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# **Cadmium in Children's Jewelry**

## **(a chemist's perspective)**

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# Cadmium

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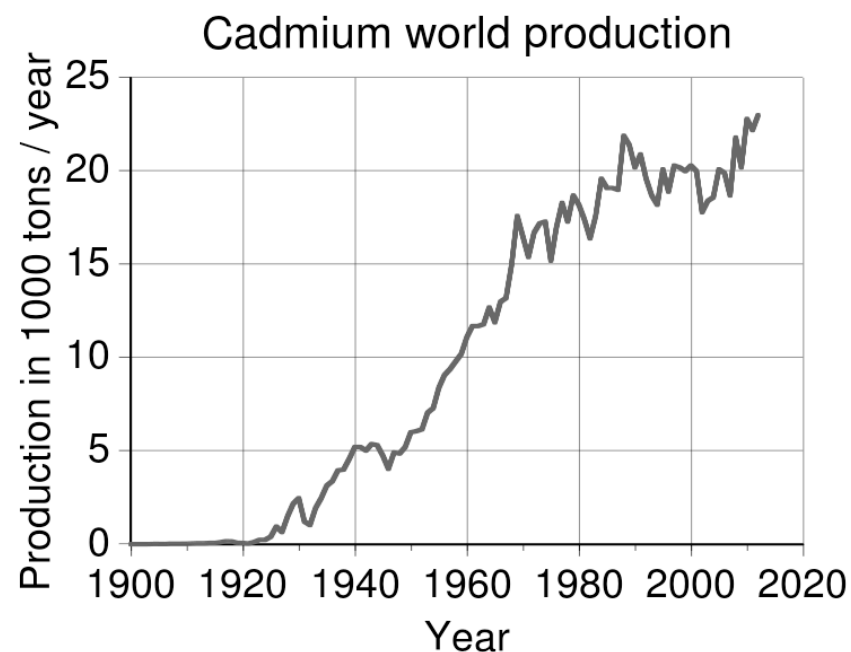
Shiny, soft, malleable metal,  
reasonable, resistant to corrosion

Density Cd:  $8.65 \text{ g/cm}^3$

Density Al:  $3.70 \text{ g/cm}^3$

Melting Point:  $321^\circ\text{C}$

Boiling Point:  $767^\circ\text{C}$



bulk pricing cadmium:  
< \$0.30/pound

bulk pricing tin:  
~\$9.00/pound

## Cadmium Distribution and Production

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Cadmium makes up  
~0.1 ppm  
of the Earth's crust

In comparison:  
65 ppm zinc  
50 ppm copper  
50,000 ppm iron

No significant  
cadmium deposits

Produced as byproduct  
from processing  
zinc, lead, and copper

**Elements never disappear,  
they only get redistributed!**

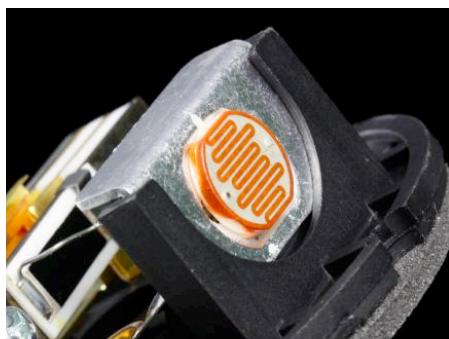


## Cadmium Uses

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Rust proofing



Semiconductors



Pigments

“Since the 1960s, when alarms were first sounded about cadmium, industry found alternatives for most products that reach the consumer.”

Emsley, J. *Nature's Building Blocks*, Oxford University Press, 2001, p. 77.



## 'Elements of Life'

1 H	<div>Macronutrients</div> <div>Micronutrients</div>																2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub		114 Uuq		116 Uuh		118 Uuo
58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu				
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr				

Cadmium has no known useful role in higher organisms.

Hogan, C. M. Heavy Metal. in *Encyclopedia of Earth*. National Council for Science and the Environment.  
E. Monosson and C. Cleveland (Eds.), Washington DC, 2010.

## Cadmium is Toxic

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In contrast to zinc, **cadmium** is not only *not essential*, it is decidedly *toxic* for organisms (max. allowed conc.  $0.05 \text{ mg m}^{-3}$ ). The human body contains about 0.4 mg Cd per kg (for smokers, the amount about 0.8 mg). The daily intake with food is usually about 0.03 mg; the limit of toleration is about 0.07 mg. *Oral intake* of cadmium salts can cause vomiting, gastrointestinal upset, liver damage and cranial damage. *Inhalation* of Cd vapors irritates the air passages and causes headaches. *Chronic poisoning* leads to anemia, yellow coloration of the necks of the teeth, anemia, pains in the vertebrae and, in advanced stages, damage to the bone marrow, osteoporosis and severe skeletal changes. Fatal chronic cadmium poisoning is called “itai-itai” disease in Japan.

Wiberg, N.; Wiberg, E.; Holleman, A.F. *Inorganic Chemistry*, English Translation of 101<sup>st</sup> Ed., Academic Press, 2001, p. 1295.

**Among UN Environmental Program Top 10 Hazardous Pollutant**

## (Non-occupational) Exposure to Cadmium

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- Cigarette smoke (most important source in many populations)
- Food (by way of phosphate fertilizers)
  - highest concentrations:* crustaceans, molluscs, kidneys, mushrooms
  - higher consumption:* grains, vegetables, starchy roots
- Production of:
  - ▶ Nonferrous metals (zinc, lead, copper, etc.)
  - ▶ Iron/steel
  - ▶ Cement
- Municipal solid waste incineration
- Fossil fuel combustion



# The Period Table of Elements: Cadmium's Neighbors

MAIN-GROUP ELEMENTS										MAIN-GROUP ELEMENTS									
1A (1)										8A (18)									
1	1									2	2								
	H										He								
	1.008										4.003								
2	3									5	6	7	8	9	10				
	Li										B	C	N	O	F	Ne			
	6.941										10.81	12.01	14.01	16.00	19.00	20.18			
3	11									13	14	15	16	17	18				
	Na										Al	Si	P	S	Cl	Ar			
	22.99										26.98	28.09	30.97	32.07	35.45	39.95			
4	19	4	47	48	49	50	51	52	53	2B (12)	30	31	32	33	34	35	36		
	K		107.9	112.4	114.8	116.0	117.9	118.7	119.9		Zn	Ga	Ge	As	Se	Br	Kr		
	39.10										65.39	69.72	72.61	74.92	78.96	79.90	83.80		
5	37		79	80	81	82	83	84	85		47	48	49	50	51	52	53	54	
	Rb		107.9	112.4	114.8	116.0	117.9	118.7	119.9		Ag	Cd	In	Sn	Sb	Te	I	Xe	
	85.47										107.9	112.4	114.8	117.7	121.8	127.6	126.9	131.3	
6	55	56	79	80	81	82	83	84	85		79	80	81	82	83	84	85	86	
	Cs	Ba	107.9	112.4	114.8	116.0	117.9	118.7	119.9		Au	Hg	Tl	Pb	Bi	Po	At	Rn	
	132.9	137.3									197.0	200.6	204.4	207.2	209.0	(209)	(210)	(222)	
7	87	88	89	104	105	106	107	108	109	110	111	112							
	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt										
	(223)	(226)	(227)	(261)	(262)	(266)	(262)	(265)	(266)	(269)	(272)	(277)	As of mid-1999, elements 110 through 112 have not yet been named.						

INNER TRANSITION ELEMENTS

6	Lanthanides	58	59	60	61	62	63	64	65	66	67	68	69	70	71
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
		140.1	140.9	144.2	(145)	150.4	152.0	157.3	158.9	162.5	164.9	167.3	168.9	173.0	175.0
7	Actinides	90	91	92	93	94	95	96	97	98	99	100	101	102	103
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
		232.0	(231)	238.0	(237)	(242)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(260)



## Toxicity of Cadmium – Cause and Effect

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### Cause

- Can displace zinc in enzymes, inactivating them (200+ zinc-dependent enzymes)
- Can displace calcium (in bones and enzymes)
- Can interfere with the uptake of copper and zinc

### Effect

- Kidney failure
- Cardiovascular diseases (at least a risk factor)
- Endocrine disruptor
- Carcinogenic effects (disputed claim)
- Bone embrittlement, painful skeletal deformations



## Toxicity of Cadmium – How Biology Mitigates It

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**Our bodies contain proteins** (so called metallothioneins) **that are designed to detoxify the body of heavy metals** (cadmium, lead, mercury, etc.): excretion through the kidneys

**Their ability to do so is limited**

**Hence, very low tolerable weekly intakes for humans are set:**

- 2.5 µg/kg body weight (EFSA Panel on Contaminants in the Food Chain)
- 7 µg/kg body weight (FAO/WHO Expert Committee on Food Additives)

**Acute cadmium poisoning hard to treat**



## Summary Comments

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- ➡ Cadmium is toxic
- ➡ We are already being exposed to multiple sources of cadmium
- ➡ “Cadmium stays in the body for a long time so it is best to prevent the exposure of young children to cadmium in jewelry.” ([www.health.ny.gov](http://www.health.ny.gov))
- ➡ Replacing lead with the arguably more toxic cadmium makes no sense
- ➡ Use of cadmium in children’s jewelry is solely to reduce costs
- ➡ Alternatives are available
- ➡ Potential harm of children’s jewelry does not outweigh its benefits
- ➡ Precautionary principle dictates: aim at lowest possible cadmium exposure

## Literature

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A. Sigel, H. Sigel, and R. K. O. Sigel, Eds. *Cadmium: From Toxicology to Essentiality*. Metal Ions in Life Sciences, Vol. 11, Springer: Dordrecht, 2013.

Scoullou, M. J. (Ed.); Vonkeman, G. H.; Thornton, I.; Makuch, Z. *Mercury, Cadmium, Lead: Handbook for Sustainable Heavy Metals Policy and Regulation*. Kluwer Academic Press: Dordrecht, 2001.

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E. Monosson and C. Cleveland (Eds.). Washington DC, 2010. ([www.eoearth.org](http://www.eoearth.org))

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Fraústo da Silva, J. J. R.; Williams, R. J. P. *The Biological Chemistry of the Elements: The Inorganic Chemistry of Life*, Clarendon/Oxford University Press: Oxford, 1993.