

Homo sapiens and the air around us

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The two causes of disease

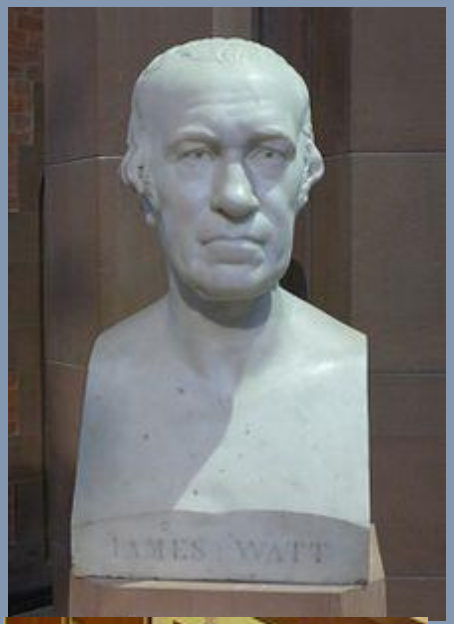
Imbalance of the humors
or
Genetic susceptibility

Attack by demons
or
Environmental hazards

What is fresh air?

- Oxygen 21%
- Inert gases 78+%
- Carbon dioxide 0.04% (400ppm)
- Other gases<0.001%
- Bacteria, fungal spores and pollen grains
- Inorganic particles c50-100µg/m^3

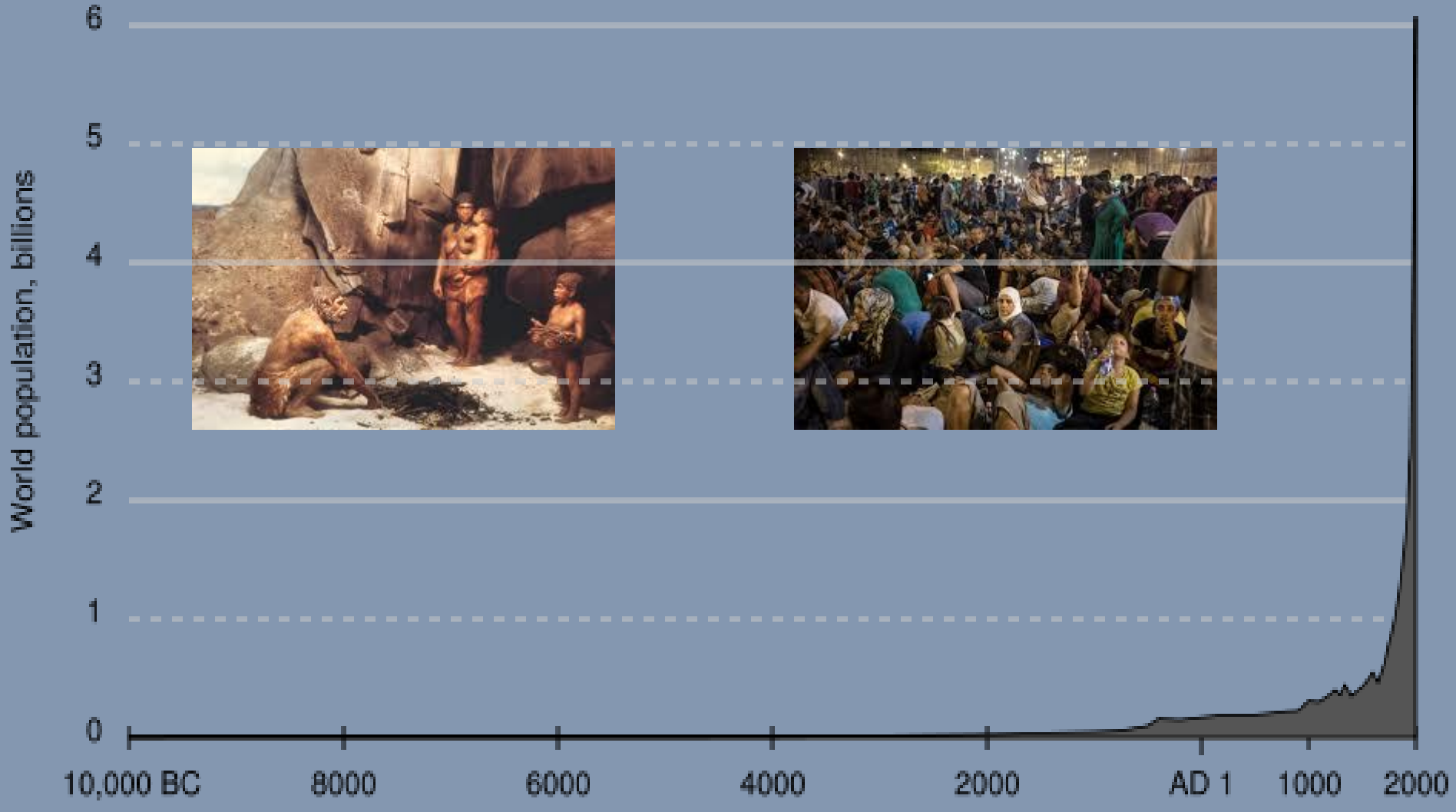
1776 – the year the world changed



- James Watt and his improved steam engine

- Adam Smith and The Wealth of Nations

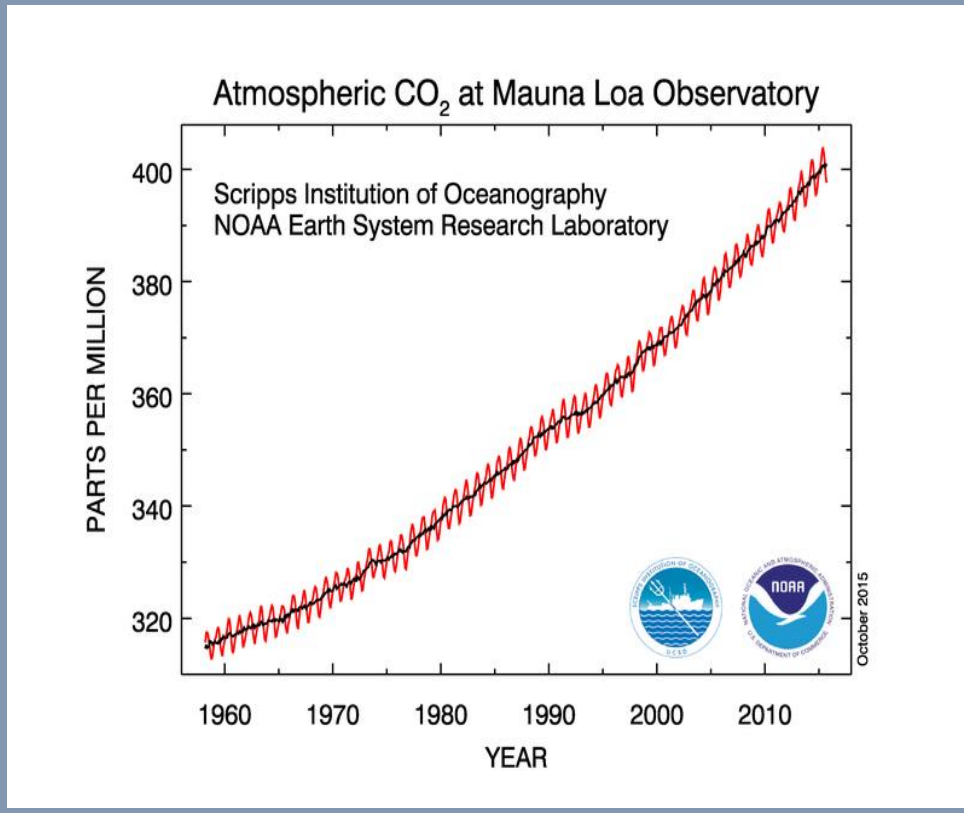
The world's population since 10,000BC



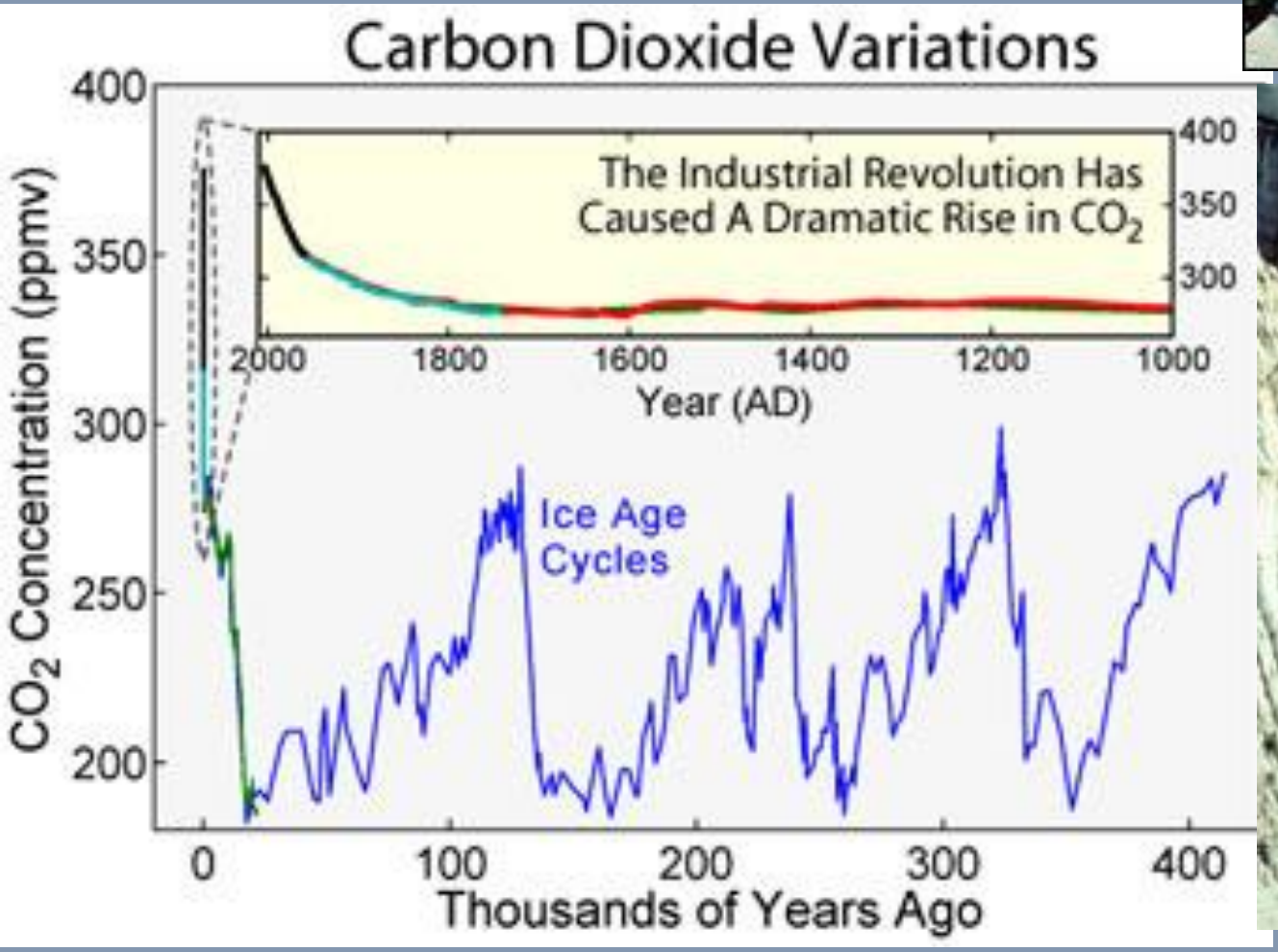
CO_2 - Mauna Loa, 1957-2015

Traps reflected radiation, raises global temperature and thus sea level.

Warmer seas, more severe storms and rainfall.



Drilling back 400,000 years: the varying atmosphere and temperature



Climate change – new challenges

- Rising temperatures and sea level
- Increasing strength of storms, flooding
- Migration and need for more accommodation
- Need for energy efficiency/self generation

1950s: start of quantification of risks from air pollution

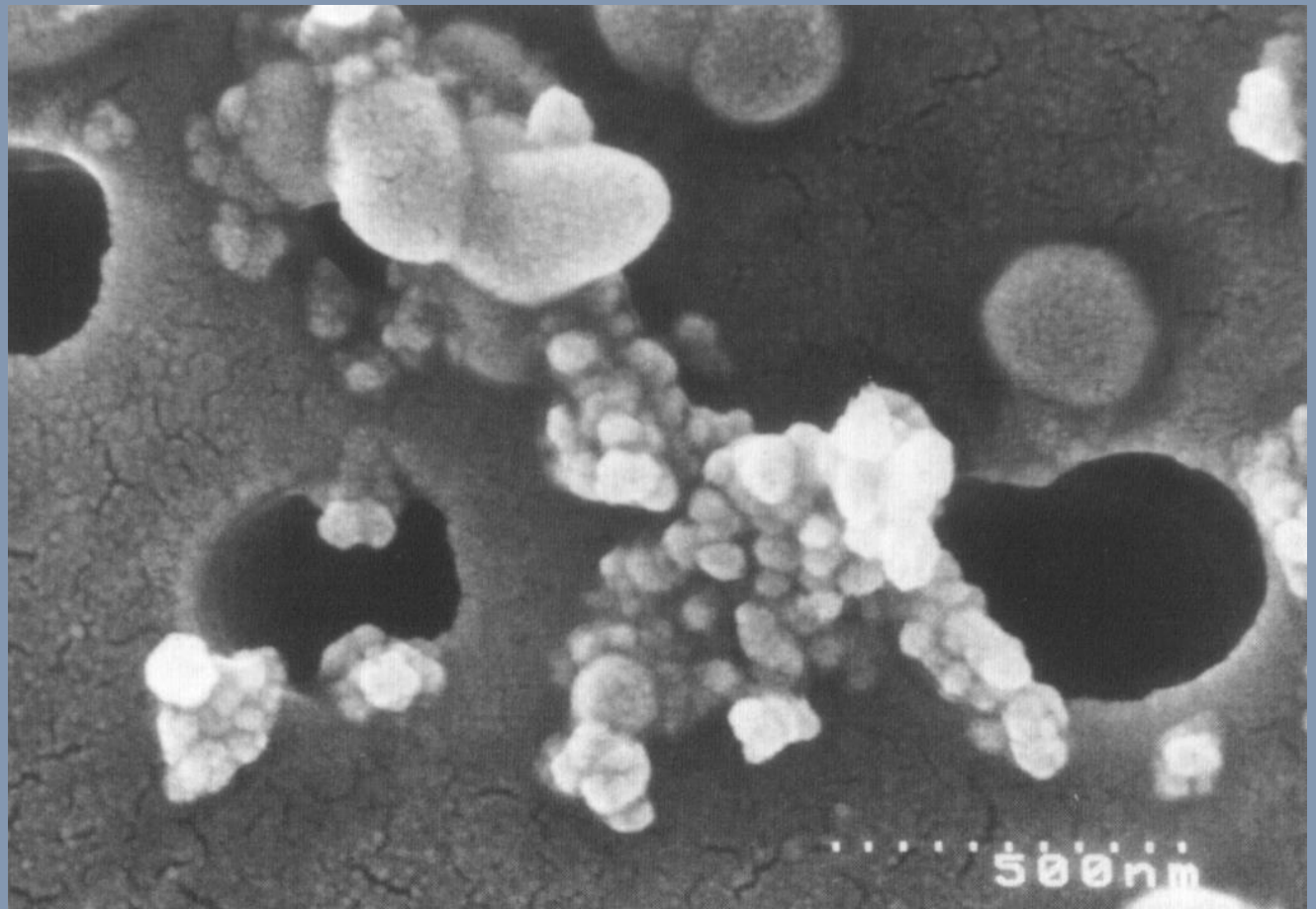
- Industrial, domestic and vehicle combustion
- Density of sources
- Wind dispersal
- Trapping by temperature inversions
- Increased death rates in populations

Outdoor air pollution: the demons

- Particles – biological and inorganic
- Nitrogen dioxide
- Sulphur dioxide
- Ozone
- Polycyclic aromatic hydrocarbons

Inorganic particles

Combustion produces very small particles that tend to coalesce into aggregates with high surface area



The indoor environment: A doctor looks at the workplace.

- **Hazard** - the potential to cause harm.
- **Exposure** – the concentration of a substance in the medium multiplied by the duration of contact.
- **Risk** – the likelihood of harm occurring.

  Hazard and risk are commonly confused

In buildings, hazards come and go

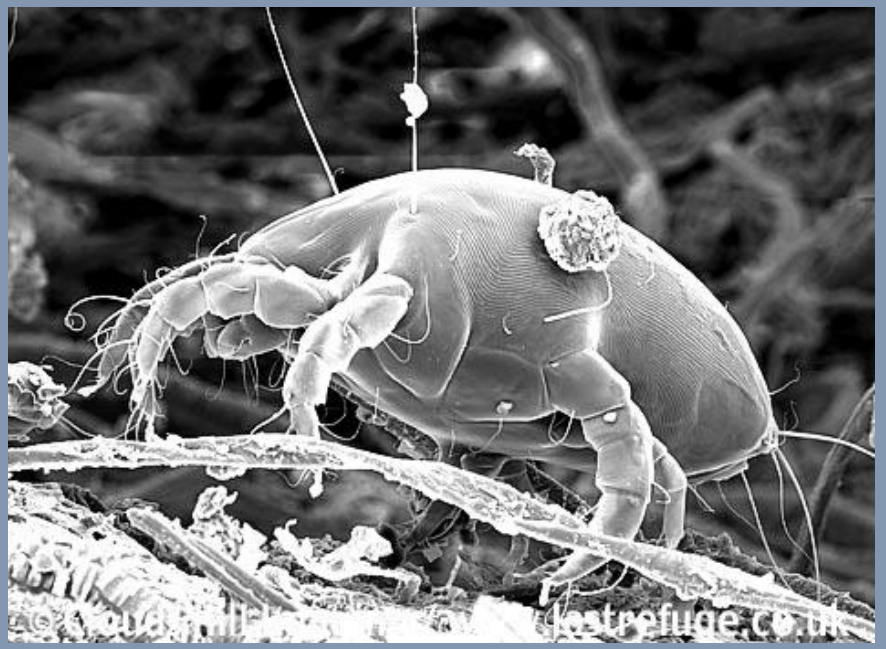
- Construction – accidents, masonry, joinery, painting
- Occupation – vapours from fixtures and fittings, radon, defective boilers, mites, fungal growth from damp, legionnaire's disease from sumps, lead from water pipes and old paint
- Maintenance – release of asbestos, paint removal, accidents
- Disposal and recycling

Classification of hazards

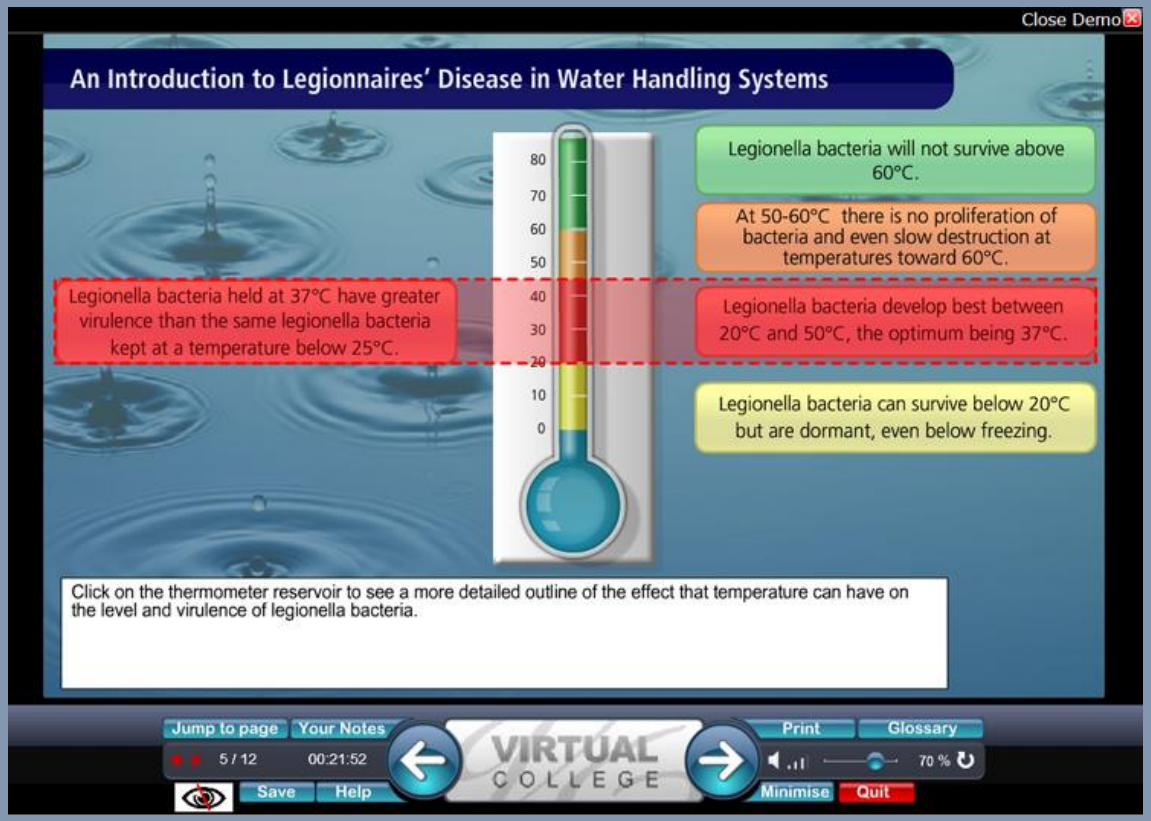
- Chemical
  - isocyanates, paint solvents, asbestos etc
- Physical
  - temperature, noise, lighting, activities, posture etc
- Biological
  - bacteria, fungi, mites etc
- Psychological
  - the job, other people etc

The larger particles deposit on the airways, potentially causing bronchitis or allergic reactions.

eg house dust mite and its faecal pellet

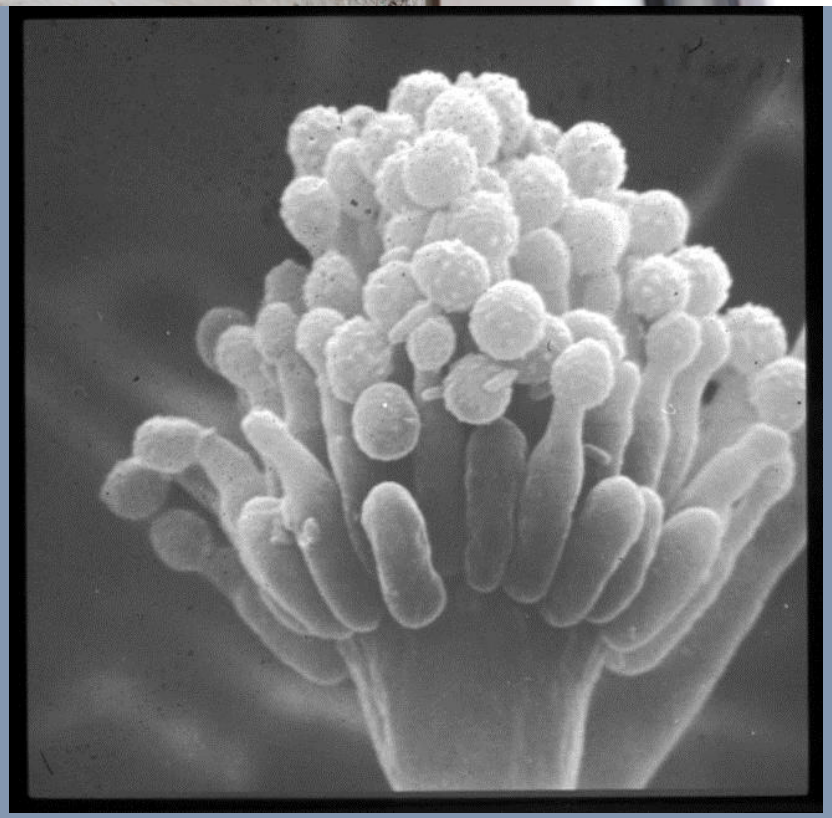


Bacteria – legionnaires' disease

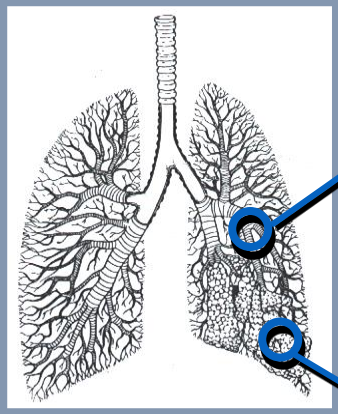


and fungal spores
eg *Aspergillus* species

- live on dead organic matter
- like damp conditions
- temperature optimum 37°C
- have small spores (c1μm diameter)



Particle clearance from the lungs



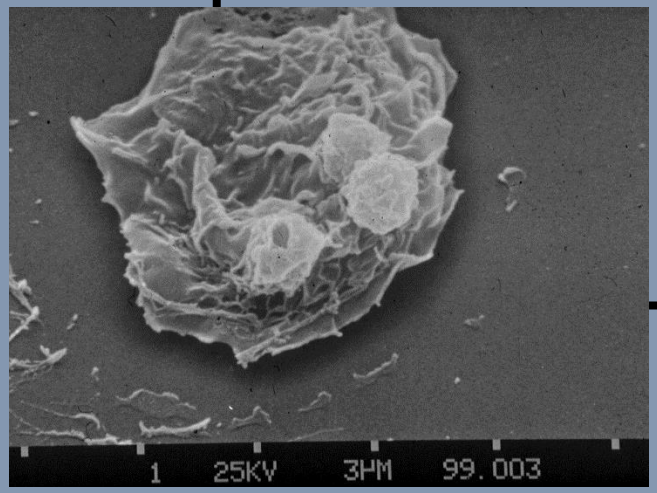
Deposition on the conducting airways

Deposition on the terminal bronchioles/ proximal alveoli

Clearance via the muco-ciliary escalator

Interstitial pathway via lymph to the lymph nodes

Clearance by alveolar macrophage phagocytosis



The lung may interpret all particles as invading organisms

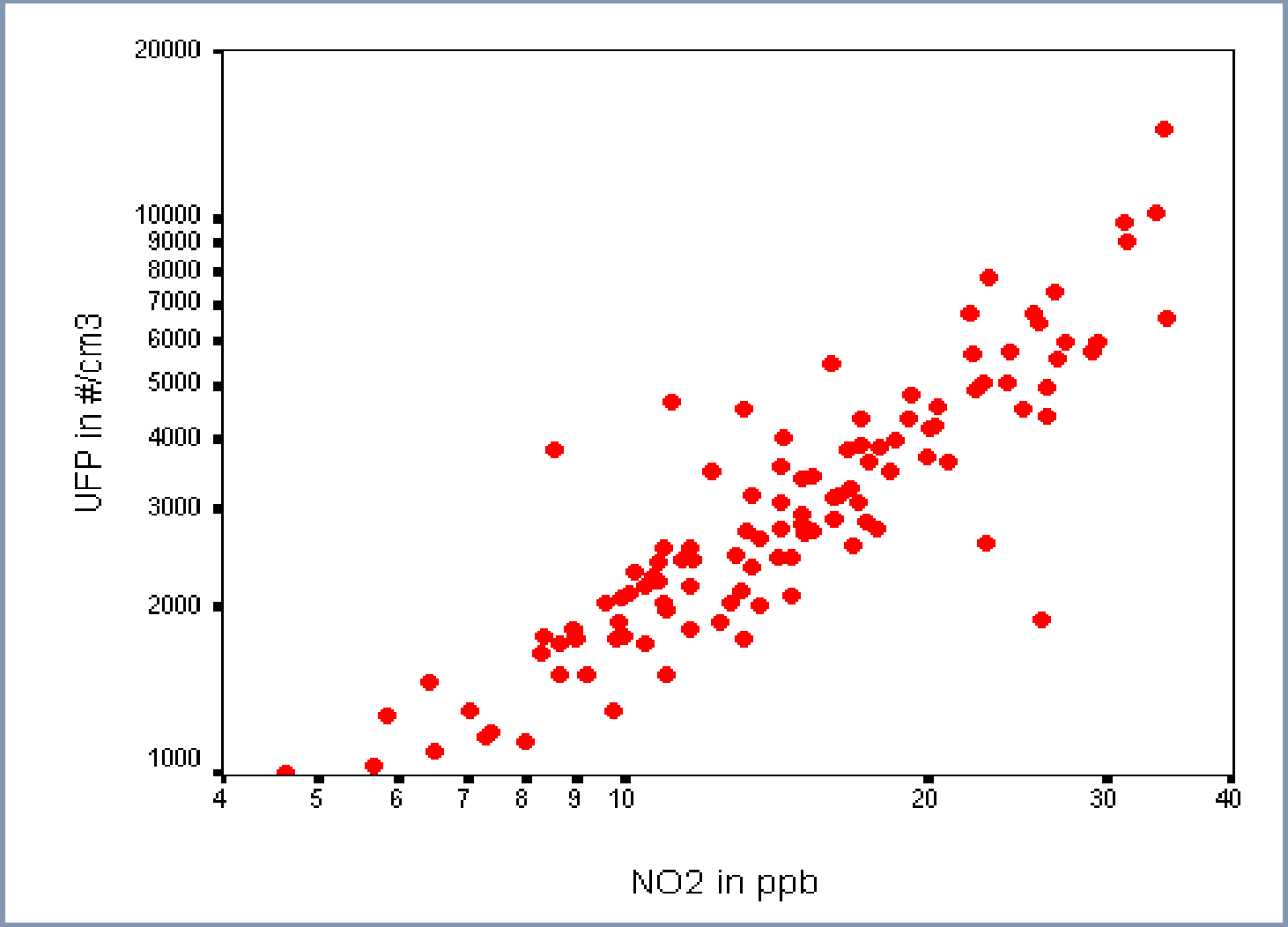
… increasing the *population* risks of

- heart attack
- asthma attack
- stroke
- bronchitis
- pneumonia

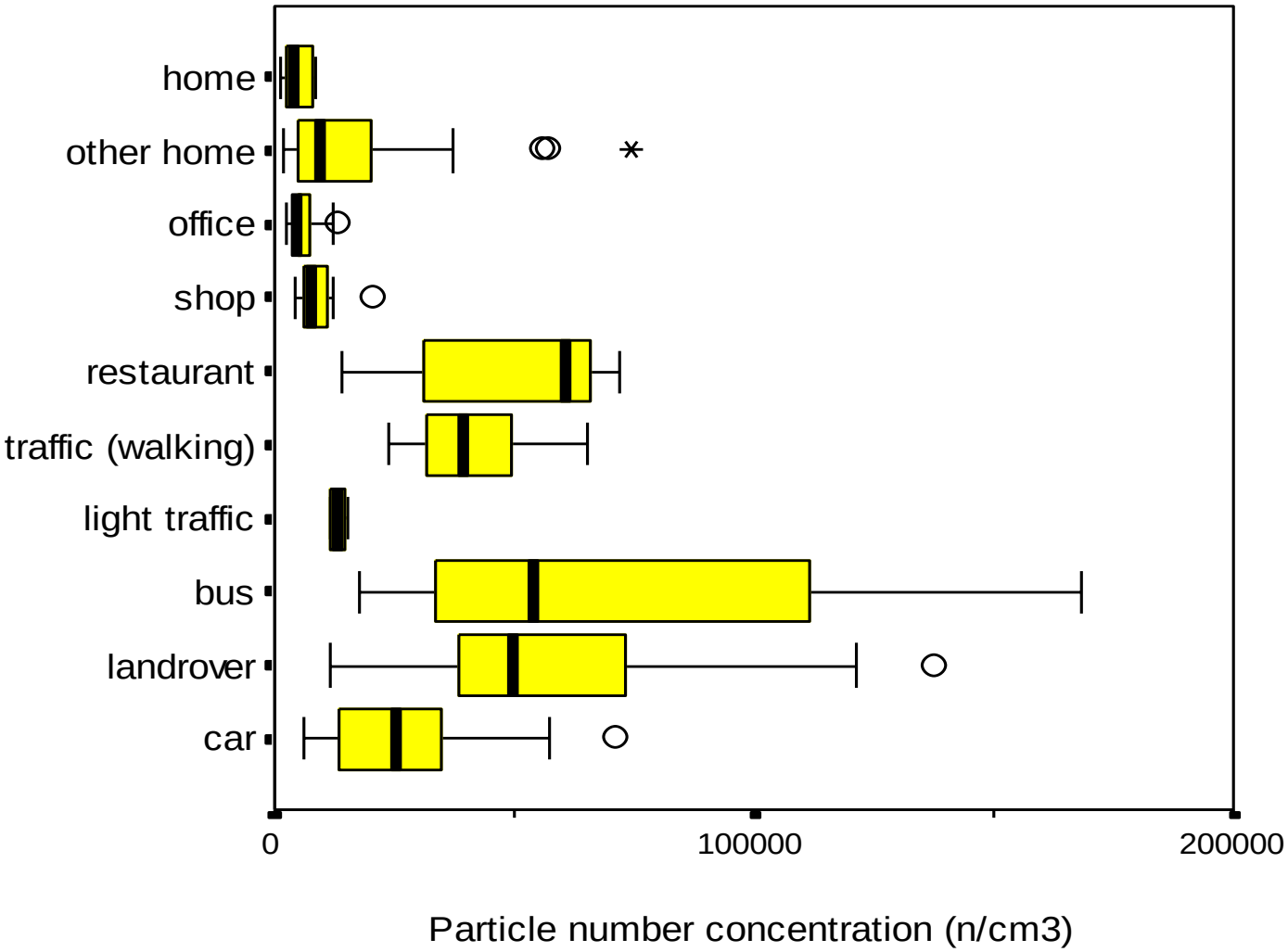
But remember, as *individuals* we have defences against bacteria. Some people are more susceptible than others.

PNC exposure while shopping

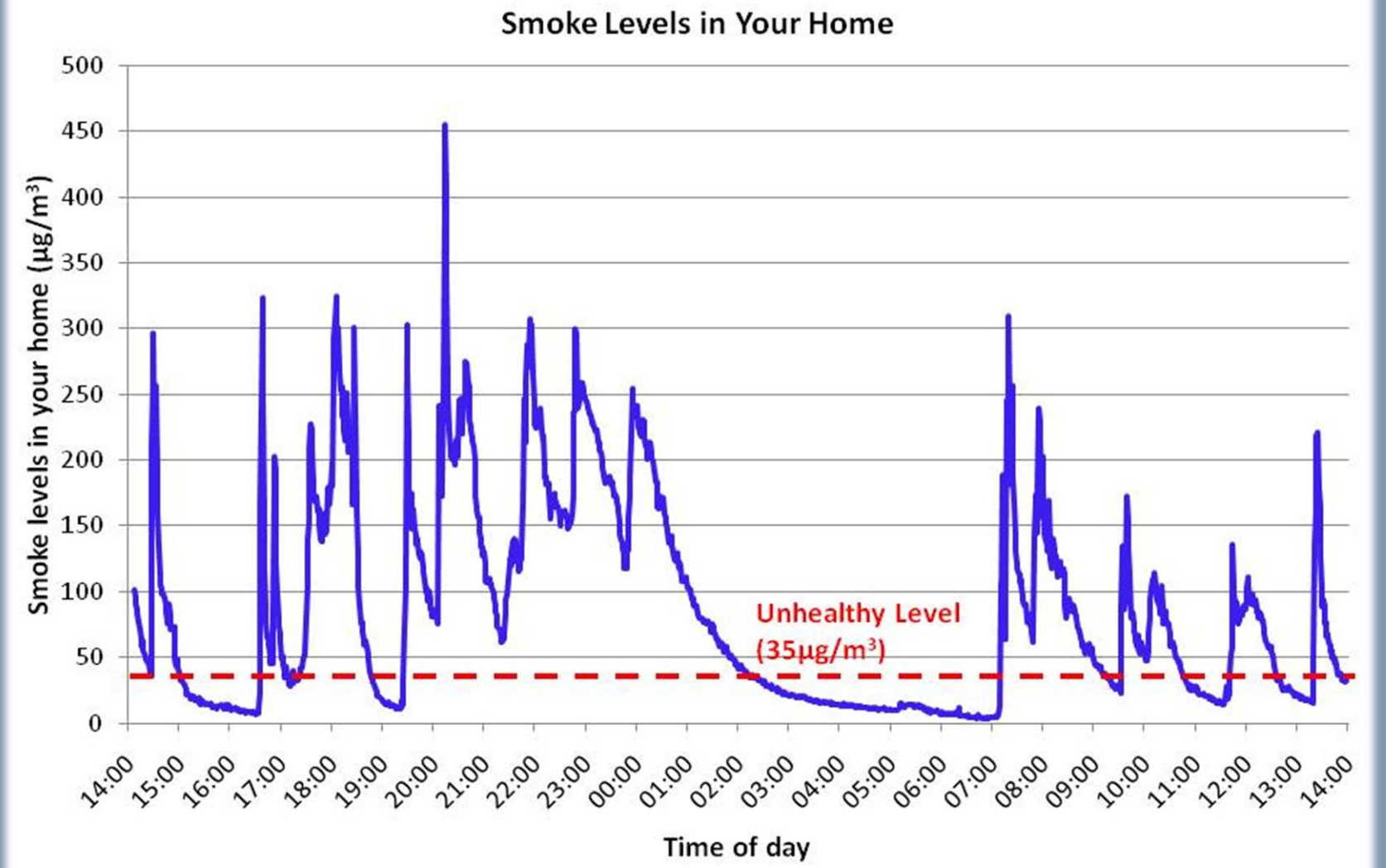
Relationship between ultrafine particle number concentration and nitrogen dioxide



Particle numbers in different environments



Smoking indoors



SUMMARY

- All air contains hazardous substances, but
- Risk depends on concentration, duration of exposure to, and toxicity of the substance
- Risk also depends on the susceptibility of individuals
- Indoor air may be cleaner than outdoor in terms of products of combustion, but has things added to it that may themselves be hazards
- Three about which insufficient is known are indoor-generated particles, nitrogen dioxide and household chemicals

Institute of Occupational Medicine

Thank you

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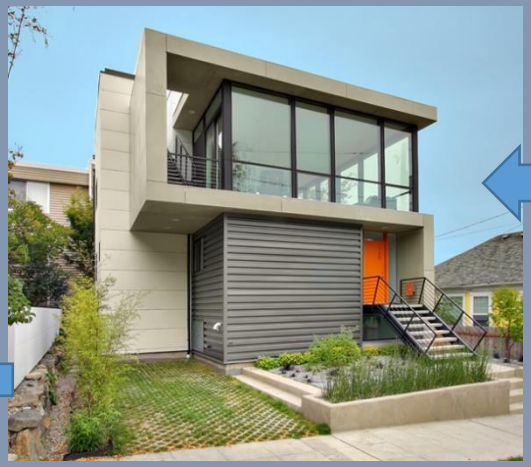
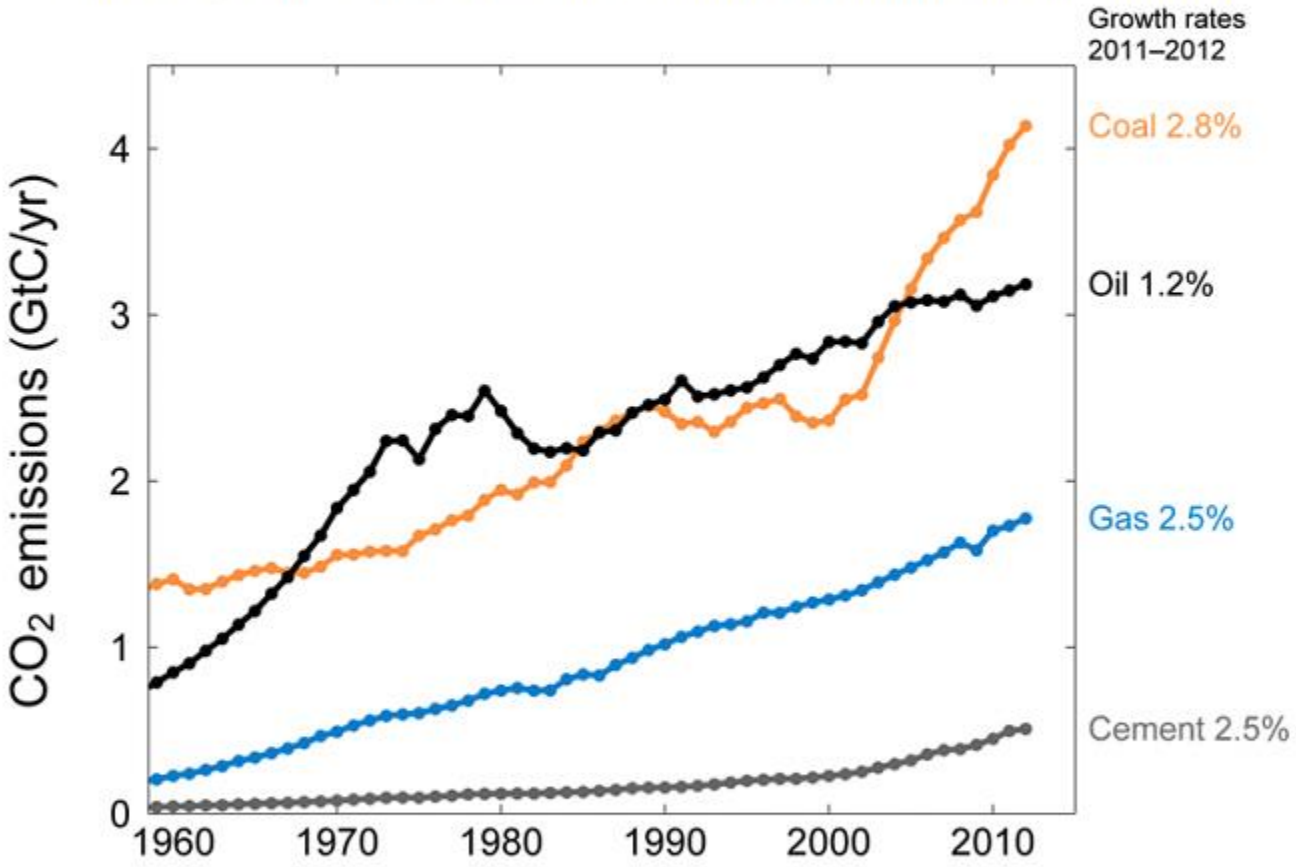
The compromises



Emissions from Coal, Oil, Gas, Cement

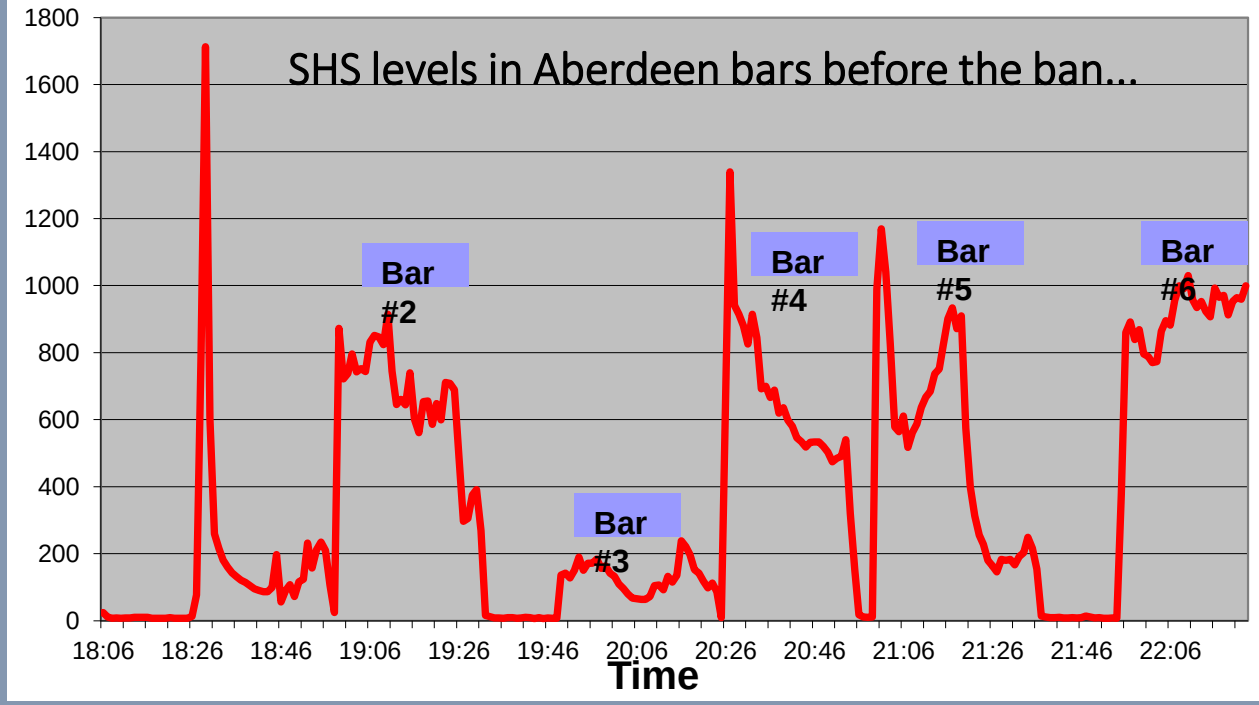
Share of global emissions in 2012:
coal (43%), oil (33%), gas (18%), cement (5%), flaring (1%, not shown)



With leap year adjustment in 2012 growth rates are: coal 2.5%, oil 0.9%, gas 2.2%, cement 2.2%.

Source: CDIAC Data; Le Quéré et al 2013; Global Carbon Project 2013

$PM_{2.5}$ levels ($\mu g/m^3$) in Aberdeen pubs before and after smoking ban.



BREATH OF FRESH AIR..IN BOOZERS

Fags ban cuts pub pollution by 86%

By ALAN CARSON

THE air inside pubs is now as clean as it is in the street, health chiefs revealed yesterday.

Pollution in boozers has plummeted by an amazing 86 per cent since the ciggie ban came in last March.

Last night Health Minister Andy Kerr said: "This research proves the new law is working. No one should have to breathe in someone else's smoke."

Quality

Before the ban, up to 2,000 non-smokers died each year from "passive" puffing. Figures since then are unavailable.

In the new study, scientists monitored the quality of air in pubs prior to the ban, then returned months later.

Before March, most bars had an air pollution score of 240micrograms. But some pubs were a lung-busting 900. By comparison, the air at the top of Ben Nevis measures only 5, the average city centre reading is between 15 and 25 and it's around 50 beside a busy motorway.

Yet now the average reading in pubs and clubs is 20.

Dr Sean Semple – who led the research team from Aberdeen University and the Institute of Occupational Medicine in Edinburgh – said: "Our bars have had a huge change in air quality. It's now almost down to the level of outside air.

"In the US, a level above 65 is termed as unhealthy while anything above 250 is seen as a health hazard. Yet before the ban some samples were almost FOUR times that.

"It's not hard to imagine how bad that is for your health."

Pub bosses have welcomed the findings. Steve Mallon, MD of Maclay Inns, said: "The smoking ban has had excellent benefits for our staff. The air quality is much fresher."

And James Rusk, of the Blue Cat bar and restaurant chain, said: "All our customers are a lot happier eating and drinking in non-smoking surroundings.

"We've seen a substantial rise in FOOD revenues, while alcohol sales have remained consistent."

Inspections

The study was commissioned by the Scottish Executive and NHS Health Scotland.

Researchers visited bars in Edinburgh and Aberdeen city centres plus rural pubs in Aberdeenshire and the Borders.

More than 3,900 inspections were carried out between March and May – and 90.4 per cent of premises were found to be free of smoking activity.

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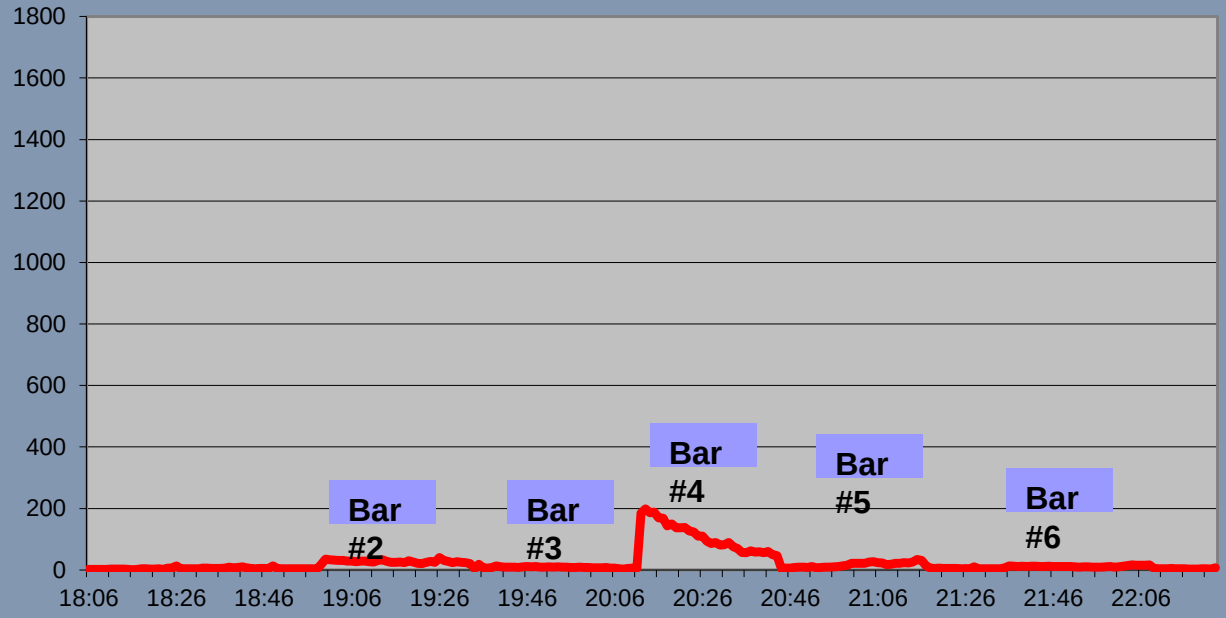
THE FUME FACTOR

5 MICROGRAMMES AT THE TOP OF BEN NEVIS

15-25 MICROGRAMMES ON A CITY CENTRE STREET

900 MICROGRAMMES IN PUBS BEFORE THE BAN

20 MICROGRAMMES IN PUBS AFTER THE BAN



The sizes of things

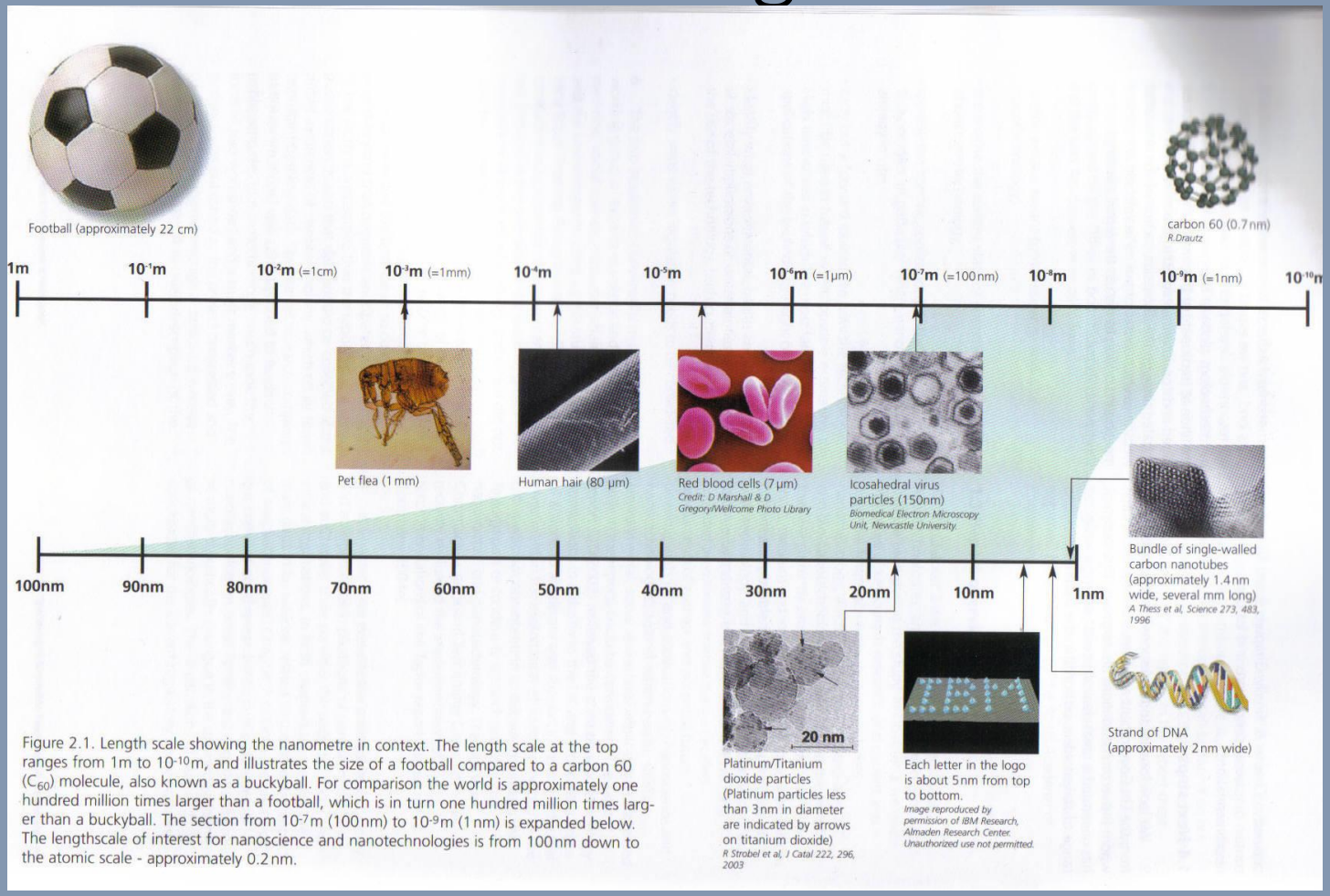
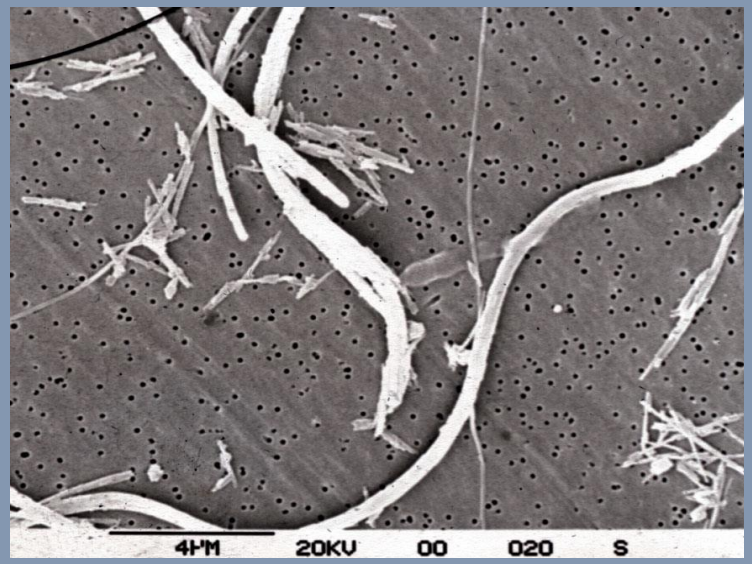
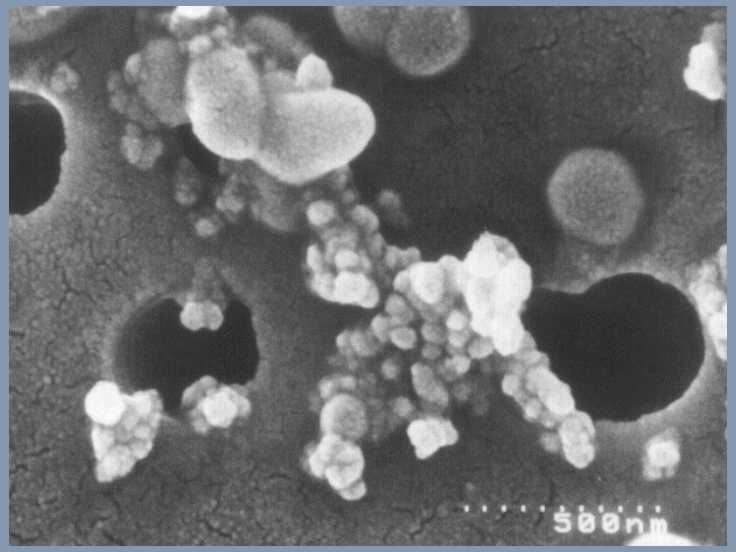


Figure 2.1. Length scale showing the nanometre in context. The length scale at the top ranges from 1m to 10^{-10}m, and illustrates the size of a football compared to a carbon 60 (C_{60}) molecule, also known as a buckyball. For comparison the world is approximately one hundred million times larger than a football, which is in turn one hundred million times larger than a buckyball. The section from 10^{-7}m (100nm) to 10^{-9}m (1nm) is expanded below. The lengthscale of interest for nanoscience and nanotechnologies is from 100nm down to the atomic scale - approximately 0.2nm.

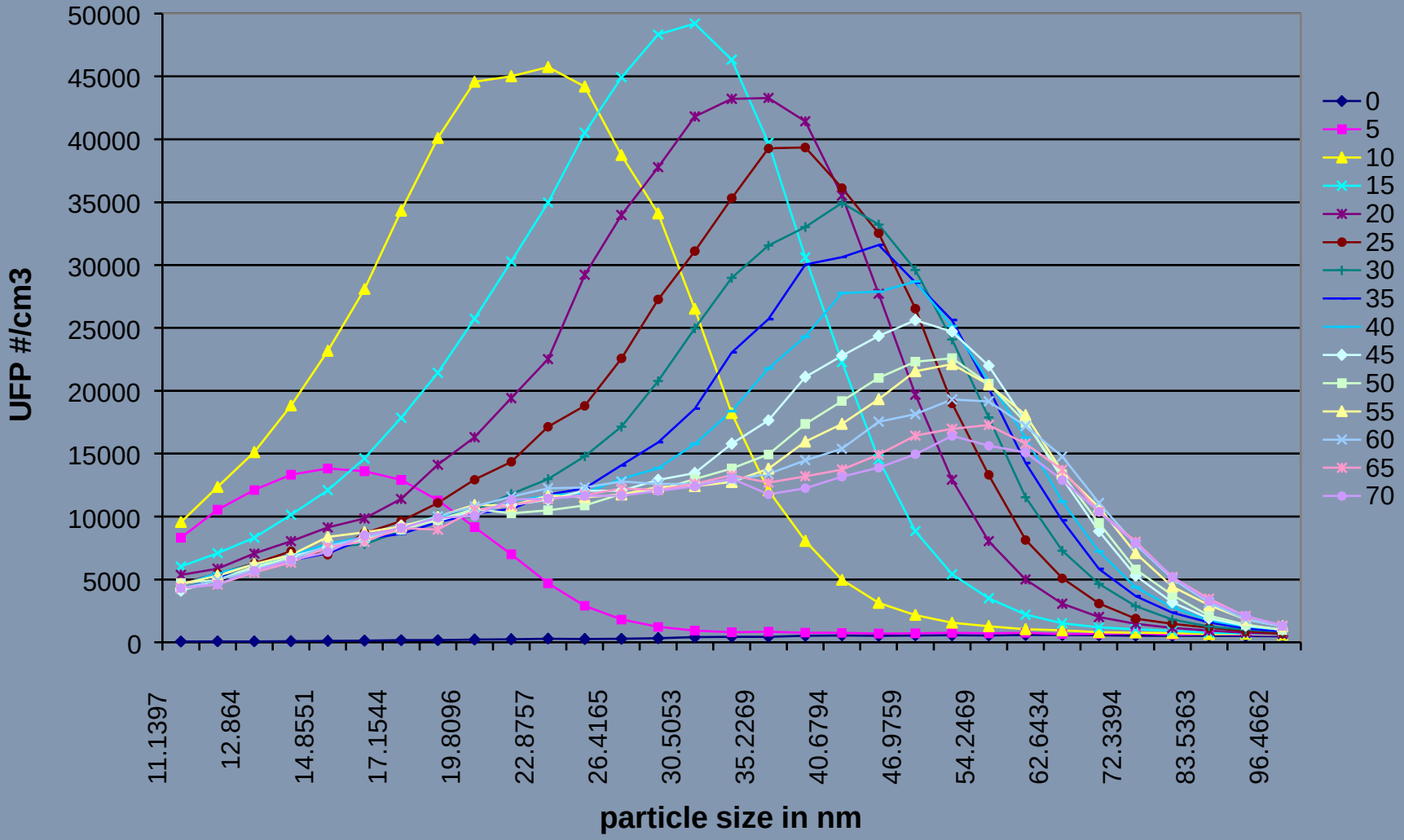
Familiar nanoparticles

- Fibers
  - asbestos
  - carbon fibers
  - erionite
- Spherical particles
  - combustion-generated
    - vehicles
    - industry
    - cigarettes, cookers
  - photochemical

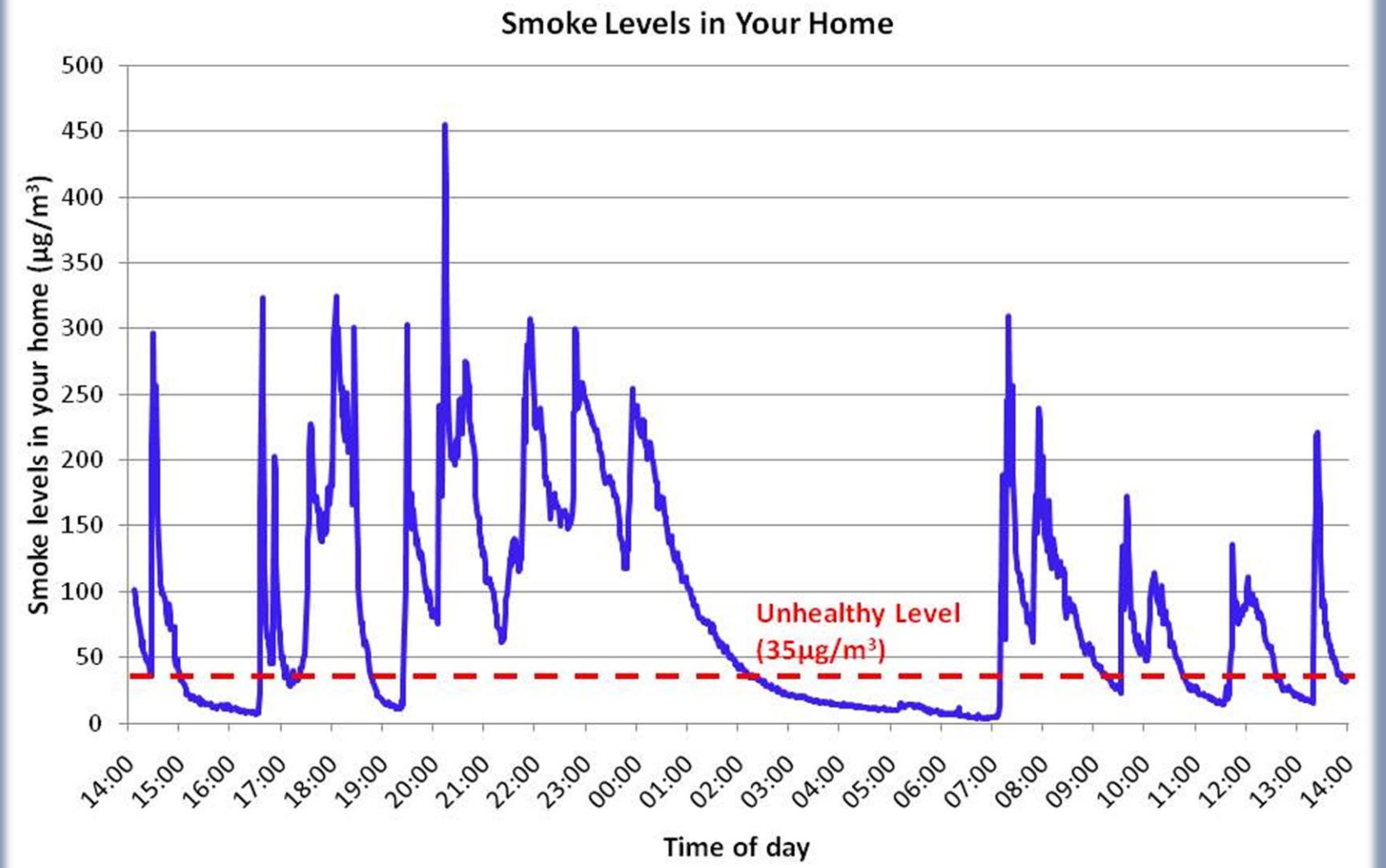




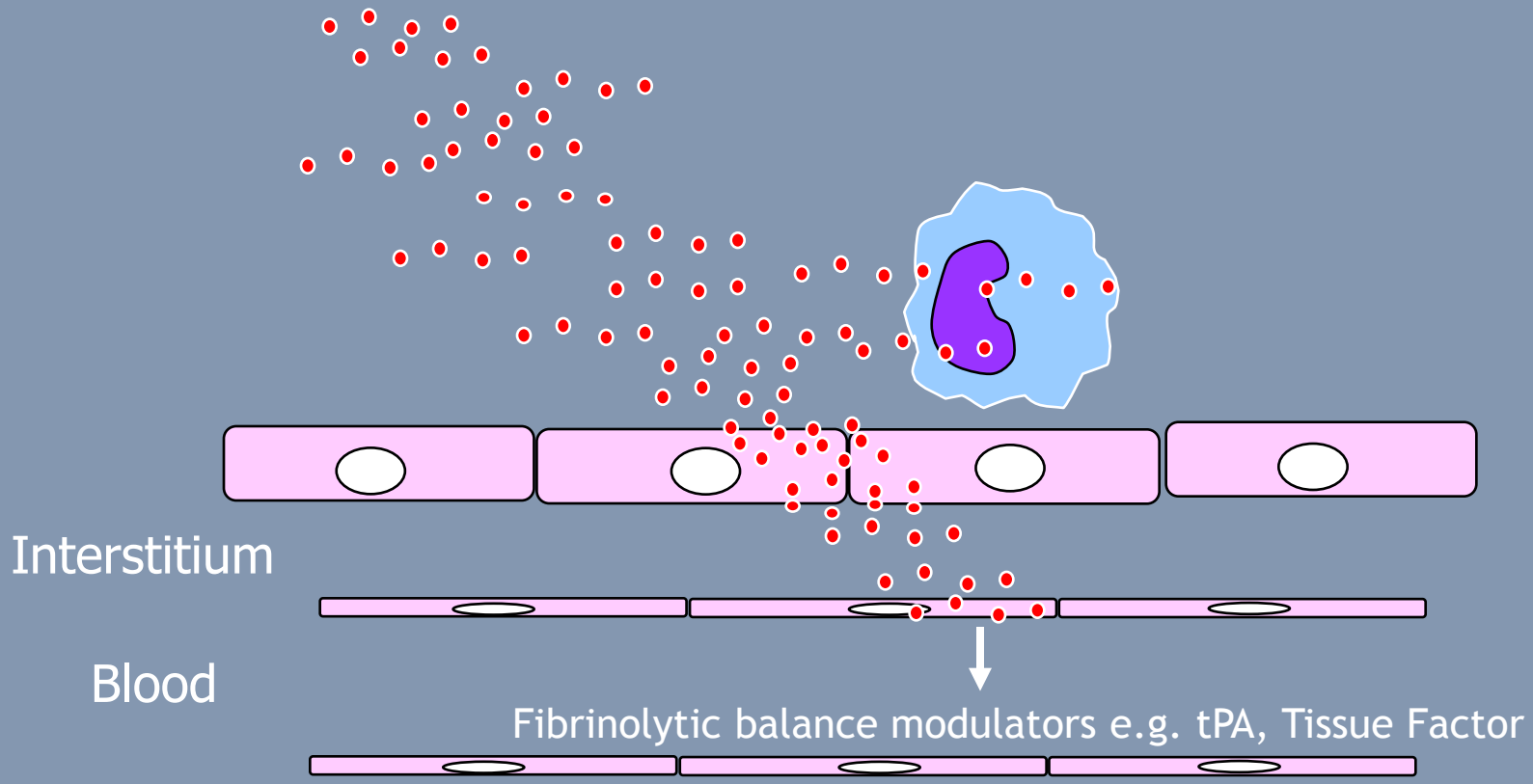
Particle size distribution in time after the ignition of 4 gas rings (full power)



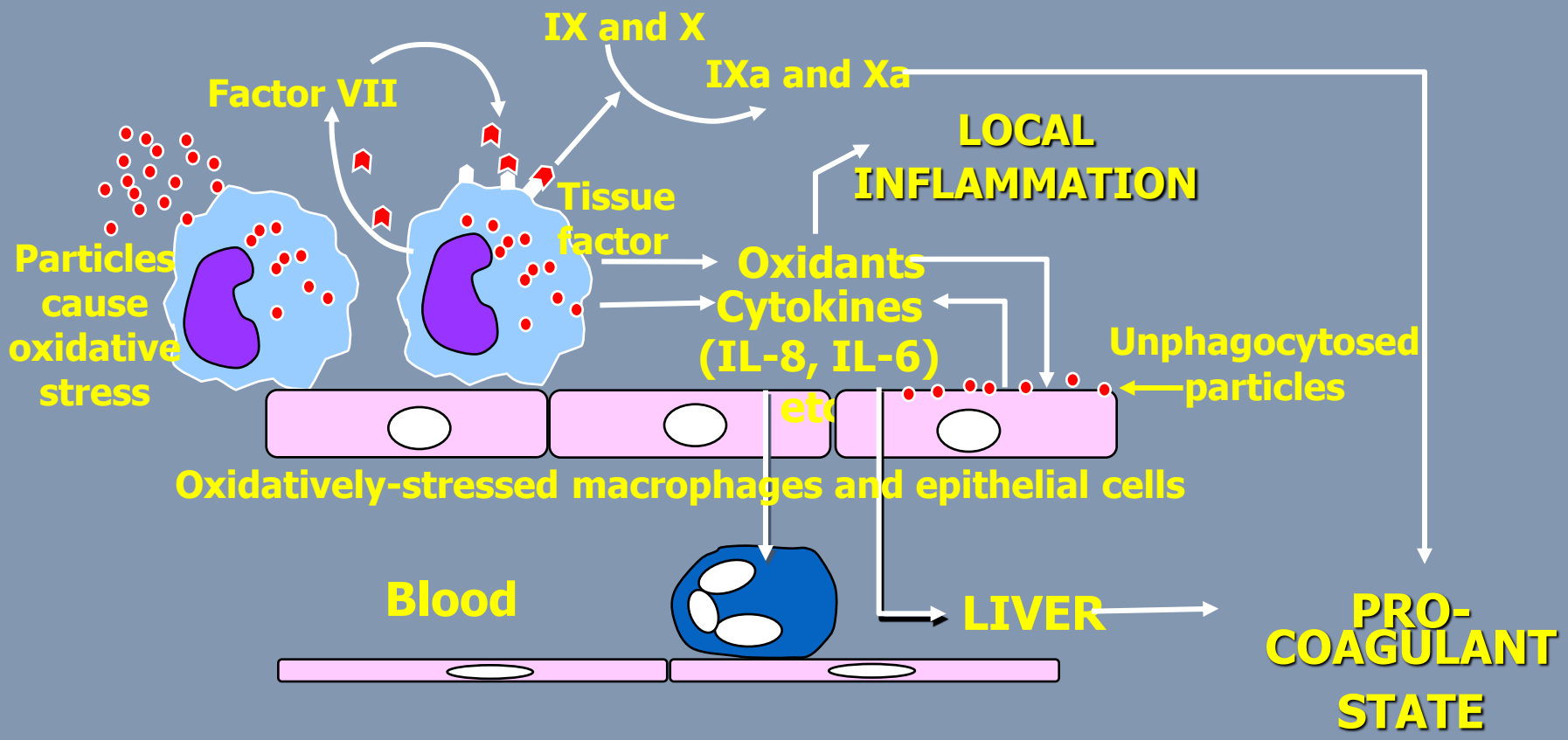
Smoking indoors



The smallest particles reach the alveoli, potentially causing inflammation or infection



Possible mechanisms for the production of local inflammation and a systemic pro-coagulant state after PM10/2.5 exposure



Hazards in the air

- Gases:
  - oxygen, carbon dioxide, nitrogen etc, radon
  - combustion – oxides of nitrogen, carbon monoxide, sulphur dioxide
- Vapours:
  - water - humidity
  - organic chemical emissions from cleaning fluids, paints, etc
  - odours
- Particles and fumes:
  - mineral
  - photochemical
  - combustion, industrial activity
- Microbes:
  - bacteria and viruses
  - fungal spores
  - arthropod faeces, etc

The roles of buildings

- Protection from the weather
- Protection from pollution
- Temperature and humidity control
- Provision of services – energy , communications, nutrition, etc
- Workplace, meetings and socialising.
- To impress neighbours, fellow architects, etc

Mechanisms of harm

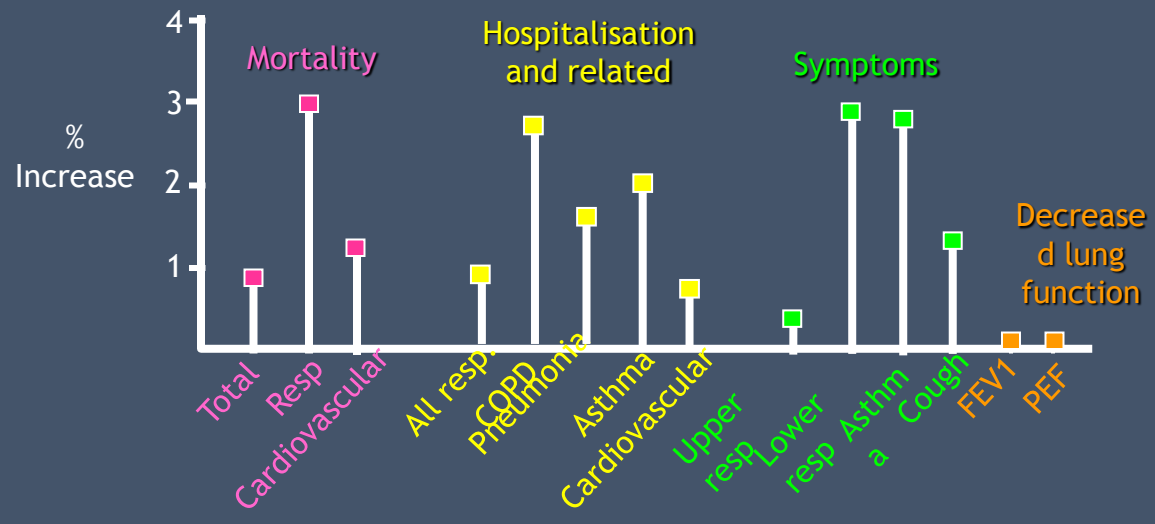
- Suffocation – insufficient oxygen, CO, H_2S
  - mines, tanks, toxic gases
- Irritation – too acidic or alkaline
  - Chlorine, household chemicals
- Allergy – nose, lungs or skin
  - washing products, fungi, mites
- Infection – microorganisms
  - *Legionella*
- Carcinogenesis – inflammation or gene damage
  - radon gas, asbestos

Ways in which particle measurement is expressed

- PM_{10} – mass of particles with an aerodynamic diameter less than 10μm (μg/m^3)
- $PM_{2.5}$ – mass of particles with an aerodynamic diameter less than 2.5μm (μg/m^3)
- PNC – number of particles in a cubic centimeter of air
- μm – one millionth of a meter.
- Nanometer – one thousand millionth of a meter!

Percentage change in any health end-point for a 10μg/m^3 increase in outdoor PM_{10}

(summarised from over 100 studies)



From Pope 2000

What *Aspergillus fumigatus* does (and *Penicillium notatum* doesn't do)

- grows happily on a culture of macrophages
- stops phagocytosis and killing

- Why? Because it doesn't like being eaten by amoebae!
  - (Lancet 1989;i:893)