Health Effects of Ultrafines:

Why Solid Particles have highest Priority

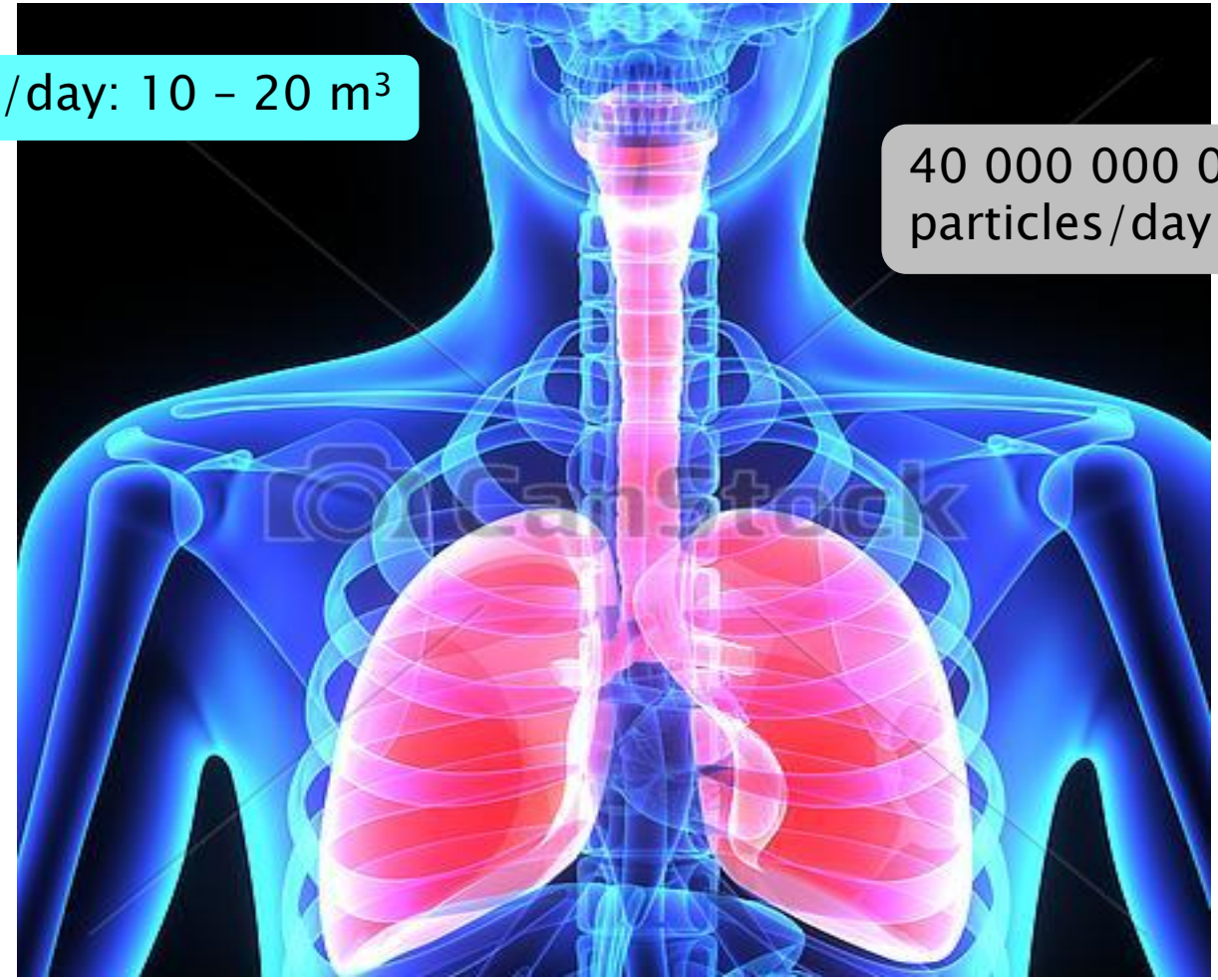
a Presentation by J. Schiltknecht MD

Table of Content

- Anatomy and Function of the Lungs and Defense Mechanisms
- Size, Distribution, Dynamics and Toxicity of Ultrafine Particles UFP
- Cellular Response to UFP and Health Impairment
- Distribution of the suspended Noxes, Monitoring
- Epidemiology and Economics

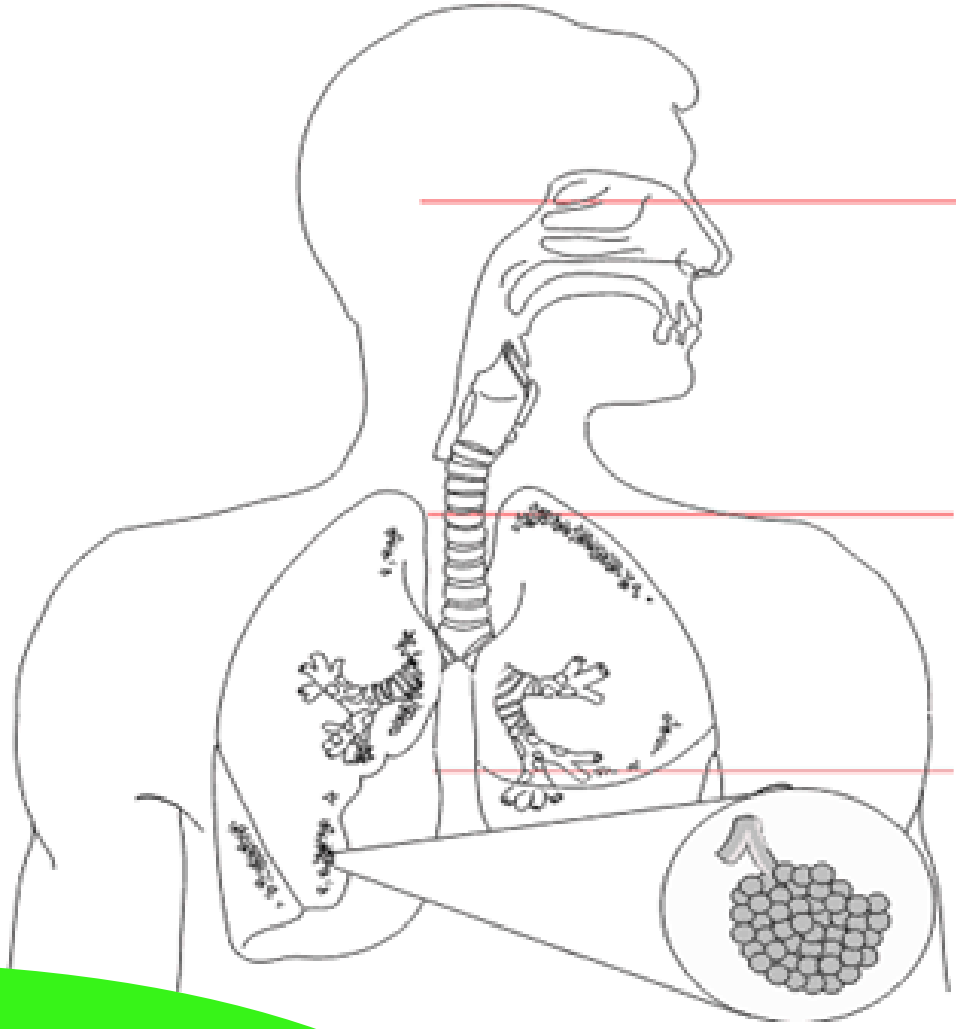
Lung Performance

Air volume/day: 10 – 20 m^3



40 000 000 000 particles/day

Airways



Upper Airways

Trachea

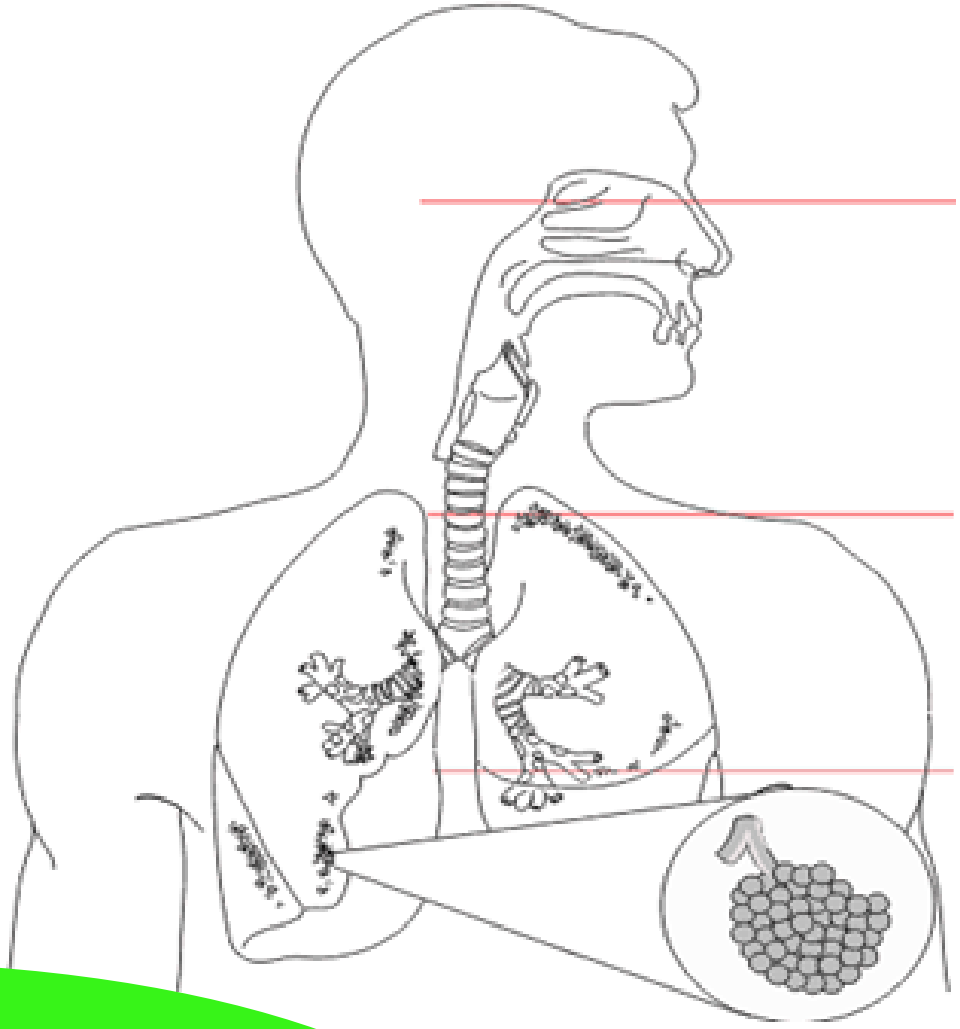
Bronchi

Bronchioles

Alveoli

P. Straehl, BAFU, Abt. Luftreinhaltung und NIS

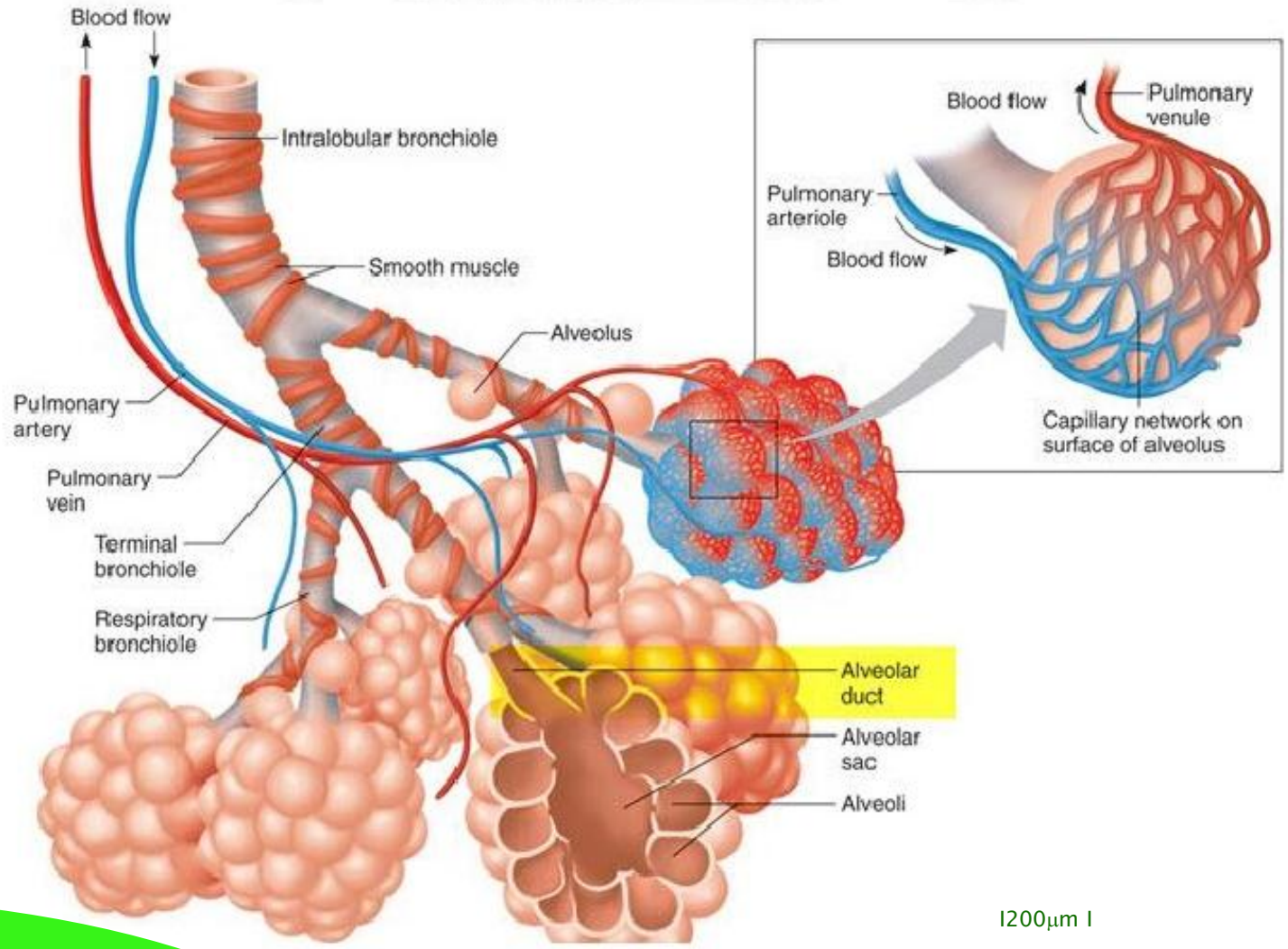
Airways & Particle Uptake



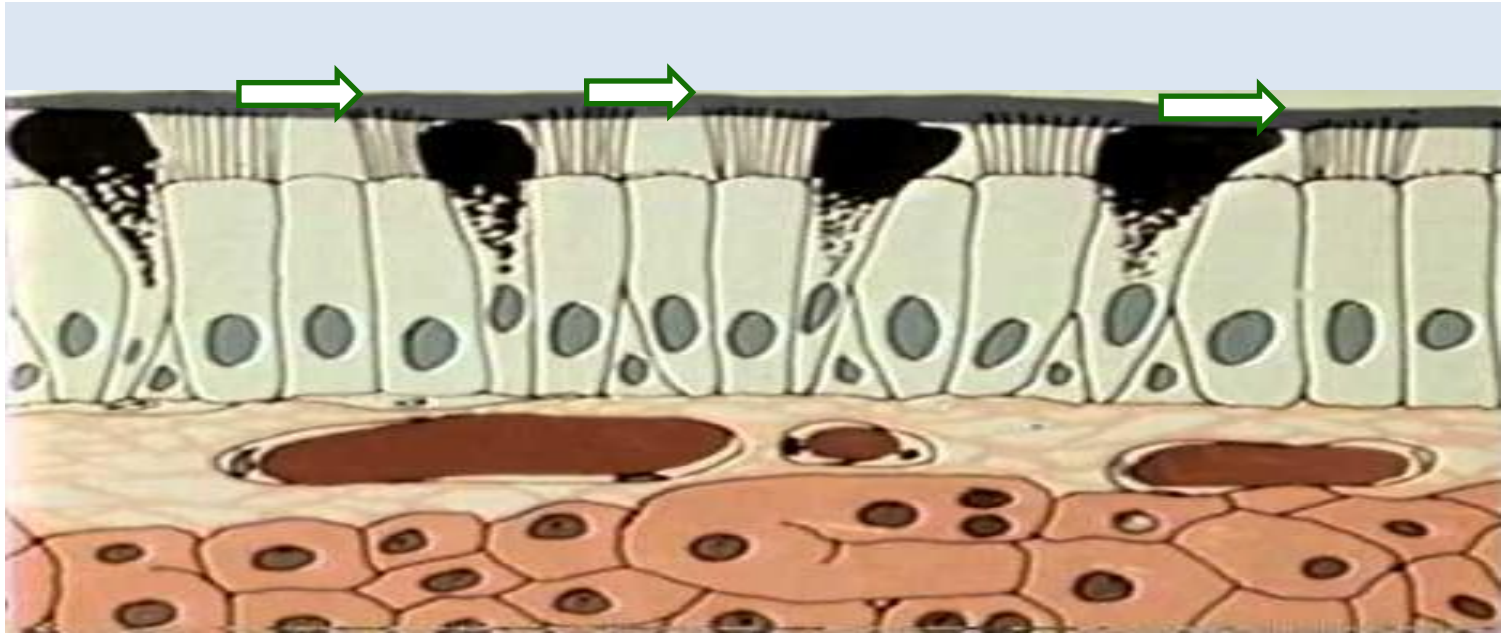
Upper Airways	5–10 µm
Trachea	3–5 µm
Bronchi	2–3 µm
Bronchioles	1–2 µm
Alveoli	<1 µm

P. Straehl, BAFU, Abt. Luftreinhaltung und NIS

Terminal Bronchioli & Alveoli

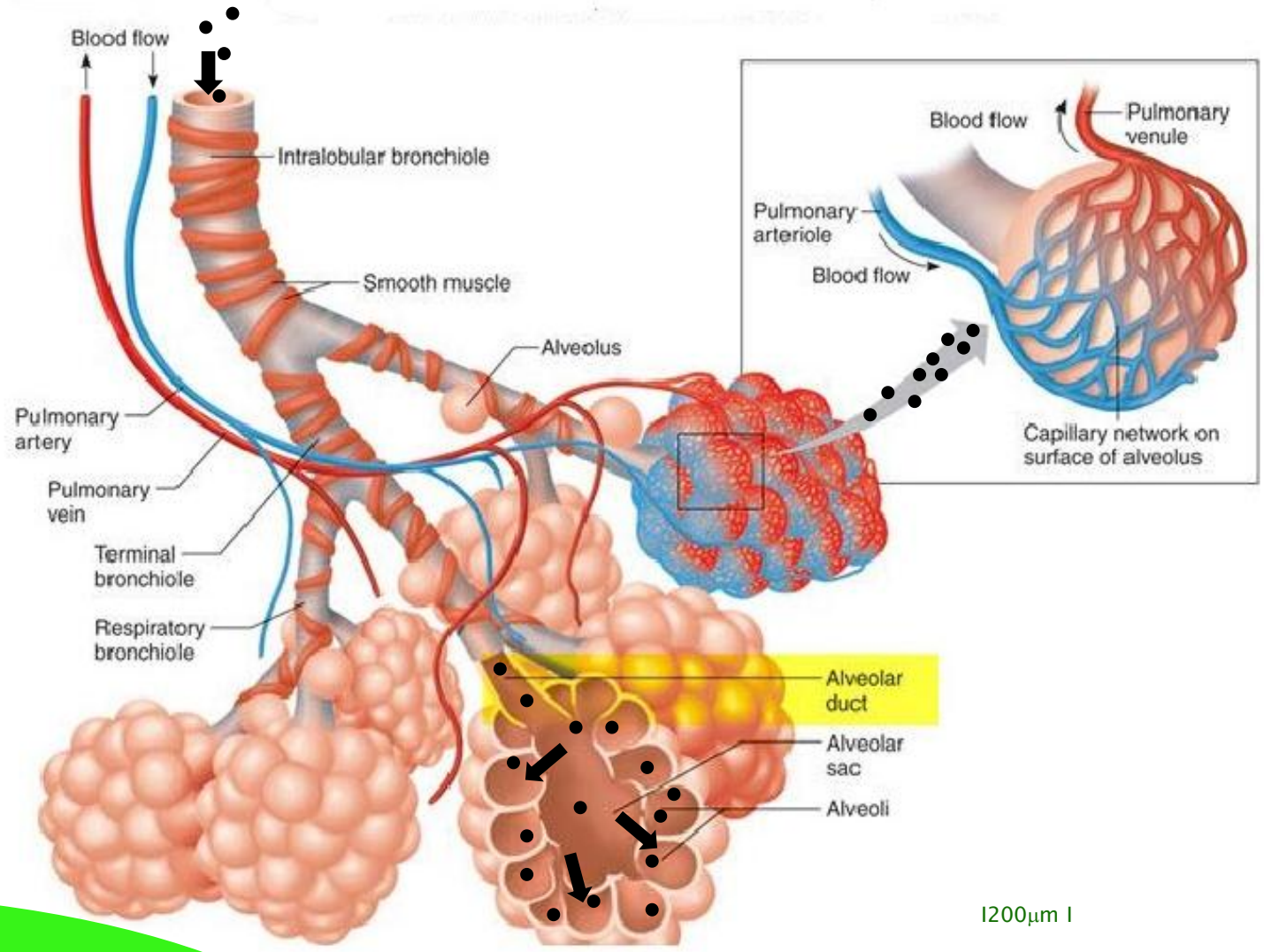


Mucociliary Apparatus

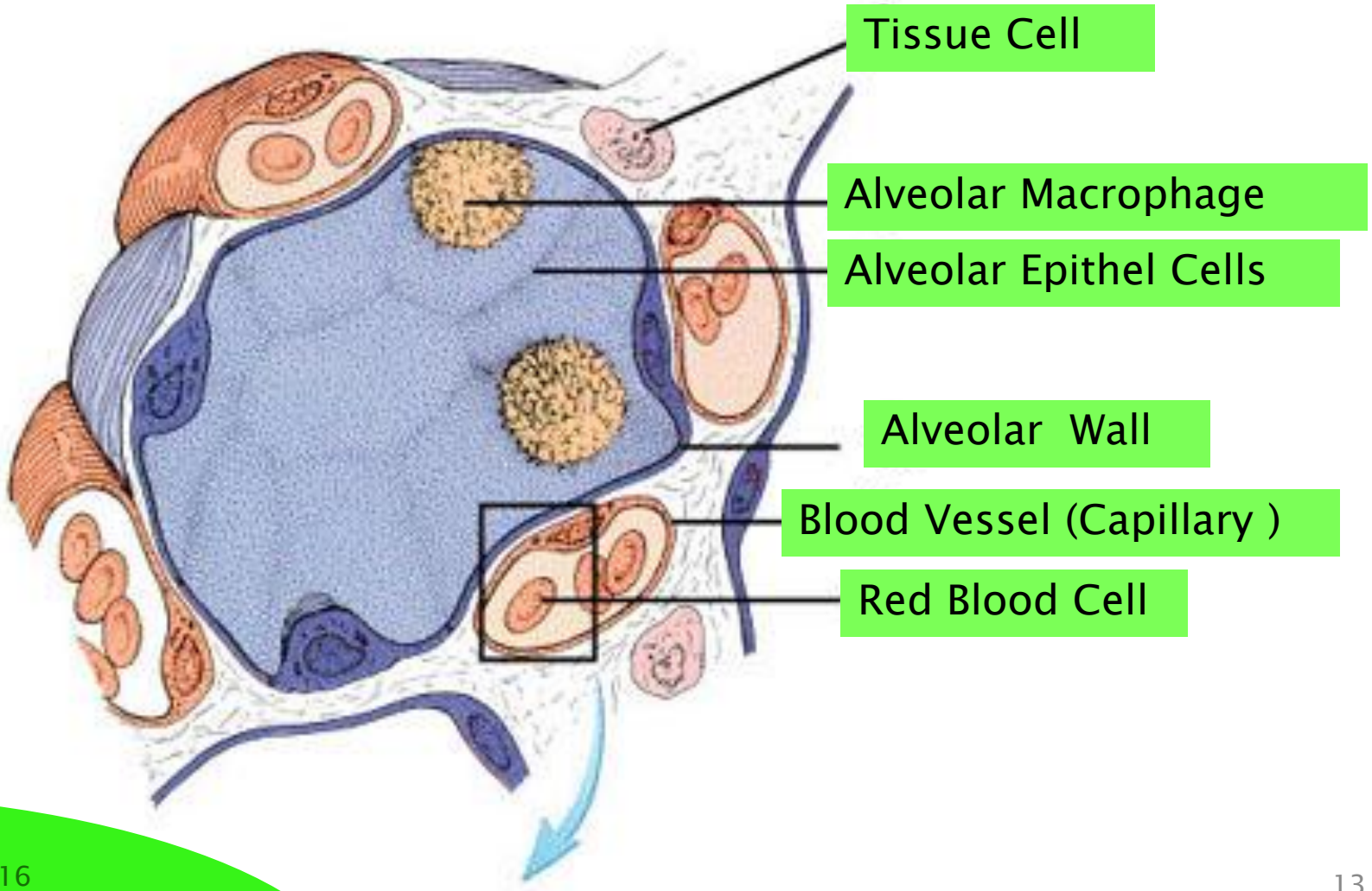


Section of a bronchial wall with ciliated cells tranporting a mucus layer and goblet cells

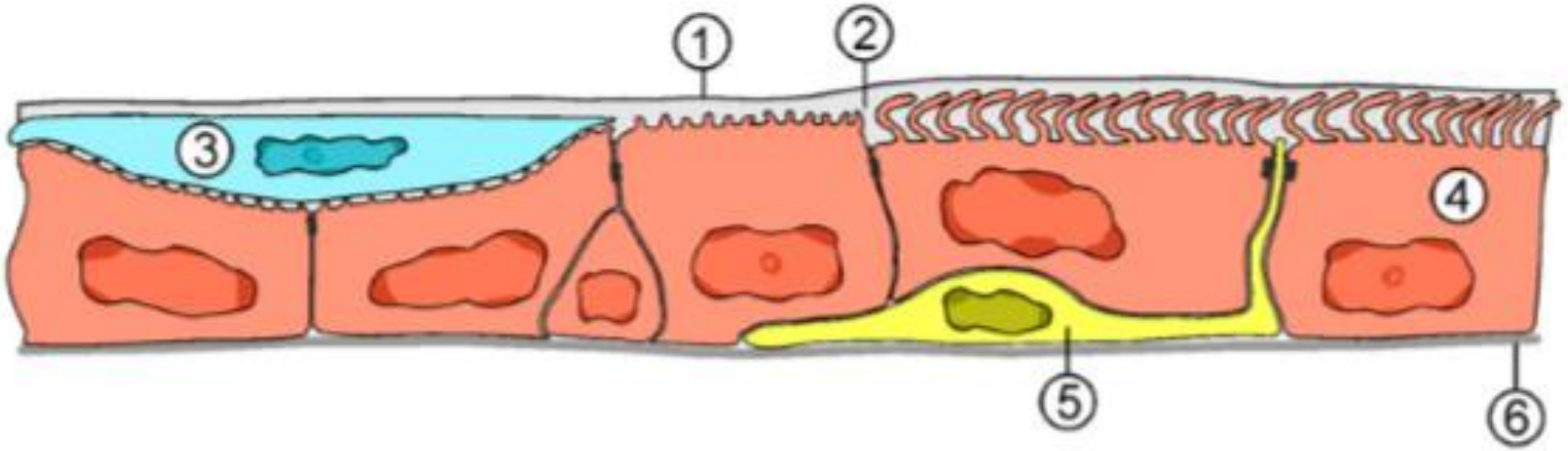
Nanoparticles entering Alveoli



Alveoli surrounded by Capillaries



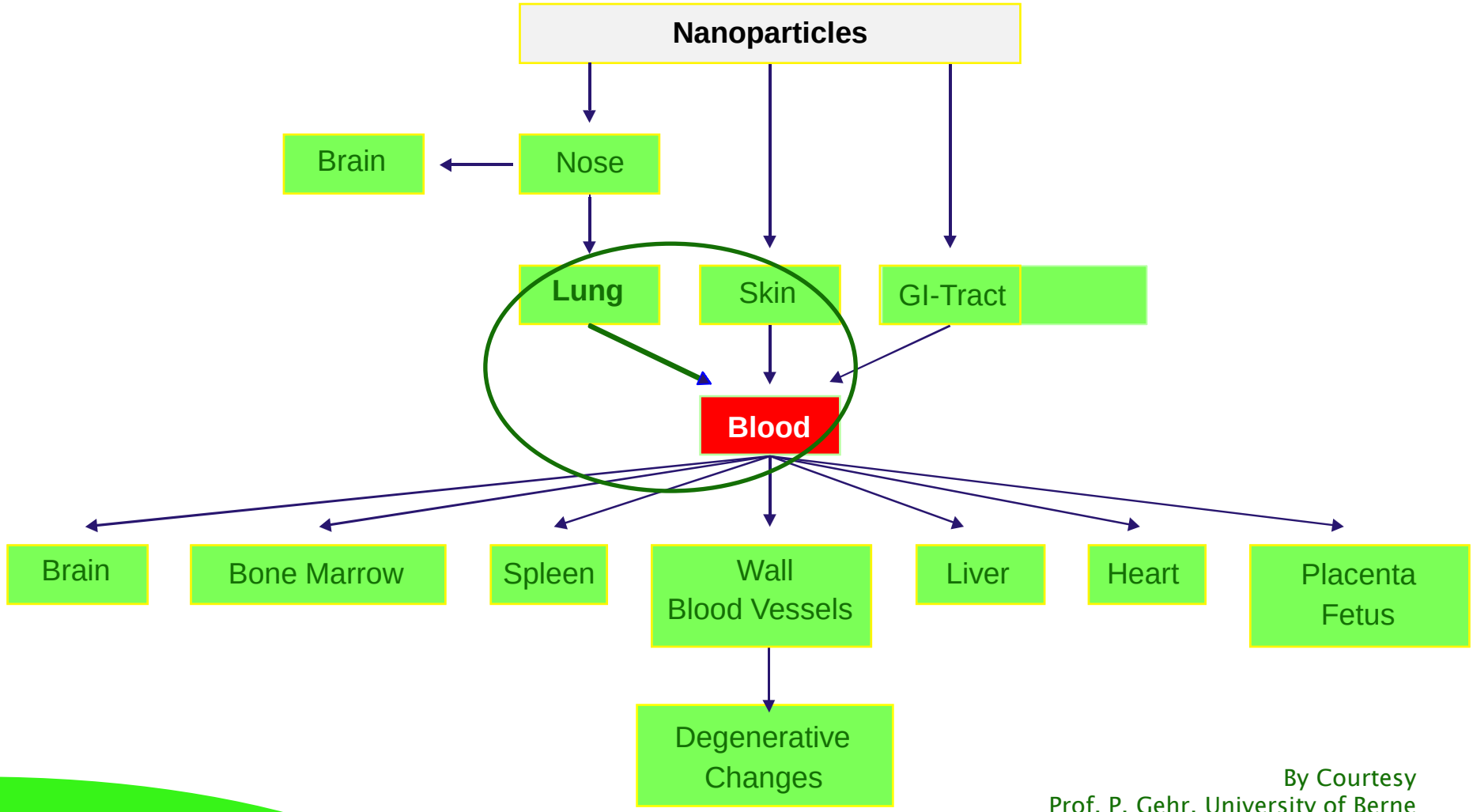
Airway Macrophage



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

American Journal of Respiratory Cell and Molecular Biology Vol. 36
Fabian Blank, Barbara Rothen-Rutishauser, Prof. Peter Gehr

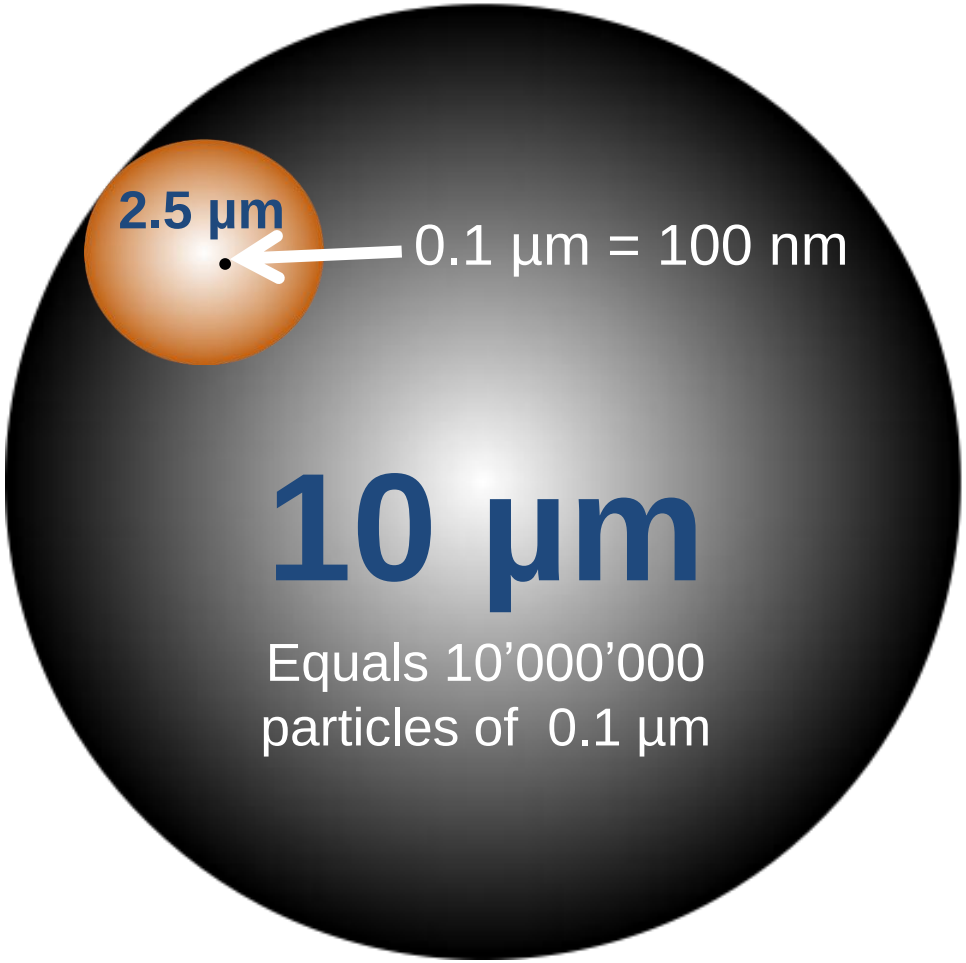
Translocation of Nanoparticles



By Courtesy
Prof. P. Gehr, University of Berne

Size, Dynamics, Toxicity

- **Size**



Size, Dynamics, Toxicity

- Size
- Persistence

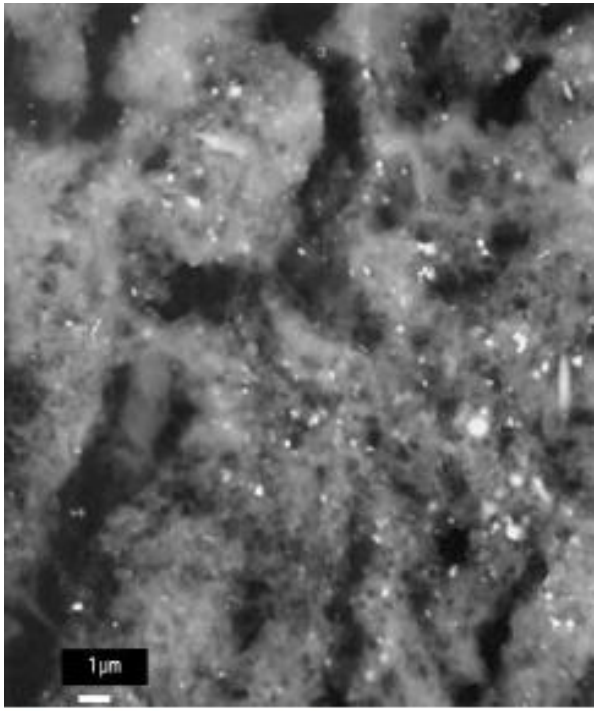


Figure 2. BE micrograph of section of airway aggregate from case 2 revealing abundant submicrometer inorganic (bright) particles.

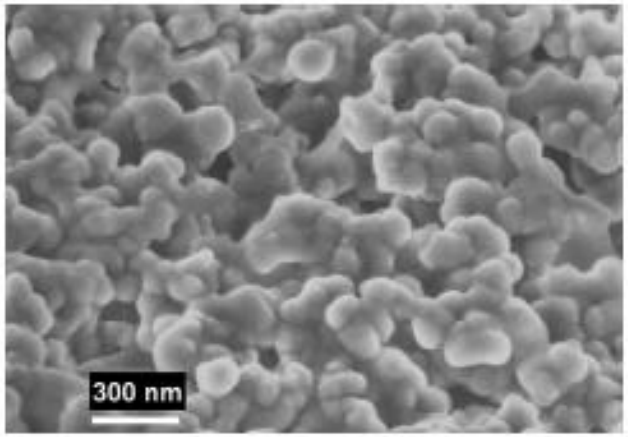
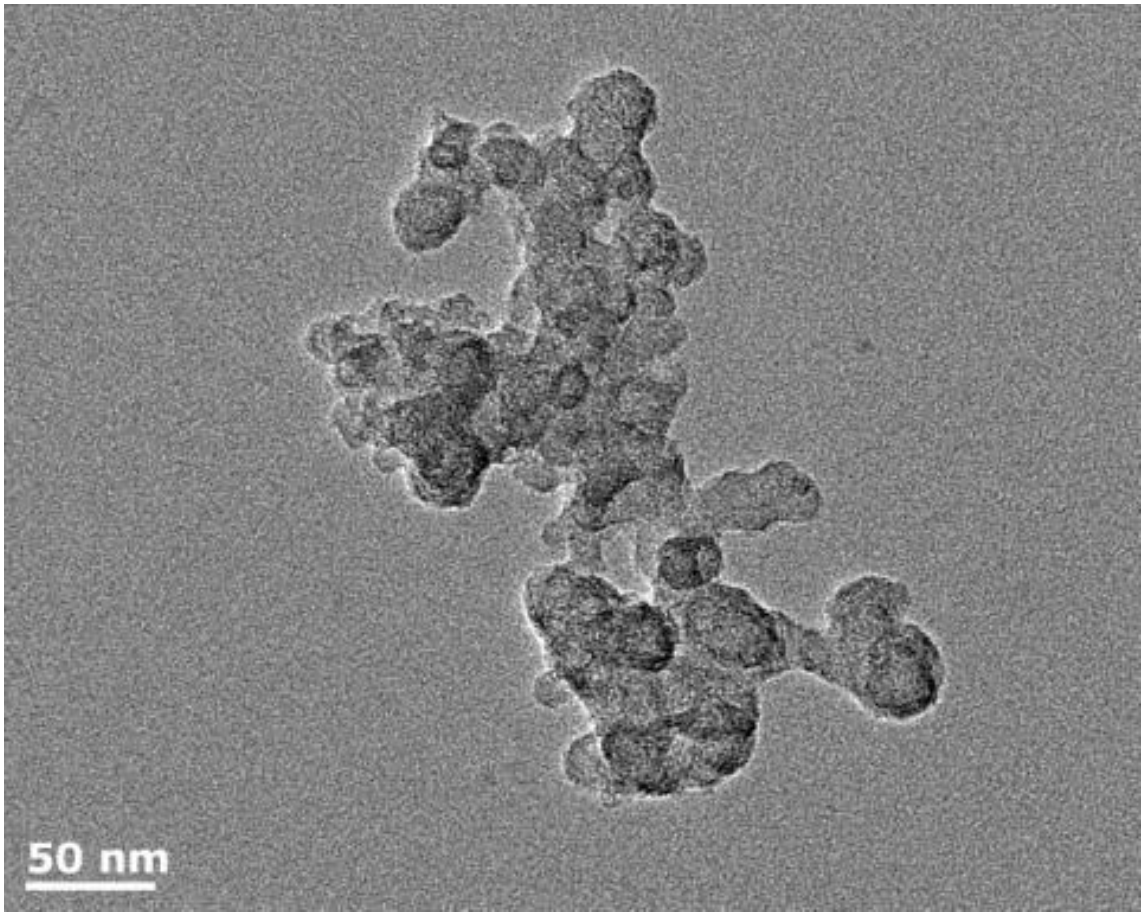


Figure 3. High-magnification field emission scanning electron micrograph of airway aggregate from case 2 showing ultrafine PM structure.

Lung Tissue
1952 London Smog Autopsy
Multiple Nanoparticles

Size, Dynamics, Toxicity

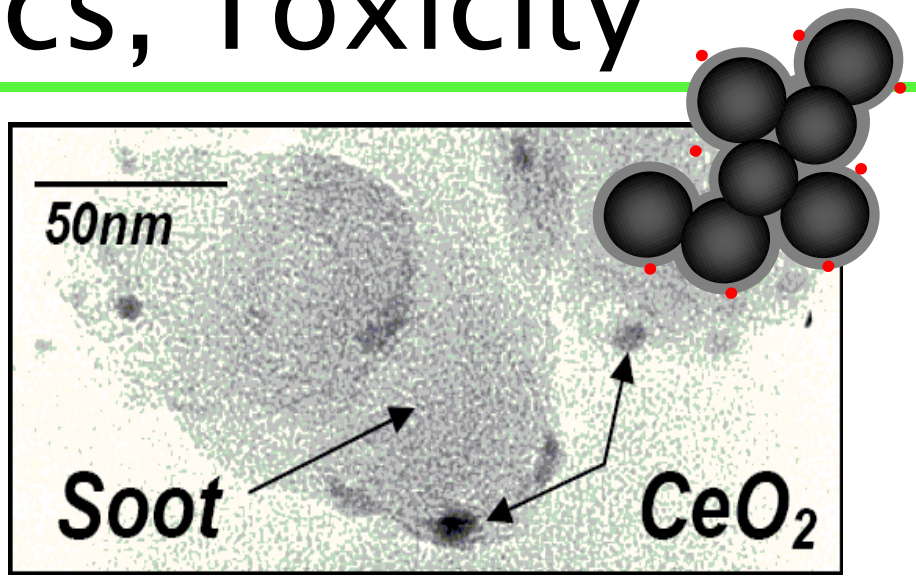
- Size
- Persistence
- Surface

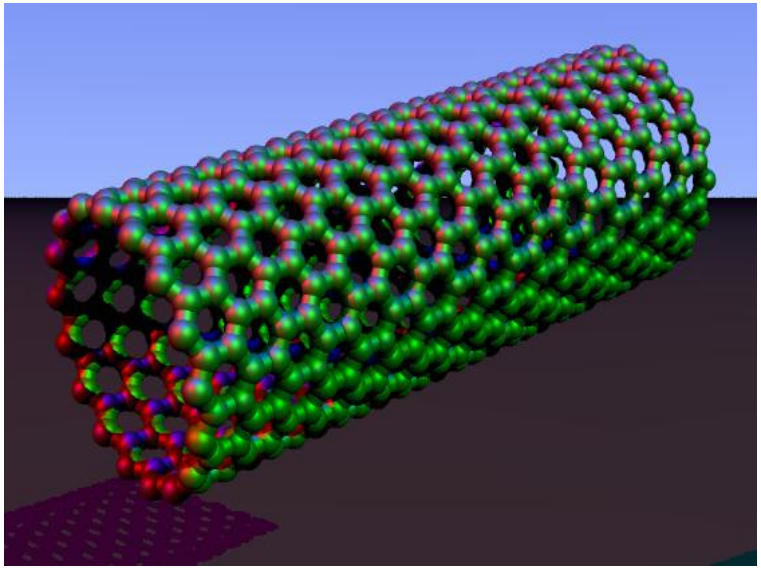


Soot Particle, transmission eletronic microscopy
De la Roca, University of Nottingham

Size, Dynamics, Toxicity

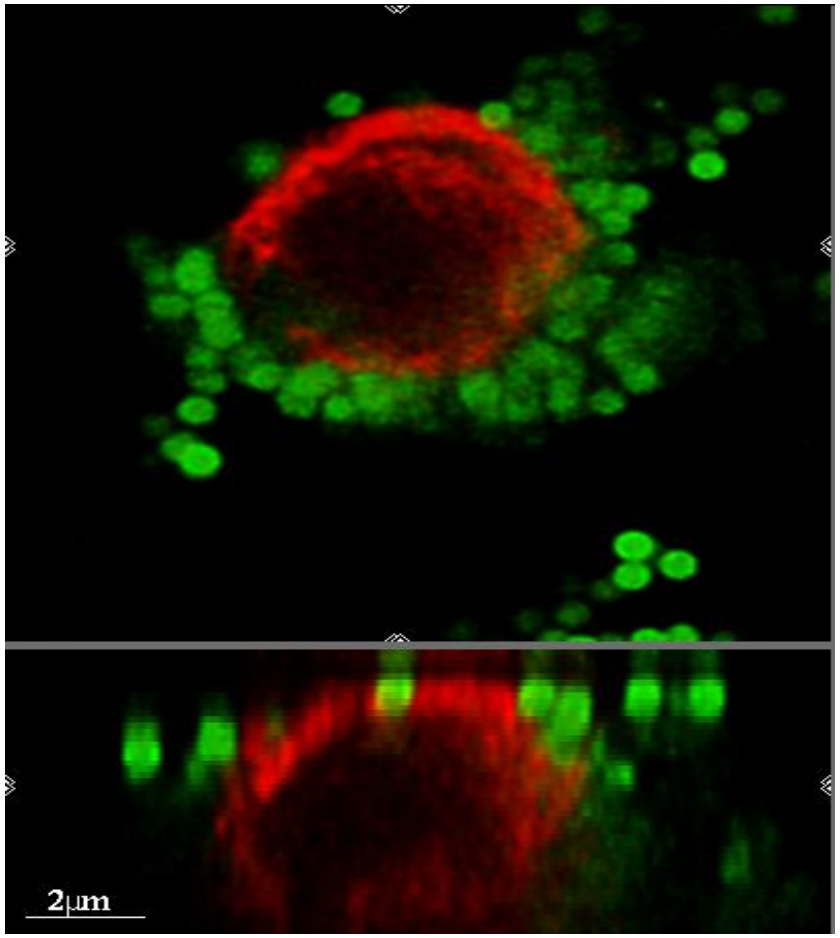
- Size
- Persistence
- Surface
- Chemical Composition & Structure



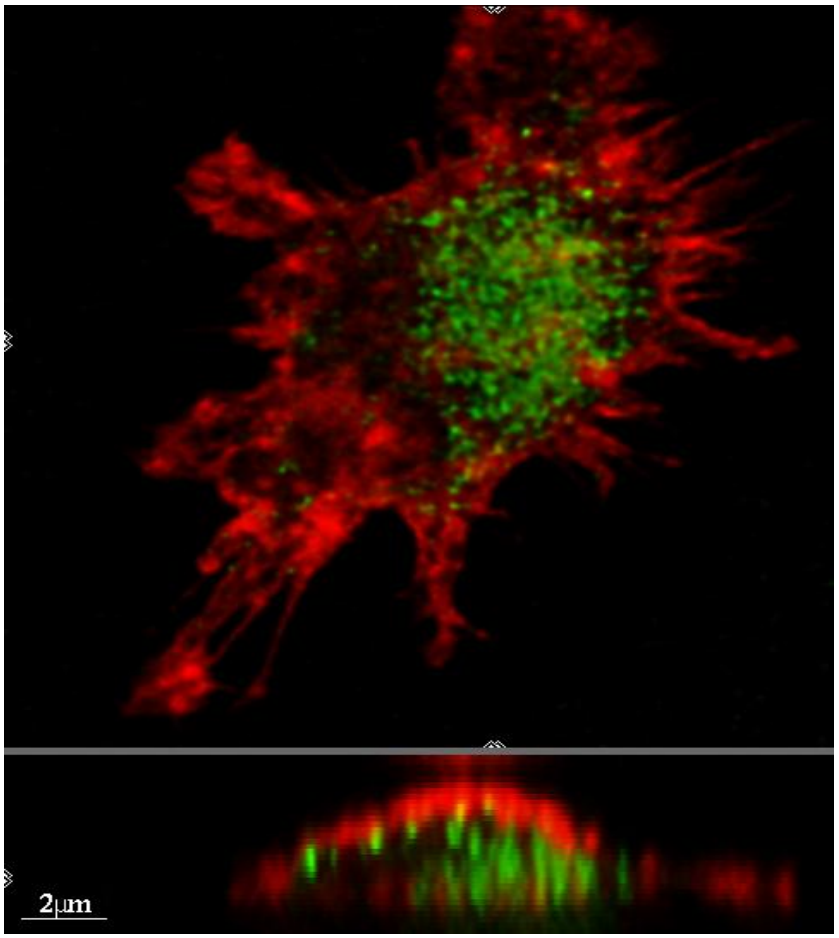


Uptake of Particles and Size

Polystyrene Particles 1000 nm

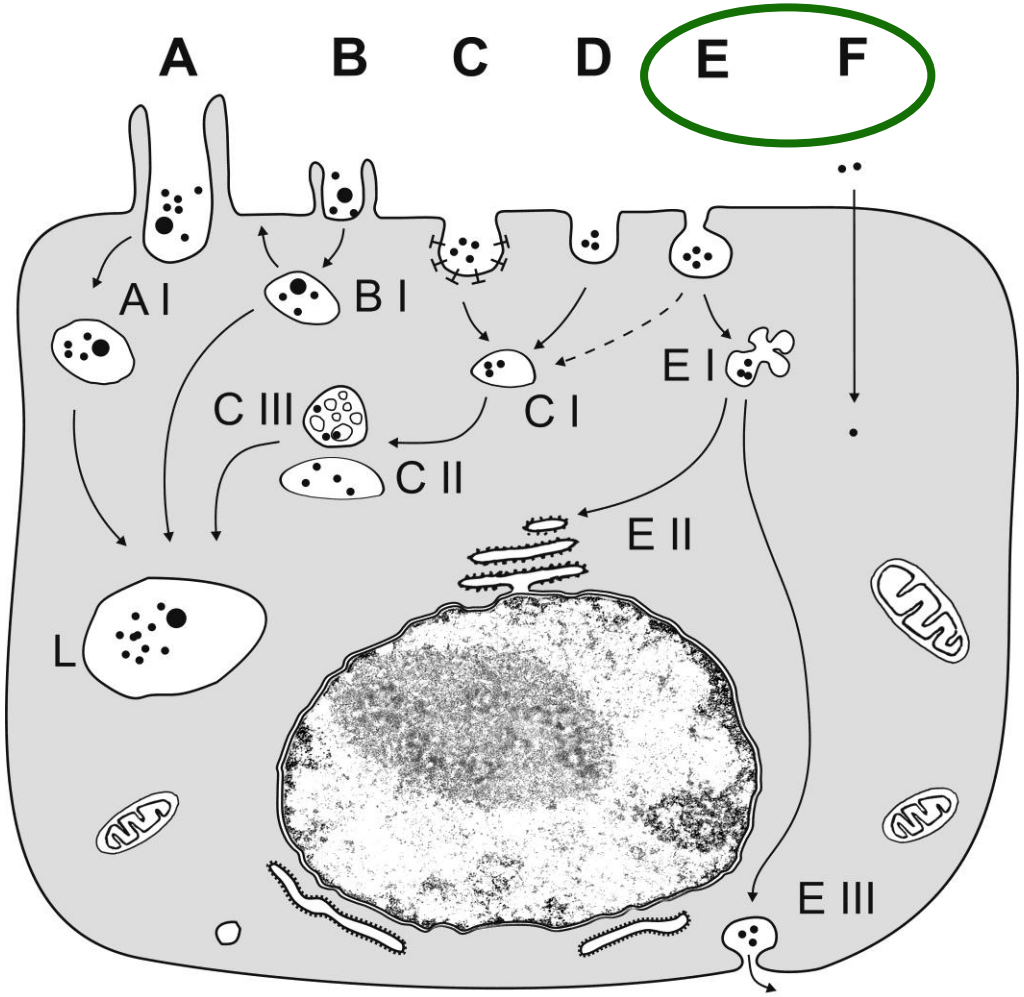


Polystyrene Particles 78 nm



Courtesy B. Rothen- Rutishauser
University of Fribourg

Cellular Uptake of Nanoparticles

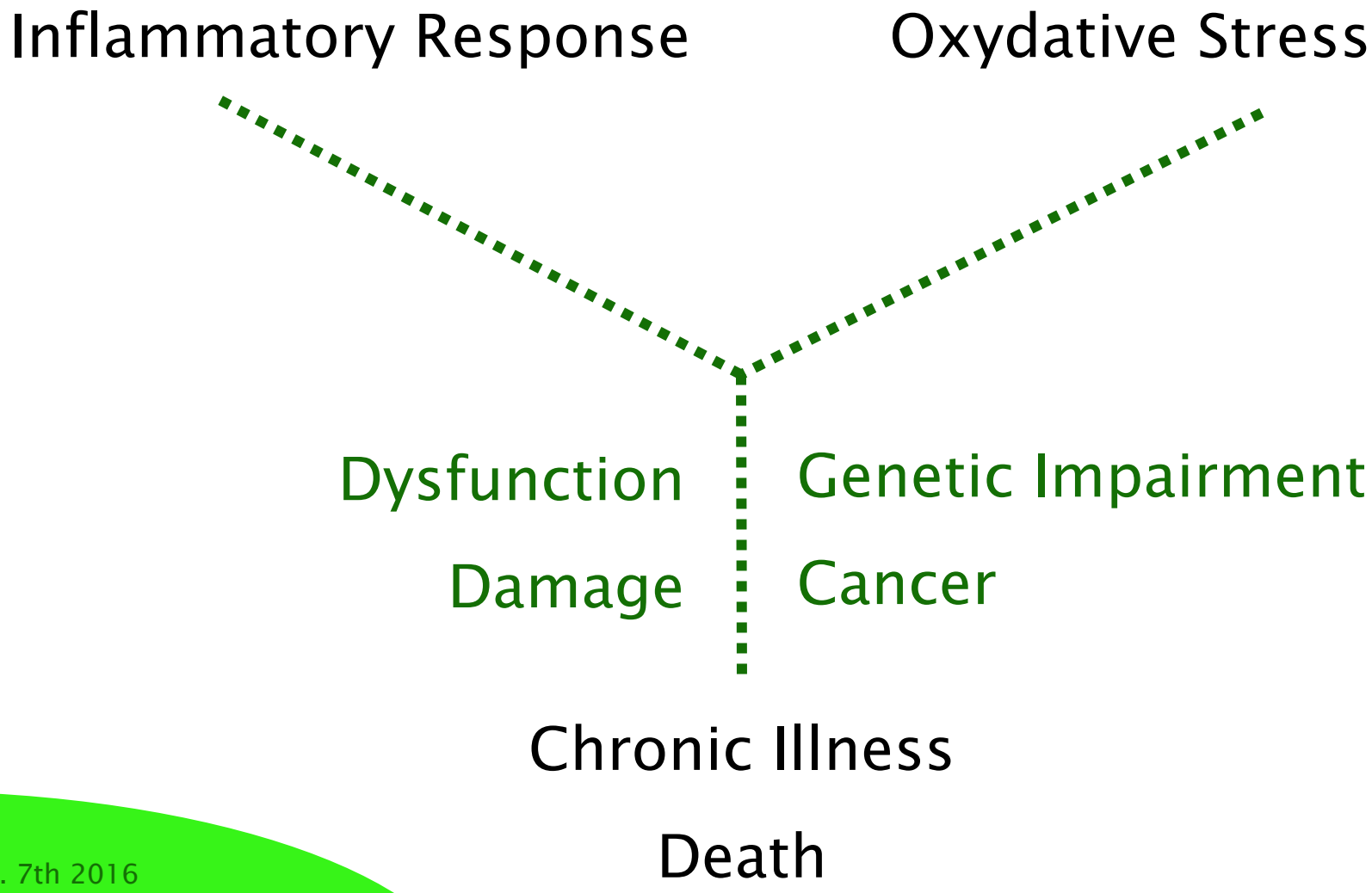


E: Caveolae-mediated Endocytosis

F: Adhesive interaction (Entering)

Brandenberger et al., Small, 2010

Reactions of Cells to (atmosperic) Noxes (simplified)



Most Important Air Pollution Related Disease

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

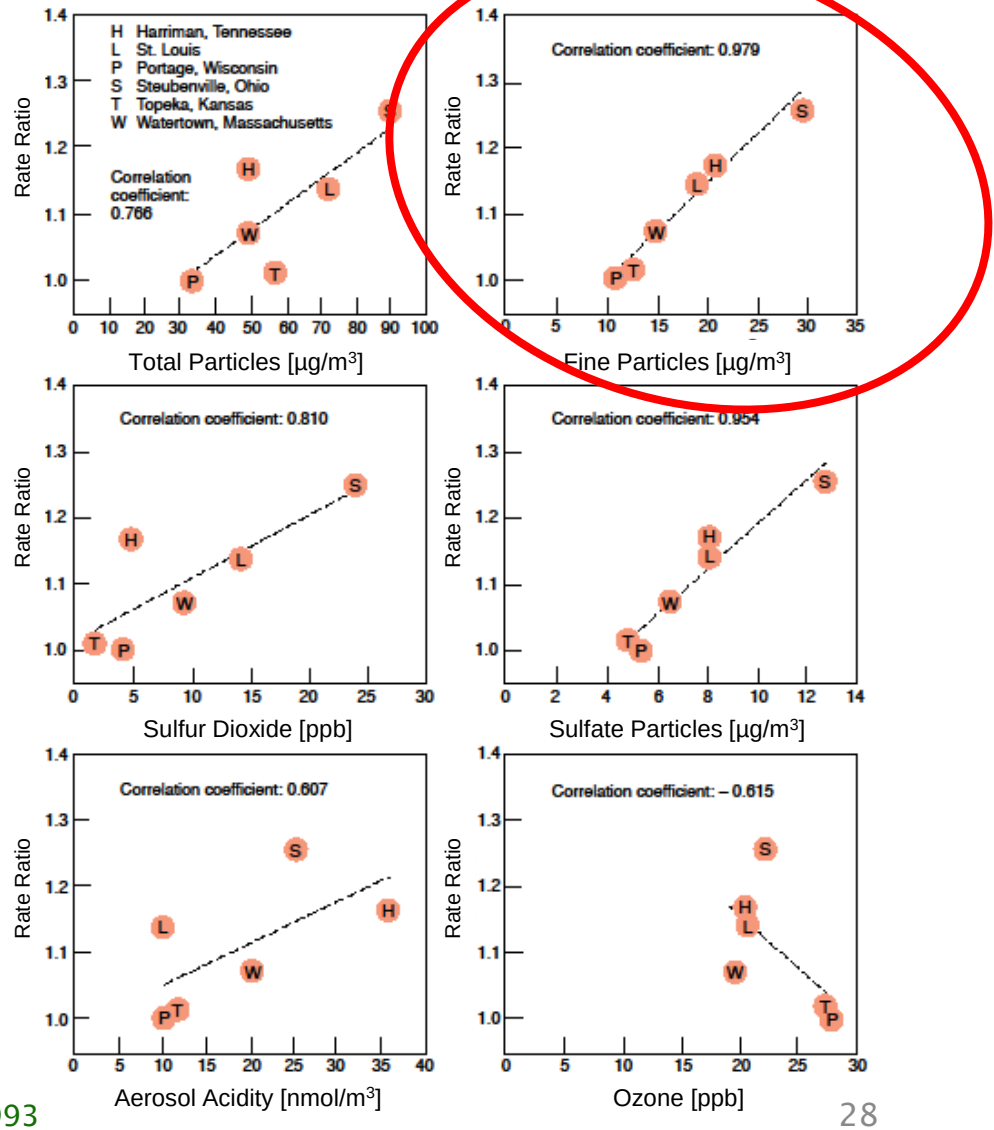
Lelieveld et al. Nature 2015

6-Cities Study

Which TOC correlates to Mortality?

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

→ Correlation with Fine Particles only



Source: Dockery NEJM 1993

Increase of Respiratory Symptoms near Highways

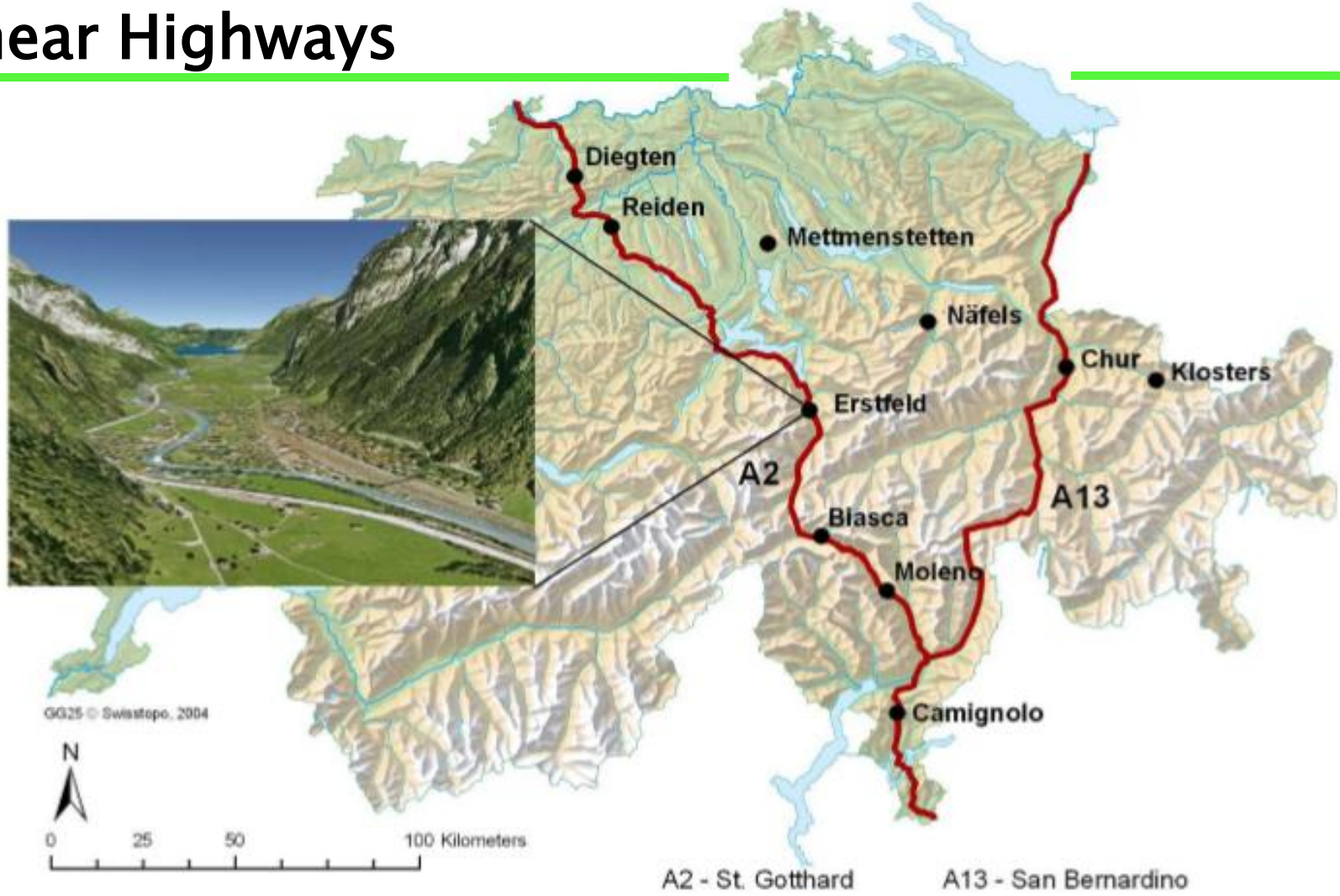
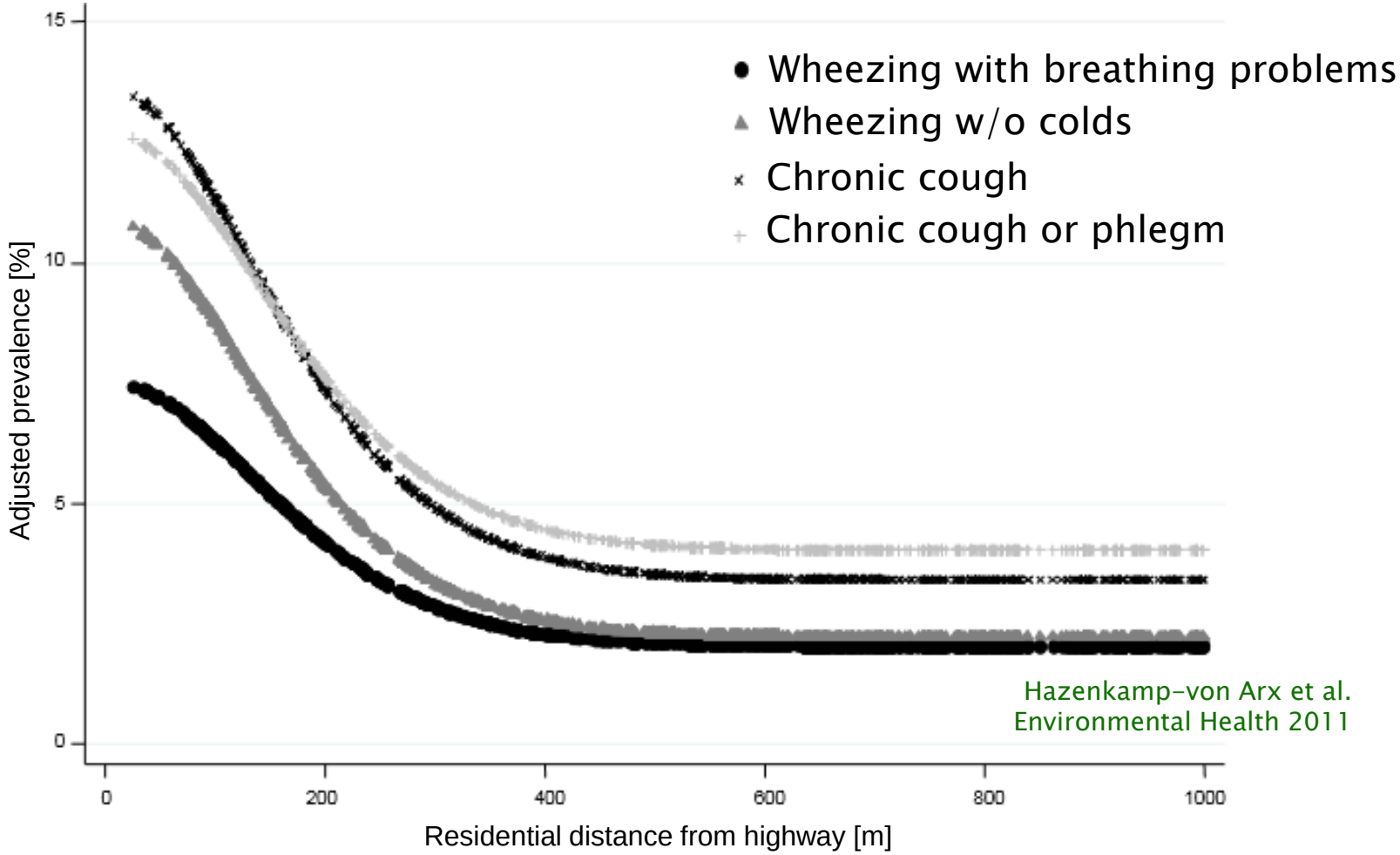


Figure 1 Study area. Map of Switzerland with the 10 study communities. The inset shows the topography in Erstfeld having a width of 800 m at the bottom of the valley.

Hazenkamp-von Arx et al.
Environmental Health 2011

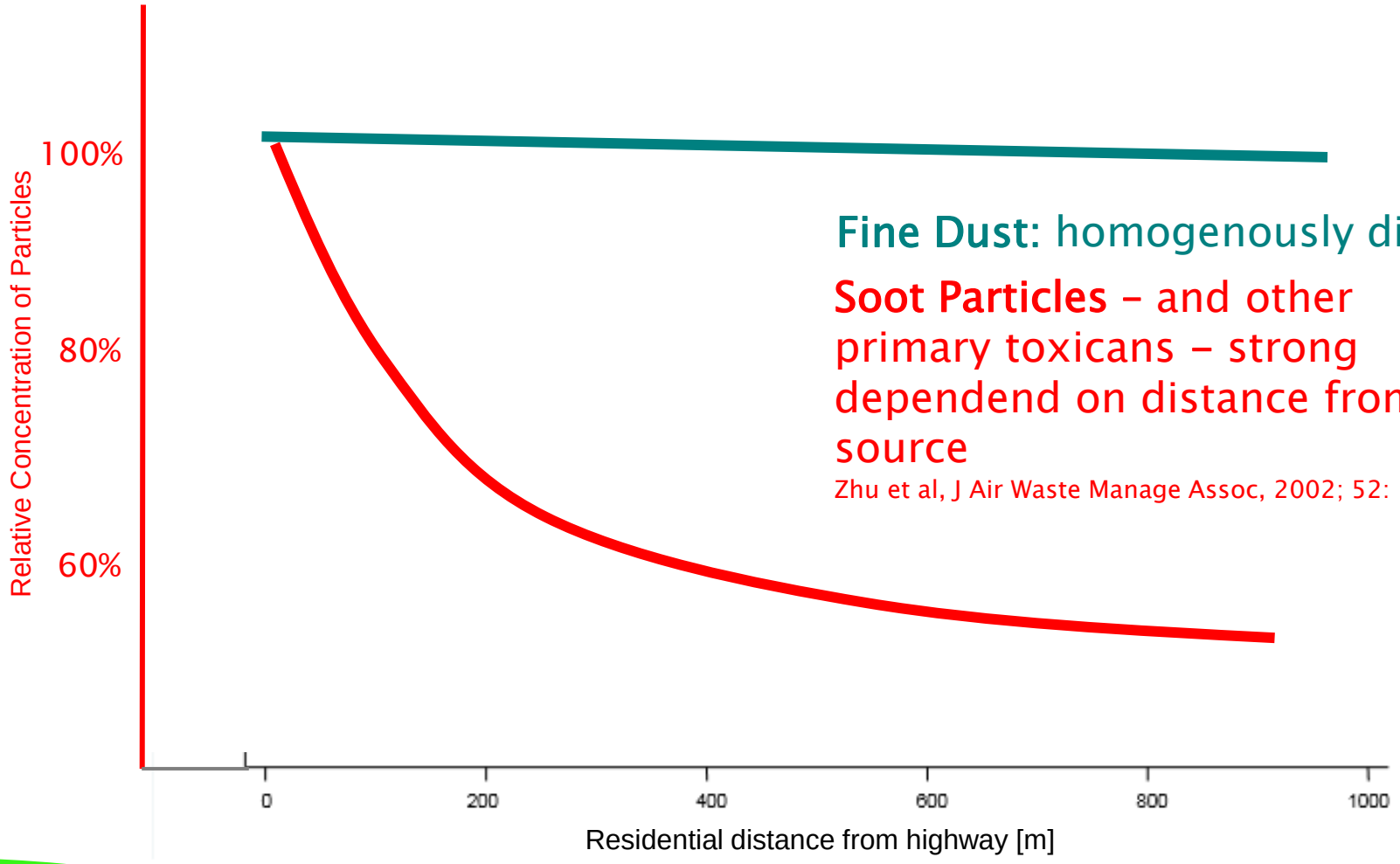
Distance to Heavy Traffic Highways (HTH) and Respiratory Symptons



Hazenkamp-von Arx et al.
Environmental Health 2011

Estimated adjusted prevalence rates of health outcomes

Distance to HTH and Particle Distribution

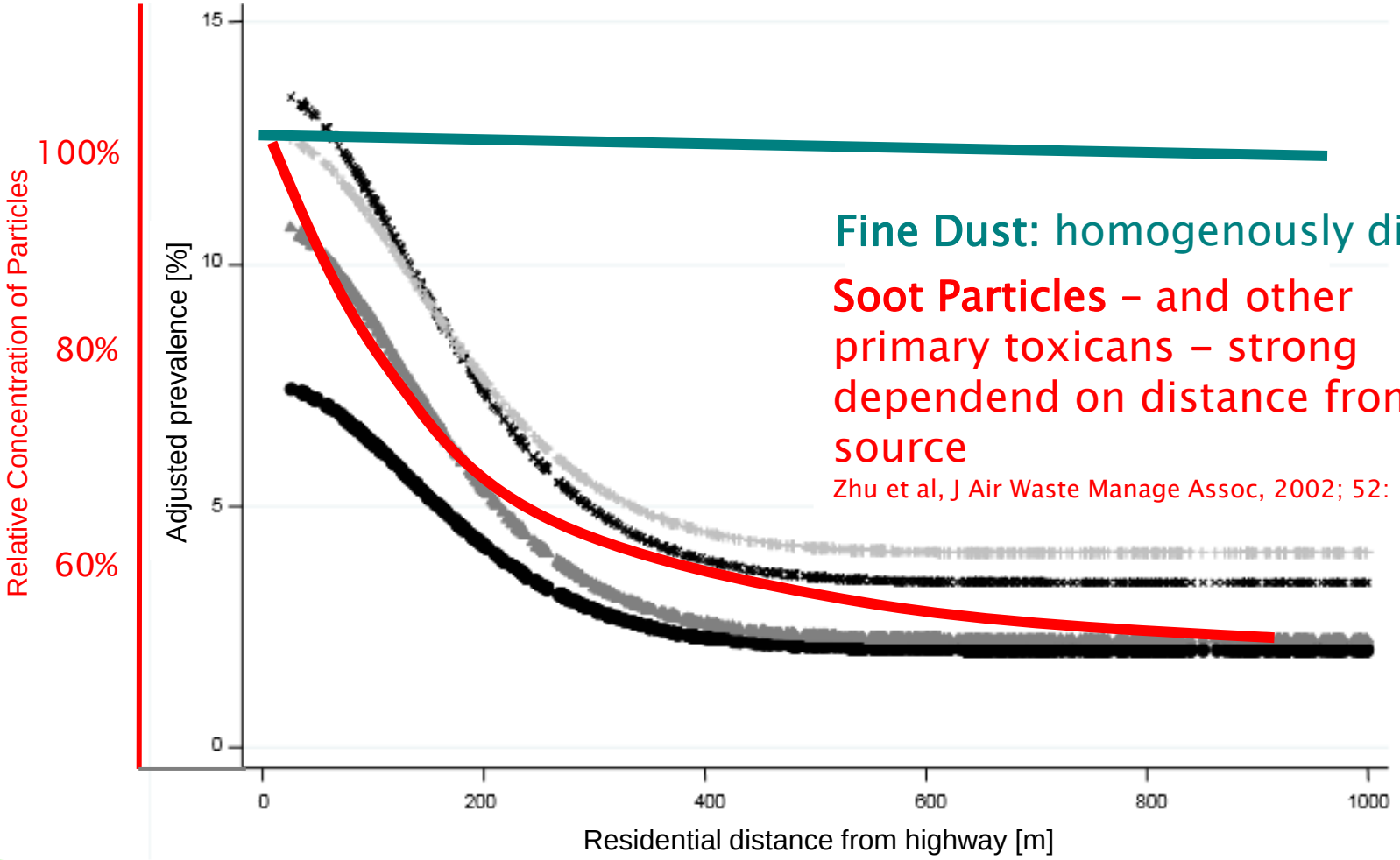


Fine Dust: homogenously distributed

Soot Particles – and other primary toxicans – strong dependend on distance from source

Zhu et al, J Air Waste Manage Assoc, 2002; 52: 1032

Ultrafine Patricle Distribution and Health Symptoms match!



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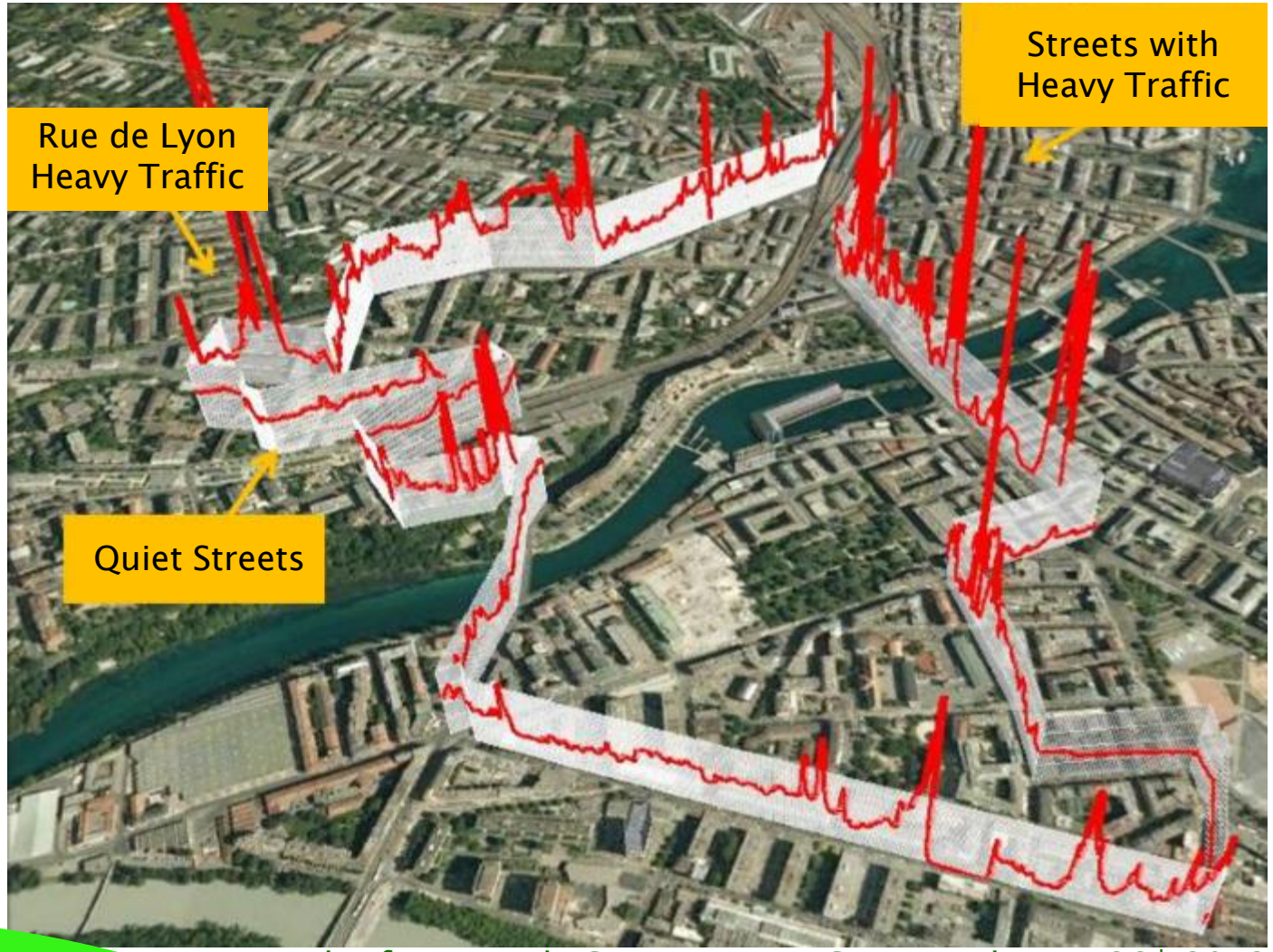
Nino Künzli
Swiss Tropical and Public Health Institute

Particle Number Concentration 10-300 nm



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

Traffic Emission Abatement

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

London "Pea Soup" Smog 1952

Picadilly Sqare, Unknown Photographer

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

• Heart	IHD	15.000
• Lung	COPD	12.000
• Brain	CEV	8.000
• Lung Infections	ALRI	5.000 **Children!**
• Cancer	LC	2.000

Lelieveld et al. Nature 2015

Effect of Air Pollution During Pregnancy

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

Economic Cost of the Health Impact of air pollution in Europe

WHO Regional Office for Europe, OECD (2015)


Soot free Tehran!