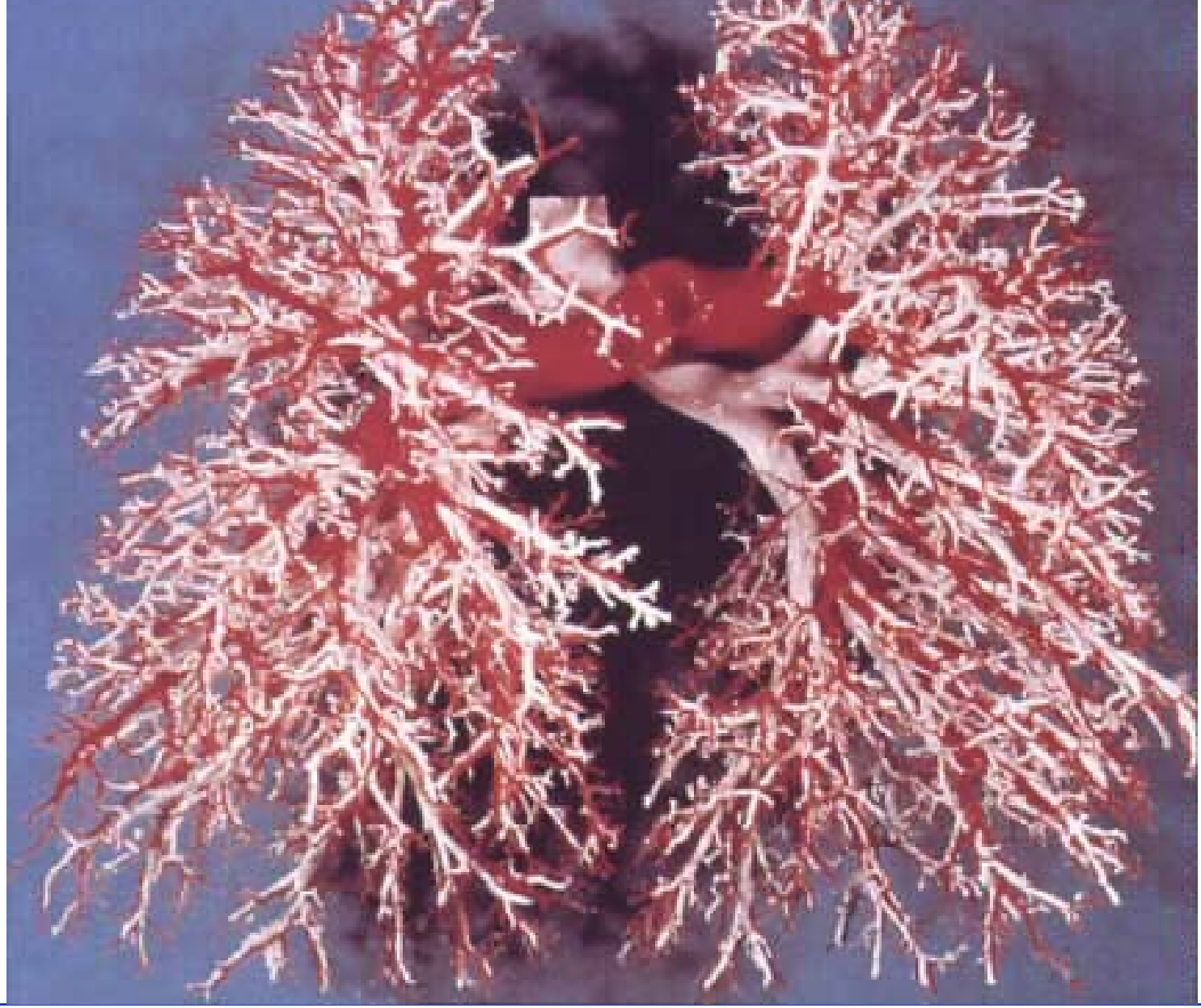
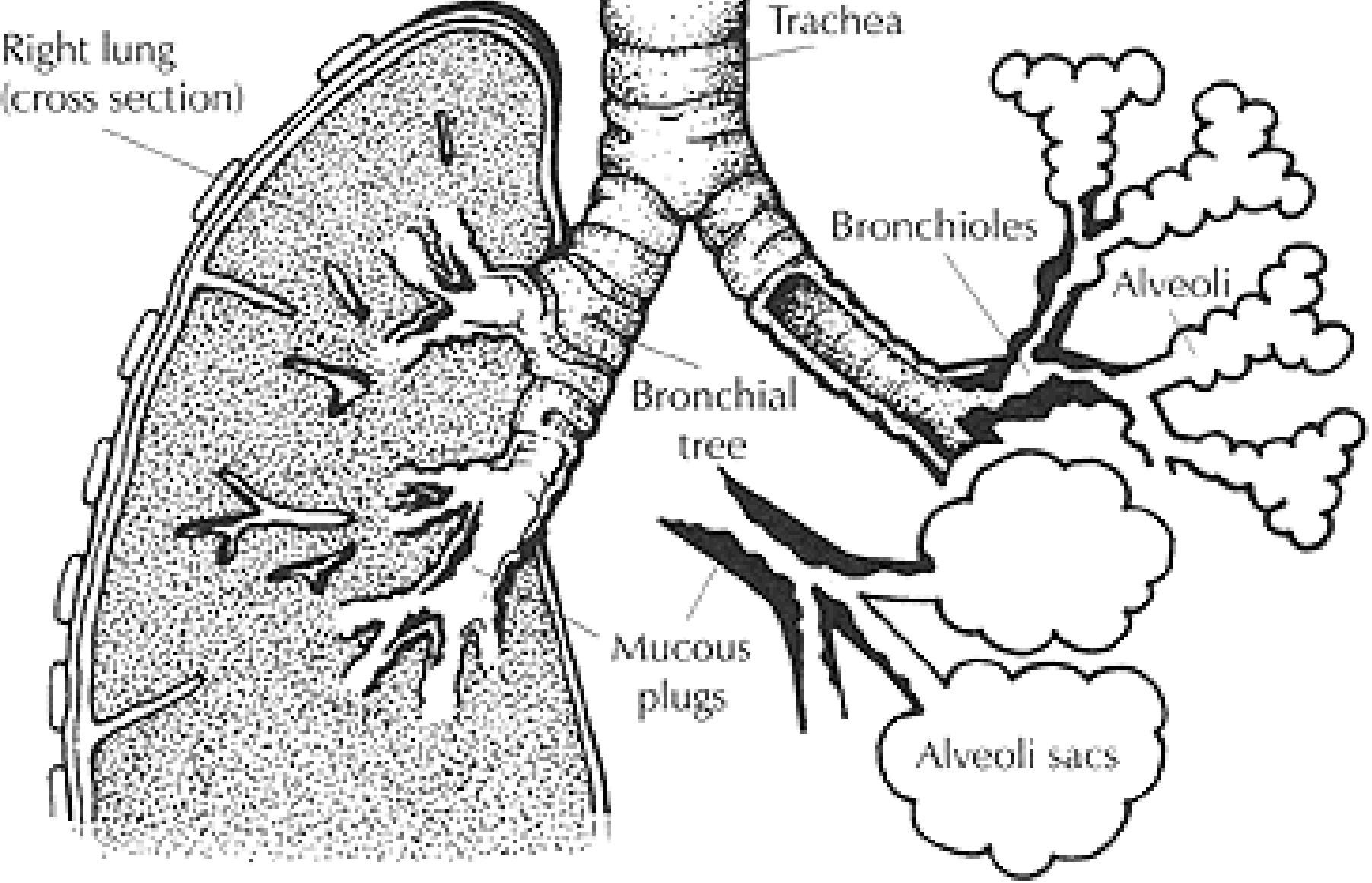
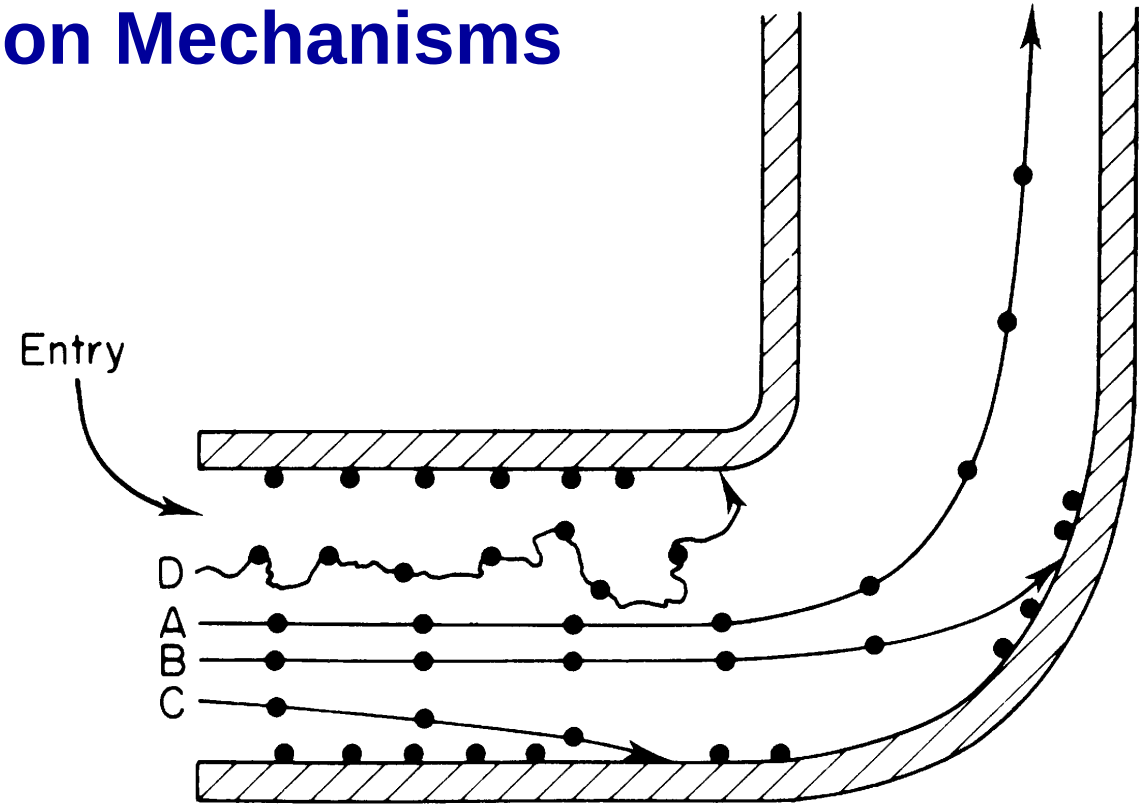
Health Effects of Ambient Aerosols

H. Hauck

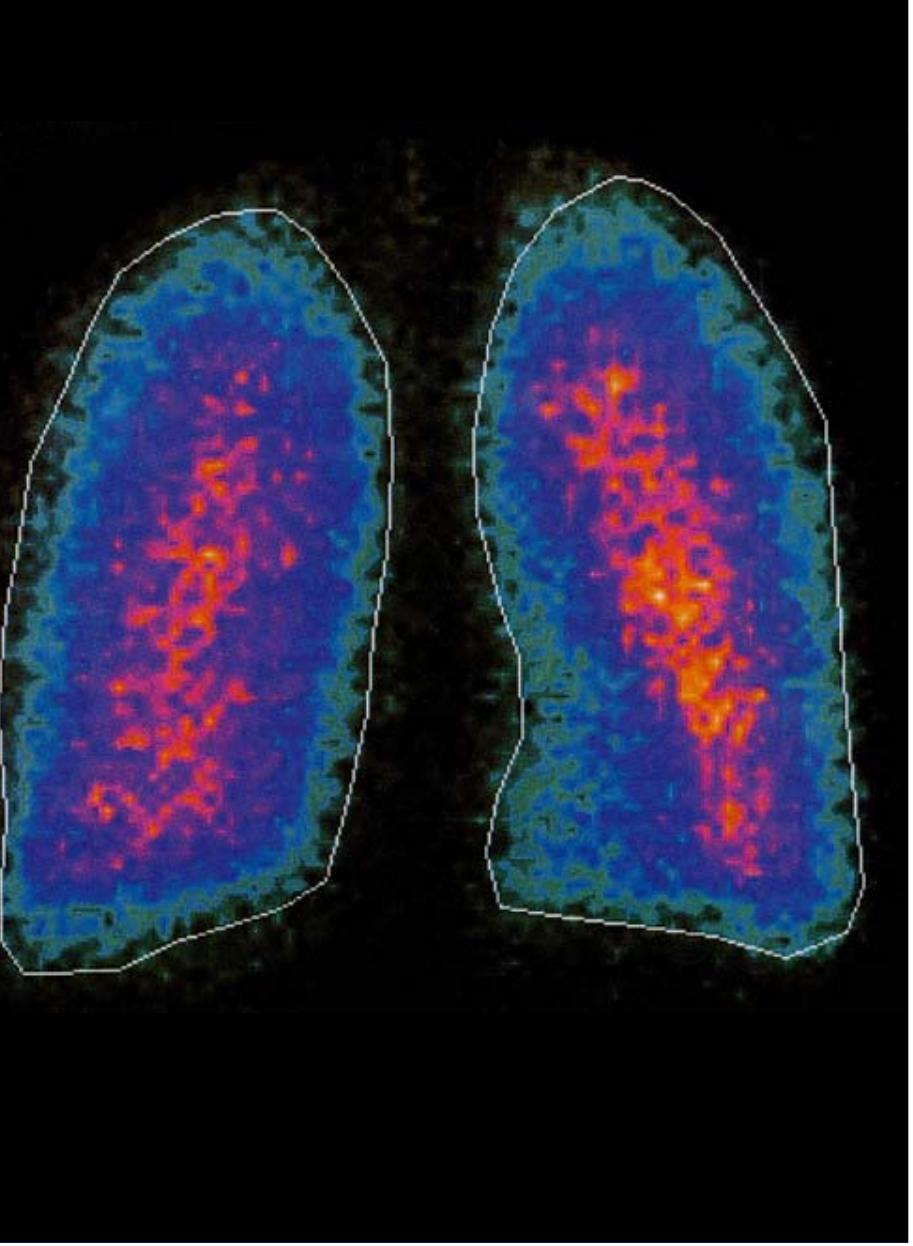


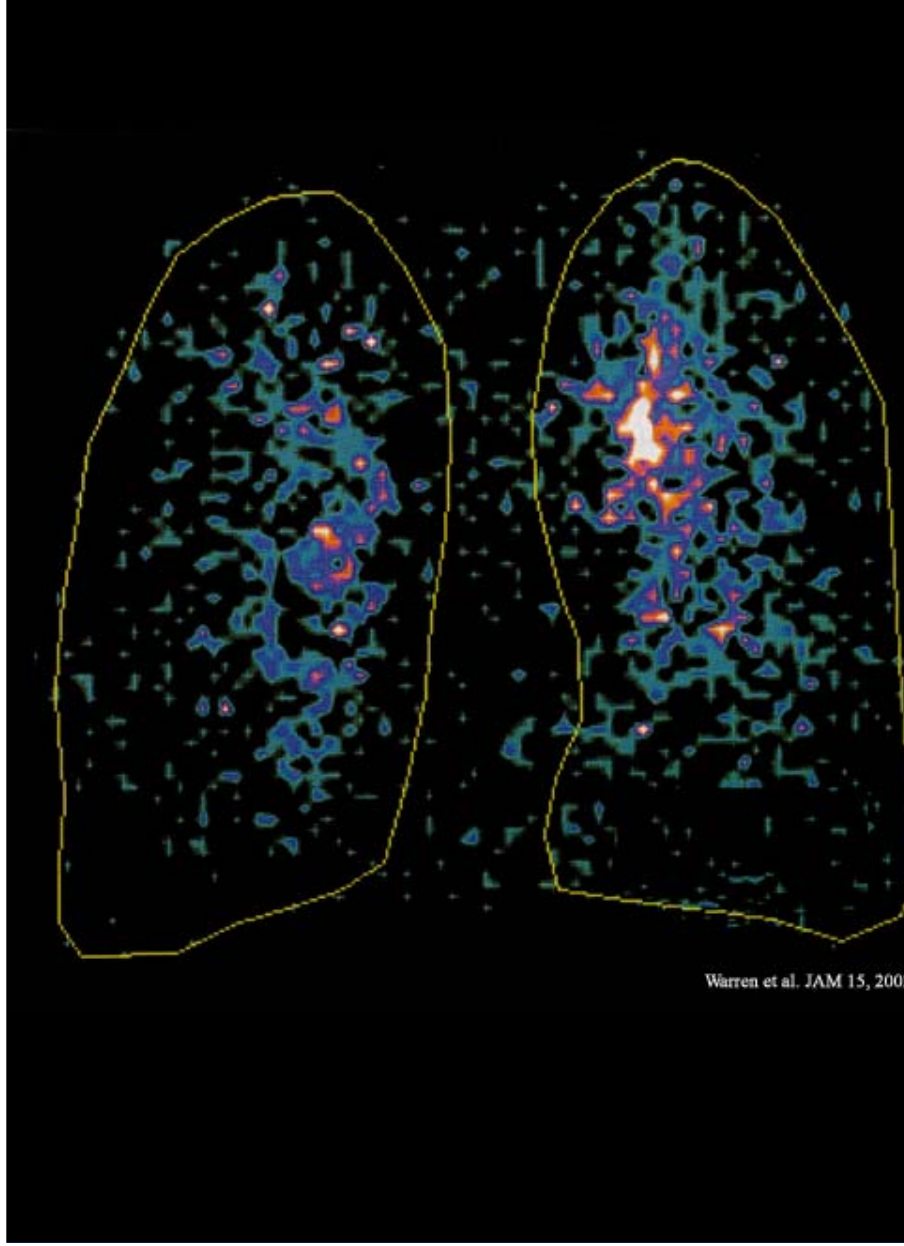

Right lung
(cross section)
Trachea
Bronchioles
Alveoli
Bronchial
tree
Mucous
plugs
Alveoli sacs

Deposition Mechanisms

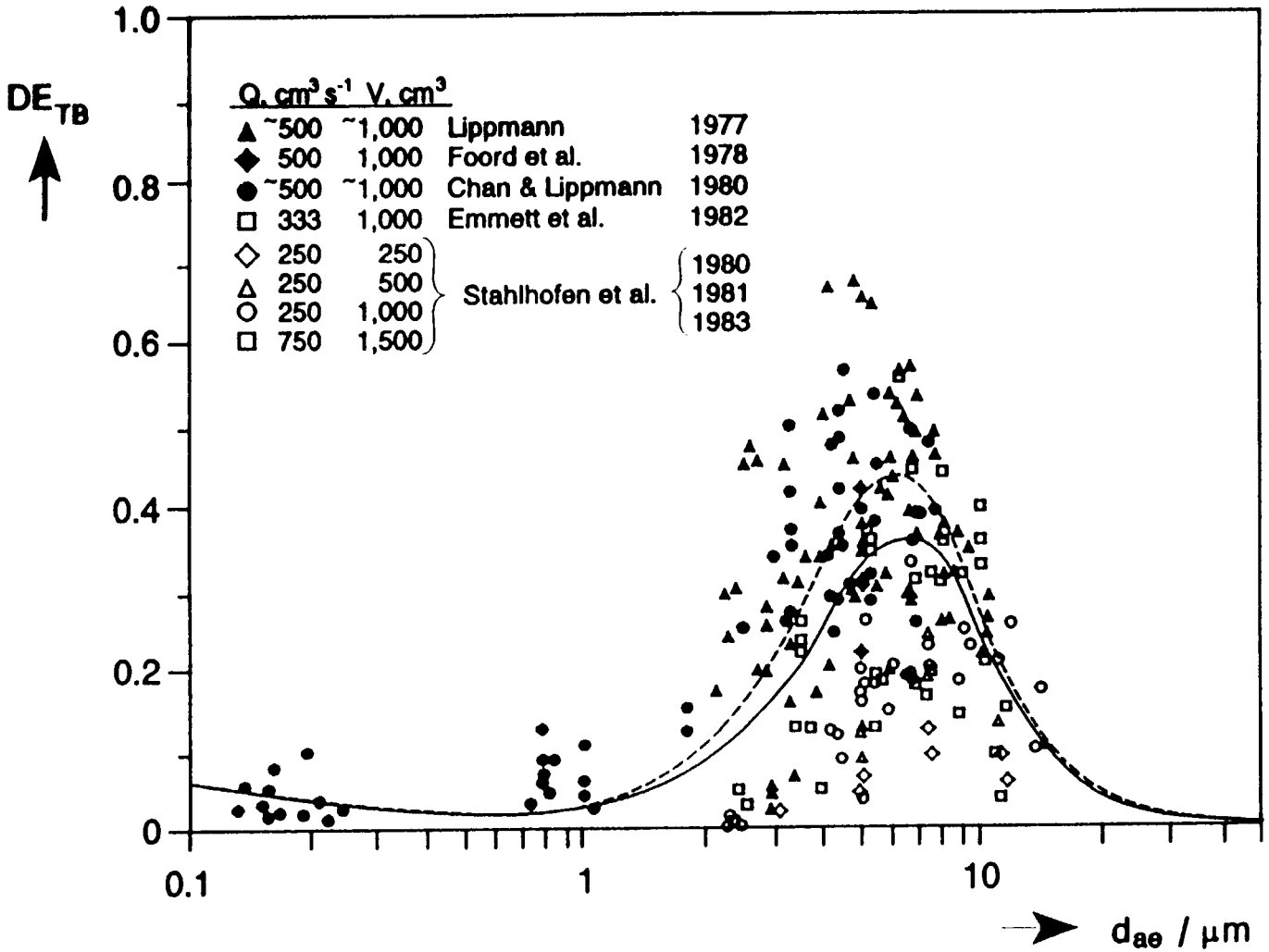


A Penetrating particle (no wall loss)
B Deposition by impaction
C Gravitational deposition
D Deposition by turbulent diffusion




Warren et al. JAM 15, 200

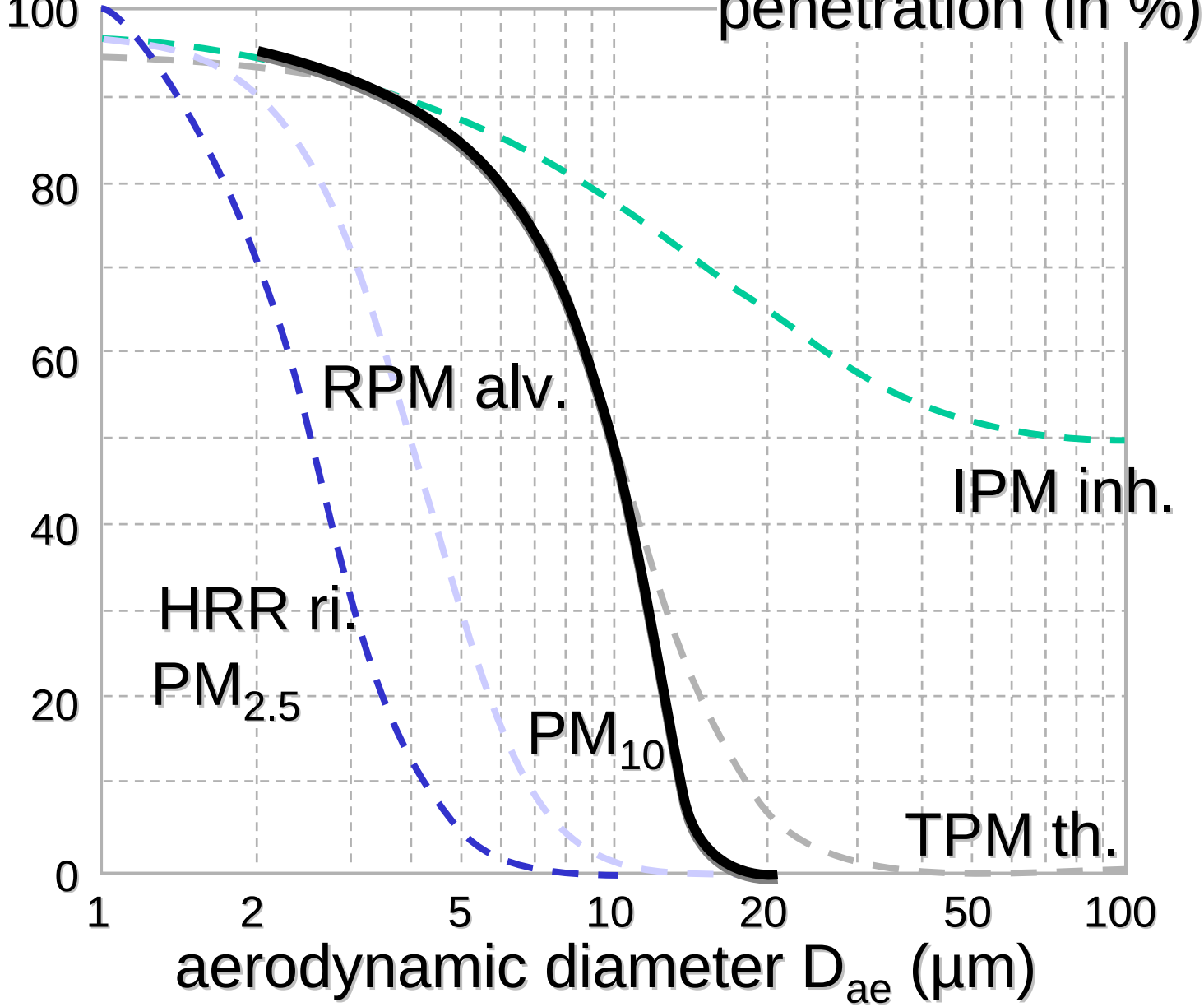
tracheo-bronchial deposition for mouth breathing in humans

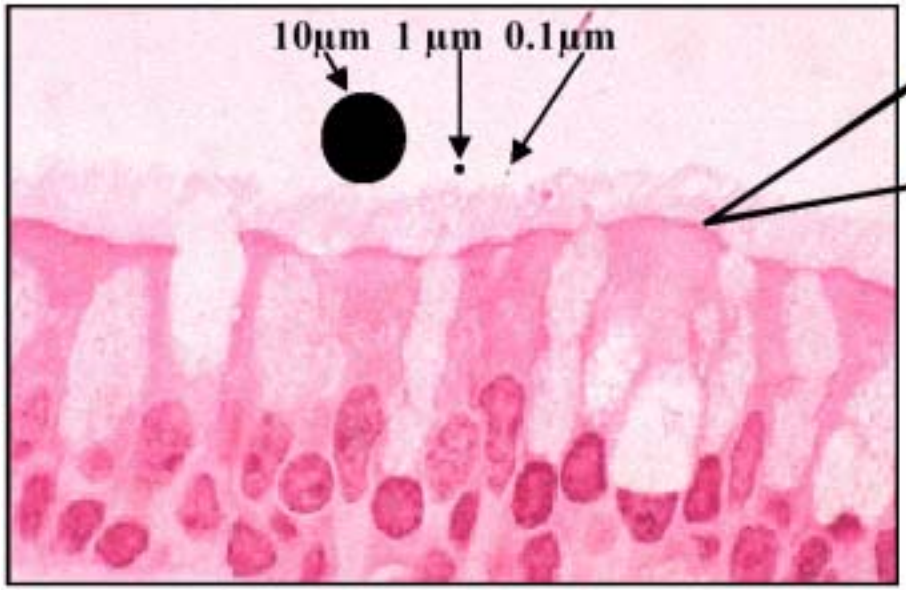


Stahlhofen et al. 1988

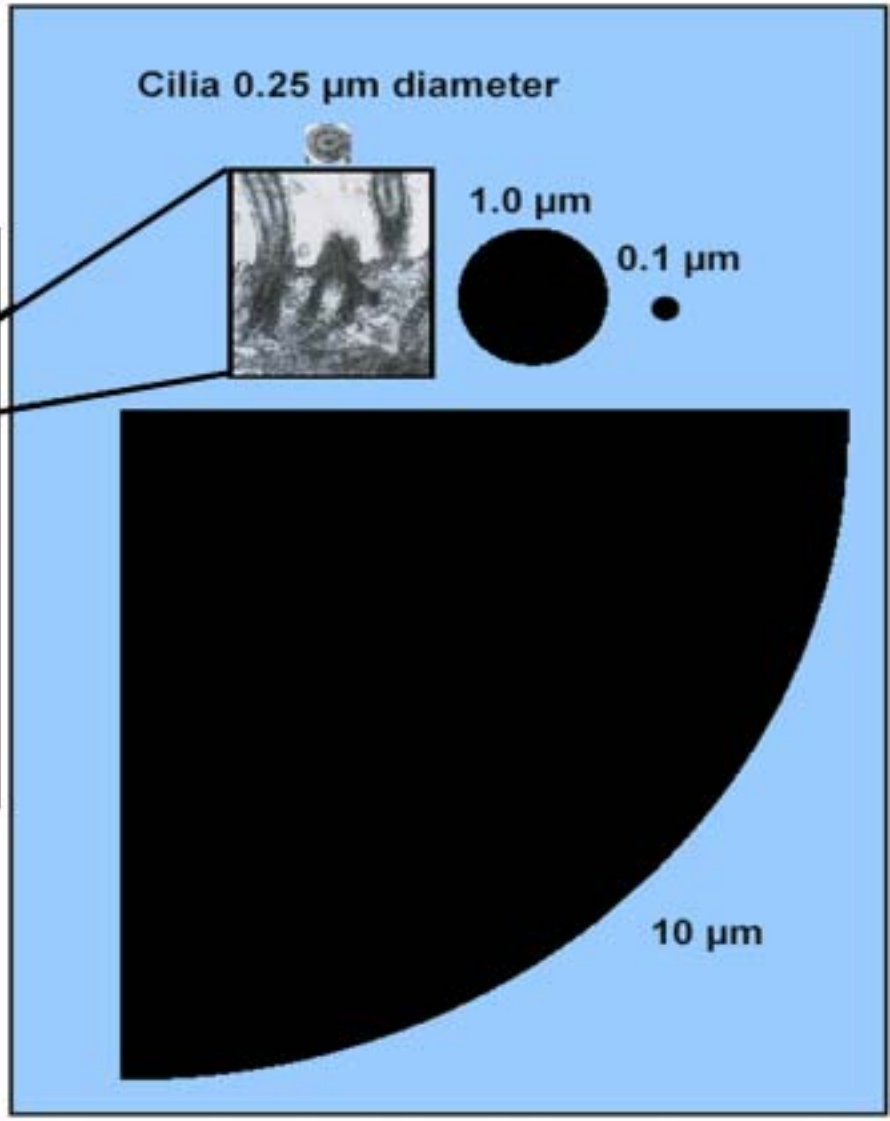
Deposition Conventions in ISO 7708 (EN481) Air Quality – Particle size fraction definitions for health – related sampling

(1.4.1995)

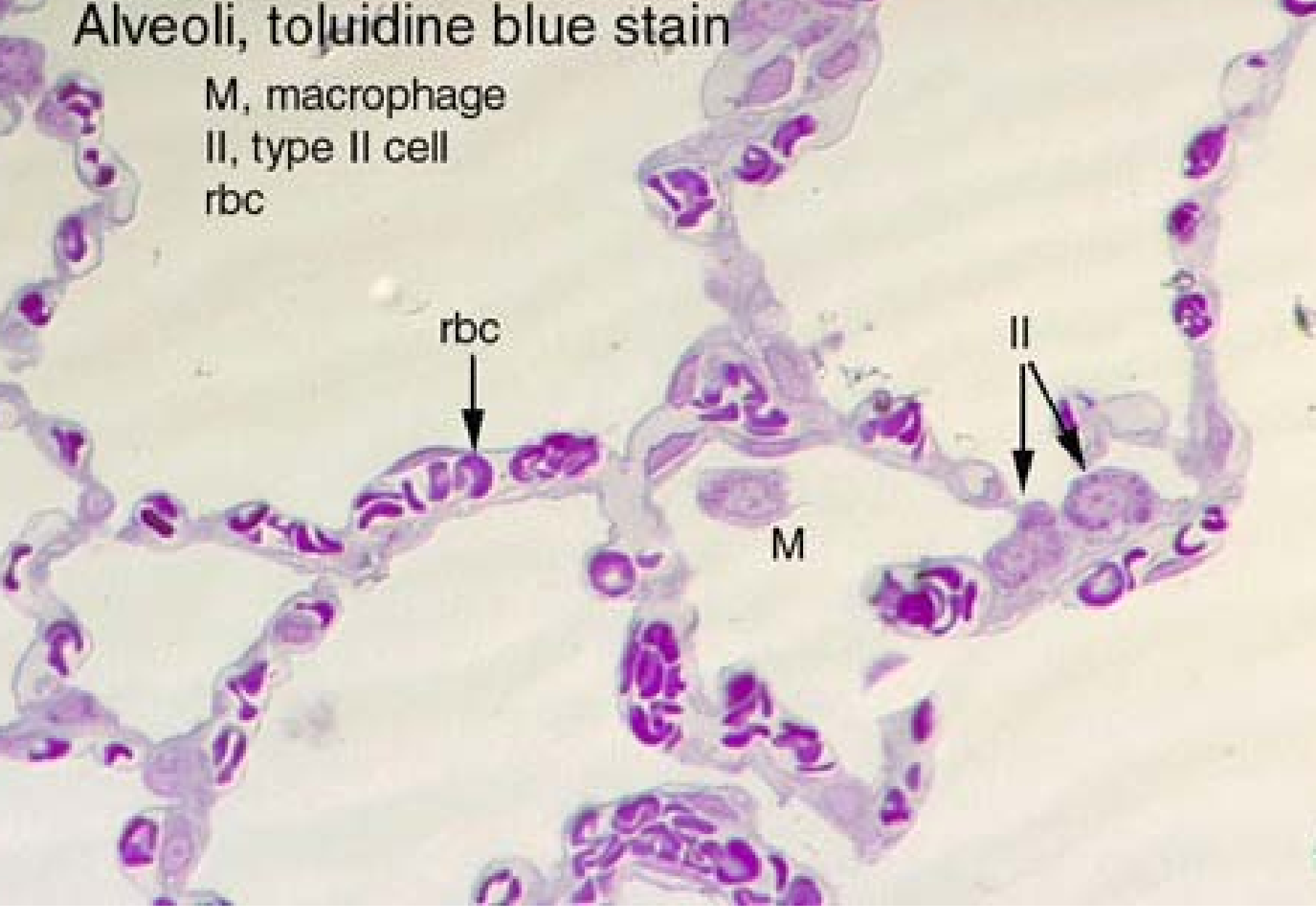

penetration (in %)
100
80
60
40
20
0
RPM alv.
IPM inh.
HRR ri.
PM2.5
PM10
TPM th.
1
2
5
10
20
50
100
aerodynamic diameter Dae (µm)

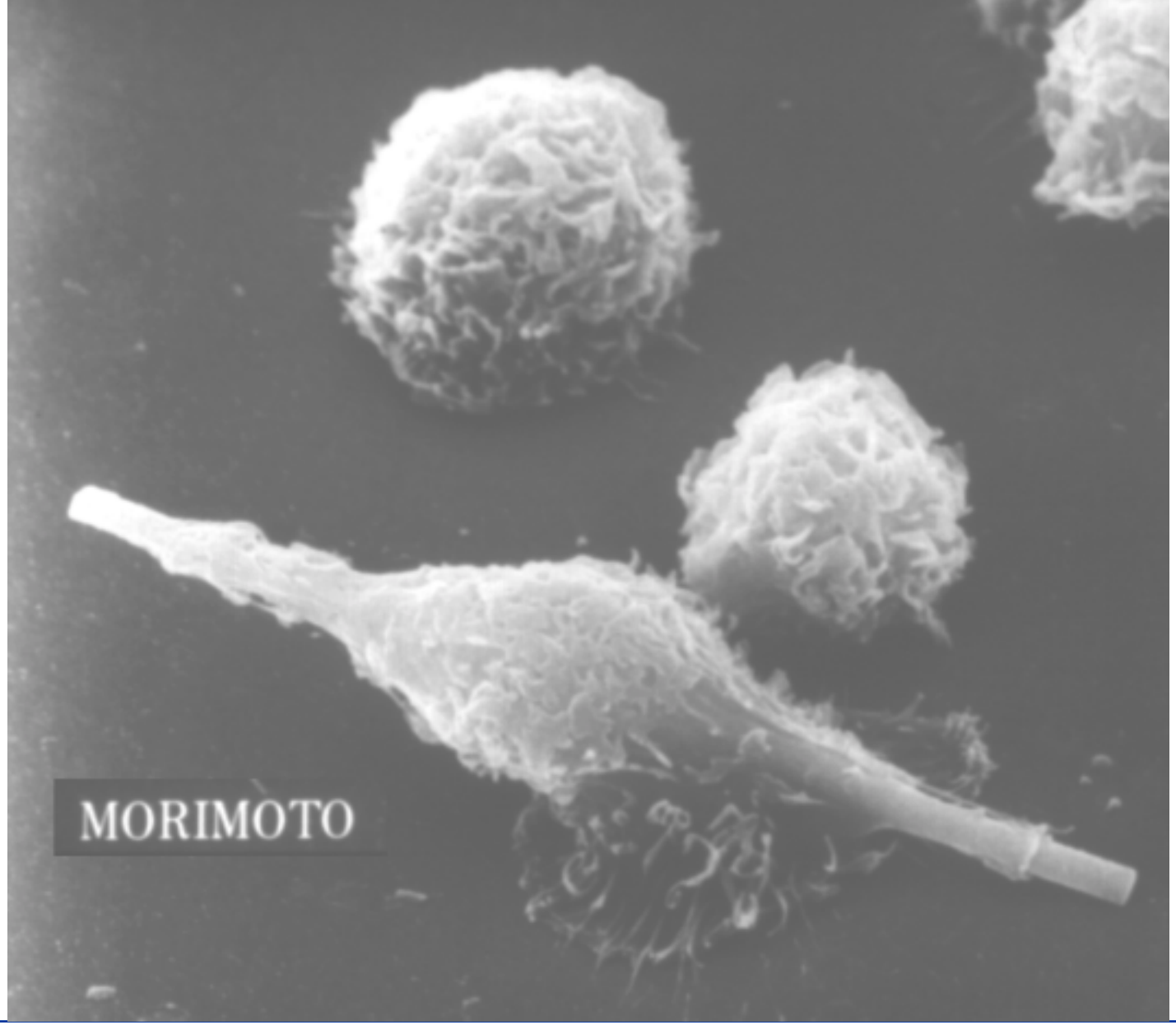


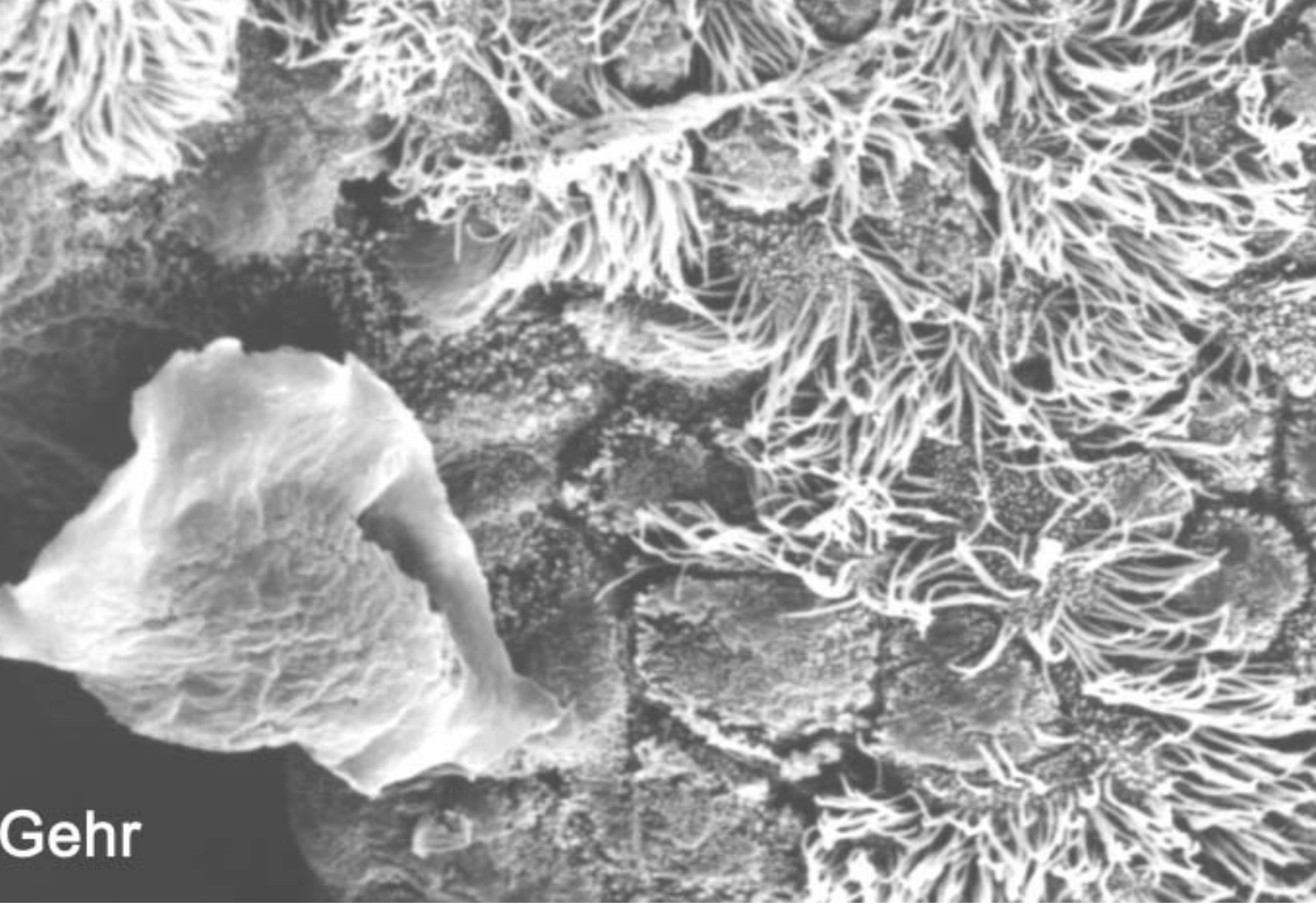
Bronchial epithelium



Courtesy: Ken Donaldsen


Alveoli, toluidine blue stain
M, macrophage
II, type II cell
rbc
rbc
II
M


MORIMOTO

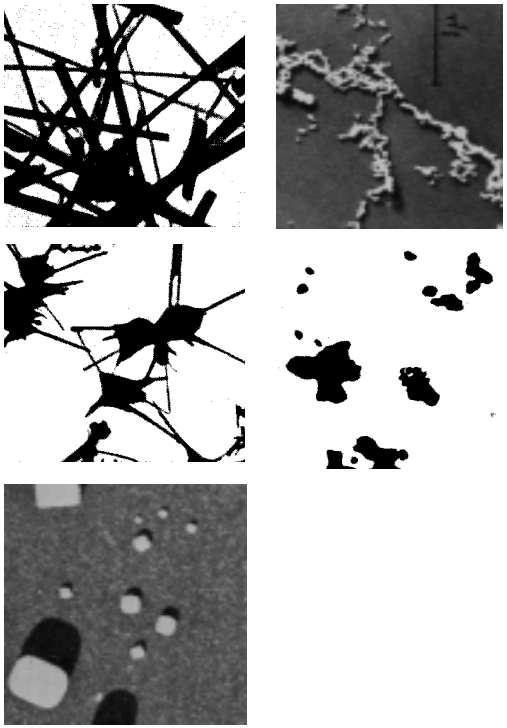


Austrian Academy of Sciences
Clean Air Commission

Aerosols in Biomass Combustion
March 18, 2005 Graz

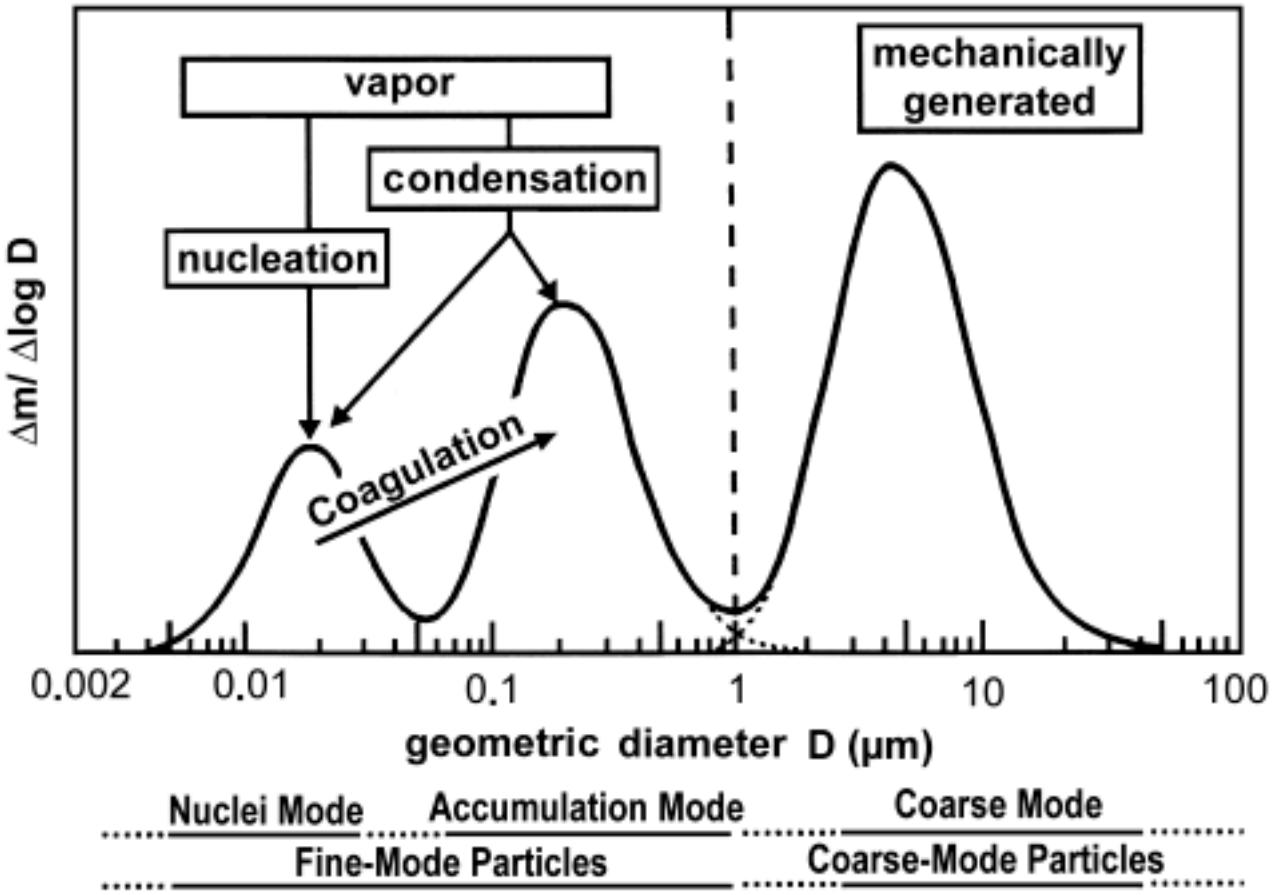
Aerosol composition

- physical properties
  - shape (sphere, fiber,...)
  - aggregate state (solid, liquid)
  - electric charge
  - hygroscopicity
- chemical composition



Atmospheric Aerosol

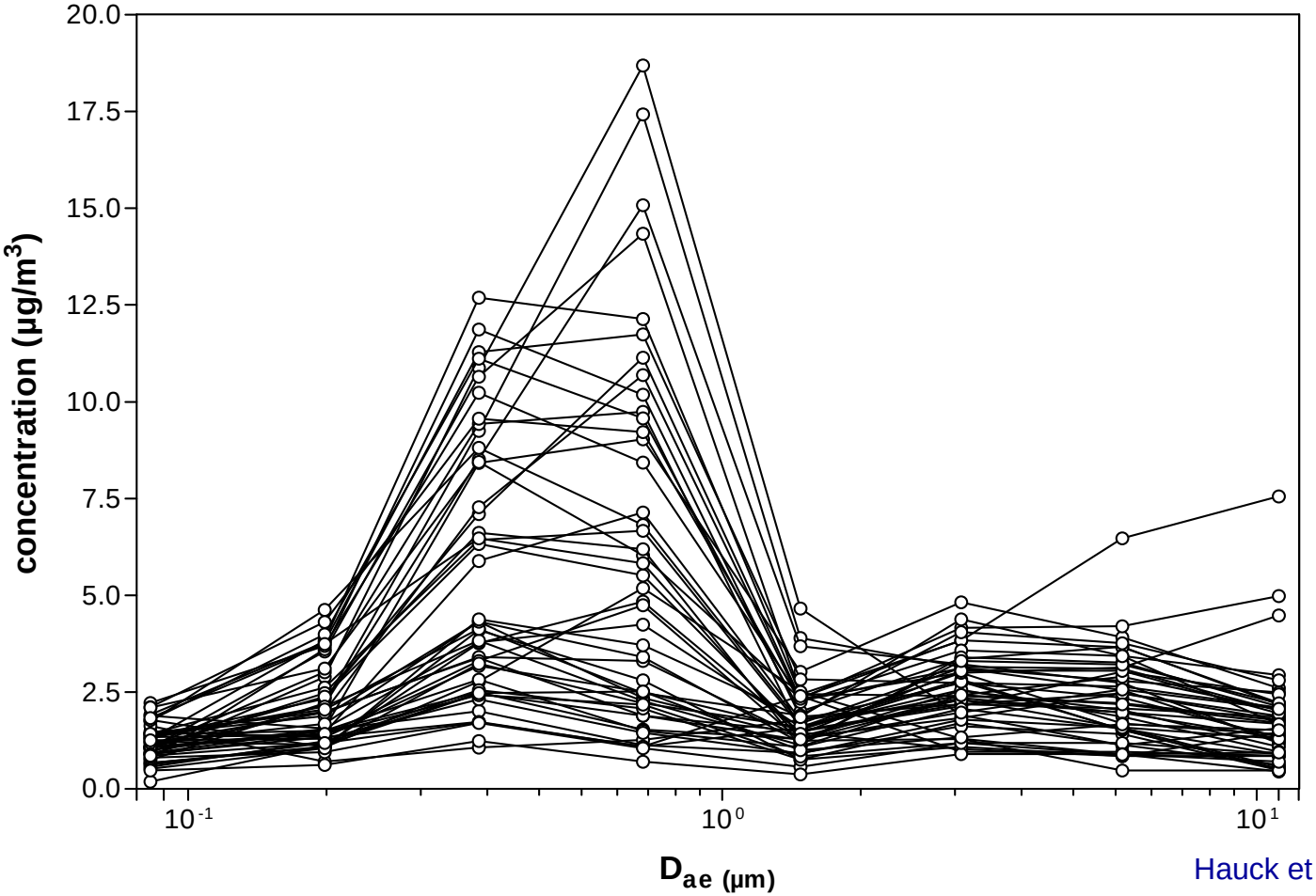
(schematic)



Wilson and Suh 1977

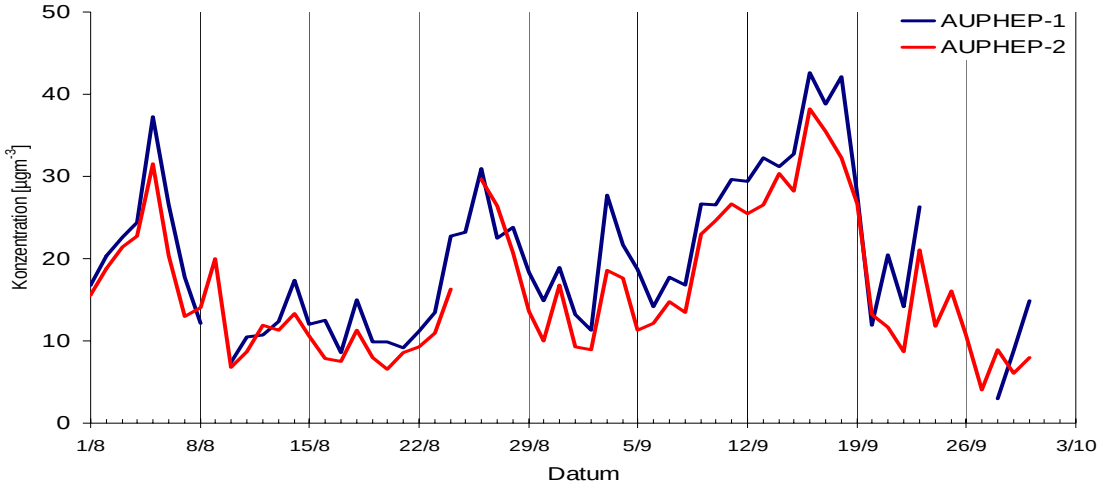
PM spectra for Vienna summer 1999

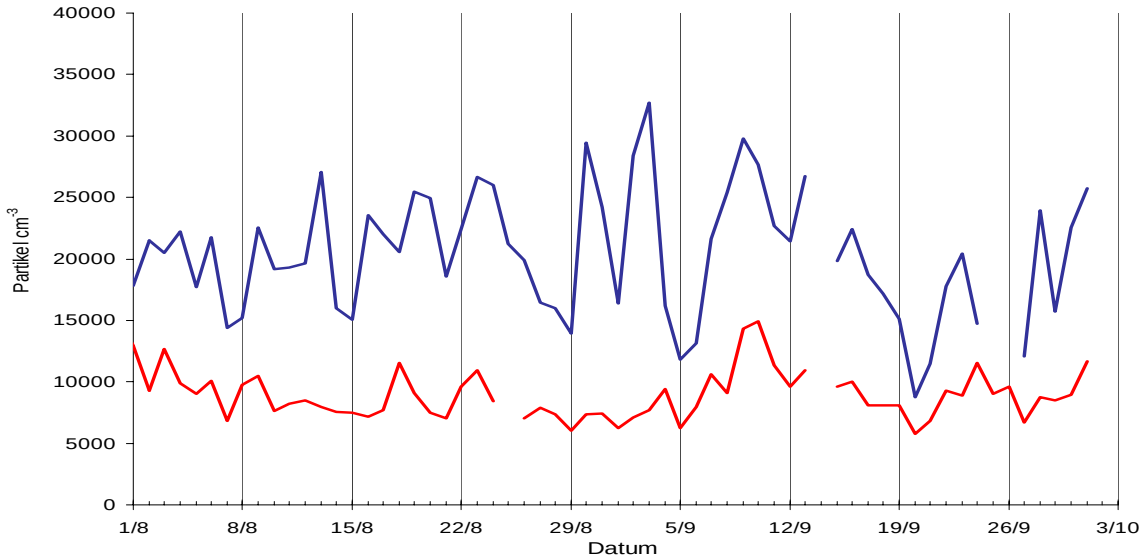
(AUPHEP-1)

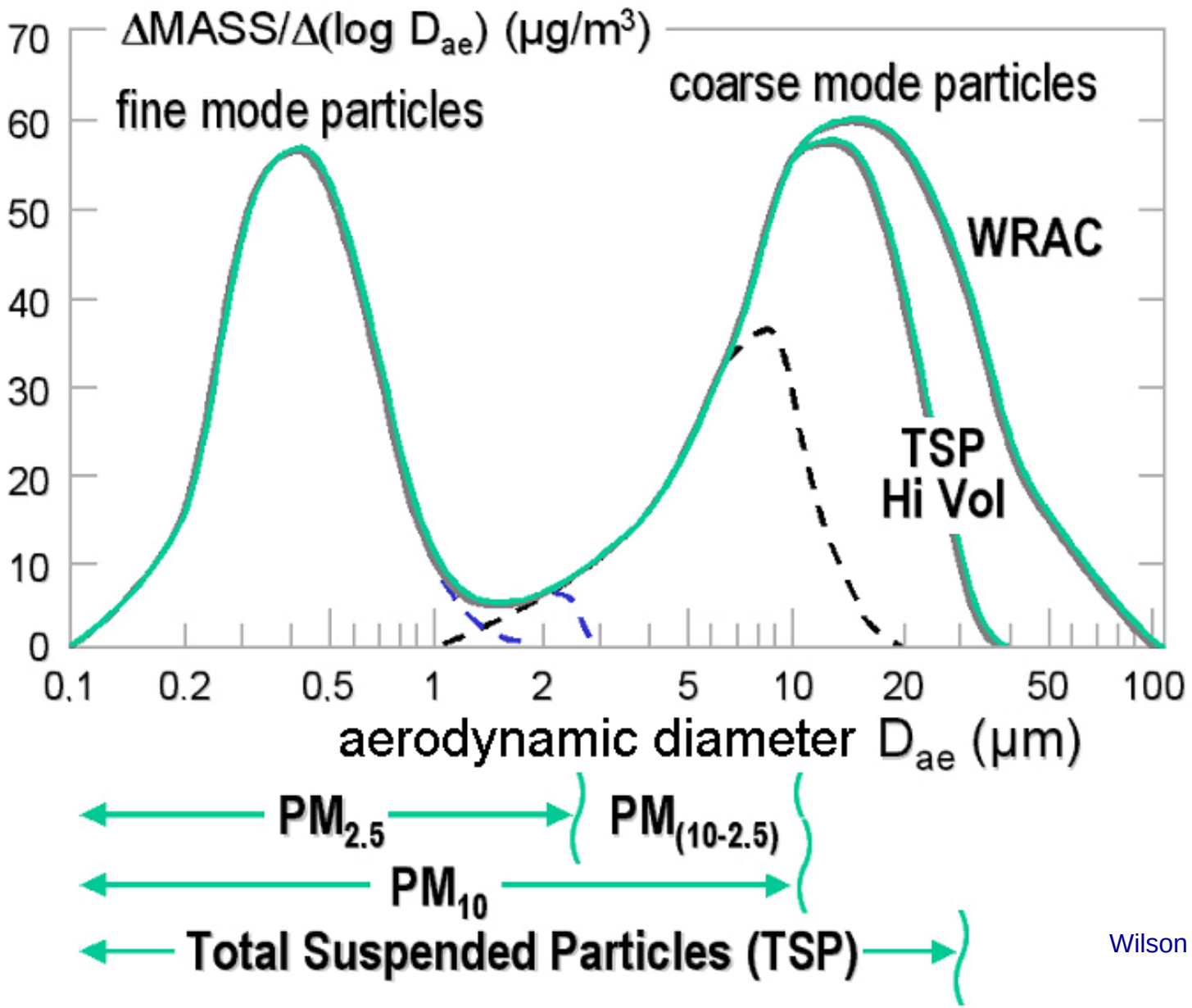


Hauck et al. 2004

PM $_{2,5}$ mass and particle number







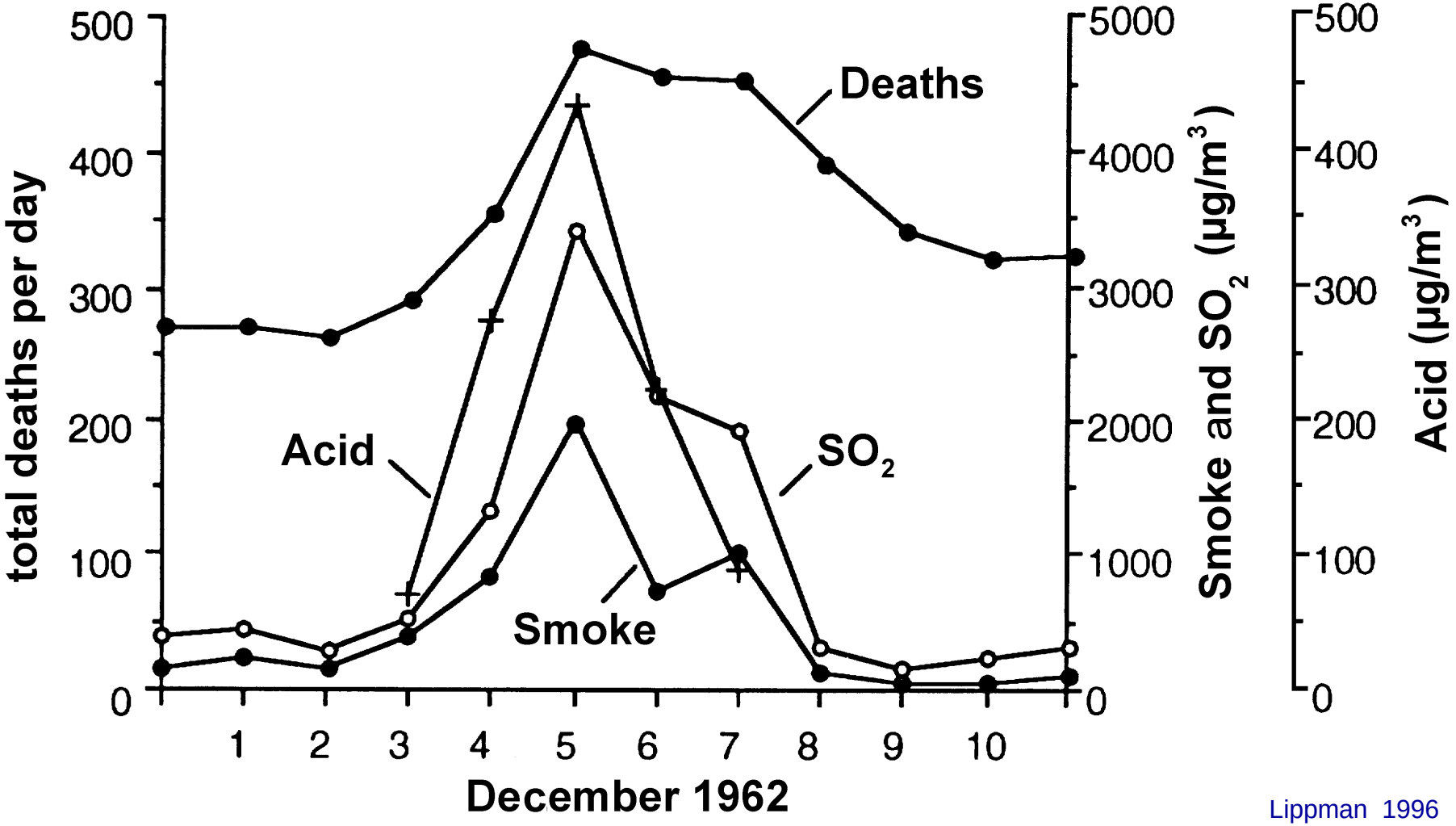
Wilson and Suh 1997

Periods of PM- Exposure

- **until 1960 Coal Smoke Era**
  (Meuse Valley (1930), Donora (1948), London (1952, 1960)
- **1960 – 1985 Intermediate Era**
- **1985 – today**
  1985 – 1995 initial US epi-studies (6 Cities, ACS)
  1995 – today many studies worldwide
  (multicenter studies in US, Europe, Asia)

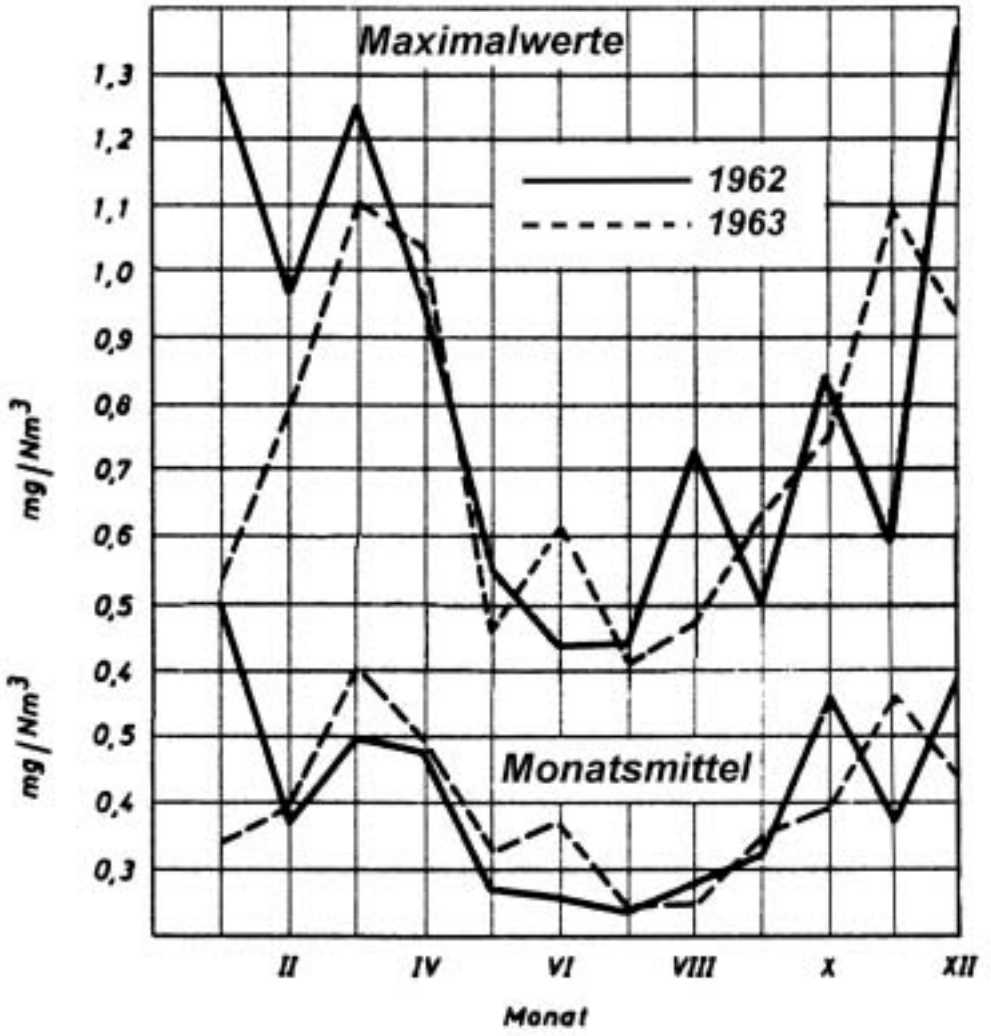
Lippman 1995

Smog - Episode London 1962



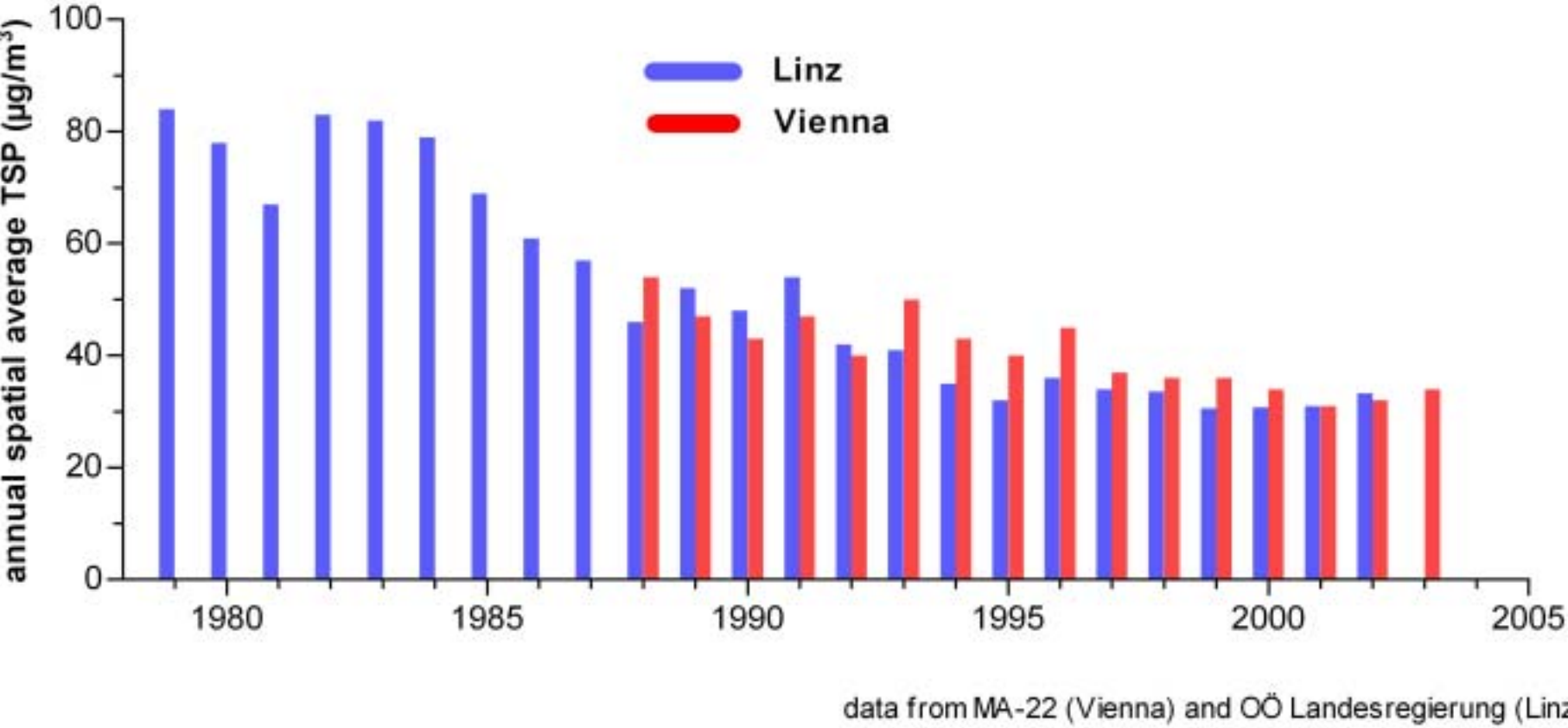
Lippman 1996

ambient TSP (daily and monthly means) in Vienna 1962/63

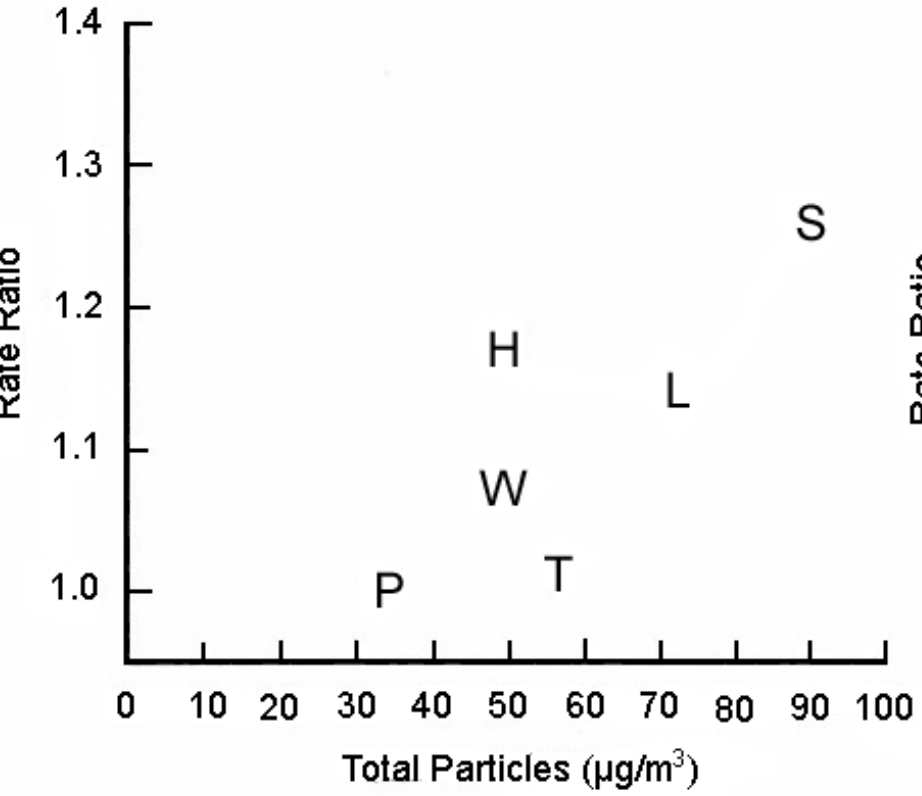


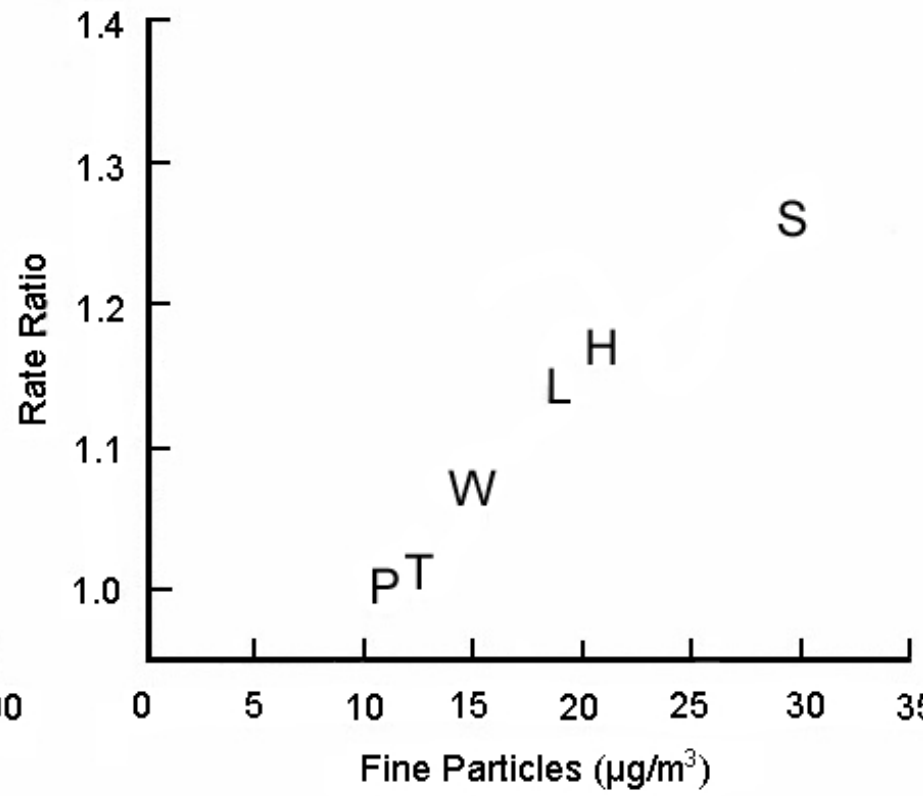
Baumann et al. 1966

PM (TSP)- trend in Vienna and Linz



6 Cities study (mortality)





Dockery et al. NEJM 1993

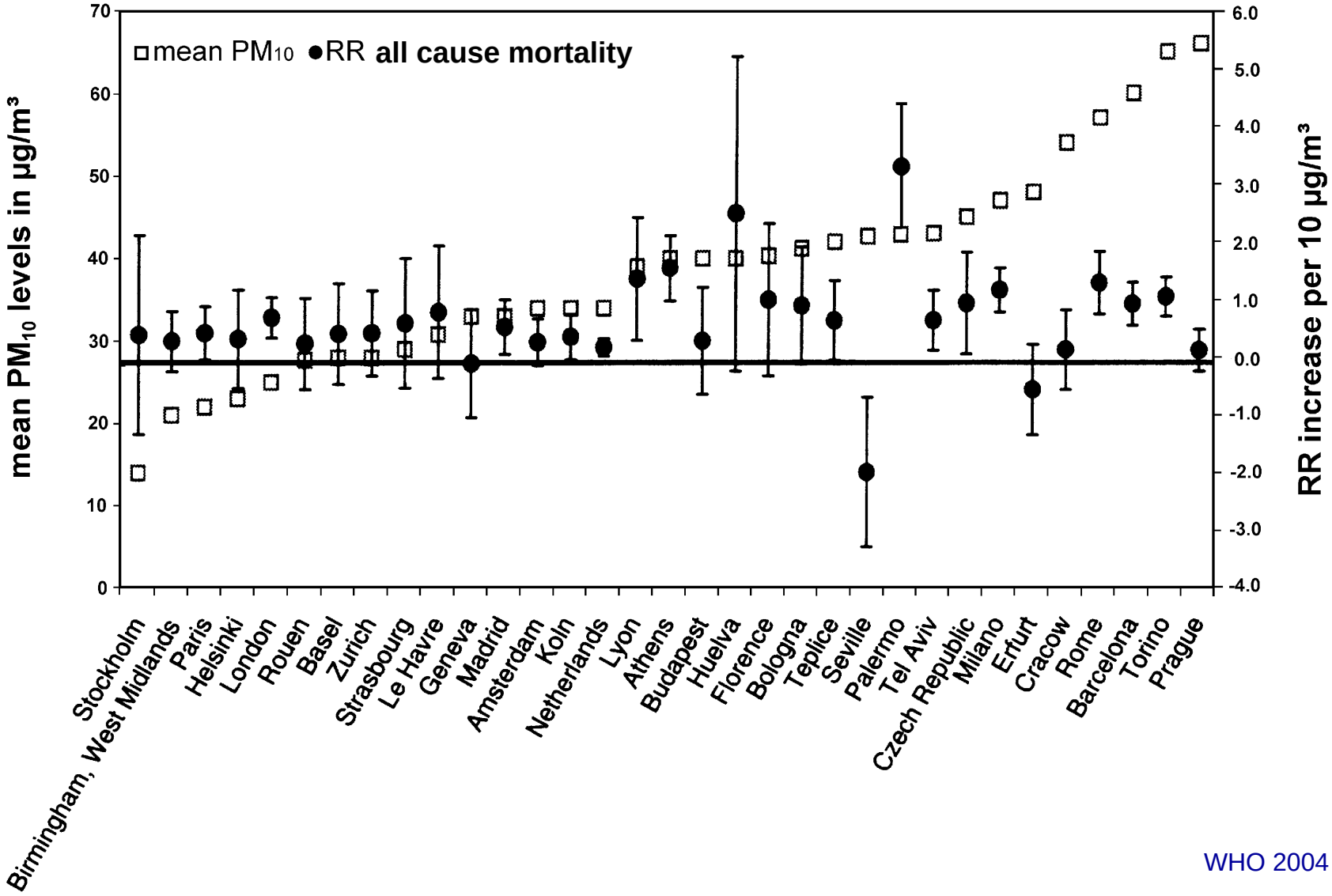
comparison of time series study estimates

study area (reference)	PM_{10} ($\mu g/m^3$) mean	PM_{10} ($\mu g/m^3$) max.	RR
Utah Valley, UT (Pope et al. 1992)	47	297	**1,16[ad]**
St.Louis, MO (Dockery et al. 1992)	28	97	**1,16[ac]**
Kingston, TN (Dockery et al. 1992)	30	67	**1,17[ac]**
Birmingham, AL (Schwartz 1993)	48	163	**1,11[ad]**
Athens, Greece (Touloumi et al. 1994)	78	306	**1,07[ac]** **1,03[ad]**
Toronto, Canada (Özkaynak et al. 1995)	40	96	**1,07[ac]** **1,05[bc]**
Los Angeles, CA (Kinney et al. 1995)	58	177	**1,05[ac]** **1,04[bc]**
Chicago, IL (Ito et al. 1995)	38	128	**1,05[bc]**
Santiago, Chile (Ostro et al. 1995)	115	367	**1,08[ac]** **1,15[ad]**

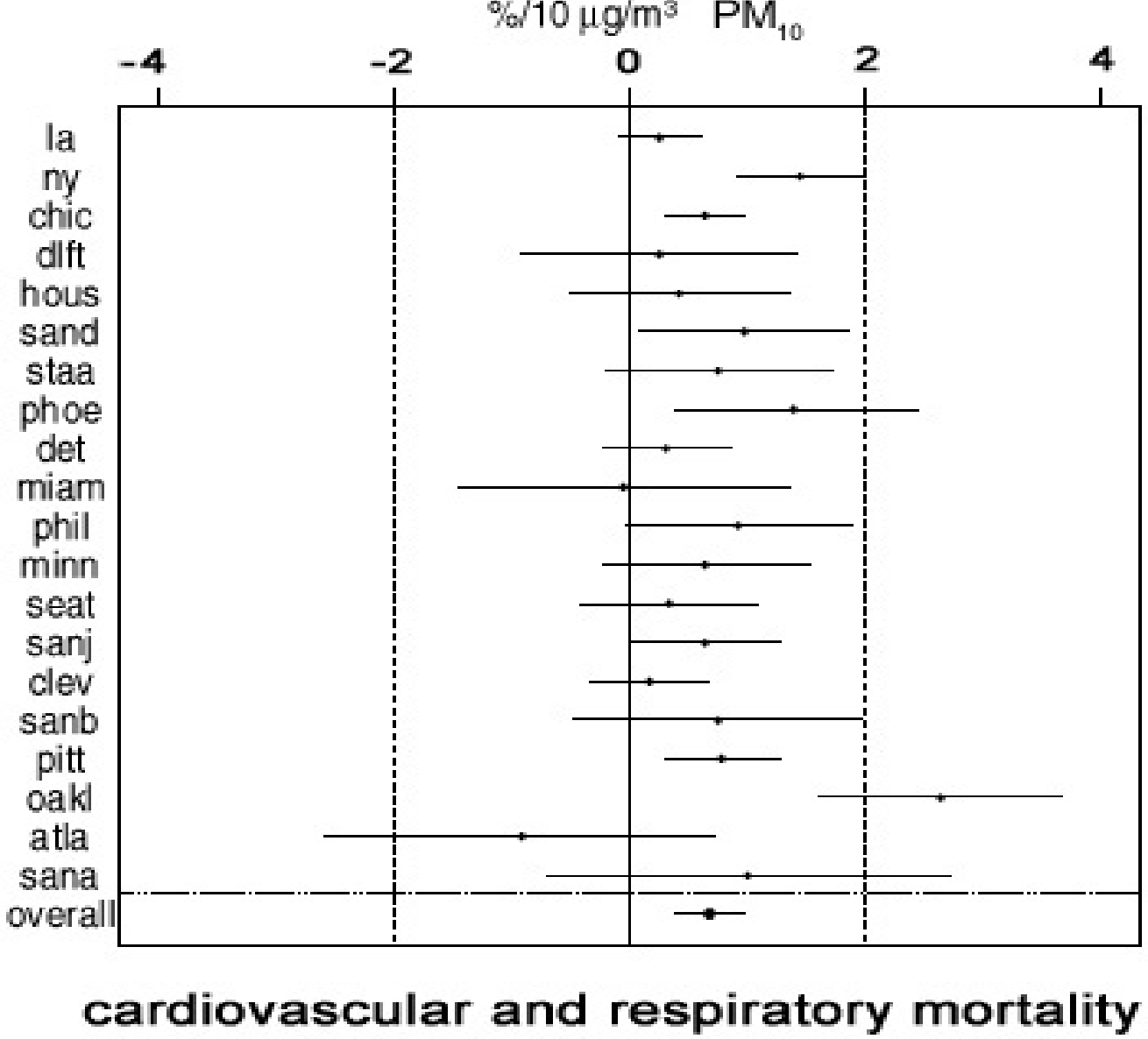
Relative risk (RR) for all cause mortality for a 100 $\mu g/m^3$ PM_{10} increase

Lippman 1996

[a] single pollutant model (PM_{10})
[b] multiple pollutant model (PM_{10} and other pollutants simutaneously)
[c] one-day mean PM_{10} concentration employ
[d] multiple-day mean PM_{10} concentration employed


mean PM10 ●RR all cause mortality
mean PM10 levels in µg/m³
RR increase per 10 µg/m³
70
60
50
40
30
20
10
0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
Stockholm
Birmingham, West Midlands
Paris
Helsinki
London
Rouen
Basel
Zurich
Strasbourg
Le Havre
Geneva
Madrid
Amsterdam
Koln
Netherlands
Lyon
Athens
Budapest
Huelva
Florence
Bologna
Teplice
Seville
Palermo
Tel Aviv
Czech Republic
Milano
Erfurt
Cracow
Rome
Barcelona
Torino
Prague

WHO 2004



cardiovascular and respiratory mortality

mean and 95% conf.int.

20 US cities

Daniels et al. 2000

Health effects of particles

- long term – short term effects
- mortality – morbidity

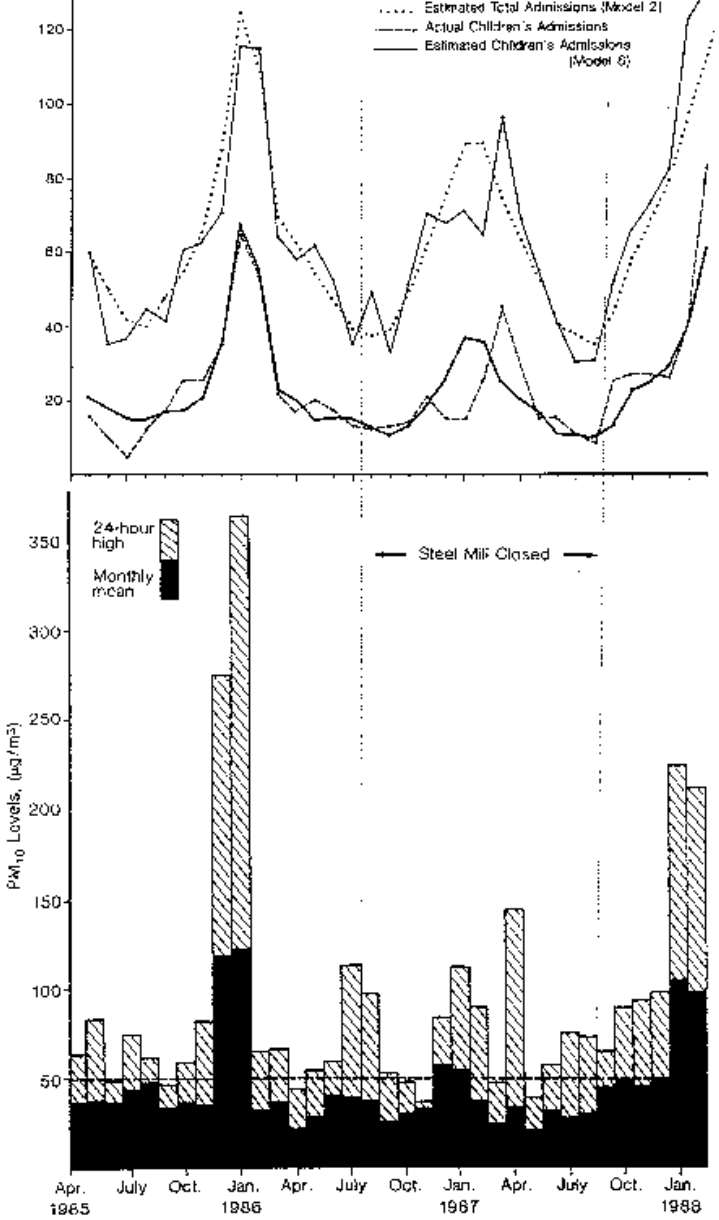
  ✓ respiratory effects
  changes in lung function, bronchitis,
  asthma acerbation

  ✓ heart rate variability
  increase in blood viscosity (thrombosis)

Hill‘s Criteria

Proc. Royal Soc. Med. (1965) 295-300

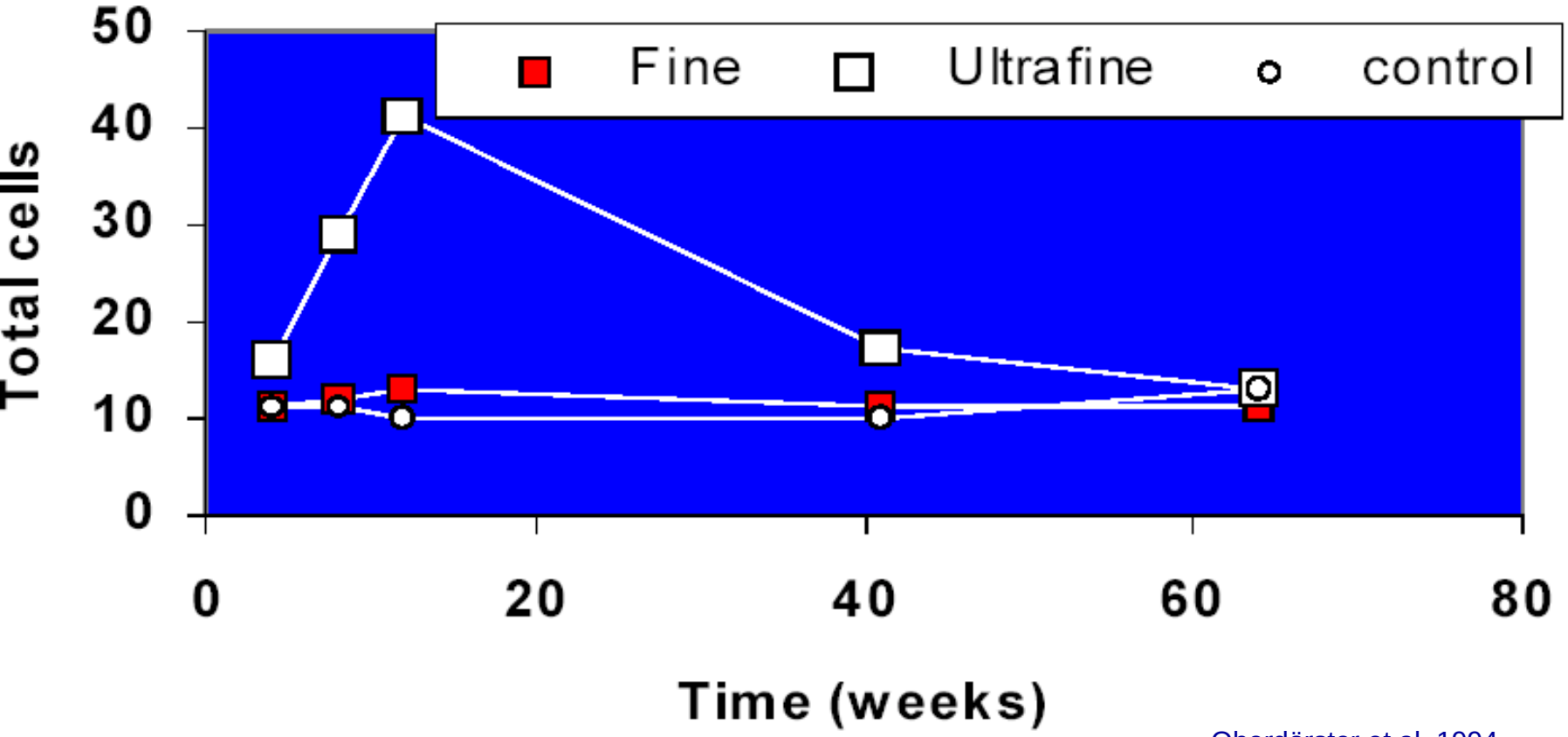
- **Strength**
- **Consistency**
- **Specificity**
- **Temporality**
- **Plausibility**
- **Dose-Response**
- **Experiment**
- **Analogy**



Utah Steelmill Experiment 1987

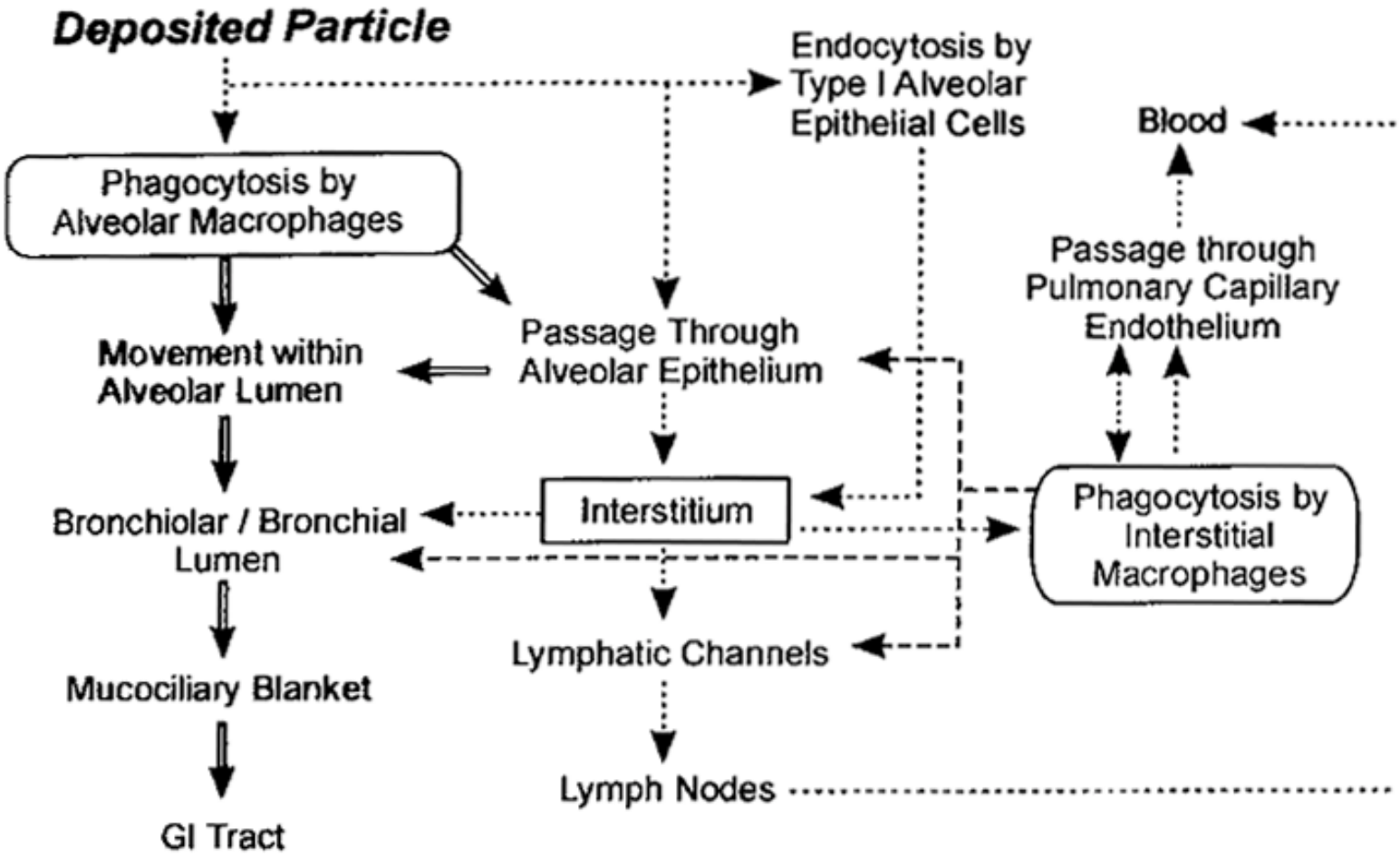
Pope 1989

Inflammation after fine vs. ultrafine TiO_2 exposure in mice



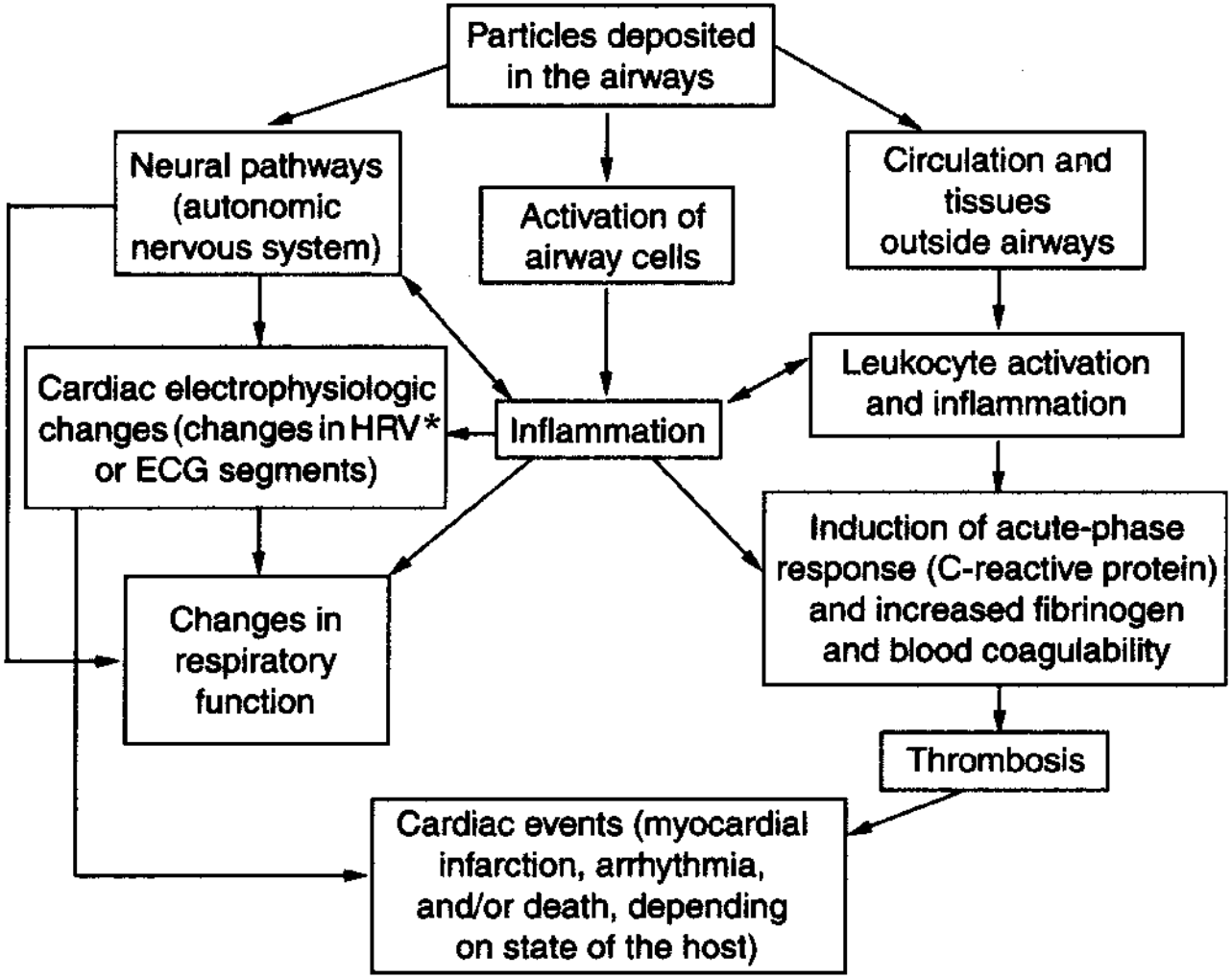
Oberdörster et al. 1994

known and suspected paths of clearance of unsoluble particles in the alveolar-region



modified from Schlesinger et al. 1997

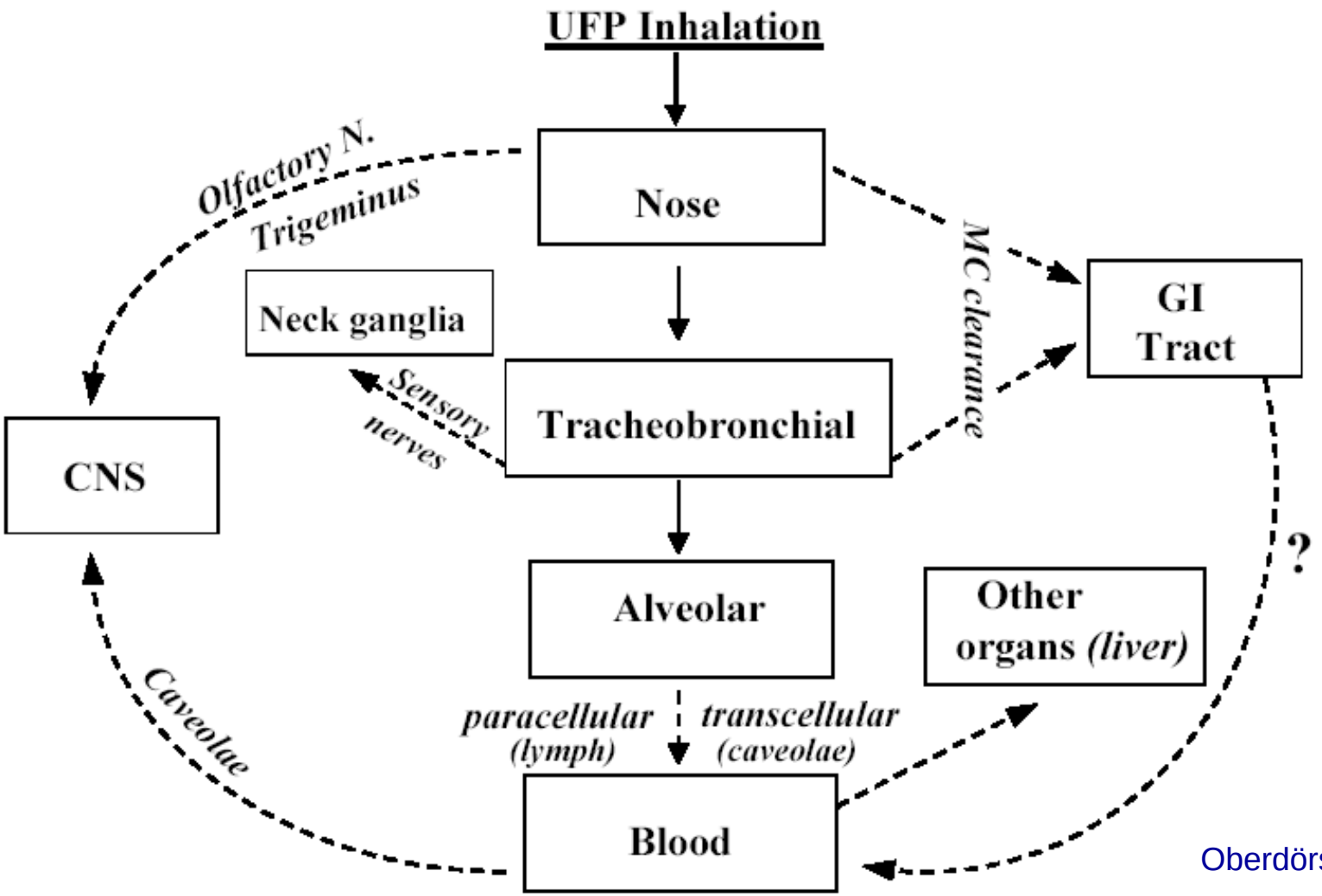
possible effects of particles on the respiratory and cardiovascular system



* HRV Heart Rate Variability

HEI Pespct. 2002

hypotheses about transport of ultrafine particles

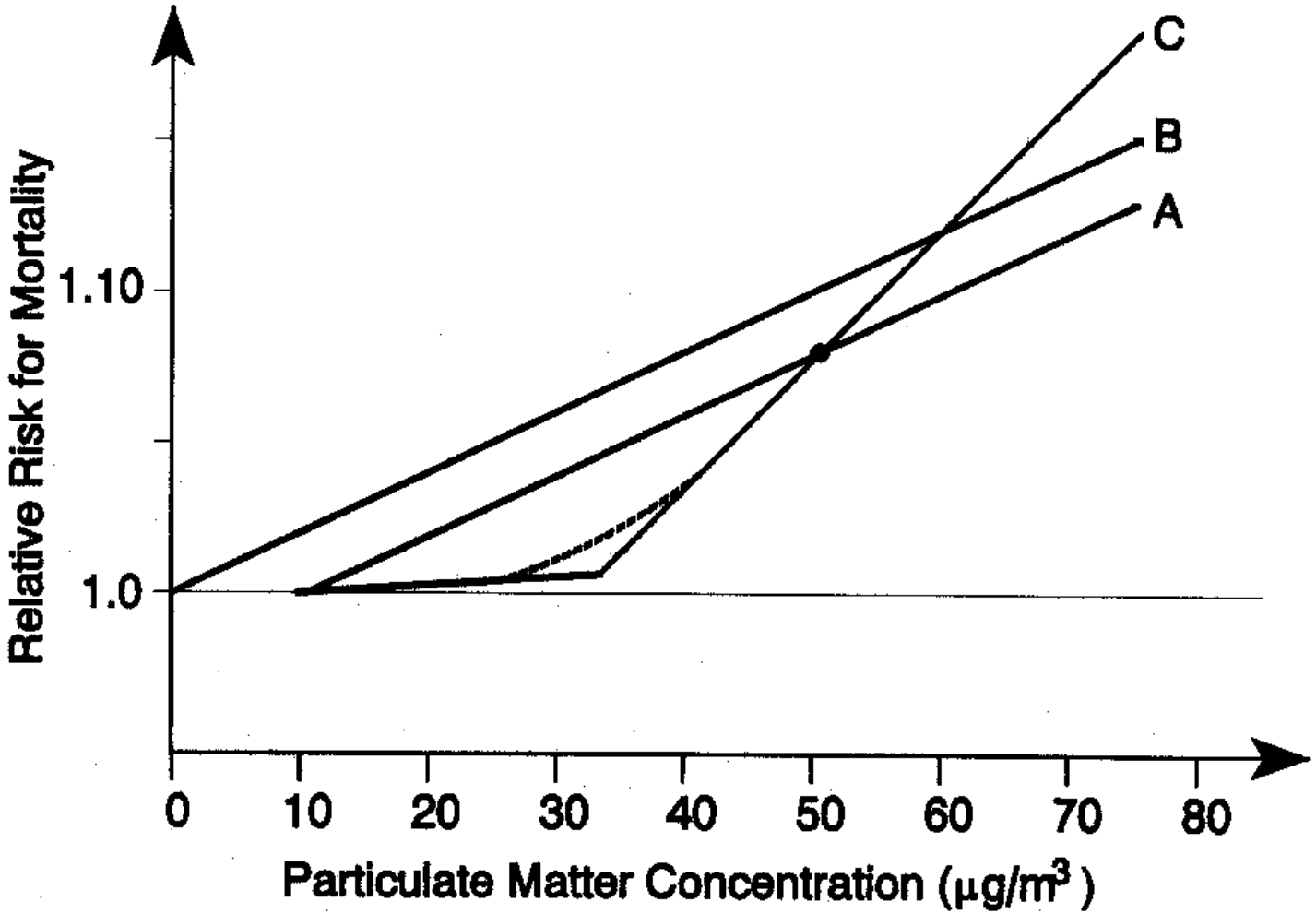


Oberdörster 2004

Which parameters define the effects of PM ?

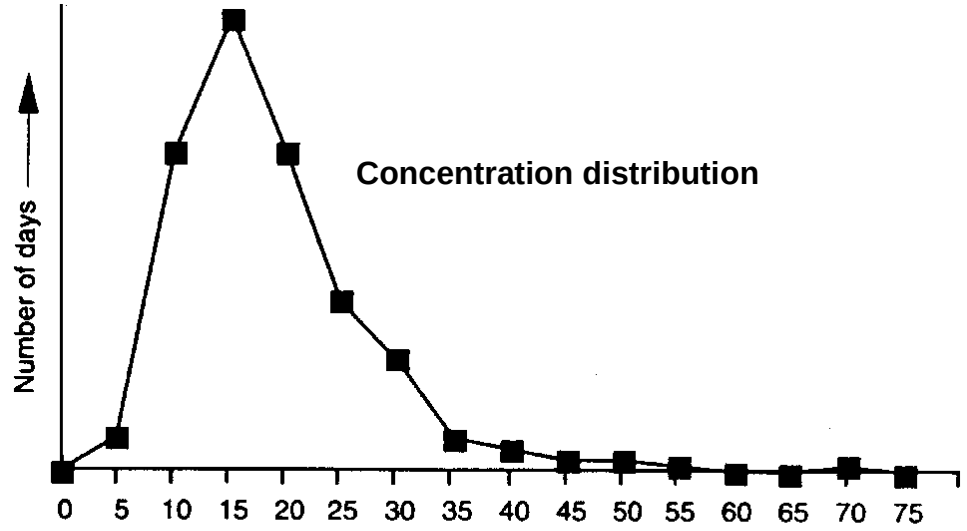
- concentration
- metrik (mass, number, surface)
- size (TSP, PM_{10}, $PM_{2.5}$, $PM_{1.0}$, $PM_{0.1}$, PM_{xx})
- chemical composition
  (C, metals, adsorbed gases,..)
- shape (fibers,..)

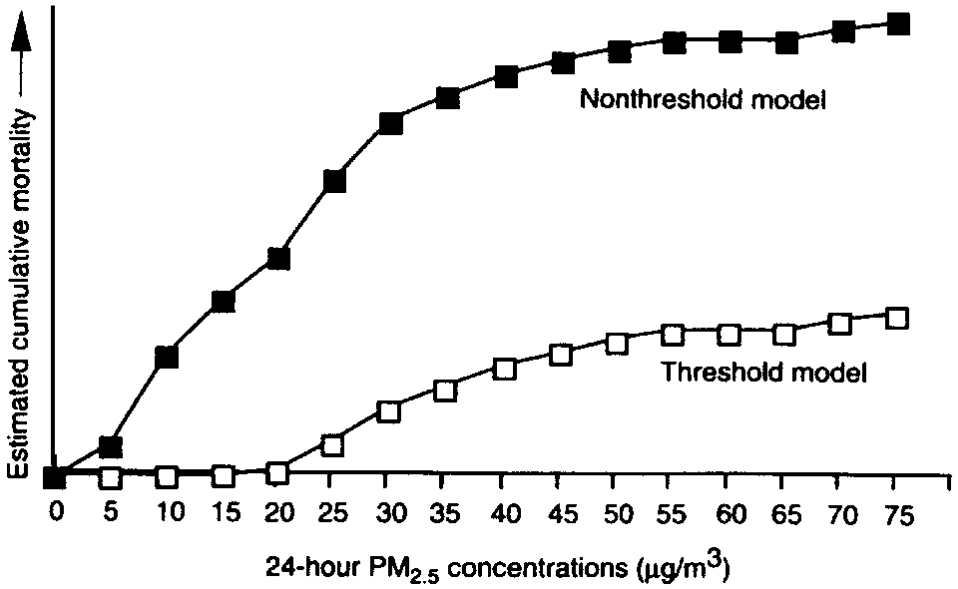
scheme of a dose-response relation



US-EPA 1996

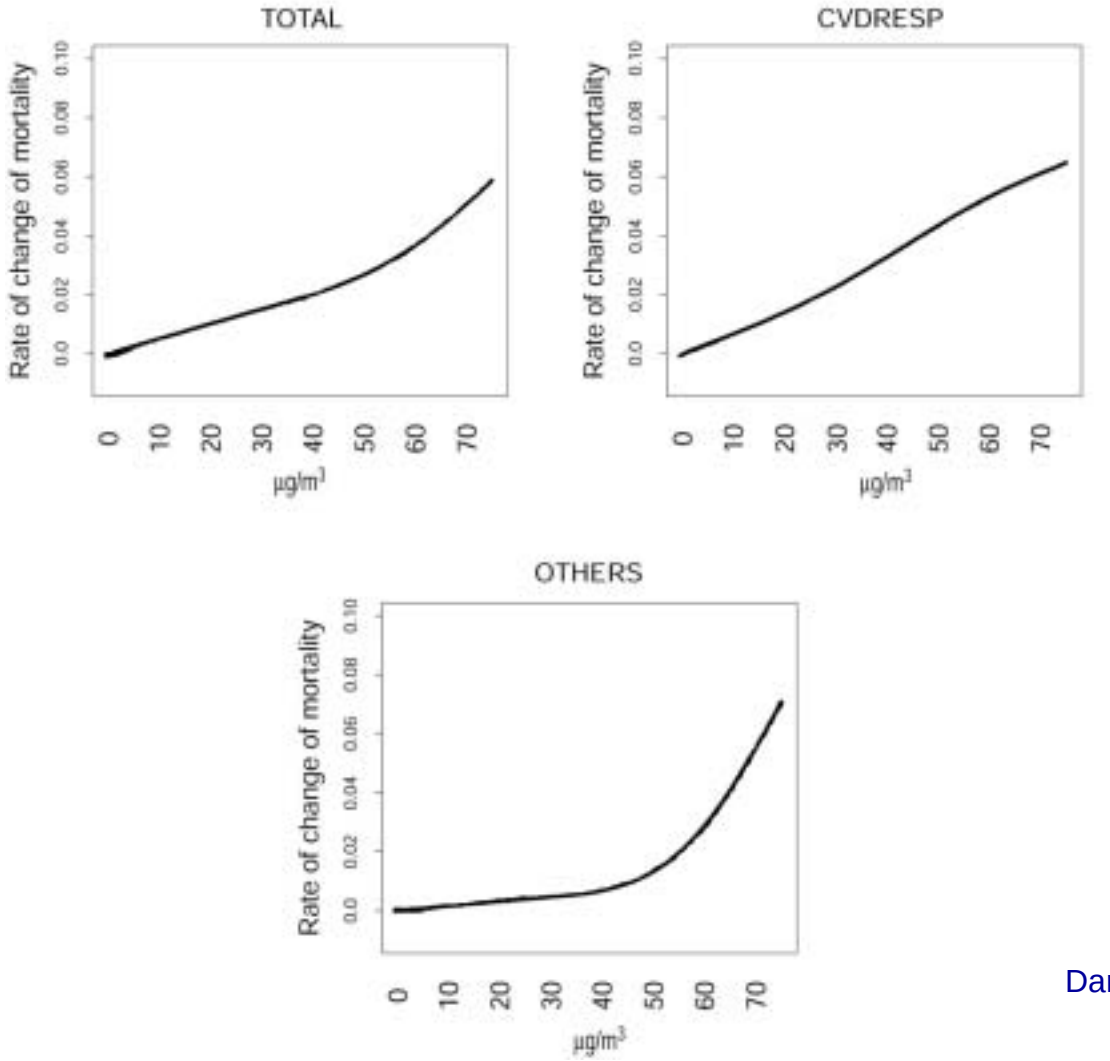
consequences of a threshold





McClellan and Miller 1997

dose-response relation – various populations



Daniels et al. AJE 2000

WHO risk assessment
for a 10 µg/m³ concentration increase
short term effects

endpoint	RR for $PM_{2.5}$	RR für PM_{10}
lower respiratory symptoms		1.0324 (1.0185-1.0464)
mortality	1.015 (1.011-1.019)	1.0074 (1.0062-1.0086)

WHO: Air Quality Guidelines for Europe 2000

	annual mean $\mu g/m^3$	daily mean $\mu g/m^3$	
EU 1999	40 (20)	50 *	PM_{10} (Dae 50% <10 µm
Austria 1997 2001	40 (20)	150 50 * (7x)	TSP PM_{10}
Switzerland 1997	20	50 **	PM_{10} (Dae <10 µm)

EU: to be reached until 2005 (2010)

* not to be exceded more than 30 (25 starting 2010) per year

** 1 excedance per year allowed

USA	annual mean µg/m³	daily mean µg/m³	
1971			
primary standard	75 (geom. mean)	260 *	TSP (HiVS)
secondary standard		150	
1987			
primary standard	50 + (arithm. mean)	150 *	PM_{10}
secondary standard	50	150	
1997			
	50	150 #	PM_{10}
	15 ++	65 ##	$PM_{2.5}$

* not to be exceeded more than once per year
+ 3-year average
++ spatial average of designated monitors

\# 99-percentile
98-percentile