The Princeton Center for Theoretical Science is dedicated to exploring the frontiers of theory in the natural sciences. Its purpose is to promote interaction among theorists and seed new directions in research, especially in areas cutting across traditional disciplinary boundaries.

The Center is home to a corps of Center Postdoctoral Fellows, chosen from nominations made by senior theoretical scientists around the world. A group of senior Faculty Fellows, chosen from science and engineering departments across the campus, are responsible for guiding the Center. Center activities include focused topical programs chosen from proposals by Princeton faculty across the natural sciences. The Center is located on the fourth floor of Jadwin Hall, in the heart of the campus "science neighborhood". The Center hopes to become the focus for innovation and cross-fertilization in theoretical natural science at Princeton.

Faculty Fellows
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Igor Klebanov, Associate Director
Adam Burrows
Curtis Callan
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To find out more about Center Postdoctoral Fellowships and Programs see: http://pcts.princeton.edu/pcts

“Intracellular Phase Transitions: RNA, Protein, Lipids and Beyond”

20-22 April 2015
Jadwin Hall, Room 407

Workshop Organizers
Cliff Brangwynne (Princeton CBE)
Mikko Haataja (Princeton MAE)
Ned Wingreen (Princeton MolBio)

This workshop is co-sponsored by the Department of Chemical and Biological Engineering; LSI in the Department of Molecular Biology; Mechanical and Aerospace Engineering; Chemistry and the NSF.
Phase Transitions have emerged as a powerful and ubiquitous organizing principle within living cells. 2D phase transitions in lipid bilayers have been suggested as a mechanism for organizing membranes and associated signal transduction networks. Intense work has shed light on the properties of these so-called “lipid rafts”, which have been suggested to arise from intracellular membranes being in close proximity to a critical point. More recently, 3D liquid-liquid phase transitions have been shown to occur within the cytoplasm of living cells, and appear to underlie the assembly of various RNA/protein organelles. Much theoretical and experimental work is underway to understand the rules governing these phase transitions, and the way in which they are coupled to RNA metabolism and other biological functions. This topic represents the interface of an exciting area of physics concerning active non-equilibrium systems and the exploding interest in the role of RNA and other molecules in the spatial organization of the cell.

### DAY 1: Monday April 20, 2015

**8:30am** Continental Breakfast/Coffee at PCTS

**8:50 am** Welcoming Remarks Cliff Brangwynne

Session Chair: **Cliff Brangwynne**

**9:00am** Observed transport as a signature of membrane composition: Subdiffusion in the liquid ordered phase. 

*Ed Lyman, Delaware*

**9:30am** Phases and Fluctuations in cell plasma membranes

*Sarah Veatch, Univ Michigan*

**10:00am** Allosteric regulation by a nearly critical membrane 

*Ben Machta, Princeton University*

**10:15am** Coffee Break

**10:45am** The quantitative effect of molecular crowding on the action of restriction enzymes on DNA brushes

*Giacinto Scoles, Emeritus, Princeton U Chemistry*

**11:00 am** Modeling lipid composition dynamics and protein motion on the surface of lipid bilayer membranes

*Frank Brown, UCSB*

**11:30 am** The differentiation of phase separation in stem cell plasma membranes

*Ilya Levental, UT Houston*

**Noon** Lunch at PCTS, Jadwin Hall, Fourth Floor

Session Chair: **Mikko Haataja**

**1:30pm** Modulation in all things

*Michael Schick Univ. Washington*

**2:00pm** Compositional control of phase separated protein droplets

*Salman Banani, UT Southwestern*

**2:15pm** An atomistic view of the liquid-liquid phase separated state of FUS

*Nick Fawzi, Brown University*

**2:30-4pm** Poster Session + Coffee (*EVEN* Posters Presenting)
Intracellular Phase Transitions:
RNA, Protein, Lipids and Beyond

DAY 1: Monday April 20, 2015 - Continued

4:00pm Development of Photonic Nanostructures in Birds and Insects
Eric Dufresne, Yale

4:45 pm <MOVE TO McDonnell A01 for public lecture>

5:00-5:45 pm "Public Lecture", Room A01, McDonnell Hall
Introduction by Mikko Haataja, Princeton University
Short stories in membrane biophysics of how complex behavior arises from minimal components
Sarah Keller, Univ. Washington

6:00pm Welcome Reception at PCTS – Drinks and Appetizers for registered attendees only.

DAY 2: Tuesday, April 21, 2015
8:30am Continental Breakfast/Coffee at PCTS
Session Chair: Ned Wingreen

9:00am RNA-driven phase separated droplets in cell cycle regulation and cell polarity
Amy Gladfelter, Dartmouth

9:30am Impact of Sequence and Cellular Contexts on Polyglutamine Phase Behavior
Rohit Pappu, Washington University in St. Louis

10:00am Nucleolar assembly and growth are governed by a concentration-dependent phase transition
Stephanie Weber, Princeton University

10:15am Coffee Break

10:45am Assembly Dynamics of Intracellular Liquid-Phase Organelles: Nucleoli and Extranucleolar Droplets in C. elegans Embryos
Joel Berry, Princeton University

11:00 am Phase Separation of Multivalent Proteins
Mike Rosen, UT Southwestern

11:30 am Liquid droplets out of equilibrium
Richard Sear, Surrey

Noon Lunch at PCTS, Jadwin Hall, Fourth Floor

DAY 2: Tuesday, April 21, 2015 - continued

Session Chair: Chase Broedersz

1:30pm Interactions of intrinsically disordered regions that drive protein phase separation and the resulting material properties
Julie Forman-Kay, University of Toronto and Hospital for Sick Children

2:00pm RNA drives phase separation of an RNA binding protein to organize the cytosol of multinucleate cells
Huaiying Zhang, Dartmouth

2:15pm Multiscale Modeling of the Impact of Sequence Context on Polyglutamine Aggregation and Phase Behavior
Kiersten Ruff, Washington U. St. Louis

2:30-4pm Poster Session + Coffee (*ODD* Posters Presenting)

4:00pm Experimental models for intracellular organization based on phase separation in aqueous polymer and biopolymer solutions
Christine Keating, PennState

4:45 pm <MOVE TO McDonnell A01 for public lecture>

5:00-5:45 pm "Public Lecture", Room A01, McDonnell Hall
Introduction by Cliff Brangwynne, Princeton University
Phase separation in biology: implications for polarity and disease.
Tony Hyman, Dresden

DAY 3: Wednesday, April 22, 2015
8:30am Continental Breakfast/Coffee at PCTS
Session Chair: Stephanie Weber

9:00am Recent advances in the understanding of intraerythrocytic sickle cell hemoglobin polymerization
Peter Vekilov, Houston

9:30am In vitro reconstitution of a P granule-like phase
Shambaditya Saha, Max Planck Institute of Molecular Cell Biology and Genetics
### Intracellular Phase Transitions: RNA, Protein, Lipids and Beyond

**DAY 3: Wednesday, April 22, 2015 - continued**

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<th>Time</th>
<th>Event</th>
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| 9:45am | The disordered P granule protein LAF-1 drives phase separation into droplets with tunable viscosity and dynamics  
  *Shani Elbaum, Princeton University* |
| 10:00am| **Coffee Break**                                                      |
| 10:30am| Keeping it together: Organizing the bacterial chromosome for division  
  *Chase Broedersz, Princeton University* |
| 10:45am| Physical properties of the bacterial cytoplasm  
  *Christine Jacobs-Wagner, Yale* |
| 11:15am| Phase separation and transport selectivity of nuclear pores  
  *Dirk Gorlich, Gottingen* |
| 11:45pm| Concluding Remarks                                                   |