NCI Alliance for Nanotechnology in Cancer

Data-enabled Predictive Modeling for NanoEHS and Nanoinformatics

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Scientific Data (Nature 461, 2009)

"Data's Shameful Neglect" (p.145)

All but a handful of disciplines still lack the technical, institutional and cultural frameworks required to support … open data access … leading to a scandalous shortfall in the sharing of data by researchers. This deficiency urgently needs to be addressed by funders, universities and the researchers themselves.

"Empty Archives" (p.160)

"We got the software up and running and said 'Give us your stuff'. That's when we hit the wall."

"Prepublication data sharing" (p.168)

…the standard requirement is that all relevant data must be made available on a publicly accessible website at the time of a paper's publication.

"Post-publication sharing of data and tools" (p.171)

… the largest part of the data underlying publications is archived on journals' supplemental information sites or authors' own sites. These data are often formatted in a non-standard way, not readily searchable, and in the long term not guaranteed to persist.

What is the role of Predictive Models?

Given the more specific, quantitative knowledge gained from theory and simulation we can build predictive models that will

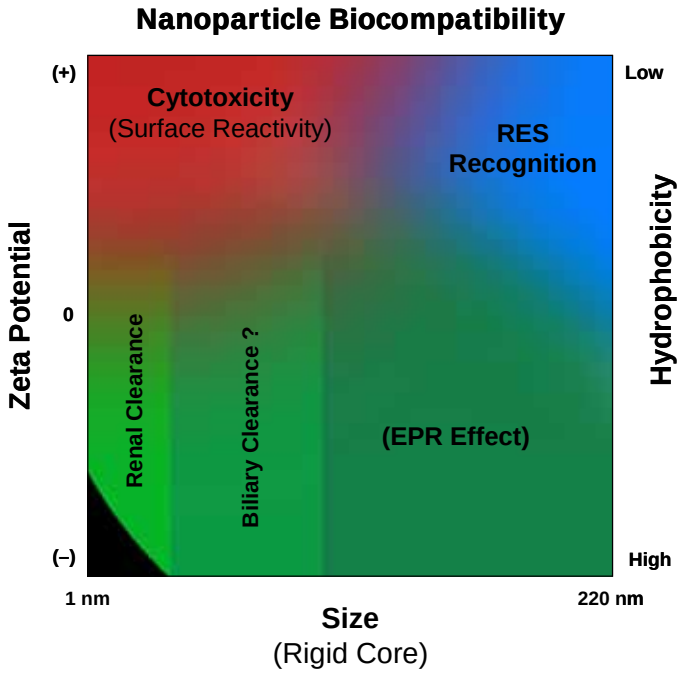
- facilitate the design of more appropriate … systems,
- protect nanomaterials from the environment as much as … protect the environment (and us) from them, and
- allow us to construct algorithms for assessing the likelihood of toxicity in a variety of natural environments.

Barnard, Amanda, "How can *ab initio* simulations address risks in nanotech?" Commentary: Nature Nanotechnology **4**, 332-335, June, 2009

The Role of Predictive Models, cont.

Nanomaterial properties depend on:
- their physical and chemical parameters (size, shape, molecular structure, charge, degree of agglomeration, solubility,…) and
- their (complex) biological environments (pH, temperature, molecular constituents, transient/equilibrium states, EM fields (including photons)…

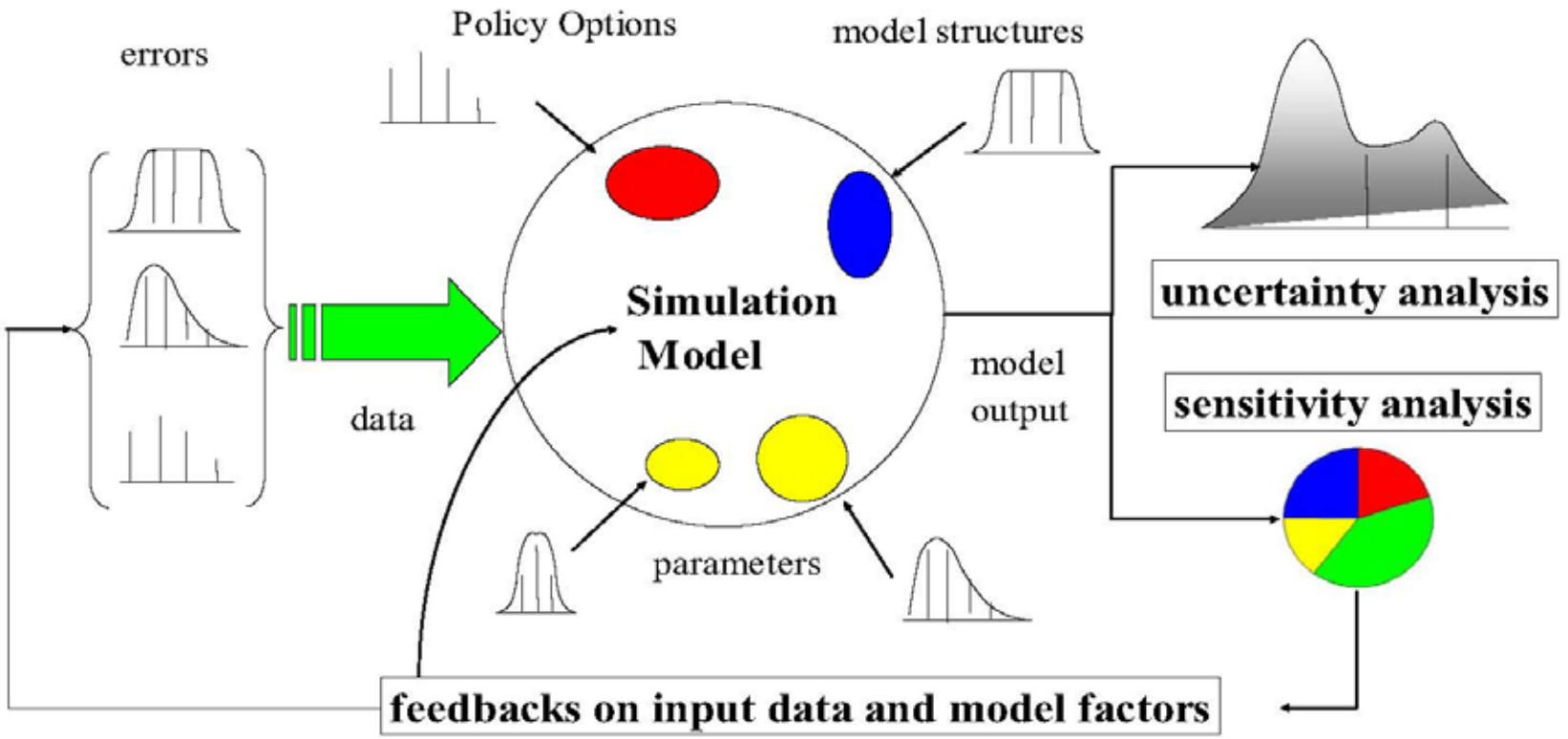
As in bulk materials, many of these dependencies are intrinsically linked and must be understood to predict possible risks



McNeil, S.E. *Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology* **1**, 264-271(2009).

Predictive models can
- control each critical parameter independently,
- identify underlying mechanisms responsible for their interaction
- investigate nanostructures in highly non-equilibrium environments
- sample the parameter space, and
- **in conjunction with experimental methods**, build predictive capabilities

Design Sensitivity Analysis and Optimization



From: “Sensitivity Analysis”, Andrea Saltelli, European Commission, Joint Research Centre, Ispra,
Presented at Piacenza, May 14-15 2009

Current Status

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Uncertainty Analysis

- Standard characterization protocols for nanomaterial are being developed – a few have been completed.
- The uncertainty and error in those protocols are beginning to be determined through interlaboratory studies (ILS)
- Data developed using those standard protocols standard protocols have barely begun to be reported in the literature
- More reference and study materials are needed to expand the range of the ILS studies

Sensitivity Analysis

- Insufficient curated data is available for data-driven sensitivity analysis for life-cycle design of nanomaterial devices
- Modeling efforts as adjuncts to nanomaterial characterization are isolated
- Despite existing modeling capabilities and design experience in related fields, rational lifecycle design of nanomaterial devices using sensitivity and error analysis is in its infancy

Informatics Needs

The need for a federated informatics infrastructure with layered access control for public and private data

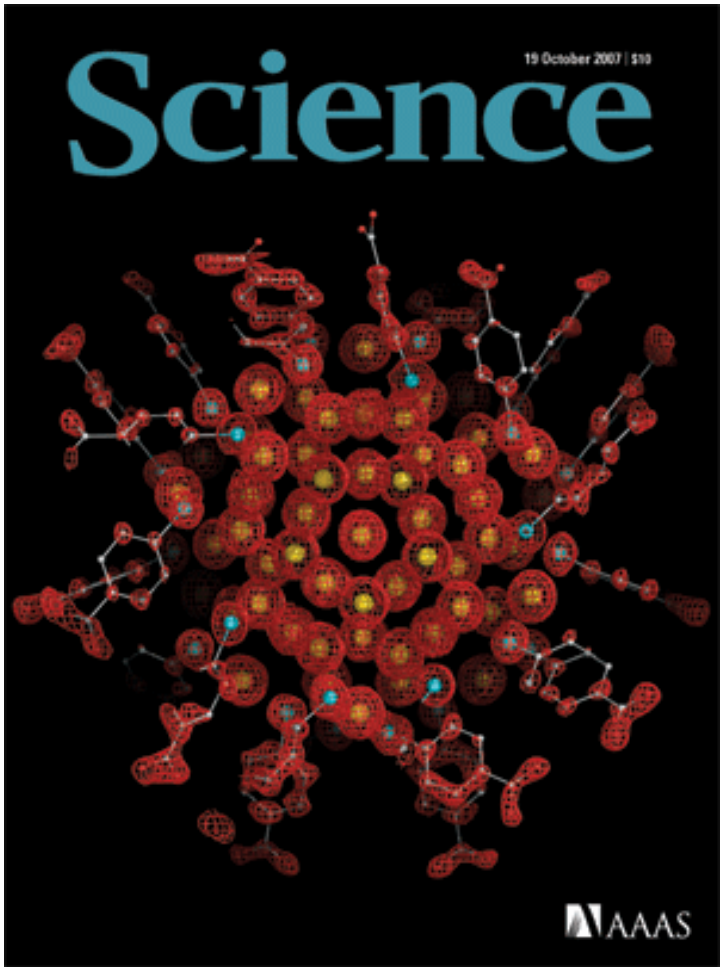
The need for measures of error and uncertainty in the data

The need for semantic search

- Ontology development and mapping
- Advanced search
- Search based on structural motifs of interest
- Nanomaterial registry

The need for coupling uncertainty analysis and sensitivity analysis using predictive models

The need to develop, share and validate structural, computational and predictive models



Summary

The need for collaboration in nanotechnology may be best summarized in analogy with the parable of the blind men and the elephant.

- Input from scientists in different disciplines is needed to develop nanotechnology applications (particularly with respect to their activity - and reporting error and uncertainty)
- Each disciplines may examine different aspects of the structure of nanomaterial using their preferred tools ("If you test with one technique you are inevitably wrong")
- Communication about both structure and activity are hindered by lack of communication of what "they mean" (i.e., lack of semantics)
- They need a shared conceptual, analysis, and simulation models through which to reference and annotate their observations and to formulate structure-activity relationships
- Intelligent design are not possible without shared models and good communication among disciplines (especially for EHS risk analysis and mitigation)

Request for your input

- Why do you need data-enabled predictive modeling?
- What do you need predicted for Nano-EHS?
- Are systems approaches important for your prediction needs?
- At what level of integration and what system?
- Are nanoEHS data needs for predictive modeling different from those for EHS?
- For what type of data? What quality of data?

There will be a parallel session on predictive modeling and data and model sharing to elicit needs and requirements and the use of existing pilots to iterate to agreement.

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