

Effects of emissions from shipping on human health

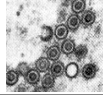
Prof. Dr. Jeroen Buters

ZAUM- Center for Allergy and Environment
Technische Universität München

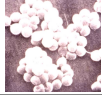
Proteins



Viruses



Bacteria

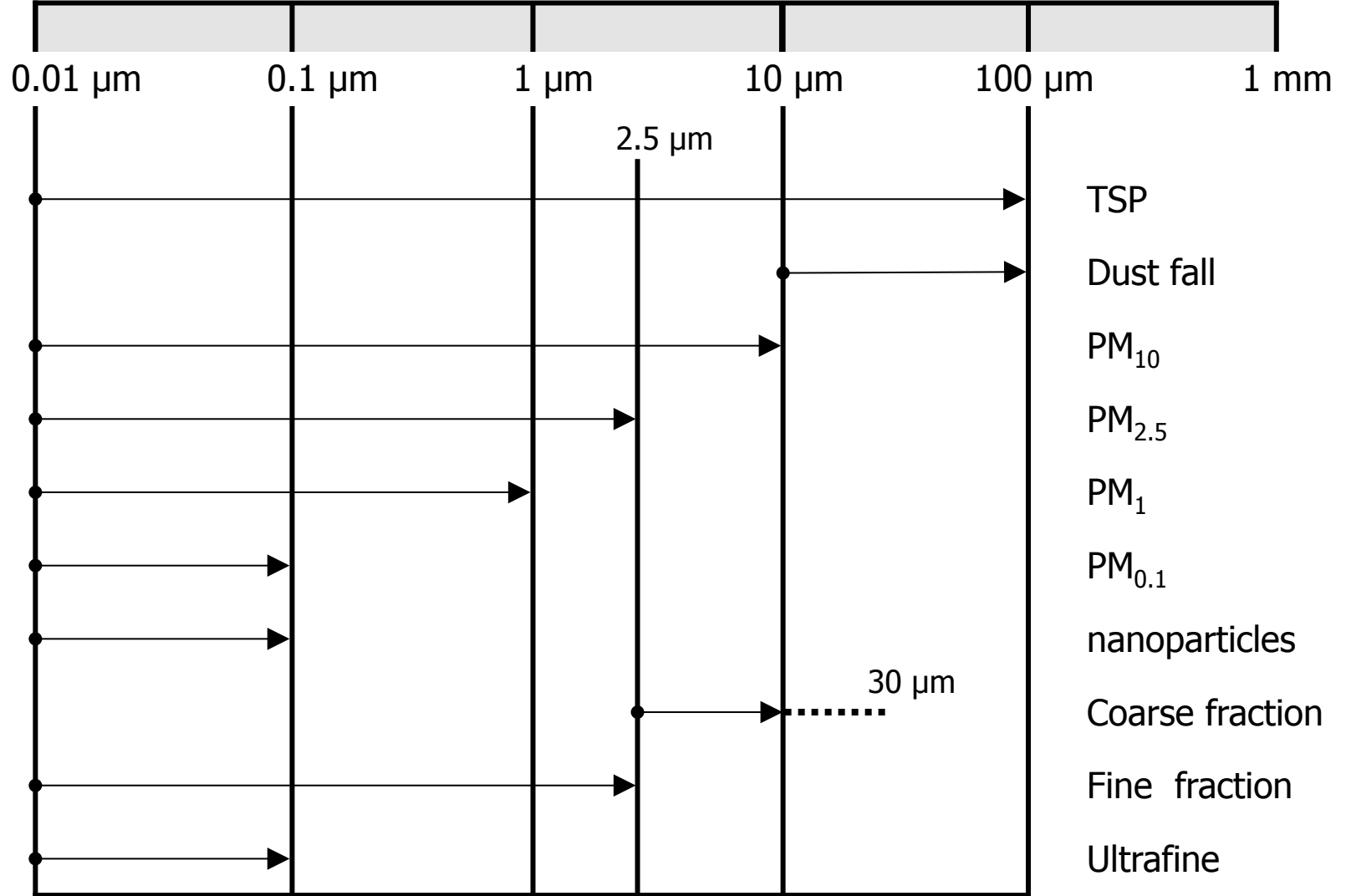


Spores of
Cladosporium
(mold)

Birch pollen

Hair

NaCl (0,7mm)



NaCl (0,7mm)

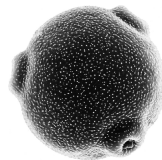
Sources of particles

Mold spores

Biogenic

- Spores
- Bacteria
- Sea salt
- Bronchosomes
- Crustal material (Sand etc.)
- Combustion of vegetable Material
- Pollen

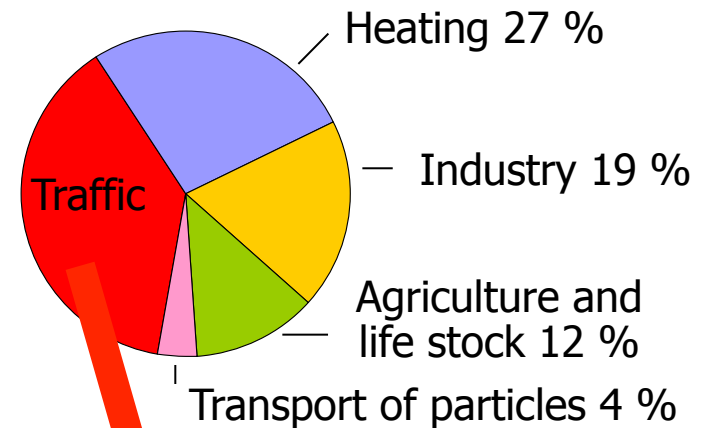
Bacteria



Birch pollen

Bronchosomes

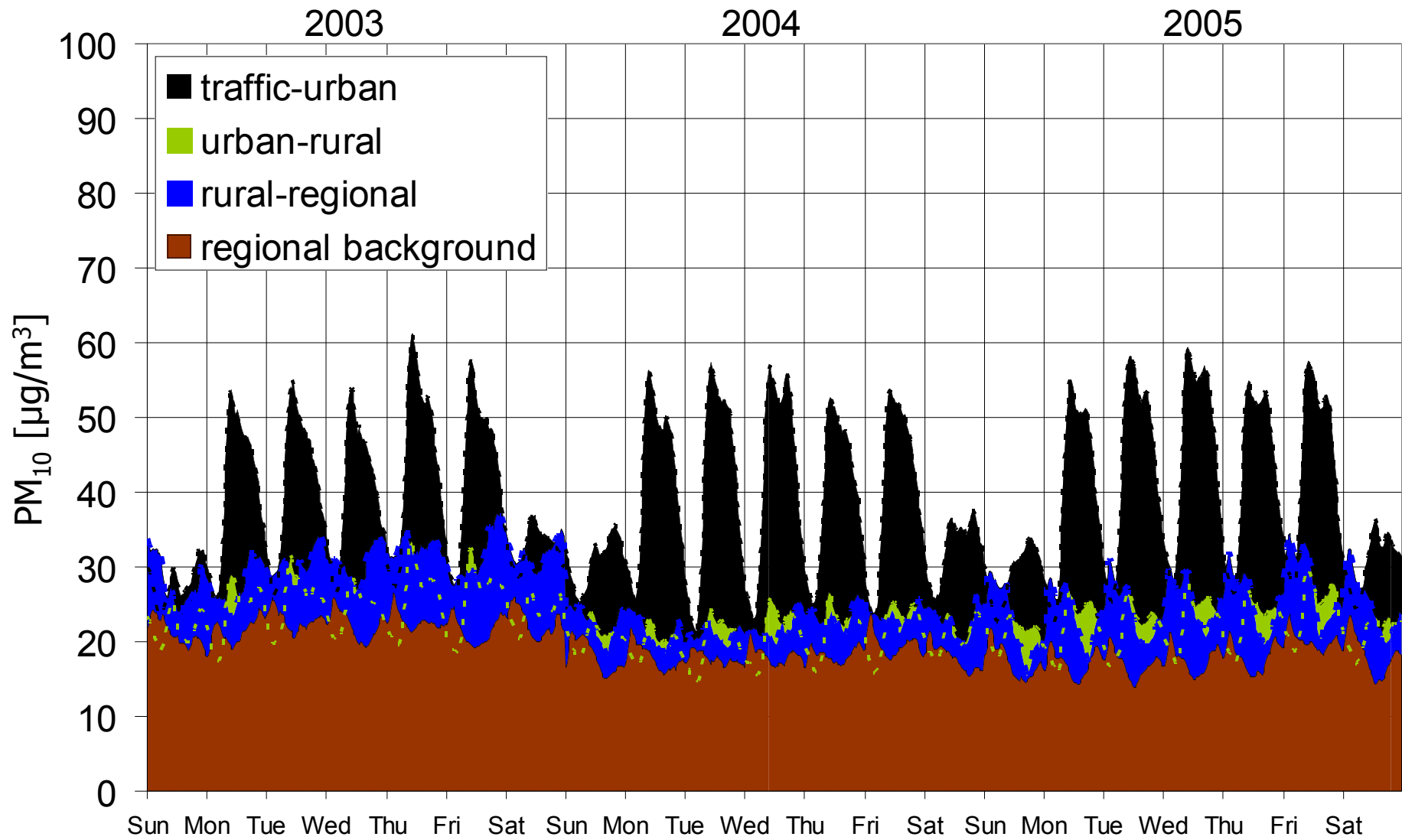
Anthropogenic



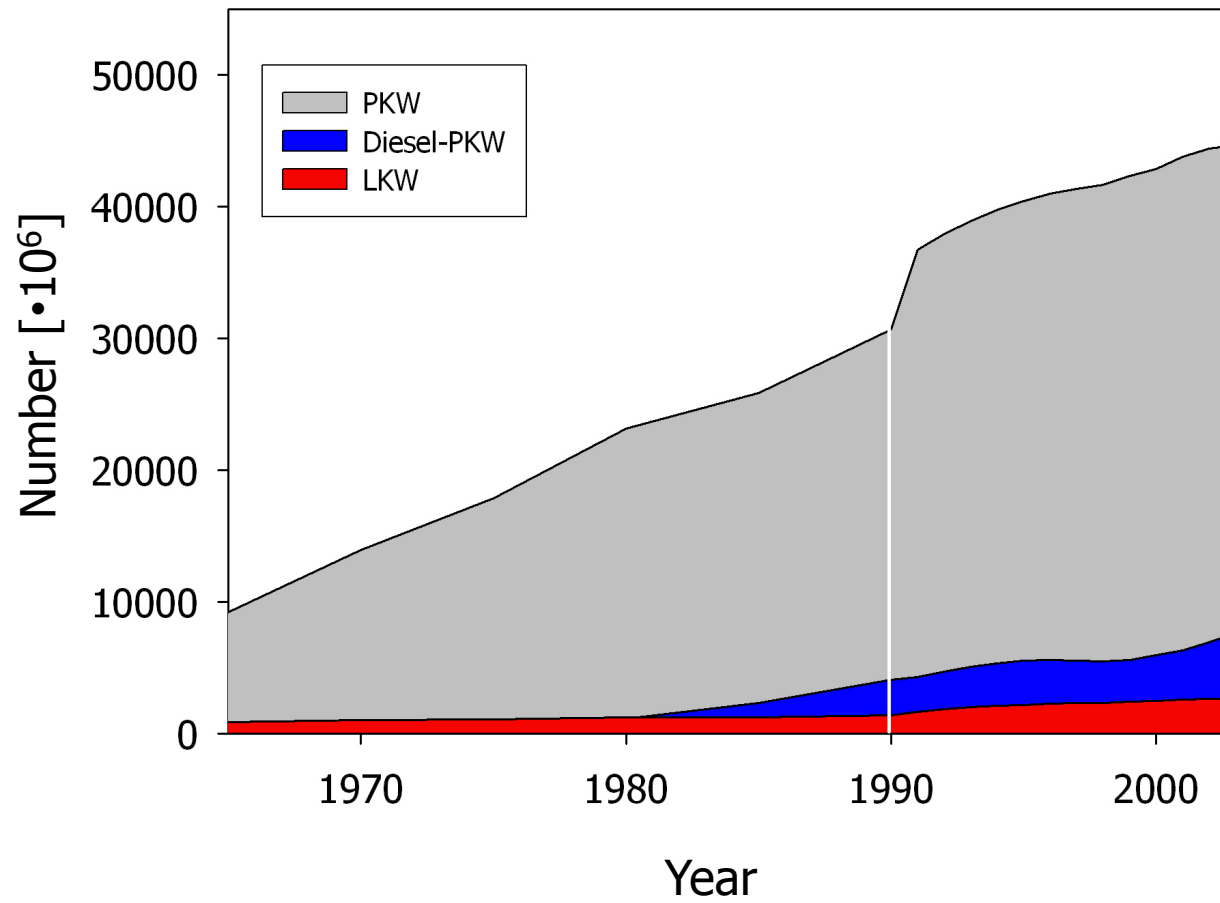
Source: Emissionskataster Bayern, 2004

- Traffic:
- 26% Off-road Diesel
 - 63% On-road vehicles (of those ca. 70 % Dieselfahrzeuge)

Diurnal Variation: Bremen (traffic site)



Vehicle development in Germany



Sources of pollution

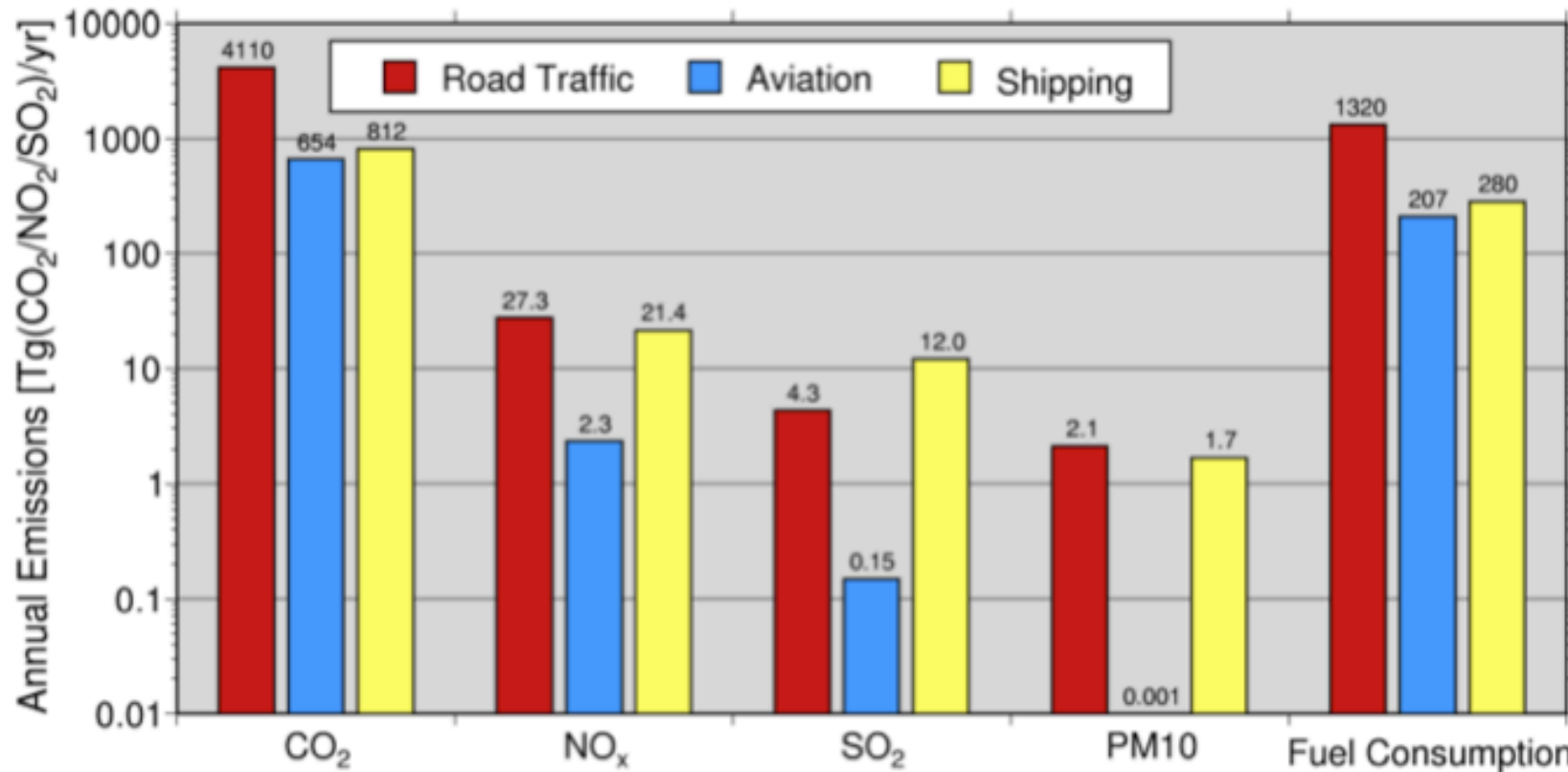


Figure 2. Transport-related annual emissions of CO₂, NO_x, SO₂ and PM10 and the fuel consumption in Tg (1 Tg = 10¹² g = Mt) estimated for the year 2000 (Eyring et al., 2007).

Ship emissions will increase

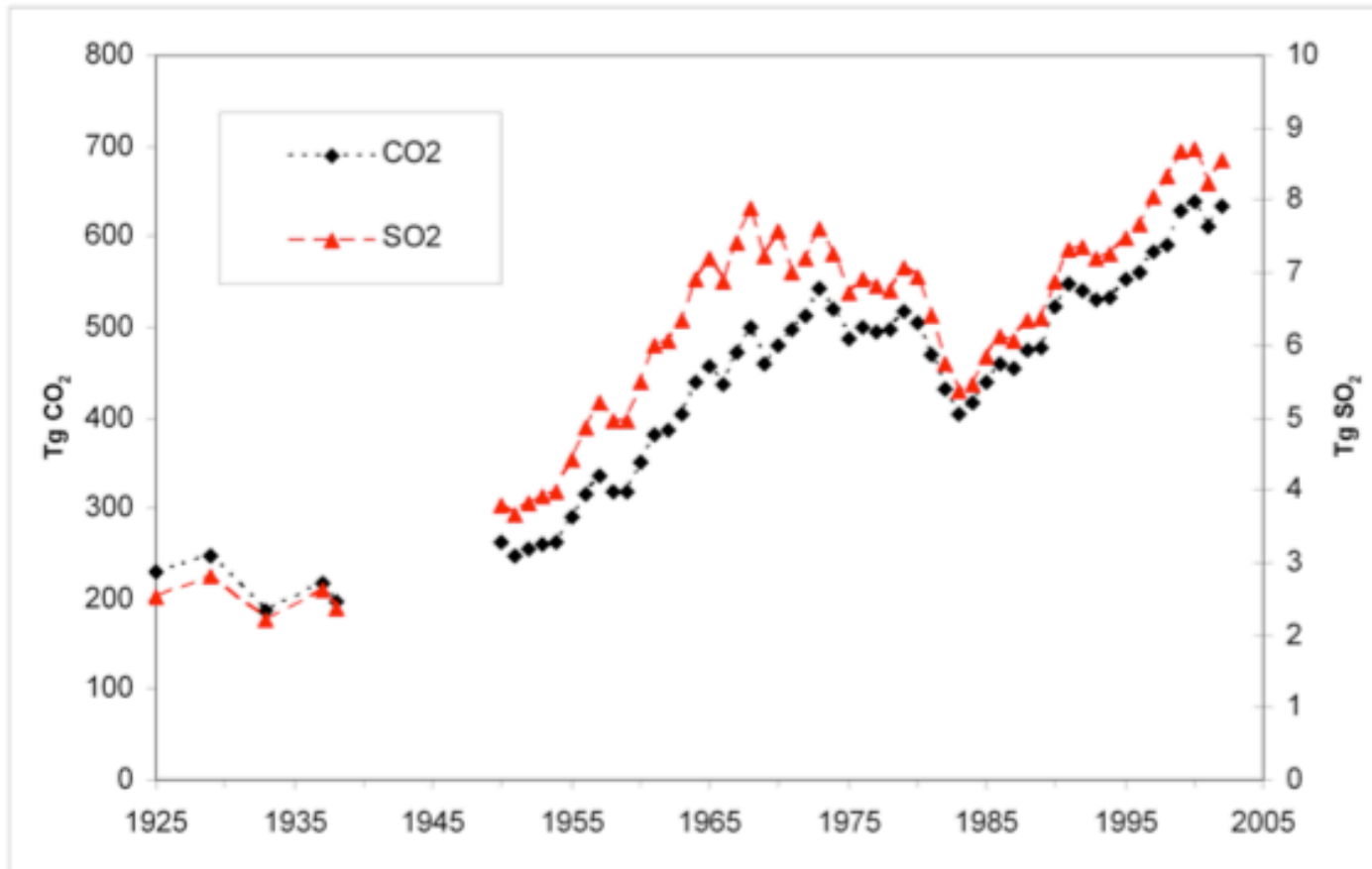


Figure 1. Development of CO₂ and SO₂ ships, emissions, based on estimated sales of marine fuel, 1925-2002. Note that no data are available for World War II (from *Endresen et al., 2007*).

Sulphur in ship emissions generates clouds



A satellite image from 4 March 2009 showing ship tracks — the bright streaks of clouds that form around the particles in ship exhaust — over the northeast Pacific Ocean. The ship tracks are brighter than the natural marine clouds around them because they contain lots of small cloud droplets, which you can see in this zoomed-in image. NASA image by the LANCE/EOSDIS MODIS Rapid Response Team.



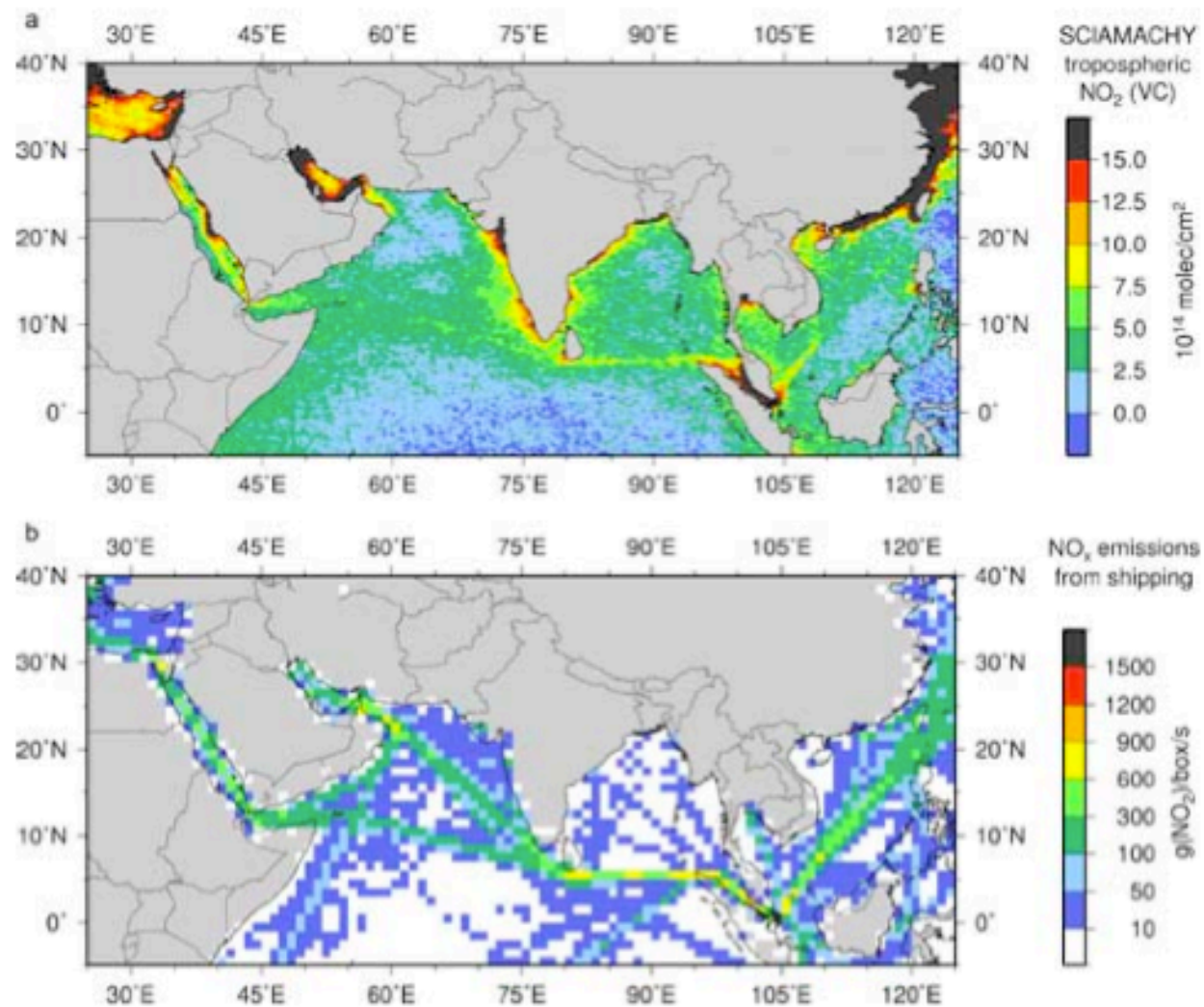


Figure 3. NO_x signature of shipping in the Indian Ocean, as detected by SCIAMACHY (a), and estimated from emission models (b). From *Richter et al.*, (2004).

Ship diesel exhaust components

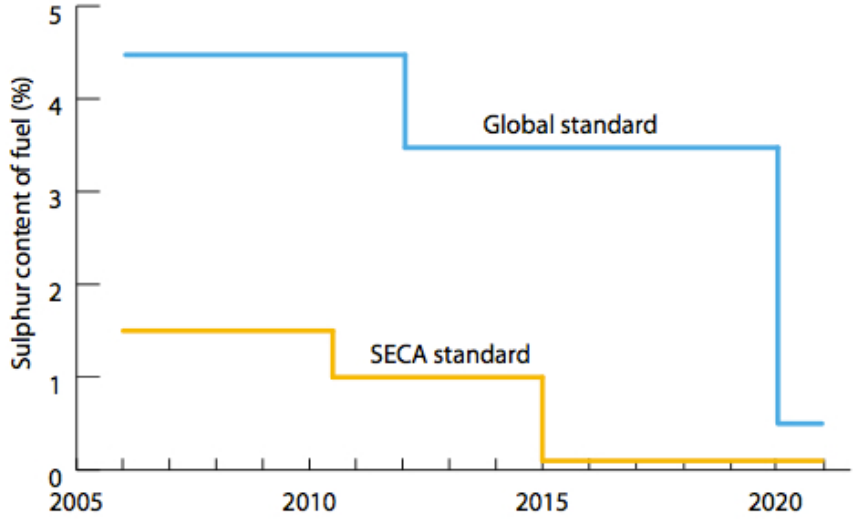
Component	Heavy Fuel *	Light Fuel**
SO ₂	600-700 ppm	1-10 ppm
NO ₂	600-700 ppm	600-700 ppm
CO	200-400 ppm	400 ppm
NO _x	600-700 ppm	600-700 ppm
PM (BC)	800-1000 µg/m ³	400-600 µg/m ³
THC	200-300 ppm	200-300 ppm

* 1.6% Sulphur (world average 2.7%, max. 4.5%)

** Diesel according DIN EN 590: <10 ppm Sulphur

Regulations of fuels

Ship-fuel



Automotive-fuel DIN EN 590 *



Abgasnorm	spätestens	Schwefelgehalt	Cetanzahl
Euro 1	1. Januar 1993	max. 0,200 %	min. 49
Euro 2	1. Januar 1996	max. 0,050 %	min. 49
Euro 3	1. Januar 2001	max. 0,035 %	min. 51
Euro 4	1. Januar 2006	max. 0,005 %	min. 51
Euro 5	1. Januar 2009	max. 0,001 %	min. 51
Euro 6	1. Januar 2014		

NC

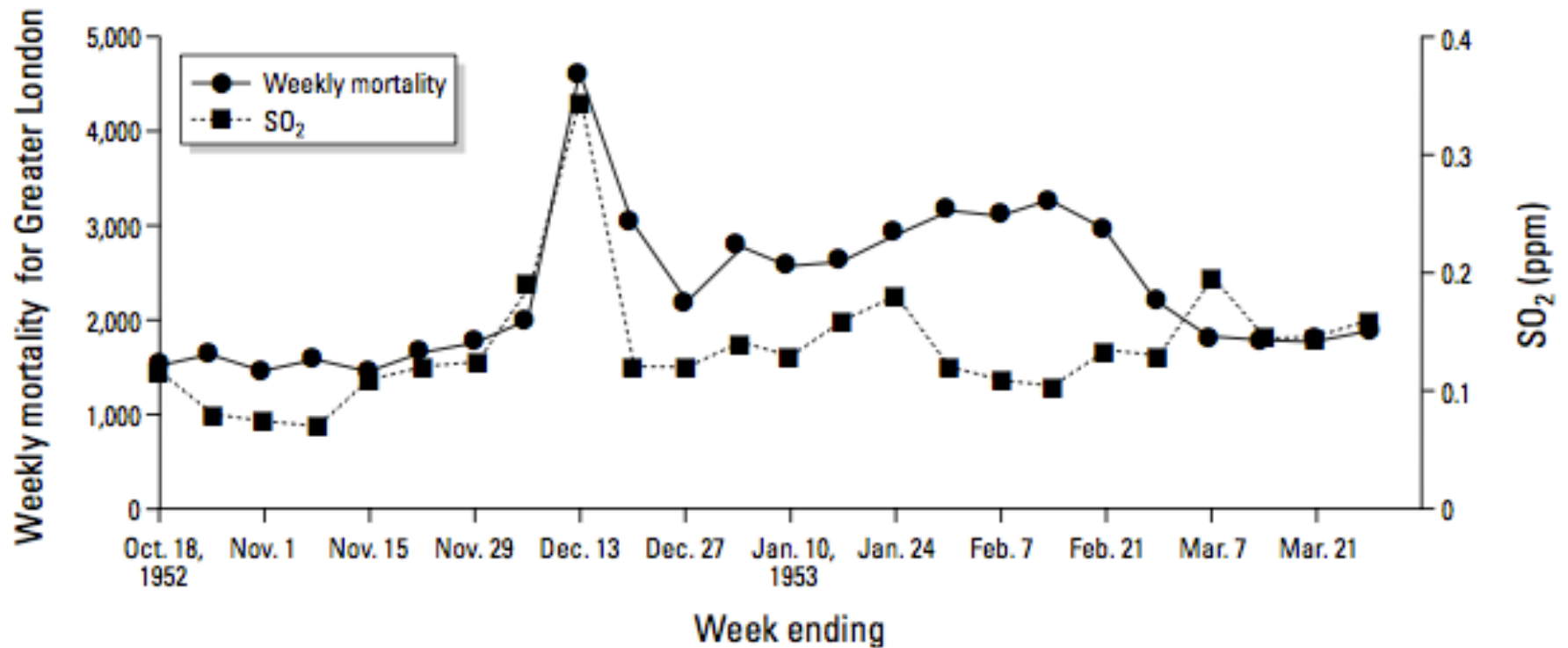
London smog



Ship diesel: 300 mg sulphur/kg

<10mg Schwefel/kg ab Jan 2013 DIN EN 228: 2013-01, standard in Germany since 2003

London smog: lethality



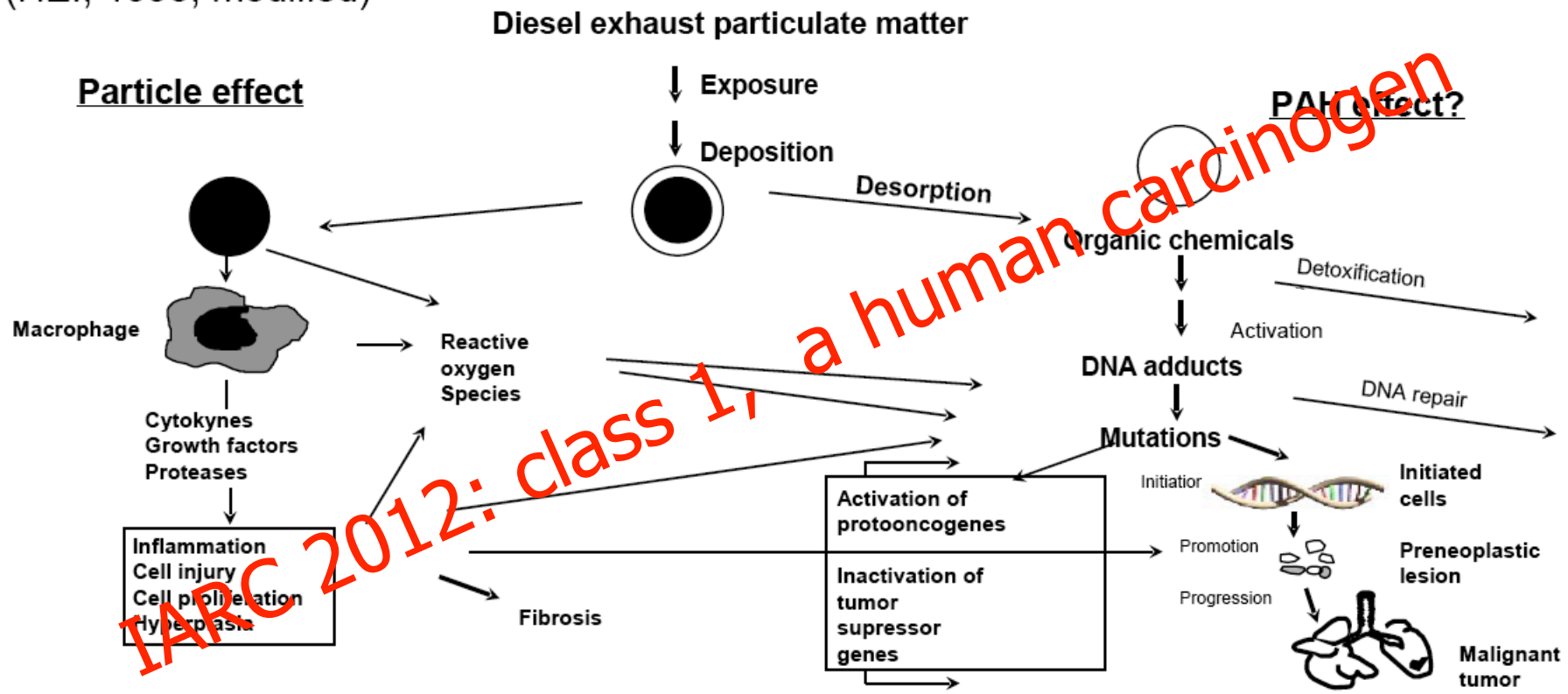
Health effects:

- Carcinogenesis
- Cardiovascular
- Respiratory
- Immunology

Effect of ambient particles: Carcinogenesis

Possible mechanisms for diesel exhaust-induced carcinogenesis

(HEI, 1995, modified)

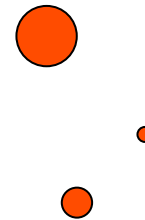
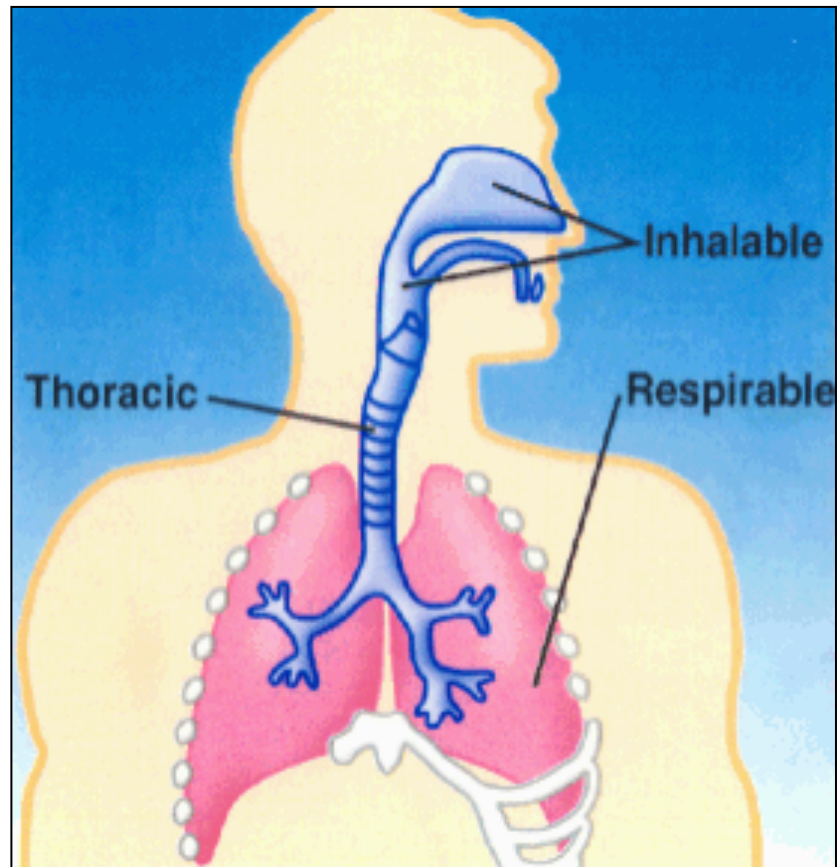


HICE

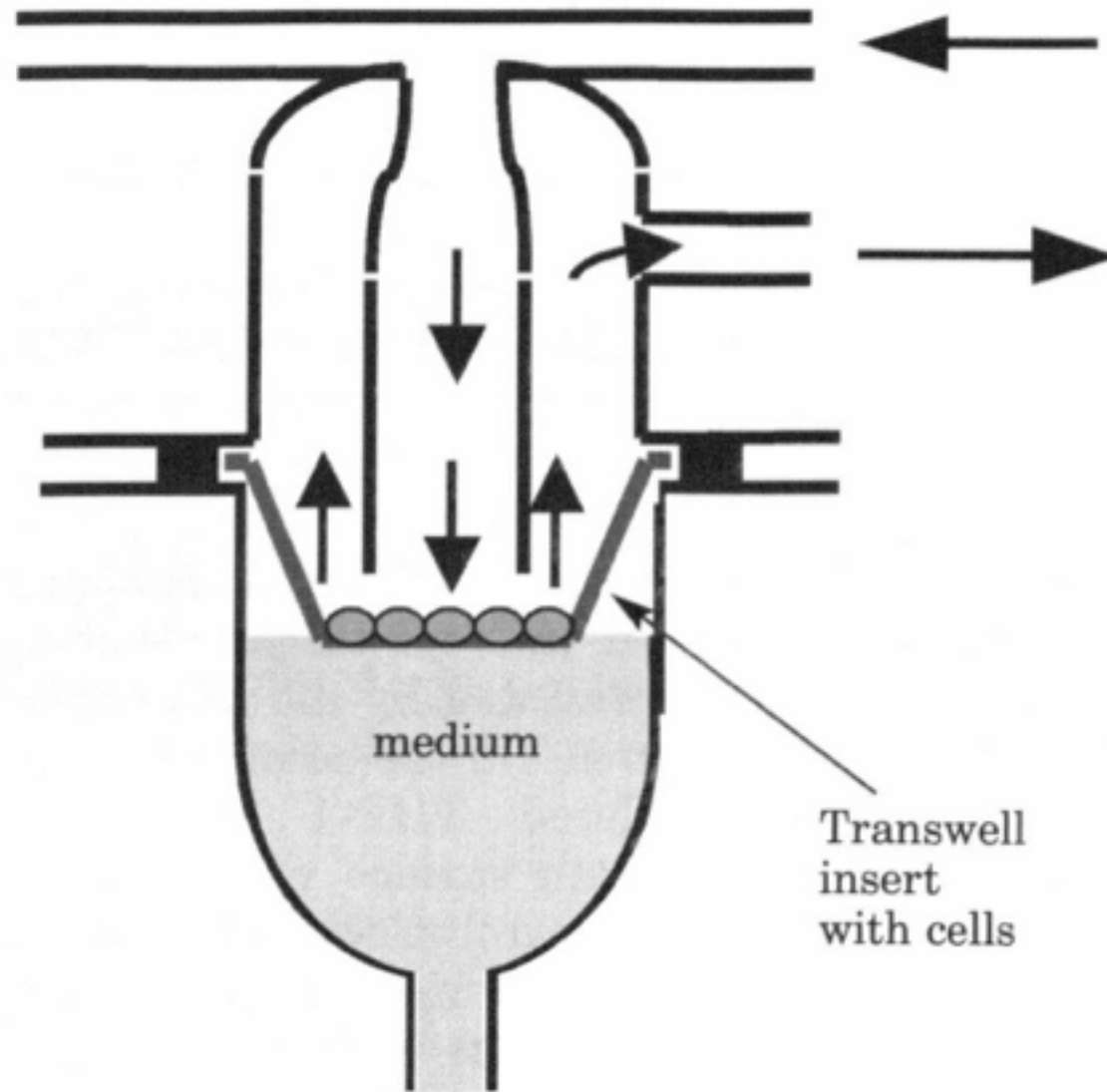
Testing toxicity of anthropogenic combustion:

ship diesel exhaust

Particle deposition in the lung

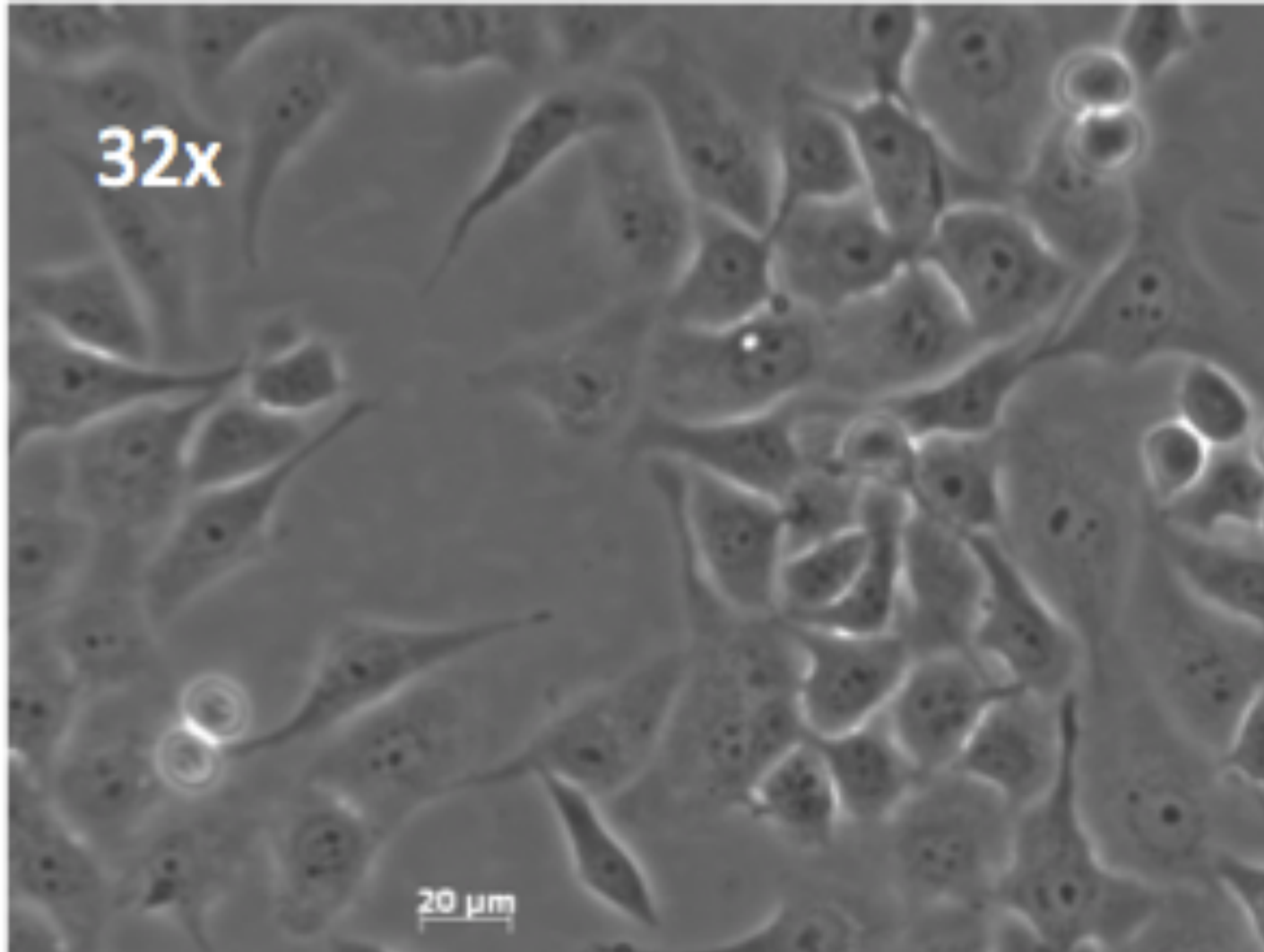


Exposing lung cells to diesel exhaust

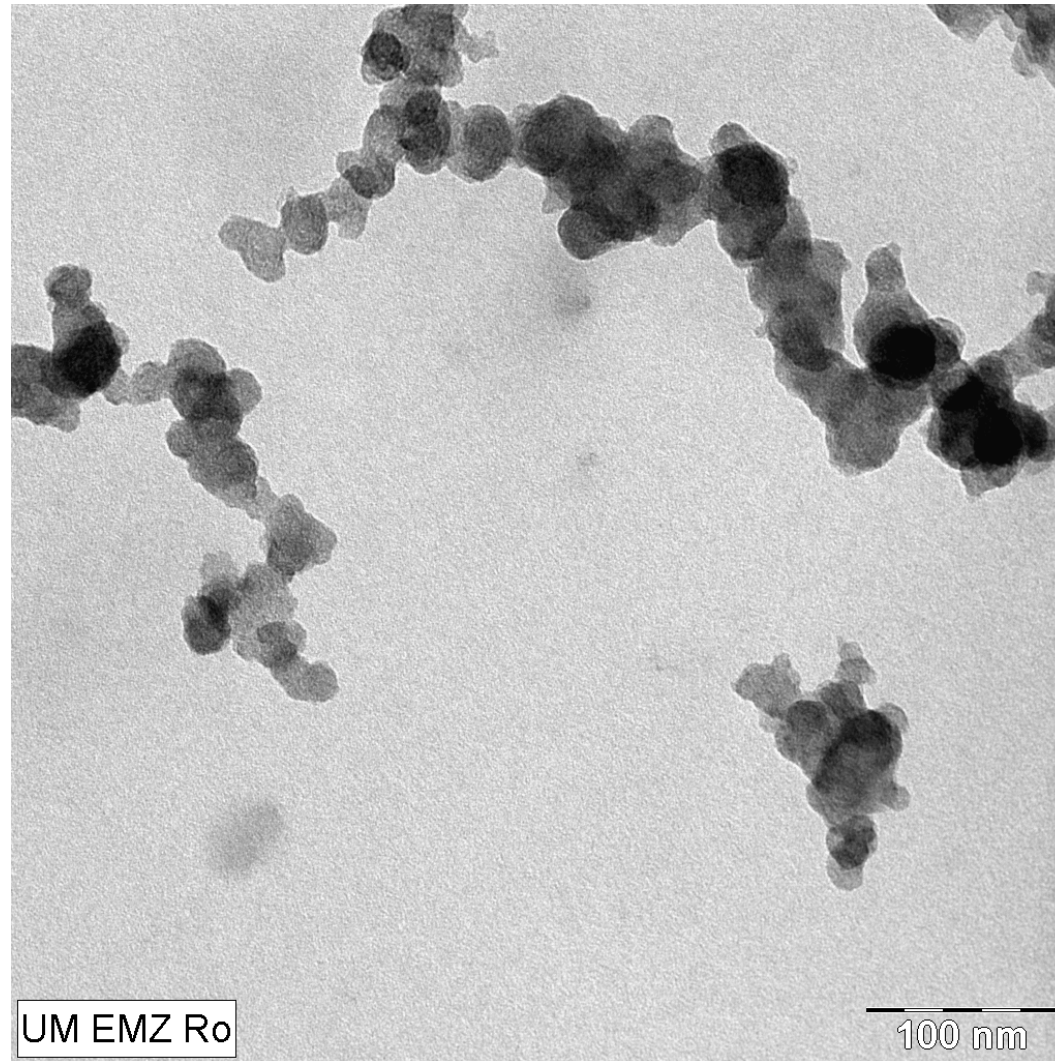


Human bronchial epithelial cells

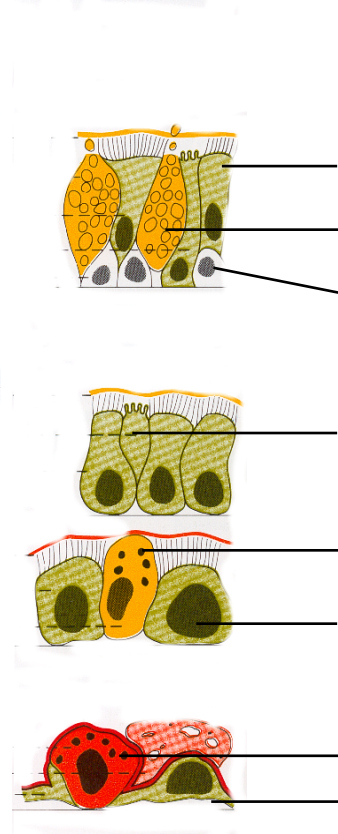
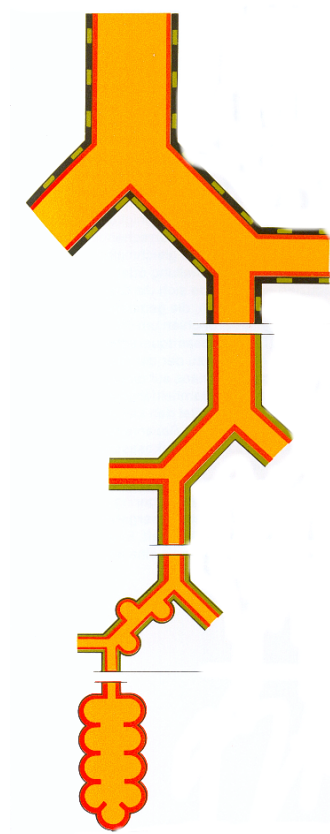
- BEAS-2B immortalized -



Ship diesel exhaust particles

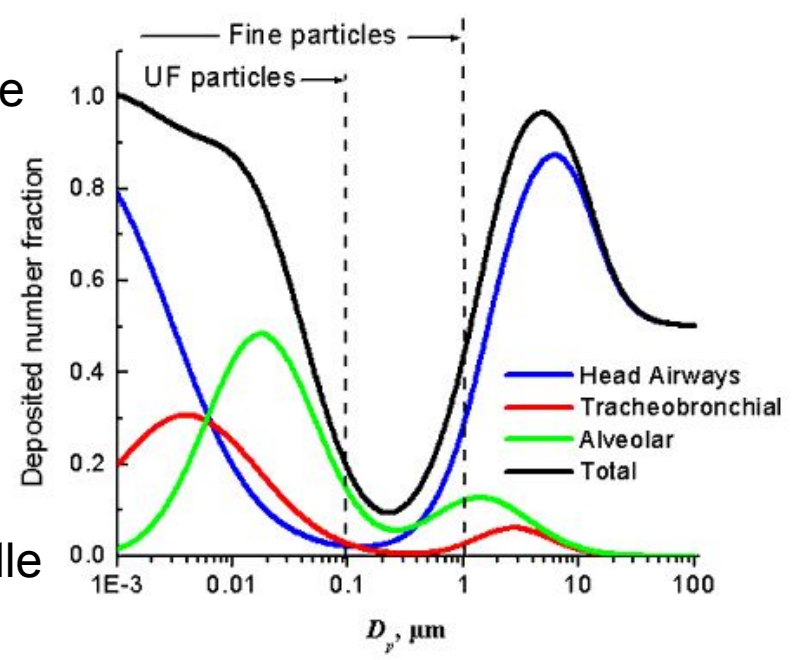


Respiratorisches Epithelium



- zyl. Flimmerzelle
- Becherzelle
- Basalzelle
- Bürstenzelle
- Clara-Zelle
- kub. Flimmerzelle
- Typ II - Zelle
- Typ I - Zelle

Deposition von Partikeln

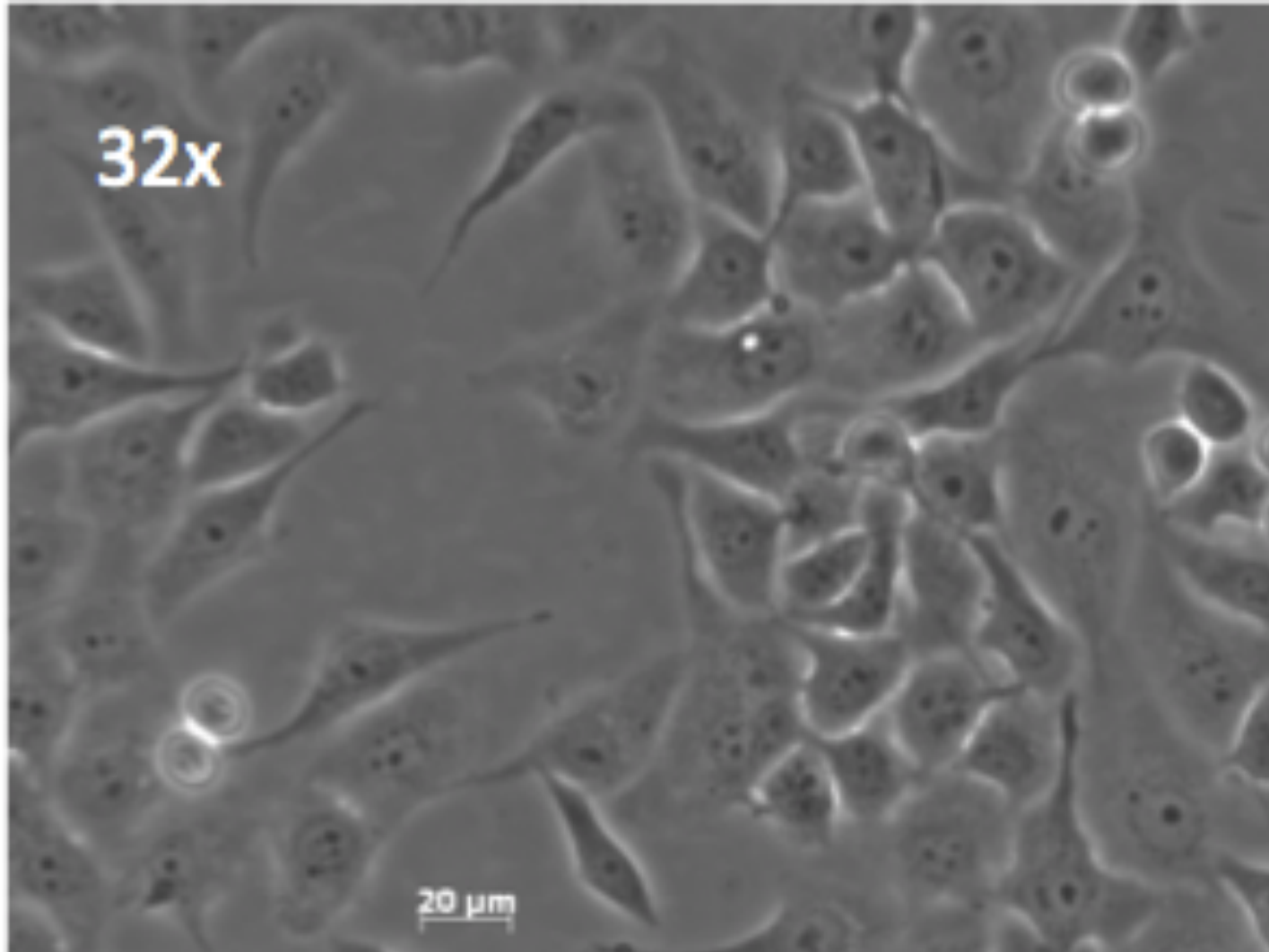


D=Diameter, UF=Ultrafeinstaub

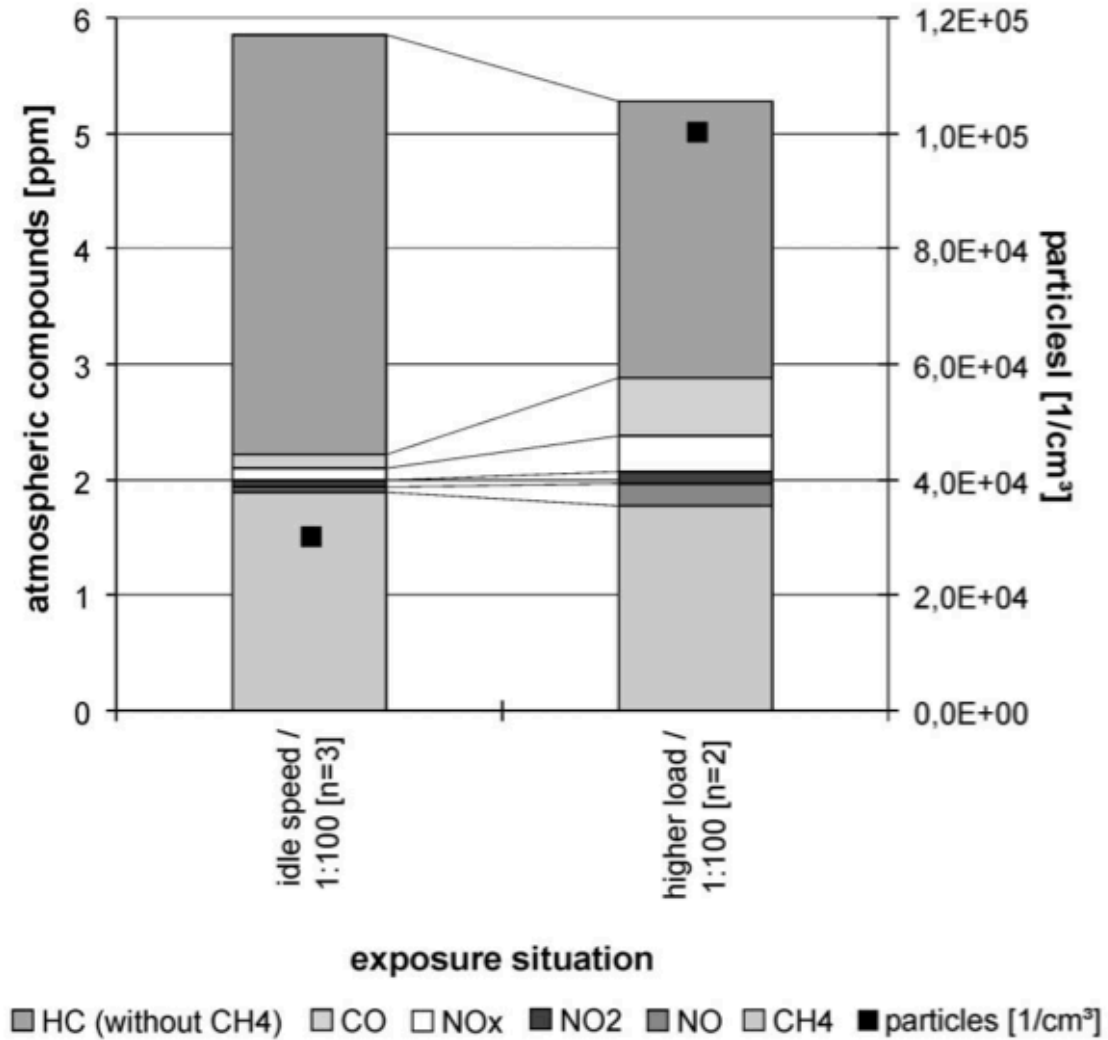
Quelle Figur: Prof. N. Krug, pers. Mitteilung

Human bronchial epithelial cells

- BEAS-2B immortalized -

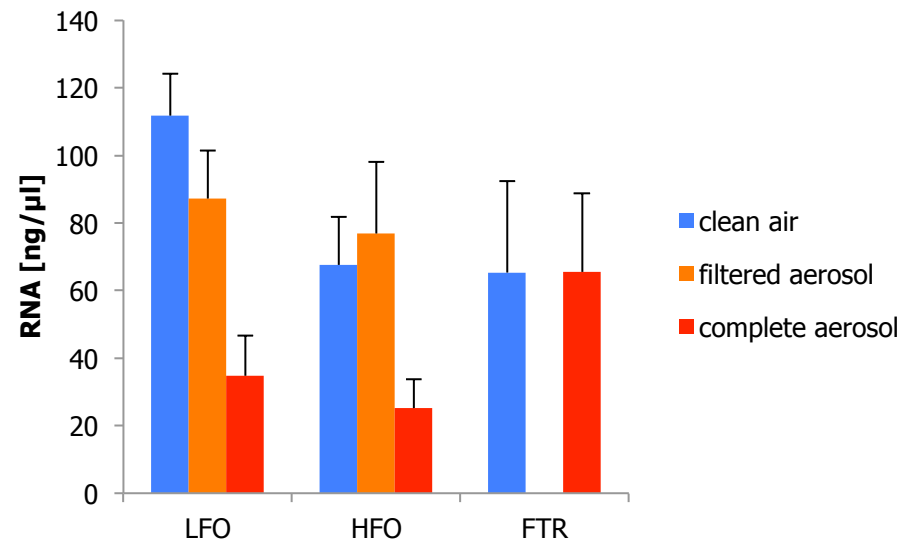


Effect of load on engine emissions



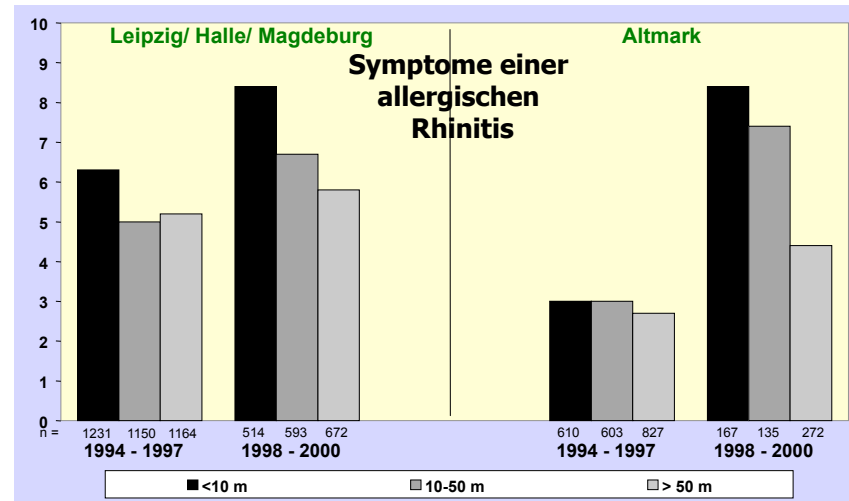
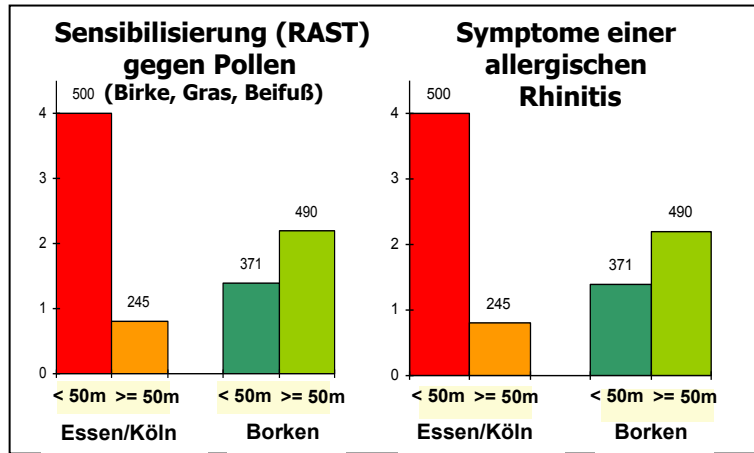
RNA after exposure to ship diesel exhaust

- BEAS-2B human lung epithelial cells -

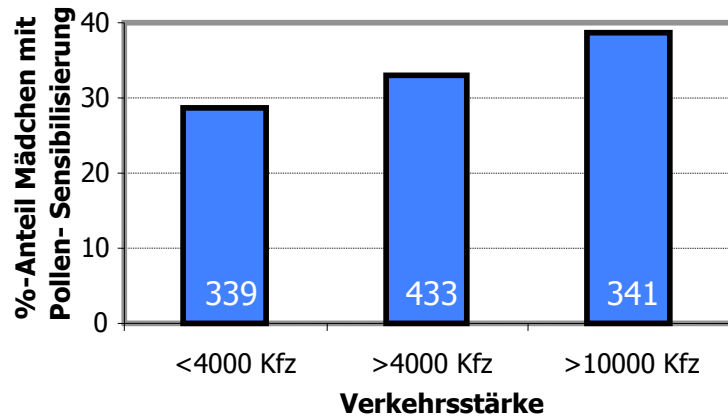


LFO = light fuel oil (1:40)
HFO = heavy fuel oil (1:100)
FTR = filtered air

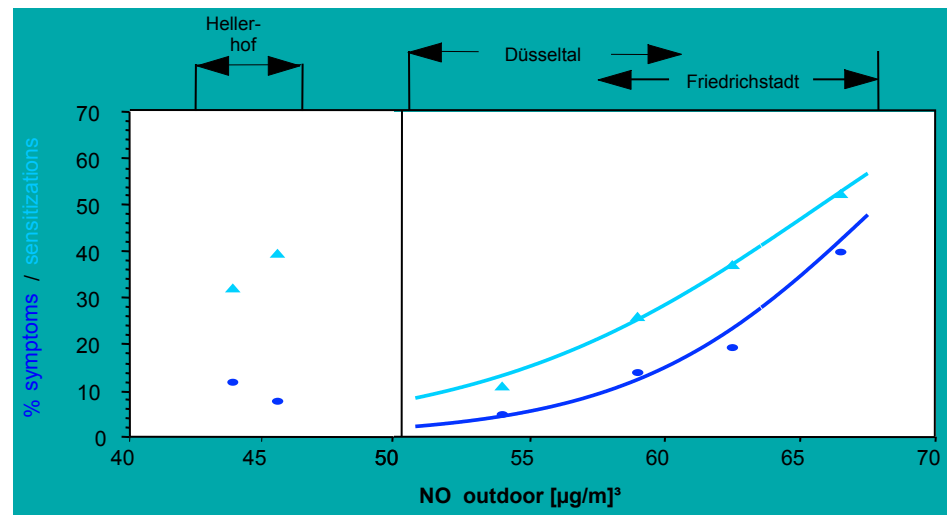
Verkehrsbelastung und Allergie



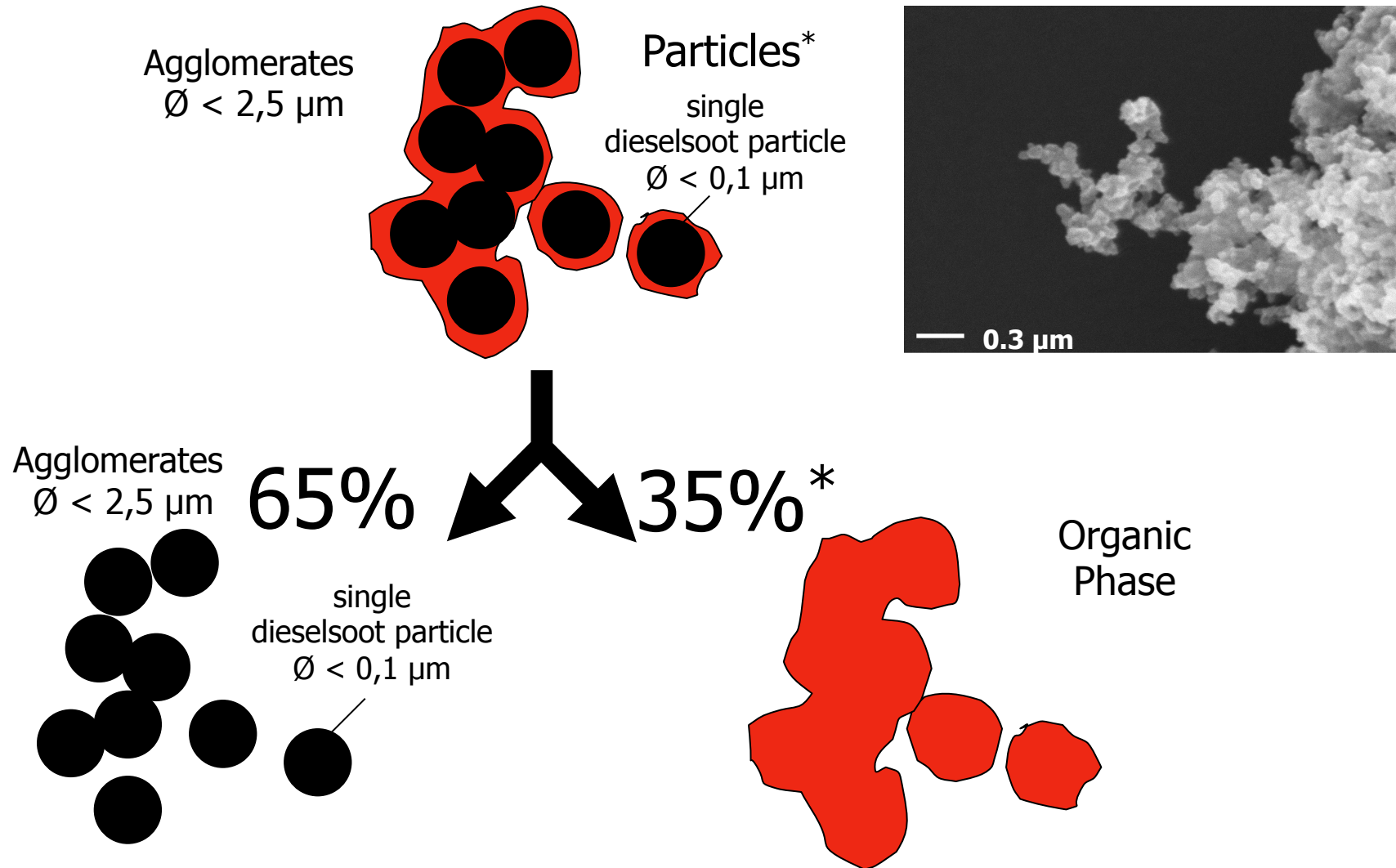
MIRIAM Augsburg 1996



Verkehrsstudie Düsseldorf 1996

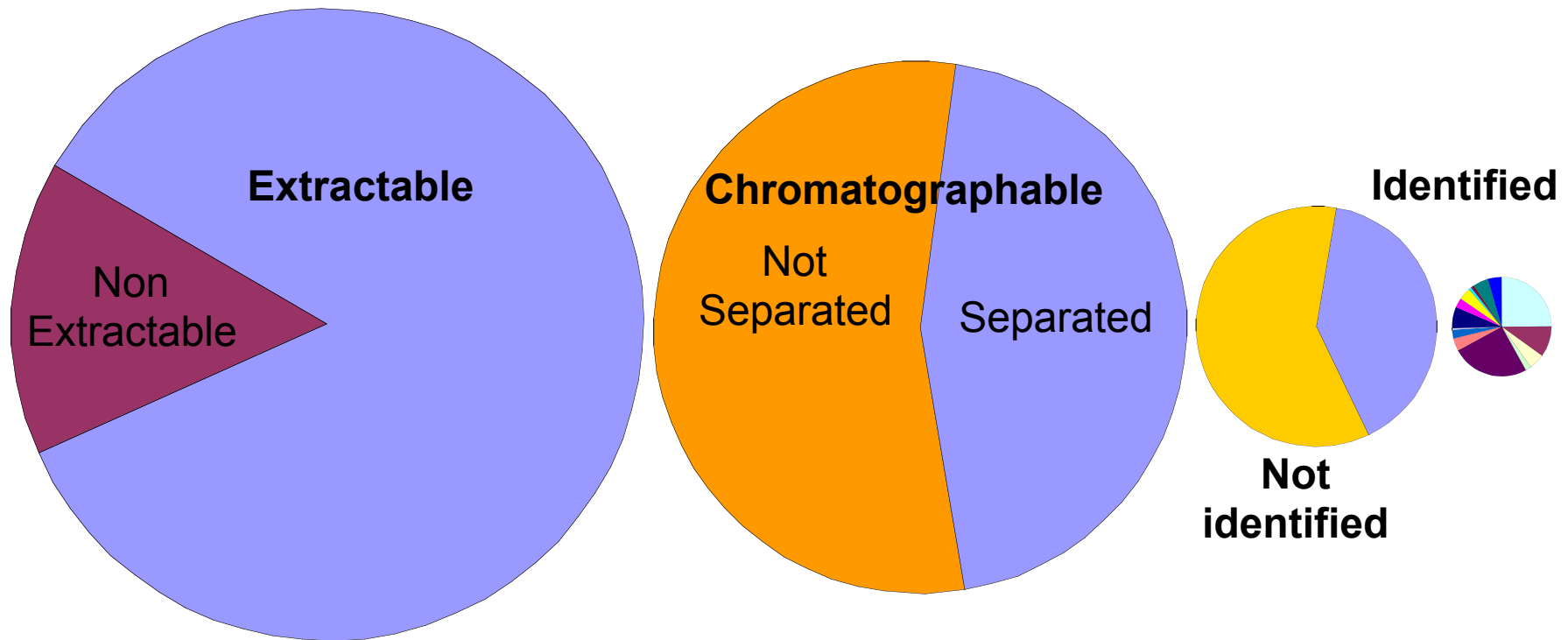


Effects of Ambient Particles Associated Organic Compounds on the IgE Mediated Immune Response



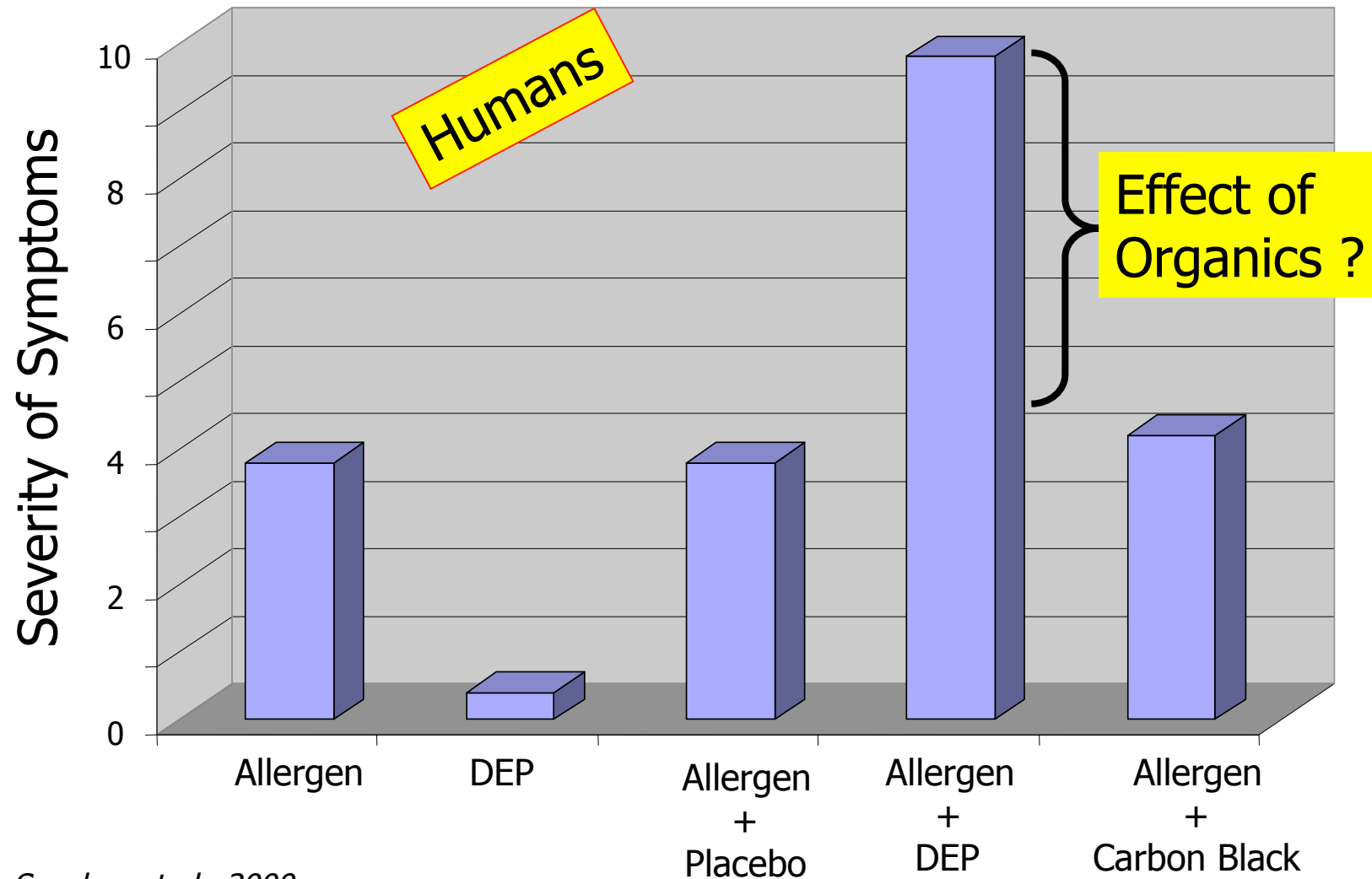
* for diesel ambient particles

Composition of PM₁₀-associated organic phase



20.000 compounds of which 33% could be identified

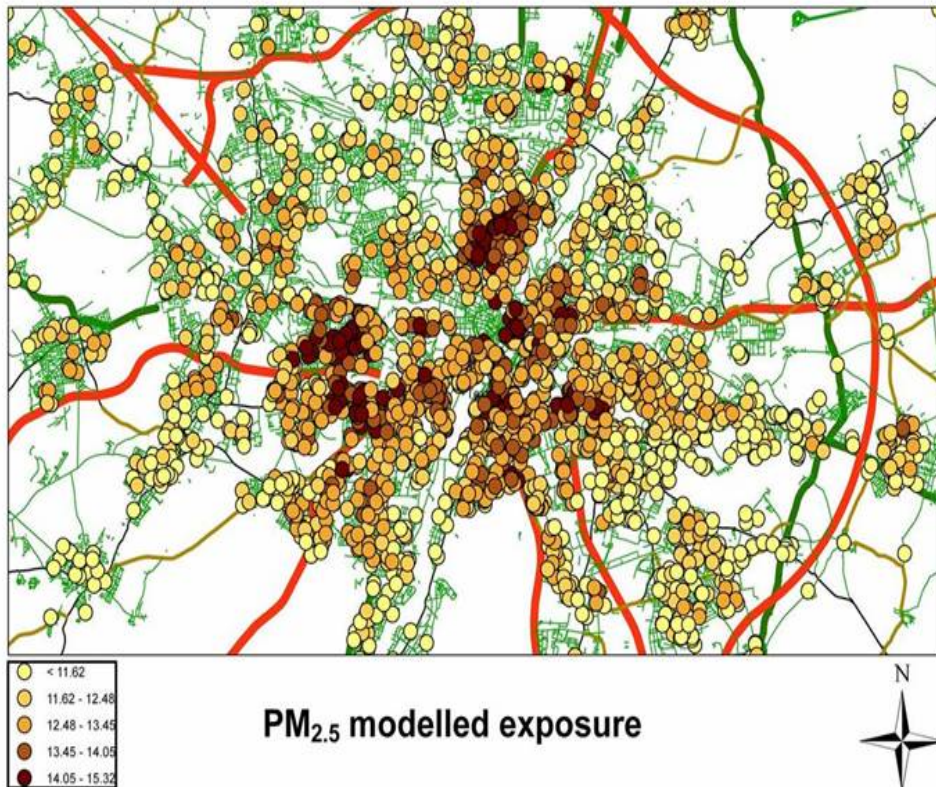
Effect of Diesel-Exhaust-Particles: Allergy Symptoms



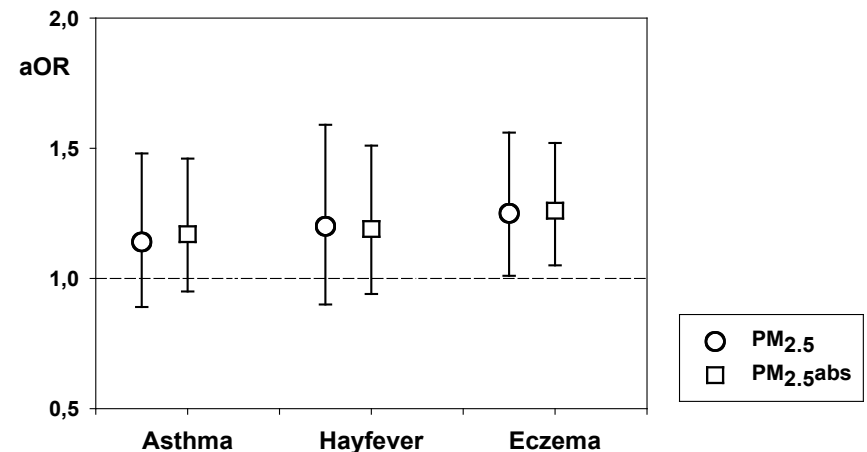
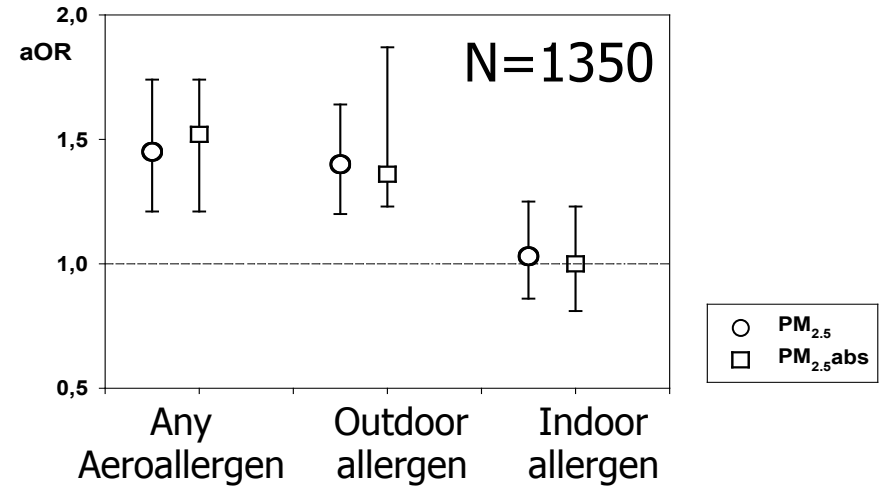
Exposure to particles from traffic increases allergic sensitization

Four 2-week periods measurements for 1 year at 40 sites (background and traffic)

Munich, Germany



GINI and LISA birth cohort studies



➤ PM_{2.5} from traffic

Sensitization is increased by DEP

- Challenge against DEP and/or Keyhole Limpet Hemocyanine-

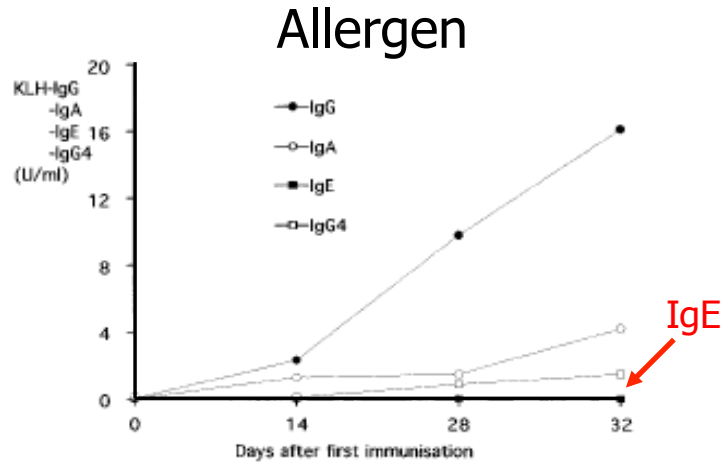


FIG 1. Appearance of antibodies to KLH in nasal fluid samples after nasal immunization with KLH. Subjects were immunized on day 0, 14, and 28, and the levels of anti-KLH IgE, IgG, IgA, and IgG4 were measured (see "Methods" section). Units are different for each isotype measured and cannot be compared. Mean of n = 10 is shown.

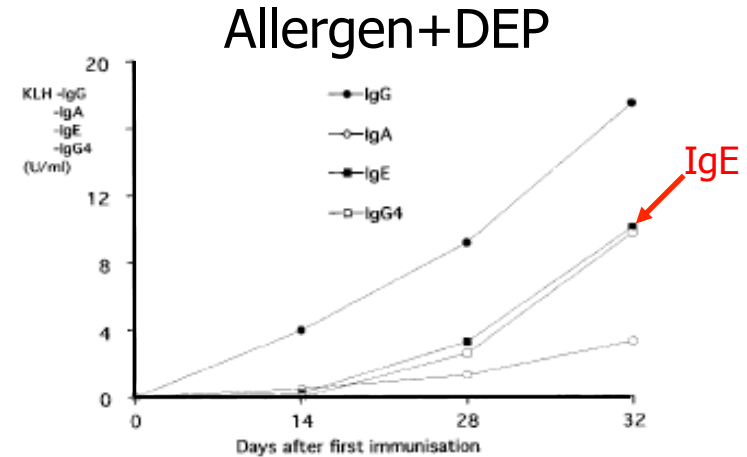


FIG 3. Appearance of antibodies to KLH in nasal fluid samples after nasal immunization with KLH plus DEPs. Subjects were immunized on days 0, 14, and 28, and the levels of anti-KLH IgE, IgG, IgA, and IgG4 were measured (see "Methods" section). Units are different for each isotype measured and cannot be compared. Mean of n = 15 is shown.

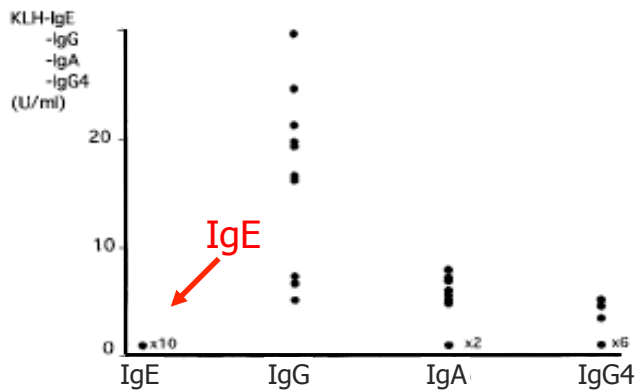


FIG 2. Individual antibody responses to KLH as measured at day 32 (4 days after the last immunization). Units are different for each isotype measured.

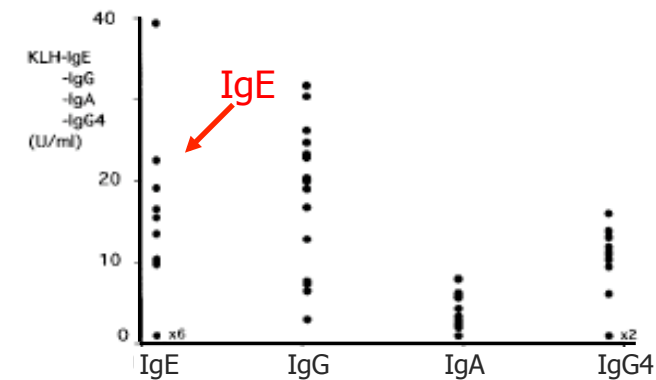


FIG 4. Individual antibody response to KLH on day 32 (4 days after the last immunization) within each isotype. Units are different for each isotype measured.

Zuviel scheint nicht gut zu sein!



Conclusions

- A comparison using the same methodology between combustion products is missing
- Mitochondrial, REM and RNA toxicity was detected
- Particles were more toxic than filtered exhaust