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Nanotechnology and Opportunities for Comprehensive Safety, Health, and Wellbeing

American Society of Safety Engineers Section Meeting
Los Alamos, New Mexico
July 16, 2013

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The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the author's organizations. Mention of company names or products does not constitute endorsement.



LA-UR-13-25228

OVERALL OBJECTIVE

Build and sustain
a total culture
of
safety, health, and well-being

A Key Concept

- The ***method*** is not the message;
[the message] is
in the ***managerial frame of mind***
determined to make ***robust decisions***.

Nano-enabled products are on the market




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



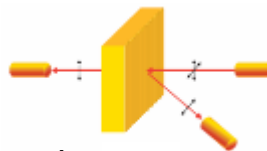
Kodak EasyShare
LS633 camera



Laufen Gallery washbasin
with Wondergliss



Samsung Nano
SilverSeal Refrigerator



NanoOpto subwavelength
polarizing beam splitter/combiner



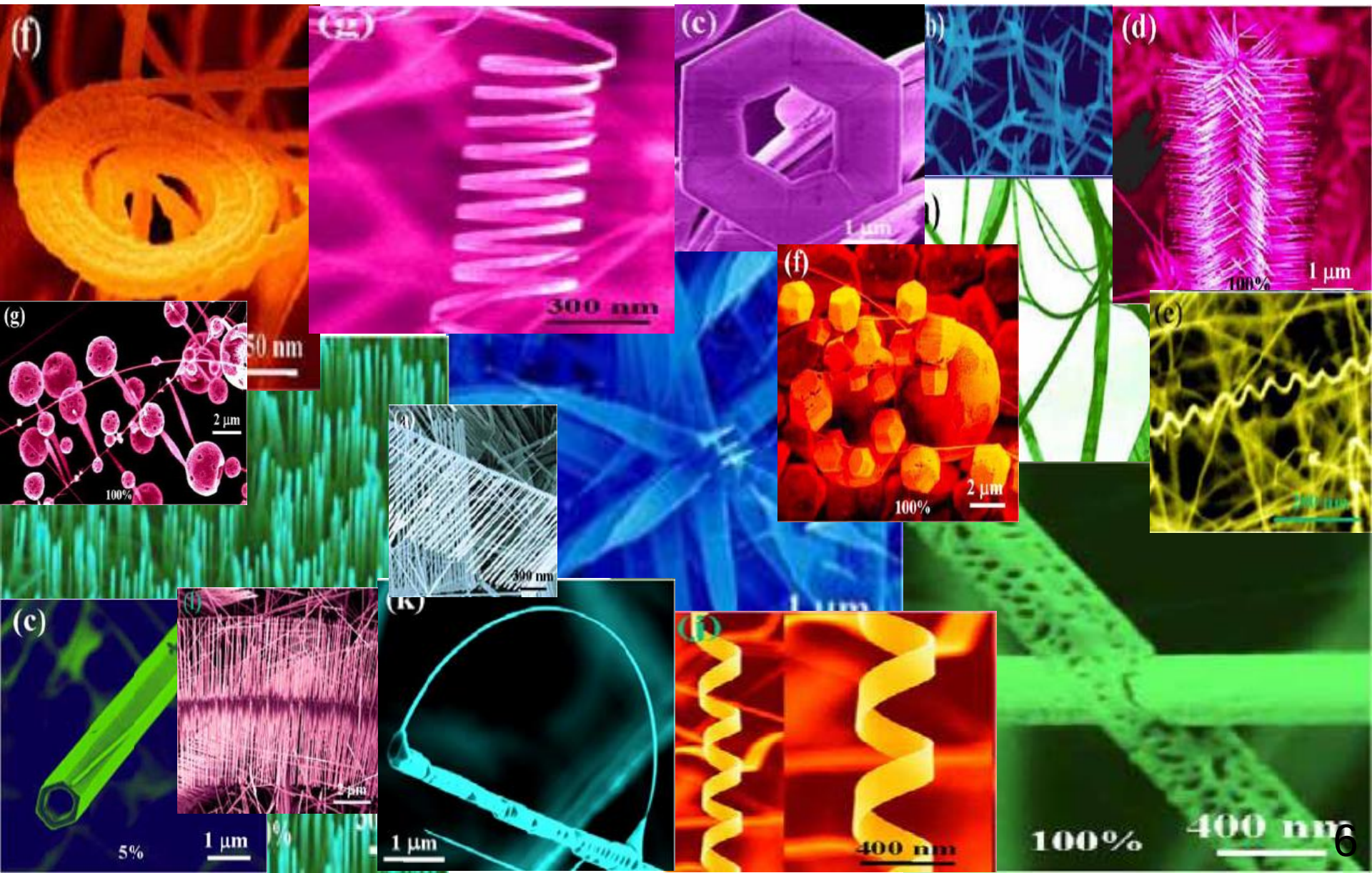
Hummer H2

Definition of Nanotechnology

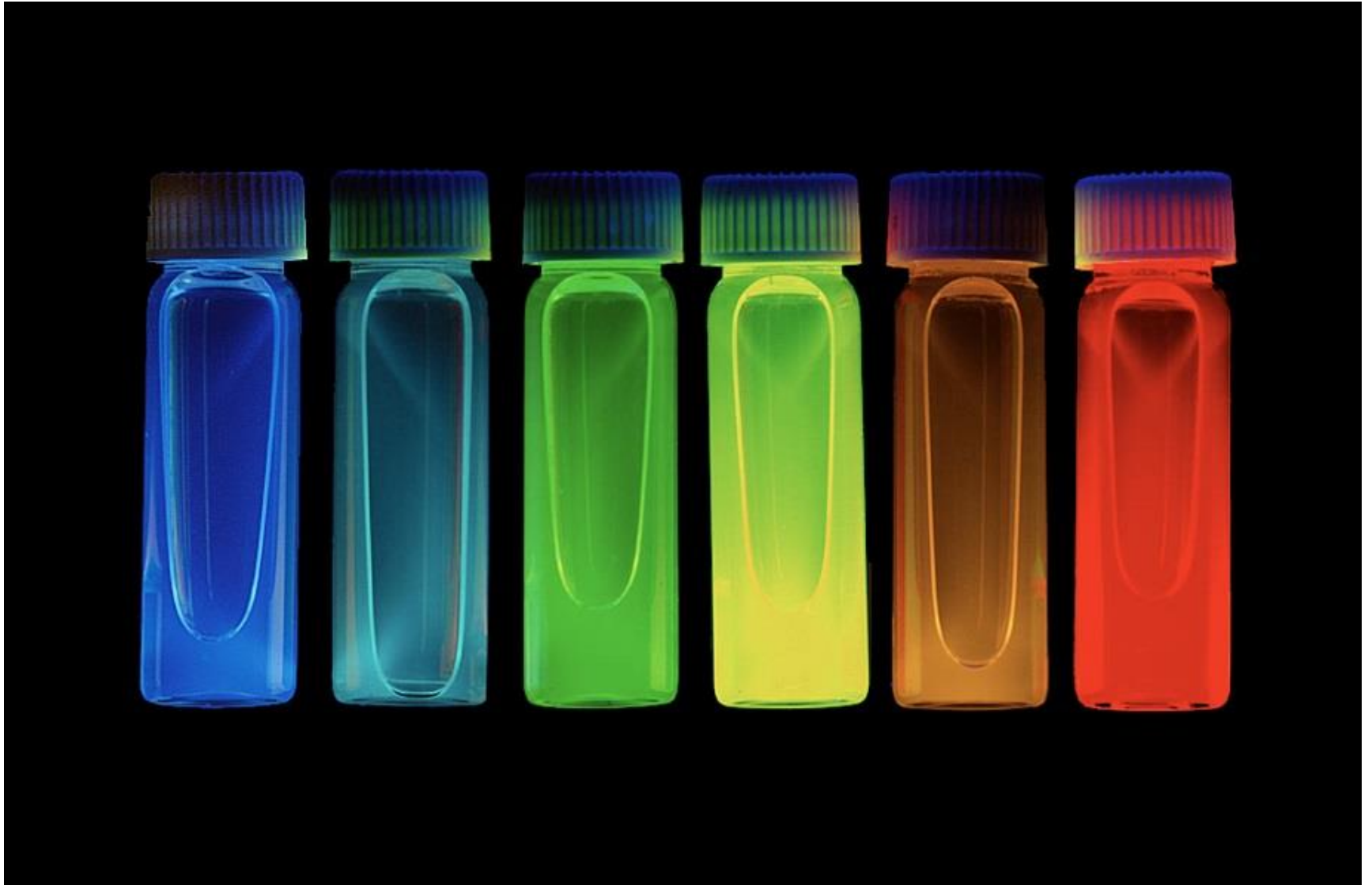
- **Definition includes all three of these features:**
 - Research and technology development at the atomic, molecular, or macromolecular levels, in the length scale of approximately **1-100 nm**.
 - Creating and using structures, devices, and systems that have **novel properties and functions** because of their small and/or intermediate size.
 - **Ability to control or manipulate on the atomic scale.**

Diversity Example: Zinc Oxide Nanomaterials

Photos: Dr. Z Wang, Georgia Tech



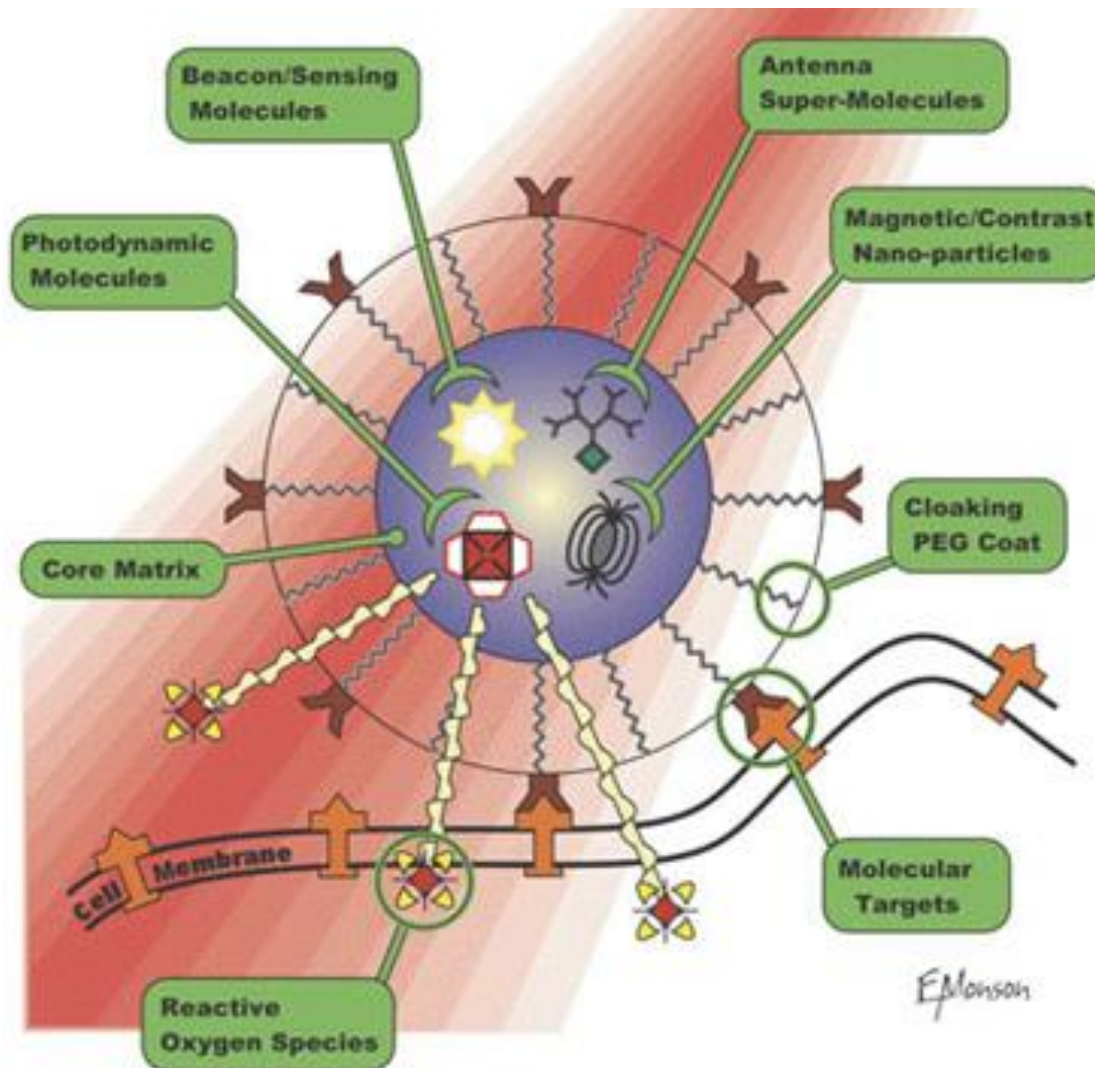
Unique Emission Qualities of Nanocrystals



Credit: Felice Frankel

Nanotechnology: Turning fiction to reality

Smart Dynamic Nanoplatforms – “Nanoclinics”

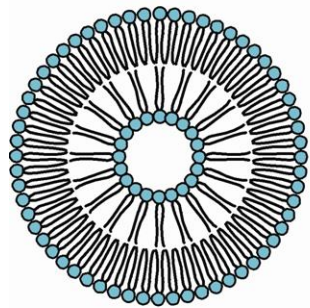
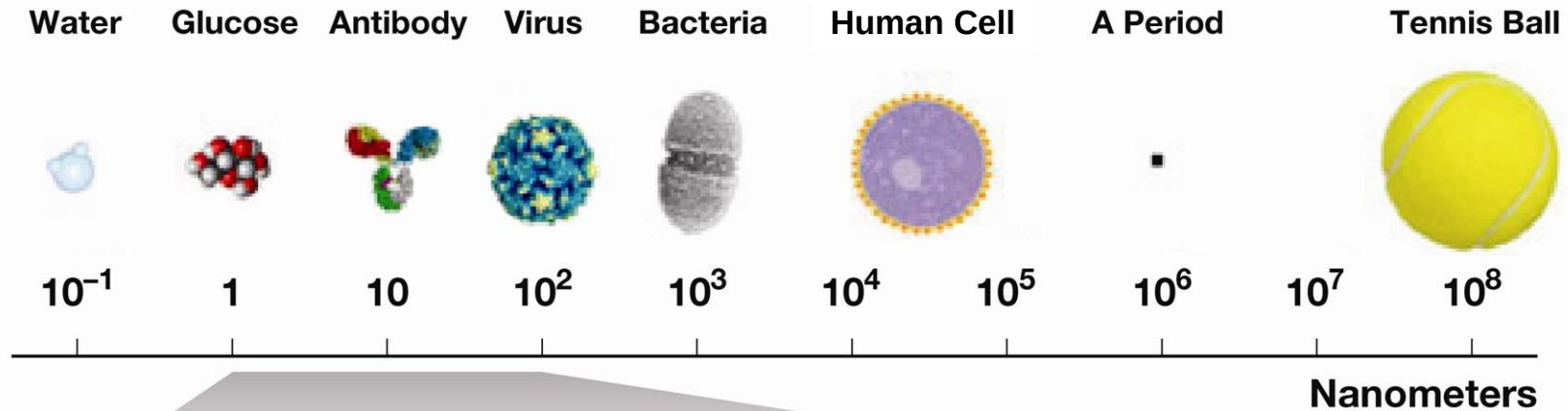


20 nm – 600 nm in diameter

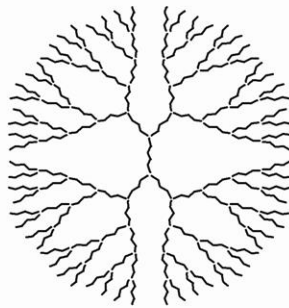
PEBBLEs

(Probe Encapsulated By
Biologically Localized
Embedding)

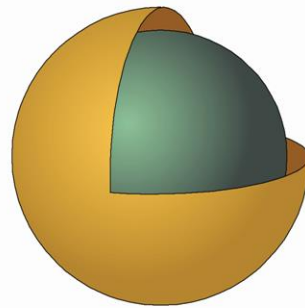
A range of particle sizes, shapes, and types



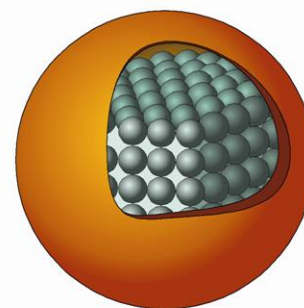
Liposome



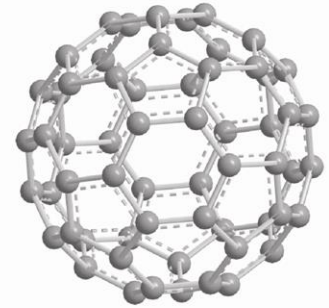
Dendrimer



Gold Nanoshell

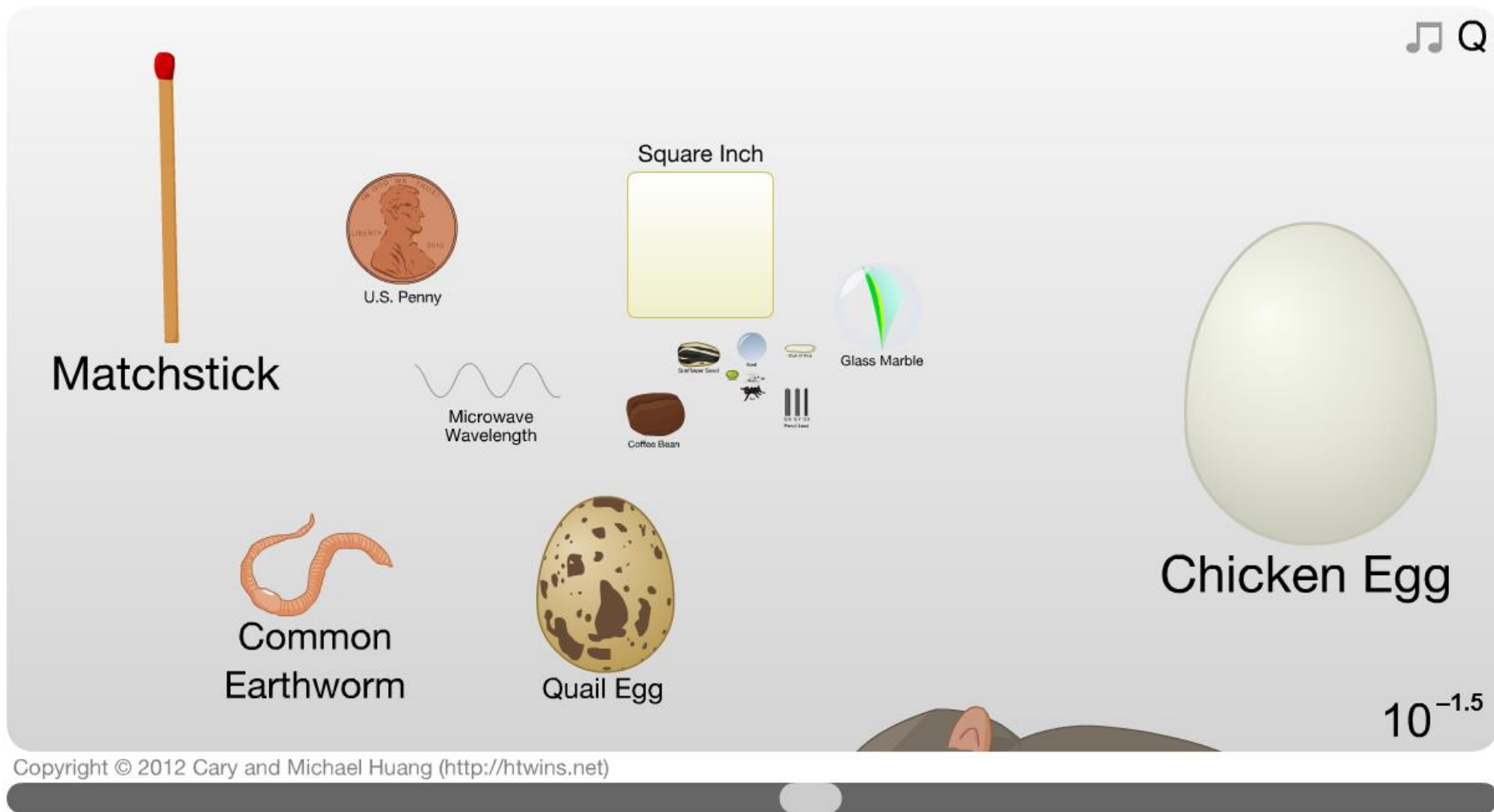


Quantum Dot



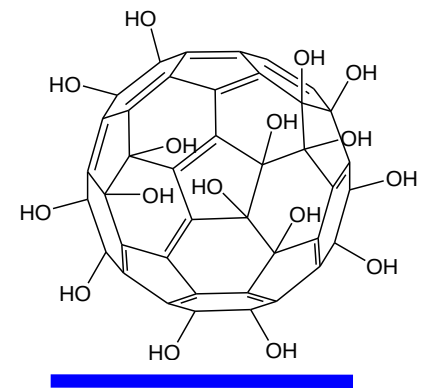
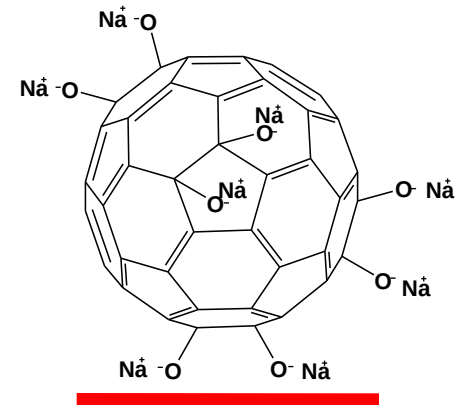
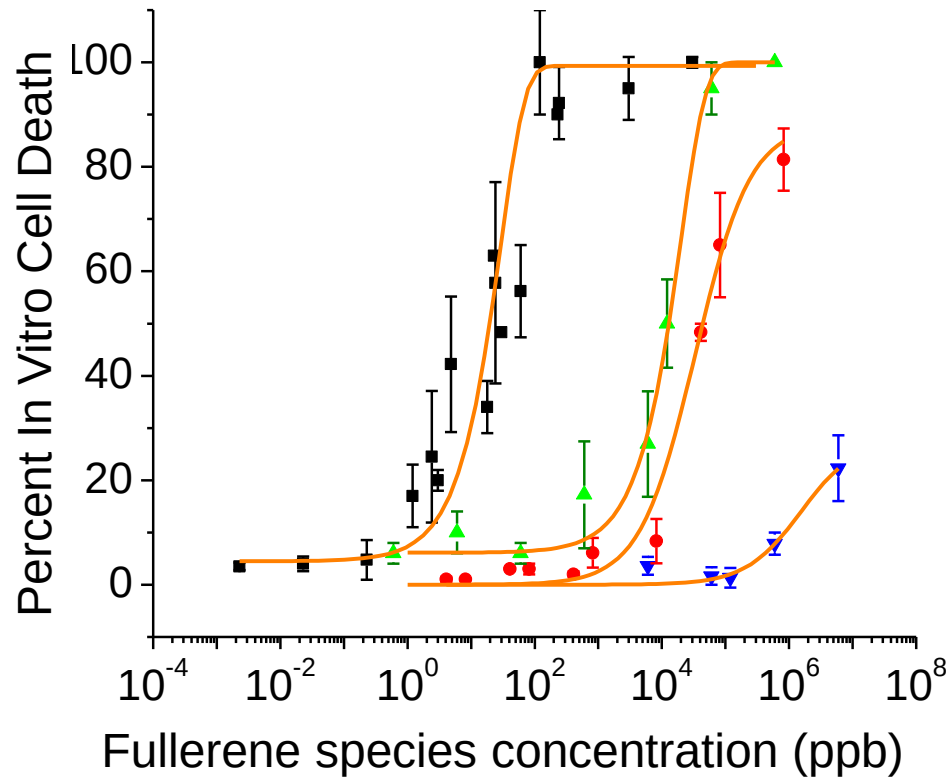
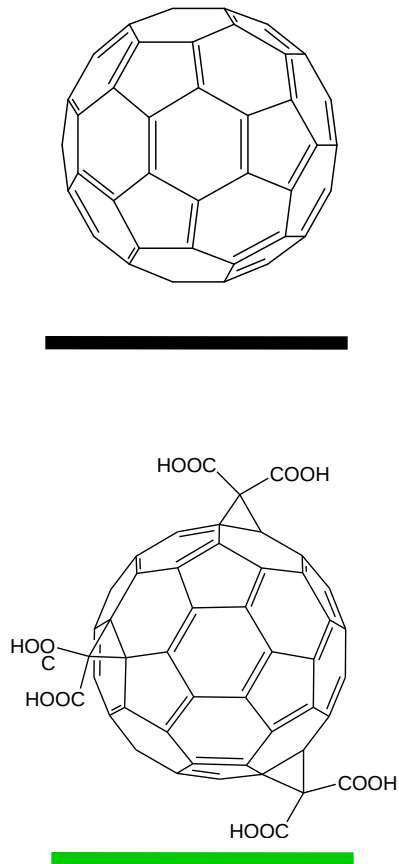
Fullerene

The Scale of the Universe



Surface species can influence bioactivity

Surface chemistry versus biological activity for C_{60} fullerenes



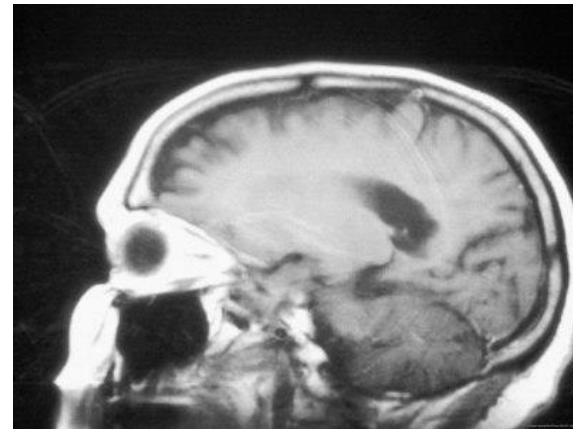
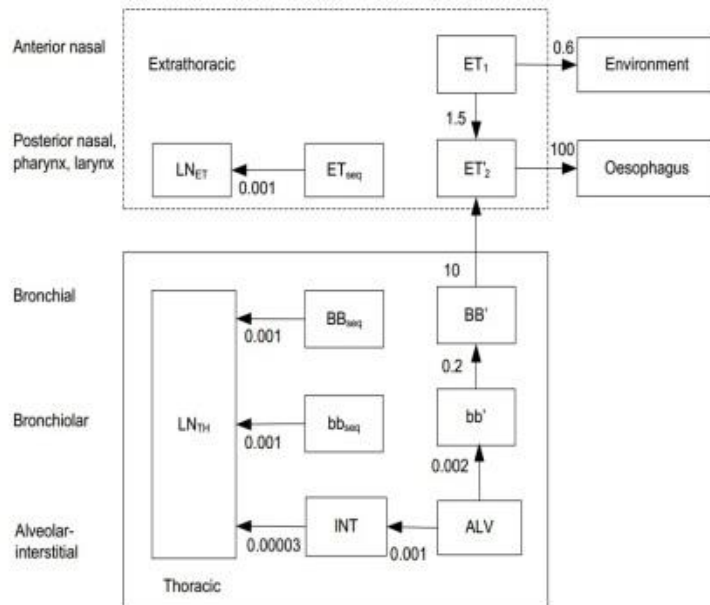
Nano-enhanced materials and processes are raising issues in radiation-related operations.



What are the sources of radiation-related nanomaterials?

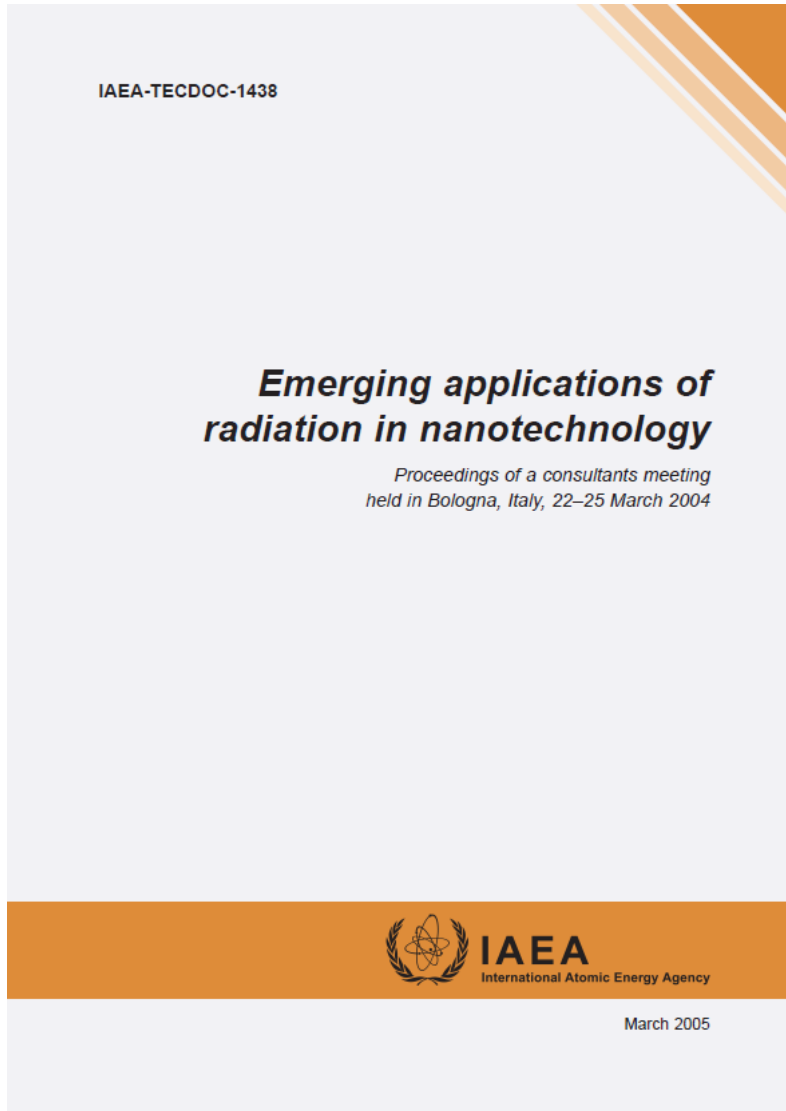


How can exposure be assessed over life-cycle processes?



How should radiation dosimetry be conducted for nanomaterials?

Applications of Radiation in Nanotechnology



- Nano-synthesis methods
- Annealing processes
- Characterization tools
- Aging studies
- Special systems
 - Plasma-focus-based radiation sources

<http://www-pub.iaea.org/books/iaeabooks/7161/Emerging-Applications-of-Radiation-in-Nanotechnology-Proceedings-of-a-consultants-meeting-held-in-Bologna-22-25-March-2004>

Applications of Nanotechnology in NPPs



Collaborative Report on the Workshop

Gaithersburg, Maryland
June 6-8, 2012



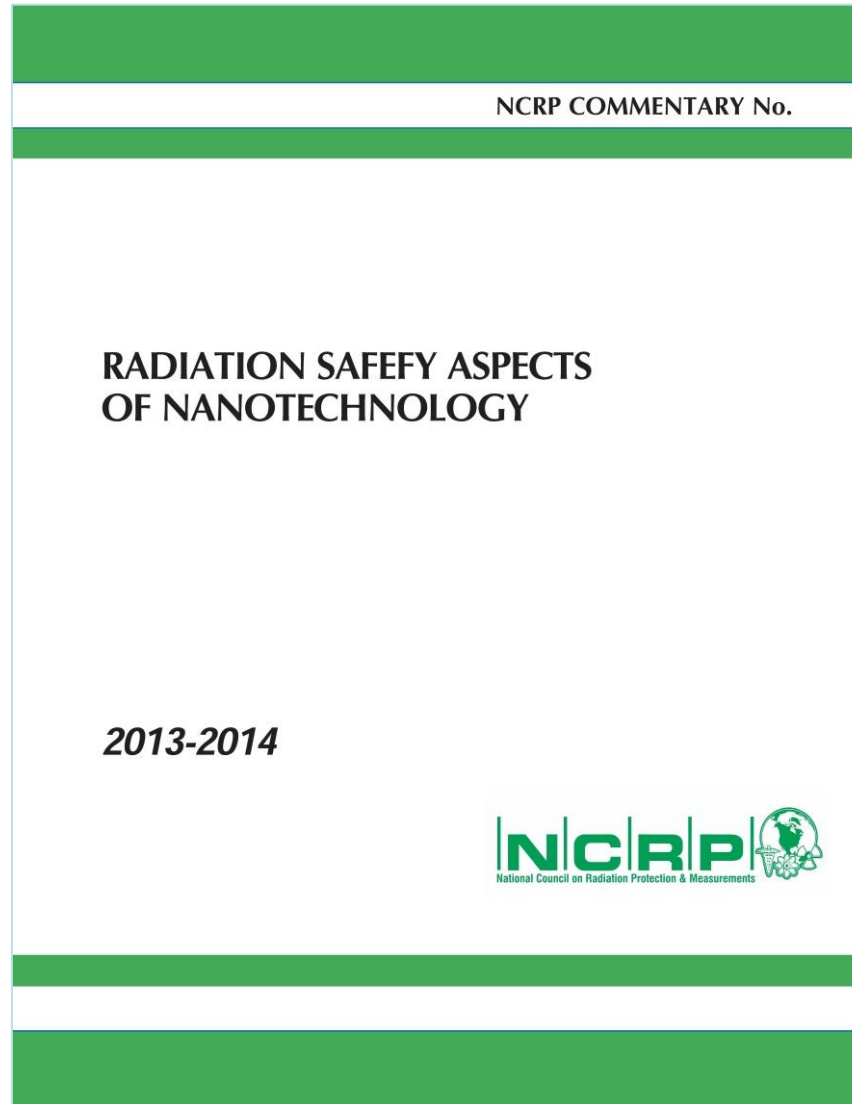
TMS
The Minerals, Metals & Materials Society



- Nano-enabled materials for components and structures
 - Are carbon nanotubes “the new steel” ?
 - Noble-metal enrichment using Pd for self-healing of cracks
- Coatings and barriers
- Coolants
- Cooling piping
- In-core reactor applications
- Sensors
 - Physical, chemical, radiological
- Separations / Sorbents
- Enhanced concretes
 - Security applications

<http://www.tms.org/meetings/2012/nanonuclear/home.aspx>

NCRP is developing a commentary on radiation safety aspects of nanotechnology.



Commentary Objective

- Provide ***practical operational information*** for
 - radiation safety officers,
 - operational health physicists,
 - dosimetrists,
 - workers,
 - management, and
 - regulators.

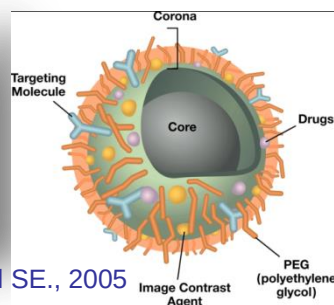
A Characterization and Informatics Challenge

Nanomaterial Diversity

Compositional diversity

Compositional diversity																		Index 2	
1		H																He	
3		Li		Be															
5		B		C															
7		N		O															
9		F		Ne															
11		Na		Mg															
13		Al		Si															
15		P		S															
17		Cl		Ar															
19		K		Ca															
21		Sc		Ti															
23		V		Cr															
25		Mn		Fe															
27		Co		Ni															
29		Cu		Zn															
31		Ga		Ge															
33		As		Se															
35		Br		Kr															
37		Rb		Sr															
39		Y		Zr															
41		Nb		Mo															
43		Tc		Ru															
45		Rh		Pd															
47		Ag		Cd															
49		In		Sn															
51		Sb		Te															
53		I		Xe															
55		Cs		Ba															
57-70		* Lu Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn																	
71		Lu		Hf															
73		Ta		W															
75		Re		Os															
77		Ir		Pt															
79		Au		Hg															
81		Tl		Pb															
83		Bi		Po															
85		At		Rn															
87		Fr		Ra															
89-102		** Lr Rf Db Sg Bh Hs Mt Uun Uuu Uub																	
103		Lr		Rf															
105		Db		Sg															
107		Bh		Hs															
109		Mt		Uun															
111		Uuu		Uub															
113		Uut		Uuq															

McNeil SE., 2005

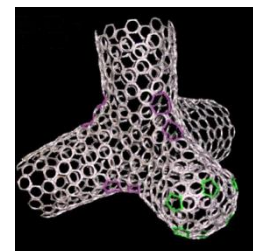
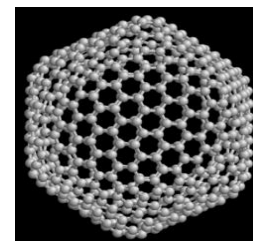


Nanomaterial Complexity

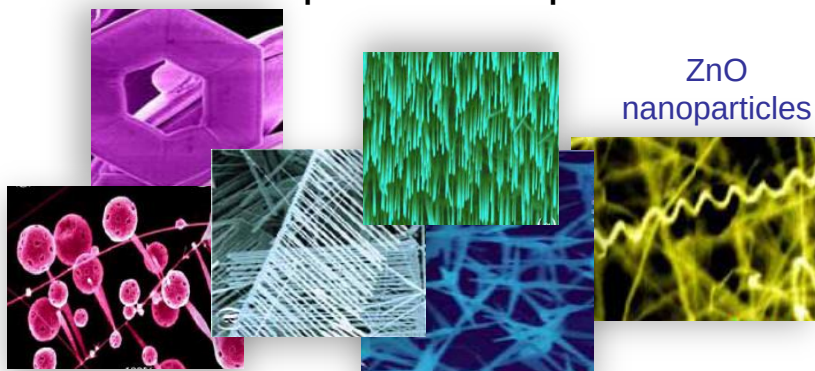
Relative importance of nanomaterial characteristics are unknown

Physicochemical properties

Chemical Structure
Core Particle Composition
Size
Shape
Charge
Surface Chemistry
Surface Area
Agglomeration State
Zeta Potential



Synthesis process influences nanoparticle shape



ZnO nanoparticles

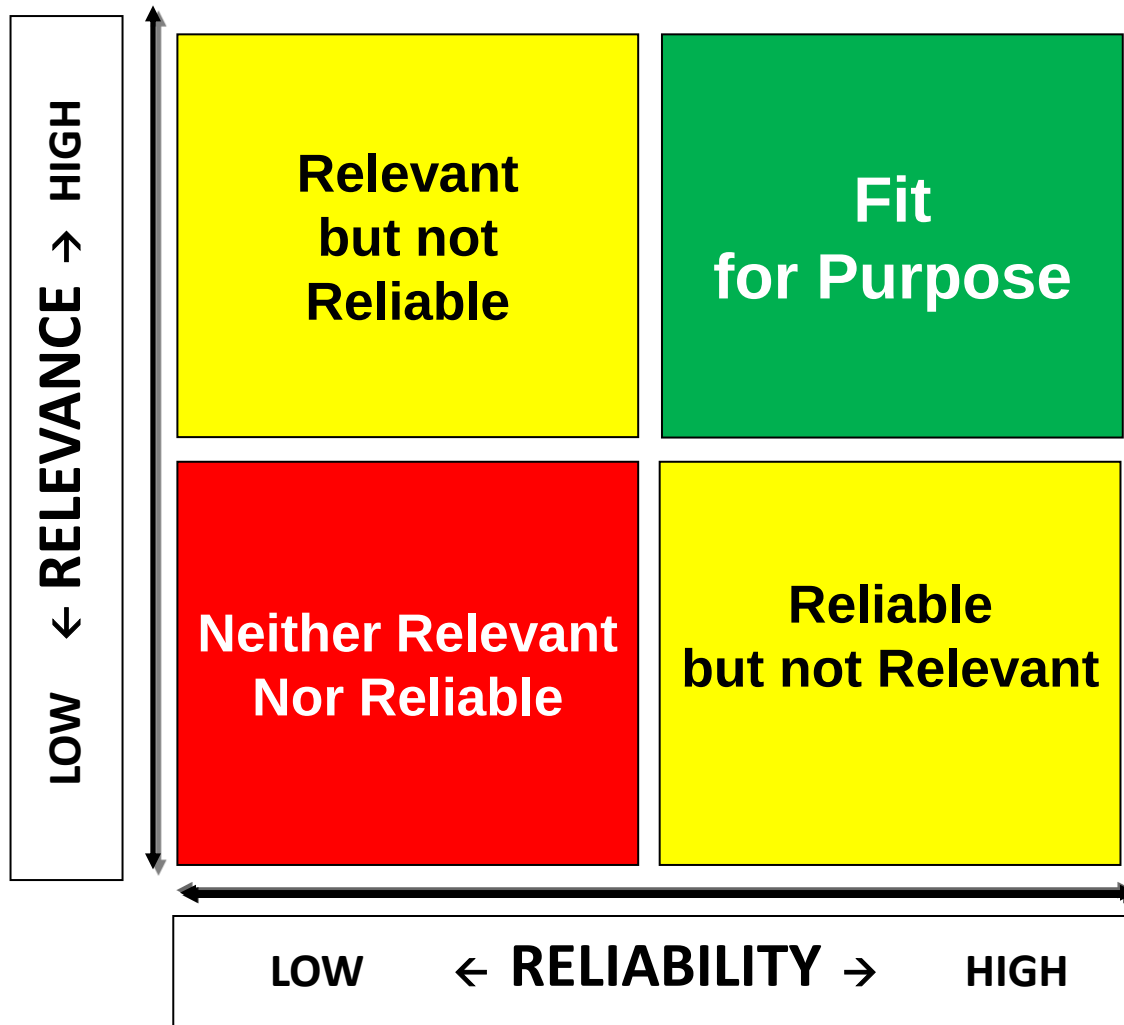
<http://www.vincentherr.com/cf/nanomaterial.html>

Nanoinformatics

(a working definition)

- The **science and practice** of determining which information is relevant to the nanoscale science and engineering community,
- and then developing and implementing effective mechanisms
- for *collecting, validating, storing, sharing, analyzing, modeling, and applying* that information.

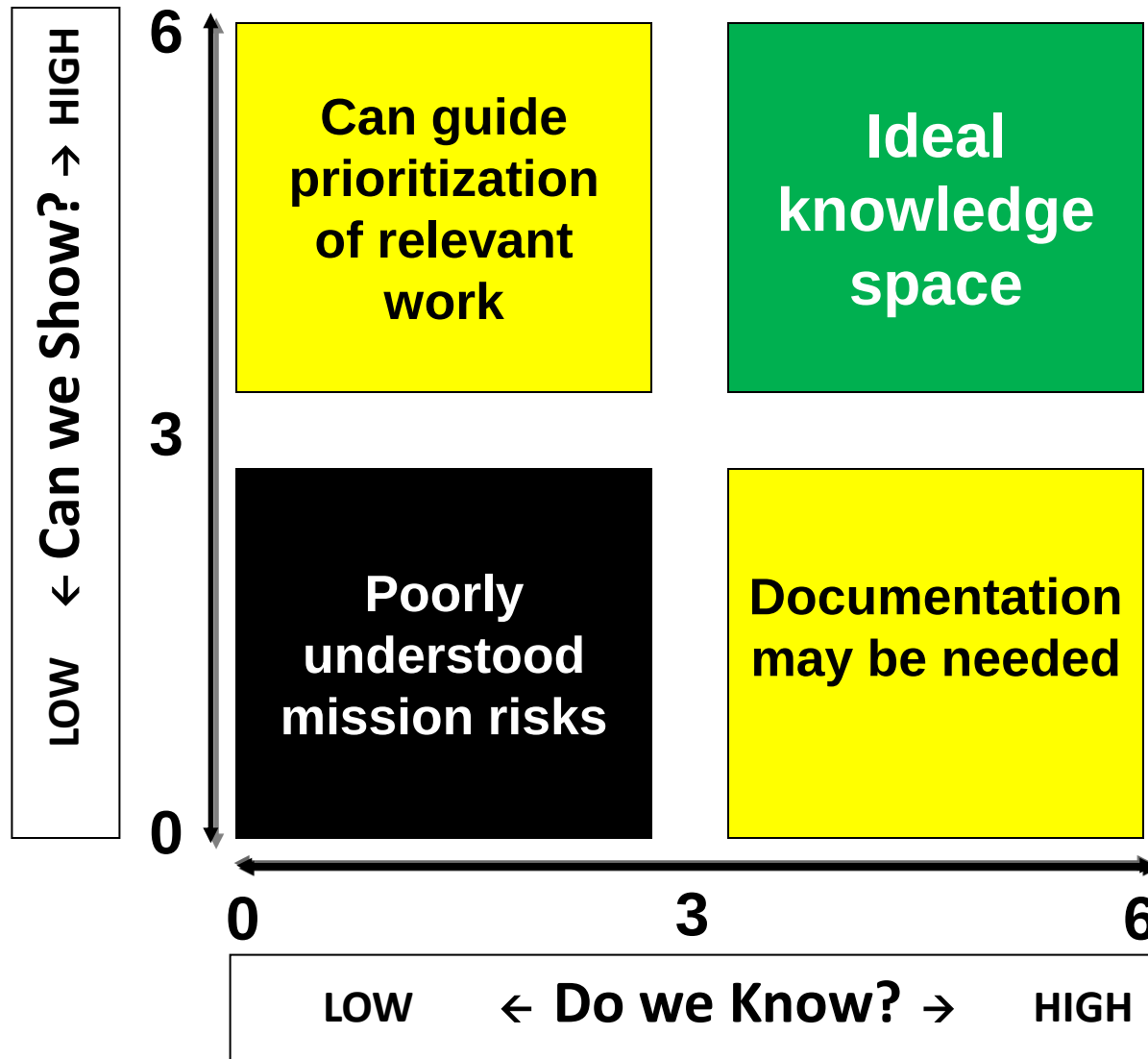
Ensuring Relevance and Reliability



We need an approach
(1) to guide fit-for-purpose development of information, and
(2) to effectively apply information developed for other purposes.

We seldom have the luxury of access to technology or data that were or will be precisely developed to meet our specific-mission objectives.

A “Know versus Show” Quadrant Approach to meet Specific Mission Objectives



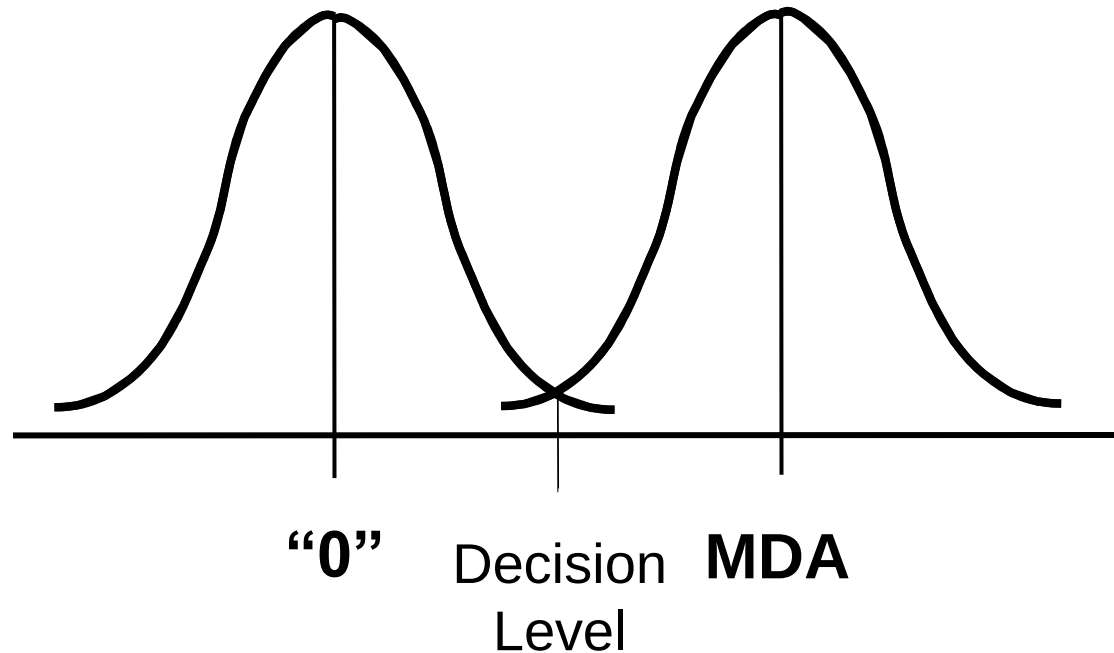
The scoring system is needed
(1) to effectively apply technology and data developed for other purposes, and
(2) to guide fit-for-purpose development of new technology and new data.

We seldom have the luxury of access to technology or data that were or will be precisely developed to meet our specific mission objectives.

Errors Affecting Decision Reliability

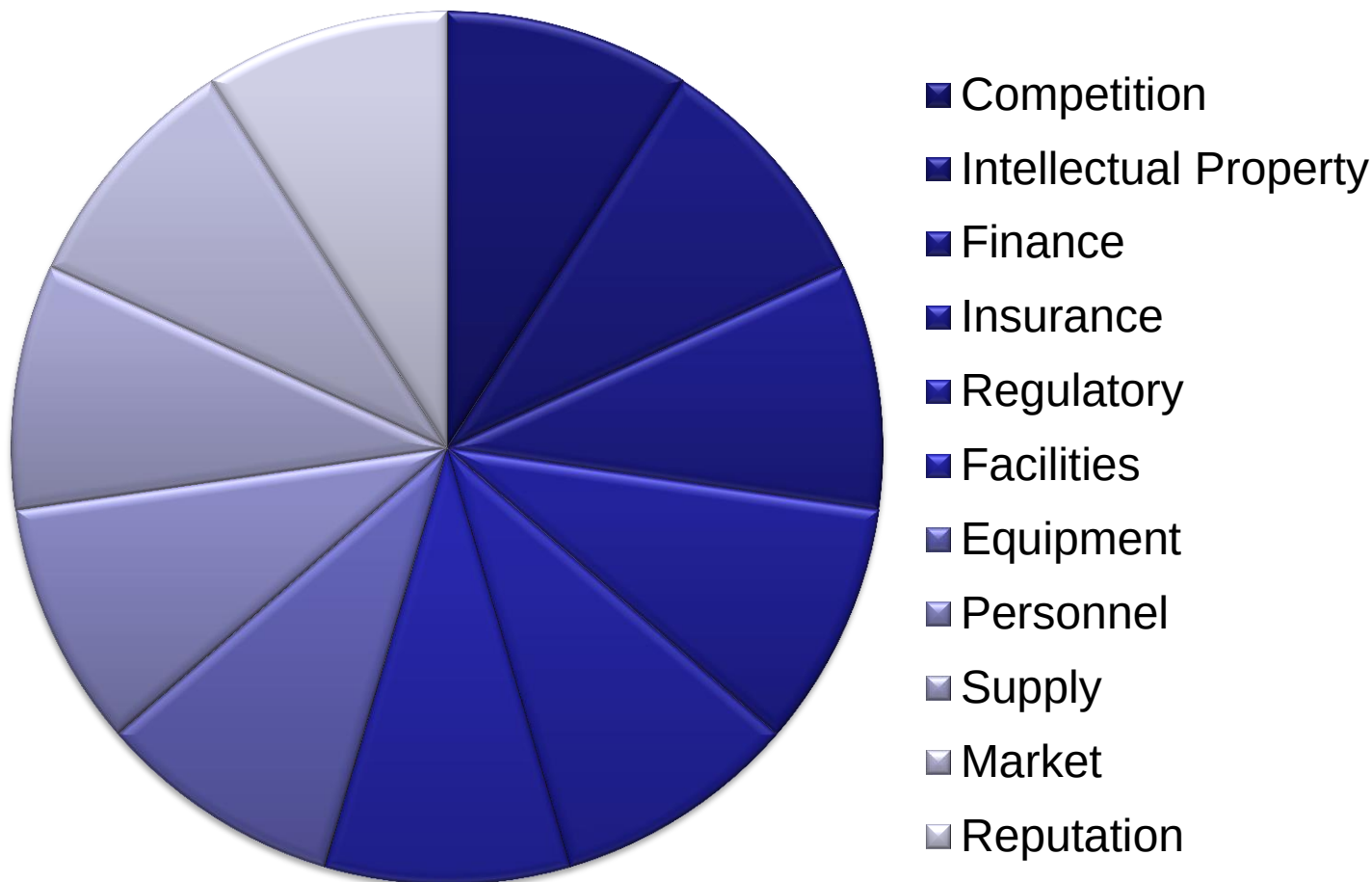
Type	Attribute
00	Lack of CLEAR objectives
0	Failure to assess uncertainty
1	False positive conclusion
2	False negative conclusion
3	Inappropriate decision level
4	Inappropriate evaluation method
5	Equating correlation and causation
6	Inappropriate extrapolation
7	Inadequate documentation
8	Mishap or misconduct

Historical View of Type I and Type II Errors



5% probability of Type I Error (false positive)
5% probability of Type II Error (false negative)

Competing Risk Priorities



**What are the “value” and priority
of health protection and health promotion?**

Definition

Organizational risks are:

- threats,
- negative effects, or
- problems

which can occur

following an event or an action
in a company or an organization.

Competing Priorities for Assessment and Management of Organizational Risks

Risk → Resource ↓	Loss or Damage	Denial of access	Other
Intellectual Property			
Finance and Insurance			
Regulatory Approval			
Facilities and Equipment			
Human Resources	?	?	?
Supply and Market Chains			
Reputation			

Threats to organizational resources:

- Competition
- Natural disasters
- Mishaps
- Misconduct (including scientific)
- Sabotage
- Theft
- Legal and regulatory challenges
- Risk to reputation
- Other

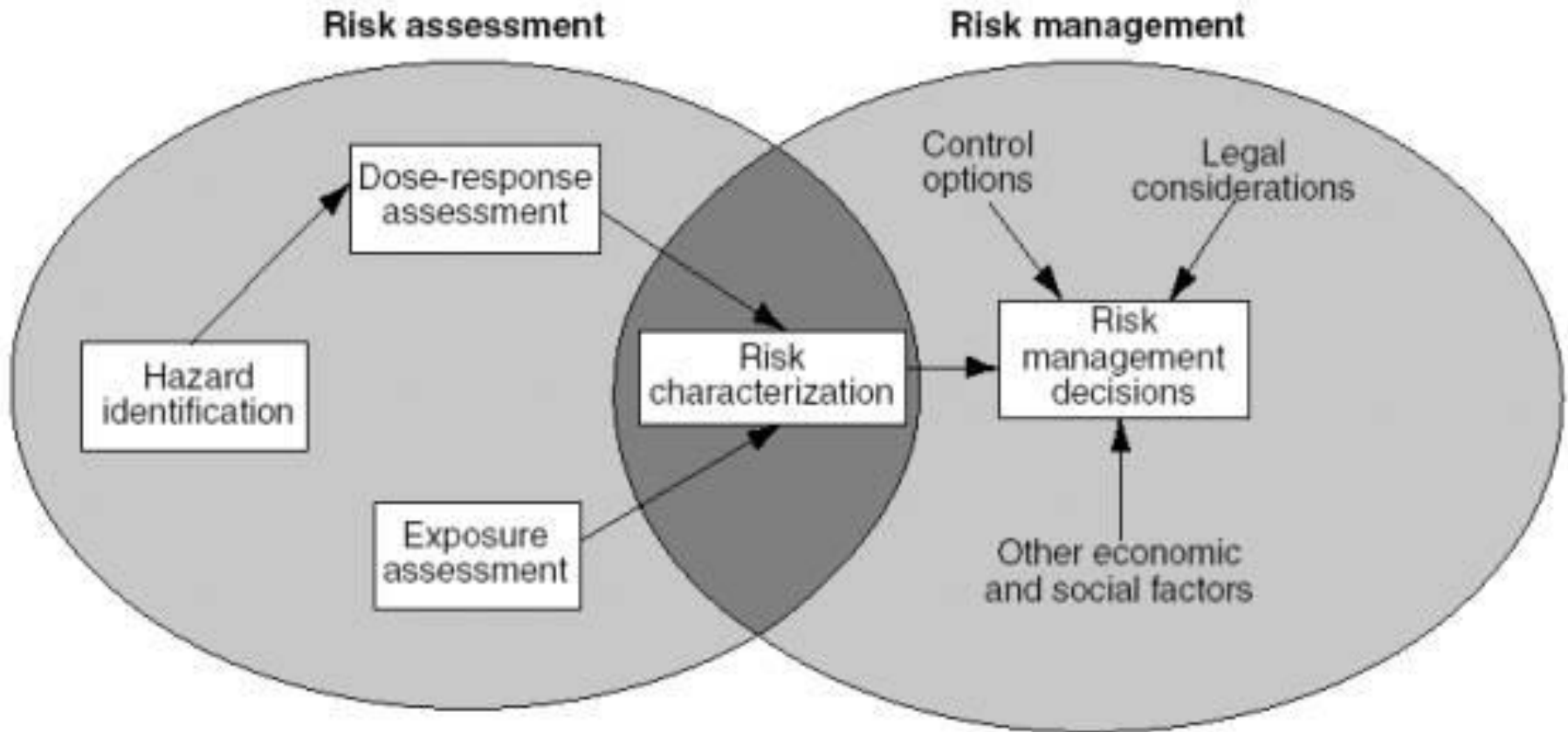
Where are risk assessment and management priorities currently placed?

What is the “*value*” of occupational safety, health, and well-being?

Does OSH have appropriate recognition and “*a seat at the table*” ?

Traditional Risk Assessment Paradigm

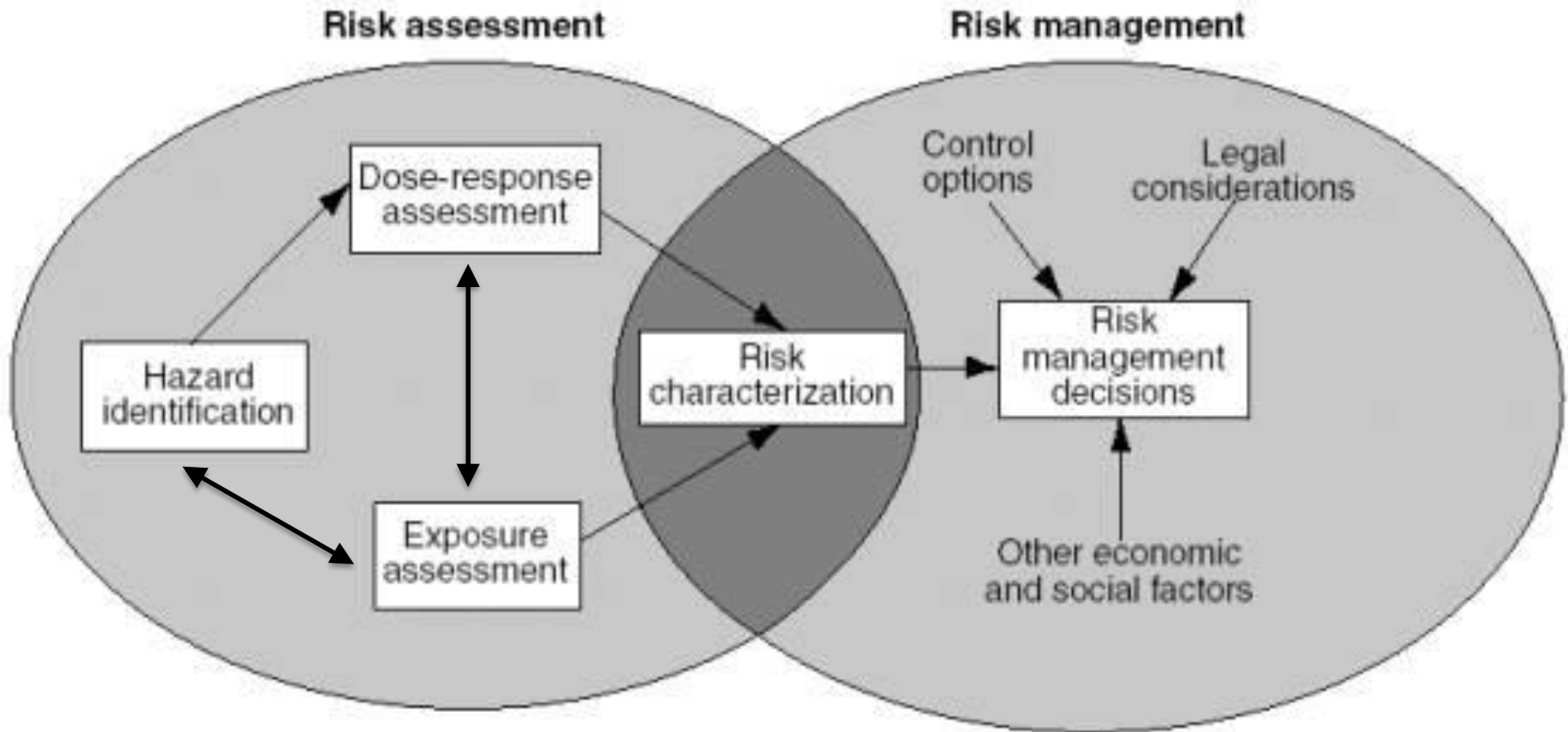
(with implied interactions among exposure assessment, hazard identification, and dose-response assessment)



Reference: National Research Council. 1983. Risk assessment in the federal government. Managing the process. National Academy Press, Washington, DC.

Adaptive Risk Assessment Paradigm

(with explicit interactions among exposure assessment, hazard identification, and dose-response assessment)



The interactive feedback relationships among exposure assessment, hazard identification, and dose-response assessment are explicitly conveyed.

Communication and Education Message and Audience Planning Tool for (insert project name)

	Workers	Health and safety practitioners	Management	Policy makers and regulators	Equipment and system vendors	Materials suppliers	Finance community	Insurers	Legal community	Researchers	Educators	Students	Emergency Responders	Media	Consumers	Society
Literacy and Critical Thinking																
Real Life Examples																
Understanding (not rote application)																
Continuous Improvement																
Modeling and Sharing																
Assessment																

Suggested Informatics Guidelines for Preventing Injury and Disease*

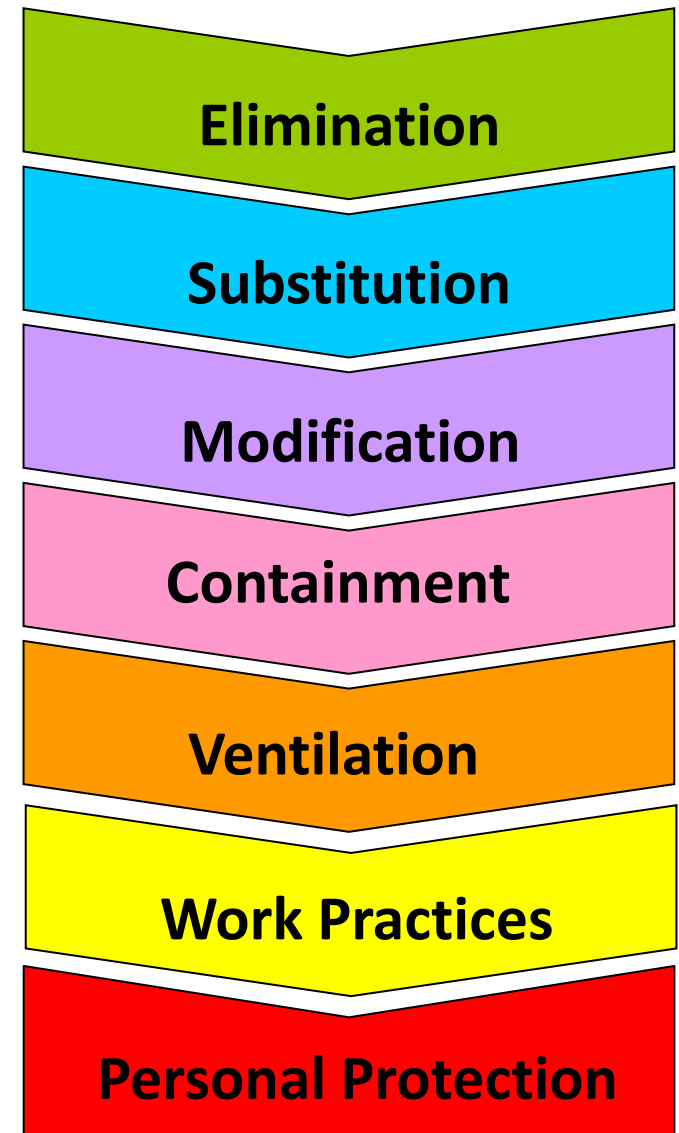
1. Emphasize literacy and develop critical thinking;
2. Develop and use real-life data examples;
3. Stress conceptual understanding rather than mere application of procedures;
4. Foster continuous improvement and active discussions;
5. Use technology for developing conceptual understanding and for analyzing and sharing information (e.g., modeling and simulation, databases, wikis, etc.);
6. Use assessments to improve and evaluate the efficacy and impact of these activities.

*as adapted by Mark Hoover from the American Statistical Association (ASA)
“*Guidelines for Assessment and Instruction in Statistics Education (GAISE)*”
which are available at <http://www.amstat.org/education/gaise/> .

Current Challenges

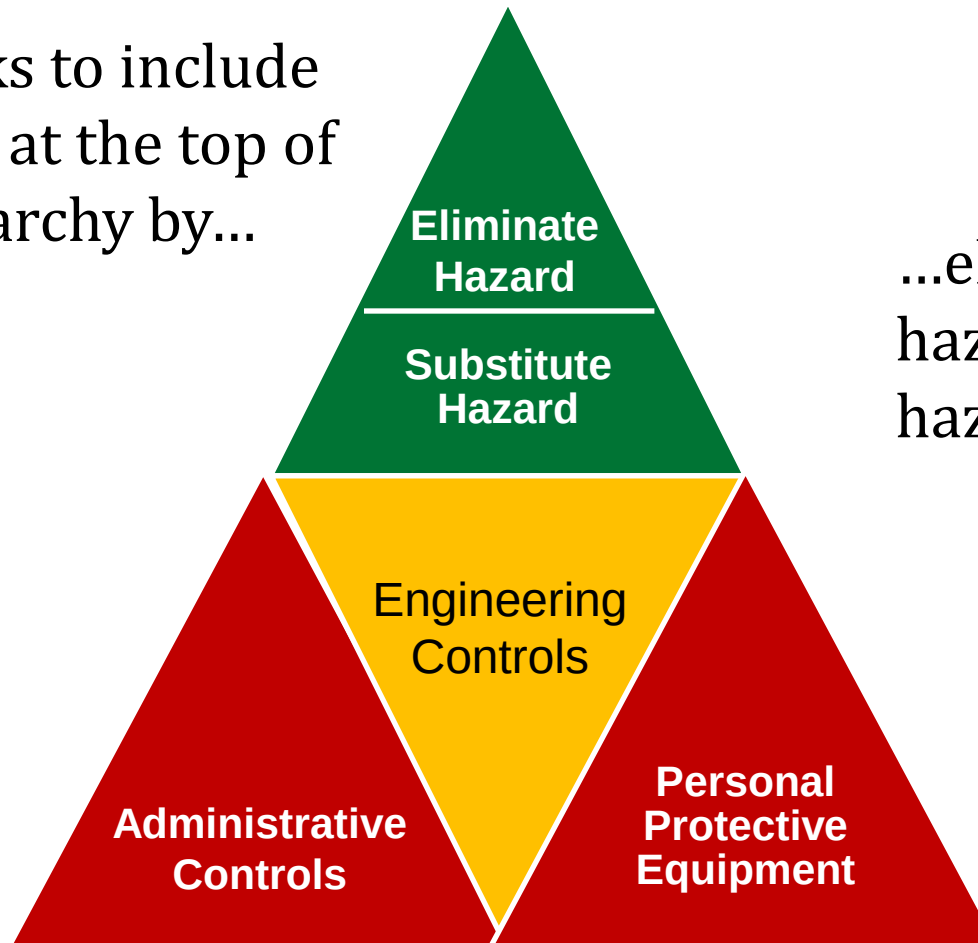
- The traditional risk assessment and management strategy requires an occupational exposure limit (OEL).
- OELs for radioactive materials are based on a unified concept of dose.
- Such a unifying concept is not available for all hazards that can affect total worker health.
- How can an effective hygiene program for all stressors be developed and implemented in the absence of comprehensive OELs?
- What control approaches are feasible and effective?

Hierarchy of Exposure Control Practices



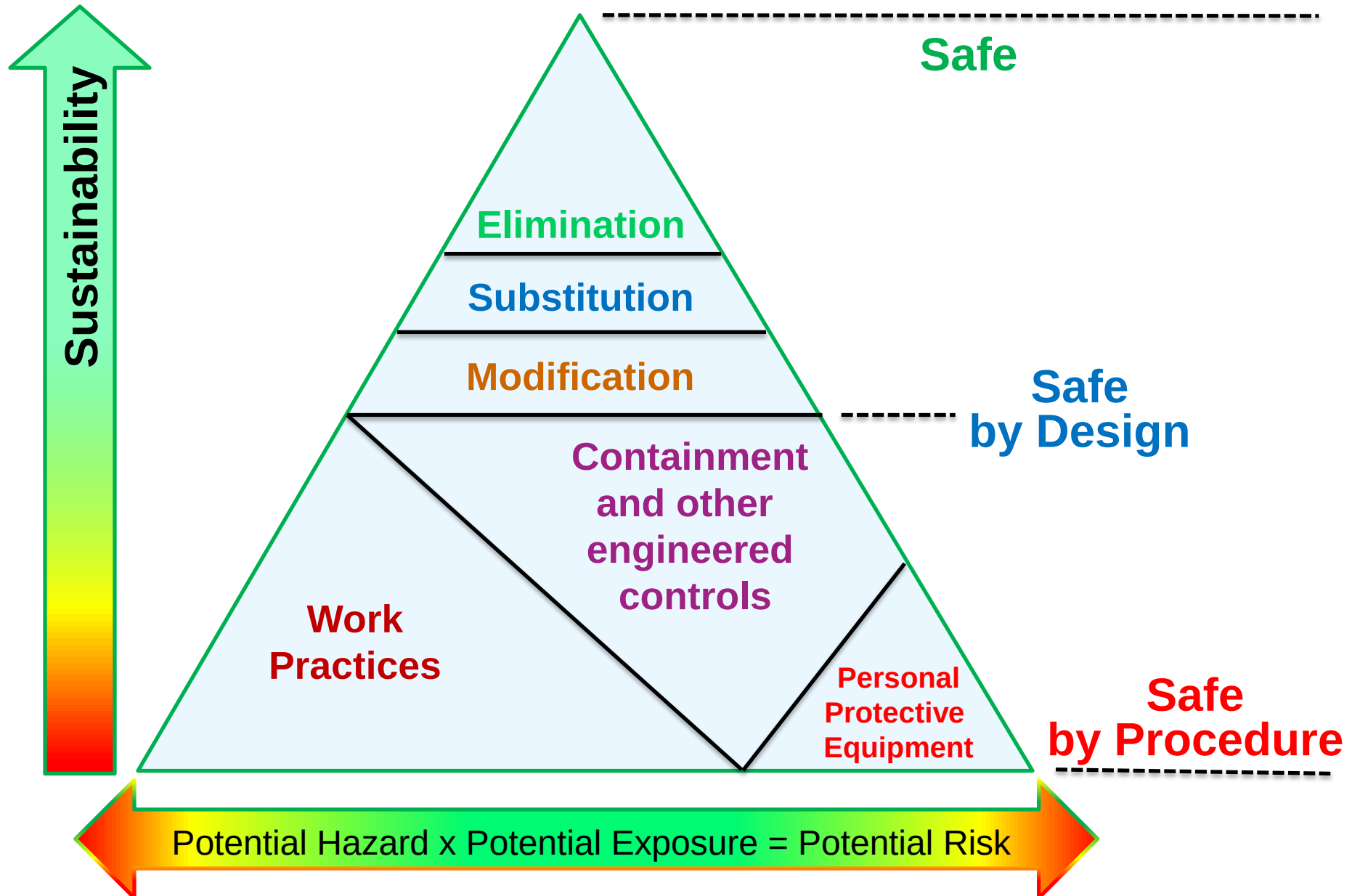
Prevention through Design Concept

PtD seeks to include controls at the top of the hierarchy by...

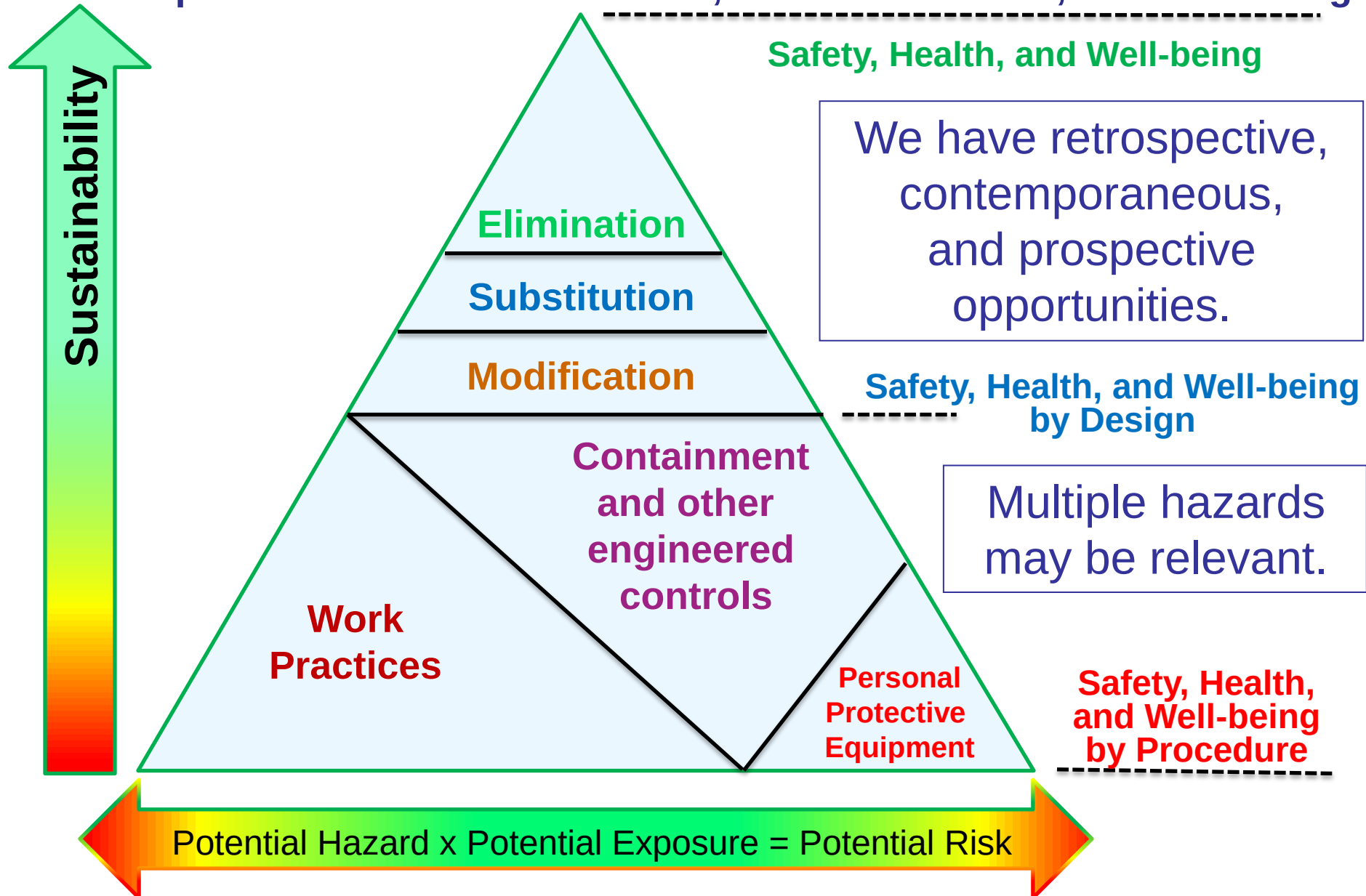


...eliminating the hazard or minimizing hazardous exposures

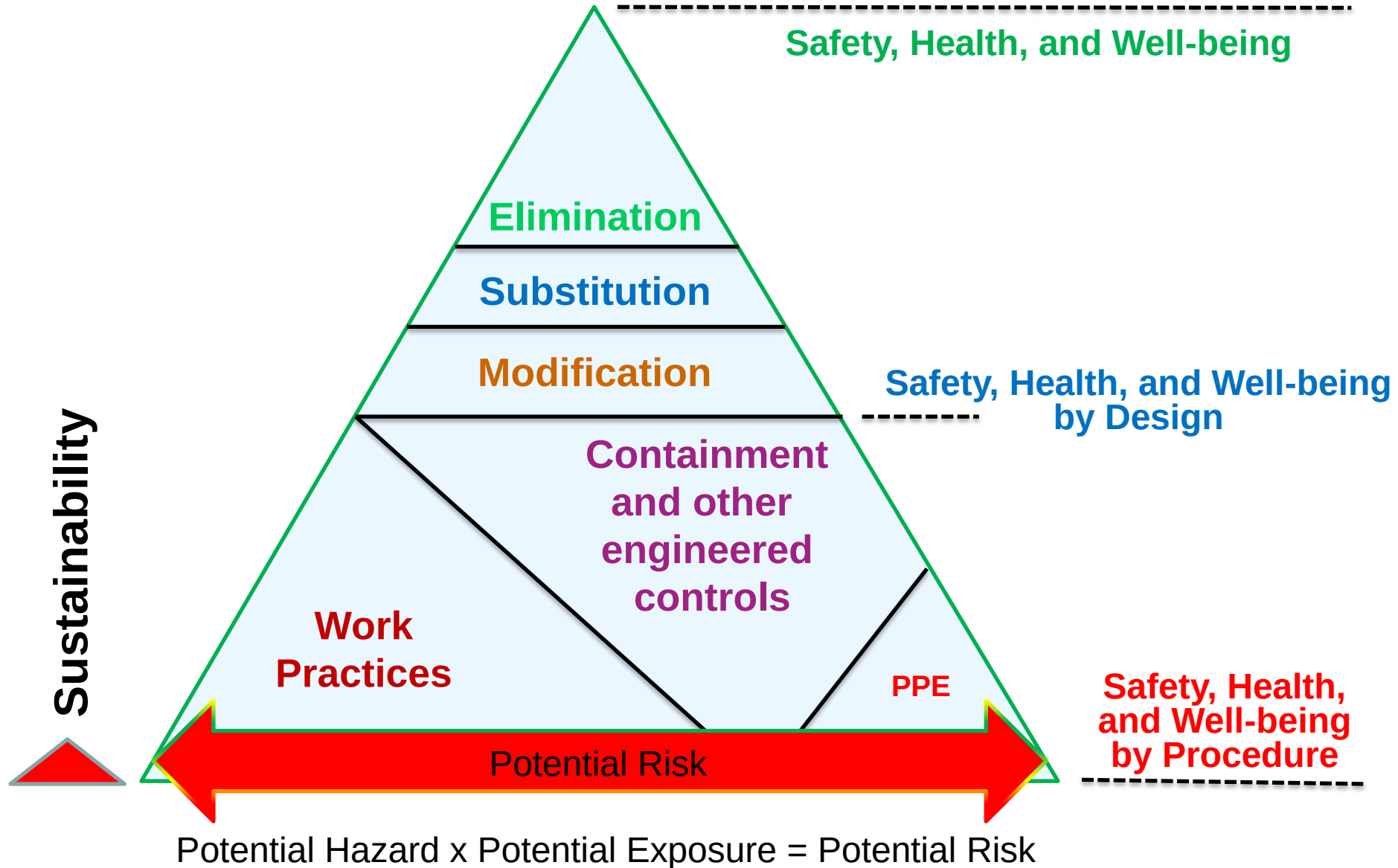
Hierarchy of Hazard and Exposure Control



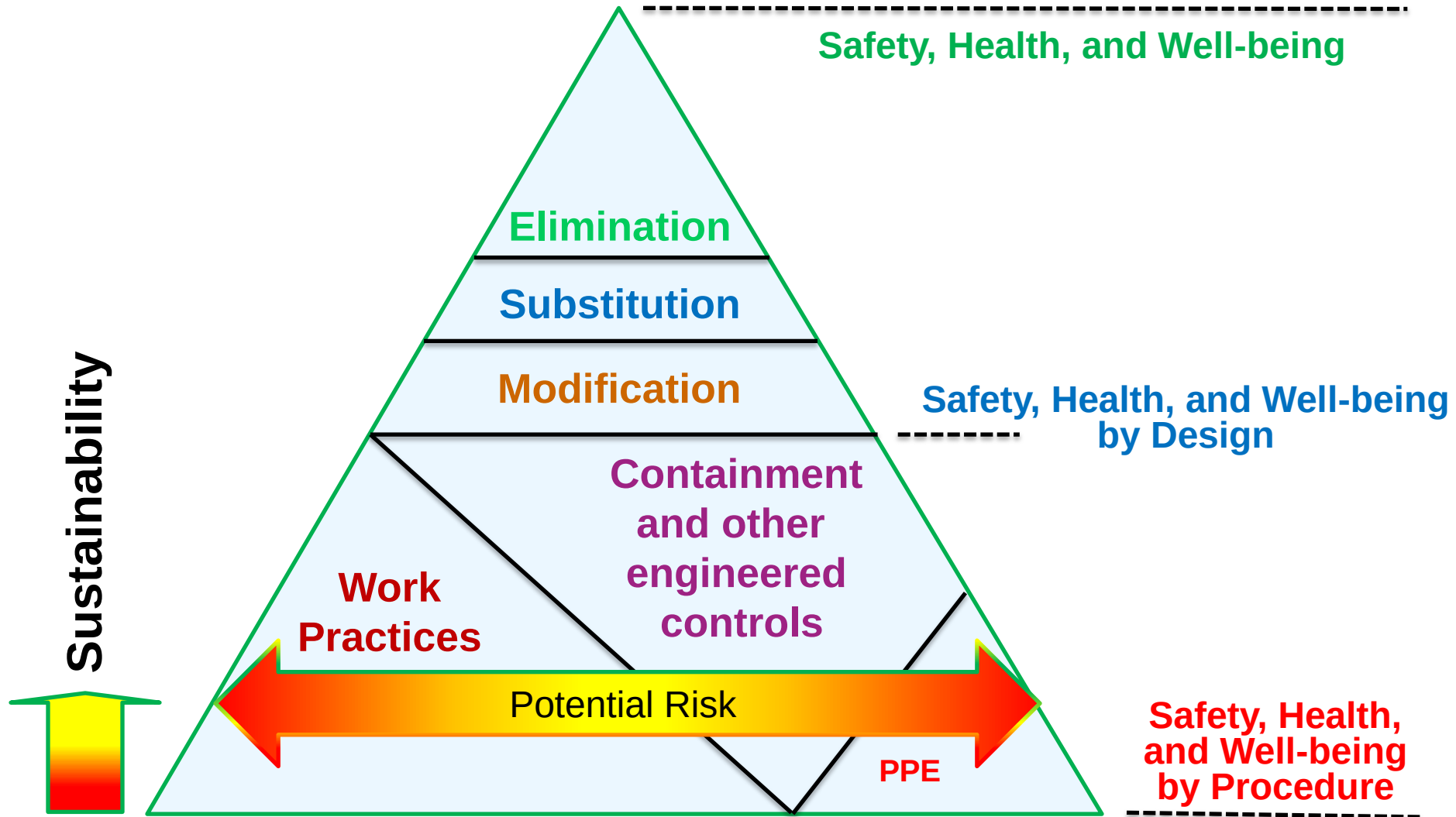
A Hierarchical Vision of Hazard and Exposure Control for Comprehensive Health Protection, Health Promotion, and Well-being



A Hierarchical Vision of Hazard and Exposure Control for Comprehensive Health Protection, Health Promotion, and Well-being

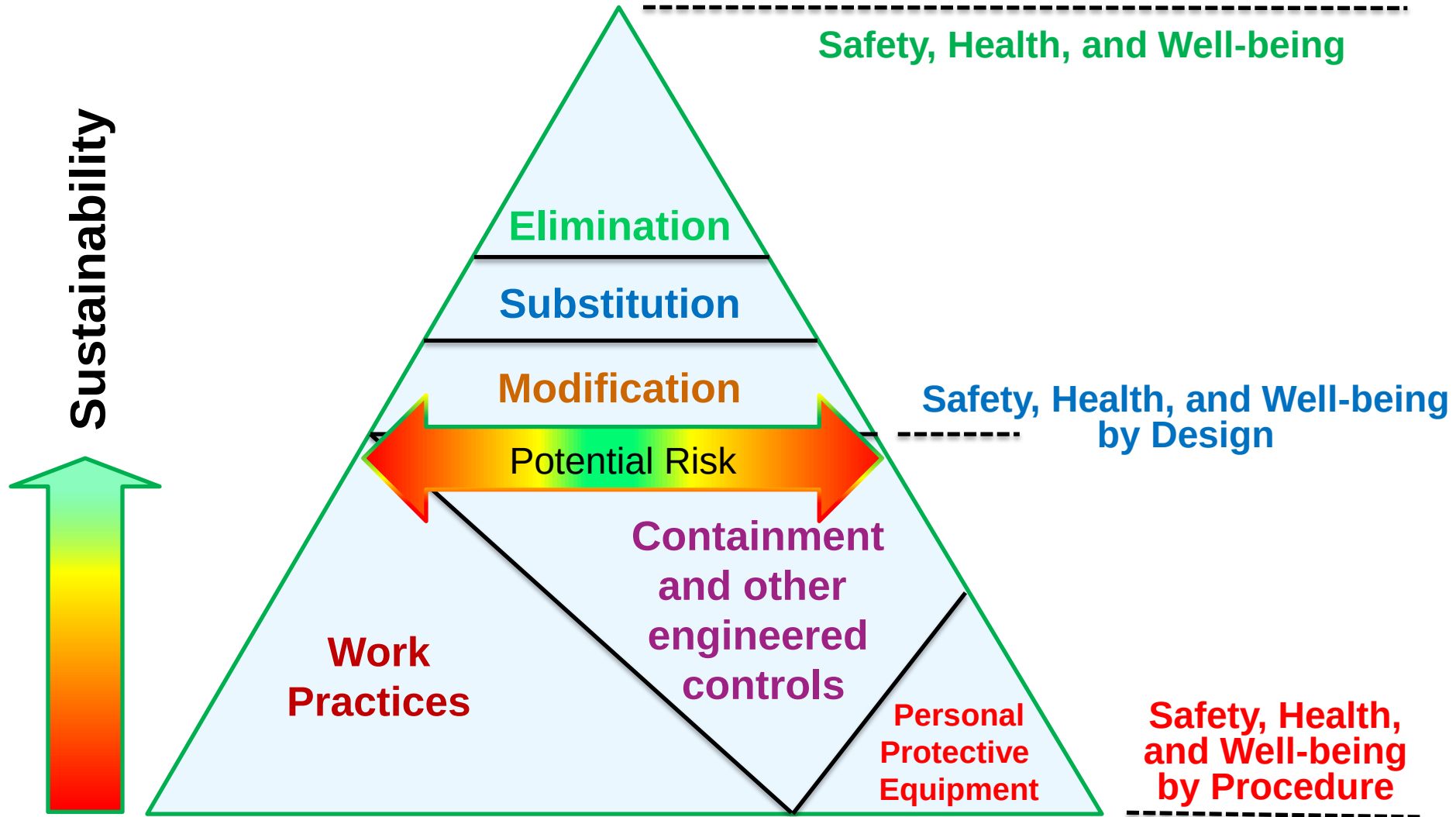


A Hierarchical Vision of Hazard and Exposure Control for Comprehensive Health Protection, Health Promotion, and Well-being



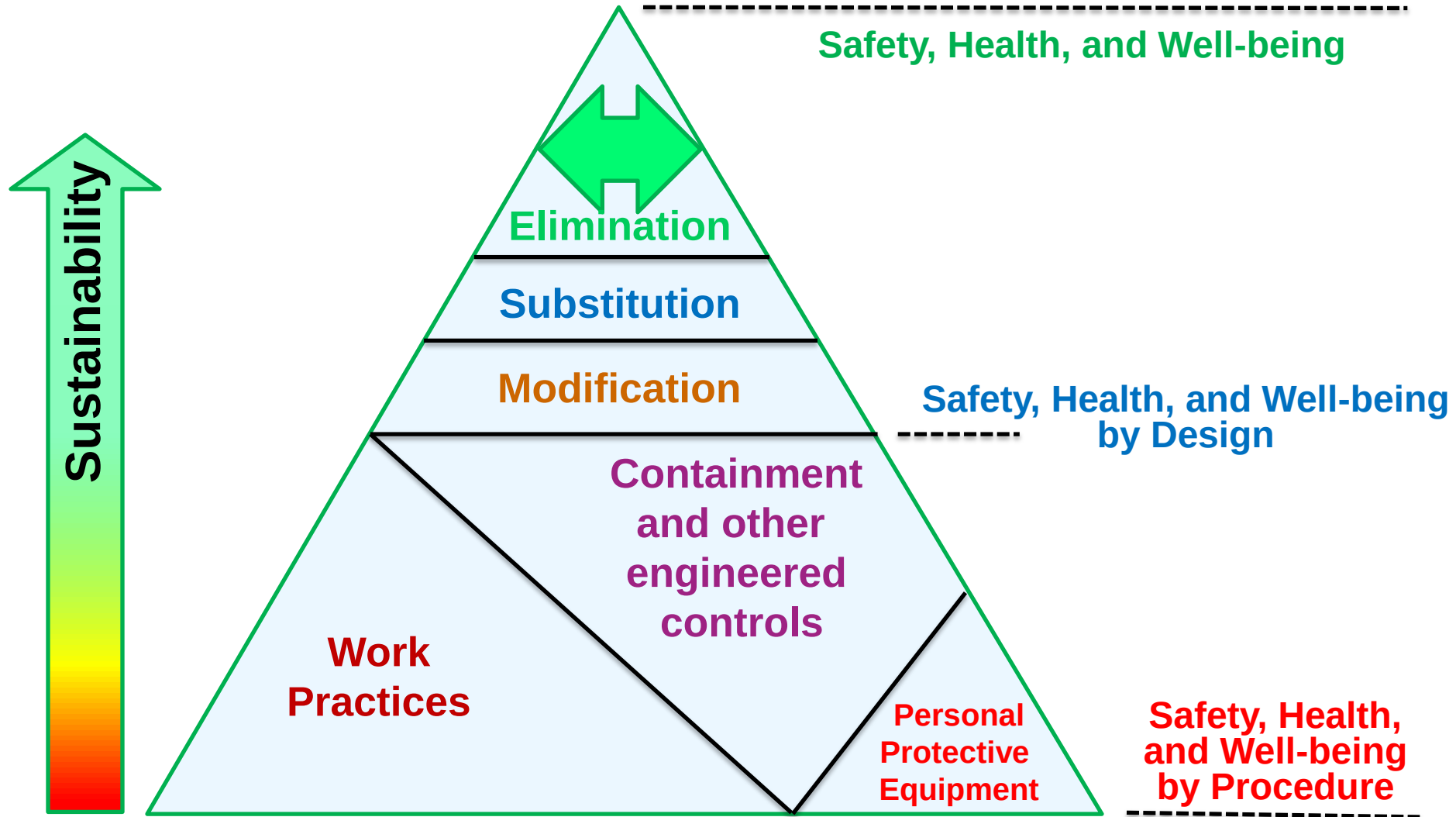
Potential Hazard x Potential Exposure = Potential Risk

A Hierarchical Vision of Hazard and Exposure Control for Comprehensive Health Protection, Health Promotion, and Well-being



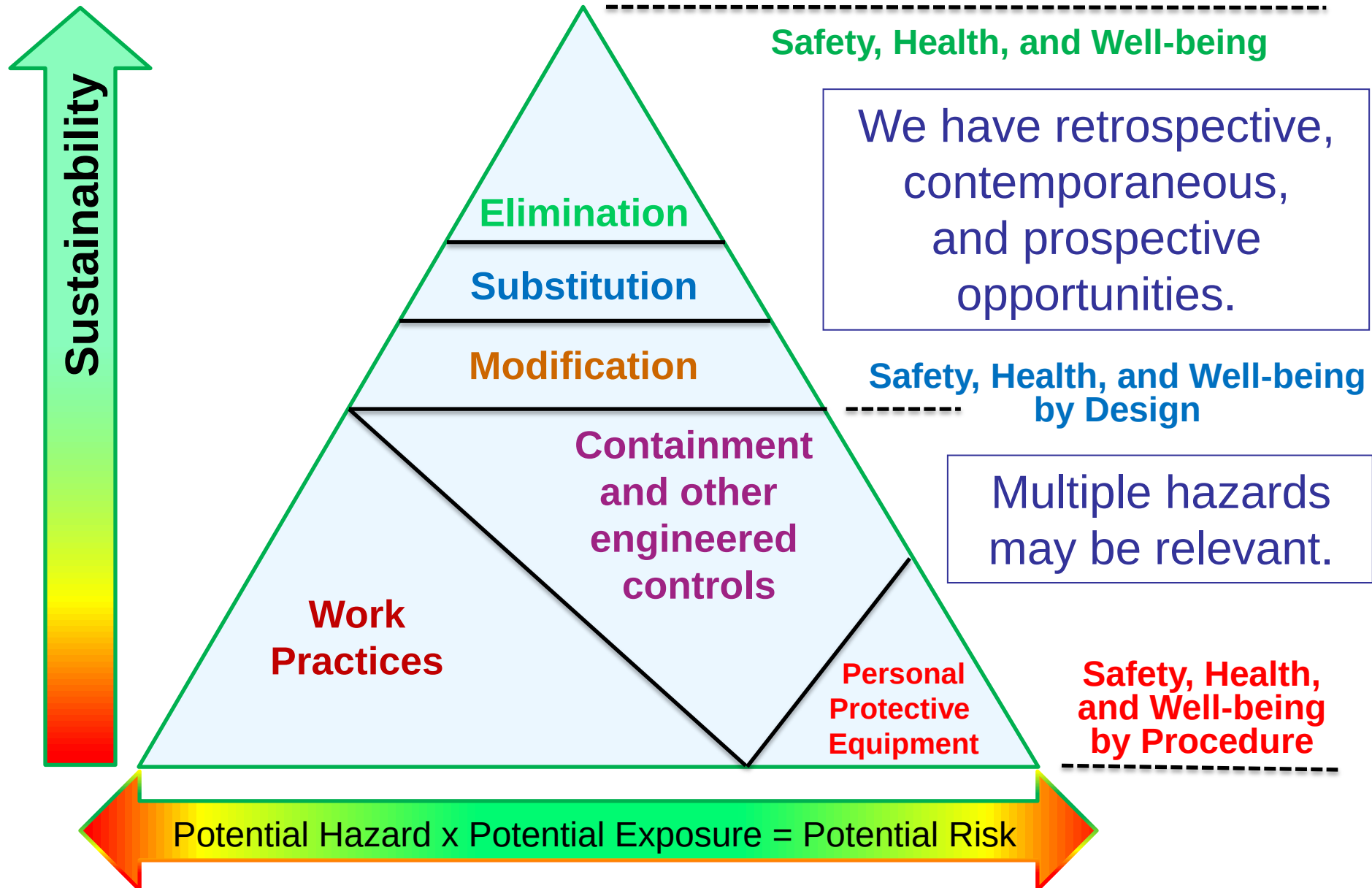
$$\text{Potential Hazard} \times \text{Potential Exposure} = \text{Potential Risk}$$

A Hierarchical Vision of Hazard and Exposure Control for Comprehensive Health Protection, Health Promotion, and Well-being



Potential Hazard x Potential Exposure = Potential Risk

A Hierarchical Vision of Hazard and Exposure Control for Comprehensive Health Protection, Health Promotion, and Well-being



Current Safety Message



After the paperwork,
after the pre-job,
before you begin the work,
take 2 minutes for you.



WHAT COULD GO WRONG?

WHAT DIDN'T I THINK OF?

IS ANYTHING MISSING?

DO I HAVE THE RIGHT TOOLS?

DO I HAVE THE REQUIRED TRAINING?

NOW DO THE JOB !

Possible Complementary Message for Total Well-being



While using TAKE2 4U
for safety at work,
also take a few
moments each day to:



Minimize stress.
Choose healthy foods.
Get some exercise.
Ensure adequate rest.
Get support when needed.

GO FOR TOTAL
WELL-BEING !

We can partner to develop a *comprehensive* risk management scheme to:

- **Anticipate,**
- **Recognize,**
- **Evaluate,**
- **Control, and**
- **Confirm**



Hoover et al., Synergist, 22(1): 10, 2011

*success in our mission through management
of hazards, exposures, and risks to safety, health, and well-being
by applying a science-based approach
to understanding and managing
the **critical elements**
over which we have control.*

A LANL implementation example

ENVIRONMENT SAFETY HEALTH

As the Laboratory experts in Environment, Safety, and Health; our primary goal is to enable and support mission success.

Our disciplines include Radiation Protection; Environmental Stewardship and Sustainability; Occupational Medicine; Industrial Hygiene and Safety; and Waste Management.

Our experts are integrated and partner with our science, technology, and engineering leaders across the Laboratory to help ensure our status as the premier national security science laboratory.



ANTICIPATE



RECOGNIZE



EVALUATE



CONTROL



CONFIRM



SUCCESS

ENABLING MISSION SUCCESS

BY PROTECTING OUR WORKERS, THE PUBLIC,
AND THE ENVIRONMENT

Acknowledgments

to many colleagues for useful discussion and input over many years

- Nathan Baker
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- Sharon Gaheen
- Chuck Geraci
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- Stacey Harper
- Donna Heidel
- Laura Hodson
- Ryan Hoover
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- John Iskander
- Michelle Johnson
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- Rick Niemeier
- Jim Neton
- Vladimir Murashov
- Carey Newton
- George Newton
- A.J. O'Sickey
- Michele Ostraat
- Alison Parks
- Terri Pearce
- Michael Phibbs
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- Paul Schulte
- James Slawski
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- Abbas Virji
- Martha Waters
- Robert Watters
- Bob Welsh
- Ainsley Weston
- David Weissman
- Gary Whitney
- Ralph Zumwalde



Questions ?

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