

Date Prepared: **January 12, 2026**Name: **Lance L. Munn****Education**

1987	B.S. summa cum laude	Chemical Engineering	University of Cincinnati
1993	Ph.D.	Chemical Engineering & Bioengineering	Rice University

Industry Experience

1984-1986	Co-op Engineer	Photolithography	Diconix, Inc. (Kodak) Dayton, OH
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Postdoctoral Training

06/93-03/96	Postdoctoral Fellow	<i>Blood Rheology & Leukocyte Trafficking</i>	Massachusetts General Hospital
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Faculty Academic Appointments

1996-1998	Instructor	Radiation Oncology	Harvard Medical School
1999-2004	Assistant Professor	Radiation Oncology	Harvard Medical School
2004-present	Associate Professor	Radiation Oncology	Harvard Medical School
2021-present	Visiting Professor	Biomechanical and Biomedical Engineering	Université de Technologie de Compiègne

Appointments at Hospitals/Affiliated Institutions

1988-1993	Asst. Fellow of Immunology	Immunology	M.D. Anderson Cancer Center
1993-1996	Research Fellow	Radiation Oncology	Massachusetts General Hospital
2004-2016	Associate Biologist	Radiation Oncology	Massachusetts General Hospital
2016-present	Investigator	MGH Research Institute	Massachusetts General Hospital

Major Administrative Leadership Positions**Local**

1995-present	Director, Bioengineering, Imaging, and Computing Core, Steele Laboratories	Massachusetts General Hospital
2010-present	Deputy Director	Steele Laboratories, MGH
2017	Co-chair and organizer	2017 Boston Angiogenesis Meeting Starr Center, Boston

Regional

<i>2006-2023</i>	Program Steering Committee Member	City College New York / Memorial Sloan
<i>2023-present</i>	Chair, Program Steering Committee	Kettering Cancer Center Partnership for Cancer Research, Training and Community Outreach

National and International

<i>2012 -2014</i>	Expert Panelist	Assessment of Physical Sciences and Engineering Advances in Life Sciences and Oncology (APHELION) in Europe NCI, Office of Physical Sciences Oncology
<i>2012</i>	Co-Chair and Organizer	US National Committee on Biomechanics 4 th Symposium on Frontiers in Biomechanics: "Mechanics in Oncology"
<i>2014</i>	Co-Chair and Organizer	Mathematical Biosciences Institute Workshop on Metastasis and Angiogenesis, Ohio State University
<i>2018</i>	Co-Chair	8 th World Congress of Biomechanics, Dublin, Ireland
<i>2019 -present</i>	SAB member	SimBioSys, Inc.
<i>2020-present</i>	Chair, External Scientific Advisory Board	Center for Cancer Engineering, The Ohio State University
<i>2021</i>	Chair, Lymphatic Modeling	Lymphatic Forum 2021
<i>2022</i>	Participant	NCI/IBM Ideas Lab on Biologically Informed Models of Combination Therapies

Committee Service**Local**

<i>1993-present</i>	Candidate Search Committee 1993-96	Steele Laboratories, MGH Chair
<i>2016-2020</i>	Co-Organizer, MGH site	Harvard Medical School Vascular Biology Seminar Series

National and International

<i>2013</i>	External thesis committee member	Univ. Waterloo, Madjid Soltani dissertation
<i>2013</i>	President, thesis committee	Institut Curie, Kevin Alessandri dissertation
<i>2016</i>	External thesis committee member	McGill University, S. Ghaffari dissertation
<i>2023</i>	External thesis committee member	Univ. Waterloo, Cameron Meaney dissertation
<i>2023</i>	External thesis committee member	Boston University, Sue Zhang dissertation
<i>2023</i>	External thesis committee member	Texas A&M Univ., Mutaz Mohammad dissertation
<i>2025</i>	External thesis committee member	Université de Technologie de Compiègne, Alaa Bou Orm dissertation

Professional Societies

<i>1993-present</i>	American Institute of Chemical Engineers	
	1999–2008	session chair
<i>2001-present</i>	Biomedical Engineering Society	
	2000–2005	session chair
<i>2002-present</i>	American Association for Cancer Research	
<i>2002-present</i>	Radiation Research Society	
<i>2010-present</i>	Microcirculatory Society	
<i>2009-present</i>	North American Vascular Biology Association	
<i>2017-present</i>	American Association for the Advancement of Science	
<i>2019-present</i>	American Physiology Society	

Grant Review Activities

<i>6/7/00</i>	Transfusion Medicine	NIH (NHLBI) Ad hoc Member
<i>3/23/01</i>	Oncological Sciences Rev. Committee	NIH (NCI) Ad hoc Member
<i>6/2/04 - 6/10/04</i>	FastLane review system	National Science Foundation Ad hoc Member
<i>3/9/05</i>	Microscopic Imaging Study Section	NIH Ad hoc Member
<i>10/12 – 10/13/06</i>	Tumor Microenvironment	NIH (NCI) Ad hoc Member
<i>6/4-6/6/07</i>	Modeling & Analysis of Biological Systems	NIH Ad hoc Member
<i>2010 -present</i>	Systems Biology, ZRG1 VH-D (55)	NIH (NHLBI) Member
<i>1/11-3/12</i>	Vascular Hematology SEP	NIH Ad hoc Member
<i>3/18/14</i>	SEP/ Scientific Review Group ZEB1 OSR-C (M3) Review panel	NIH (NIBIB) Ad hoc Member
<i>11/19/2015</i>	SEP/Scientific Review Group 2016/01 ZCA1 TCRB-T (J2) Review panel	NIH (NCI) Ad hoc Member
<i>4/14/2016</i>	Physical Sciences Oncology Centers (U54) Review panel	NIH (NCI) Ad hoc Member
<i>2014-present</i>	Research Council KU Leuven	University of Leuven, Belgium Reviewer
<i>2016-present</i>	Research Grants Council (RGC) of Hong Kong	University Grants Committee Reviewer

2/19-2/20 2019	Drug Discovery and Molecular Pharmacology Study Section	NIH (NCI) Ad hoc Member
2019-present	ITMO Cancer of the French National Alliance for Life and Health Sciences	Inserm, Reviewer
2/19-2/20/2020	Hypertension and Microvasculature	NIH (NHLBI) Ad hoc Member
7/26/2021	IVPP SEP	NIH (NHLBI) Ad hoc Member
2/17-18/2021	Integrative Vascular Physiology and Pathology	NIH (NHLBI) Ad hoc Member
4/4/2025	Physical Sciences- Oncology Projects (U01)	NIH (NCI) Ad hoc Member

Editorial Activities (reviewer)

American Journal of Physiology	Lab on a Chip
Analytical Chemistry	Lancet Oncology
Annals of Biomedical Engineering	Microcirculation
Biorheology	Microvascular Research
Biotechniques	Nature Cell Biology
Cancer Cell	Nature Methods
Cancer Research	Physical Review Letters
Integrative Biology	PLoS Computational Biology
Nature Biomedical Engineering	PNAS
Journal of Theoretical Biology	PNAS Nexus

Other Editorial Roles

2015-present	Guest Editor	PNAS
2017-2022	Editor	Microcirculation

Honors and Prizes

1987	Engineering Honor Society, Tau Beta Pi	University of Cincinnati	
1989	Cox Fellowship	Rice University	
1991	Phillips Award for Pre-doctoral Research	Rice University	
1995	Postdoctoral training grant	NIH	
2000	LJIS Travel Award	Whitaker Foundation	
2006	Outstanding cover design	Taylor & Francis Group, Computational and Mathematical Methods in Medicine	Scientific illustration for journal cover

2013	Gerritsen Award	Microcirculatory Society	Most cited journal article
2014	Gerritsen Award	Microcirculatory Society	Most cited journal article
2015	Distinguished Alumnus Award	Rice University	
2016-present	Member of the College of Fellows	American Institute for Medical and Biological Engineering	
2018	University Delegate, Inauguration of Harvard President	Rice University	
2019	Top cited article	Wires Systems Biology and Medicine	
2020-present	Top 0.05% composite citation index	Elsevier Data Repository DOI: 10.17632/btchxktzyw.6	
2024-present	Highly Ranked Scholar	ScholarGPS	Top 0.05% of all scholars

Report of Local Teaching and Training

Teaching of Students in Courses

1998-present	Tumor Pathophysiology, HST-525 20-40 graduate students/year	MIT/HST Two hour lecture
1999-2005	Biology of the Vascular Endothelium 40 undergraduate students/year	Boston University One hour lecture
2024-present	Co-Director, Tumor Pathophysiology, HST-525	MIT/HST

Formal Teaching of Residents, Clinical Fellows and Research Fellows (post-docs)

1998-present	"Preparing manuscripts and grant proposals" postgraduate & graduate students	<i>Methods in Bioengineering</i> , Rad. Onc, MGH Two hour lecture
1998-present	"In vitro methods" postgraduate & graduate students	<i>Methods in Bioengineering</i> , Rad. Onc, MGH Two hour lecture
1998-present	"Mathematical modeling of Tumor Physiology" postgraduate & graduate students	<i>Methods in Bioengineering</i> , Rad. Onc, MGH Two hour lecture
1998-present	"Scientific Illustration" postgraduate & graduate students	<i>Methods in Bioengineering</i> , Rad. Onc, MGH Two hour lecture
2017-present	"Microfluidics in cancer research" postgraduate & graduate students	<i>Methods in Bioengineering</i> , Rad. Onc, MGH One hour lecture
2017-present	"Introduction to AI and machine learning" postgraduate & graduate students	<i>Methods in Bioengineering</i> , Rad. Onc, MGH One hour lecture

Laboratory and Other Research Supervisory and Training Responsibilities

1995-present Director, Bioengineering, Imaging and Computational Core, Steele Laboratories 120 hours per year

Formally Supervised Trainees

1996—1998 **Hera Lichtenbeld, PhD**/ Currently: Assistant Director at UF Innovate Tech Licensing Postdoctoral, Project title: “Vascular Permeability of Individual Microvessels”
Published one paper.

1997—2000 **Jin Yuan, PhD**/ Currently: Senior Research Scientist at Genocoe Biosciences Postdoctoral, Project title: “Fluid Dynamics and Leukocyte Adhesion”
Published three papers.

2001-2002 **Cristina Sousa**/ Doctoral, Project title: “Trafficking of Lymphocytes and Metastatic Cancer Cells”

1998–1999 **Gerald Koenig, MD, PhD**/ Currently: Cardiologist, Henry Ford West Bloomfield Hospital, MI Postdoctoral, Project title: “Biophysics of Lymphocyte Adhesion in Tumors”
Published one manuscript, granted F32 Fellowship, co-authored patent.

1998—2000 **Yong Chang, PhD**/ Currently: Vice President at Intellia Therapeutics, Inc. Postdoctoral, Project title: “Hydraulic Conductivity and Permeability of Endothelial Monolayers”
Published three papers, one in *PNAS*.

1998—2000 **Randall Dull, MD, PhD**/ Currently: Presidential Endowed Chair in Anesthesiology, Director, Lung Vascular Biology Laboratory, Associate Professor, Bioengineering, University of Utah Postdoctoral, Project title: “PIGF-VEGF Synergy in Endothelial Responses”
Published two papers.

1998—2001 **Emmanuelle di Tomaso, PhD**/ Currently: Vice President, Translational Medicine, Syros Pharmaceuticals, Cambridge MA
Postdoctoral, Project title: “Permeability of Brain Tumor Vasculature”
Published four papers, one in *Cancer Research* and one in *PNAS*; received Claflin Distinguished Scholar Award, and Martin Prize

2000—2001 **Cristiano Migliorini, PhD**/ Currently: Executive Director at Bank Vontobel AG, Geneva, Switzerland
Postdoctoral, Project title: “Modeling Fluid Dynamics and Leukocyte Adhesion”
Published three papers.

2000-2002 **Robert Campbell, PhD**/ Currently: Associate Professor, Massachusetts College of Pharmacy and Health Sciences
Postdoctoral, Project title: “Delivery of Liposomes to Tumor Vessels”
Published one paper, *Cancer Research*.

2000-2003 **Maximilian Bockhorn, MD, PhD**/ Currently: Surgeon, Department of General & Transplant Surgery; University Hospital, Essen, Germany
Postdoctoral, Project title: “Analysis of Cancer Cells Shed from a Solid Tumor”
Published two papers, *Lancet Oncology* and *Cancer Research*.

2000-2003 **Neil Forbes, PhD**/ Currently: Professor, U. Massachusetts Amherst
Postdoctoral, Project title: “Treating Tumors with Penetrating Bacteria”
Published one paper, *Cancer Research*.

- 2002-2006 **Chenghai Sun, PhD**/ Currently: Sr. Research Scientist, Exa Corp., Burlington, MA
Postdoctoral, Project title: "Lattice-Boltzmann Modeling of Hemodynamics"
Published five papers, two in *Biophysical Journal*.
- 2003-2007 **Aaron Mulivor, PhD**/ Currently: Senior Associate, Pharma & Life Sciences Advisory at PwC
Postdoctoral, Project title: "Blood Dynamics and Atherosclerosis"
- 2004-2008 **Michael Dupin, PhD**/ Currently: Director of PPNR Analytics, SVP at Citizens Bank, Boston, MA
Postdoctoral, Project title: "3D Simulation of Blood Rheology"
Published three papers.
- 2004-2010 **Janet Tse**/ Currently: Patent Agent, Nixon Peabody LLP, Boston
Doctoral, Project title: "Tumor Solid Stress"
Published 1 paper, *PNAS*.
- 2005-2009 **Gang Cheng, PhD**/ Currently: Head of Scientific Liaison at Roche China
Postdoctoral, Project title: "Cellular mechanisms of Angiogenesis"
Published 2 papers, one in *Blood*.
- 2006-2009 **James Alex Tyrrell, PhD**/ Currently: SVP, Health & Advanced Technology at Wolters Kluwer
Postdoctoral, Project title: "Quantitative Image Analysis of Vascular Networks"
Published three papers. Co-authored successful R01 application (R01CA149285).
- 2006-2011 **Delphine Lacorre, PhD** / Currently: Research Engineer, Lille, France
Postdoctoral, Project title: "Effects of Vascular Normalization on Drug Delivery"
Published two papers; received Komen Fellowship.
- 2006-2011 **Walid Kamoun, PhD**/ Currently: Vice President, Global Head of R&D Oncology at Servier
Postdoctoral, Project title: "Blood Flow Distribution in Tumors"
Published five papers, one in *Nature Methods*; received Komen Fellowship.
- 2008-2011 **Temitope Sodunke, PhD**/ Currently: Strategy, Innovation, Medical Device Professional at BD
Postdoctoral, Project title: "Stromal Determinants of Cancer Cell Invasion"
Received Merck Postdoctoral Fellowship.
- 2008-2011 **Abhishek Jain, PhD**/ Currently: Assistant Professor, Texas A&M;
Doctoral, Project title: "Blood Microfluidics"
Published three papers, one in *Lab Chip*
- 2008-2014 **Jonathan Song, PhD** / Currently: Associate Professor, Ohio State University
Postdoctoral, Project title: "Fluid forces control endothelial morphogenesis"
Published three papers, *PNAS*, *Lab Chip*, *Integrative Biology*
- 2010-2015 **Christian Kunert, PhD**/ Currently: Amgen, Cambridge, MA
Postdoctoral, Project title: "Mechanobiology of lymphatic transport"
Received DFG Fellowship; publication in *PNAS*
- 2011-2015 **Gabriel Gruionu, PhD**/ Currently: Instructor, Massachusetts General Hospital
Postdoctoral, Project title: "Determinants of vascular remodeling in tumors"
Published 2 patents and one paper
- 2011-2016 **Despina Bazou, PhD**
Postdoctoral, Project title: "Endothelial dynamics and tumor tissue engineering"
Published 5 papers

2012-2019	Nir Maimon, PhD Postdoctoral, Project title: "Communication between blood vessel cells in tumors"
2014-2019	Hadi Tavakoli Nia, PhD/ Currently: Assistant Professor, Boston University Postdoctoral, Project title: Quantifying tumor mechanopathologies
2017-2019	Huabing Li, PhD Postdoctoral, Project title: "Lymphatic valve mechanics"
2018-2020	Mohammad Reza Nikmaneshi Doctoral, Project title: "Tumor tissue engineering and computational modeling"
2020-2021	Tuoye Xu Postdoctoral, Project title: "Stress-induced tumor immune suppression"
2020-2024	Mohammad Razavi Postdoctoral, Project title: "Systems biology of anti-cancer immunity"
2020-present	Meghan O'Melia Postdoctoral, Project title: "Lymphatic regulation of anti-tumor immunity"
2022-2023	Stacie (Si) Chen Postdoctoral, Project title: "Mechanobiology of glioma immune suppression"
2022-2024	Kohji Uzawa Postdoctoral, Project title: "Role of the glycocalyx in anti-cancer immunity"
2023-present	Mohammad Reza Nikmaneshi Postdoctoral, Project title: "Tumor Immunotherapy and Personalized Medicine"
2024-present	Xingjian Zhang Doctoral, Project title: "Glycocalyx immune mechanobiology"
2024-2025	Rieke Schleinhege Postdoctoral, Project title: "Vascularized tumor explants for drug testing"
2025-present	Nemo Noeh Postdoctoral, Project title: "Vascularized tumor engineering"

Local Invited Presentations

No presentations below were sponsored by outside entities

November 3, 2008	<i>"Multiscale analyses of blood dynamics."</i> Martinos Center for Biomedical Imaging, Neurovascular Seminar Series, MGH, Charlestown, MA
October 14, 2009	<i>"Blood dynamics and tumor micro-anatomy."</i> Harvard Catalyst, Center for Nanoscale Systems Special Seminar: Applying Nanoscale Technologies in Biomedical Research, Cambridge MA.
November 5, 2010	<i>"Connection of vascular networks via wrapping-and-tapping anastomosis."</i> Boston Angiogenesis Meeting, MEEI, 2010, Boston MA
March 8, 2011	<i>"Microanatomy and mechanobiology: how the cell microenvironment influences coordinated migration and vascular morphogenesis."</i> Topics in Bioengineering Seminar Series, Harvard School of Engineering and Applied Sciences (SEAS), Cambridge, MA.
April 21, 2013	<i>"Mechanobiology of Vascular Dynamics."</i> Mechanical Forces in Development meeting, Tufts Medical School, Boston
November 7, 2013	<i>"Biomechanical control of vessel morphogenesis, adaptation and function."</i> Boston Angiogenesis Meeting, MEEI, 2013, Boston MA

March 8, 2013	<i>"Vascular Biology and Mechanobiology."</i> MGH T32 Lecture Series
November 4, 2015	<i>"Untangling tumor vasculature."</i> Boston Angiogenesis Meeting, MEEI, 2015, Boston MA
March 9, 2020	<i>"Physical Traits of Cancer,"</i> Physics Seminar Series, Department of Radiation Oncology, Massachusetts General Hospital, Boston
November 9, 2020	<i>"Physical Traits of Cancer."</i> Ludwig Center, Harvard Medical School
January 26, 2021	<i>"Systems Biology Modeling of COVID-19."</i> Nanomedicine Academy at Northeastern University Lecture Series
December 13, 2021	<i>"Identifying COVID-19 Patient Phenotypes and Biomarkers using Mathematical Modeling."</i> Ludwig Center, Harvard Medical School

Report of Regional, National and International Invited Teaching and Presentations

Those presentations below sponsored by outside entities are so noted and the sponsor is identified.

Invited Presentations and Courses

Regional

March 31, 2009	<i>"Multi-scale Analyses of tumor physiology and blood vessel dynamics."</i> 2009 Seminar Series, Center for Fluid Dynamics, Brown University, Providence, RI.
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National

July 23-28, 1995	<i>"The Role of Erythrocytes in Leukocyte-Endothelial Interactions."</i> Annual Conference on Biorheology and Clinical Hemorheology, Big Sky, MT.
October 4-6, 1996	<i>"Quantification of Metastatic Cell Arrest, Extravasation, and Colonization."</i> Annual Meeting of the Biomedical Engineering Society, Penn State University.
June 4, 1999	<i>"Molecular Determinants of Tumor Pathophysiology."</i> American Association of Clinical Chemistry Meeting, Boston, MA
June 25-26, 1999	<i>"Transvascular Transport in Tumors."</i> 8th Annual Workshop on Advanced Methods of Pharmacokinetic and Pharmacodynamic Systems Analysis, Los Angeles, CA.
Jan 11-15, 2000	<i>"Visualization and Quantification of Gene Function in Vivo."</i> Quantitative Challenges in the Post-genomic Sequence Era: A Workshop and Symposium, San Diego, CA
January 19, 2001	<i>"Tumor Angiogenesis at the Cellular Level."</i> (Mayo Clinic) Mayo Clinic Goldman Symposium on Innovative Research in Multiple Myeloma, Amelia Island, FL
April 29, 2001	<i>"Vascular Development and Anti-angiogenic Strategies."</i> Pediatric Academic Societies' 2001 Annual Meeting, Baltimore, MD
November 8, 2001	<i>"Modeling leukocyte adhesion in small vessels: a Lattice Boltzmann approach."</i> Plenary Talk (selected abstract), American Institute of Chemical Engineering Annual Meeting, Reno, NV
September 6-8, 2002	<i>"Tumor Physics and Biology: Impact of Aberrant Vascular Architecture on Therapy."</i> Third Annual BioMEMs & Biomedical Nanotechnology World 2002 Columbus, OH
October 25, 2002	<i>"Influence of Vessel Geometry on Leukocyte Adhesion: a Lattice-Boltzmann Model."</i> Annual Meeting of the Biomedical Engineering Society, Houston, TX.
February 27, 2003	<i>"Tumor Vessel Abnormalities and Leukocyte-Erythrocyte Dynamics."</i> Penn State University, State College, PA

- November 11, 2004 *"Microfluidic device for auto-separation of white blood cells from whole blood."* Plenary Talk (selected abstract), American Institute of Chemical Engineering Annual Meeting, Austin, TX
- December 1, 2004 *"Reverse engineering of blood cell dynamics."* City College of New York, Fall 2004 Seminar Series, Department of Biomedical Engineering
- February 17-21, 2005 *"The Tumor Microenvironment: Modeling and Experimental Validation."* Mathematical Oncology: Bridging the Scientific Divide, AAAS Annual Meeting, Washington DC
- May 10, 2005 *"Biomimetic Design of a Microfluidic Device for Auto-separation of Leukocytes from Whole Blood."* NSTI Nanotechnology Conference, Anaheim CA
- December 18-19, 2006 *"Microfluidics and particle transport in tumors."* Fine Particle Society Nanotechnology in Life Sciences Symposium, San Diego, CA
- December 18-21, 2006 *"Biomimetic Design of a Microfluidic Device for Auto-separation of Leukocytes from Whole Blood."* Symposium on Nanotechnology in Life Sciences 20th International Conference on Bio and Pharmaceutical Science and Technology, San Diego, CA
- October 2-4, 2008 *"Isolation of Rare Cells from Whole Blood Using Microfluidics."* Plenary Talk (selected abstract), Annual Meeting of the Biomedical Engineering Society, St Louis, MA
- October 26-28, 2008 *"Isolation of Rare Cells from Whole Blood Using Microfluidics."* NCI Innovative Molecular Analysis Technologies (IMAT) program, Cambridge, MA
- November 30, 2008 *"Isolation of Rare Cells from Whole Blood Using Microfluidics."* Materials Research Society: Cancer Nanotechnology Med School- Real World Challenges and Nano's Strengths in Cancer Prevention, Diagnosis, and Treatment, Boston, MA
- January 26-30, 2009 *"Multi-scale tumor physiology and blood vessel dynamics."* Mathematical Biosciences Institute Workshop on Cancer Development, Angiogenesis, Progression and Invasion, Columbus, OH
- October 8, 2009 *"Tumor blood vessel dynamics."* Quantitative Pharmacology Technical Summit (Eli Lilly), Indianapolis, IN
- October 7-10, 2009 *"Tumor blood vessel dynamics."* Plenary Talk (selected abstract), Annual Meeting of the Biomedical Engineering Society, Pittsburgh, PA
- November 23, 2009 *"Tumor blood vessel dynamics."* 62nd Annual Meeting of the APS Division of Fluid Dynamics, Minneapolis, Minnesota
- April 24-28, 2010 *"Wrapping-and-tapping anastomosis between engrafted endothelial networks and host vasculature."* Plenary Talk (selected abstract), Experimental Biology Meeting, Anaheim, CA
- October 6-8, 2010 *"Wrapping-and-tapping anastomosis between engrafted endothelial networks and host vasculature."* Plenary Talk (selected abstract), Annual Meeting of the Biomedical Engineering Society, Austin, TX
- November 1-2, 2010 *"Compression-induced cancer cell invasion: don't push me 'cause I'm close to the edge."* UCSD/NSF Physics of Cancer Metastasis Meeting Arlington, VA
- April 3-6, 2011 *"Tumor vessel dynamics during anti-angiogenic therapy."* American Conference on Pharmacometrics, San Diego, CA
- Aug 30-Sept 3, 2011 *"Cell-Matrix Interactions within Tumors and Normal Tissue."* 33rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society Boston, MA
- March 7, 2011 *"Tumor blood vessel dynamics."* Physical Sciences - Oncology Center Steering Committee meeting
- October 28, 2011 *"Imaging vascular dynamics"* Multiscale Systems Biology working group of the Multiscale Modeling (MSM) Consortium
- October 24, 2012 *"Solid and Fluid Biomechanics in the Tumor Environment".* US National Committee on Biomechanics 4th Symposium on Frontiers in Biomechanics: Mechanics in Oncology

April 2, 2013	<i>"Mechanobiology and Vascular Dynamics,"</i> IME Seminar Series, University of Pennsylvania
September 27, 2013	<i>"Biomechanical determinants of cell invasion, angiogenesis and lymphatic function."</i> Custer Workplace Lecture Series, University of Western Michigan
October 15, 2014	<i>"Biomechanics of cancer invasion and vessel function."</i> Mathematical Biosciences Institute Workshop on Metastasis and Angiogenesis, Columbus, OH.
April 3, 2015	<i>"Deconvolving tumor dynamics."</i> Department of Mechanical and Aerospace Engineering Seminar Series, Ohio State University
March 29, 2016	<i>"Deconvolving tumor dynamics."</i> Rice University's Bioengineering Colloquium
October 27, 2016	<i>"Systems Biology of Lymph Transport."</i> NHLBI Systems Biology meeting, Bethesda, MD.
April 10, 2018	<i>"Tumor Engineering and Mechanobiology."</i> Department of Chemical and Biomolecular Engineering Seminar Series, Ohio State University
September 7, 2018	<i>"Engineered tumors for personalized medicine."</i> Duke University Lecture Series, Durham, NC
March 5, 2019	<i>"Reverse engineering tumors and vasculature."</i> (Keynote) University of North Carolina Integrative Vascular Biology research symposium. Chapel Hill, NC
September 12, 2019	<i>"Mechanobiological control of vascular function."</i> American Physiological Society meeting, Interface of mathematical models and experimental biology: Role of microvasculature. Scottsdale, AZ
January 20, 2020	<i>"Reengineering the Physical Microenvironment of Tumors to Improve Treatment Response"</i> Cambridge Healthtech Institute; Engineering Next Generation Cancer Immunotherapies; Part of the 19th Annual PepTalk, San Diego, CA
July 20, 2020	<i>"Optimizing treatment for COVID-19 using computational modelling: Implications for cancer patients."</i> AACR Virtual Meeting: COVID-19 and Cancer
October 6-9, 2021	<i>"In Silico Dynamics of COVID-19 Phenotypes for Optimizing Clinical Management,"</i> Annual Meeting of the Biomedical Engineering Society, Orlando, FL
November 18, 2021	<i>"Deconstructing and Reconstructing the Tumor Environment,"</i> Distinguished Lecture Series, Simbiosys, Chicago
December 1, 2021	<i>"Systems Biology of Inflammation and The Tumor Environment,"</i> Mechanical and Industrial Engineering Department Seminar Series, New Jersey Institute of Technology
October 24, 2022	<i>"Systems Biology Modeling of Tumor Immunotherapy,"</i> American Association for Cancer Research Meeting, Tumor Immunology and Immunotherapy. Boston, MA
November 10, 2022	<i>"A chemical Engineer's Journey into Cancer Research,"</i> Howard University Chemical Engineering
November 9, 2023	<i>"The Impact of Mechanical Stress on Glioblastoma Biology,"</i> NCI CSBC / PS-ON Investigators Meeting. Bethesda, MD

International

August 25-30, 1996	<i>"Interaction of Activated Leukocytes with Tumor Vessels."</i> Sixth World Congress for Microcirculation, Munich, Germany
October 3-7, 1998	<i>"Tumor Angiogenesis and Microcirculation."</i> 10th Annual Conference of the International Society of Differentiation, Houston, TX
Oct 22-25, 1999	<i>"Tumor Angiogenesis."</i> Conference on Angiogenesis and Tumors, Paris, France
Oct 12-15, 2002	<i>"Tumor Vessel Abnormalities."</i> Second Interdisciplinary Euroconference on Angiogenesis, Cascals, Portugal

April 23-24, 2004	<i>"The interaction of circulating cells with tumors: pharmacokinetic and fluid dynamic models."</i> Workshop on Mathematical Oncology, The Fields Institute, Toronto, ON
August 1, 2006	<i>"Tumor vessel abnormalities affect blood cell dynamics and flow distribution."</i> Cancer and Bioengineering; World Congress of Biomechanics, Munich Germany
July 2-4, 2008	<i>"Multi-scale analyses of tumor physiology and blood vessel dynamics."</i> Fields Institute Workshop on Growth and Control of Tumors: Theory and Experiment Toronto, CA
July 9-13, 2008	<i>"Blood dynamics in normal and abnormal vessel networks."</i> International Congress of Biorheology, Penn State University, State College, PA
January 4-7, 2010	<i>"Modeling Tumor blood vessel dynamics."</i> Workshop on Mathematical Methods in Systems Biology, Tel Aviv, Israel
March 18-20, 2010	<i>"Modeling Tumor blood vessel dynamics."</i> Fields Institute Workshop on Mathematical Oncology Toronto, CA
May 10-12, 2010	<i>"Modeling Tumor blood vessel dynamics."</i> Centre European de Calcul Atomique et Moléculaire (CECAM) Workshop on Trends in Computational Hemodynamics, Lausanne, Switzerland
Sept. 17-20, 2011	<i>"Vascular dynamics and anti-angiogenic therapy."</i> Tumor -Vessel Interface meeting, Kloster Seeon Germany
March 28-30, 2011	<i>"Targeting vascular dynamics."</i> VIIth Academician Nicolae Cajal Symposium, Bucharest, Romania
December 3, 2013	<i>"Biomechanical determinants of morphogenesis and vascular function"</i> Institut Curie, Paris France
May 29-30, 2014	<i>"Microsystems for probing blood, vessel and tumor dynamics."</i> (Keynote) Ontario-on-a-Chip Conference, University of Toronto, Toronto, CA
July 6-11, 2014	<i>"Biomechanical Control of Vessel Morphogenesis, Adaptation and Function."</i> Seventh World Congress of Biomechanics, Boston, MA
July 6-11, 2014	<i>"Biomechanical autoregulation of lymphatic transport."</i> Seventh World Congress of Biomechanics, Boston, MA
October 2-8, 2014	<i>"Biomechanical processes and topological dynamics in tumors"</i> Annual Symposium of Physics of Cancer, University of Leipzig
June 25-28, 2016	<i>"Visualizing cell and matrix dynamics in tumors"</i> AACR Special Conference on Engineering and Physical Sciences in Oncology, Westin Boston Waterfront, Boston, MA
February 5-9, 2017	<i>"Tumor solid stress and mechanobiology"</i> Physical Science of Cancer Gordon Research Conference, Galveston, TX
Dec. 7-10, 2017	<i>"Accelerating revascularization."</i> Innovations in Wound Healing Conference, Bimini, Bahamas.
July 10, 2018	<i>"Leaky Blood Vessels, GAGs and Metastasis"</i> World Congress of Biomechanics 2018, Dublin, Ireland
June 1, 2020	<i>"Physical Hallmarks of Cancer,"</i> Third Workshop on Hallmarks in cancer and the development of diagnostic tools, Porto, Portugal. [Cancelled due to COVID-19 pandemic] In Vitro Systems for Deconvolving Tumor Dynamics
August 30, 2021	<i>"The impact of tumor-generated forces on cell biology and immunotherapy"</i> 12th symposium, Physics of Cancer, University of Leipzig
October 27, 2021	Keynote talk, <i>"In Vitro Systems for Deconvolving Tumor Dynamics,"</i> FoReCaST Conference on 2D and 3D In Vitro Tissue Models for Drug Screening, Porto, Portugal.
June 14, 2024	<i>"Systems Biology of Tumor Immunology"</i> Université de technologie de Compiègne, Compiègne, France

Report of Scholarship

Publications

Peer reviewed publications in print or other media

[more than 30,000 citations; **H-index**= 81 (Google), 72 (Web of Science)]

Research Investigations

1. **Munn LL**, Glacken MW, McIntyre BW, Zygourakis K. Analysis of lymphocyte aggregation using digital image analysis. *J Immunol Methods*. 1993; 166:11-25.
2. Teague TK, **Munn L**, Zygourakis K, McIntyre BW. Analysis of lymphocyte activation and proliferation by video microscopy and digital imaging. *Cytometry*. 1993; 14:772-82.
3. **Munn LL**, Melder RJ, Jain RK. Analysis of cell flux in the parallel plate flow chamber: implications for cell capture studies. *Biophys J*. 1994; 67:889-95.
4. Melder RJ, **Munn LL**, Yamada S, Ohkubo C, Jain RK. Selectin- and integrin-mediated T-lymphocyte rolling and arrest on TNF-alpha-activated endothelium: augmentation by erythrocytes. *Biophys J*. 1995; 69:2131-8.
5. **Munn LL**, Koenig GC, Jain RK, Melder RJ. Kinetics of adhesion molecule expression and spatial organization using targeted sampling fluorometry. *Biotechniques*. 1995; 19: 622-6, 628-31.
6. Melder RJ, Koenig GC, **Munn LL**, Jain RK. Adhesion of activated natural killer cells to tumor necrosis factor-alpha-treated endothelium under physiological flow conditions. *Nat Immun*. 1996a; 15:154-63.
7. Melder RJ, Koenig GC, Witwer BP, Safabakhsh N, **Munn LL**, Jain RK. During angiogenesis, vascular endothelial growth factor and basic fibroblast growth factor regulate natural killer cell adhesion to tumor endothelium. *Nat Med*. 1996b; 2:992-7.
8. **Munn LL**, Melder RJ, Jain RK. Role of erythrocytes in leukocyte-endothelial interactions: mathematical model and experimental validation. *Biophys J*. 1996; 71:466-78.
9. Patan S, **Munn LL**, Jain RK. Intussusceptive microvascular growth in a human colon adenocarcinoma xenograft: a novel mechanism of tumor angiogenesis. *Microvasc Res*. 1996; 51:260-72.
10. Neelamegham S, **Munn LL**, Zygourakis K. A model for the kinetics of homotypic cellular aggregation under static conditions. *Biophys J*. 1997; 72:51-64.
11. Shioda T, **Munn LL**, Fenner MH, Jain RK, Isselbacher KJ. Early events of metastasis in the microcirculation involve changes in gene expression of cancer cells. Tracking mRNA levels of metastasizing cancer cells in the chick embryo chorioallantoic membrane. *Am J Pathol*. 1997; 150:2099-112.
12. Lichtenbeld HC, Ferrara N, Jain RK, **Munn LL**. Effect of local anti-VEGF antibody treatment on tumor microvessel permeability. *Microvasc Res* 1999; 57:357-62.
13. Chang YS, di Tomaso E, McDonald DM, Jones R, Jain RK, **Munn LL**. Mosaic blood vessels in tumors: frequency of cancer cells in contact with flowing blood. *Proc Natl Acad Sci U S A*. 2000a; 97:14608-13.
14. Chang YS, **Munn LL**, Hillsley MV, Dull RO, Yuan J, Lakshminarayanan S, Gardner TW, Jain RK, Tarbell JM. Effect of vascular endothelial growth factor on cultured endothelial cell monolayer transport properties. *Microvasc Res*. 2000b; 59:265-77.
15. Melder RJ, Yuan J, **Munn LL**, Jain RK. Erythrocytes enhance lymphocyte rolling and arrest in vivo. *Microvasc Res*. 2000; 59:316-22.
16. Davies Cde L, Melder RJ, **Munn LL**, Mouta-Carreira C, Jain RK, Boucher Y. Decorin inhibits endothelial migration and tube-like structure formation: role of thrombospondin-1. *Microvasc Res*. 2001; 62:26-42.
17. Dull RO, Yuan J, Chang YS, Tarbell J, Jain RK, **Munn LL**. Kinetics of placenta growth factor/vascular endothelial growth factor synergy in endothelial hydraulic conductivity and proliferation. *Microvasc Res*. 2001; 61:203-10.
18. Melder RJ, Kristensen CA, **Munn LL**, Jain RK. Modulation of A-NK cell rigidity: In vitro characterization and in vivo implications for cell delivery. *Biorheology*. 2001; 38:151-9.
19. Patan S, **Munn LL**, Tanda S, Roberge S, Jain RK, Jones RC. Vascular morphogenesis and remodeling in a model of tissue repair: blood vessel formation and growth in the ovarian pedicle after ovariectomy. *Circ Res*. 2001a; 89:723-31.

20. Patan S, Tanda S, Roberge S, Jones RC, Jain RK, **Munn LL**. Vascular morphogenesis and remodeling in a human tumor xenograft: blood vessel formation and growth after ovariectomy and tumor implantation. *Circ Res*. 2001b; 89:732-9.
21. Yuan J, Melder RJ, Jain RK, **Munn LL**. Lateral view flow system for studies of cell adhesion and deformation under flow conditions. *Biotechniques*. 2001; 30:388-94.
22. Campbell RB, Fukumura D, Brown EB, Mazzola LM, Izumi Y, Jain RK, Torchilin VP, **Munn LL**. Cationic charge determines the distribution of liposomes between the vascular and extravascular compartments of tumors. *Cancer Res*. 2002; 62:6831-6.
23. Friedrich SW, Lin SC, Stoll BR, Baxter LT, **Munn LL**, Jain RK. Antibody-directed effector cell therapy of tumors: analysis and optimization using a physiologically based pharmacokinetic model. *Neoplasia*. 2002; 4:449-63.
24. Koike C, Mckee TD, Pluen A, Ramanujan S, Burton K, **Munn LL**, Boucher Y, Jain RK. Solid stress facilitates spheroid formation: potential involvement of hyaluronan. *Br J Cancer*. 2002; 86:947-53.
25. Melder RJ, **Munn LL**, Stoll BR, Marecos EM, Baxter LT, Weissleder R, Jain RK. Systemic distribution and tumor localization of adoptively transferred lymphocytes in mice: comparison with physiologically based pharmacokinetic model. *Neoplasia*. 2002; 4:3-8.
26. Migliorini C, Qian Y, Chen H, Brown EB, Jain RK, **Munn LL**. Red blood cells augment leukocyte rolling in a virtual blood vessel. *Biophys J*. 2002; 83:1834-41.
27. Padera TP, Kadambi A, di Tomaso E, Carreira CM, Brown EB, Boucher Y, Choi NC, Mathisen D, Wain J, Mark EJ, **Munn LL**, Jain RK. Lymphatic metastasis in the absence of functional intratumor lymphatics. *Science*. 2002; 296:1883-6.
28. Forbes NS, **Munn LL**, Fukumura D, Jain RK. Sparse initial entrapment of systemically injected Salmonella typhimurium leads to heterogeneous accumulation within tumors. *Cancer Res*. 2003; 63:5188-93.
29. Friedrich EB, Tager AM, Liu E, Pettersson A, Owman C, **Munn L**, Luster AD, Gerszten RE. Mechanisms of leukotriene B₄-triggered monocyte adhesion. *Arterioscler Thromb Vasc Biol*. 2003; 23:1761-7.
30. Roose T, Netti PA, **Munn LL**, Boucher Y, Jain RK. Solid stress generated by spheroid growth estimated using a linear poroelasticity model. *Microvasc Res*. 2003; 66:204-12.
31. Stoll BR, Migliorini C, Kadambi A, **Munn LL**, Jain RK. A mathematical model of the contribution of endothelial progenitor cells to angiogenesis in tumors: implications for antiangiogenic therapy. *Blood*. 2003; 102:2555-61.
32. Sun C, Migliorini C, **Munn LL**. Red blood cells initiate leukocyte rolling in postcapillary expansions: a lattice Boltzmann analysis *Biophys J*. 2003; 85:208-22.
33. Bockhorn M, Roberge S, Sousa C, Jain RK, **Munn LL**. Differential gene expression in metastasizing cells shed from kidney tumors. *Cancer Res*. 2004; 64:2469-73.
34. Duda DG, Fukumura D, **Munn LL**, Booth MF, Brown EB, Huang P, Seed B, Jain RK. Differential transplantability of tumor-associated stromal cells. *Cancer Res*. 2004; 64:5920-4.
35. Willett CG, Boucher Y, di Tomaso E, Duda DG, **Munn LL**, Tong RT, Chung DC, Sahani DV, Kalva SP, Kozin SV, Mino M, Cohen KS, Scadden DT, Hartford AC, Fischman AJ, Clark JW, Ryan DP, Zhu AX, Blaszkowsky LS, Chen HX, Shellito PC, Lauwers GY, Jain RK. Direct evidence that the VEGF-specific antibody bevacizumab has antivasculature effects in human rectal cancer. *Nat Med*. 2004; 10:145-7.
36. Winkler F, Kozin SV, Tong RT, Chae SS, Booth MF, Garkavtsev I, Xu L, Hicklin DJ, Fukumura D, di Tomaso E, **Munn LL**, Jain RK. Kinetics of vascular normalization by VEGFR2 blockade governs brain tumor response to radiation: role of oxygenation, angiopoietin-1, and matrix metalloproteinases. *Cancer Cell*. 2004; 6:553-63.
37. Demou ZN, Awad M, Mckee T, Perentes JY, Wang X, **Munn LL**, Jain RK, Boucher Y. Lack of telopeptides in fibrillar collagen I promotes the invasion of a metastatic breast tumor cell line. *Cancer Res*. 2005; 65:5674-82.
38. di Tomaso E, Capen D, Haskell A, Hart J, Logie JJ, Jain RK, McDonald DM, Jones R, **Munn LL**. Mosaic tumor vessels: cellular basis and ultrastructure of focal regions lacking endothelial cell markers. *Cancer Res*. 2005; 65:5740-9.
39. Kashiwagi S, Izumi Y, Gohongi T, Demou ZN, Xu L, Huang PL, Buerk DG, **Munn LL**, Jain RK, Fukumura D. NO mediates mural cell recruitment and vessel morphogenesis in murine melanomas and tissue-engineered blood vessels. *J Clin Invest*. 2005; 115:1816-27.

40. Shevkoplyas SS, Yoshida T, **Munn LL**, Bitensky MW. Biomimetic autoseparation of leukocytes from whole blood in a microfluidic device. *Anal Chem*. 2005; 77:933-7.
41. Sun C, **Munn LL**. Particulate nature of blood determines macroscopic rheology: a 2-D lattice Boltzmann analysis. *Biophys J*. 2005; 88:1635-45.
42. Willett CG, Boucher Y, Duda DG, di Tomaso E, **Munn LL**, Tong RT, Kozin SV, Petit L, Jain RK, Chung DC, Sahani DV, Kalva SP, Cohen KS, Scadden DT, Fischman AJ, Clark JW, Ryan DP, Zhu AX, Blaszkowsky LS, Shellito PC, Mino-Kenudson M, Lauwers GY. Surrogate markers for antiangiogenic therapy and dose-limiting toxicities for bevacizumab with radiation and chemotherapy: continued experience of a phase I trial in rectal cancer patients. *J Clin Oncol*. 2005; 23:8136-9.
43. Jones R, Capen D, Jacobson M, **Munn L**. PDGF and microvessel wall remodeling in adult rat lung: imaging PDGF-AA and PDGF-R α molecules in progenitor smooth muscle cells developing in experimental pulmonary hypertension. *Cell Tissue Res*. 2006; 326:759-69.
44. Dupin MM, Halliday I, Care CM, Alboul L, **Munn LL**. Modeling the flow of dense suspensions of deformable particles in three dimensions. *Phys Rev E Stat Nonlin Soft Matter Phys*. 2007; 75:066707.
45. Jain RK, Tong RT, **Munn LL**. Effect of vascular normalization by antiangiogenic therapy on interstitial hypertension, peritumor edema, and lymphatic metastasis: insights from a mathematical model. *Cancer Res*. 2007; 67:2729-35.
46. Sun C, Jain RK, **Munn LL**. Non-uniform plasma leakage affects local hematocrit and blood flow: implications for inflammation and tumor perfusion. *Ann Biomed Eng*. 2007; 35:2121-9.
47. Jones RC, Capen DE, Cohen KS, **Munn LL**, Jain RK, Duda DG. A protocol for phenotypic detection and characterization of vascular cells of different origins in a lung neovascularization model in rodents. *Nat Protoc*. 2008; 3:388-97.
48. Dupin MM, Halliday I, Care CM, **Munn LL**. Efficiency-oriented, hybrid approach for modeling deformable particles in three dimensions. *Progress in Computational Fluid Dynamics*. 2008; 8109-120
49. **Munn LL**, Dupin MM. Blood cell interactions and segregation in flow. *Ann Biomed Eng*. 2008; 36:534-44.
50. Sun C, **Munn LL**. Lattice Boltzmann simulation of blood flow in digitized vessel networks. *Comput Math Appl*. 2008; 55:1594-1600.
51. Au P, Tam J, Duda DG, Lin PC, **Munn LL**, Fukumura D, Jain RK. Paradoxical effects of PDGF-BB overexpression in endothelial cells on engineered blood vessels in vivo. *Am J Pathol*. 2009; 175:294-302.
52. Cheng G, Tse J, Jain RK, **Munn LL**. Micro-environmental mechanical stress controls tumor spheroid size and morphology by suppressing proliferation and inducing apoptosis in cancer cells. *PLoS One*. 2009; 4:e4632.
53. di Tomaso E, London N, Fuja D, Logie J, Tyrrell JA, Kamoun W, **Munn LL**, Jain RK. PDGF-C induces maturation of blood vessels in a model of glioblastoma and attenuates the response to anti-VEGF treatment. *PLoS One*. 2009; 4:e5123.
54. Jain A, **Munn LL**. Determinants of leukocyte margination in rectangular microchannels. *PLoS One*. 2009; 4:e7104.
55. Kamoun WS, Ley CD, Farrar CT, Duyverman AM, Lahdenranta J, Lacorre DA, Batchelor TT, di Tomaso E, Duda DG, **Munn LL**, Fukumura D, Sorensen AG, Jain RK. Edema control by cediranib, a vascular endothelial growth factor receptor-targeted kinase inhibitor, prolongs survival despite persistent brain tumor growth in mice. *J Clin Oncol*. 2009; 27:2542-52.
56. Perentes JY, Mckee TD, Ley CD, Mathiew H, Dawson M, Padera TP, **Munn LL**, Jain RK, Boucher Y. In vivo imaging of extracellular matrix remodeling by tumor-associated fibroblasts. *Nat Methods*. 2009; 6:143-5.
57. Vakoc BJ, Lanning RM, Tyrrell JA, Padera TP, Bartlett LA, Stylianopoulos T, **Munn LL**, Tearney GJ, Fukumura D, Jain RK, Bouma BE. Three-dimensional microscopy of the tumor microenvironment in vivo using optical frequency domain imaging. *Nat Med*. 2009; 15:1219-23.
58. Chae SS, Kamoun WS, Farrar CT, Kirkpatrick ND, Niemeyer E, De Graaf AM, Sorensen AG, **Munn LL**, Jain RK, Fukumura D. Angiopoietin-2 interferes with anti-VEGFR2-induced vessel normalization and survival benefit in mice bearing gliomas. *Clin Cancer Res*. 2010; 16:3618-27.
59. Kamoun WS, Chae SS, Lacorre DA, Tyrrell JA, Mitre M, Gillissen MA, Fukumura D, Jain RK, **Munn LL**. Simultaneous measurement of RBC velocity, flux, hematocrit and shear rate in vascular networks. *Nat Methods*. 2010; 7:655-60.

60. Stylianopoulos T, Diop-Frimpong B, **Munn LL**, Jain RK. Diffusion anisotropy in collagen gels and tumors: the effect of fiber network orientation. *Biophys J*. 2010a; 99:3119-28.
61. Stylianopoulos T, Poh MZ, Insin N, Bawendi MG, Fukumura D, **Munn LL**, Jain RK. Diffusion of particles in the extracellular matrix: the effect of repulsive electrostatic interactions. *Biophys J*. 2010b; 99:1342-9.
62. Baish JW, Stylianopoulos T, Lanning RM, Kamoun WS, Fukumura D, **Munn LL**, Jain RK. Scaling rules for diffusive drug delivery in tumor and normal tissues. *Proc Natl Acad Sci U S A*. 2011; 108:1799-803.
63. Cheng G, Liao S, Kit Wong H, Lacorre DA, di Tomaso E, Au P, Fukumura D, Jain RK, **Munn LL**. Engineered blood vessel networks connect to host vasculature via wrapping-and-tapping anastomosis. *Blood*. 2011; 118:4740-9.
64. Jain A, **Munn LL**. Biomimetic postcapillary expansions for enhancing rare blood cell separation on a microfluidic chip. *Lab Chip*. 2011; 11:2941-7.
65. Liao S, Cheng G, Conner DA, Huang Y, Kucherlapati RS, **Munn LL**, Ruddle NH, Jain RK, Fukumura D, Padera TP. Impaired lymphatic contraction associated with immunosuppression. *Proc Natl Acad Sci U S A*. 2011; 108:18784-9.
66. Perentes JY, Kirkpatrick ND, Nagano S, Smith EY, Shaver CM, Sgroi D, Garkavtsev I, **Munn LL**, Jain RK, Boucher Y. Cancer cell-associated MT1-MMP promotes blood vessel invasion and distant metastasis in triple-negative mammary tumors. *Cancer Res*. 2011; 71:4527-38.
67. Song JW, **Munn LL**. Fluid forces control endothelial sprouting. *Proc Natl Acad Sci U S A*. 2011; 108: 15342-7.
68. Huang Y, Yuan J, Righi E, Kamoun WS, Ancukiewicz M, Nezivar J, Santosuosso M, Martin JD, Martin MR, Vianello F, Leblanc P, **Munn LL**, Huang P, Duda DG, Fukumura D, Jain RK, Poznansky MC. Vascular normalizing doses of antiangiogenic treatment reprogram the immunosuppressive tumor microenvironment and enhance immunotherapy. *Proc Natl Acad Sci U S A*. 2012; 109:17561-6.
69. Plotkin SR, Bredella MA, Cai W, Kassarian A, Harris GJ, Esparza S, Merker VL, **Munn LL**, Muzikansky A, Askenazi M, Nguyen R, Wenzel R, Mautner VF. Quantitative assessment of whole-body tumor burden in adult patients with neurofibromatosis. *PLoS One*. 2012; 7:e35711.
70. Song JW, Bazou D, **Munn LL**. Anastomosis of endothelial sprouts forms new vessels in a tissue analogue of angiogenesis. *Integr Biol (Camb)*. 2012a; 4:857-62.
71. Song JW, Daubriac J, Tse JM, Bazou D, **Munn LL**. RhoA mediates flow-induced endothelial sprouting in a 3-D tissue analogue of angiogenesis. *Lab Chip*. 2012b; 12:5000-6.
72. Stylianopoulos T, Martin JD, Chauhan VP, Jain SR, Diop-Frimpong B, Bardeesy N, Smith BL, Ferrone CR, Hornicek FJ, Boucher Y, **Munn LL**, Jain RK. Causes, consequences, and remedies for growth-induced solid stress in murine and human tumors. *Proc Natl Acad Sci U S A*. 2012; 109:15101-8.
73. Tse JM, Cheng G, Tyrrell JA, Wilcox-Adelman SA, Boucher Y, Jain RK, **Munn LL**. Mechanical compression drives cancer cells toward invasive phenotype. *Proc Natl Acad Sci U S A*. 2012; 109:911-6.
74. Kirkpatrick ND, Chung E, Cook DC, Han X, Gruionu G, Liao S, **Munn LL**, Padera TP, Fukumura D, Jain RK, Video-rate resonant scanning multiphoton microscopy: An emerging technique for intravital imaging of the tumor microenvironment. *IntraVital*. 2012; 1:60-68.
75. Niemeyer E, Kamoun WS, Han H-S, Huang Y, Bhaumik J, Chen Y, Gillisen M, Martin JD, Roberge S, Lanning RM, Cui J, **Munn LL**, Nocera DC, Padera T, Fukumura D, Jain RK, Bawendi MG, Dunst J, Duda DG. Multiphoton microscopy and in-situ labeling techniques allow detection of endogenous hematopoietic stem cells and measurement of functional parameters in the stem cell niche. *ONKOLOGIE*. 2013; 36:229-230.
76. Qazi, H, Palomino R, Shi Z-D, **Munn LL**, Tarbell JM. Cancer Cell Glycocalyx Mediates Mechanotransduction and Flow-Regulated Invasion. *Integr. Biol*. 2013; 5:1334-43.
77. **Munn LL**. Dynamics of tissue topology during cancer invasion and metastasis. *Physical Biology*. 2013; 10(6):065003 (13pp).
78. Kunert C, Baish JW, Liao S, Padera TP, **Munn LL**. Mechanobiological oscillators control lymph flow. *Proc Natl Acad Sci U S A*. 2015; 112:10938-43.
79. Kunert C, Baish JW, Liao S, Padera TP, **Munn LL**. Nitric oxide regulates lymphatic contractions. *Proc Natl Acad Sci U S A*. 2016. 113:E106.
80. Kloepper J, Riedemann L, Amoozgar Z, Seano G, Susek K, Yu V, Dalvie N, Amelung RL, Datta M, Song JW, Askoxylakis V, Taylor JW, Lu-Emerson C, Batista A, Kirkpatrick KD, Jung K, Snuderl M, Muzikansky A,

- Stubenrauch KG, Krieter O, Wakimoto H, Xu L, **Munn LL**, Duda DG, Fukumura D, Batchelor TT, Jain RK. Ang-2/VEGF bispecific antibody reprograms macrophages and resident microglia to anti-tumor phenotype and prolongs glioblastoma survival. *Proc Natl Acad Sci U S A*. 2016; 113:4476-4481
81. Gruionu GG, Bazou D, Maimon N, Onita-Lenco M, Gruionu LG, Huang P, **Munn LL**. Implantable Tissue Isolation Chambers for Analyzing Tumor Dynamics In Vivo. *Lab Chip*. 2016; 16:1840-51.
 82. Qazi H, Shi ZD, Song JW, Cancel LM, Huang P, Zeng Y, Roberge S, **Munn LL***, Tarbell JM.* Heparan Sulfate Proteoglycans Mediate Renal Carcinoma Metastasis. *International Journal of Cancer*. 2016; 139:2791-2801. **Equal contributions*.
 83. Bazou D, Ng MR, Song JW, Chin SM, Maimon N, **Munn LL**. Flow-induced HDAC1 phosphorylation and nuclear export in angiogenic sprouting. *Scientific Reports*. 2016a; 6:34046.
 84. Bazou D, Maimon N, Gruionu G, **Munn LL**. Self-assembly of vascularized tissue to support tumor explants *in vitro*. *Integrative Biology*. 2016b; 8:1301-11.
 85. Baish JW, Kunert C, Padera TP, **Munn LL**. Synchronization and random triggering of lymphatic vessel contractions. *PLOS Computational Biology*. 2016; 12: e1005231. doi: 10.1371/journal.pcbi.1005231.
 86. Nia HT, Liu H, Seano G, Datta M, Jones D, Rahbari N, Incio J, Chauhan VP, Jung K, Martin JD, Askoxylakis V, Padera TP, Fukumura D, Boucher Y, Hornicek FJ, Grodzinsky AJ, Baish JW, **Munn LL**, Jain RK. Solid stress and elastic energy: new measures of tumor mechanopathology. *Nature Biomedical Engineering*. 2017; 1:0004.
 87. Gupta N, Badeaux M, Liu Y, Naxerova K, Sgroi D, **Munn LL**, Jain RK, Garkavtsev I. Stress granule-associated protein G3BP2 regulates breast tumor initiation. *Proc Natl Acad Sci U S A*. 2016; 114:1033-1038. doi:10.1073/pnas.1525387114.
 88. Kozin SV, Maimon N, Wang R, Gupta N, **Munn LL**, Jain RK, Garkavtsev I. Secretory leukocyte protease inhibitor (SLPI) as a potential target for inhibiting metastasis of triple-negative breast cancers. *Oncotarget*. 2017; 8(65): 108292–108302.
 89. Bazou D, Maimon N, Munn LL, Gonzalez I. Effects of Low Intensity Continuous Ultrasound (LICU) on Mouse Pancreatic Tumor Explants. *Appl. Sci*. 2017; 7(12) 1275; doi:10.3390/app7121275.
 90. Bouta EM, Blatter C, Ruggieri TA, Meijer EFJ, **Munn LL**, Vakoc BJ, Padera TP. Lymphatic function measurements influenced by contrast agent volume and body position. 2018; *JCI Insight*. 3(2):e96591.
 91. Jones D, Meijer EFJ, Blatter C, Liao S, Pereira ER, Bouta EM, Jung K, Chin SM, Huang P, **Munn LL**, Vakoc BJ, Otto M, Padera TP. Methicillin-resistant *Staphylococcus aureus* causes sustained collecting lymphatic vessel dysfunction. 2018; *Science Translational Medicine*. 10(424), eaam7964. DOI:10.1126/scitranslmed.aam7964.
 92. Nia HT, Datta M, Seano G, Huang, P, **Munn LL**, Jain RK. Quantifying solid stress and elastic energy from excised or in situ tumors. *Nature Protocols*. 2018; 13(5) 1091-1105.
 93. Bazou D, Maimon N, Gruionu G, Grahovac J, Seano G, Liu H, Evans CL, **Munn LL**. Vascular beds maintain pancreatic tumor explants for ex vivo drug screening. *Journal of Tissue Engineering and Regenerative Medicine*. 2018; 12(1): e318-e322.
 94. Seano G, Nia, HT, Emblem KE, Datta M, Ren J, Krishnan S, Kloepper J, Pinho MC, Ho WW, Ghosh M, Askoxylakis V, Ferraro GB, Riedemann L, Gerstner ER, Batchelor TT, Wen PY, Lin NU, Grodzinsky AJ, Fukumura D, Huang P, Baish JW, Padera TP, **Munn LL**, Jain RK. Solid stress in brain tumours causes neuronal loss and neurological dysfunction and can be reversed by lithium. *Nature Biomedical Engineering* 2019; 3: 230-245.
 95. Li H, Mei Y, Maimon N, Padera TP, Baish JW, **Munn LL**. The effects of valve leaflet mechanics on lymphatic pumping assessed using numerical simulations. *Scientific Reports* 2019; 9(1): 10649.
 96. Moran H, Cancel LM, Mayer MA, Qazi H, **Munn LL**, Tarbell JM. The cancer cell glycocalyx proteoglycan glypican-1 mediates interstitial flow mechanotransduction to enhance cell migration and metastasis. *Biorheology* 1-11, 2019.
 97. Voutouri C, Kirkpatrick ND, Chung E, Mpekris F, Baish JW, **Munn LL**, Fukumura D, Stylianopoulos T, Jain RK. Experimental and computational analyses reveal dynamics of tumor vessel cooption and optimal treatment strategies. *Proceedings of the National Academy of Sciences*, 116: 2662-2671, 2019.
 98. Mpekris F, Voutouri C, Baish JW, Duda DG, **Munn LL**, Stylianopoulos T, Jain RK. Combining microenvironment normalization strategies to improve cancer immunotherapy. *Proceedings of the National Academy of Sciences*, 117: 3728-3737, 2020.

99. Nikmaneshi MR, Firoozabadi B, Mozafari A, **Munn LL**. A multi-scale model for determining the effects of pathophysiology and metabolic disorders on tumor growth. *Scientific Reports*, 10(1):3025, 2020; doi: 10.1038/s41598-020-59658-0.
100. Datta M, Nia H, Seano G, Roberge S, Huang P, **Munn L**, Jain RK. In vivo compression and imaging for causal studies of mechanical forces in the brain. *Neuro-Oncology* 2020, 22: ii235–ii236.
101. Nikmaneshi MR, B Firoozabadi B, **Munn LL**. A mechanobiological mathematical model of liver metabolism. *Biotechnology and Bioengineering* 2020. 117:2861-2874.
102. Nia HT, Datta M, Seano G, Zhang S, Ho WW, Roberge S, Huang P, **Munn LL**, Jain RK. In vivo compression and imaging in mouse brain to measure the effects of solid stress. *Nature Protocols* 2020. 15: 2321–2340. <https://doi.org/10.1038/s41596-020-0328-2>.
103. Shigeta K, Matsui A, Kikuchi H, Klein S, Mamessier E, Chen IX, Aoki S, Kitahara S, Inoue K, Shigeta A, Hato T, Ramjiawan RR, Staiculescu D, Zopf D, Fiebig L, Hobbs GS, Quaas A, Dima S, Popescu I, Huang P, **Munn LL**, Cobbold M, Goyal L, Zhu AX, Jain RK, Duda DG. Regorafenib combined with PD1 blockade increases CD8 T-cell infiltration by inducing CXCL10 expression in hepatocellular carcinoma. *J Immunother Cancer* 2020. 8(2):e001435. doi: 10.1136/jitc-2020-001435. PMID: 33234602; PMCID: PMC7689089.
104. Aoki S, Inoue K, Klein S, Halvorsen S, Chen J, Matsui A, Nikmaneshi MR, Kitahara S, Hato T, Chen X, Kawakubo K, Nia HT, Chen I, Schanne DH, Mamessier E, Shigeta K, Kikuchi H, Ramjiawan RR, Schmidt TC, Iwasaki M, Yau T, Hong TS, Quaas A, Plum PS, Dima S, Popescu I, Bardeesy N, **Munn LL**, Borad MJ, Sassi S, Jain RK, Zhu AX, Duda DG. Placental growth factor promotes tumour desmoplasia and treatment resistance in intrahepatic cholangiocarcinoma. *Gut* 2021. gutjnl-2020-322493.
105. Voutouri C, Nikmaneshi MR, Hardin CC, Patel AB, Verma A, Khandekar MJ, Dutta S, Stylianopoulos T, **Munn LL**, Jain RK. In silico dynamics of COVID-19 phenotypes for optimizing clinical management. *Proceedings of the National Academy of Sciences* 2021. 118: e2021642118.
106. Subudhi S, Verma A, Patel AB, Hardin CC, Khandekar MJ, Lee H, McEvoy D, Stylianopoulos T, **Munn LL**, Dutta S, Jain RK. Comparing Machine Learning Algorithms for Predicting ICU Admission and Mortality in COVID-19. *NPJ Digital Medicine* 2021. 4:87. doi.org/10.1038/s41746-021-00456-x.
107. Moran H, Cancel LM, Huang P, Roberge S, Xu T, Tarbell JM, **Munn LL**. Glycocalyx mechanotransduction mechanisms are involved in renal cancer metastasis. *Matrix Biology Plus* 2022. 13: 100100. doi.org/10.1016/j.mbps.2021.100100.
108. Subudhi S, Voutouri C, Hardin CC, Nikmaneshi M, Patel AB, Verma A, Khandekar MJ, Dutta S, Stylianopoulos T, Jain RK, **Munn LL**. Strategies to minimize heterogeneity and optimize clinical trials in Acute Respiratory Distress Syndrome (ARDS): Insights from mathematical modelling. *eBioMedicine* 75:103809. <https://doi.org/10.1016/j.ebiom.2021.103809>.
109. Baish JW, Padera TP, **Munn LL**. The effects of gravity and compression on interstitial fluid transport in the lower limb. *Scientific Reports* 2022. 12: 4890.
110. Li H, Wei H, Padera TP, Baish JW, **Munn LL**. Computational simulations of the effects of gravity on lymphatic transport, *PNAS Nexus* 2022, 1:237, <https://doi.org/10.1093/pnasnexus/pgac237>.
111. Voutouri C, C. Hardin CC, Naranbhai V, Nikmaneshi MR, Khandekar MJ, Gainor JF, Stylianopoulos T, **Munn LL**, Jain RK. Mechanistic model for booster doses effectiveness in healthy, cancer, and immunosuppressed patients infected with SARS-CoV-2. *PNAS* 2023. 120: e2211132120. <https://doi.org/10.1073/pnas.2211132120>.
112. Nikmaneshi MR, Jain RK, **Munn LL**. Computational simulations of tumor growth and treatment response: Benefits of high-frequency, low-dose drug regimens and concurrent vascular normalization. *PLOS Computational Biology* 2023. 19 (6), e1011131.
113. Gupta, N., Ochiai, H., Hoshino, Y., Klein, S., Zustin, J., Ramjiawan, R.R., Kitahara, S., Maimon, N., Bazou, D., Chiang, S., Li, S., Schanne, D.H., Jain, Rakesh.K., **Munn, L.L.**, Huang, P., Kozin, S.V. & Duda, D.G. Inhibition of CXCR4 Enhances the Efficacy of Radiotherapy in Metastatic Prostate Cancer Models. *Cancers* 2023. 15:1021. <http://dx.doi.org/10.3390/cancers15041021>.
114. Nikmaneshi MR, Baish JW, Zhou H, Padera TP, **Munn LL**, Transport Barriers Influence the Activation of Anti-Tumor Immunity: A Systems Biology Analysis. *Adv. Sci.* 2023. 2304076. <https://doi.org/10.1002/advs.202304076>.
115. Chen J, Amoozgar Z, Liu X, Aoki S, Liu Z, Shin SM, Matsui A, Alexei Hernandez A, Zhangya Pu Z, Stefan Halvorsen S, Pin-Ji Lei PJ, Meenal Datta M, Lingling Zhu L, Ruan Z, Shi L, Staiculescu D, Inoue K, **Munn LL**, Fukumura F, Huang P, Sassi S, Bardeesy N, Ho WJ, Jain RK, Duda DG; Reprogramming the Intrahepatic

- Cholangiocarcinoma Immune Microenvironment by Chemotherapy and CTLA-4 Blockade Enhances Anti-PD-1 Therapy. *Cancer Immunol Res* 2024. 12 (4): 400–412. <https://doi.org/10.1158/2326-6066.CIR-23-0486>.
116. Zhang Y, Liu J, de Souza Araujo IJ, Bahammam L, **Munn LL**, Huang GTJ. Neovascularization by DPSC-ECs in a Tube Model for Pulp Regeneration Study. *Journal of Dental Research* 2024. <https://doi.org/10.1177/00220345241236392>.
 117. Voutouri C, Hardin CC, Naranbhai V, Nikmaneshi MR, Khandekar MJ, Gainor JF, **Munn LL**, Jain RK, Stylianopoulos T, Dynamic heterogeneity in COVID-19: Insights from a mathematical model. *PLoS ONE* 2024. 19(5): e0301780. <https://doi.org/10.1371/journal.pone.0301780>.
 118. Li H, Zhang J, Padera TP, Baish JW, **Munn LL**, Fluid dynamics and leukocyte transit in the lymphatic system, PNAS Nexus, Volume 3, Issue 6, June 2024, gae195, <https://doi.org/10.1093/pnasnexus/pgae195>
 119. Kunz LV, Bosque JJ, Nikmaneshi M, Chamseddine I, **Munn LL**, Schuemann J, Paganetti H & Bertolet A. AMBER: A Modular Model for Tumor Growth, Vasculature and Radiation Response. *Bulletin of Mathematical Biology* 2024. 86: 139.
 120. Voutouri C, Hardin CC, Naranbhai V, Nikmaneshi MR, Khandekar MJ, Gainor JF, Stylianopoulos T, **Munn LL**, Jain RK. In silico clinical studies for optimal COVID-19 vaccination schedules in patients with cancer. *Cell Reports Medicine* 2024 5:3. <https://doi.org/10.1016/j.xcrm.2024.101436>.
 121. Gruionu G, Baish J, McMahon S, Blauvelt D, Gruionu LG, Lenco MO, Vakoc BJ, Padera TP & **Munn LL**. Experimental and theoretical model of microvascular network remodeling and blood flow redistribution following minimally invasive microvessel laser ablation. *Scientific Reports* 2024. 14: 8767.
 122. Nia HT, **Munn LL** & Jain RK. Probing the physical hallmarks of cancer. *Nature Methods* 2025. 1-19. <https://doi.org/10.1038/s41592-024-02564-4>.
 123. Razavi MS, Ruscic KJ, Korn EG, Marquez M, Houle TT, Singhal D, **Munn LL** & Padera TP. A multiresolution approach with method-informed statistical analysis for quantifying lymphatic pumping dynamics. *npj Imaging* 2025. <https://doi.org/10.1038/s44303-024-00061-z>.
 124. Nia HT, Datta M, Kumar AS, Siri S, Ferraro GB, Chatterjee S, McHugh JM, Ng PR, West TR, Rapalino O, Choi BD, Nahed BV, **Munn LL**, Jain RK; Solid Stress Estimations via Intraoperative 3D Navigation in Patients with Brain Tumors. *Clin Cancer Res* 2025. 31 (16): 3571–3580. <https://doi.org/10.1158/1078-0432.CCR-24-4159>.
 125. Voutouri C, Hardin CC, Naranbhai V, Nikmaneshi MR, Khandekar MJ, Gainor JF, Stylianopoulos T, **Munn LL**, Jain RK. In silico clinical studies for optimal COVID-19 vaccination schedules in patients with cancer. *Cell Reports Medicine* 2024 5:3. <https://doi.org/10.1016/j.xcrm.2024.101436>.
 126. Hadjigeorgiou AG, Harkos C, Mishra AK, Morad G, Johnson SB, Ajami NJ, Wargo JA, **Munn LL**, Stylianopoulos T, Jain RK. Mathematical Modeling and Association Analysis Decipher the Impact of the Gut Microbiome on Cancer Immunotherapy. *Cancer Res* 2025. 85 (16): 3139–3155. <https://doi.org/10.1158/0008-5472.CAN-24-2232>
 127. Lei P-J, Ruscic KJ, Roh K, Rajotte JJ, O'Melia MJ, Bouta EM, Marquez M, Pereira ER, Kumar AS, Razavi MS, Zhou H, Menzel L, Huang L, Kumra H, Duquette M, Huang P, Baish JW, **Munn LL**, Kurpios NA, Ubellacker JM, Padera TP. Aging-induced changes in lymphatic muscle cell transcriptomes are associated with reduced pumping of peripheral collecting lymphatic vessels in mice. *Developmental Cell* 2025. 60(7):1118-1133.e5. DOI: 10.1016/j.devcel.2024.12.010.
 128. Hadjigeorgiou AG, **Munn LL**, Stylianopoulos T, Jain RK. Physiologically based pharmacokinetic model for CAR-T cell delivery and efficacy in solid tumors *PNAS* 2025. 122(46): e2522634122.
 129. Nikmaneshi MR, **Munn LL**. A Hybrid Multiscale Model for Predicting CAR-T Therapy Outcomes in Solid Tumors *bioRxiv* 2025.
 130. Nikmaneshi MR, Padera TP, **Munn LL**. Optimizing Cancer Vaccinations Using a Physiologically Based Pharmacokinetic (PBPK) Model *bioRxiv*, 2025.
 131. Li H, Lu W, Kaoui B, Baish JW, **Munn LL**. Efficient calculation of fluid transport in porous media with moving boundaries *bioRxiv* 2025 doi: <https://doi.org/10.64898/2025.12.15.694505>.
 132. Voutouri C, **Munn LL**, Stylianopoulos T, Jain RK. Biomarkers of mRNA vaccine efficacy derived from mechanistic modeling of tumor-immune interactions. *PLoS Computational Biology* 2025; 21(6): e1013163. <https://doi.org/10.1371/journal.pcbi.1013163>.

133. Krishnan S, Lee S, Amoozgar Z, Subudhi S, Kumar AS, Posada JM, Lindeman N, Lei P, Duquette M, Steinbuch S, Charabati M, Huang P, Andersson P, Datta M, **Munn LL**, Fukumura D, Jain RK. Wnt inhibition alleviates resistance to anti-PD1 therapy and improves antitumor immunity in glioblastoma. *PNAS* 122 (38):e2414941122, <https://doi.org/10.1073/pnas.2414941122> (2025).
134. O'Melia MJ, Menzel L, Lei P-J, Zhou H, Contreras-Alvarado N, Rajotte JJ, Liu L, Nikmaneshi MR, Baish JW, Ubellacker JM, Boland GM, Cohen S, **Munn LL**, Padera TP. Overcoming impaired antigen presentation in tumor draining lymph nodes facilitates immunotherapy. *bioRxiv*, 2025.
135. O'Melia MJ, Sierra-Davidson, K Robert MA, Menzel L, Lingshan Liu L, Lei PJ, **Munn LL**, Padera TP, Cohen S. The anti-virus T cell response dominates the anti-cancer response in oncolytic virus therapy. *bioRxiv*, 2025.
136. Menzel L, Zschummel M, O'Melia MJ, Sandstedt M, Zhou H, Lei P-J, Liu L, Lee H, Sen DR, **Munn LL**, Jonasson L, Padera TP. Lymph node contraction links sex-biased naive CD8 T cell decline to compromised antigen recognition. *bioRxiv*, 2025.
137. AP Yu AP, X Zhang X, LL **Munn LL**. Optimizing T-cell-mediated cancer killing: An agent-based model *bioRxiv*, 2025.

Non-peer reviewed scientific or medical publications/materials in print or other media

Reviews, Chapters and Editorials

1. Jain RK, Koenig GC, Dellian M, Fukumura D, **Munn LL**, Melder RJ. Leukocyte-endothelial adhesion and angiogenesis in tumors. *Cancer and Metastasis Reviews* 1996; 15:195-204.
2. Melder RJ, Koenig G, **Munn LL**, Jain RK. Adhesion of activated natural killer cells to tumor necrosis factor-alpha-treated endothelium under physiological flow conditions. *Natural Immunity* 1996; 15:154-163.
3. Jain RK, LL **Munn LL**, Fukumura D, Melder RJ. In vitro and in vivo quantification of adhesion between leukocytes and vascular endothelium. In: Morgan JR, Yarmush ML, editors *Methods in Molecular Medicine* Totowa, NJ, Humana Press, Inc 1998; 18:553-575.
4. Jain RK, **Munn LL**. Leaky vessels? Call Ang1! *Nature Medicine* 2000; 6:131-2.
5. McDonald D, Munn L, Jain R. Vasculogenic mimicry: how convincing, how novel, and how significant? *American Journal of Pathology* 2000; 156:383-388.
6. Jain RK, **Munn LL**, Fukumura D. Transparent window models and intravital microscopy: imaging gene expression, physiological function and drug delivery in tumors. In: Teicher, B, editor *Tumor Models in Cancer Research* Totowa, NJ, Humana Press, Inc 2001; pp 647-672.
7. Jain RK, **Munn LL**, Fukumura D. Dissecting tumours using intravital microscopy. *Nature Reviews Cancer* 2002; 2:266-276.
8. **Munn LL**. Aberrant vascular architecture in tumors and its importance in drug-based therapies. *Drug Discovery Today* 2003; 8:396-403.
9. Jain RK, Brown EB, **Munn LL**, Fukumura D. Intravital microscopy of normal and diseased tissues in mice. In: *Live Cell Imaging - A Laboratory Manual*, Goldman RD and Spector DL, editors, CSHL Press, Cold Spring Harbor, NY 2004; Chapter 24, pp 435-466.
10. Brown EB, **Munn LL**, Fukumura D, Jain RK. A practical guide to in vivo imaging of tumors. In: *MPLSM Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY 2005; Chapter 92, pp 695-700.
11. **Munn LL**. Analytical approaches to leukocyte-endothelium interactions. In: *Microvascular Research: Biology and Pathology*, Shepro D, editor Elsevier Press, Amsterdam 2005; Chapter 117, pp 791-794.
12. Bockhorn M, Jain RK, **Munn LL**. Active versus passive mechanisms in metastasis: do cancer cells crawl into vessels, or are they pushed? *Lancet Oncol* 2007; 8:444-48.
13. Jain RK, **Munn LL**. Vascular normalization as a rationale for combining chemotherapy with antiangiogenesis agents. *Principles & Practice of Oncology* 2007; 21:1-7.
14. **Munn LL** and Jain A. Design and fabrication of microfluidic devices for flow-based separation of blood cells. *Lab-on-a-Chip Technology (Vol 2): Biomolecular Separation and Analysis* 2009 Herold, KE and Rasooly, A (Eds) Caister Academic Press, Norfolk, UK ISBN 978-1-904455-47-9.

15. Jain RK, **Munn LL**, Fukumura D. Transparent Window Models and Intravital Microscopy: Imaging Gene Expression, Physiological Function and Therapeutic Effects in Tumors. In: *Tumor Models In Cancer Research*, Beverly A Teicher, ed Cancer Drug Discovery and Development, 2011, Part 9, 641-679, DOI: 101007/978-1-60761-968-0_26.
16. Brown E, **Munn LL**, Fukumura D, Jain RK. In vivo imaging of tumors. *Cold Spring Harb Protoc*, 2010: pdb prot5452.
17. Fukumura D, Duda DG, **Munn LL**, Jain RK. Tumor microvasculature and microenvironment: novel insights through intravital imaging in pre-clinical models. *Microcirculation* 2010; 17: 206-225.
18. **Munn LL**, Kamoun, W, Dupin, M, Tyrrell JA. Modeling structural and functional adaptation of tumor vessel networks during anti-angiogenic therapy. *Modeling Tumor Vasculature*, Trachette Jackson, ed., Springer Science, 2011.
19. Goel S, Duda DG, Xu L, **Munn LL**, Boucher Y, Fukumura D, Jain RK. Normalization of the vasculature for treatment of cancer and other diseases. *Physiol Rev* 2011; 91: 1071-1121.
20. Kozin SV, Duda DG, **Munn LL**, Jain RK. Is vasculogenesis crucial for the regrowth of irradiated tumours? *Nat Rev Cancer* 2011; 11: 532.
21. **Munn LL**, Kamoun WS. Laser Scanning Methodologies for Measuring RBC Velocity, Flux, Hematocrit and Shear Rate in Vascular Networks. *The Textbook of Angiogenesis and Lymphangiogenesis: Methods and Applications*. Zudaire Enrique, Cuttitta, F (Eds.) Springer 2012, pp 417-431.
22. Jain RK, **Munn LL**, Fukumura D. Rabbit ear chambers. *Cold Spring Harb Protoc*. 2012 Jul 1;2012(7):813-14. doi: 10.1101/pdb.prot070045. PubMed PMID: 22753607.
23. Jain RK, **Munn LL**, Fukumura D. Corneal pocket assay in rabbits. *Cold Spring Harb Protoc*. 2012 Sep 1;2012(9):1017-8. doi: 10.1101/pdb.prot070052. PubMed PMID: 22949714.
24. Jain RK, **Munn LL**, Fukumura D. Mammary fat pad chamber preparation in mice. *Cold Spring Harb Protoc*. 2012 Oct 1;2012(10):1113-4. doi: 10.1101/pdb.prot071506. PubMed PMID: 23028075.
25. Jain RK, **Munn LL**, Fukumura D. Mammary fat pad tumor preparation in mice. *Cold Spring Harb Protoc*. 2012 Oct 1;2012(10):1115-6. doi: 10.1101/pdb.prot071514. PubMed PMID: 23028076.
26. Jain RK, **Munn LL**, Fukumura D. Lymphangiography of the mouse tail. *Cold Spring Harb Protoc*. 2012 Nov 1;2012(11):1177-8. doi: 10.1101/pdb.prot072108. PubMed PMID: 23118364.
27. Jain RK, **Munn LL**, Fukumura D. Lymphangiography of the mouse ear. *Cold Spring Harb Protoc*. 2012 Nov 1;2012(11):1179-80. doi: 10.1101/pdb.prot072116. PubMed PMID: 23118365.
28. Jain RK, **Munn LL**, Fukumura D. Pancreatic tumor preparation in mice. *Cold Spring Harb Protoc*. 2012 Dec 1;2012(12). doi:pii: pdb.prot072363. 10.1101/pdb.prot072363. PubMed PMID: 23209145.
29. Jain RK, **Munn LL**, Fukumura D. Liver tumor preparation in mice. *Cold Spring Harb Protoc*. 2012 Dec 1;2012(12). doi:pii: pdb.prot072371. 10.1101/pdb.prot072371. PubMed PMID: 23209146.
30. Jain RK, **Munn LL**, Fukumura D. Lung window preparation in mice. *Cold Spring Harb Protoc*. 2013 Jan 1;2013(1). doi:pii: pdb.prot072678. 10.1101/pdb.prot072678. PubMed PMID: 23282642.
31. Jain RK, **Munn LL**, Fukumura D. Measuring Interstitial Diffusion, Convection, and Binding Parameters in Mouse Tumors. *Cold Spring Harb Protoc*. 2013, 2013(7).
32. Jain RK, **Munn LL**, Fukumura D. Measuring Interstitial pH and pO₂ in Mouse Tumors. *Cold Spring Harb Protoc*. 2013, 2013(7).
33. Jain RK, **Munn LL**, Fukumura D. Measuring Leukocyte-Endothelial Interactions in Mice. *Cold Spring Harb Protoc*. 2013, 2013(6).
34. Jain RK, **Munn LL**, Fukumura D. Measuring Vascular Permeability in Mice. *Cold Spring Harb Protoc*. 2013, 2013(5).
35. Jain RK, **Munn LL**, Fukumura D. Measuring angiogenesis and hemodynamics in mice. *Cold Spring Harb Protoc*. 2013, 2013(4).
36. Duda DG, **Munn LL**, Jain RK. Can We Identify Predictive Biomarkers for Antiangiogenic Therapy of Cancer Using Mathematical Modeling? *JNCI* 2013 105: 762-765.
37. **Munn LL**, Kunert C, Tyrrell JA. Modeling Tumor Blood Vessel Dynamics. in *Mathematical Methods and Models in Biomedicine-- Lecture Notes on Mathematical Modelling in the Life Sciences*, Urszula Ledzewicz, Heinz Schättler, Avner Friedman, Eugene Kashdan ed. 2013, pp 117-147.

38. Kesler CT, Liao S, **Munn LL**, Padera TP. Lymphatic vessels in health and disease. *Wiley Interdisciplinary Reviews: Systems Biology and Medicine*, 2013.
39. Chauhan VP, Boucher Y, Ferrone CR, Roberge S, Martin JD, Stylianopoulos T, Bardeesy N, DePinho RA, Padera TP, **Munn LL**, Jain RK. Compression of pancreatic tumor blood vessels by hyaluronan is caused by solid stress and not interstitial fluid pressure. *Cancer Cell* 2014, 26(1): 14-15.
40. **Munn LL**, Padera TP. Imaging the lymphatic system. *Microvascular Research* 2014: 55-63.
41. Song JW, Bazou D, **Munn LL**. Microfluidic Model of Angiogenic Sprouting. In *Vascular Morphogenesis*, Springer, NY. (2015) pp 243-254.
42. Janmey P, Fletcher D, Gerecht S, Levine R, Mallick P, McCarty O, **Munn L**, Reinhart-King C. *Physical Sciences and Engineering Advances in Life Sciences and Oncology: A WTEC Global Assessment*. Springer, Nov 19, 2015 - 403 pages.
43. **Munn LL**. Mechanobiology of lymphatic contractions. *Seminars in Cell & Developmental Biology*. 2015 Elsevier, 38:67-74.
44. **Munn LL**. Fluid Mechanics and Transport in Tumors. *Physical Sciences and Engineering Advances in Life Sciences and Oncology*. Part of the series Science Policy Reports, 2016; pp 73-88.
45. Padera TP, Meijer EFJ, **Munn LL**. The Lymphatic System in Disease Processes and Cancer Progression. *Annu. Rev. Biomed. Eng.* (2016) 18:125-58.
46. **Munn LL**, Jain RK. The Forces of Cancer. *The Scientist*. 2016; 30: 52-57.
47. **Munn LL**. Cancer and Inflammation. *WIREs Systems Biology and Medicine*. 2017; 9:e1370 doi:10.1002/wsbm.1370.
48. Stylianopoulos T, **Munn LL**, Jain RK. Reengineering the Physical Microenvironment of Tumors to Improve Drug Delivery and Efficacy: From Mathematical Modeling to Bench to Bedside. *Trends in Cancer*. 2018; 4(4): 292-319.
49. Stylianopoulos T, **Munn LL**, Jain RK. Reengineering the Tumor Vasculature: Improving Drug Delivery and Efficacy. *Trends in Cancer*. 2018; 4(4): 258-59.
50. **Munn LL**, Garkavtsev I. SLPI: a new target for stopping metastasis. *Aging*. 2018;10(1): 13-14.
51. Nowak-Sliwinska P, Alitalo K, Allen E, Anisimov A, Aplin AC, Auerbach R, Augustin HG, Bates DO, Van Beijnum JR, Bender RHF, Bergers G, Bikfalvi A, Bischoff J, Böck BC, Brooks PC, Bussolino F, Cakir B, Carmeliet P, Castranova D, Cimpean AM, Cleaver O, Coukos G, Davis GE, De Palma M, Dimberg A, Dings RPM, Djonov V, Dudley AC, Dufton NP, Fendt S-M, Ferrara N, Fruttiger M, Fukumura D, Ghesquière B, Gong Y, Griffin RJ, Harris AL, Hughes CCW, Hultgren NW, Iruela-Arispe ML, Irving M, Jain RK, Kalluri R, Kalucka J, Kerbel RS, Kitajewski J, Klaassen I, Kleinmann HK, Koolwijk P, Kuczyński E, Kwak BR, Marien K, Melero-Martin JM, **Munn LL**, Nicosia RF, Noel A, Nurro J, Olsson A-K, Petrova TV, Pietras K, Pili R, Pollard JW, Post MJ, Quax PHA, Rabinovich GA, Raica M, Randi AM, Ribatti D, Ruegg C, Schlingemann RO, Schulte-Merker S, Smith LEH, Song JW, Stacker SA, Stalin J, Stratman AN, Van De Velde M, Van Hinsbergh VWM, Vermeulen PB, Waltenberger J, Weinstein BM, Xin H, Yetkin-Arik B, Yla-Herttuala S, Yoder MC, Griffioen AW. Consensus guidelines for the use and interpretation of angiogenesis assays. *Angiogenesis*. 2018. 21(3): 425-532. DOI:10.1007/s10456-018-9613-x.
52. Nia HT, **Munn LL**, Jain RK, Mapping physical tumor microenvironment and drug delivery. *Clinical Cancer Research*. 2019. clincanres.3724.2018.
53. **Munn LL**, Jain RK. Vascular regulation of anti-tumor immunity. *Science* 2019. 365: 544-545. DOI: 10.1126/science.aaw7875.
54. **Munn LL** and Nia HT. Mechanosensing tensile solid stresses. *Proceedings of the National Academy of Sciences* 2019. 116: 21960-21962.
55. Nia HT, **Munn LL**, Jain RK. Physical traits of cancer. *Science*, 2020 370.
56. **Munn LL**, Stylianopoulos T, Jain NK, Hardin CC, Khandekar MJ, Jain RK. Vascular Normalization to Improve Treatment of COVID-19: Lessons from Treatment of Cancer. *Clin Cancer Res* 2021. DOI: 10.1158/1078-0432.CCR-20-4750.
57. Souri M, Soltani M, Kashkooli FM, Shahvandi MK, Chiani M, Shariati FS, Mehrabi MR, **Munn LL**. Towards principled design of cancer nanomedicine to accelerate clinical translation. *Materials Today Bio* 2022. 13:100208. <https://doi.org/10.1016/j.mtbio.2022.100208>
58. Wang X, Shen Y, Shang M, Liu X, **Munn LL**, Endothelial mechanobiology in atherosclerosis, *Cardiovascular Research*, 2023 119: 1656-1675, <https://doi.org/10.1093/cvr/cvad076>

59. **Munn, L.L.**, Bazou, D. A Self-Assembly Method for Creating Vascularized Tumor Explants Using Biomaterials for 3D Culture. 2023. In: Movia, D., Prina-Mello, A. (eds) Cancer Cell Culture. *Methods in Molecular Biology*, vol 2645. Humana, New York, NY. https://doi.org/10.1007/978-1-0716-3056-3_12.
60. Razavi MS, **Munn LL** & Padera TP. Mechanics of Lymphatic Pumping and Lymphatic Function. *Cold Spring Harbor Perspectives in Medicine* 2024. a041171.
61. Linke JA, **Munn LL** & Jain RK. Compressive stresses in cancer: characterization and implications for tumour progression and treatment. *Nature Reviews Cancer* 2024. 1-24.
62. **Munn LL**, Jain RK. Challenges and opportunities for the next generation of computational tumor models. *PLoS Biol* 2025. 23(7): e3003269. <https://doi.org/10.1371/journal.pbio.3003269>.
63. **Munn LL**. The cellular dance that splits vessels, *Proc. Natl. Acad. Sci. U.S.A.* 2025.122 (22) e2508260122, <https://doi.org/10.1073/pnas.2508260122> (2025).
64. Razavi MS, **Munn LL**, and Padera TP. Mechanics of Lymphatic Pumping and Lymphatic Function. *Cold Spring Harb Perspect Med* 2025.;15:a041171doi:10.1101/cshperspect.a041171.

Patents

System and method for measuring solid stress in tissues

G Gruionu, L Gruionu, LL Munn, RK Jain

US Patent 11,259,714

Therapeutic use of bFGF to treat conditions involving adhesion of cytotoxic white cells to endothelium

Rakesh K. Jain, Robert J. Melder, Gerald C. Koenig, Lance L. Munn

US6010712A

Modified microorganisms for anti-cancer therapy

Neil S. Forbes, Lance L. Munn, Dai Fukumura, Rakesh K. Jain, Yves Boucher, Wilson Mok, Trevor D. Mckee, Xandra Breakefield

WO2005018332A1

Particle separating devices, systems, and methods

Sergey Shevkoplyas, Lance Munn, Mark Bitensky, Tatsuro Yoshida, Chenghai Sun

US20060118479A1

Method for mitigating metastasis

JM Tarbell, LL Munn, Q Ç, SHI Zhongdong

US20190144867A1