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Class 4. Swiss Re Outline, Chapters 1-2

Chapter 1: Introduction

- nm = 1 billionth of a meter = 10^{-9} m
- Bacteria ~ 1000 nm
- Ball-shaped virus ~ 60-100 nm
- Micrometer = micron = 1000 nm
- Miniaturization is nothing new
- Nanotech/science = new properties at this length scale
 - Color changes, electrically insulating becomes conducting
- New industrial revolution?
 - Impact on society, economy, life
 - Boundaries among disciplines physics, chemistry, biology merge at the atomic scale
 - May affect every conceivable branch of industry.
- Rapid increase in funding. Public funding in 2003, ~ 3 billion USD worldwide. Same for corps.
- Nanoproducts are being released with short phase of R&D. Worry?
- Behavior of nanoparticles is new:
 - Mobility: Unlike microparticles, nanoparticles have almost unrestricted access to the body. Skin? Digestive tract? Inhalation through lungs?
 - In air or water, can drift on endlessly. But might clump together.
 - If they get in the body
 - Are they more dangerous (reactivity)?
 - Where do they end up? How do they get out?
 - Nanotoxicology
 - o Risk. Insurance company.
 - For now the focus is nanoparticles and their risks (not nanobots and other crazy stuff)
- Some definitions
 - *Top-down:* Processes which reduce bulk materials into nanoparticles by removing material. Resource-wasteful.
 - Bottom-up: Larger structures are built up atom-by-atom or molecule-by-molecule or through self-assembly. Analogy of the human cell given as ideal nanofactory.
 - Self-assembly: integration method by spontaneous assembly which is governed by physical (chemical) processes (e.g. crystal growth.)

Chapter 2: Nanotechnology – primarily an order of magnitude

- Nanoparticles: Small particles, 1nm-100nm, that arise in the course of miniaturizing any given material, such as gold, carbon, or silicon. They tend to have different properties from the bulk material.
 - Titanium dioxide particles in sunscreen
 - Ferrous Oxide as a contrast medium in imaging (e.g., X-rats)
 - The admixture of nanoparticles can cause certain effects, such as materials strength, conductivity, optical properties, or scratchresistance.
- Nanotubes: Hollow, cylindrical object 1-100nm in diameter but may be much longer. A crystallographic allotrope of carbon (or other elements). (NOTE: Often confused with nanowires, which are not hollow and are more like nanoparticles.)
- Buckyballs: A 60 carbon cage-like molecule, like a soccer ball. Can be filled with other substances. (NOTE: There are other fullerene molecules with different numbers of atoms.)
- Nanotechnology as order of magnitude
- *Nanomaterials:* any materials that either contains a certain portion of nanoparticles or even exists exclusively of them.
- Swiss Re defines nanotech as nanoparticles, coatings, or materials that are less than 100 nm in size
- Nanoparticles have two new properties
 - Subject to laws of quantum physics quantum size effects. (NOTE: quantum effects can emerge at bigger, macroscopic length scales in certain situations, e.g., superconductivity)
 - Increase of surface area to mass ratio. Atoms on surface are less strongly bonded than interior (more reactive).
 - Desirable for catalytic processes?
 - Harmful when inhaled?
 - Normally harmless particles may become harmful as their size shrinks.
- Nanoparticles aren't new
 - Existed in nature
 - Salt nanocrystals (water soluble)
 - Ultra-fine carbon from diesal engines (sought)
 - But, short lived. Tend to clump together to form microparticles.
 - But artificial nanoparticles may not
 - Tend to be commercially coated to prevent clumping (and loss of nano-properties).
 - Highly mobile, reactive, forever?