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# Health Effects of Ultrafines: Why Solid Particles have highest Priority

a Presentation by J. Schiltnknecht MD



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- Anatomy and Function of the Lungs and Defense Mechanisms
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- Distribution of the suspended Noxes, Monitoring
- Epidemiology and Economics

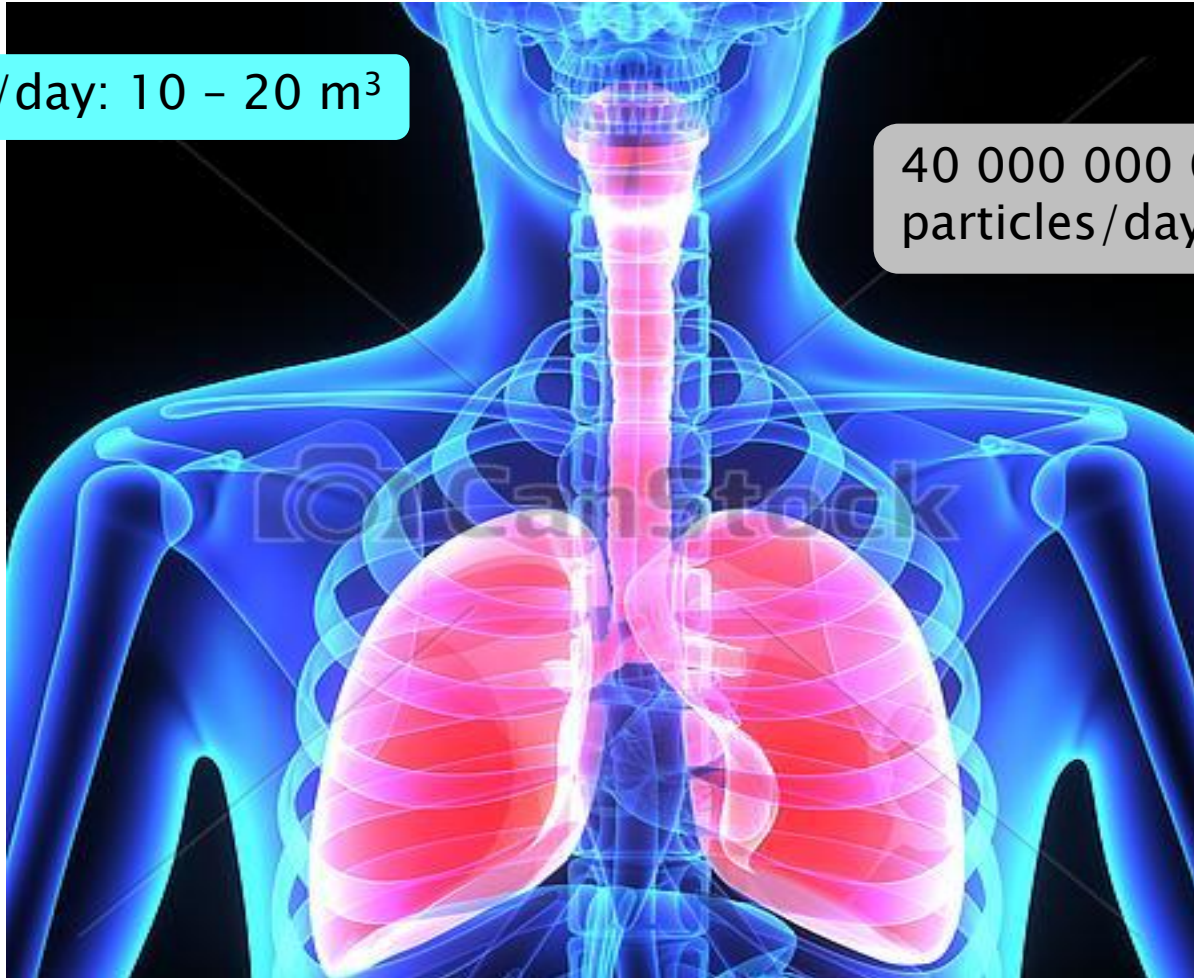


# Lung Performance

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Air volume/day: 10 – 20 m<sup>3</sup>

40 000 000 000  
particles/day

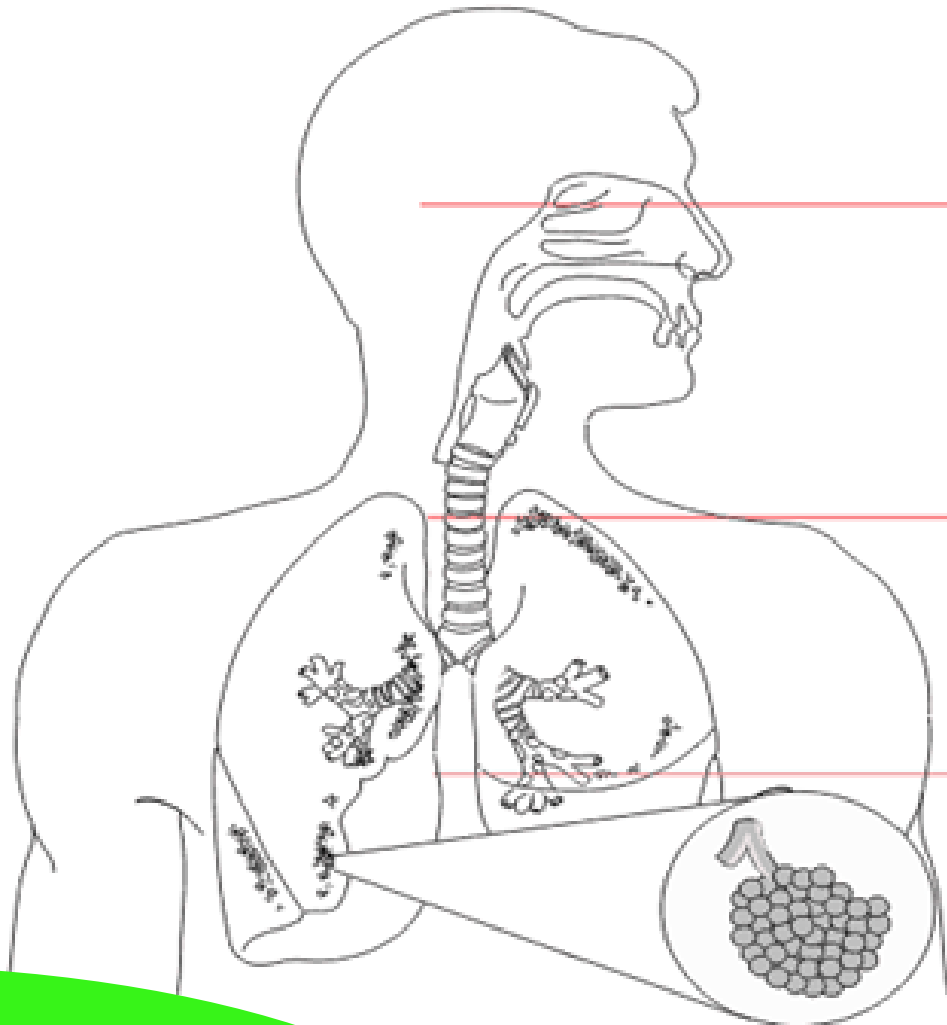






# Airways

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**Upper Airways**

**Trachea**

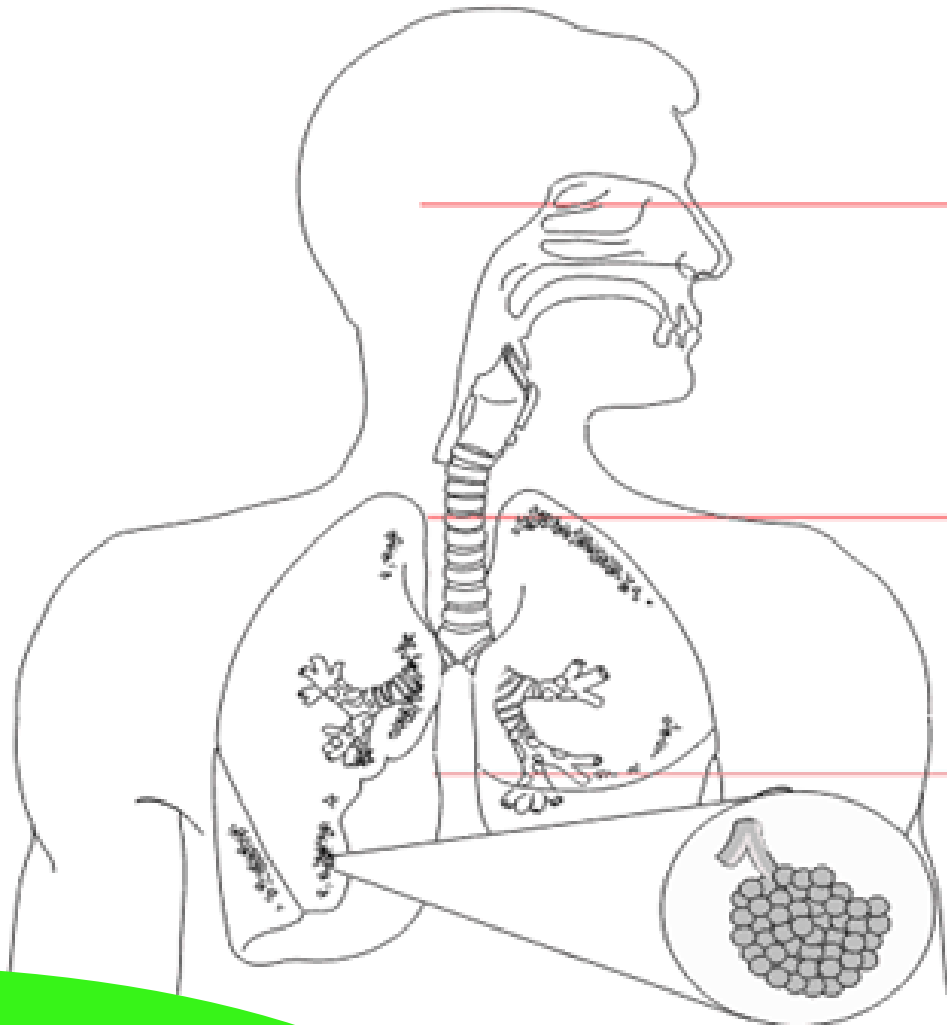
**Bronchi**

**Bronchioles**

**Alveoli**

P. Straehl, BAFU, Abt. Luftreinhaltung und NIS

# Airways & Particle Uptake



Upper Airways 5–10  $\mu\text{m}$

Trachea 3–5  $\mu\text{m}$

Bronchi 2–3  $\mu\text{m}$

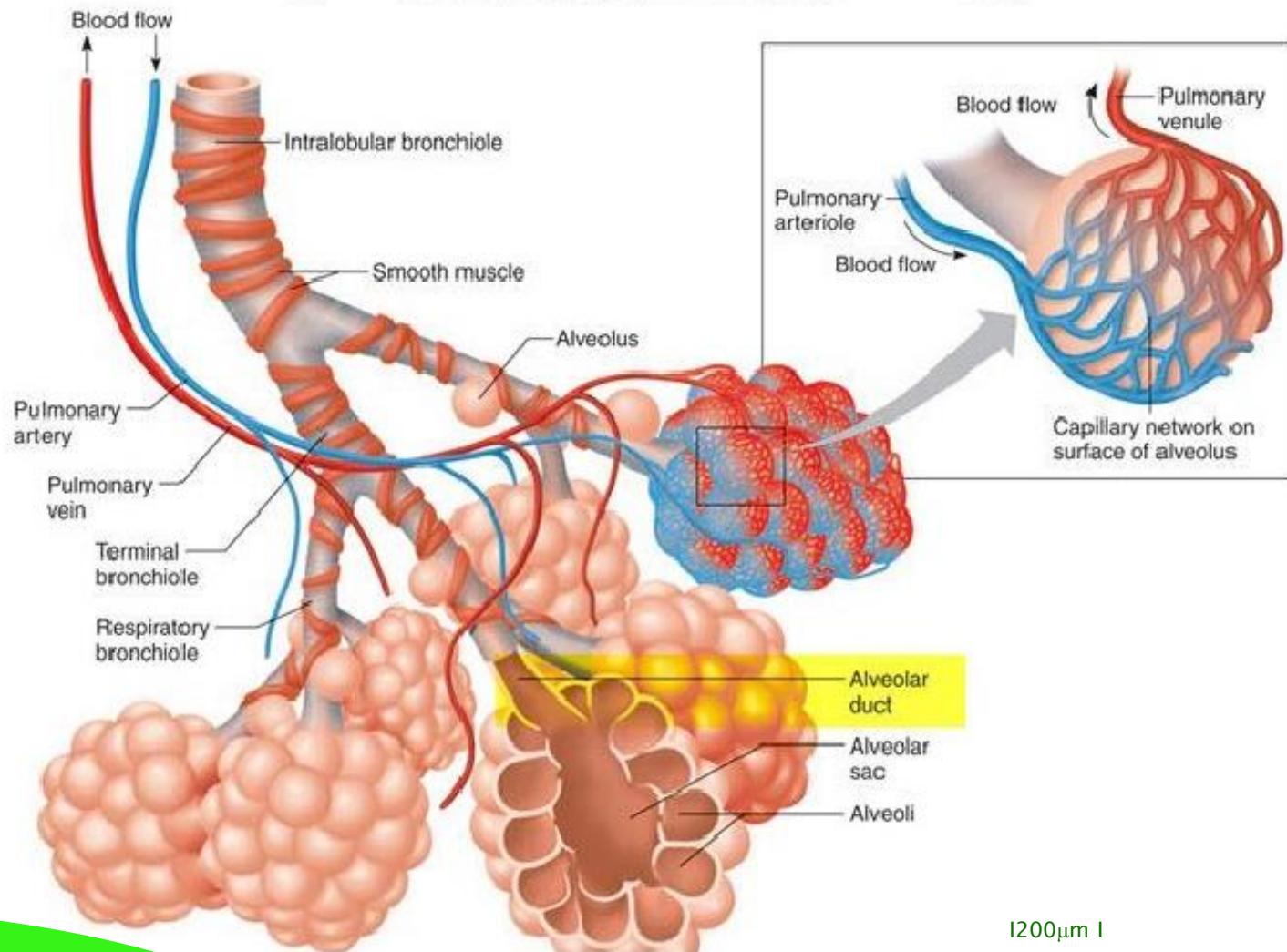
Bronchioles 1–2  $\mu\text{m}$

Alveoli <1  $\mu\text{m}$

P. Straehl, BAFU, Abt. Luftreinhaltung und NIS



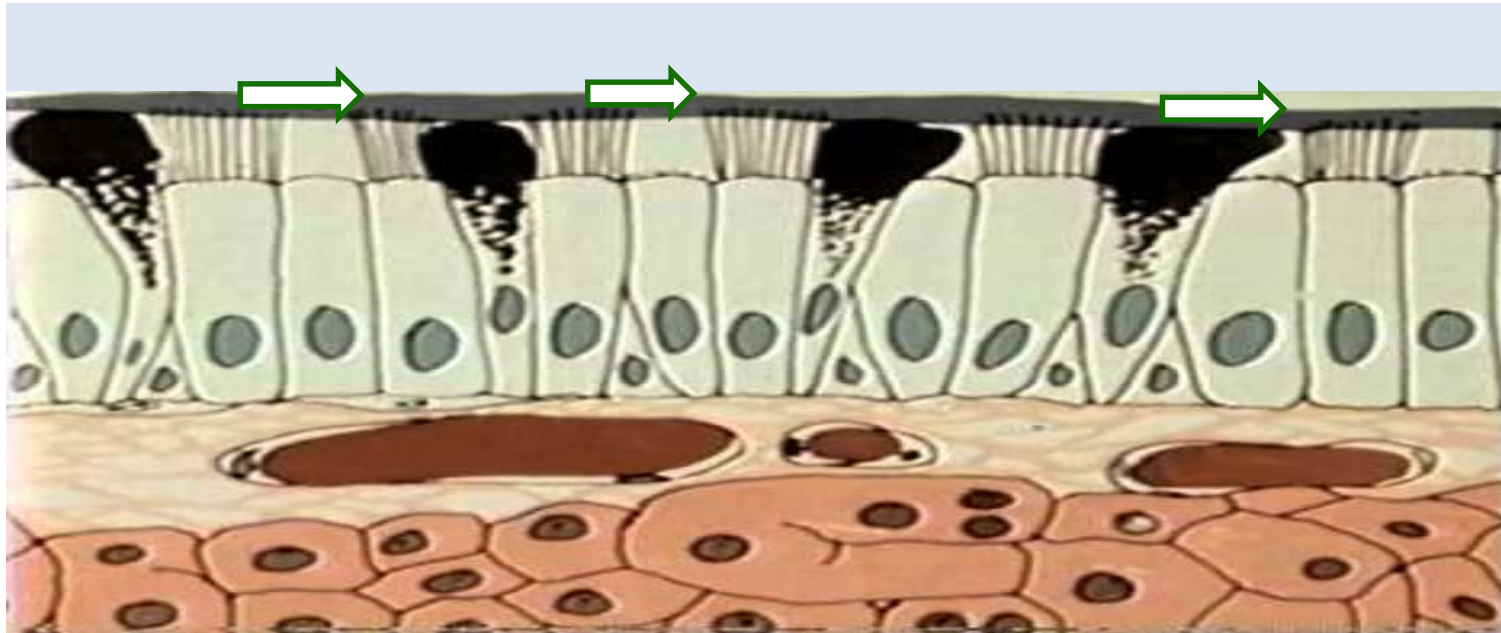
# Terminal Bronchioli & Alveoli



1200 $\mu$ m I

# Mucociliary Apparatus

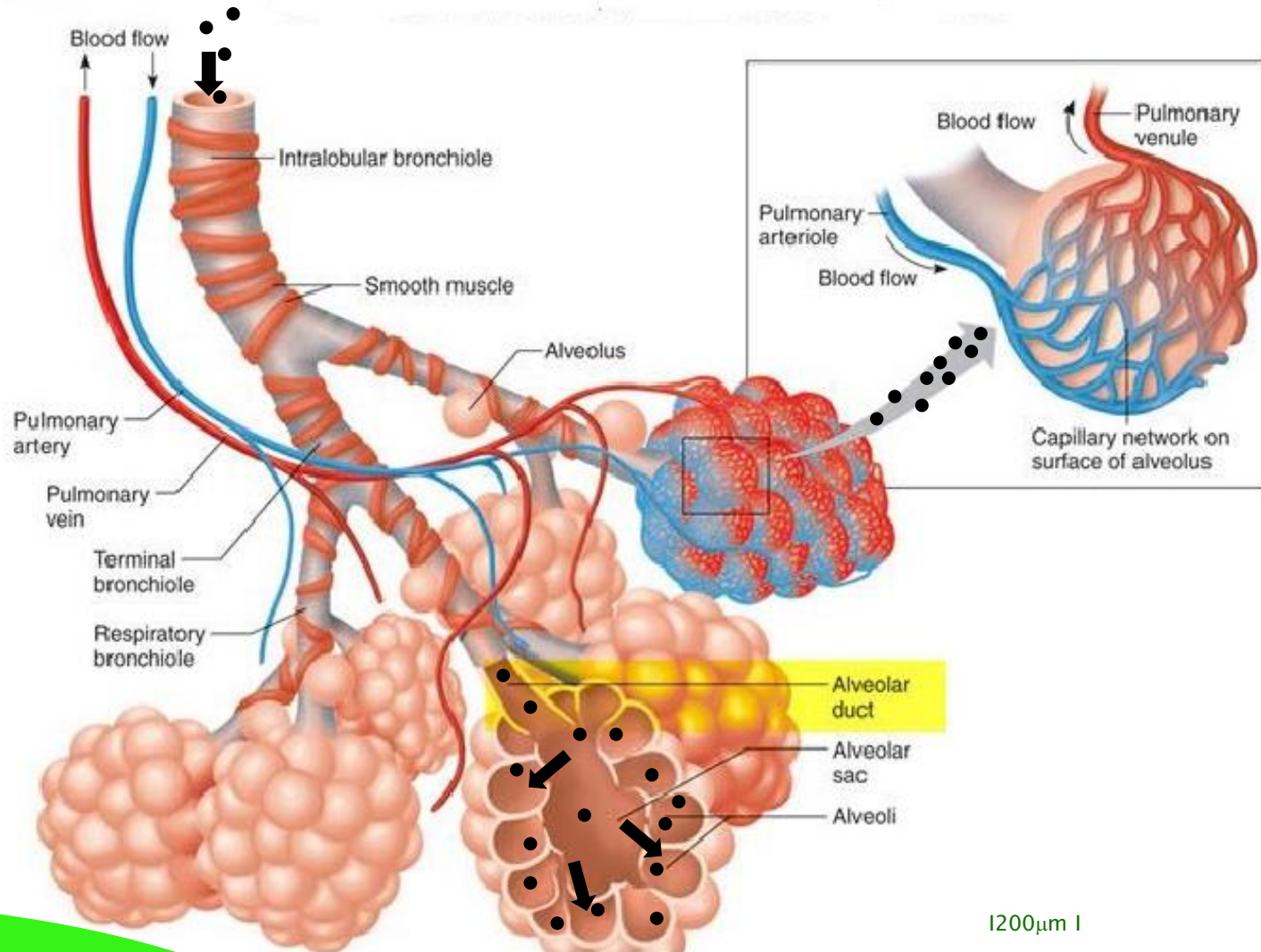
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Section of a bronchial wall with ciliated cells transporting a mucus layer and goblet cells



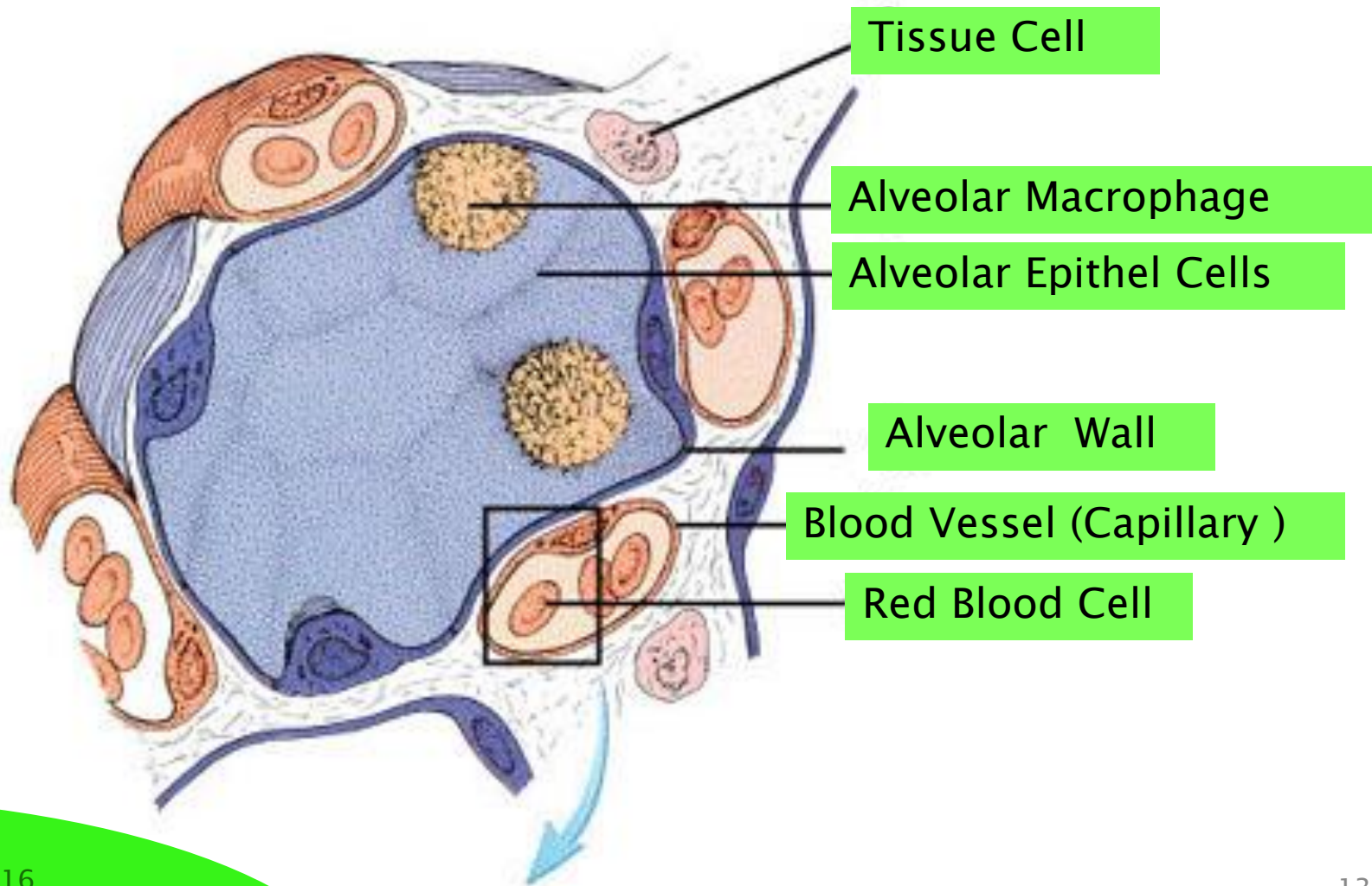
# Nanoparticles entering Alveoli



1200 $\mu$ m l

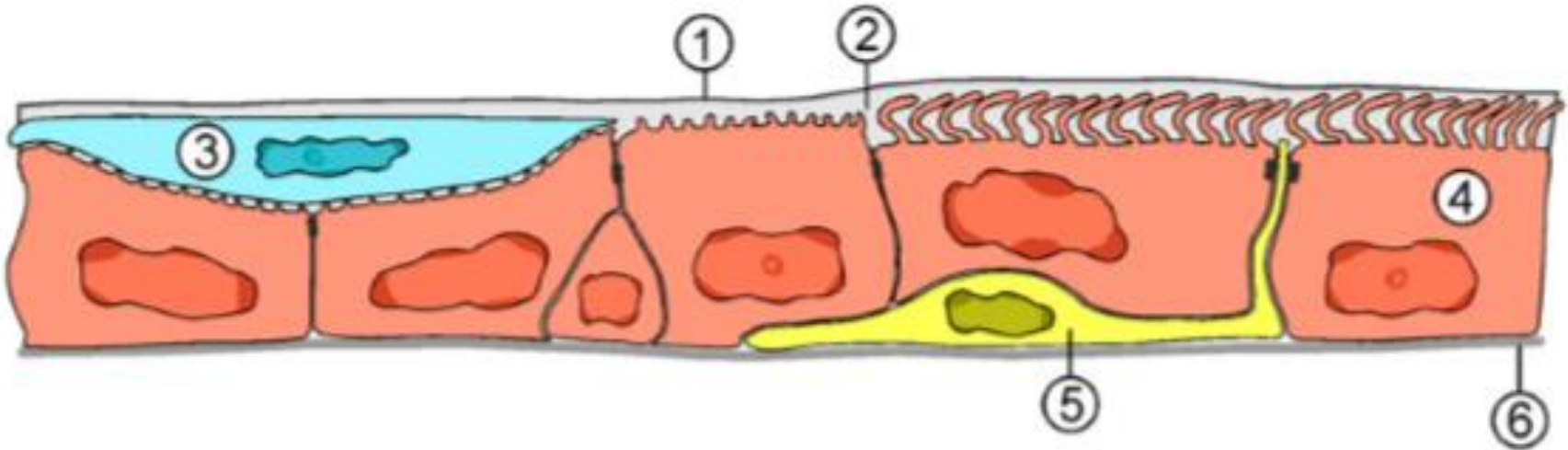


# Alveoli surrounded by Capillaries





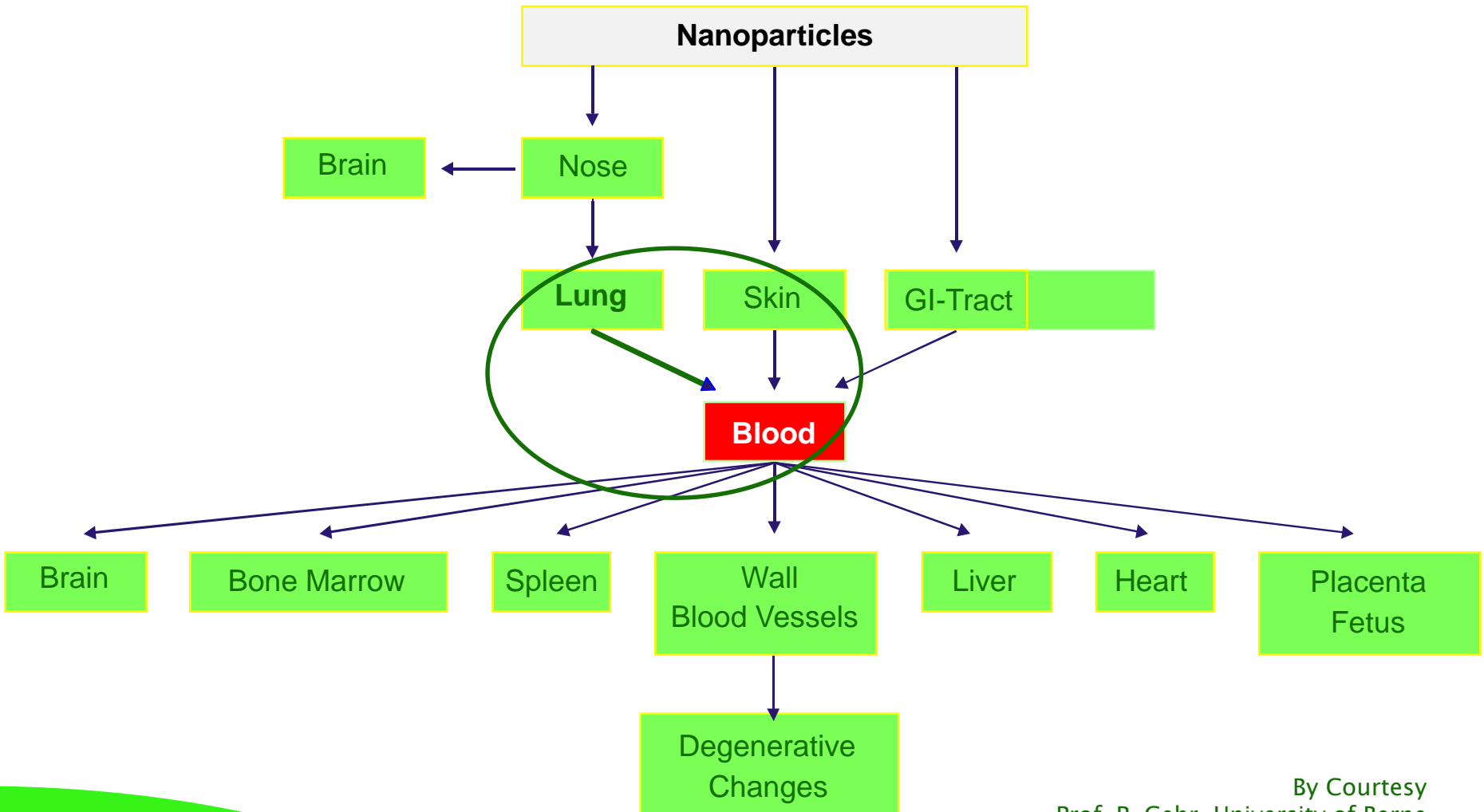
# Airway Macrophage



- 1 Surfactant film
- 2 Aqueous surface lining layer
- 3 Macrophages
- 4 Epithelium
- 5 Dendritic Cells



# Translocation of Nanoparticles



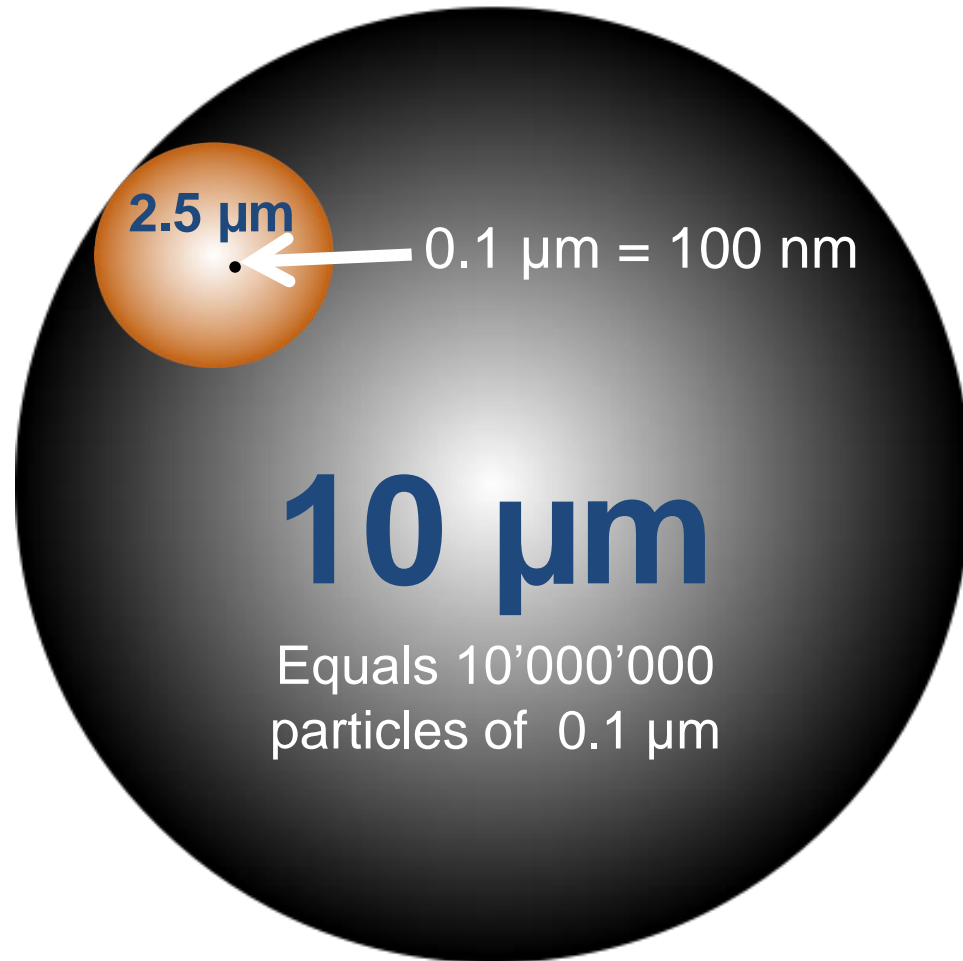
By Courtesy  
Prof. P. Gehr, University of Berne



# Size, Dynamics, Toxicity

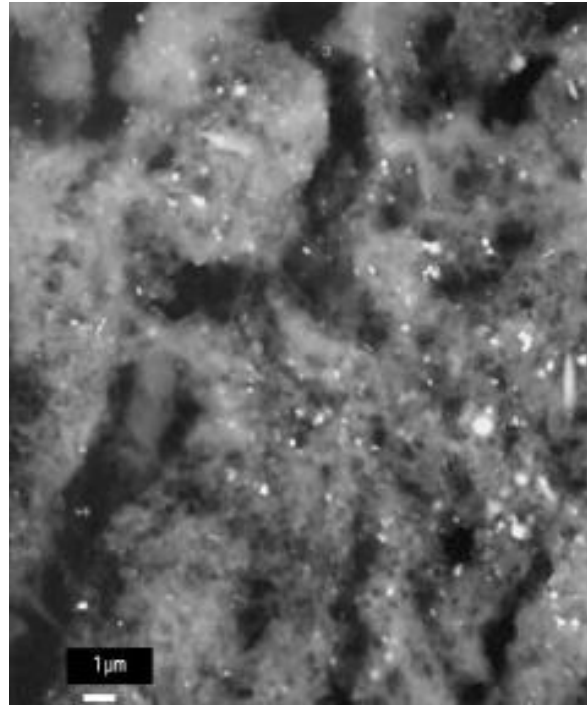
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- Size



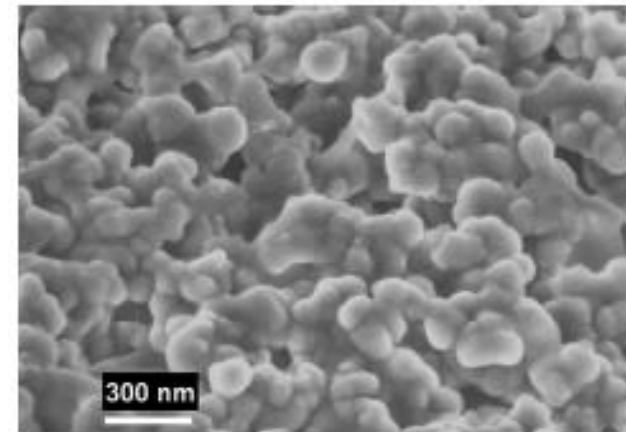
# Size, Dynamics, Toxicity

- Size
- Persistence



**Figure 2.** BE micrograph of section of airway aggregate from case 2 revealing abundant sub-micrometer inorganic (bright) particles.

Lung Tissue  
1952 London Smog Autopsy  
Multiple Nanoparticles

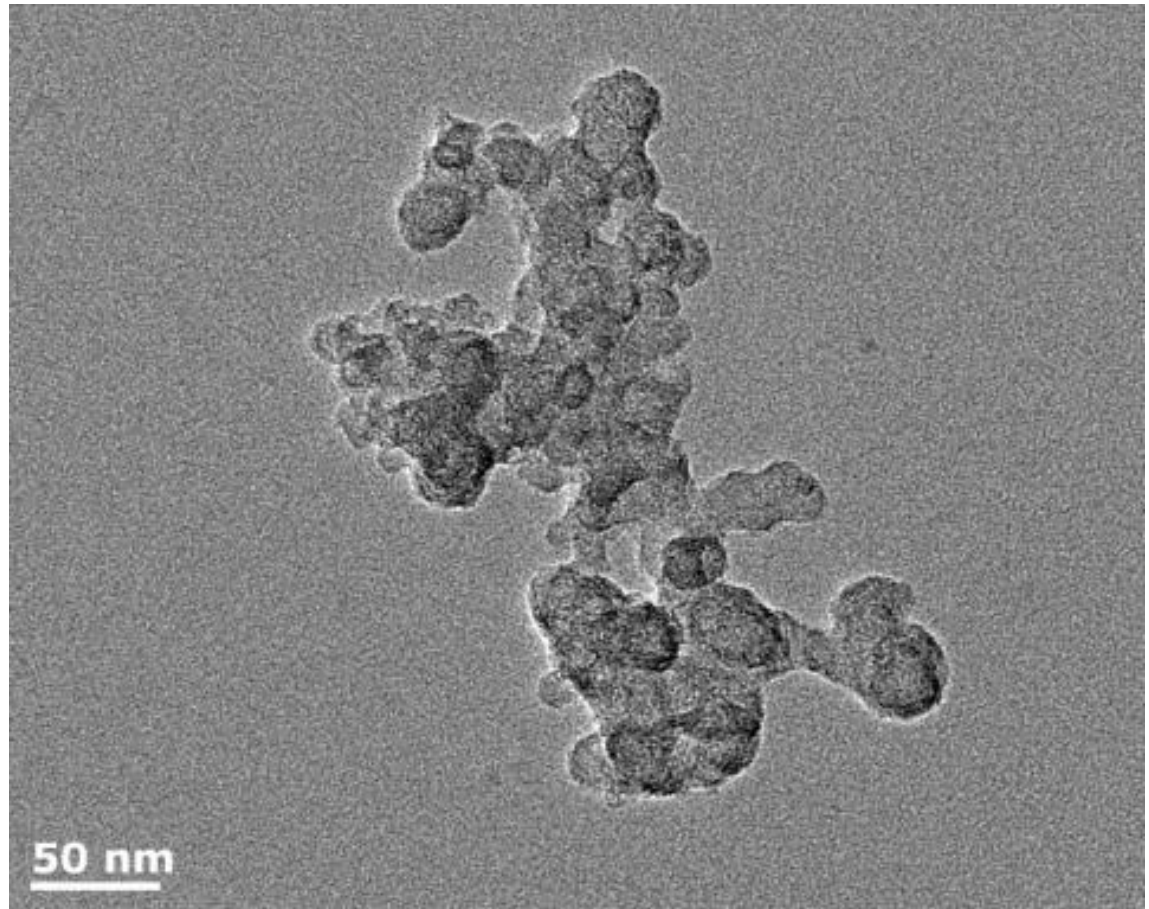


**Figure 3.** High-magnification field emission scanning electron micrograph of airway aggregate from case 2 showing ultrafine PM structure.

# Size, Dynamics, Toxicity

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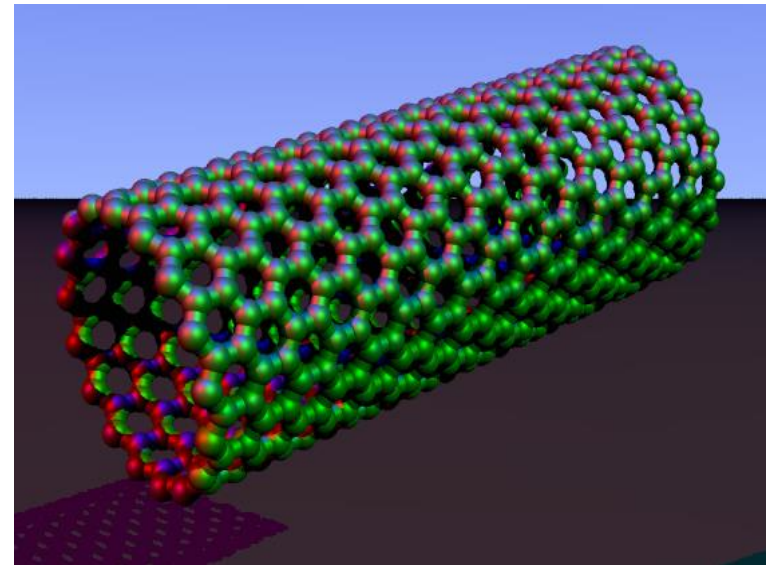
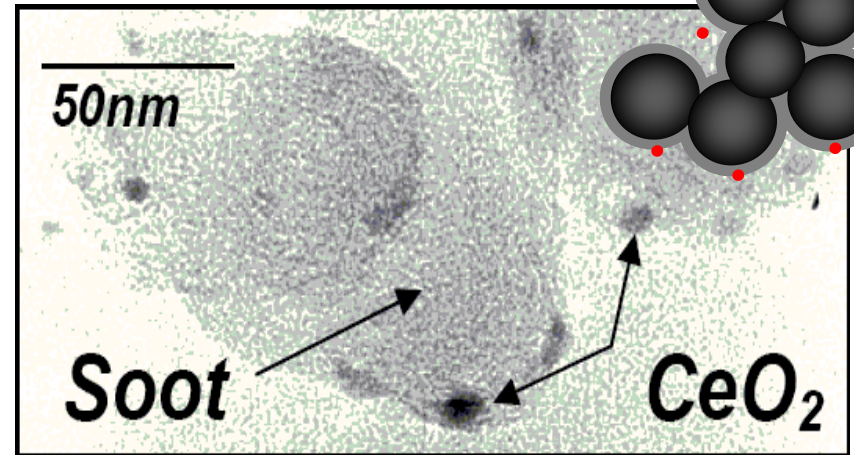
- Size
- Persistence
- Surface



Soot Particle, transmission electronic microscopy  
De la Roca, University of Nottingham

# Size, Dynamics, Toxicity

- Size
- Persistence
- Surface
- Chemical Composition & Structure

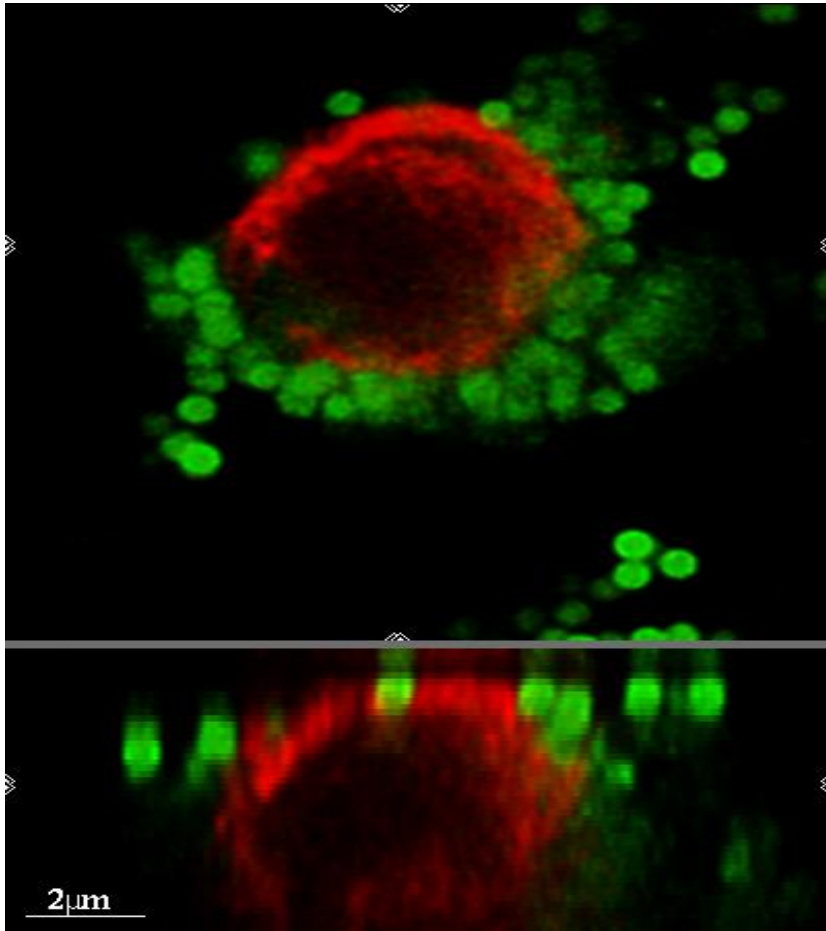




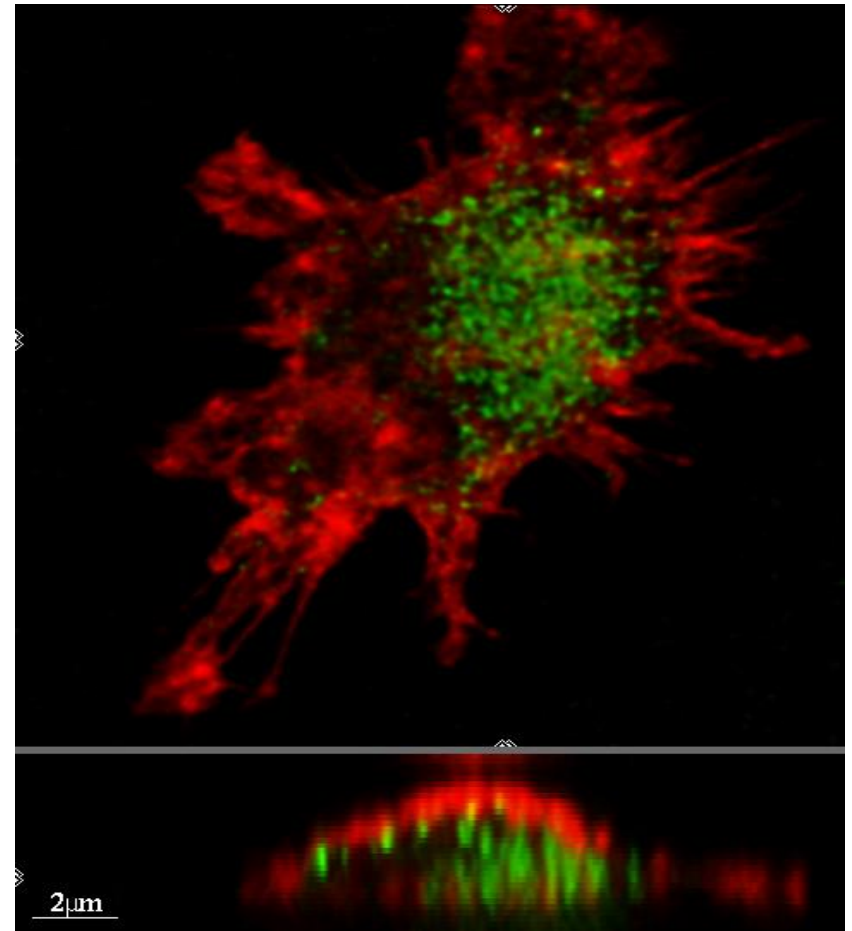


# Uptake of Particles and Size

Polystyrene Particles 1000 nm

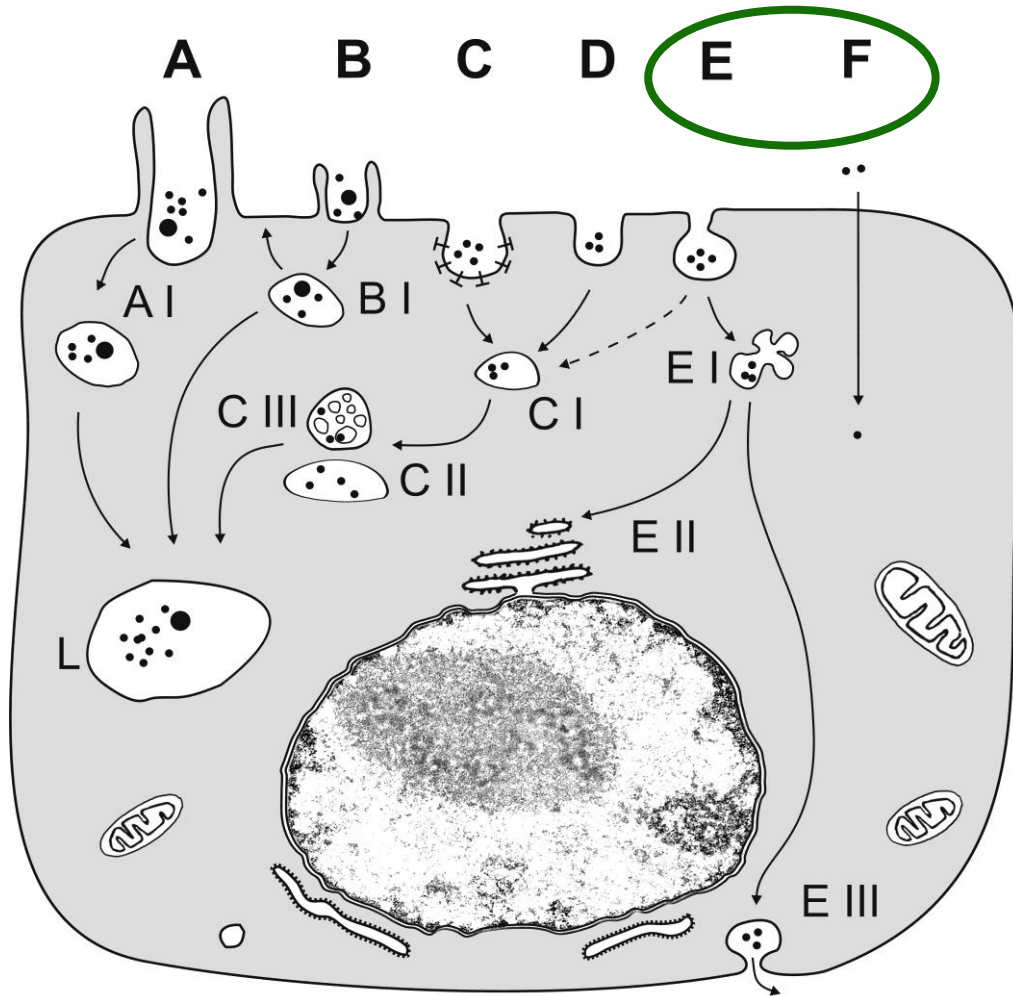


Polystyrene Particles 78 nm



Courtesy B. Rothen- Rutishauser  
University of Fribourg

# Cellular Uptake of Nanoparticles



**E: Caveolae-mediated Endocytosis**

**F: Adhesive interaction (Entering)**

# Reactions of Cells to (atmospheric) Noxes (simplified)

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Inflammatory Response

Oxydative Stress

Dysfunction

Genetic Impairment

Damage

Cancer

Chronic Illness

Death

# Most Important Air Pollution Related Disease

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- **Ischemic Heart Disease** **IHD**
- **Chronic Obstructive Pulmonary Disease** **COPD**
- **Cerebrovascular Disease** **CEV**
- **Acute Lower Respiratory Disease** **ALRI**
- **Lung Cancer** **LC**

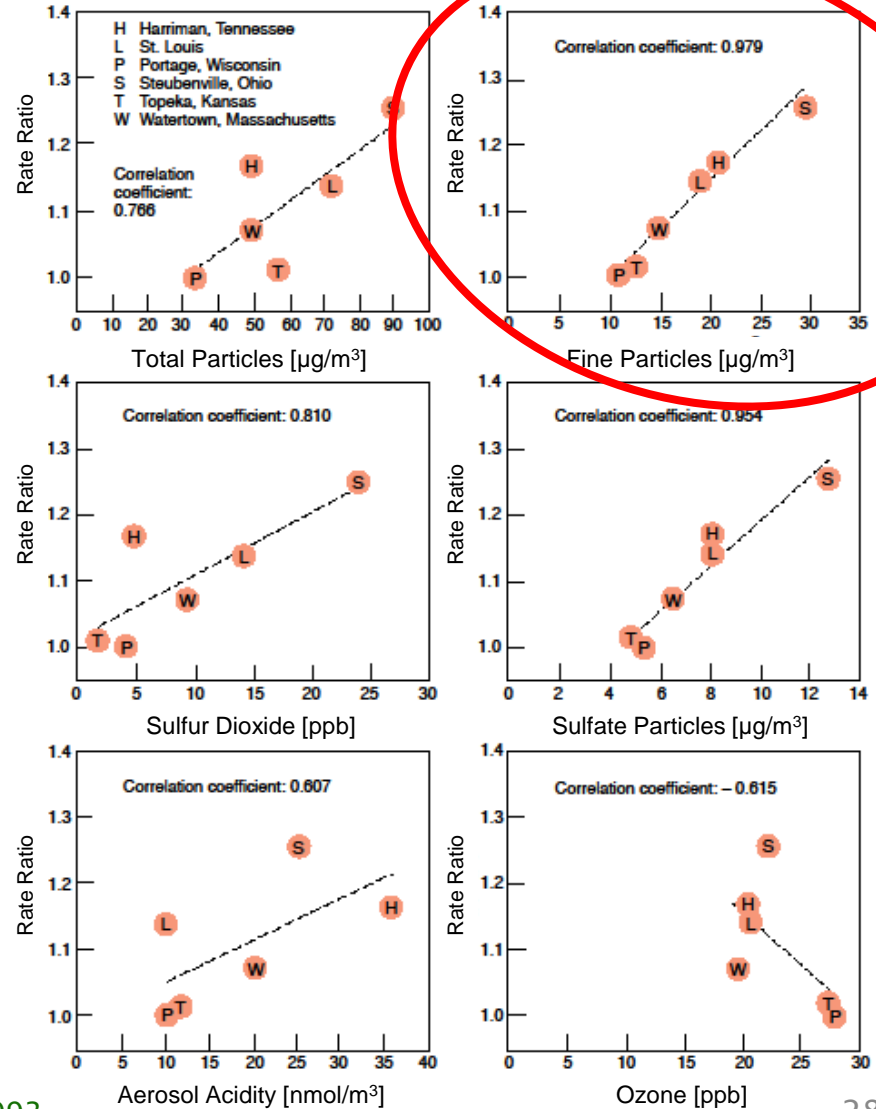


# 6-Cities Study

Which TOC correlates to Mortality?

6-Cities-Study  
USA 1978-93  
15'000 cases

→ Correlation with Fine Particles only



# Increase of Respiratory Symptoms near Highways

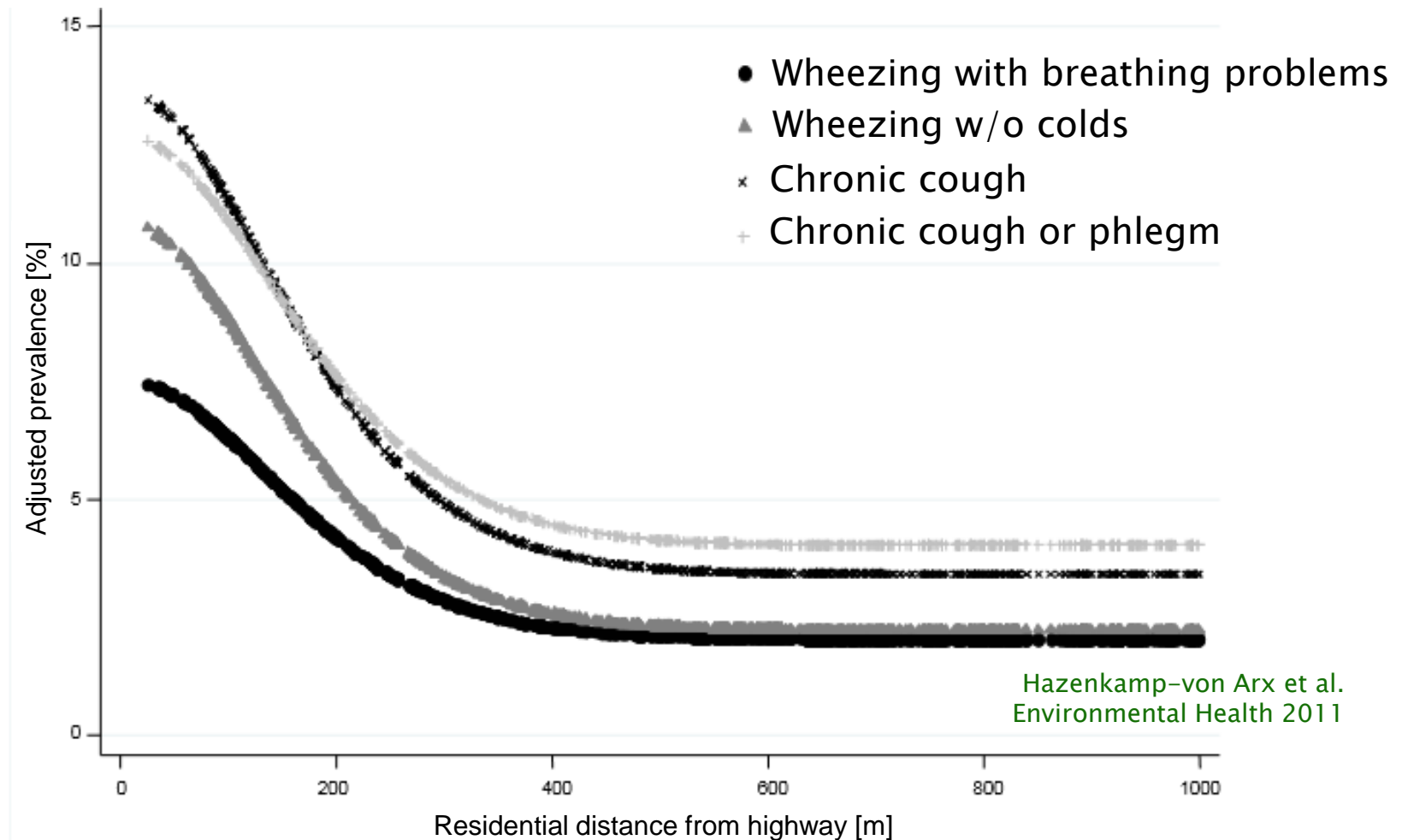


**Figure 1 Study area.** Map of Switzerland with the 10 study communities. The inset shows the topography in Erstfeld having a width of 800 m at the bottom of the valley.

Hazenkamp-von Arx et al.  
Environmental Health 2011

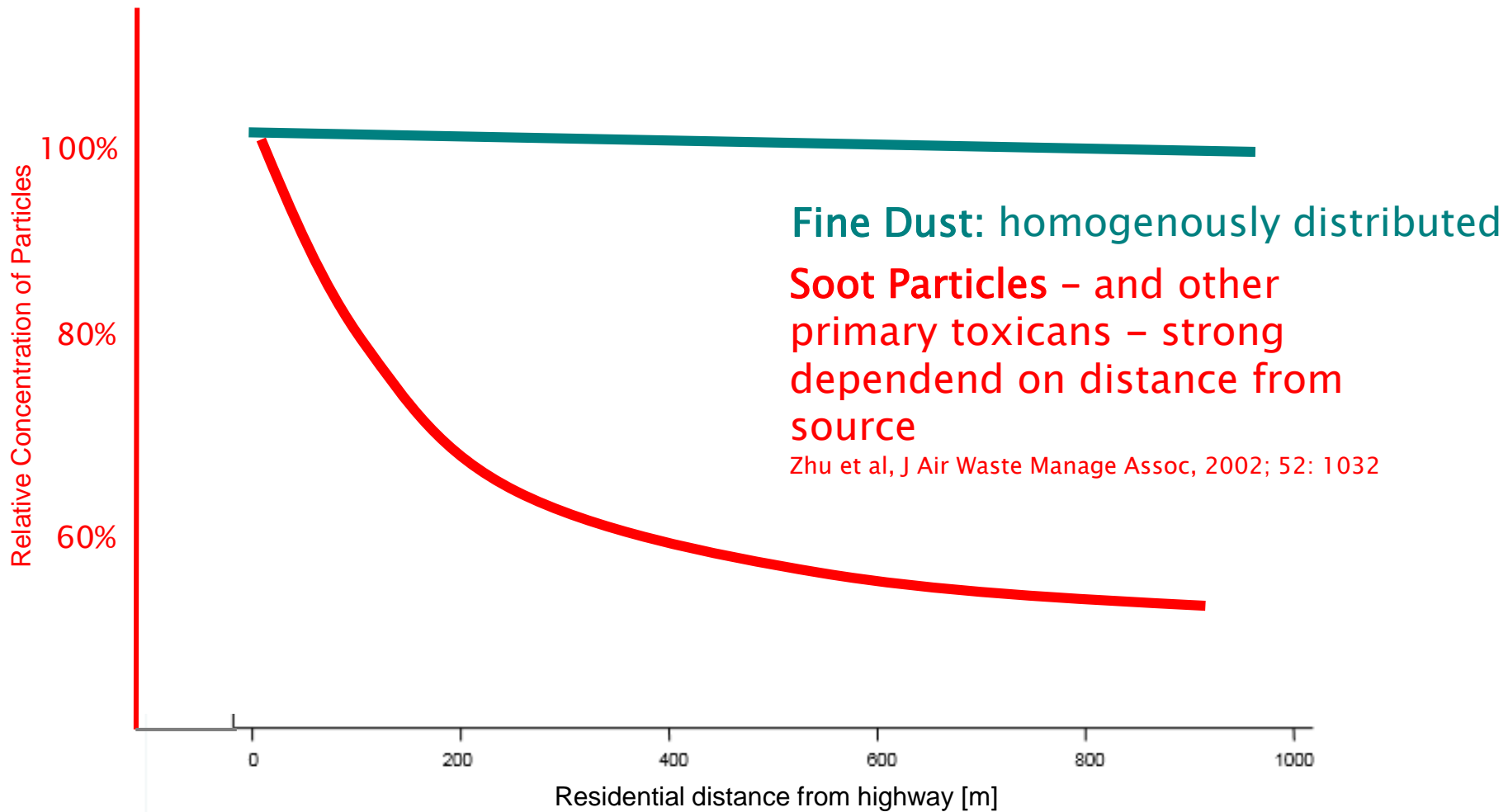


# Distance to Heavy Traffic Highways (HTH) and Respiratory Symptoms

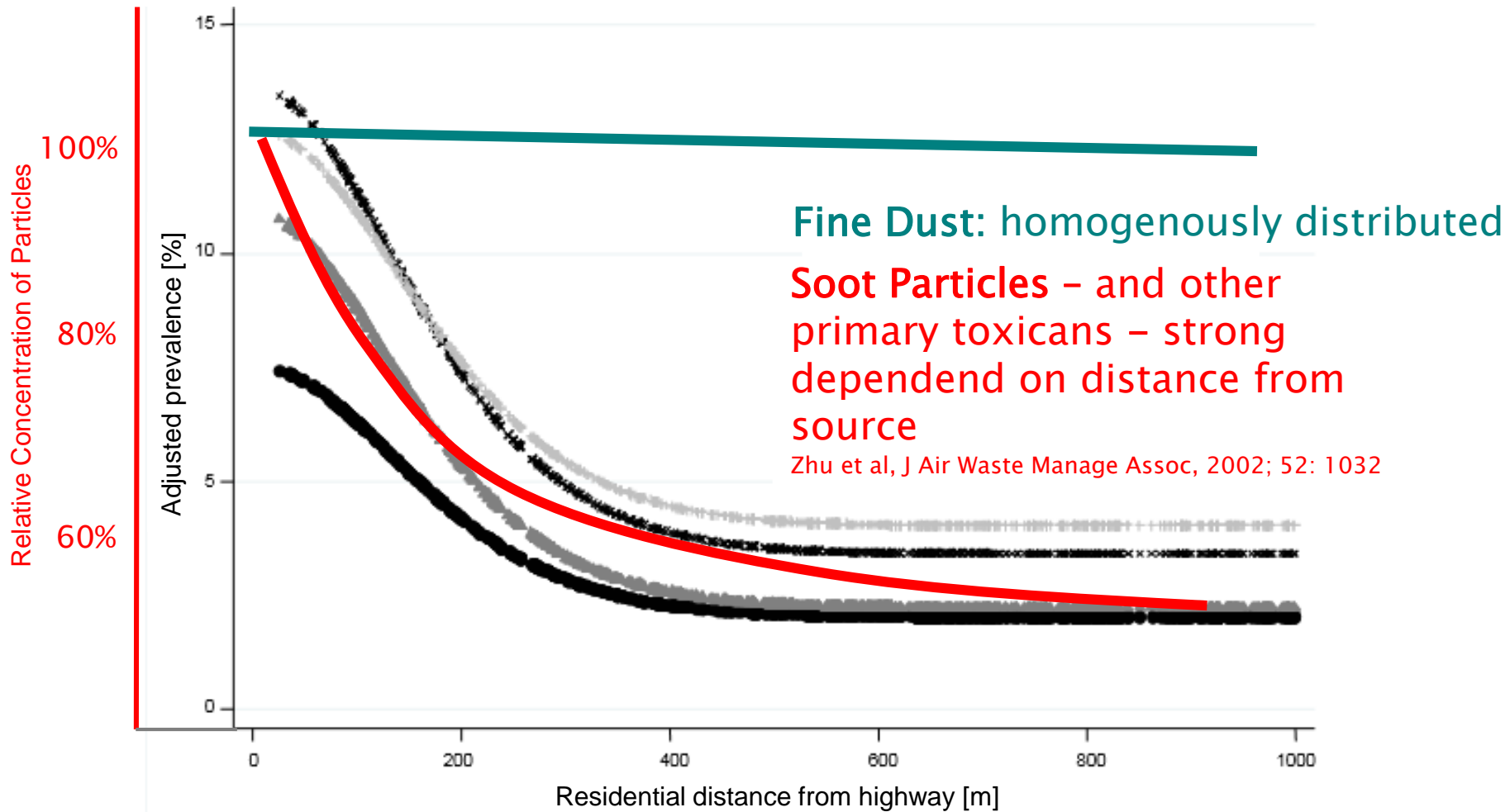


Estimated adjusted prevalence rates of health outcomes

# Distance to HTH and Particle Distribution



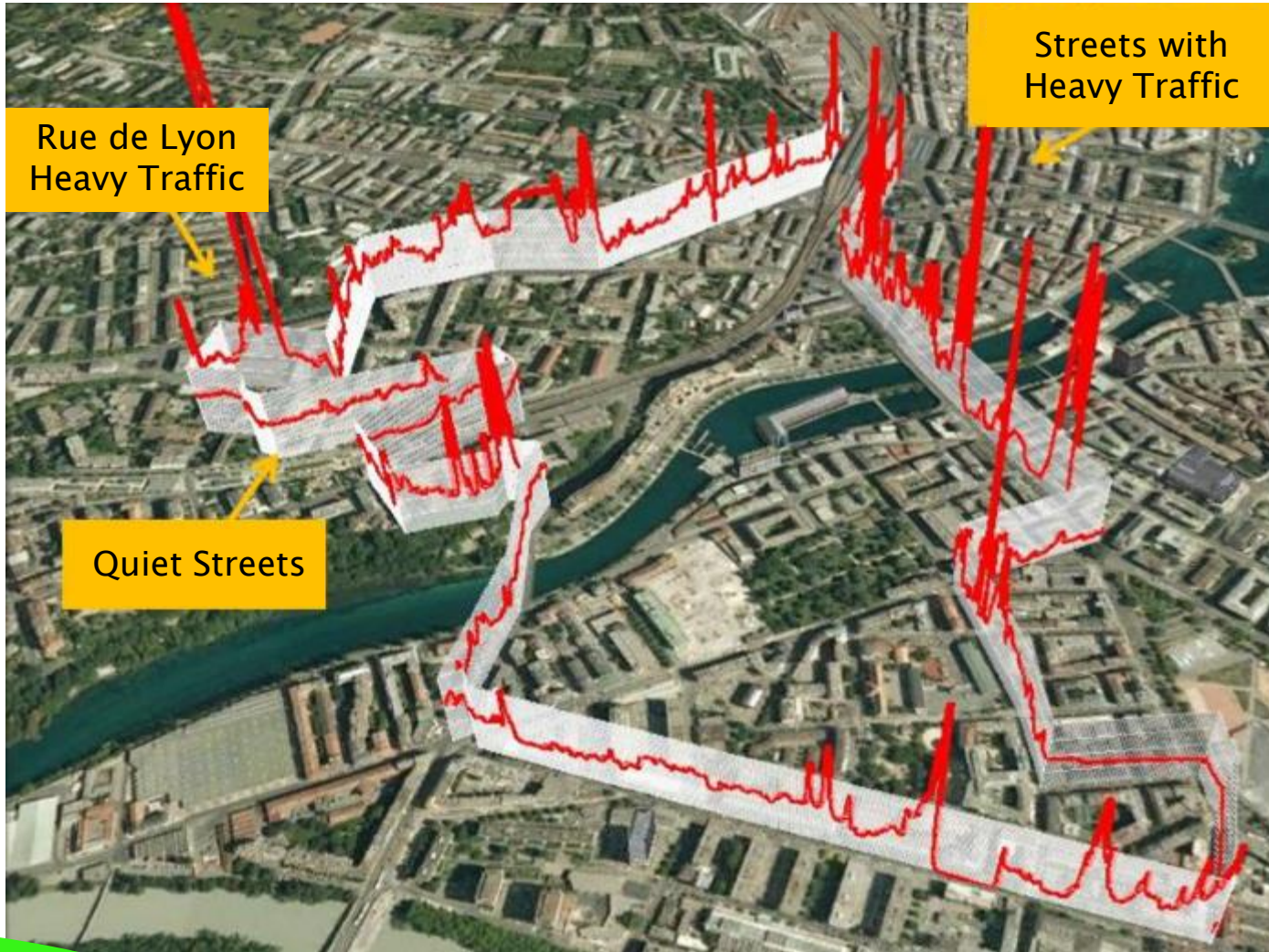
# Ultrafine Particle Distribution and Health Symptoms match!



Nino Künzli

Swiss Tropical and Public Health Institute

# Particle Number Concentration 10–300 nm



Ultrafine Particle Concentration Geneva February 26<sup>th</sup> 2012  
Particle Number Concentration (red) and Time (grey grid)  
Diagramm on Google Earth Mapping

# Traffic Emission Abatement

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Berlin LEZ: traffic emissions  
reduced by 50 % but PM10 by <5 %

# London "Pea Soup" Smog 1952

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Picadilly Sqare, Unknown Photographer

# Premature Mortality p.a. related to PM 2.5 and Ozon Estimate for Urban Population of 100 Million People

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• Heart	IHD	15.000
• Lung	COPD	12.000
• Brain	CEV	8.000
• Lung Infections	ALRI	5.000 <b>Children!</b>
• Cancer	LC	2.000



# Effect of Air Pollution During Pregnancy

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PM ↑ during Pregnancy

→ Increased **Respiratory** need  
of the Newborn

2009 Philipp Latzin, Bern University Childrens Hospital

**Lifelong impairment of the Lung  
seems possible!**

Baraldi & Filipone NEJM 2007



# WHO OECD Report

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## Economic Cost of the Health Impact of air pollution in Europe





Soot free Tehran!