RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

CPH Exam Review Session
Environmental Health

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For today to prepare for the exam we will cover:

Introduction to Environmental Health

Toxicology

Risk Assessment

Air

Water

Food

Children

DEFINITIONS

- **HEALTH** is “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1948)

- **ENVIRONMENT** is “... [All] that which is external to individual human host. [It] can be divided into physical, biological, social cultural any or all of which can influence health status in populations.” (WHO, 1995)

ENVIRONMENTAL SCALE

- **Local**: focus on the environment (e.g. water, air) on the subpopulation closest to the exposure
- **Global**: focus on effect of an unbounded environment (e.g. air) on populations anywhere

Making the case:

WHO has determined that 27 percent of global disease is caused by environmental exposures which can be averted.

Education, training and carefully targeted interventions can prevent much of this environmental risk. The WHO also estimates that more than 33 percent of disease in children under the age of 5 is caused by environmental exposures.

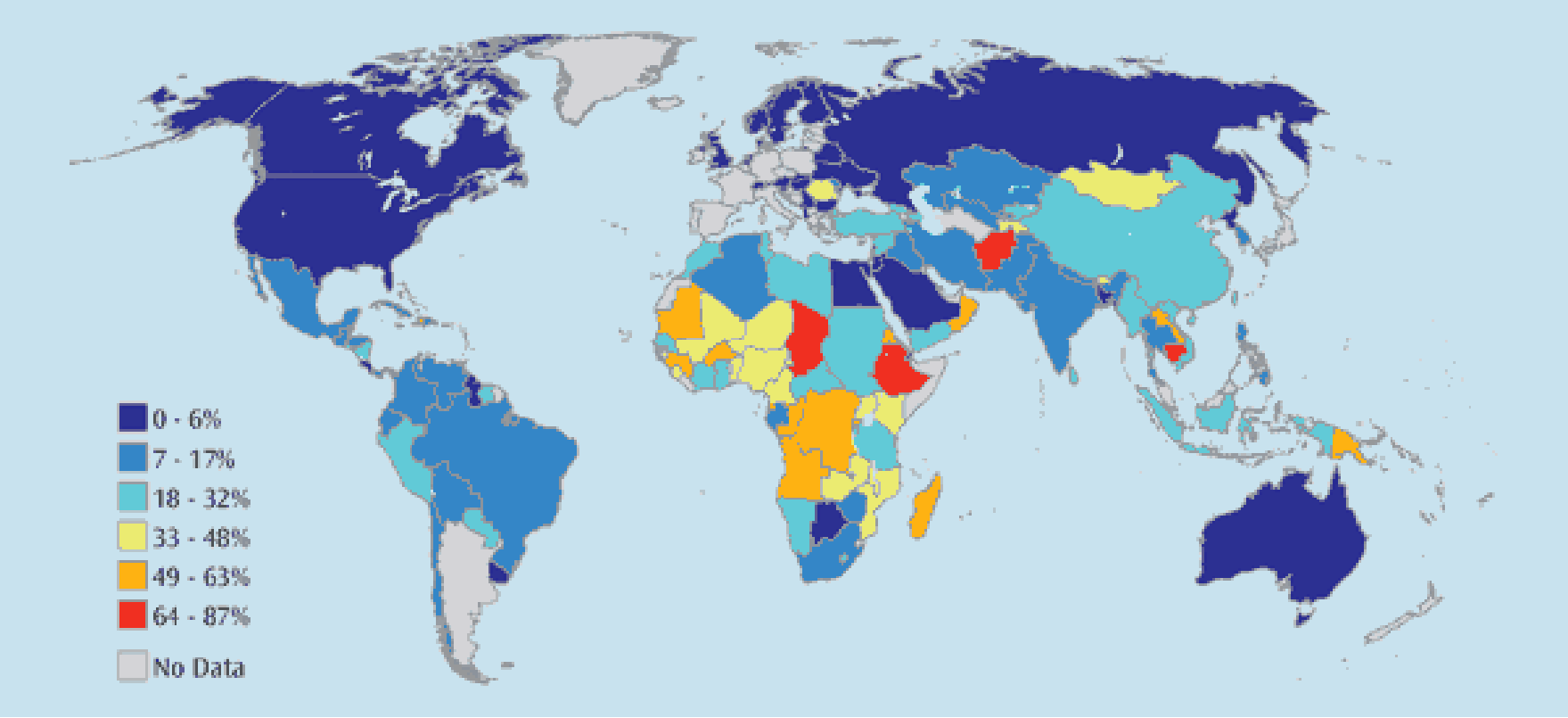
Preventing environmental risk could save as many as four million lives a year in children alone, mostly in developing countries.

Making the case:

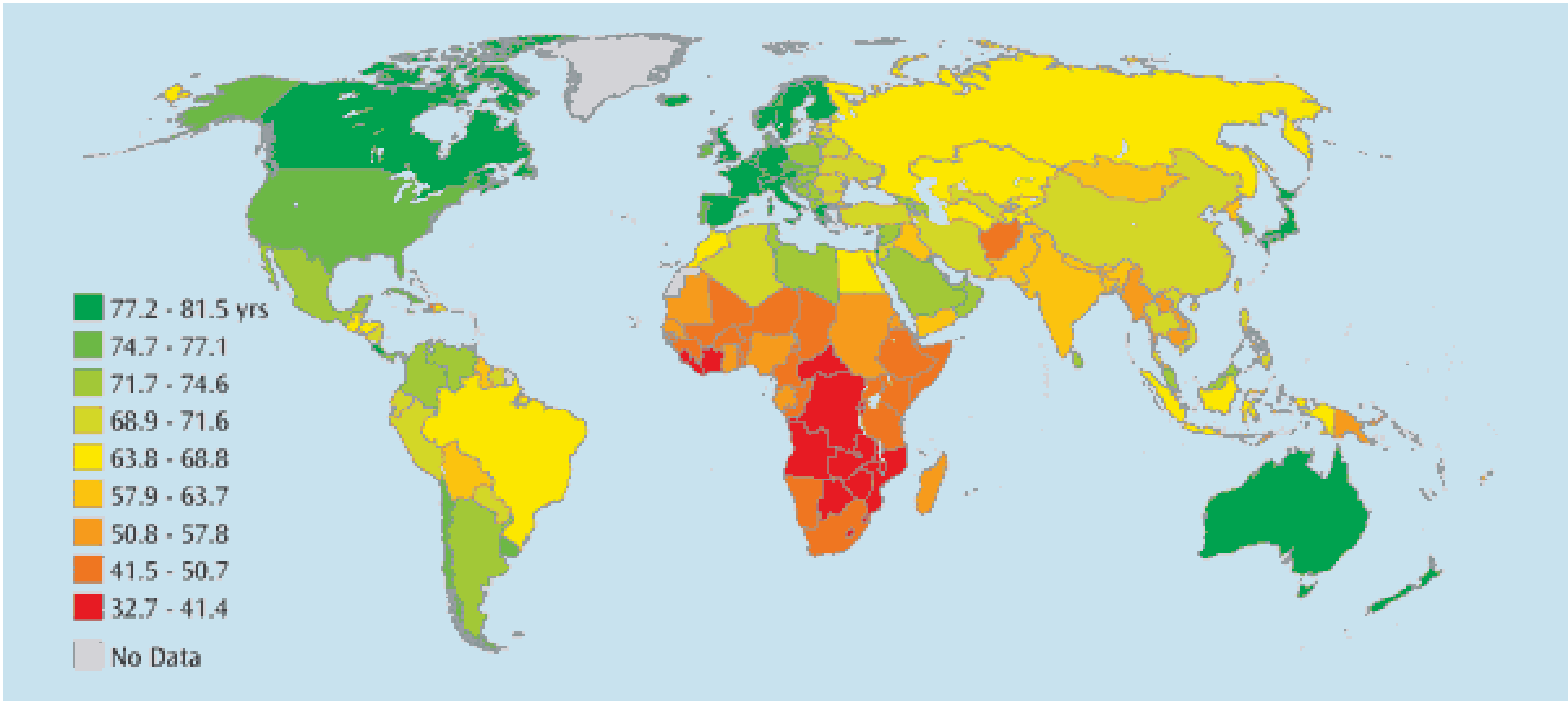
WHO estimates that more than 13 million deaths annually are due to preventable environmental causes. Nearly one third of death and disease in the least developed regions are due to environmental causes. Over 40 percent of deaths from malaria and an estimated 94 percent of deaths from diarrheal diseases, two of the world's biggest childhood killers, could be prevented through better environmental management.

The four main diseases influenced by poor environments are diarrhea, lower respiratory infections, various forms of unintentional injuries, and malaria. Measures which could be taken now to reduce this environmental disease burden include the promotion of safe household water storage and better hygienic measures; the use of cleaner and safer fuels; increased safety of the built environment, more judicious use and management of toxic substances in the home and workplace; better water resource management.

Population Without Access to Safe Water



Global Life Expectancy



Question #1

What **percentage** of the world's population is considered to be living in developing countries?

A.) 40 percent

B.) 60 percent

C.) 80 percent

Making the case:

Many countries around the world, especially in Africa and South America, are considered developing countries. It is estimated that 80 percent of the world's population live in the developing countries.

But ***MORE THAN*** 80 percent of the world's occupational and environmental health problems occur in these countries. Examples: silicosis, lead poisoning, benzene poisoning.

What is happening in the developing countries, as far as occupational and environmental risks, is what was happening in the currently developed countries 50 years ago.

Introduction to Environmental Health

Toxicology

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Question #2

Who is often called the "**Father of Toxicology**"?

A.) Paracelsus

B.) Pasteur

C.) Waksman

Paracelsus is known as the father of Toxicology

Alle Ding' sind Gift, und nichts ohn' Gift; allein die Dosis macht, daß ein Ding kein Gift ist.“

All things are poison, and nothing is without poison; only the dose permits something not to be poisonous.“

Or, more commonly, “the dose makes the poison”

That is to say, substances considered toxic are harmless in small doses, and conversely an ordinarily harmless substance can be deadly if over-consumed.


FAMOSO·DOCTOR PARESELSVS.

Lucrezia Borgia The Mother of Toxciology

•Lucrezia has been called the most depraved woman in history.

•Did she keep bottles on her boudoir with perfume to seduce and poison to kill?

•Was she pricking enemies with an arsenic - drenching ring...her favorite method of disposing of men?

HAZARD

- This is often used as a synonym for toxicity. Hazard is a more complex concept, as it includes conditions of use.
- A hazard has 2 components:
  - Inherent ability of the chemical to do harm by virtue of its explosiveness, flammability, corrosiveness, toxicity, etc.
  - The ease with which contact can be established between the chemical and the object of concern.

DOSE TIME RELATIONSHIP
or HOW MUCH AND HOW OFTEN

ACUTE TOXICITY:

Refers to the ability of a substance to do systemic damage as a result of a one-time exposure of relatively short duration.

CHRONIC TOXICITY:

Refers to the harmful systemic effects produced by long-term, low-level exposure to chemicals. Chronic toxicity is a far more complex issue.

Question #3

LD stands for:

A.) Lethal Dose

B.) Legal Dose

C.) Largest Dose

LETHAL DOSE (LD_{50})

This is a term to describe acute toxicity.

Subscript 50 means that the dose was lethal for 50% of the population who had the administered dose.

- LD_0 There were no resultant deaths
- LD_{100} The entire population died

The units for LD_{50} are in mg of chemical/kg of body weight. The smaller the LD_{50}, the fewer the mg of chemical/kg of body weight will be required to kill the animal. Conversely, the larger the the LD_{50}, the lower the acute toxicity.

We can say that LD_{50} and acute toxicity are inversely related.

LETHAL DOSE FOR HUMANS

LD_{50}	10 kg Child (22 lbs)	70 kg Adult (154 lbs)
<5	1 Drop	1/16 Tsp.
5-50	1 Drop to 1/8 Tsp.	1/16-3/4Tsp.
50-500	1/8-1 Tsp.	3/4-3 Tsp.
500-5000	1 Tsp.-4 Tbsp	3-30 Tbsp.
>5000	Over 4 Tbsp.	Over 30 Tbsp. (1 lb.)

- For inhalation work, we use a different designation: Lethal Concentration 50 (LC_{50}):

- LC_{50} is determined by exposing several groups of animals, usually rats or mice, each to a different air concentration of the chemical for a one-hour period, then they are observed for a 14-day period.

VITAMIN D

- Vitamin D is highly acutely toxic, 10 mg/kg or about 400,000 international units/kg.
- The pesticide Parathion is also acutely toxic at 10 mg/kg.
- Vitamin D is exempted from the hazardous substances labeling act because it is in food (milk) and a drug (sold as a vitamin.) Otherwise, it would be required to carry a poison label.
- Everyone of U.S. requires about 10ug per day (400 IU.)

SODIUM FLUORIDE

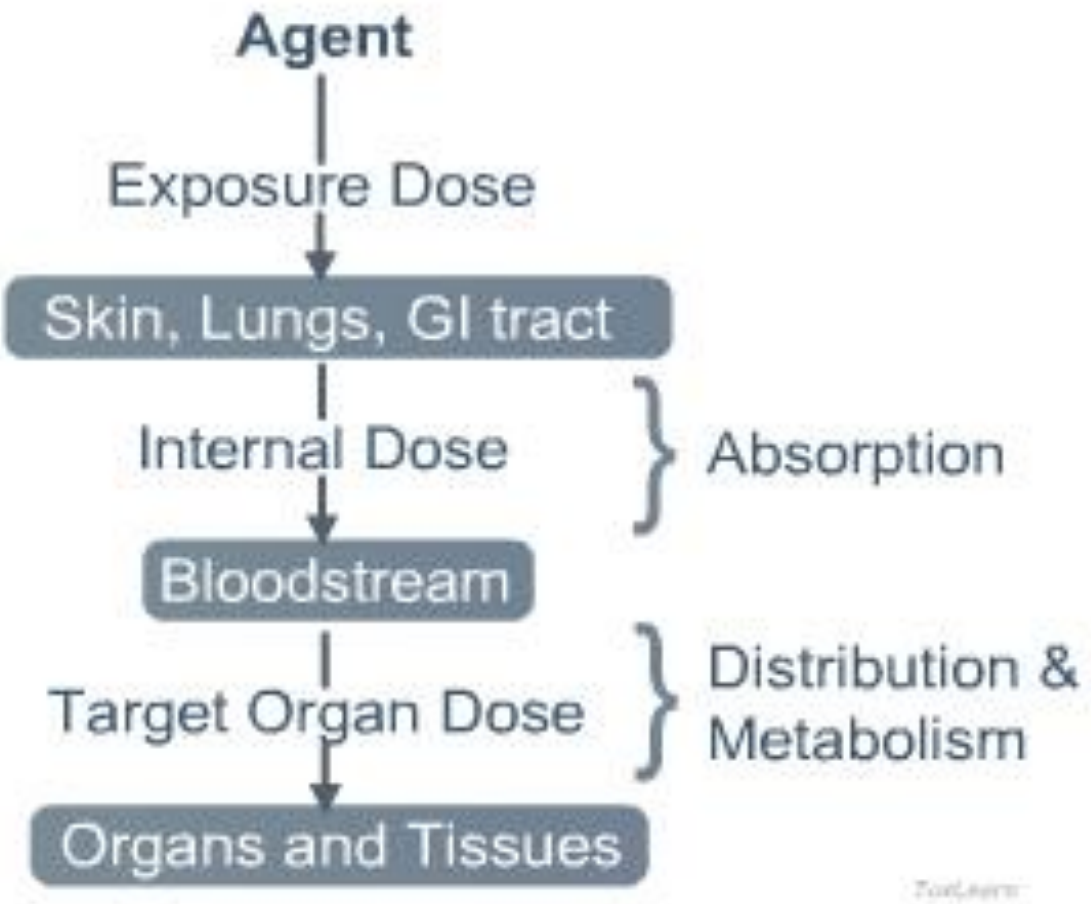
- High Acute Oral Toxicity-35 mg/kg
- We take it in chronic low dose, 1 or 2 mg daily for good dental health
- If we exceed a dose of 3 or 4 mg/day we get mottling of tooth enamel in young people
- There has been some opposition to water fluoridation. However, epidemiological studies show that there are no effects from long term use of fluoridated water.

ROUTES OF EXPOSURE

The route of exposure is the pathway by which the chemical gets into the body.

Three Major Routes:

1) Penetration through the Skin (Dermal Entry)
2) Absorption through the Lungs (Inhalation)
3) Passage across the walls of the Gastrointestinal Tract (Oral)


Agent
Exposure Dose
Skin, Lungs, GI tract
Internal Dose
Absorption
Bloodstream
Target Organ Dose
Distribution &
Metabolism
Organs and Tissues

Question #4

There are three main routes of exposure to a toxin, the **most common** of the three is:

A.) Oral

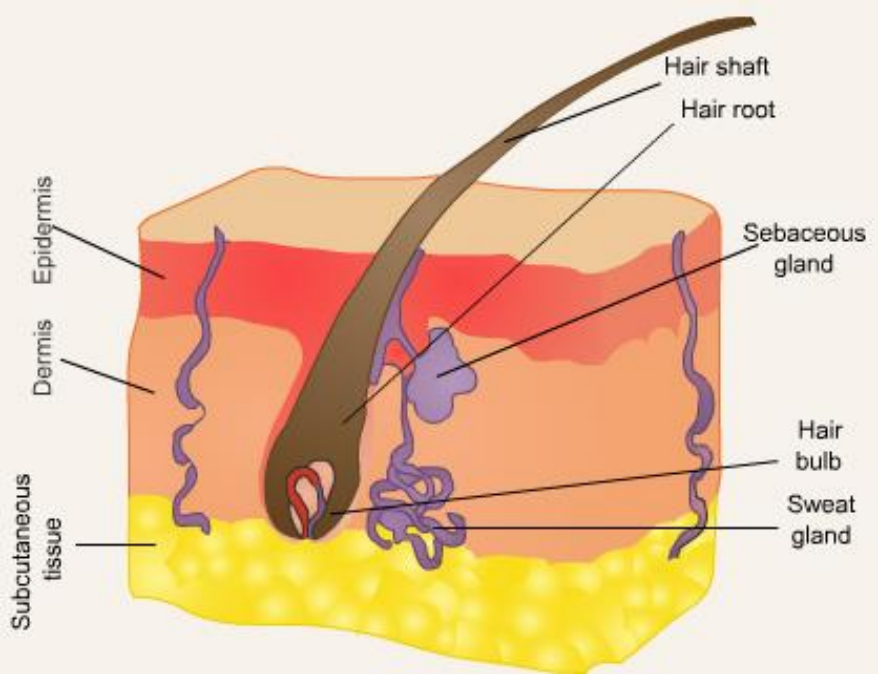
B.) Dermal

C.) Ingestion

DERMAL

- The most common way to contact chemicals is dermally. But the skin is a very effective barrier to chemicals. We have about 20 sq.ft. of skin.

- The second most common route is via inhalation. Lungs are a poor barrier to chemical. We have about 750 sq.ft. of lung surface.

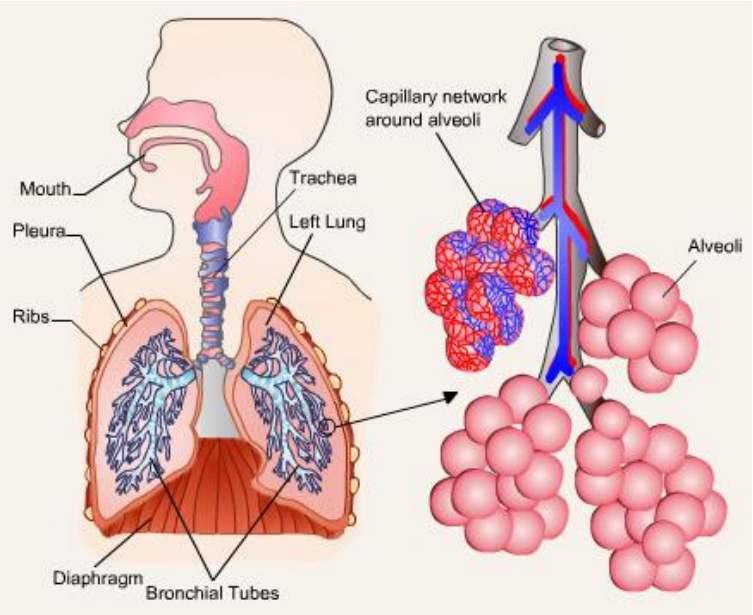


INHALATION

- Remember the function of the lungs is to deliver O_2 from air to blood and CO_2 from blood to air. The lung surface is very delicate and very thin membrane, about one cell thick.

- The one cell thick membrane allows easy passage of oxygen and other chemicals form the alveolar space to the blood. (This is why people smoke marijuana instead of eating it.)

- In addition to the systemic nature-there are also the issues of interference with function. Asbestos and Silica damage the lung surfaces, causing asbestosis and silicosis. There are other examples from cotton dust, coal dust, sugar cane pulp. Collectively these diseases are called pneumoconiosis.

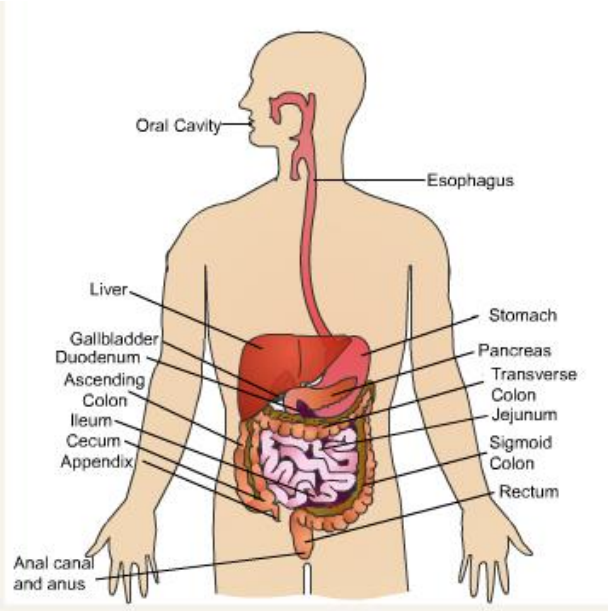


ORAL

- The oral route is through ingestion – mainly through food that we eat. Chemicals enter the body and are absorbed through the G.I. tract.

- The absorption can occur anywhere from the mouth to the rectum. The majority of the absorption takes place in the small intestine.

- Nitroglycerine is absorbed through the mucus membranes of the mouth, that is why it is taken and placed under the tongue. Ethyl alcohol is absorbed rapidly in the stomach as well as the intestine, that is why the effects are seen so quickly. It is also why food in the stomach can delay some of the effects.



SO, WHY IS THIS IMPORTANT?

- We base the toxicology and the risk assumptions on using animal models, but which animals?
- Man and monkey are fairly similar
  - Monkeys do respond to methanol the same as man
  - Monkeys do not respond to nitrobenzene the same as man
- The use of animal data to human data dates back to the amendments made in 1958 to the Food Additives Amendments Act which is known to most as the Delaney Amendment.
- The food additive is considered a carcinogen if it cause cancer in any animal species at any level of exposure.

AGE

- Age has an influence on toxicity in many models
  - DDT is not acutely toxic to newborn rats, however, it becomes progressively more toxic as the rats mature. The adult LD50 is 200-300 mg/kg.
- The organophosphate parathion is more acutely toxic to newborn rats than adults rats.
- The age difference is usually a function of the body systems and the ability to metabolize foreign chemicals-the major player being the liver microsomal enzyme system.

SEX

- There are obvious physical and physiological differences.
  - Male rats are 10X more sensitive to liver damage than female rats from chronic oral exposure to DDT.
- Sex differences are usually a function of hormone activity.
- Castration or hormone administration can limit the differences.

Question #5

For a dose-response curve the **x axis** is the:

A.) Dose

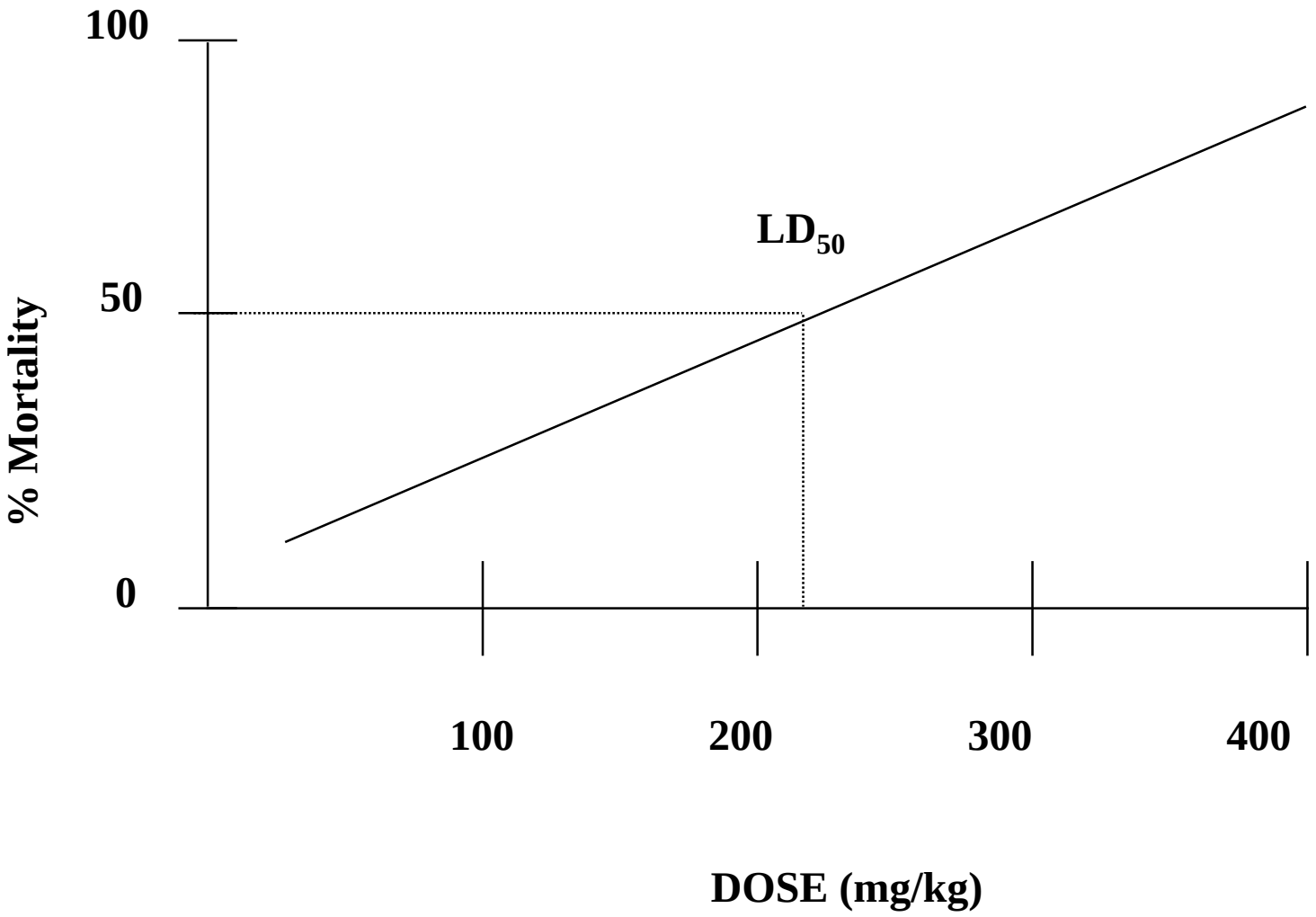
B.) Response

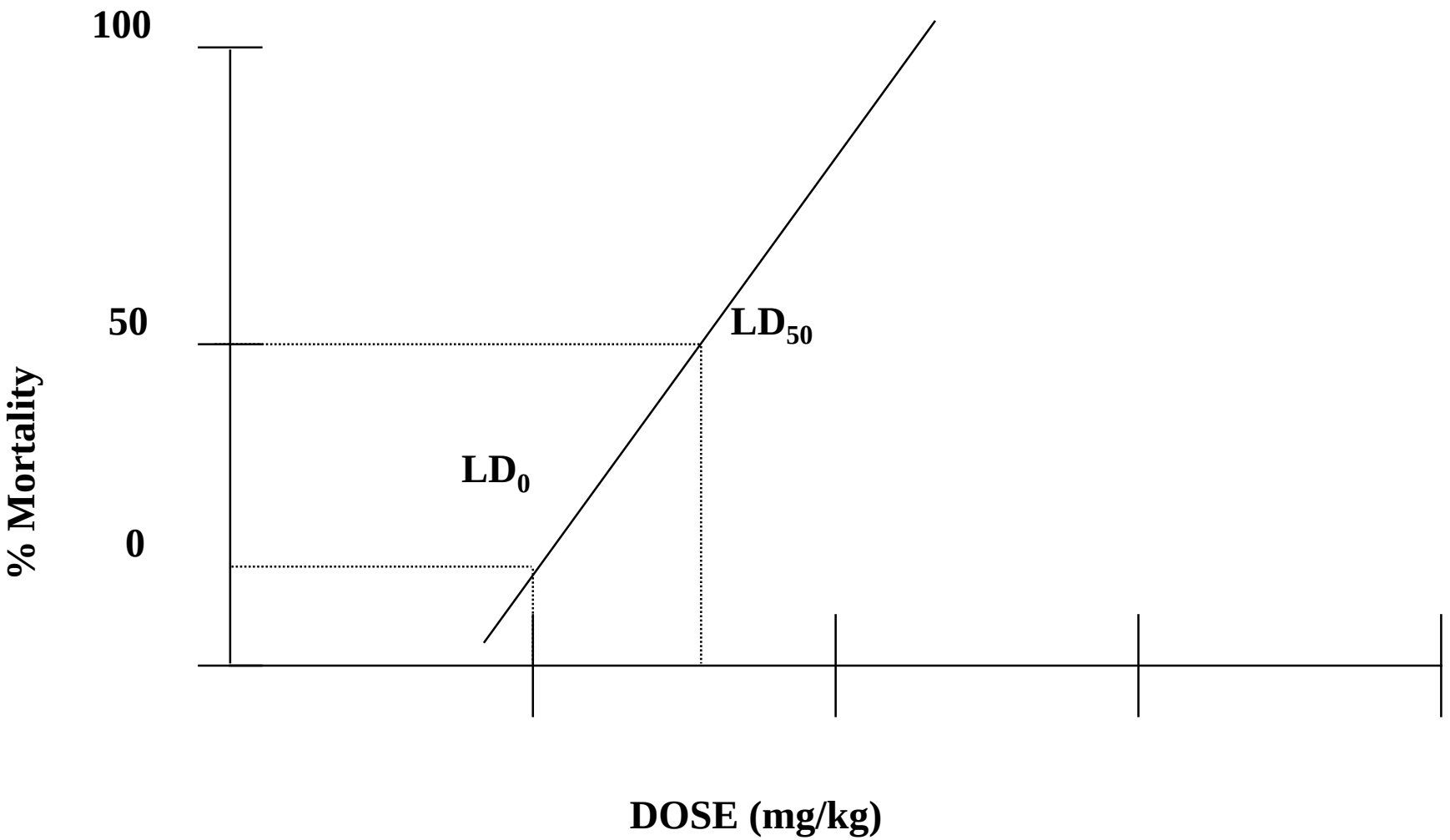
Question #6

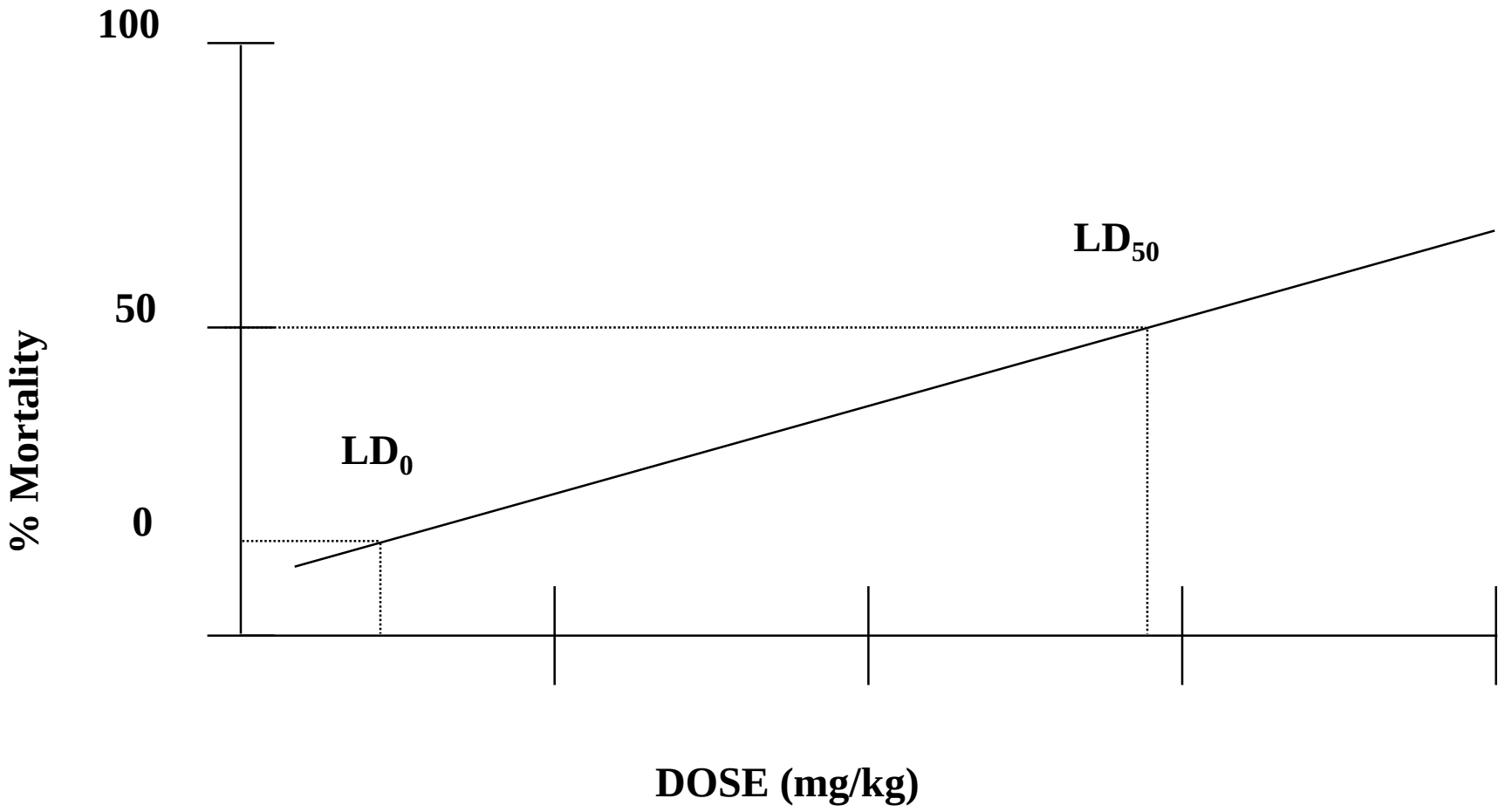
The **y axis** is:

A.) Dose

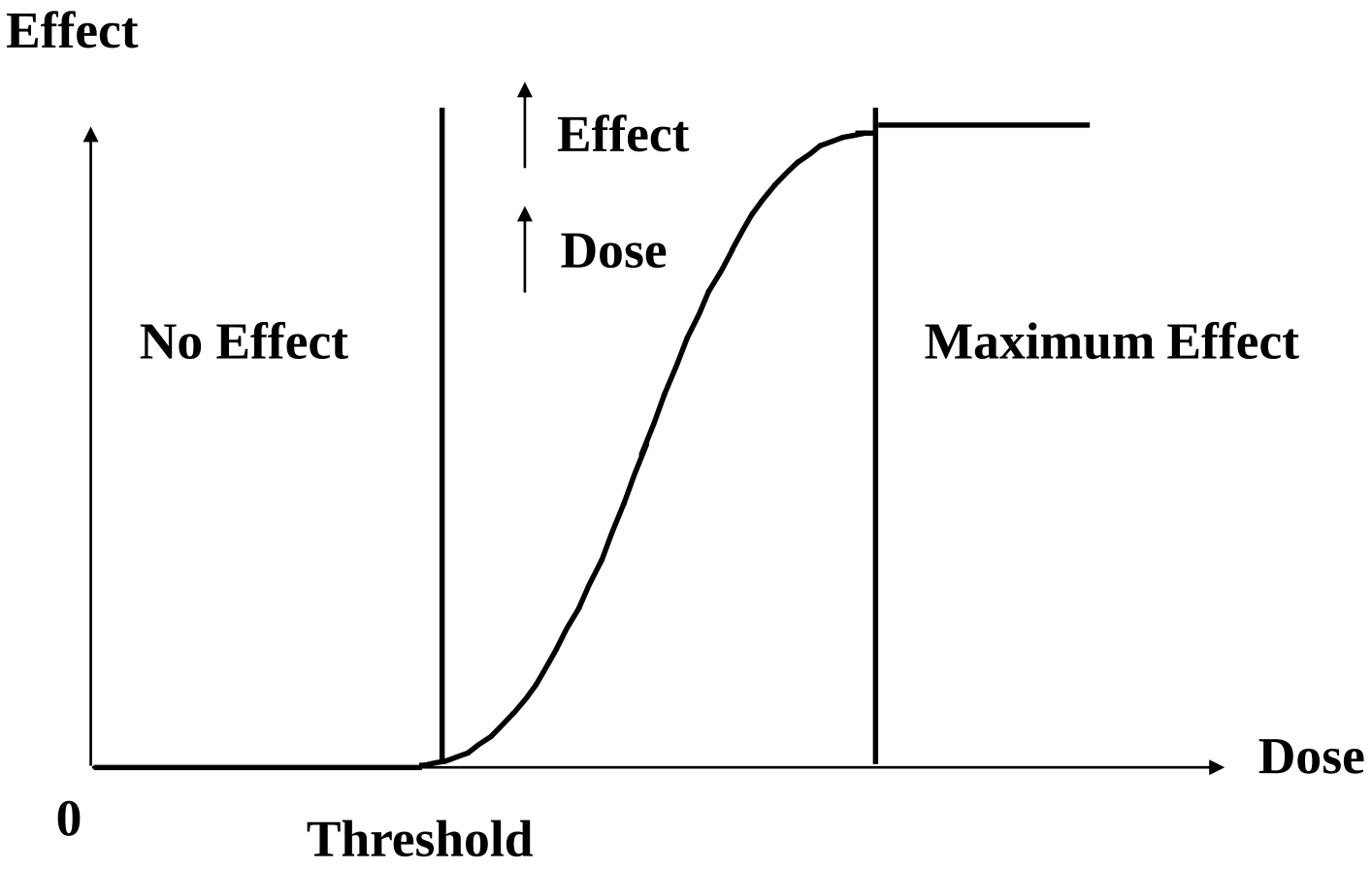
B.) Response


100
50
0
% Mortality
LD50
100
200
300
400
DOSE (mg/kg)


100
50
0
% Mortality
LD50
LD0
DOSE (mg/kg)

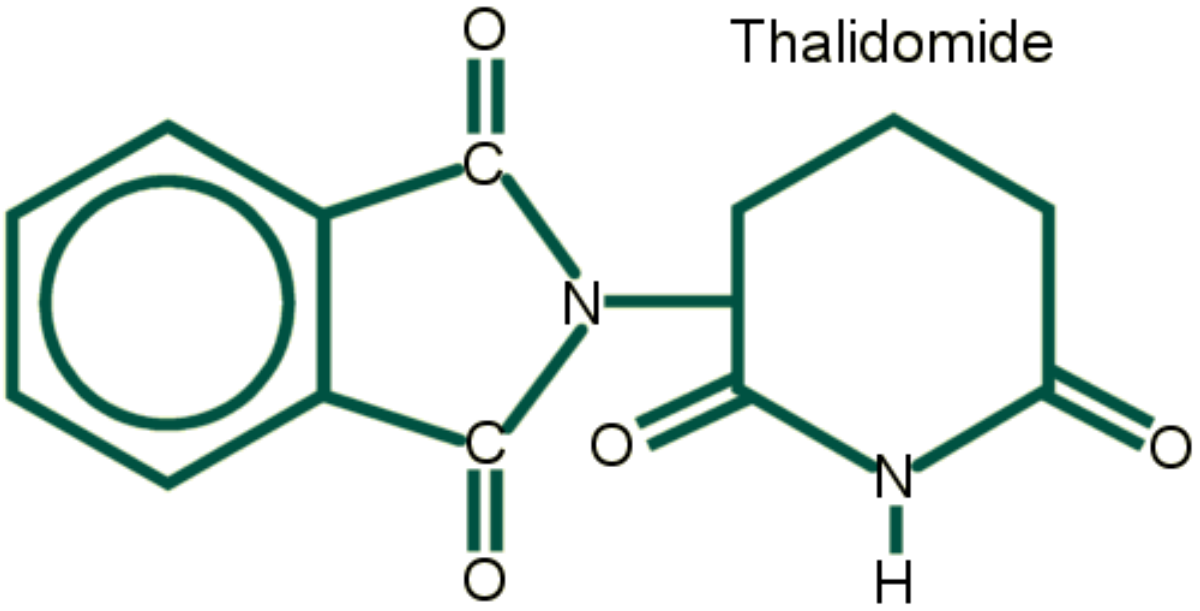

100
50
0
% Mortality
LD50
LD0
DOSE (mg/kg)

- Chronic Toxicity was recognized first in occupational illness
- Greek Physicians noted that certain trades had poorer health- e.g. mining, metallurgy, pottery.
- Hippocrates described severe colic in men who extracted metals-Pb poisoning
- Pliny wrote of Hg poisoning in miners from the quicksilver mines of Spain


Effect
Effect
Dose
No Effect
Maximum Effect
Dose
0
Threshold

THALID (THALIDOMIDE)

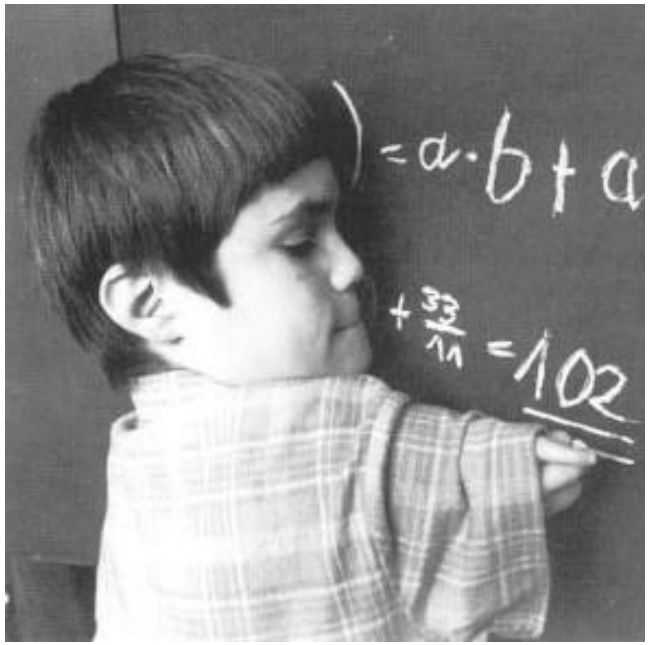
- Marketed outside the U.S. in the late 1950s as a mild sedative to combat nausea in pregnant women; used as a sleeping pill and to treat morning sickness during pregnancy
- Withdrawn from market in 1961 after it was discovered to be a human teratogen
- Not all animal species tested produced reactions to thalidomide exposure similar to those seen in humans

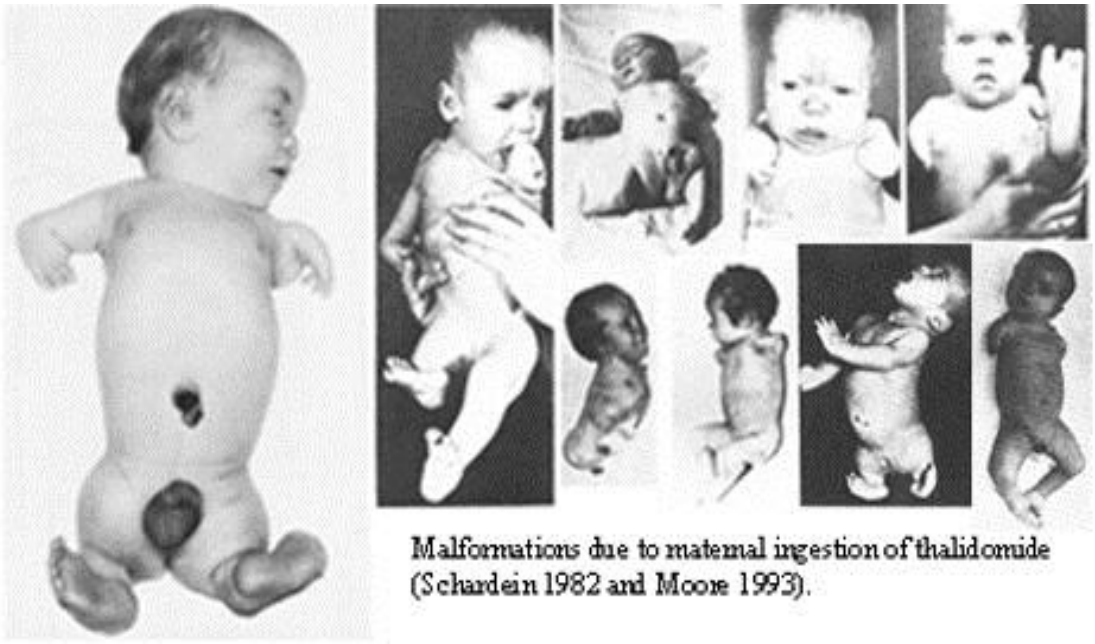

Thalidomide
O
C
N
C
O
O
N
H
O

Thalidomide

IMPORTANT PATIENT INFORMATION

When a pregnant woman takes thalidomide 34-50 days (4.5 to 7 weeks) after the beginning of her last menstrual period, there is a risk of approximately 20% or greater to have a baby with problems such as extremely short or missing arms and legs (phocomelia), missing ears (both outside and inside), and deafness





Malformations due to maternal ingestion of thalidomide (Schardein 1982 and Moore 1993).

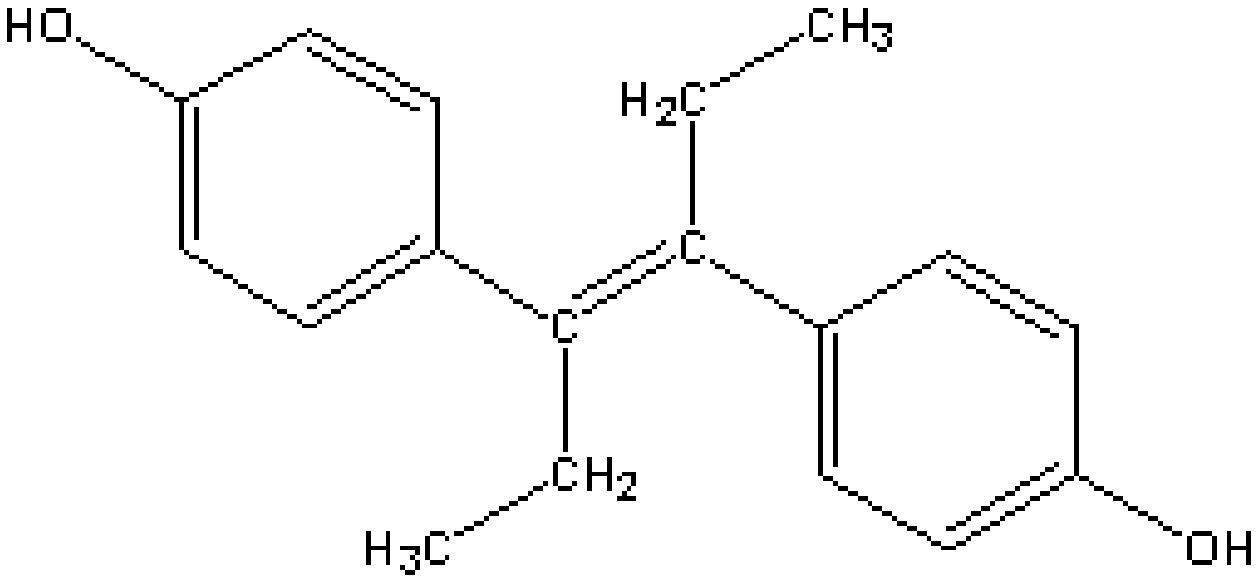
THALIDOMIDE TODAY

- Lepropsy:
  - Approved to treat & control painful, disfiguring skin sores associated with leprosy
- HIV related disorders:
  - Possibly inhibit HIV replication (so far only in laboratory tests)
  - Stop and perhaps reverse AIDS related cachexia (wasting)
- Treating non-microbial apthous ulcers of the mouth and throat

DIETHYLSTILBESTROL

- Prescribed between 1940 and 1970 to prevent miscarriages in high risk pregnancies
- Cases of vaginal adenocarcinoma in women ages 16-20 were linked to fetal exposure through maternal DES ingestion early in the pregnancy
- Approximately 1 in 1000 pregnancies were exposed

DIETHYLSTILBESTROL

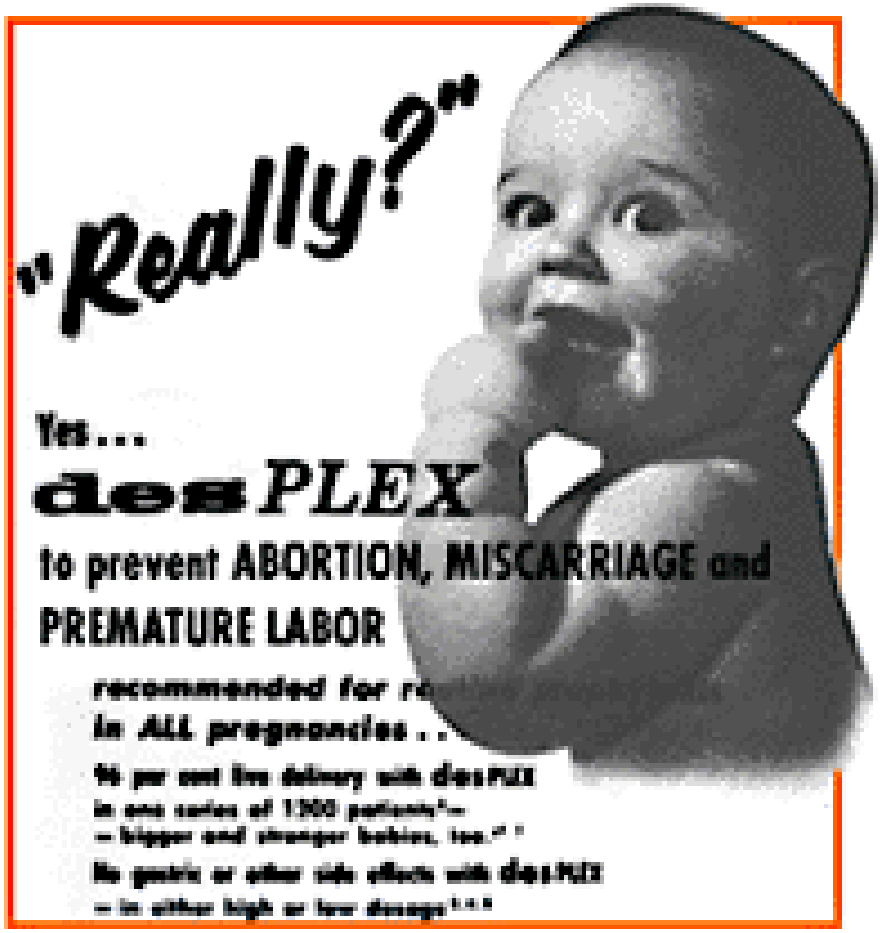


DES Ad from 1957

This ad appeared in a major medical journal in 1957. The small print at the bottom reads:

"Recommended for routine prophylaxis in ALL pregnancies...

96 per cent live delivery with desPLEX in one series of 1200 patients – bigger and stronger babies, too. No gastric or other side effects with desPLEX - in either high or low dosage."



DEVELOPMENTAL ABNORMALITIES

FEMALES

- Vaginal and cervical carcinomas
- Uterine abnormalities
- Higher risk for ectopic pregnancy, miscarriage, and preterm labor and delivery

MALES

- Abnormal genitalia (Microphallus, Testiclar varicoceles, Hypospadias)
- Epididymal cysts
- Testicular problems (undescended)

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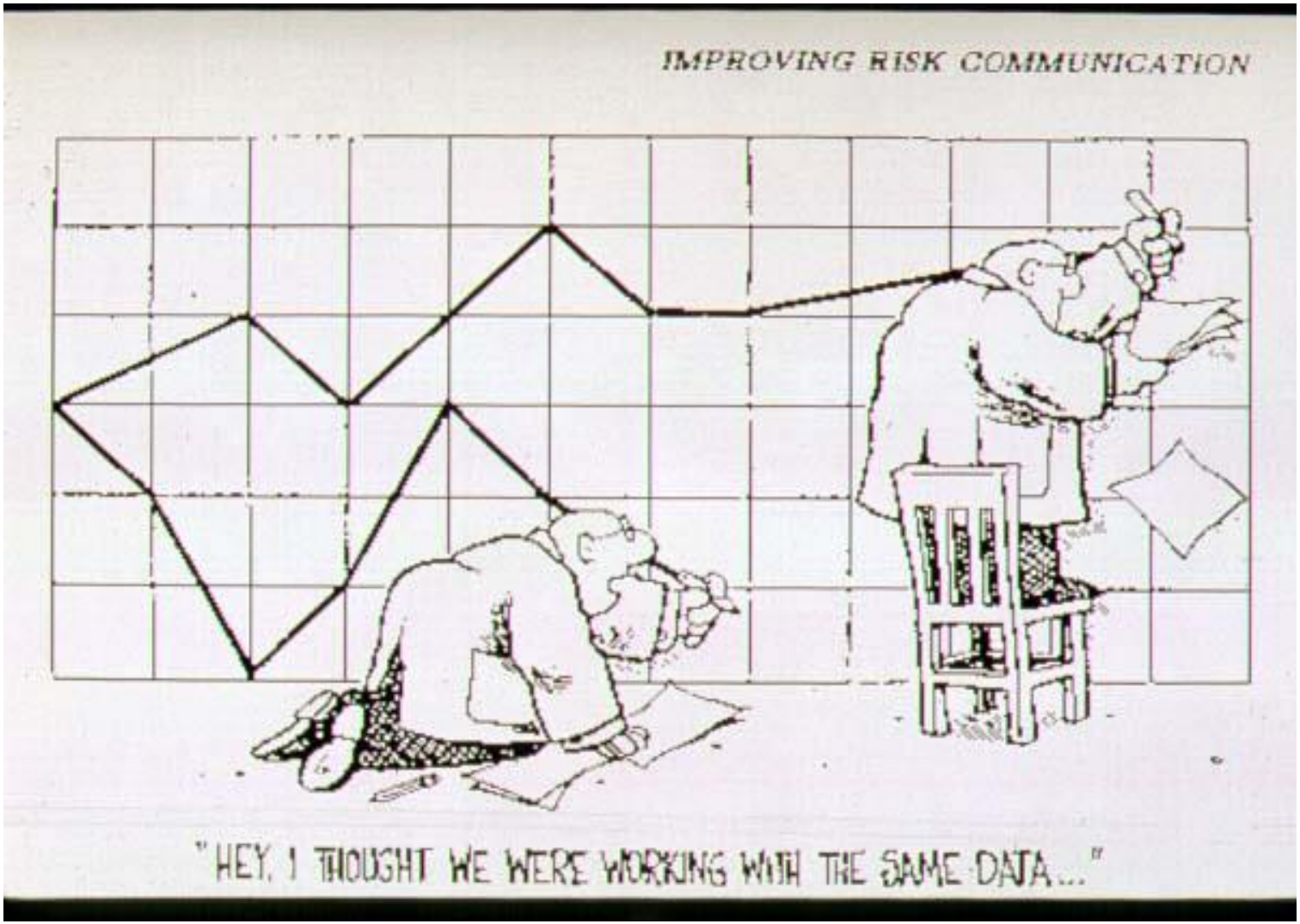
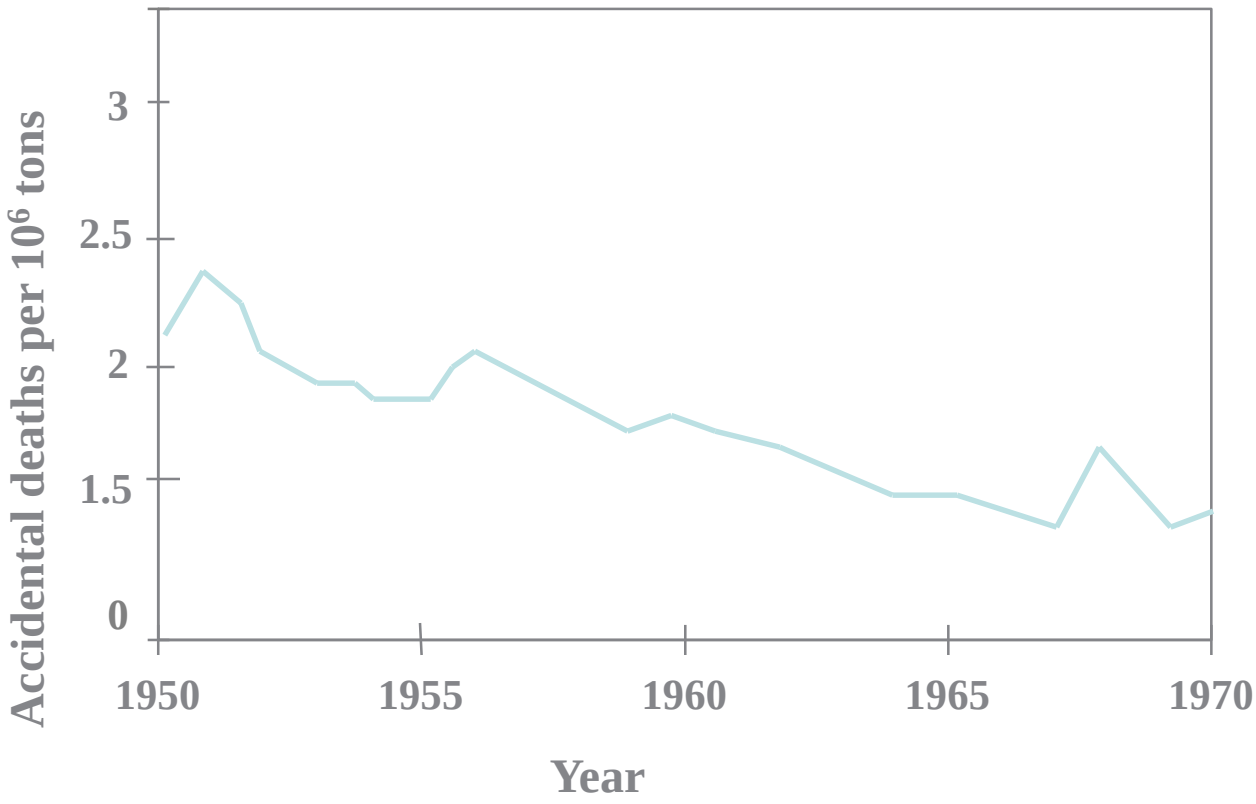

IMPROVING RISK COMMUNICATION
"HEY, I THOUGHT WE WERE WORKING WITH THE SAME DATA..."

Accidental deaths per million tons of coal mined in the U.S., 1950-1970.



Source: Crouch and Wilson Risk/Benefit Analysis, Cambridge MA, Ballinger 1982.

Accidental deaths per thousand coal mine employees in the U.S., 1950-1970.

Source: Crouch and Wilson Risk/Benefit Analysis, Cambridge MA, Ballinger 1982.

Question #7

The **generic risk equation** is:

A.) Risk = Hazard x Exposure

B.) Risk = Hazard x Time

C.) Risk = Hazard x Toxicity

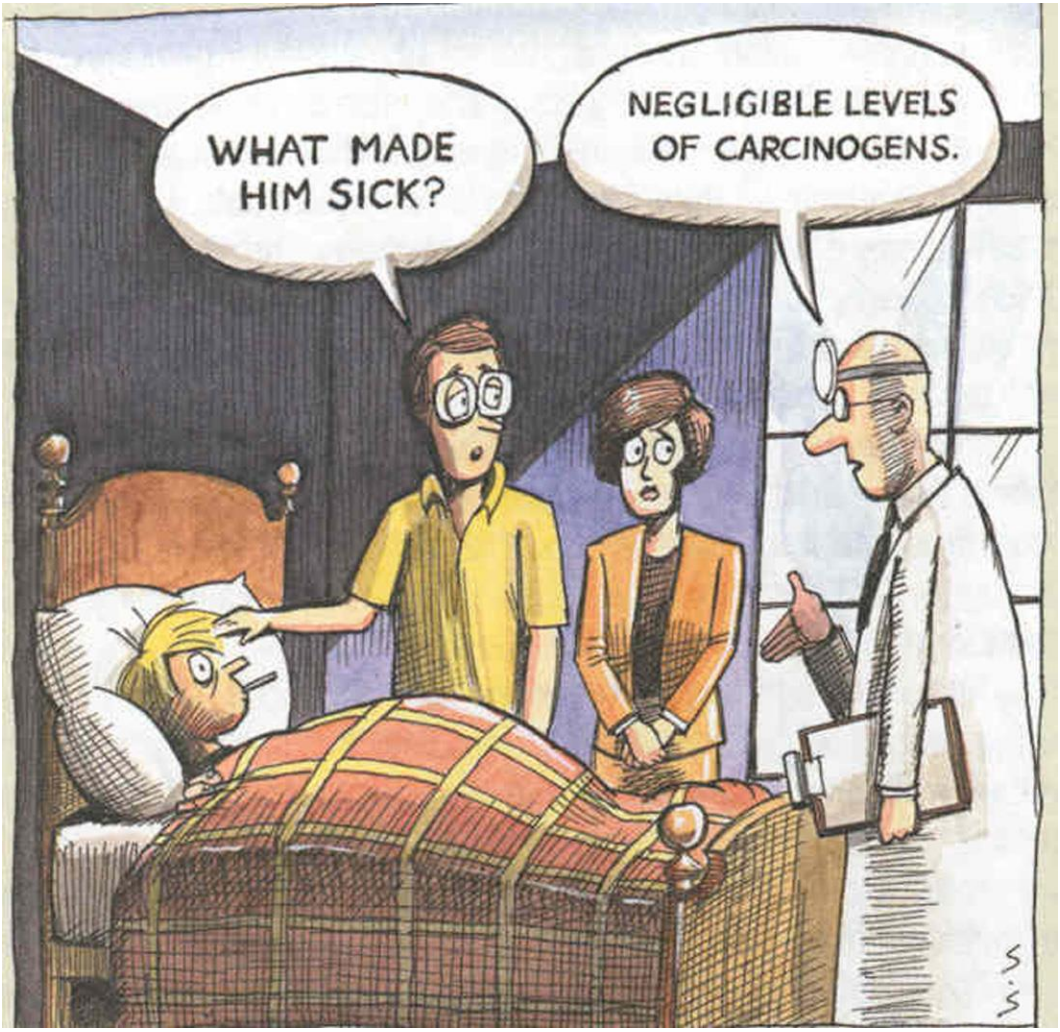
RISK = HAZARD X EXPOSURE

Risk Assessment Process

1. Hazard Identification
2. Toxicity Assessment – Dose/Response
3. Exposure Assessment
4. Risk Characterization

Some people add a 5th and 6TH step

5. Risk Management
6. Risk Communication


WHAT MADE HIM SICK?
NEGLIGIBLE LEVELS OF CARCINOGENS.


SOMETHING TO CHEW ON
CARBARYL
neurotoxin, carcinogen
ENDOSULFAN
endocrine disruptor
ORTHO-PHENYLPHENOL
probable human carcinogen
CAPTAN
probable human carcinogen
CHLORPYRIFOS
developmental neurotoxin
METHYL PARATHION
developmental neurotoxin
METHOXYCHLOR
endocrine disruptor
GUTHION
neurotoxin

Next We Look at How This is Consumed……

Crop	Fresh (%)	Processed (%)
Apples	67	33
Grapes	29	71
Potatoes	99	1

So, What's the Big Deal?

The big deal is who is at the most risk

Consumption in g/kg body weight (weight/day)

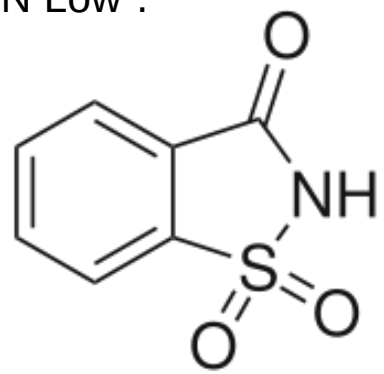
	Average	Infants	Ages 2-6
Fresh Apples	**0.457**	**2.854**	**1.222**
Apple Juice	**0.222**	**3.464**	**0.994**


APPLE JUICE


CRAB
APPLES

RISK ASSESSMENT

- Saccharin was first produced in 1878 at Johns Hopkins University. The sweet taste of saccharin was discovered when the researcher noticed a sweet taste on his hand one evening, and connected this with the compound that he had been working on that day.
- Although saccharin was commercialized not long after its discovery, it was not until sugar shortages during World War I that its use became widespread. Its popularity further increased during the 1960s and 1970s among dieters, since saccharin is a calorie-free sweetener.
- Saccharin is often found in restaurants in pink packets; the most popular brand is "Sweet'N Low".



Studies in laboratory rats during the early 1970s linked saccharin with the development of bladder cancer. For this reason, Congress mandated that further studies of saccharin be performed and required that all food containing saccharin bear the following warning label: "*Use of this product may be hazardous to your health. This product contains saccharin, which has been determined to cause cancer in laboratory animals*."

Subsequent studies in rats showed an increased incidence of urinary bladder cancer at high doses of saccharin, especially in male rats. However, mechanistic studies (studies that examine how a substance works in the body) have shown that these results apply only to rats. Human epidemiology studies (studies of patterns, causes, and control of diseases in groups of people) have shown no consistent evidence that saccharin is associated with bladder cancer incidence

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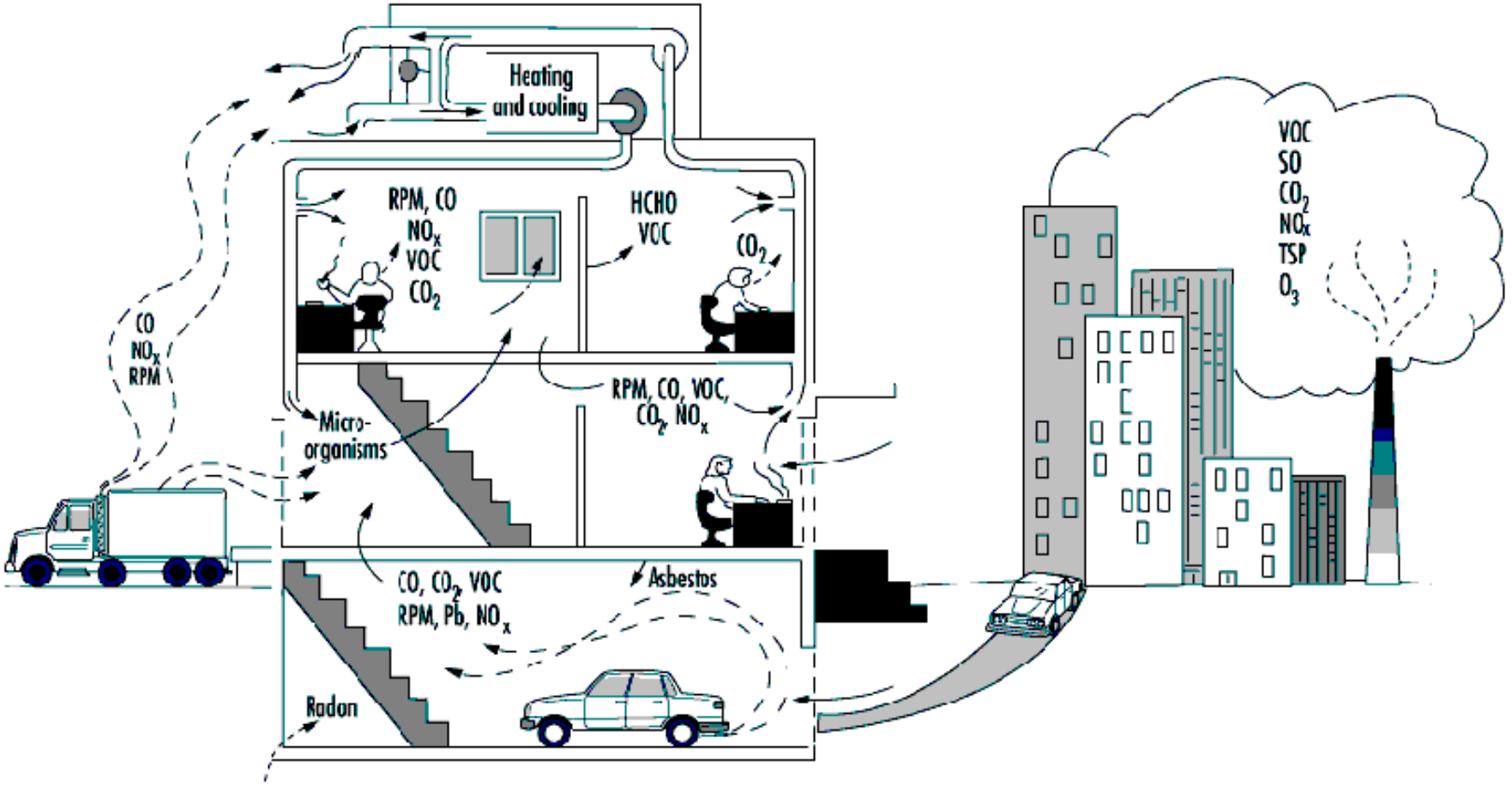
History

- The earliest form of anthropogenic airborne emission is woodsmoke
- Humans have required sources of warmth and cooking fuel for millennia
- Coal smoke contributed greatly to air pollution problems in the early days of the industrial revolution

Sources of Air Pollution



CO = carbon monoxide; CO_2 = carbon dioxide; HCHO = formaldehyde; NO_x = nitrogen oxides; Pb = lead; RPM = respirable particulate matter; VOC = volatile organic compounds.

Donora, Pennsylvania 1948

Credit: Pittsburgh Post-Gazette

1948: Donora, PA at noon.

courtesy MapQuest http://www.mapquest.com/

Donora, Pennsylvania 1948

- Small industrial town south of Philidelphia
- Between October 26 and 31, 1948, 20 people died and over 7,000 hospitalized due to air pollution.
- The air pollution was the result of a temperature inversion: cold air trapped pollution from iron and steel mills, zinc smelters and an acid plant.
- Donora and other smog problems lead to air pollution research and resulted in the Clean Air Act.

The Great London Smog of 1952

Fig 2: The London smog disaster of 1952.
Death rate with concentrations of smoke

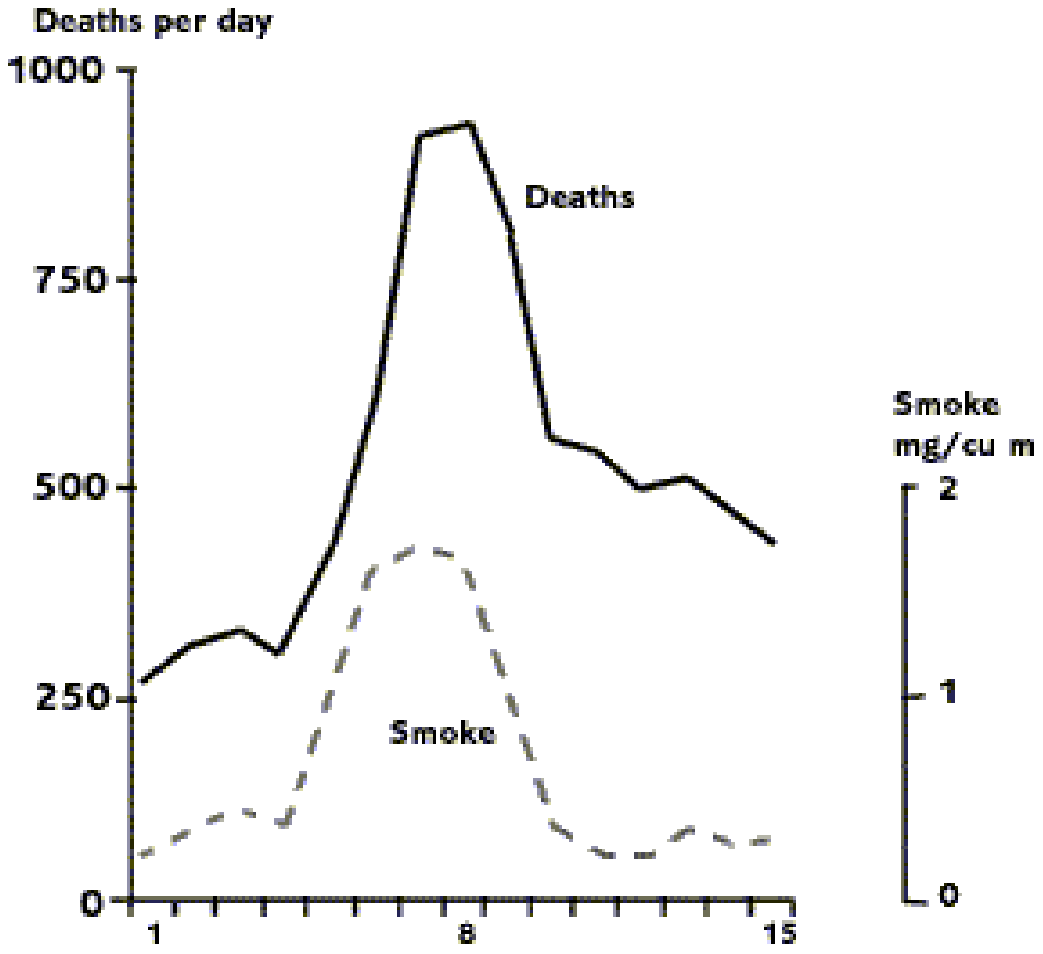
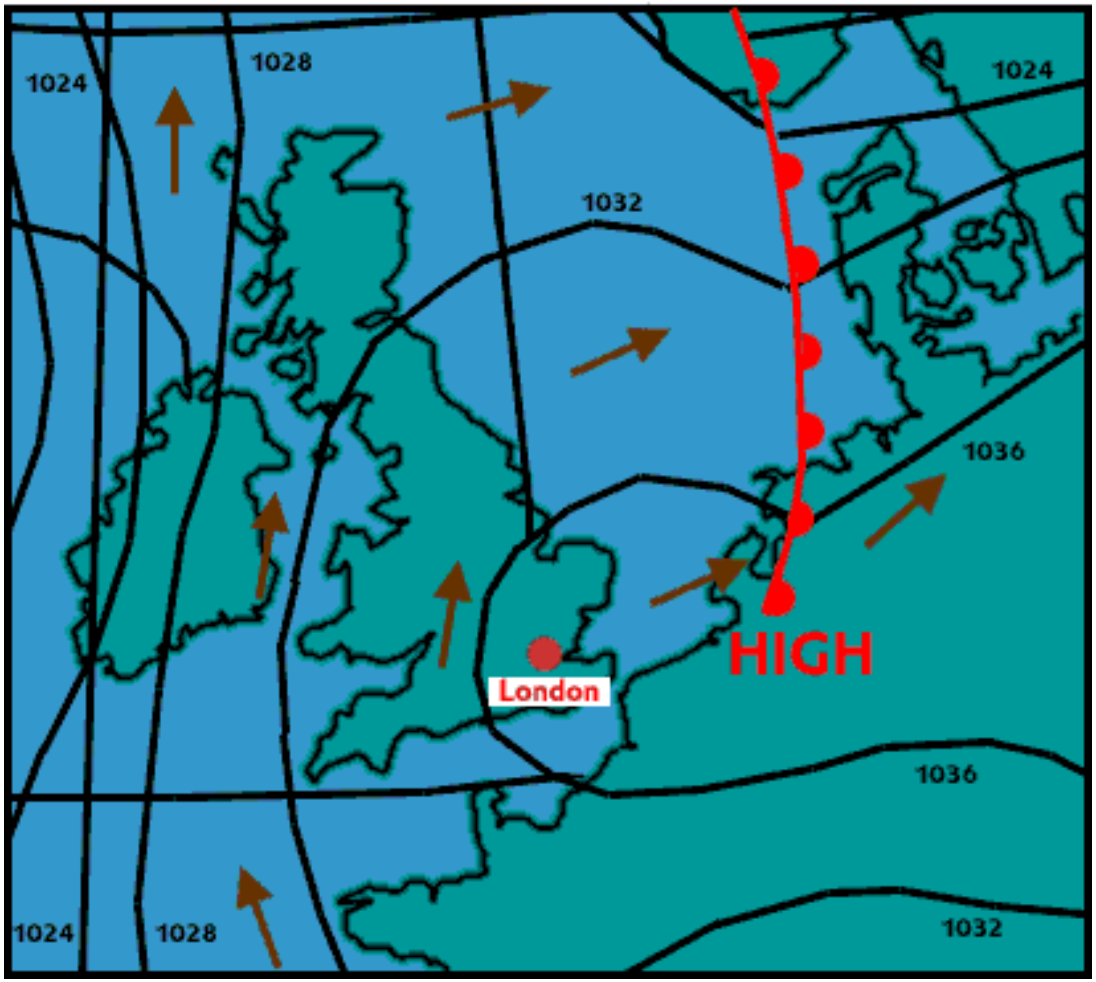


Chart for 0600 UTC on 5 December 1952



Types of Sources and Emissions to the Air

Air pollutants are characterized for regulatory purposes into two basic categories:

- Criteria Air Pollutants (CAP)
  - CAPs are typical components of smog and include chemicals emitted in large quantities and from many sources and include: CO, Pb, NO_2, O_3, PM, SO_2
  - Pollutants which the EPA has established National Ambient Air Quality Standards (NAAQS)
- Toxic Air Contaminants (TAC)
  - Everything else emitted into the air that is not a CAP and for which there is some regulatory concern
  - Also referred to as Hazardous Air Pollutants (HAPs)

National Ambient Air Quality Standards

Two types of standards established by the Clean Air Act:

- **"Primary" standards** set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.
- **"Secondary" standards** set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

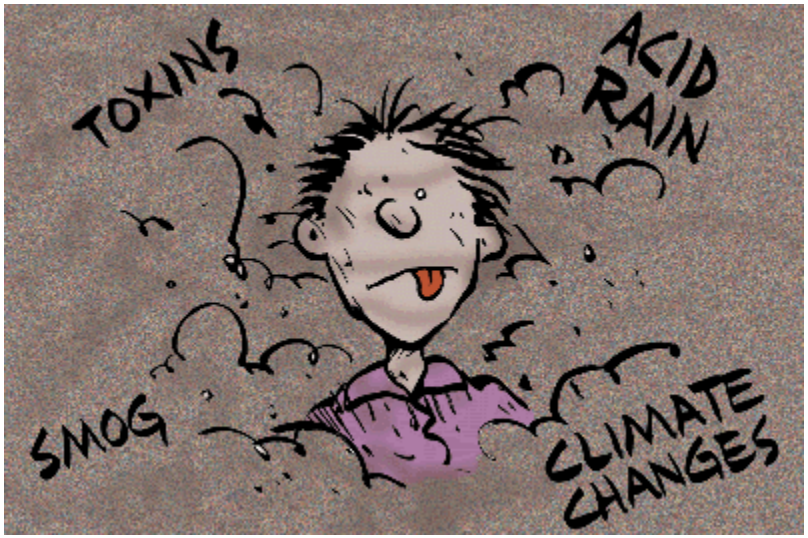
Motor vehicles

- Motor vehicles account for approximately one-fourth of emissions that produce ozone and one-third of nitrogen oxide emissions
- Particulate and sulfur dioxide emissions from motor vehicles represent approximately 20 percent and 4 percent, respectively
- Some 76.6 percent of carbon monoxide emissions are produced each year by transportation sources

Health Care Costs

- The estimated annual health costs of human exposure to all outdoor air pollutants from all sources range from $40 billion to $50 billion with an associated 50,000 premature deaths
- Ground-level ozone (smog) exposure linked to as many as 50,000 ER visits and 15,000 hospital admissions in a survey of 13 U.S. cities according to American Lung Association.
- 64,000 Americans each year die from lung and heart disease caused by fine particulates from power plants, motor vehicles, and photochemical reactions in the atmosphere.

Children are more susceptible



- About doubles the incidence of pneumonia, bronchitis, and bronchiolitis
- Increased OM, decreased lung function and lung growth
- Increased asthma and asthma severity
- Adverse effects are correlated to the amount of smoking in the house

Source: EPA Indoor Air Pollution, An Introduction for Health Professionals

The Common Air Pollutants

- Ozone
- Carbon Monoxide
- Nitrogen Dioxide
- Sulfur Dioxide
- Lead
- Particulate Matter

Good vs. Bad Ozone

Present in two layers of the atmosphere, ozone has the same chemical structure whether it occurs high above the earth (stratosphere) or at ground level (troposphere). Ozone can be described as “Good” or “Bad”:

- **“Good” ozone:** Absorbs UV-B radiation and protects the earth from excess amounts of damaging rays.

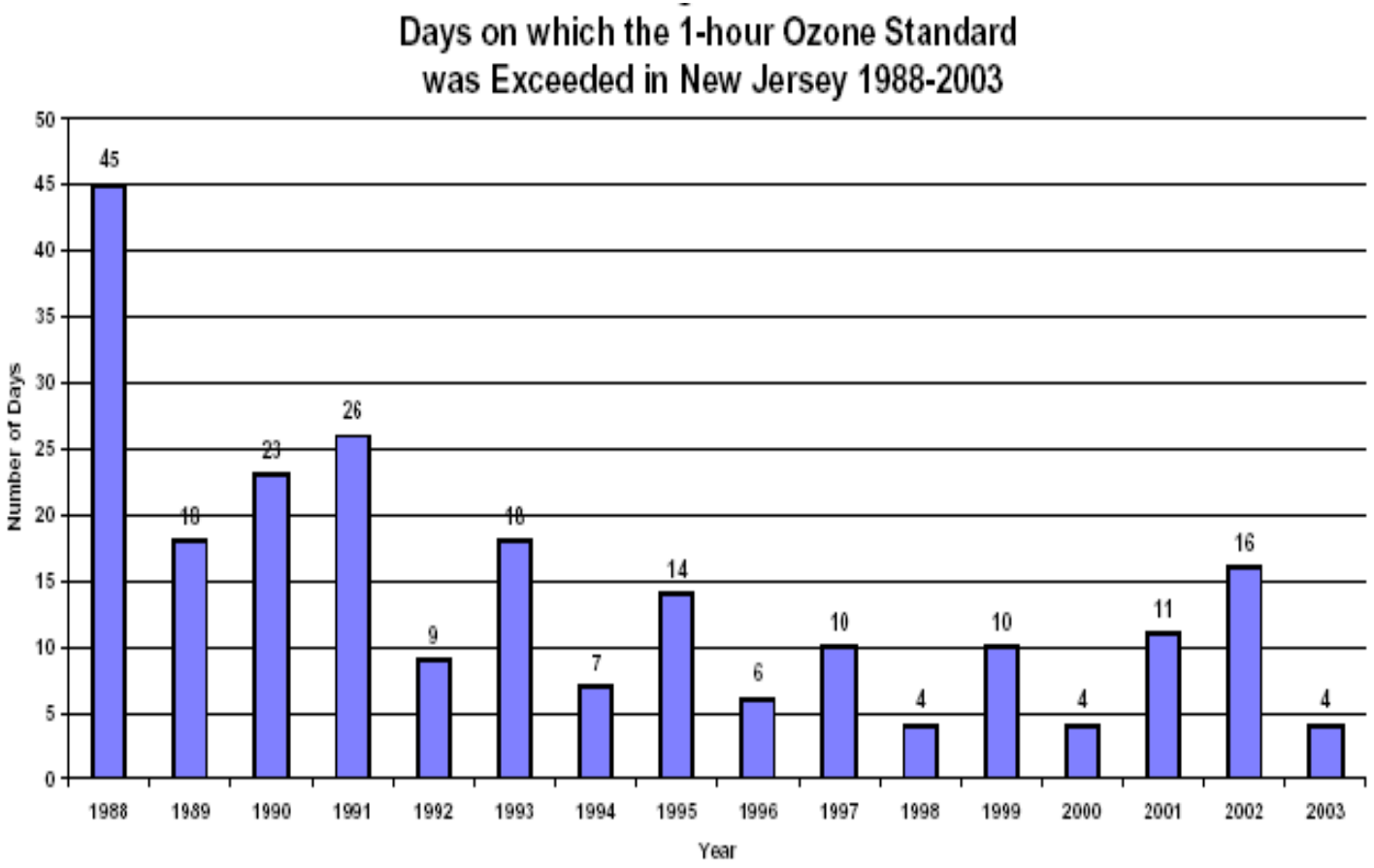
- **“Bad” ozone:** Principal component of smog. It is created by a chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of heat and sunlight.

  Bad ozone is the result of:

  VOC + NOx + Heat + Sunlight = Ozone

Ozone

- **Sources:** Chemical reaction of pollutants; VOCs and NOx
- **Health Effects:** Breathing problems, reduced lung function, asthma, irritates eyes, stuffy nose, reduced resistance to colds and other infections, may speed up aging of lung tissue
- **Levels in Homes:** Average levels in homes without gas stoves vary from 0.5 to 5 parts per million (ppm). Levels near properly adjusted gas stoves are often 5 to 15 ppm and those near poorly adjusted stoves may be 30 ppm or higher.

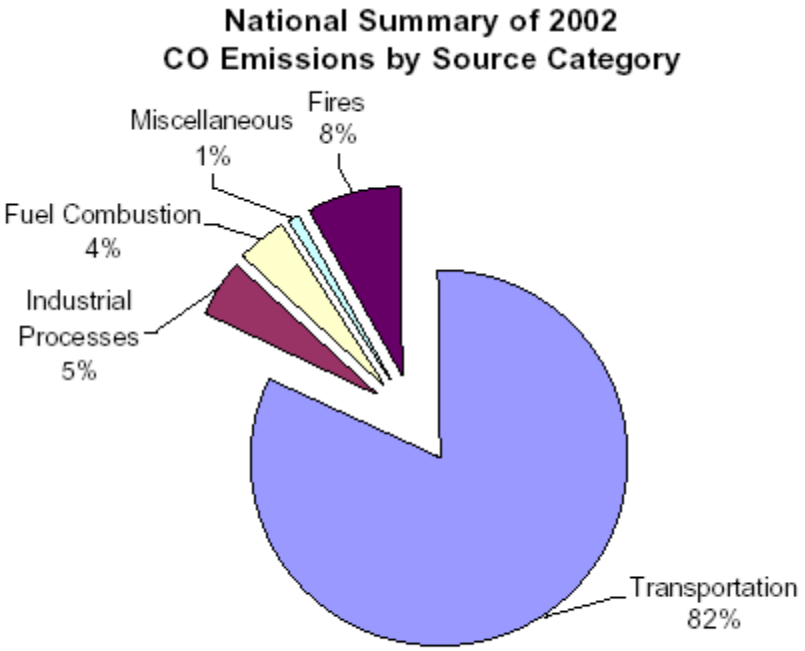


Source: 2003 Air Quality Report, NJDEP

Carbon Monoxide

- Colorless, odorless, nonirritating gas
- Generated by the incomplete combustion of carbon-containing fuels, such as oils, gasoline, coal, and wood
- Exposure to high levels of CO is the leading cause of poisoning deaths in the United States

Outdoor Sources of Carbon Monoxide



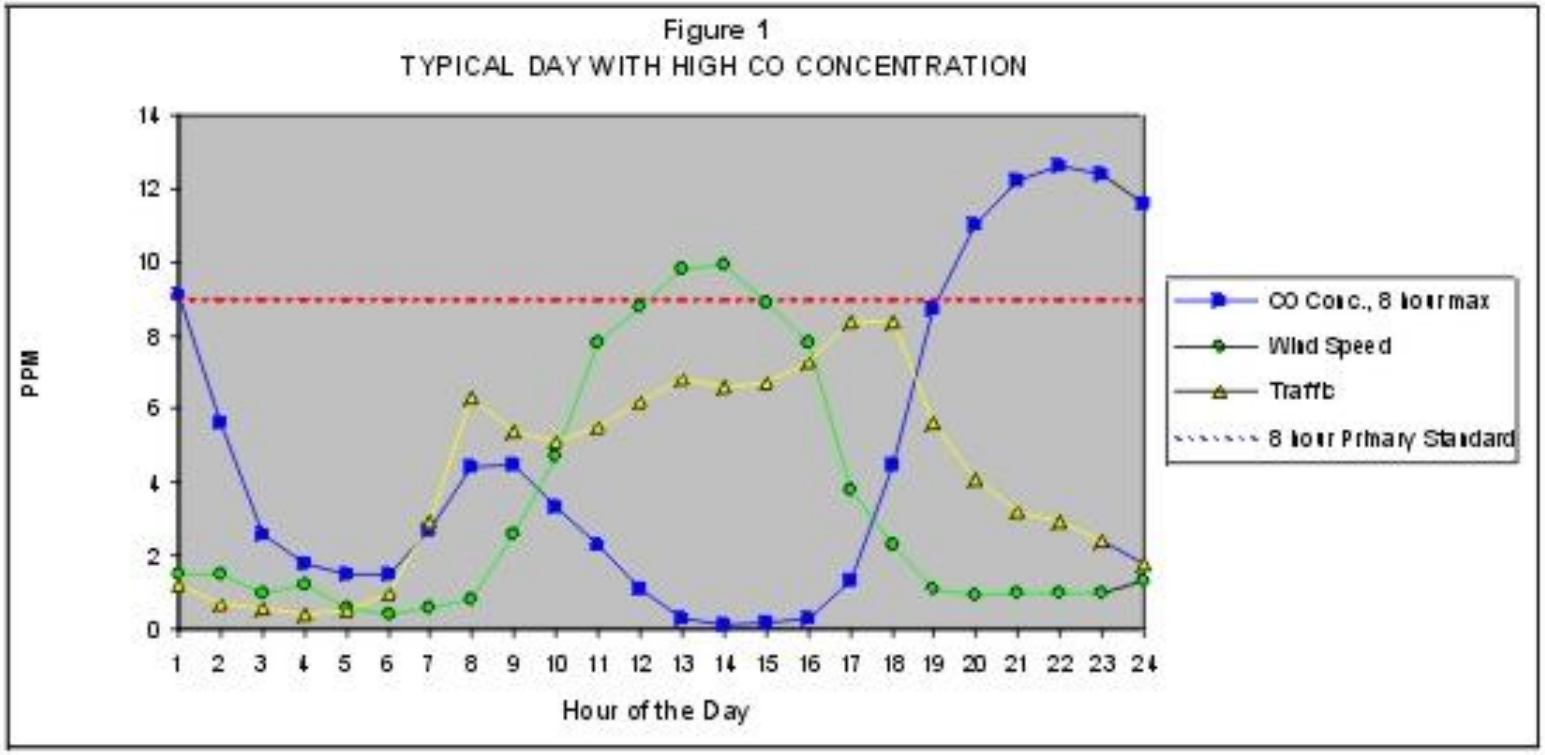
Source: USEPA National Air Quality Emissions Trends Report, 2003 Special Studies, September 2003

- CO is a by-product of MV exhaust, which contributes to over 50% if all CO emissions nationwide.
- In cities, MV pollution can cause as much as 95% of all CO emissions.
- High CO levels coincide with AM and PM rush hours.

Indoor Sources of CO

- **Sources:**
  - Unvented kerosene and gas space heaters; leaking chimneys and furnaces; back-drafting from furnaces, gas water heaters, wood stoves, and fireplaces; gas stoves. Automobile exhaust from attached garages. Environmental tobacco smoke, burning of gasoline, natural gas, coal, oil etc.

- **Levels in Homes:**
  - Average levels in homes without gas stoves vary from 0.5 to 5 parts per million (ppm). Levels near properly adjusted gas stoves are often 5 to 15 ppm and those near poorly adjusted stoves may be 30 ppm or higher.

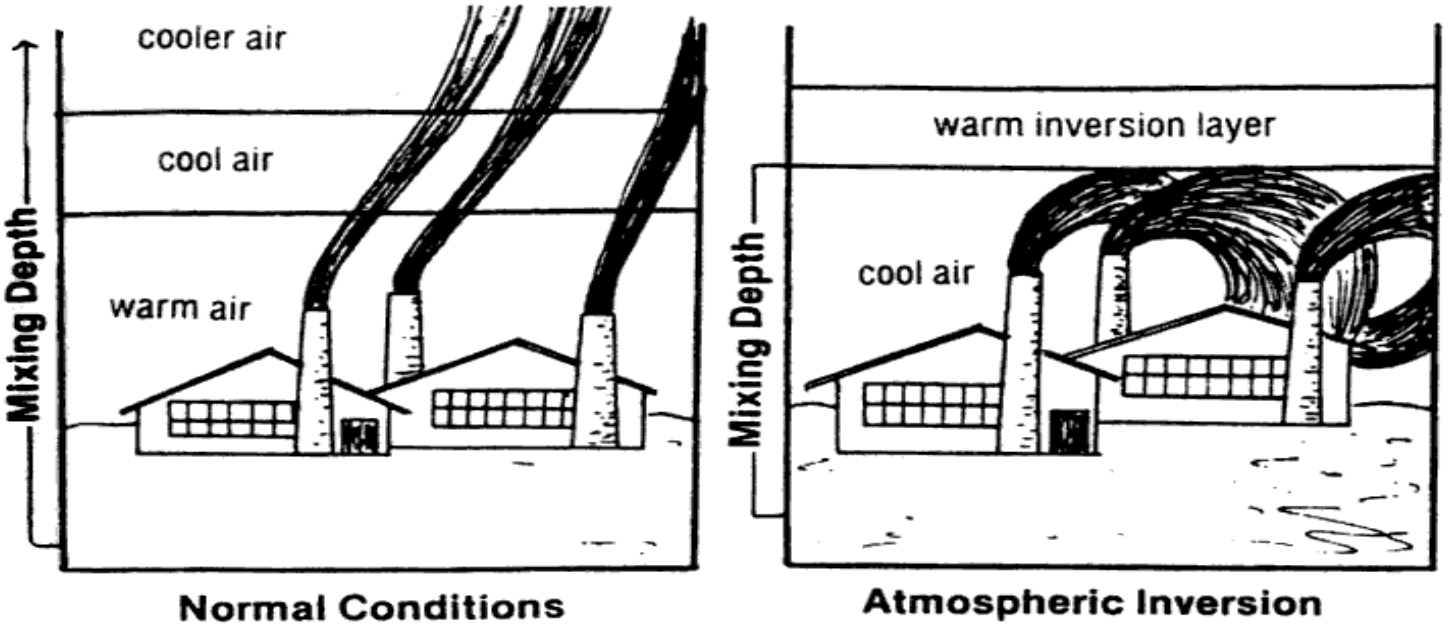


CO concentration rises with the early morning and late afternoon traffic peaks. Low wind and low temperature conditions may contribute to accumulating CO levels.

CO Concentrations

The highest levels of CO in the outside air typically occur during the colder months of the year when inversion conditions are more frequent.

The air pollution becomes trapped near the ground beneath a layer of warm air.



Nitrogen Dioxide

- Brownish, highly reactive gas that is present in all urban atmospheres

- Generated by the burning of fossil-derived fuel, during which oxygen and nitrogen react to form nitrate particles, acid aerosols, and nitrogen oxides (NO) which further react to form NO_2 and other NO_x

Indoor Nitrogen Dioxide

- Common contaminant of indoor air, and indoor levels often exceed those found outdoors

- **Sources:** Kerosene heaters, un-vented gas stoves and heaters. Environmental tobacco smoke; burning of gasoline, natural gas, coal, oil etc. Cars are an important source of NO_2.

- **Levels in Homes:** Average level in homes without combustion appliances is about half that of outdoors. In homes with gas stoves, kerosene heaters, or un-vented gas space heaters, indoor levels often exceed outdoor levels.

Outdoor Nitrogen Dioxide

- As with CO, concentration of NO are highest during AM and PM rush hours.

- Also, NO concentrations are higher in the winter than summer due in part to poorer local dispersion conditions caused by light winds and other weather inherent of the winter.

Sulfur Dioxide

- **Source** - Ambient SO_2 result largely from stationary sources such as coal and fuel combustion, steel mills, refineries, pulp and paper mills and from nonferrous smelters
- **Health Effects** – irritation to the eyes, nose, throat, and respiratory tract; affect breathing and may aggravate existing respiratory and cardiovascular disease; may cause permanent damage to lungs;
- **Environmental Effects** - SO_2 is an ingredient in acid rain (acid aerosols), which can damage trees and lakes. Acid aerosols can also reduce visibility.
- **Property Damage** - acid aerosols can eat away stone used in buildings, statues, monuments, etc.

Lead

- Lead is a metal that occurs naturally as well as being produced by human activity. Exposure to lead can be by air as well as ingestion (contaminated food, water soil or dust).

- Widespread outdoor airborne exposure has ceased to be a major health problem in the United States

- **Source -** leaded gasoline (being phased out), paint (houses, cars), smelters (metal refineries); manufacture of lead storage batteries

- **Health Effects -** brain and other nervous system damage; children are at special risk. Some lead-containing chemicals cause cancer in animals. Lead causes digestive and other health problems.

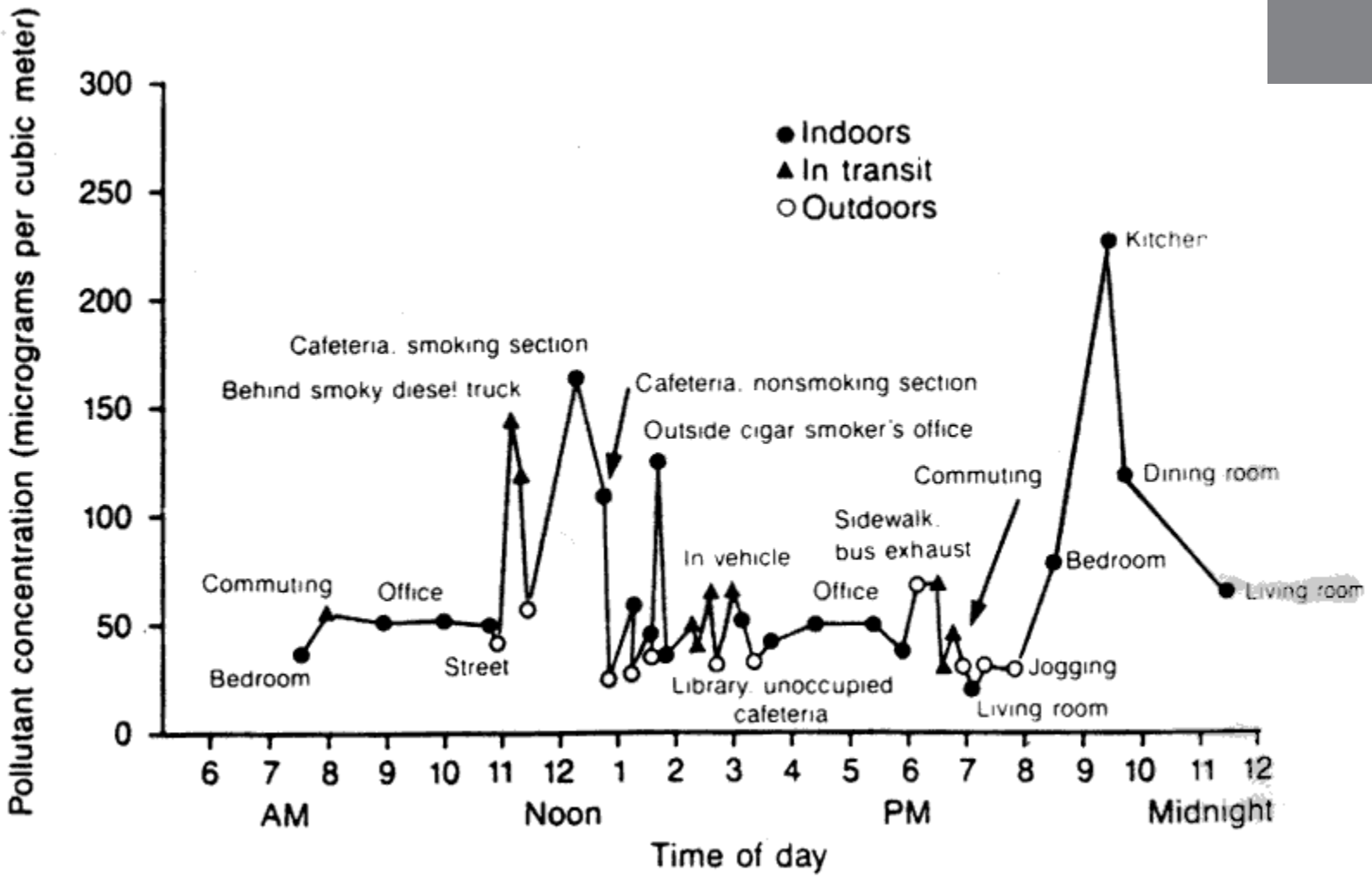
Particulate Matter

- Directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust
  - Dust
  - Dirt
  - Soot
  - Smoke
  - Liquid droplets

Particulate Matter

- **Source** - burning of wood, diesel and other fuels; industrial plants; agriculture (plowing, burning off fields); unpaved roads
- **Health Effects** - nose and throat irritation, lung damage, bronchitis, early death
- **Environmental Effects** - particulates are the main source of haze that reduces visibility
- **Property Damage** - ashes, soots, smokes and dusts can dirty and discolor structures and other property, including clothes and furniture

A day in the life of one person's exposure to respirable particles

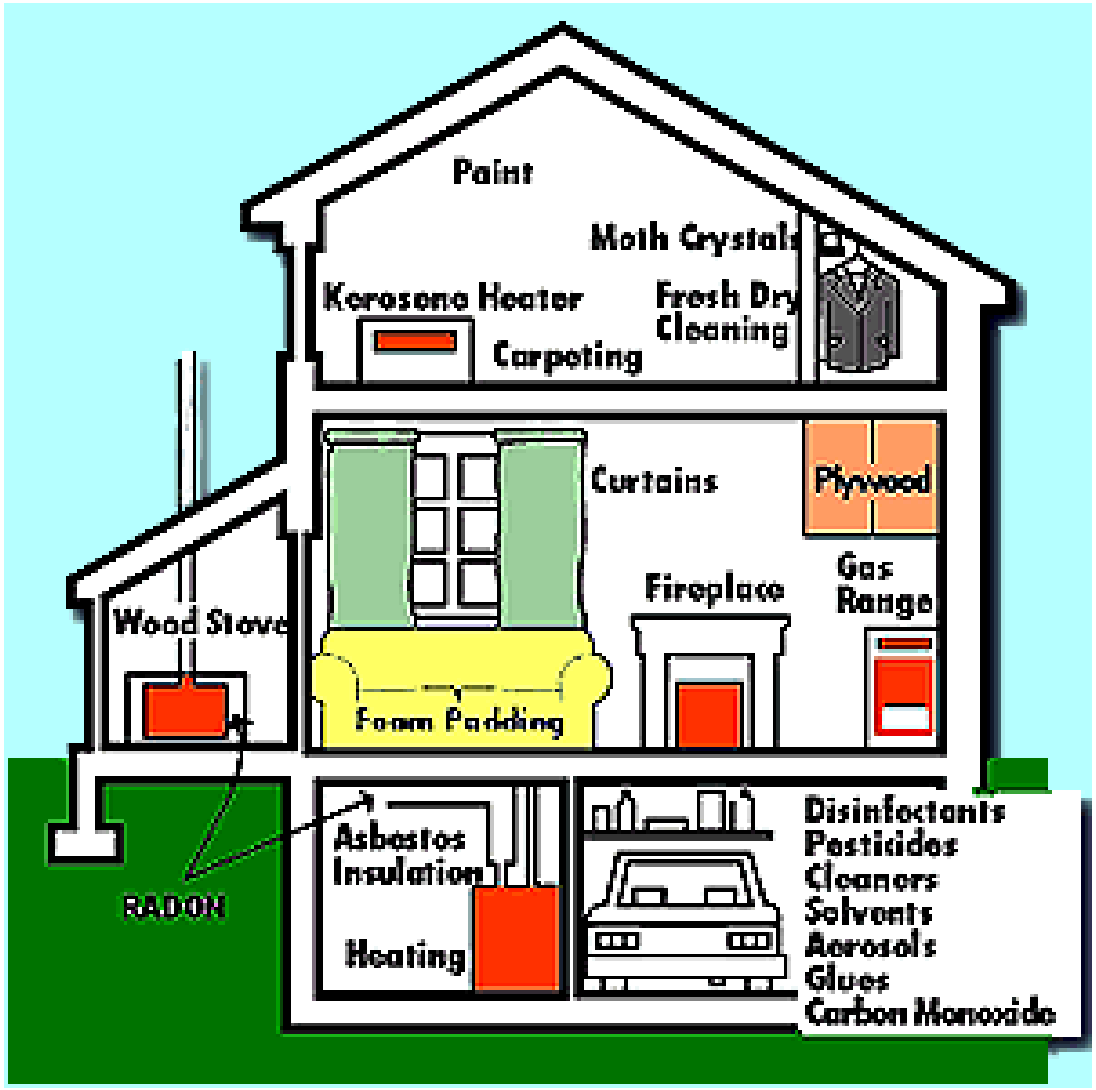


Indoor vs. Outdoor Pollution

- Average US Citizen spends 87 to 90% of their time indoors and in an urban population, those who are most vulnerable (sick, young, elderly) spend 95% of their time indoors.

- Even if concentration is low, duration of exposure could be significant.

Sources of Indoor Air Pollution



Environmental Tobacco Smoke (ETS)

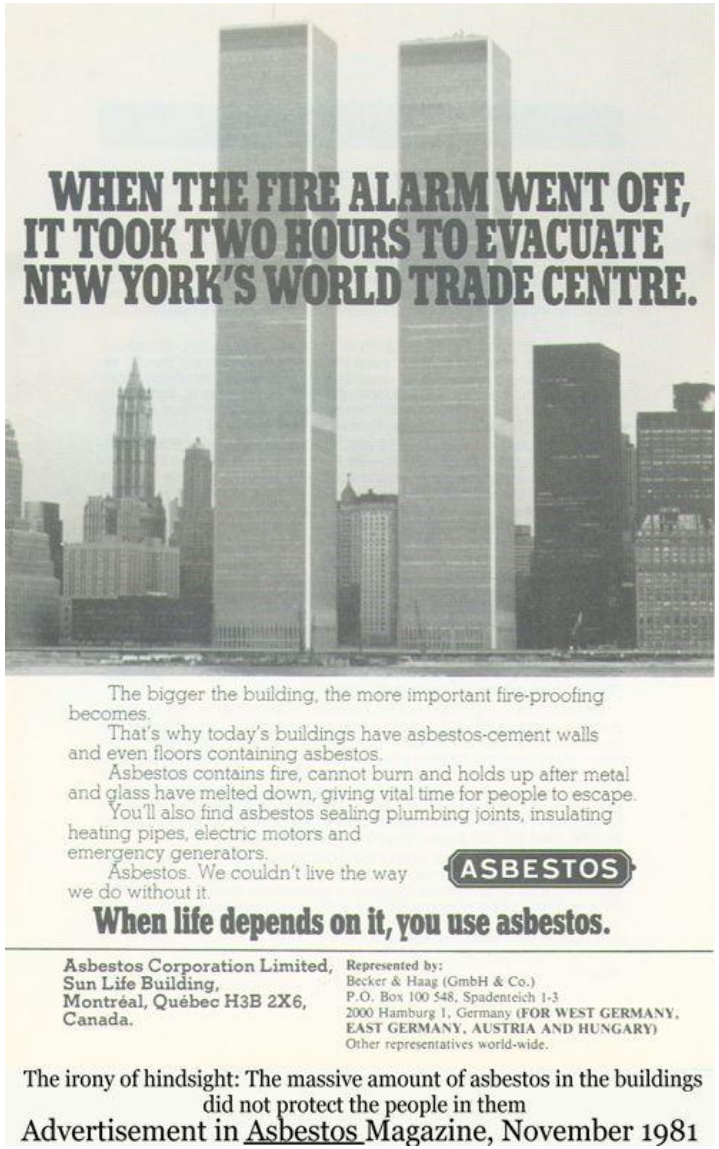
- Major source of indoor air contaminants
- 4,000 chemicals in vapor or particle phases
- Many are toxic or carcinogenic
- “Sidestream” and exhaled “mainstream” smoke
- EPA lists ETS as known human carcinogen that causes an estimated 3000 lung cancer deaths per year in nonsmokers

Asbestos

- Known human carcinogen: For lung cancer, the effect of tobacco smoking in combination with asbestos exposure appears to be synergistic by approximately fivefold.

- Sources:
  - Heating insulation
  - Acoustic insulation
  - Floor and ceiling tiles
  - Shingles

Asbestos Fiber



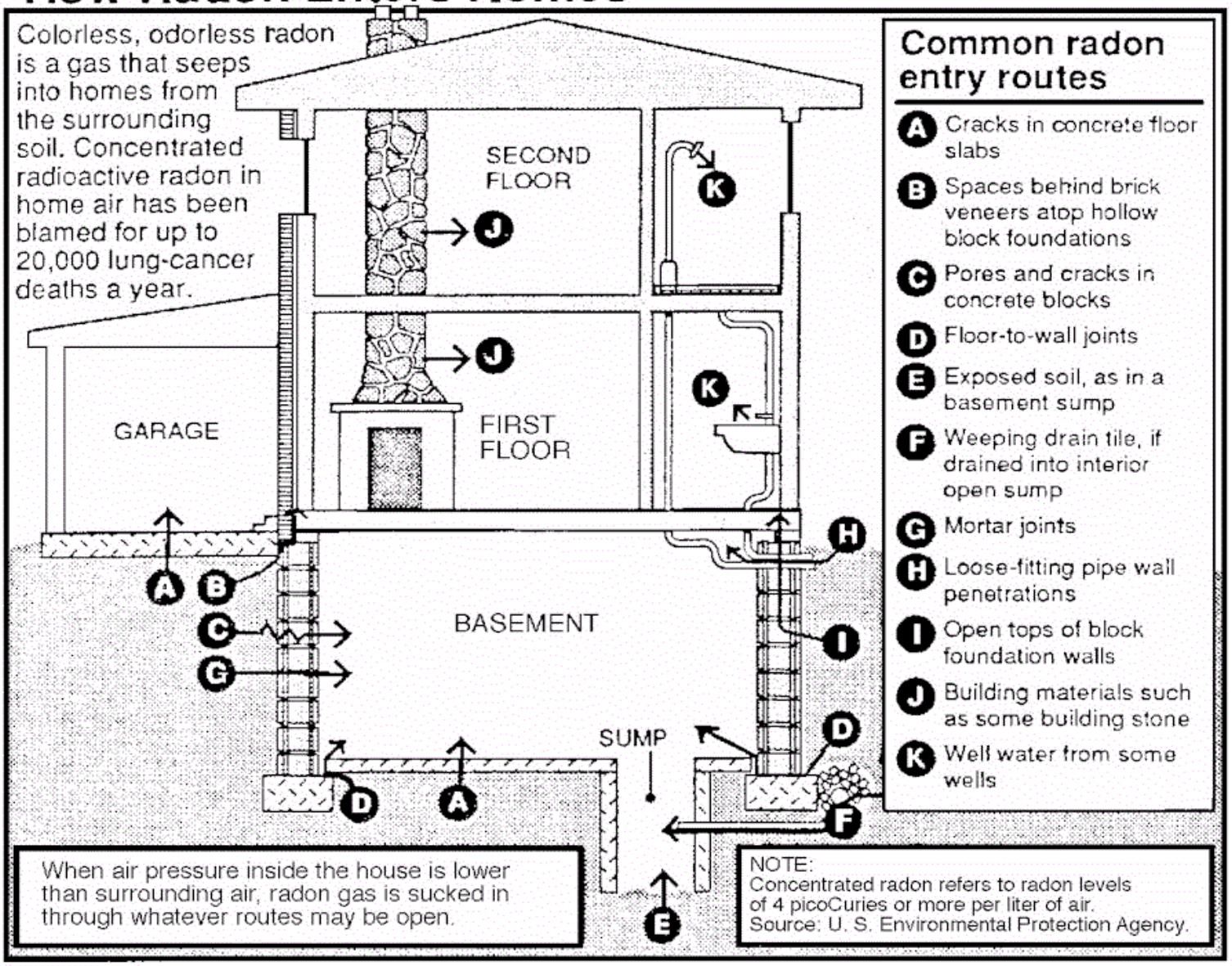
The irony of hindsight: The massive amount of asbestos in the buildings did not protect the people in them

Advertisement in Asbestos Magazine, November 1981

Radon

- Odorless, colorless, and tasteless
- Naturally occurring radioactive gas resulting from the decay of radium, itself a decay product of uranium
- Radon breaks down into radon decay products (radionuclides) which may be inhaled and continues its decay in the lungs

How Radon Enters Homes



Radon

- The EPA estimates as many as six million homes throughout the country have elevated levels of radon
- Second leading cause of lung cancer, following smoking
- Tobacco smoke and radon exposure have a synergistic effect

Introduction to Environmental Health

Toxicology

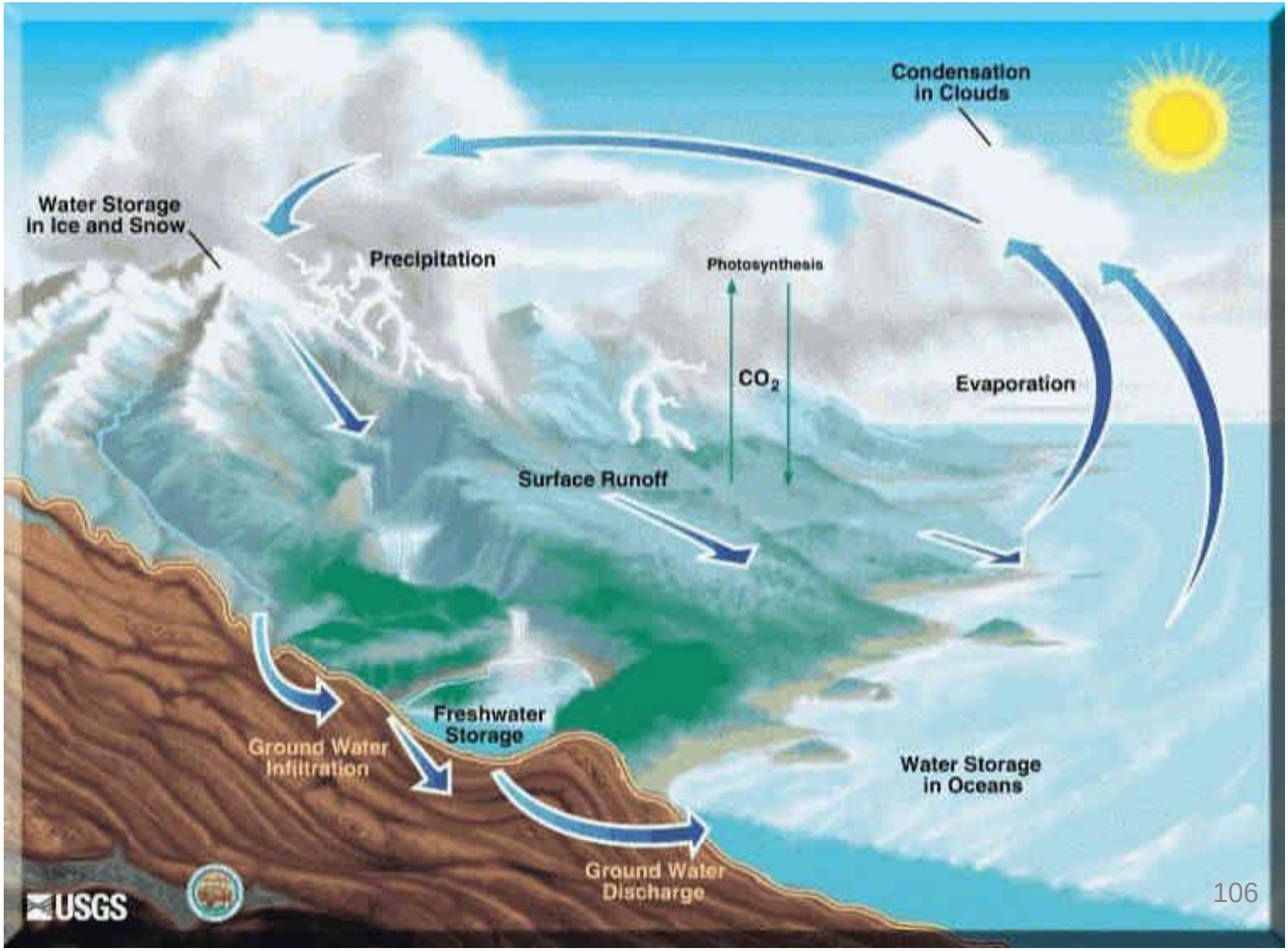
Risk Assessment

Air

Water

Food

Children


Condensation in Clouds
Water Storage in Ice and Snow
Precipitation
Photosynthesis
CO_2
Evaporation
Surface Runoff
Freshwater Storage
Ground Water Infiltration
Water Storage in Oceans
Ground Water Discharge
USGS

Approximately 71% of Earth's surface is water (volume=1.5 billion km^3)

- Approximately 97.4% is saline
- 2% in glaciers and ice caps
- Less than 1% is available as fresh water (rivers, lakes, groundwater, and water vapor in the atmosphere). Approximately 96.5% of the fresh water is groundwater

- Humans have an absolute dependence on water. We can go for weeks without food, but if we have no water, we die within a few days – WHY?
  - Water is 65% of the human adult, higher % in children
  - Blood is 83% water
  - Bones are 25% water
- Essential in the body for digestion, transport, and waste removal. We require 1 to 3 quarts per day just to maintain bodily function.
- Water is a finite resource but it is renewable. However, the rate is fixed and slow.

- Our standard of living requires a minimum of 100 quarts per day – drinking, food preparation, dish washing, and bathing.
- Sewer systems in urban areas cannot transport wastes efficiently if per capita water usage is less than 100 quarts per day.
- In affluent societies the consumption is closer to 200 to 400 quarts per person per day.
- Water is a costly commodity in many third world countries. In the poor slums of Haiti, 20% of the budget is spent on water.
- WHO published a study showing that improved water access would reduce diarrheal cases by 25%. If both access and quality were improves, the reduction would be 37%.

John Snow

- In 1854 London, the inhabitants were experiencing a severe epidemic of Asiatic cholera.
- Cholera causes watery diarrhea and vomiting, rapid dehydration and death on half the people with the disease
- Dr. John Snow observed the death rate to be 200 per 10,000 in St. James Parish. While Snow did not know that the *Cholera bacilus* was the cause, he took steps to remove the handle from the Broad Street Pump.

CHOLERA DISTRICTS.

LOOSENESS of the BOWELS is the Beginning of CHOLERA.

Thousands of Lives may be saved by attending in Time to this Complaint, which should on no account be *neglected* by either Young or Old, in Places where the Disease prevails.

When CRAMPS IN THE LEGS, ARMS, or BELLY are felt, with LOOSENESS or SICKNESS AT STOMACH, when Medical Assistance is not at hand, *Three Tea-spoonsfull* of MUSTARD POWDER *in Half a Pint of warm Water*, or the same Quantity of warm Water with as much COMMON SALT as it will melt, should be taken as a Vomit; and after the Stomach has been cleared out with more warm Water, TWENTY-FIVE DROPS OF LAUDANUM should be taken in a small Glass of any agreeable Drink.

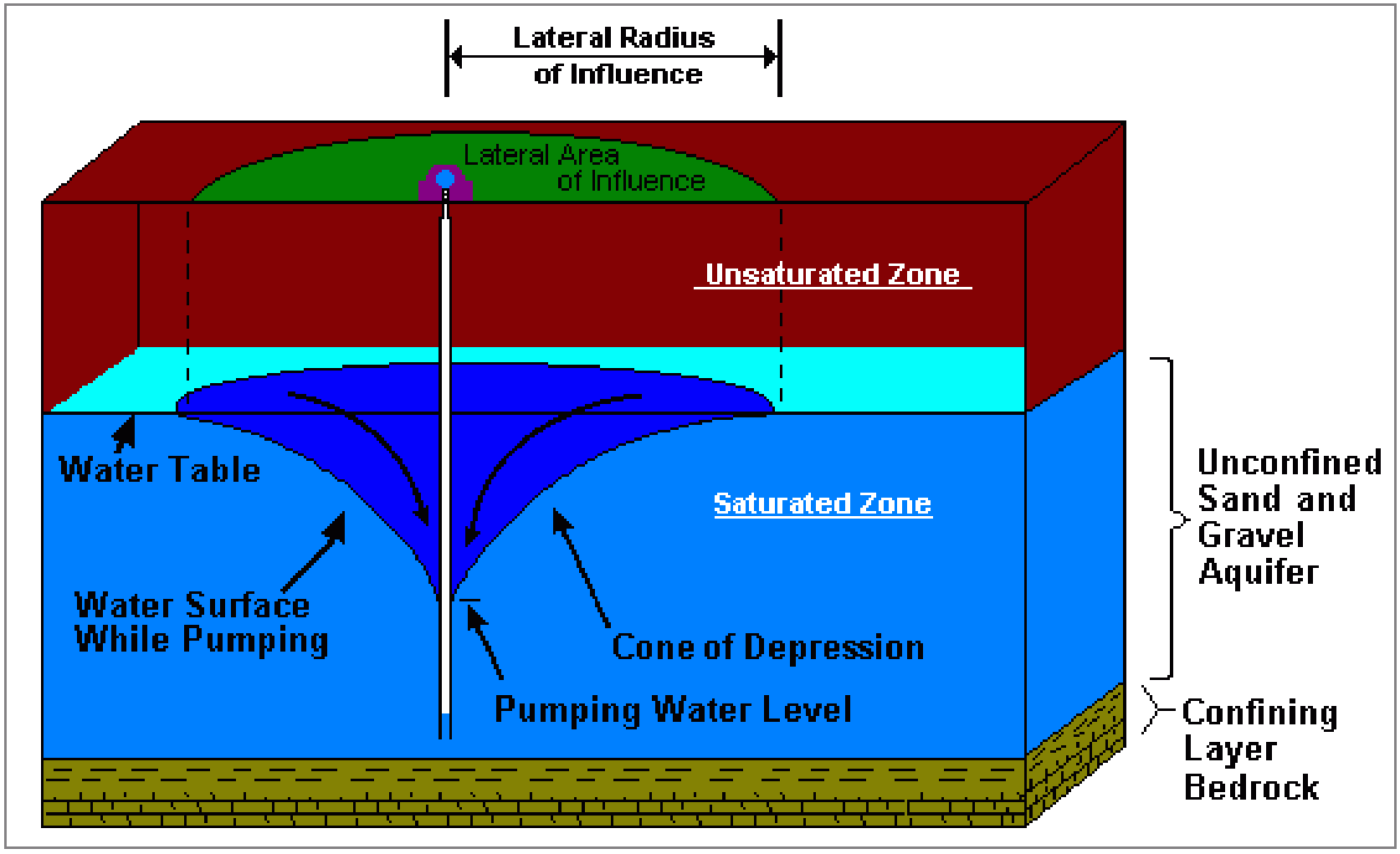
HEATED PLATES or PLATTERS to be applied to the BELLY and PIT of the STOMACH.

As Persons run considerable Risk of being infected by visiting those suffering from this Disease in crowded Rooms, it is most earnestly recommended that only such a Number of Persons as are sufficient to take care of the Sick be admitted into the Room.

W. MACLEAN, *Sec^y.*

Central Board of Health,
Council Office, Whitehall, 15th Feb. 1832.


Yards
50 0 50 100 150 200
× Pump • Deaths from cholera
OXFORD STREET
REGENT STREET
GT. MARLBOROUGH ST.
BROAD STREET
WARDOUR STREET
DEAN STREET
KING STREET
CONDUIT STREET
GOLDEN SQUARE
BREWER STREET
SAVILLE ROW
NEW BOND STREET
REGENTS QUADRANT
PICCADILLY



Source:http://www.epa.state.il.us/water/wellhead-protection/

Microbial Waterborne Disease

- In the 1880's, typhoid killed 100/100,000 in the U.S. annually.
- In 1885, 90,000 people were victims in Chicago. This caused Chicago to divert sewage from Lake Michigan.
- Today, 3 million young children die of waterborne diarrheal diseases. The deaths are directly related to a lack of adequate sewage disposal facilities.

Municipal Sewage Treatment

- Fecal wastes were dumped into an open cesspool near the well. The brick lining of the cesspool deteriorated and the wastes seeped through the ground and the pathogens contaminated well water.
- Open cesspools still common practice through the early 20th century. The waste was collected in the pits, stabilized by bacterial action, no disinfection was used.
- In the 19th century, flushing toilets became popular, which increased volume of waste water, causing overflow and increasing water borne disease (cholera, typhoid). Today, 70% of the population in the U.S. have water that goes to sewage treatment prior to discharge.

Primary Treatment

- Treatment Plant: POTW
- Sewage has human feces, urine, laundry waste, bathing, garbage grinding, and dishwashing water
- Often contains sand, gravel, baseballs, leaves, sticks, dead rats, and other wonderful items

Primary Treatment

- Removal of larger suspended solids through screening & sedimentation
- Grinders to reduce solids to uniform size
- Sedimentation Tank – solids and sludge dried and disposed
- Primary Treatment removes 50-65% of suspended solids. BOD is reduced by 25-40%

Secondary Treatment

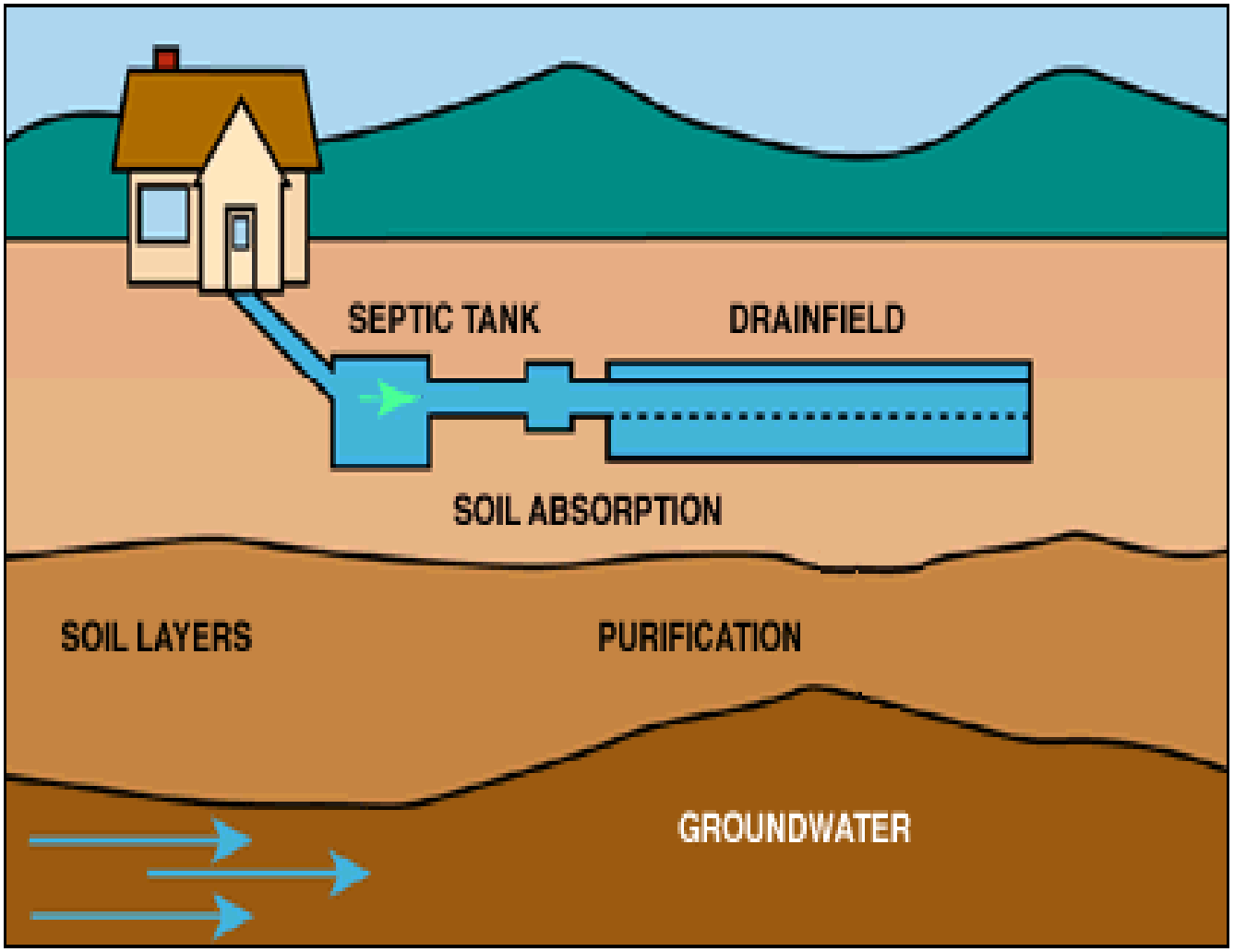
- Depends of Biological Process
- Trickling Filters
- Activated Sludge Process
- After Secondary Treatment, 90-95% of solids and BOD are reduced

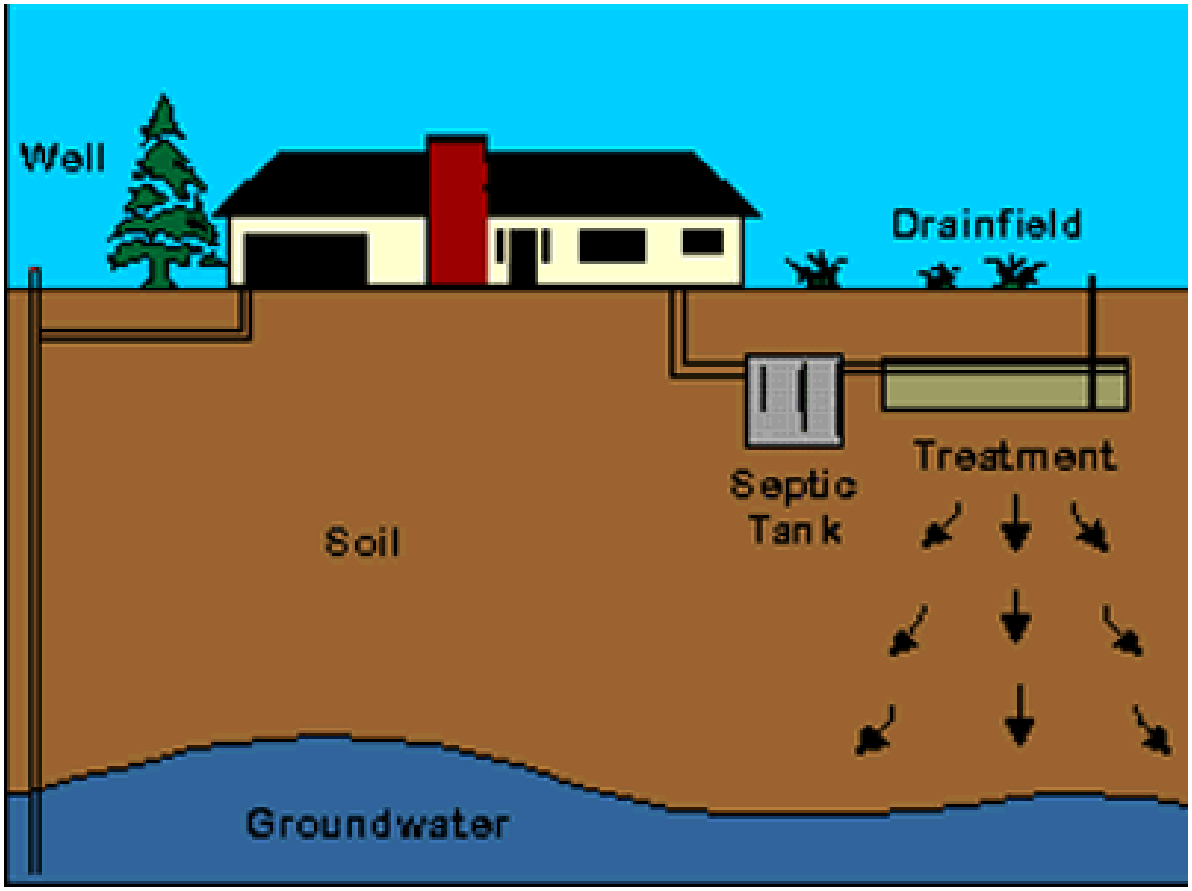
Septic Systems

- Liquid wastes deliberately discharged into the ground
- 30% of U.S. households served by septic systems
- Salmonellosis, Hepatitis A, and Typhoid Fever have been traced to well water contaminated by sewage

Septic Systems

- 2 Parts:
  - Septic Tank – buried in the ground, connected by a pipe
  - Soil absorption field or sand filter
- Sewage in the tank is partially decomposed by bacteria. Solids settle to the bottom of the tank. Lighter solids, grease, and gas rise to the top. The liquid passes to the absorption field via perforated pipes.
- Every 3-5 years, one must have the solids pumped


SEPTIC TANK
DRAINFIELD
SOIL ABSORPTION
SOIL LAYERS
PURIFICATION
GROUNDWATER


Well
Drainfield
Treatment
Septic
Tank
Soil
Groundwater

Groundwater Pollution

- 225 Chemical, Biological, and Radiological Pollutants have been identified in groundwater

- Degradation by Humans Generated pollutants occur largely from faulty waste practices or poor land management

Primary Drinking Water Contaminants

Chlorinated Solvents –

- Industrial pollution, degreasing and machine maintenance, manufacturing intermediates
- Cancer

Trihalomethanes (THMs) –

- Produced by chemical reactions in water with chlorine
- Liver and kidney damage, cancer

Lead –

- Old pipes and solder in water systems
- Nerve problems, learning disabilities, birth defects, cancer

Primary Dinking Water Contaminants

- PCBs –
  - Wastes from manufacturing operations
  - Liver damage, cancer

- Bacteria and Viruses –
  - Leaking septic tanks, overflowing sewer lines
  - GI illness, serious diseases like meningitis

Trihalomethanes

- In the 1970's it was determined that chlorine added to water with humic substances results in some unintended chemical reactions, forming disinfection by–products (DBPs). Trihalomethanes (THMs) are the most common

- THMs, in high doses, are known to cause liver and kidney disorders, CNS problems, birth defects, and cancer

Lead

- Drinking water is a major route of lead exposure. EPA estimates that more than 40 million Americans are drinking water over the legally permissible level of lead – 50 ppb.

- Lead is introduced in home plumbing through Pb pipes or when Pb solder was used. Problem when water is corrosive i.e. low pH. Also a problem when water pipes are used for electrical ground, the current accelerates the corrosion of Pb in pipes.

- Before 1930, Pb pipes; after 1930, copper pipes with Pb solder

Coliform Bacteria

- The presence of appreciable numbers of coliform bacteria in a water sample has been used as an indicator that the water is unsafe to drink

- This is more historical activity than anything else. In fact, coliforms rarely cause disease. However, because they are present in greater numbers than pathogenic bacteria of the intestines of warm-blooded animals, coliforms serve as indicators that the water is polluted.

Biochemical Oxygen Demand (BOD)

- The most common measurement of pollutant organic material in water
  - Low BOD – Good water quality
  - High BOD – Polluted Conditions
- When bacteria act upon organic sewage, a large amounts of dissolved oxygen is used up. This can result in fish kills and drastic alteration in the aquatic environment.

Water Purification

Basic steps for raw water treatment

1) **Sedimentation** – incoming raw water maintained in a “quiet pond” for settling out

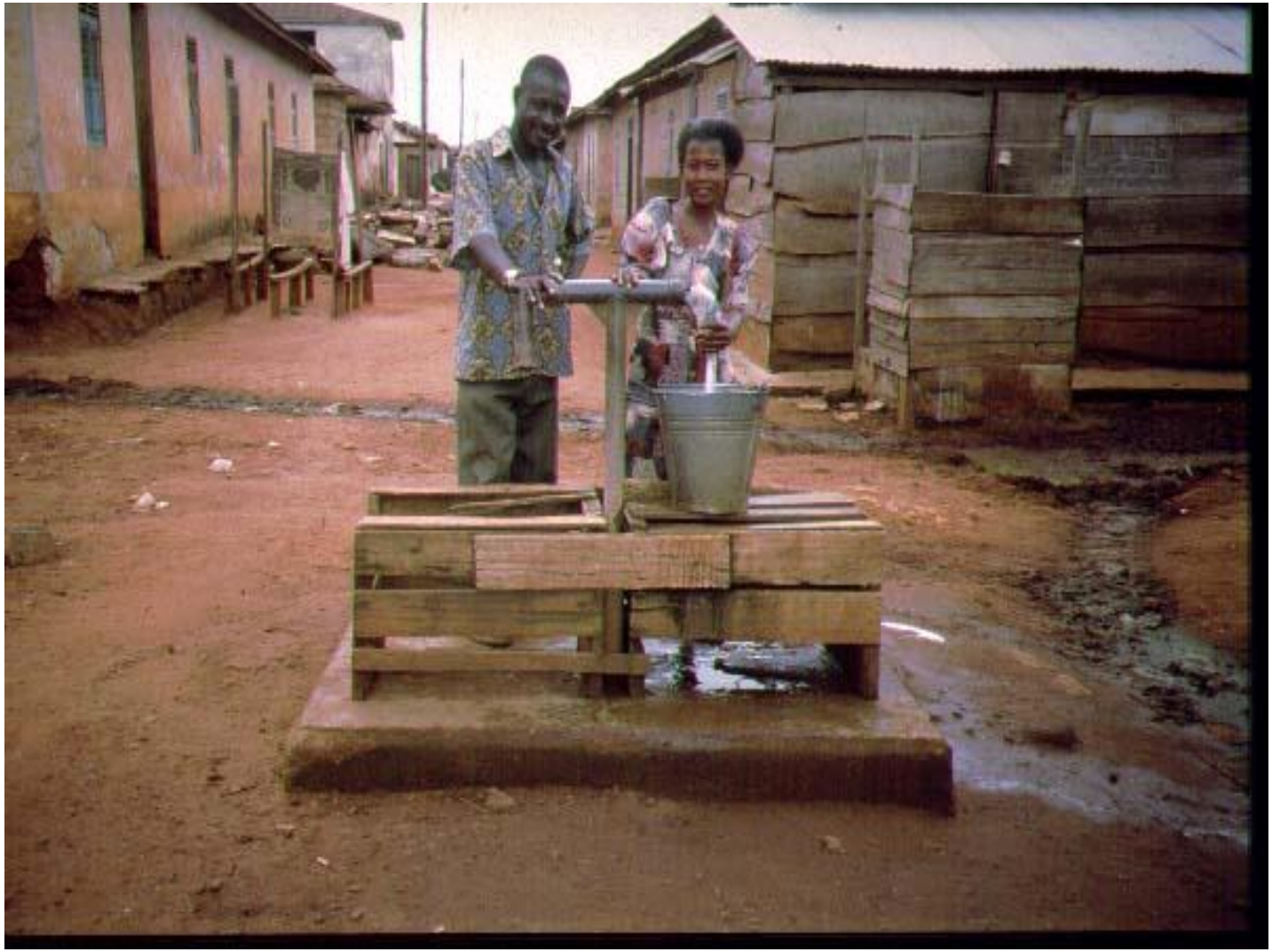
2) **Coagulation** – hydrate aluminum sulfate is added to the water to cause the suspended solids to form flocs which precipitate

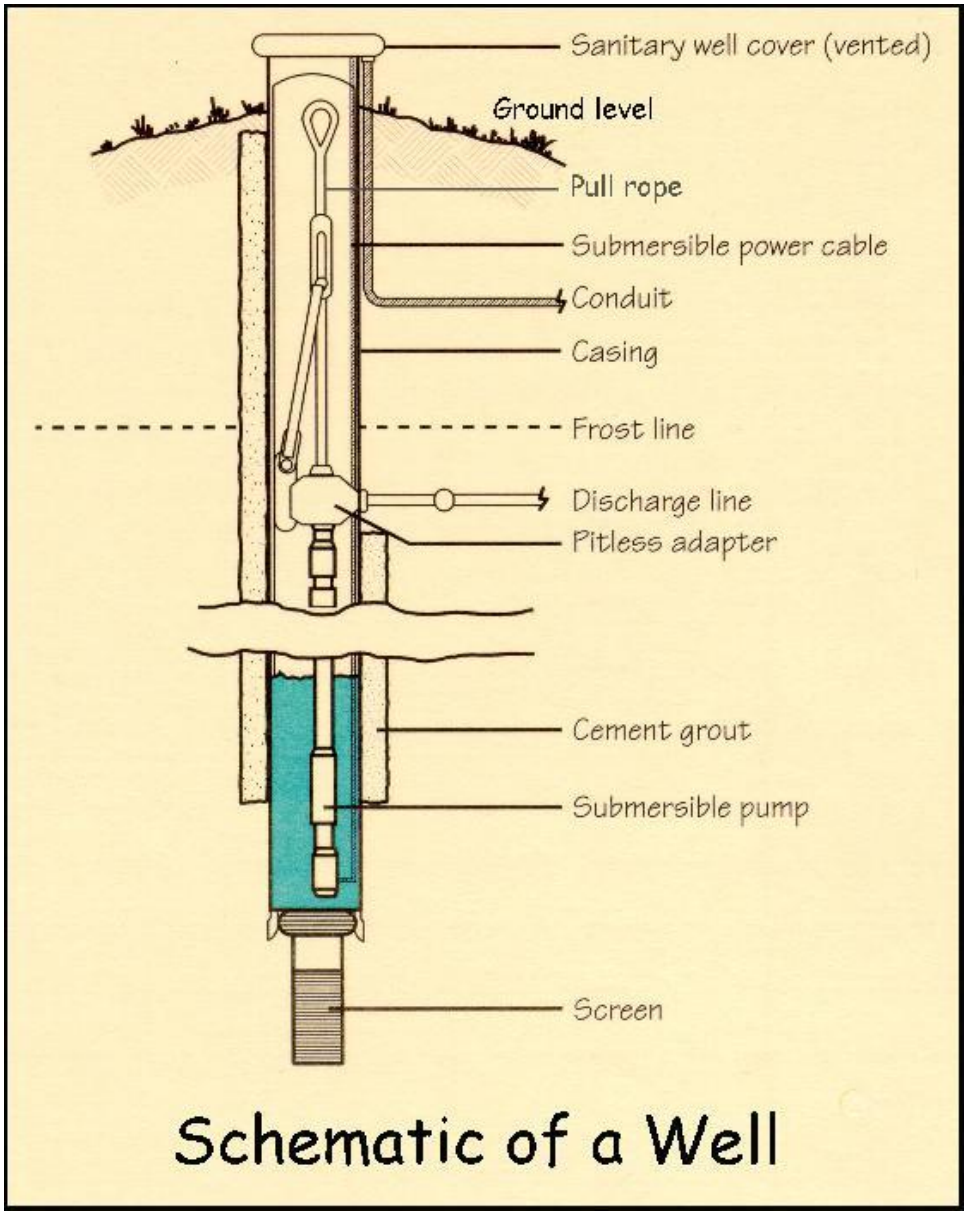
3) **Filtration** – through beds of sand, Arthracite or Diatomaceous Earth

4) **Disinfection** – Chlorine, Ozone, or UV light. Disinfection is utilized to kill pathogens in the water

Chlorination

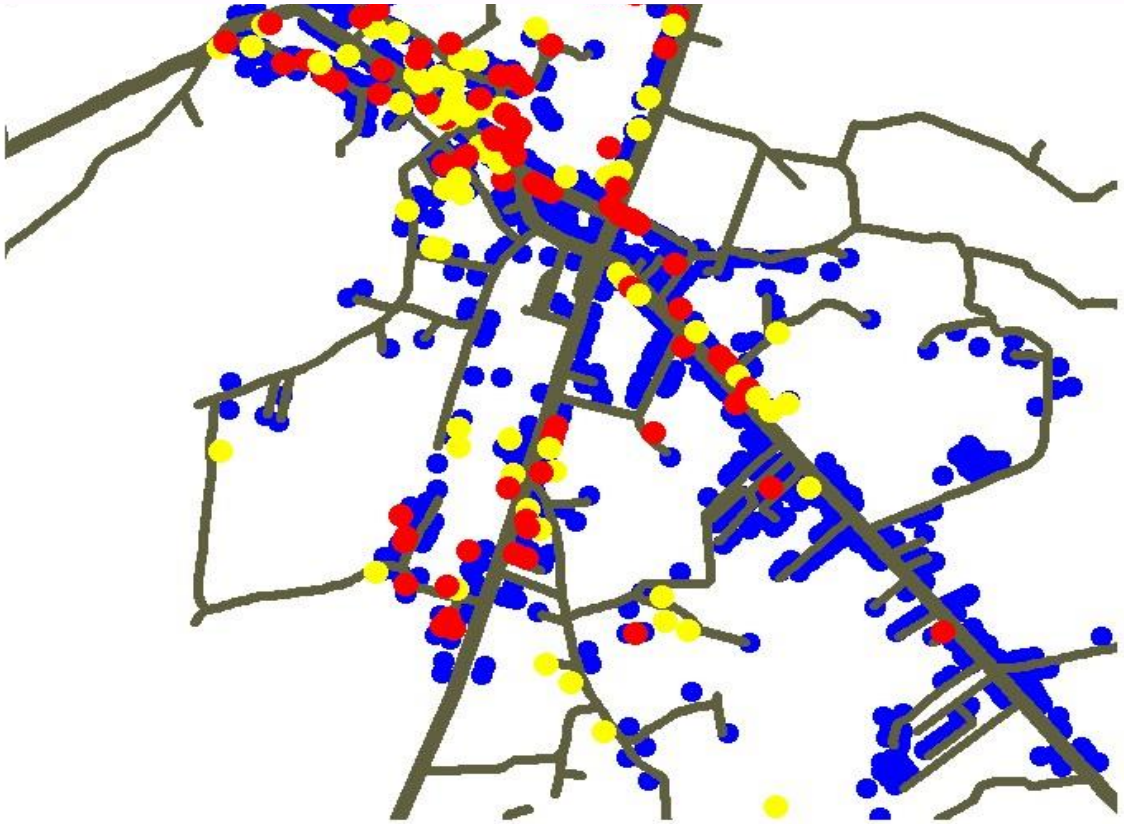
- U.S. started chlorination in 1908 in Chicago
- Chlorination of drinking water can take credit for the precipitous decline in deaths due to infectious GI diseases
- Chlorine is used in 75% of the U.S. water supply
  1) Inexpensive
  2) Highly effective in killing bacteria
  3) Residual in water to provide germ killing potential





Schematic of a Well

Distribution of household having high-As (>200ug/l As) well or low-As (<=200ug/l As) well



Introduction to Environmental Health

Toxicology

Risk Assessment

Air

Water

Food

Children

For risk assessment you need: Accurate dietary data





What type of protective equipment do you usually use when you mix and apply pesticides? (Check all that apply)

( ) 1. None

( ) 2. Chemical protective mask

( ) 3. Normal mask or clothing mask

( ) 4. Knitting faces hat

( ) 5. Loincloth

( ) 6. Sun hat

( ) 7. Goggle or glasses

( ) 8. Chemical resistant gloves

( ) 9. Fabric or Leather gloves

( ) 10. Rubber Boots

( ) 11. Shorts and shirt

( ) 12. Long pant and shirt

( ) 13.Other _____ _____

Introduction to Environmental Health

Toxicology

Risk Assessment

Air

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TERRACOTTA
INDOOR BABIES
$7.95

Truisms

- It is a truism in toxicology that humans are not simply big rats, and attempts are made in risk assessment to take into consideration important differences between rats and humans
- A less obvious truism is that children are not simply small adults

Two General Types of Differences Between Children and Adults

1. Differences in intake per unit of body weight of air, food, and water (and the associated contaminants)

2. Differences in pharmacokinetic behaviors such as absorption, distribution, metabolism and excretion of chemicals

- Because they are growing and developing, infants and children are different from adults in composition and metabolism as well as in physiological and biochemical processes

- In a period of 26 weeks, the human conceptus grows from microscopic size to a recognizable form, weighing about 500 g
  (1 pound)

- At that time the organs and body systems (cardiovascular, pulmonary, genitourinary, gastrointestinal, neurological, hematological, immunological, endocrine, and musculoskeletal) are sufficiently mature. Extrauterine existence is possible - but survival is very risky

- After 12 more weeks (38 weeks of gestation), the average fetal weight increases to 3.5 kg (7.5 pounds) and the organs and body systems become mature enough that the adaptation to life outside the uterus is relatively assured

- From birth through adolescence, physical growth and functional maturation of the body continue

- Physical development of the body (overall growth) nervous and digestive systems, liver and kidneys, and the proportions of body water and body fat are a concern in the study of developmental toxicology

- Prior to full maturation, damage to an organ or organ system, such as CNS, could permanently prevent normal physical maturation

Issues with Children

- The general principle is that the rate of absorption is faster in a child and the compound accumulates to a greater extent in the infant, resulting in enhanced toxicity.

- For example: The ability of the neonate to eliminate drugs or chemicals via the kidney, the major excretion pathway, is significantly limited by the state of development of the organ.

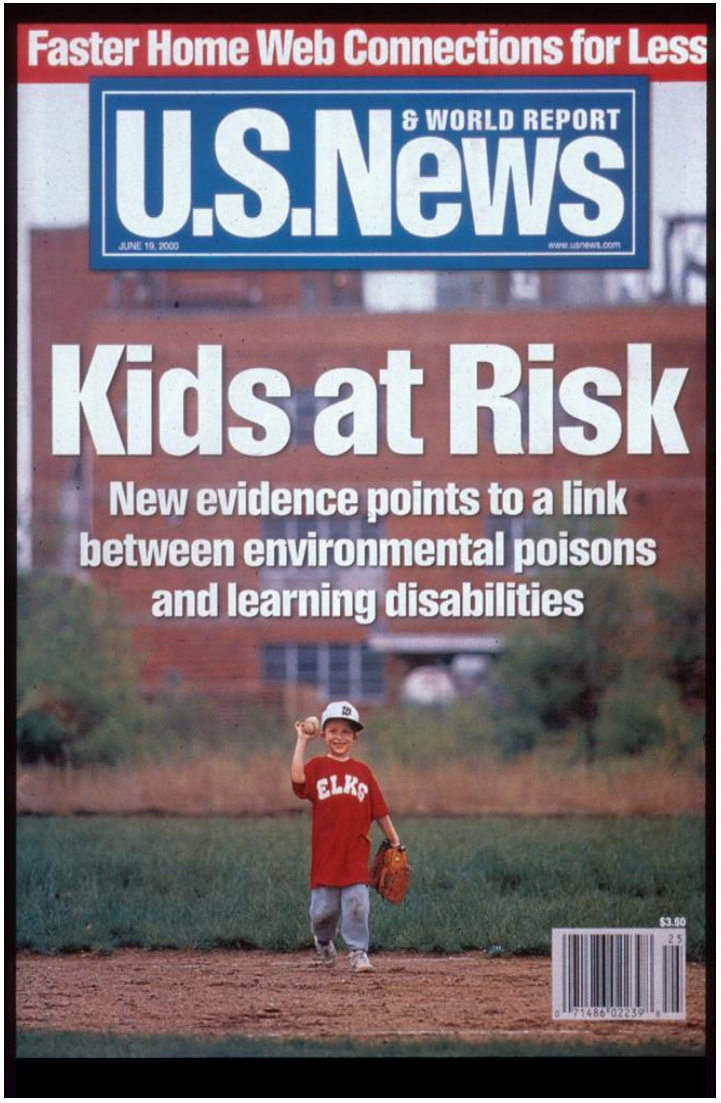
- Increased respiratory minute ventilation in infants and children result in a greater inspired air exposure per unit of time on a weight basis as compared to adults

- Particulate size then determines the amount of inspired particles/chemicals absorbed via the lungs

  – Greater portions of inhaled particles less than 5μm in diameter reach the distal airways compared to larger particles, which generally do not get past the upper airways

- The newborn infant has approximately 10 million alveoli. By 8 years of age there are 300 million lung alveoli
- The alveolar surface area increases from 3 m^2 at birth to 75 m^2 at adulthood
- The air-tissue gas exchange increases more than 20-fold from infancy to adulthood


We are not little adults
Children's Environment
Air they breathe
Water they drink
Food they eat
Where they live, learn & play
Children's Health
Asthma & upper respiratory illnesses
Developmental & neurological problems
Childhood cancer
Tips to protect your kids
Source: EPA


Faster Home Web Connections for Less
U.S.News
& WORLD REPORT
JUNE 19, 2000
www.usnews.com
Kids at Risk
New evidence points to a link between environmental poisons and learning disabilities
ELKS
$3.50

Typical Environmental Exposures:

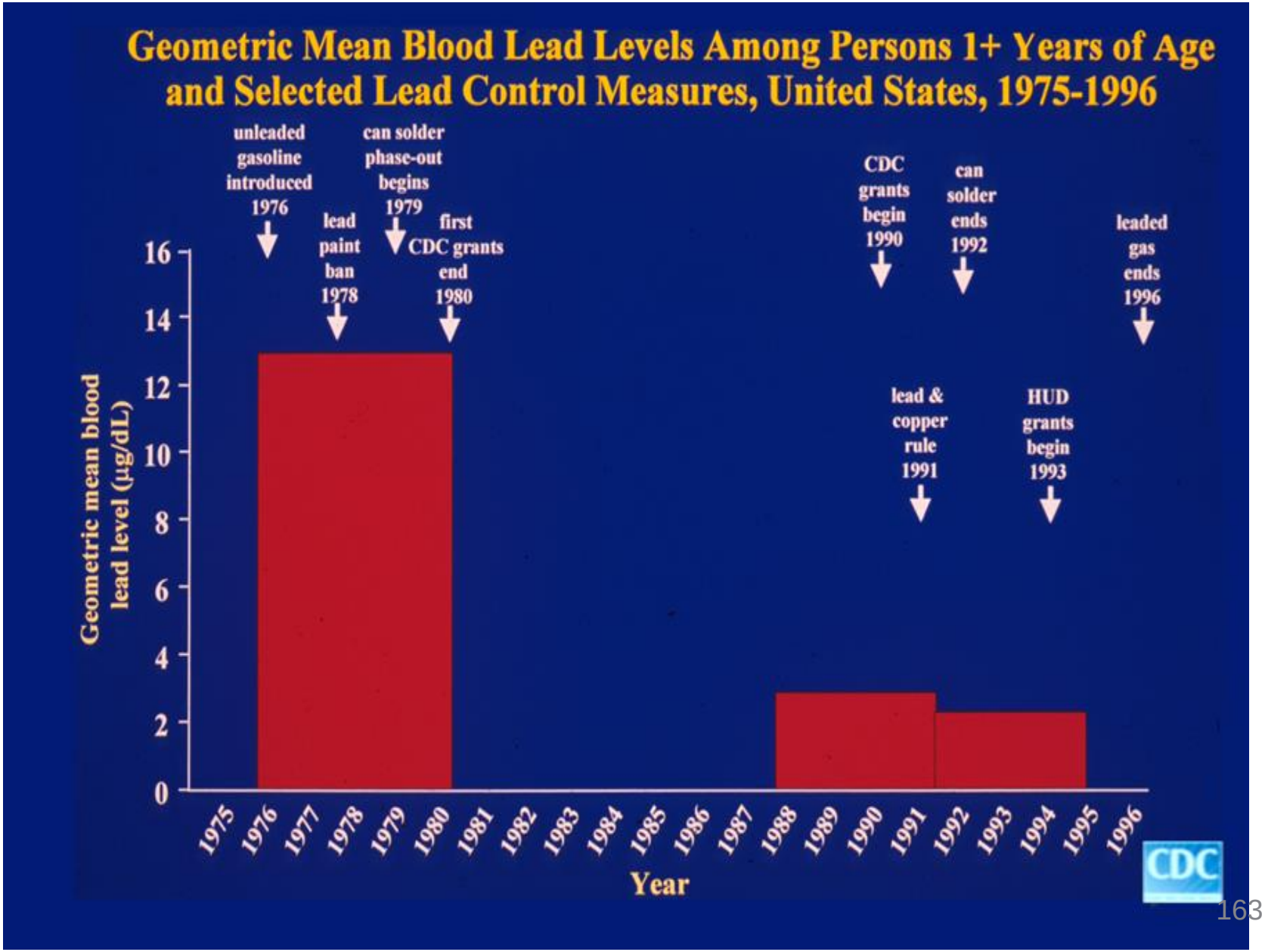
The Renaissance Era

Infectious Agents

Fire Byproducts
Particulates, PAHs, CO

Heavy Metals
Lead, Mercury


Typical Environmental Exposures:
TODAY
Industrial Chemicals
PCBs, Dioxin, Toxaphene,
VOCs, Phthalates,
Adipates, PBDEs
and many others
Infectious Agents
Chlorination Byproducts
Chloroform, Bromoform, etc.
Fire Byproducts
Particulates, PAHs, CO
Vehicular Emissions
CO, Ozone,
Particulates, Benzene, etc.
Heavy Metals
Lead, Mercury,
Palladium, Cadium
Pesticides
DDT, Mirex, 2,4-D,
Atrazine, Malathion, etc.
CDC


Geometric Mean Blood Lead Levels Among Persons 1+ Years of Age and Selected Lead Control Measures, United States, 1975-1996
unleaded gasoline introduced 1976
lead paint ban 1978
can solder phase-out begins 1979
first CDC grants end 1980
CDC grants begin 1990
can solder ends 1992
leaded gas ends 1996
lead & copper rule 1991
HUD grants begin 1993
Geometric mean blood lead level (µg/dL)
0
2
4
6
8
10
12
14
16
1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996
Year
CDC