Health Effects and What We Know and Can Do about Air Pollution and Cardiovascular Disease in Older Adults

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Does the Environmental Air Particle Pollution Contribute to Adverse Cardiovascular Health Effects?

YES!

Inhaled Air Pollution Particles Increases Morbidity and Mortality

- Increased levels of air pollution particles are associated with increased morbidity and mortality and attributable to cardiovascular and pulmonary causes particularly in older adults
- Biological mechanisms explaining PM-induced adverse cardiopulmonary health effects are not completely known but significant progress is being made

Adverse Health Effects of Air Pollution

Increased cardiopulmonary morbidity & mortality -

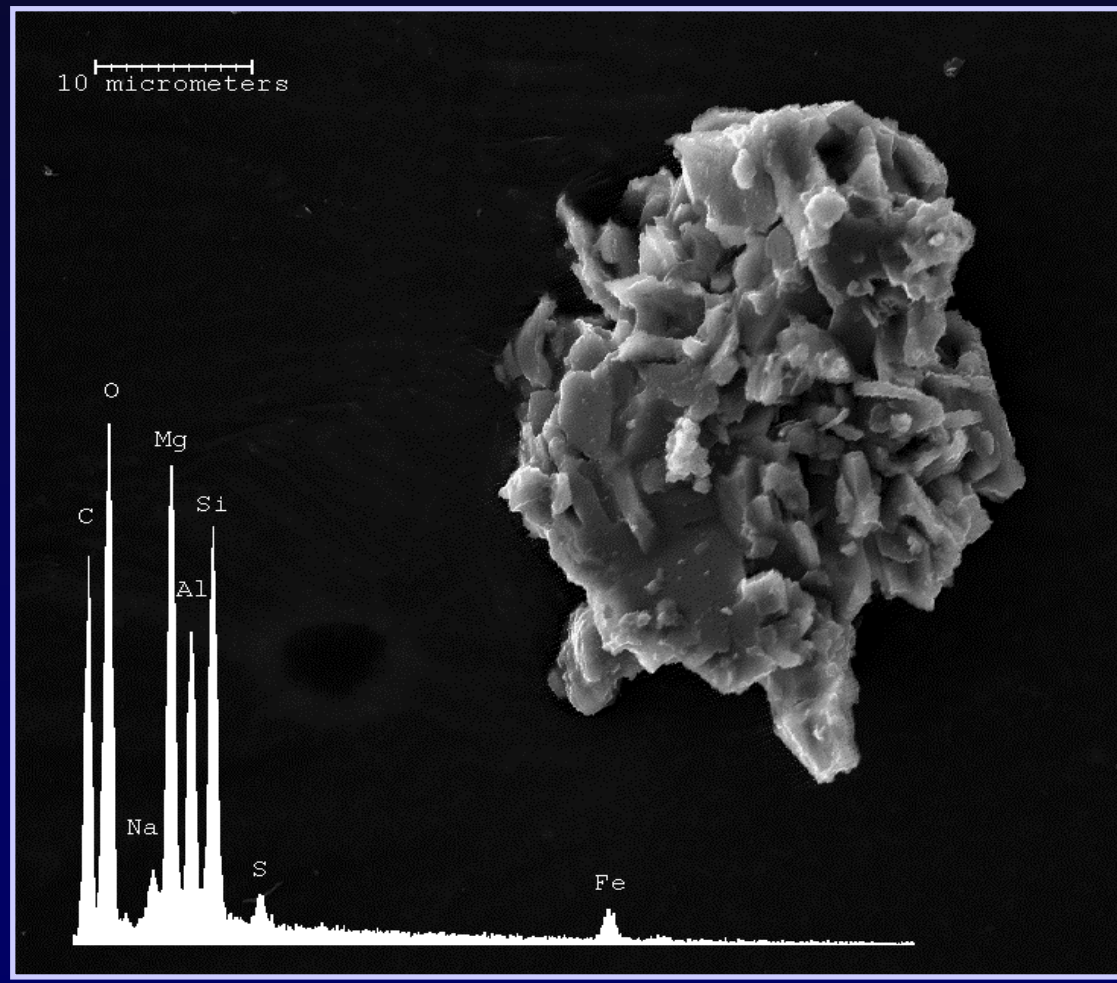
- Pulmonary
  - Acute
    - Asthma & COPD
  - Chronic
    - Lung function, lung cancer, lung development
- Cardiovascular
  - Acute
    - Heart attacks, arrhythmia, heart failure, stroke
  - Chronic
    - Premature death

Major Public Health Risks

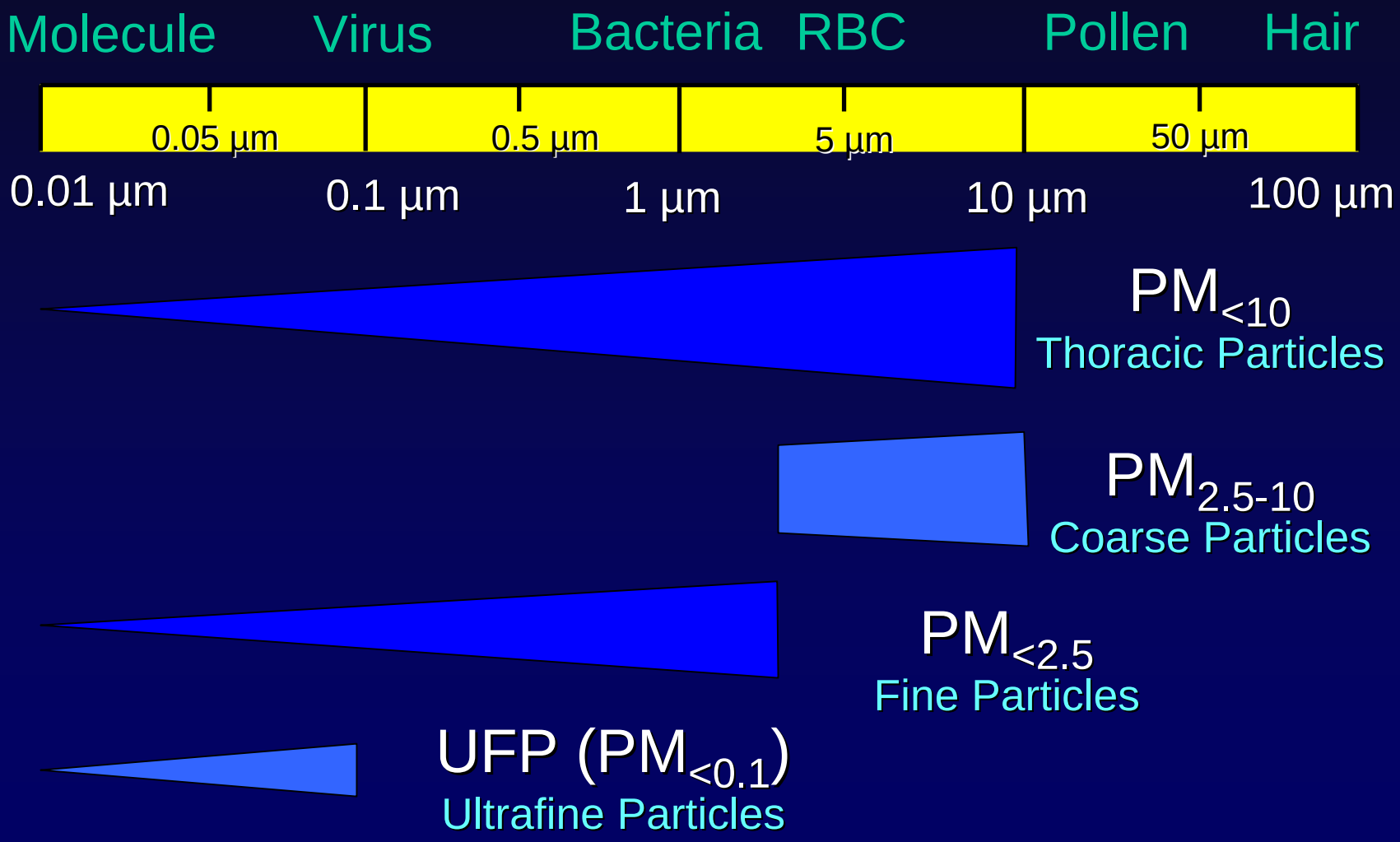
- Diabetes ~ 60,000 deaths annually in the US
- End Stage Renal Disease ~ 60,000 deaths
- Air Particle Pollution ~ 60,000 deaths

What is Air Particle Pollution?

- Aerodynamic diameter
  - <10 µm (PM_{10})
  - <2.5 µm ($PM_{2.5}$)
- Composition
  - Elemental Carbon
  - Metals
  - Sulfates / Nitrates
  - Organics
- Sources
  - Point
  - Mobile
  - Natural



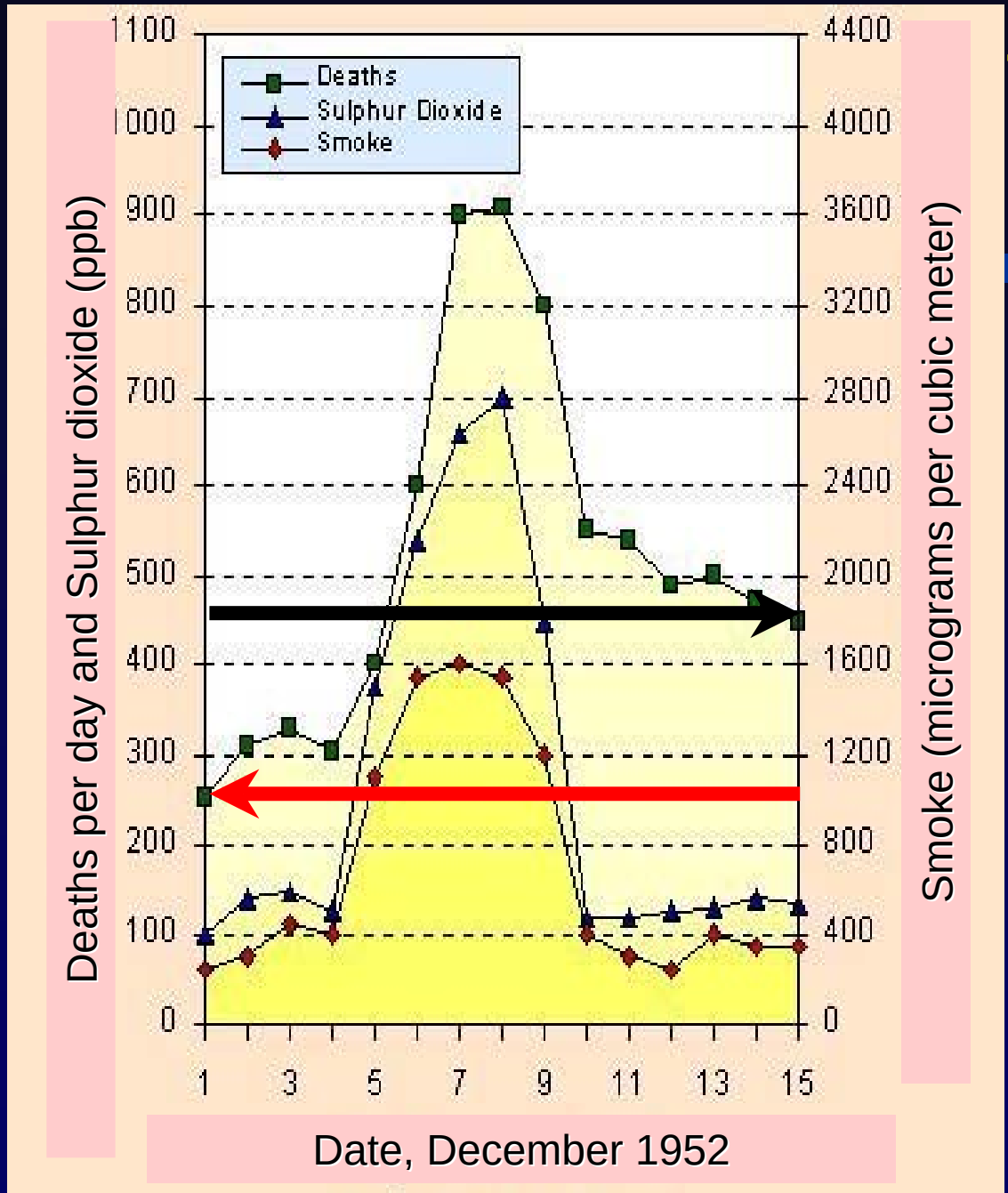
Size of Air Pollution Particles



Major Episodes of Lethal Smogs

- Meuse Valley in Belgium Dec 1-5, 1930
  - industrial pollution (steel mills, coke ovens, foundries and smelters
  - 10x normal mortality rate
- Donora, PA Oct 27-30, 1948
  - metal works, coal-fired home and industrial facilities, coke ovens and a zinc refinery, iron and steel industries
  - 6x normal mortality rate
- London, England Dec 5-9, 1952
  - coal-burning homes, power plants and factories
  - 9x normal mortality rate

The Great London Smog Dec. 1952



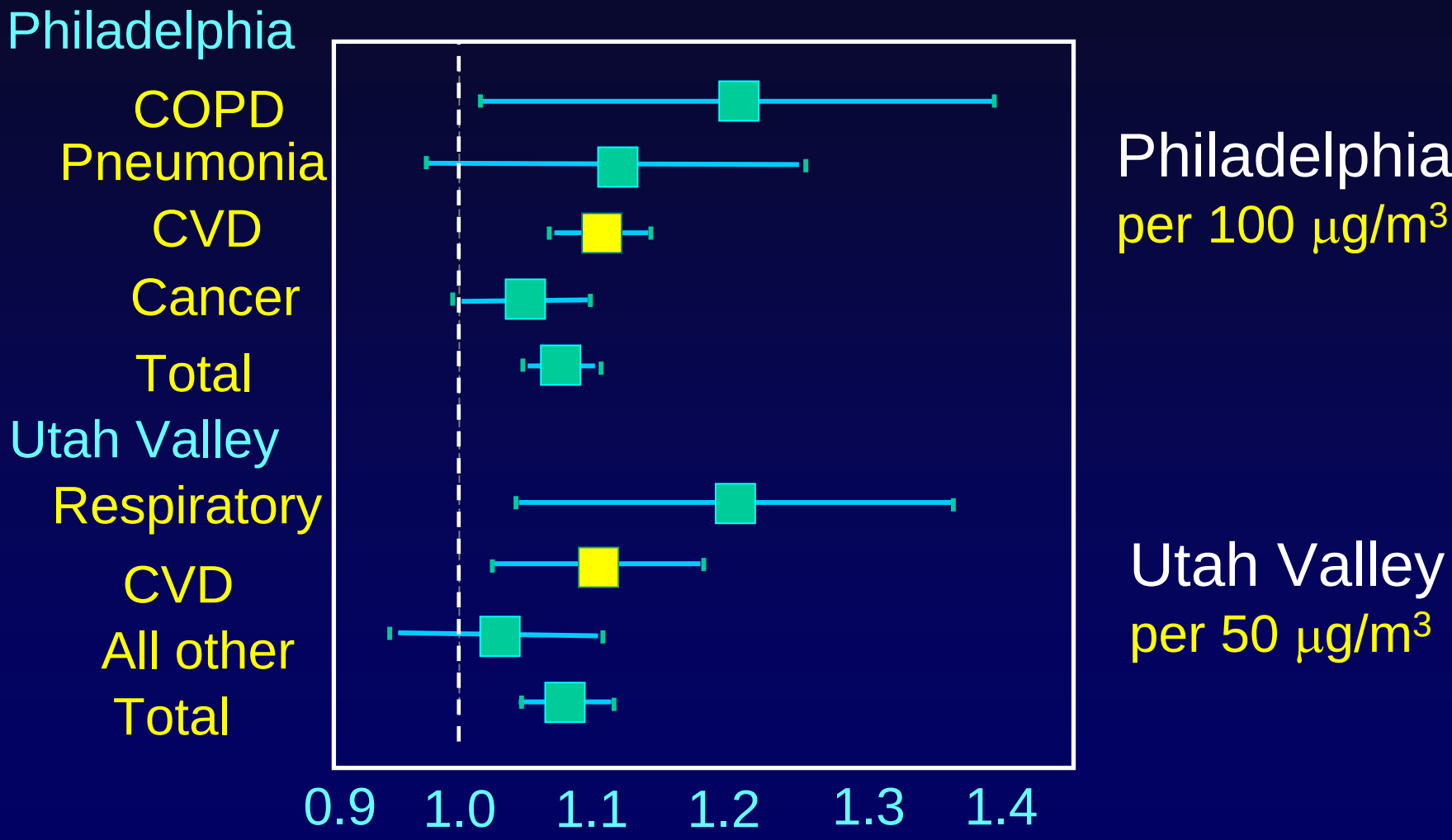
- 12,000 excess deaths
- 2/3 >65 years old
- Increased death rates persisted through the next summer

U.S. PM_{10} NMMAPS

- National Morbidity, Mortality and Air Pollution Study
  - Time-series analysis
  - Effects on mortality
  - Time period 1987 to 1994
  - 90 largest U.S. cities
- Major findings
  - PM levels positively associated with mortality
  - PM levels on the same day, or one and two days before death are positively associated with mortality
  - National combined estimate 0.2% excess deaths per 10 $\mu g/m^3$ increase in PM_{10}
  - Association most strongly associated in the Northeast

Samet HEI 2000

$PM_{2.5}$-Associated Mortality



From Pope et al, EHP, 1995

PM and Myocardial Infarction

- Peters and colleagues studied determinants of MI in the Myocardial Infarction Onset Study - Harvard University
- Case-crossover study
- 772 patients with acute MI in Boston January 1995 - May 1996
- Associations sought between hourly and 24 hr average concentrations of PM (<2.5µm), carbon black and gaseous pollutants and MI

Peters A et al. Circulation 2001

PM and Myocardial Infarction

	QUINTILES				
	I	II	III	IV	V
2-hour average $PM_{2.5}$					
Range, $\mu g/m^3$	0-5.2	5.3-7.9	7.9-11.5	11.6-17.0	17.1-74.8
Odds ratios	1.00	1.15	1.09	1.27	1.44
24-hours average $PM_{2.5}$					
Range, $\mu g/m^3$	1.6-6.4	6.5-8.6	8.7-11.5	11.6-16.2	16.3-52.2
Odds ratios	1.00	1.12	1.15	1.31	1.32

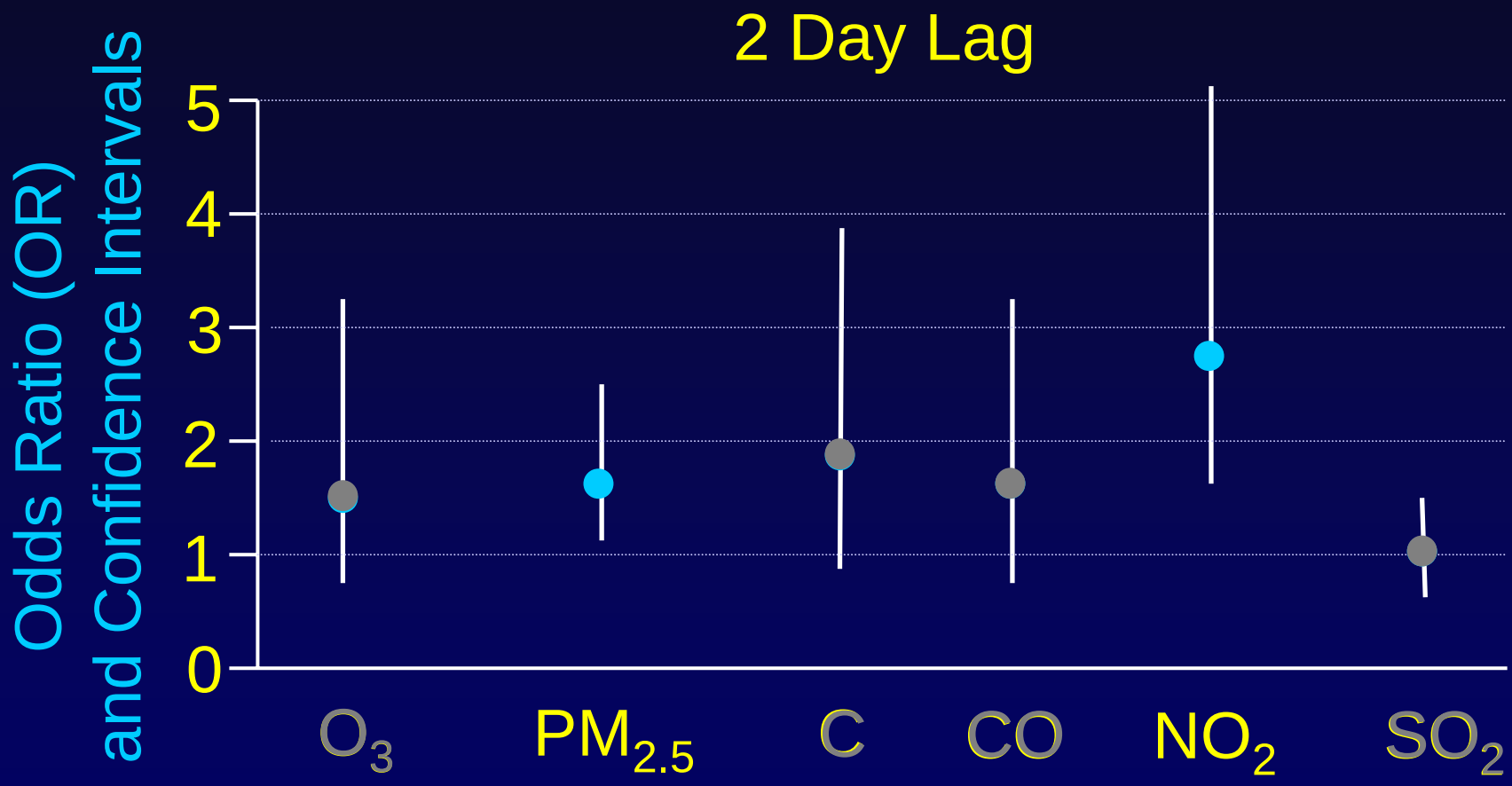
Peters A et al. Circulation 2001

Air Pollution and ICD Discharge

- 100 ICD patients
- Eastern Massachusetts
- Defibrillator discharges are related to:
  - Measurements of ambient air pollution:
    - Sulfur dioxide
    - Ozone
    - Carbon monoxide
    - $PM_{2.5}$
    - Carbon black

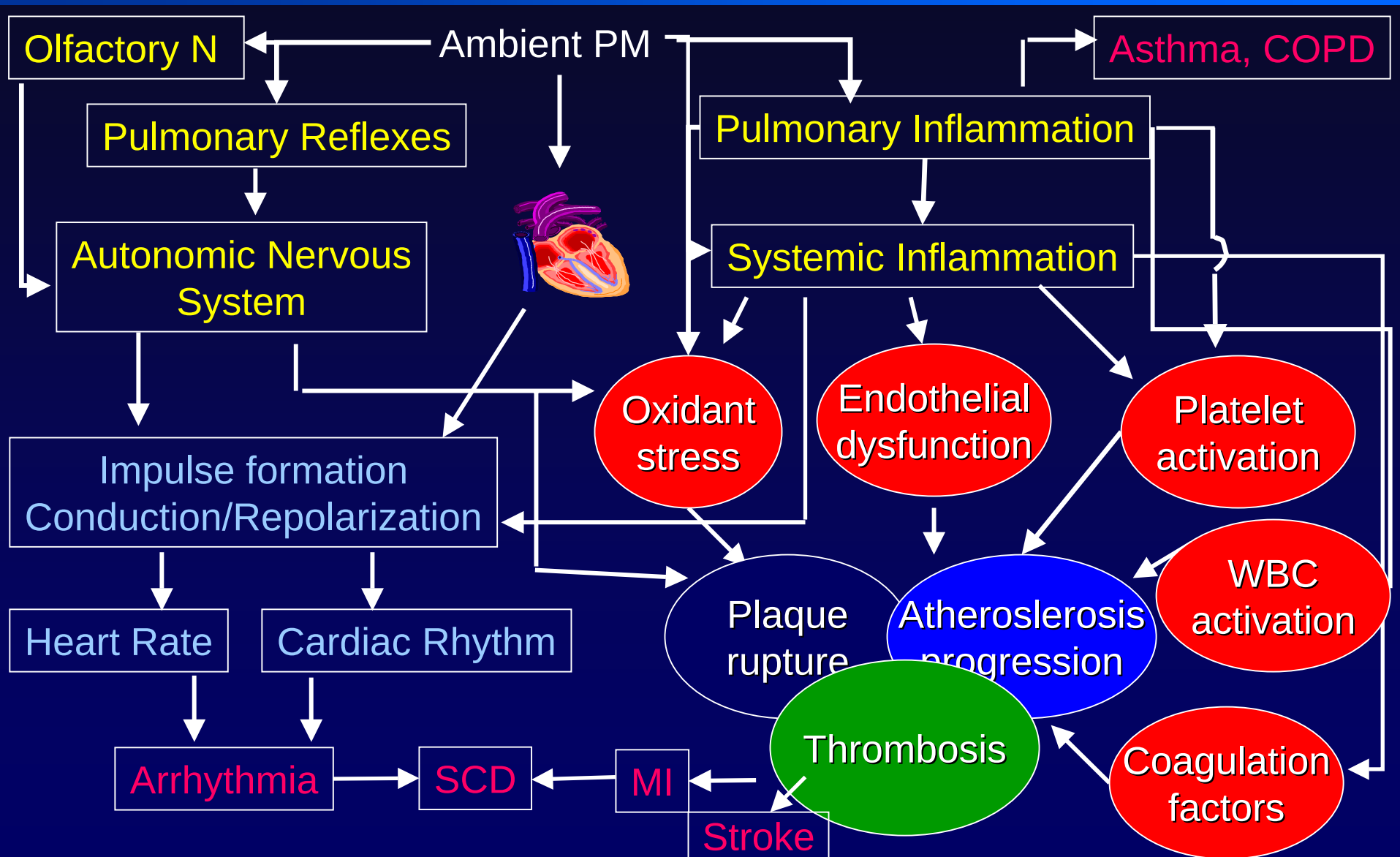
Peters et al. Epidemiology 2000

Air Pollution and ICD Discharge



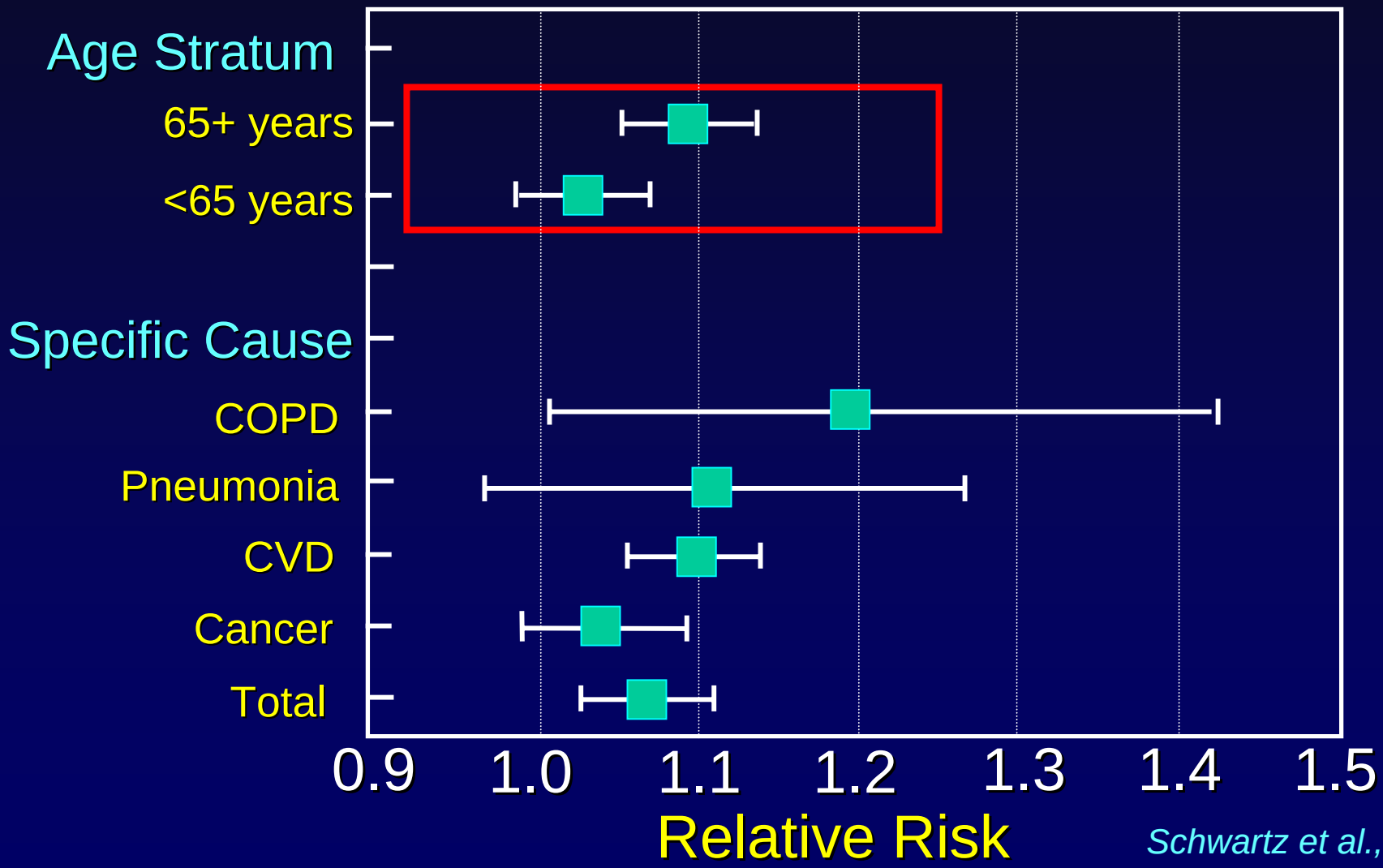
Peters et al. Epidemiology 2000

Potential Effects of PM on the Cardiopulmonary System



Are Older Adults More Susceptible?

Mortality Associated with Ambient $PM_{2.5}$ in Older Adults



Schwartz et al., 1992

Particulate Matter and Risk

- Association between PM_{10} and hospital admissions for respiratory and CV disease in 10 U.S. cities
- U.S. cities

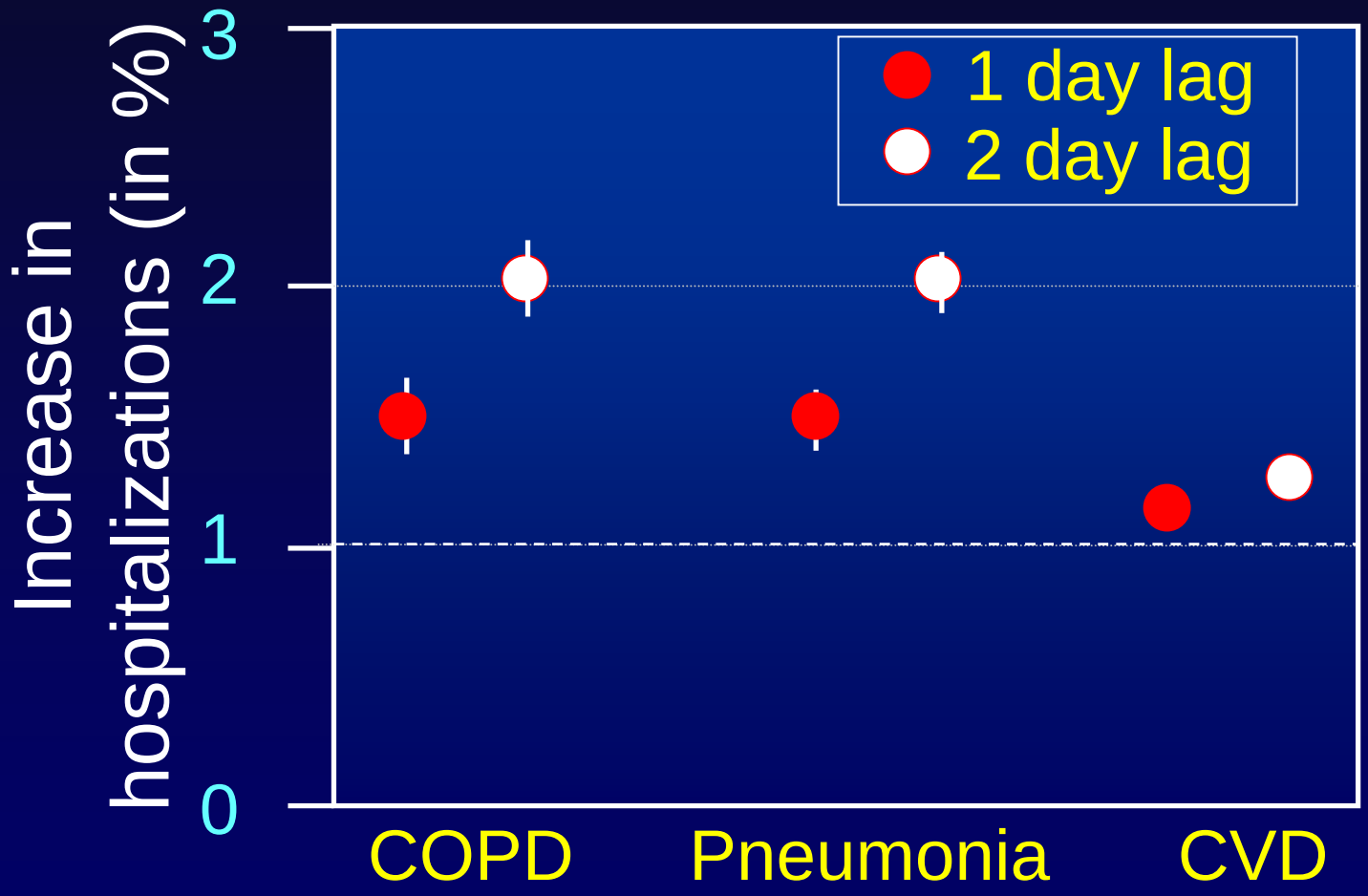
Canton	Minneapolis/St. Paul
Birmingham	New Haven
Chicago	Pittsburgh
Colorado Springs	Seattle
Detroit	Spokane

- HCFA billing records & US EPA Aerometric Information Retrieval System (1986-1994)

Zanobetti A et al. EHP 2000

Particulate Matter and Risk

Increased risk for each 10μg/m^3 increase in PM_{10}



Zanobetti A et al. EHP 2000

Cook County, Illinois PM_{10} NMMAPS

- CMS and Time period 1986 to 1991
  - Population ≥ 65 years old
  - Effects on all-cause mortality and hospitalizations
  - Considered sociodemographic data, environmental data
  - Environmental data from US EPA Aerometric Information Retrieval System

Bateson and Schwartz Epidemiology 2004

Cook County, Illinois PM_{10} NMMAPS

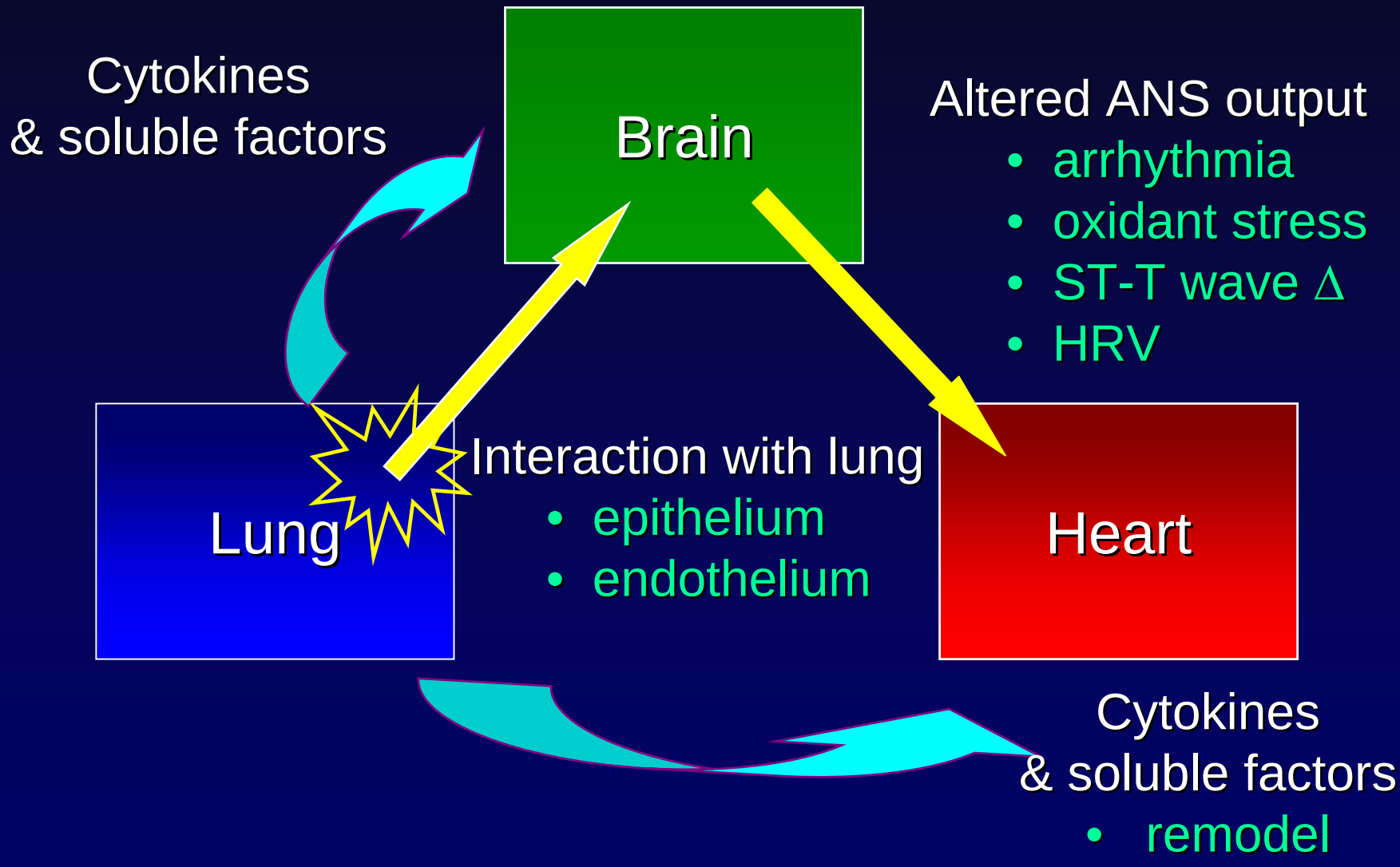
- Major findings
  - Increased excess deaths associated with PM_{10} for each increment of 10 μg/m^3 :
    - Overall 1.14%
    - Heart disease 1.98%
    - CHF 1.28%
    - Diabetes 1.49%
    - Men 1.3%
    - Women 1.0%
    - Age >65 years 0.4% for each added decade

Bateson and Schwartz Epidemiology 2004

EPA Studies - Age Related Responses

- Older adult panel studies on the east coast
  - Winter of 1997 in Baltimore, MD
- Controlled exposure to concentrated ambient PM
  - Younger adults
  - Older adults
- NC Highway Patrolman Study
  - Summer and Fall 2001

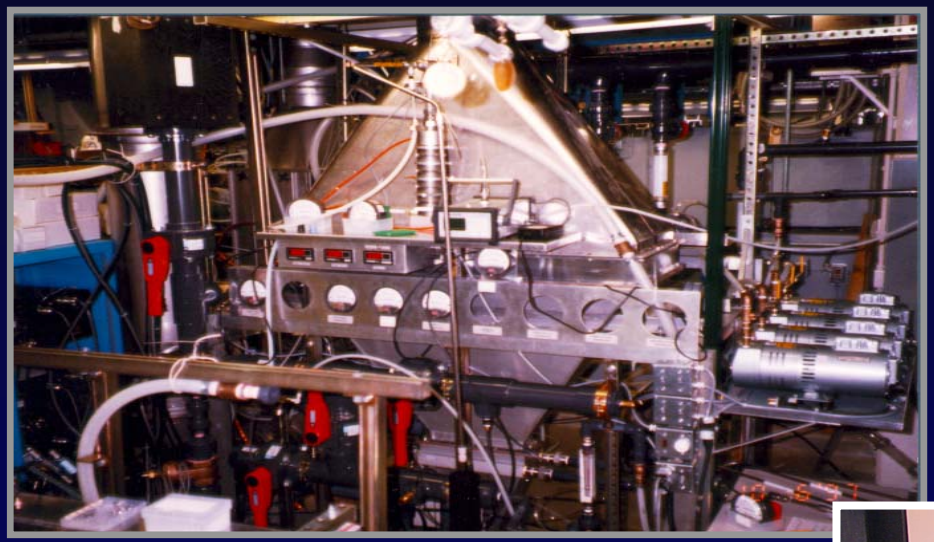
Simplified Scheme



EPA Studies - Age Related Responses

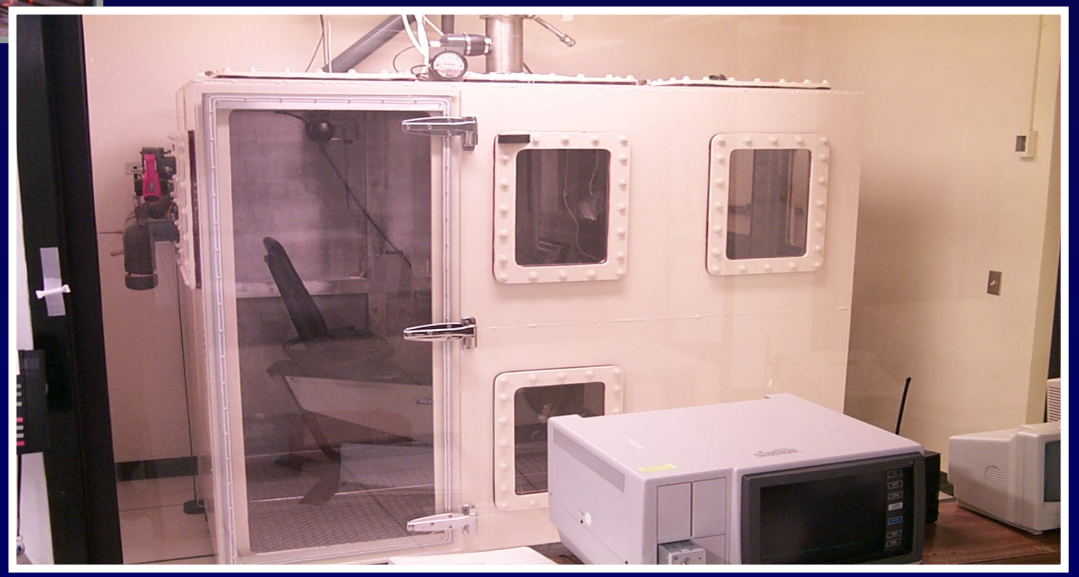
- Older adult panel studies on the east coast
  - Winter of 1997 in Baltimore, MD
  (HRV decreased in persons with CV disease)
- Controlled exposure to concentrate ambient PM
  - Older adults (HRV decreased)
  - Younger adults (HRV did not change)
- NC Highway Patrolman Study
  - Summer and Fall 2001 (HRV increased)

Human Exposure Laboratory US EPA

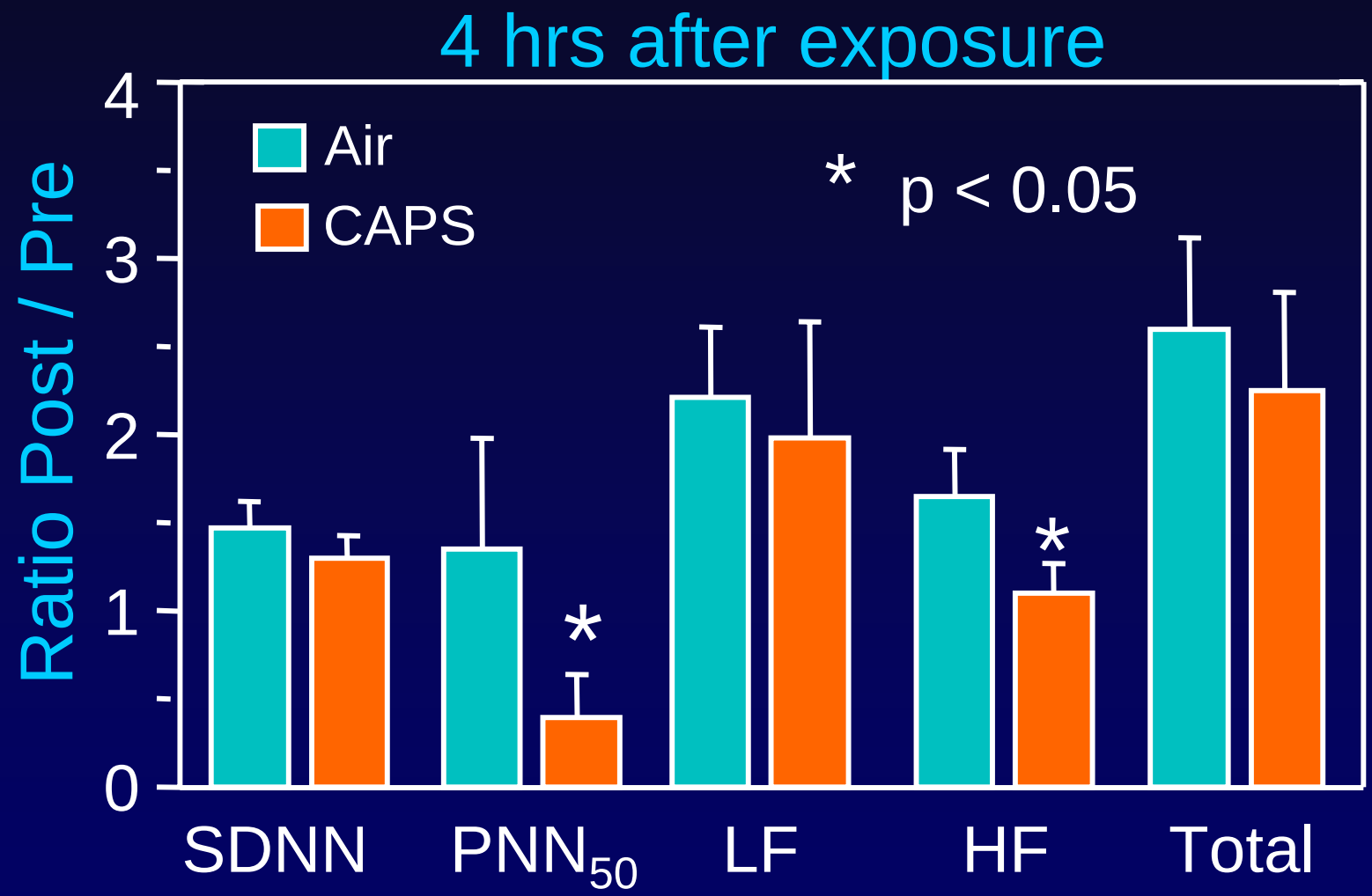


Particle concentrator

Exposure chamber

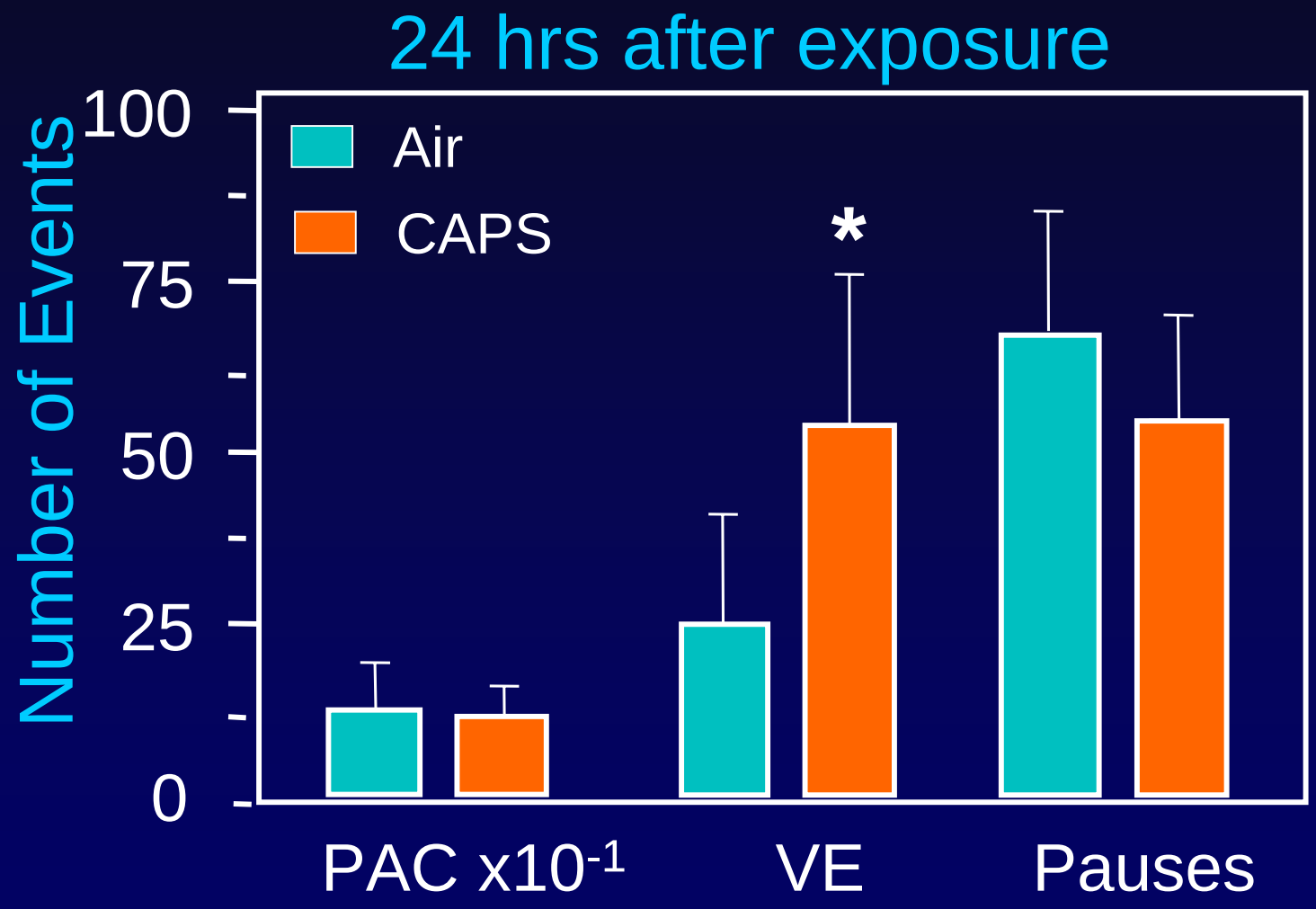


CAPS ($PM_{2.5}$) -induced Changes in HRV



Devlin et al. Eur Resp J 2003

CAPS ($PM_{2.5}$) -induced Ectopic Beats

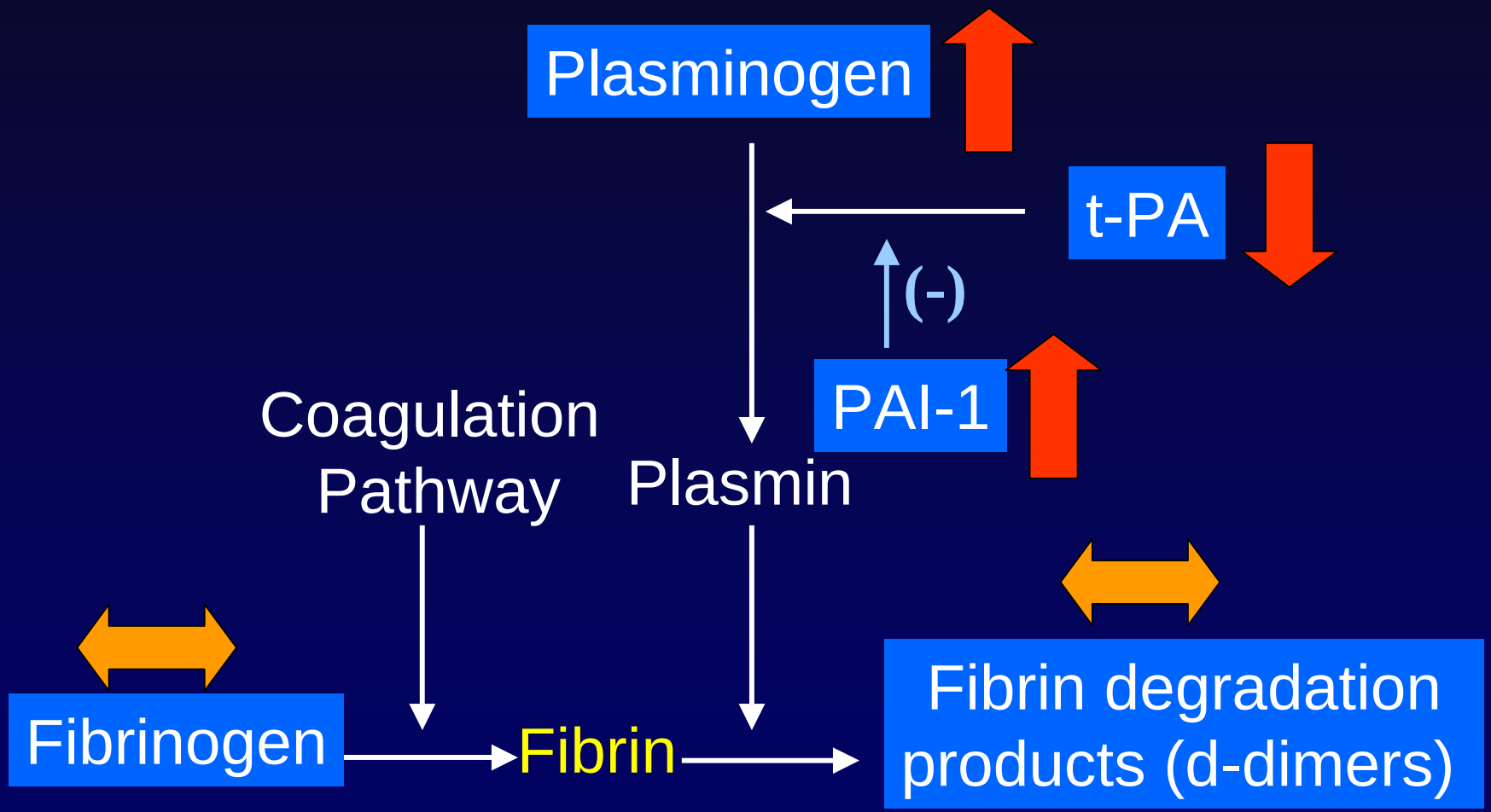


Devlin et al. Eur Resp J 2003

Contrasting Effects of PM on Older and Younger Adults

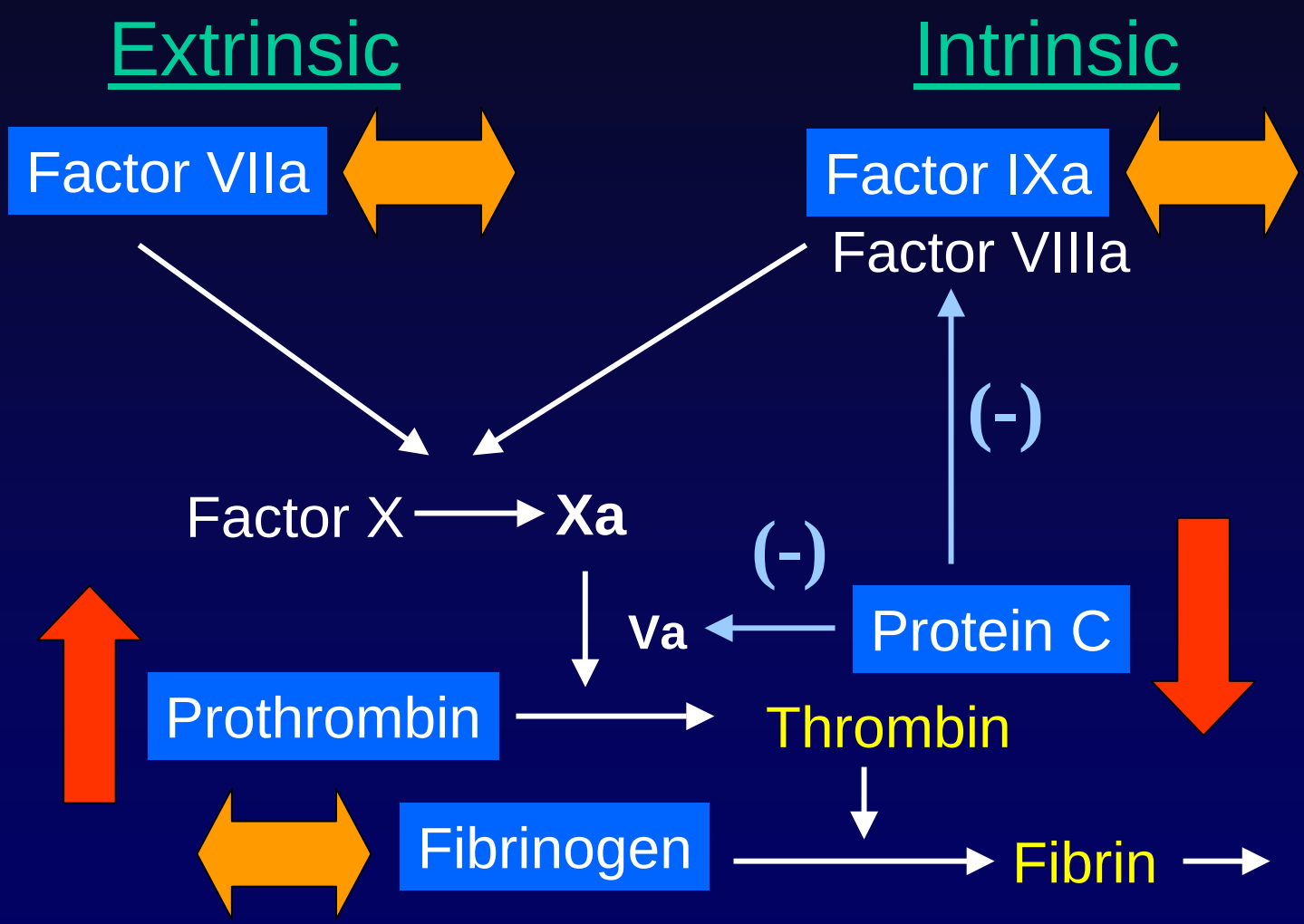
- Elevated $PM_{2.5}$ decreased HRV in older adults and had either no effect or increased HRV in young adults
- The HRV effect was seen primarily in HF domain
  - loss of parasympathetic input in the older
  - increased parasympathetic input in the young
- Could increase the susceptibility of older adults to adverse cardiac events and increase younger adults to vagally induced arrhythmia

CAPS ($PM_{2.5}$)-induced Changes in Fibrinolytic Proteins



Devlin et al. The Toxicologist 2002

CAPS ($PM_{2.5}$) -induced Changes in Coagulation Proteins



Devlin et al. The Toxicologist 2002

Contrasting Effects of PM on Older and Younger Adults

Effects were more marked in older adults

- Some plasma proteins associated with:
  - thrombosis increase
  - fibrinolysis decrease
- Such changes will favor thrombosis

Why Do Older Adults and Younger Adults Respond Differently?

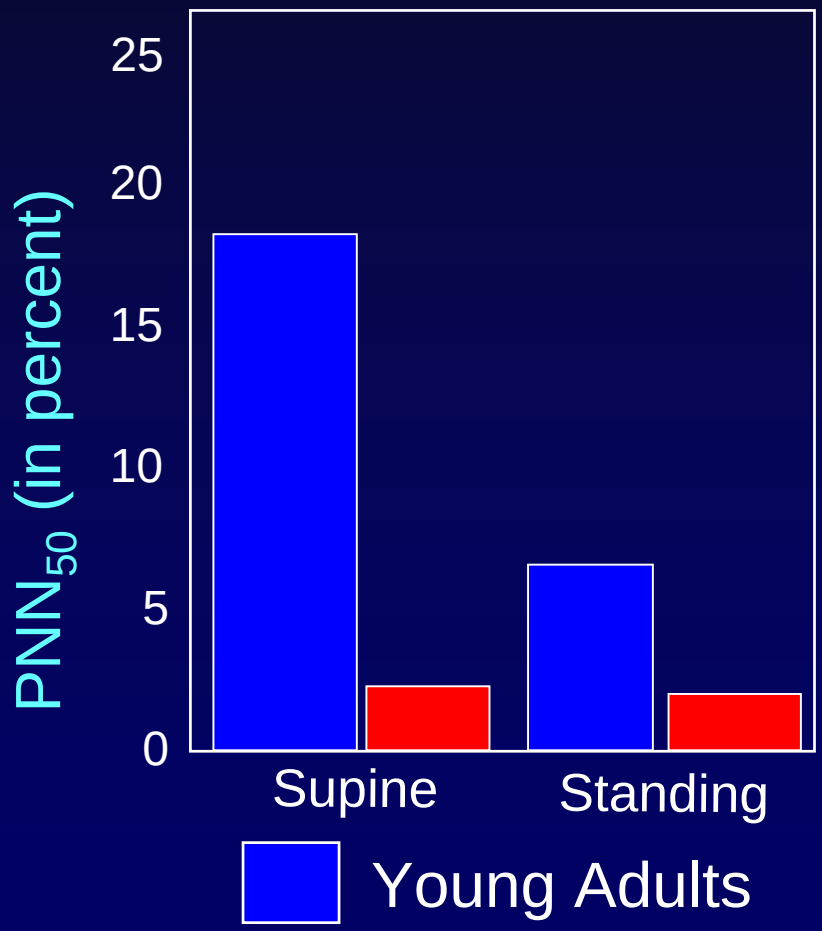
Speculated Age-Related Factors

- Factors influencing responses to air pollution
  - Altered immune response with age
  - Environmental exposure and smoking history
  - Infectious history
  - Altered deposition of PM in diseased airways
  - Antioxidant and nutritional status
  - Respiratory, CV and other concurrent diseases
  - Medication

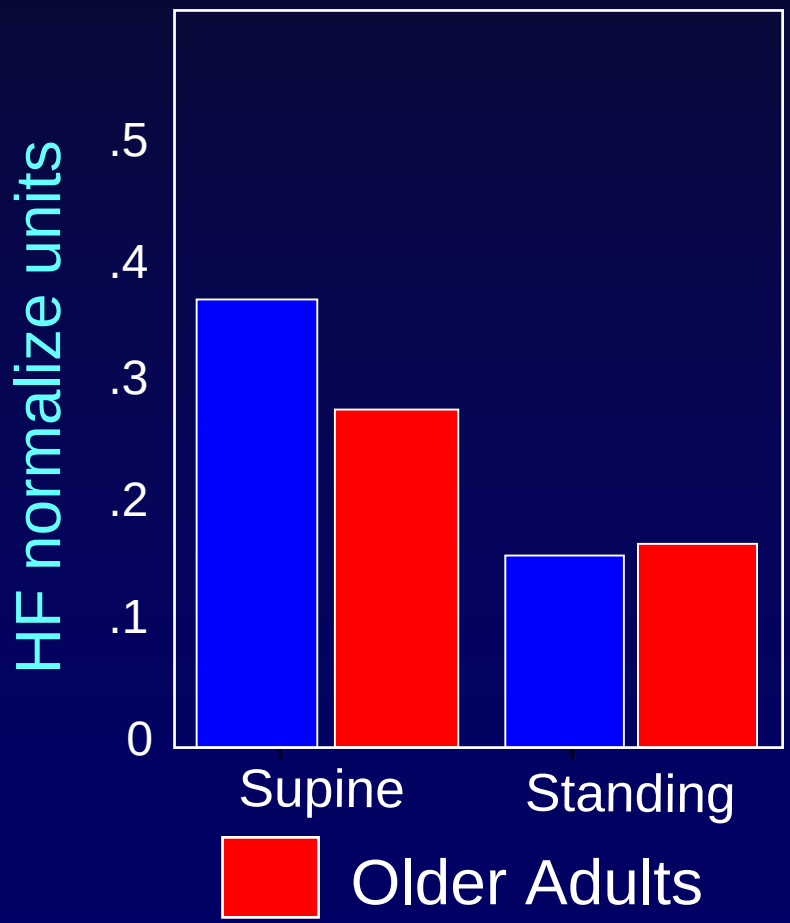
Sandströmet al. Eur Respir J 2003

Age-dependent Changes in HRV

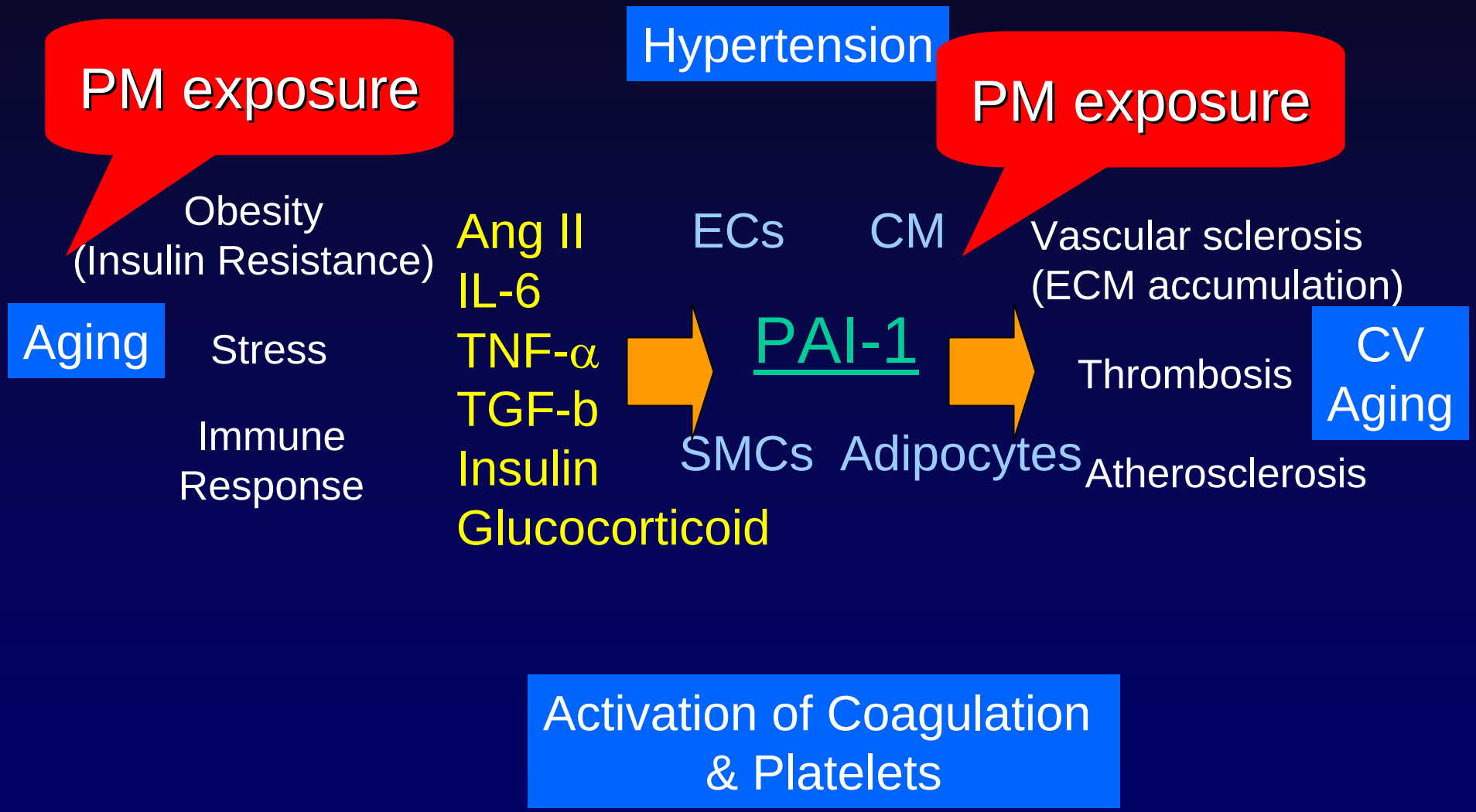
Time-Domain PNN50



Frequency-Domain HF

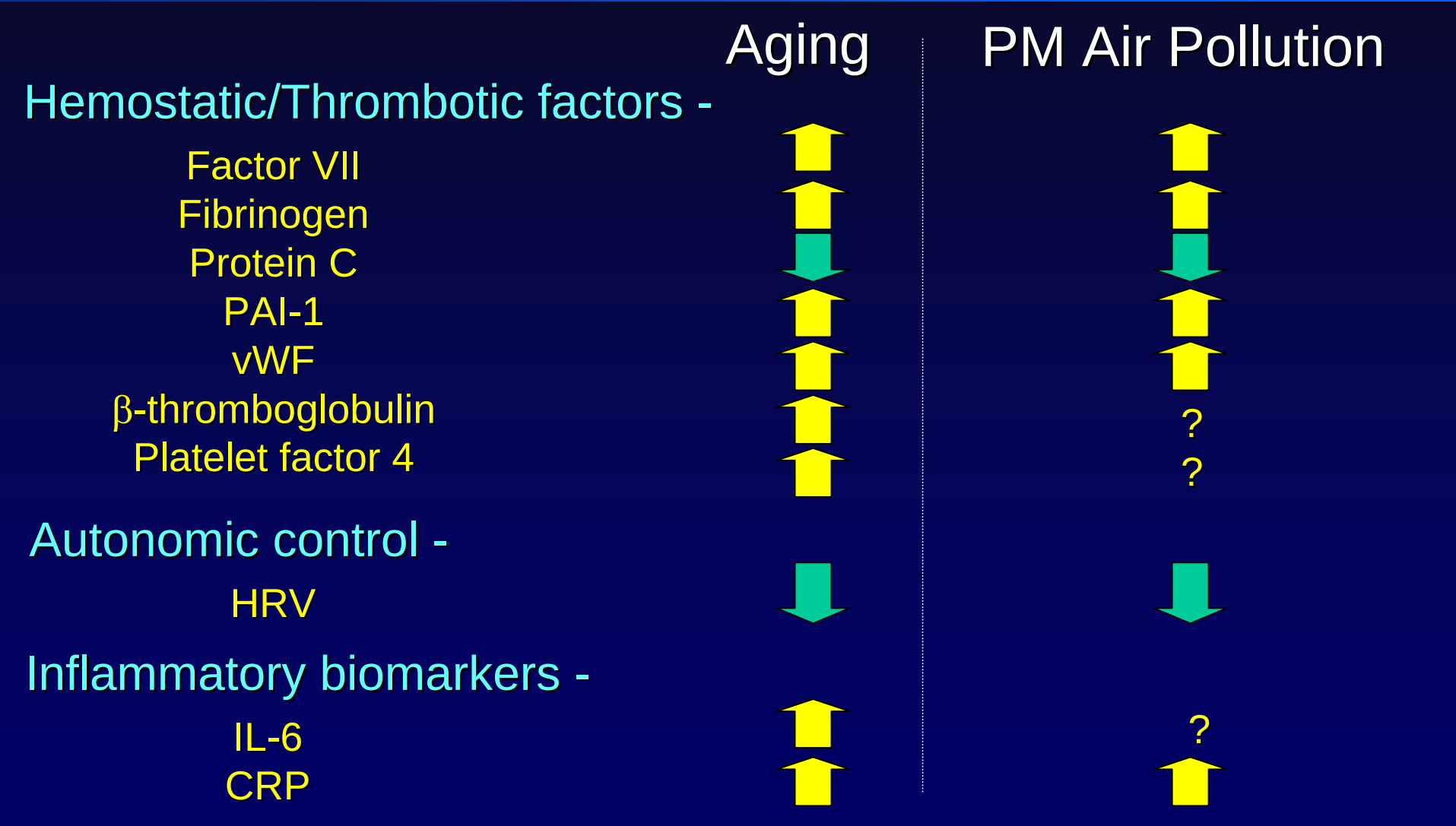


Role of PAI-1 in Cardiovascular Aging



Yamamoto Cardiovasc Res 2004

Concordance between the Influence of Age and $PM_{2.5}$ on Health Effects



What Can Be Done to Protect Older Adults from the Adverse Effects of Air Pollution?

What Can Be Done?

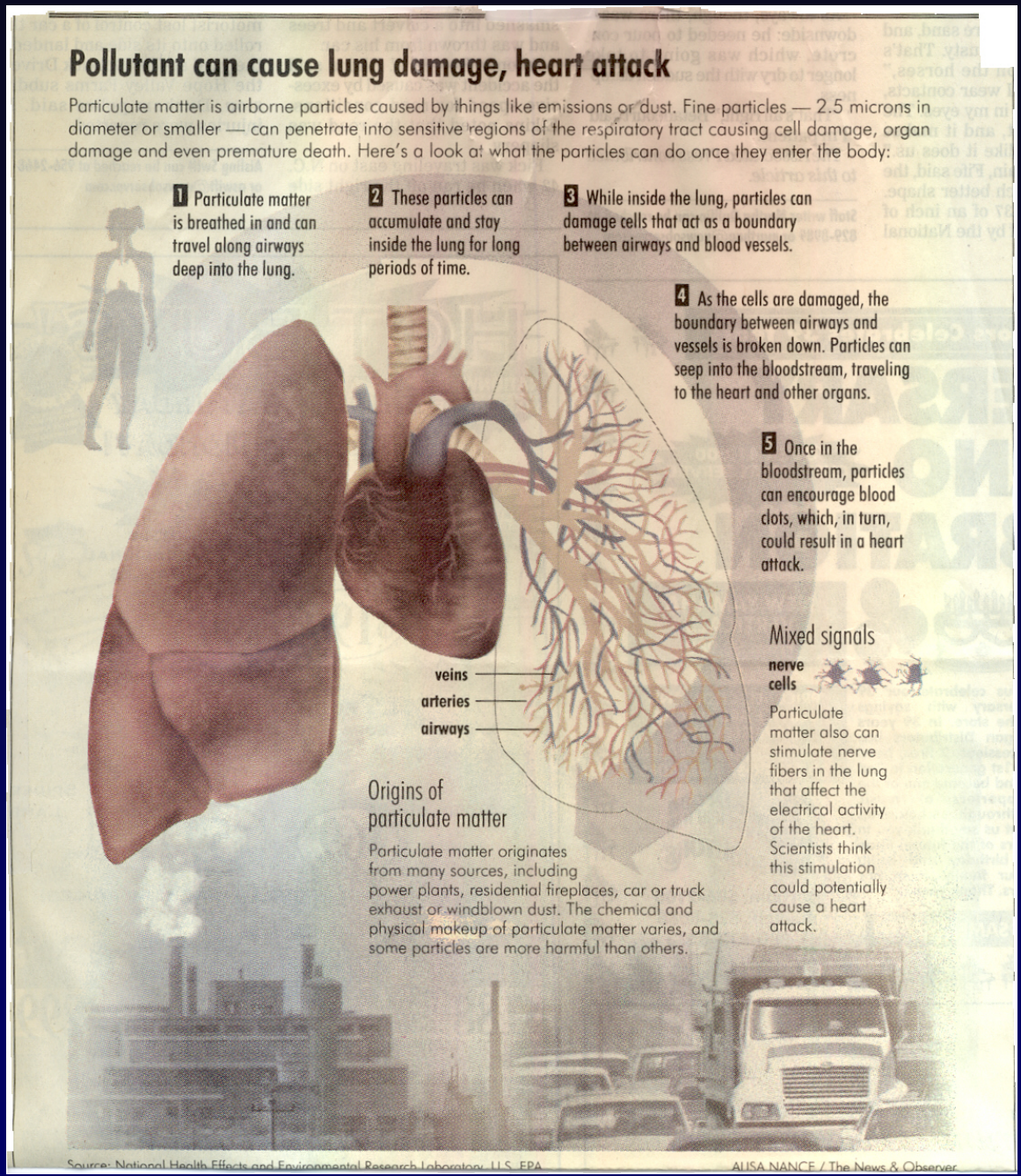
- General Recommendations
  - Decrease exposure to harmful pollutants
  - Educate the health care community and population
  - Identify high-risk populations and educate them regarding avoidance of exposure
  - Support research to identify:
    - Mechanisms of health effects
    - Specific sources of pollutants having adverse health effects
    - Develop animal models of surrogates of human disease to study the acute and chronic effects of air pollution

Identify & Educate People at Risk

- Susceptible people include those with:
  - advanced age
  - diabetes
  - coronary artery disease
  - heart failure
  - arrhythmias
  - COPD
  - asthma

Public Education

via the printed media



Pollutant can cause lung damage, heart attack

Particulate matter is airborne particles caused by things like emissions or dust. Fine particles — 2.5 microns in diameter or smaller — can penetrate into sensitive regions of the respiratory tract causing cell damage, organ damage and even premature death. Here's a look at what the particles can do once they enter the body:

1 Particulate matter is breathed in and can travel along airways deep into the lung.

2 These particles can accumulate and stay inside the lung for long periods of time.

3 While inside the lung, particles can damage cells that act as a boundary between airways and blood vessels.

4 As the cells are damaged, the boundary between airways and vessels is broken down. Particles can seep into the bloodstream, traveling to the heart and other organs.

5 Once in the bloodstream, particles can encourage blood clots, which, in turn, could result in a heart attack.

veins
arteries
airways

Origins of particulate matter

Particulate matter originates from many sources, including power plants, residential fireplaces, car or truck exhaust or windblown dust. The chemical and physical makeup of particulate matter varies, and some particles are more harmful than others.

Mixed signals

nerve cells

Particulate matter also can stimulate nerve fibers in the lung that affect the electrical activity of the heart. Scientists think this stimulation could potentially cause a heart attack.

Source: National Health Effects and Environmental Research Laboratory, U.S. EPA

ALISA NANCE / The News & Observer

Raleigh News & Observer 2001

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U.S. Environmental Protection Agency

Air Quality Index (AQI) - AIRNow

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Air Quality Index

AQI AIR QUALITY INDEX

The AQI tells you how clean the air is and whether it will affect your health. EPA, state, and local agencies work together to report current and forecast conditions for ozone and particle pollution. *AIRNow* forecasts next-day air quality.

AIRNOW

via the internet

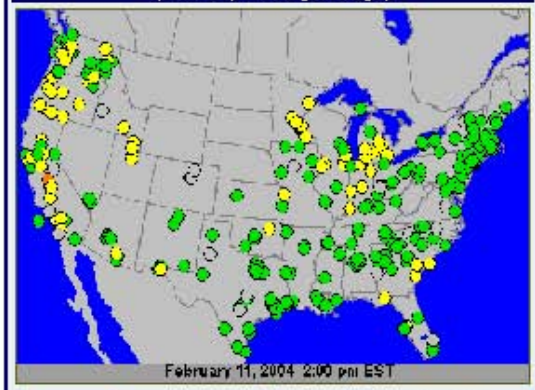
Where you live
Current air quality maps, animations, forecasts, and state and local Web sites.

National overview
Maps showing the whole country, with links to local information

- Forecasts
- Current conditions
- Cities experiencing action days

Web cams
See images from around the country that show local visibility

Featured Conditions
(click map for larger image)



Good | Moderate | Unhealthy for Sensitive Groups | Unhealthy | Very Unhealthy | Hazardous

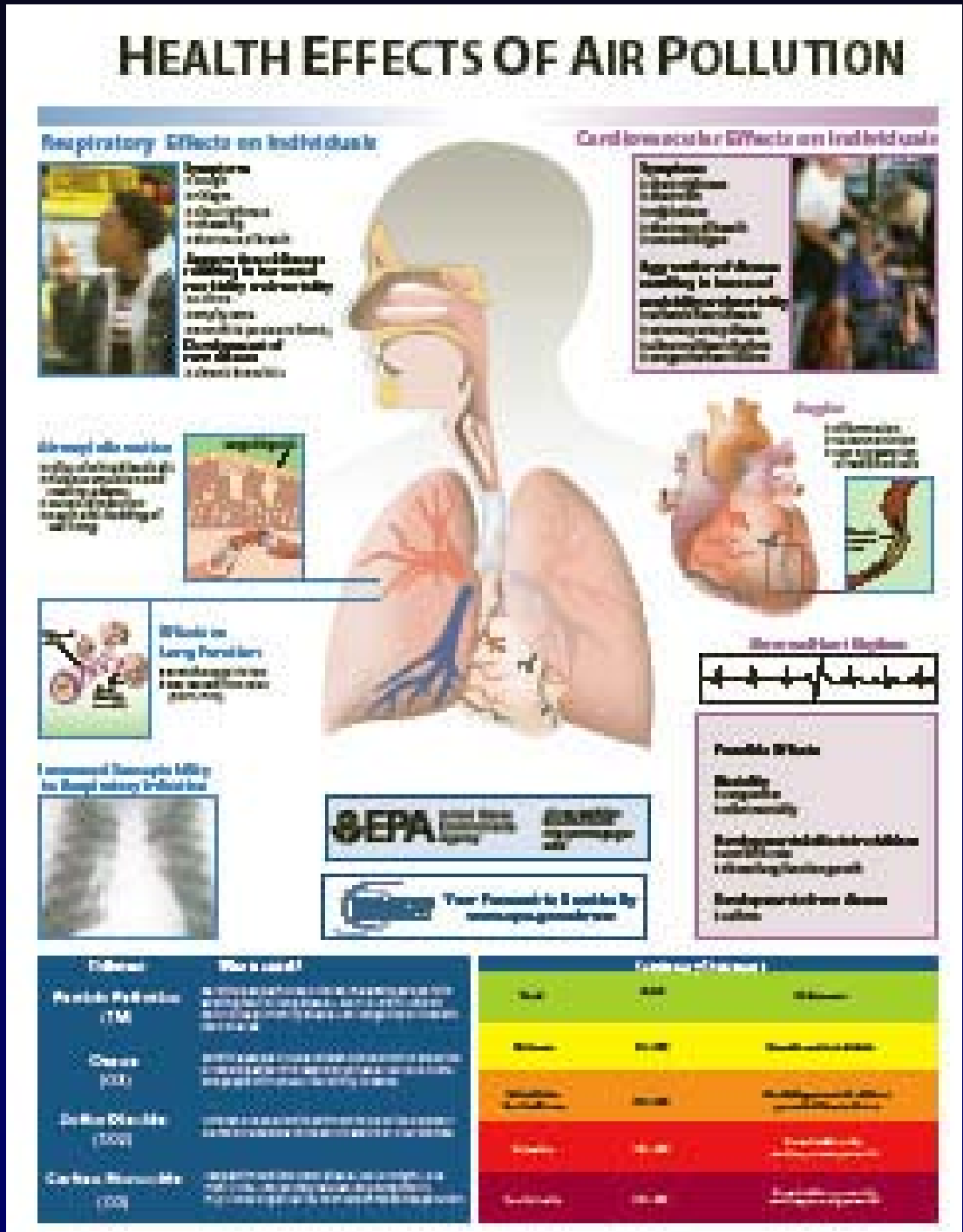
Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.

Local intranet

start | Connected - BlackBer... | Welcome - Lotus Notes | 2004 MN conference | Ozone and PM outreach | EPA AIRNow - Micros... | 3:21 PM

Public Education

via health care providers



U.S. Environmental Protection Agency

Program Overview
Research Topics
Supporting Documents
Related Links

EPA Awards $30 Million Dollar Grant for Particulate Matter Research

Michael O. Leavitt, the Administrator of the United States Environmental Protection Agency, today awarded the University of Washington with a $30 million grant to study the connection between air pollution and cardiovascular disease.

The grant is the largest ever awarded by the EPA for scientific research, and will contribute to a better understanding of the long-term effects of breathing air contaminated by particulate matter (PM) and other pollutants.

www.epa.gov

Conclusions

- Air particle pollution increases adverse CV events
  - Probably mediated by the CNS, inflammation increased oxidant stress and thrombosis
  - Might accelerate the development of atherosclerosis
- Aged-adults are at higher risk from the effects of air particle pollution probably from:
  - increased physiological response to particles
  - increased prevalence of diseases that confer risk

Conclusions

- Education of the public and medical community
- Research is needed to:
  - identify source factors
  - define the interrelationship between disease and air pollutants
  - better understand the risk in aged-adults
  - long-term risks