British Heart Foundation

Electric Vehicle Event
Napier, Edinburgh, 10th Oct 2018

THE UNIVERSITY OF EDINBURGH

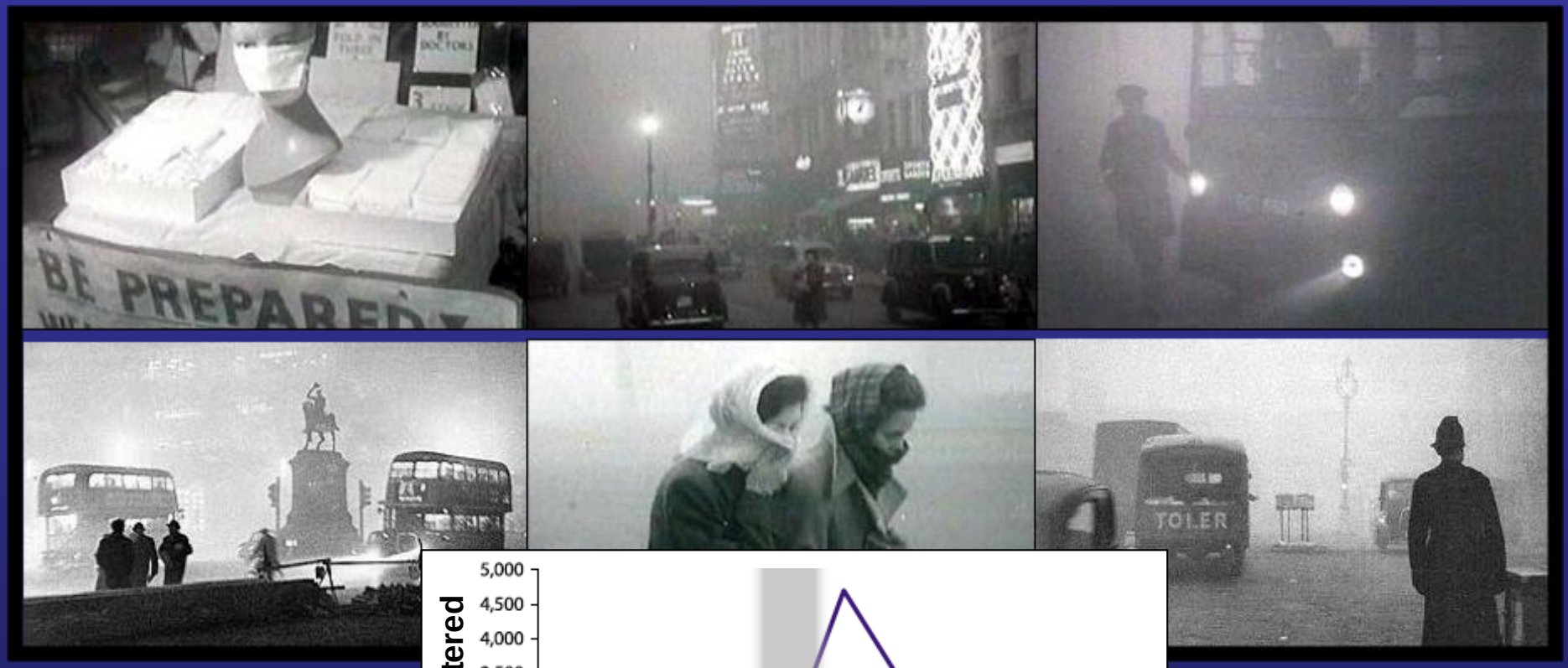
Diesel exhaust and your heart: A particularly small problem

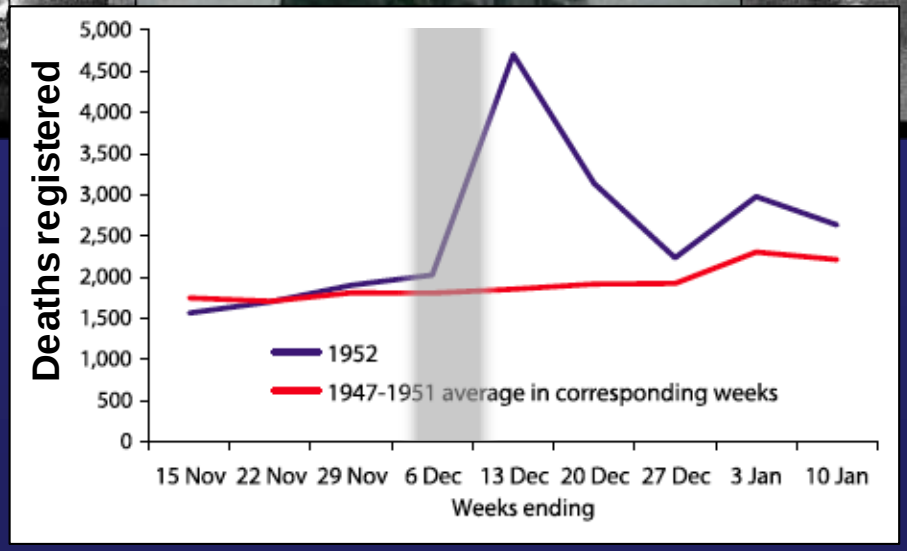
Dr Mark R. Miller

Centre for Cardiovascular Science
University of Edinburgh

mark.miller@ed.ac.uk

The Great Smog of London





Air pollution – facts and figures

Scotland:

2,100 – 3,500 deaths per year

Responsible for 3.9% of deaths of people over the ages of 25

INDEPENDENT News Voices Culture Lifestyle Tech Sport

Environment

Air pollution 'kills 3.3 million a year worldwide'

Scientists say the figure is likely to double by 2050

Steve Connor | @SteveAConnor | Wednesday 16 September 2015 18:00 BST | 0 comments

7K shares

World Health Organization

entre Publications Countries Programmes Governance About WHO

Media centre

7 million premature deaths annually linked to air pollution

News release

25 MARCH 2014 I GENEVA - In new estimates released today, WHO reports that in 2012 around 7 million people died - one in eight of total global deaths – as a result of air pollution exposure. This finding more than doubles previous estimates and confirms that air pollution is now the world's largest single environmental health risk. Reducing air pollution could save millions of lives.

World-wide:

3 - 7 million deaths per year

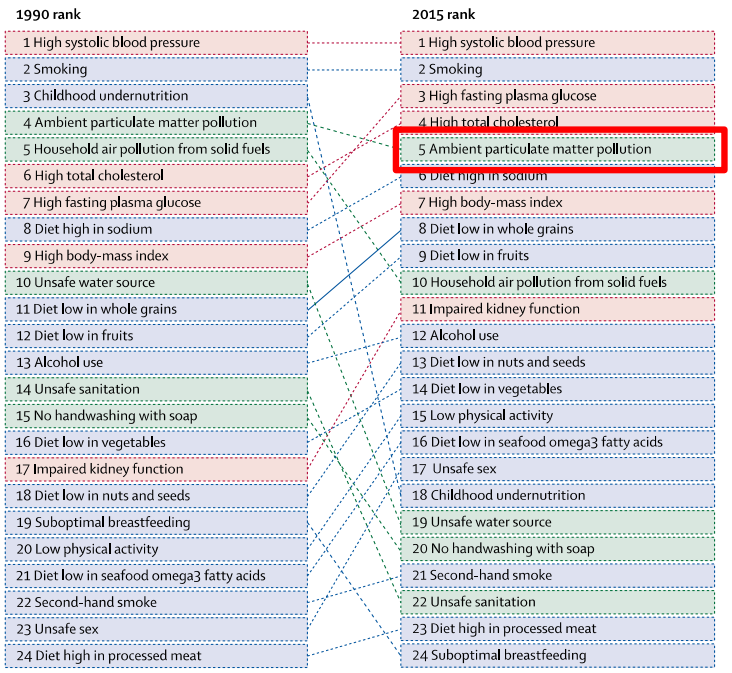
Responsible for 6% of all deaths globally

Air pollution as a risk factor for disease

The world-wide effects of air pollution are considerable

MORTALITY: 800,000 - 7 million deaths per year

MORBIDITY loss of more 5 million work days per year



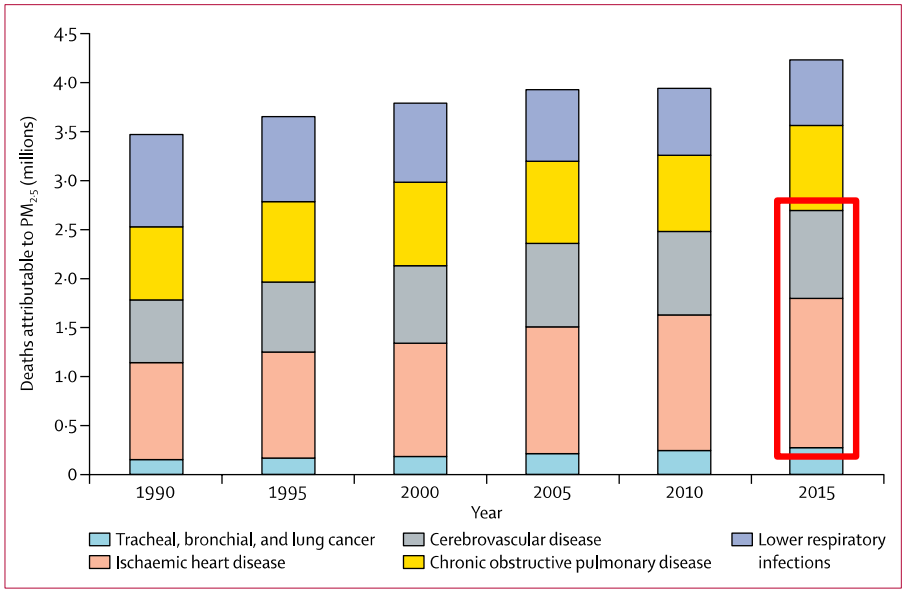


Figure 4: **Deaths attributable to ambient particulate matter pollution by year and cause**
$PM_{2·5}$=particle mass with aerodynamic diameter less than 2·5 μm.

Cohen et al. 2017. Lancet 389: 1907-18

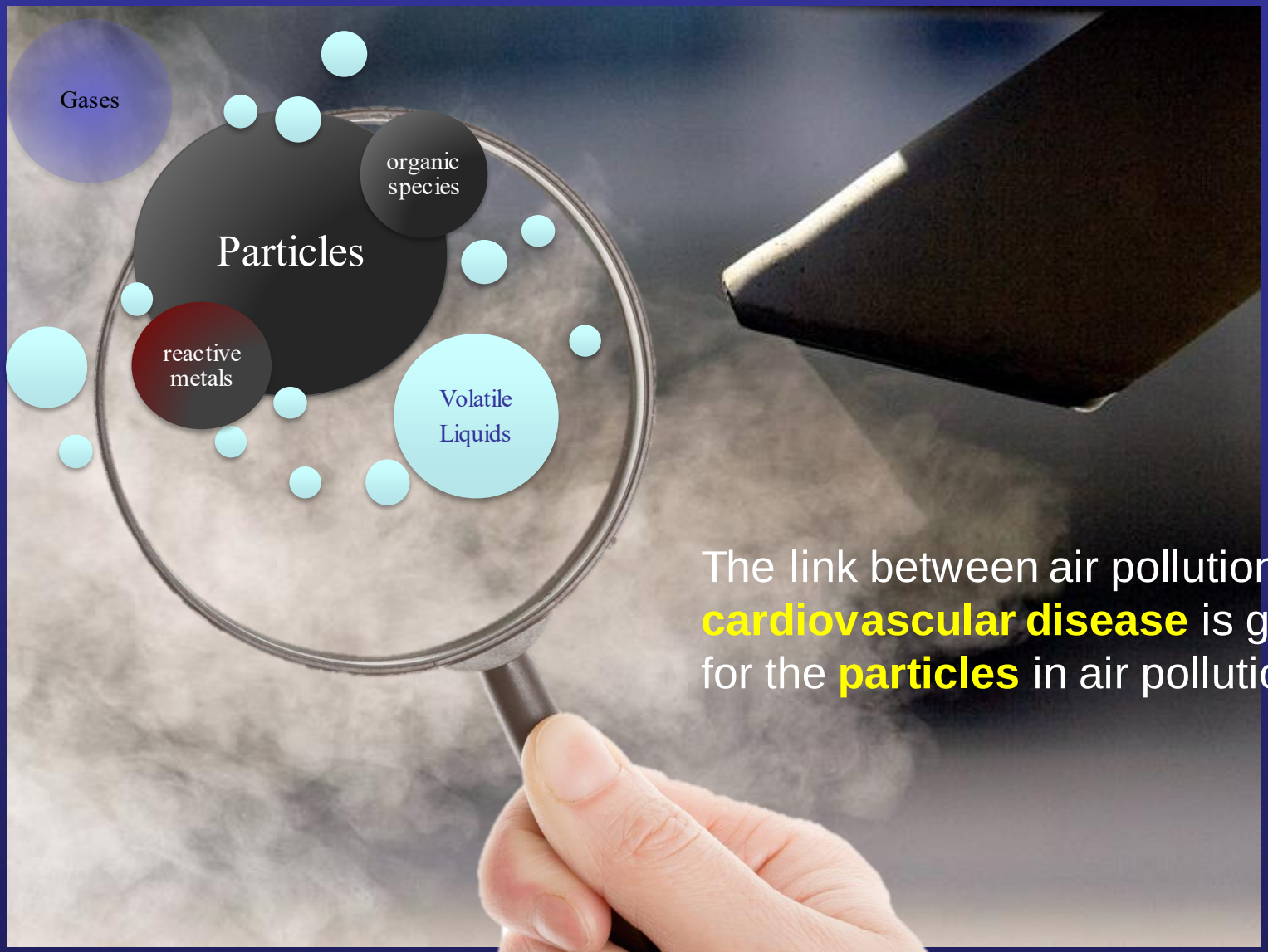
Air pollution and the cardiovascular system

- **Short term exposure to air pollution** linked to heart attacks
- **Long term exposure to air pollution** linked to heart disease

- **Underlying cause for link unknown**.

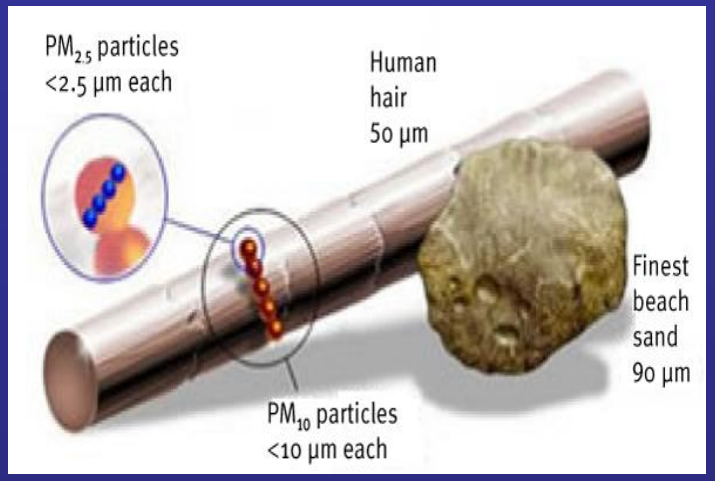
  - How does pollution cause cardiovascular effects?
  - Which components of air pollution are responsible?

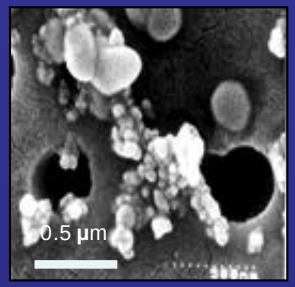
What is air pollution?



The link between air pollution and **cardiovascular disease** is greatest for the **particles** in air pollution

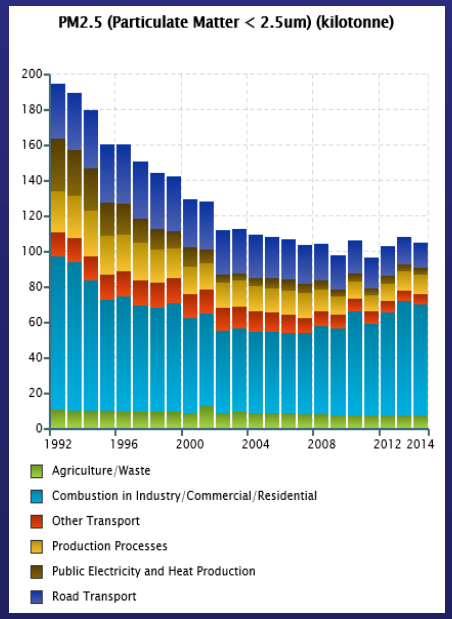
Airborne Particulate matter (PM)

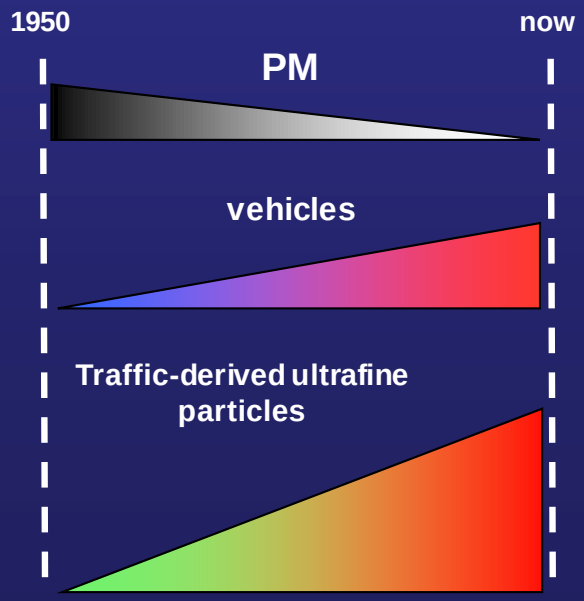




	(µm)
"Coarse" (PM_{10}):	**<10.0**
"Fine" ($PM_{2.5}$)	**<2.5**

PM_{10} is measured as the **mass** of particles with an aerodynamic diameter of 10 µm or less



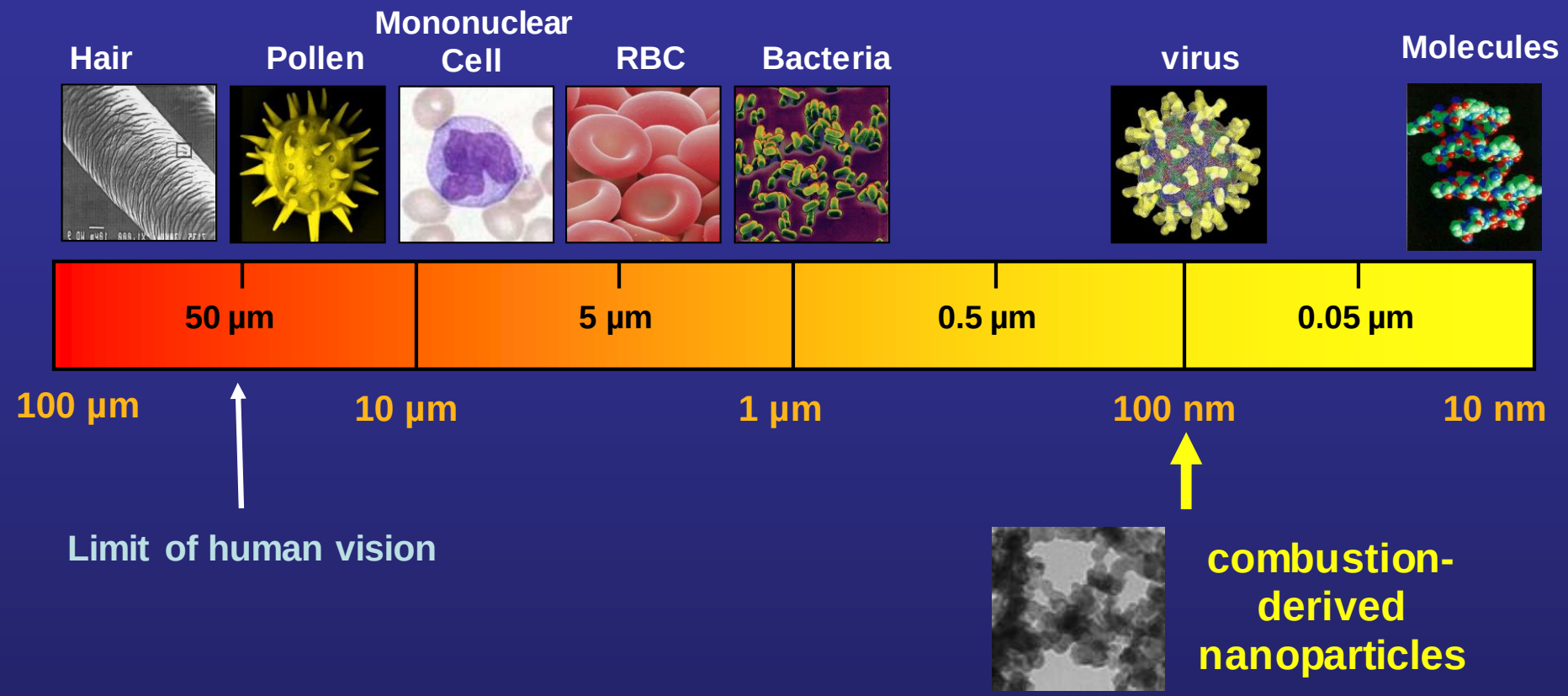


Vehicle exhaust is rich in ultrafine particles

"Ultrafine" ($PM_{0.1}$): <0.1

(nanoparticles, <100 nm)

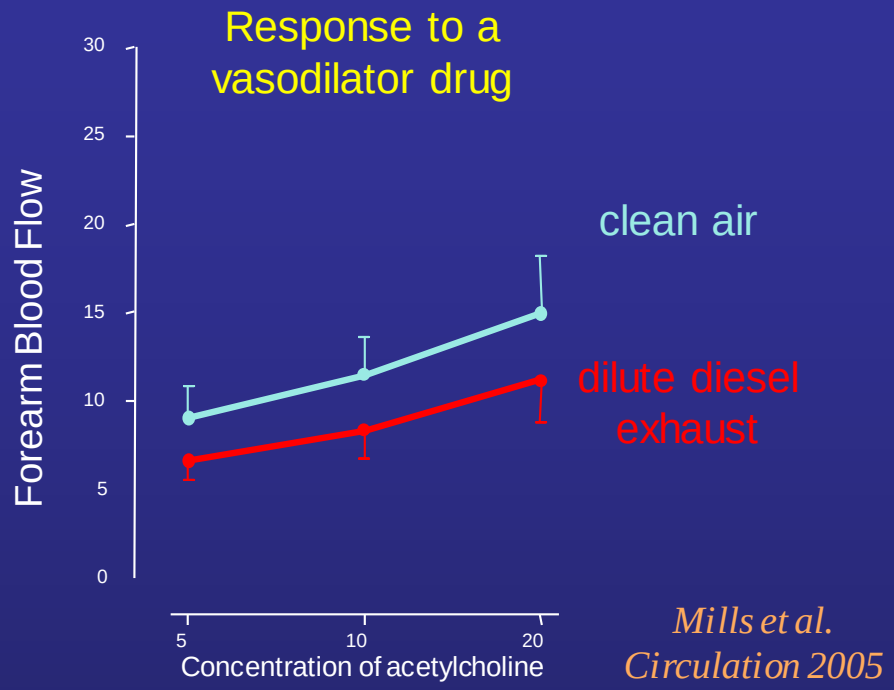
Ultrafine particles / Nanoparticles



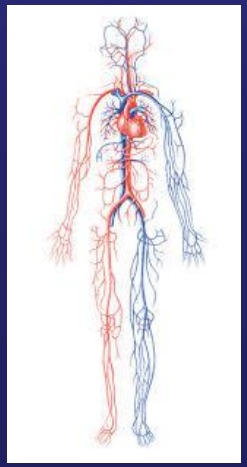
- Believed to be especially harmful
- Mass vs surface area
- Diesel engine exhaust rich in nanoparticles

Controlled exposure to dilute diesel exhaust

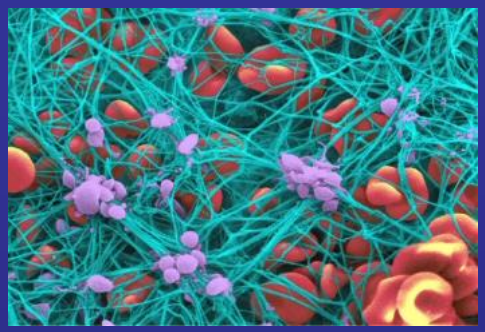
Blood vessel relaxation

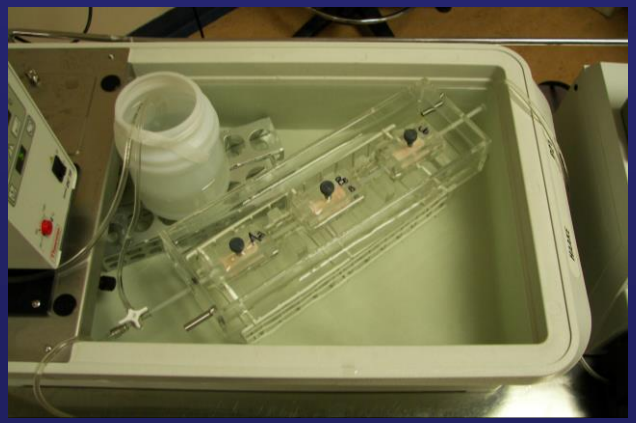


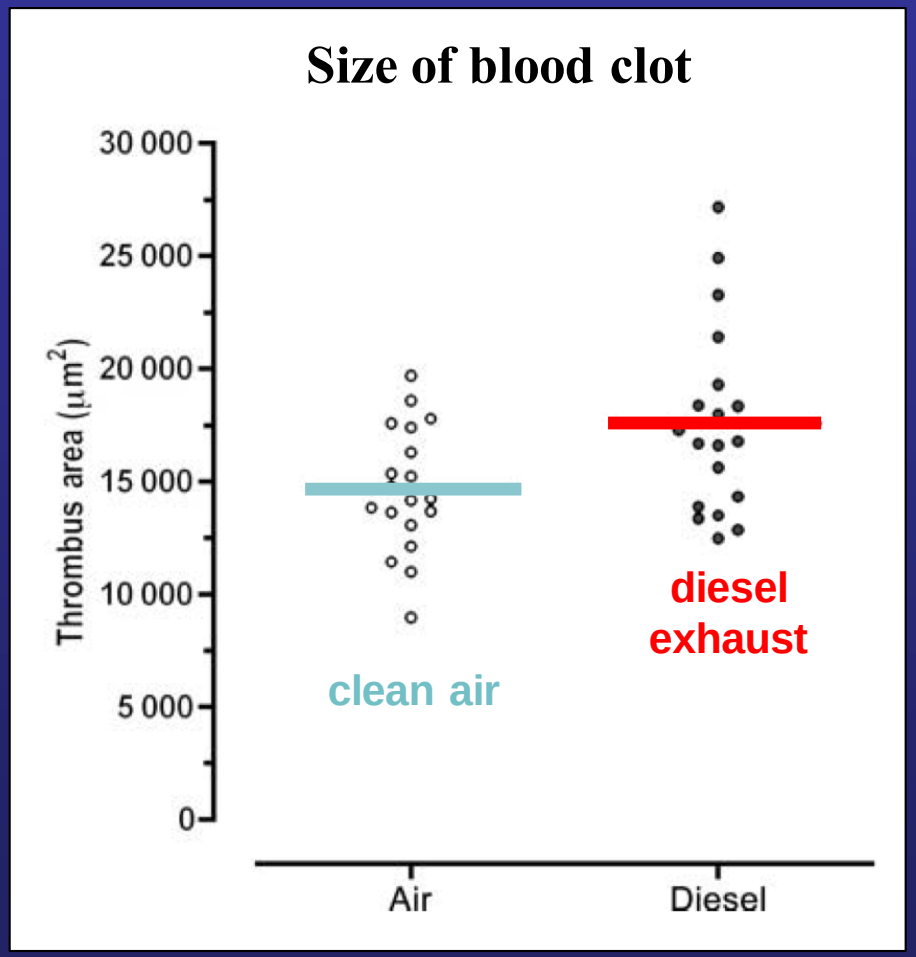
Mills et al. Circulation 2005



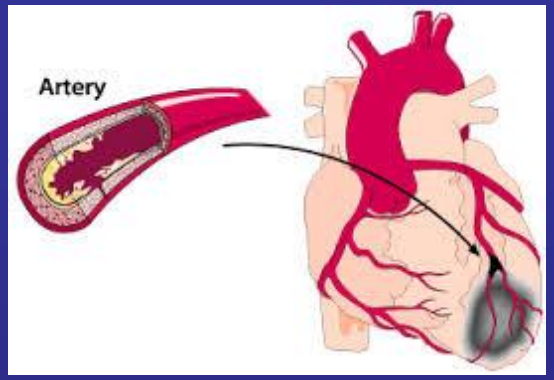
Blood Clotting



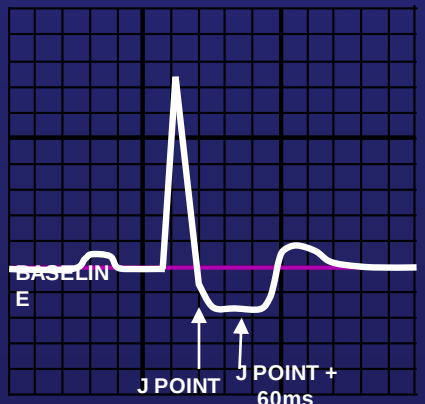




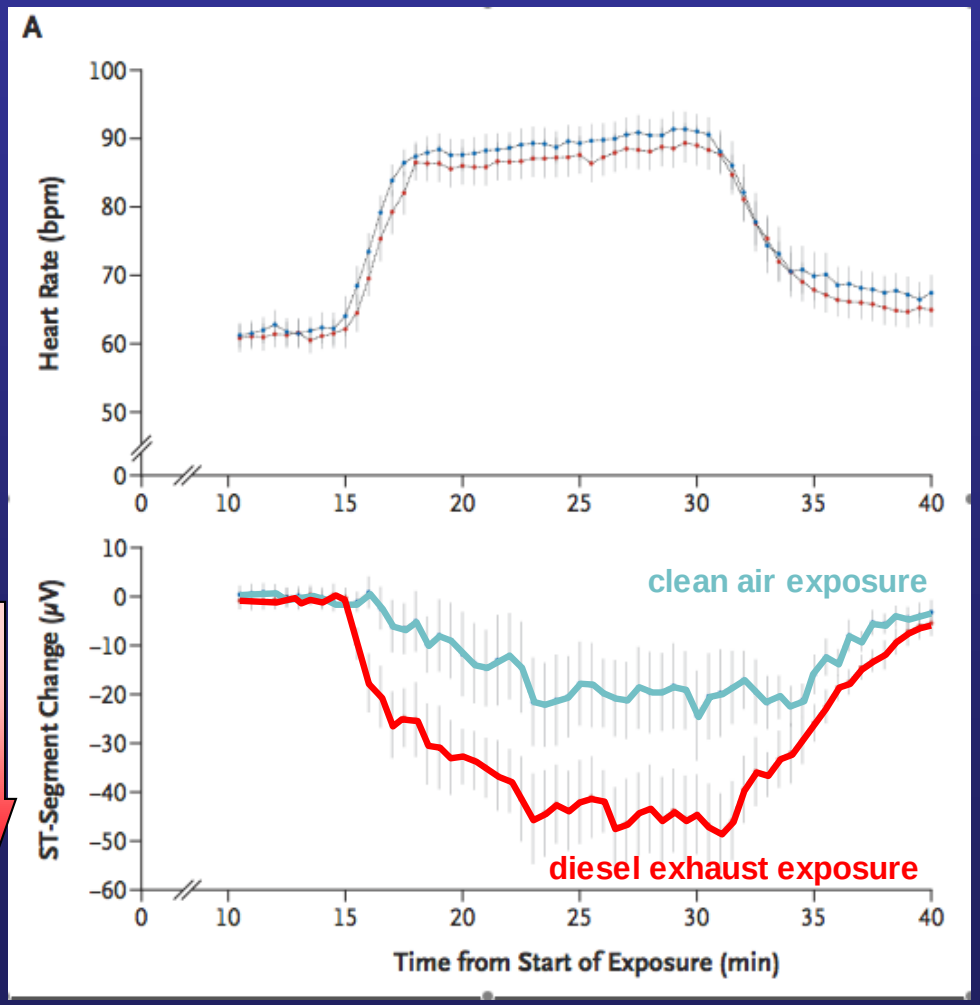
Cardiac Ischaemia



ST-SEGMENT DEPRESSION



Worsening cardiac ischaemia



Effects of air pollution around the body

Neurodegenerative Diseases

Impaired cognition
Altered behaviour

Depression

Stem cell alterations

Liver toxicity

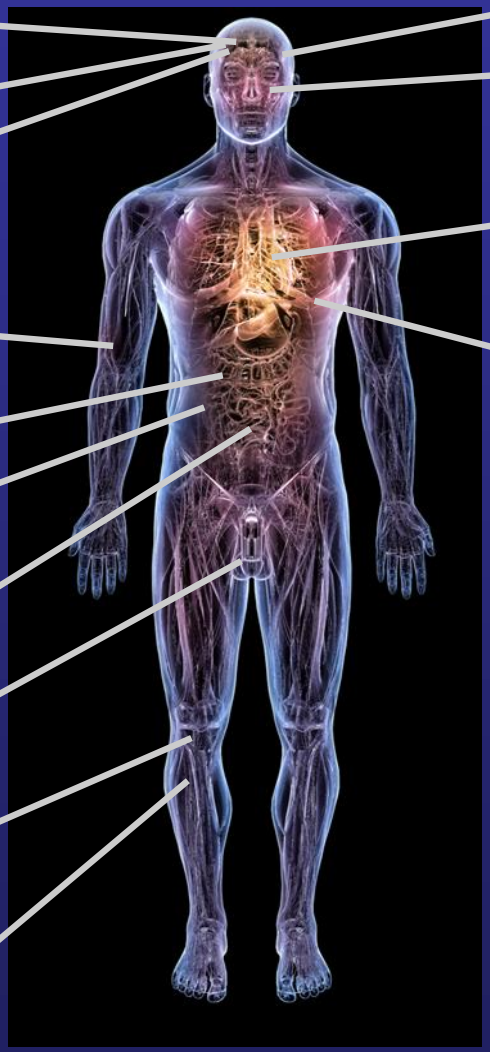
Renal Disease

Metabolic syndrome & Diabetes

Decreased Fertility

Autoimmune rheumatic diseases

Peripheral artery disease



Stroke

Olfactory deficits

Cardiovascular disease

Asthma
COPD
Respiratory infection
Lung cancer

Pre-eclampsia

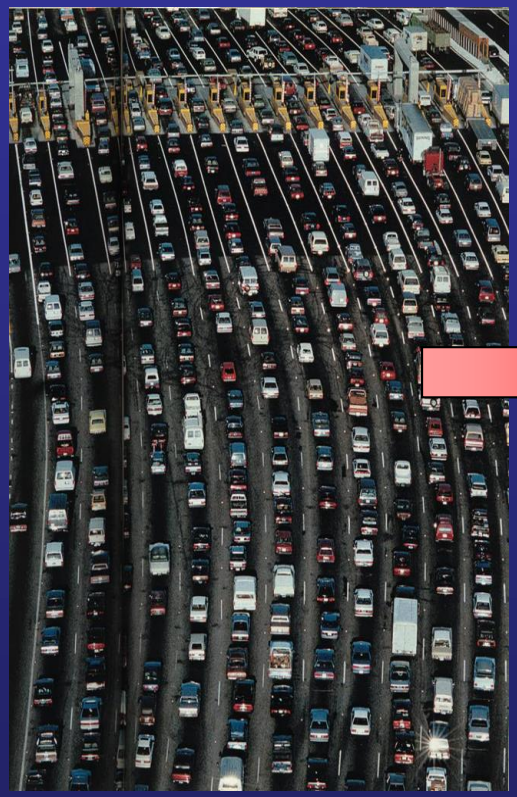
Premature birth

Low birth weights

Epigenetic changes

Detrimental health effects in offspring

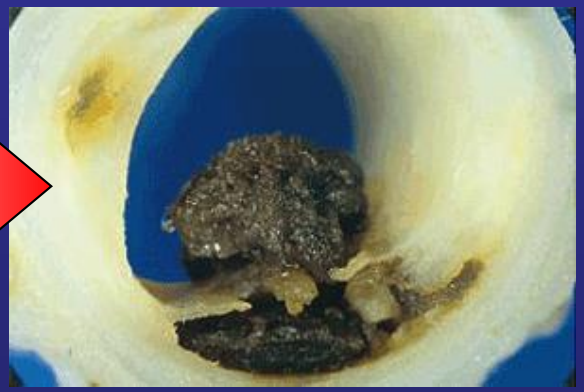
Biological mechanisms for the cardiovascular effects of air pollution



Air pollution

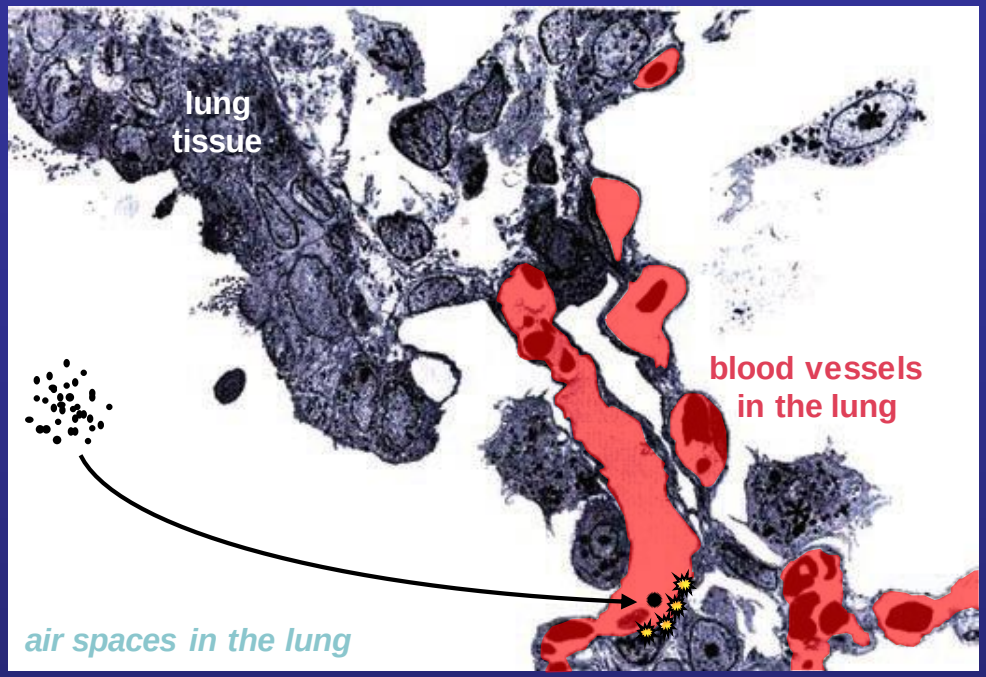
lungs

?



cardiovascular disease

Do particles move ('translocate') into the blood?

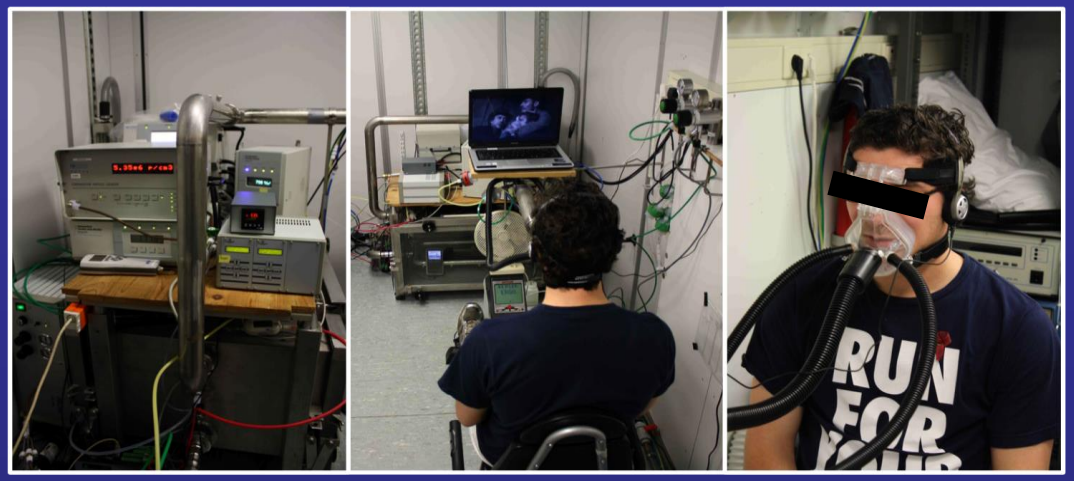


- How inhaled particles cause effects elsewhere in the body?
- Several different theories
- Can nano-particles cross into the blood and by carried around the body?
- Measuring carbon nanoparticles in the body is difficult

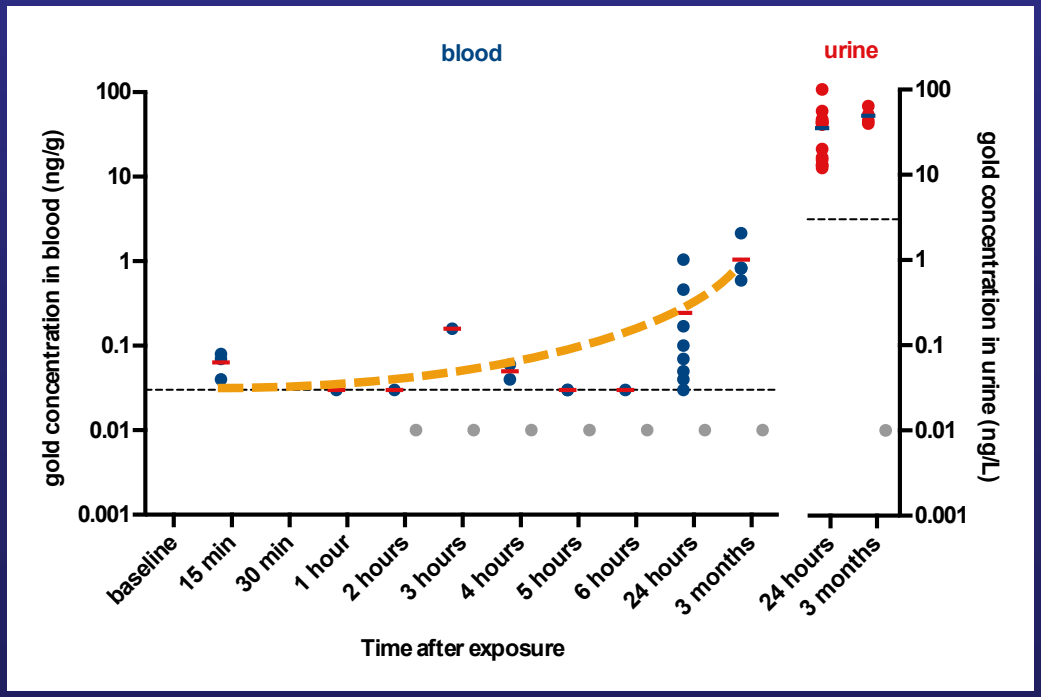
Why use gold?

- Size similar to particles in diesel exhaust
- Non-harmful
- Specialised techniques to measure very low levels

Tracking inhaled gold nanoparticles

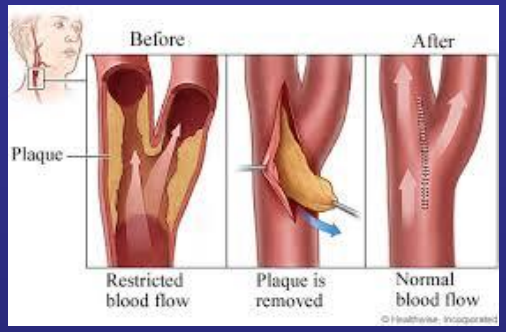


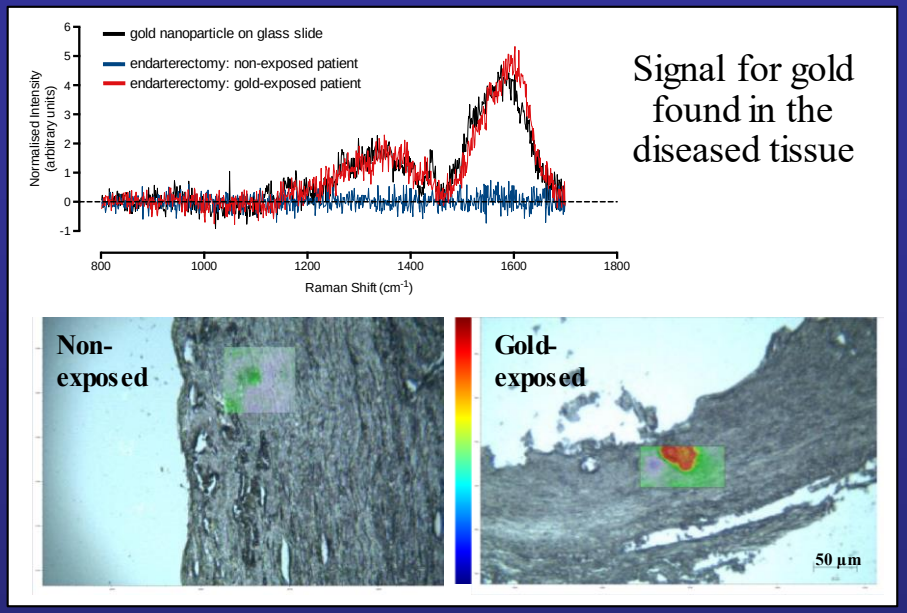
- 2-hour inhalation of gold nanoparticles during intermittent exercise
- Blood samples from 15 min – 24h & 3 months
- 24-h urine collection



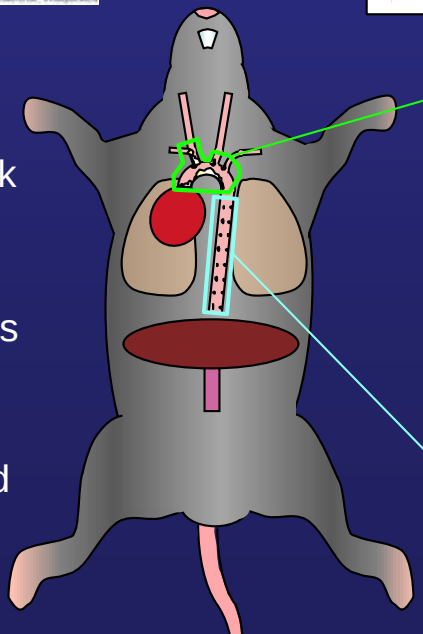
Gold nanoparticles accumulate at areas of vascular disease

- Patients with a history of stroke
- Inhalation of gold nanoparticles the day prior to surgery
- Atherosclerotic plaques removed from the major artery of the neck

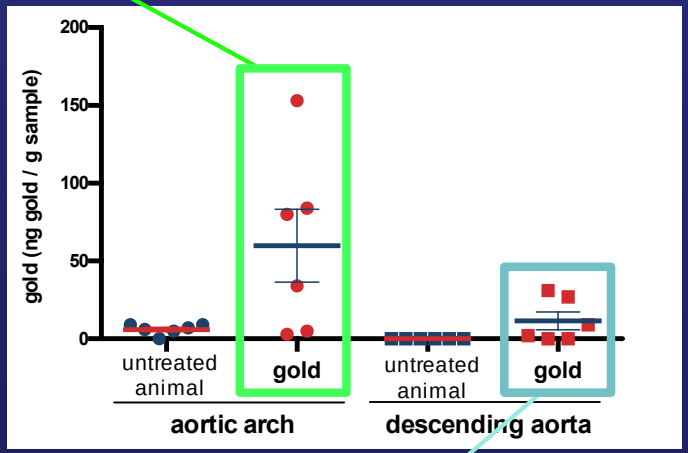




- Animal studies allow us to look at the biology more closely
- Administration of gold particles to the lung
- Look for gold in different blood vessels



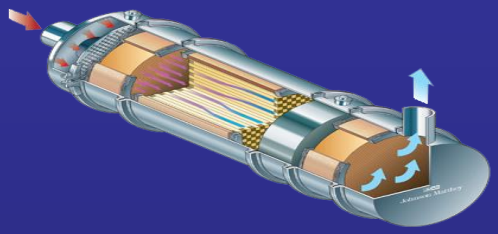
Aortic arch region – **heavily diseased** artery

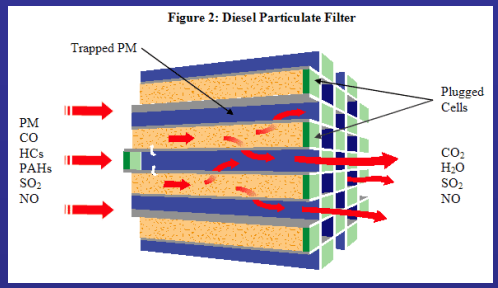


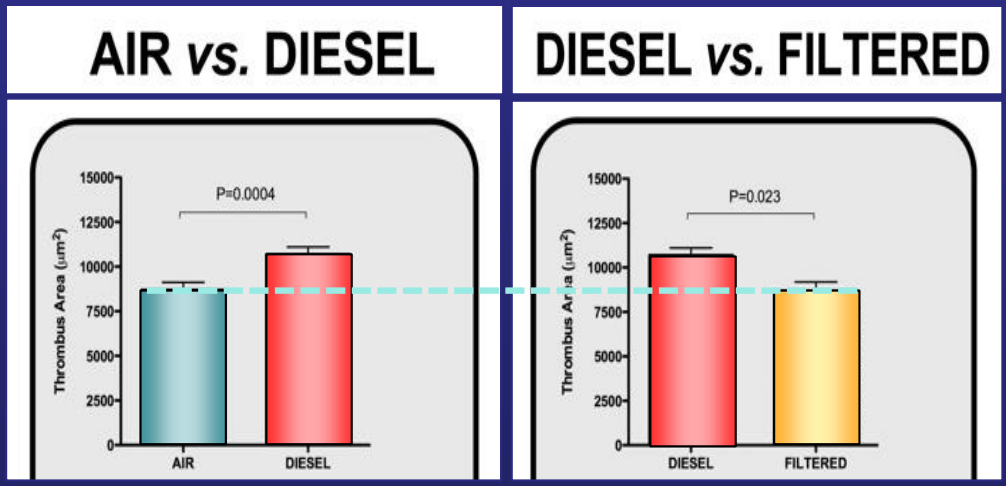
Descending Aorta – **artery with little disease**

Exhaust particle traps

- Use of ‘particle traps’ on exhausts of modern cars decreases particulate emissions







<u>But</u>…… Efficiency? Driving speed? Lifespan? Co-pollutants?

- There is still a need for alternative strategies to tackle vehicle emissions

Fuel additives

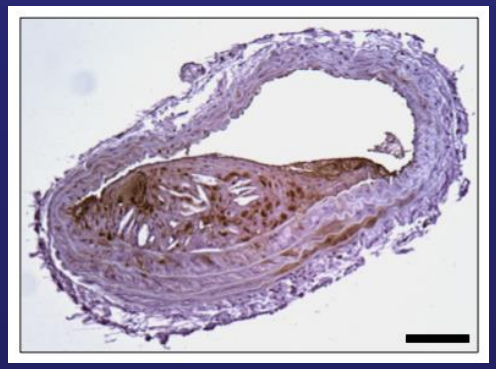
- Addition of additives to fuel to make combustion more efficient

Diesel fuel

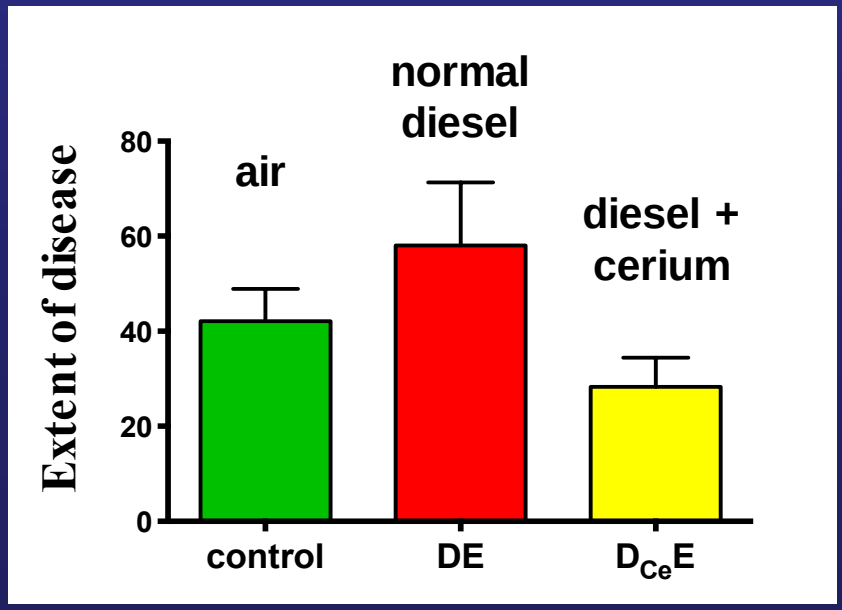
cerium catalysts

Fewer particles in exhaust

- 4 weeks inhalation
- mouse model of atherosclerosis



Cassee et al. 2012. Environ Res 115:1-10.



Summary

- Air pollution is responsible for many millions of premature deaths worldwide per year
- Diesel fumes harm the cardiovascular system in multiple ways
- Nanoparticles can enter the blood and reach areas of disease
- Removing the particles from vehicle exhaust reduces the harm to the cardiovascular system
- Adoption of electric vehicles is likely to make a major impact on reducing the health effects of air pollution

Acknowledgements

Centre for Cardiovascular Science

Steven McLean
Katie Shaw
Jeremy Langrish
Shea Connell
Alex Vesey
Andy Lucking
Simon Wilson
Anoop Shah
Paddy Hadoke
Nick Mills
Dave Newby

Centre for Inflammation Research

Jen Raftis
Ken Donaldson
Rodger Duffin

British Heart Foundation

THE COLT FOUNDATION
OCCUPATIONAL & ENVIRONMENTAL MEDICINE
The Foundation is a charity, registered No. 277189

DH Department of Health

Government of the Netherlands
Ministry of Infrastructure and the Environment

rivm
National Institute for Public Health and the Environment

Department of Chemistry

Colin Campbell
Pawitrabhorn Samutrtau

VU University, *Netherlands*

Petra Krystek

RIVM, *Netherlands*

Flemming Cassee
John Boere
Paul Fokkens
Dan Leseman
Miriam Gerlofs

Umea University, Sweden

Jenny Bosson
Thomas Sandstrom
Anders Blomberg

mark.miller@ed.ac.uk