



# The Biological Nanomotors Lab

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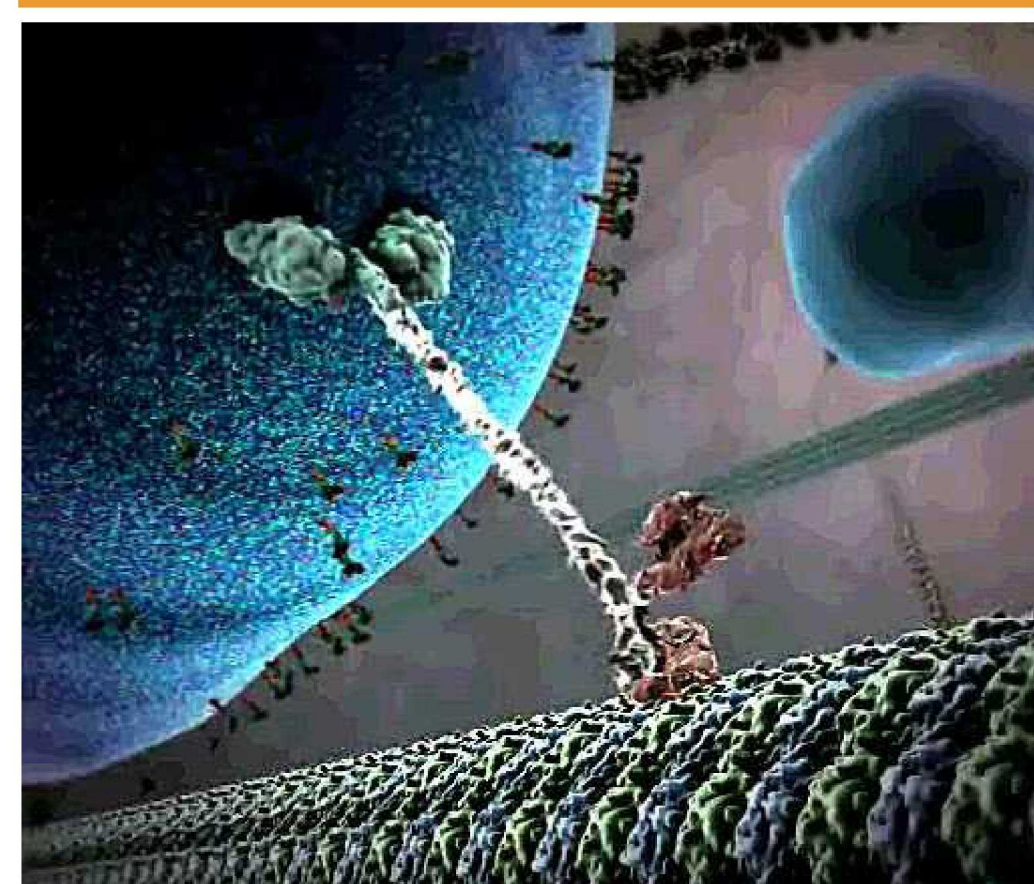
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## Biomolecular Motors & Nanotechnology

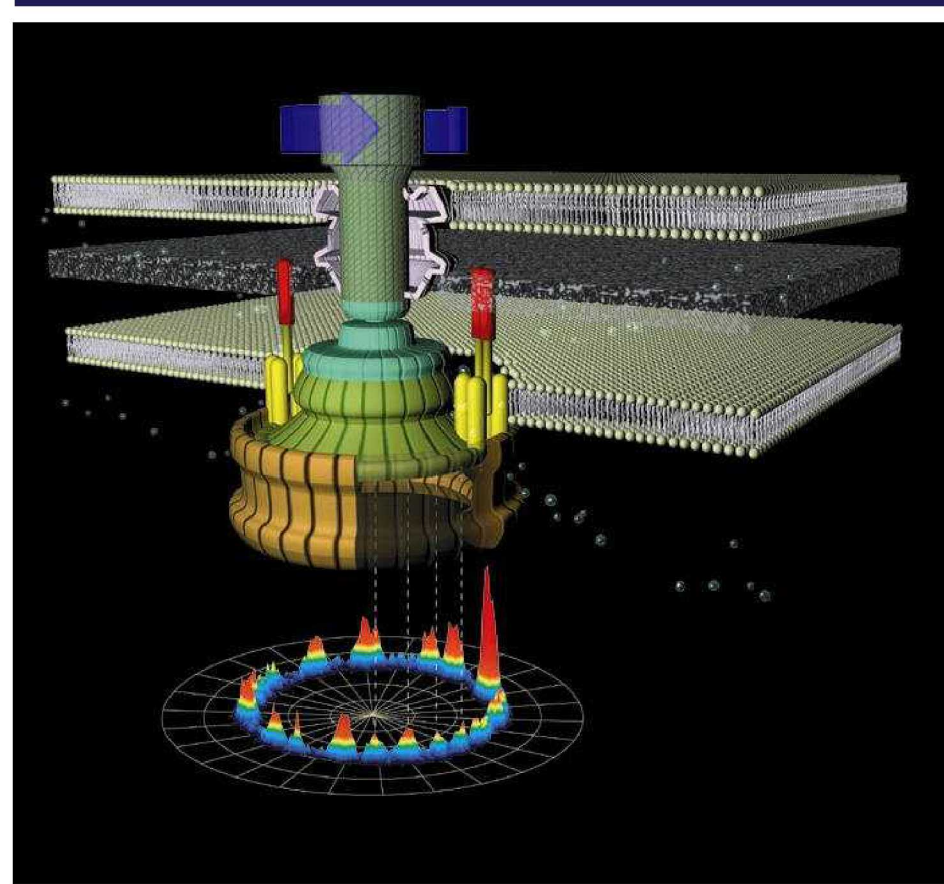
Nature provides brilliant examples of nanoscale engines and actuators that perform a variety of macroscale functions including cellular locomotion, nanofluidic transport, energy production, and muscle actuation.

### Nanoscale transport of matter



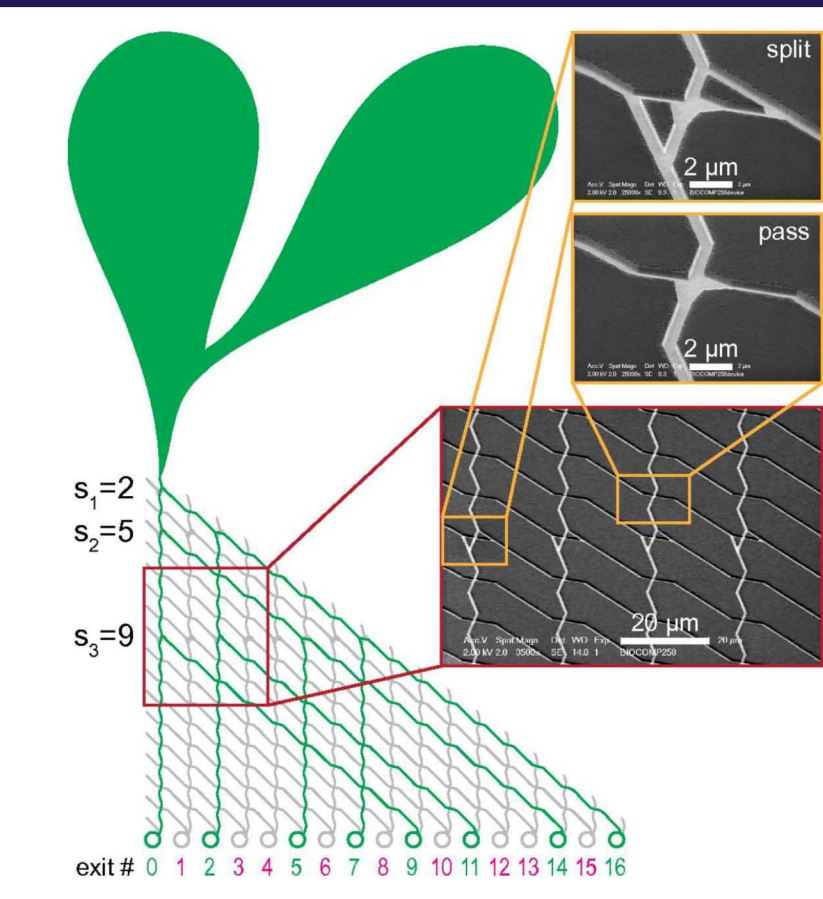
R. Lue & A. Viel/Harvard University and J. Liebler/XVIVO, LLC

### Microscale locomotion



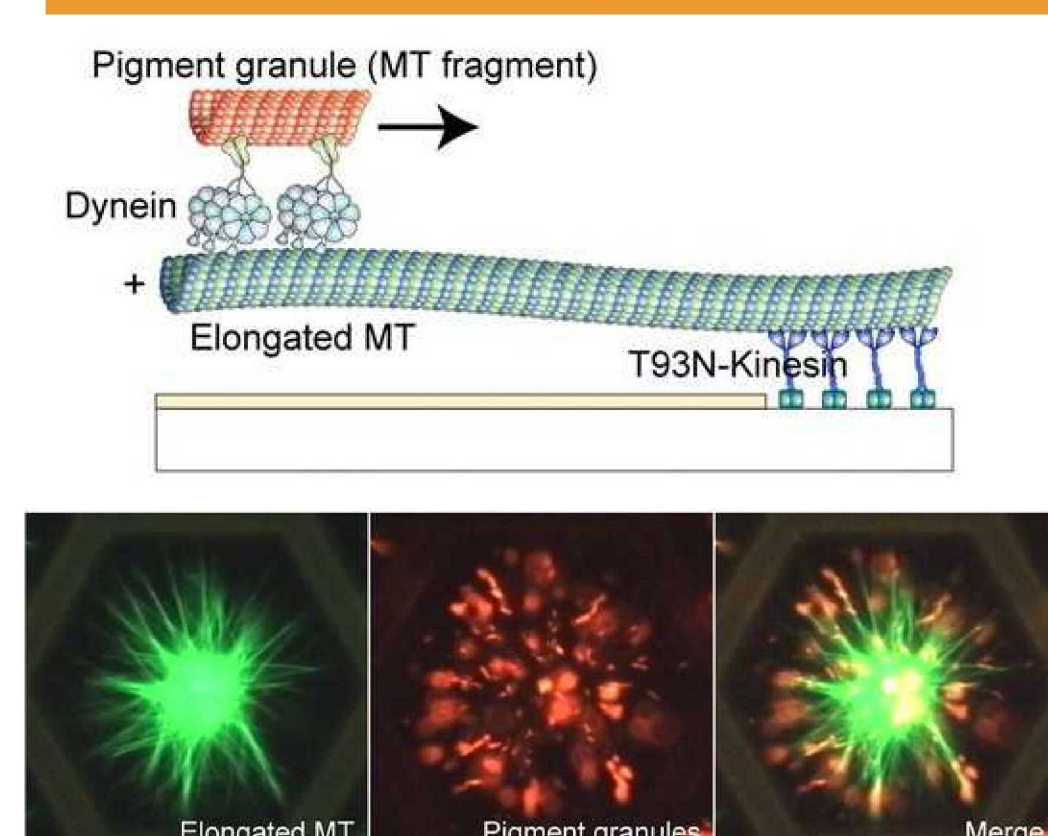
Akihiko Ishijima, <http://www.fbs.osaka-u.ac.jp/labs/ishijima/index-E.html>

### Computation using biomotors



Nicolau et al., 2016, *Proc. Natl. Acad. Sci.*

### Self-organized optical devices

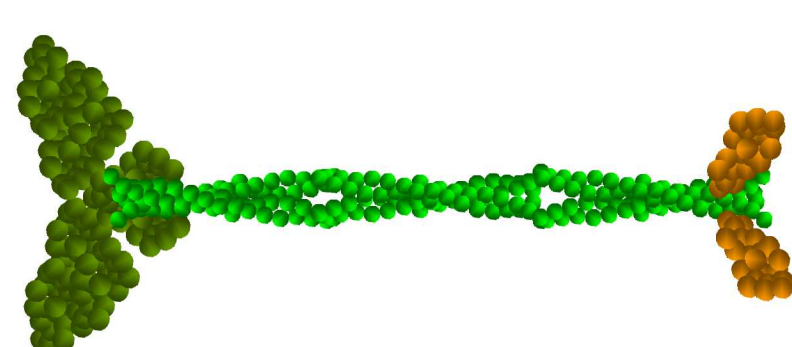


Aoyama et al., 2013, *Proc. Natl. Acad. Sci.*

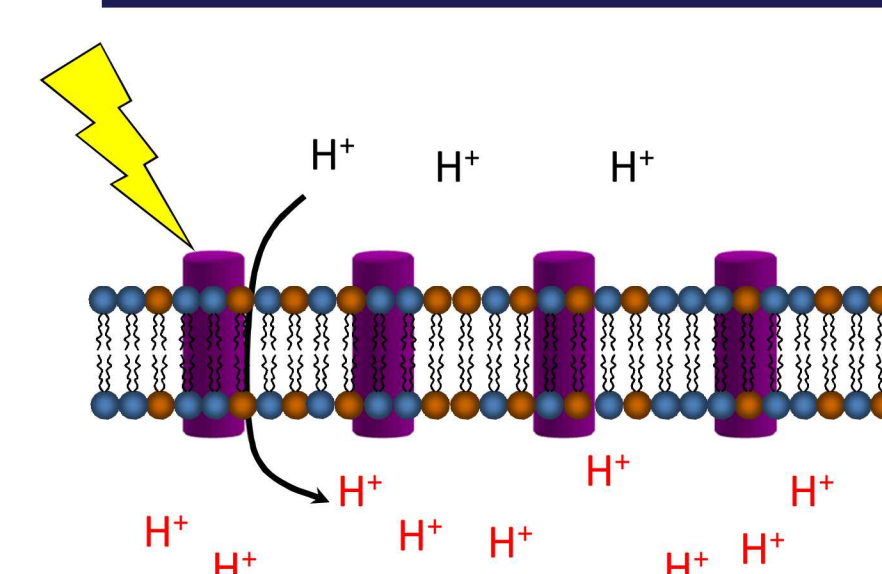
## Toolbox of Biological Nanomotors

A variety of biological nanomotors have been isolated and reconstituted *ex vivo*. CINT's library of biomotors includes:

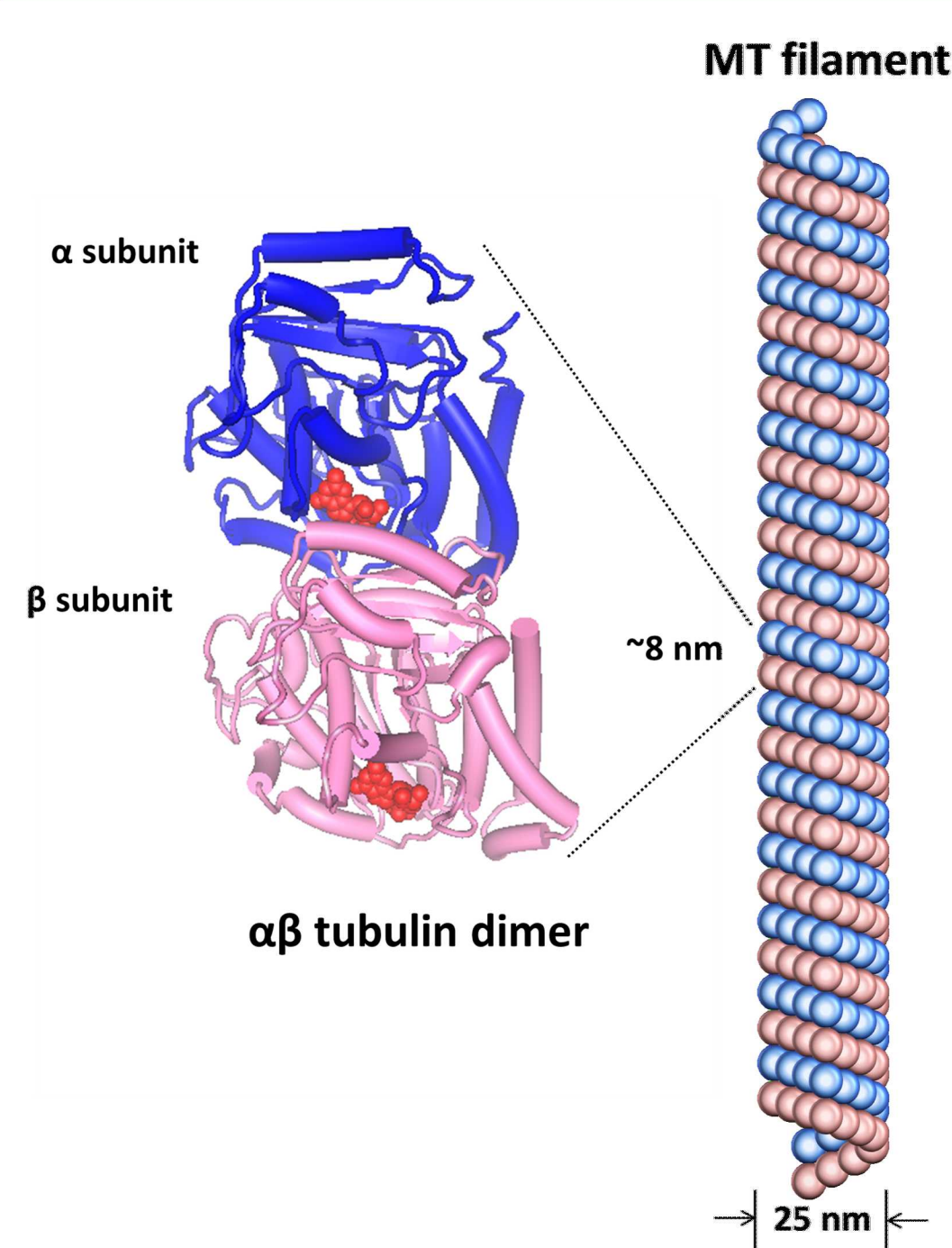
### Kinesin transport motor



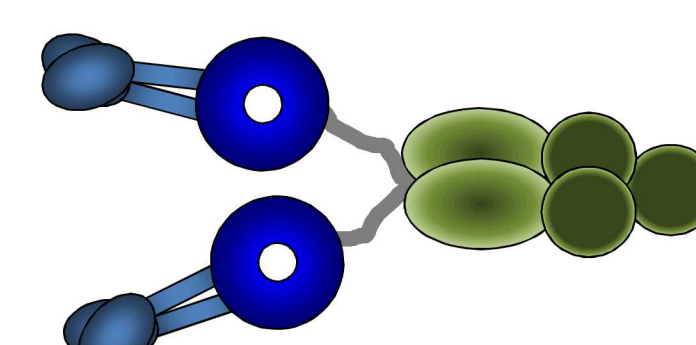
### Bacteriorhodopsin light-driven proton pump



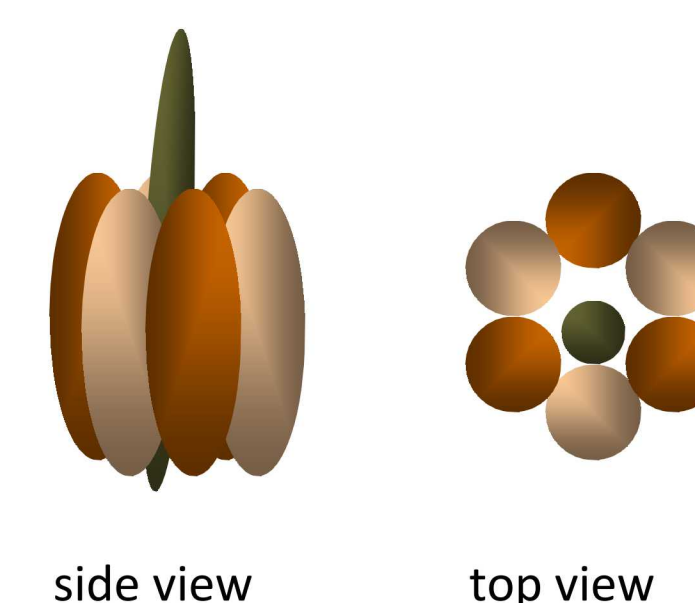
### Microtubule (MT) active biopolymer



### Dynein linear motor

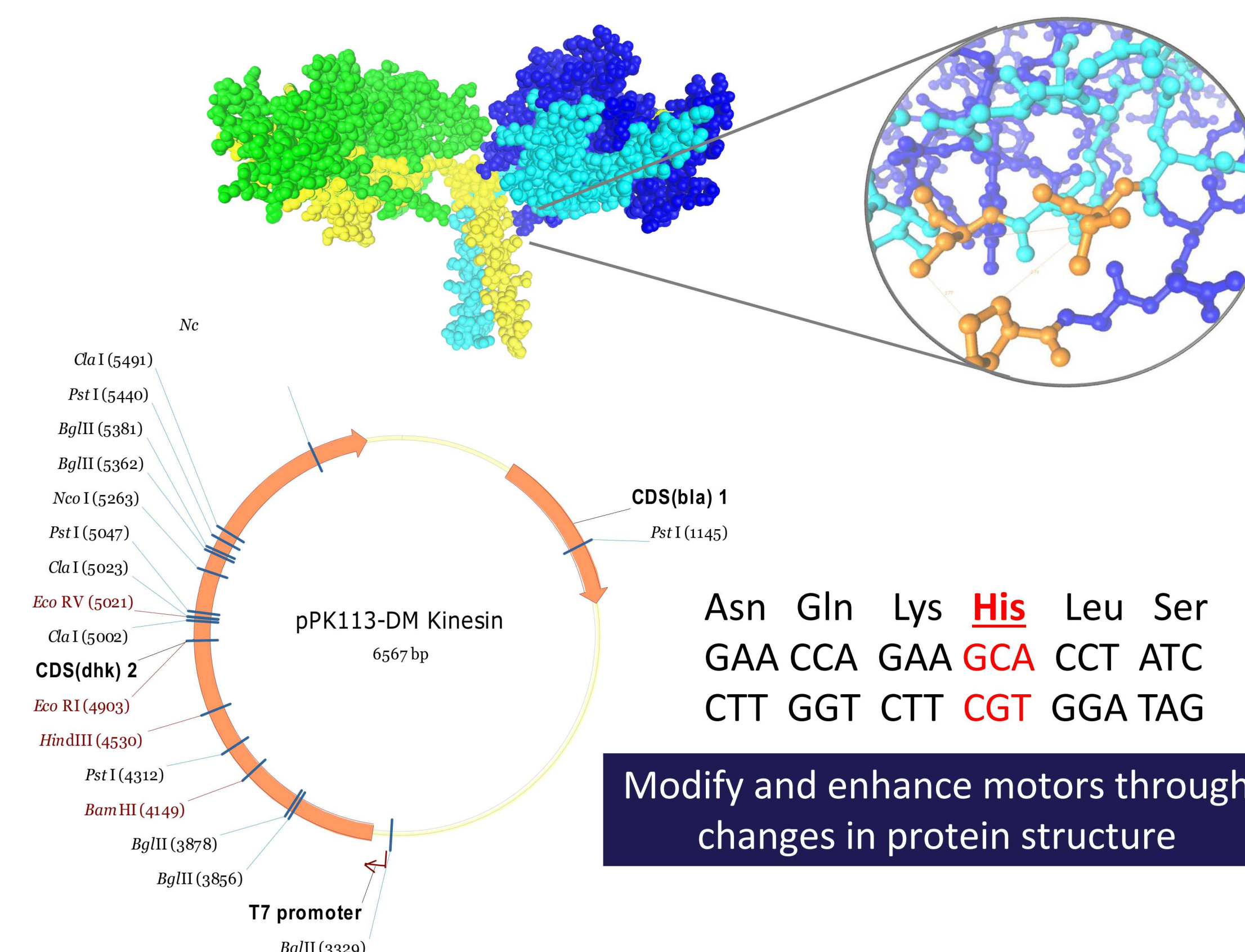


### F<sub>1</sub>-ATP synthase rotary motor



## Design and Production of Biomotors

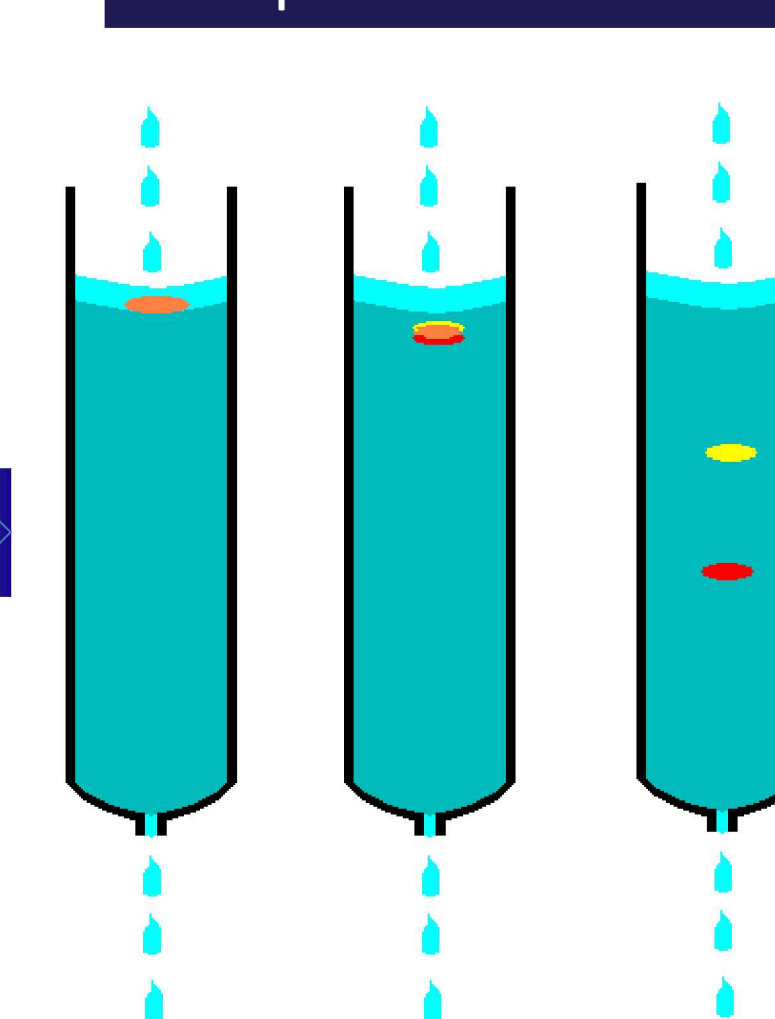
Genetic and protein engineering techniques are used to develop specialized biomotors for use in integrated nanosystems.



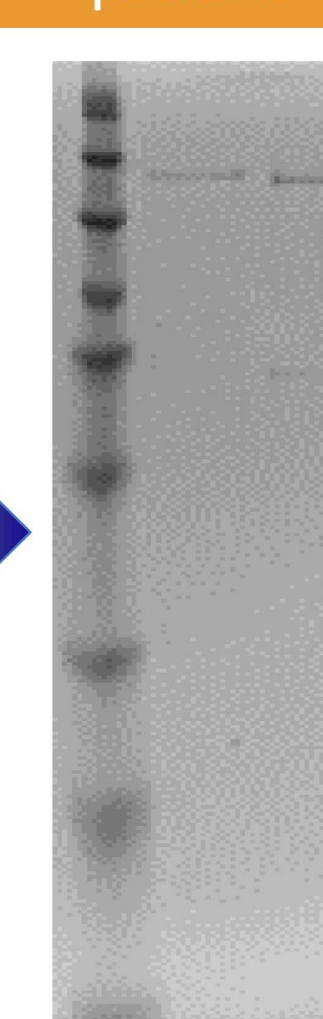
### Production in bacterial "factories"



### Separation and purification



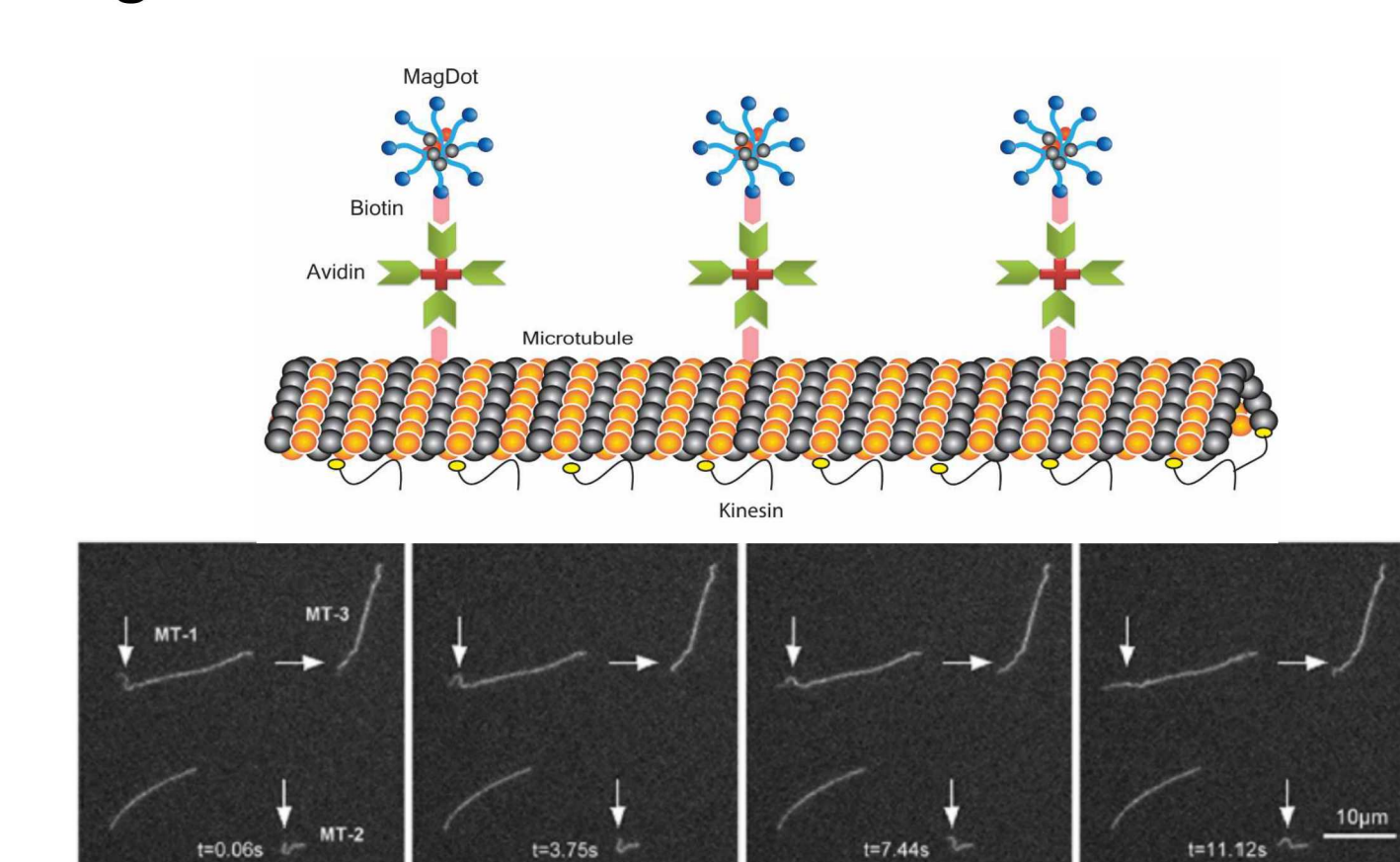
### Purified protein



## Examples of CINT User Projects

### Magnetic Steering of Biomotor Transport

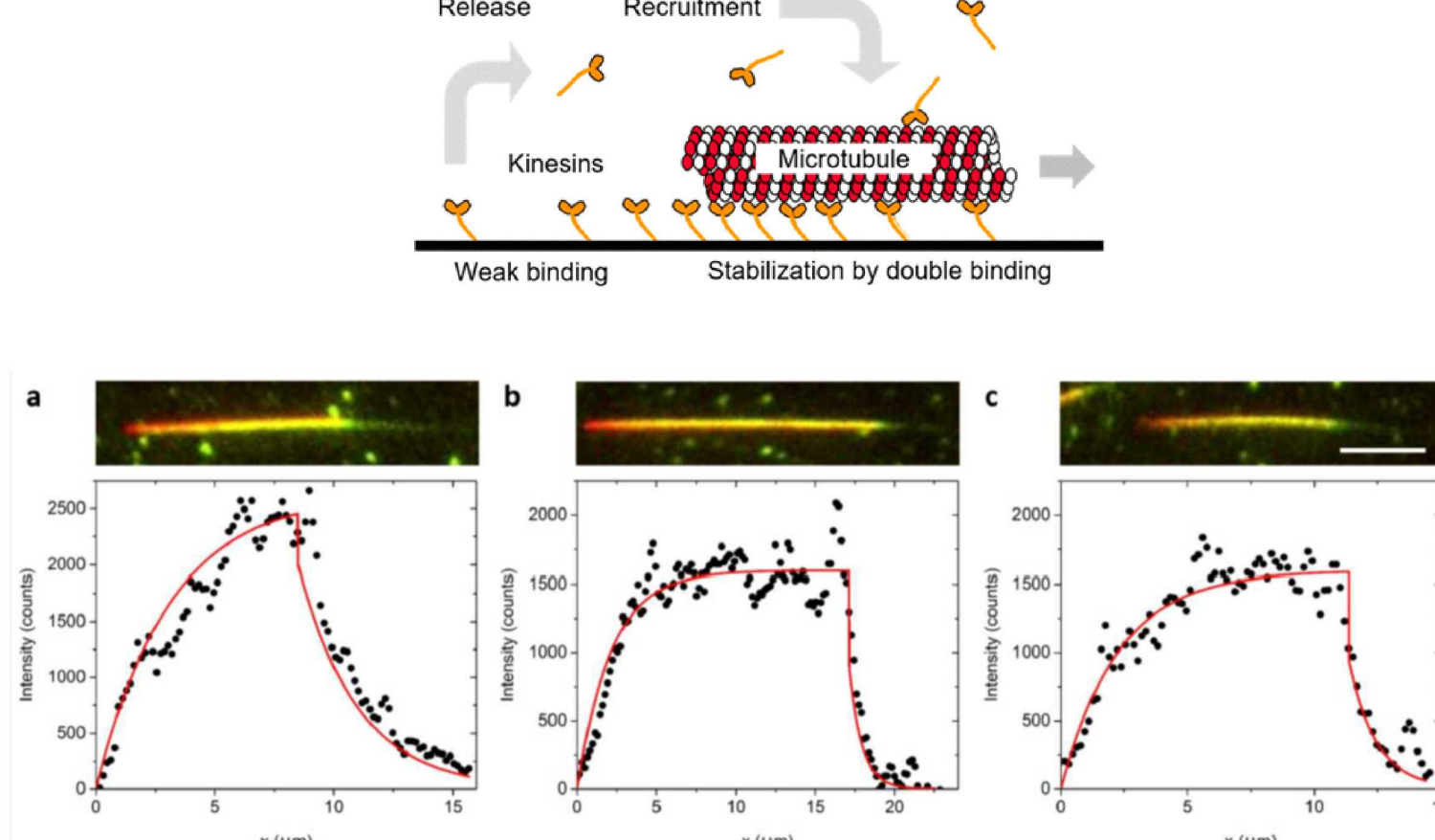
**User:** Jessica Winter (Ohio State University)  
**Accomplishment:** Demonstrated controlled steering and removal of microtubule transport using magnetic nanoparticles and external magnetic fields.



Mahajan et al., 2016, *Nanoscale*; Mahajan et al., 2018, *Biotechnol. J.*

### Dynamic Recruitment of Biomotors

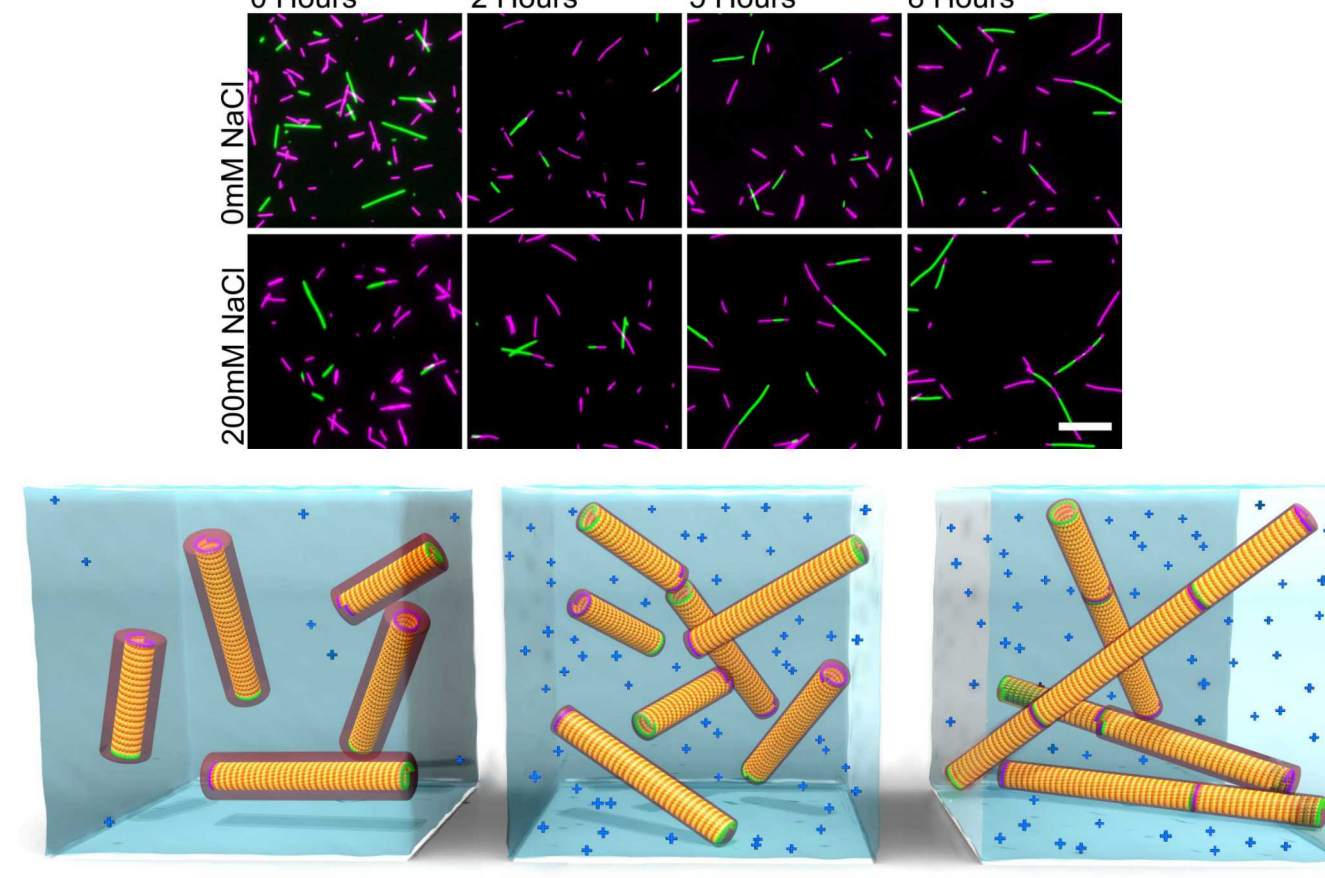
**User:** Henry Hess (Columbia University)  
**Accomplishment:** Realized a system in which active building blocks (i.e., motors) dynamically assembly and disassemble while retaining transport function.



Lam et al., 2018, *Nano Letters*

### Directed Assembly of Janus Bio-Rods

**User:** Adrienne Greene (Sandia National Labs)  
**Accomplishment:** Described the role of long- and short-range interactions in the head-to-tail assembly of microtubule filaments.



Greene et al., 2017, *Chem. Comm.*

## Acknowledgments

This work was performed, in part, at the Center for Integrated Nanotechnologies, an Office of Science User Facility operated for the U.S. Department of Energy (DOE) Office of Science. Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. DOE's National Nuclear Security Administration under contract DE-NA-0003525. The views expressed in the article do not necessarily represent the views of the U.S. DOE or the United States Government.