Social and Ethical Implications (SEI) of Nanotechnology

Larry Gibbs, CIH, FAIHA
Associate Vice Provost
Environmental Health & Safety
Stanford University

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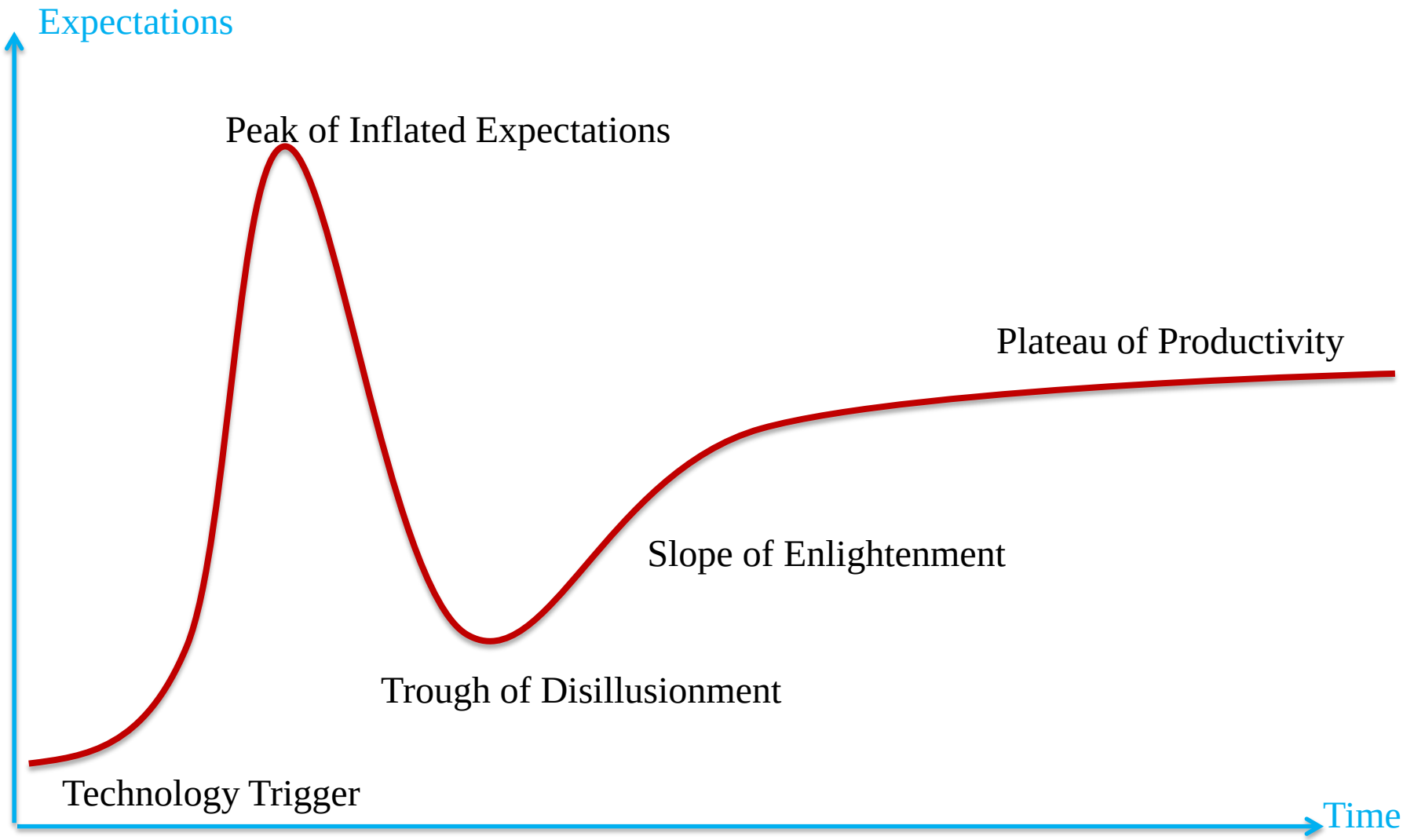
Presentation Overview

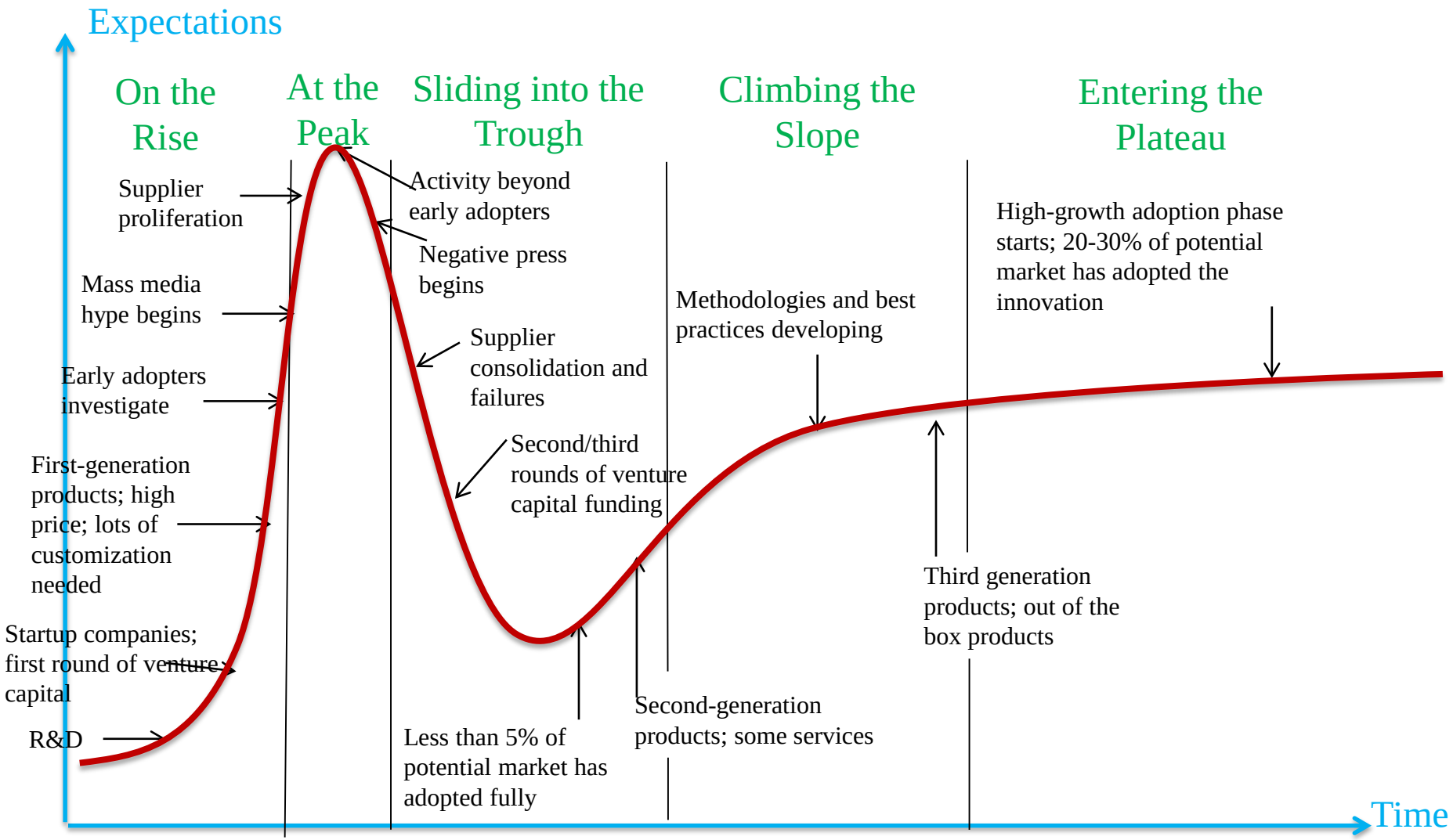
- Characteristics of Emerging Technologies
- Nanotechnology: Uniqueness, Benefits and Applications
- Related Social and Ethical Issues
- Environmental and Health and Safety Issues
- Future of Nanotechnology

Emerging Technology: Hype Cycle Phases



http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp

Emerging Technology: Hype Cycle Phases



http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp

Top 10 Emerging Technologies of 2016

Nano-sensors and the Internet of Nano-things

Next Generation Batteries

The Blockchain

2-D Materials

Autonomous Vehicles

Organ-on-Chips

Perovskite Solar Cells

Open AI Ecosystem

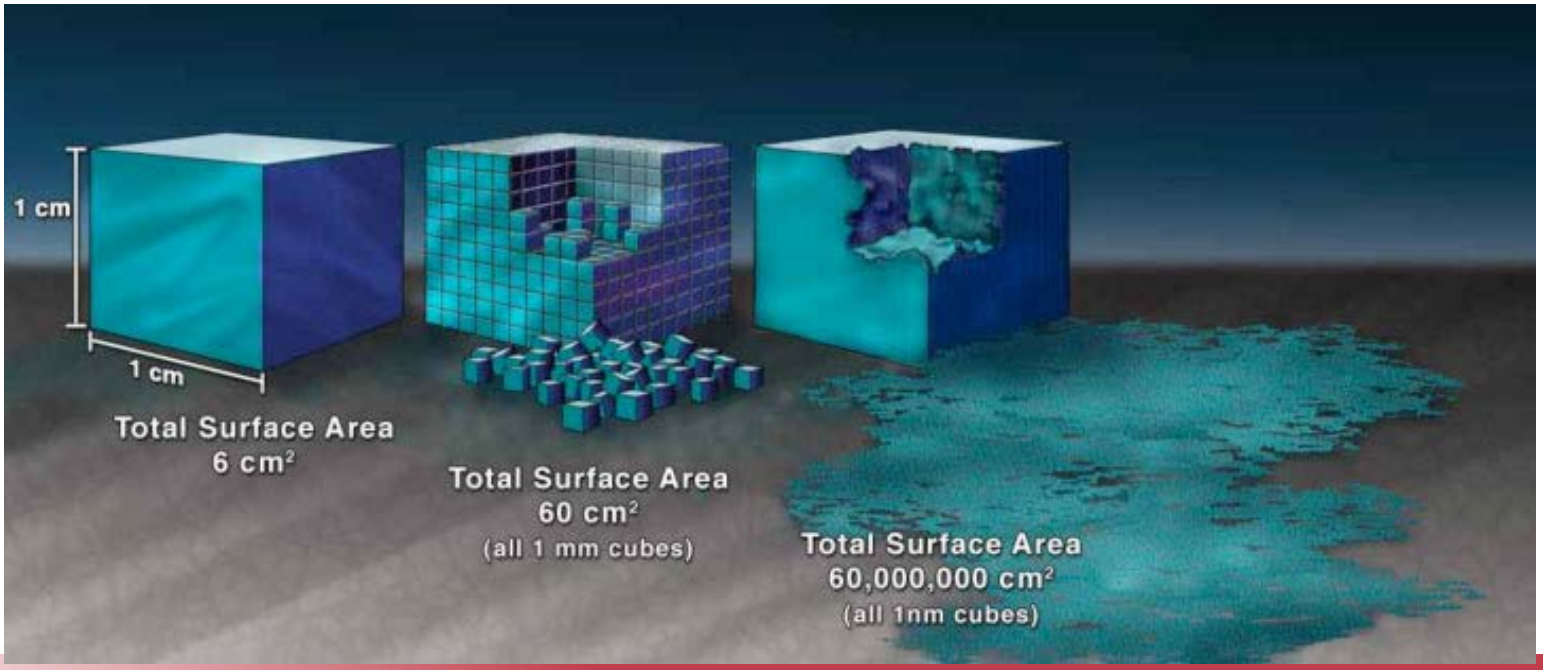
Optogentics

Systems Metabolic Engineering

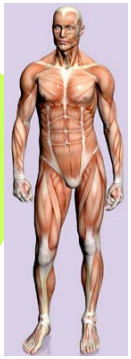
World Economic Forum 2016 - https://www.weforum.org/agenda/2016/06/top-10-emerging-technologies-2016/

What's special about the nanoscale?

- Scale at which surfaces and interfaces play a large role in materials properties and interactions (high surface to volume ratio; wave properties of light are important; allows for miniaturization)
- Scale at which quantum effects dominate properties of materials
- Scale at which much of biology occurs



Nanotechnology? Working at The Nanoscale

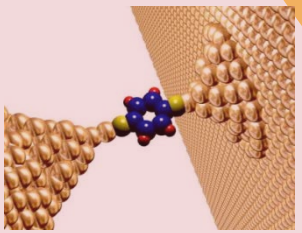


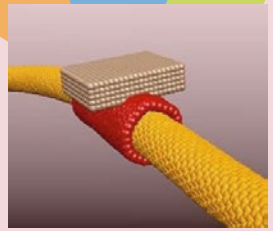
Materials Sci.

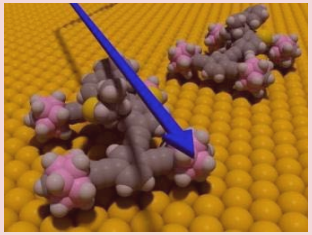
Chemistry

Biology

Nanoscale



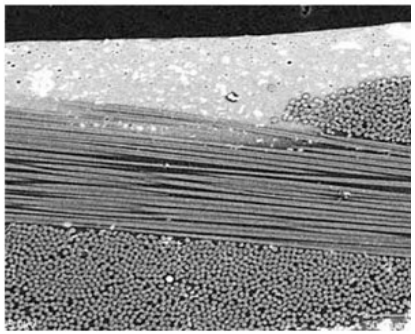




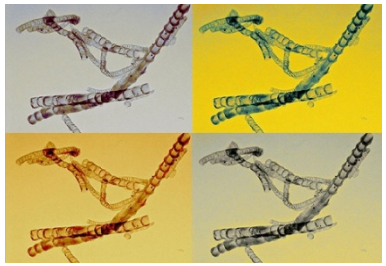
Nanoscale Science is where Physics/Materials Sciences, Biology and Chemistry fuse.

Applications of Nanomaterials

- Everyday Materials and Processes
- Electronics and IT Applications
- Medical and Healthcare Applications
- Energy Applications
- Environmental Remediation
- Future Transportation Benefits



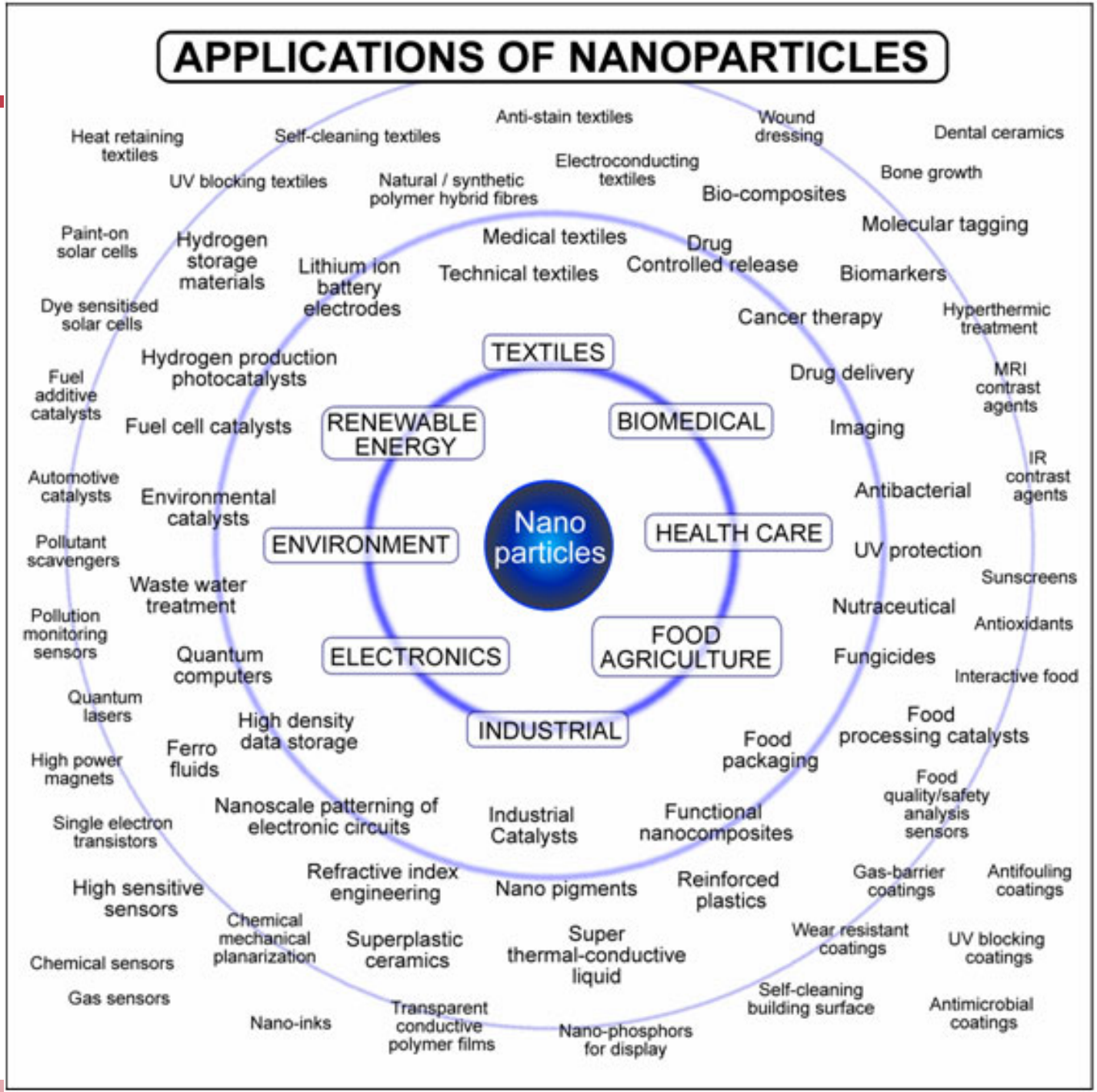
High-resolution image of a polymer-silicate nanocomposite. This material has improved thermal, mechanical, and barrier properties and can be used in food and beverage containers, fuel storage tanks for aircraft and automobiles, and in aerospace components. (Image courtesy of NASA.)



This image shows the bamboo-like structure of nitrogen-doped carbon nanotubes for the treatment of cancer. (Courtesy of Wake Forest and the National Cancer Institute)

Challenge: Maintaining the Focus on the Benefits of Nanotechnology via SEI and EHS Efforts

Source: nanowerk.com



Nanomaterials/nanoproducts currently in commercial production or use

Mercedes-Benz

Mercedes CLS-class

Wilson Double Core tennis balls

Eddie Bauer Ruston Fit Nano-Care khakis

3M Adper Single Bond Plus dental adhesive

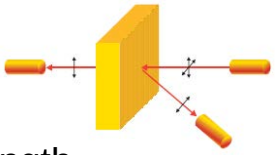
Wyeth Rapamune immuno-suppressant

Smith & Nephew Acticoat 7 antimicrobial wound dressing

Laufen Gallery washbasir with Wondergliss

Samsung Nano SilverSeal Refrigerator

Kodak EasyShare LS633 camera



NanoOpto subwavelength polarizing beam splitter/combiner

Hummer H2

Vance, M. E., Kuiken, T., Vejerano, E. P., McGinnis, S. P., Hochella, M. F., Jr., Rejeski, D. and Hull, M. S. (2015) **Nanotechnology in the real world: Redeveloping the nanomaterial consumer products inventory**. *Beilstein Journal of Nanotechnology*, 6, 1769-1780. http://dx.doi.org/10.3762/bjnano.6.181

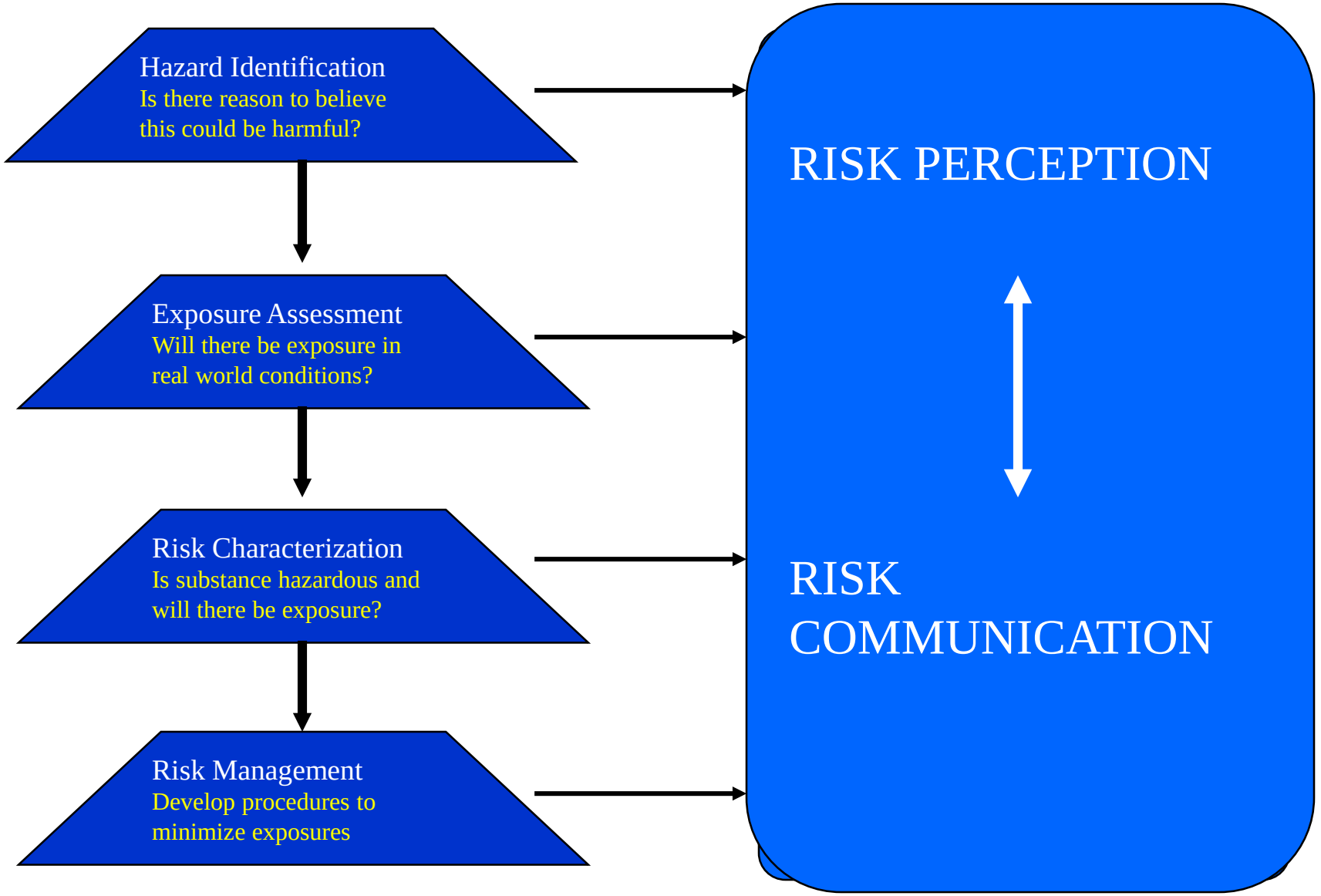
Nanotechnology Development - Opportunity and Risk

- Opportunity goes hand-in-hand with risk
- The global marketplace previously challenged by a variety of risks posed by widely used materials (asbestos, benzene, silica, lead, etc.)
- Risks carry with them the potential for far-reaching effects on market cycles, manufacturing, and the safety, security, and well-being of consumers, and the environment
- Nanotechnology adds an entirely new and largely unexplored realm of possible risks spread across the entire spectrum of modern commerce

Nano (emerging) Technology Risk Management

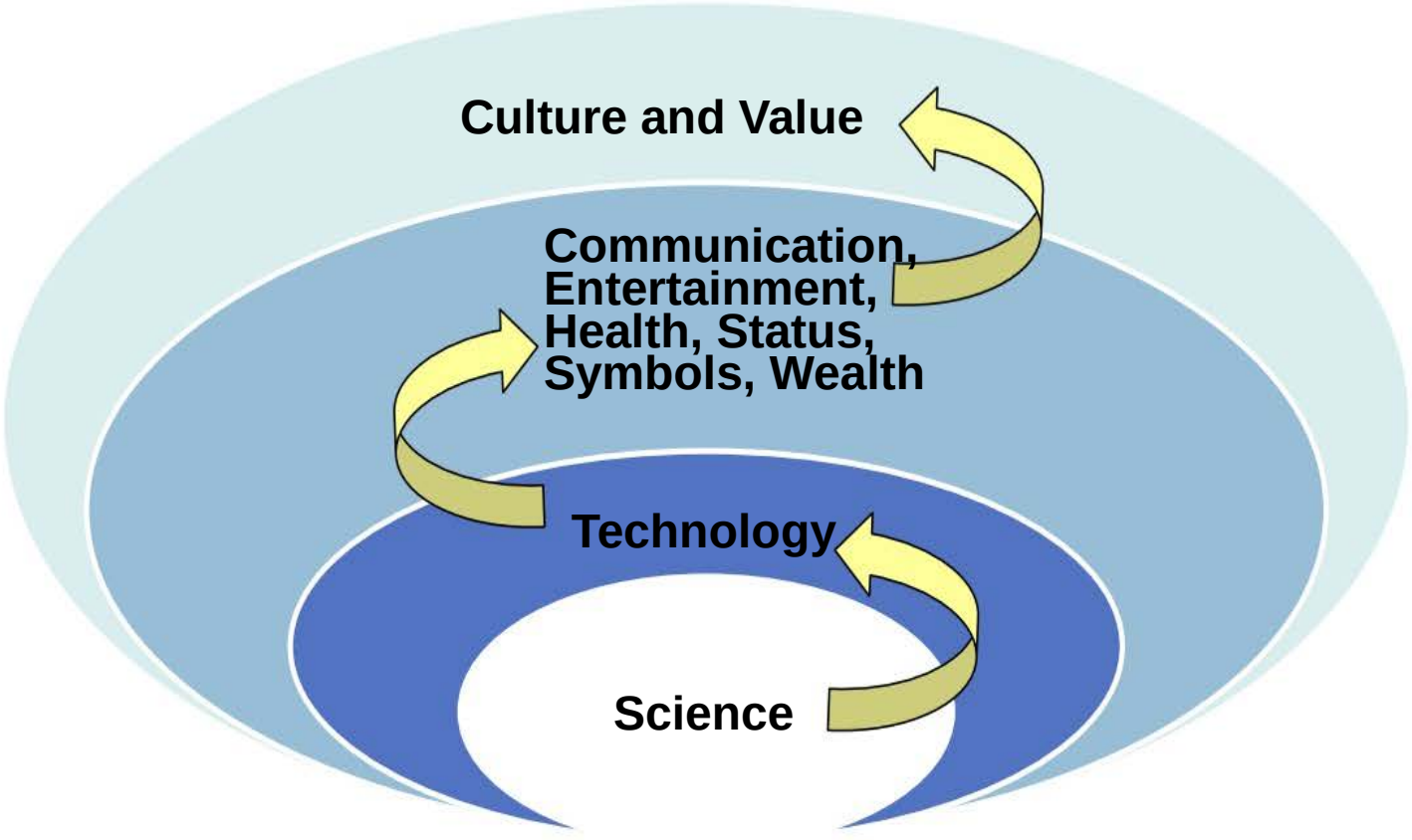
- Struggle to deal with emergent risks presented by new technologies
- There is no manual for how to address human health risks from increasingly complex technologies
- Stakeholder and citizen engagement is becoming increasingly important
- Uncertainty dominates the decision-making process
- Ill-informed decisions on risks and benefits could be potentially catastrophic

Traditional Risk Assessment and Risk Management



What are Societal and Ethical Implications(SEI)?

Science and technology are not separate from the rest of society



What are some areas of SEI in science and technology?

Health and Safety

Environment

Economics

Security and Privacy

Education

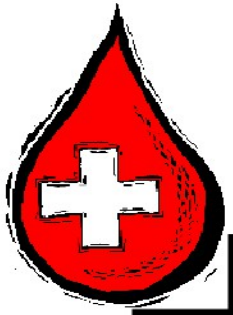
Politics

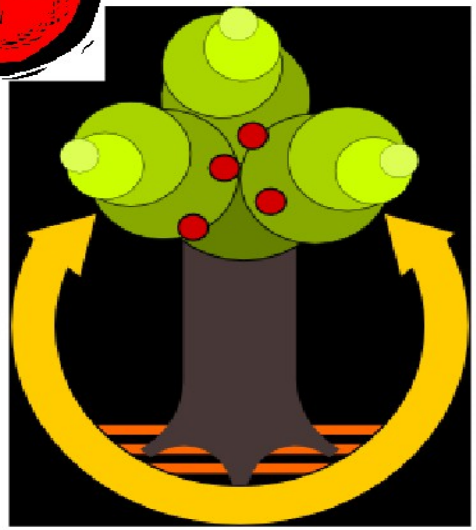
Media

Legal and Regulatory

Culture

Religion





Areas of Society Affected by Nanotechnology

Health Environment Economy

Possible Benefits

- Improved medicine

- Improved detection and removal of contaminants
- Development of benign industrial processes and materials

- Better products
- New jobs

Concerns

- Abiliity to cross cell membranes and translocate in the body
- No FDA approval needed for cosmetics or supplements

- High reactivity and toxicity
- Pervasive distribution in environment
- No nano-specific regulation

- Redistribution of wealth
- Potential cost of cleanups and healthcare impacts
- Accessibility to all income levels

Specific Societal and Ethical Issues in Nanotechnology

- Lab safety and health
  - Consideration of the health and well-being of fellow researchers; reporting on unsafe practices
- Environmental consequences of research
  - Minimization and safe disposal of hazardous substances; fate of “nanowaste”; fair notice to potentially affected parties
- Academic conduct
  - Integrity of research results; equitable authorship recognition practices
- Commercial fair dealing
  - Respect of confidentiality and trade secrets; intellectual property rights
- Science education
  - Interdisciplinary studies; ethics education

More Societal and Ethical Issues in Nanotechnology

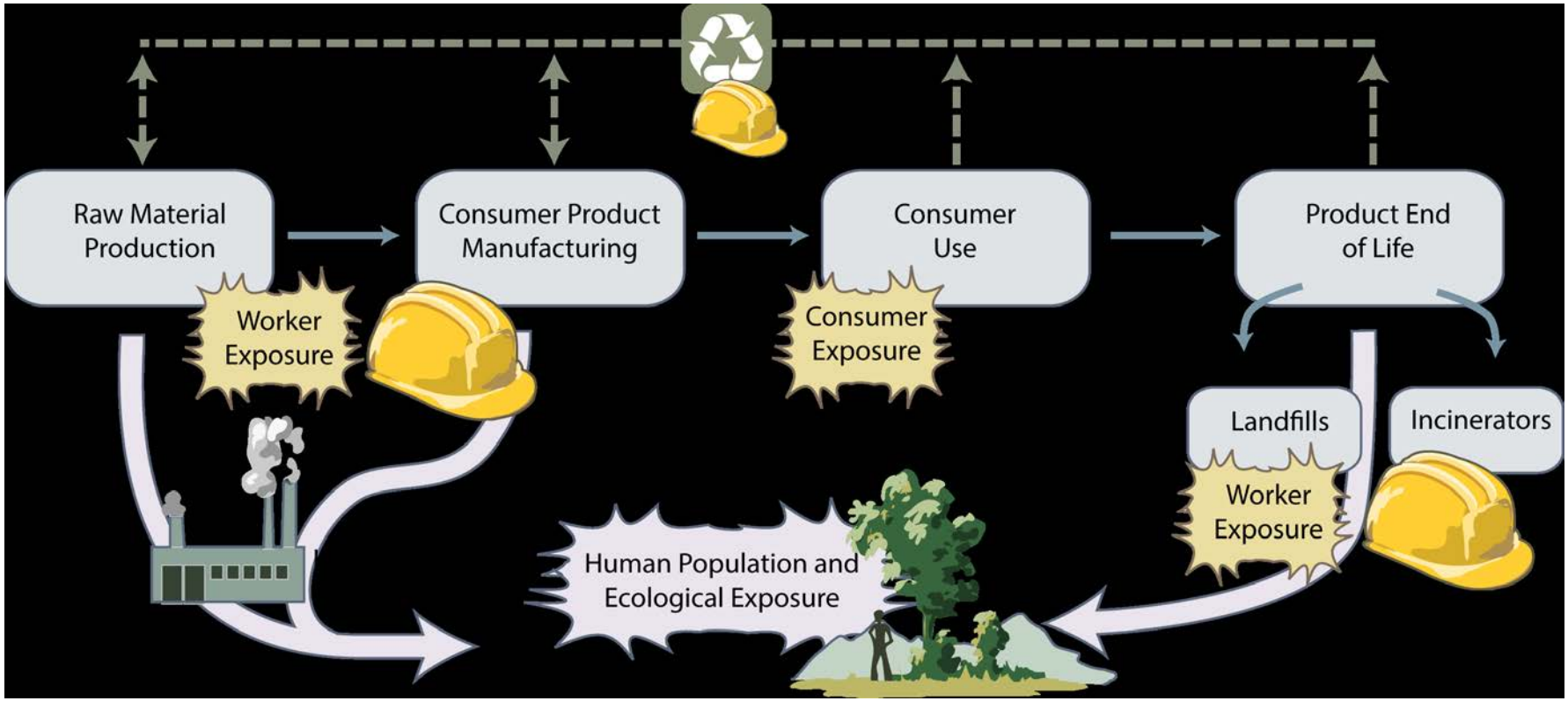
- Environmental health and safety concerns
  - Ecological and toxicological effects of nanoparticle; workplace and consumer exposures
- Economic effects
  - Rapid transformation and dislocation of industries; effects on wealth distribution; intellectual property issues
- Medical technologies
  - Prospects for human enhancement and augmentation; improved genetic screening; advanced cures
- Security and privacy implications
  - Novel weaponry and defense technologies; pervasive surveillance potential

Less Obvious Societal and Ethical Issues in Nanotechnology

- National and international politics
  - National research funding commitments and the “nanodivide;” technology transfer
- Media and public perceptions
  - Polarized reactions to nanotechnology; involvement of lay public in decision making
- Legal and regulatory issues
  - Proactive versus reactive regulation; international standard-setting
- Cultural and religious repercussions
  - New media and modes of representation; new challenges in defining life

Engineered Nanomaterial and Nanomaterial-Enabled Product Life Cycle Considerations

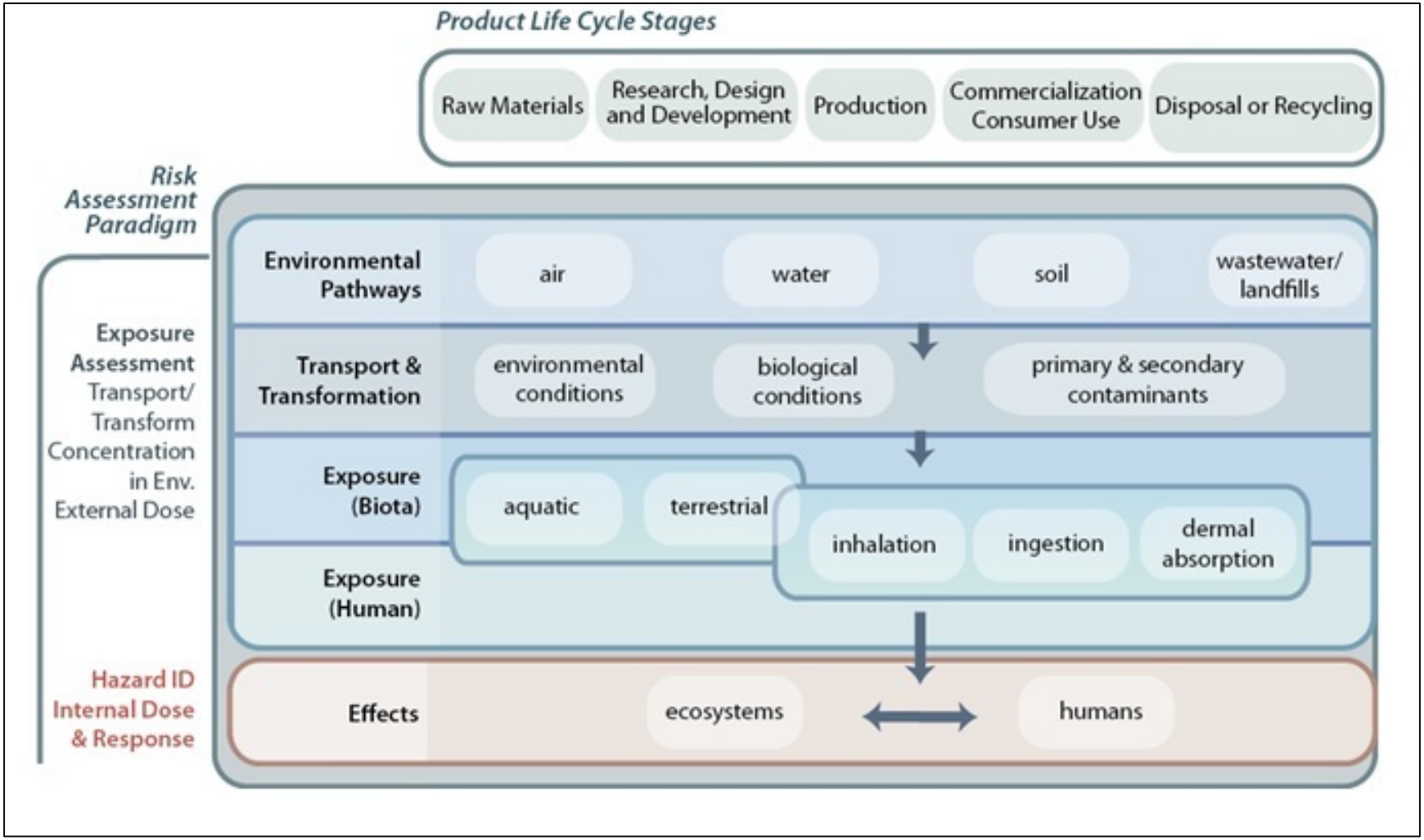
Human and environmental exposures to ENMs can occur at all life cycle stages of an NEP.



Adapted from the *2011 NNI Environmental, Health, and Safety Research Strategy*, www.nano.gov/sites/default/files/pub_resource/nni_2011_ehs_research_strategy.pdf

National Nanotechnology Initiative (NNI) 2014 Strategic Plan

Nano Risk Management Across the Life-cycle



The risk assessment paradigm (*on left*) integrated with nanomaterial life cycle stages (*across top*). (Design credit: N.R. Fuller of Sayo-Art.)

What we know about nanomaterials researchers and SEI

- Most NNIN researchers are interested in ethical issues surrounding nano (73.1%) and believe that these ethical responsibilities go beyond the laboratory (77%)

However,

- Nearly 80% did not feel that they were well informed about ethical issues relating to nanotechnology

- 64% of respondents had never taken a course in which ethical issues of science and technology were discussed

* http://www.nnin.org/society-ethics/sei-blog/what-makes-safety-nanotech-lab-"ethical-issue"
Robert McGinn, Professor, Dept. of Management Science and Engineering, and Director, Science, Technology, and Society (STS) Program, Stanford University; NNIN Ethics Investigator 2012

Safety as an "ethical issue" in the Nano-research Lab*

- **Without due regard to safety, risks include:**
  - Harming fellow researchers
  - Damaging lab equipment/facilities
  - Harming lab's/institution's reputation
  - Harming future of nanotech research enterprise itself (why should such research continue to be funded?)

- **Safety-related ethical responsibilities of nanotech researchers in the lab**

1. Take suitable precautions
   a) Having a precautionary mindset and taking suitable precautionary steps are essential for the nanotech lab researcher.
2. Avoid taking shortcuts
   a) It is ethically unacceptable to take shortcuts for reasons of personal convenience, time pressure, cost-cutting, or to realize research objective before a competitor does.
3. Support a Strong Lab Safety Culture

* http://www.nnin.org/society-ethics/sei-blog/what-makes-safety-nanotech-lab-"ethical-issue"

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Ethical Responsibility-Support a Strong Safety Culture

- **Should not assume all researchers, existing or new to the lab, share same understanding of what ethical responsibility in the lab requires of them.**
- **Lab faculty, principle investigators, directors and managers have the responsibility to create, shape and sustain a strong safety culture in the nanotech lab.**
  - First, lab leader must demonstrate, **through personal behavior and communication with the lab group,** that they take developing and preserving a strong safety culture seriously
  - Lab leader should institute periodic follow on activities and actions that support maintenance of a strong, positive safety culture as a priority for the lab.

What Can You Do?

- Be aware of the larger picture! Think critically about your role in it.
- Integrate social and ethical considerations into your research planning
  - not as an afterthought, or as something left for others decision-makers, but as a central purpose of your actions.
- Engage with others concerning these issues
  - within the lab, within the larger science community, and within the society that ultimately will influence and be influenced by your efforts.

Responsible Innovation

“Responsible innovation” (RI) is an emerging term in science and innovation policy fields across the globe. Its precise definition has been at the center of numerous meetings, research council decisions, and other activities in recent years. But today there is neither a clear, unified vision of what responsible innovation is, what it requires in order to be effective, nor what it can accomplish.

Public Perception of Emerging Technology

www.Nano.gov -Documents on the Safe Use of Nanotechnologies

NNI agencies continue to develop and disseminate guidance for the safe handling of nanomaterials.

Example:

Current Intelligence Bulletins (CIBs) are issued by NIOSH to disseminate new scientific information about occupational hazards.

Examples of Guidance Documents Developed by NNI Agencies

NNI supported center: Center for Nanotechnology in Society at Arizona State University

Source: NIOSH & OSHA