

Paul Cherukuri, Ph.D.

Rice University
Institute of Biosciences and Bioengineering
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EDUCATION

Rice University, Department of Chemistry, Houston, TX

Ph.D. Chemistry, August 2007

Thesis: “Biomedical Studies of Single-Walled Carbon Nanotubes Using Near-Infrared Fluorescence”

University of Kentucky, Department of Physics and Astronomy, Lexington, KY

B.S. Physics, May 1997

BIOSKETCH

Dr. Cherukuri is the Executive Director of the Institute of Biosciences and Bioengineering at Rice University where he develops and implements bio-related cross-disciplinary research, education, and innovation projects between Rice and the Texas Medical Center. In addition, the Cherukuri research group studies electrodynamic properties of nanoscale and biological materials aimed at developing solutions for global problems in energy and health. His discovery of Teslaphoresis has received wide acclaim by the scientific community (*e.g.* ACS Editors’ Choice) and national media (*e.g.* Wired Magazine, IEEE Spectrum) as a breakthrough technique in nanotechnology with potential applications ranging from material science to medicine.

Prior to his current role at Rice, Dr. Cherukuri was a senior scientist at Sanofi (Chattam, Inc.) where he managed the R&D of numerous top-selling drug products (*e.g.* Allegra). Prior to joining Sanofi, he was a visiting scholar at Harvard University with Prof. George Whitesides and a Research Assistant Professor of Experimental Therapeutics at the University of Texas MD Anderson Cancer Center. His pioneering work on targeted cancer therapy using radiofrequency heating of metal nanoparticles (featured on *60 Minutes*) is now in pre-clinical trials.

Dr. Cherukuri earned a B.S. in physics from the University of Kentucky and a Ph.D. in physical chemistry at Rice University under the supervision of Nobel Laureate, Prof. Richard E. Smalley and R. Bruce Weisman. He is a subject matter expert in nanotechnology, drug development, biomedical devices and technology commercialization. His unique background in the forefront of academic and industry research gives him critical insight to drive innovative solutions into the marketplace.

PROFESSIONAL EXPERIENCE

Executive Director, Rice University
Institute of Biosciences and Bioengineering

Aug 2016 – current

- Design, develop, and direct collaborative research and educational programs across all S&E departments within Rice as well as with the Texas Medical Center.
- Direct, organize and conduct IBB's meetings and colloquia, including identifying and engaging guest speakers for IBB events and in coordination with other institutes and departments within Rice.
- Coordinate, manage and review all IBB funds and similar funds offered by centers affiliated with IBB.
- Develop and manage partnerships with appropriate personnel and groups in the individual departments.
- Oversee and manage all research and restricted fund accounts for the Institute (including seed funding programs), and enforce IBB and University policies about the use of research and restricted funds.
- Lead, manage and coordinate equipment and services procurement as requested in support of faculty and the institute's mission.
- Prepare and host meetings with the institute leadership and prepare regular reports on the status of research budgets and accounts.
- Conceive, develop and implement programs in collaboration with the IBB leadership and the institute members, designed to further enhance the Institute's effectiveness in achieving stated and approved goals.
- Research, identify, qualify and develop sources of funds needed by the IBB to support research activities and programs that help to achieve stated and approved goals.
- Develop and oversee the IBB communications strategy (in collaboration with the Offices of Research and Public Affairs).
- Bring together IBB faculty and other entities in the university and with external organizations (e.g. universities, government laboratories, industry, partners, and funding agencies) to promote joint research interests.
- Oversee the preparation of grant budgets and assisting in the preparation of progress reports for IBB programs.

Lab Manager/Scientist, Rice University
Department of Chemistry

June 2014 – July 2016

- Manage Prof. James M. Tour's research directives for ~ 40-member group (visiting scholars, post-doctoral, graduate, and undergraduate students)
- Design, develop, and write federal grant proposals (DOD, NSF, NIH)
- Review and revise student/post-doc manuscripts (without co-authorship)
- Maintain good laboratory procedures and safety protocols
- Write review articles (with co-authorship)
- Interface and coordinate with industry and academic collaborators
- Present research at meetings to enable multi-institutional programs

- Mentor and advise students
- Teach CHEM 600 during Spring semesters
- Review and revise invention disclosures
- Direct independent materials/nano-bio research group (after standard business hours)

Adjunct Faculty, Univ. of Tennessee-Chattanooga 2013 – 2016
Department of Chemistry

- Radiowave directed assembly of carbon nanotube wires and thin films
- Gold nanoparticle synthesis using evanescent radiowaves
- Teach nanochemistry course to senior chemistry/chemical engineer students

Senior Scientist, Sanofi/Chattem Inc. 2010 – 2014
Analytical R&D

- Manage the R&D of Allegra[®], Gold Bond[®], Icy Hot[®], and Unisom[®]
- Process validation, water system design/validation for pharmaceutical drug products
- Lead industry-FDA panel for developing a joint guidance on consumer healthcare drug product development and measuring impurities
- Design bio-analytical assays for complex pharmaceuticals, natural products and raw materials
- Train and manage junior analysts in pharmaceutical methods and instrumentation (HPLC, GC, IR/optical microscopy, TEM, SEM, Raman, XPS, CV)
- Create cGMP compliant SOPs
- Conduct audits of pharmaceutical R&D companies and raw material facilities

Research Scientist, Rice University (and USAF) 2009 – 2010
Department of Chemistry

- Directed energy interactions with biological systems
- Synthesis of bio-compatible, antibody labeled gold nanoparticles

Adjunct Assistant Professor, Rice University 2008 – 2010
Department of Chemistry

- Formulate antibody labeled gold nanoparticles for RF heating and imaging of cells
- Engineer aligned carbon nanotube thin films using RF fields
- Optical analysis of carbon nanoparticle suspensions under RF fields

Research Assistant Professor, MD Anderson Cancer Center 2007 – 2009
Department of Experimental Therapeutics and Surgical Oncology

- Manage inter-disciplinary research group to formulate gold nanoparticles for targeted noninvasive cancer therapy
- Formulate siRNA coated gold nanoparticles and carbon nanotubes for intravascular injections
- Cellular imaging of individual carbon nanotubes using near infrared microscopy
- Formulate and characterize water soluble fullerenes for RF heating

Visiting Scholar, Harvard University 2007 – 2008

Advisor: Prof. George M. Whitesides
Department of Chemistry and Chemical Biology

- Flame suppression using AC fields and aerosolized metallic nanoparticles (co-PI with Prof. George Whitesides, DARPA)
- Designed and characterized transparent microsolidic microwave antennas
- Engineered rotating disk based tribocharging system

Graduate Student, Rice University 2004 – 2007

Advisors: Prof. Richard E. Smalley and Prof. R. Bruce Weisman
Department of Chemistry

- Designed, wrote, and managed cross-institutional research program (NASA, Rice Univ., Univ. of Texas) - “*Nanotubes for NanoHealth*” (\$2M NASA funding)
- Discovered evanescent radiowaves heat carbon nanotubes and gold nanoparticles
- Discovered siRNA coated carbon nanotubes activate RNAi in cancer cells
- Developed carbon nanotubes as *in vitro* and *in vivo* optical contrast agents
- Synthesized single-walled carbon nanotubes on silicon substrates
- Designed crosslinked diblock co-polymeric wrappers for carbon nanotubes

Research Associate, University of Texas Houston 2001–2004

Supervisor: James T. Willerson, MD
President, University of Texas Health Science Center Houston & Texas Heart Institute

- Manage vulnerable atherosclerotic plaque imaging research group
- Developed superparamagnetic iron oxide contrast agents for detection of vulnerable plaques
- Developed applications using isotropic wavelet based CT image analysis
- Superconducting quantum interference magnetocardiographic mapping of atherosclerosis and heart failure using iron oxide nanoparticles

Research Assistant, University of Kentucky 1997–2000

Advisor: Prof. Robert A. Lodder
Department of Chemistry, Department of Electrical Engineering

- Noninvasive magneto-hydrodynamic acoustic resonance near infrared spectroscopy of glucose
- 2-D statistical analysis of near infrared reflectance spectra from atherosclerotic plaques

FUNDING

NIH Director’s New Innovator Award \$1.5 million (pending*) Fall 2018-2023
*only submission from Rice University

AWARDS

Norman Hackerman Fellowship in Chemistry 2007
Univ. of Texas Health Science Center GSBS Research Day Award 2004
James T. Willerson Vulnerable Plaque Young Investigator Award 2003

TEACHING

Nanochemistry, Rice University 2015-2016
Introduction to Nanotechnology, UT-Chattanooga Spring 2013

MENTORING

Preston R. Smalley, University of Texas-Austin, Department of Physics 2015-2017
Aida C. Castillo, Rice University, Material Science and NanoEngineering 2014-2017
Lindsey R. Bornhoeft, Rice University/TAMU, Dept. of Chemistry/Biomed Eng. 2013-2016
Sophia Phounsavath, Rice University, Dept. of Chemistry 2007-2010
Matthew Cheney, Rice University, Dept. of Chemistry 2007-2010
Christine H. Moran, Rice University, Dept. of Bioengineering 2006-2010
Jenna Hook, Rice University, Dept. of Bioengineering 2006-2007
Emily H. Johnson, Michigan State Univ., Applied Physics summer, 2006
Charles Dunlap, Univ. of Penn., Dept. of Bioengineering summer, 2004

PATENTS

A magnetosensor system and method of use. WO/2006/12227, 2006, International

PUBLICATIONS

1. Bornhoeft L.R.; Castillo A.C.; Smalley P.R.; Kittrell C.; James D.K.; Brinson B.E.; Rybolt T.R.; Johnson B.R.; Cherukuri T.K.; **Cherukuri P.** Teslaphoresis of Carbon Nanotubes. *ACS Nano* **2016**, 10, 4873 – 4881. (*ACS Editors' Choice, Highest Altmetric Score – Top 1%*)
2. **Cherukuri P.**; Curley S.A. Use of nanoparticles for targeted, noninvasive thermal destruction of malignant cells. *Methods Mol. Biol.* **2010**, 624, 359 – 373.
3. Stone E.M.; Glazer E.S.; Chantranupong L.; **Cherukuri P.**; Breece R.M.; Tierney D.L., Curley S.A.; Iverson B.L.; Georgiou G. Replacing Mn(2+) with Co(2+) in Human Arginase I Enhances Cytotoxicity toward l-Arginine Auxotrophic Cancer Cell Lines. *ACS Chem. Biol.* **2010**, 5, 333 – 342.
4. **Cherukuri P.**; Glazer E.S.; Curley S.A. Targeted Hyperthermia using Metal Nanoparticles. *Adv. Drug Deliv. Rev.* **2010**, 62, 339 – 8345.
5. Papadakis M.; Bodmann B.G.; Alexander S.K.; Vela D.; Baid S.; Gittens A.A.; Kouri D.J.; Gertz S.D.; Jain S.; Romero J.R.; Li X.; **Cherukuri P.**; Cody D.D.; Gladish G.W.; Aboshady I.; Conyers J.L.; Casscells S.W. Texture-based tissue characterization for high resolution CT scans of coronary arteries. *Comm. Num. Meth. Engineering* **2009**, 25, 597 – 613.
6. Moran C.H.; Wainerdi S.M.; Cherukuri T.K.; Kittrell C.; Wiley B.J.; Nicholas N.; Curley S.A.; Kanzius J.; **Cherukuri P.** Size Dependent Joule Heating of Gold Nanoparticles Using Capacitively Coupled Radiofrequency Fields. *Nano Res.* **2009**, 2, 400 – 405.
7. Bartholomeusz G.**; Cherukuri P.**; Kingston J.; Cognet L.; Lemos R.; Leeuw T.K.; Gumbiner-Russo L.; Weisman R.B.; Powis G. In vivo Therapeutic Silencing of HIF-1 α using Single-Walled Carbon Nanotubes Coated with siRNA. *Nano Res.* **2009**, 2, 279 – 291. **co-first author

8. Pamaraj D.; Wosik W.; Xie L.M.; Hadjiev V.G.; Cherukuri P.; Wosik J. Parallel and orthogonal E-field Alignment of Single-Walled Carbon Nanotubes by AC Dielectrophoresis. *J. Nanotechnology* **2009**, 20, 5201 – 5208.
9. Curley S.A.**; **Cherukuri P.****; Briggs K.; Pattra M.; Upton M.; Dolson E.; Mukherjee P. Noninvasive Radiofrequency Field Induced Hyperthermic Cytotoxicity in Human Cancer Cells Using Cetuximab-Targeted Gold Nanoparticles. *J. Exp. Therapeutics in Oncology* **2008**, 7, 313-326. *co-first author
10. Gertz S.D.; Bodmann B.G.; Vela D.; Papadakis M.; Aboshady I.; **Cherukuri P.**; Alexander S.; Kouri D.J.; Baid S.; Gittens A.A.; Gladish G.W.; Conyers J.L.; Cody D.D.; Gavish L.; Mazraeshahi R.M.; Wilner W.T.; Frazier L.; Madjid M.; Zarrabi A.; Lukonvenkov S.; Ahmed A; Willerson J.T.; Casscells S.W. Three-dimensional isotropic wavelets for post-acquisitional extraction of latent images of atherosclerotic plaque components from micro-computed tomography of human coronary arteries. *Acad. Radiol.* **2007**, 14, 1509 – 1519.
11. Kanzius J.; Schmidt H.K.; Smalley R.E.; Curley S.A. Noninvasive Radiofrequency Thermal Destruction of Cancer Cells Using Carbon Nanotubes. *Cancer*, **2007**, 110, 2654 – 2665. *co-first author
12. Leeuw T.K.; Reith R.M.; Simonette R.A.; Harden M.; **Cherukuri P.**; Tsyboulski D.A.; Beckingham K.M.; Weisman R.B. Single-walled Carbon Nanotubes in a Living Organism: Near- Infrared Imaging and Biocompatibility Studies in Drosophila. *Nano Letters* **2007**, 7, 2650 – 2654.
13. Wang R.; **Cherukuri P.**; Duque J.G.; Leeuw T.K.; Lackey M.K.; Moran C.H.; Moore V.C.; Conyers J.L.; Smalley R.E.; Schmidt H.K.; Weisman R.B.; Engel P.S. SWCNT PEG-eggs: Single Walled Carbon Nanotubes in Biocompatible Shell Crosslinked Micelles. *Carbon*, **2007**, 45, 2388 – 2394.
14. Wilner W.T.; Mazraeshahi R.M.; Aboshady I.; Bodmann B.G.; Papadakis M.; Kouri D.J.; Conyers J.L.; **Cherukuri P.**; Vela D.; Gladish G.; Gavish L.; Cody D.D.; Frazier L.; Lukovenkov S.; Madjid M.; Zarrabi A.; Ahmed A.; Willerson J.T.; Casscells J.W.; Gertz S.D. Quantification of Roughness of Calcific Deposits in Computed Tomography Scans of Human Coronary Arteries. *Invest. Radiol.* **2007**, 42, 771-776.
15. **Cherukuri P.**; Gannon C.; Leeuw T.K.; Schmidt H.K.; Smalley R.E.; Curley S.A.; Weisman
16. R.B. Mammalian Pharmacokinetics of Carbon Nanotubes Using Intrinsic Near Fluorescence. *Proc. Natl. Acad. Sci.* **2006**, 103, 18882 – 18886.
17. Gertz, S.D.; **Cherukuri P.**; Bodmann B.G.; Gladish G.; Wilner W.T.; Conyers J.L.; Aboshady I.; Madjid M.; Vela D.; Lukovenkov S.; Papadakis M.; Kouri D.; Mazraeshahi R.M.; Frazier L.; Zarrabi A.; Elrod D.; Willerson J.T.; Casscells S.W. Usefulness of Multidetector Computed Tomography for Noninvasive Evaluation of Coronary Arteries in Asymptomatic Patients. *Am. J. Cardiol.* **2006**, 97, 287 – 293.
18. Bodmann B.G.; Papadakis M.; Kouri D.J.; Gertz S.D.; **Cherukuri P.**; Vela D.; Gladish G.W.; Cody D.; Abodashy I.; Conyers J.L.; Willerson J.T.; Casscells S.W. Frame Isotropic Multiresolution Analysis for Cardiac CT Imaging. *Proc. SPIE*, **2005**, 5914.
19. **Cherukuri P.**; Bachilo S.M.; Litovsky S.H.; Weisman R.B. Near-Infrared Fluorescence Microscopy of Single-Walled Carbon Nanotubes in Phagocytic Cells. *J. Am. Chem. Soc.* **2004**, 126, 15638 – 156639.
20. Brazdeiskis A.; Chu C.W.; **Cherukuri P.**; Litovsky S.; Naghavi M.; Changes in Magnetocardiogram Patterns of Infarcted Reperfused Myocardium after Injection of

- superparamagnetic Contrast Media. *Neuro Clin Neurophysiol*, 2004, 16.
21. **Cherukuri P.**; Riggs P.; Darrat I.; Dumstorf K.; Lodder R.A. Near-Infrared Spectrometry of Structural Components of Plaque Susceptible to Rupture or Erosion. *Anal. Chem. Preprint*, **2001**.

BOOK CHAPTERS

Cherukuri P.; Curley S.A. Use of Nanoparticles for Noninvasive Thermal Destruction of Malignant Cells; *Cancer Nanotechnology: Methods in Molecular Biology*, Humana Press: 2010.

INVITED LECTURES

1. Teslaphoresis and the Single-Walled Carbon Nanotube, Rice University, **April 2017**.
2. Teslaphoresis and the Single-Walled Carbon Nanotube, Baylor University, **Mar 2017**.
3. Biomedical Applications of Teslaphoresis, Methodist Research Institute, **Dec 2016**.
4. Biomedical Applications of Nanoscale Materials, Second Baptist School, **Oct 2015**.
5. Biomedical Applications of Single Walled Carbon Nanotubes and Gold Nanoparticles using Capacitively Coupled Radiofrequency Fields, Univ. of Tennessee-Chattanooga, Department of Chemistry, **Oct 2013**.
6. Size Matters: Adventures on the Nanoscale, ACS Chattanooga Local Section, **Oct 2011**.
7. Radiofrequency Heating of Single-Walled Carbon Nanotubes and Gold Nanoparticles, University of Wisconsin-Milwaukee, Department of Physics, **May 2010**.
8. Nanotechnology and Radiofrequency Cancer Therapy. New Frontiers Big Arts, Public Lecture, **March 2010**.
9. University of Wisconsin-Milwaukee, Department of Physics, **May 2010**.
10. Nanoparticles as a Target for Electromagnetic Radiation Induced Killing of Malignant Cells. The University of Texas MD Anderson Cancer Center, Division of Surgery Grand Rounds, **July 2008**.
11. Nanoscale Electrodynamics Cancer Therapy. MD Anderson Cancer Center, Department of Experimental Therapeutics, **Jun 2008**.
12. Biomedical Applications of Carbon Nanotubes. University of Kentucky, Department of Chemistry, **Mar 2008**.
13. Nanoparticle Enhanced RF Ablation. Rice University, Department of Chemistry, **Mar 2008**.
14. Nanomedicine and Cancer: Noninvasive Radiofrequency Ablation of Cancer Using Nanoparticles. First International Symposium on Applied Nanomedicine, Qatar, **Mar 2008**.
15. Nanoparticles as Cancer Therapeutic Agents. The University of Texas MD Anderson Cancer Center, Institutional Grand Rounds, **July 2007**.
16. NanoHealth – A Small Revolution in Medicine. Rice University, Advisory Committee Lecture Series, **Mar 2007**.
17. Applications of Nanocarbon Molecules for Imaging Vulnerable Plaques. Texas Medical Center, NanoSummit 2003, **Mar 2003**.

CONFERENCE PRESENTATIONS

1. Teslaphoresis of Carbon Nanotubes, Electrochemical Society Spring Meeting, **2017**.

2. Teslaphoresis: Scalable, bottom-up assembly of carbon nanotubes, ACS SWRM, **2016**.
3. Teslaphoresis of Carbon Nanotubes, Materials Research Society Fall Meeting, **2016**.
4. Single-Walled Carbon Nanotubes: A New Vector for Delivery of siRNA into Cancer Cells. Materials Research Society Fall Meeting, **2008**.
5. Hyperthermic Cancer Therapy: Radiofrequency Heating of Carbon Nanotubes, gold nanoparticles, and nanoshells. Materials Research Society Fall Meeting, **2008**.
6. *In Vivo* Near-IR fluorescence studies of carbon nanotube vectors - in vitro biocompatibility. Electrochemical Society Fall Meeting, **2007**.
7. Radiofrequency Heating of Cancer. National Academy of Sciences, **Fall 2007** (Poster).
8. In vivo and in vitro studies of single walled carbon nanotubes using near-IR fluorescence. Electrochemical Society Fall Meeting, **2007**.
9. Biocompatibility of carbon nanostructures for therapeutic and Diagnostic applications. Nanomedicine: Nanotechnology, Biology, and Medicine Fall Meeting, **2006**.
10. Developing carbon nanotube vectors – in vitro biocompatibility. American Chemical Society National Fall Meeting, **2006**.
11. In Vitro Studies of Vascular Cell Types Exposed to Single-Walled Carbon Nanotubes, Electrochemical Society Meeting, **2005**.
12. Near infrared fluorescence imaging of single walled carbon nanotubes in macrophages. Radiological Society of North America, **2004**.
13. Imaging Vulnerable Plaque at the early stages of coronary calcification: A pre-clinical correlation of histology with high resolution Micro-CT. Radiological Society of North America, **2004**.
14. Near infrared fluorescence as a tool for developing biomedical applications of single-walled carbon nanotubes. Electrochemical Society Meeting Spring, **2004**.
15. Contrast Enhanced Intravascular Detection of Vulnerable Plaque Using SPIO and a Novel MRI Catheter. Proc. Inter. Soc. for Magnetic Resonance in Medicine, **2003**.
16. Intravascular MRI Coils for Imaging Atherosclerosis. Proc. Inter. Soc. For Magnetic Resonance in Medicine, **2003** (Poster).
17. Comparison of MARENIR and NIR spectrometry for Nondestructive Determination of Glucose in a Simulated Biological Matrix. PittCon - Analytical Chemistry and Applied Spectroscopy, **1998** (Poster).

MEDIA REFERENCES

- “Best New Words of 2016”, *Wired* (December 2016)
- “Texas Standard Newscast”, *KUHF Radio Interview* (Apr 2016)
- “Teslaphoresis Is Here: Mind Blow #104”, YouTube (Apr 2016, >1.6 million views)
- “Tesla Coil controls self-assembly of carbon nanotubes”, *Materials Today* (Apr 2016)
- “Carbon Nanotubes Self-Assemble into Wires Thanks to a Tesla Coil”, *Tech Times* (Apr 2016)
- “Nanotube circuits self-assembled and powered at a distance via Teslaphoresis”, *Gizmag* (Apr 2016)
- “Nanotubes Self-Assemble into Wires with A Blast from A Tesla Coil”, *Gizmodo* (Apr 2016)
- “Tesla Coil Remotely Induces Nanotubes to Self-Assemble”, *IEEE Spectrum* (Apr 2016)
- “Tesla coil zaps nanotubes into a self-assembling circuit”, *Engadget*, (Apr 2016)
- “Watch nanotubes self-assemble into tiny wires”, *Futurity* (Apr 2016)

- “Nanotubes Assemble! Introducing Teslaphoresis”, *R&D Mag, Science Daily* (Apr 2016)
- “Rice University scientists discover new force field”, *Houston Chronicle*, (Apr 2016)
- “The Kanzius Machine: A Cancer Cure?”, *60 Minutes* (Apr 2008)