NanoEducation On Many Levels: Case Studies Spanning Informal Science Education to Undergraduate Research to Graduate Studies

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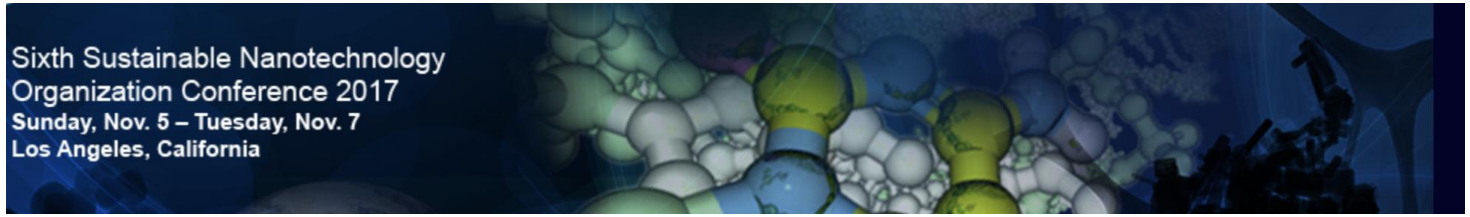

NanoEducation: Many Levels

- K-12 Education: Nano-To-Go Kit For Education and Outreach
- Undergraduate Education: Research Opportunities and Degrees in Nanoengineering
- Graduate Education: Research Opportunites, Formal Graduate Coursework and Degrees (M.S. and Ph.D.) in Nanoengineering
- Continuing Education (Lifelong Learners): Nano-To-Go Kit For Education and Outreach

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NanoEducation: K–12 Education

- **K-12 Education: Nano-To-Go Kit For Education and Outreach**
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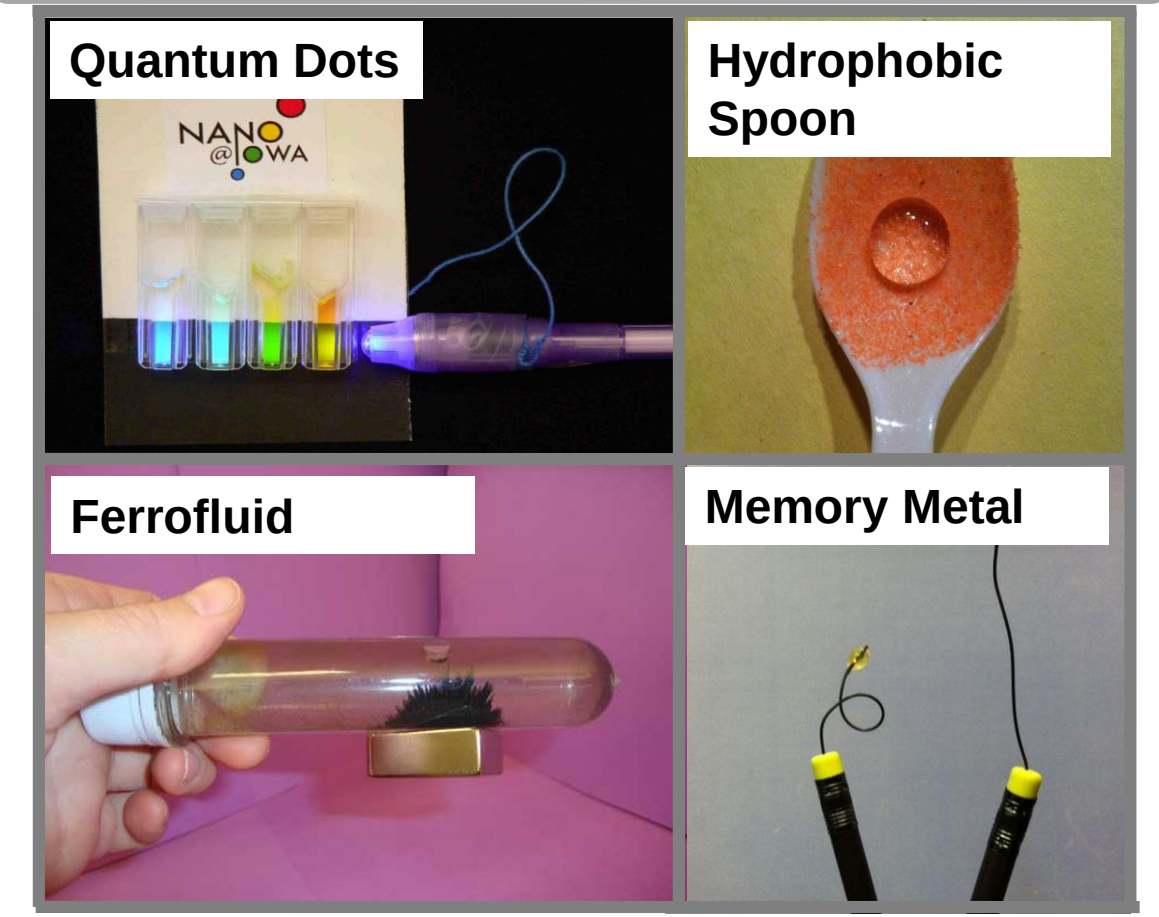
NanoEducation: K–12 Education

- Nano-to-go kit was designed for use in a range of venues
- Available for STEM Outreach events to all faculty, students and staff.
- The kit includes hands-on demos and activities, instructions for the activities and thermochromic pencils (just for fun!).
- The Nano-to-go kit is used regularly by many faculty and students.

NanoEducation: K–12 Education

Content of Nano-To-Go-Kits



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Example Outreach Events

- NanoDays at the Science Center of Iowa in Des Moines (2011-2017)
- STEM Institute presentation for 7th graders (2013-2017)
- STEM Career Days, Job Shadows, Internships
- Visits to Elementary Schools
- Visits to UIowa by Student Groups

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NanoEducation – Undergraduate Education

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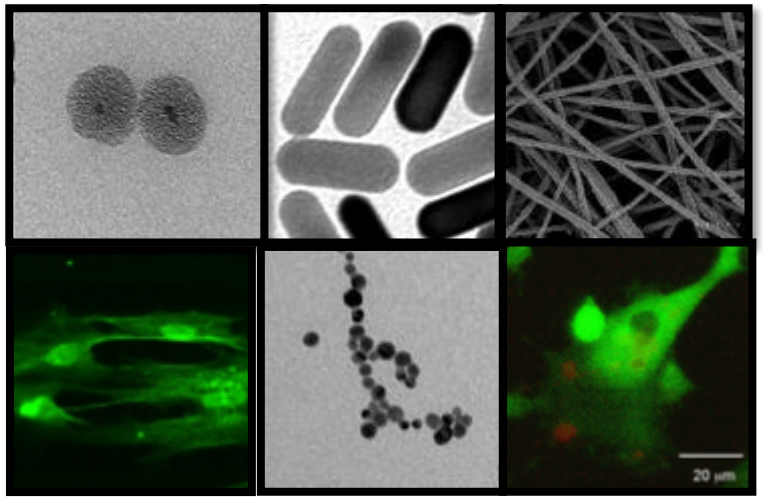
NanoEducation: Undergraduate Education Through Research

NSF REU Program in Nanoscience and Nanotechnology at The University of Iowa

Research projects focused on environmental and health aspects of nanoscience and nanotechnology



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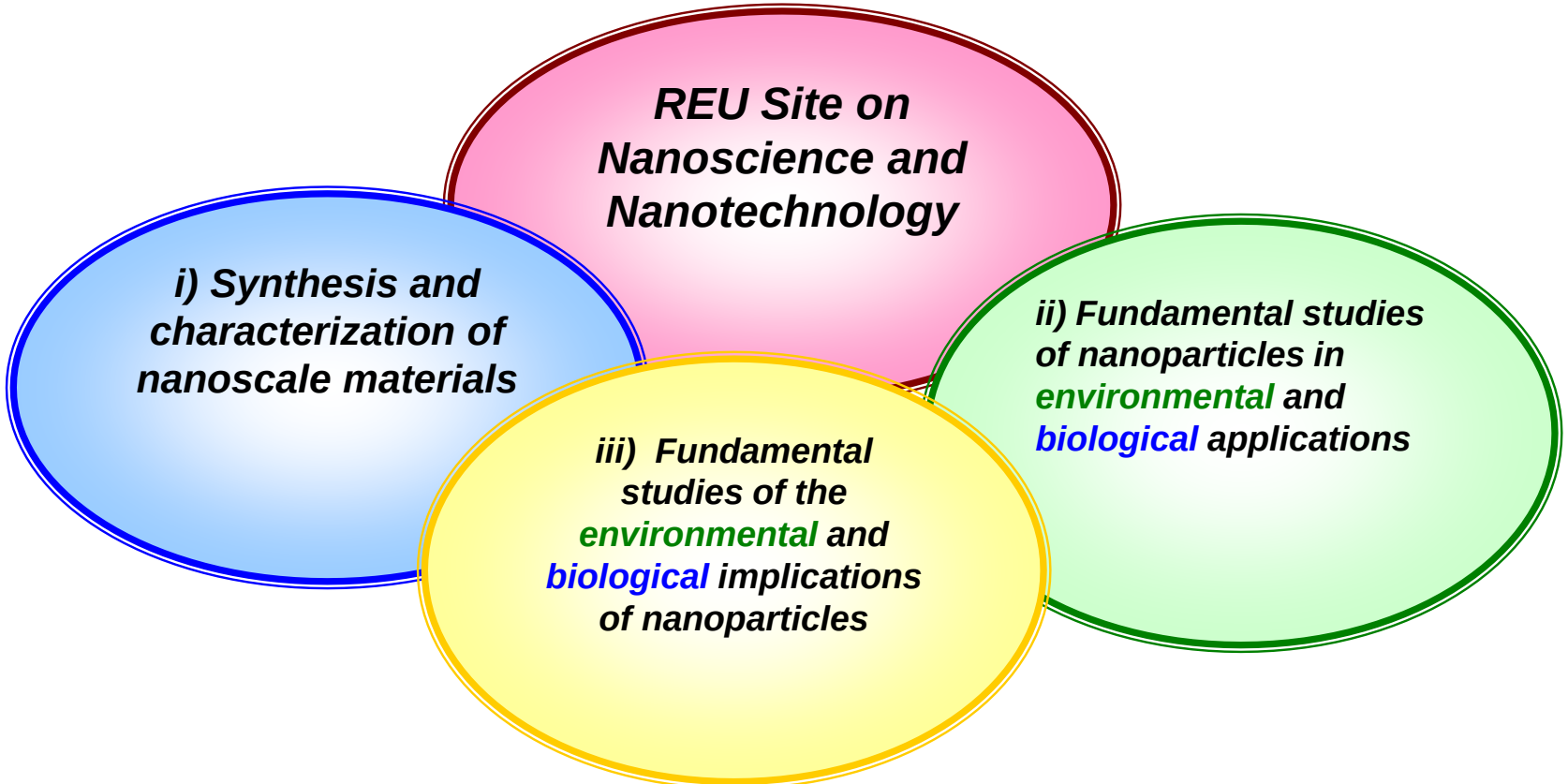
NanoEducation: Undergraduate Education Through Research

NSF REU Program in Nanoscience and Nanotechnology at The University of Iowa

NSF REU (2008-present): Multi-Department REU Program



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NanoEducation: Undergraduate Education Through Research

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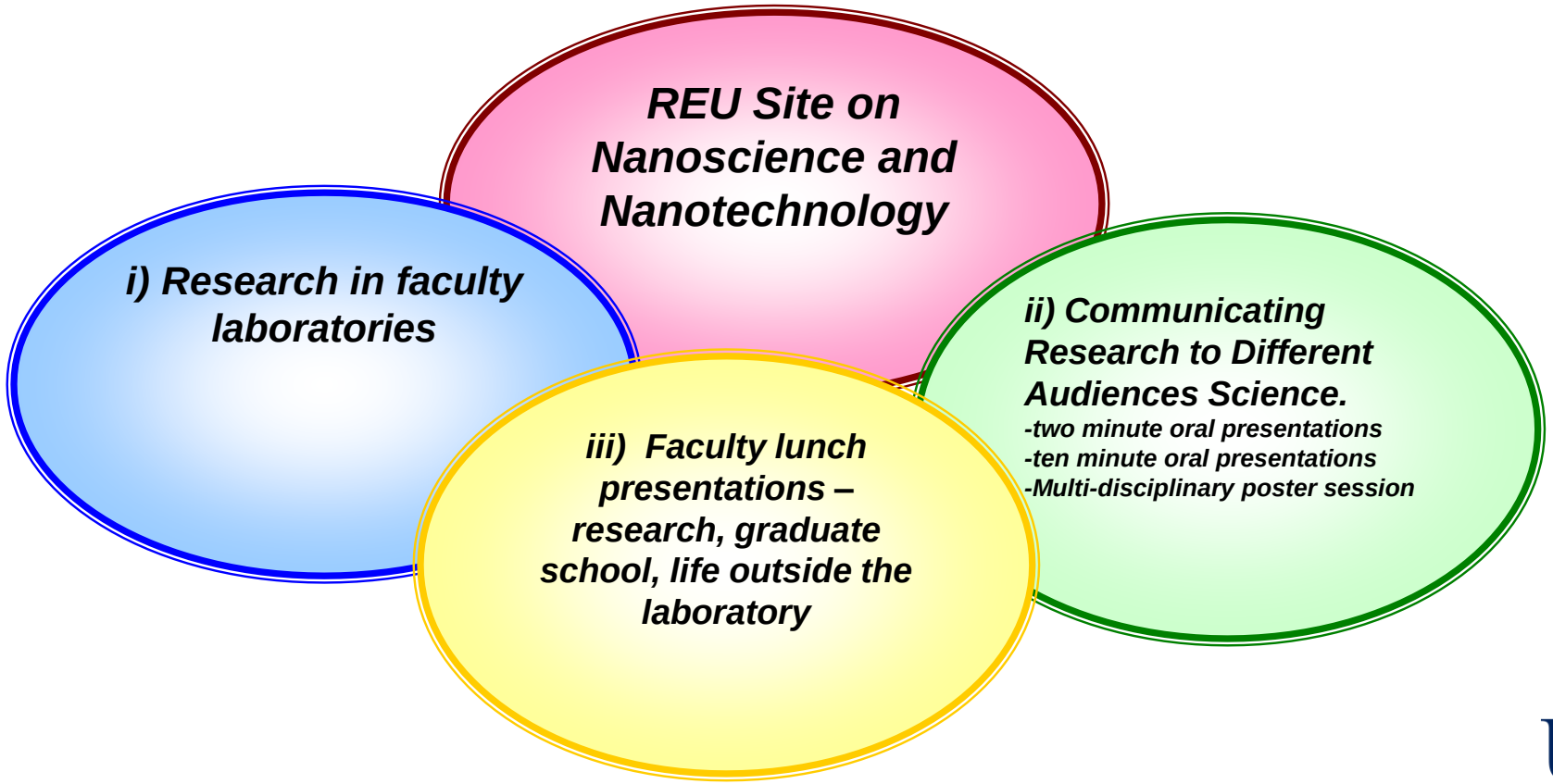
NSF REU (2008-present): Multi-Department REU Program



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NanoEducation: Undergraduate Education Through Research

NSF REU Program in Nanoscience and Nanotechnology at The University of Iowa

- Funded by three consecutive NSF grants
- ~100 total REU students
  - >50% women
  - >30% URM students

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NanoEducation: Undergraduate Education Through Research

NSF REU Program in Nanoscience and Nanotechnology at The University of Iowa

Nina Diklich
James Dillon
Caitlyn McGuire
Jose Rivera Negron
Rebecca Lindquest
Claire Doskey
Robert Lentz
Jennifer Knapp

Some publications with REU Students:

Givens, B. E.; Diklich, N. D.; Fiegel, J.; Grassian, V. H. “Adsorption of Bovine Serum Albumin on Silicon Dioxide Nanoparticles: Impact of pH on Nanoparticle-Protein Interactions” Biointerphases 2017, 12, 02D404, doi:10.1116/1.4982598.

Nanayakkara, C. E.; Dillon, J.; Grassian, V. H. “Surface Adsorption and Photochemistry of Formic Acid on TiO_2 Nanoparticles: The Role of Adsorbed Water in the Adsorption Kinetics, Surface Coordination Mode and Rate of Photoproduct Formation” Journal of Physical Chemistry C 2014, 118, 25487–25495.

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Department of NanoEngineering at UC San Diego: A Decade of Growth

NanoEngineering Undergraduate Program

The Department of NanoEngineering offers undergraduate programs leading to the B.S. degrees in Nanoengineering and Chemical Engineering.

The NanoEngineering major focuses on nanoscale science, engineering, and technology that have the potential to make valuable advances in different areas that include, to name a few, new materials, biology and medicine, energy conversion, sensors, and environmental remediation. The NanoEngineering undergraduate program is tailored to provide breadth and flexibility by taking advantage of the strength of basic sciences and other engineering disciplines at UC San Diego. The intention is to graduate nanoengineers who are multidisciplinary and can work in a broad spectrum of industries.

NanoEducation: Undergraduate Education – Course Work

NanoEngineering Undergraduate Program – One Introductory and Three Foundational Courses

NANO 101. Introduction to Nanoengineering (4) Introduction to nanoengineering; nanoscale fabrication: nanolithography and self–assembly; characterization tools; nanomaterials and nanostructures: nanotubes, nanowires, nanoparticles, and nanocomposites; nanoscale and molecular electronics; nanotechnology in magnetic systems; nanotechnology in integrative systems; nanoscale optoelectronics; nanobiotechnology: biomimetic systems, nanomotors, nanofluidics, and nanomedicine. **Prerequisites:** CHEM 6B, PHYS 2B, MATH 20C, and NANO 15 or CENG 15 or MAE 8. Priority enrollment given to nanoengineering majors. (NANO 101 is a core course for NE majors and cannot be replaced with NANO 201/ CENG 211).

NANO 102. Foundations in Nanoengineering: Chemical Principles (4) Chemical principles involved in synthesis, assembly, and performance of nanostructured materials and devices. Chemical interactions, classical and statistical thermodynamics of small systems, diffusion, carbon–based nanomaterials, supramolecular chemistry, liquid crystals, colloid and polymer chemistry, lipid vesicles, surface modification, surface functionalization, catalysis. **Prerequisites:** Chem. 6C, Math. 20D, PHYS 2D, NANO 101, NANO 106. Priority enrollment given to nanoengineering majors.

NANO 103. Foundations in Nanoengineering: Biochemical Principles (4) Principles of biochemistry tailored to nanotechnologies. The structure and function of biomolecules and their specific roles in molecular interactions and signal pathways. Detection methods at the micro and nano scales. **Prerequisites:** BILD 1, Chem. 6C, NANO 101, and NANO 102. Priority enrollment given to nanoengineering majors.

NANO 104. Foundations in Nanoengineering: Physical Principles (4) Introduction to quantum mechanics and nanoelectronics. Wave mechanics, the Schröedinger equation, free and confined electrons, band theory of solids. Nanosolids in 0D, 1D, and 2D. Application to nanoelectronic devices. **Prerequisites:** Math 20D and NANO 101. Priority enrollment given to nanoengineering majors.

http://nanoengineering.ucsd.edu/undergrad-programs/degree/bs-nanoengineering/courses

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Department of NanoEngineering at UC San Diego: A Decade of Growth

Big News–

NanoEngineering Program Receives ABET Accreditation

The NanoEngineering program at UC San Diego has received accreditation by the Accreditation Commission of ABET, the global accreditor of college and university programs in applied and natural science, computing, engineering and engineering technology. UC San Diego's NanoEngineering program is the first of its kind in the nation to receive this accreditation.

NanoEducation: Graduate Education

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NanoEducation: Graduate Education Through Degree Programs

Department of NanoEngineering at UC San Diego: A Decade of Growth

NanoEngineering Graduate Program
M.S., Ph.D. NanoEngineering

The graduate curricula leading to the M.S. and Ph.D. degrees in nanoengineering have been approved since Fall 2010 offering concentrations in
Biomedical Nanotechnology,
Molecular and Nanomaterials, and
Nanotechnologies for Energy and the Environment.

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NanoEducation: Graduate Education – Course Work

Introductory Courses:

NANO 201: Foundations of Nanoengineering I: Introduction to NanoEngineering (4). (Cross- listed with CENG 211) Understanding nanotechnology, broad implications,miniaturization: scaling laws; nanoscale physics; types and properties of nanomaterials; nanomechanical oscillators, nano(bio)electronics, nanoscale heat transfer; fluids at nanoscale; machinery cell; applications of nanotechnology and nanobiotechnology. *Prerequisites: Consent of Instructor*. (If you are a NE undergraduate student, you must take NANO 101 since this is a core course in your curriculum. NANO 101 cannot be replaced with NANO 201/ CENG 211).

NANO 202: Intermolecular and Surface Forces (4). Development of quantitative understanding of the different intermolecular forces between atoms and molecules and how these forces give rise to interesting phenomena at the nanoscale, such as flocculation, wetting, self-assembly in biological (natural) and synthetic systems. *Prerequisites: Consent of Instructor*.

NANO 203: Nanoscale Characterization (4). Examination of nanoscale characterization approaches including imaging, scattering, and spectroscopic techniques and their physical operating mechanisms. Microscopy (optical and electron: SEM, TEM); scattering & diffraction; spectroscopies (EDX, SIMS, Mass spec, Raman, XPS, XAS); scanning probe microscopes (SPM, AFM); particle size analysis.

NANO 204: Foundations of Nanoengineering II: Nanoscale Physics & Modeling (4). (Cross- listed with CENG 214) Expanded mathematical analysis of topics introduced in NANO-202. Introduction of both analytical and numerical methods through application to problems in nanoengineering. Nanoscale systems of interest include colloidal systems, block-copolymer based self-assembled materials, molecular motors made out of DNA, RNA, or proteins etc. Nanoscale phenomena including self-assembly at the nanoscale, phase separation within confined spaces, diffusion through nanopores and nanoslits etc. Modeling techniques include quantum mechanics, diffusion and kinetics theories, molecular dynamics etc. Prerequisites: NANO 202 or Consent of the Instructor.

Specialty Courses:

NANO 261: Nanoscale Energy Technology

NANO 262: Nanosensors

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NanoEducation: Graduate Education – Course Work

NANO 267:
Environmental Nanotechnology, Sustainable Nanotechnology and Nanotoxicology

(Short Title:Environmental Nanotechnology)

One-Quarter (10 weeks) Course
Developed in Spring 2017.

Co-Instructors: Vicki Grassian and Natalia Gonzalez-Pech

Dr. Natalia I. Gonzalez-Pech
Postdoctoral Scholar

Faculty for the Future Fellow
2011-2015

Ph.D. – Rice University (Colvin Group)

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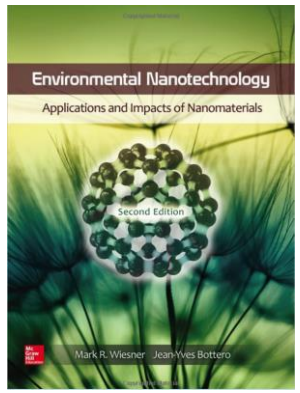
NanoEducation: Graduate Education

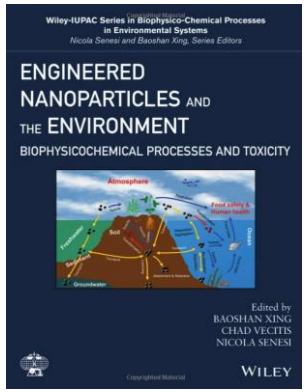
Course Content – Five Units

UNIT	TOPIC
I	Overview and basic concepts
II	Fate and transport of nanomaterials
III	Environmental applications of nanomaterials
IV	Nanotoxicology
V	Risk and policy

Course Materials



Environmental Nanotechnology, Applications and Impacts of Nanomaterials
Second Edition M. Wiesner and JY. Bottero



Engineered Nanoparticles and the Environment: Biophysicochemical Processes and Toxicity
First Edition B. Xing, C. D. Vecitis and N. Senesi

- Powerpoint slides posted before class
- Class podcasted
- 28 current articles and reviews
  PDFs available on course website
- Two Edited Books Used

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NanoEducation: Graduate Education

Course Goals

- To understand the basic concepts to design nanomaterials for applications in the environment

- To understand the fate and transport of nanomaterials in the environment

- To understand how to evaluate the negative effects of nanomaterials in organisms and the environment

- To generate an understanding of the challenges related to policies and regulations governing nanomaterials

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NanoEducation: Graduate Education

Course Goals

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NanoEducation: Future

Textbook - Introduction to the Environmental Implications of Nanomaterials

- Navid Saleh and Vicki Grassian
- Wiley and Sons

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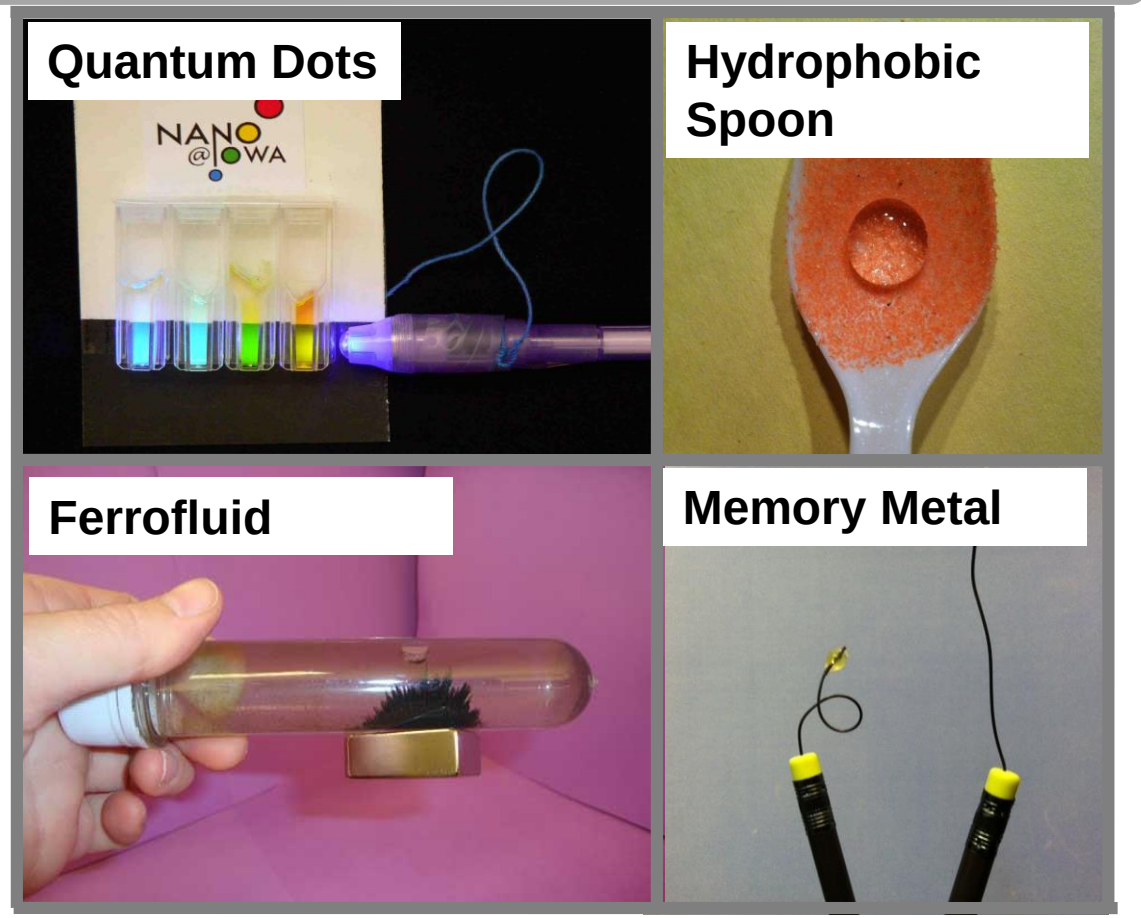
NanoEducation: Continuing Education for Lifelong Learners

Same Content



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Example Outreach Events

- University of Iowa Lifetime Enrichment Adult Program (UI LEAP)
- Oaknoll Senior Living Center
- Triangle Club Monthly Event

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Conclusion

1 K-12 Education and Continuing Education

- **Nano-to-go Kit (University of Iowa) at**
  - Outreach events
  - Schools
  - Senior Living Centers

2 Undergraduate Education

- **Research Experience (University of Iowa)**
- **First-Year Seminars, Honors Seminars (University of Iowa)**
- **Formal Coursework and Degree Programs (UC San Diego)**

3 Graduate Education

- **Research Experience and Access To Advanced Instrumentation (University of Iowa and UC San Diego)**
- **Formal Coursework and Degree Programs (UC San Diego)**
- **Seminars (University of Iowa and UC San Diego)**

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Acknowledgements

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Joe Wang, UC San Diego, Chair of Nanoengineering and Nanoengineering Department at UC San Diego

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