



Toxics Use Reduction Institute

Exposure to Nanoparticles: Is This Something We Should Worry About?

If So, What Should We Do About It?

Michael Ellenbecker



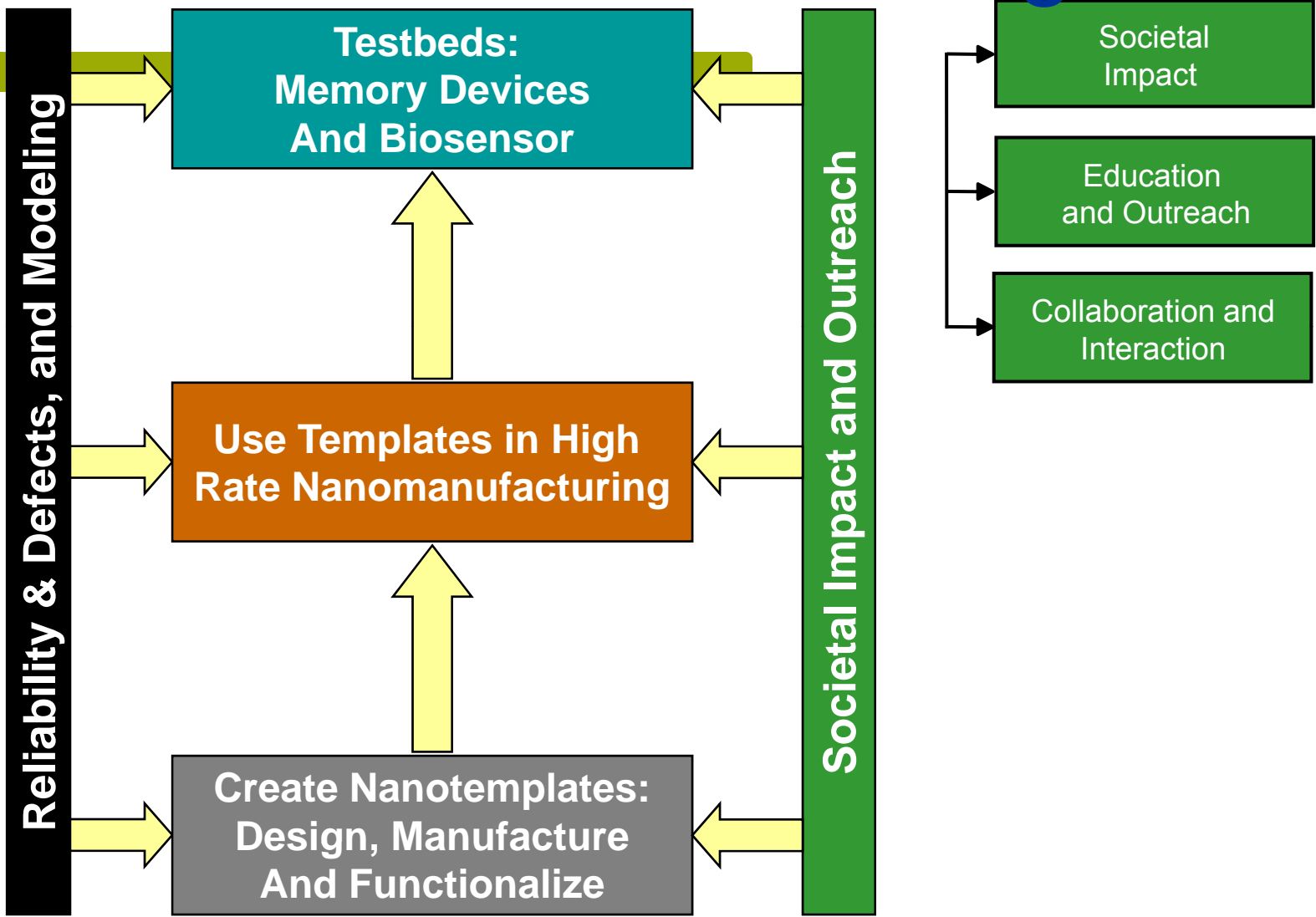
The NSF Nanoscale Science and Engineering Center for High-rate Nanomanufacturing



Center for High-Rate
Nanomanufacturing



CHN Pathway to Nanomanufacturing





Who Might be Exposed?

- Workers manufacturing nanoparticle-containing devices
- The general public



When Might We be Exposed?

Life Cycle Assessment:

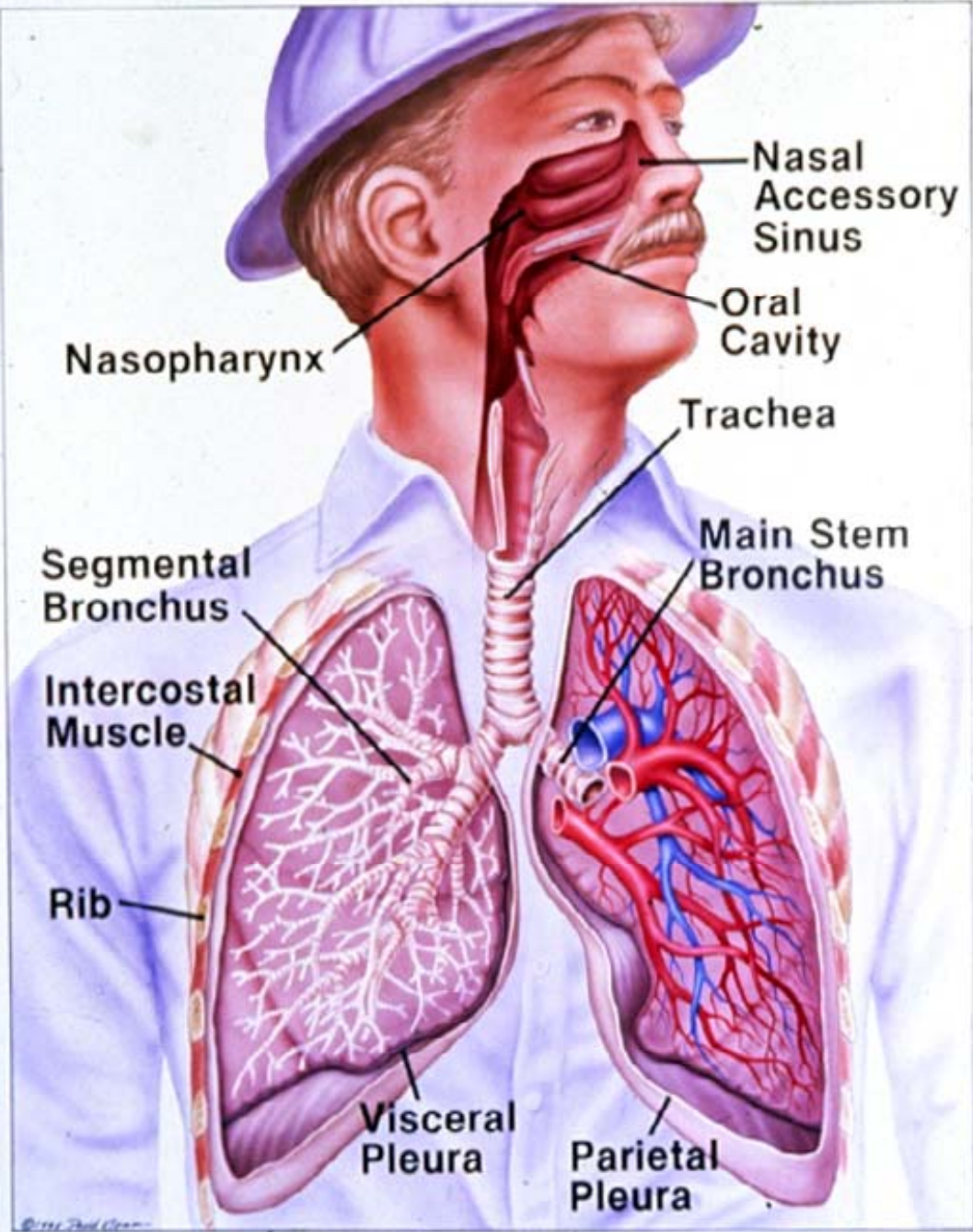
- Manufacture
- Use
- End of life disposal



How Might We be Exposed?

- Routes of exposure:
 - Injection
 - Ingestion
 - Inhalation
 - Dermal exposure

RESPIRATORY SYSTEM



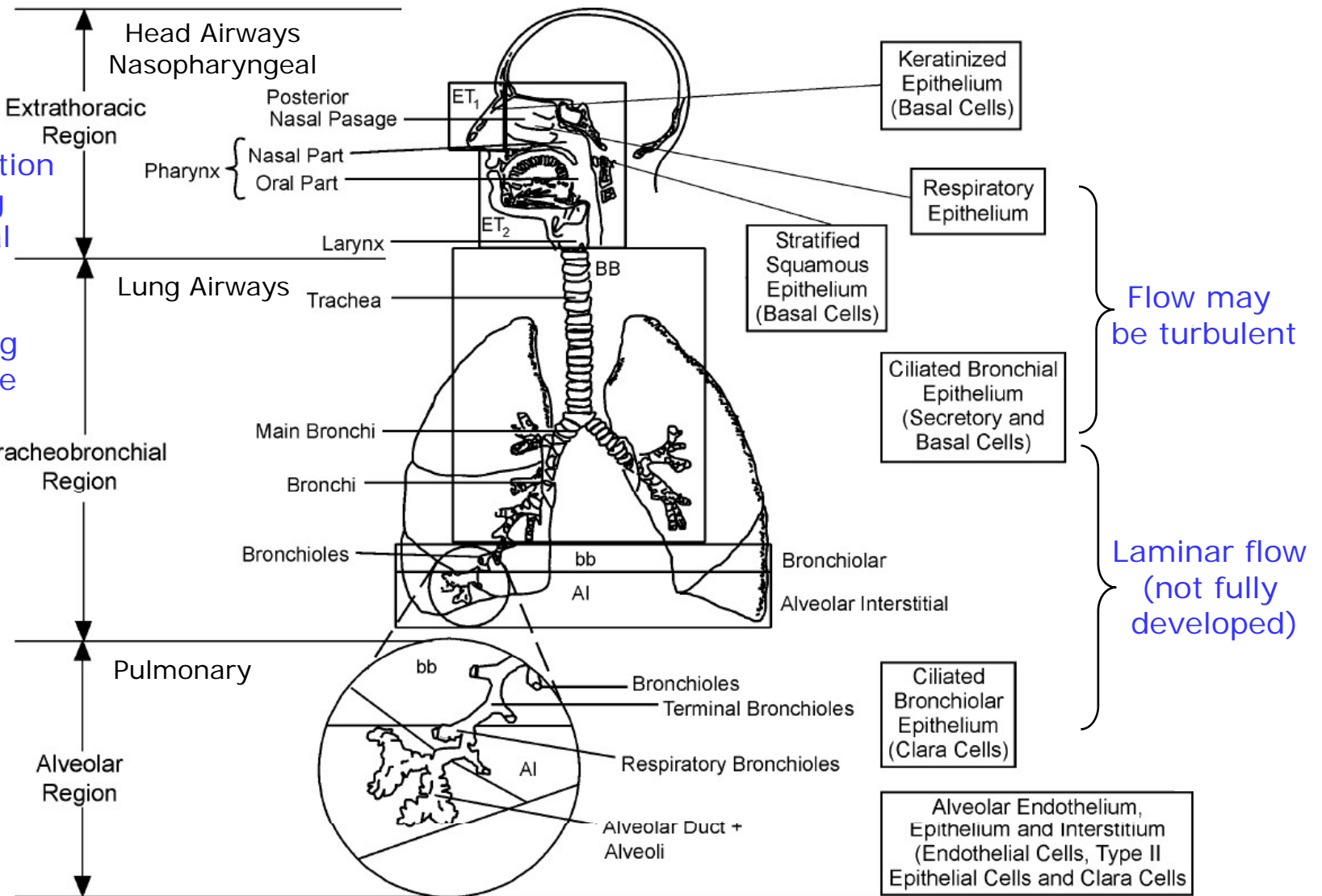


The Human Respiratory Tract

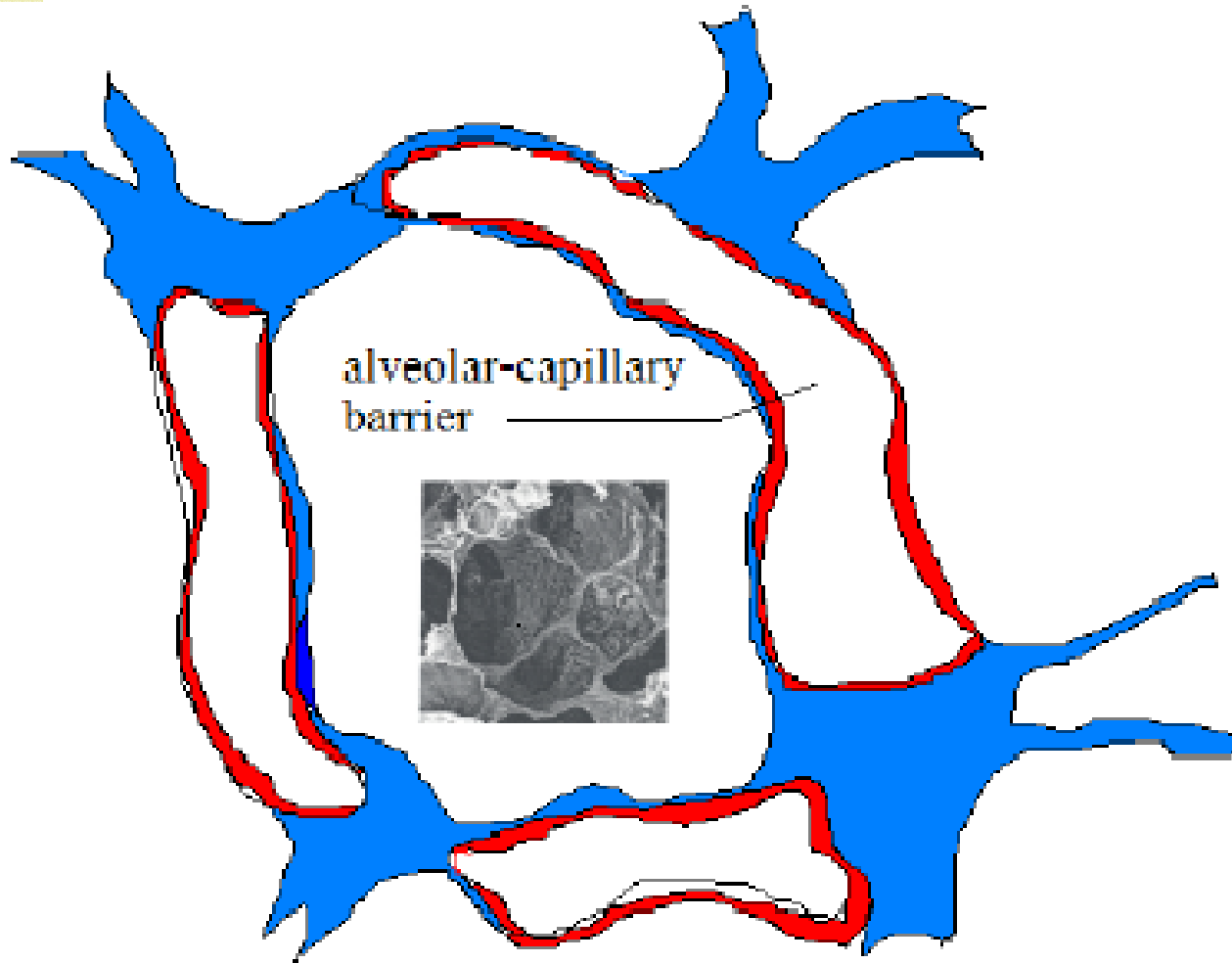
Humidification
Heating
Removal

Branching
Clearance

Gas
Exchange



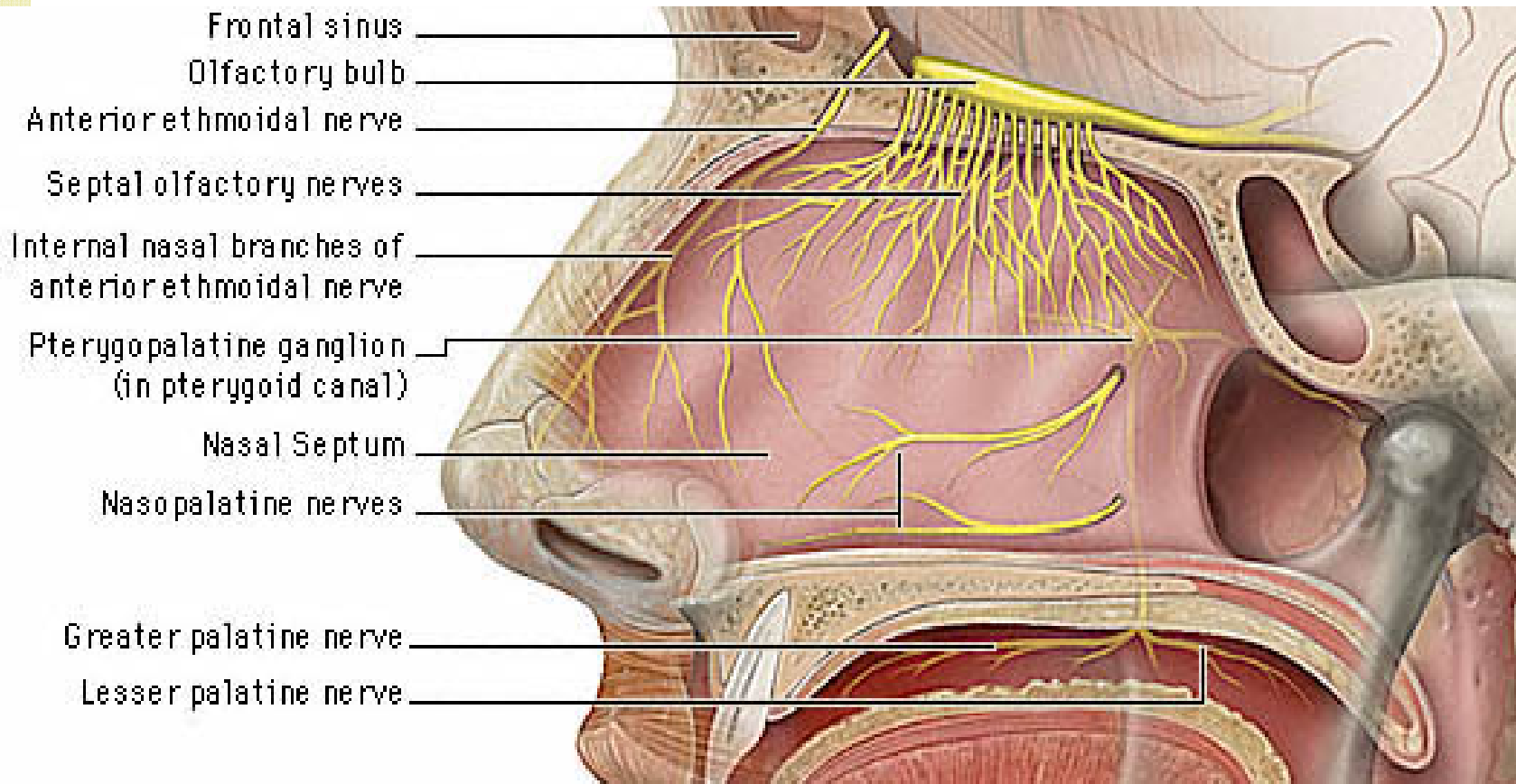
Cross-section of alveoli



Shows a very thin (500 nm) separation between blood and air. An SEM image of the alveoli is shown in the inset



Olfactory nerve exposure and central nervous system effects

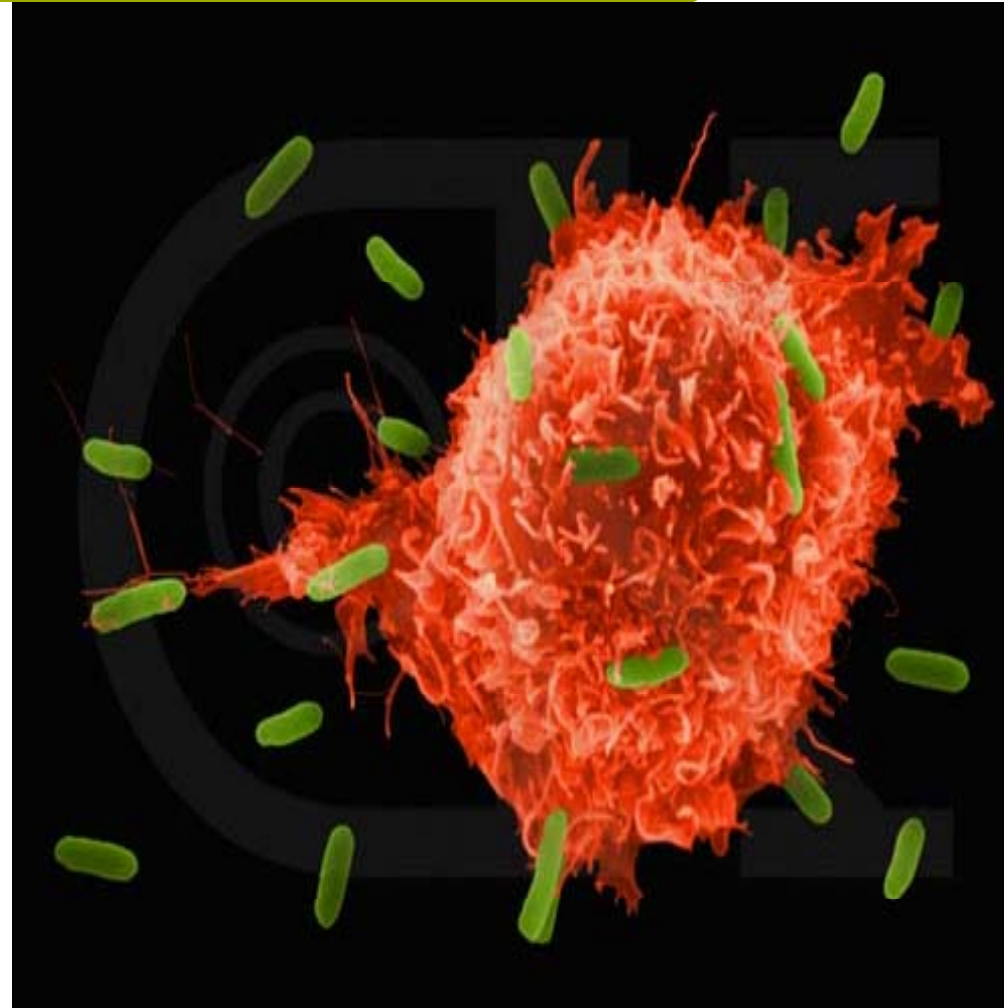


HUMAN - BRONCHIOLE





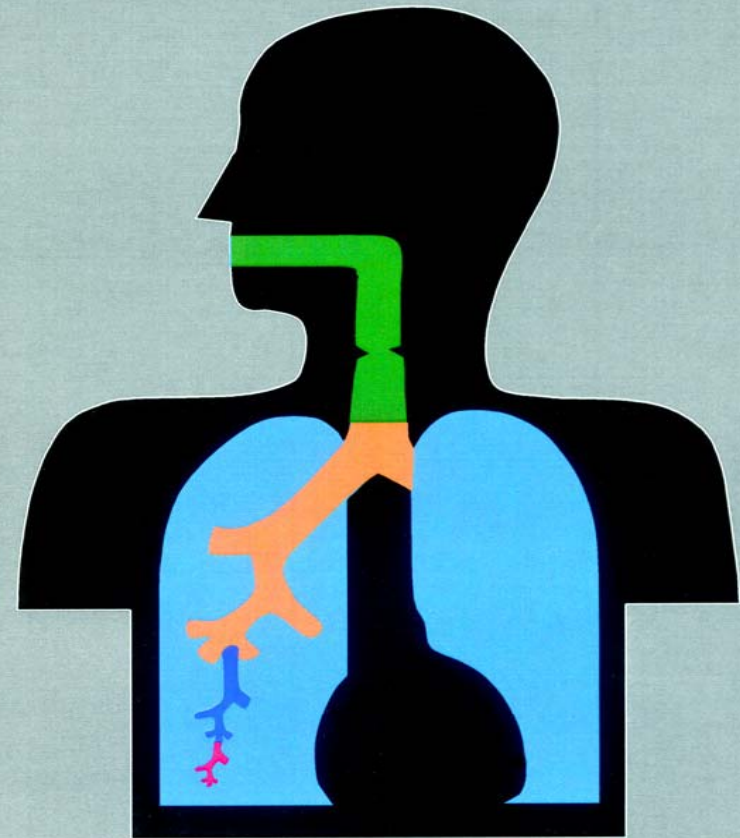
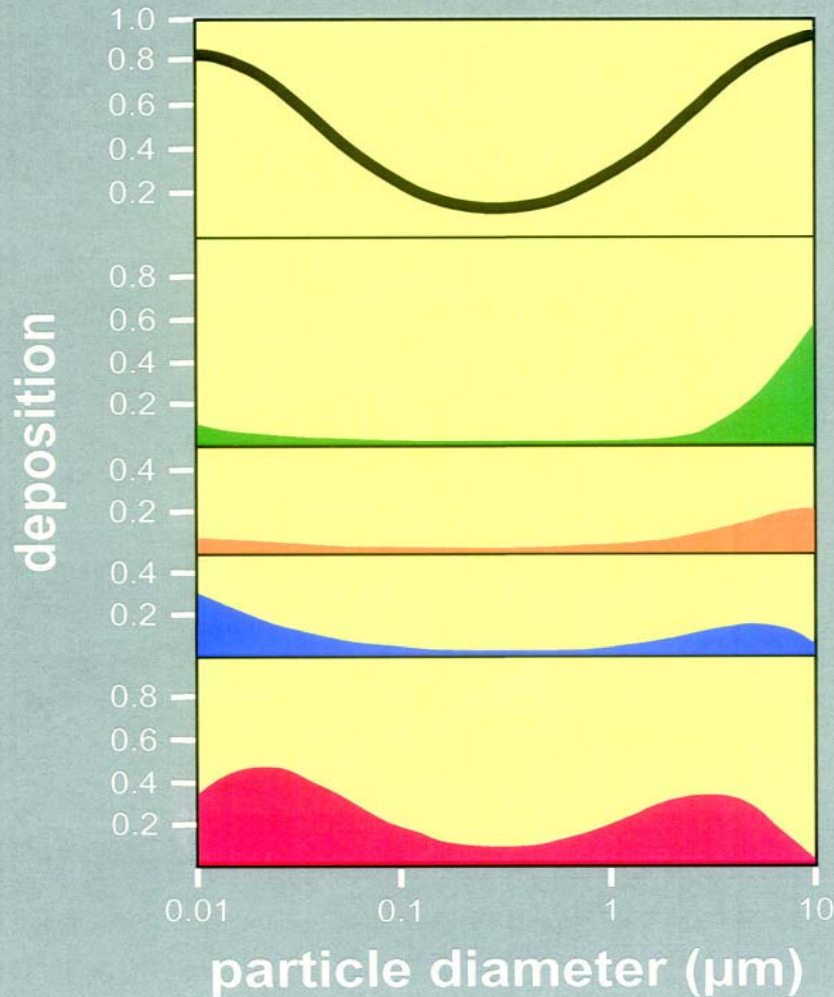
Alveolar Macrophage attacking *e. coli*





Regional Lung Deposition

particle density: 1 g cm^{-3}
 respiratory flow rate: $300 \text{ cm}^3 \text{ s}^{-1}$
 respiratory cycle period : 5 s



Modeled Total Particle Deposition Probability

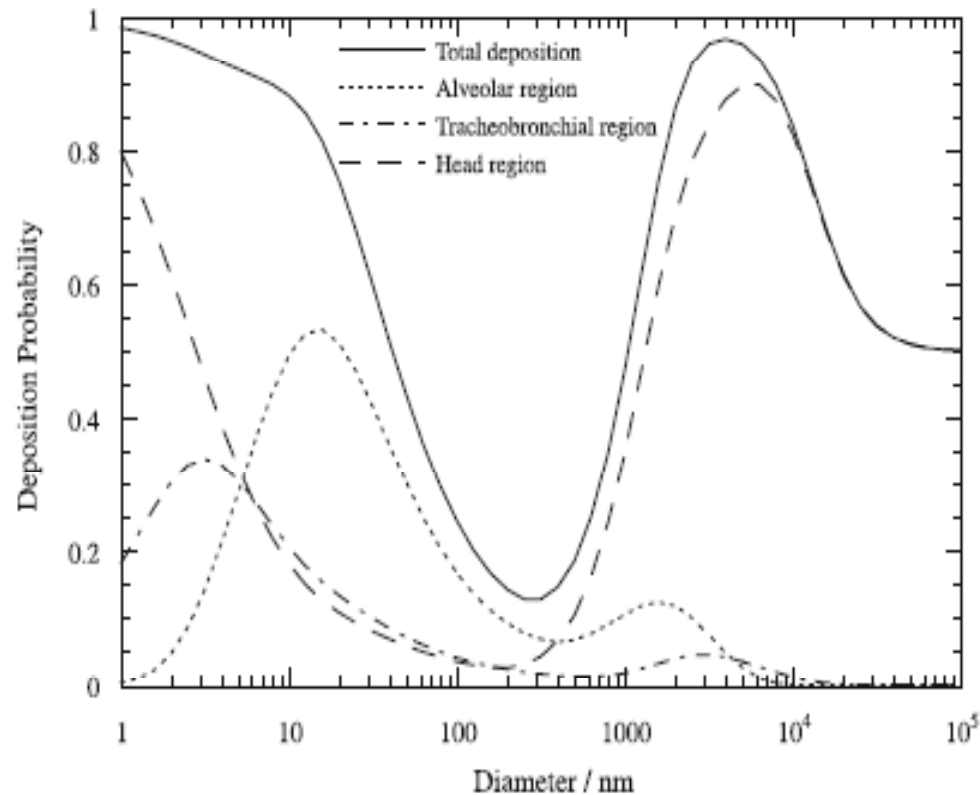


Figure 2. Modeled total particle deposition probability in the respiratory tract, and deposition probability in the alveolar region (ICRP, 1994). Deposition has been modeled assuming an adult breathing through their nose at 25 l/min (light exercise), and exposed to spherical particles with a density of 1000 kg/m³.

Source: Maynard and Kuempel, "Airborne nanostructured particles and occupational health (2005)"



NIOSH Inhalation Studies

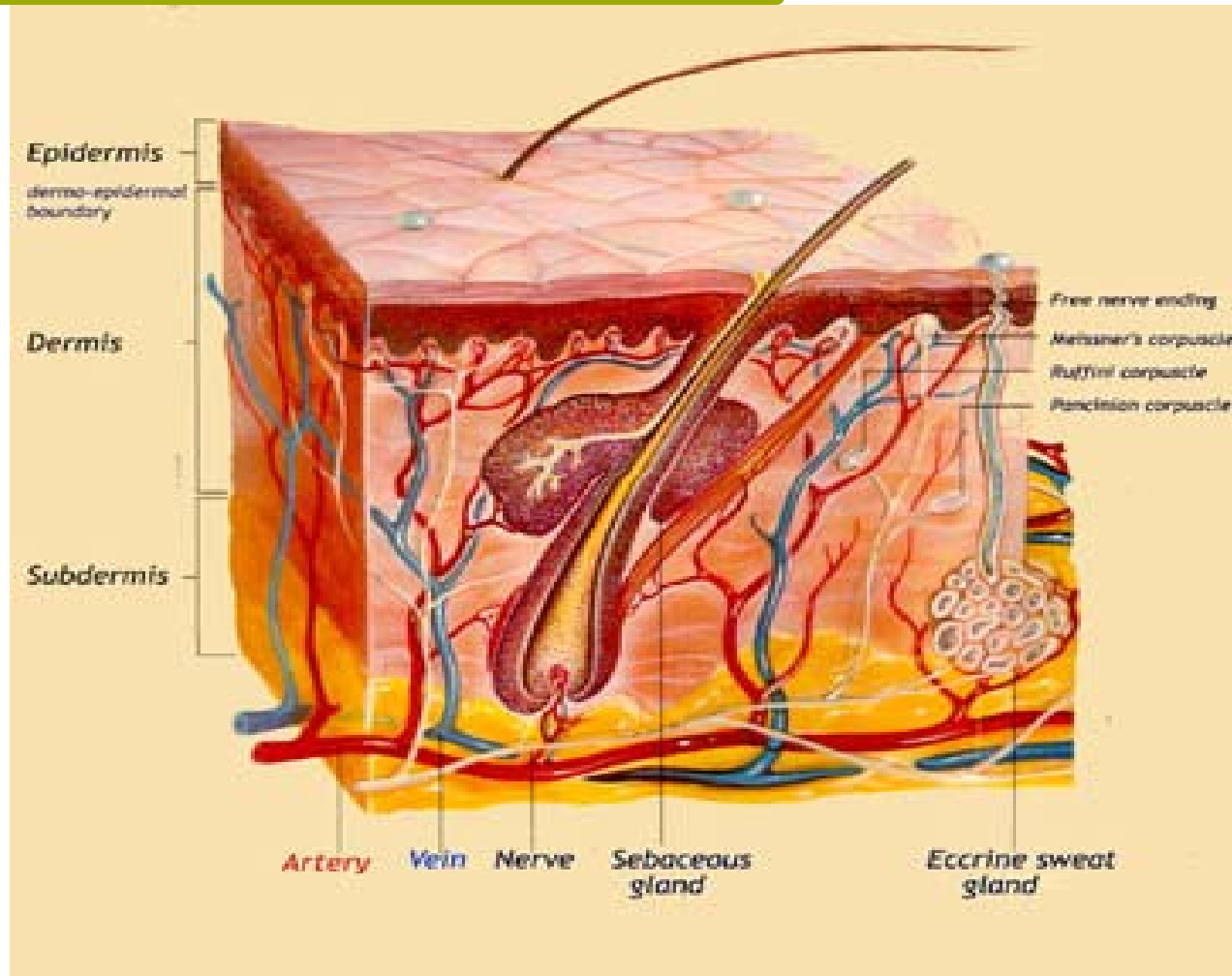
- Purified SWCNT's
- Mice
- Aspiration – 0, 10, 20, 40 $\mu\text{g}/\text{mouse}$
- Ultrafine carbon black and SiO_2 used as control
- Dose equivalent to a worker exposed to the graphite Permissible Exposure Limit ($5 \text{ mg}/\text{m}^3$) for 20 work days



Effects on Lung

- Both *inflammation* (acute response) and *fibrosis* (chronic response) were found
- Effects were dose-dependent
- No fibrosis and greatly reduced inflammation found with the reference materials

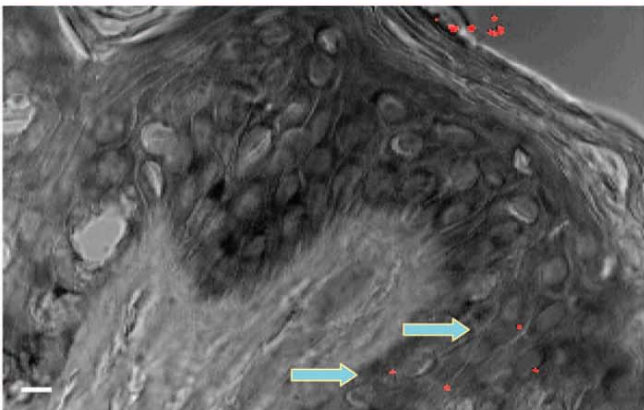
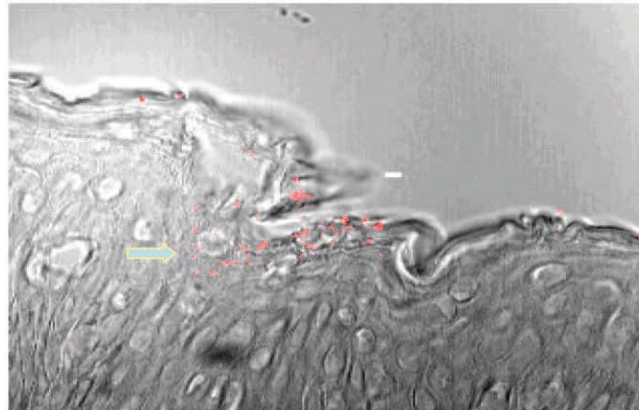
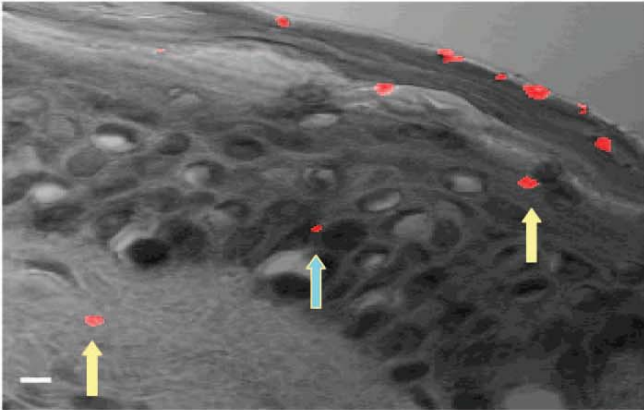
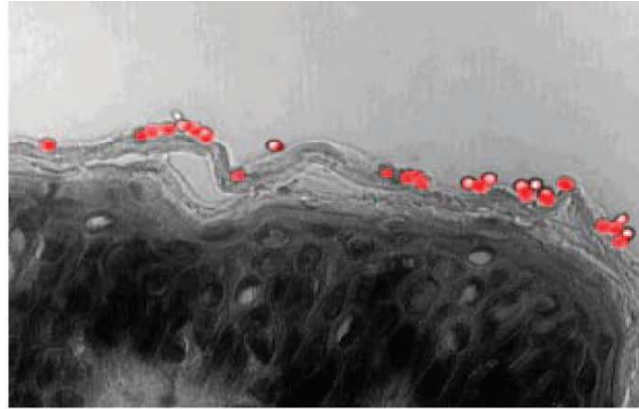
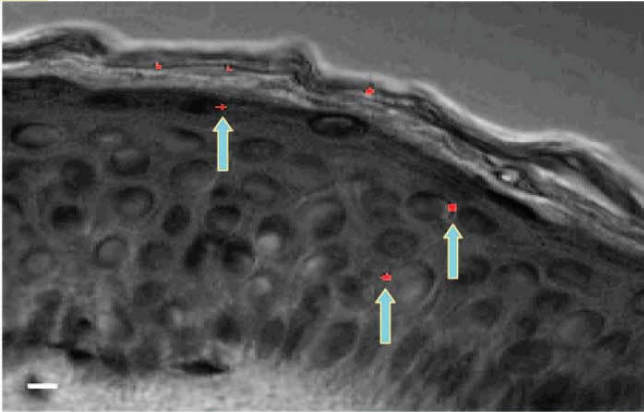
Dermal Exposures





Dermal Penetration

- Herpes virus has a diameter of ~ 150 nm
- Penetrates the skin and travels to the spinal column
- Can this happen with engineered nanoparticles?
- Particles have been found in the epidermis



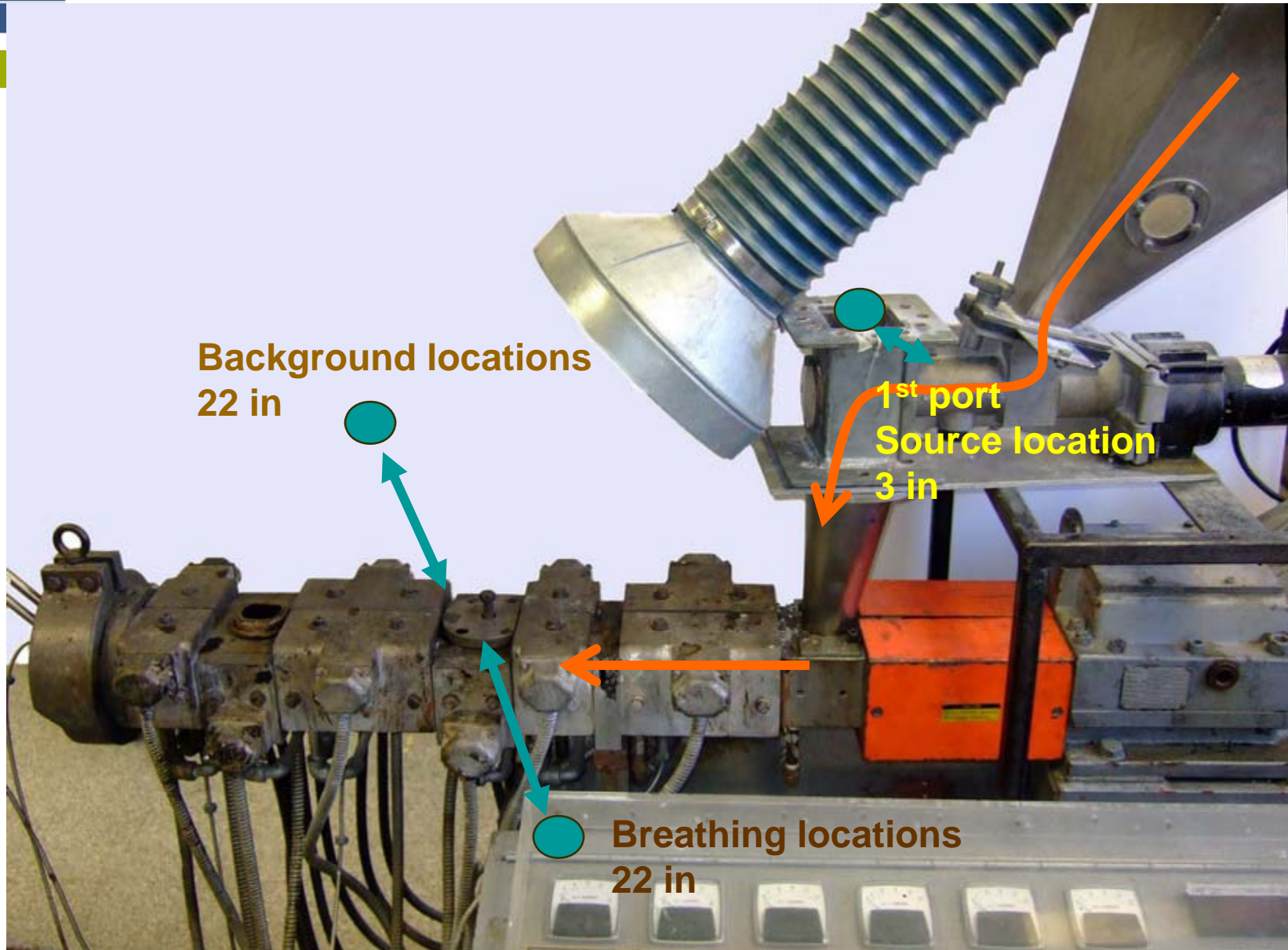
Dermal Exposure

Tinkle et al
EHP 2003



Are CHN researchers being exposed?

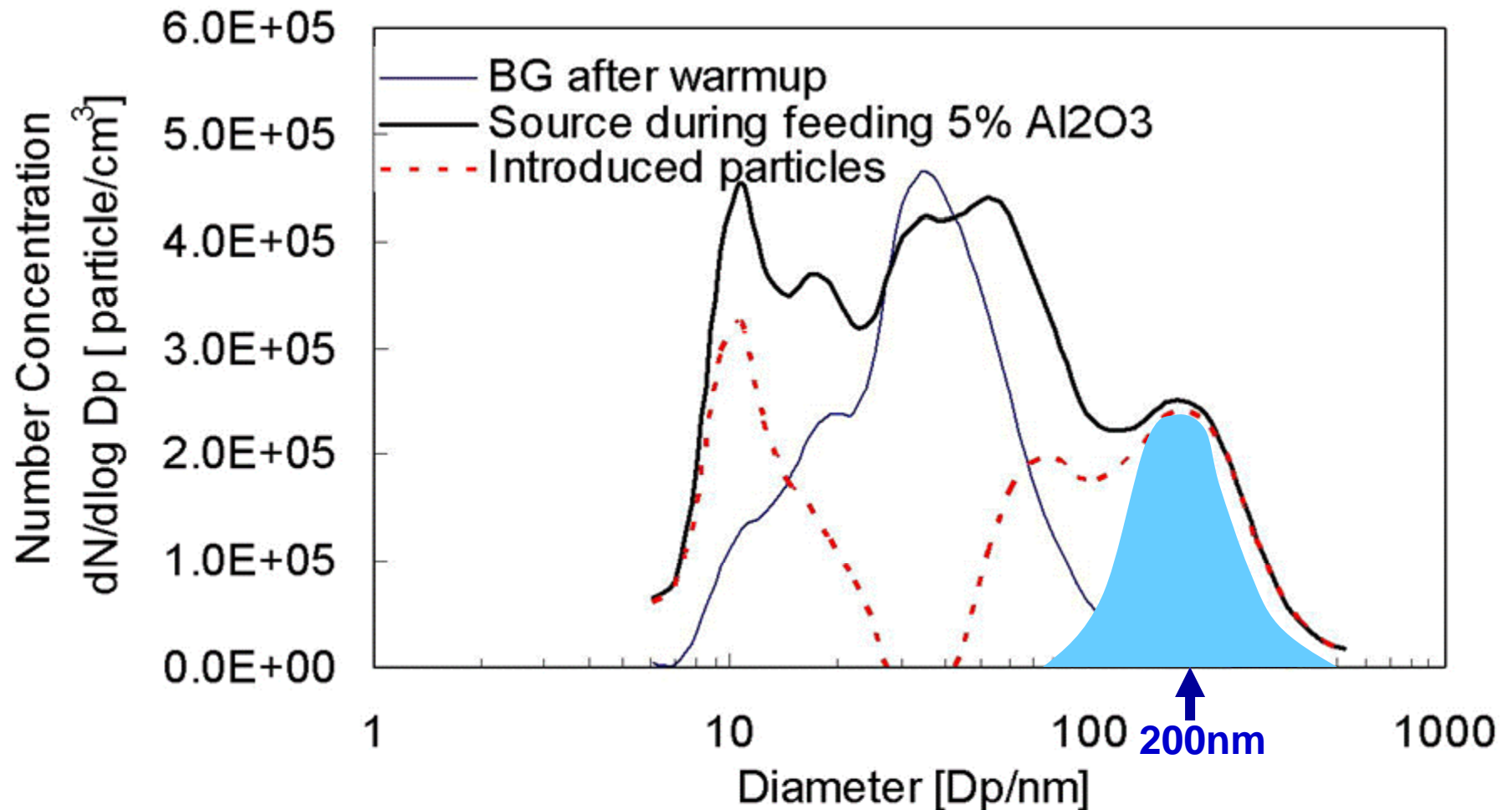
Measuring Location of TSE





Introduced Nanoparticles

At source





Fume Hoods

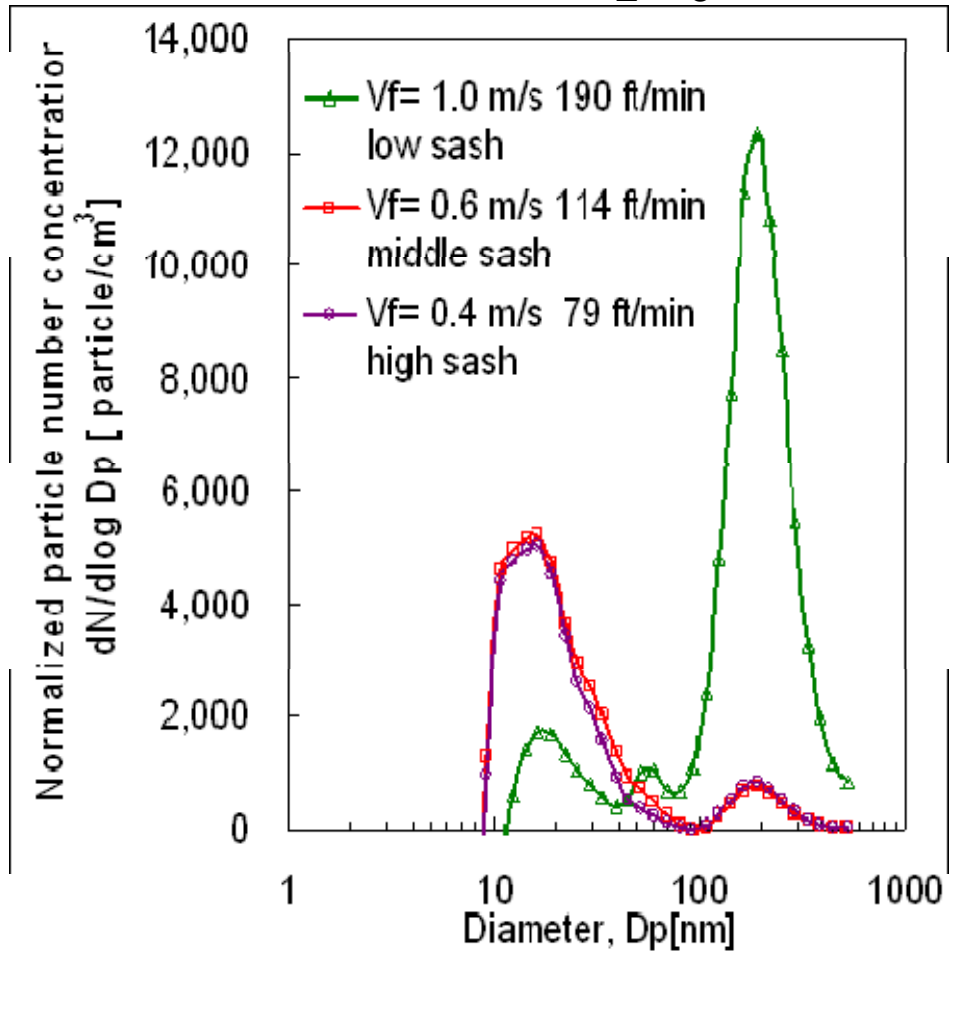
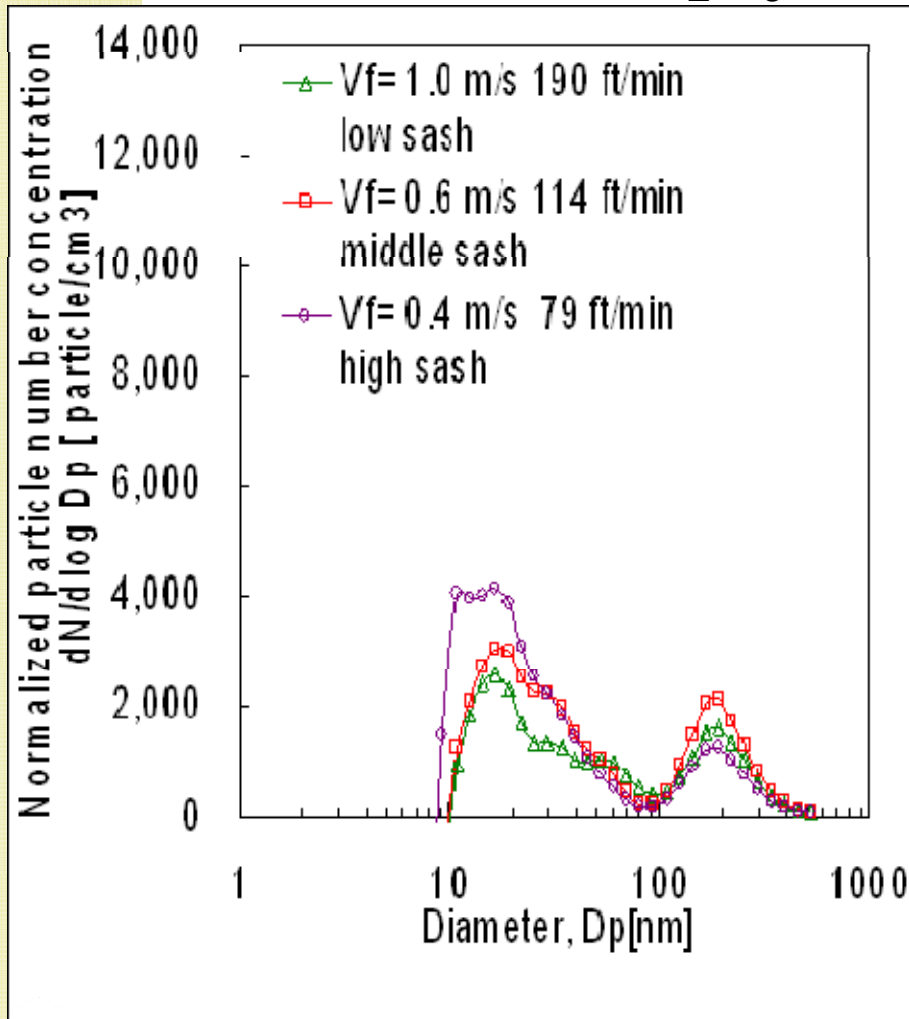




Breathing Zone- Conventional hood

Transferring 100g Al_2O_3

Pouring 100g Al_2O_3



Note: Background concentration was subtracted.



Woodrow Wilson Institute

- Project on Emerging Nanotechnologies
- Nanotechnology Consumer Products Inventory
- Currently lists 580 products, from
 - AccuFlex Evolution golf shaft, to
 - Zelens C-60 Fullerene Night Cream

<http://www.nanotechproject.org/index.php?id=44>



From Zelens web site

“Fullerene C60 is a naturally occurring microscopic form of carbon, of the same purity as a diamond, which was found to have remarkable anti-oxidant properties. The key to the power of Fullerenes C60 lies in its shape. Its 60 carbon atoms are arranged like a soccer ball, with 32 surfaces. Each of these surfaces attracts, and neutralizes, the damaging free radicals, leading scientists to call Fullerene C60 the ‘radical scavenger.’”





Air Sanitizer by Shenzen Industry

“Nano silver photocatalyst keeps the features of common air sanitizer. Because of adding nanometer Ag, etc. the air sanitizer has capabilities of stronger oxidation reductive reaction, sterilization, deodorization, decomposing and adsorption, but also has the efficiency of persisting in sterilization (Can sterilize even in the conditions of no light) and keeping moisture within 24 hours.”





Blue Lizard Baby

“Blue Lizard Baby - Chemical free formula, SPF 30 formulated in Australia using the newest Nanotechnological ingredients to meet the world's toughest sunscreen standards... Australia's and yours! “





MesoGold by Purest Colloids, Inc.

“Contains only pure water and pure gold nanometer sized particles.”

“Smallest gold nanoparticles whose diameter typically measure 3.2 nm”





NanoFilterCX Cigarette Filter

“The NanoFilterCX™ combines sub-micron fibers with nanofibers to produce a high void fiber matrix.... to provide for higher diffusion, interception and retention of smoke toxins and dangerous particulate matter without losing desired tobacco taste.”



EXPOSURE

Potential for contact with nanomaterials varies over time

FACTOR FOR CONSIDERATION	LIFE-CYCLE STAGE		
	MANUFACTURE	USE	END OF LIFE
Ability to control exposure	High	Medium	Low
Time for impact	Short or long	Long	Long
Who/what at risk for exposure	Workers	Consumers	Environment
Key form of exposure	Free particles	Fixed particles	Fixed particles
Degree of regulation	High	Medium	Low
Incentive for producer to invest in countermeasures	High	High	Medium
Number of individuals at risk	Tens to thousands	Thousands to millions	Millions
Opportunity for exposure to large volumes	Frequent	Rare	Possible over time
Unresolved questions	Fewest	More	Most

SOURCE: Lux Research



What Should We Do About It?

- Worker exposure
 - Best practices for minimizing exposure
- Consumer exposure
 - Don't buy dumb products!
- End of life
 - ??????????
- Throughout life cycle
 - Lack of government regulation/guidance



Toxics Use Reduction Institute

Best Practices for Working Safely with Nanoparticles in University Research Laboratories

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Center for High-Rate
Nanomanufacturing



Document Outline

1. Introduction
2. Basic Premises
3. Occupational Hygiene Resources Available to CHN Researchers
4. Routine R&D Laboratory Operations
5. Management of Nanomaterials
6. Management of Nanomaterial Spills



2. Basic Premises

- Relatively little known about the toxicity of nanoparticles
- Enough known about engineered nanoparticles to cause concern
- The precautionary approach must be followed, i.e., limit exposure to nanoparticles until we know that certain exposures are acceptable



Availability

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