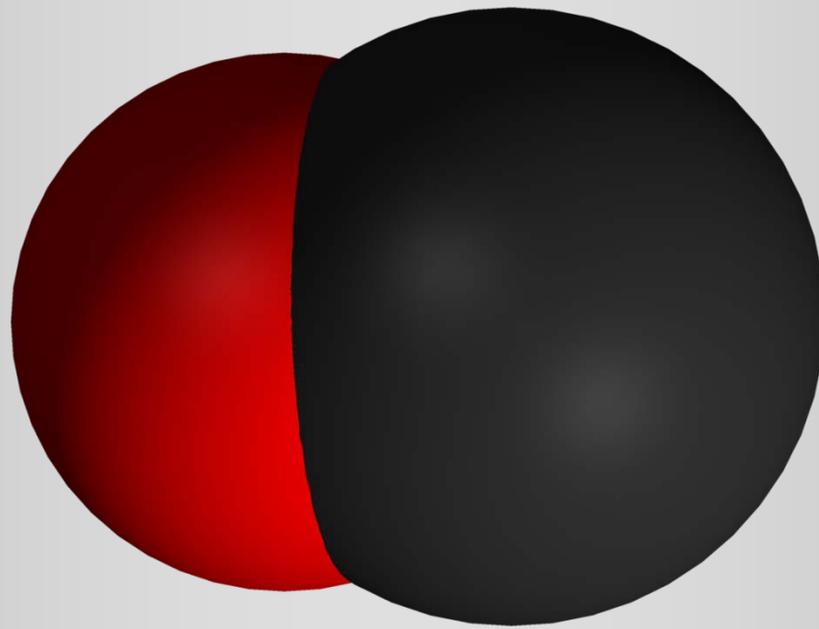


Carbon Monoxide

Carl Baum, MD

Yale University School of Medicine

Medical Director, PEHSU West



Carbon Monoxide:

Odorless, Colorless, Borderless

This material was supported by the American College of Medical Toxicology (ACMT) and funded (in part) by the cooperative agreement FAIN: U61TS000238 from the Agency for Toxic Substances and Disease Registry (ATSDR).

Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing partial funding to ATSDR under Inter-Agency Agreement #DW-75-92301301. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

Learning Objectives

Understand sources of carbon monoxide

Describe existing treatment of carbon monoxide exposure

Understand strategies for prevention of carbon monoxide exposure



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Learning Objectives

Understand sources of carbon monoxide

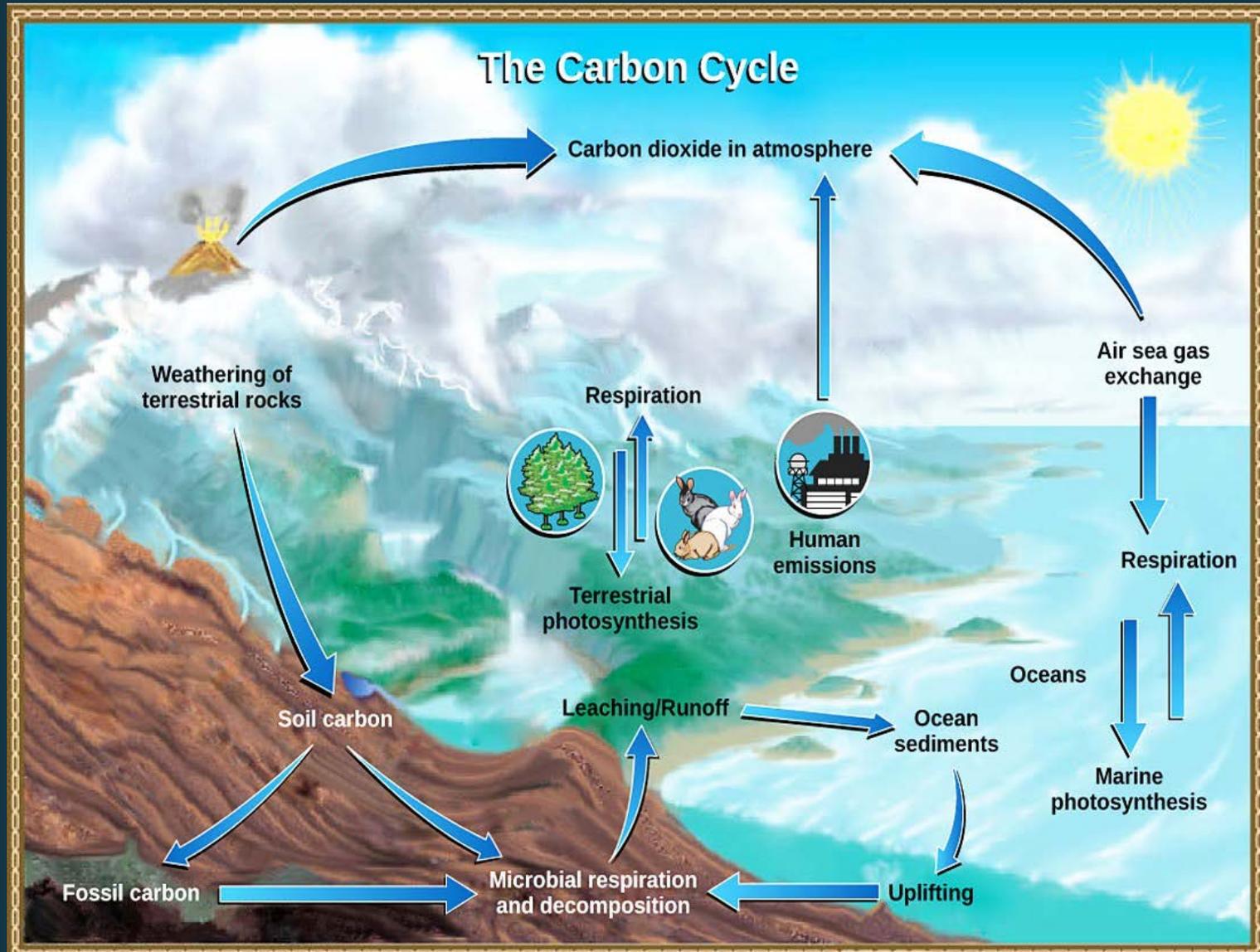
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Understand strategies for prevention of carbon monoxide exposure



Sources of CO

Sources of CO





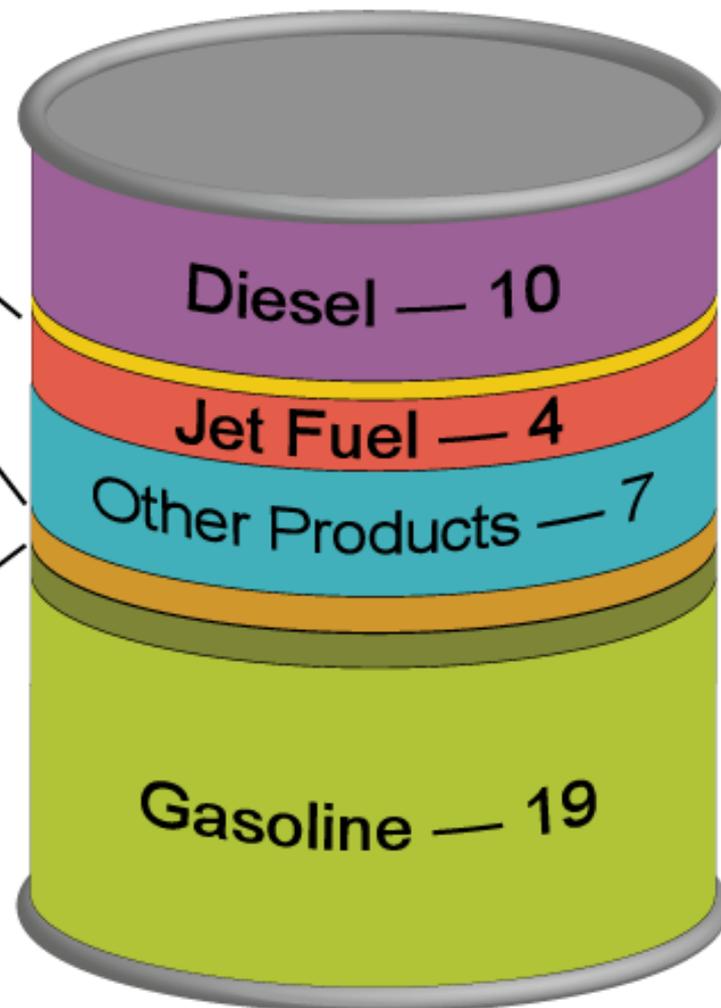


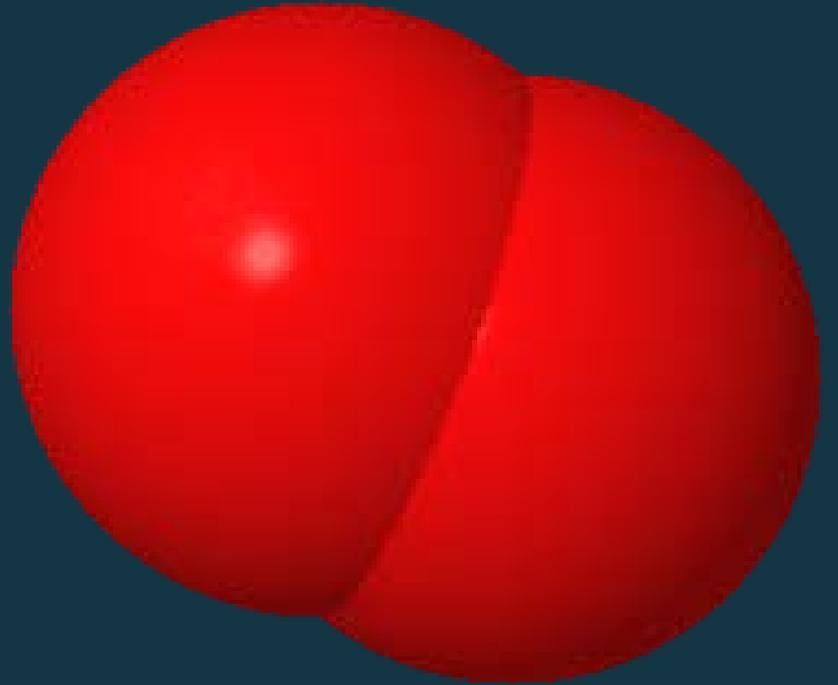
Products Made from a Barrel of Crude Oil (Gallons) (2010)

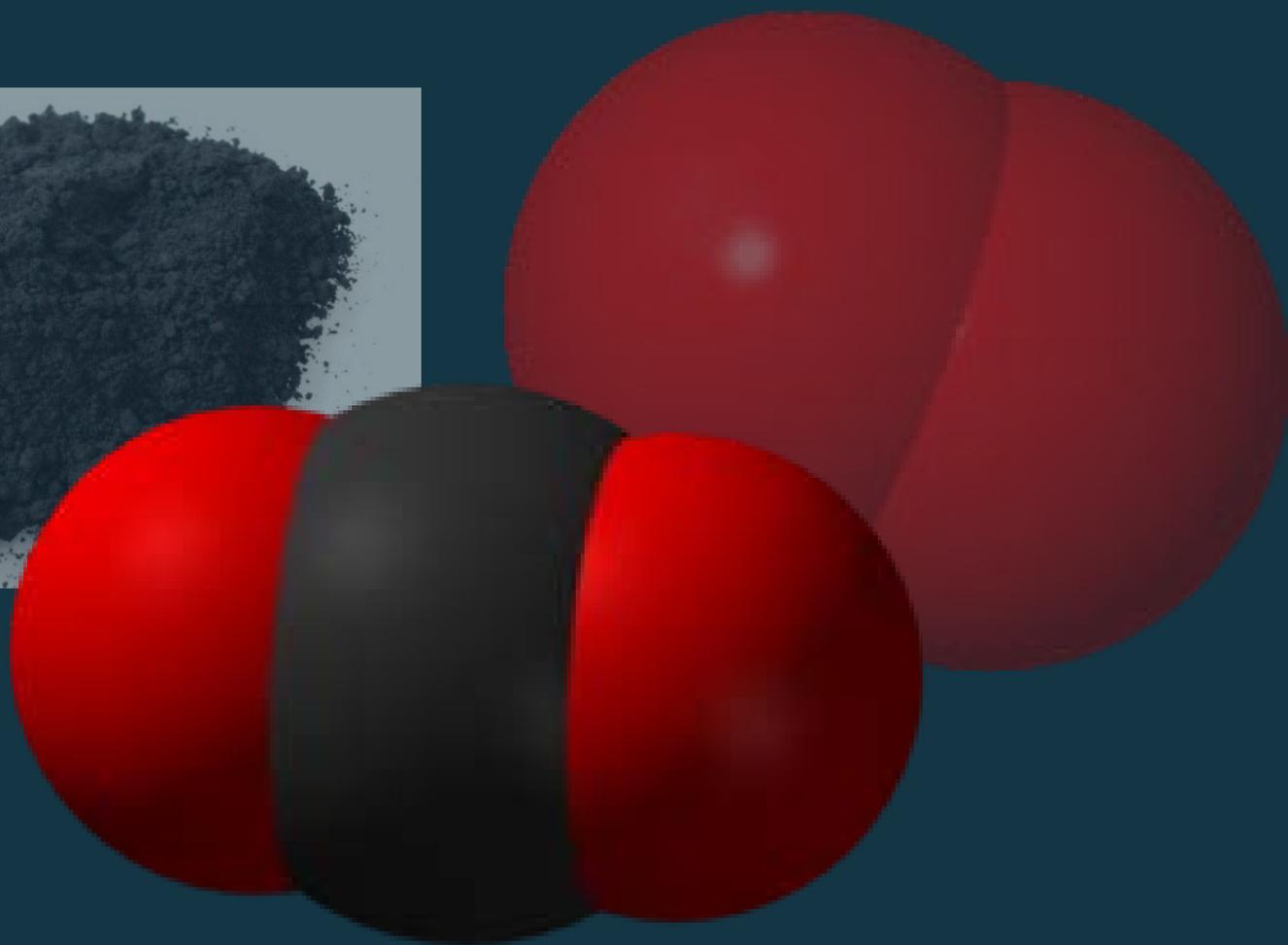
Other Distillates
(heating oil) — 1

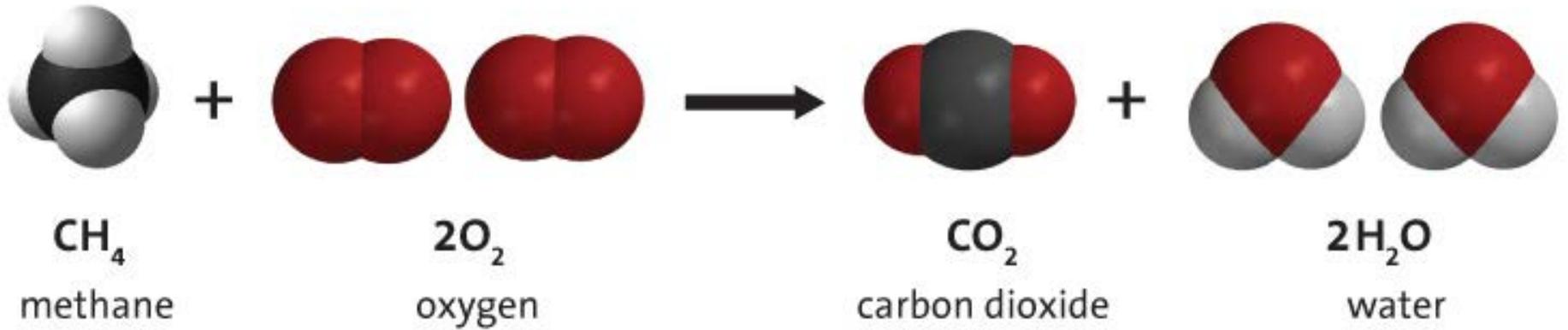
Heavy Fuel Oil
(Residual) — 2

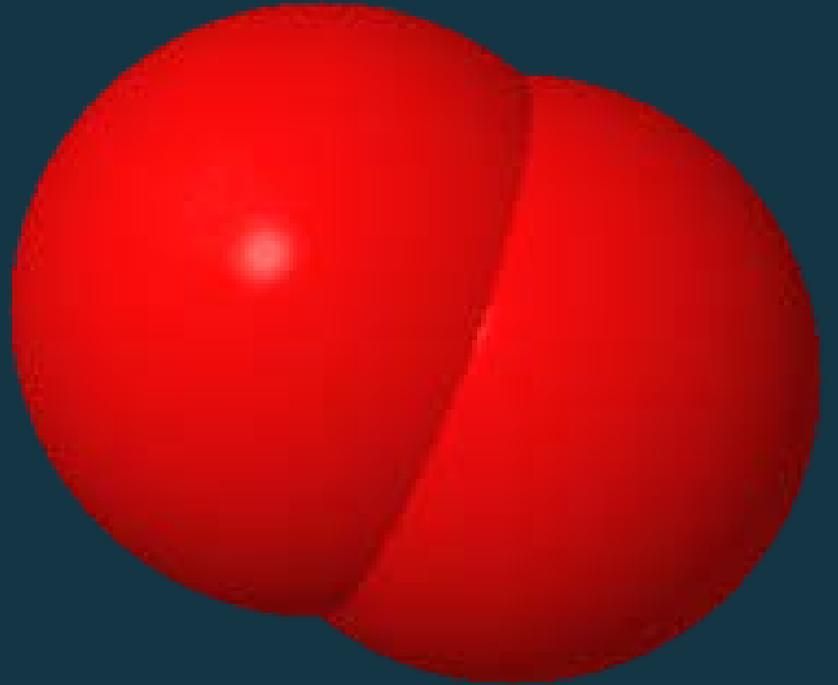
Liquefied
Petroleum Gases
(LPG) — 2

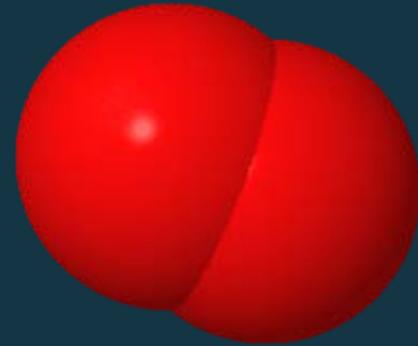


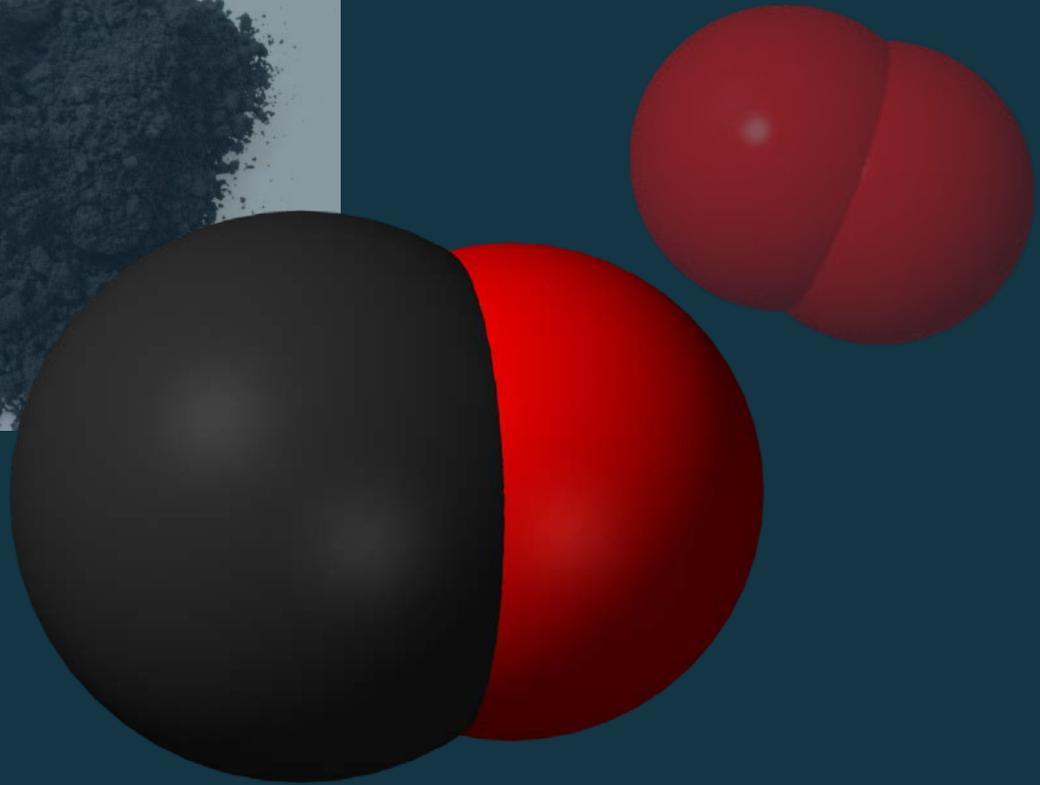


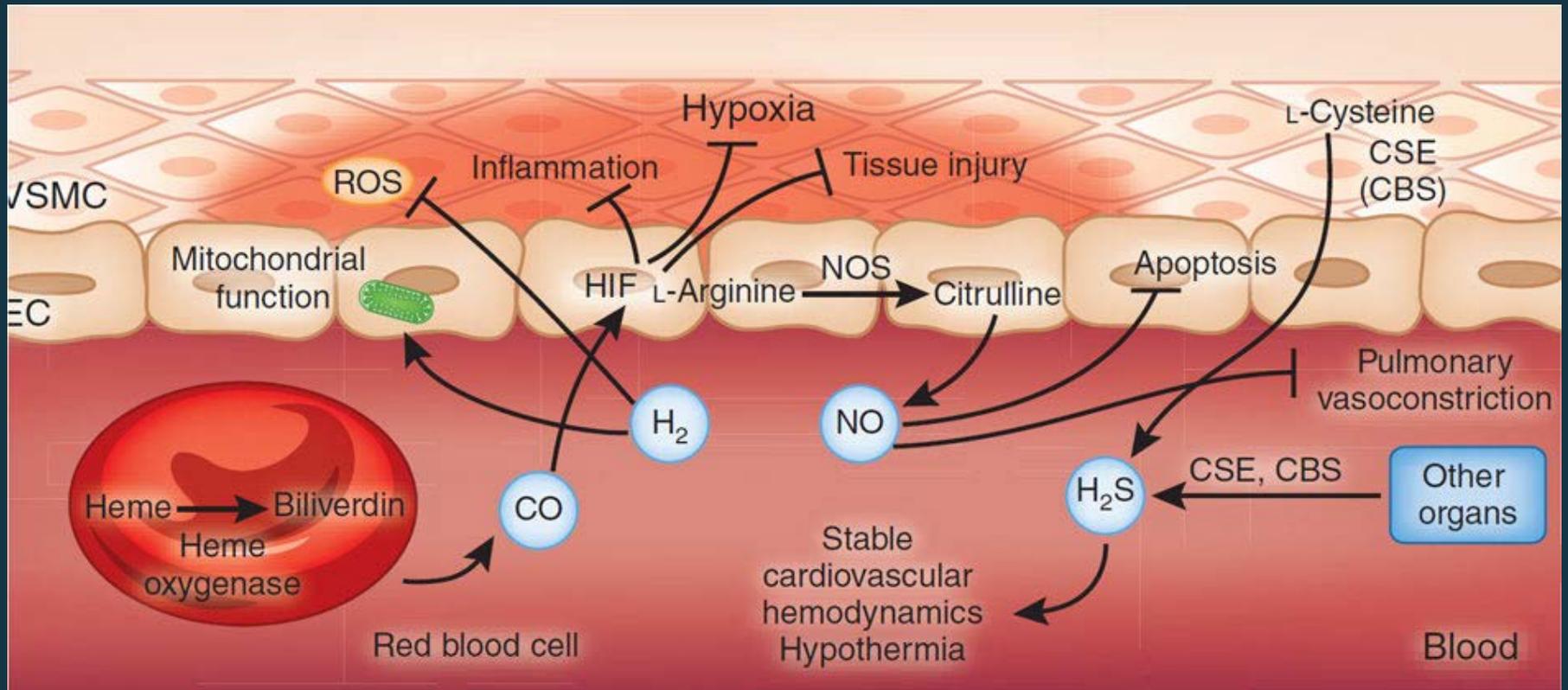


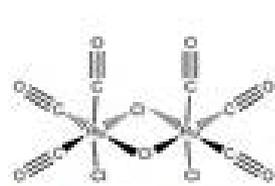




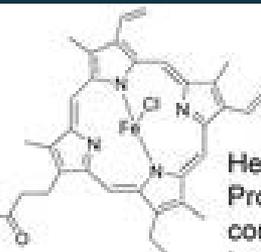




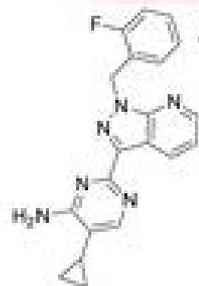
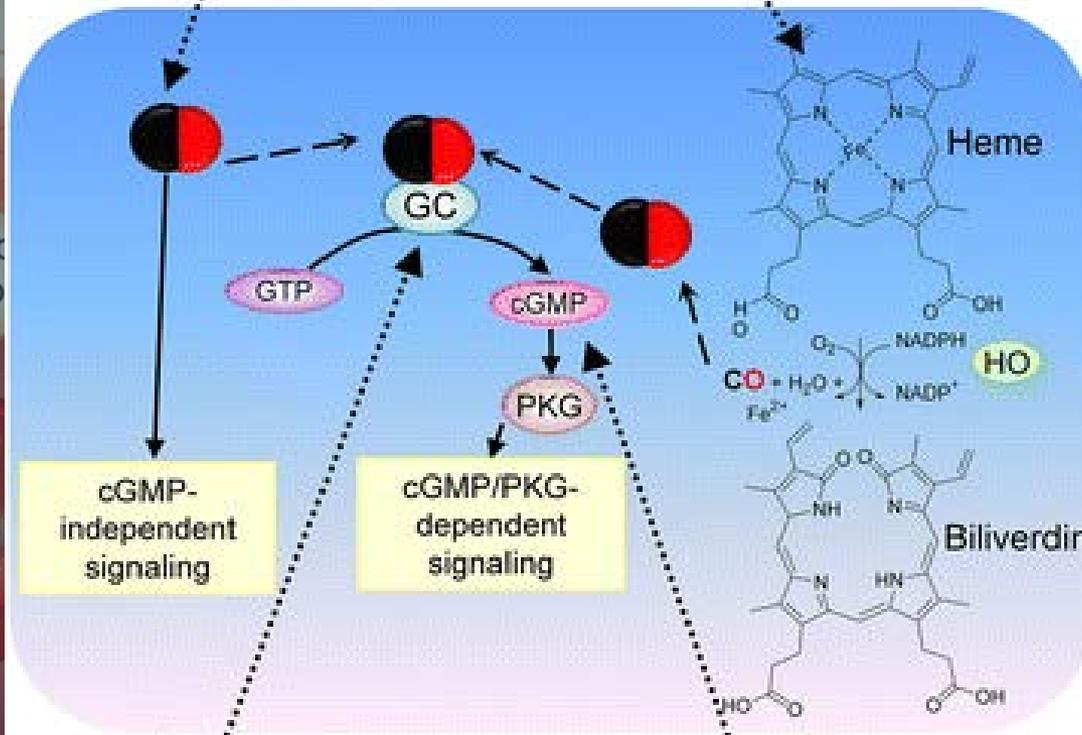




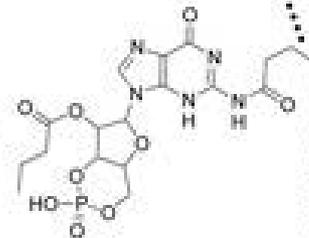
Tricarbonyl-dichlororuthenium (II) dimer, carbon monoxide releasing molecule (CORM-2)



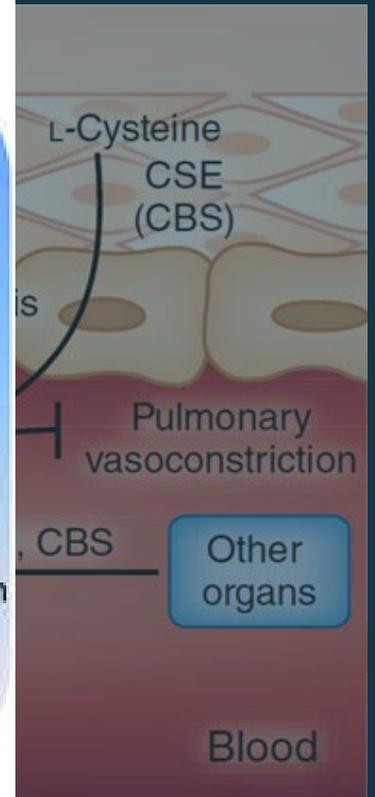
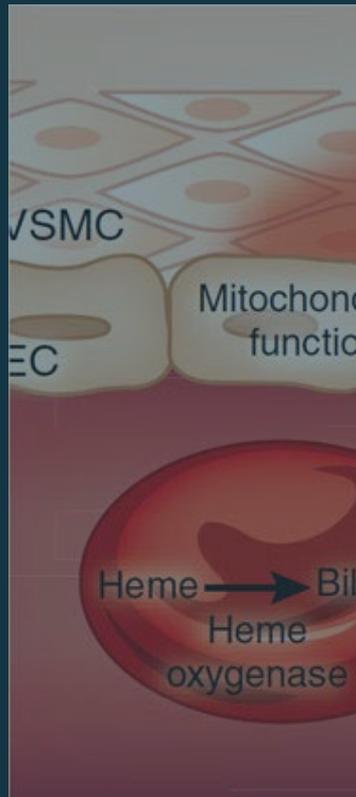
Hemin, Protoporphyrin IX containing a ferric iron ion with a chloride ligand



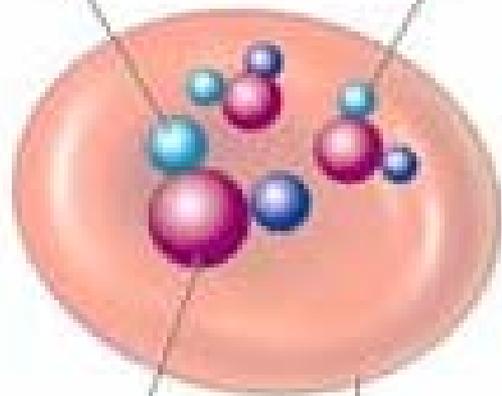
BAY 41-2272, activator of soluble guanylyl cyclase at a novel, NO-independent regulatory site



Dibutyrylguanosine 3',5'-cyclic monophosphate, cell permeable cGMP analog that activates protein kinase G



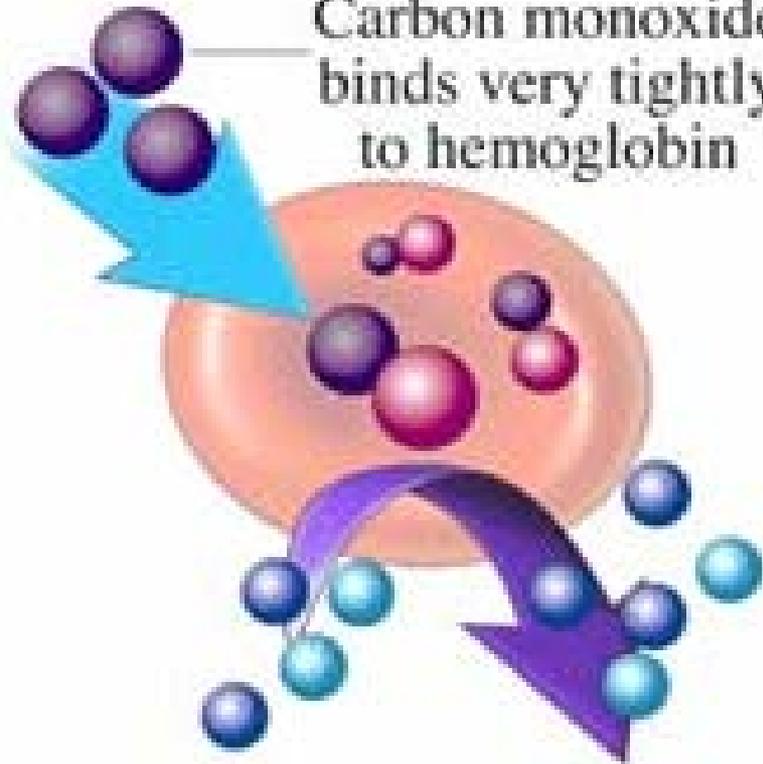
Hemoglobin carries oxygen and carbon dioxide



Hemoglobin

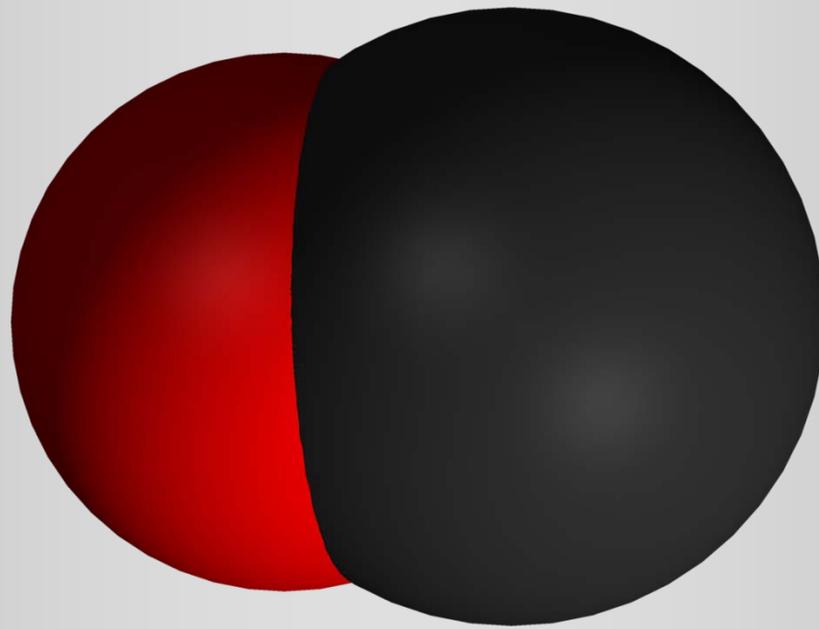
Red blood cell

Carbon monoxide binds very tightly to hemoglobin



Oxygen and carbon dioxide can no longer be carried

Diagnosis of CO Exposure



Carbon Monoxide:

Odorless, Colorless, Borderless

Annually
Up to 40,000 cases
Flu-like symptoms

The case of the slandered hamburgers

RONALD I. PAUL, MD, ROBERT R. TANZ, MD

Carbon monoxide poisoning is a common occurrence, especially during cold months. It can be overlooked, because its history and symptoms are often vague. We report a case of two children with carbon monoxide poisoning who typify the need for obtaining a careful history. A review of the literature, including clinical manifestations, diagnosis, and treatment, follows.

CASE

N.M., a three-year-old white male, was in his usual state of good health when he began to cry after eating a hamburger at a local fast food restaurant. It seemed to his parents that he was in pain, and he did not respond when his mother asked him what was wrong. She immediately picked him up and found him to be unresponsive and limp. His eyes were open but did not seem to focus. Upon arrival in the emergency department, 15 minutes later, he was described by the triage nurse as pale, lethargic, and limp.

R.M., the seven-year-old male sibling of N.M., was also described as pale and lethargic. His symptoms, which also began shortly after eating a hamburger, consisted of a severe headache, one episode of emesis, and dizziness. Neither child had been ill prior to the sudden onset of these symptoms.

The father of the two children was extremely upset. He stated that the hamburgers were spoiled, since both of his children became ill so soon after finishing their meals. He was threatening litigation against the fast food restaurant.

ened to sue the restaurant. They obviously needed explanations from the medical staff.

Were these children suffering from food poisoning acquired at the local fast food restaurant? Had they sampled some whiskey? Was there some other toxin involved? Was this all a hoax for the purpose of the father's proposed lawsuit?

The notion of food poisoning from the hamburgers must be discarded, since the symptoms started within minutes of ingestion of the maligned meat. Symptoms from most routine viral and bacterial food poisoning agents would not develop for several hours. Routine blood ethanol and glucose measurement would help dismiss the possibility of acute alcohol ingestion. It seems unlikely that this is all a hoax, since the children's symptoms were briefly witnessed by the nursing staff. Lethargy and pallor are extremely difficult symptoms for three- and seven-year-old children to fabricate. The possibility of some type of toxin remains, especially in view of both the sudden onset and recovery from unexplained symptoms in both children.

After deciding that the reported symptoms most likely represent some type of intoxication, urine from both children was sent for toxicology screening. During the three to four hour delay until the results were known, the parents once again responded to questions in greater detail. The family had traveled a distance of 20 miles, stopping several times along the way, including a 20-minute stop at a movie video store. At each stop, the children were left in the car with the engine running. Since it was a very cold autumn day, the

Annually
>2000 deaths

Poor/immigrant
at highest risk

Pulse oximetry
NOT helpful



Red LED

Infra red LED

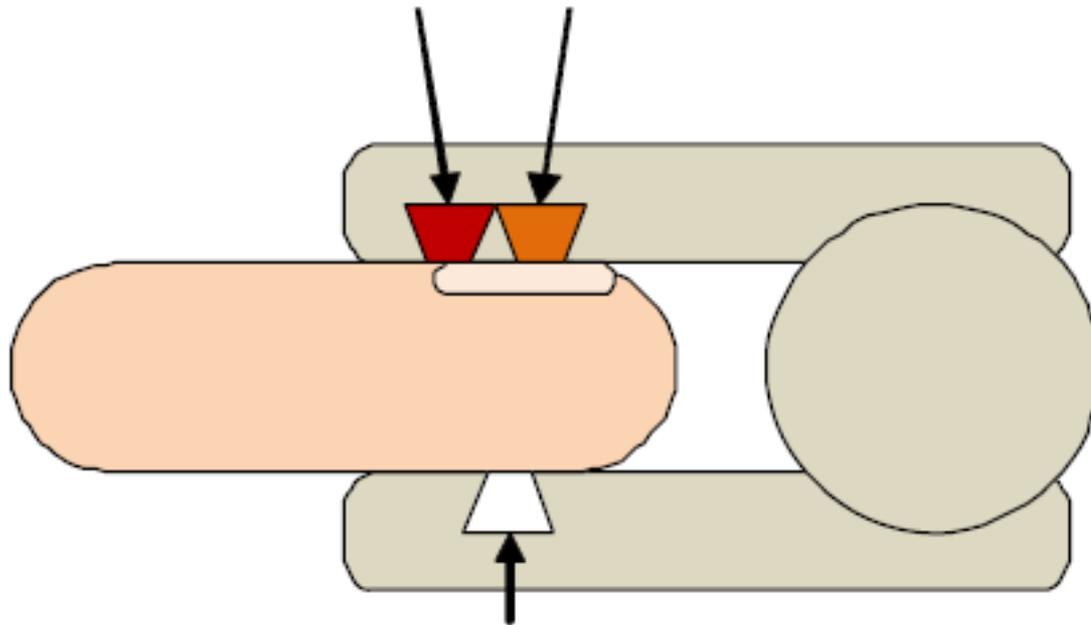
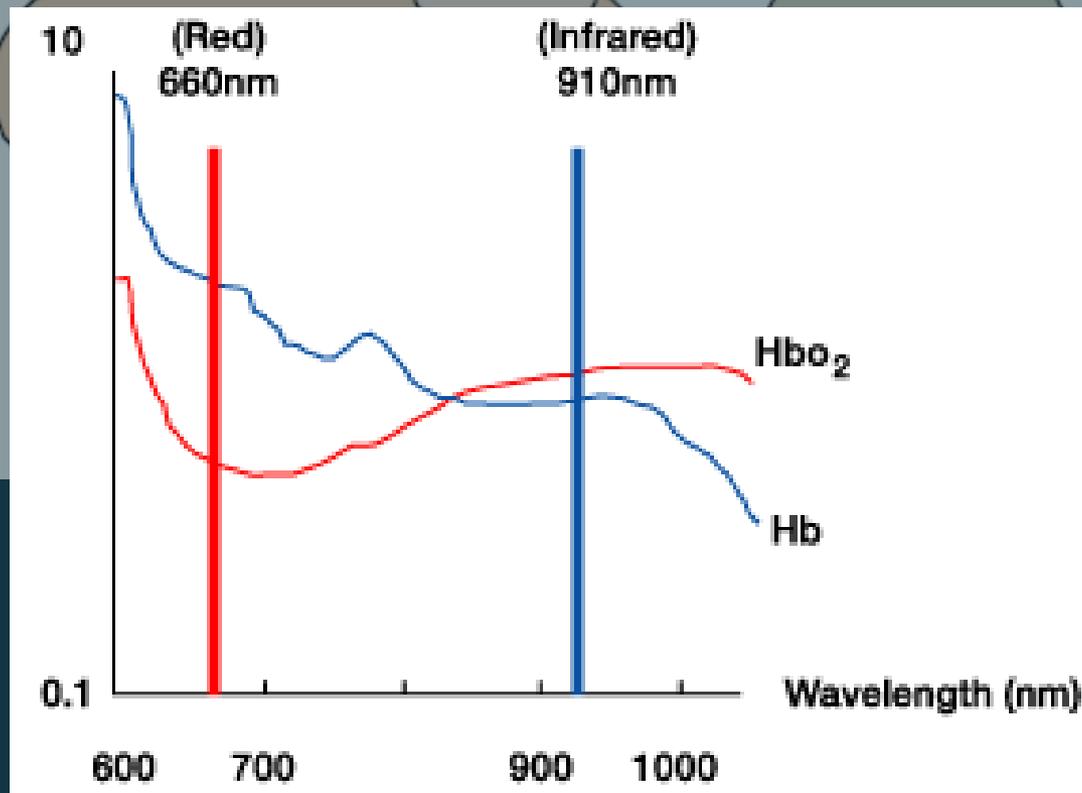


Photo sensor

Red LED

Infra red LED



Blood co-oximetry



CO (ppm)	Carboxy-hgb (%)	Notes
10	1.5	Upper limit, nonsmokers
50	5	OSHA 8-hour permissible exposure
350	35	NIOSH recommends supplied air respirator
1200	65	NIOSH immediate danger to life and health

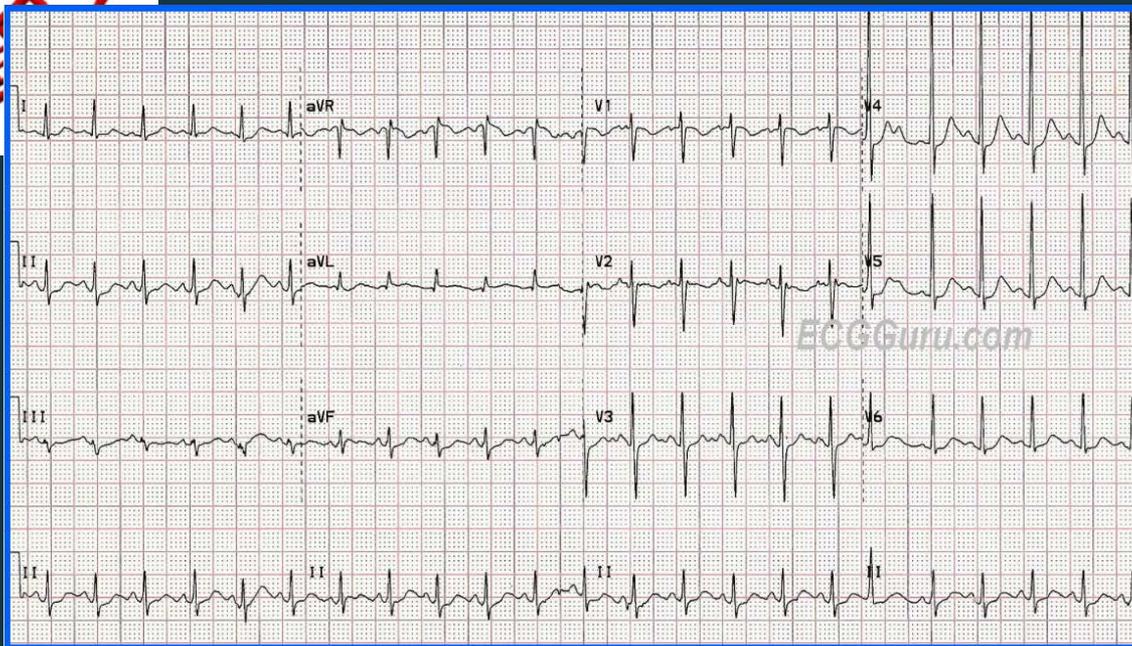
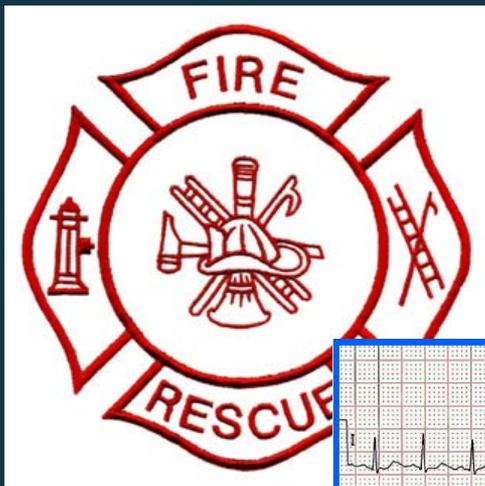
		respirator
1200	65	NIOSH immediate danger to life and health

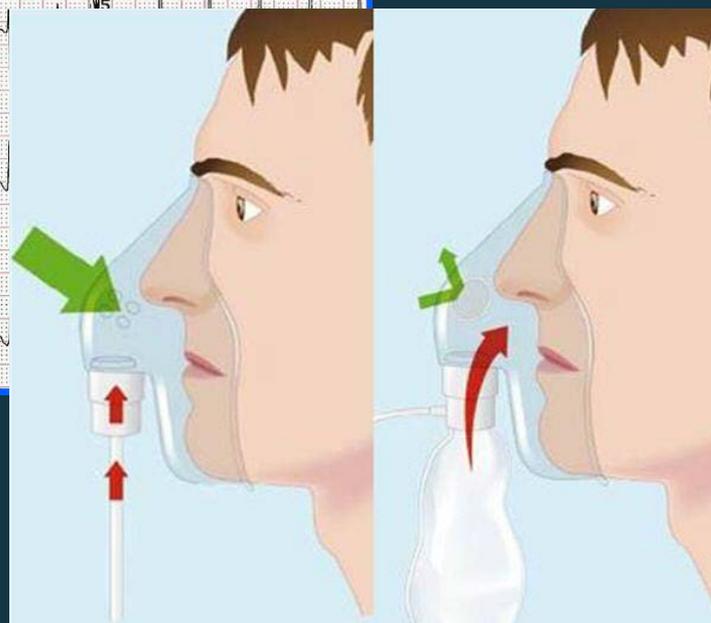
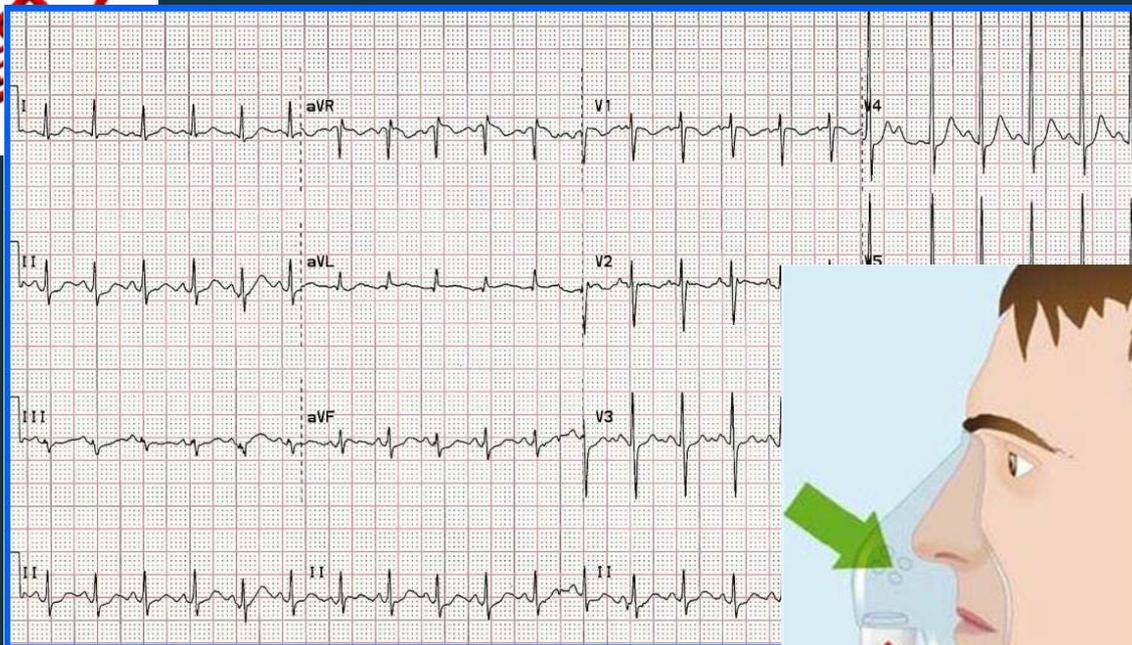
**Exhaust from
home wood fire:
5000 ppm**

Delayed Neurological
Sequelae
after 2-40 days

Treatment of CO Exposure





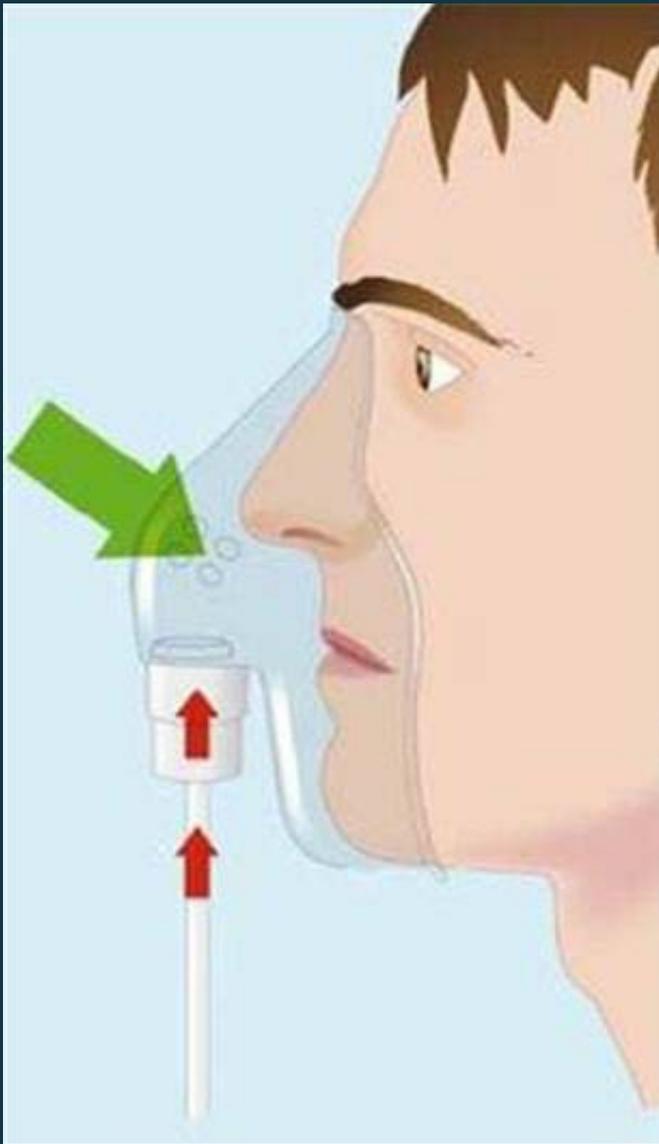


Simple facemask

- 6-10 l/min
- FiO_2 : 0.44-0.60

Facemask with reservoir bag

- 10-15 l/min,
- FiO_2 > 0.9



Simple facemask

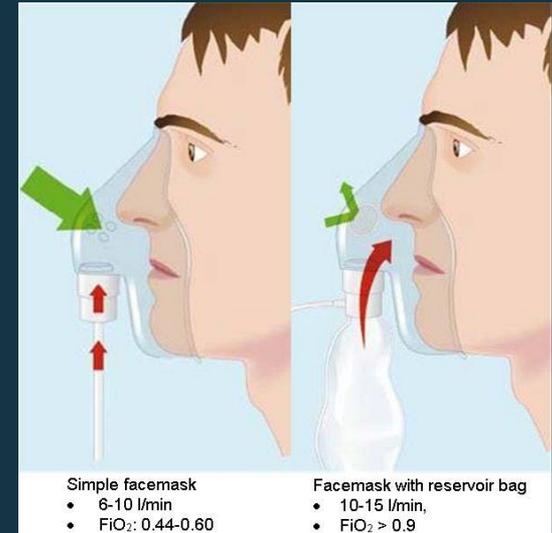
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Facemask with reservoir bag

- 10-15 l/min,
- $\text{FiO}_2 > 0.9$

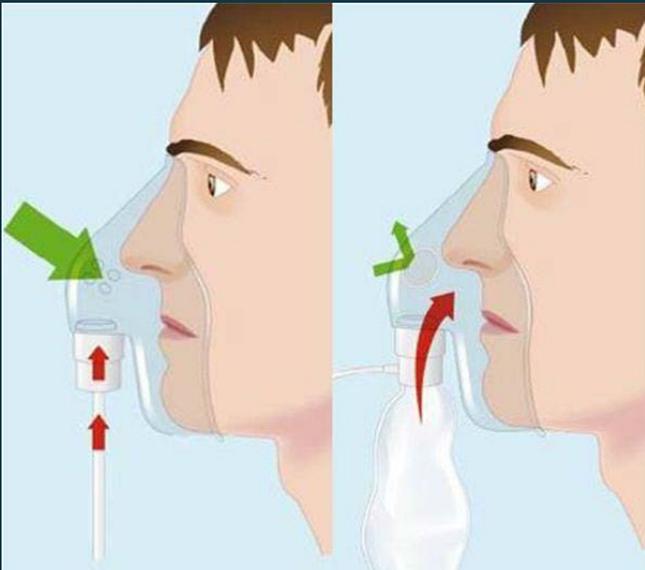
Half-life



Oxygen: 74 \pm 25 min

(Weaver, 2000)

Air: 4-6 h



Simple facemask

- 6-10 l/min
- FiO_2 : 0.44-0.60

Facemask with reservoir bag

- 10-15 l/min,
- $FiO_2 > 0.9$





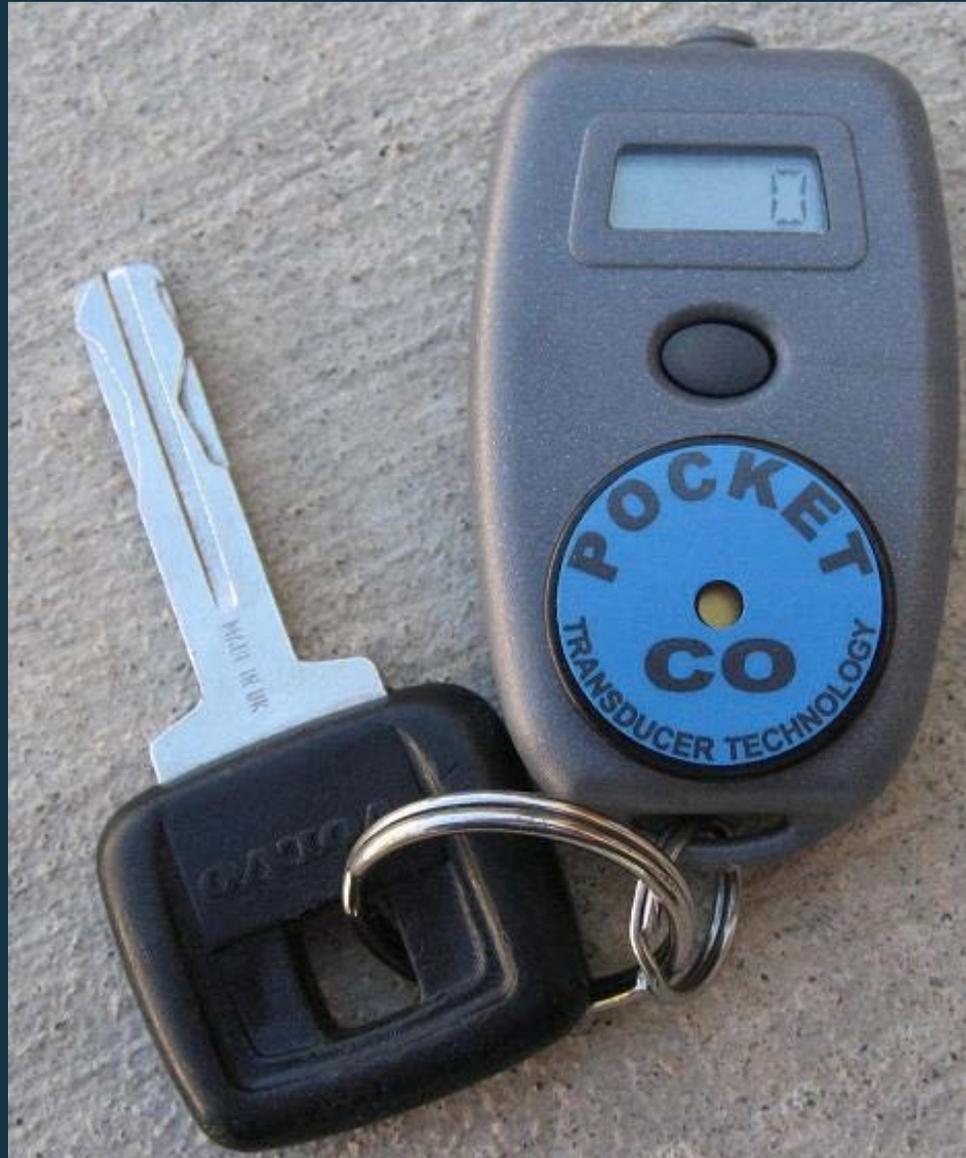
LOC / AMS
Seizures
Ataxia
Hypotension
Myocardial injury

Prevention of CO Exposure













DANGER

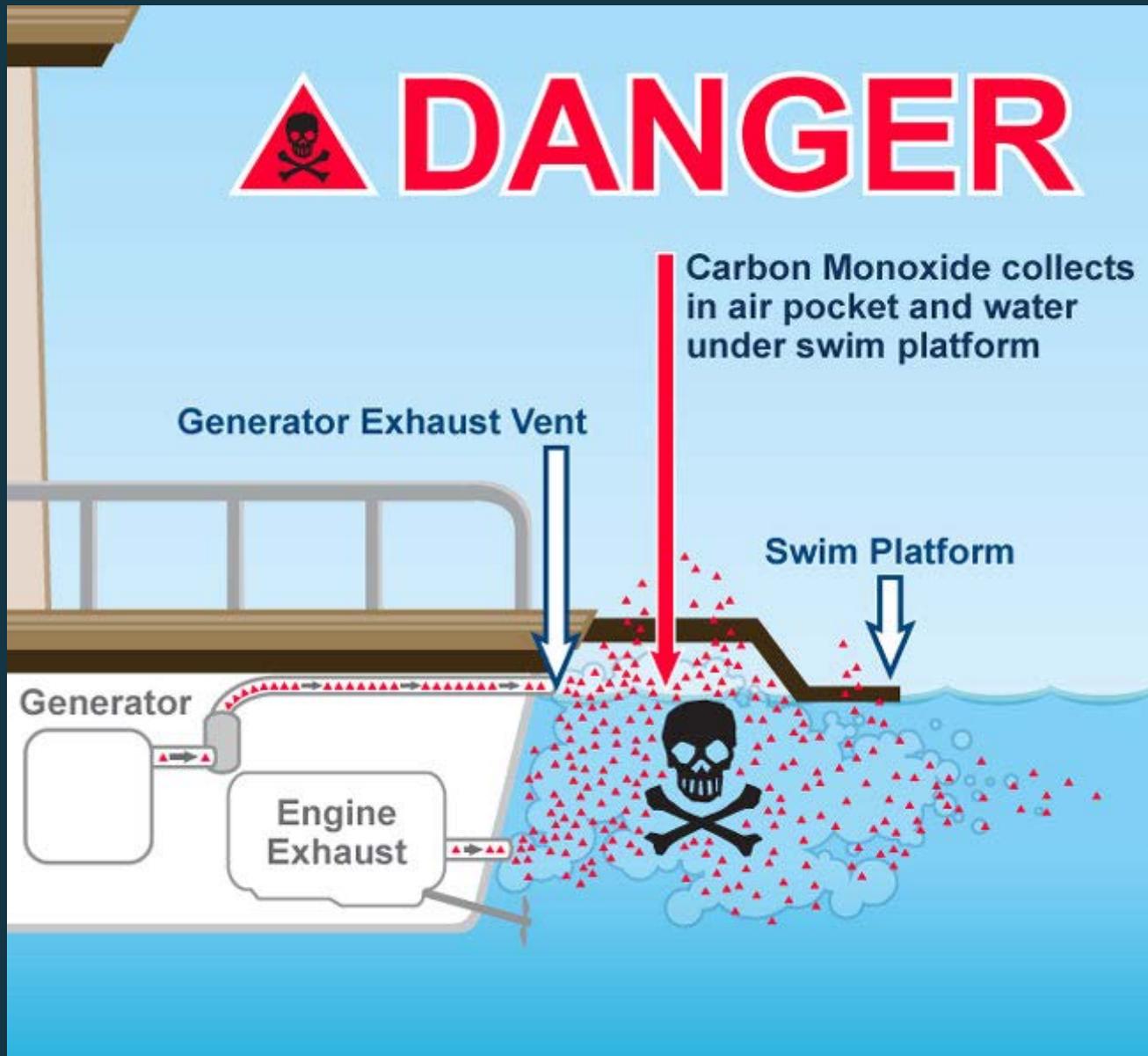
Carbon Monoxide collects
in air pocket and water
under swim platform

Generator Exhaust Vent

Swim Platform

Generator

Engine
Exhaust



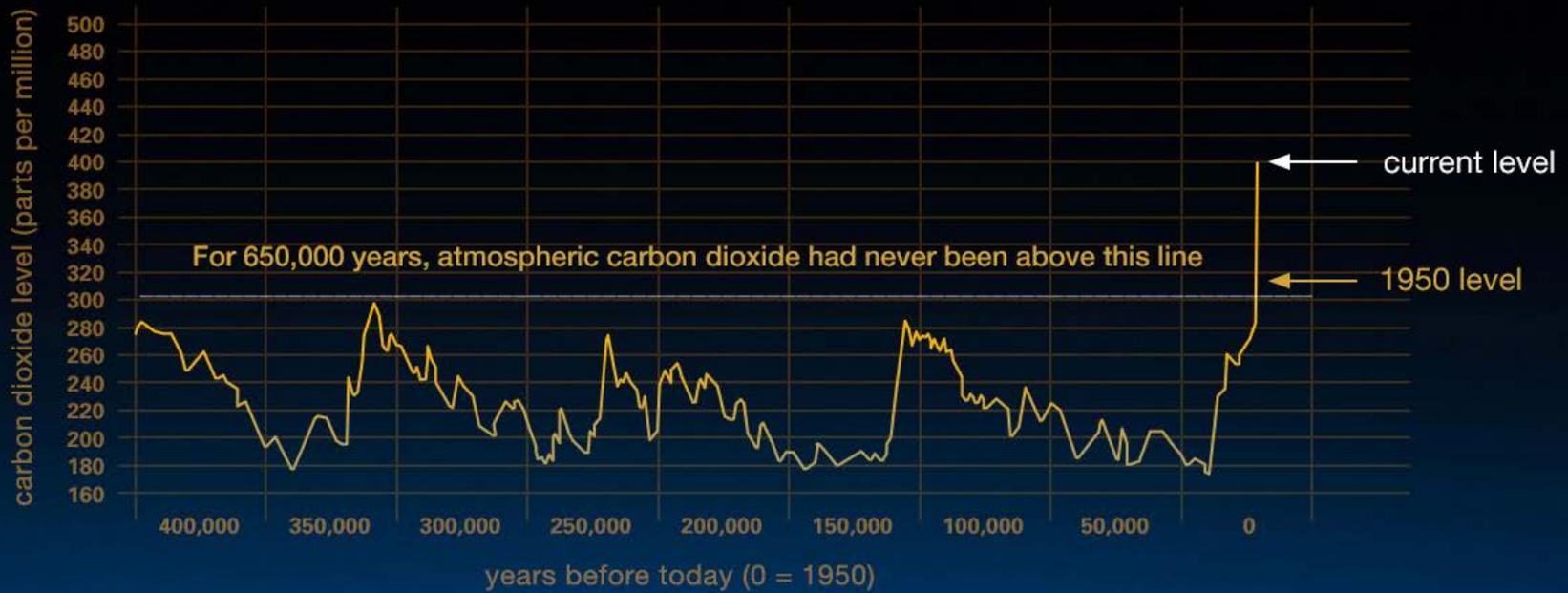
UL 2034

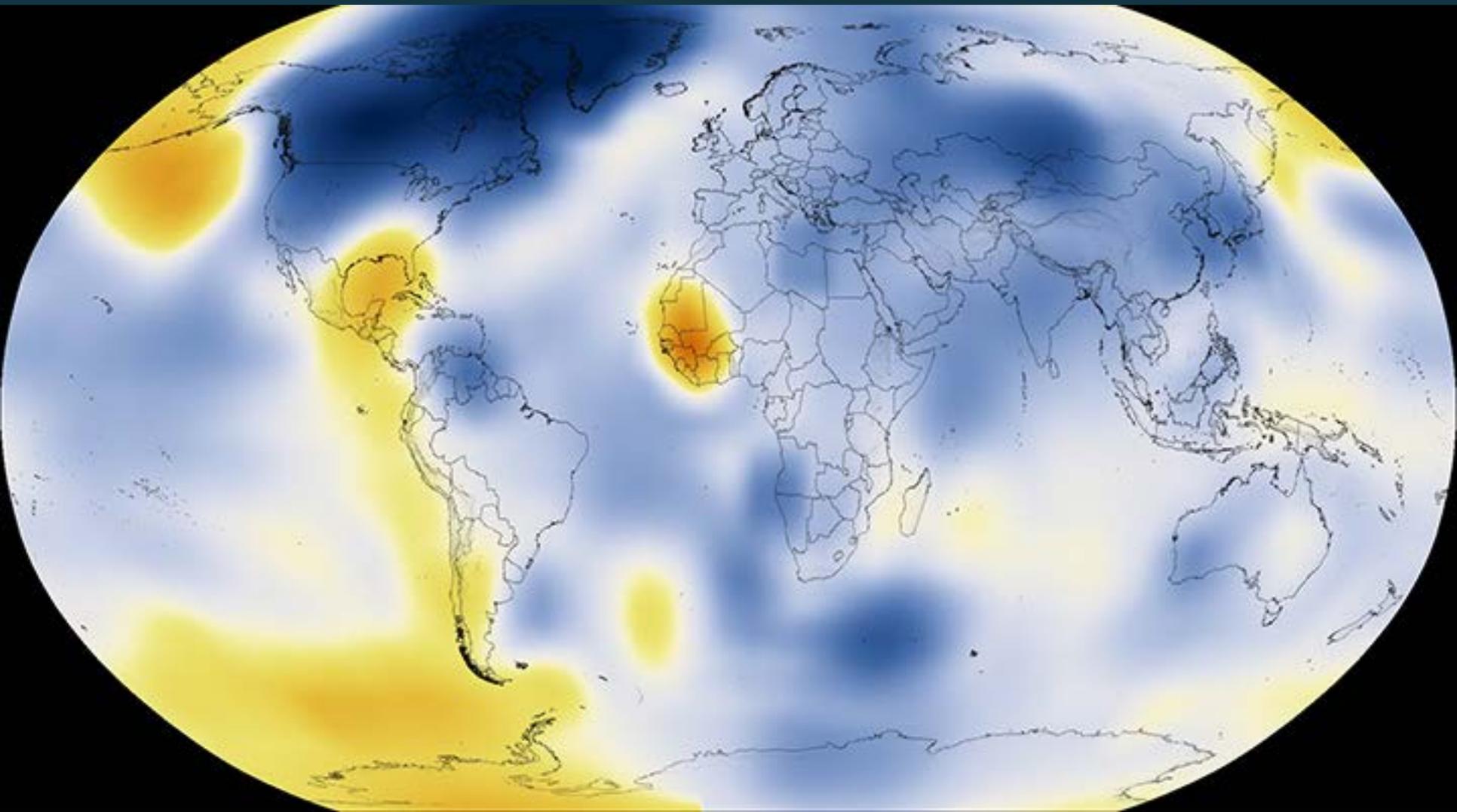
ppm time

30	30 d
70	4 h
150	50 min
400	15 min

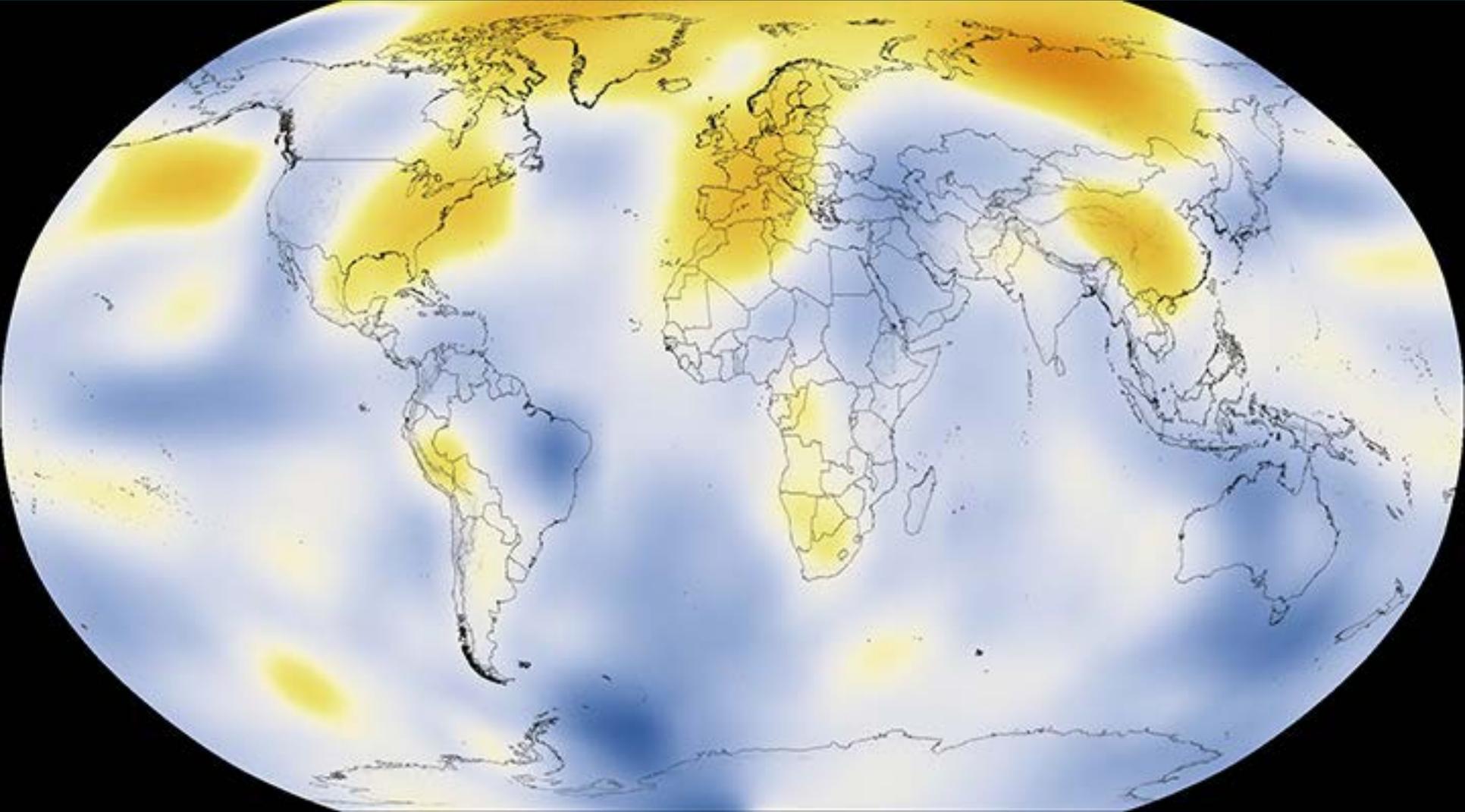
Does climate
change relate to
CO₂?

Climate change and CO₂

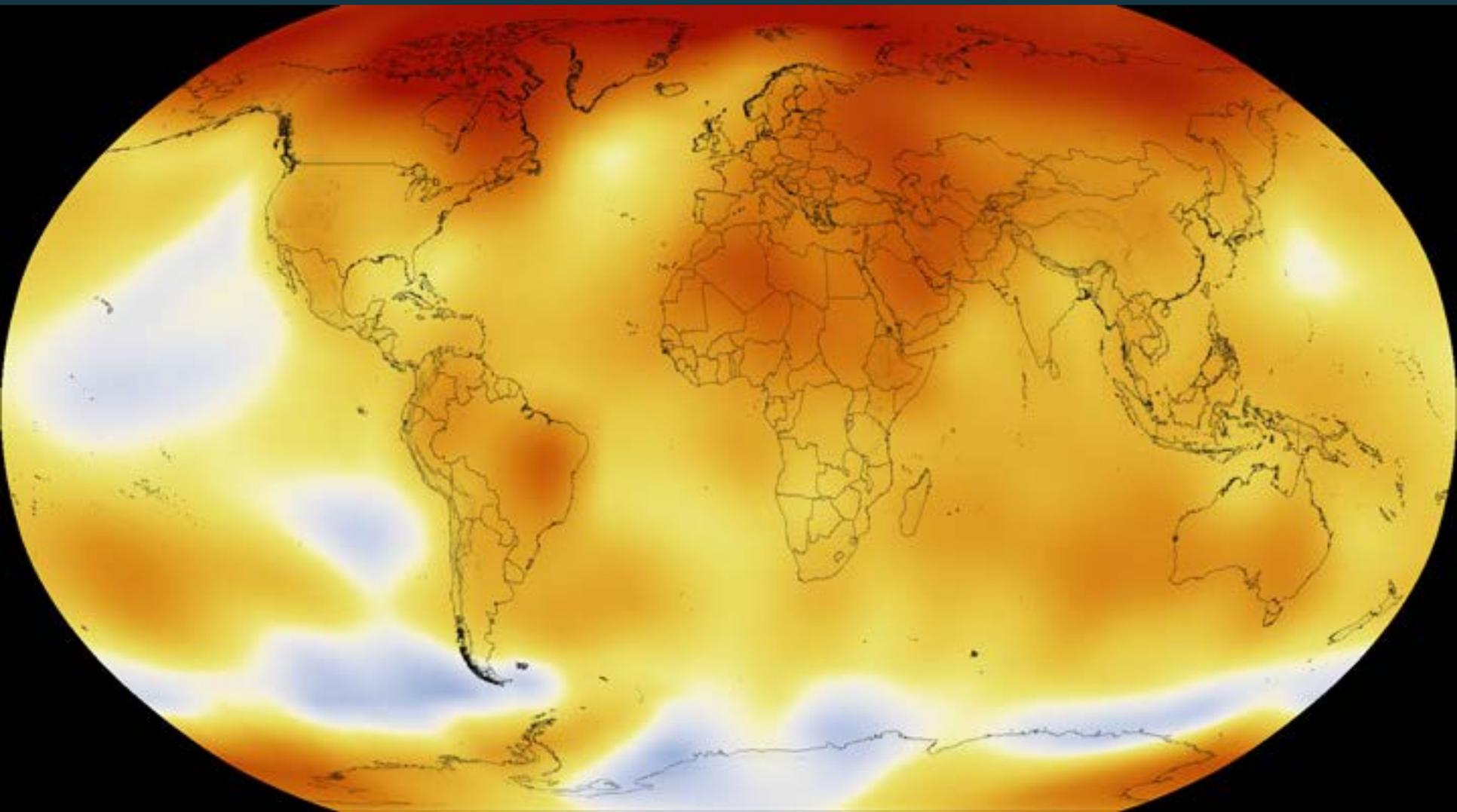




1884



1949



2014



AS OUR OCEAN WARMS, SEA LEVEL RISES

We know seas are rising and we know why. The urgent questions are by how much and how quickly.



Credit: CSIRO, updated Church and White (2011)

Sea levels have risen about **8 inches** since the beginning of the 20th century. The ocean is projected to rise by as much as **3 feet or more** by the end of this century.

Earth's climate history shows there have been times when ice sheets rapidly changed and created multiple meters of sea level rise in a century. As Earth's ice sheets continue to change, a key question facing scientists now is: Could human-caused global warming be pushing us toward one of those times?

**>1 billion live
within 20 meters
of sea level**

worldoceanreview.com



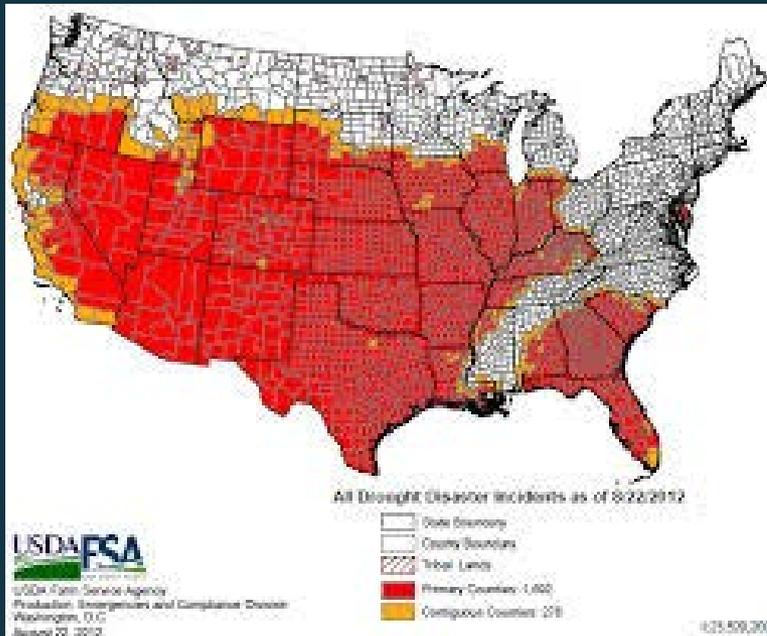
Warmer air =
more energy

Warmer air =

more

drought moisture

Warmer air = more drought moisture



Warmer air =
more
extreme weather

Does climate
change relate to
CO?

CO Exposures? Bangladesh, 2009



CO Exposures, W.S. Alfred Connecticut, 2011



CO Exposures, W.S. Alfred Connecticut, 2011



W.S. Nemo

Boston, 2011



Learning Objectives

Understand sources of carbon monoxide

Describe existing treatment of carbon monoxide exposure

Understand strategies for prevention of carbon monoxide exposure



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