MJPHD

LEAD: THE ACCIDENTAL POISON

MARK JONES
CREATIVE DIRECTOR
MJPHD, LLC

10 October 2024

photo from Cleveland Park Metro station 5 October 2024

Lead Pipe in Pompeii

Vesuvius 79 AD
pipes to 200 BC

Facts about lead (answer the question “what is lead?”).

Describe where lead is found and why (answer the question “where does lead come from?”).

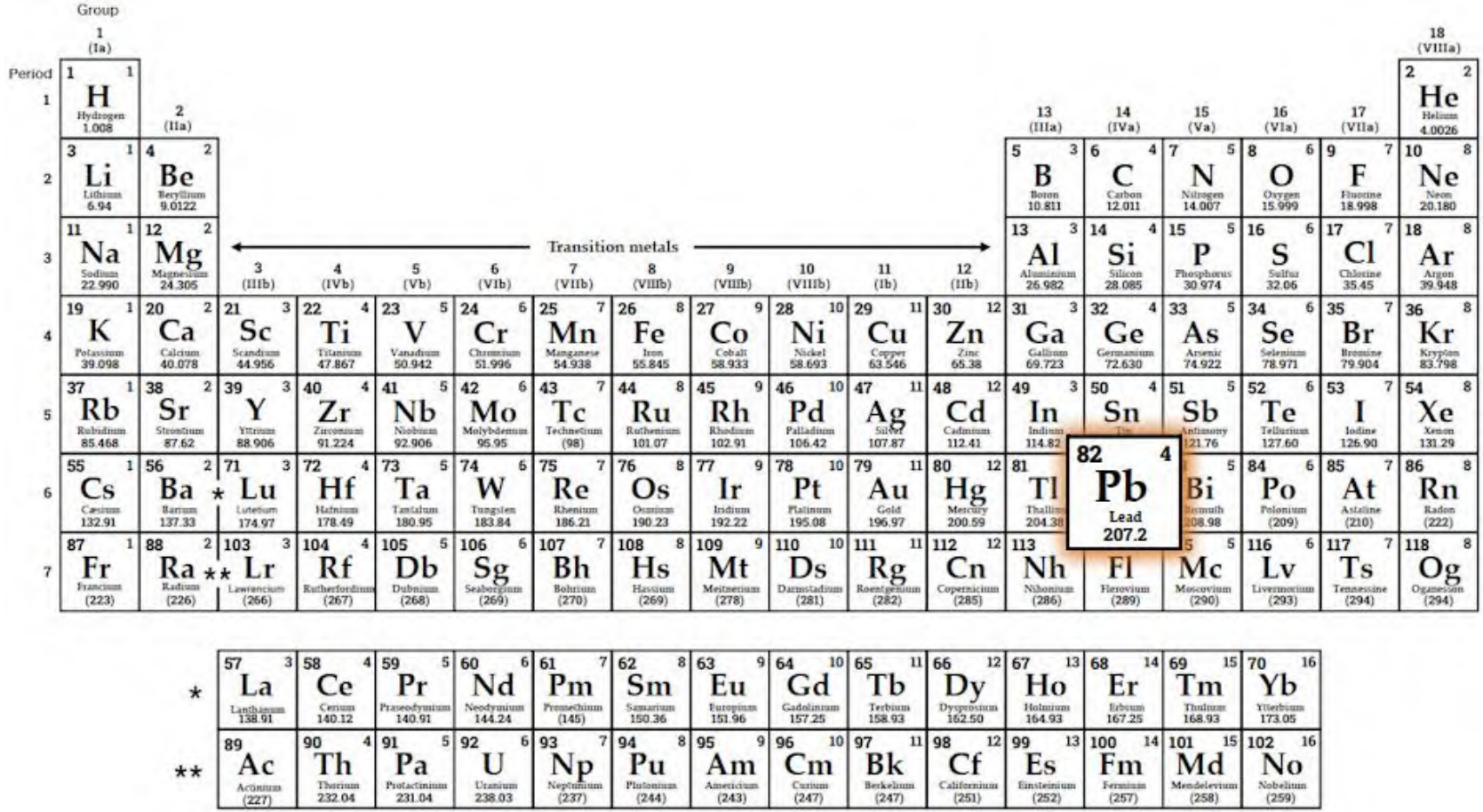
Talk through public health issues brought on by lead (answer “why should I care about lead and how concerned should I be?”).

82

Pb

Lead

207.2


Group
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3 (IIIb)
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14 (IVa)
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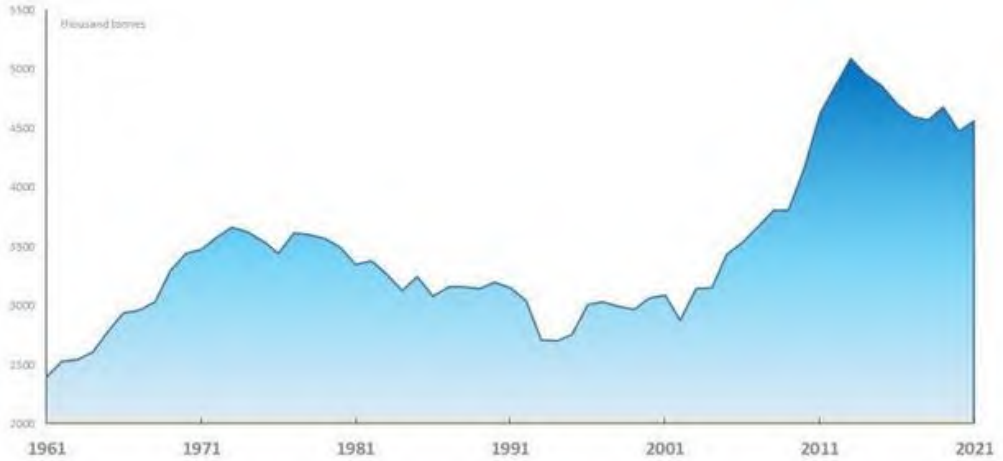
18 (VIIIa)
Period
Transition metals
82 4
Pb
Lead
207.2
* Lu Lutetium 174.97
** Lr Lawrencium (266)
* La Lanthanum 138.91
** Ac Actinium (227)

Where does lead come from?

World Lead Reserves 2021

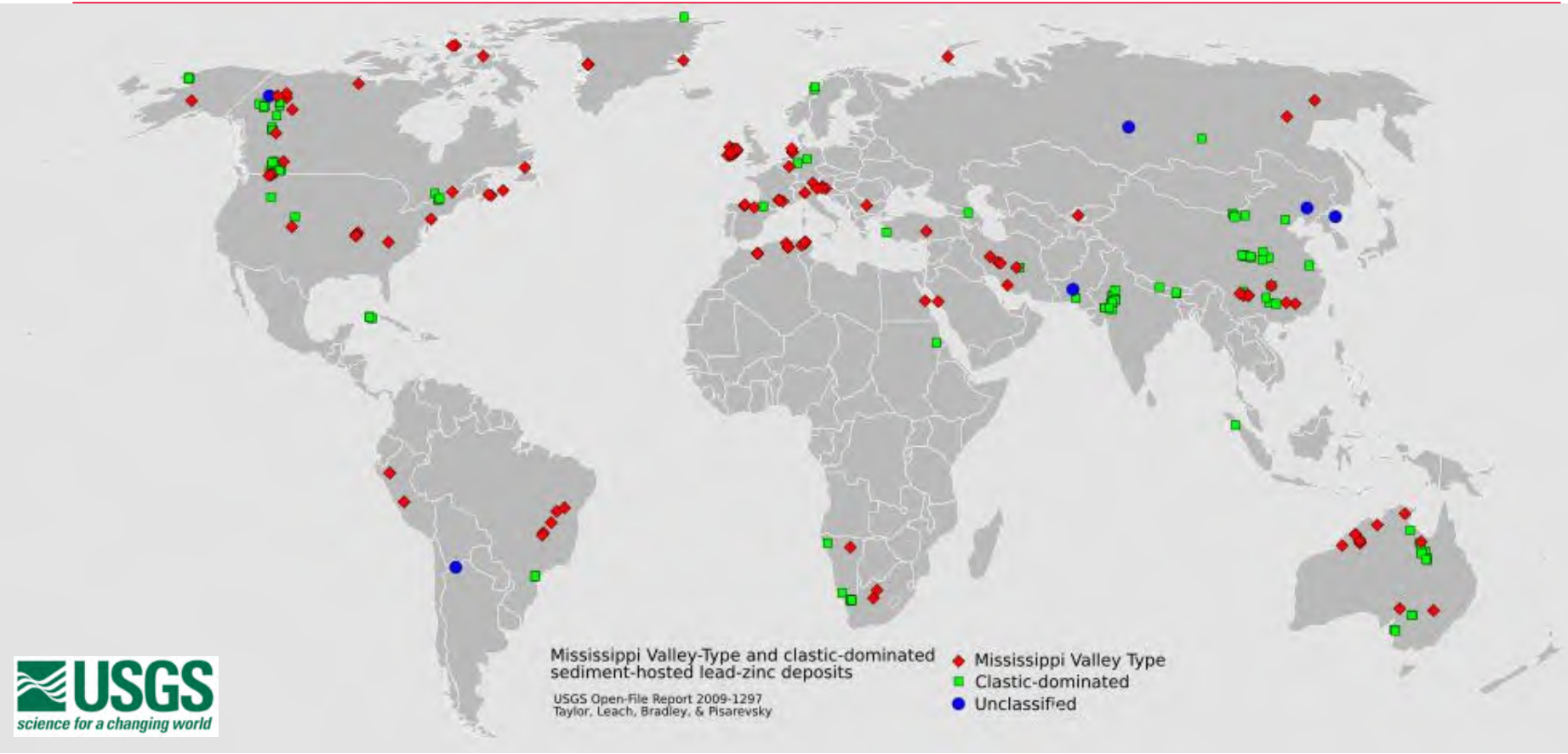
World Lead Mine Supply 1961-2021



In 2021, global lead mine production was 4.6 million tonnes.

International Lead and Zinc Study Group

Lead Ore Deposits

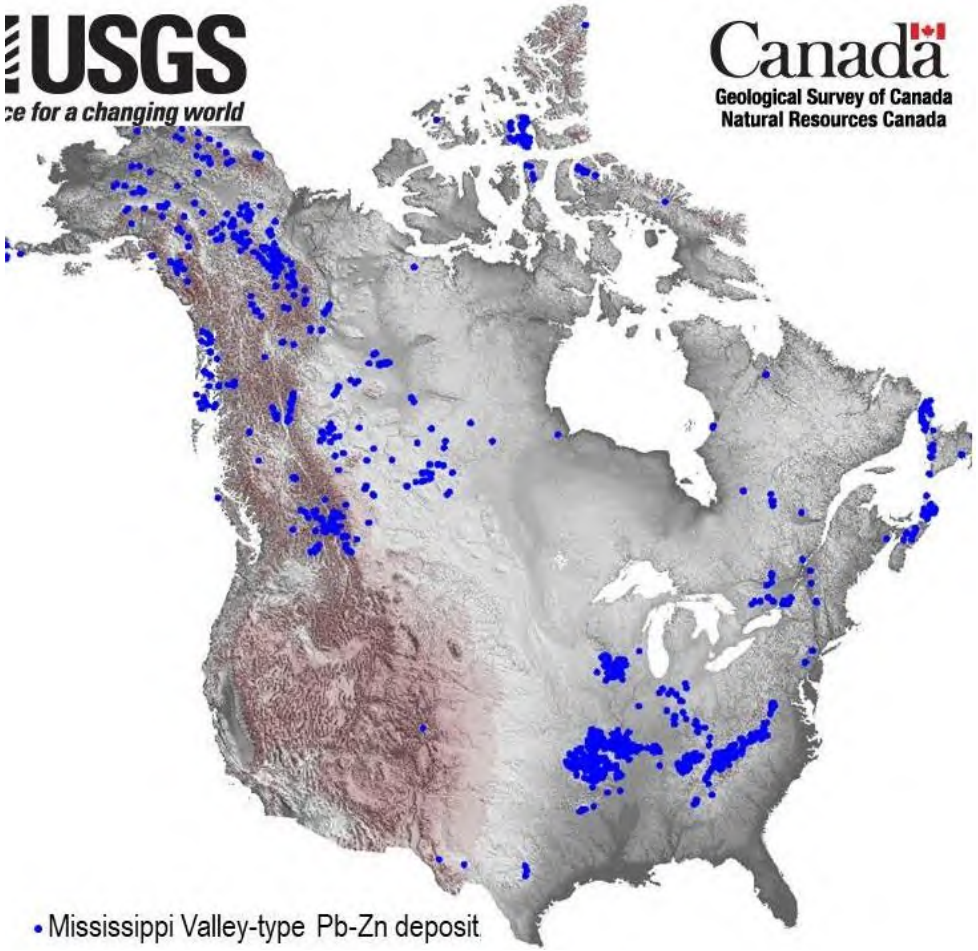


USGS science for a changing world

https://pubs.usgs.gov/of/2009/1297/

	Mine production		Reserves[7]
	2022	2023[e]	
United States	273	270	4,600
Australia	435	440	[8]35,000
Bolivia	90	90	1,600
China	1,950	1,900	20,000
India	220	220	1,900
Iran	[e]52	50	2,000
Mexico	273	270	5,600
Peru	255	250	5,000
Russia	[e]210	200	8,700
Sweden	75	70	1,700
Tajikistan	[e]53	50	NA
Turkey	[e]67	70	1,600
Other countries	507	610	5,900
World total (rounded)	4,460	4,500	95,000

USGS
science for a changing world

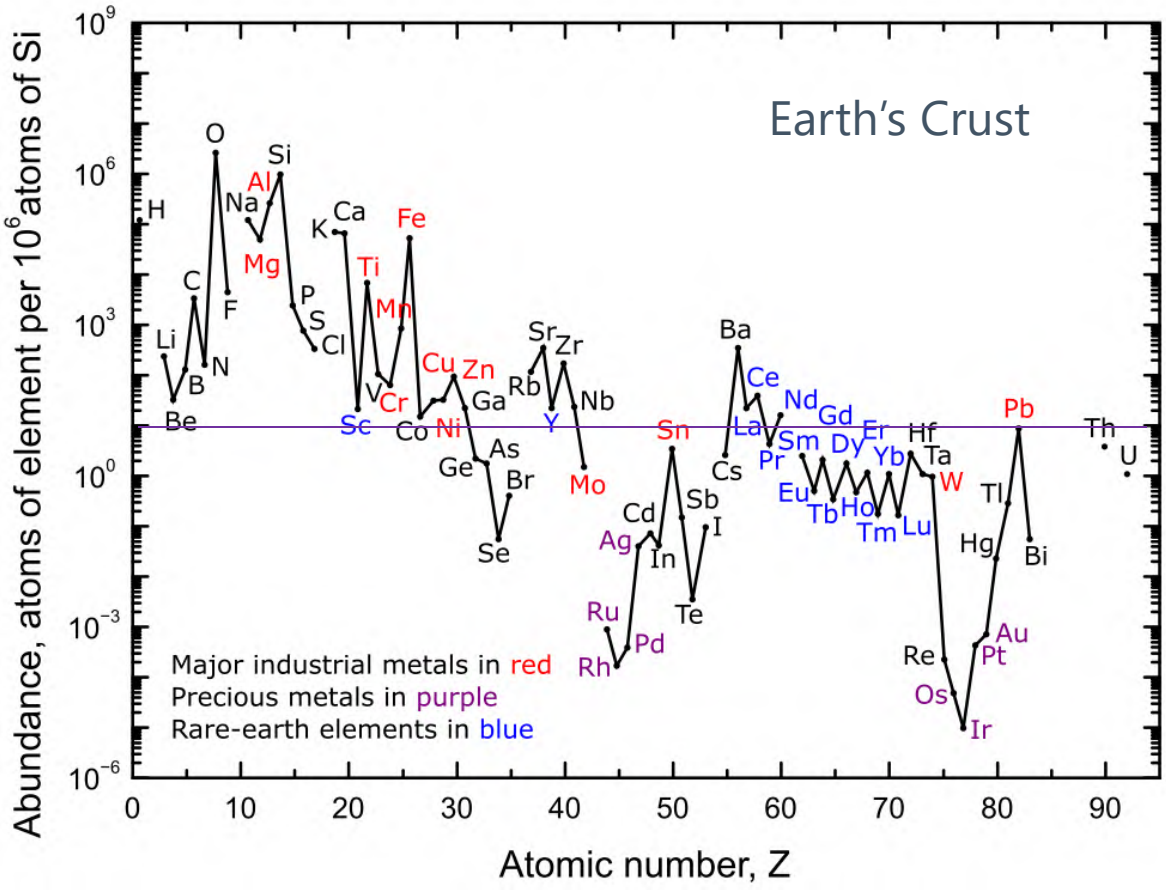


Miners came to Wisconsin in early 1800s when lead was discovered. The lead miners were nicknamed “badgers” because many of them lived in burrow-like dwellings through the winter.

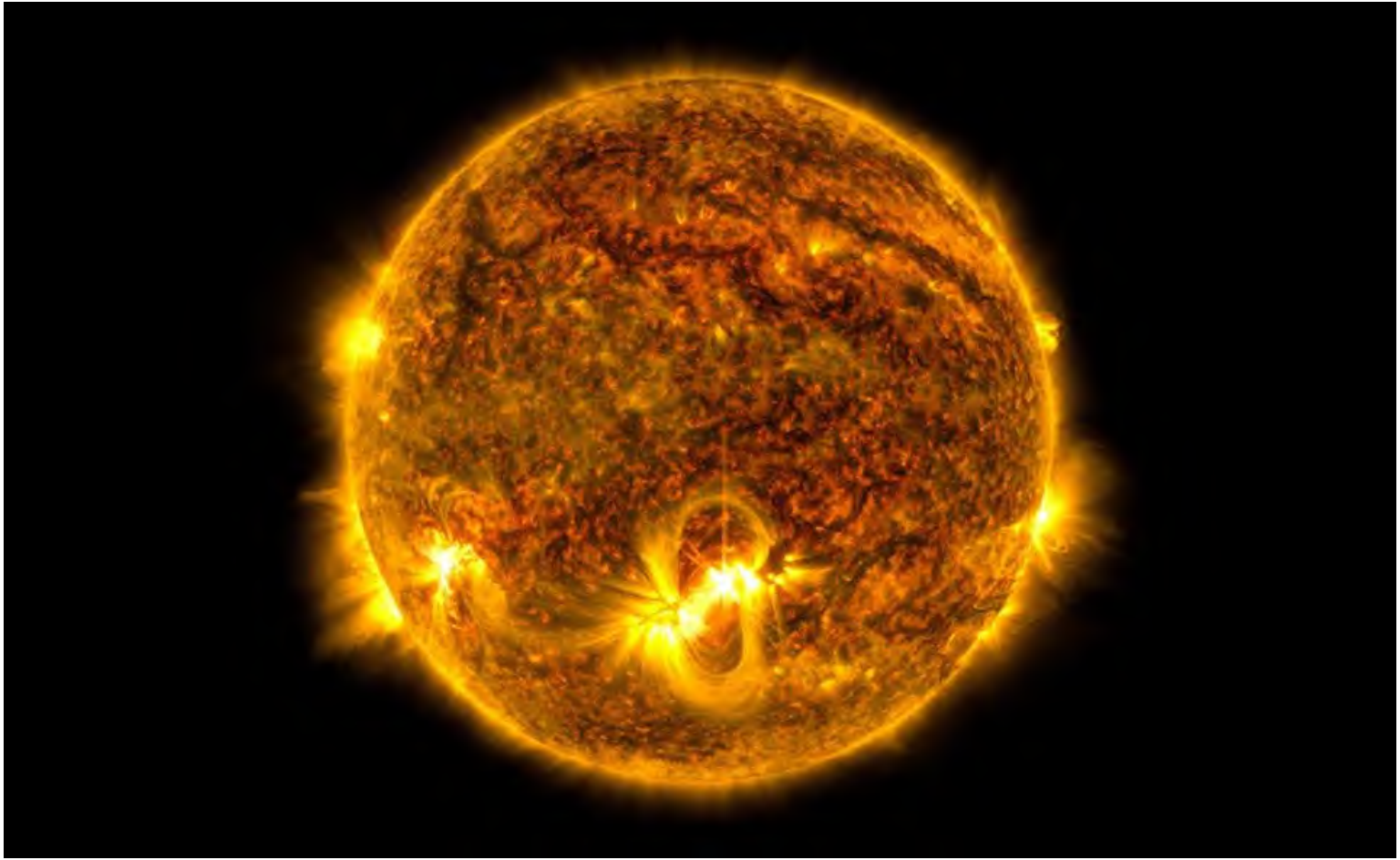
Salient Statistics—United States:	2019	2020	2021	2022	2023[e]
Production:					
Mine, lead in concentrates	274	306	294	273	270
Mine, recoverable lead	266	297	286	264	260
Primary refinery	—	—	—	—	—
Secondary refinery, old scrap	1,150	1,090	1,050	1,010	1,000
Imports for consumption:					
Lead in concentrates	(1)	(1)	1	(1)	(1)
Refined metal, unwrought	501	382	614	651	570
Exports:					
Lead in concentrates	259	265	262	255	270
Refined metal, unwrought (gross weight)	25	17	22	26	25
Consumption, apparent[2]	1,630	1,450	1,640	1,630	1,600
Price, average, North American, cents per pound[3]	99.9	91.3	113.0	116.5	115
Employment, mine and mill (average), number[4]	1,600	1,790	1,830	1,870	1,800
Net import reliance[5] as a percentage of apparent consumption, refined metal	29	25	36	38	35

Recycling: In 2023, an estimated 1,000,000 tons of secondary lead was produced, an amount equivalent to 62% of apparent domestic consumption. Nearly all secondary lead was recovered from old scrap, mostly lead-acid batteries.

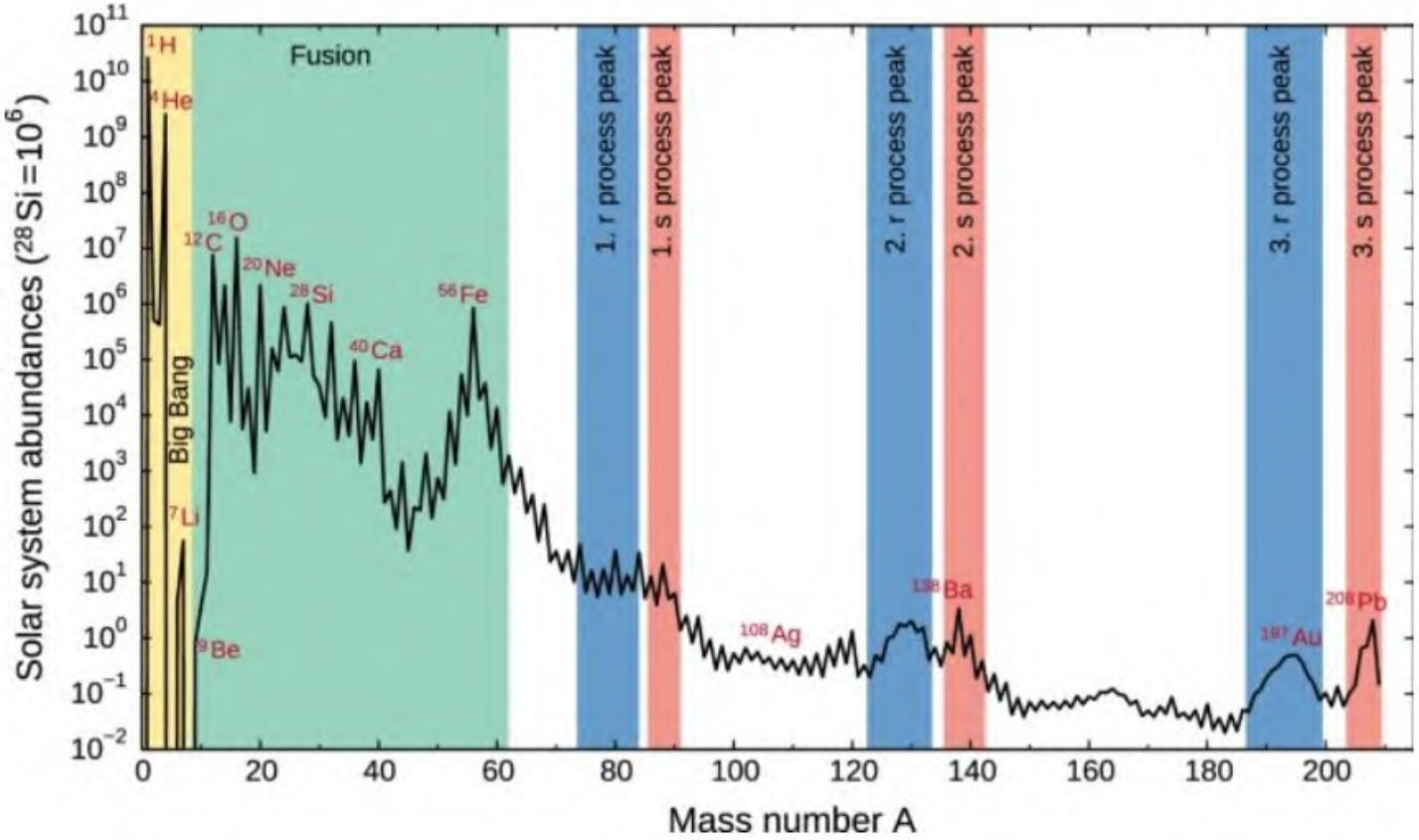
USGS
science for a changing world



By Gordon B. Haxel, Sara Boore, and Susan Mayfield from USGS; vectorized by User:michbich - http://pubs.usgs.gov/fs/2002/fs087-02/, Public Domain, https://commons.wikimedia.org/w/index.php?curid=11215468



source: NASA



Arcones, A., Thielemann, FK. Origin of the elements. *Astron Astrophys Rev* **31**, 1 (2023). https://doi.org/10.1007/s00159-022-00146-x

source: NASA; Hubble Space Telescope image of the Veil Nebula

$$2\ PbS + 3\ O_2 \longrightarrow 2\ PbO + SO_2$$

$$2\ PbO + C \longrightarrow 2\ Pb + CO_2$$

$$2\ PbS + 3\ O_2 + C \longrightarrow 2\ Pb + SO_2 + CO_2$$

$$2\ PbO + PbS \longrightarrow 2\ Pb + SO_2$$

Elemental Uses

lead projectiles 1500

Elemental Uses

Use of Lead Compounds – Pottery Glazing

https://www.invaluable.com/auction-lot/superb-roman-lead-glazed-pottery-skyphos-45b-c-5ff46fab85

Use of Lead Compounds – Paint Pigments

dates to 4th century BC; banned in 1977

Use of Lead Compounds – Paint Pigments

lead chromate

chrome yellow

used for centuries; still used in pottery, plastics, industrial coatings.

Use of Lead Compounds – Make-up

Uses of Lead – Sweetening Wine

lead acetate = sugar of lead

Romans sweetened wine with *sapa*, a syrup made by boiling down grape juice in leaded vessels

Uses of Lead – Glass Making

leaded glass - lead replaces the calcium content of a typical glass.

PbO is added, typically 18–40% (by mass), imparting clarity and improving molding.

dates to antiquity
1670’s Britain = first industrial production

Use of Lead Alloys – Solders

banned in 1986 prior
up to 50% Pb

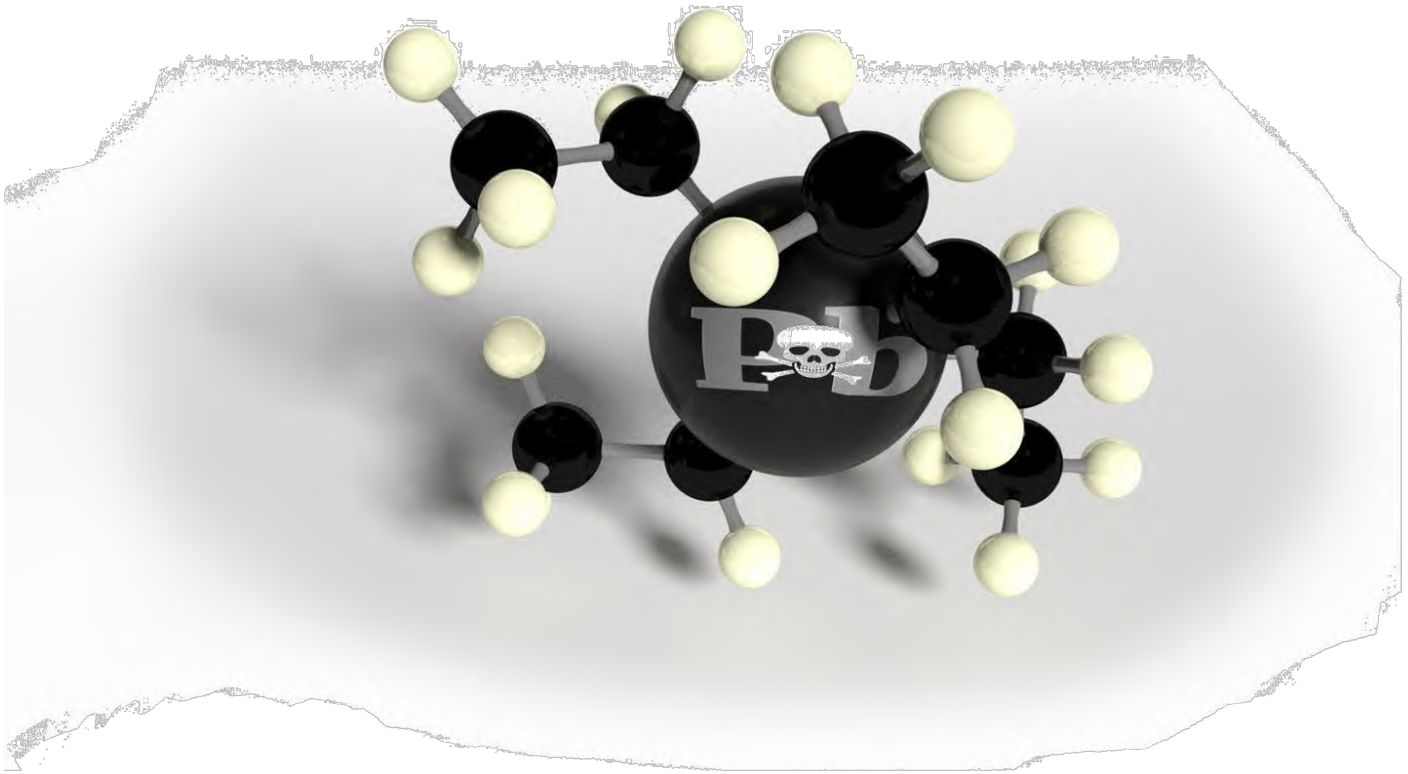
still available

Use of Lead - Elemental

Use of Lead Compounds – Gasoline Additive

introduced in late 1920's; banned in cars with catalytic converters in 1975. Complete ban in 1996.
2021 UN said no more automotive being sold

Use of Lead Compounds – Gasoline Additive



Use of Lead Alloys – Free-machining Steel

Lead is insoluble in steel and makes imperfections that result in chips that break off during cutting.

Not weldable!

Use of Lead Compounds – PVC Stabilizers

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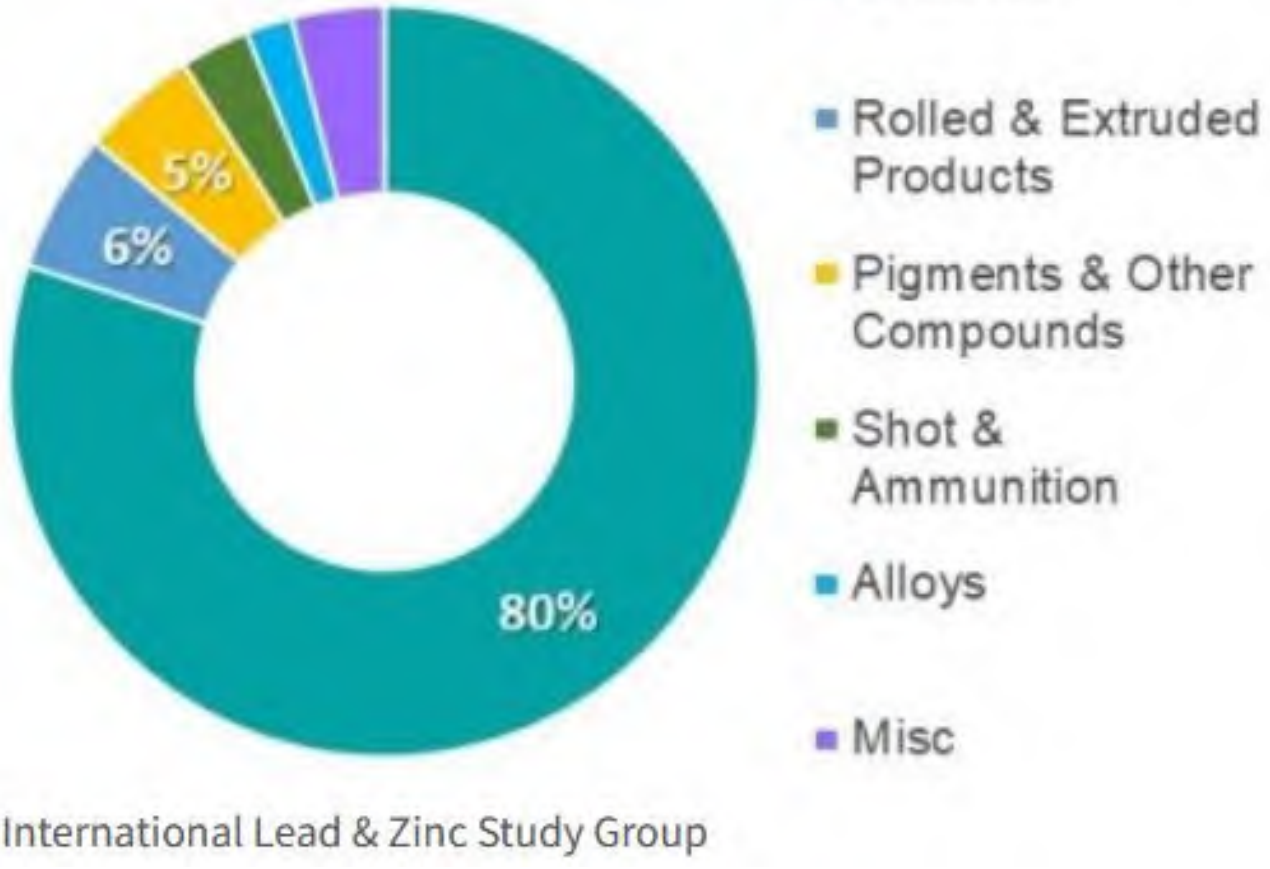
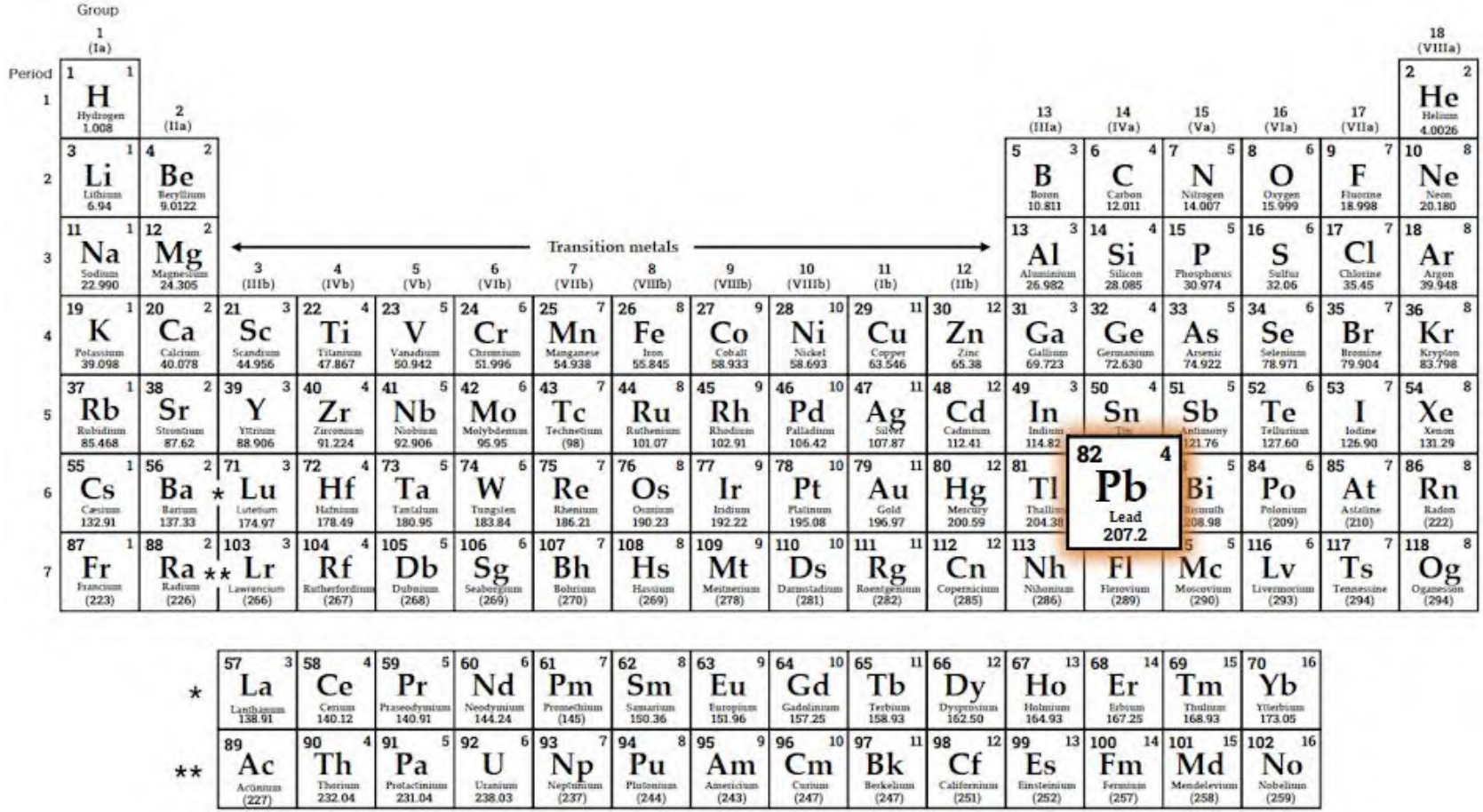

Batteries
Rolled & Extruded Products
Pigments & Other Compounds
Shot & Ammunition
Alloys
Misc
80%
6%
5%
International Lead & Zinc Study Group


POISON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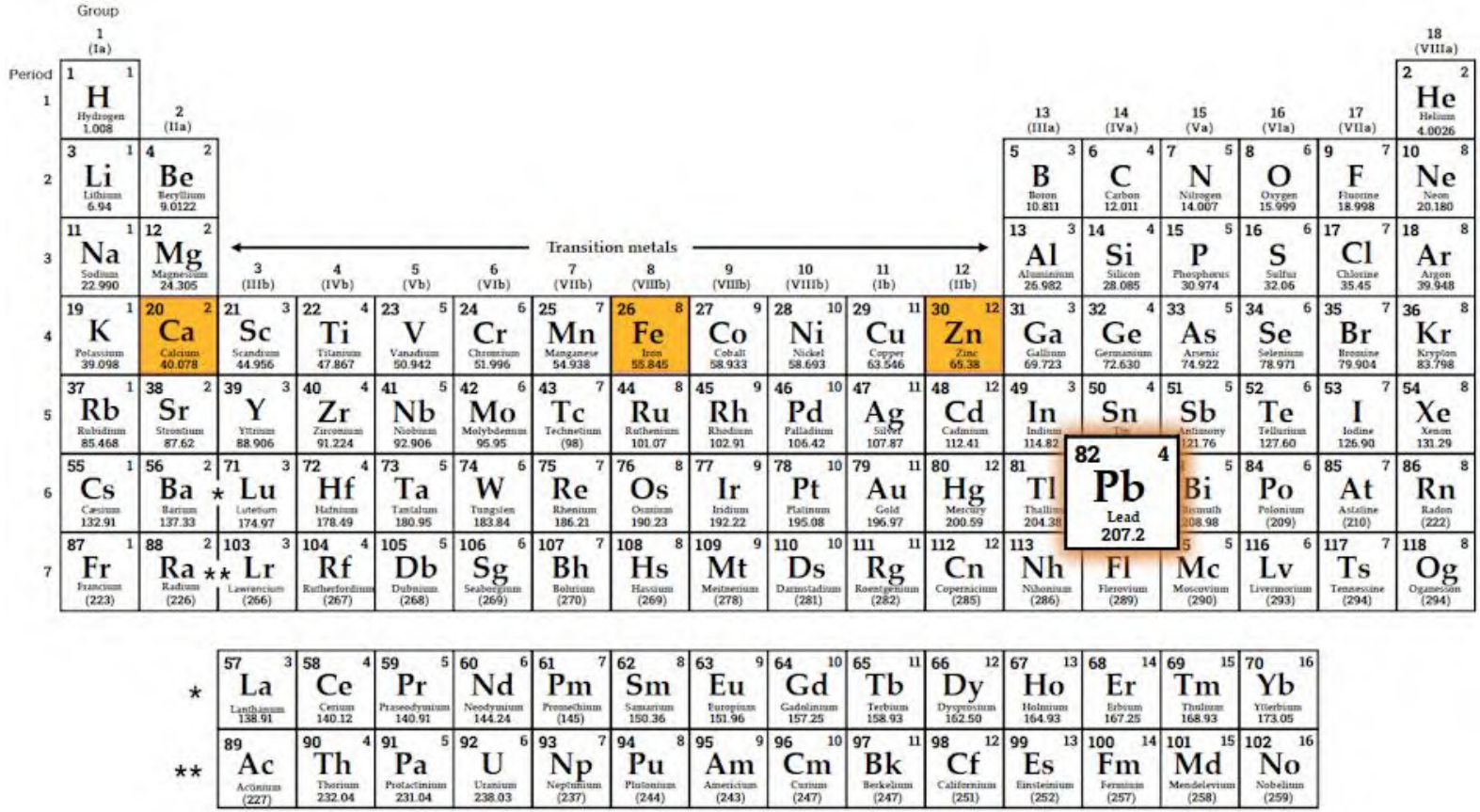
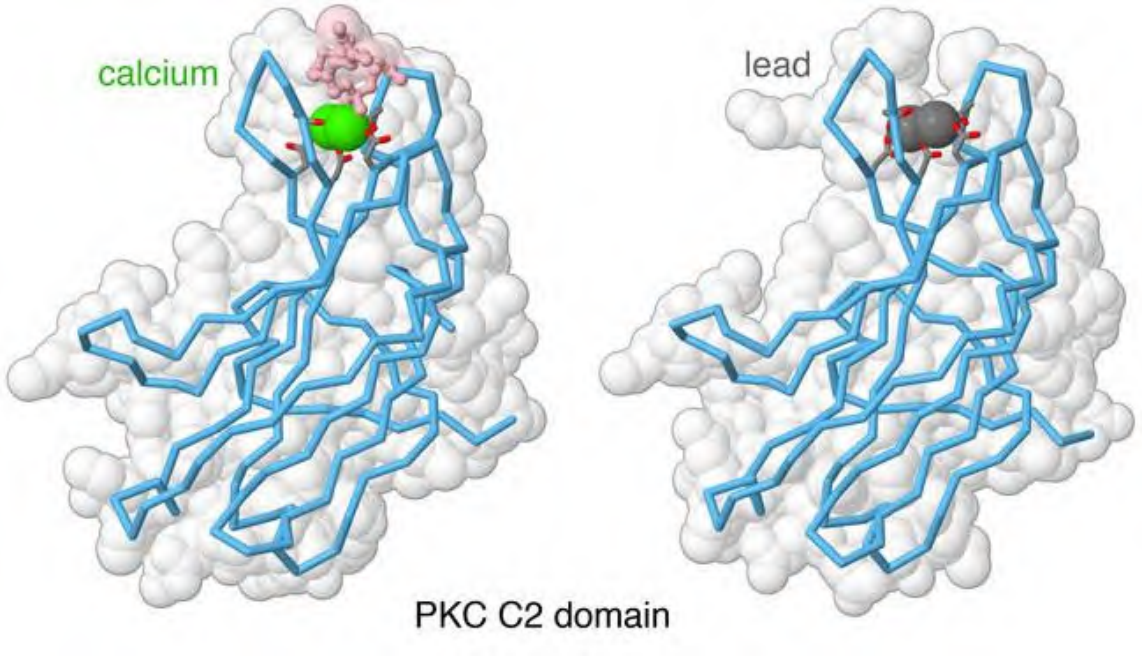
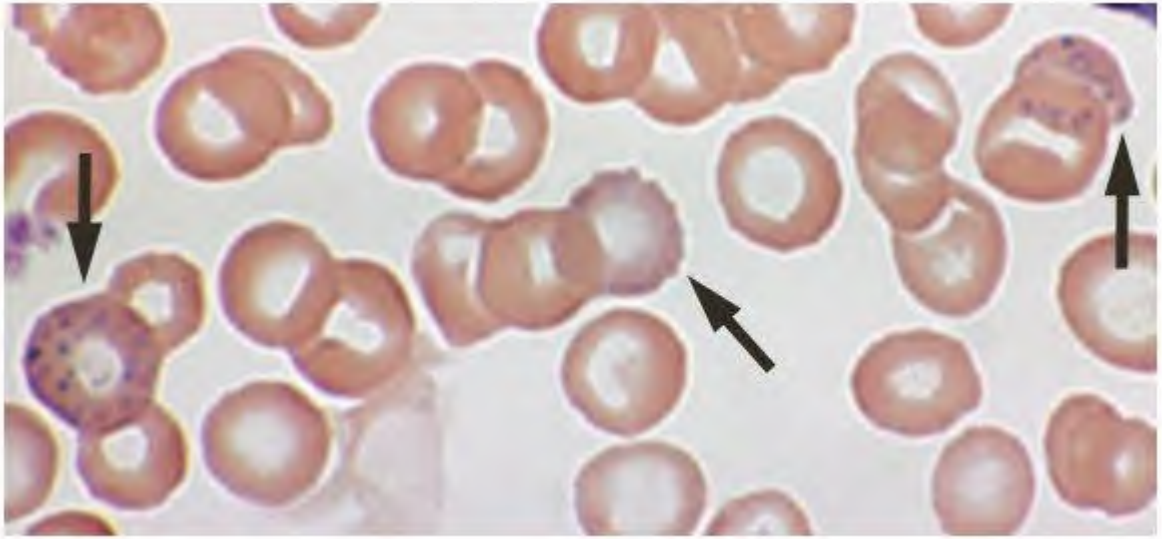


Lead Interacts with Calcium Binding Sites



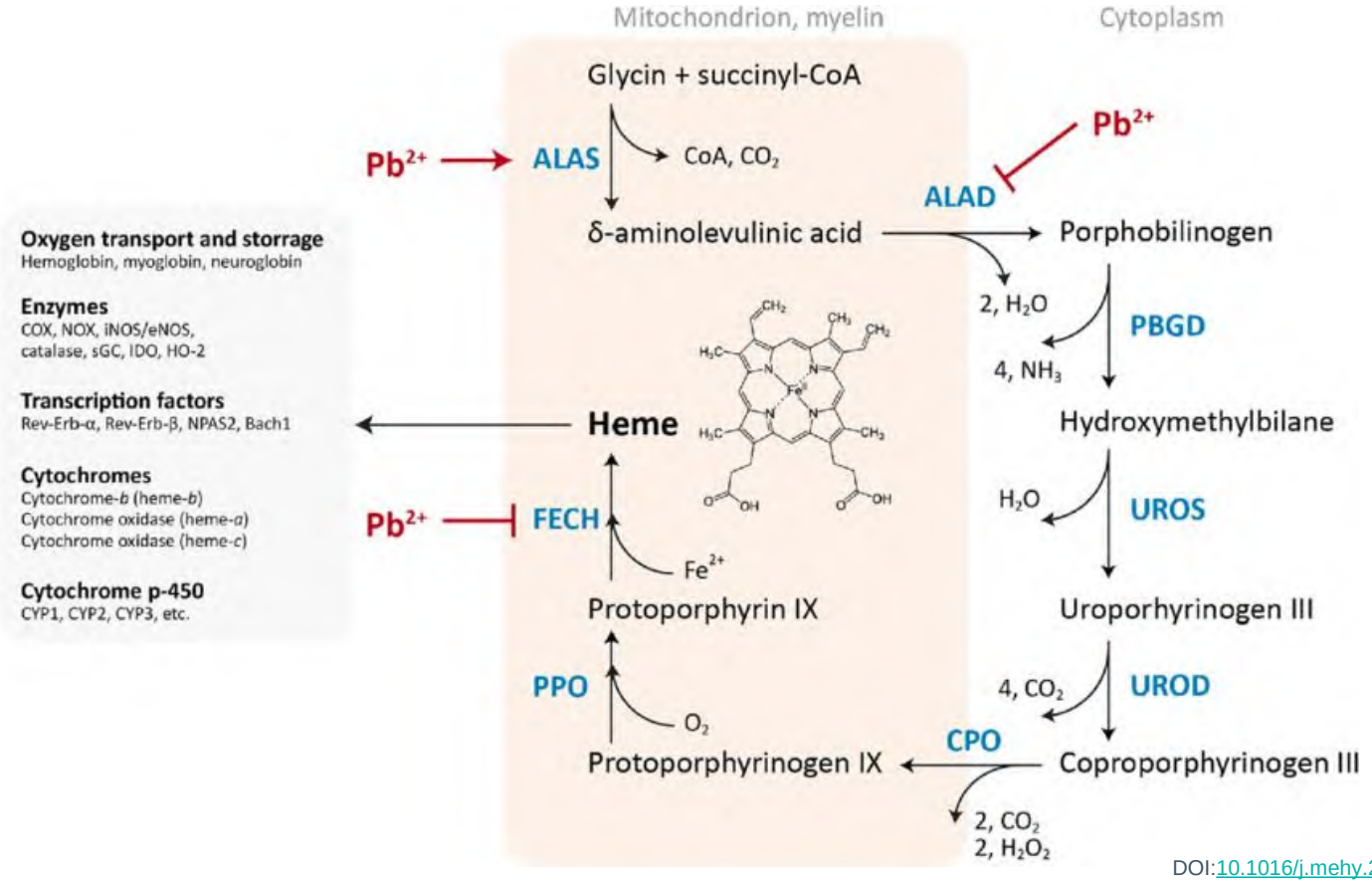
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4961898/

Lead Damages Red Blood Cells



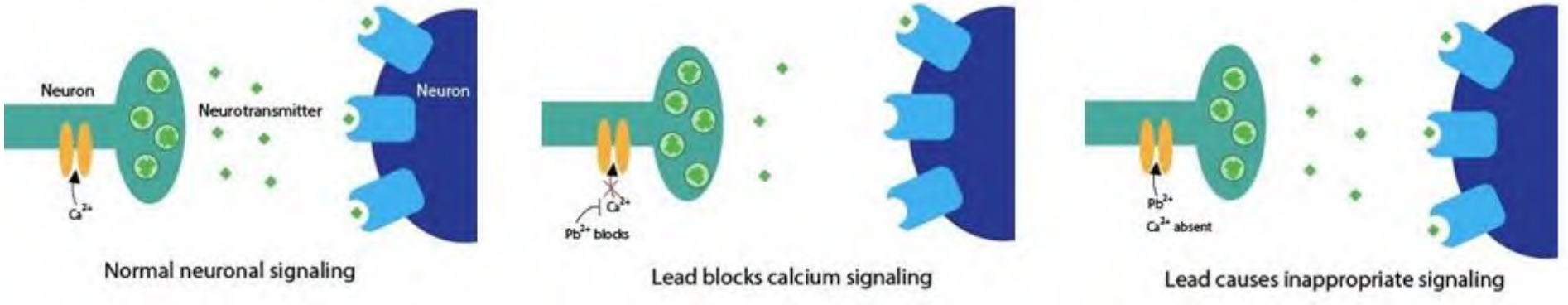
Basophilic stippling is a typical sign of lead poisoning. The term refers to small, blue, dot-like structures scattered uniformly throughout the hemoglobin area of red blood cells.

Lead Interferes with Heme Synthesis



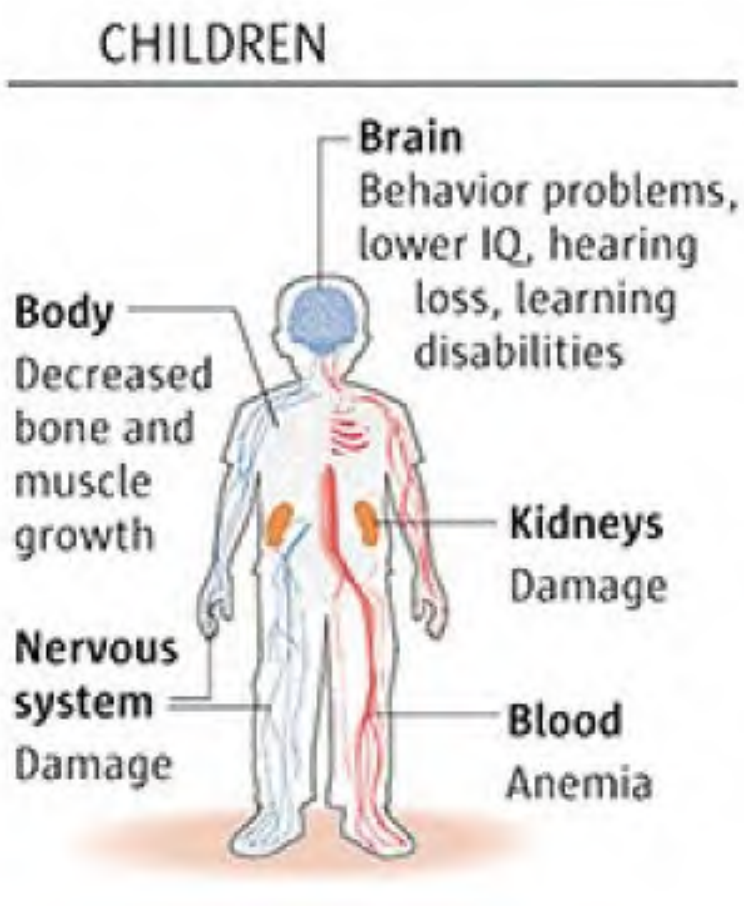
DOI:10.1016/j.mehy.2023.111095

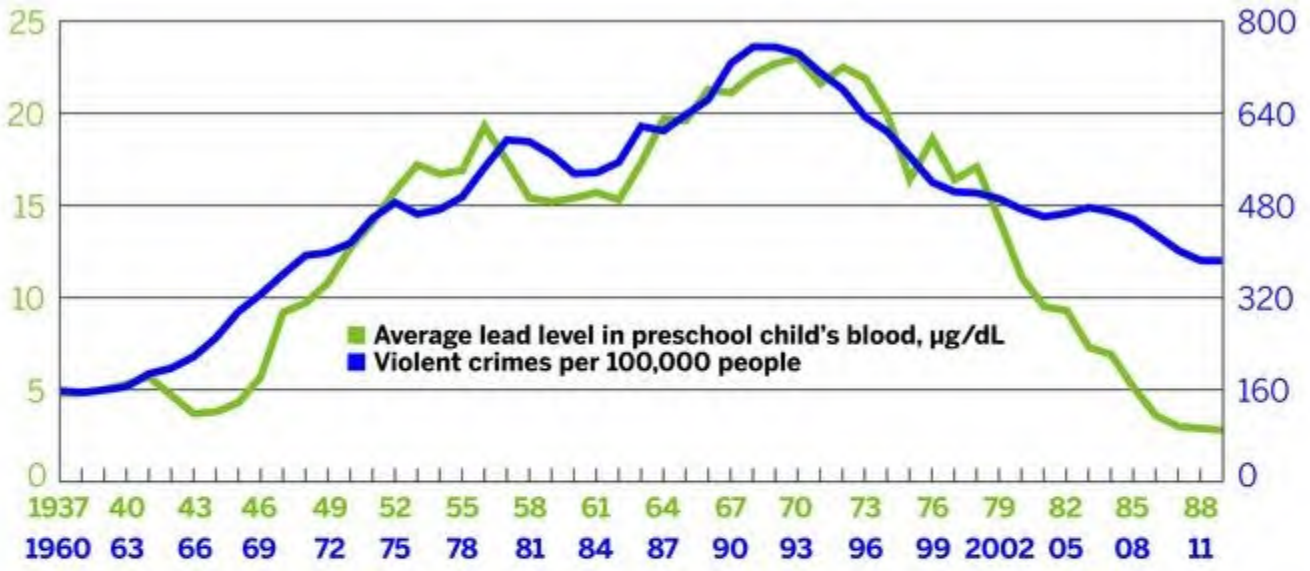
Lead Interferes with Neuronal Activity



https://sitn.hms.harvard.edu/flash/2016/deadly-biology-lead-exposure/


THE TOXIC EFFECTS OF LEAD
BRAIN & NERVE DAMAGE
DECREASED MENTAL ABILITY & LEARNING DIFFICULTIES
SPEECH, LANGUAGE & BEHAVIOUR PROBLEMS
HEARING PROBLEMS
ANAEMIA
HIGH BLOOD PRESSURE
REDUCED GROWTH
KIDNEY DAMAGE
REPRODUCTIVE PROBLEMS (ADULTS)
DIGESTIVE PROBLEMS
World Health Organization


CHILDREN
Brain
Behavior problems, lower IQ, hearing loss, learning disabilities
Body
Decreased bone and muscle growth
Kidneys
Damage
Nervous system
Damage
Blood
Anemia



A timeline of lead reduction

1970
CDC sets acceptable blood-lead level of **40 µg/dL**

1973
EPA mandates a phaseout of leaded gasoline

1978
CPSC bans residential lead paint

1991
CDC sets acceptable blood-lead level of **10 µg/dL**

1996
EPA eliminates lead from all U.S. motor fuel

2012
CDC describes blood-lead level of **>5 µg/dL** as elevated

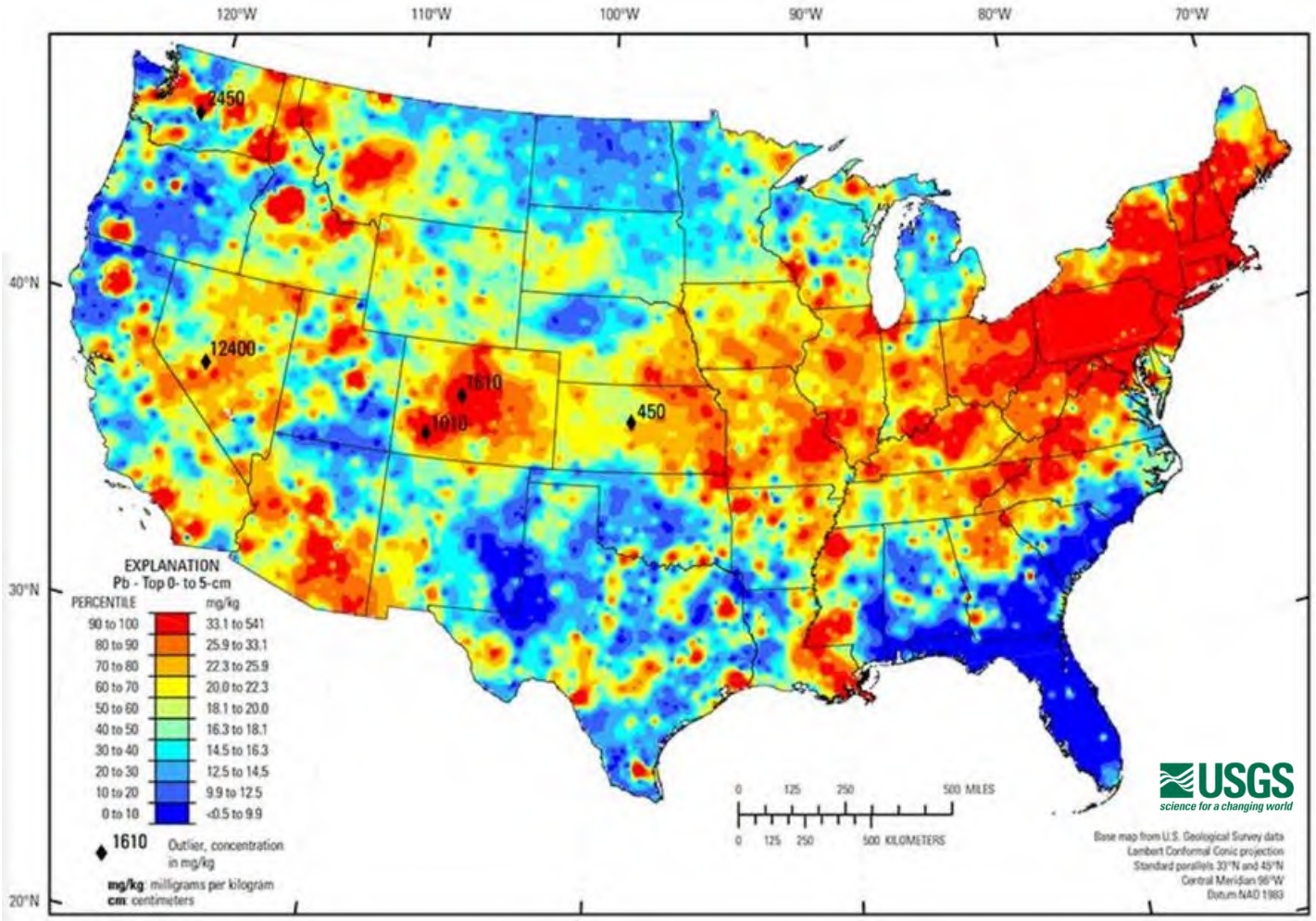
Economists hypothesize that regulation of leaded gasoline and lead paint in the 1970s caused crime rates to drop in the U.S. about 20 years later.CPSC = Consumer Product Safety Commission. SOURCES: Rick Nevin, FBI Uniform Crime Reporting Statistics

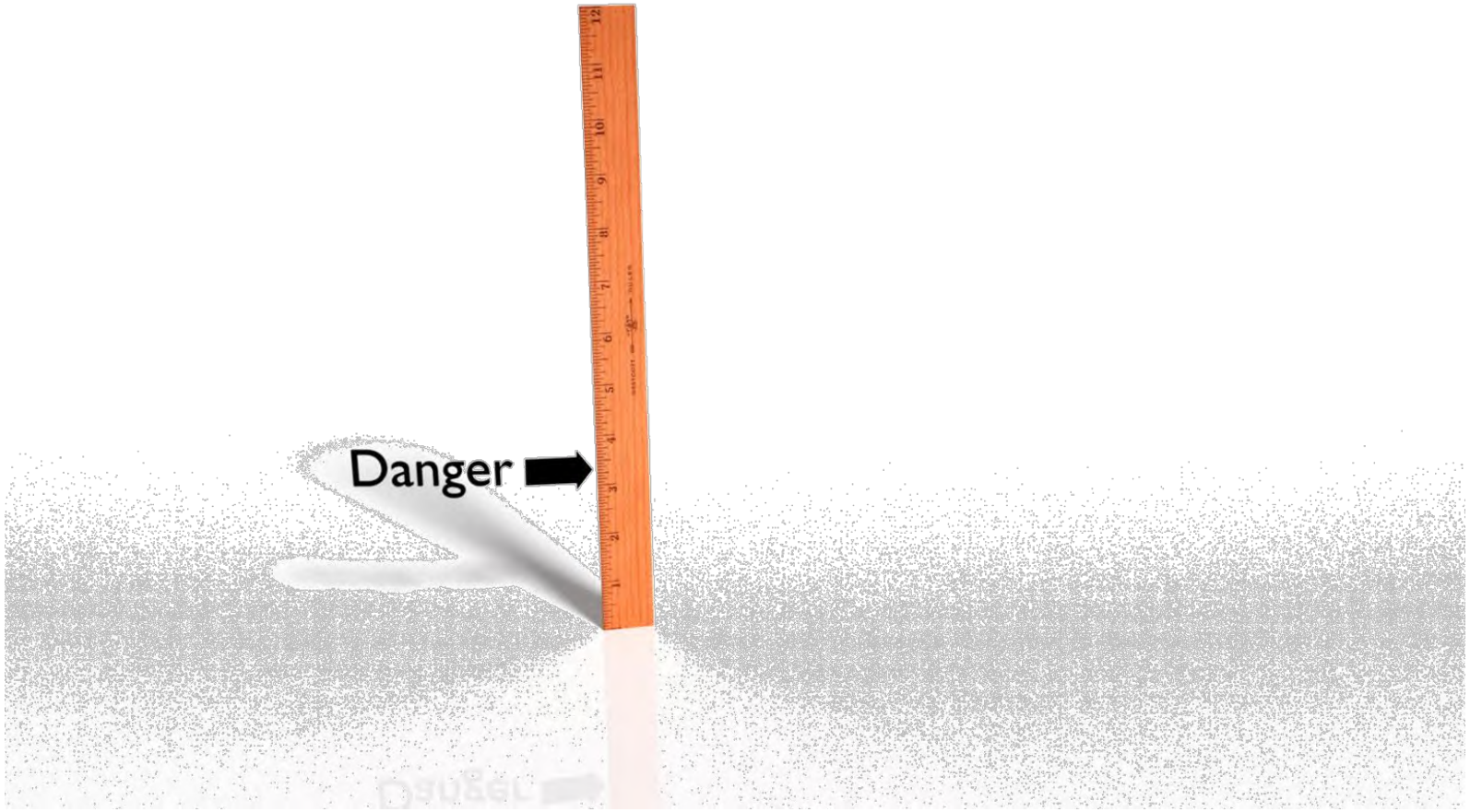
…the best available science which shows there is no safe level of exposure to lead.

There is no level of exposure to lead that is known to be without harmful effects.

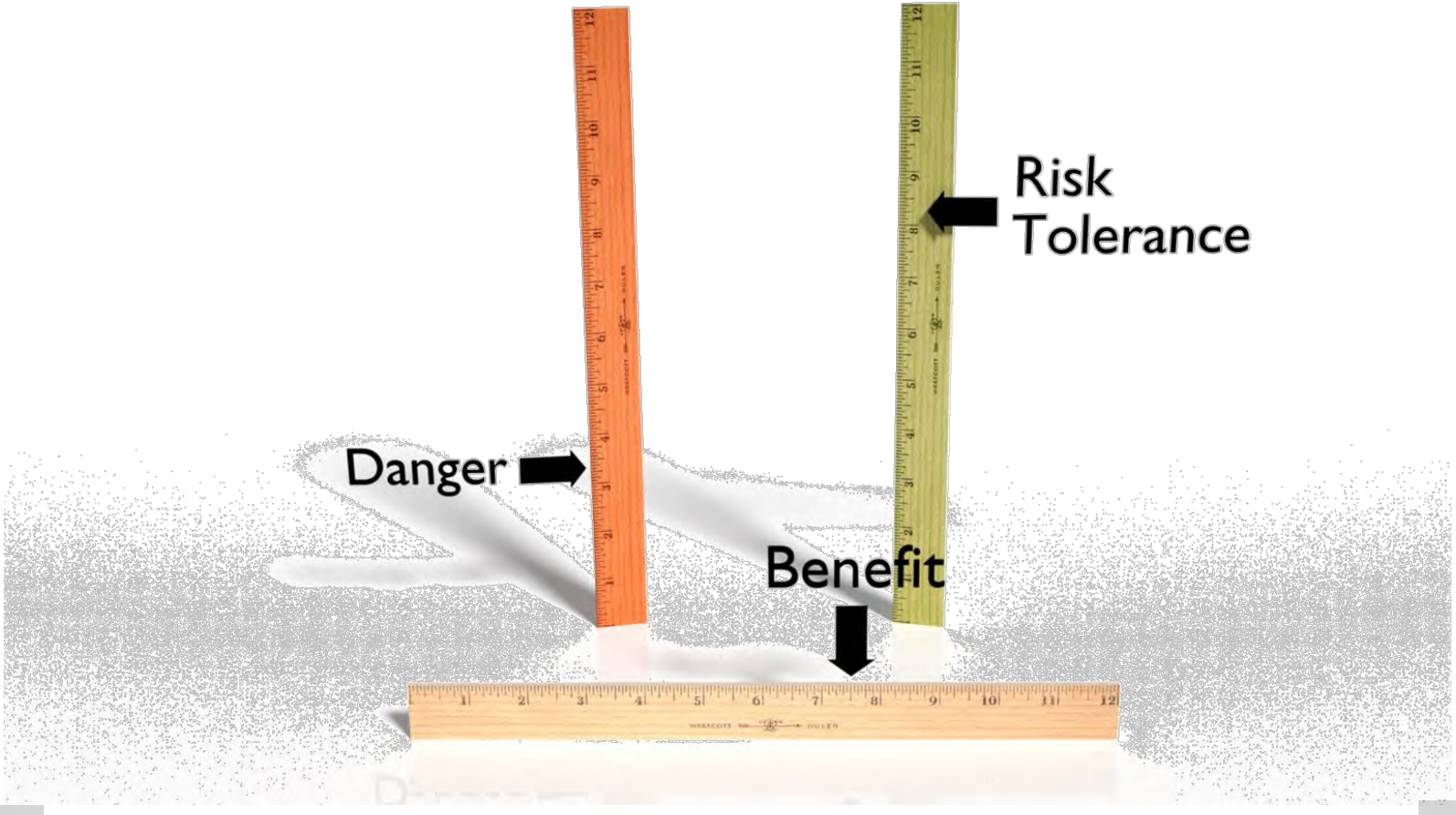
There is no level of exposure to lead that is known to be without harmful effects.

https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water
https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health
https://www.atsdr.cdc.gov/csem/leadtoxicity/physiological_effects.html


120°W
110°W
100°W
90°W
80°W
70°W
40°N
30°N
20°N
2450
12400
1610
1010
450
EXPLANATION
Pb - Top 0- to 5-cm
PERCENTILE
mg/kg
90 to 100
33.1 to 541
80 to 90
25.9 to 33.1
70 to 80
22.3 to 25.9
60 to 70
20.0 to 22.3
50 to 60
18.1 to 20.0
40 to 50
16.3 to 18.1
30 to 40
14.5 to 16.3
20 to 30
12.5 to 14.5
10 to 20
9.9 to 12.5
0 to 10
<0.5 to 9.9
1610
Outlier, concentration in mg/kg
mg/kg: milligrams per kilogram
cm: centimeters
0 125 250 500 MILES
0 125 250 500 KILOMETERS
USGS
science for a changing world
Base map from U.S. Geological Survey data
Lambert Conformal Conic projection
Standard parallels 33°N and 45°N
Central Meridian 96°W
Datum NAD 1983


Danger


Risk
Tolerance
Danger


Risk
Tolerance
Danger
Benefit



















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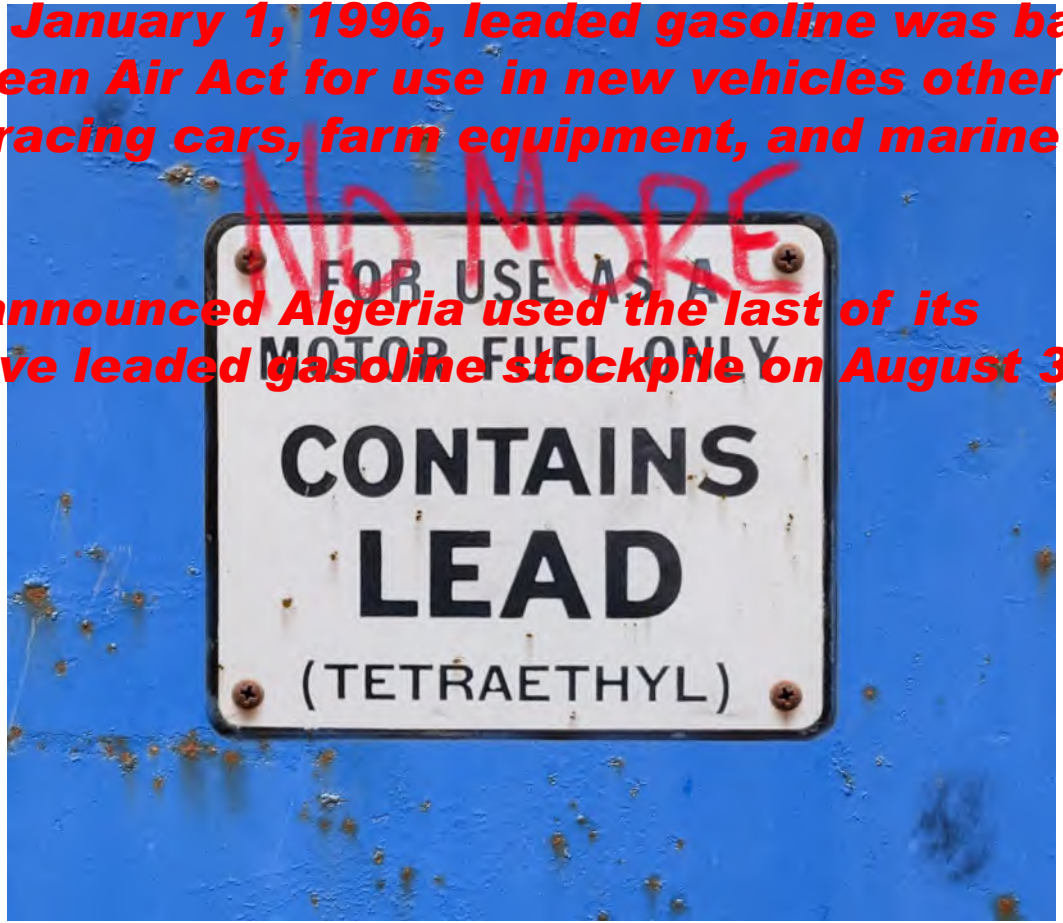
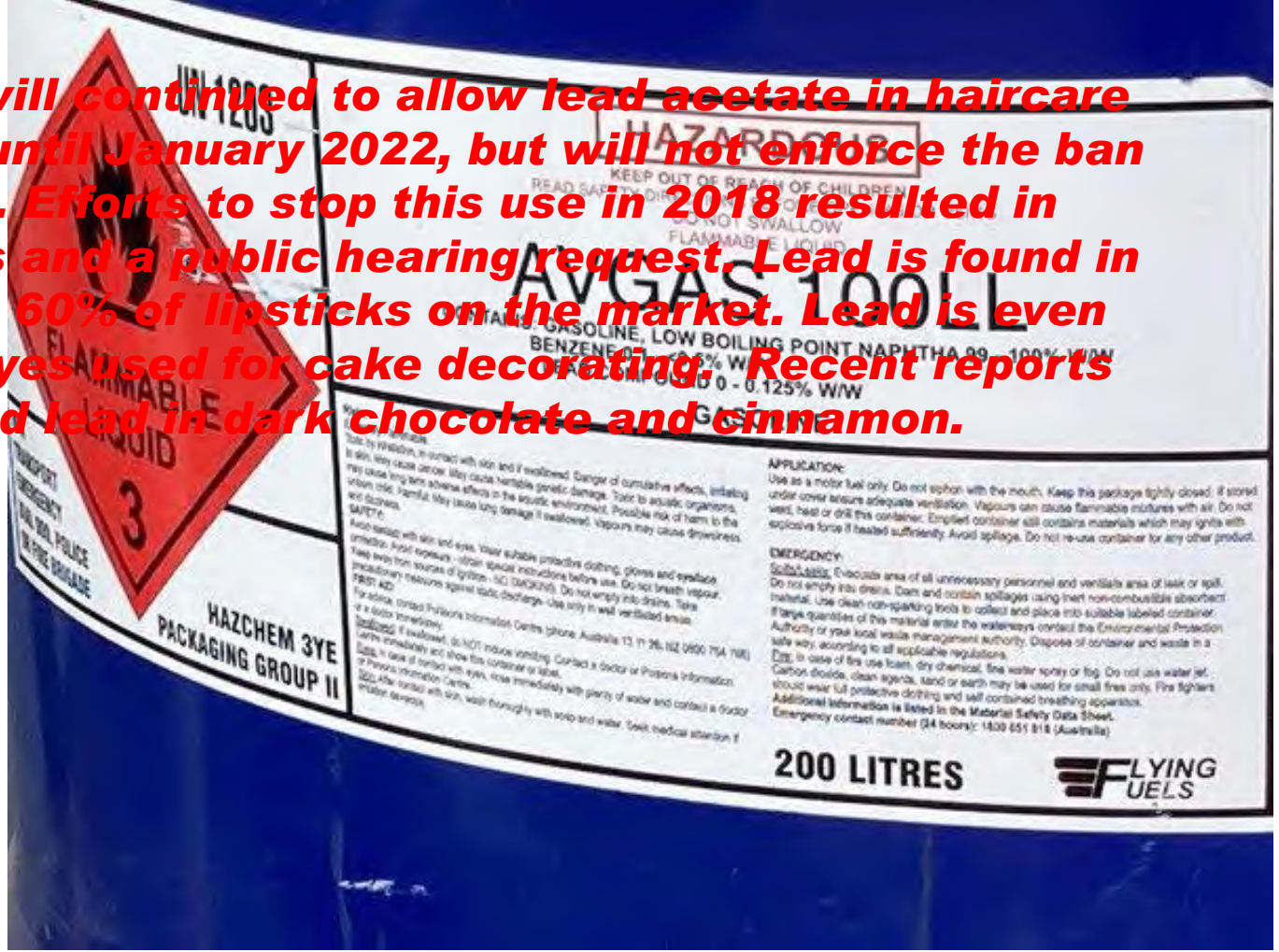
Effective January 1, 1996, leaded gasoline was banned by the Clean Air Act for use in new vehicles other than aircraft, racing cars, farm equipment, and marine engines.

The UN announced Algeria used the last of its automotive leaded gasoline stockpile on August 30, 2021.



TEL stops knock at 1 part per thousand

Ethanol requires 10%



The FDA will continued to allow lead acetate in haircare products until January 2022, but will not enforce the ban until 2023. Efforts to stop this use in 2018 resulted in objections and a public hearing request. Lead is found in more than 60% of lipsticks on the market. Lead is even found in dyes used for cake decorating. Recent reports of elevated lead in dark chocolate and cinnamon.

2010 testing
61% tested all >2, <10ppm
10 ppm FDA safe level

action level 1ppm
12 of 36 above; 3.52 highest
from soil
450 cases from apple sauce due to lead chromate

https://www.cdc.gov/lead-prevention/news/outbreak-applesauce-pouches.html

15 poisoning cases

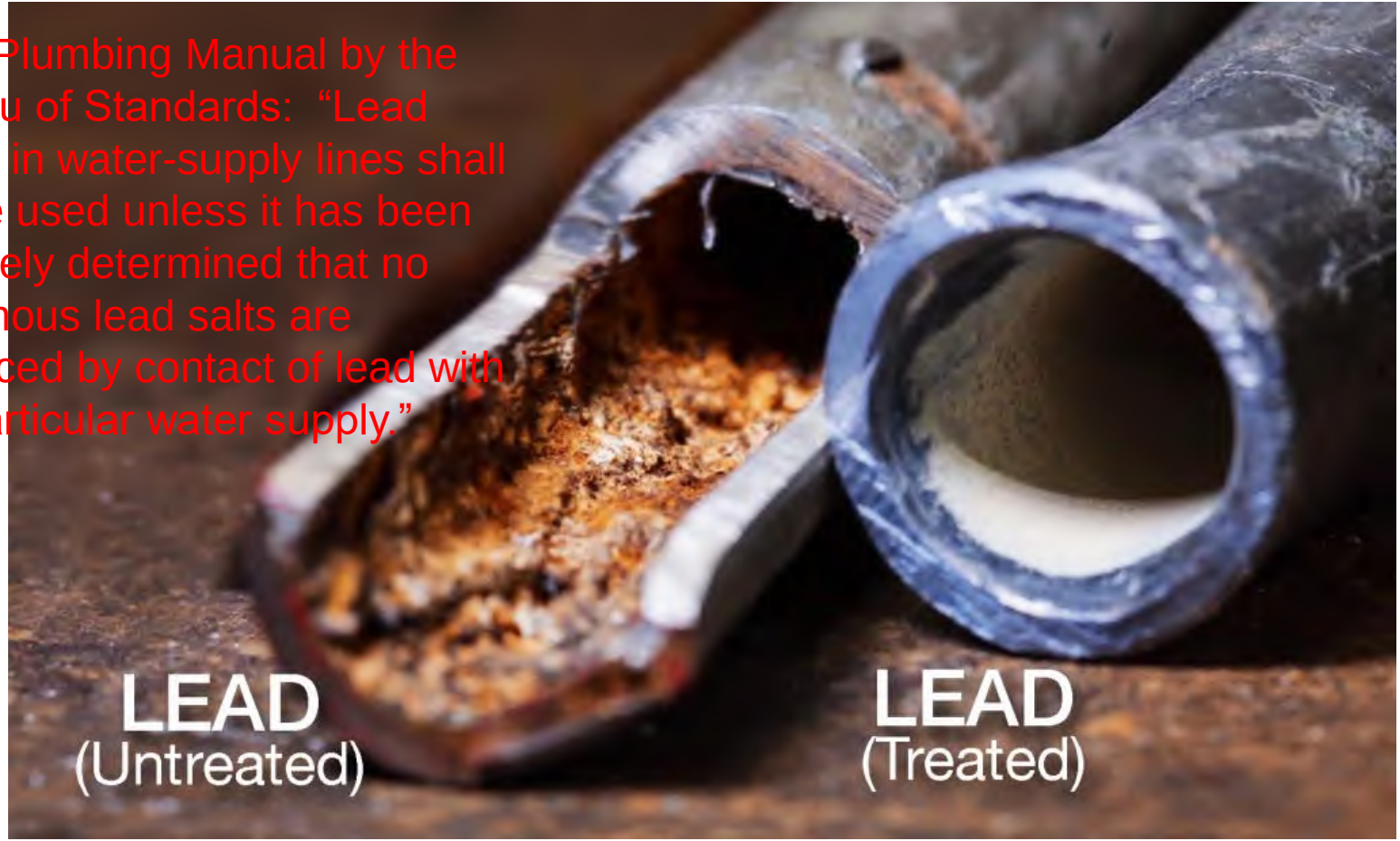
https://southernillinoisnow.com/2021/09/29/nyc-department-of-health-warns-about-lead-found-in-traditional-ceramic/

25% Pb in color dust

https://arstechnica.com/science/2021/10/toxic-frosting-children-poisoned-with-lead-copper-from-cake-decorations/

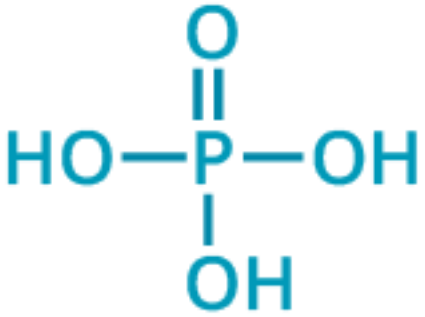

FLINT WATER PLANT

1940 Plumbing Manual by the Bureau of Standards: “Lead piping in water-supply lines shall not be used unless it has been definitely determined that no poisonous lead salts are produced by contact of lead with the particular water supply.”

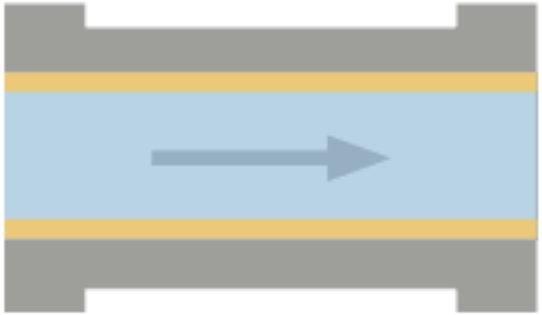


https://www.pvwc.com/lead-in-water-pipes/

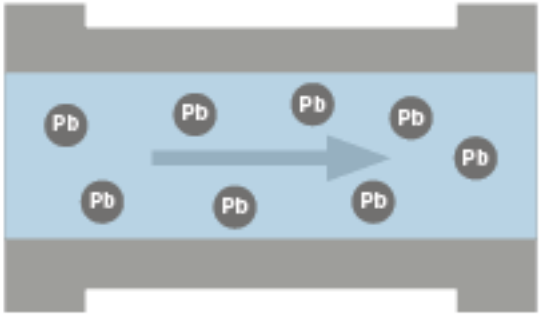
CORROSION CONTROL



WITH PHOSPHATES



WITHOUT PHOSPHATES



Orthophosphates are added to water to reduce the amount of lead leaching into it from pipes. They do this by forming a layer of low-solubility lead-phosphate complexes inside the pipe. This method of corrosion control was not used for the Flint River water supply.

EPA

FACT SHEET

EPA's Lead and Copper Rule Improvements
October 2024

Lead in drinking water irreparably harms children and adults. Lead is a highly toxic metal that can impact brain development in children, kidney function in adults, and interferes with the production of red blood cells that carry oxygen to all parts of your body. The federal government banned the installation of new lead pipes in 1986, yet up to 9 million homes and businesses are still connected to water mains through legacy lead pipes in neighborhoods across America. These remaining lead pipes are disproportionately concentrated in low-income communities and communities of color.

Key Provisions from Lead and Copper Rule Improvements

For the first time, the vast majority of water systems will be required to replace lead service lines within 10 years. By removing the greatest source of lead in drinking water nationwide, we can further the goal of safe drinking water for current and future generations.

Facts about lead (answer the question “what is lead?”).

Describe where lead is found and why (answer the question “where does lead come from?”).

Talk through public health issues brought on by lead (answer “why should I care about lead and how concerned should I be?”).

MJPHD.net