Concept Design for Optical Tweezers to be used in DNA Research

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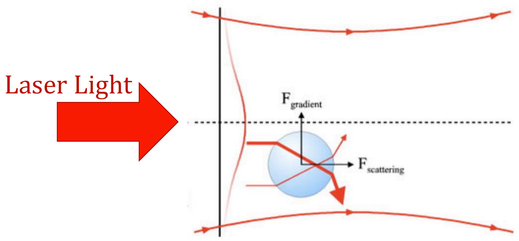
Abstract

Optical tweezers are a Nobel Prize-winning technology capable of trapping microscopic and sub-microscopic particles using a laser beam. There are several new and useful applications available with the use of optical tweezers. A single optical tweezers set up can cost upwards of two hundred thousand dollars; however, we have designed a cost effective set up to study damaged DNA for under thirty thousand dollars. Using this design, we applied for a grant that would give us the necessary funds to build this set up. The building process itself will be very useful hands-on time learning about the laser set up. In addition, our optical tweezers would be integrated into undergraduate classes.

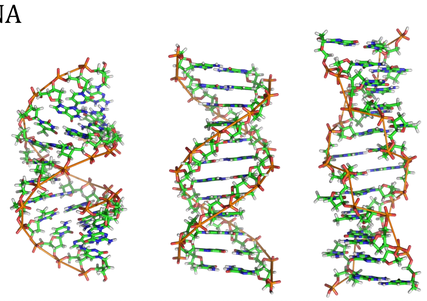
Optical Tweezers Concept

- Highly sensitive and precise devices that allow for manipulation at some of the smallest levels
- Creates two different forces on a single particle using properties of light, it creates a force on the other side of the particle creating a trap for the particle
- The laser beam can then be slightly manipulated to make tiny adjustments
- Amount of force can be precisely monitored to reduce chance of damage to the particles



Tweezing DNA

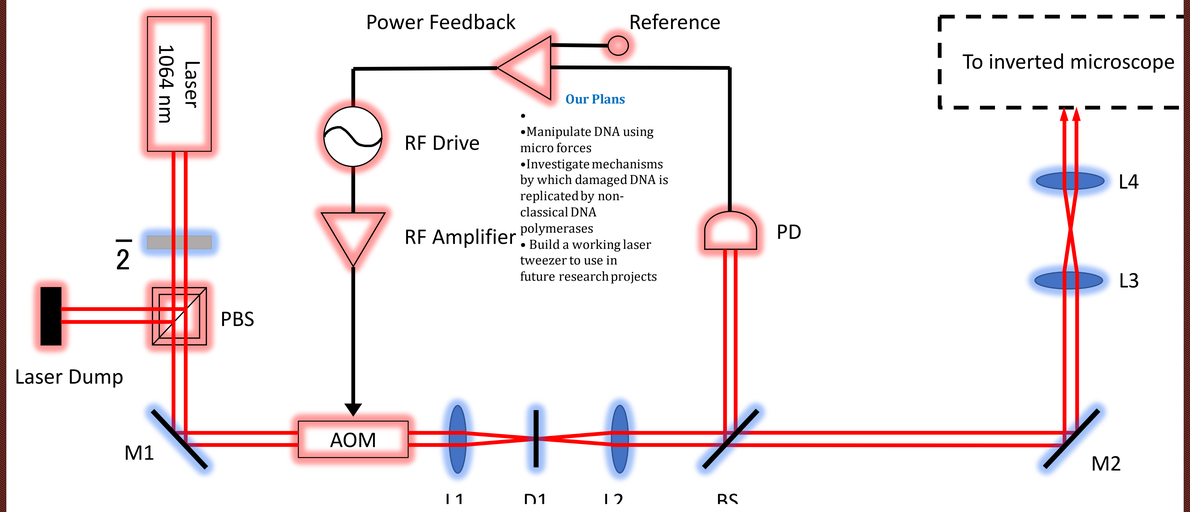
- Trap a single strand of DNA
- Manipulate DNA with small forces
- Comparing forces on damaged and undamaged DNA
- Study how the damage affects the forces on the DNA



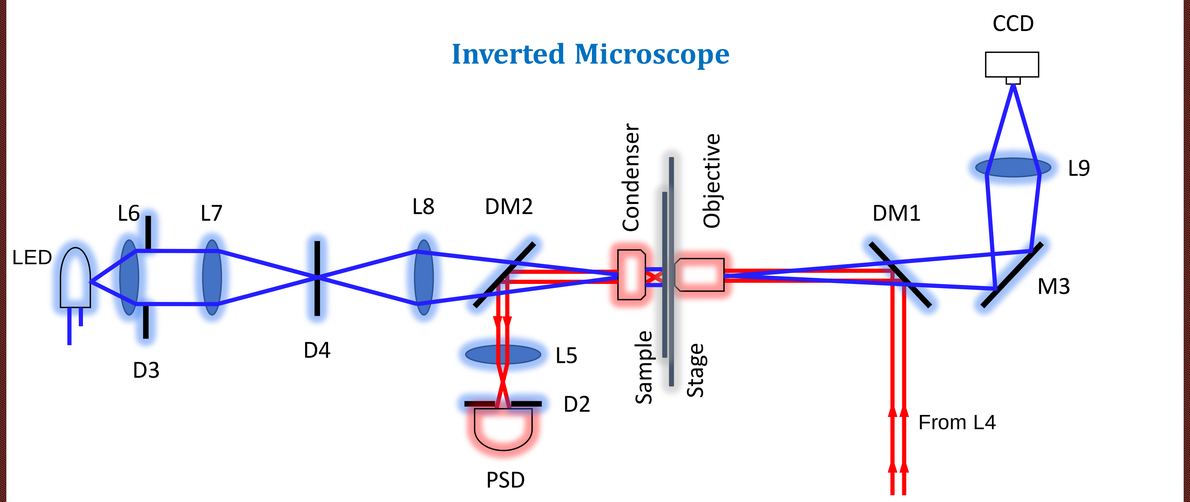
Optical Tweezers Design

- Our laser beam goes through a series of lenses and mirrors to clean the beam before entering the microscope
- The feedback loop provides us with insight as to how clean the beam is
- The beam enters the inverted microscope and enters the objective and then through the sample and stage
- The LED provides us with the image of the sample via the CCD since 1064 nm light is not visible to the human eye

Main Setup

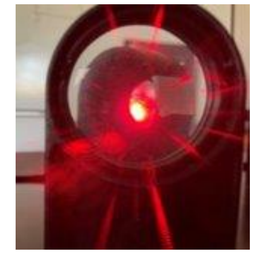


Inverted Microscope



Present Progress

- Prototype optical system assembled
- Rudimentary measurements in process of being gathered



Our Plans

- Manipulate DNA using micro forces
- Investigate mechanisms by which damaged DNA is replicated by non-classical DNA polymerases
- Build a working laser tweezer to use in future research projects

References

1. Hernández Candia, Carmen Noemí, et al. "A Minimal Optical Trapping and Imaging Microscopy System." *PLoS ONE*, vol. 8, no. 2, 2013, https://doi.org/10.1371/journal.pone.0057383.
2. Leake, Mark C. *Biophysics: Tools and Techniques*. CRC Press /Taylor & Francis Group, 2017.