UNIVERSITY OF CALIFORNIA

UC CEIN Center for Environmental Implications of Nanotechnology

Risk and Occupational Health and Safety of Nanomaterials

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Nanorisk: Advances, Challenges & Opportunities

- How we assess risk depends on the decision that needs to be made & by whom
- There are (still) data gaps, so tools for risk evaluation must include explicitly include methods for addressing & evaluating uncertainty
- Challenges to nanorisk evaluation are not unique; our advances will likely provide a path forward for evaluation of conventional chemicals as well

Challenges to Evaluating the Risks of Nanomaterials

- Decisions about risk need to be made by a wide range of stakeholders in the absence of comprehensive data
- Many of those decisions need to be made in real time (i.e., formal risk assessment would not be the solution even if there were comprehensive data)
- Greater alignment of decision-making tools with needs of specific stakeholders is required

- Adapted from Igor Linkov, NNI R3 workshop

“Humans are quite bad at making complex, unaided decisions”

- Slovic et al, 1977 (quoted from Igor Linkov)

Nano Occupational Health & Safety

Challenge	Advances
Need rigorous methodologies for exposure assessment so that we can ensure that current nanoworkers are not being exposed to undue risk; hard to distinguish	• Development of rigorous and practical methodologies (Tsai and Ellenbecker; NIOSH) for exposure assessment for high volume and carbonaceous NPs • NIOSH field site team's approach to working hand-in-hand with nano industry to decrease potential for exposure
Need practical guidance for how to work safely in the absence of time-consuming risk assessment	• Tsai and Ellenbecker; NIOSH • Nanotoolkit

Big Update from NIOSH this year: lower REL for CNTs lowered to 1 μg/m^3

NIOSH Update: April 24, 2013

NIOSH Recommends New Level of Exposure for Nanomaterials

Contact: Nura Sadeghpour (202) 245-0673

NIOSH today recommended that occupational exposures to carbon nanotubes (CNTs) and carbon nanofibers (CNFs) be controlled to reduce a potential risk of certain work-related lung effects. CNTs and CNFs are man-made elongated particles made of sheets of pure carbon that are about a thousand times smaller than a human hair.

NIOSH's recommendations, which were issued in a technical document called a Current Intelligence Bulletin, are based on peer-reviewed findings from NIOSH laboratory studies, field observations of industrial processes, intensive review of published studies by other research authorities, and public review and comment on an earlier draft of the document. Some companies already use or plan to establish control measures that achieve the recommended exposure limit and match a number of NIOSH's recommendations.

CNTs and CNFs are only two of many types of nanomaterials created through nanotechnology which is described as the manipulation of matter on a microscopic scale. This matter is smaller than what has been studied for the past 100 years by material scientists and is far too small to be seen with the human eye; their size gives them new and different properties that have not been seen by scientists before. CNTs and CNFs are being incorporated into different products to increase strength, durability, versatility, heat resistance, and other useful properties. These products include plastics and ceramics, paints and coatings, textiles, and electronics. Though it cannot be determined with certainty how many workers are currently potentially exposed to these nanomaterials, demand for carbon nanotubes and carbon nanofibers is expected to grow over the next decade with increasing use in medical devices, structural materials, consumer goods, and energy-saving products.

Recent results from experimental animal studies with rodents indicate that exposure to CNTs and CNFs may pose a respiratory hazard if inhaled. NIOSH's recommendations are expected to assist industry in establishing good risk management practices for controlling occupational exposures to free, unbound

Contact Us:

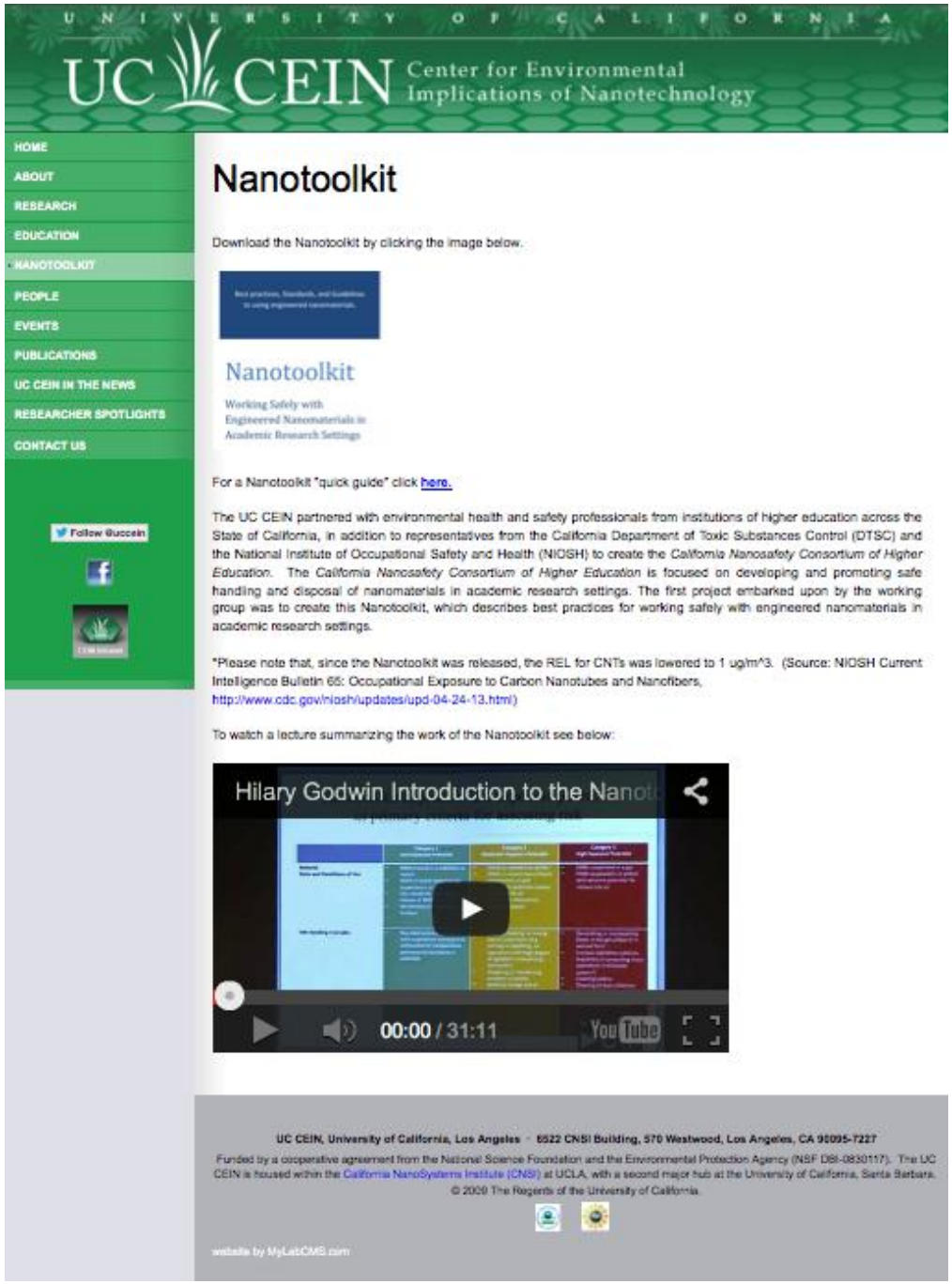
National Institute for Occupational Safety and Health (NIOSH)
Centers for Disease Control and Prevention
800-CDC-INFO (800-232-4636)
TTY: (888) 232-6348
New Hours of Operation
8am-8pm ET/Monday-Friday
Closed Holidays
Contact CDC-INFO

http://www.cdc.gov/niosh/updates/upd-04-24-13.html

NIOSH Guidance on Nano Safety

- Current Intelligence Bulletin 63: Occupational Exposure to Titanium Dioxide
  DHHS (NIOSH) Publication 2011-160
- Approaches to Safe Nanotechnology: Managing the Health and Safety Concerns Associated with Engineered Nanomaterials
  DHHS (NIOSH) Publication 2009-125
- Interim Guidance for Medical Screening and Hazard Surveillance for Workers Potentially Exposed to Engineered Nanoparticles
  DHHS (NIOSH) Publication No. 2009-116
- Safe Nanotechnology in the Workplace
  DHHS (NIOSH) Publication No. 2008-112
- NIOSH Nanotechnology Field Research Effort Fact Sheet
  DHHS (NIOSH) Publication No. 2008-121

http://www.cdc.gov/niosh/topics/nanotech/pubs.html



Resource for Academic Research Laboratories: http://www.cein.ucla.edu/

Includes:

- Quick tool
- Guidance for handling spills and waste
- SOP template

Major Advances Made in the Last Five Years in Rapid Hazard Identification and Hazard Prediction

Materials of interest OECD-WPMN (2008)

- *SWCNTs*
- *MWCNTs*
- *Ag nanoparticles*
- *Fe nanoparticles*
- *Ti dioxide*
- *Al oxide*
- *Ce oxide*
- *Zn oxide*
- *Si dioxide*
- *Nanoclays*
- *Dendrimers*
- *Au nanoparticles*
- *Fullerenes (C60)*

Groupings:

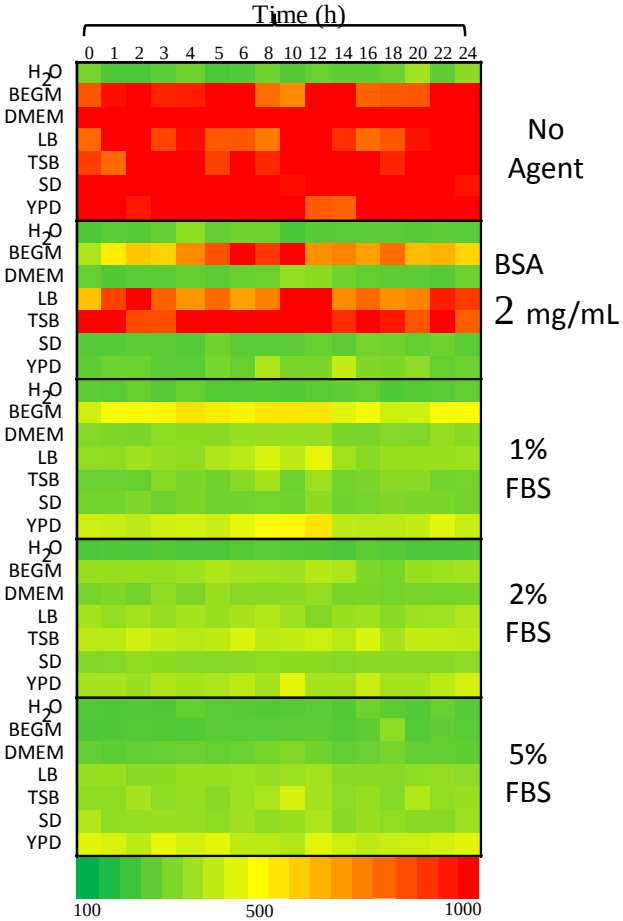
- *Properties/SARS*
- *Toxicological mechanisms*
- *Usage/exposure*

Appropriate Physicochemical Characterization

Properties
- Intrinsic — Material as acquired or synthesized
- Extrinsic — Altered properties in biological medium
- Tox SAR — Properties proximately associated with injury

etc

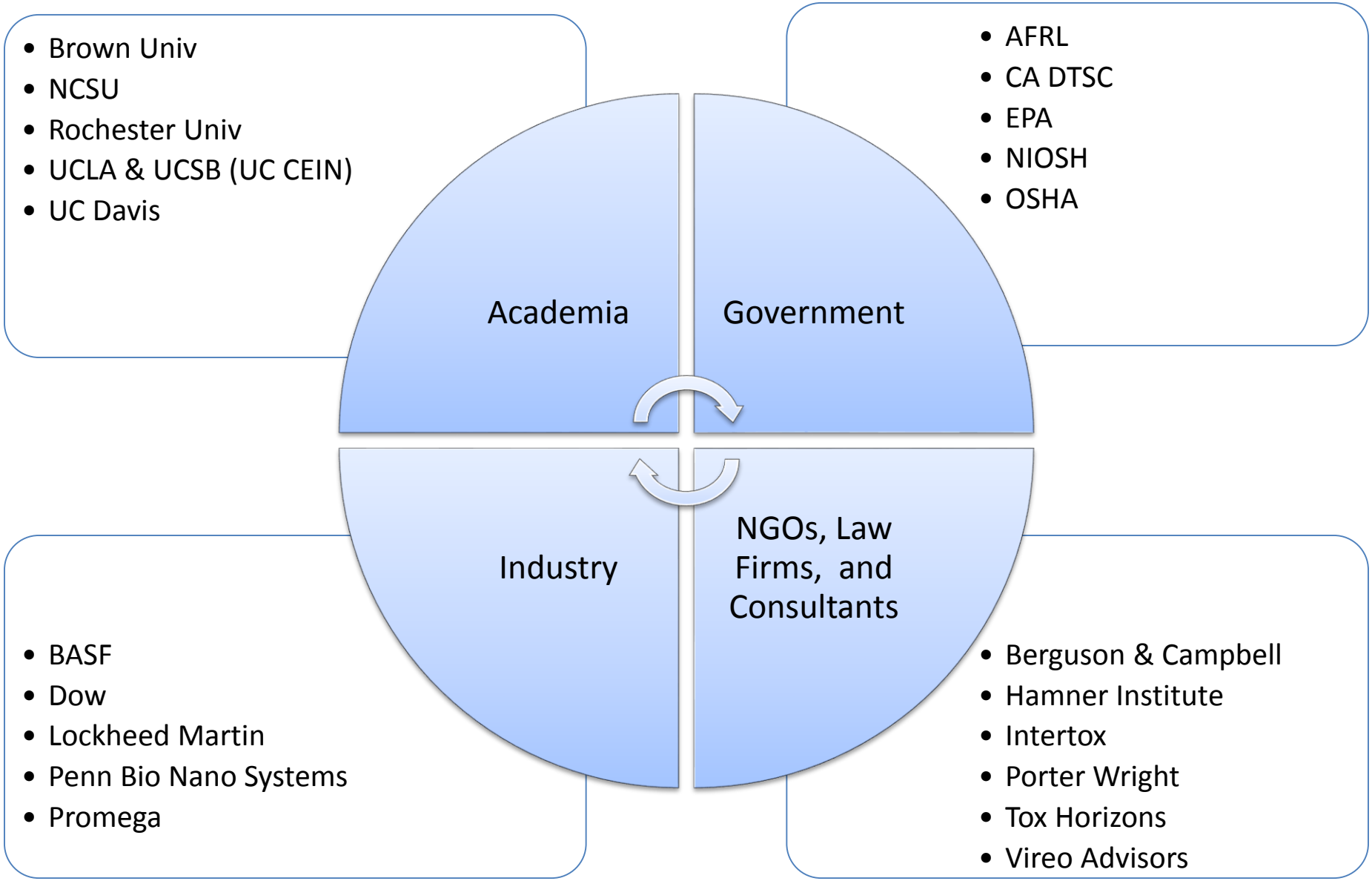
High Throughput DLS



Advances in Risk-Based Decision Making

- Open and effective forums for communication between those who need to make the decisions and those who are developing tools
  - Alternative Testing Strategies Workshop in Los Angeles in January 2013
  - NNI R3 Workshop in Washington, DC in Sept 2013
  - Health Canada Workshop in October 2013
  - SRA Workshop in Washington, DC planned for April 2014
  - OECD Workshop in Washington, DC planned for April 2014
  - Multistakeholder Workshop on Categorization in Washington, DC planned for May 2014

Stakeholders Engaged in January 2013 Alternative Testing Strategy Workshop @ UCLA



Process for Stakeholder Engagement at Alternative Testing Strategy Workshop

Definition of Questions & Goals	Conference calls with representatives from diverse stakeholder groups to define the focus and agenda for the workshop and solicit input on participants in advance
Advance Preparatory Work	Workshop statements solicited from range of stakeholders and distributed to all of the participants in advance
2-Day Roundtable Workshop	Presentations on relevant work and stakeholder perspectives; moderated discussions on specific agenda topics; minutes from workshop distributed to all immediately after workshop for input
Follow-up	Development of group publication (with 30 co-authors from diverse stakeholder groups) summarizing workshop discussions and conclusions; planning calls for follow-on activities

Nel et al, *ACS Nano* **2013**, *7(8)*, 6422-6433.

Provisional Consensus about ATS Use for Nano EHS from January Workshop

- ATS widely accepted to prioritize ENM hazard assessment but not yet ready for quantitative risk assessment or regulation

- Hazard ranking and grouping of ENMs could assist regulatory and occupational decision making

- ATS and predictive toxicological paradigms can be used to establish hazard categories and material grouping as a 1st tier of testing, which is used to prioritize more costly and elaborate animal studies

- Any framework that considers ATS for regulatory purposes needs to be transparent, participatory and engage a broad stakeholder community

Nel et al. *ACS Nano* **2013**, *7(8),* 6422-6433.

Provisional Consensus about ATS Use for Nano EHS from January Workshop, cont.

- A predictive toxicological approach for CNT is potentially helpful for hazard ranking, prioritizing animal experiments, and grouping of materials
- The development of hazard ranking, material grouping and SARs can become an integral part of new product development
- It is important to consider dose-response extrapolation and exposure scenarios that link mechanistic and predictive toxicological assessment to risk assessment

Nel et al. *ACS Nano* **2013**, *7(8),* 6422-6433.

ACSNANO
www.acsnano.org

PERSPECTIVE

A Multi-Stakeholder Perspective on the Use of Alternative Test Strategies for Nanomaterial Safety Assessment

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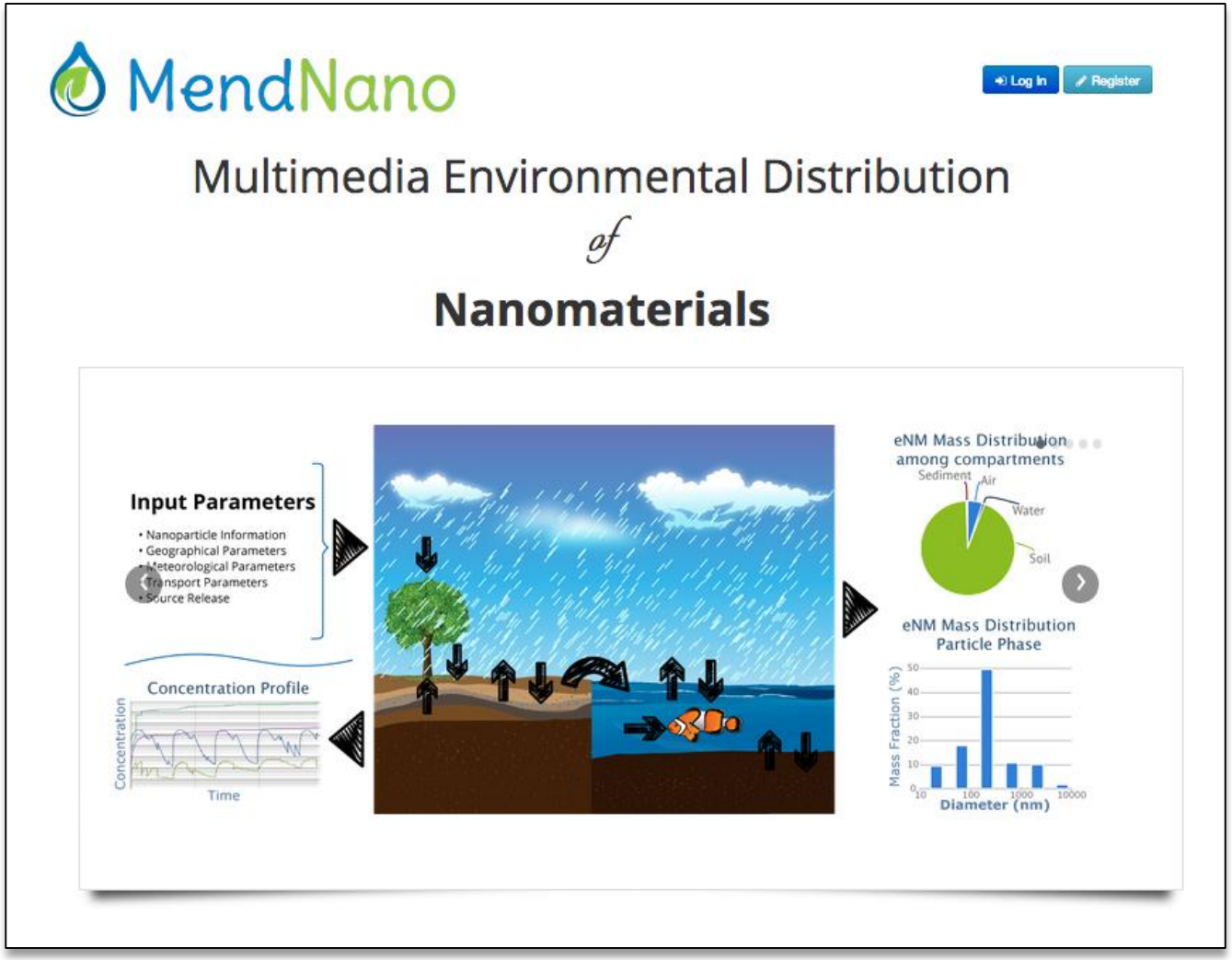
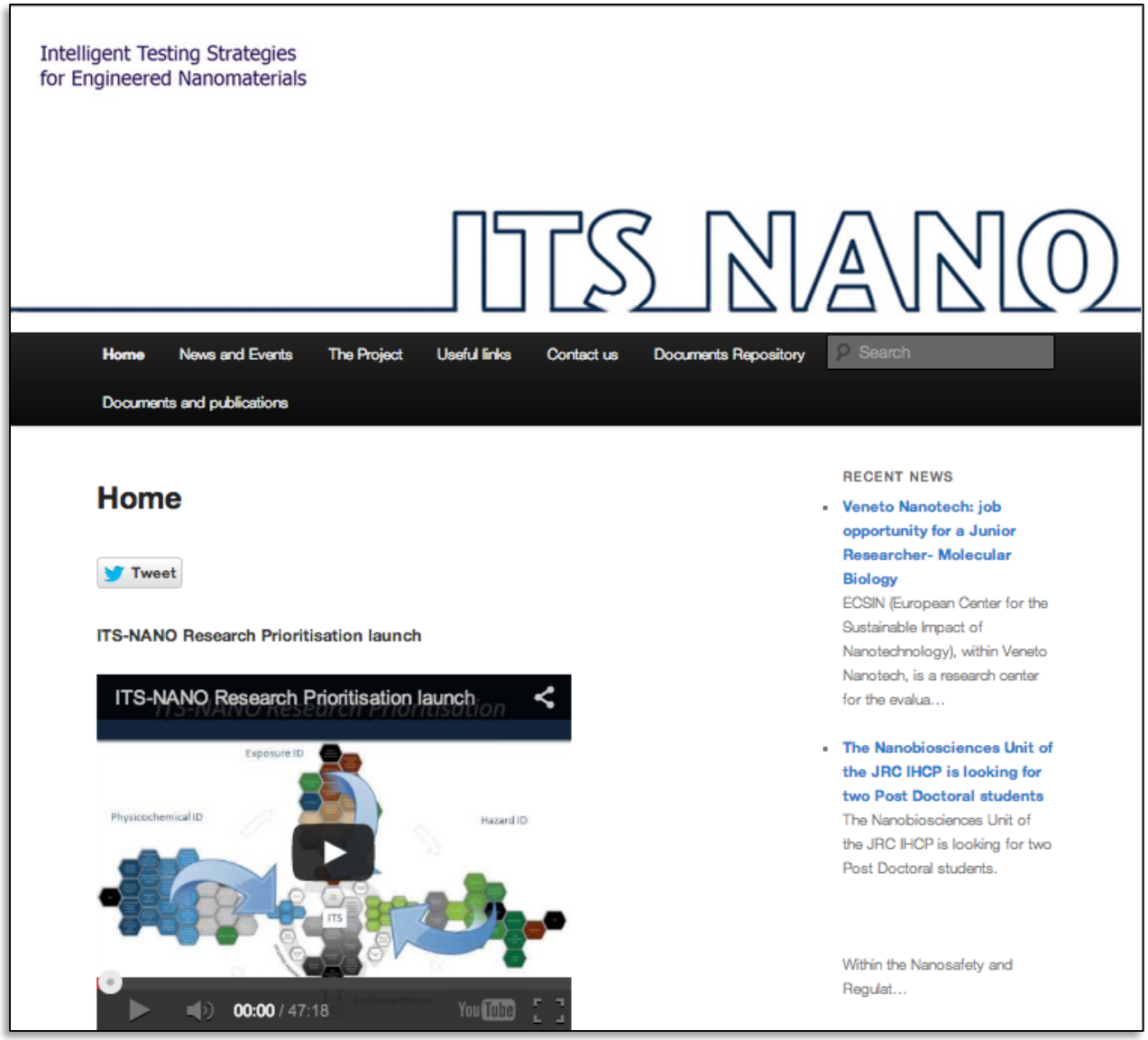
Increasing availability of tools to help bridge the knowledge gaps available online



http://www.mendnano.com/

Good compilations/summaries of gaps exist and point to priorities as we move forward



http://www.its-nano.eu/

Continuing challenges

- Decisions about risk need to be made by a wide range of stakeholders in the absence of comprehensive data
- Many of those decisions need to be made in real time (i.e., formal risk assessment would not be the solution even if there were comprehensive data)
- Greater alignment of decision-making tools with needs of specific stakeholders is required

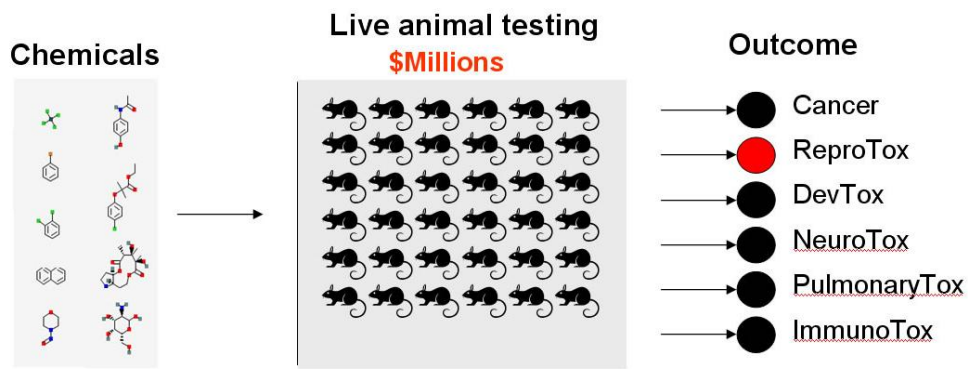
BUT THESE ISSUES ARE NOT UNIQUE TO NANO

"Toxicity Testing in the 21st Century: A Vision and a Strategy"

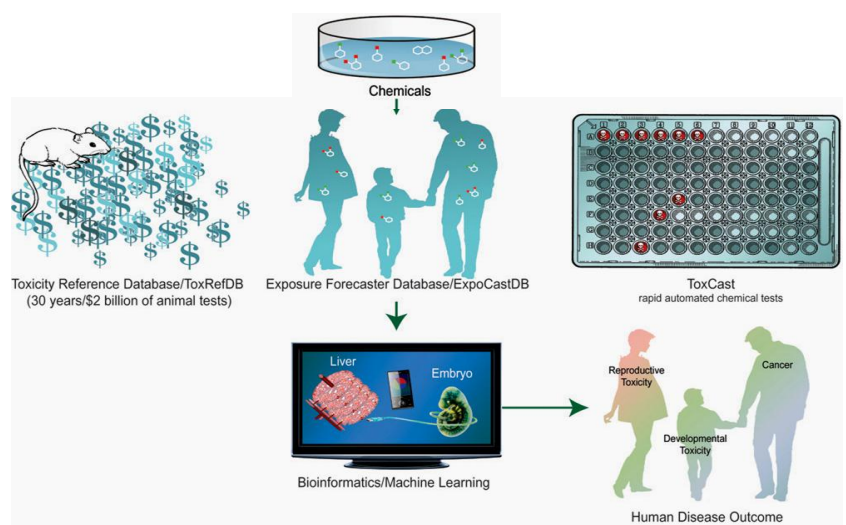
Current: One material at a time descriptive animal testing

US National Academy of Science (2007)

- Wide coverage of toxicants
- Robust scientific platform for screening
- Predictive tests utilizing toxicity mechanisms
- High throughput discovery
- Connectivity to *in vivo*



Proposed: Rapid mechanism-based predictive testing



Meng et al. ACS Nano. 2009
Nel et al. Accounts Chem Res, 2012
http://www.nap.edu/catalog.php?record_id=11970
http://www.epa.gov/ncct/toxcast

Today's Presentations:

- Laura Hodson (NIOSH) "Tools for risk management of engineered NPs in the workplace"
- Candace Tsai (Purdue) "Potential inhalation exposure and containment efficacy when using hoods for handling nanoparticles"
- Yanjun Ma (Virginia Tech) "Effects of nanomaterial disposal on wastewater microbial communities and toxicity implications"
- Erik Muller (UCSB) "Exposure time independent assessent of CuO ENP toxicity on zebrafish egg hatching"
- Jie Hong (UTEP) "Toxicity effects of seven Cu compounds/nanoparticles in lettuce (*Lactuca sativa*) and alfalfa *(Medicago sativa*)"
- Arnab Mukherjee (UTEP) "Effects of bare ZnO nanoparticles on green pea plants in soil"