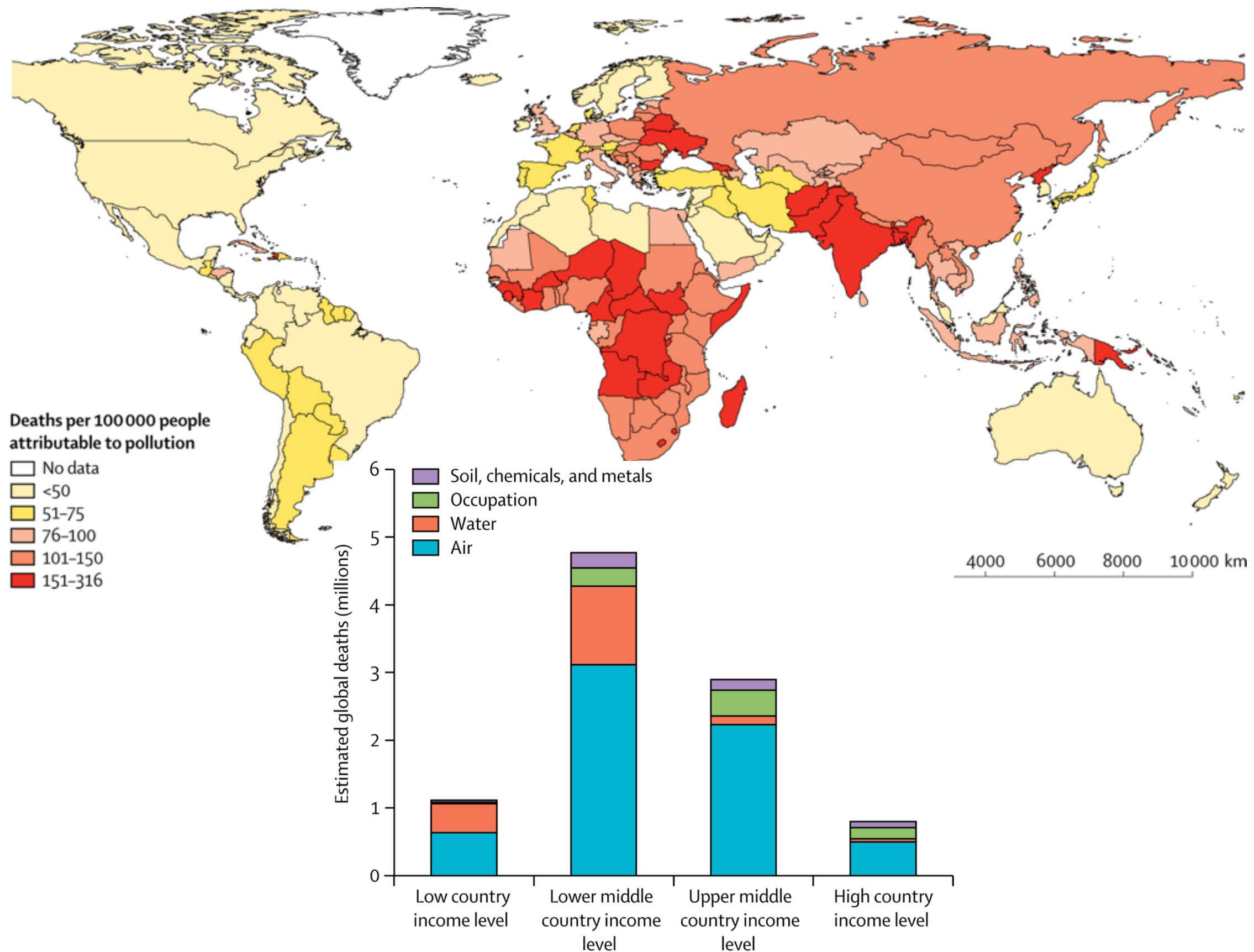


Swiss Centre for Occupational
and Environmental Health

Particulate Matter: Identification, mitigation and assessment

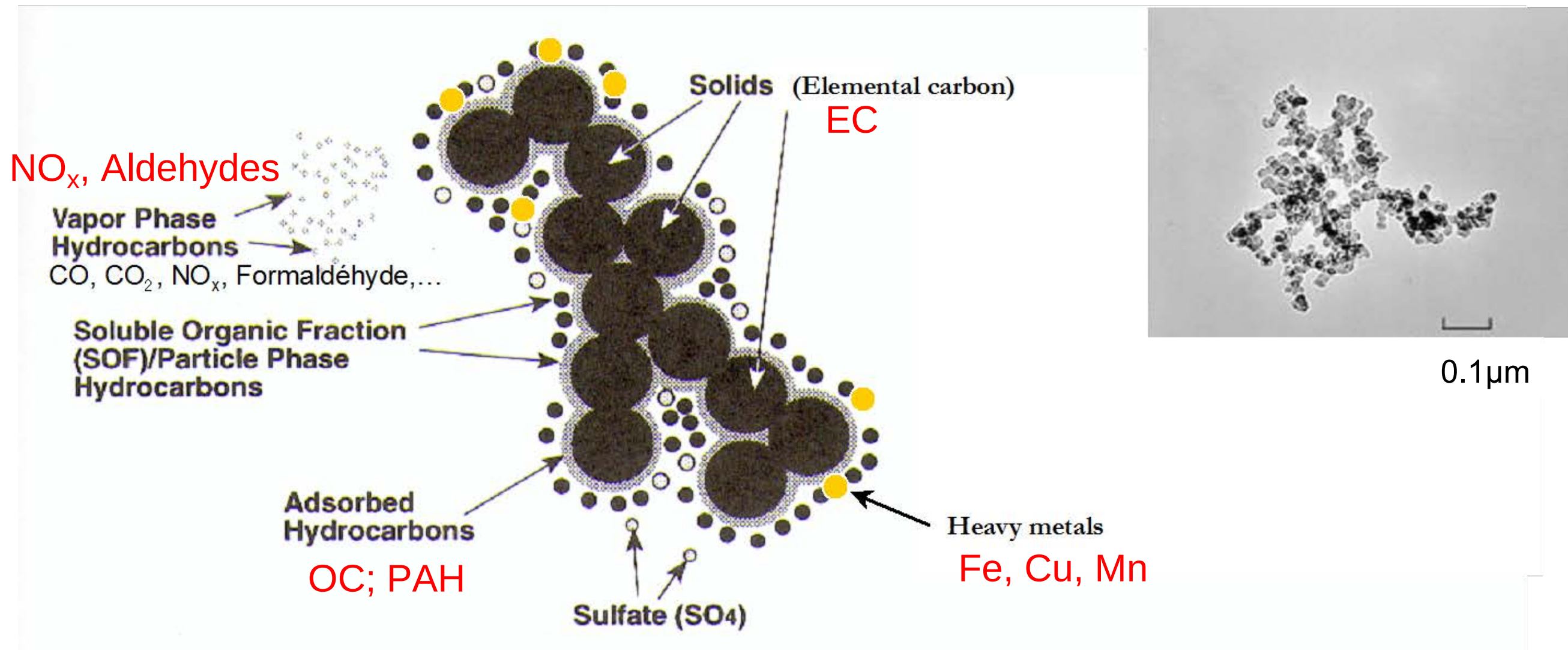
Michael Riediker
Prof., Dr.sc.nat.
Founding Director, SCOEH

Air is the biggest of the pollution problems



Ambient particles – complex substance mix

SCOEH



Health effects of PM

SCOEH



Heart

Infarction and Arrhythmias

Brain

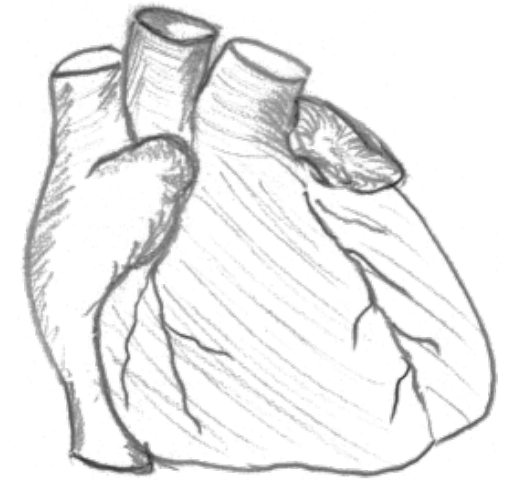
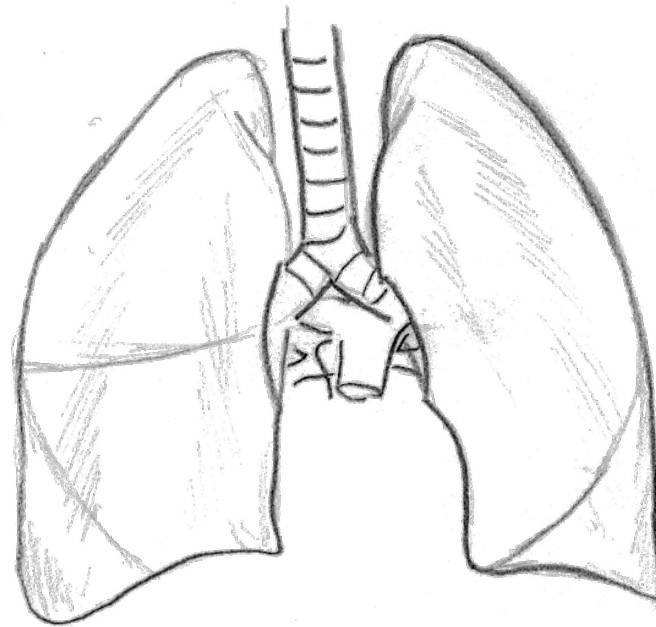
Stroke, Dementia, Cognitive function ...

Lungs

Asthma, Allergies, COPD ...

Other

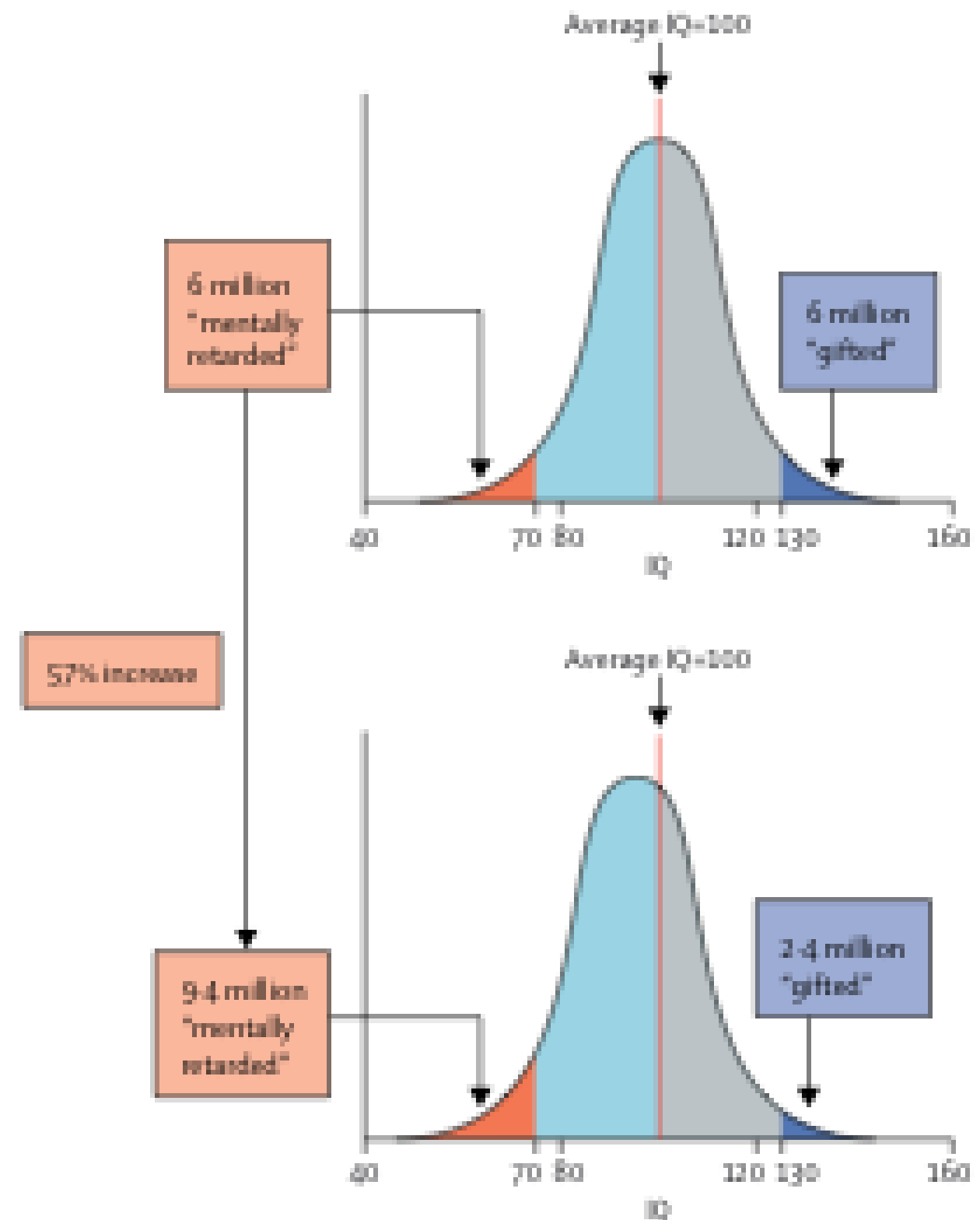
Diabetes, Obesity, Renal issues, Cancer



Understanding variability is important

- Many effects are not very relevant to the „average“ people
- Most affected are the “ends” of the distribution

Example: Drop of IQ by 5 points in a population size of 100 Millions

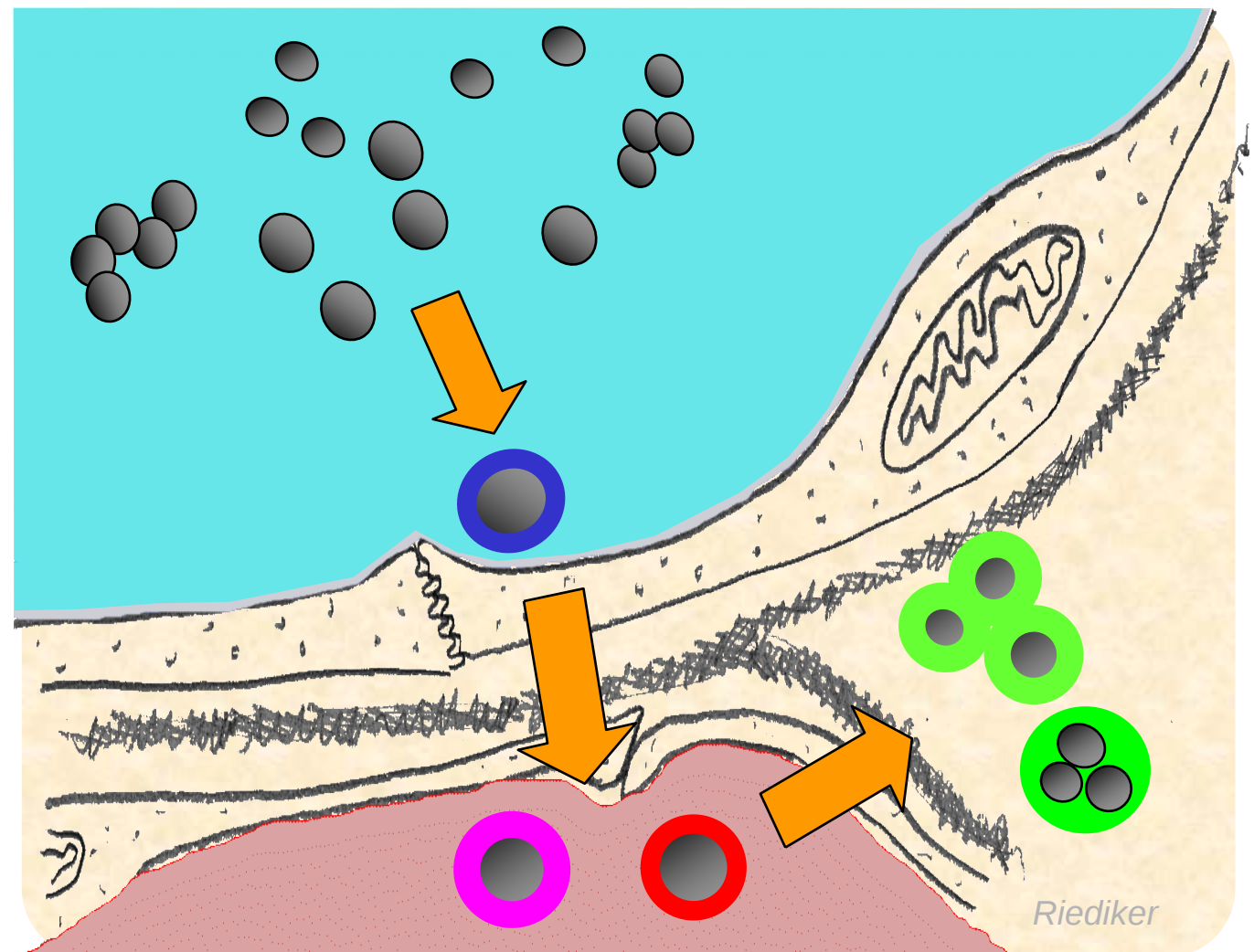


Which particle properties play a role?

SCOEH

- Number
- Size
- Dimensions
- Surface
- Volume and Mass
- Composition
- Functionalisation
- Persistence
- Activity

How do properties change in a living system?



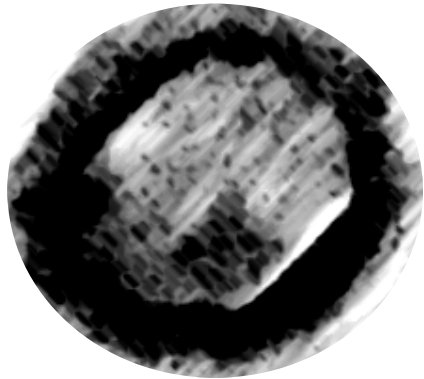
Large size range of Particulate Matter

Modified from Atmospheric Environment 38
(2004) 4347–4355

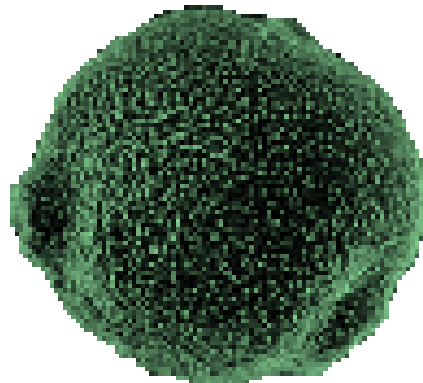
Picture taken by myself

Wikipedia.org - Bombus pascuorum

Modified from <http://www.flugtage-salzgitter.de/ballone>



Diesel fume
(20 nm)



Birch pollen
(17 μm)



Bumblebee
(18 mm)



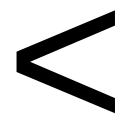
Ballon
(19 m)

*Nano-
meter*



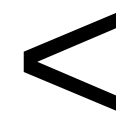
1:1000

*Micro-
meter*



1:1000

*Milli-
meter*

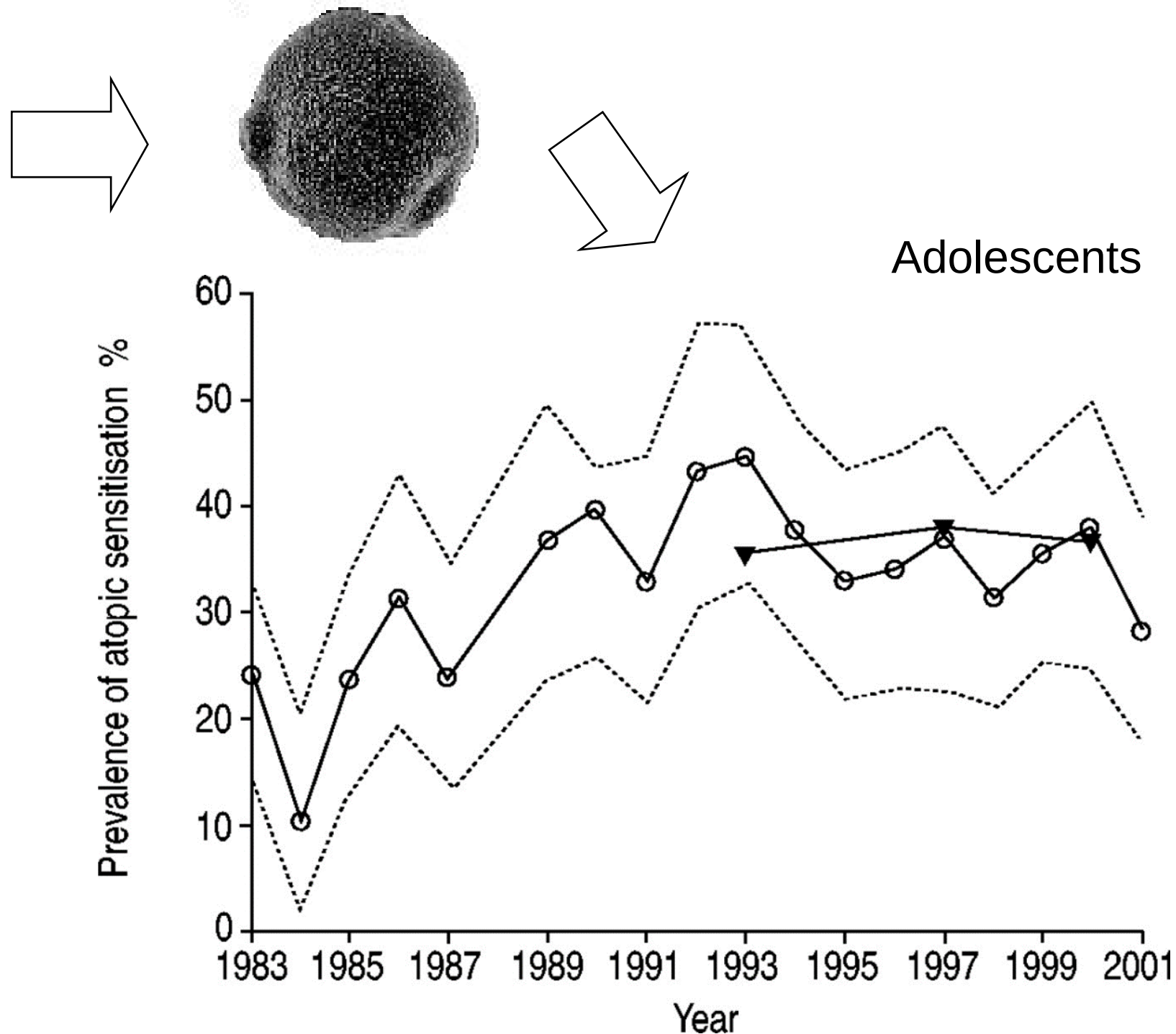


1:1000

Meter

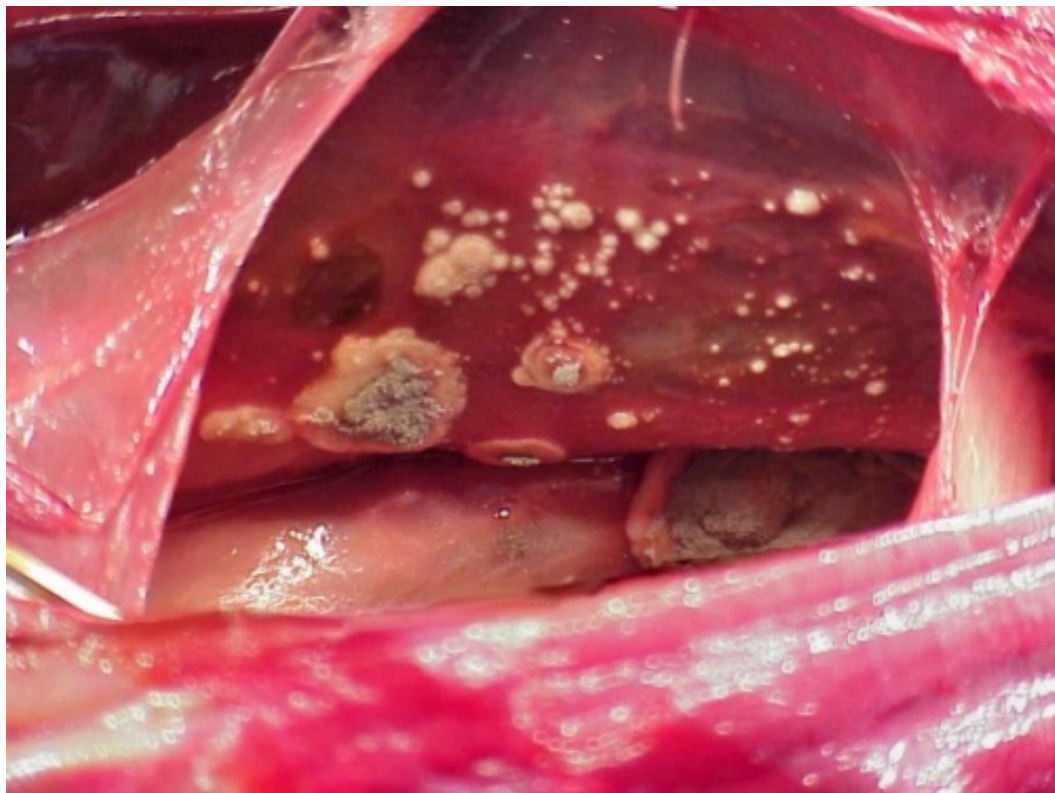
Pollen: carriers of airborne allergens

Plants release pollen that contain allergens

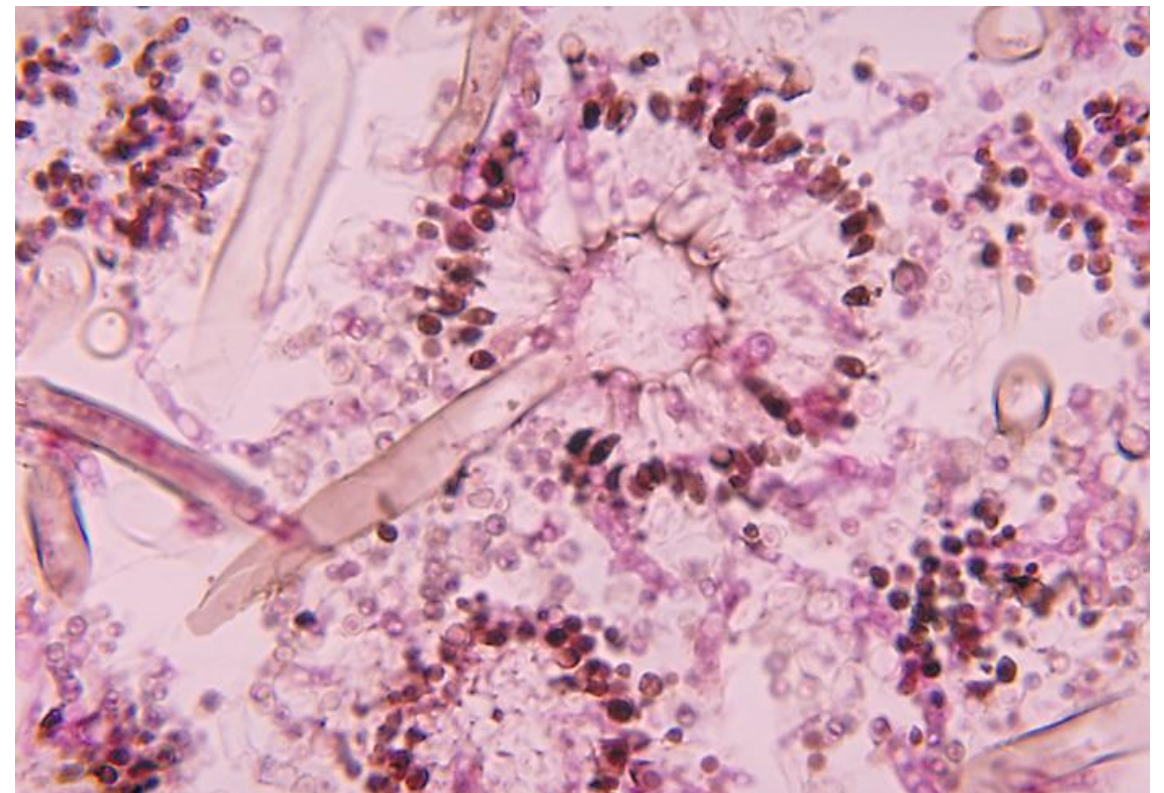


Moulds, (still!) a frequent indoor problem

- Aspergillosis caused by airborne fungal spores
- Growth of fungus in lung
- Formation of toxic m-VOC
- 600,000 deaths per year worldwide from Aspergillus alone



http://www.michigan.gov/dnr/0,4570,7-153-10370_12150_12220-26360--,00.html



https://upload.wikimedia.org/wikipedia/commons/4/4a/Histopathologic_features_of_aspergillosis_including_the_presence_of_conidial_heads_PHIL_4335_lores.jpg

Sources of outdoor particles

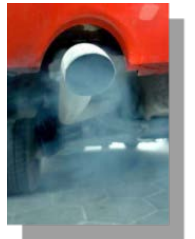
Industry:

- Energy and heat production
- Exhaust from production process



Roads:

- Engine exhaust
- Road, tire and brake wear
- Re-suspension of street dust



Agriculture:

- Engine exhaust
- Precursors gases
- Soil dust and spores



Forest fires:

- Illegal burning
- Accidents, lighting
- Draught, climate change



Secondary (SOA):

- + Ozone, NOx, VOC...
- + Light & Temperature

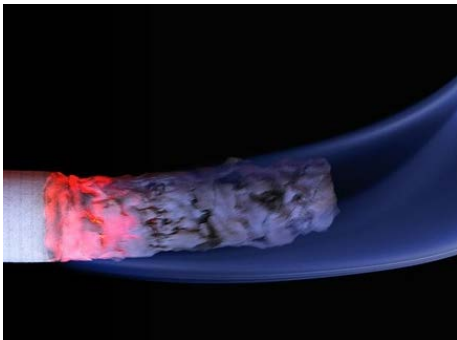
Ships:

- Diesel engines
- Bulk ship unloading
- Ground transport



Indoor sources

Smoking



Cooking



- Biomass for heat
- Cooking particles
- Precursor gases



Light



- Flame particles
- Precursor gases
- (UV-light)

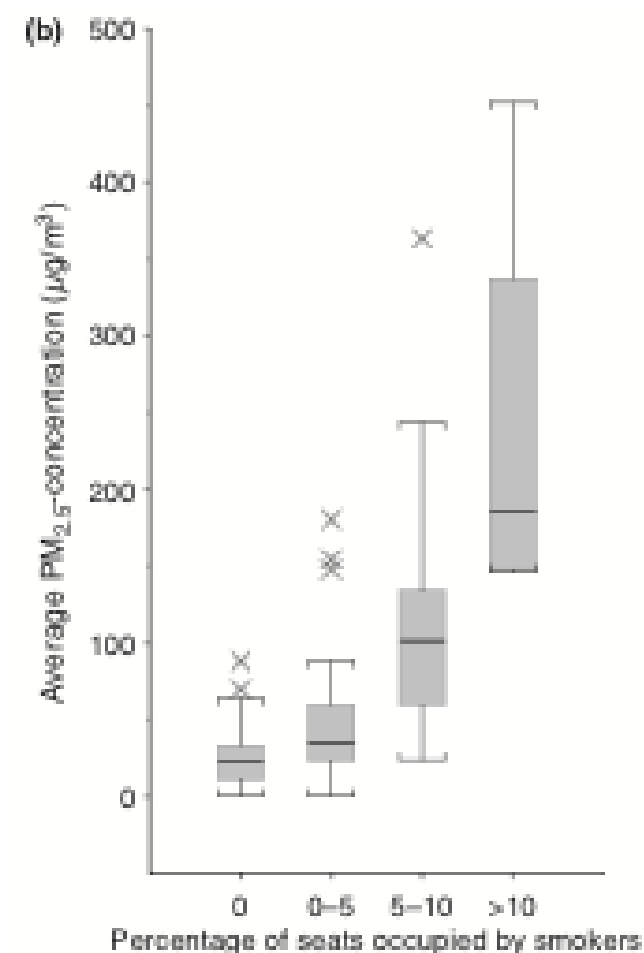
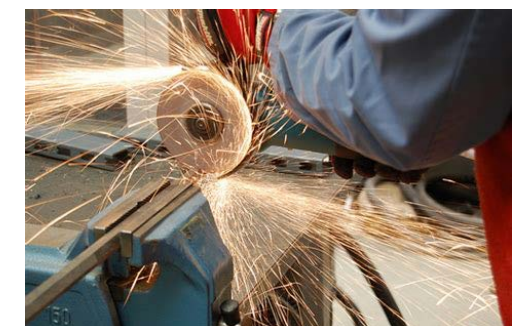


Work



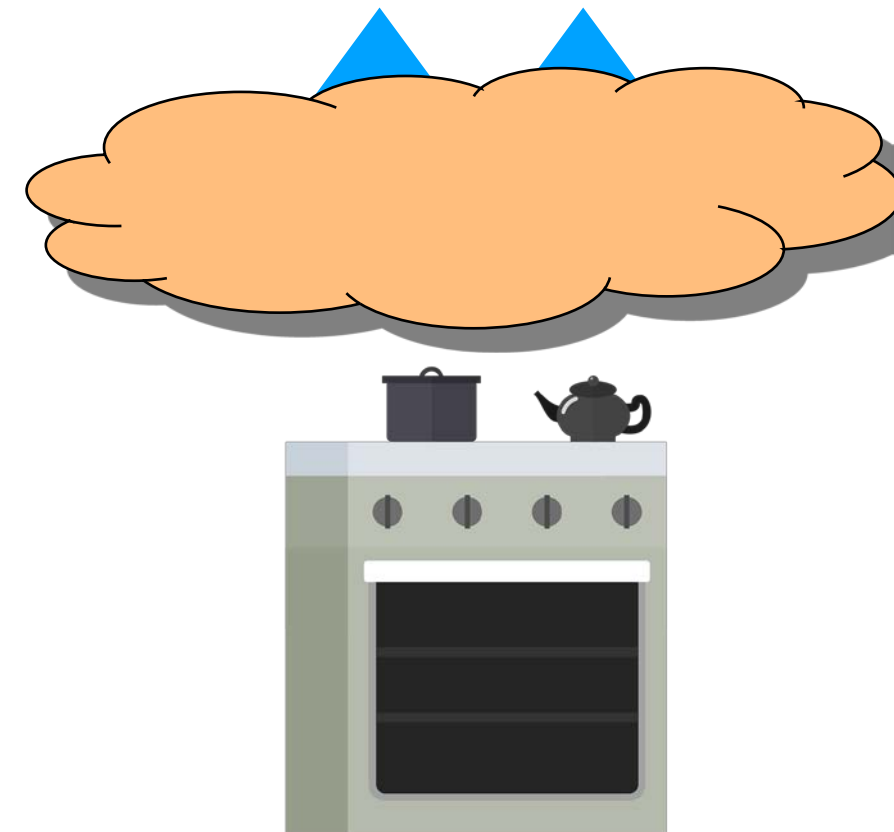
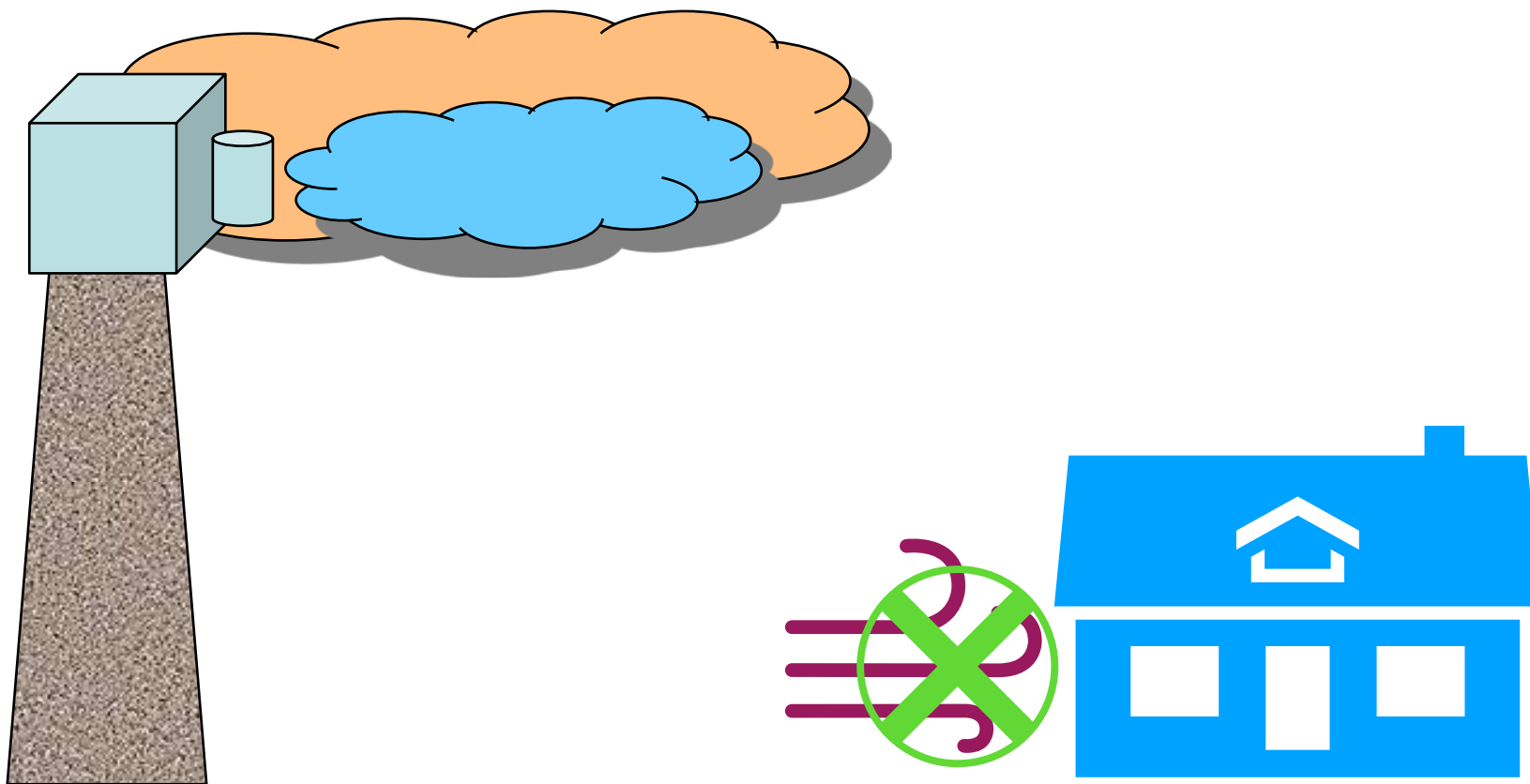
- Housekeeping (PM+precursors)
- Repairs
- Devices

- Home workers
- Indoor work environments



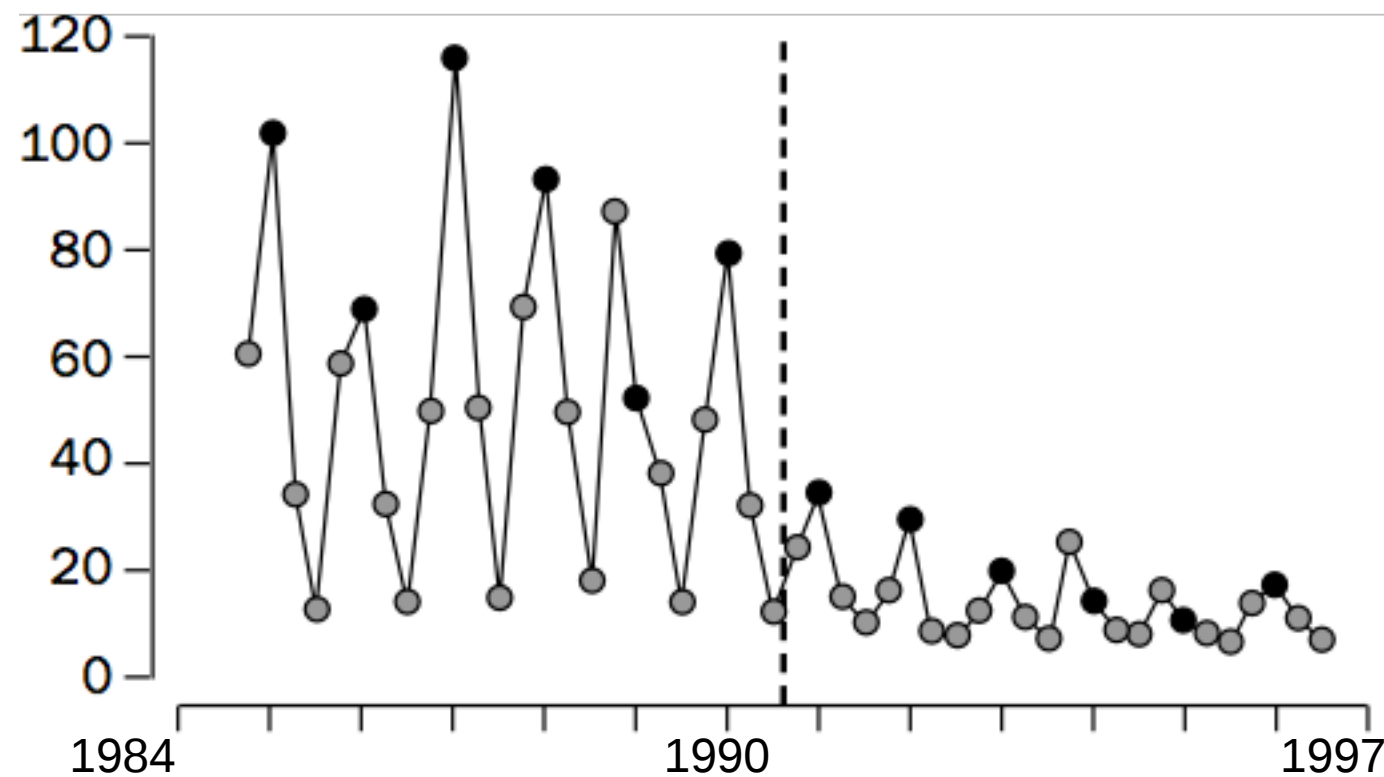
Mitigation strategies

- Control release at the source (outdoors and indoors)
- Reduce entry into the building
- Remove from indoor air

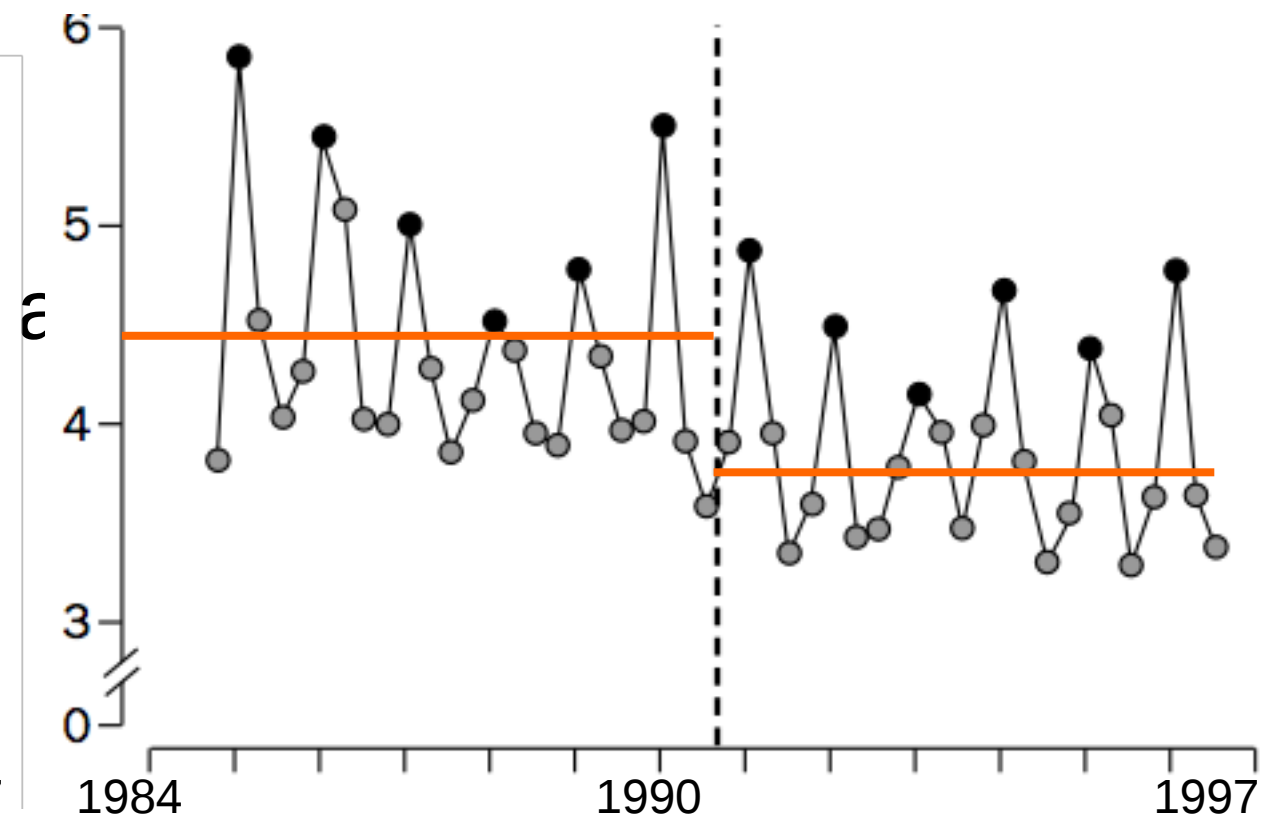


Outdoor intervention: Dublin coal ban of 1990

Black smoke ($\mu\text{g}/\text{m}^3$)



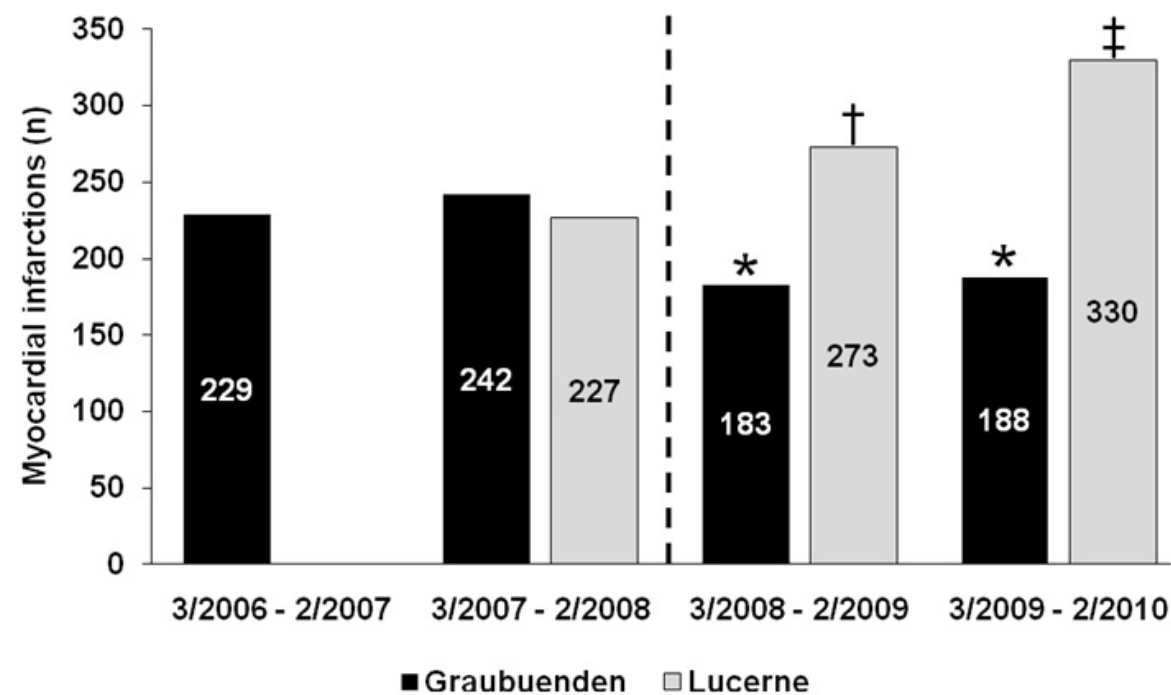
Cardiovascular deaths (per 1000 person-years)



Indoor intervention: Smoking ban in restaurants

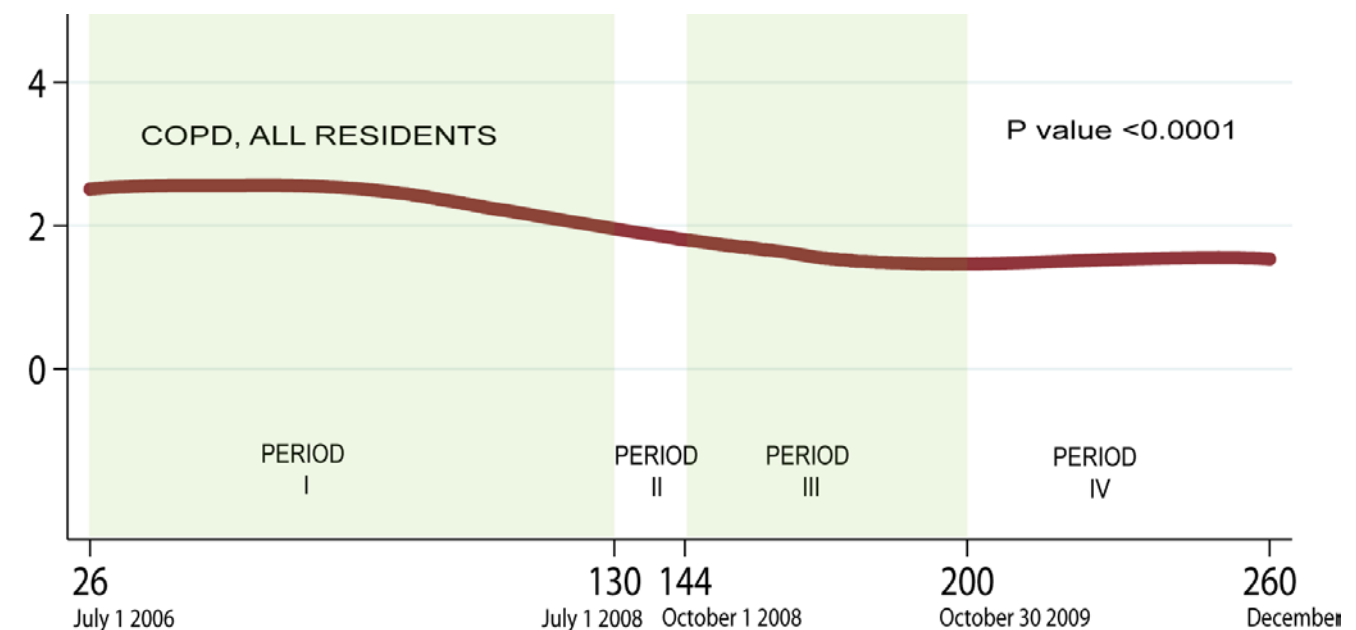
Myocardial infarctions:

- Comparison of Graubunden (ban) and Lucerne (no ban)
- 2 year before and after



Respiratory problems (COPD)

- Hospital admissions in University Hospitals of Geneva
- Assessment of four periods



Whole house systems and in-room systems

Whole house air system

- Effective if using good filters
- Can help reduce energy use („Minergie-houses“)
- Does not perform (well) when occupants open windows
- Counter-productive when not well designed and maintained (e.g. mould on filters, Legionella, ...)

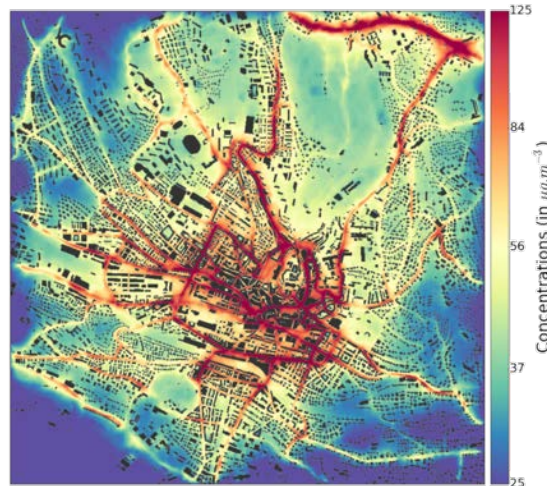
In-room (portable) system

- Work often well in small rooms
- Often devices' flow rate too low for room size
- Often filters cannot be changed without getting exposed
- Counter-productive „ionic“ cleaners (SOA-production!)

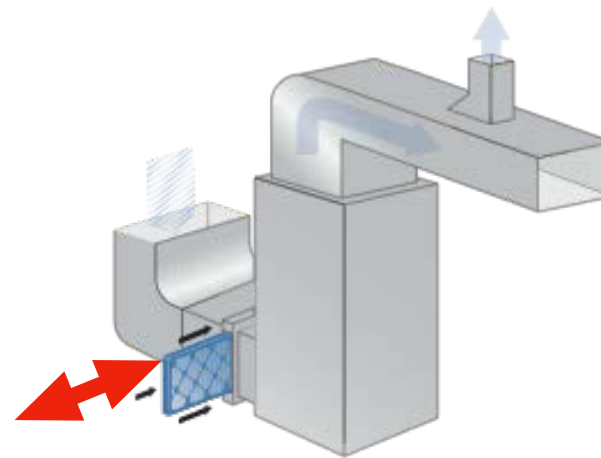
Plan, do, check, act

SCOEH

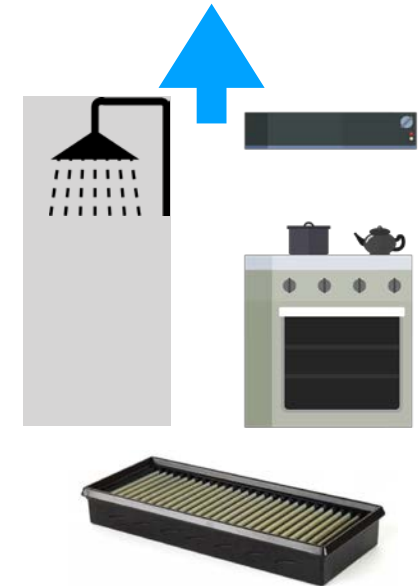
- Plan location, air entry and in-house situation
(think of maintenance, which is not just cleaning!)



Air pollution model to define living areas
GRAMM-GRAL Model of Lausanne by EMPA



Air system with space to change filter
EPA-402-F-09-002



Exhaust via problem zones, Filters at air intakes
Pixabay.com, Flickr.com

- Set up performance indicators and define when to alert users



Damaged & clogged filters
EPA-402-F-09-002



Continuous PM_{2.5} sensor for sensitive operations
(Sensirion.com)



Periodical inspection by professionals
(Wikimedia.org)



Control panels that are designed so that lay people can identify an alert (progressive)
(flickr.com)

What, when and where to assess

	Planning location, windows, air intake	Performance control of ventilation systems	Understanding health complaints
Particulate Matter < 2.5 µm	- Identify sources - Find PM_{2.5} maps (if existent)	PM removed... - At outlet? - In room?	Consider in cases of „dry air“, unspecific irritations
Ultrafine (nanoscale) PM	- Identify sources - Find NO₂ maps as a proxy	Only consider for extra control near sources (busy roads)	Consider in cases of „dry air“, unspecific irritations
Pollen, spores, mould	Identify sources	Check for indicators of mould growth in system	Consider if indicated by allergic symptoms, smell
Gases	- Identify sources - Find maps	- Check humidity - Use to obtain air exchange rates (e.g. CO₂, SF₆)	Strategy in function of symptoms and sources (in and out)

Sources, exposure maps

PM, Mould, air exchange

Need expertise, PM can mimic effects of gases

New measurement devices allow more strategies

SCOEH

Handheld monitors for ultrafine particles



On market

nanoeos.ch
tsi.com
grimm-aerosols.com

Inexpensive networked PM_{2.5} sensors



On market

sensirion.ch

Size-separated PM-collection for automated analysis

On market

statpeel.ch



Real-time pollen sensors (and soon spores?)

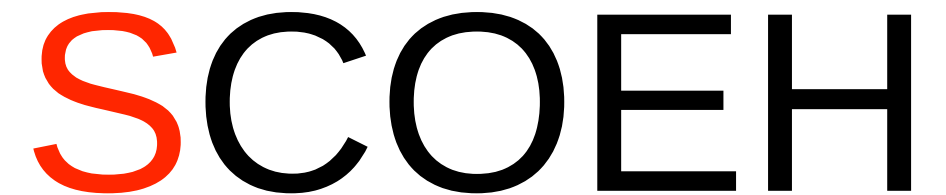
Reaching market

swisens.ch



Conclusion

- Particles of all sizes remain an important indoor health risk
- Clean outdoor air very important task for authorities
- Energy friendly and healthy houses are possible
- Still many open questions AND practical challenges
- Novel assessment methods opens way to new approaches (research, system feedback, periodic controls, regulation)



Schweizerisches Zentrum für
Arbeits- und Umweltgesundheit

Thank you!

A special thank to German
Environment Agency
(Umweltbundesamt)

For more information:

michael.riediker@scoeh.ch

Or contact me via LinkedIn or ResearchGate