NANOTECHNOLOGY:

ENVIRONMENTAL IMPLICATIONS AND SOLUTIONS

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NANOTECHNOLOGY–WHAT IS IT??????

AMBIGUITIES INHERENT IN DEFINITION

Nanoparticle:
Collection of 100+ atoms in 1-100 nm diameter range

1. Research at 1-100 nm level
2. Create uses and applications at nanosizes
3a. Molecular manufacturing via molecular assembly

Centuries vs. Decades
New vs. "Old" laws
Intuition vs. Facts

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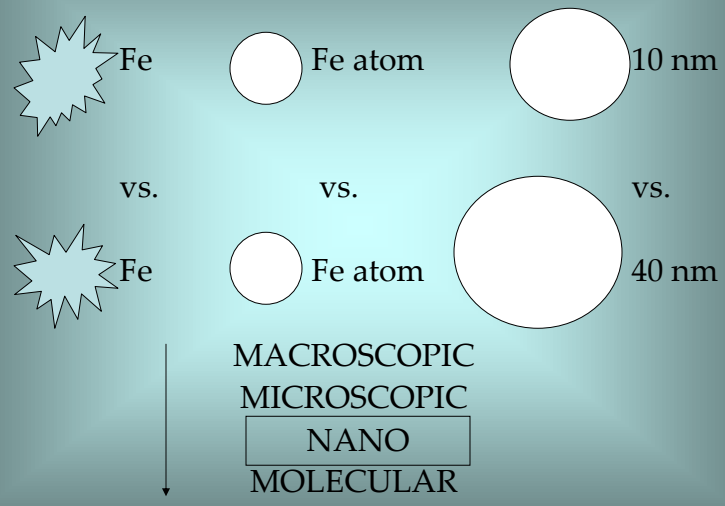
3b. Building atomically-precise products

3c. Quality control difficult, if not, impossible



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ARISTOTLE: EARTH, FIRE, WATER, AND AIR

BOYLE: TINY MATTER COMBINES IN VARIOUS WAYS TO FORM CORPUSCLES

1. "What would happen if we could arrange the atoms one by one the way we want them (within reason, of course; you could not put them so that they are chemically unstable, for example)?"
2. "So it should be possible to see the individual atoms."
3. "What would the properties of the materials be, if we could really arrange the atoms the way we want them?"
4. "But i can hardly doubt that when we have some control of the arrangement of things on a small scale, we will get an enormously greater range of possible properties that substances can have, and of different things that we can do."
5. "Atoms on a small scale behave like nothing on a large scale, for they satisfy the laws of quantum mechanics. At the atomic level, we have new kinds of possibilities, new kinds of effects."
6. "The principles of physics, as far as i can see, do not speak against the possibility of maneuvering things atom by atom. It is not an attempt to violate any laws. It is something in principle, that can be done, but in practice, it has not been done because we are too big."

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7. "I am, as I said, inspired by the biological phenomenon in which chemical forces are used in repetitious fashion to produce all kinds of weird effects (one of which is the author)."
8. "If you could swallow the surgeon, you put the mechanical surgeon inside the blood vessel, it goes into the heart, and looks around."
9. "So I want to build a billion tiny factories, models of each other, that manufacture simultaneously."

EDUCATION – MAD SCRAMBLE

1. Nano program – major (under)
2. Eng/Sci major with nano minor
3. Eng/Sci major with nano integration
4. Nano program – major (graduate)

How to best teach it
- Science
- Applied science
- Engineering fundamentals
- Engineering

Nano involves the application of previously learned material except
1…….
2…….
Most have yet to realize nano role

Attempt to apply present day environmental management to nanotechnology

Emphasis will be key on engineering approach and problem solving

4 parts

1. Chemistry fundamentals
2. Particle technology
3. Applications
4. Environmental concerns

CHEMISTRY FUNDAMENTALS – (PART 1)

1. Units, conversion constants and dimensional analysis
2. Atoms, elements, and the periodic table
3. Molecular rearrangements
4. Concentration terms
5. Particle surface area and volume
6. Material science principles
7. Physical and chemical property estimation

PARTICLE TECHNOLOGY – (PART 2)

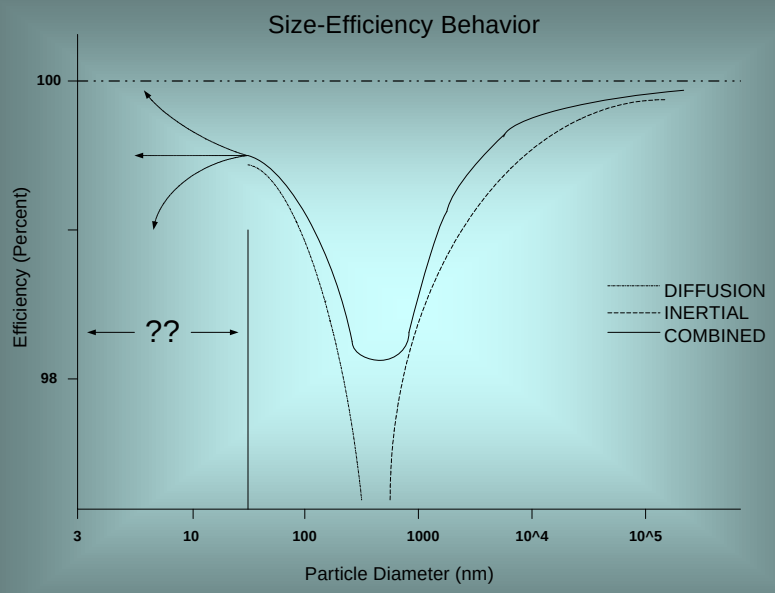
1. Nature of particles
2. Particle size distribution
3. Particle sizing and measurement methods
4. Fluid particle dynamics
5. Particle collection mechanisms
6. Particle collection efficiencies

APPLICATIONS – (PART 3)

1. Patents
2. Size reduction
3. Prime materials
4. Production/manufacturing routes
5. Ventilation
6. Dispersion
7. Ethics

ENVIRONMENTAL CONCERNS – (PART 4)

1. Environmental regulations
2. Toxicology
3. Non-carcinogens
4. Carcinogens
5. Health risk assessment
6. Hazard risk assessment
7. Epidemiology



ENVIRONMENTAL CONCERNS – (PART 4)

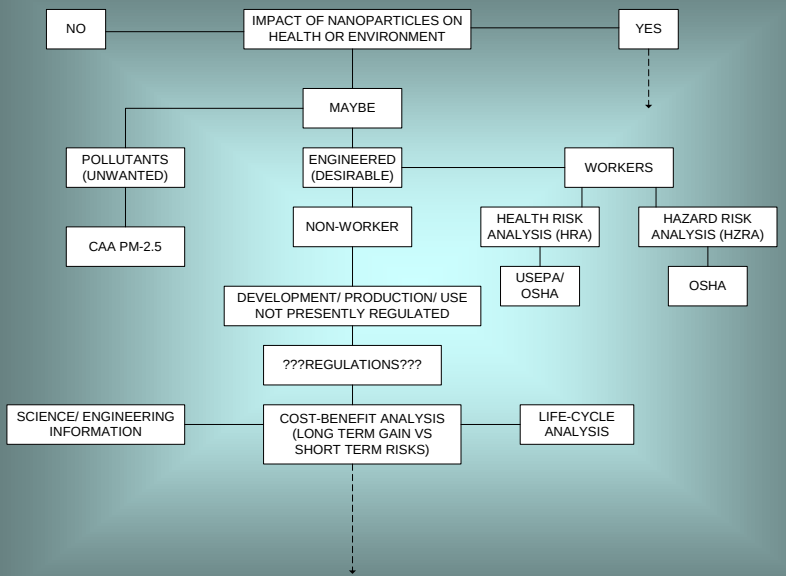
1. Environment regulations
   - Standard stuff (?)
   - Work of Bergeson

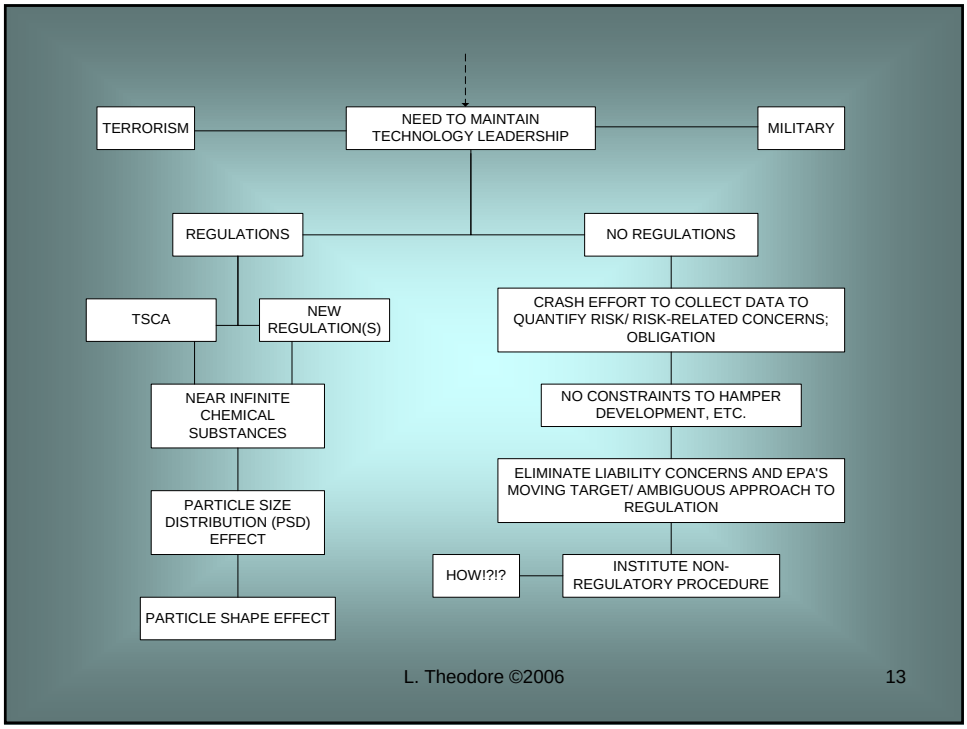
   Public perception
   - Need only one incident
   - Short- and long-term health effects
   - Zero risk???
   - Calls for more funding

2. Toxicology
   - Science of poisons
   - Boom area in nanofield
   - TLV — PEL
   - IDHL — Ceiling values

3. Non-carcinogens – threshold value

4. Carcinogens – ? threshold value





5. Health risk assessment
   Health vs. Hazard

6. Hazard risk assessment more important than health?

7. Epidemiology
   Study of frequency/occurrences

EPILOGUE

Probably no need to worry, but need near-absolute assurances ala global warming

Need a cost-effective product analysis

Cost
- Impact on existing markets
- Return (on investment)
- Patent concerns

Effectiveness
- Enjoyable life
- Healthier life
- In effect: Risk vs. Reward

Monster success story