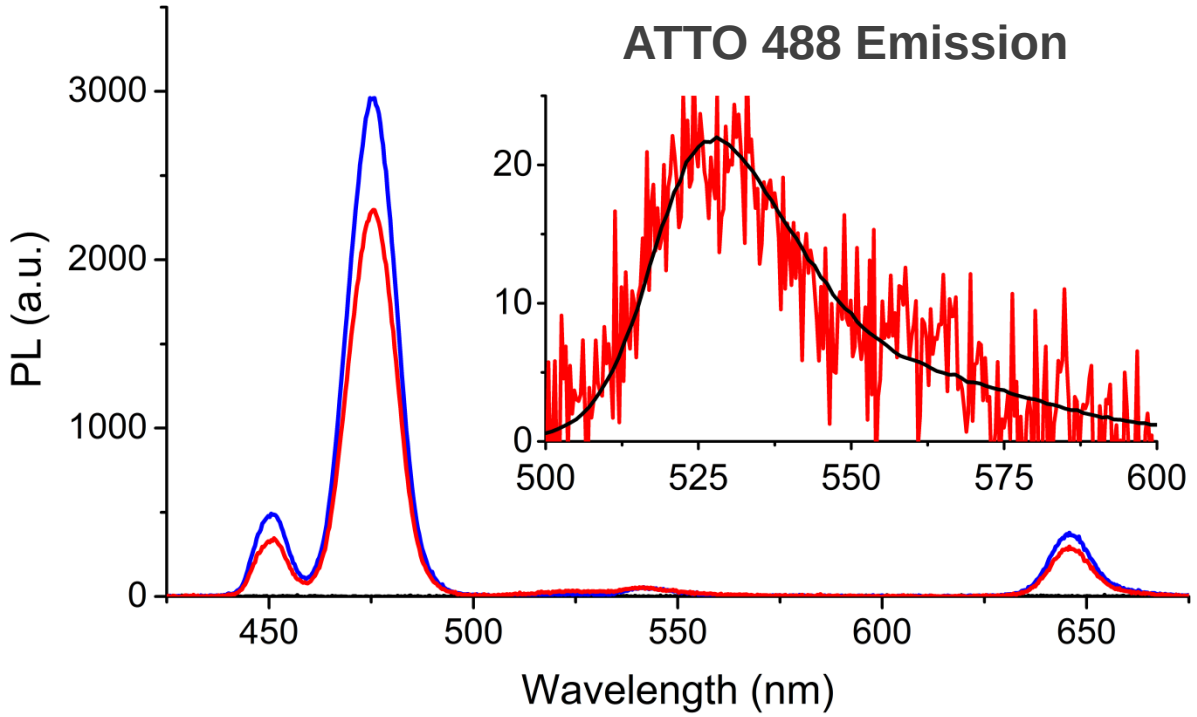




Conclusions

Summary

- RET logic – networks of fluorophores that can perform computation
- RET logic suffers from intrinsic energy loss, which prevents scaling
- Designed the UCNP based RET relay to restore this energy loss

Conclusions

- Each half of the RET relay transfers energy as designed
- Fluorophores compete for adsorption sites on the UCNP
- The full RET relay converts low energy excitons to high energy excitons

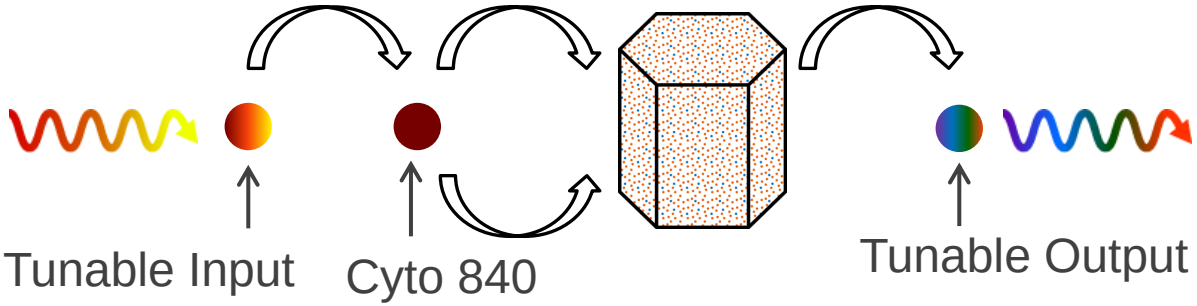
Future Work

Integrating the relay into RET networks

- Functionalize the relay for aqueous solutions and explore DNA attachment

Tunable UCNPs (The Metafluor)

- Choose different input/output fluorophores to tune excitation/emission



Thanks!

- Professor Chris Dwyer
- All of my former and current labmates