

MJPhD

LEAD: THE ACCIDENTAL POISON

MARK JONES
CREATIVE DIRECTOR
MJPHD, LLC

10 October 2024





It starts with your pipes.

Find out if your water
service line has lead.

dcwater.com/lead



COMMUNITY

CP-019

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

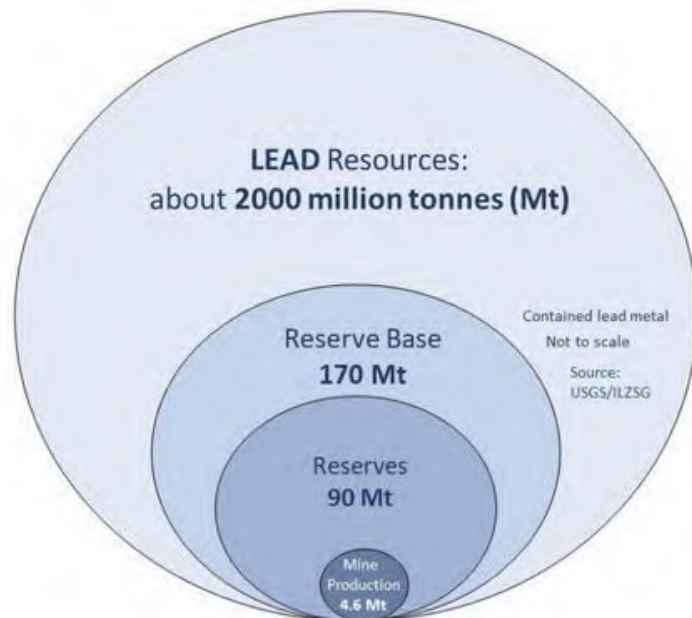
Group		18																
1 (Ia)		2 (IIa)																
Period	1	2	3 (IIa)															
1	1	2	3 (IIa)															
2	3	4	5 (IIa)															
3	11	12	7 (IIa)															
4	19	20	9 (IIa)															
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6	55	56	13 (IIa)															
7	87	88	15 (IIa)															
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* Lanthanum 138.91																					
** Actinium (227)																					

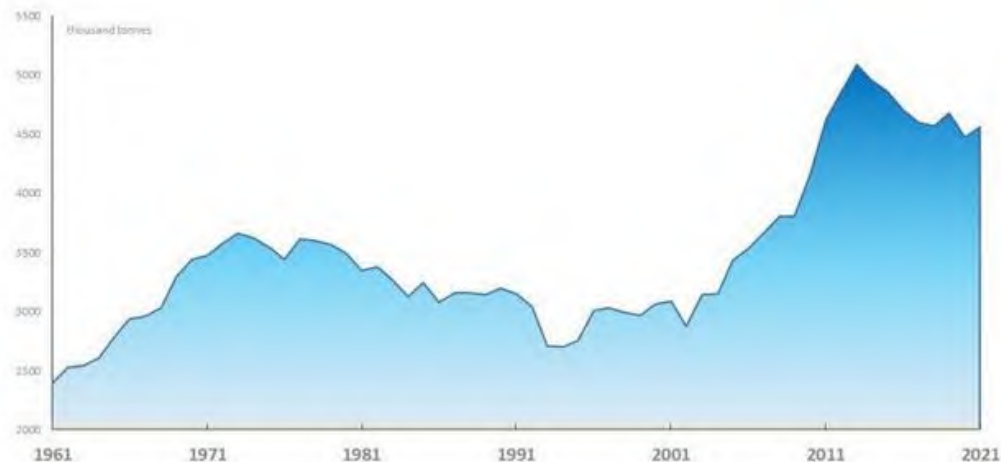
WHERE DOES LEAD COME FROM?



World Lead Reserves 2021



World Lead Mine Supply 1961-2021

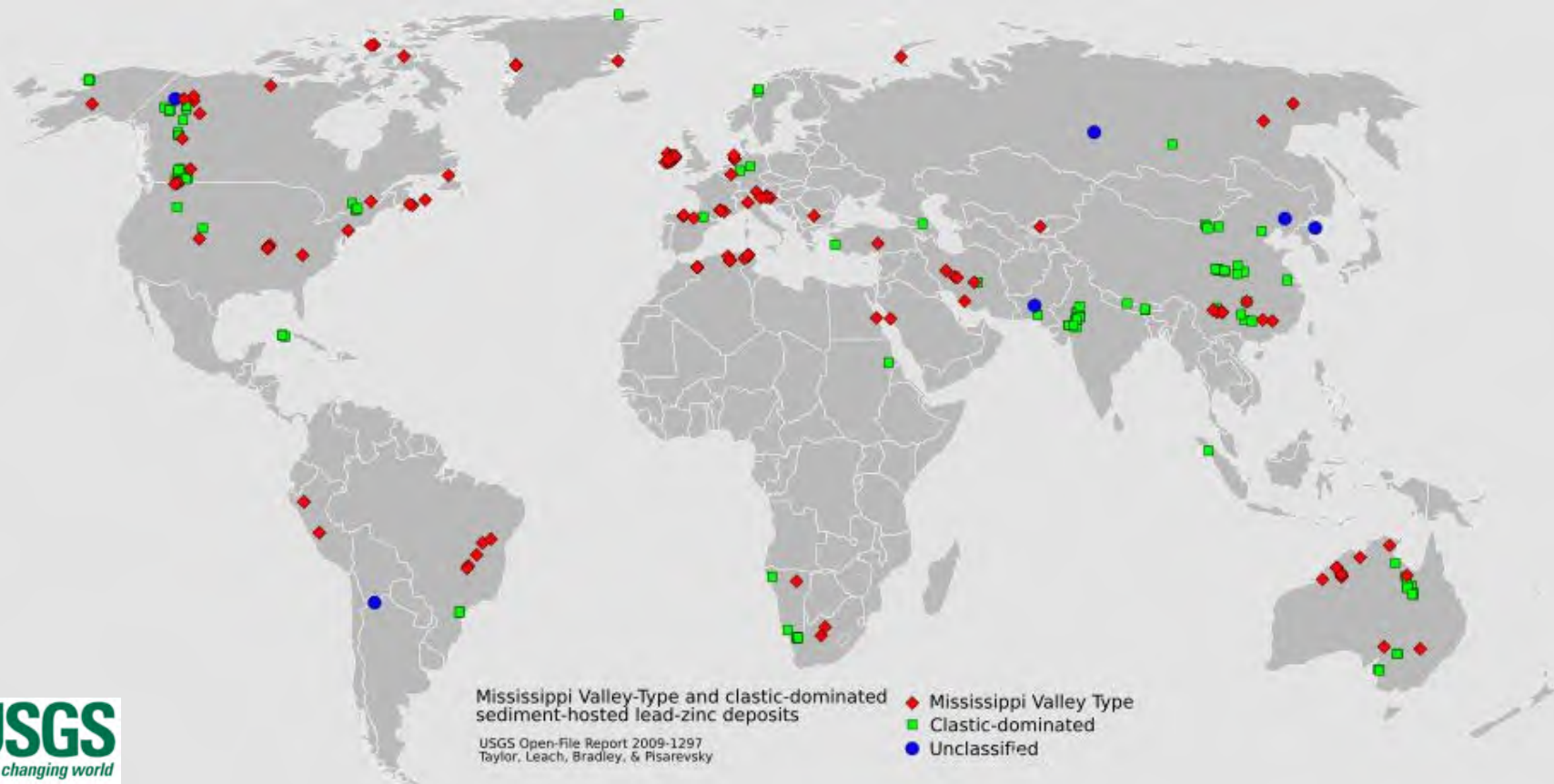


In 2021, global lead mine production was 4.6 million tonnes.

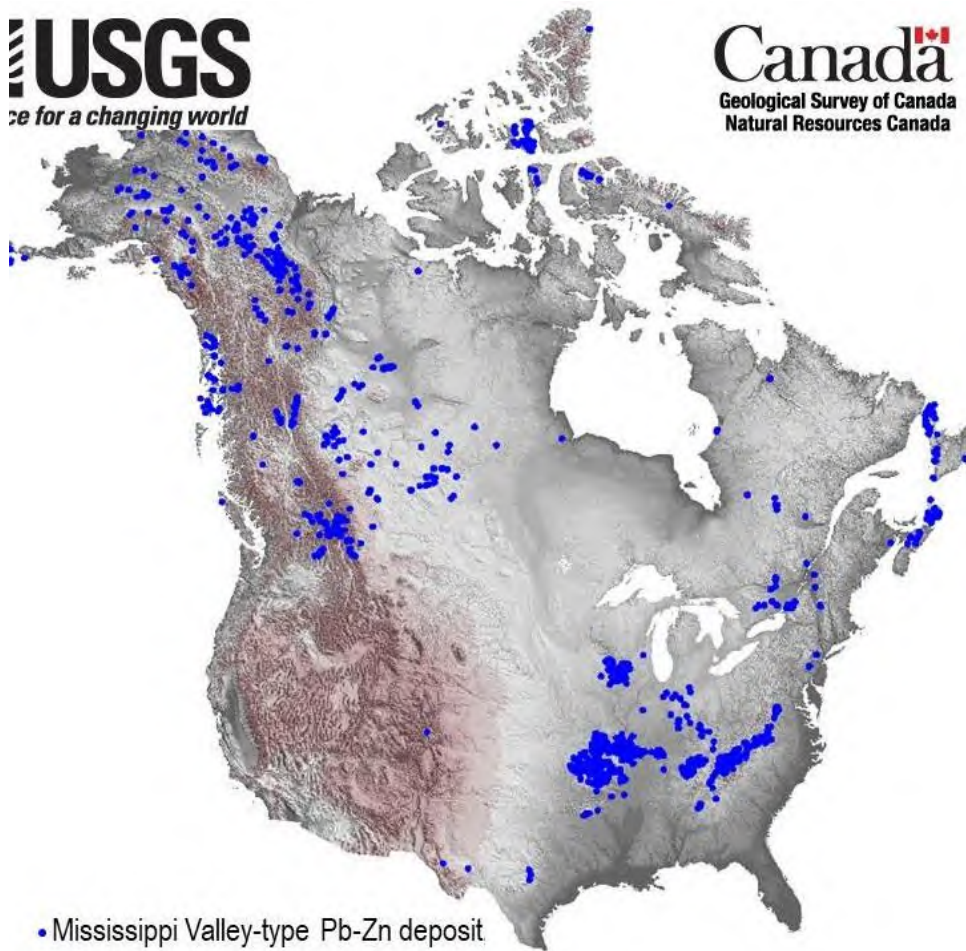


International Lead and Zinc Study Group

LEAD ORE DEPOSITS



	Mine production		Reserves⁷
	<u>2022</u>	<u>2023^e</u>	
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	<u>507</u>	<u>610</u>	<u>5,900</u>
World total (rounded)	4,460	4,500	95,000

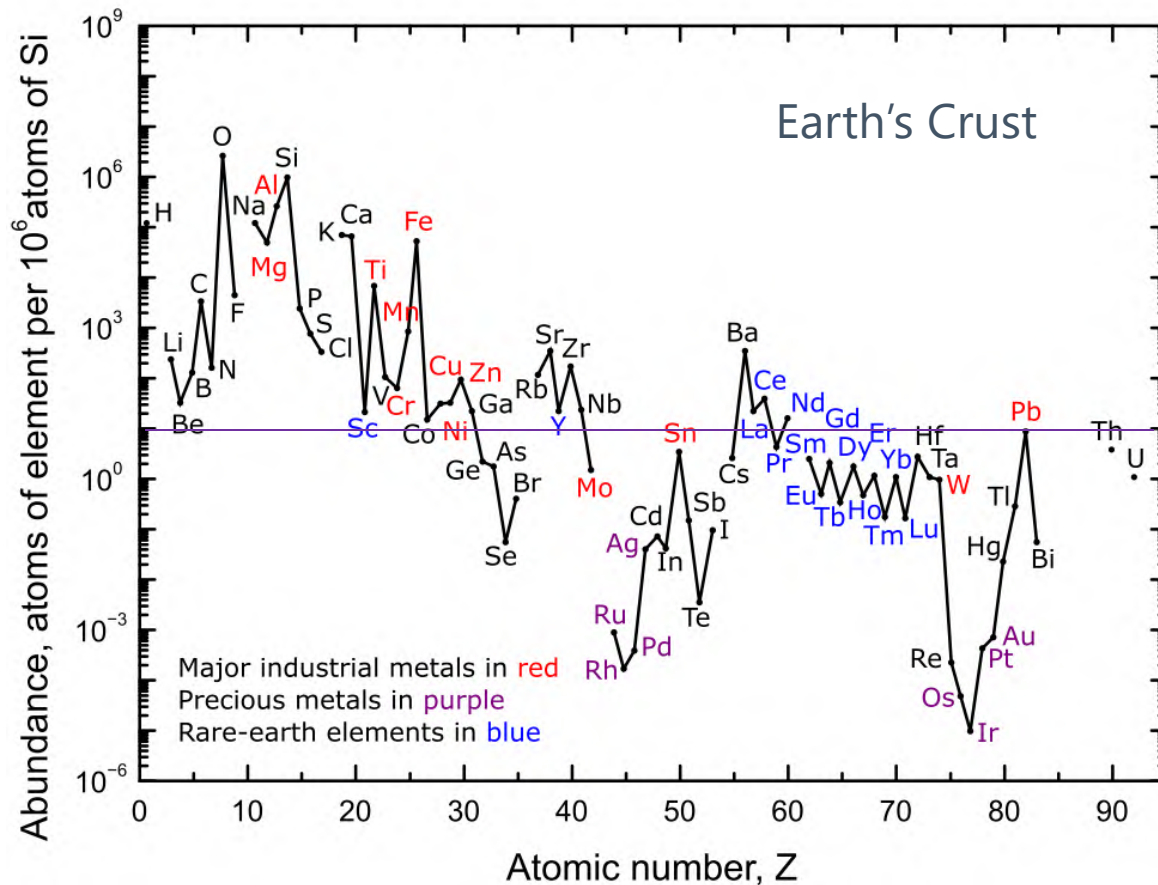


- Mississippi Valley-type Pb-Zn deposit

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.

<u>Salient Statistics—United States:</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>	<u>2022</u>	<u>2023^e</u>
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

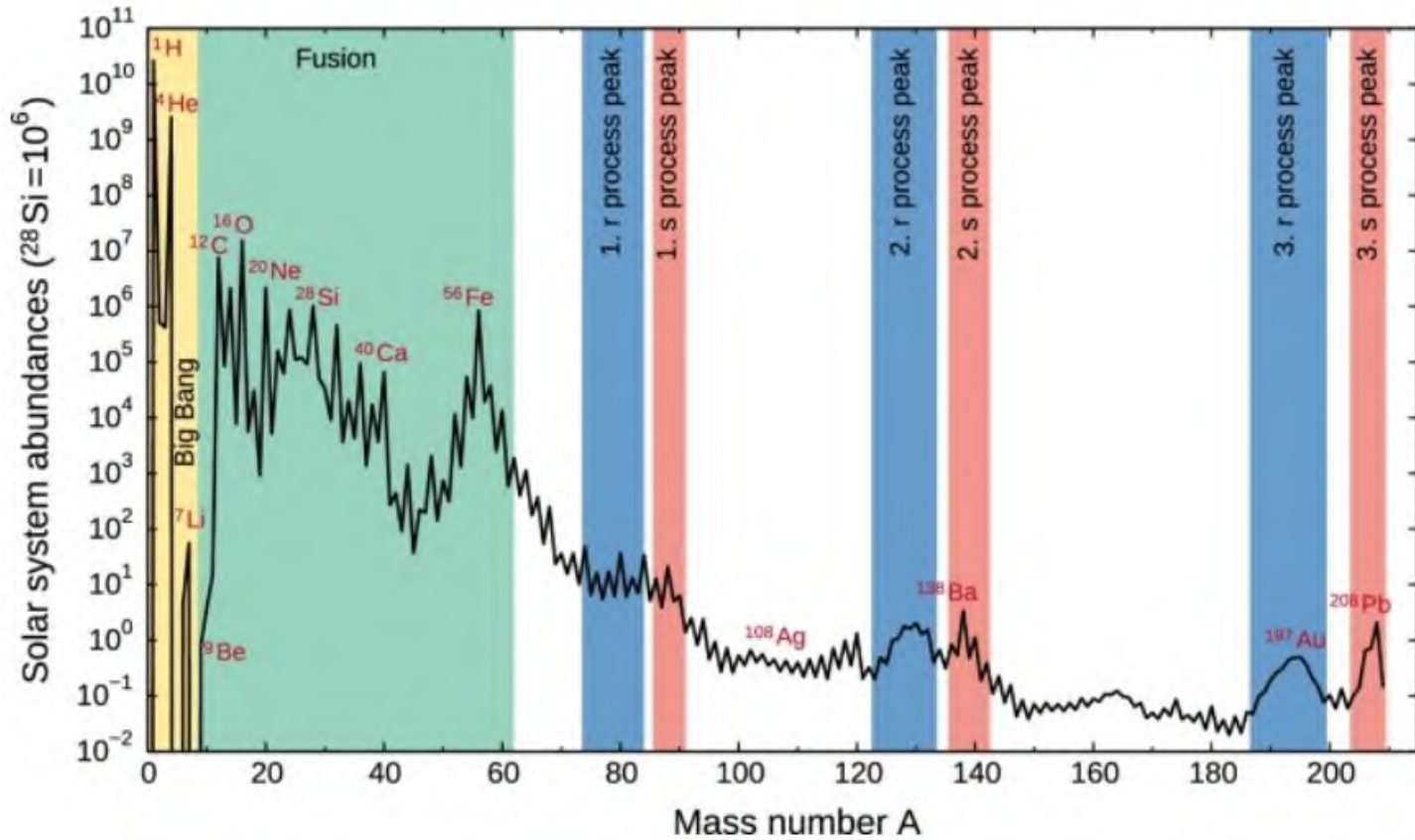
Recycling: In 2023, an estimated 1,000,000 tons of secondary lead was produced, an amount equivalent to 62% of apparent domestic consumption. Nearly all secondary lead was recovered from old scrap, mostly lead-acid batteries.



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

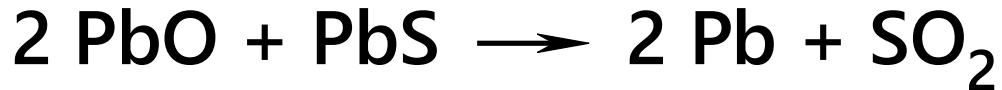
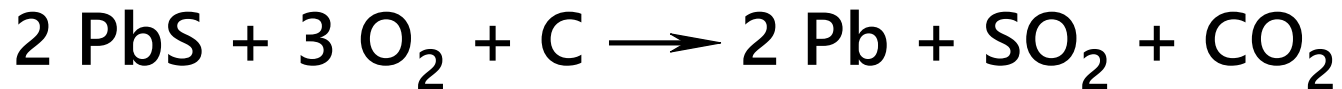
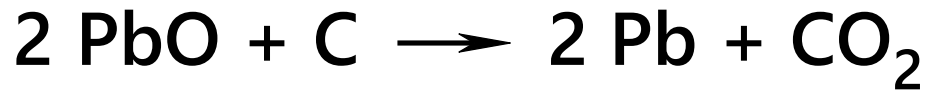
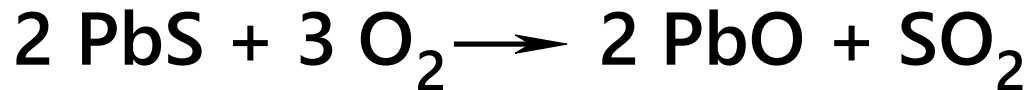


Arcones, A., Thielemann, FK. Origin of the elements. *Astron Astrophys Rev* 31, 1 (2023). <https://doi.org/10.1007/s00159-022-00146-x>



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

LEAD FROM ORE



ELEMENTAL USES



lead projectiles 1500

ELEMENTAL USES



USE OF LEAD COMPOUNDS – POTTERY GLAZING

Roman



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

USE OF LEAD COMPOUNDS – PAINT PIGMENTS



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

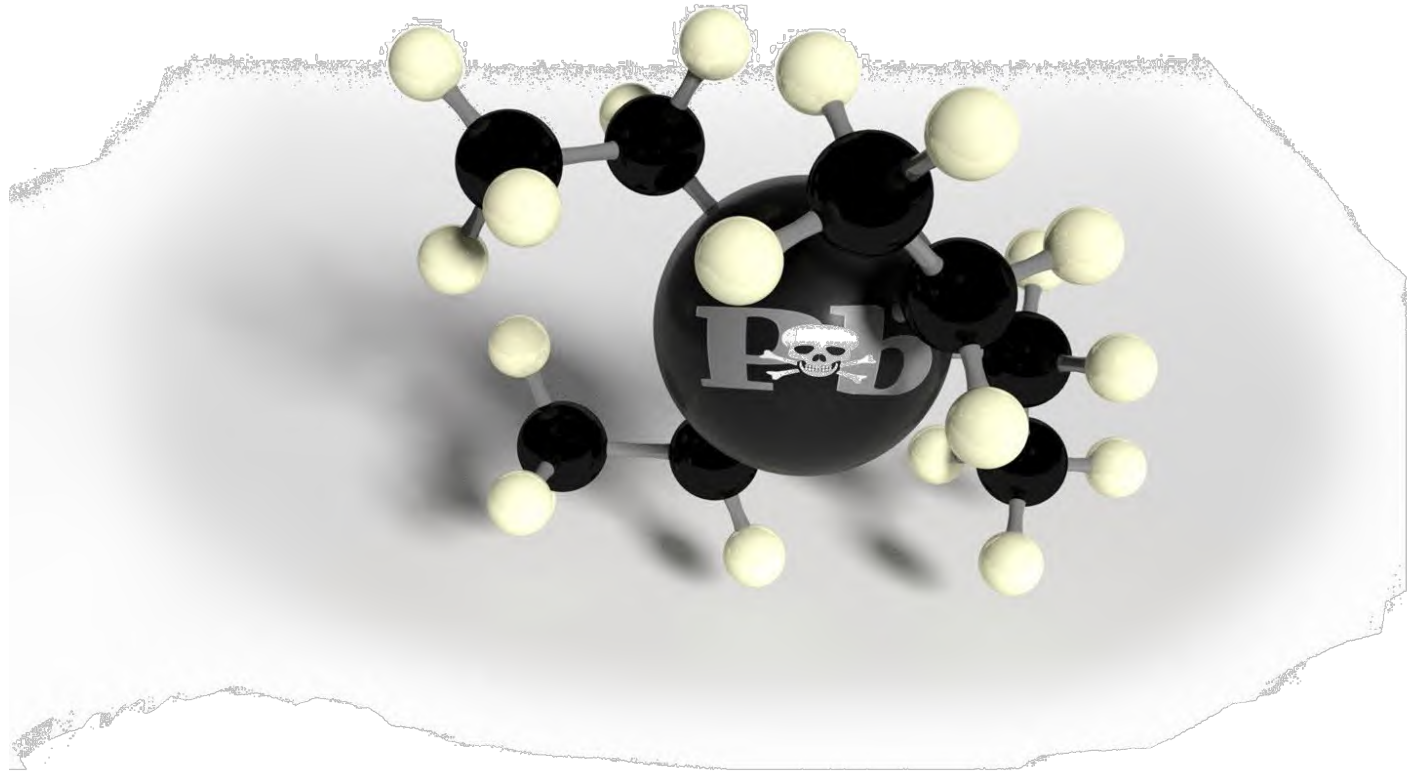


USE OF LEAD COMPOUNDS – GASOLINE ADDITIVE

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

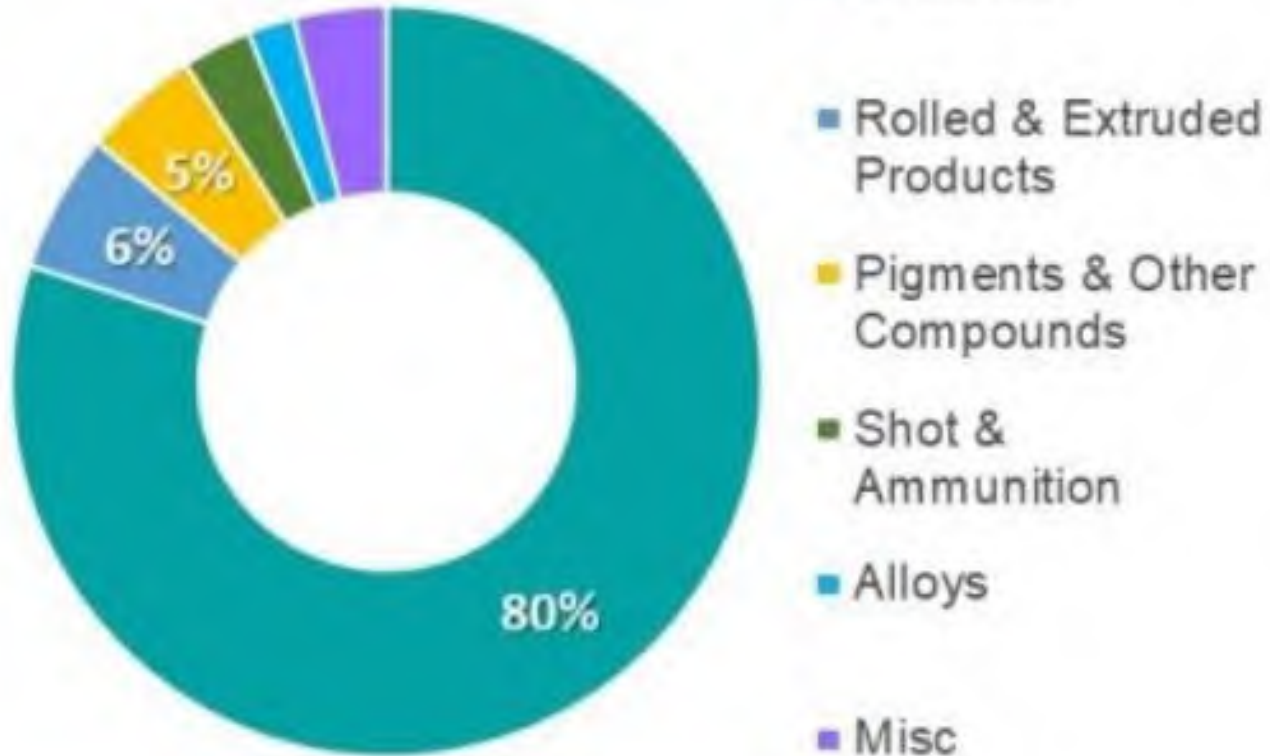


Lead is insoluble in steel and makes imperfections that result in chips that break off during cutting.

Not weldable!

USE OF LEAD COMPOUNDS – PVC STABILIZERS





International Lead & Zinc Study Group



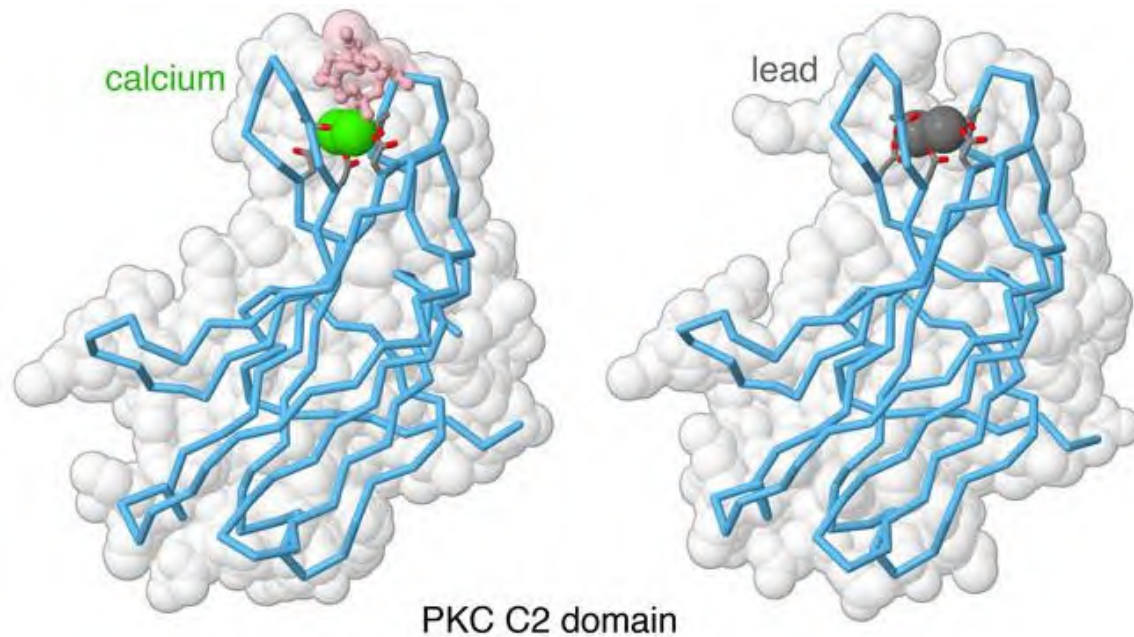
Group 1 (Ia)																										18 (VIIIa)					
Period	1	2																	3	4	5	6	7	8							
1	1	2																	13 (IIIA)	14 (IVA)	15 (Va)	16 (VIA)	17 (VIIa)	18 (VIIIa)							
	H Hydrogen 1.008																		B Boron 10.811	C Carbon 12.011	N Nitrogen 14.007	O Oxygen 15.999	F Fluorine 18.998	Ne Neon 20.180							
2	3	4																	5	6	7	8	9	10							
	Li Lithium 6.94	Be Beryllium 9.0122																	13	14	15	16	17	18							
3	11	12																	13	14	15	16	17	18							
	Na Sodium 22.990	Mg Magnesium 24.305	Transition metals																Al Aluminum 26.982	Si Silicon 28.085	P Phosphorus 30.974	S Sulfur 32.06	Cl Chlorine 35.45	Ar Argon 39.948							
			3 (IIIB) 4 (IVB) 5 (VB) 6 (VIB) 7 (VIIB) 8 (VIIIb) 9 (VIIIb) 10 (VIIIb) 11 (IB) 12 (IIB)																												
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36													
	K Potassium 39.098	Ca Calcium 40.078	Sc Scandium 44.956	Ti Titanium 47.867	V Vanadium 50.942	Cr Chromium 51.996	Mn Manganese 54.938	Fe Iron 55.845	Co Cobalt 58.933	Ni Nickel 58.693	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.630	As Arsenic 74.922	Se Selenium 78.971	Br Bromine 79.904	Kr Krypton 83.798													
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54													
	Rb Rubidium 85.468	Sr Strontium 87.62	Y Yttrium 88.906	Zr Zirconium 91.224	Nb Niobium 92.906	Mo Molybdenum 95.95	Tc Technetium (98)	Ru Ruthenium 101.07	Rh Rhodium 102.91	Pd Palladium 106.42	Ag Silver 107.87	Cd Cadmium 112.41	In Indium 114.82	Sn Tin 118.710	Sb Antimony 121.76	Te Tellurium 127.60	I Iodine 126.90	Xe Xenon 131.29													
6	55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86													
	Cs Cesium 132.91	Ba Barium 137.33	* Lu Lutetium 174.97	Hf Hafnium 178.49	Ta Tantalum 180.95	W Tungsten 183.84	Re Rhenium 186.21	Os Osmium 190.23	Ir Iridium 192.22	Pt Platinum 195.08	Au Gold 196.97	Hg Mercury 200.59	Tl Thallium 204.38	Pb Lead 207.2	Bi Bismuth 208.98	Po Polonium (209)	At Astatine (210)	Rn Radon (222)													
7	87	88	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118													
	Fr Francium (223)	Ra Radium (226)	** Lr Lawrencium (262)	Rf Rutherfordium (261)	Db Dubnium (268)	Sg Seaborgium (269)	Bh Bohrium (270)	Hs Hassium (269)	Mt Meitnerium (278)	Ds Darmstadtium (281)	Rg Roentgenium (282)	Cn Copernicium (285)	Nh Nihonium (286)	Fl Flerovium (289)	Mc Moscovium (290)	Lv Livermorium (293)	Ts Tennessine (294)	Og Oganesson (294)													

*	57	58	59	60	61	62	63	64	65	66	67	68	69	70
	La Lanthanum 138.91	Ce Cerium 140.12	Pr Praseodymium 140.91	Nd Neodymium 144.24	Pm Promethium (145)	Sm Samarium 150.36	Eu Europium 151.96	Gd Gadolinium 157.25	Tb Terbium 158.93	Dy Dysprosium 162.50	Ho Holmium 164.93	Er Erbium 167.25	Tm Thulium 168.93	Yb Ytterbium 173.05
**	89	90	91	92	93	94	95	96	97	98	99	100	101	102
	Ac Actinium (227)	Th Thorium 232.04	Pa Protactinium 231.04	U Uranium 238.03	Np Neptunium (237)	Pu Plutonium (244)	Am Americium (243)	Cm Curium (247)	Bk Berkelium (247)	Cf Californium (251)	Es Einsteinium (252)	Fm Fermium (257)	Md Mendelevium (258)	No Nobelium (259)

Group	1	2											13	14	15	16	17	18
	(1a)	(2a)											(IIIA)	(IVA)	(VA)	(VIA)	(VIIa)	(VIIIa)
Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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2	3 Li Lithium 6.94	4 Be Beryllium 9.0122											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305	Transition metals										13 Al Aluminium 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
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5	37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.91	56 Ba Barium 137.33	* Lu Lutetium 174.97	71 Hf Hafnium 178.49	72 Ta Tantalum 180.95	73 W Tungsten 183.84	74 Re Rhenium 186.21	75 Os Osmium 190.23	76 Ir Iridium 192.22	77 Pt Platinum 195.08	78 Au Gold 196.97	79 Hg Mercury 200.59	80 Tl Thallium 204.38	81 Pb Lead 207.2	82 Bi Bismuth 208.98	83 Po Polonium (209)	84 At Astatine (210)	85 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	** Lr Lawrencium (260)	103 Rf Rutherfordium (261)	104 Db Dubnium (268)	105 Sg Seaborgium (269)	106 Bh Bohrium (270)	107 Hs Hassium (269)	108 Mt Meitnerium (278)	109 Ds Darmstadtium (281)	110 Rg Roentgenium (282)	111 Cn Copernicium (285)	112 Nh Nihonium (286)	113 Fl Flerovium (289)	114 Mc Moscovium (290)	115 Lv Livermorium (293)	116 Ts Tennessine (294)	117 Og Oganesson (294)

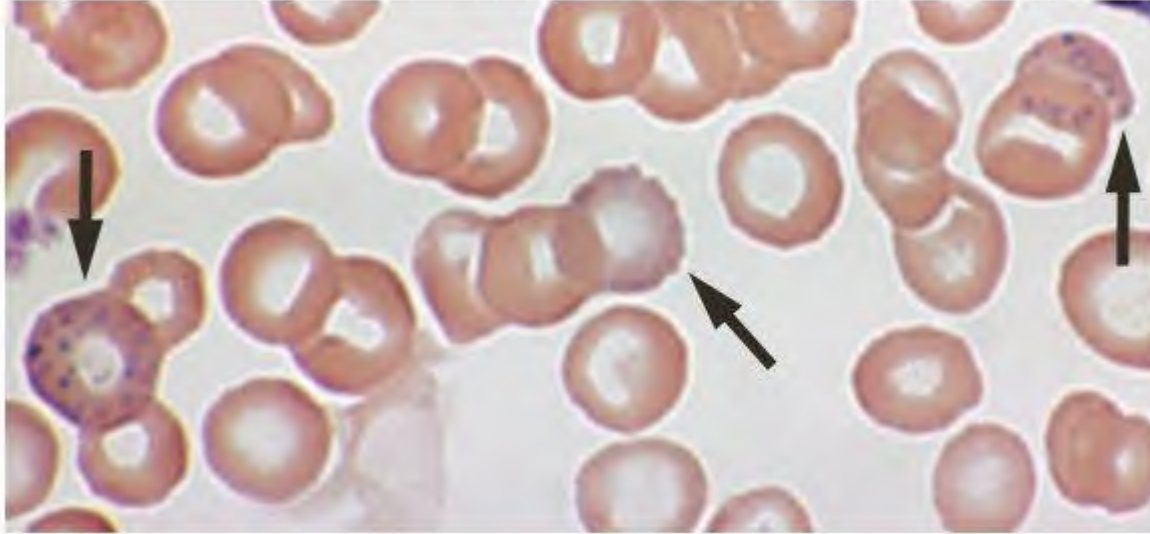
*	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.25	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05
**	89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)

LEAD INTERACTS WITH CALCIUM BINDING SITES



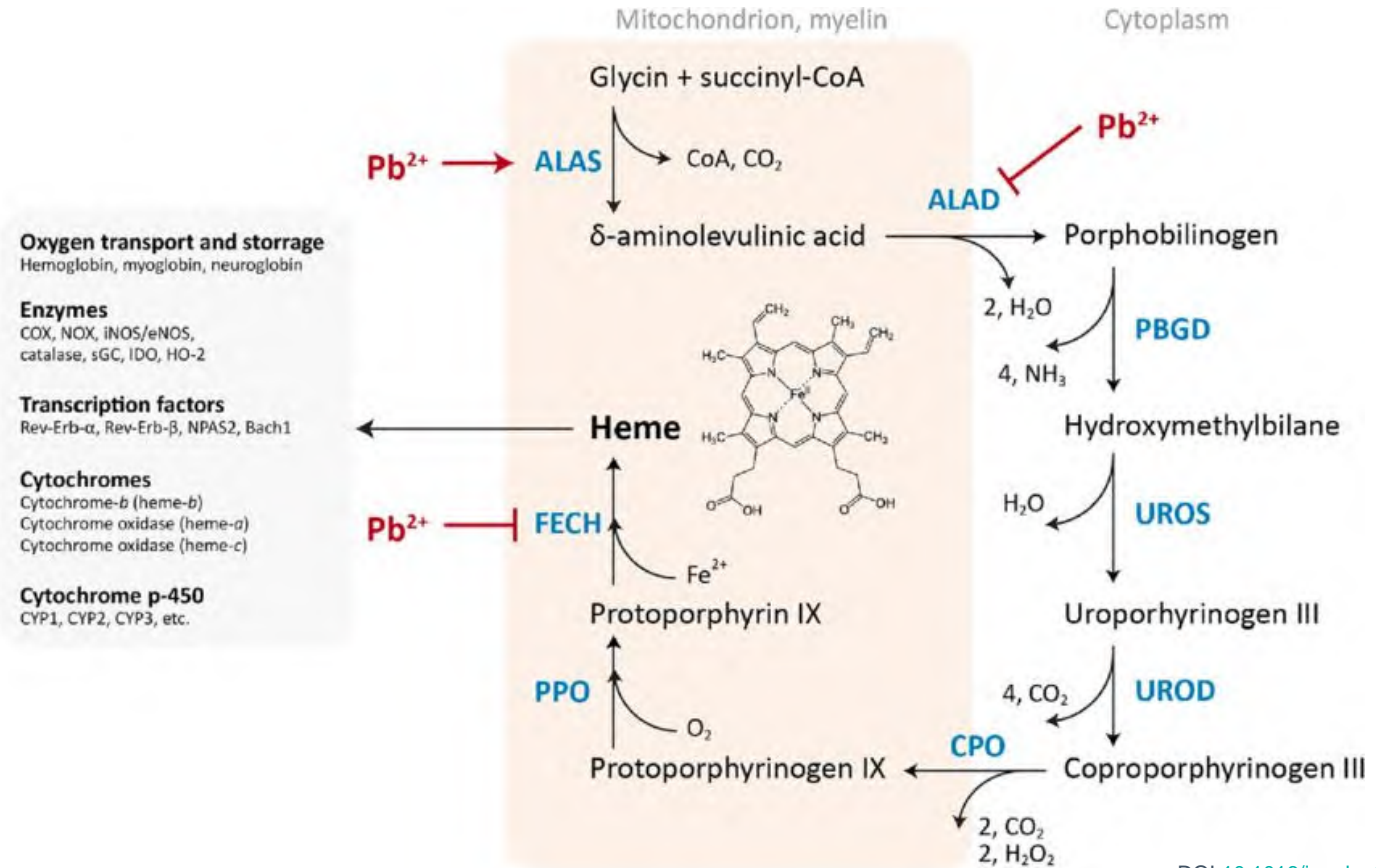
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4961898/>

LEAD DAMAGES RED BLOOD CELLS

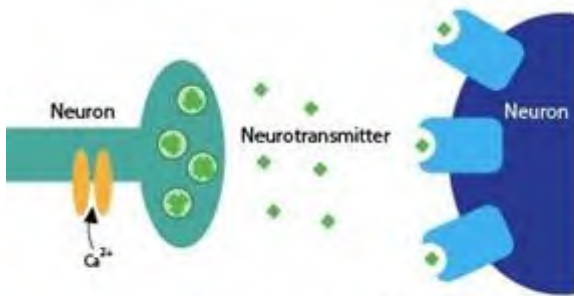


Basophilic stippling is a typical sign of lead poisoning. The term refers to small, blue, dot-like structures scattered uniformly throughout the hemoglobin area of red blood cells.

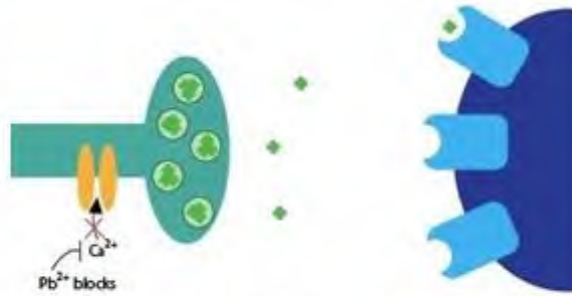
LEAD INTERFERES WITH HEME SYNTHESIS



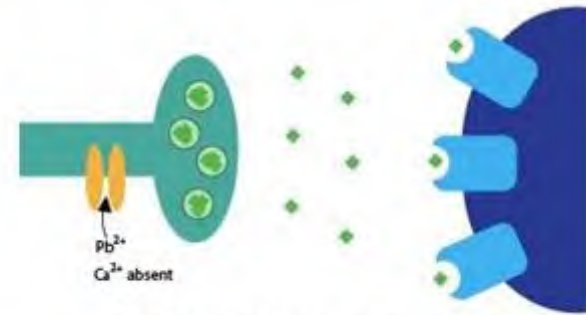
LEAD INTERFERES WITH NEURONAL ACTIVITY



Normal neuronal signaling

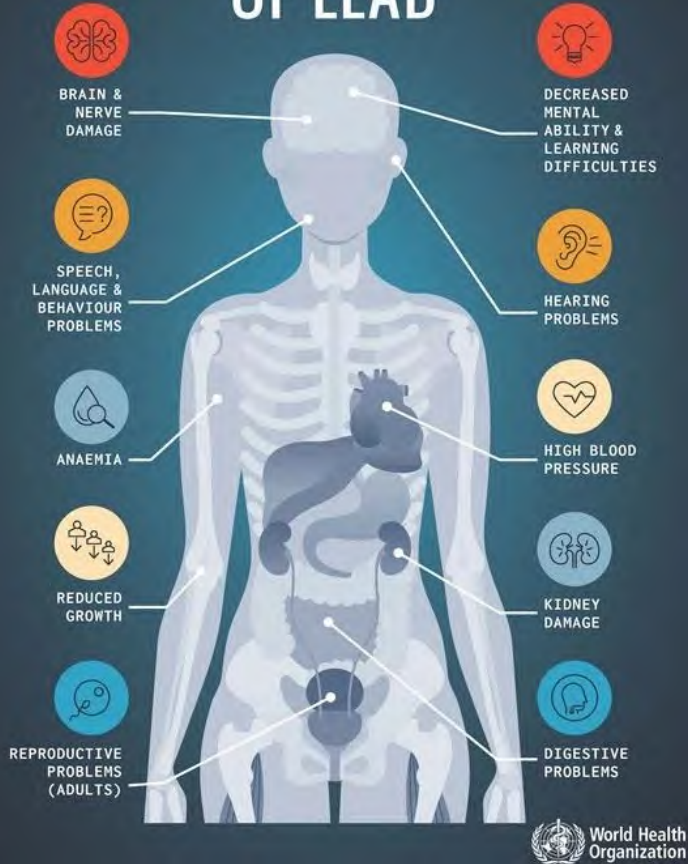


Lead blocks calcium signaling

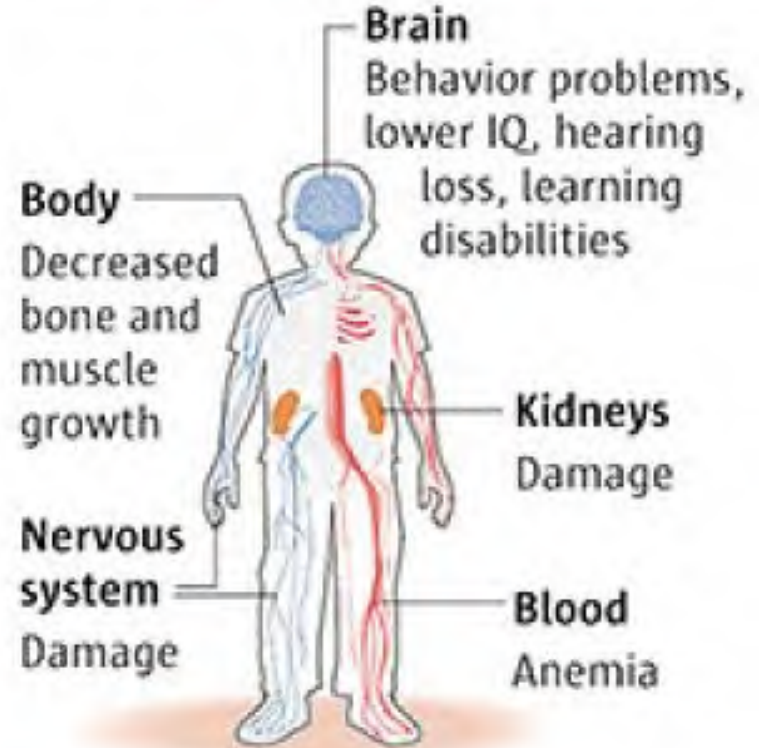


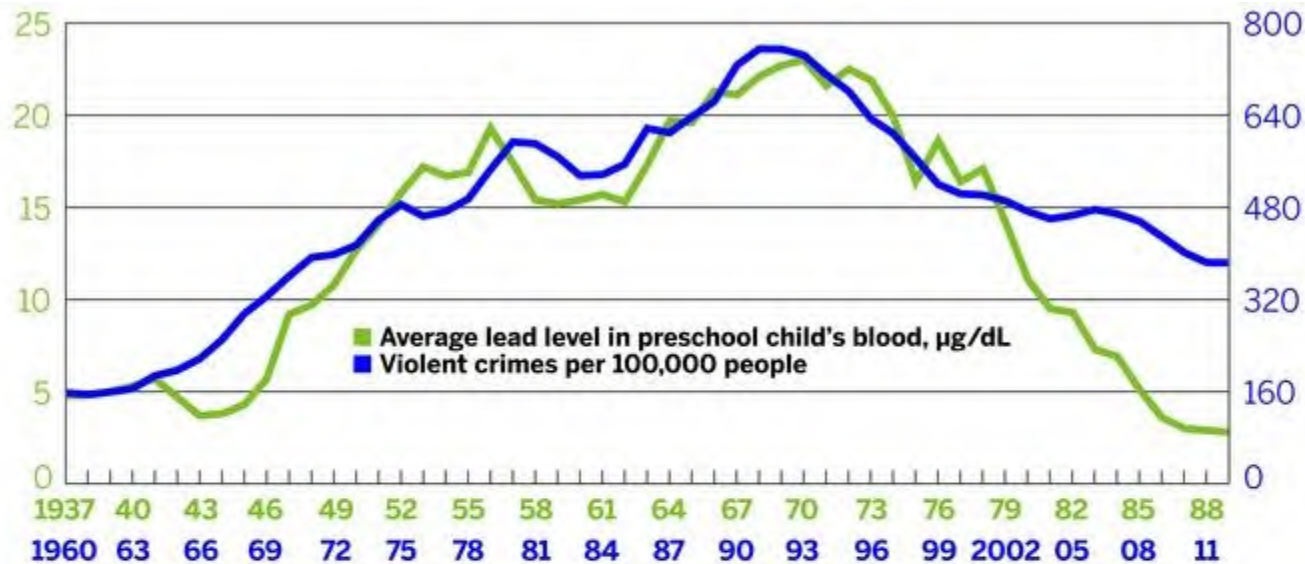
Lead causes inappropriate signaling

THE TOXIC EFFECTS OF LEAD



CHILDREN





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 ~~some~~ 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.

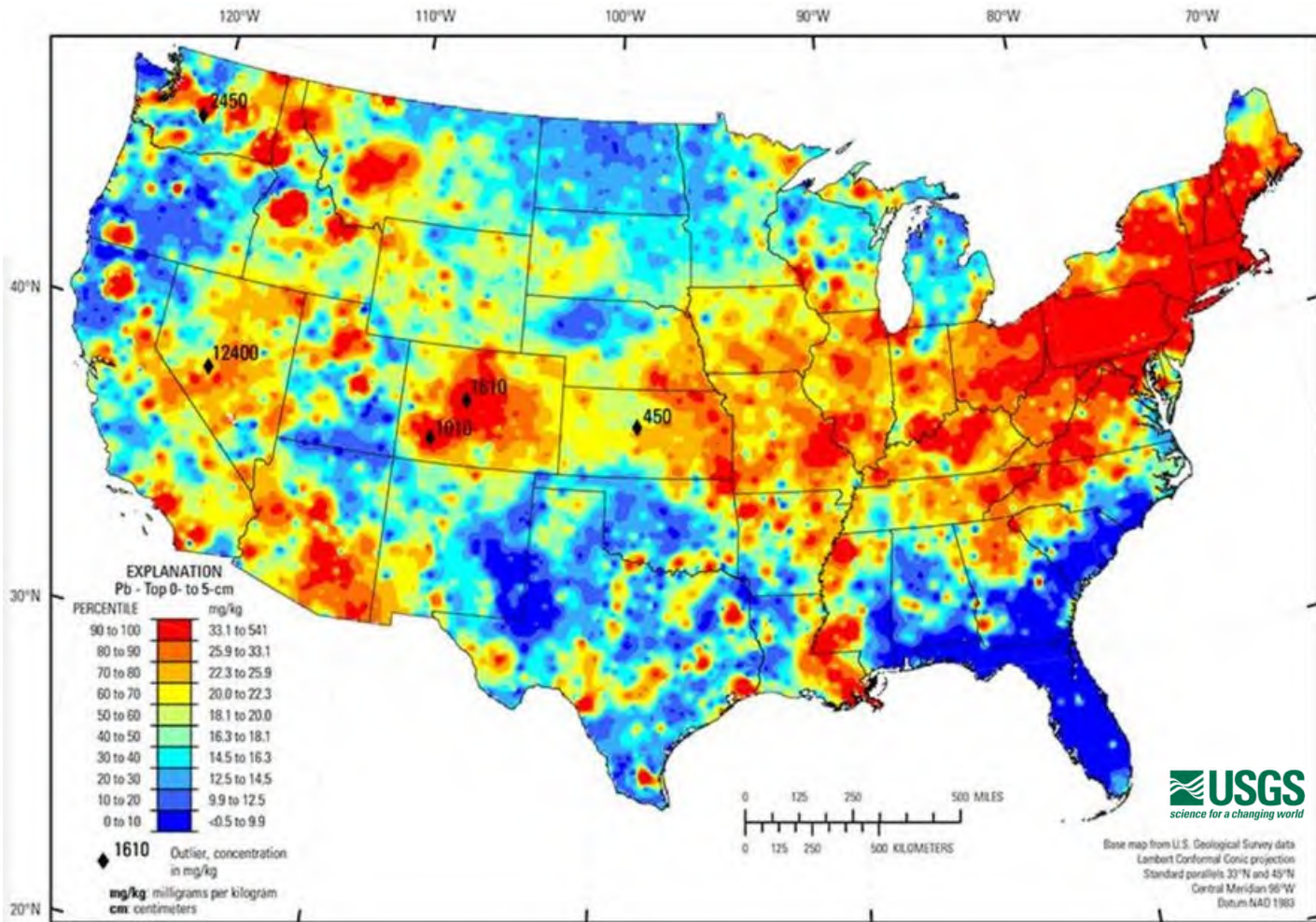


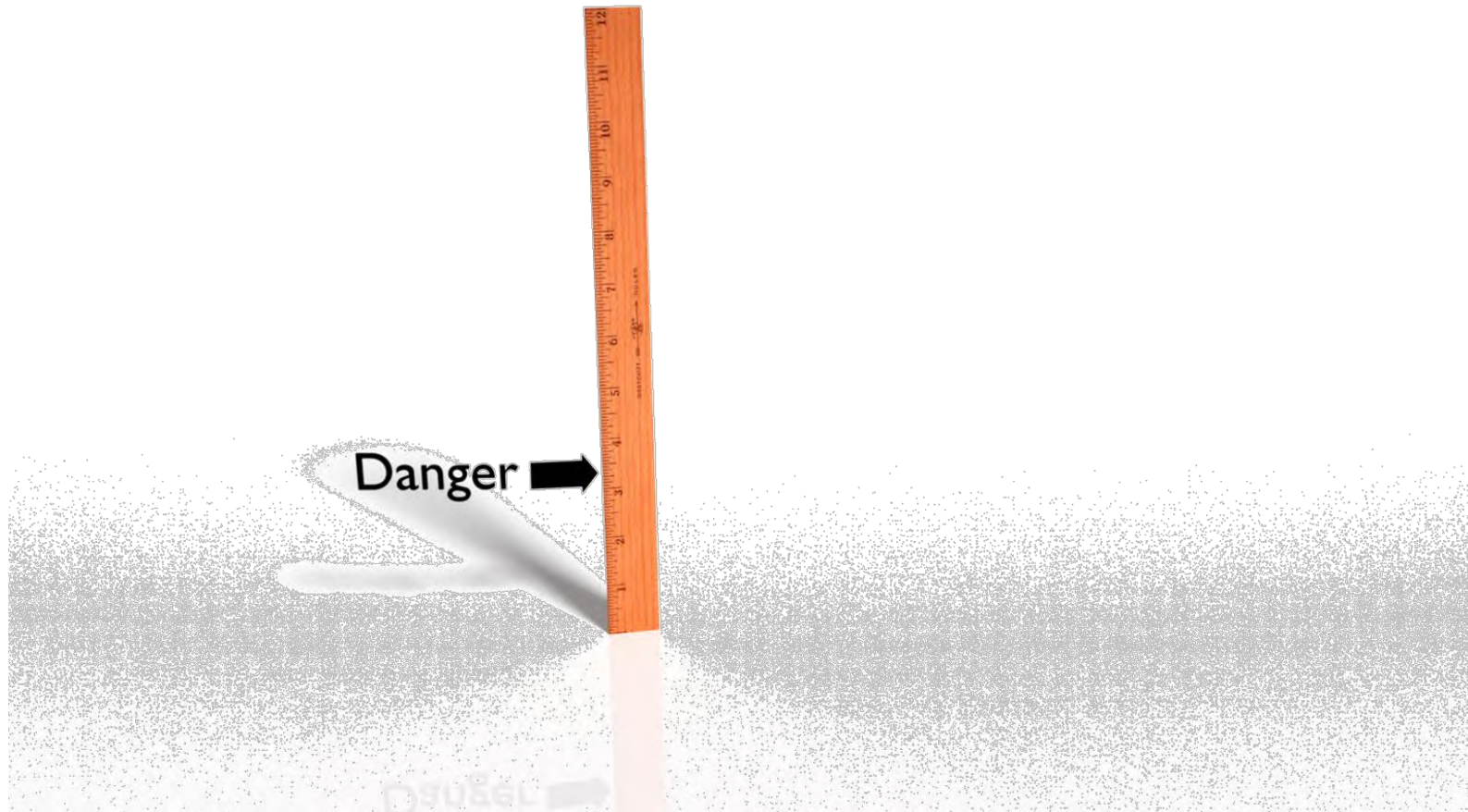
There is no level of exposure to lead that is known to be without harmful effects.

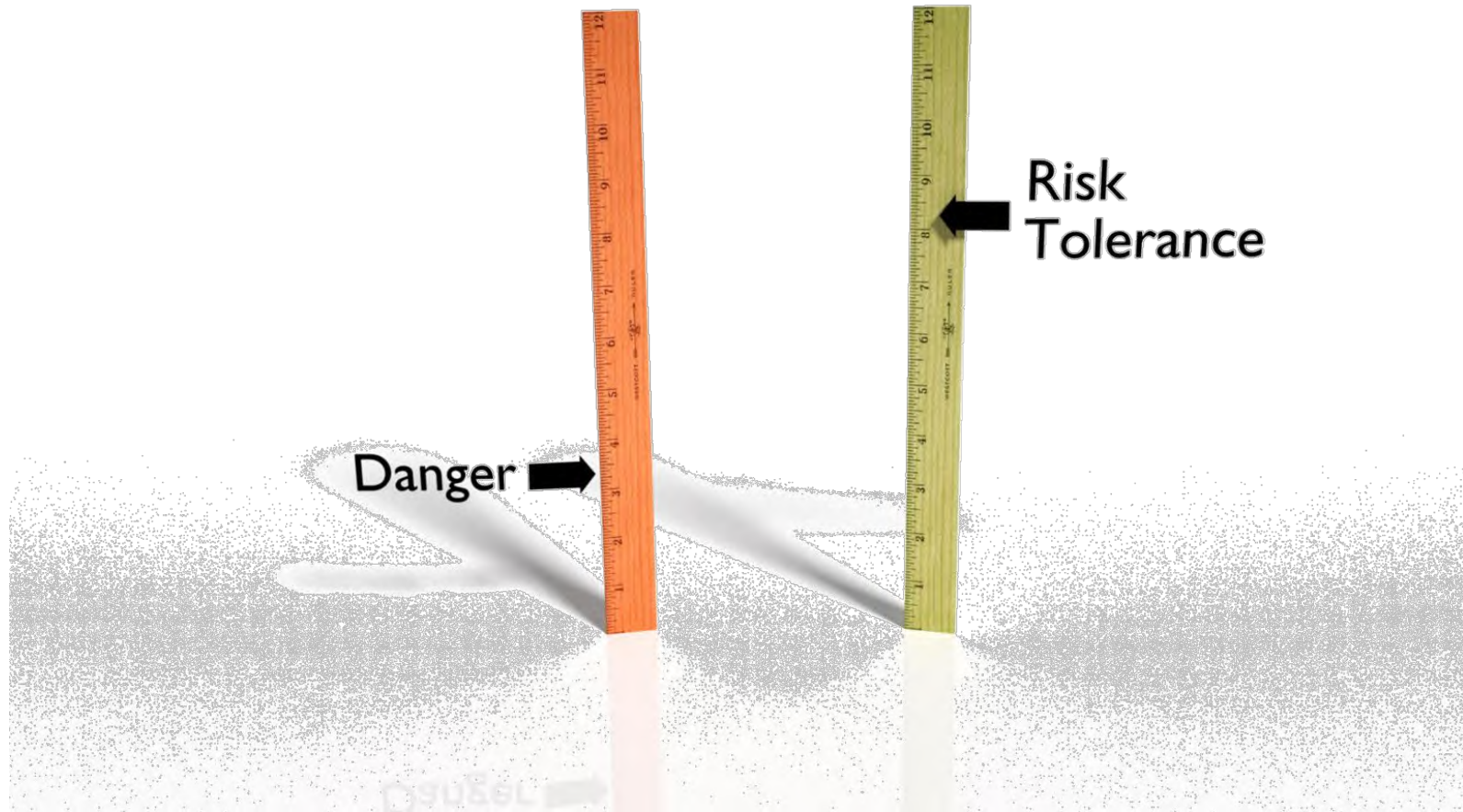


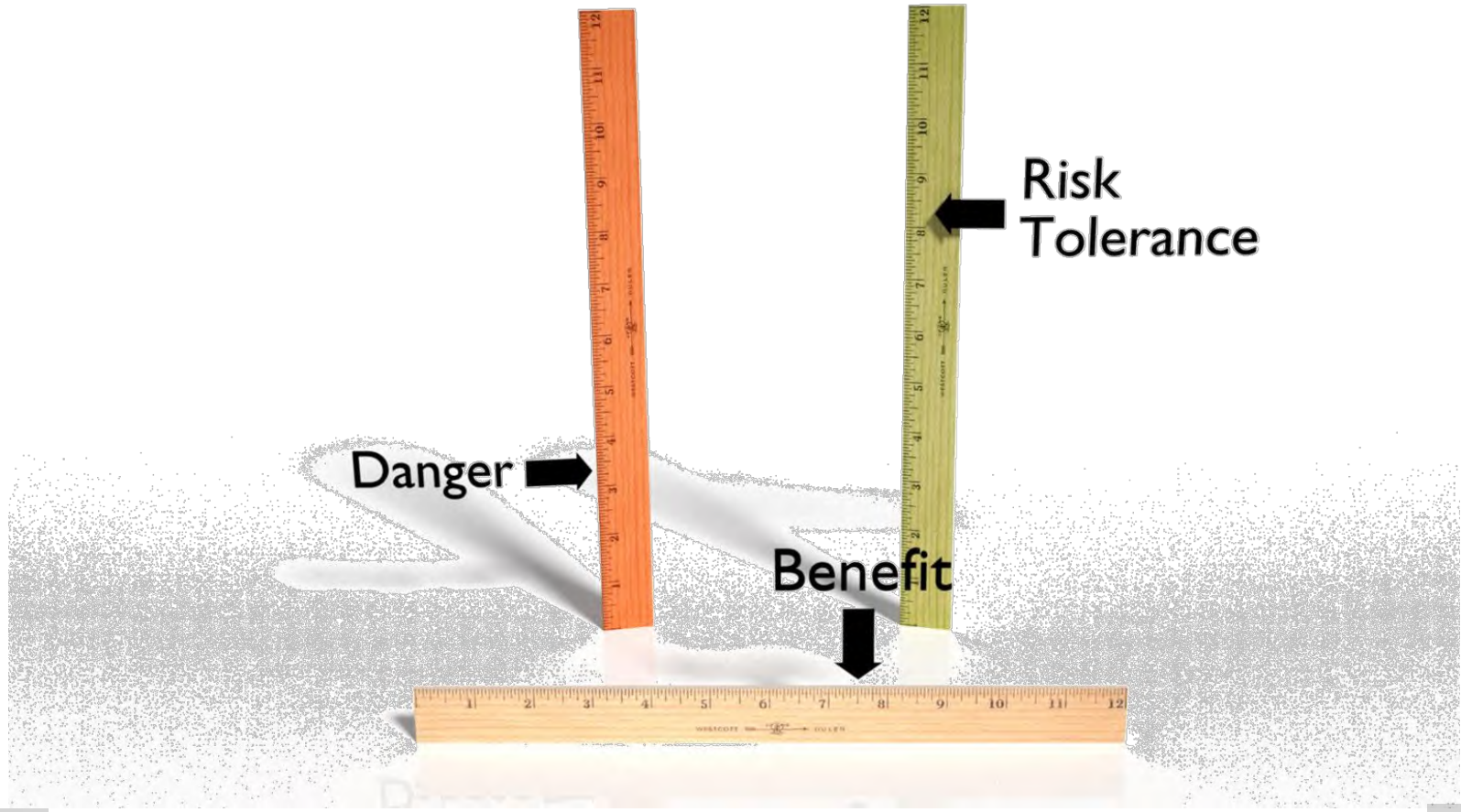
There is no level of exposure to lead that is known to be without harmful effects.

<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





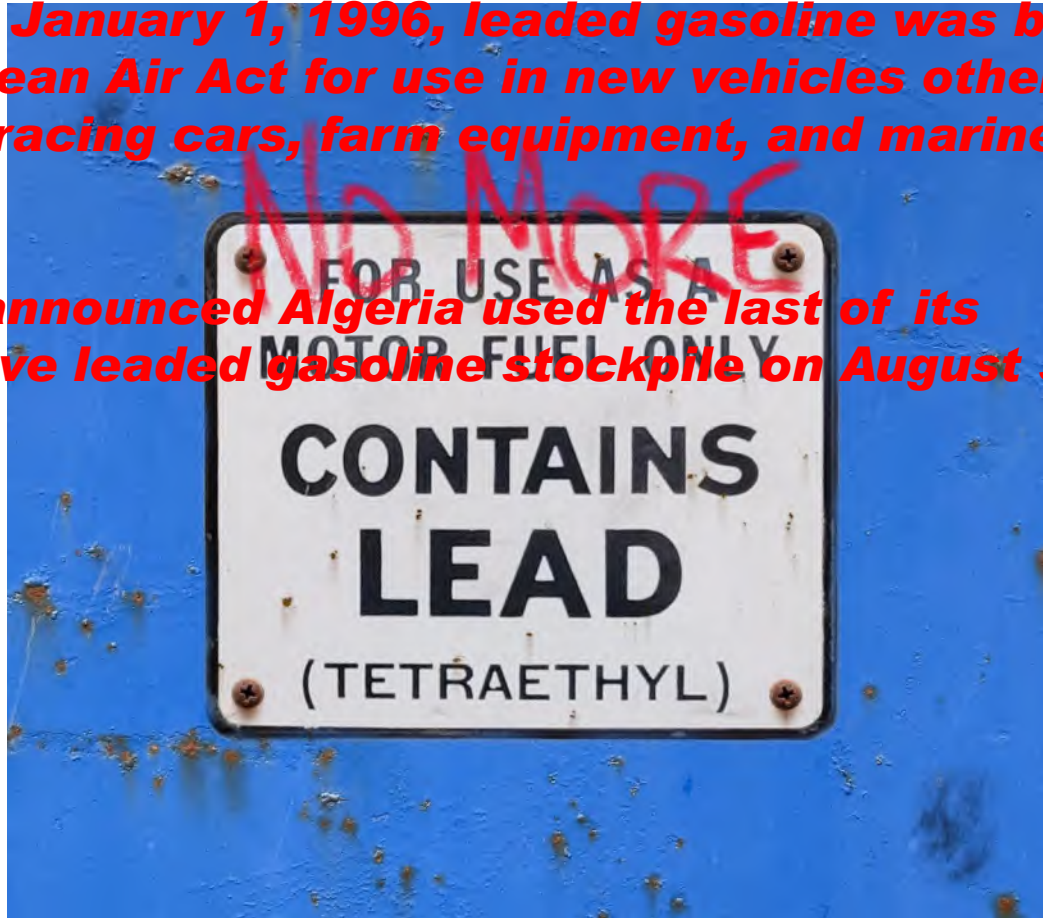






Effective January 1, 1996, leaded gasoline was banned by the Clean Air Act for use in new vehicles other than aircraft, racing cars, farm equipment, and marine engines.

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

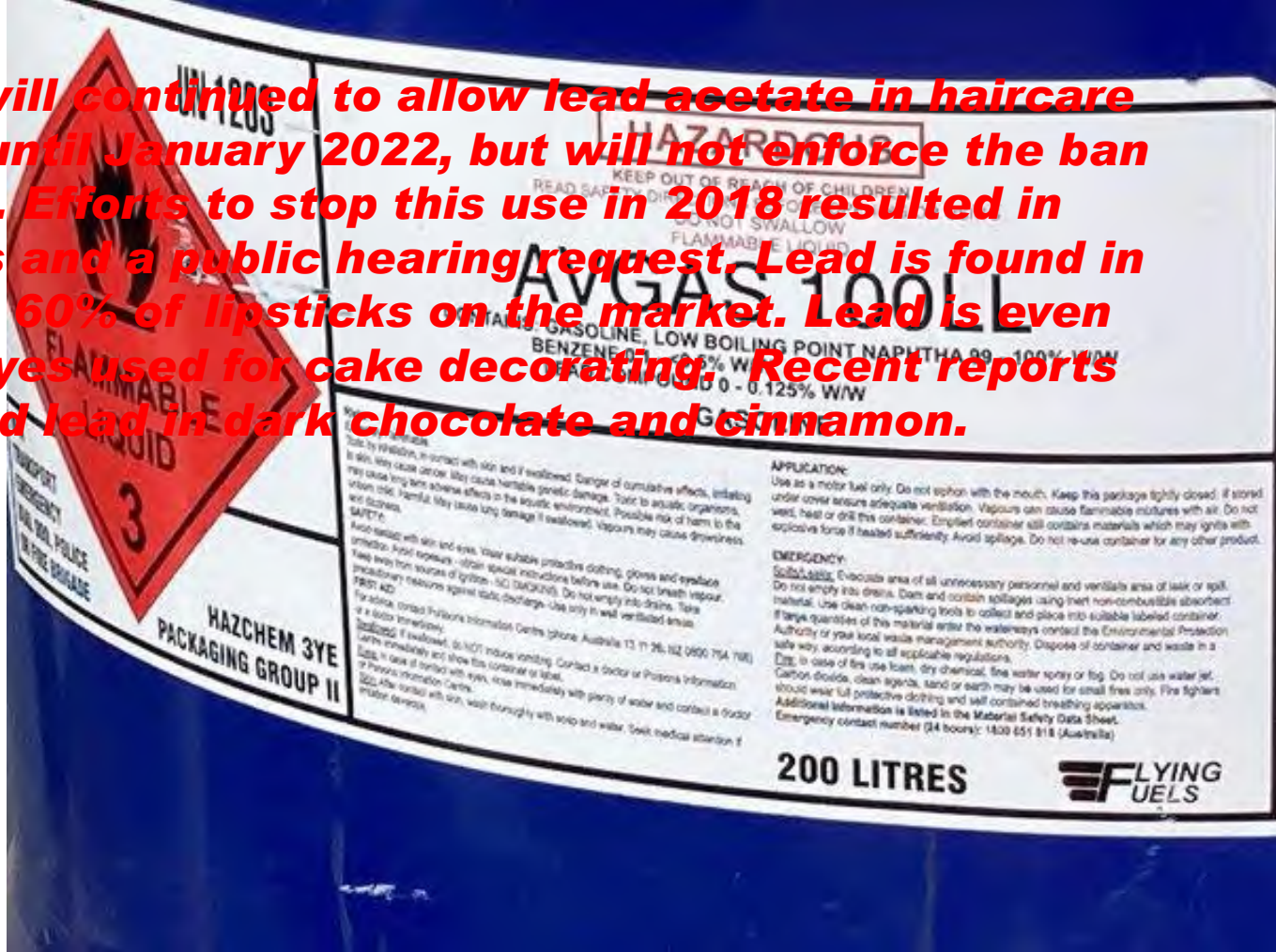


TEL stops knock at 1 part per thousand



Ethanol requires 10%

The FDA will continue 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>



2021

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



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.”

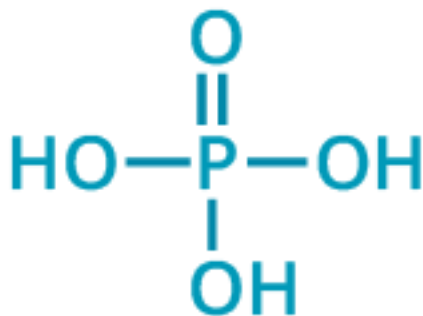


LEAD
(Untreated)

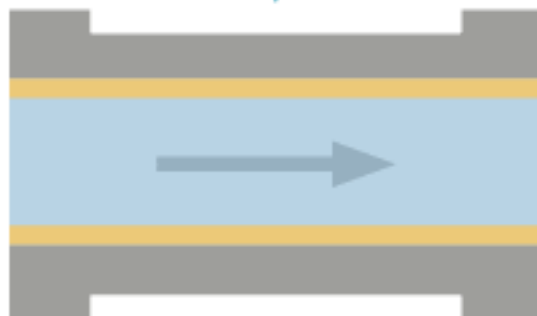
LEAD
(Treated)

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

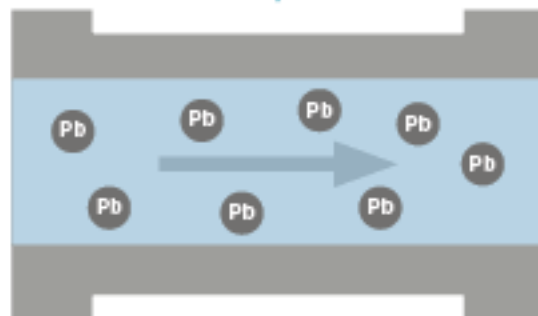
CORROSION CONTROL



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.



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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?").



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