



Nano-technology

Opportunities and Community Awareness

Critical Horizons Regional Futures Conference



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School of Biomedical, Biomolecular and Chemical Sciences
The University of Western Australia

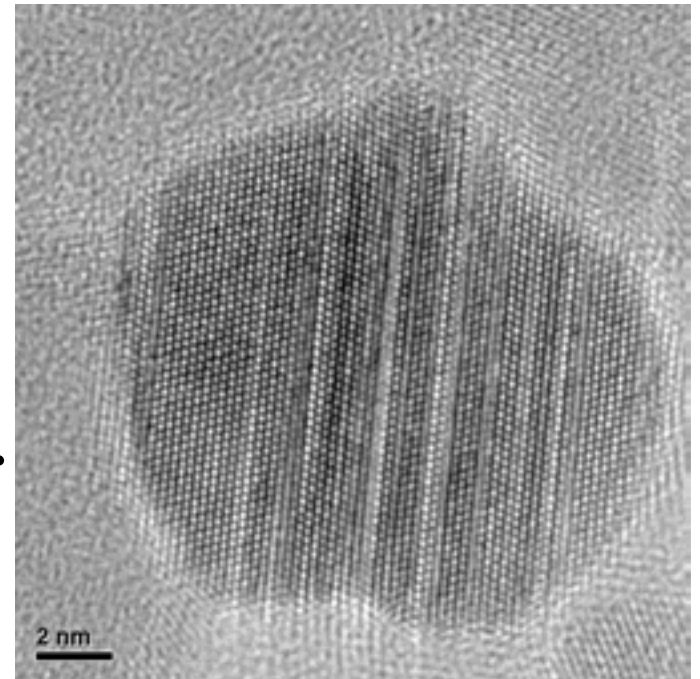
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<http://www.strategicronano.uwa.edu.au/>

What is nanotechnology?

- ⚡ Design, characterisation, production, and applications of structures, devices and systems for controlling shape and size at the nanometer level (1/1,000,000,000 m)
- ⚡ Next industrial revolution
- ⚡ Covers nanotechnology (applications) and nanoscience (research)
- ⚡ Nanomaterials: particles, nanotubes, nanowires, quantum dots, fullerenes, etc.
- ⚡ Nano-Biology: emerging of biological materials
- ⚡ Underpin and impacts on ALL industries and sectors of the economy



NANO-TECHNOLOGY APPLICATION	COMPANIES INVOLVED
Computers/Electronics	IBM, NEC, Fujitsu, Hitachi, Phillips, HP, Samsung, Motorola, Mitsubishi, GE
Food	Kraft / Altria, Unilever, Nestle, Heinz
Drugs / Healthcare	GlaxoSmithKline, Smith and Nephew, Merck, Elan
Oil / Energy	BP, Exxon, Chevron / Texaco, Shell, Halliburton
Clothing	Burlington Industries, Nike, Gap
Defence / Aerospace	Sandia / Lockheed Martin, Boeing, Qinetiq, Raytheon
Cosmetics	L'Oreal, Body Shop, Boots, Revlon, Avon
Chemicals	Dupont, Degussa, Dow, Henkel, ICI, Lanxess, Bayer, BASF
Agriculture	Sygenta, Monsanto, Bayer

L. Sales, Chain Reaction, 9-11, June, 2006.

Current Nano-products

- ↗ UV-resistance paints
- ↗ Transparent sunscreens
- ↗ Cosmetics and personal care products
- ↗ Wine and beer bottles with special finishes
- ↗ Window and building surfaces
- ↗ Automotive and aerospace parts
- ↗ Industrial catalysis
- ↗ Self cleaning surfaces
- ↗

L. Sales, Chain Reaction,
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Applications of nano-technology

- ⤵ Manufacturing
- ⤵ Health - tissue repair, drug delivery, ...
- ⤵ Transport
- ⤵ Agriculture
- ⤵ ICT
- ⤵ Energy - power generation and usage
- ⤵ Environment - potable water - pollution prevention - air, water, solid
- ⤵ Mineral resources
- ⤵ Forensics
- ⤵ Food and cosmetics

What next?

Nano-encapsulation

Nano-devices

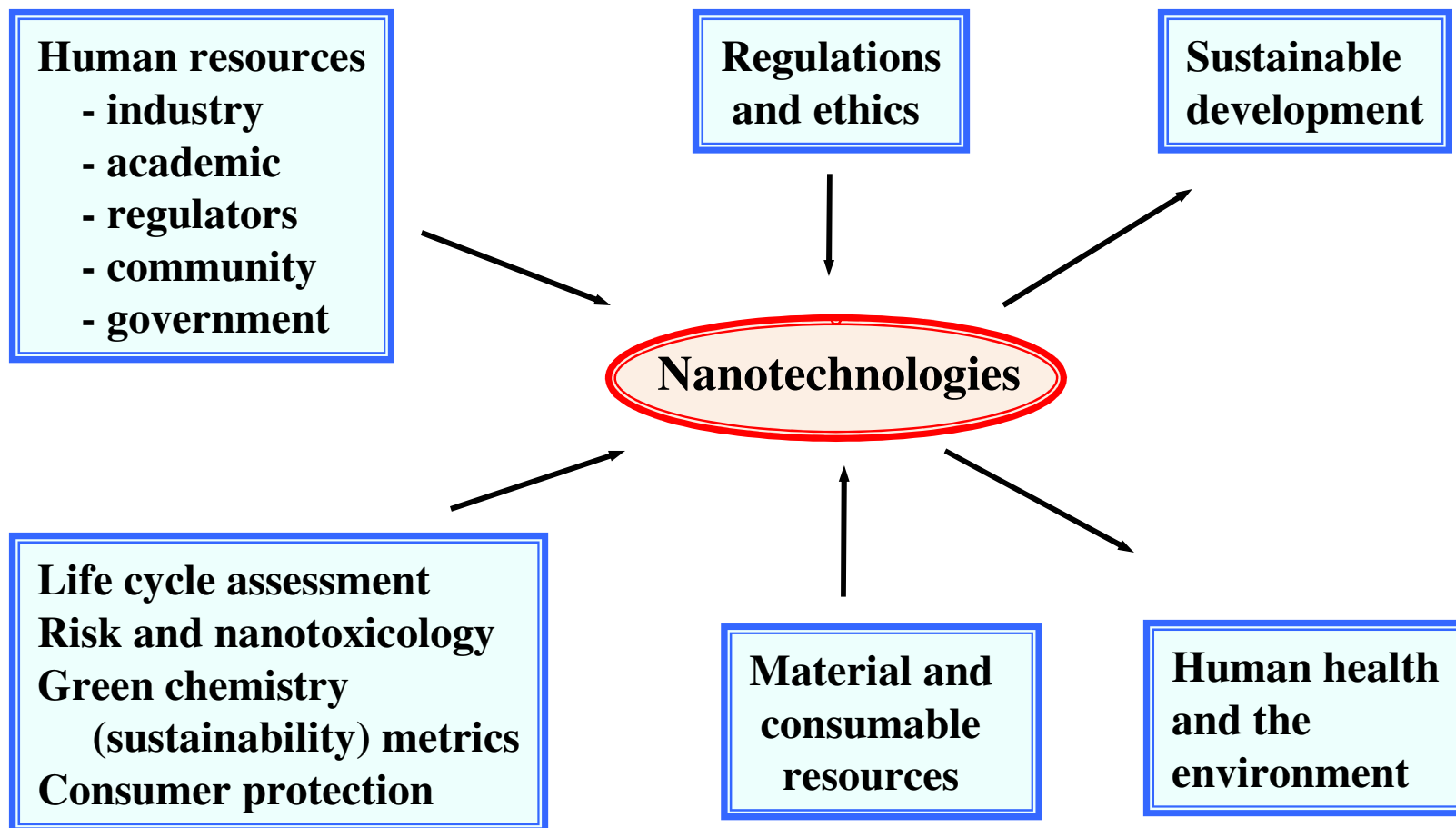
Nano-biotechnology

Human enhancement

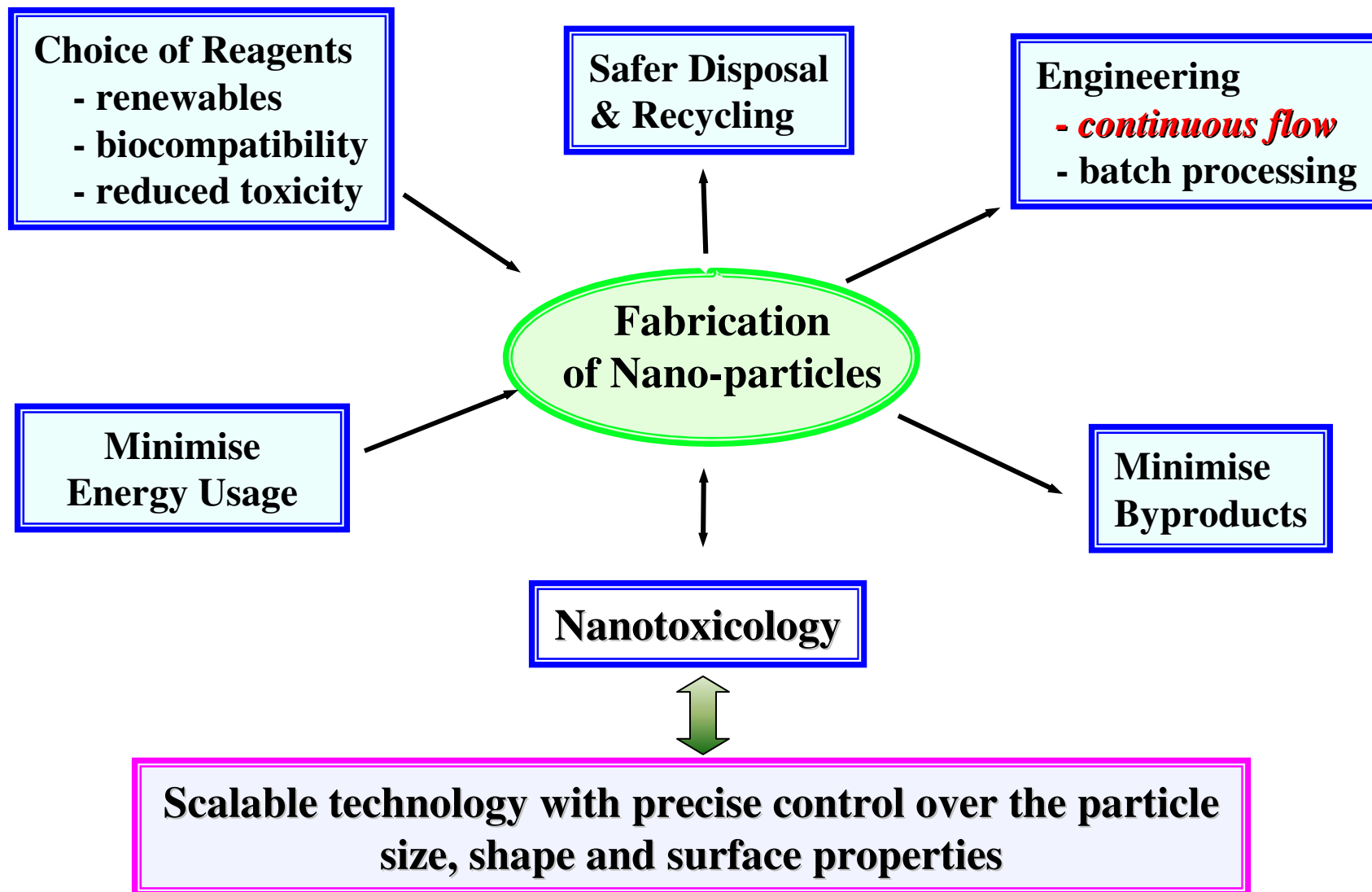
Molecular manufacturing, ..

Public acceptance?

- ⚡ Willingness to use nano-products when factoring in health and safety risks**
 - No regulations**
 - Function of material changes < 100 nm**
 - Size, shape, surface**
- ⚡ Consumers think it is less of a risk than everyday chemicals (herbicides, chemical disinfectants, food preservatives, etc.) Nano-medicine widely accepted**
- ⚡ Changes in social, economic and ecological relations**
- ⚡ Threats to human health and the environment**

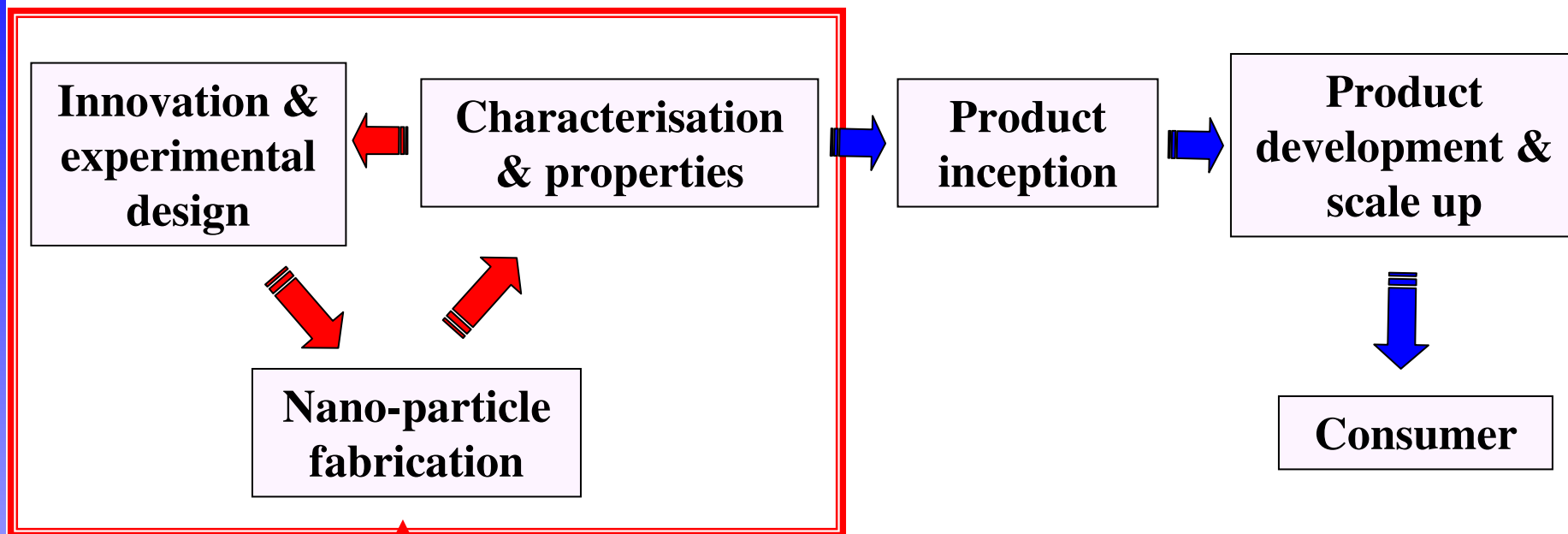


‘Green chemistry and the health implications of nano-particles’, M. A. Albrecht, C. W. Evans and C. L. Raston, *Green Chemistry*, 2006, 8, 417-432.

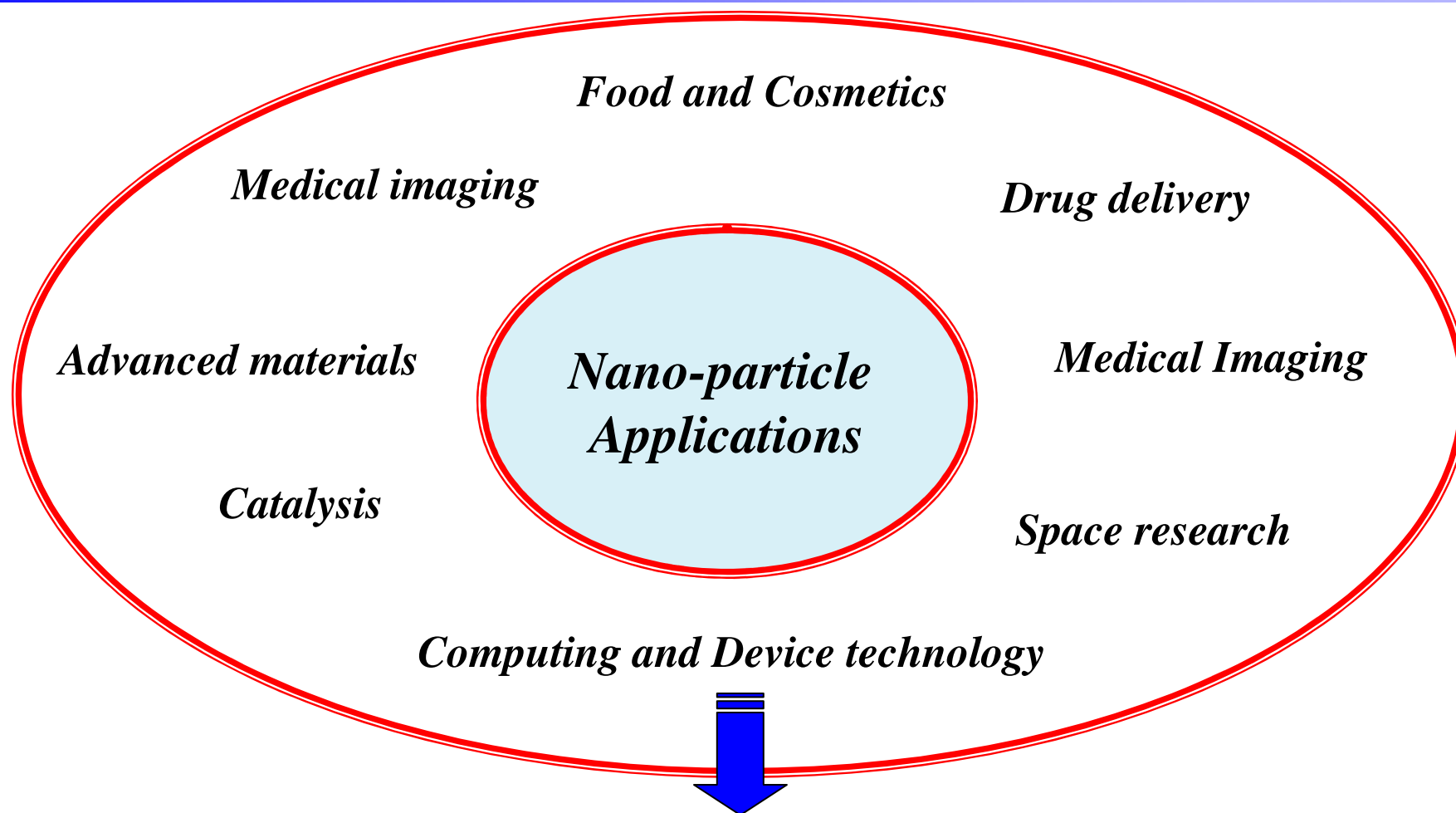


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Innovation in Nano-science to Nano-technology



- ∧ Incorporate sustainability metrics - green chemistry
- ∧ Address toxicology issues (including nano-toxicology)
- ∧ Nano-toxicology studies
- ∧ Scalability



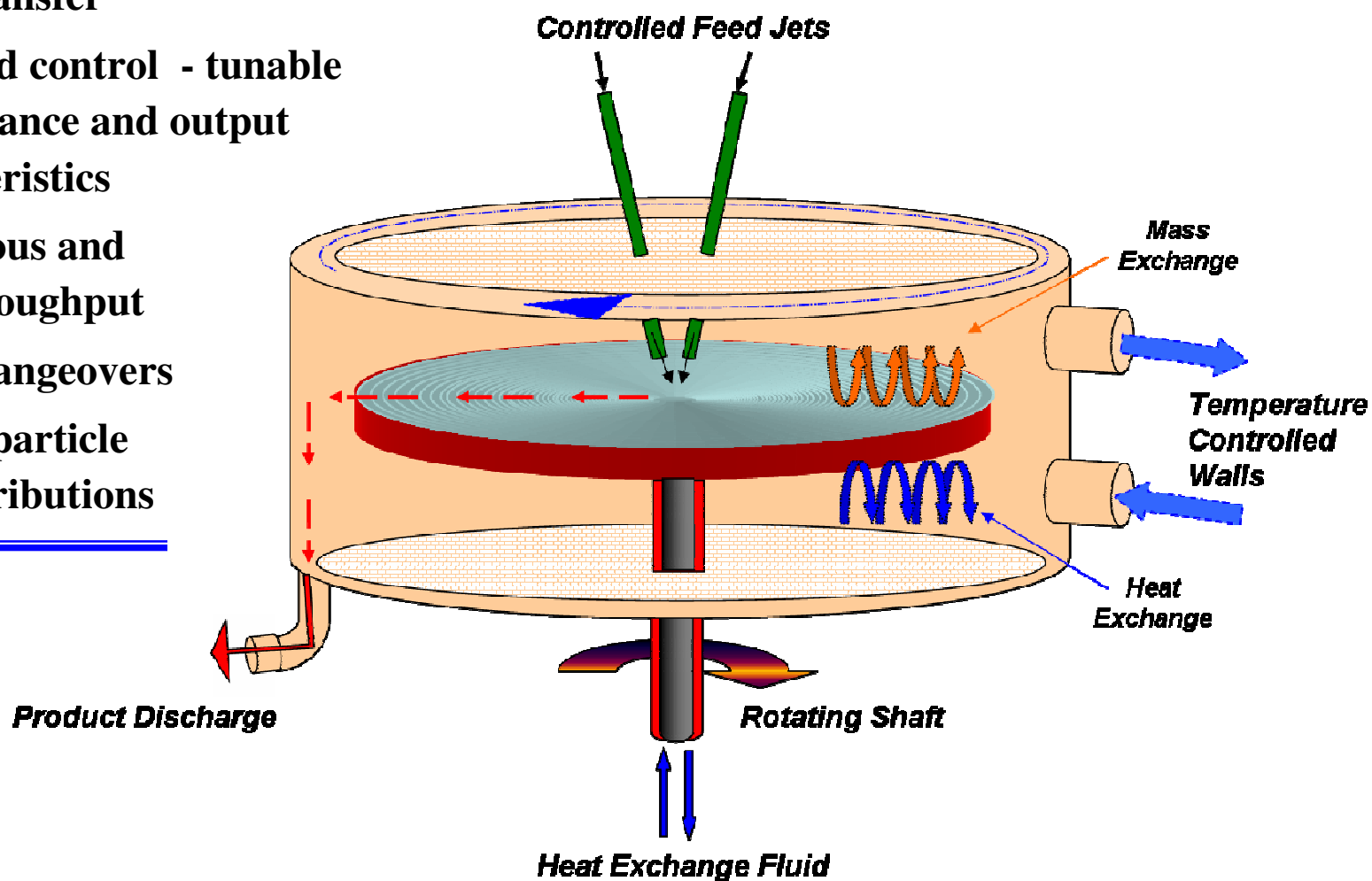
Consumer products with engineered nano-materials **< 1%**

Nanotechnology commercialisation: Where is the gap?

Spinning Disc Processing (Process Intensification)

- Extremely rapid mixing
- Fast kinetics
- Plug flow across the disk
- Solvent efficient
- Effective heat and mass transfer
- Low wastage
- Enhanced control - tunable performance and output characteristics
- Continuous and high throughput
- Short changeovers
- Narrow particle size distributions

LM Cafiero, G Baffi, A Chianese, RJJ Jachuck, *Ind. Eng. Chem. Res.* 2002, 41, 5240-5246

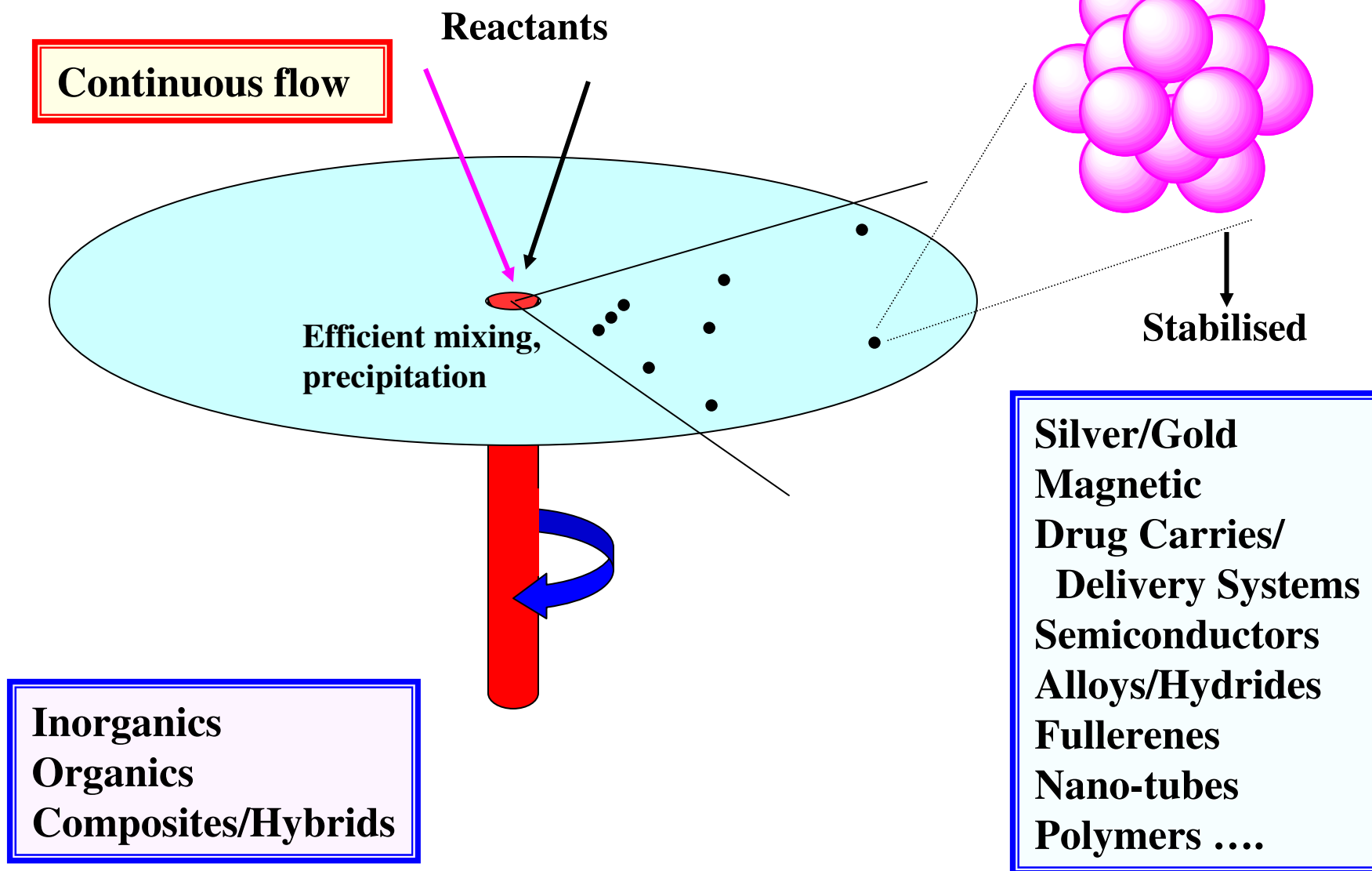




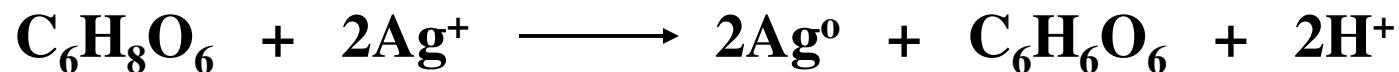


Spinning Disc Processing Nano-Particle synthesis

N. Anantachoke, M. Makha, C. L. Raston, V. Reutrakul, and N. C. Smith, *J. Am. Chem. Soc.*, **2006**, *128*, 13847 - 13853



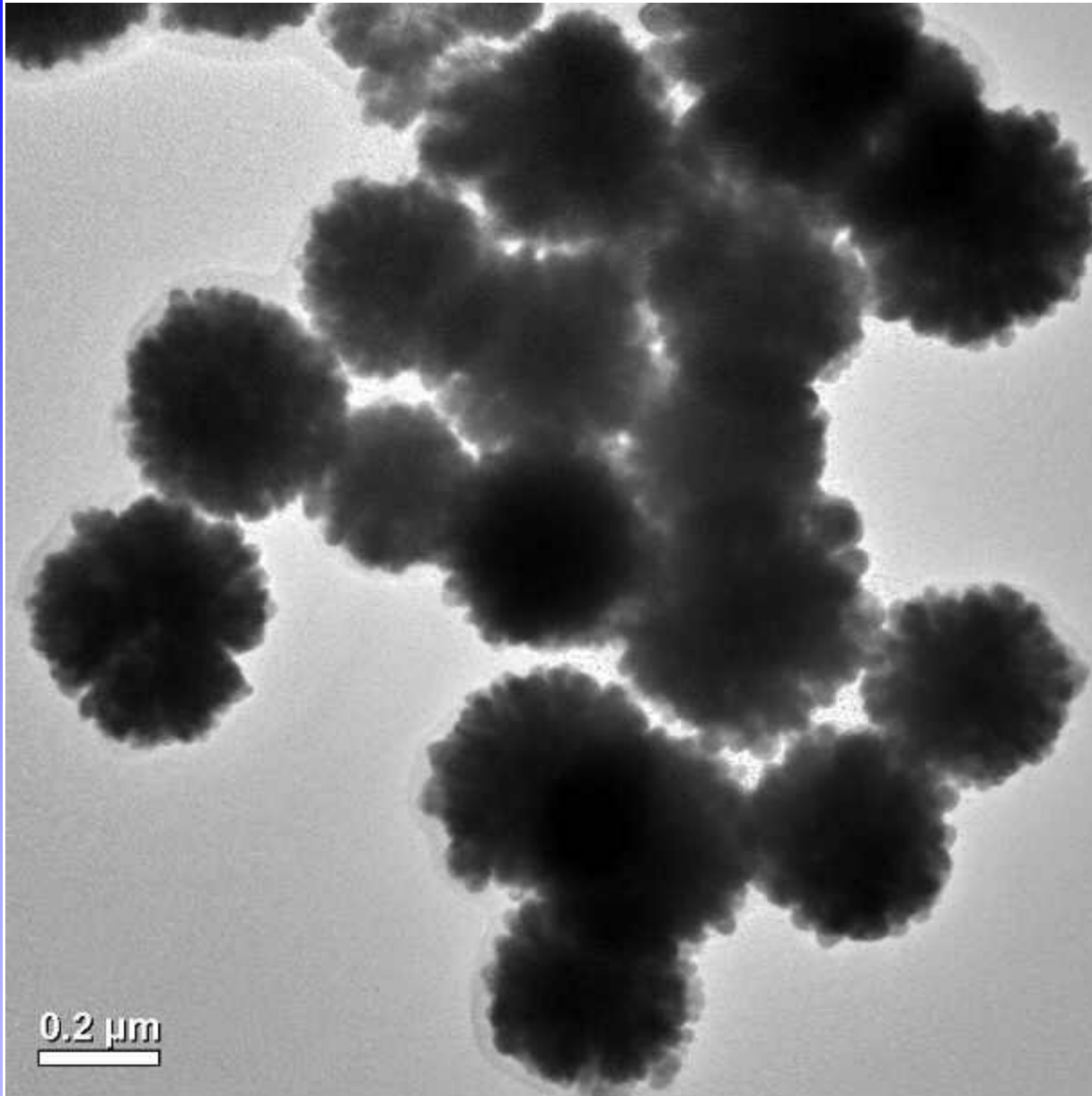
Fabrication of silver nano-particles



- ✓ Silver Nitrate; Ascorbic Acid; Soluble Starch.
- ✓ Room temperature synthesis.
- ✓ Water medium
- ✓ Control size and shape by changing concentration, pH and disc speed (SDP).

Use of starch as a stabilizer:

- Easily integrated into systems for pharmaceutical and biomedical applications.
- Stabilization is easily reversible at elevated temperatures relative to thiol based stabilizers.



Green Chemistry

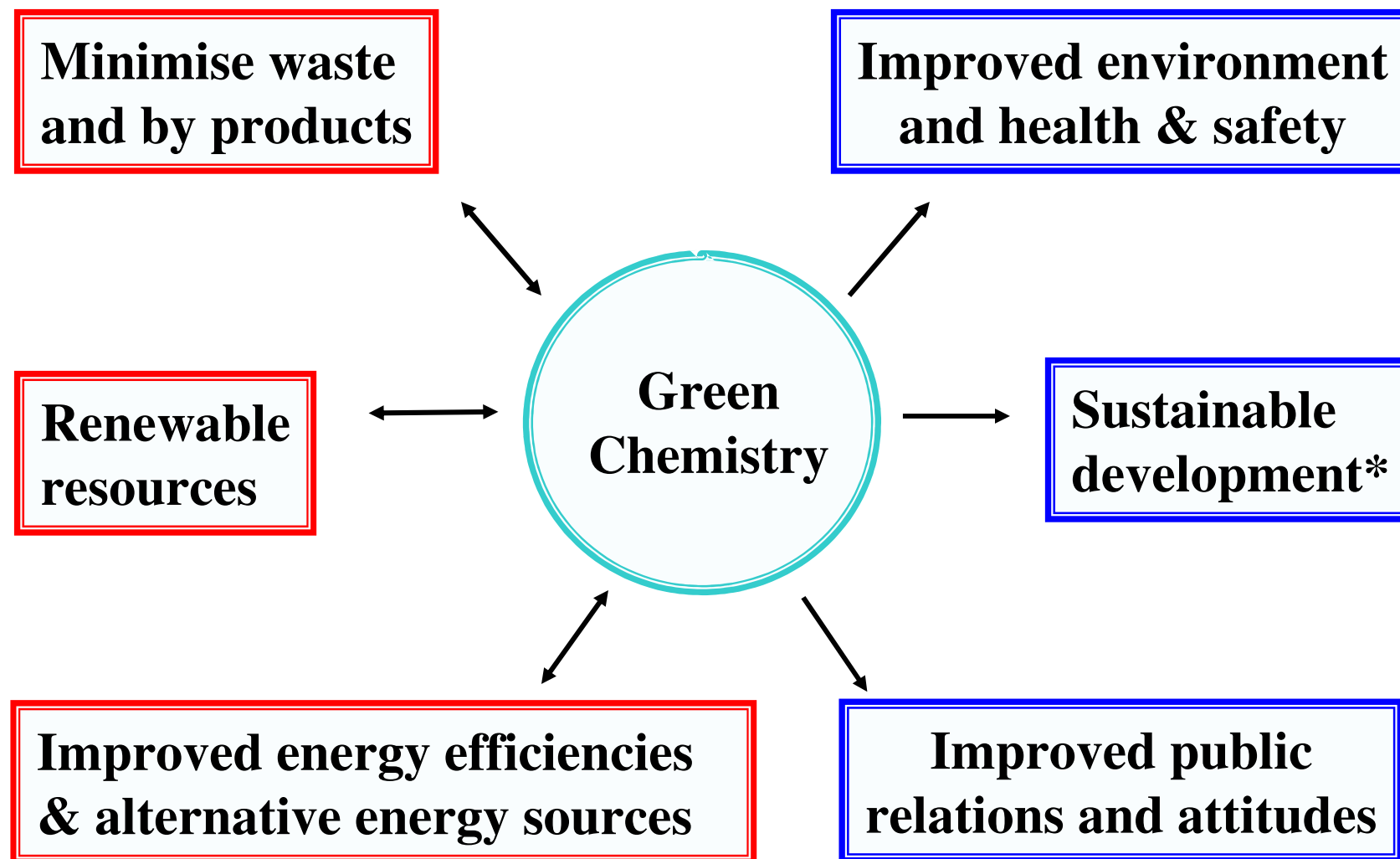
‘Chemical processes that reduce or eliminate the use or generation of hazardous substances in the design, manufacture and use of chemical products.’

BENIGN BY DESIGN

Towards a Sustainable Trajectory

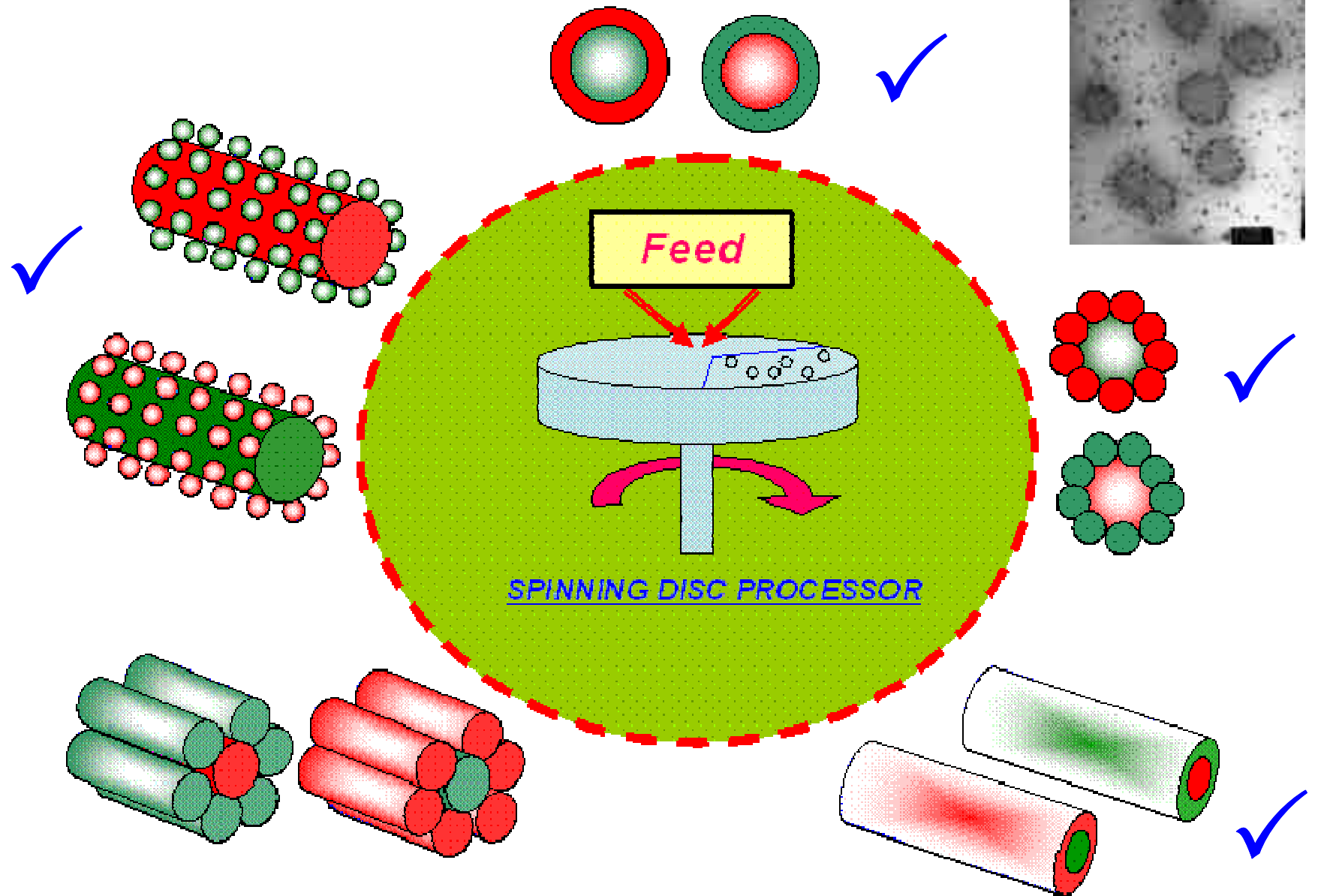
Incorporate sustainability metric at
the inception of the science

Source: P. Anastas and T. Williamson, Green Chemistry, Frontiers in Benign Chemical Synthesis and Processes, Oxford Press 1998: P. Anastas, Meeting the challenges of sustainability through Green Chemistry, Green Chemistry, 2003, 5, G29



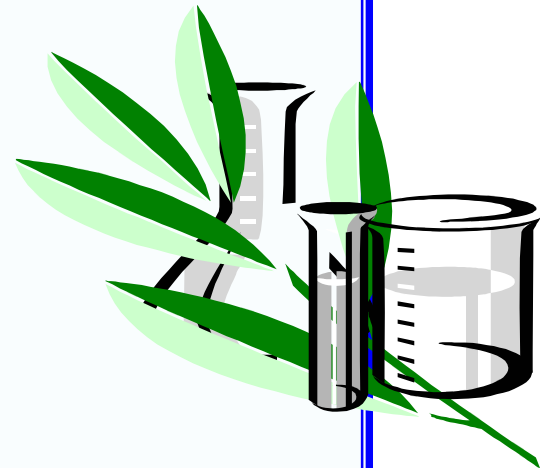
* 'meeting the needs of the present without compromising the ability of future generations to meet their own needs' [1987 UN Commission on Environment and Development]

SDP Nano-fabrication - Green Chemistry



THE FUTURE

- ⚡ Sustainable Development
- ⚡ Engagement of the Stakeholders
 - ⚡ University
 - ⚡ Industry
 - ⚡ Government
 - ⚡ Community
- ⚡ Moral and Legal Obligation?
- ⚡ Economically and Environmentally Feasible
- ⚡ Maintain and Improve Quality of Life
- ⚡ Major investment
- ⚡ Attract industry - large scale vs small scale





THE UNIVERSITY OF
WESTERN AUSTRALIA

FACULTY OF
Life and Physical
Sciences



Molecular and Chemical Sciences Building, 2005



THE UNIVERSITY OF
WESTERN AUSTRALIA



Funding

**The University of
Western Australia**

- **Fledgling Centre Program**
- **BBCS**
- **FLFS**
- **Centre for Microscopy
and Microanalysis**

DSTO

ARC



Australian Government
Australian Research Council



Collaboration

Dr Mohamed Makha

Dr Iyer Swaminathan

Dr Martin Saunders

Companies

- **AGR Matthey**
- **Protensive (UK)**
- **Dyesol**
- **CleanTeq**



To do List for a Sustainable Civilization*

- ↗ Complete re-development of our energy systems
 - ↗ Climate neutral
- ↗ Complete re-development of chemical, material and building technologies
 - ↗ 20th Century technologies
 - ↗ Biotechnology and Nano-technology
- ↗ Complete re-development of industrial agriculture
- ↗ Preservation of the world's remaining species and ecosystems - possible loss of cures for cancer, models for chemical production, farmable food sources, ...
- ↗ Zero waste society

** The Natural Advantage of Nations, Business Opportunities, Innovation and Governance in the 21st Century, Eds. K. Hargoves and M. H. Smith, Earthscan, 2005.*

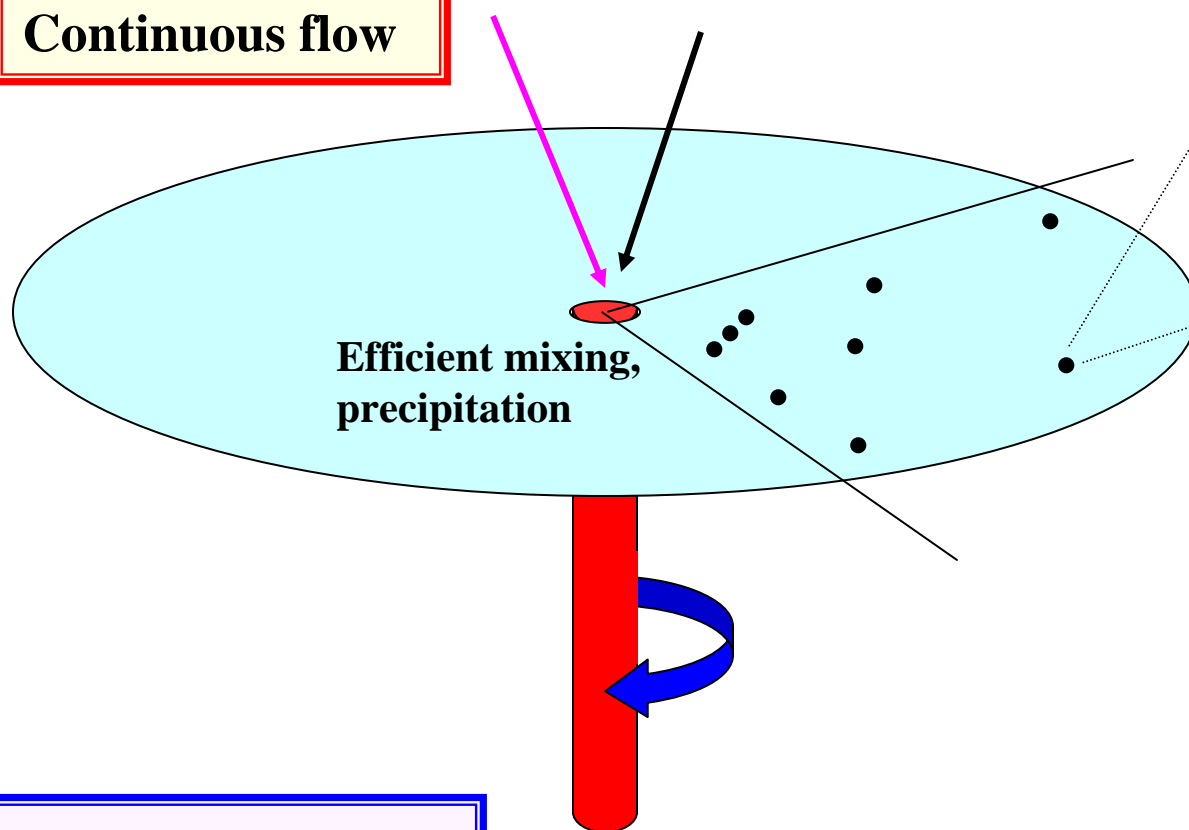


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Continuous flow

Reactants

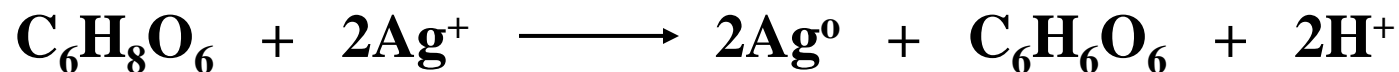


Stabilised

**Inorganics
Organics
Composites/Hybrids**

**Silver/Gold
Magnetic
Drug Carriers/
Delivery Systems
Semiconductors
Alloys/Hydrides
Fullerenes
Nano-tubes
Polymers**

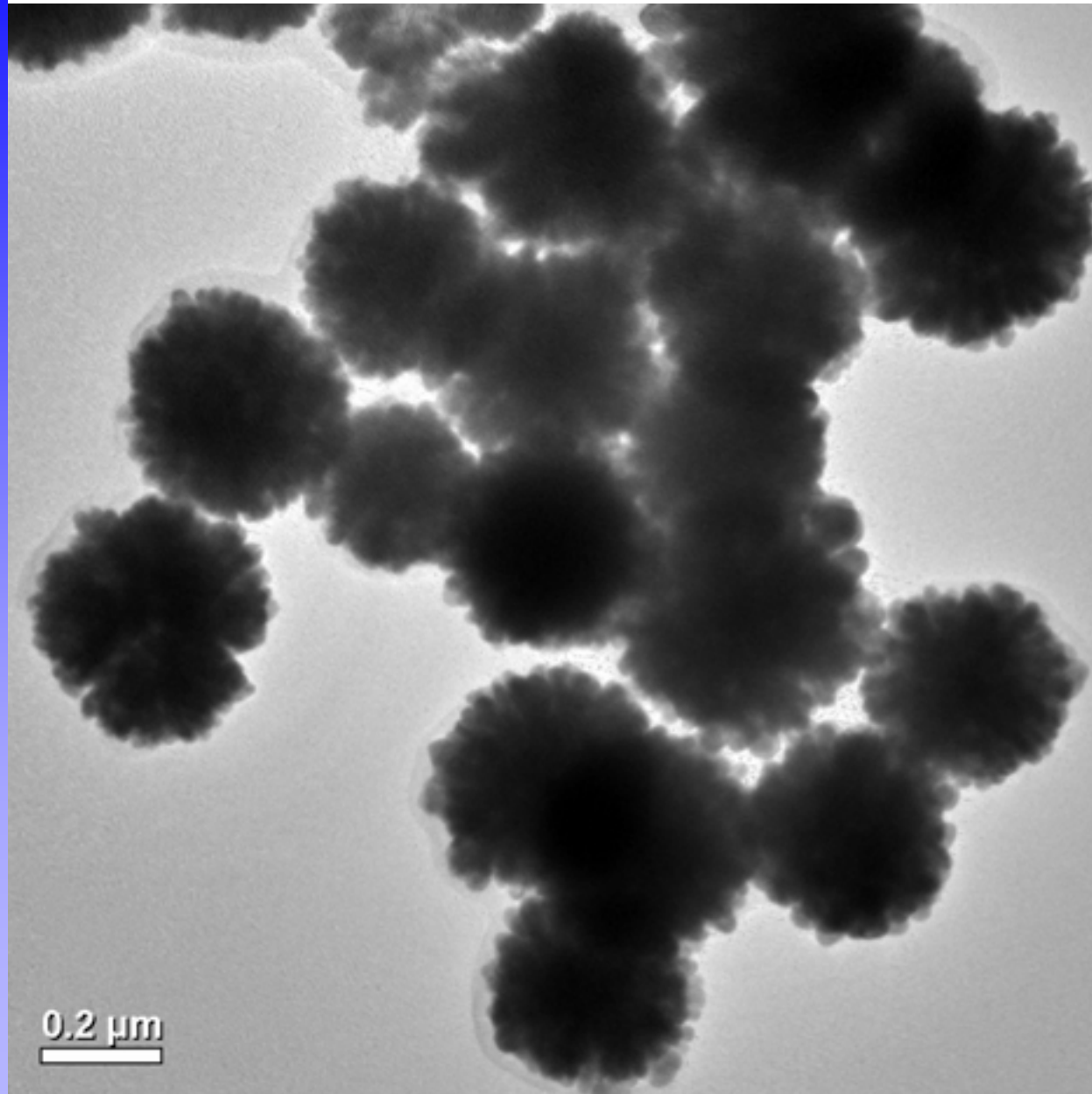
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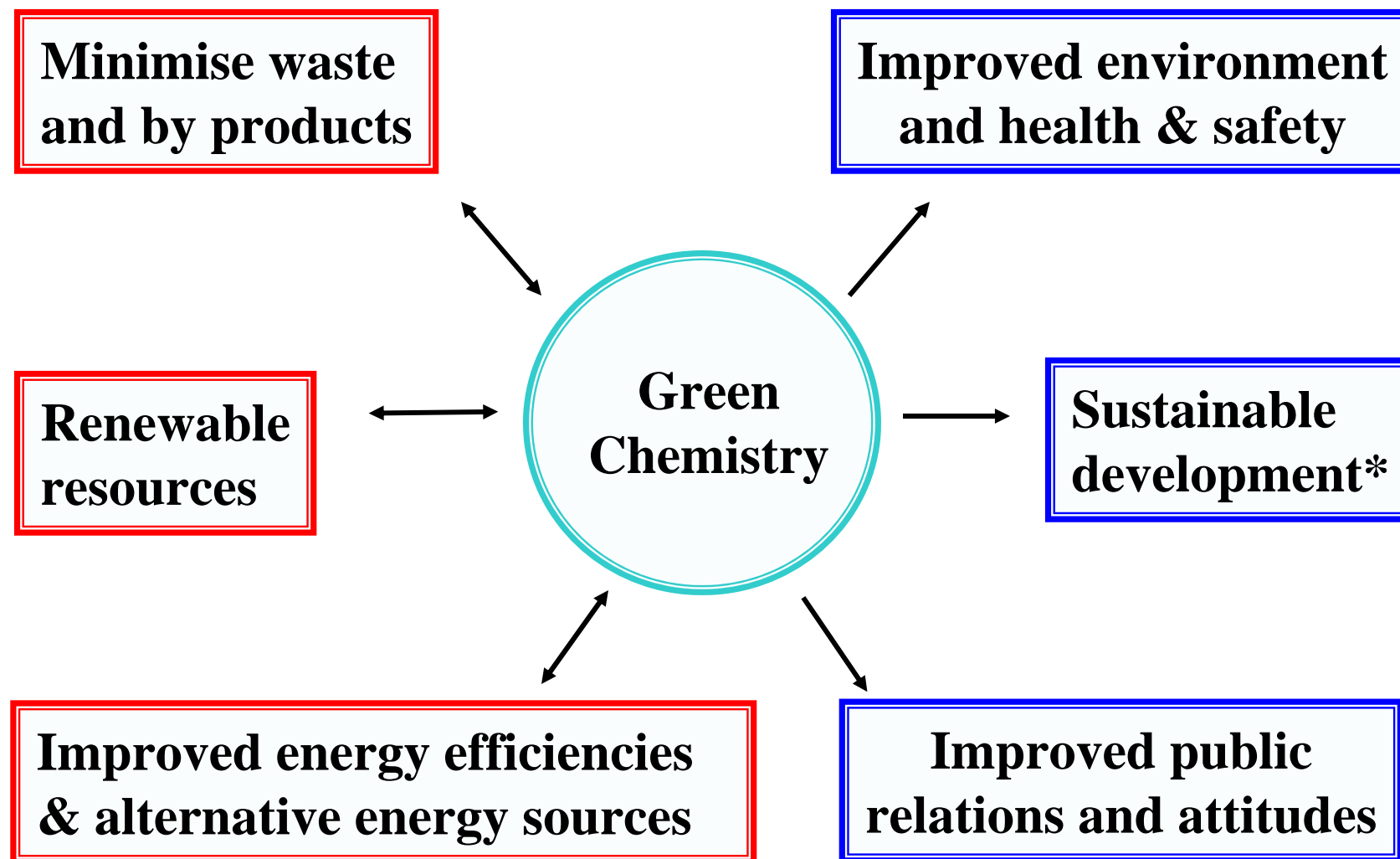
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