

# How Air Pollution Is Affecting Our Health

Environmental Science Institute

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US EPA Office of Air Quality Planning and Standards

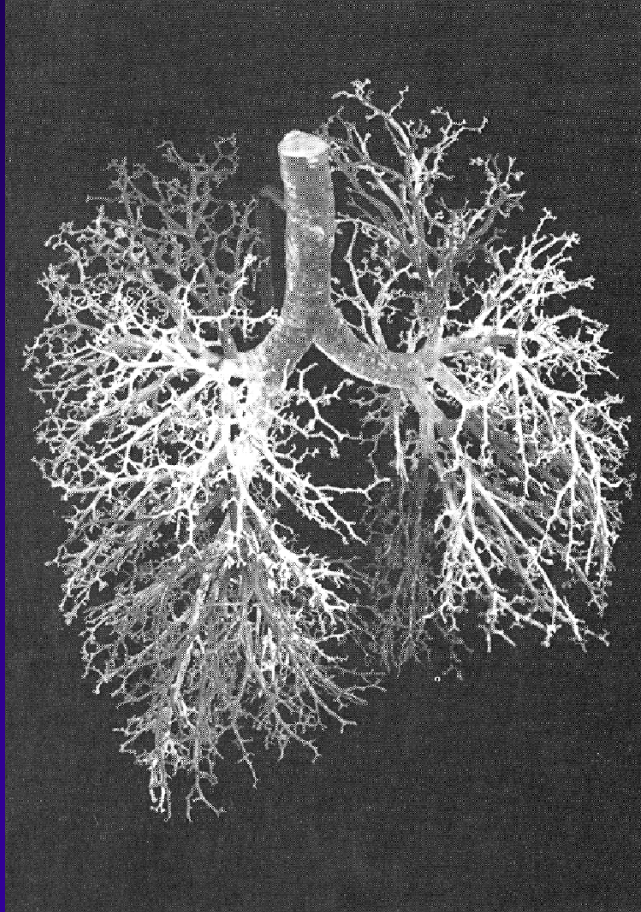
[stone.susan@epa.gov](mailto:stone.susan@epa.gov)



# Overview

- Ozone
- Particle pollution
- Air Quality Index (AQI)

# Human Lung



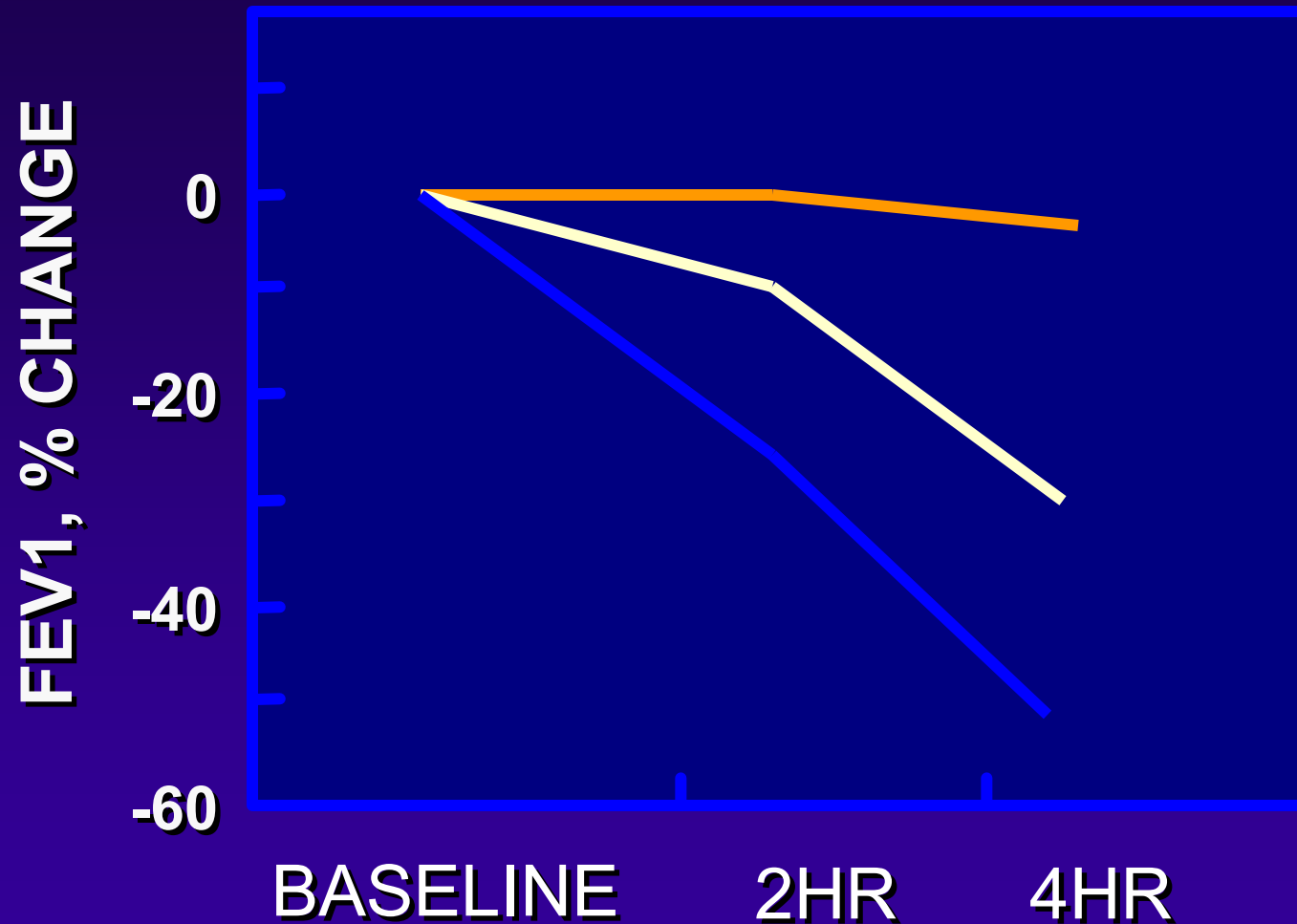
- Air conducting
  - Trachea
  - Bronchi
  - Bronchioles
- Gas exchange
  - Respiratory bronchioles
  - Alveoli

# Ozone Irritates Airways

- Symptoms
  - Cough
  - Sore or scratchy throat
  - Pain with deep breath
  - Fatigue
- Rapid onset
- Similar symptoms - people with and without asthma



# Ozone Reduces Lung Function



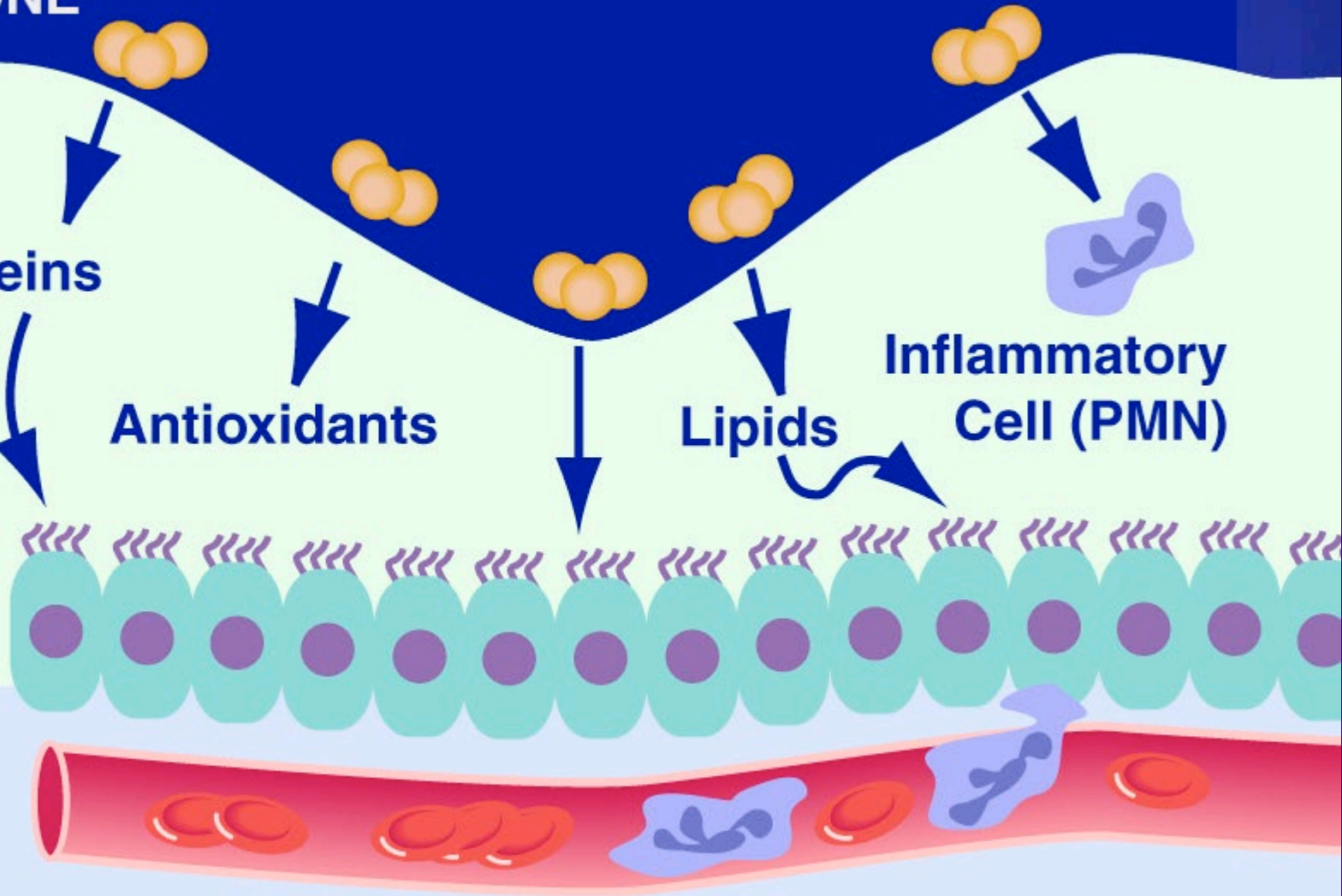
**OZONE**

**Proteins**

**Antioxidants**

**Lipids**

**Inflammatory Cell (PMN)**

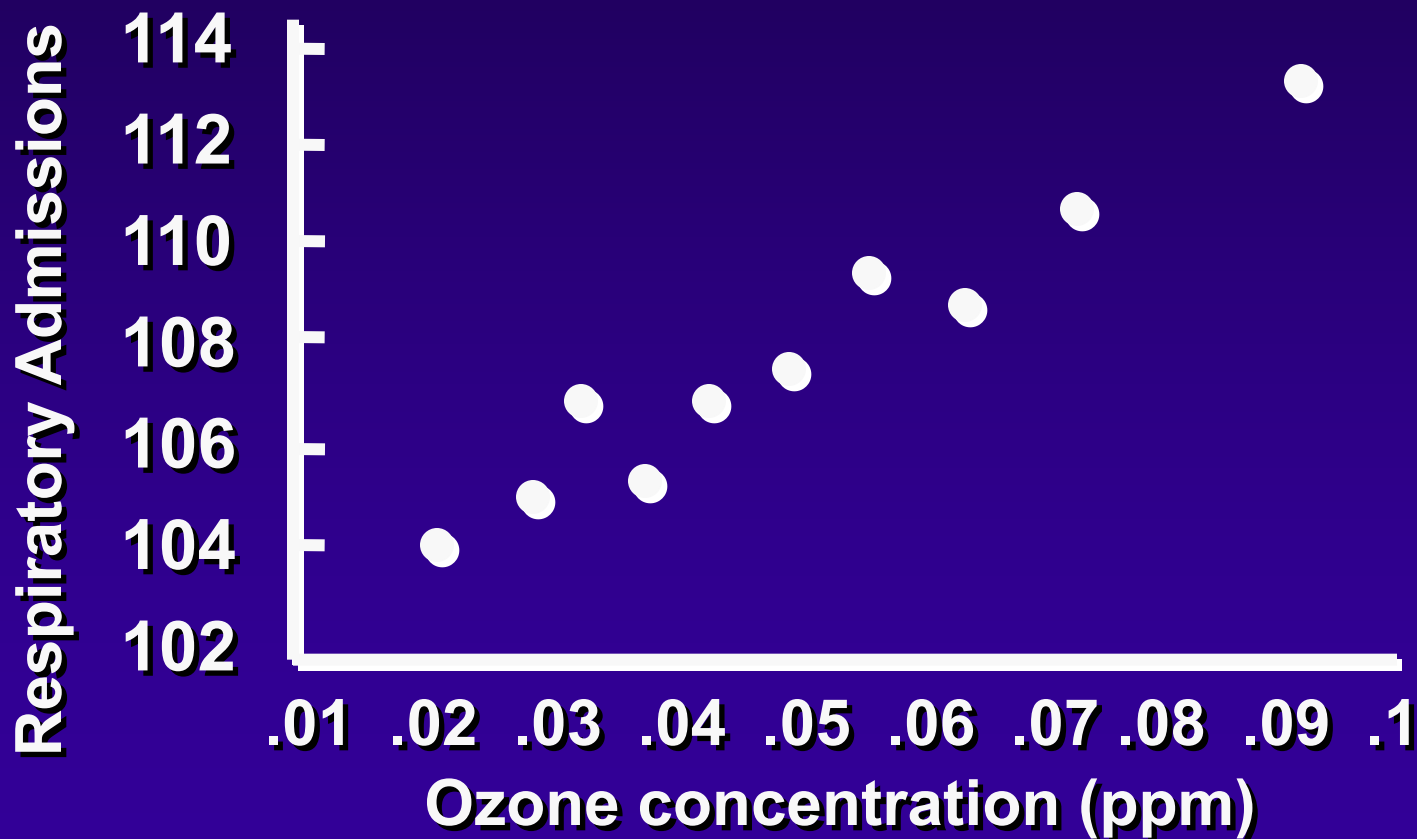




# Ozone Causes Inflammation

- Ozone reacts completely in surface layer - forms reactive oxygen molecules
- Influx of white blood cells
- Damages cells that line the airways
- Effect is greater 24 hours after exposure
- Increases airway reactivity
- Concern about repeated exposures

# Respiratory Hospital Admissions by Daily Maximum Ozone Level, Lagged One Day (Burnett et al, 1994)





# Lung Function and Respiratory Symptom Effects in Asthmatic Children

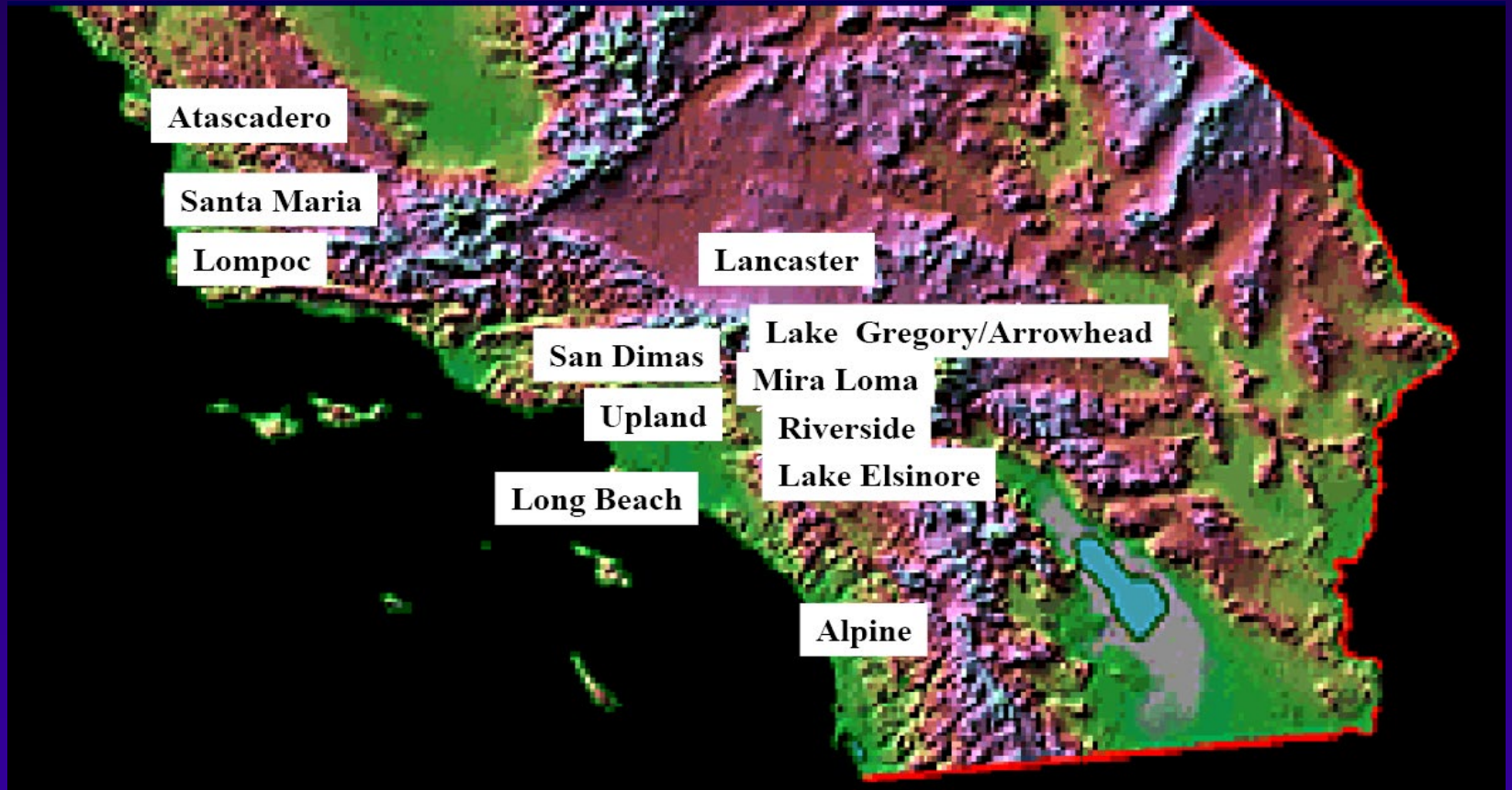
## Lung function (PEF)

- National Cooperative Inner-City Asthma Study (NCICAS) (Mortimer et al., 2002) daily peak flow measurements
  - 846 asthmatic children, 8 urban areas, morning and evening PEF measurements, 8-hr ozone (10 AM – 6 PM), June through August
  - Incidence of  $\geq 10\%$  decrements in morning PEF associated with 30 ppb increase in 8-hr average ozone

## Respiratory Symptoms

- NCICAS (Mortimer et al., 2002), daily diary of symptoms
  - Morning symptoms (i.e., cough, chest tightness, wheeze) associated with 30 ppb increase in 8-hr average ozone
- Gent et al., (2003); diary study of 271 asthmatic children in southern New England
  - 130 children used maintenance medications (moderate to severe asthma) and 141 who did not (mild asthma), symptoms (i.e., chest tightness, wheeze, shortness of breath)
  - Statistically significant effects on symptoms seen in children on maintenance medication

# California Children's Health Study



# CHS: School Absences

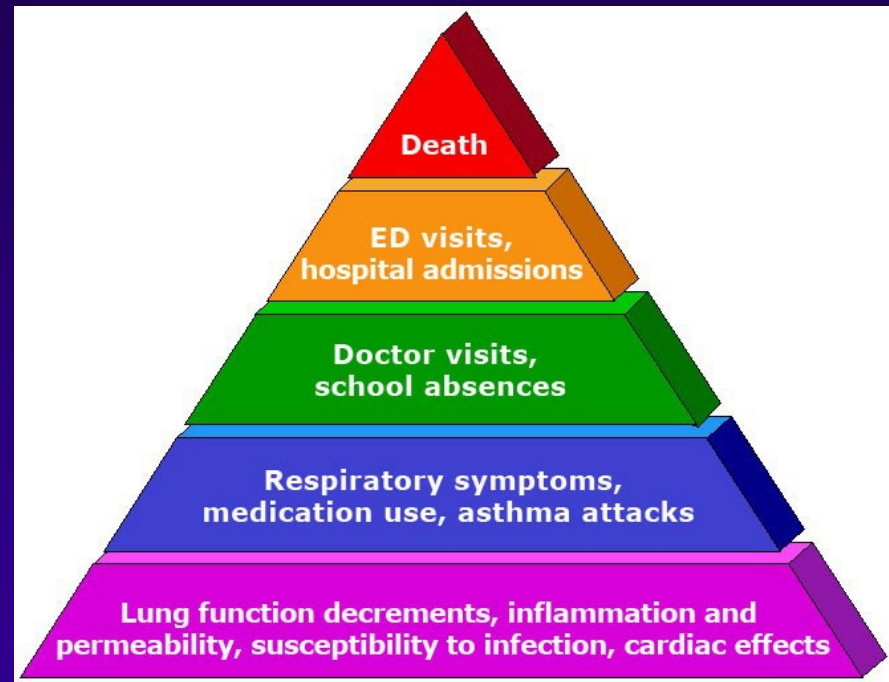
- 20 ppb increase in O<sub>3</sub> associated with an 83% increase in school absences for acute respiratory disease (Gilliland et al., 2001)
- Large economic impact of pollution-related school absences (Hall and Lurmann, 2003)

# CHS: Ozone and New-onset Asthma

<u>Sports</u>	<u>Low O<sub>3</sub> Towns</u>		<u>High O<sub>3</sub> Towns</u>	
	#	RR	#	RR
0	58	1.00	46	1.00
1	50	1.28	40	1.28
2	20	0.82	16	1.28
≥3	9	0.79	20	3.31

# “Pyramid of Effects”

- Consistent and coherent effects seen across a wide range of health outcomes
- Sensitive groups include:
  - Asthmatic children and other people with lung disease
  - All children and older adults, especially people active outdoors
  - Outdoor workers



Adversity of Effects

Proportion of Population Affected

# Sensitive Groups for Ozone

- People with lung disease
- Children
- Older adults
- People who are active outdoors

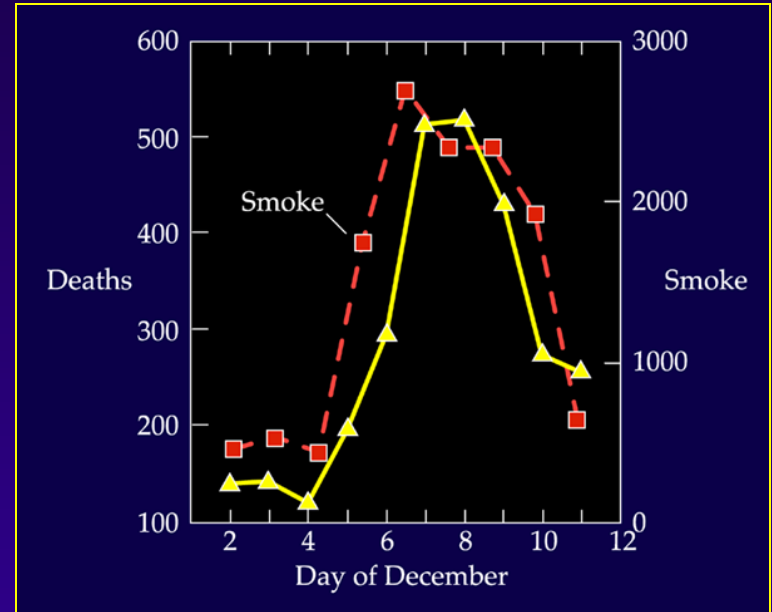
# Air Pollution Disasters



**Donora, PA at noon on  
Oct. 29, 1948**



**London buses are escorted by  
lantern at 10:30 in the morning.**





**Wood-Burning Stoves**



**Forest Fires**



**Heavy Duty Diesel Engines**



**Natural Sources**

**Particle pollution is a complex mixture derived from many sources**



**Cars and Trucks**



**Non-Road Vehicles**



**Leaf Burning**

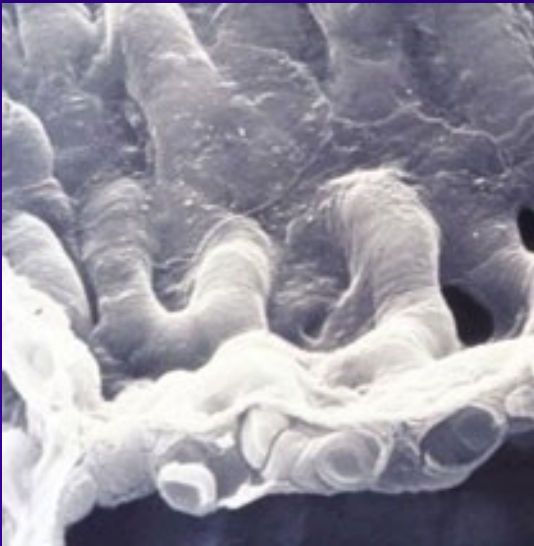


**Industrial Sources**



# Particle Deposition

- Larger particles ( $> PM_{10}$ ) deposit in the upper respiratory tract
- Inhalable particles ( $\leq PM_{10}$ ) penetrate into lungs

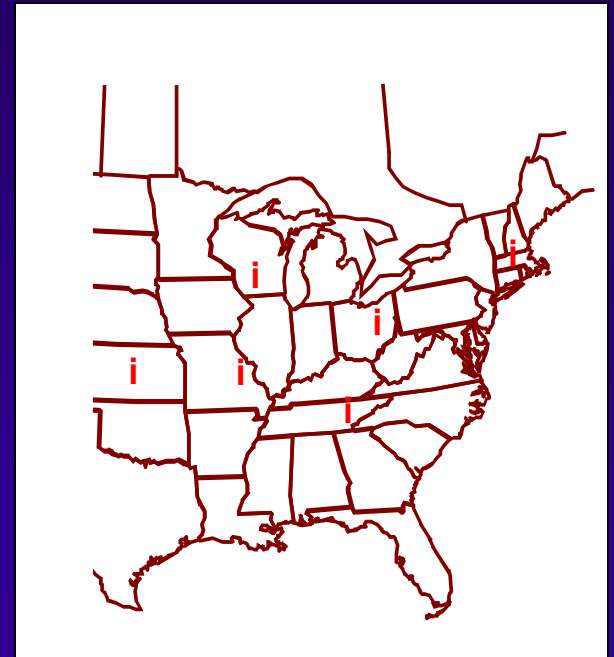


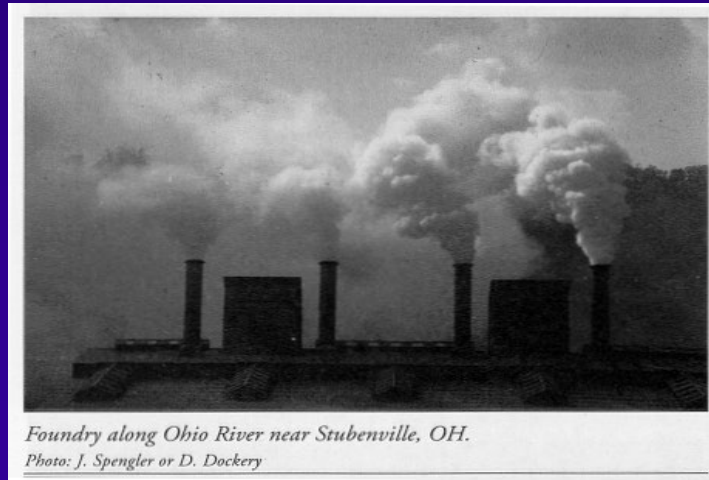
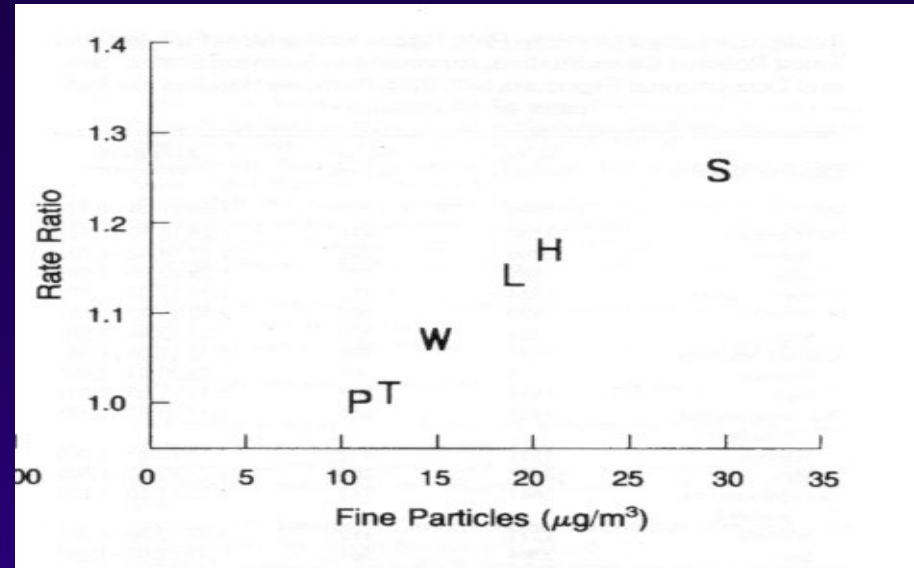
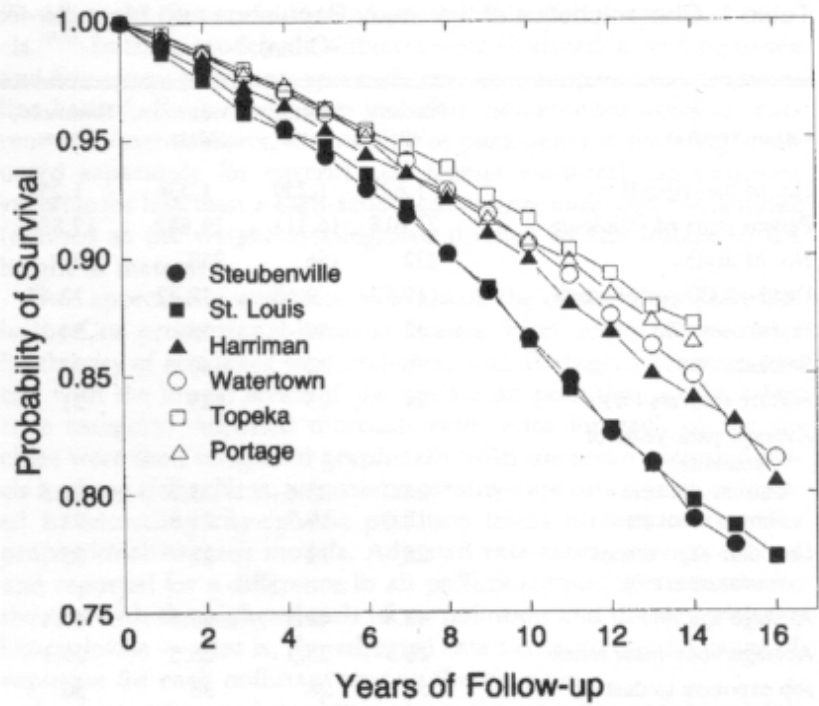
- Some particles (e.g., less than  $0.1 \mu m$ ) may enter bloodstream
- Particles may react, accumulate, be cleared or absorbed

# Association Between Long Term Exposure to PM and Mortality

## Harvard Six-Cities Adult Cohort

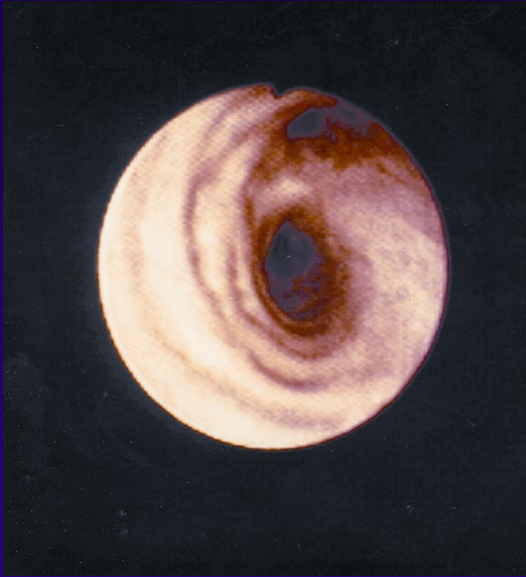
- Purpose was to study the association between pulmonary changes and long term exposure to sulfates and sulfur dioxide
- Enrollment 1974 – 1977
  - 8,111 white men and women
  - About 1,300 in each of six cities
  - Age range 25 to 74 years
- Followed until 1991 (now 1999)
  - 14 to 17 years of follow-up
  - 111,076 person-years
  - 1,430 deaths





**Dockery et al., 1993**

# Particle Pollution Affects the Lungs



**You are exposed to particle pollution simply by breathing polluted air.**

**Exposure increases when you exercise,** because you breathe more vigorously and deeply than usual.

Respiratory effects include:

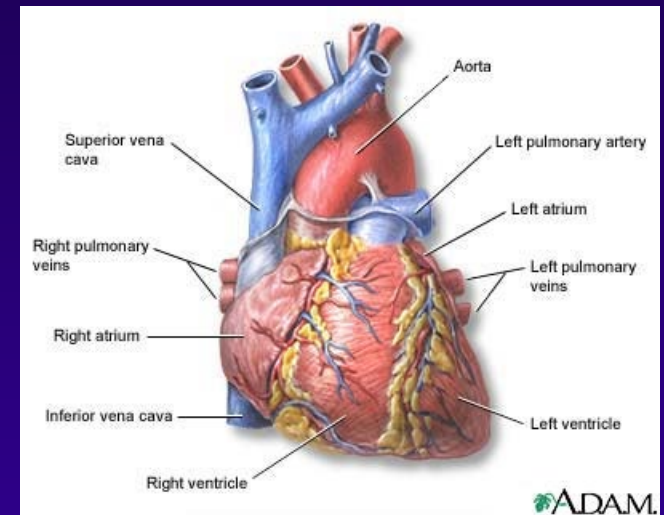
- **Airway irritation**
- **Cough**
- **Phlegm**
- **Decreased lung function**
- **Airway inflammation**
- **Asthma attacks**
- **Bronchitis**
- **Chronic bronchitis**



# And Particle Pollution Affects the Heart

Particle pollution has been linked to changes that indicate your heart isn't as healthy as it should be. Those include:

- Arrhythmias and changes in heart rate.
- Changes in the variability of your heart rate.
- Blood component changes
  - C-reactive protein
  - Fibrinogen
  - Plasma viscosity
- Some studies indicate that particle exposure may cause **heart attacks**. And particles are linked with **death from heart disease**.

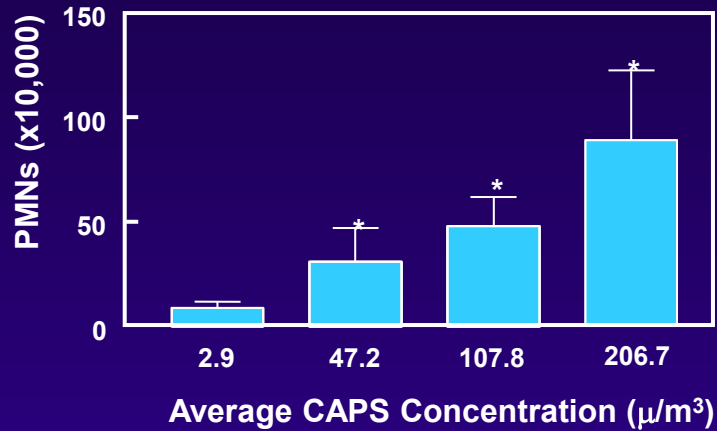


*Particle exposure has been linked to heart attacks*

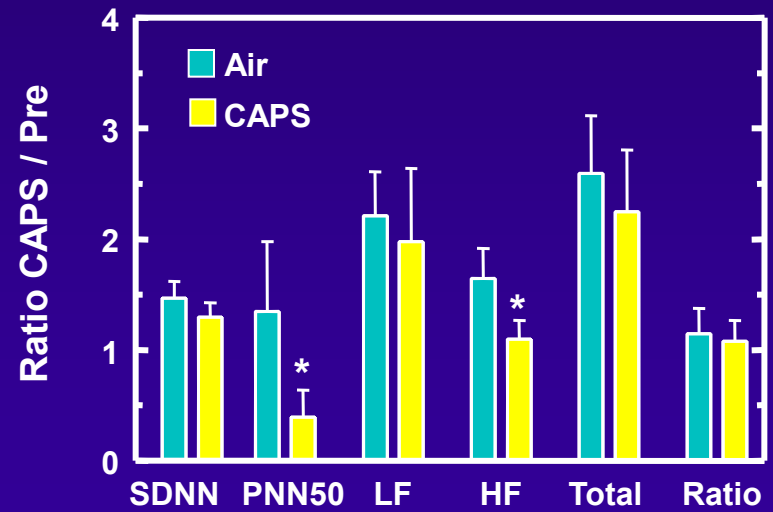
# It's a Public Health Concern

- When particles aggravate heart and lung diseases that means increases in:
  - **Hospital admissions**
  - **Doctor and emergency room visits**
  - **Medication use**
  - **Absences from work or school**
- Particulate matter is linked to significant public health risks – including **premature death** from heart and lung disease.

# PM Can Cause Effects in Healthy People

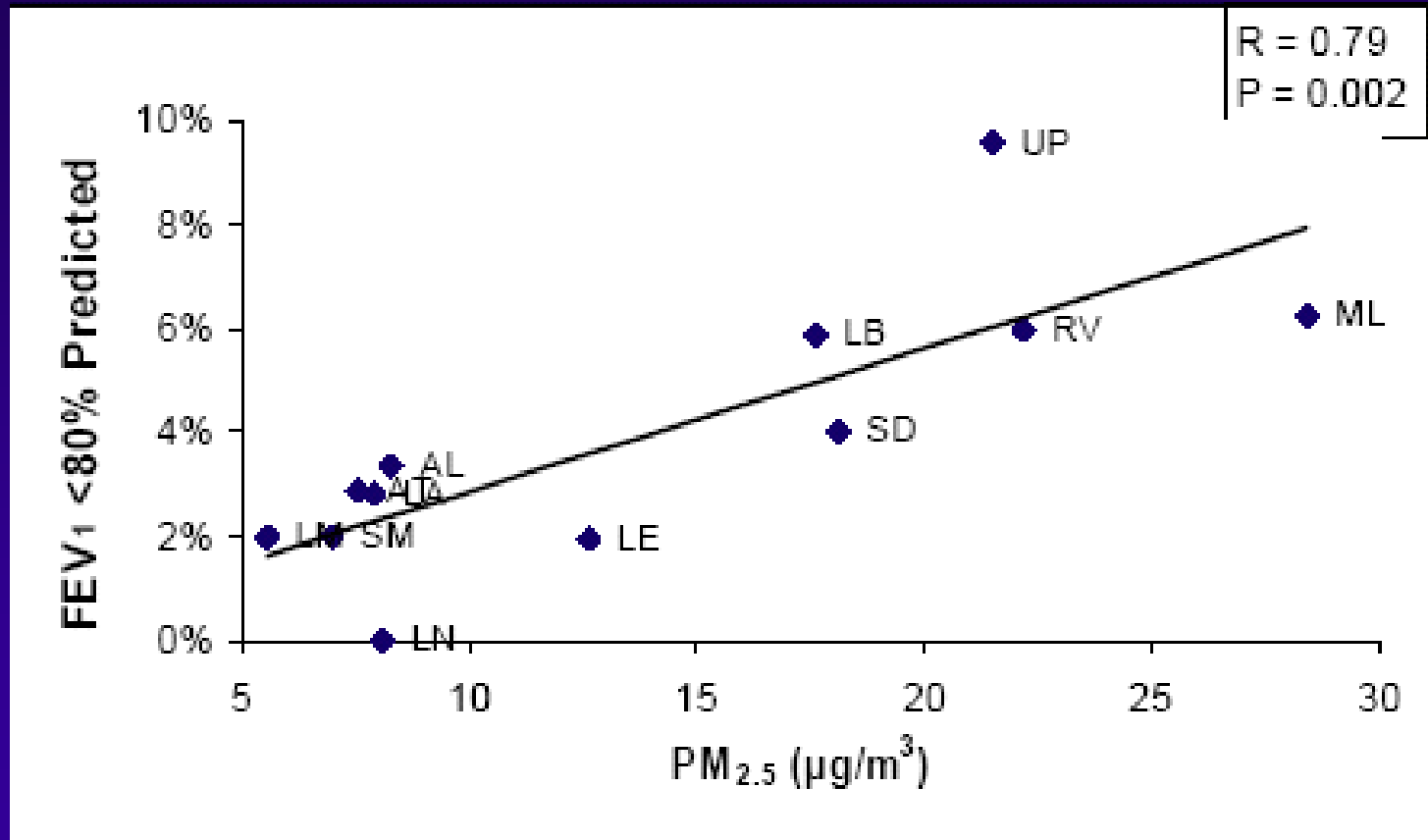


Ghio et al., 2003



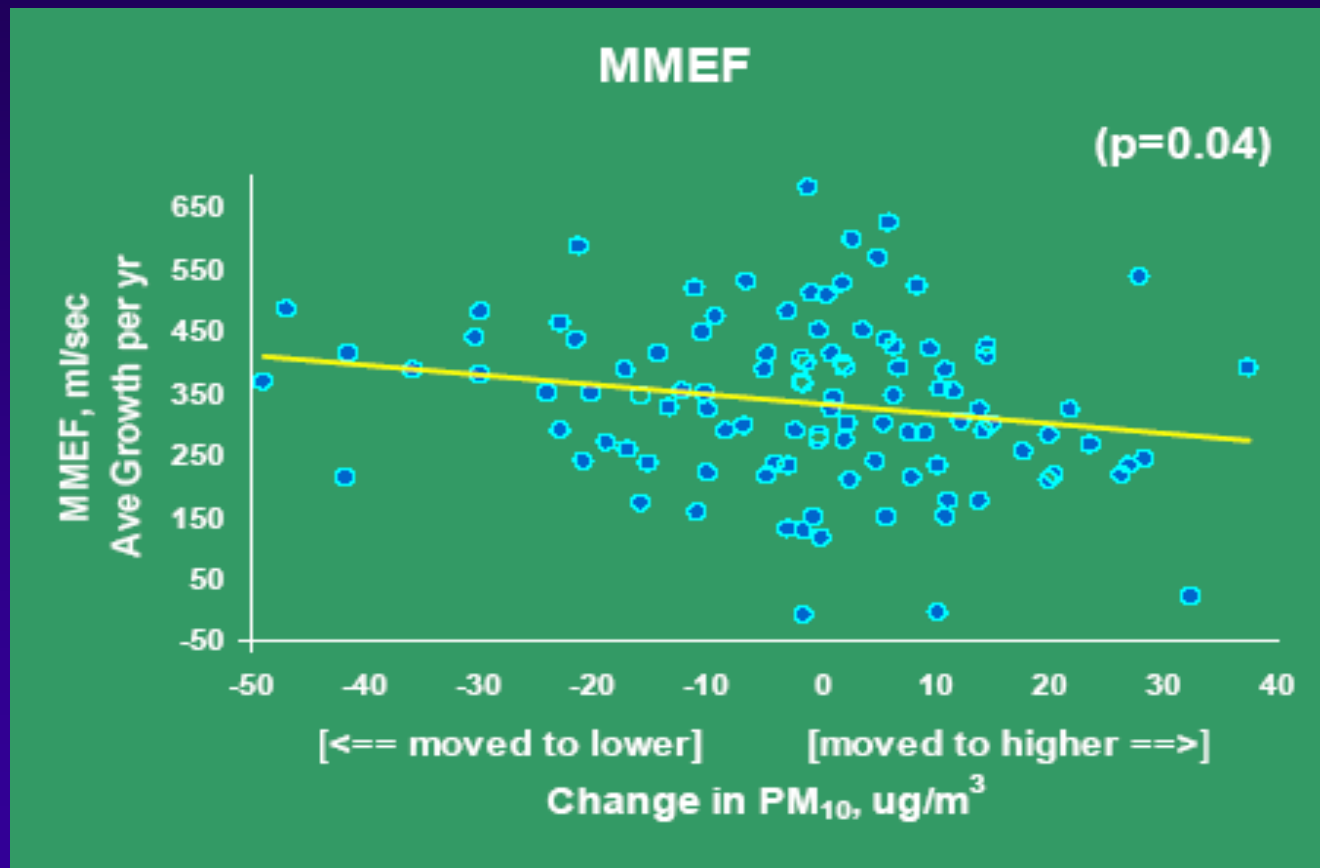
Devlin et al., 2003

# CHS: Low FEV<sub>1</sub> at Age 18 vs. Pollution



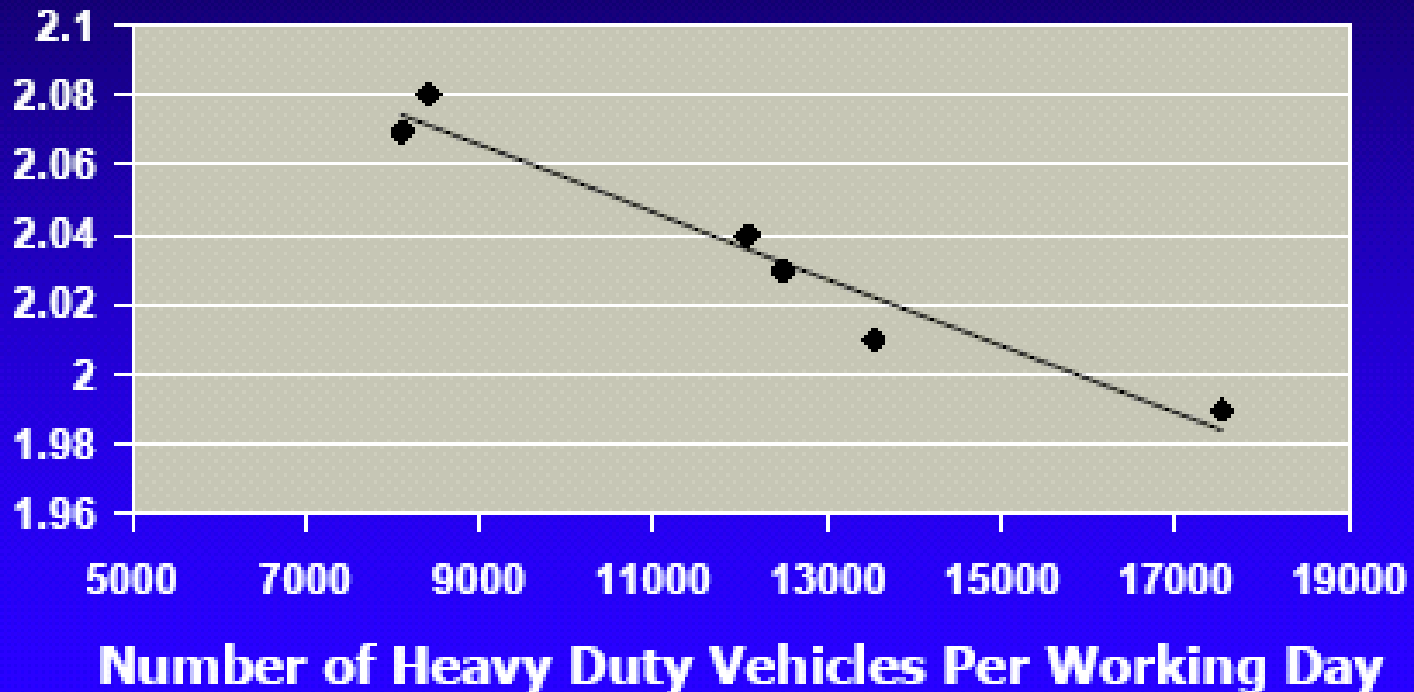


# CHS: Lung Function Growth in Movers



# Living Within 300 Meters of Local Roadways Affects FEV<sub>1</sub>

Lung Function  
FEV<sub>1</sub> (Liters)



**Brunekreef et al., 1997**

# Traffic Exposures

- Traffic exposure linked to respiratory symptoms in several European studies
- San Francisco bay area study linking pollution exposures at schools to symptoms (Kim et al., 2004)
- CHS study of residential NO<sub>2</sub>, traffic linked to asthma prevalence, symptoms, and medication use (Gauderman et al., 2005)

# Sensitive Groups for PM

- People with heart disease
- People with lung disease
- Older adults
- Children

# Air Quality Index

Descriptors	Cautionary Statement
<b>Good 0 – 50</b>	No message
<b>Moderate 51 – 100</b>	Unusually sensitive individuals
<b>Unhealthy for Sensitive Groups 101 - 150</b>	Identifiable groups at risk - different groups for different pollutants
<b>Unhealthy 151 - 200</b>	General public at risk; sensitive groups at greater risk
<b>Very Unhealthy 201 - 300</b>	General public at greater risk; sensitive groups at greatest risk

# Use AQI to Reduce Risk

**Dose = Concentration x Ventilation Rate x Time**

- Reduce these factors to reduce dose
- Pay attention to symptoms
- People with asthma – follow asthma action plan
- Coaches – rotate players frequently
- People with heart disease
  - Check with your doctor
  - Don't exercise near busy roads

AIRNow Web site  
<http://www.airnow.gov>

A cross-agency U.S. Government Web site. See a complete [list of AIRNow partner agencies](#) Search:  **GO**

**AIRNOW** Quality of Air Means Quality of Life

Home | National Forecast | Local Forecasts & Conditions | Partners

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[Air Quality Index](#)  
[Ozone](#)  
[Particle Pollution](#)  
[UV](#)

The AQI for...  
[Health Providers](#)  
[Kids](#)  
[Older Adults](#)  
[Partner agencies](#)  
[Teachers](#)  
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Key Topics:  
[Your Health](#)  
[Smoke from Fires](#)

Resources  
[Publications](#)  
[Publications](#)  
[FAQ](#)  
[What You Can Do](#)  
[Movies](#)  
[NAQ Conferences](#)  
[About the Data](#)

Contact Us

**National Overview** July 13th, 2006

**National Outlook for 7/13/06-7/14/06**  
 Unhealthy for Sensitive Groups AQI levels in the West and the East. [More](#)

National Outlook	Today's Forecast	Ozone Now	Particles Now	Today's Action Days
				Baton Rouge 5-Parish Area, LA OZONE
				Chattanooga, TN PM2.5
				El Paso, TX OZONE
				Great Smoky Mtns. Natl. Park - NC, TN PM2.5
				Knoxville, TN PM2.5
<a href="#">More</a>				
<b>Today's Highest AQI Forecasts</b>				
Bakersfield, CA OZONE				
Baton Rouge 5-Parish Area, LA OZONE				
Chattanooga, TN PM2.5				
El Paso, TX OZONE				
Fresno, CA OZONE				
<a href="#">More</a>				

Air Quality Outlook Jul 13- Jul 14, 2006

Today's National Forecast - click for larger map [view flash version of maps](#)

Today's: [Forecast](#) | [Action Days](#) Tomorrow's: [Forecast](#) | [Action Days](#)  
[Ozone Now](#) | [Particles Now](#) | [AQI Summary](#) | [Map Archives](#) | [International Air Quality](#)

**Local Resources**

**EnviroFlash** E-mail Notification  
 Sign-up for E-mail and Pager air quality notifications

[Local Forecast & Conditions](#)  
[Current Ozone & Particle Maps](#)  
[Compare Your City's Air Quality](#)  
[Submit Environmental Complaint](#)

**Web Cams** [EXIT AIRNOW](#)

07/13/2006 02:15 PM

[Newark NJ/New York City, NY](#)

[View Other Visibility Cams](#)

**Ozone: Good Up High, Bad Nearby**

Ozone acts as a protective layer high above the earth, but it can be harmful to breathe. [More](#)

**AQI**  
 AIR QUALITY INDEX

Good

Moderate

Unhealthy for Sensitive Groups

Unhealthy

Very Unhealthy

Hazardous

[More](#)

Alaska DEC continues air quality advisory due to wildfire smoke 7/12 - 7/14: The Alaska Department of Environmental Conservation has issued an air quality advisory for Interior Alaska.. [More](#) [EXIT AIRNOW](#)

U.S. EPA proposes PM-10 attainment for San Joaquin Valley air [More](#) [EXIT AIRNOW](#)

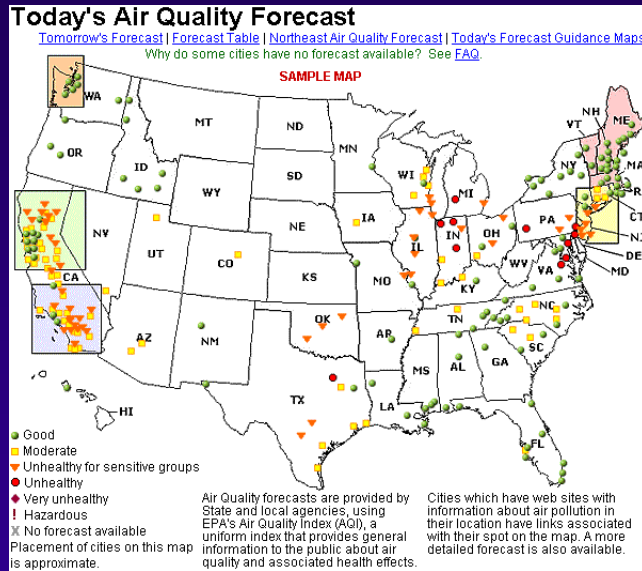
Hybrid Technology Takes Giant Leap into Commercial Vehicles - EPA Unveils UPS Delivery Truck with 60 to 70 Percent Higher Fuel Economy [More](#) [EXIT AIRNOW](#)

North Carolina expands EnviroFlash cities  
 Air quality e-mail notifications are available for [eight North Carolina cities](#).

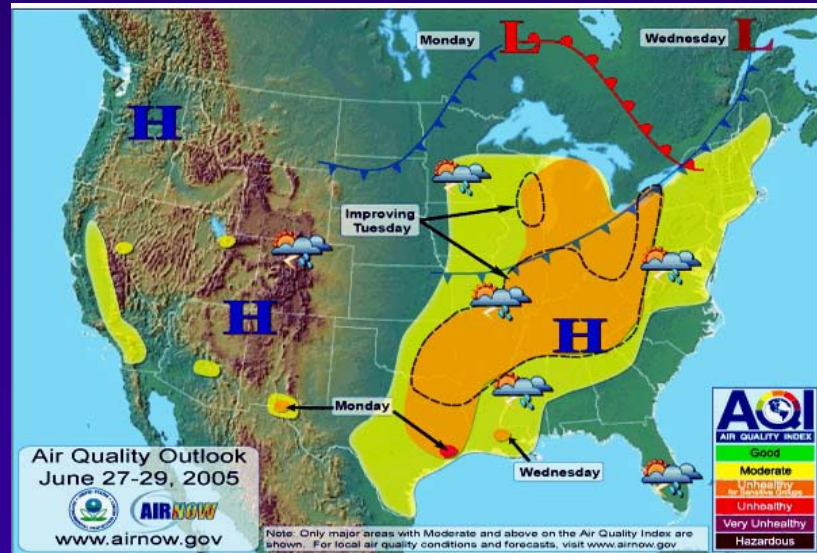
Sao Paulo, Brazil air quality data now available on-line

**Ozone**

# Air Quality Forecasting



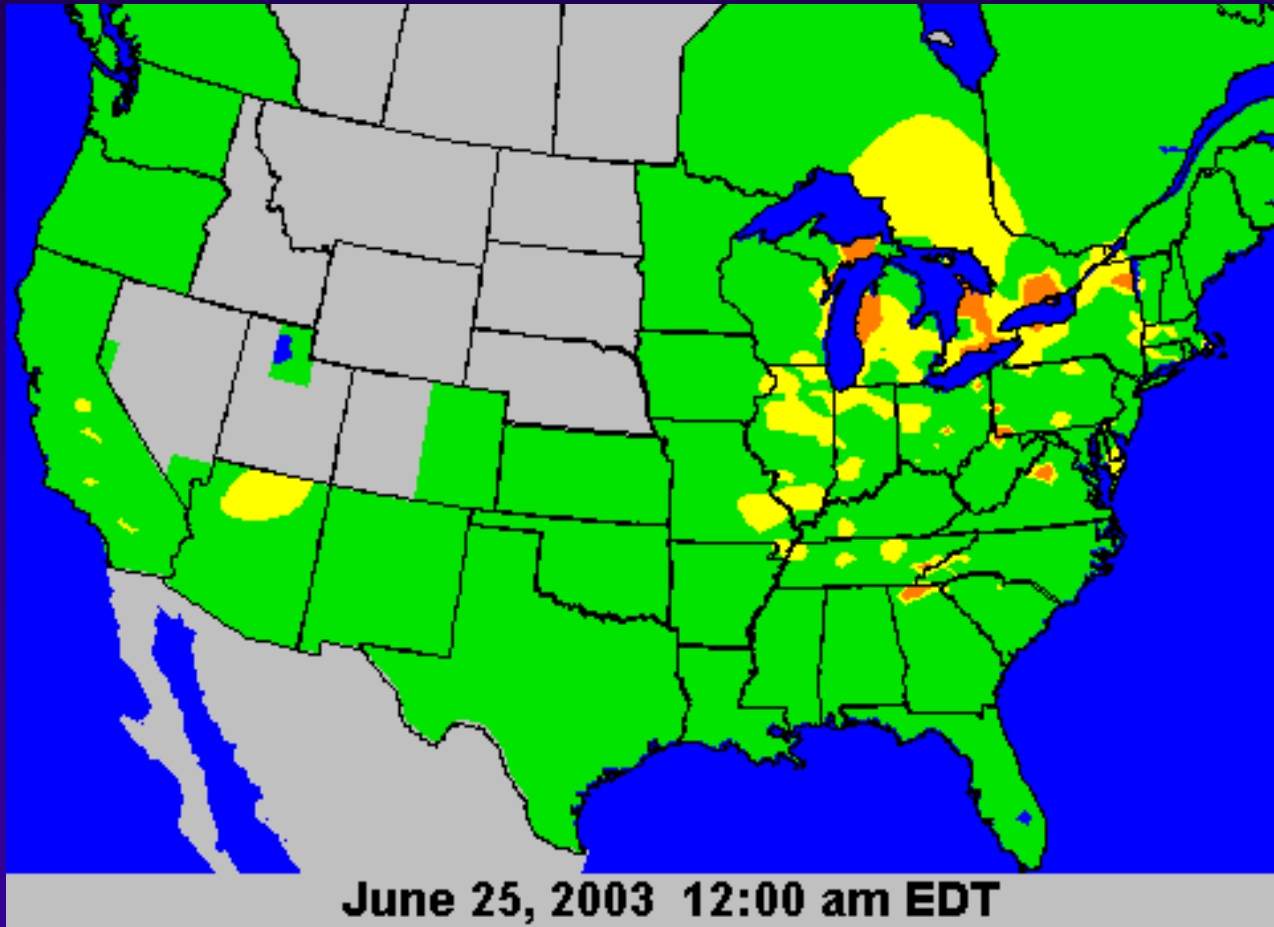
Daily



Two-Day Outlook



# Real-Time Air Quality Mapping



# Web Cameras



Phoenix, Arizona



# Teacher Curricula



### Air Quality Index Kids Website Teacher's Reference

**Clean Air and Dirty Air**

On a clear breezy day, the air smells fresh and clean. Clean air is air that has no pollutants (dirt and chemicals) in it. Clean air is good for people to breathe.



On a hot day with no wind, the air can feel heavy and have a bad smell. Once in a while, the air can even make your chest feel tight, or make you cough. Dirt and chemicals that get into the air make the air dirty or polluted. Dirty air is not good for people to breathe.

**Dirty Air Can Make You Sick**

When the air has some dust, soot or chemicals floating in it, people who are inside probably won't notice it. People who are outside might notice it.



People with asthma, a disease that can make it hard to breathe, and children who play outside a lot might feel a little strange. When you are active outdoors, for example, when you run and jump a lot, you breathe faster and take in more air. Any pollutants in the air go into your lungs.

When the air is very dirty, almost everyone will notice it. It would be good if we could stop breathing on those days, but of course we can't!


**How Can I Tell if the Air is Clean or Dirty?**

For information about visibility:  
<http://www.epa.gov/air/visibility/>

Have you ever been stopped behind a truck or a bus at a traffic light? When it starts up, sometimes a puff of dark smoke comes out of the exhaust pipe.

1

It's a **Red Day!**  
You should play outside in the **morning** when the Air Quality is better.



Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300



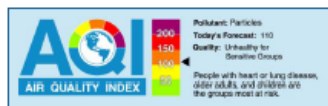
# Publications

Particle levels can be elevated indoors, especially when outdoor particle levels are high. Certain filters and room air cleaners can help reduce indoor particle levels. You also can reduce particle levels indoors by not smoking inside, and by reducing your use of other particle sources such as candles, wood-burning stoves, and fireplaces.

## How can the Air Quality Index help?

In many areas, local media provide air quality forecasts telling you when particle levels are expected to be unhealthy. Forecasts use the same format as EPA's Air Quality Index, or AQI, a tool that state and local agencies use to issue public reports of actual levels of particles, ground-level ozone, and other common air pollutants.

Using the AQI's color-coded scale, these forecasts help you quickly learn when air pollution is expected to reach unhealthy levels in your area. In the newspaper forecast below, for example, the black arrow points to the "orange" range, indicating that particle levels are expected to be unhealthy for sensitive groups. On television, you might hear a meteorologist say something like this: "Tomorrow will be a code orange air quality day, with particle pollution at levels that are unhealthy for sensitive groups. If you have heart or lung disease, or if you're an older adult or a child, you should plan strenuous activities for a time when air quality is better."



AIR QUALITY INDEX FOR PARTICLE POLLUTION		
Air Quality Index	Air Quality	Health Advisory
0 to 50	Good	None.
51 to 100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.
101 to 150	Unhealthy for Sensitive Groups	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
151 to 200	Unhealthy	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
201 to 300	Very Unhealthy	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.



Daily air quality and health information are available on the AIRNOW Web site.

## AIRNOW

AIRNOW ([www.epa.gov/airnow](http://www.epa.gov/airnow)) is a Web site that gives daily information about air quality, including ground-level ozone and particles, and how they may affect you. AIRNOW contains:

- Real-time particle levels for many locations.
- Air quality forecasts for many cities across the country.
- Kids' Web page and associated teacher curriculum.
- Smoke Web page.
- Links to state and local air quality programs.
- Ideas about what you can do to reduce particles. For example, you can keep your car, boat, and other engines well-tuned, and avoid using engines that smoke. You can also participate in local energy conservation programs.

\*Photo courtesy of The Weather Channel.

Office of Air and Radiation  
[www.epa.gov/air](http://www.epa.gov/air)  
 September 2003  
 EPA-452/F-03-001



United States  
Environmental Protection Agency

## Particle Pollution and Your Health



What Is Particle Pollution?

Are You at Risk?

How Can You Protect Yourself?

United States  
Environmental Protection Agency  
Air and Radiation

EPA-452/F-03-001  
February 2003  
Washington, DC 20460

## EPA El Ozono y Su Salud



¿Qué es el Ozono, o el Smog?

¿Corre Usted Riesgo?

¿Cómo Puede Protegerse?

# Medical Poster

## Effects of Common Air Pollutants

### RESPIRATORY EFFECTS



- Symptoms:**
- Cough
  - Phlegm
  - Chest tightness
  - Wheezing
  - Shortness of breath

**Increased sickness and premature death from:**

- Asthma
- Bronchitis (acute or chronic)
- Emphysema
- Pneumonia

**Development of new disease**

- Chronic bronchitis
- Premature aging of the lungs



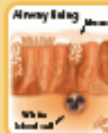
Alveolus filled with trapped air

**Effects on Lung Function**

- Narrowing of alveoli (by vasoconstriction)
- Decreased air flow

**Airway Inflammation**

- Influx of white blood cells
- Abnormal mucus production
- Rapid accumulation and swelling (edema)
- Death and shedding of cells that line airways



Airway Inflammation

**Increased Susceptibility to Respiratory Infection**



Normal



Lung with respiratory infection

### CARDIOVASCULAR EFFECTS



- Symptoms:**
- Chest tightness
  - Chest pain (anginal)
  - Palpitations
  - Shortness of breath
  - Unusual fatigue

**Increased sickness and premature death from:**

- Coronary artery disease
- Abnormal heart rhythms
- Cardiogenic heart failure

**How Pollutants May Cause Symptoms**

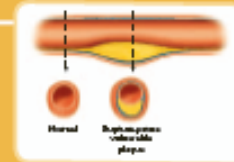


**Effects on Cardiovascular Function**

- Low oxygenation of red blood cells
- Abnormal heart rhythms
- Altered autonomic nervous system control of the heart

**Vascular Inflammation**

- Increased risk of blood clot formation
- Narrowing of vessels (vasoconstriction)
- Increased risk of atherosclerosis, plaque rupture



Normal Blood Vessel

Blood vessel with plaque



Reduce your risk by using the Air Quality Index (AQI) to plan outdoor activities – [www.airnow.gov](http://www.airnow.gov)

AQI Levels of Health Concern	AQI Values	What Action Should People Take?
Good	0-50	Enjoy Activities
Moderate	51-100	People unusually sensitive to air pollution: Plan strenuous outdoor activities when air quality is better
Unhealthy for Sensitive Groups	101-150	Sensitive Group: Cut back on moderate to strenuous outdoor activities People with asthma, heart disease, lung disease, older adults, and children Outdoor workers and people with lung disease Children, older adults, and people with heart disease Children, older adults, and people with heart disease and possibly increased asthma
Unhealthy	151-200	Everyone: Cut back on or avoid all strenuous outdoor activities Sensitive groups: Avoid strenuous outdoor activities
Very Unhealthy	201-300	Everyone: Significantly cut back on all outdoor physical activities Sensitive groups: Avoid all outdoor physical activities



# Ozone Web Course



U.S. Environmental Protection Agency

## Ozone and Your Patients' Health Training for Health Care Providers

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[EPA Home](#) > [Air & Radiation](#) > [Air Quality Planning and Standards](#) > [Air Pollution Training Institute](#) > Ozone and Your Patients' Health

### Course Overview

During the summer months millions of people in the United States are exposed to the ambient air pollutant ozone at levels that can cause uncomfortable and damaging respiratory symptoms. *Ozone and Your Patients' Health* is a short, evidence-based training course and resource that:

- Describes the physiological mechanisms responsible for the lung function changes and symptoms associated with exposure to ground-level ozone
- Helps health care providers advise their patients about exposure to ozone
- Provides practical tools to help patients understand what triggers their symptoms and how to alleviate them



*Ozone and Your Patients' Health* is designed for family practice doctors, pediatricians, nurse practitioners, asthma educators, and other medical professionals who counsel patients about asthma and respiratory symptoms. Patients and their families may also use this material to learn the science behind ozone's effect on respiration and how to manage their respiratory health using the Air Quality Index.

#### How to Use This On-line Training

*Ozone and Your Patients' Health* begins on this page and

The [Clinical Scenarios](#) section of this course discusses the following scenario and others in detail.

A 12-year-old girl and her mother arrive at your office for an evaluation of the child's asthma. At soccer practice the girl experienced chest tightness and shortness of breath, and she woke up during the night wheezing. Yesterday was

Course Overview/  
Ozone and Patients'  
Health Home

What is Ozone?

Health Effects in the  
General Population

Health Effects in  
Patients with Asthma

Patient Exposure and  
the Air Quality Index

Clinical Scenarios

Frequent Questions

Course Summary/  
Key Points

Patient Education

Glossary

References

Figures

Review Questions

Course Developers

# Asthma Factsheet



## ASTHMA AND OUTDOOR AIR POLLUTION



### 1 Air pollution can make asthma symptoms worse and trigger attacks.

If you or your child has asthma, have you ever noticed symptoms get worse when the air is polluted? Air pollution can make it harder to breathe. It can also cause other symptoms, like coughing, wheezing, chest discomfort, and a burning feeling in the lungs.

Two key air pollutants can affect asthma. One is *ozone* (found in smog). The other is *particle pollution* (found in haze, smoke, and dust). When ozone and particle pollution are in the air, adults and children with asthma are more likely to have symptoms.

### 2 You can take steps to help protect your health from air pollution.

#### ► Get to know how sensitive you are to air pollution.

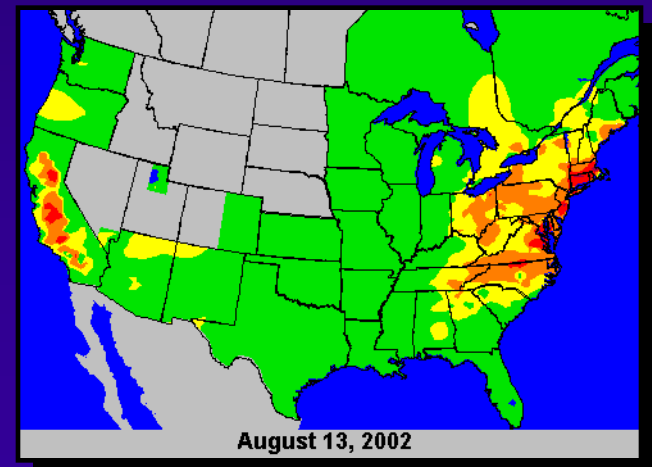
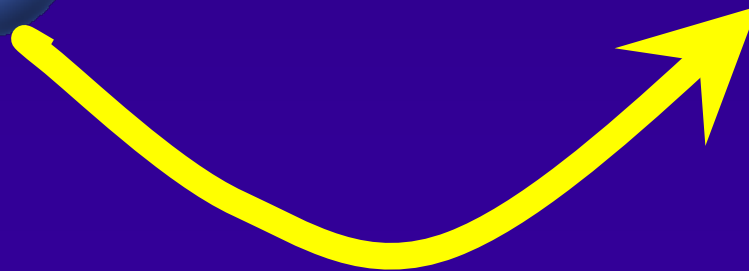
- Notice your asthma symptoms when you are physically active. Do they happen more often when the air is more polluted? If so, you may be sensitive to air pollution.

- Also notice any asthma symptoms that begin up to a day *after* you have been outdoors in polluted air. Air pollution can make you more sensitive to asthma triggers, like mold and dust mites. If you are more sensitive than usual to indoor asthma triggers, it could be due to air pollution outdoors.

#### ► Know when and where air pollution may be bad.

- *Ozone* is often worst on hot summer days, especially in the afternoons and early evenings.
- *Particle pollution* can be bad any time of year, even in winter. It can be especially bad when the weather is calm, allowing air pollution to build up. Particle levels can also be high:
  - Near busy roads, during rush hour, and around factories.
  - When there is smoke in the air from wood stoves, fireplaces, or burning vegetation.

# An Hour in the Life of an AIRNow Ozone Molecule





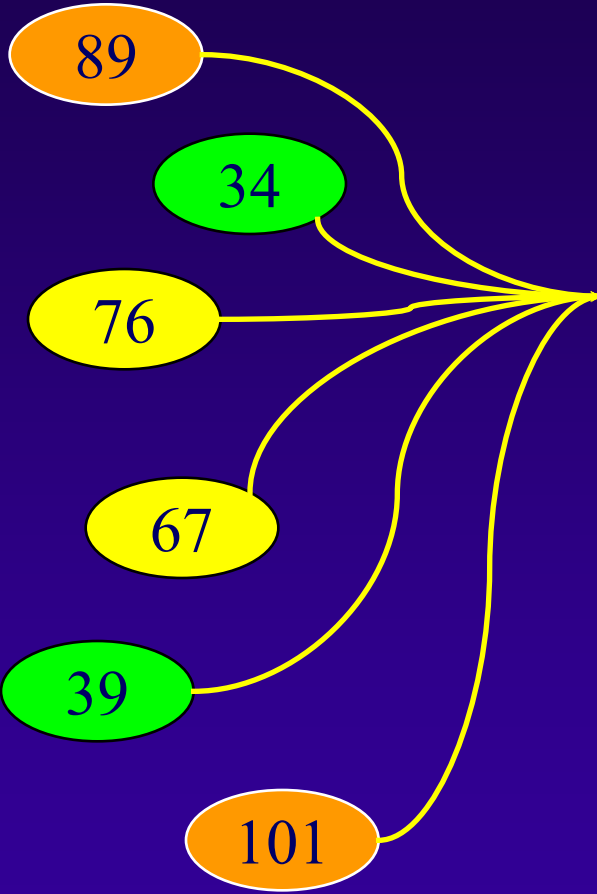
# The journey begins.....



9:59:59

10:00:01

# First stop: AQ Agency



```
START_REF. 0
NUMSTEPS. 24
AVG_TIME. 60
UNITS. PPB
STATIONS. 1342
! START HOUR
! ID AIRS CODE 0000 0100 0200 0300 0400 0500 0600
-----
BEGIN_DATA
ST.J .000010102, 5, 12, 7, 3, 2, 2, 7, 6, 9, 5, 6
ST.J .000010102, G, G, G, G, G, G, G, G, G, G, G, G
Come .000010301, 13, 13, 10, 6, 5, 7, 14, 16, 18, 22
Come .000010301, G, G, G, G, G, G, G, G, G, G, G, G
WELLI .000020301, 999, 999, 999, 999, 999, 999, 999, 999
```

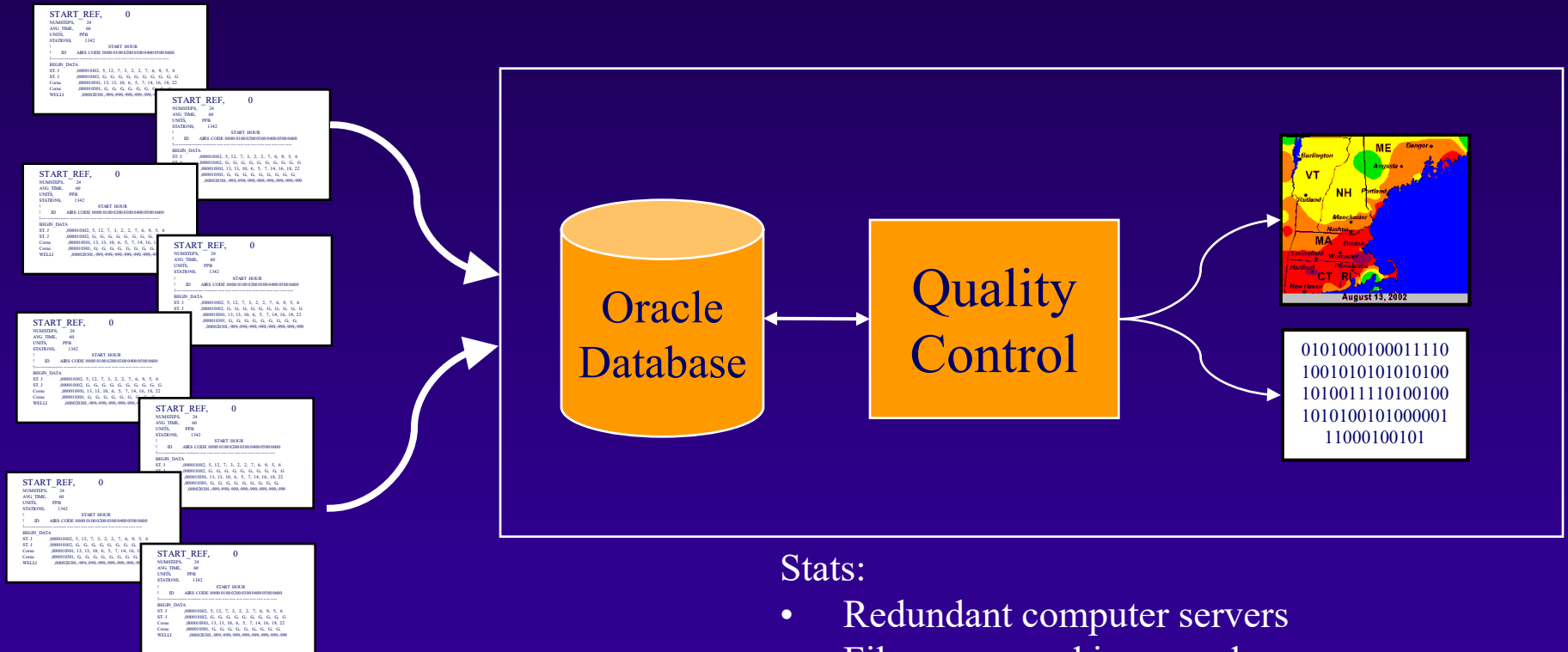
OBS data file

- Stats:
- 1200 monitors
  - 78 agencies nationwide
  - Collected every hour

10:05:29

10:15:21

# All roads lead to the DMC...



## Stats:

- Redundant computer servers
- Files processed in seconds
- Over 30,000 data values per day
- 50 maps produced every hour

10:31:45

10:45:21

# The last leg of the journey....



10:45:55

10:55:21

11:00:00