# Curriculum Vitae

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**Education**:

1996 Ph.D., Chemistry, Department of Chemistry and Biochemistry, University of Notre Dame, Notre Dame, IN
1987 B.Sc., Chemistry, Department of Chemistry, Wuhan University, China

**Professional Positions**:

2002 to present: Research Chemist, Biosystems and Biomaterials Division, National Institute of Standards and Technology (NIST), Gaithersburg, MD
1998 to 2002: Guest Scientist, Biotechnology Division, NIST, Gaithersburg, MD
1995-1998: Post-doctoral Fellow, Department of Biological Chemistry, School of Medicine, University of Maryland, Baltimore, MD
1987-1991: Scientist, Institute of Photographic Chemistry, Chinese Academia, Beijing, China

**Membership in Professional Society**:

International Society for Advancement of Cytometry (ISAC)

**Committee**:

- CDRH/FDA Hematology and Pathology Devices Panel Advisory Committee, Consultant (April 2011-April 2019)
- JCTLM Team Leader on Blood Cell Counting and Typing, 2009-2020
- ISAC Standards Committee Fluorescence Calibration Task Force, Co-chair (2009-present)
- ICCS Quality and Standards Committee, 2016-present
- USP CD34 – Positive Cells Expert Panel, 2010-2016
- IFCC cTnI Standardization Working Group, 2007-present
- CLSI Committee on Validation of Assays Performed by Flow Cytometry, August 2017-November 2022
- ISEV Rigor and Standardization: EV Reference Materials Task Force, 2020-present
- ISAC Flow Cytometry Data Standard Committee – Data Repository Task Force, 2022-present

**Award**:

- CSTL Technical Achievement Award (2004)
- CSTL Director's Cash-in-a-Flash Award (2007)

- Emerald Honor Award from Minorities in Research/Career Communications Group (2007)
- Department of Commerce Bronze Award (2015)
- Department of Commerce Gold Award (2020)
- Department of Commerce Gold Award (2021)

**Publications**:

1. H.J. Xu, S.Q. Lin, S.Y. Shen, L. Li, D.W. Chen, and G.Z. Xu. Radical mechanism in the photoinduced oxygen transfer from acridine N-oxides to cyclohexene. *J. Photochem. Photobiol*., A 48(1), 53 (1989).
2. S.Y. Shen, L. Li, Q.F. Zhou, and H.J. Xu. Photoinduced electron transfer. I. Inter- and intramolecular quenching of zinc phthalocyanine fluorescence by anthraquinone. *Chin. Chem. Lett*.(chinese) 1(3), 201 (1990).
3. S.Q. Lin, L. Li, S.Y. Shen, and H.J. Xu. A new cytochrome P-450 model-photoinduced oxygen transfer from acridine N-oxide catalyzed by phthalocyanine iron(II). *Photog. Sci. Photochem*., (chinese), 9(1), 44 (1991).
4. L. Li, S.Y. Shen, Q. Yu, Q.F. Zhou, and H.J. Xu. Photoinduced electron transfer and charge separation in anthraquinone-substituted porphyrin-phthalocyanine heterodimer. *J. Chem. Soc., Chem. Commun*. 9, 619 (1991).
5. H.J. Xu, T. Shen, Q.F. Zhou, S.Y. Shen, J.X. Liu, L. Li, S.Z. Zhou, X.F. Zhang, Q. Yu, Z.C. Bi, and X.R. Xiao. Aspects of metal phthalocyanine photosensitization systems for light energy conversion. *J. Photochem. Photobiol*., A 65(1-2), 267 (1992).
6. Q.F. Zhou, S.Y. Shen, J.X. Liu, L. Li, S.Z. Zhou, H.J. Tian, Z.C. Bi, and H.J. Xu. Photoinduced intramolecular electron transfer in phthalocyanine photosensitization systems and their photoelectric effects. *Gaojishu Tongxun*(chinese) 2(1), 41 (1992).
7. L. Li and L.K. Patterson. Kinetics of in-plane photoinduced electron transfer between lipid-functionalized pyrene and alkyl-substituted dipyridinium cation in lipid vesicles and Langmuir films. *Journal of Physical Chemistry* 99, 16149 (1995).
8. L. Li and L.K. Patterson. The use of lipid headgroup charge to enhance photoinduced electron transfer in vesicles. Reactions of functionalized pyrene with a two component viologen system. *Photochemistry and photobiology* 62, 51 (1995).
9. L. Li, H. Szmacinski, and J.R. Lakowicz. A long lifetime lipid probe containing a luminescent metal-ligand complex. *Biospectroscopy* 3, 155-159(1997).
10. L. Li, H. Szmacinski, and J.R. Lakowicz. Synthesis and luminescence spectral characterization of long-lifetime lipid metal-ligand probes. *Analytical Biochemistry* 244, 80-85(1997).
11. X.Q. Guo, L. Li, F.N. Castellano, H. Szmacinski, J.R. Lakowicz, and J. Sipior. A long-lived, highly luminescent Re(I) metal-ligand complex as a biomolecular probe. *Analytical Biochemistry* 254, 179-186(1997).
12. X.Q. Guo, F.N. Castellano, L. Li, and J.R. Lakowicz. Use of a long-lifetime Re(I) complex in fluorescence polarization immunoassays of high-molecular-weight analytes. *Analytical Chemistry*, 70, 632-637(1998).
13. X.Q. Guo, F.N. Castellano, L. Li, and J.R. Lakowicz. A long-lifetime Ru(II) metal-ligand complex as a membrane probe. *Biophysical Chemistry*, 71, 51-62(1998).
14. J.R. Lakowicz, I. Gryczynski, H. Szmacinski, F.N. Castellano, Z. Murtaza, L. Li, H. Lin, and J.D. Dattelbaum. Recent developments in fluorescence spectroscopy. *Near*

*Infrared Dyes for High Technology Applications*, S. Daehne et al. (eds.), Kluwer Academic Publishers, Netherlands, 3-19 (1998).
15. J.R. Lakowicz, I. Gryczynski, L. Tolosa, J.D. Dattelbaum, F.N. Castellano, L. Li, and G Rao. Advances in fluorescence spectroscopy: Multi-photon excitation, engineered proteins, modulated sensing and microsecond rhenium metal-ligand complexes. *Acta Physica Polonica A* 95, 179-196(1999).
16. L. Li, F.N. Castellano, I. Gryczynski, and J.R. Lakowicz. Long-lifetime lipid rhenium metal-ligand complex for probing membrane dynamics on the microsecond timescale. *Chem Phys Lipids* 99, 1-9(1999).
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18. L. Li, T. Ruzgas, and A.K. Gaigalas. Fluorescence from Alexa 488 fluorophores immobilized on a modified gold electrode. *Langmuir* 15, 6358-6363(1999).
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21. A.K. Gaigalas, L. Li, O. Henderson, R. Vogt, J. Barr, G. Marti, J. Weaver, and A. Schwartz. The development of fluorescence intensity standards. *J. Res. Natl. Inst. Stand. Technol.* 106, 381-389(2001).
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111. J.A. Welsh, E. van der Pol, B.A. Bettin, D.R.F. Carter, A. Hendrix, M. Lenassi, Marc-André Langlois, A. Llorente, A.S. van de Nes, R. Nieuwland, V. Tang, L. Wang, K.W. Witwer, J.C. Jones. Towards defining reference materials for extracellular vesicle size, concentration, refractive index and epitope abundance. Journal of Extracellular Vesicles 9: 1816641 (2020).
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115. P.C. DeRose, Linhua Tian, E.B. Elsheikh, A. Urbas, Yu-Zhong Zhang and L. Wang. Expanding NIST's Calibration of Fluorescent Microspheres for Flow Cytometry to More Fluorescence Channels and Smaller Particles. Materials, 13: 4111 (2020).
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119. A.K. Gaigalas, Yu-Zhong Zhang, L. Tian, and L. Wang. Sources of variability in the response of labeled microspheres and B cells during the analysis by a flow cytometer. Int. J. Mol. Sci. 2021, 22, 8256.
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121. S. Inwood, Linhua Tian, K. Parratt, S. Maragh, and L. Wang. Evaluation protocol for CRISPR/Cas9 mediated CD19 knockout GM 24385 cells by flow cytometry and Sanger sequencing. Biotechniques 72: 279-286 (2022).
122. P.C. DeRose, K. Benkstein, E.B. Elsheikh, A.K. Gaigalas, S. Lehman, D. Ripple, Linhua Tian, W. Vreeland, E.J. Welch, A. York, Yu-Zhong Zhang, and L. Wang. Number Concentration Measurements of Polystyrene Submicrometer Particles. Nanomaterials, 12: 3118 (2022).
123. J. Izac, E. Kwee, L. Tian, J.T. Elliott, and L. Wang. Development of a Cell-Based SARS-CoV-2 Pseudovirus Neutralization Assay Using Imaging and Flow Cytometry Analysis. Submitted to Cytometry Part A.
124. L. Tian, A. Nelson, T. Lowe, L. Weaver, C. Yuan, P.C. DeRose, M. Stetler-Stevenson, and L. Wang. Standardization of Flow Cytometric Detection of Antigen Expression. Submitted to Cytometry Part B – Clin Cytometry.

**Reference Material and Document Standard**:

- RM 8640, Microspheres with immobilized fluorescein isothiocyanate (2004).
- RM 8640 (re-certification), Microspheres with immobilized fluorescein isothiocyanate (2005).
- First International Reference Reagent, lyophilised human PBMC pre-stained with anti-CD4 FITC, as a CD4+ Cell Counting Standard (WHO/BS/10.2153; NIBSC SS-319/20; 2011-present).
- SRM 1934, Fluorescent dyes for quantitative flow cytometry (visible spectral range) (2016-present)

- Validation of Cell-based Fluorescence Assays: Practice Guidelines from the International Council for Standardization of Hematology and International Clinical Cytometry Society. Cytometry part B (Clinical Cytometry) 84B Issue 5, (2013).
- USP Chapter <127> Flow Cytometric Enumeration of CD34+ Cells
- Research Reference Materials, Preparation and Concentration Determination of Pacific Orange, Alexa Fluor 700 and Alexa Fluor 750 Solutions for Quantitative Flow Cytometry (September 2019-present)
- Establishment of the WHO international standard and reference panel for anti-SARS-CoV-2 antibody. https://www.who.int/publications/m/item/WHO-BS-2020.2403
- CLSI H62: Validation of Assays Performed by Flow Cytometry

**Measurement Service:**

- ERF value assignment service to BD Biosciences with 3 laser excitations (1 certificate report and 15 Excel Data books), August 2017.
- ERF value assignment service to Spherotech with 3 laser excitations (1 certificate report and 20 Excel Data books), October 2017.
- ERF value assignment service to the organizing committee of the international extracellular vesicle flow cytometry standardization study with 488 nm laser excitation (1 certificate report and 6 Excel Data books), September 2017.
- ERF value assignment service to Medical Discovery Partners LLC /Tufts Medical Center (1 certificate report and 10 Excel Data books), April 2019.
- ERF value assignment service to Beckman Coulter with 5 laser excitations (1 certificate report and 19 Excel Data books), November 2019.
- ERF value assignment service to Thermo Fisher Scientific with 5 laser excitations (1 certificate report and 27 Excel Data books), January 2020.
- ERF value assignment service to Thermo Fisher Scientific with 4 laser excitations (1 certificate report and 41 Excel Data books), April 2021.
- ERF value assignment service to BD Biosciences with 4 laser excitations (1 certificate report and 22 Excel Data books), September 2022.

**Workshops**:

- U.S. Measurement System Workshop: "Improved Antibody-Based Metrology in Flow Cytometry". NIST, February 23, 2006. Host: L. Wang, M. Amos, A.K. Gaigalas, R.M. Zucker (EPA), and G. Marti (FDA).
- Workshop on "Assay Development and Standardization for Immunotherapy: Opportunities for Academic, Regulatory, Standardization, and Industrial Partnership". NIST, October 4, 2006. Host: L. Wang, G. Marti (FDA) and L. Lamb (Univ. of Alabama at Birmingham).
- Workshop on "ERF-based Calibration Approach for Standardization of Quantitative Fluorescence Measurements in Highly Multiparameter Cytometry". ISAC 26$^{th}$ International Congress, Baltimore, MD, May 25, 2011. Host: L. Wang and R.A. Hoffman (BD Biosciences).

- Workshop on "Quantitative Cytometry - Calibration and Standardization". ISAC 28th International Congress, San Diego, CA, May 19, 2013. Host: L. Wang and R.A. Hoffman (Cytometry and Biophotonics Consulting).
- Workshop on Biological Reference Materials for Quantitative Flow Cytometry". ISAC 31st International Congress, Seattle, Washington, June 14, 2016. L. Wang, R. Hoffman (Cytometry and Biophotonics Consulting), and J. Nolan (Scintillon Institute).
- Workshop on Building a Quantitative Flow Cytometry Measurement System". ISAC 32st International Congress, Boston, MA, June 11, 2017. L. Wang, R. Hoffman (Cytometry and Biophotonics Consulting), G.E. Marti (CDRH, FDA), and J. Nolan (Scintillon Institute).
- NIST-FDA Flow Cytometry Workshop: Building Measurement Assurance in Flow Cytometry. NIST Gaithersburg Campus, MD, October 25, 2017. L. Wang, J.T. Elliott, S. Lin-Gibson (NIST), S. Bauer, H. Degheidy, J. Arcidiacono (FDA).
- Workshop on "Control Cells or Not". ISAC 33rd International Congress, Prague, Czech Republic, April 30, 2018. Y. Liu (BD Biosciences), P. Wallace (Roswell Park Comprehensive Cancer Center), J.S. Moore (University of Pennsylvania), V. Litwin (Caprion Biosciences), and L. Wang (NIST).
- Workshop on "Building Measurement Assurance in Flow Cytometry". ISAC 33rd International Congress, Prague, Czech Republic, May 1, 2018. L. Wang (NIST), S. Perfetto (NIH), R. Hoffman (Independent Consultant), and V. Litwin (Caprion Biosciences).
- Open virtual flow cytometry standards consortium workshop. February 16-17, 2021. L. Wang, P. DeRose, T. Eskandari, and S. Lin-Gibson.
- Open virtual flow cytometry standards consortium workshop. November 18, 2021. L. Wang.
- Workshop on "Tools for Implementing Measurement Assurance in Every Laboratory Setting: Recent Advances". ISAC 37th International Congress, Philadelphia, PA, June 5, 2022. V. Litwin, L. Wang, and J. Nolan.

**CRADAs & MTAs**:

- with Molecular Probes, Inc., 2003. "Characterizing Photophysical and Photochemical Properties of R-phycoerythrin (PE) and Alexa Fluor 546 Fluorochromes".
- with Life Technologies Corporation, 2012. "Develop a set of compensation controls based on Quantum Dot (QD) labels and establish the improvement in uncertainties associated with compensation".
- with Life Technologies Corporation, 2013. "Compare absolute volumetric cell counting and cell counting with an internal counting bead standard and establish the uncertainties".
- with Life Technologies Corporation, 2013. "Measure concentration and purity and characterize the photophysical and photochemical properties of Nile Red and allophycocyanin (APC)".
- CDA with BD Biosciences, 2015. "Develop quantitative immunophenotyping protocols for human blood and solid tumor samples using flow cytometry".

- Flow Cytometry Quantitation Consortium CRADAs with BD Biosciences, Spherotech Inc., and Bangs Laboratories, Inc., 2016. CRADA Amendment 1 with both BD Biosciences and Spherotech, 2017.
- Flow Cytometry Quantitation Consortium CRADA with Beckman Coulter, 2017. CRADA Amendment 1, 2018.
- Research Collaboration Agreement (RCA) with CBER, FDA, 2017. Amendment on the inclusion of Fuildigm Canada Inc. in the RCA. 2018.
- with Thermo Fisher Scientific, Inc. 2017. "Characterization of the Photophysical and Photochemical Properties of Fluorophores". Amendment 1 on the characterization of CountBright™ beads with Thermo Fisher Scientific, Inc. 2018. Amendment 2 on the ERF Value Assignment to the Performance Tracking Beads of the Thermo Fisher Scientific Corporation's Attune NxT Flow Cytometers. December 2018. Amendment 3 on "Concentration Measurement and the ERF Value Assignment to a Set of Nanometer Sized Fluorescent Particles Developed by Thermo Fisher Scientific for the Analysis of Viruses and Extracellular Vesicles by Flow Cytometry". July 2020.
- Flow Cytometry Quantitation Consortium CRADA with Tufts Medical Center, January 2019. CRADA Amendment 1 in February 2019.
- Research Collaboration Agreement (RCA)/MTA with ATCC on Exosome Research, September 2019. A RCA/MTA Amendment 1, May 2020.
- MOU with Beckman Coulter on "Exosome Measurement Using CytoFLEX Cytometer". December 2019.
- Material Transfer Agreement (MTA) with Michigan Technological University on "Developing potential application of boron nitride nanomaterials and high-brightness dyes/fluorophores for the detection of exosomes by flow cytometry", October 2019.
- MTA with StabiLux Biosciences, Inc. on "Application of boron nitride nanomaterials and high-brightness dyes/fluorophores", January 2020.
- Flow Cytometry Quantitation Consortium CRADAs with BD Biosciences, Spherotech Inc., Bangs Laboratories, Inc., Beckman Coulter, and Boston Cell Standards have been extended to June 2022.
- MTA with NIAID, NIH on "Monoclonal antibodies against SAR CoV for developing and qualifying serology tests and for the evaluation/development of potential reference materials for SAR-CoV-2 serology assays", July 2020.
- MTA with Leidos Biomedical Research Inc. on "SAR-CoV-2 antigens, negative serum controls, and positive convalescent serum samples for developing and validating SAR-CoV-2 serology tests", July 2020. Amendment 1, August 2021.
- MTA with NIBSC, UK on "SAR-CoV-2 antigens for developing SAR-CoV-2 serology tests", July 2020.
- Emergency Use Simple Letter Agreement for the Transfer of Materials Related to SARS-CoV-2 with BARDA, July 2020.
- Emergency Use Simple Letter Agreement for the Transfer of Materials Related to SARS-CoV-2 with NIH Clinical Center, August 2020.
- MTA with NCI, NIH on "Characterization of ATCC's Extracellular Vesicle Preparations", February 2021.

- DTA with NCI, NIH on "Use of FCM$_{PASS}$, vL Software Package for the Characterization of ATCC's Extracellular Vesicle Preparations", March 2021.
- A total of 23 Flow Cytometry Quantitation Consortium CRADAs with Agilent, AstraZeneca, BD Biosciences, Beckman Coulter Life Sciences, BioLegend, Bristol-Myers Squibb Company, Bruce H Davis MD, Cellarcus Biosciences, Curiox Biosystems, FlowMetric Life Sciences, ISAC, Kite Pharma, Luminex, Mana Therapeutics, Miftek Corp., Mojave Bio, Inc., NIIMBL/Univ. of Delaware, Raytheon BBN Technologies, Sanofi US, Slingshot Biosciences, Sloan Kettering Institute for Cancer Research, Spherotech, Inc., and Thermo Fisher Scientific (2021).
- A total of 4 Flow Cytometry Quantitation Consortium MOUs/LAs with CBER/FDA, CDRH/FDA, Walter Reed Army Institute of Research, and NIBSC (2021).
- MTA with Regeneron Pharmaceuticals for obtaining anti-SARS-CoV-2 spike IgGs to advance standardization of quantitative serological assays, May 11, 2021.
- Material transfer and collaborative testing agreement (Special Serology Interlaboratory Studies) with FNLCR/NCI, September 14, 2021.
- RCA with CDC on quantitative SARS-CoV-2 serology and neutralization assays, August 28, 2021.
- A total of 3 MTAs with CBER/FDA, FNLCR/NCI, and Abbott for NIST-CDC led serology interlaboratory study, May-September 2021.
- MTA with Roche for NIST-CDC led serology interlaboratory study, November 2021.
- Flow Cytometry Quantitation Consortium CRADA Amendment with BioLegend and Qognit, March 2022.
- Flow Cytometry Quantitation Consortium CRADA with Ahead Medicine, August 2022.
- Flow Cytometry Quantitation Consortium MOU with KRISS, South Korea, September 2022.
- Flow Cytometry Quantitation Consortium CRADA with Regeneron Pharmaceuticals, November 2022.

## **NIST-NRC Postdoctoral Fellowship Opportunities:**

1. Quantitative Flow Cytometry Measurements (RO#: 50.64.41.B6740)
2. Multiplexed Assays for Cell-based Production of Biopharmaceuticals (RO#: 50.64.41.B8223)
3. Analytical Metrology for Isolating, Purifying and Characterizing Extracellular Vesicles (EVs) for Development and Delivery of Gene and Protein-Based Therapeutics (RO#: 50.64.41.C0414)