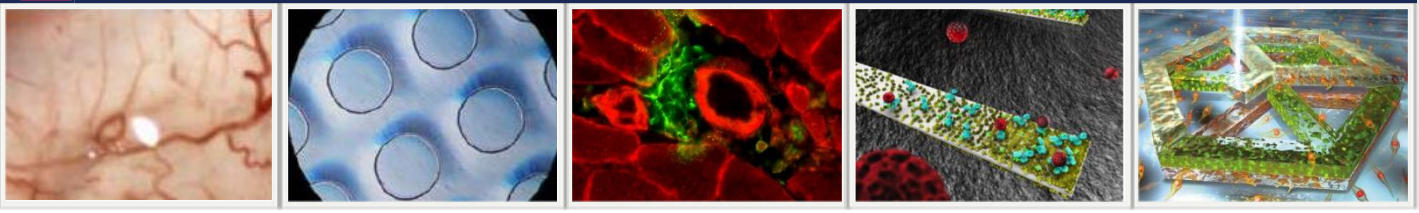
# BioNanotechnology Seminar Series

Spring 2012




# Nanotechnology Approaches For Regulating Stem/Cancer Cell Fate


## Professor KiBum Lee

**Department of Chemistry and Chemical Biology**
**Rutgers, The State University of New Jersey**


**Date:** **Tuesday, April 24, 2012**

**Time:** **12:00 – 1:00 p.m. CST (10:00 – 11:00 a.m. PST)**

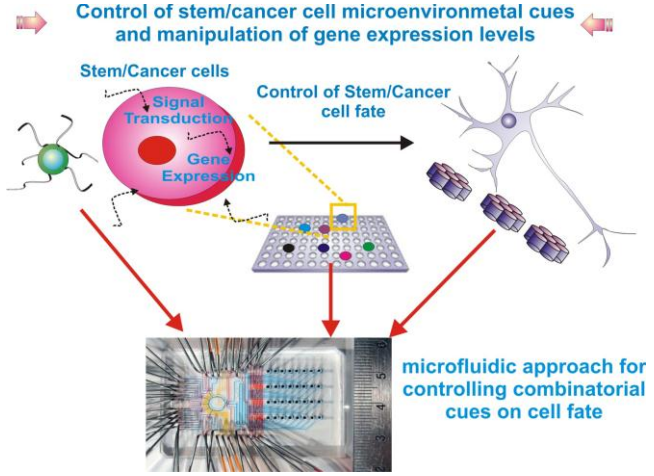
**Location:** **1000 MNTL at Illinois (SSM 150 at UC Merced)**


## Abstract:

This talk will focus on the interface of micro-/nano science and cell biology. Even though cell fate (e.g. stem cell differentiation and cancer cell apoptosis) is regulated by interactions with microenvironment cues and intrinsic cellular programs, understanding the functions of microenvironments and manipulating gene expression in stem/cancer cells are hampered by limitations of conventional methods and the lack of extensive knowledge of multiple regulatory signals. If the complex cell behaviors are to be fully investigated, both approaches from nanotechnology—the "top-down" patterning of extracellular matrix (ECM) and signal molecules in combinatorial ways (e.g. ECM compositions, pattern geometry, pattern density and gradient patterns), and the "bottom-up" synthesis of multifunctional nanoparticles and their surface modification with specific signal molecules—should be combined synergistically. To address the aforementioned challenge, our research mainly focuses on three approaches: i) development of combinatorial arrays of microenvironmental signal molecules for investigating

cell behaviors; ii) synthesis and utilization of multifunctional nanoparticles as chemotherapeutic reagents against glioblastoma multiforme (GBM); and iii) development of a microfluidic assay platform to identify the optimal conditions for stem cell differentiation and self-renewal.

More specifically, we have applied the combinatorial signal arrays to study the temporal/spatial effect of microenvironmental cues on adhesion, growth, differentiation of functional cells (e.g. neural stem cells and glioblastoma cells). Furthermore, novel synthetic approaches for anti-cancer drugs [e.g. Erlotinib and Histone deacetylase inhibitors (HDAC inhibitors)] and modified siRNA to be linked with nanoparticles have been developed. In parallel research efforts, we have developed a high throughput screening method based on microfluidics to study human embryonic stem cell (hESCs) responses toward multiple microenvironmental cues at the single cell level. In this talk, a summary of the most updated results from these efforts and future directions will be discussed.




*Combinatorial nanotechnology approaches for stem/cancer cell research*


**Key References:**

1. *Angew. Chem. Int. Ed.* **2010,** *49,* 103**.**
2. *Cell Stem Cell* **2009,** *5,* 204
3. ACS Nano **2011**, *5*, 4704
4. *Advanced Materials*, **2011**, *23*, 2221.
5. *Small*, **2010**, *6*, 2509.
6. *Small*, **2011**, 6, 741.
7. *Cancer Research*, **2010**, 70, 6128.
8. *Lab Chip* **2009,** *9,* 555.
9. *ChemBioChem* **2010**, *11*, 755.


**Seminar Presented by:**

Center for Cellular Mechanics
University of Illinois at Urbana-Champaign

IGERT Integrative Graduate Education and Research Traineeship
Cellular and Molecular Mechanics and BioNanotechnology

M-CNTC NCI Alliance for Nanotechnology in Cancer
Midwest Cancer Nanotechnology Training Center

CNST University of Illinois Center for Nanoscale Science and Technology

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## ACADEMIC POSITION

2008 - Present Assistant Professor
Rutgers, The State University of New Jersey, Piscataway, NJ
Dept. of Chemistry and Chemical Biology

*Rutgers faculty in the following programs and institutes:*
Biomedical Engineering Dept. graduate program (2008- present)
Graduate Program in Molecular Biosciences (2009-present)
The Rutgers Stem Cell Research Center(2008- present)
NSF IGERT on Integrated Science and Engineering of Stem Cells / Nanotechnology for Clean Energy
Institute for Advanced Materials, Devices and Nanotechnology/Laboratory for Surface Modification

2007 Visiting Scholar
UCLA Medical School, Los Angeles, CA
Dept. of Molecular and Medical Pharmacology

## EDUCATION

**B. S.** Chemistry, Kyung Hee University, Seoul, Korea, Feb. 1998, graduated summa cum laude.
**M. S.** Physical Chemistry, KAIST (Korea Advanced Institute of Science and Technology), Taejon, Korea, Feb. 2000.
**Ph. D.** Bio-material/analytical/inorganic Chem., Nanotechnology, Northwestern University, Evanston, IL, Aug. 19, 2004
**PostDoc** Chemical Biology, The Scripps Research Institute, La Jolla, CA, 2004~2007.

## AWARDS AND HONORS

NIH Director's New Innovator Awards, Rutgers University (2009~2014)
Faculty Research Grant Award, Rutgers University (2012~2013)
Johnson and Johnson Proof-of-Concept Award, Rutgers University (2011~2012)
New Jersey Spinal Cord Research Award, Rutgers University (2009~2013)
Grant Proposal Development Award, Rutgers University (2008)
CIRM (California Institute for Regenerative Medicine) Post-doctoral Fellowship, The Scripps Research Inst. (2006~2007)
NSEC (Nanoscale Science and Engineering Center) Outstanding Research Award, Northwestern University (2004)
MRS (Materials Research Society) Graduate Student Award, Northwestern University (2003)
Korean-American Scholarship (2003), Northwestern University
L. Carroll King Award for Excellence Chemistry Teaching, Northwestern University (2001)
University Presidential Fellowship, Northwestern University (2001)
Honor scholarship, Kyung Hee University (95-97)
NSEC Board of Student Advisors (2000-2004)

## PROFESSIONAL EXPERIENCE

*Assistant Professor*, Dept. of Chem. & Chemical Biology, Rutgers, The State University of New Jersey (Jan. 2008 to present)

- Area: Analytical and Inorganic Chemistry, Chemical biology, Nanotechnology, Drug/Gene Delivery, Biomaterials/Tissue Engineering, Regenerative Medicine, Microfluidics, Molecular Imaging, Synthetic Biology, Functional Genomics
- Research Topic: *Develop and integrate nanotechnologies and chemical functional genomics to modulate signaling pathways in cells (e.g. stem cells and cancer cells) and to investigate cell behaviors (e.g. self-renewal, differentiation, apoptosis, and migration)*

*Visiting Professor* at UCLA Medical School, Dept. of Molecular & Medical Pharmacology (Sep. 2007 to Dec. 2007)
Research Topic: *Engineering the stem cell microenvironment using microfluidics* (Collaboration with Dr. Tseng lab)

*Post-doctoral research* with Prof. Peter G. Schultz, The Scripps Research Institute (Sep. 2004 to Aug. 2007)

- Area: Chemical biology, High through-put screening, Stem cell biology, Drug discovery, Phospho- Proteomics, Synthetic Biology, Regenerative medicine, Functional Genomics
- Research Topic: *Chemical and functional genomic approaches for regulating stem cell fate*

*Graduate research* with Prof. Chad A. Mirkin, Northwestern University (Aug. 2000 to Aug. 2004)
- ❖ Area: Nanobiotechnology, Biomaterials, Bio-surface science, Biosensors, Synthesis of nanocomposites
- ❖ PhD Thesis: "Nanostructures for Biomolecular Assays"

Research Scientist at SAMSUNG SDI CO., LTD, Suwon, Korea. (2000)

Graduate research with Prof. Bongsoo Kim, KAIST (1998-2000).
- ❖ Area: Physical Chemistry

Master's Thesis: "*Study of the Electronic Structure of KRb by Resonance Enhanced Two Photon Ionization (RE2PI) Spectroscopy in a Supersonic Molecular Beam*"

**PUBLICATIONS** (TOTAL CITATION #: ~1800 UPDATED ON OCT, 2011)
*(After Independent Position)*

1. Myung, S.; Solanki, A.; Kim, C.; Park, J.; Kim, K. S.; **Lee, K.-B.†**, " Graphene-encapsulated Nanoparticle-based Biosensor for the Selective Detection of Cancer Biomarkers", *Advanced Materials*, **2011**, *23*, 2221–2225**.**

2. Kim, C.; Shah, B. P.; Subramaniam, P.; **Lee, K.-B.†**, "Cooperative induction of brain tumor cell apoptosis by targeted co-delivery of siRNA and anticancer drugs", *Molecular Pharmaceutics*, **2011**, *8,* 1955-1961**.**

3. Park, J. K.; Jung, J.; Subramaniam, P.; Shah, B.; Kim, C.; Lee, J. K.; Cho, C.; **Lee, K.-B.†**, "Graphite-Coated Magnetic Nanoparticles as Multimodal Imaging Probes and Cooperative Therapeutic Agents for Tumor Cells", *Small*, **2011**, *7*, 1647-1652.
*Highlighted in ACS Chemical & Engineering News (September 26, 2011 Volume 89, Number 39 pp. 29 – 32)*

4. Reyes, P. I.; Ku, C.-J.; Duan, Z.; Lu, Y.†; Solanki A.; **Lee, K.-B.†**, "ZnO Thin Film Transistor Immunosensor with High Sensitivity and Selectivity", *Applied Physics Letters*, **2011**, *98***,** 173702**.**

*5.* Park, S. Y.; Choi, D. S.; Jin, H. J.; Park, J.; Byun, K.-E.; **Lee, K.-B.†**; Hong, S.†, " Polarization-controlled differentiation of human neural stem cells using synergistic cues of carbon nanotube network patterns", *ACS Nano*, **2011**, *5,* 4704-4711**.** *Highlighted in Neural Cell News 5.19, May 18, 2011*

6. Baik, K. Y.; Park, S. Y.; Heo, K.; **Lee, K.-B.**; Hong, S.†, " Carbon Nanotube Monolayer Cues for Osteogenesis of Mesenchymal Stem Cells ", *Small*, **2011**, 6, 741-745*.*

7. Jung, J.; Solanki, A.; Memoli, K. A.; Kamei, K.-I.; Kim, H. ; Drahl, M. A.; Williams, L. J.; Tseng, H.-R.; **Lee, K.-B.†**, "Selective inhibition of human brain tumor cell proliferation via multifunctional quantum dot-based siRNA delivery", *Angew. Chem. Int. Ed.*, **2010**, *49*, 103–107**.** (†:corresponding author)
*Highlighted in Nanowerk, " Quantum dot based siRNA approach selectively inhibits brain cancer cells"*

8. Solanki A.; Shah,S.; Park, S. Y.; Hong, S; **Lee, K.-B.†**, " Controlling differentiation of neural stem cells using extracellular matrix protein patterns", *Small*, **2010**, *6*, 2509-2513. *Highlighted in* (***Frontispiece*** in Small 22/2010)

9. Solanki, A.; **Lee, K.-B.†**, " A Step Closer to Complete Chemical Reprogramming for Generating iPS Cells", *ChemBioChem*, **2010**, *11*, 755-757.

10. Kamei, K.-I.; Ohashi, M.; Suh, J.; Ho, Q.; Yu, Z. T. F.; Tang, J. ; Teitell, M. A.; Clark, A. T.; Pyle, A. D.; **Lee, K.-B.**; Witte, O. W.; Tseng, H.-R., " Microfluidic Image Cytometry for Quantitative Single-Cell Profiling of Human Pluripotent Stem Cells in Chemically Defined Conditions", *Lab Chip*, **2010**, *10*, 1113-1119.

11. Sun, J.; Masterman, S. M.; Graham, N. A. ; Jiao, J. ; Mottahedeh, J.; Laks, D. R. ; Ohashi, M.; DeJesus, J.; Kamei, K.-I.; **Lee, K.-B.**; Wang, H.;. Yu, Z. T. F; Lu, Y.-T. ; Wang, S.; Hou, S. ; Li, K.; Liu, M.; Zhang, N.; Angenieux, B.; Panosyan, E.; Samuels, E.; Park, J.; Williams, D.; Konkankit V.; Nathanson, D.; van Dam, R. M. ; Phelps, M. E.; Wu, H.; Liau, L. M. ; Mischel, P. S.; Lazareff, J. A.; Kornblum, H.; Yong, W. H.; Graeber, T. G. and H.-R. Tseng, "A microfluidic platform for systems pathology: multiparameter single-cell signaling measurements of clinical brain tumor specimens", *Cancer Research*, **2010**, *70 (15)*, 6128-6138**.**

12. Brill, L. M.*; Xing W.*; **Lee, K.-B.***; Ficarro, S.B.; Xu, Y.; Terskikh, A., Snyder E. Y.; Ding, S., " Phosphoproteomic Analysis of Human Embryonic Stem Cells", *Cell Stem Cell* **2009,** *5***,** 204-213**.** (* Equal First Authors.)
*Highlighted* "Unraveling the Human Embryonic Stem Cell Phosphoproteome", *Cell Stem Cell* **2009**, *5*, 126-127.
*Highlighted in Faculty of 1000 Biology*, 29 Sep 2009

13. 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. (†: corresponding authors)

14. Yu, Z. T. F.; Kamei, K.-I.; Shu, C. J.; He, G. W.; Silverman, R.; Radu, C. G.; Witte, O. W.[†]; **Lee, K.-B.[†]**; Tseng, H.-R.[†], " Integrated microfluidic devices for combinatorial cell-based assays ", *Biomedical Microdevices*, **2009**, *11*, 547- 555. (†: corresponding authors)

15. Solanki, A.; Kim, J. D.; **Lee, K.-B.[†]**, "Nanotechnology for Regenerative Medicine: nanomaterials for stem cell imaging ", *Nanomedicine,* **2008***, 3,* 567-578. (†: corresponding author)

16. **Lee, K.-B.[†] ;** Solanki, A.; Kim, J. D.; Jung J.,"Nanomedicine: dynamic integration of nanotechnology with biomedical science ", Zhang, M., Editors, World Scientific, **2008.** (†: corresponding author)

17. Solanki, A.; Shah, S.; Koucky, M.; **Lee, K.-B.[†]**, "Nanomaterials for stem cell imaging in neuroscience", Preedy, V. R., Editors, CRC Press, **2011.** (Invited Book Chapter)

18. Subramaniam, P.; Lee, S.; Shah, S.; Park, J. K.; **Lee, K.-B.[†]**, "Generation of a library of non-toxic quantum dots for cellular imaging and siRNA delivery", *submitted*, **2012.**

19. Myung, S.; Kim, C.; Yin, P. T.; Park, J.; Solanki, A.; Reyes, P. I.; Yicheng, L.; Kim, K. S.; **Lee, K.-B.[†]**, "Label-free Polypeptide-based Enzyme Detection Using a Graphene-nanoparticle Hybrid Sensor", *submitted*, **2012.**

*(Before Independent Position)*

20. Oh, B.-K; Park, S.; Millstone, J. E.; Lee, S. W.; **Lee, K.-B.**; Mirkin, C. A., " Separation of Tricomponent Protein Mixtures with Triblock Nanorods", *J. Am. Chem. Soc.*, **2006,** *128***,** 11825-11829.

21. **Lee, K. -B.**; Kim, E. -Y.; Wolinsky, S. M.; Mirkin, C. A., "The use of nanoarrays for highly sensitive and selective detection of human immunodeficiency virus in plasma", *Nano Letters,* **2004***, 4,* 1869-1872.
*See also* "Nanoarrays for ultrasensitive biodetection", *NanoToday*", 9 (Dec. 2004).

22. **Lee, K. -B**.; Park, S.; Mirkin, C. A., "Multicomponent Magnetic Nanorods for Biomolecular Separations", *Angew. Chem. Int. Ed.,* **2004**, *43*, 3048-3050.

23. Zhang, Y.; Salaita, K.; Lim, J -H.; **Lee, K. -B.**; Mirkin, C. A., "A Massively Parallel Electrochemical Approach to the Miniaturization of Organic Micro- and Nanostructures on Surfaces", *Langmuir,* **2004**, *20*, 962-968.

24. Nam, J. -M.; Han, S. W.; **Lee, K. -B.**; Liu, X.; Mirkin, C. A., "Bioactive Protein Nanoarrays on Nickel Oxide Surfaces Formed by Dip-Pen Nanolithography ", *Angew. Chem. Int. Ed.,* **2004**, *43,* 2146-1249.

25. Zhang, H.; **Lee, K. -B.**; Li, Z.; Mirkin, C. A., "Biofunctionalized nanoarrays of inorganic structures prepared by dip-pen nanolithography", *Nanotechnology,* **2003,** *14*, 1113–1117.

26. Smith, J. C. *; **Lee, K. -B**.*; Wang, Q. *; Finn, M. G.; Johnson, J. E.; Mrksich, M.; Mirkin, C. A., "Nanopatterning the Chemospecific Immobilization of Cowpea Mosaic Virus Capsid", *Nano Letters,* **2003**, *3*, 883-886.
(* These authors contributed equally to this work.)

27. Lim, J. -H.; Ginger, D.; **Lee, K. -B**.; Heo, J.; Nam, J. -M.; Mirkin, C. A., "Direct-Write Dip-Pen Nanolithography of Proteins on Modified Silicon Oxide Surfaces" *Angew. Chem. Int. Ed.,* **2003**, *20,* 2411-2414.

28. **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.
*See also* one of "Most Intriguing" documents for 2Q2003 by CAS scientists

29. **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.

*See also* "Technique makes protein arrays", *C&EN News* **80**, 6 (Feb. 11, 2002).
*See also* "Protein nanoarrays", *Materials Today*, 12 (Jun. 2002).
*See also* Chemistry Highlights 2003, *C&EN News* **80**, 46 (December 16, 2002).

30. Ivanisevic, A.; Im, J.-H.; **Lee, K. -B.;** Park, S.-J.; Demers, L. M.; Watson, K. J.; Mirkin, C. A., "Redox-Controlled Orthogonal Assembly of Charged Nanostructures", *J. Am. Chem. Soc.*, **2001**, *123*, 12424-12425.

**PATENTS**

1. **Lee, K. -B.**; Mirkin, C. A.; Park, S. "Multicomponent Magnetic Nanorods for Biomolecular Separations", *U.S. Patent Application* No. 60/546641, **2005**. (Northwestern University)
2. Mirkin, C. A.; Park, S. -J.; **Lee, K. -B.**; Demers, L. "Protein Arrays with Nanoscopic Features Generated by Dip-Pen Nanolithography, Non-provisional title-- "Protein and Peptide Nanoarrays", *U.S. Patent Application* No. 10/261663, 2002. (Northwestern University)
3. Mirkin, C. A.; Lim, J. -H.; Ginger, D.; **Lee, K. -B.**; Nam, J. -M.; Demers, L. "Peptide And Protein Arrays And Direct-Write Lithographic Printing Of Peptides and Proteins" *U.S. Patent Number 7,842,344*, **2010**. (Northwestern University)
4. **Lee, K. -B.**; Kim, C.; Shah, B. P.; Subramaniam, P., "Cyclodextrin containing branched polyamines for delivery of nucleic acids and drugs asgenetic manipulation tools in cancer/stem cells ", *U.S. Patent Application* No. 13/270,261, **2010**. (Rutgers University)
5. **Lee, K. -B.**; Solanki, A.; Shah, S., "Controlling stem cell behaviors using combinatorial cue arrays of microenvironmental cuesand nanomaterials", *U.S. Patent Application* No. 13/214,824, **2010**. (Rutgers University)
6. **Lee, K. -B.**; Solanki, A.; Myung, S., "Graphene-encapsulated nanoparticle-based biosensors for the selective detection of cancer biomarker", *U.S. Patent Application* No. 61/443,950, **2011**. (Rutgers University)
7. **Lee, K. -B.**; Shah, S., "Investigating stem cell differentiation using three-demensional patterns of novel light-responsive hydrogels", *U.S. Patent Application* No. 13/314,891, **2011**. (Rutgers University)
8. **Lee, K. -B.**; Lu, Y.;Reyes, P.; Solanki, A., "NanoStructured ZnO Thin Film Transistor ("TFT")", *U.S. Patent Application* No. 61/441,354, **2011**. (Rutgers University)
9. **Lee, K. -B.**; Subramaniam, P., "Generation of a library of non-toxic quantum dots for cellular imaging and siRNA delivery", *U.S. Patent Application* No. 61/592,090, **2012**. (Rutgers University)
10. **Lee, K. -B.**; Solanki, A.; Shah, S., "Nanotopography-mediated siRNA and gene delivery into neural stem cells", *U.S. Patent Application* No. 61/591,303, **2012**. (Rutgers University)
11. **Lee, K. -B.**; Solanki, A.; Shah, S., "Magneto-plasmonic nanoparticles for magnetically-enhanced intraceullar delivery, molecular imaging, and effective hyperthermia-based therapy", *U.S. Patent Application* No. 61/597,407, **2012**. (Rutgers University)

**SELECTED INVITED PRESENTATIONS**

1. **Lee, K. -B.**; Park, S. -J.; Mirkin, C. A., "Protein nanoarrays generated by Dip-Pen Nanolithography" Presentation, 223rd ACS National Meeting, Orlando, FL, United States, April 7-11, 2002.

2. **Lee, K. -B.**; Mirkin, C. A.; Smith, J. C.; Mrksich, M., "Biomolecular Arrays Formed by Dip-Pen Nanolithography (DPN) " Presentation, MRS meeting, Spring 2003, San Francisco, CA, April 22-25, 2003. *(Award Talk)*

3. **Lee, K. -B.**; Park, S. H.; Mirkin, C. A., "Nanostructures for Detection and Separation of Biomolecules" Joint Regional Meeting of the Northwest and Rocky Mountain sections of ACS, Logan, Utah, United States, June 6-9, 2004.

4. BWF Career Awards at the Scientific Interface (finalist, award competition talk), Oct 2006
5. *University of California at San Diego*, Department of Bioengineering, Oct 2006
6. *University of Texas Southwestern Medical Center*, Simmons Comprehensive Cancer Center, Nov 2006
7. *University of Massachusetts at Amherst*, Department of Chemistry, Dec 2006
8. *POSTECH*, Interdisciplinary Bioscience and Bioengineering, Dec 2006
9. *KAIST*, Department of Biological Sciences, Dec 2006
10. *University of Southern California*, Department of Chemistry, Jan 2007
11. *University of Michigan at Ann Arbor*, Department of Chemistry & LSI, Feb 2007
12. *University of California at Berkeley*, Nansosciences & Nanoengineering Institute, Feb 2007
13. *University of California at Riverside*, Department of Bioengineering, Feb 2007
14. *University of Texas at Austin*, Nano Science and Technology & Dept. of Chemistry, Feb 2007
15. *University of North Carolina at Chapel Hill*, School of Pharmacy, Feb 2007
16. *University of Wisconsin at Madison*, School of Pharmacy, Feb 2007
17. *Rutgers, The State University of New Jersey*, Chemistry & Chemical Biology, Feb 2007
18. *Purdue University*, Department of Chemistry, Feb 2007
19. *Duke University*, Biomedical Engineering, Mar 2007
20. *University of California at San Francisco*, Departments of Pharmaceutical Chemistry, Mar 2007
21. *University of Illinois at Urbana-Champaign*, Department of Bioengineering, Apr 2007
22. *University of California at Los Angeles*, Department of Molecular & Medical Pharmacology, Aug 2007
23. *Kyung Hee University*, Department of Chemistry, Sep 2007 *(Seoul, Korea)*
24. *Rutgers University,* LSM (Laboratory for Surface Modification)*,* Feb 2008
25. *The Cancer Institute of New Jersey,* New Jersey stem cell conference*,* Apr 2008
26. *Rutgers University,* BioMaPS Institute for Quantitative Biology, May 2008
27. *Brookhaven National Lab,* The Center for Functional Nanomaterials, Jan 2009
28. *Kyung Hee University*, College of Science, Mar 2009 (Seoul, Korea)
29. *POSTECH,* Department of Chemistry, Mar 2009
30. *Korea Research Institute of Chemical Technology,* Bio-Organic Science Division, Mar 2009
31. *KAIST,* Department of Bio and Brain Engineering, Mar 2009
32. *Korea Research Institute of Bioscience and Biotechnology,* Bio-Monitoring Res. Center, Mar 2009
33. *Sogang University,* Department of biochemical engineering, Mar 2009 (Seoul, Korea)
34. *Gwangju Institute of Science and Technology,* Department of Life Science, Mar 2009
35. *Seoul National University,* NANO System Institute, May 2009 (Seoul, Korea)
36. *Rutgers University,* IAMDN(Inst. of Adv. Mat. Dev. and Nanotech.)/LSM, Apr 2009
37. *Naval Research Laboratory*, Surface Nanoscience and Sensor Technology, Apr 2009

38. *Universidade de São Paulo (Brazil),* Departamento de Bioquímica Instituto de Química, May 2009
39. ACS, IACIS International Conference and ACS colloid & Surface Science Symposium (*Three Talks*), Jun 2009 (New York, NY)
40. The Fifth Annual NIH Director's Pioneer Award Symposium, Sep, 2009 (Washington, DC)
41. BioTronics 2009, International Conference on Biosensors, Biochips and Bioelectronic Devices, Oct 2009 (Seoul, Korea)
42. BIOCHIP 2009, "*Recent Trends in Nanomedicine*", Oct 2009 (Seoul, Korea)
43. Ajou University, Department of Molecular Science and Technology, Oct 2009 (Suwon, Korea)
44. NIH Workshop for Junior Faculty in Organic Chemistry and Chemical Biology, Oct 2009 (Irvine, CA)
45. The Laboratory Robotics Interest Group Mid Atlantic Chapter (LRIG), Nov 2009 (New Brunswick, NJ)
46. MRS 2009 Fall Meeting, Dec 2010 (Boston, MA)
47. Peking University, College of Chemistry and Molecular Engineering, Jan 2010 (Peking, China)
48. Nankai University, College of Chemistry, Jan 2010 (Tianjin, China)
49. Nanjing University, School of Chemistry & Chemical Engineering, Jan 2010 (Nanjing, China)
50. USTC, Department of Chemistry, Jan 2010 (Hefei, China)
51. Zhejiang University, Department of Chemistry, Jan 2010 (Hangzhou, China)
52. Fudan University, Department of Chemistry, Jan 2010 (Shanghai, China)
53. Korea Advanced Inst. of Science and Technology (KAIST), Medical Science and Engineering, Jan 2010 (Taejon, Korea)
54. *Gwangju Institute of Science and Technology (GIST),* Department of Materials Science and Engineering, Jan 2010 (Gwangju, Korea)
55. Rutgers Energy Institute/Princeton University, Solar Energy Seminar, Apr 2010 (Princeton, NJ)
56. University of Connecticut, Department of Chemistry, Mar 2010 (Storrs, CT)
57. Columbia University, NYKB (New York Korean Biologists) Symposium, Mar 2010 (New York, NY)
58. Gordon Research Conferences (Signal Transduction by Engineered Extracellular Matrices), Jul 2010 (University of New England, Biddeford, ME)
59. IEEE NANO 2010, Nano-Bio Fusion, Nano-Biology and Nanomedicine, Aug 2010 (Seoul, Korea)
60. Kyoto University, Institute for Integrated Cell-Material Sciences (iCeMS), Aug, 2010 (Kyoto, Japan)
61. RAMNUC Meeting, Sep, 2010 (Imperial College, London, UK)
62. The Sixth Annual NIH Director's Pioneer Award Symposium, Sep, 2010 (Washington, DC)
63. MRS Workshop, Functionalized Nanobiomaterials for Medical Applications, Oct, 2010 (Denver, CO)
64. Boston University, Department of Chemistry, Oct, 2010 (Boston, MA)
65. Johns Hopkins University, BLSA (Baltimore Life Scientists Association), *Stem Cell: Past, Present, and Future, Nov*, 2010 (Baltimore, MD)
66. Institute Pasteur Korea, 3$^{rd}$ International Collaborative Symposium on Stem Cell Research, Apr, 2011 (Seoul, Korea)
67. ISSCR (International Society for Stem Cell Rearch) 9$^{th}$ Annual Meeting, June, 2011 (Toronto, Canada)
68. Kyung Hee University, Medical School, June, 2011 (Seoul, Korea)

69. KunKuk University, Medical School and Stem Cell Center, June, 2011 (Seoul, Korea)
70. SoGang University, Department of Chemical and Biological Engineering, June, 2011 (Seoul, Korea)
71. Cha University, Medical School and Stem Cell Center, June, 2011 (Seoul, Korea)
72. Scripps Korea Antibody Institute, June, 2011 (Seoul, Korea)
73. ICMAT (International Conference on Materials for Advanced Technologies) (*Two Invited Talks*), June, 2011 (Suntec, Singapore)
74. Nanyang Technological University, School of Chemical and Biomedical Engineering, June, 2011 (Singapore)
75. National University of Singapore, Department of Chemistry, June, 2011 (Singapore)
76. Kang Dong KyungHee Medical Center, June, 2011 (Seoul, Korea)
77. Kyoto University, Institute for Integrated Cell-Material Sciences (iCeMS), July, 2011(Kyoto, Japan)
78. Gordon Research Conferences (Cancer Nanotechnology), July 2011 (Colby College, Waterville, ME)
79. MIRKUNITE (Invited talk at “a 20 year celebration of the Mirkin Research Group), Aug 2011 (Northwestern Univ., IL)
80. ACS, Fall Meeting (*Three Invited Talks*), Aug 2011 (Denver, CO)
81. SU International Symposium 2011, Shizuoka University, Nov, 2011 (Shizuoka, Japan)
82. University of Maryland, Department of Chemistry and Biochemistry, Feb 2012 (College Park, MD)
83. University of Florida, Department of Chemistry, Feb 2012 (Gainesville, FL)
84. University of Washington, Center of NanoTechnology, Feb 2012 (Seattle, WA)
85. Florida State University, Department of Biological Science and Integrative NanoScience Institute, Mar 2012 (Tallahassee, FL)
86. University of Central Florida, College of Medicine, Mar 2012 (Orlando, FL)
87. Rutgers Cancer Diagnostics and Therapeutic Symposium, Mar 2012 (Piscataway, NJ)
88. University of California at San Diego (UCSD), Department of Chemistry, Apr 2012 (San Diego, CA)
89. University of California at Los Angeles (UCLA), NanoSystems Institute, Apr 2012 (Los Angeles, CA)
90. University of Illinois at Urbana-Champaign, Biotechnology Seminar Series of CCM/IGERT/M-CNT, Apr 2012 (Urbana-Champaign, IL)
91. University of Pennsylvania, Department of Chemistry, May 2012 (Philadelphia, PA)
92. Jilin University, Department of Chemistry, State Key Lab of Supramolecular Structure and Materials, May 2012 (Changchun, China)
93. Annual Spring Meeting of The Korean BioChip Society, May 2012 (Hanyang University, Korea)
94. The 31$^{st}$ International Union of Biological Science (IUBS) Conferences on Biological Sciences, July 2012 (Suzhou, China)
95. International Biotechnology Symposium (IBS) 2012, Oct 2012 (Daegu, Korea)