

# SNO letter

NEWSLETTER OF THE SUSTAINABLE NANOTECHNOLOGY ORGANIZATION



**Sustainable  
Nanotechnology  
Organization**

Research | Education | Responsibility

## INSIDE THIS ISSUE:

Introduction	1
SNO Q&A Session	2-5
3 <sup>rd</sup> SNO Summary	6-11
Announcements	12-13

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### SNO Newsletter Submissions

Please send news, conference announcements, job postings, letters to the editor, and other contributions to the newsletter to Drs. Sadik or Karn  
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The next newsletter will be released in August 2015.

Edited by:  
**Kyle Doudrick**  
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Message from SNO's Executive Director:

Wunmi is taking a break this issue, so I'm filling in. We are thrilled with the progress of SNO and the amazing accomplishments of this all-volunteer nascent organization with about 300 members. In November, we finished our 3<sup>rd</sup> successful conference, and we are looking forward to the March Venice conference with our European partners. In November 2015 we will hold our 4<sup>th</sup> conference in Portland, Oregon. We will again participate in the Sustainability Expo in Washington, DC as part of our outreach to potential graduate students in the K-12 range. We are in the midst of producing our 4<sup>th</sup> special issue of a journal and have published 8 newsletters. We will have a presence at two Gordon Research Conferences this summer and the NSTI nanotech meeting. We are facilitating some potential research projects and workshops. We have presented many awards to SNO leaders, poster presenters, student members, and added a new investigator award this year. I am always pleasantly surprised by how many individuals and organizations find us and contact us.



For the future, however, we need to be concerned about our own sustainability as an organization. We need to build a strong, sustainable program base with strong, sustainable leadership. We need to ensure our financial viability. All of this future takes vision and hard work. SNO is very unique in its mission of focusing on a very new technology and its relationship to sustainability. No other organization has this combination of science and values. Our members think beyond the science and engineering research to how their results will move us all to a sustainable future. We must continue to keep a strong and growing organization to promote this research. SNO is your organization. Let us all work toward its sustainable future through research, education, and responsibility.

Barbara Karn

In this *Issue* we have an exciting Q&A featuring a historical look at nanotechnology development through the experiences of **Dr. Clayton Teague**. Additionally, you can find a summary of the 3<sup>rd</sup> SNO conference and announcements pertaining to sustainable nanotechnology.

## SNO Q &amp; A SESSION



**DR. CLAYTON TEAGUE (SNO Award Winner)**  
***Pixelligent Technologies Advisory Board***  
***Formally NIST and NNCO***

**(Doudrick)** You have more than twenty years experience in nanotechnology, with appointments at both NIST, working on nanometrology, and as Director of the National Nanotechnology Coordination Office. Currently, do you see the progress of nanotechnology being where you envisioned it when you first became involved?

**(Teague)** When I first became engaged with what we now call nanotechnology – because of my background as I’ll explain later – I saw nanotechnology as being composed of two main areas: (1) materials that had unique properties because of quantum confinement resulting from their nanoscale dimensions and fields that would develop primarily from these material properties and (2) the production of new materials, devices, and systems enabled by the profound capability to manipulate matter at the atomic- and nano-scale via the scanning tunneling microscope. The progress since that time is amazing to me – a whole world of new nanoscale materials has been discovered and the capabilities for measurement, control, and *design* of matter has grown astoundingly. I was surprised by how nanotechnology has expanded into so many different disciplines – physics, chemistry, materials, medicine, biology, catalysis, etc., and how it has initiated growth in collaboration across these many disciplines. By collaboration I mean embarking upon efforts from two or more disciplines with strong input toward accomplishing goals of mutual benefit to society and to all of science and technology. In this collaboration the disciplines that surprised me the most were the very important ones related to health and the environment; human and eco-toxicology; occupational safety; risk analysis and management; pharmacology; biotechnology; medicine; and epidemiology – fields of research and application in which I had never before been involved.

Some background for these surprises: I first became engaged with the size quantization effects of nanotechnology in 1968 when I began work to complete my Ph.D. at the University of North Texas. While working at Texas Instruments in about 1965 I was assigned research in the then new area of integrated circuits –growing germanium islands epitaxially on semi-insulating gallium arsenide. At Texas Instruments I noted that the dimensions of base regions of some of the junction transistors were approaching levels that could possibly produce quantization of the electron conduction and valence bands of the materials being used. When I began the experimental part of my dissertation work, I proposed to my advisor that I do an experiment to observe these quantized states in materials. Metal-insulator-metal tunneling experiments were an active field at this time so I proposed and began an attempt to observe the quantized energy states in bismuth and use it as one of the electrodes in a metal-insulator-bismuth thin film experiment. (Electrons in bismuth have an effective mass of about 0.01 times the mass of an electron, thus producing very large spacings of the quantized electron states, more easily observed experimentally in thin films.) In an attempt to make this long story a shorter one, after years of efforts to unsuccessfully perform this experiment I ended up at the National Bureau of Standards (now the Na-

## SNO Q &amp; A SESSION

tional Institute of Standards and Technology) still wanting to see the quantized energy states, but now using a vacuum barrier. This led to my final experimental work on gold-vacuum-gold tunneling experiments and the successful completion of my dissertation in 1978. Four of the intervening years were occupied with surface and micrometer-scale metrology work at NBS/NIST. While I did not succeed in observing the quantized energy states in thin films – Jakelvic and Lamb in 1975 did! I then became enchanted with all the possibilities of metal-vacuum-metal (MVM) tunneling and what these quantized states offered for new materials and new devices, principally for electronic and photoelectronic devices – e.g., dimensionally tunable laser frequencies, dimensionally tunable colors of nanoscale crystal materials – and the extraordinary sensitivity of a vacuum tunneling device as a displacement sensor. Because of my work with MVM tunneling, I became heavily engaged with the new field of scanning tunneling microscopy (STM), which started about three years after I completed my dissertation. This new instrument enabled operators to truly “see” at the atomic and nanoscale level. The STM’s capability initially enabled its application to greatly improving our understanding of metal and semiconductor surfaces and to the dimensional measurement of nanoscale objects and features on surfaces.

While I did see and wanted to explore all the possibilities that the new quantized states in materials offered for producing and controlling the properties of nanoscale materials, I had no idea of the wide diversity of nanoscale materials that have now been discovered and are now being explored. The world of nanotechnology grew tremendously over the decade from 1981 to 1991:

- 1981 – Binnig and Rohrer invention of the STM
- 1985 – the discovery of buckyballs and quantum dots
- 1986 – the development of the atomic force microscope
- 1989 – manipulation of atoms with the STM by Eigler and Schweizer
- 1991 – Iijima discovery of the carbon nanotube.

When Eigler and coworkers used the STM to manipulate atoms in 1989 the door to nanotechnology – controlling matter at the nanoscale - was opened wide.

As the field developed over the years, I was completely surprised by the growing concern that many health and environmental researchers were raising about all these new nanomaterials. From my very early days as a ham radio enthusiast at 14-15 years of age I had learned to be very cautious of high voltages. I still have a vivid memory of being badly shocked by the 600 volt supply for my home-brew transmitter. At Texas Instruments, I was carefully taught about the dangers of working with chemicals such as hydrofluoric acid and the possibilities of explosions because hydrogen was used as a major component of the carrier gas for most of the chemical vapor deposition reactors. My supervisor somewhat proudly told me that my laboratory had been constructed so that if there was an explosion the walls were designed to fall outward so we would have a good chance to escape! We also were taught how to appropriately dispose of chemicals so that the pH of the water effluent from the site would not exceed environmental limits. While these chemical, electrical, explosive, and other hazards and safety concerns were always a top priority for me, my fellow workers, and those I supervised, I am embarrassed to admit that I had never been concerned or thought much about the safety of products of my research and how they might pose potential hazards for the health of others or

## SNO Q &amp; A SESSION

even have potentially negative impacts for the environment. My work had always centered on what I considered benign – making semiconductor chips at Texas Instruments and making instruments at NBS/NIST to perform accurate measurements of use to industry.

As I became involved with the U.S. Government's National Nanotechnology Initiative in about 2000 I definitely became more aware of these concerns about nanomaterials, thanks to my interactions with colleagues from the EPA, NIOSH, FDA, USDA and other agencies. Shortly after the White House Office of Science and Technology Policy (OSTP) invited me to become the NNCO Director, I organized a workshop to focus on health and environmental issues with respect to nanomaterials and the efforts within the agencies to address these concerns to which all the agencies participating in the NSET Subcommittee were invited. This workshop then led to the formation of NSET's Nanotechnology Environmental and Health Implications (NEHI) Working Group. Under NSET, NEHI is charged with supporting Federal activities to protect public health and the environment with respect to the use of nanotechnology. The purposes and goals of the NEHI Working Group are spelled out in detail on the NNI website: [www.nano.gov](http://www.nano.gov) (see in particular <http://nano.gov/nehil>). Through our mutual involvement in NEHI, I met Dr. Barbara Karn and many others in the fields of research related to protecting the environment and public health. Even more I grew to greatly admire their deep dedication to all aspects of this goal.

**(Doudrick) Why did SNO draw your interest?**

**(Teague)** First, I was invited to participate in SNO by Barbara Karn, someone I admire and highly respect! As explained in my response to your first question, I was drawn to nanotechnology R&D because of all the powerful applications of the field. Yet, as I have learned more about the potential and real hazards associated with these applications, I am continually torn between how to develop the applications and at the same time how to address the concerns for protecting the environment and public health. SNO is dedicated to addressing both the applications and implications of what I consider to be one of the most promising technologies to be developed in my lifetime. I hope that through SNO I can make some contribution to realizing the benefits of nanotechnology for human health, the environment, and society as a whole. At the same time, I hope to contribute to a fuller understanding of the risks of nanotechnology and how those risks may be addressed. An area that I see as very promising is the developing effort to design nanomaterials that can achieve the benefits of nanotechnology applications and simultaneously that don't introduce materials with toxicity to the environment or public health. In fact, one of the things that we have learned over the last decade of the NNI is that there are great opportunities for nanotechnology to reduce the impact of our modern technological society on the environment and on human health by reducing waste and by enabling the development of new products and industrial processes that are "safe by design" from their inception.

**(Doudrick) What do you see as the biggest challenge for moving nanotechnology-enabled products to the market?**

**(Teague)** The biggest challenge is to appropriately address the joint challenge of fully realizing the benefits of nanotechnology-enabled products and, concurrently, dealing proactively with the potential

## SNO Q &amp; A SESSION

risks of these products. This is, in a sense, a microcosm of the broader issues that our society faces in realizing the promise of any number of other emerging technologies. One of the most promising trends in this field is the development of the concept of “Prevention through Design” – as championed by the National Institute of Occupational Safety and Health (an important NNI and NEHI participant) and other NNI agencies.

The tremendous benefits of nanotechnology will not be realized in new devices and systems unless we can overcome and address the concerns so often raised about the potential risks of nanomaterials. Some promising directions of providing information for this challenge are the developing efforts in predictive toxicology, informatics applied to all the data and information about nanomaterials, and *in-silico* tools – moving away from traditional animal studies. These new approaches rely on modeling and simulation and the growing amount of information about chemical structures and their impacts on biological processes. Without question there is much to be done here. The collection of the toxicological data to guide the effort will be ongoing for some time. These issues are not easy ones to resolve: the elimination of animal models entirely will probably take sustained and prolonged research effort before we can be certain that they are no longer needed. The issues with respect to nanotechnology are just examples of the broader issues facing our society – reducing the need for using animal models for assessing toxicological impacts of new technologies, or for understanding the safety and efficacy of novel medical therapies, are ethical issues that have far broader implications and applications than in just the nanotechnology sphere.

**(Doudrick) Do you have any words of wisdom for the new generation of nanotechnology scientists?**

**(Teague)** I’m unsure of how wise my comments may be, but I will share some lessons learned from my experience as I pursued my research. First, I’d urge young scientists to choose a field of work in which they have a keen intellectual interest and/or deep curiosity. Then let this interest or curiosity drive you to obtain as much data - experimental, non-experimental, qualitative, quantitative, or theoretical – about your subject as you can. Keep pursuing, testing, analyzing, and trusting your evaluated data until it has resolved some of the questions that aroused your curiosity or interest. My drive has most often been in the area of building new instrumentation to obtain data in previously unexplored topics. The two early questions that drove me were: can one experimentally see quantized states? and can one measure the exponential change in quantum tunneling current as a function of the spacing between two electrodes separated by a vacuum? Finally, write, write, write up your findings in the open literature – something, I did not do very well beyond my dissertation! There are many new challenges and exciting topics that have opened up during the last ten or so years related to the applications and implications of nanotechnology and how this wonderful technology can make our world sustainable. Such a broad field of possibilities can make a sharp focus difficult. Again, I would return to my first recommendation – follow your keen interest and curiosity.

## 2014 SNO CONFERENCE SUMMARY

### AWARDS



**Clayton Teague (Pixelligent Technologies) is awarded the 2<sup>nd</sup> annual SNO Award for his work with the National Nanotechnology Initiative and sustainable nanotechnology.**

**Deborah Rodrigues (University of Houston) is awarded the 1<sup>st</sup> annual SNO Young Investigator Award by Vicki Grassian and Harpal Minhas of the Royal Society .**



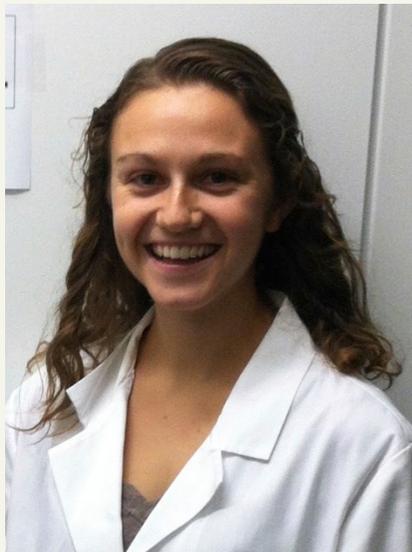
**Vicki Grassian (University of Iowa) is awarded the RSC 2014 John Jeyes Award by Harp Minhas.**



**2014 SNO CONFERENCE SUMMARY****STUDENT POSTER AWARDS****1<sup>st</sup> Place****Sanghamitra Majumdar****UTEP****Trophic transfer of metal oxide nanoparticles along a terrestrial food chain: an ecological risk****2<sup>nd</sup> Place****Victor Kariuki****SUNY Binghamton University****Synthesis of  $\pi$ -conjugated poly (amic) acid stabilized gold and silver nanoparticles****3<sup>rd</sup> Place****Matthew Chan****Virginia Tech****Three-Dimensional Nanomaterial Mapping in Complex Media Via Confocal Raman Spectroscopy**

## 2014 SNO CONFERENCE SUMMARY

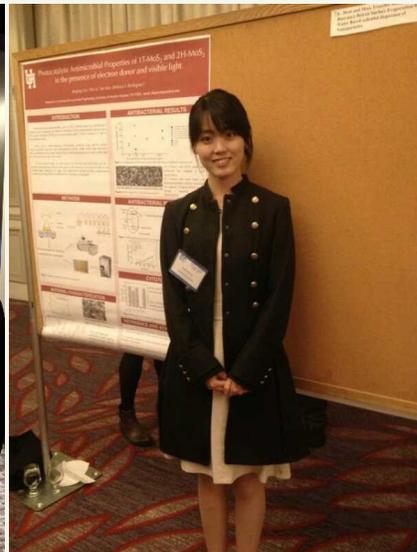
### Nano Pitch: Condensing years of research into a 100-second Pitch



**Katherine Peter**



**Andrew Lake**



**Jingjing Fan**

The first Nano Pitch Contest was successfully completed at the 2014 SNO conference. Sixteen graduate students participated in this post dinner activity, and cash awards were given away to the top three pitchers. Participants were challenged to present their research within 100 seconds using only one slide. While a typical research pitch (i.e., elevator talk) is 2-3 minutes, we decided to keep this one at 100 seconds, sticking to the traditional size definition of a nanoparticle (<100 nm). A panel of distinguished researchers (Drs. Stephen Ebbs, Barbara Karn, Mihail Roco, and Clayton Teague) served as the judges, and Drs. Achintya Bezbaruah and Jason White coordinated the event.

**1<sup>st</sup> Katherine Peter** (University of Iowa, Dr. David Cwiertny). Kathy impressed the audience with her presentation on how she is using electrospun carbon nanofibers for point-of-use drinking water treatment with specific reference to pollution from animal agriculture.

**2<sup>nd</sup> Andrew Lake** (State University of New York at Binghamton, Dr. Omowunmi Sadik). Andrew showed that electrical impedance spectroscopy provides information on nanoparticle size; charge & agglomeration and could complement conventional techniques such as TEM or SEM. Andrew will graduate in May 2015.

**3<sup>rd</sup> Jingjing Fan** (The University of Houston, Dr. Debora Rodrigues). Jingjing gave a pitch on her work on the antimicrobial activity of nanostructured molybdenum disulphide.

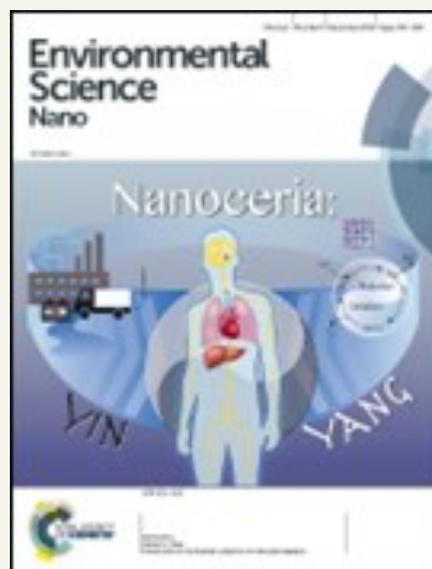
## SNO CONFERENCE ANNOUNCEMENTS

### Portland Pitch!

It is time to get ready for the Nano Pitch Contest 2015 in the SNO Conference at Portland (OR). Students will be able register for the contest on-site in Portland. Each participant will be given 100 seconds (don't forget nano!) to present her/his work using one slide (without animation). Three cash prizes will be awarded. Contestants will be judged by a panel of experts. Given the enthusiasm of the participants in Boston and popularity of the contest, more participants are expected in the Portland Conference.

### SNO's special issue on Nanoceria

The SNO workshop on Nanoceria resulted in a themed collection of research papers published in *Environmental Science: Nano*, SNO's official journal. Robert Yokel from the University of Kentucky led the workshop which resulted in the most comprehensive and current source of information on the chemistry, biology, and beneficial and untoward effects of nanoceria. The issue may be found at <http://rsc.li/18lnkvg>.



### SNO guest-edits a special issue

Papers from the 2014 SNO Conference in Boston will be featured in a special issue of *Environmental Science: Nano*, SNO's official journal, in partnership with the Royal Society of Chemistry. Conference co-chairs, Jackie Isaacs and Phil Demokritou, plus SNO leaders Wunmi Sadik and Barbara Karn will be guest editors. Invitations to submit were sent to the best papers presented at the conference. Over 40 articles are expected for this issue. In addition, plenary speakers will give their insights on what they think about sustainable nanotechnology. Currently, issues of *ES: Nano* are available online by registering at <http://pubs.rsc.org/en/journals/journalissues/en#!recentarticles&all>.

SNO 2014 CONFERENCE PHOTOS

Dr. Barbara Karn



Dr. Omowunmi Sadik



Dr. Jacqueline Isaacs



Lynn L. Bergeson



Drs. Whitesides, Roco, Teague and Bergeson



Dr. George Whitesides



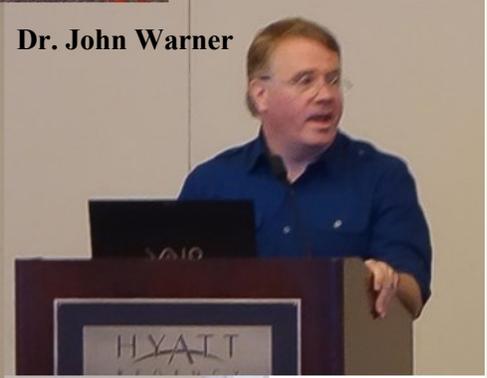
Dr. Mihail Roco



Dr. Mark Wiesner



Dr. John Warner



Dr. Clayton Teague



Larry Bell



## SNO 2014 CONFERENCE PHOTOS



For more images please visit our [Facebook page](#): Sustainable Nanotechnology Organization.

## U p c o m i n g C o n f e r e n c e s

### SNO goes international

On March 9-11, Venice (Italy, not California) will be the scene for almost 200 researchers in sustainable nanotechnology when SNO with partners [SUN](#) (Sustainable Nanotechnology) and [GuideNano](#) present a joint EU-US conference on sustainable nanotechnology. Featured plenary speakers are **Mike Roco**, **Tom van Teunenbroek**, **Lynn L. Bergeson**, **Wendel Wohlleben**, **Mark Wiesner**, and **John Warner**. Over 20 SNO members are coming from the US—the largest country group. Other sizeable delegations come from Italy, France, Denmark, Germany, Greece, Spain, Switzerland, and the UK.



With researchers from Taiwan and Korea joining other countries from Europe and Asia, the conference will be a truly international event that could lead to more global partnerships for SNO.



### SNO gets ready for 4<sup>th</sup> conference

SNO will be traveling from the northeast to the northwest this year. The 4<sup>th</sup> SNO Conference will be held in **Portland, Oregon**, November 8-10, at the historic Benson Hotel. Co-chairs **Greg Lowry** and **Jim Hutchison** are hard at work developing an exciting program. Mark your calendar and watch the [web](#) for a chance to participate in a great conference in a great part of the country.

## ANNOUNCEMENTS

**Two Gordon Conferences of interest to SNO members**

This June will hold two Gordon Research Conferences of interest to SNO members and their colleagues. The first is **Nanoscale Science & Engineering for Agriculture & Food Systems**, June 7-12 at Bentley University in Waltham, Mass. SNO supporters and early members Norman Scott and Hongda Chen chair with Cristina Sabliov and David Brit as vice-chairs. Applications are due May 10. See <http://www.grc.org/programs.aspx?id=16884> for details.

The second GRC of interest is **Environmental Nanotechnology**-Steps for Environmentally Safe Implementation of Nanotechnology. It will be held **June 21-26** at Mount Snow Resort in West Dover, Vermont. SNO members Paul Westerhoff chairs with Sharon Walker as vice-chair. SNO president, Wunmi Sadik, chaired the first Environmental Nanotechnology GRC in 2011 where SNO was officially conceived. For details see <http://www.grc.org/programs.aspx?id=14914>. Applications are **due May 24**.

**SUN-SNO-GUIDENANO Conference**  
**March 9-11, 2015 in Venice, Italy**

More info at <http://www.susnano.org/conferenceOverview2015SNO-SUN-GN.html>

**Annual SNO Meeting**  
**Portland, OR**  
**November 8-10, 2015****WANTED: Good ideas for SNO**

SNO is your organization. If you have an idea you want to implement through SNO—a workshop, a publication, an outreach activity, a new curriculum, a different session, etc.—please let us know. We are always open to great new ideas.

We also welcome members to **post ads** including news, student/postdoc openings, job opportunities, and other member related announcements. ([info@susnano.org](mailto:info@susnano.org))

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