Strategy for Nanotechnology-related Environmental, Health and Safety Research

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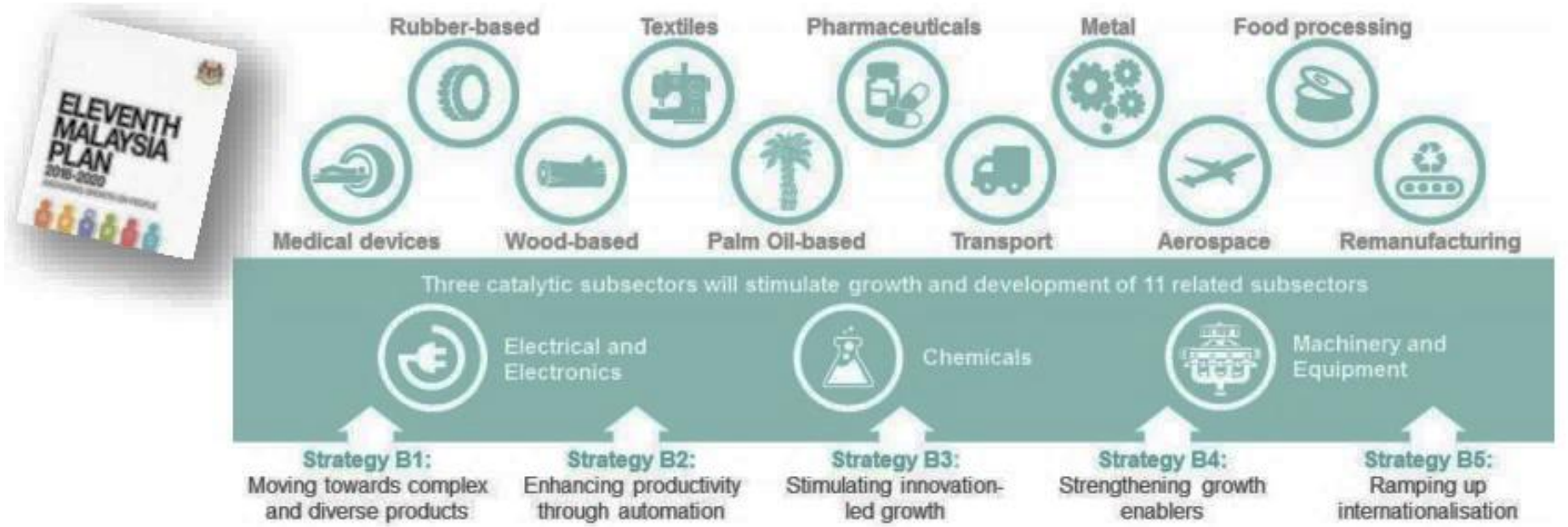
Regional Conference on Nanotechnology for Safe and Sustainable Development
& Consultative Meeting on Proposed Nanosafety Netowrking Platform
02 – 04 May, 2017

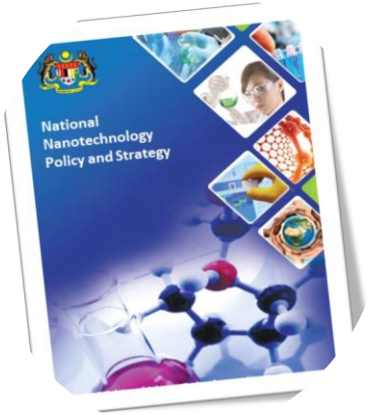
Eleventh Malaysia Plan (2016-2020)



- **Three (3) catalytic subsectors** namely **E&E, Chemicals and M&E industries**; and **two (2) subsectors** of high potential growth namely **Aerospace and Medical devices** have been identified in the 11th MP to drive the growth of the manufacturing sector.
- The **3 + 2 subsectors** were selected due to their strong inter-linkages with other subsectors and indirectly their capacities will be the base to support the development of the overall manufacturing sector.

Resources: Economic Planning Unit and Ministry of International Trade and Industry

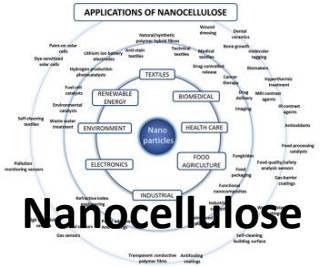
Eleventh Malaysia Plan (2016-2020)



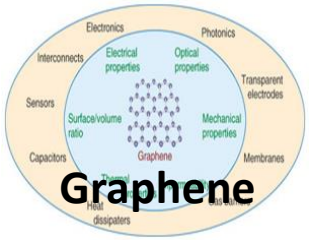
National Nanotechnology Policy and Strategy

Nanotechnology Strategic Thrust Areas for 11th Malaysia Plan (2016-2020)

Long Term Research Strategy for 11th Malaysia Plan (2016-2020)

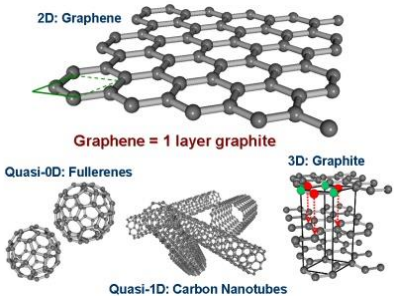


Nanocellulose



Graphene

Road Mapping 2020 and Beyond



National Graphene Action 2016- 2020

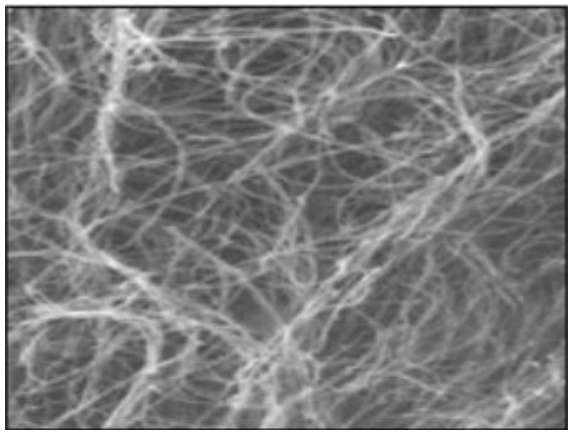
Nanosafety and Regulatory Program

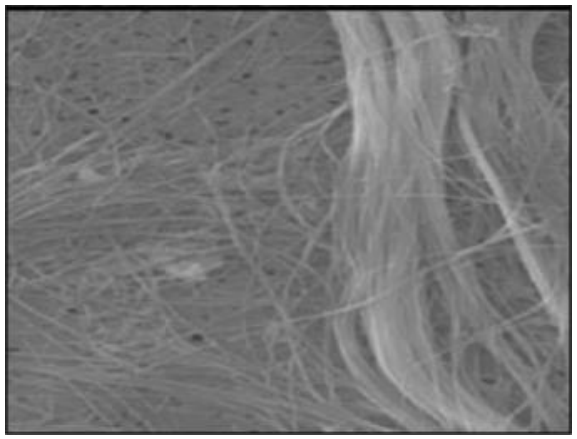
BBC NEWS

Toxic warnings for nano industry

By Jonathan Fildes
BBC News science and technology reporter

Inhalation of the asbestos fibres caused lung diseases and cancers



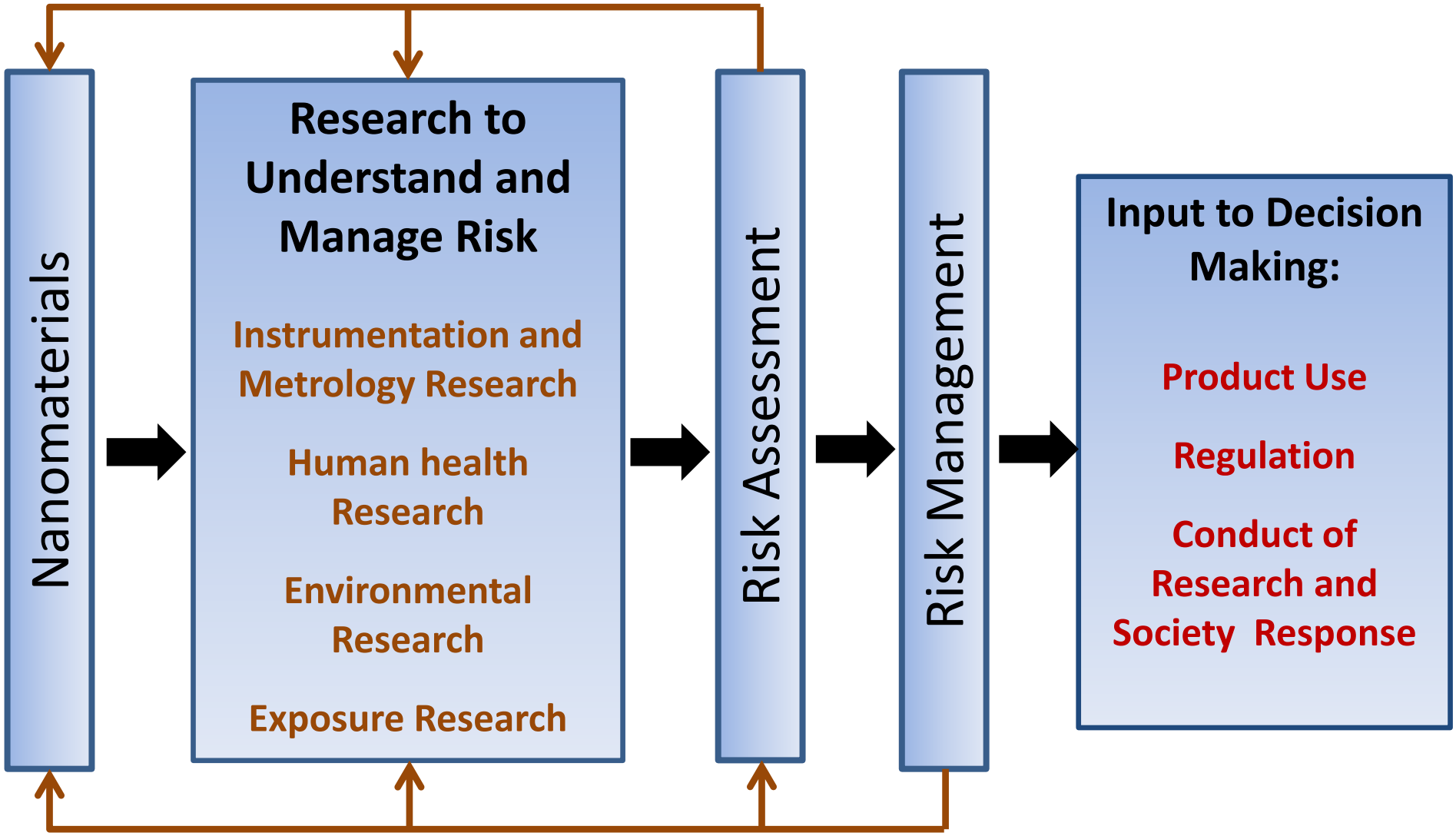


Carbon nanotubes (Left) show similarities with asbestos (Right)

Historical lessons:

Nanoparticles could become the asbestos of the 21st century**?**

EHS research in Risk Management of NMs



Strategy for Nanotechnology related EHS

- **Instrumentation & Metrology**
- **NMs & Human Health**
- **NMs & the Environment**
- **Human and Environmental Exposure Assessment**
- **Risk Management**
- **Frameworks for addressing EHS Research Needs**

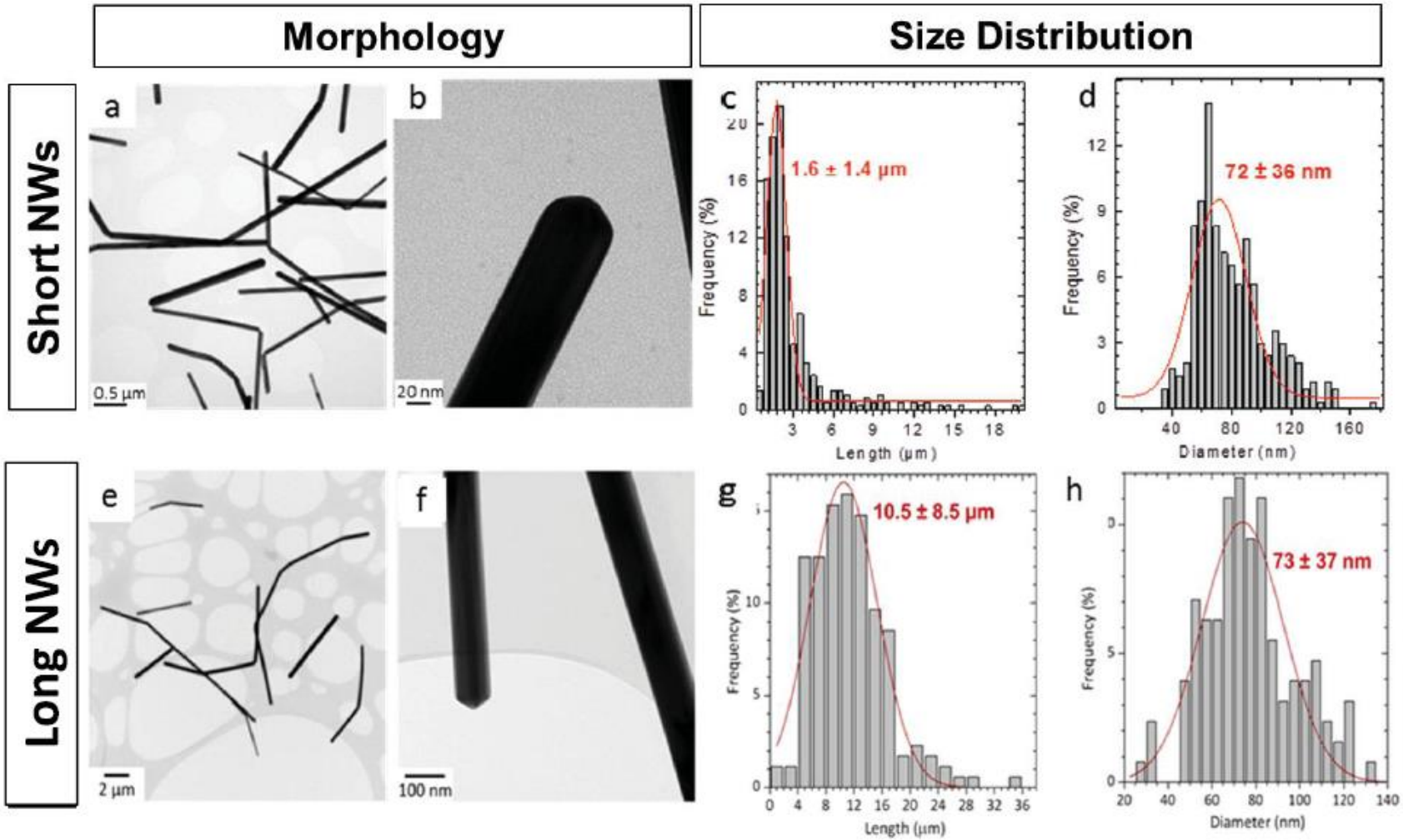
Studies concentrated on "manufactured nanomaterials" have the highest priority

Instrumentation & Metrology

Prioritised EHS Research needs:

- Develop method to detect nanomaterials (NMs) in biological matrices , the environment and the workplace
- Understand how chemical and physical modifications effect the properties of NMs
- Develop certified reference materials for chemical and physical characterisation of NMs
- Develop methods to characterise a nanomaterial's spatio-chemical composition, purity and heterogeneity
- Develop methods for standardising assessment of particle size, size distribution, shape, structure and surface area

Physicochemical Characterisation



Physicochemical Characterisation

Nanostructure Property	Characterization Technique(s)
Size / size distribution / Aggregation	TEM, SEM, DLS
Morphology	TEM , SEM
Surface Area	TEM
Chemical Composition	ICP-MS, Raman
Phase Information	XRD, TEM
Surface Chemistry	XPS, UPS, FT-IR, Inverse Gas Chromatography
Surface Charge / Adsorption	Zeta potential , IR, UV-vis
Dissolution Kinetics	Electrochemistry, ICP-MS, XAS

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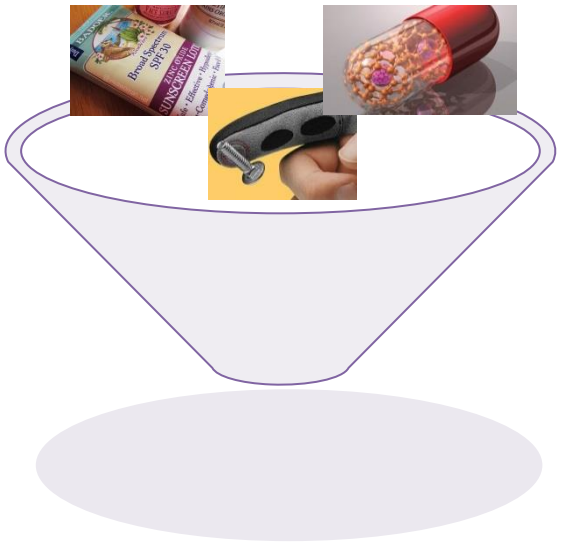

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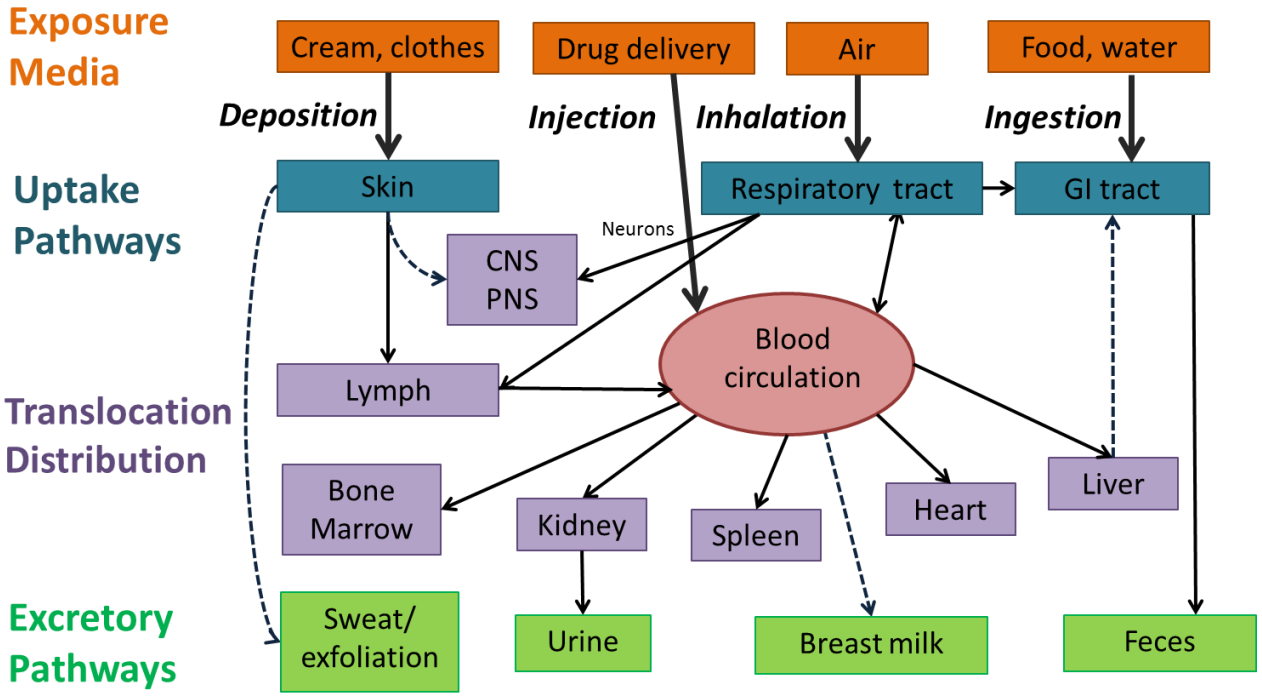
Nanomaterials & Human Health

Research Need #1:

Understand the absorption and transport of NMs throughout the human body



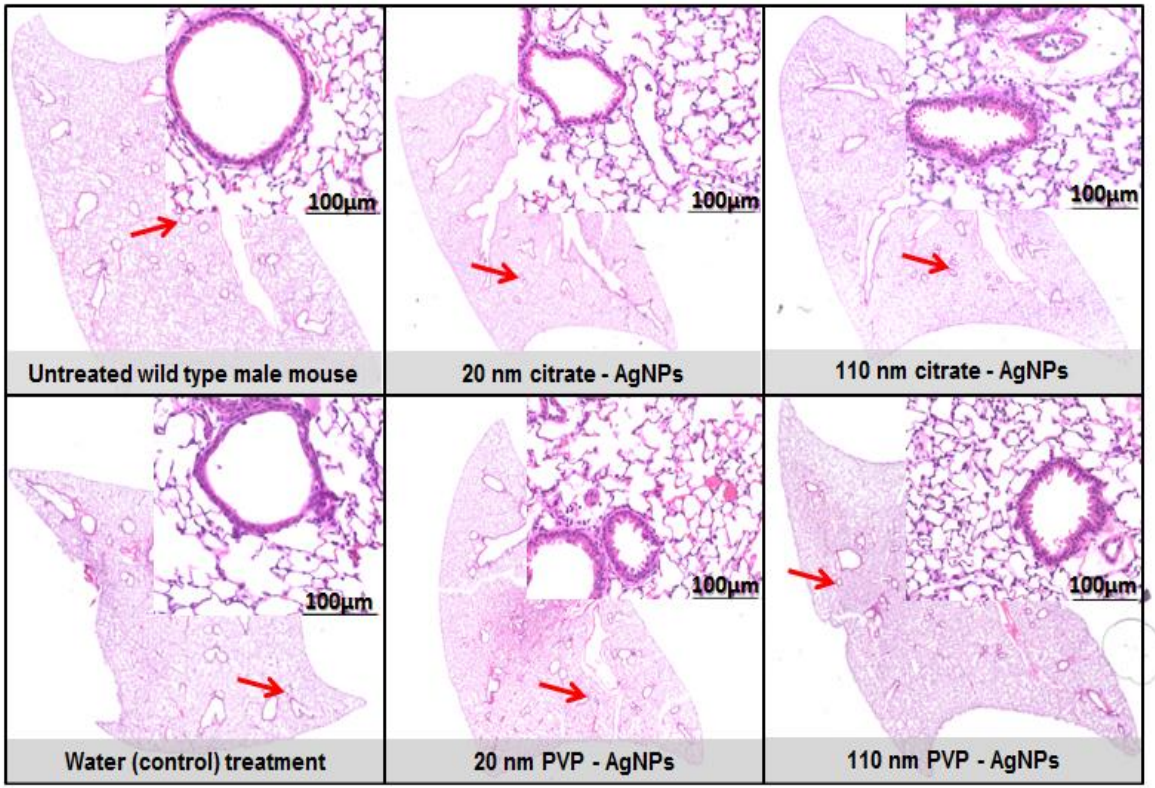
*CNS: Central nervous system; PNS: Peripheral nervous system

- Interaction of NMs with exposure organ
- Metabolism or biological transformation of materials
- Translocation out of the exposure organ
- Mechanism of transport through the body and excretion route

Nanomaterials & Human Health

Research Need #2:

Develop methods to quantify and characterise exposure to NMs in biological matrices



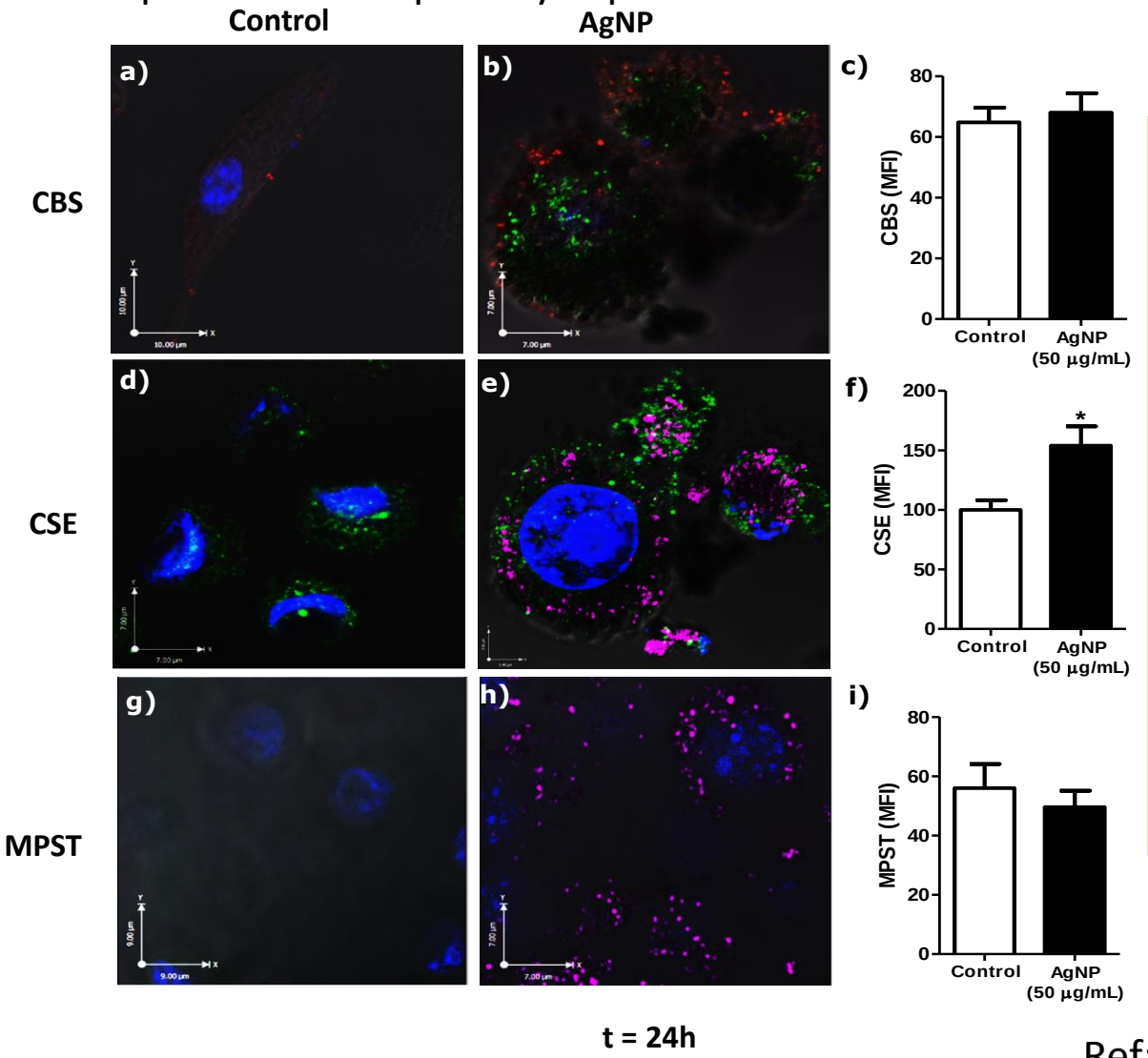
- **Determine relevant measurement parameters for each class of NMs in simple and complex biological matrices**
- Establish methods for quantification and characterisation
- Validate methods exposure route
- Develop Biomarker for exposure

Ref: Daniel *et.al.* Nanotoxicology (2015)

Nanomaterials & Human Health

Research Need #2:

Develop methods to quantify exposure to NMs and characterise NMs in biological matrices



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Ref: Leo *et.al.* Scientific report (2017)

Nanomaterials & Human Health

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3D imaging of a silver nanowires inside a macrophage

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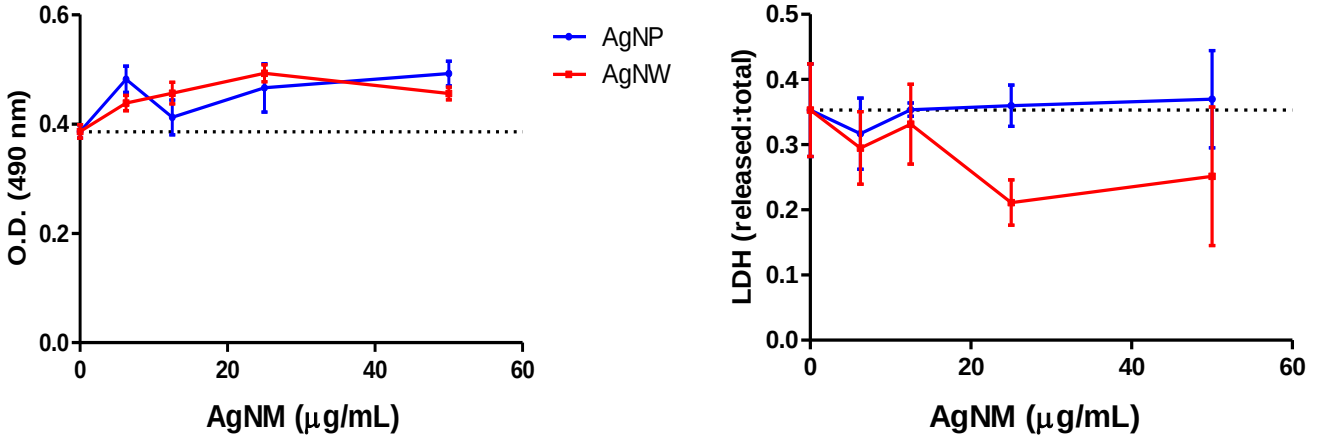
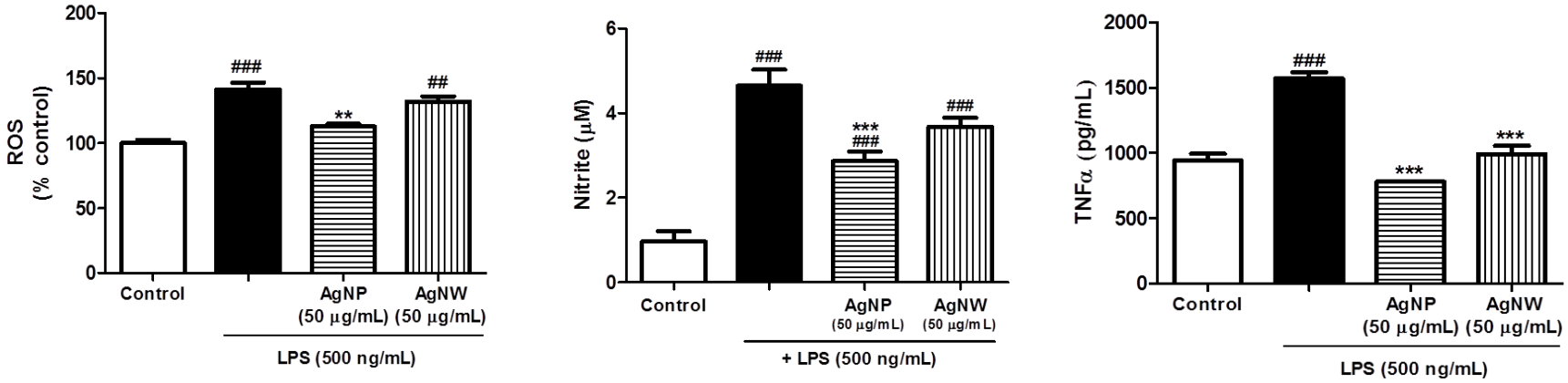
Cell viability and reactivity in response to AgNMs exposure





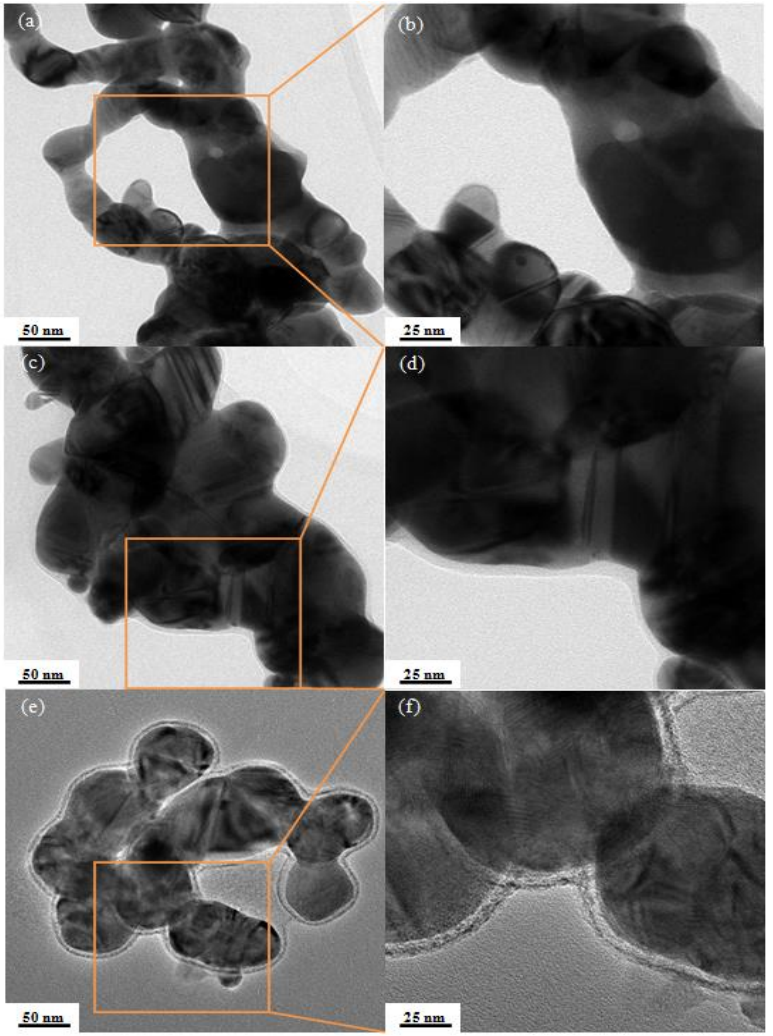
- Neither NPs nor NWs alter microglia reactivity or induce oxidative stress.
- Decrease LPS-induced microglia reactivity, reduce ROS production and cytokine release.

Nanomaterials & Human Health

Research Need #3:

Identify or develop appropriate *in vitro* and *in vivo* assays or models to predict *in vivo* human responses to NMs exposure

- **Validate existing *in vitro* and *in vivo* test methods**
- **Determine appropriate methods to suspend and administer NMs**
- Develop method to visualise NMs in biological matrices
- Develop throughput screening technologies
- Translate research data into computational models that predict toxicity *in silico*



Ref: Leo *et.al.* ES&T (2013)

Nanomaterials & Human Health

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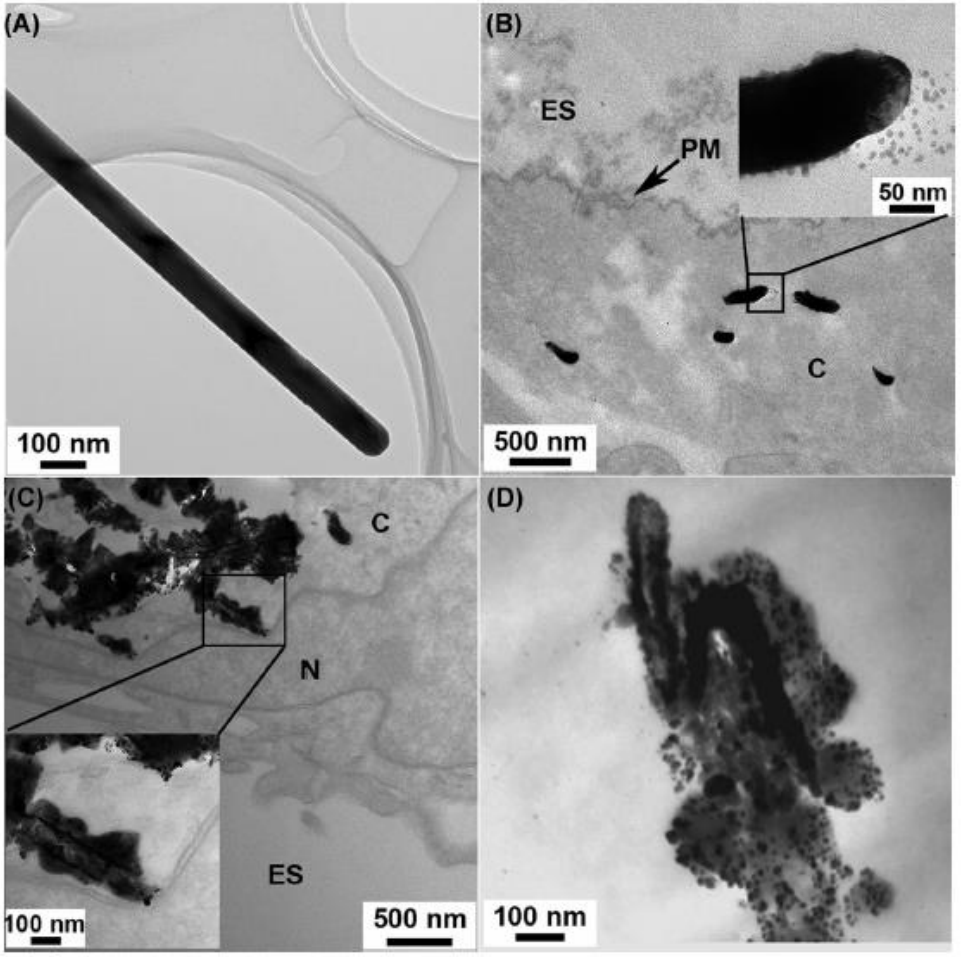

C, cytoplasm; ES, extracellular space; N, nucleus.

Ref: Shu *et.al.* Journal of MIcroscopy (2015)

Nanomaterials & Human Health

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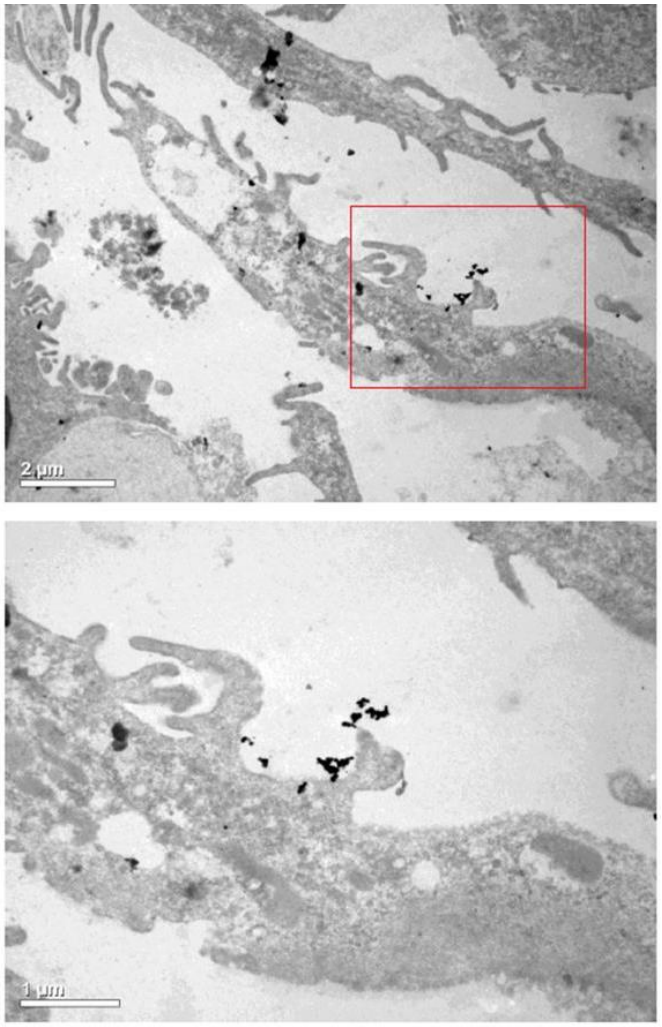
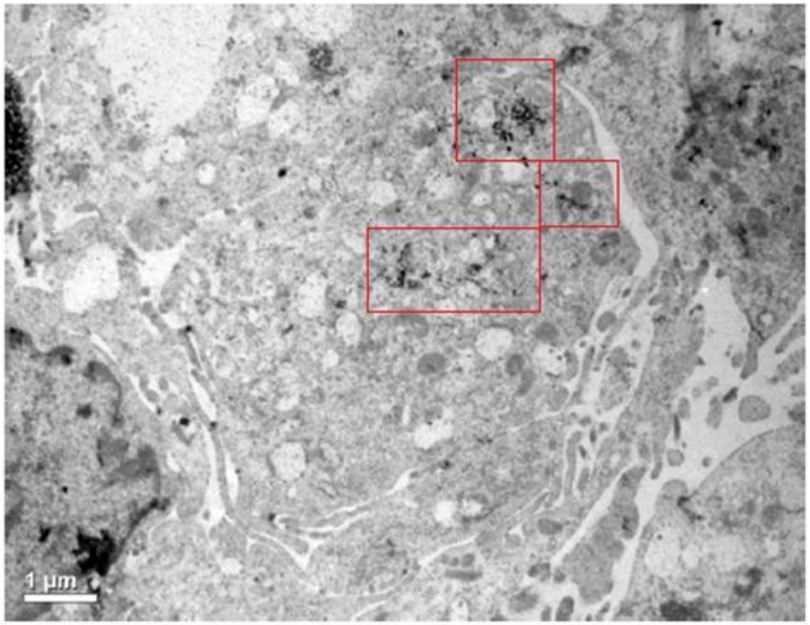
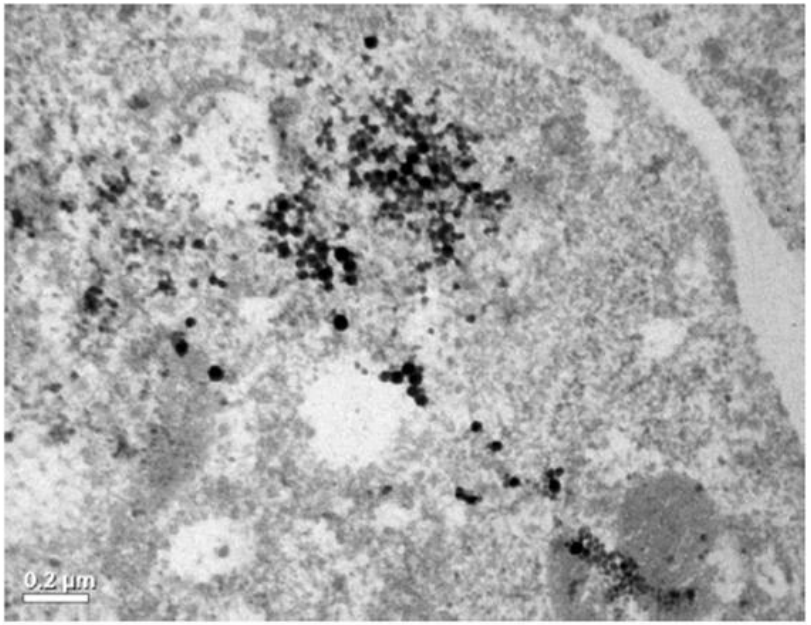
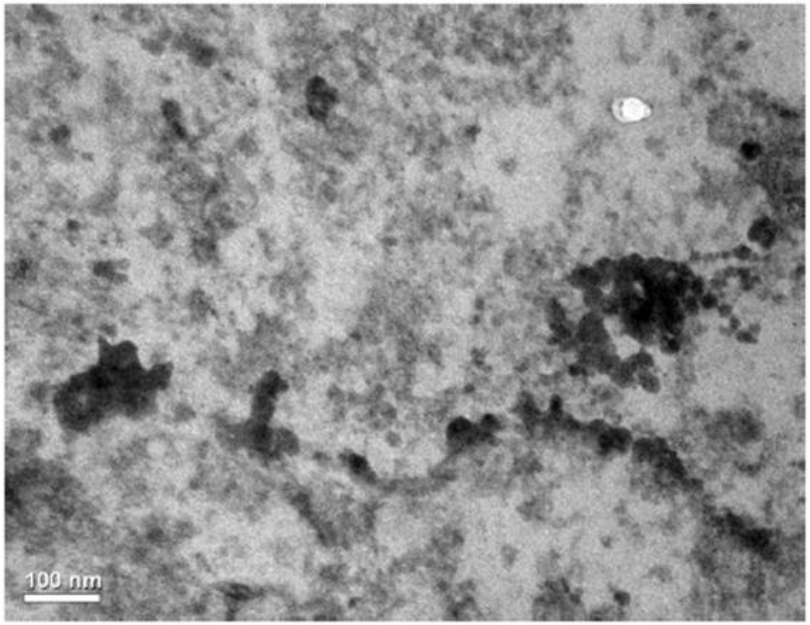
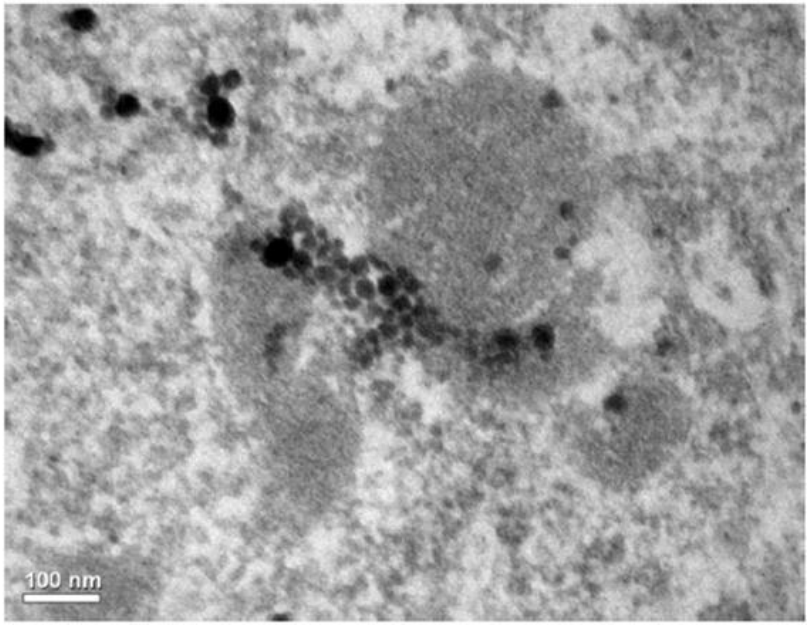


50 nm AgNPs in macrophages (24 hrs)









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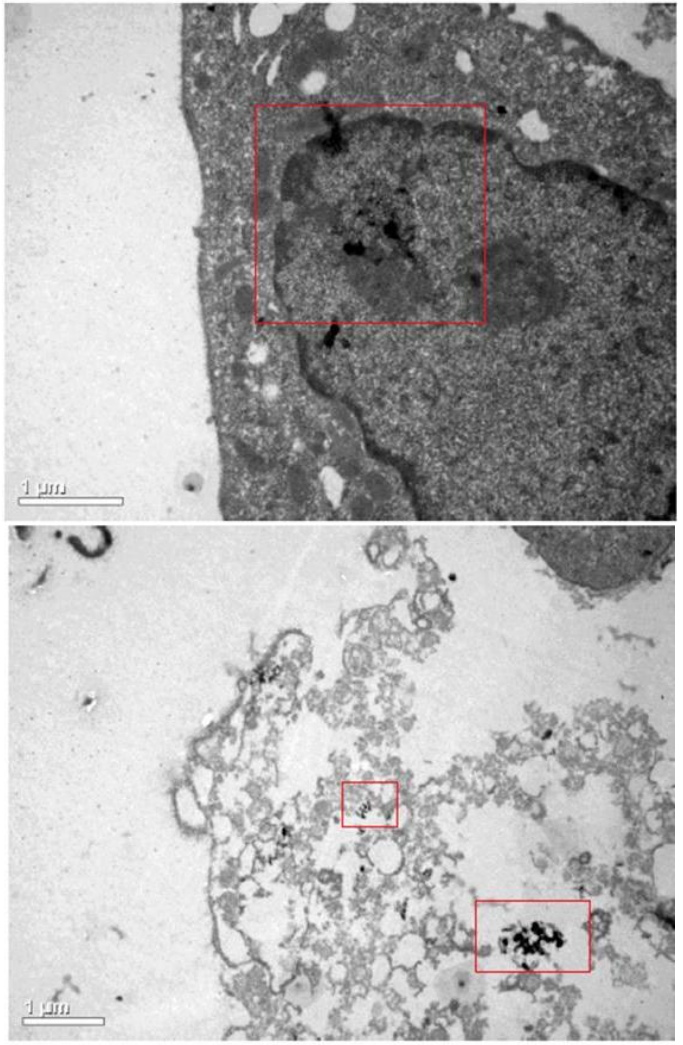
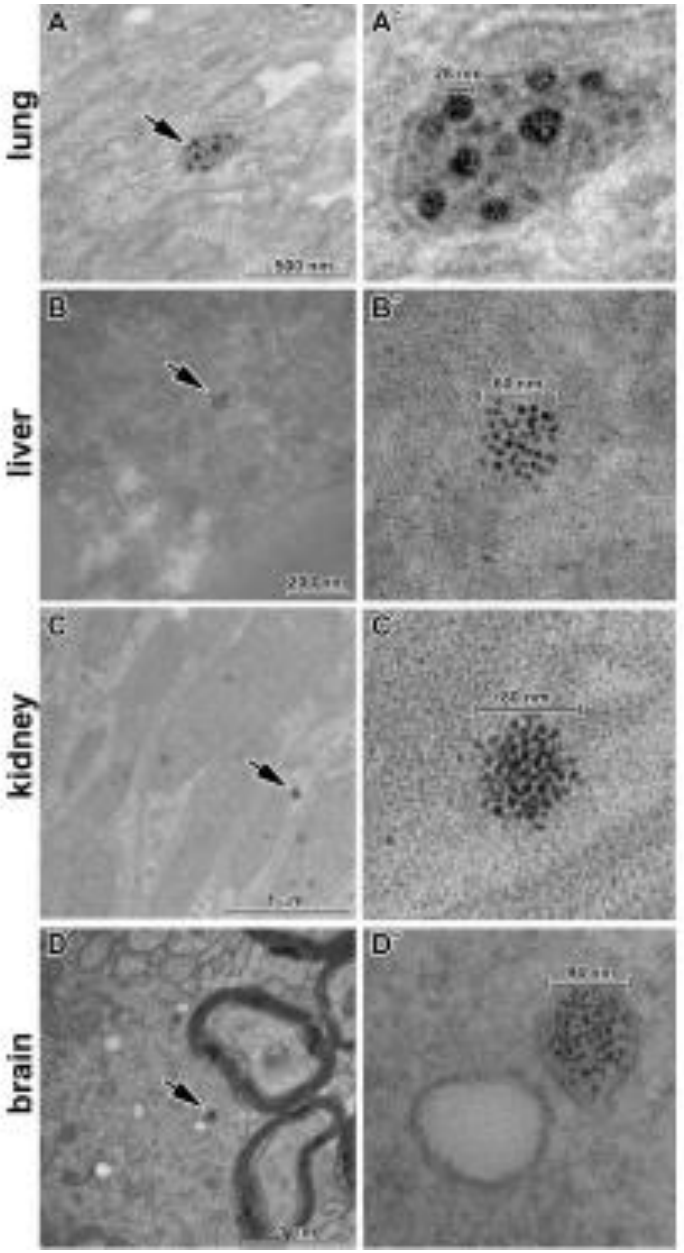


Nanomaterials & Human Health

Research Need #4:
Understand the relationship btw the properties of NMs and uptake *via* the respiratory or digestive tracts or through the eyes or skin and assess body burden

- Characterise the physical and chemical properties of the major classes of NMs by exposure route
- Determine the relationship of acute or chronic exposure/ uptake to body burden by class of NMs



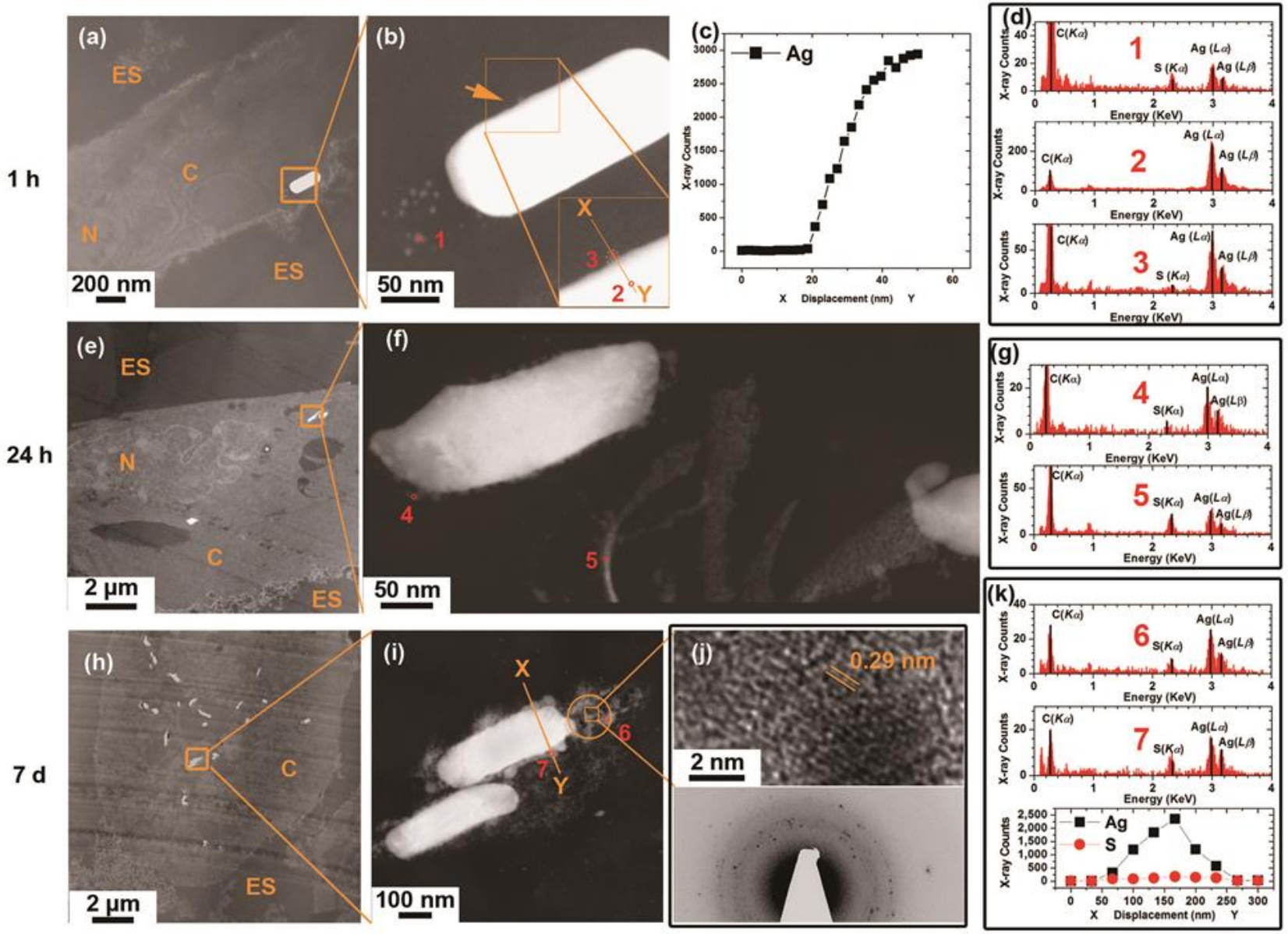
Nanomaterials & Human Health

Research Need #5:

Determine the mechanism of interaction btw NMs and the body at the molecular and cellular levels

- Identify mechanism though which NMs interact with fundamental, protective biological response pathways
- Identify mechanism by which NMs disrupt protective pathways and cause adverse health effects
- Determine the relationship of dose , physical and chemical properties to protective *vs.* adverse responses
- Determine the relationship of biological response in animal models to human response

Dissolution and transformation of NWs inside the cells



Nanoparticles - Induced Oxidative Stress

Critical determinants:

- physicochemical properties of NPs

  (size, shape, surface charge, capping agent and particle purity)
- medium pH
- cellular type

Affect ion release from NPs and production of ROS

Key determinant of toxicity

Adverse Outcome Pathway (AOP)

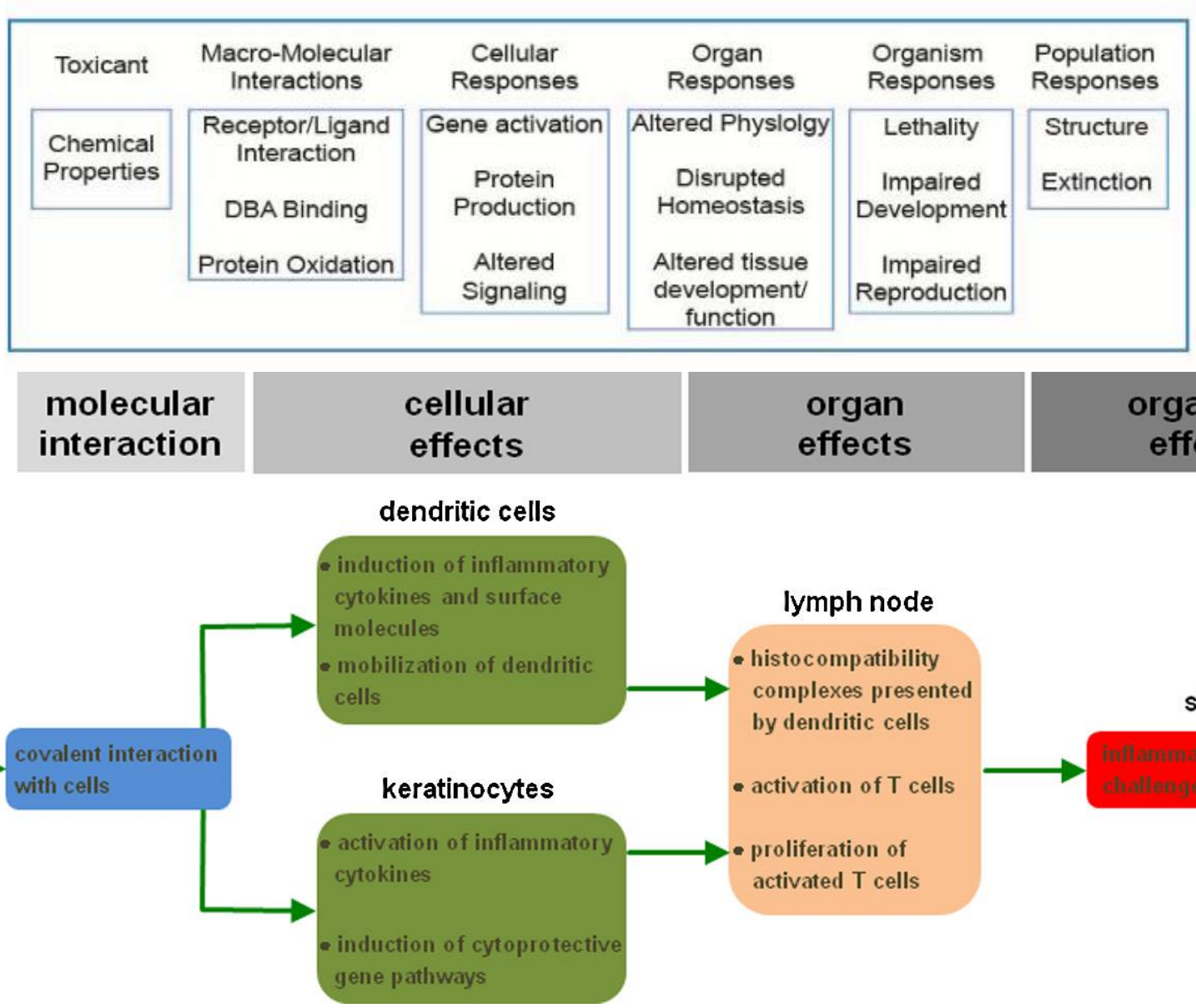
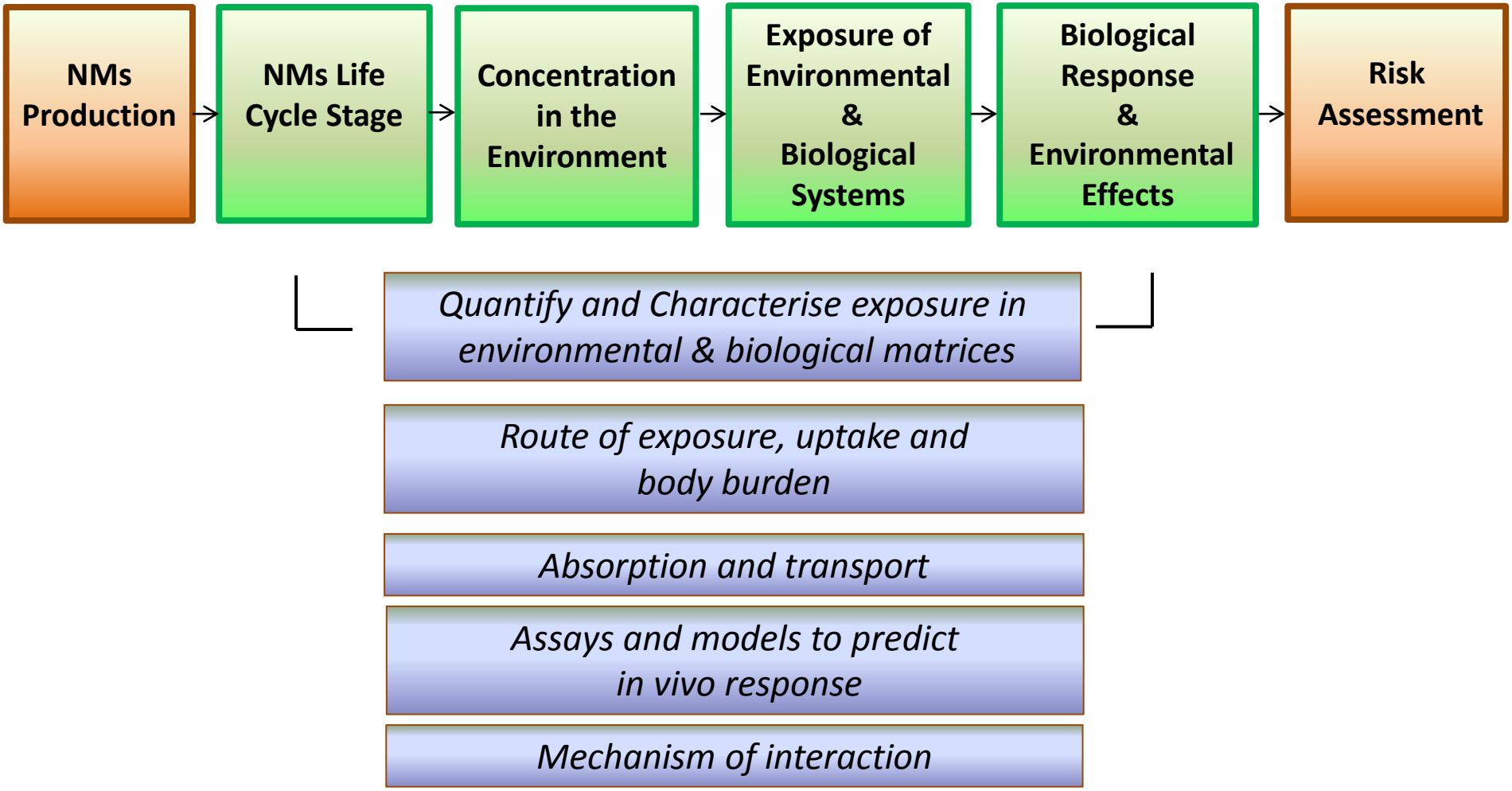


Fig: AOP for chemical-induced skin sensitisation

Reference: OECD

Nanomaterials & Human Health



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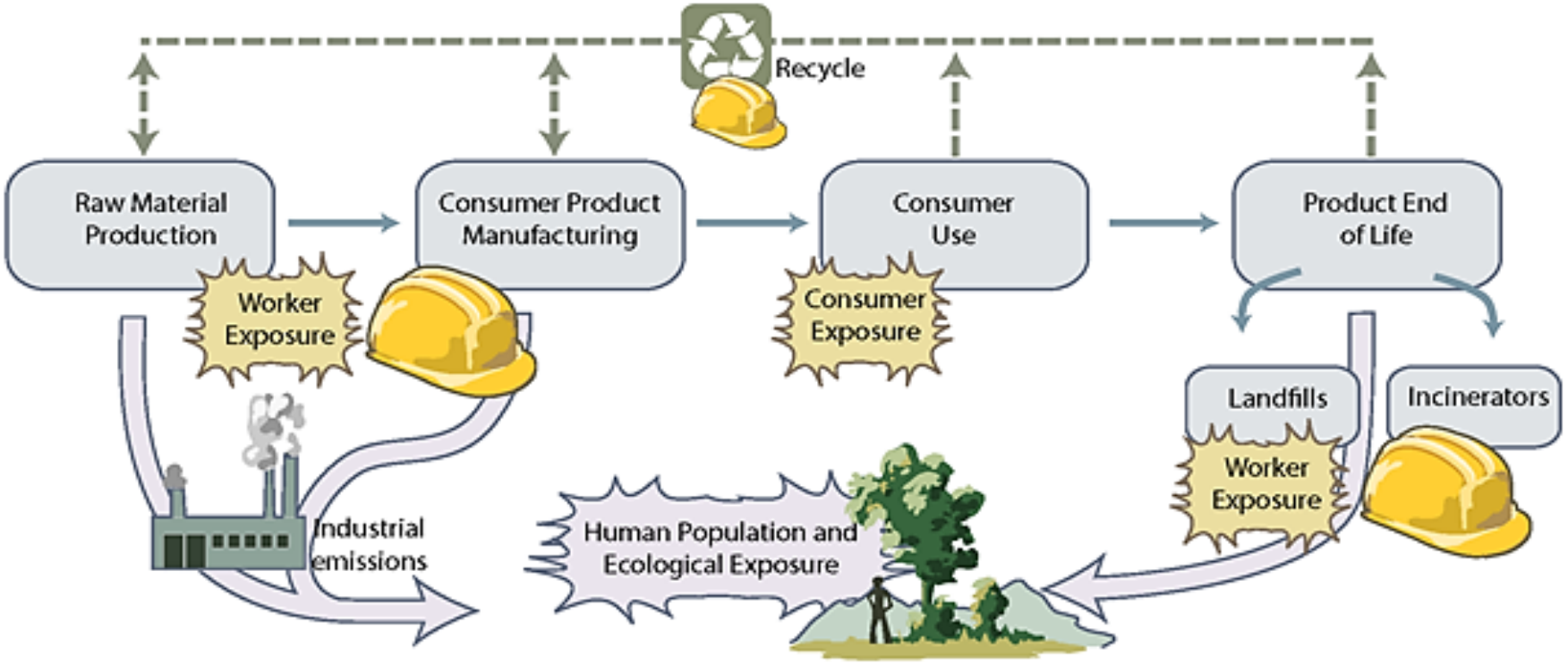
Environmental, Health and Safety of NMs



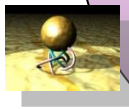
NMs Production → **NMs Life Cycle Stage** → **Concentration in the Environment** → **Exposure of Environmental & Biological Systems** → **Biological Response & Environmental Effects** → **Risk Assessment**

- Analysing life cycle behaviour and potential risks of new technologies
- Identify the ways in which ENPs present a new challenge for current risk assessment systems and what modifications are needed to make these work better.

Nanomaterials: Emission & Exposure to Environment

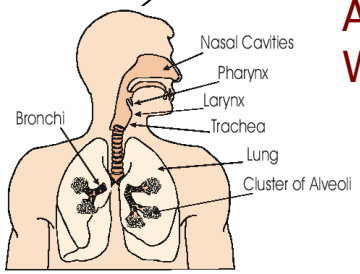
Sources

Point :
Manufacturing,
Landfills,
Wastewater effluent



Non-Point :
Wear/Attrition of tires,
Sunscreen, Brake pads, etc;
Storm water run-off;
Wet deposition

Exposure



Inhalation
Ambient air,
Workplace exposure

Ingestion
Food, Drinking water,
Incidental

Dermal
Sunscreen, Cosmetics

Transport & Transformation

Accumulation
Uptake
Release

Surface Water

Photolysis
UV

Ground Water

Air

Aggregation

Biotransformation

Removal

Air filtration

Coagulation and Sedimentation

Sand filtration

Source: NIER

Nanomaterials & the Environment

Focusing areas:

- Understand the effects of ENMs in individual of a species, and applicability of testing schemes to measure effects
- Understand environmental exposures through identification of principle sources of exposures and exposure routes
- Evaluate abiotic and ecosystem-wide effects
- Determine factors affecting the environmental transport of NMs
- Understand the transformation of NMs under different environmental conditions

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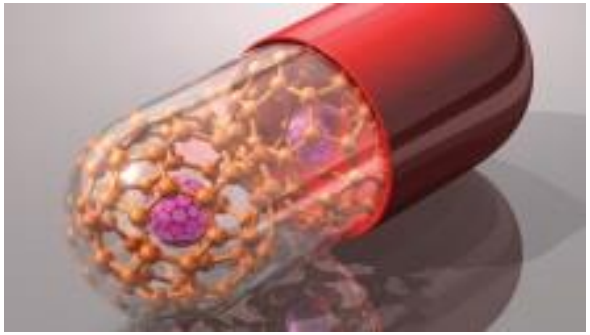
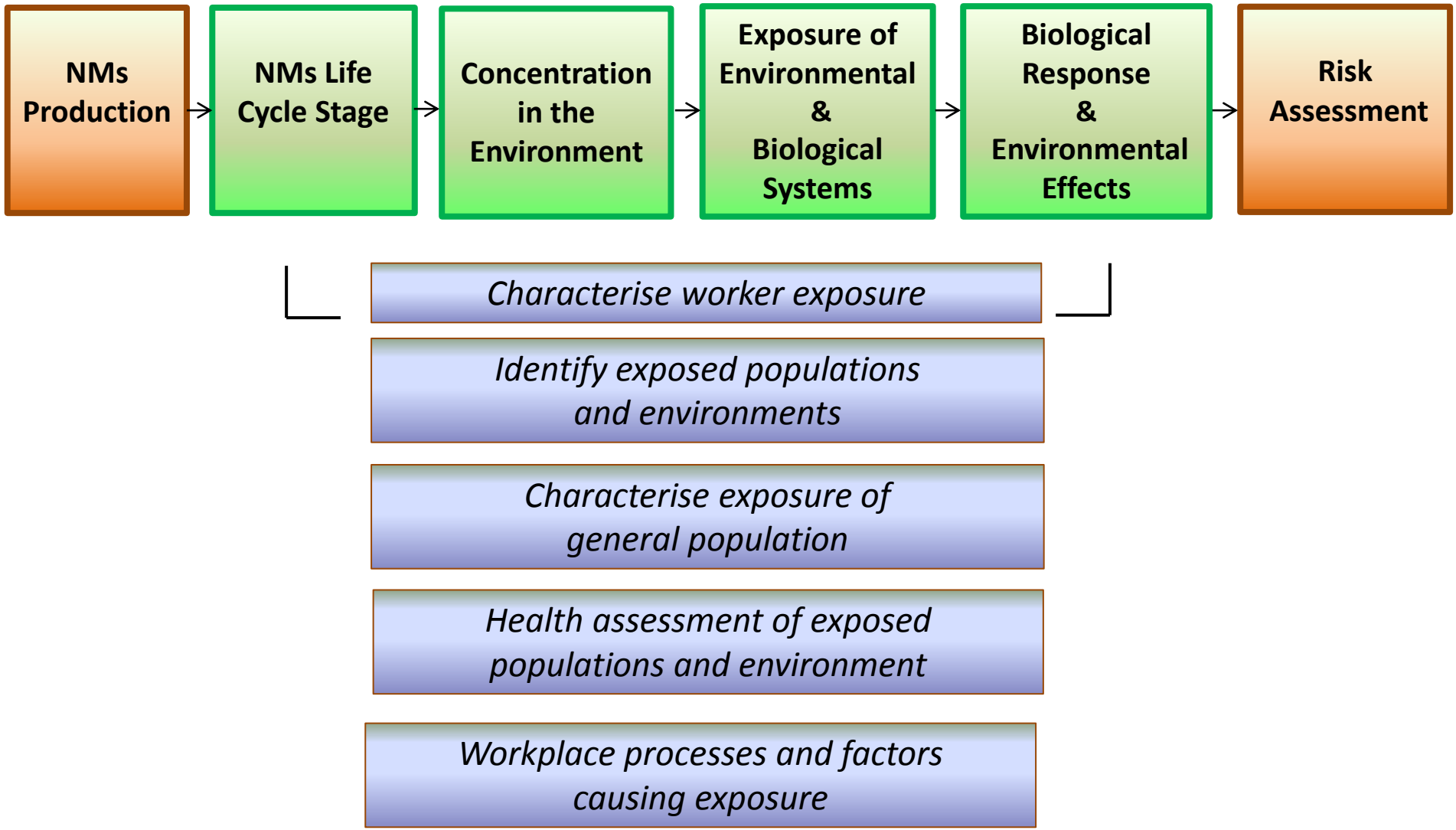


Human & Environmental Exposure Assessment



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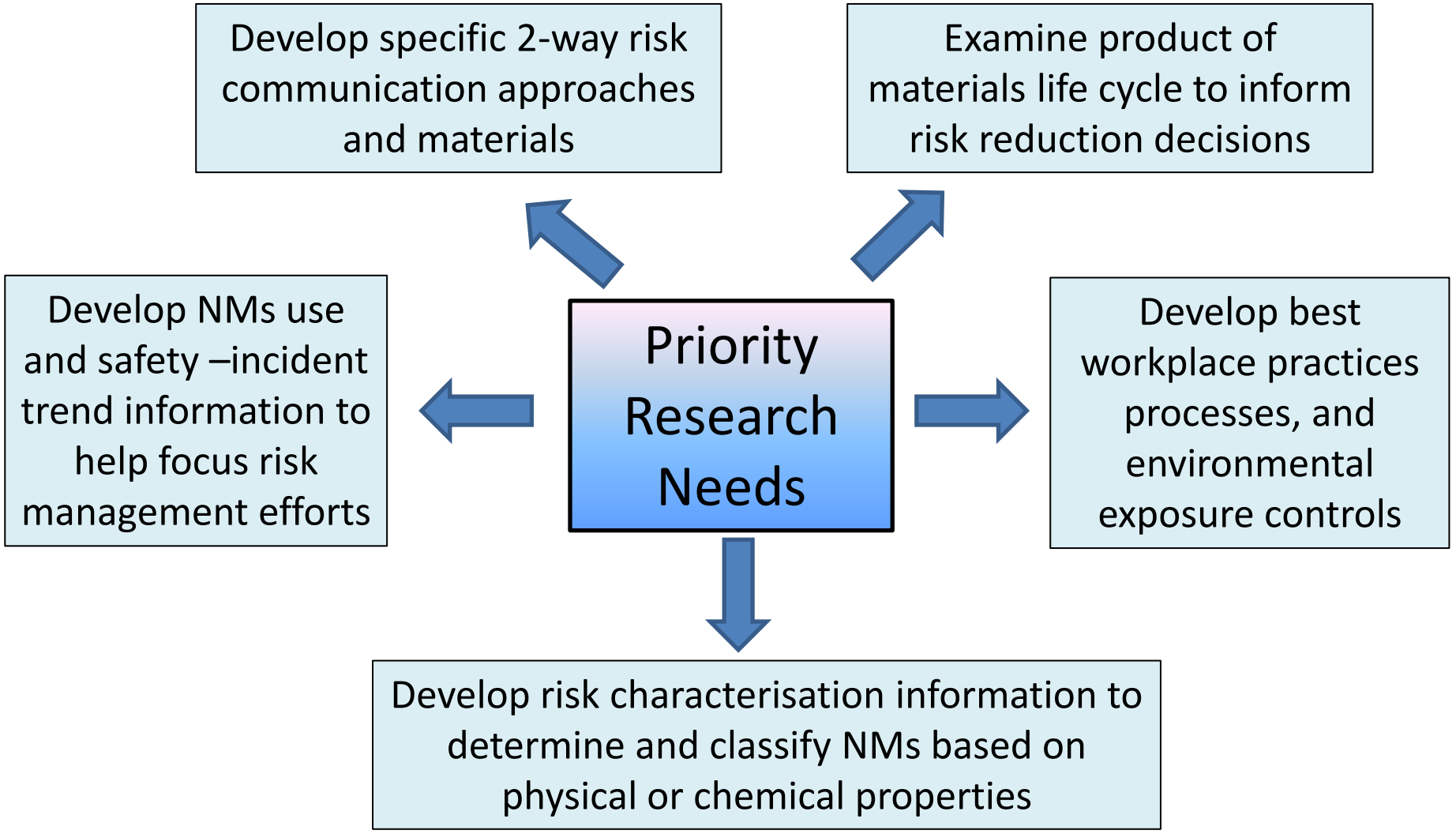
Risk Managements Methods Category



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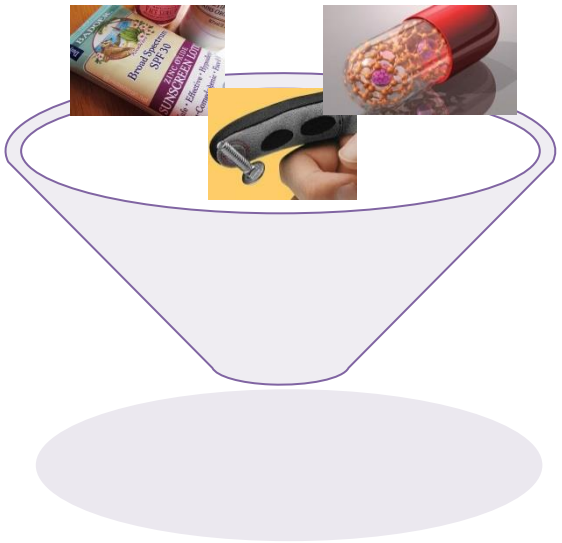

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Implementation of Strategy for Nanotechnology related EHS Research

- Support broad base of research to facilitate regulatory decision making and to expand the horizons of Nanotechnology-based applications for health and the environment.
- Coordinate existing, and foster agency efforts to address priority EHS research needs and identified gaps.
- Establish regular review process.
- Facilitate partnerships with industry
- Coordinate efforts internationally
- Facilitate wide dissemination of research results


Thank you
With Great Power Comes Great Responsibility
~ Stan Lee writer of Spiderman, Franklin D Rosevelt

Acknowledgement

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NANOTECHNOLOGY AND CATALYSIS RESEARCH CENTRE

National Heart and Lung Institute

NIEHS
National Institute of Environmental Health Sciences

NATURAL ENVIRONMENT RESEARCH COUNCIL