

# ***The Fourth International Workshop on Hyperpolarized Carbon-13 and Its Applications in Metabolic Imaging***



***Philadelphia, PA  
February 25-27<sup>th</sup>, 2016***

**Organized by:**

- The Functional and Metabolic Imaging Group**
- Department of Radiology**

## ***Organizing Committee***

Rahim R. Rizi  
David Mankoff  
Masaru Ishii

Stephen J. Kadlecsek  
Huiming Zhang  
Mitchell D. Schnall

## ***Scientific Committee***

Douglas Rothman  
John P. Mugler  
Zahi Fayad  
Warren S. Warren

**University of Pennsylvania  
421 Curie Boulevard  
Biomedical Research Building II/III  
Philadelphia, PA 19104**

# Foreword

On behalf of the organizing committee, I would like to welcome you to The Fourth International Workshop on Metabolic Imaging. Over the course of this three-day workshop, leading experts from a variety of fields will present their current research and discuss how significant biological problems can be probed with a variety of imaging and non-imaging technologies including hyperpolarized carbon-13, PET, PET/MRI, and mass spectroscopy.

The academic sessions of this workshop will cover a wide range of clinically relevant topics including, but not necessarily limited to, molecular pathways, systems biology of the mitochondria, and metabolomics. Discussion of the most recent advances in hardware development and pulse sequence design will also be included.

In planning this workshop, the organizing committee has sought to unify aspects of molecular biology, medicine, physical chemistry, and engineering with the intention of appealing to a broad audience of investigators, postdoctoral fellows, clinical fellows, and students of all levels. The workshop will bring its audience to the technological forefront of metabolic imaging research while demonstrating the power of modern interdisciplinary science.

It is my utmost pleasure to welcome you to our campus.

Rahim R. Rizi, Ph.D.

Professor of Radiology

# Program Schedule

**Thursday, February 25, 2016**

**7:00 – 7:50 AM**

**Registration & Breakfast**

**7:50 – 8:05 AM**

**Introduction**

Rahim R. Rizi, Ph.D.  
University of Pennsylvania

**8:05 – 8:20 AM**

**Welcome Remarks**

Mitchell Schnall, M.D., Ph.D.  
University of Pennsylvania

## **Session I: Special Lecture** **Moderator: Mitchell Schnall, M.D., Ph.D.**

**8:20 – 9:05 AM**

**Immunotherapy and the Need for Advance Imaging**

Carl H. June, M.D.  
University of Pennsylvania

## **Session II: General Session** **Moderator: Jerry Glickson, Ph.D.**

**9:05 – 9:35 AM**

**Assessing Tumor Progression and Mutational Status Using Metabolic Imaging with Hyperpolarized  $^{13}\text{C}$  Labelled Cell Substrates**

Kevin Brindle, Ph. D.  
University of Cambridge, United Kingdom

**9:35 – 10:05 AM**

**Current Status of Prostate Cancer Hyperpolarized  $^{13}\text{C}$  MR Clinical Trials**

John Kurhanewicz, Ph.D.  
University of California, San Francisco

**10:05 – 10:20 AM**

**Refreshment Break**

**10:20 – 10:50 AM**

**Mass Spectrometry-based Approaches to Studies of Cancer Metabolism**

Ian Blair, Ph.D.  
University of Pennsylvania

**10:50 – 11:20 AM**

**Structure Function of the Mitochondrion in Muscle Cells**

Robert Balaban, Ph.D.  
National Institutes of Health

**11:20 – 11:30 AM**

**Discussion**

## **Session III: Student and Postdoctoral Presentations** **Moderators: Thomas Theis, Ph.D. and Cornelius von Morze, Ph.D.**

**11:30 – 11:40 AM**

**Development of a 3D Dynamic Compressed-sensing (CS) EPSI Sequence for Human Prostate Cancer Studies**

Hsin-Yu Chen, M.S.  
University of California, San Francisco

**11:40 – 11:50 AM**

**Speeding up Dynamic Spiral Chemical Shift Imaging with Incoherent Sampling and Low-Rank Matrix Completion**

Stephen DeVience, Ph.D.  
University of Maryland

11:50 AM – 12:00 PM

**Optimized Cardiac CEST MRI for Assessment of Metabolic Activity in the Heart**

Zhengwei Zhou, M.S.  
Cedars-Sinai Medical Center

12:00 – 12:10 PM

**Towards High-resolution Imaging of the Lung Tissue Using Hyperpolarized Carbon-13**

Mehrdad Pourfathi, M.S.  
University of Pennsylvania

12:10 – 12:20 PM

**Metabolic Adaptations Induced by Acute Nicotine Inhalation in Smokers Measured by Magnetic Resonance Spectroscopy In Vivo**

Lihong Jiang, Ph.D.  
Yale University

12:20 – 12:30 PM

**Discussion**

12:30 – 1:30 PM

**Lunch**

**Session IV: Focused Session I – Metabolism**  
**Moderator: Mark A. Rosen, M.D., Ph.D.**

1:30 – 1:55 PM

**Metabolic Reprogramming in Glioma –  $^{13}\text{C}$  MRS Studies**

Sabrina Ronen, Ph.D.  
University of California, San Francisco

1:55 – 2:15 PM

**Metabolic Imaging and Spectroscopy Using Hyperpolarized Carbon-13 Pyruvate: The Challenge of Low-Dose Conditions**

Ralph Hurd, Ph.D.  
General Electric

2:15 – 2:35 PM

**Pre-clinical Studies Profiling Tumor Metabolism and Physiology to Guide Treatment**

Murali K. Cherukuri, Ph.D.  
National Institutes of Health

2:35 – 2:55 PM

**Hyperpolarized  $^{13}\text{C}$  Metabolic Imaging in Traumatic Brain Injury**

Dirk Mayer, Ph.D.  
University of Maryland

2:55 – 3:15 PM

**Imaging of Cardiac Metabolism and Perfusion**

Angus Lau, Ph.D.  
University of Oxford, United Kingdom

3:15 – 3:35 PM

**Taking Hyperpolarized Metabolic Imaging from Pets to People**

Kayvan Keshari, Ph.D.  
Memorial Sloan Kettering Cancer Center

3:35 – 3:50 PM

**Discussion**

3:50 – 4:05 PM

**Break**

**Session V: Applications of Carbon-13 in Metabolism-Session I**  
**Moderator: Stephen Kadlecsek, Ph.D.**

4:05 – 4:25 PM

**New and Old Molecular Targets for Parahydrogen Induced Polarization**

Eduard Chekmenev, Ph.D.  
Vanderbilt University

4:25 – 4:45 PM

**ParaHydrogen Hyperpolarization of Pyruvate for Metabolic Studies**

Francesca Reineri, Ph.D.  
University of Torino, Italy

4:45 – 5:05 PM	<b>PHIP Amino Acid and Peptide Hyperpolarization</b> Shawn Wagner, Ph.D. Cedars-Sinai Medical Center
5:05 – 5:25 PM	<b>Preclinical Metabolic Studies Using Hyperpolarized <math>^{13}\text{C}</math>-Labeled Endogenous Substrates</b> Arnaud Comment, Ph.D. Ecole Polytechnique Fédérale de Lausanne, Switzerland
5:25 – 5:45 PM	<b>Novel Approaches for Enhancing NMR and MRI via SABRE Involving Heterogeneous Conditions, Aqueous Solutions, and Heteronuclei</b> Boyd Goodson, Ph.D. Southern Illinois University
5:45 – 6:05 PM	<b>Monitoring of Reactions and Kinetics Using Rapid Injection – In Vitro Dissolution DNP</b> Christian Hilty, Ph.D. Texas A&M University
6:05 – 6:20 PM	<b>Review of Current Status of Hyperpolarized Agents for Research and Clinical Trials</b> C.T. Tan, Ph.D. Sigma-Aldrich/Isotec
6:20 – 6:30 PM	<b>Discussion</b>
6:30 – 7:30 PM	<b>Poster Session &amp; Light Reception</b>

## **Friday, February 26, 2016**

7:00 – 8:00 AM	<b>Breakfast</b>
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### **Session VI: Technological Advances in Hyperpolarized Carbon-13 Moderator: Rahim R. Rizi, Ph.D.**

8:00 – 8:25 AM	<b>New Hyper Polarization Approaches: Faster, Longer-lived, Cheaper, Better</b> Warren S. Warren, Ph.D. Duke University
8:25 – 8:50 AM	<b>Progress Towards <i>In Vivo</i> Imaging Using SABRE Derived Hyperpolarization</b> Simon Duckett, Ph.D. University of York, United Kingdom
8:50 – 9:15 AM	<b>A Comprehensive Picture of Metabolism by Integrated <math>^{13}\text{C}</math> Isotopomer Methods and Hyperpolarization</b> Craig Malloy, M.D. University of Texas, Dallas
9:15 – 9:40 AM	<b>Preclinical Hyperpolarized MR Molecular Imaging and Translation for Clinical Research</b> Daniel Vigneron, Ph.D. University of California, San Francisco
9:40 – 9:55 AM	<b>Discussion</b>
9:55 – 10:10 AM	<b>Refreshment Break</b>

**Session VII: Metabolism and Metabolic Imaging**  
**Moderator: Zahi Fayad, Ph.D.**

10:10 – 10:30 AM	<b>Bonded Cumomer Analysis of Tumor Metabolism Monitored by <sup>13</sup>C NMR Spectroscopy</b> Jerry Glickson, Ph.D. University of Pennsylvania
10:30 – 10:50 AM	<b>Metabolic Imaging of Pulmonary Disorders with Polarized Carbon-13</b> Rahim R. Rizi, Ph.D. University of Pennsylvania
10:50 – 11:05 AM	<b>Using an Anaplerotic Substrate to Study <math>\beta</math>-oxidation and Glycolysis in the Heart</b> Matthew Merritt, Ph.D. University of Florida
11:05 – 11:20 AM	<b>Hyperpolarized <sup>13</sup>C MRSI in the Era of Precision Medicine</b> Huiming Zhang, Ph.D. National Institutes of Health
11:20 – 11:30 AM	<b>Discussion</b>

**Session VIII: Presentations from Submitted Abstracts**  
**Moderators: Sarmad Siddiqui and Mehrdad Pourfathi**

11:30 – 11:40 AM	<b>Detection of Localized Changes in the Metabolism of Hyperpolarized Gluconeogenic Precursors <sup>13</sup>C-Lactate and <sup>13</sup>C-Pyruvate in Kidney and Liver</b> Cornelius von Morze, Ph.D. University of California, San Francisco
11:40 – 11:50 AM	<b>A Ketogenic Diet Increases Transport and Oxidation of Ketone Bodies in RG2 and 9L Gliomas Without Affecting Tumor Growth</b> Henk M. De Feyter, Ph.D. Yale University
11:50 AM – 12:00 PM	<b>Investigation of Hepatic Metabolism In Vivo with Near-physiological Concentrations of Hyperpolarized [1-<sup>13</sup>C] Pyruvate</b> Emine Can, M.S. Ecole Polytechnique Fédérale de Lausanne, Switzerland
12:00 – 12:10 PM	<b>In Vivo pH and Metabolite MR Imaging Using Hyperpolarized <sup>13</sup>C-Pyruvate</b> Nicholas Drachman University of Pennsylvania
12:10 – 12:20 PM	<b>Metabolic Reprograming in Pulmonary Arterial Hypertension</b> Jose Izquierdo-Garcia, Ph.D. Spanish National Center for Cardiovascular Research, Spain
12:20 – 12:30 PM	<b>Discussion</b>
12:30 – 1:30 PM	<b>Lunch</b>

**Session IX: Polarization and Acquisition Hardware**  
**Moderator: John P. Mugler, Ph.D.**

1:30 – 1:45 PM	<b>Latest Development in PET/MRI and Carbon-13 Polarizer</b> Jonathan Murray, M.S., M.B.A. General Electric
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1:45 – 2:00 PM	<b>The NCI (formerly GE) IND for C-13 Pyruvate: A Resource for the Community</b> Paula Jacobs, Ph.D. National Institutes of Health
2:00 – 2:15 PM	<b>Hyperpolarized <sup>13</sup>C Spectroscopy and Imaging with a Pre-Clinical 1T Permanent Magnet System</b> Peter Bendel, Ph.D. Aspect Imaging
2:15 – 2:30 PM	<b>NMR Probes for Non-Hydrogen Nuclei</b> James Tropp, Ph.D. General Electric
2:30 – 2:45 PM	<b>RF Coils for Hyperpolarized <sup>13</sup>C Studies: Towards Human Application</b> Titus Lanz, Ph.D. Rapid Biomedical
2:45 – 2:55 PM	<b>Discussion</b>
2:55 – 3:05 PM	<b>Break</b>

**Session X: Focused Session II – Metabolism II**  
**Moderator: David Mankoff, M.D., Ph.D.**

3:05 – 3:30 PM	<b>PET Molecular Imaging to Probe Cancer Metabolism</b> David Mankoff, M.D., Ph.D. University of Pennsylvania
3:30 – 3:50 PM	<b>Imaging Glutamine Metabolism with PET</b> Robert Mach, Ph.D. University of Pennsylvania
3:50 – 4:10 PM	<b>Stress and Atherosclerotic Plaque Macrophages – A System Biology Approach</b> Zahi Fayad, Ph.D. Mount Sinai Hospital
4:10 – 4:30 PM	<b>Initial Experience with Simultaneous PET/MR and Hyperpolarized <sup>13</sup>C</b> Daniel Spielman, Ph.D. Stanford University
4:30 – 4:40 PM	<b>Discussion</b>
4:40 – 4:50 PM	<b>Break</b>

**Session XI: Applications of Carbon-13 in Metabolism – Session II**  
**Moderator: Graeme Mason, Ph.D.**

4:50 – 5:10 PM	<b>What Can We Learn from Hyperpolarized <sup>13</sup>C MR Studies of Brain Function and Diseases?</b> Douglas Rothman, Ph.D. Yale University
5:10 – 5:30 PM	<b>Probing Prostate Metabolic Pathways Associated with Cancer Aggressiveness</b> Leo L. Cheng, Ph.D. Harvard University
5:30 – 5:50 PM	<b>Towards Targeted Molecular and Metabolic Imaging of Ovarian Cancer In Vivo</b> Pratip Bhattacharya, Ph.D. University of Texas, MD Anderson Cancer Center



5:50 – 6:05 PM	<b>Using Hyperpolarized <math>^{13}\text{C}</math> Labeled Urea as a Possible Endogenous Marker for Identifying Renal Impairment</b> Christoffer Laustsen, Ph.D. Aarhus University, Denmark
6:05 – 6:20 PM	<b><i>In Vivo</i> and <i>In Vitro</i> Metabolism in Acute Myeloid Leukemia after Treatment with Glutaminase Inhibitor CB839</b> Niki Zacharias Millward, Ph.D. University of Texas, MD Anderson Cancer Center
6:20 – 6:35 PM	<b>Methods to Improve Quantification of <i>In Vivo</i> Metabolism Using Hyperpolarized <math>^{13}\text{C}</math> Agents</b> Erin Adamson University of Wisconsin
6:35 – 6:45 PM	<b>Discussion</b>

## **Saturday, February 27, 2016**

7:00 – 8:00 AM                      **Breakfast**

### **Session XII: Pulse Sequence Development Moderator: Felix W. Wehrli, Ph.D.**

8:00 – 8:20 AM	<b>Pulse Sequences Optimized for Hyperpolarized Carbon-13</b> John P. Mugler, Ph.D. University of Virginia
8:20 – 8:40 AM	<b>RF Pulses for <math>^{13}\text{C}</math> MRSI and How to Use Them to Make Interesting Pulse Sequences</b> John Pauly, Ph.D. Stanford University
8:40 – 9:00 AM	<b>Pulse Sequence Design for Improved Coverage in Hyperpolarized <math>^{13}\text{C}</math> CMR</b> Charles H. Cunningham, Ph.D. University of Toronto, Canada
9:00 – 9:20 AM	<b>Advanced Imaging Methods for Hyperpolarized Carbon-13 MRI</b> Peder Larson, Ph.D. University of California, San Francisco
9:20 – 9:40 AM	<b>Recent Advances in Inverse <math>^1\text{H}</math>- [<math>^{13}\text{C}</math>] MR Spectroscopy</b> Robin de Graaf, Ph.D. Yale University
9:40 – 9:55 AM	<b>Discussion</b>
9:55 – 10:10 AM	<b>Refreshment Break</b>

### **Session XIII: Applications of Carbon-13 in Metabolism-Session III Moderator: Masaru Ishii, M.D., Ph.D.**

10:10 – 10:30 AM	<b>Principles of Metabolic Modeling of Isotopic Labeling</b> Graeme Mason, Ph.D. Yale University
10:30 – 10:50 AM	<b>Tracing Metabolic Pathways at the Cellular and Subcellular Level Using Mass Spectrometry</b> Christian Metallo, Ph.D. University of California, San Diego



<b>10:50 – 11:10 AM</b>	<b>Isotopic Tracing Through Acyl-CoA Analysis by Liquid Chromatography-mass Spectrometry</b> Nate Snyder, Ph.D. Drexel University
<b>11:10 – 11:30 AM</b>	<b>Molecular Clock Control of Metabolism and Implications in Cancer</b> Aalim Weljie, Ph.D. University of Pennsylvania
<b>11:30 – 11:45 AM</b>	<b>Generalizing SABRE to a Wide Range of Substrates with Signal Lifetimes in Excess of Twenty Minutes</b> Thomas Theis, Ph.D. Duke University
<b>11:45 – 11:55 AM</b>	<b>Break</b>
<b>11:55 AM – 12:10 PM</b>	<b>Metabolic Changes in Lung Injury</b> Stephen Kadlecsek, Ph.D. University of Pennsylvania
<b>12:10 – 12:25 PM</b>	<b>Image-based Phenotyping of Hepatocellular Carcinoma Cell Survival Under Ischemic Stress: Toward Metabolic Imaging of Cancer Dormancy Using Hyperpolarized Carbon-13 Technology</b> Terence Gade, M.D., Ph.D. University of Pennsylvania
<b>12:25 – 12:40 PM</b>	<b>Imaging Intratumor Redox Heterogeneity and Its Value for Breast Cancer Prognosis</b> Lin Z. Li, Ph.D. University of Pennsylvania
<b>12:40 – 12:55 PM</b>	<b>The Magritek Spinsolve Benchtop NMR</b> Douglas Boyd and Robert Espina Magitrek
<b>12:55 – 1:05 PM</b>	<b>Discussion</b>
<b>1:05 – 1:10 PM</b>	<b>Final Remarks</b> Rahim R. Rizi, Ph.D. University of Pennsylvania