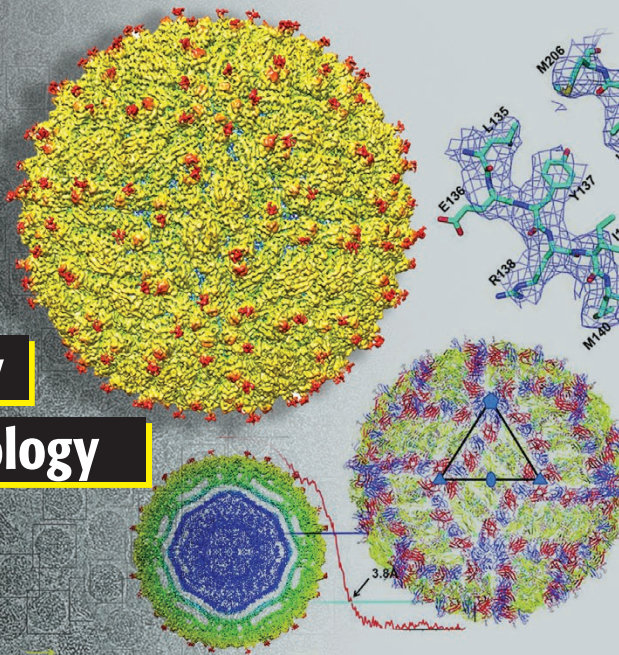


**4<sup>th</sup> Annual**  
**Interdisciplinary**  
**Quantitative Biology**  
**BOOT CAMP**



# Single Particle Cryo-Electron Microscopy

## Program

**January 3–13, 2017**

**Center for Integrative Proteomics Research**  
Rutgers University • Busch Campus  
174 Frelinghuysen Rd  
Piscataway, NJ 08854-8076



Institute for Quantitative  
Biomedicine at Rutgers

Graduate Program in  
Quantitative Biomedicine

Center for Integrative  
**PROTEOMICS**  
Research

[iqb.rutgers.edu/bootcamp](http://iqb.rutgers.edu/bootcamp)

**RUTGERS**  
THE STATE UNIVERSITY  
OF NEW JERSEY

# Interdisciplinary Quantitative Biology Boot Camp

## Single Particle Cryo-Electron Microscopy

The Center for Integrative Proteomics Research, home to the Institute for Quantitative Biomedicine, and the Graduate Program in Quantitative Biomedicine are delighted to be hosting the Fourth Annual Rutgers Interdisciplinary Quantitative Biology Boot Camp. This year's Boot Camp is focused on Single-Particle Cryo-Electron Microscopy.

Boot Camp is designed to complement traditional Rutgers course offerings by actively illustrating to our students, staff, and faculty, and research scientists from the pharmaceutical industry, the value of integrating biology and medicine with mathematics, physics, chemistry, computer science, statistics and biostatistics, and engineering.

The 2017 immersive two-week Boot Camp has been designed to provide participants with:

(1) a fundamental understanding of the cryo-electron microscope and its capabilities and limitations, (2) guidance in how to evaluate their own sample(s) prior to microscopy using biochemical and biophysical characterization tools, (3) an opportunity to evaluate their own sample(s) by taking a limited number of test images with the new Rutgers microscope, and (4) familiarity and competency with the computational approaches and tools used for processing single-particle cryo-electron microscopy (cryo-EM) image data and determining and interpreting three-dimensional structures derived therefrom.

Instruction will take the form of morning lectures on the A-to-Z of single-particle cryo-EM, highlighting the power of modern instrumentation, best practices in sample preparation, and methods for analyzing and interpreting the data obtained. In addition to the lectures, a broad range of collaborative hands-on afternoon workshops will empower attendees with the skills needed to uncover the three-dimensional structures of their favorite biological machines. Attendees will be divided into teams, each tasked with determining a given biological structure using previously measured single-particle cryo-EM images. There will also be career development activities, tours of the Rutgers New Jersey Cryo-Electron Microscopy and Tomography Core Facility, the Rutgers Core Imaging Lab, and the Biological Mass Spectrometry Facility, a variety of fun activities for relaxing, and two end-of-week networking opportunities.

The final afternoon of the Boot Camp will be devoted to a participant-led presentation on single-particle cryo-EM and related methods using data generated during the course of Boot Camp. This activity will require collaborative synthesis of the material covered in the two-week program.

The Boot Camp would not have been possible without tireless efforts of the many contributors listed in the back of this Program.

Special thanks go out to Michelle Sanghera, Abayomi Olaogun, Kenneth Dalenberg, Luz Fajardo, Bernie Cariaga, and Don Corrette of the Institute for Quantitative Biomedicine and/or the Center for Integrative Proteomics Research, and Rutgers undergraduate student Krupa Shah.

Note:



All sessions will be held in **PROTEOMICS, ROOM 120**  
unless designated otherwise



Laptop computers are required for sessions  
designated with this icon

Tuesday, January 3<sup>rd</sup> 2017

9:00 AM	<b>Welcome and Orientation</b> Stephen K. Burley and Gail Ferstandig Arnold, IQB
9:20 AM	<b>Cryo-Electron Microscopy: Resolution Revolution</b> Stephen K. Burley
9:40 AM	<b>History of Electron Microscopy</b> Dennis Thomas, CIPR
10:30 AM	<i>Coffee/Tea Served</i>
11:00 AM	<b>What Makes a Good Sample for Structural Studies?</b> Stephen K. Burley and Dennis Thomas
12:00 PM	<i>Lunch Served Proteomics Main Lobby</i>
1:00 PM	<b>Career Byte: Branching Out: Meeting Colleagues!</b> Maria Qadri, BME
2:00 PM	<b>Organizational Meeting</b> • Review of Boot Camp program and goals • Organization of participants into teams Stephen K. Burley and Dennis Thomas
3:00 PM	<b>Core Facility Tours:</b> • Mass Spectrometry Facility (Proteomics) Peter Lobel and Team, CABM • CryoEM Plunger (Proteomics) Wei Dai, CIPR • Cryo-Electron Microscope (Proteomics) Dennis Thomas • Negative Stain Imaging Electron Microscope Facility, Core Imaging Lab (School of Public Health) Rajesh Patel, RWJMS
5:00 PM	<i>Welcome Reception Proteomics Main Lobby</i> <b>BINGO Mixer</b>

9:00 AM	<b>Objectives for Days 2-4</b> Stephen K. Burley and Dennis Thomas
9:15 AM	<b>Producing Samples for Single Particle Cryo-EM</b> Stephen K. Burley
10:00 AM	<b>Gel Electrophoresis Sample Loading by Participants</b> Joe Marcotrigiano and Team, CABM
10:45 AM	<i>Coffee/Tea Served</i>
11:05 AM	<b>Assessing Molecular Weight/Composition II</b> Peter Lobel , CABM
12:00 PM	<i>Lunch (independent)</i>
1:00 PM	<b>Career Byte: Resources Available at Rutgers Career Services; How to Make a Winning CV or Resume</b> Joe Scott, University Career Services
1:30 PM	<b>Organizational Meeting</b> Stephen K. Burley and Dennis Thomas
1:45 PM	 <b>Hands-On Mass Spectrometry Data Interpretation</b> Peter Lobel and Team
3:10 PM	<i>Coffee/Tea Served</i>
3:30 PM	 <b>Hands-On Gel Electrophoresis Data Interpretation</b> Joe Marcotrigiano and Team



9:00 AM	<b>Report Out</b> Participants
9:15 AM	<b>Assessing Monodispersity and Size I</b> Stephen K. Burley
10:00 AM	<b>Assessing Monodispersity and Size II</b> Davide Comoletti, CHINJ
10:45 AM	<i>Coffee/Tea Served</i>
11:15 AM	<b>A Single-Molecule Super-Resolution Microscopy View of Macromolecular Complexes in Cells</b> Sang-Hyuk Lee, CIPR
12:00 PM	<i>Lunch (independent)</i>
1:00 PM	<b>Career Byte: Giving an Engaging Presentation</b> Jerome Kukor, Graduate School, New Brunswick
1:30 PM	<b>Organizational Meeting</b> Stephen K. Burley and Dennis Thomas
1:45 PM	 <b>Hands-On Gel Filtration Data Interpretation</b> Joe Marcotrigiano and Team
3:10 PM	<i>Coffee/Tea served</i>
3:30 PM	 <b>Hands-On Light Scattering Data Interpretation</b> Eddy Arnold and Team, CABM




Friday, January 6<sup>th</sup>, 2017

9:00 AM	<b>Report Out</b> Participants
9:15 AM	<b>CryoEM Workflow: Test Tube → Images</b> Dennis Thomas
10:00 AM	<b>Choosing Your Buffer and Plunging Conditions</b> Dennis Thomas
10:45 AM	<i>Coffee/Tea Served</i>
11:00 AM	<b>Sample Grid Plunging, Data Screening, Preparation for and Acquisition of Data, and Preprocessing of Images*</b> Dennis Thomas and Wei Dai
12:00 PM	<i>Lunch (independent)</i>
1:00 PM	<b>Career Byte: Rutgers iJOBS; The Elevator Pitch</b> Janet Alder, RWJMS
1:30 PM	<b>Sample Grid Plunging, Data Screening, Preparation for and Acquisition of Data, and Preprocessing of Images* (Cont.)</b>
3:10 PM	<i>Coffee/Tea served</i>
3:30 PM	<b>Sample Grid Plunging, Data Screening, Preparation for and Acquisition of Data, and Preprocessing of Images* (Cont.)</b>
5:00 PM	<b>Networking Event</b> <i>Proteomics Main Lobby</i>

\* Participants will have an opportunity to have their samples plunged and screened for image quality and initial data acquisition (possibly over the weekend).



Monday, January 9<sup>th</sup> 2017

9:00 AM	<b>Welcome and Organizational Meeting</b> Stephen K. Burley and Gail Ferstandig Arnold
9:15 AM	<b>Cryo-Electron Microscopy: Resolution Revolution and Ligands</b> Stephen K. Burley
9:35 AM	<b>The Electron Microscope: Physics, Optics, and the Electron as a Photon</b> Dennis Thomas
10:10 AM	<b>Image Formation, Electron Detection, and Frame Alignment</b> Dennis Thomas
10:55 AM	<i>Coffee/Tea Served</i>
11:15 AM	<b>Image Contrast: Contrast Transfer Function (CTF) Determination and Correction, Phase Plate Technology</b> Dennis Thomas
12:00 PM	<i>Lunch (independent)</i>
1:00 PM	<b>Career Byte: Securing an Industrial Position</b> Edward Sherer, Merck & Co.
1:30 PM	<b>Cryo-EM Workflow: Data Processing</b> Dennis Thomas
2:00 PM	 <b>Workshop – Image Processing I: Evaluate Raw Images, Align Frames, Pick Particles</b> Dennis Thomas
3:10 PM	<i>Coffee/Tea Served</i>
3:30 PM	 <b>Workshop – Image Processing II: CTF Correction, Reference Free Alignment, 2D Classification</b> Dennis Thomas
5:00 PM	<i>Welcome Reception <b>Proteomics Main Lobby</b></i>

9:00 AM	<b>Report Out</b> Participants
9:15 AM	<b>One Size Does Not Fit All</b> <b>Initial Model Generation: <i>De Novo</i>, Common Lines, Basic Shapes, and Pre-Existing Models from Structure Databases</b> Dennis Thomas
10:15 AM	<i>Coffee/Tea Served</i>
10:30 AM	<b>KEYNOTE LECTURE:</b> <b>The Structure of Zika Virus as Determined Using Cryo-EM</b> Michael Rossmann, Purdue University
12:00 PM	<i>Lunch Served</i> <i>Proteomics Main Lobby</i>
1:00 PM	 <b>Career Byte:</b> <ul style="list-style-type: none"> <li>• <b>GradFund</b> Teresa Delcorso Ellmann, GSNB and Senem Kaptan, Rutgers</li> <li>• <b>Being Organized; Making Business Cards</b> Gail Ferstandig Arnold</li> </ul>
1:45 PM	<b>Organizational Meeting</b> <b>Molecular Origami</b> Stephen K. Burley and Dennis Thomas
2:15 PM	 <b>Workshop – Initial Model Generation</b> Dennis Thomas
2:45 PM	<i>Coffee/Tea Served</i>
3:00 PM	 <b>Workshop – Iterative Refinement/Launch Overnight Refinement</b> Dennis Thomas



9:00 AM	<b>Report Out</b> Participants
9:15 AM	<b>Common Methods/Software Packages: The Image Processing Toolbox</b> Dennis Thomas
9:50 AM	<b>Classification Methods: 2D, 3D; Maximum Likelihood</b> Dennis Thomas
10:25 AM	<i>Coffee/Tea Served</i>
10:45 AM	 <b>Structure Validation: Is the Structure Right? What is the Resolution? How Do I Know? Deposition to the PDB and EMDB Databases</b> Cathy Lawson, EMDataBank
11:30 AM	<b>How to become a Rutgers CryoEM User</b> Dennis Thomas
12:00 PM	<i>Lunch (independent)</i>
1:00 PM	 <b>Career Byte: Finding Jobs and Collaborators Using LinkedIn</b> Gail Ferstandig Arnold
1:30 PM	<b>Organizational Meeting</b> Stephen K. Burley and Dennis Thomas
1:45 PM	 <b>Workshop – Structure Visualization: How to Look at a Three-Dimensional Map and Interpret It</b> Brian Hudson, RCSB PDB; Shuchismatta Dutta, RCSB PDB; Christopher Markosian, Rutgers
3:10 PM	<i>Coffee/Tea Served</i>
3:30 PM	 <b>Workshop – Molecular Modeling: Fitting Atomic Structures, Rigid Body versus Flexible Fitting; Molecular Dynamics</b> Dennis Thomas; Matthew Miller, CABM; David Case, CIPR
5:00 PM	<b>Downtown Meeting</b> <i>Meet in Proteomics Main Lobby</i>

9:00 AM	<b>Report Out</b> Participants
9:15 AM	 <b>Workshop – Molecular Modeling: Fitting Your Data Using the PDB and Databases to Evaluate and Interpret Your Results</b> Dennis Thomas
10:30 AM	<i>Coffee/Tea Served</i>
10:50 AM	 <b>Workshop – Preparing Your Results for Publication: How Do I Make CryoEM Structures Clear and Understandable? Structure Informs Biology!</b> Dennis Thomas
12:00 PM	<i>Lunch (independent)</i>
1:00 PM	<b>Round Up</b> Dennis Thomas, Stephen K. Burley, Wei Dai, Gail Ferstandig Arnold
1:15 PM	<b>Structural Data Analysis; Preparation for Final Presentation</b>
3:00 PM	<b>Career Byte: Being All You Can Be and Showing It</b> Larry Jacobs, Career Development Specialist and Professor
3:30 PM	<b>Structural Data Analysis; Preparation for Final Presentation (Cont.)</b> <i>Coffee/Tea available throughout afternoon</i>

9:00 AM	<b>Finalization of Presentation</b> <i>Coffee/Tea available throughout morning</i>
12:00 PM	<i>Lunch Served <b>Proteomics Main Lobby</b></i>
1:00 PM	<b>Final Presentation</b>
3:00 PM	<b>Networking with "Speed Dating" and Group Style Meet and Greet</b> <i>Reception with Special Dessert <b>Proteomics Main Lobby</b></i>

## **Janet Alder, Ph.D.**

Associate Professor, Neuroscience and Cell Biology  
Assistant Dean, Graduate Academic and Student Affairs  
Rutgers Robert Wood Johnson Medical School

## **Eddy Arnold, Ph.D.**

Board of Governors Professor, Chemistry and Chemical Biology  
Resident Member, Center for Advanced Biotechnology and Medicine  
Member, Center for Integrative Proteomics Research  
Full Member, Rutgers Cancer Institute of New Jersey  
Rutgers University

## **Gail Ferstandig Arnold, Ph.D.**

Associate Director, Institute for Quantitative Biomedicine  
Associate Director of Graduate Studies, Quantitative Biomedicine  
Rutgers University

## **Stephen K. Burley, M.D., D.Phil.**

Director, Center for Integrative Proteomics Research  
Founding Director, Institute for Quantitative Biomedicine  
Director, Research Collaboratory for Structural Bioinformatics Protein Data Bank  
Distinguished Professor, Chemistry and Chemical Biology  
Full Member, Rutgers Cancer Institute of New Jersey  
Rutgers University

## **Bernadette Cariaga, C.P.A.**

Business Manager, Center for Integrative Proteomics Research  
Rutgers University

## **David A. Case, Ph.D.**

Distinguished Professor, Chemistry and Chemical Biology  
Resident Member, Center for Integrative Proteomics Research  
Rutgers University

## **Davide Comoletti, D.V.M., Ph.D.**

Assistant Professor, Neuroscience and Cell Biology  
Child Health Institute of New Jersey  
Rutgers Robert Wood Johnson Medical School

## **Don Corrette**

Building Manager, Center for Integrative Proteomics Research  
Rutgers University

## **Wei Dai, Ph.D.**

Assistant Professor, Cell Biology and Neuroscience  
Resident Member, Center for Integrative Proteomics Research  
Associate II Member, Cancer Metabolism and Growth Program  
Rutgers University

## **Kenneth Dalenberg, B.A.**

Unit Computing Specialist, Center for Integrative Proteomics Research  
Rutgers University

**Kalyan Das, Ph.D.**

Research Professor, Chemistry and Chemical Biology  
Investigator, Center for Advanced Biotechnology and Medicine  
Rutgers University

**Teresa Delcorso Ellmann, M.A.**

Assistant Dean, Graduate Student External Support  
Director, GradFund  
Rutgers University

**Shuchismita Dutta, Ph.D.**

Assistant Research Professor, Chemistry and Chemical Biology  
Senior Educational Coordinator, Research Collaboratory for Structural Bioinformatics Protein Data Bank  
Rutgers University

**Luz A. Fajardo, B.Sc.**

Administrative Coordinator, Center for Integrative Proteomics Research  
Rutgers University

**Jonathan Hackett, B.A.**

Accounting Assistant, Center for Integrative Proteomics Research  
Rutgers University

**Brian Hudson, Ph.D.**

Research Associate, Chemistry and Chemical Biology  
Biocurator, Research Collaboratory for Structural Bioinformatics Protein Data Bank  
Rutgers University

**Larry Jacobs, M.Sc., Ed.S.**

Career Development Specialist for Undergraduate Academic Affairs  
University Career Services  
Adjunct Professor, Psychology  
Rutgers University

**Senem Kaptan, B.A.**

Graduate Student, Anthropology  
Rutgers University

**Jerome Kukor, Ph.D.**

Dean, Graduate School - New Brunswick  
Professor, Environmental Science  
Rutgers University

**Catherine Lawson, Ph.D.**

Associate Research Professor, Chemistry and Chemical Biology  
Rutgers University

**Sang-Hyuk Lee, Ph.D.**

Assistant Professor, Physics and Astronomy  
Resident Member, Center for Integrative Proteomics Research  
Associate II Member, Cancer Pharmacology Program, Rutgers Cancer Institute of New Jersey  
Rutgers University

**Peter Lobel, Ph.D.**

Professor, Pharmacology  
Resident Member, Center for Advanced Biotechnology and Medicine  
Member, Center for Integrative Proteomics Research  
Full Member, Cancer Metabolism and Growth Program  
Rutgers Robert Wood Johnson Medical School

**Joseph Marcotrigiano, Ph.D.**

Associate Professor, Chemistry and Chemical Biology  
Resident Member, Center for Advanced Biotechnology and Medicine  
Member, Center for Integrative Proteomics Research  
Rutgers University

**Christopher Markosian**

Undergraduate Student, Molecular Biology and Biochemistry  
Rutgers University

**Jennifer Casiano Matos, M.Sc.**

Graduate Student, Microbiology and Molecular Genetics  
Rutgers University

**Matthew Miller, Ph.D.**

Research Assistant Professor, Chemistry and Chemical Biology  
Rutgers University

**Harry Namkoong, B.Sc.**

System Administrator, Center for Integrative Proteomics Research  
Rutgers University

**Abayomi Olaogun, B.A.**

Administrative Assistant, Institute for Quantitative Biomedicine  
Rutgers University

**Rajesh Patel, Ph.D.**

Laboratory Manager, Core Imaging Lab  
Rutgers Robert Wood Johnson Medical School

**Maria Qadri, M.Sc.**

Graduate Student, Biomedical Engineering and Quantitative Biomedicine  
Graduate Student Fellow, Rutgers Academy for the Scholarship of Teaching and Learning  
Rutgers University

**Michael Rossmann, Ph.D.**

Hanley Distinguished Professor of Biological Sciences  
Purdue University

**Michelle Sanghera, B.A.**

Administrative Coordinator, Institute for Quantitative Biomedicine  
Rutgers University

**Krupa Shah**

Undergraduate Student  
Rutgers University

**Edward Sherer, Ph.D.**

Principal Scientist, Structural Chemistry  
Merck & Company, Inc.

**Joe Scott, M.A.**

Associate Director, Career Development (STEM Clusters)  
University Career Services  
Rutgers University

**Dennis Thomas, Ph.D.**

Associate Research Professor, Cell Biology and Neuroscience  
Manager, Rutgers-New Jersey Cryo-Electron Microscopy and Tomography Core Facility, Center for Integrative Proteomics Research  
Rutgers University

**Lynda Tuberty, M.Sc.**

Laboratory Researcher/Laboratory Manager  
Center for Advanced Biotechnology and Medicine  
Rutgers University

**Maria Voigt, M.A.**

Outreach Coordinator, Research Collaboratory for Structural Bioinformatics Protein Data Bank  
Center for Integrative Proteomics Research  
Rutgers University

**Chen Wang, B.Sc.**

Graduate Student, Microbiology and Molecular Genetics  
Rutgers University

**Yuanyuan Wang, M.Sc.**

Graduate Student, Chemistry and Chemical Biology  
Rutgers University

**Samantha Yost, Ph.D.**

Postdoctoral Fellow, Chemistry and Chemical Biology  
Rutgers University

**Caifeng Zhao**

Research Specialist, Biological Mass Spectrometry Facility  
Rutgers University

**Haiyan Zheng, Ph.D.**

Principle Research Associate, Biological Mass Spectrometry Facility  
Rutgers University

# RUTGERS BUSCH CAMPUS MAP

Center for Integrative Proteomics Research (Proteomics)

Parking with valid Faculty/Staff Permit

Parking with valid Student Permit

Bus Stop

