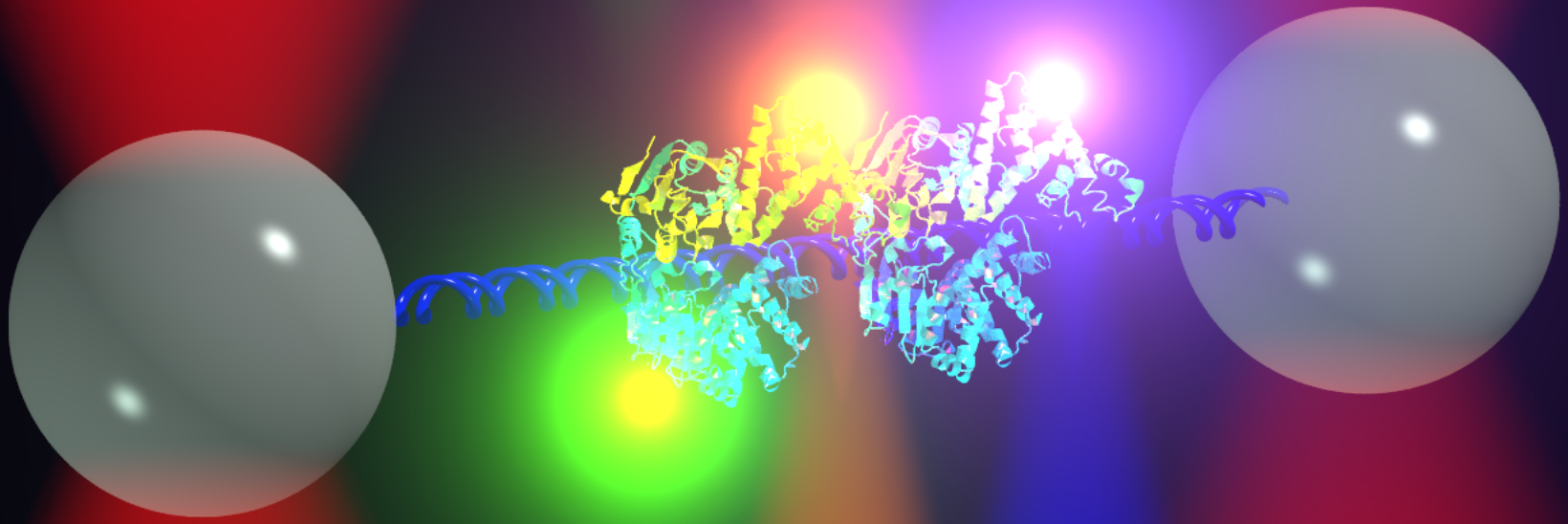
Watching Biological Machines at Work



Matt Comstock

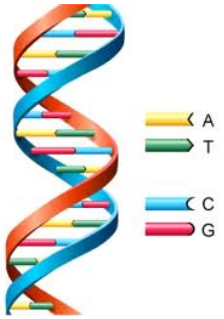
Michigan State University
September 20, 2012

Biology

You! Made of ➔ Cells Made of ➔ Molecules

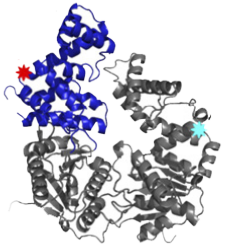
Dreamstime.com

DNA



Information

Proteins



Building blocks
Enzymes (chemistry)
Motors

1 m

10 µm

100,000 X
smaller

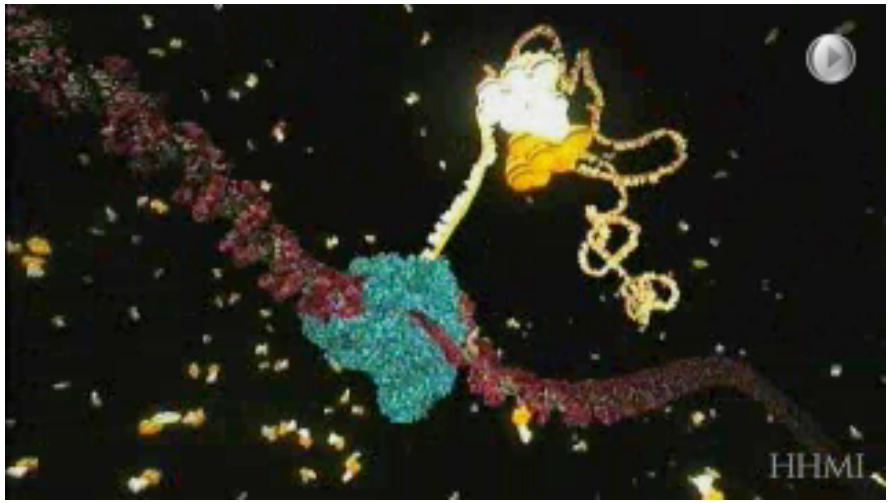
1 nm

10,000 X
smaller

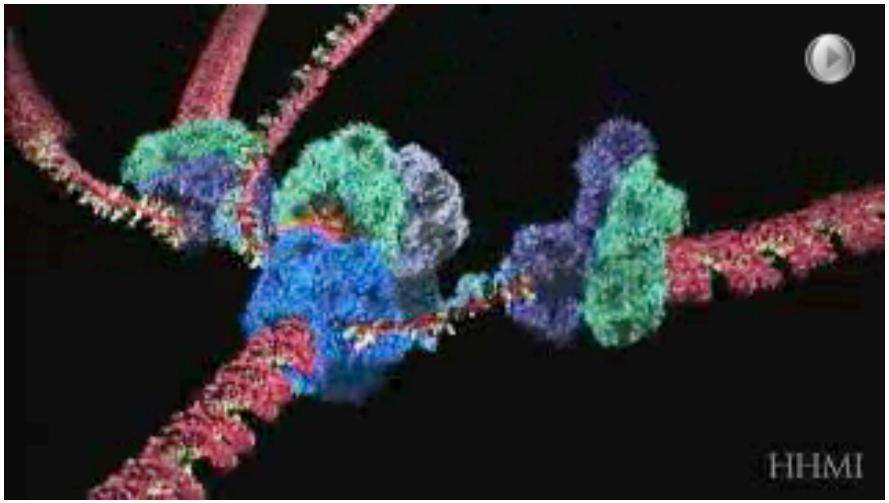
Biological Molecular Motors

Proteins moving on DNA

Making RNA



Copying DNA



- Motion (x vs. t, angstrom-scale)
- Forces (work, stall, pN-scale)
- Multi-component machines (coordination/competition)

Physics!

Impact: Motors involved in all aspects of DNA processing

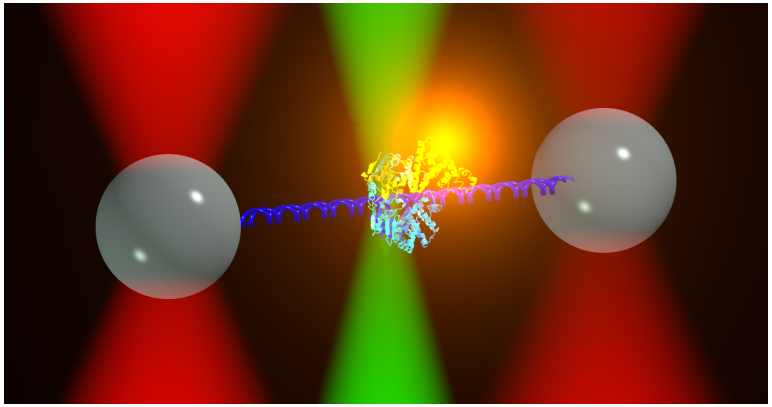
Problems lead to disease (cancer)

How do they work?

Images are from excellent educational animations produced by the Howard Hughes Medical Institute and available on their website: http://www.hhmi.org

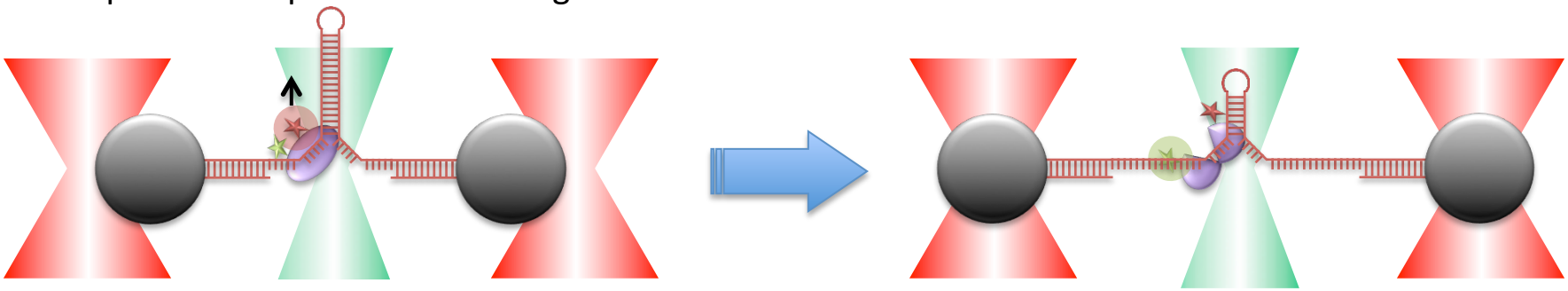
Watching Individual Motors: *Fleezers*

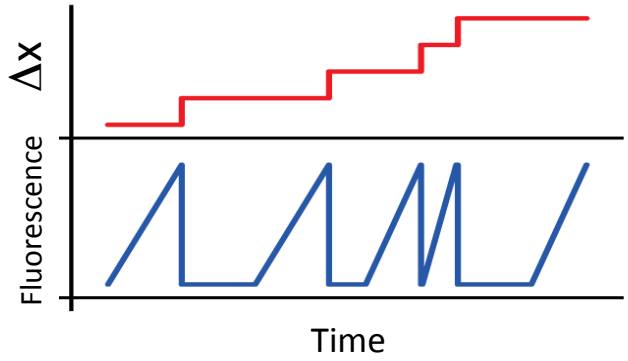
Optical tweezers



Fluorescence

Example: Motor protein unwinding DNA





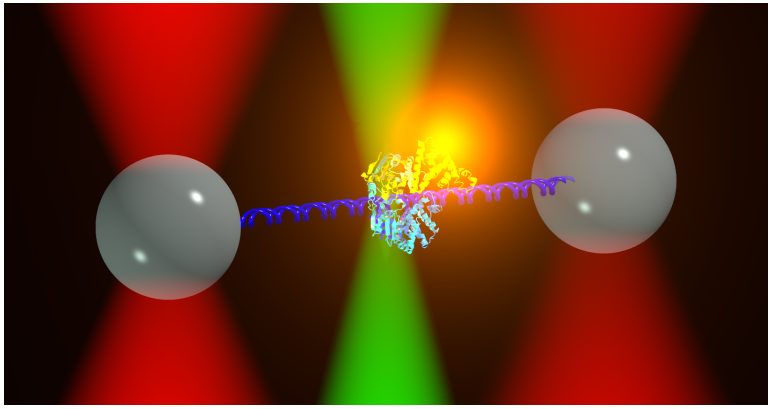
Motor motion

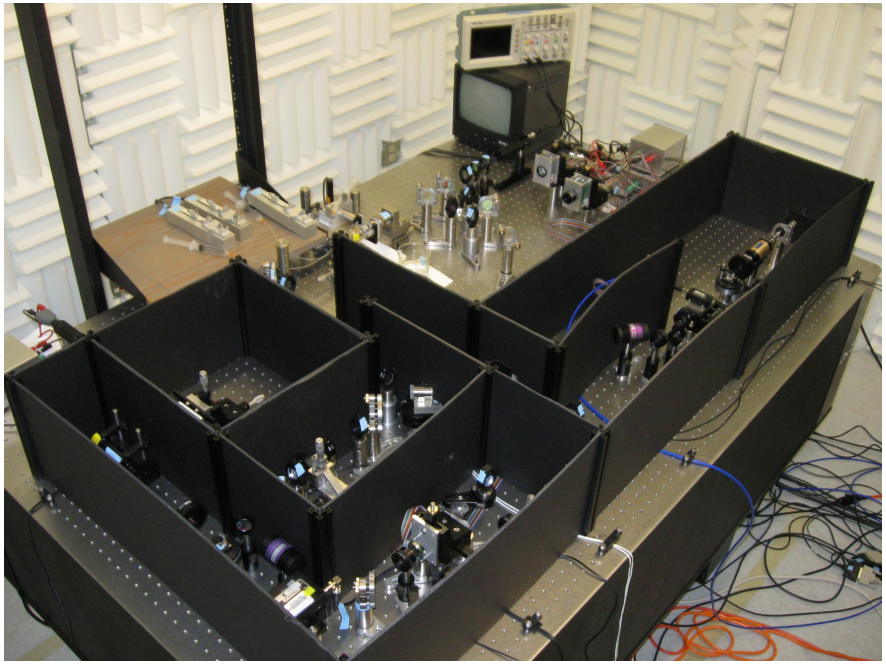
What motor parts are doing

How the motor works!

Instrument publication: Comstock, Ha and Chemla, Nature Methods, 2011

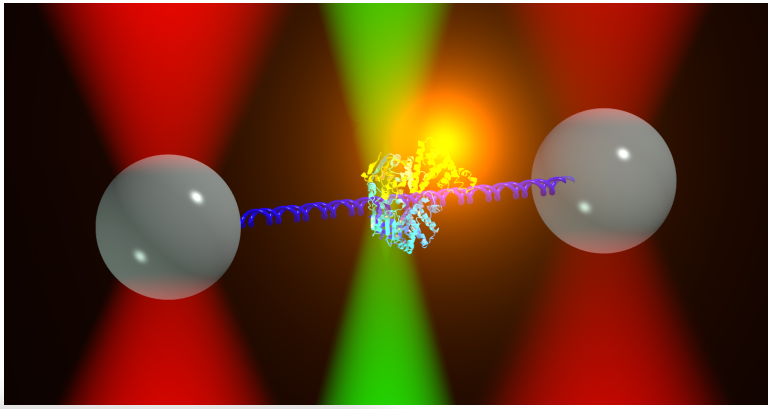
Experimental Physics Challenge

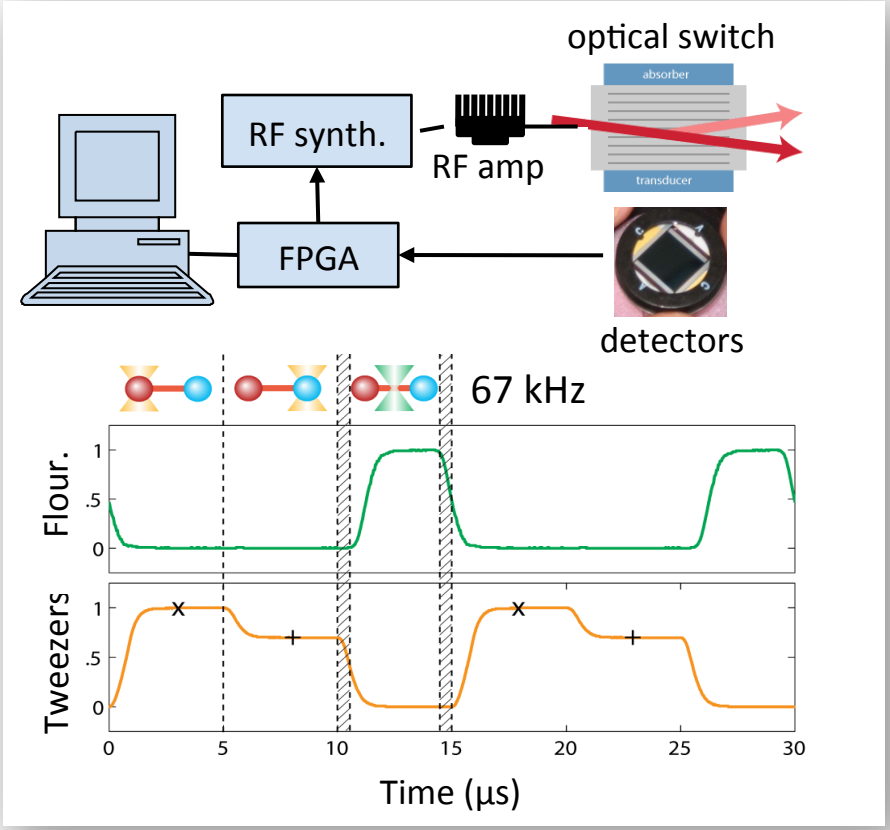




- Home-built microscope
- Sound-proof, low noise, temperature stabilized environment

Experimental Physics Challenge





- Home-built microscope
- Sound-proof, low noise, temperature stabilized environment
- Dynamic control of lasers
- High-speed synchronized electronics and computer control

We are building this at Michigan State!