## BIOGRAPHICAL SKETCH

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NAME: Lee, KiBum

eRA COMMONS USER NAME (credential, e.g., agency login): kibumlee

POSITION TITLE: Distinguished Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

| INSTITUTION AND LOCATION | DEGREE *(if applicable)* | Completion Date MM/YYYY | FIELD OF STUDY |
|---|---|---|---|
| Kyung Hee University, Seoul, Korea | B.S. | 02/1998 | Chemistry |
| KAIST (Korea Advanced Inst. of Sci. & Tech.) | M.S. | 02/2000 | Physical Chemistry |
| Northwestern University, Evanston, IL | Ph.D. | 12/2004 | Bio-inorganic/ Nano-Chemistry (*Chad A. Mirkin*) |
| The Scripps Research Institute, La Jolla, CA | Post Doc | 07/2007 | Chemical and Stem Cell Biology (*Peter G. Schultz*) |
| UCLA Medical School, LA, CA | Visiting Prof. | 12/2007 | Medical Pharmacology |
| Princeton Univ. (Princeton Neuroscience Inst.) | Visiting Prof. | 08/2013 | Neuroscience |
| Kyoto University, Kyoto, Japan | Visiting Prof. | 12/2017 | Chemical Biology/Stem Cell Biology |

## A. PERSONAL STATEMENT

I have been involved in research at the interface between nanotechnology, chemical biology, and stem cell biology, since I began my doctoral work/PD at Northwestern and Scripps (with *Chad Mirkin* and *Peter G. Schultz*) in 2000 and 2004 respectively. My ***long-term research goal*** is to develop and integrate nanotechnologies and chemical biology tools to modulate signaling pathways in stem cells towards specific cell lineages or controlling their behavior. To address the challenges associated with conventional stem/cancer cell biology, my research program at Rutgers University focuses on developing novel nanotechnology and chemical biology methods such as nanoparticle-based drug/gene delivery, molecular imaging, nanobioscaffolds, and microfluidics for the investigation and modulation of complex signaling pathways during certain stem/cancer cell behaviors. This approach was leveraged into a successful NIH Director's New Innovator Awards (**2009**) to study multiple microenvironmental cues controlling human pluripotent stem cell neurogenesis.

The accumulated knowledge and publications under this award project showed that we have the ability to modulate disease microenvironment as well as control the fate/behaviors of cancer/stem cells into specific cell lineages or states in both effective and selective manners. ***The objective of this proposal*** is to develop a novel treatment based on memory-like bsCAR-NK38 for a functional cure for HIV infection. Specifically, I will oversee the development of the proposed NanoScript systems for decorating onto bsCAR-NK cells for eradicating HIV reservoirs in the CNS with minimal toxicity. *As a preliminary studies,* we have developed an innovative nanoparticle-based synthetic transcription factors (*NanoScript*) method for effective genetic manipulation, controlling stem cell differentiation, and for other applications [*ACS Nano*, **2014**; *J. Am. Chem. Soc.*, **2015**; *ACS Nano*, **2015**; *Angew. Chem. Int. Ed.*, **2015**; *Nature Communications*, **2018**; *Advanced Materials*, **2020 (I & II)**]. My experiences in chemical biology, nanotechnology, and stem cell biology demonstrate my capability to lead this project. I am the first author, co-author, or corresponding author of approximately 138 articles such as *Science, Science Advances, Cell Stem Cell, Nature Chemical Biology, Nature Communications, J. Am. Chem.*

*Soc., Angewandte. Chem, Int. Ed., Accounts of Chemical Research, Chemical Reviews, Nano Letters, ACS Nano, Advanced Materials, Lab Chip, Small, and Cancer Research*, which are highly cited (>11,000). In summary, my experience in nanomedicine and cell biology demonstrates my capability to collaborate this multi-PI project with Profs. Dongfang Liu, Qingsheng Li, and other collaborators.

**REPRESENTATIVE PAPERS RELATED TO THIS GRANT PROPOSAL:**

a. Patel S, Jung D, Yin PT, Carlton P, Yamamoto M, Bando T, Sugiyama H, Lee KB. Nanoscript: A nanoparticle-based artificial transcription factor for effective gene regulation. *ACS Nano.* **2014;** 8(9): 8959-67. PMCID: PMC4174092.

b. Patel S, Chueng ST, Yin PT, Dardir K, Song Z, Pasquale N, Kwan K, Sugiyama H, Lee KB. Induction of stem-cell-derived functional neurons by nanoscript-based gene repression. *Angew Chem Int Ed Engl.* **2015;** 54(41): 11983-8. PMCID: PMC5568028.

c. Patel S, Pongkulapa T, Yin PT, Pandian GN, Rathnam C, Bando T, Vaijayanthi T, Sugiyama H, Lee KB. Integrating epigenetic modulators into nanoscript for enhanced chondrogenesis of stem cells. *J Am Chem Soc.* **2015;** 137(14): 4598-601. PMCID: PMC5702886.

d. Patel S, Yin PT, Sugiyama H, Lee KB. Inducing stem cell myogenesis using nanoscript. *ACS Nano.* **2015;** 9(7): 6909-17. PMCID: PMC5808887.

**ONGOING AND RECENTLY COMPLETED PROJECTS TO HIGHLIGHT:**

NIH R01 DC016612-01 Lee KB (contact-PI) & Kwan K (PI) 05/01/2018 – 04/30/2024
*A Bio-Inspired Artificial Transcription Factor for Regeneration of Functional Hair Cells (MPI)*
The objective of this proposal is to design non-viral-based artificial transcription factors (TFs) that mimic three natural TFs essential for hair cell differentiation (Gfi1, Pou4f3, and Atoh1; GPA). Role: PI, no overlap

NIH 5T32EB005583-18 Lee KB (contact-PI) & PAREKKADAN B (PI) 09/01/2020 – 05/31/2024
*Postdoctoral Training for Translating Research in Regenerative Medicine (MPI)*
The overall objective of this proposal has focused on developing innovative PD training using a combination of conventional academic training (state-of-the-art science, proposal writing, responsible conduct of research) together with training in translation and commercialization. Role: PI, no overlap

CSCR22ERG023 Lee KB (PI) & Young W (Co-I) 12/01/2021 – 11/30/2023
New Jersey Commission for Spinal Cord Research
*Direct Conversion of Reactive Astrocytes into Neurons for Combined Immunomodulatory and Cell Replacement Therapy after Spinal Cord Injury*
The overall objective of this proposal is to develop a nanoparticle-based artificial transcription factor, termed NanoScript, for the treatment of Spinal Cord Injury Role: PI, no overlap

AARG-NTF-21-847862 Lee KB (PI) 02/01/2022 – 01/31/2025
Alzheimer's Association
A Bioinspired Nonviral Gene Therapy to Enhance TFEB-mediated Tau Clearance
The overall objective of this proposal is to develop CLEAR- NanoScript, a bio-inspired nanoparticle-based transcription factor designed to mimic the structure and function of natural TFEB protein, to enhance lysosomal biogenesis further and thus promote phospho-tau clearance in a non-viral, biocompatible, and highly efficient/selective manner. Role: PI, no overlap

COCR23PPR007 Lee KB (PI) 07/01/2022 – 06/30/2024
New Jersey Commission on Cancer Research
*Developing Advanced Liquid Biopsy Diagnostics Targeting Tumor-derived Exosomes using a Liposome-mediated CRISPR/Cas13 System*
The objectives of this proposal are to develop innovative CRISPR/Cas-enabled nanobiosensing technology combined with microfluidics as an advanced liquid biopsy platform for a cancer diagnosis, and to investigate multiple types of tumor-biomarkers derived from both membrane proteins and internal miRNAs at the single exosome level. Role: PI, no overlap

## B. POSITIONS, SCIENTIFIC APPOINTMENTS, AND HONORS

### Positions and Employment

| | |
|---|---|
| *2022 – Present* | *Distinguished Professor, Rutgers Dept. of Chemistry and Chemical Biology, Piscataway, NJ* |
| 2018 – Present | Full Members, Cancer Institute of New Jersey |
| 2016 – Present | Ctr. for Integrative Proteomics Research/ Quantitative Biomedicine Graduate Program |
| 2015 – Present | Affiliated Faculty, Rutgers Brain Health Institute |
| 2014 – Present | Affiliated Faculty, Human Genetics Institute of New Jersey |
| 2009 – Present | Affiliated Faculty, Graduate Program in Molecular Biosciences |
| 2008 – Present | Affiliated Faculty, Biomedical Engineering Dept. and Rutgers Stem Cell Research Center |
| 2016 – 2022 | Professor, Rutgers University, Dept. of Chemistry and Chemical Biology, Piscataway, NJ |
| 2013 – 2016 | Associate Professor, Rutgers, Dept. of Chemistry and Chemical Biology, Piscataway, NJ |
| 2008 – 2013 | Assistant Professor, Rutgers, Dept. of Chemistry and Chemical Biology, Piscataway, NJ |
| 2007 | Visiting Scientist, UCLA Medical School, LA, CA |
| 2004 – 2007 | Postdoctoral Fellow, Dept. of Chemistry & The Skaggs Institute for Chemical Biology, The Scripps Research Institute, La Jolla, CA (Post-doc Advisor: Peter G. Schultz) |
| 2000 – 2004 | Doctoral Candidate, Dept. of Chemistry & Nanoscale Science and Engineering Center, Northwestern University, Evanston, IL (Graduate Advisor: Chad A. Mirkin) |

### Honors

| | |
|---|---|
| 2017 and 2019 | Rutgers Patent Award (X2) |
| 2014 and 2019 | Burroughs Wellcome Fund (BWF) Collaborative Research Grant Award (X2) |
| 2017 | Japan Society for the Promotion of Science (JSPS) Fellowship |
| 2016 | The University City Science Center's QED Award |
| 2015 | American Chemical Society New Directions (ND) Award |
| 2013 | Board of Trustees Research Award for Scholarly Excellence |
| 2012 | Faculty Research Award, Rutgers University |
| 2011 | Johnson and Johnson Proof-of-Concept Research Award |
| 2009 | NIH Director's New Innovator Awards |
| 2004 | NSEC (Nanoscale Science and Engineering Center) Outstanding Research Award |
| 2006 – 2007 | CIRM (California Institute for Regenerative Medicine) Post-doctoral Fellowship |
| 2003 | MRS (Materials Research Society) Graduate Student Award |
| 2001 – 2002 | University President Fellowship, Northwestern University |
| 2001 | L. Carroll King Award for Excellence Chemistry Teaching, Northwestern University |

### Other Experience and Professional Memberships

| | |
|---|---|
| 2020-2024 | **NIH Nano Study Section (Standing Member)** |
| 2020-2022 | Singapore National Medical Research Council (NMRC)-International Expert Review Panel |
| 2020 – Present | Nano Convergence (Impact Factor: 10.038), Executive Editor |
| 2020 | CDMRP Ad hoc reviewer (X2) |
| 2020 | NIH Ad hoc reviewer (X3), [MTE], DP2, and SARS-CoV-2 Emergency Awards |
| 2020 | NSF Panel Reviewer (X2), BMMB CASIS and BIOSENSING CAREER |
| 2019 | NIH Ad hoc reviewer (X4), [GDD], [MTE], and [BMBI] |
| 2018 | NIH Ad hoc reviewer (X4), NIH/NIBIB Study Section, [GDD], Musculoskeletal Tissue Engineering Study Section [MTE], and [BMBI] |
| 2018 | CDMRP- Advancing Innovation in Military Medicine Research Award Review Panel Member |
| 2018-Feb | NIH Ad hoc reviewer (x2), [BMBI], Musculoskeletal Tissue Engineering Study Section [MTE] |
| 2017 | Ad hoc reviewer (X2), NIH/NIBIB Study Section, Gene and Drug Delivery [GDD] |
| 2017 | CDMRP Ad hoc reviewer |
| 2017 | NIH Ad hoc reviewer (X2), Biomaterials & Biointerfaces [BMBI]; NANO Study Section [NANO] |
| 2016 | CDMRP Ad hoc reviewer |
| 2016 | NSF Panel Reviewer (x2), MRI Microscopy; MRI NanoFab |
| 2016 | Ad hoc reviewer, NIH Nanomaterials Health Implications Research (NHIR) Special Emphasis Panel |
| 2016 | Ad hoc reviewer, NIH Biomaterials and Biointerfaces Study Section [BMBI] |
| 2015 | CDMRP Panel Reviewer, Spinal Cord Research Program |
| 2015 | NSF Panel Reviewer, Tissue Engineering and Stem Cell Technology |
| 2014 | Ad hoc reviewer, National Medical Research Council (NMRC, Singapore) |
| 2014 | Ad hoc reviewer, The Wellcome Trust (UK) |

2013 CDMRP Panel Reviewer, Ovarian Cancer Research Program
2013 NSF Panel Reviewer (X2), NanoEHS and Tissue Engineering and Stem Cell Technology
2011 – 2013 Ad hoc reviewer, Medical Research Council (MRC, UK)
2011 NSF Panel Reviewer, Biomaterials Programs
2010 – International Society for Stem Cell Research (ISSCR)
2005 – The New York Academy of Sciences
2000 – American Chemical Society, Material Research Society

## C. CONTRIBUTION TO SCIENCE *I have made substantial contributions to the following areas:*

**PUBLICATIONS [TOTAL PUBLICATIONS (~ # 138 ), CITATION #: ~11, 000 UPDATED ON JAN 2023]**

1. ***Early Career Training in Nanomedicine and Stem Cell Biology:*** My main research interest and contribution involves integrating nanotechnology-based approaches for controlling biomolecular surface architecture on 1-100 nm length scale (***Science* 2002**) and eventual stem cell-based applications. By taking advantage of the unique molecular properties of nanostructures and nanomaterials, which intrinsically interact with biological systems at the fundamental, molecular level with high specificity as well as selectivity, I have developed nanotechnology-based novel methods for detecting and isolating target biomolecules. Stem cells hold immense potential for many applications of regenerative medicine. Towards the goal of probing the fundamental mechanisms of stem cell biology differentiation, I published a paper in ***Cell Stem Cell*** in 2009, which probed the signaling pathway that regulated protein function to broaden the understanding of embryonic stem cell fate.
   a. **Lee, K. -B.**; Park, S. -J.; Mirkin, C. A.; Smith, J. C.; Mrksich, M., "Protein Nanoarrays Generated by Dip-Pen Nanolithography", *Science*, **2002**, *295*, 1702-1705. (PMID:19664994)
   b. **Lee, K. -B.**; Lim, J. -H.; Mirkin, C. A., "Protein Nanostructures Formed Via Direct-Write Dip-Pen Nanolithography", *J. Am. Chem. Soc*., **2003**, *125*, 5588-5589. (PMID: 12733870)
   c. Kamei, K.-I.; Yu, Z. T. F.; Guo, S.; Takahashi, H.; Gschweng, E.; Wang, X.; Suh, C.; Tang, J.; Witte, O. W.†; **Lee, K.-B.† ;** Tseng, H.-R.†,"An integrated microfluidic device for quantitative assay of human embryonic stem cells ", *Lab Chip,* **2009**, *9*, 555-563. (PMID: 19190791)
   d. **Lee, K.-B.***; Brill, L. M.*; Xing W.*; Ficarro, S.B.; Xu, Y.; Terskikh, A.; Snyder E.; Ding, S. " Phosphoproteomic Analysis of Human Embryonic Stem Cells", *Cell Stem Cells,* **2009**, *5*, 204-213. (* equal contribution) (PMID:19664994)

2. ***Nanotechnology-based novel methods for controlling stem cell fate:*** This experience and knowledge served as a springboard to explore converting stem cells into the neuronal lineage using various nanomaterial-based platforms. The use of nanomaterials for controlling stem cell differentiation holds immense potential in the field neuroscience, due to their biological inertness and high functional potency. To this end, I have been involved in developing platforms and technologies for stem cell differentiation and related applications. We have published several papers in this area of research. For example, we have recently published a few papers that integrate different types of materials (e.g. graphene and cationic polymers) with nanomaterials (e.g. nanoparticles, nanotubes, and core-shell nanoparticles) to regulate and induce neuronal differentiation.
   a. Lee, J.-H.; Cho, H. K.; Yang, L.; Chueng, S. –T.; Choi, J.-W.†; **Lee, K.-B.†**, "Non-destructive Real-Time Monitoring of Enhanced Stem Cell Differentiation using a Graphene-Au Hybrid Nanoelectrode Array", *Advanced Materials*, **2018** (PMCID: PMC6452898)
   b. Lee, J.-H.; Choi, J.-H.; Chueng, S. –T.; Pongkulapa, T.; Yang, L.; Cho, H.-Y.; Choi, J.-W.†; **Lee, K.-B.†**, "Nondestructive Characterization of Stem Cell Neurogenesis By a Magneto-Plasmonic Nanomaterial-based Exosomal miRNA Detection", *ACS Nano*, **2019**. *13,* 8793. (PMID: 31361458)
   c. Yang, L.; Conley, B. M.; Cerqueira, S. R.; Pongkulapa, T.; Wang, S.; Lee, J.K†; **Lee, K.-B.†**, " Effective Modulation of CNS Inhibitory Microenvironment using Bio-inspired Hybrid Nanoscaffold-based Therapeutic Interventions", *Advanced Materials*, **2020,** *DOI: 10.1002/adma.202002578* (PMID: 32893402)
   d. Luo, J.; Darai, A.; Pongkulapa, T.; Conley, B. M.; Yoon, J.; Yang, L.; Han, I.†; **Lee, K.-B.†**, " Injectable BIOorthogonal HydroGEL (BIOGEL) Accelerates Tissue Regeneration in Degenerated Intervertebral Discs", *Bioactive Materials,* **2022,** 23: 562. (PMID: 36582500)

3. ***Innovative Hybrid Nanomaterial-based Drug/Gene Delivery and Genetic Manipulation:*** At Rutgers University, I have been developing novel nanoparticle [e.g. magnetic core-shell nanoparticles (MCNPs), upconversion nanoparticles (UCNPs)]-based delivery of therapeutic molecules (neurotransmitters, siRNA,

miRNAs, and small molecules). Notably, our paper published in *ACS Nano,* **2015**, demonstrates our *nanoparticle-based synthetic transcription factors* (***NanoScript***) method for effective genetic manipulation, controlling stem cell differentiations and for other applications. NanoScript, synergistically combined with epigenetic modulators (e.g., SAHA and CTB), has been demonstrated to replicate natural TFs that are specific for myogenic regulatory factors (MRFs), Sox9, neural switch gene to induce stem cell myogenesis (*ACS Nano*, **2015**), chondrogenesis (*J. Am. Chem. Soc.,* **2015**), and neurogenesis (*Angew. Chem. Int. Ed.*, **2015**) respectively.

a. Patel, S.; Jung, D.; Yin, P. T.; Carlton, P.; Yamamoto, M.; Bando, T.; Sugiyama, H.; **Lee, K.-B.†**, " NanoScript: A nanoparticle-based artificial transcription factor for effective gene expression", *ACS Nano*, **2014**, *9, 8959-8967* (PMCID: PMC4174092)
b. Patel, S.; Pongkulapa, T.; Yin, P.T.; Pandian, G; Rathnam, C.; Bando, T.; Vaijayanthi, T.; Sugiyama, H.†; **Lee, K.-B.†**, "Integrating Epigenetic Modulators into NanoScript for Enhanced Chondrogenesis of Stem Cells", *J. Am. Chem. Soc.,* **2015**, *137*, 4598-4601. (PMID: 25789886)
c. Rabie, H.; Zhang, Y.; Pasquale, N.; Lagos, M.; Batson, P.; **Lee, K.-B.†**,"NIR Biosensing of Neurotransmitters in Stem Cell-derived Neural Interface Using Advanced Core-shell Upconversion Nanoparticles", *Advanced Materials*, **2019**, *31,* 1806991. (PMID: 30761616)
d. Rathnam, C.; Yang, L.; Castro-Pedrido, S.; Cai, L.; **Lee, K.-B.†**, "Hybrid SMART Spheroids for Enhanced Stem Cell-based Cell Replacement Therapy ", *Science Advances*, **2021**, *7, 40.* (PMCID: PMC8480929)

**4.** ***Bioengineering approaches for enhanced s cell therapies:*** In a parallel research effort, I have extensively developed genetically engineered stem cells for enhanced therapies and genetic manipulation against many devastating diseases including spinal cord injuries and cancers, using novel nanomaterial-based approaches. Notably, the recent paper published in *Angew. Chem. Int. Ed.* **2013**, describes our magnetic core-shell nanoparticle (MCNP)-mediated delivery of genetic materials into stem cells in a highly efficient, spatiotemporally controlled, and biocompatible manner. These novel nanomaterials also can be used for non-invasive molecular imaging probes as well as magnetically facilitated transfection.

a. Yin, P.T.; Shah, S.; Chhowalla, M.; **Lee, K.-B.†**, "Design, Synthesis, and Characterization of Graphene-Nanoparticle Hybrid Materials for Bio-applications", *Chemical Reviews*, **2015**, *115*, 2483-2531. (PMID: 25692385)
b. Shah, S.; Solanki, A.; **Lee, K.-B.†**, "Nanotechnology-based Approaches for Guiding Neural Regeneration", *Accounts of Chemical Research*, **2016**, *49, 17-26.* (PMID: 26653885)
c. Yang, C; Lue, J.; Pounas, M.; Bosnjak, N.; Chueng, S. –T.; Chadwick, M.; Sabaawy, H.E.; Chester, S. A.; **Lee, K.-B.†**;Lee, H.†,"4D Printed Transformable Tube Array for High-throughput 3D Cell Culture and Histology", *Advanced Materials*, **2020,** *DOI: 10.1002/adma.202004285* (PMID: 32864842)
d. Yang, L.; Conley, B. M.; Rathnam, C.; Cho, H.-Y.; Ponkulapa, T.; Conklin, B.; **Lee, K.-B.†**, "Predictive Biophysical Cue Mapping for Cellular Differentiation and Reprogramming Using Combinatorial Nanoarrays",*ACS Nano*,**2022**, *18*, 5577-5586. (PMID: 35301847)

**Complete List of Published Works in MyBibliography:** http://www.ncbi.nlm.nih.gov/pubmed/?term=Ki-Bum+Lee